OCS Study
BOEM 2019-021

Distribution and Relative Abundance of Marine Mammals in the Eastern Chukchi and Western Beaufort Seas, 2018
Annual Report

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Gray whale near mud plume and sea ice
Northeastern Chukchi Sea
July 2018
Photo by Amy Willoughby
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Final Report

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DISCLAIMER

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ABSTRACT

This report describes field activities of the Aerial Surveys of Arctic Marine Mammals (ASAMM) project conducted during summer and fall (1 July–29 October) 2018, and data and analyses used to summarize field activities. Surveys were based in Utqiaġvik (formerly Barrow), Alaska, and Deadhorse, Alaska, and targeted the northeastern and southcentral Chukchi and western Beaufort seas, between 67°N and 73°N latitude, 140°W and 169°W longitude.

Sea ice cover in the Chukchi Sea study area in 2018 was extremely light in August, September, and October. Sea ice cover in the Beaufort Sea study area was heavy in July, August, early September and the latter half of October, and light in late September and early October. When surveys commenced in early July, sea ice remained throughout the Beaufort Sea study area and north of 70.5°N in the Chukchi Sea study area and remained there through mid-July. Sea ice persisted throughout the Alaskan Beaufort Sea in August, but the Chukchi Sea study area was nearly sea ice free by mid-August. Areas completely devoid of sea ice in the Alaskan Beaufort Sea remained limited through mid-September, and the study area was completely ice free for <20 days (from late September through mid-October). By mid-October, new ice was forming nearshore and offshore in the Beaufort Sea study area and this area was effectively covered with >90% new ice by the end of the field season. The Chukchi Sea study area remained ice-free through September and October.

A total of 99 survey flights were conducted. The Utqiaġvik-based aerial survey team conducted surveys from 3 July through 27 October 2018, and the Deadhorse-based aerial survey team conducted surveys from 20 July through 8 October 2018. Total combined flight time was 481.4 hours, including 248.5 hours of transect effort. Nearly 125,000 km were flown, with 54,277 km of effort on transect. Data were also collected during Focal Group Follow (FGF), Field of View (FOV), and Cetacean Aggregation Protocols (CAPs) mode. Images from a camera mounted in the belly of one of the survey aircraft were collected during 32 flights. Surveys were conducted in the western Beaufort Sea in summer (July-August) for the seventh consecutive year and in survey block 23 (southcentral Chukchi Sea) for the fifth consecutive year.

There were 3,249 sightings of 192,333 marine mammals observed during all (transect, CAPs, search, and circling) survey modes, including:

- 430 sightings of 571 bowhead whales (*Balaena mysticetus*),
- 295 sightings of 493 gray whales (*Eschrichtius robustus*),
- 53 sightings of 79 humpback whales (*Megaptera novaeangliae*),
- 77 sightings of 117 fin whales (*Balaenoptera physalus*),
- 3 sightings of 6 minke whales (*Balaenoptera acutorostrata*),
- 583 sightings of 1,814 belugas (*Delphinapterus leucas*),
- 2 sightings of 16 killer whales (*Orcinus orca*),
- 15 sightings of 21 harbor porpoises (*Phocoena phocoena*),
- 60 sightings of 111 unidentified cetaceans,
- 991 sightings of 185,688 Pacific walruses (*Odobenus rosmarus divergens),*
- 86 sightings of 97 bearded seals (*Erignathus barbatus*),
- 627 sightings of 3,193 pinnipeds that could not be identified to species, and

- 27 sightings of 127 polar bears (*Ursus maritimus*).

Bowhead whales were seen in all months of the study period, with fewer whales observed in July and August compared to 2012-2017. Distribution in the western Beaufort Sea (140°W-157°W) in July and August ranged from the inner continental shelf to the slope (≤50-2,000 m depth), then became progressively closer to shore in fall, except in Barrow Canyon where bowheads remained well offshore. The bowhead whale sighting rate (whales per on-effort km) by depth zone between 140°W and 154°W in the western Beaufort Sea was highest in the 51-200 m zone in July, and the 21-50 m zone in August, September and October. Sighting rate by depth zone in the Barrow Canyon area (154°W-157°W) was highest in the 21-50 m zone in July, and the 201-2000 m zone in August, September and October. In the northeastern Chukchi Sea (69°N-73°N, 157°W-169°W), few bowhead whales were seen in July and August. The highest sighting rates in September and October were in the 51-200 m North depth zone. The survey block with the highest overall bowhead whale sighting rate in summer and fall was block 12. The eastern Chukchi Sea survey block with the highest overall sighting rate was block 13. Bowhead whales were not seen in block 13N (north of 72°N) despite surveys conducted there in July and August.

Compared to previous years with light sea ice cover (i.e., 1989, 1990, 1993-2017), bowhead whale sightings (not normalized by survey effort) in the western Beaufort Sea in fall (September-October) were significantly nearer to shore and in shallower water in the East (140°W-148°W) region, and significantly farther from shore and in deeper water in the West (148°W-156°W) region. The same trends were noted when bowhead whale sightings in fall 2018 were compared to previous years with heavy ice cover (i.e., 1991, 1992), although differences were not significant in the West region. Bowhead whale sightings in summer 2018 showed some significant differences in offshore distance and depth distribution compared to sightings in summer 2012-2017.

Spatial models of bowhead whale relative abundance in the western Beaufort Sea were created to examine high-use areas (HUAs) during fall (September-October) 2018 and each month from July through October for the 19-year period from 2000 to 2018. These models accounted for heterogeneous survey effort and group sizes across the survey area. The area of highest predicted relative abundance in fall 2018 was located just outside the barrier islands between approximately 145°W and 149°W, north of Deadhorse. High predicted relative abundance was also evident offshore of the 50-m isobath, from 152°W to 156°W, including part of Barrow Canyon. The estimated median distance-from-shore statistics for the East region (140°W-148°W) in 2000-2018 decreased from 55.7 km in July to 23.7 km in August, 20.2 km in September, and 25.4 km in October. In the West region (148°W-156°W), the 2000-2018 model predicted that the median distance from shore varied from 44.2 km in July to 28.1 km in August, 25.5 km in September, and 31.1 km in October.

Bowhead whales were observed feeding and milling from August through mid-October in the western Beaufort Sea; feeding was not observed in the eastern Chukchi Sea. The percentage of bowhead whales observed feeding and milling was lower (14%) than in previous years. Surveys were conducted east of Point Barrow in a well-documented bowhead whale core area where "krill traps" often form and, while small groups of bowhead whales were often seen in this area, relatively few were observed feeding. In fall, feeding and milling were most often observed in the western Alaskan Beaufort Sea from Harrison Bay to Point Barrow (approximately 150°W-157°W).

Twenty-eight bowhead whale calves were seen in 2018, including three calves seen during summer and 25 calves seen in fall; most calves were seen in the western Beaufort Sea. The summer and fall bowhead whale calf ratios (number of calves per number of total whales) were similar to calf ratios in many previous years that ASAMM surveyed from 1982 to 2016 but substantially lower than calf ratios in 2017. Bowhead whale calf sighting rates (calves per transect km) in the western Beaufort Sea were very low in summer 2018 compared to calf rates in summer 2012-2017, and much lower in fall 2018 compared to fall 2016 and 2017.

Gray whales were seen in all months of the study period in the northeastern Chukchi Sea, primarily within ~120 km of the Alaskan coastline between Point Franklin and Icy Cape. Relatively few gray whales were seen in the area between Point Franklin and Point Barrow, where they have been reliably seen in past years, and no gray whales were seen between Icy Cape and Point Hope. One gray whale was seen within the confines of Peard Bay. Gray whale aggregations were also seen in the southcentral Chukchi Sea southwest of Point Hope. The highest sighting rate by depth zone was in the 51-200 m North depth zone, which is different from any previous year since surveys were extended to encompass a rich benthic habitat in the southern Chukchi Sea. Highest sighting rates by month occurred in July. Most gray whales observed were feeding (82%). Thirty-seven gray whale calves were seen resulting in a calf ratio of 0.075 which is lower than calf ratios in 2012-2017 but higher than calf ratios in 2009-2011.

Belugas were sighted primarily in the western Beaufort Sea, with very few sightings in the northeastern Chukchi Sea. Highest sighting rates occurred in July, decreased in August, and remained even lower in September and October. The highest sighting rates by depth zone were in the 201-2,000 m zone between 140°W and 157°W, and in the 51-200 m North zone in the Chukchi Sea. One beluga was sighted between the barrier islands and the mainland in the central Alaskan Beaufort Sea.

Additional noteworthy results from the 2018 ASAMM field effort included:

- Humpback whales (53 sightings of 79 whales, including two calves) were sighted in the southcentral Chukchi Sea from July through September.
- Fin whales (77 sightings of 117 whales, including one calf), were sighted in the southcentral Chukchi Sea in July, September, and October.
- Minke whales (3 sightings of 6 whales) were sighted in the eastern Chukchi Sea in July, August, and September.
- Killer whales (2 sightings of 16 whales) were sighted in the northeastern Chukchi Sea in August and September.
- Harbor porpoises (15 sightings of 21 porpoises) were sighted in the eastern Chukchi Sea. Porpoises were sighted in the northeastern Chukchi Sea in September and October, and in the southcentral Chukchi Sea in July and September.
- Walruses were observed in the water and on ice (particularly near Hanna Shoal) and land. A walrus haulout was documented on 30 August on a barrier island near Point Lay. The

onshore haulout, which varied in size from 11,000 to 40,000 walruses, persisted until late October.

- The sighting rate for unidentified pinnipeds and small unidentified pinnipeds (combined) in the ASAMM study area was low compared to previous years. One small unidentified pinniped was observed inshore of the barrier islands in the central Alaskan Beaufort Sea. Four groups, ranging from 55 to 1,300 seals, were observed hauled out on barrier islands near Point Franklin and Icy Cape in the northeastern Chukchi Sea in mid-August and mid-October, and one group of 15 was sighted on a beach in Harrison Bay in mid-September.
- Relatively few polar bears were observed in 2018 compared to previous years that ASAMM surveys were conducted. Polar bears were seen from east of Kaktovik to approximately 120 km northwest of Wainwright; most polar bears were seen in the western Beaufort Sea. Most polar bears were seen on shore or barrier islands, or swimming within 3 km of land. Seven bears were seen on sea ice between 20 and 82 km from shore. Three polar bears were observed swimming in areas of 75-85% sea ice cover between 34 and 106 km from shore, and four polar bears were observed swimming in ice-free areas between 17 and 107 km from shore. All bears observed swimming in ice-free areas were seen in September, at which time sea ice had receded from shore.

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Abbreviations and Acronyms

ADF&G	Alaska Department of Fish and Game
AFSC	Alaska Fisheries Science Center
ARBO	Arctic Region Biological Opinion
ARCWEST	Arctic Whale Ecology Study
ASAMM	Aerial Surveys of Arctic Marine Mammals
BLM	Bureau of Land Management
BOEM	Bureau of Ocean Energy Management
BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement
BPC	Belly Port Camera
BS	Beaufort Sea (specific to beluga population)
BWASP	Bowhead Whale Aerial Survey Project
C	Celsius
CAPs	Cetacean Aggregation Protocols
COMIDA	Chukchi Offshore Monitoring in Drilling Area
CPUE	calves per unit effort (index of relative abundance or occurrence)
CSESP	Chukchi Sea Environmental Studies Program
ECS	Eastern Chukchi Sea (specific to beluga population)
e.g.	for example
ESA	Endangered Species Act
FGF	Focal Group Follow
FOV	Field of View
GPS	Global Positioning System
hr	hour
HUA	high-use area
i.e.	that is
km	kilometer
m	meter
max	maximum
min	minimum
MML	Marine Mammal Laboratory (formerly NMML)
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
n_i	number of individuals
n_s	number of sightings
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NMML	National Marine Mammal Laboratory
No.	number
NSB	North Slope Borough
NOAA	National Oceanic and Atmospheric Administration
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
P	probability
PBPUE	polar bear per unit effort

PMEL	Pacific Marine Environmental Laboratory
PPUE	pinnipeds per unit effort (index of relative abundance or occurrence)
s	second
SD	standard deviation
°T	degrees True
TB	terabyte
Tr	transect
TrC	circling from transect
TrSi	transect sightings
UAF	University of Alaska Fairbanks
UAS	unmanned aerial system
UAV	unmanned aerial vehicle
USC	U.S. Code
USCG	U.S. Coast Guard
USDOC	U.S. Department of Commerce
USDOD	U.S. Department of Defense
USDOI	U.S. Department of the Interior
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WPUE	whales or walruses per unit effort (index of relative abundance or occurrence)
Z	standard normal variable

INTRODUCTION

In 1953, the Outer Continental Shelf Lands Act (OCSLA) (43 USC 1331-1356) charged the U.S. Secretary of the Interior with the responsibility of administering minerals exploration within and development of the Outer Continental Shelf (OCS). The Act empowered the Secretary to formulate regulations so that its provisions could be met. The OCSLA Amendments of 1978 (43 USC 1802) established a policy for the management of oil and natural gas in the OCS and for protection of the marine and coastal environments. The amended OCSLA states that the Secretary of the Interior shall conduct studies in areas or regions of sales to ascertain the "environmental impacts on the marine and coastal environments of the Outer Continental Shelf and the coastal areas which may be affected by oil and gas development" (43 USC 1346).

Subsequent to the passage of the OCSLA, the Secretary of the Interior designated the Bureau of Land Management (BLM), U.S. Department of the Interior (USDOI), as the administrative agency responsible for leasing submerged federal lands, and the Conservation Division of the U.S. Geological Survey (USGS) for classifying and evaluating submerged federal lands and regulating exploration and production. In 1982, the U.S. Minerals Management Service (MMS) assumed these responsibilities. The MMS was renamed the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) in 2010. In 2011, the Bureau of Ocean Energy Management (BOEM) assumed responsibilities for administering environmentally and economically responsible development of offshore resources.

The history of the management recommendations and decisions relevant to natural resource exploration, development, and production in the Alaska OCS and associated effects on marine mammals is summarized here. In June 1978, the BLM entered into a consultation with the National Marine Fisheries Service (NMFS) under Section 7 of the Endangered Species Act (ESA) of 1973 (16 USC 1531-1543). The purpose of the consultation was to determine the likely effects of the proposed Beaufort Sea Oil and Gas Lease Sale on endangered bowhead (*Balaena mysticetus*) and gray (*Eschrichtius robustus*) whales. NMFS determined that insufficient information existed to conclude whether the proposed Beaufort Sea sale was likely to jeopardize the continued existence of bowhead and gray whales. In August 1978, NMFS recommended studies to the BLM that would fill the information needs identified during the Section 7 consultation. Subsequent Biological Opinions for leasing and exploration in the Beaufort Sea (Sales 71, 87, and 97) and the 1988 Arctic Region Biological Opinion (ARBO) used for Beaufort and Chukchi sea sales (Sales 124, 126, 144, and 170) recommended continuing studies of whale distribution and OCS-industry effects on bowhead whales (USDOC, NOAA, NMFS 1982, 1983, 1987, and 1988), in addition to monitoring bowhead whale presence during periods when geophysical exploration and drilling were occurring. The 2006 and 2008 ARBO issued by NMFS for leasing and exploration in the U.S. Beaufort and Chukchi seas, Alaska, and authorizations of small takes under the Marine Mammal Protection Act (MMPA) of 1972 (16 USC 1361-1407) (USDOC, NOAA, NMFS 2008) recommended the following conservation actions:

> MMS and NMFS should continue research to update environmental inventories of marine mammals for the Chukchi Sea. Marine mammal surveys should be continued. MMS should consider a comprehensive program for this purpose which employs aerial and ship

> based efforts as well as the use of passive acoustics. In particular, the current BWASP [Bowhead Whale Aerial Survey Project] program should be expanded to include Block 13. MMS should particularly engage in research to describe bowhead whale behavior, movements and distribution, and important habitats in these waters. Efforts should be made to obtain photographs of humpback whales within the area for photo-identification.
>
> MMS should continue research to describe the impact of exploration activities on the migrational movements and feeding behavior of the bowhead whale. Specific plans should be developed and implemented to monitor the cumulative effects of exploration, development, and production on the bowhead whale. These research designs and results should be reviewed annually to ensure that the information collected is addressing the concerns of NMFS and the affected Native communities.

The current ARBO, issued by NMFS in 2013 for oil and gas leasing and exploration activities in the U.S. Beaufort and Chukchi seas over a 14-year period beginning March 2013 and ending in March 2027 (USDOC, NOAA, NMFS 2013), includes the following conservation recommendations specific to marine mammal studies:

> Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).
>
> 9. Under the BOEM Environmental Studies Program, consider studies to monitor abundance, trends, habitat use, and productivity of listed species to assist with understanding potential effects of human activities on populations;
>
> 10. Under the BOEM Environmental Studies Program, consider specifically [studies] designed to assess abundance, population trends, habitat use, and productivity of ringed and bearded seal populations that may be affected by oil and gas development.

Biological opinions issued in 2015 and 2018 included conservation recommendations specific to Lease Sale 193 in the northeastern Chukchi Sea (USDOC, NOAA, NMFS 2015) and development of the Liberty Prospect in the central Alaskan Beaufort Sea (USDOC, NOAA, NMFS 2018a), which are in addition to those recommended in the 2013 ARBO.

Following several years when drilling was limited to 1 November through 31 March (USDOI, MMS 1979), variable two-month seasonal drilling restrictions on fall exploratory activity in the joint Federal/State Beaufort Sea sale area were implemented in May 1982. The Diapir Field Sale 87 Notice of Sale (1984) stated that “Bowhead whales will be monitored by the Government, the lessee, or both to determine their locations relative to operational sites as they migrate through or adjacent to the sale area” (USDOI, MMS 1984). Subsequent lease sales in the Beaufort Sea Planning Area (Sales 97, 124, 144, 170, 186, 195, and 202) and Lease Sale 193 in the Chukchi Sea Planning Area did not include a seasonal drilling restriction, but the Notice of Sale for each contained an Information to Lessees clause stating that the “MMS intends to continue its area wide endangered whale monitoring program in the Beaufort Sea during exploration activities” (USDOI, MMS 1988, 1991, 1996, 1998).

To provide information used in Environmental Impact Statements and Environmental Assessments under the National Environmental Policy Act (NEPA) of 1969 (42 USC 4321-4347), and to assure protection of marine mammals under the MMPA and the ESA, the BLM (and, later, MMS) funded numerous studies involving acquisition and analysis of marine mammal and other data, including an endangered whale monitoring plan that required aerial surveys. Information gathered during the monitoring program was used to help determine the extent, if any, of adverse effects on the species. From 1979 to 1987, the BLM and then the MMS (Alaska OCS Region) funded annual monitoring of endangered whales via aerial surveys in arctic waters under Interagency Agreements with the Naval Ocean Systems Center and through subcontracts to SEACO, Inc. (e.g., Ljungblad et al. 1987). The MMS used agency personnel to perform field work and reporting activities for surveys conducted in the western Beaufort Sea on an annual basis from 1987 to 2006 (referred to as the Bowhead Whale Aerial Survey Project, BWASP) (Treacy 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000, 2002a, 2002b; Monnett and Treacy 2005; USDOI, MMS 2008). In 2007, an Interagency Agreement between the MMS (U.S. Department of the Interior) and NMFS (specifically, the Alaska Fisheries Science Center [AFSC], NOAA, U.S. Department of Commerce) was established to authorize the National Marine Mammal Laboratory (NMML, a division of AFSC) to conduct BWASP surveys and assume partial responsibility for the management of the project. In 2008, NMML adopted full responsibility for all aspects of the BWASP surveys and related tasks, with continued funding and co-management by the MMS (now BOEM) (Clarke et al. 2011a, 2011b, 2011c). In 2016, NMML was re-named the Marine Mammal Laboratory (MML).

The Chukchi Offshore Monitoring in Drilling Area (COMIDA) marine mammal aerial survey component was initiated in 2008, via an Interagency Agreement between the MMS and AFSC. These surveys were a continuation of aerial surveys that were conducted by MMS-sponsored contractors from 1982 to 1991 (Ljungblad et al. 1987; Moore and Clarke 1992) and used similar methodology. The goal of the COMIDA aerial surveys was to investigate the distribution and relative abundance of marine mammals in the Chukchi Sea Planning Area during the open water (ice-free) months of June-October, when various species undertake seasonal migrations through the area. The COMIDA study area encompassed the northeastern Chukchi Sea from the shore seaward, 68°N-72°N and 157°W-169°W, and overlaid Lease Sale 193 (offered in February 2008) (Clarke et al. 2011d).

In 2011, an Interagency Agreement between BOEM and AFSC was established to authorize NMML to continue the BWASP and COMIDA studies under the auspices of a single study, Aerial Surveys of Arctic Marine Mammals (ASAMM). The goal of the ASAMM study is to document the distribution and relative abundance of bowhead, gray, and fin whales and other marine mammals in areas of potential seismic surveying, drilling, construction, and production activities in the western Beaufort and eastern Chukchi seas (Clarke et al. 2012, 2013a, 2014, 2015a, 2017a, b, 2018a). Data from the project shall be used to relate variation in marine mammal distribution or relative abundance to other variables, such as physical oceanographic conditions, indices of potential prey density, and anthropogenic activities, if information on these variables is available.

The objectives of the ASAMM study are to:

1) Monitor the spatial and temporal variability in the density, distribution, and behavior (including calving/pupping, feeding, hauling out) of marine mammals (cetaceans, ice seals, walruses, and polar bears) in the Alaskan Arctic, primarily through line-transect aerial survey data, with supplementary information from aerial photo-identification data;
2) Describe the annual migration of bowhead whales across the U.S. Arctic, including inter-annual variability or long-term trends in the spatial distribution and timing of the migration;
3) Provide near real-time data or derived products, such as graphical data summaries, on marine mammals and environmental conditions in the U.S. Arctic to BOEM and NMFS;
4) Provide information on marine mammal abundance and distribution to Alaska Natives for use in management of subsistence hunts and assessments of anthropogenic impacts on marine mammal resources; and
5) Provide an objective wide-area context for understanding marine mammal ecology in the U.S. Arctic to help inform management decisions and interpret results of other small-scale studies.

METHODS AND MATERIALS

Study Area

The ASAMM study area encompasses the western Beaufort and eastern Chukchi seas (Figure 1), and partially overlaps the Chukchi Sea Planning Area and Beaufort Sea Planning Area but does not completely encompass either. Survey blocks overlay active federal oil and gas lease areas in the Alaskan Arctic, all of which are in the Beaufort Sea (Figure 1). The present study area includes survey blocks 1 through 23 and block 13N, between 140°W and 169°W longitude and 67°N and 73°N latitude, and encompasses approximately 253,000 km^2. Survey blocks 1 through 12 (140°W-157°W) comprise the western Beaufort Sea (formerly BWASP) study area, while survey blocks 13 through 23 and 13N (157°W-169°W) comprise the eastern Chukchi Sea (formerly COMIDA) study area. Survey block 1a encompasses the area between the barrier islands and the mainland in block 1. Survey block 13N is directly north of block 13, from 72°N to 73°N latitude.

The northern Chukchi Sea is largely ice-covered from early winter through early spring, although dramatic environmental changes have reduced modern sea ice extent from historical levels (Wood et al. 2015). In spring, open water leads begin to develop as ambient temperatures increase and warmer water flows northward from the Pacific Ocean through the Bering Sea and Bering Strait. The most nutrient rich waters flow in the Siberian Coastal Current, west of the ASAMM study area. Two less productive water masses, the Alaska Coastal Water and Bering Shelf/Anadyr Water, are found in the eastern Chukchi Sea (Figure 2). Current flow may be with or against the predominant wind direction.

In the Beaufort Sea, the Beaufort Gyre moves surface waters clockwise in the offshore regions. Underlying the gyre is the eastward-flowing Beaufort Undercurrent, which flows subsurface in areas where the sea floor is 51-2,000 m deep and undergoes frequent current reversals to the west (Aagaard 1984; Carmack and MacDonald 2002). In the nearshore shallow waters of the Beaufort inner shelf (≤ 50 m depth), currents tend to follow local wind patterns during periods of open water. Based on analysis of modeled sea level and ice motion, wind-driven currents in the Arctic between 1948 and 1996 were found to alternate between anticyclonic and cyclonic circulation, with each regime persisting from five to seven years (Johnson et al. 1999; Proshutinsky and Johnson 1997; Proshutinsky et al. 2015). However, the wind-driven regime has been largely anticyclonic since 1997, with a cyclonic regime observed only in 2009 (Richter-Menge et al. 2011). Intra-annual variation was especially noticeable in 2011-2012, when large-scale circulation was weakly anticyclonic from September 2011 to August 2012, followed by a strong cyclone event that occurred in the first week of August 2012 (Jeffries et al. 2012).

Shorefast ice forms during the fall and may eventually extend up to 50 km offshore by the end of winter (Norton and Weller 1984). The pack ice, which historically included multiyear ice averaging 4 m in thickness with pressure ridges up to 50 m thick (Norton and Weller 1984; Wood et al. 2015), becomes contiguous with new and shorefast ice in late fall. From late November to mid-May, the Beaufort Sea normally remains almost completely covered by ice. In

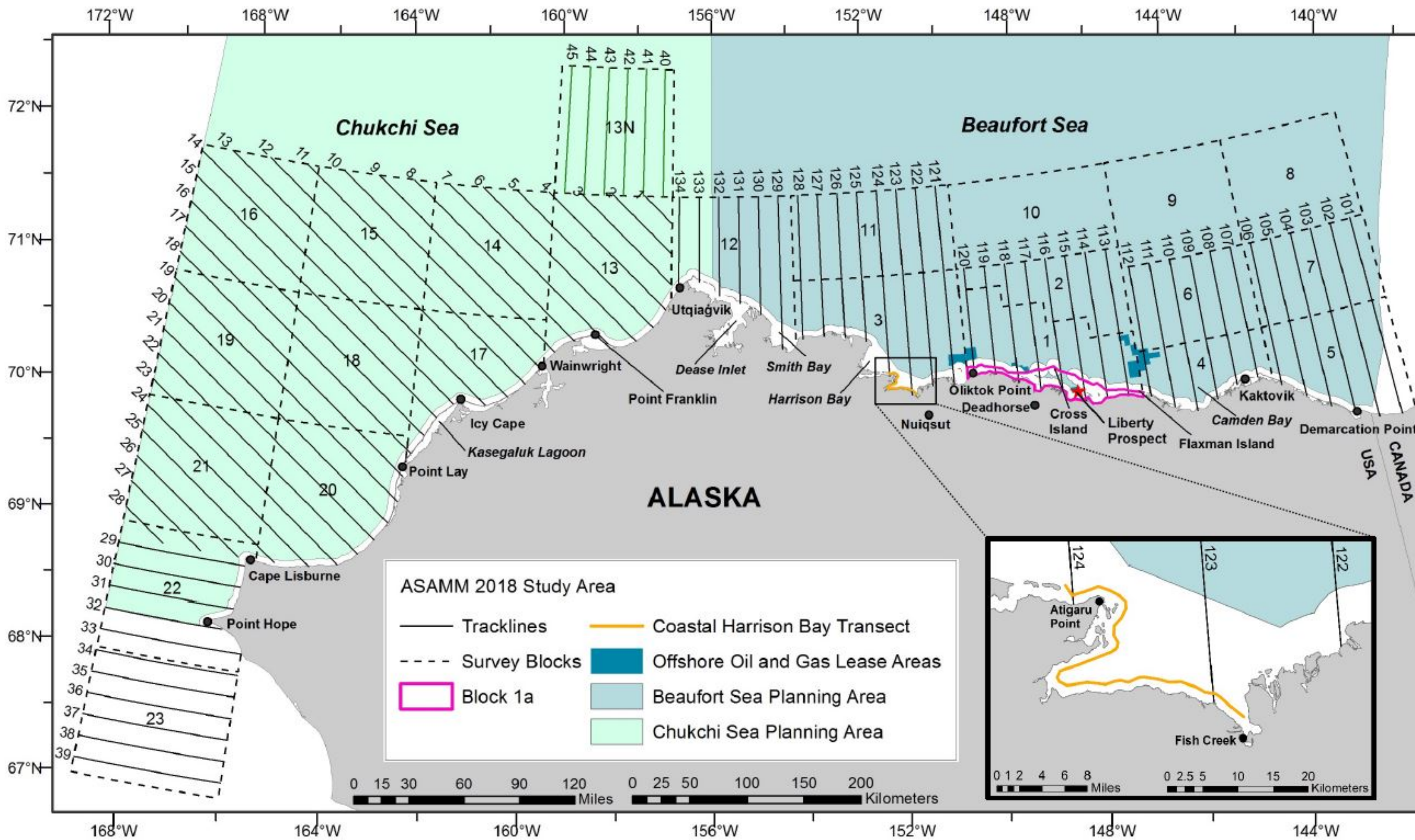

Figure 1. ASAMM study area showing survey blocks, 2018 ASAMM tracklines (numbered), Chukchi Sea Planning Area, Beaufort Sea Planning Area, Liberty Prospect, and active lease areas. The inset provides a zoomed view of the coastal transect in Harrison Bay between Fish Creek and Atigaru Point

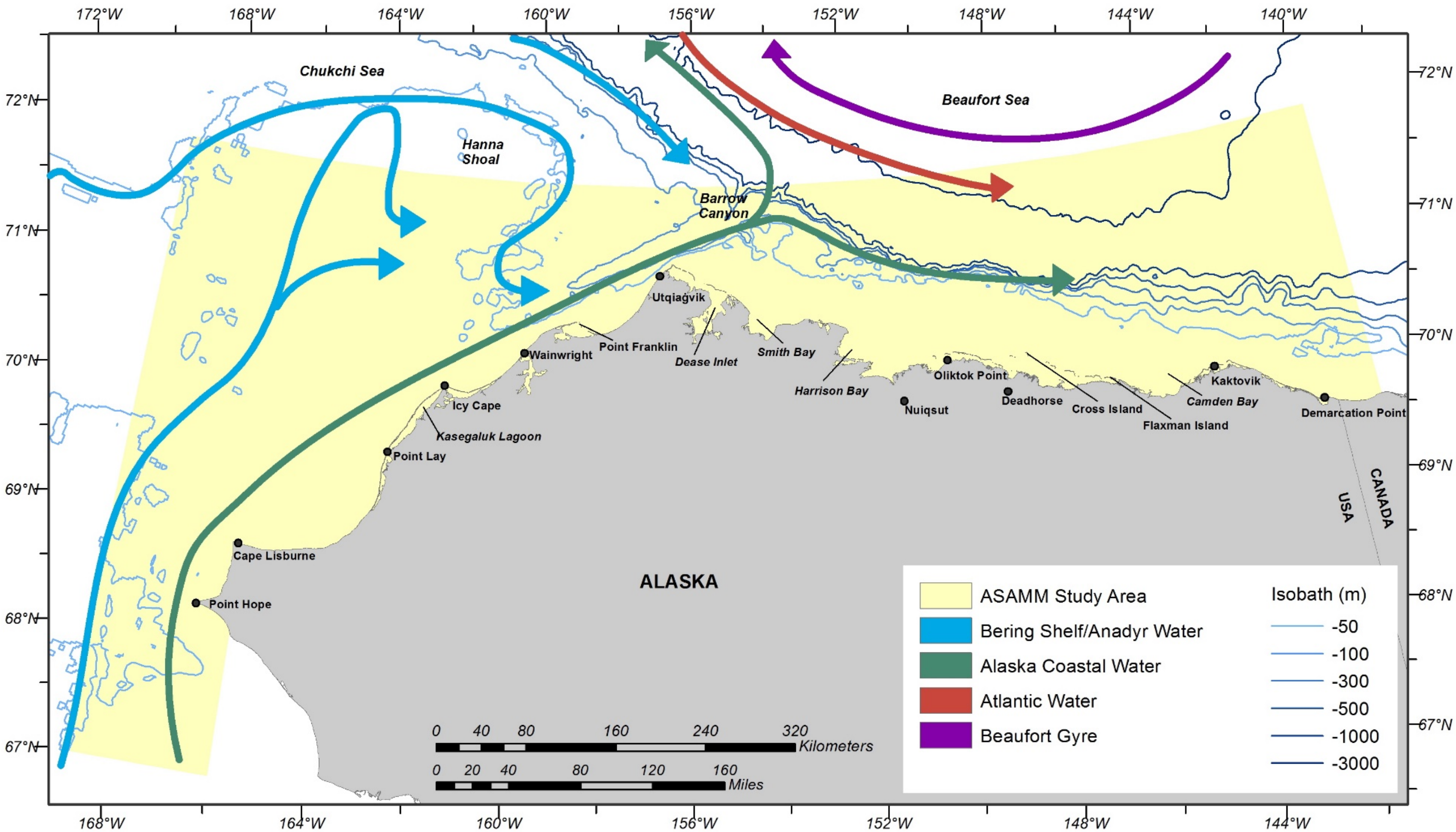

Figure 2. Eastern Chukchi Sea and western Beaufort Sea oceanographic features. Adapted from Citta et al. (2015).

spring, a recurring lead forms just seaward of the stable shorefast ice, followed by decreasing ice concentrations (LaBelle et al. 1983) and large areas of open water in summer. In recent years, the minimum area of the summer ice pack has been shrinking, setting records for new minima in several years, including 2007-2018 (National Snow and Ice Data Center 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016a, b, 2017, 2018b). Since 2007, the open water season has lengthened and the southern edge of the ice pack has been farther from Alaskan coastlines during annual sea ice minima. The decrease in sea ice extent has been correlated with an increase in Arctic Ocean cloud cover (Eastman and Warren 2010) and higher sea states (Thomson et al. 2016).

Local weather patterns affect the frequency and efficacy of marine aerial surveys. The ASAMM study area is in the Arctic climate zone, where marine climate data collected from various sources between 1854-1985 indicated that mean air temperatures at western Beaufort Sea coastal locations ranged from -0.9°C to -0.1°C during September and from -9.7°C to -8.5°C during October (Brower et al. 1988). More recently, mean annual air temperatures measured at Utqiaġvik from 1979 to 2012 had warmed by 2.7°C, with greatest warming (6.3°C) occurring in fall (Wendler et al. 2014). The heaviest precipitation (snow and rain) reported by Brower et al. (1988) from historical records occurred in September and October. Although total annual precipitation in the Alaskan Arctic has decreased since the late 1940s (Stafford et al. 2000), Wendler et al. (2014) noted that warmer air holds more water vapor and that there was an increase in precipitation for Utqiaġvik from 1979 to 2014. Wind speeds in September and October are generally higher than during other times of the year, perhaps because the open water and cooling land mass increase thermal instability (Wendler et al. 2009). Wind direction is predominantly easterly, driving the Beaufort Gyre, but winds occasionally shift to being westerly. The occurrence of storms during which at least one hourly reading of wind speed exceeded 15 m/s (approximately Beaufort wind force 7) also increased from 1972 to 2007 (Wendler et al. 2009). Mean annual wind speed recorded at Utqiaġvik from 1972 to 2007 was 5.6 m/s (approximately Beaufort wind force 4) (Wendler et al. 2009).

Sea state also affects visibility during aerial surveys. Visibility in ice-free surface waters in the Beaufort and Chukchi seas is influenced primarily by wind. Ocean waves are primarily from the north or east during September and October. Prior to 1997, significant wave heights were reduced by a factor of four from heights that would otherwise be expected during the open water season because pack ice limited fetch. Since 1997, large expanses of open water have been present during some or all of the field season. Corresponding wave heights have been considerably higher during periods of strong wind, obscuring visibility of marine mammals due to wave height, whitecaps, and/or spray.

Equipment

Surveys are flown in Turbo Commander aircraft, provided by Clearwater Air, Inc., and are conducted with highest regard for flight safety. Onboard safety equipment includes an impact-triggered emergency locator transmitter installed in the aircraft, an 8-person search and rescue life raft equipped with an emergency survival kit, portable personal locator beacons, portable marine and aviation band transceivers, satellite phones, electronics fire containment bag, and immersion suits. All personnel participating in the surveys undergo safety trainings, are thoroughly briefed on aircraft operations, and participate in aircraft egress drills. All personnel wear either flotation or dry suits and are outfitted with Switliks or other personal floatation devices containing emergency equipment. Details related to aviation safety protocols, emergency support services, firearms protocols, and means of mitigating risks to project personnel posed by wildlife encounters on the ground are included in a Safety and Logistics Plan (Appendix H). Observers and pilots are linked with a common communication system. The maximum time aloft in the Turbo Commander is approximately 6 hours, including fuel reserve.

Aircraft are equipped with bubble windows that afford primary observers a complete view of the trackline. A removable side window permits unobstructed photography. The pilot and copilot have good forward and side viewing. Each observer is issued a hand-held clinometer for measuring the angle of declination to sighting locations. A laptop computing system is used aboard each aircraft to display, store, and analyze flight and observational data. The computer system is connected to a Garmin Global Positioning System (GPS) with an external antenna, independent of the aircraft GPS. Latitude, longitude, and aircraft altitude from the GPS are transmitted to the data recorder's computer through a universal serial bus (USB) connection. Specialized software developed for ASAMM is used to record data. A custom mapping component of the software permits the data recorder to view sightings relative to the aircraft's trackline in real time. Data are continually backed up to an onboard external hard drive throughout each flight.

To collect data to address perception bias during ASAMM surveys, a downward-facing digital single lens reflex camera with a 20-mm lens is mounted in the belly port of one survey aircraft to collect continuous images at two- or three-second (time) intervals. The mounted camera is connected to an intervalometer that remotely triggers the camera's shutter, and a geo-tagging device that communicates with a GPS receiver to record the time, aircraft position (latitude/longitude), and altitude above ground level (AGL) to image metadata of every image that the intervalometer triggers. Additional details related to the belly port camera (BPC) data collection are included in Appendix D.

ASAMM efforts to collect left and right observer Field of View (FOV) data specific to Turbo Commander aircraft outfitted with bubble windows continued in 2018. The FOV data will provide some of the information required to address availability bias, which needs to be defined if ASAMM data are to be used to derive absolute estimates of density or abundance. Details of this effort and preliminary results are provided in Appendix G.

The USDOI, Bureau of Land Management, Alaska Interagency Coordination Center, South Zone Dispatch, uses Automated Flight-Following for real-time satellite-tracking of ASAMM aircraft. Dispatch personnel monitor current flight status via continuously updated maps, and pilots communicate hourly updates from the aircraft to Dispatch via Iridium satellite phones. In addition to these flight-following protocols, onboard transponders are set at discrete identification codes for radar tracking by air-traffic-control personnel.

Survey methods, equipment, and standard procedures have been developed and refined over the duration of the ASAMM project and precursor studies (1979-2017). Additional details of onboard equipment, data collection, and post-field analyses for historical surveys are described in detail elsewhere (e.g., Monnett and Treacy 2005; USDOI, MMS 2008; Clarke et al. 2011a, 2012, 2013a, 2014, 2015a, 2017a, b, 2018a).

Aerial Survey Design

Surveys are divided into two study areas for logistical reasons and to address objectives specific to each area. Aerial surveys are based out of Utqiaġvik to target the eastern Chukchi Sea study area and out of Deadhorse to target the western Beaufort Sea study area. Survey teams at each location are prepared to conduct surveys in either study area to take full advantage of optimal weather conditions and provide the best coverage possible of the entire ASAMM study area.

The field schedule is designed to maximize survey effort during the open water time period in the eastern Chukchi Sea and to monitor bowhead whale habitat use in the western Beaufort Sea during the open water season.

Transects in both study areas are oriented perpendicular to the coastline to cross major bathymetric features, such as Barrow Canyon, Hanna Shoal, and Beaufort Sea shelf and slope, and bowhead whale and beluga migration paths. Transect endpoints along shore in each study area are randomly shifted each year. Transects are generated once at the beginning of the field season and then flown for the duration of the field season (Figure 1). In the Chukchi Sea study area (157°W-169°W), 38 transects are spaced 19 km apart, extending 59 to 313 km offshore. In the Beaufort Sea study area (140°W-157°W), 34 transects are spaced 18 km apart, extending 72 to 177 km offshore. Surveys in block 13N are included in the 2018 survey design to investigate use of that area in summer by bowhead whales; transects follow the Beaufort Sea design because the north-south transect orientation crosses the bowhead whale migration path at that latitude. The survey design allows examination of differences in marine mammal distribution and relative abundance at each unique transect over the course of a field season and theoretically generates uniform coverage throughout the ASAMM study area when multiple years of effort are pooled. This survey design has been used in the Chukchi Sea study area since 2009 and was implemented in the Beaufort Sea study area in 2017. Transect spacing in the Beaufort Sea study area remains consistent with transect spacing used in 1979-2016, with one transect every 30 minutes (0.5 degrees) of longitude. The survey design also includes a coastal transect located one km offshore between Demarcation Bay in the Beaufort Sea and Point Hope in the Chukchi Sea. The coastal transect allows better documentation of nearshore habitat, including pinniped haulouts and polar bear aggregation areas. In 2018, a short section of the coastal transect in Harrison Bay, between Atigaru Point and Fish Creek, was specifically targeted to record the occurrence of marine or terrestrial mammals, as part of a partnership with ConocoPhillips (Figure 1). Note that the current survey design, in which geographically fixed transects are flown numerous times within the year, will make it appear on maps as if less effort has been flown relative to past years when new transects were randomly generated prior to each flight.

Transects are terminated at coastal endpoints located 1 km offshore of the main coastline or barrier islands, when present, except for transects 113-120 in the Beaufort Sea. Transects 113-120, in survey block 1, are extended inshore to cover the area between the barrier islands and shoreline (referred to as “block 1a”) to provide systematic survey coverage of the area around the

Liberty Prospect (Figure 1). Transects in the Chukchi Sea study area are truncated at ~168.75°W to avoid overflights of the International Dateline (169°W).

The selection of transects or survey blocks to be flown on a given day is non-random, based on reported or observed weather conditions in the study area, avoidance of recently surveyed areas, the need to deconflict airspace with unmanned aerial vehicles (UAV) and other aerial operations, and avoidance of marine subsistence activities. Surveys are not preferentially conducted in areas or during time periods with a higher likelihood of seeing whales (e.g., based on recent wind conditions, historical ASAMM data, or traditional ecological knowledge). Weather permitting, the project attempts to distribute effort evenly across the entire study area, with the exception of the northeastern Beaufort Sea survey blocks (blocks 8, 9, and 10). Allocations of survey effort in the Beaufort Sea favor coverage of survey blocks 1 through 7, 11, and 12 because bowhead whales were rarely sighted north of these blocks in three decades of previous aerial surveys, and this bowhead whale distribution pattern has been confirmed by satellite telemetry data (Quakenbush et al. 2010b). Survey-effort allocations increase survey effort and the number of bowhead whale sightings within high-use areas (HUA), thus increasing the available information in the region of greatest interest for this high-priority species.

Survey Flight Procedures

Surveys are conducted using line-transect methodology (Buckland et al. 2001). One primary observer is stationed on each side of the aircraft at bubble windows that permit an unobstructed field of vision from the trackline directly below the aircraft to the horizon. The data recorder is primarily responsible for data entry, but also functions as a secondary observer. Sightings from primary observers are considered "on effort" when the aircraft is on a trackline. Except for a few specific circumstances, non-primary observers, which include the data recorder, an occasional "fourth observer", and the pilots, do not announce sightings until those sightings are past abeam of the aircraft. Sightings by non-primary observers are generally considered "off effort". To maintain consistency in data acquisition between 2018 and previous years, all observers underwent training in ASAMM data collection techniques prior to and during the 2018 field season. Data quality was also enhanced by ensuring that at least two observers on each field team had previous experience conducting ASAMM surveys.

Ten survey modes are defined for data collection (Table 1), including five modes that are new in 2018. During a typical flight, a search or deadhead leg is flown to a targeted transect line. Survey effort over land or in areas with zero visibility is designated as deadhead. Aircraft position data, including latitude, longitude, heading, altitude, and time, are automatically recorded during deadhead segments but environmental and sighting data are not. Deadhead effort is not incorporated into further analyses. A series of transect lines are then flown, followed by a search or deadhead leg back to the base of operations. Transects are joined together by short search or deadhead legs. Sightings made on transect are all considered on effort. When large cetaceans are encountered, the aircraft usually diverts from the transect for brief (usually <10 minutes) periods and circles the original sighting location to verify species, observe behavior, improve group size estimates, determine whether calves are present, and, if conditions allow, take photographs. Any new sightings of whales made while circling the original sighting location are recorded as sightings on circling-transect and are considered off

Table 1. ASAMM survey mode definitions.

Survey Mode	Definition
Transect	Systematic survey effort (non-CAPs) along a prescribed line; sightings not limited to any distance from the trackline; on-effort.
Circling from transect	Directed effort searching a small localized area after diverting from transect; sightings limited to area inside the circle; off-effort.
Search	Non-systematic survey effort during transit or between transects; off-effort.
Circling from search	Directed effort searching a small localized area after diverting from search; off-effort.
Cetacean Aggregation Protocols (CAPs) - passing	Systematic survey effort along a prescribed transect in an area of high density large cetaceans; sightings limited to within 3 km of the trackline; on-effort.
Circling from CAPs	Directed effort searching the area out to 3 km from the trackline immediately after completing CAPs passing; excludes any ares surveyed in CAPs strip mode; off-effort.
CAPs strip	Systematic survey effort along a prescribed transect in an area of extremely high density large cetaceans; sightings limited to within 1 km of the trackline; on-effort.
Focal Group Follow (FGF)	Behavioral data collected on small groups (2-5 whales or 3 cow-calf pairs) of bowhead whales; off-effort.
Field of View (FOV)	Sighting data collected specifically to estimate the amount of time an object is within an observer's field of view from bubble windows on the Turbo Commander; off-effort.
Deadhead	High-speed, high-altitude transits to and from transects, and areas over land or without any downward visibility; no effort.

effort; sightings outside the perimeter of the circle are not recorded. Sightings made during search are recorded as sightings on search or on circling-search, and considered off effort. In areas where large cetacean sightings exceed the observers' ability to mark the location, record an accurate clinometer angle, and circle each sighting, Cetacean Aggregation Protocols (CAPs) are initiated (Appendix D). CAPs enable collection of data that can be used to derive an unbiased estimate of density or abundance. Sightings made during CAPs passing and CAPs strip are on effort. When small groups (2-5 whales or 3 cow-calf pairs) of bowhead whales are sighted, Focal Group Follow (FGF) may be initiated to collect behavioral data on group surface and dive intervals (Appendix D); all sightings entered during FGF are off effort. Field of View (FOV) data collection uses repeated sightings of stationary terrestrial targets at known offsets (perpendicular distances from the aircraft flight path) to collect data specific to observers' ability to see objects along the trackline (Appendix G). Marine mammal sightings are not recorded during FOV sessions.

Software on the laptop computing system allows for detailed real-time tracking of all effort to minimize chances of duplicate sightings being recorded during circling. Survey speed during transect and search segments is generally 213 km/hr, while survey speed during deadhead is usually in excess of 333 km/hr. Survey altitudes are chosen to maximize visibility of large cetaceans and minimize potential disturbance to marine mammals. All surveys are flown following guidelines prescribed in research permits from NMFS (Permit No. 20465) and the U.S. Fish and Wildlife Service (USFWS; Permit No. MA212570-1). Surveys are generally flown at a target altitude of 335 m, but can be flown as low as 305 m. In particular circumstances as specified in the research permits, survey altitude may be lower than 305 m. Generally, when cloud ceilings are consistently less than ~335 m or the wind force is above Beaufort 5, survey flights are redirected to survey blocks or transects with better conditions. Survey flights are aborted when conditions consistently did not meet minimum altitude (305 m) or wind force (Beaufort 5) requirements.

Transects are occasionally adjusted to avoid direct overflights of subsistence activities or of large groups of pinnipeds hauled out on sea ice or along the coast. In those situations, the pilots alert the science team of the upcoming object(s) prior to overflying and, depending on the situation, transects are truncated or survey altitudes increased. Transects are truncated by 5-8 km whenever small boats are observed to avoid interference with subsistence activities. During the fall subsistence hunt of bowhead whales, a minimum altitude of 458 m is maintained near Pt. Barrow, Cross Island, and Kaktovik. If 458 m cannot be maintained, transects are truncated to avoid a 37-km radius around each whaling area. Transects are adjusted by 3.7 km distance offshore and a minimum altitude of 610 m near coastal walrus haulouts. When walruses are encountered hauled out on sea ice, transects are diverted around the haulouts or survey altitude is increased to a minimum of 458 m. If walruses appear to react to the aircraft after these adjustments are initiated, diversion distances and survey altitudes are increased as needed. Transects are diverted to avoid direct overflights of haulouts of small pinnipeds on beaches or barrier islands. Behavioral data collected during FGF is also collected from a survey altitude of 458 m.

When weather and fuel conditions allow, circling is initiated in areas where aggregations of polar bears are known to occur onshore: on Cross Island and in the vicinity of Kaktovik (Figure 1). While circling these areas, photographic images are collected of as much of the island or coastline as possible and reviewed post-flight to obtain more precise counts of polar bears. Circling around polar bear aggregation areas is conducted at a survey altitude of 305 m and is not conducted for more than 15 minutes to reduce potential impacts to polar bears. Circling is not initiated on polar bears observed on ice or swimming in open water.

Coordination with Resource Users

MANNED AND UNMANNED AERIAL SURVEYS

ASAMM maintains daily contact with Flight Service, and direct contact with operators of all aircraft that may be operating in offshore and coastal regions.

Subsistence Activity

ASAMM coordinates with the North Slope Borough (NSB) Department of Wildlife Management regarding subsistence activities and strives to avoid direct overflights of areas where subsistence hunting of marine mammals is occurring. Transect lines are diverted away from coastal villages and from whalers in boats during hunting seasons.

Data Entry

Identical protocols are used to collect data in the two study areas. Customized, menu-driven, data-entry software is used to record all data in Microsoft Access database format. Details on all fields in the historical database are provided in the metadata (USDOC, NOAA, NMFS 2018b). Time and location data (date, local time, latitude, longitude, altitude, and aircraft heading) and environmental conditions (sky conditions, visibility [km] and visual impediments, percent sea ice cover, ice type, and Beaufort wind force) are recorded at sightings, during transitions in survey mode (e.g., transect, search, circling, CAPs, FGF, or FOV), when environmental conditions change, or at 5-minute (in time) intervals. Time and location only (date, time, latitude, longitude, and altitude) are automatically recorded from the GPS feed every 30 seconds (in time) to provide a detailed record of the flight track. Wind force is recorded according to Beaufort scale (Maloney 2006). Ice type is identified using terminology presented in Naval Hydrographic Office Publication Number 609 (USDOD, Navy, Naval Hydrographic Office 1956). Average sea ice cover within the field of view from the aircraft is estimated as a single percentage for each side of the trackline, regardless of ice types.

Common and scientific names used for marine mammals in this report are taken from Rice (1998). All marine mammals sighted are recorded during transect and search effort. The suite of data recorded for cetacean, walrus, and polar bear sightings during transect and search includes time, location, environmental conditions, survey mode, species, initial estimate of total number (low, high, and final estimates of group size are recorded as necessary), observer, swim direction (degrees True; cetaceans only), clinometer angle, side of plane, number of "calves" (including bear cubs, walrus calves, and pinniped pups), behavior, sighting cue, habitat, calf detection certainty, whether it is a same-day repeat sighting, and response to the aircraft. Calves are recorded based on several types of information, including relative size of the animal, proximity to a larger adult, behavior, color, and the observer's judgment. Marine mammal observers and flight crew watch for and record sudden overt changes in marine mammal behavior that might indicate a response to the survey aircraft (e.g., an abrupt dive, course diversion, or cessation of initial observed behavior). Reduced data subsets are sometimes recorded for non-cetacean marine mammals to expedite data entry, but always include time, location, environmental conditions, survey mode, observer name, species, total number, and response to aircraft. In areas of extremely high beluga, walrus, and pinniped density, sightings are combined together in "pooled" increments, and details pertaining to the sighting may be included in notes. Data collection software includes a "hot key" feature enabling rapid data entry for small unidentified pinnipeds, belugas, and walruses. This feature likely results in less pooling and increases recording of unique sightings of these species in high density areas relative to previous years (e.g., prior to 2017 when the hot key feature was introduced). On rare occasions, when the density of cetacean sightings is extremely high, unidentified pinnipeds and small unidentified pinnipeds are not recorded.

During CAPs mode, recorded marine mammal sightings are limited to large whales within 3 km of the trackline. Sighting data collected during CAPs passing include observer, species, clinometer angle, initial group size, and behavior. If sighting density is so high during CAPs passing that distinct sightings cannot be recorded separately, CAPs strip is initiated and recorded sightings are limited to those within 1 km of the trackline. Data collected during CAPs passing and strip mode are used to estimate encounter (or sighting) rate. Sighting data collected during CAPs circling, which always follows CAPs passing, include the full suite of sighting data (species, high/low/final group size, number of calves, behavior, calf detection certainty, and response to the aircraft). Data collected during CAPs circling are used to estimate group size, calf presence, behavior, and extrapolate species identification to sightings of unidentified cetaceans recorded during CAPs passing. Additional details on CAPs are included in Appendix D. Clinometer and observer are not recorded during CAPs circling; the entire observer team works as one to record groups.

Marine mammal sightings recorded during FGF effort are limited to the bowhead whale group being followed. Initial sighting data are entered as described above for transect or search sightings, but routine data collection ceases and instead focuses on surface and dive intervals and environmental conditions that affect visibility. Time and location data are automatically recorded. Data manually entered at each subsequent sighting of the focal group includes behavior, total whales, total calves, water column visibility, surface visibility, group identification certainty, and response to the aircraft. Additional details on FGF are included in Appendix D.

Behavior generally reflects what the individual or group is doing at the time it is first sighted and represent the observer's best interpretation gleaned during a very short period (< 1 minute) when the sighting is visible. Behavior may be updated if additional observations are made during circling or if analysis of images reveals new information. Behaviors are entered as one of several categories (Table 2), although additional details about behaviors may be included in notes.

Swim direction, collected only for whales for which the behaviors "swim" and "dive" are recorded, is entered relative to the aircraft's heading and then converted to actual swim direction via a module incorporated into the data collection software. Swim direction is not recorded when the aircraft is circling.

General Data Analyses

Preliminary data review and editing are conducted immediately following each survey flight by project personnel with comprehensive knowledge of the ASAMM database and metadata, with assistance from the observers who participated in the flight. Preliminary analysis is performed in the field after each flight using a customized computer program that provides daily summaries of marine mammal sightings and effort (time and distance on transect, search, circling, CAPs, FGF, FOV, and deadhead) and plots the paths of one or more flights by Beaufort wind force.

Table 2. ASAMM operational definitions of observed marine mammal behaviors.

Behavior	Definition
Breach	Animal(s) launching a significant portion of the body above the water surface then falling back down again, creating an obvious splash.
Dead	Animal(s) that is clearly deceased, in water or on beach; carcass often but not always bloated, with sloughing skin and accompanied by oil slicks, feeding birds, or scavenging bears.
Dive	Animal(s) changing swim direction or body orientation relative to the water surface, resulting in submergence; may or may not include lifting the tail out of the water.
Feed	Animal(s) diving repeatedly in a fixed area, sometimes with mud streaming from the mouth and/or defecation observed upon surfacing; synchronous diving and surfacing or echelon formations at the surface, with swaths of clearer water behind the whale(s), or surface swimming with mouth agape (bowhead whales); mud plumes streaming from mouths while surfacing (gray whales); mouths open and/or throat grooves extended (balaenopterid whales); bubble nets (humpback whales).
Flipper Slap	Animal(s) striking the water surface with a pectoral flipper.
Hunt	Animal(s) actively pursuing prey.
Log Play	Animal(s) milling or thrashing in association with a floating log.
Mate	Whales in ventral-ventral orientation, often with one or more other whales present to stabilize the mating pair.
Mill	Two or more animals moving slowly at the surface with varying headings, in close proximity (within 100 m) to, but not obviously interacting with, other animals.
Rest	Animal(s) at the surface with head, or head and back, exposed, or resting on ice; showing no movement.
Roll	Animal(s) rotating on longitudinal axis.
SAG	Surface Active Group – two or more whales within a body length of each other, interacting and socializing at the surface.
Spy Hop	Whale(s) extending head vertically above the water surface.
Stand	Animal(s) standing upright on ground or ice.
Swim	Animal(s) proceeding forward through the water, propelled by tail or limbs.
Tail Slap	Whale(s) striking the water surface with the tail.
Thrash	Animal(s) exhibiting rapid flexure or gyration in the water.
Underwater Blow	Animal(s) exhaling under water, creating a visible bubble.
Unknown	Behavior not able to be determined, usually due to the sighting occurring at some distance from the aircraft location.
Walk/Run	Animal(s) moving on ground or ice at slow or normal pace (walking) or more rapid pace (running).

Aerial photographic images (not including BPC images) are examined opportunistically during post-flight review to confirm or revise group size estimates for polar bears, large pinniped haulouts, and cetaceans. An additional customized computer program is used for post-season analysis and production of figures and tables. Maps are prepared using ArcGIS 10.3.1 (Environmental Systems Resource Institute [ESRI 2014], Redlands, CA) based on Universal Transverse Mercator Zone 5 (central meridian = -154.000000°, latitude of origin = 70.000000°, false easting = 500000.000000, false northing = 0.000000, spheroid = Geodetic Reference System 80, scale factor = 0.999600). The Alaskan coastline is adapted from the World Vector Shoreline produced by the U.S. Defense Mapping Agency, now called the National Geospatial-Intelligence Agency.

Data from the Aerial_Master_2018_v4 database are used for all analyses. Data from the Beaufort Sea and Chukchi Sea study areas are combined into one large dataset for editing and archiving and are parsed into smaller subsets for various analyses of sighting rates, relative abundance, swimming direction, and HUAs. Survey effort and observed bowhead whale and gray whale distributions are plotted semimonthly over the study area. All other species distributions are plotted monthly (July-October). All sightings are shown on most distribution maps regardless of survey mode (e.g., transect, CAPs, search, and circling), observer type (primary or secondary), or the prevailing environmental conditions (wind force, sea ice cover, etc.) when the sightings were made. As with previous reports in this series (e.g., Monnett and Treacy 2005; USDOI, MMS 2008; Clarke et al. 2012, 2013a, 2014, 2015a, 2017a, b, 2018a), same-day repeat sightings or sightings of dead marine mammals are not included in summary analyses or maps. Bowhead whale sightings during FGF are not plotted because those sightings represent known same-day repeat sightings. Data exclusions are indicated in the captions. Because feeding is likely underreported or recorded as milling, figures showing cetacean feeding occurrence include all sightings reported as feeding and milling, regardless of survey mode, observer type, or prevailing environmental conditions.

Post-processing algorithms estimate the water depth at each sighting and the sighting's distance from shore. The water depth at each sighting in the ASAMM database is derived from the International Bathymetric Chart of the Arctic Ocean Version 3.0 (Jakobsson et al. 2013), which has a pixel resolution of 500 m. The shoreline used to calculate a sighting's distance from shore is "normalized" from the actual shoreline to provide standardized distance-from-shore measurements regardless of the coastline database being used to depict distribution data (Figure 3). The normalized shoreline was redefined in 2011 to better represent the actual coastline of Alaska from 140°W (the easternmost part of the ASAMM study area) to 67°N (the southernmost part of the study area) and to improve representation of bays and barrier islands. The normalized shoreline does not include areas between barrier islands and the mainland. To maintain consistency with the historical database, any sightings within lagoons formed by barrier islands have negative distance-from-shore measurements. The projection used for the normalized shoreline analysis is North American Equidistant Conic, appropriate for distance measurements, with custom projection parameters (false easting: 0.0; false northing: 0.0; central meridian: -155.0°, latitude of origin: 70.0°, standard parallels: 69.0°, 71.0°; linear unit: meter [1.0]).

Mean vector headings and circular standard deviations for headings of swimming and diving cetaceans are determined using Oriana statistical software (Rayleigh Test; KCS 2013) for three

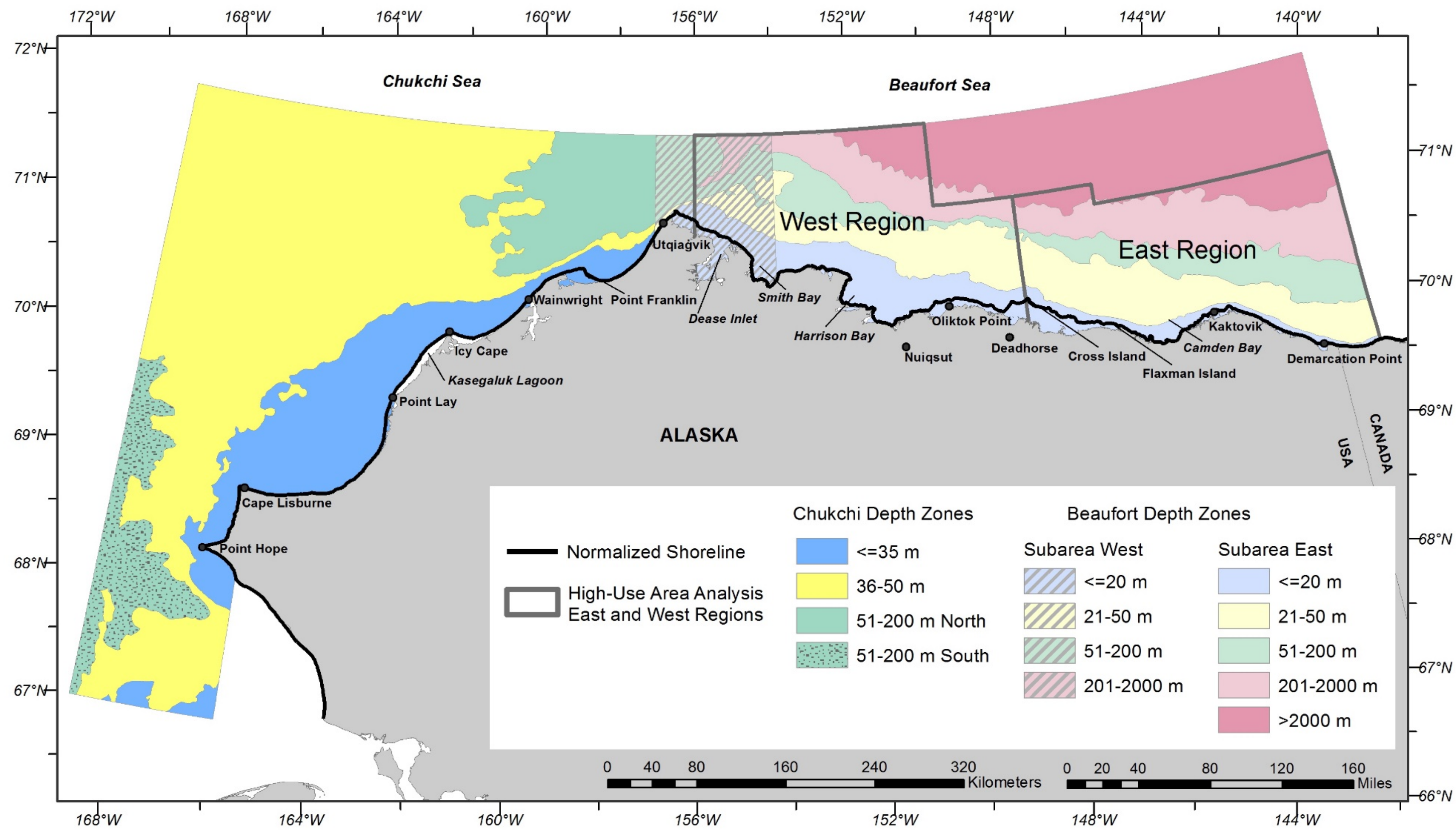

Figure 3. East and West regions and normalized shoreline used in ASAMM bowhead whale high-use area (HUA) analysis, and depth zone subareas used for sighting rate analyses.

subareas (Beaufort Sea subarea 140°W-154°W; northeastern Chukchi Sea subarea 69°N-72°N, 154°W-169°W; southcentral Chukchi Sea subarea 67°N-69°N). The 154°W demarcation between the Beaufort Sea and northeastern Chukchi Sea subareas for swim direction most closely approximates the natural break between the Beaufort and Chukchi basins. The two subareas delineated for the Chukchi Sea are based on ecosystem differences.

Environmental information, including wind speed and direction, cloud ceiling, visibility, temperature, dew point, sea ice cover, and sea surface temperature, is collected from National Weather Service websites and other weather and climate-related web pages for the duration of the field season. Data are collected and stored electronically for specific locations along the northern coast of Alaska (e.g., Point Hope, Cape Lisburne, Point Lay, Wainwright, Utqiaġvik, Alpine, Kuparuk, West Dock, Deadhorse, and Barter Island) and for the broader Chukchi Sea and Beaufort Sea regions.

Sea ice information is obtained from the U.S. National Ice Center (2018), where it is available as charts or shapefiles. Sea ice analyses by the National Ice Center uses data from several sources, including Environmental Satellite (ENVISAT) imagery and Moderate Resolution Imaging Spectroradiometer (MODIS), to show sea ice concentration. Summer and fall sea ice conditions in 2018 are categorized as light, moderate, or heavy for use in multiyear analyses. Shapefiles for the Beaufort and Chukchi seas are combined to produce biweekly sea ice concentration maps, included in Appendix A.

Analytical methods in this report use many stats and maintain many similarities with previous years' reports dating back to 2008. However, there are some notable exceptions. One exception involves the distinction between sightings made by primary and secondary observers. Analyses and figures prior to 2012 using transect data included all transect sightings regardless of observer type (e.g., Clarke et al. 2012). Collection of data denoting primary observers began in 1989, and the ASAMM historical database was amended in 2012 to include a field specifically denoting whether a sighting was made by a primary or secondary observer. In 2018, sightings made by primary observers only are included in most analyses that use on-effort sightings, including sighting rate and central tendency analyses.

Integration of CAPs Data

A significant difference in analytical methods between 2018 and previous years is the integration in 2018 of data collected during CAPs. In past years, when a cetacean was sighted on transect in an area of high cetacean density and circling from transect commenced, all cetaceans observed in the extended circling area were recorded, regardless of distance from the transect. Effort and sightings during circling from transect were considered on effort. In 2018, circling from transect is limited to only the immediate area of each original sighting, and effort and sightings during circling from transect are off effort. In lieu of extensive circling in areas where cetacean density is high, CAPs are initiated. Since CAPs are new ASAMM survey modes, several modifications are needed to integrate CAPs data with data from previously existing ASAMM survey types.

Survey effort during CAPs passing and CAPs strip is equivalent to transect effort and considered on effort. Determining species, group size, and calf presence during CAPs passing is difficult because sightings are collected out to 3 km from the trackline, and CAPs passing sightings may be entered as unidentified cetaceans. Species identification for unidentified cetacean sightings is inferred based on sighting data collected during CAPs circling, when cetacean species and group sizes are recorded. Statistics for CAPs passing mode that are inferred from CAPs circling data are referred to as CAPs-adjusted statistics. Additional detail about the integration of CAPs data is included in Appendix D.

Sighting Rate and Relative Abundance Analyses

Sighting rates (number of whales or walruses [WPUE], pinnipeds [PPUE], polar bears [PBPUE], or calves [CPUE] per unit [km] effort) quantify relative abundance by accounting for heterogeneity in survey effort and group size across the study area. Sighting rates are derived for three different spatial scales, each limited to on-effort sightings by primary observers. Sighting rates are not corrected for availability or perception bias (Buckland 2001).

To calculate monthly, seasonal, and annual sighting rates per survey block for bowhead whales, gray whales, belugas, and other cetaceans, the number of on-effort whales is divided by effort (transect, CAPs passing, and CAPs strip km) per survey block. Although survey blocks are arbitrary geographic areas, they provide a basis for inter-annual comparisons. Effort over land, between barrier islands and the mainland (except for block 1a), and north of the study area (except for block 13N) is not included in the survey block sighting rate analysis to facilitate comparisons with previous years. Effort in blocks 1a and 13N is included in the survey block sighting rate analysis.

To calculate monthly, seasonal, and annual sighting rates per depth zone for bowhead whales, gray whales, belugas, and other cetaceans, the number of on-effort whales is divided by effort (transect, CAPs passing, and CAPs strip km) per depth zone. Depth zones are defined based on depth data in the International Bathymetric Chart of the Arctic Ocean Version 2.23 (Jakobsson et al. 2008), which has a pixel resolution of 2 km. Depth zone analysis in the western Beaufort Sea study area is computed for two subareas (Figure 3). One subarea spans 154°W-157°W and includes Barrow Canyon and its surrounding area, which has noticeably different bathymetry than the rest of the Beaufort Sea study area. The other subarea spans 140°W-154°W, an area that incorporates a well-defined continental shelf and slope. Beaufort Sea subareas use depth zones of ≤20 m, 21-50 m, 51-200 m, 201-2,000 m, and >2,000 m. Depth zone analysis in the Chukchi Sea uses slightly different depth zones to better reflect the bathymetric features of the area (≤35 m, 36-50 m, and 51-200 m); the 51-200 m depth zone is divided into North and South regions because they are separated by a large expanse of shallower depths (Figure 3). Sighting rate analyses for survey blocks and depth zones use an Equidistant Conic projection (false easting: 0.0; false northing: 0.0; central meridian: -154.5°; latitude of origin: 70.5°; standard parallels: 60.5°, 80.5°; linear unit: meter [1.0]). Depth zone sighting rate analysis does not include survey effort flown north of 72°N but does include effort between barrier islands and the mainland in block 1a. Sightings per depth zone are based on geographic placement of sightings within depth strata, not on the depth associated with each individual sighting in the ASAMM database.

Finally, sighting rate is calculated for fine-scale areas, using a grid consisting of approximately equilateral cells (5 minutes latitude by 15 minutes longitude, roughly 5 km x 5 km) superimposed across the study area. Seasonal (summer and fall) sighting rates are calculated for bowhead whales, gray whales, and belugas for each cell. Sighting rates for walruses are calculated to provide an index of relative abundance prior to and after the formation of an onshore haulout near Point Lay. The fine-scale grid analysis includes effort and animals observed within barrier islands and north of 72°N.

Sighting rates calculated for each of the three spatial scales described above for large cetaceans use effort on transect, CAPs passing, and CAPs strip, in combination with transect and CAPs-adjusted sightings from primary observers. This differs from large cetacean sighting rate analyses in previous years when sighting rate analyses used transect effort only. In 2014-2017, large whale sighting rate analyses were also conducted using sightings and effort on transect combined with sightings and effort during circling from transect. That metric is no longer used, as sightings and effort during circling from transect are considered off effort.

Beluga sighting rates calculated for each of the three spatial scales described above use effort on transect and sightings from primary observers on transect.

Fine-scale sighting rates for walruses use effort on transect and sightings from primary observers on transect.

Indices of relative abundance of bowhead whale and gray whale feeding and milling behaviors, quantified as WPUE, are calculated for the fine-scale grid using effort on transect, CAPs passing, and CAPs strip, in combination with transect and CAPs-adjusted sightings from primary observers.

Analysis of Bowhead Whale High-Use Areas (HUA) in the Beaufort Sea

There is no evidence to suggest that bowhead whales remain in the Beaufort Sea throughout winter; at some point, bowhead whales observed in the Beaufort Sea in summer and fall migrate through the Chukchi Sea to return to wintering areas in the Bering Sea. It was thought that most bowhead whales summered in the eastern Beaufort Sea then actively migrated westward through the western Beaufort Sea in fall (Moore and Reeves 1993). Previous central tendency analyses (e.g., Treacy 2002a; Monnett and Treacy 2005; Clarke et al. 2011b, 2012) defined results as "migratory corridors." However, results of satellite telemetry studies have shown that some bowhead whales crisscross the western Beaufort Sea during summer (Quakenbush et al. 2010b). Furthermore, large dynamic groups of bowhead whales have been documented feeding in the western Alaskan Beaufort Sea as early as July and continuing into October (e.g., Clarke et al. 2015a; 2017b). There is no reliable way, via data collected during line-transect aerial surveys, to differentiate between whales that are actively undergoing a focused, unidirectional, westward fall migration and whales that are crisscrossing the western Beaufort Sea prior to undergoing directed migration.

To acknowledge that some bowhead whales observed in the western Beaufort Sea in summer and fall might not be actively migrating, the term "high-use area", or HUA, is used in lieu of migratory corridor for this report. HUA designation, in this context, describes areas in the western Beaufort Sea where bowhead whales are expected to occur in greatest densities, based on data collected during ASAMM surveys. HUAs can be considered one component used to interpret the relative biological importance of certain areas within the western Beaufort Sea, based on the numbers of whales expected to be present in a given area during a particular month or season. HUAs are not defined based on specific activity states (e.g., migrating or feeding).

Bowhead whale HUAs are analyzed separately for two regions (Figure 3), the boundaries of which correspond roughly to oceanographic patterns and the offshore extent of sampling, described in more detail below. The delineation between East and West regions for this analysis occurs at 148°W, based upon association with the general distribution patterns of water masses. Oceanographic patterns common to waters off northern Alaska are reviewed in Moore and DeMaster (1998). In brief, cold saline Bering Shelf Water and warm fresh Alaska Coastal Water enter the western Beaufort Sea through Barrow Canyon. Both water masses are identifiable on the outer shelf (seaward of 50 m) as the eastward flowing Beaufort Undercurrent (Aagaard 1984). Bering Shelf Water has been traced at least as far east as Barter Island (~143°W), but the Alaska Coastal Water mixes with ambient surface waters as it moves eastward and is not clearly identifiable east of Prudhoe Bay, Alaska (~147°W-148°W).

The northern extent of each region is based upon historical survey effort. The East region extends from 140°W to 148°W and northward from shore to 71.166°N, except between 146°W and 148°W where the region extends to 71.333°N. The eastern boundary (140°W) is the easternmost longitude of the survey blocks. The northern boundary for this region corresponds with the boundaries of blocks 2, 6, and 7 (Figure 1), blocks with enough survey effort to support analyses (Treacy 1998). The West region extends from 148°W to 156°W and northward from shore to 72°N, except between 148°W and 150°W where the region extends to 71.333°N due to the layout of block 2. The northern boundary for this region corresponds with the boundaries of blocks 2, 11, and 12 (Figure 1); therefore, sightings north of 72°N are not included. The western cutoff at 156°W limits the analysis to bowhead whales seen in the western Beaufort Sea and minimizes the influence of Barrow Canyon on bowhead whale depth distribution.

Central tendency analyses do not incorporate sighting data collected during Arctic ACEs transects in 2015 (Clarke et al. 2016). The limitation on circling from transect during ACEs surveys likely negatively impacted the identification of some whales to species and the ability to accurately estimate group size, and Arctic ACEs transects started 22 km (12 nm) offshore. These differences in survey protocol and coverage could introduce bias in to analyses specifically directed at determining habitat use.

Two analyses of bowhead whale HUAs in the western Beaufort Sea are undertaken.

Bowhead Whale Central Tendency – Analysis 1

Non-parametric statistical tests, via the non-parametric Mann-Whitney *U*-test, are used to examine differences in median depth and distance from shore. Treacy (1998) found that median and mean bowhead whale distance from shore values were only slightly different. The non-parametric test is used for these data because distributions generally do not fit assumptions necessary to use the two-sample *t*-test. The variances are not equal between time periods for both depth and distance from shore; in addition, the depth data are considerably skewed and the distance from shore data are slightly skewed, so neither distribution strictly meets the assumption of normality. When assumptions of the *t*-test are seriously violated, the Mann-Whitney *U*-test may be more powerful than the two-sample *t*-test (Hodges and Lehmann 1956; Zar 1984). Statistical tests were undertaken using *Statistica*™ StatSoft Version 13.0 and ArcGIS Version 10.3.

Bowhead whale HUA is examined using the median water depth at, and mean and median distance from shore of, transect and CAPs-adjusted sightings (Houghton et al. 1984). Median distance from shore and depths for bowhead whale sightings in fall 2018, a year with light sea ice cover (National Snow and Ice Data Center, 2018b), are compared with analogous values for combined data from previous years having light sea ice cover (i.e., 1989, 1990, 1993-2017; Treacy 1990, 1991, 1994, 1995, 1996, 1997, 1998, 2000, 2002a, 2002b; Monnett and Treacy 2005; USDOI, MMS 2008; Clarke et al. 2011a, 2011b, 2012, 2013a, 2014, 2015a, 2017a, b, 2018a). Sea ice cover in fall 2018 was not uniformly light in the western Beaufort Sea, however. Sea ice cover in early September and mid-October was moderate (Figures A-6, A-9, A-10), so median distance from shore and depths for bowhead whale sightings in fall 2018 were also compared with analogous values for combined data from previous years with moderate to heavy sea ice cover (1991-1992) (Treacy 1992, 1993). Median distance from shore and depths at bowhead whale sightings in summer (July-August) 2018 are compared to bowhead whale sightings in summer 2012-2017 and fall (September-October) 2018.

All transect and CAPs-adjusted bowhead whale sightings by primary observers, regardless of distance from the transect line, are included in the non-parametric central tendency analyses. Neither group size nor survey effort (km) is considered.

One caveat to the non-parametric analyses is that analyzing bowhead whale HUAs based only on number of sightings may be biased because survey effort often varies spatially both within and across years and because sightings of a single whale are weighted equally to sightings of several whales. Therefore, there may be more sightings in areas with greater effort and fewer sightings in areas with less effort, even if the density of individuals in the two areas was the same.

Bowhead Whale Central Tendency – Analysis 2

The second method for investigating the central tendency of the fall bowhead whale distribution in the Alaskan Beaufort Sea in 2018 involves a three-step process: 1) constructing spatial models of bowhead whale relative abundance (encounter rate) based on bowhead whale sightings from 2018; 2) applying the spatial relative abundance model to predict the expected number of bowhead whales in every cell of a grid overlying the study area; and 3) using the predicted number of bowhead whales in each cell to compute the median distance from shore of the whales sighted in 2018. This analysis is based on transect and CAPs-adjusted bowhead whale sightings made by primary observers in September and October 2018. This analysis does not account for availability or perception bias. Estimates of median distance from shore are calculated for the East and West regions separately. The analysis is conducted in R version 3.5.1 (R Core Team 2018) using packages *sp* (Pebesma and Bivand 2005; Bivand et al. 2013), *maptools* (Bivand and Lewin-Koh 2018), *raster* (Hijmans 2017), *rgeos* (Bivand and Rundel 2018), *rgdal* (Bivand et al. 2018), and *mgcv* (Wood 2017).

To begin, the western Beaufort Sea study area is partitioned into a 5-km x 5-km grid. This grid resolution was chosen as a compromise between having adequate survey effort and sightings in each cell to construct models, versus maximizing the resolution of the distance from shore data. All geospatial data are projected into an Equidistant Conic projection (false easting: 0.0; false northing: 0.0; central meridian: -148.0°; latitude of origin: 70.75°; standard parallels: 69.9°, 71.6°; linear unit: meter [1.0]). Data extracted for each cell include the total number of whales sighted, the projected x and y coordinates of the midpoint of each cell, and the shortest distance from that midpoint to the normalized shoreline. Bowhead whale relative abundance is modeled as a generalized additive model, parameterized by a negative binomial distribution with a natural logarithmic link function. Tweedie (Tweedie 1984; Dunn and Smith 2005) models were also considered, but examination of model residuals (Ver Hoef and Boveng 2007) suggests that the negative binomial distribution provided a better fit to the data. The model formula is represented as

$$ln(E(W_i)) = ln(\mu_i) = \alpha + s(X_i, Y_i) + offset(ln(L_i))$$

where

W_i: random variable for the number of individual bowhead whales in cell i, with W_i referring to the associated observations and $E(W_i)$ the expected value (mean) of W_i;

μ_i: number of individual bowhead whales expected to be observed in cell i;

α: intercept;

X_i: projected (equidistant conic) longitude of the midpoint of cell i;

Y_i: projected (equidistant conic) latitude of the midpoint of cell i;

$s()$: smooth function (Wood et al. 2008) of location covariates used to describe bowhead whale relative abundance; this function is parameterized in the model-fitting process;

L_i: length (km) of transect, CAPs passing, and CAPs strip effort in cell i, which was incorporated into the model as a constant (an offset) to account for spatially heterogeneous survey effort throughout the study area.

The median distance from shore of the fall distribution of bowhead whales in 2018 is estimated using the spatial model to predict the number of individuals likely to be observed in each cell after a uniform amount of effort (a constant L_i for all i) was covered throughout the portion of the study area contained within the East and West regions. The magnitude of L_i used in the predictions does not affect the resulting median statistic as long as L_i is constant across all cells, thereby eliminating apparent variability in bowhead whale distribution due only to spatial heterogeneity in survey effort. The predicted number of individuals per cell is cumulated, beginning with the cell closest to the normalized shoreline and ending with the farthest. The median distance from shore is calculated as the distance corresponding to the midpoint of the cell for which one-half of the total predicted number of individuals are assigned to cells located closer to shore and one-half assigned to cells located farther from shore.

This method of estimating the median distance from shore is also applied to ASAMM bowhead whale data from 2000 to 2018 combined. The analysis for the pooled years uses the same data filtering criteria as described above (transect and CAPs-adjusted bowhead whale sightings) and does not account for availability or perception bias. It includes data from July to October, and a varying-coefficient generalized additive model (Wood 2017) is used to examine the spatial distribution of bowhead whale relative abundance by month. In essence, the varying-coefficient model structure enables estimation of a separate smooth function for each month, allowing both the location and intensity of areas with high or low relative abundance to vary by month. Median distances from shore for the 19-year time period are calculated for the East and West regions separately.

The median is also referred to as the 50^{th} percentile or quantile. An additional analysis undertaken defined the location of bowhead whale HUAs in 2018 alone and in 2000-2018 (all years pooled) based on the locations of the 30^{th}, 40^{th}, 50^{th}, 60^{th}, and 70^{th} percentiles of predicted bowhead whale relative abundance for each column of 5-km x 5-km cells in the East and West regions. For example, in this analysis the location of the 30^{th} percentile in a specific column of cells refers to the location where 30% of the predicted number of bowhead whales would be closer to shore and 70% would be farther offshore. Due to the granularity of the spatial grid used for this analysis, adjacent percentiles may overlap in a single cell in locations where the predicted distribution of bowhead whales changes rapidly with distance from shore. The midpoints of all cells corresponding to the 30^{th} percentile are connected across the entire region to define a linear boundary across the western Beaufort Sea corresponding to the 30^{th} percentile of bowhead whale HUAs, and similarly for the 40^{th}, 50^{th}, 60^{th}, and 70^{th} percentiles.

Multiyear Analyses

To expand the usefulness of ASAMM data collected in 2018, several multiyear analyses that use many stats are also conducted. The results of some analyses are included in Results (e.g., HUA), and several are referenced in more detail in Discussion. Temporal and spatial parameters for each multiyear analysis are specifically chosen to maximize the amount of relevant information contained in the ASAMM dataset used to address the objectives of the particular analysis. These parameters vary substantially across multiyear analyses due to annual differences in when and where surveys were conducted. For example, multiyear analyses for the northeastern Chukchi Sea include data collected in summer and fall 2009-2018 because survey effort was equivalent during those time periods. Conversely, multiyear analyses for the western Beaufort Sea in summer are usually limited to 2012-2018 because broad-scale summer surveys in that area did not occur prior to 2012. Analyses comparing summer and fall data from the western Beaufort Sea are limited to 2012-2018. Multiyear analyses for the western Beaufort Sea in fall justifiably can, in some situations (e.g., calf ratios), incorporate data from 1982 through 2018. Other applications require sightings from primary observers only and, therefore, incorporate data from only 1989 through 2018, which is when details related to primary observers are recorded in the dataset.

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RESULTS

Environmental Conditions

Sea ice cover in the Chukchi Sea study area in 2018 was light in August, September, and October. Sea ice cover in the Beaufort Sea study area was more variable than observed in recent years. Sea ice conditions were heavy in July, August, and late October, moderate in early September and mid-October, and light in September and early October. When surveys commenced in early July, sea ice remained throughout the Beaufort Sea study area and north of 70.5°N in the Chukchi Sea study area (Appendix A, Figures A-1 and A-2). Sea ice persisted throughout the Alaskan Beaufort Sea in August, but the Chukchi Sea study area was nearly sea ice free by mid-August (Figures A-4 and A-5). Areas completely devoid of sea ice in the Alaskan Beaufort Sea remained limited through mid-September (Figure A-6), and the study area was completely ice free for <20 days (from late September through mid-October). By mid-October, new ice was forming nearshore and offshore in the Beaufort Sea study area (Figure A-9); the Beaufort Sea study area was covered with >90% new ice by the end of the field season (Figure A-10). The Chukchi Sea study area remained ice-free through September and October (Figures A-6 through A-9).

Arctic sea ice extent reached the seasonal minimum on 19 and 23 September 2018. The Arctic sea ice seasonal minimum extent was sixth lowest, tied with 2008, since satellite data were first recorded in 1979 (National Snow and Ice Data Center 2018b). As indicated above, sea ice extent in the western Beaufort Sea, particularly in July and August, was anomalous to what had been observed there during ASAMM surveys conducted in summer 2012-2017. Sea ice remained present in the study area for much longer in summer 2018 due, at least in part, to lower than average air temperatures in the Beaufort Sea and the prevalence of thicker ice (National Snow and Ice Data Center 2018a). To examine interannual variability in bowhead whale and other marine mammal distributions and relative abundance, 2018 data were compared to data from previous years with heavy sea ice cover for summer in the Beaufort Sea and light sea ice cover for summer in the Chukchi Sea and fall in both areas.

Observer Experience

Data quality is a direct reflection of the capabilities and experience of the field personnel (Zongker 2006). In 2018, 13 observers participated in ASAMM surveys. All ASAMM observers were experienced field biologists and most (85%) had previous experience with ASAMM surveys, which ensured consistency in data collection among years. ASAMM field experience ranged from 1 to 24 years (mean = 7.2 years, median = 7 years). Less experienced ASAMM observers were integrated into teams consisting of more experienced ASAMM observers and all observers were provided feedback throughout the field season to help maintain data consistency.

Table 3. ASAMM aerial survey flight effort in chronological order, 3 July–27 October 2018, by survey flight and semimonthly time period. On-effort includes distance (km) and time (hr) during transect, CAPs passing, and CAPs strip survey modes. Off-effort includes distance during search, circling from search, and circling from transect survey modes. Semimonthly totals may not exactly match the sum of individual surveys for the time period due to rounding error.

Day	Flight No.	On-Effort (km)	Off-Effort (km)	CAPs circling (km)	FGF (km)	FOV (km)	Deadhead (km)	Total (km)	On-Effort (hr)	Total (hr)
3 Jul	201	463	68	0	0	0	434	964	2.1	4.0
6 Jul	202	511	152	0	0	0	203	866	2.2	3.7
9 Jul	203	856	93	0	0	0	614	1,564	3.9	6.4
10 Jul	204	855	112	0	0	0	652	1,619	3.9	6.6
11 Jul	205	454	98	26	0	0	392	970	2.0	4.0
12 Jul	206	103	44	0	0	0	541	688	0.4	2.4
13 Jul	207	1,044	96	0	0	0	752	1,892	4.8	7.6
14 Jul	208	688	401	13	0	0	1,527	2,628	3.1	9.6
19 Jul	209	9	35	0	0	0	265	309	0	1.1
20 Jul	210	460	110	0	0	0	298	868	2.1	3.7
20 Jul	1	694	36	0	0	0	435	1,165	3.2	4.8
21 Jul	211	580	91	0	0	0	422	1,093	2.6	4.6
21 Jul	2	418	56	0	0	0	536	1,010	1.9	3.8
22 Jul	3	46	1	0	0	0	389	436	0.2	1.4
24 Jul	212	297	82	0	0	0	348	727	1.3	2.8
26 Jul	4	1,215	90	0	0	0	717	2,022	5.4	8.1
29 Jul	213	561	285	0	0	147	1,652	2,645	2.6	9.5
29 Jul	5	646	122	0	0	0	586	1,355	2.8	5.1
30 Jul	214	1,178	199	0	0	0	561	1,938	5.2	8.3
30 Jul	6	715	6	0	0	0	687	1,408	3.1	5.2
31 Jul	215	0	152	0	0	234	209	596	0	2.2
31 Jul	7	762	140	0	0	0	301	1,202	3.4	5.2
3 Aug	8	432	22	0	0	0	294	748	2	3.1
5 Aug	216	501	51	0	0	0	1,400	1,952	2.3	6.6
6 Aug	217	0	0	0	0	0	511	511	0	1.7
8 Aug	218	301	145	0	0	0	251	698	1.4	3.0
8 Aug	9	628	91	0	0	0	481	1,199	2.8	4.8
9 Aug	219	310	26	0	0	0	622	958	1.4	3.4
9 Aug	10	1,018	7	0	0	0	1,125	2,150	4.7	8.2
12 Aug	11	445	2	0	0	833	681	1,961	1.9	7.4
14 Aug	220	580	118	0	0	0	311	1,009	2.6	4.2

Day	Flight No.	On-Effort (km)	Off-Effort (km)	CAPs circling (km)	FGF (km)	FOV (km)	Deadhead (km)	Total (km)	On-Effort (hr)	Total (hr)
17 Aug	221	194	34	0	0	0	284	512	0.9	2.0
14 Aug	12	72	9	0	0	13	460	554	0.3	1.9
15 Aug	13	637	2	0	0	0	644	1,282	2.9	5.1
17 Aug	14	0	0	0	0	0	553	553	0	1.6
18 Aug	15	872	25	0	0	0	629	1,526	3.8	6.1
19 Aug	222	370	128	0	0	0	237	734	1.6	3.2
19 Aug	16	511	104	0	0	0	1,076	1,691	2.3	6.3
22 Aug	223	411	56	0	0	0	319	785	1.9	3.2
25 Aug	224	331	174	0	0	0	241	746	1.4	3.1
26 Aug	17	0	0	0	0	0	545	545	0	1.8
28 Aug	225	888	143	0	0	0	641	1,672	4.0	6.9
28 Aug	18	1,115	66	0	0	0	717	1,898	5.0	7.9
29 Aug	19	660	105	0	0	0	829	1,594	2.9	5.9
30 Aug	226	1,073	28	0	0	0	1,211	2,312	4.9	8.8
30 Aug	20	1,103	278	0	0	0	970	2,352	4.9	9.2
31 Aug	21	429	2	0	0	0	683	1,114	1.9	4.2
1 Sep	227	1,016	300	0	0	0	422	1,739	4.6	7.5
1 Sep	22	681	67	0	0	0	258	1,006	2.9	4.2
2 Sep	228	448	368	0	0	0	486	1,301	2.0	5.3
2 Sep	23	432	53	0	0	622	413	1,520	1.8	6.4
4 Sep	229	270	12	0	0	0	342	623	1.2	2.5
4 Sep	24	352	27	0	0	0	424	803	1.5	3.1
5 Sep	25	467	149	0	8	0	624	1,247	2.1	4.8
7 Sep	26	229	29	0	0	0	861	1,119	1.0	3.6
8 Sep	27	1,161	131	0	0	0	982	2,273	5.2	8.8
9 Sep	28	187	43	0	0	0	673	904	0.8	3.0
11 Sep	230	357	10	0	0	0	422	788	1.6	3.0
11 Sep	29	57	3	0	0	0	584	644	0.2	2.0
12 Sep	231	521	91	73	0	0	1,564	2,248	2.3	8.0
15 Sep	232	470	23	0	0	0	618	1,112	2.1	4.2
15 Sep	30	122	65	0	0	0	1,268	1,454	0.6	4.4
16 Sep	233	499	82	0	0	0	1,367	1,949	2.2	6.9
18 Sep	234	329	85	0	0	0	653	1,067	1.5	4.0
18 Sep	31	0	0	0	0	870	112	982	0	4.0
19 Sep	235	431	62	0	0	0	1,587	2,080	2.0	7.1
19 Sep	32	218	2	0	0	641	732	1,593	1.0	5.9

Day	Flight No.	On-Effort (km)	Off-Effort (km)	CAPs circling (km)	FGF (km)	FOV (km)	Deadhead (km)	Total (km)	On-Effort (hr)	Total (hr)
20 Sep	33	1,036	139	0	256	0	593	2,025	4.7	8.8
21 Sep	236	431	101	0	0	0	229	761	2.0	3.3
22 Sep	237	142	55	0	0	0	184	380	0.6	1.6
23 Sep	238	458	162	75	0	0	1,522	2,217	2.1	7.9
23 Sep	34	471	100	0	0	0	896	1,466	2.1	5.5
24 Sep	35	574	18	0	0	0	629	1,221	2.6	4.8
25 Sep	239	909	452	0	0	0	412	1,773	4.1	7.6
25 Sep	36	919	114	0	158	0	1,312	2,503	4.1	9.5
26 Sep	240	712	231	0	46	0	501	1,490	3.2	6.1
26 Sep	37	57	245	0	0	0	456	759	0.2	2.8
27 Sep	241	497	32	0	0	0	562	1,091	2.2	4.2
28 Sep	242	280	16	0	0	0	814	1,110	1.3	3.7
30 Sep	243	985	340	26	0	0	680	2,032	4.6	8.8
30 Sep	38	703	147	98	0	0	1,114	2,061	3.1	7.6
2 Oct	244	534	56	0	0	0	592	1,182	2.4	4.4
3 Oct	245	530	60	0	0	0	775	1,364	2.4	5.0
3 Oct	39	111	20	0	0	0	338	469	0.5	1.6
5 Oct	246	452	34	0	0	0	804	1,290	2.0	4.7
6 Oct	247	486	29	0	0	0	766	1,280	2.1	4.8
7 Oct	248	0	0	0	0	0	553	553	0	1.5
7 Oct	40	1,110	130	0	0	0	564	1,805	4.9	7.2
8 Oct	249	499	80	175	0	0	224	978	2.3	4.7
8 Oct	41	703	61	0	0	0	493	1,257	3.3	5.1
9 Oct	250	527	92	63	0	0	390	1,072	2.4	4.6
14 Oct	251	436	54	0	0	0	538	1,028	1.8	3.9
15 Oct	252	445	49	0	0	0	278	772	1.8	3.0
19 Oct	253	176	106	0	0	0	756	1,038	0.8	3.7
20 Oct	254	150	18	0	0	0	333	501	0.7	1.9
22 Oct	255	184	3	0	0	0	507	694	0.8	2.4
23 Oct	256	502	85	0	0	0	439	1,026	2.2	4.1
26 Oct	257	549	32	0	0	0	657	1,238	2.4	4.5
27 Oct	258	581	25	0	0	0	269	874	2.5	3.5

Date	On-Effort (km)	Off-Effort (km)	CAPs circling (km)	FGF (km)	FOV (km)	Dead-head (km)	Total (km)	On-Effort (hr)	Total (hr)
Semimonthly Summary									
1-15 Jul	4,974	1,064	39	0	0	5,115	11,191	22.5	44.3
16-31 Jul	7,582	1,403	0	0	381	7,407	16,773	33.8	65.8
1-15 Aug	4,924	472	0	0	846	6,779	13,021	22.2	49.4
16-31 Aug	7,956	1,144	0	0	0	8,934	18,035	35.6	70.2
1-15 Sep	6,768	1,369	73	8	622	9,941	18,781	30.1	70.8
16-30 Sep	9,650	2,384	200	460	1,511	14,356	28,560	43.7	110.1
1-15 Oct	5,834	665	238	0	0	6,314	13,051	26.0	50.5
16-31 Oct	2,142	270	0	0	0	2,960	5,372	9.3	20.1
Total	**49,830**	**8,771**	**550**	**468**	**3,360**	**61,806**	**124,784**	**223.2**	**481.2**

Survey Effort

The ASAMM field season commenced 1 July 2018 and ended 29 October 2018. Survey flights were conducted from 3 July to 27 October (Table 3), corresponding to the summer and fall months when open-water anthropogenic activities occur. Surveys were conducted from one aircraft based in Utqiaġvik from 1 July to 29 October, primarily targeting the northeastern and southcentral Chukchi Sea, and from one aircraft based in Deadhorse from 18 July to 10 October, primarily targeting the western Beaufort Sea. There were 99 survey flights, of which 22 were in July, 25 in August, 34 in September, and 18 in October. Surveys originating on the aircraft based in Utqiaġvik were numbered sequentially starting with 201; surveys originating on the aircraft based in Deadhorse were numbered sequentially starting with 1. On 36 occasions, multiple flights in one day were completed by the same survey team to take advantage of favorable survey conditions. Surveys were conducted concurrently by both survey teams on 26 days. Surveys were conducted on 60% of days during the field season (73 out of 121 days). Surveys were not conducted on 40% of field days (48 out of 121 days) due to weather (40 days) or a combination of weather and aircraft inspections, maintenance, or transits (8 days).

Survey effort is summarized by hours or kilometers flown in different survey modes. Over 124,000 km were flown during 481.2 hours (Figure 4). A total of 49,830 km was flown on effort (transect and CAPs passing) during 223.2 hours (Figure 5); there was no effort on CAPs strip. Most offshore transects were surveyed completely at least once. Kilometers on effort constituted 40% of the total kilometers flown and 46% of the total flight hours. Minimal effort was flown on CAPs circling and FGF (<1% of total effort), and 3% of total effort was dedicated to FOV. Forty percent of total survey hours were flown on deadhead. Four flights were entirely on deadhead due to poor weather conditions. During an average survey, an aerial survey team covered 1,260 km, ranging from 309 km to 2,645 km. The longer distances required 2-3 flights per survey.

Survey effort (transect, CAPs, search, circling, and FGF) is plotted semimonthly in Figure 6. Survey effort was distributed throughout the ASAMM study area in most months, although regions closer to communities with infrastructure support, such as fuel and lodging and including Deadhorse, Utqiaġvik, and Kotzebue, were targeted more often than areas farther from those communities (e.g., survey blocks 18-21). Survey coverage in the entire ASAMM study area was broadly and evenly distributed in late August and late September. Survey effort in early July and late October was limited due to the presence of only one survey team, based in Utqiaġvik. In late July, early August, early September, and early October, survey coverage was limited due to widespread poor weather conditions, particularly in the eastern Chukchi Sea, and poor weather conditions at the bases of operation. Poor survey conditions also limited coverage in the southcentral Chukchi Sea in August, when no surveys were conducted in survey block 23. During times when there were two aircraft conducting surveys, survey coverage (time and distance) was greatest in late September, when 19 surveys were flown, and lowest in early August, when eleven surveys were flown.

Systematic broad-scale coverage of the western Beaufort Sea in summer (July through August) was conducted for the seventh consecutive year and included transects extending between the

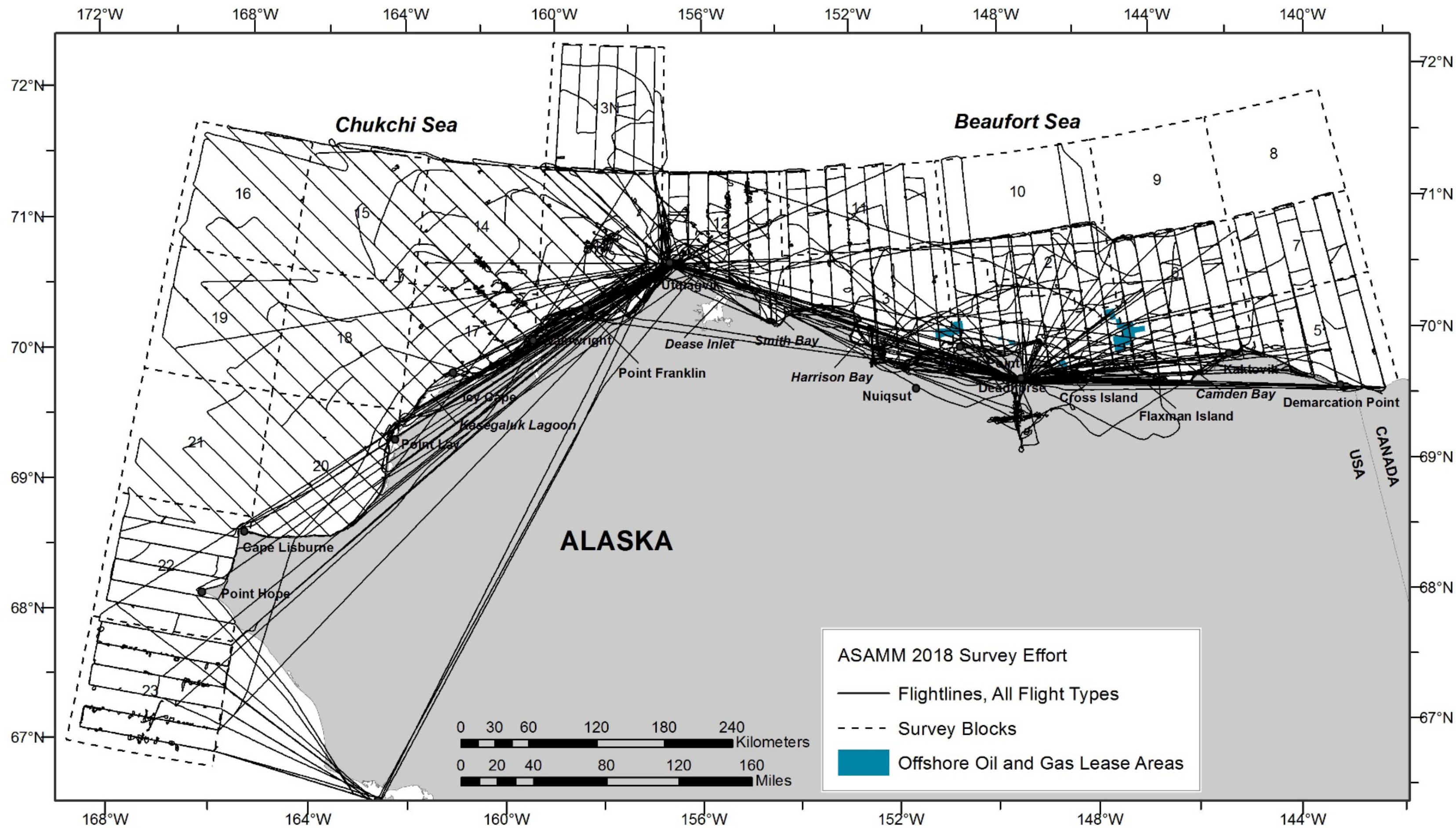


Figure 4. ASAMM 2018 combined flight tracks, all survey modes (transect, CAPs, search, circling, FGF, FOV, and deadhead), July-October.

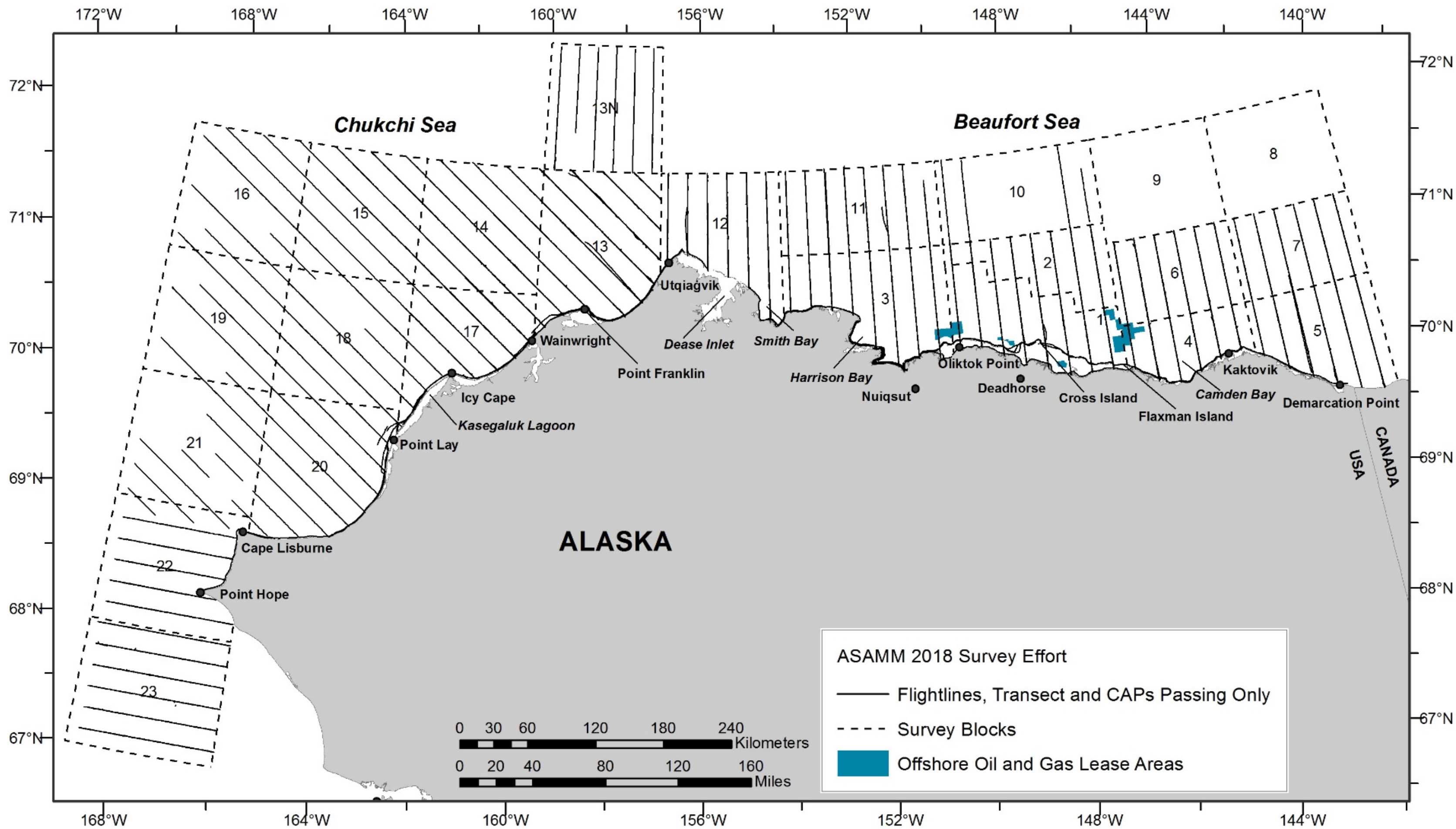


Figure 5. ASAMM 2018 combined flight tracks, transect and CAPs passing effort only, July-October.

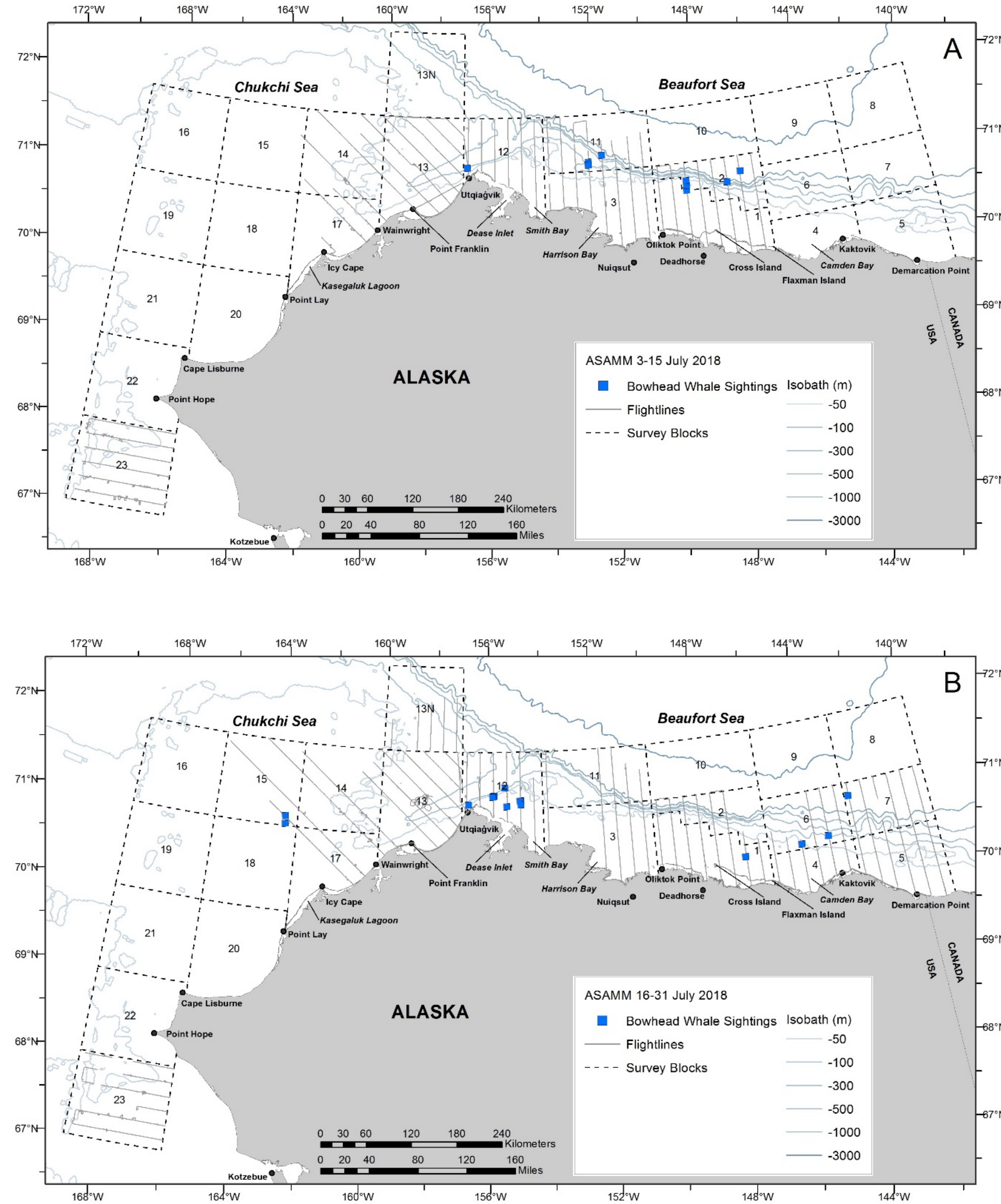
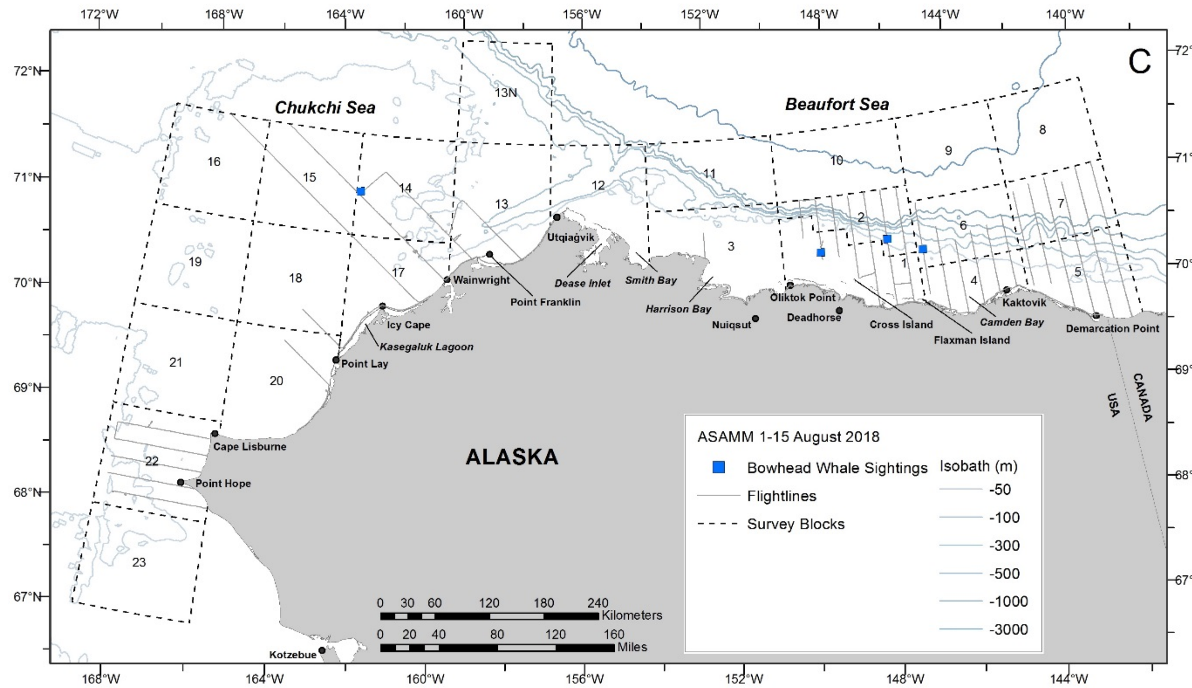


Figure 6. ASAMM 2018 semimonthly bowhead whale sightings, all survey modes, with transect, CAPs, search, circling, and FGF survey effort, July-October. A: 3-15 July. B: 16-31 July. Deadhead flight tracks are not shown.



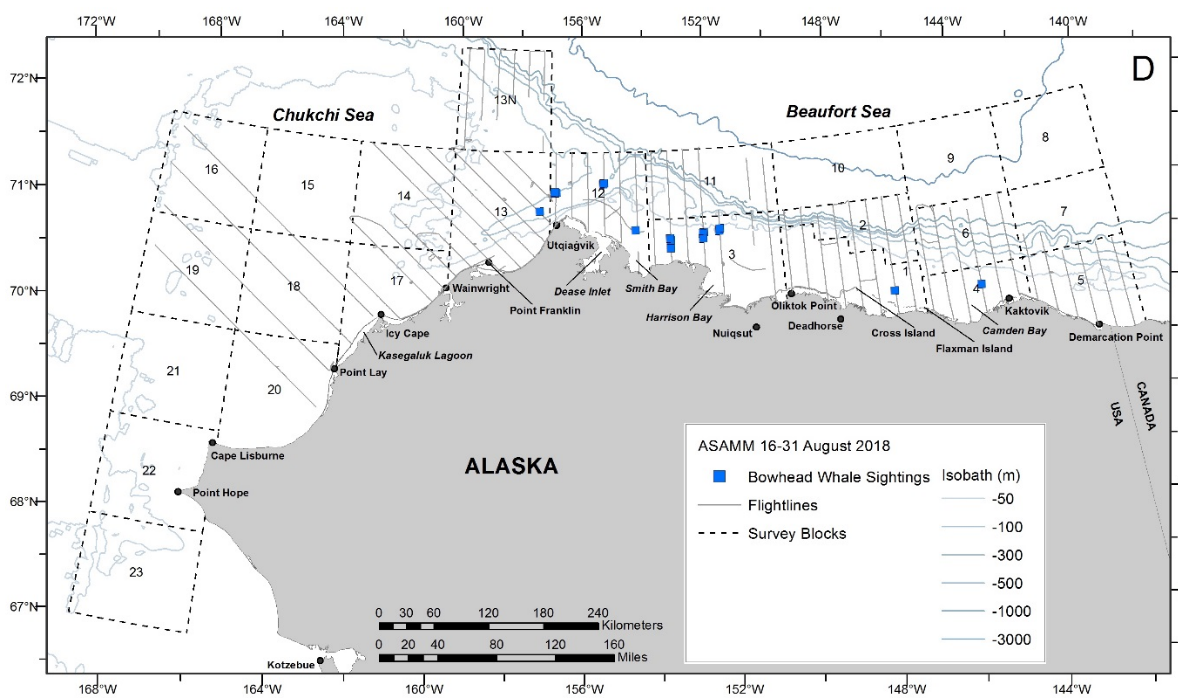
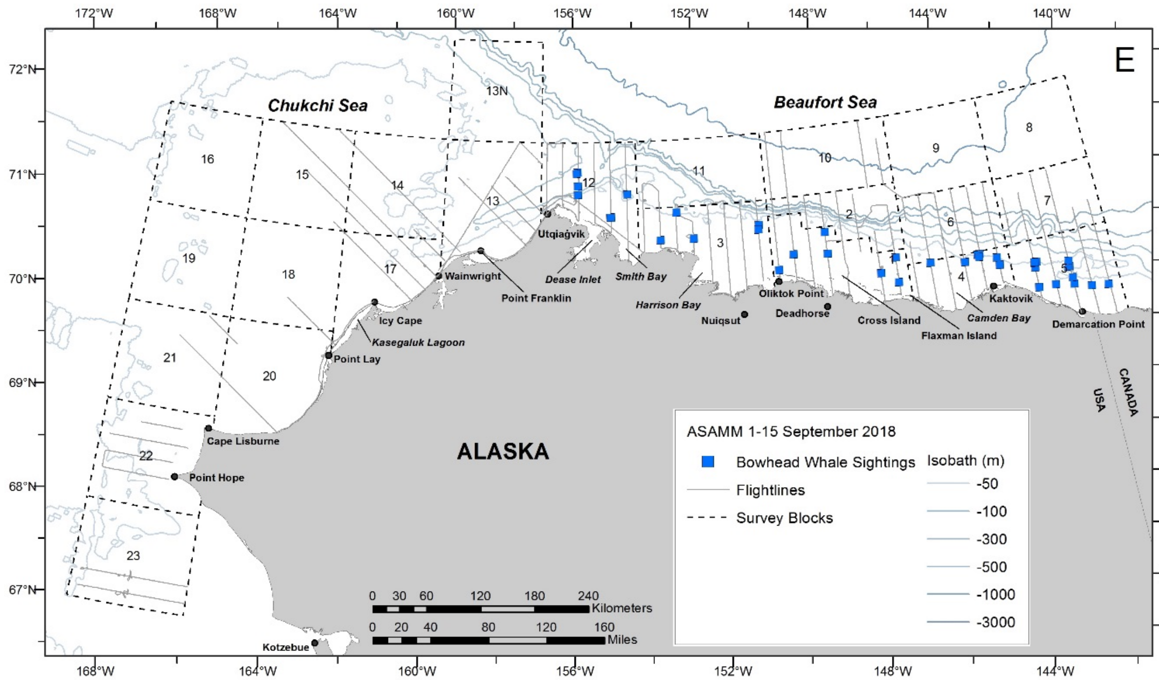


Figure 6 (cont). ASAMM 2018 semimonthly bowhead whale sightings, all survey modes, with transect, CAPs, search, circling, and FGF survey effort, July-October. C: 1-15 August. D: 16-31 August. Deadhead flight tracks are not shown.



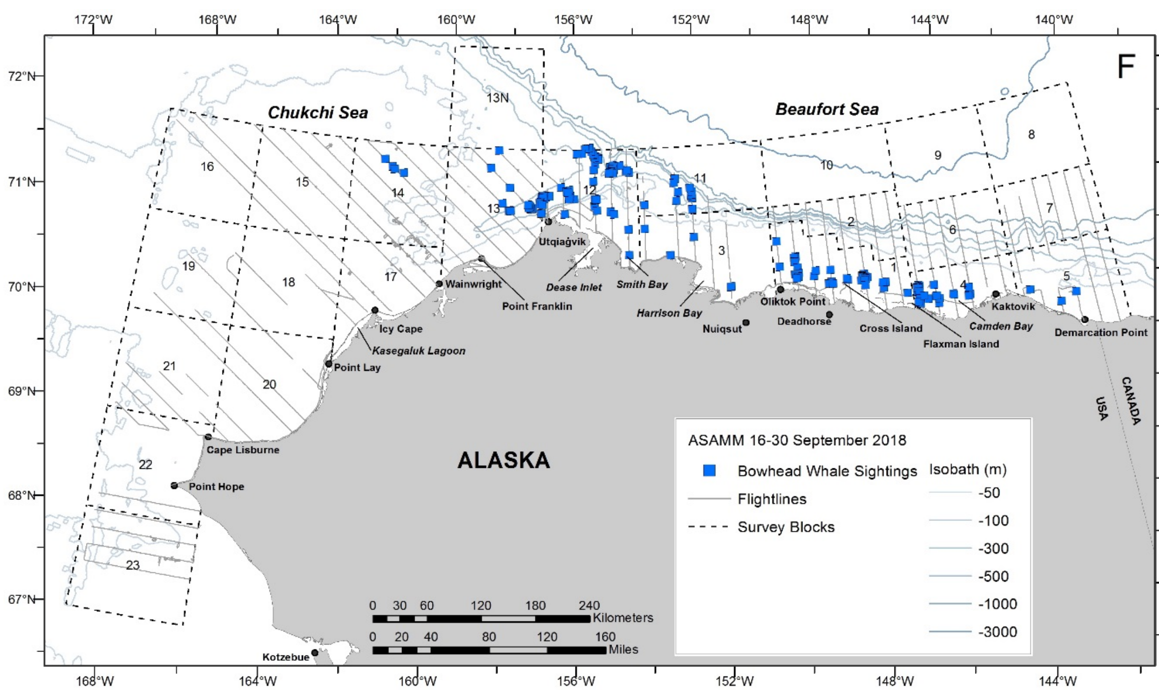
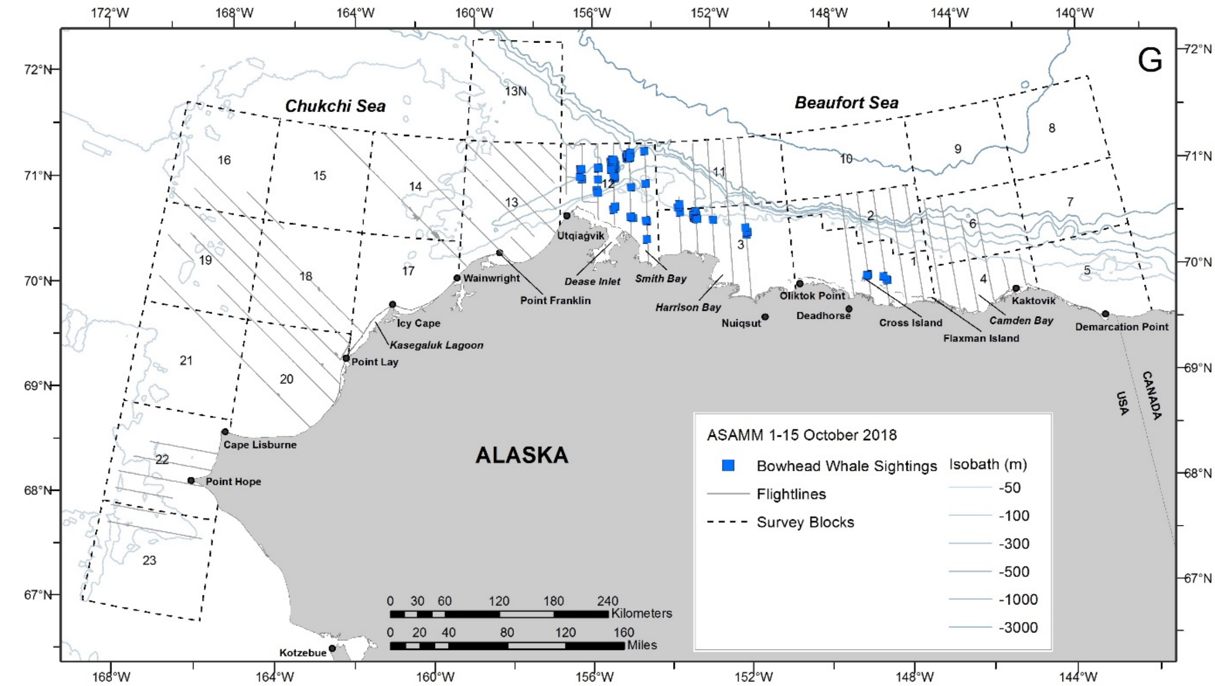


Figure 6 (cont). ASAMM 2018 semimonthly bowhead whale sightings, all survey modes, with transect, CAPs, search, circling, and FGF survey effort, July-October. E: 1-15 September. F: 16-30 September. Deadhead flight tracks are not shown.



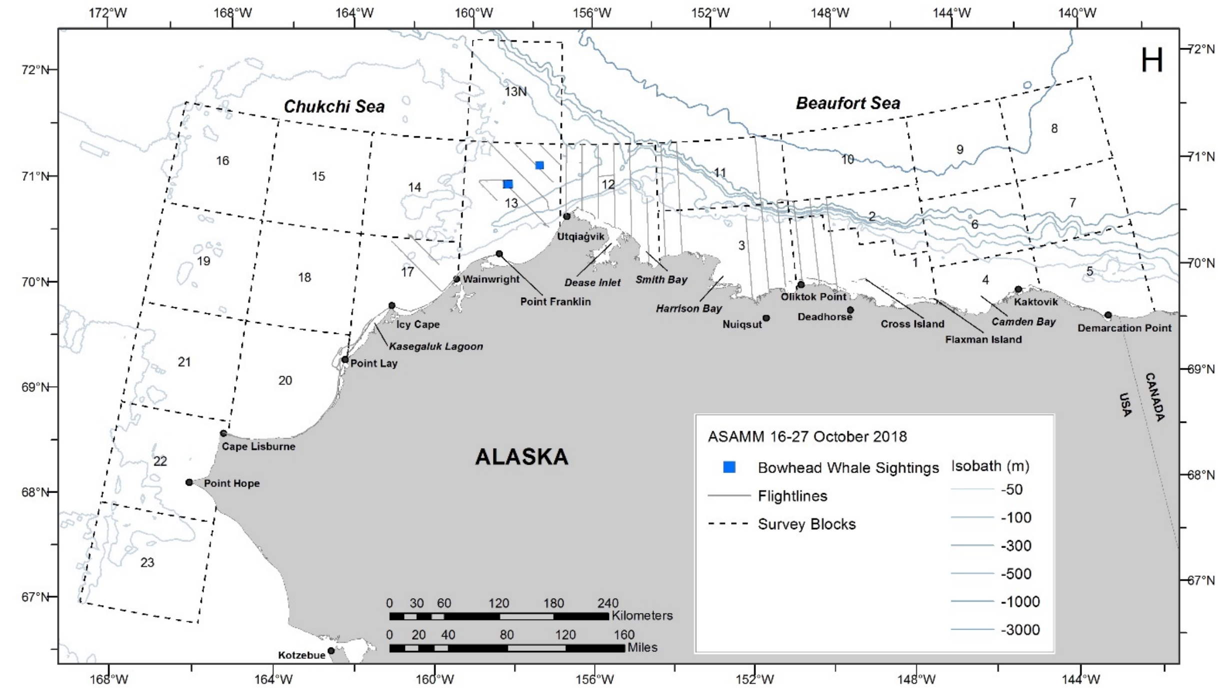


Figure 6 (cont). ASAMM 2018 semimonthly bowhead whale sightings, all survey modes, with transect, CAPs, search, circling, and FGF survey effort, July-October. G: 1-15 October. H: 16-27 October. Deadhead flight tracks are not shown.

barrier islands and the mainland in block 1a to survey areas near the Liberty Prospect. Block 1a was surveyed in all months.

Surveys were conducted north of 72°N in block 13N on five days between 19 July and 22 August, covering 879 on-effort km. Poor weather conditions prevented additional effort in block 13N, and transect effort was frequently truncated to avoid poor visibility.

Block 23 was surveyed for the fifth consecutive year, with effort in July, September, and October.

Portions of the coastal transect in the eastern Chukchi Sea were surveyed on 15 days between 9 July and 20 October, covering approximately 1650 km. In the western Beaufort Sea, portions of the coastal transect were surveyed on 19 days between 3 July and 23 October, covering approximately 2,520 km.

The section of coastal transect between Atigaru Point and Fish Creek in Harrison Bay was surveyed on 17 days, with 5 surveys in July, 3 surveys in August, 5 surveys in September, and 4 surveys in October, for a total of 827 km (Figure 7).

Photos were collected from the BPC on 32 flights, the majority of which were in the Beaufort Sea. The belly camera system was not deployed when surveys were conducted in areas of heavy sea ice (e.g., Beaufort Sea from 9 August to 9 September) because images with >50% sea ice cover are excluded from image analysis. Over 9.6 TB of imagery data were collected, representing over 167,800 images.

Survey effort in 2018 was impacted by poor weather conditions and avoidance of subsistence activities. Fog, low ceilings, and strong winds curtailed survey effort throughout the field season, but particularly in late July and early August when surveys were not conducted by either survey team on 21 of 47 days. In late October, forecasted strong winds encompassing the entire study area led to the 2018 field season ending three days early. The longest period when no ASAMM flights occurred was four days. Mitigating the lack of survey effort during periods of poor weather was achieved by taking full advantage of good weather days to conduct multiple flights in one day. Observers also took advantage of non-flight days to analyze images collected from the BPC and assess bowhead whale images for photo ID analyses.

Direct avoidance of subsistence (or possible subsistence) activities, specifically the fall bowhead whale hunt occurring near Kaktovik, Cross Island, and Utqiaġvik, occurred on five days in 2018. On 1 September, transects were truncated near Cross Island to avoid potential interference with subsistence whaling. Near Kaktovik, small boat activity was avoided on 5 September by maintaining appropriate minimum altitude. On 8, 15, and 23 October, transects were truncated near Utqiaġvik to avoid potential interference with subsistence whaling.

Flights to collect FOV data were initiated on six days, including two flights using an offshore target (floating carcass) and four flights using stationary terrestrial targets. Flights to collect FOV data were flown in lieu of a survey flight on two days when survey conditions offshore were not optimal, and were combined with survey flights on four days (Appendix G).

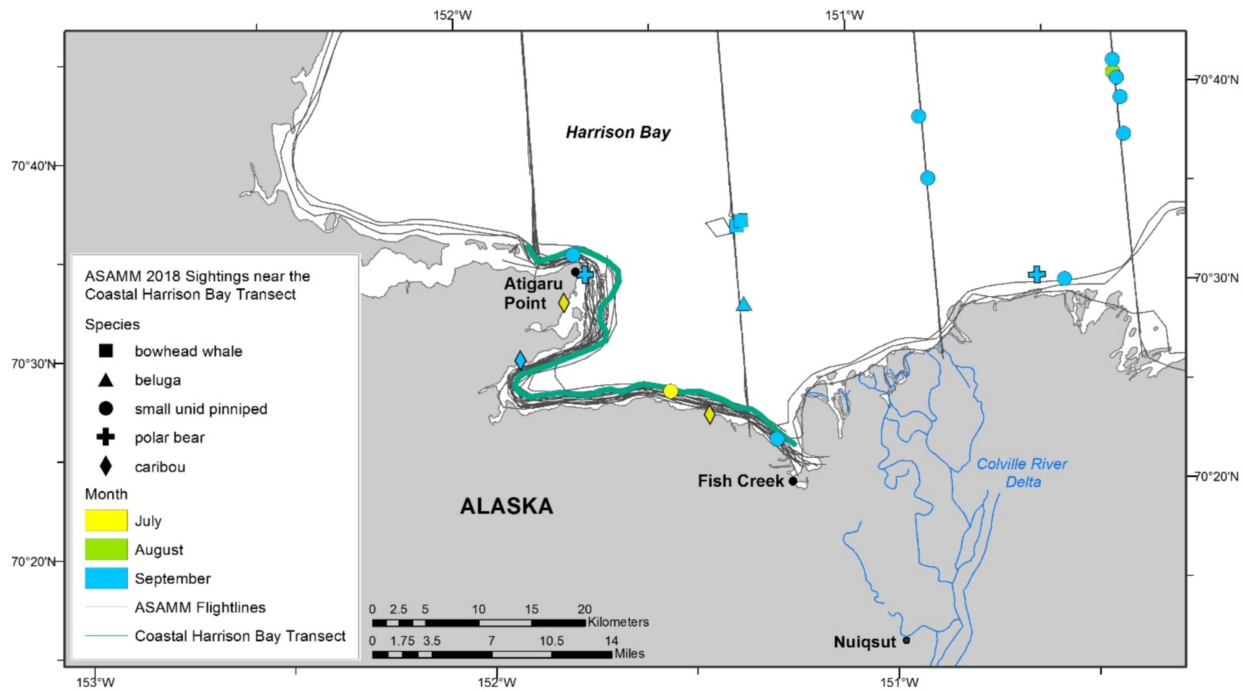


Figure 7. ASAMM 2018 Coastal Harrison Bay (CHB) sightings, all survey modes, and transect, CAPs, search, circling, and FGF survey effort, July-October. Deadhead flight tracks are not shown.

Aerial surveys supporting sea ice and marginal ice zone research were conducted in the northeastern Chukchi Sea by researchers using a NOAA Twin Otter. A UAV operating from Oliktok Point resulted in a wide swath (~90 km, encompassing five ASAMM transects) of restricted airspace limitations. Daily review of Notices to Airmen and Mariners and frequent communications with researchers and UAV operators assisted with mitigating adverse effects on ASAMM survey effort.

Survey coverage was greatest in blocks 13, 14, and 17 in the Chukchi Sea and blocks 12, 3, and 1 in the Beaufort Sea (Figure 8) due, in part, to the proximity of those blocks to Utqiaġvik and Deadhorse. Block 23, in the southern Chukchi, also had relatively good survey coverage due, in part, to its proximity to Kotzebue. When weather conditions were marginal, survey teams remained relatively close to their bases of operation in case weather conditions started to rapidly worsen. When conditions quickly deteriorated, survey effort was immediately aborted so that survey teams could return safely to base. The higher effort in blocks 12 and 13 is partially due to basing the single survey team at Utqiaġvik before 19 July and after 10 October. Flight lines, associated sea states, and sightings on individual flights are shown in Appendix B.

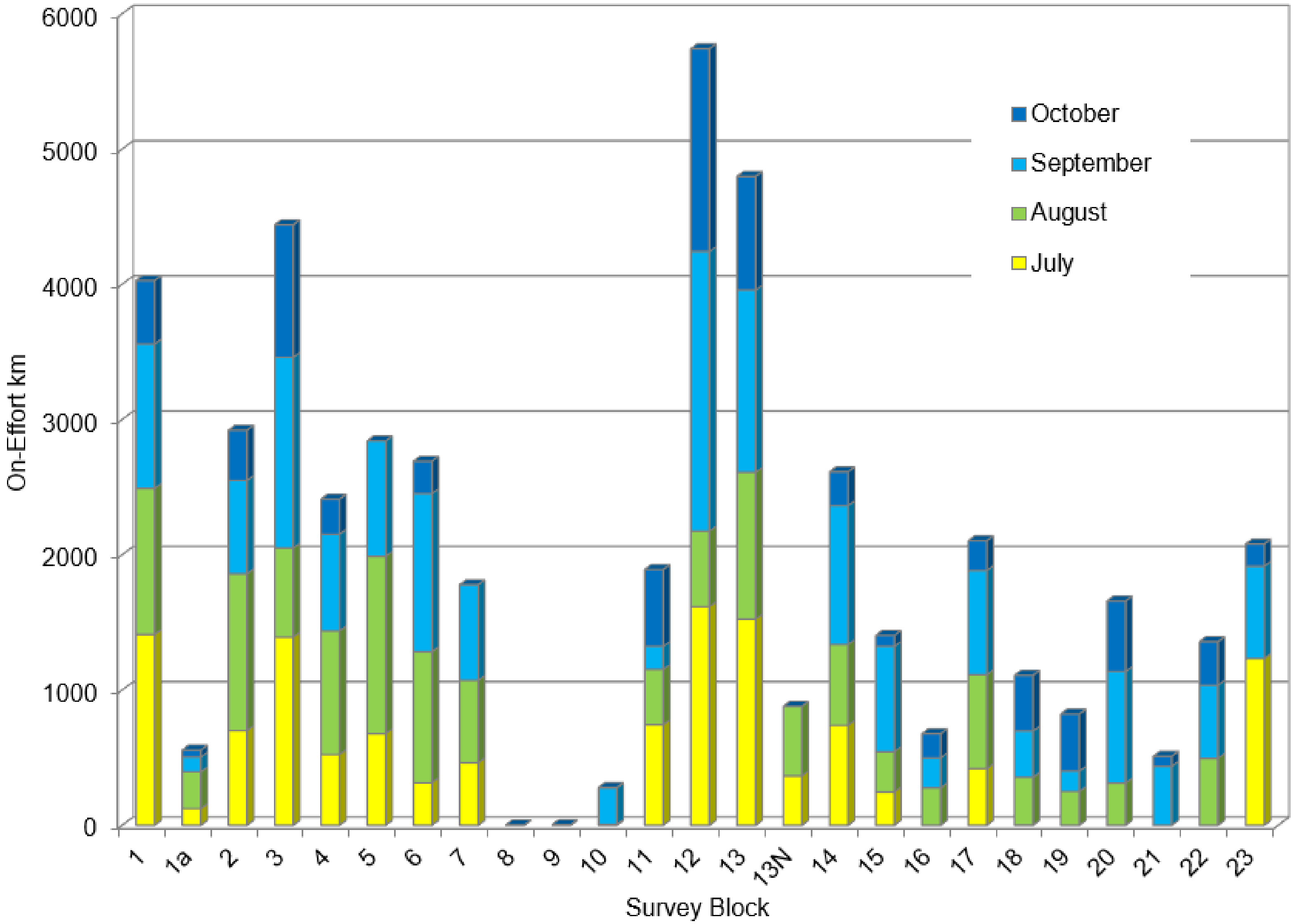


Figure 8. ASAMM 2018 kilometers on effort (transect and CAPs passing) per survey block, July-October.

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Cetaceans

Bowhead Whales

BOWHEAD WHALE SIGHTING SUMMARY

During 2018 ASAMM surveys, 430 sightings of 571 bowhead whales (*Balaena mysticetus*) of the Western Arctic (also known as the Bering-Chukchi-Beaufort) stock were observed during transect, CAPs, search, and circling survey modes from July through October (Table 4; Figure 9). Compared to 2012-2017, the period when ASAMM surveys have been conducted on a regular basis during summer and fall in the western Beaufort and eastern Chukchi seas, the total number of bowhead whales recorded in 2018 was the lowest on record.

Thirty-four bowhead whales were seen in July (Figures 6A and 6B). Sightings were widely dispersed in the western Beaufort Sea, with sightings over the slope (201-2,000 m depth), outer continental shelf (51-200 m) and inner continental shelf (≤50 m). One bowhead whale was seen over the basin (>2,000 m depth). Bowhead whale distribution observed in July extended from 142.8°W to 157°W in the western Beaufort Sea; bowhead whales were not seen east of 142.8°W despite effort in that area. Most of the bowhead whales observed (77%) in the western Beaufort Sea were west of 148°W; only seven whales were observed east of 148°W. Four bowhead whales were seen in the northeastern Chukchi Sea; bowhead whales were not seen in block 13N. The highest number of bowhead whales per survey block in July was in block 12 (n_i = 13). In August, 25 bowhead whales were seen (Figures 6C and 6D), which is far fewer than the number observed in August 2012-2017 (Clarke et al. 2013a, 2014, 2015a, 2017a, b, 2018a). Bowhead whales were observed in the western Beaufort Sea from 144°W to 157°W in outer and inner shelf waters; two bowhead whales were observed in the Chukchi Sea. The highest number of bowhead whales per survey block in August was in block 3 (n_i = 9). In September, 354 bowhead whales were seen. In the western Beaufort Sea, bowhead whale distribution in September was primarily on the inner shelf (≤50 m depth) east of 152°W, and over the slope, outer shelf, inner shelf, and in Barrow Canyon west of 152°W (Figures 6E and 6F). In the Chukchi Sea in September, bowhead whales were observed between 71.3°N and 72°N, with the majority of sightings 12-100 km west and northwest of Point Barrow, and a few whales (n_i = 5) 170-200 km west-northwest of Point Barrow. The greatest number of bowhead whales per survey block in September was in block 12 (n_i = 155). In October, 158 bowhead whales were seen. All bowhead whales observed in the first half of October were in the western Alaskan Beaufort Sea, distributed in Barrow Canyon and the inner shelf west of 147°W (Figures 6G and 6H). All bowhead whales observed in the latter half of October were in the Chukchi Sea, northwest of Point Barrow. The greatest number of bowhead whales per survey block in October was seen in block 12 (n_i = 118).

Poor weather conditions and the presence of heavy sea ice in the western Beaufort Sea likely influenced observed bowhead whale distribution in July and August. Poor weather conditions combined with inconsistent survey effort likely influenced observed bowhead whale distribution in October more than other months; there was minimal survey effort east of 146°W and inconsistent effort in the Chukchi Sea. Bowhead whale sightings in the northeastern Chukchi Sea in September 2018 reinforce previous observations from aerial surveys, satellite telemetry (Quakenbush et al.

Table 4. Summary of ASAMM 2018 cetacean sightings (number of sightings/number of individuals) during transect, CAPs, search, and circling survey modes in chronological order, 3 July–27 October 2018, by survey flight and semimonthly time period. Excludes dead and repeat sightings.

Day	Flight No.	Bowhead Whale	Gray Whale	Humpback Whale	Fin Whale	Minke Whale	Beluga	Killer Whale	Harbor Porpoise	Unidentified Cetacean
3 Jul	201	4/6	0	0	0	0	3/26	0	0	0
6 Jul	202	1/1	0	0	0	0	2/26	0	0	0
9 Jul	203	0	0	0	0	0	0	0	0	0
10 Jul	204	0	0	0	0	0	7/36	0	0	0
11 Jul	205	0	18/47	0	0	0	1/400	0	0	1/1
12 Jul	206	0	5/7	0	0	0	1/8	0	0	0
13 Jul	207	5/7	0	0	0	0	32/156	0	0	0
14 Jul	208	0	44/67	21/28	4/4	0	0	0	1/1	8/9
19 Jul	209	0	0	0	0	0	0	0	0	0
20 Jul	210	2/3	12/28	0	0	0	0	0	0	0
20 Jul	1	0	0	0	0	0	25/45	0	0	0
21 Jul	211	6/9	2/2	0	0	0	12/66	0	0	0
21 Jul	2	2/2	0	0	0	0	31/54	0	0	0
22 Jul	3	0	0	0	0	0	0	0	0	0
24 Jul	212	0	0	0	0	0	6/14	0	0	0
26 Jul	4	0	0	0	0	0	25/43	0	0	0
29 Jul	5	3/3	0	0	0	0	20/119	0	0	0
29 Jul	213	0	11/31	10/17	5/9	0	0	0	0	3/4
30 Jul	214	0	17/26	0	0	1/2	1/1	0	0	0
30 Jul	6	0	0	0	0	0	41/99	0	0	0
31 Jul	215	1/1	0	0	0	0	0	0	0	0
31 Jul	7	2/2	0	0	0	0	4/4	0	0	0

Day	Flight No.	Bowhead Whale	Gray Whale	Humpback Whale	Fin Whale	Minke Whale	Beluga	Killer Whale	Harbor Porpoise	Unidentified Cetacean
3 Aug	8	0	0	0	0	0	8/11	0	0	0
5 Aug	216	0	0	1/1	0	1/1	0	0	0	0
6 Aug	217	0	0	0	0	0	0	0	0	0
8 Aug	218	0	13/21	0	0	0	0	0	0	2/2
8 Aug	9	3/3	0	0	0	0	16/25	0	0	0
9 Aug	219	0	0	0	0	0	0	0	0	1/1
9 Aug	10	0	0	0	0	0	26/50	0	0	0
12 Aug	11	0	0	0	0	0	0	0	0	0
14 Aug	12	0	0	0	0	0	0	0	0	0
14 Aug	220	1/1	4/5	0	0	0	0	0	0	0
15 Aug	13	0	0	0	0	0	15/20	0	0	0
17 Aug	14	0	0	0	0	0	0	0	0	0
17 Aug	221	0	0	0	0	0	3/6	0	0	0
18 Aug	15	0	0	0	0	0	12/16	0	0	0
19 Aug	16	0	0	0	0	0	11/19	0	0	2/2
19 Aug	222	0	7/14	0	0	0	0	0	0	0
22 Aug	223	0	0	0	0	0	2/2	0	0	0
25 Aug	224	0	6/6	0	0	0	0	0	0	1/1
26 Aug	17	0	0	0	0	0	0	0	0	0
28 Aug	225	6/7	0	0	0	0	15/31	0	0	0
28 Aug	18	1/1	0	0	0	0	15/26	0	0	0
29 Aug	19	1/2	0	0	0	0	14/24	0	0	0
30 Aug	226	0	0	0	0	0	0	0	0	0
30 Aug	20	10/11	0	0	0	0	6/16	1/4	0	1/1
31 Aug	21	0	0	0	0	0	7/11	0	0	0

Day	Flight No.	Bowhead Whale	Gray Whale	Humpback Whale	Fin Whale	Minke Whale	Beluga	Killer Whale	Harbor Porpoise	Unidentified Cetacean
1 Sep	227	5/5	2/2	0	0	0	6/15	0	0	0
1 Sep	22	2/2	0	0	0	0	12/19	0	0	1/1
2 Sep	228	4/33	0	0	0	0	0	0	0	0
2 Sep	23	2/8	0	0	0	0	2/2	0	0	0
4 Sep	229	0	1/1	0	0	0	0	0	0	0
4 Sep	24	1/1	0	0	0	0	4/8	0	0	0
5 Sep	25	4/5	0	0	0	0	27/49	0	0	0
7 Sep	26	1/3	0	0	0	0	0	0	0	0
8 Sep	27	16/19	0	0	0	0	6/7	0	0	1/1
9 Sep	28	4/5	0	0	0	0	1/1	0	0	0
11 Sep	230	0	3/4	0	0	0	0	0	0	0
11 Sep	29	0	0	0	0	0	0	0	0	0
12 Sep	231	0	1/4	8/9	27/47	0	0	0	1/4	19/56
15 Sep	30	0	0	0	0	0	2/2	0	0	0
15 Sep	232	0	0	0	0	0	0	0	0	0
16 Sep	233	0	0	0	0	0	0	0	0	0
18 Sep	234	0	0	0	0	0	0	0	0	0
18 Sep	31	0	0	0	0	0	0	0	0	0
19 Sep	235	0	0	0	0	0	0	0	0	0
19 Sep	32	0	0	0	0	0	0	0	0	0
20 Sep	33	45/64	0	0	0	0	18/54	0	0	2/2
21 Sep	236	16/20	0	0	0	0	0	0	0	0
22 Sep	237	0	0	0	0	0	0	0	0	0
23 Sep	34	17/20	0	0	0	0	9/13	0	0	0
23 Sep	238	0	0	13/24	40/56	0	0	0	8/8	10/22
24 Sep	35	0	0	0	0	0	11/18	0	0	1/1

Day	Flight No.	Bowhead Whale	Gray Whale	Humpback Whale	Fin Whale	Minke Whale	Beluga	Killer Whale	Harbor Porpoise	Unidentified Cetacean
25 Sep	239	56/63	4/5	0	0	0	0	0	0	2/2
25 Sep	36	17/21	0	0	0	0	21/33	0	0	0
26 Sep	240	48/70	0	0	0	0	14/68	0	0	2/2
26 Sep	37	8/8	0	0	0	0	0	0	0	0
27 Sep	241	0	1/1	0	0	1/3	0	0	0	1/1
28 Sep	242	0	0	0	0	0	0	0	0	0
30 Sep	243	0	59/91	0	0	0	1/1	1/12	1/1	0
30 Sep	38	4/7	54/94	0	0	0	0	0	0	0
2 Oct	244	0	0	0	0	0	0	0	2/3	0
3 Oct	245	0	0	0	0	0	0	0	0	0
3 Oct	39	0	0	0	0	0	0	0	0	0
5 Oct	246	0	0	0	0	0	0	0	2/4	0
6 Oct	247	0	2/3	0	1/1	0	0	0	0	0
7 Oct	248	0	0	0	0	0	0	0	0	0
7 Oct	40	7/8	0	0	0	0	22/29	0	0	0
8 Oct	249	89/101	0	0	0	0	23/60	0	0	0
8 Oct	41	18/23	0	0	0	0	15/37	0	0	1/1
9 Oct	250	0	26/31	0	0	0	0	0	0	1/1
14 Oct	251	14/17	0	0	0	0	2/3	0	0	0
15 Oct	252	0	0	0	0	0	1/1	0	0	0
19 Oct	253	0	0	0	0	0	0	0	0	0
20 Oct	254	0	2/2	0	0	0	0	0	0	0
22 Oct	255	0	0	0	0	0	0	0	0	0
23 Oct	256	4/9	1/1	0	0	0	15/21	0	0	0
26 Oct	257	0	0	0	0	0	6/9	0	0	0
27 Oct	258	0	0	0	0	0	4/10	0	0	0

Day	Bowhead Whale	Gray Whale	Humpback Whale	Fin Whale	Minke Whale	Beluga	Killer Whale	Harbor Porpoise	Unidentified Cetacean
				Semimonthly Summary					
1-15 Jul	10/14	67/121	21/28	4/4	0	46/652	0	1/1	9/10
16-31 Jul	16/20	42/87	10/17	5/9	1/2	165/445	0	0	3/4
1-15 Aug	4/4	17/26	1/1	0	1/1	65/106	0	0	3/3
16-31 Aug	18/21	13/20	0	0	0	85/151	1/4	0	4/4
1-15 Sep	39/81	7/11	8/9	27/47	0	60/103	0	1/4	21/58
16-30 Sep	211/273	118/191	13/24	40/56	1/3	74/187	1/12	9/9	18/30
1-15 Oct	128/149	28/34	0	1/1	0	63/130	0	4/7	2/2
16-31 Oct	4/9	3/3	0	0	0	25/40	0	0	0
TOTAL	430/571	295/493	53/79	77/117	3/6	583/1,814	2/16	15/21	60/111

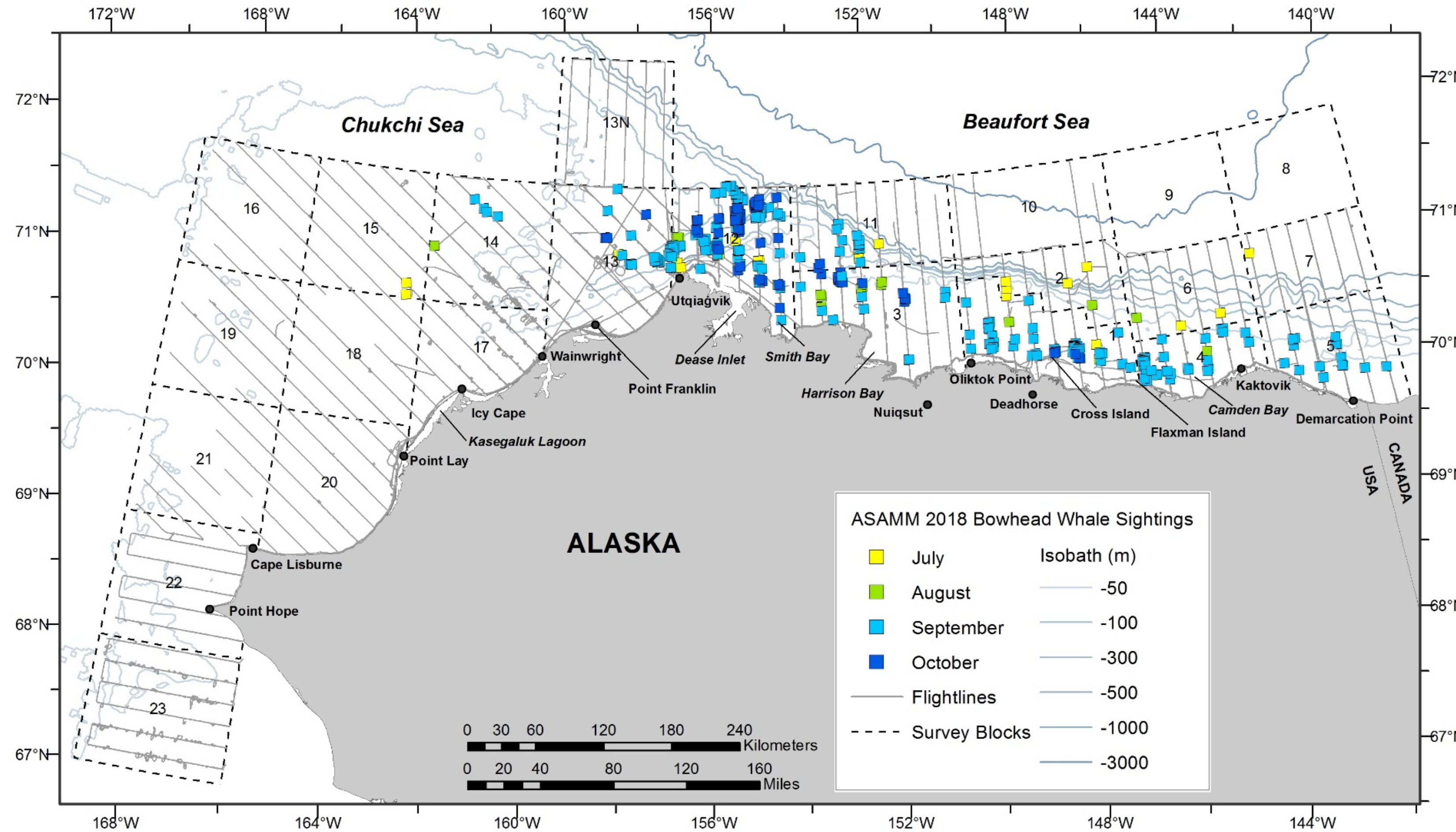


Figure 9. ASAMM 2018 bowhead whale sightings, all survey modes, plotted by month, with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.

2010a), and acoustics (Delarue et al. 2011), describing a broad migration route that spreads across the northeastern Chukchi Sea.

Bowhead whales were last observed on 23 October, when nine whales were seen in block 13, northwest of Point Barrow. No bowhead whales were observed in block 1a.

BOWHEAD WHALE SIGHTING RATES

In summer and fall 2018, bowhead whales were seen on effort (transect and CAPs-adjusted) from 140.3°W to 163.5°W. There were 281 sightings of 366 bowhead whales on effort by primary observers, ranging from one whale per sighting (n_s = 228) to 7 whales per sighting (n_s = 2). The highest number of sightings on effort was in block 12 (n_s = 105), followed by block 1 (n_s = 53). The largest groups of bowhead whales on effort (n_i = 7) were observed on 2 September in block 3 and 26 September in block 12.

Highest fine-scale sighting rates (WPUE, 5-km grid) for summer (July-August) were limited to offshore north of Harrison Bay and northwest of Wainwright (Figure 10A). In fall (September-October), highest fine-scale sighting rates were distributed throughout the western Beaufort Sea from east of Kaktovik to northeast of Utqiaġvik, and west of Utqiaġvik in the northeastern Chukchi Sea (Figure 10B).

Monthly and seasonal shifts in bowhead whale distribution were evident in results of the analysis of sighting rates by survey block. For all months combined, the highest sighting rates per survey block were in block 12 (0.024 WPUE), block 1 (0.018 WPUE), and block 4 (0.013 WPUE), with an overall sighting rate of 0.008 WPUE.

Sighting rates in the western Beaufort Sea were low in July in most survey blocks except blocks 2, 6, 11, and 12 (Figure 11). Sighting rate per block in July 2018 indicated a predominantly offshore distribution, as noted in some previous years. Sighting rates in August were all much lower than have been observed in previous years, with relatively high sighting rates in only block 3 (0.011 WPUE) and block 12 (0.009 WPUE). Sighting rates for summer (July and August combined) were highest in block 12 (0.008 WPUE) and block 11 (0.005 WPUE), and overall sighting rate in summer for all blocks combined in the western Beaufort Sea was 0.002 WPUE (Appendix E, Table E-1). Sighting rates in September were highest in block 11 (0.088 WPUE), block 1 (0.057 WPUE), and block 4 (0.042 WPUE). Sighting rates in October were highest in block 12 (0.036 WPUE) and blocks 1 and 3 (0.017 WPUE). Combined sighting rates for fall (September-October) were highest in block 1 (0.045 WPUE), block 12 (0.034 WPUE), and block 4 (0.031 WPUE); overall sighting rate in fall for all blocks combined in the western Beaufort Sea was 0.013 WPUE (Appendix E, Table E-1).

Sighting rates in all Chukchi Sea blocks (13-23 and 13N) in summer were very low (Figure 11); bowhead whales were seen only in block 15 in July and block 13 in August. In the Chukchi Sea in fall, the highest sighting rate was 0.012 WPUE in block 13 (Appendix E, Table E-1). The overall sighting rate for all Chukchi Sea survey blocks (13-23) in fall was 0.003 WPUE, which was similar to the overall sighting rate for this area in 2013, 2014, 2015, 2016, and 2017 (Clarke

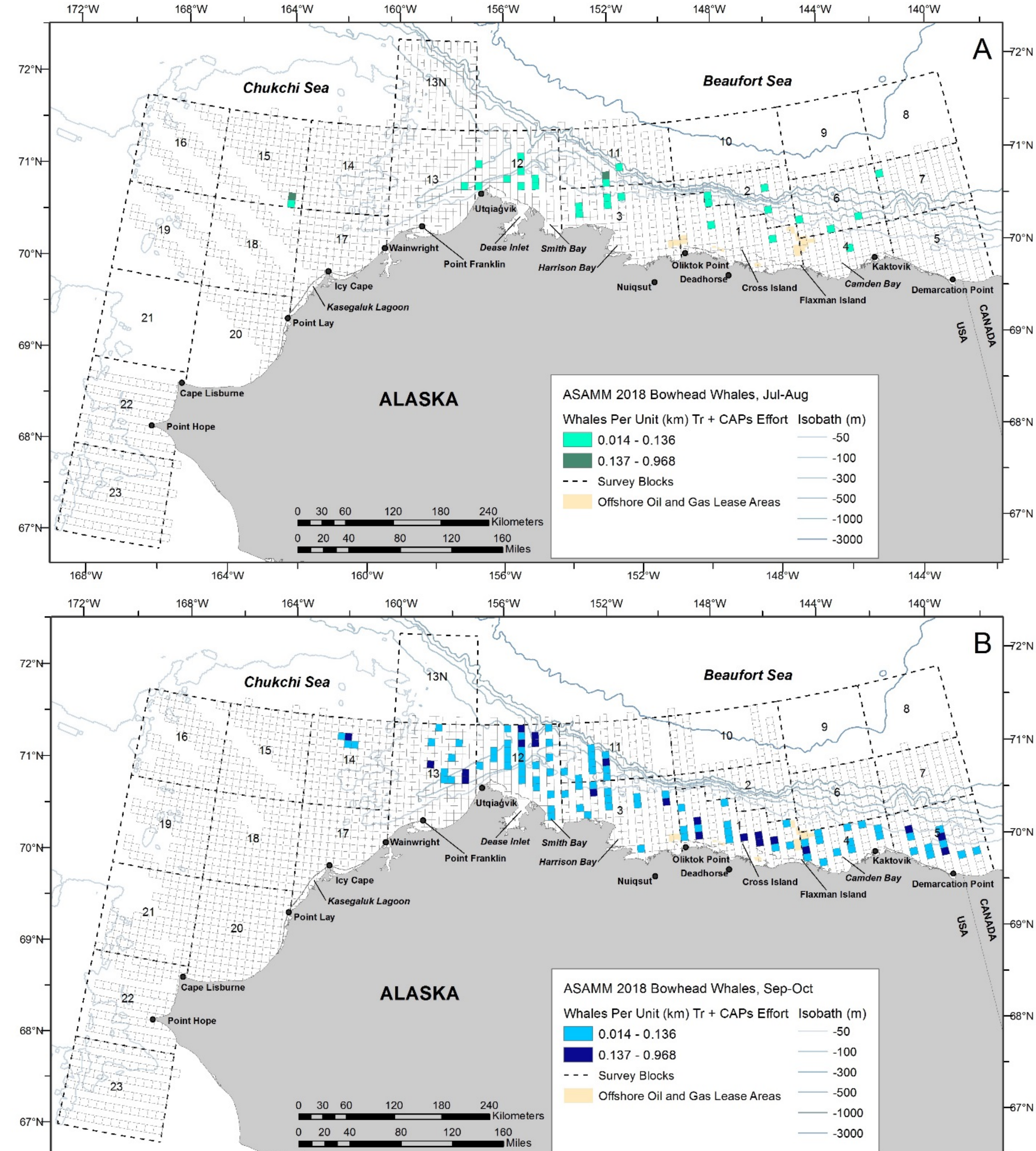


Figure 10. ASAMM 2018 bowhead whale on-effort seasonal sighting rates (WPUE; sightings from primary observers only). A: summer (July-August pooled). B: fall (September-October pooled). Empty cells indicate sighting rates of zero. Transect and CAPs survey effort were not conducted in areas without cell outlines.

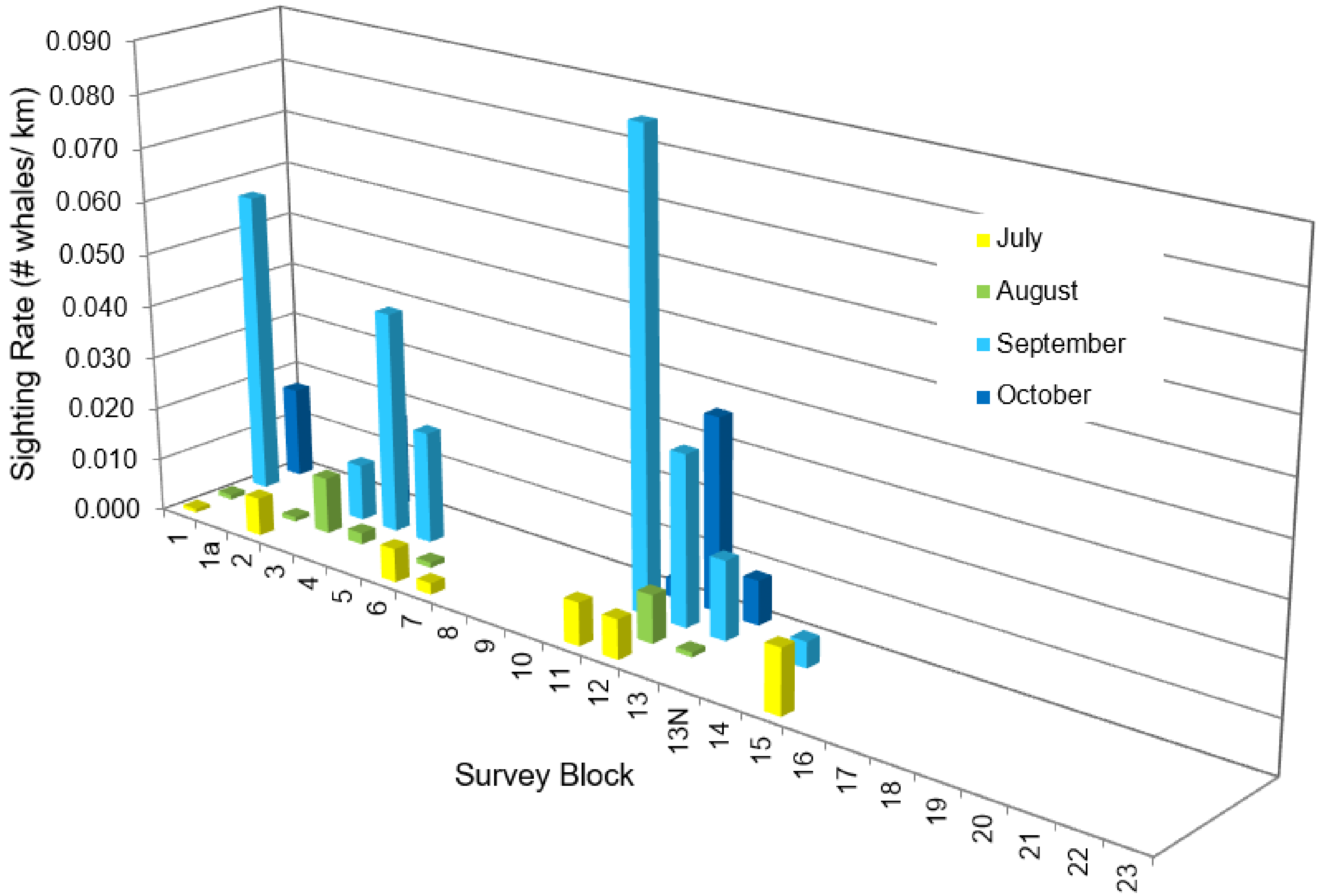


Figure 11. ASAMM 2018 bowhead whale on-effort monthly sighting rates (WPUE; sightings from primary observers only) per survey block, July-October. Sighting rates of zero were removed from the graph for clarity.

et al. 2014, 2015a, 2017a, b, 2018a) and lower than the sighting rate for this area in 2012 (Clarke et al. 2013a).

For summer months, the highest sighting rates per depth zone (Figure 12; Appendix E, Table E-2) were as follows:

- 36-50 m depth zone (0.001 WPUE) in the eastern Chukchi Sea subarea (157°W-169°W);
- 21-50 m depth zone (0.022 WPUE) in the western (154°W-157°W) Alaskan Beaufort Sea subarea; and
- 21-50 m and 51-200 m depth zone (0.003 WPUE) in the central-eastern (140°W-154°W) Alaskan Beaufort Sea subarea.

A shift from higher sighting rates in offshore, deeper water (51-200 m) in July to shallower water (21-50 m) in August in the central-eastern (140°W-154°W) Alaskan Beaufort Sea, as noted in previous years (2012-2017; Clarke et al. 2013a, 2014, 2015a, 2017a,b, 2018a) was also observed in 2018 (Figure 12), although sighting rates were relatively low in all depth zones in summer.

During fall, the highest sighting rates per depth zone (Figure 12; Appendix E, Table E-2) were as follows:

- 51-200 m North depth zone (0.014 WPUE) in the eastern Chukchi Sea subarea (157°W-169°W);
- 201-2,000 m depth zone (0.122 WPUE) in the western (154°W-157°W) Alaskan Beaufort Sea subarea; and
- 21-50 m depth zone (0.034 WPUE) in the central-eastern (140°W-154°W) Alaskan Beaufort Sea subarea.

Patterns in sighting rates per depth zone were consistent in all subareas from September to October.

Bowhead Whale Sea Ice Associations

Most bowhead whales (85%, n_i = 483) were observed in 0% sea ice cover (Table 5). Forty bowhead whales (7%) were sighted in 1-10% sea ice cover, 23 bowhead whales (4%) were sighted in 11-40% sea ice cover, and 25 bowhead whales (4%) were sighted in 40-100% sea ice cover. Most bowhead whales observed in areas of sea ice were seen in July and August in the western Beaufort Sea, where heavy sea ice concentrations remained (Appendix A, Figures A-3 and A-4). The heavy sea ice likely negatively influenced bowhead whale sightings in summer, either because whales were harder to detect amongst the broken jumbles of sea ice or because bowhead whales did not migrate into the western Beaufort Sea as early as past years due to the dampening effect of sea ice on feeding opportunities, or a combination of both.

Bowhead Whale Behaviors

Bowhead whale behaviors observed during all survey modes (i.e., transect, CAPs, search, and circling) and by primary and secondary observers in 2018 are summarized in Table 6. The

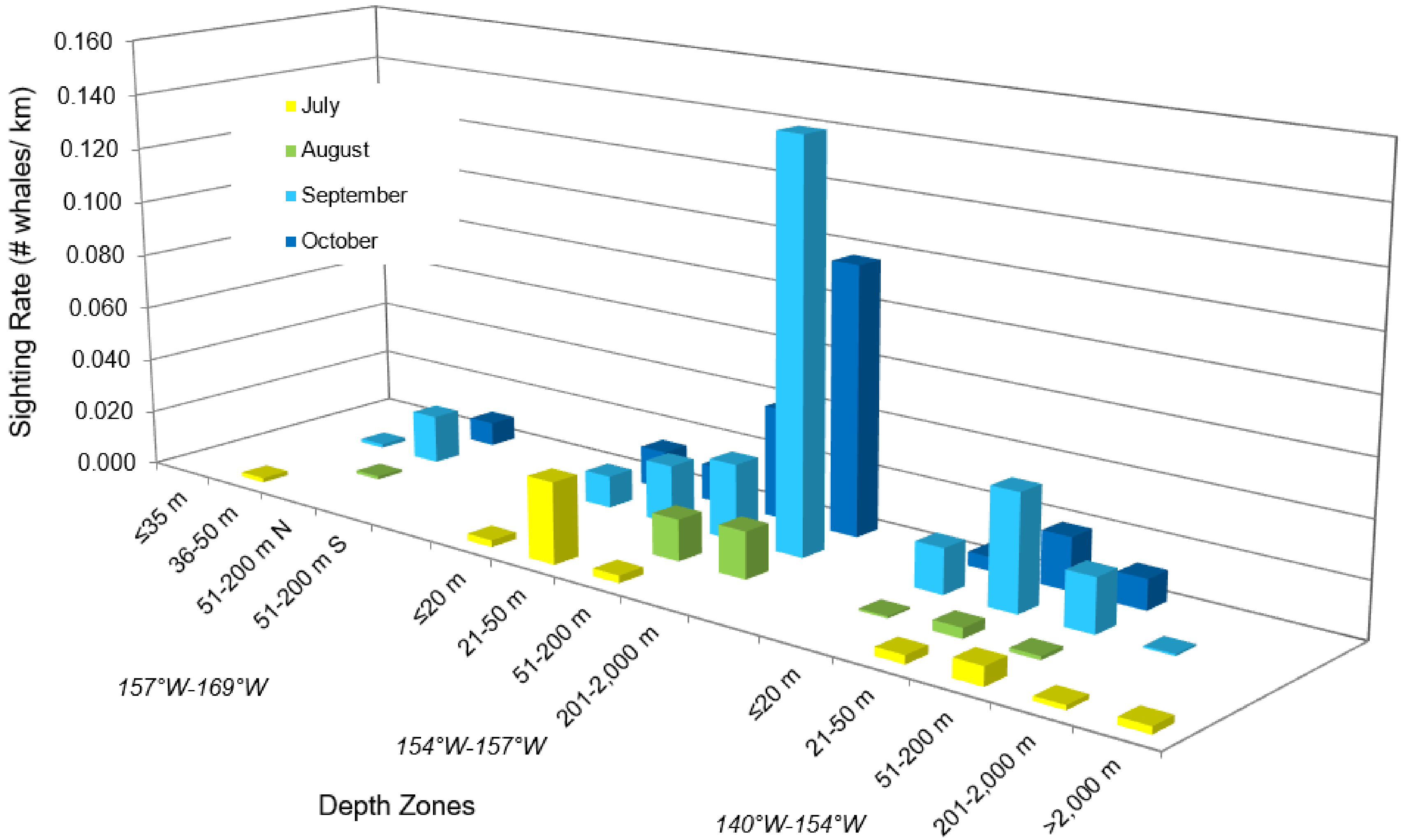


Figure 12. ASAMM 2018 bowhead whale on-effort monthly sighting rates (WPUE; sightings from primary observers only) per depth zone, July-October. Sighting rates of zero were removed from the graph for clarity.

Table 5. ASAMM 2018 semimonthly summary of bowhead whales (number of sightings/number of individuals) observed during transect, CAPs, search, and circling survey modes, by percent sea ice cover at sighting location. Excludes dead and same-day repeat sightings.

Percent Sea Ice Cover	1-15 Jul	16-31 Jul	1-15 Aug	16-31 Aug	1-15 Sep	16-30 Sep	1-15 Oct	16-31 Oct	Total
0	0	4/5	0	8/9	10/41	209/271	127/148	4/9	362/483
1-5	0	2/2	0	3/4	12/19	0	0	0	17/25
6-10	0	3/3	1/1	4/4	4/6	0	1/1	0	13/15
11-20	0	0	0	2/3	2/2	2/2	0	0	6/7
21-30	1/1	0	0	1/1	5/6	0	0	0	7/8
31-40	1/1	2/2	0	0	4/5	0	0	0	7/8
41-50	0	0	1/1	0	0	0	0	0	1/1
51-60	0	1/1	0	0	0	0	0	0	1/1
61-70	0	1/1	0	0	1/1	0	0	0	2/2
71-80	0	1/4	0	0	0	0	0	0	1/4
81-90	5/7	1/1	2/2	0	0	0	0	0	8/10
91-100	3/5	1/1	0	0	1/1	0	0	0	5/7
TOTAL	10/14	16/20	4/4	18/21	39/81	211/273	128/149	4/9	430/571

Table 6. ASAMM 2018 semimonthly summary of bowhead whales (number of sightings/number of individuals) observed during transect, CAPs, search, and circling survey modes, by behavioral category. SAG = surface active group. Excludes dead and same-day repeat sightings.

Behavior	1-15 Jul	16-31 Jul	1-15 Aug	16-31 Aug	1-15 Sep	16-30 Sep	1-15 Oct	16-31 Oct	Total
Breach	0	1/1	0	0	0	3/3	0	0	4/4
Dive	0	0	2/2	1/1	0	3/3	5/5	0	11/11
Feed	0	0	0	0	1/30	1/2	0	0	2/32
Mill	0	0	0	1/2	1/7	10/25	4/12	0	16/46
Rest	3/4	4/7	0	0	9/9	2/2	23/27	0	41/49
SAG	0	0	0	0	0	0	2/5	1/3	3/8
Swim	7/10	11/12	2/2	16/18	27/34	190/236	92/98	3/6	348/416
Tail Slap	0	0	0	0	0	1/1	0	0	1/1
Unknown	0	0	0	0	1/1	1/1	2/2	0	4/4
TOTAL	10/14	16/20	4/4	18/21	39/81	211/273	128/149	4/9	430/571

behavior most often recorded was swimming (73%, $n_i = 416$), followed by resting (9%, $n_i = 49$), milling (8%, $n_i = 46$), feeding (6%, $n_i = 32$), and diving (2%, $n_i = 11$). Feeding behavior was likely underreported due to the difficulty of identifying this behavior for animals feeding on benthic or mid-water prey; milling was recorded in situations where obvious evidence of feeding was not directly observed but was suspected. Bowhead whales were difficult to resight, particularly in July and August, even in areas of open water within sea ice, and appeared to spend more time underwater than during summer 2012-2017. Five whales were recorded exhibiting display behaviors, including breaching (four whales) and tail slapping (one whale). Eight whales were recorded as engaging in surface active group (SAG) behavior. Behavior was recorded as unknown for four whales, likely because the sightings were too far away to determine a behavior. Two bowhead whales (<1% of all bowhead whales sighted) appeared to respond to the survey aircraft; both reacted by diving.

Seasonal differences were observed in bowhead whale swim direction. In the western Beaufort Sea, mean vector bowhead whale swim direction in summer was southwesterly (230°T), but headings were scattered in several directions (Rayleigh $Z = 0.799$, $P = 0.457$, 16 observations). In fall in the western Beaufort Sea, bowhead whale swim direction was significantly clustered in a northwesterly heading (289°T; Rayleigh $Z = 40.301$, $P < 0.0001$, 111 observations). Similarly, in the northeastern Chukchi Sea, mean vector bowhead whale swim direction in summer was southwesterly (227°T), with headings scattered in several directions (Rayleigh $Z = 2.489$, $P = 0.081$, 15 observations), and significantly clustered in a westerly heading in fall (278°T; Rayleigh $Z = 13.120$, $P < 0.0001$, 81 observations). There were no swim direction data to conduct statistical analyses for bowhead whales in the southcentral Chukchi Sea in summer or fall.

Bowhead Whale Calves

Out of the 571 bowhead whales sighted, 28 were identified as calves (Figure 13). Most calves ($n_i = 19$, 68%) were sighted after circling was initiated and likely would not have been observed if circling had not commenced. Calves were seen from early July through late October, distributed from 142°W to 159°W. Calves were seen in the central Alaskan Beaufort Sea (148°W-152.5°W) in July. No calves were seen in August. Calf distribution was most widespread in September, extending from ~142°W to 156.5°W. Calf sightings in October were mainly limited to Barrow Canyon; one calf was also observed immediately north of a barrier island in the central Alaskan Beaufort Sea. Calves were seen only in the western Beaufort Sea until late October, when four calves were seen in the northeastern Chukchi Sea. Calves were observed with adult bowhead whales that were resting, swimming, and engaging in SAG behavior. There was one sighting of an adult bowhead whale with two calves. Six calves were sighted without a closely associated adult, although in most of those cases ($n_i = 4$) adult whales were in the general vicinity.

Seasonal differences in bowhead whale calf distribution reflected the differences observed for the population, wherein relatively few whales were seen during summer months. Three bowhead whale calves (11%) were sighted during summer months (all in July) on the outer shelf in the central Alaskan Beaufort Sea, for a summer calf ratio (number of calves/number of total whales)

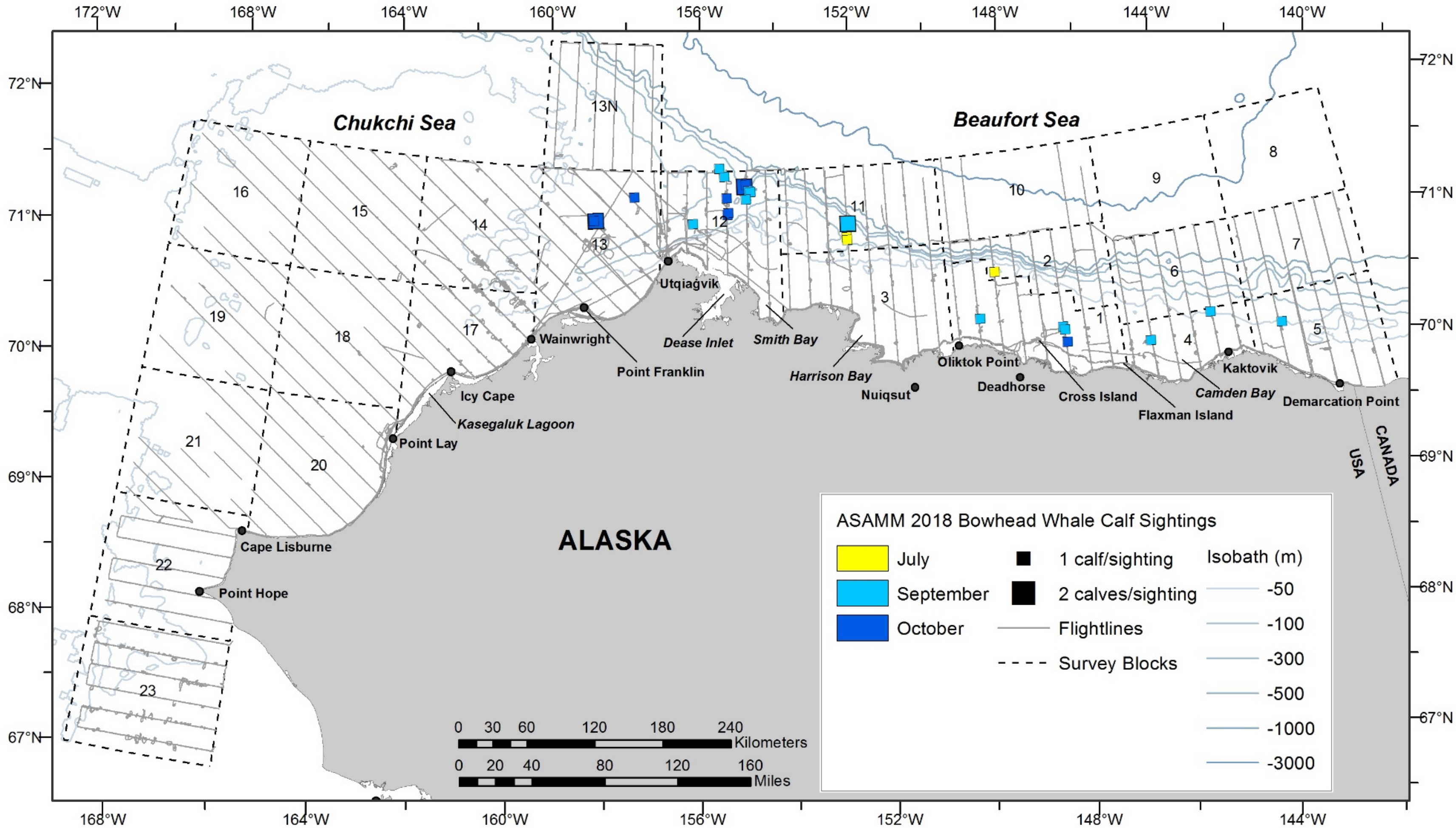


Figure 13. ASAMM 2018 bowhead whale calf sightings, all survey modes, plotted by month, with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.

of 0.051. Twenty-five (89%) calves were sighted during fall months, distributed on the inner shelf and in Barrow Canyon. The calf ratio during fall was 0.049.

Bowhead Whale Feeding

Bowhead whale feeding behavior, which includes sightings reported as milling, was observed from late August through mid-October 2018. Feeding was not observed in July, and was documented on only one day in August, when two whales were observed nearshore east of Smith Bay (Figure 14A). In fall (September-October), feeding behavior was observed on 7 days in the western Beaufort Sea, including small groups offshore in Barrow Canyon (Figure 14B). Water depths at sightings of feeding whales in fall in the western Beaufort Sea ranged from 4 m to 212 m (2 km to 71 km from shore). Bowhead whale feeding was not observed in the Chukchi Sea. Sighting rates for feeding and milling bowhead whales in summer and fall are shown in Figure 15.

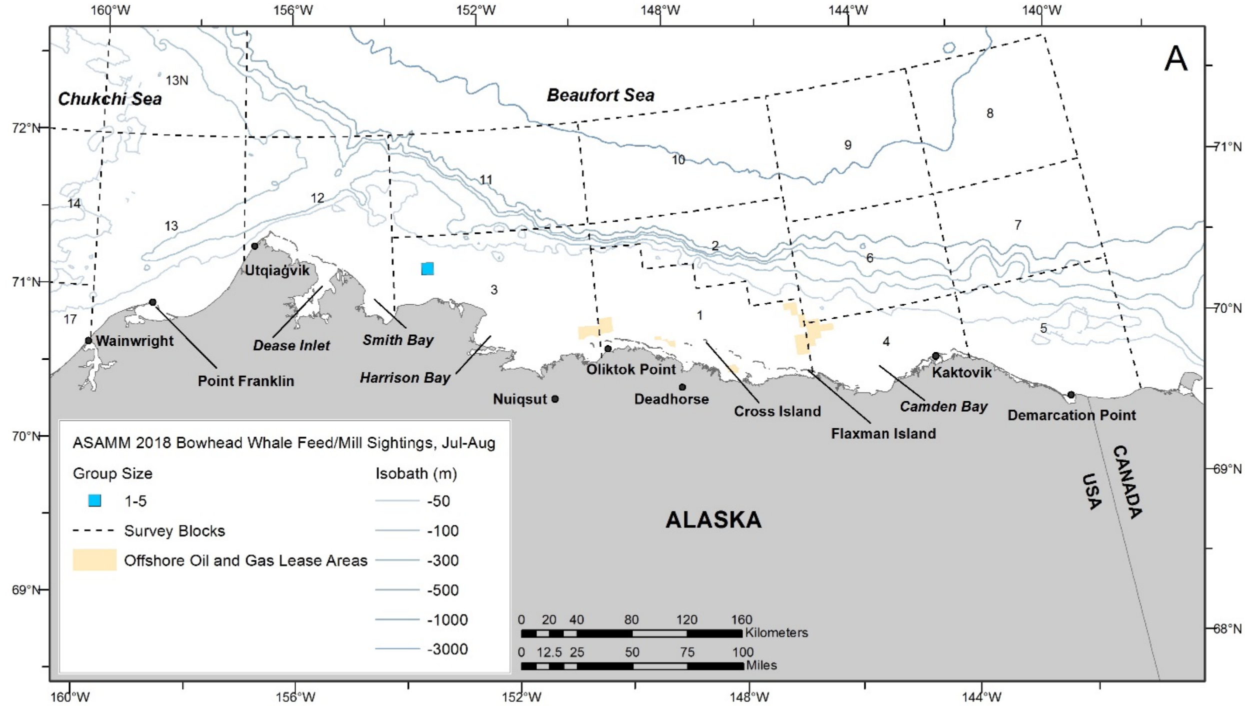
The area between roughly Cape Halkett and Point Barrow (~152.5°W-157°W) encompasses a well-documented bowhead whale feeding area (Moore and Reeves 1993; Mocklin et al. 2011; Shelden et al. 2017) that has been linked to upwelling-favorable winds and the formation of a "krill trap" (Ashjian et al. 2010). In 2018, surveys were conducted in this area on 18 days, and bowhead whales were observed on 15 of the days that surveys were conducted. To limit data biases, surveys were not preferentially conducted on days with a higher likelihood of seeing bowhead whales, based on recent wind conditions. Of the 334 bowhead whales that were observed between Cape Halkett and Point Barrow, 20% ($n_i = 67$) were recorded as feeding or milling. Bowhead whales were observed feeding on 7 of the 15 days (Figure 16). Several of the feeding whales were 65-80 km offshore, in Barrow Canyon. Only one large group ($n_i = 30$) was observed; all other feeding groups were small (<5 whales per group).

BOWHEAD WHALE CENTRAL TENDENCY – ANALYSIS 1

Distribution of Bowhead Whales, Summer 2018, Relative to Summer Bowhead Whale Distribution 2012-2017

Bowhead whale distribution in the western Beaufort Sea in summer (July-August) 2018, based on sightings from primary and secondary observers in all survey modes, was different from the distribution of bowhead whales observed in summer in previous years having moderate to heavy sea ice cover (i.e., 1983-85, 1991-92) (Figure 17). In previous years, distribution was limited to mainly east of Kaktovik, despite suitable survey effort throughout the study area, while distribution in 2018 was scattered throughout the western Beaufort Sea with almost no sightings east of Kaktovik. There are insufficient on-effort sighting data to test for central tendency from the 1980s and early 1990s; therefore, the distribution of bowhead whales in summer 2018 was compared to that of summer 2012-2017, even though those years are considered light ice years (Figure 18).

In the East region, mean depth at sightings made on effort by primary observers in summer 2018 was 552 m (SD = 909.4 m, range 35-2,902 m) and median depth was 53 m (Table 7). In the



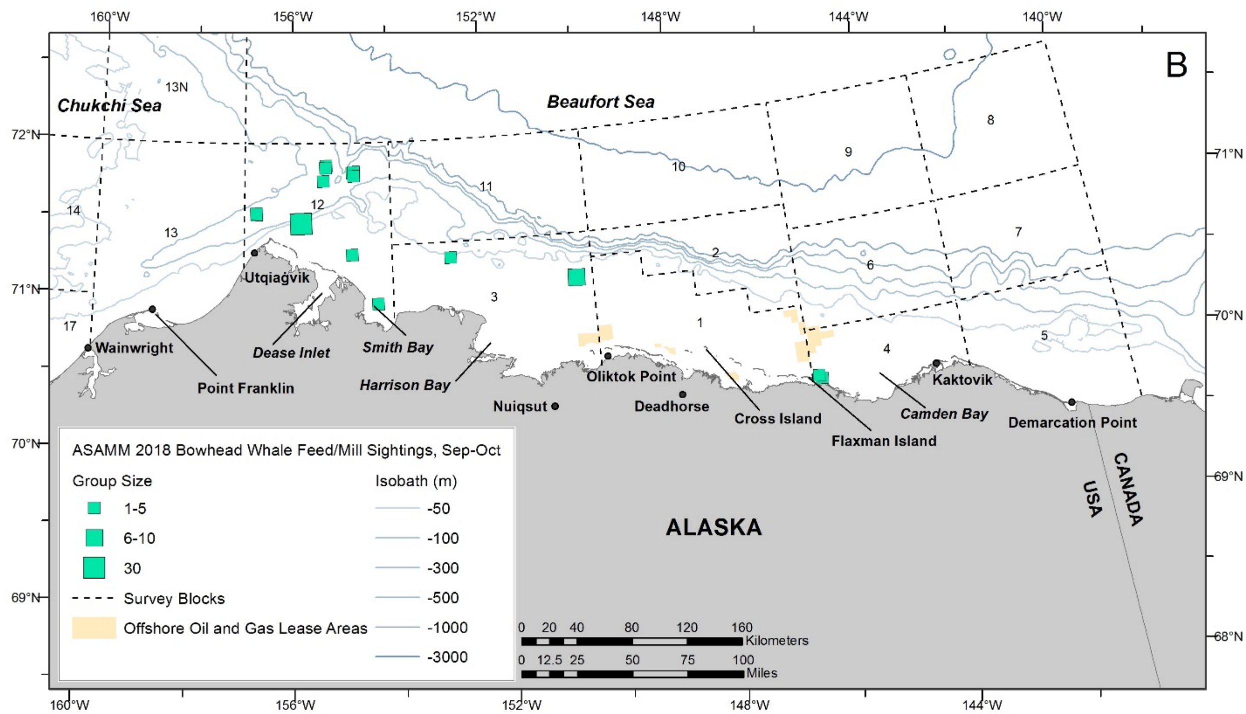
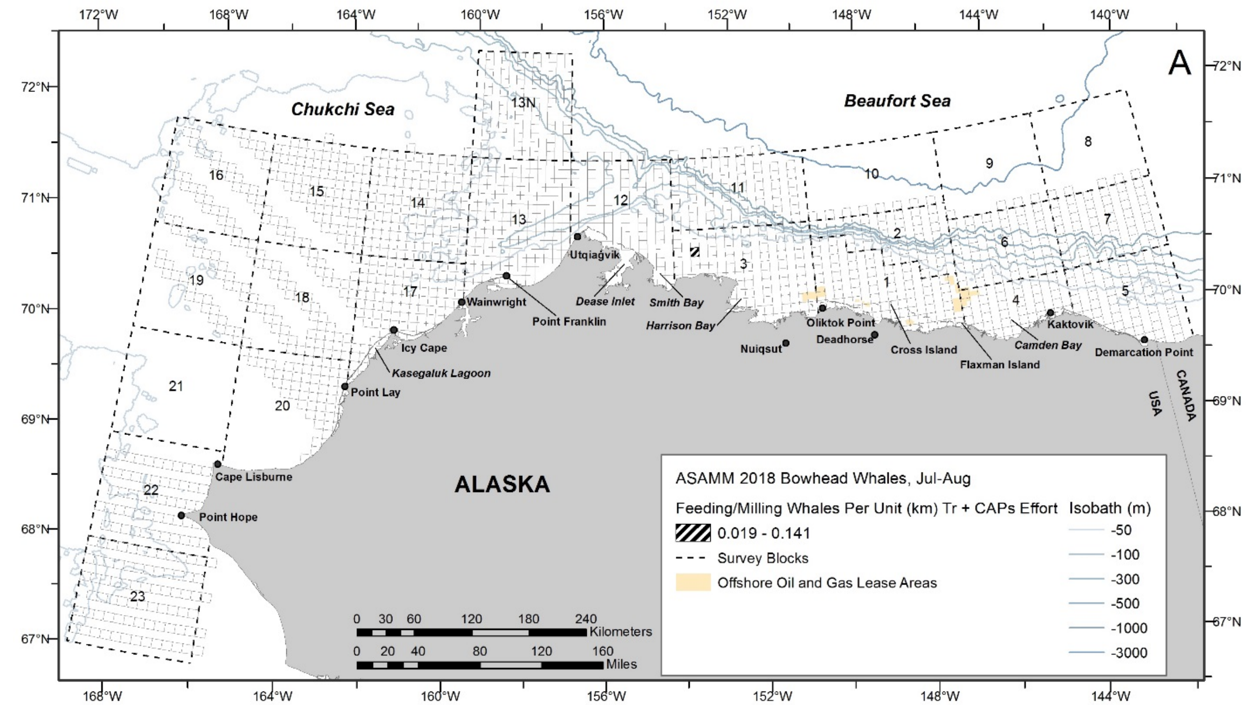


Figure 14. ASAMM 2018 bowhead whale seasonal feeding and milling sightings, transect, CAPs, search, and circling survey modes. A: summer (July-August). B: fall (September-October).



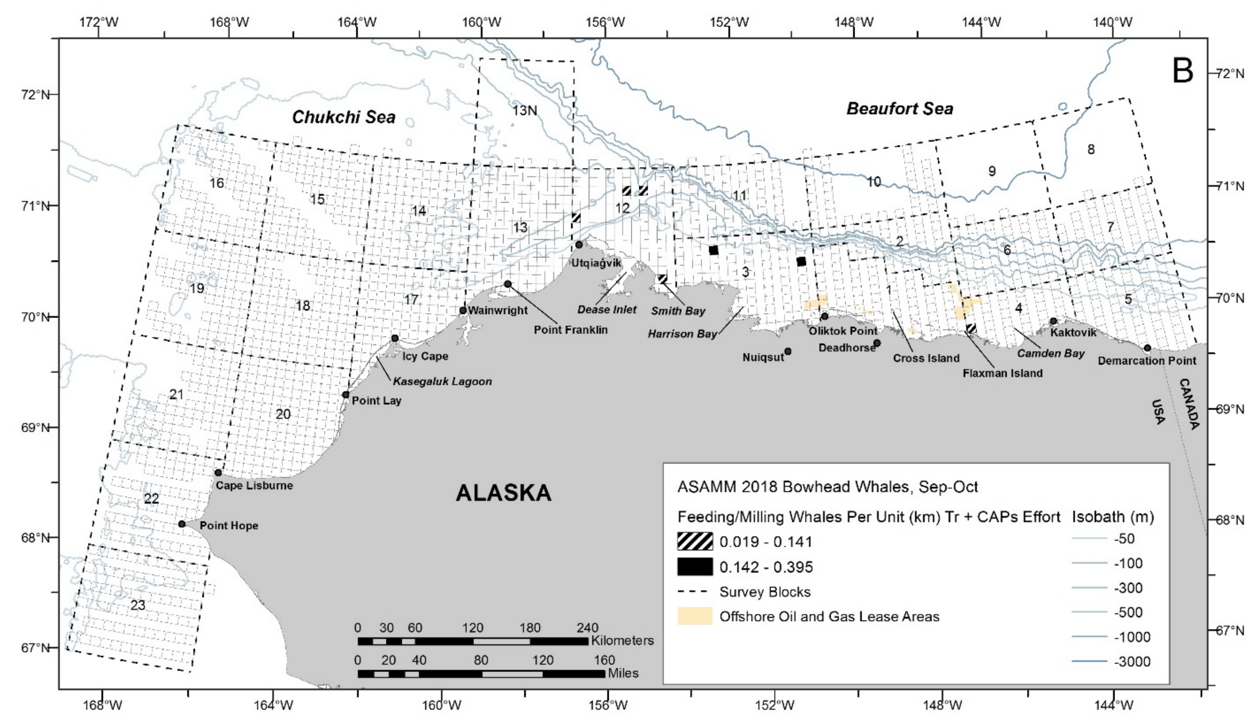


Figure 15. ASAMM 2018 bowhead whale on-effort seasonal feeding and milling sighting rates (WPUE; sightings from primary observers only). A: summer (July-August pooled). B: fall (September-October pooled). Empty cells indicate sighting rates of zero. Transect and CAPs survey effort were not conducted in areas without cell outlines.

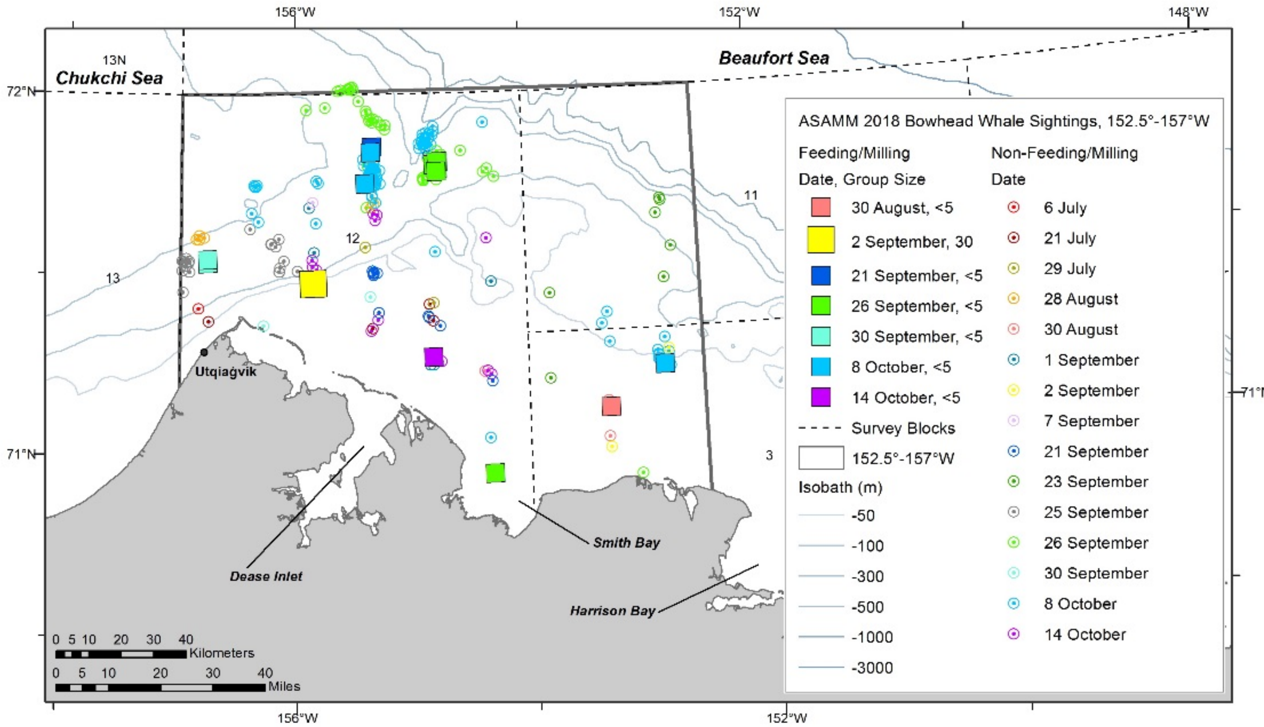


Figure 16. ASAMM 2018 bowhead whale sightings by date and group size, 152.5°W-157°W, transect, CAPs, search, and circling survey modes, July-October.

West region, mean depth was 84 m (SD = 143.4 m, range 12-691 m) and median depth was 35 m.

In the East region, mean and median distances to the normalized shoreline from bowhead whale sightings made on effort by primary observers in summer 2018 were 56.3 km (SD = 24.6 km) and 54.6 km, respectively (Table 7). In the West region, mean and median distances to the normalized shoreline were 39.0 km (SD = 18.3 km) and 34.4 km, respectively.

To evaluate whether significant displacements occurred in western Beaufort Sea bowhead whale HUAs during summer 2018, estimates of median depth at sightings and distance of sightings from the normalized shoreline were compared with pooled data from previous summers. Survey effort during summer in the western Beaufort Sea prior to 2012 was sporadic and inconsistent, so testing for differences was limited to sightings in summer 2012-2017 and 2018.

A Mann-Whitney *U*-test of significant difference of medians indicated that bowhead whales sighted on effort by primary observers in summer 2018 in the East region were significantly farther from shore (median distance from shore = 54.6 km; Z = 2.322, P = 0.0202) than bowhead whales sighted in 2012-2017 (median distance from shore = 29.9 km) (Table 7); there was no significant difference in median depths between 2018 (53 m depth) and 2012-2017 (43 m). In the West region, bowhead whales in 2018 were in significantly deeper water (median depth = 35 m; Z = -2.533, P = 0.0113) than bowhead whales sighting in 2012-2017 (median depth = 22 m);

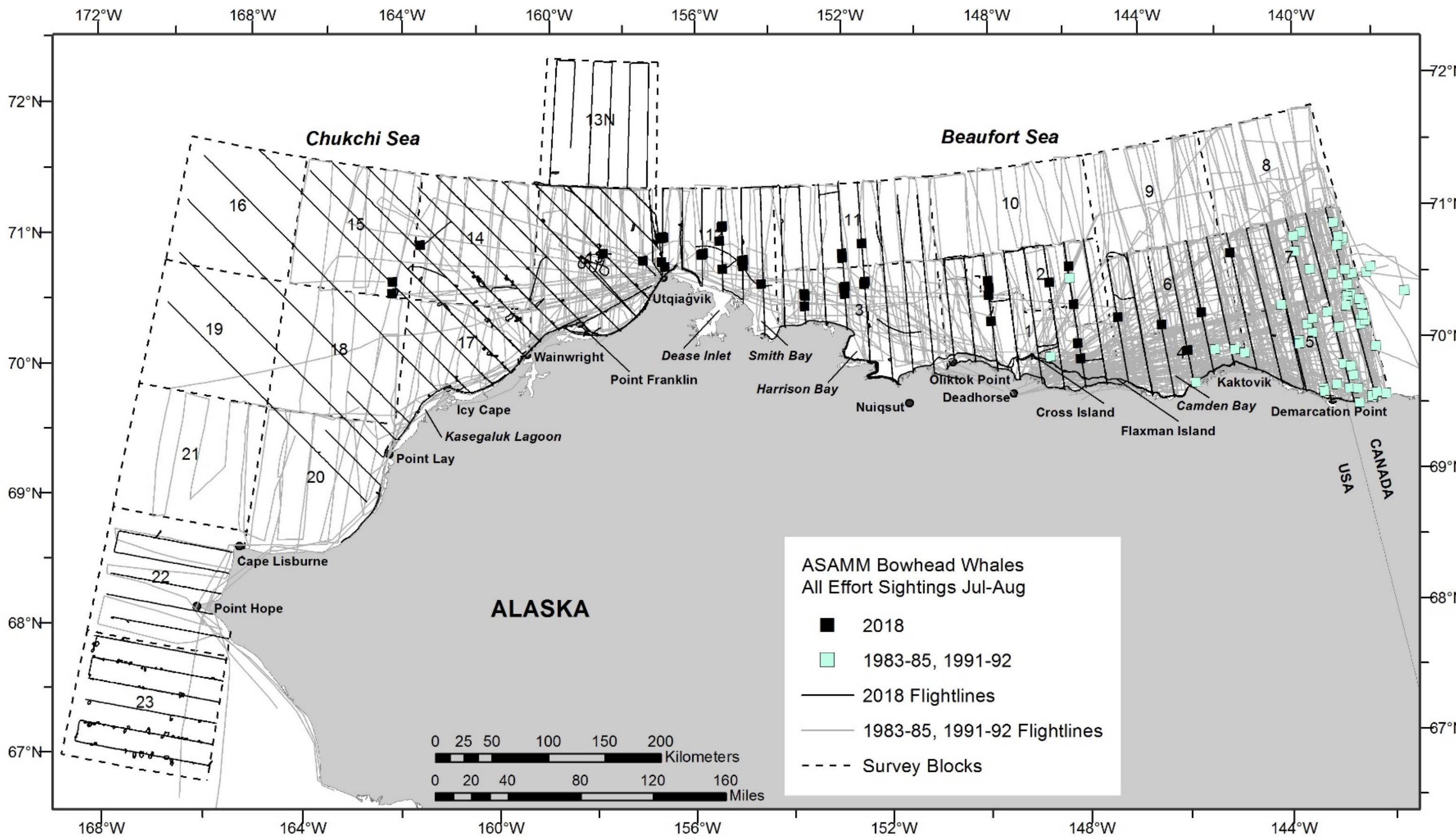


Figure 17. ASAMM bowhead whale sightings, summer (July-August), all survey modes, in years with moderate to heavy sea ice cover: 1983-1985, 1991-1992, and 2018. Includes all sightings from primary and secondary observers.

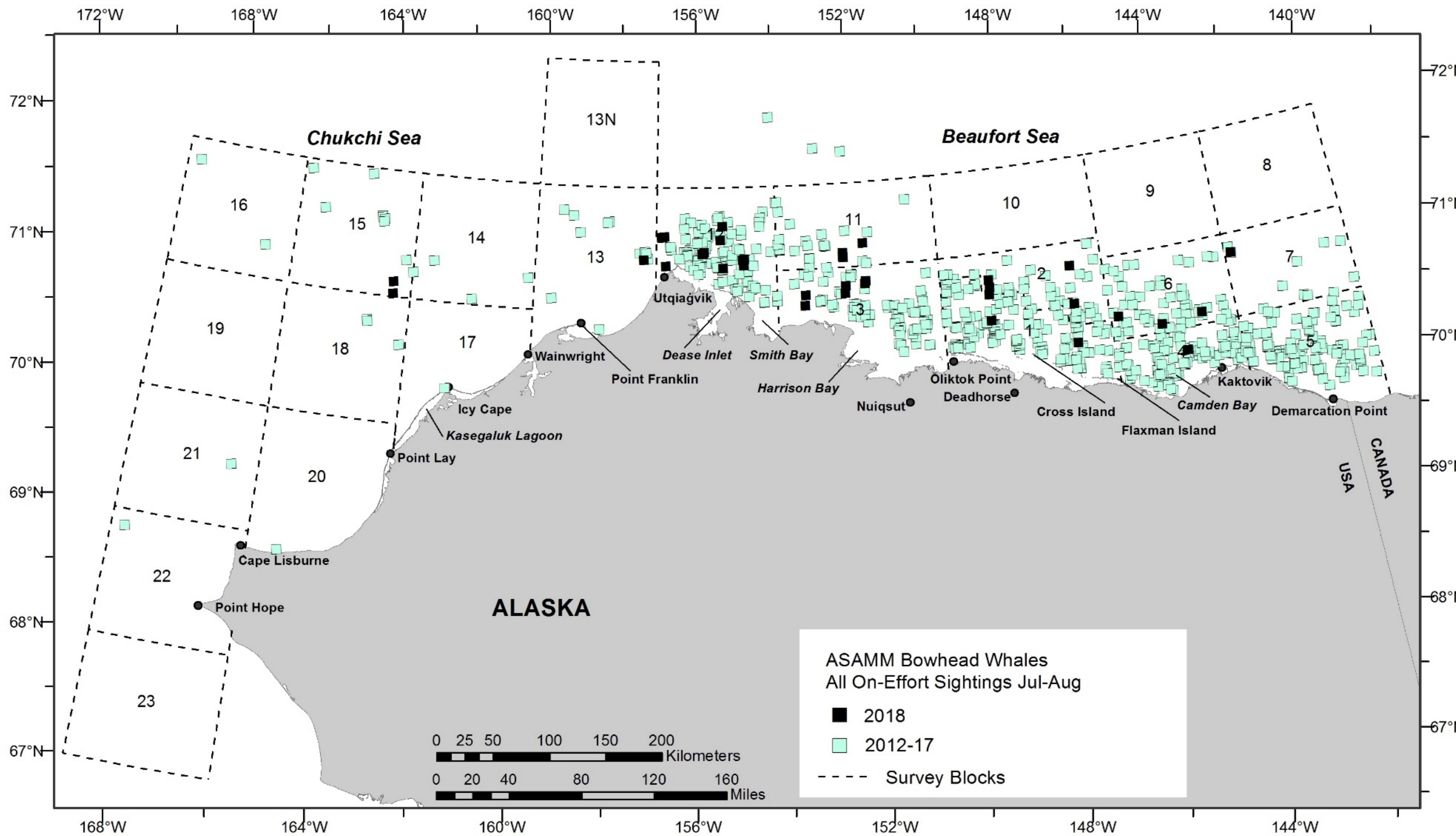


Figure 18. ASAMM bowhead whale on-effort sightings, summer (July-August) 2012-2017 (light ice years) and summer (July-August) 2018 (heavy ice year). Includes sightings from primary observers.

Table 7. ASAMM central tendency statistics for depth (m) and distance from shore (km) at bowhead whale on-effort sightings, by season and region in the western Beaufort Sea, 2012-2018. Si = number of on-effort sightings made by primary observers.

2012-2018 Summer, by Region			**DEPTH (M)**				**DISTANCE FROM SHORE (KM)**			
Year/Season	**Region**	**Si**	**Median**	**Mean**	**SD**	**Min-Max**	**Median**	**Mean**	**SD**	**Min-Max**
2018 Summer	East	8	53	552	909.4	35-2,092	54.6	56.3	24.6	25-96
2012-17 Summer	East	365	43	160	385.9	6-2,461	29.9	37.0	25.5	1-134
2018 Summer	West	23	35	84	143.4	12-691	34.4	39.0	18.3	13-75
2012-17 Summer	West	267	22	61	198.4	6-2,614	30.1	34.0	21.2	1-124
2012-2018 Summer, by Month			**DEPTH (M)**				**DISTANCE FROM SHORE (KM)**			
Year/Season	**Month**	**Si**	**Median**	**Mean**	**SD**	**Min-Max**	**Median**	**Mean**	**SD**	**Min-Max**
2018 Summer	Jul	20	46	287	612.0	18-2,092	52.5	47.4	23.8	16-96
2018 Summer	Aug	11	39	55	65.7	12-249	34.4	36.4	13.4	13-55
2012-2017 Summer	Jul	116	85	352	560.0	9-2,614	54.5	54.5	26.7	5-124
2012-2017 Summer	Aug	516	33	66	208.6	6-2,461	26.5	31.4	20.9	1-134
2018 Season, by Region			**DEPTH (M)**				**DISTANCE FROM SHORE (KM)**			
Season	**Region**	**Si**	**Median**	**Mean**	**SD**	**Min-Max**	**Median**	**Mean**	**SD**	**Min-Max**
Summer	East	8	53	552	909.4	35-2,092	54.6	56.3	24.6	25-96
Fall	East	67	31	31	12.3	5-52	16.8	19.1	10.9	2-49
Summer	West	23	35	84	143.4	12-691	34.4	39.0	18.3	13-75
Fall	West	144	90.5	112	92.4	3-341	47.6	46.1	22.6	2-88

there was no significant difference in median distance from shore between 2018 (34.4 km) and 2012-2017 (30.1 km) (Table 7).

Distribution of Bowhead Whales During Summer and Fall Months, 2018

Summary statistics for bowhead whale data from the western Beaufort Sea in summer (July-August) 2018 were compared to values for fall (September-October) 2018 (Table 7). In the East region, bowhead whales sighted on effort in summer were in significantly deeper water (median depth 53 m vs 31 m, $Z = -3.716$, $P = 0.0002$) and significantly farther from shore (median distance 54.6 km vs 16.8 km, $Z = 3.990$, $P < 0.0001$) than bowhead whales sighted on effort in fall. In the West region, median depth and distance from shore were not significantly different for bowhead whales sighted on effort in summer (median depth 35 m, median distance 34.4 km) and fall (median depth 90.5 m, median distance 47.6 km). This is similar to what was observed in 2016, when bowhead whales were in shallower waters and closer to shore in summer in the west region (Clarke et al. 2017b), and the opposite of observations in 2012-2015 and 2017 when bowhead whales were consistently seen in deeper waters and farther from shore in summer compared to fall (Clarke et al. 2018a).

Distribution of Bowhead Whales, Fall 2018, Relative to Bowhead Whale Distribution in Previous Years with Light Sea Ice Cover

Bowhead whale distribution in the western Beaufort Sea in September-October 2018, based on on-effort sightings from primary and secondary observers, shared similarities with the distribution of on-effort sightings observed in fall in previous years having light sea ice cover (i.e., 1982, 1986, 1987, 1989, 1990, 1993-2017) (Figure 19).

Summary statistics for bowhead whale data from the western Beaufort Sea in fall (September-October) 1989-2018 are shown in Table 8. Summary statistics are from sightings made by primary observers only. Limiting sightings for this analysis to only primary observers results in the exclusion of greater than 800 sightings and provides tighter data constraints resulting in a more robust analysis.

In the East region, mean depth at bowhead whale sightings made on effort by primary observers in fall 2018 was 31 m (SD = 12.3 m, range 2-52 m) and median depth was 31 m (Table 8). In the West region, mean depth was 113 m (SD = 92.4 m, range 3-341 m) and median depth was 90.5 m. In the East region, mean and median distances to the normalized shoreline from bowhead whale sightings made on effort by primary observers in September-October 2018 were 19.1 km (SD = 10.9 km) and 16.8 km, respectively (Table 8). In the West region, mean and median distances to the normalized shoreline were 46.1 km (SD = 22.6 km) and 47.6 km, respectively.

To evaluate whether significant displacements occurred in western Beaufort Sea bowhead whale HUAs during fall 2018 compared to previous years with light sea ice cover, estimates of median depth at sighting and distance of sightings from the normalized shoreline were compared with pooled data from previous years.

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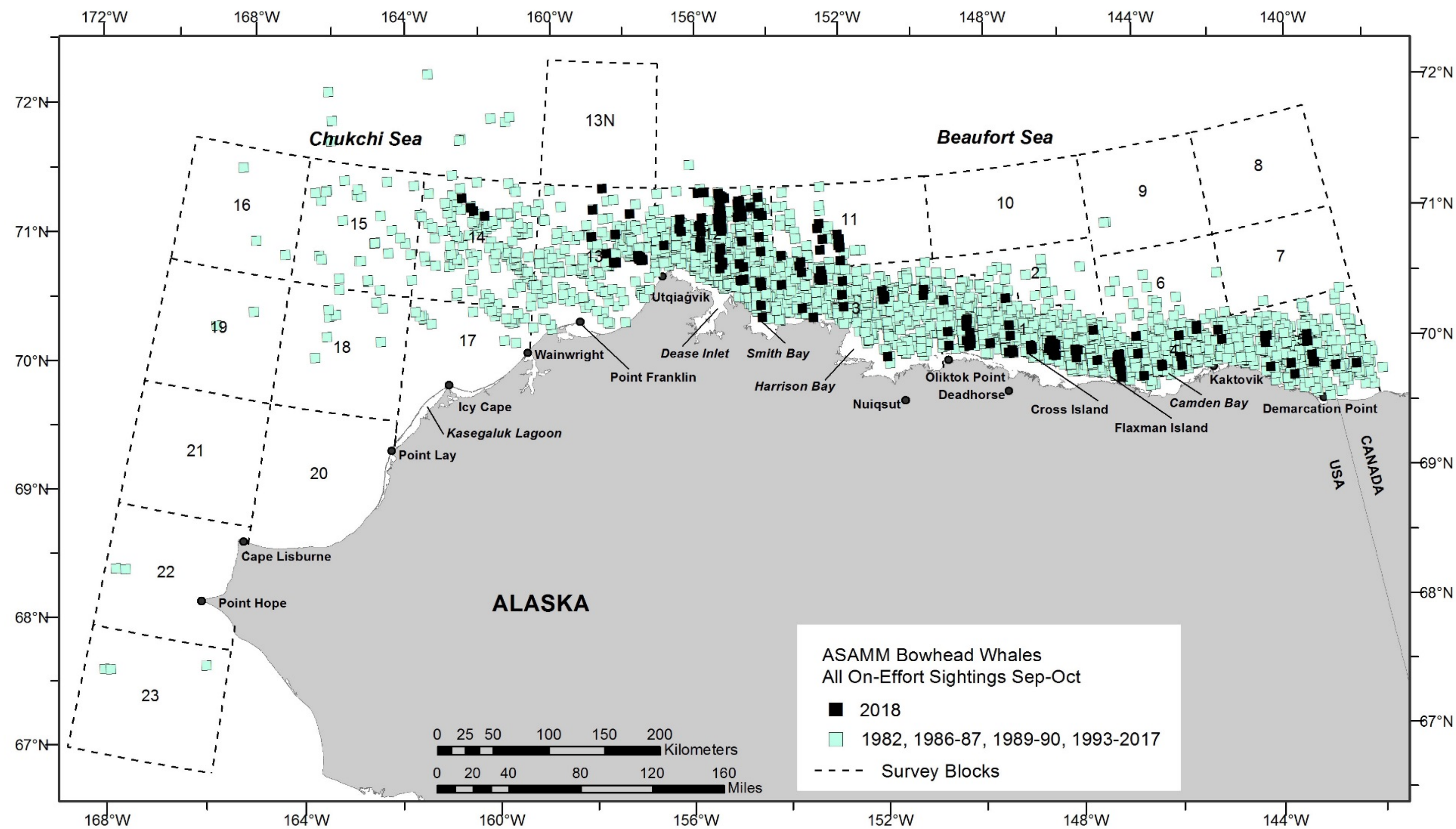


Figure 19. ASAMM bowhead whale sightings, fall (September-October), in years with light sea ice cover: 1982, 1986-1987, 1989-1990, 1993-2017, and 2018. Includes all on-effort sightings from primary and secondary observers.

Table 8. ASAMM central tendency statistics for depth (m) and distance from shore (km) at bowhead whale on-effort sightings in fall (September-October), by year and region in the western Beaufort Sea, 1989-2018. Si = number of on-effort sightings made by primary observers.

			DEPTH (M)				DISTANCE FROM SHORE (KM)			
Year	**Region**	**Si**	**Median**	**Mean**	**SD**	**Min-Max**	**Median**	**Mean**	**SD**	**Min-Max**
1989	East	1	48	48			43.8	43.8		
	West	6	16	16	6.4	7-24	17.7	18.6	13.6	4-35
1990	East	35	45	45	9.8	25-72	32.2	30.8	11.1	11-53
	West	6	32.5	33	11.6	20-50	30.8	34.2	11.7	24-54
1991	East	6	119.5	120	71.8	44-228	60.3	55.6	14.7	36-72
	West	1	383	383			72.8	72.8		
1992	East	6	47.5	48	7.7	40-59	28.9	30.7	5.6	24-40
	West	6	57	66	20.4	52-106	53.1	52.5	6.7	43-63
1993	East	35	40	57	96.7	11-610	25.5	25.8	11.8	6-64
	West	23	20	22	8.9	12-49	24.3	25.6	11.9	11-61
1994	East	17	45	46	9.1	33-64	27.9	33.1	16.7	11-66
	West	2	12.5	13	0.7	12-13	15.0	15.0	6.0	11-19
1995	East	57	43	54	76.1	13-604	27.2	29.8	16.0	3-97
	West	22	30	89	272.5	6-1,308	33.9	35.7	18.9	10-102
1996	East	6	40	41	4.4	34-46	27.7	26.5	6.4	19-33
	West	4	33.5	31	7.6	20-37	37.6	33.5	9.3	20-39
1997	East	15	21	21	7.1	13-33	7.7	9.7	6.7	4-24
	West	65	19	25	19.2	5-100	21.9	24.8	11.0	7-52
1998	East	70	31.5	33	10.7	13-56	17.0	19.5	11.4	2-49
	West	71	16	48	235.4	7-2,001	17.1	22.7	18.0	3-118
1999	East	58	50	49	14.3	7-83	34.4	33.3	12.3	4-57
	West	43	29	41	41.9	10-211	29.6	31.9	16.8	6-73
2000	East	19	39	46	18.0	28-101	31.7	31.8	11.1	14-55
	West	15	11	24	42.0	5-173	7.7	15.8	19.0	1-73
2001	East	13	46	44	9.1	28-53	31.8	27.9	10.7	12-41
	West	2	42	42	43.8	11-73	29.6	39.6	43.5	9-70
2002	East	9	25	25	14.3	3-48	8.5	15.1	18.2	0-58
	West	20	24.5	30	20.6	11-88	31.2	33.9	12.6	9-56
2003	East	17	36	35	16.0	12-72	28.4	24.4	16.6	3-46
	West	29	20	50	67.3	12-310	27.2	28.9	15.7	2-72
2004	East	53	40	44	42.5	7-337	21.5	23.4	12.0	5-71
	West	47	24	34	36.5	5-206	22.7	23.6	10.6	5-65
2005	East	16	40.5	39	13.0	13-61	21.5	23.0	13.0	5-40
	West	17	33	60	66.3	12-227	37.3	34.6	16.0	6-55
2006	East	29	44	215	524.2	9-1,966	28.0	34.7	22.5	2-89
	West	28	37.5	45	36.2	4-175	37.0	35.7	18.9	1-67

			DEPTH (M)				DISTANCE FROM SHORE (KM)			
Year	Region	Si	Median	Mean	SD	Min-Max	Median	Mean	SD	Min-Max
2007	East	46	33.5	43	50.3	17-362	20.7	22.9	13.6	5-69
	West	6	23	24	8.6	13-36	24.0	25.2	6.2	18-33
2008	East	24	32	32	6.0	20-43	18.6	20.5	9.6	7-36
	West	32	16.5	18	6.4	7-40	18.1	19.1	10.2	4-52
2009	East	9	21	29	19.4	11-55	6.3	19.9	22.4	3-58
	West	42	17	30	43.6	8-239	16.7	21.7	16.1	4-81
2010	East	43	30	30	11.1	13-49	11.9	14.2	7.7	3-29
	West	25	20	32	34.2	10-189	20.6	26.3	14.8	3-76
2011	East	12	27	31	8.9	22-50	10.7	13.7	6.8	7-27
	West	28	20	26	23.1	15-141	25.5	26.8	10.4	16-64
2012	East	25	35	51	48.8	11-213	24.9	28.5	19.8	6-76
	West	58	29	51	92.5	11-648	31.0	36.4	18.9	8-76
2013	East	20	35.5	36	6.7	24-54	24.7	25.9	10.8	9-45
	West	37	26	72	75.5	6-258	27.7	37.6	25.8	3-87
2014	East	49	20	24	19.1	5-124	7.2	13.9	12.9	1-56
	West	77	19	36	50.4	5-220	22.2	28.6	23.0	2-84
2015	East	24	44.5	87	107.8	6-418	29.2	37.7	25.4	6-85
	West	112	18	19	17.0	5-173	19.5	21.7	13.5	4-69
2016	East	63	36	40	44.4	5-372	19.5	21.3	12.0	4-60
	West	118	44	59	52.4	8-227	46.5	46.6	19.9	9-90
2017	East	86	27.5	27	10.5	6-67	15	15.8	9.9	1-43
	West	91	17	26	39.0	7-239	16.1	18.1	10.0	4-49
2018	East	67	31	31	12.3	5-52	16.8	19.1	10.9	2-49
	West	144	90.5	113	92.4	3-341	47.6	46.1	22.6	2-88

In fall (September-October) 2018 in the East region, bowhead whale sightings were in significantly shallower water (median depth 31 m vs. 36 m, Z = -2.996, P = 0.0027) and closer to shore (median distance from shore 16.8 km vs. 21.3 km, Z = 2.221, P = 0.0264) than in previous years with light sea ice cover. Bowhead whale sightings in the West region in fall 2018 were in significantly deeper water (median depth 90.5 m vs. 20 m, Z = 9.975, P < 0.0001) and farther from shore (median distance from shore 47.6 km vs. 23.8 km, Z = -8.621, P < 0.0001) than in previous years with light sea ice cover.

Distribution of Bowhead Whales, Fall 2018, Relative to Bowhead Whale Distribution in Previous Years with Moderate to Heavy Sea Ice Cover

Sea ice cover in the western Beaufort Sea was not uniformly light throughout fall 2018. In early September and mid-October, sea ice cover was moderate to heavy (Figures A-6, A-9, A-10), so median distance from shore and depths for bowhead whale sightings in fall 2018 were also compared with analogous values for combined data from previous years with moderate to heavy sea ice cover (1991-1992) (Treacy 1992, 1993).

In fall (September-October) 2018 in the East region, bowhead whale sightings were in significantly shallower water (median depth 31 m vs. 53 m, Z = 4.672, P < 0.0001) and nearer to shore (median distance from shore 16.8 km vs. 37.6 km, Z = 4.309, P < 0.0001) than in fall 1991-1992 when sea ice cover was moderate to heavy. In the West region, bowhead whales were in deeper water and farther from shore in fall 2018 (depth = 90.5 m; distance from shore = 46.1 km) compared to fall 1991-1992 (depth = 58 m; distance from shore = 54.8 km), but the differences were not significant (depth Z = 0.367, P = 0.7134; distance from shore Z = 0.889, P = 0.374).

BOWHEAD WHALE CENTRAL TENDENCY – ANALYSIS 2

The 2018 spatial relative abundance model for fall (September-October) incorporated 216 bowhead whale sightings of 286 total individuals (Figure 20A). Relative abundance predictions resulting from the spatial model applied to the 2018 survey data for the western Beaufort Sea are shown in Figure 20B. The area of highest predicted relative abundance was located just outside the barrier islands between approximately 145°W and 149°W, north of Deadhorse. High predicted relative abundance was also evident offshore of the 50-m isobath, from 152°W to 156°W, including part of Barrow Canyon.

The 2000-2018 model (July-October) incorporated 2,345 bowhead whale sightings of 4,230 individuals. In July, there were 137 bowhead whale sightings (233 individuals) (Figure 21A), all of which were sighted from 2012 to 2018. The majority of the July sightings were located in the East region. Limited sample size in the West region provided minimal information for the spatial model in July (Figure 21B). The spatial model predicted that bowhead whale HUAs were located farthest offshore in July, with the highest relative abundance over the outer continental shelf, approximately 45-90 km offshore, from ~140°W to ~142.5°W.

There were a total of 552 bowhead whale sightings (1,076 individuals) in August (Figure 21C), most of which were from 2012 to 2018. The spatial model predicted that bowhead whale HUAs were closest to shore from 142° to 144°W, north of Kaktovik (Figure 21D). Three distinct areas had the highest predicted relative abundance in August: an area centered on Kaktovik, 90 km long and extending up to 30 km offshore; north of Nuiqsut, 15-60 km offshore; and north of Dease Inlet, from the barrier islands to 30 km offshore.

The model incorporated 1,223 bowhead whale sightings (2,150 individuals) in September (Figure 21E) and 433 sightings (771 individuals) in October (Figure 21G). In September, bowhead whale relative abundance was highest, and HUAs located closest to shore, from Dease Inlet to Smith Bay, and just outside the barrier islands from ~144°W to ~149°W (Figure 21F). In October, the highest predicted abundance was from north of Dease Inlet to ~152.5°W, with relatively high abundance extending to the mouth of Barrow Canyon and nearshore northwest of Cape Halkett, and patches of high relative abundance outside the barrier islands from ~146°W to ~148.5°W (Figure 21H). The HUA was farther offshore between Cape Halkett and Utqiaġvik in October than in September.

The estimated median distance-from-shore statistics for fall 2018 that were derived using the spatial model were 23.8 km for the East region and 48.0 km for the West region (Table 9). The model-derived results were 7.0 km farther from shore in the East region and 0.4 km farther from shore in the West region compared to the results from the analysis of bowhead whale sightings that were unadjusted for transect effort or group size (median values of 16.8 km and 47.6 km, respectively; Table 8).

The estimated median distance-from-shore statistics for the East region in 2000-2018, derived using the spatial model, decreased from 55.7 km in July to 23.7 km in August, 20.2 km in September, and 25.4 km in October (Table 9). In the West region, the 2000-2018 model predicted that the median distance from shore varied from 44.2 km in July to 28.1 km in August, 25.5 km in September, and 31.1 km in October (Table 9).

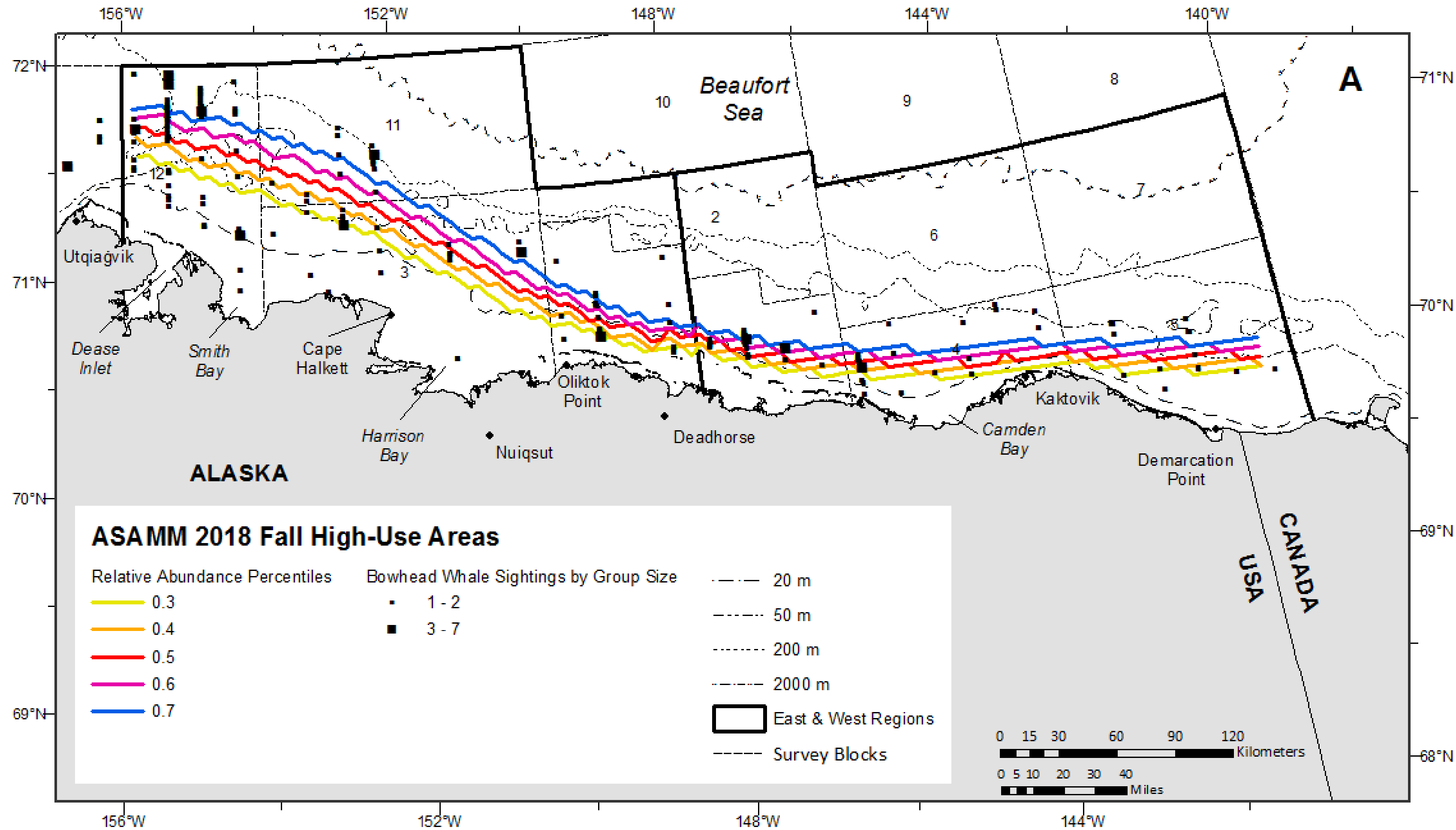


Figure 20. ASAMM fall (September and October) 2018 bowhead whale transect and CAPs passing sightings (primary observers only) by group size and predicted relative abundance, based on a spatial model that accounted for effort by assuming a uniform 5-km of transect and CAPs passing effort in every cell in the western Beaufort Sea. A: Transect and CAPs passing sightings. The bowhead whale high-use area is represented by distribution percentiles (30th, 40th, 50th, 60th, and 70th), which represent the offshore extent of 30%, 40%, 50%, 60%, and 70% of the predicted number of bowhead whales from the spatial model.

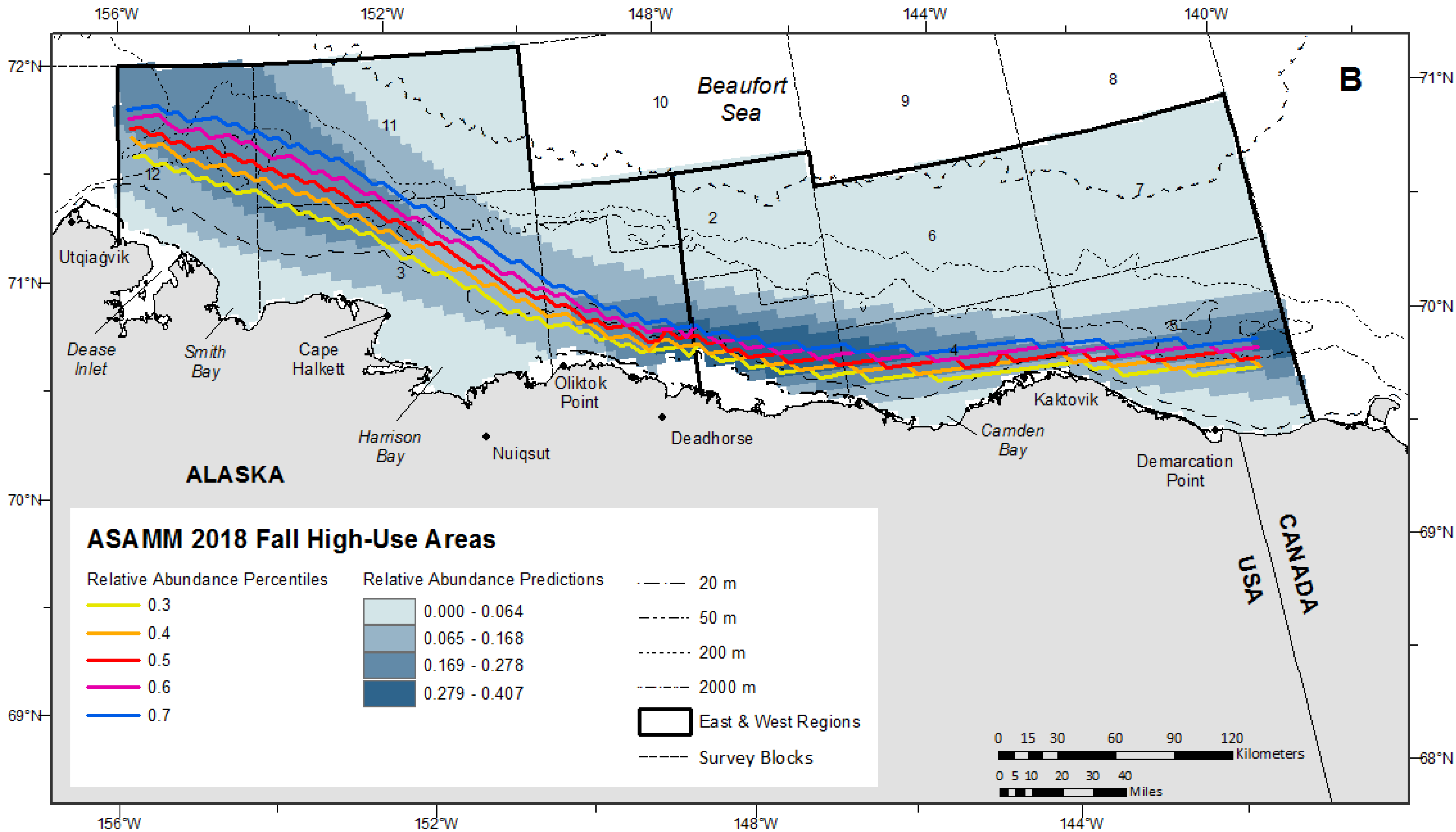


Figure 20 (cont.). ASAMM fall (September and October) 2018 bowhead whale transect and CAPs passing sightings (primary observers only) by group size and predicted relative abundance, based on a spatial model that accounted for effort by assuming a uniform 5-km of transect and CAPs passing effort in every cell in the western Beaufort Sea. B: Predicted relative abundance. The bowhead whale high-use area is represented by distribution percentiles (30th, 40th, 50th, 60th, and 70th), which represent the offshore extent of 30%, 40%, 50%, 60%, and 70% of the predicted number of bowhead whales from the spatial model.

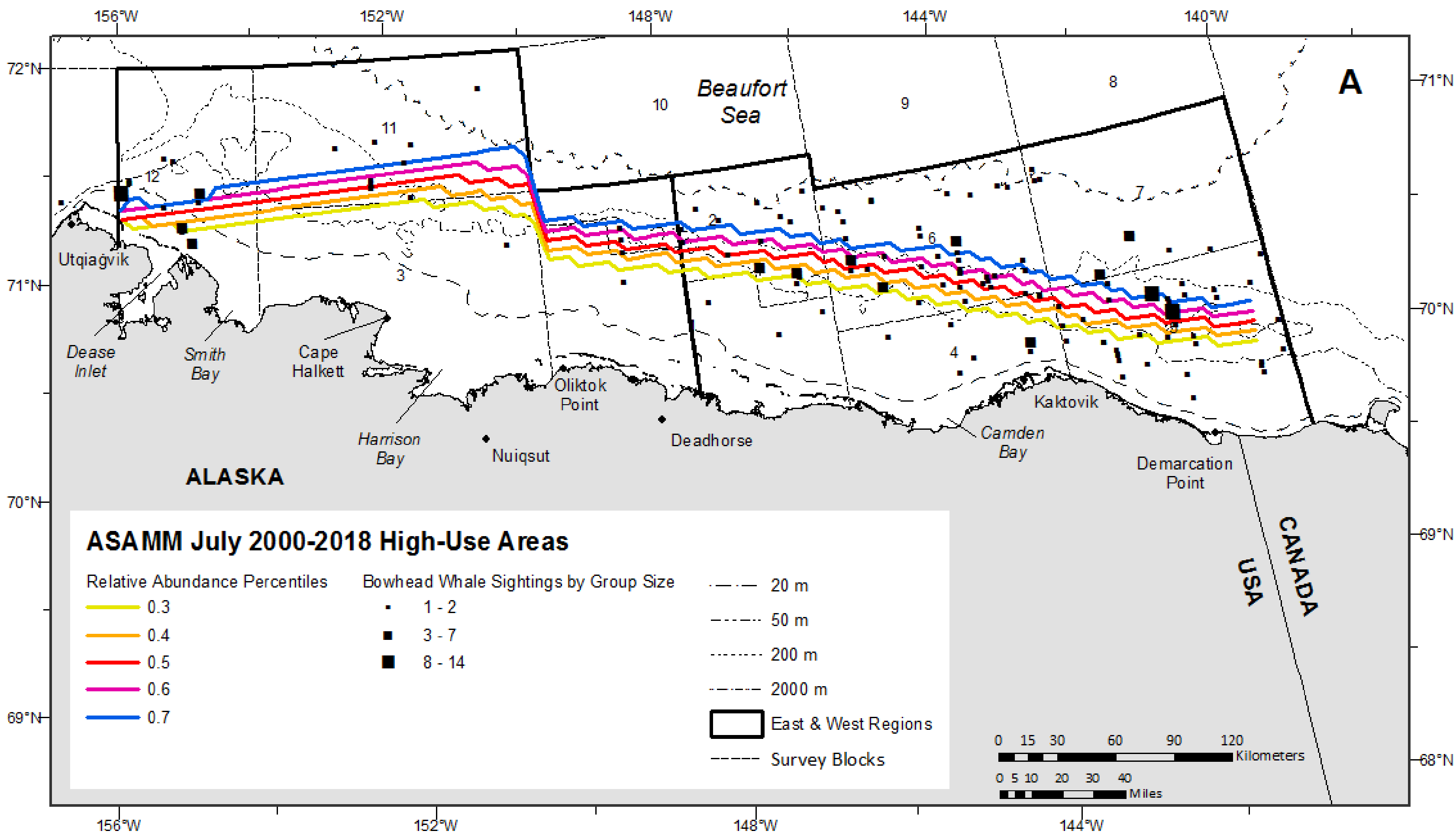


Figure 21. ASAMM 2000-2018 bowhead whale transect and CAPs passing sightings (primary observers only) by group size and predicted relative abundance, based on a spatial relative abundance model that accounted for effort by assuming a uniform 5-km of transect and CAPs passing effort in every cell in the western Beaufort Sea in July, August, September, and October. A: July sightings. The bowhead whale high-use area is represented by distribution percentiles (30th, 40th, 50th, 60th, and 70th), which represent the offshore extent of 30%, 40%, 50%, 60%, and 70% of the predicted number of bowhead whales from the spatial model.

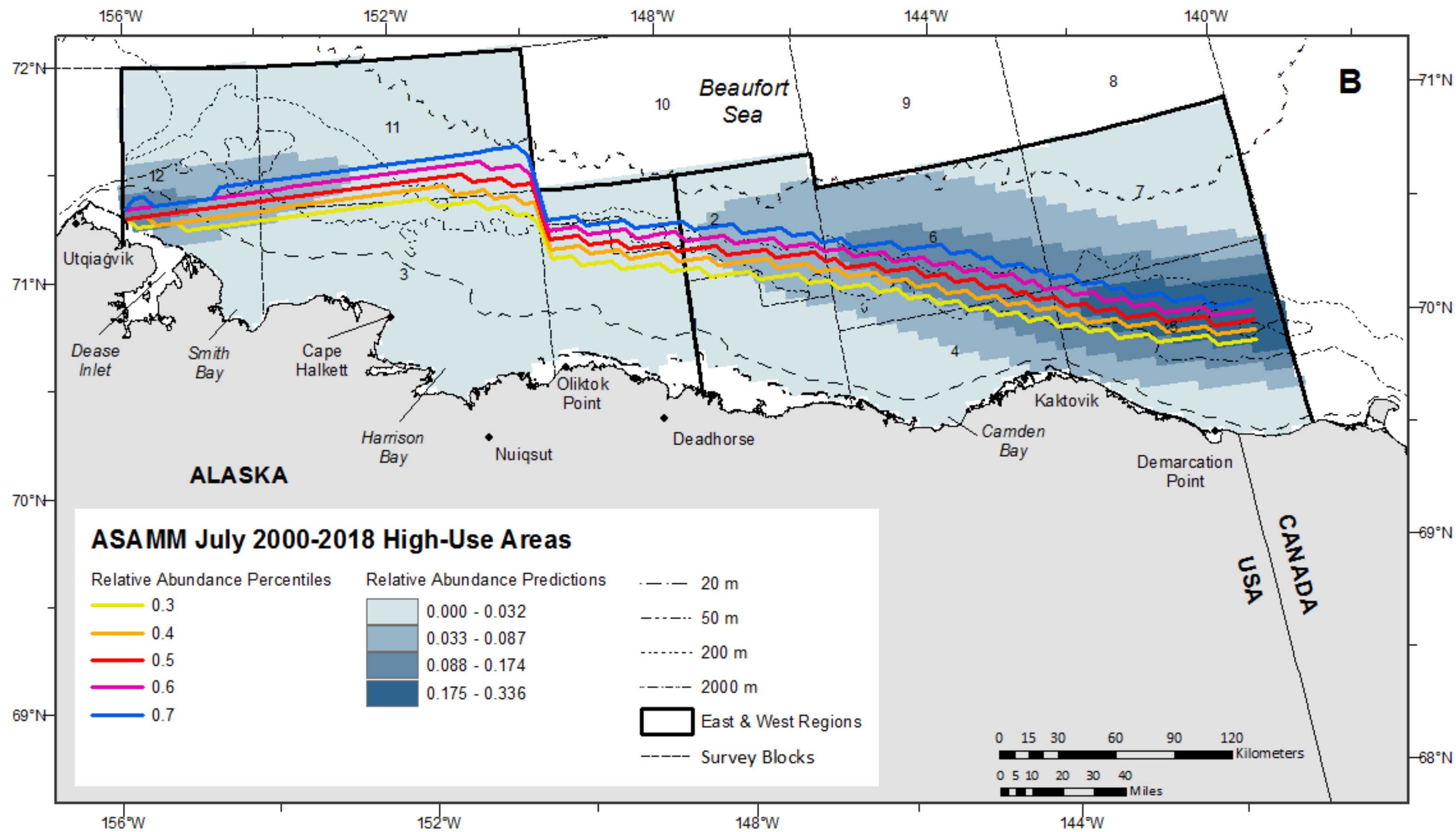


Figure 21 (cont.). ASAMM 2000-2018 bowhead whale transect and CAPs passing sightings (primary observers only) by group size and predicted relative abundance, based on a spatial relative abundance model that accounted for effort by assuming a uniform 5-km of transect and CAPs passing effort in every cell in the western Beaufort Sea in July, August, September, and October. B: July predicted relative abundance. Predictions are not corrected for perception or availability bias. The bowhead whale high-use area is represented by distribution percentiles (30th, 40th, 50th, 60th, and 70th), which represent the offshore extent of 30%, 40%, 50%, 60%, and 70% of the predicted number of bowhead whales from the spatial model.

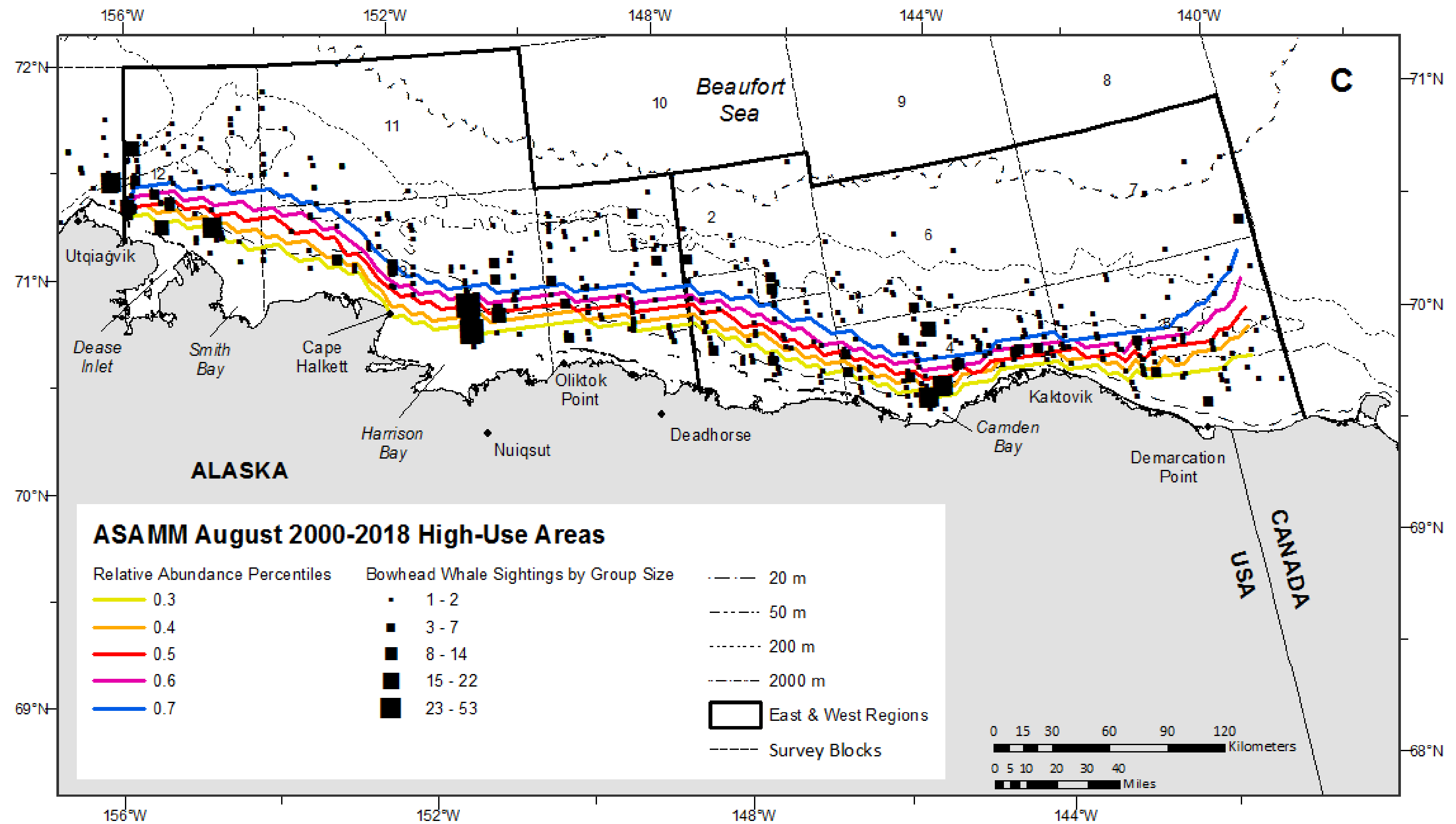


Figure 21 (cont.). ASAMM 2000-2018 bowhead whale transect and CAPs passing sightings (primary observers only) by group size and predicted relative abundance, based on a spatial relative abundance model that accounted for effort by assuming a uniform 5-km of transect and CAPs passing effort in every cell in the western Beaufort Sea in July, August, September, and October. C: August sightings. The bowhead whale high-use area is represented by distribution percentiles (30th, 40th, 50th, 60th, and 70th), which represent the offshore extent of 30%, 40%, 50%, 60%, and 70% of the predicted number of bowhead whales from the spatial model.

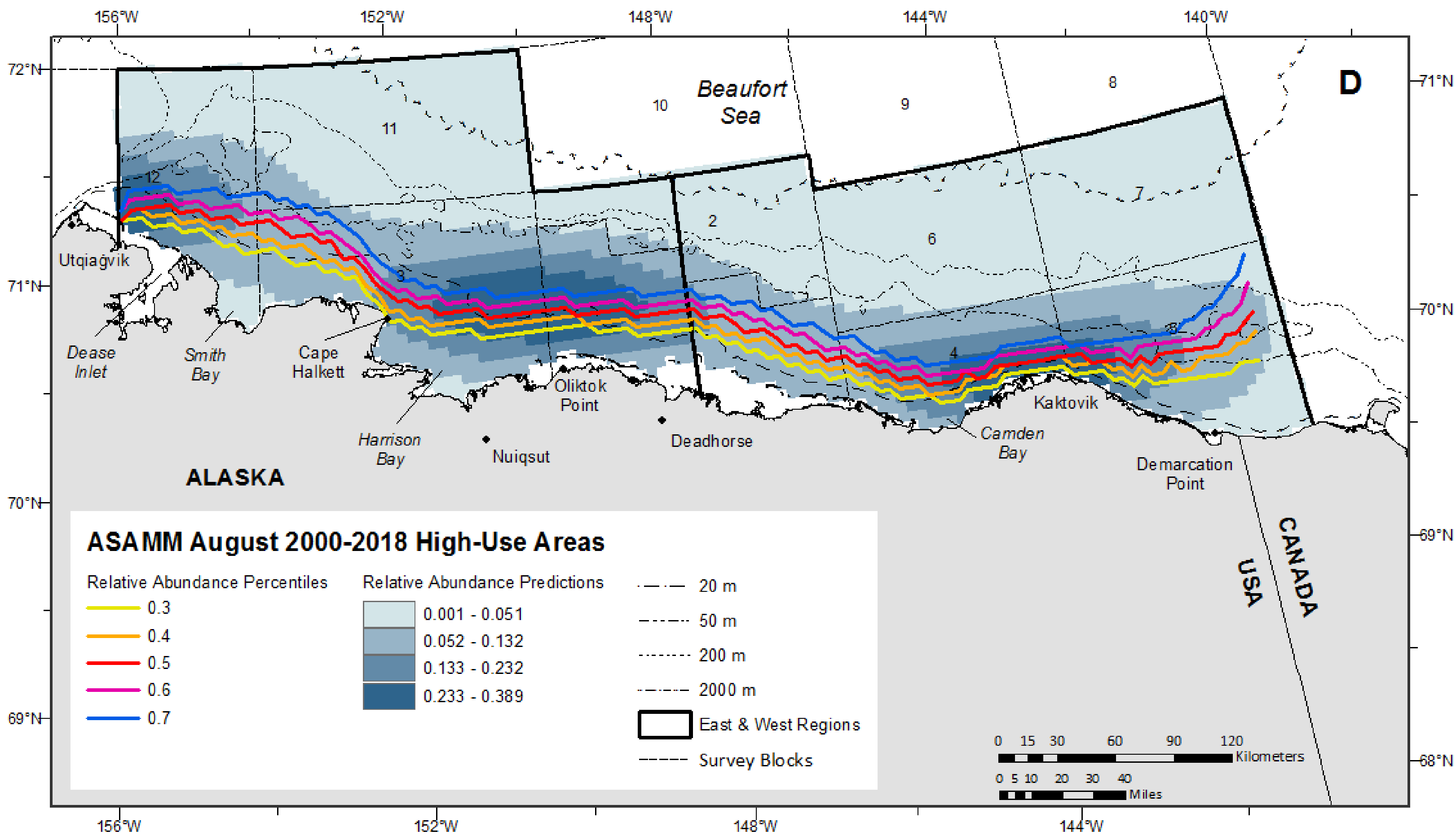


Figure 21 (cont.). ASAMM 2000-2018 bowhead whale transect and CAPs passing sightings (primary observers only) by group size and predicted relative abundance, based on a spatial relative abundance model that accounted for effort by assuming a uniform 5-km of transect and CAPs passing effort in every cell in the western Beaufort Sea in July, August, September, and October. D: August predicted relative abundance. Predictions are not corrected for perception or availability bias. The bowhead whale high-use area is represented by distribution percentiles (30th, 40th, 50th, 60th, and 70th), which represent the offshore extent of 30%, 40%, 50%, 60%, and 70% of the predicted number of bowhead whales from the spatial model.

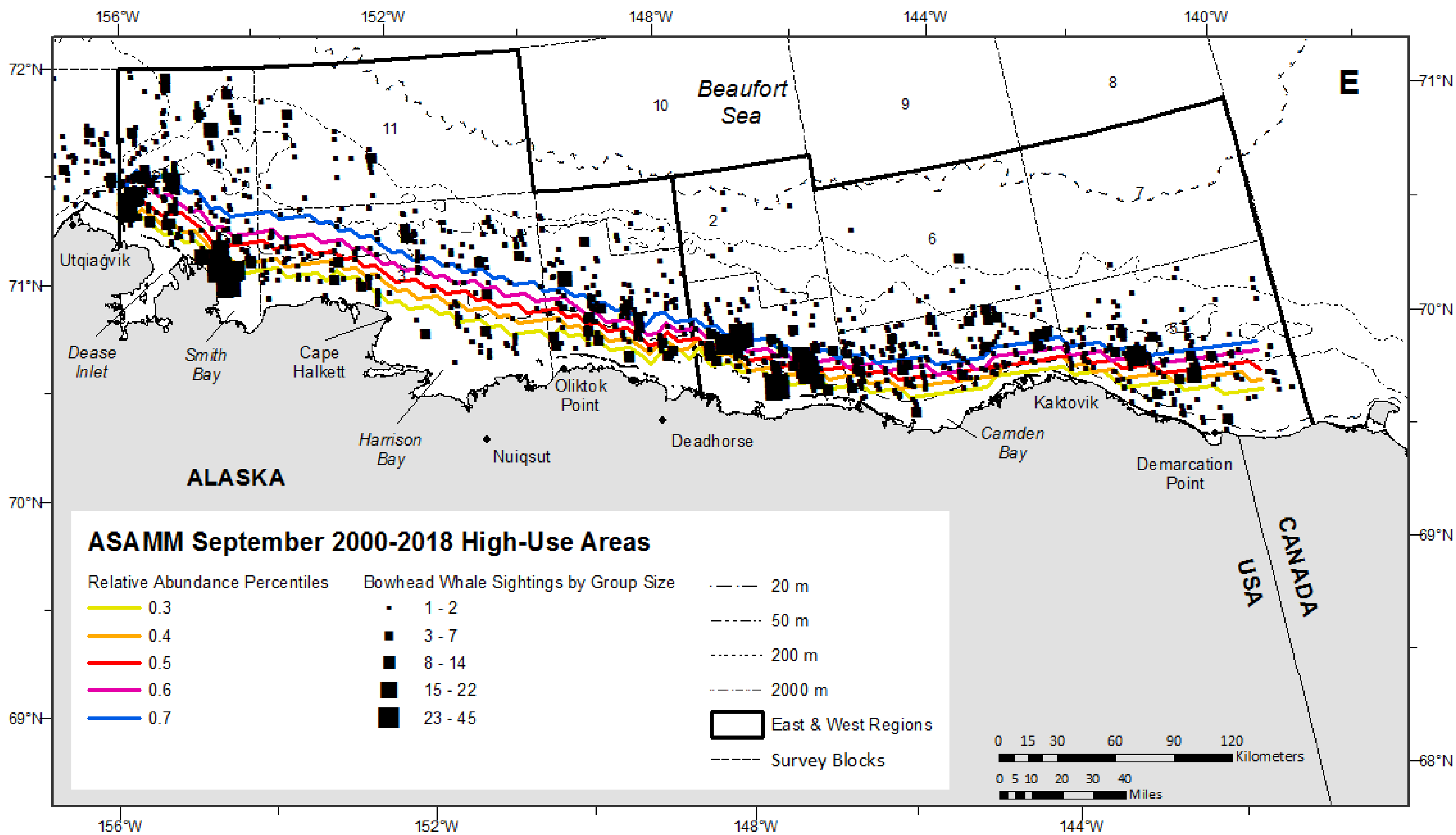


Figure 21 (cont.). ASAMM 2000-2018 bowhead whale transect and CAPs passing sightings (primary observers only) by group size and predicted relative abundance, based on a spatial relative abundance model that accounted for effort by assuming a uniform 5-km of transect and CAPs passing effort in every cell in the western Beaufort Sea in July, August, September, and October. E: September sightings. The bowhead whale high-use area is represented by distribution percentiles (30th, 40th, 50th, 60th, and 70th), which represent the offshore extent of 30%, 40%, 50%, 60%, and 70% of the predicted number of bowhead whales from the spatial model.

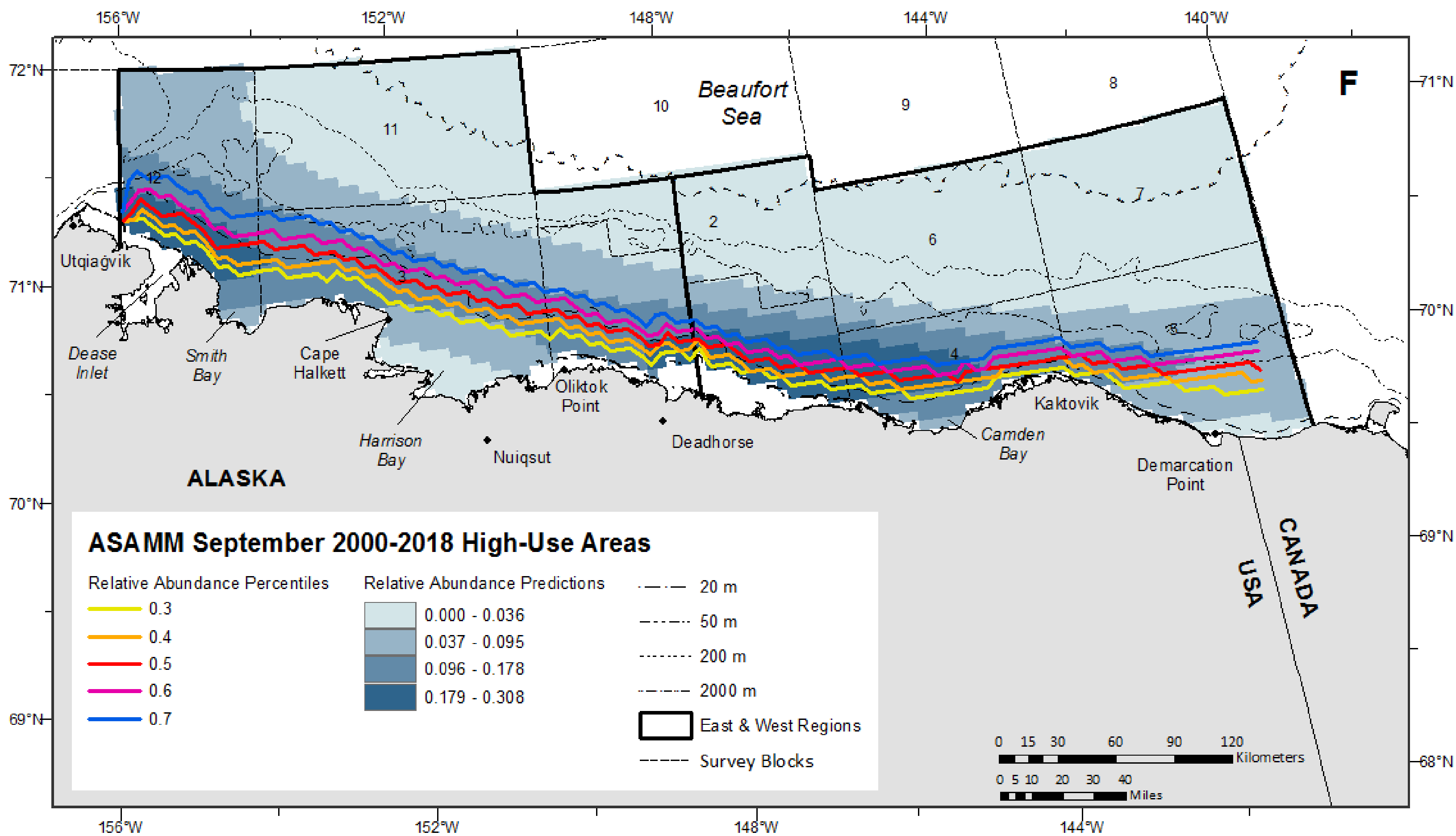


Figure 21 (cont.). ASAMM 2000-2018 bowhead whale transect and CAPs passing sightings (primary observers only) by group size and predicted relative abundance, based on a spatial relative abundance model that accounted for effort by assuming a uniform 5-km of transect and CAPs passing effort in every cell in the western Beaufort Sea in July, August, September, and October. F: September predicted relative abundance. Predictions are not corrected for perception or availability bias. The bowhead whale high-use area is represented by distribution percentiles (30th, 40th, 50th, 60th, and 70th), which represent the offshore extent of 30%, 40%, 50%, 60%, and 70% of the predicted number of bowhead whales from the spatial model.

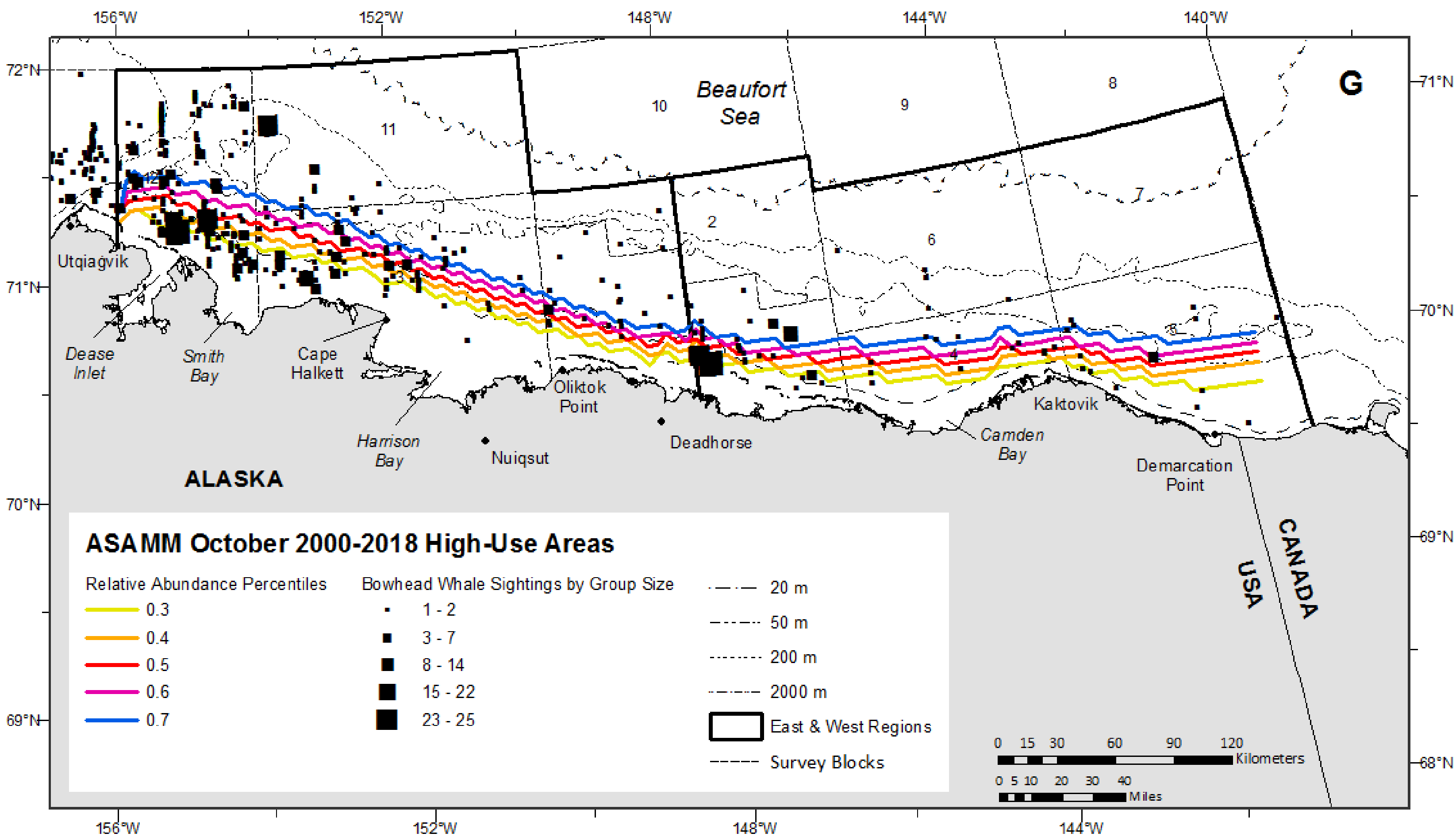


Figure 21 (cont.). ASAMM 2000-2018 bowhead whale transect and CAPs passing sightings (primary observers only) by group size and predicted relative abundance, based on a spatial relative abundance model that accounted for effort by assuming a uniform 5-km of transect and CAPs passing effort in every cell in the western Beaufort Sea in July, August, September, and October. G: October sightings. The bowhead whale high-use area is represented by distribution percentiles (30th, 40th, 50th, 60th, and 70th), which represent the offshore extent of 30%, 40%, 50%, 60%, and 70% of the predicted number of bowhead whales from the spatial model.

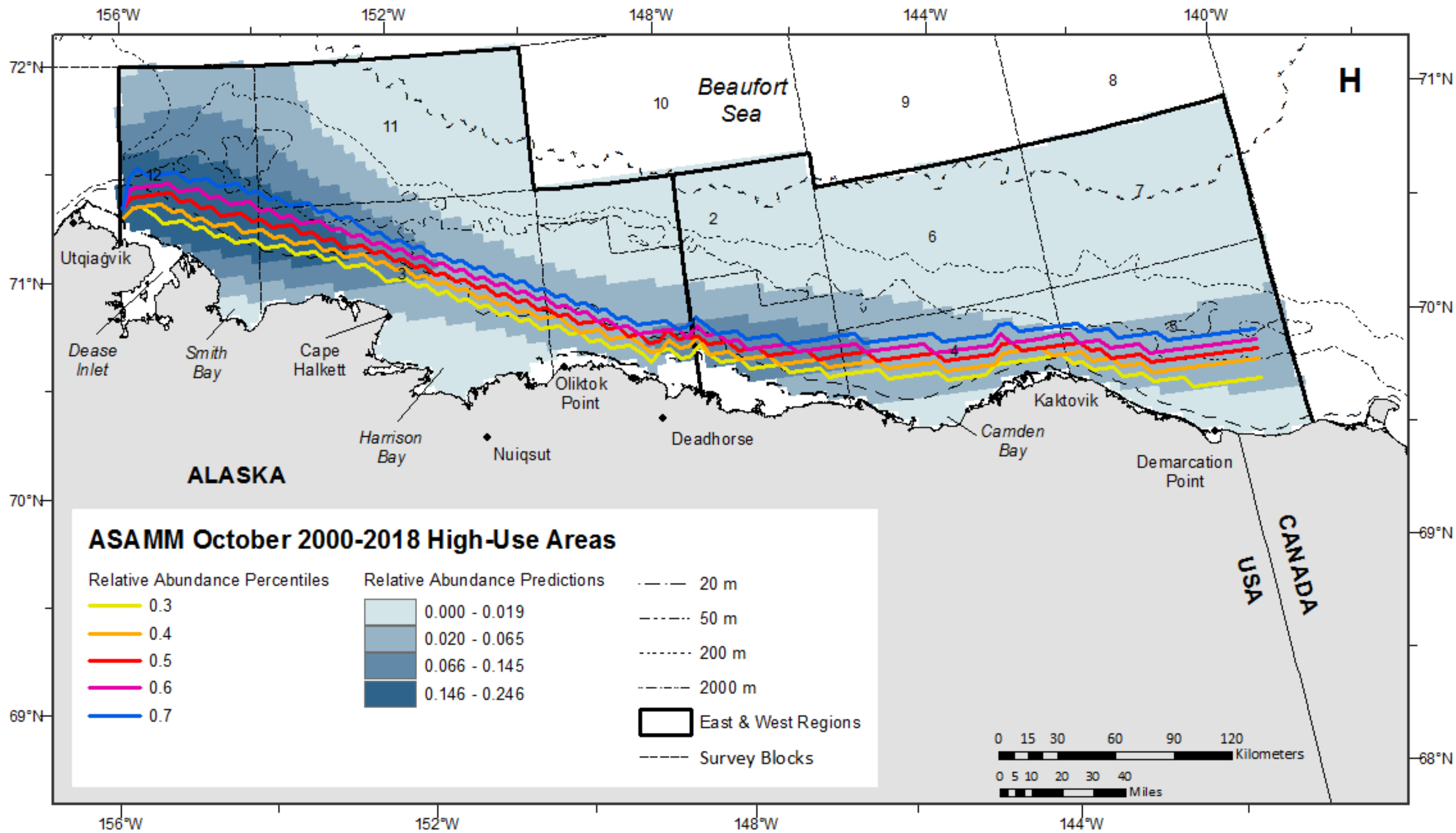


Figure 21 (cont.). ASAMM 2000-2018 bowhead whale transect and CAPs passing sightings (primary observers only) by group size and predicted relative abundance, based on a spatial relative abundance model that accounted for effort by assuming a uniform 5-km of transect and CAPs passing effort in every cell in the western Beaufort Sea in July, August, September, and October. H: October predicted relative abundance. Predictions are not corrected for perception or availability bias. The bowhead whale high-use area is represented by distribution percentiles (30th, 40th, 50th, 60th, and 70th), which represent the offshore extent of 30%, 40%, 50%, 60%, and 70% of the predicted number of bowhead whales from the spatial model.

Table 9. Percentiles of bowhead whale predicted distribution (km) from the spatial model for the West and East regions of the ASAMM study area. For 2018, the predictions correspond to September and October pooled. Monthly predictions are provided for 2000-2018.

	WEST REGION (KM)					EAST REGION (KM)				
	2018	2000-2018				2018	2000-2018			
Percentile	Sep-Oct	Jul	Aug	Sep	Oct	Sep-Oct	Jul	Aug	Sep	Oct
30th	33.0	27.1	18.7	14.9	20.9	16.0	43.7	14.5	12.1	16.0
40th	40.6	35.9	23.3	19.7	26.1	19.8	49.8	19.0	16.1	20.5
50th	48.0	44.2	28.1	25.5	31.1	23.8	55.7	23.7	20.2	25.4
60th	55.4	52.8	33.3	31.5	36.5	28.2	61.7	29.3	24.4	30.2
70th	63.9	61.5	38.7	38.8	42.8	33.0	68.0	35.6	29.7	35.5

Gray Whales

Gray Whale Sighting Summary

During the 2018 ASAMM surveys, 295 sightings of 493 gray whales (*Eschrichtius robustus*) of the Eastern North Pacific stock were observed in the study area during all survey modes (transect, CAPs, search and circling) (Table 4). Gray whales were seen in all months in the eastern Chukchi Sea (Figure 22). In the northeastern Chukchi Sea, gray whales were seen nearshore (<40 km) from Point Barrow to Icy Cape, although few were seen between Point Franklin and Point Barrow. Gray whales were seen from mid-July through mid-October near Utqiaġvik and in the northern part of block 17 and southern part of block 14, between 30 and 120 km offshore and just south of Hanna Shoal. In the southcentral Chukchi Sea, gray whales were seen offshore approximately 70-140 km southwest of Point Hope, a known gray whale and benthic hotspot (Grebmeier et al. 2015; Kuletz et al. 2015). No gray whales were seen between Icy Cape and Point Hope. Two gray whales were seen in Peard Bay on one day in late July; based on photo identification, these gray whales are not the same whales observed in Peard Bay in 2016 and 2017. Gray whales were not seen east of Point Barrow or north of 72°N. Locations of gray whale sightings during semimonthly periods are shown in Figure 23.

Gray whale distribution in 2018 (all sightings regardless of survey mode or observer type) was generally similar to that documented from 2008 to 2017 and in earlier years with light sea ice coverage, with a few exceptions:

- Gray whales continued to be mostly absent from Hanna Shoal, but were observed immediately south of Hanna Shoal (block 14) in summer and fall.
- Gray whales were not seen in shallow waters immediately south of Point Hope.
- Gray whales appeared sparse in the area between Point Franklin and Utqiaġvik.
- Two gray whales were seen in Peard Bay during a search survey on 29 July; Peard Bay was searched on 6 additional flights from 8 August to 9 October and gray whales were not observed.

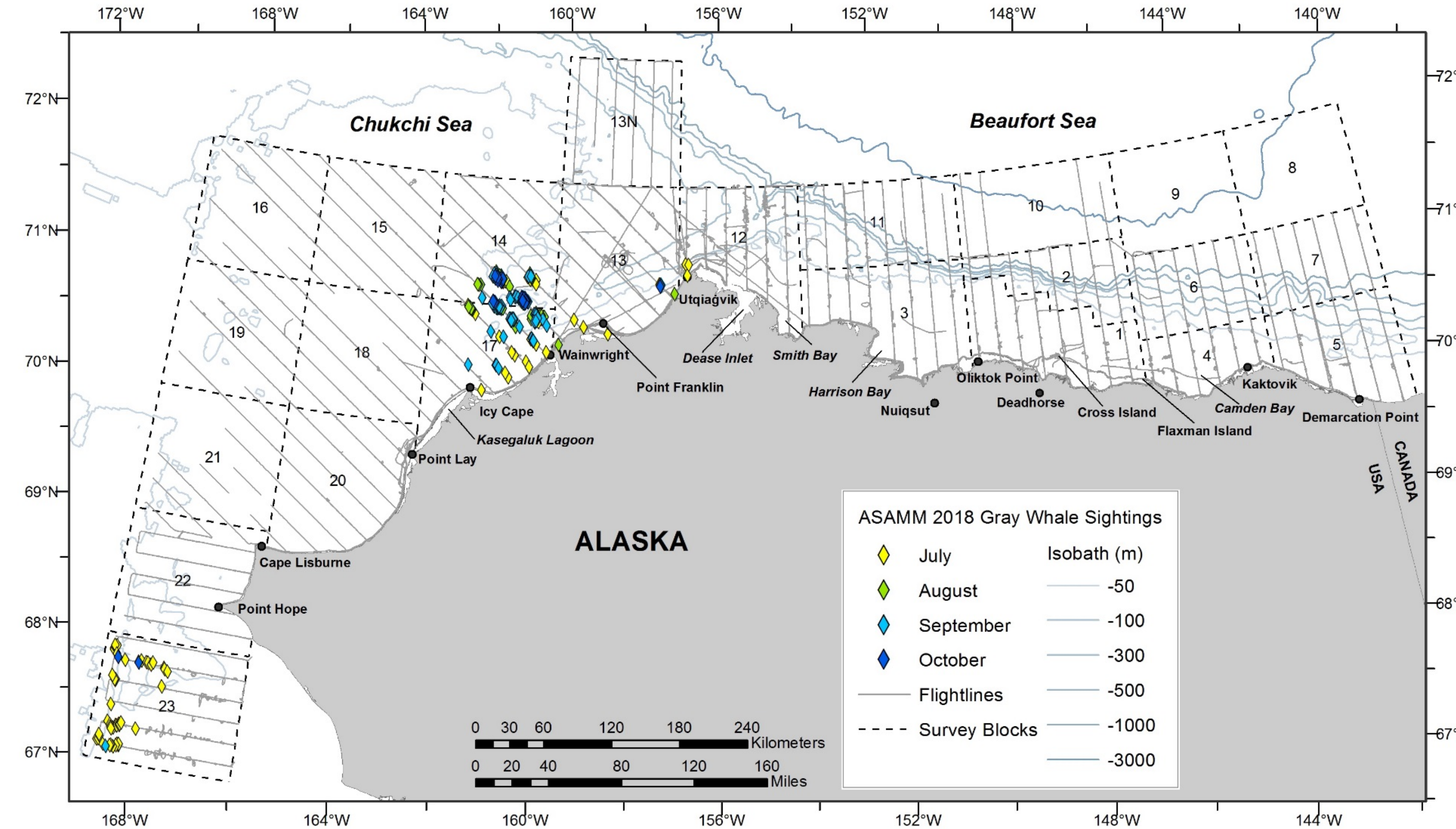
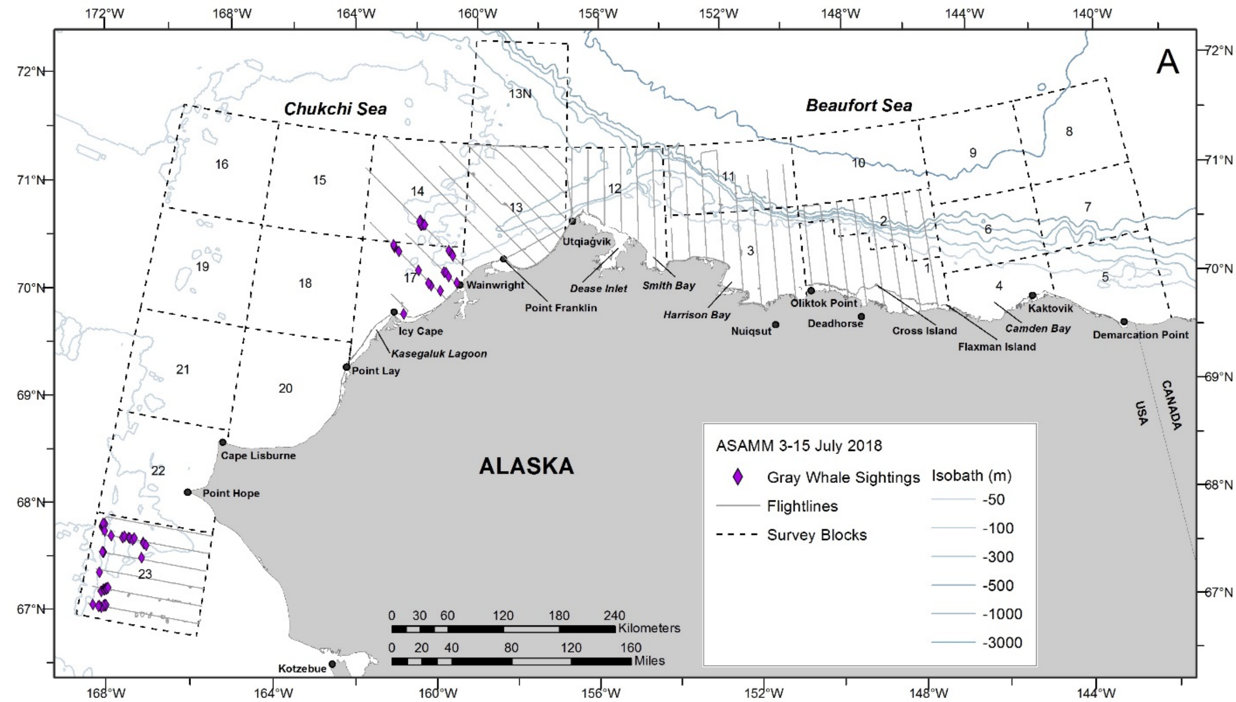


Figure 22. ASAMM 2018 gray whale sightings, all survey modes, plotted by month, with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.



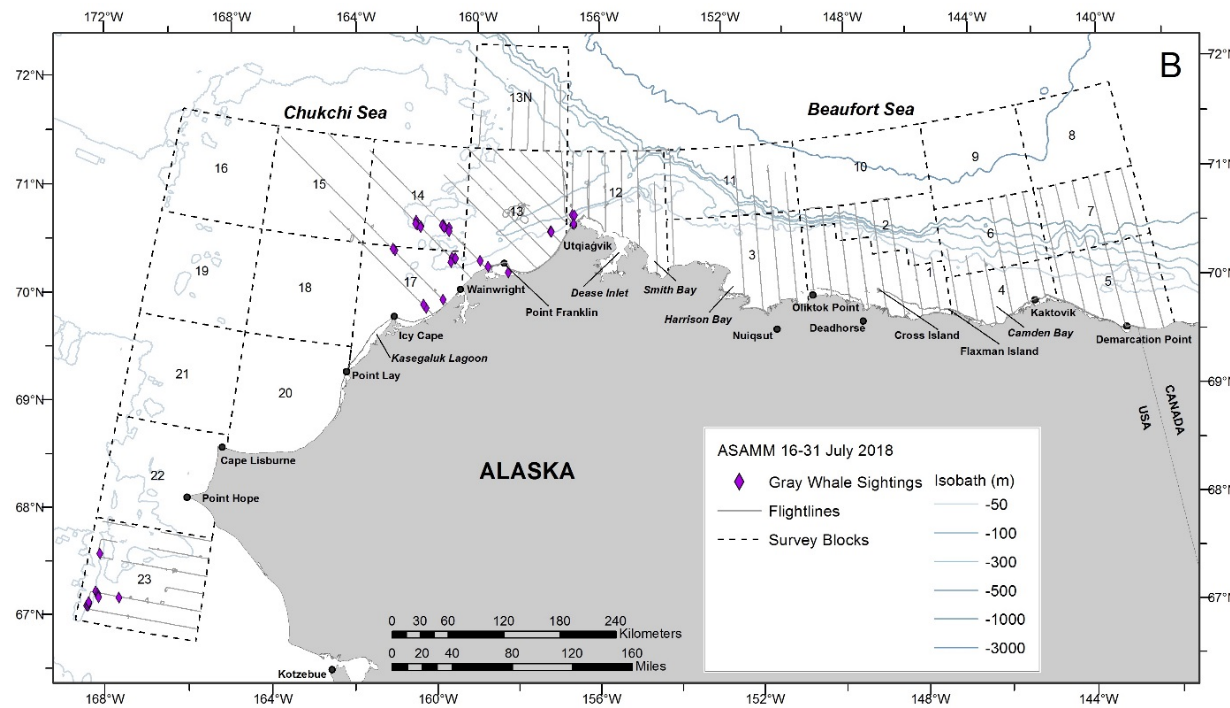
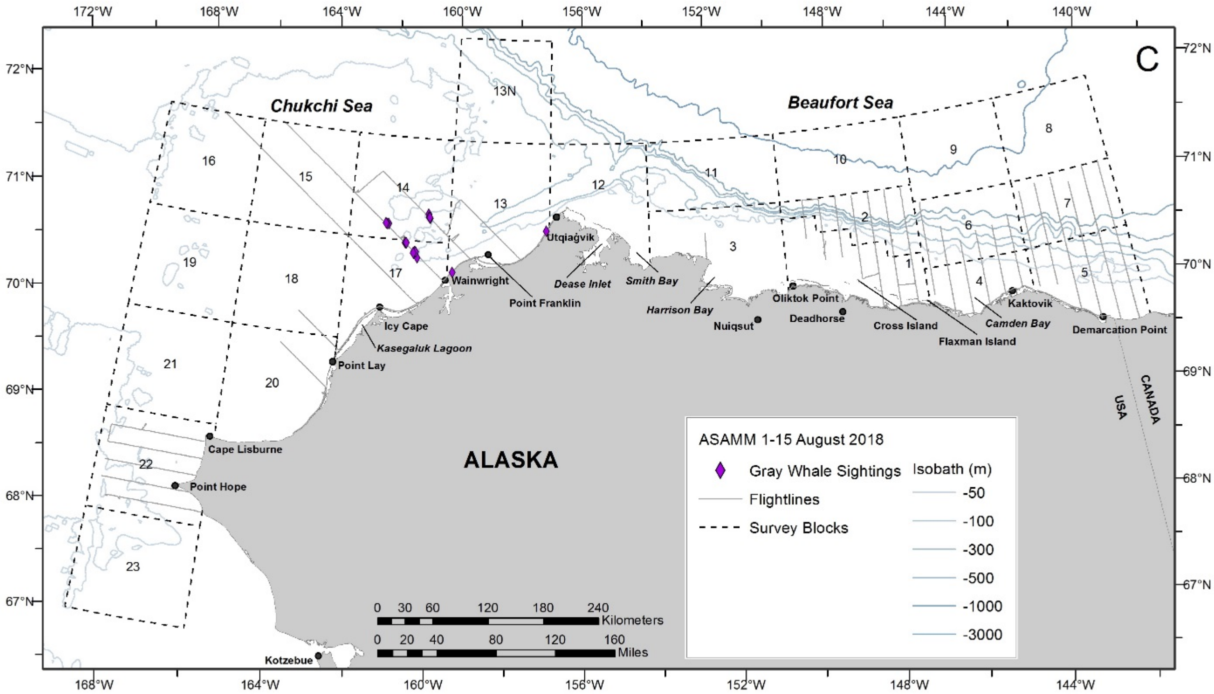


Figure 23. ASAMM 2018 semimonthly gray whale sightings, all survey modes, with transect, CAPs, search, circling, and FGF effort, July-October. A: 3-15 July. B: 16-31 July. Deadhead flight tracks are not shown.



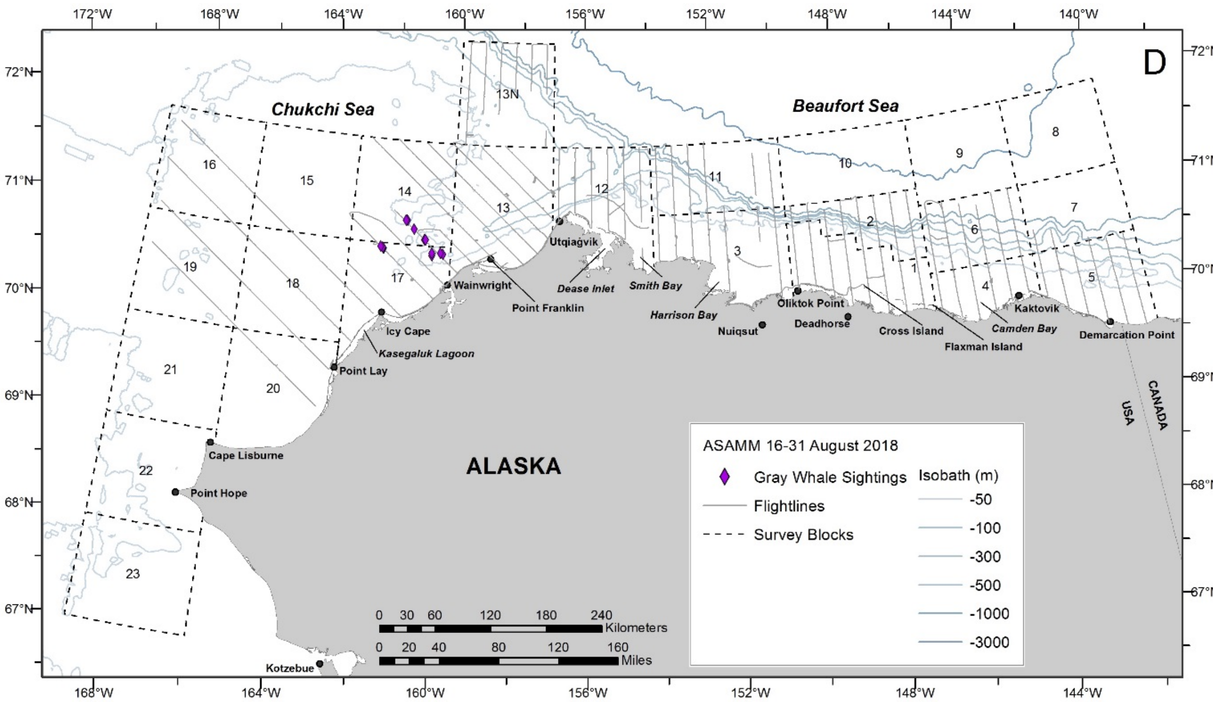
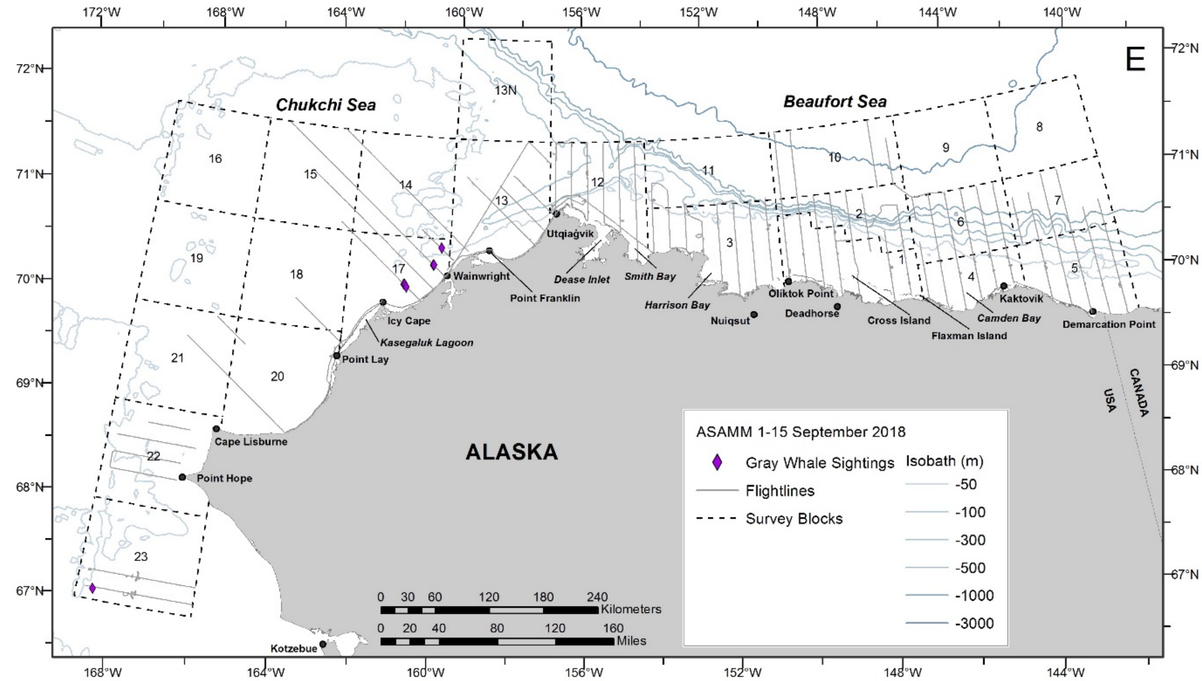


Figure 23 (cont). ASAMM 2018 semimonthly gray whale sightings, all survey modes, with transect, CAPs, search, circling, and FGF effort, July-October. C: 1-15 August. D: 16-31 August. Deadhead flight tracks are not shown.



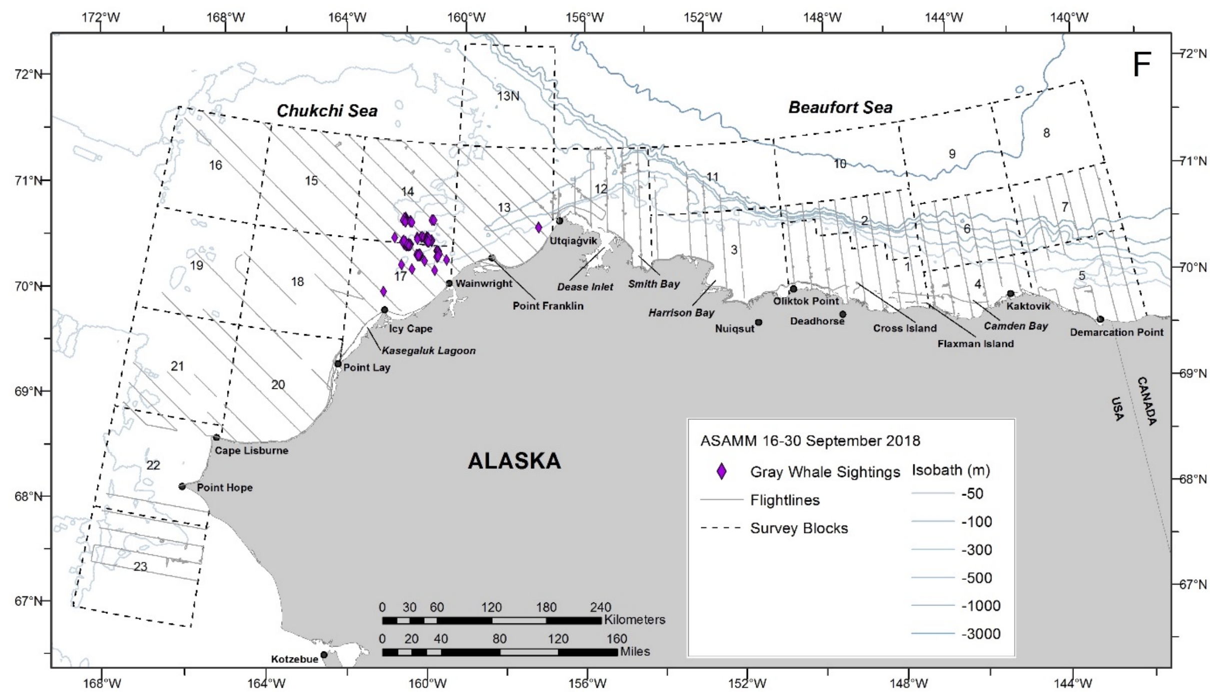
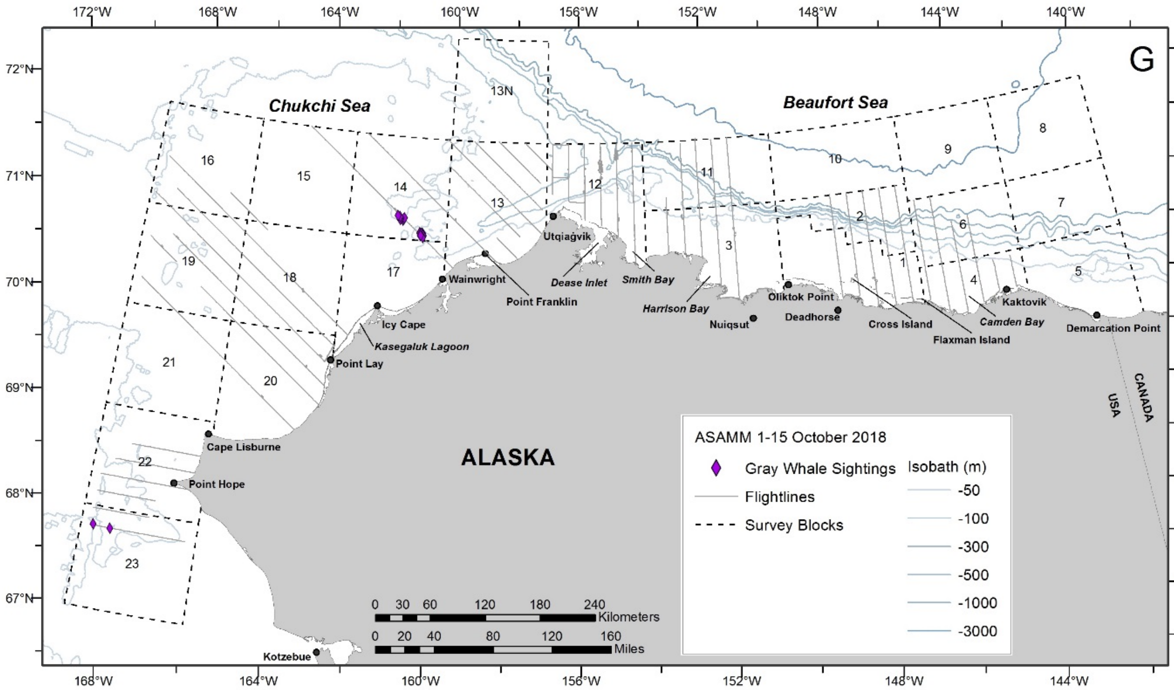


Figure 23 (cont). ASAMM 2018 semimonthly gray whale sightings, all survey modes, with transect, CAPs, search, circling, and FGF effort, July-October. E: 1-15 September. F: 16-30 September. Deadhead flight tracks are not shown.



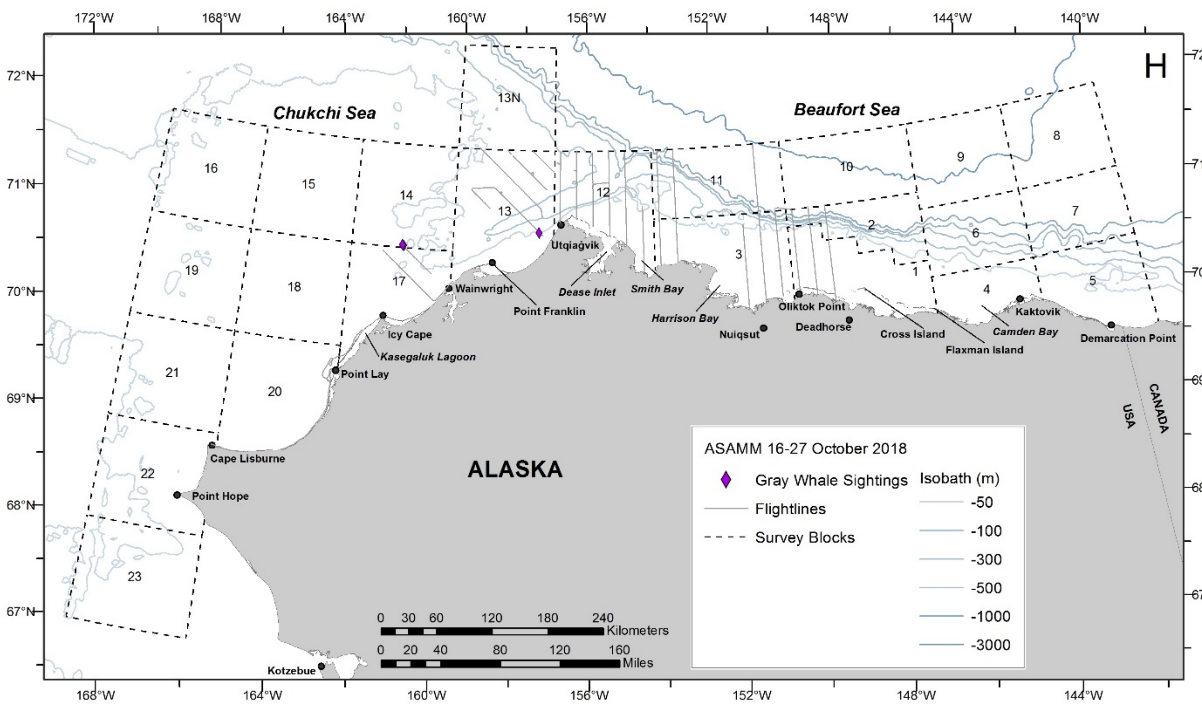


Figure 23 (cont). ASAMM 2018 semimonthly gray whale sightings, all survey modes, with transect, CAPs, search, circling, and FGF effort, July-October. G: 1-15 October. H: 16-27 October. Deadhead flight tracks are not shown.

GRAY WHALE SIGHTING RATES

In summer and fall 2018, gray whales were seen on effort from 67.1°N to 71.4°N and 156.7°W to 168.8°W. There were 179 sightings of 324 gray whales on effort by primary observers (Appendix E, Table E-3), ranging from one whale per sighting ($n_s = 107$) to 14 whales per sighting ($n_s = 1$). The greatest numbers of sightings on transect were in block 14 ($n_s = 64$), block 17 ($n_s = 64$) and block 23 ($n_s = 36$).

The highest gray whale fine-scale (5-km grid) sighting rates (WPUE) in summer were approximately 30-90 km west and northwest of Wainwright, and 100-150 km southwest of Point Hope (Figure 24A). In fall, the highest gray whale fine-scale sighting rates (WPUE) were approximately 30-100 km west and northwest of Wainwright (Figure 24B). There were few gray whales seen on transect between Utqiaġvik and Point Franklin in summer or fall.

Gray whale sighting rate analyses per survey block and depth zone were limited to the study area west of 154°W to encompass the region where gray whales were predominantly seen in 2018 and historically. For all months combined, the highest sighting rates per survey block were in block 17 (0.057 WPUE), block 14 (0.043 WPUE), and block 23 (0.034 WPUE). Sighting rates were highest in block 17 in July and September and in block 14 in August and October (Figure 25) (Appendix E, Table E-3).

Monthly sighting rates in 2018 were higher in July and September compared to monthly sighting rates in 2009-2017, all years combined (Figure 26). The peak monthly gray whale sighting rate in the eastern Chukchi Sea (67°N-72°N, 154°W-169°W) in 2018 was in July (0.029 WPUE), decreasing substantially in August (0.008 WPUE), increasing in September (0.012 WPUE), before decreasing again in October (0.003 WPUE). When sighting rates were calculated separately for the northeastern Chukchi Sea (69°N-72°N, 154°W-169°W; 2009-2017) and southcentral Chukchi Sea (67°N-69°N, 166°W-169°W; 2014-2017) and compared to 2018, sighting rates in the northeastern Chukchi Sea were highest in July and decreased in August in both 2018 and 2009-2017 combined. However, sighting rates increased in September 2018, which was not observed in September 2009-2017 combined (Figure 27A). Sighting rates in the southcentral Chukchi Sea in 2018 differed considerably from those in 2009-2014 and from those in the northeastern Chukchi Sea in 2018 (Figure 27B).

The highest sighting rate per depth zone in the Chukchi Sea (157°W-169°W) for the entire study period was in the 51-200 m North depth zone (0.029 WPUE) (Appendix E, Table E-4). Unlike in previous years when high numbers of gray whales observed in the benthic hotspot in the southcentral Chukchi Sea overwhelmed most sighting rate analyses, gray whales were seen in the 51-200 m South depth zone in the southcentral Chukchi Sea in 2018 only in July (Figure 28). Sighting rates in July 2018 were high in all depth zones in the Chukchi Sea. In August and September, highest sighting rates were in the 51-200 m North and 36-50 m depth zones. When aerial surveys recommenced in the northeastern Chukchi Sea in 2008, gray whale depth zone preference was for shallower water (≤35 m) in the northern Chukchi Sea in summer and deeper water (>35 m) in fall (Clarke et al. 2012, 2013a, 2014, 2015a). However, starting in 2015 and continuing in 2016, 2017 (Clarke et al. 2016, 2017a, b, 2018a), and 2018, gray whale preference for deeper water was noted throughout summer and fall.

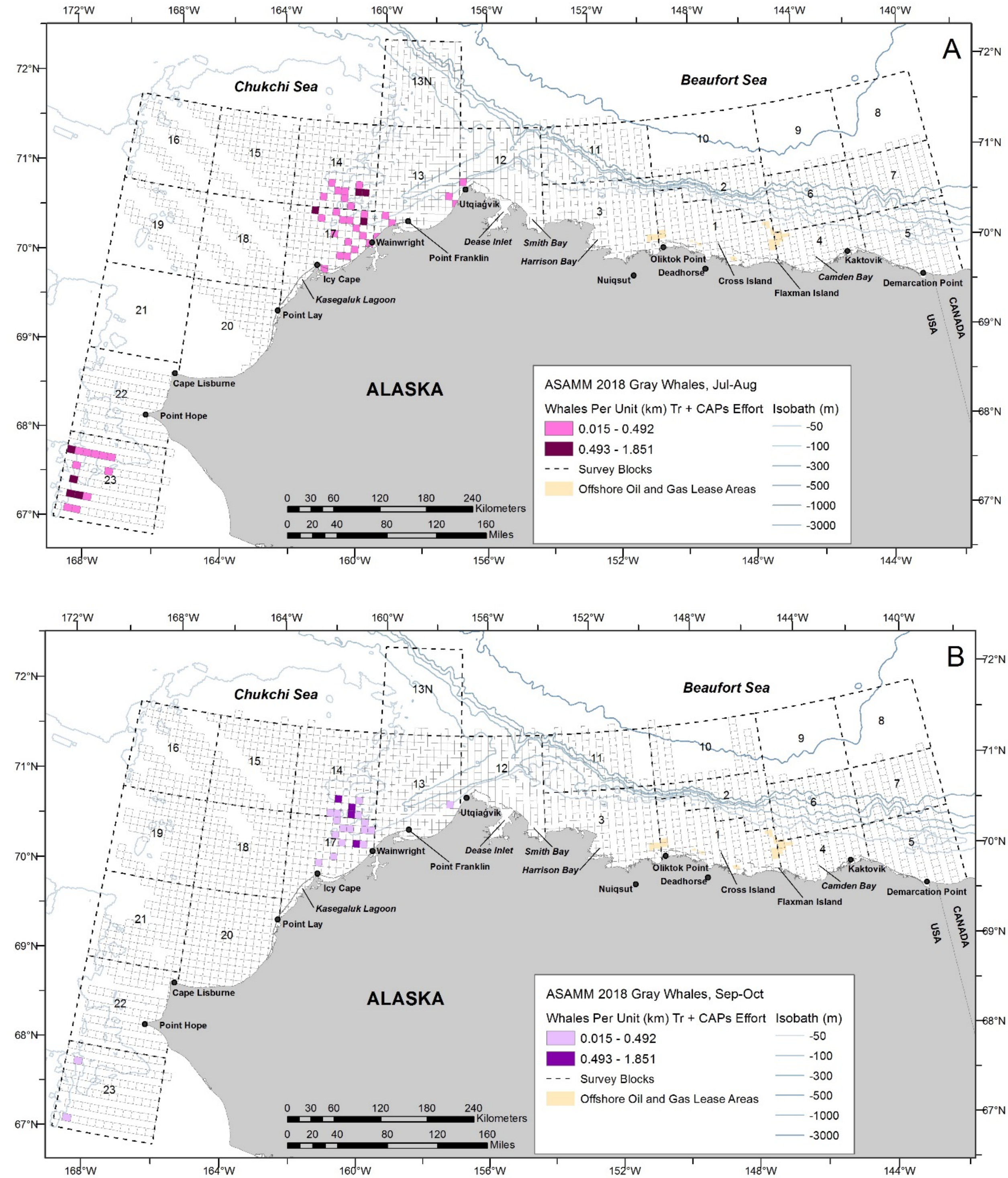


Figure 24. ASAMM 2018 gray whale on-effort seasonal sighting rates (WPUE; sightings from primary observers only). A: summer (July-August pooled). B: fall (September-October pooled). Empty cells indicate sighting rates of zero. Transect and CAPs survey effort was not conducted in areas without cell outlines.

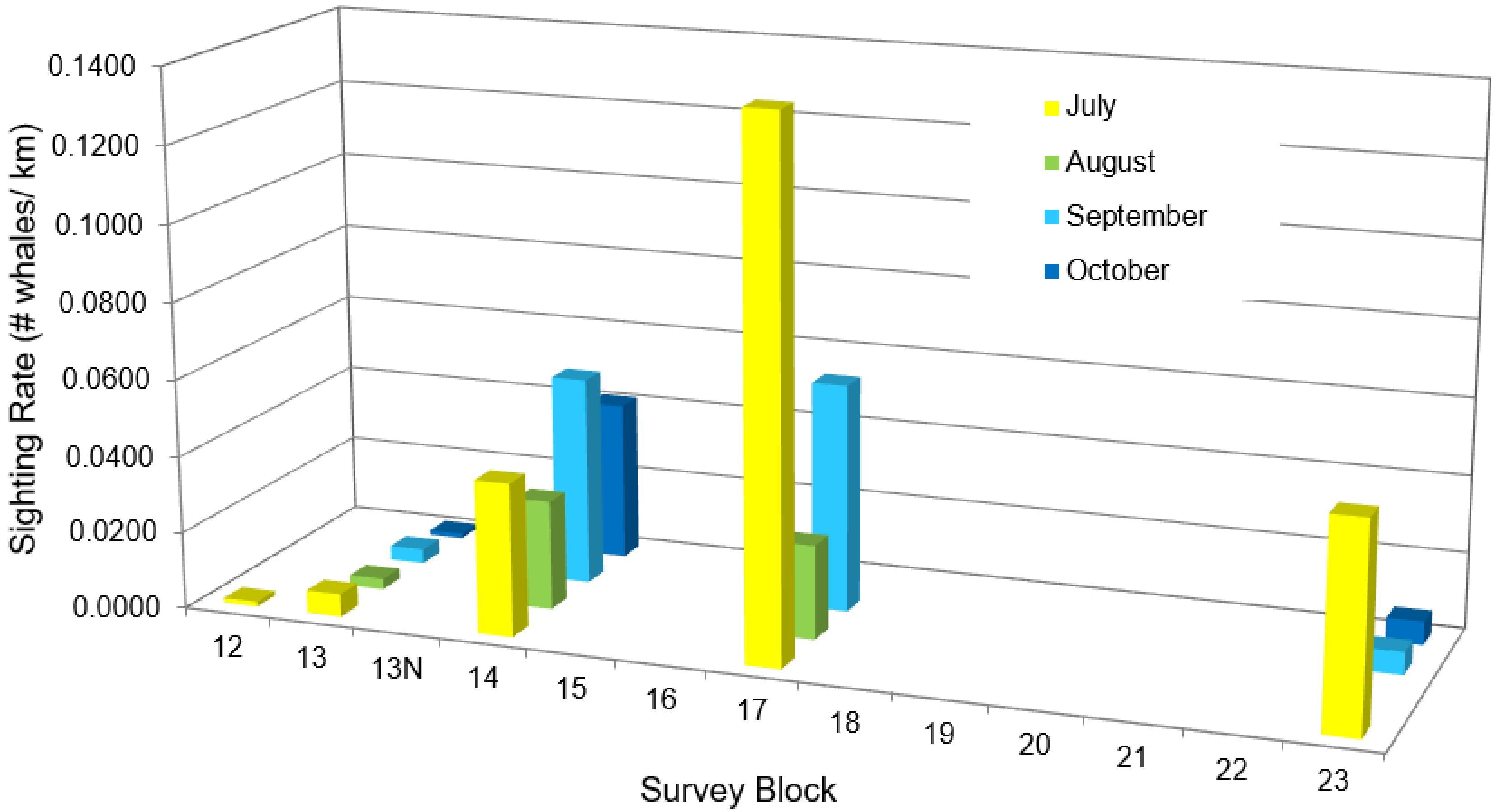


Figure 25. ASAMM 2018 gray whale on-effort monthly sighting rates (WPUE; sightings from primary observers only) per survey block, July-October. Sighting rates of zero were removed from the graph for clarity.

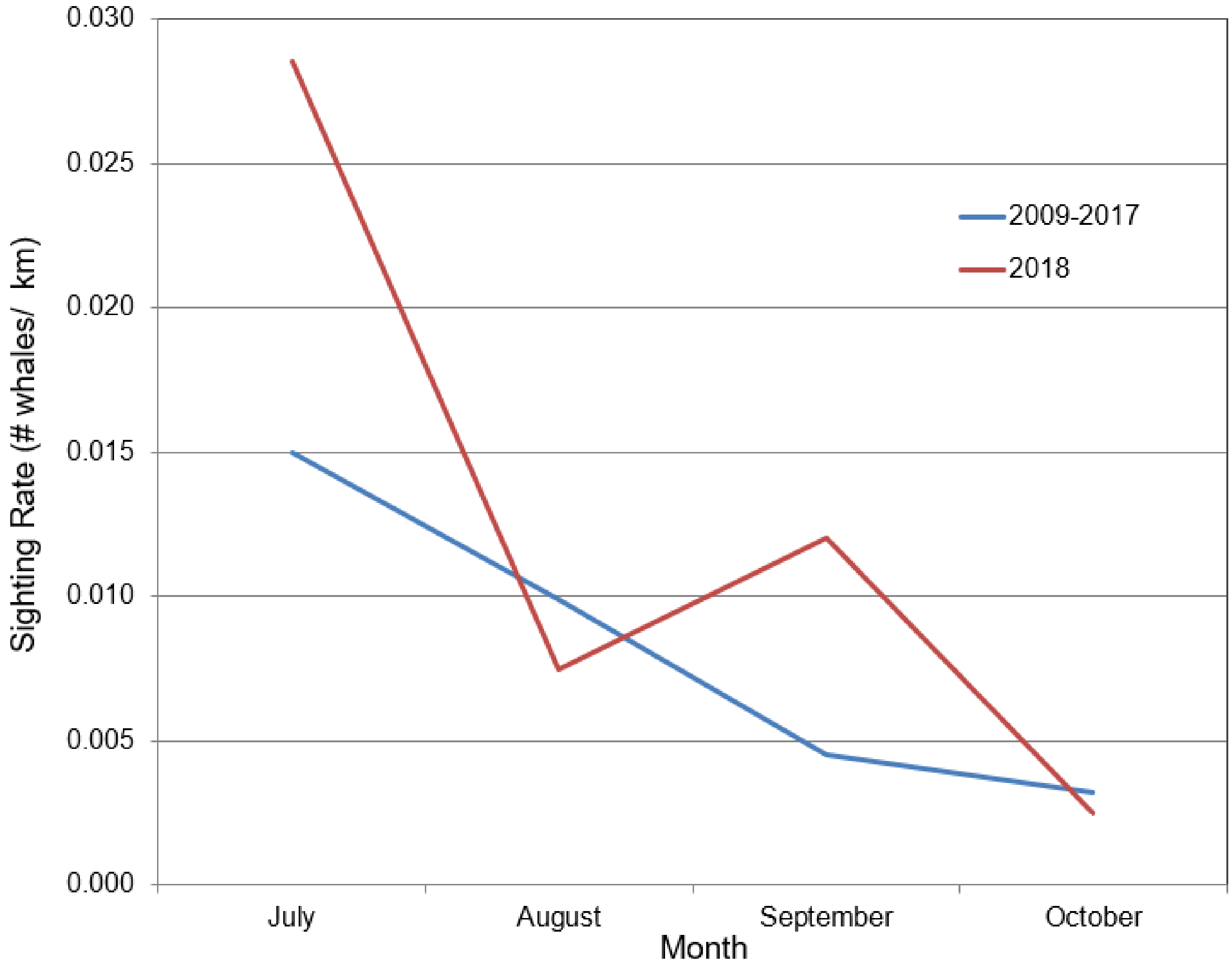


Figure 26. ASAMM gray whale on-effort monthly sighting rates (WPUE; sightings from primary observers only) in the eastern Chukchi and western Alaskan Beaufort seas (67°N-72°N, 154°W-169°W), July-October, 2009-2017 pooled and 2018.

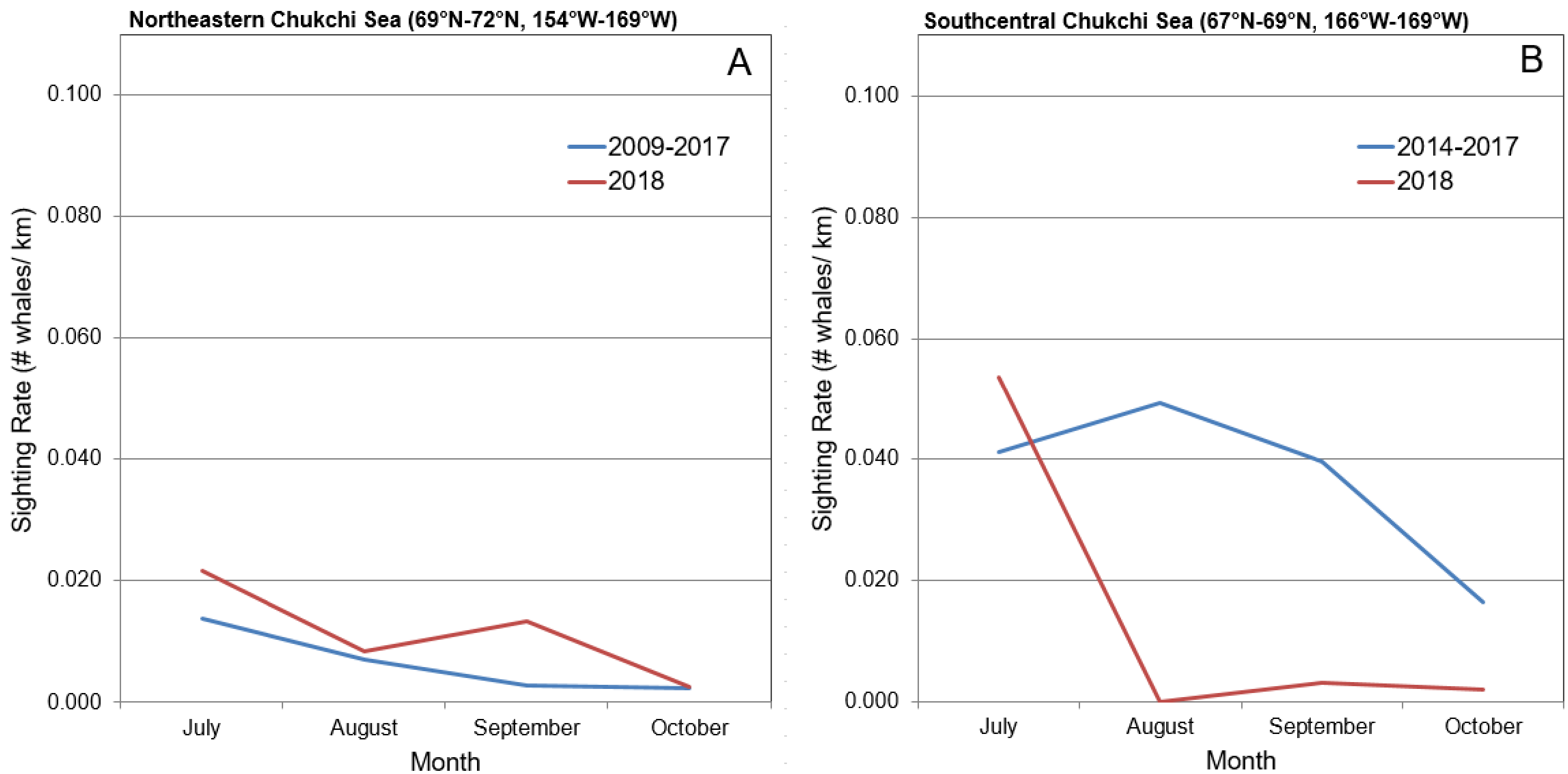


Figure 27. ASAMM gray whale on-effort monthly sighting rates (WPUE; sightings from primary observers only), July-October. A: northeastern Chukchi and western Alaskan Beaufort Sea (69°N-72°N, 154°W-169°W), 2009-2017 pooled and 2018. B: southcentral Chukchi Sea (67°N-69°N, 166°W-169°W), 2014-2017 pooled and 2018.

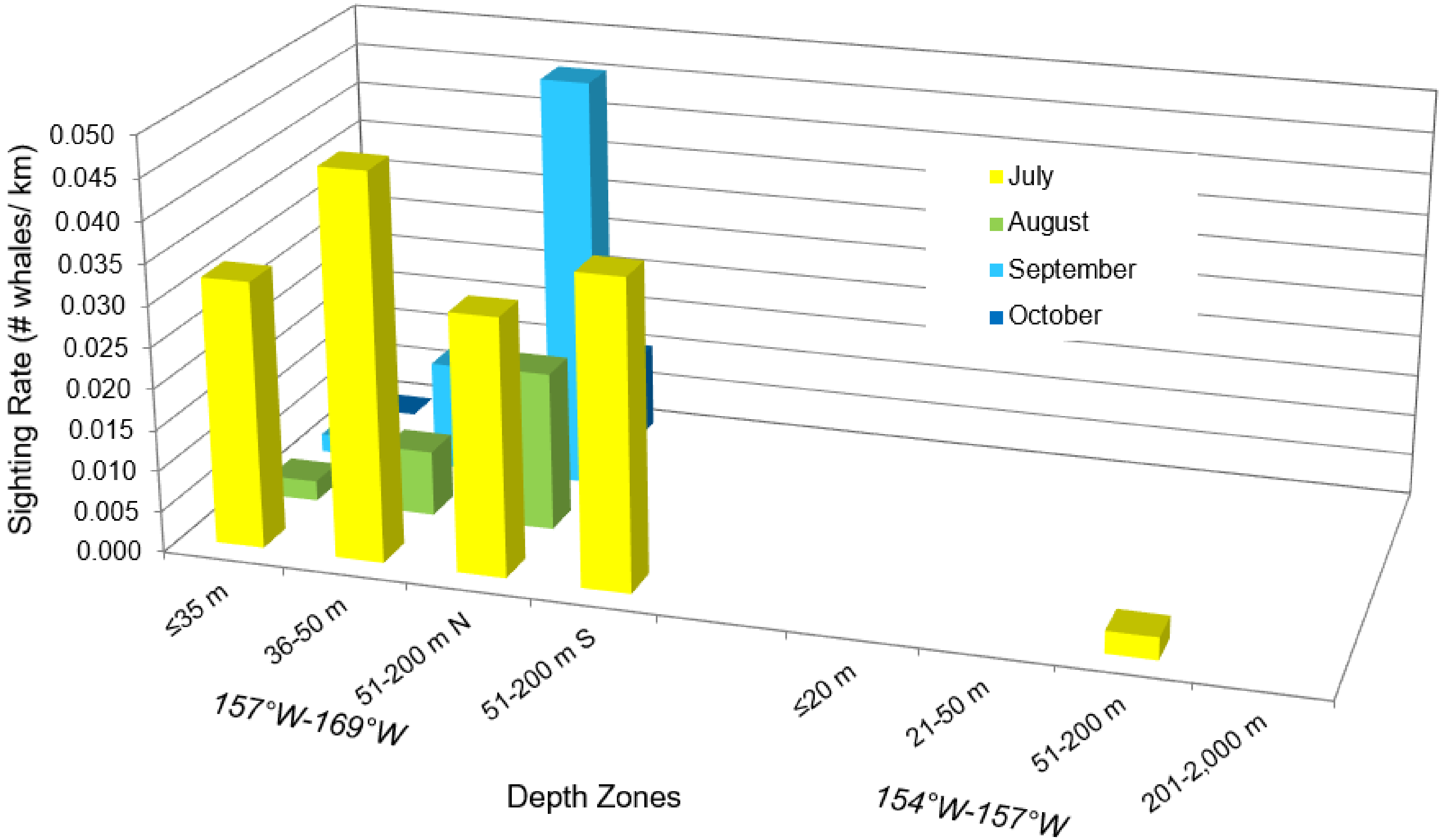


Figure 28. ASAMM 2018 gray whale on-effort monthly sighting rates (WPUE; sightings from primary observers only) per depth zone, July-October. Sighting rates of zero were removed from the graph for clarity.

The highest sighting rate per depth zone in the western Alaskan Beaufort Sea (154°W-157°W) for gray whales for the entire study period was in the 51-200 m zone (0.0008 WPUE) (Appendix E, Table E-4). Gray whales were not seen on transect in any other depth zone in the western Alaskan Beaufort Sea.

Gray whale distribution in 2018 using on-effort sightings overlapped the distribution of on-effort sightings observed in previous years having light sea ice cover (Figure 29).

Gray Whale Sea Ice Associations

Most gray whales (92%, $n_i = 452$) were observed in 0% sea ice cover. Sea ice was largely absent from the Chukchi Sea study area by late August (Appendix A, Figure A-5). Gray whales were observed in 1-95% broken floe sea ice in early July, and in 60% grease sea ice in late October.

Gray Whale Behaviors

Behaviors of gray whales observed during all survey modes (transect, CAPs, search, and circling) in 2018 are summarized in Table 10. The behaviors most often recorded were feeding (82%) and swimming (13%). Resting was recorded for 11 whales (2%). Other behaviors recorded included milling ($n_i = 5$), spy hopping ($n_i = 2$), engaging in SAG behavior ($n_i = 2$), and body contact (not nursing or mating; $n_i = 2$). Gray whales observed in the southcentral Chukchi Sea (south of 69°N) were primarily feeding (82%) and swimming (14%), and the gray whales observed in Peard Bay were feeding. Fine-scale sighting rates of feeding and milling gray whales in 2018 are shown in Figure 30. In summer, feeding and milling sighting rates were highest west and northwest of Wainwright, and southwest of Point Hope, while in fall highest sighting rates were limited to west and northwest of Wainwright only. Gray whales recorded as feeding were likely all feeding in the benthos, as evidenced by the presence of mud plumes. Gray whale feeding was likely underreported due to the difficulty of identifying surface or water column feeding during aerial surveys. One (<1% of all gray whales seen) gray whale appeared to respond to the aircraft by diving.

In 2018, 37 gray whale calves were seen (Figure 31). Most calves ($n_i = 31$, 84%) were sighted after circling was initiated and likely would not have been observed if circling had not commenced. The calf ratio (number of calves/number of total whales) was 0.075, which is higher than calf ratios in 2009-2011, but lower than calf ratios recorded in 2012-2017 (Figure 32). Calf ratio was highest in August, when seven calves were observed out of a total 46 gray whales. Calf distribution in 2018 overlapped that of adult gray whales temporally and spatially in the northeastern Chukchi Sea, but not in the southcentral Chukchi Sea where only two calves were seen, both in July. Most calves (92%, $n_i = 34$) were seen between Point Franklin and Icy Cape, from 10 to 90 km from shore.

In July, 25 calves were observed, seven calves were observed in August, four calves were seen in September, and one calf was seen in October. On 6 occasions, multiple calves were seen in one day, with the highest daily total on 11 July (11 calves; Appendix B, Flight 205). Some calves may have been sighted on more than one day. However, preliminary analysis of

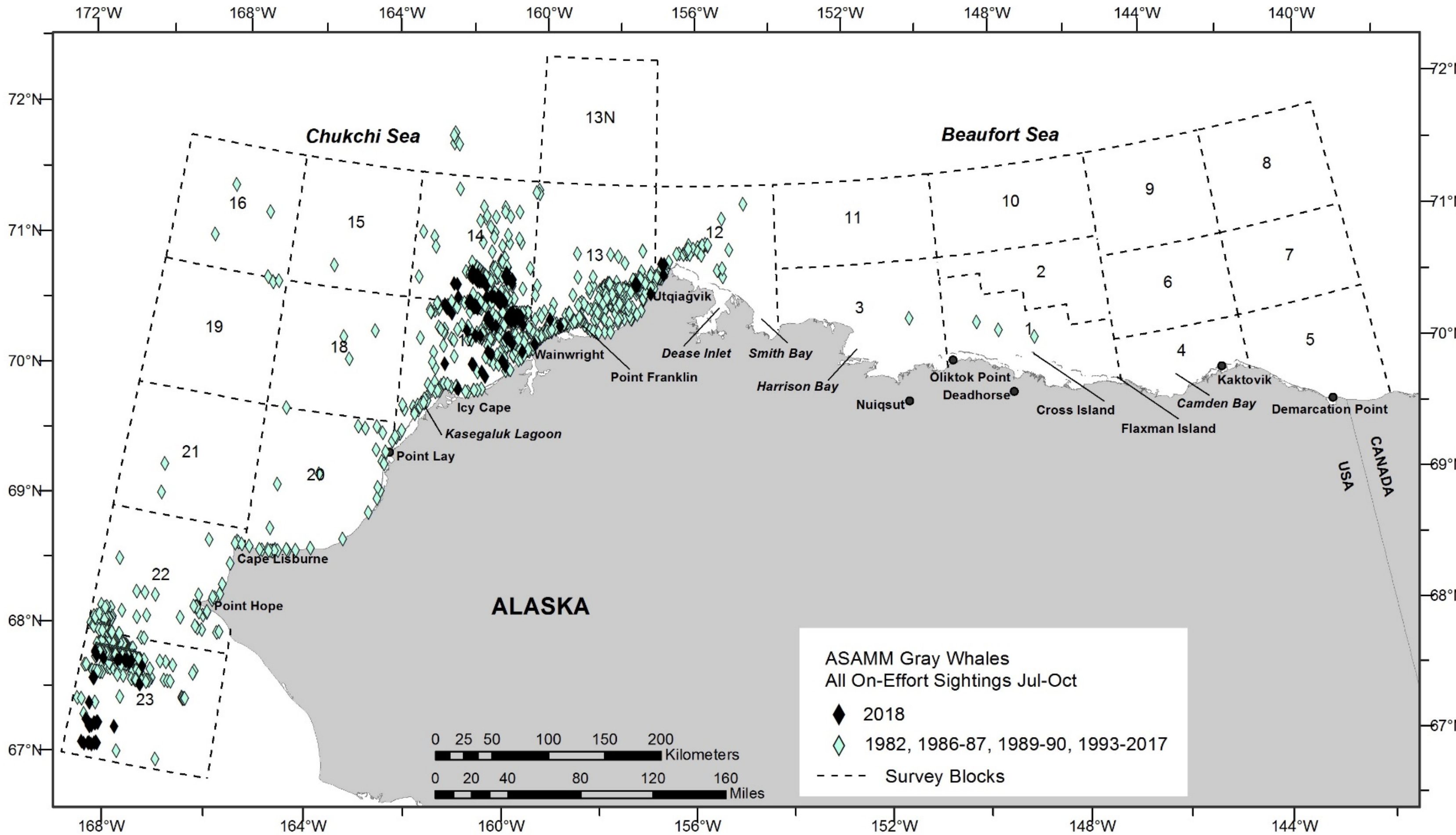


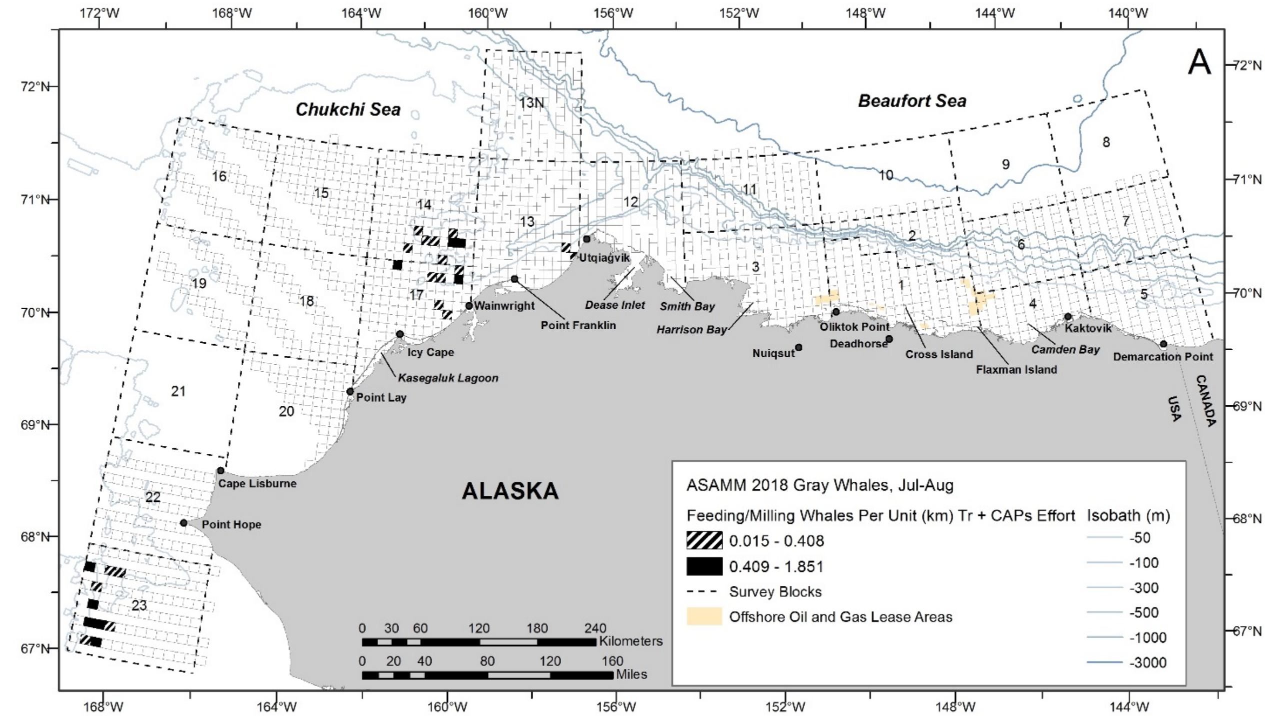
Figure 29. ASAMM gray whale sightings, July-October, in years with light sea ice cover: 1982, 1986-1987, 1989-1990, 1993-2017, and 2018. Includes all on-effort sightings from primary and secondary observers.

Table 10. ASAMM 2018 semimonthly summary of gray whales (number of sightings/ number of individuals) observed during transect, CAPs, search, and circling survey modes, by behavioral category. Excludes dead and same-day repeat sightings.

Behavior	1-15 Jul	16-31 Jul	1-15 Aug	16-31 Aug	1-15 Sep	16-30 Sep	1-15 Oct	16-31 Oct	Total
Feed	40/86	31/71	11/16	12/19	4/7	111/177	23/27	2/2	234/405
Mill	0	0	0	0	0	1/3	1/2	0	2/5
Other	1/2	0	0	0	0	0	0	0	1/2
Rest	7/7	1/2	1/2	0	0	0	0	0	9/11
SAG	0	0	0	0	0	0	1/2	0	1/2
Spy Hop	0	1/2	0	0	0	0	0	0	1/2
Swim	19/26	9/12	5/8	1/1	3/4	6/11	3/3	1/1	47/66
TOTAL	67/121	42/87	17/26	13/20	7/11	118/191	28/34	3/3	295/493

opportunistically collected photo-identification data collected in 2017 indicate that relatively few calves are resighted within the year (Willoughby et al. 2018b).

Gray whale swim direction was not significantly clustered around a mean heading in any month in either the northeastern or southcentral Chukchi Sea. Most gray whales observed during ASAMM were at the far northern extent of the species' range and were feeding, so a lack of directed migratory movement is expected.



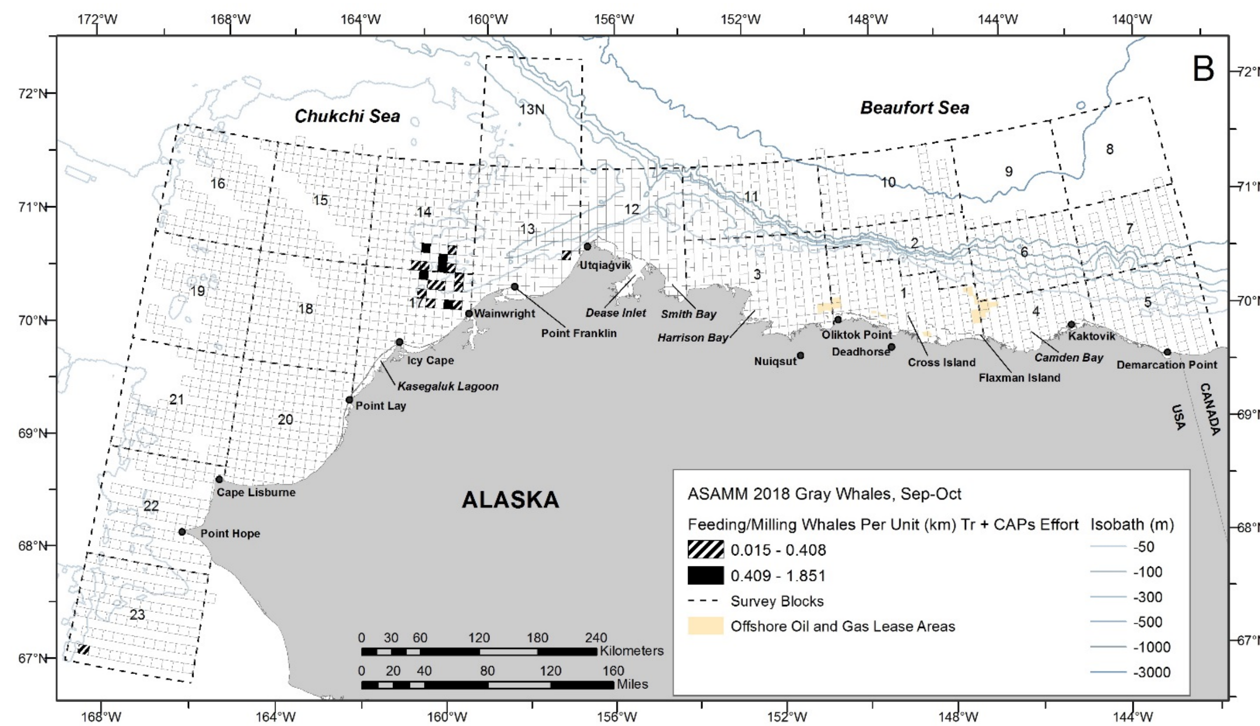


Figure 30. ASAMM 2018 gray whale on-effort seasonal feeding and milling sighting rates (WPUE; sightings from primary observers only). A: summer (July-August pooled). B: fall (September-October pooled). Empty cells indicate sighting rates of zero. Transect and CAPs survey effort was not conducted in areas without cell outlines.

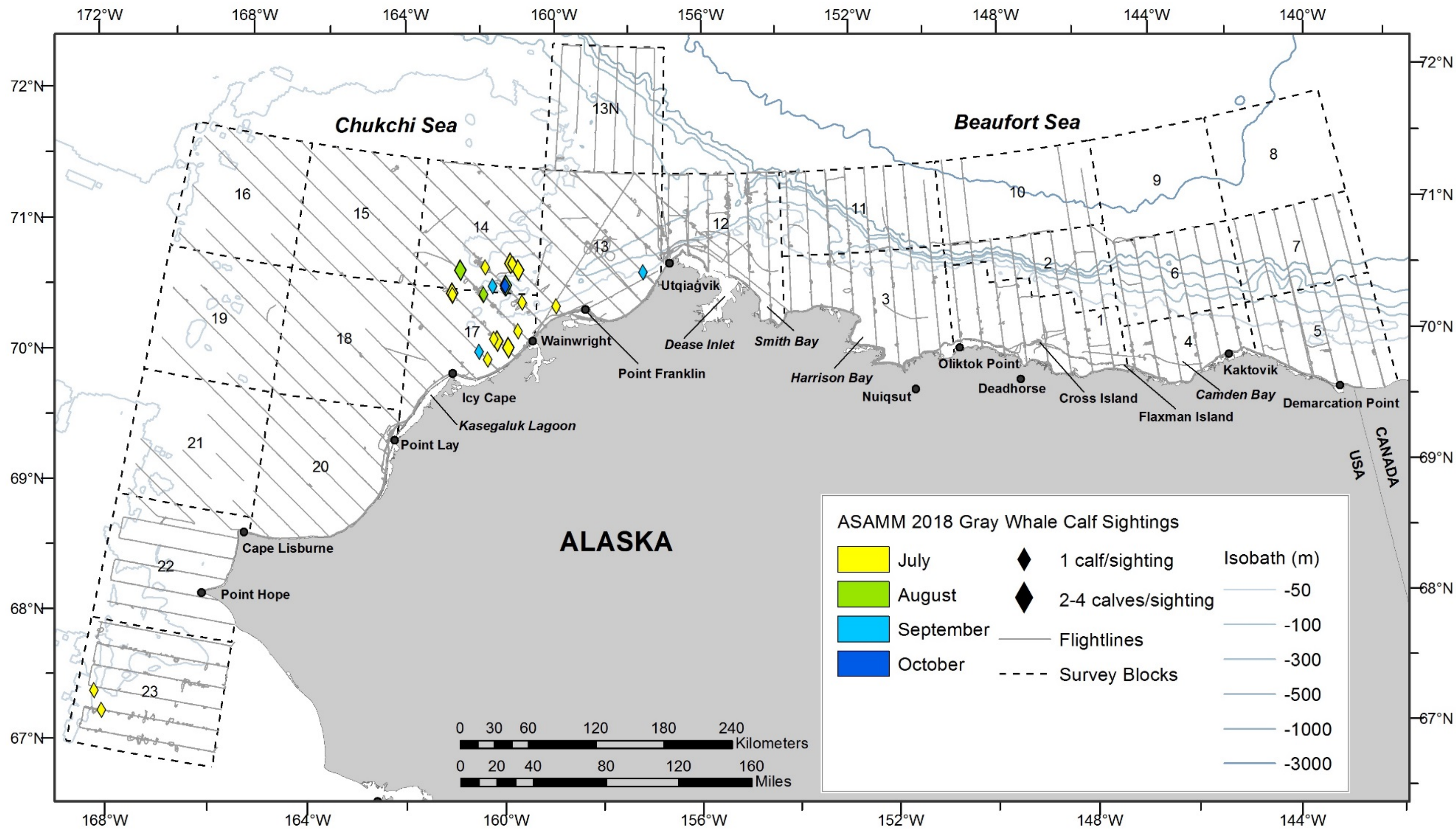


Figure 31. ASAMM 2018 gray whale calf sightings, all survey modes, plotted by month, with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.

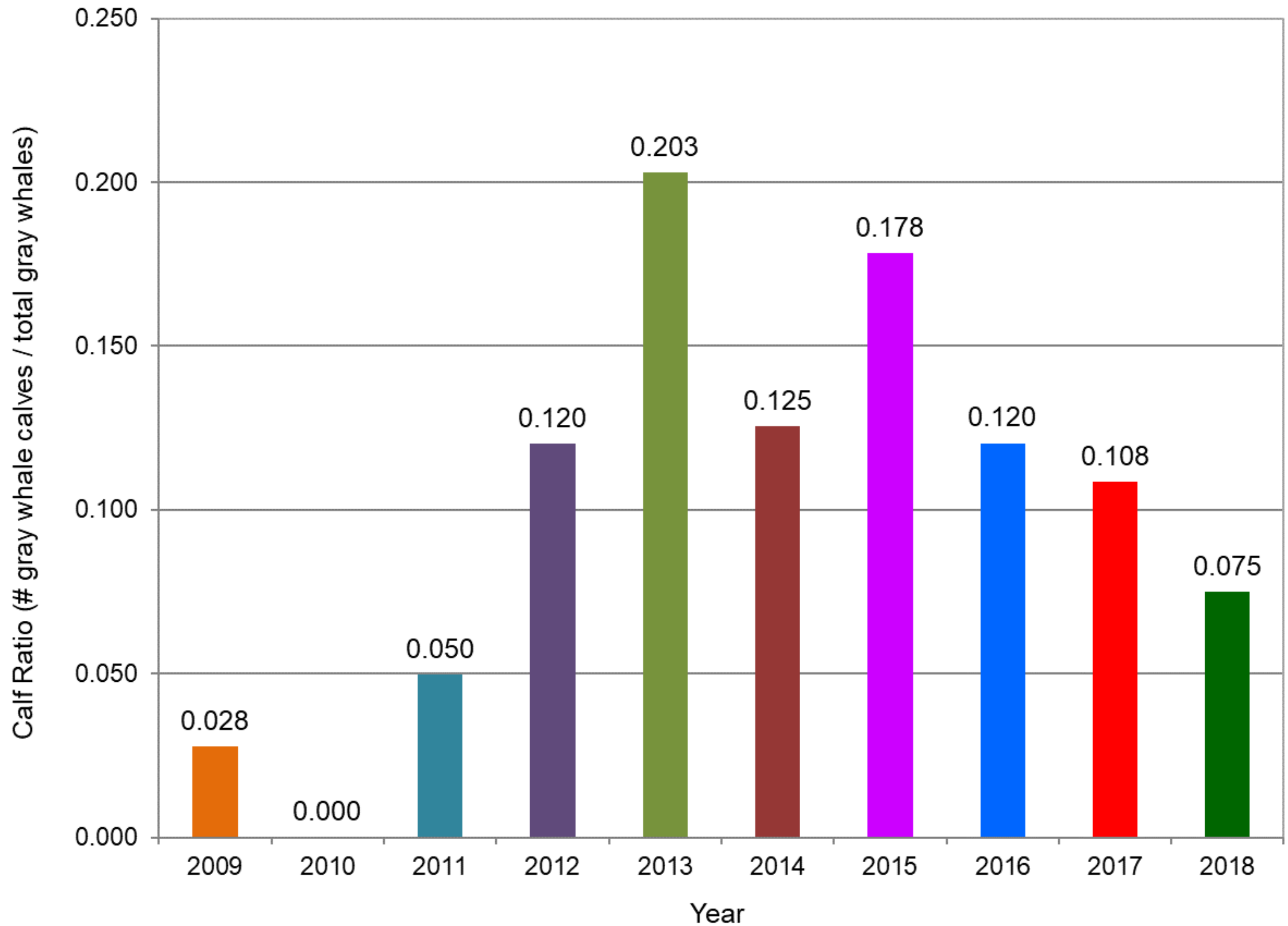


Figure 32. ASAMM gray whale annual calf ratios (number of gray whale calves per total gray whales), all survey modes, 2009-2018.

Humpback Whales

There were 53 sightings of 79 humpback whales (*Megaptera novaeangliae*), including two calves, in 2018 (Table 4, Figure 33). Stock affiliation of humpback whales in this region is unknown. Humpback whales were seen in July (n_i = 45), August (n_i = 1), and September (n_i = 33), and were all in the southcentral Chukchi Sea between 67°N-68.2°N. Images of humpback whales are too few to allow determination of inter- or intra-year resightings. Sighting rates were highest in the ≤35 m South depth zone in both summer and fall (Figure 34). Humpback whales were seen in close proximity to fin whales. Humpback whales were observed swimming (49%), feeding (23%), milling (5%), resting (5%), and displaying (3%). Feeding behaviors included lunge feeding (seven whales); red-colored defecation was also observed for one whale which suggests feeding on krill. Displays included breaching (one whale) and flipper slapping (one whale). Behavior was unknown or unrecorded for 12 humpback whales. Calves were seen in July (n_i = 1) and September (n_i = 1). None of the humpback whales appeared to respond to the survey aircraft.

Fin Whales

There were 77 sightings of 117 fin whales (*Balaenoptera physalus*) of the Northeast Pacific stock in 2018, including one calf. All fin whales were seen in the southcentral Chukchi Sea between 67°N and 67.8°N (Table 4; Figure 33). Fin whales were seen in July (n_i = 13), September (n_i = 103), and October (n_i = 1). Images of fin whales are too few to allow determination of inter- or intra-year resightings. Sighting rates were highest in the ≤35 m South depth zone in summer and fall (Figure 34); sighting rates in the ≤35 m South depth zone in fall were >15 times higher than sighting rates in any other depth zone in either season. Fin whales were seen in close proximity to humpback whales. Fin whales were observed swimming (68%), feeding (4%), milling (4%), and diving (3%). Behavior was unknown or unrecorded for 25 fin whales. The only calf observed was seen in July. None of the fin whales appeared to respond to the survey aircraft.

Minke Whales

There were three sightings of six minke whales (*Balaenoptera acutorostrata*) of the Alaska stock in 2018 (Table 4; Figure 33). Two milling minke whales were seen in July approximately 25 km west of Wainwright, a single swimming minke whale was seen in August approximately 60 km southwest of Point Hope, and a group of three feeding minke whales was seen in September approximately 130 km west-northwest of Wainwright. Sighting rates were low in all depth zones and both seasons (Figure 34). Minke whales were generally not sighted in close proximity to other cetaceans. All minke whales sighted were adults. None of the minke whales appeared to respond to the survey aircraft.

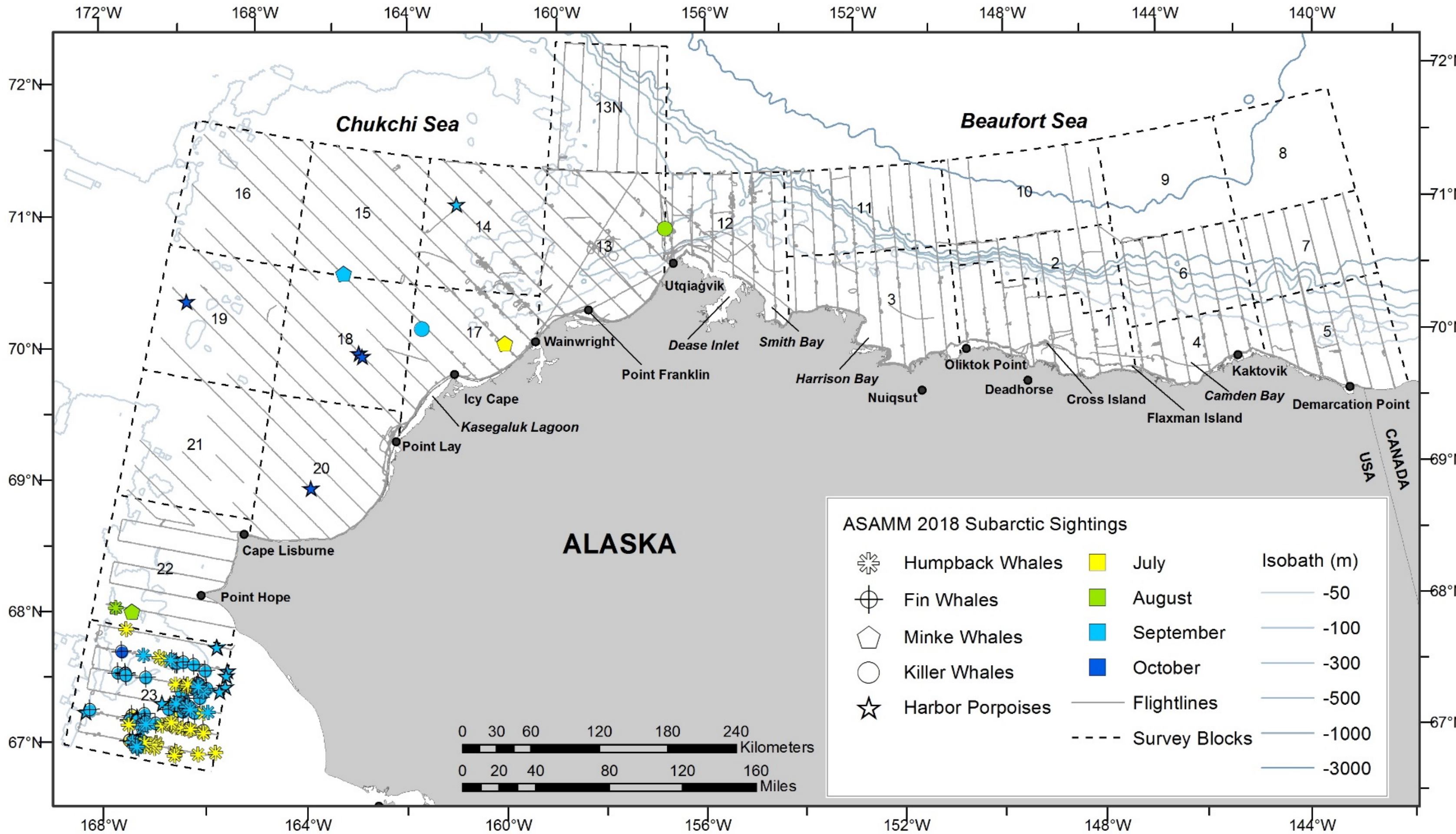


Figure 33. ASAMM 2018 harbor porpoise and humpback, fin, minke, and killer whale sightings, all survey modes, plotted by month, with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.

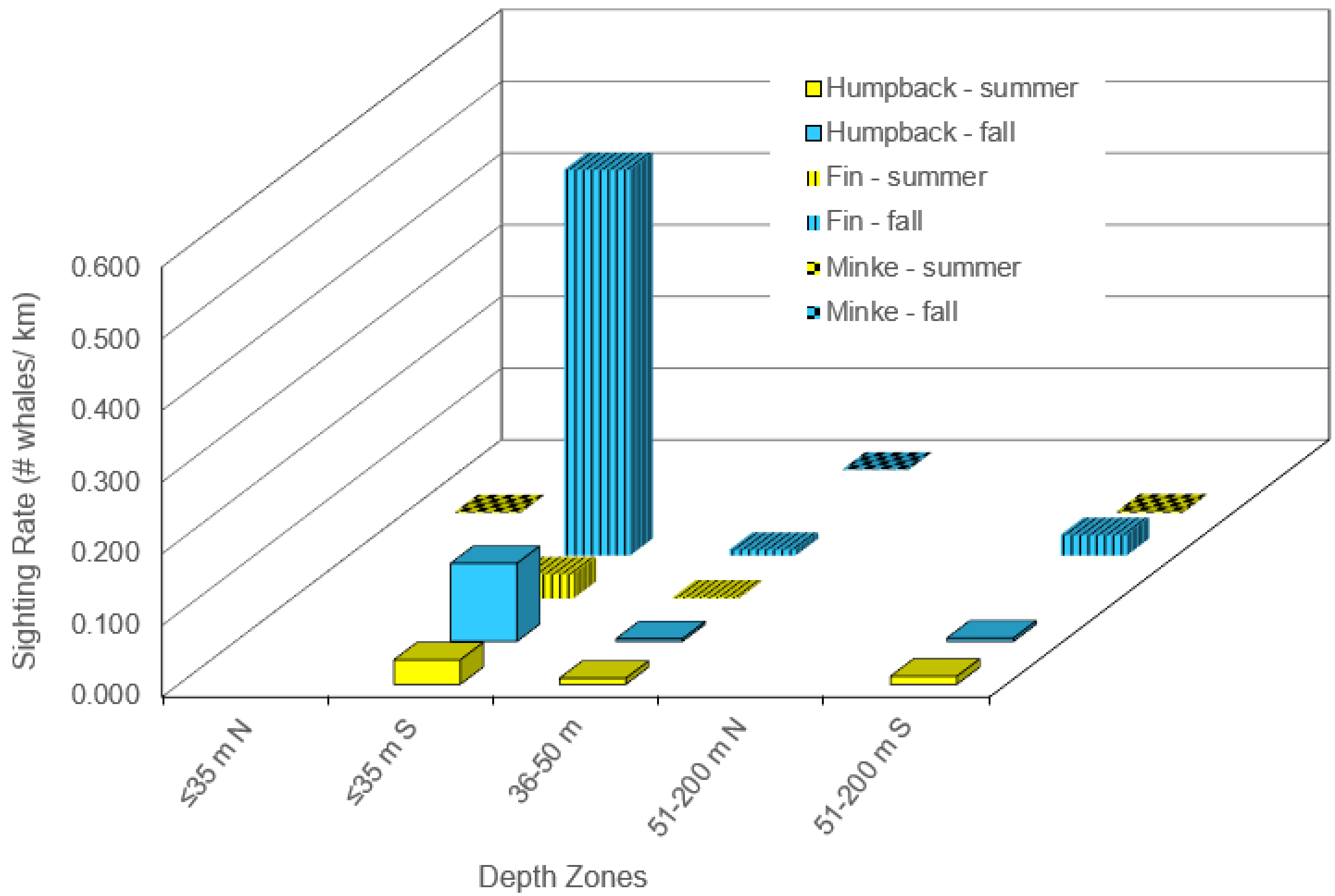


Figure 34. ASAMM 2018 humpback, fin, and minke whale on-effort summer (July-August pooled) and fall (September-October pooled) sighting rates (WPUE; sightings from primary observers only) per depth zone in the eastern Chukchi Sea (67°N-72°N, 157°W-169°W). Sighting rates of zero were removed from the graph for clarity.

Belugas

Beluga Sighting Summary

During the 2018 ASAMM surveys, 583 sightings of 1,814 belugas (*Delphinapterus leucas*) were observed during all survey modes (transect, CAPs, circling, and search) (Table 4). Beluga stock affiliation is impossible to determine from aerial surveys, and sightings likely included belugas from the Eastern Chukchi Sea (ECS) and Beaufort Sea (BS) stocks (Hauser et al. 2014). In the eastern Chukchi Sea, beluga sightings were limited to 21 sightings of 466 whales, most of which were seen in July (Figure 35). Belugas were seen in block 13N (north of 72°N) during surveys conducted there in late July (n_i = 14) and late August (n_i = 2). Belugas were seen in all months surveyed (July-October) in the western Beaufort Sea (Figure 34) along the continental slope, with few sightings nearshore. Sightings nearshore, however, included one moderately large group of 10 whales, sighted east of Kaktovik on 20 July. One beluga was seen in block 1a, between the barrier islands and the shoreline, in late July. Belugas were seen near Barrow Canyon from July through October. Beluga distribution in 2018 was generally like that documented in previous years with moderate to heavy sea ice cover in July and August and years with light sea ice cover in September and October in the western Beaufort Sea (Figure 36). The distribution of the few beluga sightings in the eastern Chukchi Sea in 2018 overlapped that of past years.

Beluga Sighting Rates

In summer and fall 2018, belugas were seen from 69.7°N to 72.7°N between 140.3°W and 161.7°W. There were 508 sightings of 1,194 belugas on transect by primary observers, ranging from one beluga per sighting (n_s = 307) to 58 belugas per sighting (n_s = 1). Some of the larger beluga groups were pooled counts. The highest number of sightings on transect per survey block was in block 7 (n_s = 119), followed by block 2 (n_s = 117), block 6 (n_s = 76), and block 12 (n_s = 74). In the western Beaufort Sea, sighting rates were highest in July (0.070 WPUE), decreased in August (0.029 WPUE) and again in September (0.023 WPUE), then increased in October (0.028 WPUE) (Figure 37; Appendix E, Table E-5). In the eastern Chukchi Sea, sighting rates were highest in July (0.012 WPUE), and decreased in August (0.002 WPUE) and October (<0.001 WPUE); belugas were not observed on transect in the eastern Chukchi Sea in September. Sighting rates likely reflect the presence of the ECS stock in the northeastern Chukchi and western Beaufort seas in summer (July-August) (Hauser et al. 2014).

Areas of highest fine-scale sighting rates in summer and fall were offshore on the continental slope and in the deepest area surveyed in the western Beaufort Sea (Figure 38).

For all months combined, block 7 had the highest transect sighting rate (0.114 WPUE), followed by block 2 (0.103 WPUE), and block 6 (0.057 WPUE) (Appendix E, Table E-5). Offshore survey blocks located over the continental slope in the western Beaufort Sea (i.e., 2, 6, 7, 11, and 12) generally had higher transect sighting rates than blocks near shore (i.e., 1, 3, 4 and 5) in summer and fall (Figure 39).

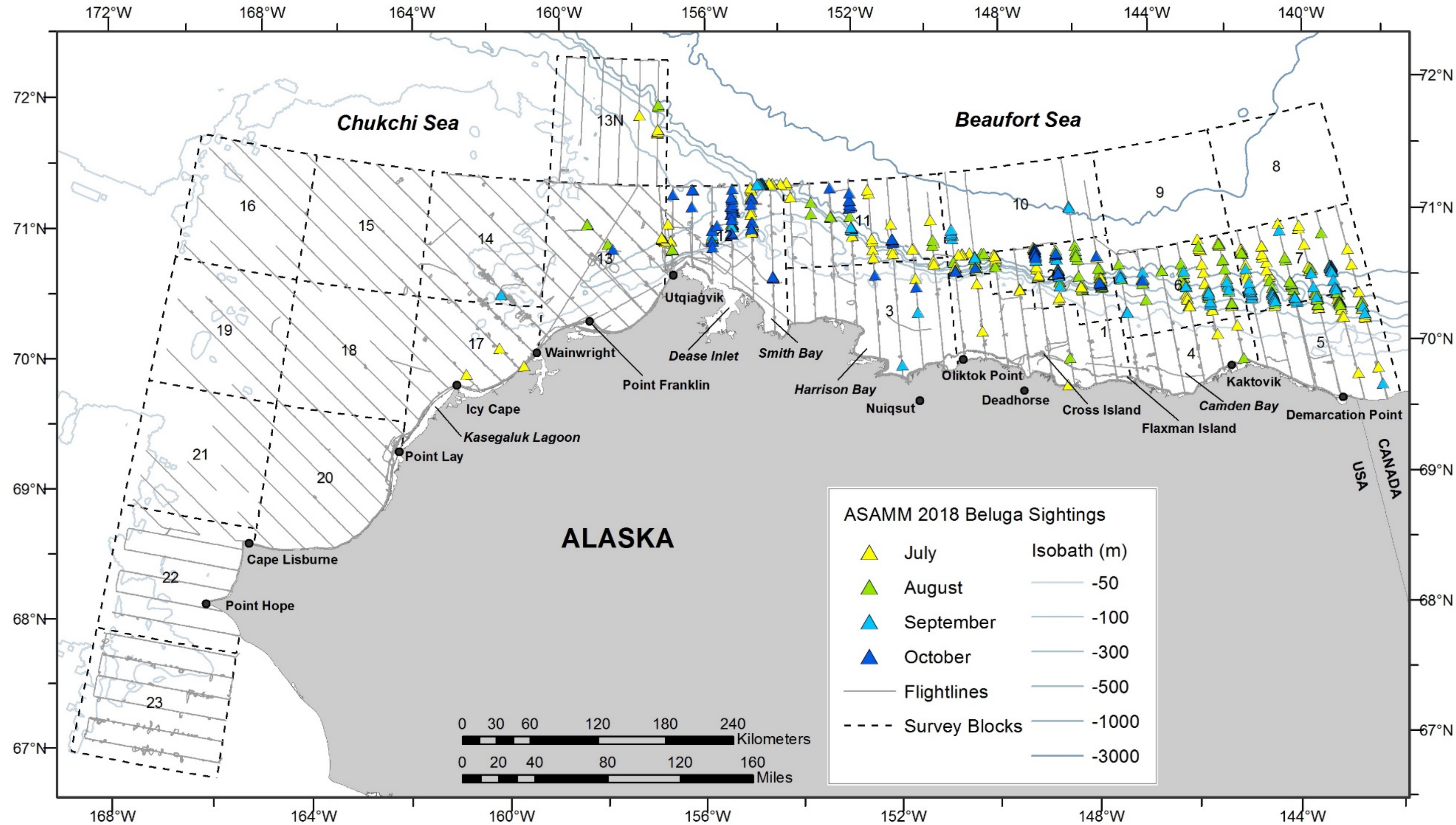
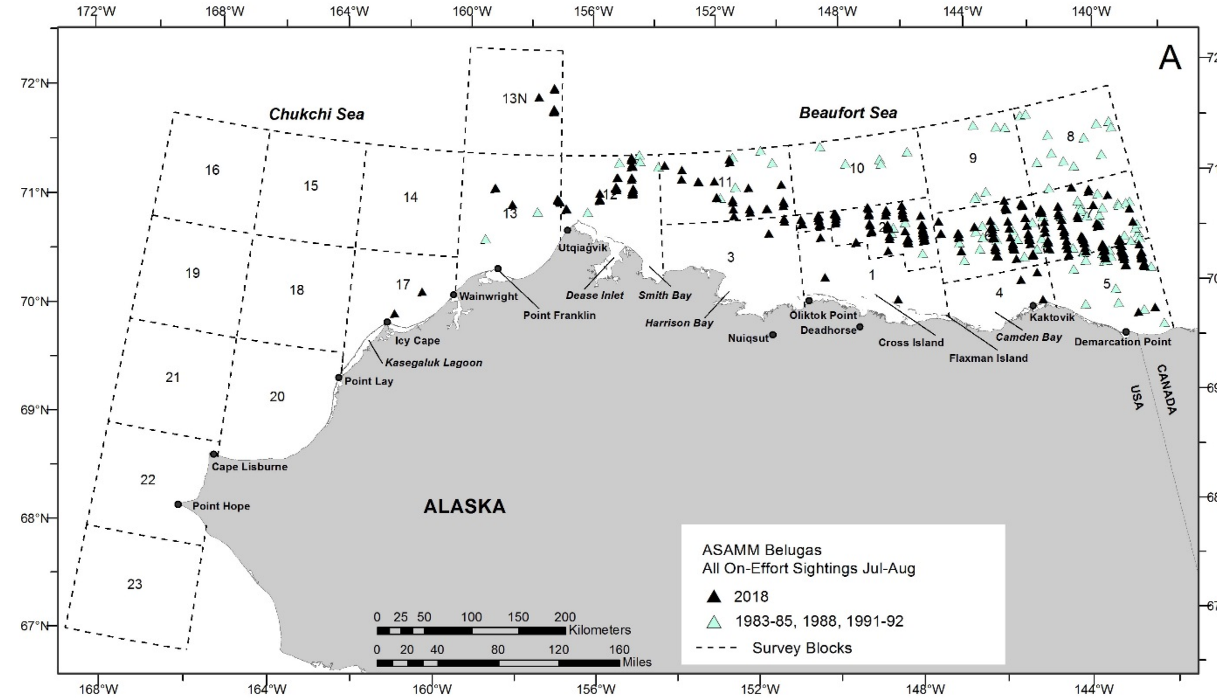


Figure 35. ASAMM 2018 beluga sightings, all survey modes, plotted by month, with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.



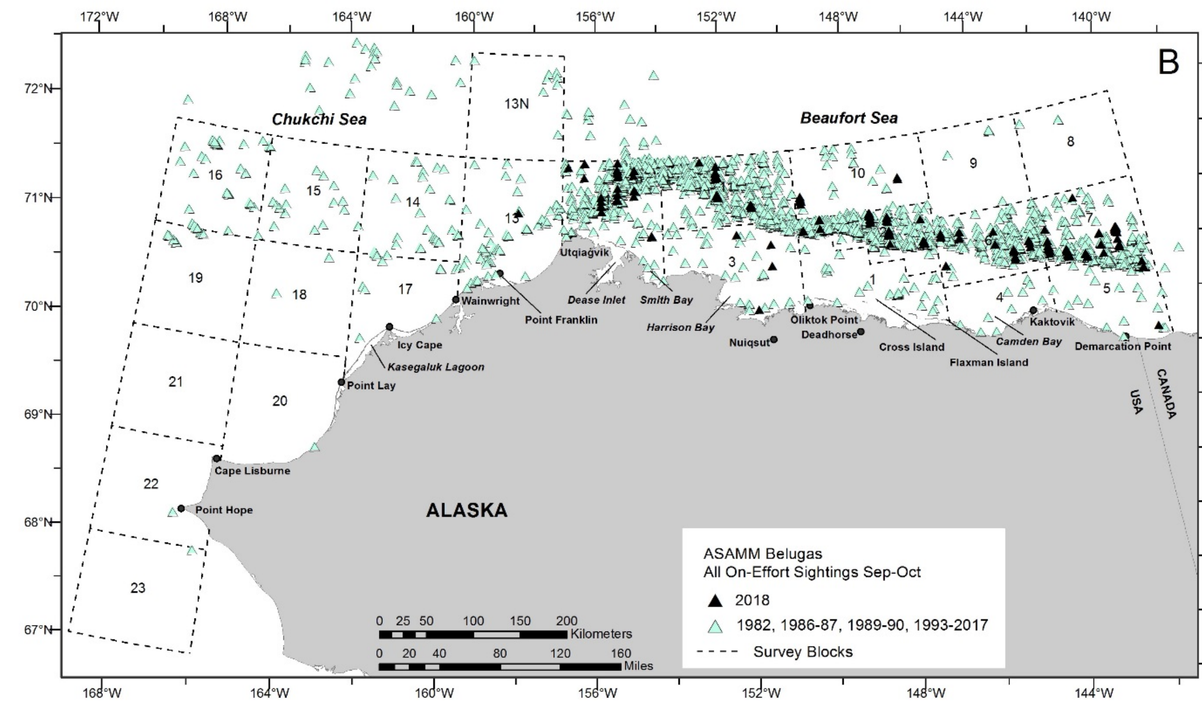


Figure 36. ASAMM beluga on-effort seasonal sightings, 1982-2018. A: summer (July-August) in years with moderate to heavy sea ice cover (1983-1985, 1988, 1991-1992, 2018). B: September-October in years with light ice cover (1982, 1986-1987, 1989-1990, 1993-2018). Includes all on-effort sightings made by primary and secondary observers.

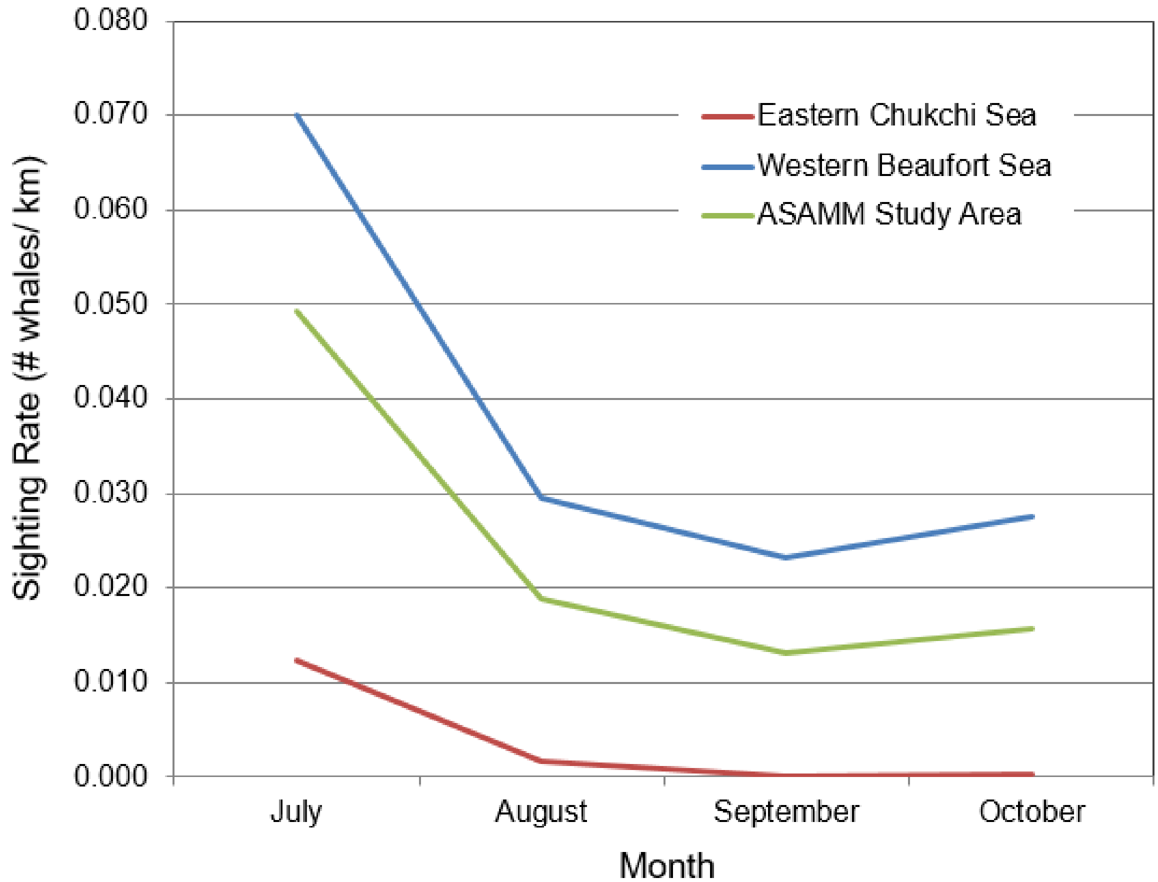


Figure 37. ASAMM 2018 beluga on-effort monthly sighting rates (WPUE; transect sightings from primary observers only) in the western Beaufort and eastern Chukchi seas, and in the entire ASAMM study area.

Beluga transect sighting rates per depth zone were highest in the 201-2,000 m depth zone near Barrow Canyon (154°W-157°W) and in the centra-eastern Beaufort Sea (140°W-154°W) (Figure 40; Appendix E, Table E-6). In the northeastern Chukchi Sea (157°W-169°W), beluga transect sighting rate per depth zone was highest in the 51-200 m North depth zone (Appendix E, Table E-6).

Beluga Sea Ice Associations

Belugas were observed in sea ice cover ranging from no ice to 98% floe, broken floe, or new-grease ice. Over half of the belugas sightings (51%, $n_i = 925$) were in areas with no ice, 13% ($n_i = 234$) were in 1-29% sea ice cover, 6% ($n_i = 101$) were in 30-59% sea ice cover, and 30% ($n_i = 554$) were in ≥60% sea ice cover. Most of the belugas observed in ≥60% sea ice were seen in July and August in the western Beaufort Sea, where sea ice persisted well into September (Appendix A, Figure A-6).

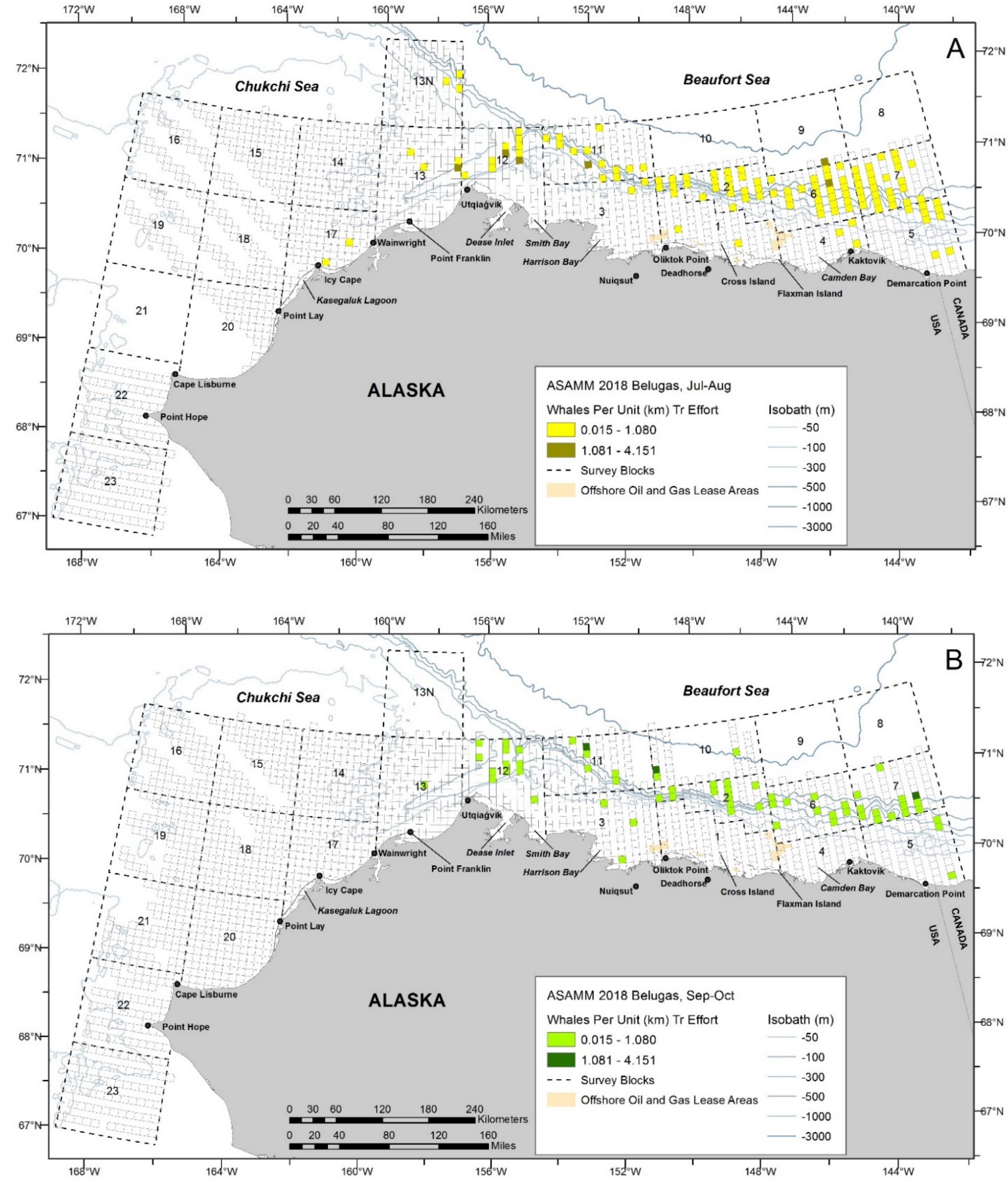


Figure 38. ASAMM 2018 beluga on-effort seasonal sighting rates (WPUE; sightings from primary observers only). A: summer (July-August pooled). B: fall (September-October pooled). Empty cells indicate sighting rates of zero. Transect survey effort was not conducted in areas without cell outlines.

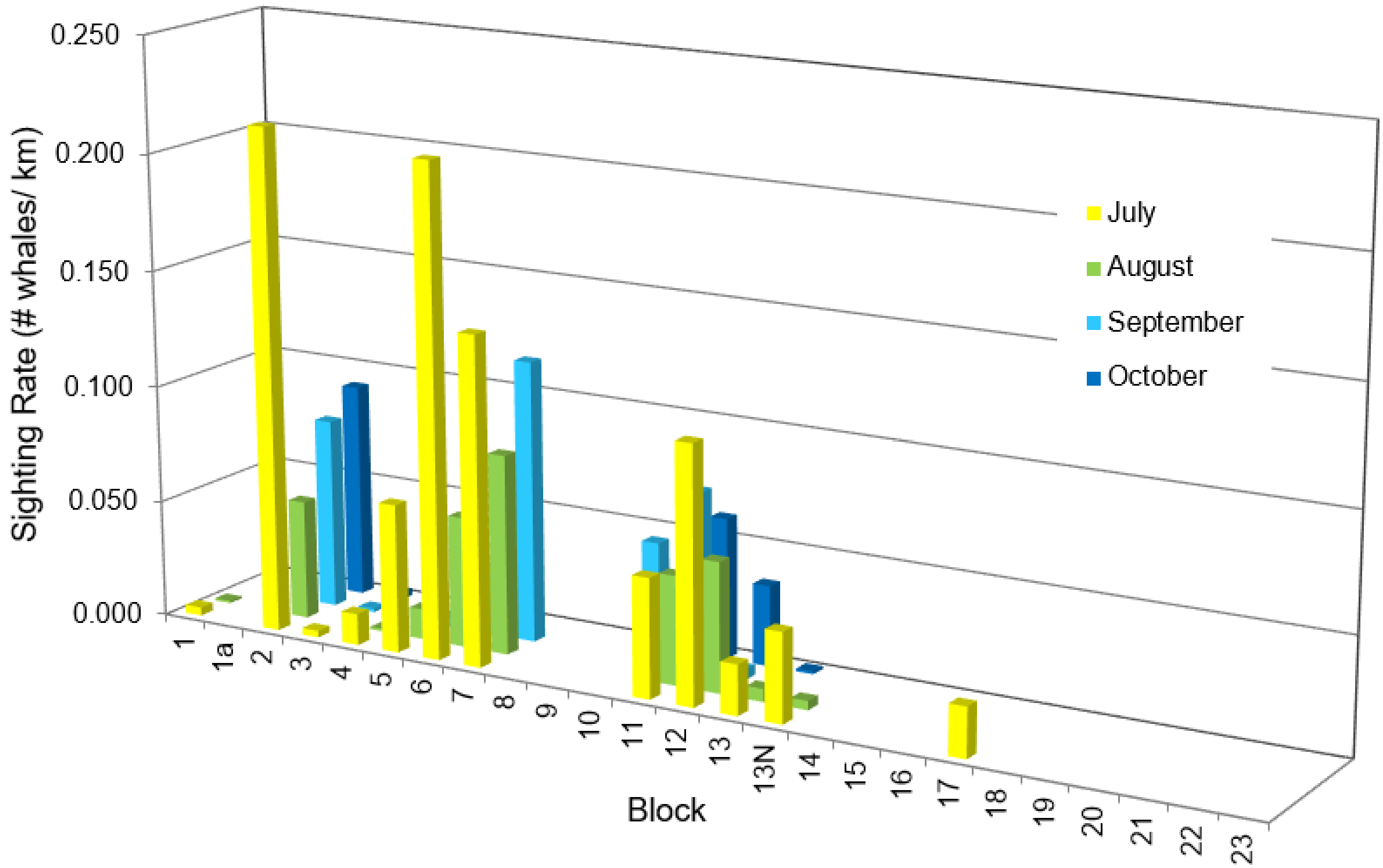


Figure 39. ASAMM 2018 beluga on-effort monthly sighting rates (WPUE; sightings from primary observers only) per block, July-October. Sighting rates of zero were removed from the graph for clarity.

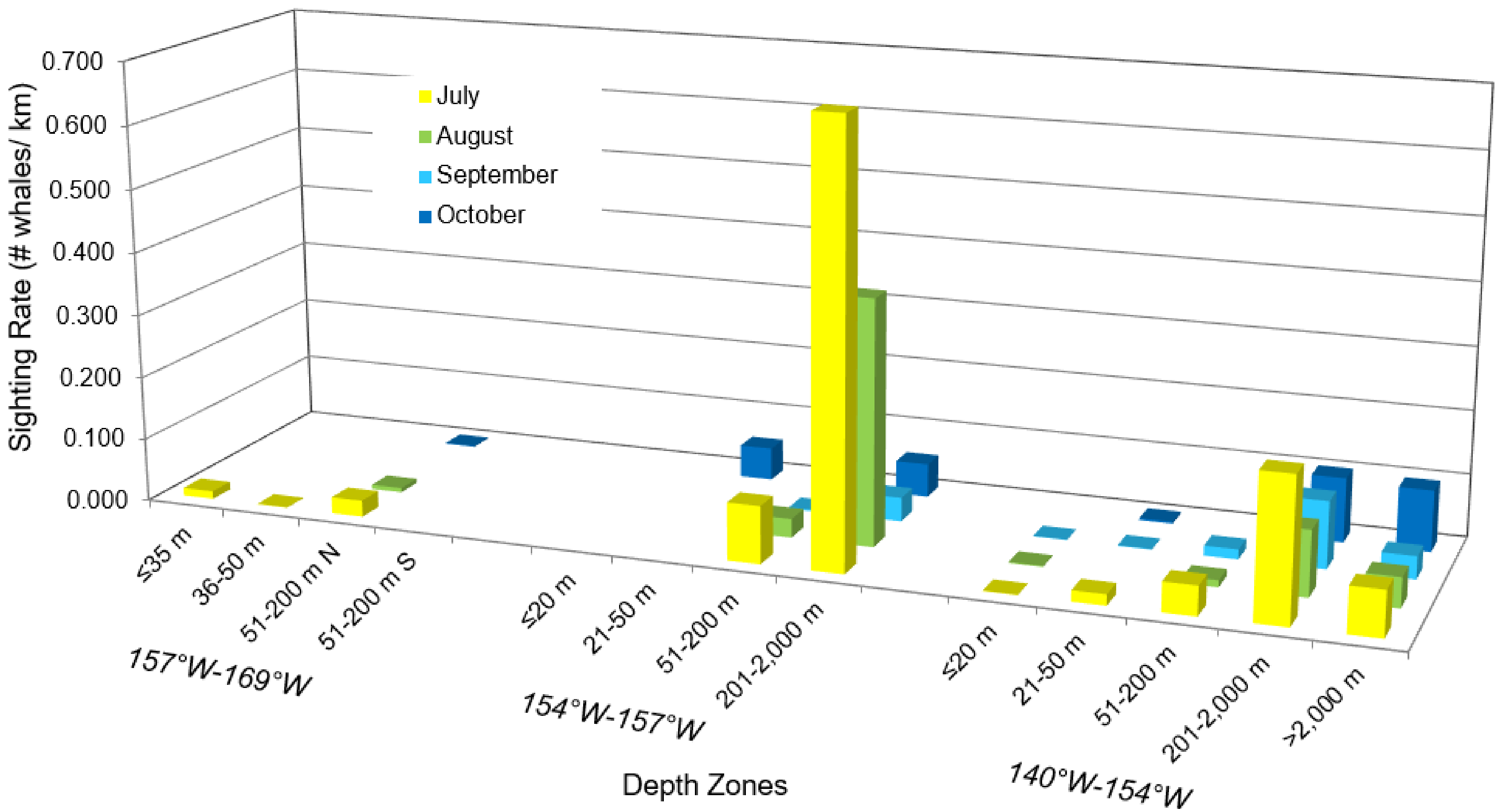


Figure 40. ASAMM 2018 beluga on-effort monthly sighting rates (WPUE; sightings from primary observers only) per depth zone, July-October. Sighting rates of zero were removed from the graph for clarity.

Beluga Behaviors

Beluga behaviors observed during transect, CAPs, circling, and search survey modes in 2018 are summarized in Table 11. The behavior most often recorded was swimming (87%). Milling was recorded for 120 belugas (7%), resting was recorded for 115 belugas (6%), and eight belugas (<1%) were observed diving. Twenty-two belugas (1%) appeared to respond to the survey aircraft by changing their initially observed behavior, usually from swimming or milling to diving.

Swim direction was evaluated for belugas for different regions and time periods. Swim direction was westerly in the western Beaufort Sea (140°W-154°W) in summer, clustered around a mean heading of 280°T ($Z = 47.257$, $P < 0.0001$, 228 observations). In fall, swim direction in the western Beaufort Sea remained westerly, significantly clustered around a mean heading of 279°T ($Z = 21.442$, $P < 0.0001$, 135 observations). Mean vector swim directions for belugas in the northeastern Chukchi Sea (154°W-169°W, to incorporate Barrow Canyon) were not significantly clustered around a mean heading in summer or fall.

There were 144 sightings of 230 beluga calves observed during transect, CAPs, circling, and search survey modes (Figure 41). Animals identified as calves likely included belugas up to a few years old. Calves nurse for up to two years but may remain with their mothers after weaning (Suydam 2009), often forming triads when a new calf is born. Color is not necessarily a good indication of age because beluga calves lighten progressively over time, changing from charcoal gray at birth to blue-gray then light gray before becoming completely white by 7-9 years of age. Beluga calf sightings were scattered across the western Beaufort Sea slope and in Barrow Canyon (Figure 41). The largest calf concentration was observed south of Wainwright in mid-July, part of a group of approximately 400 belugas.

Beluga calves may be underrepresented in the dataset because of their small size and the infrequency of circling over beluga sightings.

Killer Whales

There were two sightings of 16 killer whales (*Orcinus orca*) in 2018 (Table 4; Figure 33). A group of four killer whales were observed on 30 August, approximately 35 km north of Utqiaġvik. Twelve killer whales, in five small closely aligned groups, were seen on 30 September, approximately 50 km west of Wainwright. The latter sighting included one adult male and one calf, and individuals were observed swimming subsurface upside down and tail lobbing while on their sides. None of the killer whales appeared to respond to the survey aircraft.

Table 11. ASAMM 2018 semimonthly summary of belugas (number of sightings/ number of individuals) observed during transect, circling, and search survey modes, by behavioral category. Excludes dead and same-day repeat sightings.

Behavior	1-15 Jul	16-31 Jul	1-15 Aug	16-31 Aug	1-15 Sep	16-30 Sep	1-15 Oct	16-31 Oct	Total
Dive	0	3/4	0	2/3	0	0	0	1/1	6/8
Mill	6/53	6/28	6/15	3/17	1/7	0	0	0	22/120
Rest	5/40	22/37	7/9	6/8	4/5	4/4	5/6	5/6	58/115
Swim	35/559	134/376	52/82	74/123	55/91	70/183	58/124	19/33	497/1,571
TOTAL	46/652	165/445	65/106	85/151	60/103	74/187	63/130	25/40	583/1,814

Harbor Porpoises

There were 15 sightings of 21 harbor porpoises (*Phocoena phocoena*) in 2018, all in the eastern Chukchi Sea (Table 4; Figure 33). One harbor porpoise was observed in July in the southcentral Chukchi Sea. Sightings of harbor porpoises in September were primarily in the southcentral Chukchi Sea, except for one porpoise sighted approximately 135 km west-northwest of Utqiaġvik. All harbor porpoises sighted in October were in the northeastern Chukchi Sea. All porpoises were observed swimming or diving, and none appeared to respond to the survey aircraft.

Unidentified Cetaceans

Sightings were recorded as unidentified when a positive species identification was not possible. This usually occurred when an animal dived and could not be resighted or when environmental conditions such as fog, low cloud ceilings, glare, or sea state hindered efforts to relocate the initial sighting. Some cetacean sightings were also recorded as unidentified during CAPs passing, which resulted in higher than normal unidentified sighting totals in 2018. There were 60 sightings of 111 unidentified cetaceans in 2018 (Table 4; Figure 42); 28 sightings of 78 unidentified cetaceans were recorded during CAPs passing mode. Ten of the unidentified cetaceans were in the western Beaufort Sea and 101 unidentified cetaceans were in the eastern Chukchi Sea. Most (n_i = 91) unidentified cetacean sightings were in block 23, sighted during CAPs passing, and were likely fin or humpback whales based on species identification during CAPs circling. Four of the unidentified cetaceans in the western Beaufort Sea were probable bowhead whales, based on their size and darker color. One unidentified cetacean was likely a gray whale and one was possibly a minke whale, but several unidentified cetacean sightings were not seen clearly enough to infer species with any probability. None of the unidentified cetaceans appeared to respond to the survey aircraft.

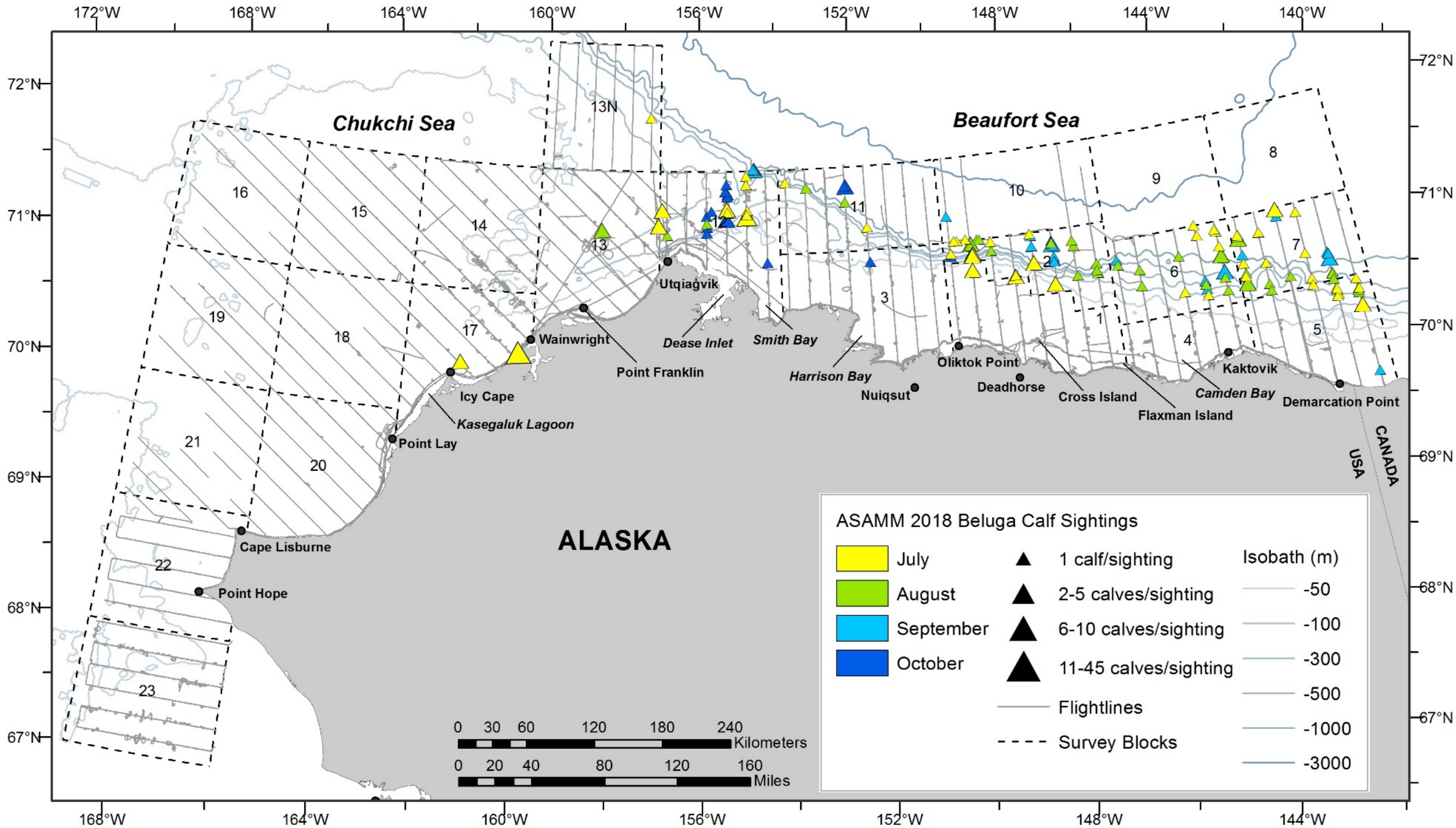


Figure 41. ASAMM 2018 beluga calf sightings, all survey modes, plotted by month, with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.

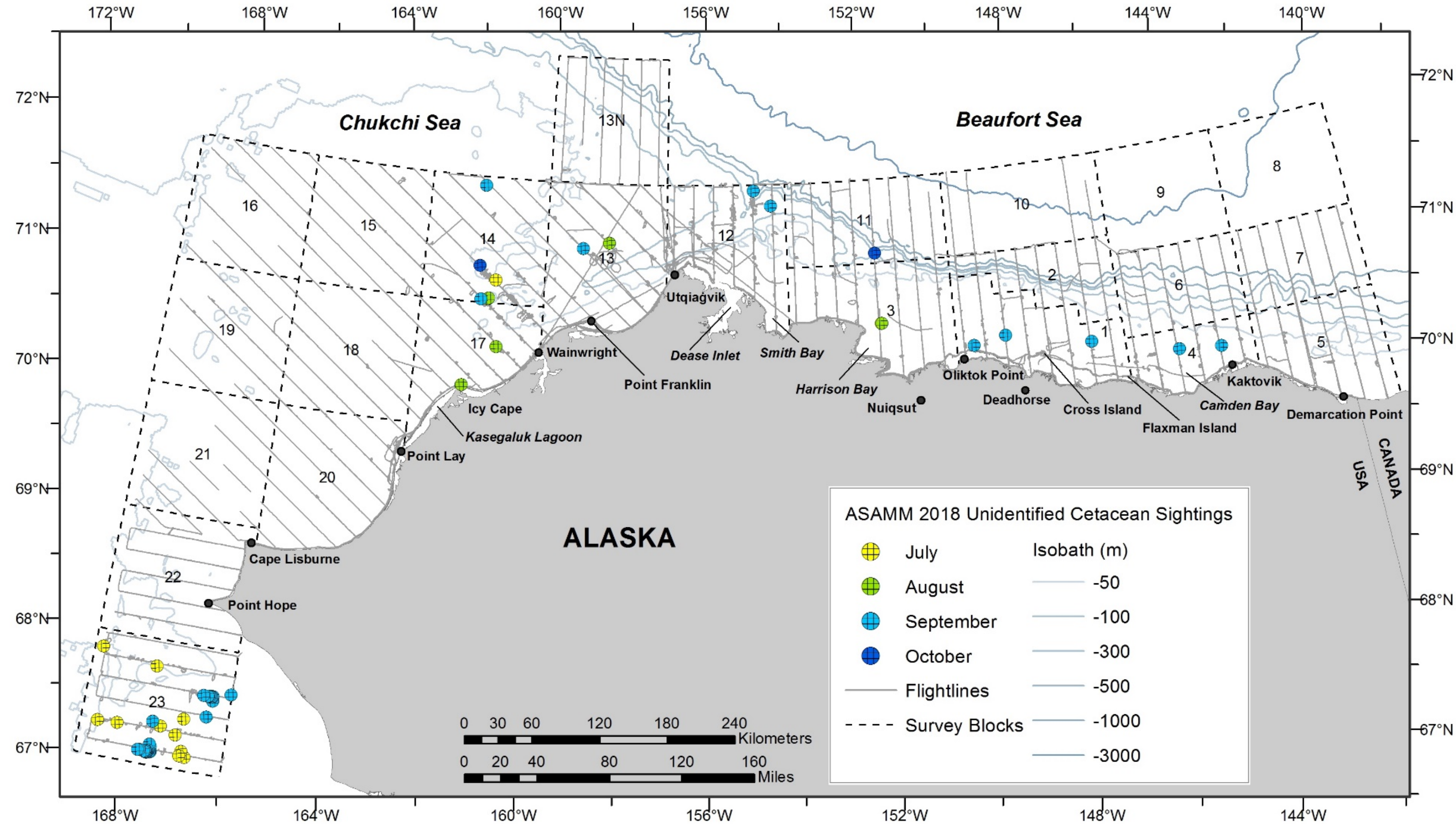


Figure 42. ASAMM 2018 unidentified cetacean sightings, all survey modes, plotted by month, with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.

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Pinnipeds

Walruses

Pacific walruses (*Odobenus rosmarus divergens*) were observed every month in the eastern Chukchi Sea (Figure 43). Excluding dead walruses and walruses that were known to be duplicate sightings within the same day, there were 991 sightings of 185,688 walruses observed from July to October 2018 (Tables 12 and 13). This total is deceptively high because it includes resightings of a large, coastal walrus haulout near Point Lay. When only the highest group size estimate of the haulout is considered (n_s = 1, n_i = 40,000), there were 979 sightings of 65,138 walruses in 2018. Excluding sightings of the Point Lay haulout, most walruses (77%, n_i = 19,443 out of 25,138) were sighted in July, with the majority of sightings in the northeastern Chukchi Sea. Relatively few walruses (n_s = 16, n_i = 494) were observed in the western Beaufort Sea, between Point Barrow and 154.3°W.

Excluding walruses that hauled out on shore, most walruses (97%, n_i = 21,367 out of 22,104) observed in July and August were hauled out on sea ice that remained in the northeastern Chukchi Sea study area. Several large groups of walruses were observed hauled out on shorefast ice between Point Franklin and Wainwright and on sea ice west and northwest of Utqiaġvik (Figure 43A, B). Walruses were also seen during surveys north of 72°N on the westernmost transect in block 13N. In September, walruses were observed widely scattered in the northeastern Chukchi Sea between 157°W and 166°W (Figure 43C). By October, most walruses were sighted within approximately 70 km of Point Lay, with a few sightings on Hanna Shoal (Figure 43D). Walruses hauled out on sea ice were in groups ranging in size from 1 to 5,500 animals. Walruses not hauled out were observed swimming, resting, milling, or diving.

The United States Geological Survey (USGS) informed ASAMM that walruses began coming ashore on 24 August 2018 to a barrier island near Point Lay (C. Jay, USGS, pers comm to J. Clarke, 28 August 2018). An ASAMM survey conducted on 30 August (Appendix B, Flight 226) documented a large haulout numbering approximately 25,000 walruses located on a barrier island west of Point Lay. The initial position of the haulout was within 2 km of the location of walrus haulouts west of Point Lay documented during ASAMM surveys in 2010 (Clarke et al. 2011d), 2013 (Clarke et al. 2014), 2015 (Clarke et al. 2017a), and 2016 (Clarke et al. 2017b), and slightly south of haulout locations in 2011 (Clarke et al. 2012) and 2014 (Clarke et al. 2015a). ASAMM observed the walrus haulout aggregation(s) during six subsequent surveys, on 15, 18, and 28 September; and 2, 3, and 19 October. Group size estimates ranged from 11,000 (19 October) to 40,000 (2 October). Over the nearly two-month time period that the haulout was documented on the barrier island in summer and fall 2018, the location of the haulout was dynamic, moving approximately 1 km south and 3 km north from the initial location. To avoid disturbing the walruses, photographs of the haulout were taken from greater than 3.7 km lateral distance and 2000 m altitude.

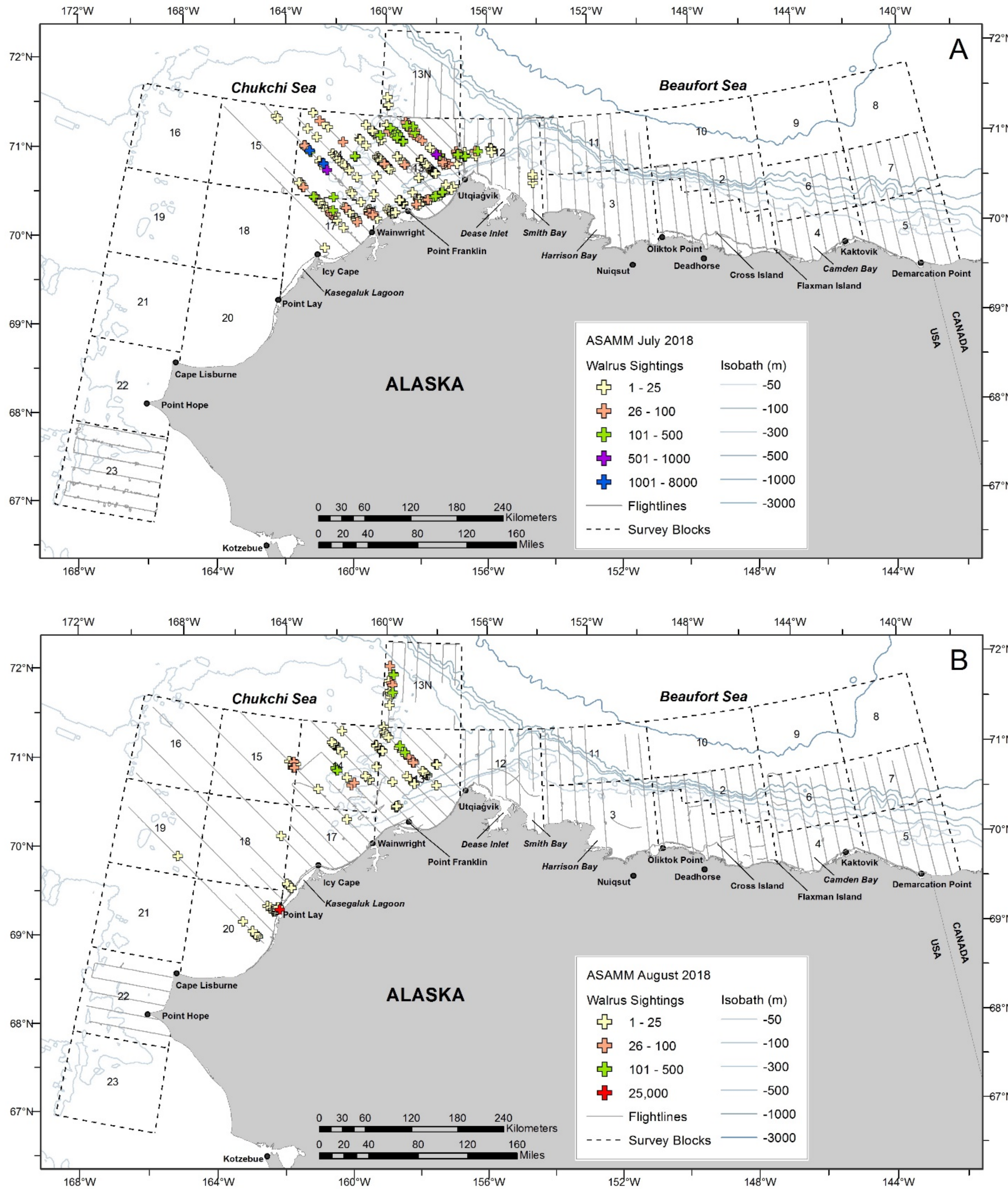

Figure 43. ASAMM 2018 walrus sightings, plotted by month and group size; sightings and effort from transect, CAPs, search, circling, and FGF survey mode, July-October. A: July. B: August. Deadhead flight tracks are not shown.

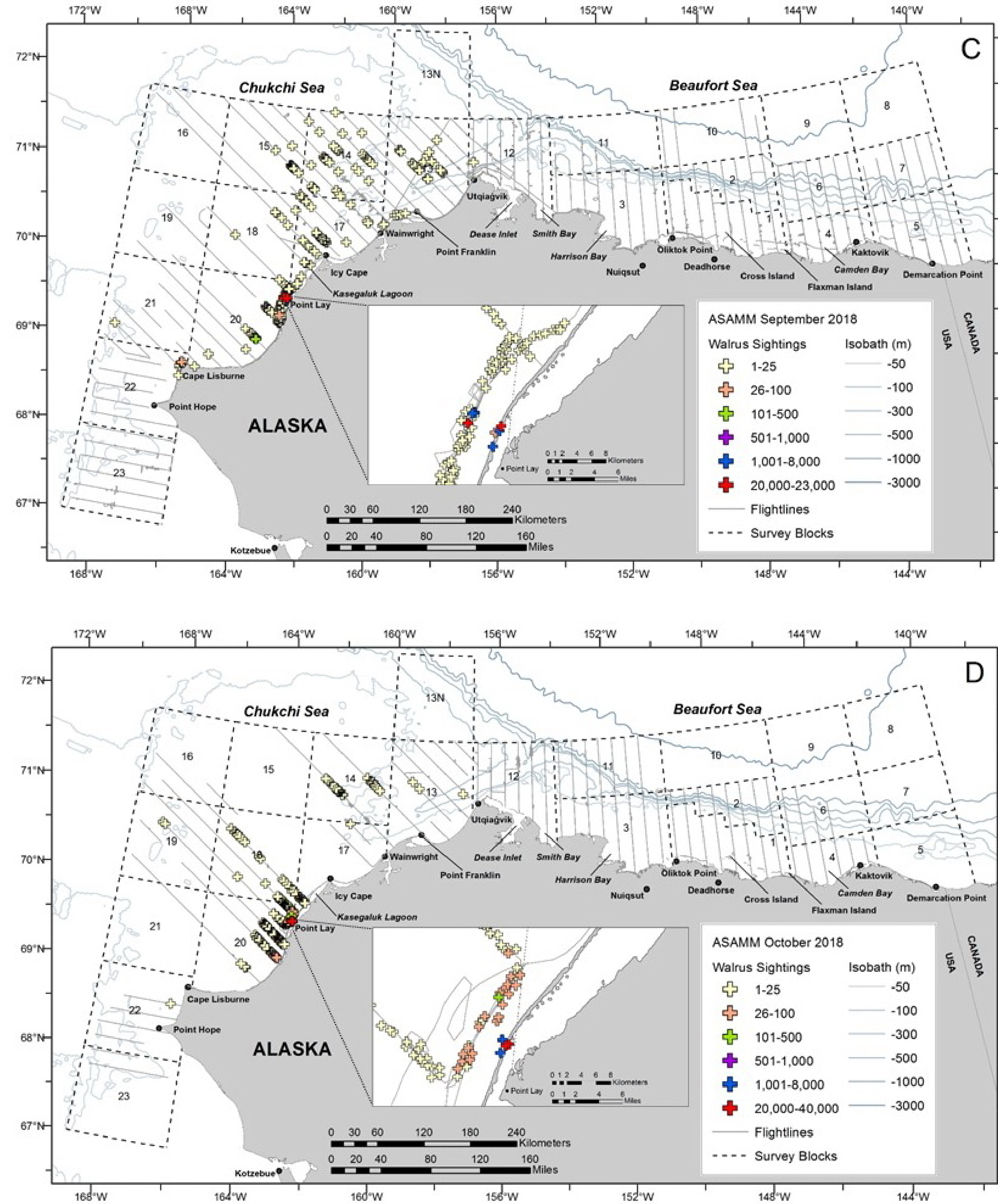

Figure 43 (cont.). ASAMM 2018 walrus sightings, plotted by month and group size; sightings and effort from transect, CAPs, search, circling, and FGF survey mode, July-October. C: September. D: October. Deadhead flight tracks are not shown.

Table 12. Summary of ASAMM pinniped and polar bear sightings (number of sightings/number of individuals) during transect, search, and circling survey modes, in chronological order, 3 July–27 October 2018, by survey flight and semimonthly time period. Excludes dead and repeat sightings.

Day	Flight No.	Walrus	Bearded Seal	Unidentified Pinniped*	Polar Bear
3 Jul	201	0	0	3/4	0
6 Jul	202	35/189	20/20	10/11	0
9 Jul	203	25/960	3/3	4/4	1/1
10 Jul	204	2/24	3/5	7/8	1/1
11 Jul	205	65/11,176	3/5	6/6	0
12 Jul	206	12/334	1/1	9/11	0
13 Jul	207	0	1/1	4/4	0
14 Jul	208	0	0	10/10	0
19 Jul	209	0	1/2	0	0
20 Jul	210	23/40	0	11/11	1/1
20 Jul	1	0	1/2	11/11	0
21 Jul	211	8/331	2/4	11/85	0
21 Jul	2	0	0	2/2	0
22 Jul	3	0	0	0	0
24 Jul	212	13/252	0	2/13	0
26 Jul	4	0	1/1	4/5	1/1
29 Jul	213	0	1/1	24/28	0
29 Jul	5	7/162	2/2	12/12	0
30 Jul	214	87/5,975	2/2	2/2	0
30 Jul	6	0	0	1/1	1/1
31 Jul	215	0	0	0	0
31 Jul	7	0	1/1	7/10	0
3 Aug	8	0	0	2/2	0
5 Aug	216	0	0	0	0
6 Aug	217	0	0	0	0
8 Aug	218	2/2	0	0	0
8 Aug	9	0	1/1	1/1	0
9 Aug	219	0	0	3/2,051	0
9 Aug	10	0	1/1	1/2	1/3
12 Aug	11	0	0	0	0
14 Aug	220	15/1,129	1/1	3/3	0
14 Aug	12	0	0	1/1	0

Day	Flight No.	Walrus	Bearded Seal	Unidentified Pinniped*	Polar Bear
15 Aug	13	0	0	4/4	0
17 Aug	221	30/1,330	12/14	7/7	0
17 Aug	14	0	0	0	0
18 Aug	15	0	0	3/3	1/1
19 Aug	222	0	7/7	6/60	1/1
19 Aug	16	0	0	2/2	0
22 Aug	223	2/12	0	0	0
25 Aug	224	0	0	0	0
26 Aug	17	0	0	0	0
28 Aug	225	36/125	0	0	0
28 Aug	18	0	2/2	3/3	0
29 Aug	19	0	2/2	4/5	1/1
30 Aug	226	29/25,035	0	6/8	0
30 Aug	20	15/28	0	3/3	1/1
31 Aug	21	0	0	0	0
1 Sep	227	16/20	0	2/2	0
1 Sep	22	0	1/1	4/4	1/1
2 Sep	228	7/16	0	0	0
2 Sep	23	0	1/1	16/17	0
4 Sep	229	20/30	1/1	17/17	0
4 Sep	24	0	0	2/2	0
5 Sep	25	0	0	10/85	0
7 Sep	26	0	0	0	0
8 Sep	27	0	2/2	16/17	0
9 Sep	28	0	1/1	7/7	0
11 Sep	230	11/12	0	0	0
11 Sep	29	0	0	0	0
12 Sep	231	0	0	1/1	0
15 Sep	232	72/27,699	0	10/13	0
15 Sep	30	0	0	0	0
16 Sep	233	3/6	0	5/5	0
18 Sep	234	62/11,169	0	3/3	0
18 Sep	31	0	0	0	0
19 Sep	235	14/538	1/1	47/168	0
19 Sep	32	0	0	1/15	3/3
20 Sep	33	0	3/3	8/10	1/1

Day	Flight No.	Walrus	Bearded Seal	Unidentified Pinniped*	Polar Bear
21 Sep	236	0	0	0	0
22 Sep	237	0	0	0	0
23 Sep	238	0	0	17/18	0
23 Sep	34	0	0	1/1	1/1
24 Sep	35	0	1/1	1/1	1/1
25 Sep	239	3/4	0	8/8	0
25 Sep	36	0	3/4	32/42	2/3
26 Sep	240	0	1/1	40/55	1/3
26 Sep	37	0	0	2/2	2/44
27 Sep	241	14/23	0	12/12	1/1
28 Sep	242	26/23,162	0	8/8	0
30 Sep	243	52/140	0	57/60	0
30 Sep	38	15/20	0	0	1/2
2 Oct	244	64/40,134	0	37/47	0
3 Oct	245	126/24,218	1/1	11/11	0
3 Oct	39	0	0	0	1/37
5 Oct	246	39/333	0	20/21	0
6 Oct	247	1/2	0	1/1	0
7 Oct	248	0	0	0	0
7 Oct	40	0	0	25/31	0
8 Oct	249	0	0	1/1	0
8 Oct	41	0	0	0	0
9 Oct	250	35/55	0	10/10	0
14 Oct	251	0	0	0	0
15 Oct	252	0	0	0	0
19 Oct	253	3/11,001	0	1/100	0
20 Oct	254	1/1	0	0	0
22 Oct	255	0	0	1/1	0
23 Oct	256	1/1	2/2	3/3	0
26 Oct	257	0	0	0	1/13
27 Oct	258	0	0	1/1	1/5

Date	Walrus	Bearded Seal	Unidentified Pinniped*	Polar Bear
		Semimonthly Summary		
1-15 Jul	139/12,683	31/35	53/58	2/2
16-31 Jul	138/6,760	11/15	87/180	3/3
1-15 Aug	17/1,131	3/3	15/2,064	1/3
16-31 Aug	112/26,530	23/25	34/91	4/4
1-15 Sep	126/27,777	6/6	85/165	1/1
16-30 Sep	189/35,062	9/10	242/408	13/59
1-15 Oct	265/64,742	1/1	105/122	1/37
16-31 Oct	5/11,003	2/2	6/105	2/18
TOTAL	991/185,688	86/97	627/3,193	27/127

* Includes sightings designated as 'unidentified pinniped' and 'small unidentified pinniped'

Fine-scale transect sighting rates of walruses prior to the formation of the coastal haulout near Point Lay on 30 August were highest in block 14, which encompasses Hanna Shoal, and block 13 (Figure 44A). Highest fine-scale transect sighting rates of walruses observed after the Point Lay haulout was established were in block 20, near to and south of the haulout (Figure 44B).

There were 2,926 walruses (representing <2% of all walruses sighted) that appeared to respond to the survey aircraft, including one group of 1,600 that flushed off an ice floe in mid-July despite a higher-than-normal survey altitude (>2300 ft). Reactions included flushing from ice floes into the water (n_i = 2,870) and diving (n_i = 56). No walruses in the large coastal haulout appeared to respond to the survey aircraft.

Other Pinnipeds

Pinnipeds were distributed throughout most of the study area, primarily on the continental shelf, and during all months (Figures 45 and 46). One pinniped was seen in block 1a, between the barrier islands and the shoreline.

Bearded seals (*Erignathus barbatus*; n_s = 86, n_i = 97) were observed from early July through late October (Table 12, Figure 46). Fewer bearded seals were seen in the western Beaufort Sea (n_i = 35) than in the northeastern Chukchi Sea (n_i = 61); one bearded seal was seen in the southcentral Chukchi Sea. More than half of the bearded seals were seen in July (n_i = 50), when sea ice remained in the study area; 22 bearded seals were observed hauled out on sea ice. Bearded seals were not observed hauled out on the beach. Four bearded seals (4%) responded to the aircraft by diving.

Table 13. ASAMM 2018 walrus sightings observed during transect, search and circling survey modes.

	No. Sightings	No. Individuals
Dead*	24	24
Highest estimate of Point Lay haulout**	1	40,000
Total, excluding repeat sightings	1,010	185,707
Total, excluding dead and repeat sightings	991	185,688
Total, excluding dead, repeat, & additional Point Lay haulout sightings***	979	65,138

* May include duplicates of carcasses sighted on different survey dates.

** Highest group size estimate was observed on 10/2/2018.

*** Includes only the highest estimate of the Point Lay haulout.

Other pinnipeds not identifiable to species were recorded as either unidentified pinnipeds (n_s = 55; n_i = 58) or small unidentified pinnipeds (n_s = 572; n_i = 3,135) (Figure 45). Unidentified pinnipeds likely included sightings of ringed (*Pusa hispida*), spotted (*Phoca largha*), ribbon (*Histriophoca fasciata*), and bearded seals, in addition to small walruses. Small unidentified pinnipeds included sightings of small pinnipeds (ringed and spotted seals and possibly juvenile bearded seals) only.

Most unidentified pinnipeds were observed in the water swimming, diving, milling, and resting. Small groups of one to 66 seals were observed hauled out on sea ice in the northeastern Chukchi and central Alaskan Beaufort seas in July and early August. Five groups of unidentified pinnipeds, likely spotted seals, were seen hauled out on barrier islands or the beach. Two groups (n_i = 1,300 and 750) were sighted on 9 August and one group (n_i = 55) was sighted on 19 August on a barrier island east of Icy Cape. One group of 15 was sighted on a beach in Harrison Bay on 19 September (Figure 7). One group of 100 was sighted south of Point Lay on 19 October.

One hundred eleven unidentified pinnipeds (3% of all unidentified pinnipeds sighted) appeared to respond to the aircraft. Most pinnipeds that responded were initially swimming, milling, or resting in the water and responded by diving, but one moderately large group (n_i = 55) and a few smaller groups flushed from haulouts on the ice or land.

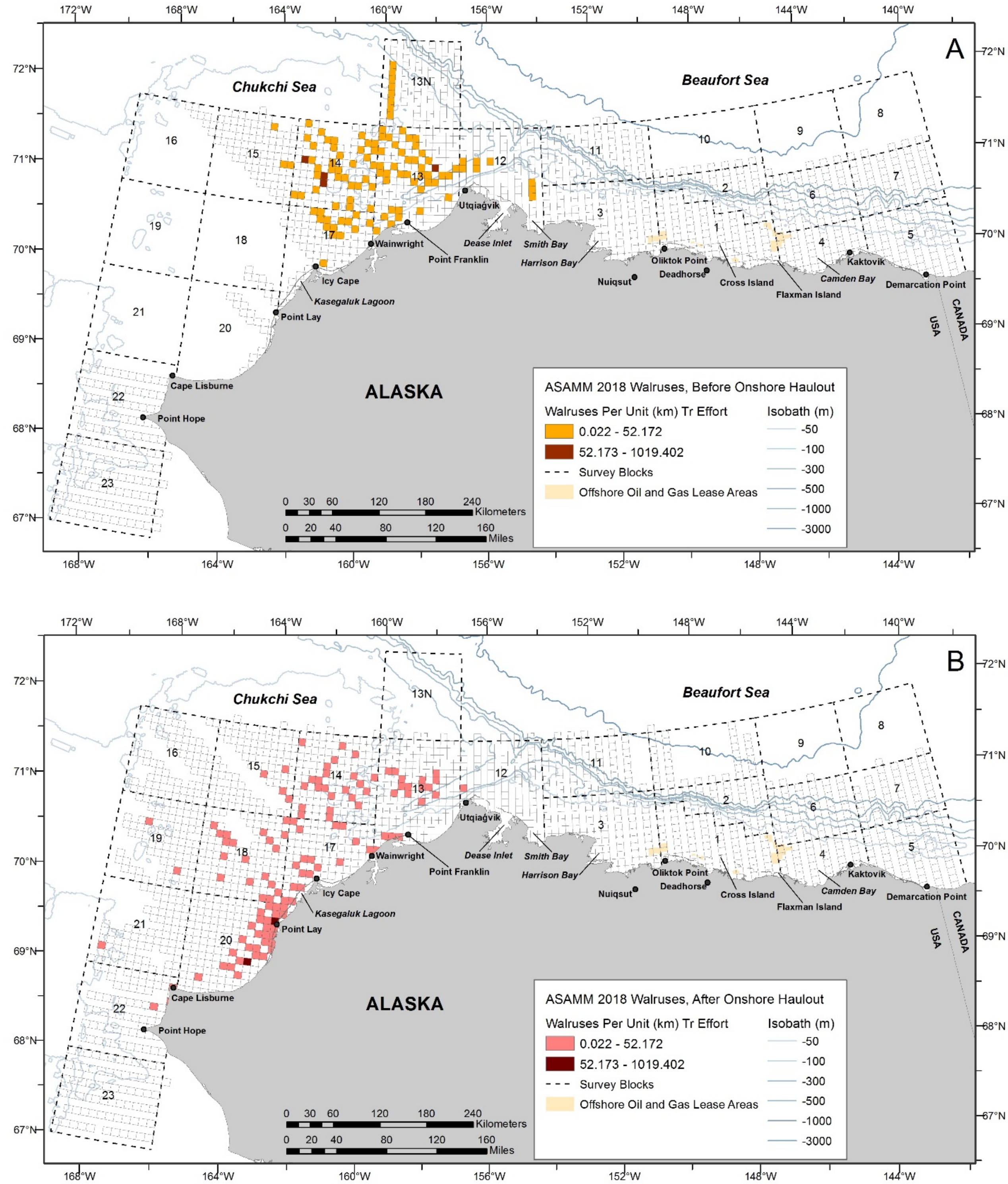

Figure 44. ASAMM 2018 walrus on-effort sighting rates (WPUE; transect sightings from primary observers only). A: 3 July-29 August pooled (prior to the formation of the coastal haulout at Point Lay. B: 30 August-27 October pooled (after the formation of coastal haulout at Point Lay). Empty cells indicate sighting rates of zero. Transect survey effort was not conducted in areas without cell outlines.

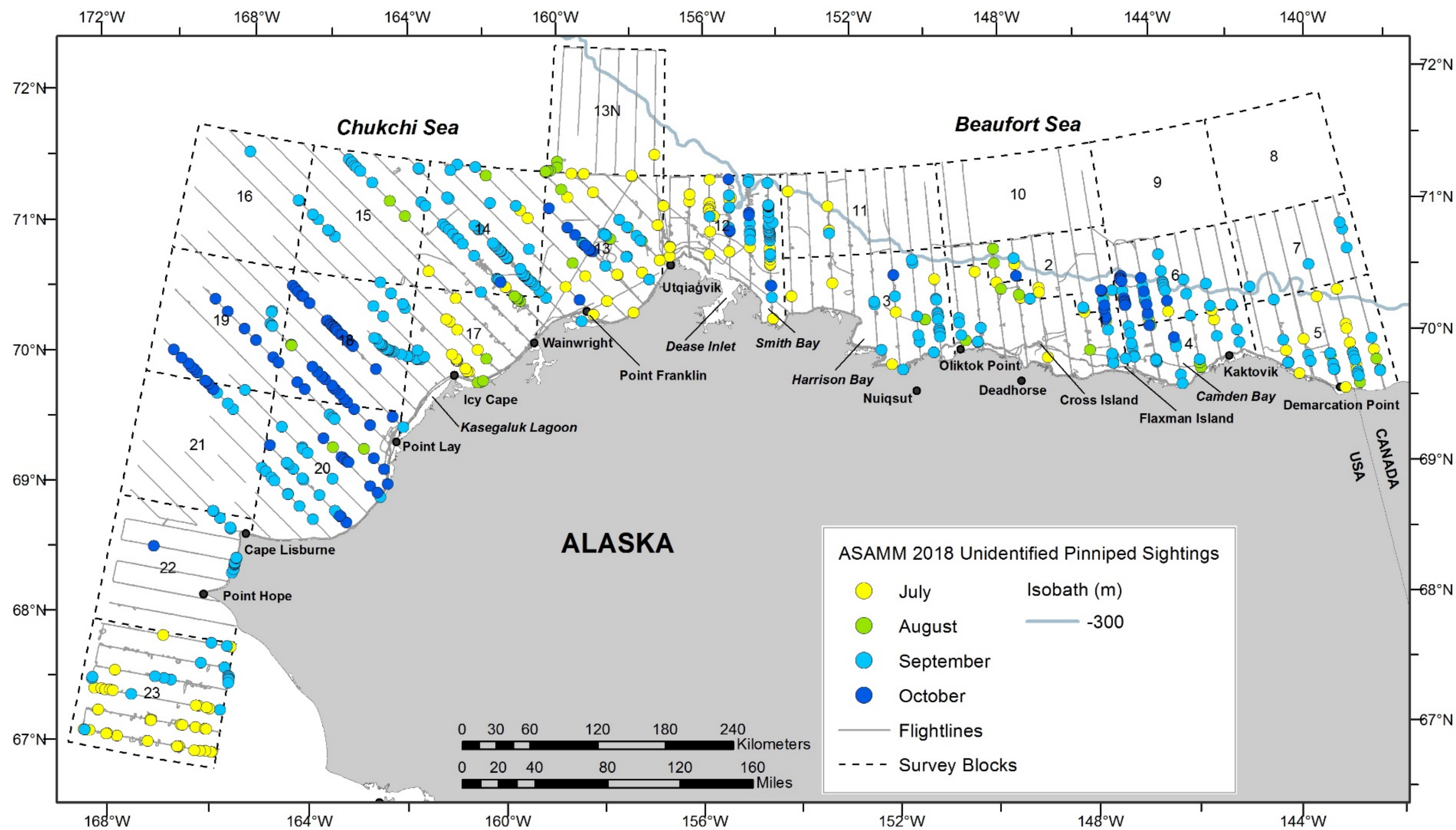

Figure 45. ASAMM 2018 unidentified pinniped (including small unidentified pinniped) sightings, all survey modes, plotted by month, with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.

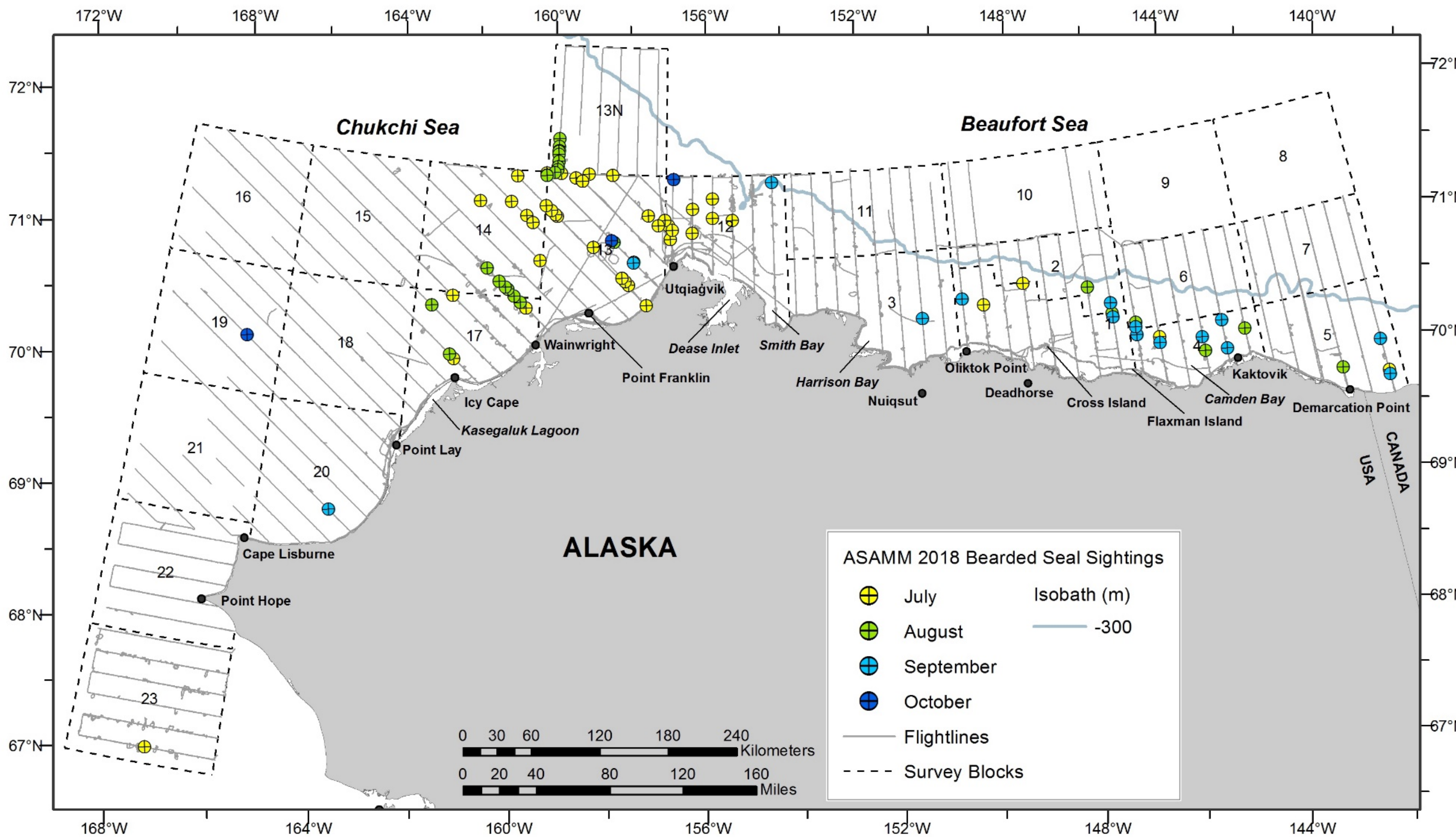

Figure 46. ASAMM 2018 bearded seal sightings, all survey modes, plotted by month; with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.

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Polar Bears

There were 27 sightings of 127 polar bears (*Ursus maritimus*) during ASAMM 2018 (Table 12, Figure 47). Polar bear sightings were distributed from east of Kaktovik to ~120 km northwest of Wainwright, with the majority of sightings in the western Beaufort Sea. Most polar bears (89%, n_i = 113) were seen on shore or barrier islands, or on sea ice or swimming within 3 km of land. Seven bears were seen on sea ice between 20 and 82 km from shore. Three polar bears were observed swimming in areas of 75-85% sea ice cover between 34 and 106 km from shore, and four polar bears were observed swimming in ice-free areas between 17 and 107 km from shore. All bears observed swimming in ice-free areas were seen in September, at which time sea ice had receded from shore. There were five sightings of five polar bears in July, five sightings of seven polar bears in August, 14 sightings of 60 polar bears in September, and three sightings of 55 polar bears in October. Some polar bears were undoubtedly resightings of bears seen on previous flights, especially at known aggregation areas.

Polar bears (n_s = 4; n_i = 94) were seen on or near (within 3 km) Cross Island, northeast of Deadhorse, on three days (Figure 47). Cross Island attracts scavenging polar bears because bowhead whale carcasses from fall subsistence harvests are hauled there by whalers from Nuiqsut, Alaska. Polar bears were not seen on Cross Island prior to the 2018 subsistence hunt.

Polar bear aggregations were not seen near Kaktovik, where they have been documented in the past, particularly after the fall subsistence hunt. Survey effort near Kaktovik was limited to two surveys after the fall 2018 subsistence hunt was completed in late September, so there were few opportunities to assess polar bear aggregations.

There was one sighting of one polar bear south of the barrier islands in block 1a.

The remaining polar bears, excluding bears seen offshore or near Cross Island or in block 1a, were sighted on barrier islands or the shoreline between Kaktovik and Point Franklin.

Polar bears were observed milling, resting, running, standing, swimming, and walking. Forty-four bears (35%) appeared to respond to the survey aircraft. Thirty-five bears looked up, three bears ran, three bears started walking, two bears flushed from land into the water, and one bear dived.

Beginning in 2012, photographs were opportunistically taken of polar bears on Cross Island and near Kaktovik and analyzed post-flight to more accurately count the total number of bears (Clarke et al. 2013a). In some of these instances, the final group size more than doubled the initial estimate once the photo analysis was completed. Photographic images from the ASAMM aircraft often did not capture the entire area of a location (e.g., all Cross Island or Bernard Spit), so polar bears that were present at a location but not photographed were not included in the revised total number, and the revised total was still considered an underestimate. In 2018, there were three opportunities to photograph Cross Island. Photographs were taken of Cross Island on 26 September, and 3 and 26 October. Although the entire island was not photographed on any of those dates, final group size estimates changed based on post-flight image analysis. On two of the three days, final group size increased from 20 to 37 (3 October) and from 5 to 13 (26

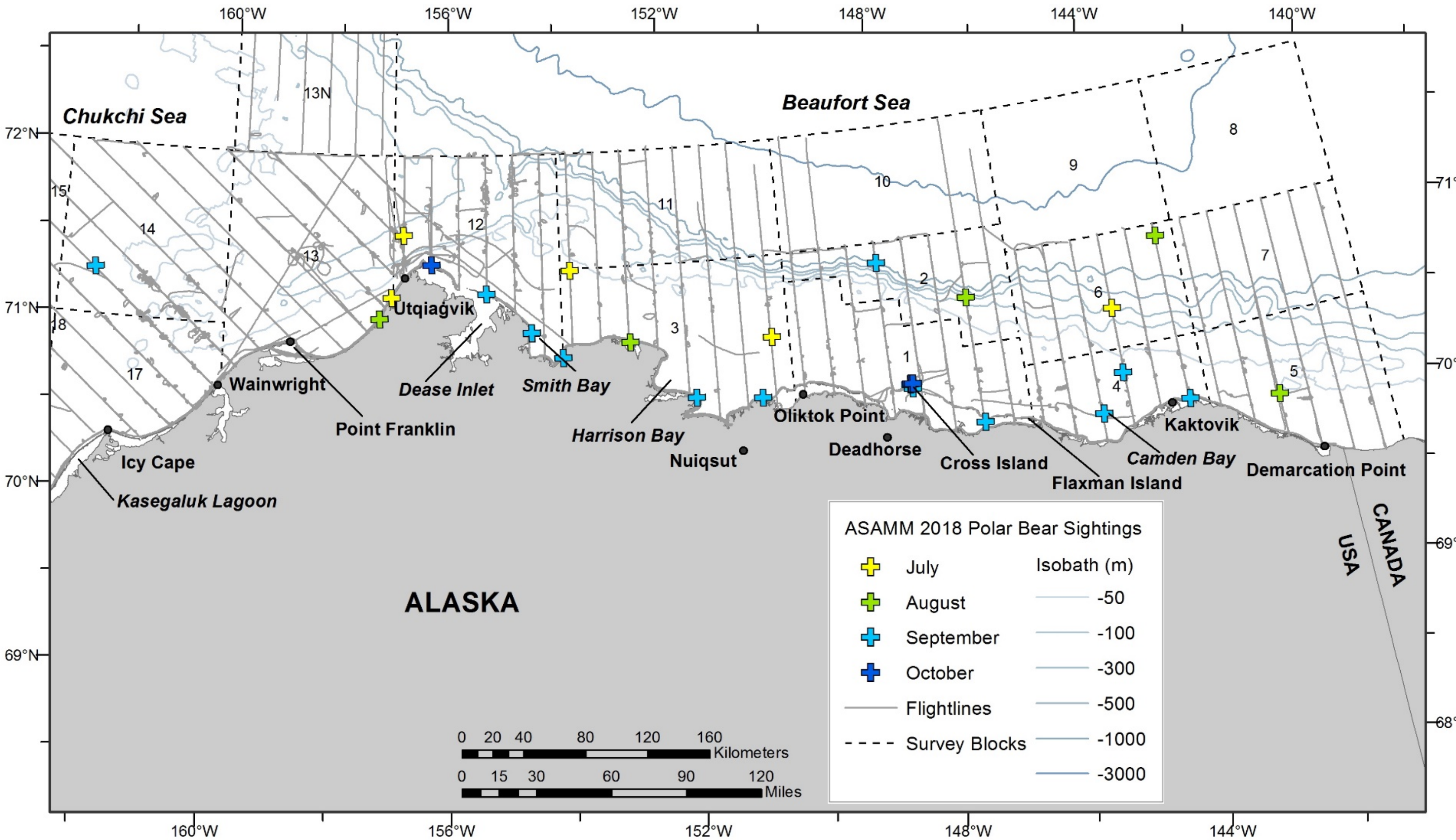

Figure 47. ASAMM 2017 polar bear sightings, all survey modes, plotted monthly, with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.

October); on 26 September, final group size decreased from 48 to 44 based on image analysis. These results confirm that initial polar bear counts at known aggregation areas such as Cross Island or near Kaktovik are often, but not always, underestimates that should be verified by post-flight image analysis whenever possible.

Dead Marine Mammals

There were 50 sightings of 51 dead marine mammals in 2018 (Table 14). Most (88%) of the carcasses were observed in the Chukchi Sea. Twenty-three of the carcasses were cetaceans, including bowhead whales (n_s = 10; n_i = 10), gray whales (n_s = 9; n_i = 9), and unidentified cetaceans (n_s = 4; n_i = 4). Nineteen of the carcasses observed were walruses, one carcass was a bearded seal, and four of the carcasses were unidentified pinnipeds. Four carcasses were in advanced states of decomposition and not identifiable beyond "marine mammal". Twenty-eight of the carcasses were observed in open water, 21 were on the beach or barrier islands, and two were on the ice.

Level A stranding forms were completed by field teams and forwarded to personnel at the NSB Department of Wildlife Management (all sightings), NMFS (cetaceans and ice seals) and USFWS (walruses).

Table 14. ASAMM 2018 dead marine mammal sightings during transect, search, and circling survey modes, in chronological order, 3 July-27 October.

Flight No.	Date	Latitude (°N)	Longitude (°W)	Species	No. Individuals	Habitat
210	20 Jul 18	70.8838	159.0356	walrus	1	open water
211	21 Jul 18	71.4759	155.3343	unidentified marine mammal	1	broken floes
213	29 Jul 18	67.6314	167.6077	unidentified cetacean	1	open water
213	29 Jul 18	67.2921	167.3444	walrus	1	open water
214	30 Jul 18	71.3865	158.7416	bowhead whale	1	open water
214	30 Jul 18	71.0200	157.3129	walrus	1	beach
214	30 Jul 18	71.0478	157.2528	gray whale	1	beach
214	30 Jul 18	71.0699	157.2119	gray whale	1	beach
214	30 Jul 18	71.3453	156.6116	bowhead whale	1	open water
215	31 Jul 18	71.4702	158.3094	bowhead whale	1	open water
216	5 Aug 18	68.8851	167.9404	walrus	1	open water
218	8 Aug 18	71.0684	157.2129	gray whale	1	beach
218	8 Aug 18	71.0957	159.7463	bowhead whale	1	open water
219	9 Aug 18	70.3004	162.0690	walrus	1	open water
219	9 Aug 18	70.1122	162.4849	gray whale	1	barrier island
219	9 Aug 18	69.8881	162.8669	walrus	1	barrier island
222	19 Aug 18	70.5868	160.1587	bearded seal	1	beach
222	19 Aug 18	70.6761	159.9516	gray whale	1	beach
222	19 Aug 18	70.6838	159.9325	bowhead whale	1	beach
222	19 Aug 18	70.7654	159.7401	unidentified pinniped	1	open water
222	19 Aug 18	70.8166	158.1760	bowhead whale	1	beach
222	19 Aug 18	71.0526	157.2398	walrus	1	beach
222	19 Aug 18	71.0555	157.2542	unidentified pinniped	1	beach
222	19 Aug 18	71.0824	157.2173	gray whale	1	beach
222	19 Aug 18	71.0968	157.1936	walrus	1	beach
225	28 Aug 18	71.3207	160.1408	walrus	1	open water
227	1 Sep 18	71.8076	157.0744	walrus	1	open water
228	2 Sep 18	71.0825	157.2141	gray whale	1	beach
228	2 Sep 18	71.0510	157.2709	bowhead whale	1	beach
228	2 Sep 18	71.0853	157.2097	unidentified cetacean	1	beach
228	2 Sep 18	70.8758	152.3629	unidentified cetacean	1	open water
228	2 Sep 18	71.4699	156.0470	gray whale	1	open water

Flight No.	Date	Latitude (°N)	Longitude (°W)	Species	No. Individuals	Habitat
28	9 Sep 18	70.3005	143.8293	unidentified pinniped	1	broken floes
233	16 Sep 18	68.9983	167.7274	unidentified cetacean	1	open water
234	18 Sep 18	69.9594	164.8574	walrus	1	open water
237	22 Sep 18	71.0767	157.2014	gray whale	1	beach
237	22 Sep 18	71.0391	157.2647	bowhead whale	1	beach
238	23 Sep 18	67.4894	168.1163	walrus	1	open water
239	25 Sep 18	71.8037	157.7603	walrus	1	open water
239	25 Sep 18	70.9052	158.7457	walrus	1	open water
240	26 Sep 18	71.8407	154.7363	bowhead whale	1	open water
243	30 Sep 18	71.9035	163.8133	bowhead whale	1	open water
243	30 Sep 18	71.2610	161.4358	walrus	1	open water
244	2 Oct 18	69.7778	163.3446	walrus	1	open water
245	3 Oct 18	70.7104	167.9418	walrus	1	open water
245	3 Oct 18	69.6697	163.7110	walrus	1	open water
246	5 Oct 18	69.9317	165.5354	unidentified marine mammal	1	open water
250	9 Oct 18	71.2345	159.7433	unidentified marine mammal	2	open water
253	19 Oct 18	68.8667	165.9510	walrus	1	beach
253	19 Oct 18	68.8641	165.9144	unidentified pinniped	1	beach

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Accomplishments and Outreach

Data from ASAMM 2018 were shared throughout the field season with researchers and interested parties within BOEM and other agencies:

- Daily reports of flight and sighting information were posted to the ASAMM project website (USDOC, NOAA, NMFS 2018).
- Ice data, including photos of representative sea ice cover, were sent to the National Weather Service Ice Desk, Alaska Center for Climate Assessment and Policy, NOAA National Ocean Service, U.S. Coast Guard (USCG), USGS, USFWS, University of Alaska Fairbanks (UAF), Old Dominion University, Pacific Marine Environmental Laboratory (PMEL), NOAA National Marine Fisheries Service, National Aeronautics and Space Administration, and BOEM.
- Biweekly effort and sighting summary figures were sent to BOEM, NMFS, PMEL, Alaska Department of Fish and Game (ADF&G), NSB, USCG, BLM, USGS, USFWS, Canadian Department of Fisheries and Oceans, and UAF to provide an overview of data collected.
- Biweekly walrus sighting figures showing distribution and group size were sent to researchers at BOEM, NMFS, USFWS, USGS, ADF&G, Pt. Lay Tribal Council, and NSB.
- Biweekly polar bear sighting figures were sent to BOEM, NMFS, USFWS, USGS, ADF&G, NSB, and University of Washington Polar Science Center.
- Daily reports specific to the effort on the coastal transect in Harrison Bay were shared with ConocoPhillips and BOEM.
- All Level A stranding forms (38 total forms) were sent to the relevant agencies: NMFS, NSB, and the Alaska Marine Advisory Program received forms for cetaceans and ice seals, and USFWS, NSB, and the Alaska Marine Advisory Program received forms for walruses.

Community outreach in 2018 included:

- Meeting with the NSB Search and Rescue to familiarize them with our project.
- Coordinating with the UIC North Slope Science Liaison and AEWC Administrative Manager to assist with communicating with the communities of Kaktovik and Nuiqsut during the fall bowhead whale hunt.
- Communication with Principal Investigators of vessel-based research operating in the study area.
- Posting daily reports to the ASAMM project website within ~24-48 hrs after completion of each ASAMM flight.

Survey protocols for collecting data on large cetaceans in high density areas (CAPs), bowhead whale group surface and dive data (FGF), and photographic images from a camera mounted in the aircraft belly port (BPC) were successfully integrated into ASAMM in 2018 with no negative impact to meeting ASAMM objectives.

Data for determining observer field of view (FOV) from the survey aircraft were collected, and preliminary analyses suggest that no additional FOV data will be needed to define the general field of view from Turbo Commander bubble windows.

Marine mammal photos taken by ASAMM personnel in 2018 were shared with interested parties in federal, state, and local government (including NOAA, BOEM, NSB, ADF&G, USFWS, and

USGS), media, and non-governmental organizations. Media efforts were coordinated through NOAA and BOEM Public Affairs Offices.

ASAMM provided subsets of the 1982-2017 database to several research groups planning or conducting various studies in, or near, the ASAMM study area. These groups included, but were not limited to University of Alaska Fairbanks, BOEM, NMFS Alaska Regional Office, PMEL, NMFS Protected Resources Division, USFWS, Duke University, UAF, and NSB.

Results from the 2018 ASAMM field season were presented at several venues, including:

Brower, A.A., A. Willoughby, J. Clarke, M. Ferguson, C. Accardo, L. Barry, N. Brandt Turner, M. Foster, K. Jackson, and K. Pagan. 2019. Fin and Humpback Whale Occurrence in the South-Central Chukchi Sea, 2014-2018. Poster: Alaska Marine Science Symposium, Anchorage, AK, January, 2019.

Clarke, J.T., M.C. Ferguson, A.A. Brower, and A.L. Willoughby. 2019. Bowhead whales in the western Beaufort Sea, Summer 2012-2018. Poster: Alaska Marine Science Symposium, Anchorage, AK, January, 2019.

A complete listing of publications, posters, and oral presentations from the ASAMM project from 2018 (not included in Clarke et al. 2018) to 2019 is included in Appendix C, and ASAMM contributions to the scientific community are included in Appendix F.

DISCUSSION

Unique Observations in 2018

- Heavy sea ice persisted in much of the western Beaufort Sea study area well into early September.
- Very low numbers of bowhead whales were in the Alaskan Beaufort Sea in summer compared to 2012-2017.
- Bowhead whale calf ratios and sighting rates decreased considerably compared to 2016 and 2017.
- Gray whale calf counts in the eastern Chukchi Sea decreased for the second year in a row, continuing to mirror calf count trends noted during the gray whale northbound migration along the California coast.
- A beluga was observed between the barrier islands and the mainland in the central Alaskan Beaufort Sea. This is only the second cetacean observed by ASAMM within the barrier islands.
- A record number of humpback whales and fin whales, all in the southcentral Chukchi Sea, were sighted.
- Very few polar bears were sighted in the Alaskan Beaufort Sea. Polar bear aggregations were seen at Cross Island after subsistence whaling was finished, but relatively few polar bears were seen elsewhere along the coast or on the sea ice offshore.
- A large walrus haulout was documented on a barrier island near Point Lay on 30 August and remained in place until at least 19 October. This represents the latest recorded date and largest number of walruses still using the coastal haulout in mid-October in the northeastern Chukchi Sea.
- Pinniped sighting rate was the lowest of any previous year, 2009-2017.
- Several new protocols were seamlessly integrated into ASAMM methods, including Cetacean Aggregation Protocols (CAPs), Focal Group Follow (FGF), and Belly Port Camera (BPC). Some of these protocols are specific to ASAMM survey data collection to compute for bowhead whale population abundance estimates (e.g., FGF, BPC), while CAPs is an improved method of determining group size and encounter rate that will remain part of ASAMM protocol indefinitely.

Summary

Sea ice conditions in the eastern Chukchi Sea study area in 2018 were similar to conditions observed in recent years, but conditions in the western Beaufort Sea were drastically different from those in recent years. Sea ice was largely absent from the northeastern Chukchi Sea study area by mid-August but remained in the western Alaskan Beaufort Sea through early September. Furthermore, sea ice cover in the Beaufort Sea consisted of large pieces of old, or multiyear, ice which resulted in lower water temperatures in the ASAMM study area even when sea ice had receded north of 72°N. The colder water temperatures likely positively influenced the early formation of new ice in fall in the Beaufort Sea, which was largely frozen by the end of October.

Broad-scale aerial surveys were conducted regularly in the western Beaufort Sea during summer (July-August) for the seventh consecutive year. Total and on-effort survey hours in 2018 were similar to other years with equivalent field periods (2012-2017) (Figure 48). Total hours were greater in 2012, 2015, 2016, and 2017. On-effort hours were lower in 2018 than in most previous years, due in part because on-effort hours in past years included time in circling-from-transect mode, which was not considered on effort in 2018. Due to poor weather conditions, surveys were not conducted for four consecutive days in mid-July and mid-October 2018, and the field season ended early due to inclement weather. Since 2012, there have been relatively few instances when ASAMM surveys were not possible during extended periods. In 2013, the only extended period when surveys could not be conducted was in the first half of October, when the partial federal government shutdown forced a temporary cessation of ASAMM surveys for 19 days (Clarke et al. 2014). There were two extended periods in 2014 (7 days in mid-September and 10 days in mid-October) and one extended period in 2015 (12 days in mid-July) when surveys could not be conducted because of poor weather conditions (Clarke et al. 2015a, 2017a). The geographic immensity of the study area, combined with the flexibility of having two survey teams based at different locations and the ability of the ASAMM survey aircraft to transit to distant parts of the study area at speeds in excess of 330 km/hr, has permitted ASAMM to focus on areas where weather conditions were most amenable to surveying. This has resulted in the most pragmatic use of ASAMM flight hours and assets annually.

Systematic surveys were conducted in block 1a, encompassing the area between the barrier islands and the shoreline in block 1, for the third consecutive year. In 2018, 556 km were flown on effort in this small area; the three-year average is 550 km on effort per year. Sightings have included 1 beluga (2018), 1 harbor porpoise (2017), several small unidentified pinnipeds (2016-2018), and polar bears (2016-2018).

Systematic surveys were conducted in block 13N for the first time since 1991 (Moore and Clarke 1992), specifically to investigate the potential use of that area by bowhead whales during summer months. Bowhead whales were not seen in block 13N in 2018, but survey coverage was not substantial due to persistently poor survey conditions. Satellite tagged bowhead whales transited through block 13N (and even farther offshore) during the fall migration in 2006-2015 (Citta et al. 2018), and about 21% of whales with tags during the months of July and August, 2006-2017, transited through this area during those months (J. Citta, ADF&G, pers comm to J.

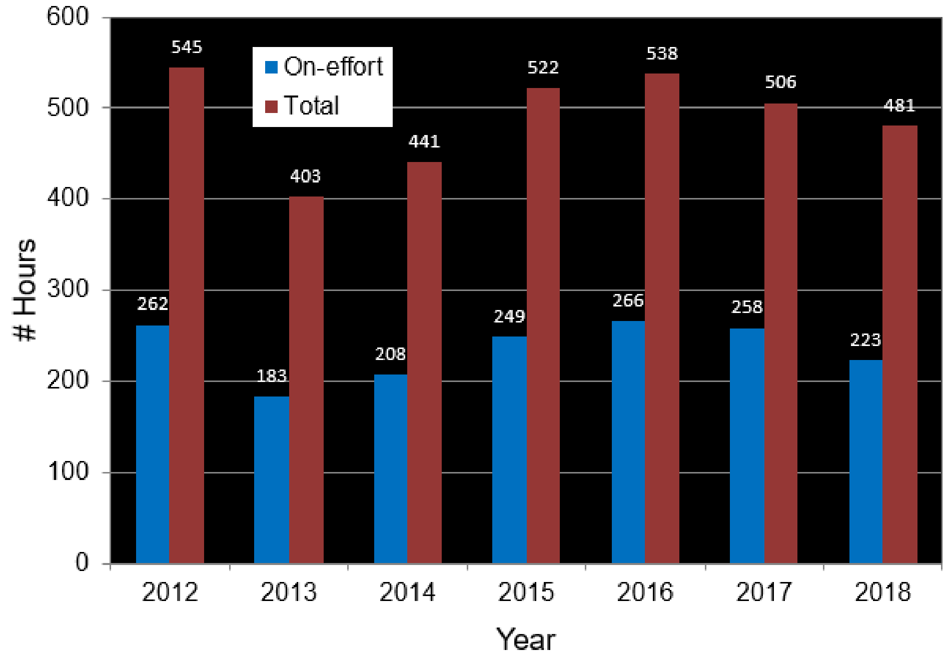

Figure 48. ASAMM on-effort and total survey hours, July-October pooled, 2012-2018.

Clarke and M. Ferguson, 21 March 2018). None of the bowhead whales with satellite tags transited block 13N in summer 2018; all three of those whales remained in the Canadian Beaufort Sea until mid-September 2018 (Alaska Department of Fish and Game 2019).

Surveys were conducted along the coastal transect in Harrison Bay, between Atigaru Point and Fish Creek, almost weekly. This collaboration, between BOEM, NOAA, and Conoco-Phillips, is an example of a successful use of research assets already in place, eliminating the need for an additional dedicated survey team.

Bowhead whales were distributed from 140°W to 164°W in 2018. On-effort sighting rates in the western Beaufort Sea in 2018 were low in July and August, increased in September, and decreased slightly in October (Figure 49). The overall on-effort sighting rate in the western Beaufort Sea in summer 2018 was 0.003 (WPUE), which is the lowest summer sighting rate since surveys commenced in 2012. The lower sighting rate was likely not related to changes in survey protocols initiated in 2018, because sighting rates incorporate effort equally across all years. Likewise, survey coverage in the western Beaufort Sea in summer 2018 was temporally and geographically similar to survey coverage in 2012-2017 (Figure 50A), but bowhead whale distribution differed from previous years (Figure 50B). In addition to being scarce, bowhead whales were difficult to resight in areas of heavy sea ice and areas of open water within the sea ice, and appeared to spend more time underwater. The presence of persistent heavy sea ice in July and August may have had a negative impact on bowhead whale detectability. Thomas et al. (2002) reported exactly this effect when analyzing aerial survey data collected in the eastern Alaskan Beaufort Sea from 1979-2000 on several aerial platforms, noting that the ability to sight bowhead whales at long lateral distances was reduced when substantial ice was present. Sighting

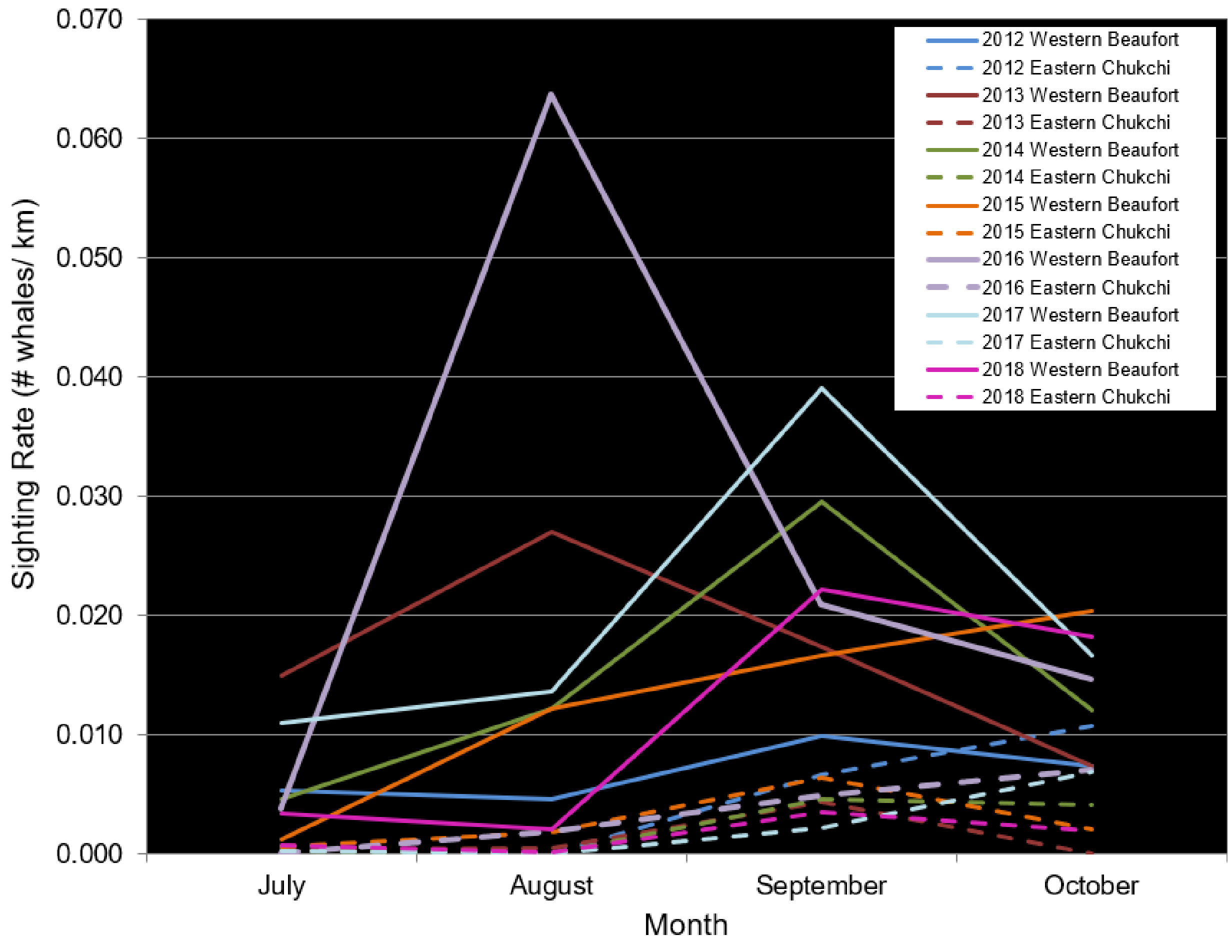

Figure 49. ASAMM bowhead whale on-effort monthly sighting rates (WPUE; sightings from primary observers only) in the eastern Chukchi and western Beaufort seas, July-October, 2012-2018.

rates of belugas, which are much smaller in size, were also relatively low in the western Beaufort Sea in summer 2018.

It is possible that the heavy sea ice that persisted in the western Beaufort Sea from July through early September influenced bowhead whale summer and fall distribution and migration timing because potential feeding opportunities were fewer. Bowhead whale distribution and sighting rates per survey block in July (Appendix E, Table E-1) indicated an offshore distribution, similar to that observed in 2012-2016; July distribution in 2017 was closer to shore than in 2018, although remained in deeper water compared to August 2017 (Clarke et al., 2018a). Although the same trend was observed in summer 2018, median water depth and distance from shore were not significantly different from July to August. Bowhead whales move to inner shelf (≤50 m depth) habitat in the western Beaufort Sea in August in most years, likely to take advantage of feeding opportunities resulting from ice-free summers, warmer currents, and increased upwelling (Clarke et al. 2018c).

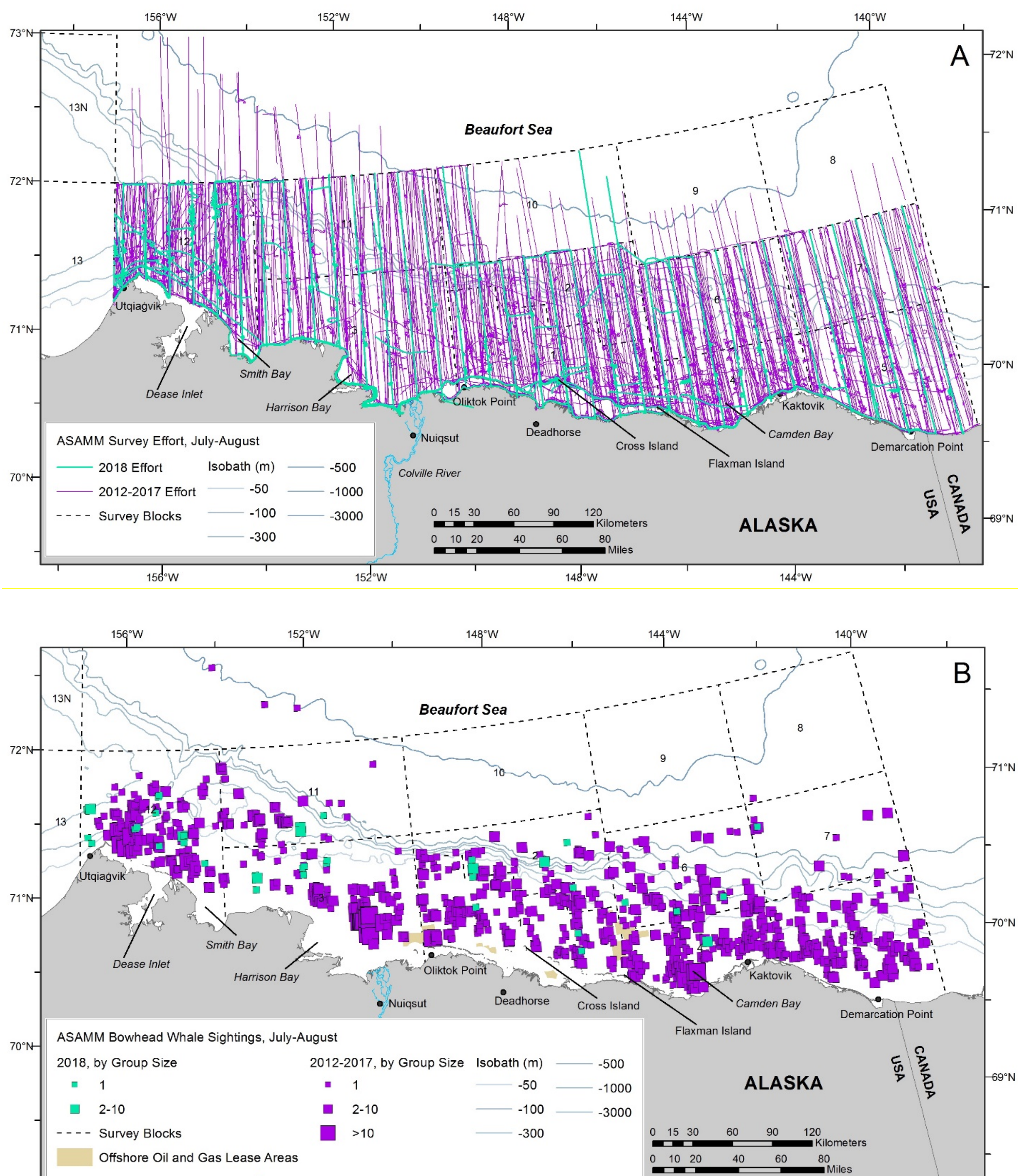

Figure 50. ASAMM 2012-2017 and 2018 summer (July-August) survey effort and bowhead whale sightings from transect, CAPs, search, circling, and FGF survey modes. A: survey effort. B: bowhead whale sightings, by group size. Includes all sightings by primary and secondary observers.

The whereabouts of bowhead whales in summer 2018 is unknown, but they likely remained in the eastern Beaufort Sea. Information on bowhead whale occurrence in the eastern Beaufort Sea in summer 2018 is limited, as there were no surveys conducted there. However, three bowhead whales that retained satellite tags applied in summer 2017 remained in the Canadian Beaufort Sea until mid-September 2018. Citta et al. (2015) used satellite tag data from 2006-2012 to identify a bowhead whale core use area in Amundsen Gulf, with peak use from 7 May through 5 July, and a second core use area in the Canadian Beaufort Sea on the Tuktoyaktuk Shelf. with peak use from 12 July to 25 September. Prolonged residency of the tagged whales is not unprecedented.

Bowhead whale distribution in summer 2018 in the eastern Chukchi Sea was like that observed in most years 2009-2017 (Figure 51), when bowhead whale sightings were scattered in offshore areas west and southwest of Utqiaġvik, AK. Despite good survey coverage (Figure 6A-D), there were only five sightings of six bowhead whales in July and August 2018. Bowhead whale use of offshore areas in the Chukchi Sea in summer also has been documented by satellite telemetry data (Quakenbush et al. 2013), albeit with low sample sizes, and detected via passive acoustic recorders (Clark et al. 2015).

Bowhead whale distribution in the western Beaufort Sea in fall overlaid the general distribution observed in past years with light sea ice cover (Figure 19), with a few notable differences. Bowhead whales were relatively scarce in the Harrison Bay area, despite consistent effort, and were observed in deeper water and farther from shore in the West region compared to 2009-2017, previous years with light ice. A comparison of sighting rates per depth zone illustrates the extent of the difference (Figure 52). Bowhead whale sighting rate per depth zone in fall 2018 in the western Alaskan Beaufort Sea (154°W-157°W) was highest in the 201-2,000 m depth zone, a phenomenon not observed from 2009 to 2017 (Figure 52B).

The area east of Point Barrow is a well-documented bowhead whale feeding area in years when upwelling winds create advantageous conditions for aggregating krill that have been advected north from the Bering Sea (Ashjian et al. 2010). The formation of a "krill trap" in this area often leads to increased bowhead whale sighting rates due to the presence of large feeding aggregations (Clarke et al. 2017a). This area has been identified as a bowhead whale core-use area in fall based on satellite tag data collected from 2006 to 2012 (Citta et al. 2015) and a summer and fall bowhead whale hotspot based on aerial survey data collected from 2007 to 2012 (Kuletz et al. 2015). The core-use area and the hotspot area are close to shore and at depths <200 m, which differs markedly from where most bowhead whales were observed in fall 2018; several of the satellite-tagged whales also appeared to transit offshore (Alaska Department of Fish and Game 2019). Conditions for the formation of krill traps occurred in fall 2018 (S. Okkonen, pers comm to J. Clarke, 5 January 2019), but a relatively large aggregation (n_i = 30) of feeding whales was observed on only one day (2 September). Furthermore, surveys conducted in this area in 2018 when, based on wind conditions, bowhead whale aggregations would be expected, yielded few bowhead whale sightings. The lack of real-time oceanographic sampling effort makes it impossible to know how much krill were advected north into the krill trap area in 2018, but the lack of whales in the nearshore core-use area and the high sighting rate offshore indicate that perhaps relatively few krill were present and feeding opportunities nearshore were consequently suboptimal in fall 2018.

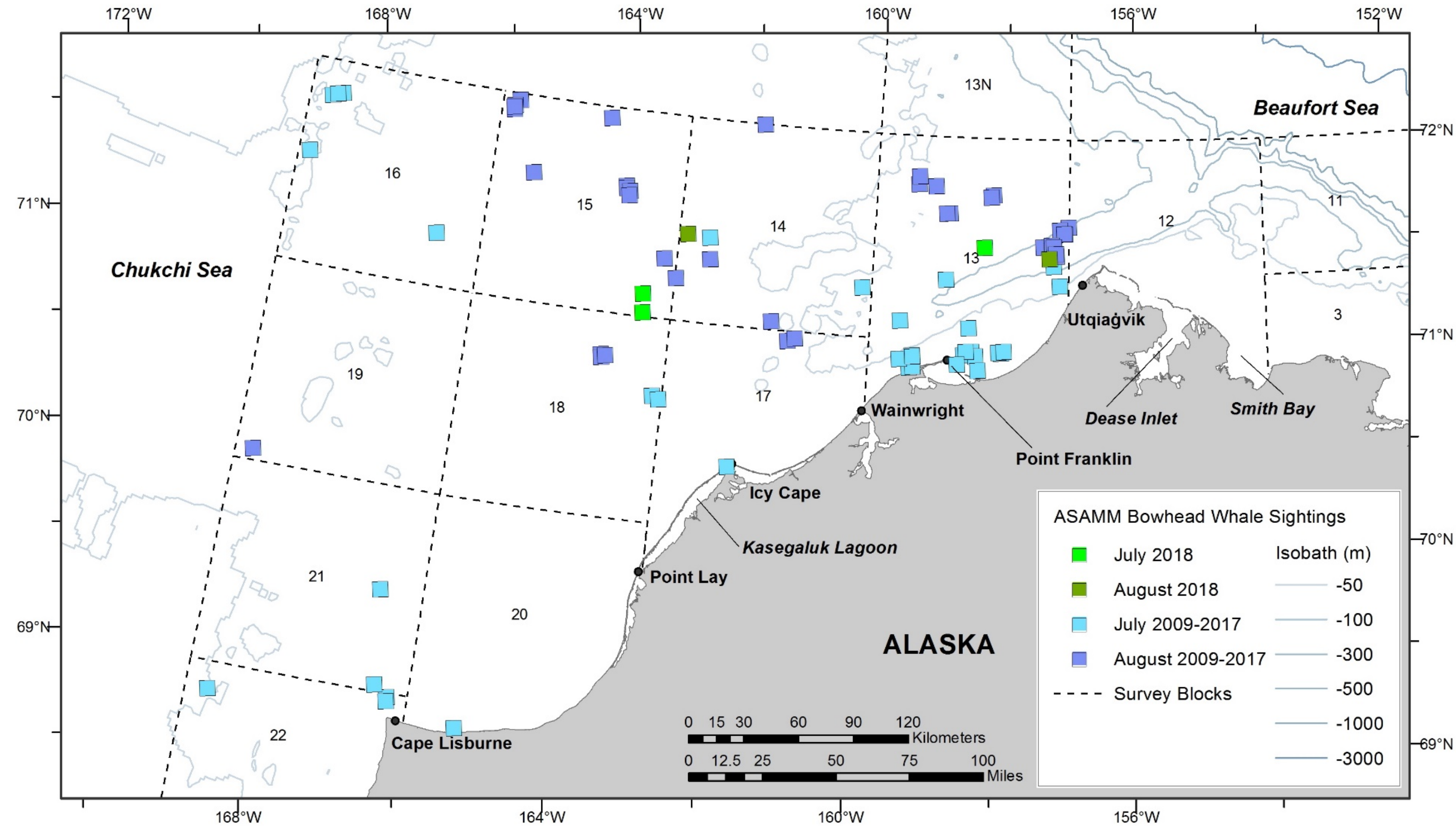

Figure 51. ASAMM bowhead whale distribution in the northeastern Chukchi Sea, transect, CAPs, search, circling, and FGF survey modes, summer (July and August), 2009-2017, and 2018.

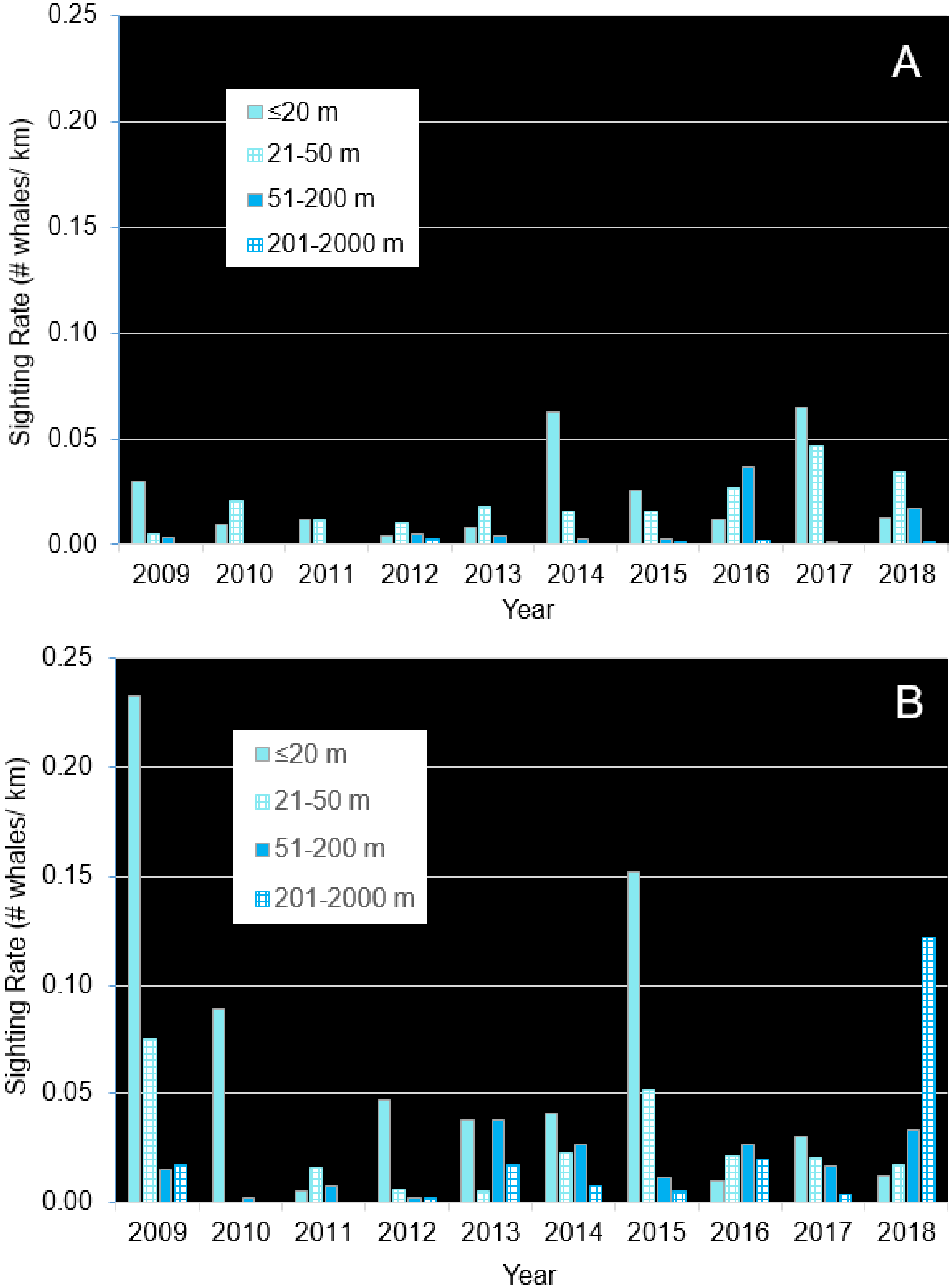

Figure 52. ASAMM bowhead whale on-effort annual sighting rates (WPUE; sightings from primary observers only) per depth zone, fall (September-October pooled) 2009-2018. A: central-eastern Alaskan Beaufort Sea (140°W-154°W). B: western Alaskan Beaufort Sea (154°W-157°W).

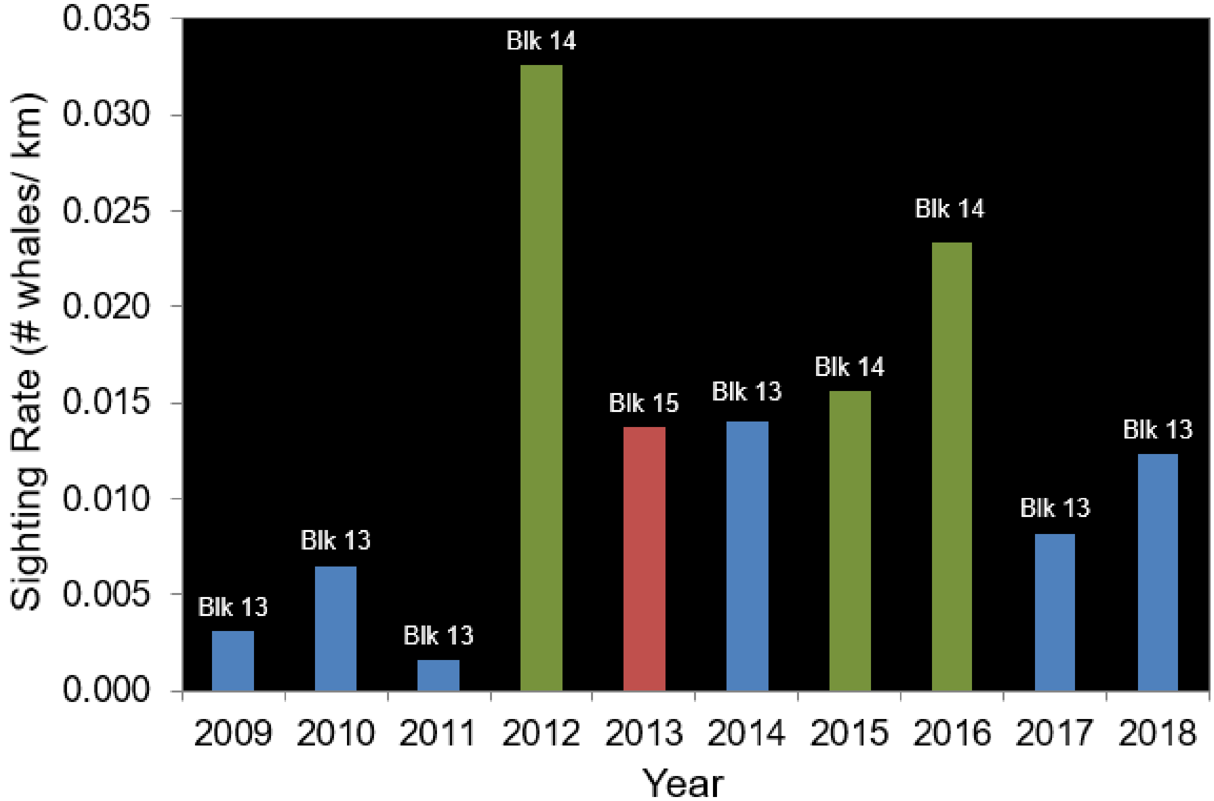

Figure 53. Annual maxima of ASAMM bowhead whale on-effort sighting rates (WPUE; sightings from primary observers only), fall (September-October pooled), by survey block, eastern Chukchi Sea, 2009-2018.

Bowhead whale distribution in the northeastern Chukchi Sea in fall 2018 overlaid the distribution observed from 2009 through 2017 and continued to suggest a broad migratory corridor heading southwest across the northeastern Chukchi Sea, with little use of the nearshore area between Icy Cape and Cape Lisburne. These results are corroborated with data from satellite telemetry (Quakenbush et al. 2010a, 2013) and passive acoustics (Hannay et al. 2013). In this region, bowhead whale habitat preference continued to skew towards deeper water (51-200 m) in fall, similar to observations in 2009-2017 (Clarke et al. 2018c). The highest fall sighting rate for bowhead whales in the northeastern Chukchi Sea was in block 13 in 2009, 2010, 2011, 2014, 2017, and 2018, block 14 in 2012, 2015, and 2016, and block 15 in 2013 (Figure 53). Block 13 encompasses the area first encountered by most bowhead whales exiting the western Beaufort Sea during the fall migration, so the high sighting rates there are expected. The high sighting rate in block 15 in 2013 is somewhat perplexing, but it is worth mentioning that surveys were conducted in the northeastern Chukchi Sea only in September in 2013 due to the federal government partial shutdown in October (Clarke et al. 2014). The distribution and abundance of bowhead whales in October 2013 remains unknown. Finally, two of the three years during which fall sighting rates were highest in block 14 (2012 and 2015) were years during which offshore exploratory drilling occurred (Bisson et al. 2013; Ireland and Bisson 2016); there were no drilling activities in 2018.

Patterns in the spatial model predictions of bowhead whale monthly HUAs from the 2000-2018 data were similar to the analogous models limited to the 2000-2017 period (Clarke et al. 2018a). One notable exception is the model predictions from July in the western Beaufort Sea (152°-156°W), where additional bowhead whale sightings offshore of the 50-m isobath resulted in higher predicted densities offshore, pushing the HUAs farther offshore. Sample sizes used to fit the models increased from 2% (August) to 18% (July and October) with the inclusion of the 2018 data. The 18% increase in the July sample sizes had a pronounced effect because it corresponded to an increase from 116 sightings in the 2000-2017 model to 137 in the 2000-2018 model, whereas the corresponding sample size for the October models increased from 265 to 433 sightings. In July, HUAs were located over the outer continental shelf and slope, the farthest offshore of the four months examined. The HUAs in August identified three patches of relatively high abundance, located offshore of Kaktovik, Nuiqsut, and Dease Inlet. The spatial patterns in relative abundance in September were similar to those for October, with the highest predicted values located outside the barrier islands from Camden Bay to Prudhoe Bay and on the shelf southeast of Barrow Canyon. The highest densities in the September model were farther east than those in the October model, reflecting the westward progression of the fall migration. Relative abundance predictions from the spatial model built on only 2018 transect data from fall (September and October data pooled) in the East and West regions were more similar to 2016 than any other previous year, suggesting that bowhead whales in 2018 migrated farther offshore than expected based on ASAMM historical data, satellite tag data (Quakenbush et al. 2013), and traditional ecological knowledge.

The 2018 bowhead whale calf ratios (number of calves/number of total whales) for summer, fall, and summer and fall combined were similar to seasonal or annual bowhead whale calf ratios in many previous years (Figure 54), although substantially lower than calf ratios in 2017 (Clarke et al., 2018b). The majority of calves (86%) were seen in the Beaufort Sea, similar to past years. Since 1982, most bowhead whale calves (73%) observed during ASAMM have been in the western Beaufort Sea (Stimmelmayr et al. 2018). This pattern may in part be due to the scarcity of survey effort in the eastern Chukchi Sea, particularly from 1992-2007. Calf distribution is generally similar to the distribution of all bowhead whales sighted in summer and fall (Stimmelmayr et al. 2018). Bowhead whale calf sighting rates (calves per unit effort, CPUE) in the western Beaufort Sea were highest in 2017 (0.0023 CPUE), followed by 2016 (0.0021 CPUE) and 2013 (0.0019 CPUE) (Clarke et al. 2018b); calf sighting rates in 2018 were comparable to calf sighting rates in 2012, 2014, and 2015 (Figure 55). Bowhead whale calf occurrence likely reflects geographic and temporal variation in the interannual use of the western Beaufort Sea by different bowhead whale size classes, as suggested by Koski and Miller (2009). The Western Arctic bowhead whale stock is in good physical condition, as determined from an analysis of body condition of subadult whales harvested by Inupiat whalers (George et al. 2015). The Western Arctic stock also has increased in population size in the last decade (Givens et al. 2013, 2017), perhaps because increased body condition may have improved rates of survival and reproduction. Increased body condition, rate of survival, and reproduction may be related to the overall reduction of summer sea ice, increased duration of open water, changes in upwelling potential, and higher primary productivity (Harwood et al. 2015). Continued collection of bowhead whale data in summer and fall in the western Beaufort Sea in future years should shed light on whether the exceptionally high calf ratios and sighting rates of 2013, 2016, and 2017, or

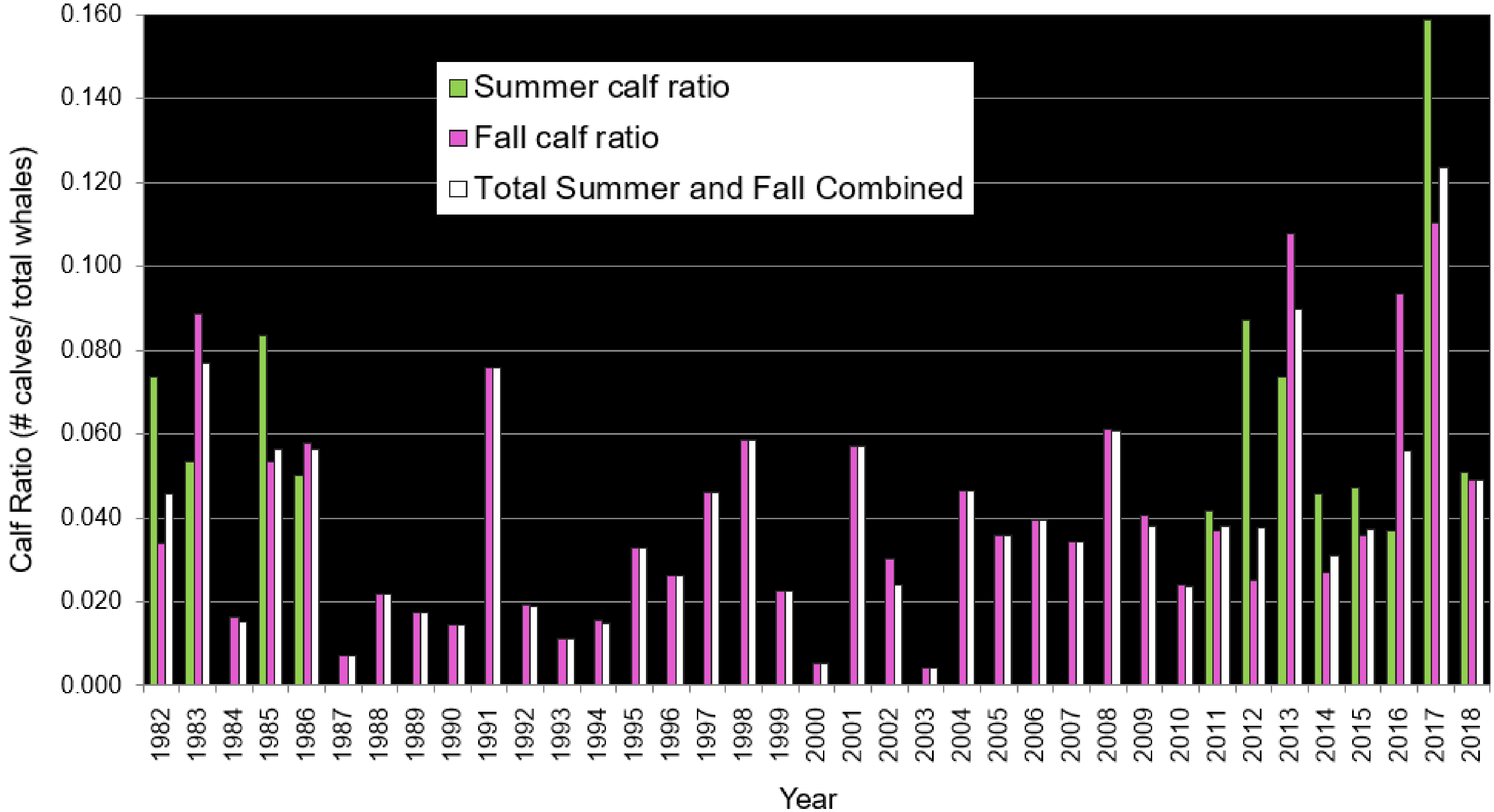

Figure 54. ASAMM bowhead whale annual calf ratios (number of bowhead whale calves per number of total bowhead whales, all survey modes), in summer (July-August pooled), fall (September-October pooled), and summer and fall combined, 1982-2018. Ratios are for the entire ASAMM study area.

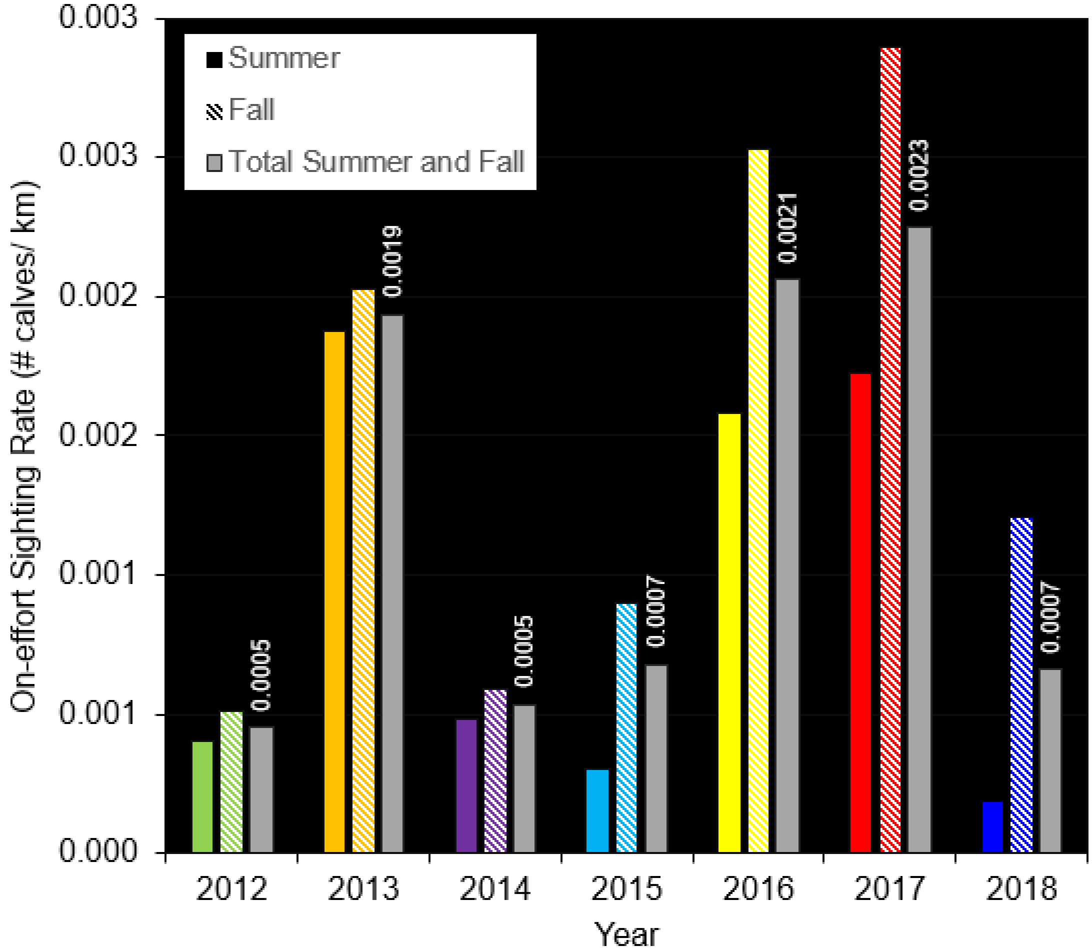

Figure 55. ASAMM bowhead whale on-effort annual calf sighting rates (CPUE; sightings from primary observers only), western Beaufort Sea, summer (July-August pooled), fall (September-October pooled), and summer and fall combined, 2012-2018.

the comparatively lower calf ratios of 2012, 2014, 2015, and 2018, are more representative of the 'new' Arctic.

Gray whale habitat preference in the northeastern Chukchi Sea continues to be seasonally and annually variable. Distribution in 2018 appeared similar to that observed in 2015 to 2017, with an even greater preference for the area northwest of Wainwright out to ~100 km offshore. In the northeastern Chukchi Sea in 2018, gray whales preferred waters 36-200 m deep in summer (July-August) and 51-200 m deep in fall (September-October) (Appendix E, Table E-4). ASAMM and other researchers reliably observe gray whales in the region between Icy Cape and Point Barrow, extending from the shoreline to approximately 90 km offshore, encompassed by ASAMM survey blocks 13, 14, and 17. In this area, gray whales, including cow-calf pairs, have been seen from July through October, primarily shoreward and south of Barrow Canyon (Clarke et al. 2016), at depths ≤50 m where preferred benthic prey are found in highest abundances (Brower et al. 2017). Prior to 2015, gray whales were distributed mainly between Point Franklin and Utqiaġvik, within a few kilometers of the shoreline between Point Lay and Utqiaġvik, and within ~45 km of shore northwest of Wainwright, an area encompassed by blocks 13 and 17. Relatively small numbers of gray whales were found farther offshore in the southern part of block 14 prior to 2015. Starting in 2015, fewer gray whales were seen nearshore between Point Lay and Utqiaġvik, and increasing numbers of gray whales were found offshore in the southern part of block 14. Sighting rates in block 13 were fairly consistent from 2014 to July 2017, but dramatically decreased in August 2017 and remained low though 2018 (Figure 56A). Sighting rates in block 14 in 2015-2018 were higher than sighting rates in that block in most months in 2009-2014 (Figure 56B). The 2015-2018 increase in gray whale relative occurrence in block 14 did not coincide with a decrease in relative occurrence in block 13 until August. Block 17 relative occurrence was particularly high in July 2018, representing the highest sighting rate recorded in any month for these three survey blocks, and September 2018 (Figure 56C).

Gray whale sighting rates per depth zone for blocks 13, 14, and 17 combined illustrate annual and seasonal shifts between shallower (nearshore) areas to deeper (offshore) areas. For this analysis, effort and whales observed on the coastal transect were removed to avoid any biases towards shallow depths. In most years from 2009 to 2015, sighting rates in summer were either highest in ≤35 m depths (2009, 2012, 2015) or about the same across all depth zones (2010, 2011); in 2014, summer sighting rate was highest in the 36-50 m depth zone (Figure 57A). From 2016 to 2018, summer sighting rates were highest in the 51-200 m depth zone (2016-2017) or similar across all depth zones (2018). In fall, sighting rates were highest in the 51-200 m depth zone in 2014, 2016, and 2018 (Figure 57B). Sighting rates were especially high in fall 2018 compared to 2009-2017.

Gray whale use of the southcentral Chukchi Sea also varies between years. ASAMM effort in block 22 (68°N-69°N, 166°W-169°W) started in 2009. The main benthic hotspot area located in the southernmost portion of the current ASAMM study area (67°N-68°N, 166°W-169°W; block 23) was not surveyed until 2014. In this region, gray whales show a strong preference for deeper water in both summer and fall in most years, with the highest sighting rates per depth zone consistently in depths >50 m (Figure 58). The rare exceptions to this depth preference were in summer 2018, when sighting rate was higher in the 36-50 m depth zone, and summer 2013 when sighting rate was higher in the ≤35 m depth zone. Gray whales are rarely found in shallow (≤35 m) depth zones in the southcentral Chukchi Sea. Sighting rates were particularly high in summer and fall 2014, fall 2016, and summer 2017.

Interannual variability in monthly patterns of gray whale distribution and relative abundance was also documented in the southcentral Chukchi Sea. Sighting rates were higher in the southcentral Chukchi Sea in July 2018 compared to July 2014-2017 combined, but then decreased considerably in August and remained low through fall (Figure 27). In 2014 to 2017 combined, sighting rates in the southcentral Chukchi Sea increased from July to August, then decreased in fall. On-effort sighting rates were considerably higher in the northeastern Chukchi Sea in August-October 2018 than in the southcentral Chukchi Sea, which has rarely been observed in previous years (Figure 59). The only other year in which this occurred was in 2015 when the difference was less extreme.

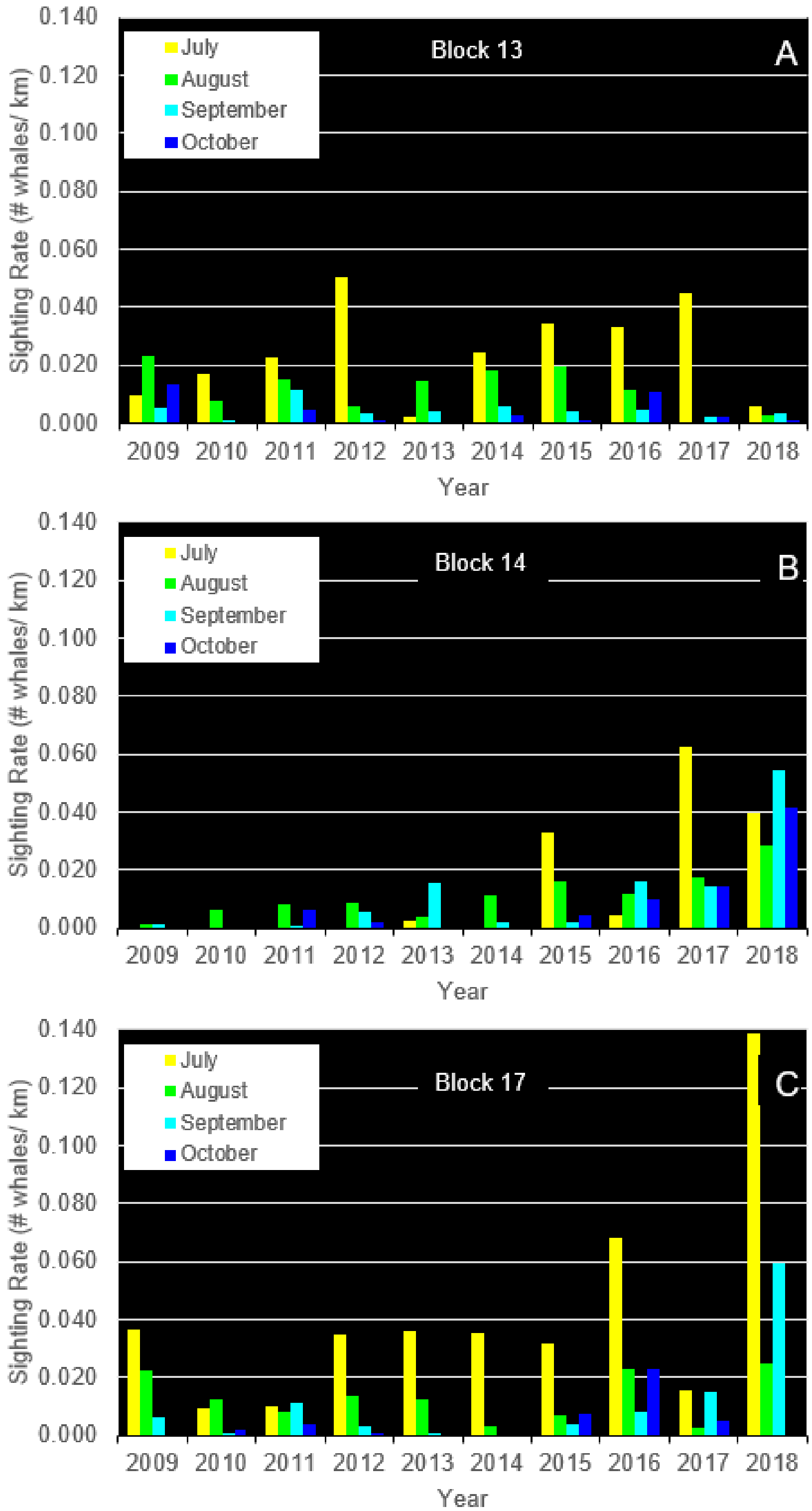

Figure 56. ASAMM gray whale on-effort annual sighting rates (WPUE; sightings from primary observers only) in the northeastern Chukchi Sea, July-October pooled, 2009 to 2018. A: block 13. B: block 14. C: block 17. Sighting rates of zero were removed from the graph for clarity.

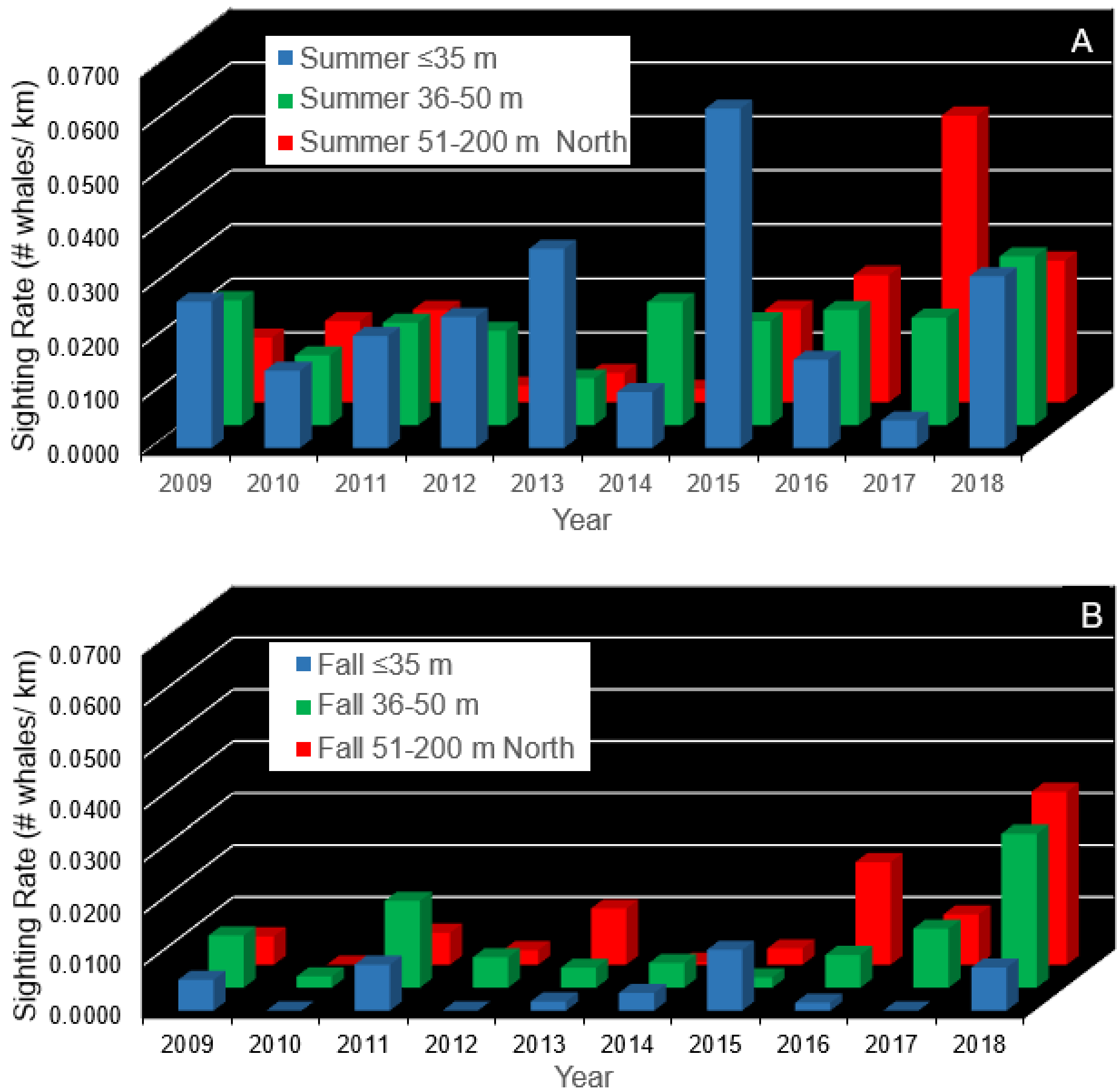

Figure 57. ASAMM gray whale on-effort annual sighting rates (WPUE; sightings from primary observers only) per season per depth zone in the northeastern Chukchi Sea (blocks 13, 14, and 17 combined), 2009-2018. A: summer (July-August pooled). B: fall (September-October pooled).

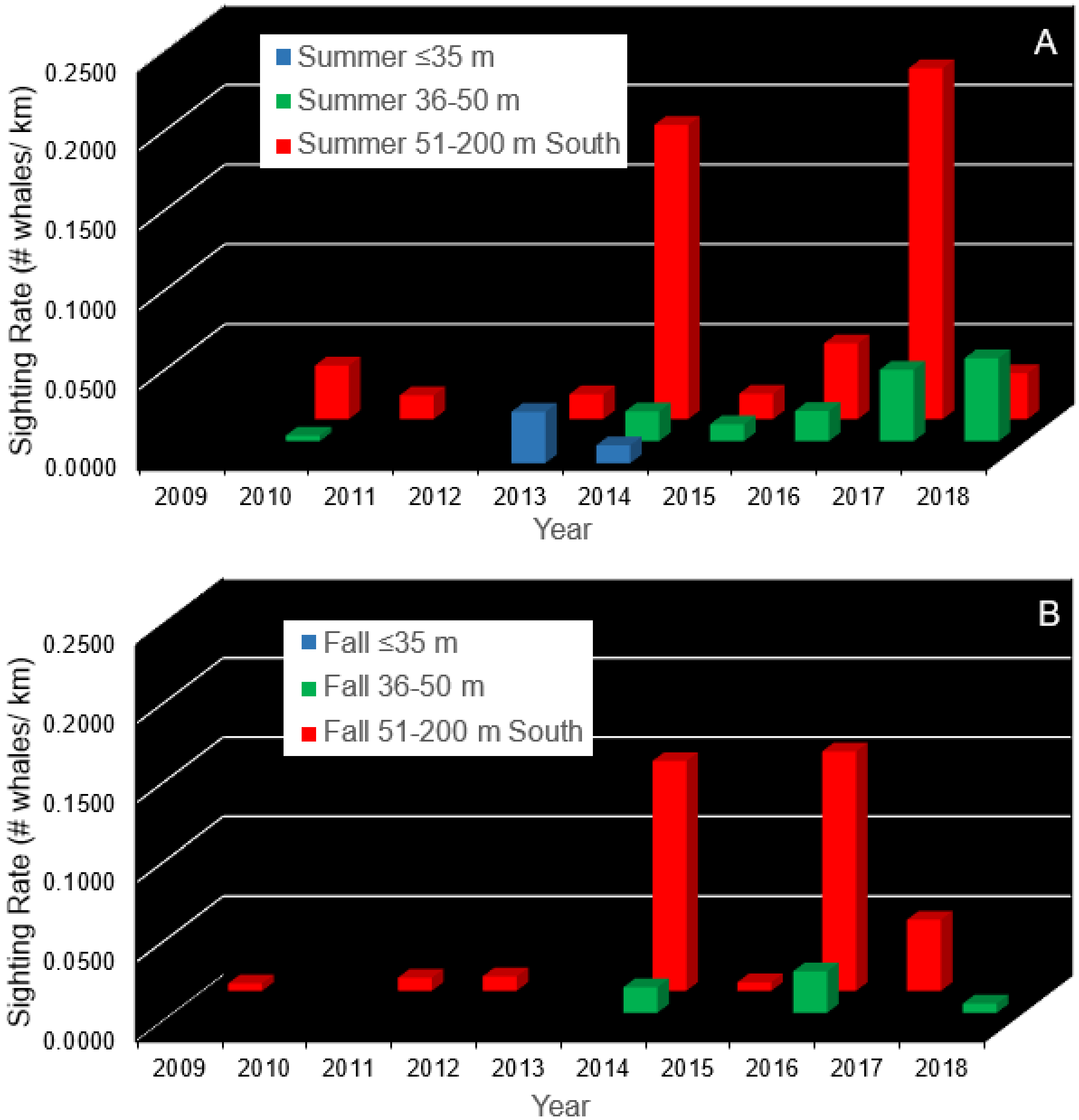

Figure 58. ASAMM gray whale on-effort annual sighting rates (WPUE; sightings from primary observers only) per season per depth zone in the southcentral Chukchi Sea subarea (blocks 22 and 23 combined), 2009-2018. A: summer (July-August pooled). B: fall (September-October pooled). Sighting rates of zero were removed from the graph for clarity.

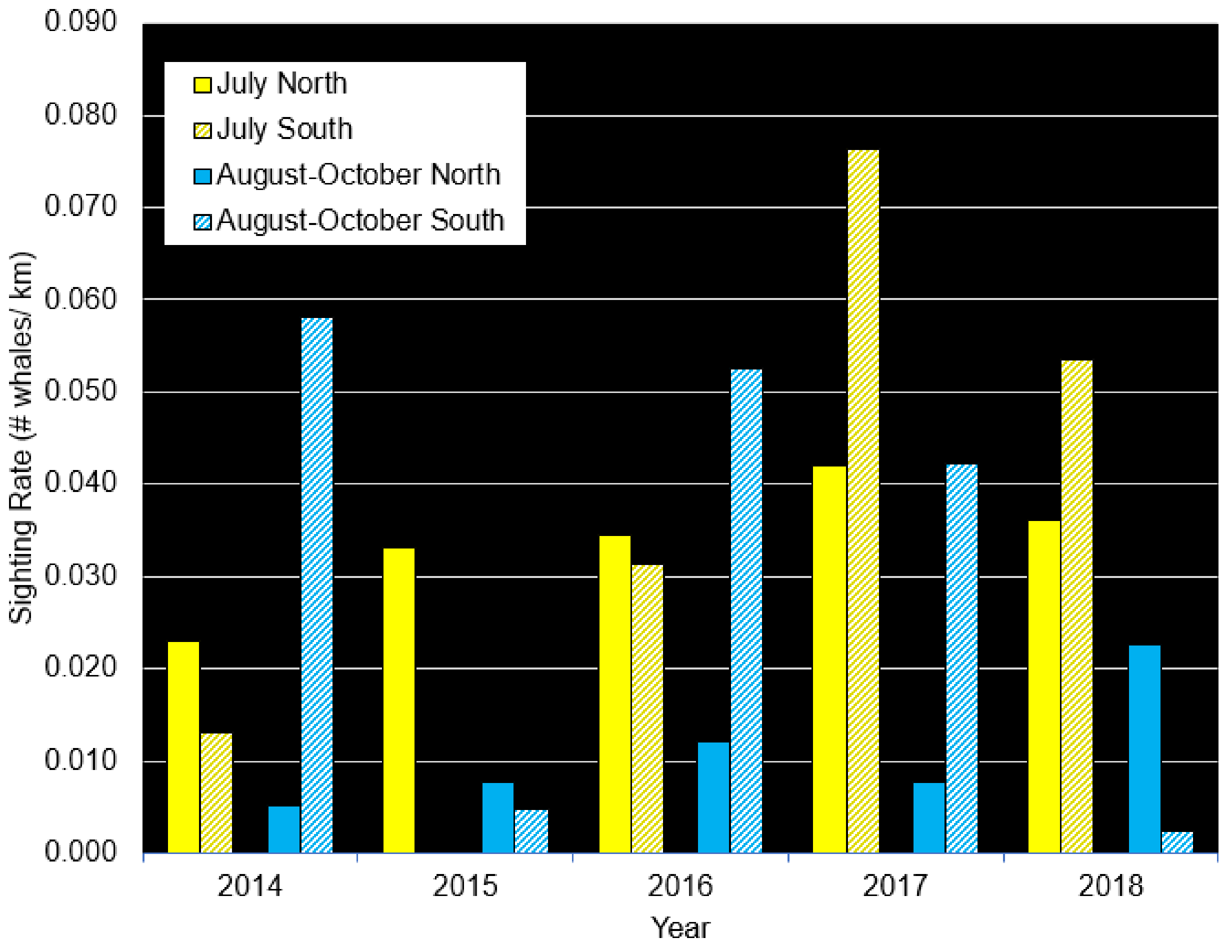

Figure 59. ASAMM gray whale on-effort annual sighting rates (WPUE; sightings from primary observers only) in the northeastern Chukchi Sea (North, blocks 13, 14, and 17 combined) and southcentral Chukchi Sea (South, blocks 22 and 23 combined), July and August-October pooled, 2014 to 2018. Sighting rates of zero were removed from the graph for clarity.

Feeding is the primary gray whale behavior observed in the eastern Chukchi Sea. Gray whale distribution is closely associated with prey availability, including, but not limited to, benthic amphipods (Brower et al. 2017). Intense feeding on dense amphipod patches may reduce the density of available gray whale prey within or between years. Unlike amphipods in temperate areas, high latitude amphipods tend to have slow maturation and low growth rates, long generation times, and low production to biomass ratios (Highsmith and Coyle 1992). If amphipod patches are depleted in some years, gray whales may disperse to adjacent feeding areas to take advantage of relatively high-density prey patches elsewhere. Sighting rate for summer and fall combined in the northeastern Chukchi Sea (blocks 13, 14, and 17 combined) was highest in 2018 (Figure 60) and increased each year since 2013 (with a slight drop in 2017). Also worth noting is that, for the third consecutive year since dedicated summer and fall surveys commenced in the northeastern Chukchi Sea in 2008, gray whales were sighted within the confines of Peard Bay. Despite hundreds of survey overflights of Peard Bay, neither gray whales nor mud plumes, which are indicators of gray whale presence, had been seen before 2016.

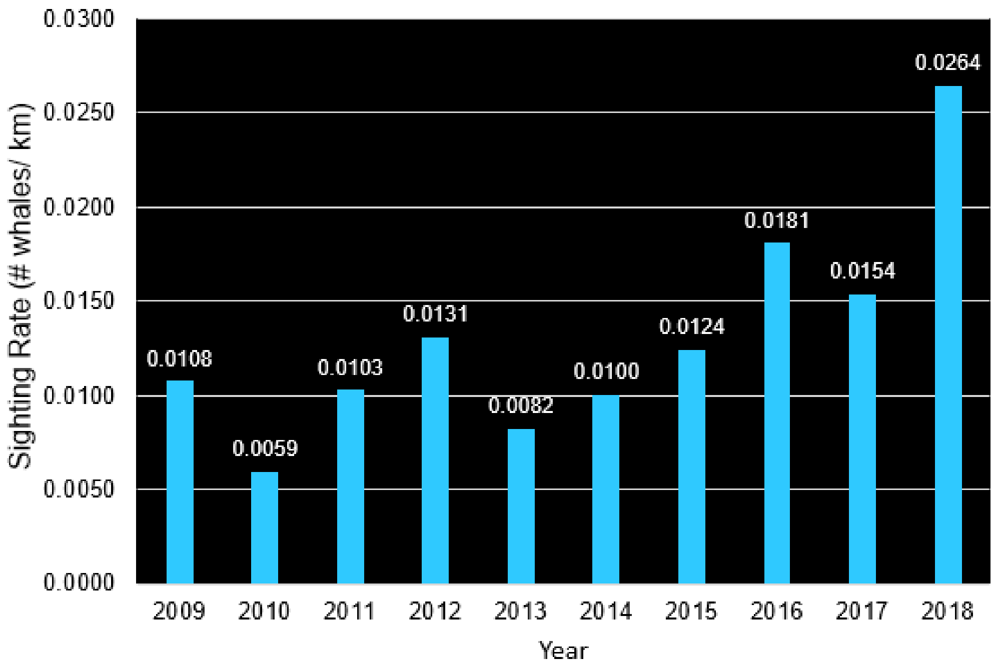

Figure 60. ASAMM gray whale annual on-effort sighting rates (WPUE; sightings from primary observers only) in the northeastern Chukchi Sea (blocks 13, 14, and 17 combined), July-October pooled, 2009-2018.

Changing hydrographic conditions or earlier sea ice melt may be altering ecosystem processes that lead to the location and abundance of amphipods in the eastern Chukchi Sea.

The eastern North Pacific (ENP) gray whale population is currently estimated at 20,990 (CV = 0.050) (Durban et al. 2013, 2016), based on a census conducted in 2010-2011. While the population appears stable (Carretta et al. 2015), population estimates in the last 30 years have varied from a high of 26,916 (CV = 0.058) in 1987-1988 to a low of 15,762 (CV = 0.080) in 1992-1993 (Laake et al. 2012). The proportion of the ENP population that migrates into the eastern Chukchi Sea in any given year is unknown, as is the timing of the southbound migration. These data gaps make it difficult to determine the relative importance of eastern Chukchi Sea foraging grounds to ENP gray whales. Continued broad-scale aerial surveys in the northeastern Chukchi Sea will help identify gray whale foraging patterns in relation to climate change.

The importance of the northeastern Chukchi Sea to gray whale calves has persevered for several decades and is possibly increasing. Maher (1960) noted that several gray whales taken between July and September by hunters from the villages of Wainwright and Utqiaġvik in the 1950s were calves of the year, based on length measurements. Based on ASAMM data, gray whale calf occurrence in the eastern Chukchi Sea has been inconsistent among years. Gray whale calves have been seen in 16 of the 21 years that ASAMM aerial surveys have been conducted in the region with some regularity (1982-1991, 2008-2018); sightings of more than one gray whale calf per year were recorded in only 10 of the 21 years (Clarke et al. 1989, 2012, 2013a, 2014, 2018a).

Fewer gray whale calves were seen in the eastern Chukchi Sea in 2018 than in 2016 ($n_i = 58$) and 2017 ($n_i = 55$) (Clarke et al. 2017a, b, 2018a). When calf sightings were corrected for survey effort, the gray whale calf on-effort sighting rate in 2018 was 0.0013 CPUE, which was lower than the on-effort sighting rate in 2014, 2016, and 2017, but higher than annual gray whale calf sighting rates from 2009 to 2013 and 2015 (Figure 61). Calf sighting rate was particularly high in July 2018 in block 17 (Figure 62), which is reflective of the July overall gray whale sighting rate in that block (Figure 25).

July remained the month when most gray whale calves were seen. Weaning likely takes place in late summer or early fall (Sumich 1986); therefore, all gray whales identified during ASAMM as calves based on significantly smaller size and close association with an adult were likely calves of the year. It is also possible that small gray whales seen in late August or September that were not closely associated with an adult may have been calves of the year that had already been weaned, but they were not identified as such and were not included in the calf count.

Revisions to ASAMM circling protocols in 2018 limited the opportunities to collect gray whale cow-calf photos. However, ASAMM collected opportunistic photographs of gray whale cow-calf pairs in 2016 and 2017, with a focus on fluke imagery. Gray whales, including calves, can be individually identified in photographs, which have nearly always been collected from vessels (e.g., Calambokidis et al. 2002; Bradford et al. 2011) and, more recently, from drones (Press 2015). Identification during systematic aerial surveys is nearly impossible if photographs are not collected. Analysis of photographs obtained in 2016 and 2017 indicate that gray whale calf resights in the eastern Chukchi Sea may not be common and that high calf sighting rates documented by ASAMM are not inflated by resights (Willoughby et al. 2018b).

ASAMM gray whale calf counts in the eastern Chukchi Sea are consistent with counts of cow-calf pairs documented during the northward spring migration off the central California coast by NMFS Southwest Fisheries Science Center (through 2016; Perryman et al. 2017) and off the southern California coast by the Los Angeles Chapter of the American Cetacean Society (American Cetacean Society, Los Angeles Chapter 2019) (Figure 63). In both the eastern Chukchi Sea and off the southern California coast, calf counts peaked in 2016 and decreased in 2017 and again in 2018. Calf counts may have been related to favorable foraging conditions from 2011 to 2016, resulting in higher reproductive success.

In 2014, the ASAMM study area was expanded to include regular surveys from July through October in block 23 (67°-68°N), allowing multiyear comparisons of data collected in the southcentral Chukchi Sea (blocks 22 and 23). This area southwest of Point Hope encompasses a known gray whale hotspot (Kuletz et al. 2015), with high benthic biomass (Moore et al. 2003; Bluhm et al. 2007; Grebmeier et al. 2015) and one of the Distributed Biological Observatory (DBO) transect lines. Gray whales have been sighted in this area during aerial and vessel surveys conducted in summer and fall since at least the 1980s (e.g., Moore 2000), but dedicated survey effort was rare prior to the most recent decade. In 2018, gray whales were sighted in this benthic hotspot from mid-July through early October. Humpback and fin whales were also sighted in this area, but gray whales were spatially and temporally segregated from the balaenopterids. The majority of gray whales were observed in the western half of block 23 in July, while humpback and fin whales were primarily observed in the eastern half of block 23 in

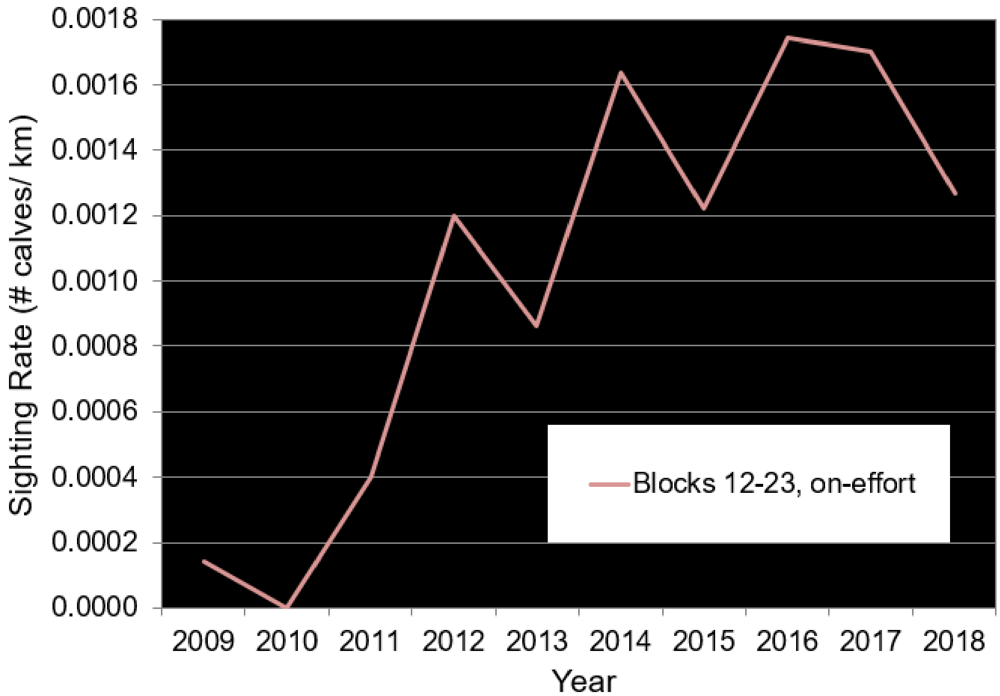

Figure 61. ASAMM gray whale on-effort annual calf sighting rates (CPUE; sightings from primary observers only), blocks 12-23 combined, 2009-2018.

July and September. The lack of overlap between gray, humpback, and fin whales was similar to 2015 and 2017 (Clarke et al. 2017a, 2018a), but the opposite of what was observed during all months from 2009 to 2012 (Clarke et al. 2013b) and in August 2016 (Clarke et al. 2017b).

Distributions of large whales in the southcentral Chukchi Sea are likely related to water masses (including Bering Shelf Water, Anadyr Water, and Alaska Coastal Water), which collectively produce sharp temperature and salinity gradients between 166°W and 168°W at ~67.5°N (Eisner et al. 2013). Sharp density gradients can aggregate zooplankton and fishes that feed on zooplankton. Analysis of data from the DBO will possibly reveal oceanographic and biological parameters that may have influenced gray whale and other large whale distributions and densities in 2014-2018.

Beluga distribution in the ASAMM study area in 2018 remained similar to the distribution observed over the past 30 years (Figure 36). It is well known that ASAMM effort does not document the full extent of beluga range in the eastern Chukchi and western Beaufort seas (Stafford et al. 2017). Aerial survey effort conducted north of the current ASAMM study area from 1989 to 1991 (Moore and Clarke 1992) and in 2016 (Clarke et al. 2017b), results from beluga satellite telemetry efforts (e.g., Richard et al. 2001; Suydam et al. 2001; Hauser et al. 2014, 2015; L. Loseto, Fisheries and Oceans Canada, pers comm. to J. Clarke, 8 March 2019), and acoustic detections (Moore et al. 2012) indicate that belugas regularly traverse the eastern Chukchi and western Beaufort seas much farther north than the current ASAMM study area. Moore et al. (2012) reported beluga calls recorded from May through August 2009 on a passive

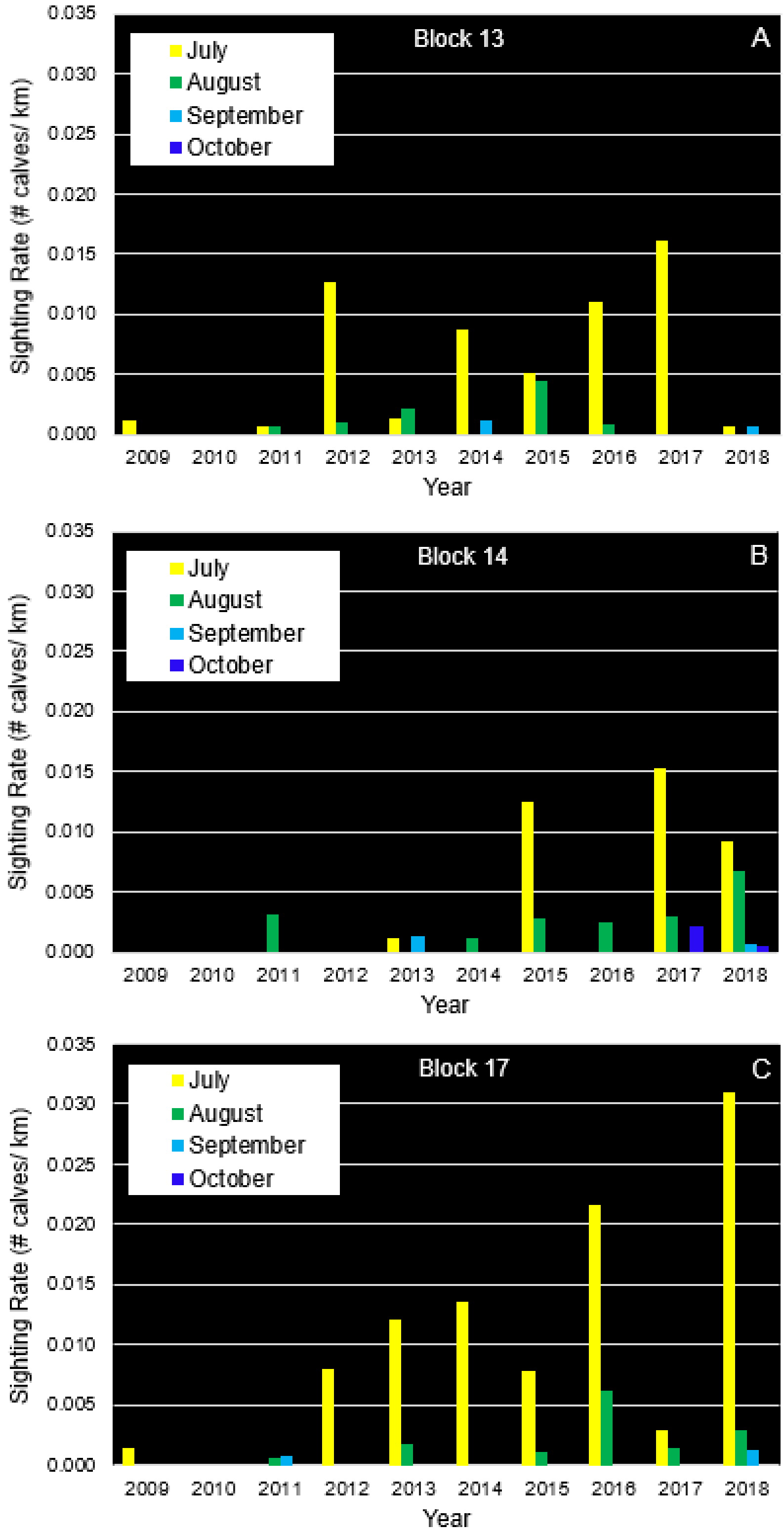

Figure 62. ASAMM gray whale on-effort annual calf sighting rates (CPUE; sightings from primary observers only) the northeastern Chukchi Sea, July-October pooled, 2009 to 2018. A: block 13. B: block 14. C: block 17. Sighting rates of zero were removed from the graph for clarity.

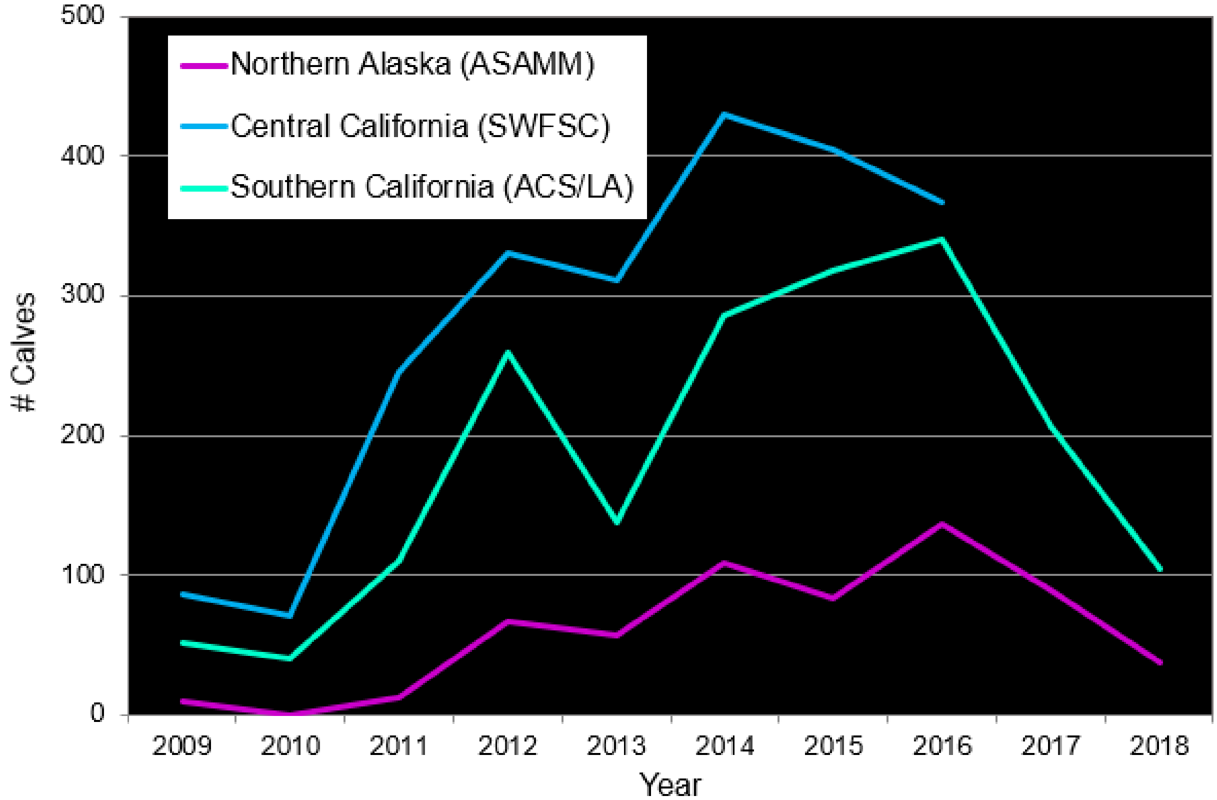

Figure 63. ASAMM gray whale annual calf counts in the eastern Chukchi Sea off northern Alaska, summer and fall 2009-2018, ACS/LA northbound calf counts off southern California, spring 2009-2018, and SWFSC northbound calf counts off central California, spring 2009-2016. Calf counts from central California in 2017 and 2018 are still under analysis.

acoustic recorder moored on the Chukchi Plateau (75.1°N, 168°W), more than 340 km north of the ASAMM study area. Two stocks of belugas, the ECS and the Beaufort Sea stocks, are found in the ASAMM study area in fall (Hauser et al. 2014). These two stocks combined may comprise ~60,000 belugas (Hill and DeMaster, 1999; Muto et al. 2018; Lowry et al. 2017), all of which presumably migrate through the western Beaufort and eastern Chukchi seas each fall. Although beluga habitat extends north to at least 76.5°N, ASAMM data allow for inter-year comparisons of distribution and relative abundance within the ASAMM study area. Compared to 2012-2017, the beluga sighting rate in 2018 in the western Beaufort Sea was within the normal range for July and decreased to lower than previously observed in August (Figure 64A). The presence of heavy ice in the western Beaufort Sea throughout August may have affected detectability. The overall fall beluga sighting rate in the western Beaufort Sea was higher than sighting rates in 2016 and 2017 (Figure 64B), but lower than sighting rates in 2013-2015.

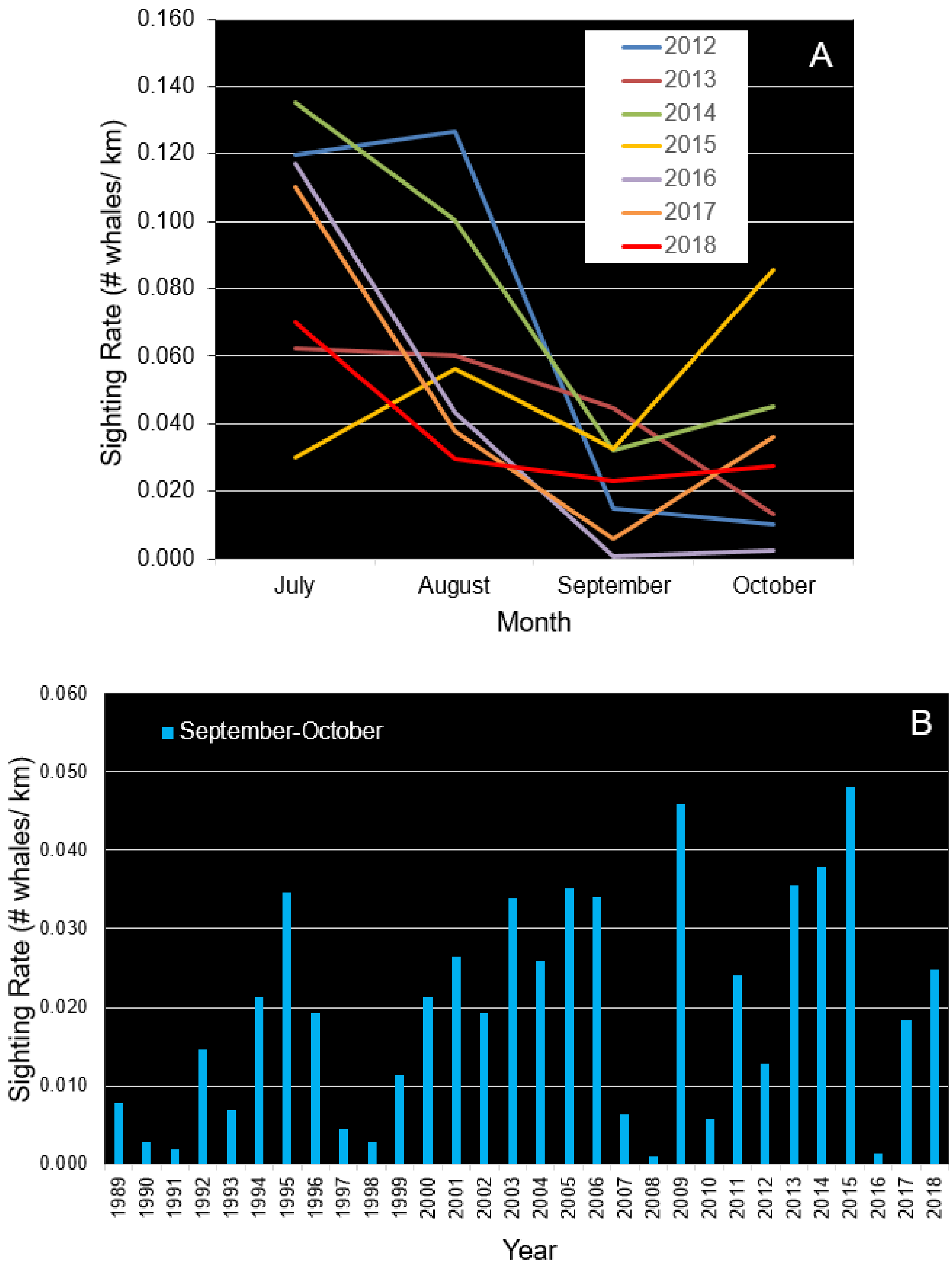

Figure 64. ASAMM beluga on-effort annual sighting rates (WPUE; sightings from primary observers only), 1989-2018. A: monthly sighting rates in the western Beaufort Sea (140°W-157°W), 2012-2018. B: fall (September-October pooled) sighting rates in the western Beaufort Sea, 1989-2018.

Beluga distribution and depth preference in the ASAMM western Beaufort Sea study area have not perceptibly changed over 35 years. Analysis of ASAMM data from 1982 to 1991 indicated a strong preference for continental slope habitat, which remained unchanged in data from 2009 to 2016 (Clarke et al. 2018a). Sea ice preference did appear to change over time, from a preference for heavy ice in 1982-1991 to a preference for open water/light ice in 2009-2016. However, this is likely due to the change in sea ice conditions between the two time periods. It is likely that the relationship of belugas to sea ice cover in the western Beaufort Sea reflected differences in the geographic distribution of sea ice rather than the geographic distribution of belugas, suggesting that sea ice may not be a good habitat indicator for belugas in this region. Hauser et al. (2016) found that ECS and BS belugas had non-uniform phenological responses to shifts in regional sea ice freeze-up in fall: ECS beluga migration was associated with the onset of freeze-up while BS beluga migration was not. Sea ice characteristics, including sea ice concentration and proximity to sea ice edge (15% concentration) and pack ice (90% concentration), were not found to be the strongest predictors of monthly habitat use by either ECS or BS beluga populations, although ice edge proximity was an important predictor for ECS and BS males and ECS females (Hauser et al. 2017). Hauser et al. (2017) also found that depth, slope, and proximity to bathymetric features like Barrow Canyon were greater influences on seasonal habitat selection than sea ice. Finally, Hauser et al. (2018) found that summer distribution of ECS belugas may be more related to bathymetric features, and that sea ice likely has a limited effect on beluga habitat selection, although sea ice may indirectly impact foraging opportunities.

Marine mammal data collected during the 2018 ASAMM field season provide a vital contribution to the overall understanding of marine mammal ecosystems in the eastern Chukchi and western Beaufort seas. In addition to continuing to document bowhead whale, gray whale, and beluga distribution, relative abundance, and habitat use during summer and fall, important information was also obtained in 2018 relating to unique situations and other species. Harbor porpoises, and minke, humpback, fin, and killer whales seasonally inhabit arctic and subarctic habitats (Suydam and George 1992; Higdon and Ferguson 2009, 2011; Laidre and Heide-Jørgensen 2012; Clarke et al. 2013b; Christman and Aerts 2015), and have been increasingly encountered in the eastern Chukchi Sea since 2009 (Brower et al. 2018a). As in 2009-2017, most observations of these species in 2018 were limited to the southcentral Chukchi Sea (Figure 65). Minke whales, killer whales, and harbor porpoises were seen in the northeastern Chukchi Sea.

This is the eighth consecutive year that ASAMM has documented minke whales in the northeastern Chukchi Sea (Clarke et al. 2012, 2013a, 2014, 2015a, 2017a, b, 2018a; Brower et al. 2018a). Minke whales were also sighted in summer 2009, summer and fall 2012, fall 2013, and summer 2014 in the northeastern Chukchi Sea during marine mammal vessel-based surveys conducted by the oil industry (Brueggeman 2010; Bisson et al. 2013; Aerts et al. 2013; Smultea et al. 2014; C. Christman, CLC Research, pers. comm. to J. Clarke, 27 February 2014). Dave Roseneau (USFWS) reported seeing one to three minke whales per year near Cape Lisburne from 1995 to 2009 (pers. comm. to J. Denton, BOEM, 15 October 2010). Minke whales were encountered from 2010 to 2012 during marine mammal surveys conducted in the southern Chukchi Sea (from the Bering Strait to 69°N) (Clarke et al. 2013b), although less frequently than either humpback or fin whales. One minke whale was sighted southeast of Point Hope during

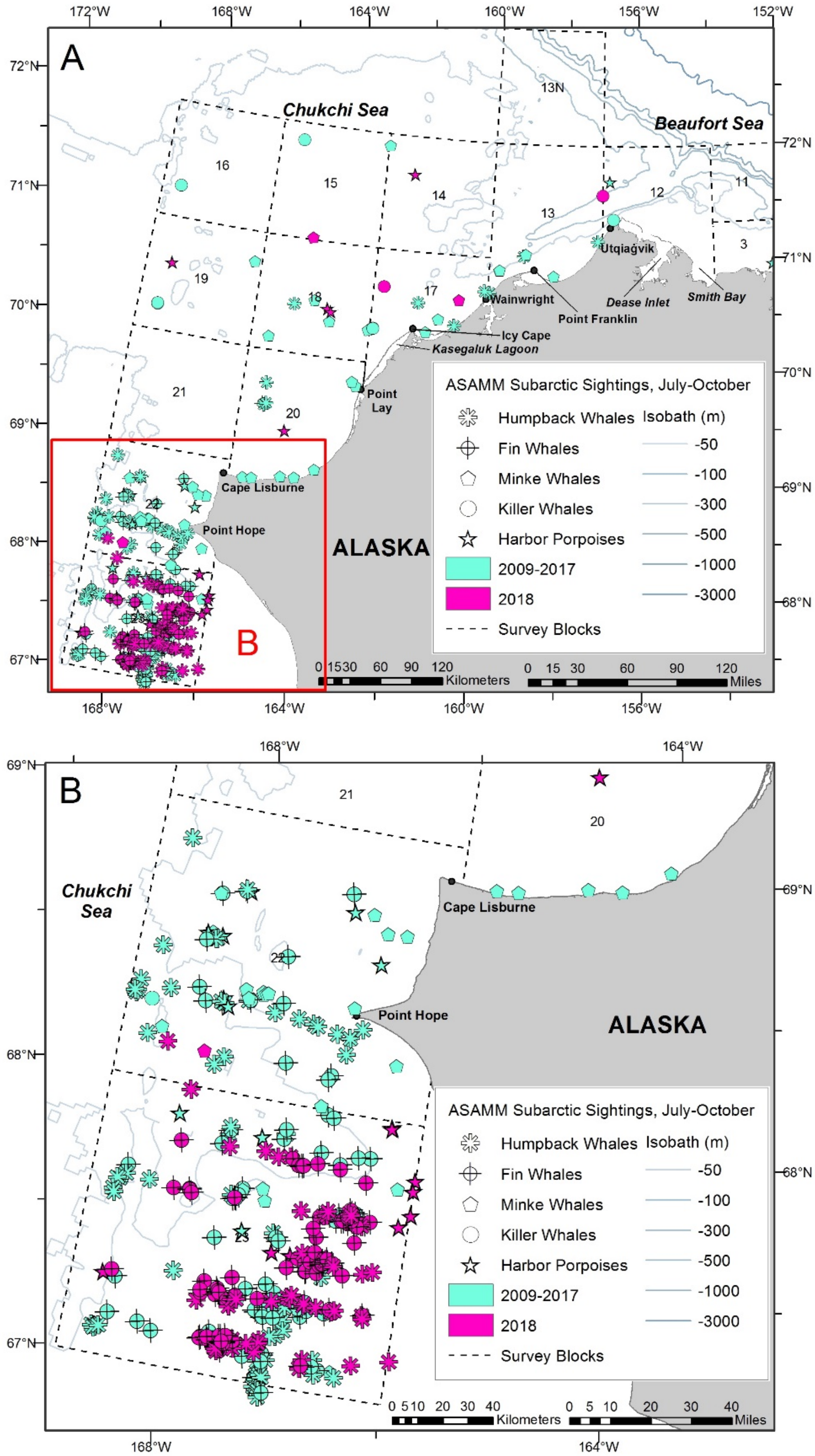

Figure 65. ASAMM subarctic cetacean distribution (transect, CAPs, search and circling modes), July-October, 2009-2018. A: eastern Chukchi Sea. B: southcentral Chukchi Sea.

the Arctic Whale Ecology study (ARCWEST) in mid-September 2014 (NMML/RACE/PMEL 2014).

Humpback whales have been frequently encountered since 2009 in the southern Chukchi Sea (from Bering Strait to 69°N) (Clarke et al. 2013b; Brower et al. 2018a). More humpback whales were seen in 2018 than in any past year, and sighting rates were higher in July and September compared to those months in any previous year 2014-2017 (Brower et al. 2019; Appendix C). Humpback whales are occasionally observed in the western Beaufort (Hashagen et al. 2009) or northeastern Chukchi seas (Clarke et al. 2011d, 2013a), but their occurrence is not regular or frequent. One humpback whale was seen associated with a group of gray whales in shelf waters off Point Barrow in 2009 (Shelden et al. 2017). Five humpback whales were seen north of 69°N during ASAMM surveys in 2012 (Clarke et al. 2013a). One humpback whale was seen west of Utqiaġvik in summer 2012 during oceanographic surveys conducted by the oil industry (L. Aerts, LAMA Ecological, pers. comm. to J. Clarke, 12 April 2013). Two humpback whales were seen in the northeastern Chukchi Sea by industry observers in fall 2013 (Smultea et al. 2014).

Fin whales occur regularly in the northern Bering Sea (Moore et al. 2002) and have been documented every year since 2010 in the southern Chukchi Sea (from Bering Strait to 69°N) (Clarke et al. 2013b; Brower et al. 2018a). More fin whales were seen in 2018 than in previous years, and sighting rates were higher in July and September 2018 compared to those months in previous years 2014-2017 (Brower et al. 2019; Appendix C). Fin whales were the most common acoustically detected species in the Chukchi Sea during the September-October 2014 ARCWEST cruise (NMML/RACE/PMEL 2014), with all detections in the southcentral Chukchi Sea. Fin whale occurrence in the northeastern Chukchi Sea remains rare, with two sightings in 2013 (Clarke et al. 2014; L. Aerts, LAMA Ecological, pers comm. to J. Clarke, 10 February 2014) and one sighting in 2008 (Clarke et al. 2011d). Fin whale calls detected near Barrow Canyon in August 2012 represent the farthest north acoustic fin whale detection in the Pacific Arctic (Crance et al. 2015).

Humpback, fin, and minke whales are frequently seen near one another, particularly in the southern Chukchi Sea near a well-documented benthic hotspot. Although feeding is not always directly observed of humpback, fin, and minke whales during ASAMM surveys, it is likely that foraging opportunities are the main reason large whales migrate to the southern Chukchi Sea. ASAMM has documented indicators that humpback and fin whales were feeding in the southern Chukchi Sea from 2014 to 2018, including lunge feeding, expanded throat grooves, water streaming from mouth, bubbles, defecation, and many animals with short surfacing bouts in a small area. Fin and humpback whales sighted in September 2018 were primarily concentrated in dense aggregations in relatively small areas (~6 km wide x ~15 km long). These whales had short surfacing bouts, and it is likely these animals were feeding subsurface in the water column. In some years, although not in 2018, these balaenopterid whales are also seen in close proximity to gray whales. While gray whales are known to feed pelagically, in the southern Chukchi Sea they appear to be mainly benthic feeders as evidenced by the presence of mud plumes. Balaenopterid whales, on the other hand, likely feed on pelagic euphausids and small schooling fishes such as capelin and sand lance, as documented in other parts of their range. Close temporal and spatial association between humpback, fin, and minke whales may indicate that these sympatric species use trophic niche partitioning, like that documented in the Gulf of Alaska (Witteveen and Wynne 2016) and Gulf of St. Lawrence (Gavrilchuk et al. 2014). Determining exactly how habitat and prey resources are partitioned among humpback, fin, and minke whales would likely require site-specific ship surveys combining simultaneous prey sampling for species identification, prey abundance estimation using active acoustics, and visual observations, similar to research reported in Laidre et al. (2010).

Humpback, fin, and minke whales were not sighted in the eastern Chukchi Sea study area during aerial surveys conducted in 1982-1991 (Moore and Clarke 1992; Brower et al. 2018a). Increasingly frequent sightings of these species in the eastern Chukchi Sea by ASAMM and other researchers reinforce the possibility of the species expanding (or perhaps re-inhabiting) their range in the Pacific Arctic. The occurrence and relative abundance of balaenopterids in the eastern Chukchi Sea may provide important information about marine ecosystem shifts (Moore 2016). The seasonal occurrence of humpback, fin, and minke whales, in addition to bowhead and gray whales, in the ASAMM study area underscores the importance of carefully investigating all cetacean sightings to confirm species identification.

Killer whales have been visually documented, sporadically, in the eastern Chukchi Sea. Hunters from Utqiaġvik and biologists from the NSB report that a few killer whales are seen each year in the Point Barrow area (George et al. 1994). ASAMM documented killer whales near Utqiaġvik and northwest of Point Hope in 2012 (Clarke et al. 2013a), but not during surveys in 2009-2011 and 2013-2015. ARCWEST acoustically detected killer whales in the southcentral Chukchi Sea in September 2014 near a benthic hotspot frequented by gray whales (NMML/RACE/PMEL 2014). Killer whales were also detected acoustically at several recorders in the northeastern Chukchi Sea in summer 2010 (Delarue et al. 2011), and Stafford (2018) documented an increase in acoustic detections of killer whales in the southern Chukchi Sea, just north of Bering Strait, from 2009 to 2016, possibly related to greater access to sea-ice-free habitat. Killer whales were not seen during aerial surveys conducted nearshore by the oil industry from 2006 to 2010 (Thomas and Koski 2011) but were seen during the Chukchi Sea Environmental Studies Program (CSESP) in 2008 (Aerts et al. 2013) and 2012 (L. Aerts, LAMA Ecological, pers. comm. to J. Clarke, 12 April 2013). Killer whales are known predators of gray whale calves (Barrett-Leonard et al. 2011), and ARCWEST documented a killer whale predatory attack on a gray whale calf near Wainwright in September 2013 (NMML, unpublished data; B. Rone, NMML-AFSC, pers. comm. to A. Brower, 18 December 2013). One of the male killer whales documented near Utqiaġvik during ASAMM surveys in August 2012 had been sighted on numerous occasions near False Pass, Unimak Island, in the Aleutian Island chain (Clarke et al. 2013a), which is prime territory for hunting gray whales. Killer whales also prey on belugas (Shelden et al. 2003; O'Corry-Crowe et al. 2016) and narwhals (Campbell et al. 1988). Bowhead whales are also preyed on by killer whales, and the frequency of killer whale scars on bowhead whales in the Pacific Arctic increased significantly from 1990-2001 to 2002-2012 (George et al. 2017). The occurrence of killer whales in the Arctic is expected to continue to increase with decreasing sea ice cover (Higdon and Ferguson 2009; Stafford 2018).

Harbor porpoise distribution extends north to Point Barrow and the offshore areas of the northeastern Chukchi Sea (Muto et al. 2018), and sightings in the western Beaufort Sea indicate that their range may be expanding (Clarke et al. 2018a). However, despite the uptick in research in the northeastern Chukchi Sea since 2008, there have been relatively few harbor porpoise sightings. During thousands of kilometers of CSESP vessel survey effort between 2008 and 2014, only 27 harbor porpoises were seen, primarily in the northeastern Chukchi Sea (Aerts et al. 2013; Christman et al. 2015). Aerial surveys conducted along the northwestern Alaskan coastline of Point Hope and Point Barrow in 2006-2008 and 2010 by contractors for Shell yielded four harbor porpoise sightings (Thomas and Koski 2011). Observers on ARCWEST cruises in 2013 and 2014 reported a few (<10) sightings in the southern Chukchi Sea (Friday et al. 2016) and ASAMM observed one harbor porpoise during hundreds of thousands of kilometers flown prior to 2016. Suydam and George (1992) reported nine records of live and dead harbor porpoises near Point Barrow, Alaska, from 1985 to 1991. The relative paucity of sightings may indicate that harbor porpoises are not densely distributed in the eastern Chukchi Sea. However, harbor porpoises are small and often do not stay at the surface very long, making them difficult to see during either vessel surveys or aerial surveys conducted at >305 m altitude, particularly in sea states that are ≥ Beaufort 2. Harbor porpoises have not been detected acoustically in the Chukchi or Beaufort seas, likely because harbor porpoise sound production is at a higher frequency (>100 kHZ) than most recorders can detect (e.g., Garland et al. 2015; Hannay et al. 2013).

Temperate odontocetes acoustically detected in the southeastern Chukchi Sea in 2016 and 2017 include Pacific white-sided dolphins (*Lagenorhychus obliquidens)* and Risso's dolphins (*Grampus griseus*) (Seger and Miksis-Olds 2019). Neither of these species have been visually detected north of the southern Bering Sea (Jefferson et al. 2014; Muto et al. 2018).

A coastal walrus haulout on a barrier island west of Point Lay formed in late August 2018 and persisted until at least 19 October. This is the latest date for a coastal haulout to remain onshore at Point Lay since onshore haulouts were first documented along the northeastern Chukchi Sea coast in 2007. The estimated number of walruses at the Point Lay haulout varied considerably over the 2.5 months of use in 2018, similar to what was documented in previous years (Figure 66). The use of coastal haulouts in the Chukchi Sea has been linked to receding summer sea ice; sea ice extent in the Chukchi Sea in August 2018 was again historically low (National Snow and Ice Data Center 2018a).

ASAMM surveys are not designed to continuously monitor coastal walrus haulouts, and most observations of coastal haulouts have been opportunistic (e.g., data collected during transits to or from targeted survey areas elsewhere). Walrus coastal haulout data collected by ASAMM have demonstrated the dynamic nature of coastal haulouts within short periods of time. In 2014, an ASAMM survey near the Point Lay haulout yielded an estimate of 35,000 walruses, while a photographic survey six hours later on that same day estimated that the haulout was significantly smaller (20,300) as walruses presumably left to feed offshore (Battaile et al. 2017). Similarly, estimates from ASAMM surveys conducted within one or two days of each other in 2010, 2011, and 2018 also showed large fluctuations in group sizes (Figure 66). The use of photographs, even those taken obliquely from a distance greater than 4 km offshore, has proven to be an effective means of estimating haulout size in lieu of direct overflights that have a higher likelihood of causing disturbance to walruses, and further enhance the utility of ASAMM for documenting the haulout. All public dissemination of walrus sighting information was coordinated through USFWS, the federal agency responsible for managing walruses.

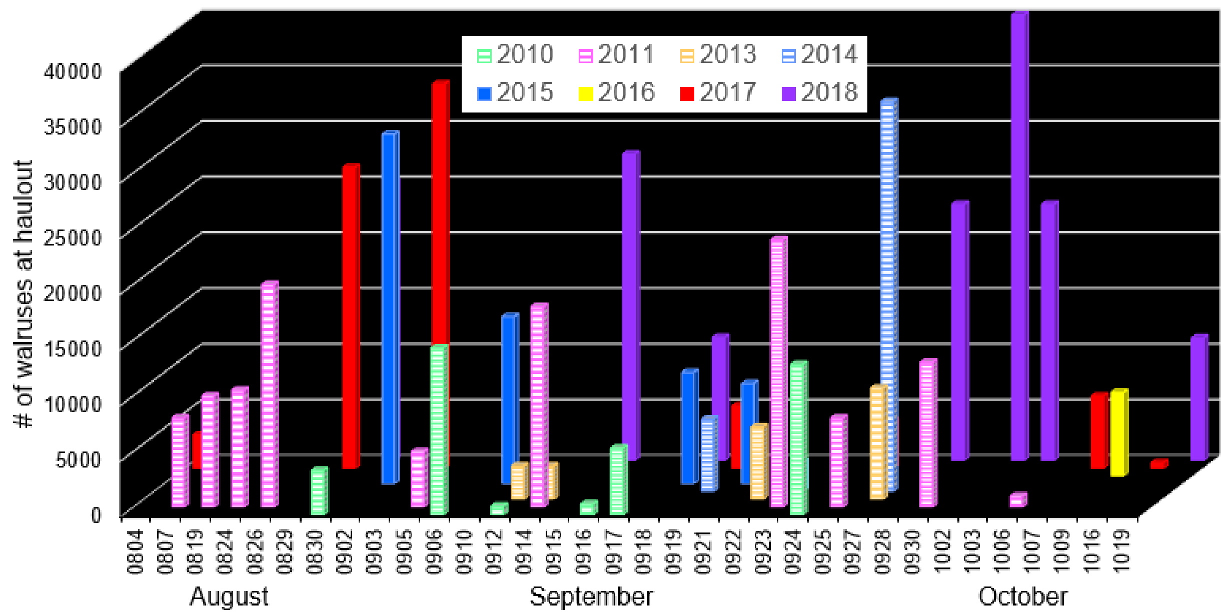

Figure 66. ASAMM walrus group size estimates by month and day (e.g., 0804 is 4 August) and year at coastal haulouts near Point Lay, 2010-2018. Walruses hauled out near Icy Cape but not at Point Lay in 2009; walruses did not haul out at any location along the northeastern Chukchi Sea coastline in 2012.

Sighting rates (number of pinnipeds per km) of unidentified pinnipeds and small unidentified pinnipeds combined, excluding seals observed on coastal haulouts, were low in both the eastern Chukchi Sea and western Beaufort Sea in 2018 compared to previous years (Figure 67). Sighting rates in summer 2018 were the lowest recorded compared to any previous year in both areas (Figure 67A). Whether the low sighting rates are an indication of low relative abundance is difficult to deduce. Heavy sea ice persisted throughout summer in the western Beaufort Sea, and pinnipeds are difficult to detect visually hauled out in heavy sea ice (Young et al. 2019). In fact, aerial surveys conducted to specifically assess ice seal abundance use double sampling data collection methods, like infrared imaging combined with high resolution digital photography, to locate ice seals hauled out on sea ice (Conn et al. 2014); surveys are also conducted at lower altitudes (300 m) than ASAMM surveys. Therefore, it is possible that seals hauled out on sea ice were not seen by ASAMM observers. Additionally, ASAMM surveys prioritize cetaceans so some pinnipeds may not be recorded in areas of high cetacean density, which would also negatively affect sighting rates. It is worth noting that sighting rates in summer and fall 2018 in the eastern Chukchi Sea, which was essentially sea ice-free from mid-August through the end of October, were also low compared to previous years sighting rates (lowest ever in summer, Figure 67A; lowest since 2013 in fall, Figure 67B). This would imply that pinnipeds were indeed scarcer in 2018.

The distribution of pinnipeds in 2018 was similar to observed distributions in previous years (Clarke et al. 2011a, d, 2012, 2013a, 2014, 2015a, 2017a, b, 2018a). Most pinnipeds were within the 300-m isobath in the ASAMM study area (Figures 45 and 46), which is also where the

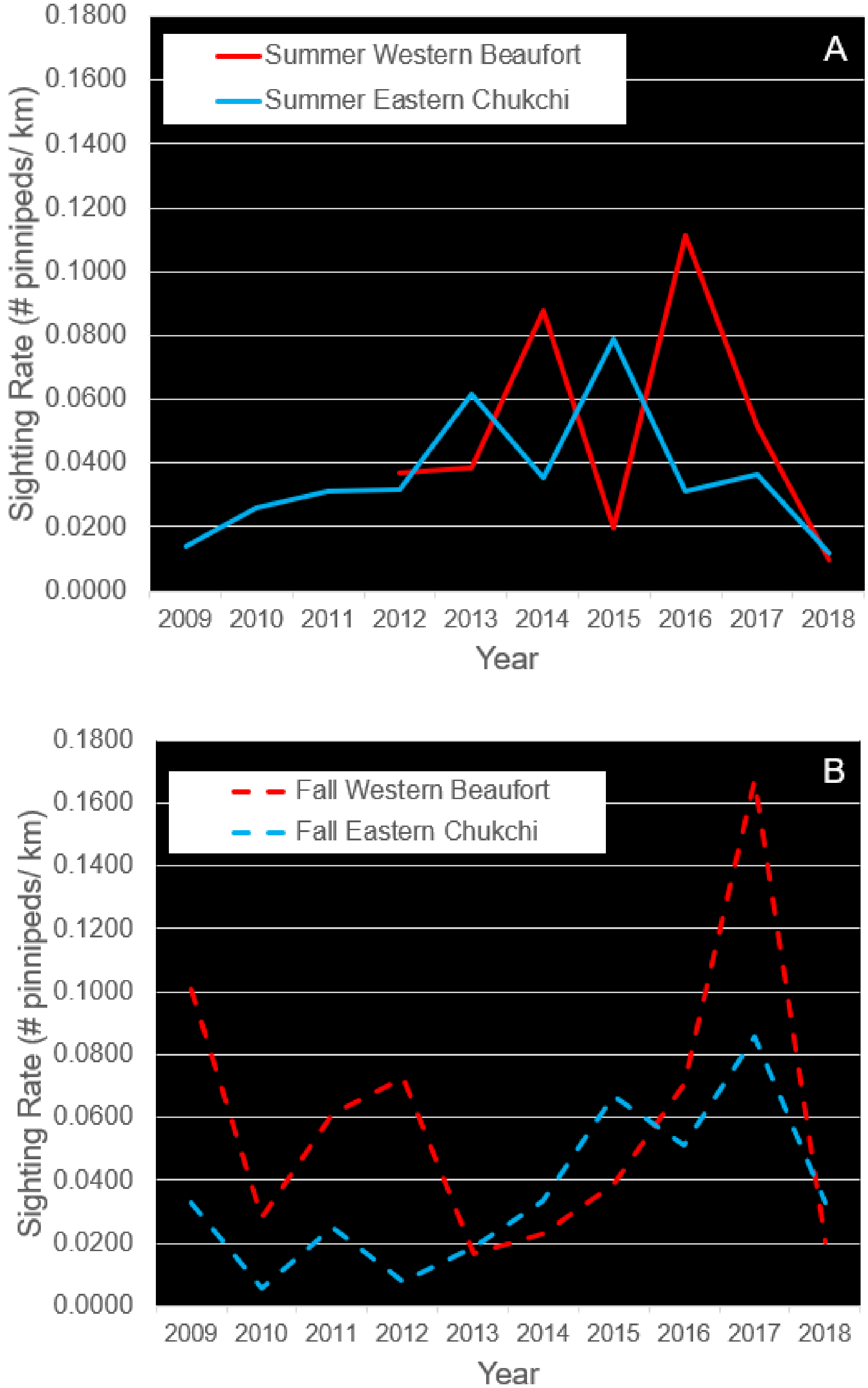

Figure 67. ASAMM unidentified pinniped and small unidentified pinniped (combined) annual sighting rates (PPUE; sightings from primary observers only) in the eastern Chukchi and western Beaufort seas, 2009-2018. A: summer (July-August pooled). B: fall (September-October pooled). Excludes pinnipeds observed at onshore haulouts.

majority of satellite-tagged ringed, spotted, and bearded seals were found in July-October from 2012-2019 (Alaska Department of Fish and Game 2019). Migration paths of eight ringed seals tagged in the eastern Beaufort Sea in September 2001 and 2002 were also within the 200 m isobath in the western Beaufort Sea (Harwood et al. 2012).

The distributions of ringed, spotted, and bearded seals overlap in the western Beaufort and northeastern Chukchi seas (Lowry et al. 1998; Boveng et al. 2009; Muto et al. 2018). Behaviors and physical characteristics of small pinnipeds observable from the survey altitude of the ASAMM aircraft (365-458 m) are not distinguishable enough to allow positive species identification (MML, unpublished data; D. Rugh and D. Withrow, MML-AFSC, pers. comm. to J. Clarke, 8 December 2009). To better identify pinnipeds to species, ASAMM would likely need to conduct surveys at lower altitudes, which could negatively impact observations of other species and increase incidental takes. Incorporating a high-resolution camera system for continuous collection of digital images during ASAMM surveys is another possible means of increasing the ability to identify pinnipeds to species. However, results from surveys conducted specifically to collect digital images of ice seals still had problems with species misidentification, particularly of spotted seals (McClintock et al. 2015). Images in the McClintock study were taken from a lower altitude (300 m) than target ASAMM altitudes and were limited to seals that were hauled out on ice, which provided better visibility compared to pinnipeds in water. Furthermore, preliminary results from images collected from a vertical camera installed during 2015 ASAMM surveys are not promising. Post-flight processing is time intensive, and the images do not have the resolution to distinguish between spots or rings on seals in water (K. Leonard, LGL, pers. comm. to M. Ferguson, 25 January 2017).

Polar bear sightings decreased substantially in 2018 compared to previous years. Only eight polar bears (n_i = 1 in July, n_i = 7 in September) were sighted in 2018 during coastal transect surveys in the western Beaufort Sea for an overall sighting rate of 0.003 polar bears per km. Polar bears were rarely seen along the western Beaufort Sea coast in July 2012-2017, but often seen in September (Brower et al. 2018a). The Beaufort Sea coastal sighting rate in September 2018 (7 bears per 640 km = 0.011) was lower than sighting rates calculated for 2012-2017 (Brower et al. 2018a).

Decreased polar bear sightings in 2018 may be partially related to the presence of sea ice on the continental shelf in the western Beaufort Sea during summer months. The majority of the southern Beaufort subpopulation of polar bears remain with the sea ice year round, though the numbers of bears coming ashore in summer and fall has been increasing substantially since the mid-2000s (Atwood et al. 2016). Polar bears use sea ice as a platform to hunt ringed and bearded seals. Based on satellite tag data from the Beaufort Sea and elsewhere, bearded seals, ringed seals, and spotted seals are usually found in waters >200 m, on the continental shelf and slope (e.g., Gjertz et al. 2000; Hamilton et al. 2018; Lowry et al. 2000). When sea ice retreats beyond the continental shelf and slope in the western Beaufort Sea, some polar bears respond to the lack of a floating platform from which to feed offshore by coming to shore where they have access to subsistence-harvested bowhead whale carcasses (McKinney et al. 2017). Sea ice retreat in the western Beaufort Sea usually commences in late July or early August but was delayed in 2018 until early September; polar bears probably remained on sea ice offshore in summer. ASAMM sighted 14 polar bears offshore in sea ice cover ranging from 60 to 95% and between 20 and 106 km offshore, but many bears were likely not detected by observers because polar bears are difficult to detect in heavy sea ice, particularly from a survey altitude ≥1100 ft. By comparison, aerial surveys conducted to assess polar bear abundance are often flown at lower altitudes (60 m) and slower speeds (185.km) than ASAMM (Aars et al. 2009) or use automated remote sensing technology to find polar bears using thermal and single-lens reflex cameras (Conn et al. 2016). The whereabouts of polar bears in September and October 2018, when the western Beaufort Sea continental shelf was either ice free or covered with new ice too thin to support a polar bear, is unknown, but they likely remained farther offshore on thicker sea ice.

Care needs to be taken when analyzing ASAMM polar bear data due to effort inconsistencies. ASAMM survey design has had minor tweaks over the years, some of which are better suited for coastal polar bear data collection (e.g., adding coastal survey effort). Many factors affect ASAMM polar bear data: amount of coastal survey effort per month and year, weather conditions at known congregation areas during ASAMM surveys of those areas (e.g., fog, snow showers, or snow on the ground that camouflages bears), survey constraints such as time aloft and fuel reserves, and whether photographs of the congregation areas were taken.

Changes to the arctic marine environment observed over the past several decades (increasing mean annual temperatures, increasing mean annual wind speed, increasing storm frequency, decreasing annual sea ice thickness and extent; Wendler et al. 2009) accelerated in the 2000s (Walsh 2008), perhaps most noticeably in the record-low sea ice extent observed in 2007 and again in 2012 (National Snow and Ice Data Center 2007, 2012). Future arctic summer and fall seasons are predicted to have continued decreasing sea ice cover and younger ice, and associated climatic impacts (e.g., Simmonds et al. 2008). These changes have likely impacted or will impact most marine mammal species (Kovacs et al. 2011). Comparisons of marine mammal distributions over periods spanning more than 35 years (1982-2018) should be interpreted with caution because different ecological mechanisms could have been acting during different periods over the duration of the study.

Ongoing interest in sea ice distribution and movement, ice forecasting, and the relationship of sea ice to marine mammals and other biological communities has expanded ASAMM's impact. Because ASAMM has such a large study area and collects aerial visual data in regions where no one else does, it has become a useful platform for collecting aerial digital photographs of sea ice. These images are shared throughout the field season with multiple institutions to assist with ground-truthing remotely-sensed sea ice data and train ice analysts. These associations, ongoing since 2010, underscore the multidisciplinary nature of ASAMM and render it more than simply a "marine mammal survey".

Management Use of Real-Time Field Information

BOEM issues various permits to industry for gas and oil exploration, including open water and on-ice seasonal vessel-based geophysical permits for exploration using array(s) of deep-seismic airguns; vessel-based geological-geophysical permits for shallow-seismic exploration using airguns; on-ice geophysical permits using VIBROSEIS technology; both vessel-based and on-ice geological permits for obtaining core samples; and permits to drill for gas and oil. Summaries of ASAMM aerial survey data in the form of daily reports were made available to representatives of oil companies, the NSB Department of Wildlife Management, federal agencies, and the general public on a near real-time basis to encourage data transfer and enhance management via a website maintained by AFSC (USDOC, NOAA, NMFS 2018).

Management Use of Interannual Monitoring

This BOEM-sponsored marine mammal monitoring study began in 1979 and has continued every year up to the present. While some aspects of this study have been updated, the data collected have remained remarkably consistent (especially data from 1982 to 2018), thus permitting many direct comparisons across years. Such continuous, long-term, broad-scale, aerial monitoring of large whale migration and associated marine mammal communities is indeed unique. In addition to the accomplishments specifically mentioned in Results, the ASAMM historical dataset has been used by industry, government, and academic entities (e.g., Schick and Urban 2000; Manly et al. 2007; Givens et al. 2010; Okkonen et al. 2011, 2017; Christman et al. 2013; Clarke et al. 2013b, 2015b, 2016, 2018b, c; Stafford et al. 2013, 2017; Schonberg et al. 2014; Ferguson et al. 2015, 2018a, b; Grebmeier et al. 2015; Kuletz et al. 2015; Satterthwaite-Phillips et al. 2016; Battaile et al. 2017; Brower et al. 2017, 2018a; Lowry et al. 2017; Druckenmiller et al. 2017; Young et al. 2017; Willoughby et al. 2018a, c; Angliss et al. 2018; Stimmelmayr et al. 2018) to better understand, manage, and conserve arctic resources.

ASAMM data are critical to addressing near real-time management concerns and aid in future planning. Without current, reliable data, BOEM and other agencies, including NOAA and the Department of Defense, would be more vulnerable to litigation, and their ability to make management decisions about future anthropogenic activities in this region during summer and fall would likely be delayed.

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APPENDIX A: 2018 ICE CONCENTRATION MAPS

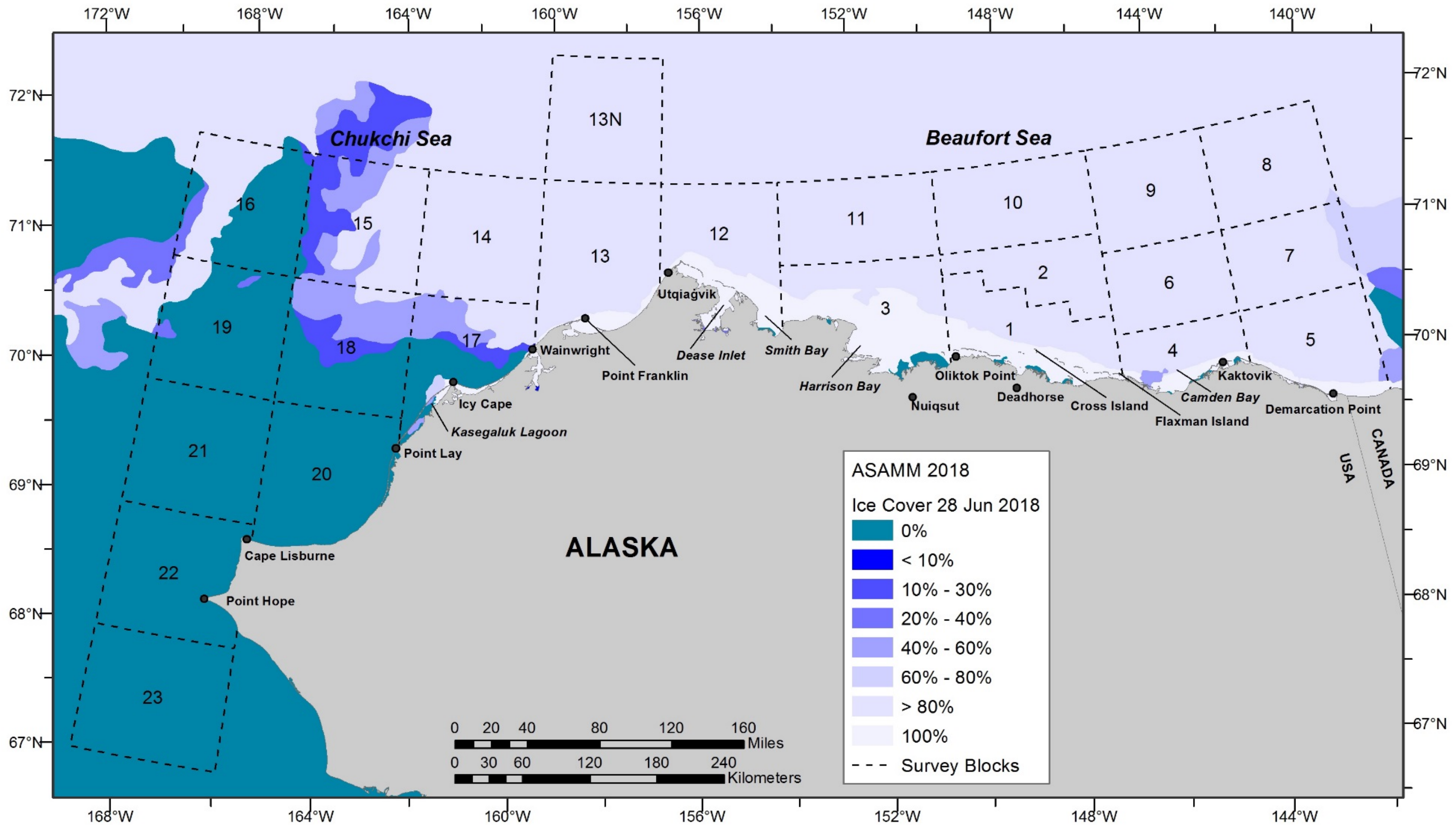

Figure A-1. Ice concentrations in the eastern Chukchi and western Beaufort seas, 28 June 2018. Sea ice information was obtained from the National Ice Center (U.S. National Ice Center 2018).

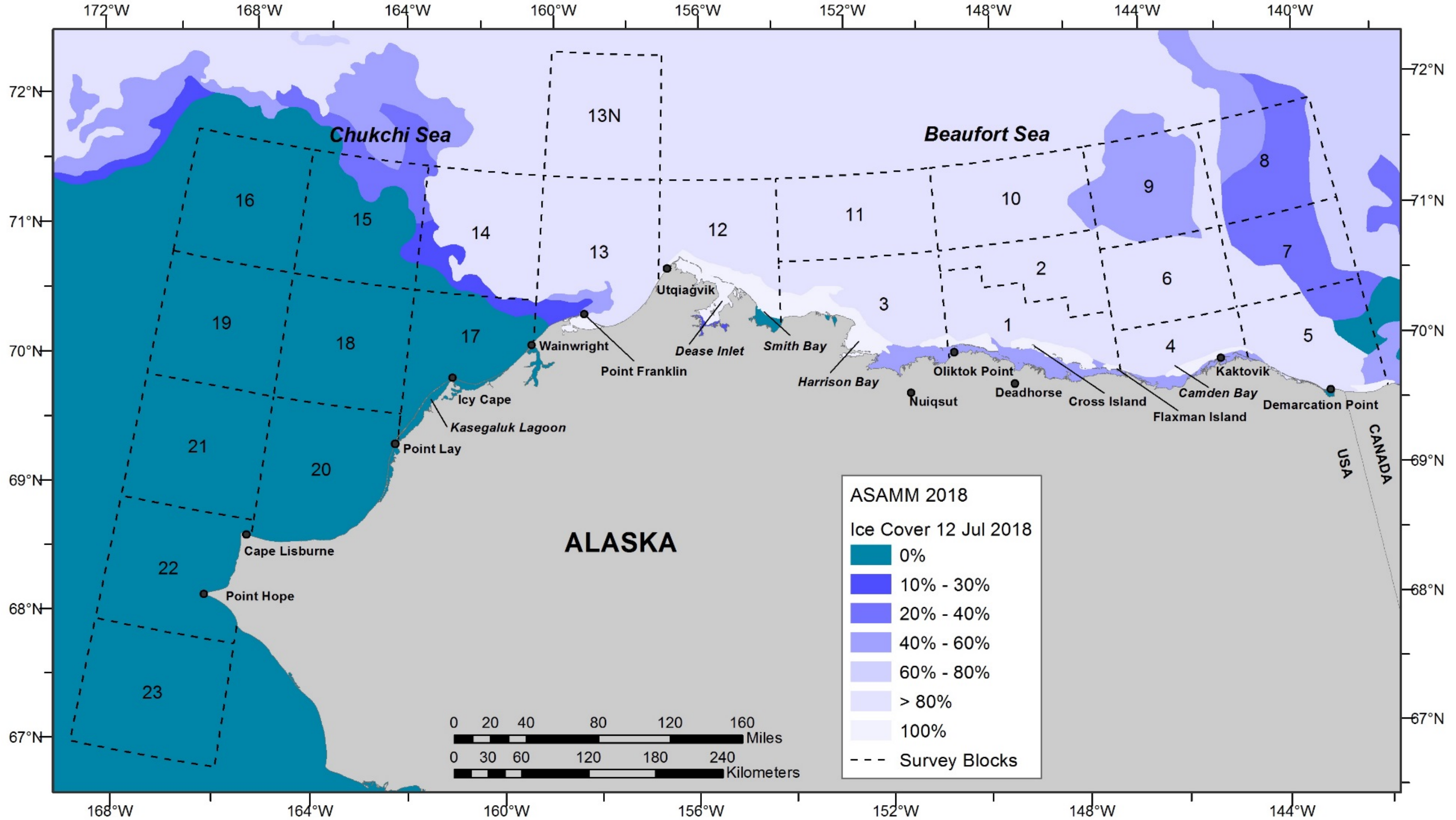

Figure A-2. Ice concentrations in the eastern Chukchi and western Beaufort seas, 12 July 2018. Sea ice information was obtained from the National Ice Center (U.S. National Ice Center 2018).

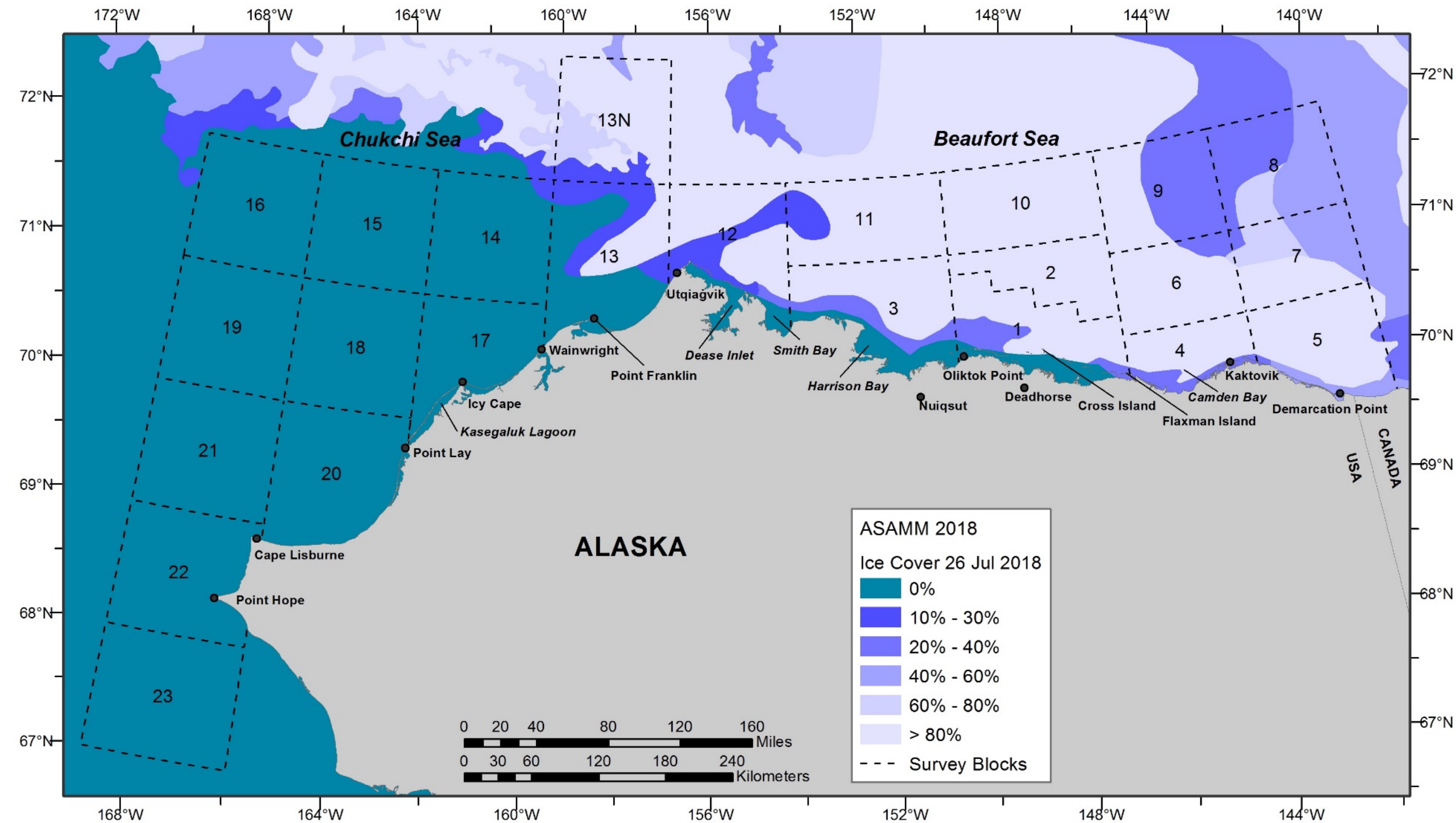

Figure A-3. Ice concentrations in the eastern Chukchi and western Beaufort seas, 28 July 2018. Sea ice information was obtained from the National Ice Center (U.S. National Ice Center 2018).

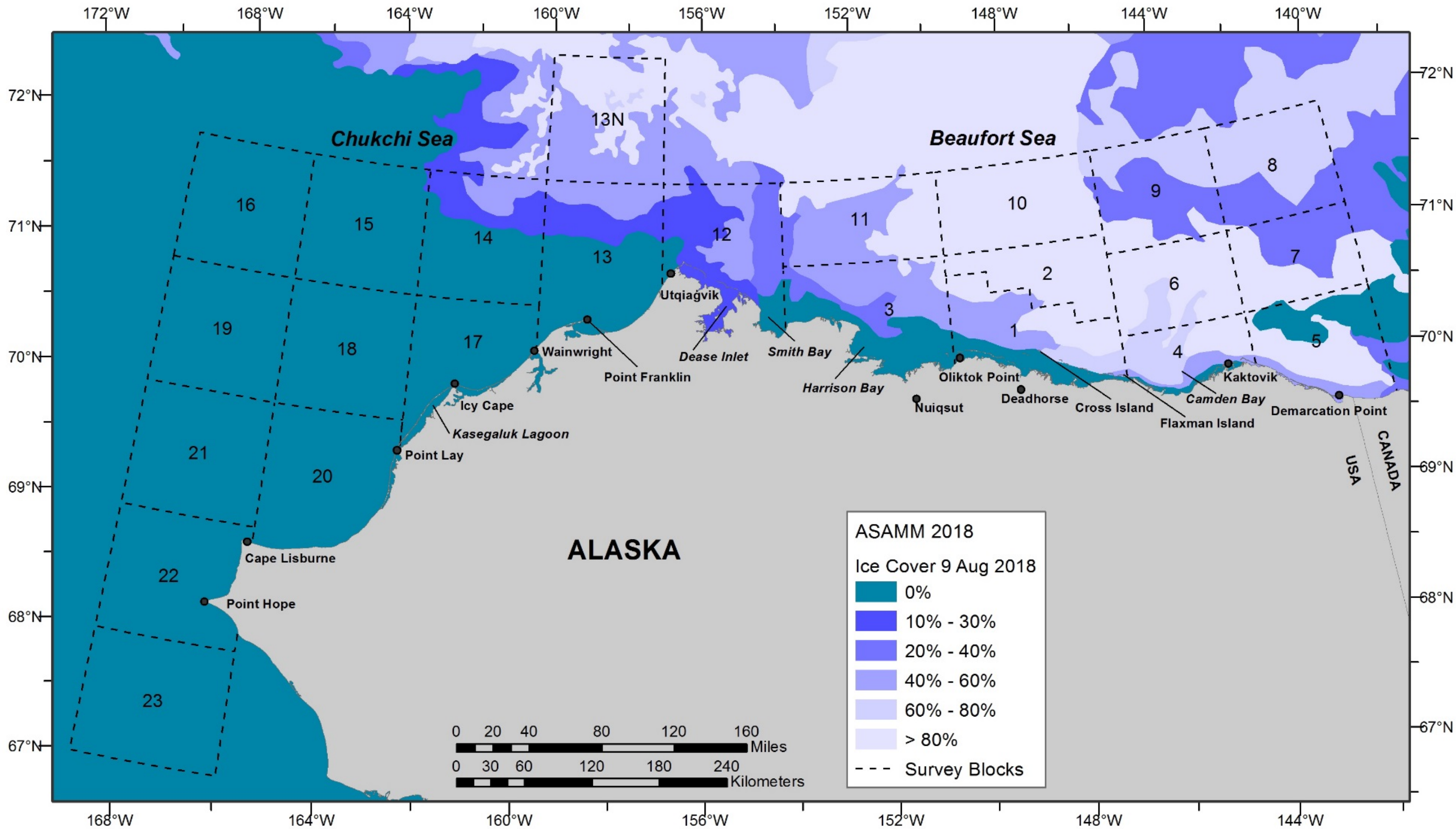

Figure A-4. Ice concentrations in the eastern Chukchi and western Beaufort seas, 9 August 2018. Sea ice information was obtained from the National Ice Center (U.S. National Ice Center 2018).

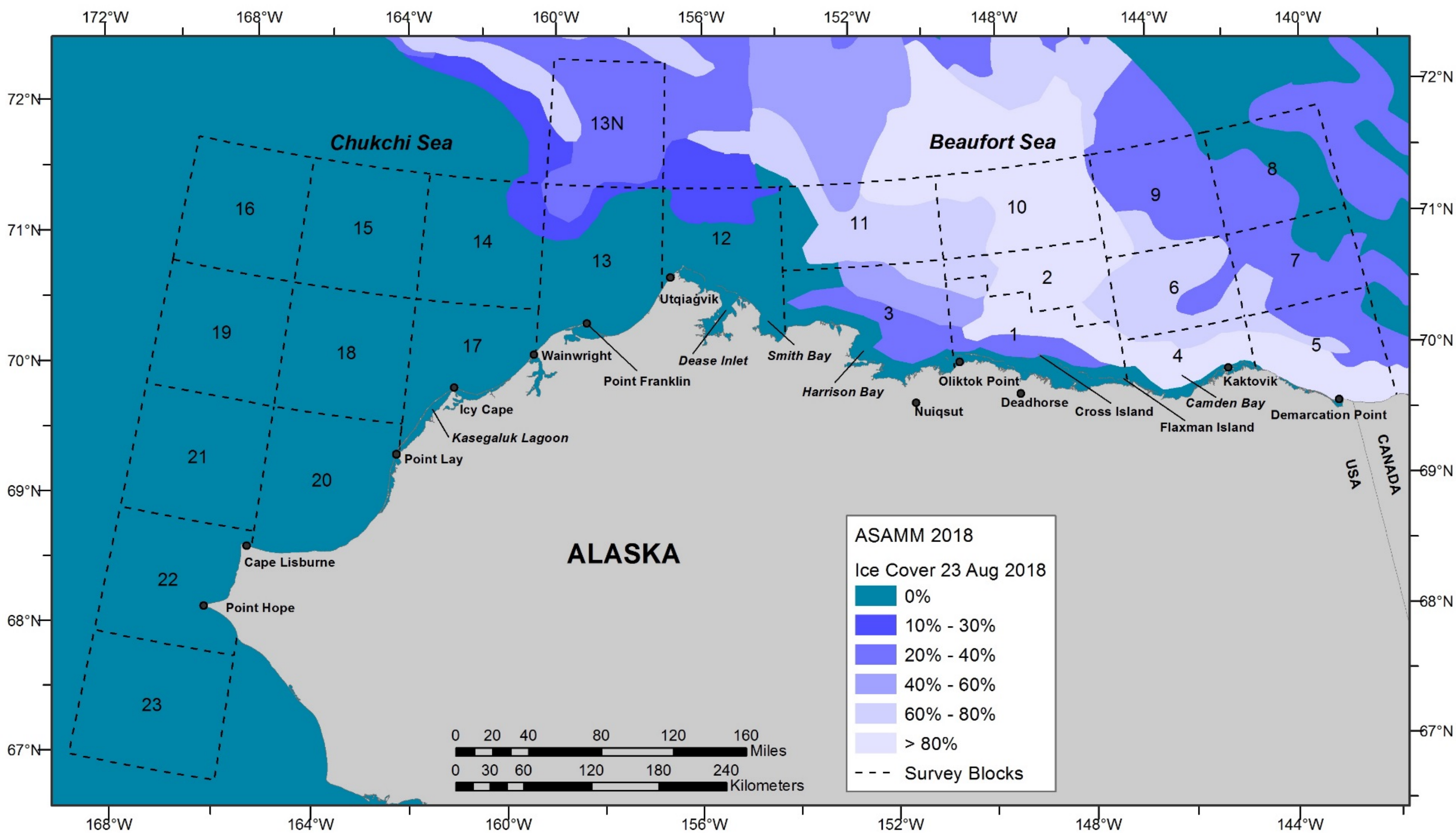

Figure A-5. Ice concentrations in the eastern Chukchi and western Beaufort seas, 23 August 2018. Sea ice information was obtained from the National Ice Center (U.S. National Ice Center 2018).

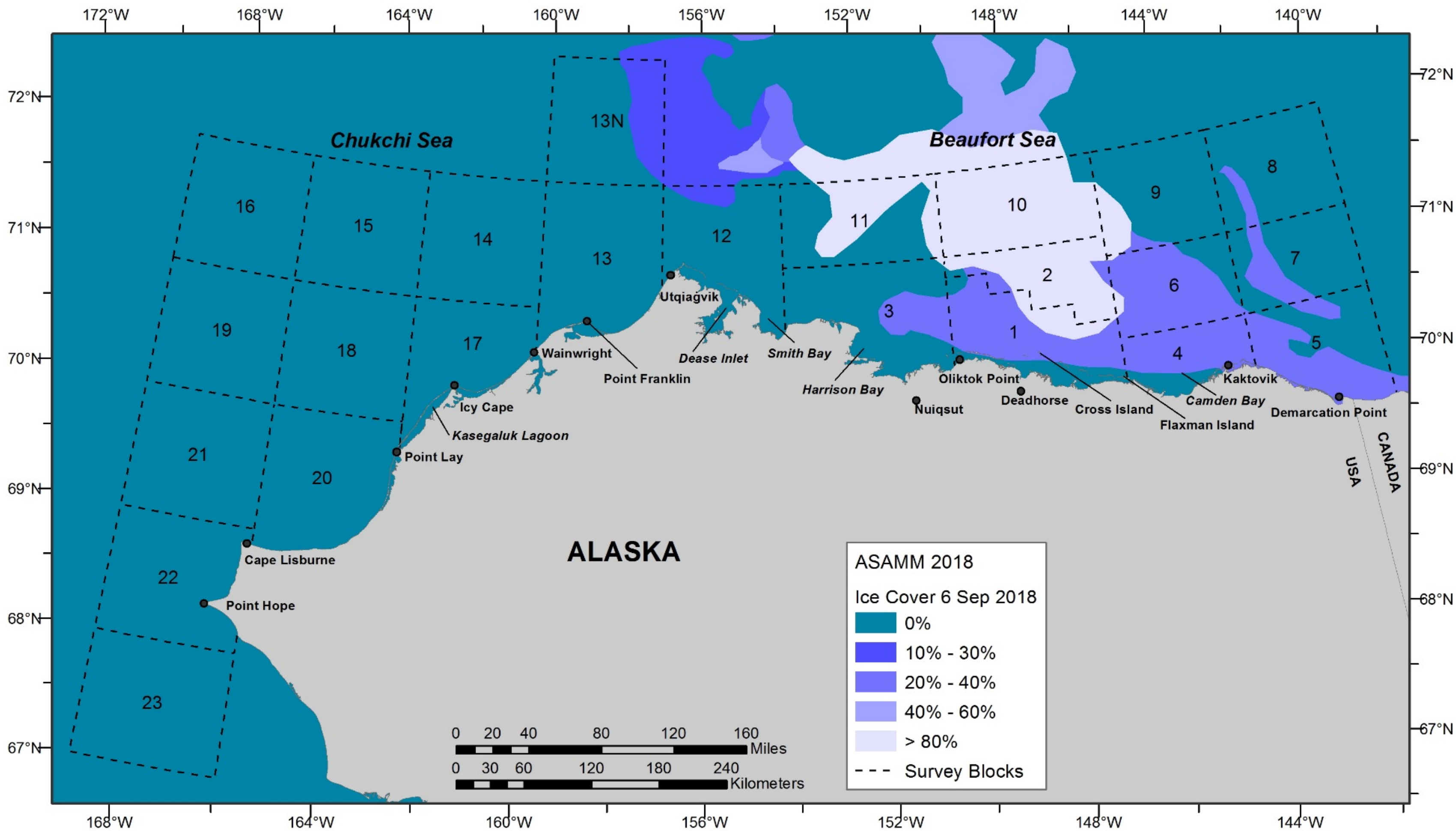

Figure A-6. Ice concentrations in the eastern Chukchi and western Beaufort seas, 6 September 2018. Sea ice information was obtained from the National Ice Center (U.S. National Ice Center 2018).

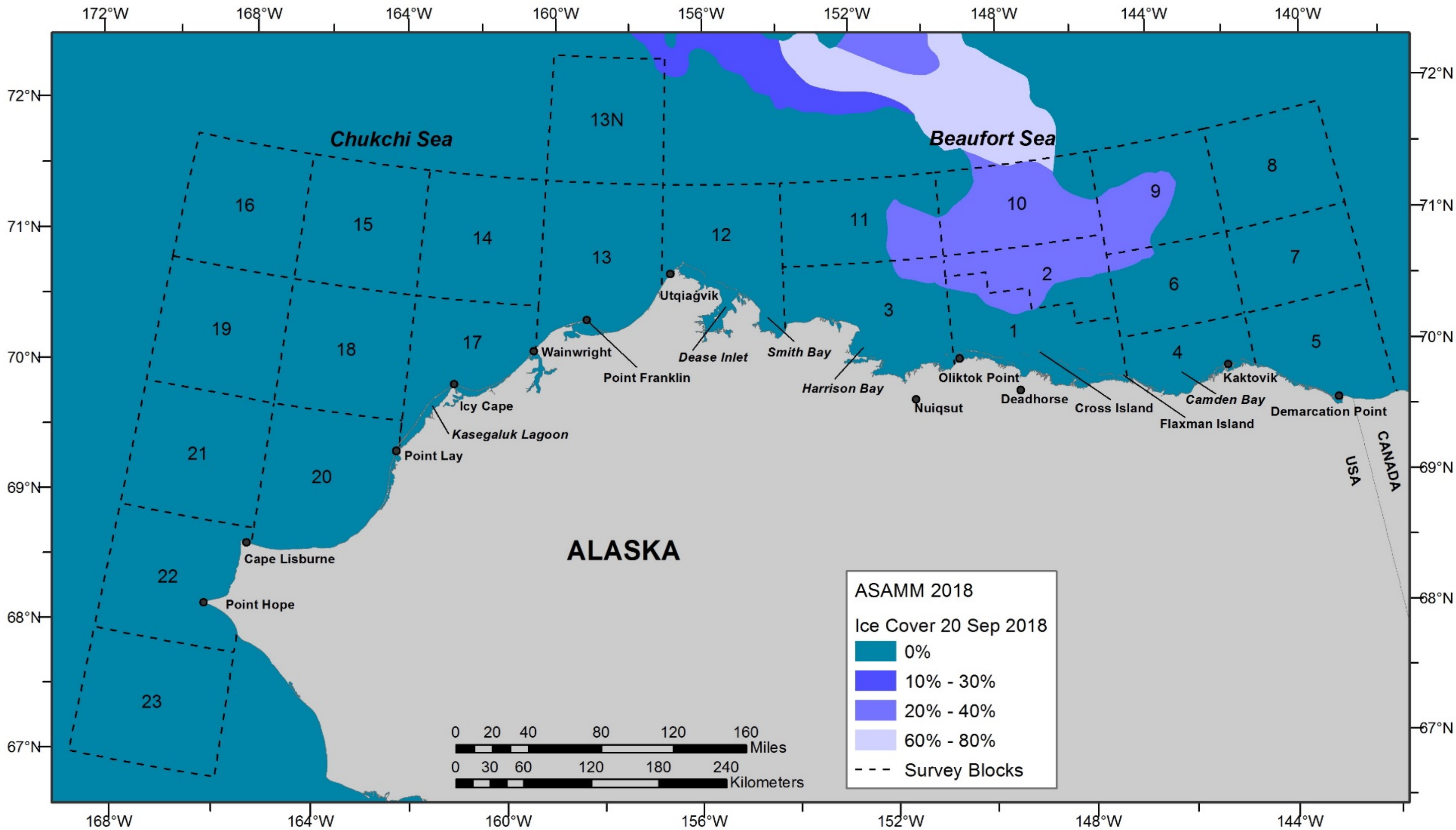

Figure A-7. Ice concentrations in the eastern Chukchi and western Beaufort seas, 20 September 2018. Sea ice information was obtained from the National Ice Center (U.S. National Ice Center 2018).

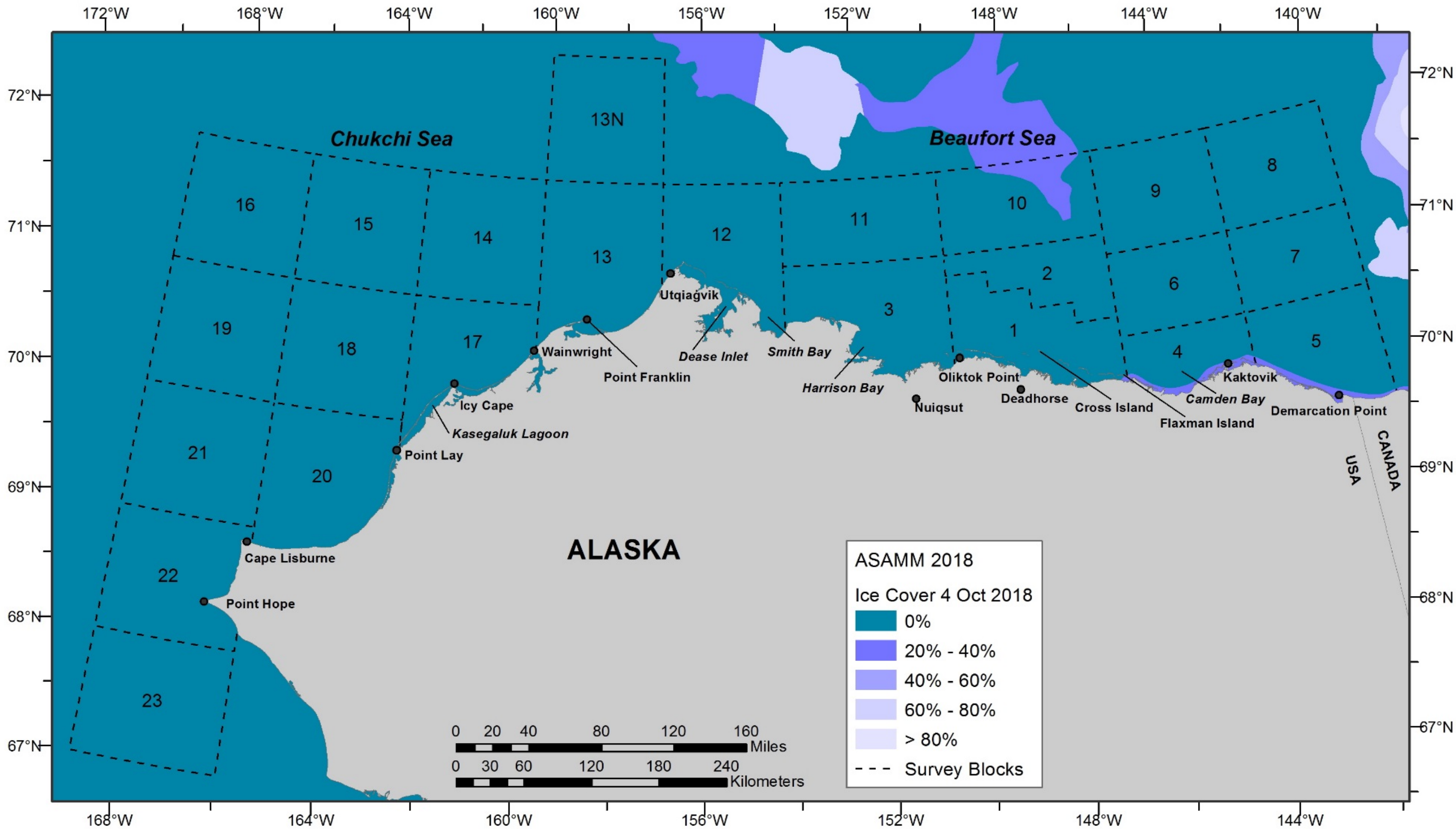

Figure A-8. Ice concentrations in the eastern Chukchi and western Beaufort seas, 4 October 2018. Sea ice information was obtained from the National Ice Center (U.S. National Ice Center 2018).

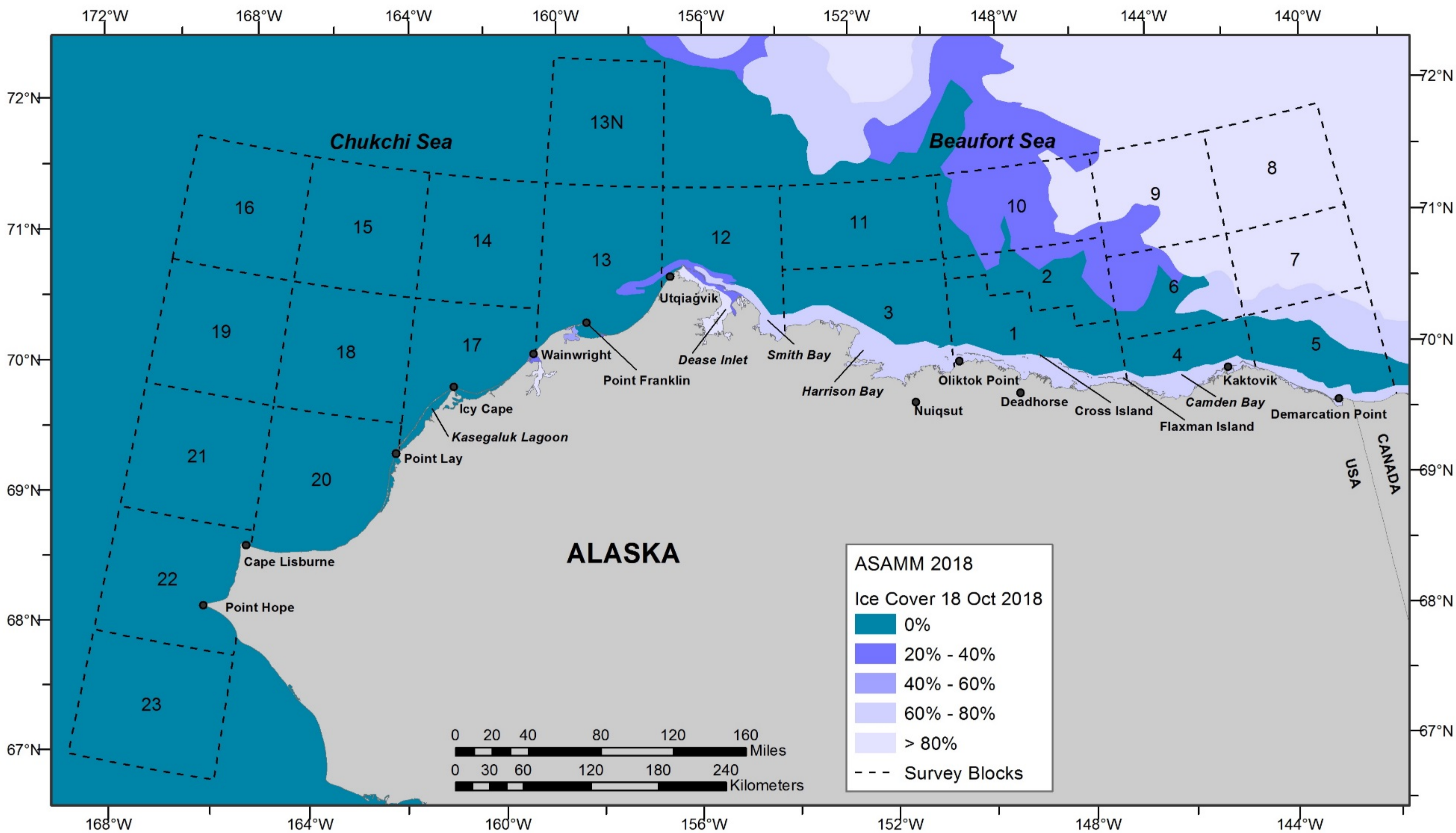

Figure A-9. Ice concentrations in the eastern Chukchi and western Beaufort seas, 18 October 2018. Sea ice information was obtained from the National Ice Center (U.S. National Ice Center 2018).

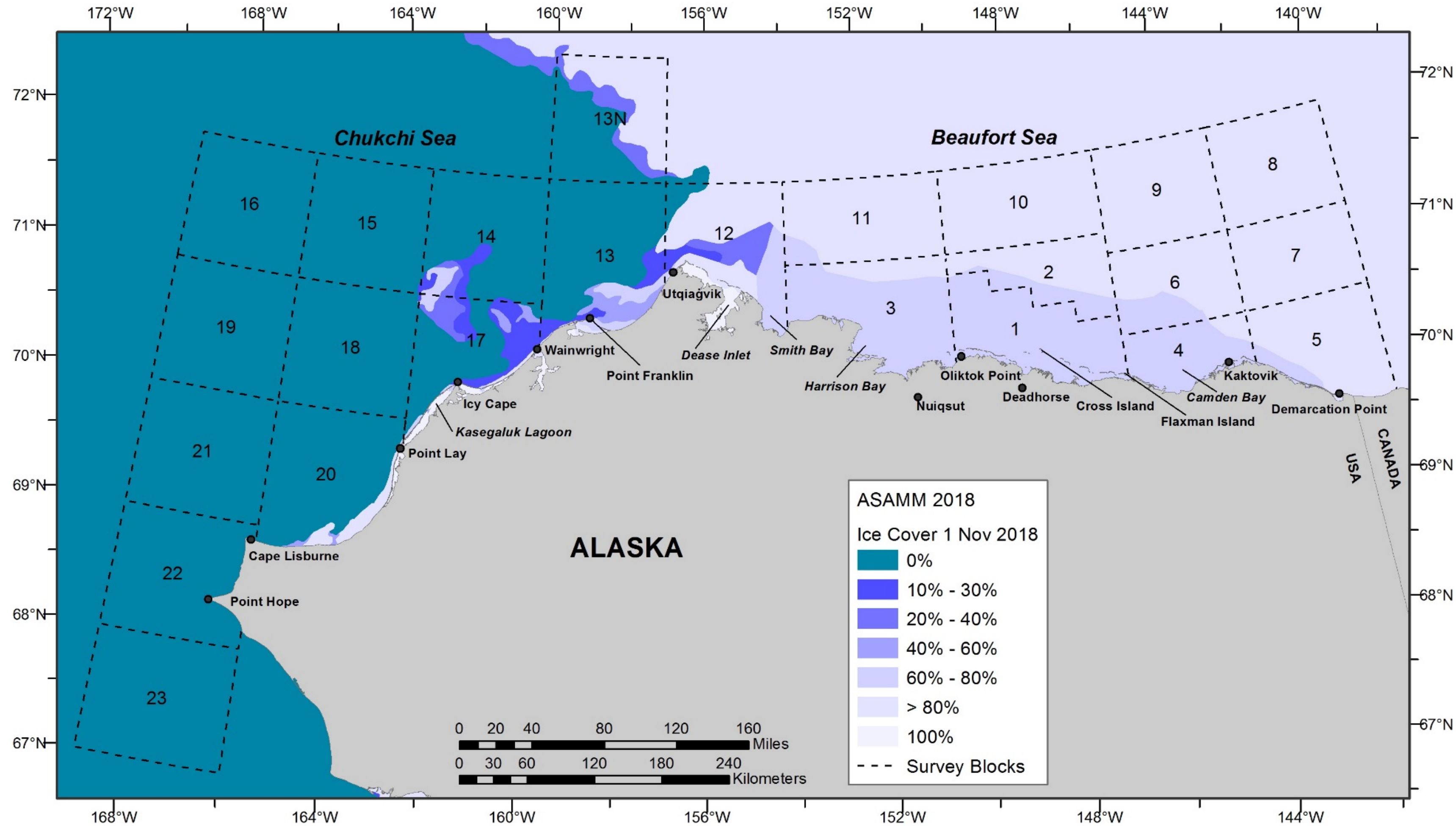

Figure A-10. Ice concentrations in the eastern Chukchi and western Beaufort seas, 1 November 2018. Sea ice information was obtained from the National Ice Center (U.S. National Ice Center 2018).

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APPENDIX B: 2018 DAILY FLIGHT SUMMARIES

3 July 2018, Flight 201

Flight was a partial survey of transects 124, 125, 126, 127, and 128, and coastal transect in Harrison Bay. Survey conditions included partly cloudy to overcast skies, <1 km to unlimited visibility, with fog, glare, haze, and precipitation, and Beaufort 0-3 sea states. Sea ice ranged from 2-98% broken floe, floe, and shorefast ice in the area surveyed. Sightings included bowhead whales (including 2 calves), belugas, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
201	7/3/2018 17:07	71.380	151.816	beluga	swim	2	0	11
201	7/3/2018 17:11	71.511	151.830	bowhead whale	swim	1	0	11
201	7/3/2018 17:28	71.568	152.296	beluga	swim	15	0	11
201	7/3/2018 17:28	71.564	152.308	beluga	swim	9	0	11
201	7/3/2018 17:32	71.443	152.343	bowhead whale	swim	2	1	11
201	7/3/2018 17:34	71.417	152.342	bowhead whale	swim	2	1	11
201	7/3/2018 17:43	71.405	152.343	bowhead whale	swim	1	0	11

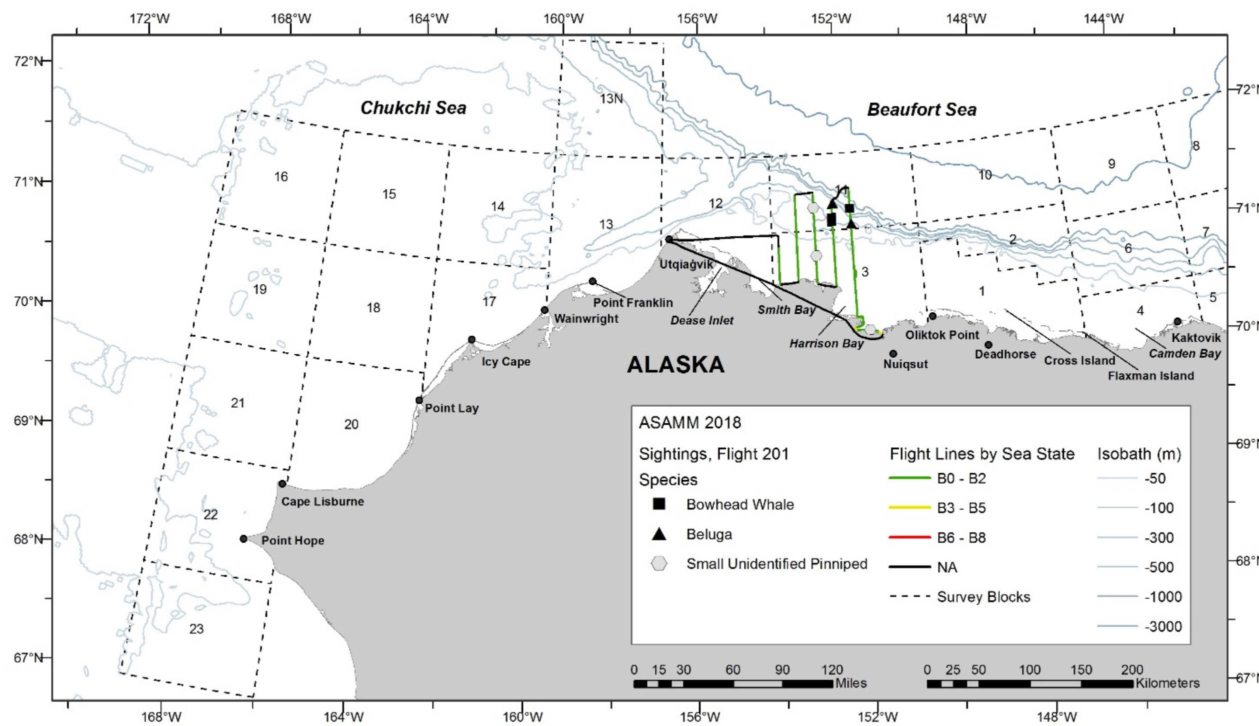

Figure B-1. Flight 201 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

6 July 2018, Flight 202

Flight was a complete survey of transects 1, 3, and 5, and partial survey of transects 6 and 7. Survey conditions included partly cloudy to overcast skies, <1 km to unlimited visibility, with fog and glare, and Beaufort 1-4 sea states. Sea ice ranged from 0-97% broken floe and floe in the area surveyed. Sightings included one bowhead whale, belugas (including 2 calves), walruses, bearded seals, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
202	7/6/2018 13:41	71.410	156.843	bowhead whale	swim	1	0	12
202	7/6/2018 13:48	71.560	156.866	beluga	mill	20	0	12
202	7/6/2018 13:53	71.696	156.941	beluga	mill	6	2	12

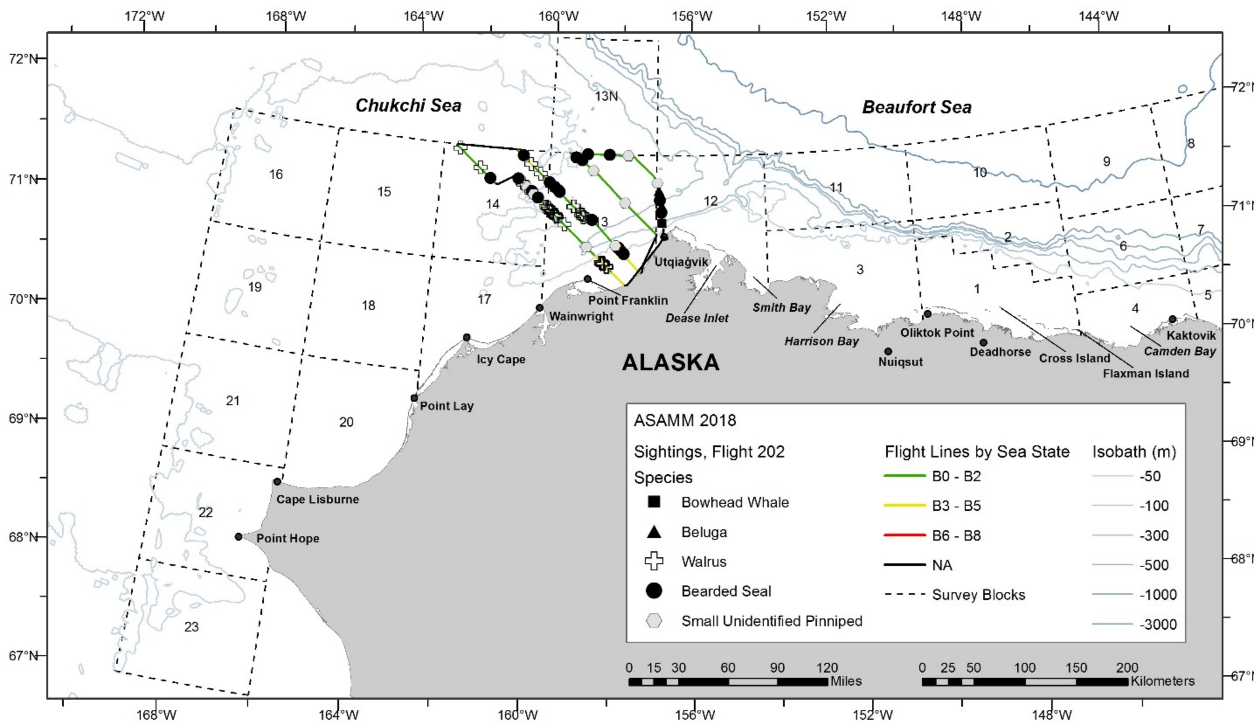

Figure B-2. Flight 202 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

9 July 2018, Flight 203

Flight was a complete survey of transects 129, 130, 131, 132, 133, and 134, coastal transect from Smith Bay to western Harrison Bay and from Point Barrow to Point Franklin, and offshore search effort from Point Franklin to Utqiaġvik. Survey conditions included clear to partly cloudy skies, <1 km to unlimited visibility, with fog, glare, and low ceilings, and Beaufort 0-2 sea states. Sea ice ranged from 0-98% broken floe, floe, and shorefast ice in the area surveyed. Sightings included walruses, bearded seals, small unidentified pinnipeds, and one polar bear.

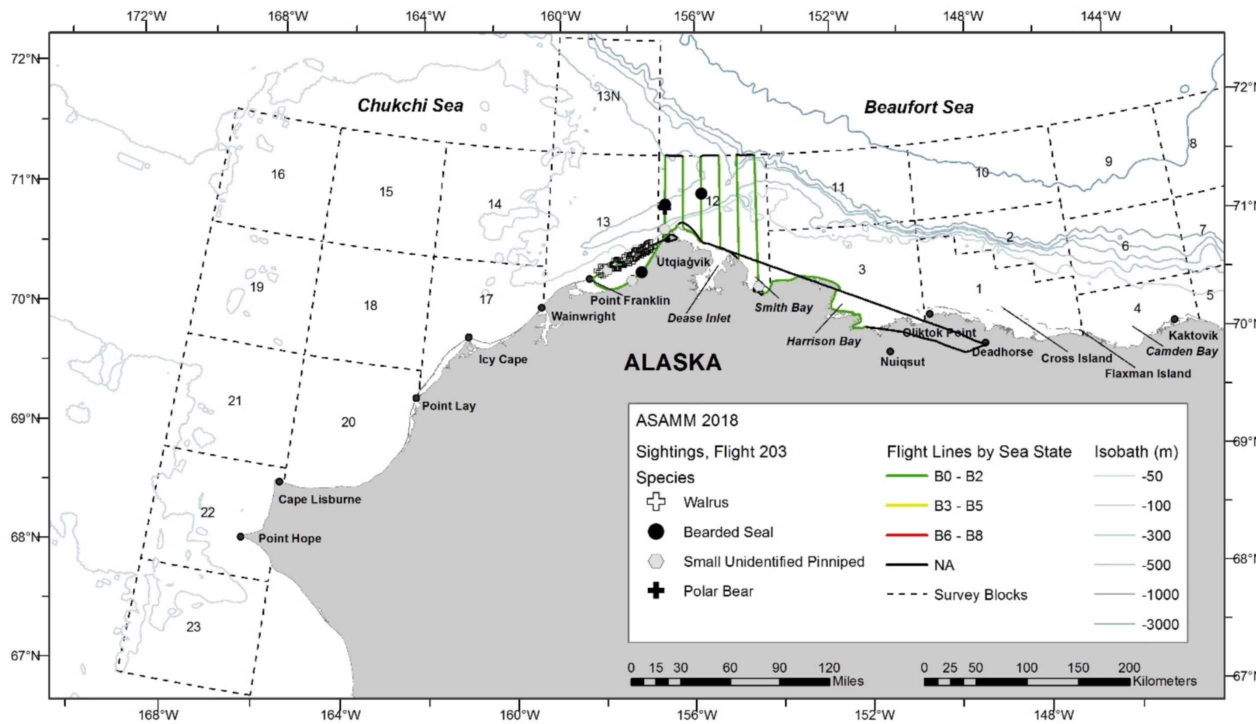

Figure B-3. Flight 203 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

The 2018 inaugural ASAMM-Chukchi team enjoying their first sunny day in Utqiaġvik, Alaska. From left to right: Megan Ferguson, Sarah Corbin, Stan Churches, Marjorie Foster, and Katie Jackson. Photo by Amy Willoughby.

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10 July 2018, Flight 204

Flight was a complete survey of transects 2 and 4, partial survey of transects 121, 122, 123, 125, 126, 127, and 128, and coastal transect in Harrison Bay. Survey conditions included clear to overcast skies, <1 km to unlimited visibility, with fog, glare, and haze, and Beaufort 0-3 sea states. Sea ice ranged from 0-97% broken floe and floe in the area surveyed. Sightings included belugas (including 5 calves), walruses, bearded seals, small unidentified pinnipeds, and one polar bear.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
204	7/10/2018 10:31	71.898	153.825	beluga	swim	2	1	11
204	7/10/2018 11:33	71.402	151.331	beluga	swim	1	0	11
204	7/10/2018 16:28	71.559	157.018	beluga	swim	1	0	13
204	7/10/2018 16:28	71.571	157.037	beluga	rest	28	4	13
204	7/10/2018 16:29	71.577	157.083	beluga	rest	1	0	13
204	7/10/2018 16:29	71.584	157.091	beluga	rest	1	0	13
204	7/10/2018 16:29	71.590	157.092	beluga	rest	2	0	13

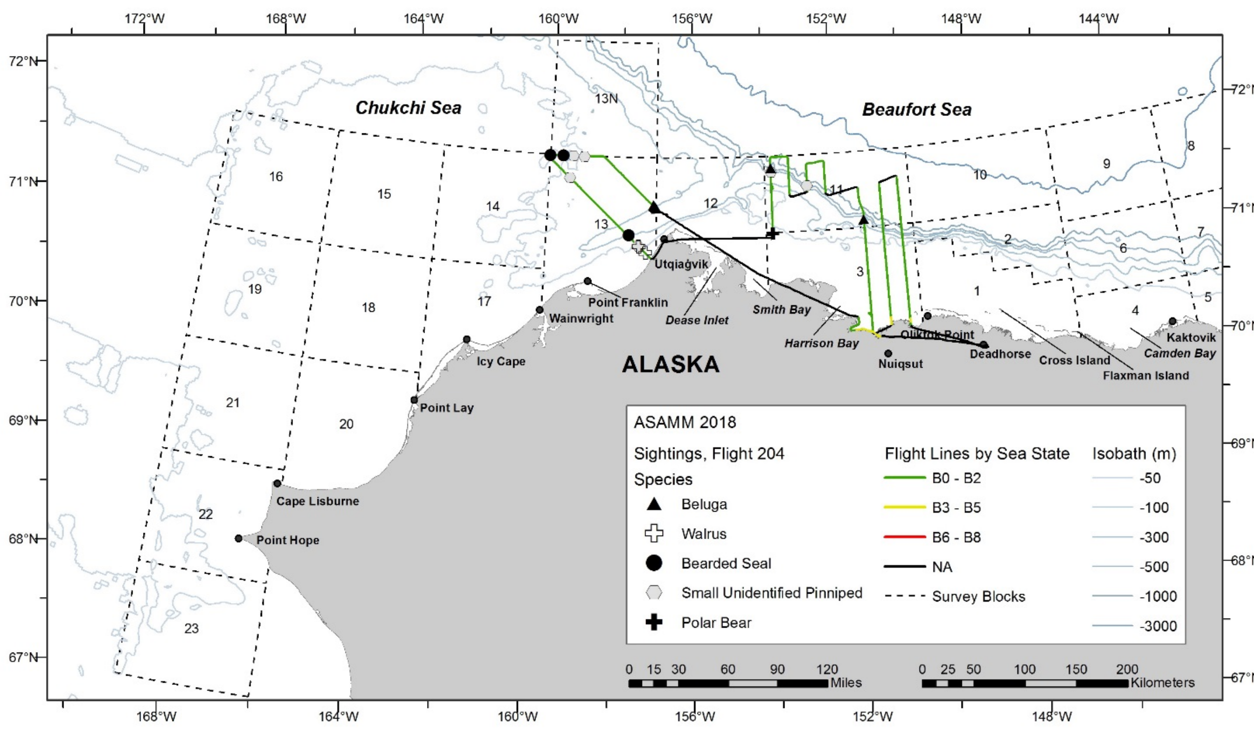

Figure B-4. Flight 204 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

11 July 2018, Flight 205

Flight was a partial survey of transects 7, 9, and 11. Survey conditions included clear to partly cloudy skies, <1 km to unlimited visibility, with fog and glare, and Beaufort 0 to 3 sea states. Sea ice ranged from 0-95% broken floe in the area surveyed. Sightings included gray whales (including 11 calves), belugas (including 45 calves), one unidentified cetacean, walruses, bearded seals, unidentified pinnipeds, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
205	7/11/2018 10:45	71.230	161.360	gray whale	swim	1	0	14
205	7/11/2018 10:50	71.184	161.314	gray whale	feed	2	0	14
205	7/11/2018 10:50	71.188	161.269	gray whale	feed	1	0	14
205	7/11/2018 10:50	71.188	161.212	unid cetacean	feed	1	0	14
205	7/11/2018 10:54	71.185	161.343	gray whale	feed	1	0	14
205	7/11/2018 10:54	71.191	161.318	gray whale	feed	2	1	14
205	7/11/2018 10:56	71.215	161.382	gray whale	feed	1	0	14
205	7/11/2018 10:58	71.189	161.223	gray whale	rest	1	0	14
205	7/11/2018 11:08	70.958	160.446	gray whale	feed	1	0	17
205	7/11/2018 11:12	70.928	160.350	gray whale	feed	1	0	17
205	7/11/2018 11:13	70.912	160.323	gray whale	feed	1	0	17
205	7/11/2018 11:32	70.525	160.329	beluga	swim	400	45	17
205	7/11/2018 11:38	70.567	160.617	gray whale	feed	5	2	17
205	7/11/2018 11:43	70.612	160.895	gray whale	feed	7	2	17
205	7/11/2018 11:47	70.632	160.972	gray whale	swim	2	1	17
205	7/11/2018 11:56	70.748	161.296	gray whale	swim	2	0	17
205	7/11/2018 12:05	70.911	161.921	gray whale	rest	1	0	17
205	7/11/2018 12:08	70.950	162.057	gray whale	swim	3	1	17
205	7/11/2018 12:09	70.960	162.073	gray whale	feed	14	4	17
205	7/11/2018 12:13	70.970	162.087	gray whale	swim	1	0	17

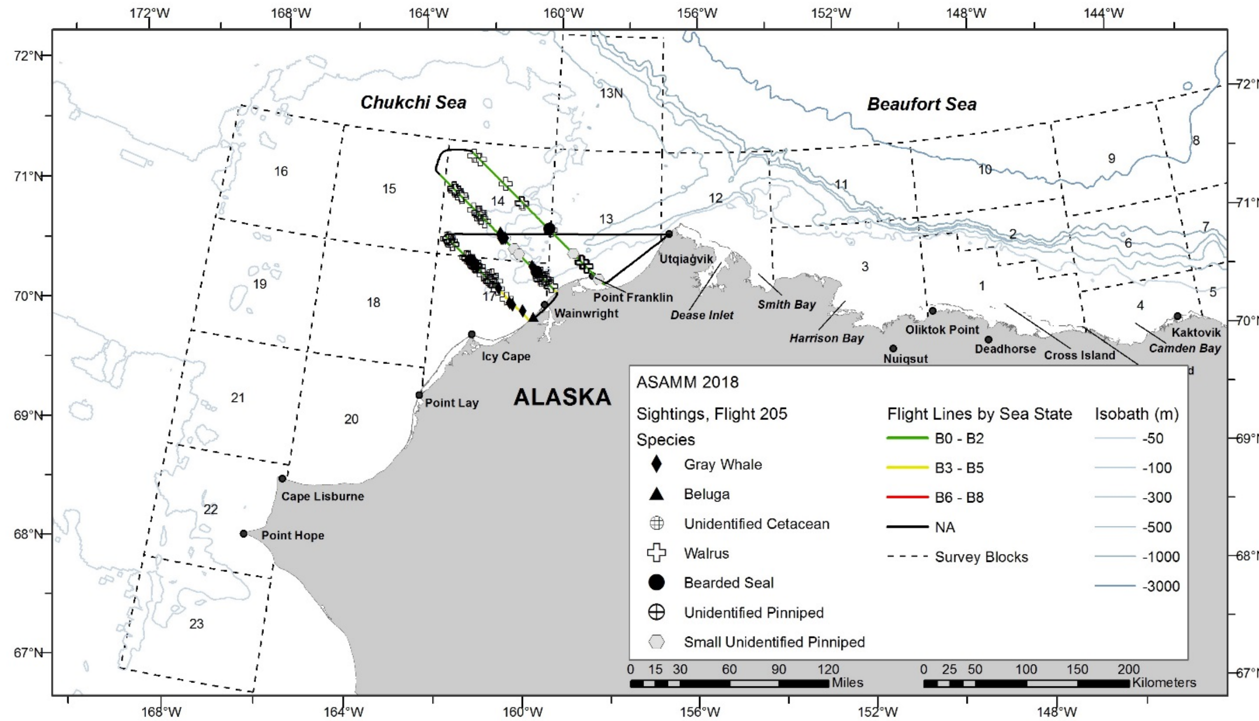

Figure B-5. Flight 205 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Belugas sighted approximately 20 km southwest of Wainwright, Alaska, during Flight 205, 11 July 2018.

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12 July 2018, Flight 206

Flight was a partial survey of transects 10 and 13. Survey conditions included partly cloudy skies, 0 km to unlimited visibility, with fog and glare, and Beaufort 0-2 sea states. Sea ice ranged from 0-90% broken floe in the area surveyed. Sightings included gray whales (including 1 calf), belugas (including 3 calves), walruses, one bearded seal, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
206	7/12/2018 11:12	70.316	161.609	gray whale	swim	1	0	17
206	7/12/2018 11:22	70.422	161.676	beluga	rest	8	3	17
206	7/12/2018 12:17	70.749	160.545	gray whale	rest	1	0	17
206	7/12/2018 12:18	70.743	160.481	gray whale	rest	1	0	17
206	7/12/2018 12:20	70.708	160.408	gray whale	swim	2	1	17
206	7/12/2018 12:26	70.654	160.149	gray whale	swim	2	0	17

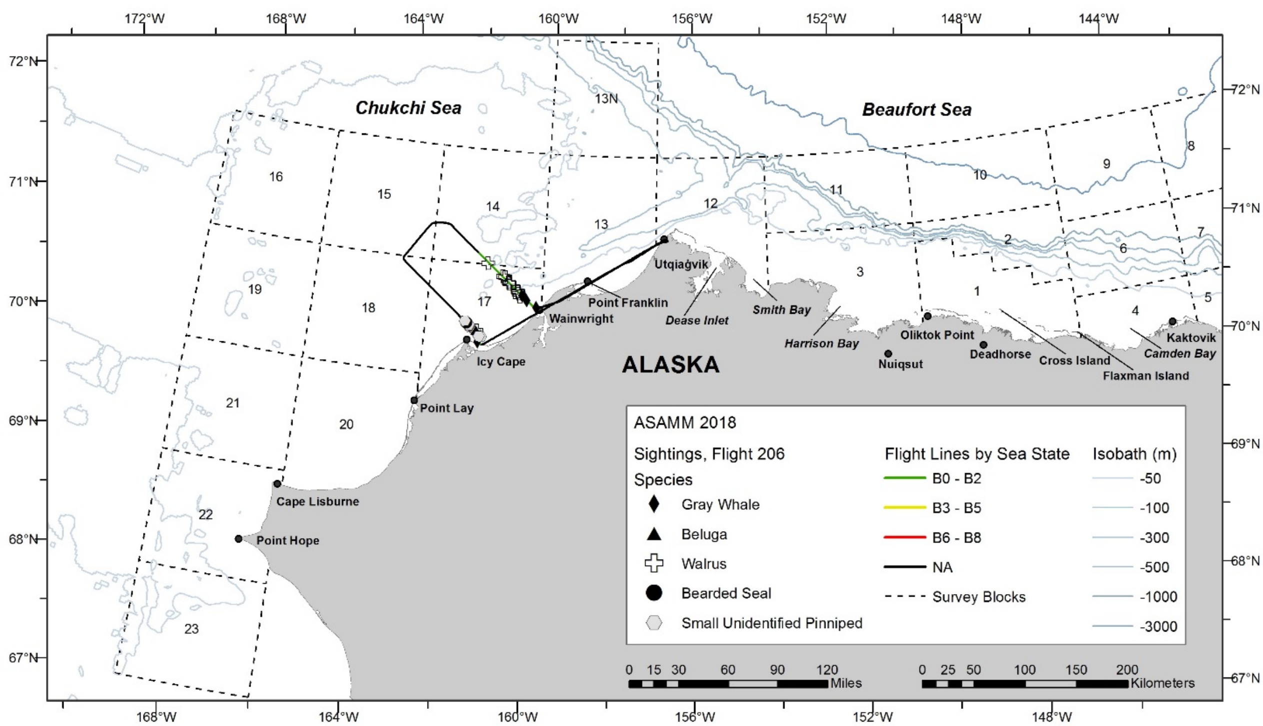

Figure B-6. Flight 206 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

13 July 2018, Flight 207

Flight was a complete survey of transects 113, 114, 115, 116, 117, 118, 119, and 120, and coastal transect in survey block 1. Survey conditions included clear to partly cloudy skies, unlimited visibility, with glare, and Beaufort 0-3 sea states. Sea ice ranged from 0-98% broken floe in the area surveyed. Sightings included bowhead whales (including one calf), belugas (including 17 calves), one bearded seal, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
207	7/13/2018 10:12	71.243	149.817	beluga	mill	4	1	2
207	7/13/2018 10:12	71.247	149.823	beluga	swim	1	0	2
207	7/13/2018 10:21	71.225	149.288	beluga	swim	25	4	2
207	7/13/2018 10:23	71.220	149.320	beluga	swim	2	0	2
207	7/13/2018 10:24	71.211	149.305	beluga	swim	9	2	2
207	7/13/2018 10:27	71.096	149.332	beluga	swim	4	2	1
207	7/13/2018 11:09	71.001	148.834	bowhead whale	rest	1	0	2
207	7/13/2018 11:16	71.058	148.805	bowhead whale	rest	2	1	2
207	7/13/2018 11:19	71.116	148.808	bowhead whale	rest	1	0	2
207	7/13/2018 11:25	71.282	148.802	beluga	mill	7	0	2
207	7/13/2018 11:26	71.299	148.814	beluga	swim	1	0	2
207	7/13/2018 11:40	71.014	148.309	beluga	swim	6	1	2
207	7/13/2018 11:40	71.007	148.310	beluga	swim	25	2	2
207	7/13/2018 12:32	71.091	147.834	beluga	swim	2	0	2
207	7/13/2018 12:32	71.095	147.826	beluga	swim	8	2	2
207	7/13/2018 12:32	71.100	147.816	beluga	swim	4	0	2
207	7/13/2018 12:32	71.104	147.809	beluga	swim	2	0	2
207	7/13/2018 12:34	71.173	147.843	beluga	swim	2	0	2
207	7/13/2018 12:38	71.314	147.816	beluga	swim	1	0	2
207	7/13/2018 12:39	71.325	147.841	beluga	swim	9	1	2
207	7/13/2018 12:39	71.327	147.841	beluga	swim	2	0	2
207	7/13/2018 12:50	71.134	147.324	beluga	mill	8	0	2
207	7/13/2018 12:50	71.129	147.320	beluga	swim	1	0	2
207	7/13/2018 12:50	71.125	147.316	beluga	swim	2	0	2
207	7/13/2018 12:50	71.118	147.326	beluga	swim	2	0	2
207	7/13/2018 12:50	71.115	147.311	beluga	swim	1	0	2
207	7/13/2018 12:51	71.104	147.323	beluga	swim	5	0	2
207	7/13/2018 12:53	71.038	147.323	bowhead whale	swim	2	0	2
207	7/13/2018 12:54	71.000	147.323	beluga	swim	2	0	2
207	7/13/2018 12:57	70.889	147.414	beluga	swim	1	0	2
207	7/13/2018 12:59	70.906	147.380	beluga	swim	4	2	2
207	7/13/2018 14:58	70.955	146.797	beluga	swim	2	0	2
207	7/13/2018 14:58	70.964	146.823	beluga	mill	8	0	2

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
207	7/13/2018 15:04	71.143	146.794	bowhead whale	swim	1	0	2
207	7/13/2018 15:23	71.174	146.323	beluga	swim	4	0	2
207	7/13/2018 15:28	71.009	146.323	beluga	swim	1	0	2
207	7/13/2018 15:29	71.004	146.307	beluga	swim	1	0	2

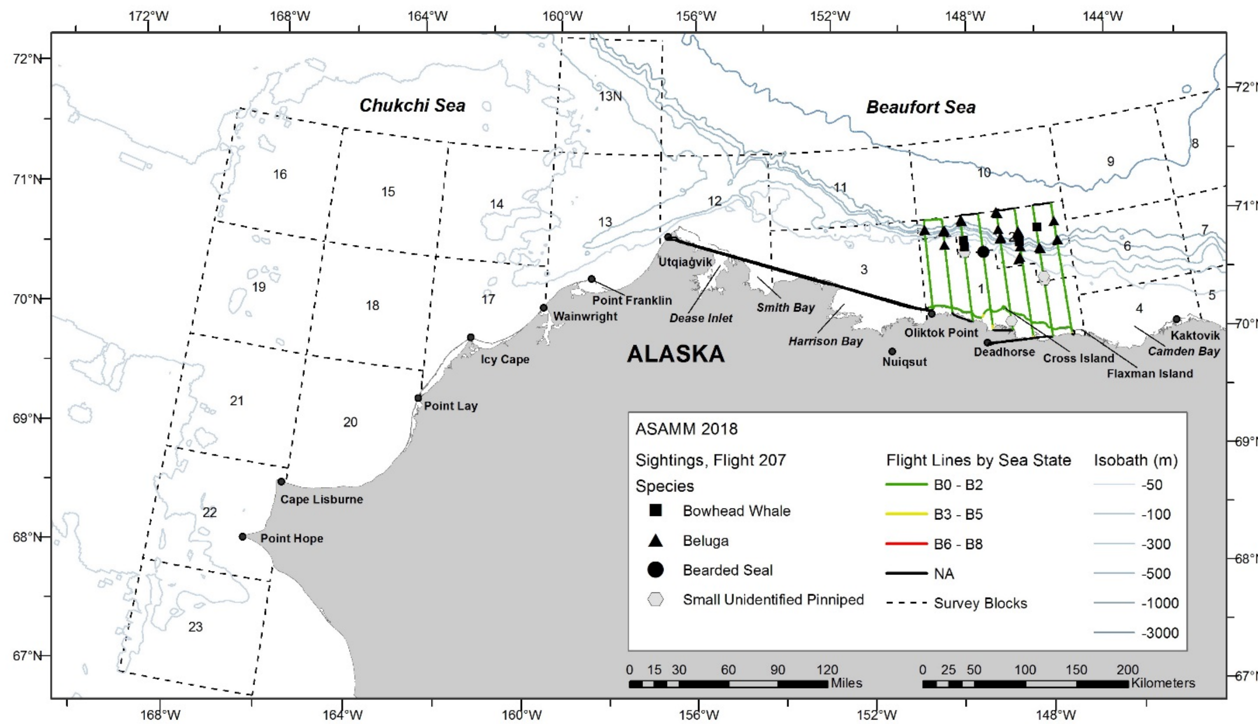

Figure B-7. Flight 207 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

14 July 2018, Flight 208

Flight was a complete survey of transects 34, 35, 36, 37, 38, and 39. Survey conditions included partly cloudy to overcast skies, 5 km to unlimited visibility, with glare, and Beaufort 1-3 sea states. There was no sea ice in the area surveyed. Sightings included gray whales (including 2 calves), humpback whales, fin whales, one harbor porpoise, unidentified cetaceans, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
208	7/14/2018 11:14	67.899	168.812	gray whale	feed	1	0	23
208	7/14/2018 11:14	67.895	168.807	gray whale	feed	1	0	23
208	7/14/2018 11:14	67.876	168.821	gray whale	feed	1	0	23
208	7/14/2018 11:15	67.864	168.815	gray whale	feed	1	0	23
208	7/14/2018 11:15	67.859	168.839	unid cetacean	feed	1	0	23
208	7/14/2018 11:17	67.877	168.794	gray whale	feed	2	0	23
208	7/14/2018 11:18	67.883	168.794	gray whale	feed	1	0	23
208	7/14/2018 11:18	67.894	168.795	gray whale	feed	1	0	23
208	7/14/2018 11:18	67.898	168.769	gray whale	rest	1	0	23
208	7/14/2018 11:20	67.898	168.813	gray whale	feed	1	0	23
208	7/14/2018 11:25	67.833	168.742	gray whale	feed	2	0	23
208	7/14/2018 11:29	67.799	168.551	gray whale	swim	1	0	23
208	7/14/2018 11:36	67.802	168.258	gray whale	feed	1	0	23
208	7/14/2018 11:38	67.805	168.261	gray whale	swim	1	0	23
208	7/14/2018 11:40	67.818	168.210	gray whale	swim	1	0	23
208	7/14/2018 11:44	67.814	168.103	gray whale	swim	1	0	23
208	7/14/2018 11:46	67.814	168.070	gray whale	feed	2	0	23
208	7/14/2018 11:48	67.801	167.998	gray whale	swim	1	0	23
208	7/14/2018 11:49	67.822	167.961	gray whale	other	2	0	23
208	7/14/2018 11:54	67.794	167.713	gray whale	swim	1	0	23
208	7/14/2018 11:55	67.787	167.704	gray whale	feed	1	0	23
208	7/14/2018 11:56	67.786	167.664	unid cetacean	rest	1	0	23
208	7/14/2018 11:57	67.773	167.638	gray whale	feed	3	0	23
208	7/14/2018 12:02	67.819	167.436	humpback whale	swim	1	0	23
208	7/14/2018 12:43	67.649	167.693	gray whale	swim	1	0	23
208	7/14/2018 12:56	67.635	168.658	gray whale	rest	1	0	23
208	7/14/2018 12:56	67.627	168.676	gray whale	feed	1	0	23
208	7/14/2018 12:56	67.633	168.683	gray whale	swim	1	0	23
208	7/14/2018 13:04	67.434	168.654	gray whale	feed	7	1	23
208	7/14/2018 13:25	67.470	167.043	harbor porpoise	dive	1	0	23
208	7/14/2018 13:32	67.447	166.351	humpback whale	swim	2	0	23
208	7/14/2018 15:35	67.153	165.985	humpback whale	breach	1	0	0
208	7/14/2018 15:43	67.119	166.323	humpback whale	swim	1	0	23
208	7/14/2018 15:50	67.111	166.771	humpback whale	feed	1	0	23

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
208	7/14/2018 15:50	67.108	166.782	unid cetacean	feed	1	0	23
208	7/14/2018 15:51	67.079	166.787	humpback whale	feed	1	0	23
208	7/14/2018 15:55	67.090	166.776	fin whale	swim	1	0	23
208	7/14/2018 15:57	67.155	166.864	unid cetacean	swim	1	0	23
208	7/14/2018 15:58	67.113	166.894	unid cetacean	.	2	0	23
208	7/14/2018 16:07	67.155	167.189	humpback whale	swim	1	0	23
208	7/14/2018 16:12	67.142	167.195	humpback whale	swim	1	0	23
208	7/14/2018 16:14	67.110	167.218	humpback whale	swim	1	0	23
208	7/14/2018 16:17	67.133	167.298	humpback whale	swim	2	0	23
208	7/14/2018 16:20	67.108	167.414	humpback whale	rest	1	0	23
208	7/14/2018 16:20	67.139	167.428	humpback whale	swim	1	0	23
208	7/14/2018 16:25	67.135	167.426	fin whale	swim	1	0	23
208	7/14/2018 16:27	67.104	167.545	unid cetacean	swim	1	0	23
208	7/14/2018 16:41	67.128	168.345	gray whale	feed	1	0	23
208	7/14/2018 16:41	67.133	168.359	gray whale	feed	1	0	23
208	7/14/2018 16:42	67.134	168.364	gray whale	feed	2	0	23
208	7/14/2018 16:42	67.135	168.367	gray whale	feed	3	0	23
208	7/14/2018 16:43	67.138	168.375	gray whale	feed	1	0	23
208	7/14/2018 16:45	67.141	168.339	gray whale	feed	2	0	23
208	7/14/2018 16:46	67.126	168.391	gray whale	swim	1	0	23
208	7/14/2018 16:46	67.110	168.445	gray whale	feed	1	0	23
208	7/14/2018 16:49	67.121	168.493	gray whale	feed	1	0	23
208	7/14/2018 16:49	67.115	168.515	gray whale	feed	1	0	23
208	7/14/2018 16:51	67.119	168.659	gray whale	feed	1	0	23
208	7/14/2018 16:59	67.259	168.525	gray whale	feed	1	0	23
208	7/14/2018 17:03	67.283	168.472	gray whale	feed	5	0	23
208	7/14/2018 17:04	67.280	168.457	gray whale	feed	1	0	23
208	7/14/2018 17:06	67.292	168.422	gray whale	swim	2	1	23
208	7/14/2018 17:06	67.287	168.410	gray whale	swim	1	0	23
208	7/14/2018 17:06	67.296	168.404	gray whale	feed	3	0	23
208	7/14/2018 17:07	67.308	168.377	gray whale	rest	1	0	23
208	7/14/2018 17:09	67.287	168.257	unid cetacean	swim	1	0	23
208	7/14/2018 17:17	67.254	167.821	humpback whale	swim	3	0	23
208	7/14/2018 17:29	67.297	167.141	humpback whale	rest	1	0	23
208	7/14/2018 17:31	67.274	167.040	unid cetacean	swim	1	0	23
208	7/14/2018 17:36	67.301	166.848	humpback whale	swim	1	0	23
208	7/14/2018 17:36	67.308	166.841	humpback whale	swim	2	0	23
208	7/14/2018 17:41	67.302	166.727	humpback whale	swim	2	0	23
208	7/14/2018 17:47	67.296	166.582	humpback whale	rest	1	0	23
208	7/14/2018 17:48	67.303	166.600	fin whale	swim	1	0	23
208	7/14/2018 17:49	67.301	166.554	humpback whale	swim	1	0	23
208	7/14/2018 17:53	67.300	166.298	humpback whale	swim	2	0	23

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
208	7/14/2018 17:53	67.302	166.293	fin whale	swim	1	0	23
208	7/14/2018 17:56	67.290	166.288	humpback whale	rest	1	0	23

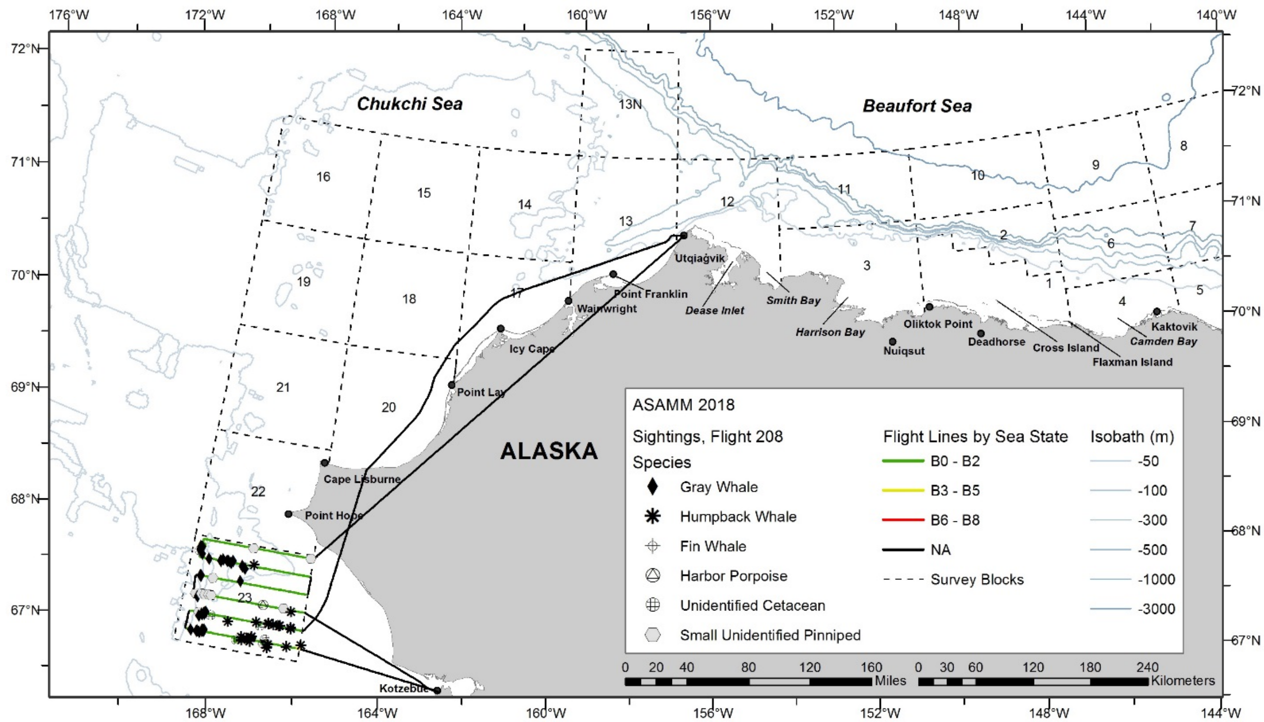

Figure B-8. Flight 208 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

19 July 2018, Flight 209

Flight was negligible effort on transect 40 and approximately 30 km of search enroute to the transect. Survey conditions included overcast skies, 0-10 km visibility, with fog and ice on the window, and Beaufort 1 sea state. Sea ice was 90% broken floe in the area surveyed. Sightings included bearded seals.

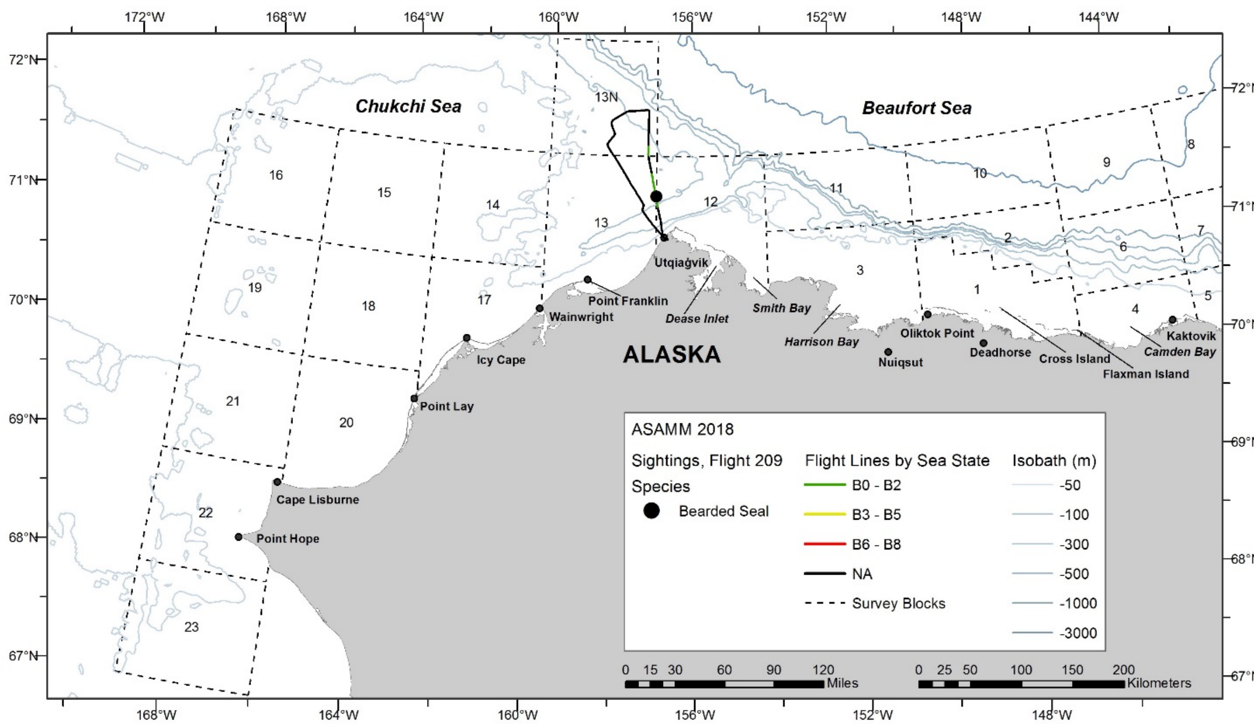

Figure B-9. Flight 209 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

20 July 2018, Flight 210

Flight was a partial survey of transects 8 and 12, and coastal transect from south of Point Franklin to Point Barrow. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare and low ceilings, and Beaufort 2-4 sea states. Sea ice ranged from 0-80% broken floe in the area surveyed. Sightings included bowhead whales, gray whales (including 10 calves), walruses, unidentified pinnipeds, small unidentified pinnipeds, and one polar bear.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
210	7/20/2018 14:48	70.433	161.007	gray whale	swim	1	0	17
210	7/20/2018 14:51	70.466	161.085	gray whale	swim	2	1	17
210	7/20/2018 15:22	71.022	163.425	bowhead whale	breach	1	0	15
210	7/20/2018 15:30	71.115	163.455	bowhead whale	swim	2	0	15
210	7/20/2018 16:26	71.241	160.680	gray whale	feed	2	0	14
210	7/20/2018 16:26	71.238	160.675	gray whale	feed	2	1	14
210	7/20/2018 16:26	71.237	160.670	gray whale	feed	2	1	14
210	7/20/2018 16:28	71.235	160.717	gray whale	feed	4	2	14
210	7/20/2018 16:31	71.218	160.657	gray whale	feed	1	0	14
210	7/20/2018 16:36	71.215	160.508	gray whale	feed	1	0	14
210	7/20/2018 16:37	71.218	160.504	gray whale	feed	1	0	14
210	7/20/2018 16:39	71.186	160.509	gray whale	feed	8	4	14
210	7/20/2018 16:57	70.921	159.531	gray whale	swim	2	1	13
210	7/20/2018 17:03	70.867	159.285	gray whale	swim	2	0	13

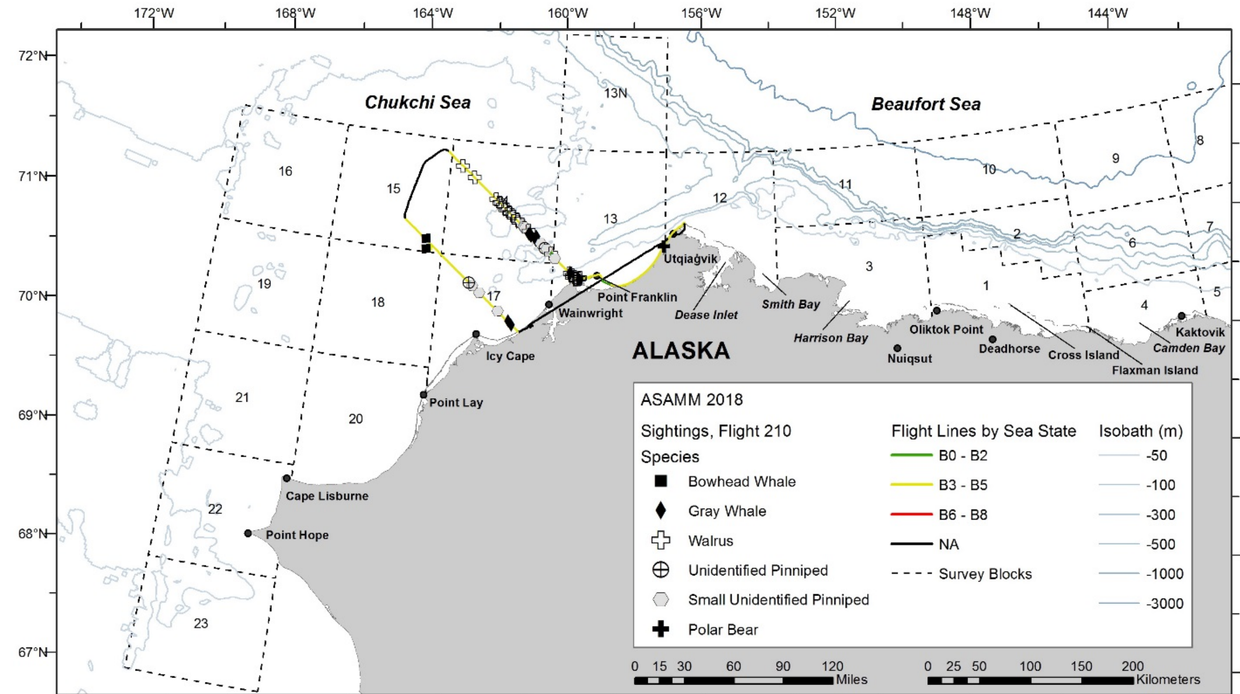

Figure B-10. Flight 210 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

20 July 2018, Flight 1

Flight was a partial survey of transects 101, 102, 103, and 104, and coastal transect from east of Kaktovik to Cross Island. Survey conditions included partly cloudy to overcast skies, 1 km to unlimited visibility, with fog and glare, and Beaufort 0-3 sea states. Sea ice was 0-100% floe and broken floe in the area surveyed. Sightings included belugas (including 7 calves), bearded seals, unidentified pinnipeds, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
1	7/20/2018 14:49	70.255	140.326	beluga	swim	1	0	5
1	7/20/2018 14:50	70.256	140.325	beluga	rest	10	2	5
1	7/20/2018 14:50	70.266	140.347	beluga	mill	5	0	5
1	7/20/2018 14:52	70.330	140.330	beluga	swim	1	0	5
1	7/20/2018 14:52	70.336	140.360	beluga	swim	1	0	5
1	7/20/2018 14:52	70.343	140.314	beluga	swim	1	0	5
1	7/20/2018 14:53	70.351	140.332	beluga	swim	1	0	5
1	7/20/2018 14:54	70.389	140.305	beluga	swim	2	1	5
1	7/20/2018 14:56	70.467	140.325	beluga	rest	2	1	5
1	7/20/2018 15:03	70.691	140.327	beluga	swim	1	0	7
1	7/20/2018 15:22	70.512	140.844	beluga	rest	1	0	7
1	7/20/2018 15:22	70.489	140.804	beluga	swim	1	0	5
1	7/20/2018 15:23	70.456	140.855	beluga	swim	1	0	5
1	7/20/2018 15:24	70.443	140.832	beluga	swim	1	0	5
1	7/20/2018 15:24	70.439	140.823	beluga	swim	1	0	5
1	7/20/2018 15:26	70.384	140.809	beluga	mill	2	1	5
1	7/20/2018 15:26	70.369	140.837	beluga	rest	2	1	5
1	7/20/2018 15:28	70.309	140.851	beluga	rest	1	0	5
1	7/20/2018 15:42	69.847	140.818	beluga	rest	1	0	5
1	7/20/2018 16:20	70.528	141.299	beluga	swim	1	0	7
1	7/20/2018 16:20	70.531	141.343	beluga	swim	1	0	7
1	7/20/2018 16:20	70.540	141.348	beluga	swim	1	0	7
1	7/20/2018 16:20	70.544	141.313	beluga	swim	2	0	7
1	7/20/2018 16:20	70.548	141.325	beluga	swim	2	0	7
1	7/20/2018 16:20	70.554	141.330	beluga	swim	2	1	7

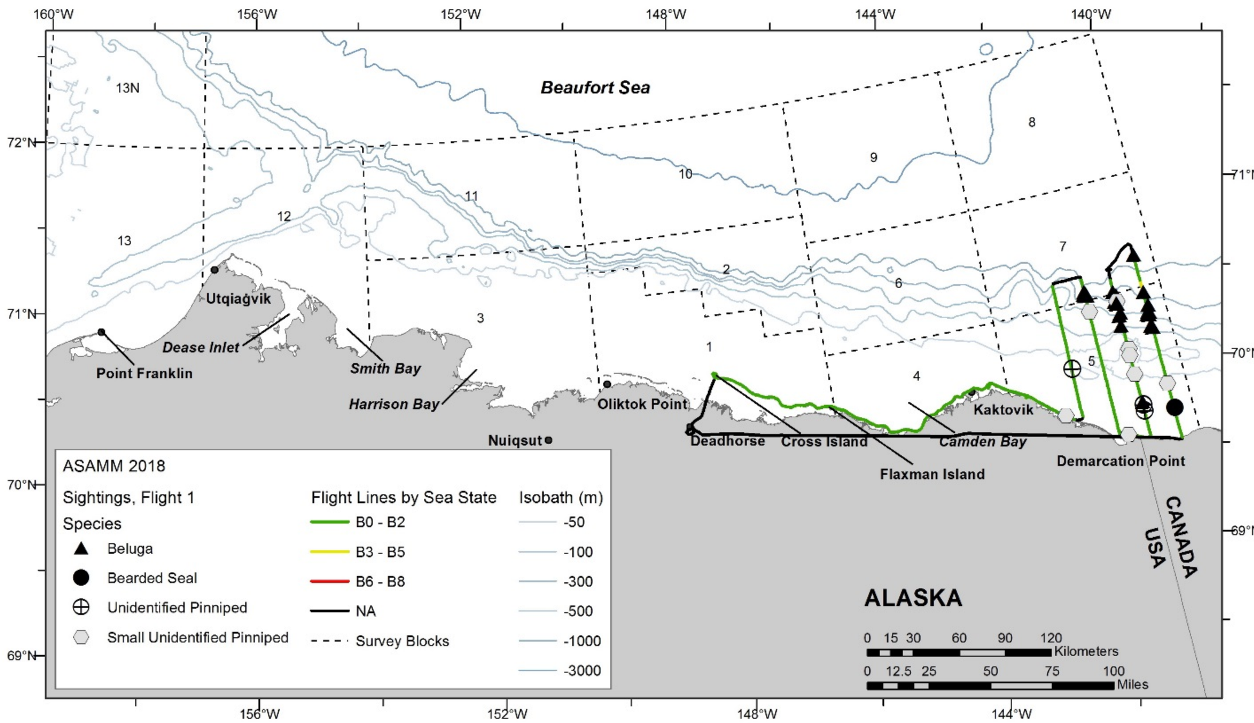

Figure B-11. Flight 1 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

21 July 2018, Flight 211

Flight was a complete survey of transects 130, 131, 132, 133, and 134, partial survey of transects 40 and 129, and negligible effort on transect 42. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with fog and glare, and Beaufort 1-3 sea states. Sea ice ranged from 0- 95% broken floe in the area surveyed. Sightings included bowhead whales, gray whales, belugas (including 9 calves), walruses, bearded seals, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
211	7/21/2018 18:00	71.389	156.840	gray whale	swim	1	0	12
211	7/21/2018 18:00	71.384	156.770	gray whale	swim	1	0	12
211	7/21/2018 18:05	71.374	156.755	bowhead whale	swim	1	0	12
211	7/21/2018 18:53	71.471	155.831	bowhead whale	swim	1	0	12
211	7/21/2018 18:53	71.470	155.849	bowhead whale	swim	1	0	12
211	7/21/2018 19:12	71.355	155.336	bowhead whale	rest	1	0	12
211	7/21/2018 19:38	71.984	154.836	beluga	swim	1	0	12
211	7/21/2018 19:45	71.772	154.844	beluga	rest	1	0	12
211	7/21/2018 19:48	71.686	154.802	beluga	mill	8	1	12
211	7/21/2018 19:49	71.670	154.808	beluga	swim	1	0	12
211	7/21/2018 19:49	71.659	154.833	beluga	swim	2	1	12
211	7/21/2018 19:49	71.654	154.820	beluga	swim	2	1	12
211	7/21/2018 19:49	71.650	154.828	beluga	swim	2	0	12
211	7/21/2018 19:49	71.647	154.826	beluga	swim	1	0	12
211	7/21/2018 19:50	71.643	154.833	beluga	swim	6	0	12
211	7/21/2018 19:50	71.639	154.816	beluga	swim	30	6	12
211	7/21/2018 19:50	71.633	154.826	beluga	swim	8	0	12
211	7/21/2018 19:50	71.629	154.839	beluga	swim	4	0	12
211	7/21/2018 20:06	71.419	154.841	bowhead whale	rest	4	0	12
211	7/21/2018 20:13	71.373	154.813	bowhead whale	swim	1	0	12

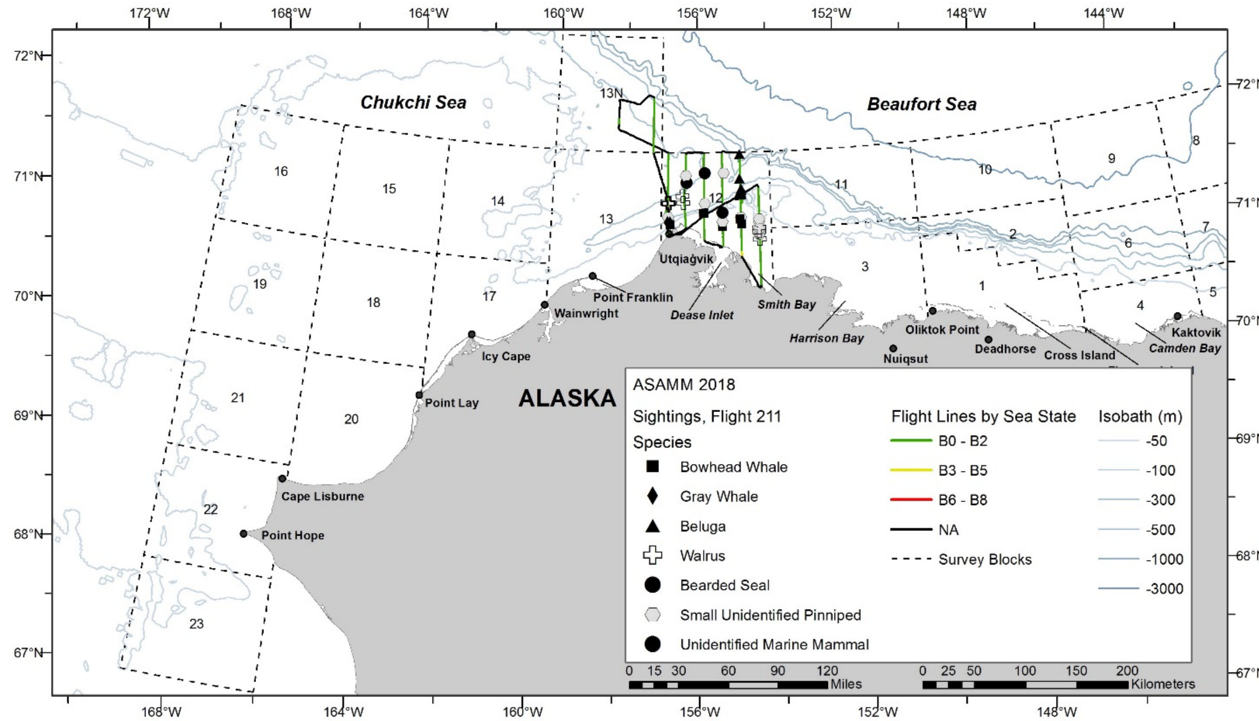

Figure B-12. Flight 211 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

21 July 2018, Flight 2

Flight was a complete survey of transects 105 and 106, and partial survey of transect 107 and 108. Survey conditions included partly cloudy to overcast skies, <1 km to unlimited visibility, with fog and glare, and Beaufort 0-2 sea states. Sea ice was 0-98% floe and broken floe in the area surveyed. Sightings included bowhead whales, belugas (including 12 calves), and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
2	7/21/2018 13:00	70.523	142.348	beluga	swim	1	0	7
2	7/21/2018 13:03	70.627	142.339	beluga	rest	1	0	7
2	7/21/2018 13:03	70.631	142.327	beluga	rest	1	0	7
2	7/21/2018 13:07	70.756	142.309	beluga	swim	2	1	7
2	7/21/2018 13:08	70.773	142.301	beluga	swim	2	0	7
2	7/21/2018 13:09	70.814	142.339	beluga	swim	1	0	7
2	7/21/2018 13:11	70.874	142.302	beluga	swim	1	0	7
2	7/21/2018 13:12	70.921	142.362	beluga	rest	1	0	7
2	7/21/2018 13:13	70.943	142.355	beluga	swim	1	0	7
2	7/21/2018 13:15	71.002	142.322	beluga	swim	2	1	7
2	7/21/2018 13:15	71.006	142.322	beluga	swim	2	1	7
2	7/21/2018 13:29	71.017	142.823	beluga	swim	2	1	7
2	7/21/2018 13:30	71.008	142.851	bowhead whale	swim	1	0	7
2	7/21/2018 13:30	71.006	142.843	beluga	swim	2	1	7
2	7/21/2018 13:30	70.998	142.819	beluga	swim	6	0	7
2	7/21/2018 13:31	71.015	142.840	beluga	swim	3	1	7
2	7/21/2018 13:39	70.889	142.805	beluga	rest	1	0	7
2	7/21/2018 13:41	70.831	142.832	beluga	rest	1	0	7
2	7/21/2018 13:42	70.790	142.837	beluga	swim	2	1	7
2	7/21/2018 13:45	70.693	142.822	beluga	rest	1	0	7
2	7/21/2018 13:45	70.690	142.845	beluga	swim	2	1	7
2	7/21/2018 13:45	70.685	142.828	beluga	swim	1	0	7
2	7/21/2018 14:31	70.781	143.338	beluga	swim	2	0	6
2	7/21/2018 14:32	70.811	143.327	beluga	swim	1	0	6
2	7/21/2018 14:32	70.813	143.330	beluga	swim	1	0	6
2	7/21/2018 14:37	70.966	143.324	beluga	swim	2	1	6
2	7/21/2018 14:40	71.084	143.334	beluga	swim	3	1	6
2	7/21/2018 14:41	71.094	143.326	beluga	swim	1	0	6
2	7/21/2018 14:41	71.097	143.318	beluga	swim	1	0	6
2	7/21/2018 14:41	71.103	143.357	beluga	swim	4	1	6
2	7/21/2018 15:00	70.604	143.812	beluga	swim	2	1	6
2	7/21/2018 15:00	70.595	143.831	bowhead whale	swim	1	0	6
2	7/21/2018 15:03	70.593	143.812	beluga	swim	1	0	6

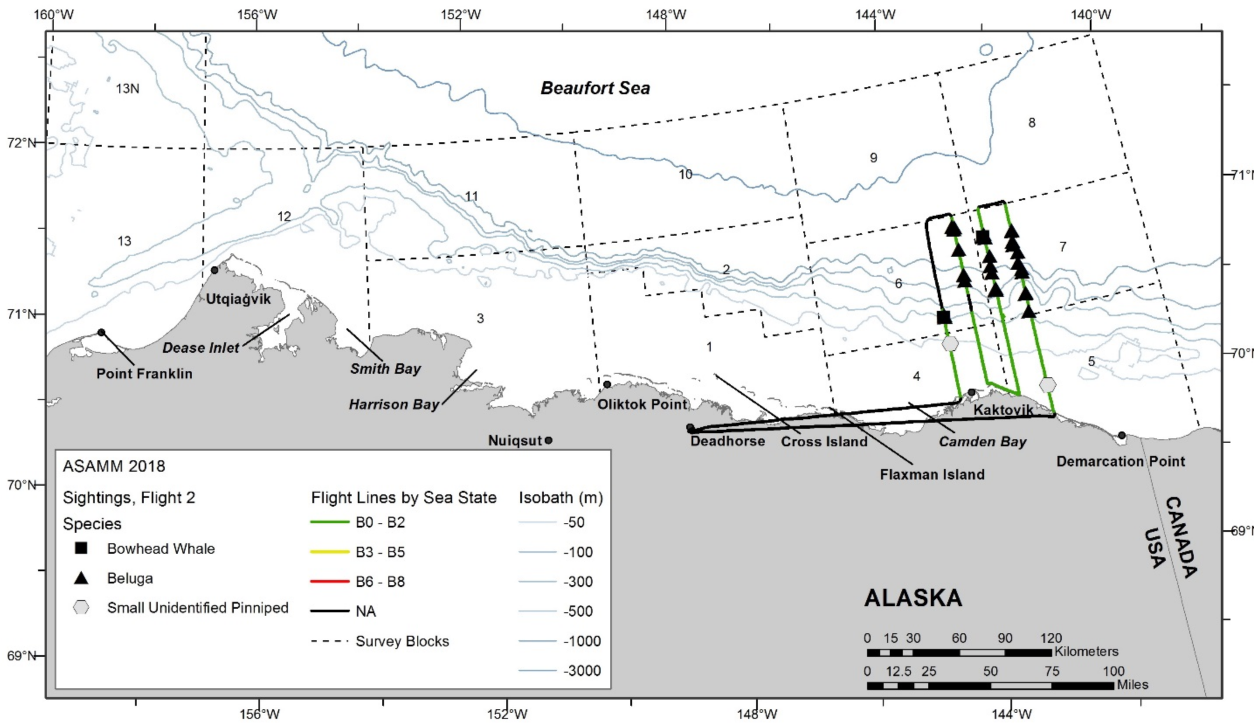

Figure B-13. Flight 2 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

22 July 2018, Flight 3

Flight was a survey of coastal transect in Harrison Bay. Survey conditions included partly cloudy skies, unlimited visibility, and Beaufort 2 sea state. There was no sea ice in the area surveyed. There were no marine mammal sightings.

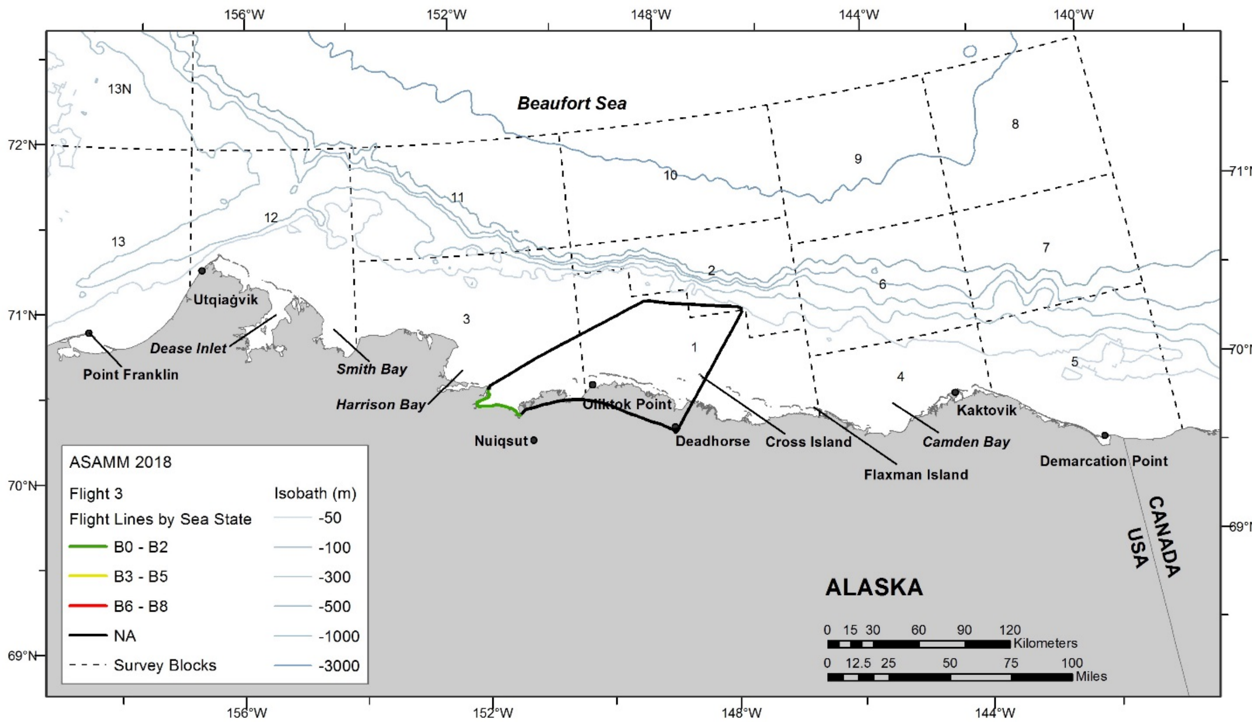

Figure B-14. Flight 3 survey track, depicted by sea state.

24 July 2018, Flight 212

Flight was a partial survey of transects 40, 41, 42, 43, and 45, and search effort from Utqiaġvik to 72°N. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with fog and glare, and Beaufort 1-5 sea states. Sea ice ranged from 0-90% broken floe in the area surveyed. Sightings included belugas (including 1 calf), walruses, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
212	7/24/2018 18:02	72.555	157.728	beluga	rest	1	0	13N
212	7/24/2018 18:35	72.417	157.247	beluga	swim	5	0	13N
212	7/24/2018 18:36	72.424	157.250	beluga	swim	3	1	13N
212	7/24/2018 18:36	72.430	157.255	beluga	swim	1	0	13N
212	7/24/2018 18:36	72.435	157.223	beluga	swim	3	0	13N
212	7/24/2018 18:36	72.446	157.237	beluga	swim	1	0	13N

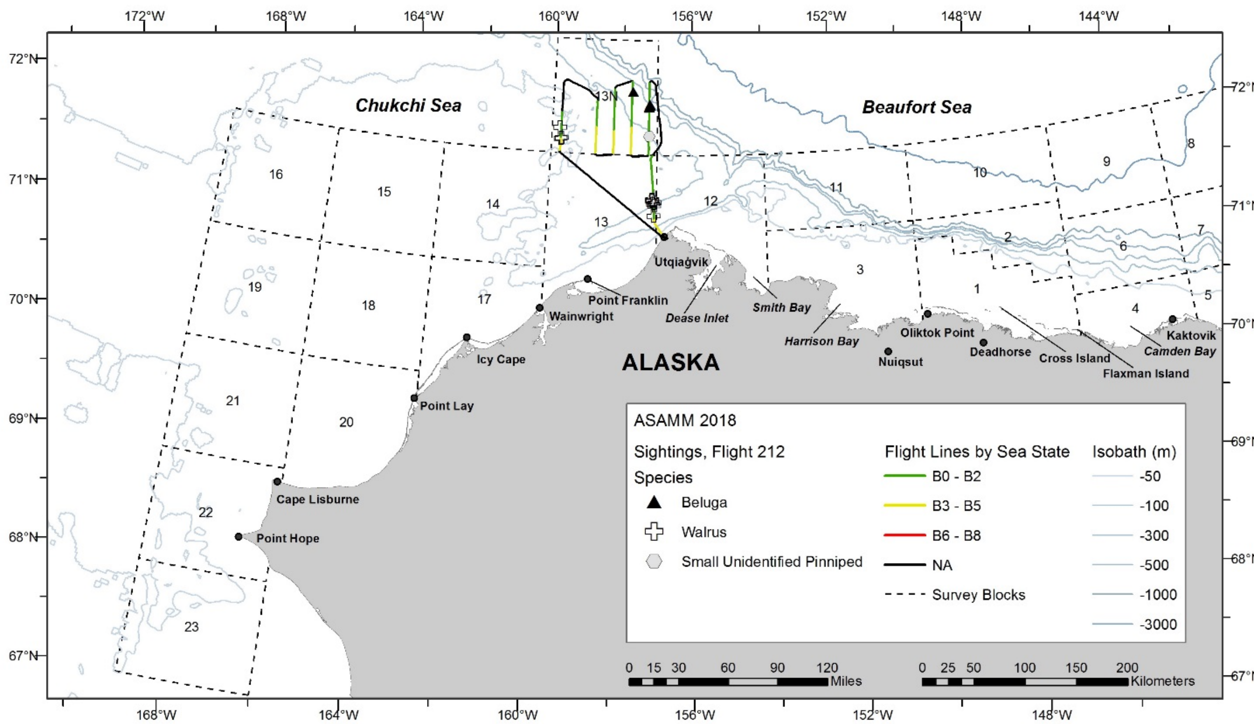

Figure B-15. Flight 212 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

26 July 2018, Flight 4

Flight was a complete survey of transects 118, 119, 120, 123, and 124, and partial survey of transects 109, 115, 116, 117, 121, and 122. Survey conditions included partly cloudy to overcast skies, <1 km to unlimited visibility, with fog, glare, haze, low ceilings, and precipitation, and Beaufort 0-3 sea states. Sea ice was 0-95% floe and broken floe in the area surveyed. Sightings included belugas (including 5 calves), one bearded seal, small unidentified pinnipeds, and one polar bear.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
4	7/26/2018 13:16	71.155	147.835	beluga	swim	2	0	2
4	7/26/2018 13:17	71.100	147.811	beluga	rest	1	0	2
4	7/26/2018 14:14	71.304	148.818	beluga	dive	2	1	2
4	7/26/2018 14:15	71.258	148.818	beluga	rest	1	0	2
4	7/26/2018 15:11	71.309	149.323	beluga	swim	1	0	2
4	7/26/2018 15:13	71.344	149.430	beluga	mill	3	1	10
4	7/26/2018 15:14	71.342	149.602	beluga	mill	7	0	10
4	7/26/2018 15:14	71.344	149.613	beluga	swim	1	0	10
4	7/26/2018 15:15	71.338	149.639	beluga	mill	3	1	10
4	7/26/2018 15:15	71.341	149.712	beluga	swim	2	1	10
4	7/26/2018 15:19	71.241	149.828	beluga	swim	1	0	2
4	7/26/2018 17:41	71.445	151.823	beluga	swim	1	0	11
4	7/26/2018 17:43	71.510	151.822	beluga	swim	2	1	11
4	7/26/2018 17:44	71.532	151.828	beluga	swim	1	0	11
4	7/26/2018 17:55	71.891	151.822	beluga	swim	1	0	11
4	7/26/2018 17:56	71.922	151.844	beluga	rest	1	0	11
4	7/26/2018 18:13	71.636	151.323	beluga	rest	1	0	11
4	7/26/2018 18:19	71.435	151.337	beluga	swim	4	0	11
4	7/26/2018 19:17	71.187	150.826	beluga	rest	1	0	3
4	7/26/2018 19:24	71.421	150.809	beluga	swim	1	0	11
4	7/26/2018 19:24	71.422	150.839	beluga	swim	1	0	11
4	7/26/2018 19:43	71.641	150.323	beluga	dive	1	0	11
4	7/26/2018 19:49	71.457	150.297	beluga	swim	1	0	11
4	7/26/2018 19:53	71.314	150.344	beluga	swim	2	0	3
4	7/26/2018 19:53	71.286	150.340	beluga	swim	1	0	3

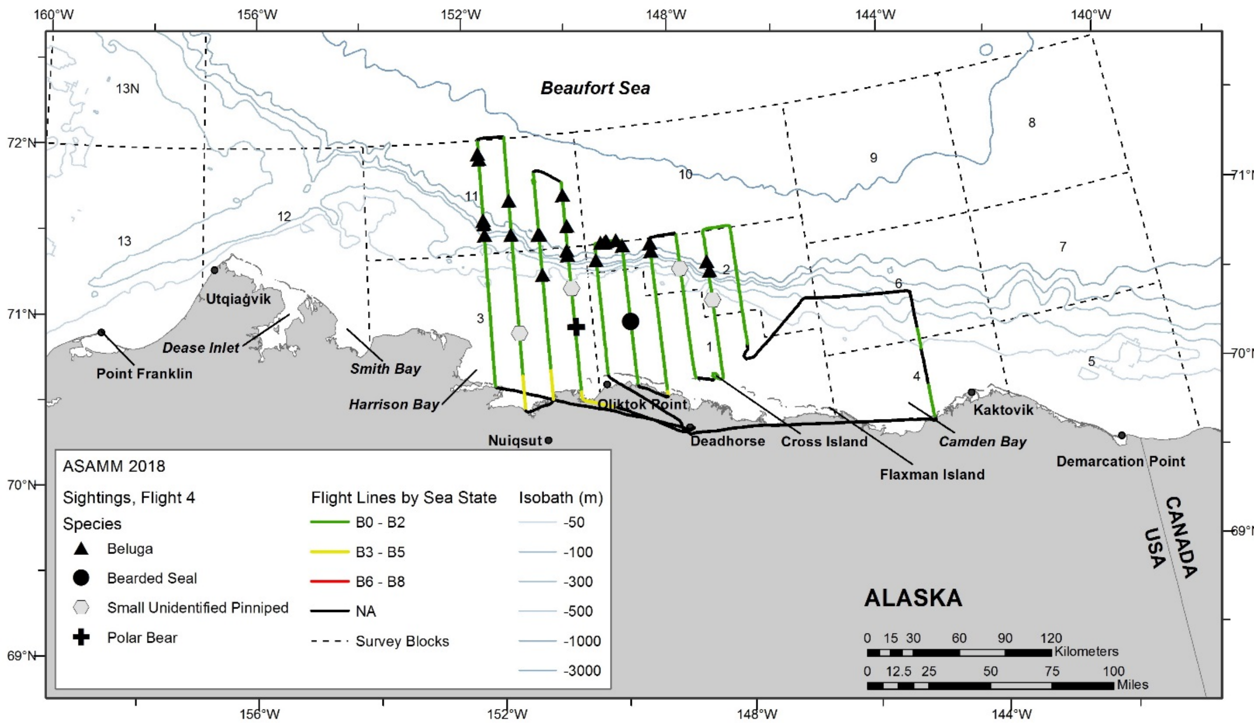

Figure B-16. Flight 4 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

29 July 2018, Flight 213

Flight was a complete survey of transects 38 and 39, partial survey of transects 34, 35, 36, and 37; and search effort in Peard Bay. Survey conditions included clear to partly cloudy skies, 0 km to unlimited visibility, with fog and glare, and Beaufort 1 to 3 sea states. There was no sea ice in the area surveyed. Sightings included gray whales, humpback whales (including 1 calf), fin whales (including 1 calf), unidentified cetaceans (including 1 carcass), one bearded seal, one unidentified pinniped, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
213	7/29/2018 11:20	67.985	168.237	humpback whale	swim	2	0	23
213	7/29/2018 12:12	67.807	167.307	humpback whale	swim	1	0	23
213	7/29/2018 12:34	67.661	168.746	gray whale	feed	2	0	23
213	7/29/2018 12:49	67.631	167.608	unid cetacean	dead	1	0	23
213	7/29/2018 13:00	67.633	167.012	humpback whale	flipper slap	1	0	23
213	7/29/2018 13:04	67.621	166.832	fin whale	swim	2	0	23
213	7/29/2018 13:11	67.627	166.802	humpback whale	feed	2	1	23
213	7/29/2018 13:12	67.632	166.775	humpback whale	feed	1	0	23
213	7/29/2018 13:12	67.632	166.769	humpback whale	feed	3	0	23
213	7/29/2018 13:12	67.646	166.762	humpback whale	feed	1	0	23
213	7/29/2018 15:44	67.129	167.723	fin whale	swim	1	0	23
213	7/29/2018 15:44	67.125	167.733	fin whale	feed	2	1	23
213	7/29/2018 16:03	67.147	168.804	gray whale	feed	3	0	23
213	7/29/2018 16:03	67.152	168.774	gray whale	feed	1	0	23
213	7/29/2018 16:06	67.172	168.762	gray whale	feed	1	0	23
213	7/29/2018 16:06	67.185	168.771	gray whale	feed	4	0	23
213	7/29/2018 16:12	67.279	168.661	unid cetacean	unknown	1	0	23
213	7/29/2018 16:12	67.300	168.654	gray whale	swim	1	0	23
213	7/29/2018 16:17	67.279	168.594	gray whale	feed	1	0	23
213	7/29/2018 16:19	67.259	168.572	gray whale	feed	7	0	23
213	7/29/2018 16:19	67.248	168.559	gray whale	feed	6	0	23
213	7/29/2018 16:31	67.284	168.063	gray whale	feed	3	0	23
213	7/29/2018 16:36	67.325	167.778	fin whale	mill	2	0	23
213	7/29/2018 16:43	67.322	167.368	unid cetacean	unknown	2	0	23
213	7/29/2018 17:38	67.321	167.004	humpback whale	feed	2	0	23
213	7/29/2018 17:39	67.318	166.980	humpback whale	feed	2	0	23
213	7/29/2018 17:39	67.331	166.965	humpback whale	feed	2	0	23
213	7/29/2018 18:12	67.424	166.876	fin whale	swim	2	0	23
213	7/29/2018 18:13	67.410	166.922	unid cetacean	unknown	1	0	23
213	7/29/2018 19:32	70.820	158.696	gray whale	feed	2	0	13

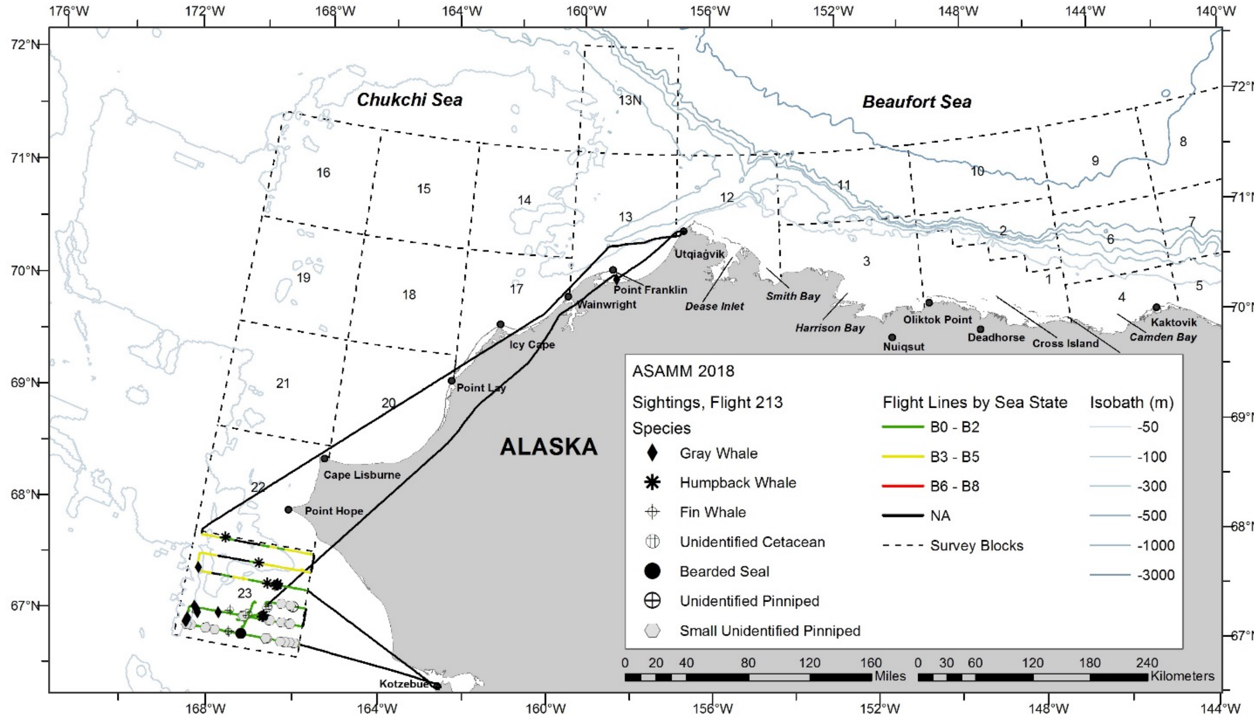

Figure B-17. Flight 213 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

29 July 2018, Flight 5

Flight was a complete survey of transects 128, 130, 131, 132, 133, and 134, and coastal transect in Harrison Bay. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with fog and glare, and Beaufort 0-3 sea states. Sea ice was 0-95% broken floe in the area surveyed. Sightings included bowhead whales, belugas (including 11 calves), walruses, bearded seals, unidentified pinnipeds, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
5	7/29/2018 15:18	71.997	153.911	beluga	swim	3	0	11
5	7/29/2018 15:18	72.013	153.914	beluga	swim	1	0	0
5	7/29/2018 15:20	72.006	154.066	beluga	swim	1	0	0
5	7/29/2018 15:22	72.009	154.270	beluga	swim	1	0	0
5	7/29/2018 15:22	72.001	154.304	beluga	swim	1	0	0
5	7/29/2018 15:23	72.015	154.358	beluga	swim	1	0	0
5	7/29/2018 15:28	71.969	154.831	beluga	swim	1	0	12
5	7/29/2018 15:28	71.960	154.813	beluga	swim	2	1	12
5	7/29/2018 15:30	71.913	154.832	beluga	swim	1	0	12
5	7/29/2018 15:30	71.901	154.808	beluga	swim	1	0	12
5	7/29/2018 15:30	71.895	154.841	beluga	swim	3	0	12
5	7/29/2018 15:30	71.893	154.818	beluga	swim	3	1	12
5	7/29/2018 15:30	71.893	154.838	beluga	swim	6	0	12
5	7/29/2018 15:33	71.791	154.834	beluga	swim	1	0	12
5	7/29/2018 15:45	71.422	154.806	bowhead whale	swim	1	0	12
5	7/29/2018 16:17	71.578	155.393	bowhead whale	swim	1	0	12
5	7/29/2018 16:21	71.675	155.303	beluga	swim	2	1	12
5	7/29/2018 16:22	71.700	155.323	beluga	swim	30	3	12
5	7/29/2018 16:22	71.700	155.323	beluga	swim	58	5	12
5	7/29/2018 16:24	71.791	155.286	beluga	swim	1	0	12
5	7/29/2018 16:24	71.796	155.268	beluga	swim	1	0	12
5	7/29/2018 16:46	71.646	155.815	beluga	dive	1	0	12
5	7/29/2018 16:55	71.482	155.797	bowhead whale	swim	1	0	12

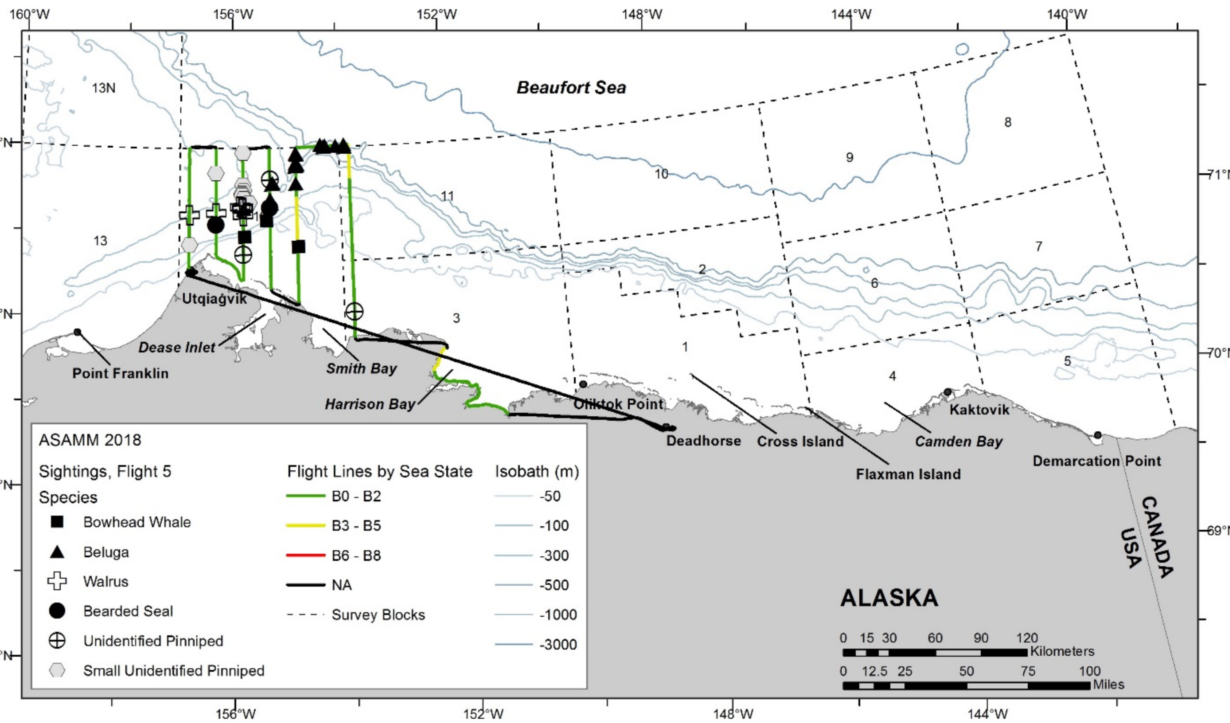

Figure B-18. Flight 5 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

30 July 2018, Flight 214

Flight was a complete survey of transects 1, 2, 3, 4, 9, and 11, partial survey of transects 5 and 6, and coastal transect from northeast of Point Franklin to Point Barrow. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with fog, glare, and precipitation, and Beaufort 0-4 sea states. Sea ice ranged from 0-75% broken floe in the area surveyed. Sightings included two bowhead whale carcasses, gray whales (including 1 calf and 2 carcasses), minke whales, one beluga, walruses, bearded seals, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
214	7/30/2018 9:15	70.526	160.539	gray whale	swim	1	0	17
214	7/30/2018 9:20	70.611	160.766	minke whale	mill	2	0	17
214	7/30/2018 9:28	70.650	160.945	beluga	swim	1	0	17
214	7/30/2018 9:42	70.959	162.057	gray whale	feed	1	0	17
214	7/30/2018 9:48	70.975	162.107	gray whale	swim	1	0	17
214	7/30/2018 11:24	71.262	161.503	gray whale	feed	3	0	14
214	7/30/2018 11:28	71.222	161.466	gray whale	feed	1	0	14
214	7/30/2018 11:32	71.233	161.509	gray whale	feed	1	0	14
214	7/30/2018 11:33	71.213	161.349	gray whale	feed	3	0	14
214	7/30/2018 11:33	71.203	161.362	gray whale	feed	1	0	14
214	7/30/2018 11:51	70.934	160.355	gray whale	rest	2	1	17
214	7/30/2018 11:55	70.889	160.386	gray whale	feed	1	0	17
214	7/30/2018 11:55	70.925	160.278	gray whale	feed	2	0	17
214	7/30/2018 11:55	70.929	160.259	gray whale	feed	2	0	17
214	7/30/2018 15:26	71.227	157.477	gray whale	feed	1	0	13
214	7/30/2018 15:26	71.226	157.471	gray whale	feed	1	0	13
214	7/30/2018 15:26	71.228	157.460	gray whale	feed	2	0	13
214	7/30/2018 15:26	71.222	157.463	gray whale	feed	1	0	13
214	7/30/2018 15:59	71.387	158.742	bowhead whale	dead	1	0	13
214	7/30/2018 17:17	71.048	157.253	gray whale	dead	1	0	13
214	7/30/2018 17:20	71.070	157.212	gray whale	dead	1	0	13
214	7/30/2018 17:30	71.302	156.789	gray whale	spy hop	2	0	12
214	7/30/2018 17:34	71.345	156.612	bowhead whale	dead	1	0	12

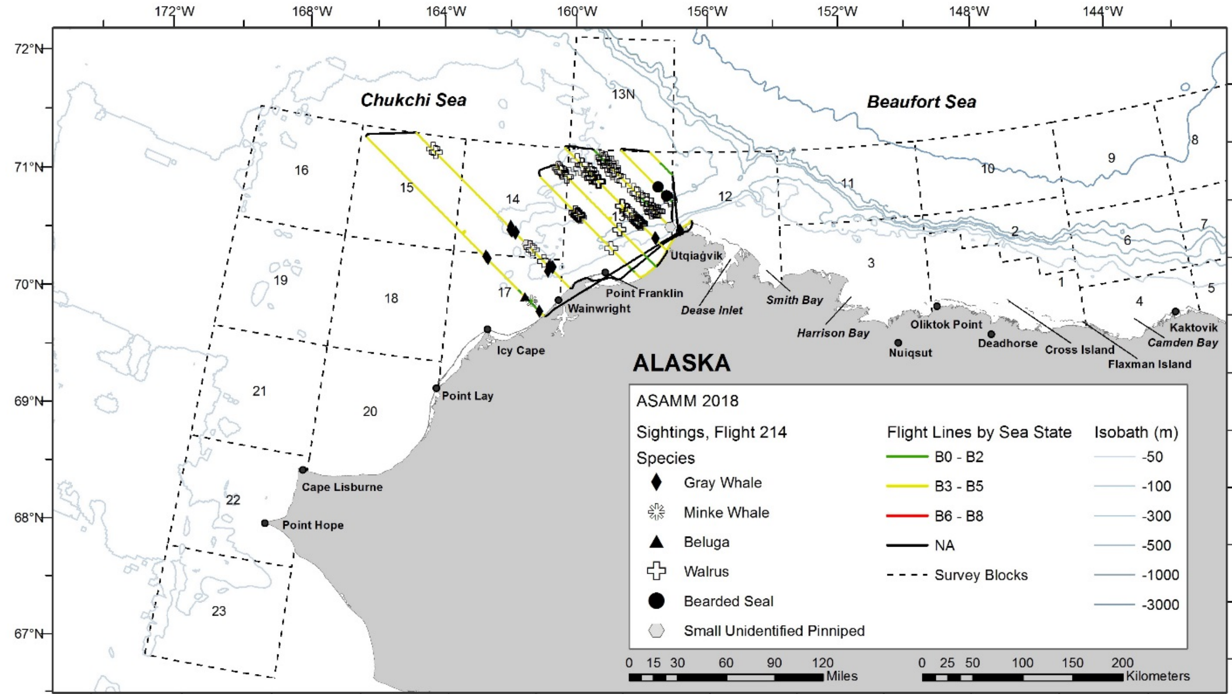

Figure B-19. Flight 214 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

30 July 2018, Flight 6

Flight was a complete survey of transects 101, 108, and 109, and partial survey of transects 102, 103, 104, and 107. Survey conditions included clear to partly cloudy skies, <1 km to unlimited visibility, with fog, glare, and haze, and Beaufort 0-2 sea states. Sea ice was 5-100% broken floe and floe in the area surveyed. Sightings included belugas (including 9 calves), one small unidentified pinniped, and one polar bear.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
6	7/30/2018 13:47	69.851	140.340	beluga	swim	1	0	5
6	7/30/2018 13:59	70.282	140.317	beluga	swim	1	0	5
6	7/30/2018 14:14	70.821	140.326	beluga	swim	7	0	7
6	7/30/2018 14:51	70.447	140.820	beluga	swim	1	0	5
6	7/30/2018 14:51	70.427	140.812	beluga	swim	1	1	5
6	7/30/2018 14:55	70.308	140.821	beluga	swim	1	0	5
6	7/30/2018 15:11	70.421	141.348	beluga	swim	1	0	5
6	7/30/2018 15:11	70.425	141.336	beluga	swim	1	0	5
6	7/30/2018 15:11	70.449	141.342	beluga	swim	1	0	5
6	7/30/2018 15:12	70.457	141.345	beluga	swim	1	0	5
6	7/30/2018 15:13	70.491	141.342	beluga	swim	1	0	5
6	7/30/2018 15:13	70.503	141.330	beluga	swim	2	1	7
6	7/30/2018 15:13	70.503	141.299	beluga	swim	1	0	7
6	7/30/2018 15:14	70.551	141.318	beluga	rest	5	0	7
6	7/30/2018 15:19	70.730	141.336	beluga	swim	1	0	7
6	7/30/2018 15:19	70.733	141.275	beluga	swim	1	0	7
6	7/30/2018 15:19	70.749	141.310	beluga	swim	1	0	7
6	7/30/2018 15:20	70.761	141.343	beluga	swim	2	1	7
6	7/30/2018 15:24	70.939	141.308	beluga	swim	1	0	7
6	7/30/2018 15:28	71.073	141.351	beluga	swim	1	0	7
6	7/30/2018 15:28	71.095	141.329	beluga	swim	2	1	7
6	7/30/2018 15:35	71.150	141.811	beluga	swim	5	2	7
6	7/30/2018 15:59	70.601	143.341	beluga	swim	1	0	6
6	7/30/2018 15:59	70.598	143.338	beluga	swim	1	0	6
6	7/30/2018 16:04	70.436	143.312	beluga	swim	6	0	4
6	7/30/2018 16:26	70.400	143.807	beluga	swim	1	0	4
6	7/30/2018 16:38	70.814	143.865	beluga	swim	1	0	6
6	7/30/2018 16:41	70.901	143.844	beluga	swim	1	0	6
6	7/30/2018 16:43	70.967	143.840	beluga	swim	21	0	6
6	7/30/2018 16:46	71.078	143.800	beluga	swim	1	0	6
6	7/30/2018 16:46	71.085	143.801	beluga	swim	2	1	6
6	7/30/2018 16:46	71.095	143.824	beluga	swim	1	0	6
6	7/30/2018 16:49	71.169	143.826	beluga	swim	2	1	9
6	7/30/2018 17:01	70.893	144.331	beluga	swim	5	0	6

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
6	7/30/2018 17:05	70.758	144.348	beluga	swim	7	0	6
6	7/30/2018 17:06	70.734	144.361	beluga	swim	2	0	6
6	7/30/2018 17:06	70.720	144.341	beluga	swim	3	0	6
6	7/30/2018 17:08	70.668	144.348	beluga	swim	1	0	6
6	7/30/2018 17:08	70.666	144.327	beluga	swim	1	0	6
6	7/30/2018 17:08	70.663	144.343	beluga	swim	2	1	6
6	7/30/2018 17:08	70.661	144.324	beluga	swim	1	0	6

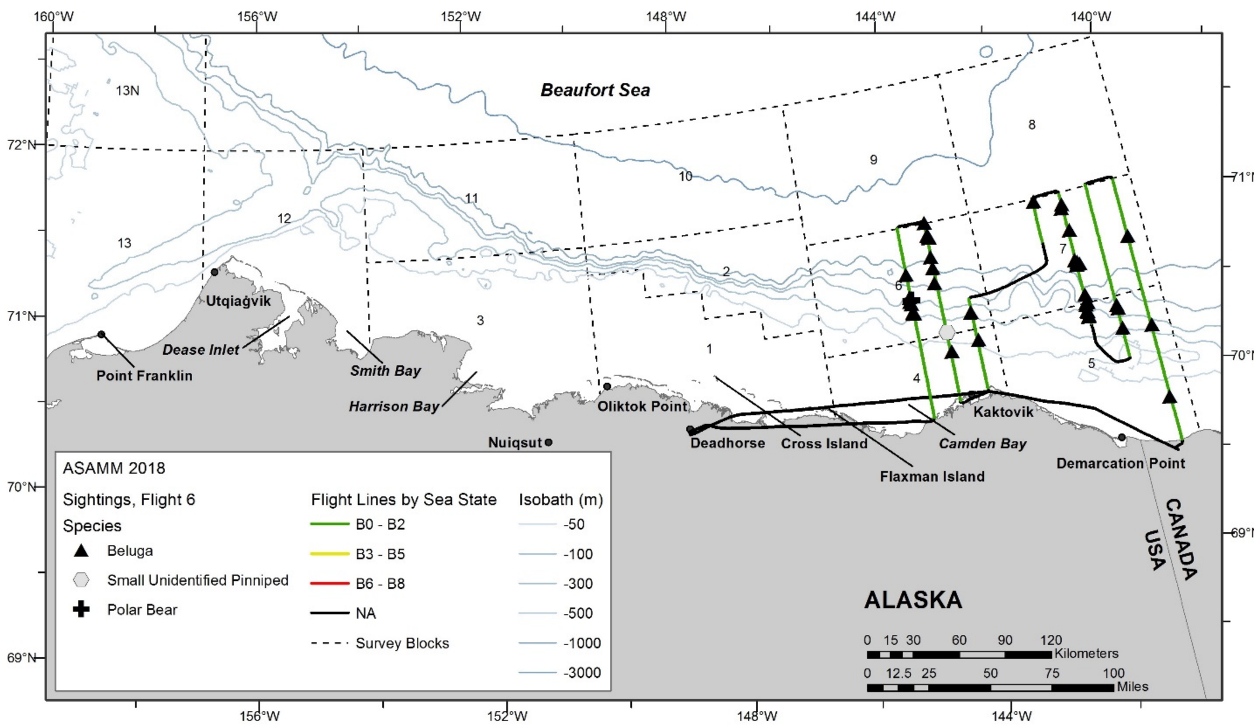

Figure B-20. Flight 6 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

31 July 2018, Flight 215

Flight was an attempt to use a floating carcass to estimate field of view from the survey aircraft. Survey conditions included partly cloudy skies, 3-5 km visibility, with fog and glare, and Beaufort 3 sea state. There was no sea ice in the area surveyed. Sightings included bowhead whales (including 1 carcass). The carcass was originally sighted during Flight 214 on 30 July 2018, and was specifically resighted for the field of view attempt.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
215	7/31/2018 16:13	71.470	158.309	bowhead whale	dead	1	0	13
215	7/31/2018 16:15	71.467	158.305	bowhead whale	swim	1	0	13

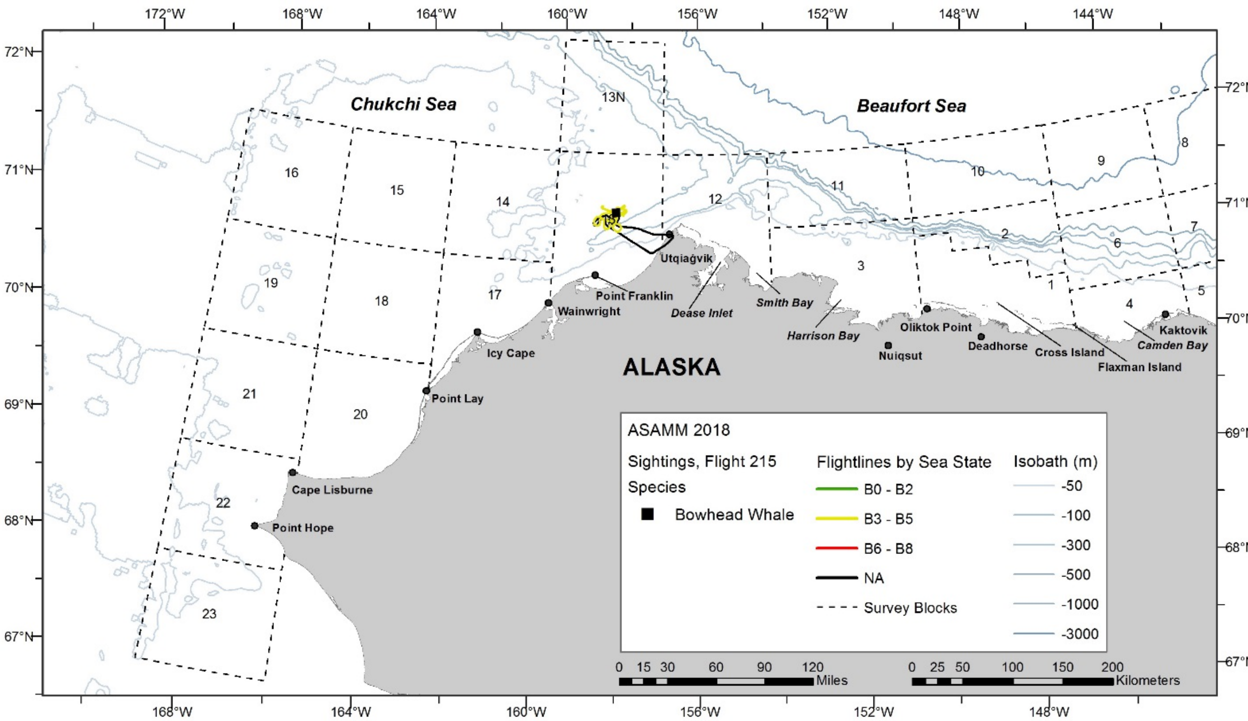

Figure B-21. Flight 215 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

31 July 2018, Flight 7

Flight was a complete survey of transects 118 and 119, and partial survey of transects 110, 111, 112, 113, 114, 115, 116, and 117. Survey conditions included partly cloudy to overcast skies, <1 km to unlimited visibility, with fog and glare, and Beaufort 0-3 sea states. Sea ice was 0-95% broken floe and floe in the area surveyed. Sightings included bowhead whales, belugas, one bearded seal, unidentified pinnipeds, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
7	7/31/2018 13:49	70.559	144.812	bowhead whale	rest	1	0	6
7	7/31/2018 15:23	70.526	146.858	bowhead whale	rest	1	0	1
7	7/31/2018 16:05	70.208	147.470	beluga	swim	1	0	1
7	7/31/2018 17:35	71.306	148.812	beluga	rest	1	0	2
7	7/31/2018 17:35	71.310	148.840	beluga	rest	1	0	2
7	7/31/2018 17:58	70.718	149.326	beluga	swim	1	0	1

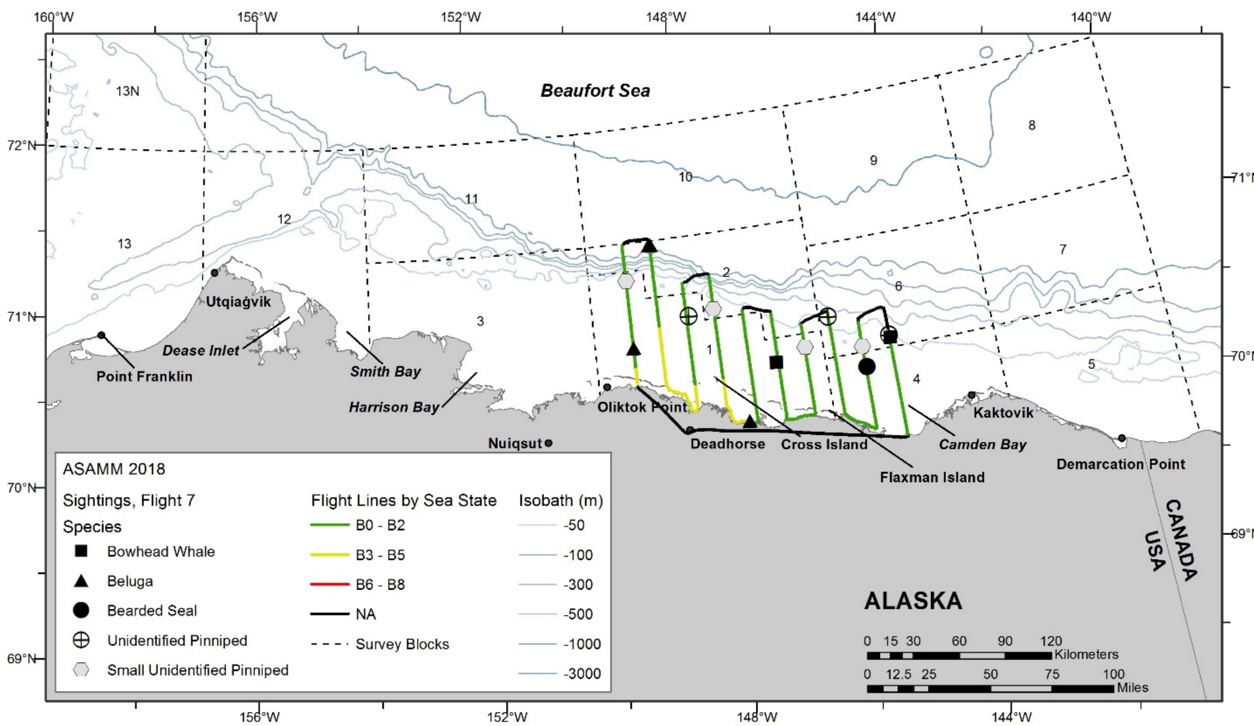

Figure B-22. Flight 7 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

3 August 2018, Flight 8

Flight was a complete survey of transects 113 and 115, and partial survey of transects 111 and 114. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with fog, glare, low ceilings, and precipitation, and Beaufort 1-4 sea states. Sea ice was 0-99% broken floe and floe in the area surveyed. Sightings included belugas (including 3 calves), one unidentified pinniped, and one small unidentified pinniped.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
8	8/3/2018 14:35	70.776	145.328	beluga	swim	2	1	6
8	8/3/2018 15:04	71.035	146.334	beluga	swim	1	0	2
8	8/3/2018 15:04	71.012	146.323	beluga	rest	2	1	2
8	8/3/2018 15:04	71.008	146.328	beluga	swim	1	0	2
8	8/3/2018 15:05	70.987	146.348	beluga	swim	1	0	2
8	8/3/2018 15:07	70.937	146.320	beluga	rest	2	1	2
8	8/3/2018 15:07	70.930	146.348	beluga	rest	1	0	2
8	8/3/2018 16:11	71.096	147.317	beluga	rest	1	0	2

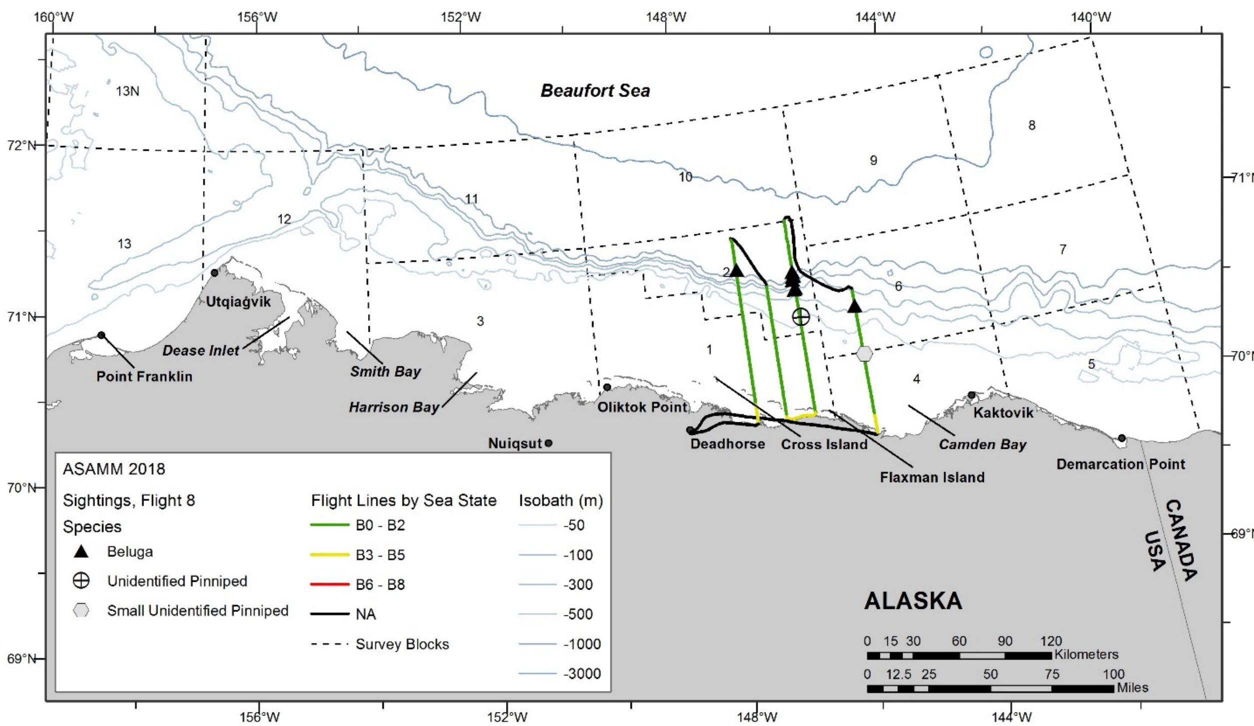

Figure B-23. Flight 8 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

5 August 2018, Flight 216

Flight was a complete survey of transects 29, 30, 31, and 32, and partial survey of transect 33. Survey conditions included partly cloudy to overcast skies, 5 km to unlimited visibility, with glare, and Beaufort 3-5 sea states. There was no sea ice in the area surveyed. Sightings included one humpback whale and one minke whale.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
216	8/5/2018 15:16	68.129	168.186	minke whale	swim	1	0	22
216	8/5/2018 15:23	68.136	168.542	humpback whale	swim	1	0	22

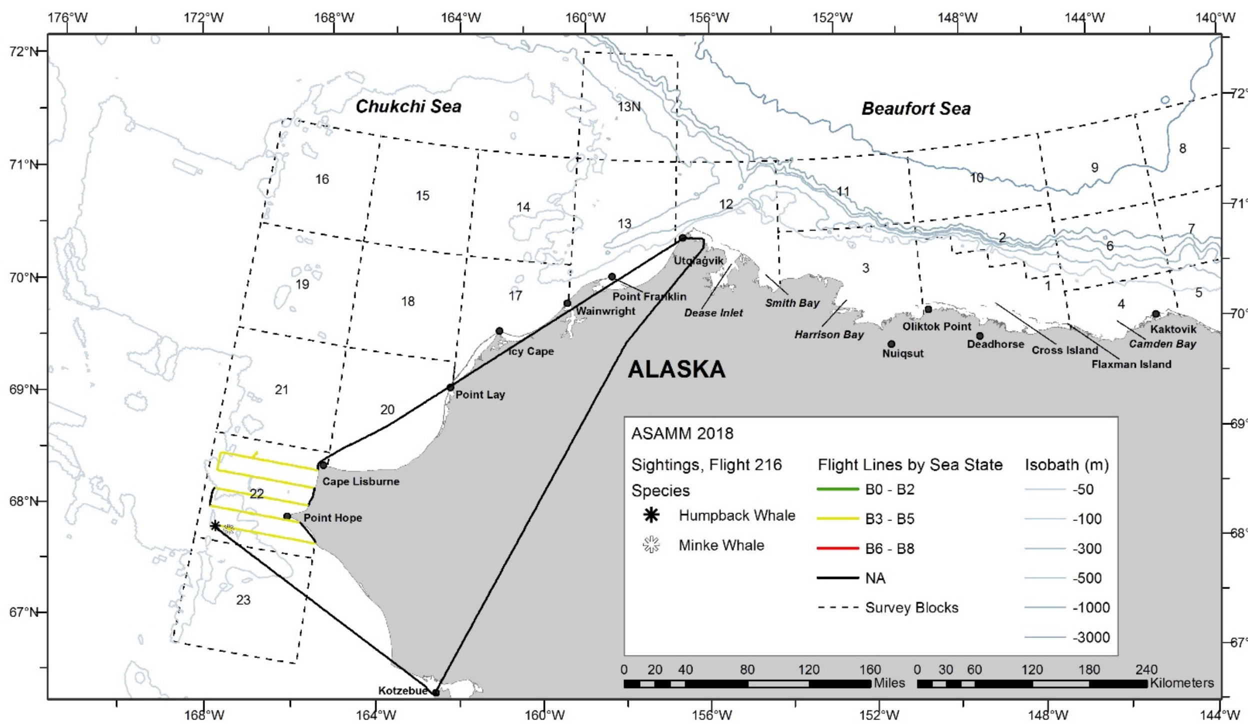

Figure B-24. Flight 216 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

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6 August 2018, Flight 217

Flight was a deadhead flight in an attempt to survey transect 14. Widespread low ceilings and high sea state prevented survey effort. There were no marine mammal sightings.

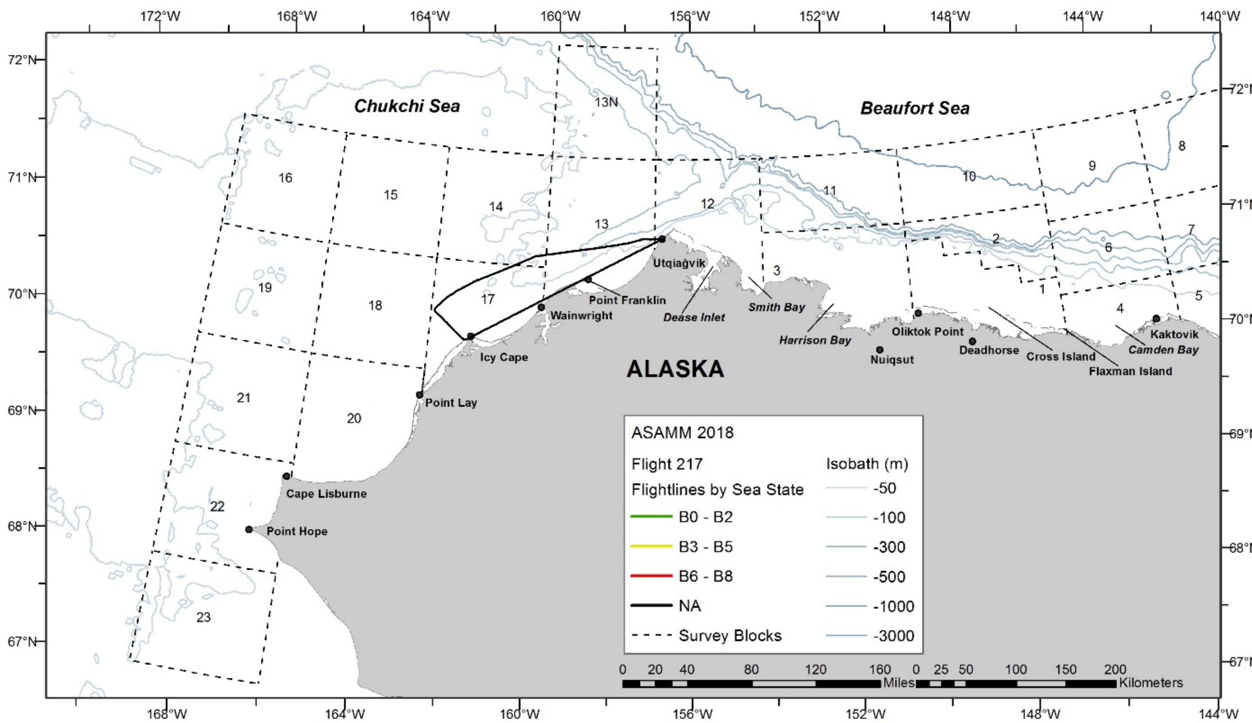

Figure B-25. Flight 217 survey track, depicted by sea state.

8 August 2018, Flight 218

Flight was a partial survey of transects 8 and 10, and coastal transect from Barrow to Wainwright, with a deviation from the coastal transect for search effort in Peard Bay. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 2-4 sea states. There was no sea ice in the area surveyed. Sightings included one bowhead whale carcass, gray whales (including 4 calves and 1 carcass), unidentified cetaceans, and walruses. The gray whale carcass was likely previously sighted on flight 214 on 30 July 2018. The bowhead whale carcass was a resight of a carcass that was previously sighted floating on flight 214 on 30 July 2018 and flight 215 on 31 July 2018.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
218	8/8/2018 13:01	71.152	157.103	gray whale	feed	1	0	13
218	8/8/2018 13:05	71.068	157.213	gray whale	dead	1	0	13
218	8/8/2018 13:38	70.717	159.862	gray whale	rest	2	0	13
218	8/8/2018 13:54	70.837	160.930	gray whale	feed	1	0	17
218	8/8/2018 13:58	70.892	161.014	gray whale	feed	1	0	17
218	8/8/2018 13:58	70.881	161.042	gray whale	feed	1	0	17
218	8/8/2018 13:59	70.891	160.985	gray whale	feed	1	0	17
218	8/8/2018 14:03	70.881	161.049	gray whale	feed	1	0	17
218	8/8/2018 14:07	70.969	161.311	gray whale	swim	2	1	17
218	8/8/2018 14:07	70.976	161.311	gray whale	swim	2	1	17
218	8/8/2018 14:08	70.974	161.274	gray whale	swim	1	0	17
218	8/8/2018 14:12	71.034	161.373	unid cetacean	swim	1	0	14
218	8/8/2018 14:12	71.041	161.358	unid cetacean	swim	1	0	14
218	8/8/2018 14:24	71.146	161.852	gray whale	feed	2	0	14
218	8/8/2018 14:25	71.143	161.903	gray whale	swim	2	0	14
218	8/8/2018 14:28	71.149	161.929	gray whale	feed	4	2	14
218	8/8/2018 15:18	71.096	159.746	bowhead whale	dead	1	0	13

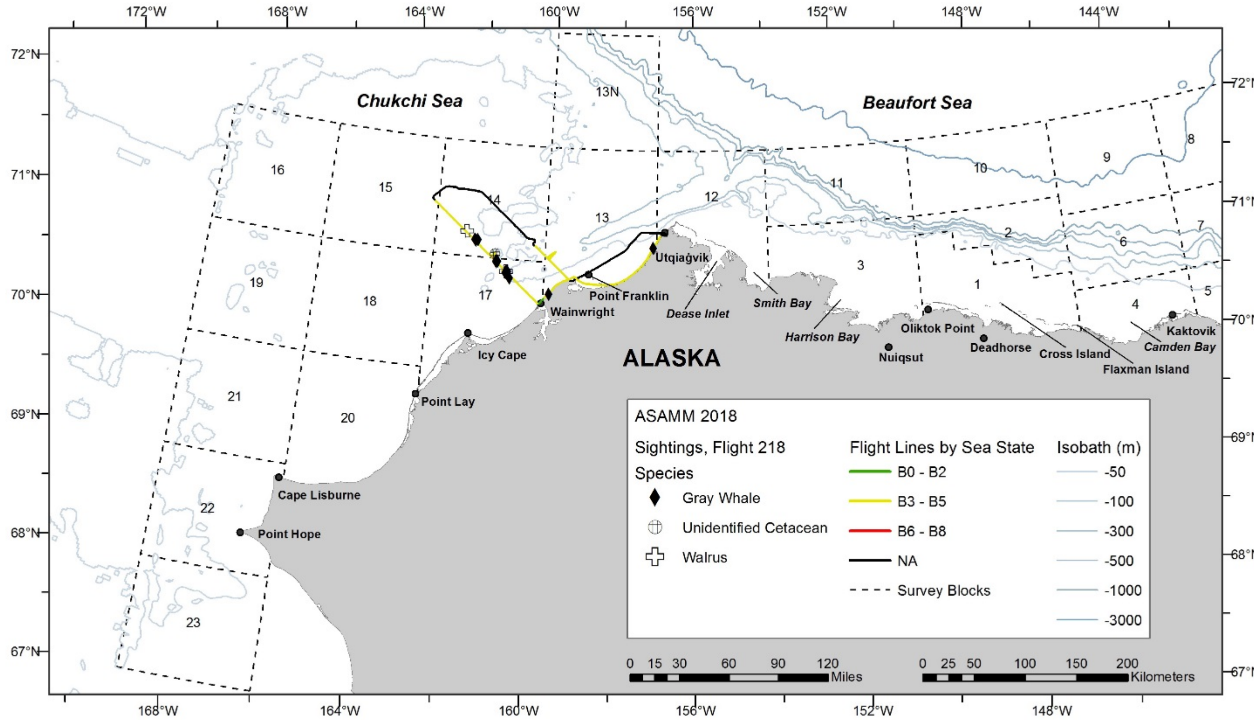

Figure B-26. Flight 218 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

8 August 2018, Flight 9

Flight was a partial survey of transects 112, 113, 114, 115, 116, 117, 118, and 119. Survey conditions included overcast skies, < 1 km to unlimited visibility, with fog and low ceilings, and Beaufort 0-1 sea states. Sea ice was 30-95% broken floe and floe in the area surveyed. Sightings included bowhead whales, belugas (including 7 calves), one bearded seal, and one unidentified pinniped.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
9	8/8/2018 16:35	71.266	149.317	beluga	mill	3	0	2
9	8/8/2018 16:36	71.302	149.306	beluga	mill	4	2	2
9	8/8/2018 16:38	71.315	149.155	beluga	swim	1	0	2
9	8/8/2018 16:39	71.331	149.142	beluga	mill	2	1	2
9	8/8/2018 16:39	71.329	149.085	beluga	rest	1	1	2
9	8/8/2018 16:44	71.233	148.830	beluga	swim	2	1	2
9	8/8/2018 16:44	71.215	148.842	beluga	swim	1	0	2
9	8/8/2018 16:58	70.795	148.847	bowhead whale	swim	1	0	1
9	8/8/2018 17:33	71.268	147.823	beluga	rest	1	0	2
9	8/8/2018 17:34	71.252	147.830	beluga	swim	1	0	2
9	8/8/2018 18:24	71.228	147.342	beluga	swim	2	1	2
9	8/8/2018 18:25	71.259	147.314	beluga	swim	1	0	2
9	8/8/2018 18:25	71.278	147.307	beluga	swim	1	0	2
9	8/8/2018 18:32	71.295	146.825	beluga	swim	1	0	2
9	8/8/2018 18:34	71.227	146.842	beluga	swim	1	0	2
9	8/8/2018 18:35	71.181	146.806	beluga	swim	2	1	2
9	8/8/2018 18:43	70.836	146.817	bowhead whale	dive	1	0	2
9	8/8/2018 19:22	70.936	146.311	beluga	swim	1	0	2
9	8/8/2018 19:45	70.680	145.818	bowhead whale	dive	1	0	6

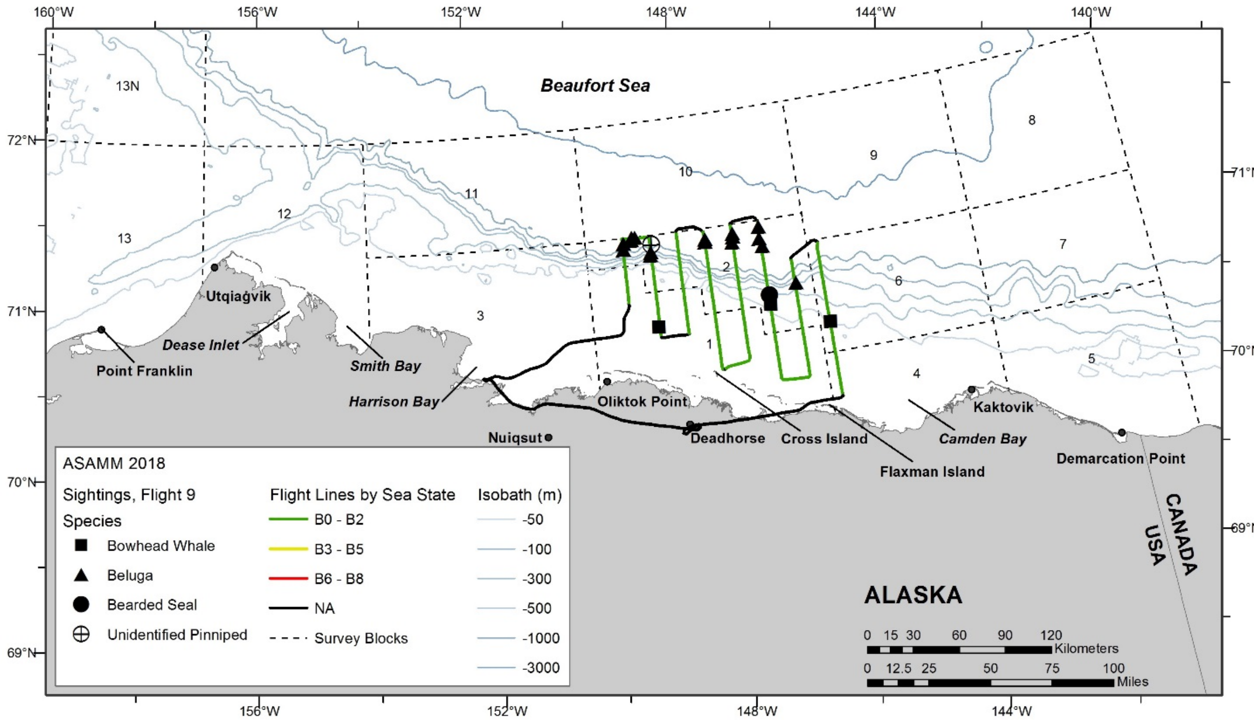

Figure B-27. Flight 9 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

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9 August 2018, Flight 219

Flight was a partial survey of transects 17 and 19, and coastal transect from approximately 20 km southwest of Wainwright to approximately 15 km northeast of Point Lay and from approximately 30 km south of Point Lay to approximately 85 km south of Point Lay. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 2-6 sea states. There was no sea ice in the area surveyed. Sightings included one gray whale carcass, one unidentified cetacean, one unidentified pinniped, and small unidentified pinnipeds. Two haulouts, of approximately 1300 and 750 small unidentified pinnipeds, were observed on barrier islands east of Icy Cape.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
219	8/9/2018 12:40	70.335	161.829	unid cetacean	swim	1	0	17
219	8/9/2018 12:52	70.112	162.485	gray whale	dead	1	0	17

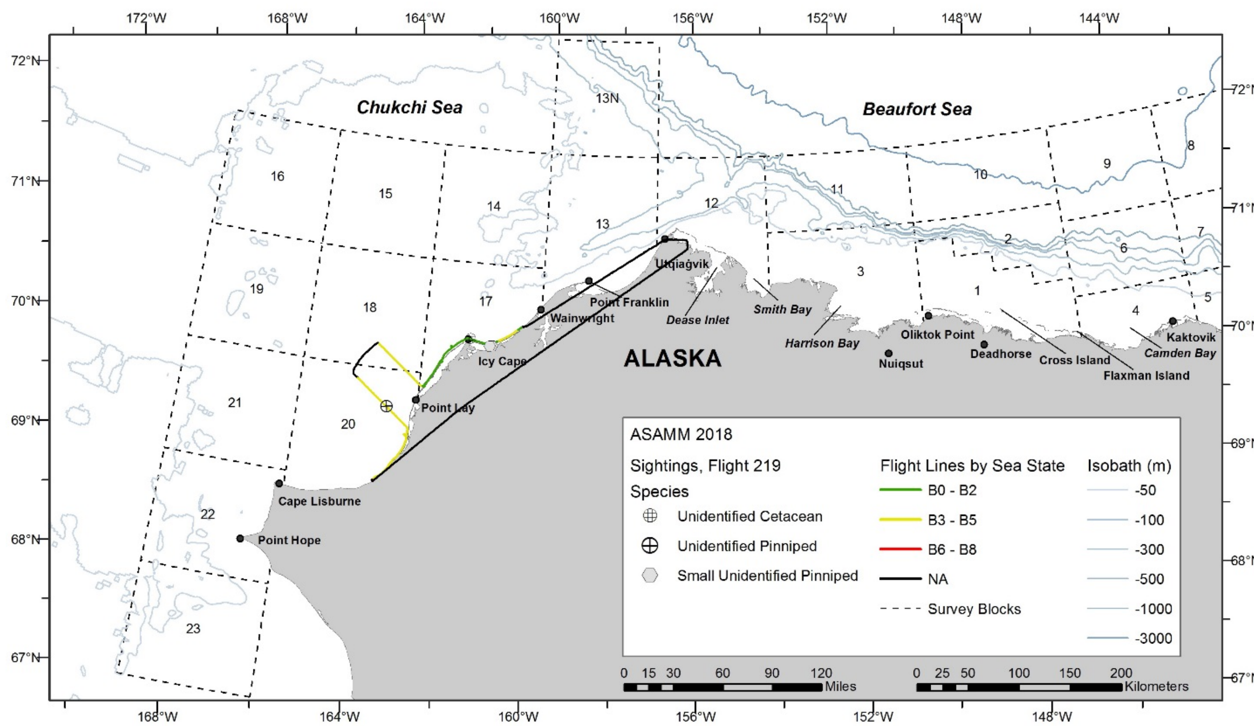

Figure B-28. Flight 219 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

9 August 2018, Flight 10

Flight was a partial survey of transects 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, and 111. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 0-5 sea states. Sea ice was 0-95% broken floe in the area surveyed. Sightings included belugas (including 10 calves), one bearded seal, small unidentified pinnipeds, and polar bears.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
10	8/9/2018 11:08	70.543	141.311	beluga	swim	1	0	7
10	8/9/2018 12:04	70.565	141.833	beluga	swim	1	0	7
10	8/9/2018 12:06	70.609	141.810	beluga	swim	2	1	7
10	8/9/2018 12:06	70.615	141.821	beluga	swim	1	0	7
10	8/9/2018 12:07	70.643	141.823	beluga	swim	1	0	7
10	8/9/2018 12:07	70.655	141.836	beluga	rest	1	0	7
10	8/9/2018 12:07	70.660	141.826	beluga	swim	1	0	7
10	8/9/2018 12:07	70.665	141.829	beluga	mill	2	0	7
10	8/9/2018 12:13	70.854	141.834	beluga	swim	1	0	7
10	8/9/2018 12:14	70.877	141.837	beluga	swim	1	0	7
10	8/9/2018 12:39	70.724	142.324	beluga	swim	8	0	7
10	8/9/2018 12:40	70.666	142.307	beluga	swim	1	0	7
10	8/9/2018 12:42	70.590	142.327	beluga	swim	2	1	7
10	8/9/2018 12:44	70.536	142.322	beluga	swim	2	1	7
10	8/9/2018 13:18	70.631	142.840	beluga	swim	4	2	7
10	8/9/2018 13:18	70.638	142.839	beluga	swim	1	0	7
10	8/9/2018 13:20	70.711	142.825	beluga	mill	2	1	7
10	8/9/2018 13:29	70.981	142.821	beluga	swim	1	0	7
10	8/9/2018 13:29	70.990	142.837	beluga	swim	7	2	7
10	8/9/2018 15:56	70.610	143.318	beluga	swim	2	1	6
10	8/9/2018 15:57	70.613	143.337	beluga	swim	1	0	6
10	8/9/2018 15:57	70.614	143.319	beluga	swim	1	0	6
10	8/9/2018 16:01	70.753	143.324	beluga	mill	2	0	6
10	8/9/2018 16:01	70.759	143.335	beluga	swim	1	0	6
10	8/9/2018 16:14	70.703	143.846	beluga	swim	1	0	6
10	8/9/2018 16:15	70.692	143.813	beluga	swim	2	1	6

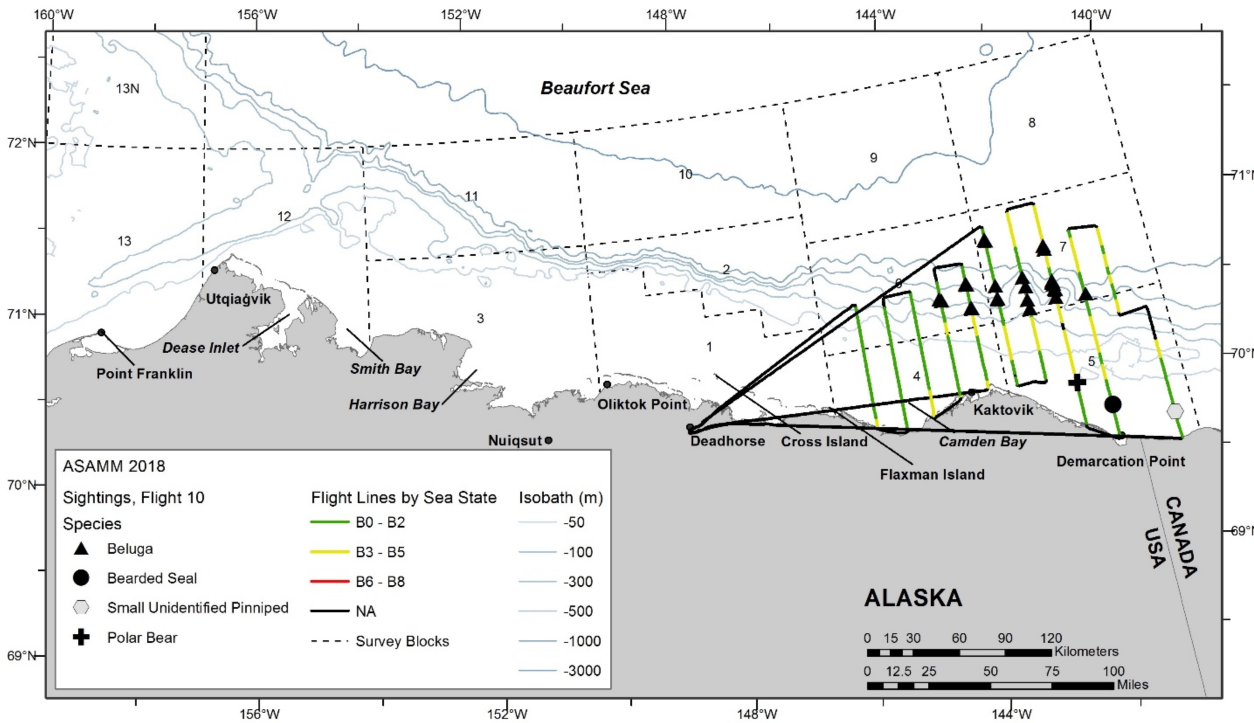

Figure B-29. Flight 10 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

12 August 2018, Flight 11

Flight was the coastal transect from Demarcation Point to Oliktok Point and in Harrison Bay, and field of view transects near a terrestrial target on the coast in Harrison Bay. Survey conditions included clear to overcast skies, 0 km to unlimited visibility, with fog and glare, and Beaufort 0-3 sea states. Sea ice was 0-60% broken floe in the area surveyed. There were no marine mammal sightings.

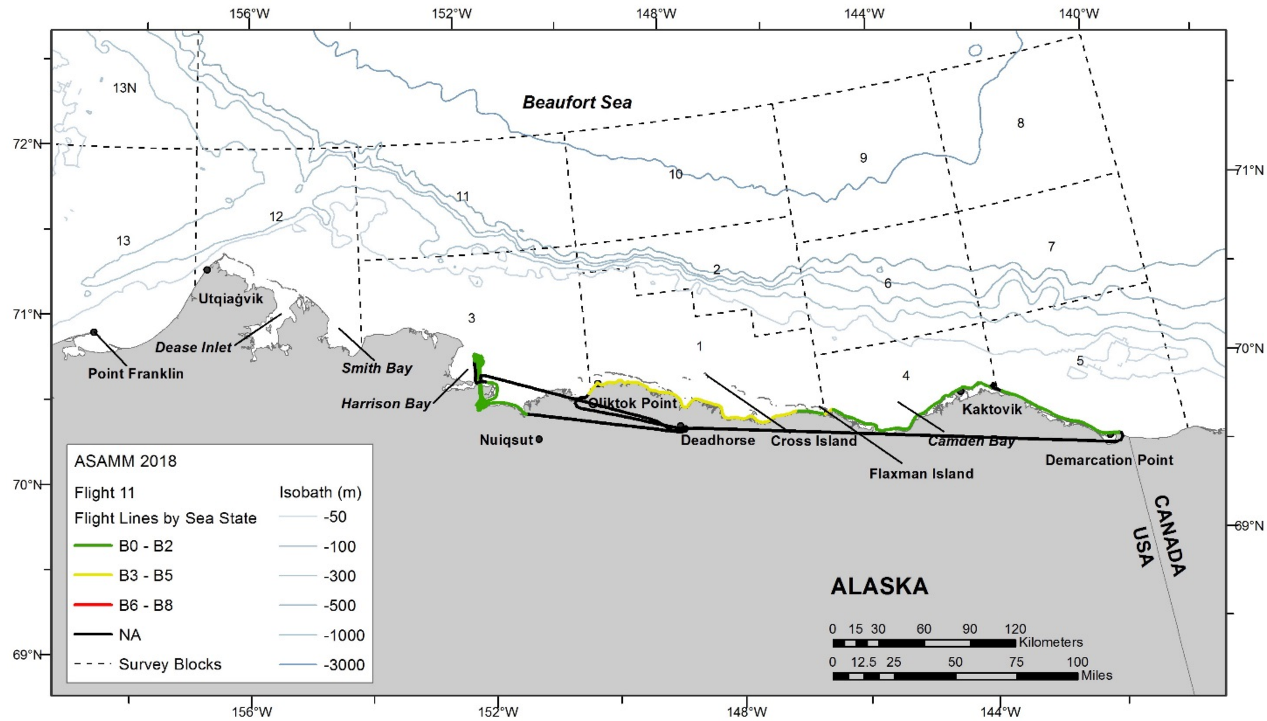

Figure B-30. Flight 11 survey track, depicted by sea state.

14 August 2018, Flight 220

Flight was a complete survey of transect 12, and partial survey of transects 6, 8, and 10. Survey conditions included partly cloudy to overcast skies, 3 km to unlimited visibility, with glare, haze, and low ceilings, and Beaufort 3-6 sea states. Sea ice was 0-25% broken floe in the area surveyed. Sightings included one bowhead whale, gray whales (including 1 calf), walruses, one bearded seal, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
220	8/14/2018 17:43	71.430	162.871	bowhead whale	swim	1	0	14
220	8/14/2018 18:15	71.267	160.665	gray whale	feed	1	0	14
220	8/14/2018 18:17	71.239	160.654	gray whale	swim	1	0	14
220	8/14/2018 18:20	71.229	160.620	gray whale	feed	1	0	14
220	8/14/2018 18:21	71.233	160.632	gray whale	feed	2	1	14

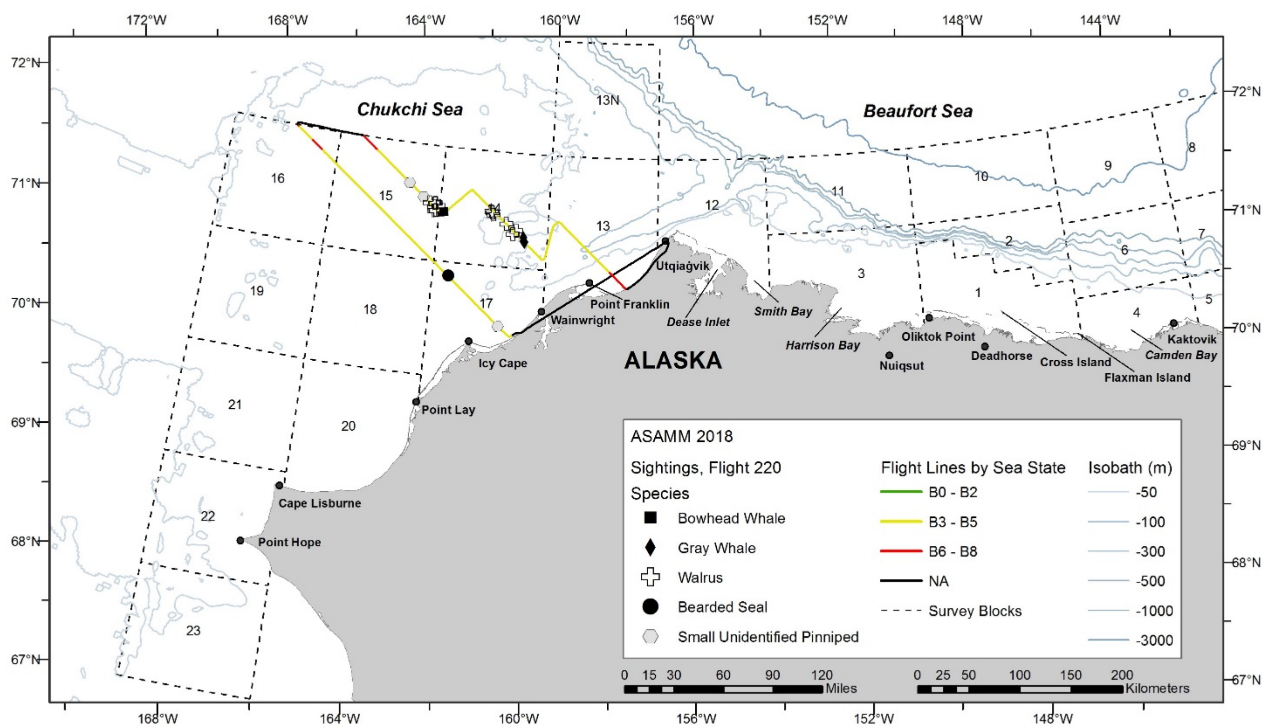

Figure B-31. Flight 220 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

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14 August 2018, Flight 12

Flight was a partial survey of transects 117 and 125, and an attempt to fly field of view transects using a terrestrial target in Harrison Bay. Survey conditions included partly cloudy skies, 0 km to unlimited visibility, with fog, glare, and low ceilings, and Beaufort 0-5 sea states. Sea ice was 0-95% broken floe in the area surveyed. Sightings included one small unidentified pinniped.

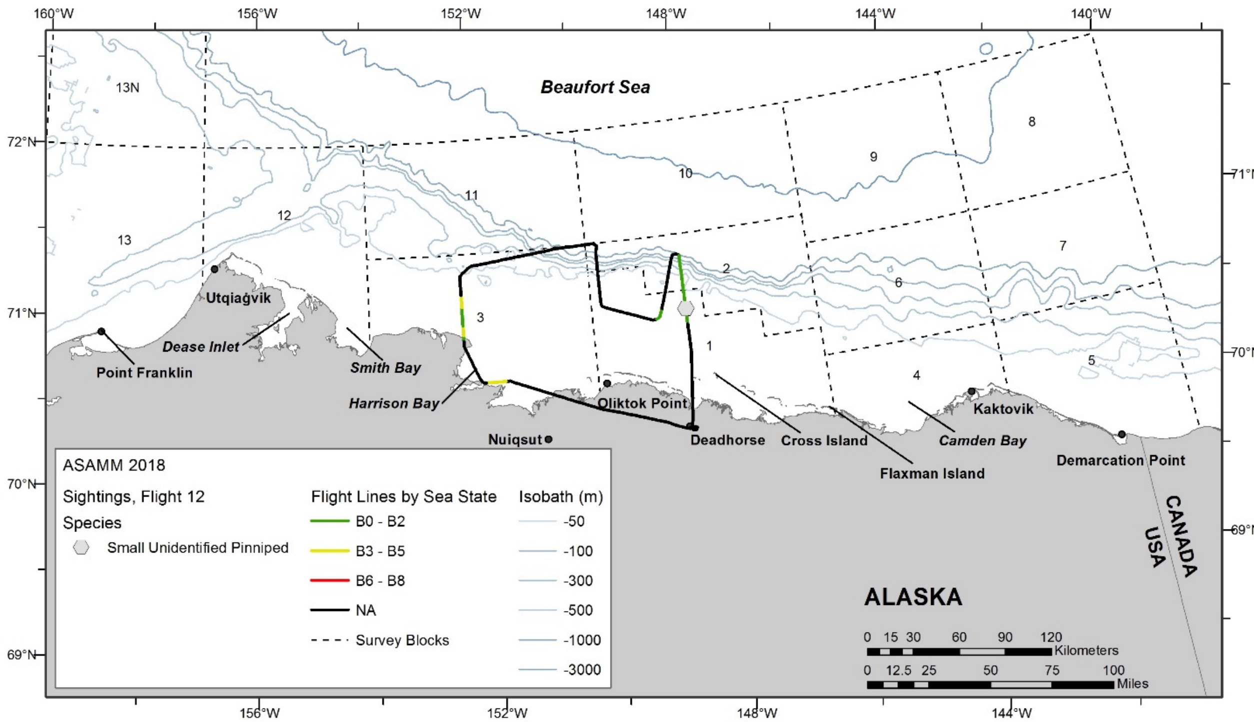

Figure B-32. Flight 12 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

15 August 2018, Flight 13

Flight was a complete survey of transects 101 and 102, and partial survey of transects 103 and 104. Survey conditions included partly cloudy to overcast skies, <1 km to unlimited visibility, with glare and precipitation, and Beaufort 0-6 sea states. Sea ice was 0-95% broken floe in the area surveyed. Sightings included belugas (including 4 calves) and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
13	8/15/2018 10:26	70.388	140.322	beluga	swim	2	1	5
13	8/15/2018 11:00	70.996	140.837	beluga	swim	1	0	7
13	8/15/2018 11:13	70.561	140.814	beluga	swim	2	1	7
13	8/15/2018 11:14	70.561	140.835	beluga	swim	1	0	7
13	8/15/2018 11:14	70.555	140.835	beluga	swim	1	0	7
13	8/15/2018 11:14	70.550	140.833	beluga	swim	2	1	7
13	8/15/2018 11:15	70.507	140.832	beluga	swim	1	1	7
13	8/15/2018 11:15	70.506	140.826	beluga	swim	1	0	7
13	8/15/2018 12:09	70.452	141.333	beluga	swim	1	0	5
13	8/15/2018 12:10	70.493	141.320	beluga	swim	1	0	5
13	8/15/2018 12:11	70.494	141.317	beluga	swim	3	0	5
13	8/15/2018 12:11	70.495	141.330	beluga	swim	1	0	5
13	8/15/2018 12:18	70.745	141.309	beluga	swim	1	0	7
13	8/15/2018 12:44	70.680	141.860	beluga	swim	1	0	7
13	8/15/2018 12:49	70.528	141.830	beluga	swim	1	0	7

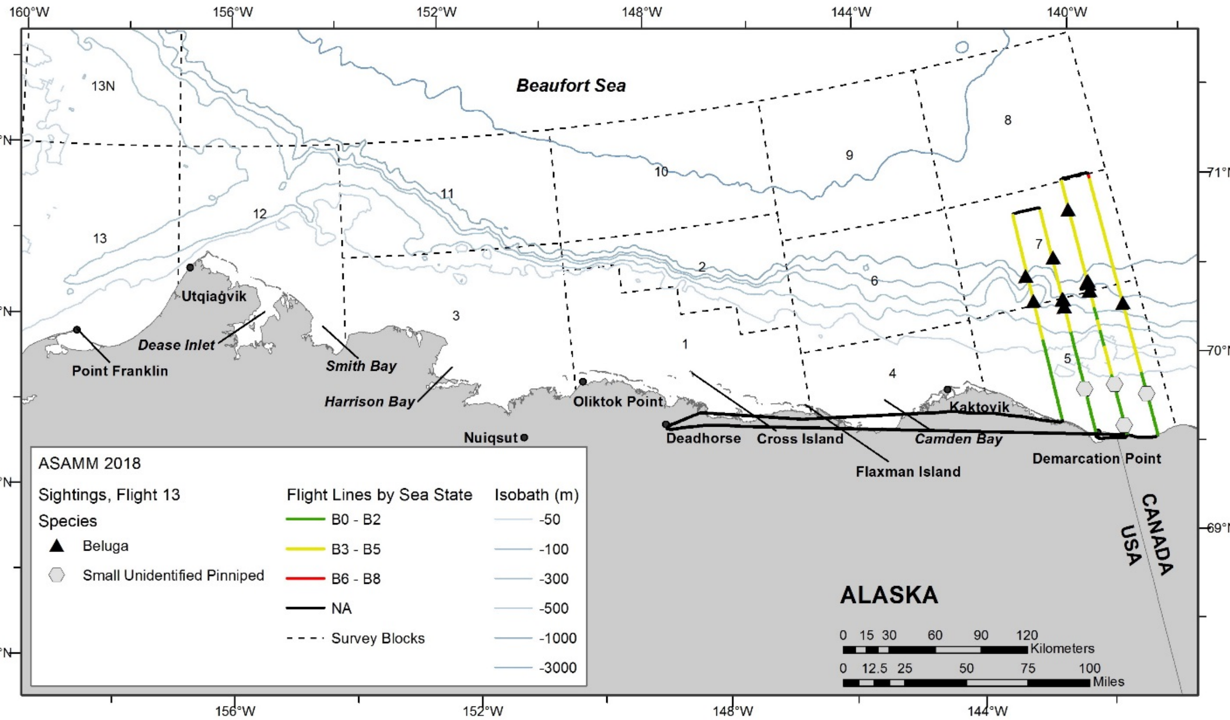

Figure B-33. Flight 13 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

17 August 2018, Flight 221

Flight was a partial survey of transects 4, 40, and 45. Survey conditions included clear skies, 0-10 km visibility, with fog, and Beaufort 0-1 sea states. Sea ice was 0-60% broken floe in the area surveyed. Sightings included belugas (including 2 calves), walruses, bearded seals, unidentified pinnipeds, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
221	8/17/2018 16:12	71.679	158.973	beluga	rest	1	0	13
221	8/17/2018 16:12	71.671	158.987	beluga	swim	1	0	13
221	8/17/2018 16:19	71.527	158.442	beluga	swim	4	2	13

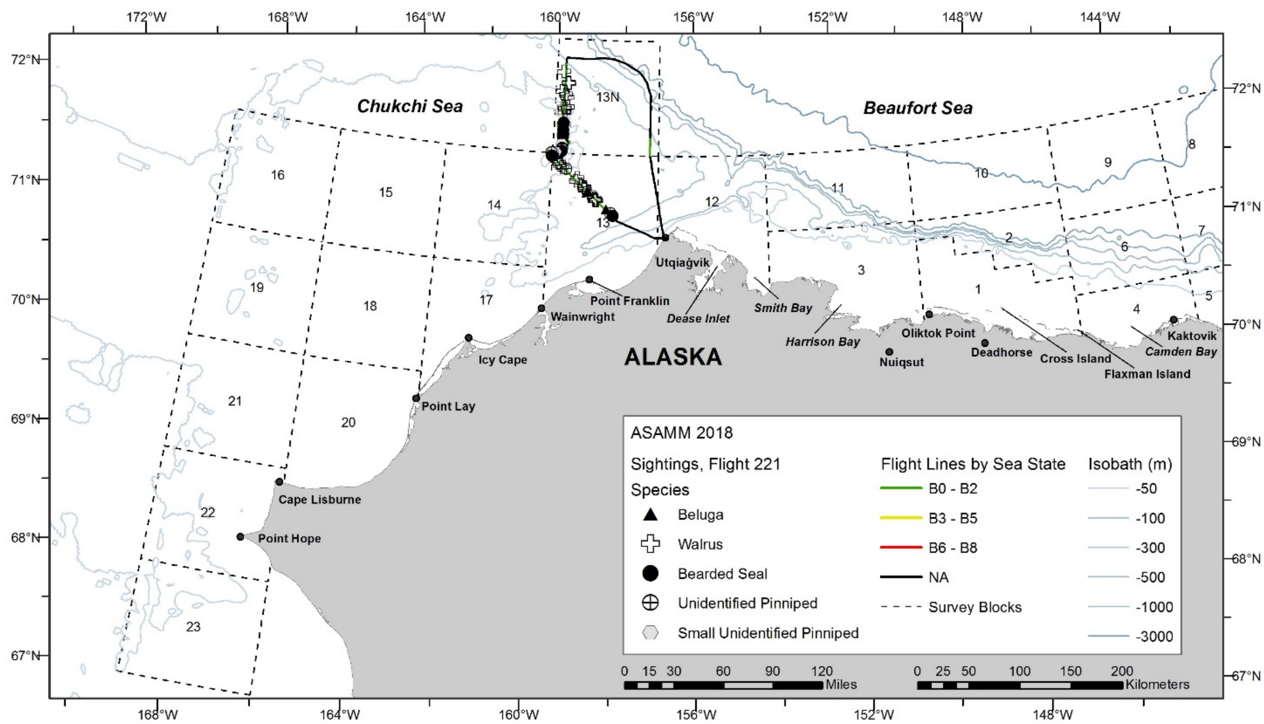

Figure B-34. Flight 221 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

17 August 2018, Flight 14

Flight was conducted entirely in deadhead mode. Survey conditions included widespread fog and low ceilings, which precluded survey effort. There were no marine mammal sightings.

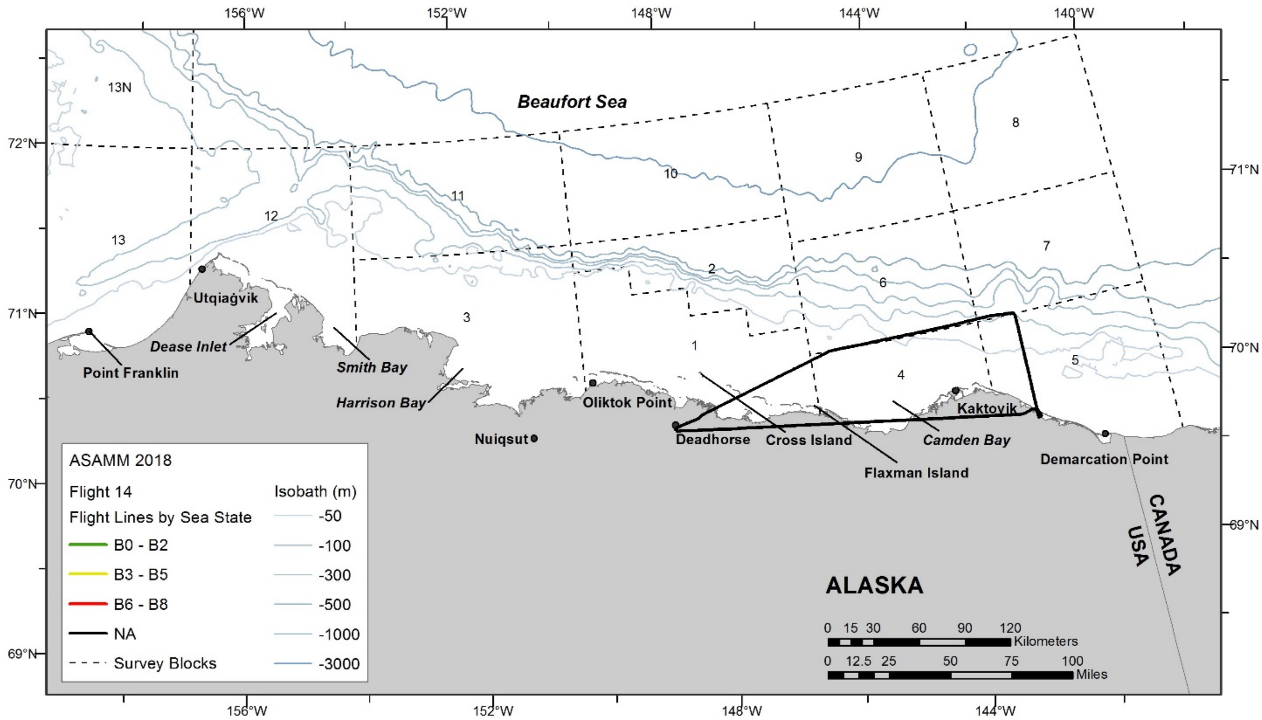

Figure B-35. Flight 14 survey track, depicted by sea state.

18 August 2018, Flight 15

Flight was a complete survey of transect 113, partial survey of transects 110, 111, 112, 114, 115, 116, and 117, and coastal transect from Harrison Bay to Cross Island. Survey conditions included partly cloudy to overcast skies, <1 km to unlimited visibility, with fog, low ceilings, and precipitation, and Beaufort 0-3 sea states. Sea ice was 0-99% broken floe in the area surveyed. Sightings included belugas (including 3 calves), small unidentified pinnipeds, and one polar bear.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
15	8/18/2018 10:49	70.967	146.324	beluga	swim	1	0	2
15	8/18/2018 10:50	70.989	146.314	beluga	swim	1	0	2
15	8/18/2018 11:12	70.971	145.831	beluga	rest	1	0	6
15	8/18/2018 11:12	70.970	145.817	beluga	swim	2	1	6
15	8/18/2018 11:57	70.905	145.318	beluga	swim	2	1	6
15	8/18/2018 11:58	70.941	145.336	beluga	swim	1	0	6
15	8/18/2018 11:58	70.945	145.336	beluga	swim	1	0	6
15	8/18/2018 12:14	70.981	144.823	beluga	swim	1	0	6
15	8/18/2018 12:14	70.979	144.825	beluga	swim	1	0	6
15	8/18/2018 14:24	70.934	146.794	beluga	swim	1	0	2
15	8/18/2018 14:24	70.943	146.810	beluga	swim	3	1	2
15	8/18/2018 14:25	70.981	146.790	beluga	swim	1	0	2

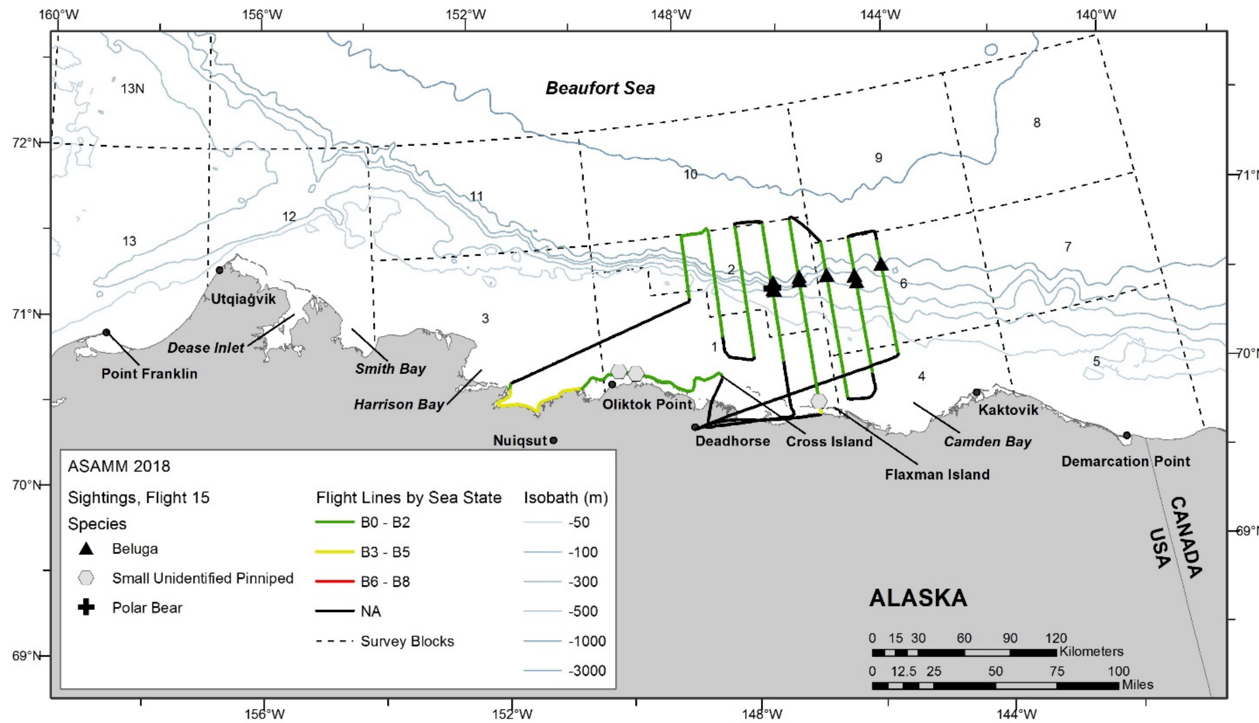

Figure B-36. Flight 15 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

19 August 2018, Flight 222

Flight was a partial survey of transects 9 and 13, coastal transect from Icy Cape to Point Barrow, and search effort in Peard Bay. Survey conditions included partly cloudy to overcast skies, 0-10 km visibility, with fog, glare, and low ceilings, and Beaufort 1-3 sea states. There was no sea ice in the area surveyed. Sightings included two bowhead whale carcasses, gray whales (including 2 calves and 2 carcasses), bearded seals, small unidentified pinnipeds, and one polar bear. One bowhead whale carcass was a resight of a carcass that was previously sighted during flight 214 on 30 July 2018, flight 215 on 31 July 2018, and flight 218 on 8 August 2018. One haulout, of approximately 55 small unidentified pinnipeds, was observed on a barrier island east of Icy Cape.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
222	8/19/2018 13:41	70.931	160.249	gray whale	feed	4	0	17
222	8/19/2018 13:44	70.938	160.316	gray whale	feed	1	0	17
222	8/19/2018 13:52	71.057	160.784	gray whale	feed	4	2	14
222	8/19/2018 13:52	71.056	160.813	gray whale	feed	2	0	14
222	8/19/2018 14:03	71.150	161.149	gray whale	swim	1	0	14
222	8/19/2018 14:07	71.233	161.364	gray whale	feed	1	0	14
222	8/19/2018 14:08	71.232	161.407	gray whale	feed	1	0	14
222	8/19/2018 15:23	70.676	159.952	gray whale	dead	1	0	13
222	8/19/2018 15:23	70.684	159.933	bowhead whale	dead	1	0	13
222	8/19/2018 15:46	70.817	158.176	bowhead whale	dead	1	0	13
222	8/19/2018 16:03	71.082	157.217	gray whale	dead	1	0	13

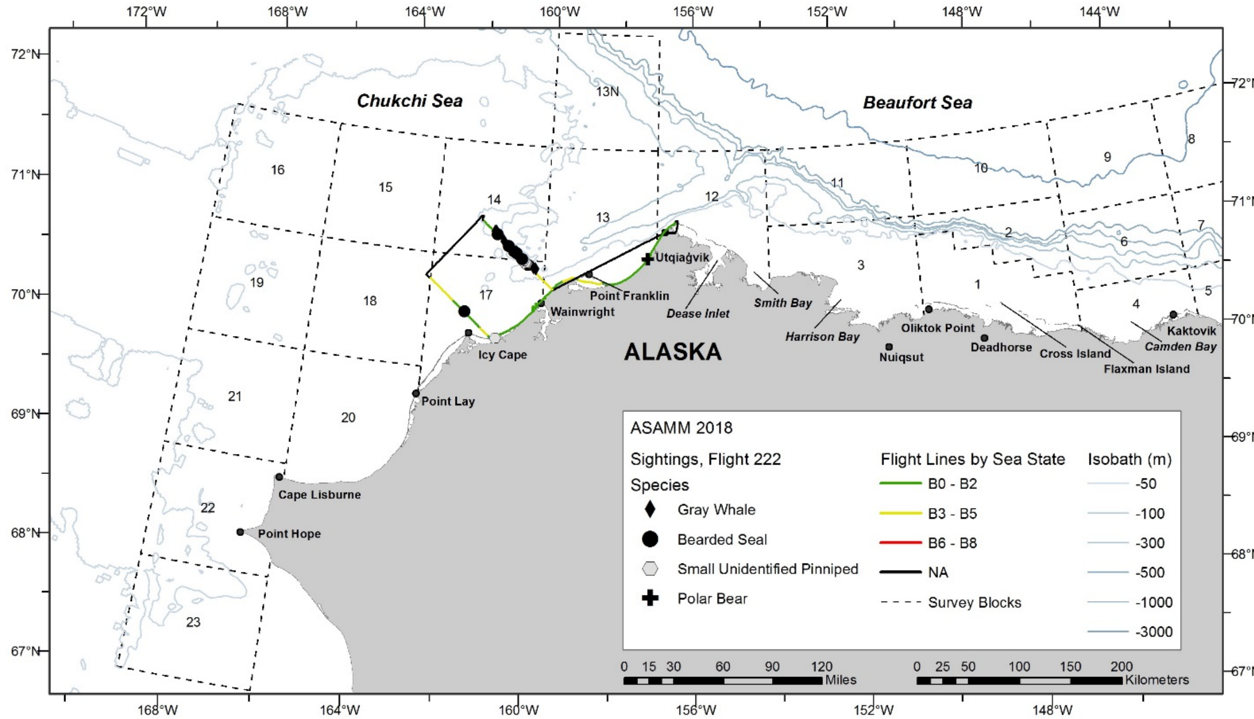

Figure B-37. Flight 222 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Gray whale cow-calf pair sighted approximately 50 km northwest of Wainwright, Alaska, on Flight 222, 19 August 2018. The calf is ventral (or belly) side up.

19 August 2018, Flight 16

Flight was a partial survey of transects 105, 106, 107, 108, 109, 110, and 124, search effort north of Harrison Bay, and a search for alternate field of view targets over land. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with fog, glare, low ceilings, and precipitation, and Beaufort 0-3 sea states. Sea ice was 0-85% broken floe in the area surveyed. Sightings included belugas (including 2 calves), unidentified cetaceans, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
16	8/19/2018 11:24	70.713	143.334	beluga	swim	1	1	6
16	8/19/2018 11:35	70.755	143.825	beluga	swim	1	0	6
16	8/19/2018 11:35	70.742	143.823	beluga	swim	1	0	6
16	8/19/2018 11:36	70.729	143.845	beluga	swim	1	0	6
16	8/19/2018 11:36	70.717	143.833	beluga	swim	1	0	6
16	8/19/2018 12:25	70.837	144.331	beluga	swim	1	0	6
16	8/19/2018 12:25	70.838	144.318	beluga	swim	1	0	6
16	8/19/2018 12:25	70.844	144.356	beluga	swim	6	0	6
16	8/19/2018 12:28	70.924	144.326	beluga	swim	1	0	6
16	8/19/2018 12:28	70.952	144.332	beluga	swim	2	1	6
16	8/19/2018 12:30	71.007	144.335	beluga	swim	3	0	6
16	8/19/2018 15:41	70.854	151.781	unid cetacean	swim	1	0	3
16	8/19/2018 15:41	70.856	151.770	unid cetacean	swim	1	0	3

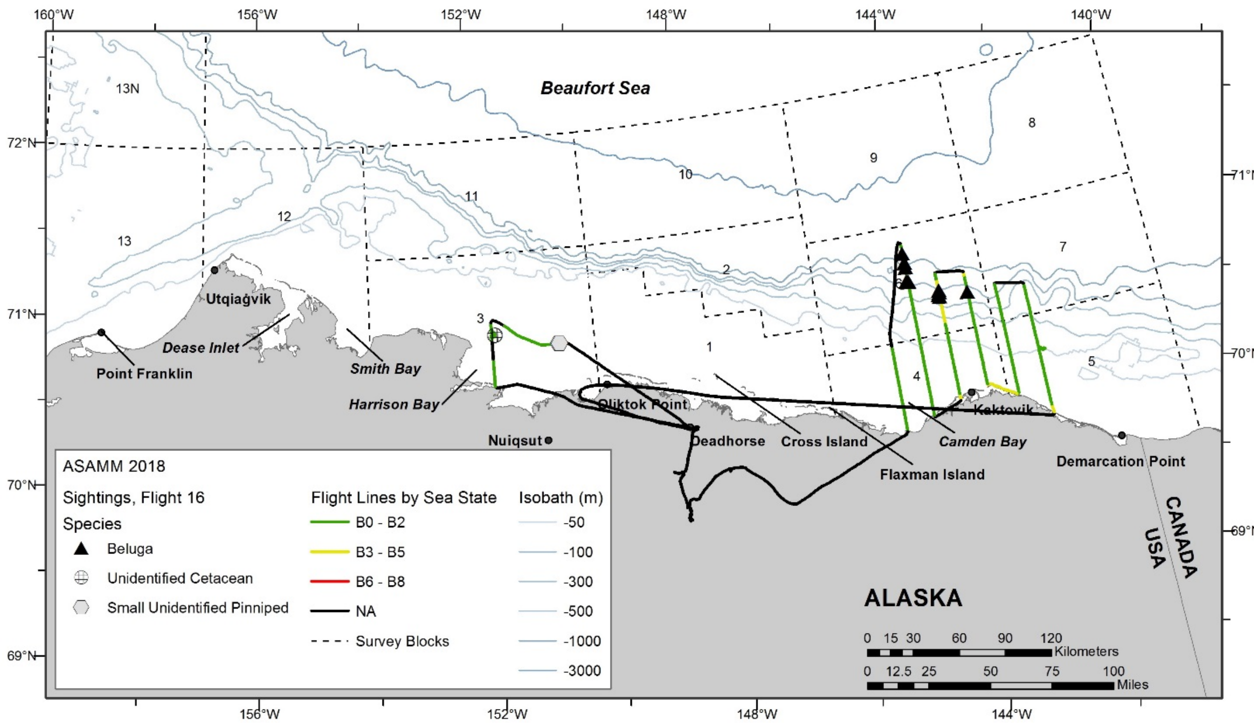

Figure B-38. Flight 16 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

22 August 2018, Flight 223

Flight was a complete survey of transect 45, and partial survey of transects 40, 41, 42, 43, and 44. Survey conditions included partly cloudy to overcast skies, 0-10 km visibility, with fog, glare, low ceilings, and precipitation, and Beaufort 2-6 sea states. Sea ice ranged 0-70% broken floe in the area surveyed. Sightings included belugas and walruses.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
223	8/22/2018 11:43	72.632	157.233	beluga	swim	1	0	13N
223	8/22/2018 11:43	72.644	157.240	beluga	swim	1	0	13N

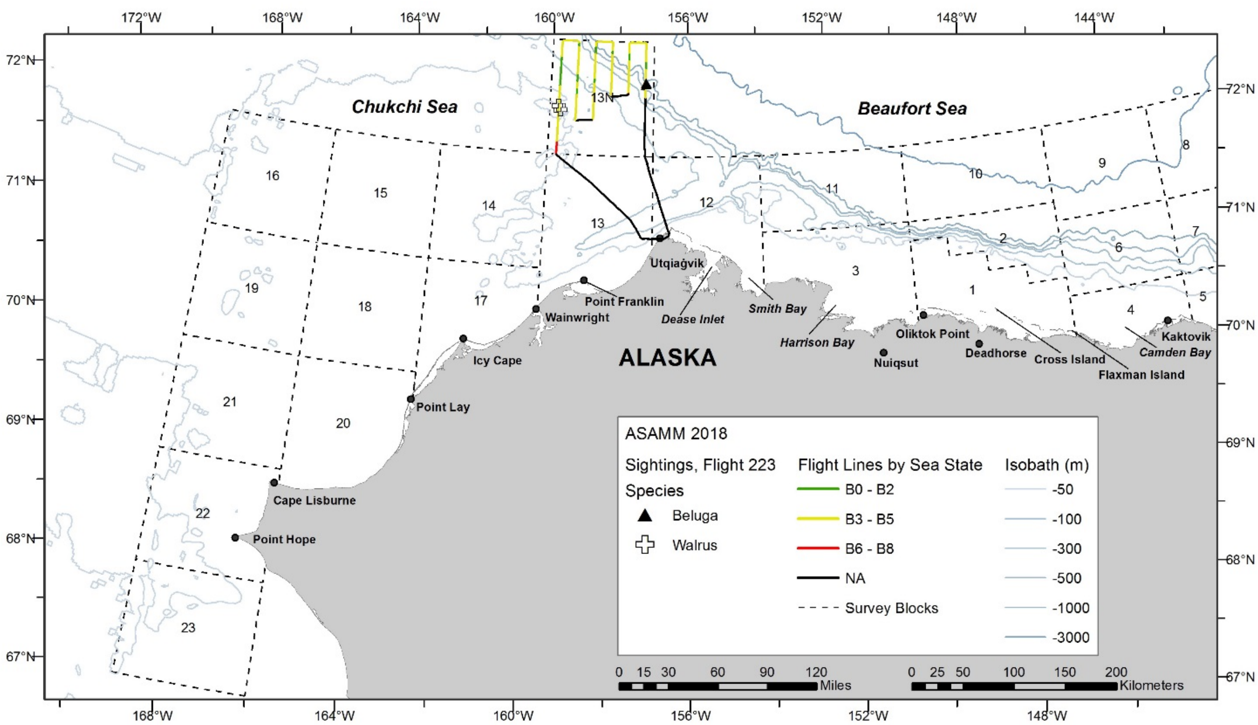

Figure B-39. Flight 223 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

25 August 2018, Flight 224

Flight was a partial survey of transects 8, 9, 10, and 11. Survey conditions included partly cloudy to overcast skies, <1 km to unlimited visibility, with glare, haze, low ceilings, and precipitation, and Beaufort 4-6 sea states. There was no sea ice in the area surveyed. Sightings included gray whales and one unidentified cetacean.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
224	8/25/2018 17:07	70.658	161.089	unid cetacean	breach	1	0	17
224	8/25/2018 17:23	70.943	162.006	gray whale	feed	1	0	17
224	8/25/2018 17:23	70.947	162.019	gray whale	feed	1	0	17
224	8/25/2018 17:24	70.951	162.030	gray whale	feed	1	0	17
224	8/25/2018 17:27	70.962	162.094	gray whale	feed	1	0	17
224	8/25/2018 18:35	70.908	160.565	gray whale	feed	1	0	17
224	8/25/2018 18:36	70.934	160.571	gray whale	feed	1	0	17

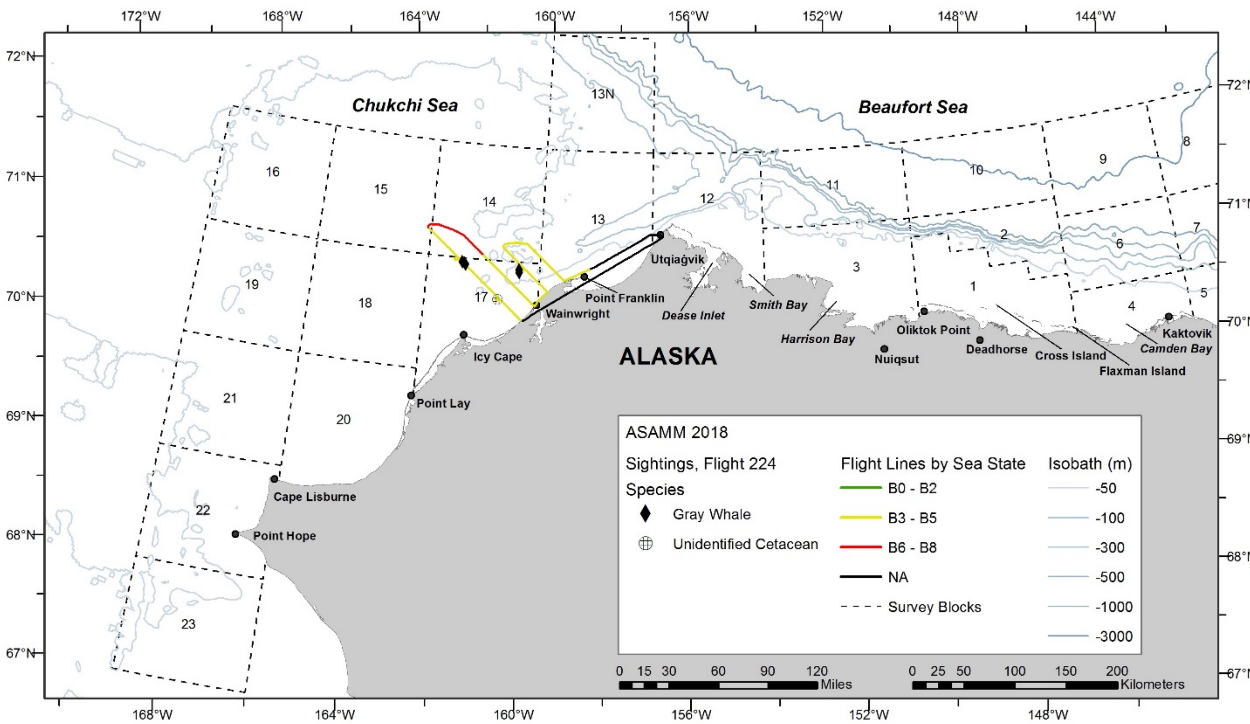

Figure B-40. Flight 224 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

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26 August 2018, Flight 17

Flight was conducted entirely in deadhead mode in an attempt to survey blocks 1 and 2 and the coastal transect in Harrison Bay. Widespread fog and low ceilings prevented survey effort. There were no marine mammal sightings.

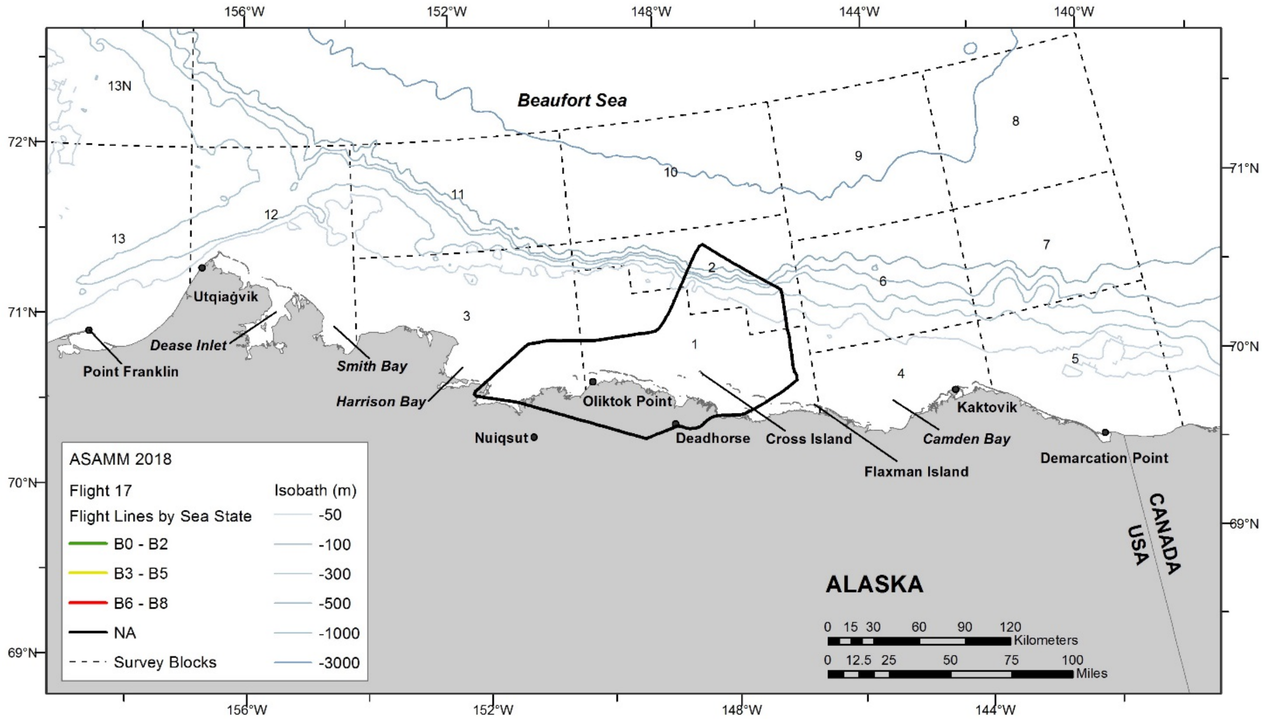

Figure B-41. Flight 17 survey track, depicted by sea state.

28 August 2018, Flight 225

Flight was a complete survey of transects 5, 7, 130, 131, 132, 133, and 134, and partial survey of transect 129. Survey conditions included clear to overcast skies, 0 km to unlimited visibility, with fog, glare, haze, and low ceilings, and Beaufort 2-6 sea states. Sea ice was 0-25% broken floe in the area surveyed. Sightings included bowhead whales, belugas (including 6 calves), and walruses.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
225	8/28/2018 18:38	71.491	156.830	beluga	swim	1	0	12
225	8/28/2018 18:38	71.493	156.821	beluga	rest	1	0	12
225	8/28/2018 18:38	71.494	156.816	beluga	rest	3	1	12
225	8/28/2018 18:38	71.499	156.826	beluga	swim	1	0	12
225	8/28/2018 18:41	71.605	156.800	bowhead whale	swim	2	0	12
225	8/28/2018 18:45	71.599	156.844	bowhead whale	swim	1	0	12
225	8/28/2018 18:45	71.601	156.864	bowhead whale	swim	1	0	12
225	8/28/2018 18:46	71.611	156.839	bowhead whale	swim	1	0	12
225	8/28/2018 19:46	71.578	155.822	beluga	dive	1	0	12
225	8/28/2018 19:46	71.581	155.827	beluga	swim	1	0	12
225	8/28/2018 19:46	71.586	155.824	beluga	swim	1	0	12
225	8/28/2018 19:46	71.589	155.817	beluga	swim	2	1	12
225	8/28/2018 19:46	71.590	155.831	beluga	swim	2	0	12
225	8/28/2018 20:12	71.704	155.317	beluga	swim	1	0	12
225	8/28/2018 20:12	71.701	155.338	beluga	mill	2	0	12
225	8/28/2018 20:12	71.697	155.304	beluga	swim	1	0	12
225	8/28/2018 20:12	71.694	155.325	beluga	swim	2	1	12
225	8/28/2018 20:12	71.690	155.321	beluga	swim	3	0	12
225	8/28/2018 20:12	71.690	155.324	beluga	mill	9	3	12
225	8/28/2018 20:12	71.687	155.337	bowhead whale	swim	1	0	12
225	8/28/2018 20:14	71.696	155.315	bowhead whale	swim	1	0	12

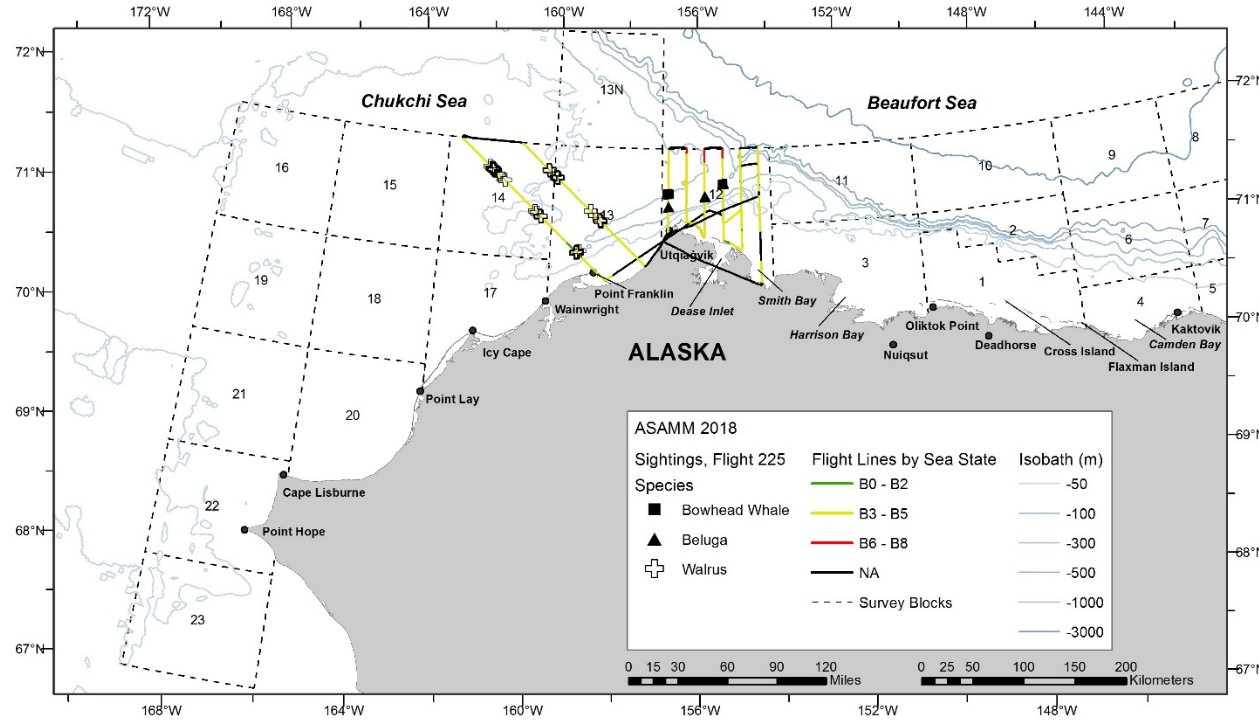

Figure B-42. Flight 225 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

28 August 2018, Flight 18

Flight was a complete survey of transects 113 and 120, partial survey of transects 111, 112, 114, 115, 116, 117, 118, 119, 121, and 122, and the coastal transect in Harrison Bay. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with fog, glare, ice on the window, low ceilings, and precipitation, and Beaufort 0-3 sea states. Sea ice was 0-98% broken floe, pack ice, and pack/floe in the area surveyed. Sightings included one bowhead whale, belugas (including 3 calves), bearded seals, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
18	8/28/2018 11:59	71.288	149.851	beluga	swim	1	0	2
18	8/28/2018 13:03	71.436	150.330	beluga	rest	1	0	11
18	8/28/2018 13:04	71.479	150.310	beluga	swim	2	0	11
18	8/28/2018 18:44	70.938	146.335	beluga	swim	1	0	2
18	8/28/2018 18:44	70.939	146.323	beluga	swim	3	1	2
18	8/28/2018 18:45	70.961	146.331	beluga	swim	2	1	2
18	8/28/2018 18:46	71.012	146.338	beluga	swim	1	0	2
18	8/28/2018 18:47	71.049	146.328	beluga	swim	1	0	2
18	8/28/2018 18:48	71.078	146.306	beluga	swim	1	0	2
18	8/28/2018 18:49	71.086	146.335	beluga	swim	1	0	2
18	8/28/2018 19:03	71.252	146.830	beluga	swim	2	0	2
18	8/28/2018 19:04	71.224	146.832	beluga	mill	6	1	2
18	8/28/2018 19:04	71.208	146.841	beluga	swim	2	0	2
18	8/28/2018 19:09	71.050	146.841	beluga	swim	1	0	2
18	8/28/2018 19:31	70.405	146.848	bowhead whale	swim	1	0	1
18	8/28/2018 19:54	70.417	147.337	beluga	swim	1	0	1

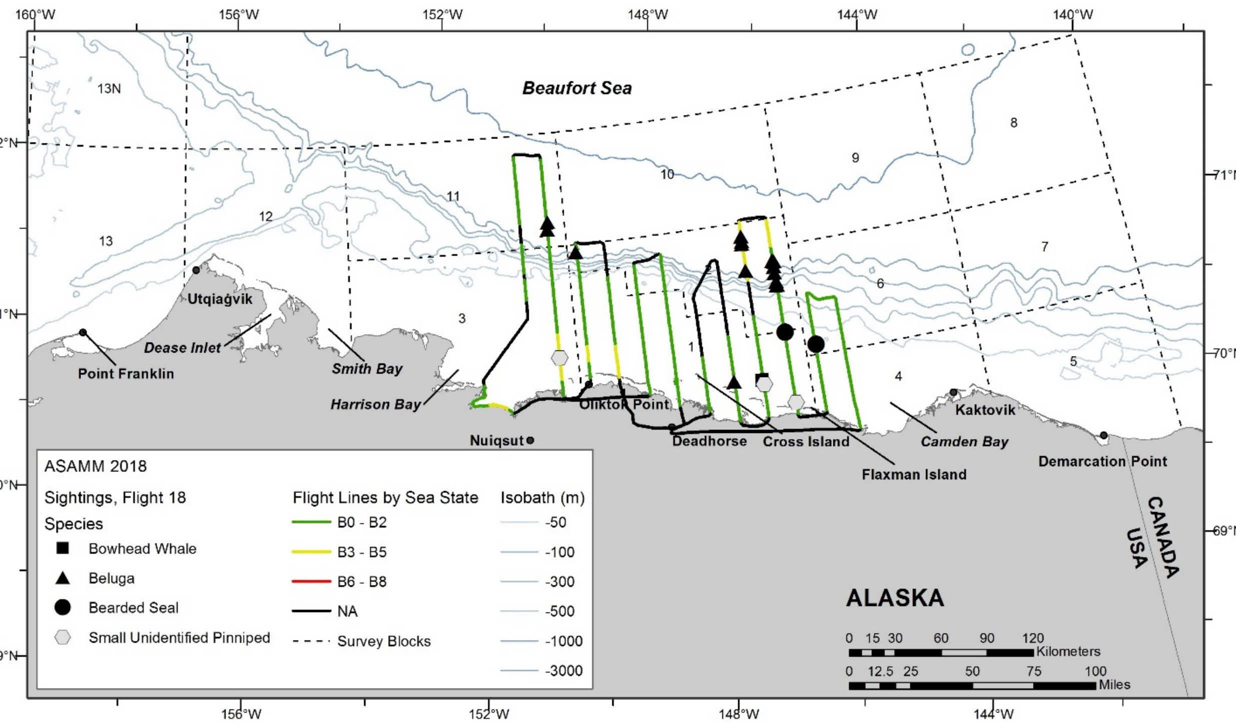

Figure B-43. Flight 18 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

29 August 2018, Flight 19

Flight was a complete survey of transects 107 and 108, and partial survey of transects 109, 110, 111, 112, 114, 115, 116, 117, 118, and 119. Survey conditions included overcast skies, 0-10 km visibility, with glare, low ceilings, and precipitation, and Beaufort 2-5 sea states. Sea ice was 0-95% broken floe and pack/floe in the area surveyed. Sightings included bowhead whales, belugas (including 3 calves), bearded seals, small unidentified pinnipeds, and one polar bear.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
19	8/29/2018 12:28	71.261	149.324	beluga	swim	1	0	2
19	8/29/2018 12:29	71.291	149.328	beluga	swim	2	1	2
19	8/29/2018 13:02	71.085	147.832	beluga	dive	2	0	2
19	8/29/2018 13:35	71.026	147.331	beluga	swim	1	0	2
19	8/29/2018 13:35	71.027	147.313	beluga	swim	1	0	2
19	8/29/2018 14:18	71.092	145.830	beluga	rest	1	0	6
19	8/29/2018 14:31	70.939	145.306	beluga	swim	1	0	6
19	8/29/2018 14:32	70.909	145.339	beluga	swim	2	0	6
19	8/29/2018 16:32	70.172	143.316	beluga	swim	1	0	4
19	8/29/2018 16:50	70.766	143.333	beluga	swim	2	0	6
19	8/29/2018 16:54	70.892	143.320	beluga	swim	7	2	6
19	8/29/2018 16:56	70.967	143.321	beluga	swim	1	0	6
19	8/29/2018 17:00	71.097	143.332	beluga	swim	1	0	6
19	8/29/2018 17:08	71.111	143.832	beluga	swim	1	0	6
19	8/29/2018 17:51	70.320	144.324	bowhead whale	swim	2	0	4

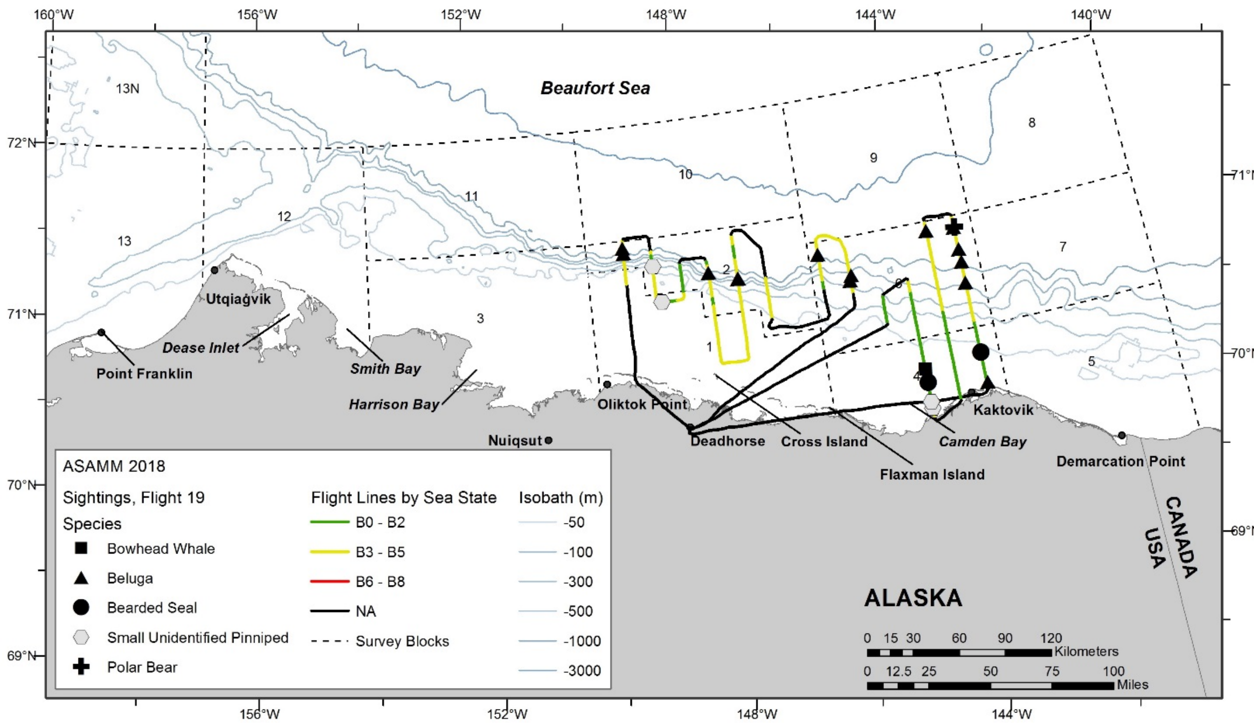

Figure B-44. Flight 19 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

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30 August 2018, Flight 226

Flight was a complete survey of transects 14, 16, 18, and 20. Survey conditions included partly cloudy to overcast skies, <1 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 2-3 sea states. There was no sea ice in the area surveyed. Sightings included walruses and small unidentified pinnipeds. A walrus haulout, estimated at 25,000 walruses, was observed on a barrier island near Point Lay.

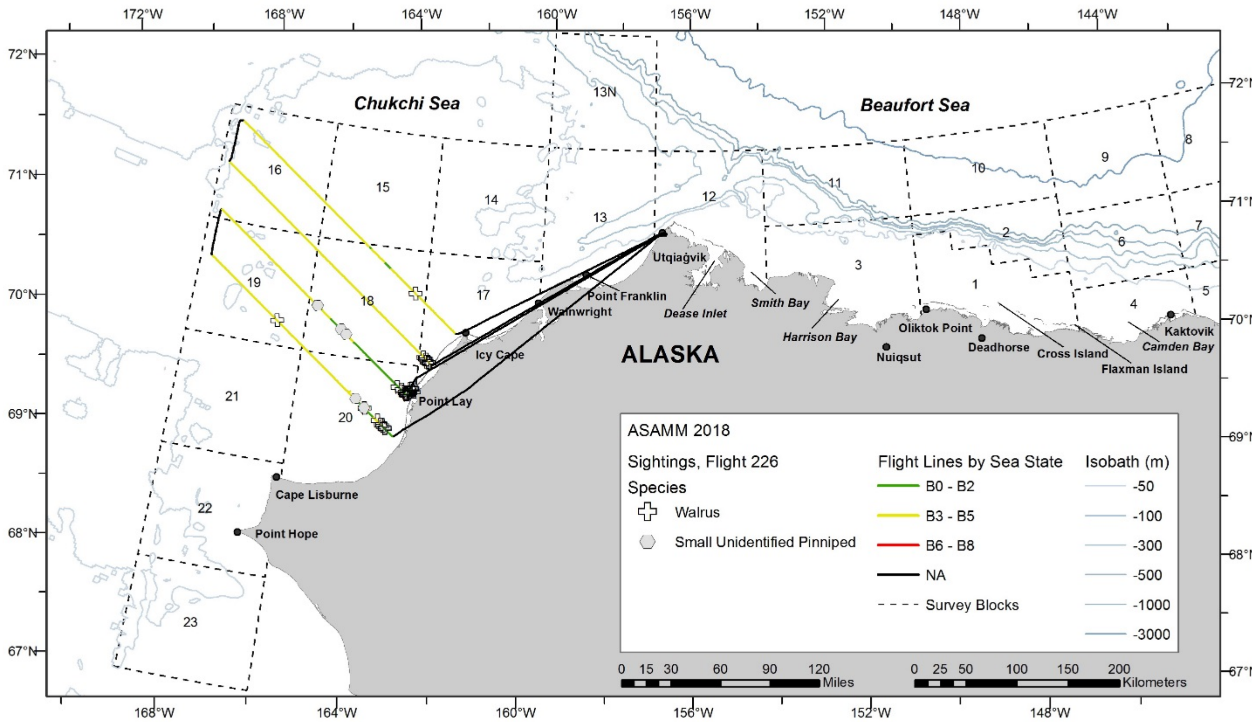

Figure B-45. Flight 226 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

30 August 2018, Flight 20

Flight was a complete survey of transects 2, 3, 4, 6, 125, 126, 127, and 128, partial survey of transect 124, and search effort through block 12. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility with glare, ice on the window, low ceilings, and precipitation, and Beaufort 1-5 sea states. Sea ice was 0-98% broken floe in the area surveyed. Sightings included bowhead whales, belugas (including 2 calves), killer whales, one unidentified cetacean, walruses, small unidentified pinnipeds, and one polar bear.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
20	8/30/2018 12:42	71.848	153.302	beluga	swim	9	1	11
20	8/30/2018 12:44	71.758	153.325	beluga	swim	1	0	11
20	8/30/2018 13:02	71.120	153.313	bowhead whale	mill	2	0	3
20	8/30/2018 13:06	71.138	153.331	bowhead whale	swim	1	0	3
20	8/30/2018 13:09	71.039	153.333	bowhead whale	swim	1	0	3
20	8/30/2018 13:52	71.722	152.808	beluga	swim	1	0	11
20	8/30/2018 13:53	71.723	152.831	beluga	swim	1	0	11
20	8/30/2018 13:53	71.729	152.825	beluga	swim	2	0	11
20	8/30/2018 14:14	71.722	152.337	beluga	swim	2	1	11
20	8/30/2018 14:29	71.179	152.308	bowhead whale	swim	1	0	3
20	8/30/2018 14:33	71.168	152.344	bowhead whale	swim	1	0	3
20	8/30/2018 14:35	71.120	152.336	bowhead whale	swim	1	0	3
20	8/30/2018 15:17	71.186	151.844	bowhead whale	dive	1	0	3
20	8/30/2018 15:21	71.207	151.819	bowhead whale	swim	1	0	3
20	8/30/2018 15:49	71.230	154.381	bowhead whale	swim	1	0	12
20	8/30/2018 17:18	71.569	157.005	killer whale	swim	4	0	13
20	8/30/2018 18:39	71.418	157.302	bowhead whale	swim	1	0	13
20	8/30/2018 19:10	71.532	158.454	unid cetacean	swim	1	0	13

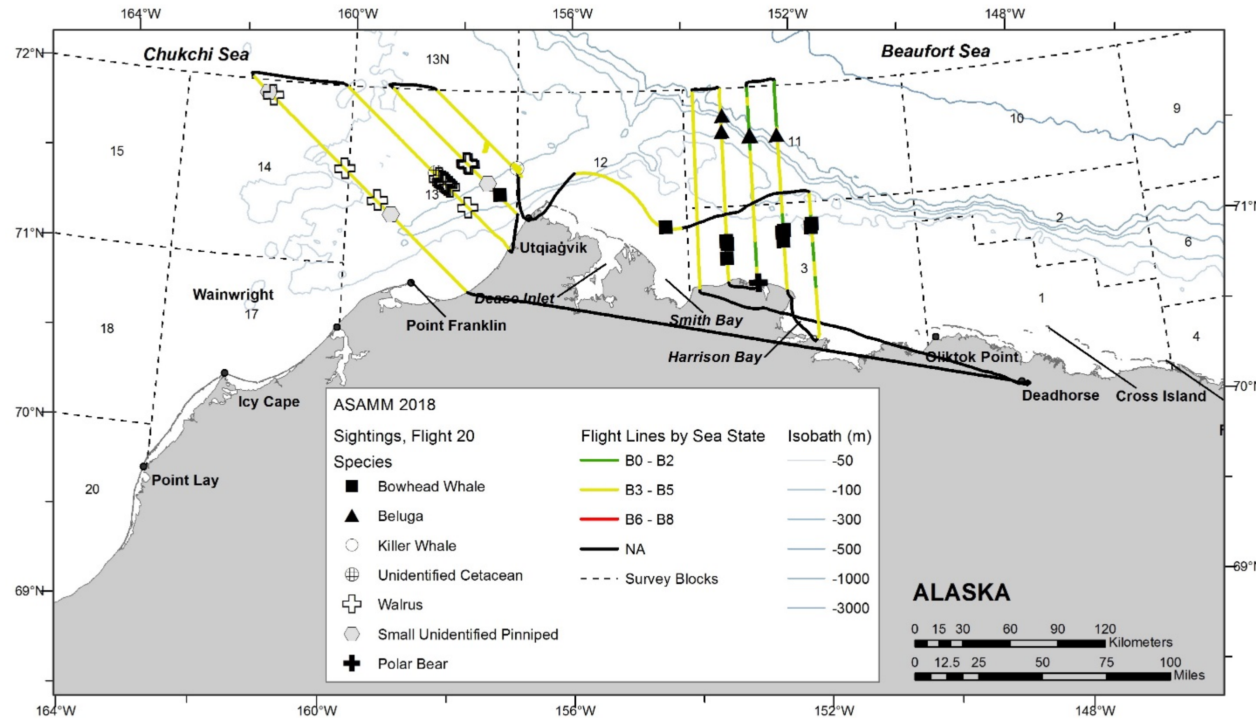

Figure B-46. Flight 20 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

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31 August 2018, Flight 21

Flight was a partial survey of transects 101, 102, 103, 104, and 105. Survey conditions included partly cloudy to overcast skies, less <1 km to unlimited visibility with glare, low ceilings, and precipitation, and Beaufort 1-6 sea states. Sea ice was 0-60% broken floe in the area surveyed. Sightings included belugas (including 4 calves).

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
21	8/31/2018 11:36	70.354	140.327	beluga	swim	2	1	5
21	8/31/2018 11:37	70.371	140.338	beluga	swim	2	1	5
21	8/31/2018 11:47	70.433	140.830	beluga	swim	1	0	5
21	8/31/2018 11:47	70.433	140.826	beluga	swim	2	1	5
21	8/31/2018 11:48	70.423	140.832	beluga	swim	1	0	5
21	8/31/2018 11:48	70.415	140.819	beluga	swim	2	1	5
21	8/31/2018 11:48	70.406	140.838	beluga	swim	1	0	5

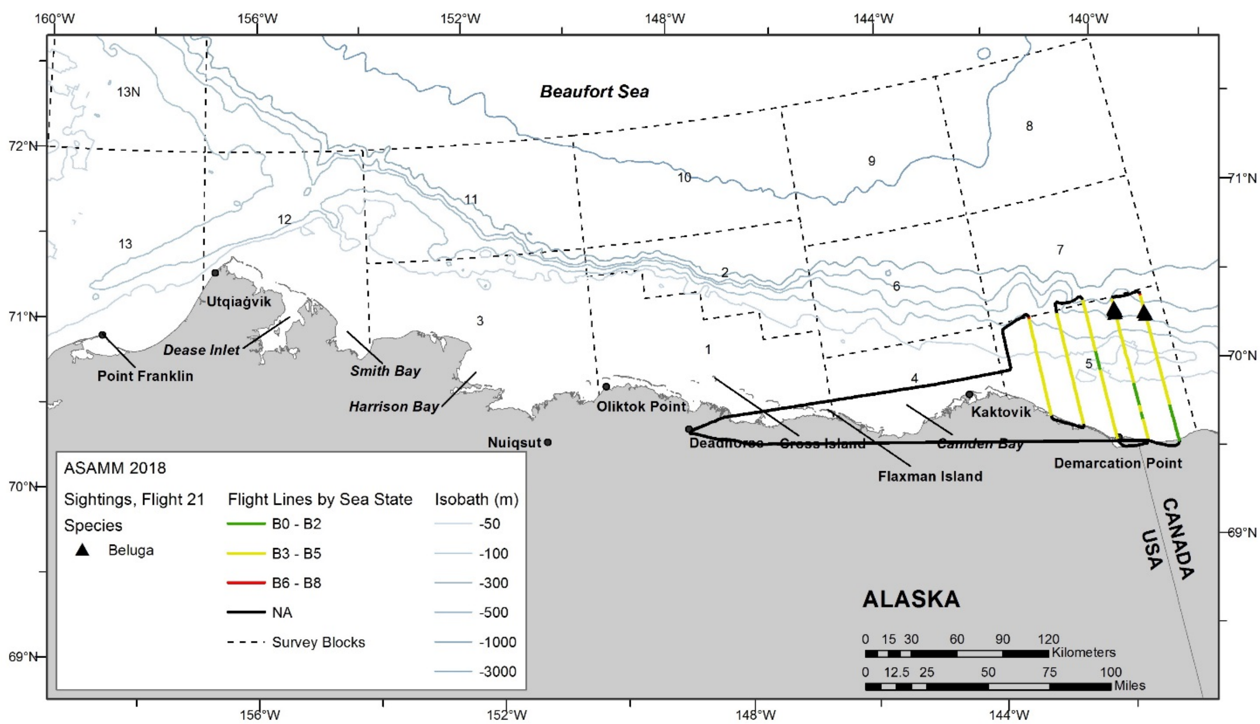

Figure B-47. Flight 21 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

1 September 2018, Flight 227

Flight was a complete survey of transects 1, 8, 10, 129, 130, 131, 132, 133, and 134, and search effort in block 13. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 2-5 sea states. Sea ice was 0-20% broken floe in the area surveyed. Sightings included bowhead whales, gray whales, belugas (including 2 calves), walruses, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
227	9/1/2018 11:19	70.735	160.489	gray whale	feed	1	0	17
227	9/1/2018 11:23	70.736	160.473	gray whale	feed	1	0	17
227	9/1/2018 14:30	71.565	155.839	bowhead whale	swim	1	0	12
227	9/1/2018 14:33	71.609	155.830	beluga	swim	1	0	12
227	9/1/2018 14:35	71.688	155.881	bowhead whale	swim	1	0	12
227	9/1/2018 14:53	71.878	155.319	beluga	swim	2	0	12
227	9/1/2018 14:59	71.674	155.321	beluga	swim	4	1	12
227	9/1/2018 14:59	71.674	155.323	beluga	swim	1	0	12
227	9/1/2018 14:59	71.673	155.323	beluga	swim	5	0	12
227	9/1/2018 14:59	71.673	155.330	beluga	swim	2	1	12
227	9/1/2018 15:27	71.252	154.844	bowhead whale	swim	1	0	12
227	9/1/2018 15:27	71.251	154.818	bowhead whale	rest	1	0	12
227	9/1/2018 16:10	71.477	154.307	bowhead whale	swim	1	0	12

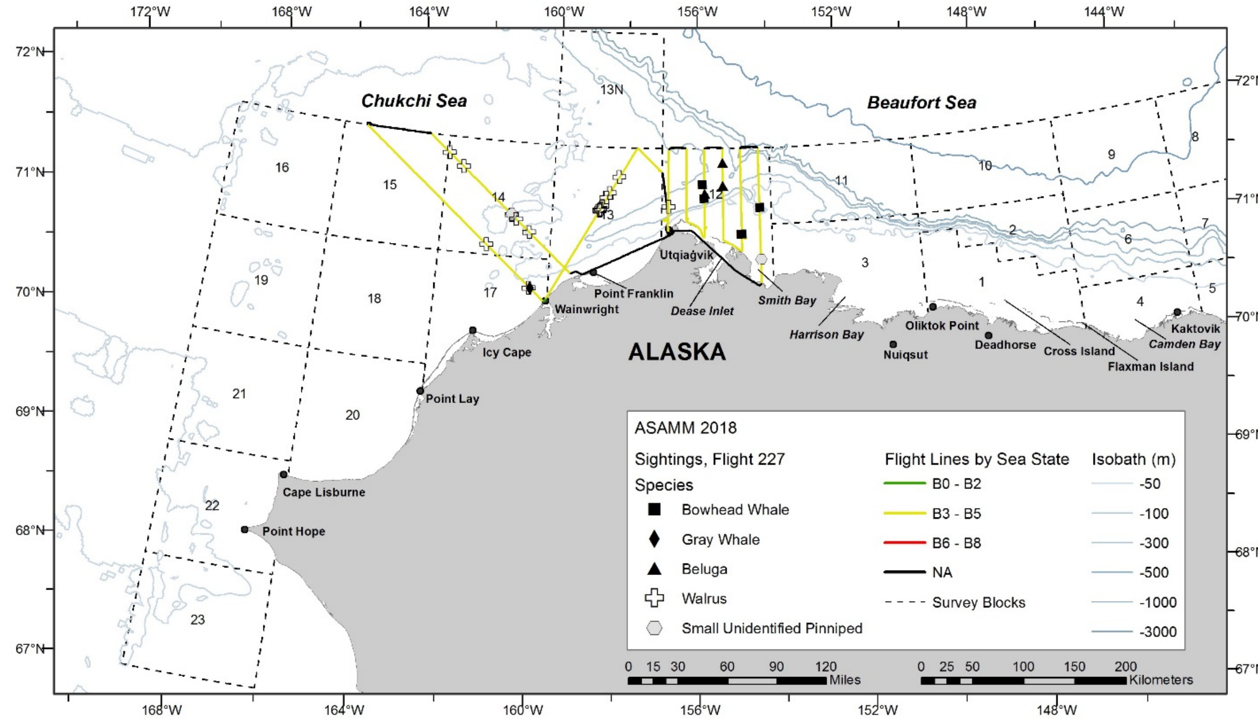

Figure B-48. Flight 227 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

1 September 2018, Flight 22

Flight was a complete survey of transects 118, 119, and 120, and partial survey of transects 114, 115, 116, and 117. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 1-5 sea states. Sea ice was 0-95% broken floe in the area surveyed. Sightings included bowhead whales, belugas (including 3 calves), one unidentified cetacean, one bearded seal, small unidentified pinnipeds, and one polar bear.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
22	9/1/2018 13:09	71.474	149.830	beluga	swim	1	0	10
22	9/1/2018 13:10	71.502	149.804	beluga	swim	1	0	10
22	9/1/2018 13:10	71.509	149.854	beluga	swim	4	0	10
22	9/1/2018 13:10	71.521	149.821	beluga	swim	1	0	10
22	9/1/2018 13:11	71.540	149.838	beluga	swim	4	1	10
22	9/1/2018 13:11	71.547	149.820	beluga	swim	1	0	10
22	9/1/2018 13:47	71.312	149.311	beluga	swim	1	0	2
22	9/1/2018 13:47	71.305	149.312	beluga	swim	1	0	2
22	9/1/2018 14:02	70.760	149.332	bowhead whale	swim	1	0	1
22	9/1/2018 15:01	70.944	148.318	bowhead whale	swim	1	0	1
22	9/1/2018 15:36	71.222	147.815	beluga	swim	1	0	2
22	9/1/2018 15:36	71.224	147.830	beluga	swim	2	1	2
22	9/1/2018 15:36	71.224	147.828	beluga	swim	1	1	2
22	9/1/2018 15:53	70.994	147.332	beluga	swim	1	0	2
22	9/1/2018 16:09	70.521	146.803	unid cetacean	unknown	1	0	1

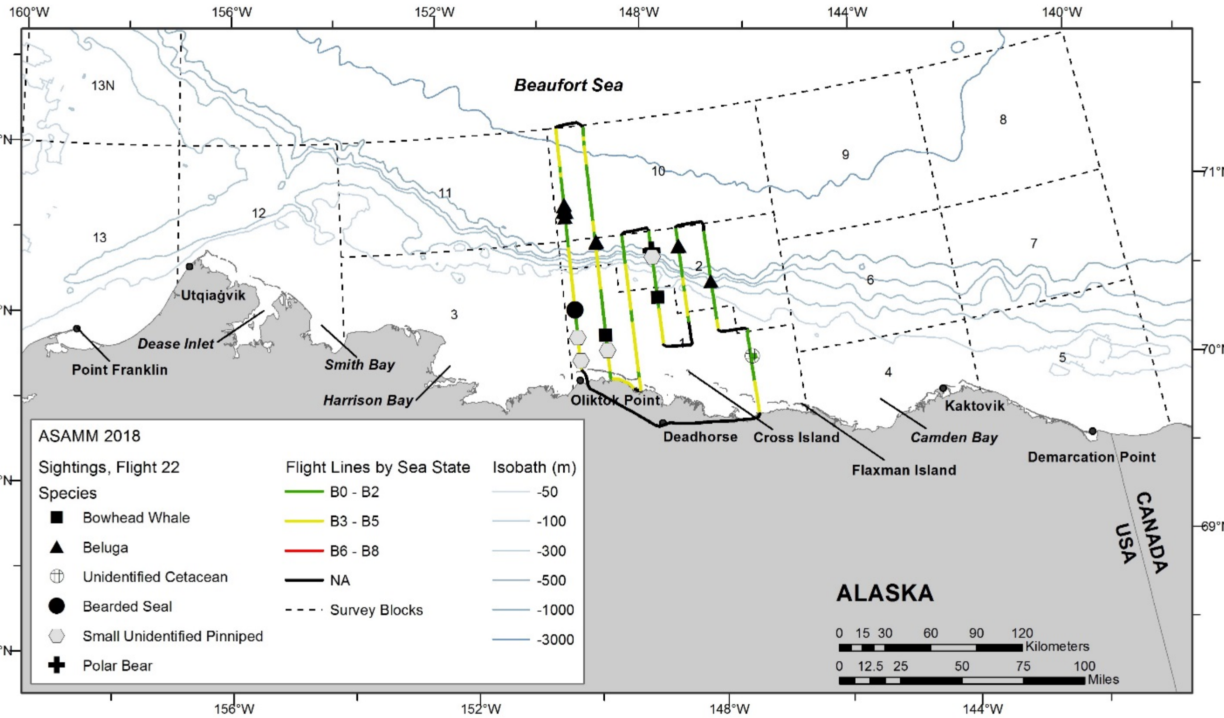

Figure B-49. Flight 22 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

2 September 2018, Flight 228

Flight was a partial survey of transects 9, 125, 126, 127, and 128, coastal transect from Wainwright to Point Barrow, and search effort in Block 12. Survey conditions included partly cloudy to overcast skies, <1 km to unlimited visibility, with glare and low ceilings, and Beaufort 2-6 sea states. Sea ice was 0-5% broken floe in the area surveyed. Sightings included bowhead whales (including 1 carcass), two gray whale carcasses, two unidentified cetacean carcasses, and walruses. One gray whale carcass was a resight of a carcass previously sighted during flight 222 on 19 August 2018.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
228	9/2/2018 11:08	71.478	155.846	bowhead whale	feed	30	0	12
228	9/2/2018 12:53	71.082	157.214	gray whale	dead	1	0	13
228	9/2/2018 12:58	71.051	157.271	bowhead whale	dead	1	0	13
228	9/2/2018 13:02	71.085	157.210	unid cetacean	dead	1	0	13
228	9/2/2018 14:41	70.876	152.363	unid cetacean	dead	1	0	3
228	9/2/2018 14:47	71.003	152.308	bowhead whale	swim	1	0	3
228	9/2/2018 15:11	71.273	152.795	bowhead whale	swim	1	0	3
228	9/2/2018 15:33	71.008	153.323	bowhead whale	swim	1	0	3
228	9/2/2018 16:46	71.470	156.047	gray whale	dead	1	0	12

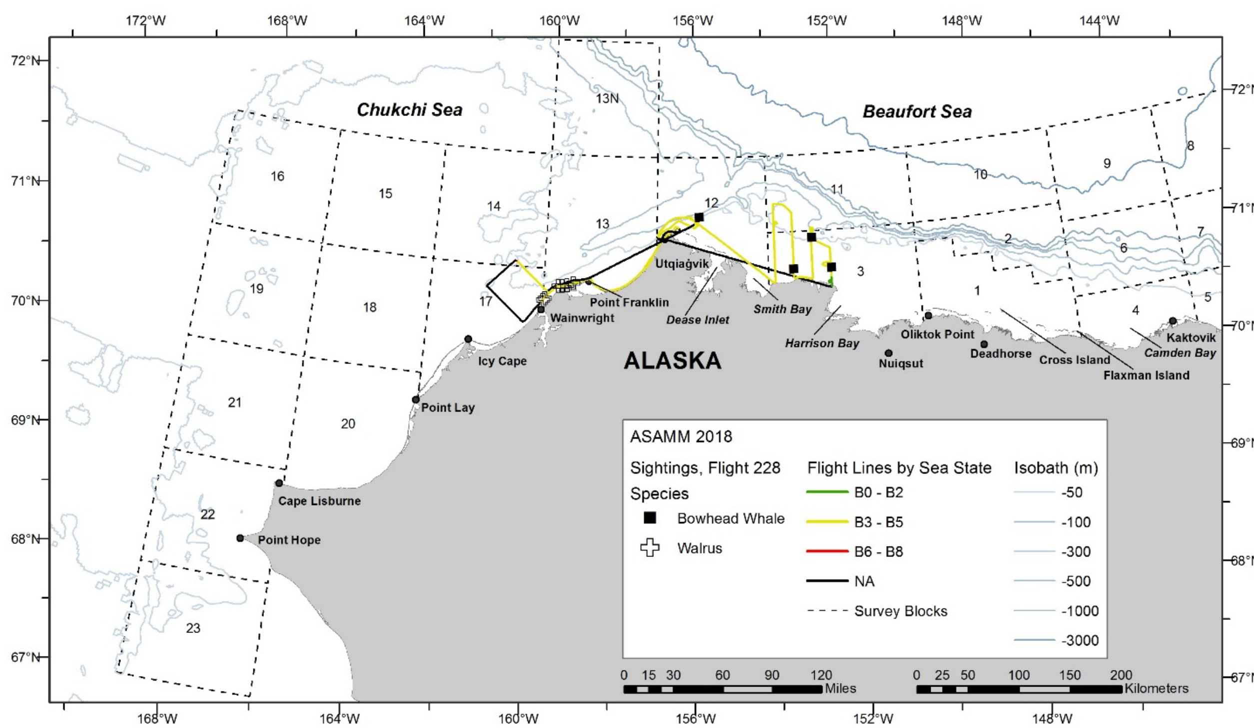

Figure B-50. Flight 228 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

2 September 2018, Flight 23

Flight was a partial survey of transects 121, 122, 123, and 124, coastal transect in Harrison Bay, and transects past a terrestrial target south of Deadhorse to estimate field of view from the survey aircraft. Survey conditions included clear to partly cloudy skies, 5 km to unlimited visibility, with glare and low ceilings, and Beaufort 1-4 sea states. Sea ice was 0-75% broken floe in the area surveyed. Sightings included bowhead whales, belugas, one bearded seal, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
23	9/2/2018 17:49	70.512	151.313	beluga	swim	1	0	3
23	9/2/2018 18:08	70.917	150.837	beluga	swim	1	0	3
23	9/2/2018 18:31	71.088	150.294	bowhead whale	swim	1	0	3
23	9/2/2018 18:36	71.043	150.322	bowhead whale	mill	7	0	3

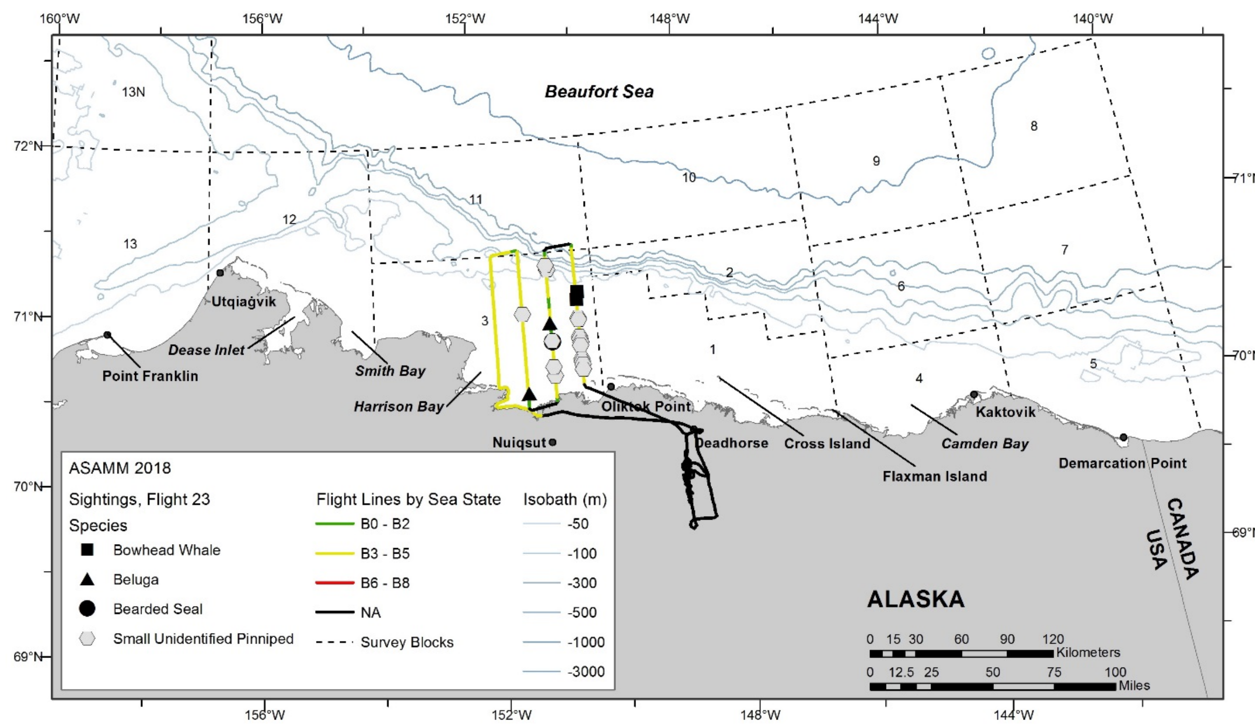

Figure B-51. Flight 23 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

4 September 2018, Flight 229

Flight was a partial survey of transects 3, 4, 5, and 9. Survey conditions included partly cloudy to overcast skies, 0-10 km visibility, with glare, haze, low ceilings, and precipitation, and Beaufort 3-5 sea states. There was no sea ice in the area surveyed. Widespread low ceilings precluded further survey effort. Sightings included one gray whale, walruses, one bearded seal, unidentified pinnipeds, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
229	9/4/2018 9:54	70.910	160.277	gray whale	feed	1	0	17

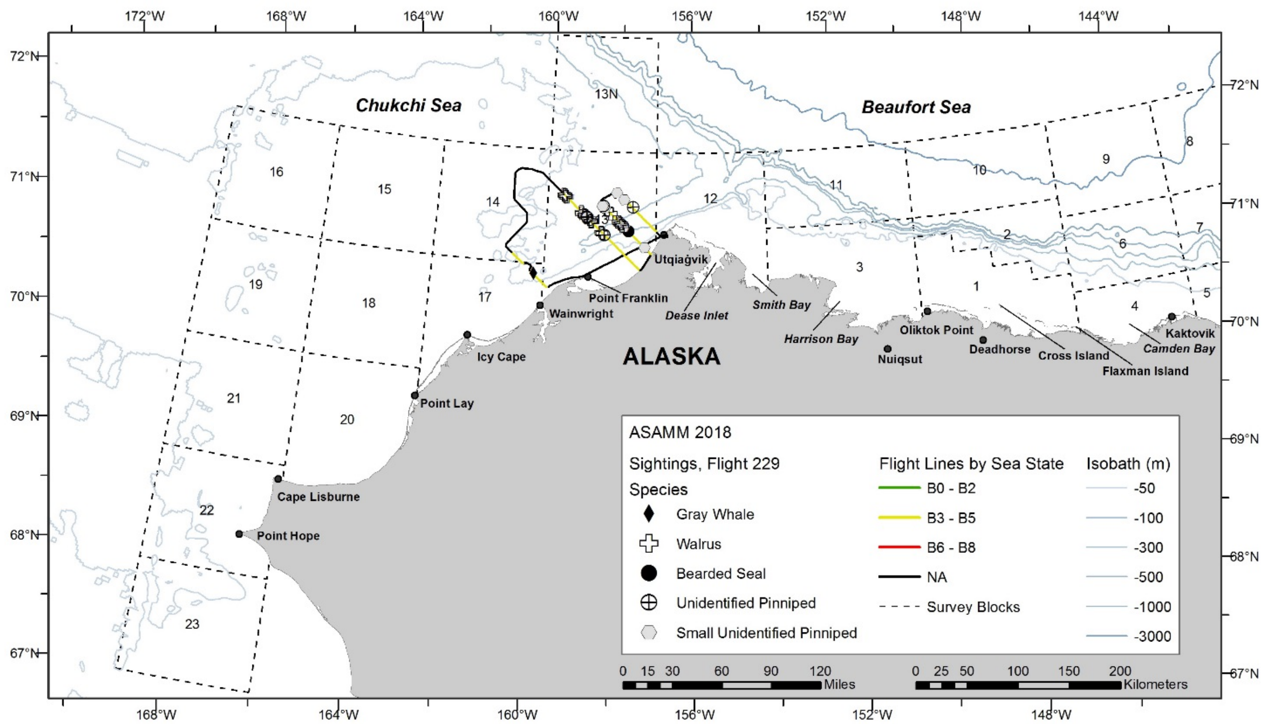

Figure B-52. Flight 229 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

4 September 2018, Flight 24

Flight was a partial survey of transects 109, 110, 111, 112, 116, and 117. Survey conditions included overcast skies, 0 km to unlimited visibility, with low ceilings and precipitation, and Beaufort 1-4 sea states. Sea ice was 0-98% broken floe and pack/floe in the area surveyed. Sightings included one bowhead whale, belugas (including 1 calf), and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
24	9/4/2018 12:42	70.818	144.318	beluga	swim	2	0	6
24	9/4/2018 12:42	70.821	144.320	beluga	swim	1	0	6
24	9/4/2018 13:32	70.945	145.306	beluga	swim	2	0	6
24	9/4/2018 13:48	71.013	145.829	beluga	swim	3	1	6
24	9/4/2018 14:40	70.724	148.311	bowhead whale	rest	1	0	1

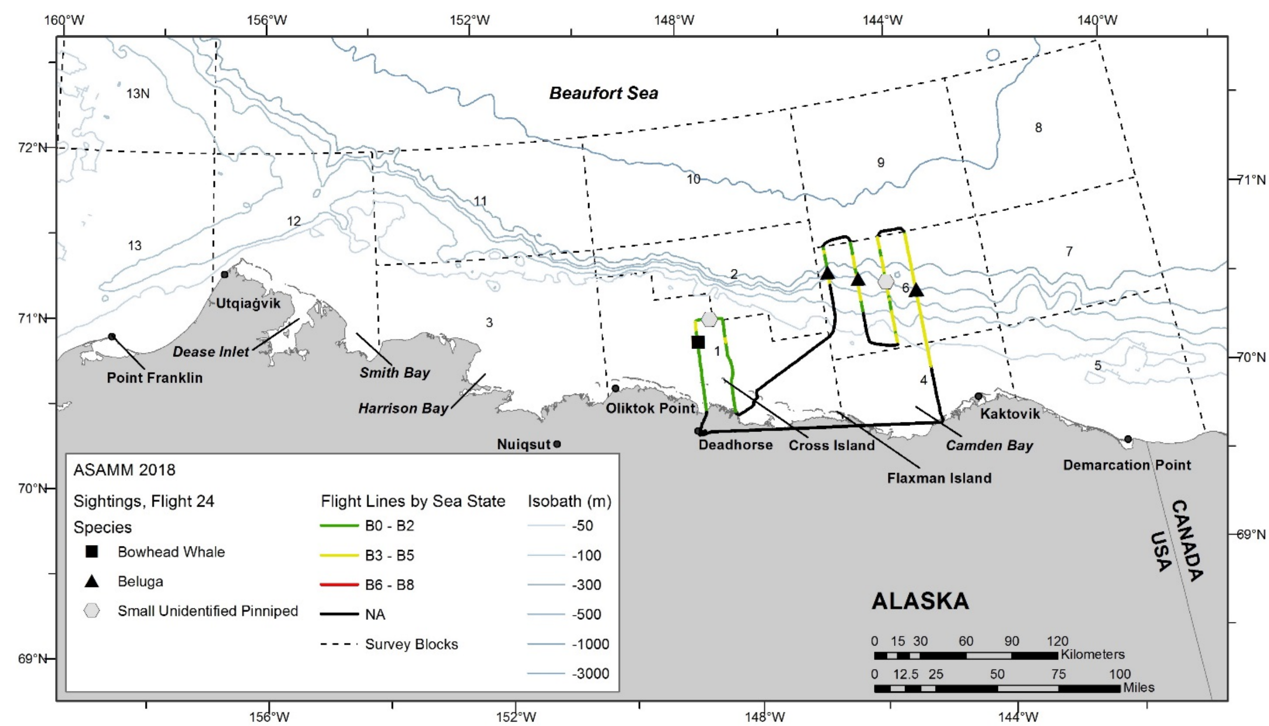

Figure B-53. Flight 24 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

5 September 2018, Flight 25

Flight was a partial survey of transects 104, 105, 106, 107, 108, 113, 114, and 120. Survey conditions included overcast skies, 0 km to unlimited visibility, with fog, glare, low ceilings, and precipitation, and Beaufort 1-4 sea states. Sea ice was 0-90% broken floe and pack/floe in the area surveyed. Sightings included bowhead whales, belugas (including 4 calves), and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
25	9/5/2018 14:13	70.619	149.822	bowhead whale	unknown	1	0	1
25	9/5/2018 15:31	70.640	143.836	beluga	swim	1	0	6
25	9/5/2018 15:31	70.655	143.813	beluga	swim	2	1	6
25	9/5/2018 15:31	70.664	143.821	beluga	swim	1	0	6
25	9/5/2018 16:01	70.764	143.320	beluga	swim	7	2	6
25	9/5/2018 16:02	70.726	143.330	beluga	swim	1	0	6
25	9/5/2018 16:13	70.324	143.317	bowhead whale	swim	2	0	4
25	9/5/2018 16:48	70.622	142.833	beluga	swim	1	0	7
25	9/5/2018 16:49	70.646	142.809	beluga	swim	1	0	7
25	9/5/2018 16:49	70.653	142.812	beluga	swim	1	0	7
25	9/5/2018 16:50	70.667	142.820	beluga	swim	1	0	7
25	9/5/2018 16:50	70.673	142.844	beluga	rest	1	0	7
25	9/5/2018 16:50	70.685	142.806	beluga	swim	1	0	7
25	9/5/2018 16:51	70.698	142.845	beluga	swim	1	0	7
25	9/5/2018 16:52	70.744	142.818	beluga	swim	1	0	7
25	9/5/2018 16:59	70.859	142.823	beluga	swim	2	1	7
25	9/5/2018 17:18	70.632	142.334	beluga	swim	1	0	7
25	9/5/2018 17:18	70.626	142.332	beluga	swim	1	0	7
25	9/5/2018 17:19	70.619	142.314	beluga	swim	2	0	7
25	9/5/2018 17:19	70.615	142.315	beluga	swim	3	0	7
25	9/5/2018 17:19	70.614	142.321	beluga	mill	7	0	7
25	9/5/2018 17:19	70.609	142.342	beluga	swim	1	0	7
25	9/5/2018 17:19	70.607	142.316	beluga	swim	1	0	7
25	9/5/2018 17:20	70.586	142.310	beluga	swim	3	0	7
25	9/5/2018 17:20	70.579	142.329	beluga	swim	1	0	7
25	9/5/2018 17:20	70.575	142.301	beluga	swim	4	0	7
25	9/5/2018 17:20	70.572	142.303	beluga	swim	1	0	7
25	9/5/2018 17:20	70.564	142.324	beluga	swim	1	0	7
25	9/5/2018 17:21	70.555	142.304	beluga	swim	1	0	7
25	9/5/2018 17:31	70.221	142.320	bowhead whale	swim	1	0	5
25	9/5/2018 17:42	70.023	142.328	bowhead whale	rest	1	0	5

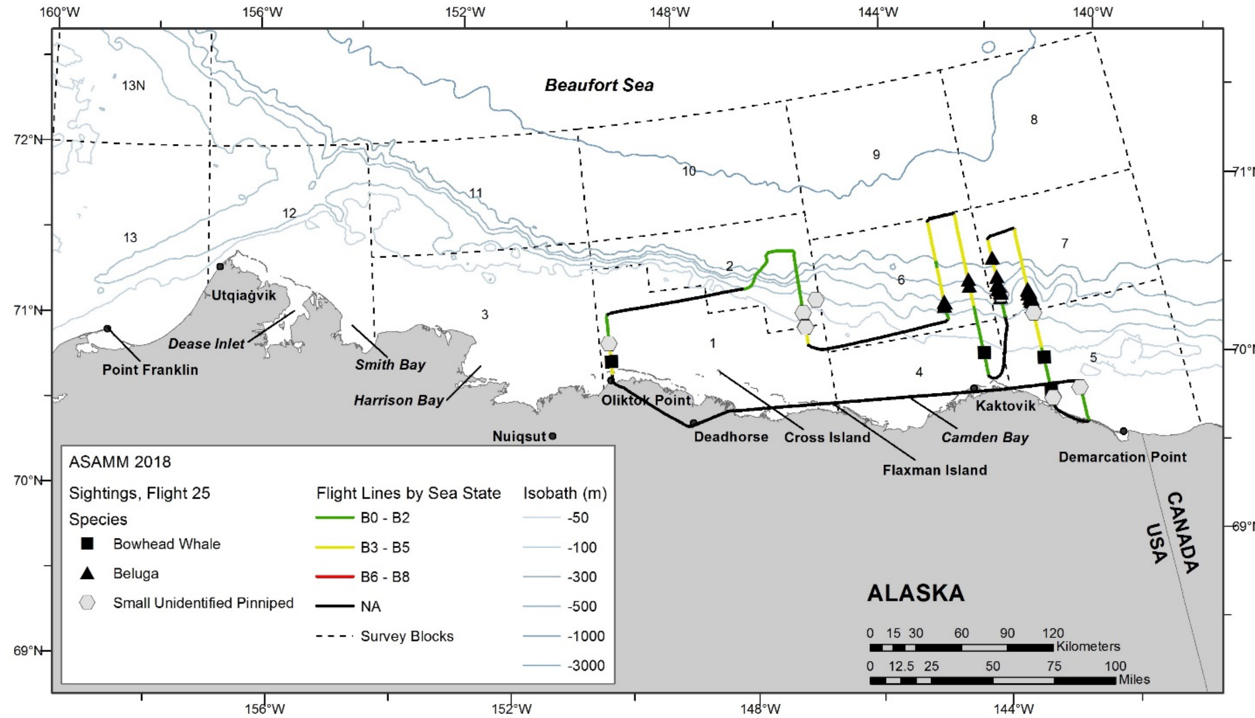

Figure B-54. Flight 25 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

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7 September 2018, Flight 26

Flight was a complete survey of transects 132, 133, and 134. Survey conditions included partly cloudy skies, 2 km to unlimited visibility, with glare and low ceilings, and Beaufort 4-6 sea states. Sea ice was 0-75% broken floe in the area surveyed. Sightings included bowhead whales.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
26	9/7/2018 17:46	71.702	155.849	bowhead whale	swim	3	0	12

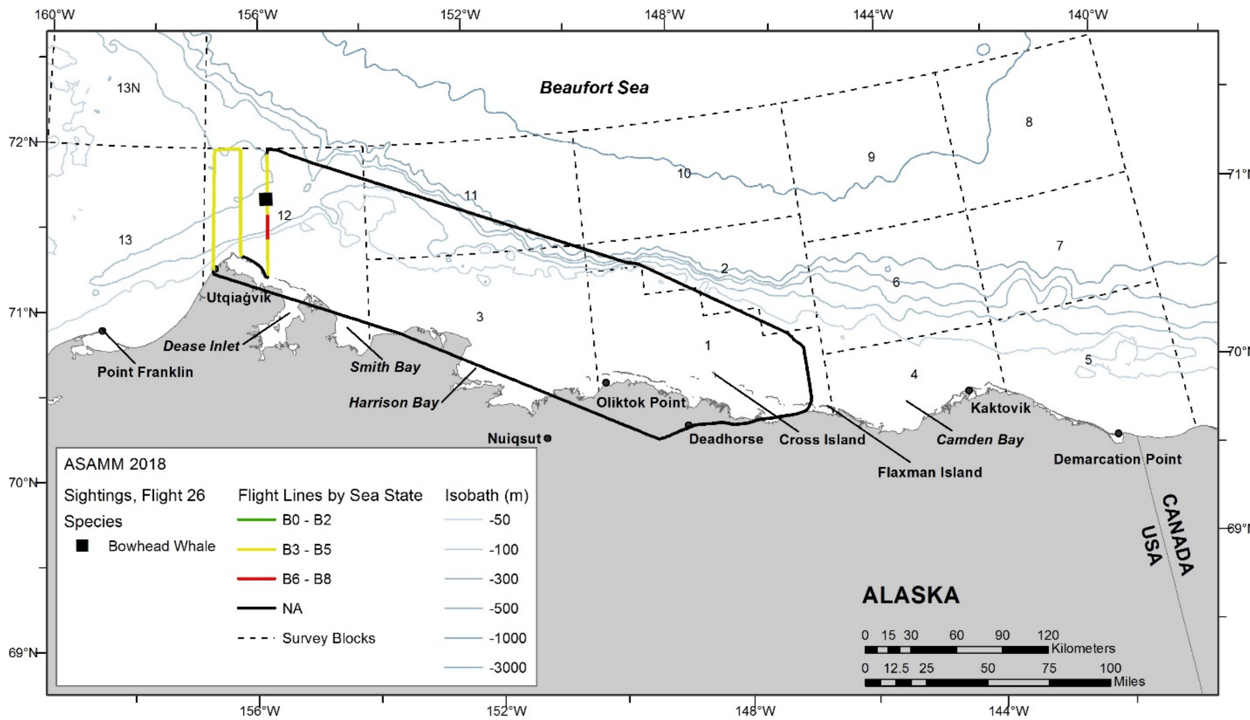

Figure B-55. Flight 26 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

8 September 2018, Flight 27

Flight was a complete survey of transects 103, 104, 109, and 110, and partial survey of transects 101, 102, 105, 111, 112, 113, and 114. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with fog, glare, and low ceilings, and Beaufort 0-6 sea states. Sea ice was 0-95% broken floe and new ice in the area surveyed. Sightings included bowhead whales (including 1 calf), belugas (including 2 calves), one unidentified cetacean, bearded seals, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
27	9/8/2018 11:10	69.717	140.333	beluga	swim	1	1	5
27	9/8/2018 11:15	69.885	140.364	bowhead whale	swim	2	0	5
27	9/8/2018 11:37	70.350	140.323	beluga	swim	1	0	5
27	9/8/2018 11:59	70.558	140.833	beluga	rest	1	0	7
27	9/8/2018 12:17	69.916	140.841	bowhead whale	swim	1	0	5
27	9/8/2018 12:44	69.976	141.313	bowhead whale	rest	1	0	5
27	9/8/2018 12:47	70.041	141.319	bowhead whale	rest	1	0	5
27	9/8/2018 12:52	70.151	141.337	bowhead whale	swim	1	0	5
27	9/8/2018 12:52	70.152	141.363	bowhead whale	swim	1	0	5
27	9/8/2018 12:56	70.209	141.328	bowhead whale	swim	1	0	5
27	9/8/2018 13:10	70.595	141.338	beluga	rest	1	0	7
27	9/8/2018 13:32	71.094	141.815	beluga	rest	2	1	7
27	9/8/2018 14:03	70.014	141.841	bowhead whale	rest	1	0	5
27	9/8/2018 14:26	70.267	142.307	bowhead whale	swim	1	0	5
27	9/8/2018 14:28	70.273	142.251	bowhead whale	swim	2	1	5
27	9/8/2018 14:30	70.274	142.295	bowhead whale	swim	1	0	5
27	9/8/2018 16:57	70.422	144.308	bowhead whale	rest	1	0	4
27	9/8/2018 17:14	70.940	144.302	beluga	swim	1	0	6
27	9/8/2018 17:56	70.343	144.785	unid cetacean	swim	1	0	4
27	9/8/2018 18:31	70.479	145.318	bowhead whale	rest	1	0	4
27	9/8/2018 19:12	70.343	146.334	bowhead whale	swim	2	0	1
27	9/8/2018 19:27	70.589	146.310	bowhead whale	swim	1	0	1
27	9/8/2018 19:55	70.458	146.808	bowhead whale	rest	1	0	1

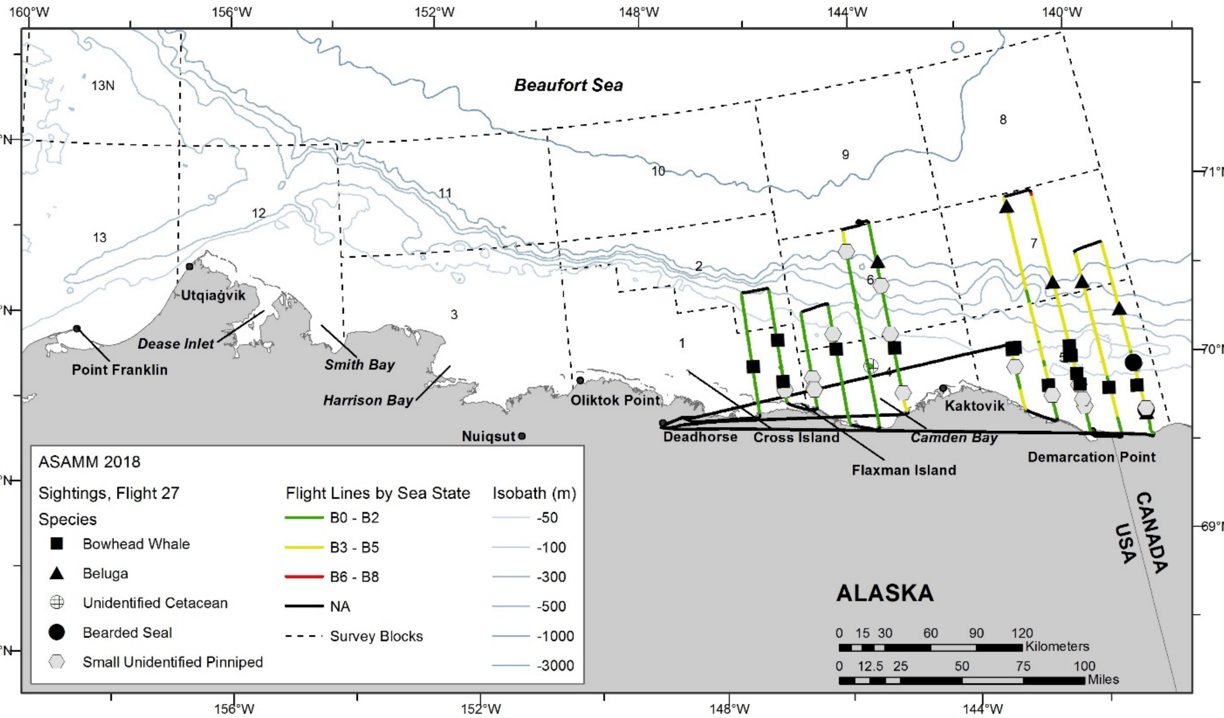

Figure B-56. Flight 27 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

9 September 2018, Flight 28

Flight was a partial survey of transects 107 and 108. Survey conditions included overcast skies, <1 km to unlimited visibility, with fog and precipitation, and Beaufort 0-3 sea states. Sea ice was 1-95% broken floe and new ice in the area surveyed. Sightings included bowhead whales (including 1 calf), one beluga, one bearded seal, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
28	9/9/2018 11:25	70.402	143.356	bowhead whale	swim	1	0	4
28	9/9/2018 11:40	70.792	143.336	beluga	swim	1	0	6
28	9/9/2018 12:05	70.471	143.845	bowhead whale	swim	2	1	4
28	9/9/2018 12:08	70.467	143.894	bowhead whale	swim	1	0	4
28	9/9/2018 12:11	70.443	143.865	bowhead whale	swim	1	0	4

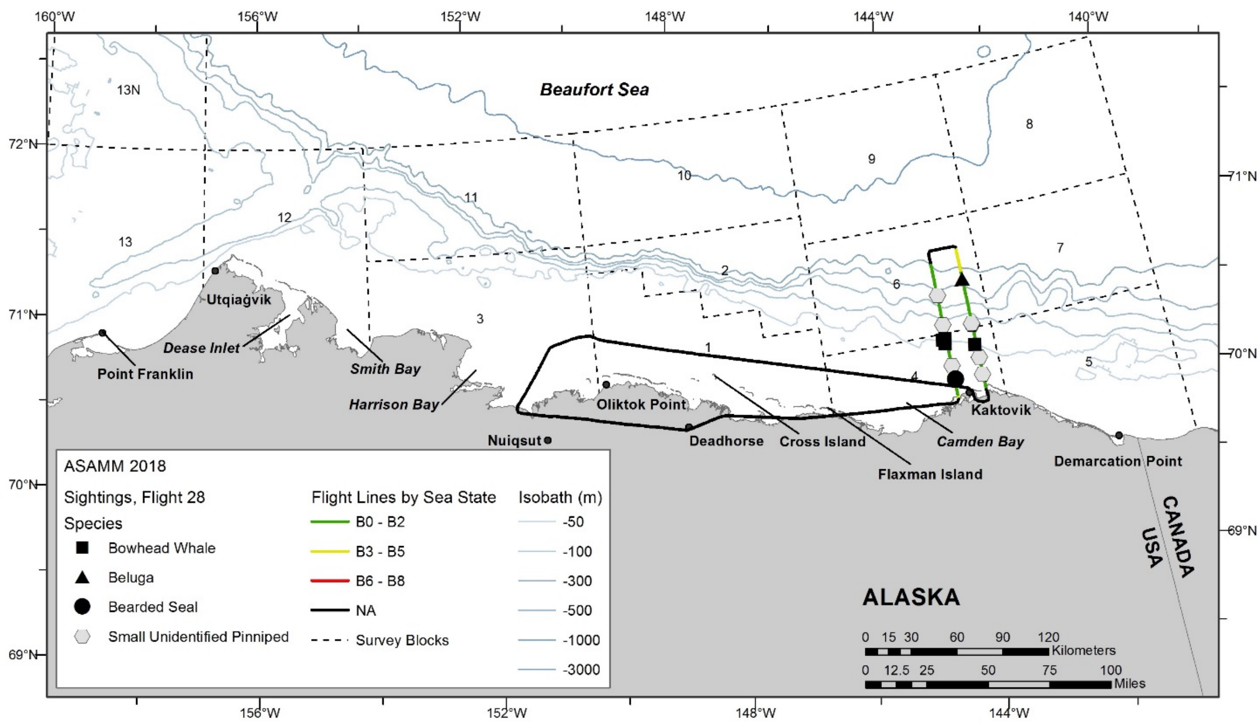

Figure B-57. Flight 28 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

11 September 2018, Flight 230

Flight was a partial survey of transects 11 and 12, and the coastal transect near Wainwright. Survey conditions included partly cloudy skies, 0 km to unlimited visibility, with glare and low ceilings, and Beaufort 2-5 sea states. There was no sea ice in the area surveyed. Sightings included gray whales (including 1 calf) and walruses.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
230	9/11/2018 11:32	70.522	161.328	gray whale	swim	1	0	17
230	9/11/2018 11:32	70.522	161.300	gray whale	swim	2	1	17
230	9/11/2018 11:35	70.499	161.253	gray whale	swim	1	0	17

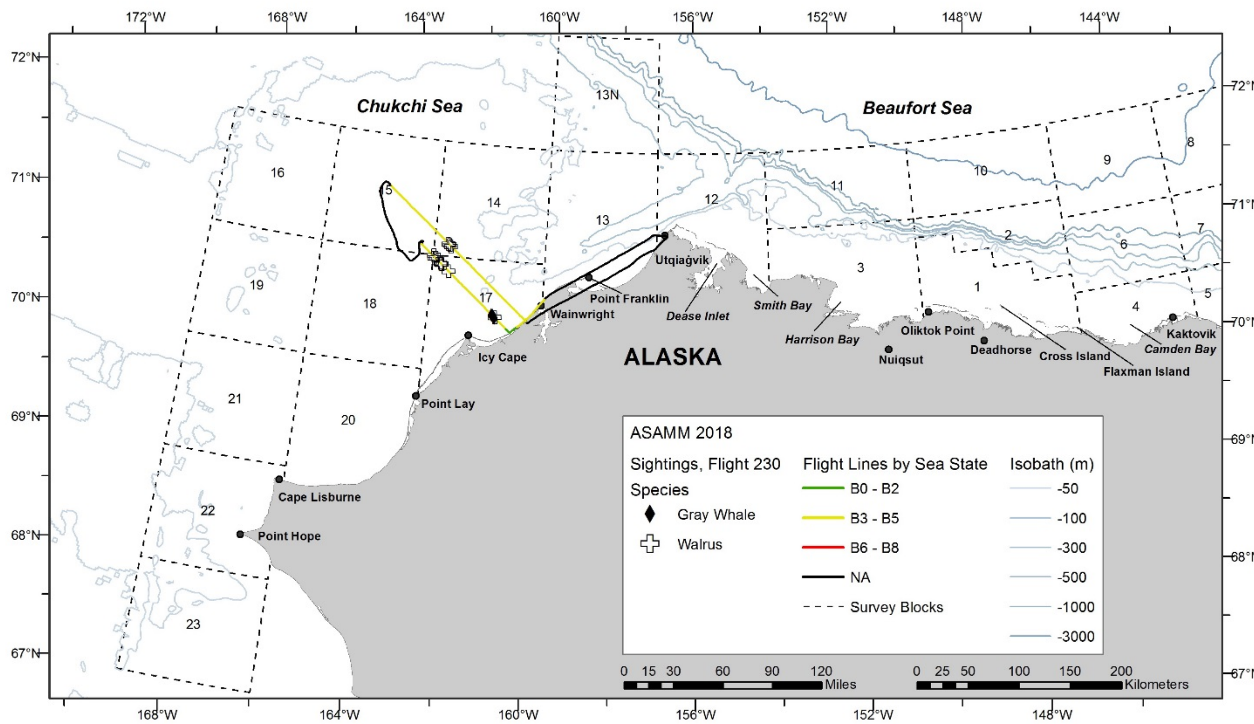

Figure B-58. Flight 230 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

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11 September 2018, Flight 29

Flight was negligible effort on transect 124 and the coastal transect in Harrison Bay. The team also searched over land for alternative targets to conduct field of view trials. Survey conditions included partly cloudy skies, 5-10 km visibility, with glare and haze, and Beaufort 4-6 sea states. There was no sea ice in the area surveyed. There were no marine mammal sightings.

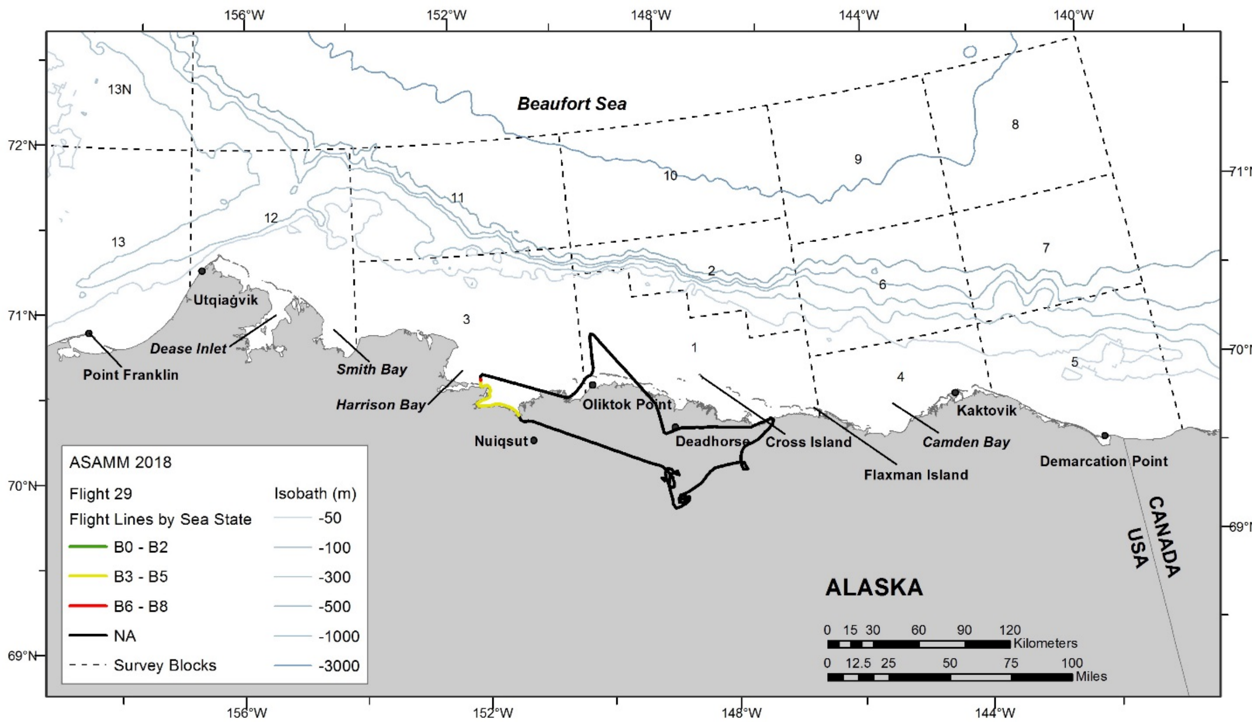

Figure B-59. Flight 29 survey track, depicted by sea state.

12 September 2018, Flight 231

Flight was a complete survey of transects 38 and 39, partial survey of transects 29, 30, 31, and 32, and negligible effort on transect 5. Survey conditions included partly cloudy skies, 0 km to unlimited visibility, with glare, haze, and low ceilings, and Beaufort 2-6 sea states. There was no sea ice in the area surveyed. Sightings included gray whales, humpback whales, fin whales, harbor porpoises, unidentified cetaceans, and one small unidentified pinniped.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
231	9/12/2018 16:33	67.110	167.479	unid cetacean	.	3	0	23
231	9/12/2018 16:33	67.106	167.489	unid cetacean	.	2	0	23
231	9/12/2018 16:33	67.150	167.499	unid cetacean	.	2	0	23
231	9/12/2018 16:33	67.106	167.505	unid cetacean	.	3	0	23
231	9/12/2018 16:33	67.169	167.521	unid cetacean	.	1	0	23
231	9/12/2018 16:33	67.113	167.525	unid cetacean	.	4	0	23
231	9/12/2018 16:34	67.118	167.531	unid cetacean	.	4	0	23
231	9/12/2018 16:34	67.108	167.535	unid cetacean	.	2	0	23
231	9/12/2018 16:34	67.103	167.542	unid cetacean	.	2	0	23
231	9/12/2018 16:34	67.099	167.560	unid cetacean	.	20	0	23
231	9/12/2018 16:34	67.103	167.567	unid cetacean	.	1	0	23
231	9/12/2018 16:34	67.106	167.574	unid cetacean	.	2	0	23
231	9/12/2018 16:34	67.111	167.583	unid cetacean	.	1	0	23
231	9/12/2018 16:34	67.110	167.588	unid cetacean	.	1	0	23
231	9/12/2018 16:34	67.110	167.595	unid cetacean	.	2	0	23
231	9/12/2018 16:35	67.106	167.617	unid cetacean	.	1	0	23
231	9/12/2018 16:35	67.129	167.659	humpback whale	.	1	0	23
231	9/12/2018 16:36	67.111	167.709	unid cetacean	.	2	0	23
231	9/12/2018 16:36	67.108	167.739	unid cetacean	.	2	0	23
231	9/12/2018 16:39	67.124	167.650	fin whale	swim	1	0	23
231	9/12/2018 16:40	67.133	167.664	fin whale	swim	1	0	23
231	9/12/2018 16:41	67.100	167.577	humpback whale	swim	1	0	23
231	9/12/2018 16:42	67.099	167.560	humpback whale	swim	1	0	23
231	9/12/2018 16:42	67.108	167.563	fin whale	swim	1	0	23
231	9/12/2018 16:42	67.103	167.559	fin whale	feed	2	0	23
231	9/12/2018 16:43	67.092	167.528	fin whale	swim	1	0	23
231	9/12/2018 16:44	67.089	167.560	humpback whale	swim	1	0	23
231	9/12/2018 16:44	67.098	167.564	humpback whale	swim	1	0	23
231	9/12/2018 16:45	67.123	167.520	fin whale	swim	3	0	23
231	9/12/2018 16:45	67.123	167.516	fin whale	swim	2	0	23
231	9/12/2018 16:46	67.124	167.511	fin whale	swim	1	0	23
231	9/12/2018 16:46	67.125	167.508	fin whale	swim	2	0	23
231	9/12/2018 16:47	67.143	167.539	fin whale	swim	2	0	23
231	9/12/2018 16:47	67.144	167.556	fin whale	swim	1	0	23

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
231	9/12/2018 16:50	67.119	167.508	fin whale	swim	3	0	23
231	9/12/2018 16:52	67.144	167.498	fin whale	swim	2	0	23
231	9/12/2018 16:52	67.148	167.502	fin whale	swim	1	0	23
231	9/12/2018 16:55	67.126	167.528	fin whale	swim	2	0	23
231	9/12/2018 17:08	67.105	168.594	gray whale	feed	4	0	23
231	9/12/2018 17:17	67.291	168.713	harbor porpoise	swim	4	0	23
231	9/12/2018 17:22	67.305	168.635	fin whale	swim	2	0	23
231	9/12/2018 17:32	67.282	167.795	fin whale	swim	2	0	23
231	9/12/2018 17:33	67.293	167.804	fin whale	swim	2	0	23
231	9/12/2018 17:35	67.285	167.659	fin whale	swim	2	0	23
231	9/12/2018 17:35	67.307	167.651	fin whale	swim	1	0	23
231	9/12/2018 17:36	67.300	167.641	fin whale	swim	2	0	23
231	9/12/2018 17:38	67.296	167.628	fin whale	swim	1	0	23
231	9/12/2018 17:39	67.350	167.545	unid cetacean	dive	1	0	23
231	9/12/2018 17:39	67.264	167.513	fin whale	dive	2	0	23
231	9/12/2018 17:41	67.356	167.533	fin whale	swim	2	0	23
231	9/12/2018 17:43	67.271	167.548	fin whale	swim	3	0	23
231	9/12/2018 17:44	67.254	167.522	humpback whale	unknown	1	0	23
231	9/12/2018 17:46	67.281	167.504	humpback whale	feed	1	0	23
231	9/12/2018 17:46	67.295	167.479	fin whale	swim	2	0	23
231	9/12/2018 17:46	67.282	167.464	humpback whale	feed	2	0	23
231	9/12/2018 17:50	67.297	167.272	fin whale	dive	1	0	23

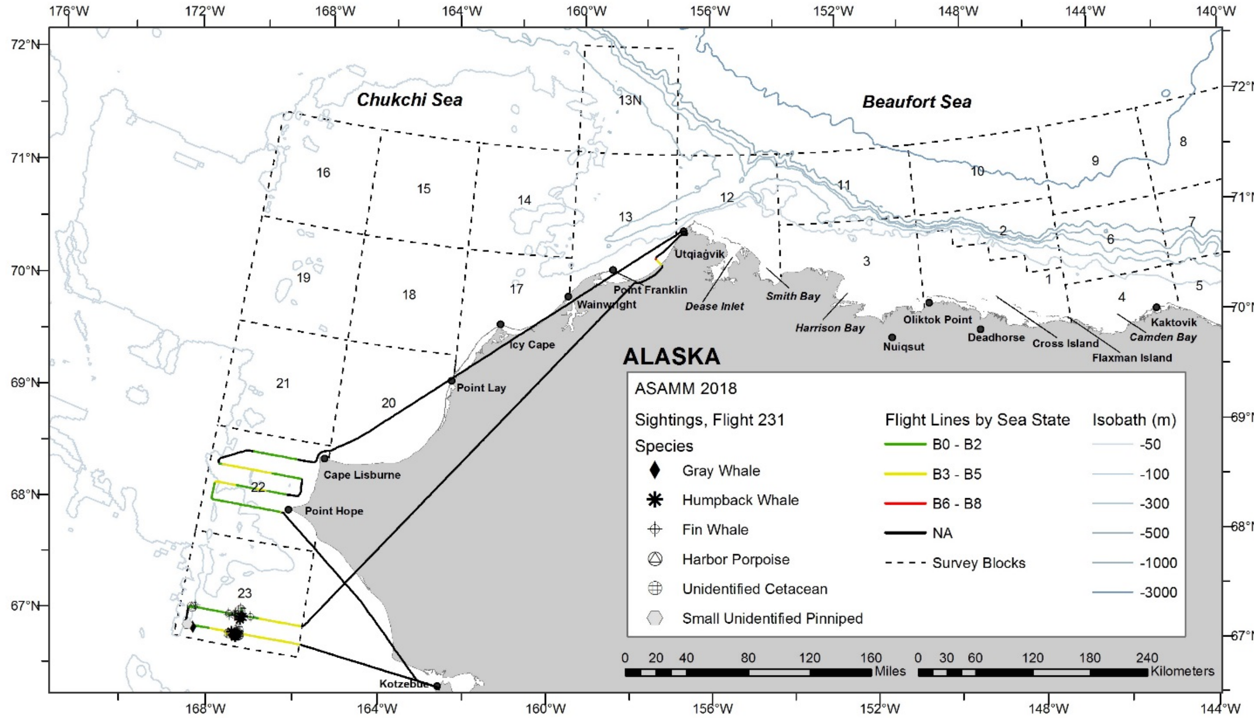

Figure B-60. Flight 231 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

15 September 2018, Flight 232

Flight was a partial survey of transects 17, 21, and 23, and the coastal transect from east of Cape Lisburne to Icy Cape. Survey conditions included partly cloudy skies, 0 km to unlimited visibility, with glare and low ceilings, and Beaufort 1-6 sea states. There was no sea ice in the area surveyed. Sightings included walruses and small unidentified pinnipeds. Three groups of walruses, estimated at 6,000, 1,500, and 20,000 walruses respectively, were observed hauled out on a barrier island near Point Lay.

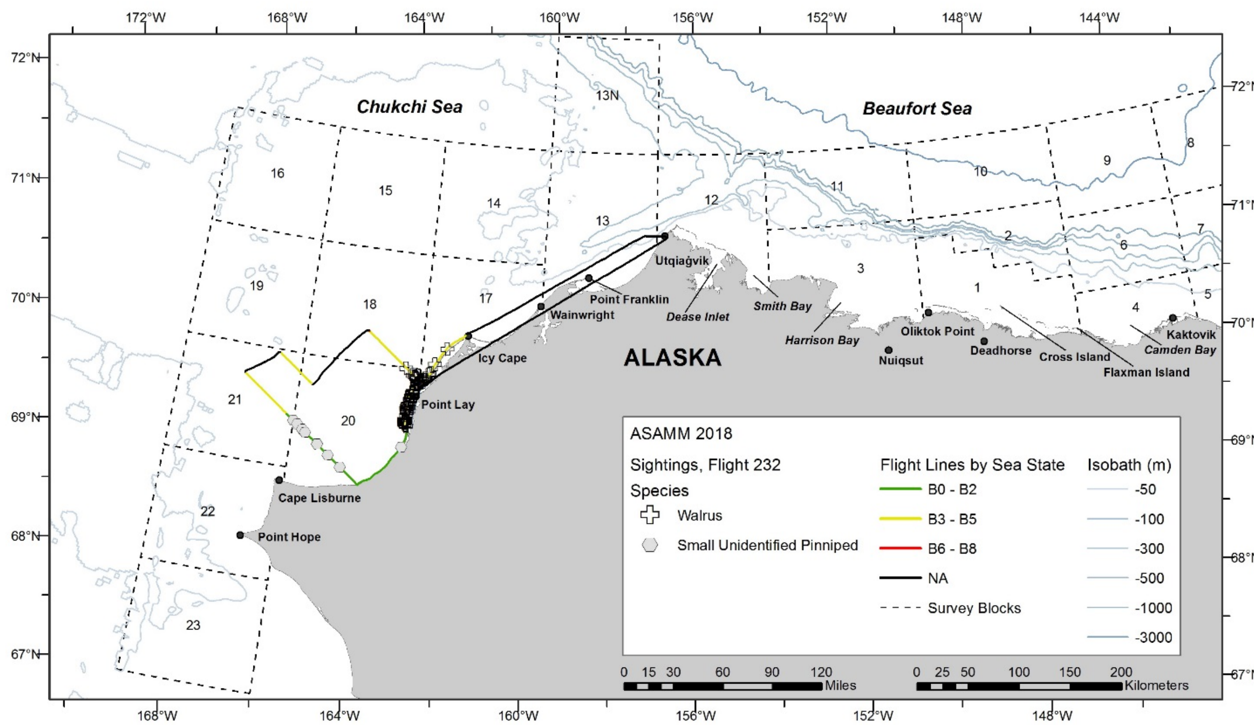

Figure B-61. Flight 232 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

15 September 2018, Flight 30

Flight was a partial survey of transects 113 and 114, and search effort in block 6. Survey conditions included clear skies, 5 km to unlimited visibility, with glare, and Beaufort 3-7 sea states. Sea ice was 5-80% broken floe and new ice in the area surveyed. Sightings included belugas.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
30	9/15/2018 13:54	71.611	146.825	beluga	swim	1	0	10
30	9/15/2018 13:55	71.596	146.823	beluga	swim	1	0	10

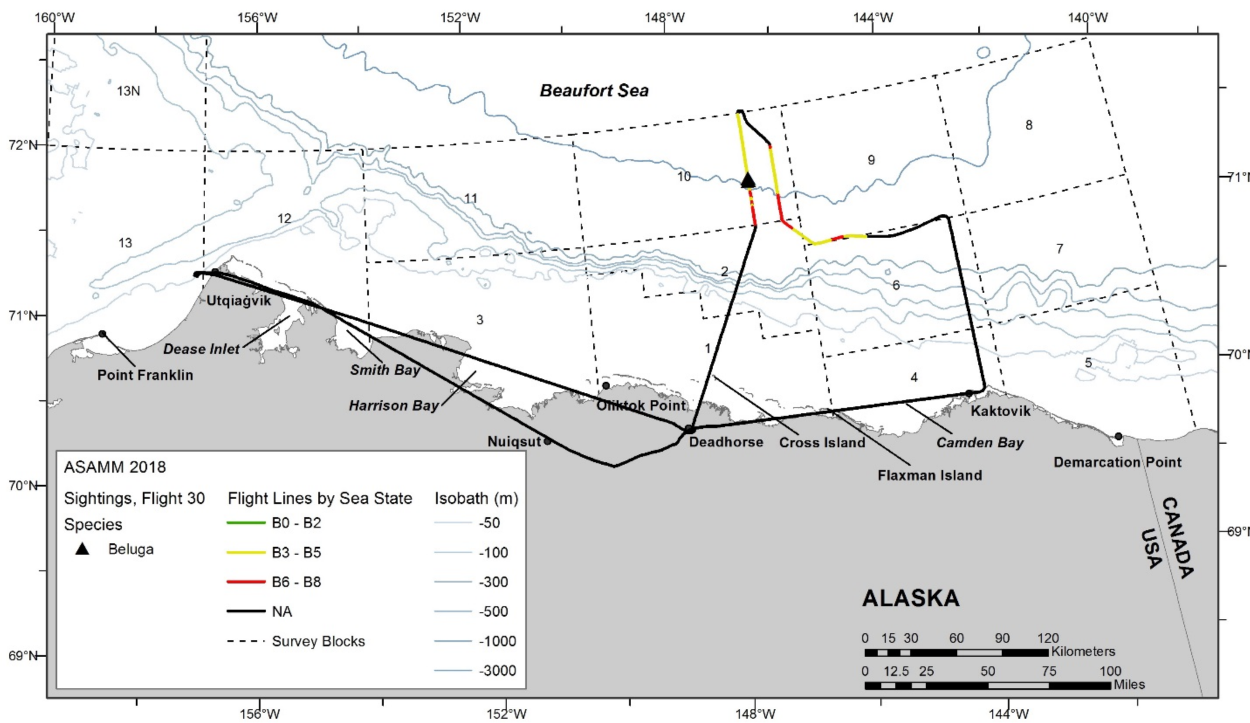

Figure B-62. Flight 30 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

16 September 2018, Flight 233

Flight was a complete survey of transects 26, 27, 28, and 33, and partial survey of transects 24 and 25. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare and low ceilings, and Beaufort 2-6 sea states. There was no sea ice in the area surveyed. Sightings included one unidentified cetacean carcass, walruses, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
233	9/16/2018 12:34	68.998	167.727	unid cetacean	dead	1	0	22

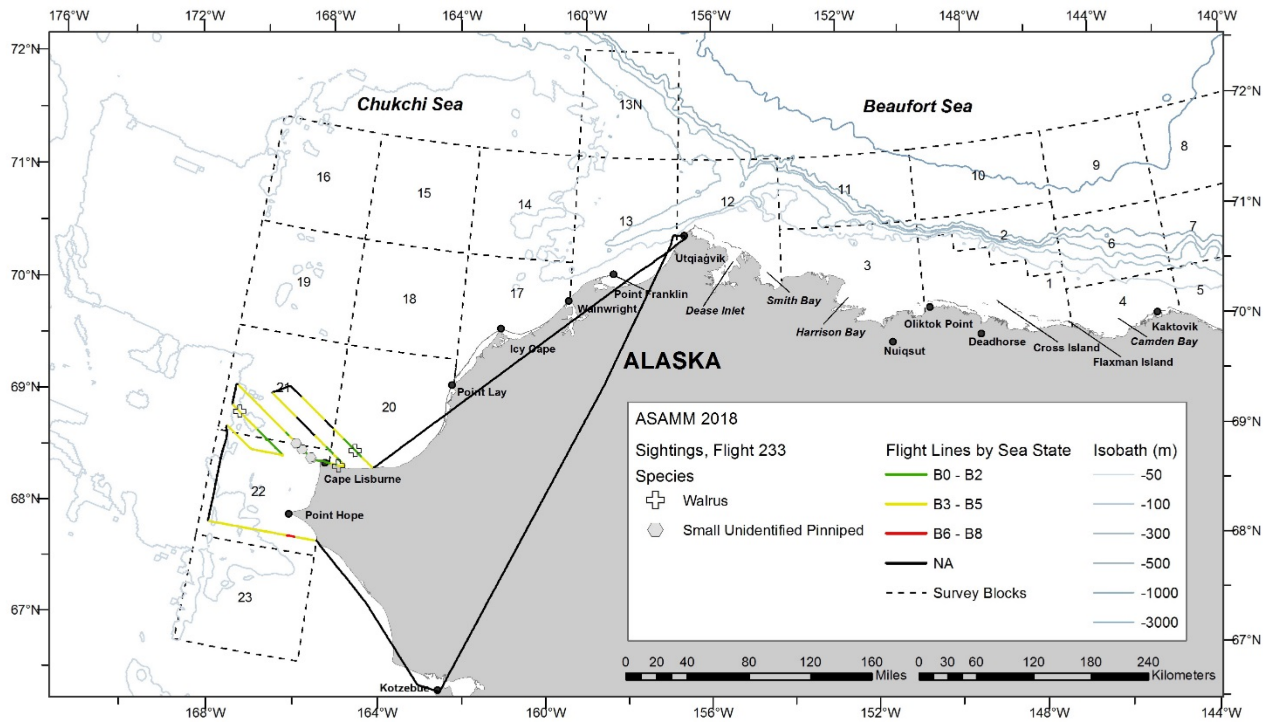

Figure B-63. Flight 233 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

18 September 2018, Flight 234

Flight was a partial survey of transects 15, 17, and 19, and coastal search effort near Pt. Lay. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 2-4 sea states. There was no sea ice in the area surveyed. Sightings included walruses and small unidentified pinnipeds. Three groups of walruses, estimated at 5,000, 50, and 6,000 respectively, were observed hauled out on a barrier island near Point Lay.

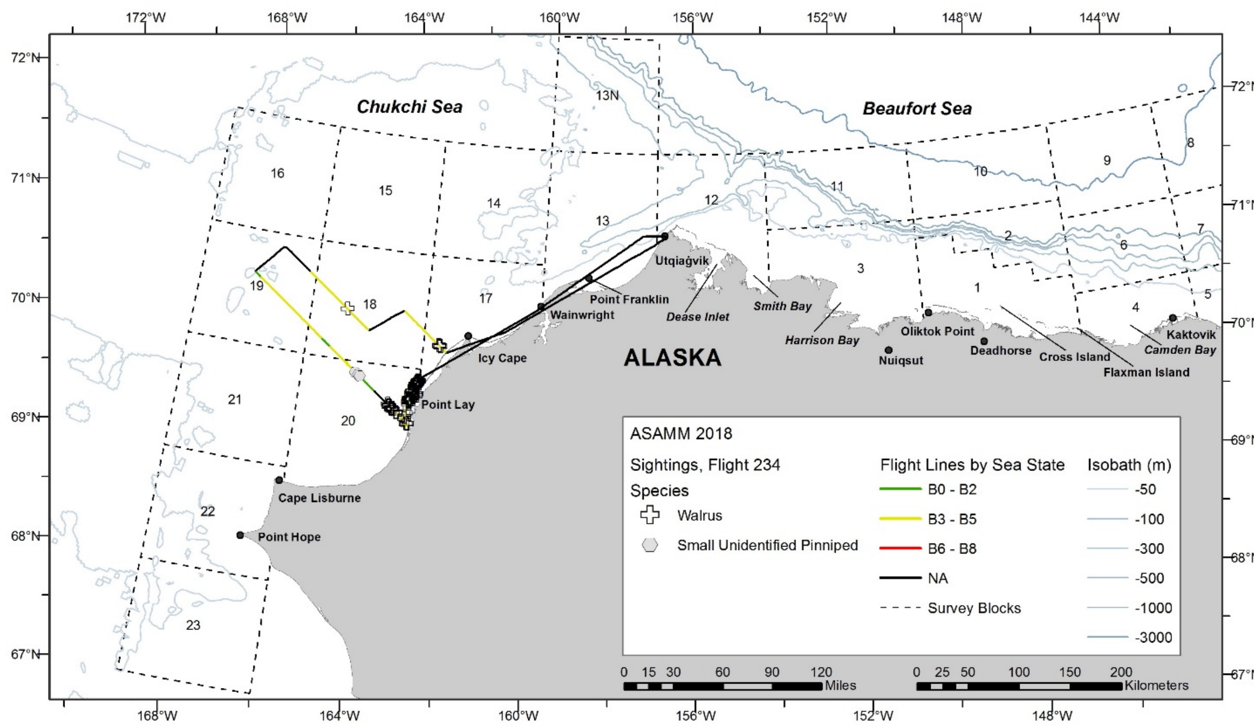

Figure B-64. Flight 234 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

18 September 2018, Flight 31

Flight was a series of field of view transects associated with a terrestrial target south of Deadhorse, Alaska. Survey conditions near the target included clear skies and unlimited visibility. Survey conditions in the Beaufort Sea study area were unacceptable due to strong winds (>30 kts). There were no marine mammal sightings.

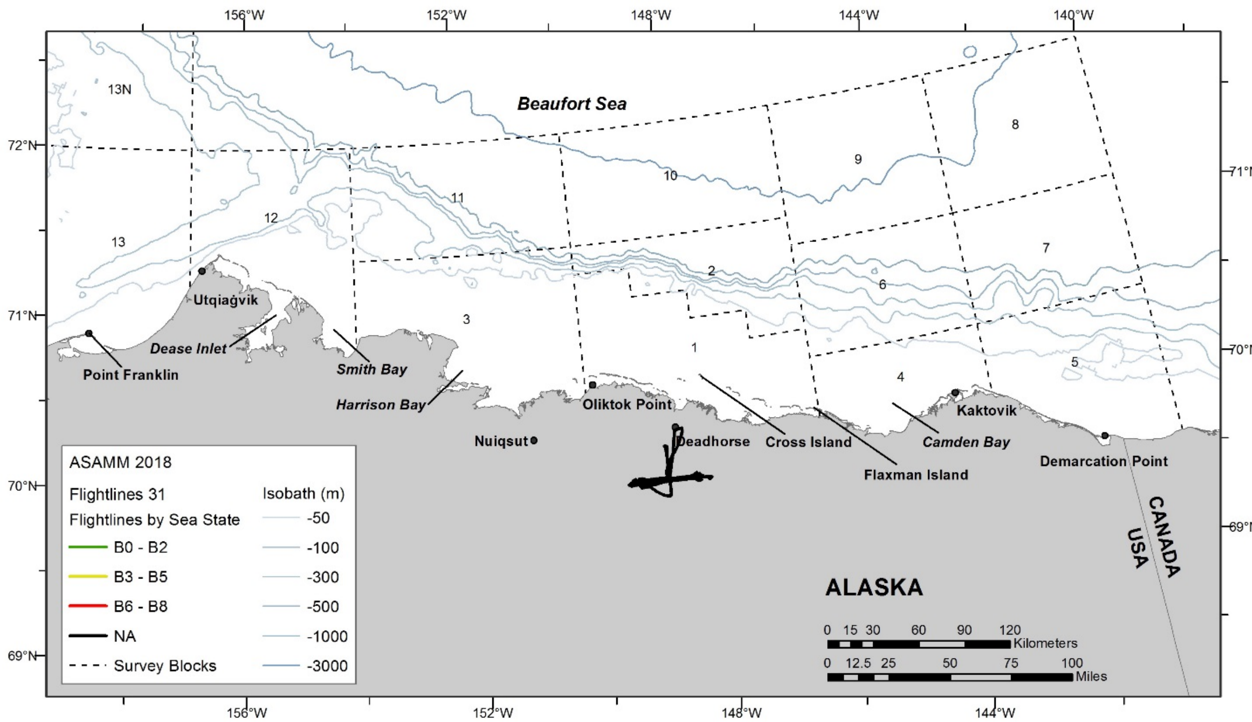

Figure B-65. Flight 31 survey track, depicted by sea state.

19 September 2018, Flight 235

Flight was a partial survey of transects 21 and 22, and negligible effort on transects 15 and 18. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare and low ceilings, and Beaufort 2-4 sea states. There was no sea ice in the area surveyed. Sightings included walruses, one bearded seal, unidentified pinnipeds, and small unidentified pinnipeds.

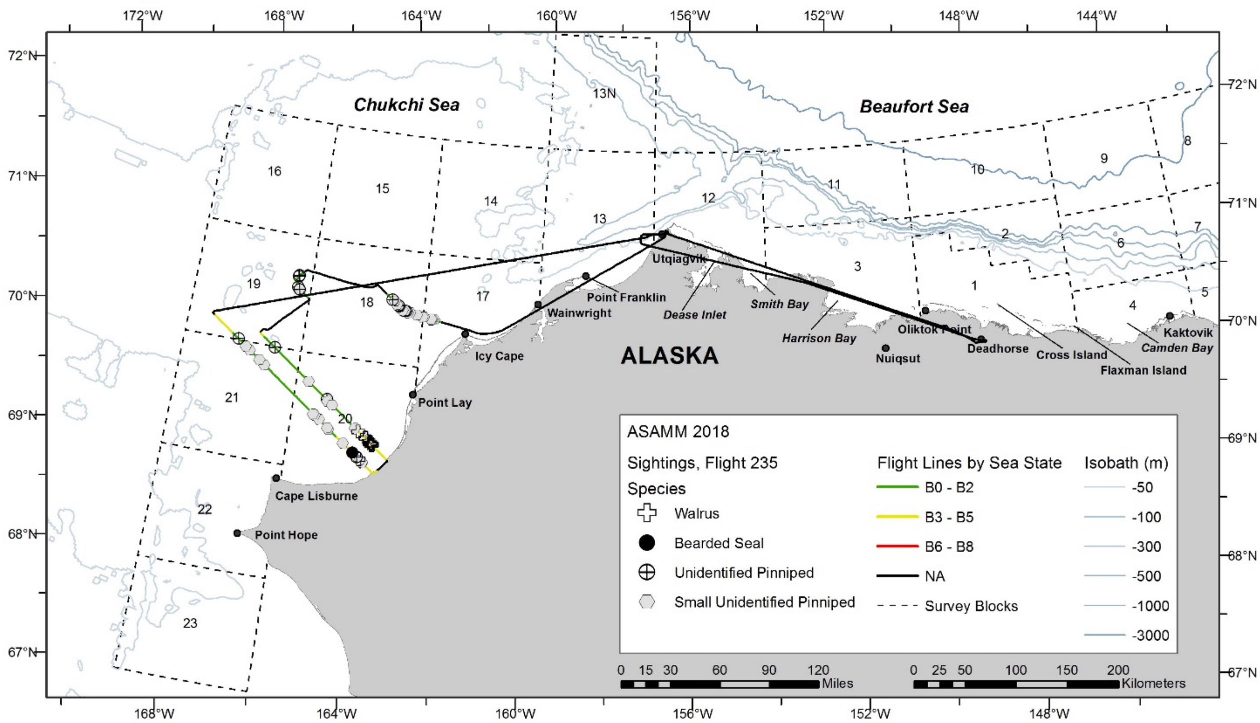

Figure B-66. Flight 235 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

19 September 2018, Flight 32

Flight was a partial survey of transects 124 and 130, the coastal transect in Harrison Bay and Smith Bay, and a series of field of view transects associated with a terrestrial target south of Deadhorse, Alaska. Survey conditions included clear skies, 1 km to unlimited visibility, with glare, haze, and low ceilings, and Beaufort 2-6 sea states. Sea ice was 0-1% broken floe ice in the area surveyed. Sightings included small unidentified pinnipeds and polar bears. A small group of approximately 15 small unidentified pinnipeds was hauled out on a beach north of Nuiqsut.

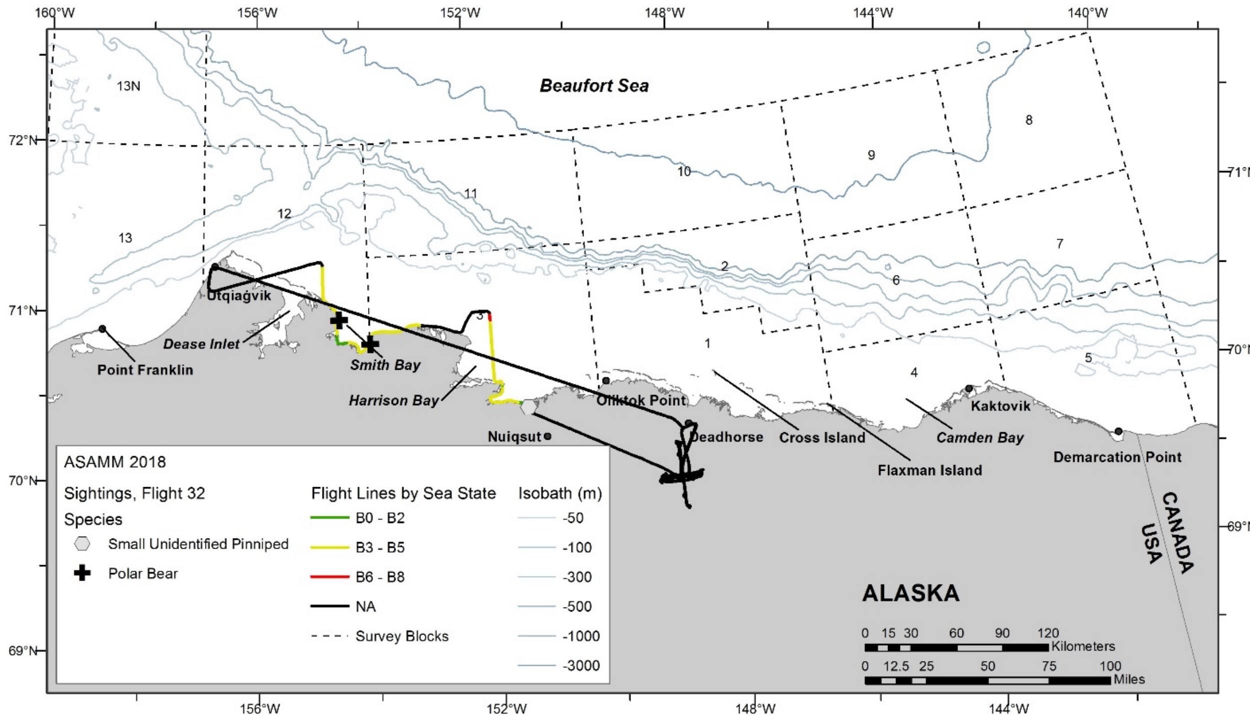

Figure B-67. Flight 32 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

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20 September 2018, Flight 33

Flight was a complete survey of transects 112, 113, 114, 115, 116, 117, 118, 119, and 120, partial survey of transect 111, and focal group follow session of a bowhead whale cow-calf pair. Survey conditions included clear skies, 3 km to unlimited visibility, with glare and haze, and Beaufort 1-6 sea states. Sea ice was 0-90% broken floe and grease/new ice in the area surveyed. Sightings included bowhead whales (including 4 calves), belugas (including 7 calves), unidentified cetaceans, bearded seals, one unidentified pinniped, small unidentified pinnipeds, and one polar bear.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
33	9/20/2018 9:34	70.731	149.815	bowhead whale	dive	1	0	1
33	9/20/2018 9:46	70.986	149.831	bowhead whale	swim	2	0	1
33	9/20/2018 10:20	70.815	149.309	bowhead whale	swim	2	0	1
33	9/20/2018 10:21	70.806	149.314	bowhead whale	swim	1	0	1
33	9/20/2018 10:21	70.804	149.341	bowhead whale	swim	2	0	1
33	9/20/2018 10:23	70.806	149.352	bowhead whale	breach	1	0	1
33	9/20/2018 10:25	70.769	149.351	bowhead whale	swim	1	0	1
33	9/20/2018 10:25	70.765	149.350	bowhead whale	swim	1	0	1
33	9/20/2018 10:30	70.703	149.283	bowhead whale	swim	2	1	1
33	9/20/2018 10:33	70.649	149.268	bowhead whale	swim	1	0	1
33	9/20/2018 10:33	70.642	149.380	bowhead whale	swim	1	0	1
33	9/20/2018 10:33	70.642	149.361	bowhead whale	swim	1	0	1
33	9/20/2018 10:37	70.613	149.604	unid cetacean	swim	1	0	1
33	9/20/2018 10:37	70.614	149.291	bowhead whale	swim	3	0	1
33	9/20/2018 10:37	70.612	149.283	bowhead whale	swim	2	0	1
33	9/20/2018 10:38	70.600	149.336	bowhead whale	swim	1	0	1
33	9/20/2018 10:56	70.601	148.823	bowhead whale	swim	1	0	1
33	9/20/2018 10:58	70.664	148.824	unid cetacean	unknown	1	0	1
33	9/20/2018 11:00	70.655	148.760	bowhead whale	swim	1	0	1
33	9/20/2018 11:50	70.641	148.317	bowhead whale	swim	1	0	1
33	9/20/2018 11:55	70.523	148.319	bowhead whale	swim	1	0	1
33	9/20/2018 11:55	70.511	148.411	bowhead whale	tail slap	1	0	1
33	9/20/2018 11:56	70.505	148.290	bowhead whale	swim	1	0	1
33	9/20/2018 12:13	70.523	147.839	bowhead whale	swim	1	0	1
33	9/20/2018 12:13	70.539	147.861	bowhead whale	swim	1	0	1
33	9/20/2018 12:36	71.307	147.831	beluga	swim	4	1	2
33	9/20/2018 12:36	71.311	147.818	beluga	swim	2	0	2
33	9/20/2018 12:36	71.313	147.836	beluga	swim	1	0	2
33	9/20/2018 12:44	71.218	147.337	beluga	swim	11	2	2
33	9/20/2018 12:45	71.208	147.316	beluga	swim	2	1	2
33	9/20/2018 12:47	71.121	147.318	beluga	swim	5	1	2
33	9/20/2018 12:48	71.107	147.321	beluga	swim	2	0	2

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
33	9/20/2018 12:48	71.086	147.310	beluga	swim	1	0	2
33	9/20/2018 12:48	71.084	147.328	beluga	swim	2	0	2
33	9/20/2018 12:48	71.083	147.315	beluga	swim	2	1	2
33	9/20/2018 12:48	71.080	147.322	beluga	swim	3	0	2
33	9/20/2018 12:48	71.080	147.332	beluga	swim	12	1	2
33	9/20/2018 12:49	71.075	147.320	beluga	swim	2	0	2
33	9/20/2018 13:05	70.558	147.341	bowhead whale	swim	2	1	1
33	9/20/2018 13:05	70.543	147.383	bowhead whale	swim	1	0	1
33	9/20/2018 13:05	70.541	147.395	bowhead whale	swim	2	0	1
33	9/20/2018 13:05	70.538	147.388	bowhead whale	swim	1	0	1
33	9/20/2018 13:05	70.534	147.371	bowhead whale	swim	1	0	1
33	9/20/2018 13:06	70.532	147.388	bowhead whale	swim	1	0	1
33	9/20/2018 13:06	70.531	147.307	bowhead whale	swim	2	1	1
33	9/20/2018 13:06	70.527	147.371	bowhead whale	swim	2	0	1
33	9/20/2018 13:06	70.518	147.261	bowhead whale	swim	3	0	1
33	9/20/2018 13:06	70.511	147.315	bowhead whale	swim	2	0	1
33	9/20/2018 13:06	70.506	147.298	bowhead whale	swim	1	0	1
33	9/20/2018 13:07	70.496	147.443	bowhead whale	swim	1	0	1
33	9/20/2018 13:07	70.492	147.338	bowhead whale	swim	1	0	1
33	9/20/2018 13:08	70.444	147.351	bowhead whale	swim	1	0	1
33	9/20/2018 13:26	70.392	146.818	bowhead whale	swim	1	0	1
33	9/20/2018 13:29	70.447	146.746	bowhead whale	swim	3	0	1
33	9/20/2018 13:30	70.450	146.820	bowhead whale	dive	1	0	1
33	9/20/2018 16:19	70.989	145.832	beluga	swim	1	0	6
33	9/20/2018 16:19	70.984	145.831	beluga	swim	1	0	6
33	9/20/2018 16:19	70.981	145.848	beluga	swim	1	0	6
33	9/20/2018 16:27	70.705	145.829	beluga	swim	1	0	6
33	9/20/2018 16:28	70.702	145.827	beluga	swim	1	0	6
33	9/20/2018 16:39	70.300	145.859	bowhead whale	swim	3	0	4
33	9/20/2018 16:40	70.292	145.805	bowhead whale	swim	1	0	4
33	9/20/2018 16:42	70.301	145.845	bowhead whale	swim	1	0	4
33	9/20/2018 16:48	70.241	145.833	bowhead whale	swim	1	0	4
33	9/20/2018 17:07	70.339	145.348	bowhead whale	swim	2	1	4

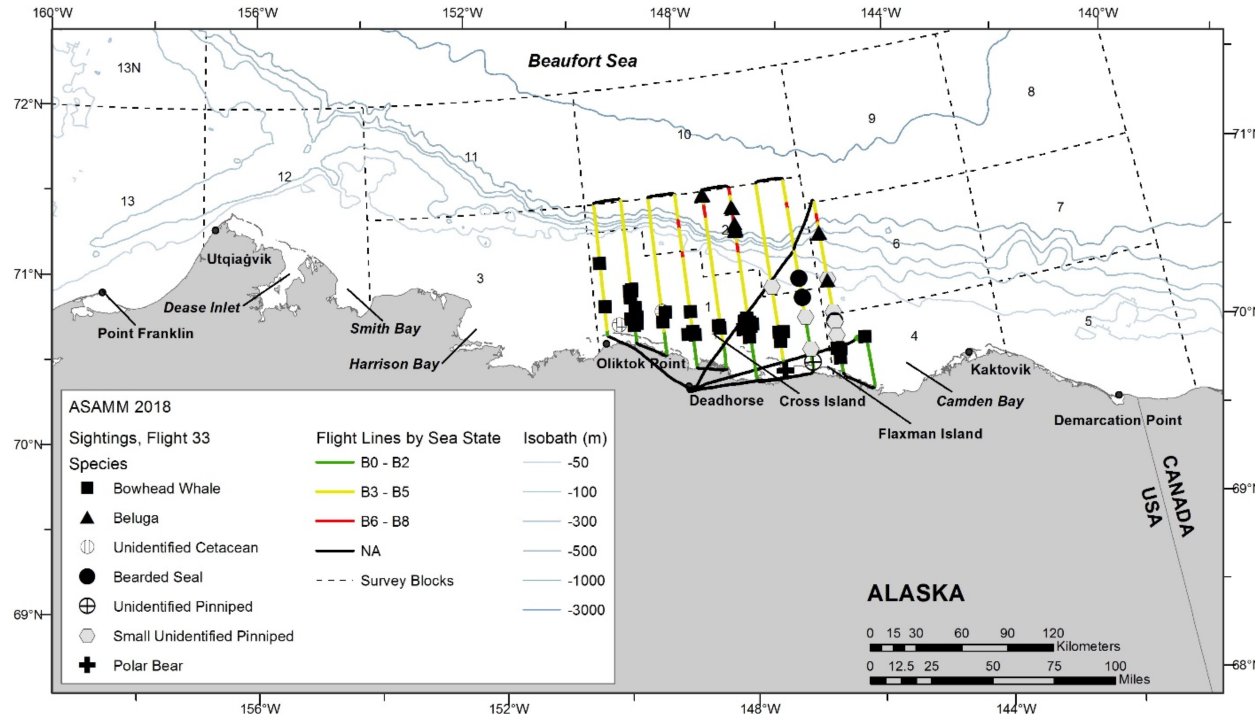

Figure B-68. Flight 33 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

21 September 2018, Flight 236

Flight was a complete survey of transects 129, 130, 131, and 132, and partial survey of transect 133. Survey conditions included partly cloudy to overcast skies, 0-10 km visibility, with glare, precipitation, and low ceilings, and Beaufort 2-5 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
236	9/21/2018 16:50	71.203	154.317	bowhead whale	swim	3	0	12
236	9/21/2018 17:28	71.827	154.829	bowhead whale	swim	1	0	12
236	9/21/2018 17:30	71.810	154.806	bowhead whale	swim	2	0	12
236	9/21/2018 17:31	71.815	154.789	bowhead whale	swim	1	0	12
236	9/21/2018 17:44	71.386	154.856	bowhead whale	swim	1	0	12
236	9/21/2018 17:44	71.382	154.849	bowhead whale	swim	1	0	12
236	9/21/2018 17:46	71.359	154.754	bowhead whale	breach	1	0	12
236	9/21/2018 18:08	71.397	155.281	bowhead whale	dive	1	0	12
236	9/21/2018 18:12	71.501	155.323	bowhead whale	swim	1	0	12
236	9/21/2018 18:12	71.502	155.322	bowhead whale	swim	1	0	12
236	9/21/2018 18:12	71.505	155.324	bowhead whale	swim	1	0	12
236	9/21/2018 18:12	71.507	155.321	bowhead whale	swim	1	0	12
236	9/21/2018 18:12	71.509	155.322	bowhead whale	swim	1	0	12
236	9/21/2018 18:12	71.512	155.334	bowhead whale	swim	1	0	12
236	9/21/2018 18:15	71.507	155.291	bowhead whale	swim	1	0	12
236	9/21/2018 18:27	71.854	155.323	bowhead whale	mill	2	0	12

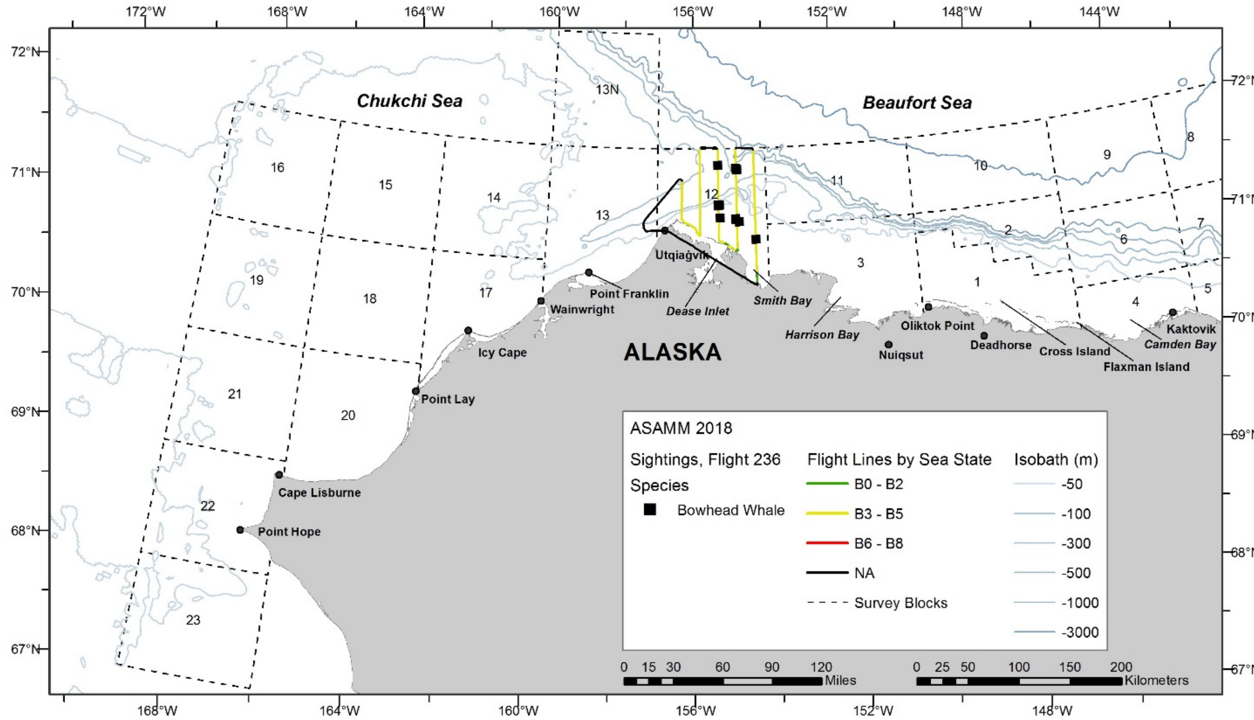

Figure B-69. Flight 236 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

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22 September 2018, Flight 237

Flight was a partial survey of transect of 134, negligible effort on transects 3 and 4, coastal transect from approximately 12 miles south of Utqiaġvik to Point Franklin, and search effort in Peard Bay. Survey conditions included partly cloudy to overcast skies, 0-10 km visibility, with low ceilings and precipitation, and Beaufort 3-6 sea states. There was no sea ice in the area surveyed. Sightings included one bowhead whale and one gray whale carcass. The gray whale carcass was a resight of a carcass previously sighted during flight 222 on 19 August 2018 and flight 228 on 2 September 2018. The bowhead whale carcass was a resight of a carcass previously sighted during flight 228 on 2 September 2018.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
237	9/22/2018 10:04	71.077	157.201	gray whale	dead	1	0	13
237	9/22/2018 10:07	71.039	157.265	bowhead whale	dead	1	0	13

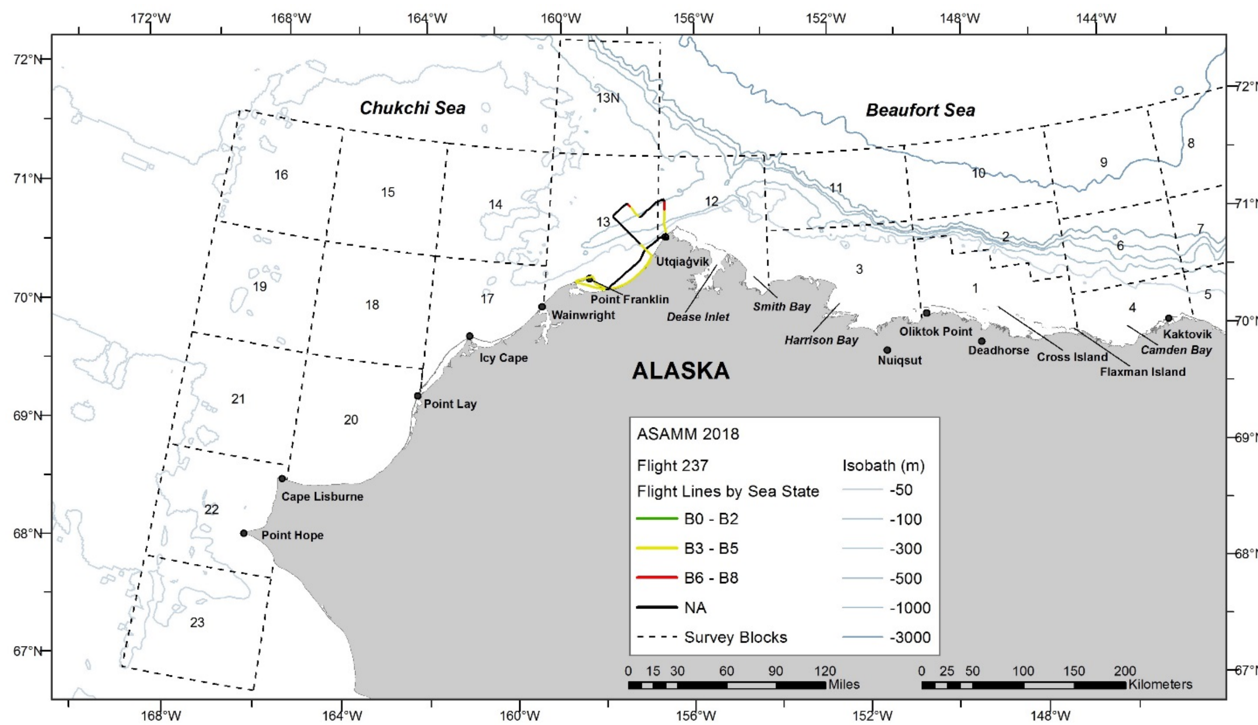

Figure B-70. Flight 237, survey track, depicted by sea state, excluding marine mammal carcasses.

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23 September 2018, Flight 238

Flight was a complete survey of transects 34, 35, 36, and 37. Survey conditions included clear to overcast skies, 5 km to unlimited visibility, with glare, and Beaufort 2-5 sea states. There was no sea ice in the area surveyed. Sightings included humpback whales (including 1 calf), fin whales, harbor porpoises, unidentified cetaceans, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
238	9/23/2018 14:24	67.975	166.297	harbor porpoise	swim	1	0	23
238	9/23/2018 14:24	67.972	166.299	harbor porpoise	swim	1	0	23
238	9/23/2018 15:08	67.811	167.776	humpback whale	swim	1	0	23
238	9/23/2018 15:19	67.814	167.195	humpback whale	swim	2	1	23
238	9/23/2018 15:23	67.809	167.172	fin whale	swim	1	0	23
238	9/23/2018 15:25	67.789	167.108	fin whale	unknown	2	0	23
238	9/23/2018 15:25	67.788	167.076	fin whale	unknown	2	0	23
238	9/23/2018 15:25	67.791	167.061	fin whale	swim	1	0	23
238	9/23/2018 15:33	67.805	166.932	fin whale	swim	1	0	23
238	9/23/2018 15:35	67.800	166.716	fin whale	mill	3	0	23
238	9/23/2018 15:39	67.767	166.458	fin whale	swim	2	0	23
238	9/23/2018 15:49	67.802	166.006	harbor porpoise	swim	1	0	23
238	9/23/2018 15:50	67.764	166.010	harbor porpoise	swim	1	0	23
238	9/23/2018 15:53	67.677	165.997	harbor porpoise	swim	1	0	0
238	9/23/2018 15:53	67.660	166.038	unid cetacean	swim	1	0	23
238	9/23/2018 15:58	67.632	166.094	harbor porpoise	swim	1	0	23
238	9/23/2018 16:01	67.588	166.390	unid cetacean	.	6	0	23
238	9/23/2018 16:01	67.625	166.399	unid cetacean	.	3	0	23
238	9/23/2018 16:02	67.618	166.417	unid cetacean	.	4	0	23
238	9/23/2018 16:02	67.619	166.433	unid cetacean	.	2	0	23
238	9/23/2018 16:02	67.624	166.456	unid cetacean	.	1	0	23
238	9/23/2018 16:02	67.624	166.468	fin whale	.	1	0	23
238	9/23/2018 16:02	67.620	166.485	unid cetacean	.	1	0	23
238	9/23/2018 16:02	67.622	166.498	unid cetacean	.	1	0	23
238	9/23/2018 16:03	67.656	166.538	fin whale	.	1	0	23
238	9/23/2018 16:03	67.663	166.559	fin whale	.	1	0	23
238	9/23/2018 16:03	67.615	166.565	fin whale	.	1	0	23
238	9/23/2018 16:04	67.622	166.596	unid cetacean	.	2	0	23
238	9/23/2018 16:04	67.627	166.611	fin whale	.	2	0	23
238	9/23/2018 16:04	67.620	166.630	fin whale	.	2	0	23
238	9/23/2018 16:08	67.621	166.611	fin whale	swim	2	0	23
238	9/23/2018 16:10	67.618	166.518	humpback whale	swim	1	0	23
238	9/23/2018 16:11	67.623	166.516	humpback whale	swim	1	0	23
238	9/23/2018 16:12	67.620	166.477	harbor porpoise	swim	1	0	23
238	9/23/2018 16:13	67.623	166.408	fin whale	swim	1	0	23

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
238	9/23/2018 16:15	67.632	166.362	fin whale	swim	2	0	23
238	9/23/2018 16:18	67.614	166.434	humpback whale	swim	2	0	23
238	9/23/2018 16:19	67.608	166.475	fin whale	swim	1	0	23
238	9/23/2018 16:21	67.626	166.534	fin whale	swim	1	0	23
238	9/23/2018 16:22	67.640	166.563	humpback whale	mill	2	0	23
238	9/23/2018 16:24	67.636	166.565	fin whale	swim	1	0	23
238	9/23/2018 16:24	67.637	166.573	fin whale	swim	2	0	23
238	9/23/2018 16:25	67.650	166.564	humpback whale	swim	1	0	23
238	9/23/2018 16:25	67.645	166.543	humpback whale	swim	1	0	23
238	9/23/2018 16:31	67.548	166.834	fin whale	swim	1	0	23
238	9/23/2018 16:33	67.578	166.873	fin whale	swim	2	0	23
238	9/23/2018 16:48	67.469	167.221	harbor porpoise	swim	1	0	23
238	9/23/2018 16:49	67.423	167.057	fin whale	unknown	2	0	23
238	9/23/2018 16:51	67.463	166.968	fin whale	swim	1	0	23
238	9/23/2018 16:51	67.485	166.931	humpback whale	mill	2	0	23
238	9/23/2018 16:52	67.457	166.848	fin whale	swim	1	0	23
238	9/23/2018 16:52	67.494	166.824	fin whale	unknown	1	0	23
238	9/23/2018 16:53	67.422	166.773	fin whale	unknown	1	0	23
238	9/23/2018 16:53	67.451	166.762	fin whale	unknown	1	0	23
238	9/23/2018 16:53	67.457	166.743	fin whale	.	2	0	23
238	9/23/2018 16:53	67.468	166.733	fin whale	.	1	0	23
238	9/23/2018 16:53	67.458	166.732	fin whale	.	2	0	23
238	9/23/2018 16:54	67.471	166.719	humpback whale	.	6	0	23
238	9/23/2018 16:54	67.476	166.704	humpback whale	.	2	0	23
238	9/23/2018 16:54	67.477	166.696	fin whale	.	1	0	23
238	9/23/2018 16:54	67.466	166.645	fin whale	.	1	0	23
238	9/23/2018 16:55	67.456	166.627	humpback whale	.	2	0	23
238	9/23/2018 16:56	67.429	166.535	fin whale	swim	1	0	23
238	9/23/2018 16:57	67.551	166.473	fin whale	unknown	1	0	23
238	9/23/2018 16:57	67.454	166.472	unid cetacean	swim	1	0	23
238	9/23/2018 16:59	67.459	166.266	humpback whale	swim	1	0	23
238	9/23/2018 19:30	67.631	168.221	fin whale	swim	1	0	23
238	9/23/2018 19:33	67.638	168.071	fin whale	swim	1	0	23
238	9/23/2018 19:33	67.635	168.070	fin whale	swim	2	0	23
238	9/23/2018 19:33	67.625	168.049	fin whale	swim	1	0	23
238	9/23/2018 19:39	67.637	167.645	fin whale	swim	2	0	23

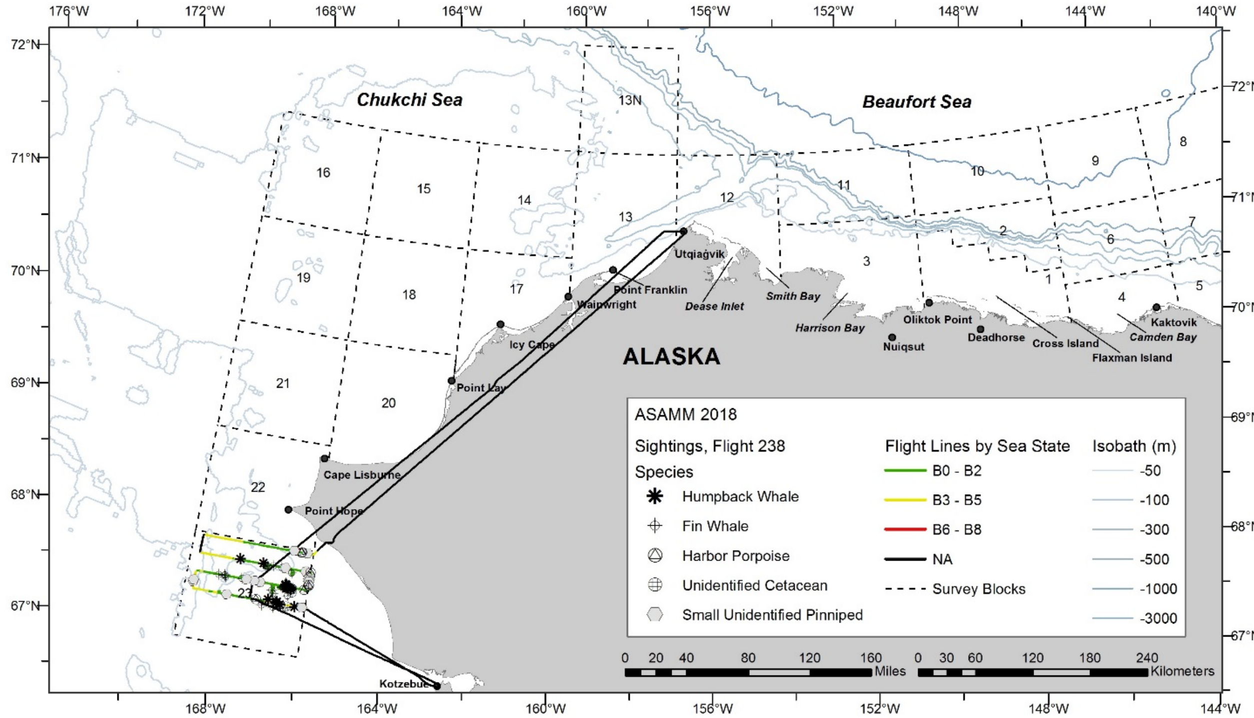

Figure B-71. Flight 238 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

23 September 2018, Flight 34

Flight was a partial survey of transects 123, 124, 125, 126, and 128, and coastal transect in Harrison Bay. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare, ice on the window, low ceilings, and precipitation, and Beaufort 2-6 sea states. Sea ice was 0-1% broken floe in the area surveyed. Sightings included bowhead whales (including 2 calves), belugas, one small unidentified pinniped, and one polar bear.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
34	9/23/2018 10:25	71.205	153.819	bowhead whale	swim	1	0	3
34	9/23/2018 10:33	71.439	153.802	bowhead whale	swim	1	0	11
34	9/23/2018 10:57	71.682	152.803	bowhead whale	swim	1	0	11
34	9/23/2018 10:59	71.688	152.808	bowhead whale	swim	1	0	11
34	9/23/2018 11:00	71.647	152.852	bowhead whale	swim	1	0	11
34	9/23/2018 11:04	71.555	152.732	bowhead whale	swim	1	0	11
34	9/23/2018 11:10	71.469	152.808	bowhead whale	swim	1	0	11
34	9/23/2018 11:42	71.100	152.334	bowhead whale	swim	1	0	3
34	9/23/2018 11:51	71.376	152.315	bowhead whale	swim	1	0	11
34	9/23/2018 11:56	71.481	152.304	bowhead whale	swim	1	0	11
34	9/23/2018 11:57	71.506	152.339	bowhead whale	swim	1	0	11
34	9/23/2018 11:58	71.515	152.330	bowhead whale	swim	1	0	11
34	9/23/2018 11:58	71.520	152.313	bowhead whale	swim	1	0	11
34	9/23/2018 12:01	71.548	152.307	bowhead whale	swim	4	2	11
34	9/23/2018 12:05	71.586	152.356	bowhead whale	swim	1	0	11
34	9/23/2018 12:06	71.605	152.300	beluga	swim	2	0	11
34	9/23/2018 12:07	71.620	152.327	beluga	swim	1	0	11
34	9/23/2018 12:07	71.622	152.315	beluga	swim	1	0	11
34	9/23/2018 12:07	71.624	152.308	beluga	swim	1	0	11
34	9/23/2018 12:07	71.624	152.332	beluga	swim	2	0	11
34	9/23/2018 12:07	71.628	152.314	beluga	swim	2	0	11
34	9/23/2018 12:07	71.630	152.306	beluga	swim	2	0	11
34	9/23/2018 12:07	71.632	152.322	beluga	swim	1	0	11
34	9/23/2018 12:07	71.634	152.328	beluga	swim	1	0	11
34	9/23/2018 12:58	70.578	151.317	bowhead whale	swim	1	0	3
34	9/23/2018 12:59	70.582	151.304	bowhead whale	swim	1	0	3

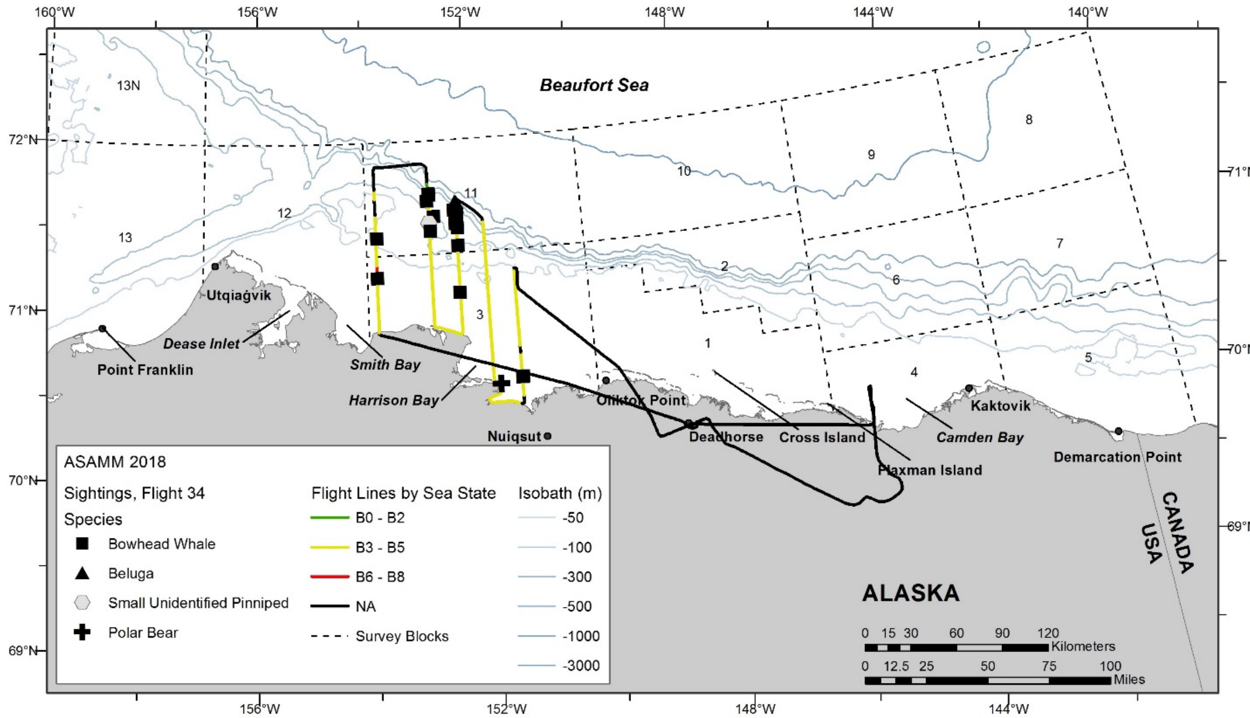

Figure B-72. Flight 34 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

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24 September 2018, Flight 35

Flight was a partial survey of transects 103, 104, 105, 106, 107, 108, 109, and 110. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 2-6 sea states. Sea ice was 0-5% broken floe ice in the area surveyed. Sightings included belugas (including 2 calves), one unidentified cetacean, one bearded seal, one small unidentified pinniped, and one polar bear.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
35	9/24/2018 14:38	70.305	143.792	unid cetacean	swim	1	0	4
35	9/24/2018 14:53	70.715	143.826	beluga	swim	2	1	6
35	9/24/2018 14:53	70.724	143.821	beluga	swim	2	1	6
35	9/24/2018 14:54	70.738	143.817	beluga	swim	1	0	6
35	9/24/2018 16:25	70.512	141.806	beluga	swim	1	0	7
35	9/24/2018 16:26	70.521	141.793	beluga	swim	6	0	7
35	9/24/2018 16:26	70.544	141.829	beluga	swim	1	0	7
35	9/24/2018 16:27	70.551	141.829	beluga	rest	1	0	7
35	9/24/2018 16:27	70.552	141.823	beluga	rest	1	0	7
35	9/24/2018 17:03	70.710	141.312	beluga	rest	1	0	7
35	9/24/2018 17:03	70.703	141.307	beluga	swim	1	0	7
35	9/24/2018 17:09	70.515	141.316	beluga	swim	1	0	7

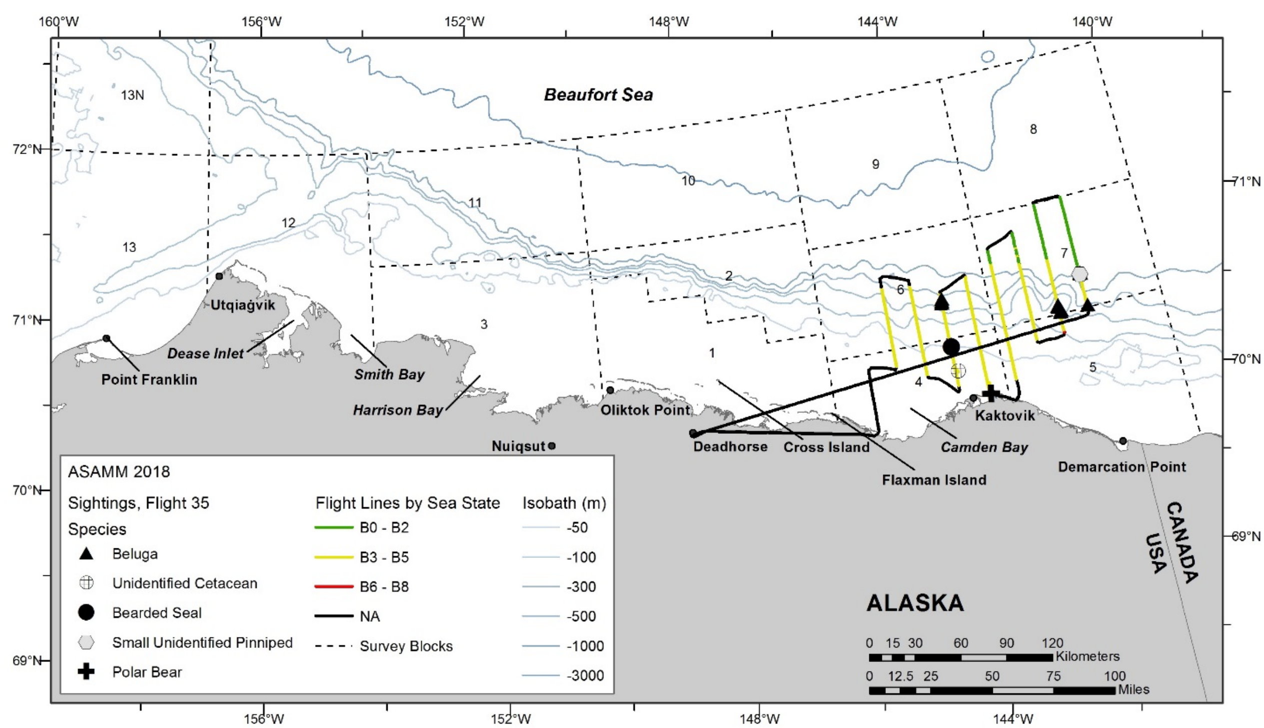

Figure B-73. Flight 35 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

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25 September 2018, Flight 239

Flight was a complete survey of transects 1, 2, 3, 4, 5, 6, and 7, and search effort in block 12. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 2-6 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales (including 1 calf), gray whales (including 1 calf), unidentified cetaceans, walruses, unidentified pinnipeds, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
239	9/25/2018 11:28	71.514	155.985	bowhead whale	swim	1	0	12
239	9/25/2018 11:33	71.541	156.105	bowhead whale	swim	1	0	12
239	9/25/2018 11:33	71.522	156.138	bowhead whale	swim	1	0	12
239	9/25/2018 11:34	71.511	156.143	bowhead whale	swim	1	0	12
239	9/25/2018 11:35	71.511	156.143	bowhead whale	swim	1	0	12
239	9/25/2018 11:35	71.511	156.143	bowhead whale	swim	1	0	12
239	9/25/2018 11:35	71.511	156.143	bowhead whale	swim	1	0	12
239	9/25/2018 11:36	71.511	156.143	bowhead whale	swim	1	0	12
239	9/25/2018 11:37	71.602	156.146	bowhead whale	swim	1	0	12
239	9/25/2018 11:37	71.588	156.216	bowhead whale	swim	1	0	12
239	9/25/2018 11:41	71.581	156.175	bowhead whale	swim	2	1	12
239	9/25/2018 11:41	71.589	156.208	bowhead whale	swim	1	0	12
239	9/25/2018 11:49	71.630	156.398	bowhead whale	swim	1	0	12
239	9/25/2018 12:16	71.983	158.385	bowhead whale	swim	1	0	13
239	9/25/2018 12:39	71.541	156.989	bowhead whale	swim	1	0	12
239	9/25/2018 12:39	71.538	156.979	bowhead whale	swim	1	0	12
239	9/25/2018 12:39	71.537	156.956	bowhead whale	swim	1	0	12
239	9/25/2018 12:39	71.535	156.935	bowhead whale	swim	1	0	12
239	9/25/2018 12:41	71.549	156.953	bowhead whale	swim	1	0	12
239	9/25/2018 12:41	71.540	156.928	bowhead whale	swim	4	0	12
239	9/25/2018 12:43	71.514	157.022	bowhead whale	swim	1	0	13
239	9/25/2018 12:43	71.510	156.926	bowhead whale	swim	2	0	12
239	9/25/2018 12:45	71.514	156.988	bowhead whale	swim	1	0	12
239	9/25/2018 12:47	71.527	156.957	bowhead whale	swim	2	0	12
239	9/25/2018 12:49	71.485	157.028	bowhead whale	swim	1	0	13
239	9/25/2018 12:49	71.477	157.060	bowhead whale	rest	1	0	13
239	9/25/2018 12:53	71.461	157.036	bowhead whale	swim	1	0	13
239	9/25/2018 12:56	71.455	156.978	bowhead whale	swim	1	0	12
239	9/25/2018 13:00	71.369	157.014	bowhead whale	swim	1	0	13
239	9/25/2018 13:01	71.371	157.003	bowhead whale	swim	1	0	13
239	9/25/2018 13:07	71.417	157.290	bowhead whale	swim	1	0	13
239	9/25/2018 13:07	71.412	157.337	bowhead whale	swim	1	0	13
239	9/25/2018 13:07	71.424	157.319	bowhead whale	swim	1	0	13

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
239	9/25/2018 13:07	71.430	157.378	bowhead whale	swim	1	0	13
239	9/25/2018 13:08	71.409	157.329	bowhead whale	swim	1	0	13
239	9/25/2018 13:08	71.420	157.344	bowhead whale	swim	1	0	13
239	9/25/2018 13:11	71.432	157.350	bowhead whale	swim	1	0	13
239	9/25/2018 13:11	71.429	157.369	bowhead whale	swim	1	0	13
239	9/25/2018 13:11	71.434	157.352	bowhead whale	swim	1	0	13
239	9/25/2018 13:11	71.427	157.387	bowhead whale	swim	1	0	13
239	9/25/2018 13:11	71.439	157.375	bowhead whale	swim	1	0	13
239	9/25/2018 13:11	71.436	157.405	bowhead whale	swim	1	0	13
239	9/25/2018 13:11	71.447	157.388	bowhead whale	swim	1	0	13
239	9/25/2018 13:13	71.422	157.402	bowhead whale	swim	1	0	13
239	9/25/2018 13:15	71.452	157.421	bowhead whale	swim	1	0	13
239	9/25/2018 13:23	71.619	158.004	bowhead whale	swim	1	0	13
239	9/25/2018 13:32	71.808	158.615	bowhead whale	swim	1	0	13
239	9/25/2018 14:14	71.461	158.219	bowhead whale	swim	1	0	13
239	9/25/2018 14:17	71.390	158.029	bowhead whale	swim	1	0	13
239	9/25/2018 14:17	71.393	157.996	bowhead whale	swim	1	0	13
239	9/25/2018 14:19	71.391	157.968	bowhead whale	swim	1	0	13
239	9/25/2018 14:19	71.387	157.964	bowhead whale	swim	1	0	13
239	9/25/2018 14:27	71.227	157.440	gray whale	feed	1	0	13
239	9/25/2018 14:27	71.222	157.441	gray whale	feed	1	0	13
239	9/25/2018 14:27	71.219	157.441	gray whale	feed	2	1	13
239	9/25/2018 14:27	71.218	157.435	gray whale	feed	1	0	13
239	9/25/2018 15:01	71.481	159.097	unid cetacean	swim	1	0	13
239	9/25/2018 17:33	71.930	161.659	unid cetacean	swim	1	0	14
239	9/25/2018 17:57	71.828	161.989	bowhead whale	swim	1	0	14
239	9/25/2018 18:01	71.761	161.738	bowhead whale	swim	1	0	14
239	9/25/2018 18:04	71.736	161.661	bowhead whale	swim	1	0	14
239	9/25/2018 18:07	71.707	161.369	bowhead whale	swim	2	0	14

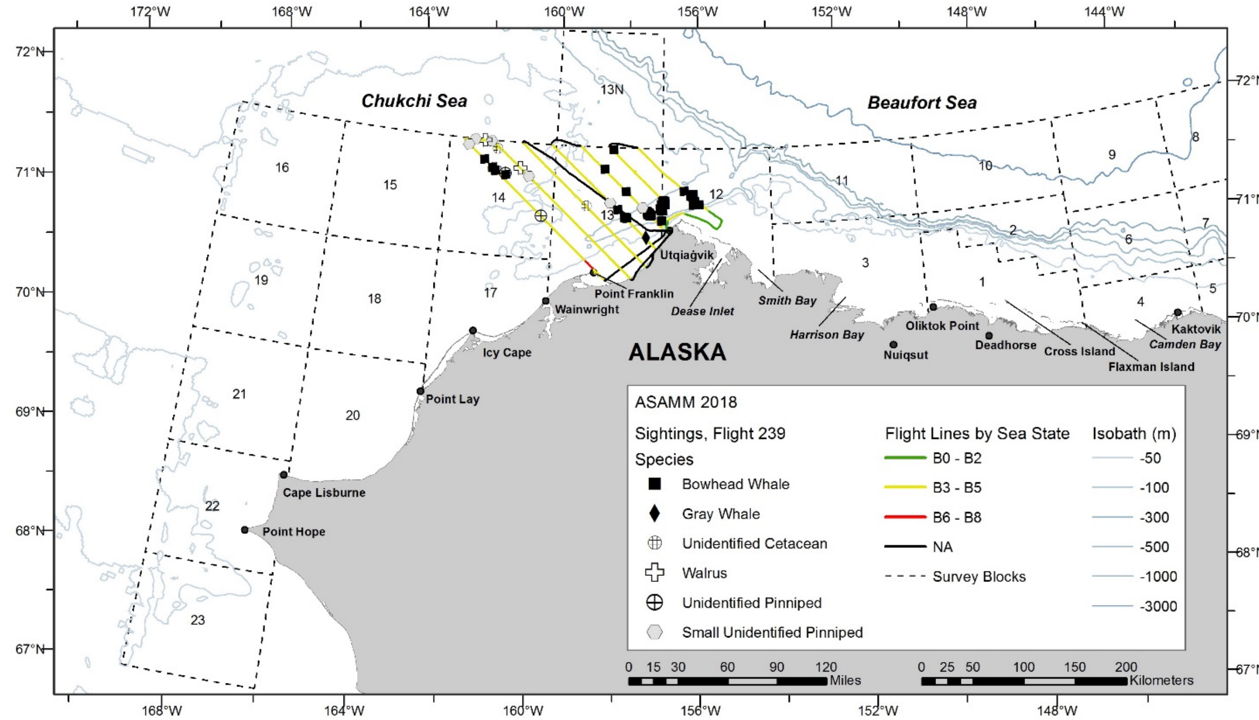

Figure B-74. Flight 239 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

25 September 2018, Flight 36

Flight was a complete survey of transects 101, 102, 109, 110, 111, 112, partial survey of transects 103 and 124, and focal group follow session of two bowhead whales. Survey conditions included partly cloudy to overcast skies, <1 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 2-5 sea states. Sea ice was 0-20% broken floe and new ice in the area surveyed. Sightings included bowhead whales, belugas (including 5 calves), bearded seals, one unidentified pinniped, small unidentified pinnipeds, and polar bears.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
36	9/25/2018 11:36	70.362	145.796	bowhead whale	swim	1	0	4
36	9/25/2018 11:39	70.355	145.779	bowhead whale	swim	1	0	4
36	9/25/2018 11:39	70.350	145.839	bowhead whale	swim	1	0	4
36	9/25/2018 11:39	70.340	145.797	bowhead whale	swim	1	0	4
36	9/25/2018 11:39	70.339	145.850	bowhead whale	swim	1	0	4
36	9/25/2018 11:46	70.332	145.821	bowhead whale	swim	2	0	4
36	9/25/2018 11:48	70.299	145.802	bowhead whale	unknown	1	0	4
36	9/25/2018 11:53	70.230	145.811	bowhead whale	swim	1	0	4
36	9/25/2018 11:56	70.179	145.827	bowhead whale	mill	2	0	4
36	9/25/2018 12:00	70.198	145.877	bowhead whale	mill	2	0	4
36	9/25/2018 12:14	70.154	145.295	bowhead whale	swim	1	0	4
36	9/25/2018 12:44	70.996	145.291	beluga	swim	1	0	6
36	9/25/2018 13:22	70.220	144.839	bowhead whale	swim	1	0	4
36	9/25/2018 13:23	70.207	144.826	bowhead whale	swim	1	0	4
36	9/25/2018 13:42	70.182	144.363	bowhead whale	swim	1	0	4
36	9/25/2018 13:45	70.169	144.404	bowhead whale	breach	1	0	4
36	9/25/2018 13:48	70.251	144.359	bowhead whale	swim	1	0	4
36	9/25/2018 17:04	70.293	140.318	beluga	swim	1	0	5
36	9/25/2018 17:50	70.729	140.832	beluga	swim	2	1	7
36	9/25/2018 17:50	70.725	140.798	beluga	swim	1	0	7
36	9/25/2018 17:50	70.724	140.833	beluga	swim	4	0	7
36	9/25/2018 17:50	70.718	140.804	beluga	swim	2	1	7
36	9/25/2018 17:50	70.713	140.801	beluga	swim	1	0	7
36	9/25/2018 17:50	70.712	140.815	beluga	swim	3	1	7
36	9/25/2018 17:50	70.710	140.844	beluga	swim	1	0	7
36	9/25/2018 17:51	70.707	140.821	beluga	swim	1	0	7
36	9/25/2018 17:51	70.704	140.833	beluga	swim	1	0	7
36	9/25/2018 17:51	70.702	140.835	beluga	swim	1	0	7
36	9/25/2018 17:51	70.697	140.828	beluga	swim	1	0	7
36	9/25/2018 17:51	70.695	140.826	beluga	swim	1	0	7
36	9/25/2018 17:51	70.692	140.826	beluga	swim	1	0	7
36	9/25/2018 17:51	70.688	140.833	beluga	swim	1	0	7
36	9/25/2018 17:51	70.686	140.836	beluga	swim	1	0	7

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
36	9/25/2018 17:51	70.674	140.812	beluga	swim	6	2	7
36	9/25/2018 17:53	70.611	140.839	beluga	swim	1	0	7
36	9/25/2018 17:55	70.546	140.848	beluga	swim	1	0	7
36	9/25/2018 17:56	70.533	140.828	beluga	rest	1	0	7
36	9/25/2018 18:34	69.980	141.336	bowhead whale	swim	2	0	5

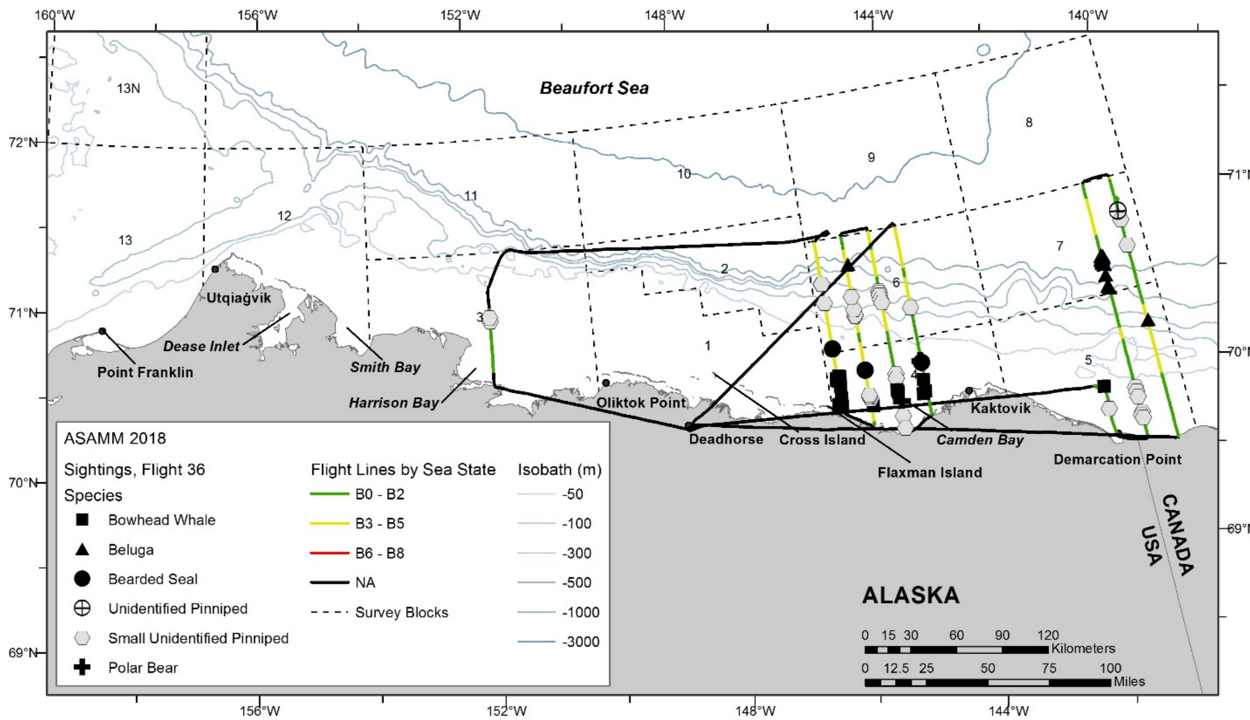

Figure B-75. Flight 36 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

26 September 2018, Flight 240

Flight was a complete survey of transects 129, 130, 131, 132, and coastal transect from ~148.3°W to Smith Bay. Survey conditions included clear to overcast skies, 3 km to unlimited visibility, with glare, low ceilings, precipitation, and Beaufort 1-3 sea states. Sea ice was 0-90% broken floe and grease/new in the area surveyed. Sightings included bowhead whales (including 5 calves), belugas (including 8 calves), unidentified cetaceans, one bearded seal, unidentified pinnipeds, small unidentified pinnipeds, and polar bears.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
240	9/26/2018 14:51	70.933	153.069	bowhead whale	swim	1	0	3
240	9/26/2018 15:13	70.949	154.318	bowhead whale	feed	2	0	12
240	9/26/2018 16:06	71.766	154.254	bowhead whale	swim	1	0	12
240	9/26/2018 16:09	71.780	154.349	bowhead whale	rest	1	0	12
240	9/26/2018 16:09	71.789	154.314	bowhead whale	swim	1	0	12
240	9/26/2018 16:12	71.832	154.385	unid cetacean	unknown	1	0	12
240	9/26/2018 16:21	72.004	154.512	beluga	swim	1	0	0
240	9/26/2018 16:21	72.003	154.514	beluga	swim	1	0	0
240	9/26/2018 16:21	72.015	154.527	beluga	swim	1	0	0
240	9/26/2018 16:21	72.002	154.529	beluga	swim	1	0	0
240	9/26/2018 16:21	72.005	154.533	beluga	swim	1	0	0
240	9/26/2018 16:21	72.014	154.552	beluga	swim	1	0	0
240	9/26/2018 16:22	72.006	154.568	beluga	swim	1	0	0
240	9/26/2018 16:22	72.014	154.574	beluga	swim	1	0	0
240	9/26/2018 16:22	72.003	154.585	beluga	swim	1	1	0
240	9/26/2018 16:22	72.009	154.588	beluga	swim	30	1	0
240	9/26/2018 16:22	72.009	154.614	beluga	swim	22	4	0
240	9/26/2018 16:22	72.010	154.614	beluga	swim	4	1	0
240	9/26/2018 16:22	72.010	154.647	beluga	swim	2	1	0
240	9/26/2018 16:23	72.004	154.668	beluga	swim	1	0	0
240	9/26/2018 16:25	71.957	154.809	unid cetacean	unknown	1	0	12
240	9/26/2018 16:30	71.840	154.541	bowhead whale	swim	1	0	12
240	9/26/2018 16:31	71.821	154.832	bowhead whale	swim	1	0	12
240	9/26/2018 16:34	71.841	154.752	bowhead whale	swim	1	1	12
240	9/26/2018 16:35	71.841	154.736	bowhead whale	dead	1	0	12
240	9/26/2018 16:36	71.830	154.712	bowhead whale	swim	1	1	12
240	9/26/2018 16:42	71.804	154.784	bowhead whale	mill	2	0	12
240	9/26/2018 16:43	71.792	154.750	bowhead whale	mill	2	0	12
240	9/26/2018 16:43	71.795	154.726	bowhead whale	swim	1	0	12
240	9/26/2018 16:43	71.801	154.730	bowhead whale	swim	1	0	12
240	9/26/2018 16:44	71.802	154.742	bowhead whale	swim	1	0	12
240	9/26/2018 16:45	71.804	154.726	bowhead whale	swim	1	0	12
240	9/26/2018 16:45	71.810	154.744	bowhead whale	mill	2	0	12

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
240	9/26/2018 16:45	71.812	154.753	bowhead whale	mill	4	0	12
240	9/26/2018 16:46	71.785	154.760	bowhead whale	mill	4	0	12
240	9/26/2018 16:46	71.779	154.799	bowhead whale	swim	1	0	12
240	9/26/2018 16:46	71.776	154.835	bowhead whale	swim	1	0	12
240	9/26/2018 16:46	71.775	154.804	bowhead whale	swim	1	0	12
240	9/26/2018 16:49	71.773	154.833	bowhead whale	swim	2	1	12
240	9/26/2018 16:52	71.762	154.762	bowhead whale	swim	1	0	12
240	9/26/2018 16:52	71.762	154.878	bowhead whale	swim	1	0	12
240	9/26/2018 16:52	71.760	154.874	bowhead whale	swim	1	0	12
240	9/26/2018 16:53	71.767	154.877	bowhead whale	swim	1	0	12
240	9/26/2018 17:34	71.687	155.379	bowhead whale	swim	1	0	12
240	9/26/2018 17:40	71.802	155.364	bowhead whale	swim	1	0	12
240	9/26/2018 17:45	71.914	155.240	bowhead whale	swim	1	0	12
240	9/26/2018 17:45	71.914	155.206	bowhead whale	swim	3	0	12
240	9/26/2018 17:45	71.924	155.270	bowhead whale	swim	1	0	12
240	9/26/2018 17:46	71.926	155.344	bowhead whale	swim	1	0	12
240	9/26/2018 17:46	71.931	155.331	bowhead whale	swim	1	0	12
240	9/26/2018 17:46	71.932	155.310	bowhead whale	swim	1	0	12
240	9/26/2018 17:48	71.902	155.207	bowhead whale	swim	2	0	12
240	9/26/2018 17:50	71.922	155.321	bowhead whale	swim	1	0	12
240	9/26/2018 17:51	71.946	155.366	bowhead whale	swim	2	0	12
240	9/26/2018 17:53	71.954	155.371	bowhead whale	swim	7	1	12
240	9/26/2018 17:57	71.980	155.438	bowhead whale	swim	1	0	12
240	9/26/2018 17:57	72.013	155.520	bowhead whale	swim	1	0	0
240	9/26/2018 17:57	72.016	155.527	bowhead whale	swim	1	0	0
240	9/26/2018 17:59	72.019	155.491	bowhead whale	swim	2	1	0
240	9/26/2018 17:59	72.011	155.485	bowhead whale	swim	1	0	0
240	9/26/2018 18:01	72.018	155.508	bowhead whale	swim	1	0	0
240	9/26/2018 18:02	72.012	155.594	bowhead whale	swim	1	0	0
240	9/26/2018 18:03	72.009	155.624	bowhead whale	swim	1	0	0
240	9/26/2018 18:08	71.963	155.737	bowhead whale	swim	1	0	12
240	9/26/2018 18:08	71.957	155.902	bowhead whale	swim	1	0	12

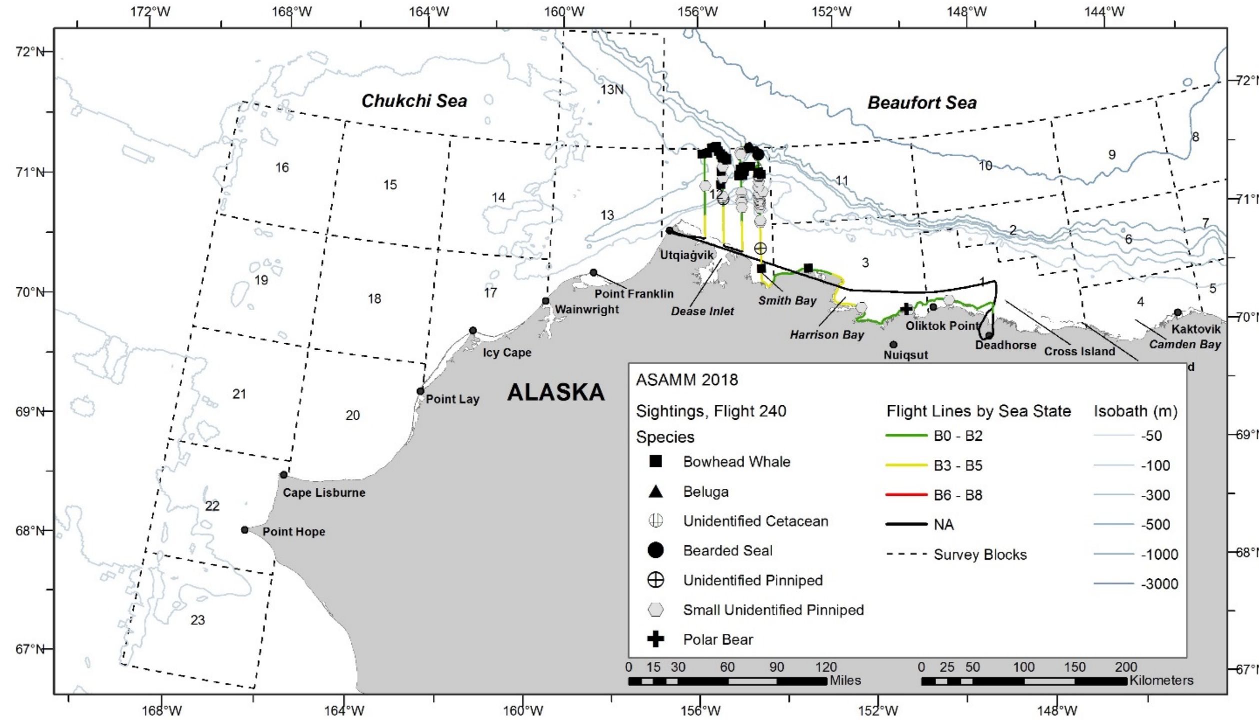

Figure B-76. Flight 240 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

26 September 2018, Flight 37

Flight was negligible effort on portions of transects 103, 104, 105, and 106, and offshore search effort from Cross Island to Camden Bay. Survey conditions included clear to partly cloudy skies, 1 km to unlimited visibility, with glare and low ceilings, and Beaufort 1-6 sea states. Sea ice was 0-25% broken floe and grease/new ice in the area surveyed. Sightings included bowhead whales, small unidentified pinnipeds, and polar bears.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
37	9/26/2018 16:25	69.921	141.818	bowhead whale	swim	1	0	5
37	9/26/2018 16:45	70.103	142.617	bowhead whale	swim	1	0	5
37	9/26/2018 17:16	70.222	145.345	bowhead whale	swim	1	0	4
37	9/26/2018 17:18	70.199	145.254	bowhead whale	swim	1	0	4
37	9/26/2018 17:20	70.227	145.318	bowhead whale	swim	1	0	4
37	9/26/2018 17:25	70.209	145.577	bowhead whale	swim	1	0	4
37	9/26/2018 17:32	70.250	145.680	bowhead whale	swim	1	0	4
37	9/26/2018 17:40	70.303	146.155	bowhead whale	swim	1	0	1

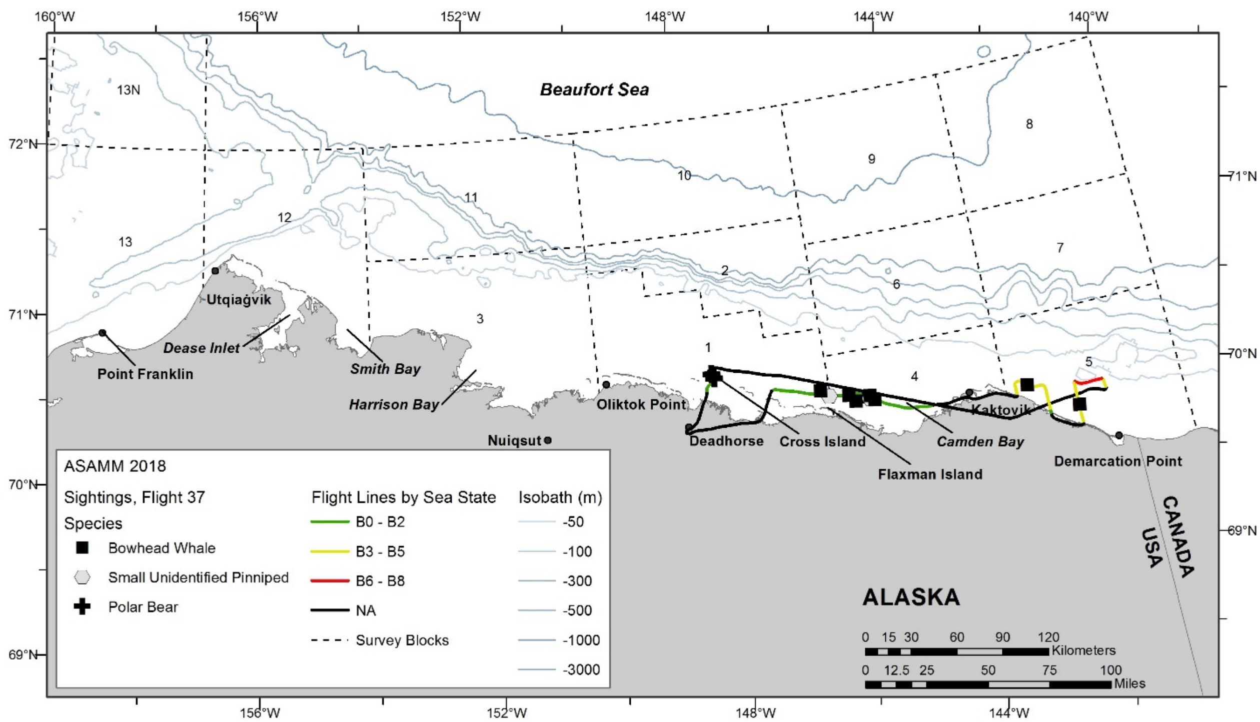

Figure B-77. Flight 37 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

27 September 2018, Flight 241

Flight was a complete survey of transect 14 and partial survey of transect 10. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 2-4 sea states. There was no sea ice in the area surveyed. Sightings included one gray whale, minke whales, one unidentified cetacean, walruses, small unidentified pinnipeds, and one polar bear.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
241	9/27/2018 12:13	71.019	164.773	minke whale	feed	3	0	15
241	9/27/2018 14:27	71.027	161.544	unid cetacean	unknown	1	0	14
241	9/27/2018 14:27	71.025	161.507	gray whale	feed	1	0	14

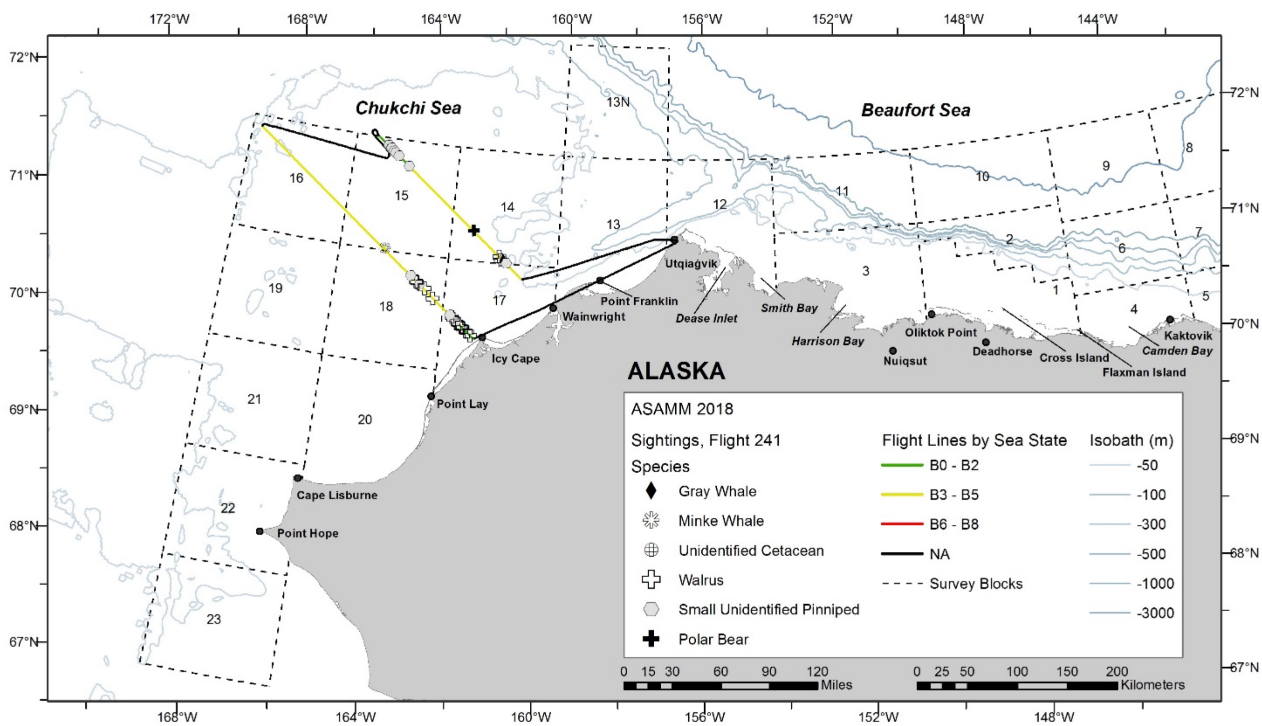

Figure B-78. Flight 241 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

28 September 2018, Flight 242

Flight was a coastal transect from Point Hope to north of Point Lay. Survey conditions included partly cloudy to overcast skies, 5 km to unlimited visibility, with glare and low ceilings, and Beaufort 2-6 sea states. There was no sea ice in the area surveyed. Sightings included walruses and small unidentified pinnipeds. A walrus haulout, estimated at 23,000 walruses, was observed on a barrier island near Point Lay.

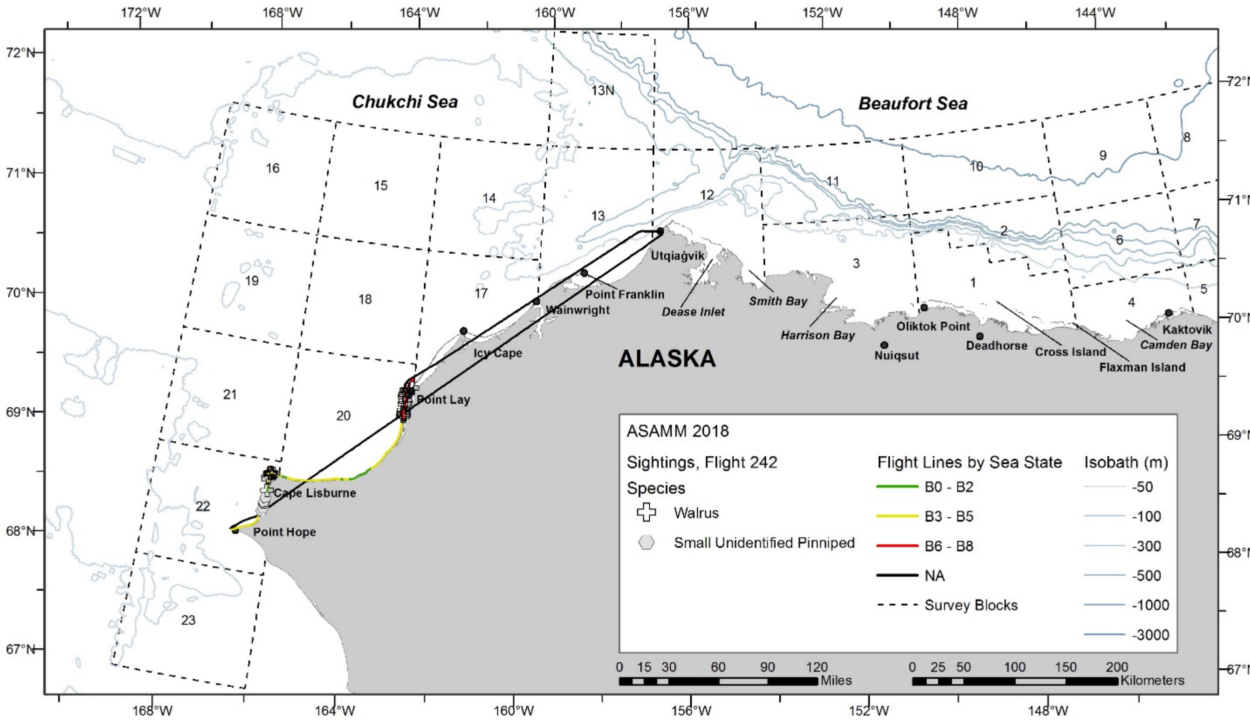

Figure B-79. Flight 242 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

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30 September 2018, Flight 243

Flight was a complete survey of transects 8, 9, 11, and 13. Survey conditions included clear skies, unlimited visibility, with glare, and Beaufort 1-4 sea states. There was no sea ice in the area surveyed. Sightings included one bowhead whale carcass, gray whales (including 2 calves), killer whales (including 1 calf), one beluga, one harbor porpoise, walruses, unidentified pinnipeds, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
243	9/30/2018 10:50	71.245	160.645	gray whale	feed	1	0	14
243	9/30/2018 10:56	71.248	160.666	gray whale	feed	1	0	14
243	9/30/2018 10:56	71.242	160.704	gray whale	feed	1	0	14
243	9/30/2018 11:20	71.667	162.220	harbor porpoise	swim	1	0	14
243	9/30/2018 11:53	71.904	163.813	bowhead whale	dead	1	0	15
243	9/30/2018 12:33	71.251	161.505	gray whale	feed	1	0	14
243	9/30/2018 12:33	71.250	161.501	gray whale	feed	1	0	14
243	9/30/2018 12:33	71.240	161.518	gray whale	feed	1	0	14
243	9/30/2018 12:34	71.231	161.478	gray whale	swim	1	0	14
243	9/30/2018 12:36	71.243	161.545	gray whale	feed	1	0	14
243	9/30/2018 12:37	71.219	161.579	gray whale	feed	1	0	14
243	9/30/2018 12:42	71.213	161.500	gray whale	feed	2	0	14
243	9/30/2018 12:46	71.204	161.513	gray whale	feed	2	0	14
243	9/30/2018 12:51	71.222	161.358	gray whale	feed	1	0	14
243	9/30/2018 12:51	71.210	161.356	gray whale	feed	1	0	14
243	9/30/2018 12:51	71.208	161.312	gray whale	feed	1	0	14
243	9/30/2018 13:01	71.066	161.109	gray whale	feed	4	0	14
243	9/30/2018 13:02	71.072	160.997	gray whale	swim	3	0	14
243	9/30/2018 13:02	71.076	160.964	gray whale	feed	3	0	14
243	9/30/2018 13:06	71.075	161.003	beluga	swim	1	0	14
243	9/30/2018 13:08	71.047	161.100	gray whale	feed	5	1	14
243	9/30/2018 13:15	71.067	160.913	gray whale	feed	1	0	14
243	9/30/2018 13:16	71.078	160.827	gray whale	feed	4	0	14
243	9/30/2018 13:16	71.073	160.808	gray whale	feed	3	0	14
243	9/30/2018 13:16	71.050	160.827	gray whale	feed	1	0	14
243	9/30/2018 13:16	71.040	160.838	gray whale	feed	1	0	14
243	9/30/2018 13:16	71.072	160.787	gray whale	feed	4	0	14
243	9/30/2018 13:16	71.070	160.782	gray whale	feed	1	0	14
243	9/30/2018 13:25	71.058	160.750	gray whale	feed	1	0	14
243	9/30/2018 13:25	71.046	160.775	gray whale	feed	1	0	14
243	9/30/2018 13:26	71.030	160.798	gray whale	feed	2	0	14
243	9/30/2018 13:26	71.046	160.749	gray whale	feed	1	0	14
243	9/30/2018 13:26	71.043	160.747	gray whale	feed	1	0	14
243	9/30/2018 13:26	71.042	160.744	gray whale	feed	1	0	14

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
243	9/30/2018 13:26	71.025	160.757	gray whale	feed	1	0	14
243	9/30/2018 13:26	71.043	160.685	gray whale	feed	1	0	14
243	9/30/2018 13:26	71.038	160.672	gray whale	feed	1	0	14
243	9/30/2018 13:29	71.042	160.683	gray whale	feed	2	0	14
243	9/30/2018 13:29	71.046	160.664	gray whale	feed	1	0	14
243	9/30/2018 13:30	71.044	160.668	gray whale	feed	1	0	14
243	9/30/2018 13:30	71.042	160.664	gray whale	feed	1	0	14
243	9/30/2018 13:30	71.043	160.697	gray whale	feed	1	0	14
243	9/30/2018 13:31	71.057	160.741	gray whale	feed	1	0	14
243	9/30/2018 13:31	71.060	160.753	gray whale	feed	2	0	14
243	9/30/2018 13:31	71.062	160.761	gray whale	feed	1	0	14
243	9/30/2018 13:32	71.040	160.809	gray whale	feed	2	0	14
243	9/30/2018 13:32	71.039	160.808	gray whale	feed	1	0	14
243	9/30/2018 13:32	71.038	160.798	gray whale	feed	2	1	14
243	9/30/2018 13:34	71.029	160.770	gray whale	feed	1	0	14
243	9/30/2018 13:34	71.028	160.764	gray whale	feed	1	0	14
243	9/30/2018 13:38	70.949	160.498	gray whale	swim	2	0	17
243	9/30/2018 13:38	70.949	160.470	gray whale	swim	3	0	17
243	9/30/2018 13:39	70.942	160.437	gray whale	feed	1	0	17
243	9/30/2018 13:39	70.940	160.443	gray whale	feed	1	0	17
243	9/30/2018 13:46	70.916	160.402	gray whale	feed	2	0	17
243	9/30/2018 13:46	70.883	160.475	gray whale	feed	1	0	17
243	9/30/2018 13:49	70.888	160.487	gray whale	feed	1	0	17
243	9/30/2018 13:50	70.893	160.445	gray whale	feed	1	0	17
243	9/30/2018 13:55	70.864	160.185	gray whale	swim	1	0	17
243	9/30/2018 15:57	70.506	161.976	gray whale	swim	1	0	17
243	9/30/2018 16:12	70.668	162.741	killer whale	swim	12	1	17
243	9/30/2018 18:53	70.785	161.514	gray whale	feed	3	0	17
243	9/30/2018 18:58	70.750	161.190	gray whale	feed	1	0	17

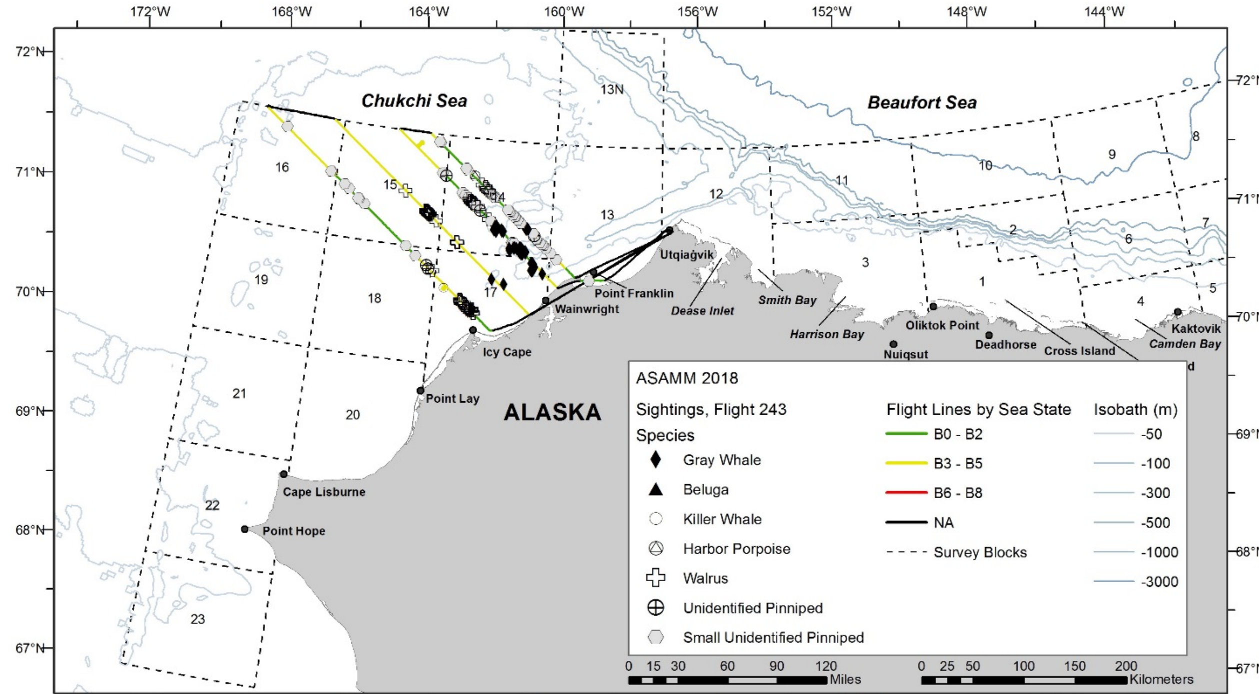

Figure B-80. Flight 243 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

30 September 2018, Flight 38

Flight was a complete survey of transect 10 and partial survey of transects 7, 129, 130, 131, 132, 133, and 134. Survey conditions included clear to partly cloudy skies, <1 km to unlimited visibility, with glare and low ceilings, and Beaufort 2-6 sea states. Sea ice was 0-5% grease/new ice in the area surveyed. Sightings included bowhead whales, gray whales, walruses, and polar bears.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
38	9/30/2018 12:31	71.442	155.353	bowhead whale	swim	1	0	12
38	9/30/2018 13:08	71.363	156.280	bowhead whale	swim	1	0	12
38	9/30/2018 13:27	71.535	156.765	bowhead whale	mill	3	0	12
38	9/30/2018 13:28	71.545	156.768	bowhead whale	mill	2	0	12
38	9/30/2018 15:31	70.754	160.511	gray whale	feed	2	0	17
38	9/30/2018 15:38	70.839	160.835	gray whale	mill	3	0	17
38	9/30/2018 15:44	70.893	161.003	gray whale	feed	1	0	17
38	9/30/2018 15:44	70.896	161.009	gray whale	feed	1	0	17
38	9/30/2018 15:44	70.891	161.034	gray whale	feed	1	0	17
38	9/30/2018 15:44	70.899	161.015	gray whale	feed	1	0	17
38	9/30/2018 15:44	70.897	161.053	gray whale	feed	1	0	17
38	9/30/2018 15:47	70.897	161.086	gray whale	feed	1	0	17
38	9/30/2018 15:49	70.893	161.012	gray whale	feed	1	0	17
38	9/30/2018 15:50	70.901	160.985	gray whale	feed	1	0	17
38	9/30/2018 15:50	70.887	160.988	gray whale	feed	1	0	17
38	9/30/2018 15:50	70.893	160.973	gray whale	feed	1	0	17
38	9/30/2018 15:52	70.896	160.996	gray whale	feed	1	0	17
38	9/30/2018 15:52	70.893	160.997	gray whale	feed	1	0	17
38	9/30/2018 15:53	70.897	160.993	gray whale	feed	1	0	17
38	9/30/2018 15:54	70.885	161.059	gray whale	feed	1	0	17
38	9/30/2018 15:54	70.887	161.037	gray whale	feed	1	0	17
38	9/30/2018 16:04	70.979	161.341	gray whale	feed	1	0	17
38	9/30/2018 16:04	70.983	161.341	gray whale	feed	1	0	17
38	9/30/2018 16:05	70.981	161.352	gray whale	feed	1	0	17
38	9/30/2018 16:05	70.983	161.358	gray whale	feed	1	0	17
38	9/30/2018 16:05	70.982	161.370	gray whale	feed	1	0	17
38	9/30/2018 16:05	70.988	161.359	gray whale	feed	2	0	17
38	9/30/2018 16:05	70.984	161.393	gray whale	feed	3	0	17
38	9/30/2018 16:05	70.978	161.417	gray whale	feed	3	0	17
38	9/30/2018 16:07	70.988	161.494	gray whale	feed	1	0	17
38	9/30/2018 16:07	70.991	161.492	gray whale	feed	2	0	17
38	9/30/2018 16:08	70.984	161.481	gray whale	feed	1	0	17
38	9/30/2018 16:10	70.974	161.414	gray whale	feed	1	0	17
38	9/30/2018 16:10	70.974	161.413	gray whale	feed	1	0	17

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
38	9/30/2018 16:11	70.981	161.445	gray whale	feed	1	0	17
38	9/30/2018 16:11	70.977	161.434	gray whale	feed	1	0	17
38	9/30/2018 16:13	70.978	161.388	gray whale	feed	1	0	17
38	9/30/2018 16:13	70.980	161.387	gray whale	feed	8	0	17
38	9/30/2018 16:16	70.984	161.371	gray whale	feed	1	0	17
38	9/30/2018 16:16	70.984	161.363	gray whale	feed	1	0	17
38	9/30/2018 16:16	70.982	161.354	gray whale	feed	1	0	17
38	9/30/2018 16:16	70.980	161.353	gray whale	feed	1	0	17
38	9/30/2018 16:17	70.976	161.359	gray whale	feed	7	0	17
38	9/30/2018 16:17	70.983	161.378	gray whale	feed	1	0	17
38	9/30/2018 16:17	70.982	161.348	gray whale	feed	4	0	17
38	9/30/2018 16:17	70.979	161.346	gray whale	feed	1	0	17
38	9/30/2018 16:18	70.981	161.327	gray whale	feed	8	0	17
38	9/30/2018 16:19	70.986	161.319	gray whale	feed	2	0	17
38	9/30/2018 16:21	70.991	161.296	gray whale	feed	1	0	17
38	9/30/2018 16:21	70.983	161.315	gray whale	feed	1	0	17
38	9/30/2018 16:22	70.996	161.347	gray whale	feed	1	0	17
38	9/30/2018 16:24	70.987	161.365	gray whale	feed	2	0	17
38	9/30/2018 16:24	70.986	161.366	gray whale	feed	1	0	17
38	9/30/2018 16:30	71.006	161.495	gray whale	feed	2	0	14
38	9/30/2018 16:36	71.016	161.454	gray whale	feed	2	0	14
38	9/30/2018 16:37	71.013	161.527	gray whale	feed	2	0	14
38	9/30/2018 16:37	71.010	161.542	gray whale	feed	1	0	14
38	9/30/2018 16:43	71.044	161.795	gray whale	feed	4	0	14

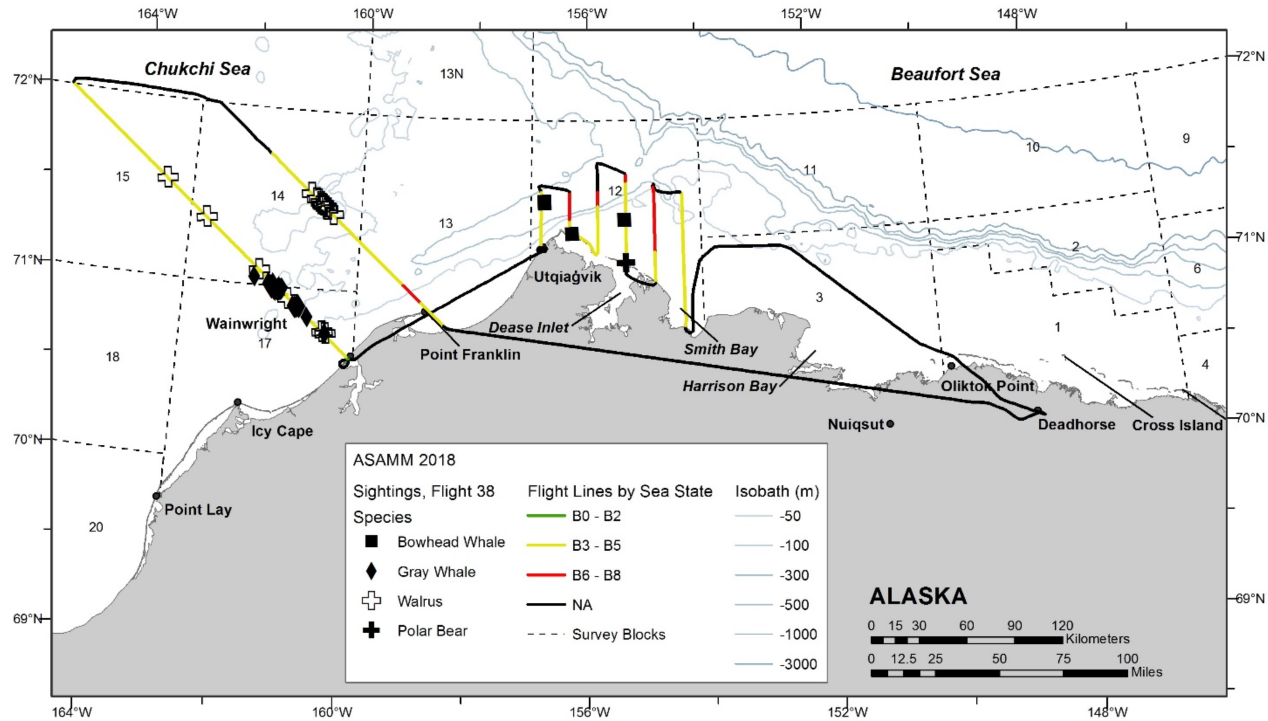

Figure B-81. Flight 38 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

2 October 2018, Flight 244

Flight was a complete survey of transects 16 and 18. Survey conditions included clear skies, unlimited visibility, with glare, and Beaufort 2-4 sea states. There was no sea ice in the area surveyed. Sightings included harbor porpoises, walruses, unidentified pinnipeds, and small unidentified pinnipeds. A walrus haulout, estimated at 40,000 walruses, was observed on a barrier island near Point Lay, Alaska.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
244	10/2/2018 13:18	70.420	164.150	harbor porpoise	swim	1	0	18
244	10/2/2018 13:19	70.396	164.056	harbor porpoise	swim	2	0	18

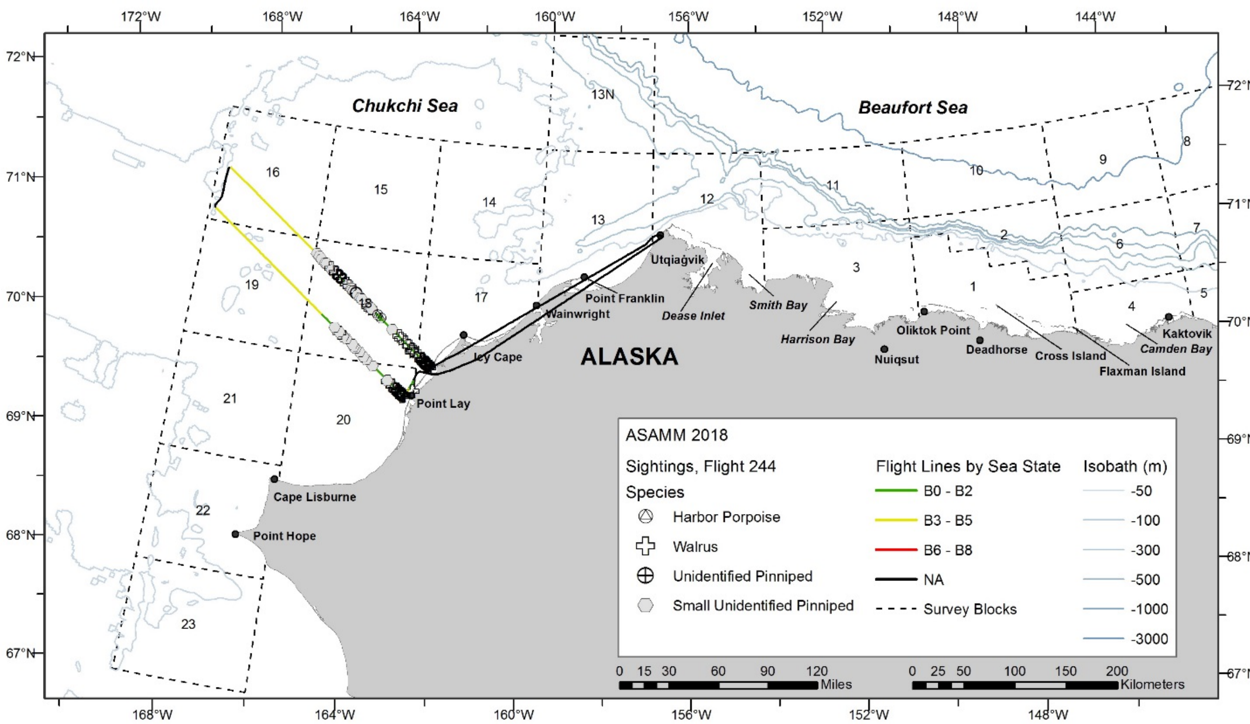

Figure B-82. Flight 244 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

3 October 2018, Flight 245

Flight was a partial survey of transects 15, 17, and 19. Survey conditions included clear skies, <1 km to unlimited visibility, with glare, haze, and low ceilings, and Beaufort 2-6 sea states. There was no sea ice in the area surveyed. Sightings included walruses, one bearded seal, and small unidentified pinnipeds. Two walrus haulouts, estimated at 20,000 and 3,000 walruses, were observed on a barrier island near Point Lay, Alaska.

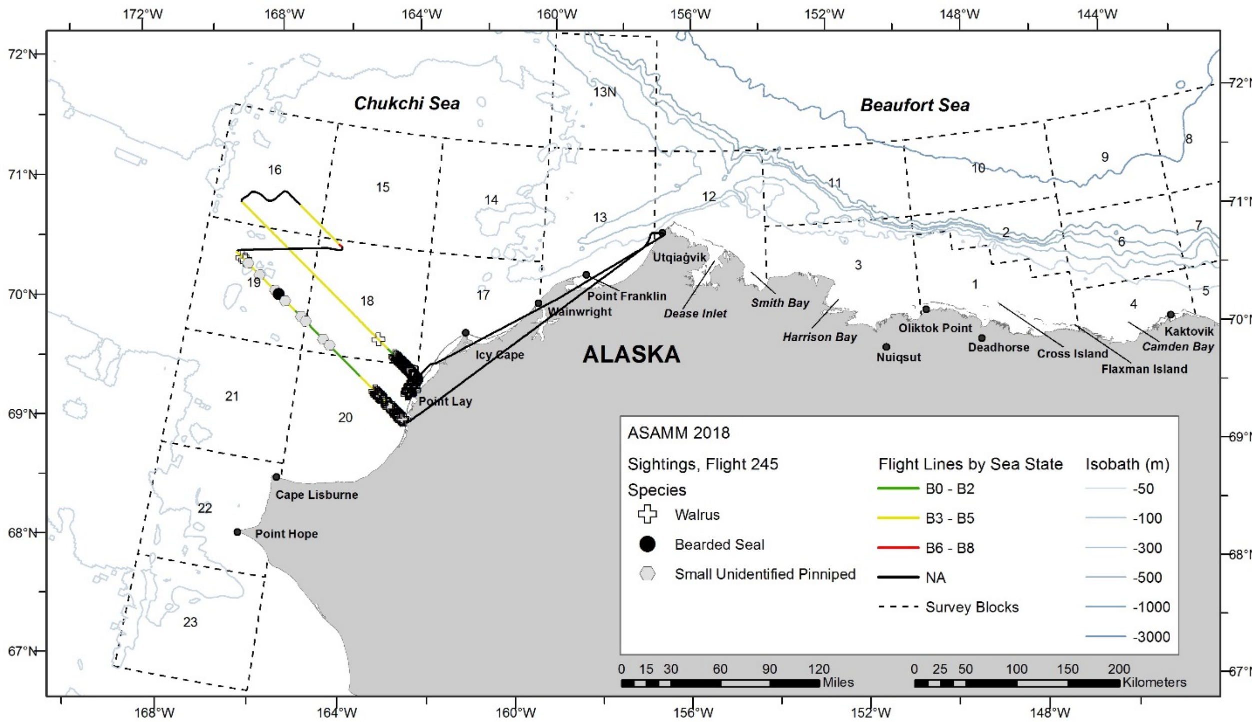

Figure B-83. Flight 245 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

3 October 2018, Flight 39

Flight was a coastal transect from the western side of Harrison Bay to approximately 150°W and search effort at Cross Island. Survey conditions included clear skies, 2 km to unlimited visibility, with glare and haze, and Beaufort 0-7 sea states. Sea ice was 0-100% broken floe and grease/new ice in the area surveyed. Sightings included polar bears.

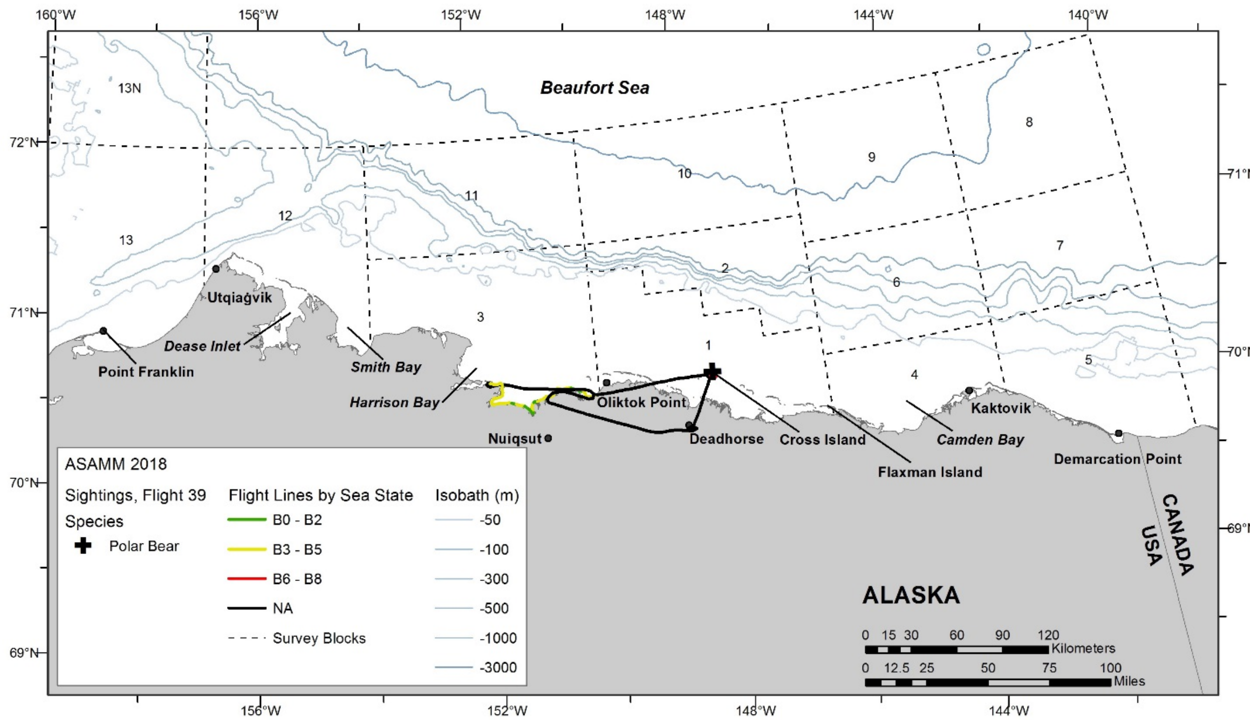

Figure B-84. Flight 39 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

5 October 2018, Flight 246

Flight was a complete survey of transect 22 and partial survey of transect 20. Survey conditions included clear to partly cloudy skies, 0 km to unlimited visibility, with glare and low ceilings, and Beaufort 1-4 sea states. There was no sea ice in the area surveyed. Sightings included harbor porpoises, walruses, one unidentified pinniped, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
246	10/5/2018 13:35	69.318	164.812	harbor porpoise	swim	1	0	20
246	10/5/2018 14:46	70.596	168.337	harbor porpoise	swim	3	0	19

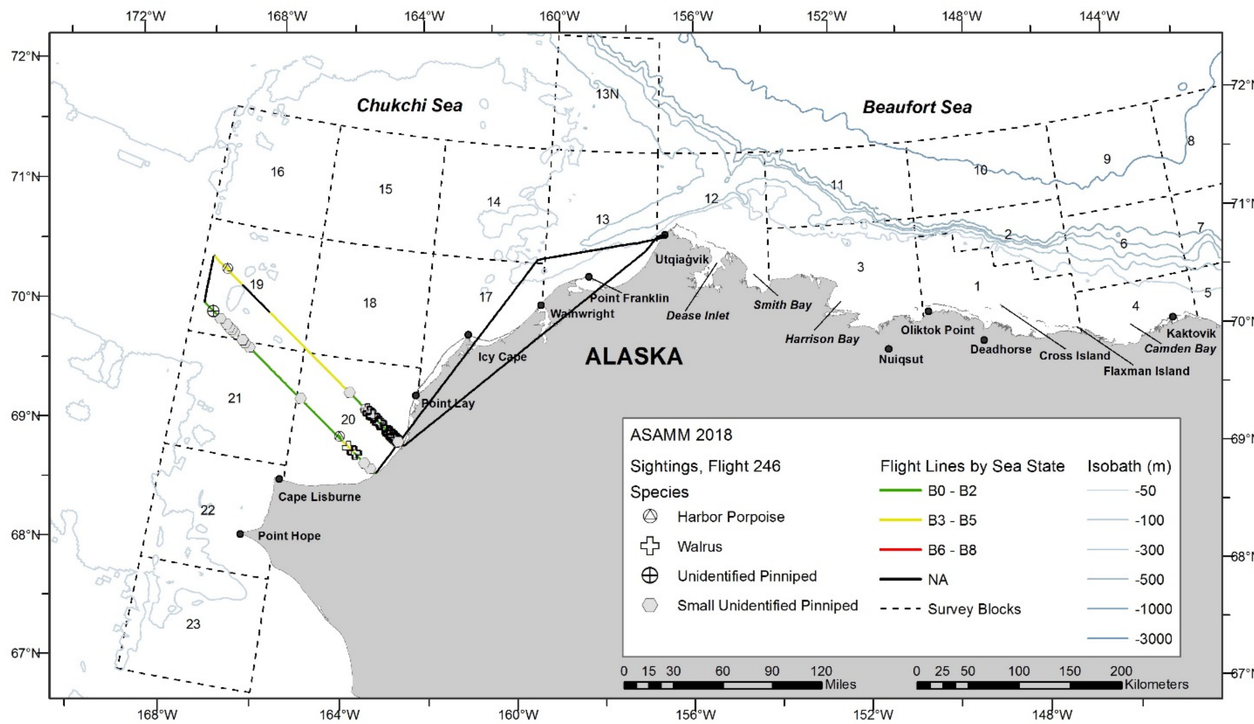

Figure B-85. Flight 246 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

6 October 2018, Flight 247

Flight was a complete survey of transect 32 and partial survey of transects 30, 31, 33, 34, and 35. Survey conditions included clear to partly cloudy, 2 km to unlimited visibility, with glare and low ceilings, and Beaufort 2-6 sea states. There was no sea ice in the area surveyed. Sightings included gray whales, one fin whale, walruses, and one small unidentified pinniped.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
247	10/6/2018 13:37	67.810	168.701	gray whale	swim	1	0	23
247	10/6/2018 13:44	67.800	168.233	fin whale	feed	1	0	23
247	10/6/2018 13:45	67.801	168.256	gray whale	feed	2	0	23

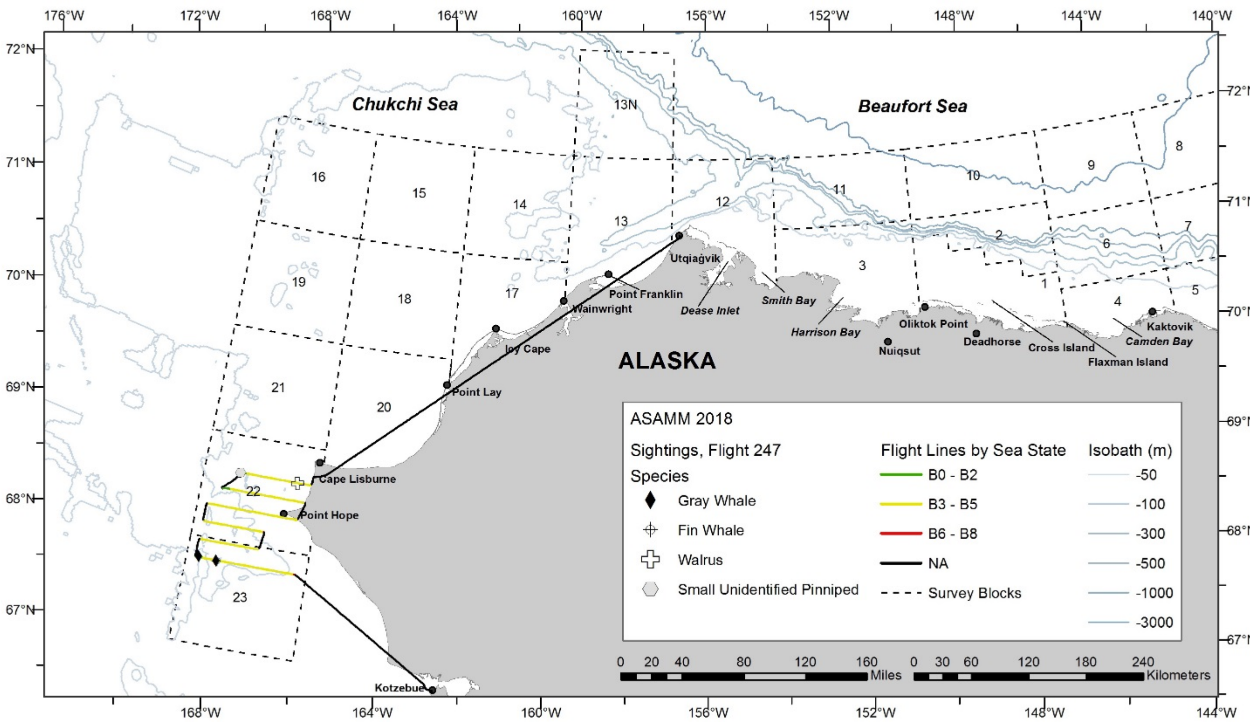

Figure B-86. Flight 247 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

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7 October 2018, Flight 248

Flight was a deadhead transit from Kotzebue to Utqiaġvik following aircraft maintenance, with reconnaissance of offshore survey conditions. Fog and high sea states prevented the commencement of survey efforts. There were no marine mammal sightings.

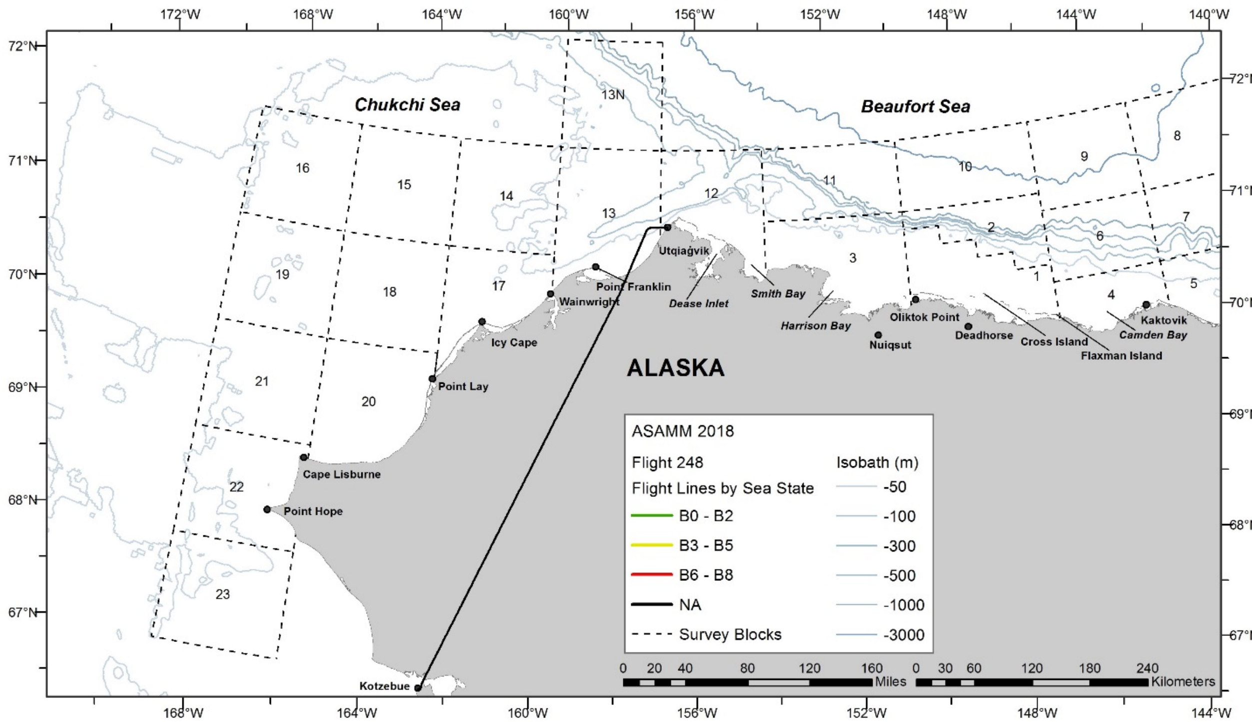

Figure B-87. Flight 248 survey track, depicted by sea state; and excludes carcass sightings.

7 October 2018, Flight 40

Flight was a complete survey of transects 111, 112, 113, 114, 115, 116, and 117, and partial survey of transects 107, 108, 109, and 110. Survey conditions included clear skies, unlimited visibility with glare, and Beaufort 1-6 sea states. Sea ice was 0-100% grease/new ice in the area surveyed. Sightings included bowhead whales (including 1 calf), belugas (including 2 calves), and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
40	10/7/2018 12:07	70.934	145.326	beluga	swim	1	0	6
40	10/7/2018 13:17	70.949	146.332	beluga	swim	1	0	2
40	10/7/2018 13:18	70.953	146.342	beluga	swim	1	0	2
40	10/7/2018 13:18	70.965	146.347	beluga	swim	1	0	2
40	10/7/2018 13:18	70.968	146.338	beluga	swim	1	0	2
40	10/7/2018 13:18	70.973	146.366	beluga	swim	2	0	2
40	10/7/2018 13:24	71.183	146.344	beluga	swim	1	0	2
40	10/7/2018 15:26	70.434	147.288	bowhead whale	swim	2	1	1
40	10/7/2018 15:26	70.443	147.314	bowhead whale	swim	1	0	1
40	10/7/2018 15:32	70.476	147.385	bowhead whale	swim	1	0	1
40	10/7/2018 15:52	71.089	147.317	beluga	swim	1	0	2
40	10/7/2018 15:52	71.093	147.327	beluga	swim	3	0	2
40	10/7/2018 15:52	71.100	147.328	beluga	swim	2	1	2
40	10/7/2018 15:56	71.243	147.303	beluga	swim	1	0	2
40	10/7/2018 15:56	71.247	147.330	beluga	swim	2	1	2
40	10/7/2018 15:56	71.252	147.316	beluga	swim	1	0	2
40	10/7/2018 15:56	71.255	147.309	beluga	swim	1	0	2
40	10/7/2018 16:03	71.311	147.830	beluga	swim	1	0	2
40	10/7/2018 16:04	71.311	147.814	beluga	swim	1	0	2
40	10/7/2018 16:04	71.293	147.828	beluga	swim	1	0	2
40	10/7/2018 16:04	71.291	147.817	beluga	swim	1	0	2
40	10/7/2018 16:04	71.283	147.828	beluga	swim	1	0	2
40	10/7/2018 16:05	71.280	147.821	beluga	swim	1	0	2
40	10/7/2018 16:05	71.260	147.816	beluga	swim	1	0	2
40	10/7/2018 16:06	71.249	147.825	beluga	swim	3	0	2
40	10/7/2018 16:29	70.516	147.835	bowhead whale	swim	1	0	1
40	10/7/2018 16:29	70.515	147.842	bowhead whale	swim	1	0	1
40	10/7/2018 16:29	70.512	147.840	bowhead whale	swim	1	0	1
40	10/7/2018 16:29	70.506	147.869	bowhead whale	swim	1	0	1

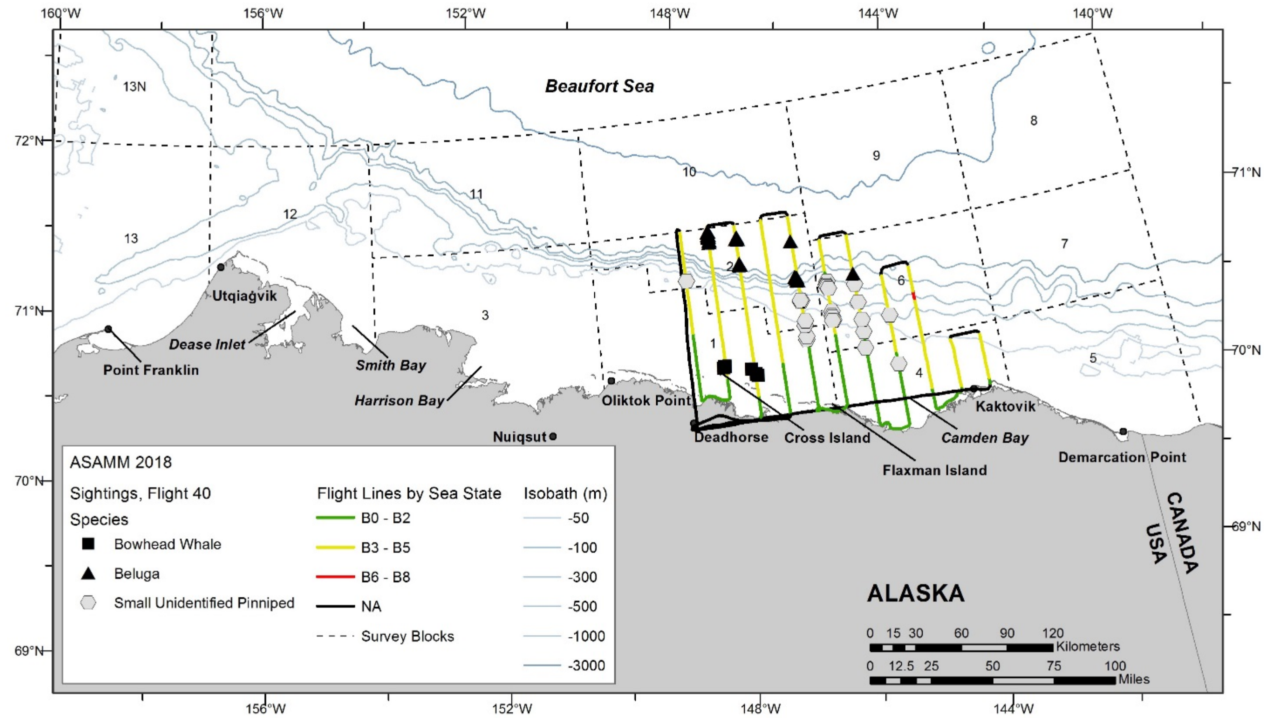

Figure B-88. Flight 40 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

8 October 2018, Flight 249

Flight was a complete survey of transects 129, 130, and 131, and partial survey of transects 132, 133, and 134. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 1-5 sea states. Sea ice ranged 0-80% grease/new ice in the area surveyed. Sightings included bowhead whales (including 4 calves), belugas (including 6 calves), and one unidentified pinniped.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
249	10/8/2018 10:43	71.046	154.347	bowhead whale	swim	1	0	12
249	10/8/2018 10:52	71.261	154.326	beluga	swim	1	0	12
249	10/8/2018 10:52	71.264	154.326	beluga	swim	2	0	12
249	10/8/2018 10:52	71.264	154.323	beluga	swim	2	0	12
249	10/8/2018 10:52	71.269	154.330	beluga	swim	10	1	12
249	10/8/2018 10:52	71.271	154.334	beluga	swim	1	0	12
249	10/8/2018 11:12	71.917	154.339	bowhead whale	swim	1	0	12
249	10/8/2018 11:30	71.891	154.847	bowhead whale	swim	1	0	12
249	10/8/2018 11:30	71.889	154.818	bowhead whale	swim	1	1	12
249	10/8/2018 11:30	71.877	154.819	bowhead whale	swim	1	0	12
249	10/8/2018 11:30	71.876	154.825	bowhead whale	swim	1	0	12
249	10/8/2018 11:31	71.866	154.862	bowhead whale	swim	1	0	12
249	10/8/2018 11:31	71.861	154.858	bowhead whale	swim	1	0	12
249	10/8/2018 11:31	71.849	154.854	bowhead whale	swim	1	0	12
249	10/8/2018 11:33	71.853	154.829	bowhead whale	swim	1	0	12
249	10/8/2018 11:34	71.848	154.903	bowhead whale	swim	1	0	12
249	10/8/2018 11:36	71.860	154.874	bowhead whale	swim	2	0	12
249	10/8/2018 11:37	71.862	154.908	bowhead whale	swim	1	0	12
249	10/8/2018 11:38	71.867	154.881	bowhead whale	swim	1	0	12
249	10/8/2018 11:39	71.872	154.853	bowhead whale	rest	1	0	12
249	10/8/2018 11:40	71.875	154.857	bowhead whale	rest	1	0	12
249	10/8/2018 11:40	71.876	154.874	bowhead whale	SAG	2	2	12
249	10/8/2018 11:43	71.887	154.876	bowhead whale	unknown	1	0	12
249	10/8/2018 11:48	71.895	154.780	bowhead whale	swim	1	0	12
249	10/8/2018 11:48	71.886	154.790	bowhead whale	SAG	3	0	12
249	10/8/2018 11:50	71.908	154.781	bowhead whale	swim	1	0	12
249	10/8/2018 11:52	71.858	154.800	bowhead whale	swim	1	0	12
249	10/8/2018 11:58	71.706	154.810	beluga	swim	1	0	12
249	10/8/2018 11:58	71.705	154.835	beluga	swim	1	0	12
249	10/8/2018 11:58	71.705	154.805	beluga	swim	1	0	12
249	10/8/2018 12:00	71.653	154.833	beluga	swim	1	0	12
249	10/8/2018 12:02	71.563	154.784	bowhead whale	swim	1	0	12
249	10/8/2018 12:41	71.701	155.299	bowhead whale	rest	1	0	12
249	10/8/2018 12:42	71.717	155.328	bowhead whale	swim	1	0	12

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
249	10/8/2018 12:42	71.721	155.329	bowhead whale	swim	1	0	12
249	10/8/2018 12:48	71.748	155.300	bowhead whale	swim	1	0	12
249	10/8/2018 12:48	71.754	155.386	bowhead whale	mill	3	0	12
249	10/8/2018 12:49	71.761	155.337	bowhead whale	swim	1	0	12
249	10/8/2018 12:49	71.764	155.307	bowhead whale	swim	1	0	12
249	10/8/2018 12:49	71.767	155.339	bowhead whale	swim	1	0	12
249	10/8/2018 12:49	71.771	155.285	bowhead whale	swim	1	0	12
249	10/8/2018 12:49	71.772	155.324	bowhead whale	swim	1	0	12
249	10/8/2018 12:49	71.783	155.348	bowhead whale	swim	1	0	12
249	10/8/2018 12:49	71.787	155.346	bowhead whale	swim	1	0	12
249	10/8/2018 12:50	71.789	155.321	bowhead whale	swim	1	0	12
249	10/8/2018 12:50	71.790	155.340	bowhead whale	swim	1	0	12
249	10/8/2018 12:50	71.793	155.318	bowhead whale	swim	1	0	12
249	10/8/2018 12:50	71.795	155.317	bowhead whale	swim	1	0	12
249	10/8/2018 12:50	71.809	155.309	bowhead whale	swim	1	0	12
249	10/8/2018 12:50	71.816	155.354	bowhead whale	swim	1	0	12
249	10/8/2018 12:50	71.819	155.305	bowhead whale	swim	1	0	12
249	10/8/2018 12:52	71.808	155.309	bowhead whale	swim	1	0	12
249	10/8/2018 12:53	71.816	155.300	beluga	swim	2	1	12
249	10/8/2018 12:53	71.815	155.281	beluga	swim	2	1	12
249	10/8/2018 12:53	71.800	155.278	beluga	swim	2	0	12
249	10/8/2018 12:54	71.796	155.306	bowhead whale	swim	1	0	12
249	10/8/2018 12:54	71.799	155.312	beluga	swim	4	1	12
249	10/8/2018 12:55	71.789	155.310	bowhead whale	swim	1	0	12
249	10/8/2018 12:56	71.795	155.309	bowhead whale	rest	1	0	12
249	10/8/2018 12:56	71.799	155.305	beluga	swim	3	0	12
249	10/8/2018 12:57	71.786	155.328	bowhead whale	rest	1	0	12
249	10/8/2018 12:58	71.790	155.259	bowhead whale	swim	1	0	12
249	10/8/2018 12:59	71.763	155.287	bowhead whale	rest	1	0	12
249	10/8/2018 13:00	71.765	155.318	bowhead whale	swim	1	0	12
249	10/8/2018 13:00	71.761	155.320	bowhead whale	swim	1	0	12
249	10/8/2018 13:01	71.757	155.296	bowhead whale	swim	1	0	12
249	10/8/2018 13:01	71.750	155.298	bowhead whale	rest	2	0	12
249	10/8/2018 13:01	71.751	155.303	bowhead whale	rest	1	0	12
249	10/8/2018 13:01	71.755	155.311	bowhead whale	swim	1	0	12
249	10/8/2018 13:02	71.753	155.258	bowhead whale	swim	1	0	12
249	10/8/2018 13:03	71.752	155.314	bowhead whale	rest	2	0	12
249	10/8/2018 13:04	71.759	155.321	bowhead whale	swim	1	0	12
249	10/8/2018 13:08	71.745	155.319	beluga	swim	1	0	12
249	10/8/2018 13:09	71.763	155.356	bowhead whale	swim	1	0	12
249	10/8/2018 13:09	71.760	155.362	bowhead whale	dive	1	0	12
249	10/8/2018 13:09	71.758	155.362	bowhead whale	swim	2	0	12

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
249	10/8/2018 13:09	71.753	155.344	bowhead whale	swim	1	0	12
249	10/8/2018 13:10	71.768	155.322	bowhead whale	rest	1	0	12
249	10/8/2018 13:11	71.774	155.351	beluga	swim	2	0	12
249	10/8/2018 13:11	71.769	155.354	bowhead whale	rest	1	0	12
249	10/8/2018 13:11	71.767	155.346	bowhead whale	rest	1	0	12
249	10/8/2018 13:13	71.783	155.320	bowhead whale	swim	1	1	12
249	10/8/2018 13:13	71.786	155.299	bowhead whale	swim	1	0	12
249	10/8/2018 13:14	71.785	155.341	bowhead whale	swim	1	0	12
249	10/8/2018 13:15	71.788	155.313	beluga	swim	1	0	12
249	10/8/2018 13:15	71.799	155.318	bowhead whale	swim	1	0	12
249	10/8/2018 13:15	71.810	155.339	bowhead whale	dive	1	0	12
249	10/8/2018 13:17	71.824	155.309	beluga	swim	8	0	12
249	10/8/2018 13:17	71.833	155.320	beluga	swim	4	0	12
249	10/8/2018 13:19	71.820	155.404	bowhead whale	rest	2	0	12
249	10/8/2018 13:20	71.803	155.399	bowhead whale	rest	1	0	12
249	10/8/2018 13:22	71.774	155.361	bowhead whale	swim	1	0	12
249	10/8/2018 13:22	71.779	155.347	bowhead whale	rest	1	0	12
249	10/8/2018 13:22	71.769	155.365	bowhead whale	rest	1	0	12
249	10/8/2018 13:24	71.746	155.394	bowhead whale	swim	1	0	12
249	10/8/2018 13:24	71.740	155.399	bowhead whale	swim	1	0	12
249	10/8/2018 13:25	71.744	155.392	bowhead whale	rest	1	0	12
249	10/8/2018 13:30	71.841	155.324	beluga	swim	3	0	12
249	10/8/2018 13:30	71.842	155.355	bowhead whale	swim	1	0	12
249	10/8/2018 13:31	71.839	155.335	bowhead whale	mill	2	0	12
249	10/8/2018 13:32	71.841	155.328	beluga	swim	2	1	12
249	10/8/2018 13:33	71.840	155.356	beluga	swim	4	1	12
249	10/8/2018 13:33	71.850	155.298	beluga	swim	2	0	12
249	10/8/2018 13:52	71.756	155.801	bowhead whale	rest	1	0	12
249	10/8/2018 13:54	71.762	155.818	bowhead whale	swim	1	0	12
249	10/8/2018 13:58	71.645	155.822	bowhead whale	dive	1	0	12
249	10/8/2018 14:15	71.650	156.325	bowhead whale	swim	1	0	12
249	10/8/2018 14:16	71.673	156.384	bowhead whale	swim	1	0	12
249	10/8/2018 14:19	71.746	156.359	bowhead whale	swim	2	0	12
249	10/8/2018 14:20	71.749	156.364	bowhead whale	swim	1	0	12
249	10/8/2018 14:21	71.745	156.348	bowhead whale	swim	1	0	12
249	10/8/2018 14:21	71.750	156.340	bowhead whale	swim	1	0	12

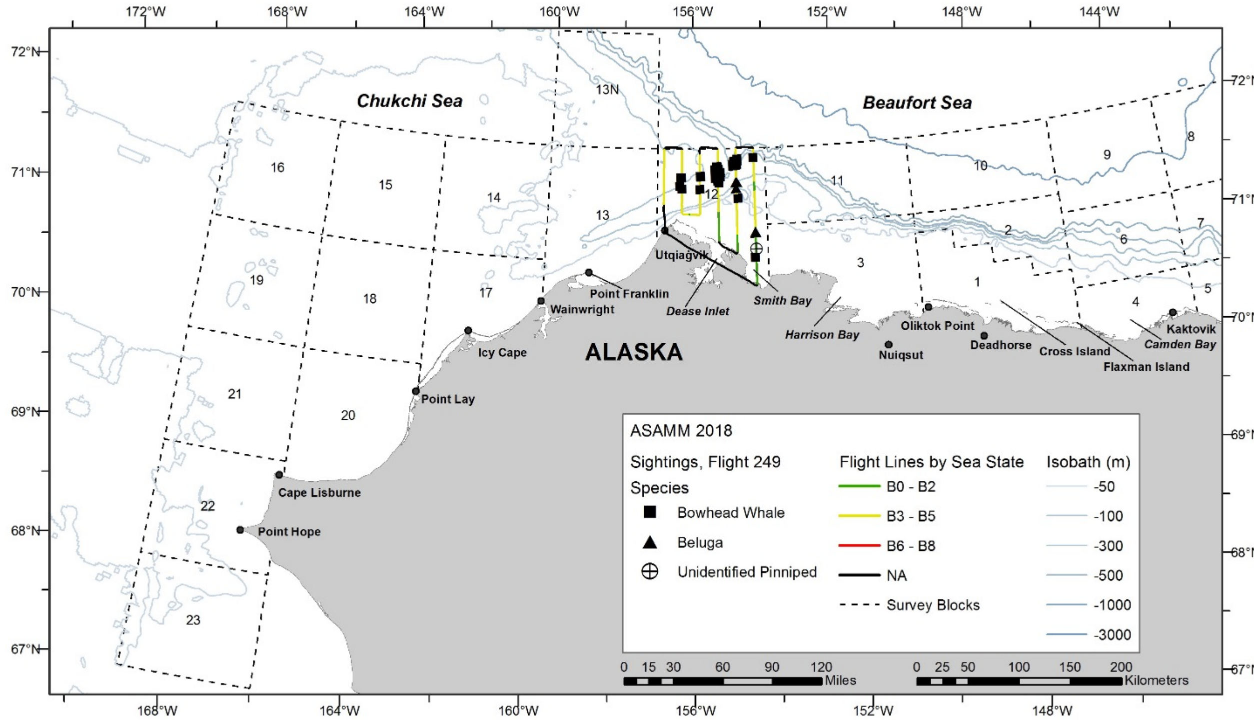

Figure B-89. Flight 249 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

8 October 2018, Flight 41

Flight was a complete survey of transects 123, 124, 125, and 126, partial survey of transect 127, and coastal transect in Harrison Bay. Survey conditions included partly cloudy to overcast skies, 5 km to unlimited visibility, with glare, and Beaufort 1-4 sea states. Sea ice was 0-95% grease/new ice in the area surveyed. Sightings included bowhead whales, belugas (including 4 calves), and one unidentified cetacean.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
41	10/8/2018 11:18	71.039	151.317	bowhead whale	swim	1	0	3
41	10/8/2018 11:21	71.059	151.277	bowhead whale	swim	1	0	3
41	10/8/2018 11:21	71.063	151.288	bowhead whale	swim	1	0	3
41	10/8/2018 11:25	71.107	151.332	bowhead whale	swim	1	0	3
41	10/8/2018 11:39	71.485	151.301	beluga	swim	2	0	11
41	10/8/2018 11:39	71.493	151.302	beluga	swim	1	0	11
41	10/8/2018 11:39	71.508	151.327	beluga	rest	1	0	11
41	10/8/2018 11:39	71.511	151.304	beluga	swim	1	0	11
41	10/8/2018 11:40	71.515	151.326	beluga	rest	1	0	11
41	10/8/2018 12:18	71.417	151.822	unid cetacean	unknown	1	0	11
41	10/8/2018 12:28	71.239	151.806	beluga	swim	3	1	3
41	10/8/2018 13:08	71.210	152.298	bowhead whale	swim	1	0	3
41	10/8/2018 13:27	71.785	152.349	beluga	swim	1	0	11
41	10/8/2018 13:27	71.795	152.309	beluga	swim	1	0	11
41	10/8/2018 13:27	71.796	152.303	beluga	rest	1	0	11
41	10/8/2018 13:27	71.805	152.292	beluga	rest	1	0	11
41	10/8/2018 13:28	71.814	152.336	beluga	swim	1	0	11
41	10/8/2018 13:28	71.844	152.316	beluga	swim	11	2	11
41	10/8/2018 13:29	71.847	152.337	beluga	swim	5	1	11
41	10/8/2018 13:30	71.906	152.313	beluga	swim	6	0	11
41	10/8/2018 13:39	71.953	152.803	beluga	swim	1	0	11
41	10/8/2018 14:00	71.304	152.826	bowhead whale	swim	1	0	3
41	10/8/2018 14:01	71.263	152.797	bowhead whale	swim	1	0	3
41	10/8/2018 14:02	71.245	152.886	bowhead whale	swim	2	0	3
41	10/8/2018 14:03	71.245	152.878	bowhead whale	swim	1	0	3
41	10/8/2018 14:03	71.255	152.885	bowhead whale	swim	1	0	3
41	10/8/2018 14:03	71.258	152.886	bowhead whale	swim	1	0	3
41	10/8/2018 14:04	71.269	152.891	bowhead whale	swim	1	0	3
41	10/8/2018 14:06	71.231	152.832	bowhead whale	mill	5	0	3
41	10/8/2018 14:06	71.229	152.800	bowhead whale	swim	1	0	3
41	10/8/2018 14:06	71.225	152.786	bowhead whale	swim	1	0	3
41	10/8/2018 14:33	71.299	153.299	bowhead whale	rest	1	0	3
41	10/8/2018 14:38	71.350	153.361	bowhead whale	swim	1	0	11
41	10/8/2018 14:40	71.382	153.313	bowhead whale	rest	1	0	11

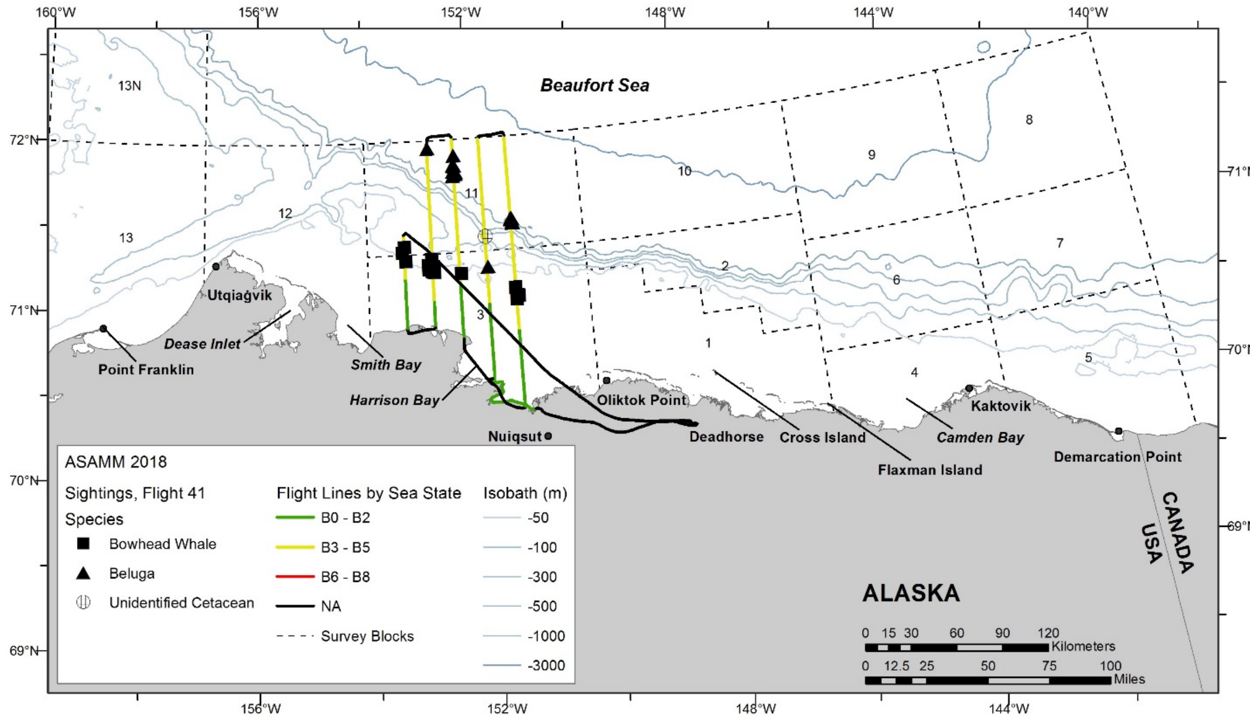

Figure B-90. Flight 41 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

9 October 2018, Flight 250

Flight was a complete survey of transects 7 and 9, and partial survey of transect 5. Survey conditions included partly cloudy skies, <1 km to unlimited visibility, with glare, ice on the window, low ceilings, and precipitation, and Beaufort 2-4 sea states. There was no sea ice in the area surveyed. Sightings included gray whales (including 1 calf), one unidentified cetacean, walruses, one unidentified pinniped, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
250	10/9/2018 12:57	71.058	160.787	gray whale	feed	1	0	14
250	10/9/2018 12:58	71.073	160.826	gray whale	feed	1	0	14
250	10/9/2018 12:59	71.069	160.820	gray whale	feed	1	0	14
250	10/9/2018 13:01	71.058	160.794	gray whale	feed	1	0	14
250	10/9/2018 13:01	71.058	160.793	gray whale	feed	2	1	14
250	10/9/2018 13:01	71.061	160.785	gray whale	feed	1	0	14
250	10/9/2018 13:02	71.061	160.777	gray whale	feed	1	0	14
250	10/9/2018 13:03	71.059	160.745	gray whale	mill	2	0	14
250	10/9/2018 13:04	71.051	160.739	gray whale	feed	1	0	14
250	10/9/2018 13:04	71.066	160.737	gray whale	feed	1	0	14
250	10/9/2018 13:04	71.068	160.741	gray whale	feed	1	0	14
250	10/9/2018 13:04	71.069	160.746	gray whale	feed	1	0	14
250	10/9/2018 13:05	71.065	160.773	gray whale	feed	1	0	14
250	10/9/2018 13:06	71.047	160.714	gray whale	feed	1	0	14
250	10/9/2018 13:06	71.047	160.713	gray whale	feed	1	0	14
250	10/9/2018 13:06	71.049	160.727	gray whale	SAG	2	0	14
250	10/9/2018 13:10	71.046	160.808	gray whale	swim	1	0	14
250	10/9/2018 13:13	71.029	160.733	gray whale	swim	1	0	14
250	10/9/2018 13:15	71.048	160.797	gray whale	feed	1	0	14
250	10/9/2018 13:26	71.184	161.367	gray whale	feed	1	0	14
250	10/9/2018 13:26	71.197	161.341	gray whale	feed	1	0	14
250	10/9/2018 13:32	71.208	161.318	gray whale	feed	2	0	14
250	10/9/2018 13:34	71.201	161.420	gray whale	feed	1	0	14
250	10/9/2018 13:35	71.191	161.444	gray whale	feed	2	0	14
250	10/9/2018 13:39	71.218	161.454	gray whale	feed	1	0	14
250	10/9/2018 13:40	71.224	161.515	gray whale	feed	1	0	14
250	10/9/2018 13:46	71.294	161.638	unid cetacean	swim	1	0	14

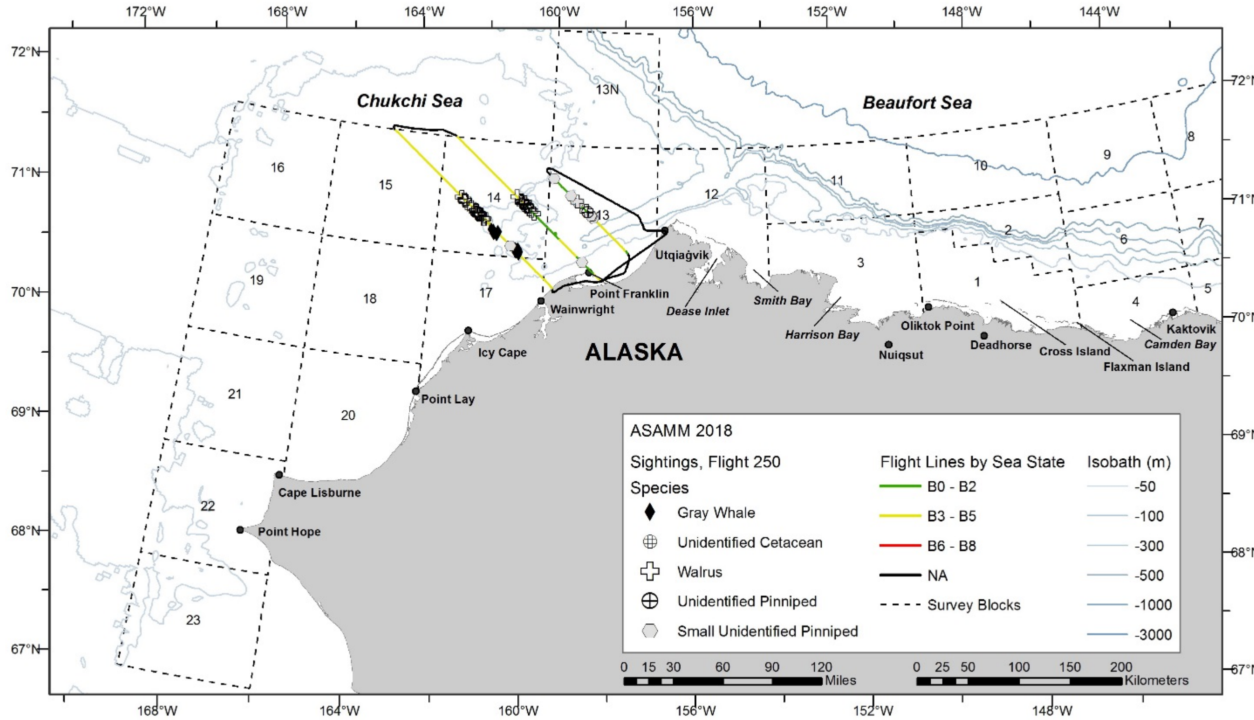

Figure B-91. Flight 250 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

14 October 2018, Flight 251

Flight was a complete survey of transects 130, 131, and 132, partial survey of transect 129, negligible effort on transect 124, and coastal transect in Harrison Bay. Survey conditions included partly cloudy to overcast skies, <1 km to unlimited visibility, with ice on the window, low ceilings, and precipitation, and Beaufort 0-5 sea states. There was 0-100% grease/new ice in the area surveyed. Sightings included bowhead whales (including 2 calves) and belugas (including 1 calf).

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
251	10/14/2018 13:24	71.222	154.325	bowhead whale	swim	1	0	12
251	10/14/2018 13:25	71.232	154.355	bowhead whale	swim	1	0	12
251	10/14/2018 13:35	71.597	154.336	bowhead whale	swim	1	0	12
251	10/14/2018 14:12	71.260	154.748	bowhead whale	swim	1	0	12
251	10/14/2018 14:15	71.275	154.810	bowhead whale	unknown	1	0	12
251	10/14/2018 14:15	71.273	154.817	bowhead whale	mill	2	0	12
251	10/14/2018 14:30	71.347	155.349	bowhead whale	swim	1	0	12
251	10/14/2018 14:31	71.378	155.289	bowhead whale	swim	1	0	12
251	10/14/2018 14:39	71.652	155.304	bowhead whale	rest	2	1	12
251	10/14/2018 14:42	71.667	155.287	bowhead whale	swim	2	1	12
251	10/14/2018 14:44	71.670	155.317	bowhead whale	rest	1	0	12
251	10/14/2018 15:11	71.649	155.830	beluga	swim	1	0	12
251	10/14/2018 15:11	71.647	155.828	beluga	rest	2	1	12
251	10/14/2018 15:14	71.526	155.855	bowhead whale	dive	1	0	12
251	10/14/2018 15:16	71.544	155.856	bowhead whale	dive	1	0	12
251	10/14/2018 15:17	71.517	155.821	bowhead whale	rest	1	0	12

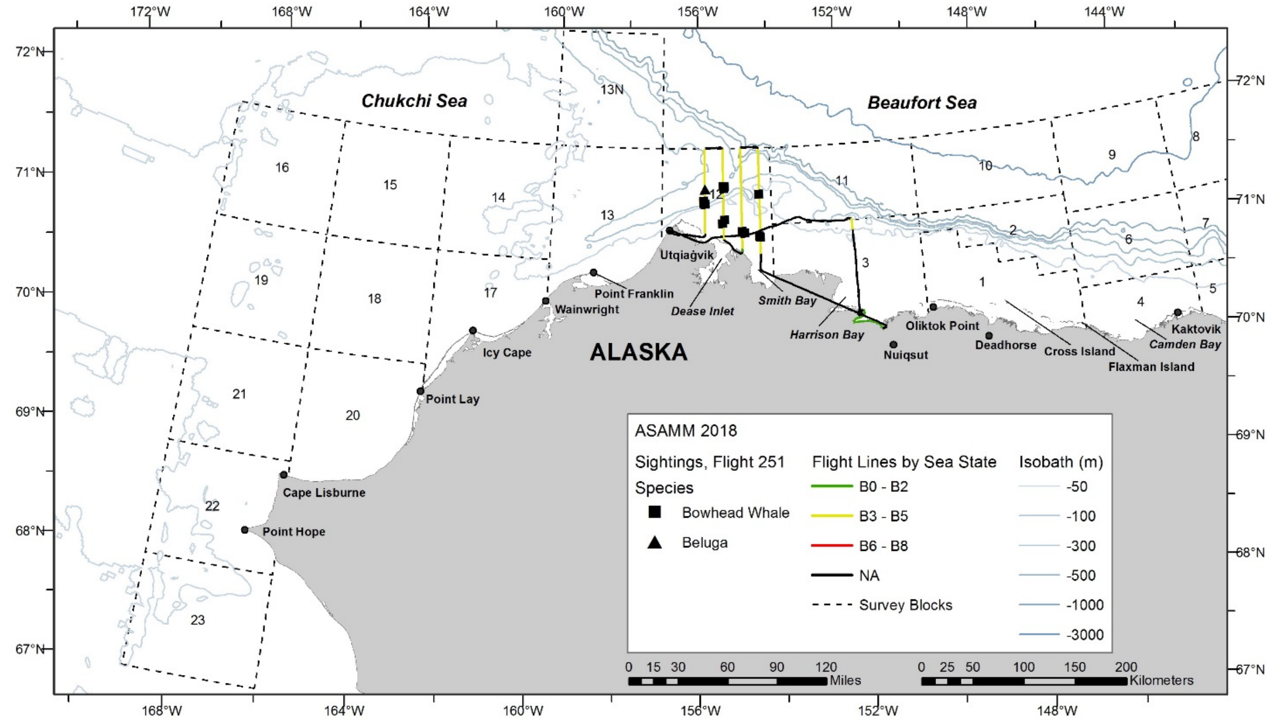

Figure B-92. Flight 251 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

15 October 2018, Flight 252

Flight was a complete survey of transects 1 and 4, and partial survey of transects 2, 3, 6, 133, and 134. Survey conditions included partly cloudy to overcast skies, 1 km to unlimited visibility, with glare, ice on the window, low ceilings, and precipitation, and Beaufort 3-6 sea states. There was no sea ice in the area surveyed. Sightings included one beluga.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
252	10/15/2018 12:28	71.485	158.312	beluga	swim	1	0	13

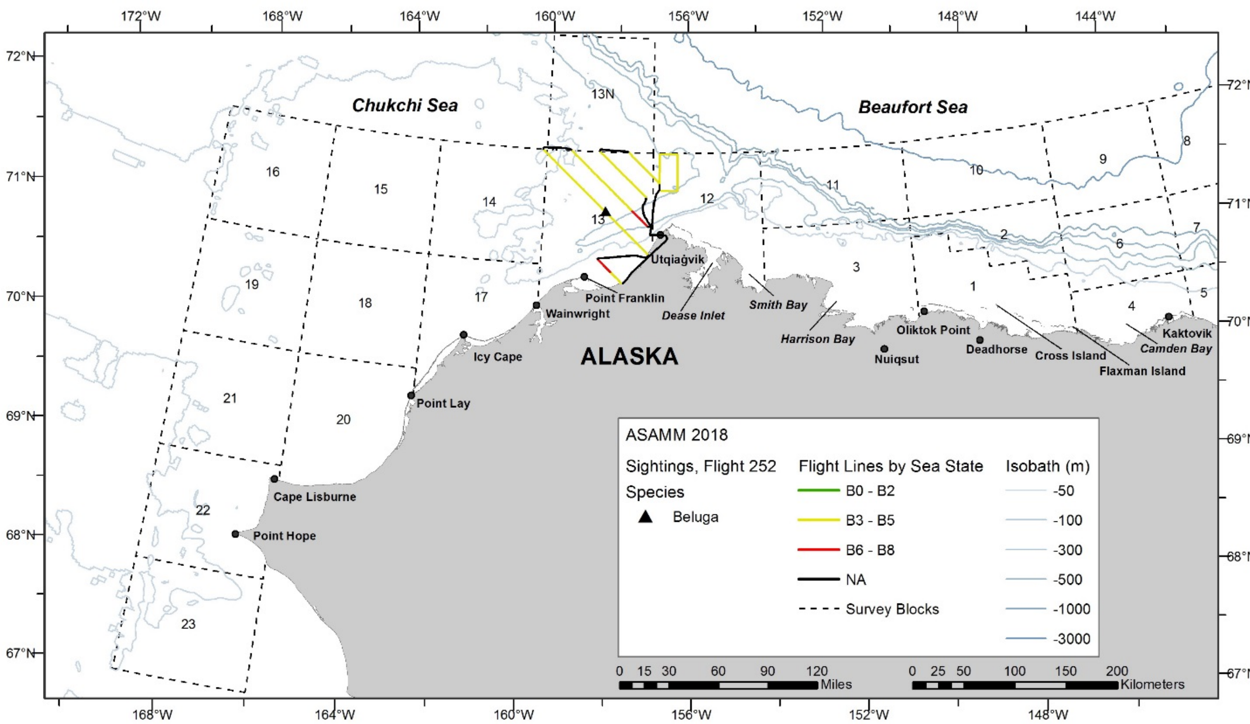

Figure B-93. Flight 252 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

19 October 2018, Flight 253

Flight was a coastal transect from Cape Lisburne to south of Icy Cape. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 4-6 sea states. There was no sea ice in the area surveyed. Sightings included walruses and small unidentified pinnipeds. A small group of approximately 100 small unidentified pinnipeds was hauled out on a barrier island south of Point Lay. Two walrus haulouts, of approximately 8,000 and 3,000 walruses, were observed on barrier islands near Point Lay.

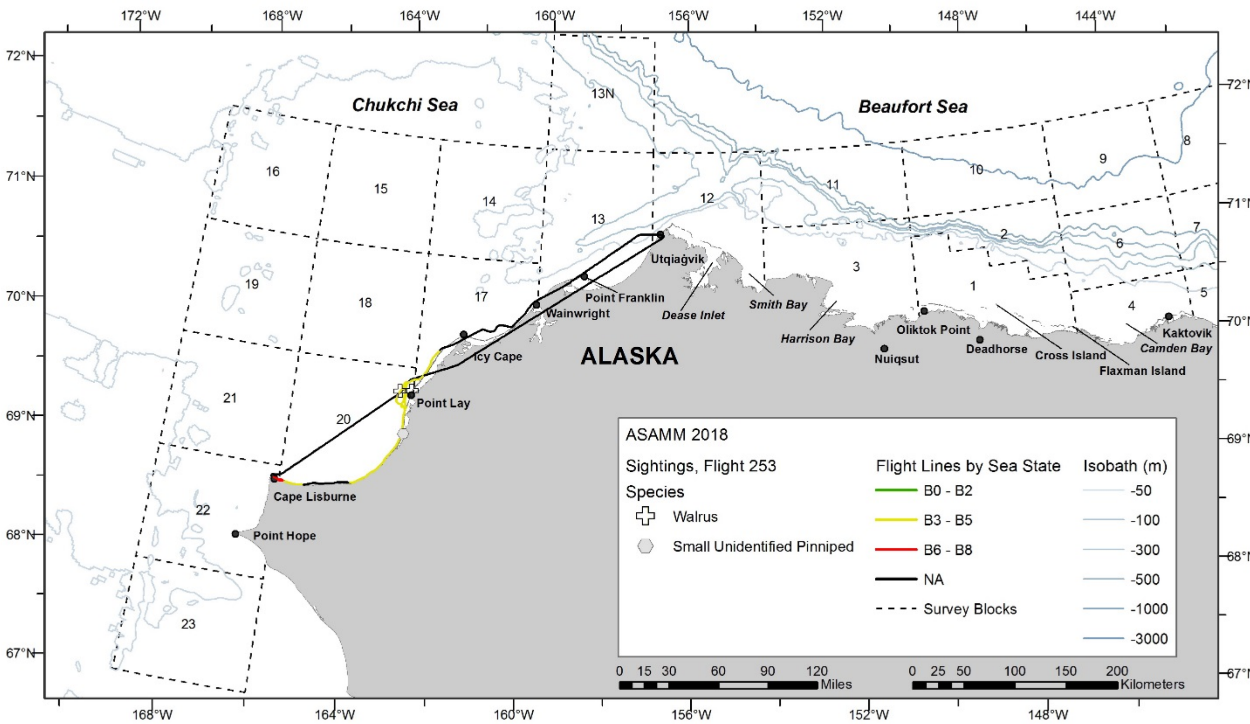

Figure B-94. Flight 253 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

20 October 2018, Flight 254

Flight was a partial survey of transects 10 and 11, and coastal transect near Wainwright. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with low ceilings, and Beaufort 3 to 5 sea states. There was no sea ice in the area surveyed. Sightings included gray whales and one walrus.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
254	10/20/2018 14:31	71.019	161.474	gray whale	feed	1	0	14
254	10/20/2018 14:34	71.025	161.512	gray whale	feed	1	0	14

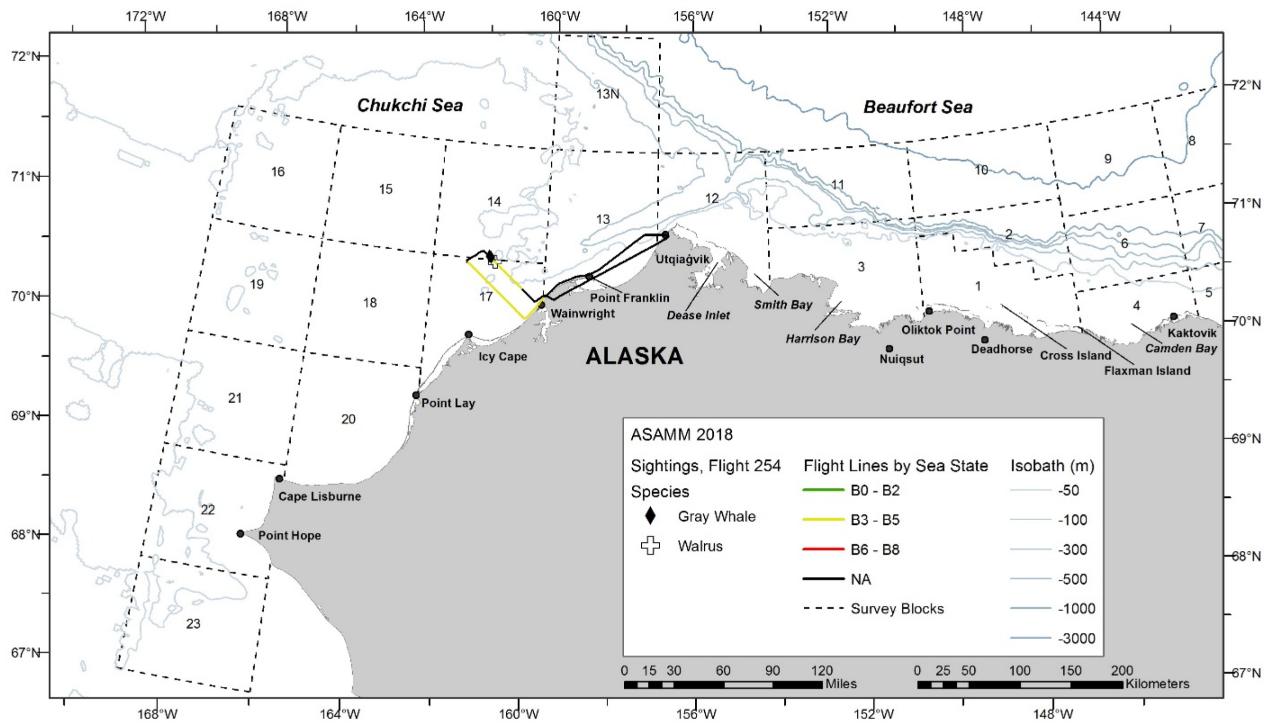

Figure B-95. Flight 254 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

22 October 2018, Flight 255

Flight was a partial survey of transects 123 and 128, and coastal transect in Harrison Bay. Survey conditions included partly cloudy to overcast skies, <1-10 km visibility, with fog, low ceilings, and precipitation, and Beaufort 0-3 sea states. Sea ice ranged from 0-100% grease/new ice in the area surveyed. Sightings included one small unidentified pinniped.

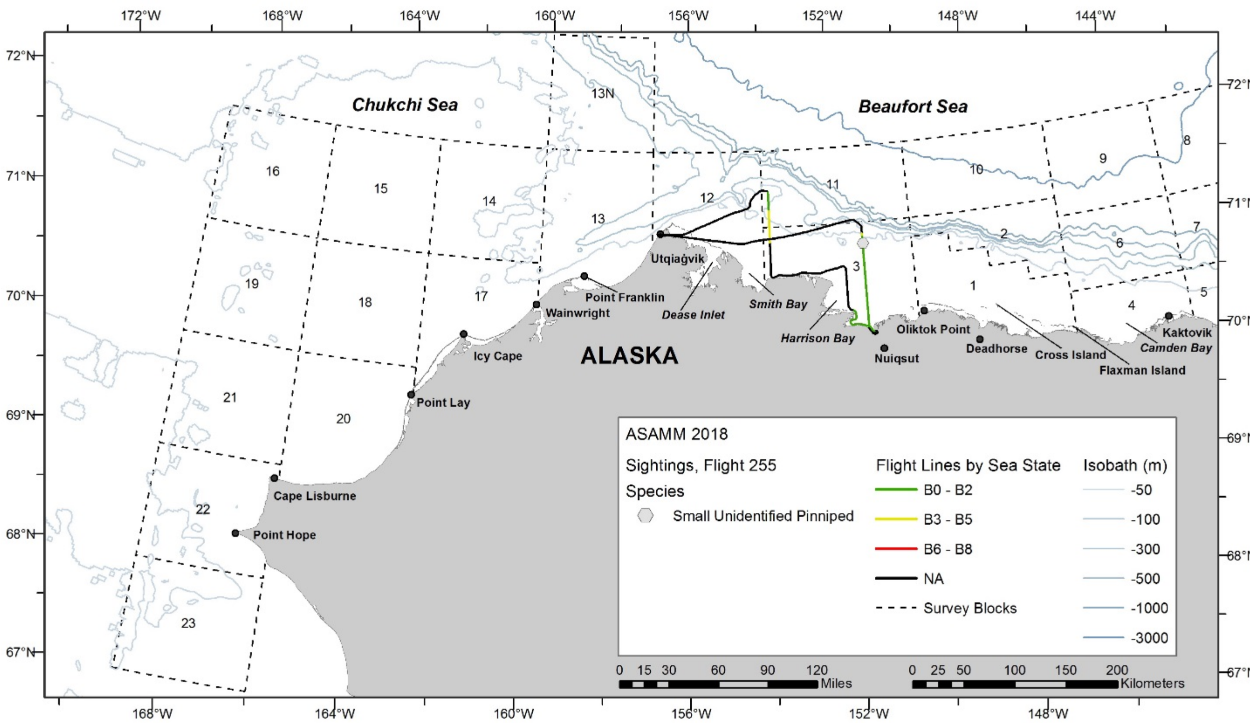

Figure B-96. Flight 255 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

23 October 2018, Flight 256

Flight was a complete survey of transect 1, and partial survey of transects 2, 3, 4, 5, 130, 131, 132, 133, and 134. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare and low ceilings, and Beaufort 1-5 sea states. Sea ice ranged from 0-98% grease/new ice in the area surveyed. Sightings included bowhead whales (including 4 calves), one gray whale, belugas (including 3 calves), one walrus, bearded seals, and small unidentified pinnipeds.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
256	10/23/2018 13:06	71.593	158.616	bowhead whale	SAG	3	2	13
256	10/23/2018 13:06	71.592	158.602	bowhead whale	swim	2	0	13
256	10/23/2018 13:07	71.594	158.651	bowhead whale	swim	2	1	13
256	10/23/2018 13:27	71.209	157.456	gray whale	swim	1	0	13
256	10/23/2018 14:23	71.787	157.654	bowhead whale	swim	2	1	13
256	10/23/2018 14:56	71.930	156.822	beluga	swim	2	0	12
256	10/23/2018 15:10	71.834	156.343	beluga	swim	1	0	12
256	10/23/2018 15:15	71.968	156.316	beluga	rest	1	0	12
256	10/23/2018 15:15	71.972	156.329	beluga	dive	1	0	12
256	10/23/2018 15:39	71.613	155.317	beluga	swim	2	0	12
256	10/23/2018 15:39	71.621	155.337	beluga	swim	4	2	12
256	10/23/2018 15:39	71.625	155.340	beluga	swim	1	0	12
256	10/23/2018 15:42	71.732	155.322	beluga	swim	1	0	12
256	10/23/2018 15:48	71.896	155.310	beluga	rest	1	0	12
256	10/23/2018 15:48	71.896	155.319	beluga	rest	2	1	12
256	10/23/2018 15:48	71.911	155.332	beluga	swim	1	0	12
256	10/23/2018 15:50	71.975	155.308	beluga	swim	1	0	12
256	10/23/2018 15:58	71.901	154.806	beluga	rest	1	0	12
256	10/23/2018 15:58	71.895	154.816	beluga	rest	1	0	12
256	10/23/2018 15:59	71.851	154.828	beluga	swim	1	0	12

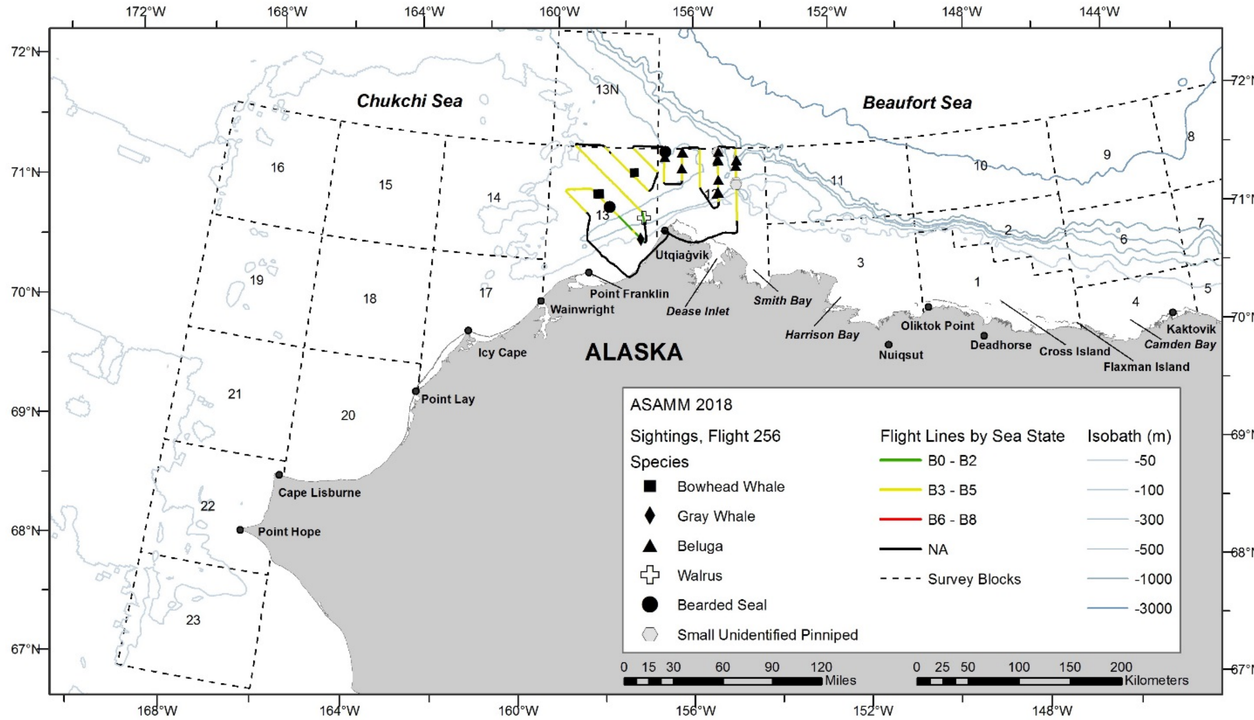

Figure B-97. Flight 256 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

26 October 2018, Flight 257

Flight was a complete survey of transects 118, 119, 120, and 122, partial survey of transect 121, and search effort at Cross Island. Survey conditions included partly cloudy to overcast skies, 1 km to unlimited visibility, with fog, glare, low ceilings, and precipitation, and Beaufort 0-4 sea states. Sea ice ranged from 0-99% broken floe and grease/new ice in the area surveyed. Sightings included belugas (including 2 calves) and polar bears.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
257	10/26/2018 13:07	71.119	150.823	beluga	swim	1	0	3
257	10/26/2018 14:05	71.223	149.824	beluga	swim	2	1	2
257	10/26/2018 14:05	71.219	149.827	beluga	swim	1	0	2
257	10/26/2018 14:05	71.215	149.820	beluga	swim	1	0	2
257	10/26/2018 14:50	71.223	149.324	beluga	swim	2	1	2
257	10/26/2018 14:50	71.225	149.327	beluga	swim	2	0	2

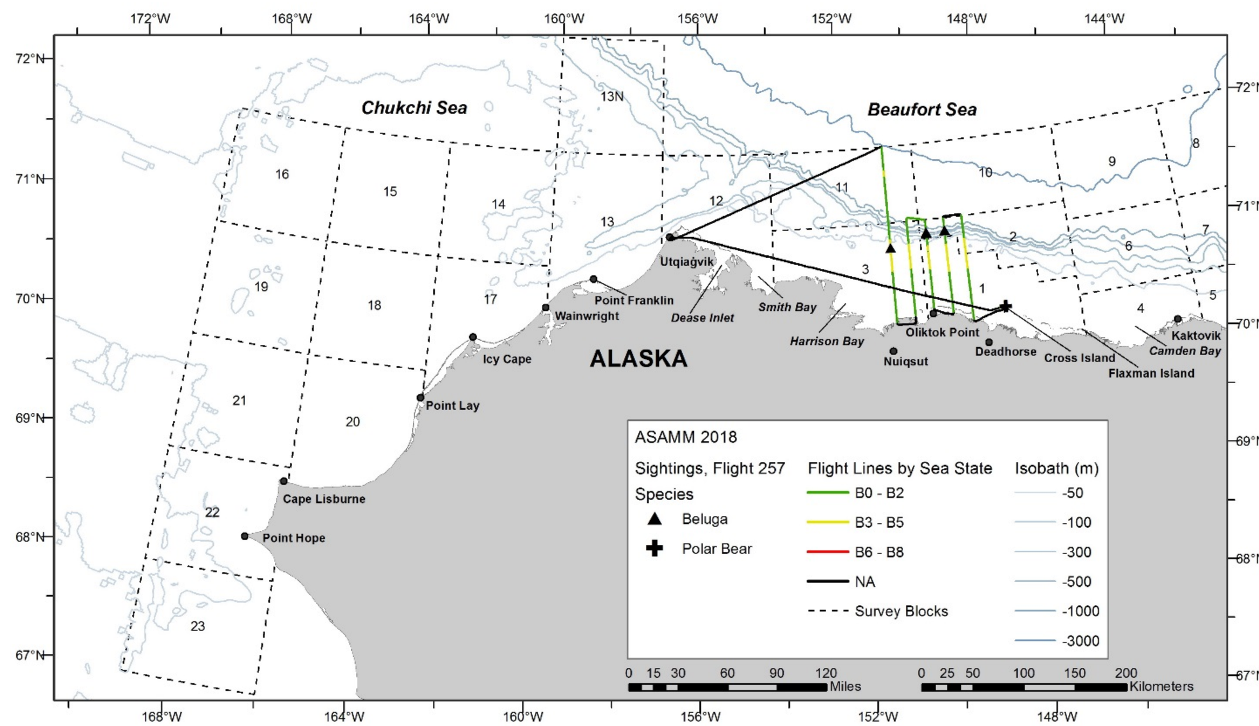

Figure B-98. Flight 257 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

27 October 2018, Flight 258

Flight was a complete survey of transects 127 and 128, and partial survey of transects 129, 130, 131, 132, 133, and 134. Survey conditions included partly cloudy to overcast skies, 0-10 km visibility, with low ceilings and precipitation, and Beaufort 0-5 sea states. Sea ice ranged from 0-99% broken floe and grease/new ice in the area surveyed. Sightings included belugas (including 3 calves), one small unidentified pinniped and polar bears.

Cetacean sightings only (transect, CAPs, circling, and search effort):

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
258	10/27/2018 16:08	71.685	155.702	beluga	swim	3	1	12
258	10/27/2018 16:12	71.564	155.840	beluga	swim	1	0	12
258	10/27/2018 16:13	71.560	155.817	beluga	swim	4	1	12
258	10/27/2018 16:14	71.512	155.819	beluga	swim	2	1	12

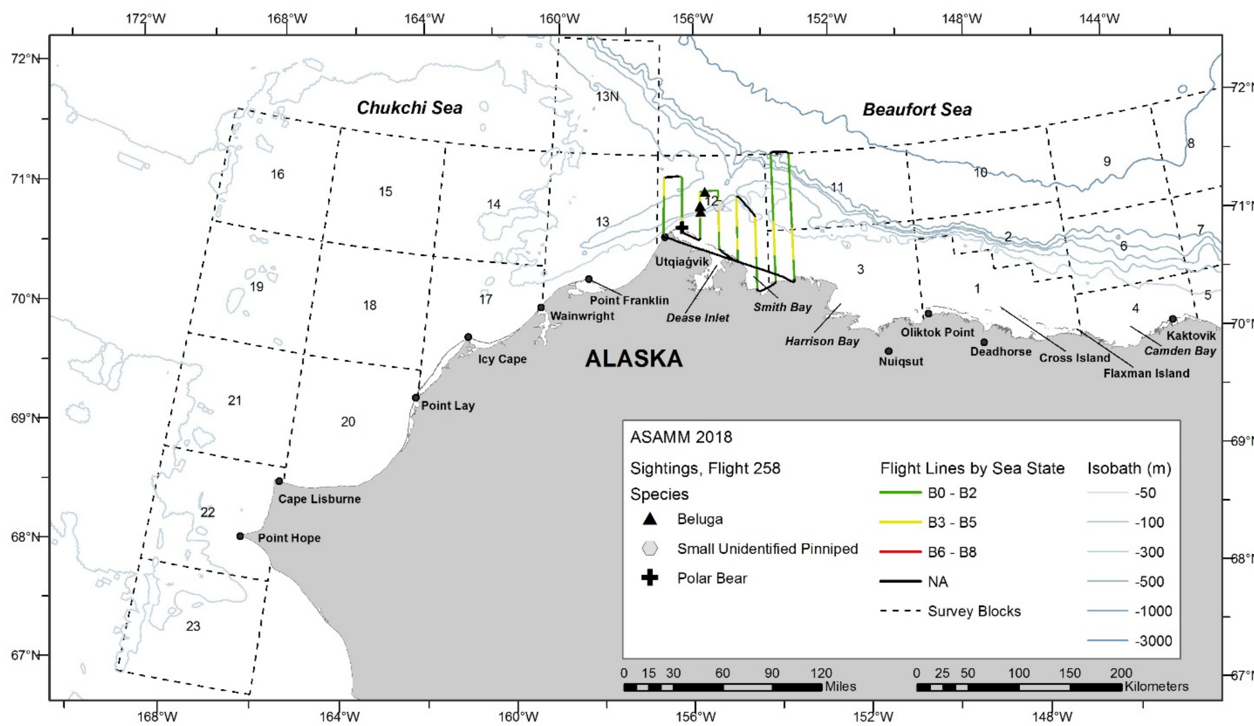

Figure B-99. Flight 258 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

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APPENDIX C: PUBLICATIONS, POSTERS, PRESENTATIONS AND MEDIA OUTREACH FROM ASAMM, SPRING 2018-SPRING 2019

List of Publications, Posters, and Presentations

Includes material published or produced since the 2017 ASAMM report.

2018

Clarke, J.T., A.A. Brower, M.C. Ferguson, and A.L. Willoughby. 2018. Distribution and Relative Abundance of Marine Mammals in the Eastern Chukchi and Western Beaufort Seas, 2017. Annual Report, OCS Study BOEM 2018-023. Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349.

Clarke, J., M. Ferguson, A. Brower, and A. Willoughby. 2018. Bowhead whale calves in the western Beaufort Sea, 2012-2017. SC/67b/AWMP3.

Ferguson, M.C., J.T. Clarke, R. Angliss, J. Bengtson, A. Brower, J. Citta, P.J. Clapham, P. Conn, K.A. Forney, J.C. George, and G.H. Givens. 2018. Bering-Chukchi-Beaufort bowhead whale abundance estimation survey workshop report. SC/67b/AWMP16.

Stimmelmayr, R., J.C. George, A. Willoughby, A. Brower, J. Clarke, M. Ferguson, G. Sheffield, K. Stafford, A. Von Duyke, T. Sformo, B. Person, L. Sousa, and R. Suydam. 2018. 2017 health report for the Bering-Chukchi-Beaufort Seas bowhead whales – preliminary findings. SC/67b/AWMP8.

Willoughby, A., J. Clarke, M. Ferguson, R. Stimmelmayr, and A. Brower. 2018. Bowhead whale carcasses in the eastern Chukchi and western Beaufort seas, 2009-2017. SC/67b/AWMP2.

Clarke, J.T. and M.C. Ferguson. 2018. Bowhead whale distribution, 140°W-157°W, July-October, 2009-2017. Presentation: Camden Bay Workshop, Anchorage, AK, April, 2018.

2019

Brower, A.A., M. Ferguson, J. Clarke, A. Willoughby, C. Accardo, L. Barry, N. Brant-Turner, M. Foster, K. Jackson, K. Pagan. 2019. Fin and Humpback Whale Occurrence in the South-Central Chukchi Sea, 2014-2018. Poster: Alaska Marine Science Symposium, Anchorage, AK, January, 2019.

Clarke, J.T., M. Ferguson, A. Brower, A. Willoughby. 2019. Bowhead whales in the western Beaufort Sea, mid-July to August, 2012-2018. Poster: Alaska Marine Science Symposium, Anchorage, AK, January, 2019.

Snapshots of Media Outreach and Blogs

ANCHORAGE DAILY NEWS

Alaska News

Bowhead whales, dwellers of icy seas, enjoy steady growth off Alaska in the age of climate change

Author: **Alex DeMarban** Updated: 28 minutes ago Published 23 hours ago

Bowhead whales feed in echelon formation near Camden Bay, Alaska in August 17, 2016. (Photo by Lisa Barry / NOAA/NMFS/AFSC/MML, NMFS Permit No. 14245-4)

Bowhead whales in Alaska's Arctic waters appear to be thriving even as sea ice shrinks, offering a counterpoint to climate-change concerns that have prompted federal threatened status for some other northern animals such as polar bears.

"Multiple lines of evidence all point to the Alaska (bowhead) stock doing really well," said Craig George, senior wildlife biologist for the North Slope Borough, on Wednesday.

https://www.adn.com/alaska-news/2018/05/13/bowhead-whales-dwellers-of-icy-seas-enjoy-steady-growth-off-alaska-in-the-age-of-climate-change/

September 2018

2018 Issue #3

Recent Publications

Performance of manned and unmanned aerial surveys to collect visual data and imagery for estimating Arctic cetacean density and associated uncertainty, *Ferguson et al.*

New technology and methods for aerial cetacean surveys are constantly emerging and need to be compared to existing, accepted methods for efficiency, cost-effectiveness, and efficacy. The authors compared visual data collected using three methods: 1) marine mammal observers aboard a manned aircraft, 2) autonomously collected imagery from the manned aircraft, and 3) autonomously collected imagery from a ScanEagle unmanned aircraft system (UAS). These data were used to calculate ten different performance metrics evaluating the precision and uncertainty in abundance estimates, species identification, and cost. Results suggest that visual data collected by marine mammal observers required the least post-processing, were a fraction of the cost to collect and interpret, and provided estimates of cetacean density with lower uncertainty than the other two methods. The study concluded that the use of UAS

https://www.fisheries.noaa.gov/resource/document/science-connect-2018-issue-3

ANCHORAGE DAILY NEWS

Wildlife

Thousands of Pacific walruses again herd up on Alaska coast

Author: Dan Joling, The Associated Press   Updated: 6 hours ago   Published 20 hours ago

This Thursday, Aug. 30, 2018 photo provided by the National Oceanic and Atmospheric Administration shows hundreds of walruses gathered together on Barrier Island, Alaska. The U.S. Fish and Wildlife Service is monitoring Pacific walruses resting on Alaska's northwest coast. Walruses over the last decade have come to shore on the Alaska and Russia side of the Chukchi Sea as sea ice diminishes because of global warming. (Vickie Beaver/NOAA via AP)

Thousands of Pacific walruses have again gathered on the northwest shore of Alaska as the Chukchi Sea approaches its annual sea ice minimum.

Residents of the Inupiaq village of Point Lay on Aug. 22 reported hearing walruses, said Andrea Medeiros, spokeswoman in Alaska for the U.S. Fish and Wildlife Service.

https://www.adn.com/alaska-news/wildlife/2018/09/13/thousands-of-pacific-walruses-again-herd-up-on-alaska-coast/

NOAA FISHERIES

2018 Aerial Surveys of Arctic Marine Mammals - Post 1

September 11, 2018

This Arctic survey of marine mammals in the Beaufort and Chukchi seas has been conducted every year off the northern and western coasts of Alaska since 1979. A long-term dataset like this is extraordinary because it is both unusual and important. Exact survey dates and boundaries have varied over time, but the study goals, general survey area, and survey methods have stayed remarkably similar. ASAMM is co-managed and conducted by the NOAA Fisheries Alaska Fisheries Science Center, and funded and co-managed by the Bureau of Ocean Energy Management.

In recent years, July through September has been considered ice-free months in the Beaufort and Chukchi sea ASAMM study areas.

ASAMM goals are to examine the distribution, relative numbers of animals using certain areas, and behavior of bowhead, gray, humpback, fin, minke, and killer whales, belugas, harbor porpoises, walruses, ice seals, and polar bears. ASAMM is focused in areas of potential interest to petroleum exploration, development, and production, and surrounding areas used by these species, in the Alaskan Arctic. Results from ASAMM provide an objective, broad-scale understanding of marine mammal ecology in the Alaskan Arctic that helps inform management decisions.

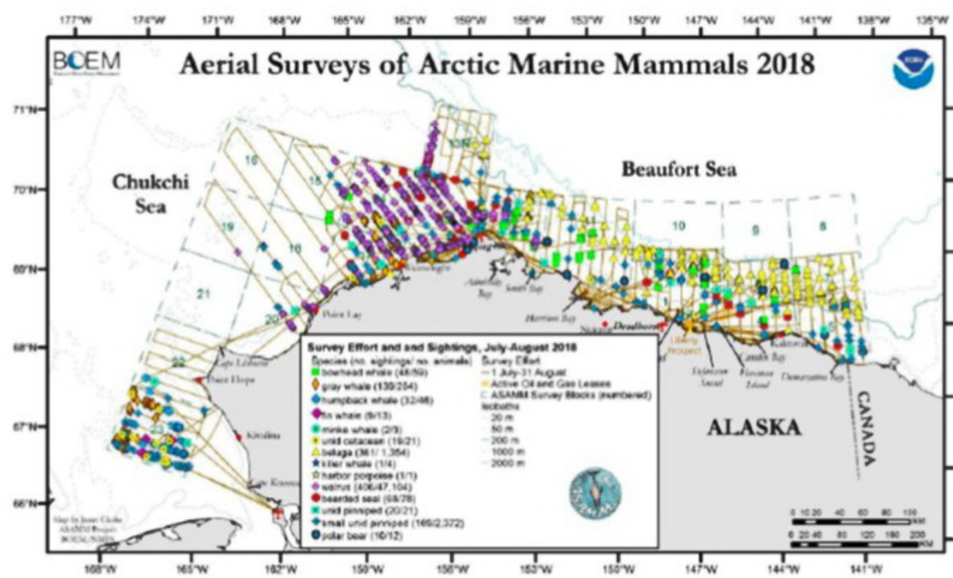
https://www.fisheries.noaa.gov/science-blog/2018-aerial-surveys-arctic-marine-mammals-post-1

NOAA FISHERIES

2018 Aerial Surveys of Arctic Marine Mammals - Post 2

September 18, 2018

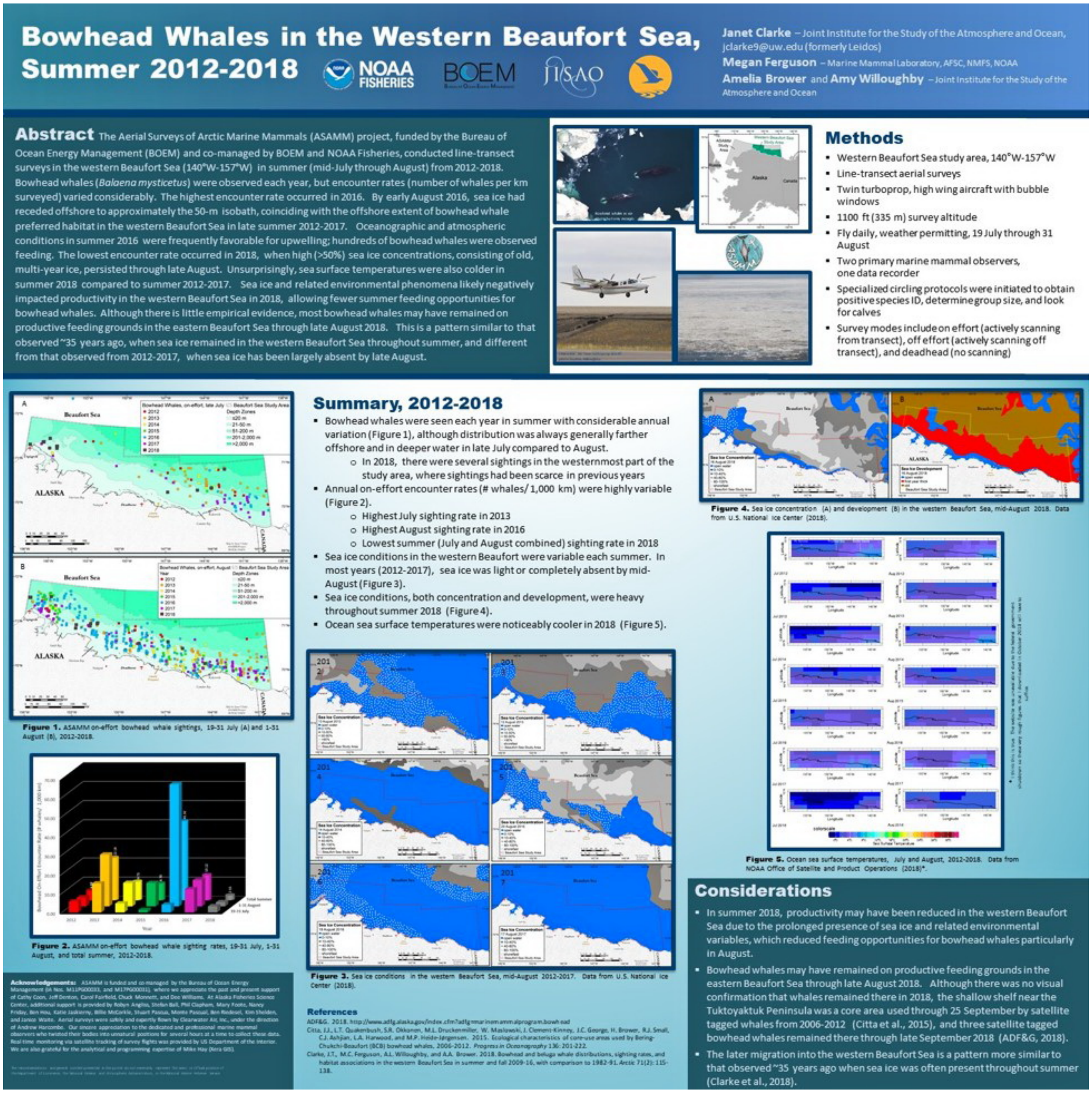
This Arctic survey of marine mammals in the Beaufort and Chukchi seas has been conducted every year off the northern and western coasts of Alaska since 1979. A long-term dataset like this is extraordinary because it is both unusual and important. Exact survey dates and boundaries have varied over time, but the study goals, general survey area, and survey methods have stayed remarkably similar. ASAMM is co-managed and conducted by the NOAA Fisheries Alaska Fisheries Science Center, and funded and co-managed by the Bureau of Ocean Energy Management.

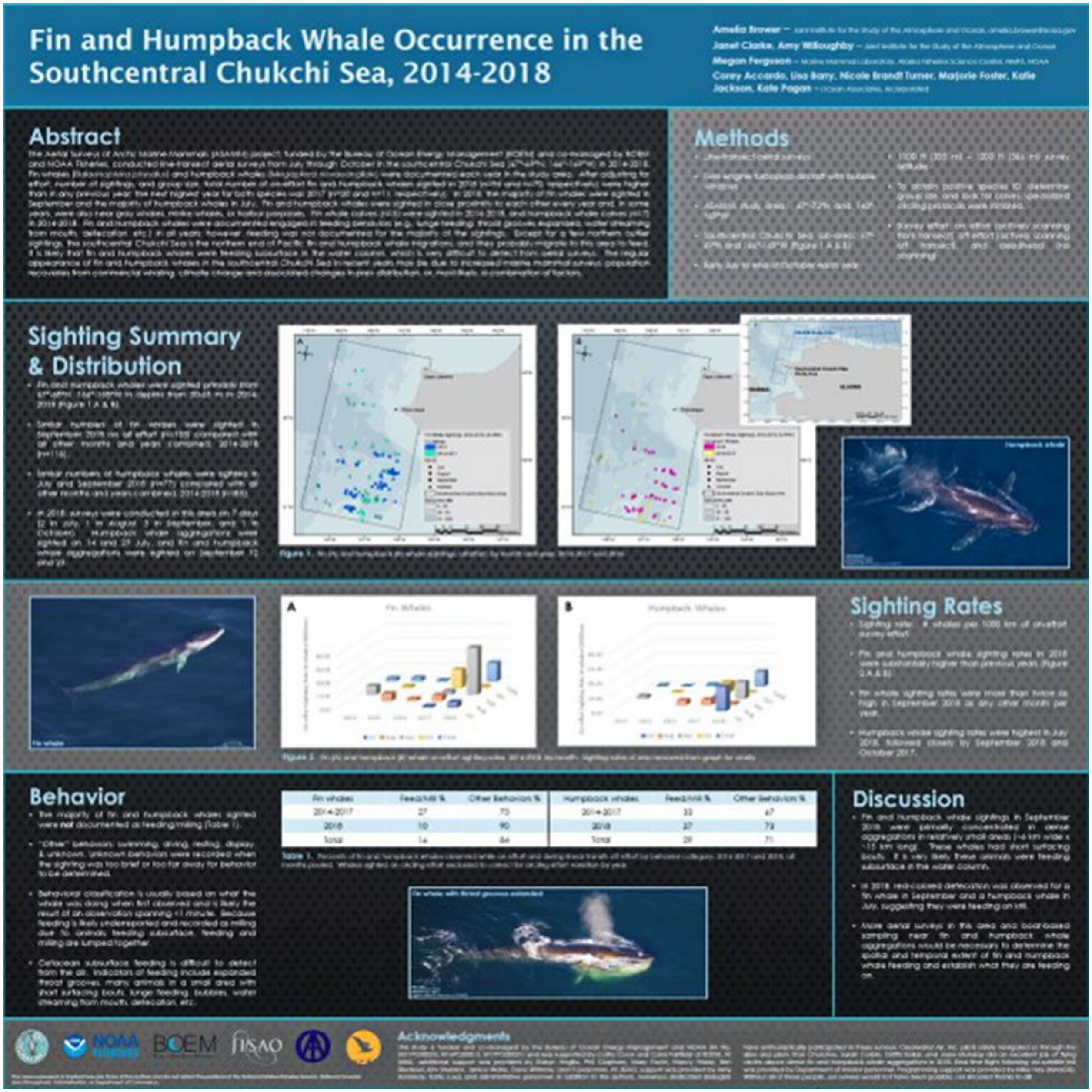


ASAMM July-August 2018 marine mammal sightings by species, tracklines flown, and study area.

https://www.fisheries.noaa.gov/science-blog/2018-aerial-surveys-arctic-marine-mammals-post-2

Poster Presentations




Fin and Humpback Whale Occurrence in the Southcentral Chukchi Sea, 2014-2018
Amelia Brower
Janet Clarke, Amy Willoughby
Megan Ferguson
Corey Accardo, Lisa Barry, Nicole Brandt Turner, Marjorie Foster, Katie Jackson, Kate Pagan
Abstract
Methods
Sighting Summary & Distribution
Sighting Rates
Behavior
Discussion
Acknowledgments

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APPENDIX D: NEW SURVEY PROTOCOLS IN 2018
INCLUDING CETACEAN AGGREGATION PROTOCOLs (CAPs),
FOCAL GROUP FOLLOW (FGF),
AND BELLY PORT CAMERA (BPC)

Three new data collection protocols were incorporated into ASAMM in 2018: Cetacean Aggregation Protocols (CAPs), Focal Group Follow (FGF), and Belly Port Camera (BPC). Summaries of these protocols are included in this appendix. Detailed documentation is provided in the ASAMM observer manual.

CAPs were developed specifically for dense aggregations of large cetaceans, to collect encounter rate and group size data that are unbiased for standard distance sampling analyses. Starting in 2018, ASAMM will implement CAPs in lieu of extensive circling-from-transect that was routinely conducted in high density large cetacean aggregations from 2009-2017.

Data from FGF and BPC protocols will be used to estimate availability and perception biases in ASAMM aerial line-transect data. Availability bias refers to animals that are located on or near the trackline but cannot be seen because they are underwater or they are too far fore or aft of the aircraft and, therefore, are not in observers' field of view. Perception bias refers to animals that are available to be seen, but observers fail to detect them due to high sea states, glare, etc.

The FGF protocol standardizes methods for collecting data on the amount of time that small groups of bowhead whales (2-5 whales or 3 cow-calf-pairs) are visible at the surface versus too deep to be seen. These surface and dive time data will be combined with data from the field of view trials (Appendix G) to derive correction factors for availability bias. ASAMM focused on collecting surface and dive intervals for small groups of bowhead whales because analogous data for individual animals can be obtained from the literature (e.g., Würsig and Clark, 1993) and determined via telemetry data. The ADF&G has several years of bowhead whale satellite tag data that can be used to estimate dive duration and may provide rough estimates of surface duration. In 2018, ADF&G and NSB DWM collaborated to deploy satellite tags that were programmed to collect data that are optimal for estimating surface duration (J. Citta, ADF&G, pers comm. to M. Ferguson and J. Clarke, 3 August 2018).

The BPC protocol standardizes methods for collecting imagery using a downward-facing camera mounted to the belly of the aircraft. BPC imagery serves as an independent observer and will be used to develop correction factors for perception bias. BPC imagery is the best way to correct for perception bias for ASAMM observers onboard the Turbo Commander because that aircraft has neither the space nor the window configuration for independent observers.

CETACEAN AGGREGATION PROTOCOLS (CAPs)

Adapted from Version 20, 15 March 2019

Background

During all ASAMM surveys, when large cetaceans (bowhead, gray, humpback, fin, and minke whales) are encountered, data collection on those large cetacean species should take precedence over any other species. Data should not be recorded on pinniped or small cetacean sightings so that the ability to record accurate and complete data for targeted cetacean speciess is not compromised.

Temporary marks indicating distances of 1 km (0.5 nmi) and 3 km (1.6 nmi) from the transect should be made on each bubble window for each observer at the beginning of every flight. Observers should check the accuracy of the 1-km and 3-km marks with their clinometer a few times over the course of a flight, in case the observer's posture in the window changes substantially and affects the location of these marks.

The definition of a "sighting" is all whales within 5 body lengths of each other. For example, a sighting could comprise a single whale, one cow-calf pair swimming closely together, or several whales located within 5 body lengths of each other. A patch of tens of whales causing a broad disturbance on the surface of the water should be counted as a single sighting only if all whales are within 5 body lengths of their nearest neighbor. Whales separated from neighbors by greater than 5 body lengths should be recorded as separate sightings. The final group size estimate for a sighting can be updated to incorporate additional animals associated with (e.g., within 5 body lengths of) the initial detection. Any whale sighted during circling that was not in close proximity to the originally detected sighting will be considered a separate sighting on circling.

An aggregation is a high-density patch of cetaceans. An aggregation may span several transects (Figure D-1).

Data Collection

LOW SIGHTING DENSITY

When a sighting is detected in an area of low sighting density, the clinometer and an initial estimate of group size should be recorded when the aircraft is on the transect and the sighting is abeam. The aircraft should circle the sighting, as weather and fuel allow, to confirm species identification, obtain a final estimate of group size, determine whether calves are present, and record any other relevant sighting data. Circling should only occur over areas that have already been surveyed on effort (i.e., passed abeam). ***The observer on the opposite side of the aircraft from the original transect sighting should avoid scanning for new animals on the outside of the circle while circling.***

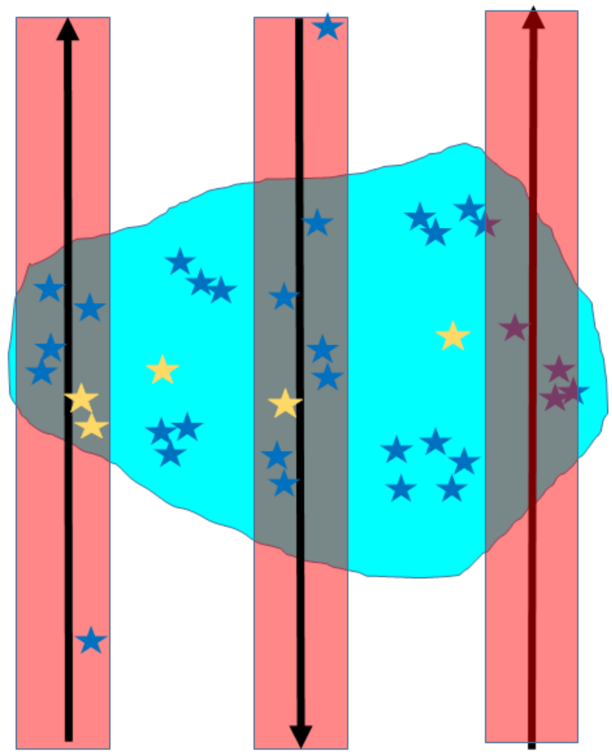

Figure D-1. A cetacean sighting comprises all whales within 5 body lengths of each other. The final group size estimate for a sighting can be updated to incorporate additional animals detected near the initial detection (e.g., within ~ 5 body lengths of the cetaceans that were initially sighted). An aggregation comprises all cetaceans in a high-density patch of cetaceans, including those beyond 3 km from a transect, depicted within the turquoise blob. An aggregation may span more than one transect. The survey and analytical methods allow for whales in an aggregation to go undetected. Black arrows: transects. Salmon shading: 3-km strip on each side of a transect. Stars: individual whales, with different colors used to depict different species.

Sightings during circling-from-transect will inevitably occur. Guidelines for entering s(ighting) on circling:

- S on circling are low priority and should not compromise the team's ability to accurately record s on transect. For example, it might be a good idea to not enter s on circling detected immediately prior to a resume transect in an area of moderately-high to high density because that might tie up the data recorder and affect the ability to record upcoming s on transect.
- Do not enter any s on circling that are located on fresh transect and have a chance of being sighted from transect.
- S on circling located inside the circle can be recorded.
- S on circling located far from the transect (e.g., > 3 km) are the lowest of the low priority.

HIGH SIGHTING DENSITY

CAPs will be triggered when the density of large cetacean sightings on transect exceeds the observers' ability to mark, ***record an accurate clinometer for***, and circle every sighting (Figure D-2). Also consider entering CAPs mode if you detect several s on circling-from-transect within a short period of time. There may be circumstances when the pilots detect extremely dense aggregations of large cetaceans prior to detection by observers; in those situations, the pilots will communicate this information to the team leader to assist with decisions concerning if and when CAPs should be initiated.

There are two strategies for dealing with high-density aggregations of large cetaceans, CAPs passing and CAPs strip. CAPs passing is implemented in areas where large cetacean sighting densities are dispersed enough that the observers are able to mark individual sightings and accurately collect sighting data within 3 km of the trackline. CAPs strip is initiated when large cetacean sighting density becomes so high that it is impossible to record groups of whales within 5 body lengths of each other as individual sighting events. CAPs strip is limited to sightings within 1 km of the track.

CAPs Passing

During CAPs passing, the first step is to continue to fly directly on the transect without circling (i.e., survey in "passing mode"), and record data for large cetacean sightings located within 3 km of the transect. Only primary observers should call out sightings.

CAPs Circling

When the aircraft reaches the point where large cetacean density has obviously diminished to background levels, CAPs circling will commence. During CAPs circling, the full suite of ASAMM sighting data should be recorded for each cetacean sighting that is located ≤3 km of the transect covered during CAPs passing mode. It might be most effective for the aircraft to travel approximately 1.5 km from the trackline while scanning for sightings during CAPs circling so that each observer is responsible for scanning the same perpendicular distance from the aircraft. While circling during CAPs, do not record data for cetaceans located >3 km from the transect. Sightings recorded during CAPs circling do not need to match sightings during CAPs passing mode. We do not expect or need to obtain a direct match because sightings in passing mode are used to estimate encounter rate, while sightings on circling are used to infer average group size, number of calves present, and species ID. During CAPs circling, it is acceptable to circle a fresh mud plume until a cetacean surfaces in order to record the sighting as s on CAPs circling. Note that if CAPs strip is initiated in association with a CAPs segment, circling should not be conducted in the area flown in CAPs strip mode.

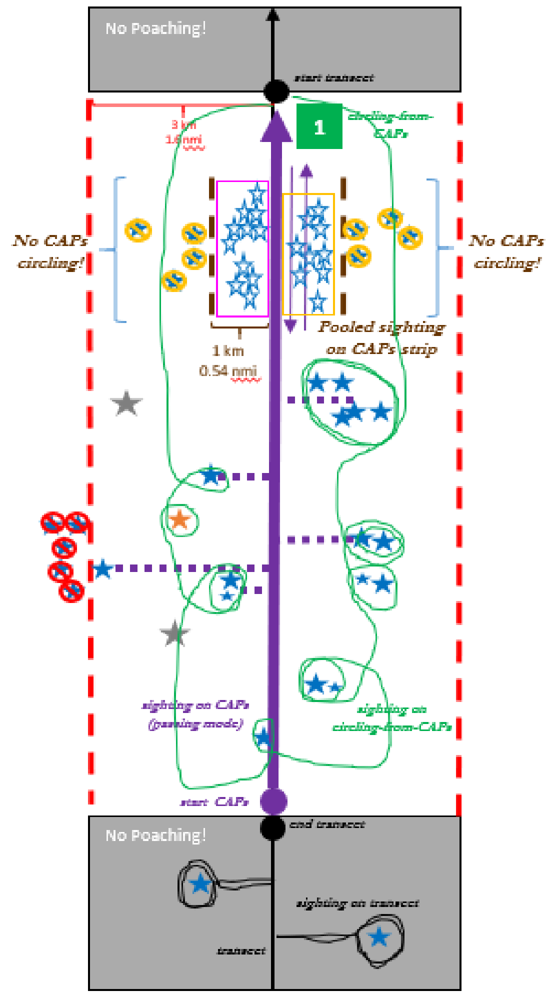

Figure D-2. Black: transect and circling-from-transect, surveyed using standard ASAMM protocols, from bottom to top of figure. Purple: CAPs passing mode effort (solid line) and perpendicular distances to sightings (dotted lines). Magenta and yellow boxes: CAPs strip effort in extremely high-density area, only 1 km wide. Green "1": commence CAPs circling. Green line: CAPs circling effort; no circling along CAPs strip section. Red dashed line is 3 km (1.6 nmi) from transect. Red circle-and-slash symbols: do not count these cetaceans at any time during CAPs passing or CAPs circling because they are >3 km from transect. Orange circle-and-slash symbols: do not count these cetaceans during CAPs strip or CAPs circling because they are >1 km from transect. Solid blue and orange stars: cetaceans detected during either CAPs passing or CAPs circling mode; species denoted by color, and calves denoted by small stars. Open blue stars: cetaceans detected during CAPs strip. Some cetacean sightings will be detected only during CAPs passing mode, some will be detected only during CAPs circling mode, and some will never be detected (gray stars). While in CAPs passing or CAPs circling mode, do not record sightings that are located before start CAPs or after the initial divert to circling during CAPs (green "1"); these off-limit areas are shaded gray.

When both sides of the transect have been surveyed under CAPs circling out to a maximum of 3 km from the transect (with the exception of CAPs strip segments), the survey team will do one of the following: a) return to the point on the transect downstream of the aggregation where only unsurveyed transect lies ahead and proceed to survey using standard ASAMM protocols; b) deadhead (e.g., if weather, fuel, or other logistical constraints require returning to base); or c) repeat CAPs passing survey mode in the current CAPs segment. Option "c" would be initiated if, based on CAPs circling sightings, the team has reason to believe that during the initial CAPs passing effort the whales were diving synchronously and many whales were underwater, and conditions (fuel, weather, etc.) allow. The subsequent effort should include, at a minimum, CAPs passing over the same section of transect as flown initially, and preferably would include a second CAPs circling session (although that is not a necessity). Sighting data should not be entered as "repeat" on the second pass. The data recorder should include notes either in the database or in the log book describing the events and decision-making, so that project management will be able to determine the best way to incorporate the data.

If the aggregation extends farther than the initial CAPs segment, a new CAPs session can be started.

CAPs Strip

If, during transect or CAPs passing mode, the large cetacean sighting density becomes so high that it is impossible to record groups of whales within 5 body lengths of each other as individual sighting events, the survey mode will become a strip transect, "CAPs strip", in which it is assumed that every large cetacean at the surface in the field of view within a certain distance of the transect is detected and recorded. To meet this strict assumption of 100% detectability of surfaced cetaceans, observers should include animals located only within 1 km of the transect. Observers may pool sightings into single sighting events for each side of the aircraft (Figure D-3). Because strip-transect methods assume that 100% of surfaced cetaceans will be detected and counted in passing mode, the area covered during CAPs strip will not be included in subsequent circling effort (Figure D-2). When the sighting density within the aggregation thins to a level at which it is possible to resume collecting data for individual sightings (groups), resurvey the CAPs strip two more times. After the third CAPs strip transect, resume collecting sighting-specific CAPs passing mode sighting data. Sightings should be pooled only during CAPs strip mode, never during CAPs passing or CAPs circling modes.

Additional Considerations

CAPs sessions should always include, at a minimum, CAPs passing and CAPs circling. If conditions (weather, fuel, etc.) will not support CAPs circling, CAPs should not be initiated because the resulting data would be incomplete. There is no time limit for collecting data during CAPs, assuming weather and fuel allow. There is no limit to the "length" along the transect of a CAPs segment; however, CAPs circling should never extend beyond the bounds of the initial CAPs segment (gray areas in Figure D-2). Continue to enter environmental updates as time allows during CAPs, CAPs strip, and CAPs circling survey modes.

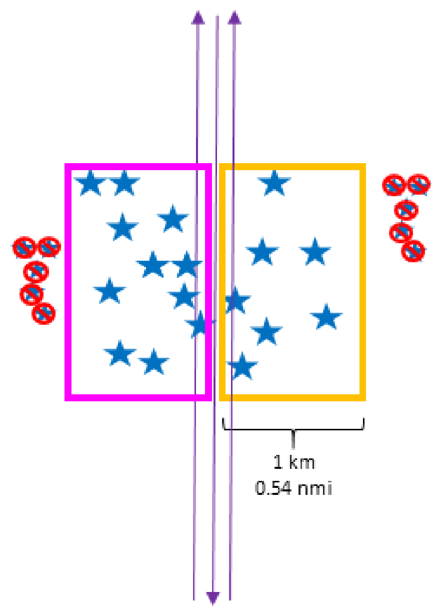

Figure D-3. Schematic of CAPs strip mode. During CAPs passing mode, if sighting density precludes the ability to enter a new sighting record for each sighting, survey the high-density area using strip-transect methods. Make three passes through the area (depicted by adjacent purple arrows but actually flown along the exact same path), without circling. It is o.k. to pool sightings located on one side of the aircraft into a single sighting record for that side. It is o.k. to record multiple pooled sighting events per side per pass. For each sighting record, enter group size, number of calves, species, behavior, NoReacted (number reacted – leave blank if no reaction), and clinometer corresponding to the center of the pooled sightings. Focus only on the animals located within 1 km of the transect; do not include cetaceans farther than 1 km from the transect in the group size estimate for a pooled sighting. The area in which pooled sightings are recorded should not be included in the area subsequently circled during CAPs circling.

CAPs will not be used during search effort. Do not survey in search mode between transects in areas with known moderately-high to high densities of large whales (e.g., western edge of block 23) because searching between transects in those areas has a relatively high chance of taking s on transect away from the next transect. If you find yourself surprised by moderately-high to high densities of large whales during a search between transects, enter the original s on search, mop up the relevant s on circling-search, then resume and switch to deadhead mode as quickly as possible. Deadhead for the remainder of the transit between transects.

In situations where large whale density slowly increases on transect and the team determines that the density is enough to initiate CAPs, it is possible to backtrack along a transect to return to a logical trigger point to implement CAPs. In that situation, all the original sightings on transect located perpendicular to the CAPs segment should be identified and deleted (see example in Figure D-4). The data recorder can make a list of duplicate sightings-on-transect that need to be

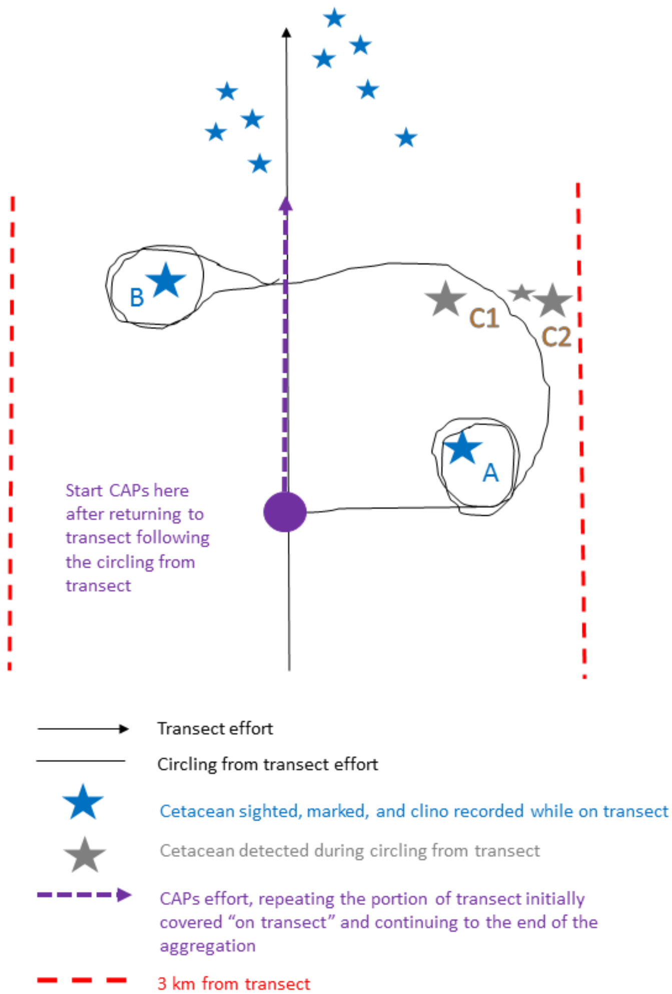

Figure D-4. Schematic illustrating "backtracking" to start CAPs. Cetaceans A and B were detected from the transect at approximately the same time. Cetacean A was marked with a clinometer; the aircraft continued on the transect to mark and record the clinometer for B before diverting to circle from transect. The aircraft circled B first, then crossed the transect to circle A. While flying towards A, cetacean sightings C1 and C2 were detected for the first time, and the team realized they were entering a high-density patch of cetaceans that is ≤3 km of the trackline. Because C1 and C2 were not detected (or marked) from the transect and are not within 5 body lengths of A or B, they are entered as "sighting on circling – transect." Because C1 and C2 represent distinct detection events, they could be entered as separate sightings or, for expediency, they can be lumped into a single pooled sighting. No effort should be made to circle C1 or C2. It is o.k. to circle A to collect the full suite of sighting data before returning to the transect. Upon returning to the transect at the point perpendicular to sighting A, end the transect and start a CAPs session. Continue surveying the aggregation using standard CAPs protocols (not shown in diagram; refer to Figures D-2 and D-3). Note the event numbers of sightings A and B because they will need to be deleted during post-flight processing.

deleted and give that list to the data editor to make the necessary edits during post-flight processing. CAPs should not be initiated if visibility is <1-2 km on either side of the aircraft, or the aircraft is frequently passing through cloud layers that obscure visibility. CAPs can be initiated when visibility is 2-3 km, but the limited visibility should be noted. CAPs can be initiated during the coastal transect. Because sightings are limited to 1 km on the shoreward side of the coastal transect, conduct all CAPs sessions during coastal transect effort as CAPs strip, recording sightings only out to 1 km, replicating the strip three times, and do not circle sightings.

CAPs should not be initiated in areas where walruses are hauled out on ice or along the coast. Care should be taken when initiating CAPs near known areas of polar bears aggregations (i.e., near Barter and Cross islands). CAPs can be initiated in those areas but circling needs to be limited to 15 minutes.

The following “shades of gray” should also be considered when deciding whether to begin CAPs:

- An s on transect at approximately clino 9 or farther when the aircraft altitude is 1,100 ft is on the edge of the CAPs 3-km strip. In an area of moderately-high large cetacean density, diverting to circle distant sightings will likely result in s on circling, which may or may not have been detectable from the transect.
- In areas with multiple species of large cetaceans (e.g., southern Chukchi Sea), CAPs passing will likely result in many unidentified cetacean sightings. The team leader needs to make a judgment call regarding whether the inability to positively ID sightings to species is outweighed by the advantages of getting accurate encounter rates during CAPs passing or strip modes, supplemented by group size, cafl numbers, and species ID info from CAPs circling modes.
- If the team refrains from calling sightings located on fresh transect during circling-from-transect, those sightings may be detected from the trackline after resuming transect mode. This discipline helps justify staying in transect mode rather than entering CAPs mode.

Due to the subjective nature of the CAPs decision-making process, it is quite possible that CAPs may be initiated prematurely or in an area that can be adequately surveyed in transect mode. When in “CAPs fail” (i.e., after starting CAPs, but realizing there are not many whales in the area), return to specific s on CAPs passing locations during CAPs circling to increase your chances of finding animals. Depending on the time passed since marking the s on CAPs passing, the separation of sightings, and other factors, it might be possible to gather additional info for the s on CAPs passing sighting during CAPs circling. If there is confidence that an s on CAPs passing was resighted during CAPs circling, enter the resight as an s on CAPs circling and, post-flight, make a note in the s on CAPs passing stating what s on CAPs circling it corresponds to. If a sighting is found during CAPs circling in the general vicinity of an s on CAPs passing, but there is not very high confidence that the exact same sighting was relocated during CAPs circling, enter it as an s on CAPs circling; no additional notation needed.

Data Integration

Survey effort on CAPs passing and CAPs strip is equivalent to transect effort and is included in total on-effort kilometers for sighting rate and HUA analyses. Survey effort on CAPs circling is considered off-effort.

Sightings made during CAPs passing may be identified to species, but sightings may need to be recorded as unidentified cetaceans, particularly sightings that are farther from the trackline and in areas where multiple large cetacean species are expected to occur (e.g., southcentral Chukchi Sea and near Point Barrow).

We use many stats to incorporate sightings from CAPs into sighting rate and HUA analyses:

1. Species ID: Species ID for sightings identified to species during CAPs passing are unchanged. For each CAPs session, sightings entered as unidentified cetaceans during CAPs passing are adjusted based on the proportion of sightings positively identified to each large whale species during CAPs circling. The resulting adjusted number of CAPs passing sightings assigned to each species might not be an integer value; that is, the CAPs-adjusted number of sightings might be a real number, with non-zero digits to the right of the decimal place.
2. For each CAPs session, average group size and average number of calves per CAPs passing sighting are updated based on CAPs circling statistics.
    a. Average group size and average number of calves are computed for each positively identified species. These statistics are computed separately for CAPs passing and CAPs circling.
    b. The CAPs-adjusted average group size corresponds to the average group size from either CAPs passing or CAPs circling, whichever is largest.
    c. Similarly, the CAPs-adjusted average number of calves per sighting corresponds to the average from either CAPs passing or CAPs circling, whichever is largest.
    d. The total CAPs-adjusted number of sightings, whales, and calves used in sighting rate and HUA analyses result from summing sightings, whales, and calves identified to species during CAPs passing with sightings, whales, and calves assigned proportionally to species based on CAPs circling statistics.
3. Behavior is left unchanged for CAPs passing sightings with behaviors recorded in the original survey data. For CAPs passing sightings lacking behavior in the original survey data, behavior is adjusted for each species according to the proportion of sightings during CAPs circling that were recorded as feeding/milling. Only two behavior states are possible for CAPs-adjusted data: feeding/milling or not feeding/milling.

Sightings from CAPs are depicted in distribution maps exactly as entered in the ASAMM database; in other words, distribution maps do not show the CAPs-adjusted statistics described above.

FOCAL GROUP FOLLOW (FGF)

Adapted from Version 8, 27 June 2018

Focal Group Follow refers to data collected on dive and surface intervals for small groups of bowhead whales (e.g., 2-5 whales within 5 body lengths of each other; a group of six whales may be followed if the group comprises three cow-calf pairs). Larger groups (>5 whales or >3 cow-calf pairs) will not be followed because they bring a higher risk that the collected data actually represent more than one small group and collecting data in that circumstance could lead to inaccurate dive and surface intervals.

Ideally, FGF will be conducted in a variety of habitats (e.g., depths), behaviors, and geographic locations. Project management will provide guidance on areas where FGF has been carried out previously. Bowhead whale dive durations can range from 2 to >60 minutes, depending on depth, behavior, and age class, although dive durations of <15 minutes are more common (e.g., Figure D-5). Results from various bowhead whale satellite tag studies have shown a positive correlation between water depth and dive duration (Krutzikowsky and Mate, 2000; Quakenbush et al. 2013), so the deeper the water, the longer the expected dive interval. In the ASAMM study area, bowhead whales are found in deep water (>200 m) in the western Beaufort Sea (blocks 2, 6, and 7) generally in July and early August, so observed dive intervals (and surface intervals) are expected to be longer in those locations. Barrow Canyon (block 12) is another area where bowhead whales may dive deeper and for longer periods of time. Bowhead whales in shallower depths are expected to have shorter dive and surface intervals.

Data Collection

When a bowhead whale is sighted, the data recorder will enter the initial sighting (on transect or search) according to normal ASAMM protocol, wherein the aircraft will divert to circling after the initial mark is made. If, upon circling, the sighting turns out to be a small group (e.g., 2-5 whales, or three cow-calf pairs), there are no other bowhead whale groups evident in the area, environmental conditions are suitable for extended circling in the area (e.g., sea states ≤B03, good visibility, ceilings ~1500'), and fuel considerations allow, circling-from-transect will cease and FGF will start. Several dive and surface intervals from the same group should be collected, wherever possible. However, the amount of time dedicated to each FGF session will likely depend on several factors, including environmental conditions, fuel considerations, level of certainty of following the same group, habitat being sampled, and meeting other ASAMM objectives.

FGF data to be recorded will include overall behavior for the group, the time (AK Local) and position at which the last whale in the group is no longer visible, and the time (AK Local) and position that the first whale in the group is subsequently visible after a dive interval. Recording the exact *time* that whales appear or disappear is <u>more important</u> than recording the exact location; in other words, the group location does not need to be marked precisely. Note that whales do not need to be "at the surface", with body parts visible, to be classified as being in a surface interval. Whales that are subsurface (e.g., feeding or swimming just below the surface)

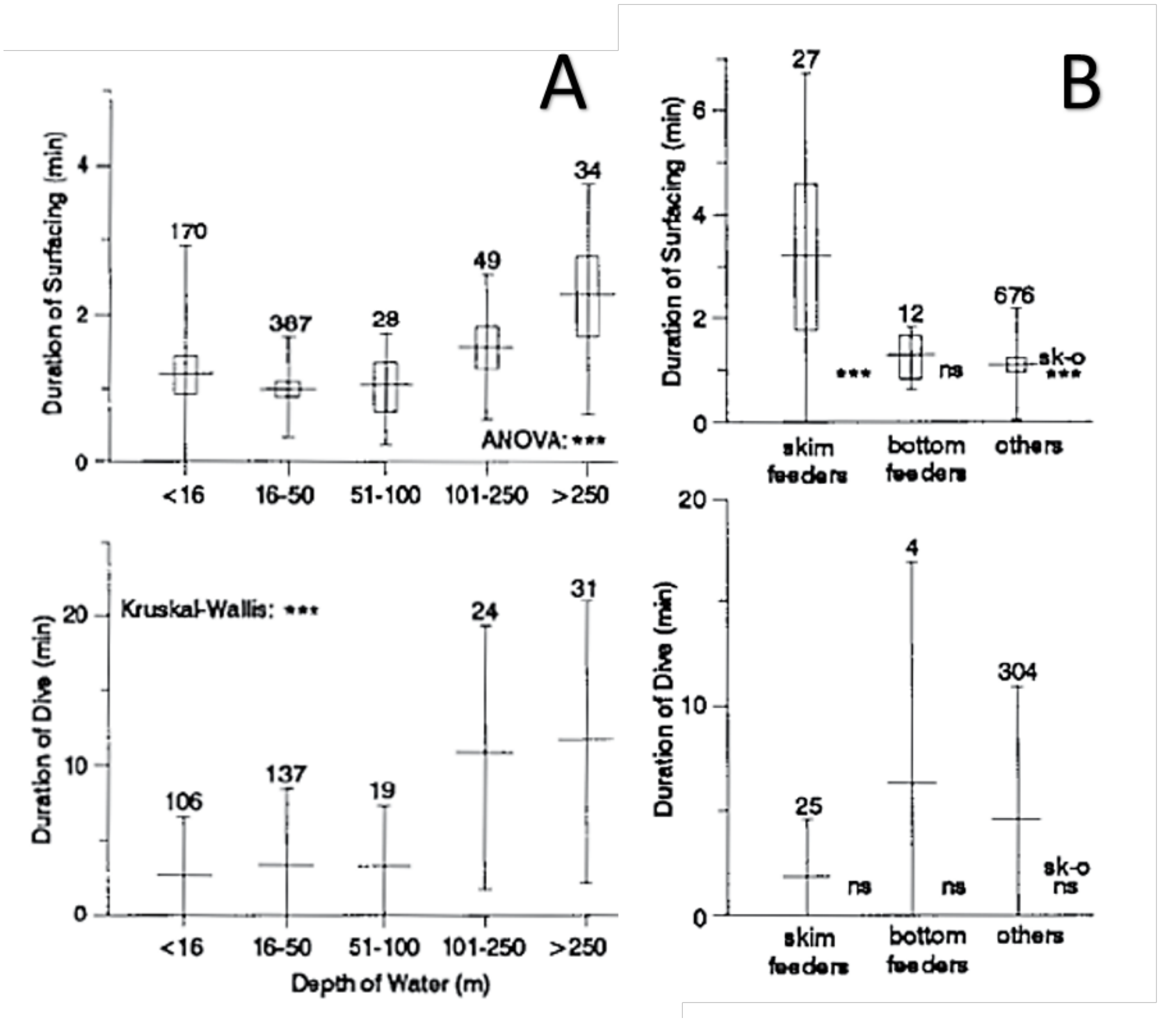

Figure D-5. Durations of surfacings and dives (min) for bowhead whales in five categories of water depth (A) and types of feeding (B), 1980-1984. Does not include any calves. (From Würsig and Clark, 1993).

that are still visible to observers should be included in surface intervals; dive intervals start when none of the whales in the group are visible, either at the surface or subsurface. Consensus behavior for the group will generally be either that the whales are traveling (i.e., behavior of "swim") or the whales are lingering (i.e., behavior of "feed", "mill", or "SAG"). Display behavior should not be denoted unless every animal in the group is displaying; specific display behaviors can be included in notes. Additional fields in the FGF protocol will include the total number of whales and calves in the group, water column visibility, surface visibility, certainty that the group being followed is the same as the initial group, reaction, photos, and notes (Table D-1). Clinometer angles are not necessary. Spatio-temporal data (latitude, longitude, altitude, time) for the group will be automatically recorded each time an FGF event is entered. FGF can be continued for as long as conditions (environmental, fuel, observer sanity) allow, with consideration for other ASAMM objectives.

Table D-1. Focal Group Follow data entry.

Field	Description
Behavior	Overall behavior of group - swim, feed, mill, SAG (additional behaviors can be included in Notes)
Total whales	# whales in group
Calves	# calves in group
Water column visibility	Relative measure of how well a whale can be seen under the surface of the water - excellent, moderate, poor
Surface visibility	Relative measure of how well a whale can be seen at the surface - excellent, moderate, poor
Certainty	Degree of confidence that the group being followed is the same as the initial group - high, medium, low
Reaction	Did any of the whales show response to the aircraft - no, yes (if yes, include details of what and how in notes)
Photos	Check box, yes or no
Notes	Additional behaviors, photo frames, unique markings, late or early marks on surfacings, types of reactions, etc.

During FGF, the aircraft will circle around the perimeter of the group while the whales are at the surface. When the last whale in the group is no longer visible, the aircraft will continue to circle the general area (Figure D-6). Circling position relative to the original group location will be trackable via the data recorder's and pilots' GPS units. If the group appeared to be traveling in a specific direction, the aircraft may reposition to better relocate the group when it surfaces. If the group was milling or feeding, circling should remain in the general area of the initial group sighting.

During FGF, altitude should be increased to 1500', if ceilings allow, both to allow a larger overall view of the area to improve the chances of recording first re-surfacings and to decrease the chances that the whales will respond to the aircraft. If whales do appear to respond to the aircraft, FGF should be discontinued, and the type and time of response included in notes.

FGF sessions may extend across adjacent transects if reliable dive and surface intervals are being recorded.

More than one FGF session may be initiated per flight if opportunities present themselves to collect focal group data.

Environmental updates may also be entered during FGF sessions, but sightings of other marine mammals should not be entered unless the sighting is unique (e.g., North Pacific right whale, narwhal).

There are some circumstances and areas that will limit FGF sessions or preclude FGF from being initiated. FGF should never take place near swimming polar bears, haulouts of walruses or SUPs (on ice or land), or in the vicinity of small craft. FGF should not be initiated near (within ~9 km)

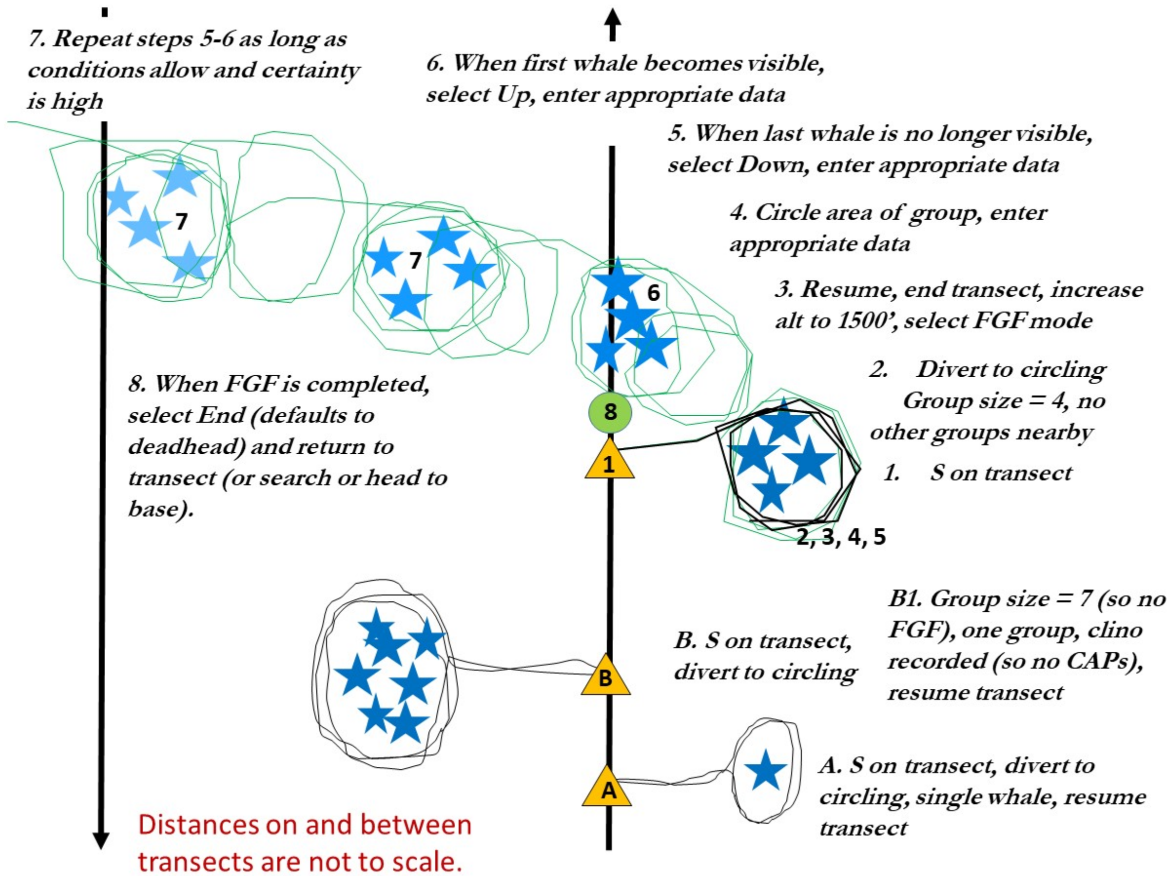

Figure D-6. Schematic showing hypothetical Focal Group Follow scenario. The straight black lines are transects surveyed using standard ASAMM protocols (note that transect distances are not to scale). The black circling represents circling on transect. The green circling is circling on FGF. Orange triangles are sightings on transect. Dark blue stars are bowhead whales; lighter blue stars are sightings on FGF.

Barter Island (Kaktovik) or Cross Island because there is a high likelihood of polar bear occurrence and circling would need to be limited to 15 minutes as per ASAMM's USFWS permit. Circling for FGF can be conducted in other nearshore areas unless polar bears were sighted in the area on the same day; circling in the vicinity of polar bears is limited to 15 minutes, which is insufficient for FGF.

BELLY PORT CAMERA (BPC)

Adapted from Version 2, 27 June 2018

ASAMM will be collecting images from a downward-facing camera mounted in one of the survey aircraft from July to October 2018. Imagery will be collected at two- or three-second intervals. Teams flying on the aircraft with the belly port camera (BPC) are responsible for the camera equipment on and off the plane, imagery management, storage, QA\QC, and photo analysis (PA).

Methods

Per normal ASAMM data collection protocol, aerial observer marine mammal and environmental data will be collected throughout the flight with a portable global positioning system (GPS) unit attached to the field laptop computer and set to automatically record time, the plane's position, and above ground level altitude (AGL) at 2- or 3-second intervals in time.

Concurrently, a downward facing digital single lens reflex camera (Nikon D810) with a 20-mm lens will be mounted to the belly port of the aircraft (Table D-2). The mounted camera will have a splitter cable attached to the front of it to connect an intervalometer (Nikon MC-36) and geo-tagging device (Red Hen Blue2CAN). The intervalometer is a time counting device set to remotely trigger the camera's shutter creating one image at 2- or 3-second intervals. The geo-tagging device will communicate, via Bluetooth, with a GPS receiver (HOLUX RCV-3000 GPS Receiver) located in a window the aircraft. In communication with the GPS receiver, the geo-tagging device writes the time, plane's position (latitude/longitude), and AGL altitude to the image metadata of every image that the intervalometer triggers. A Garmin GPSMAP 78sc will also internally collect time, position, and AGL altitude at one second intervals as a backup in the event that there is a disruption in the Bluetooth capable devices. Additional equipment is included in Table D-2. Imagery will be recorded during all transect and search survey modes, and are not necessary during deadheads.

Immediately after each flight, observers will download and save images and geospatial data to the network attached storage (NAS). Observers will rename images and geospatial data files following a specific naming convention to ensure continuity. The RAW imagery flight folder on the NAS will be used to extract image file names and metadata (including date, time, AGL, and latitude/longitude) to a *.csv file table. The resulting table will be used for all subsequent PA by field observers. Only images verified as valid will be evaluated. An image will be considered valid if it was collected during transect, search, or CAPs passing mode and the GPS altitude recorded in the imagery metadata was <473 m (1550 ft). Every third valid image will be viewed for cetacean sightings. Image environmental and sighting data will be recorded in the PA spreadsheet. At the end of the season all sighting data resulting from observer PA will be quality checked, PA sightings will be cross-checked to the ASAMM aerial observer sighting data, and ASAMM aerial observer data cross-checked with BPC imagery.

Table D-2. Belly Port Camera Equipment.

Equipment	Function
Nikon D810	camera body
Nikon Batteries	camera batteries for operating the camera while at camp
Nikon Battery Charger	charges the Nikon batteries at camp
Lexar Professional 800x 512 GB CF memory card (CF card)	serves as the primary memory card; thick
SanDisk Extreme PRO 512 GB SD memory card (SD card)	serves as secondary memory card; small
Nikon 20 mm F/1.8 lens (20 mm lens)	primary lens
Zeiss Milvus 21 mm F/2.8 lens (21 mm lens)	backup lens
Kapaxen AC Adapter	power adaptor to provide continuous power to the camera from the aircraft
Nikon Power Connector EP-5B	plugs into the camera and adapter to power the camera
Solmeta 10-pin Y splitter cable	attaches to the front of the camera to allow more than one piece of equipment to operate with the camera
Nikon MC-36 Remote Cord	intervalometer – counts intervals of time and will trigger the shutter to release at 2- or 3-second intervals
Red Hen Blue2CAN	geo-tagging device that writes the plane's position (latitude/longitude), AGL altitude, and time to each image's metadata
HOLUX RCV-3000 GPS Receiver	device that communicates geo-tagging information to the red hen via Bluetooth
Garmin GPSMAP 78sc	backup GPS set to internally log the plane's position (latitude/longitude), AGL altitude, and time if geo-tagging metadata is disrupted or missing
Lexar USB 3.0 Duel Slot memory card reader	used to download images from the CF and SD cards
Synology 8 Bay Field Storage Array DiskStation (aka NAS)	field-based mass storage; five of the eight bays are outfitted 12TB disk drives
Seagate 12TB IronWolf Field Storage Array internal hard drives	inserted into five of the eight NAS bays for storing imagery data in the field
HGST 4TB internal hard drives	for transferring imagery data to MML
Internal hard drive docking station	facilitates data transfer to internal hard drives
High- resolution monitors (2)	for reviewing and assessing images during PA
ACDSee	software for conducting PA
Insomnia	software that prevents the laptop from going to sleep or into hibernation so that image download is continuous

Equipment	Function
Holux ezTour	software for setting up the GPS Receiver (Holux RCV-3000) and downloading flight track data
Garmin HomePort	software for converting Garmin GPX files into Excel files and for plotting flight tracks to a map
Laptop computers (2)	one laptop is designated specifically for downloading imagery and geospatial data and used for PA; the other is a backup field laptop and used for PA

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APPENDIX E: SIGHTING RATE TABLES, 2018

Table E-1. ASAMM 2018 on-effort (transect and CAPs passing) kilometers (km), bowhead whale on-effort sightings (primary observers only), and bowhead whale sighting rate (WPUE = bowhead whales per km surveyed) per survey block per month. NA – surveys were not conducted.

	July				August				Summer			
BLOCK	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
1	1,411	1	1.0000	0.0007	1,080	1	1.0000	0.0009	2,491	2	2.0000	0.0008
1a	123	0	0.0000	0.0000	272	0	0.0000	0.0000	395	0	0.0000	0.0000
2	700	4	5.0000	0.0071	1,159	1	1.0000	0.0009	1,859	5	6.0000	0.0032
3	1,391	0	0.0000	0.0000	658	6	7.0000	0.0106	2,049	6	7.0000	0.0034
4	523	0	0.0000	0.0000	914	1	2.0000	0.0022	1,437	1	2.0000	0.0014
5	677	0	0.0000	0.0000	1,312	0	0.0000	0.0000	1,989	0	0.0000	0.0000
6	314	2	2.0000	0.0064	968	1	1.0000	0.0010	1,282	3	3.0000	0.0023
7	462	1	1.0000	0.0022	609	0	0.0000	0.0000	1,071	1	1.0000	0.0009
8	2	0	0.0000	0.0000	0	0	NA	NA	2	0	0.0000	0.0000
9	0	0	0.0000	NA	0	0	NA	NA	0	0	0.0000	NA
10	2	0	0.0000	0.0000	4	0	0.0000	0.0000	6	0	0.0000	0.0000
11	744	4	6.0000	0.0081	409	0	0.0000	0.0000	1,153	4	6.0000	0.0052
12	1,616	9	12.0000	0.0074	559	4	5.0000	0.0089	2,175	13	17.0000	0.0078
13	1,524	0	0.0000	0.0000	1,086	1	1.0000	0.0009	2,610	1	1.0000	0.0004
13N	365	0	0.0000	0.0000	514	0	0.0000	0.0000	879	0	0.0000	0.0000
14	739	0	0.0000	0.0000	597	0	0.0000	0.0000	1,336	0	0.0000	0.0000
15	246	2	3.0000	0.0122	298	0	0.0000	0.0000	544	2	3.0000	0.0055
16	0	0	0.0000	NA	276	0	0.0000	0.0000	276	0	0.0000	0.0000
17	419	0	0.0000	0.0000	695	0	0.0000	0.0000	1,114	0	0.0000	0.0000
18	2	0	0.0000	0.0000	353	0	0.0000	0.0000	355	0	0.0000	0.0000
19	0	0	0.0000	NA	250	0	0.0000	0.0000	250	0	0.0000	0.0000
20	0	0	0.0000	NA	312	0	0.0000	0.0000	312	0	0.0000	0.0000
21	0	0	0.0000	NA	0	0	0.0000	NA	0	0	0.0000	NA
22	0	0	0.0000	NA	495	0	0.0000	0.0000	495	0	0.0000	0.0000
23	1,233	0	0.0000	0.0000	0	0	0.0000	NA	1,233	0	0.0000	0.0000
Total	12,493	23	30.0000	0.0024	12,820	15	18.0000	0.0014	25,313	38	48.0000	0.0019

	September				October				Fall			
BLOCK	Km	Sightings	Whales	WPUE	Km	Sightings	Whales	WPUE	Km	Sightings	Whales	WPUE
1	1,067	44	61.0000	0.0572	468	7	8.0000	0.0171	1,535	51	69.0000	0.0450
1a	109	0	0.0000	0.0000	52	0	0.0000	0.0000	161	0	0.0000	0.0000
2	690	0	0.0000	0.0000	371	0	0.0000	0.0000	1,061	0	0.0000	0.0000
3	1,410	9	15.0000	0.0106	980	12	17.0000	0.0173	2,390	21	32.0000	0.0134
4	715	23	30.0000	0.0420	259	0	0.0000	0.0000	974	23	30.0000	0.0308
5	853	15	18.0000	0.0211	0	0	0.0000	NA	853	15	18.0000	0.0211
6	1,169	0	0.0000	0.0000	239	0	0.0000	0.0000	1,408	0	0.0000	0.0000
7	707	0	0.0000	0.0000	0	0	0.0000	NA	707	0	0.0000	0.0000
8	0	0	0.0000	NA	0	0	0.0000	NA	0	0	0.0000	NA
9	2	0	0.0000	0.0000	1	0	0.0000	0.0000	2	0	0.0000	0.0000
10	270	0	0.0000	0.0000	3	0	0.0000	0.0000	273	0	0.0000	0.0000
11	170	12	15.0000	0.0882	567	2	2.0000	0.0035	737	14	17.0000	0.0231
12	2,067	45	66.0000	0.0319	1,499	47	54.1538	0.0361	3,566	92	120.1538	0.0337
13	1,347	20	20.0000	0.0148	840	3	7.0000	0.0083	2,187	23	27.0000	0.0123
13N	0	0	0.0000	NA	0	0	0.0000	NA	0	0	0.0000	NA
14	1,027	4	5.0000	0.0049	250	0	0.0000	0.0000	1,277	4	5.0000	0.0039
15	779	0	0.0000	0.0000	81	0	0.0000	0.0000	860	0	0.0000	0.0000
16	222	0	0.0000	0.0000	178	0	0.0000	0.0000	400	0	0.0000	0.0000
17	770	0	0.0000	0.0000	220	0	0.0000	0.0000	990	0	0.0000	0.0000
18	342	0	0.0000	0.0000	412	0	0.0000	0.0000	754	0	0.0000	0.0000
19	150	0	0.0000	0.0000	422	0	0.0000	0.0000	572	0	0.0000	0.0000
20	824	0	0.0000	0.0000	521	0	0.0000	0.0000	1,346	0	0.0000	0.0000
21	436	0	0.0000	0.0000	73	0	0.0000	0.0000	509	0	0.0000	0.0000
22	541	0	0.0000	0.0000	322	0	0.0000	0.0000	863	0	0.0000	0.0000
23	682	0	0.0000	0.0000	164	0	0.0000	0.0000	846	0	0.0000	0.0000
Total	16,349	172	230.0000	0.0141	7,922	71	88.1538	0.0111	24,271	243	318.1538	0.0131

Total effort (Km) may differ from values in Tables 3 and E-2 because effort between barrier islands and the mainland was not included in the sighting rate per survey block analysis, except for block 1a, and effort in block 13N was not included in the sighting rate per depth zone analysis.

Table E-2. ASAMM 2018 on-effort (transect and CAPs passing) kilometers (km), bowhead whale on-effort sightings (primary observers only), and bowhead whale sighting rate (WPUE = bowhead whales per km surveyed) per depth zone per month. NA – surveys were not conducted.

	July				August				Summer			
DEPTH ZONE	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
157°W-169°W												
≤ 35 m	648	0	0.0000	0.0000	1,227	0	0.0000	0.0000	1,875	0	0.0000	0.0000
36-50 m	1,890	2	3.0000	0.0016	2,153	0	0.0000	0.0000	4,043	2	3.0000	0.0007
51-200 m N	1,277	0	0.0000	0.0000	884	1	1.0000	0.0011	2,161	1	1.0000	0.0005
51-200 m S	347	0	0.0000	0.0000	99	0	0.0000	0.0000	446	0	0.0000	0.0000
154°W-157°W												
≤ 20 m	407	1	1.0000	0.0025	119	0	0.0000	0.0000	526	1	1.0000	0.0019
21-50 m	309	6	9.0000	0.0291	110	0	0.0000	0.0000	419	6	9.0000	0.0215
51-200 m	740	2	2.0000	0.0027	270	3	4.0000	0.0148	1,010	5	6.0000	0.0059
201-2,000 m	160	0	0.0000	0.0000	59	1	1.0000	0.0169	219	1	1.0000	0.0046
140°W-154°W												
≤ 20 m	1,814	0	0.0000	0.0000	1,403	1	1.0000	0.0007	3,217	1	1.0000	0.0003
21-50 m	1,962	5	6.0000	0.0031	2,450	7	9.0000	0.0037	4,412	12	15.0000	0.0034
51-200 m	904	4	6.0000	0.0066	1,479	2	2.0000	0.0014	2,383	6	8.0000	0.0034
201-2,000 m	1,225	2	2.0000	0.0016	1,595	0	0.0000	0.0000	2,820	2	2.0000	0.0007
>2,000 m	387	1	1.0000	0.0026	445	0	0.0000	0.0000	832	1	1.0000	0.0012
TOTAL	**12,070**	**23**	**30.0000**	**0.0025**	**12,293**	**15**	**18.0000**	**0.0015**	**24,363**	**38**	**48.0000**	**0.0020**

	September				October				Fall			
DEPTH ZONE	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
157°W-169°W												
≤ 35 m	1,814	0	0.0000	0.0000	826	0	0.0000	0.0000	2,640	0	0.0000	0.0000
36-50 m	3,770	4	5.0000	0.0013	1,618	0	0.0000	0.0000	5,388	4	5.0000	0.0009
51-200 m N	1,144	20	20.0000	0.0175	809	3	7.0000	0.0087	1,953	23	27.0000	0.0138
51-200 m S	392	0	0.0000	0.0000	230	0	0.0000	0.0000	622	0	0.0000	0.0000
154°W-157°W												
≤ 20 m	610	4	7.0000	0.0115	288	4	4.0000	0.0139	898	8	11.0000	0.0122
21-50 m	427	9	9.0000	0.0211	309	4	4.0000	0.0129	736	13	13.0000	0.0177
51-200 m	842	16	23.0000	0.0273	723	25	28.8750	0.0399	1,565	41	51.8750	0.0331
201-2,000 m	185	16	27.0000	0.1459	178	14	17.2789	0.0971	363	30	44.2789	0.1220
140°W-154°W												
≤ 20 m	1,614	22	26.0000	0.0161	811	4	4.0000	0.0049	2,425	26	30.0000	0.0124
21-50 m	2,187	62	90.0000	0.0412	960	12	18.0000	0.0188	3,147	74	108.0000	0.0343
51-200 m	1,146	18	22.0000	0.0192	462	5	5.0000	0.0108	1,608	23	27.0000	0.0168
201-2,000 m	1,544	1	1.0000	0.0006	522	0	0.0000	0.0000	2,066	1	1.0000	0.0005
>2,000 m	611	0	0.0000	0.0000	155	0	0.0000	0.0000	766	0	0.0000	0.0000
TOTAL	**16,286**	**172**	**230.0000**	**0.0141**	**7,891**	**71**	**88.1539**	**0.0112**	**24,177**	**243**	**318.1539**	**0.0132**

Total effort (Km) may differ from values in Tables 3 and E-1 because effort between barrier islands and the mainland was included in the sighting rate per depth zone analysis and effort in block 13N was not included in the sighting rate per depth zone analysis.

Table E-3. ASAMM 2018 on-effort (transect and CAPs passing) kilometers (km), gray whale on-effort sightings (primary observers only), and gray whale sighting rate (WPUE = gray whales per km surveyed) per survey block per month. NA – surveys were not conducted.

	July				August				Summer			
BLOCK	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
12	1,616	2	2.0000	0.0012	559	0	0.0000	0.0000	2,175	2	2.0000	0.0009
13	1,524	6	9.0000	0.0059	1,086	2	3.0000	0.0028	2,610	8	12.0000	0.0046
13N	365	0	0.0000	0.0000	514	0	0.0000	0.0000	879	0	0.0000	0.0000
14	739	14	29.5000	0.0399	597	9	17.0000	0.0285	1,336	23	46.5000	0.0348
15	246	0	0.0000	0.0000	298	0	0.0000	0.0000	544	0	0.0000	0.0000
16	0	0	0.0000	NA	276	0	0.0000	0.0000	276	0	0.0000	0.0000
17	419	25	58.0000	0.1384	695	12	17.0000	0.0245	1,114	37	75.0000	0.0673
18	2	0	0.0000	0.0000	353	0	0.0000	0.0000	355	0	0.0000	0.0000
19	0	0	0.0000	NA	250	0	0.0000	0.0000	250	0	0.0000	0.0000
20	0	0	0.0000	NA	312	0	0.0000	0.0000	312	0	0.0000	0.0000
21	0	0	0.0000	NA	0	0	0.0000	NA	0	0	0.0000	NA
22	0	0	0.0000	NA	495	0	0.0000	0.0000	495	0	0.0000	0.0000
23	1,233	34	66.0000	0.0535	0	0	0.0000	NA	1,233	34	66.0000	0.0535
Total	**6,143**	**81**	**164.5000**	0.0268	**5,436**	**23**	**37.0000**	0.0068	**11,579**	104	201.5000	0.0174

	September				October				Fall			
BLOCK	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
12	2,067	0	0.0000	0.0000	1,499	0	0.0000	0.0000	3,566	0	0.0000	0.0000
13	1,347	4	5.0000	0.0037	840	1	1.0000	0.0012	2,187	5	6.0000	0.0027
13N	0	0	0.0000	NA	0	0	0.0000	NA	0	0	0.0000	NA
14	1,027	32	55.7692	0.0543	250	9	10.3529	0.0414	1,277	41	66.1221	0.0518
15	779	0	0.0000	0.0000	81	0	0.0000	0.0000	860	0	0.0000	0.0000
16	222	0	0.0000	0.0000	178	0	0.0000	0.0000	400	0	0.0000	0.0000
17	770	27	45.6667	0.0593	220	0	0.0000	0.0000	990	27	45.6667	0.0461
18	342	0	0.0000	0.0000	412	0	0.0000	0.0000	754	0	0.0000	0.0000
19	150	0	0.0000	0.0000	422	0	0.0000	0.0000	572	0	0.0000	0.0000
20	824	0	0.0000	0.0000	521	0	0.0000	0.0000	1,345	0	0.0000	0.0000
21	436	0	0.0000	0.0000	73	0	0.0000	0.0000	509	0	0.0000	0.0000
22	541	0	0.0000	0.0000	322	0	0.0000	0.0000	863	0	0.0000	0.0000
23	682	1	4.0000	0.0059	164	1	1.0000	0.0061	846	2	5.0000	0.0059
Total	**9,187**	**64**	**110.4359**	0.0120	**4,982**	**11**	**12.3529**	0.0025	**14,169**	75	122.7888	0.0087

Total transect effort (Tr Km) may differ from values in Tables 3 and E-4 because effort between barrier islands and the mainland was not included in the sighting rate per survey block analysis and effort in block 13N was not included in the sighting rate per depth zone analysis.

Table E-4. ASAMM 2018 on-effort (transect and CAPs passing) kilometers (km), gray whale on-effort sightings (primary observers only), and gray whale sighting rate (WPUE = gray whales per km surveyed) per depth zone per month.

	July				August				Summer			
DEPTH ZONE	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
157°W-169°W												
≤ 35 m	648	8	21.0000	0.0324	1,227	2	3.0000	0.0024	1,875	10	24.0000	0.0128
36-50 m	1,890	38	88.5000	0.0468	2,153	11	17.0000	0.0079	4,043	49	105.5000	0.0261
51-200 m N	1,277	22	40.0000	0.0313	884	10	17.0000	0.0192	2,161	32	57.0000	0.0264
51-200 m S	347	11	13.0000	0.0375	99	0	0.0000	0.0000	446	11	13.0000	0.0291
154°W-157°W												
≤ 20 m	407	0	0.0000	0.0000	119	0	0.0000	0.0000	526	0	0.0000	0.0000
21-50 m	309	0	0.0000	0.0000	110	0	0.0000	0.0000	419	0	0.0000	0.0000
51-200 m	740	2	2.0000	0.0027	270	0	0.0000	0.0000	1,010	2	2.0000	0.0020
201-2,000 m	160	0	0.0000	0.0000	59	0	0.0000	0.0000	219	0	0.0000	0.0000
Total	**5,778**	**81**	**164.5000**	**0.0285**	**4,921**	**23**	**37.0000**	**0.0075**	**10,699**	**104**	**201.5000**	**0.0188**

	September				October				Fall			
DEPTH ZONE	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
157°W-169°W												
≤ 35 m	1,814	3	4.0000	0.0022	826	0	0.0000	0.0000	2,640	3	4.0000	0.0015
36-50 m	3,770	26	49.2821	0.0131	1,618	4	4.0000	0.0025	5,388	30	53.2821	0.0099
51-200 m N	1,144	35	57.1538	0.0500	809	7	8.3529	0.0103	1,953	42	65.5067	0.0335
51-200 m S	392	0	0.0000	0.0000	230	0	0.0000	0.0000	622	0	0.0000	0.0000
154°W-157°W												
≤ 20 m	610	0	0.0000	0.0000	288	0	0.0000	0.0000	898	0	0.0000	0.0000
21-50 m	427	0	0.0000	0.0000	309	0	0.0000	0.0000	736	0	0.0000	0.0000
51-200 m	842	0	0.0000	0.0000	723	0	0.0000	0.0000	1,565	0	0.0000	0.0000
201-2,000 m	185	0	0.0000	0.0000	178	0	0.0000	0.0000	363	0	0.0000	0.0000
Total	**9,184**	**64**	**110.4359**	**0.0120**	**4,981**	**11**	**12.3529**	**0.0025**	**14,165**	**75**	**122.7888**	**0.0087**

Total transect effort (Tr km) may differ from values in Tables 3 and E-3 because effort between barrier islands and the mainland was included in the sighting rate per depth zone analysis, and effort in block 13N was not included in the sighting rate per depth zone analysis.

Table E-5. ASAMM 2018 on-effort (transect) kilometers (km), beluga transect sightings (primary observers only), and beluga sighting rate (WPUE = belugas per transect km surveyed) per survey block per month. NA – surveys were not conducted.

	July				August				Summer			
BLOCK	Tr Km	Tr Sightings	Tr Whales	WPUE	Tr Km	Tr Sightings	Tr Whales	WPUE	Tr Km	Tr Sightings	Tr Whales	WPUE
1	1,411	2	5	0.0035	1,080	1	1	0.0009	2,491	3	6	0.0024
1a	123	0	0	0.0000	272	0	0	0.0000	395	0	0	0.0000
2	700	35	151	0.2157	1,159	38	59	0.0509	1,859	73	210	0.1130
3	1,391	3	4	0.0029	658	0	0	0.0000	2,049	3	4	0.0020
4	523	2	7	0.0134	914	1	1	0.0011	1,437	3	8	0.0056
5	677	26	43	0.0635	1,312	11	17	0.0130	1,989	37	60	0.0302
6	314	24	66	0.2102	968	32	54	0.0558	1,282	56	120	0.0936
7	462	38	65	0.1407	609	29	52	0.0854	1,071	67	117	0.1092
8	2	0	0	0.0000	0	0	0	NA	2	0	0	0.0000
9	0.4	1	2	5.0000	0	0	0	NA	0.4	1	2	2.1431
10	2	0	0	0.0000	4	0	0	0.0000	6	0	0	0.0000
11	744	11	38	0.0511	409	8	19	0.0465	1,153	19	57	0.0495
12	1,616	26	177	0.1095	559	15	31	0.0555	2,175	41	208	0.0956
13	1,524	5	33	0.0217	1,086	3	6	0.0055	2,610	8	39	0.0149
13N	365	6	14	0.0384	514	2	2	0.0039	879	8	16	0.0182
14	731	0	0	0.0000	597	0	0	0.0000	1,328	0	0	0.0000
15	246	0	0	0.0000	298	0	0	0.0000	544	0	0	0.0000
16	0	0	0	NA	276	0	0	0.0000	276	0	0	0.0000
17	419	2	9	0.0215	695	0	0	0.0000	1,114	2	9	0.0081
18	2	0	0	0.0000	353	0	0	0.0000	355	0	0	0.0000
19	0	0	0	NA	250	0	0	0.0000	250	0	0	0.0000
20	0	0	0	NA	312	0	0	0.0000	312	0	0	0.0000
21	0	0	0	NA	0	0	0	NA	0	0	0	NA
22	0	0	0	NA	495	0	0	0.0000	495	0	0	0.0000
23	1,230	0	0	NA	0	0	0	NA	1,230	0	0	0.0000
Total	**12,482**	**181**	**614**	**0.0495**	**12,820**	**140**	**242**	**0.0195**	**25,302**	**321**	**856**	**0.0338**

	September				October				Fall			
BLOCK	Tr Km	Tr Sightings	Tr Whales	WPUE	Tr Km	Tr Sightings	Tr Whales	WPUE	Tr Km	Tr Sightings	Tr Whales	WPUE
1	1067	0	0	0.0000	468	0	0	0.0000	1535	0	0	0.0000
1a	109	0	0	0.0000	52	0	0	0.0000	161	0	0	0.0000
2	690	19	56	0.0812	371	25	34	0.0916	1061	44	90	0.0848
3	1410	2	2	0.0014	980	1	3	0.0031	2390	3	5	0.0021
4	715	0	0	0.0000	259	0	0	0.0000	974	0	0	0.0000
5	853	3	3	0.0035	0	0	0	NA	853	3	3	0.0035
6	1169	20	33	0.0282	239	0	0	0.0000	1408	20	33	0.0234
7	707	52	85	0.1202	0	0	0	NA	707	52	85	0.1203
8	0	0	0	NA	0	0	0	NA	0	0	0	NA
9	2	0	0	0.0000	1	0	0	0.0000	3	0	0	0.0000
10	270	8	14	0.0519	3	0	0	0.0000	273	8	14	0.0514
11	170	9	13	0.0765	567	14	34	0.0600	737	23	47	0.0637
12	2067	4	9	0.0044	1480	29	51	0.0345	3547	33	60	0.0169
13	1347	0	0	0.0000	840	1	1	0.0012	2187	1	1	0.0005
13N	0	0	0	NA	0	0	0	NA	0	0	0	NA
14	1020	0	0	0.0000	243	0	0	0.0000	1263	0	0	0.0000
15	779	0	0	0.0000	81	0	0	0.0000	860	0	0	0.0000
16	222	0	0	0.0000	178	0	0	0.0000	400	0	0	0.0000
17	758	0	0	0.0000	220	0	0	0.0000	978	0	0	0.0000
18	342	0	0	0.0000	412	0	0	0.0000	754	0	0	0.0000
19	150	0	0	0.0000	422	0	0	0.0000	572	0	0	0.0000
20	824	0	0	0.0000	521	0	0	0.0000	1345	0	0	0.0000
21	436	0	0	0.0000	73	0	0	0.0000	509	0	0	0.0000
22	541	0	0	0.0000	322	0	0	0.0000	863	0	0	0.0000
23	654	0	0	0.0000	164	0	0	0.0000	818	0	0	0.0000
Total	**16302**	**117**	**215**	**0.0132**	**7896**	**70**	**123**	**0.0156**	**24189**	**187**	**338**	**0.0140**

Total transect effort (Tr Km) may differ from values in Tables 3 and E-6 because effort between barrier islands and the mainland was not included in the sighting rate per survey block analysis, except for block 1a, and effort in block 13N was not included in the sighting rate per depth zone analysis.

Table E-6. ASAMM 2018 on-effort (transect) kilometers (km), beluga Tr sightings (primary observers only), and beluga sighting rate (WPUE = belugas per Tr km surveyed) per depth zone per month.

	July				August				Summer			
DEPTH ZONE	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
157°W-169°W												
≤ 35 m	648	1	8	0.0123	1,227	0	0	0.0000	1,875	1	8	0.0043
36-50 m	1,881	1	1	0.0005	2,153	0	0	0.0000	4,034	1	1	0.0002
51-200 m N	1,275	5	33	0.0259	884	3	6	0.0068	2,159	8	39	0.0181
51-200 m S	347	0	0	0.0000	99	0	0	0.0000	446	0	0	0.0000
154°W-157°W												
≤ 20 m	407	0	0	0.0000	119	0	0	0.0000	526	0	0	0.0000
21-50 m	309	0	0	0.0000	110	0	0	0.0000	419	0	0	0.0000
51-200 m	740	13	67	0.0905	270	6	8	0.0296	1,010	19	75	0.0743
201-2,000 m	160	13	110	0.6875	59	9	23	0.3898	219	22	133	0.6073
140°W-154°W												
≤ 20 m	1,814	1	1	0.0006	1,403	2	2	0.0014	3,217	3	3	0.0009
21-50 m	1,962	7	34	0.0173	2,450	0	0	0.0000	4,412	7	34	0.0077
51-200 m	904	16	42	0.0465	1,479	10	16	0.0108	2,383	26	58	0.0243
201-2,000 m	1,225	107	276	0.2253	1,595	95	164	0.1028	2,820	202	440	0.1560
>2,000 m	387	11	28	0.0724	445	13	21	0.0472	832	24	49	0.0589
TOTAL	**12,059**	**175**	**600**	**0.0498**	**12,293**	**138**	**240**	**0.0195**	**24,352**	**313**	**840**	**0.0345**

	September				October				Fall			
DEPTH ZONE	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
157°W-169°W												
≤ 35 m	1,801	0	0	0.0000	826	0	0	0.0000	2,627	0	0	0.0000
36-50 m	3,741	0	0	0.0000	1,617	0	0	0.0000	5,358	0	0	0.0000
51-200 m N	1,141	0	0	0.0000	803	1	1	0.0012	1,944	1	1	0.0005
51-200 m S	392	0	0	0.0000	230	0	0	0.0000	622	0	0	0.0000
154°W-157°W												
≤ 20 m	610	0	0	0.0000	288	0	0	0.0000	898	0	0	0.0000
21-50 m	427	0	0	0.0000	309	5	16	0.0518	736	5	16	0.0217
51-200 m	842	1	2	0.0024	714	16	26	0.0364	1,556	17	28	0.0180
201-2,000 m	185	3	7	0.0378	169	8	9	0.0533	354	11	16	0.0452
140°W-154°W												
≤ 20 m	1,614	1	1	0.0006	811	0	0	0.0000	2,425	1	1	0.0004
21-50 m	2,187	2	2	0.0009	960	1	3	0.0031	3,147	3	5	0.0016
51-200 m	1,146	13	18	0.0157	462	0	0	0.0000	1,608	13	18	0.0112
201-2,000 m	1,544	86	163	0.1056	522	27	53	0.1015	2,066	113	216	0.1045
>2,000 m	611	11	22	0.0360	155	12	15	0.0968	766	23	37	0.0483
TOTAL	**16,241**	**117**	**215**	**0.0132**	**7,866**	**70**	**123**	**0.0156**	**24,107**	**187**	**338**	**0.0140**

Total transect effort (Tr Km) may differ from values in Tables 3 and E-5 because effort between barrier islands and the mainland was included in the sighting rate per depth zone analysis and effort in block 13N was not included in the sighting rate per depth zone analysis.

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APPENDIX F: ASAMM CONTRIBUTIONS TO THE SCIENTIFIC COMMUNITY, 2008-Spring 2019

The Aerial Surveys of Arctic Marine Mammals (ASAMM) project is critical to understanding the arctic ecosystem and managing arctic natural resources in the past, present, and future.

- ASAMM is the only long-term broad-scale time series of data on marine mammal distribution, relative abundance, and behavior that exists for the Alaskan Arctic (140°-169°W, 68°-72°N, with surveys in adjoining regions in some years). The surveys have been conducted every year since 1979, with remarkably consistent data collection protocols from 1982 to the present.
- Information on marine mammal distribution and relative abundance in the western Beaufort and northeastern Chukchi seas during summer and fall can be reliably obtained only through aerial surveys conducted in these regions during the relevant seasons. This information is needed to generate species-specific estimates of the number of animals that are likely to be affected by future anthropogenic activities that are proposed to occur in the ASAMM study area during summer and fall. This information is required by BOEM and NOAA to fulfill the agencies' obligations under the NEPA, MMPA, and ESA. Without current, reliable data, the agencies will be vulnerable to litigation and their ability to make management decisions about future anthropogenic activities in this region during summer and fall will likely be delayed.
- Colleagues at multiple federal and state agencies, academic institutions, and private companies rely on the data in the ASAMM historical database to make decisions regarding marine mammal conservation and management, and to better understand marine mammal roles in the arctic ecosystem. Results from ASAMM have also been of interest to the general public, and have been communicated through newspaper articles, online blogs and radio interviews. Additional details are provided in Figure F-1 and summary sections below.
- There is minimal time lag between when ASAMM data are collected and when they may be used to inform management decisions. The survey aircraft can use the satellite telephone to convey critical information to contacts on the ground without any delay. This information has proven valuable in reporting walrus distributions and numbers to research vessels searching for walruses to tag and in relaying the exact location and approximate size of mass coastal walrus haulouts to USFWS in order to implement additional protection measures. Furthermore, the first draft of the entire database for each ASAMM flight is available within hours of the end of the survey, providing near real-time information to BOEM and NOAA for use in offshore oil exploration mitigation and oil-spill response drills. The final database is available within a few months of the end of the field season, and this rapid turn-around time has proven valuable in generating abundance estimates for eastern Chukchi Sea belugas and Western Arctic bowhead whales, resulting in a considerable cost savings to the Federal government.
- Due to the inter-annual variability in the arctic ecosystem and observed and expected changes to the ecosystem due to the changing climate, it is critical to survey the region every year to capture the range of ecosystem dynamics.
- The phenology of the arctic ecosystem is changing, with sea ice melt occurring earlier and freeze-up occurring later in the year. One result of the lengthened open water season is a greater period of time during which the arctic marine ecosystem is accessible to human activities with the potential to affect arctic resources, such as vessel traffic and oil

	Daily Reports	Biweekly Maps and Reports	Annual Reports	Maps	Shapefiles	Carcass Data	Sea Ice Photos	Sighting and Effort Data	Expert Input into Management Decisions	Aerial Recon
USCG				x			x			
BOEM	x	x	x	x	x		x	x	x	
USGS	x	x	x	x			x	x		x
NOAA	x	x	x	x	x	x	x	x	x	
USFWS	x	x	x	x		x	x	x		x
US Marine Mammal Commission			x						x	
Alaska Ocean Observing System					x			x		
Arctic ERMA					x			x		
NSB	x	x	x	x		x		x		
Oil & Gas Industry	x	x	x	x			x	x		
OBIS-SEAMAP								x		
Non-Governmental Organizations	x		x					x	x	
Other Researchers	x	x	x	x	x		x	x		x

Figure F-1. Matrix Summarizing ASAMM Products Distributed to Institutions and Agencies, 2008-Present.

and natural gas exploration, development, and production. In order to implement effective marine mammal conservation and management practices, it is important to continue to conduct broad-scale surveys for marine mammals throughout the entire seasonal range in which anthropogenic activities are likely to occur. Currently, ASAMM captures this critical time period from early July through the end of October.

- Weather in the Arctic can be extreme and is highly dynamic in space and time. There is no way to predict when the good weather will occur during the open water season within the ASAMM study area. To maximize the chances of obtaining useful data and be most efficient with limited government resources, best practice is to have ASAMM field teams maintain a constant presence in the study area throughout the open water season. Transits between the study area and home bases in lower latitudes cost money due to increased flight time for the survey aircraft and travel expenses for the aerial observers.
- The U.S. is a member of Arctic Council and was chair of the Council from 2015 to 2017. The Arctic Council is a high level, intergovernmental forum providing a means for promoting cooperation, coordination and interaction on common issues among the Arctic States, with the involvement of Arctic Indigenous communities and other arctic inhabitants. Sustainable development and environmental protection are particular issues

of concern. Other member nations of the Arctic Council include Canada, Denmark, Finland, Iceland, Norway, Russia, and Sweden, in addition to six Permanent Participants representing Indigenous peoples. ASAMM represents the most extensive marine mammal dataset from any Arctic Council nation and is an example of the usefulness of a multi-decadal time series.

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Brower, A. and J. Waite. 2018. Annual report for activities conducted by the National Marine Mammal Laboratory under Federal Fish and Wildlife Permit MA212570-1 in calendar year 2017. Prepared by the Marine Mammal Laboratory (NMFS) for U.S. Fish and Wildlife Service. 15 pp.

Christman, C. and B. Rone. 2011. Annual report for activities conducted by the National Marine Mammal Laboratory under Federal Fish and Wildlife Permit MA212570-0 for calendar year 2010. Prepared by the National Marine Mammal Laboratory (NMFS) for U.S. Fish and Wildlife Service. 12 pp.

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Clarke, J. and M. Ferguson. 2010. Aerial surveys of large whales in the Northeastern Chukchi Sea, 2008-2009, with review of 1982-1991 data. SC/62/BRG13 presented at the International Whaling Commission Scientific Committee Meetings, Morocco, June 2010. 18 pp.

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Clarke, J. and B. Rone. 2010. Annual report for activities conducted by the National Marine Mammal Laboratory under Federal Fish and Wildlife Permit MA212570-0 in calendar year 2009. Prepared by the National Marine Mammal Laboratory (NMFS) for U.S. Fish and Wildlife Service. 11 pp.

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Clarke, J., C. Christman, S. Grassia, A. Brower, and M. Ferguson. 2011. Aerial surveys of endangered whales in the Beaufort Sea, fall 2009. Final report, OCS Study BOEMRE 2011-040. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC, Seattle, WA 98115-6349. 92 pp.

Clarke, J., M. Ferguson, C. Christman, S. Grassia, A. Brower, and L. Morse. 2011. Chukchi Offshore Monitoring in Drilling Area (COMIDA) distribution and relative abundance of marine mammals: aerial surveys. Final report, OCS Study BOEMRE 2011-06. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC, Seattle, WA 98115-6349. 296 pp.

Clarke, J., C. Christman, A. Brower, and M. Ferguson. 2012. Distribution and relative abundance of marine mammals in the Alaskan Chukchi and Beaufort Seas, 2011. Annual report, OCS Study BOEM 2012-009. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC, Seattle, WA 98115-6349. 344 pp.

Clarke, J., C. Christman, A. Brower, and M. Ferguson. 2013. Distribution and relative abundance of marine mammals in the northeastern Chukchi and western Beaufort Seas, 2012. Annual report, OCS Study BOEM 2013-00117. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC, Seattle, WA 98115-6349. 349 pp.

Clarke, J., A. Brower, C. Christman, and M. Ferguson. 2014. Distribution and relative abundance of marine mammals in the northeastern Chukchi and western Beaufort Seas, 2013. Annual report, OCS Study BOEM 2014-0018. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC, Seattle, WA 98115-6349. 330 pp.

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Clarke, J., A. Brower, M. Ferguson, and A. Willoughby. 2017b. Distribution and relative abundance of marine mammals in the eastern Chukchi and western Beaufort Seas, 2016. Annual report, OCS Study BOEM 2017-078. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC, Seattle, WA 98115-6349.

Clarke, J.T., M.C. Ferguson, A.A. Brower, and A.L Willoughby. 2018. Bowhead whale calves in the western Beaufort Sea, 2012-2017. Paper SC/67/XX presented to the IWC Scientific Committee, April 2018 (unpublished), Bled, Slovenia.

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George, J.C., R. Stimmelmayr, A. Brower, J. Clarke, M. Ferguson, A. Von Duyke, G. Sheffield, K. Stafford, T. Sformo, B. Person, L. Sousa, B. Tudor, and R. Suydam. 2017. 2016 health report for the Bering-Chukchi-Beaufort seas bowhead whales - preliminary findings. Presented to the 2017 Scientific Committee of the International Whaling Commission. 21pp. SC/67a/AWMP.

Givens, G.H., M.C. Ferguson, J. Clarke, J.C. George, and R. Suydam. 2016. Can SLAs use minimum population size estimates? Presented at the International Whaling Commission Scientific Committee Aboriginal Subsistence Whaling Management Procedure Workshop, Copenhagen, December 2016.

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VENUES WHERE ASAMM RESULTS WERE PRESENTED (ALPHABETIZED):

Alaska Beluga Whale Committee Workshop, Anchorage, AK. 2012, 2016, 2018. Presentations (3).
Alaska Marine Science Symposium, Anchorage, AK. 2009-2019. Presentations (2), posters (47).
American Cetacean Society, Monterey, CA. 2008. Poster.
Applied Physics Lab, Polar Science Center, Seattle, WA. 2016. Presentation.
Arctic Council/PAME Workshop, Science and tools for developing Arctic MPA Networks, Washington, DC, 2016. Presentation.
Arctic Open Water Meetings, Anchorage, AK. 2009-2013. Presentations (2).
Bering Sea Open Science Meeting, Honolulu, HI. 2014. Poster.
Bowhead Whale Feeding Ecology Study Workshop, Anchorage, AK. 2009. Presentation.
Camden Bay Collaborative Study Workshop, Fairbanks, AK, 2014 and Anchorage, AK, 2016. Presentations (2).
Distributed Biological Observatory Data Workshops, Seattle, WA. 2014, 2016, 2017. Presentations (3).
Duke University, Marine Geospatial Ecology Lab, Durham, NC. 2017. Presentation.
International Whaling Commission Scientific Committee Meeting, Morocco. 2010 and 2017. Reports (3).
Minerals Management Service Information Transfer Meeting, Anchorage, AK. 2008. Presentations (2).

NSB Marine Mammal Observer training class, Barrow, AK. 2009. Presentation.
Ocean Sciences Meeting. 2014 and 2016. Presentations (2), poster (1).
Society for Marine Mammalogy, 2009, 2011, 2015. Presentation (1), posters (2).
United States-Canada North Oil and Gas Forum, Anchorage, AK. 2012. Presentation.
USFWS Workshop on Assessing Pacific Walrus Population Attributes from Coastal Haul-outs, Anchorage, AK. 2012. Presentation.

TIMELINE OF ASAMM MARINE MAMMAL DATA REQUESTS (ALL GRANTED) AND USES (CHRONOLOGICAL):

Feb 2010: Conoco-Phillips requested ASAMM 2008 aerial survey data for use in an Environmental Impact Study.
Mar 2010: Greg Balogh (USFWS) requested an ASAMM 2009 Icy Cape walrus haulout photograph for use in a USFWS Landscape Conservation Cooperative planning document.
Apr 2010: Bill Lorand (SFSU Geographic Information System student) requested the ASAMM 2008-2009 walrus sighting data for use in a Coastal & Marine Applications Geographic Information System course project.
May 2010: Lisa Rotterman (NMFS) requested maps of ASAMM data for potential use in Arctic Incidental Harassment Authorization Biological Opinion.
June 2010: Dave Rugh (NMML) requested maps of ASAMM 2009 effort for use in an informal discussion about NMML arctic surveys with a Naval Officer.
2010: Dan Pendleton (NOAA) requested 1982-2010 ASAMM bowhead whale data for a research project funded by NASA entitled "Forecasting Changes in Habitat Use by Bowhead Whales in Response to Arctic Climate Change: Integration of Physical-Biological Models with Satellite, Biological Survey and Oceanographic Data."
April 2011: Lisanne Aerts (OASIS Environmental) requested ASAMM 1982-2010 sightings within the Olgoonik-Fairweather study area for use in a comparison of aerial sightings with shipboard sightings.
Oct 2011: Joel Kasser and Jeadiz Wiedmer (Van Hall Larenstein, Netherlands BSc students) requested ASAMM walrus sightings from 2008-2010 for use in a thesis project for the Dutch WWF.
2011: Ken Dunton and Susan Schonberg (UT) requested shapefiles of ASAMM 2008-2010 bowhead whale, gray whale, and walrus sightings for comparison with benthic data.
2011: Provided the ASAMM 1979-2010 historical data and associated metadata to OBIS-SEAMAP, a spatially referenced online database, aggregating marine mammal, seabird and sea turtle observation data from across the globe.
2011: NMFS Cetacean Density and Distribution Mapping (CetMap) Working Group requested ASAMM data to conduct a "gap analysis" of cetacean data within the US EEZ.
2012-present: Hajo Eicken and Olivia Lee (UAF) requested ASAMM walrus and sea ice data to investigate walrus use of sparse sea ice habitat and to calibrate remotely sensed sea ice data.
2012: NSB requested data collected during ASAMM surveys conducted in the Alaskan Beaufort Sea in July and August 2012 to calculate a population estimate for the ECS beluga stock.

2012: Alyson Azzara (Committee on the Marine Transportation System) requested use of ASAMM data for an analysis of ship traffic in the Arctic. Azzara, A., H Wang, and D. Rutherford. 2015. A 10-year projection of maritime activity in the U.S. Arctic Region. Prepared by The International Council on Clean Transportation for the U.S. Committee on the Marine Transportation System.

2012: Amy Merten (NOAA) requested the ASAMM 1979-2012 database and tracklines for use in Arctic ERMA.

2012: Sadie Wright (NOAA) requested the ASAMM bowhead whale sightings from summer 2012 for use in Noise Exposure Analysis section of the 2013 Arctic Biological Opinion.

2013: Lucy Romeo (OSU graduate student) requested ASAMM beluga data to investigate the association between beluga and arctic cod.
Romeo, L.F. "Spatial distribution and the probability of occurrence of beluga whales (*Delphinapterus leucas*) in Alaskan Arctic." Master's thesis, Oregon State University, 2014.

2013: Peter Winsor (UAF) requested near real-time ASAMM marine mammal data to inform decisions on deploying an underwater glider equipped with a passive acoustic monitoring device for recording cetacean vocalizations.

2013: John Brandon (Greeneridge Sciences, Inc.) requested ASAMM bowhead whale sighting data for the Point Franklin-Peard Bay region in summer 2009-2012.

2011, 2012, 2013: Sue Moore (NOAA) requested map of ASAMM gray whale and walrus sighting data from 1982-2013 overlying areas covered by the Distributed Biological Observatory.

April 2014: Craig George (NSB) requested map of ASAMM 2013 bowhead whale calf sighting data.

April 2014: Sue Moore (NOAA) requested map of gray whale data (sightings, calves, feeding) to include in discussions at the IWC Workshop "Rangewide review of the population structure and status of North Pacific gray whale."

2014: Ying-Chih Fang (UAF) requested ASAMM 2010 bowhead and gray whale sighting data for comparison with surface current data in the Chukchi Sea, obtained from high-frequency radar.

2014: Elizabeth Edwards (NOAA) requested ASAMM fin whale sightings for a summary analysis of fin whale global distribution.

October 2014: Craig George (NSB) requested map of ASAMM 2014 bowhead whale Beaufort Sea sighting data to present at quarterly AEWC meeting.

November 2014: Sue Moore (PMEL) requested map of ASAMM 2014 feeding bowhead whale sightings for presentation at SOAR workshop.

November 2014: Chris Krenz (Oceana) and Nathan Walker (Audubon) requested ASAMM 2013 data. ASAMM data were used to produce various documents including:
Oceana and Audubon Alaska. 2015. Marine Mammal Species Core Area Analysis. Juneau and Anchorage, AK.
Satterthwaite-Phillips, D., C. Krenz, G. Gray, and L. Dodd. 2016. Iñuuniałiqput Iḷiḷugu Nunaŋ ŋ uanun (Documenting Our Way of Life with Mapping). Northwest Arctic Borough subsistence mapping project. Chapter 4.

December 2014: Alicia Bishop (NMFS Alaska Regional Office) requested estimates of densities, representing the best available science, for ESA listed species in the northeastern Chukchi Sea. This information is to be used in NMFS AKRO's consultation with BOEM over a proposed action on Lease Sale 193.

2014-2015: ASAMM historical database was used to determine the best study area for the Arctic Aerial Calibration Experiments (Arctic ACEs), a collaboration among BOEM, US Navy, NOAA, and Royal Dutch Shell.

March 2015: Guy Fleischer (AFSC, RACE division) requested the best available estimates of cetacean densities in the Arctic Large Marine Ecosystem for use in an Environmental Assessment.

May 2015: Craig George (NSB) requested information on historical bowhead whale calf ratios and Sue Moore (NOAA) requested 2014 gray whale sighting and abundance information for presentation at International Whaling Commission Scientific Committee meetings.

July-October 2015: Cetacean, walrus and polar bears sightings were shared with BOEM and Shell for discussion during weekly PSO conference.

September 2015: Craig George (NSB) requested near real-time bowhead sighting information to directly assist with satellite tagging project. Three bowhead whales were tagged northwest of Point Barrow on 2 September using information provided by ASAMM for bowhead locations on 1 September.

October 2015: Kate Stafford (PMEL) requested ASAMM 2015 beluga sighting data for presentation at ABWC meetings to be held in November 2015.

October 2015: Craig George (NSB) requested ASAMM 2015 bowhead whale carcass sighting data. More bowhead whale carcasses were seen in 2015 than in any prior year of ASAMM surveys; speculation is increased killer whale predation.

January 2016: Beth Sharp (Hilcorp Alaska) requested information pertaining to the potential of bowhead whales occurring between the mainland and barrier islands in the Alaskan Beaufort Sea.

March 2016: Steve Okkonen (UAF) and Craig George (NSB) requested information on survey effort and bowhead whale sightings at <50 m and >50 depths in the Barrow area.

July 2016: Raphaela Stimmelmayr (NSB) requested polar bear and brown bear sighting records from the ASAMM database, July-October, 1979-2016.

July 2016: Carin Ashjian (WHOI) and Craig George (NSB) requested maps of bowhead and gray whale transect sightings in the Barrow region for inclusion in an NSF proposal for Long Term Ecological Research.

August 2016: Sadie Wright (NMFS) requested near real-time data on marine mammal occurrence in the area of an oil spill drill near Oliktok Point, Beaufort Sea, AK.

May 2017: Don Dragoo (Chukchi Sea area biologist) and Jeff Williams (Alaska Maritime National Wildlife Refuge Manager) requested photos of Cape Lisburne for use in managing the refuge.

May 2017: Martin Robards (Director, Arctic Beringia Program, Wildlife Conservation Society) requested marine mammal photos to be used in an op-ed in Scientific American highlighting the abundance of marine mammals north of Bering Strait during fall.

June 2017: Lori Quakenbush (ADFG) requested photos of belugas to be used in an education and outreach presentation about aerial surveys.

July 2017: Sue Moore (NOAA PMEL) requested photos and flight track from ASAMM-Beaufort Flight 2, 21 July 2017, to be included in a presentation on the "krill trap" that she will present to vessel operators and participants conducting the fall 2017 Arctic EIS cruise.

July 2017: Raphaela Stimmelmayr (NSB) requested information pertaining to unidentified shark sightings in 2012 and 2017.

July 2017: Sadie Wright (NMFS AKRO) requested recent data on ASAMM sightings near Northstar Island in the Beaufort Sea, to be used in a hypothetical oil spill response drill.

August 2017: Cleridy Lennert-Cody (Inter-American Tropical Tuna Commission) requested an estimate of the cost of conducting ASAMM surveys to be included in: Lennert-Cody, C.E., S.T. Buckland, T. Gerrodette, A. Webb, J. Barlow, P.T. Fretwell, M.N. Maunder, T. Kitakado, J.E. Moore, M.D. Scott, and H.J. Skaug. Review of potential line-transect methodologies for estimating abundance of dolphin stocks in the Eastern Tropical Pacific. *Paper in review: Journal of Cetacean Research and Management.*

September 2017: Willow Hetrick (Fairweather Science) requested gray whale range data for use in an IHA.

April 2018: NMFS AKRO requested ASAMM data and shapefiles for survey blocks 1 and 1a, to be used in an ESA section 7 consultation for the Liberty development project.

April 2018: Sue Moore (NOAA PMEL) requested data on gray whale sightings in the Beaufort Sea to be used as background information in response to a letter from the U.S. Marine Mammal Commission.

May 2018: Amy Fowler (NOAA OPR) requested input on "Request for Incidental Harassment Authorization for the Incidental Harassment of Marine Mammals Resulting from the Office of Naval Research Arctic Research Activities 2018-2019"

July 2018: Sue Moore (PMEL) requested use of a figure showing all baleen whales sighted in 2017 to be included in a baleen whale occurrence review paper she is co-authoring.

August 2018: Alicia Bishop (NOAA) requested information on species expected to occur in the Pt. Thomson area in response to an oil spill drill

January 2019: Robyn McPhee (ConocoPhillips) requested ASAMM historical database 1979-2018 and information specific to the Coastal Harrison Bay transect surveyed in 2018.

2008-present: Level A stranding reports and photos were sent to NSB, NMFS, and USFWS.

2008-present: Marine mammal photos taken during ASAMM have been shared with numerous entities, including WWF, DFO, NOAA HQ, NSB, APR, and Arctic Sounder.

2010-present: Biweekly maps of ASAMM bowhead whale sightings were sent to BOEM, NMFS, NSB, USFWS, USGS, ADFG, USCG.

NON-MARINE MAMMAL DATA COLLECTED:

April 2012: provided ASAMM sea ice observations made in September and October from 2007-2011 to Warren Horowitz (BOEM) to compare and ground-truth remotely sensed sea ice data. Extracted data, created feature classes for import into Geographic Information System, and stored in a file geo-database.

Distributed sea ice photos and data from 2011-2017 to the following:

- NOAA, National Weather Service and Pacific Marine Environmental Laboratory: Ground-truth remotely sensed data, train staff, and include in presentations
- UAF: Examine sparse sea ice habitat for walruses
- BOEM: Manage and plan open water season activities
- USCG: Navigation
- USFWS: Investigate walrus habitat
- USGS: Sea ice reconnaissance during walrus tagging events
- Alaska Center for Climate Assessment and Policy
- Shell: Develop sea ice predictions for ice management during offshore operations

Sea ice data sent to Tom Weingartner (UAF) in September 2013 to provide information about sea ice coverage in offshore areas where a sea glider was to be launched.

Several meteorological instruments were located on shore and locations relayed to project owners for retrieval.

December 2014: marine debris sightings sent to Peter Murphy, Regional Coordinator of NOAA Marine Debris Program, Office of Response and Restoration.

February 2017: Provided ASAMM sea ice imagery from 2014-2015 to Victoria Hill (Old Dominion University, Department of Ocean, Earth and Atmospheric Sciences) to provide visual information about surface sea ice conditions in locations where buoy data overlap.

August 2018: Aerial photos of PMEL sail drones were provided to Heather Tabisola, Research Coordinator, EcoFoci and ITAE.

WALRUS AND POLAR BEAR COLLABORATIONS WITH USFWS AND USGS (CHRONOLOGICAL):

2009-present: Detailed information on ASAMM walrus and polar bear sightings were provided to USFWS to comply with research permit requirements. These data provide USFWS with information useful in Section 7 consultations required under the US ESA.

2009-present: Provided USGS and USFWS with the earliest and most comprehensive information about mass walrus haulouts located on the northeastern Chukchi Sea coast. USFWS used these data to implement management decisions affecting air traffic near the haulouts. USFWS and USGS use these data to study walrus haulout dynamics over time.

2010-2012: Provided ASAMM walrus sighting data, 1982-2011, to USFWS to investigate its utility in estimating walrus population size.

2011-2015: Multiple reconnaissance flights in July to locate walrus haulouts on offshore sea ice to assist USGS in satellite tagging efforts. Positions of large, small-boat-accessible walrus groups and surrounding ice conditions were relayed to biologists onboard the surface ship, resulting in a considerable cost savings to the government and an efficient use of uniquely qualified field personnel.

2014: Coordinated survey time with Brian Battaile and Chad Jay (USGS) to allow for dedicated overflights of walrus haulout at Point Lay and coastal surveys between Point Barrow and Cape Lisburne specifically for photography of haulouts.

2014: Special Agent Ryan Cote (USFWS Office of Law Enforcement) requested ASAMM archived and future Level As for walrus and polar bears to help investigations into potential criminal matters.

2015: Provided USGS updated information on walrus haulout near Point Lay to assist with their planning for overflights of the haulout using a small drone. The haulout needed to be a minimum of 3 nm from the airport in order for the drone to fly.

2015-2017: Incorporated searches of western Beaufort Sea coastline and barrier islands into flight plans, where possible, to search for polar bears; response to USFWS not conducting their biweekly coastal searches as they have in most recent past years.

2017: Michelle St. Martin (USFWS) requested data on all polar bear sightings from 2008-2016. Also provided all polar bear photographs in the ASAMM photo archive.

2017: James MacCracken and Jonathan Snyder (USFWS), and Anthony Fischbach and Chad Jay (USGS) requested recent photos of the coastal walrus haulout at Point Lay, Alaska.

2018: Sent summary of polar bear reactions, 2012-2017, from ASAMM database, to Michelle St. Martin and Kimberly Klein, USFWS.

2018: Shared ASAMM database 1979-2017, metadata, flightlines, version histories, etc., with Kristin Laidre, Eric Regehr, Harry Stern and Ben Cohen (UW Applied Physics Lab, Polar Science Center.

2018: Photo of walrus haulout at Pt. Lay and daily walrus sightings shared with James MacCracken and Jonathan Snyder (USFWS), and Anthony Fischbach and Chad Jay (USGS).

INCIDENTAL HARASSMENT AUTHORIZATIONS THAT USED ASAMM SIGHTING AND EFFORT DATA FOR MARINE MAMMAL DENSITY CALCULATIONS AND TAKE ESTIMATES (CHRONOLOGICAL):

Shell Exploration and Production: Application for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with a proposed open water seismic program in the Chukchi and Beaufort Seas, Alaska, during 2007.

ASRC Energy Services: Revised request for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with a proposed marine survey program in the Chukchi Sea, Alaska, in 2007.

BP Exploration: Request for an Incidental Harassment Authorization pursuant to section 101(A)(5) of the MMPA covering incidental harassment of marine mammals during an OBC seismic survey in the Liberty Prospect, Beaufort Sea, Alaska, in 2008.

Shell Exploration and Production: Application for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with a proposed open water seismic and marine survey program in the Chukchi and Beaufort Seas, Alaska, during 2008-2009.

Shell Exploration and Production: Application for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with a proposed open water marine survey program in the Chukchi and Beaufort Seas, Alaska, during 2009-2010.

Shell Exploration and Production: Application for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with planned 2010 exploration drilling program near Camden Bay in the Beaufort Sea, Alaska.

Shell Exploration and Production: Application for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with planned 2010 exploration drilling program, Chukchi Sea, Alaska.

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Statoil: Request for an Incidental Harassment Authorization by Statoil to allow incidental harassment of marine mammals during a 3D marine seismic survey in the Chukchi Sea, Alaska, 2010.

US Geological Survey: Request by US Geological Survey for an Incidental Harassment Authorization to allow the incidental take of marine mammals during a marine seismic survey of the Arctic Ocean, August-September 2010.

Statoil: Request by Statoil for an Incidental Harassment Authorization to allow the incidental take of marine mammals during a shallow hazards survey in the Chukchi Sea, Alaska, 2011.

University of Alaska Geophysics Institute: Request by the University of Alaska Geophysics Institute for an Incidental Harassment Authorization to allow the incidental take of marine mammals during a marine geophysical survey by the R/V Marcus G. Langseth in the Arctic Ocean, September-October 2011.

BP Exploration: Incidental Harassment Authorization request for the non-lethal harassment of whales and seals during the Simpson Lagoon OBC seismic survey, Beaufort Sea, Alaska, 2012.
ConocoPhillips: Application for Incidental Harassment Authorization for the non-lethal harassment of cetaceans and seals during exploration drilling activities in the Devil's Paw Prospect, Chukchi Sea, Alaska, 2012.
Ion Geophysical: Request by ION Geophysical for an Incidental Harassment Authorization to allow the incidental take of marine mammals during a marine seismic survey in the Arctic Ocean, October-December, 2012.
Shell Exploration and Production: Application for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with planned exploration drilling program during 2012 near Camden Bay in the Beaufort Sea, Alaska.
Shell Exploration and Production: Application for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with planned exploration drilling program during 2012 in the Chukchi Sea, Alaska.
Shell Exploration and Production: Application for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with a proposed open water marine surveys program in the Chukchi Sea, Alaska, during 2013.
SAExploration: Application for the Incidental Harassment Authorization for the Taking of Whales and Seals in Conjunction with the SAE Proposed 3D Seismic Survey in the Beaufort Sea, Alaska, Summer 2013.
SAExploration: Application for the Incidental Harassment Authorization for the Taking of Whales and Seals in Conjunction with the SAE Proposed 3D Seismic Survey in the Beaufort Sea, Alaska, Summer 2014.
BP Exploration: Incidental Harassment Authorization request for the non-lethal harassment of marine mammals during the Prudhoe Bay OBS Seismic Survey, Beaufort Sea, Alaska, 2014.
BP Exploration: Incidental Harassment Authorization request for the non-lethal harassment of marine mammals during the Liberty Geohazard survey, Beaufort Sea, Alaska, 2014.
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Hilcorp Alaska: Incidental Harassment Authorization request for the non-lethal harassment of marine mammals during the Liberty Unit geohazard surveys, Beaufort Sea, Alaska, 2015.
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SAExploration, Inc.: Application for the Incidental Harassment Authorization for the Taking of Marine Mammals in Conjunction with the SAE's Proposed 3D Seismic Survey in the Beaufort Sea, Alaska, 2016.
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Ferguson, M.C. and J.T. Clarke. Detecting spatial variability in the autumn migration of the Bering-Chukchi-Beaufort stock of bowhead whales across the Alaskan Beaufort Sea. *Paper in revision.*

APPENDIX G: ASAMM FIELD OF VIEW EFFORTS, SEPTEMBER 2018

Background

Aerial line-transect survey data have two sources of bias that need to be accounted for in order to derive absolute estimates of density or abundance: availability bias and perception bias. Availability bias refers to animals that are located on or near the trackline but cannot be seen because they are underwater or too far fore or aft of the aircraft and, therefore, not in the observers' field of view. Perception bias refers to animals that are available to be seen, but the observers fail to detect them due to distance, high sea states, glare, etc.

In order to derive a correction factor for availability bias in line-transect surveys, it is necessary to have behavioral data on the amount of time animals spend at the surface, or within the depth range where they can be seen from the air, and the amount of time at greater depths where they are invisible to an aerial observer. ASAMM will be collecting behavioral data using Focal Group Follow (FGF) protocols, which are addressed in Appendix D. In addition, the amount of time that an observer has to detect an available object must also be known. This can be determined for a given aircraft speed by quantifying the observer's field of view (FOV).

The FOV is a function of the configuration of the observer's window and varies from one observer to the next due to differences in posture, height, position in the window, eyesight, and familiarity with the target. Because the left and right bubble windows on the ASAMM survey aircraft (Clearwater Turbo Commanders) are slightly different from each other, ASAMM quantified the left and right fields of view separately. Numerous other conditions also affect FOV, including: sun position (direction and angle); precipitation, including rain, snow, haze, or fog; sea state; winds at the altitude of the survey aircraft, which affect the aircraft's angle relative to its direction of travel; and object color, reflectance, size, and shape.

During the 2018 field season, the ASAMM project collected data to estimate the dimensions of the survey aircraft's left and right fields of view. This effort was a continuation of initial FOV data collection in summer and fall 2017 (Clarke et al. 2018, Appendix D) and January 2018, and incorporated important refinements based on lessons learned. This appendix documents ASAMM's FOV 2018 protocols; provides references to the analytical methods for estimating FOV; summarizes the ASAMM survey effort dedicated to collecting FOV data; provides limited preliminary results; and discusses future ASAMM efforts to estimate FOVs.

Field Methods

To quantify FOV from the Turbo Commander, the aircraft flew short, predetermined transects located at designated distances from a stationary target on land. The target was located in an area of relatively low air traffic (>10 miles from any airport) to minimize distractions and maximize safety. Ideally, the target should be symmetrical, so that it appears the same regardless of viewing direction, and should not be extremely reflective because that could result in time-in-view estimates that are biased high. This ideal is nearly impossible to achieve in reality, due to differences in sun position and aircraft heading, among other things. Transects were located on relatively flat terrain that did not interfere with target visibility.

A tight cluster of Conex boxes (Figure G-1) located between the Dalton Highway and Franklin Bluffs, approximately 34 km south of Deadhorse, Alaska, was chosen as the designated target after considerable scouting and practice FOV trials using a variety of targets. The target coordinates, determined by the ASAMM GPS on the ground, were 69.9°N, 148.7°W (the coordinates in degrees, decimal minutes are 69°54.84'N, 148° 43.85'W).

The goal was to fly transects located 500 m and 2000 m from the target (Figure G-2). Transect waypoints were all centered on the target. Coordinates of each waypoint in degrees, decimal minutes are provided in Table G-1. The length of each transect was long enough so that the observer could not see the target at the beginning and end of the transect. Based on experience, the 500-m transects were designed to be 40 km long and the 2000-m transects were 50 km long. Transects were truncated in flight to minimize the amount of time spent unnecessarily scanning empty tundra, and the aircraft increased speed once the target left the observer's field of view towards the aft of the aircraft to increase efficiency.

Previous experience proved that targets disappeared under the wing or in exhaust from the aircraft engines when transects were flown farther than 750 m perpendicular distance at altitudes ≤1500 ft AGL, and this biases the results of the FOV analysis. Experience also proved, on multiple occasions, that data from FOV trials are extremely noisy. To obtain meaningful results, FOV data from the approximate altitude that ASAMM surveys are flown need to be collected on transects separated by at least 1500 ft perpendicular distance. To maintain the target in the aft FOV until it disappears due to distance, the Turbo Commander must fly at an altitude of approximately 2000 ft AGL or higher. Therefore, all FOV trials were conducted at 2000 ft AGL. Cloud ceilings were high enough to not affect visibility of the target at distance; if low ceilings were to impede detection of the target, FOV trials would have ceased and the aircraft would have either returned to base or commenced offshore survey effort if survey conditions were acceptable.

ASAMM typically conducts surveys between 1000 ft and 1500 ft altitude. A bowhead whale is approximately 60 ft long, although often the whale's total length is not visible to an aerial observer upon initial detection. A 60-ft object viewed from 1000 ft will appear to be the same size as a 120-ft object viewed from 2000 ft (Figure G-3). The footprint of the two large ochre and one large light blue Conex boxes in the Franklin Bluffs target (Figure G-1) is approximately 32 ft x 40 ft; therefore, the apparent size of the target at 2000 ft altitude was roughly the size of a sighting cue for a bowhead whale at typical ASAMM survey altitude.

Transects were generated along four axes: north/south, east/west, northwest/southeast, and northeast/southwest (Figure G-2). For each orientation, there is one set of transects on each side of the target. A "set" of transects consists of transects located 500 m and 2000 m perpendicular to the target. For example, there is one set of north/south transects located east of the target and one set of north/south transects located west of the target. The survey team chose the orientation that minimized the effects of crabbing due to crosswinds at the altitude of the aircraft and optimized viewing conditions for both observers during the same trial. In Table G-1, the transect name for all transects on one side of the target ends in either 1 or 2, and the name for all lines on

Figure G-1. Aerial view of the Conex boxes located along the Sagavanirktok River, between the Dalton Highway and Franklin Bluffs south of Deadhorse, Alaska, that were used for the ASAMM FOV target in September 2018.

the opposite side of the target ends in either 1x or 2x. For a single FOV flight, the goal was to fly only the 500-m and 2000-m transects.

Transects were flown at typical ASAMM survey speed (approximately 115 kts). Because the target was stationary and above ground, survey speeds ranging from 110 to 130 kts were acceptable.

One entire set of transects for a given transect orientation was flown two times for each observer, left and right, in order to collect replicate data that can be used to estimate measurement error. In order to differentiate between potential differences due to side-of-plane vs. observer effects, observer A remained in the left window for two sets of transects, then observers traded positions and repeated two more sets of transects. The exact details on the order in which transects were flown are documented in the database; an example is provided in Table G-2. To complete the entire experiment with one pair of observers, each observer needed to fly eight transects: two perpendicular distances (500 m and 2000 m), two replicates, and two sides of the plane (left and right). It took approximately 11 minutes to complete one transect and line up for the next

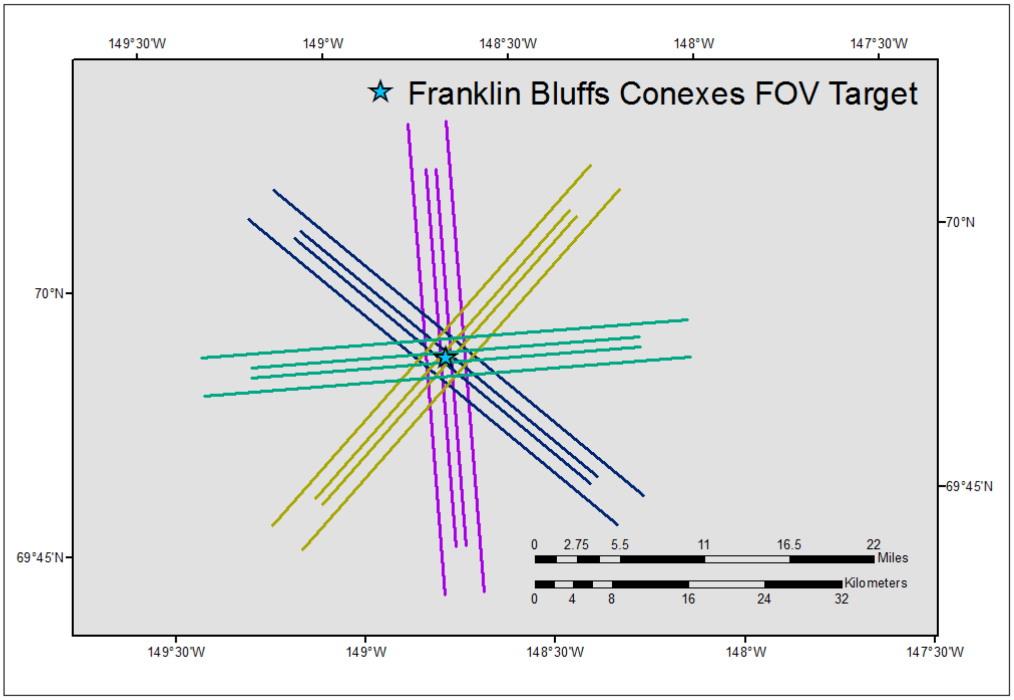

Figure G-2. Franklin Bluffs Conex box FOV target and transects oriented north/south, east/west, northwest/southeast, and northeast/southwest. A "set" of transects consists of transects located 500 m and 2000 m perpendicular to the target. There are two sets of transects for each transect orientation. Only one set of transects was flown during a single FOV flight to minimize variability in environmental effects that affect detectability.

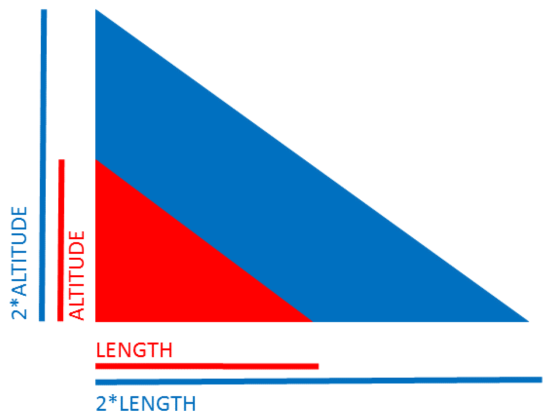

Figure G-3. The height and length of a right triangle (a triangle with one 90^{o} angle) scale directly in proportion with each other. Therefore, a 60-ft bowhead whale viewed from 1000 ft altitude will appear to be the same length as a 120-ft target viewed from 2000 ft altitude.

Table G-1. Franklin Bluffs Conex box transect waypoints (degrees, decimal minutes).

ID	lat.deg	lat.dec.min	long.deg	long.dec.min
500EW1	69	55.0669177	-148	12.548212
500EW2	69	55.0669177	-149	15.151788
2000EW1	69	55.84772788	-148	4.698190703
2000EW2	69	55.84772788	-149	23.0018093
500EW1x	69	54.52911728	-148	12.56158977
500EW2x	69	54.52911728	-149	15.13841023
2000EW1x	69	53.69657622	-148	4.765076579
2000EW2x	69	53.69657622	-149	22.93492342
500NE1	70	2.616896981	-148	22.13605436
500NE2	69	47.40527005	-149	6.402925317
2000NE1	70	5.075483576	-148	18.17522675
2000NE2	69	46.06117467	-149	13.53472399
500NE1x	70	2.236612362	-148	21.03635485
500NE2x	69	47.02497427	-149	5.289845891
2000NE1x	70	3.55436888	-148	13.78331328
2000NE2x	69	44.54000366	-149	9.0759079
500NW1	69	47.40527005	-148	21.29707468
500NW2	70	2.616896981	-149	5.563945636
2000NW1	69	46.06117467	-148	14.16527601
2000NW2	70	5.075483576	-149	9.52477325
500NW1x	69	47.02497427	-148	22.41015411
500NW2x	70	2.236612362	-149	6.663645146
2000NW1x	69	44.54000366	-148	18.6240921
2000NW2x	70	3.55436888	-149	13.91668672
500NS1	70	5.600315124	-148	43.06760351
500NS2	69	44.08740809	-148	43.06760351
2000NS1	70	8.288935932	-148	40.72041475
2000NS2	69	41.39780174	-148	40.72041475
500NS1x	70	5.600315124	-148	44.63239649
500NS2x	69	44.08740809	-148	44.63239649
2000NS1x	70	8.288935932	-148	46.97958525
2000NS2x	69	41.39780174	-148	46.97958525

Table G-2. Sample FOV transect order. Blue cells indicate that observers switched sides of plane.

Trial #		Observer Name	SOP	Transect Distance
1		A	R	500m
2		B	L	500m
3		A	R	500m
4		B	L	500m
5		A	R	2000m
6		B	L	2000m
7		A	R	2000m
8		B	L	2000m
9		B	R	2000m
10		A	L	2000m
11		B	R	2000m
12		A	L	2000m
13		B	R	500m
14		A	L	500m
15		B	R	500m
16		A	L	500m

transect. For flight planning, we estimated that 16 transects at 11 minutes per transect would take 176 minutes (~3 hrs) on site, plus time to transit between the target and Deadhorse airport.

Data were recorded into a specialized component of the ASAMM survey program by the data recorder. For each transect, data included: 1) time and position at which the target was first clearly visible (e.g., the Conex boxes appeared as separate structures); 2) time and position at which the target was perpendicular to the aircraft; and 3) time and position at which the target was no longer clearly visible. The notes field in the data entry software was used to consistently label the transect distance ("500m" or "2000m") and orientation (NS, EW, NW, or NE) for the abeam sightings. If the observers knew that one mark was "bad" (e.g., the observer detected the target late or the data recorder input the data late), the data recorder entered a note with a brief description of what went wrong (e.g., "entered mark late"). Environmental updates (wind speed and direction, lighting effects) were recorded opportunistically throughout the flight.

For this experiment, the element of surprise is not necessary. The ability to accurately and precisely record the times and locations described above is most important. Perception bias will be computed using other methods (see Appendix D). To maximize the accuracy and precision in the data, the FOV flight was the first flight of the day to minimize observer fatigue. Additionally, each observer focused all their attention on detecting and maintaining sight of the target. At the beginning of the transect, the observer focused all search effort in front of the plane, searching only the small area where they expected to find the target, in order to determine the moment when the target became clearly visible. The observer called "mark" only when they were certain that they could identify the target. Once the target was aft of the aircraft, the observer kept their eyes on the target until they were no longer able to differentiate among the Conex boxes. The observer did not scan the field of view like they would during a survey because that likely introduces measurement error into the data. The observer tried to maintain typical survey posture in the window while on transect because head position will affect the field of view.

Preliminary Results

FOV flights were flown over the Franklin Bluffs target with four ASAMM observers using the methods defined above on 18 (Figure G-4) and 19 September 2018. Survey conditions on both days included clear skies, unlimited visibility, and no impediments to visibility. The east/west transects located south of the target were flown for all trials in order to minimize effects of crabbing and to keep the sun's glare at the observers' backs. All trials were conducted at constant speed of ~115 kts.

Although there was variability in the field of view among observers, the data showed that the target remained in view longer from the 2000-m transect compared to the 500-m transect.

Future Directions

The FOV data from the Franklin Bluffs trials conducted on 18 and 19 September 2018 will be analyzed further to quantify the variability among observers and to estimate the dimensions of the FOV from the ASAMM survey aircraft that can be used in conjunction with bowhead whale surface and dive interval data to derive an estimate of availability bias specific to ASAMM surveys.

Acknowledgments

Special thanks to the ASAMM observers and pilots who enthusiastically flew racetracks around stationary objects on the tundra to their hearts' content (see Figure G-4) and provided invaluable feedback on ways to improve the FOV experimental design: Corey Accardo, Lisa Barry, Vicki Beaver, Dirk Bowen, Nicole Brandt Turner, Amelia Brower, Stan Churches, Janet Clarke, Sarah Corbin, Carol Fairfield, Megan Ferguson, Marjorie Foster, Laura Ganley, Griffin Kellar, Suzie Hanlan, Andy Harcombe, Jesse Munday, Kate Pagan, Jake Turner, and Amy Willoughby. We also thank Laura Ganley for providing analytical expertise and sample computer code for analyzing the FOV data.

Figure G-4. Screenshot from the pilots' GPS unit of the eastern end of FOV flight tracks, ASAMM-Beaufort Flight 31, 18 September 2018. All we need is love.

Literature Cited

Clarke, J.T., A.A. Brower, M.C. Ferguson, and A.L. Willoughby. 2018. Distribution and relative abundance of marine mammals in the eastern Chukchi and western Beaufort seas, 2017. Annual Report, OCS Study BOEM 2018-023. Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA.

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APPENDIX H: SAFETY AND LOGISTICS PLAN, 2018

AERIAL SURVEYS OF ARCTIC MARINE MAMMALS: SAFETY AND LOGISTICS PLAN
29 June 2018

The Aerial Surveys of Arctic Marine Mammals (ASAMM) project is co-managed by BOEM and the Alaska Fisheries Science Center (AFSC, NOAA Fisheries), conducted by AFSC, and funded by BOEM. The ASAMM survey area covers the eastern Chukchi and western Beaufort seas, from 140° – 169°W, 67° – 72°N, with a small bump north to 73° (Figure 1). The 2018 field season will begin on 1 July and run until approximately 31 October, although field operations may cease a few days early depending on weather conditions in the study area. This safety plan provides information about emergency support services, aviation safety protocols, firearms protocols, and protocols for mitigating risks to project personnel posed by wildlife encounters on the ground.

Emergency Support Services at the ASAMM Bases of Operations

ASAMM will operate from two bases, Utqiaġvik and Deadhorse, located on the North Slope of Alaska (Figure 1). Lodging in Utqiaġvik will be provided by the King Eider Inn, and lodging in Deadhorse will be provided by MagTec. The Utqiaġvik team will be in the field from 1 July until the end of the field season in late October, and the Deadhorse team will be in the field from 18 July – 11 October. One Turbo Commander, operated by Clearwater Air, Inc., will be stationed at each ASAMM base and will be available to ASAMM under an exclusive use contract for the duration of the Utqiaġvik and Deadhorse field seasons.

The primary emergency support services in Utqiaġvik include 9-1-1, the Samuel Simmonds Memorial Hospital, and the North Slope Borough Search and Rescue (NSB SAR) Department. The hospital is an outpatient unit providing emergency clinic and urgent care, among other things. It is open for emergencies 24 hours a day, and accepts non-emergency walk-ins until 4:30 PM. It is located at 7000 Uula St., and the phone number is 907 852 4611. The NSB SAR crew are well-trained and have well-maintained equipment to provide a rapid response. They are available around the clock at 907 852 0401 and 907 852 2822. At the beginning of the ASAMM field season, ASAMM Project Management, along with at least one of the Clearwater Air pilots, will make contact with the NSB SAR to let them know of our presence and activities, including our aircraft type, call sign, emergency frequencies, contact phone numbers, and map of the study area and survey blocks. This visit has a dual purpose: to introduce our project in the event that we should need assistance and to let NSB SAR know that our aircraft and crew could be available for coordination and assistance should the occasion arise for a SAR effort while we are based in Utqiaġvik.

Medical assistance and emergencies in Deadhorse will be handled by a medical clinic operated by BP. The clinic is referred to as the "MCC" (main construction camp). MCC can facilitate MedEvac air transfers, triage trauma, and provide a spectrum of acute care, emergency medicine, and first aid. The clinic is open and staffed around the clock, 365 days a year; they are located on the lease land, and their phone number is 907 659 5239. The facility is accessed via the Central Check Point gate in Deadhorse; all non-badged personnel need to be escorted to MCC by

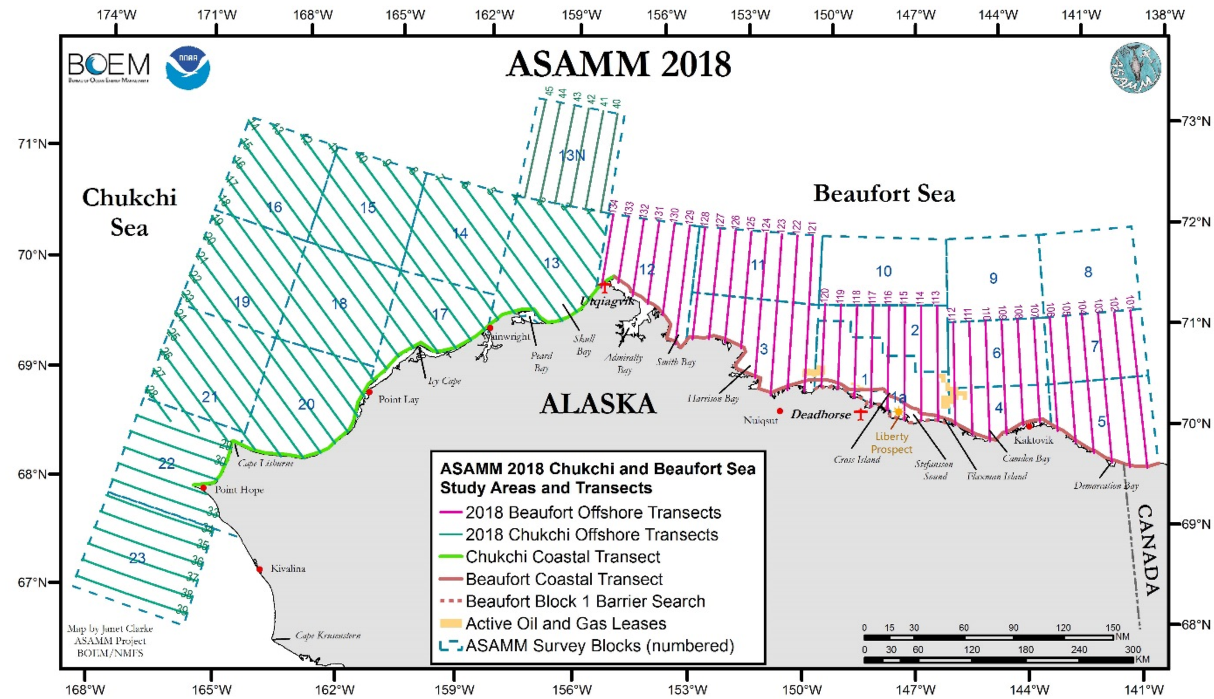

Figure 1. ASAMM study area and survey blocks with 2018 offshore transects, coastal transects, and offshore oil and gas lease areas.

security. Deadhorse is also served by the North Slope Borough Police, who can be reached by calling 9-1-1.

Both Utqiaġvik and Deadhorse are served by commercial jets at least once daily, weather permitting. It is also possible that the ASAMM survey aircraft could be used for an emergency medevac to Anchorage. There are two main hospitals in the Anchorage area, both of which provide emergency services 24 hours a day:

Alaska Regional Hospital	Providence Alaska Medical Center
2801 DeBarr Road	3200 Providence Drive
Anchorage, AK 99508	Anchorage, AK 99508
907 276 1131	907 562 2211

Aviation Safety Protocols

The ASAMM aviation safety protocols are based on training, emergency preparedness, flight following, and reporting, as detailed below.

Training

Each person flying on ASAMM surveys must have a combination of annual, periodic, and one-time trainings.
The ASAMM field teams will ensure that personnel rotating into the field for the first time during the 2018 field season are thoroughly briefed on aircraft operations, have practiced

donning the Ice Commander Immersion Suits, and participate in aircraft egress drills. The egress drills will allow each team member the opportunity to practice preparing for and surviving an in-air emergency so that everyone onboard the aircraft knows precisely what their responsibilities are in an emergency situation. These trainings will review emergency materials, including use of GPS units, satellite phones, PLB, and aircraft and marine band handheld radios.
The aircraft used during the 2018 season will include Turbo Commander (twin turbine, high fixed-wing) aircraft used during previous ASAMM field seasons. All of the Clearwater Air Pilots in Command (PIC) have previously flown ASAMM surveys from 2011-2017. The Clearwater Air Pilots in Command have an average of over 8500 hrs flying experience and considerable experience flying small aircraft in arctic Alaska. Clearwater PICs also conduct a comprehensive Flight Risk Assessment (Figure 2) as part of survey planning, which incorporates inputs about crew, environment, operations, and aircraft, and allows for inputs from aircraft management.

NOAA's aviation safety policy is available online: (https://sites.google.com/a/noaa.gov/omao-intranet-dev/operations/hq/safety/aviation-safety/safety-training). Annual training for personnel participating in NOAA aerial surveys includes reviewing three of NOAA's aviation safety modules: 1) NOAA Aviation Policy and Procedures; 2) Basic Aviation Safety and Survival; and 3) Aviation Health. In addition, NOAA requires all personnel participating in aerial surveys to complete a water ditching, safety, and survival course once every 5 years; AFSC policy is more stringent, requiring this training once every 3 years due to the remote and harsh environments that our field teams operate in. ASAMM follows AFSC's guidelines for ditching certification. Aerial survey personnel may optionally be trained in the use of helicopter emergency egress devices. Aerial survey personnel must be current in first aid and CPR training. Finally, all aerial survey personnel who conduct NOAA operations in cold environments must have training in aviation safety and cold weather survival.

Under NOAA policy, one-time flights are possible for non-egress-trained individuals ("VIPs") and must be pre-approved by ASAMM Project Management, a NMFS Aviation Safety Officer, and Clearwater Air. Individuals requesting to participate in an ASAMM survey must have a mission-applicable reason (e.g., representatives from the NSB, BOEM, NMFS, ADF&G, USGS). Survey flights will not be altered to suit the needs of VIPs (e.g., flying to specific areas for sightseeing), and all VIPs must be made aware that the flight may last in excess of five hours.

Emergency Preparedness

Emergency preparedness for survey flights will be achieved by wearing appropriate clothing, maintaining and having access to necessary emergency gear, being knowledgeable about aviation safety risks, feeling comfortable voicing safety concerns, and having reliable protocols in place that will be followed in the event of an emergency.

During ASAMM surveys, all personnel onboard the aircraft will wear either flight or dry suits and be outfitted with Switliks or other personal floatation devices containing emergency equipment. Onboard safety equipment will include an impact-triggered emergency locator transmitter (ELT) installed in the aircraft, an 8-person search and rescue life raft equipped with an emergency survival kit, PLB, portable marine and aviation band transceivers, satellite

Risk Assessment Template.xlsx

Clearwater Air

Flight Risk Assessment

Multi-Engine IFR

PIC: **SIC:** **Aircraft:** **Date:**

For single pilot operations use score in parenthesis.

Crew				Total
≤ 10 Hrs in last 30 days		1(3)	1	1
≤ 2000 hrs TT			1	0
≤ 200 hrs in type		2(4)	1	0
Fatigue (Less than 8 hours of sleep)		2(4)	1	0
Divorce / Separation / Death		2(4)	1	0
Illness requiring medication		2(4)	1	0
Crew Total				1

Aircraft			
Inoperative Instruments (MEL)		1	0
Max Gross T/O Weight		2	2
Aircraft Hangared		-2	0
Preflight deicing required		2	2
Weight and Balance Completed		-1	-1
Aircraft Total			3

Environment			
Departure: Vis ≤3 Miles		3	3
Departure: Vis 3-5 Miles		1	0
Icing Conditions Forecast		2	2
Ice on Runway		2	0
Arrival:Precision Approach Available		-2	-2
Fog in Forecast		3	3
Wind ≥ 20 knots		2	2
Arrival Forecast: ≤ Special VFR		4	0
Arrival: Vis ≤ 3 miles		2	0
Arrival Forecast: Night		2	0
Alternate Forecast: Wx ≤ 5mile vis		4	4
Enviroment Total*			12

***If Enviroment total score is ≥15 weather observer must be used.**

Grand Total	27
Go	≤23
Manager Approval	23-34
NO GO	>34

PIC Initials: ____________________

Operations			
2nd Survey Flt of the day (≥5.5 Hrs)		3	0
Late departure (after 5pm)		2	0
Reposition Flight		1	0
Max Endurance Survey Flight		3	3
Survey Altitude ≤ 500 ft		4	0
Offshore ≥ 50 miles		3	3
Circling on Target required		2	2
Near/Over Mountainous Terrain		2	0
New Survey Type		1	0
Slow Flight Required ≤ 115kts		3	3
Remote Fueling		2	0
Operations Total			11

Figure 2. Clearwater Air's Flight Risk Assessment, which is completed prior to every ASAMM survey flight.

telephones, flares, immersion suits, and helicopter emergency egress devices. The emergency satellite telephones and radios will be charged and tested at the beginning of each month during the field season. All safety gear will be maintained and inspected according to the manufacturer's instructions.

Safety is everyone's responsibility. Aerial survey team members are encouraged to ask questions or voice concerns if they notice any potential safety hazards. Any team member has the right to "call" (i.e., abort) a flight based on questionable weather conditions or other safety considerations.

Every survey flight will be satellite-tracked in real-time by the Automated Flight Following (AFF) system via SpiderTracks. AFF is software that automatically tracks the location and velocity of specially equipped aircraft, providing this information in near-real-time to dispatchers, aviation managers, and other authorized users. The equipment includes geolocation and data communication devices that use satellite-based technology. As in 2013-2017, the aviation dispatchers from the Alaska Fire Service, Bureau of Land Management, will provide real-time flight following assistance to the project. See the document entitled "Flight Following Procedures and Emergency Contact Numbers for the Aerial Surveys of Arctic Marine Mammals (ASAMM) Project and Norton Sound Beluga Aerial Surveys conducted by NOAA Fisheries/Marine Mammal Laboratory (MML)" for complete details on ASAMM's flight following and emergency protocols. Emergency reporting procedures internal to MML are provided in the "Emergency Notification Plan for 2018 MML Field Operations."

Aviation Safety Reporting

Two types of safety reporting mechanisms may be used by ASAMM personnel: SAFECOM reporting is a tool that is maintained by the Department of Interior, and Clearwater Air has their own Safety Management System in place. ASAMM personnel have been instructed that, in the event of an incident, hazard, maintenance, or airspace issue, ASAMM Project Management should be informed immediately.

Department of Interior agencies require that aviation mishaps be reported to the Aviation Safety Communique (SAFECOM) database. Categories of reports include incidents, hazards, maintenance, and airspace. The system uses the SAFECOM Form AMD-34/FS-5700-14 to report any condition, observation, act, maintenance problem, or circumstance with personnel or the aircraft that has the potential to cause an aviation-related mishap. The SAFECOM system is not intended for initiating punitive actions. Submitting a SAFECOM is not a substitute for "on-the-spot" correction(s) to a safety concern. It is a tool used to identify, document, track, and correct safety related issues. A SAFECOM does not replace the requirement for initiating an accident or incident report. The main reporting to SAFECOM is generally by the pilots; however, reporting by observers may also be required at the request of the NOAA Aviation Safety Officer(s), or BOEM representatives. ASAMM Project Management will coordinate with observers, pilots, NOAA Aviation Safety Officer(s), and BOEM representatives to determine the best course of action. The SAFECOM website (https://www.safecom.gov) includes more information; a completed SAFECOM form can be found at https://www.safecom.gov/searchone.asp?ID=16510.

Clearwater has implemented an online Safety Management System for reporting any safety, security, quality, compliance, or environmental concerns that may arise during the season, which is accessible via a link on the Safety tab on Clearwater's webpage (www.clearwaterair.com). Clearwater management encourages ASAMM personnel to utilize this tool to address any aviation safety concerns. The link for reporting concerns can be found at http://clearwatersms.com/MySafety/PublicIssueReporting.aspx.

During an ASAMM flight, if a safety orange object (e.g., life vest, raft, streamer) is sighted or if people are sighted and there is suspicion that they might be in distress (e.g., in the middle of nowhere, waving their arms; smoke signals), ASAMM personnel are instructed to take the following steps:

1) Make a comment in the data to note the position and time of sighting, and include a brief description of what was seen. The pilots will also mark the position on their GPS and, if it is clear that it is an emergency, they will report the sighting to Flight Service.

2) Circle to try to get more information about whether it likely represents a genuine emergency. Descend to a lower altitude and take photographs to get a better look at the scene, if necessary.
3) If it is an emergency and people are in distress:
    a) Contact NSB Search and Rescue, who have an established protocol for dealing with these situations.
    b) If the survey aircraft has enough fuel to continue circling, do so. For as long as safety will allow, stay in visual contact with the people in order to update rescuers on the location and status of the emergency.
    c) Try to make contact via marine band radio.
4) DO NOT take any measures that would jeopardize the safety of the survey team.

Firearms

The ASAMM project does not provide firearms and no personal observer firearms are allowed on the survey aircraft. Clearwater Air's pilots may use their discretion regarding whether they bring personal firearms onto the plane. The King Eider Inn allows firearms in their establishments, but with caution. They ask that the firearms stay unloaded and locked or stowed away while in the hotel. MagTec does not allow personal firearms.

Ground Safety and Bear Awareness

The North Slope is home to two bear species, polar bears and brown bears. Awareness of their presence and behavior is important for personal safety. Each ASAMM team has bear deterrent devices for carrying during survey flights or when on the ground. Devices include bear bangers and air horns. Situational awareness is the best form of defense. ASAMM provides field personnel with access to a Bear Awareness and Defense Training Manual on the survey laptops. In Utqiaġvik, polar bear sightings are common along the beach and, on occasion, in town. While walking around town it is important to remain aware of surroundings and places to take cover, including flagging down anyone in a vehicle. The King Eider managers usually hear the latest on if/where bears are present. If ASAMM personnel think a bear has gone undocumented, they will report it to the NSB Department of Wildlife Management.

Brown bears are year-round residents in the Deadhorse area and are frequently seen around the camp dumpsters. Walking around Deadhorse is frowned upon, due to the bear presence, industrial activity, and truck traffic in the area. Polar bears are rarely sighted in Deadhorse, are far less habituated to human activity, and may be far more aggressive than resident brown bears. If ASAMM personnel observe any bears anywhere in Deadhorse, they will immediately report the sighting to the NSB police located in SA-10 or to camp managers.

Contact Information

ASAMM Project Management maintains an updated list of emergency contact information for all NOAA employees and contractors participating in ASAMM surveys. Additional emergency contact information is provided in the ASAMM master contact list, which is distributed to all ASAMM personnel.

The Department of the Interior Mission

As the Nation’s principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under US administration.

The Bureau of Ocean Energy Management

As a bureau of the Department of the Interior, the Bureau of Ocean Energy Management (BOEM) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS) in an environmentally sound and safe manner.

The BOEM Environmental Studies Program

The mission of the Environmental Studies Program (ESP) is to provide the information needed to predict, assess, and manage impacts from offshore energy and marine mineral exploration, development, and production activities on human, marine, and coastal environments.