OCS Study
BOEM 2020-027

Distribution and Relative Abundance of Marine Mammals in the Eastern Chukchi Sea, Eastern and Western Beaufort Sea, and Amundsen Gulf, 2019
Annual Report

U.S. Department of the Interior
Bureau of Ocean Energy Management (BOEM)
Alaska OCS Region
3801 Centerpoint Drive, Suite 500
Anchorage, AK 99503

Cover Photo Credit:
Bowhead Whales
Western Beaufort Sea
July 2019
Photo by Kate Pagan
NMFS Permit No. 20465

OCS Study
BOEM 2020-027

Distribution and Relative Abundance of Marine Mammals in the Eastern Chukchi Sea, Eastern and Western Beaufort Sea, and Amundsen Gulf, 2019
Final Report

Authors
Janet T. Clarke, Amelia A. Brower, Megan C. Ferguson, Amy L. Willoughby, and Audrey D. Rotrock

Prepared under Interagency Agreement M17PG00031

By
Marine Mammal Laboratory
Alaska Fisheries Science Center, NMFS, NOAA
7600 Sand Point Way NE
Seattle, Washington 98115-6349

For
U.S. Department of the Interior
Bureau of Ocean Energy Management
Alaska Outer Continental Shelf Region
Environmental Studies Program
Anchorage, Alaska

June 2019

DISCLAIMER

This study was funded, in part, by the U.S. Department of the Interior, Bureau of Ocean Energy Management, Environmental Studies Program, Washington, D.C., through Interagency Agreement Number M17PG00031 with the Alaska Fisheries Science Center. This report has been technically reviewed by BOEM and it has been approved for publication. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Government, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

REPORT AVAILABILITY

To download a PDF file of this Environmental Studies Program report, go to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Environmental Studies Program Information System website and search on OCS Study BOEM 2020-027.

This report can be viewed at select Federal Depository Libraries. It can also be obtained from the National Technical Information Service. The contact information is below.

U.S. Department of Commerce
National Technical Information Service
5301 Shawnee Rd.
Springfield, VA 22312
Phone: (703) 605-6000, 1(800) 553-6847
Fax: (703) 605-6900
Website: http://www.ntis.gov/

CITATION

Clarke, J.T., A.A. Brower, M.C. Ferguson, A.L. Willoughby, and A.D. Rotrock. 2020. Distribution and Relative Abundance of Marine Mammals in the Eastern Chukchi Sea, Eastern and Western Beaufort Sea, and Amundsen Gulf, 2019. Annual Report, OCS Study BOEM 2020-027. Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349.

Email of corresponding authors: jclarke9@uw.edu and megan.ferguson@noaa.gov

ACKNOWLEDGEMENTS

This study was funded and co-managed by the U.S. Department of the Interior (USDOI), Bureau of Ocean Energy Management (BOEM, formerly MMS), Alaska Outer Continental Shelf Region, Anchorage, Alaska, through Interagency Agreement No. M17PG00031, as part of the Alaska Environmental Studies Program, supported by Cathy Coon and Richard Raymond.

Numerous Alaska Fisheries Science Center (AFSC) personnel participated in the surveys or assisted with technical, administrative, or logistical aspects of the study. Observers included Corey Accardo, Lisa Barry, Vicki Beaver, Amelia Brower, Cynthia Christman, Janet Clarke, Megan Ferguson, Heather Foley, Laura Ganley, Rachel Hardee, Suzie Hanlan, Richard Holt, Katie Jackson, Nicholas Metheny, Kate Pagan, and Amy Willoughby. Robyn Angliss, Phil Clapham, Mary Foote, Nancy Friday, Ben Hou, Stuart Pascua, Monte Pascual, Ben Riedesel, Kim Shelden, and Janice Waite provided logistical and program support.

Mike Hay of XeraGIS provided timely assistance with the data collection program, data analysis, and report preparation.

The Turbo Commander aircraft, pilots, and mechanical support were provided by Clearwater Air, Inc., of Soldotna, Alaska, via Contract No. D15PC00102 with USDOI Office of Aviation Services, funded by BOEM Alaska Outer Continental Shelf Region. The surveys would not be possible without the enthusiastic support of Andy Harcombe. We were especially grateful to fly with Stan Churches, Jacob Creglow, Andy Harcombe, Elijah Jensen, Ben McDaniel, Robert McPhie, and Jake Turner. Mary Pratt provided administrative support.

The Twin Otter aircraft, pilots, and mechanical support were provided by Kenn Borek Air, Ltd., of Calgary, Alberta, via Contract No. 140D8119C0004 with USDOI Office of Aviation Services, funded by BOEM Alaska Outer Continental Shelf Region. We were fortunate to fly with Chantelle Callaway, Alexander de Boer, and Markku Vanonen, with on-site mechanical support from Andre Martineau and William Allen. Joel Consaul provided administrative support and Kenn Borek Dispatch provided flight following for the Twin Otter.

Real-time monitoring via satellite tracking of all ASAMM survey flights was provided by USDOI, Bureau of Land Management (BLM), Alaska Interagency Coordination Center, South Zone Dispatch. We especially thank Jerrid Palmatier for coordinating BLM flight followers.

In 2019, the Aerial Surveys of Arctic Marine Mammals (ASAMM) project sparked the interest of the general public. We greatly appreciate the assistance and guidance of Julie Speegle (NOAA Public Affairs Officer), Maggie Mooney-Seus (AFSC Communications Program Manager), John Callahan (BOEM Public Affairs Officer), and Maureen Clark (U.S. Fish and Wildlife Service Public Affairs Officer) on media relations. We are also grateful to the Alaska Fisheries Science Center's Operations, Management, and Information Division for maintaining and quickly posting daily reports to the ASAMM website.

Arctic research necessarily relies on cooperation and timely sharing of information to ensure safe and successful operations. We appreciate the cooperation of the agencies, individuals, and entities who assisted or coordinated with the ASAMM team in 2019, including Craig George, Raphaela Stimmelmayr, and Robert Suydam (North Slope Borough Department of Wildlife Management); Alaska Eskimo Whaling Commission; Katie Luxa (Joint Institute for the Study of the Atmosphere and Ocean); King Eider Inn; Brooks Camp; Arctic Char Inn; Capitol Suites; Robyn McGhee (ConocoPhillips); Andy Majewski and Jane Eert (and the crew of the FV *Frosti*); and Lisa Loseto, Shannon McPhee, and Marianne Marcoux (Canada Department of Fisheries and Oceans).

ABSTRACT

This report describes field activities of the Aerial Surveys of Arctic Marine Mammals (ASAMM) project conducted during summer and fall (1 July–31 October) 2019, and data and analyses used to summarize field activities. Surveys were based in Utqiaġvik, and Deadhorse, Alaska, USA, and targeted the eastern Chukchi Sea and western Beaufort Sea, between 67°N and 72°N latitude, 140°W and 169°W longitude, referred to as the ASAMM study area. Field activities also included surveys conducted in August 2019 in the eastern Beaufort Sea and Amundsen Gulf, between 67°N and 73°N latitude, 118°W and 140°W longitude, in support of the ASAMM Bowhead Abundance (ABA) project, to collect aerial survey data specific to estimating abundance of the Western Arctic (also known as the Bering-Chukchi-Beaufort Seas) bowhead whale population. Surveys in the ABA study area were based in Inuvik and Ulukhaktok, Northwest Territories, Canada.

Sea ice cover in the eastern Chukchi Sea survey area in 2019 was extremely light in July, August, September, and October. Sea ice cover in the western Beaufort Sea survey area in summer was similar to that observed from 2012 to 2017. When surveys commenced in early July, sea ice remained in much of the western Beaufort Sea survey area, but was entirely absent by early August. The western Beaufort Sea survey area remained sea ice-free through October, except for new ice that started to form in lagoons and other shallow water areas in mid-October. In the eastern Beaufort Sea, sea ice remained in the ABA study area north of Cape Bathurst throughout August, periodically repositioning depending on prevailing wind conditions. Amundsen Gulf was essentially ice-free throughout August. Viscount Melville Sound, McClure Strait, and west of Banks Island remained heavily covered by sea ice throughout August.

A total of 131 survey flights were conducted. The Utqiaġvik-based aerial survey team conducted surveys from 2 July through 2 August and 30 August through 29 October 2019, and the Deadhorse-based aerial survey team conducted surveys from 19 July through 10 October 2019. Surveys were conducted from survey teams based in Inuvik and Ulukhaktok from 8 to 27 August 2018. Total combined flight time was 611.2 hours, including 278.1 hours of transect effort. Over 157,000 km were flown, with 62,216 km of effort on transect. Data were also collected during Focal Group Follow (FGF), Field of View (FOV), and Cetacean Aggregation Protocols (CAPs) modes. Images from a camera mounted in the belly of one of the survey aircraft were collected during 58 flights. Surveys were conducted in the western Beaufort Sea in summer (July-August) for the eighth consecutive year and in survey block 23 (southcentral Chukchi Sea) for the sixth consecutive year.

There were 5,561 sightings of 105,301 marine mammals observed during all (transect, CAPs, search, and circling) survey modes, including:

- 518 sightings of 749 bowhead whales (*Balaena mysticetus*),
- 315 sightings of 446 gray whales (*Eschrichtius robustus*),
- 15 sightings of 24 humpback whales (*Megaptera novaeangliae*),
- 19 sightings of 36 fin whales (*Balaenoptera physalus*),
- 12 sightings of 13 minke whales (*Balaenoptera acutorostrata*),
- 1,555 sightings of 3,847 belugas (*Delphinapterus leucas*),

- 4 sightings of 15 killer whales (*Orcinus orca*),
- 32 sightings of 35 cetaceans that could not be identified to species,
- 959 sightings of 93,416 Pacific walruses (*Odobenus rosmarus divergens),*
- 85 sightings of 89 bearded seals (*Erignathus barbatus*),
- 1,866 sightings of 6,087 pinnipeds that could not be identified to species, and
- 181 sightings of 544 polar bears (*Ursus maritimus*).

Bowhead whales were seen in all months of the study period, but their distribution was unlike any previously documented and sighting rates were low except in the eastern Beaufort Sea and Amundsen Gulf. 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) and remained offshore throughout September and October. Relatively few bowhead whales were seen in the Barrow Canyon area, which in most years is an area where aggregations are seen. 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 August, and the 21-50 m zone in September and October. Sighting rate by depth zone in the Barrow Canyon area (154°W-157°W) was highest in the 51-200 m zone in July, the 201-2000 m zone in September, and the 51-200 m zone in October; whales were not seen in this area during surveys conducted in August. In the northeastern Chukchi Sea (69°N-73°N, 157°W-169°W), few bowhead whales were seen in July and August, and no bowheads were seen in September or October. The survey block with the highest overall bowhead whale sighting rate in summer and fall was block 5. The only survey block in which bowhead whales were seen in the eastern Chukchi Sea was block 13. Sighting rates in the eastern Beaufort Sea and Amundsen Gulf in August far exceeded any sighting rates in the western Beaufort Sea or eastern Chukchi Sea.

Bowhead whale sightings (not normalized by survey effort) in the western Beaufort Sea in summer (July-August) 2019 were significantly ($P < 0.001$) farther from shore and in deeper water in the East (140°W-148°W) and West (148°W-156°W) regions compared to previous years with light summer sea ice cover (2012-2017). Compared to previous years with light sea ice cover in fall (i.e., 1989, 1990, 1993-2018), bowhead whale sightings in the western Beaufort Sea in fall (September-October) 2019 were significantly ($P < 0.0001$) farther from shore and in deeper water in the East and West regions. Median depth in fall 2019 for East and West regions combined (46 m) was deeper than in any previous year except 1991 (139 m) and 1992 (55 m) (Figure 21), which were both years when heavy sea ice persisted. Median distance from shore in fall 2019 for East and West regions combined (46.2 km) was farther than in any previous years except 1991 (61 km), a heavy ice year.

The spatial relative abundance model for fall (September-October) 2019 predicted two areas of high relative abundance: from 140°W to 143°W, between the 50- and 200-m isobaths; and from 146°W to 149.5°W, between the 20- and 200-m isobaths. The estimated median distance-from-shore statistics for fall 2019 that were derived using the spatial model were 48.7 km for the East region and 50.9 km for the West region. The model-derived results were 6.0 km farther from shore in the East region and 0.1 km closer to 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 42.7 km and 51.0 km, respectively).

The 2000-2019 monthly spatial model (July-October) predicted that bowhead whale high-use areas (HUAs) were located farthest offshore in July, with the highest relative abundance over the outer portions of the continental shelf, approximately 25-50 km offshore, from 141°W to 143°W. In August, the spatial model predicted that bowhead whale HUAs were closest to shore from 142° to 146°W, north of Kaktovik and Camden Bay. The area of highest predicted relative abundance in August was offshore of Harrison Bay, 40-80 km offshore, centered on the 20-m isobath. Other areas of high predicted relative abundance were located east of Kaktovik (~142°W, centered on the 50-m isobath), north of Camden Bay (between the 20- and 50-m isobaths) and east of Point Barrow, from the barrier islands to the 50-m isobath. 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 ~146.5°W to ~148°W. In October, the highest predicted relative abundance was shoreward of the 50-m isobath, north of Dease Inlet and Smith Bay. In October, patches of relatively high abundance were located from the mouth of Barrow Canyon and nearshore northwest of Cape Halkett, near the barrier islands from ~146°W to ~147°W, and near the barrier islands north and east of Kaktovik. The HUA was farther offshore between Cape Halkett and Utqiaġvik in October than in September. The estimated median distance-from-shore statistics for the East region in 2000-2019, derived using the spatial model, decreased from 51.7 km in July to 27.7 km in August, 20.7 km in September, and 20.8 km in October. In the West region, the 2000-2019 model predicted that the median distance from shore decreased from 58.9 km in July to 32.1 km in August, 25.8 km in September, and 30.3 km in October.

Only 11% of all bowhead whales observed in 2019 were feeding or milling, which is a lower percentage than in most previous years. In summer, feeding was observed primarily in the eastern Beaufort Sea during ABA surveys there. Feeding behavior in fall was observed between 147°W and 154°W; large aggregations of bowhead whales were encountered only in the eastern Beaufort Sea. 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.

One hundred twenty-one bowhead whale calves were seen in 2019, including 72 calves seen during summer and 49 calves seen in fall; more than half of the calves observed were seen in the eastern Beaufort Sea in August. The summer bowhead whale calf ratio (number of calves per number of total bowhead whales) in the western Beaufort Sea in 2019 (0.072) was similar to calf ratios in 2012 and 2013 but substantially lower than the calf ratio in 2017. The calf ratio in the eastern Beaufort Sea and Amundsen Gulf in August 2019 (0.160) was twice that of the calf ratio in the western Beaufort Sea during the same time. The fall 2019 bowhead whale calf ratio (0.209) was the highest recorded since 1982. Bowhead whale calf sighting rate (calves per transect km) in the western Beaufort Sea in summer 2019 was lower than in summer 2013, 2016, and 2017; calf sighting rate in fall 2019 was second only to that calculated for fall 2017. Calf sighting rate in the eastern Beaufort Sea and Amundsen Gulf in August 2019 was higher than all calf sighting rates reported for the western Beaufort Sea in any year.

Gray whales were seen in all months of the 2019 study period in the northeastern Chukchi Sea, primarily between 20 and 120 km of the Alaskan coastline between Point Franklin and Icy Cape. Very few gray whales were seen in the area between Point Franklin and Point Barrow, where they were reliably seen prior to 2016, and there were only two sightings of gray whales between Icy Cape and Point Hope. Gray whale aggregations were also seen in all months in the southcentral Chukchi Sea, southwest of Point Hope. The highest sighting rate by depth zone was in the 51-200 m South depth zone, which is the depth zone with the highest sighting rate each year except 2018. Highest sighting rate by month occurred in July. Most gray whales observed were feeding (78%). Fourteen gray whale calves were seen, resulting in a calf ratio in the ASAMM study area of 0.031 which is lower than calf ratios in 2011-2018. Gray whales were seen in the eastern Beaufort Sea in August during ABA surveys, including one calf.

Belugas were sighted primarily in the eastern and western Beaufort Sea and Amundsen Gulf, with very few sightings in the northeastern Chukchi Sea. Highest sighting rates in the ASAMM study area occurred in July, decreased considerably in August before increasing slightly in September, and ultimately decreasing in 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 ≤35 m zone in the Chukchi Sea. The beluga sighting rate in the western Beaufort Sea in fall was the second highest recorded since 1989.

Additional noteworthy results from the 2019 ASAMM field effort included:

- Eleven bowhead whale carcasses were recorded, representing the highest number of bowhead whale carcasses annually since standardized carcass reporting methods began in 2009. More bowhead whale carcasses were sighted in the western Beaufort in 2019 than in 2009-2018 combined. Eight gray whale carcasses were recorded in 2019, second only to 2012 when 13 carcasses were documented.
- Humpback whales, fin whales, and minke whales were observed in the southcentral Chukchi Sea as in past years but were also observed on Herald Shoal (block 19) for the first time during ASAMM surveys.
- Fin whales were visually detected farther north than previously recorded in the Pacific Arctic.
- Killer whales (4 sightings of 15 whales) were sighted in the northeastern Chukchi Sea in late August and mid-September.
- Walruses were observed in the water and on ice (particularly near Hanna Shoal) and land. A walrus haulout formed in late July on a barrier island near Point Lay, and was documented by ASAMM on 31 August. The onshore haulout, which varied in size from 10,300 to 45,000 walruses, persisted until late September.
- The sighting rate for unidentified pinnipeds and small unidentified pinnipeds (combined) in the ASAMM study area was moderately high in summer in the western Beaufort Sea and relatively low in fall in the western Beaufort and eastern Chukchi seas compared to previous years. Eleven unidentified pinnipeds were observed inshore of the barrier islands in the central Alaskan Beaufort Sea. Groups of small unidentified pinnipeds, likely spotted seals, were sighted at coastal haulouts from July through October. Large aggregations (n_i = 150-1000 seals) were sighted on barrier islands near Icy Cape in the northeastern Chukchi Sea in July, August, and October, and small groups (n_i = 1 to 25 seals) were seen hauled out near the mouth of Fish Creek in Harrison Bay from early September to early October.

- Polar bears were distributed from south of Banks Island, Canada, to north of Point Barrow. Most polar bears were seen between Point Barrow and Herschel Island, Canada, on shore or barrier islands, or on sea ice or swimming within 5 km of land. Seven polar bears were seen on sea ice between 79 and 105 km from shore, and five polar bears were observed swimming in areas of 5 to 20% sea ice cover between 25 and 139 km from shore. All but one of the polar bears observed near sea ice were in the eastern Beaufort Sea or Amundsen Gulf, where sea ice persisted in late August. Thirteen polar bears were observed swimming or resting in ice-free areas between 10 and 58 km from shore.

This page intentionally left blank.

Table of Contents

List of Figures

List of Tables

Abbreviations and Acronyms

ABA	ASAMM Bowhead Abundance
ACEs	Aerial Calibration Experiments
ADF&G	Alaska Department of Fish and Game
AEWC	Alaska Eskimo Whaling Commission
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)
BSAW	Bering Shelf Anadyr Water
BSW	Bering Shelf Water
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
Si	sightings
°T	degrees True
TB	terabyte
Tr	transect
UAF	University of Alaska Fairbanks
UAV	unmanned aerial vehicle
UME	Unusual Mortality Event
USC	U.S. Code
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 (e.g., Sales 71, 87, and 97) and the 1988 Arctic Region Biological Opinion (ARBO) used for Beaufort and Chukchi sea sales (e.g., 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), respectively, 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” (e.g., USDOI, MMS 1988, 1996, 2008a).

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 2008b). In 2007, an Interagency Agreement between the MMS 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 survey 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, 2019). 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.

In 2019, an additional objective was added to the ASAMM study, specifically to conduct an aerial survey across the entire Beaufort Sea and Amundsen Gulf to obtain data to estimate the size of the Western Arctic bowhead whale population. As a member of the International Whaling Commission, the United States, in cooperation with the North Slope Borough (NSB) and the Alaska Eskimo Whaling Commission (AEWC), have committed to providing data on the size and trend of this bowhead whale population on a regular basis, at least every 10 years. In the past, estimates of population size have been obtained by counting bowhead whales as they migrate along the ice edge past Utqiaġvik, Alaska, during the spring. A warming Arctic has made sea ice less predictable and less safe for conducting an ice-based survey. Observations of large groups of bowhead whales during the late summer in the Alaskan Beaufort Sea suggested that it would be possible to count these whales using aerial surveys flown from the western Beaufort Sea to Amundsen Gulf. These surveys, referred to as ASAMM Bowhead Abundance (ABA), were conducted in August 2019.

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, between 140°W and 169°W longitude and 67°N and 72°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) survey area, while survey blocks 13 through 23 (157°W-169°W) comprise the eastern Chukchi Sea (formerly COMIDA) survey area. Survey block 1a encompasses the area between the barrier islands and the mainland in block 1.

ASAMM Bowhead Abundance (ABA) surveys, conducted in August 2019, extended beyond the ASAMM study area into the eastern Beaufort Sea and Amundsen Gulf (118°W-140°W), referenced in this report as the ABA study area. The study area was primarily inshore of the 200-m depth contour (Figure 2) and encompasses approximately 183,000 km^2. Areas off the east and west coasts of Banks Island and in Viscount Melville Sound were identified as potentially important habitat for Western Arctic bowhead whales and are considered of secondary importance. Detailed information on ABA surveys is included in Appendix I.

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 3). 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. On the Canadian shelf, Mackenzie Canyon and Kugmallit Canyon provide potential sites for upwelling, particularly in summer when easterly winds combine with the influx of freshwater from river runoff and melting sea ice (Carmack and MacDonald 2002).

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.

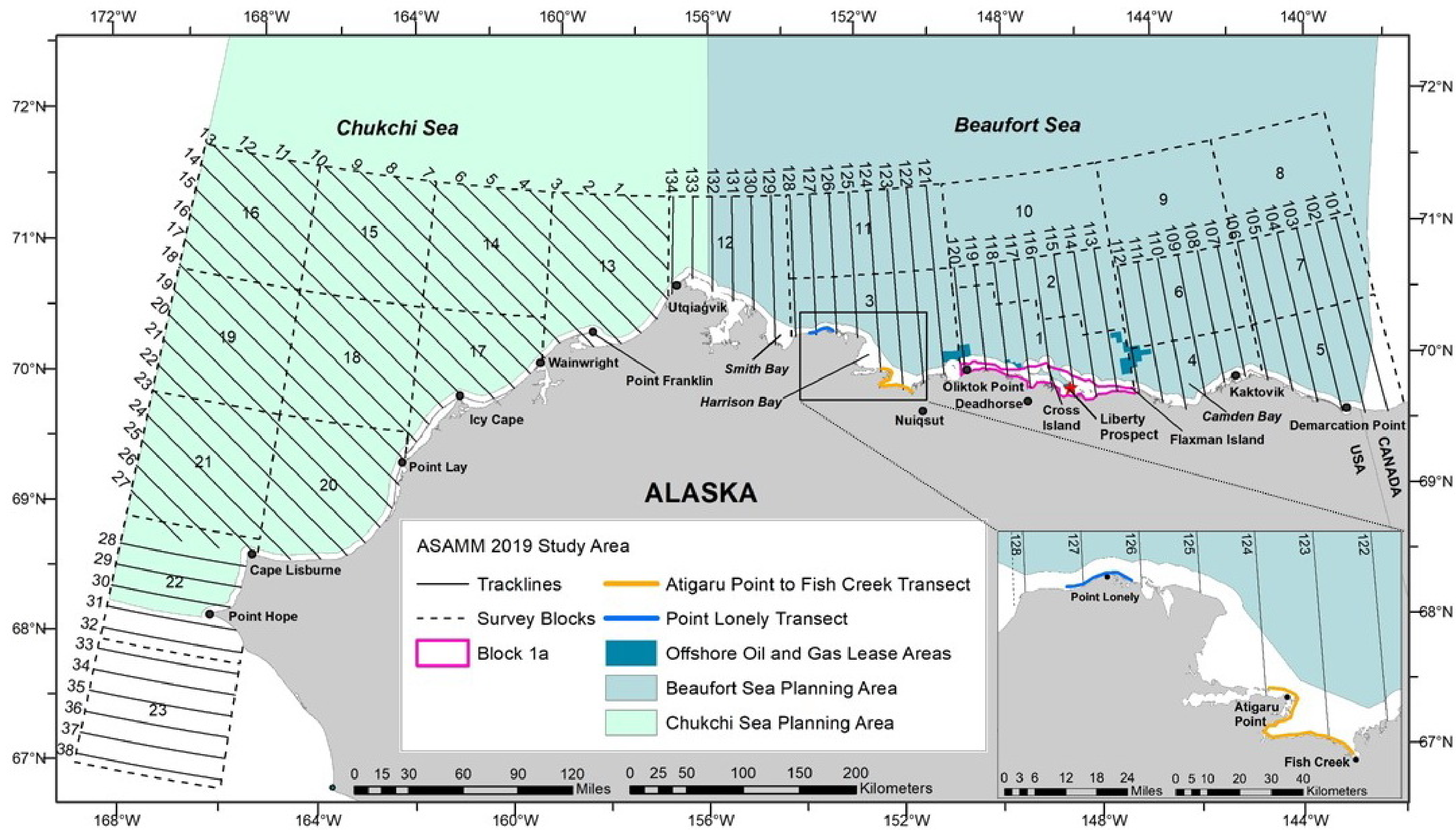


Figure 1. ASAMM study area showing survey blocks, 2019 ASAMM tracklines (numbered), Chukchi Sea Planning Area, Beaufort Sea Planning Area, Liberty Prospect, and active lease areas. The inset provides a zoomed view of the coastal transect in Harrison Bay between Fish Creek and Atigaru Point and near Pt. Lonely.

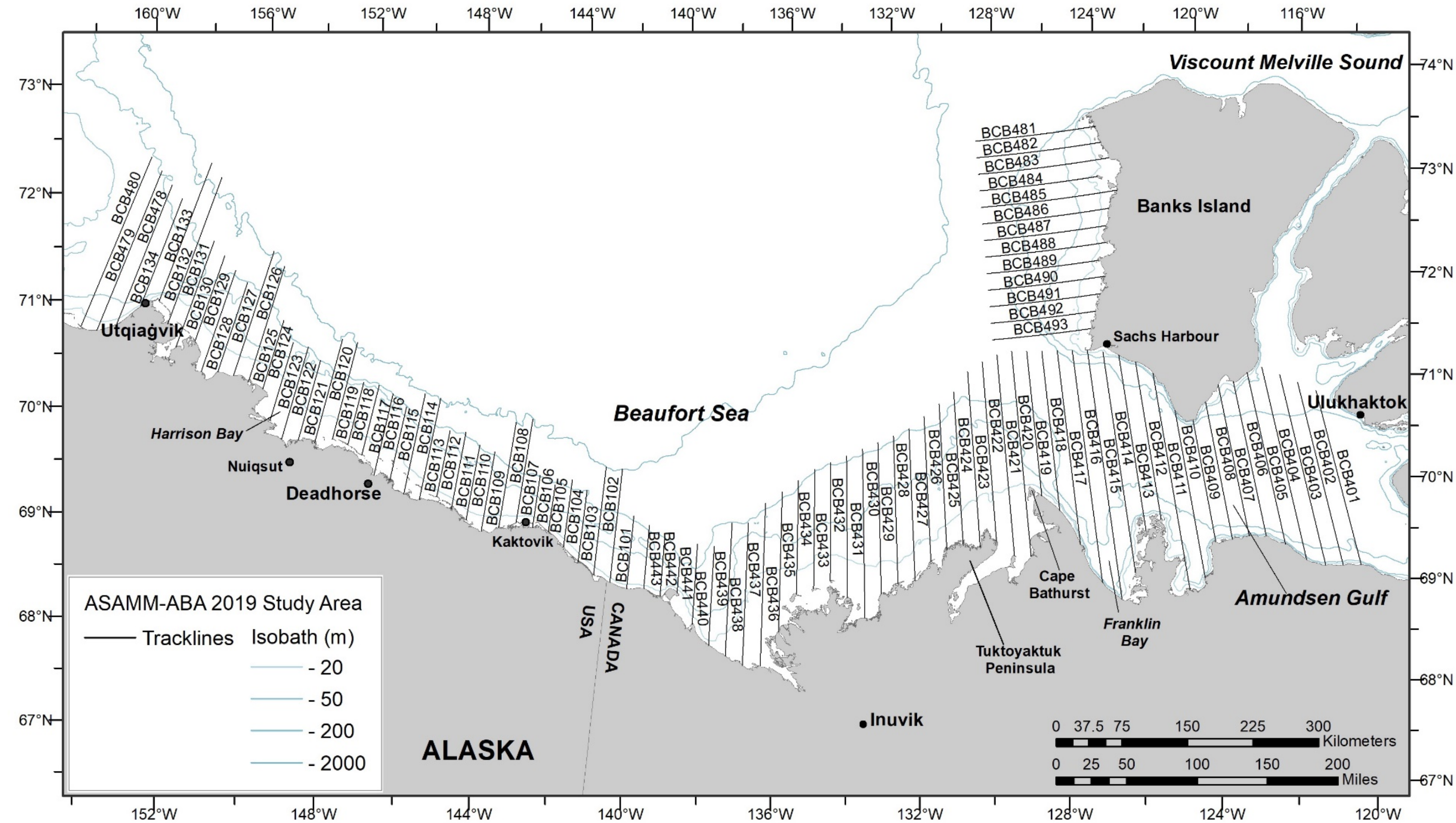


Figure 2. ASAMM Bowhead Abundance (ABA) study area showing ABA tracklines (numbered) and depth contours.

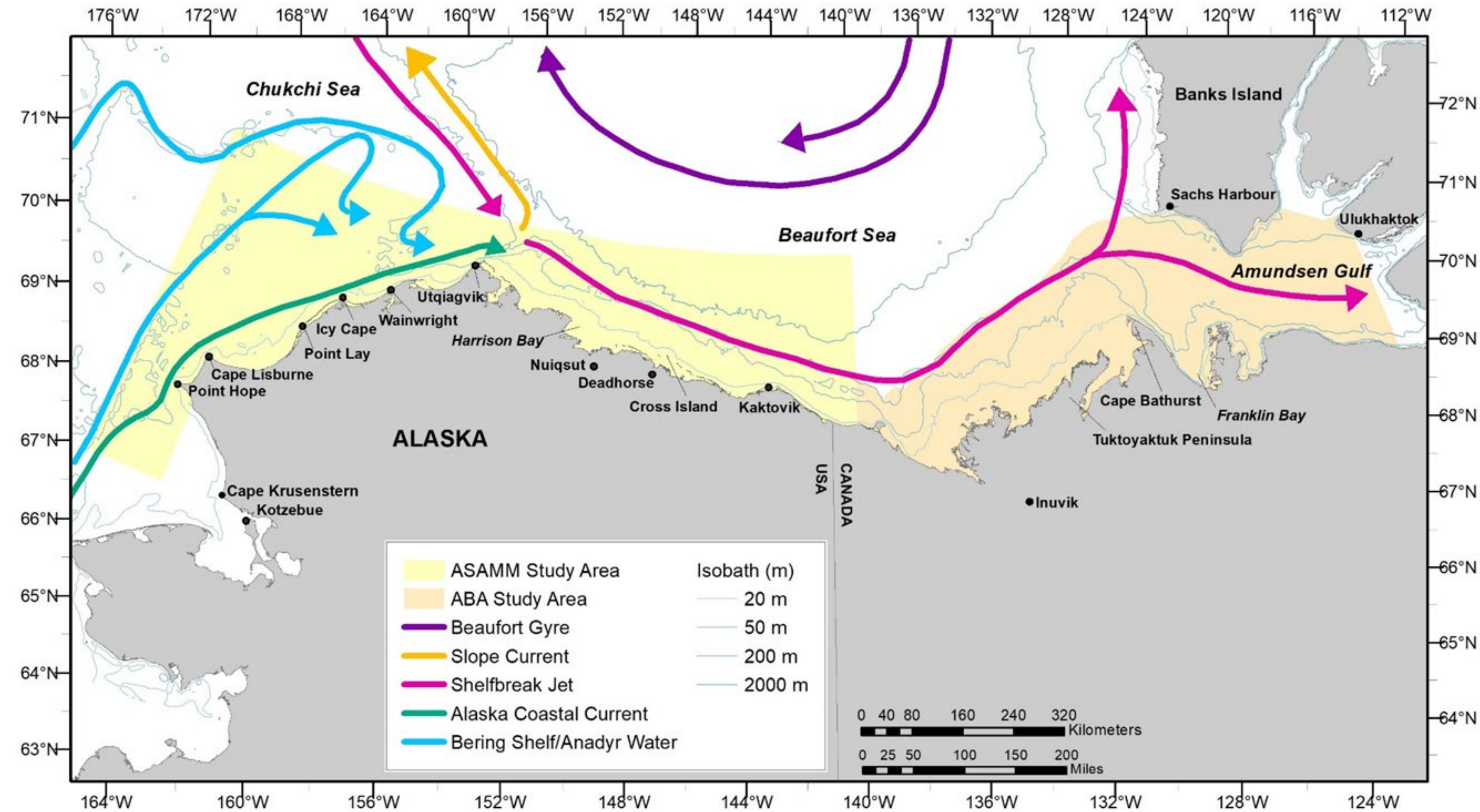


Figure 3. Eastern Chukchi Sea, western and eastern Beaufort Sea, and Amundsen Gulf oceanographic features. Adapted from Corlett and Pickart (2017) and Richerol et al. (2018).

2011). Intra-annual variation was especially noticeable in 2011 and 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 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 2007-2019 (National Snow and Ice Data Center 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016a, b, 2017, 2018, 2019). 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 and ABA study areas are 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, and have been increasing in height since 1990 (Thomson et al. 2016). 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 a De Havilland Twin Otter provided by Kenn Borek Air, Ltd. All surveys are conducted with highest regard for flight safety. Safety equipment onboard each aircraft includes an impact-triggered emergency locator transmitter, 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 Commanders is approximately 6 hours, including fuel reserve. The maximum time aloft in the Twin Otter is approximately 5 hours, including fuel reserve.

Aircraft are equipped with bubble windows that afford primary observers an unobstructed view of the trackline. On the Commanders, an openable 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 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 of the Commanders 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, to image metadata of every image that the intervalometer triggers. Additional details related to the belly port camera (BPC) data collection are included in Clarke et al. (2019) and briefly summarized in Appendix K.

The USDOI, BLM, 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 (1979-2018). 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 2008b; Clarke et al. 2011a, 2012, 2013a, 2014, 2015a, 2017a, b, 2018a, 2019).

ASAMM Aerial Survey Design

ASAMM surveys are divided into two survey 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 survey area and out of Deadhorse to target the western Beaufort Sea survey area. Survey teams at each location are prepared to conduct surveys in either survey 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 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 survey 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 survey 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). 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. In the eastern Chukchi Sea survey area (157°W-169°W), 38 transects are spaced 19 km apart, extending 56 to 311 km offshore. In the western Beaufort Sea survey area (140°W-157°W), 34 transects are spaced 18 km apart, extending 70 to 176 km offshore. 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 eastern Chukchi Sea survey area since 2009 and was implemented in the western Beaufort Sea survey area in 2017. Transect spacing in the western Beaufort Sea survey 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 western Beaufort Sea and Point Hope in the eastern Chukchi Sea. The coastal transect allows better documentation of nearshore habitat, including pinniped haulouts and polar bear aggregation areas. In 2019, short sections of the coastal transect near Point Lonely and in Harrison Bay, between Atigaru Point and Fish Creek, were specifically targeted to record the occurrence of marine or terrestrial mammals, as part of a partnership with ConocoPhillips (Figure 1).

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 western Beaufort Sea survey area. 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 eastern Chukchi Sea survey 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 indigenous knowledge). Weather permitting, the project attempts to distribute effort evenly across the entire study area, except for the northeastern Beaufort Sea survey blocks (blocks 8, 9, and 10). Allocations of survey effort in the western 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.

ASAMM Bowhead Abundance (ABA) Aerial Survey Design

ASAMM Bowhead Whale Abundance (ABA) surveys are divided into three survey areas for logistical reasons. Aerial surveys based out of Deadhorse target the western Beaufort Sea survey area in the ASAMM study area. Surveys based out of Inuvik and Ulukhaktok, Northwest Territories, Canada, target the eastern Beaufort Sea and Amundsen Gulf survey areas, respectively. Survey teams at each location are prepared to conduct surveys in adjacent survey areas to take full advantage of optimal weather conditions and provide the best coverage possible of the entire ABA study area.

ABA survey design is applicable to August only. The field schedule is designed to maximize survey effort during the period when most of the Western Arctic bowhead whale stock would likely be present in the ABA study area and when conditions (e.g., absence of sea ice) would be most conducive for successful aerial surveys.

Primary ABA transects are oriented north-south, perpendicular to the coastline, to cross major bathymetric features, such as Barrow Canyon, the Beaufort Sea shelf and slope, Mackenzie Canyon, and Amundsen Gulf (Figure 2). Primary transects directly overlay ASAMM 2019 transects in the western Beaufort Sea and continue into the eastern Beaufort Sea and Amundsen Gulf, using identical spacing (18 km). Three ABA transects are placed in the northeastern Chukchi Sea between 157°W and 158.5°W. Transects are spaced 18 km apart, extending 65 to 287 km offshore. The majority of transects extend offshore to the 200-m depth contour, however some transects extend offshore to the 2,000-m depth contour. Secondary transects west of Banks Island are oriented east-west and extend up to 160 km offshore to encompass waters >200-m deep. Transects are terminated at coastal endpoints located 1 km offshore of the main coastline or barrier islands, when present.

The selection of ABA transects 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. Weather permitting, ABA attempts to distribute effort evenly across the entire primary ABA study area.

Survey Flight Procedures

Surveys during ASAMM and ABA are conducted using line-transect methodology (Buckland 2001). One primary observer is stationed on each side of the aircraft at bubble windows that permit an unobstructed field of view 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 and visibility is conducive to sighting marine mammals. 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 considered "off effort". To maintain consistency in data acquisition between 2019 and previous years, all observers underwent training in ASAMM data collection techniques prior to and during the 2019 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). 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 during acceptable viewing conditions on transect are all considered on effort. When large cetacean sightings are within 3 km of the trackline, 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 and survey priorities 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 effort; sightings outside the perimeter of the circle are not recorded. Circling is usually not initiated if a sighting is greater than 3 km from the trackline. 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

Table 1. 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; immediately followed by CAPs circling.
CAPs circling	Directed effort searching the area out to 3 km from the trackline immediately after completing CAPs passing; excludes any areas surveyed in CAPs strip mode; off effort.
CAPs strip	Systematic survey effort along a prescribed transect in an area of extremely high density of 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 or Twin Otter; off effort.
Deadhead	High-speed, high-altitude transits to and from transects, and areas over land or without any downward visibility; off effort.

effort; sightings on CAPs circling are off 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 (Clarke et al. 2019); 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).

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 speed during deadhead is usually greater than 333 km/hr. Survey altitudes are chosen to maximize visibility of large cetaceans and minimize potential disturbance to marine mammals and subsistence hunting activities. 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 396 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 do not meet minimum altitude (305 m), visibility, 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 Point 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, photographs 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 and ABA maintain daily contact with Flight Service, and direct contact with operators of all known aircraft that may be operating in offshore and coastal regions.

Subsistence Activity

ASAMM and ABA coordinate with the North Slope Borough (NSB) Department of Wildlife Management, the Department of Fisheries and Oceans (DFO) Canada, the Inuvialuit Game Council (IGC), and the Fisheries Joint Management Council (FJMC), Canada, regarding subsistence activities, and strives to avoid direct overflights of areas where subsistence hunting of marine mammals is occurring. Survey altitude is increased or transect lines are diverted away from coastal villages and from hunters in boats during subsistence activities. Transits over land are conducted at higher altitudes (>1220 m).

Data Entry

Identical data entry protocols are used to collect data during ASAMM and ABA. 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, Alaska Daylight Saving 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, inclusive of all 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 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 walrus calves, pinniped pups, and bear cubs), behavior, sighting cue, habitat, calf detection certainty (cetaceans only), whether it is a same-day repeat sighting, and response to the aircraft. Calves are designated 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 may be combined in "pooled" counts, 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 (Appendix D). Sighting data collected during CAPs passing include observer, species, clinometer angle, initial group size, number of calves, 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 but not CAPs strip, include the full suite of sighting data (species, initial/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 average group size, calf presence, behavior, and extrapolate species identification to sightings of unidentified cetaceans recorded during CAPs passing. Beluga sightings are not recorded during CAPs mode, but the presence or absence of belugas is noted.

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 behavioral information may be added as notes. Additional details on FGF are included in Clarke et al. (2019).

Recorded 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 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 (i.e., within 2 hours of the final touchdown for the day) 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 for a single survey team by Beaufort wind force.

Aerial photographs from the observer's handheld camera (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

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

Behavior	Definition
Breach	Animal(s) launching a substantial 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 or land; 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).

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 various projections depending on the geographic focus (Appendix J). 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_2019_v5 database are used for all analyses. Data from ASAMM and ABA are combined into one large dataset (hereafter referred to as the ASAMM database) 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 in the ASAMM and ABA study areas. All other species distributions are plotted monthly (July-October) in the ASAMM and ABA study areas. All sightings are shown on most distribution maps regardless of survey mode (e.g., transect, CAPs, search, or 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 2008b; Clarke et al. 2012, 2013a, 2014, 2015a, 2017a, b, 2018a, 2019), same-day repeat sightings or sightings of dead marine mammals are not included in most summary analyses or maps unless specifically stated. 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 distribution 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 4). 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. In 2019, the normalized shoreline was extended to include the eastern Beaufort Sea and Amundsen Gulf. 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 projections used for the normalized shoreline analysis are included in Appendix J.

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 subareas (Beaufort Sea subarea 118°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.

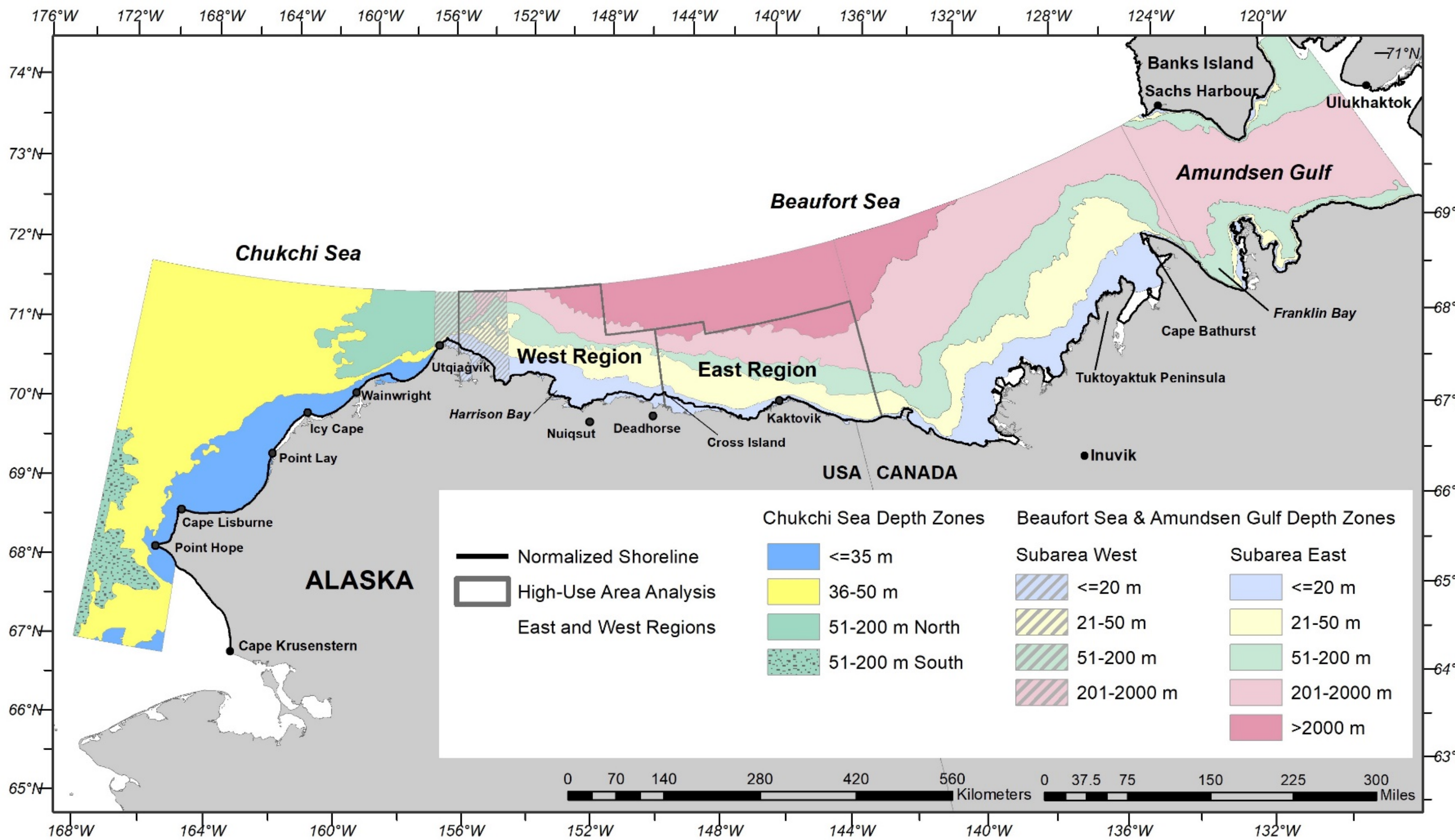


Figure 4. East and West regions and normalized shoreline used in ASAMM bowhead whale high-use area (HUA) analysis, and depth zone subareas used for sighting rate analyses.

Environmental information, including wind speed and direction, cloud ceiling, visibility, temperature, dew point, sea ice cover, and sea surface temperature, is collected from the U.S. National Weather Service and Environment Canada 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 Northwest Territories, Canada (e.g., Inuvik, Tuktoyaktuk, Paulatuk, Sachs Harbour, and Ulukhaktok) and for the broader Chukchi Sea, Beaufort Sea, and Amundsen Gulf regions.

Sea ice information is obtained from the U.S. National Ice Center (2019), where it is available as charts or shapefiles. Sea ice analyses by the National Ice Center use 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 2019 are categorized as "light" for use in multiyear analyses. Shapefiles for Amundsen Gulf and the Beaufort and Chukchi seas are combined to produce biweekly sea ice concentration maps, included in Appendix A.

Analytical methods in this report maintain many similarities with previous years' reports dating back to 2008, with some 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 2019, sightings made by primary observers only are included in most analyses that use on-effort sightings, including sighting rate and central tendency analyses.

An additional exception involves how the percentage of sea ice cover is tabularized for each sighting. Prior to 2018, ice percentage was entered as a single value representing the average sea ice cover within the entire field of view of the aircraft, inclusive of all ice types. Starting in 2018, average sea ice percentage was recorded separately for each side of the trackline. Sea ice percentages from the left side of the trackline are applied to sightings on the left and sea ice percentages from the right side are applied to sightings on the right. Multiyear analyses using sea ice percentage average sea ice percentages from both sides of the aircraft.

Integration of CAPs Data

An important difference in analytical methods that began in 2018 is the integration of data collected during CAPs. Prior to 2018, 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. Starting in 2018 and continuing in 2019, 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. 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 of the high density of sightings and 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 (e.g., group size and number of calves) are referred to as CAPs-adjusted statistics. Additional detail about the integration of CAPs data is included in Clarke et al. (2019) and 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).

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. Fine-scale grid analyses are calculated for bowhead whales and belugas in the eastern Beaufort Sea and Amundsen Gulf in August.

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 in the ASAMM study area. Although survey blocks are arbitrary geographic areas, they provide a basis for inter-annual comparisons in the eastern Chukchi and western Beaufort seas. Effort over land, between barrier islands and the mainland (except for block 1a), and north of the study area is not included in the survey block sighting rate analysis to facilitate comparisons with previous years. Effort in block 1a 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 in the ASAMM and ABA study areas. 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 eastern and western Beaufort Sea and Amundsen Gulf is computed for four subareas (Figure 4). The East and West subareas in the western Beaufort Sea are identical to previous analyses and the Canadian Beaufort and Amundsen Gulf subareas are applicable to August 2019 only. The West subarea spans 154°W-157°W and includes Barrow Canyon and its surrounding area, which has noticeably different bathymetry than the rest of the western Beaufort Sea survey area. The East subarea spans 140°W-154°W, an area that incorporates a well-defined continental shelf and slope. The Canadian Beaufort subarea spans 127°W-140°W and encompasses the eastern Beaufort Sea continental shelf and slope. The Amundsen Gulf subarea includes the area spanning 118.7°W-127°W. Beaufort Sea and Amundsen Gulf 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 eastern 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 ≤35m and 51-200 m depth zones may be divided into North and South regions because they are separated by large expanses of intermediate (36-50 m) depths (Figure 4). Projections used for sighting rate analyses for survey blocks and depth zones are included in Appendix J. 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.

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 prior to 2018 when sighting rate analyses used transect effort only. In 2014-2017, large whale sighting rate analyses incorporated 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 (HUAs) in the Western Beaufort Sea

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 previously 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 an 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 in the western Beaufort Sea (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 in the western Beaufort Sea 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 data collected east of 140°W in August 2019 in the ABA study area. Central tendency analyses are used to compare HUAs between current and historical years, and equivalent surveys east of 140°W were not conducted in prior years.

Central tendency analyses do not incorporate sighting data collected during Arctic Aerial Calibration Experiments (ACEs) transects in 2015 (Clarke et al. 2017b). 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 Real Statistics Using Excel Resource Pack (2020).

Bowhead whale HUAs are 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 at bowhead whale sightings in 2019, a year with light sea ice cover (NSIDC 2019) in summer and fall, are compared with analogous values from previous years having light sea ice cover (i.e., 1989, 1990, 1993-2018; Treacy 1990, 1991, 1994, 1995, 1996, 1997, 1998, 2000, 2002a, 2002b; Monnett and Treacy 2005; USDOI, MMS 2008b; Clarke et al. 2011a, 2011b, 2012, 2013a, 2014, 2015a, 2017a, b, 2018a, 2019). Summer (July-August) 2019 central tendency values are compared to bowhead whale sightings in summer 2012-2017 and fall (September-October) 2019. Median distance from shore and depths for bowhead whale sightings in fall 2019 are compared to values from fall 1989, 1990, and 1993-2018.

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 2019 involves a three-step process: 1) constructing spatial models of bowhead whale relative abundance (encounter rate) based on bowhead whale sightings from 2019; 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 2019. This analysis is based on transect and CAPs-adjusted bowhead whale sightings made by primary observers in September and October 2019. 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 3.6.2 (R Core Team 2019) using packages *sp* (Pebesma and Bivand 2005; Bivand et al. 2013), *maptools* (Bivand and Lewin-Koh 2019), *raster* (Hijmans 2020), *rgeos* (Bivand and Rundel 2019), *rgdal* (Bivand et al. 2019), and *mgcv* (Wood 2017).

To begin, the western Beaufort Sea survey 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 2019 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 2019 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 20-year time period are calculated for the East and West regions separately.

The median is also referred to as the 50th percentile or quantile. An additional analysis undertaken defined the location of bowhead whale HUAs in 2019 alone and in 2000-2019 (all years pooled) based on the locations of the 30th, 40th, 50th, 60th, and 70th 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 30th 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 30th percentile are connected across the entire region to define a linear boundary across the western Beaufort Sea corresponding to the 30th percentile of bowhead whale HUAs, and similarly for the 40th, 50th, 60th, and 70th percentiles.

Multiyear Analyses

To expand the usefulness of ASAMM data collected in 2019, several multiyear analyses that use many stats are also conducted. The results of some analyses (e.g., HUA) are included in Results, 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 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 2009-2019 because survey effort was mostly equivalent during those time periods. Conversely, multiyear analyses for the western Beaufort Sea in summer are usually limited to 2012-2019 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 2012-2019. Multiyear analyses for the western Beaufort Sea in fall justifiably can, in some situations (e.g., calf ratios), incorporate data from 1982 through 2019. Other applications require sightings from primary observers only and, therefore, incorporate data from only 1989 through 2019, which is when details related to primary observers are recorded in the dataset.

RESULTS

Environmental Conditions

Sea ice cover in the eastern Chukchi Sea survey area in 2019 was extremely light from July through October. Sea ice cover in the western Beaufort Sea survey area in summer was like that observed from 2012 to 2017. When surveys commenced in early July, sea ice remained in much of the western Beaufort Sea survey area (Appendix A, Figures A-1 and A-2), but was entirely absent by early August (Figure A-4). The western Beaufort Sea survey area remained sea ice-free through October (Figures A-4 through A-9), with the exception of new ice that started to form in lagoons and other shallow water areas in mid-October (Figure A-10). In the eastern Beaufort Sea, sea ice remained in the ABA study area north of Cape Bathurst throughout August, periodically repositioning depending on prevailing wind conditions (Figures A-4 through A-6). Amundsen Gulf was essentially ice-free throughout August. Viscount Melville Sound, McClure Strait, and west of Banks Island remained heavily covered by sea ice throughout August (Figure A-6).

Arctic sea ice extent reached the seasonal minimum on 18 September 2019. The Arctic sea ice seasonal minimum extent was second lowest, tied with 2007, since satellite data were first recorded in 1979 (National Snow and Ice Data Center 2019). To examine interannual variability in bowhead whale and other marine mammal distributions and relative abundance, 2019 data were compared to data from previous years with light sea ice cover.

Observer Experience

Data quality is a direct reflection of the capabilities and experience of the field personnel (Baldassarre 2020). In 2019, 16 observers participated in ASAMM and ABA surveys. All ASAMM and ABA observers were experienced field biologists and most (81%) had previous experience with ASAMM surveys, which ensured consistency in data collection among years. ASAMM field experience ranged from 1 to 25 years (mean = 7.3 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.

Integration of ABA Data

Data collected during ABA surveys conducted in August 2019 in Amundsen Gulf and the eastern and western Beaufort Sea were integrated into overall 2019 ASAMM results. Additional details specific to ABA only are summarized in Appendix I.

Survey Effort

The ASAMM field season commenced 1 July 2019 and ended 31 October 2019. Survey flights were conducted from 2 July to 29 October (Table 3), corresponding to the summer and fall months when open-water anthropogenic activities occur. Surveys were conducted from one

Table 3. ASAMM and ABA aerial survey flight effort in chronological order, 2 July–29 October 2019, by survey flight and semimonthly 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.

Day	Flight No.	On-Effort (km)	Off-Effort (km)	CAPs circling (km)	FGF (km)	FOV (km)	Deadhead (km)	Total (km)	On-Effort (hrs)	Total (hrs)
2 Jul	201	682	122	0	0	0	152	956	3.0	4.2
3 Jul	202	550	127	0	0	0	514	1,192	2.4	4.8
4 Jul	203	774	21	0	0	0	810	1,605	3.5	6.2
6 Jul	204	204	365	0	0	0	368	937	1.0	4.1
7 Jul	205	416	215	0	0	0	1,374	2,004	1.8	7.1
11 Jul	206	615	68	0	0	0	756	1,439	2.8	5.5
12 Jul	207	649	100	0	480	0	780	2,009	2.8	8.5
13 Jul	208	402	132	0	0	0	469	1,003	1.7	4.0
17 Jul	209	453	153	0	0	0	355	962	2.0	4.0
18 Jul	210	101	31	0	0	0	395	527	0.4	1.9
19 Jul	1	659	28	0	54	0	276	1,017	3.0	4.5
21 Jul	2	224	66	0	276	0	442	1,008	1.0	4.5
21 Jul	211	445	67	0	0	0	177	689	1.9	2.8
22 Jul	3	542	189	0	0	0	325	1,055	2.5	4.5
22 Jul	212	301	32	0	0	0	705	1,038	1.3	3.8
23 Jul	213	670	79	0	0	0	338	1,087	2.9	4.6
25 Jul	4	495	60	0	0	0	593	1,149	2.2	4.4
27 Jul	214	356	57	0	0	0	715	1,127	1.5	4.0
27 Jul	5	118	14	0	0	0	759	891	0.5	2.9
30 Jul	6	928	94	0	0	0	1,150	2,172	4.2	8.0
31 Jul	7	1,229	112	0	0	0	607	1,948	5.6	8.1
2 Aug	8	158	81	0	0	0	379	618	0.8	2.4
2 Aug	215	0	254	0	0	0	256	510	0.0	2.4
4 Aug	9	0	266	0	0	0	946	1,212	0.0	4.0
5 Aug	10	538	39	0	0	0	444	1,021	2.4	4.1
6 Aug	11	0	0	0	0	0	436	436	0.0	1.3
8 Aug	401	178	20	0	0	0	261	459	0.8	2.0
8 Aug	216	352	43	0	0	0	485	881	1.6	3.4
9 Aug	217	0	43	0	0	0	967	1,009	0.0	3.0
9 Aug	402	159	3	0	0	0	282	445	0.8	1.9

Day	Flight No.	On-Effort (km)	Off-Effort (km)	CAPs circling (km)	FGF (km)	FOV (km)	Deadhead (km)	Total (km)	On-Effort (hrs)	Total (hrs)
11 Aug	12	0	0	0	0	0	444	444	0.0	1.3
11 Aug	403	230	33	0	0	0	533	796	1.1	3.2
12 Aug	13	400	136	0	0	0	405	941	1.8	3.7
12 Aug	218	449	37	80	0	0	511	1,077	2.0	4.2
13 Aug	404	0	0	0	0	0	152	152	0.0	0.6
13 Aug	219	112	45	0	0	0	642	798	0.5	2.7
14 Aug	14	0	0	0	0	74	164	238	0.0	0.9
14 Aug	220	325	30	150	0	0	730	1,236	1.5	4.9
15 Aug	405	160	26	0	0	0	635	820	0.8	3.3
15 Aug	15	93	114	0	0	0	369	576	0.4	2.1
16 Aug	16	127	2	0	0	0	321	449	0.6	1.6
16 Aug	221	364	48	0	0	0	940	1,352	1.7	4.7
17 Aug	222	375	18	0	0	0	1,640	2,032	1.7	6.4
17 Aug	17	476	68	0	0	0	2,237	2,781	2.1	9.0
19 Aug	406	610	106	0	0	0	940	1,655	2.8	7.1
19 Aug	223	621	53	0	0	0	1,079	1,753	2.9	6.5
20 Aug	407	58	0	0	0	0	645	703	0.3	2.6
20 Aug	224	904	149	0	0	0	1,586	2,639	4.2	9.8
21 Aug	408	909	200	0	0	0	942	2,051	4.3	8.8
21 Aug	225	648	151	0	0	0	935	1,734	3.0	7.0
21 Aug	18	942	137	0	0	0	709	1,788	4.2	7.3
22 Aug	409	449	138	0	0	549	593	1,729	2.1	7.6
22 Aug	226	413	76	0	0	0	779	1,268	1.9	4.7
22 Aug	19	398	25	0	0	0	380	803	1.8	3.1
23 Aug	410	287	37	0	0	0	468	792	1.3	3.3
23 Aug	227	63	2	0	0	0	552	616	0.3	2.0
25 Aug	411	495	103	0	0	0	525	1,123	2.3	4.8
25 Aug	228	600	14	0	0	0	797	1,411	2.7	5.2
25 Aug	20	274	135	0	0	0	458	867	1.2	3.3
26 Aug	229	434	32	0	0	0	1,094	1,560	2.0	5.4
26 Aug	412	403	114	0	0	0	566	1,083	1.9	4.8
26 Aug	21	727	57	0	0	0	734	1,517	3.2	5.8
27 Aug	230	280	35	0	0	0	912	1,227	1.3	4.3
27 Aug	413	308	53	0	0	0	679	1,041	1.4	4.3
27 Aug	22	492	174	0	0	0	132	798	2.2	3.5
28 Aug	23	525	66	0	0	0	245	836	2.4	3.6

Day	Flight No.	On-Effort (km)	Off-Effort (km)	CAPs circling (km)	FGF (km)	FOV (km)	Deadhead (km)	Total (km)	On-Effort (hrs)	Total (hrs)
29 Aug	24	572	64	0	0	0	342	977	2.6	4.0
30 Aug	25	1,060	155	0	0	0	660	1,875	4.7	7.6
30 Aug	231	664	110	0	0	0	312	1,086	3.0	4.7
31 Aug	26	70	39	0	0	0	203	312	0.2	1.0
31 Aug	232	939	218	0	0	0	1,123	2,279	4.1	8.6
2 Sep	27	290	37	0	0	0	262	589	1.3	2.4
2 Sep	233	195	164	0	0	0	199	558	0.9	2.4
3 Sep	28	754	180	0	0	0	376	1,309	3.2	5.5
4 Sep	29	314	66	0	0	0	172	552	1.3	2.3
5 Sep	234	1,099	200	0	0	0	595	1,894	4.9	7.9
5 Sep	30	554	171	0	0	0	576	1,300	2.4	5.1
6 Sep	235	361	63	0	0	0	778	1,201	1.6	4.4
7 Sep	31	0	0	0	0	468	222	690	0.0	2.9
7 Sep	236	53	1	0	0	0	626	680	0.2	2.2
8 Sep	32	554	2	0	0	0	426	982	2.5	3.8
8 Sep	237	442	51	0	0	0	568	1,061	1.9	4.0
9 Sep	33	476	178	33	0	0	487	1,174	2.1	4.7
10 Sep	34	492	124	0	0	0	304	920	2.2	3.9
14 Sep	238	362	4	0	0	0	243	610	1.6	2.5
17 Sep	239	1,006	100	0	0	0	484	1,591	4.5	7.0
17 Sep	35	441	67	0	0	0	657	1,165	2.0	4.2
18 Sep	36	466	135	0	0	0	2,048	2,649	2.1	8.7
18 Sep	240	498	54	0	0	0	518	1,071	2.2	4.2
20 Sep	241	614	134	0	0	0	858	1,606	2.7	6.0
21 Sep	242	693	102	0	0	0	1,194	1,989	3.1	7.2
22 Sep	243	404	113	0	0	0	718	1,236	1.8	4.6
23 Sep	244	663	129	0	0	0	1,024	1,817	2.9	7.0
24 Sep	37	454	127	0	0	0	510	1,091	2.1	4.5
24 Sep	245	674	88	0	0	0	1,124	1,887	3.0	7.2
25 Sep	246	133	54	0	0	0	192	379	0.6	1.6
25 Sep	38	479	157	0	0	0	409	1,045	2.2	4.3
26 Sep	247	1,046	151	0	0	0	547	1,743	4.7	7.4
26 Sep	39	0	0	0	0	0	739	739	0.0	2.2
27 Sep	40	1,098	177	0	0	0	520	1,796	4.9	7.7
28 Sep	41	1,260	124	0	0	0	878	2,262	5.6	9.1
28 Sep	248	955	81	0	0	0	921	1,957	4.2	7.6

Day	Flight No.	On-Effort (km)	Off-Effort (km)	CAPs circling (km)	FGF (km)	FOV (km)	Deadhead (km)	Total (km)	On-Effort (hrs)	Total (hrs)
29 Sep	249	537	2	0	0	0	511	1,050	2.3	4.0
29 Sep	42	519	200	0	0	0	510	1,230	2.3	5.0
30 Sep	43	658	50	0	0	0	572	1,279	2.9	5.0
1 Oct	250	574	24	0	0	0	197	794	2.6	3.5
3 Oct	44	764	98	0	0	0	273	1,136	3.4	4.8
3 Oct	251	535	16	0	0	0	212	762	2.4	3.3
5 Oct	45	466	49	0	0	0	872	1,387	2.0	5.0
5 Oct	252	367	16	0	0	0	710	1,093	1.6	4.1
7 Oct	253	548	80	0	0	0	399	1,027	2.5	4.3
7 Oct	46	248	104	0	0	0	294	646	1.1	2.6
8 Oct	47	944	83	0	0	0	833	1,861	4.2	7.3
8 Oct	254	672	26	0	0	0	749	1,447	3.0	5.4
9 Oct	48	563	203	0	0	0	444	1,211	2.5	4.9
9 Oct	255	208	56	0	0	0	406	671	1.0	2.6
10 Oct	49	312	16	0	0	0	360	687	1.3	2.7
10 Oct	256	453	61	0	0	0	498	1,012	2.0	3.9
13 Oct	257	302	66	0	0	0	443	812	1.4	3.4
14 Oct	258	610	52	0	0	0	268	929	2.8	3.9
15 Oct	259	921	169	0	0	0	1,270	2,360	4.0	8.7
17 Oct	260	570	121	0	0	0	1,155	1,845	2.5	6.7
18 Oct	261	391	75	217	0	0	1,613	2,296	1.7	8.4
20 Oct	262	88	6	0	0	0	370	465	0.4	1.7
22 Oct	263	898	36	0	0	0	678	1,612	4.0	6.5
23 Oct	264	733	57	0	0	0	1,017	1,807	3.2	6.9
24 Oct	265	706	26	0	0	0	478	1,209	3.0	4.9
25 Oct	266	519	32	0	0	0	365	915	2.3	3.7
26 Oct	267	548	37	0	0	0	818	1,404	2.4	5.1
28 Oct	268	491	56	0	0	0	923	1,471	2.1	5.1
29 Oct	269	790	182	0	0	0	910	1,882	3.4	7.2

Day	On-Effort (km)	Off-Effort (km)	CAPs circling (km)	FGF (km)	FOV (km)	Dead-head (km)	Total (km)	On-Effort (hrs)	Total (hrs)
				Semimonthly Summary					
1-15 Jul	4,291	1,151	0	480	0	5,222	11,144	19.0	44.4
16-31 Jul	6,521	983	0	330	0	6,838	14,672	29.3	58.1
1-15 Aug	3,153	1,169	230	0	74	9,043	13,669	14.4	51.6
16-31 Aug	15,486	2,577	0	0	549	23,524	42,137	70.5	162.6
1-15 Sep	5,945	1,241	33	0	468	5,834	13,520	26.2	53.8
16-30 Sep	12,600	2,047	0	0	0	14,934	29,581	56.1	114.3
1-15 Oct	8,486	1,120	0	0	0	8,227	17,834	37.6	70.3
16-31 Oct	5,734	628	217	0	0	8,327	14,905	25.0	56.1
Total	**62,216**	**10,916**	**480**	**810**	**1,091**	**81,949**	**157,462**	**278.1**	**611.2**

Turbo Commander aircraft based in Utqiaġvik from 1 July to 2 August and 30 August to 31 October, primarily targeting the northeastern and southcentral Chukchi Sea, and from one Turbo Commander aircraft based in Deadhorse from 18 July to 10 October, primarily targeting the western Beaufort Sea. During ABA surveys in August 2019, one Turbo Commander aircraft was based in Inuvik, Northwest Territories, Canada, and one Twin Otter aircraft was based in Ulukhaktok, Northwest Territories, Canada, from 5 to 15 August and in Inuvik from 16 to 27 August. There were 131 survey flights, of which 21 were in July, 50 in August, 34 in September, and 26 in October. Thirty-nine of the survey flights in August were ABA surveys in the eastern and western Beaufort Sea and Amundsen Gulf. Surveys originating on the Turbo Commander aircraft based in Utqiaġvik and in Inuvik were numbered sequentially starting with 201; surveys originating on the Turbo Commander aircraft based in Deadhorse were numbered sequentially starting with 1; and surveys originating on the Twin Otter aircraft based in Ulukhaktok and Inuvik were number sequentially starting with 401. On 41 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 two survey teams on 35 days and by three survey teams on 5 days. Surveys were conducted on 71% of days during the field season (86 out of 121 days). Surveys were not conducted on 29% of field days (35 out of 121 days) due to weather (28 days) or a combination of weather and aircraft inspections, maintenance, or transits between bases of operation (7 days).

Survey effort was summarized by hours or kilometers flown in different survey modes. Over 157,000 km were flown during 611 hours total effort (Figure 5). A total of 62,216 km was flown on effort (transect and CAPs passing) during 278.1 hours (Figure 6); 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 45% of the total flight hours. Minimal effort was flown on CAPs circling, FGF, and FOV (<1% of total effort for each). Forty-three percent of total survey hours were flown on deadhead. Four flights were entirely on deadhead due to poor weather conditions. The average survey distance flown was 1,202 km, ranging from 152 km to 2,781 km. The longer distances required 2-3 flights per survey.

Survey effort (transect, CAPs, search, circling, and FGF) is plotted semimonthly in Figure 7. Survey effort was distributed throughout the entire ASAMM study area in July, September, and October, 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 20-21). Survey effort in August was distributed from Amundsen Gulf to Point Barrow. Survey coverage in the ASAMM study area was broadly and evenly distributed in late September and early October. 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 and early September, survey coverage was limited due to widespread poor weather conditions in the study area, particularly in the eastern Chukchi Sea, and poor weather conditions at the bases of operation. Survey coverage in August in the ASAMM study area was considerably different from previous years and from other months in 2019 because surveys were largely focused on ASAMM Bowhead Abundance (ABA) surveys conducted in the Beaufort Sea and Amundsen Gulf. Consequently, there was relatively little survey effort in the eastern Chukchi Sea in August.

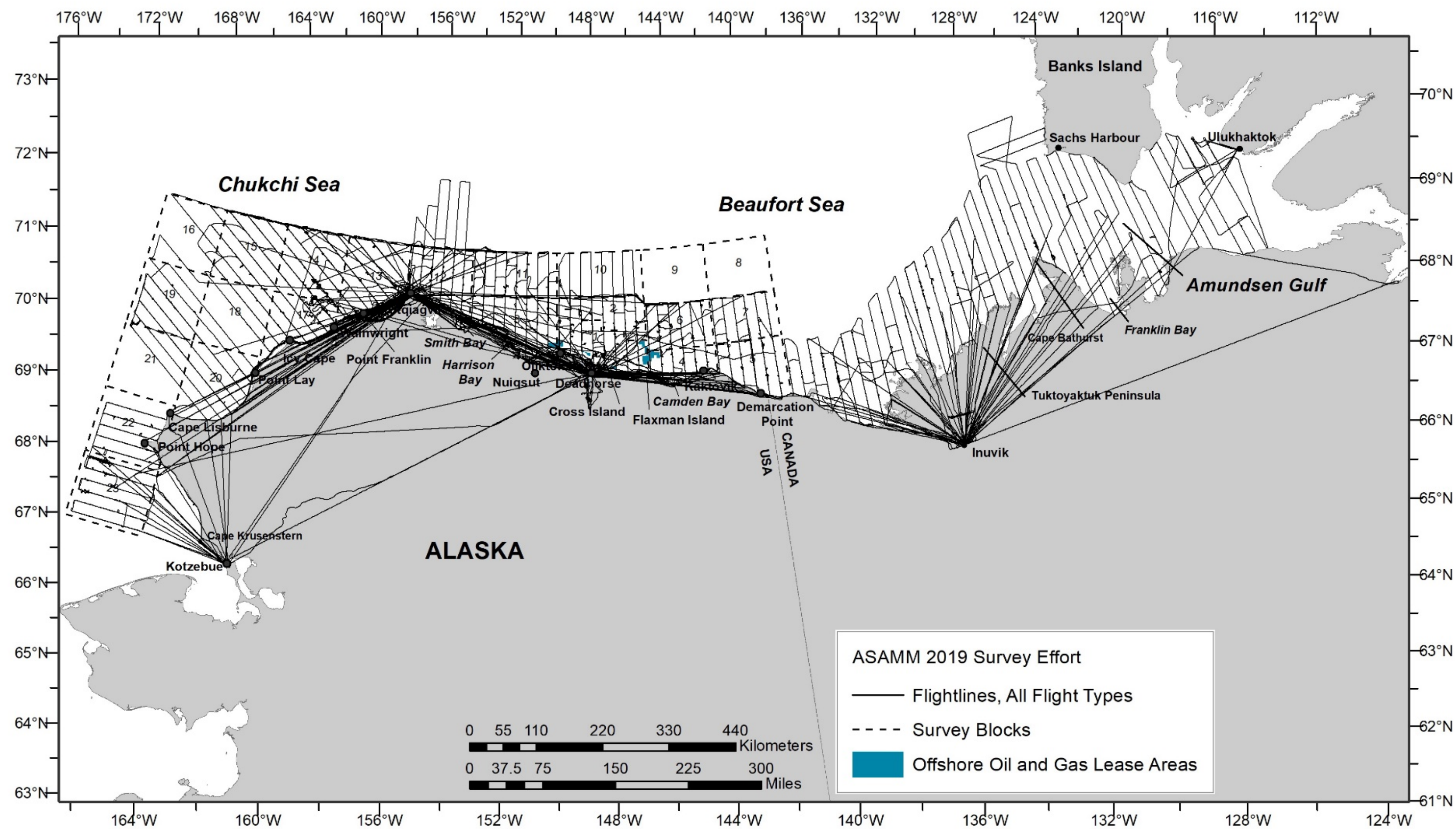


Figure 5. ASAMM 2019 combined flight tracks in the ASAMM and ABA study areas, all survey modes (transect, CAPs, search, circling, FGF, FOV, and deadhead), July-October.

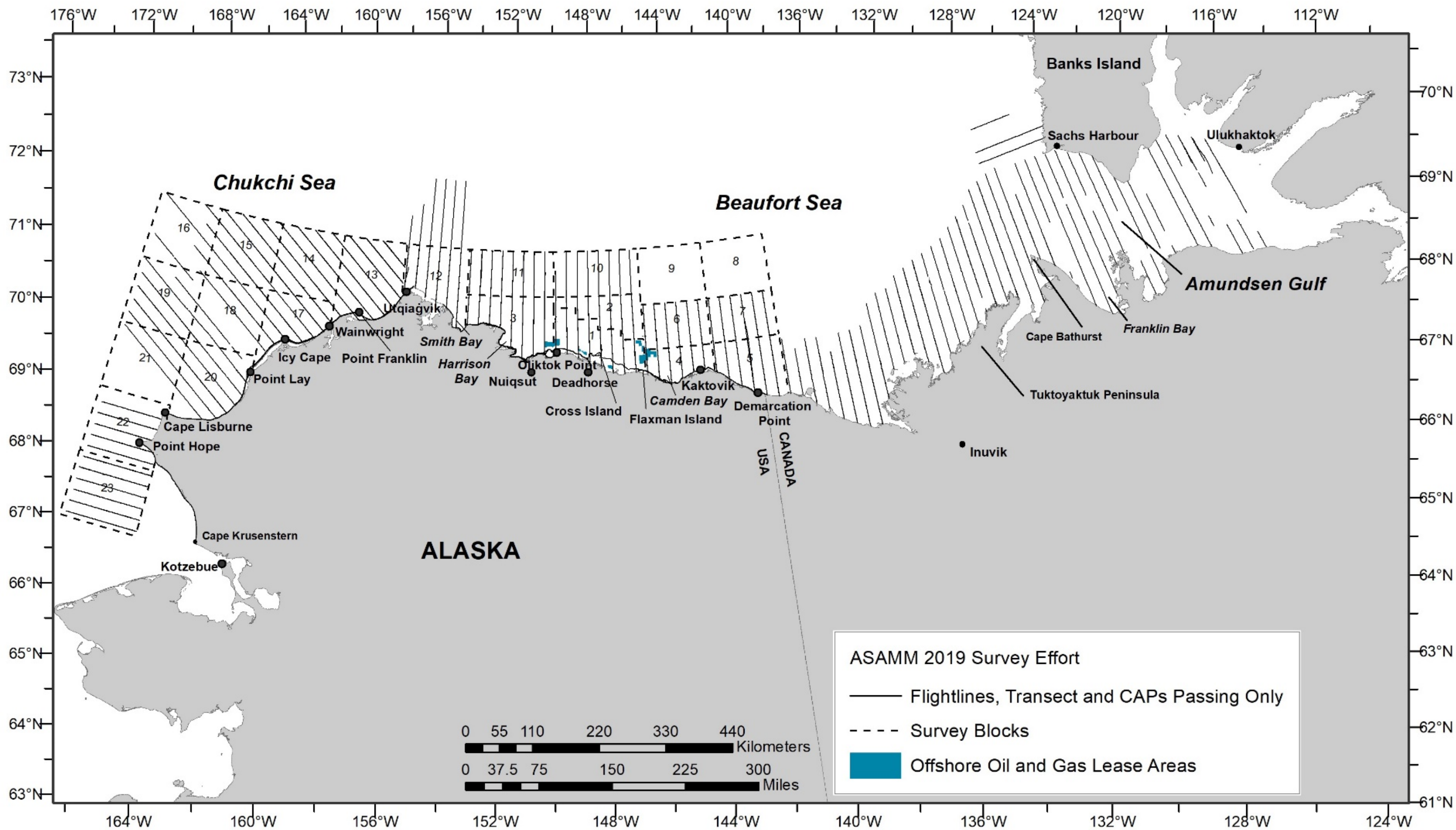


Figure 6. ASAMM 2019 combined flight tracks in the ASAMM and ABA study areas, transect and CAPs passing effort only, July-October.

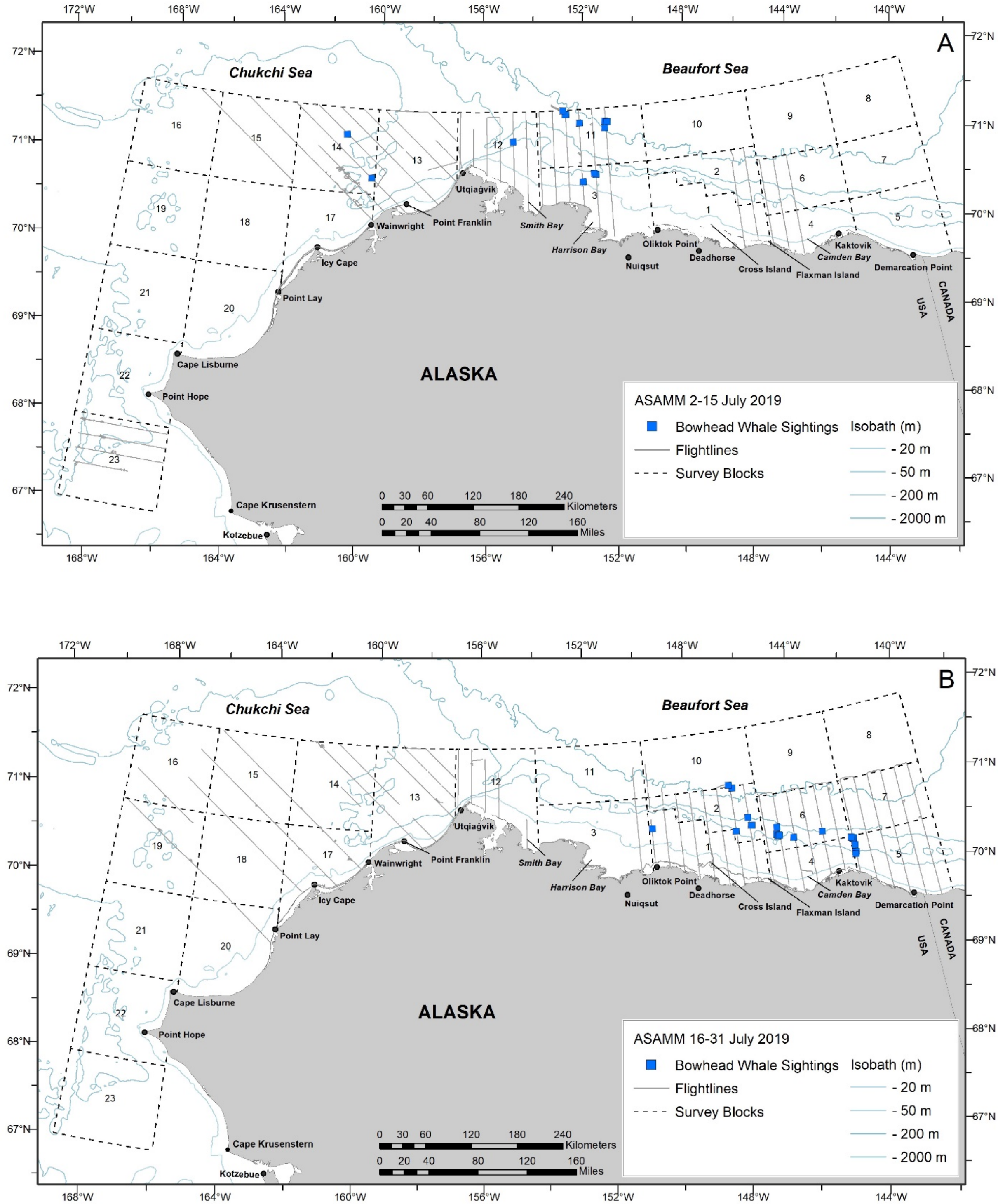


Figure 7. ASAMM 2019 semimonthly bowhead whale sightings in the ASAMM and ABA study areas, all survey modes, with transect, CAPs, search, circling, and FGF survey effort, July-October. A: 2-15 July. B: 16-31 July. Deadhead flight tracks are not shown.

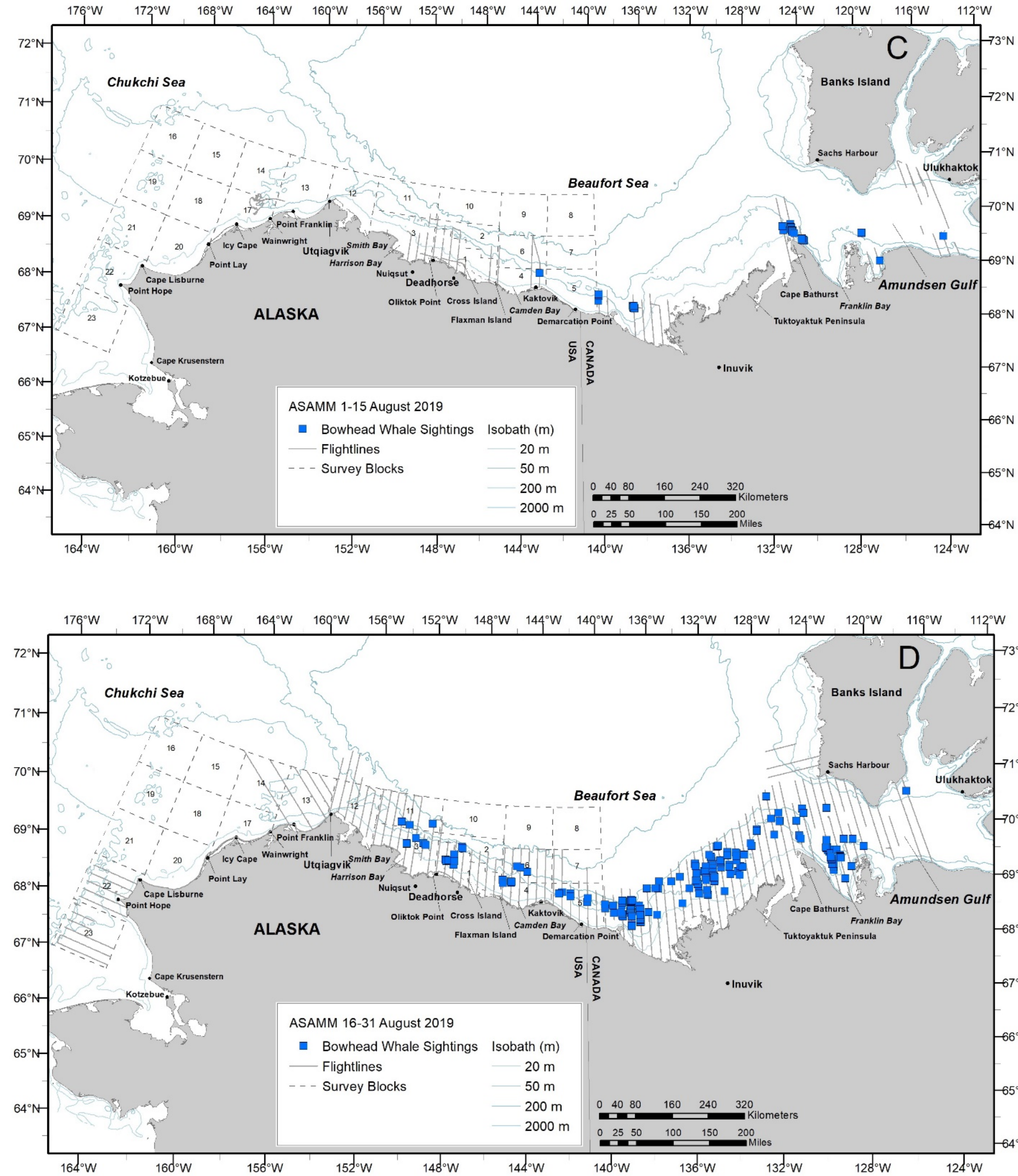
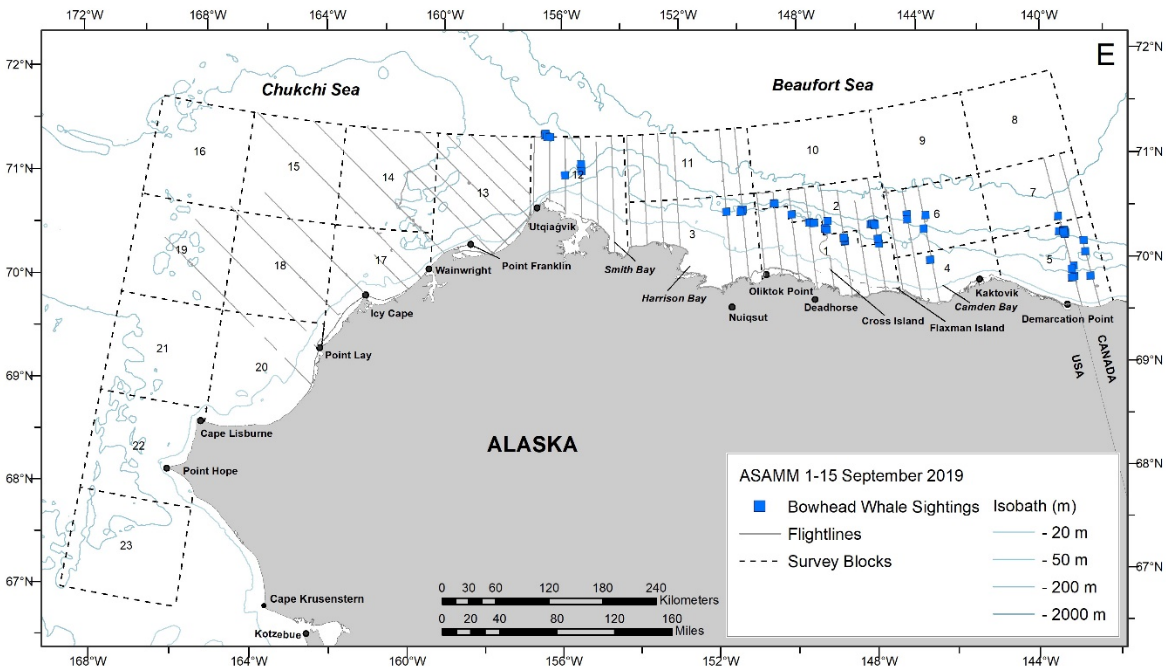


Figure 7 (cont). ASAMM 2019 semimonthly bowhead whale sightings in the ASAMM and ABA study areas, all survey modes, with transect, CAPs, search, circling, and FGF survey effort, July-October. C: 1-15 August. D: 16-31 August. Deadhead flight tracks are not shown.



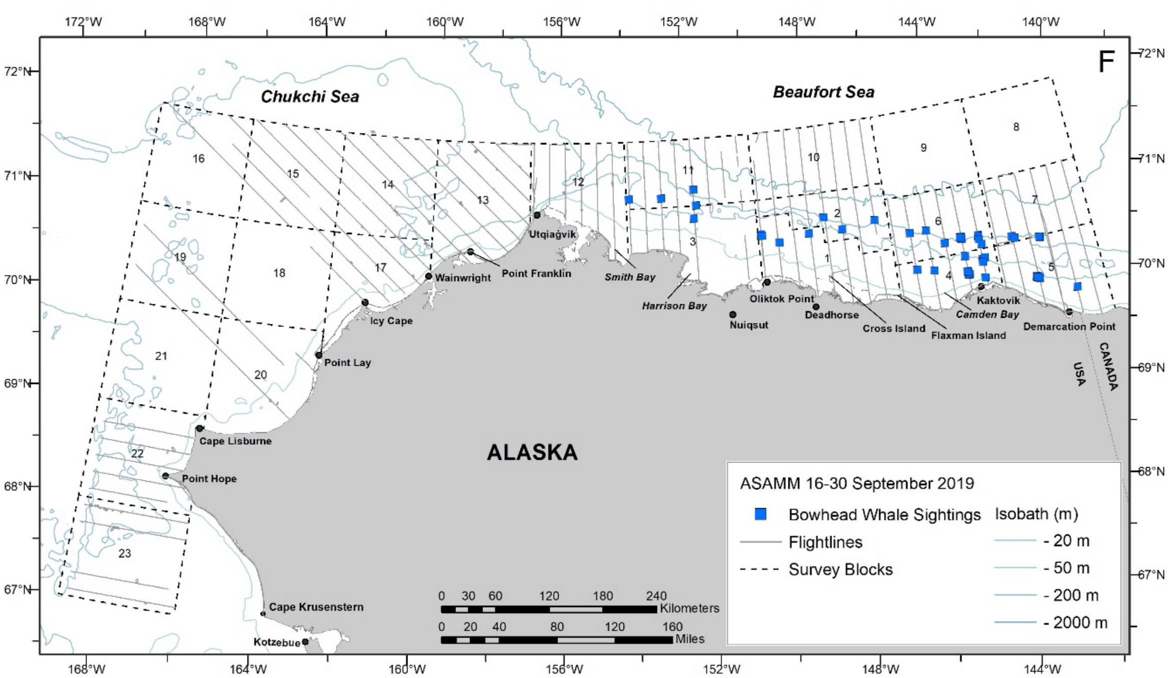
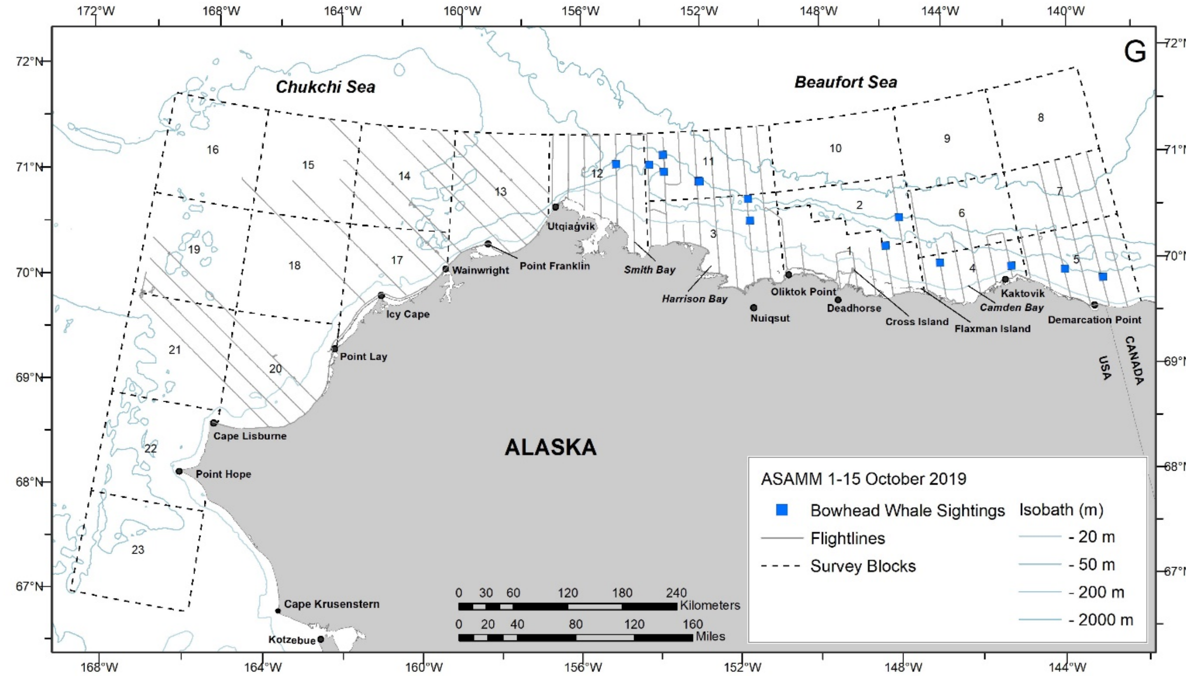


Figure 7 (cont). ASAMM 2019 semimonthly bowhead whale sightings in the ASAMM and ABA study areas, all survey modes, with transect, CAPs, search, circling, and FGF survey effort, July-October. E: 1-15 September. F: 16-30 September. Deadhead flight tracks are not shown.



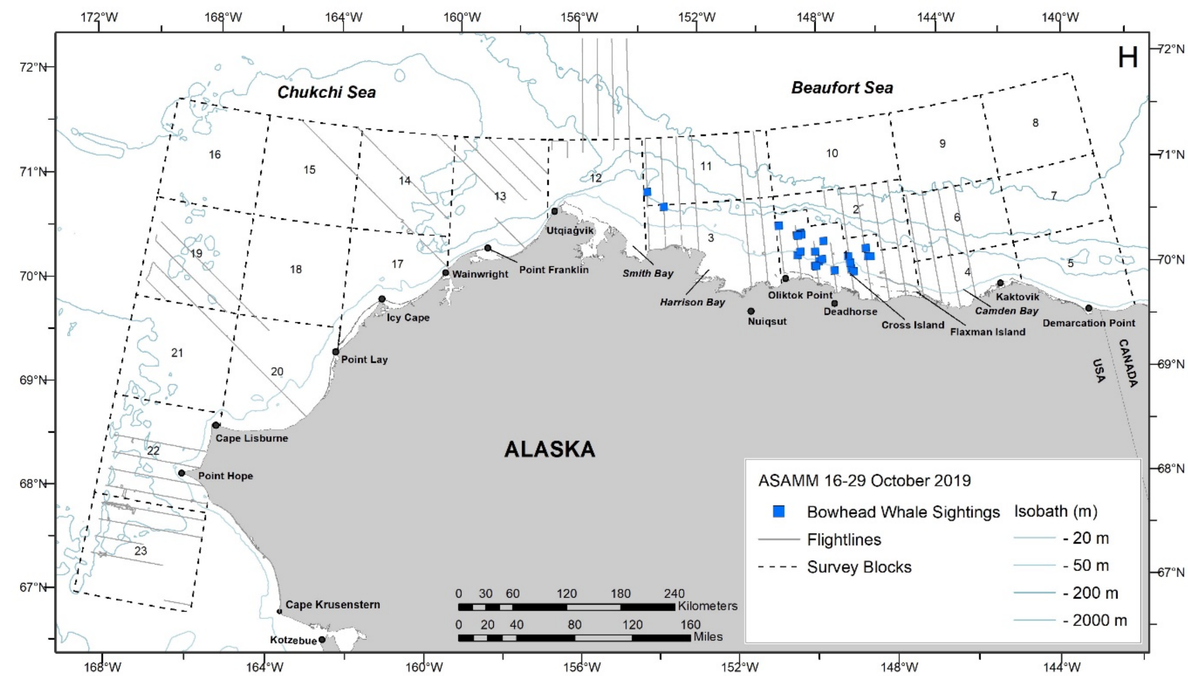


Figure 7 (cont). ASAMM 2019 semimonthly bowhead whale sightings in the ASAMM and ABA study areas, all survey modes, with transect, CAPs, search, circling, and FGF survey effort, July-October. G: 1-15 October. H: 16-29 October. Deadhead flight tracks are not shown.

Systematic broad-scale coverage of the western Beaufort Sea in summer (July through August) was conducted for the eighth consecutive year and included transects extending between the barrier islands and the mainland in block 1a to survey areas near the Liberty Prospect. Block 1a was surveyed in all months.

Block 23, in the southcentral Chukchi Sea, was surveyed for the sixth consecutive year, with effort in July, August, September, and October.

Portions of the coastal transect in the eastern Chukchi Sea were surveyed on 9 days between 2 July and 20 October, covering approximately 1560 km. In the western Beaufort Sea, portions of the coastal transect were surveyed on 27 days between 4 July and 29 October, covering approximately 2,260 km.

The sections of coastal transect near Point Lonely and between Atigaru Point and Fish Creek in Harrison Bay were surveyed on 18 days, with 4 surveys in July, 4 surveys in August, 4 surveys in September, and 6 surveys in October, for a total of 1,442 km (Figure 8).

Surveys were conducted north of 72°N, between 154°W and 157°W, on one day in August and one day in October.

Photos were collected from the BPC on 58 flights, the majority of which were in the Beaufort Sea. Over 13.2 TB of imagery data were collected, representing over 314,500 images.

Survey effort in 2019 was nominally impacted by poor weather conditions and avoidance of subsistence activities. Fog, low ceilings, and strong winds limited survey effort during the first half of ABA from 6 to 15 August, and curtailed survey effort in mid-September when only one survey was conducted during a six-day period. The longest period when no ASAMM flights occurred was three days. Mitigating 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, assess bowhead whale images for photo ID analyses, and review gray whale images for body condition analyses (Zongker 2006).

Direct avoidance of subsistence (or possible subsistence) activities, specifically the fall bowhead whale hunt occurring near Kaktovik, Cross Island, and Utqiaġvik, occurred on four days in 2019. On 3 September, transects were truncated near Cross Island to avoid potential interference with subsistence whaling. On 9 September, areas near Kaktovik and Cross Island were deliberately avoided during a survey of the coastal transect. On 3 and 25 October, transects were truncated near Utqiaġvik to avoid potential interference with subsistence whaling.

ASAMM efforts to collect left and right observer field of view (FOV) data specific to Turbo Commander aircraft continued in 2019 and were initiated to collect equivalent data specific to the Twin Otter. Flights to collect FOV data occurred on four days, including one flight to scout for a suitable terrestrial target to be used by the Twin Otter in Canada and three flights using stationary terrestrial targets. Flights to collect FOV data were flown in lieu of a survey flight on three days when survey conditions offshore were not optimal and were combined with

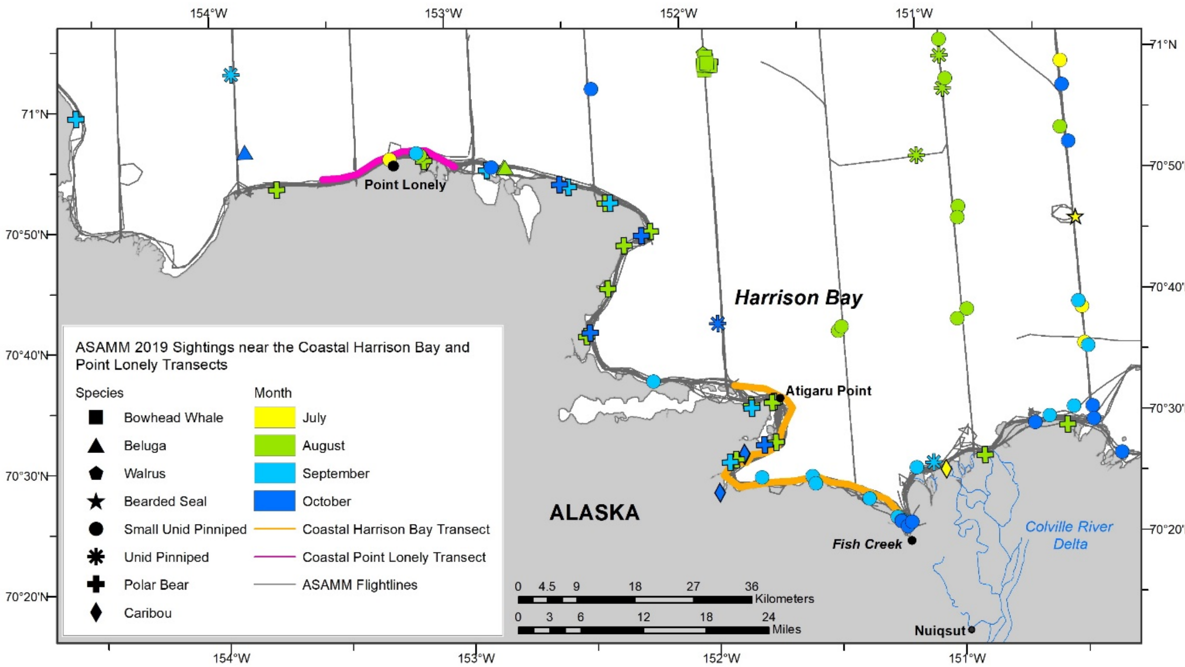


Figure 8. ASAMM 2019 Coastal Harrison Bay (CHB) and Coastal Point Lonely (CPL) sightings, all survey modes, and transect, CAPs, search, circling, and FGF survey effort, July-October. Deadhead flight tracks are not shown.

survey flights on one day. Details of this effort and preliminary results are provided in Appendix G.

Aerial surveys supporting sea ice and marginal ice zone research were conducted in the northeastern Chukchi Sea by researchers using a NOAA Twin Otter. Daily review of Notices to Airmen and Mariners and frequent communications with researchers assisted with mitigating adverse effects on ASAMM survey effort.

Survey coverage in the ASAMM study area was greatest in block 13 in the Chukchi Sea and blocks 3 and 12 in the Beaufort Sea (Figure 9) due, in part, to the proximity of blocks 12 and 13 to Utqiaġvik. The addition of the short sections of coastal transect near Point Lonely and between Atigaru Point and Fish Creek was the likely cause for effort being high in block 3; often the coastline between those two transects was also surveyed (Figure 8). 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 also 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.

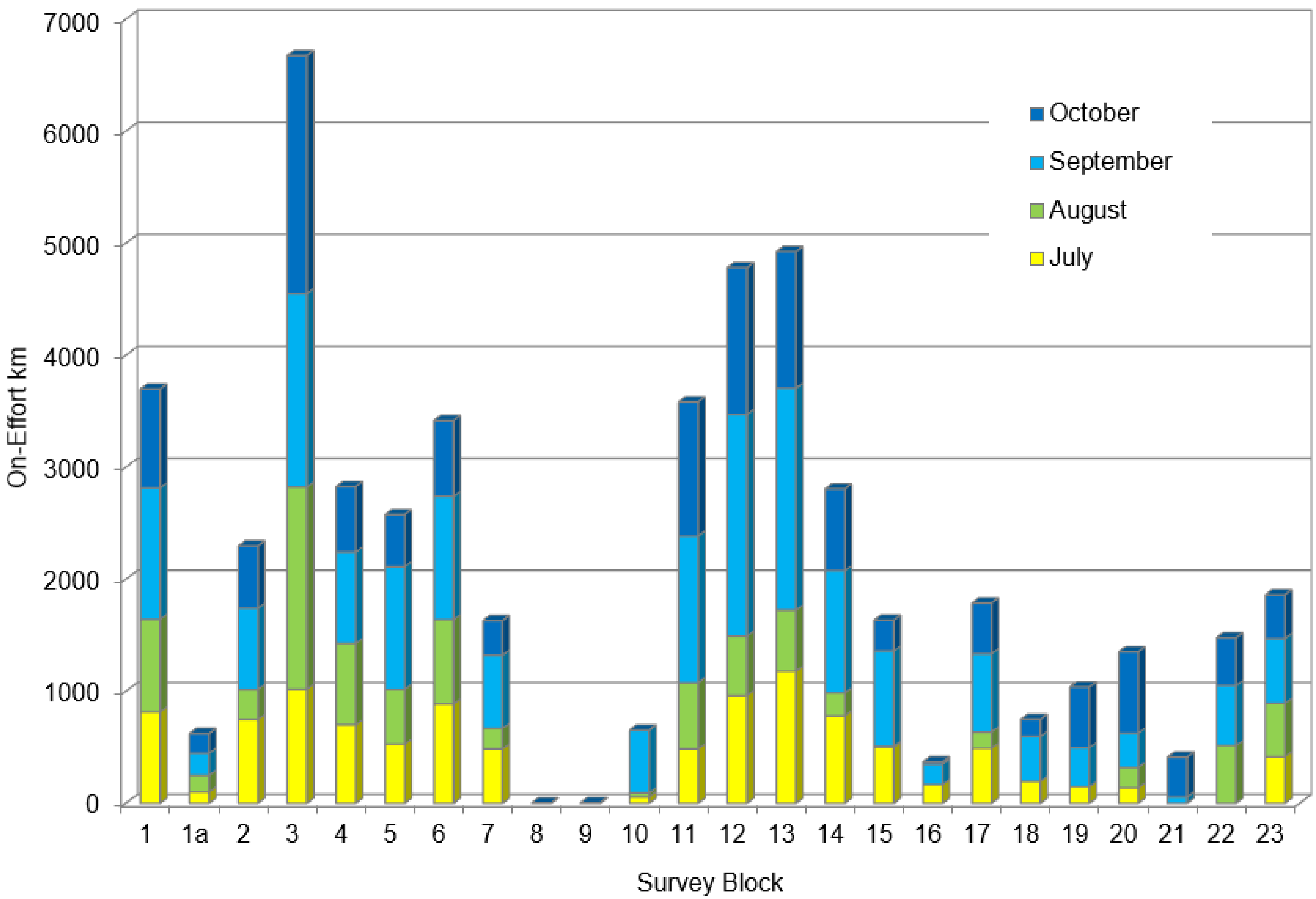


Figure 9. ASAMM 2019 kilometers on effort (transect and CAPs passing) per survey block in the ASAMM study area, July-October.

Cetaceans

Bowhead Whales

BOWHEAD WHALE SIGHTING SUMMARY

During the 2019 ASAMM and ABA surveys, 518 sightings of 749 bowhead whales (*Balaena mysticetus*) of the Western Arctic (also known as the Bering-Chukchi-Beaufort Seas) stock were observed during transect, CAPs, search, and circling survey modes in the ASAMM and ABA study areas from July through October (Table 4; Figure 10). Within the ASAMM study area, 235 sightings of 349 bowhead whales were observed during transect, CAPs, search, and circling survey modes; two whales seen slightly north of 72°N are included in total numbers for the ASAMM study area. Compared to 2012-2018, 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 number of bowhead whales recorded in 2019 in the ASAMM study area was the lowest on record (Clarke et al. 2013, 2014, 2015, 2017a,b, 2018, 2019). There were 283 sightings of 400 bowhead whales in the ABA study area (east of 140°W) in August (Appendix I).

Fifty-eight bowhead whales were seen in July (Figures 7A and 7B). Sightings were widely dispersed in the western Beaufort Sea, with sightings over the slope (201-2,000 m depth), outer portion of the continental shelf (51-200 m), and inner continental shelf (≤50 m). Seven bowhead whales were seen over the basin (>2,000 m depth). Bowhead whale distribution observed in July extended from 142.8°W to 155°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 (68%) in the western Beaufort Sea were east of 148°W; eighteen whales were observed west of 148°W. Two bowhead whales were seen in the northeastern Chukchi Sea. The highest number of bowhead whales per survey block in July was in block 5 ($n_i = 19$). In August, 55 bowhead whales were seen in the ASAMM study area (Figures 7C and 7D), which is far fewer than the number observed in August 2012-2017 (Clarke et al. 2013a, 2014, 2015a, 2017a, b, 2018a, 2019). Bowhead whales were observed in the western Beaufort Sea from 140.9°W to 152.5°W in outer and inner continental shelf waters and over the slope; no bowhead whales were observed in the Chukchi Sea in August, although survey effort was abnormally low due to the geographic shift to survey the Beaufort Sea and Amundsen Gulf during ABA. The highest number of bowhead whales per survey block in the western Beaufort Sea in August was in block 3 and block 5 ($n_i = 13$). Four hundred bowhead whales were seen in the eastern Beaufort Sea and Amundsen Gulf in August during ABA surveys (Figure I-3). Bowhead whales were observed between 119.3°W and 140°W in outer and inner shelf waters and over the slope. In September, 177 bowhead whales were seen, all in the western Beaufort Sea; no bowhead whales were seen in the Chukchi Sea in September. Bowhead whale distribution in September was primarily on the outer portion of the continental shelf and over the slope (Figures 7E and 7F); only 42% of whales were seen on the inner continental shelf. The greatest number of bowhead whales per survey block in September was in block 5 ($n_i = 50$). In October, 59 bowhead whales were seen, distributed from 140.8°W to 154.9°W. No bowhead whales were seen in the Chukchi Sea in October. Only 23 bowhead whales were observed in the first half of October; more than half of the total bowhead whales observed in October were seen on the final survey day of 2019 ($n_i = 30$). The greatest number of bowhead whales per survey block in October was seen in block 1 ($n_i = 33$).

Table 4. Summary of ASAMM and ABA 2019 cetacean sightings (number of sightings/number of individuals) during transect, CAPs, search, and circling survey modes, in chronological order, 2 July–29 October 2019, 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	Unidentified Cetacean*
2 Jul	201	1/1	2/2	0	0	0	2/154	0	0
3 Jul	202	2/2	0	0	0	0	10/71	0	0
4 Jul	203	0	0	0	0	0	58/162	0	0
6 Jul	204	0	31/40	0	0	0	1/2	0	0
7 Jul	205	0	44/57	5/9	3/5	0	0	0	0
11 Jul	206	0	1/1	0	0	0	22/52	0	0
12 Jul	207	10/15	0	0	0	0	88/468	0	2/2
13 Jul	208	0	22/36	0	0	0	0	0	0
17 Jul	209	0	7/17	0	0	0	0	0	1/1
18 Jul	210	0	0	0	0	0	0	0	0
19 Jul	1	1/2	0	0	0	0	25/69	0	0
21 Jul	2	6/13	0	0	0	0	11/21	0	0
21 Jul	211	0	0	0	0	0	1/1	0	0
22 Jul	3	12/17	0	0	0	0	86/223	0	0
22 Jul	212	0	0	0	0	0	0	0	0
23 Jul	213	0	0	1/1	0	0	0	0	0
25 Jul	4	0	0	0	0	0	0	0	0
27 Jul	214	0	0	3/5	1/2	0	0	0	0
27 Jul	5	0	0	0	0	0	0	0	0
30 Jul	6	6/8	0	0	0	0	112/289	0	1/2
31 Jul	7	0	0	0	0	0	23/51	0	1/1
2 Aug	8	0	0	0	0	0	0	0	0

Day	Flight No.	Bowhead Whale	Gray Whale	Humpback Whale	Fin Whale	Minke Whale	Beluga	Killer Whale	Unidentified Cetacean*
2 Aug	215	0	16/39	0	0	0	2/2	0	0
4 Aug	9	0	16/24	0	0	0	0	0	0
5 Aug	10	0	0	0	0	0	1/1	0	0
6 Aug	11	0	0	0	0	0	0	0	0
8 Aug	401	0	0	0	0	0	0	0	0
8 Aug	216	0	0	0	0	0	14/62	0	0
9 Aug	217	3/3	0	0	0	0	2/6	0	0
9 Aug	402	0	0	0	0	0	19/103	0	0
11 Aug	12	0	0	0	0	0	0	0	0
11 Aug	403	1/1	0	0	0	0	1/1	0	0
12 Aug	13	1/1	0	0	0	0	17/18	0	0
12 Aug	218	29/36	0	0	0	0	18/21	0	0
13 Aug	404	0	0	0	0	0	0	0	0
13 Aug	219	4/5	0	0	0	0	6/7	0	1/1
14 Aug	14	0	0	0	0	0	0	0	0
14 Aug	220	51/58	0	0	0	0	9/13	0	0
15 Aug	405	1/1	0	0	0	0	1/1	0	0
15 Aug	15	0	0	0	0	0	2/2	0	0
16 Aug	16	0	0	0	0	0	0	0	0
16 Aug	221	1/1	0	0	0	0	38/56	0	0
17 Aug	222	1/1	0	0	0	0	68/108	0	0
17 Aug	17	0	5/6	0	0	0	0	0	0
19 Aug	406	26/37	0	0	0	0	17/55	0	0
19 Aug	223	6/8	0	0	0	0	24/31	0	0
20 Aug	407	0	0	0	0	0	5/5	0	0

Day	Flight No.	Bowhead Whale	Gray Whale	Humpback Whale	Fin Whale	Minke Whale	Beluga	Killer Whale	Unidentified Cetacean*
20 Aug	224	34/55	0	0	0	0	169/294	0	1/1
21 Aug	408	22/33	8/15	0	0	0	24/28	0	0
21 Aug	225	24/37	0	0	0	0	47/57	0	0
21 Aug	18	9/14	0	0	0	0	31/103	0	0
22 Aug	226	11/18	0	0	0	0	29/36	0	0
22 Aug	409	21/37	0	0	0	0	14/16	0	2/2
22 Aug	19	0	0	0	0	0	0	0	0
23 Aug	410	3/5	0	0	0	0	2/2	0	0
23 Aug	227	0	0	0	0	0	0	0	0
25 Aug	411	13/19	0	0	0	0	2/2	0	0
25 Aug	228	2/2	0	0	0	0	12/17	0	0
25 Aug	20	6/8	0	0	0	0	1/1	0	0
26 Aug	229	0	0	0	0	0	24/35	0	0
26 Aug	21	0	0	0	0	0	1/1	0	0
26 Aug	412	21/31	0	0	0	0	9/13	0	0
27 Aug	230	4/5	0	0	0	0	3/4	0	0
27 Aug	413	7/12	0	0	0	0	8/9	0	0
27 Aug	22	10/12	0	0	0	0	7/16	0	1/1
28 Aug	23	0	0	0	0	0	8/11	0	0
29 Aug	24	3/3	0	0	0	0	40/65	0	0
30 Aug	25	7/8	0	0	0	0	49/63	0	0
30 Aug	231	0	1/3	0	0	0	0	1/2	0
31 Aug	26	4/4	0	0	0	0	0	0	0
31 Aug	232	0	0	0	0	0	1/1	0	1/1
2 Sep	27	0	0	0	0	0	0	0	0

Day	Flight No.	Bowhead Whale	Gray Whale	Humpback Whale	Fin Whale	Minke Whale	Beluga	Killer Whale	Unidentified Cetacean*
2 Sep	233	0	8/14	0	0	0	0	0	0
3 Sep	28	18/25	0	0	0	0	16/53	0	0
4 Sep	29	6/12	0	0	0	0	11/41	0	0
5 Sep	30	7/8	0	0	0	0	7/51	0	0
5 Sep	234	0	12/20	0	0	0	1/1	0	1/1
6 Sep	235	0	0	2/2	3/5	0	0	0	0
7 Sep	31	0	0	0	0	0	0	0	0
7 Sep	236	0	0	0	0	0	0	0	0
8 Sep	32	0	0	0	0	0	12/32	0	0
8 Sep	237	0	0	0	0	0	0	0	0
9 Sep	33	25/39	0	0	0	0	0	0	2/2
10 Sep	34	9/17	0	0	0	0	22/42	0	4/4
14 Sep	238	0	0	0	0	0	4/6	0	0
17 Sep	239	0	3/3	0	0	0	1/1	3/13	0
17 Sep	35	0	0	0	0	0	0	0	0
18 Sep	36	0	6/15	0	2/2	0	0	0	7/8
18 Sep	240	0	0	0	0	0	0	0	1/1
20 Sep	241	2/3	0	0	0	0	17/20	0	1/1
21 Sep	242	0	0	0	0	2/2	0	0	0
22 Sep	243	0	0	0	0	1/1	0	0	0
23 Sep	244	2/3	9/13	3/6	0	0	2/3	0	0
24 Sep	37	10/15	0	0	0	0	29/51	0	0
24 Sep	245	5/6	0	0	0	0	5/7	0	0
25 Sep	246	0	1/5	0	0	0	0	0	0
25 Sep	38	4/6	0	0	0	0	4/4	0	0

Day	Flight No.	Bowhead Whale	Gray Whale	Humpback Whale	Fin Whale	Minke Whale	Beluga	Killer Whale	Unidentified Cetacean*
26 Sep	247	0	11/11	0	0	0	5/7	0	1/1
26 Sep	39	0	0	0	0	0	0	0	0
27 Sep	40	1/2	0	0	0	0	15/213	0	0
28 Sep	41	8/13	1/1	0	0	0	29/39	0	1/1
28 Sep	248	0	0	0	0	0	1/2	0	0
29 Sep	249	0	0	0	0	0	0	0	0
29 Sep	42	17/25	0	0	0	0	42/82	0	0
30 Sep	43	2/3	0	0	0	0	26/37	0	0
1 Oct	250	0	0	0	0	0	0	0	0
3 Oct	44	0	0	0	0	0	1/10	0	0
3 Oct	251	0	0	0	0	0	14/34	0	0
5 Oct	45	0	7/9	0	0	0	0	0	0
5 Oct	252	0	0	0	0	0	0	0	0
7 Oct	253	0	12/14	0	0	0	0	0	0
7 Oct	46	0	0	0	0	0	0	0	0
8 Oct	47	4/11	0	0	0	0	7/8	0	0
8 Oct	254	2/2	0	0	0	0	30/47	0	0
9 Oct	48	2/3	0	0	0	0	2/3	0	0
9 Oct	255	3/3	0	0	0	0	11/16	0	0
10 Oct	49	0	0	0	0	0	0	0	0
10 Oct	256	0	0	0	0	0	0	0	0
13 Oct	257	1/1	0	0	0	0	1/9	0	1/2
14 Oct	258	2/3	0	0	0	0	8/33	0	0
15 Oct	259	0	0	0	3/5	5/6	0	0	1/2
17 Oct	260	0	1/1	0	1/3	4/4	0	0	0

Day	Flight No.	Bowhead Whale	Gray Whale	Humpback Whale	Fin Whale	Minke Whale	Beluga	Killer Whale	Unidentified Cetacean*
18 Oct	261	0	90/100	1/1	6/14	0	0	0	0
20 Oct	262	0	0	0	0	0	0	0	0
22 Oct	263	2/3	0	0	0	0	16/28	0	0
23 Oct	264	2/3	0	0	0	0	20/25	0	1/1
24 Oct	265	0	1/1	0	0	0	9/29	0	0
25 Oct	266	0	0	0	0	0	14/42	0	0
26 Oct	267	0	0	0	0	0	1/1	0	0
28 Oct	268	0	0	0	0	0	2/2	0	0
29 Oct	269	21/30	0	0	0	0	6/39	0	1/1
				Semimonthly Summary					
1-15 Jul		13/18	100/136	5/9	3/5	0	181/909	0	2/2
16-31 Jul		25/40	7/17	4/6	1/2	0	258/654	0	2/2
1-15 Aug		90/105	32/63	0	0	0	92/237	0	1/1
16-31 Aug		235/350	14/24	0	0	0	633/1,029	1/2	5/5
1-15 Sep		65/101	20/34	2/2	3/5	0	73/226	0	7/7
16-30 Sep		51/76	31/48	3/6	2/2	3/3	176/466	3/13	11/12
1-15 Oct		14/23	19/23	0	3/5	5/6	74/160	0	2/4
16-31 Oct		25/36	92/102	1/1	7/17	4/4	68/166	0	2/2
TOTAL		518/749	315/447	15/24	19/36	12/13	1,555/3,847	4/15	32/35

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

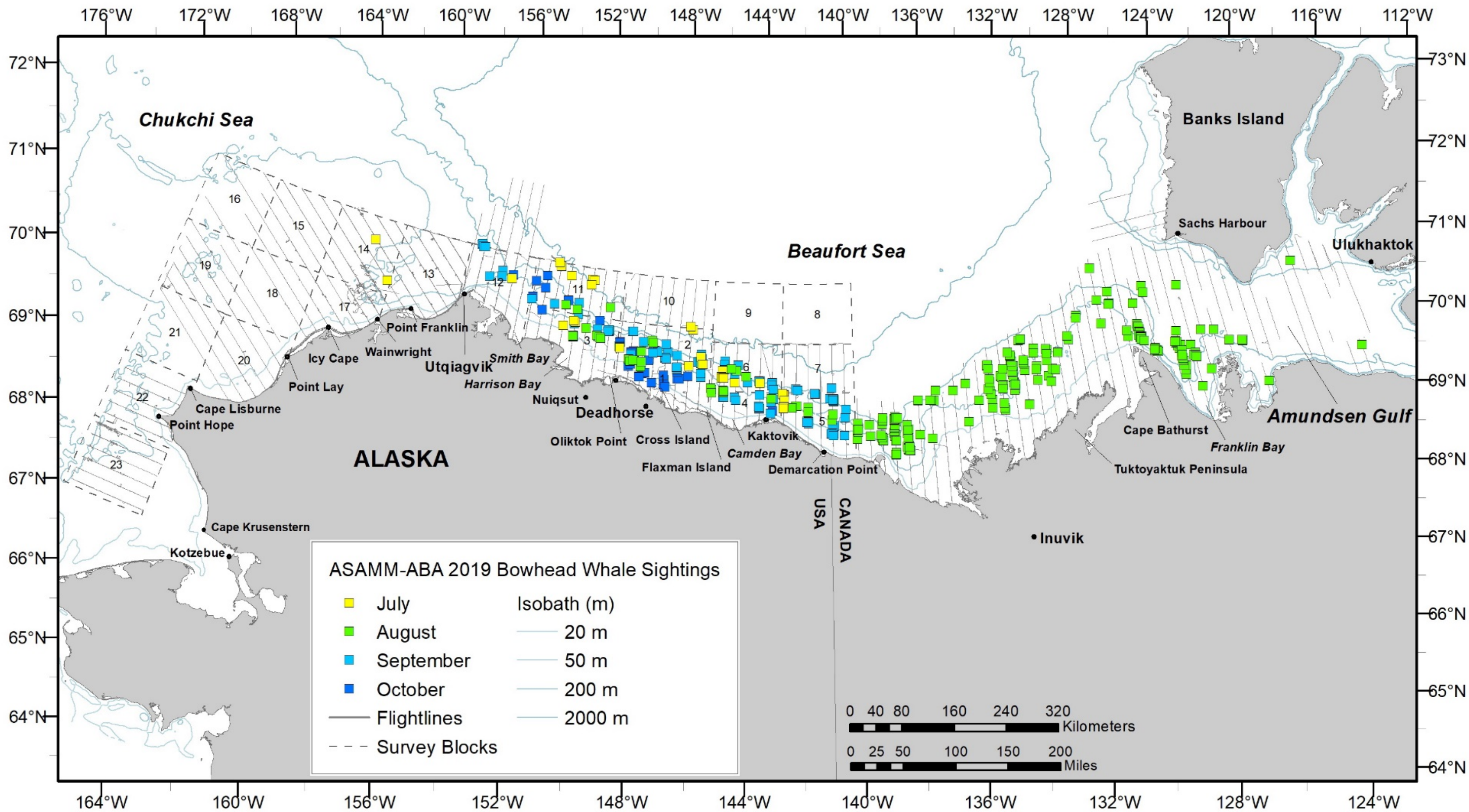


Figure 10. ASAMM 2019 bowhead whale sightings in the ASAMM and ABA study areas, all survey modes, plotted by month, with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.

The lack of bowhead whale sightings in the northeastern Chukchi Sea in September and October 2019 is unusual compared to previous observations from aerial surveys (Clarke et al. 2019), satellite telemetry (Quakenbush et al. 2010a), and acoustics (Delarue et al. 2011), which have all described a broad migration route that spreads across the northeastern Chukchi Sea in fall. Bowhead whales were last observed on 29 October, when 30 whales were seen in block 1. No bowhead whales were observed in block 1a.

Bowhead Whale Sighting Rates

In summer and fall 2019, bowhead whales were seen on effort (transect and CAPs-adjusted) from 119.3°W to 161.2°W. There were 360 sightings of 540 bowhead whales on effort by primary observers, ranging from one whale per sighting ($n_s = 206$) to 5 whales per sighting ($n_s = 4$). The highest number of sightings on effort in the ASAMM study area was in block 1 ($n_s = 33$), followed by block 5 ($n_s = 32$). The largest groups of bowhead whales on effort ($n_i = 5$) were observed in mid and late August in the Canadian Beaufort and on 4 September in block 2. Fifty-five percent ($n_i = 295$) of all bowhead whales on effort were seen in the eastern Beaufort Sea and Amundsen Gulf during ABA.

In the ASAMM study area, highest fine-scale sighting rates (WPUE, 5-km grid) for summer (July-August) were limited to offshore north and east of Kaktovik and far offshore (>140 km) north of Harrison Bay (Figure 11A). In fall (September-October), highest fine-scale sighting rates were distributed throughout the western Beaufort Sea from east of Kaktovik to north of Oliktok Point (Figure 11B). Most of the cells with higher sighting rates were >50 km offshore. Figure I-6 shows fine-scale sighting rates in Canada.

Monthly and seasonal shifts in bowhead whale distribution in the ASAMM study area were evident in results of the analysis of sighting rates by survey block. Sighting rates in the western Beaufort Sea were low in July in most survey blocks except blocks 2, 5, and 11 (Figure 12). Sighting rate per block in July 2019 indicated a predominantly offshore distribution, as noted in some previous years. Sighting rates in August were relatively high in only block 5 (0.018 WPUE). Sighting rates for summer (July and August combined) were highest in block 5 (0.019 WPUE) and block 11 (0.013 WPUE), and overall sighting rate in summer for all blocks combined in the western Beaufort Sea was 0.005 WPUE (Appendix E, Table E-1). Sighting rates in September were highest in block 2 (0.029 WPUE), block 5 (0.027 WPUE), block 6 (0.024 WPUE), and block 4 (WPUE 0.021). Sighting rates in October were highest in block 1 (0.025 WPUE), due almost entirely to a single flight conducted on the last day of the field season when 19 on-effort bowhead whales were seen (Appendix B, Flight 269). Combined sighting rates for fall (September-October) were highest in block 1 (0.022 WPUE), block 5 (0.020 WPUE), and block 2 (0.018 WPUE); overall sighting rate in fall for all blocks combined in the western Beaufort Sea was 0.009 WPUE (Appendix E, Table E-1). For all months combined, the highest sighting rates per survey block were in block 5 (0.020 WPUE), block 2 (0.014 WPUE), and block 1 (0.014 WPUE), with an overall sighting rate of 0.005 WPUE.

Sighting rates in all eastern Chukchi Sea blocks (13-23) in summer were very low (Figure 12); bowhead whales were seen only in block 14 in July (Appendix E, Table E-1). No bowhead

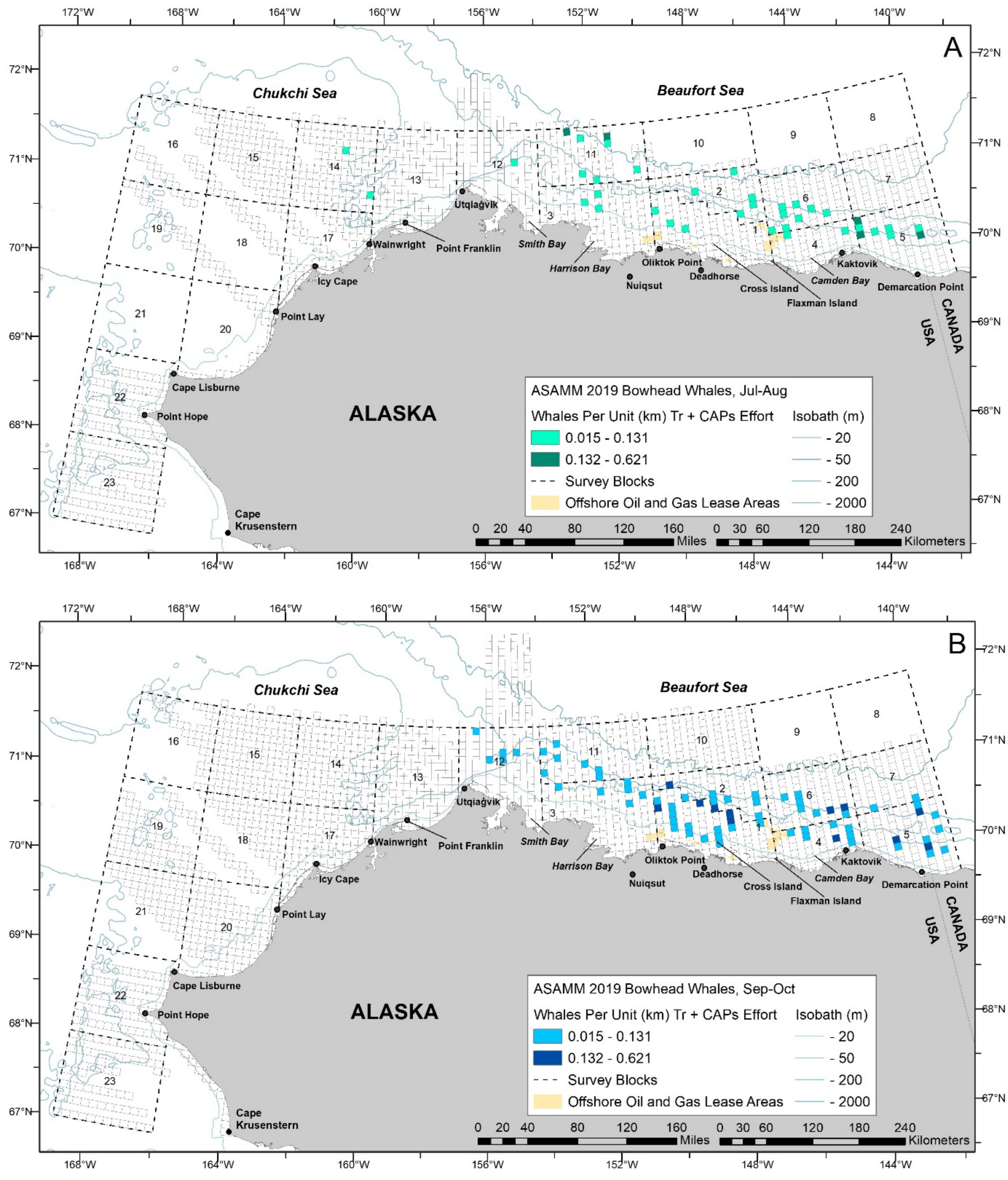


Figure 11. ASAMM 2019 bowhead whale on-effort seasonal sighting rates (WPUE; sightings from primary observers only) in the ASAMM study area. A: summer (July-August pooled). B: fall (September-October pooled). Empty cells indicate sighting rates of zero. Transect and CAPs survey effort were not conducted in areas without cell outlines.

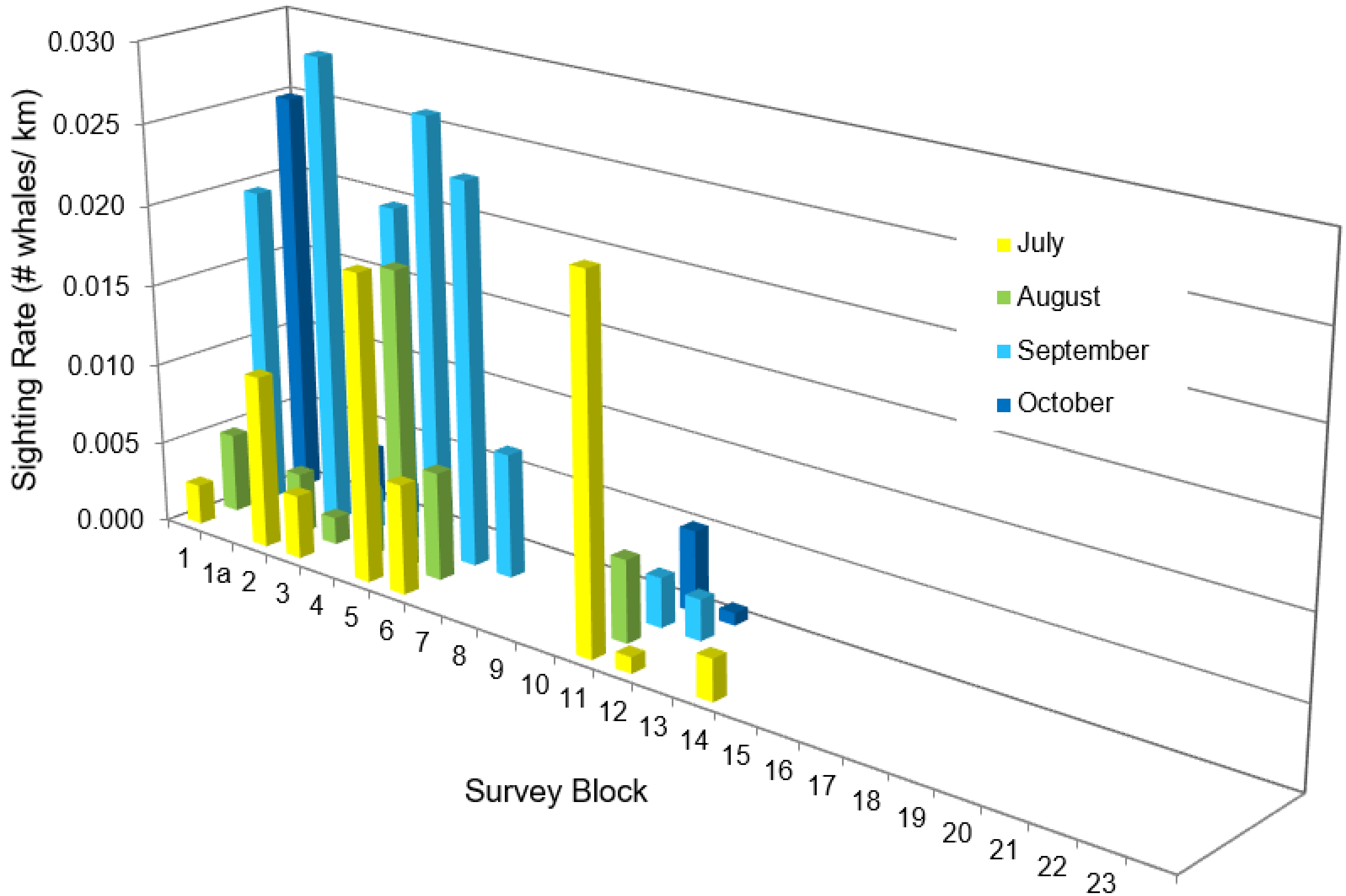


Figure 12. ASAMM 2019 bowhead whale on-effort monthly sighting rates (WPUE; sightings from primary observers only) per survey block in the ASAMM study area, July-October. Sighting rates of zero were removed from the graph for clarity.

whales were seen in the Chukchi Sea in fall despite considerable survey effort (Figure 12), which is unprecedented compared to all previous years in which ASAMM surveys have been conducted.

For summer months, the highest sighting rates per depth zone (Figure 13; Appendix E, Table E-2) were as follows:

- 51-200 m depth zone (0.001 WPUE) in the eastern Chukchi Sea subarea (157°W-169°W);
- 51-200 m depth zone (0.001 WPUE) in the western (154°W-157°W) Alaskan Beaufort Sea subarea;
- 51-200 m depth zone (0.017 WPUE) in the central-eastern (140°W-154°W) Alaskan Beaufort Sea subarea.

Bowhead whale sighting rates per depth zone for the western Beaufort, eastern Beaufort, and Amundsen Gulf survey areas during ABA are discussed in Appendix I.

The 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 that was observed in previous years (2012-2018; Clarke et al. 2013a, 2014, 2015a, 2017a,b, 2018a, 2019), was not observed in August 2019 (Figure 13), as sighting rates remained highest in the 51-200 m zone.

During fall, the highest sighting rates per depth zone (Figure 13; Appendix E, Table E-2) were as follows:

- 51-200 m and 201-2,000 m depth zone (0.003 WPUE) in the western (154°W-157°W) Alaskan Beaufort Sea subarea; and
- 21-50 m depth zone (0.018 WPUE) in the central-eastern (140°W-154°W) Alaskan Beaufort Sea subarea; sighting rate was also relatively high (0.015 WPUE) in the 51-200 m depth zone.

Bowheads were not seen in the eastern Chukchi Sea subarea (157°W-169°W) in fall (Figure 13).

Bowhead Whale Sea Ice Associations

Most bowhead whales (90%, n_i = 670) were observed in 0% sea ice cover (Table 5). Fifty-five bowhead whales (7%) were sighted in 1-10% sea ice cover, 17 bowhead whales (2%) were sighted in 11-40% sea ice cover, and 7 bowhead whales (1%) were sighted in 41-100% sea ice cover. Most bowhead whales observed in areas of sea ice were seen in August in the eastern Beaufort Sea, where sea ice remained throughout August (Appendix A, Figures A-4 through A-6). A few whales were seen near newly formed grease ice in late October, but most of the ASAMM study area remained ice-free through the end of the ASAMM field season (Appendix A, Figure A-9).

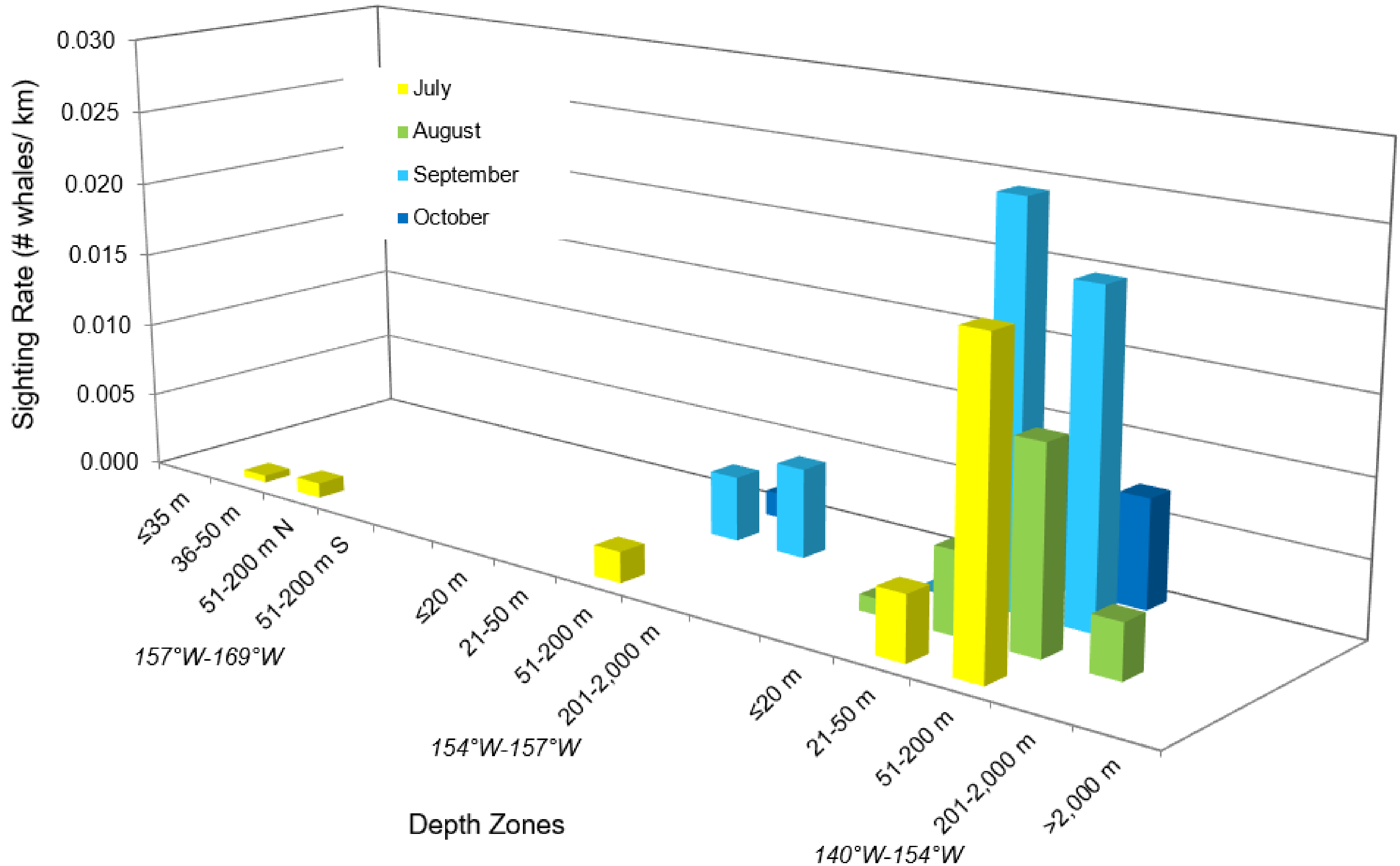


Figure 13. ASAMM 2019 bowhead whale on-effort monthly sighting rates (WPUE; sightings from primary observers only) per depth zone in the ASAMM study area, July-October. Sighting rates of zero were removed from the graph for clarity.

Table 5. ASAMM 2019 semimonthly summary of bowhead whales (number of sightings/number of individuals) observed during transect, CAPs, search, and circling survey modes in the ASAMM and ABA study areas, 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	5/5	23/36	69/79	212/318	65/101	51/76	14/23	22/32	461/670
1-5	2/4	2/4	21/26	4/6	0	0	0	2/3	31/43
6-10	1/1	0	0	9/11	0	0	0	0	10/12
11-20	2/4	0	0	4/6	0	0	0	0	6/10
21-30	2/2	0	0	3/4	0	0	0	0	5/6
31-40	0	0	0	0	0	0	0	1/1	1/1
41-50	1/2	0	0	3/5	0	0	0	0	4/7
>50	0	0	0	0	0	0	0	0	0
TOTAL	13/18	25/40	90/105	235/350	65/101	51/76	14/23	25/36	518/749

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 2019 are summarized in Table 6. The behavior most often recorded was swimming (65%, $n_i = 484$), followed by resting (14%, $n_i = 102$), milling (9%, $n_i = 71$), diving (2%, $n_i = 14$), surface active group (2%, $n_i = 12$), and feeding (1%, $n_i = 11$). 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. Thirty-one whales were recorded exhibiting display behaviors, including breaches ($n_i = 16$), log play ($n_i = 10$), and tail slaps ($n_i = 5$). One whale was recorded as turning abruptly. Behavior was recorded as unknown for 23 whales, likely because the sightings were too far away to determine a behavior. One bowhead whale (<1% of all bowhead whales sighted) appeared to respond to the survey aircraft by rolling slightly and looking up towards the aircraft.

Seasonal differences were observed in bowhead whale swim direction. In the Beaufort Sea, mean vector bowhead whale swim direction in summer was southwesterly (220°T), but headings were scattered in several directions (Rayleigh Z = 2.299, P = 0.10, 152 observations). Mean vector swim directions varied between the eastern Beaufort Sea and Amundsen Gulf (203°T) and western Beaufort Sea (249°T), with headings in all directions. In fall in the western Beaufort Sea, bowhead whale swim direction was significantly clustered in a westerly heading (268°T; Rayleigh Z = 13.379, P < 0.0001, 82 observations). In the northeastern Chukchi Sea, mean vector bowhead whale swim direction in summer was northwesterly (286°T; Rayleigh Z = 4.23,

Table 6. ASAMM 2019 semimonthly summary of bowhead whales (number of sightings/number of individuals) observed during transect, CAPs, search, and circling survey modes in the ASAMM and ABA study areas, 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	5/5	6/6	1/1	2/3	0	0	15/16
Dive	1/3	0	4/4	4/4	1/1	1/2	0	0	11/14
Feed	0	0	2/4	2/5	0	0	0	1/2	5/11
Log Play	0	0	0	2/6	2/4	0	0	0	4/10
Mill	0	2/4	5/12	16/46	1/3	0	0	3/6	27/71
Other	0	0	0	0	0	1/1	0	0	1/1
Rest	2/2	2/4	23/24	43/60	2/4	5/6	0	2/2	79/102
SAG	0	1/2	0	1/3	0	0	1/7	0	3/12
Swim	10/13	19/29	50/54	151/203	52/79	42/64	13/16	19/26	356/484
Tail Slap	0	0	1/2	0	2/3	0	0	0	3/5
Unknown	0	0	0	10/17	4/6	0	0	0	14/23
TOTAL	13/18	25/40	90/105	235/350	65/101	51/76	14/23	25/36	518/749

P = 0.006, 5 observations); bowhead whales were not observed east of 157°W in fall. Bowhead whales were not observed in the southcentral Chukchi Sea in summer or fall.

Bowhead Whale Calves

Of the 749 bowhead whales sighted, 121 were identified as calves (Figure 14). Most calves (n_i = 76, 63%) were sighted after circling was initiated and likely would not have been observed if circling had not commenced. Calves were seen from mid-July through late October, distributed from 127.4°W to 156.4°W. Calves were seen in the central Alaskan Beaufort Sea (142.9°W-151.4°W) in July. Calf sightings in August were limited to the Canadian Beaufort Sea and western Amundsen Gulf (127.4°W-139.9°W), concentrated west of the Tuktoyaktuk Peninsula and in Mackenzie Canyon (Figure I-5). Calf distribution in September extended from 140.4°W to 156.4°W. Calf sightings in October were limited to the western Alaskan Beaufort Sea (145.4°W-153.5°W). No calves were seen in the Chukchi Sea. Calves were observed with adult bowhead whales that were swimming, resting, milling, feeding, and displaying. Calf behavior usually mirrored that of the accompanying adult, but calves were also observed playing with a log, rolling with another calf, and breaching. On five occasions, one adult whale was sighted with two similarly-sized calves in close proximity. Fifteen calves were sighted without a closely associated adult although, in some of those cases (n_i = 6), adult whales were in the general vicinity.

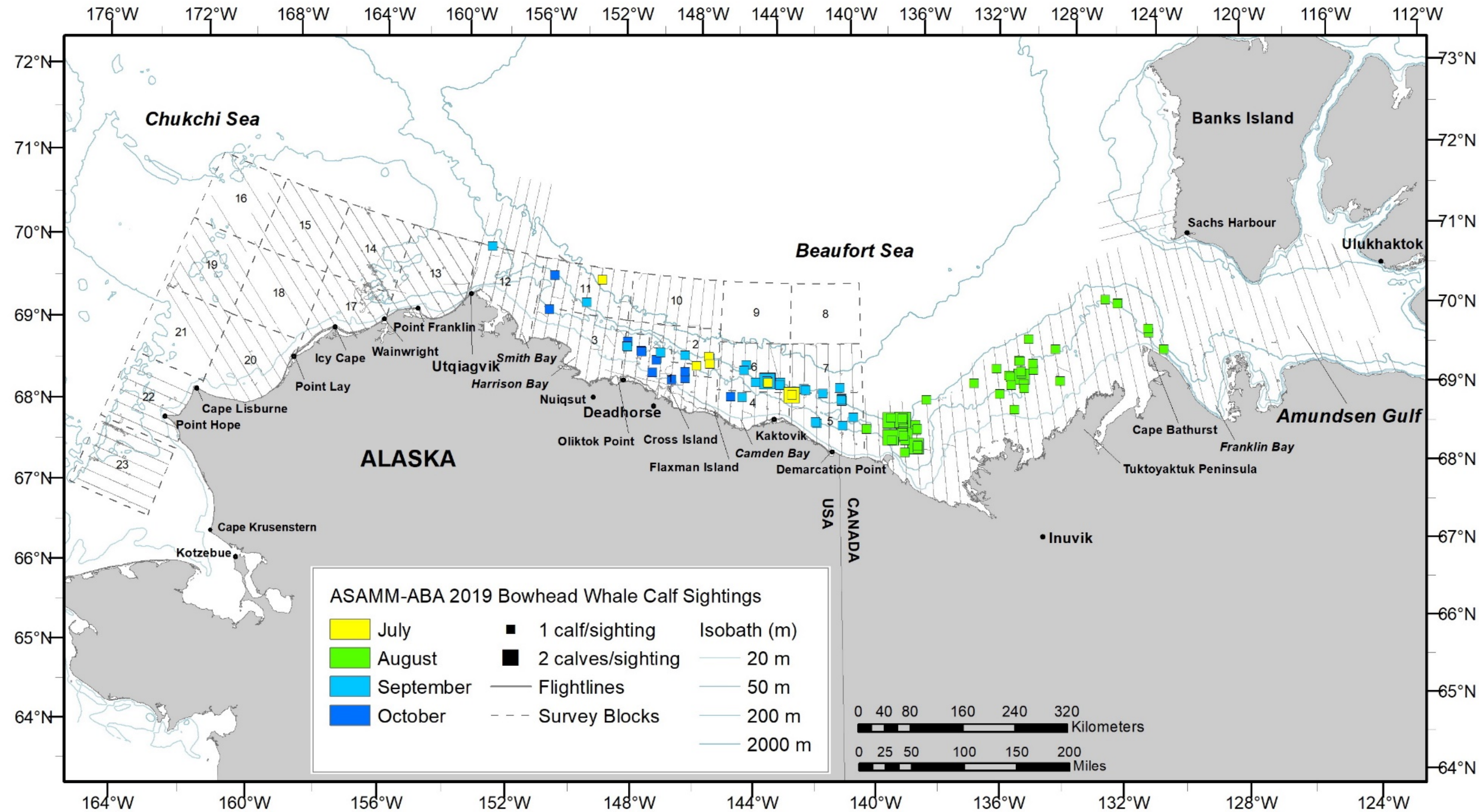


Figure 14. ASAMM 2019 bowhead whale calf sightings in the ASAMM and ABA study area, all survey modes, plotted by month, with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.

Seasonal differences in bowhead whale calf distribution in the ASAMM study area reflected the differences observed for the population, wherein relatively few whales were seen during summer months in the western Beaufort Sea. Eight bowhead whale calves (7% of total calves) were sighted during summer months on the outer shelf and slope in the western Beaufort Sea, for a summer calf ratio (number of calves/number of total whales) of 0.072.

Sixty-four calves (53% of total calves) were sighted in August in the eastern Beaufort Sea and western Amundsen Gulf, for a calf ratio of 0.160 (Appendix I). Forty-nine (40% of total calves) calves were sighted during fall months in the ASAMM study area, distributed on the western Beaufort Sea inner shelf and slope. The calf ratio during fall was 0.209.

Bowhead Whale Feeding

Bowhead whale feeding behavior, which includes sightings reported as milling, was observed from late July through late October 2019. Feeding was observed on one day in July, east of Barter Island, and documented on seven days in August, all east of 141°W (Figure 15A). Feeding was observed in the central Alaskan Beaufort Sea on one day in September and one day in October (Figure 15B); one whale (the cow in a cow-calf pair) was observed feeding northwest of Harrison Bay in October. Water depths at sightings of feeding whales in the western Beaufort Sea ranged from 20 m to 58 m (17 km to 53 km from shore). Water depths at sightings of feeding whales in the eastern Beaufort Sea ranged from 53 m to 330 m (10 km to 404 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 in the ASAMM study area are shown in Figure 16. Sighting rates for feeding and milling bowhead whales in the ABA study area are shown in Figure I-4.

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). Wind conditions recorded at Utqiaġvik in 2019 suggest that upwelling-favorable winds followed by decreased winds, necessary to activate the krill trap, were present in mid-August, early and mid-September, and early and late October (Figure 17). In 2019, surveys were conducted in this area on 23 days (not including coastal transects near Point Lonely), and bowhead whales were observed on eight 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 25 bowhead whales that were observed between Cape Halkett and Point Barrow, 8% ($n_i = 2$) were recorded as feeding or milling. Bowhead whales were observed feeding on only one of the eight days, in late October (Figure 18). The feeding group was a cow-calf pair, and the cow was observed with mud trailing behind her, suggesting she was feeding near the bottom. Depth at the sighting was 50 m.

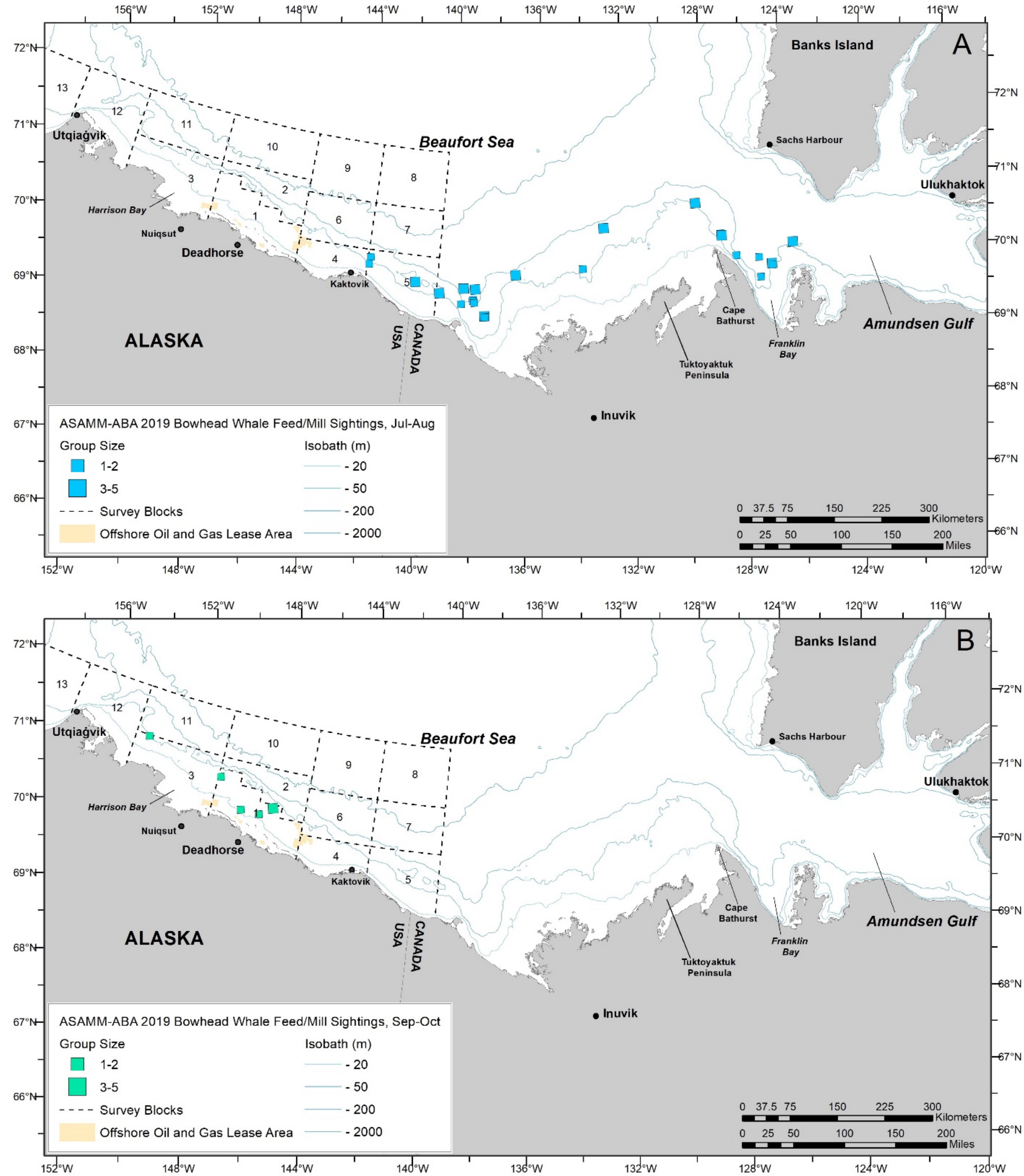


Figure 15. ASAMM 2019 bowhead whale seasonal feeding and milling sightings in the ASAMM and ABA study areas, transect, CAPs, search, and circling survey modes. A: summer (July-August). B: fall (September-October).

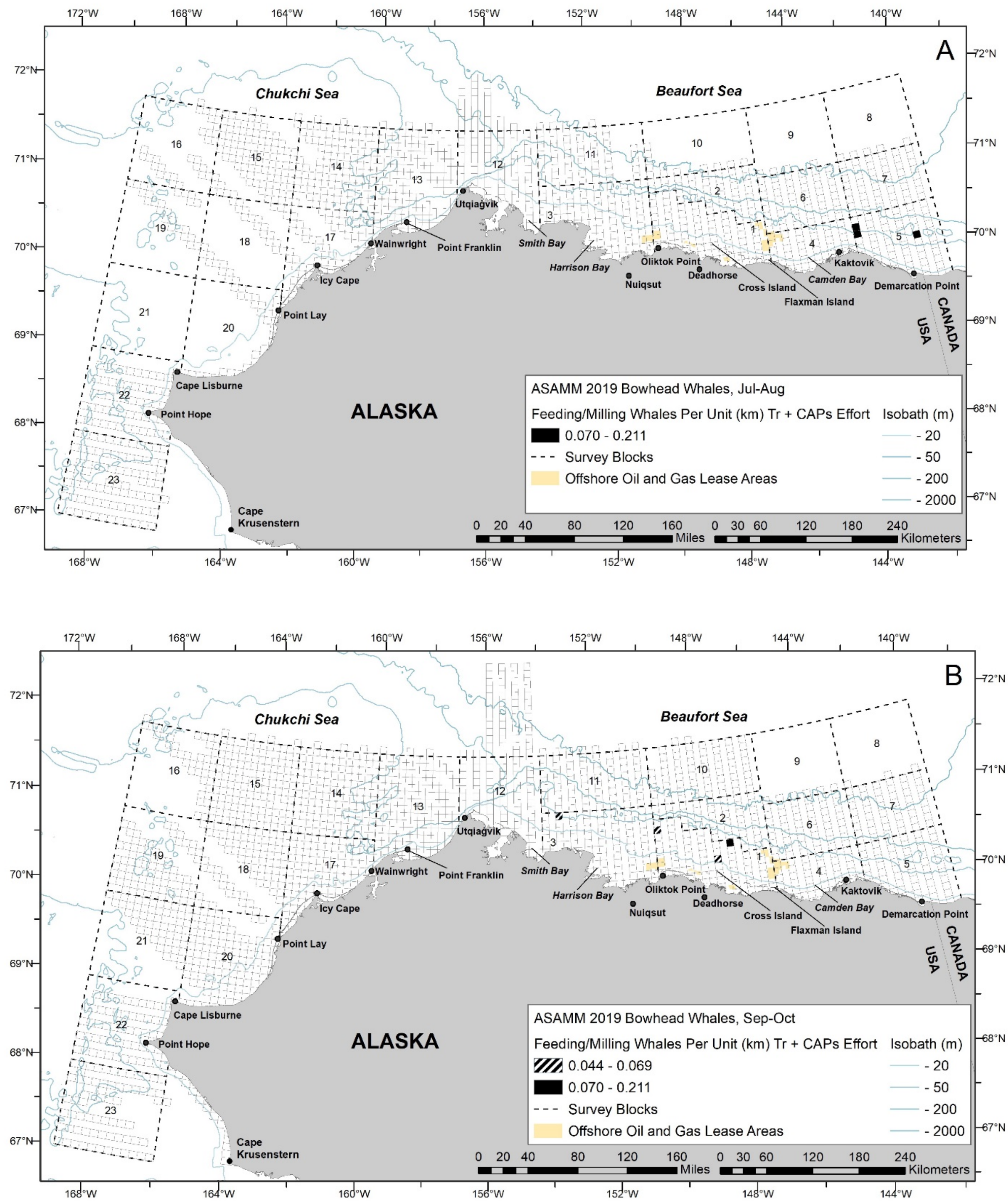


Figure 16. ASAMM 2019 bowhead whale on-effort seasonal feeding and milling sighting rates (WPUE; sightings from primary observers only) in the ASAMM study area. A: summer (July-August pooled). B: fall (September-October pooled). Empty cells indicate sighting rates of zero. Transect and CAPs survey effort were not conducted in areas without cell outlines.

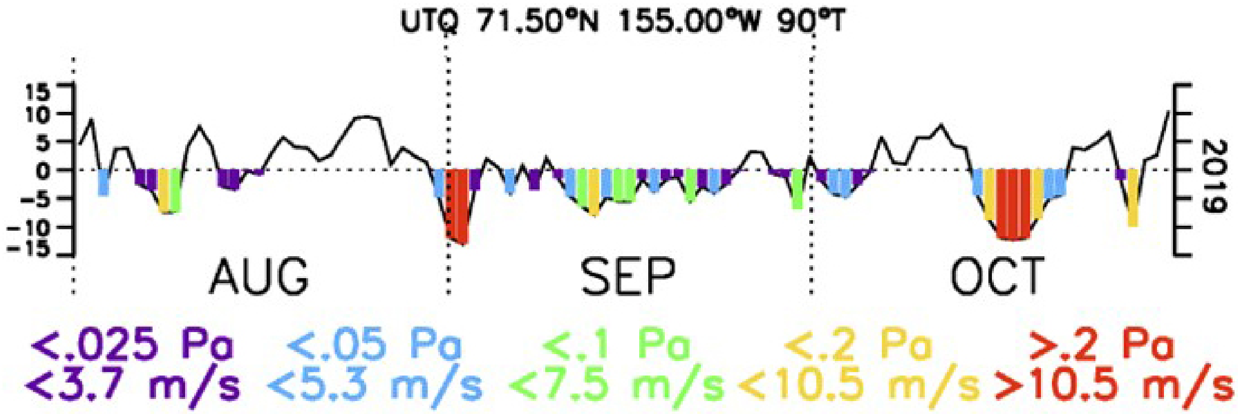


Figure 17. Wind speed near Utqiaġvik, AK, from 1 August to 31 October 2019. Upwelling-favorable winds are indicated by green, yellow, and red bars.

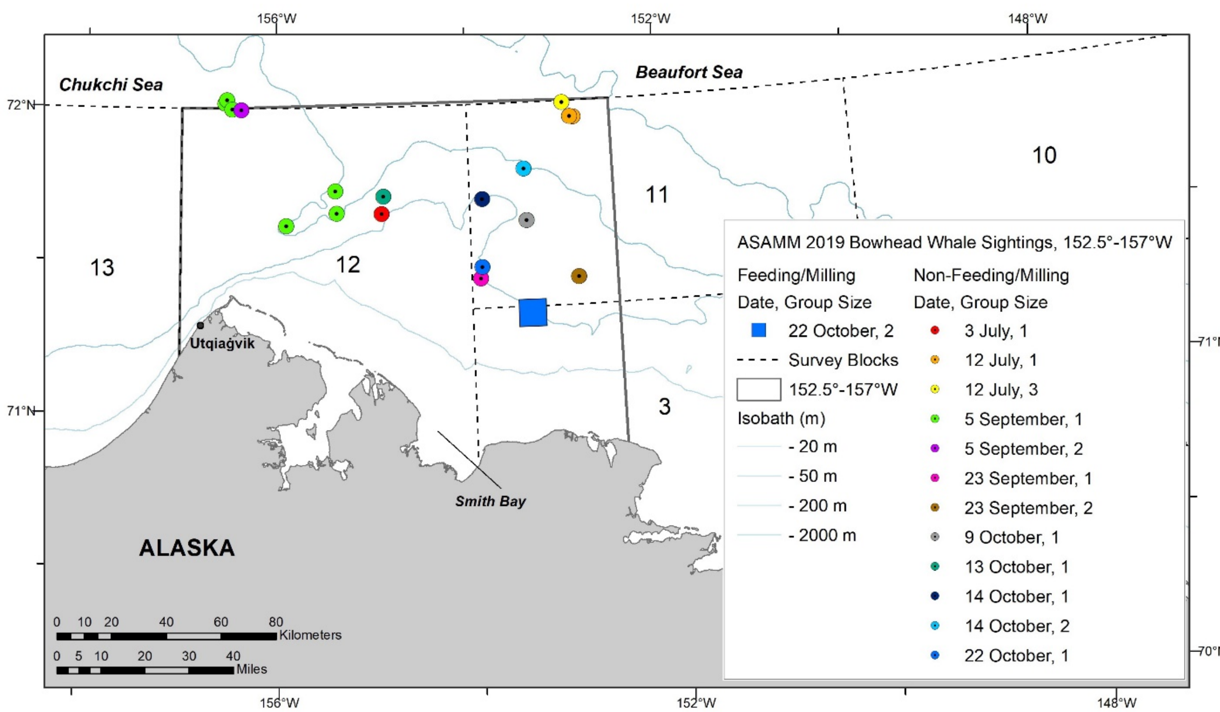


Figure 18. ASAMM 2019 bowhead whale sightings by date and group size, 152.5°W-157°W, observed during transect, CAPs, search, and circling survey modes, July-October.

Bowhead Whale Central Tendency – Analysis 1

Distribution of Bowhead Whales, Summer 2019, Relative to Summer Bowhead Whale Distribution 2012-2018 in the western Beaufort Sea

Bowhead whale distribution in the western Beaufort Sea in summer (July-August) 2019, based on transect and CAPs sightings from primary and secondary observers, was different from the distribution of bowhead whales observed in summer in previous years with light sea ice cover (i.e., 1982, 1986, 1987, 1989, 1990, 1993-2017) (Figure 19). Distribution overlapped with previous years in the eastern Alaskan Beaufort Sea, but distribution was farther offshore in the western Alaskan Beaufort Sea.

In the East region, mean depth at sightings made on effort by primary observers in summer 2019 was 172 m (SD = 455.2 m, range 39-2,418 m) and median depth was 55 m (Table 7). In the West region, mean depth was 754 m (SD = 936.9 m, range 19-2,357 m) and median depth was 65 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 2019 were 48.1 km (SD = 19.9 km) and 42.6 km, respectively (Table 7). In the West region, mean and median distances to the normalized shoreline were 67.9 km (SD = 36.8 km) and 60.3 km, respectively.

To evaluate whether significant displacements occurred in western Beaufort Sea bowhead whale HUAs during summer 2019 compared to previous years with light sea ice cover, estimates of median depth and distance from shore 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 2019. Summer 2018 had moderate to heavy sea ice cover so was not included in this analysis.

A Mann-Whitney *U*-test of significant difference of medians indicated that bowhead whales sighted on effort by primary observers in summer 2019 in the East region were in significantly deeper water (median depth = 55 m; $Z = 3.666$, $P = 0.0002$) and significantly farther from shore (median distance from shore = 42.6 km; $Z = 2.924$, $P = 0.0035$) than bowhead whales sighted in 2012-2017 (median depth = 43 m; median distance from shore = 29.9 km) (Table 7). In the West region, bowhead whales in 2019 were in significantly deeper water (median depth = 65 m; $Z = 4.387$, $P < 0.0001$) and significantly farther from shore (median distance from shore = 60.3 km; $Z = 4.183$, $p < 0.0001$) than bowhead whales sighted in 2012-2017 (median depth = 22 m; median distance from shore = 30.1 km) (Table 7).

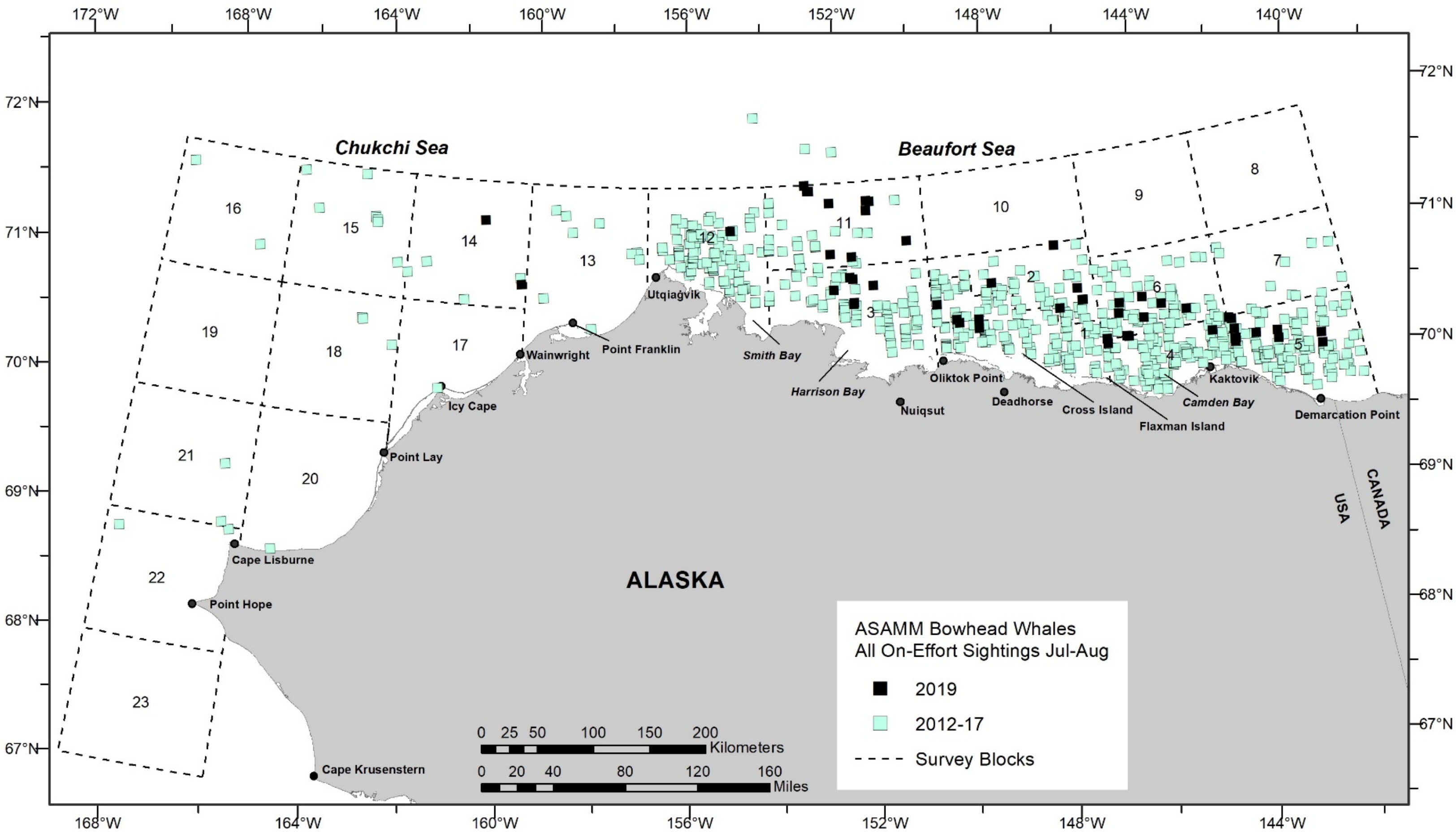


Figure 19. ASAMM bowhead whale sightings in the ASAMM study area, summer (July-August), in years with light sea ice cover: 1982, 1986-87, 1989-90, 1993-2017, and 2019. Includes all sightings on transect and CAPs from primary and secondary observers.

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, 2019 and 2012-2017. Si = number of on-effort sightings made by primary observers.

2019 and 2012-2017 Summer, by Region			**DEPTH (M)**				**DISTANCE FROM SHORE (KM)**			
Year/Season	**Region**	**Si**	**Median**	**Mean**	**SD**	**Min-Max**	**Median**	**Mean**	**SD**	**Min-Max**
2019 Summer	East	27	55	172	455.2	39-2,418	42.6	48.1	19.9	20-100
2012-17 Summer	East	365	43	160	385.9	6-2,461	29.9	37.0	25.5	1-134
2019 Summer	West	21	65	754	936.9	19-2,357	60.3	67.9	36.8	24-120
2012-17 Summer	West	267	22	61	198.4	6-2,614	30.1	34.0	21.2	1-124
2019 Summer and 2012-2017 Summer, by Month			**DEPTH (M)**				**DISTANCE FROM SHORE (KM)**			
Year/Season	**Month**	**Si**	**Median**	**Mean**	**SD**	**Min-Max**	**Median**	**Mean**	**SD**	**Min-Max**
2019 Summer	Jul	28	62.5	619	900.9	28-2,418	56.8	64.1	33.7	20-120
2019 Summer	Aug	20	48.5	158	366.8	19-1,678	41.1	46.5	20.3	24-98
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
2019 Season, by Region			**DEPTH (M)**				**DISTANCE FROM SHORE (KM)**			
Season	**Region**	**Si**	**Median**	**Mean**	**SD**	**Min-Max**	**Median**	**Mean**	**SD**	**Min-Max**
Summer	East	27	55	172	455.2	39-2,418	42.6	48.1	19.9	20-100
Fall	East	72	50	127	143.2	6-816	42.7	45.0	21.9	3-89
Summer	West	21	65	754	936.9	19-2,357	60.3	67.9	36.8	24-120
Fall	West	39	45	78	91.1	13-503	51	49.3	20.0	5-92

Distribution of Bowhead Whales During Summer and Fall Months, 2019

Summary statistics for bowhead whale data from the western Beaufort Sea in summer (July-August) 2019 were compared to values for fall (September-October) 2019 (Table 7). Bowhead whales were in deeper water in both the East and West regions in summer, but the differences were not significant compared to median depths in fall. Bowhead whales were also not significantly farther from shore in either region in summer; median distance from shore was actually slightly farther in fall in the East region. These results differ from those for most years since ASAMM commenced surveying the western Beaufort Sea in summer in which summer depth and distance-from-shore medians were significantly greater than those for fall.

Distribution of Bowhead Whales, Fall 2019, Relative to Bowhead Whale Distribution in Previous Years with Light Sea Ice Cover

Bowhead whale distribution in the western Beaufort Sea in September-October 2019, from on-effort sightings by 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, 1993-2018), particularly in the eastern Alaskan Beaufort Sea (Figure 20). In the western Alaskan Beaufort Sea, sightings in fall 2019 were noticeably farther from shore.

Summary statistics for bowhead whale data from the western Beaufort Sea in fall (September-October) 1989-2019 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 but 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 2019 was 127 m (SD = 143.2 m, range 6-816 m) and median depth was 50 m (Table 8). In the West region, mean depth was 78 m (SD = 91.1 m, range 13-503 m) and median depth was 45 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 2019 were 45.0 km (SD = 21.9 km) and 42.7 km, respectively (Table 8). In the West region, mean and median distances to the normalized shoreline were 49.3 km (SD = 20.0 km) and 51 km, respectively.

To evaluate whether significant displacements occurred in western Beaufort Sea bowhead whale HUAs during fall 2019 compared to previous years with light sea ice cover, estimates of median depth and distance from shore were compared with pooled data from previous years.

In fall (September-October) 2019 in the East region, bowhead whale sightings were in significantly deeper water (median depth 50 m vs. 36 m, $Z = 7.800$, $P < 0.0001$) and farther from shore (median distance from shore 42.7 km vs. 21.0 km, $Z = 8.223$, $P < 0.0001$) than in previous years with light sea ice cover. Bowhead whale sightings in the West region in fall 2019 were in significantly deeper water (median depth 45 m vs. 22 m, $Z = 4.501$, $P < 0.0001$) and farther from shore (median distance from shore 51.0 km vs. 26.0 km, $Z = 5.270$, $P < 0.0001$) than in previous years with light sea ice cover.

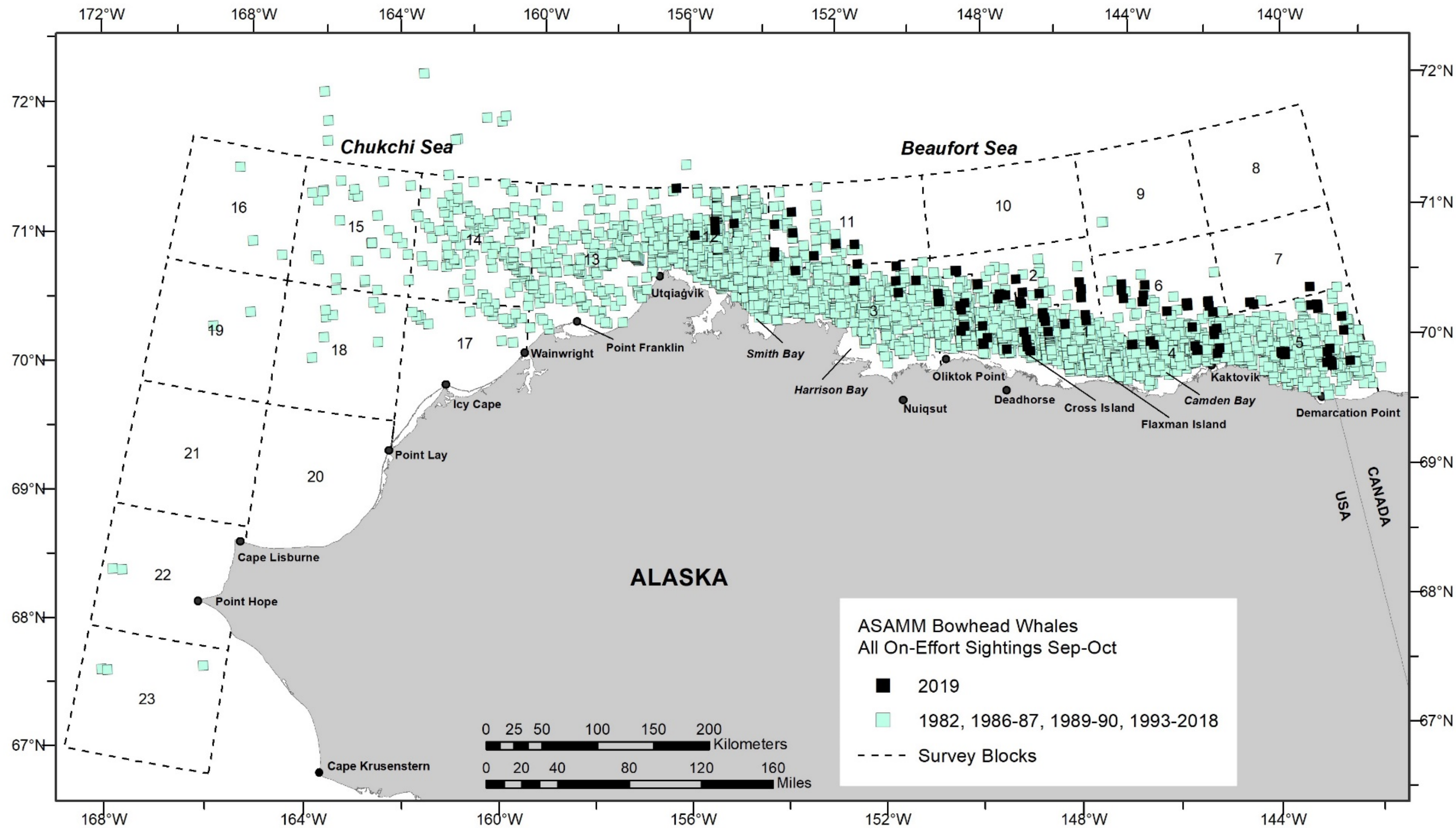


Figure 20. ASAMM bowhead whale sightings in the ASAMM study area, fall (September-October), in years with light sea ice cover: 1982, 1986-1987, 1989-1990, 1993-2018, and 2019. Includes all on-effort sightings from primary and secondary observers.

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, 1989-2019. 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
2019	East	72	50	127	143.2	6-816	42.7	45.0	21.9	3-89
	West	39	45	78	91.1	13-503	51	49.3	20.0	5-92

Median depth in fall 2019 for East and West regions combined (46 m) was deeper than in any previous year except 1991 (139 m) and 1992 (55 m) (Figure 21), which were both years when heavy sea ice persisted. Median distance from shore in 2019 for East and West regions combined (46.2 km) was farther than in any previous years except 1991 (61 km), a heavy ice year.

BOWHEAD WHALE CENTRAL TENDENCY – ANALYSIS 2

The 2019 spatial relative abundance model for fall (September-October) incorporated 112 bowhead whale sightings of 173 total individuals (Figure 22A). Relative abundance predictions resulting from the spatial model applied to the 2019 survey data for the western Beaufort Sea are shown in Figure 22B. There were two areas of high predicted relative abundance: from 140°W to 143°W, between the 50- and 200-m isobaths; and from 146°W to 149.5°W, between the 20- and 200-m isobaths (Figure 22B).

The 2000-2019 model (July-October) incorporated 2,482 bowhead whale sightings of 4,446 individuals. In July, there were 165 bowhead whale sightings (n_i = 275) (Figure 23A), all of which were sighted from 2012 to 2019. Most of the July sightings were in the East region. Limited sample size in the West region provided minimal information for the spatial model in July (Figure 23B). The spatial model predicted that bowhead whale HUAs were located farthest offshore in July, with the highest relative abundance over the outer portion of the continental shelf, approximately 25-50 km offshore, from 141°W to 143°W.

There were 572 bowhead whale sightings (n_i = 1,104) in August (Figure 23C), most of which were from 2012 to 2019. The spatial model predicted that bowhead whale HUAs were closest to shore from 142° to 146°W, north of Kaktovik and Camden Bay (Figure 23D). The area of highest predicted relative abundance in August was offshore of Harrison Bay, 40-80 km offshore, centered on the 20-m isobath. Other areas of high predicted relative abundance were located east of Kaktovik (~142°W, centered on the 50-m isobath), north of Camden Bay (between the 20- and 50-m isobaths) and east of Point Barrow, from the barrier islands to the 50-m isobath.

The model incorporated 1,306 bowhead whale sightings (n_i = 2,285) in September (Figure 23E) and 439 sightings (n_i = 782) in October (Figure 23G). 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 ~146.5°W to ~148°W (Figure 23F). In October, the highest predicted relative abundance was shoreward of the 50-m isobath, north of Dease Inlet and Smith Bay. In October, patches of relatively high abundance were located from the mouth of Barrow Canyon and nearshore northwest of Cape Halkett, near the barrier islands from ~146°W to ~147°W, and near the barrier islands north and east of Kaktovik (Figure 23H). The HUA was farther offshore between Cape Halkett and Utqiaġvik in October than in September.

The estimated median distance-from-shore statistics for fall 2019 that were derived using the spatial model were 48.7 km for the East region and 50.9 km for the West region (Table 9). The model-derived results were 6.0 km farther from shore in the East region and 0.1 km nearer to 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 42.7 km and 51.0 km, respectively; Table 8).

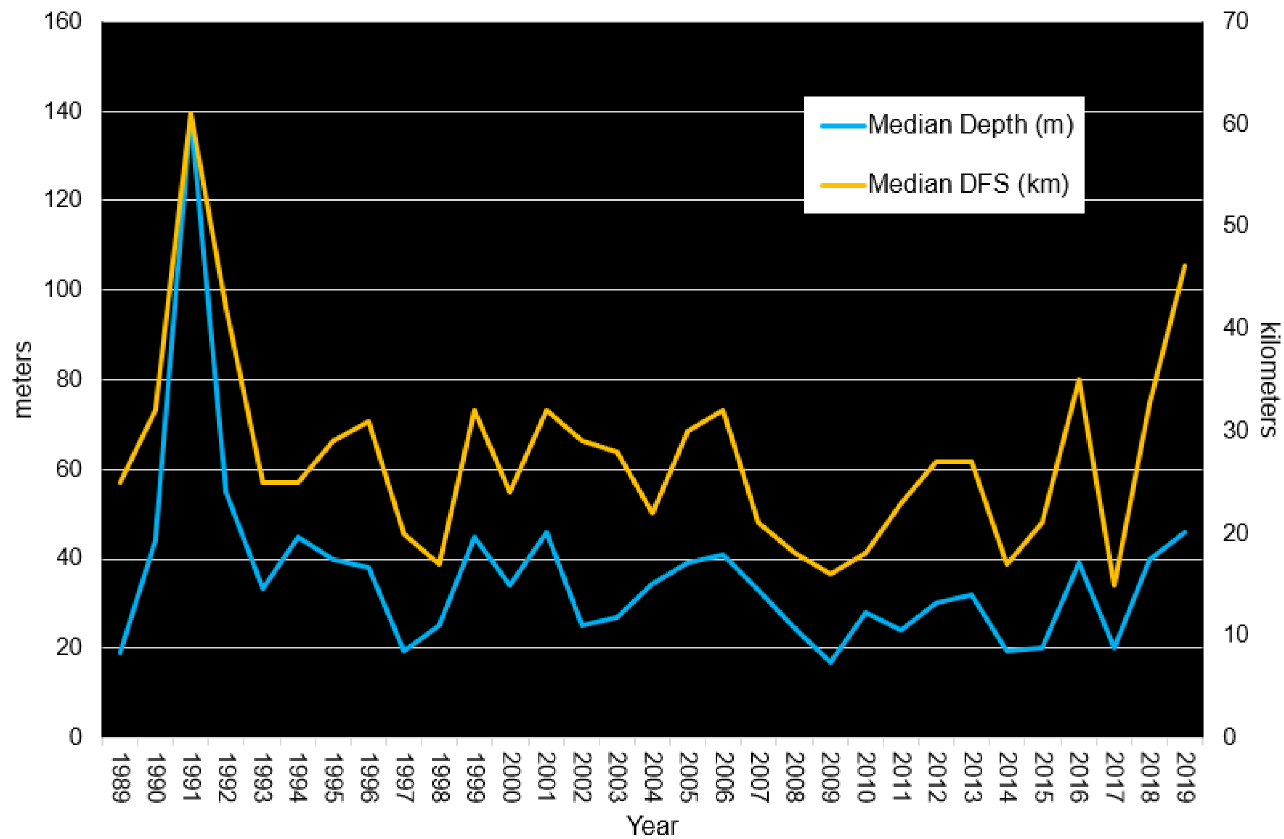


Figure 21. ASAMM bowhead whale annual median depth (meters) and distance from shore (kilometers), western Beaufort Sea East and West regions combined, fall (September-October), 1989-2019. All years except 1991 and 1992 were light sea ice cover; 1991 and 1992 had heavy sea ice cover.

The estimated median distance-from-shore statistics for the East region in 2000-2019, derived using the spatial model, decreased from 51.7 km in July to 27.7 km in August, 20.7 km in September, and 20.8 km in October (Table 9). In the West region, the 2000-2019 model predicted that the median distance from shore decreased from 58.9 km in July to 32.1 km in August, 25.8 km in September, and 30.3 km in October (Table 9).

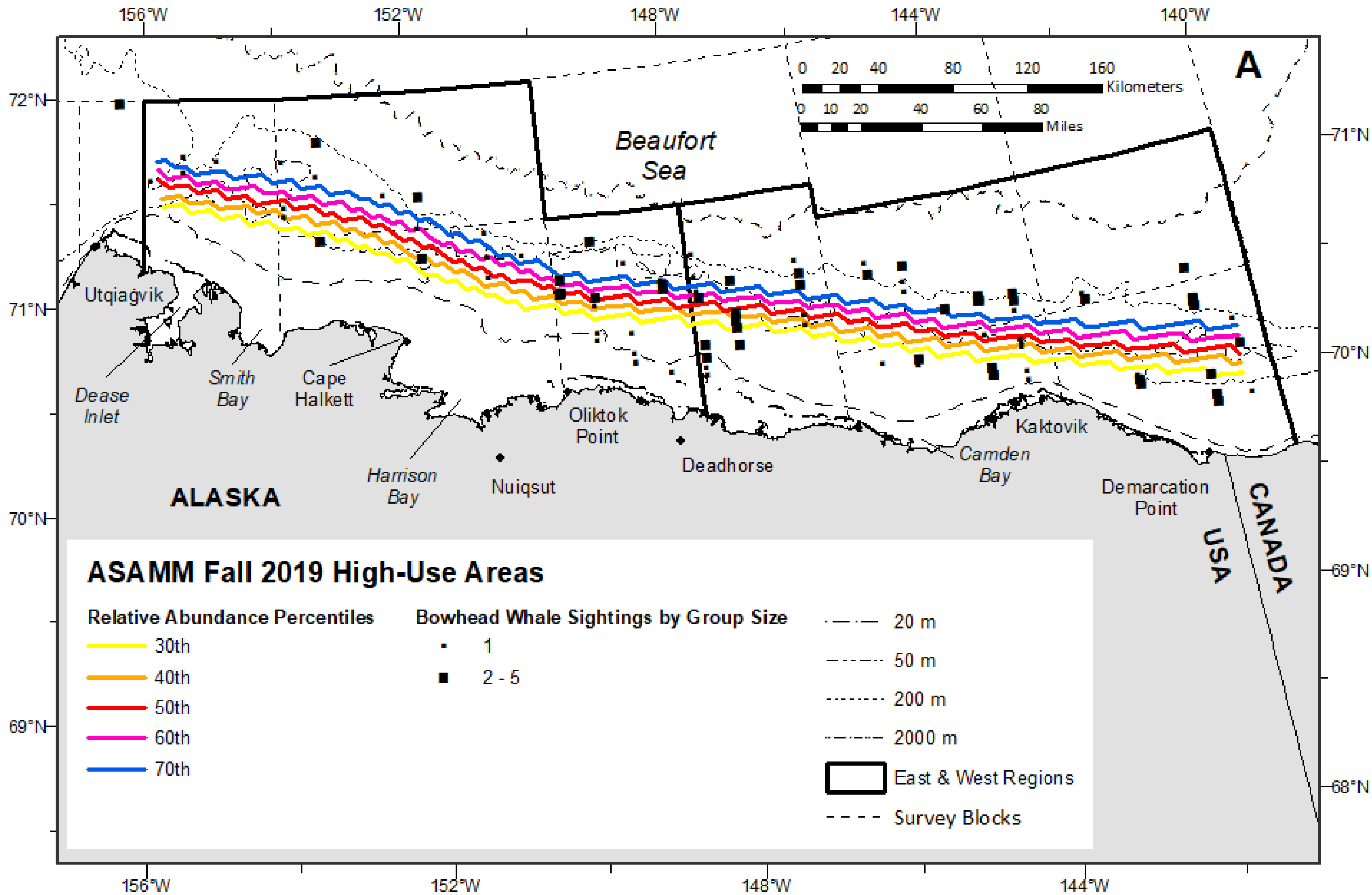


Figure 22. ASAMM fall (September-October) 2019 bowhead whale transect and CAPs passing sightings (primary observers only) by group size and predicted relative abundance, based on a spatial model that accounted for effort by assuming a uniform 5-km of transect and CAPs passing effort in every cell in the western Beaufort Sea. A: Transect and CAPs passing sightings. The bowhead whale high-use area is represented by distribution percentiles (30^{th}, 40^{th}, 50^{th}, 60^{th}, and 70^{th}), which represent the offshore extent of 30%, 40%, 50%, 60%, and 70% of the predicted number of bowhead whales from the spatial model.

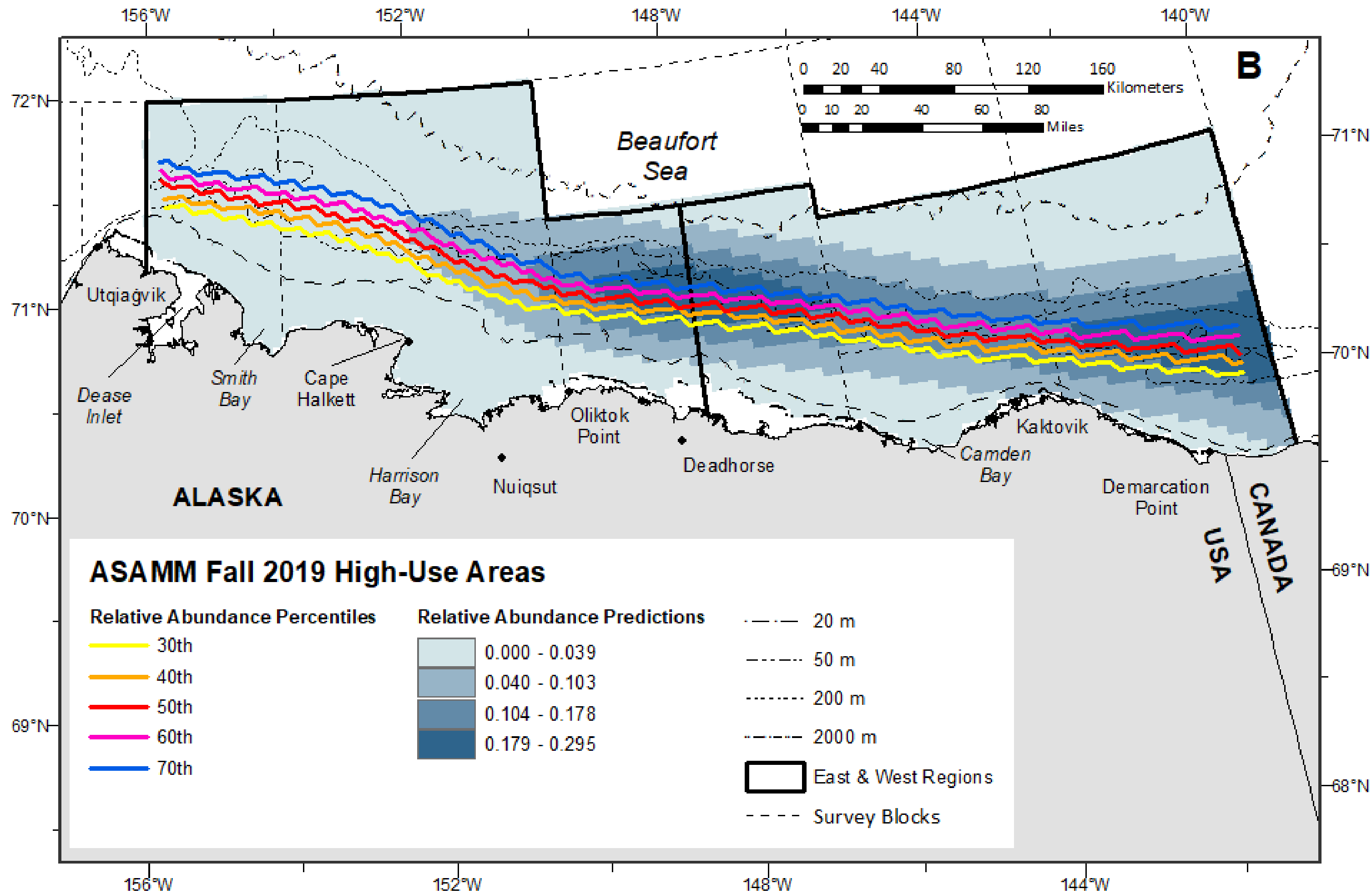


Figure 22 (cont.). ASAMM fall (September-October) 2016 bowhead whale transect and CAPs passing sightings (primary observers only) by group size and predicted relative abundance, based on a spatial model that accounted for effort by assuming a uniform 5-km of transect and CAPs passing effort in every 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.

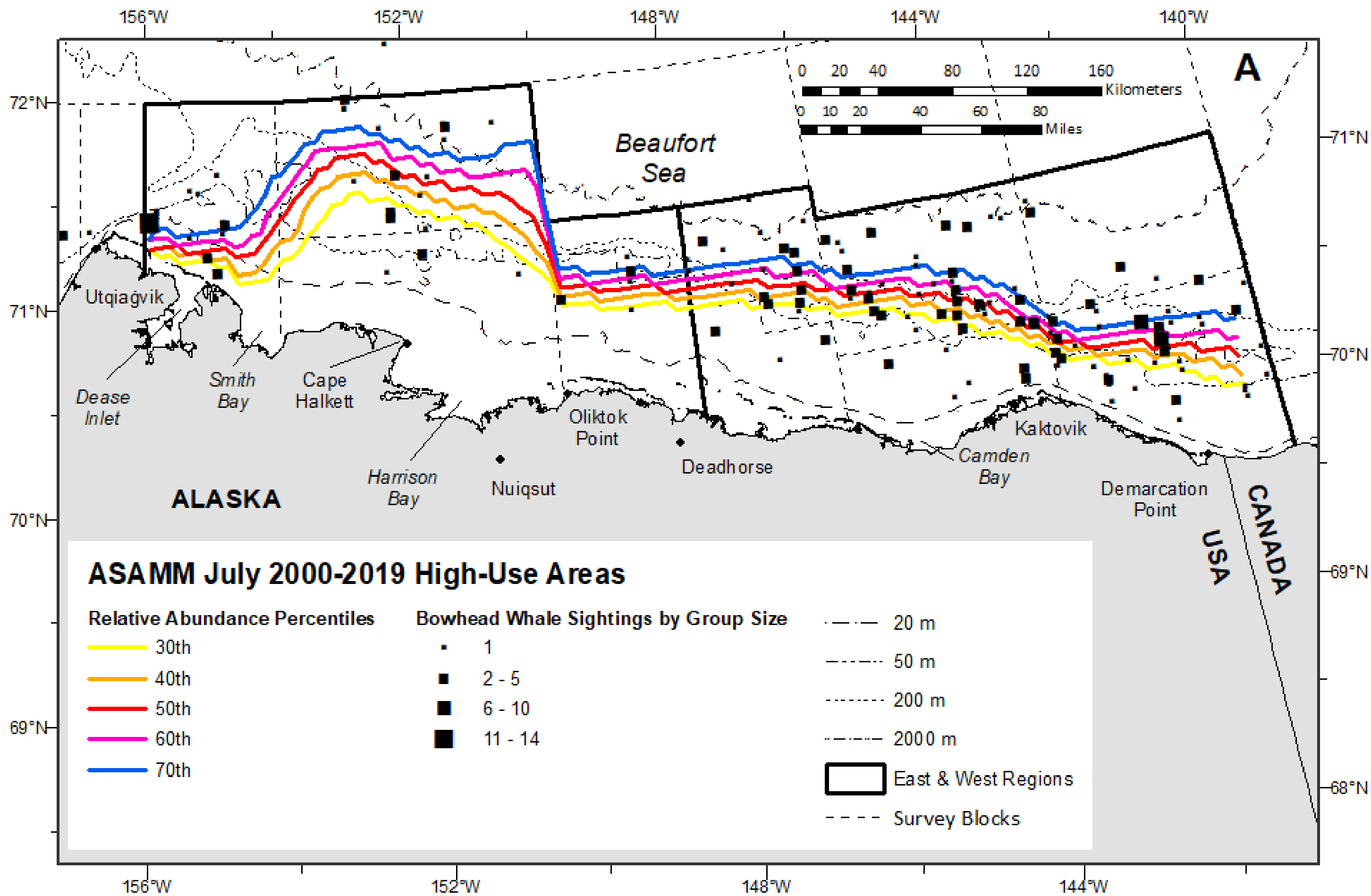


Figure 23. ASAMM 2000-2019 bowhead whale transect and CAPs passing sightings (primary observers only) by group size and predicted relative abundance, based on a spatial relative abundance model that accounted for effort by assuming a uniform 5-km of transect and CAPs passing effort in every cell in the 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.

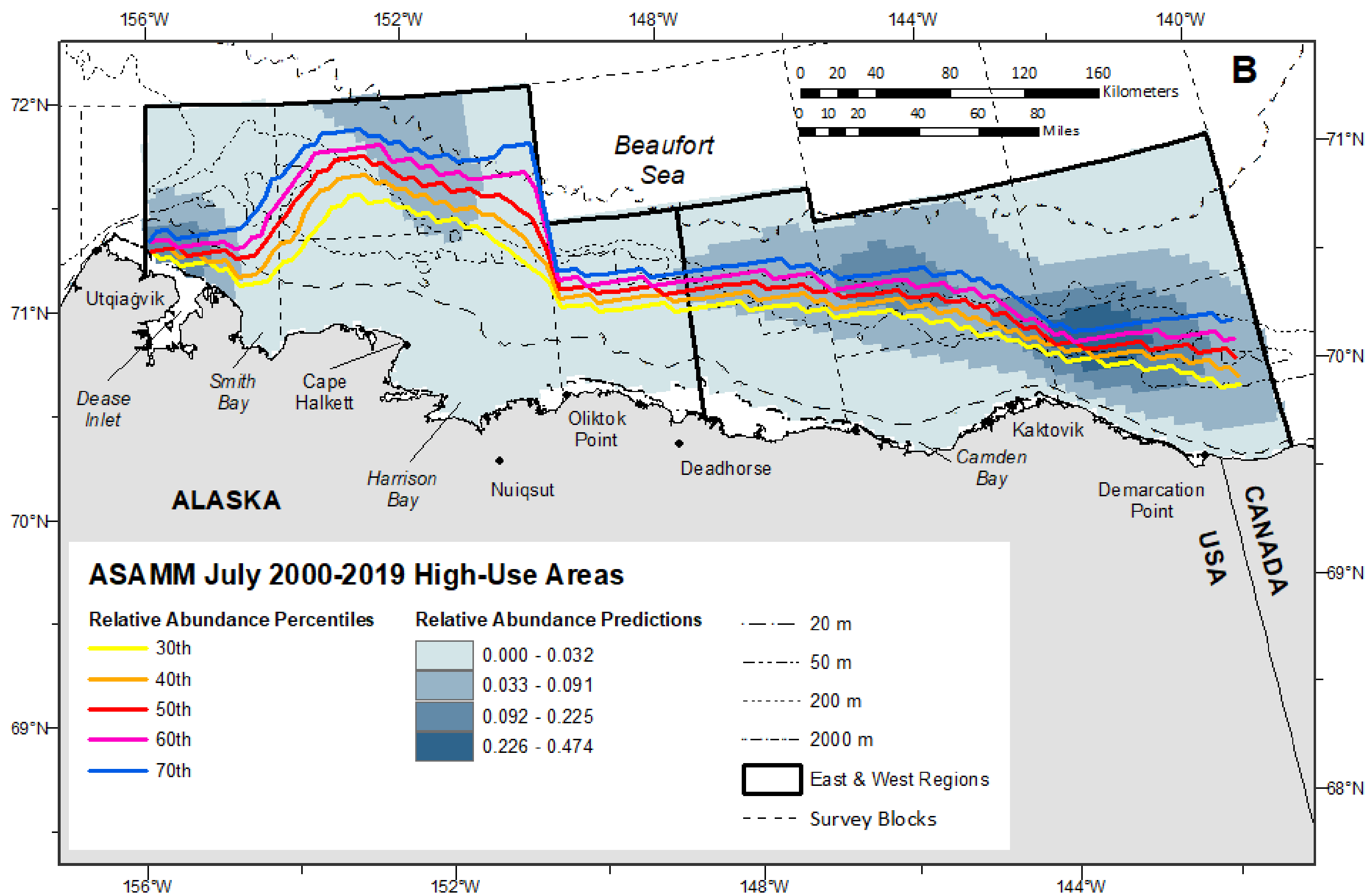


Figure 23 (cont.). ASAMM 2000-2019 bowhead whale transect and CAPs passing sightings (primary observers only) by group size and predicted relative abundance, based on a spatial relative abundance model that accounted for effort by assuming a uniform 5-km of transect and CAPs passing effort in every cell 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.

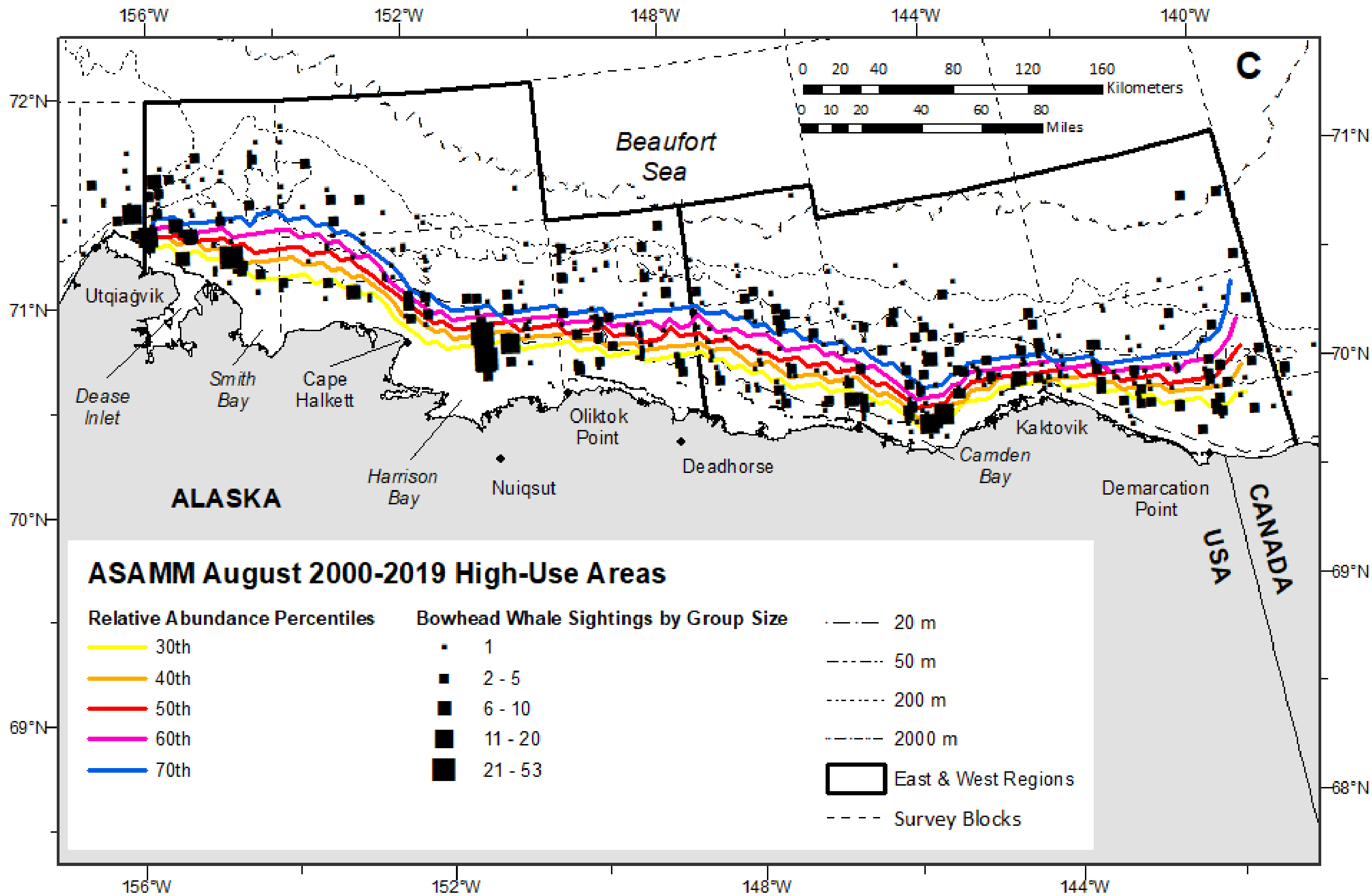


Figure 23 (cont.). ASAMM 2000-2019 bowhead whale transect and CAPs passing sightings (primary observers only) by group size and predicted relative abundance, based on a spatial relative abundance model that accounted for effort by assuming a uniform 5-km of transect and CAPs passing effort in every cell 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.

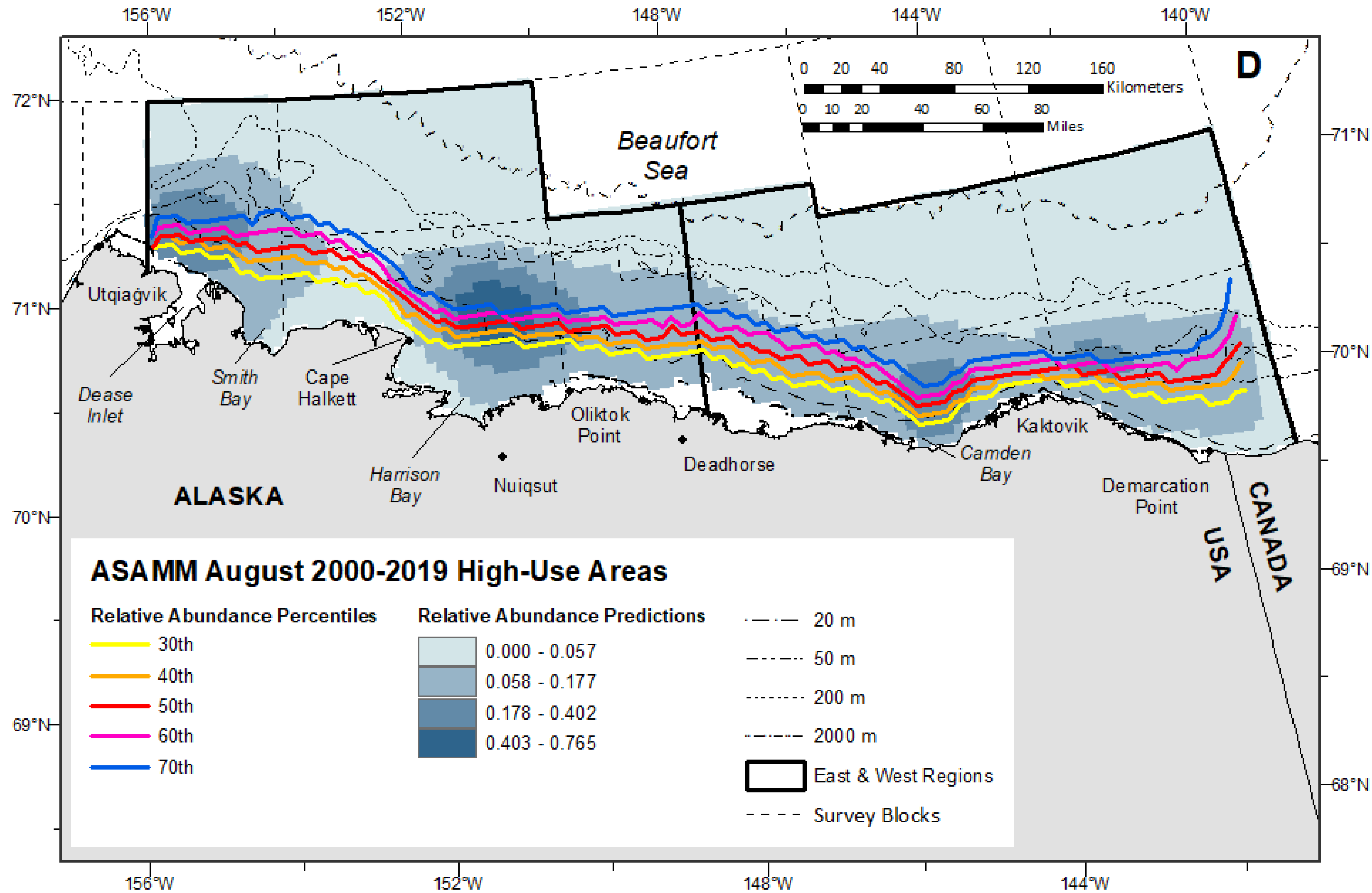


Figure 23 (cont.). ASAMM 2000-2019 bowhead whale transect and CAPs passing sightings (primary observers only) by group size and predicted relative abundance, based on a spatial relative abundance model that accounted for effort by assuming a uniform 5-km of transect and CAPs passing effort in every cell 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.

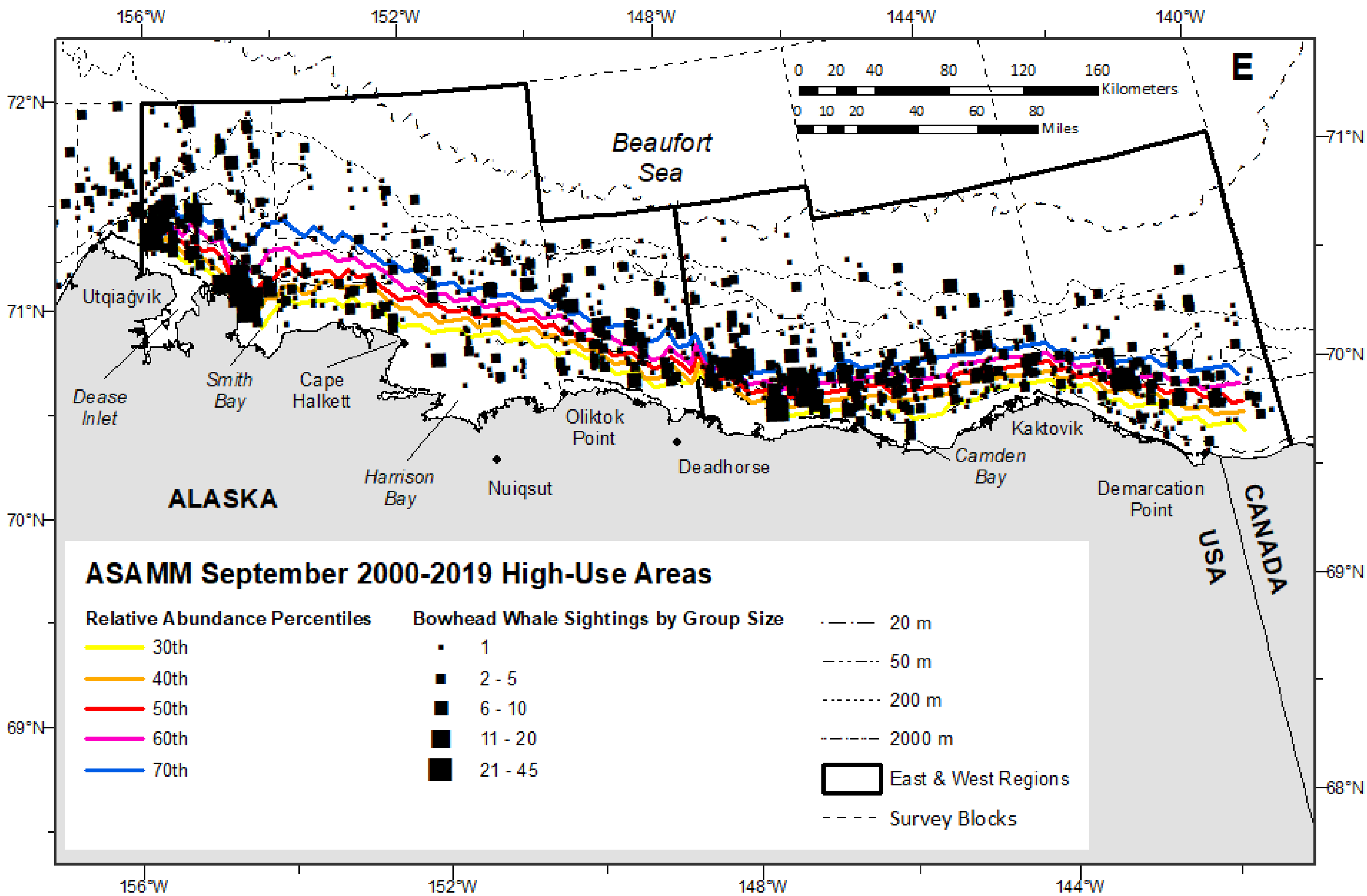


Figure 23 (cont.). ASAMM 2000-2019 bowhead whale transect and CAPs passing sightings (primary observers only) by group size and predicted relative abundance, based on a spatial relative abundance model that accounted for effort by assuming a uniform 5-km of transect and CAPs passing effort in every cell 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.

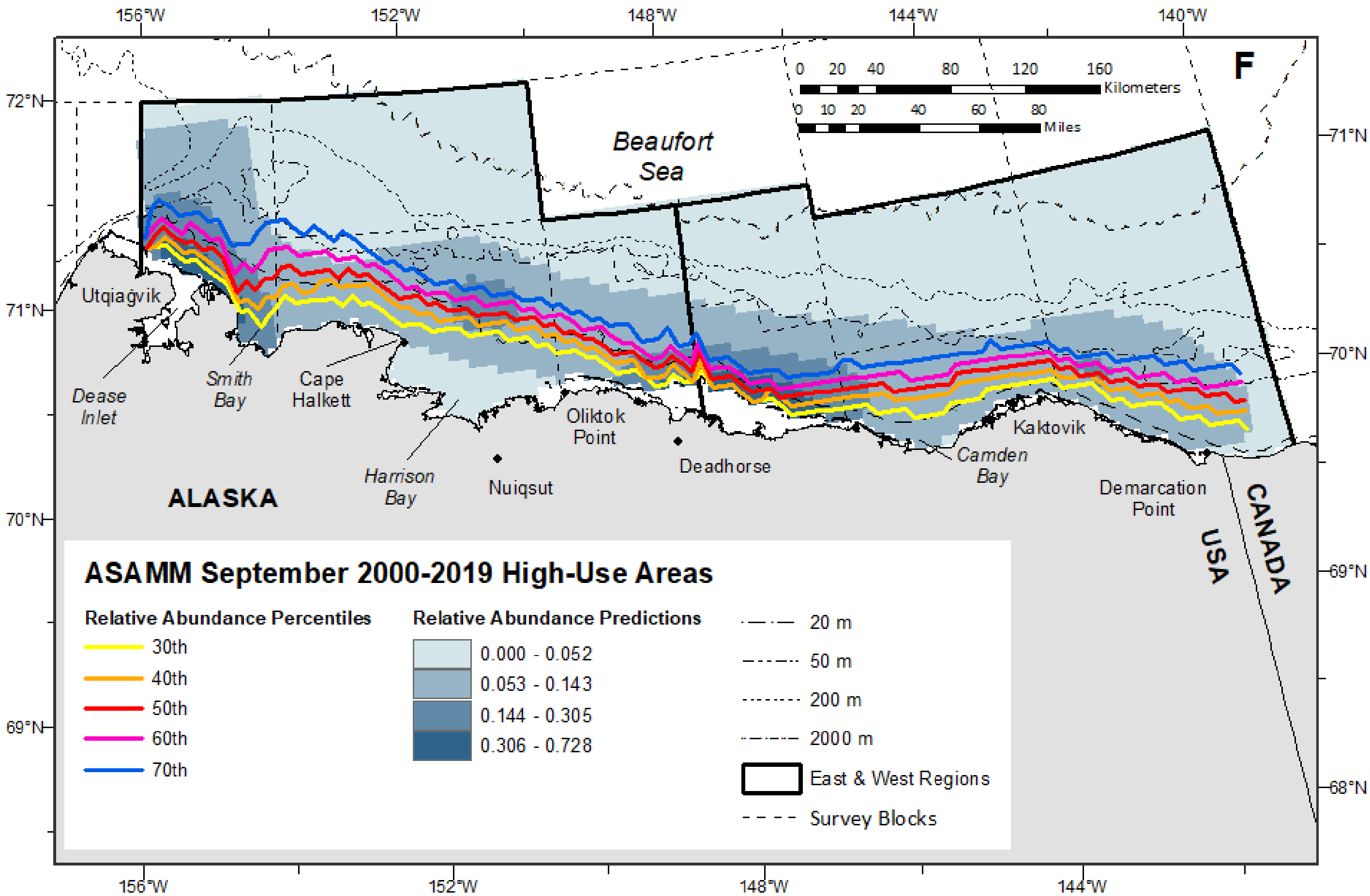


Figure 23 (cont.). ASAMM 2000-2019 bowhead whale transect and CAPs passing sightings (primary observers only) by group size and predicted relative abundance, based on a spatial relative abundance model that accounted for effort by assuming a uniform 5-km of transect and CAPs passing effort in every cell 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.

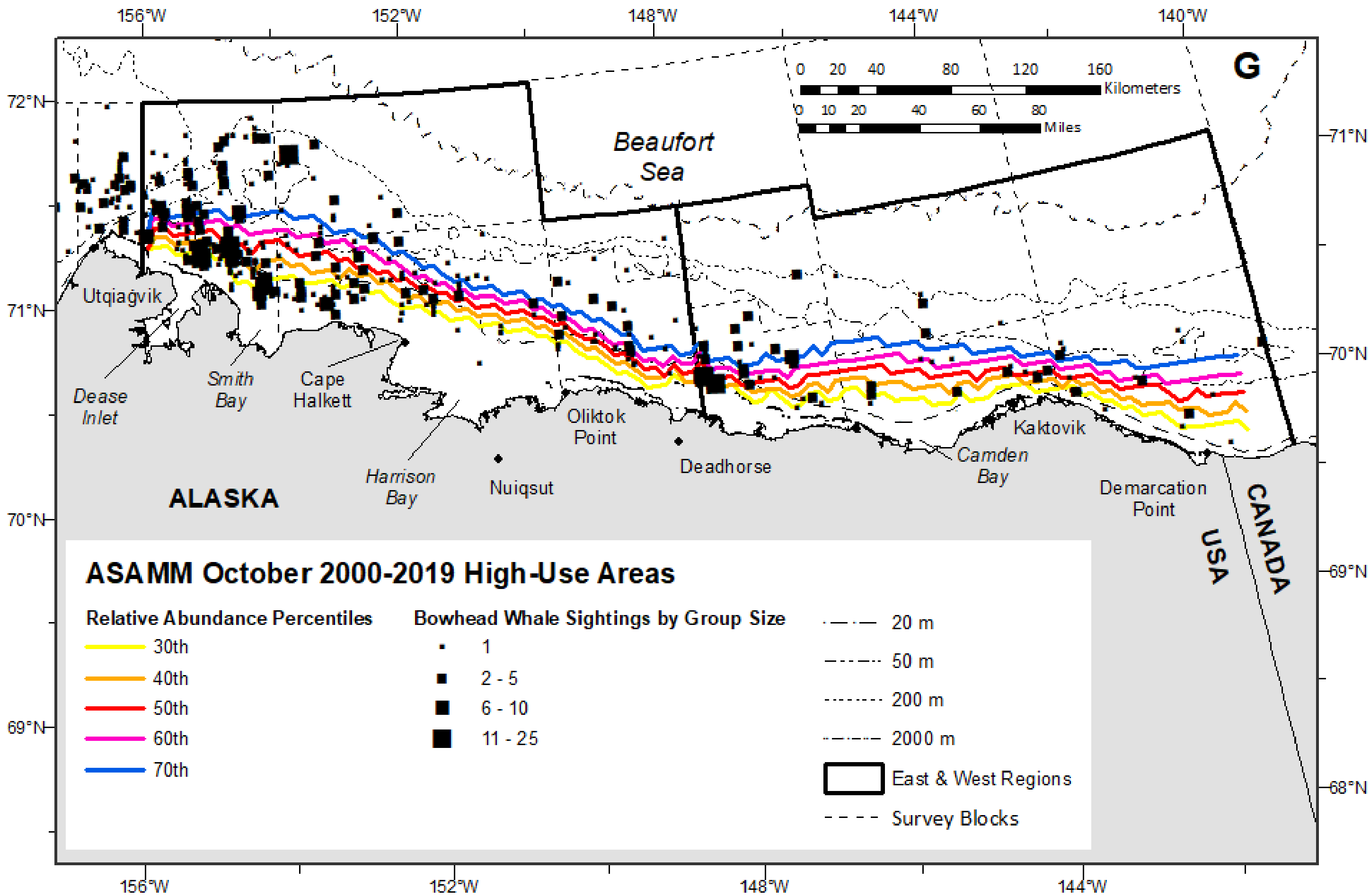


Figure 23 (cont.). ASAMM 2000-2019 bowhead whale transect and CAPs passing sightings (primary observers only) by group size and predicted relative abundance, based on a spatial relative abundance model that accounted for effort by assuming a uniform 5-km of transect and CAPs passing effort in every cell 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.

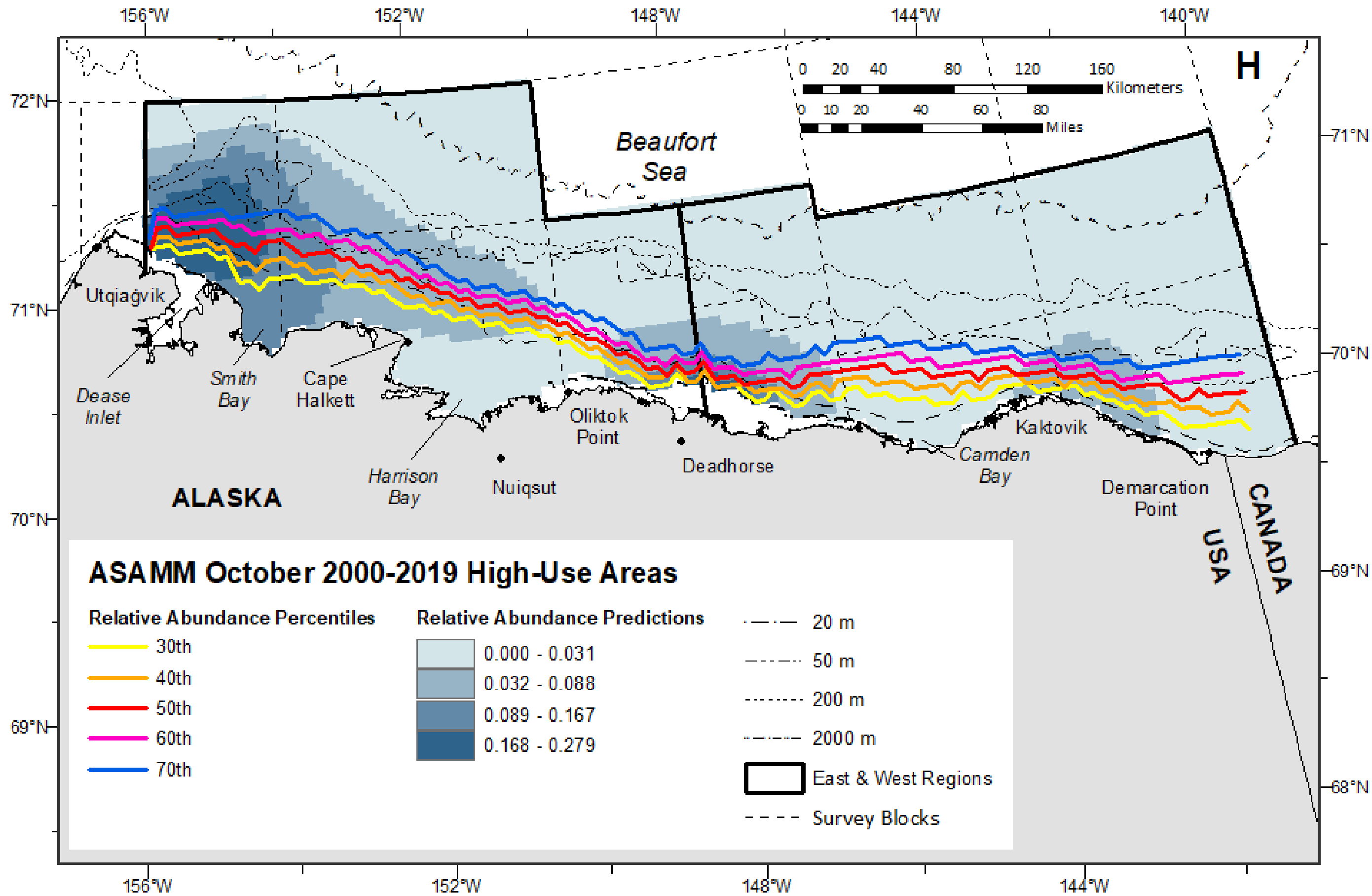


Figure 23 (cont.). ASAMM 2000-2019 bowhead whale transect and CAPs passing sightings (primary observers only) by group size and predicted relative abundance, based on a spatial relative abundance model that accounted for effort by assuming a uniform 5-km of transect and CAPs passing effort in every cell 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 western Beaufort Sea West and East regions in the ASAMM study area. For 2019, the predictions correspond to September and October pooled. Monthly predictions are provided for 2000-2019.

	WEST REGION (KM)					**EAST REGION (KM)**				
	2019	**2000-2019**				**2019**	**2000-2019**			
Percentile	**Sep-Oct**	**Jul**	**Aug**	**Sep**	**Oct**	**Sep-Oct**	**Jul**	**Aug**	**Sep**	**Oct**
30th	40.4	28.9	21.7	13.9	18.5	37.4	38.8	17.6	11.3	11.3
40th	45.6	44.2	26.9	19.4	24.6	43.4	44.9	22.8	15.9	15.9
50th	50.9	58.9	32.1	25.8	30.3	48.7	51.7	27.7	20.7	20.8
60th	56.3	72.5	36.7	33.4	37.1	54.3	59.1	33.0	26.5	27.0
70th	62.1	86.5	41.6	40.7	44.0	59.8	67.1	39.7	33.1	34.1

Gray Whales

GRAY WHALE SIGHTING SUMMARY

During the 2019 ASAMM surveys, 315 sightings of 447 gray whales (*Eschrichtius robustus*) of the Eastern North Pacific stock were observed during all survey modes (transect, CAPs, search and circling) in the ASAMM and ABA study areas from July to October (Table 4). Gray whales were seen in all months in the eastern Chukchi Sea (Figure 24). In the northeastern Chukchi Sea, most gray whales were seen in the northern part of block 17 and southern part of block 14, between 20 and 120 km offshore and just south of Hanna Shoal. There were a few gray whale sightings nearshore (<2 km) between Point Franklin and Point Barrow and a few sightings on Hanna Shoal along the northern edge of block 14. 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). Gray whales were not seen between Point Lay and Point Hope nor in Peard Bay. One gray whale was sighted in the central Alaskan Beaufort Sea in late September. Fifteen gray whales were observed in the eastern Beaufort Sea in August (Appendix I, Figure I-8). Locations of gray whale sightings in the ASAMM study area during semimonthly periods are shown in Figure 25. Relatively few gray whales were seen in August in the eastern Chukchi Sea due, at least in part, to the geographic shift of survey effort to the Beaufort Sea and Amundsen Gulf for ABA.

GRAY WHALE SIGHTING RATES

In summer and fall 2019, gray whales were seen on effort from 67.4°N to 72.0°N and 131.9°W to 168.8°W. There were 140 sightings of 207 gray whales on effort by primary observers within blocks 12-23 in the ASAMM study area (Appendix E, Table E-3), ranging from one whale per sighting ($n_s = 81$) to 5 whales per sighting ($n_s = 3$). The greatest numbers of sightings on effort were in block 23 ($n_s = 75$), block 14 ($n_s = 40$) and block 17 ($n_s = 22$).

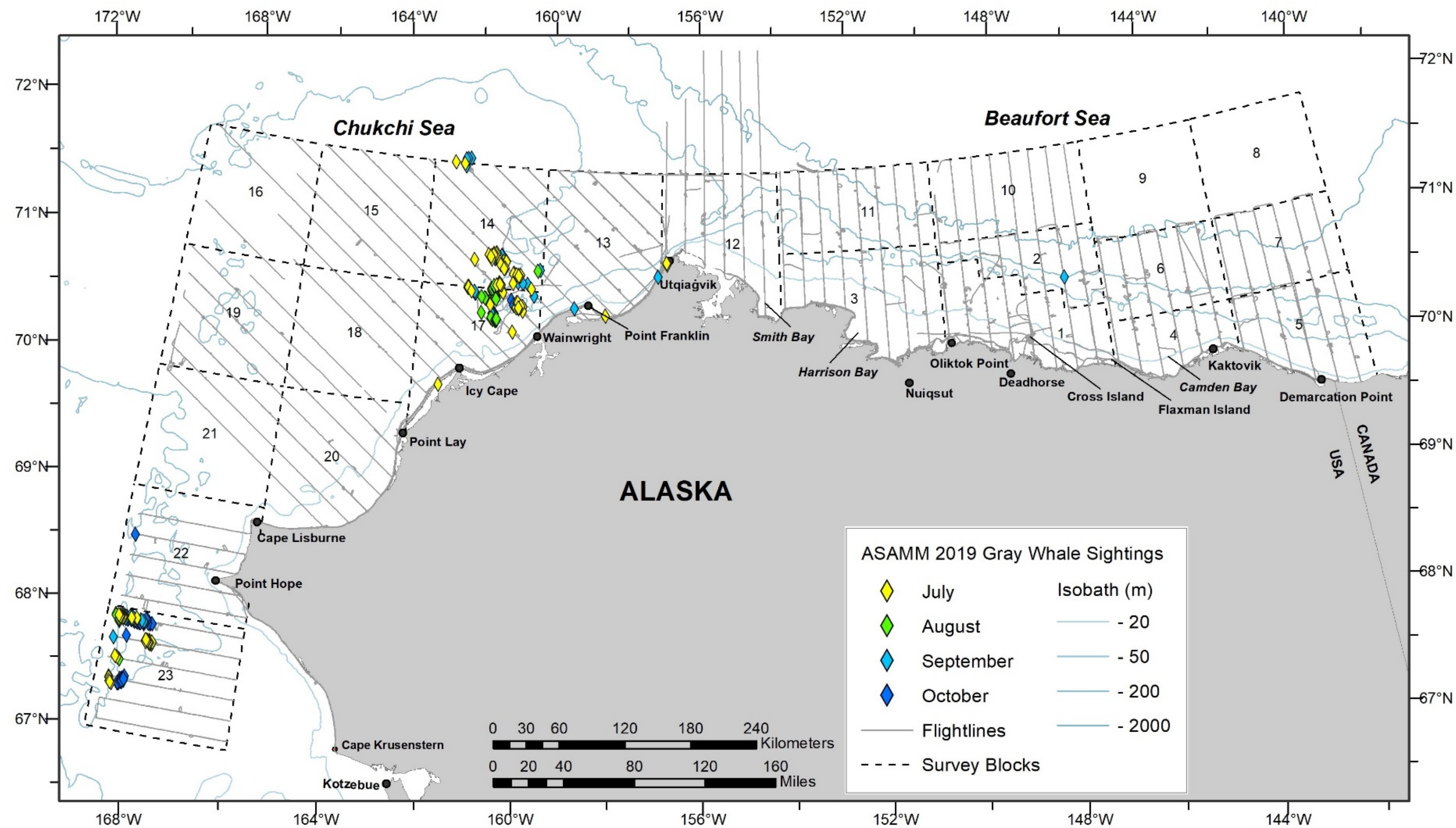


Figure 24. ASAMM 2019 gray whale sightings in the ASAMM study area, all survey modes, plotted by month, with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.

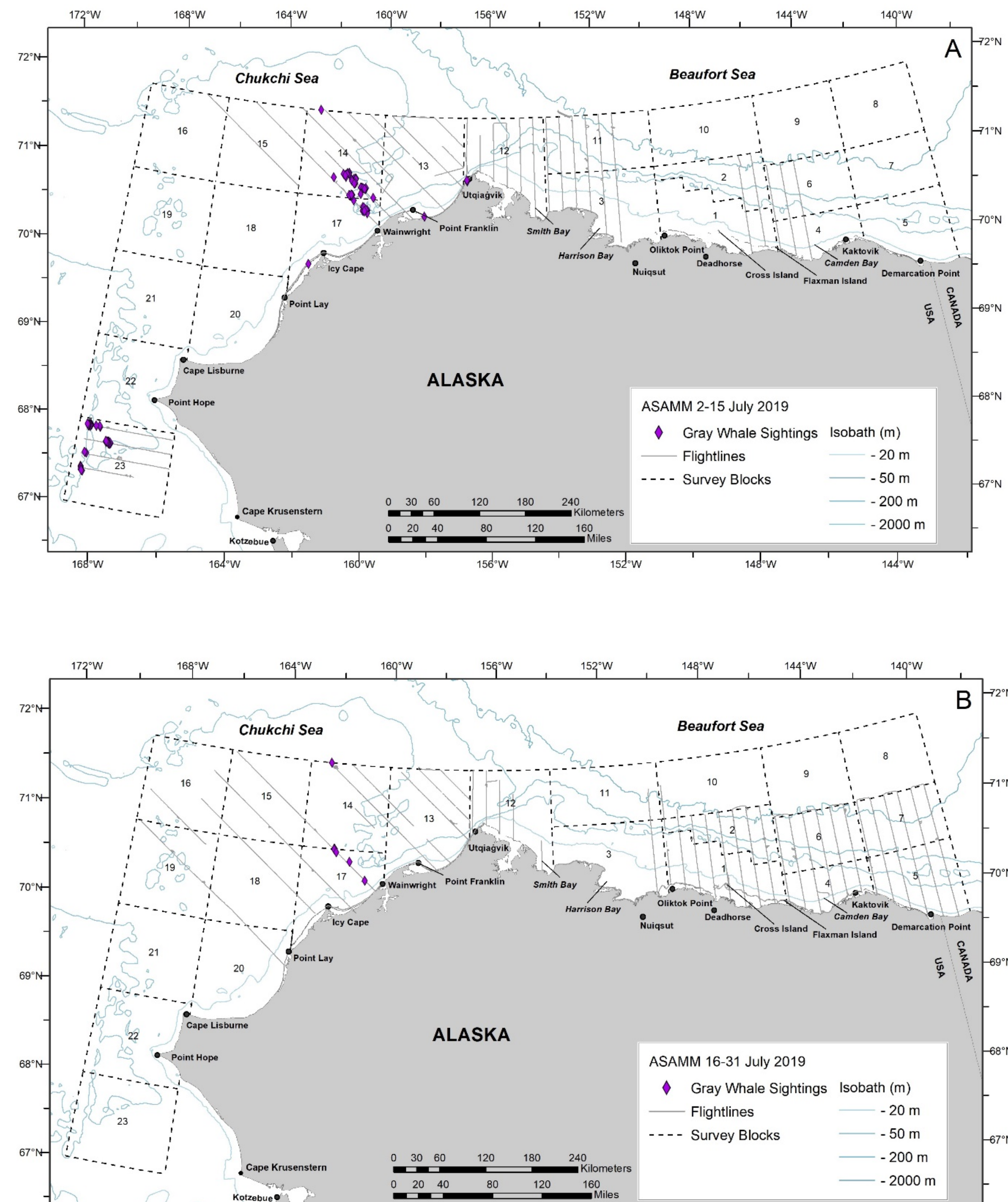
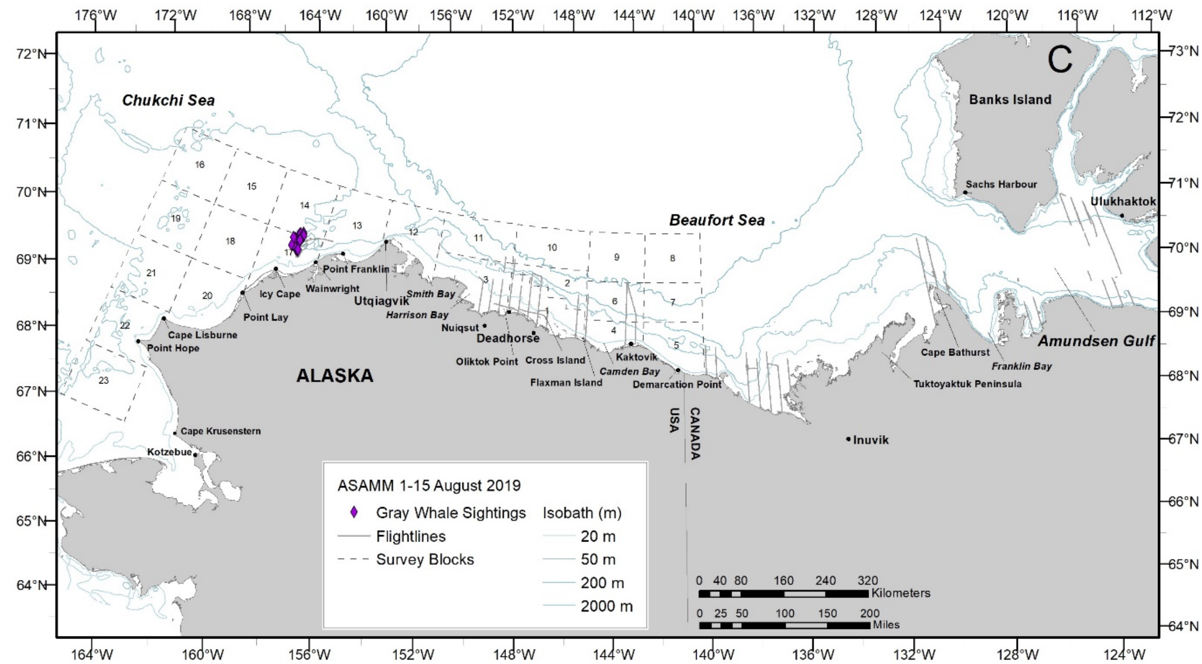


Figure 25. ASAMM 2019 semimonthly gray whale sightings in the ASAMM and ABA study areas, all survey modes, with transect, CAPs, search, circling, and FGF effort, July-October. A: 2-15 July. B: 16-31 July. Deadhead flight tracks are not shown.



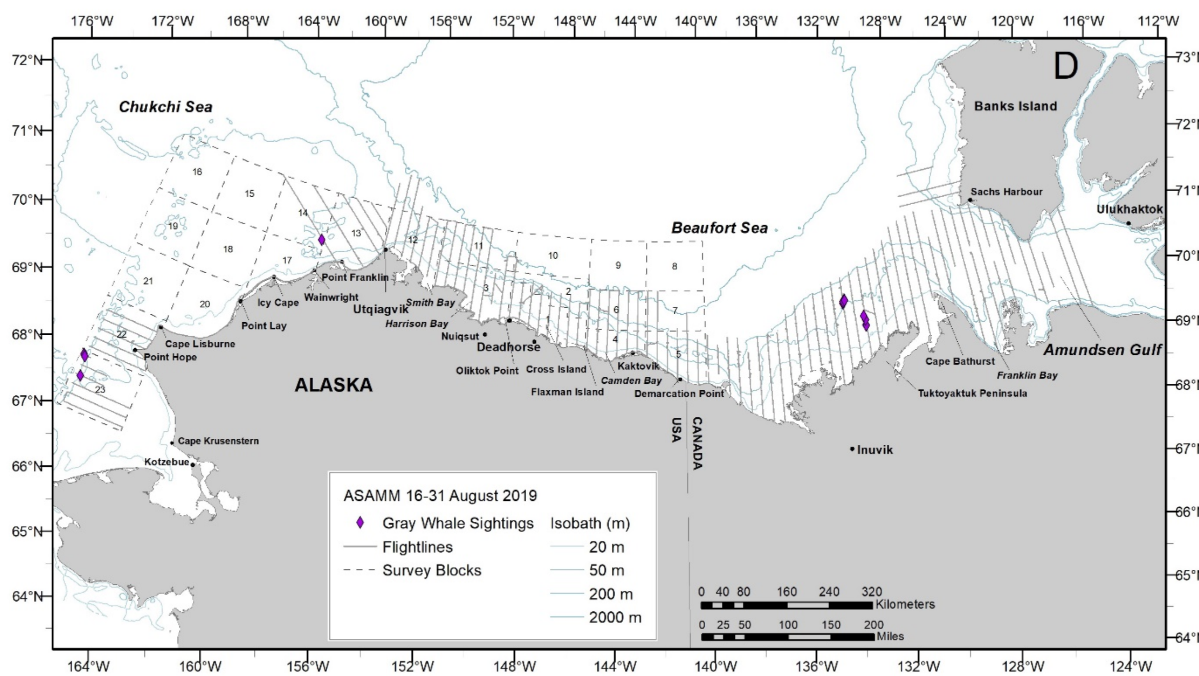
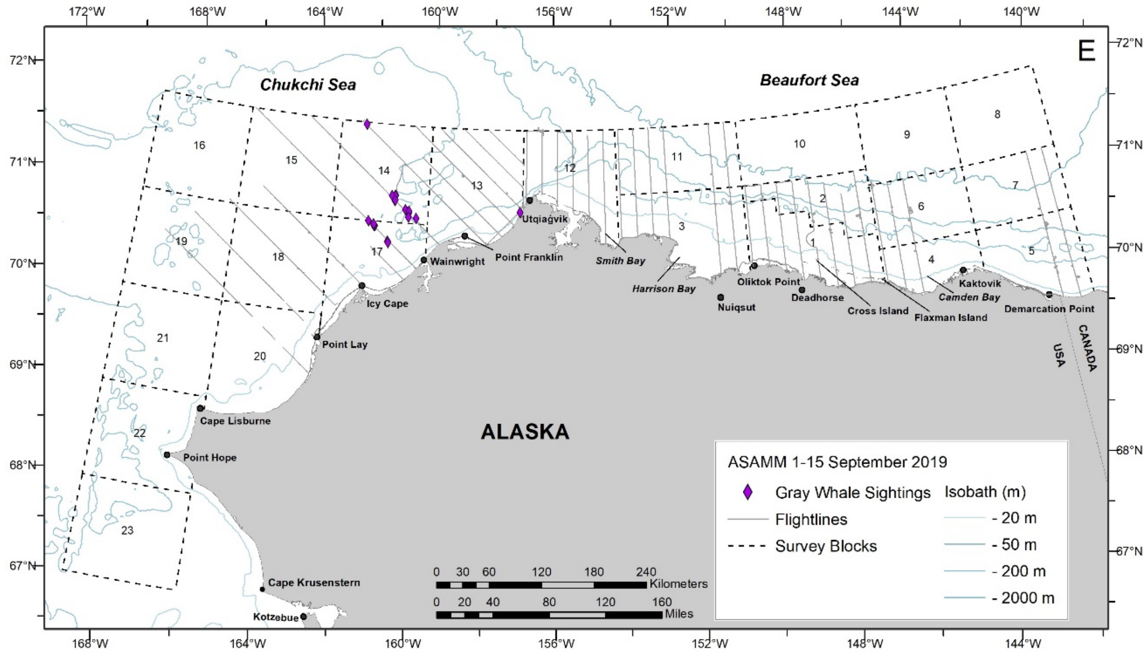


Figure 25 (cont). ASAMM 2019 semimonthly gray whale sightings in the ASAMM and ABA study areas, all survey modes, with transect, CAPs, search, circling, and FGF effort, July-October. C: 1-15 August. D: 16-31 August. Deadhead flight tracks are not shown.



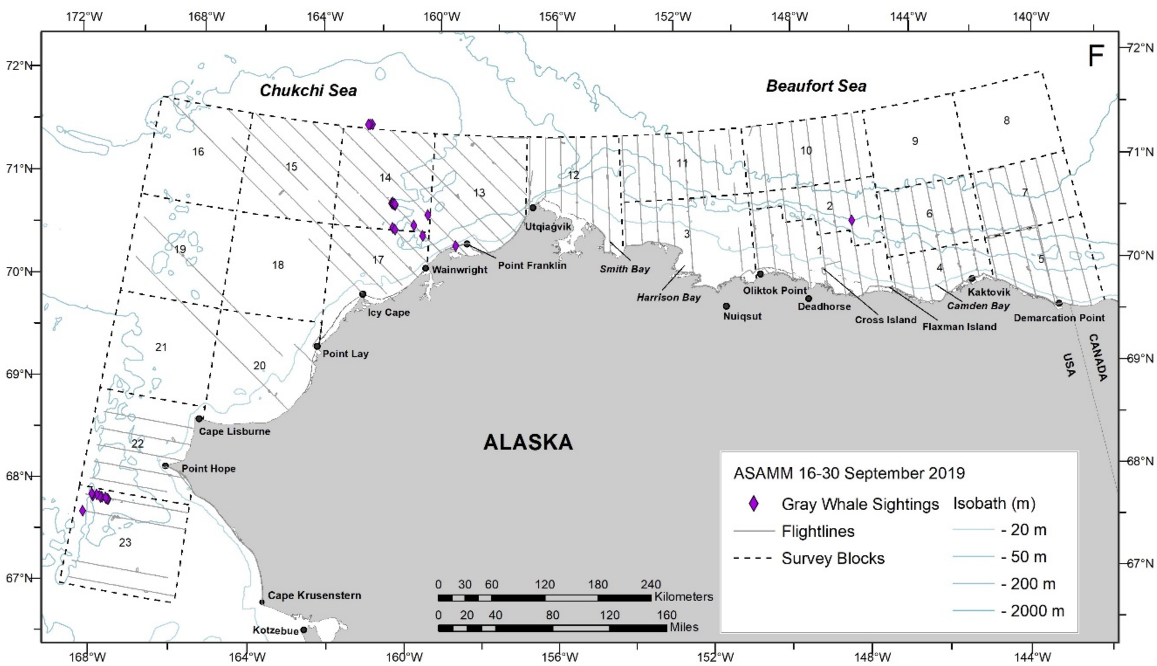
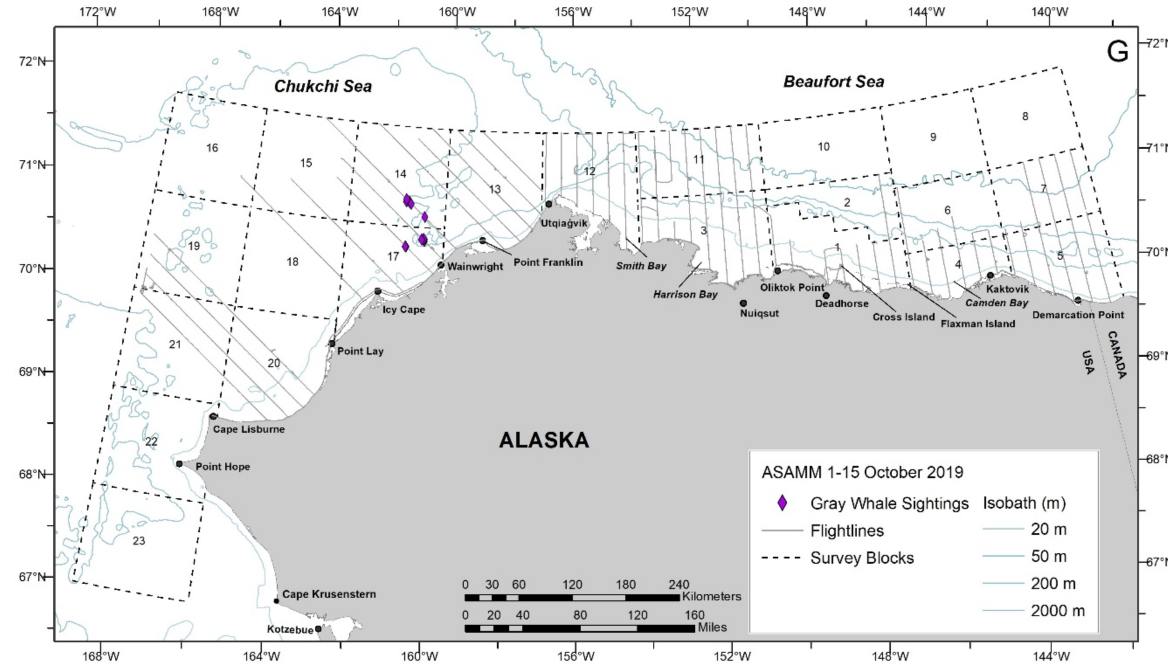


Figure 25 (cont). ASAMM 2019 semimonthly gray whale sightings in the ASAMM and ABA study areas, all survey modes, with transect, CAPs, search, circling, and FGF effort, July-October. E: 1-15 September. F: 16-30 September. Deadhead flight tracks are not shown.



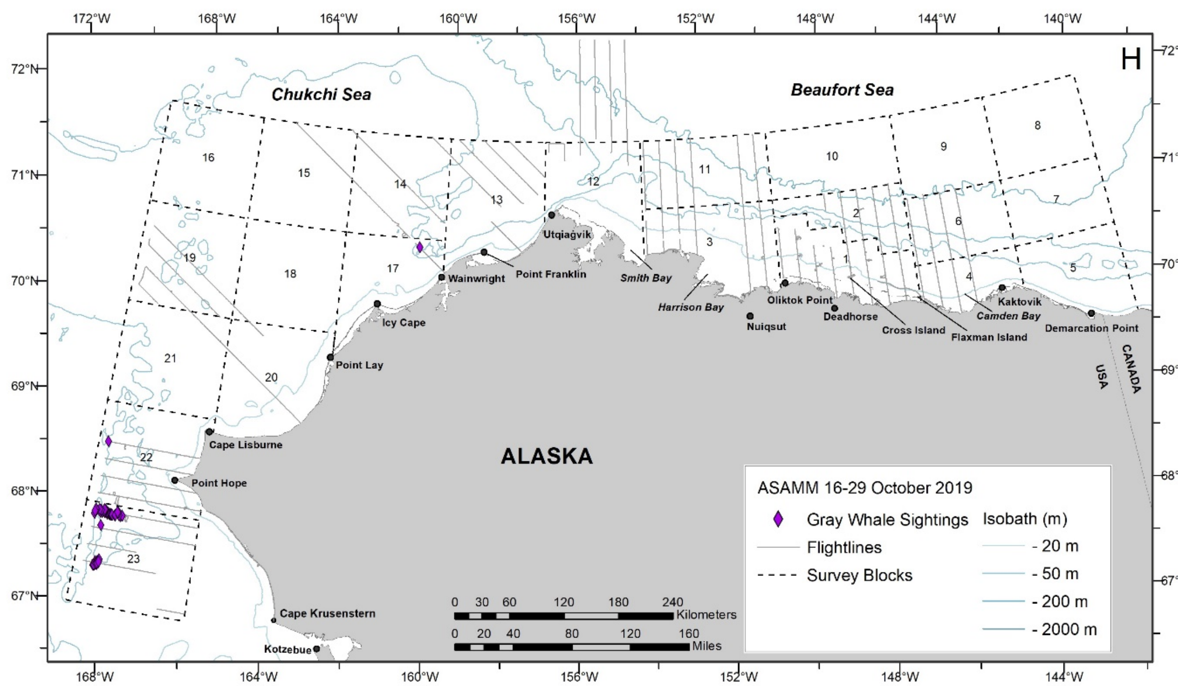


Figure 25 (cont). ASAMM 2019 semimonthly gray whale sightings in the ASAMM and ABA study areas, all survey modes, with transect, CAPs, search, circling, and FGF effort, July-October. G: 1-15 October. H: 16-29 October. Deadhead flight tracks are not shown.

The highest gray whale fine-scale (5-km grid) sighting rates (WPUE) in the ASAMM study area in summer were approximately 60-80 km northwest of Wainwright and approximately 80 km southwest of Point Hope (Figure 26A). In fall, the highest gray whale fine-scale sighting rates (WPUE) were approximately 60 km west and 100 km southwest Point Hope (Figure 26B). 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 ASAMM study area west of 154°W to encompass the region where gray whales were predominantly seen in 2019 and historically. For all months combined, the highest sighting rates per survey block were in block 23 (0.054 WPUE), block 17 (0.022 WPUE), and block 14 (0.020 WPUE). Sighting rates per block per month were highest in block 23 in July, September, and October, and in block 14 in August (Figure 27) (Appendix E, Table E-3).

Monthly sighting rates in 2019 were higher in July, September, and October compared to monthly sighting rates in 2009-2018, all years combined (Figure 28). The peak monthly gray whale sighting rate in the eastern Chukchi Sea (67°N-72°N, 154°W-169°W) in 2019 was in July (0.019 WPUE), then decreased substantially in August (0.002 WPUE), before increasing in September and October (0.007 WPUE). When historical sighting rates were calculated separately for the northeastern Chukchi Sea (69°N-72°N, 154°W-169°W; 2009-2018) and southcentral Chukchi Sea (67°N-69°N, 166°W-169°W; 2014-2018) and compared to 2019, sighting rate patterns differed between 2019 and earlier years in both areas but was more dramatic in the southcentral Chukchi Sea (Figure 29). Historical sighting rates from 2009-2018 (Figure 29A) and 2014-2018 (Figure 29B) show an overall decrease in gray whale sighting rates from July to October while sighting rates in 2019 decreased in August before increasing in September and October. Sighting rate results in 2019 were likely affected by the relative lack of on-effort surveys in the Chukchi Sea in August due to ABA (Figure 25 C and D).

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 South depth zone (0.072 WPUE) (Appendix E, Table E-4). Sighting rates were also highest in the 51-200 m South depth zone for each individual month, and much lower in depth zones in the northeastern Chukchi Sea (Figure 30). Few gray whales were seen on effort in August 2019 due to ABA, and sighting rates reflected that.

When aerial surveys commenced 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, 2018 (Clarke et al. 2016, 2017a, b, 2018a, 2019), and 2019, gray whale preference for deeper water was observed throughout summer and fall.

The highest gray whale sighting rate per depth zone in the western Alaskan Beaufort Sea (154°W-157°W) for the entire study period was in the 21-50 m zone (0.002 WPUE) (Appendix E, Table E-4). The single gray whale observed in the central Alaskan Beaufort Sea was in the 51-200 m depth zone.

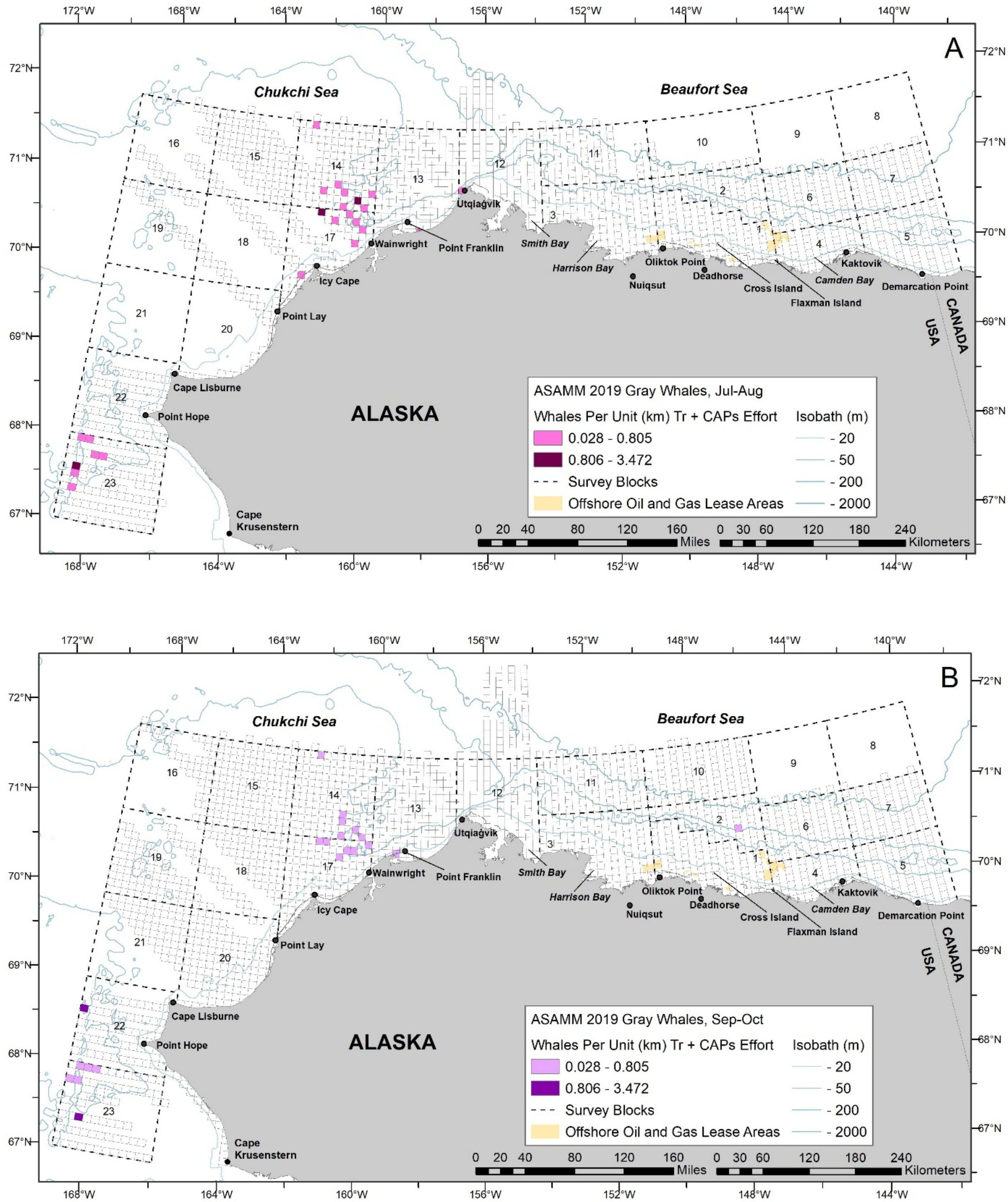


Figure 26. ASAMM 2019 gray whale on-effort seasonal sighting rates (WPUE; sightings from primary observers only) in the ASAMM study area. A: summer (July-August pooled). B: fall (September-October pooled). Empty cells indicate sighting rates of zero. Transect and CAPs survey effort was not conducted in areas without cell outlines.

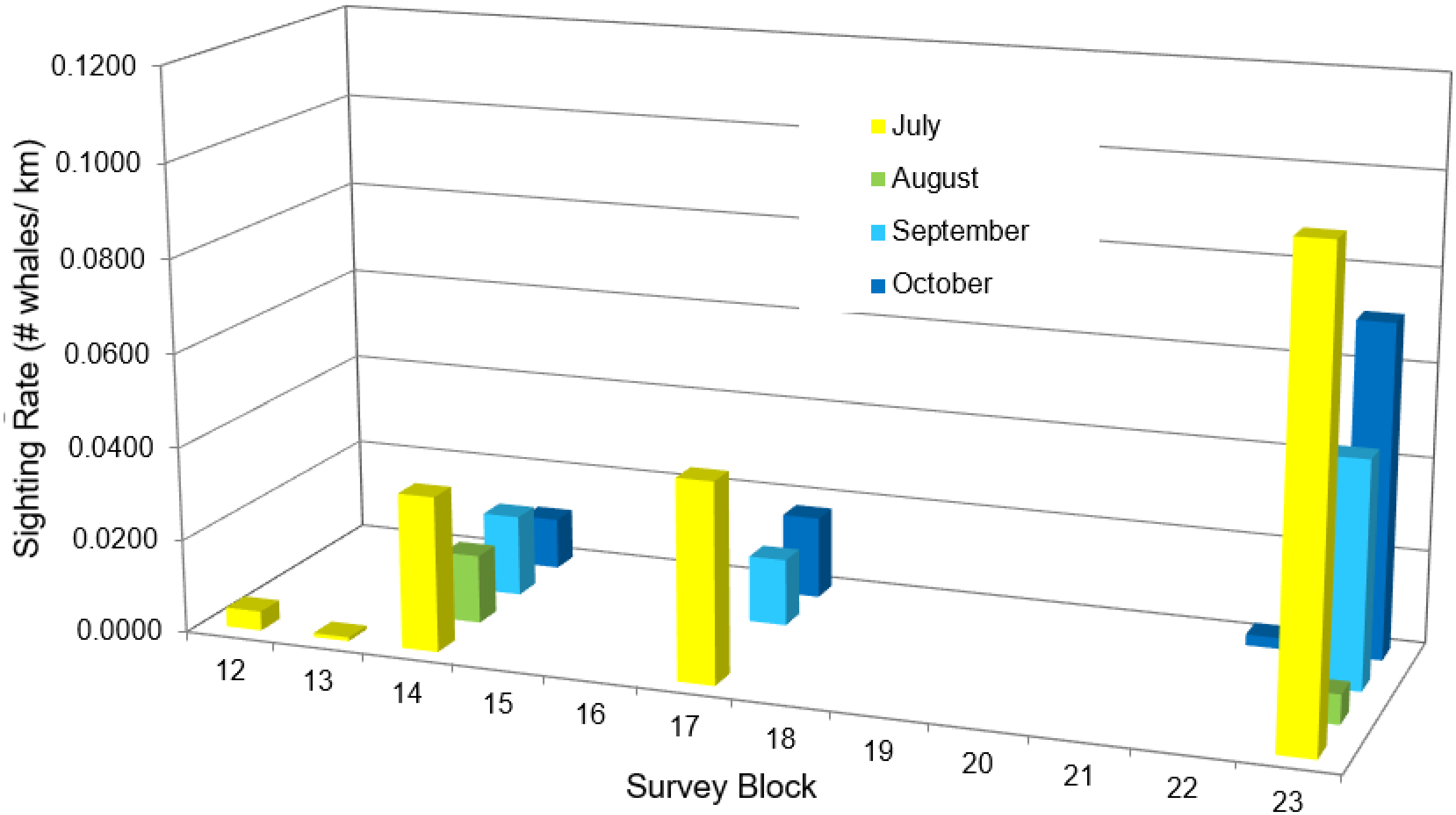


Figure 27. ASAMM 2019 gray whale on-effort monthly sighting rates (WPUE; sightings from primary observers only) per survey block in the eastern Chukchi and western Alaskan Beaufort seas, July-October. Sighting rates of zero were removed from the graph for clarity.

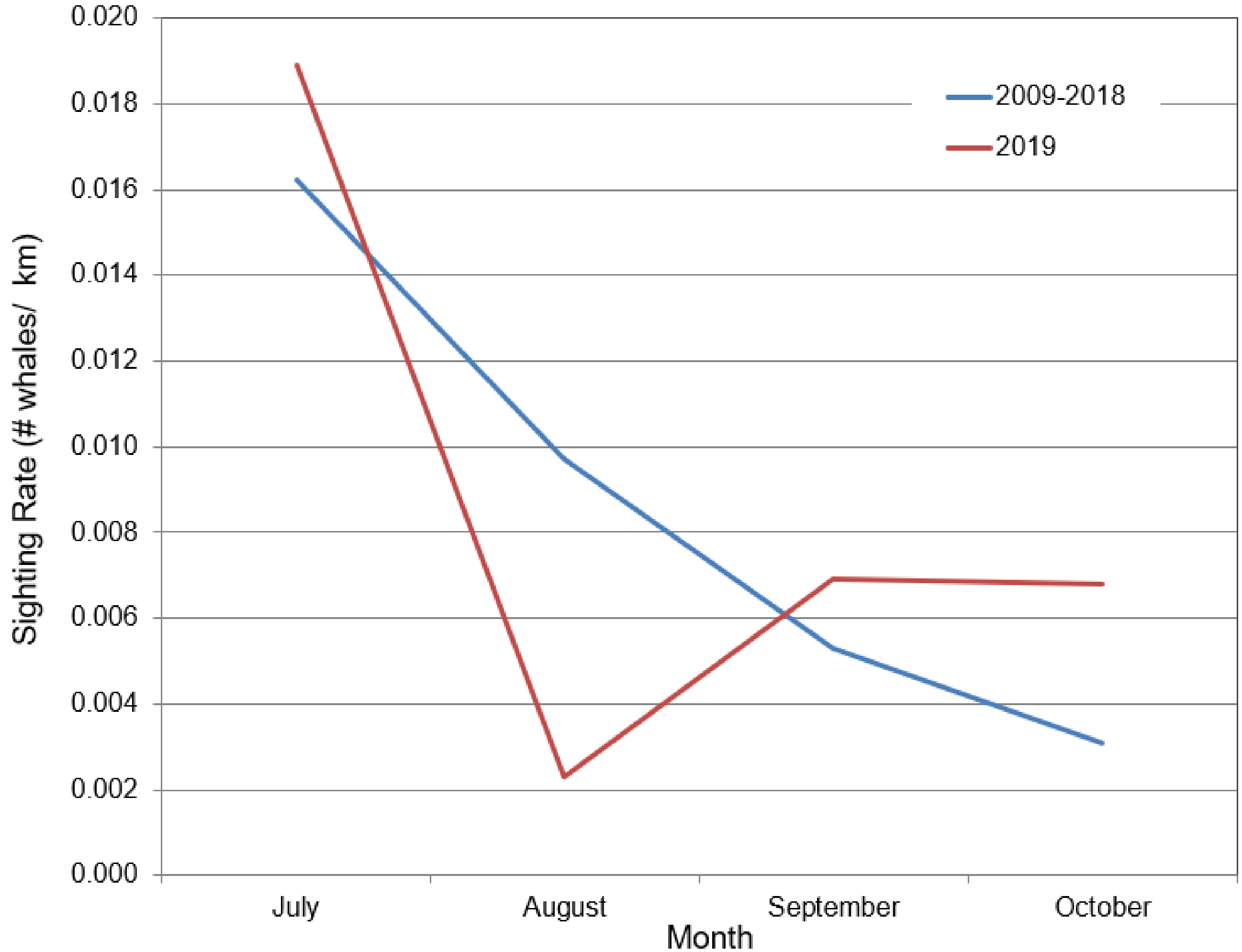


Figure 28. ASAMM gray whale on-effort monthly sighting rates (WPUE; sightings from primary observers only) in the eastern Chukchi and western Alaskan Beaufort seas (67°N-72°N, 154°W-169°W), July-October, 2009-2018 pooled and 2019. Gray whale sighting rate results in August 2019 were likely affected by the relative lack of on-effort surveys in the Chukchi Sea in August due to ABA.

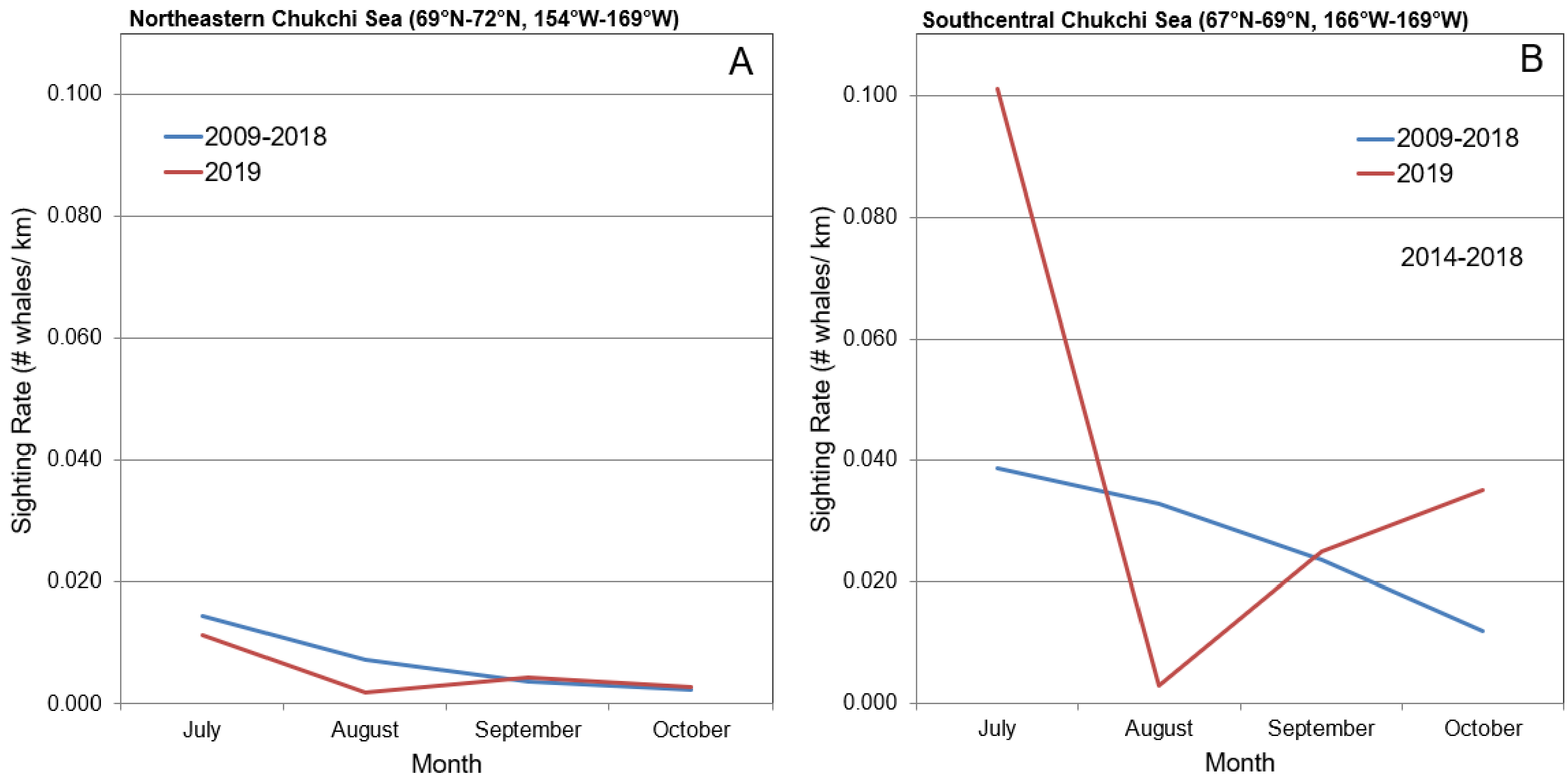


Figure 29. ASAMM gray whale on-effort monthly sighting rates (WPUE; sightings from primary observers only), July-October. A: northeastern Chukchi and western Alaskan Beaufort Sea (69°N-72°N, 154°W-169°W), 2009-2018 pooled and 2019. B: southcentral Chukchi Sea (67°N-69°N, 166°W-169°W), 2014-2018 pooled and 2019. Gray whale sighting rate results in August 2019 were likely affected by the relative lack of on-effort surveys in the Chukchi Sea in August due to ABA.

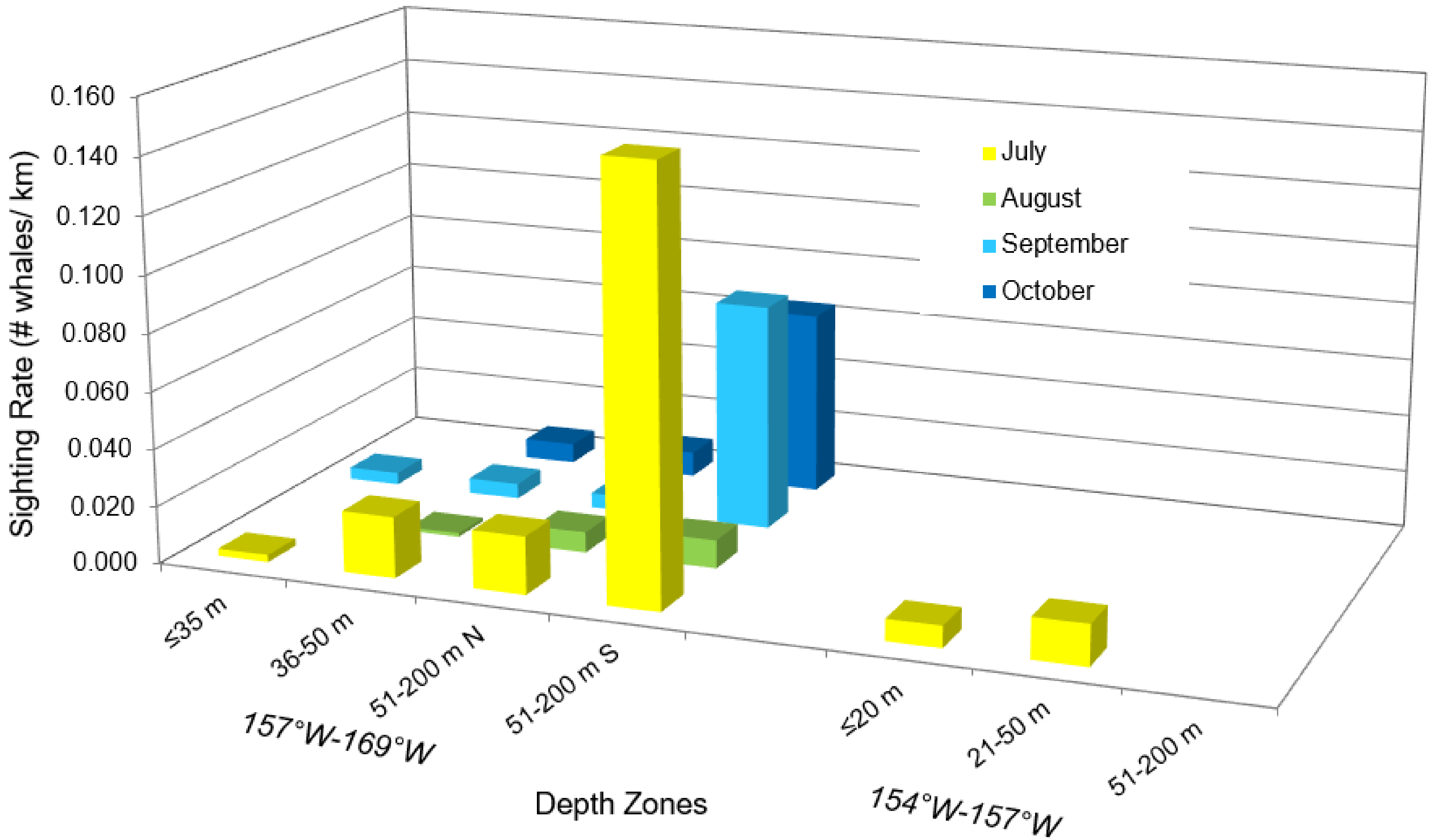


Figure 30. ASAMM 2019 gray whale on-effort monthly sighting rates (WPUE; sightings from primary observers only) per depth zone in the eastern Chukchi and western Alaskan Beaufort seas, July-October. Sighting rates of zero were removed from the graph for clarity.

Gray whale distribution in 2019 using on-effort sightings overlapped the distribution of on-effort sightings observed in previous years having light sea ice cover (Figure 31).

Gray Whale Sea Ice Associations

Most gray whales (99%, $n_i = 446$) were observed in 0% sea ice cover. Sea ice was absent from the eastern Chukchi Sea survey area by early July (Appendix A, Figure A-2). One gray whale was observed in 25% broken floe sea ice in early July.

Gray Whale Behaviors

Behaviors of gray whales observed in the ASAMM and ABA study areas during all survey modes (transect, CAPs, search, and circling) in 2019 are summarized in Table 10. The behaviors most often recorded were feeding (78%) and swimming (12%). Resting was recorded for 35 whales (8%). Other behaviors recorded included diving ($n_i = 4$), milling ($n_i = 2$), and breaching ($n_i = 2$). Gray whales observed in the southcentral Chukchi Sea (south of 69°N) were primarily feeding (70%) and swimming (16%). Gray whales observed in the eastern Beaufort Sea in August were feeding and swimming (Appendix I). Fine-scale sighting rates of feeding and milling gray whales in the ASAMM study area in 2019 are shown in Figure 32. In summer, feeding and milling sighting rates were highest northwest of Wainwright and southwest of Point Hope, while in fall highest sighting rates were limited to southwest of Point Hope 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 rolling.

In 2019, 14 gray whale calves were seen in the ASAMM and ABA study areas (Figure 33). Most calves ($n_i = 11$, 79%) 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) in the ASAMM study area was 0.031, which is lower than calf ratios in 2011-2018 (Figure 34). Calf ratio was highest in July, when eight calves were observed out of a total 152 gray whales. Calf distribution in 2019 overlapped that of adult gray whales temporally and spatially. Most calves (57%, $n_i = 8$) were seen between Point Franklin and Icy Cape, from <1 to 71 km from shore. Four calves were seen in the southcentral Chukchi Sea, and one calf was seen in the eastern Beaufort Sea (Appendix I).

Eight calves were observed in July, one calf was observed in August, three calves were seen in September, and two calves were seen in October. On two occasions, multiple calves were seen in one day, with the highest daily total on 6 July (5 calves; Appendix B, Flight 204). Some calves may have been sighted on more than one day. However, preliminary analysis of opportunistically collected photo-identification data from 2017 indicate that relatively few calves are resighted within the year (Willoughby et al. 2018b).

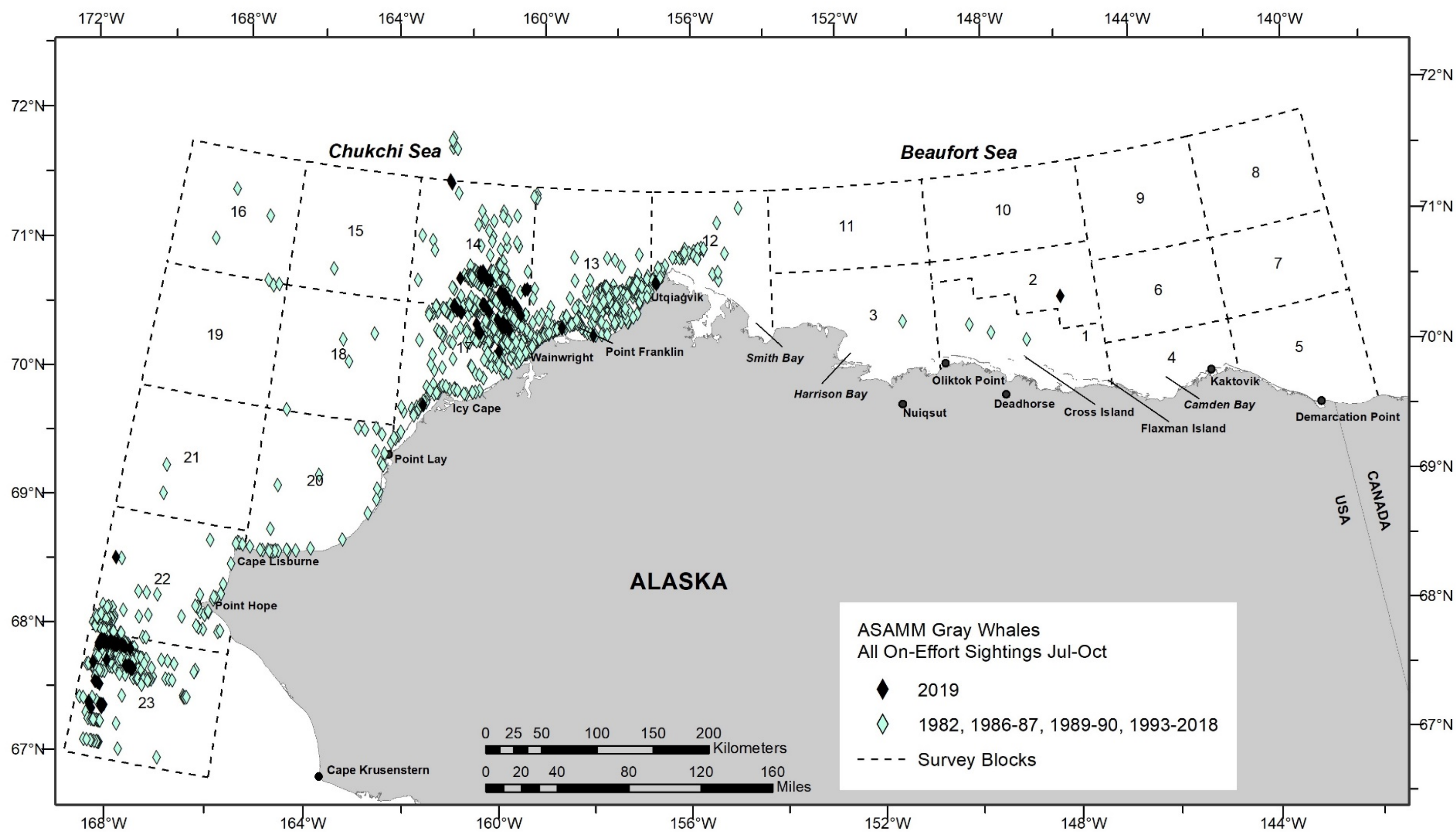


Figure 31. ASAMM gray whale sightings in the ASAMM study area, July-October, in years with light sea ice cover: 1982, 1986-1987, 1989-1990, 1993-2018, and 2019. Includes all on-effort sightings from primary and secondary observers.

Table 10. ASAMM 2019 semimonthly summary of gray whales (number of sightings/ number of individuals) observed during transect, CAPs, search, and circling survey modes in the ASAMM and ABA study areas, 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
Breach	1/2	0	0	0	0	0	0	0	1/2
Dive	0	0	2/2	0	0	0	0	2/2	4/4
Feed	74/105	6/13	29/59	11/16	18/30	22/37	17/21	60/69	237/350
Mill	0	0	0	0	0	1/2	0	0	1/2
Rest	16/18	1/4	1/2	0	1/1	2/2	0	8/8	29/35
Swim	9/11	0	0	3/8	1/3	6/7	2/2	22/23	43/54
TOTAL	100/136	7/17	32/63	14/24	20/34	31/48	19/23	92/102	315/447

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.

Humpback Whales

There were 15 sightings of 24 humpback whales (*Megaptera novaeangliae*), including one calf, in the ASAMM study area in 2019 (Table 4, Figure 35). Stock affiliation of humpback whales in this region is unknown. Humpback whales were seen in the southcentral Chukchi Sea between 67.4°N-68°N in July ($n_i = 9$), September ($n_i = 6$), and October ($n_i = 1$). Humpback whales were seen in July ($n_i = 5$) and September ($n_i = 2$), approximately 145 to 205 km northwest of Point Lay, in an area where few sightings of any cetacean species have been previously encountered. One humpback whale was also sighted approximately 95 km west of Wainwright in July. Images of humpback whales are too few to allow determination of inter- or intra-year resightings. Sighting rates were highest in the 36-50 m depth zone in summer and the 51-200 m South depth zone in fall (Figure 36; Appendix E, Table E-5). Humpback whales were seen in close proximity to gray and fin whales. Humpback whales were observed swimming (38%), feeding (25%), milling (21%), resting (8%), and diving (8%). The only calf observed was seen in July with a group of three adults. None of the humpback whales appeared to respond to the survey aircraft.

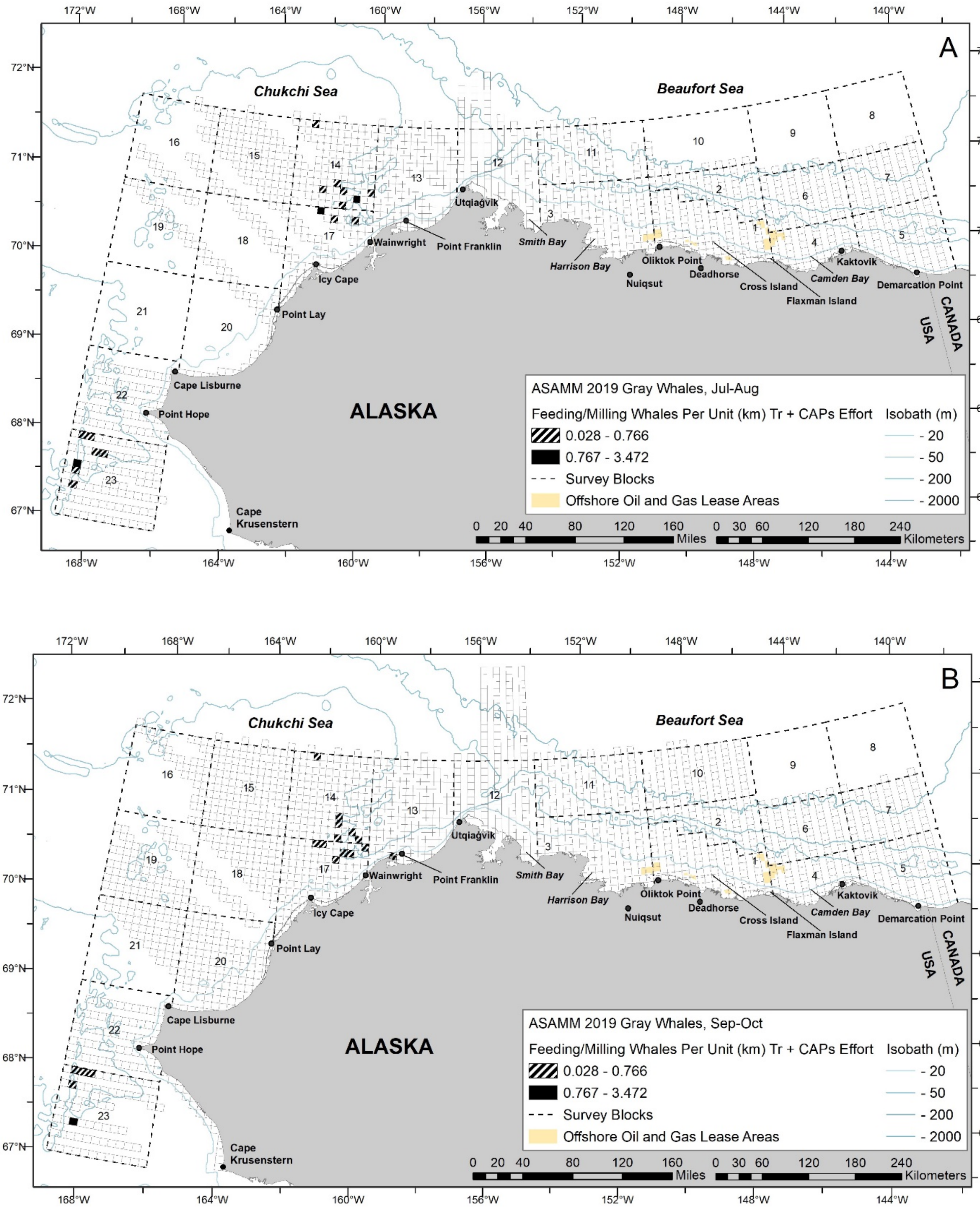


Figure 32. ASAMM 2019 gray whale on-effort seasonal feeding and milling sighting rates (WPUE; sightings from primary observers only) in the ASAMM study area. A: summer (July-August pooled). B: fall (September-October pooled). Empty cells indicate sighting rates of zero. Transect and CAPs survey effort was not conducted in areas without cell outlines.

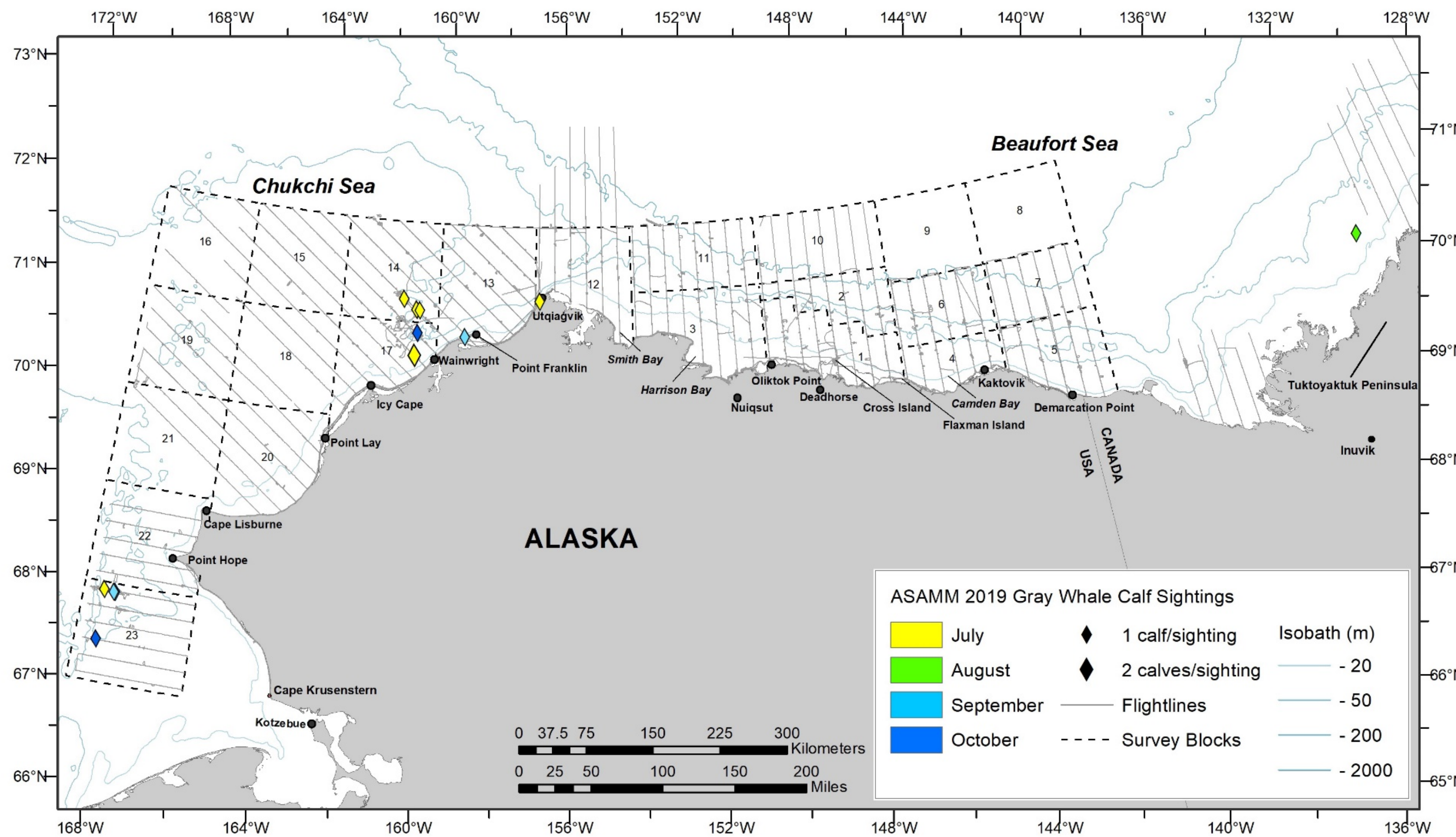


Figure 33. ASAMM 2019 gray whale calf sightings in the ASAMM and ABA study areas, all survey modes, plotted by month, with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.

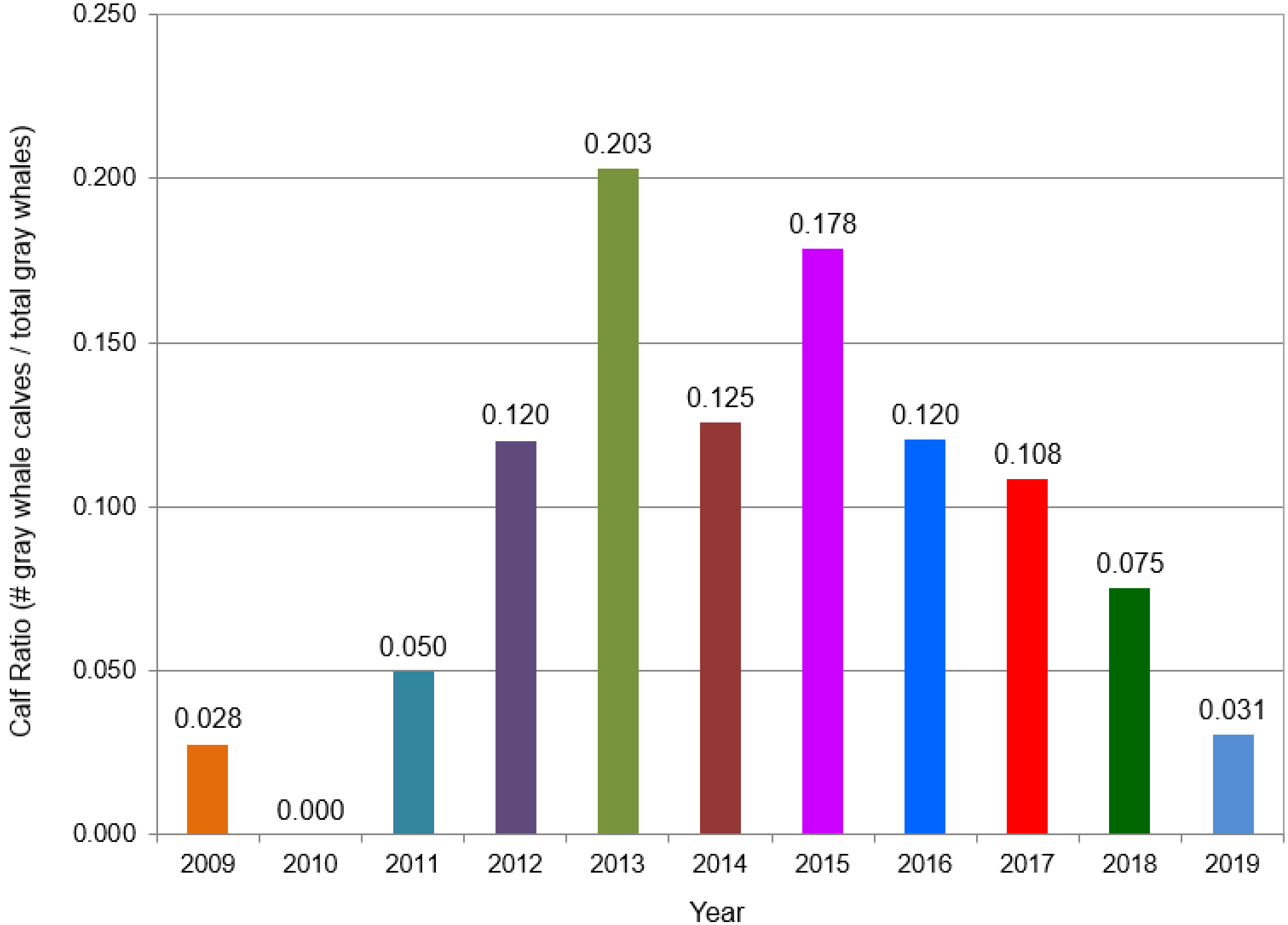


Figure 34. ASAMM gray whale annual calf ratios (number of gray whale calves per total gray whales) in the ASAMM study area, all survey modes, 2009-2019.

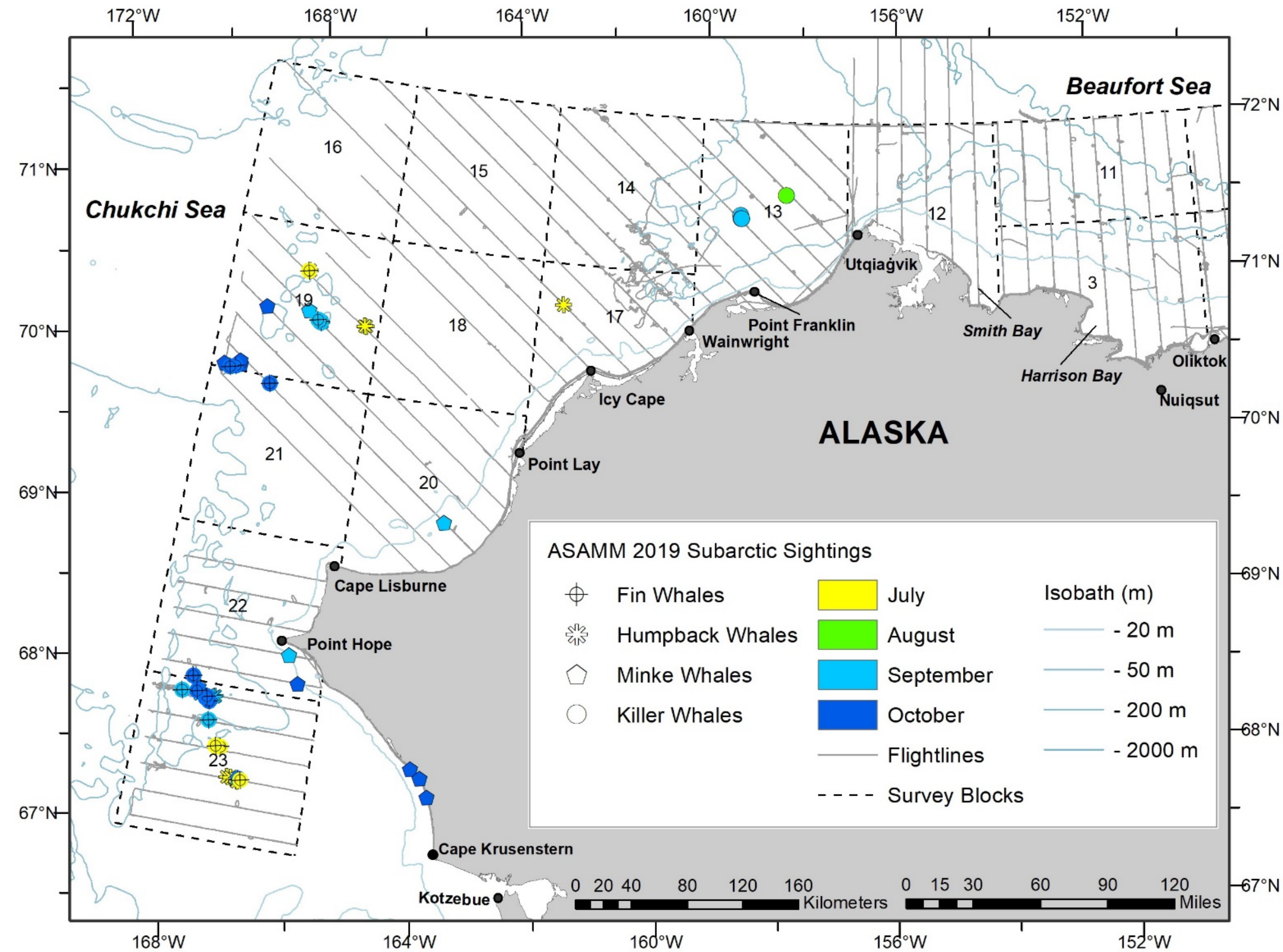


Figure 35. ASAMM 2019 humpback, fin, minke, and killer whale sightings in the ASAMM study area, all survey modes, plotted by month, with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.

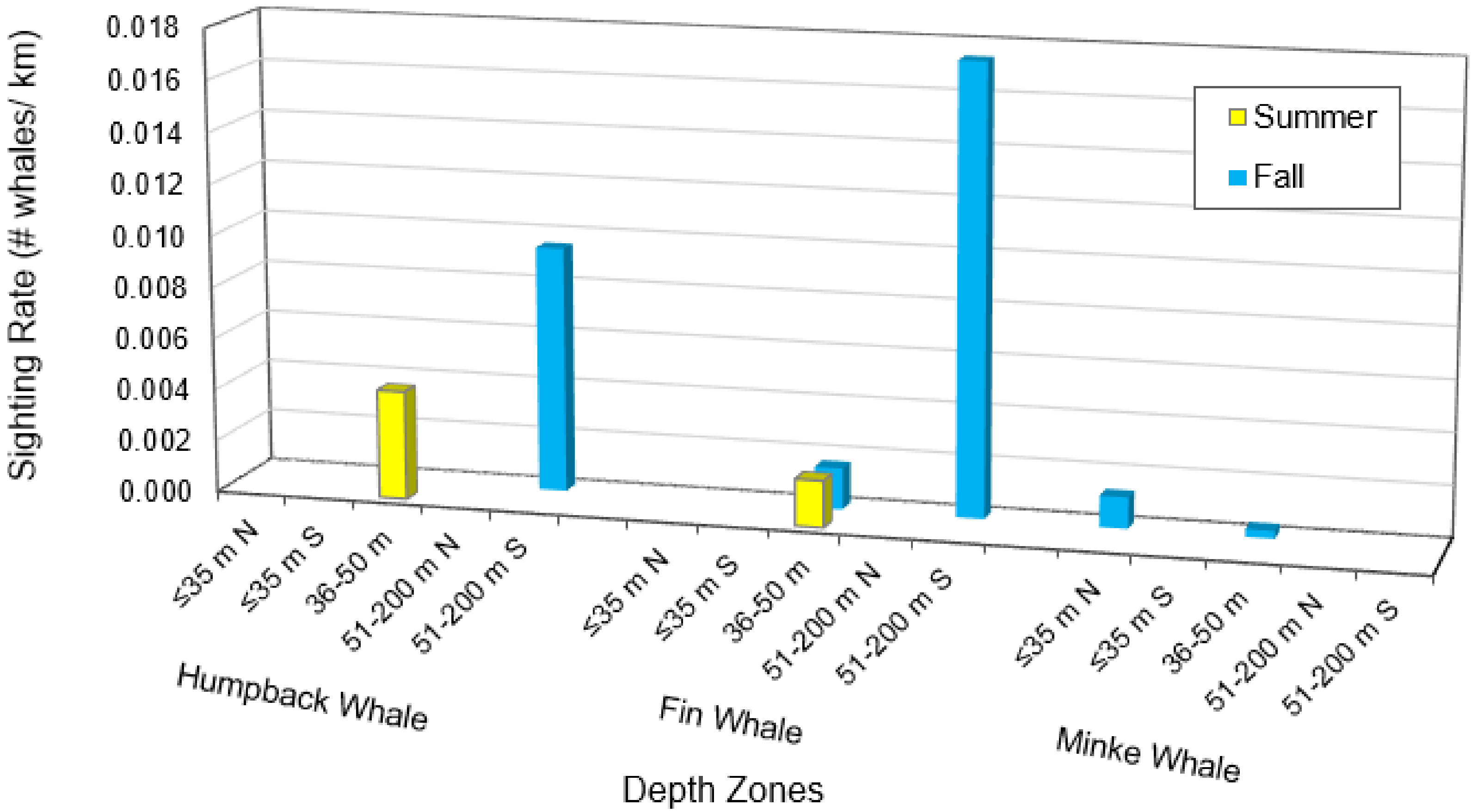


Figure 36. ASAMM 2019 humpback, fin, and minke whale on-effort summer (July-August pooled) and fall (September-October pooled) sighting rates (WPUE; sightings from primary observers only) per depth zone in the eastern Chukchi Sea (67°N-72°N, 157°W-169°W). Sighting rates of zero were removed from the graph for clarity.

Fin Whales

There were 19 sightings of 36 fin whales (*Balaenoptera physalus*) of the Northeast Pacific stock in 2019, including one calf, in the ASAMM study area. Fin whales were seen in the southcentral Chukchi Sea between 67.5°N-68.0°N in July (n_i = 5), September (n_i = 2), and October (n_i = 17) (Table 4; Figure 35). Fin whales were seen in July (n_i = 2), September (n_i = 5), and October (n_i = 5) approximately 145 to 205 km northwest of Point Lay, in the same area where humpback whales were also unexpectedly encountered in 2019. A pair of fin whales sighted on 27 July (Appendix B, Flight 214) represent the farthest north recorded sighting of this species in the Pacific Arctic. Images of fin whales are too few to allow determination of inter- or intra-year resightings. Sighting rates were highest in the 36-50 m depth zone in summer and the 51-200 m South depth zone in fall (Figure 36; Appendix E, Table E-6). Fin whales were seen in close proximity to gray, humpback, and minke whales. Fin whales were observed swimming (50%) and milling (50%). The only calf observed was seen in October with a group of three adults. None of the fin whales appeared to respond to the survey aircraft.

Minke Whales

There were 12 sightings of 13 minke whales (*Balaenoptera acutorostrata*) of the Alaska stock in 2019 in the ASAMM study area (Table 4; Figure 35). Minke whales were observed in September approximately 190 km northwest of Point Lay (n_i = 1), approximately 80 km southwest of Point Lay (n_i = 1), and approximately 10 km south of Point Hope (n_i = 1). In October, minke whales were sighted approximately 210-230 km northwest of Point Lay (n_i = 6), approximately 30 km south of Point Hope (n_i = 1), and along the coastline approximately 40-80 km north of Cape Krusenstern (n_i = 3) Sighting rates were highest in the 0-35 m North depth zone (Figure 36; Appendix E, Table E-7). Minke whales were sighted in close proximity to fin whales. All minke whales sighted were adults. None of the minke whales appeared to respond to the survey aircraft.

Belugas

Beluga Sighting Summary

During the 2019 ASAMM and ABA surveys, 1,555 sightings of 3,847 belugas (*Delphinapterus leucas*) were observed during all survey modes (transect, CAPs, circling, and search) in the ASAMM and ABA study areas from July through October (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). Within the ASAMM study area, 1,007 sightings of 2,885 belugas were observed during transect, CAPs, search, and circling survey modes (Figure 37). There were 548 sightings of 962 belugas in the ABA study area in August (Appendix I).

In the eastern Chukchi Sea, beluga sightings were limited to 23 sightings of 197 whales (Figure 37). Belugas were seen in all months surveyed (July-October) in the western Beaufort Sea along the continental slope (Figure 37), with relatively higher occurrence of belugas nearshore in shelf

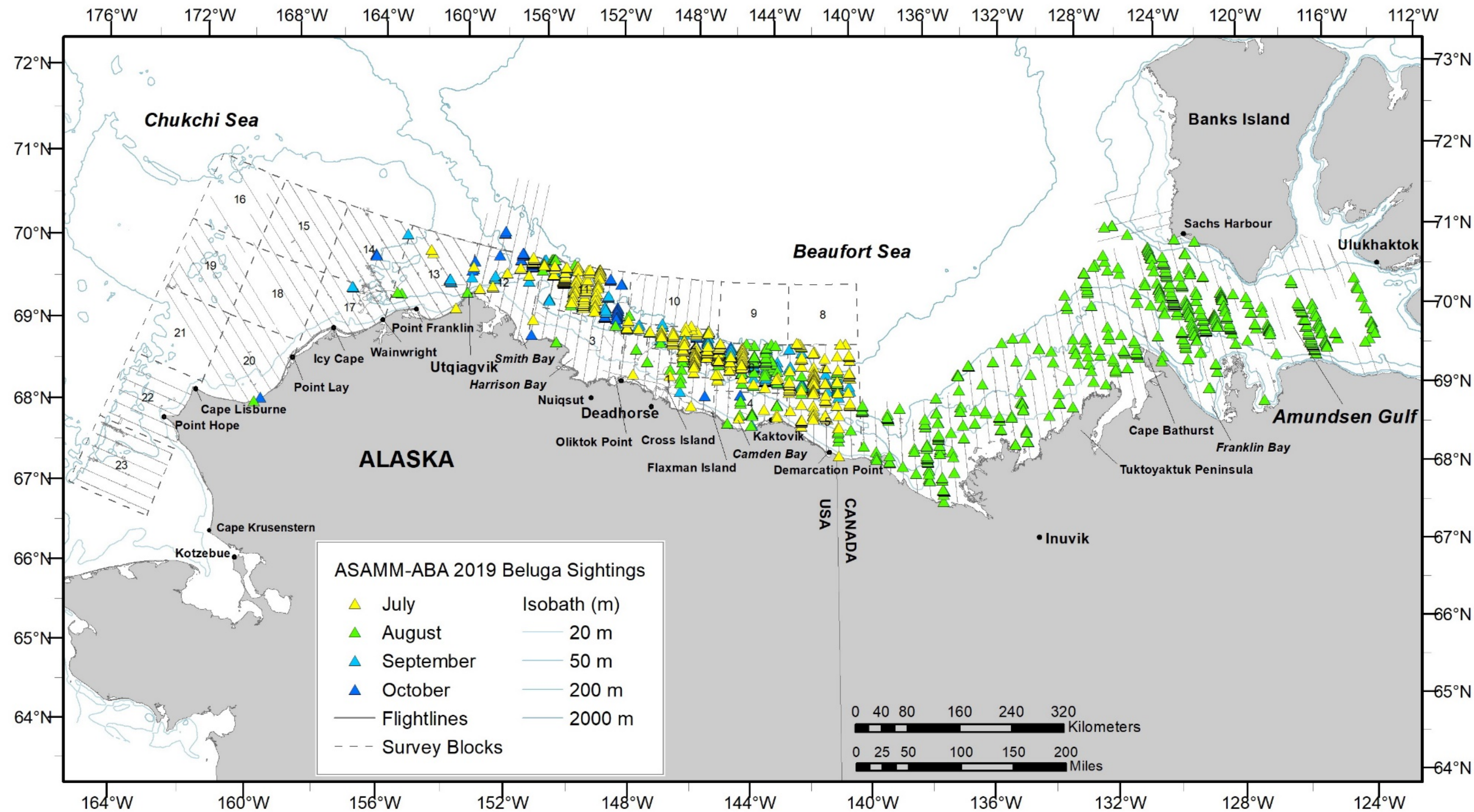


Figure 37. ASAMM 2019 beluga sightings in the ASAMM and ABA study areas, all survey modes, plotted by month, with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.

waters compared to 2012-2018. Sightings nearshore included several moderately large groups of >10 whales. Belugas were seen near Barrow Canyon from July through October. Beluga distribution in 2019 was similar to previous years with light sea ice cover in summer and fall in the western Beaufort Sea (Figure 38). The distribution of the few beluga sightings in the eastern Chukchi Sea in 2019 overlapped that of past years.

Beluga Sighting Rates

In summer and fall 2019, belugas were seen on effort from 68.9°N to 72.4°N between 118.8°W and 163.9°W. There were 1,490 sightings of 3,625 belugas on transect by primary observers in the ASAMM and ABA study areas, ranging from one beluga per sighting ($n_s = 973$) to 200 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 11 ($n_s = 254$), followed by block 6 ($n_s = 196$), and block 2 ($n_s = 188$). In the western Beaufort Sea, sighting rates were highest in July (0.204 WPUE), decreased in August (0.042 WPUE), increased in September (0.057 WPUE), then decreased again October (0.034 WPUE) (Figure 39; Appendix E, Table E-8). In the eastern Chukchi Sea, sighting rates were highest in July (0.039 WPUE), and much lower in August (<0.001 WPUE), September (0.001 WPUE), and October (0.006 WPUE). There were 536 sightings of 844 belugas on transect in the ABA study area Appendix I.

In the ASAMM study area, areas of highest fine-scale sighting rates in summer were mostly offshore on the continental slope and Barrow Canyon (Figure 40). Areas of highest fine-scale sighting rates in fall were offshore on the continental slope.

In the ASAMM study area for all months combined, block 11 had the highest transect sighting rate (0.269 WPUE), followed by block 2 (0.225 WPUE), and block 7 (0.180 WPUE) (Appendix E, Table E-8). Offshore survey blocks located over the continental slope in the western Beaufort Sea (i.e., 2, 6, 7, and 11) generally had higher transect sighting rates than blocks near shore (i.e., 1, 3, and 4) in summer and fall (Figure 41).

Beluga transect sighting rates per depth zone in the ASAMM study area were highest in the 201-2,000 m depth zone near Barrow Canyon (154°W-157°W) and in the central-eastern Beaufort Sea (140°W-154°W) (Figure 42; Appendix E, Table E-9). In the northeastern Chukchi Sea (157°W-169°W), beluga transect sighting rate per depth zone was highest in the 0-35 m depth zone (Appendix E, Table E-9).

Beluga sighting rates per depth zone for the western Beaufort, eastern Beaufort, and Amundsen Gulf during ABA are discussed in Appendix I.

Beluga Sea Ice Associations

Belugas were observed in sea ice cover ranging from no ice to 50% broken floe or new-grease ice. The majority of belugas sightings (95%, $n_i = 3,636$) were in areas with no ice, 4% ($n_i = 141$) were in 1-10% sea ice cover, 1% ($n_i = 44$) were in 11-20% sea ice cover, <1% ($n_i = 24$) were in 21-40% sea ice cover, and <1% ($n_i = 2$) were in 41-50% sea ice cover. Most of the belugas observed in ≥20% sea ice were seen in the western Beaufort Sea in early to mid-July.

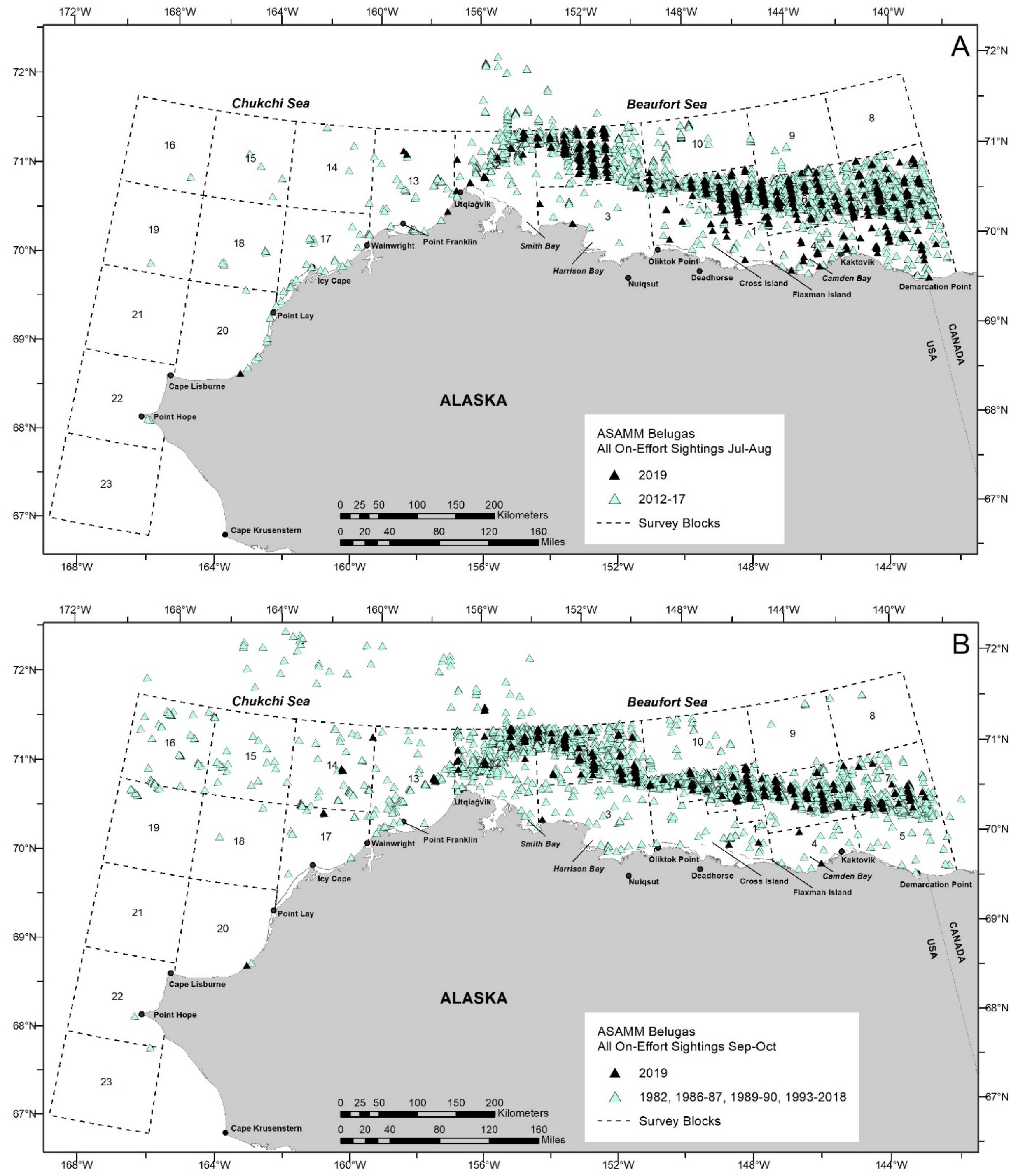


Figure 38. ASAMM beluga on-effort seasonal sightings in the ASAMM study area, 1982-2019. A: summer (July-August) in years with light sea ice cover (2012-2017, 2019). B: September-October in years with light sea ice cover (1982, 1986-1987, 1989-1990, 1993-2019). Includes all on-effort sightings made by primary and secondary observers.

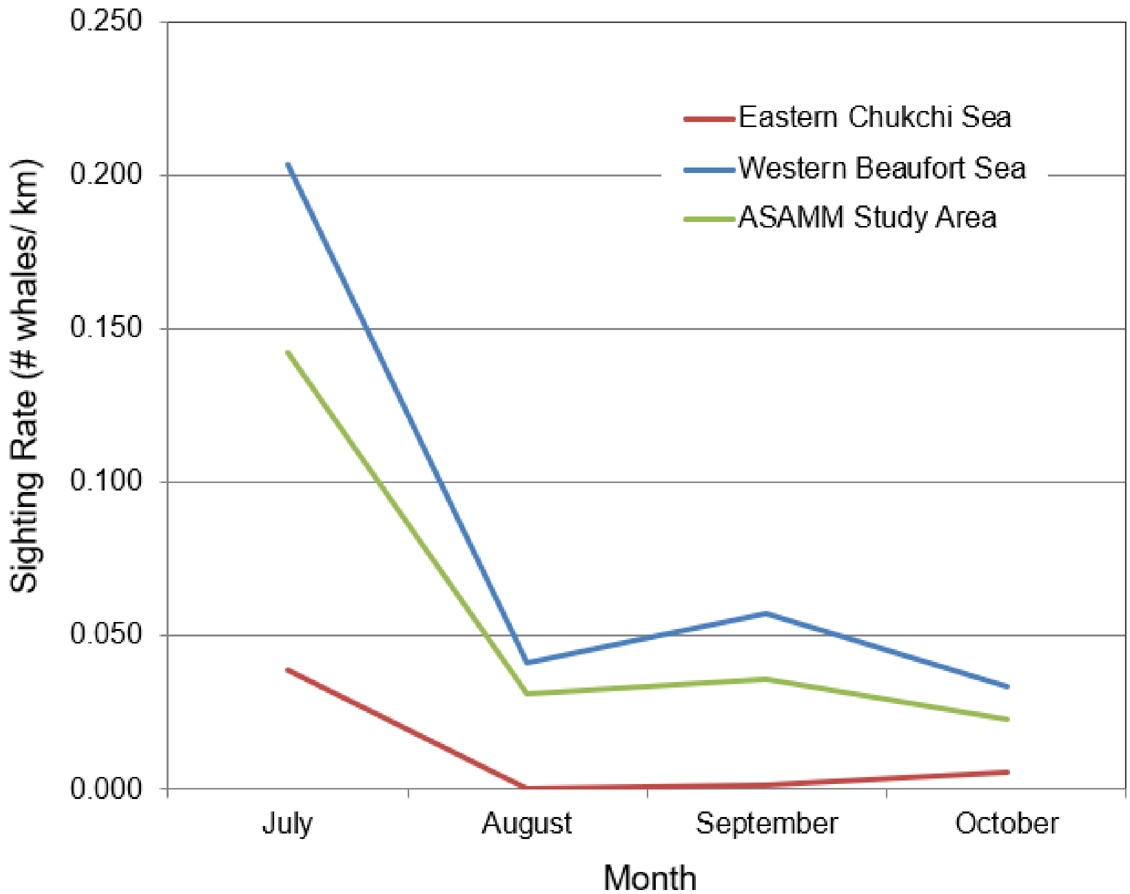
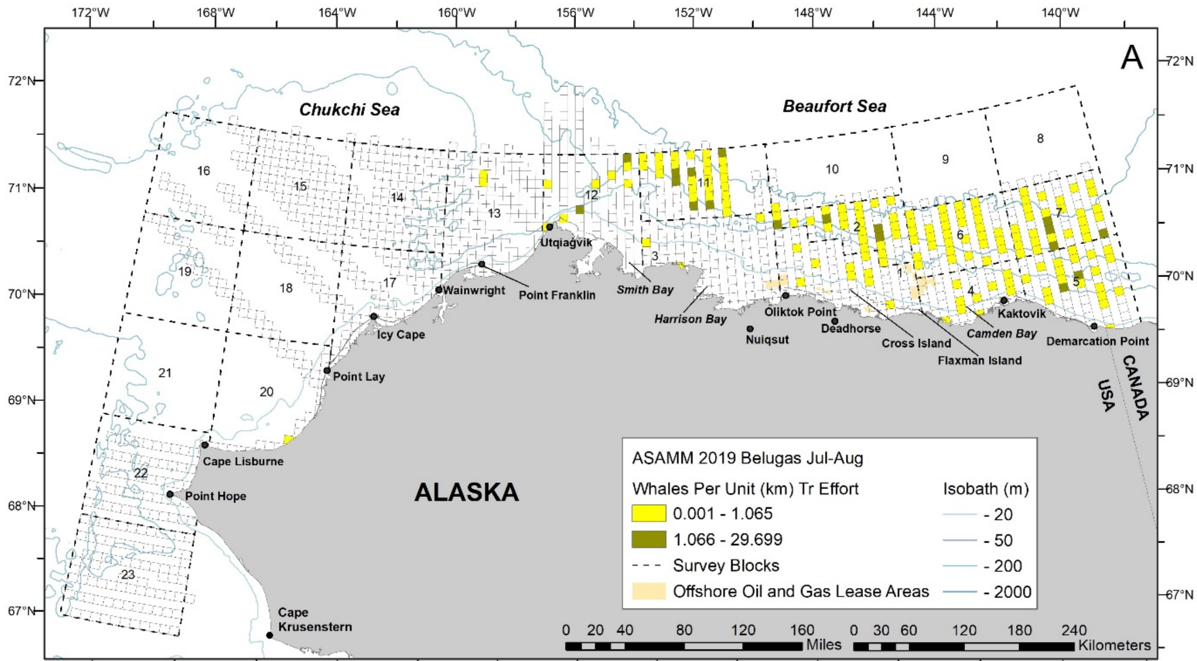


Figure 39. ASAMM 2019 beluga on-effort monthly sighting rates (WPUE; transect sightings from primary observers only) in the western Beaufort Sea, eastern Chukchi Sea, and combined ASAMM study area.

Beluga Behaviors

Beluga behaviors observed in the ASAMM and ABA study areas during transect, CAPs, circling, and search survey modes in 2019 are summarized in Table 11. The behavior most often recorded was swimming (79%). Resting was recorded for 408 belugas (11%), milling was recorded for 366 belugas (10%), and 14 belugas (<1%) were observed diving. Three belugas were observed feeding. Fourteen belugas (<1%) appeared to respond to the survey aircraft by changing the behavior initially observed, usually from swimming to diving.

Swim direction was evaluated for belugas for different regions and time periods. Swim direction was westerly in the Beaufort Sea and Amundsen Gulf (118°W-154°W) in summer, clustered around a mean heading of 273°T ($Z = 20.154$, $P < 0.0001$, 907 observations). In fall, swim direction in the western Beaufort Sea (140°W-154°W) remained westerly, significantly clustered around a mean heading of 287°T ($Z = 36.722$, $P < 0.0001$, 299 observations). Mean vector swim direction for belugas in the northeastern Chukchi Sea (154°W-169°W, to incorporate Barrow



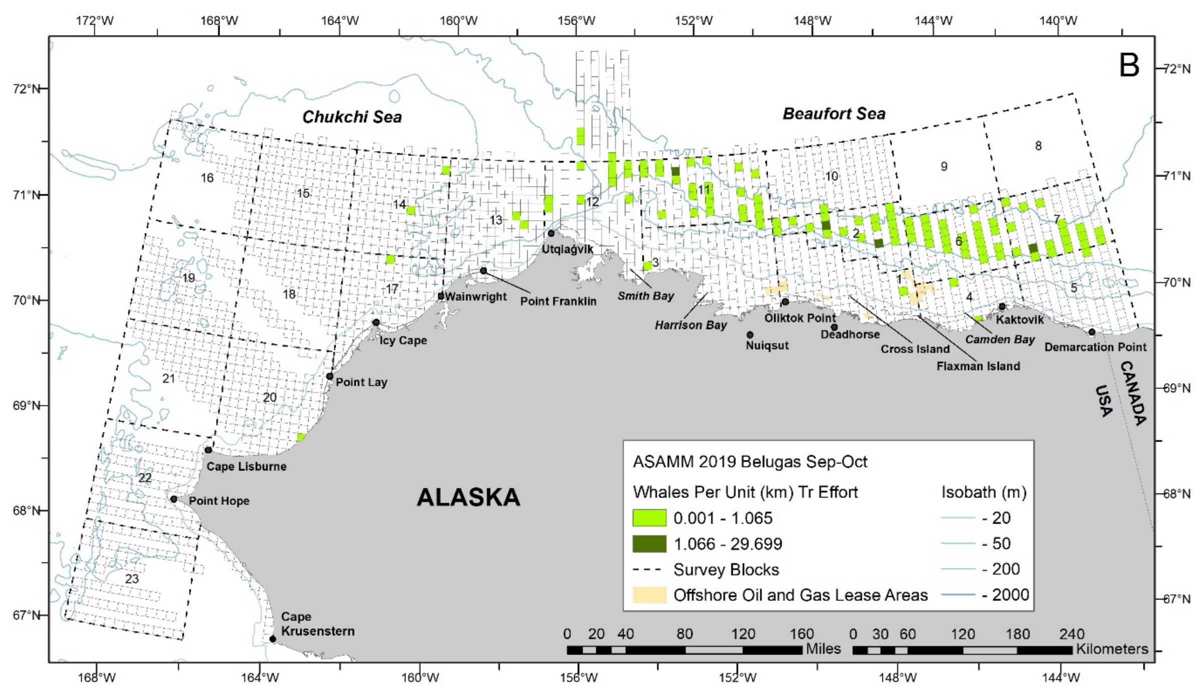


Figure 40. ASAMM 2019 beluga on-effort seasonal sighting rates (WPUE; sightings from primary observers only) in the ASAMM study area. A: summer (July-August pooled). B: fall (September-October pooled). Empty cells indicate sighting rates of zero. Transect survey effort was not conducted in areas without cell outlines.

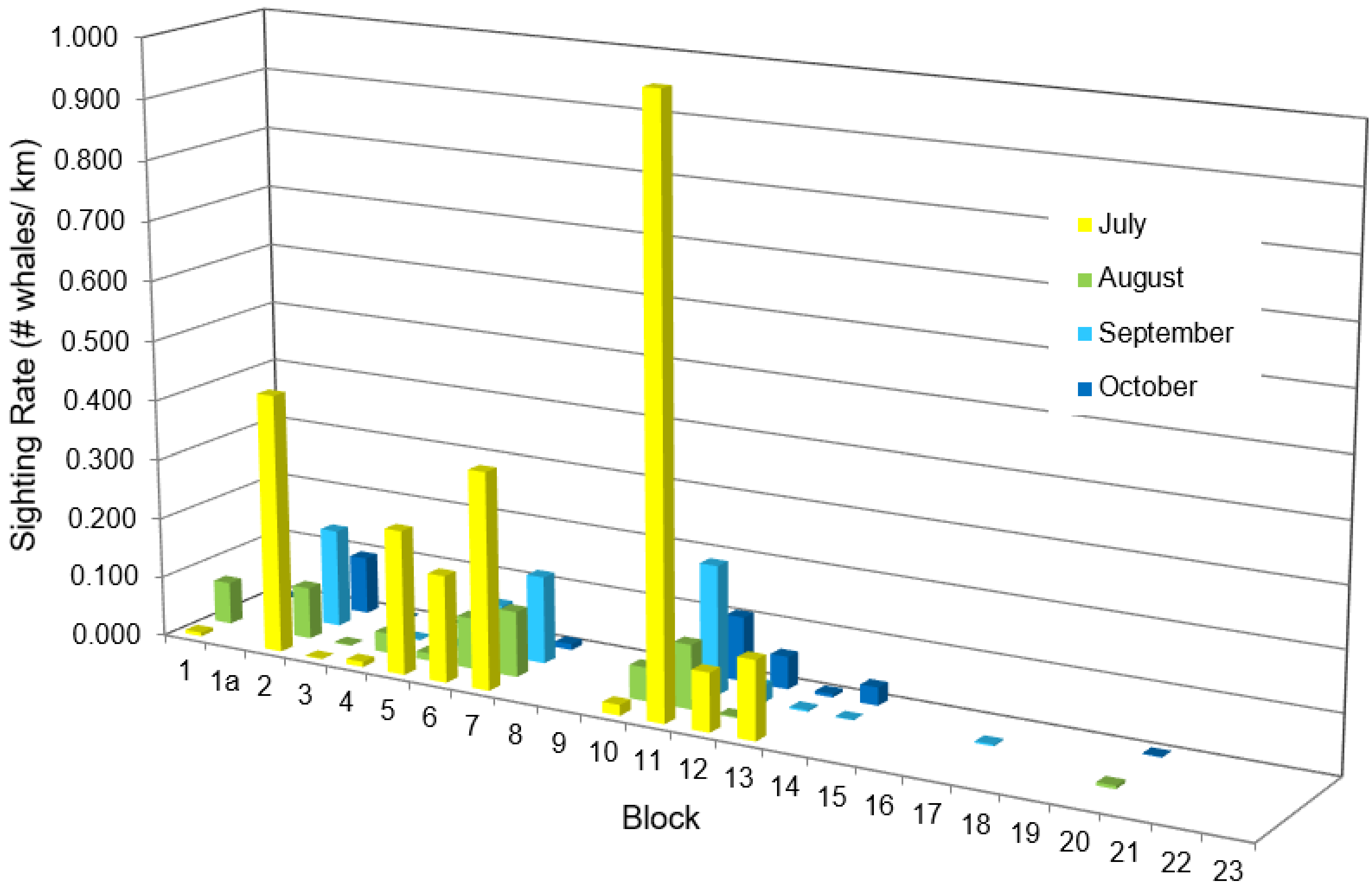


Figure 41. ASAMM 2019 beluga on-effort monthly sighting rates (WPUE; sightings from primary observers only) per block in the ASAMM study area, July-October. Sighting rates of zero were removed from the graph for clarity.

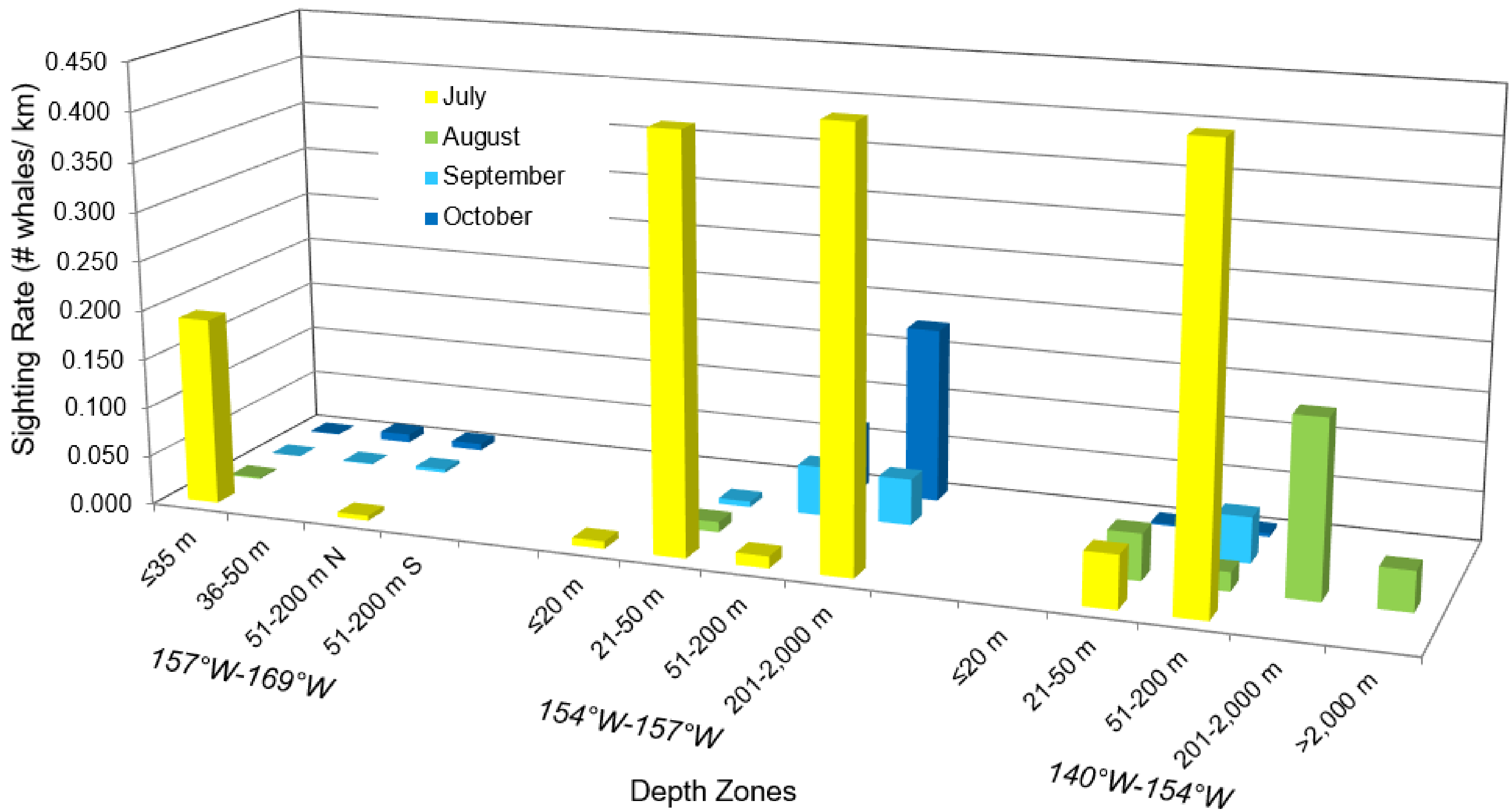


Figure 42. ASAMM 2019 beluga on-effort monthly sighting rates (WPUE; sightings from primary observers only) per depth zone in the ASAMM study area, July-October. Sighting rates of zero were removed from the graph for clarity.

Table 11. ASAMM 2019 semimonthly summary of belugas (number of sightings/ number of individuals) observed during transect, circling, and search survey modes in the ASAMM and ABA study areas, 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	1/1	4/5	1/1	6/6	0	1/1	0	0	13/14
Feed	0	0	0	0	0	0	1/3	0	1/3
Mill	10/81	7/25	2/73	19/123	2/46	3/8	1/10	0	44/366
Rest	6/155	66/121	8/8	36/44	11/18	11/11	7/14	20/37	165/408
Swim	164/672	181/503	81/155	567/848	60/162	161/446	65/133	48/129	1,327/3,048
Unknown	0	0	0	5/8	0	0	0	0	5/8
TOTAL	181/909	258/654	92/237	633/1,029	73/226	176/466	74/160	68/166	1,555/3,847

Canyon) was significantly clustered around a mean heading in summer (271°T, $Z = 6.953$, $P < 0.0001$, 23 observations) but not in fall (257°T, $Z = 2.563$, $P < 0.075$, 14 observations).

There were 247 sightings of 339 beluga calves observed in the ASAMM and ABA study areas during transect, CAPs, circling, and search survey modes (Figure 43). 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 extended from eastern Amundsen Gulf to the western Beaufort Sea slope and in Barrow Canyon, with scattered calf sightings in the northeastern Chukchi Sea (Figure 43). The largest calf concentration was observed north of Harrison Bay in mid-July, part of a group of approximately 200 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 four sightings of 15 killer whales (*Orcinus orca*) in the ASAMM study area in 2019 (Table 4; Figure 35). A pair of killer whales was observed on 30 August, approximately 55 km northwest of Utqiaġvik. Thirteen killer whales, in three small closely aligned groups, were seen on 17 September, approximately 80 km west of Utqiaġvik. The latter sighting included two calves. None of the killer whales appeared to respond to the survey aircraft.

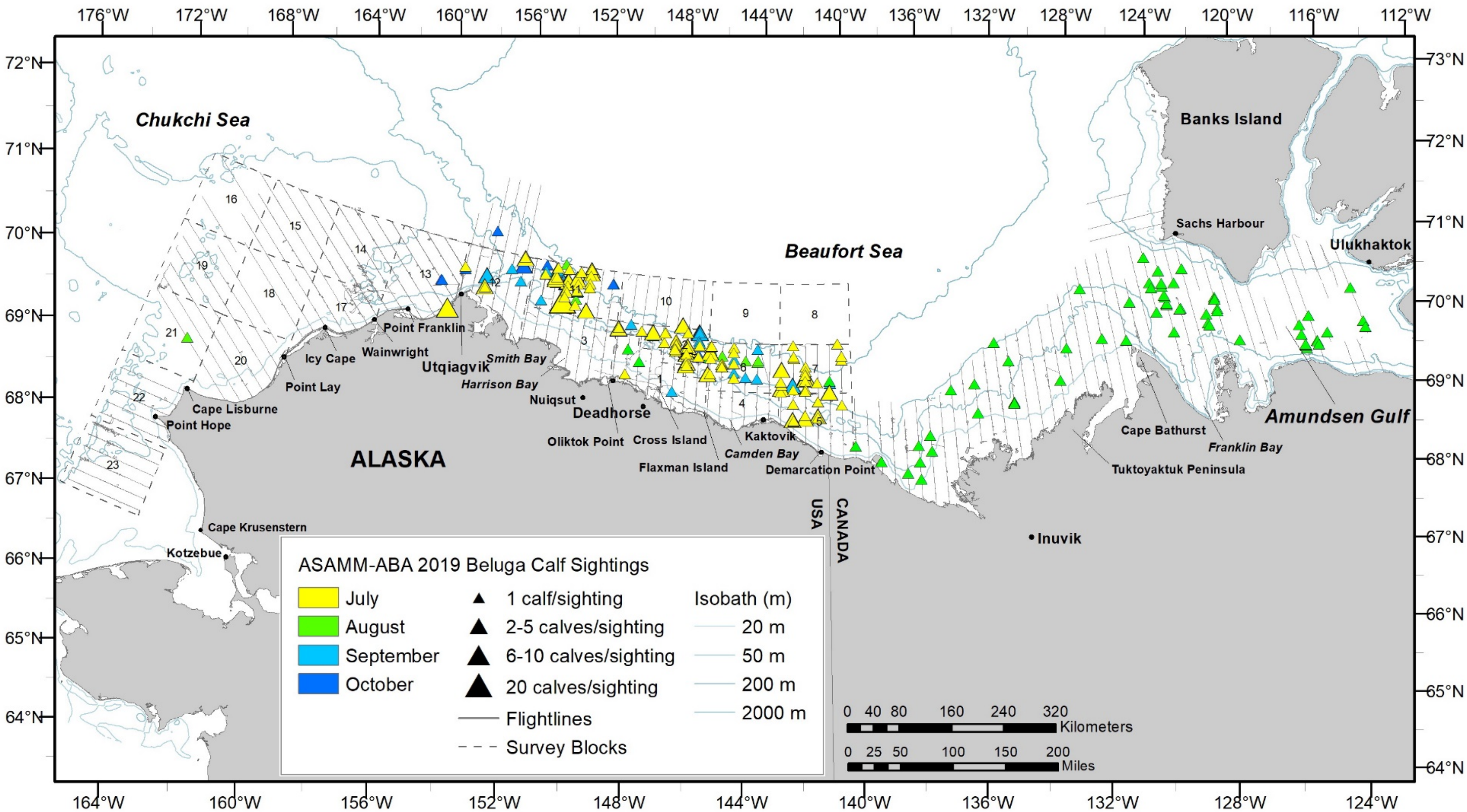


Figure 43. ASAMM 2019 beluga calf sightings in the ASAMM and ABA study areas, all survey modes, plotted by month, with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.

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, when the sighting was >3 km from the trackline, or when environmental conditions such as fog, low cloud ceilings, glare, or sea state hindered efforts to relocate the initial sighting. There were 32 sightings of 35 unidentified cetaceans and 1 sighting of 2 small unidentified cetaceans in the ASAMM and ABA study areas in 2019 (Table 4; Figure 44). Four of the unidentified cetaceans were in the eastern Beaufort Sea or Amundsen Gulf, 18 of the unidentified cetaceans (including the 2 small unidentified cetaceans) were in the western Beaufort Sea, and 15 unidentified cetaceans were in the eastern Chukchi Sea. Several (n_i = 9) unidentified cetacean sightings were in blocks 22 and 23 and were likely fin or humpback whales based on the presence of those species in mixed species groups nearby. One of the unidentified cetaceans in the western Beaufort Sea was probably a bowhead whale, based on its size and darker color. Two unidentified cetaceans were likely minke whales and the small unidentified cetaceans were likely belugas, 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.

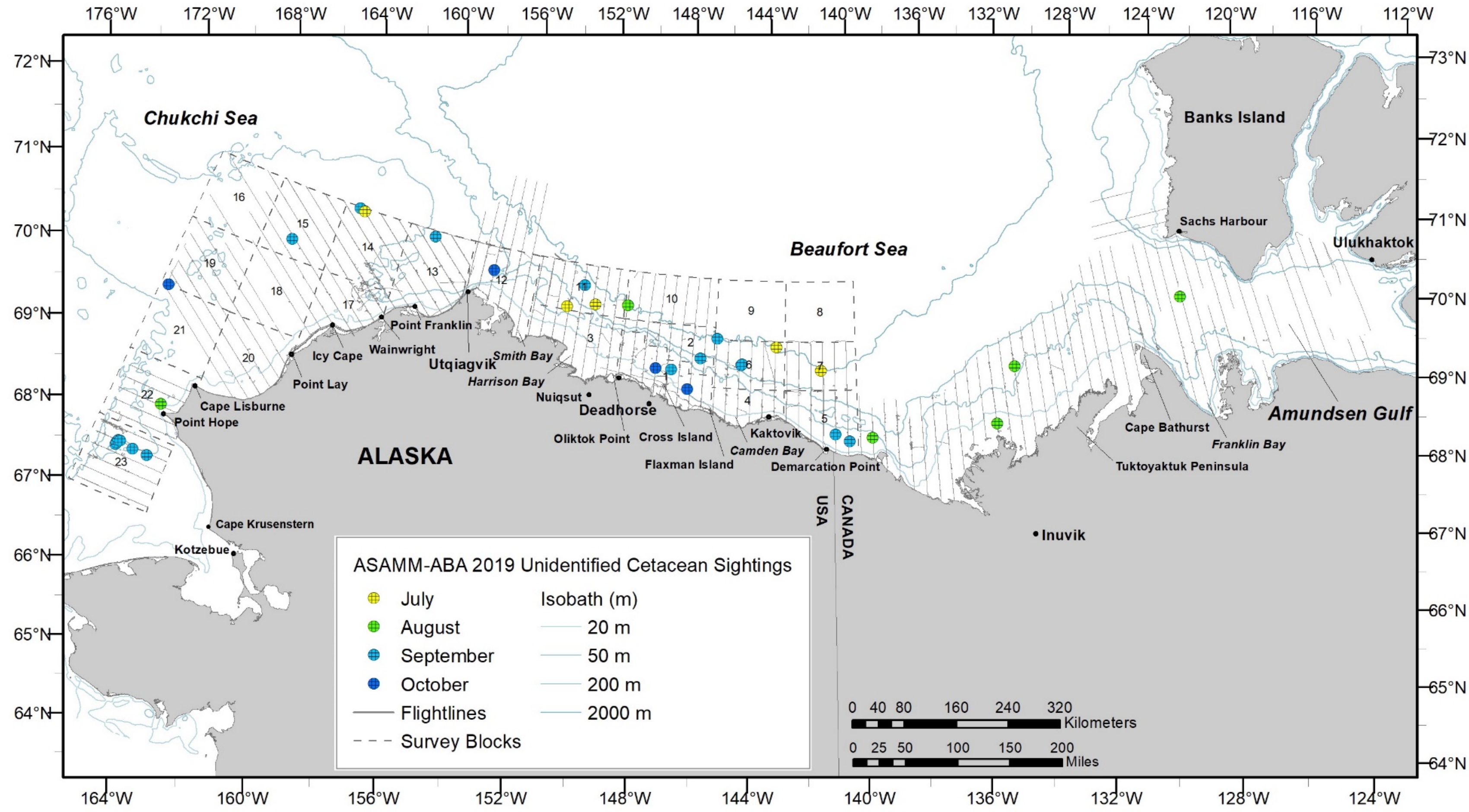


Figure 44. ASAMM 2018 unidentified cetacean sightings in the ASAMM and ABA study areas, all survey modes, plotted by month, with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.

This page intentionally left blank.

Pinnipeds

Walruses

Pacific walruses (*Odobenus rosmarus divergens*) were observed every month in the eastern Chukchi Sea (Figure 45). Excluding dead walruses and walruses that were known to be duplicate sightings within the same day, there were 959 sightings of 93,416 walruses observed from July to October 2019 (Table 12). 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 = 2, n_i = 45,000), there were 953 sightings of 52,616 walruses in 2019. Excluding sightings of the Point Lay haulout, most walruses (51%, n_i = 3,884 out of 7,616) were sighted in September. Relatively few walruses (n_s = 12, n_i = 15) were observed in the western Beaufort Sea, between Point Barrow and 151.4°W.

Most walruses (64%, n_i = 1,891 out of 2,975) observed in July were hauled out on sea ice that remained in the eastern Chukchi Sea survey area (Figure 45A). Group sizes of walruses on ice were moderately large, ranging from 15 to 700 walruses. Relatively few walruses were seen in August in the eastern Chukchi Sea due, at least in part, to the eastward shift of survey effort for ABA (Figure 45B). In September, walruses were observed widely scattered in the northeastern Chukchi Sea between 154.9°W and 167.4°W (Figure 45C). A large group of walruses (n_i = 3,000) was observed milling approximately 25 km offshore in Ledyard Bay in mid-September. By October, most walruses were sighted on Hanna Shoal, within a few km of the coastal haulouts at Point Lay, and south of Point Lay in Ledyard Bay (Figure 45D). Walruses not hauled out on sea ice or on the coast were observed swimming, resting, milling, or diving.

ASAMM was informed by USFWS on 30 July 2019 that walruses were ashore on the barrier island west of Point Lay. Due to other survey priorities, including ABA, ASAMM was unable to document the haulout until 31 August (Appendix B, Flight 232), when three groups of walruses totaling approximately 10,300, were photographed. The 2019 haulout was located on the same barrier island where walrus haulouts were documented during ASAMM surveys in 2010, 2011, 2013, 2014, 2015, 2016, 2017, and 2018 (Clarke et al. 2011d, 2012, 2014, 2015, 2017a,b, 2018, 2019). ASAMM observed the walrus haulout aggregation(s) during two subsequent surveys on 6 September (30,500 walruses) and 21 September (45,000 walruses). A survey near Point Lay on 5 October indicated that the haulout was no longer occupied. To avoid disturbing the walruses, photographs of the haulout were taken from greater than 3.7 km lateral distance and 2000 m altitude.

Fine-scale transect sighting rates of walruses prior to the formation of the coastal haulout near Point Lay on 30 July were uniform in the northern half of block 14, which encompasses Hanna Shoal, and block 13 (Figure 46A). Highest fine-scale transect sighting rates of walruses observed after the Point Lay haulout was established were in block 20, immediately offshore of the coastal haulout and approximately 80 km southwest of Point Lay in Ledyard Bay (Figure 46B).

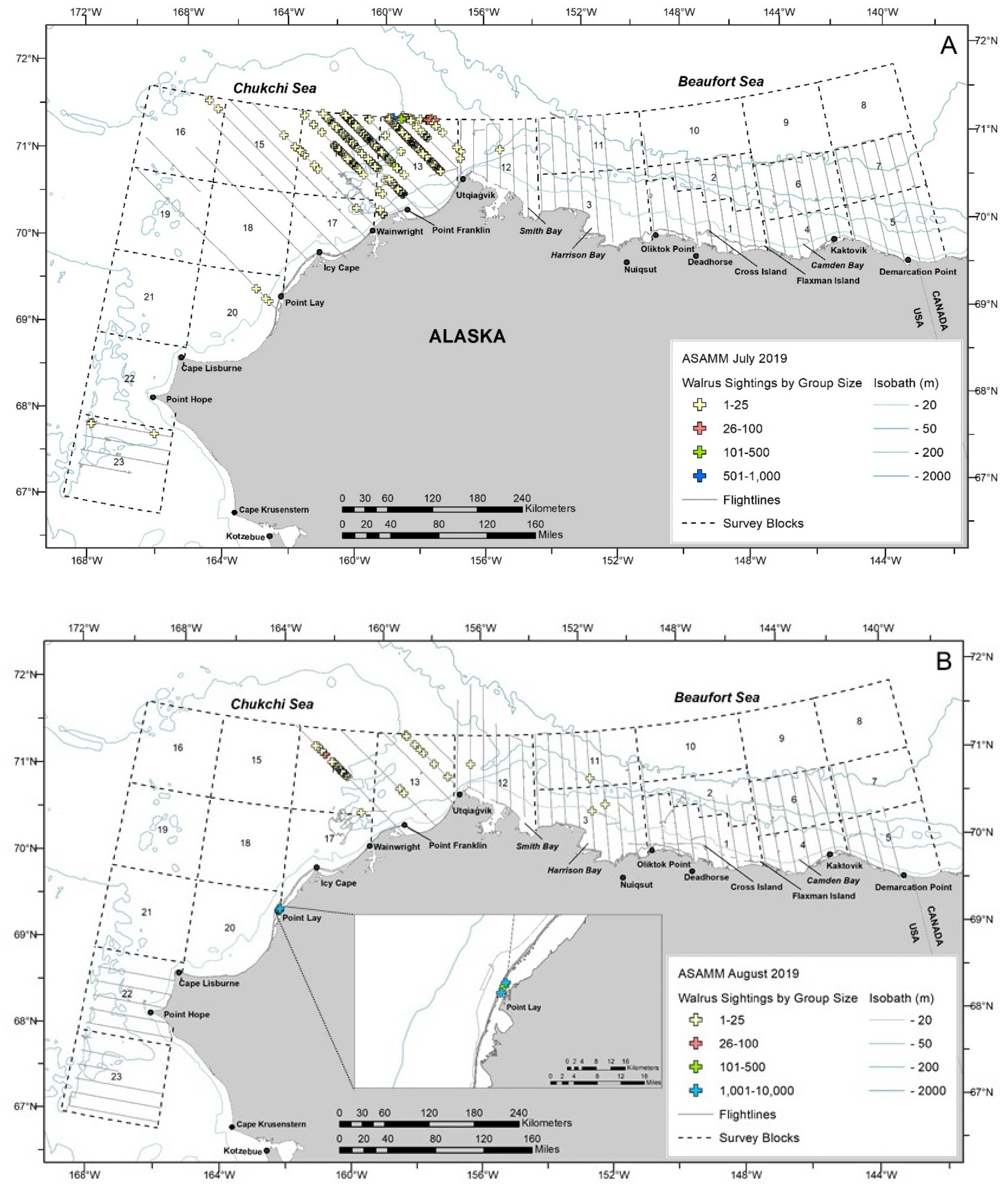
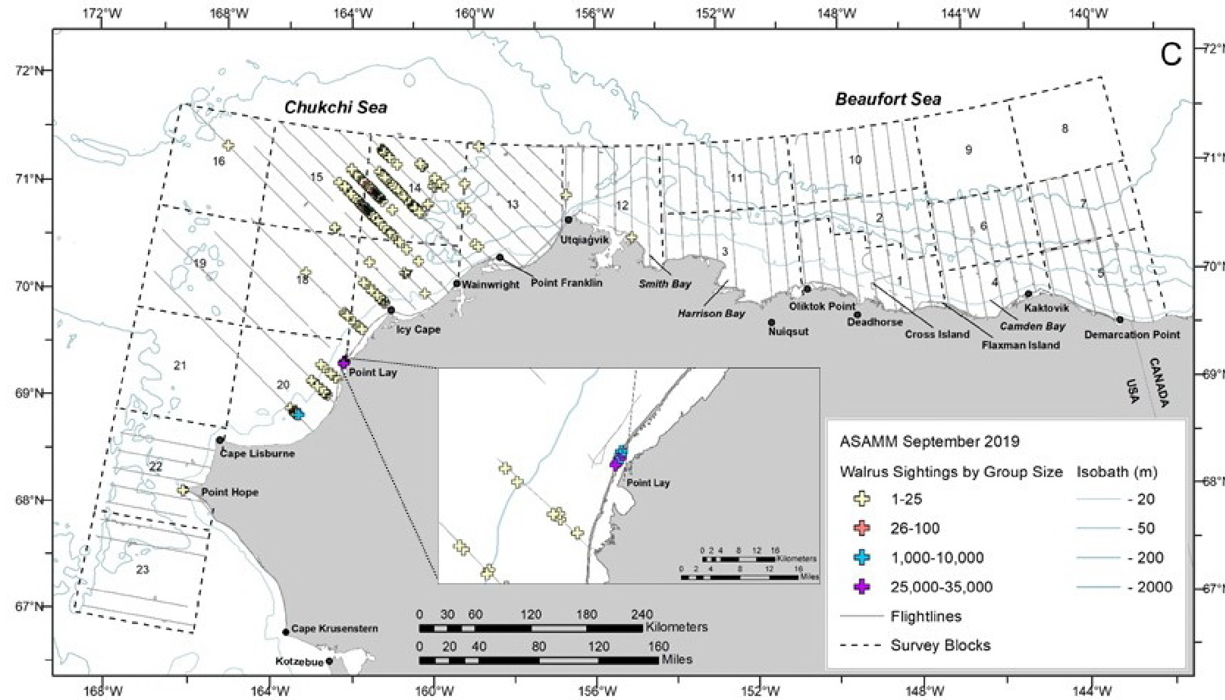


Figure 45. ASAMM 2019 walrus sightings in the ASAMM study area, plotted by month and group size; sightings and effort from transect, CAPs, search, circling, and FGF survey mode, July-October. A: July. B: August. Deadhead flight tracks are not shown.



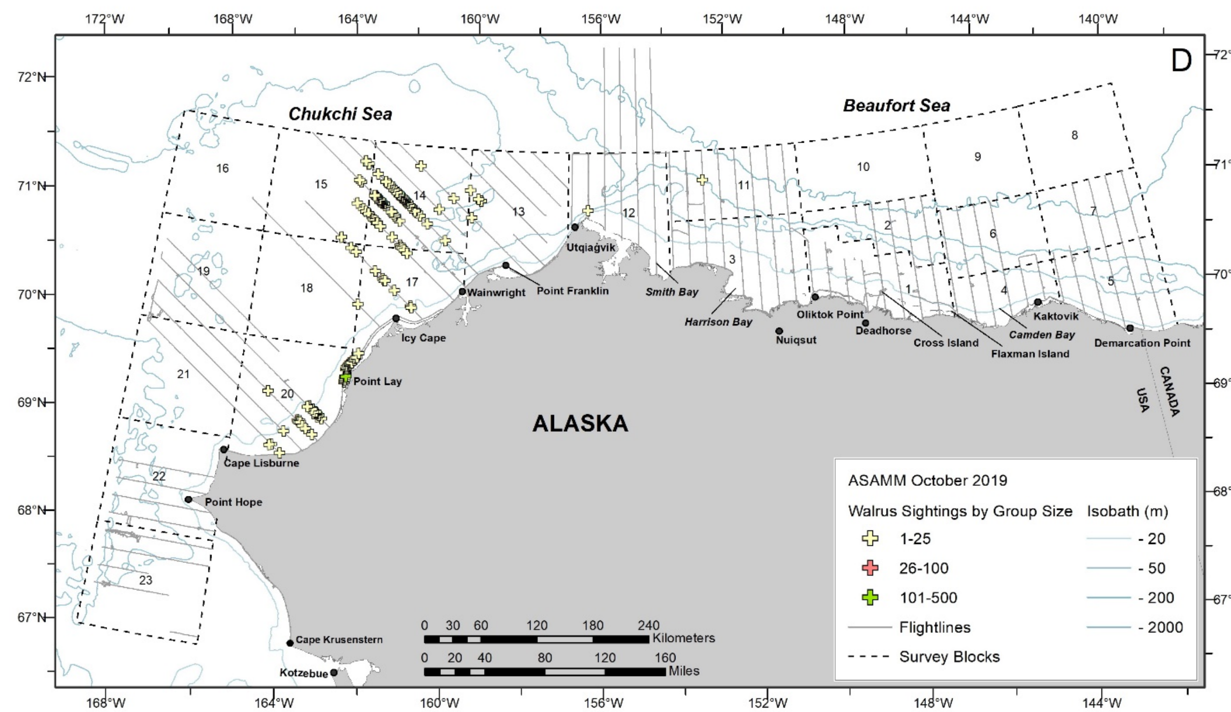


Figure 45 (cont.). ASAMM 2019 walrus sightings in the ASAMM study area, plotted by month and group size; sightings and effort from transect, CAPs, search, circling, and FGF survey mode, July-October. C: September. D: October. Deadhead flight tracks are not shown.

Table 12. Summary of ASAMM and ABA 2019 pinniped and polar bear sightings (number of sightings/number of individuals) during transect, search, and circling survey modes, in chronological order, 2 July–29 October 2019, by survey flight and semimonthly period. Excludes dead and repeat sightings.

Day	Flight No.	Walrus	Bearded Seal	Unidentified Pinniped*	Polar Bear
2 Jul	201	142/1,772	0	3/3	0
3 Jul	202	24/36	0	11/16	0
4 Jul	203	0	0	5/5	0
6 Jul	204	7/8	0	12/13	1/1
7 Jul	205	3/4	0	61/100	0
11 Jul	206	0	2/2	32/750	0
12 Jul	207	0	0	20/39	1/1
13 Jul	208	10/10	1/1	34/37	0
17 Jul	209	72/90	0	21/23	0
18 Jul	210	2/4	0	0	0
19 Jul	1	0	4/4	8/8	0
21 Jul	2	0	1/1	0	3/7
21 Jul	211	214/1,047	1/1	22/22	0
22 Jul	3	0	4/4	32/58	0
22 Jul	212	1/1	0	3/3	1/1
23 Jul	213	0	0	26/277	0
25 Jul	4	0	0	0	3/3
27 Jul	214	3/3	0	2/9	0
27 Jul	5	0	0	0	0
30 Jul	6	0	12/13	25/55	0
31 Jul	7	0	9/10	47/163	6/29
2 Aug	8	0	0	1/1	5/9
2 Aug	215	1/3	0	0	0
4 Aug	9	0	0	0	0
5 Aug	10	0	0	13/13	1/1
6 Aug	11	0	0	0	0
8 Aug	401	0	0	0	0
8 Aug	216	0	0	0	0
9 Aug	217	0	0	0	0
9 Aug	402	0	0	1/3	0
11 Aug	12	0	0	0	0
11 Aug	403	0	0	0	0
12 Aug	13	0	0	0	1/17
12 Aug	218	0	0	2/4	0
13 Aug	404	0	0	0	0

Day	Flight No.	Walrus	Bearded Seal	Unidentified Pinniped*	Polar Bear
13 Aug	219	0	0	3/3	1/1
14 Aug	14	0	0	0	0
14 Aug	220	0	0	0	0
15 Aug	405	0	0	2/2	0
15 Aug	15	0	0	0	1/9
16 Aug	16	0	0	0	3/4
16 Aug	221	0	0	16/17	4/4
17 Aug	222	0	0	4/22	0
17 Aug	17	0	0	3/4	0
19 Aug	406	0	0	38/60	0
19 Aug	223	0	1/1	18/30	4/4
20 Aug	407	0	0	1/1	0
20 Aug	224	0	0	29/63	1/1
21 Aug	408	0	0	34/44	0
21 Aug	225	0	0	24/152	0
21 Aug	18	2/2	2/2	39/52	2/27
22 Aug	226	0	0	12/31	0
22 Aug	409	0	0	29/52	0
22 Aug	19	0	0	0	3/3
23 Aug	410	0	0	4/10	0
23 Aug	227	0	0	0	0
25 Aug	411	0	0	10/25	0
25 Aug	228	0	0	4/17	4/6
25 Aug	20	0	0	23/57	17/61
26 Aug	229	0	0	1/1	3/5
26 Aug	21	1/1	0	8/8	0
26 Aug	412	0	0	3/3	0
27 Aug	230	0	0	15/17	1/2
27 Aug	413	0	0	36/48	1/1
27 Aug	22	0	1/1	0	2/3
28 Aug	23	0	0	5/6	5/8
29 Aug	24	1/1	1/1	36/79	0
30 Aug	25	0	1/1	92/341	6/7
30 Aug	231	37/188	1/1	50/64	0
31 Aug	26	0	0	0	0
31 Aug	232	3/10,300	0	5/1,203	0
2 Sep	27	0	0	0	4/6
2 Sep	233	6/7	0	3/3	0
3 Sep	28	0	1/1	28/72	2/3
4 Sep	29	0	1/1	35/231	0

Day	Flight No.	Walrus	Bearded Seal	Unidentified Pinniped*	Polar Bear
5 Sep	30	1/1	1/1	25/34	6/11
5 Sep	234	60/242	0	77/106	0
6 Sep	235	14/30,555	0	7/8	0
7 Sep	31	0	0	0	0
7 Sep	236	3/3	0	3/3	0
8 Sep	32	0	1/1	35/88	1/1
8 Sep	237	24/43	0	18/32	0
9 Sep	33	0	1/2	40/74	4/8
10 Sep	34	0	3/3	16/37	1/1
14 Sep	238	0	0	0	0
17 Sep	239	63/290	0	14/17	0
17 Sep	35	0	0	1/1	0
18 Sep	36	0	0	2/2	0
18 Sep	240	6/12	0	0	0
20 Sep	241	0	0	0	1/1
21 Sep	242	23/48,080	0	15/21	0
22 Sep	243	0	0	0	0
23 Sep	244	0	0	8/9	0
24 Sep	37	0	5/5	35/53	4/6
24 Sep	245	0	0	66/207	5/29
25 Sep	246	0	0	1/1	0
25 Sep	38	0	0	1/1	27/54
26 Sep	247	79/147	0	56/63	0
26 Sep	39	0	0	0	0
27 Sep	40	0	0	10/17	3/5
28 Sep	41	0	1/1	53/135	7/38
28 Sep	248	1/3	0	16/19	2/2
29 Sep	249	1/1	0	7/7	0
29 Sep	42	0	0	1/1	11/19
30 Sep	43	0	1/1	20/21	2/3
1 Oct	250	5/12	3/3	68/92	0
3 Oct	44	0	0	8/9	9/57
3 Oct	251	1/2	0	4/4	0
5 Oct	45	42/70	0	5/8	3/7
5 Oct	252	11/23	0	3/4	0
7 Oct	253	45/67	1/1	54/77	0
7 Oct	46	0	0	3/3	0
8 Oct	47	0	3/3	38/43	0
8 Oct	254	0	0	1/1	0
9 Oct	48	0	2/2	43/58	5/43

Day	Flight No.	Walrus	Bearded Seal	Unidentified Pinniped*	Polar Bear
9 Oct	255	0	0	3/6	0
10 Oct	49	0	0	4/12	1/1
10 Oct	256	23/349	0	6/354	0
13 Oct	257	0	0	0	0
14 Oct	258	0	0	0	0
15 Oct	259	24/35	3/3	7/10	0
17 Oct	260	0	0	4/7	0
18 Oct	261	0	0	1/1	0
20 Oct	262	0	0	2/2	0
22 Oct	263	1/1	0	5/9	0
23 Oct	264	0	0	2/2	2/33
24 Oct	265	2/2	0	17/19	0
25 Oct	266	0	0	10/14	0
26 Oct	267	1/1	14/14	21/21	0
28 Oct	268	0	1/1	5/7	0
29 Oct	269	0	2/3	34/47	1/1
		Semimonthly Summary			
1-15 Jul		186/1,830	3/3	178/963	2/2
16-31 Jul		292/1,145	31/33	186/618	13/40
1-15 Aug		1/3	0	22/26	9/37
16-31 Aug		44/10,492	7/7	539/2,407	56/136
1-15 Sep		108/30,851	8/9	287/688	18/30
16-30 Sep		173/48,533	7/7	306/575	62/157
1-15 Oct		151/558	12/12	247/681	18/108
16-31 Oct		4/4	17/18	101/129	3/34
TOTAL		959/93,416	85/89	1,866/6,087	181/544

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

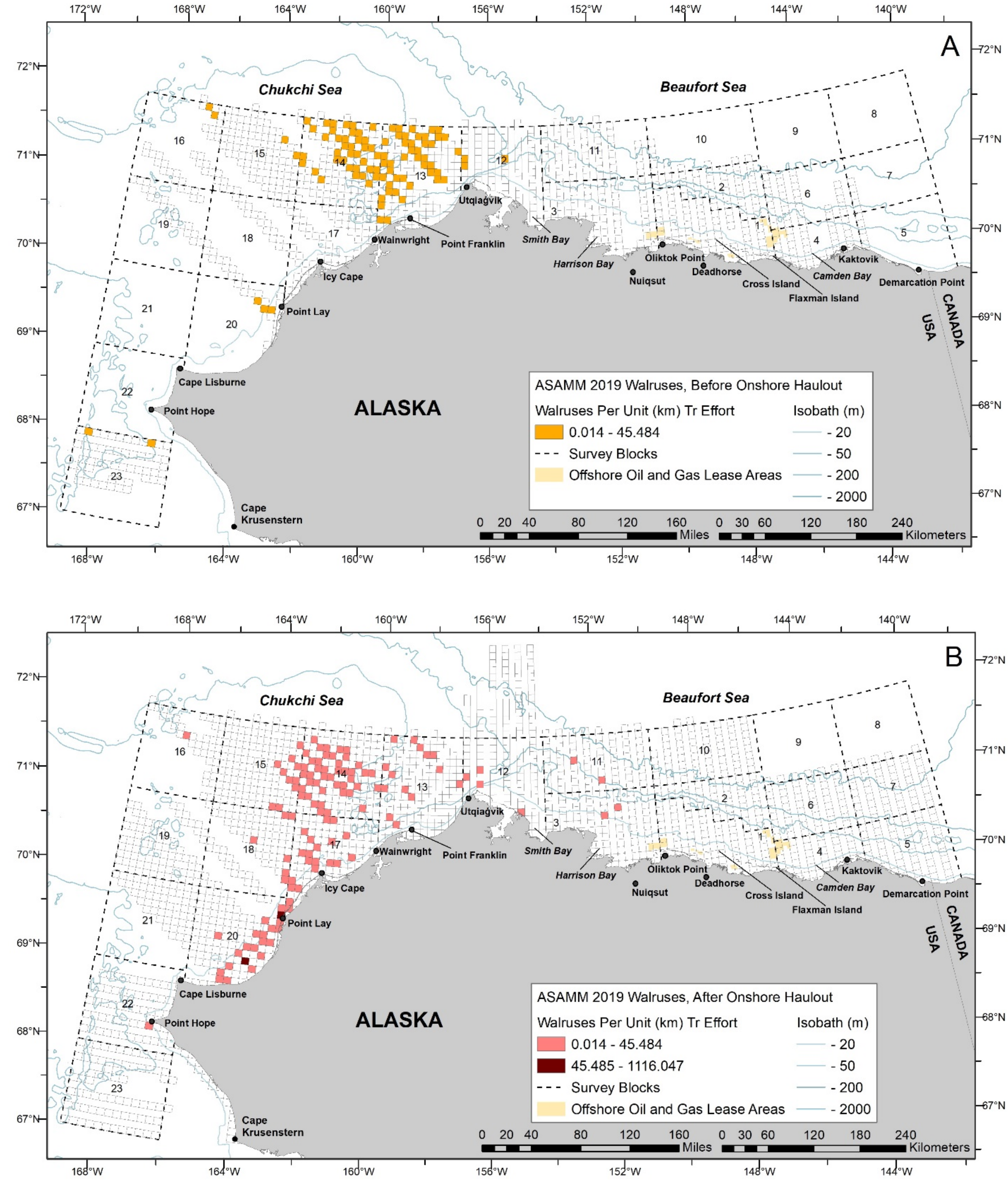


Figure 46. ASAMM 2019 walrus on-effort sighting rates (WPUE; transect sightings from primary observers only) in the ASAMM study area. A: 3 July-30 July pooled (prior to the formation of the coastal haulout at Point Lay. B: 31 July-29 October pooled (after the formation of coastal haulout at Point Lay). Empty cells indicate sighting rates of zero. Transect survey effort was not conducted in areas without cell outlines.

There were 158 walruses (representing <1% of all walruses sighted) that appeared to respond to the survey aircraft. Reactions included flushing from ice floes into the water (n_i = 110) and diving (n_i = 48). No walruses in the large coastal haulout appeared to respond to the survey aircraft.

Other Pinnipeds

Pinnipeds were distributed throughout most of the ASAMM and ABA study areas during all months (Figures 47 and 48). Eleven pinnipeds were seen in block 1a, between the barrier islands and the shoreline.

Bearded seals (*Erignathus barbatus*; n_s = 85, n_i = 89) were observed from mid-July through late October in the ASAMM study area; one bearded seal was observed in the ABA study area in August (Table 12, Figure 48). Fewer bearded seals were seen in the eastern Chukchi Sea (n_i = 24) than in the Beaufort Sea (n_i = 65). Several bearded seals (n_i = 17) were seen in mid- to late October near Herald Shoal, near the area where subarctic cetaceans were also observed (Figure 35). One bearded seal was observed hauled out on sea ice north of the Tuktoyaktuk Peninsula in mid-August and two bearded seals were observed hauled out on a barrier island in Camden Bay in early September. Five bearded seals (6%) responded to the aircraft by diving.

Other pinnipeds not identifiable to species were recorded as either unidentified pinnipeds (n_s = 176; n_i = 186) or small unidentified pinnipeds (n_s = 1,690; n_i = 5,901) (Figure 47). 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, feeding, and resting. Small groups of one to six seals were observed hauled out on sea ice in Amundsen Gulf in mid- to late August. Groups of small unidentified pinnipeds, likely spotted seals, were sighted at coastal haulouts from July through October. Large aggregations were sighted on barrier islands near Icy Cape in the northeastern Chukchi Sea on 11 July (n_i = 700), 23 July (n_i = 250), 31 August (2 groups, n_i = 200 and 1000), and 10 October (2 groups, n_i = 150 and 200). Small groups (n_i = 1 to 25 seals) were seen hauled out near the mouth of Fish Creek in Harrison Bay from early September to early October (Figure 8). Single seals (n_i = 3) were also sighted hauled out on the beach in Stefanson Sound east of Prudhoe Bay and in western Camden Bay in early September.

Two hundred twenty-four unidentified pinnipeds (4% 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 = 50) and a few smaller groups flushed from haulouts on land.

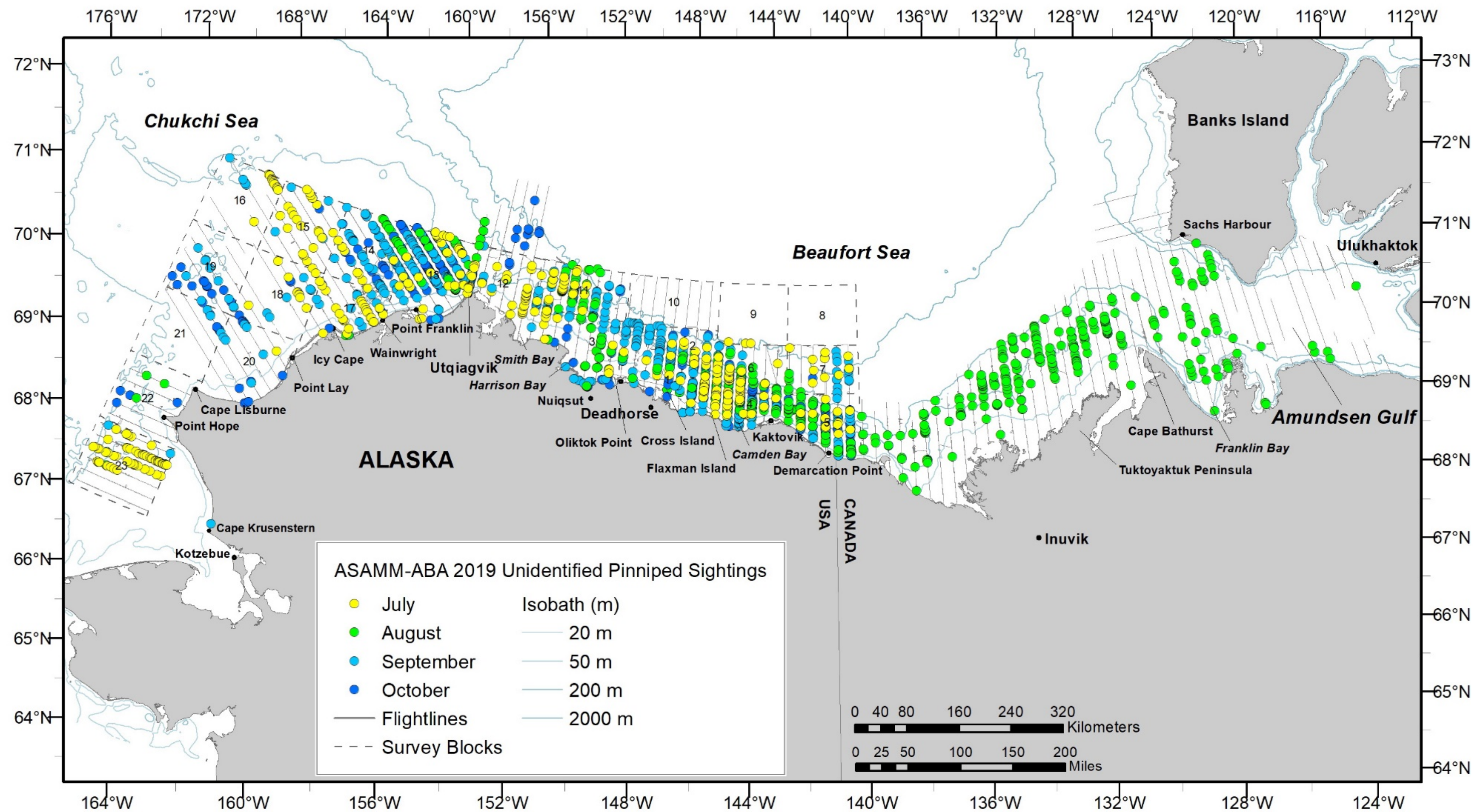


Figure 47. ASAMM 2019 unidentified pinniped (including small unidentified pinniped) sightings in the ASAMM and ABA study areas, all survey modes, plotted by month, with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.

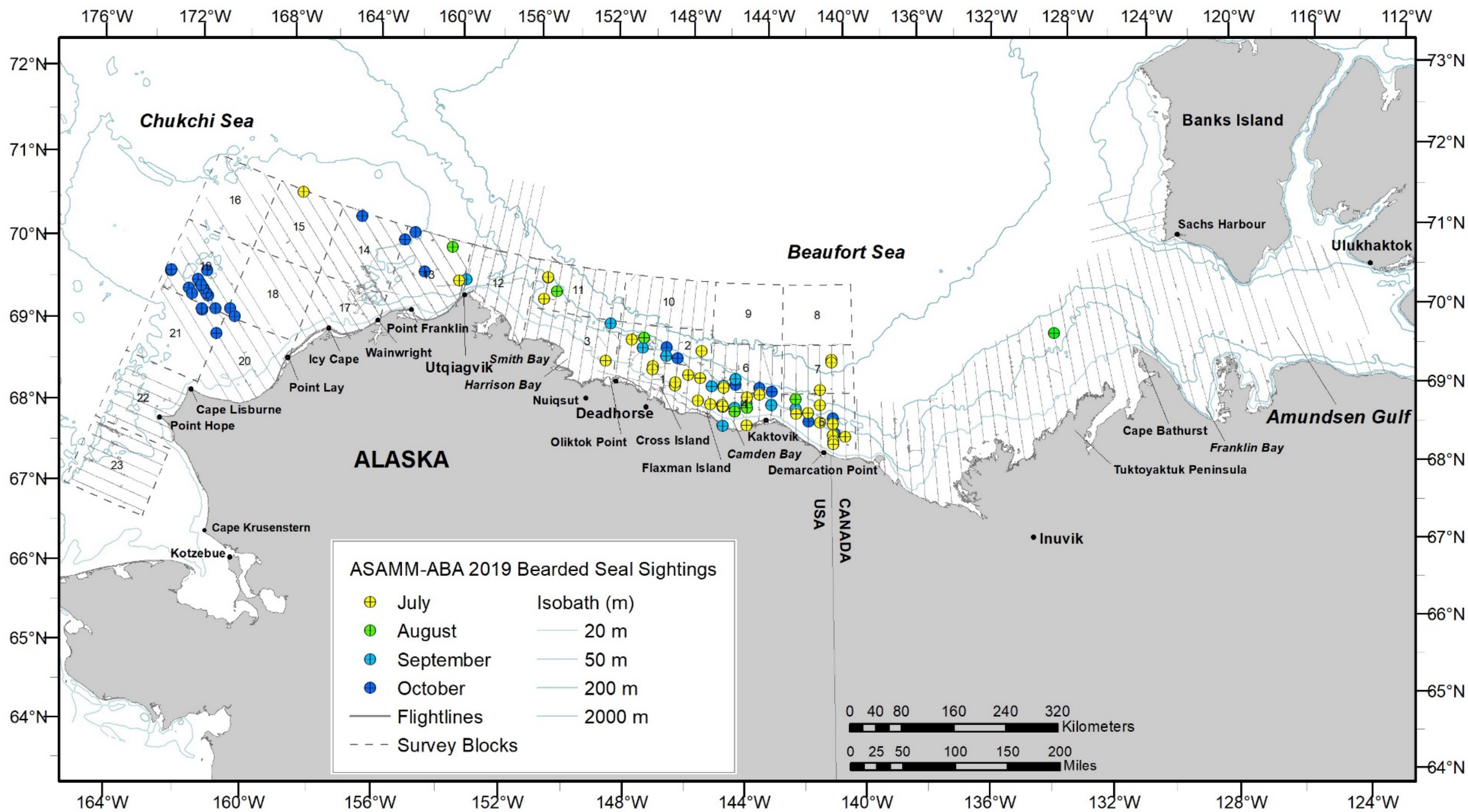


Figure 48. ASAMM 2019 bearded seal sightings in the ASAMM and ABA study areas, all survey modes, plotted by month; with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.

This page intentionally left blank.

Polar Bears

There were 181 sightings of 544 polar bears (*Ursus maritimus*) in the ASAMM and ABA study areas in 2019 (Table 12, Figure 49). Within the ASAMM study area, 162 sightings of 520 polar bears were observed during transect, CAPs, search, and circling survey modes. There were 19 sightings of 24 polar bears in the ABA study area in August (Appendix I). Polar bear sightings were distributed from southern Banks Island to north of Point Barrow. No polar bears were seen west of 157°W. Most polar bears (94%, n_i = 510) were seen between Point Barrow and Herschel Island on shore or barrier islands, or on sea ice or swimming within 5 km of land. Six polar bears were seen on sea ice between 78 and 105 km from shore. Five polar bears were observed swimming in areas of 5 to 20% sea ice cover between 25 and 140 km from shore, and one polar bear was seen resting in the water in an area of 60% sea ice cover. All but one of the polar bears observed near sea ice were in the eastern Beaufort Sea or Amundsen Gulf, where sea ice persisted in late August (Appendix A, Figure A-5). Thirteen polar bears were observed swimming or resting in ice-free areas between 10 and 59 km from shore. There were 15 sightings of 42 polar bears in July, 65 sightings of 173 polar bears in August, 80 sightings of 187 polar bears in September, and 21 sightings of 142 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 = 13; n_i = 252) were seen on or near (within 3 km) Cross Island, northeast of Deadhorse, on nine days (Figure 49). Cross Island attracts scavenging polar bears because bowhead whale carcasses from fall subsistence harvests are hauled there by whalers from Nuiqsut, Alaska. Polar bear aggregations (n_i = 9 to 26) were seen on Cross Island on one day in late July and three days in early and mid-August, prior to the 2019 subsistence hunt.

Polar bears were observed along the coastline near Kaktovik, between 143.2°W and 143.9°W, on 21 July (n_i = 7), 25 August (n_i = 60), 30 August (n_i = 3), 24 September (n_i = 5), 25 September (n_i = 37), 29 September (n_i = 19), and 9 October (n_i = 4). The area of greatest concentration was near a barrier island approximately 12 km east of Kaktovik, where 36 polar bears were seen on 25 August and 16 polar bears were seen on 25 September.

There were two sightings of four polar bears south of the barrier islands in block 1a, and one sighting of one polar bear south of the barrier islands in block 4.

Polar bears were observed resting, milling, running, standing, swimming, feeding, and walking. Ninety-two polar bears (17% of total polar bears seen) appeared to respond to the survey aircraft. Eighty-one bears looked up, seven bears ran, one bear started walking faster, one bear stood, one bear sat up, 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

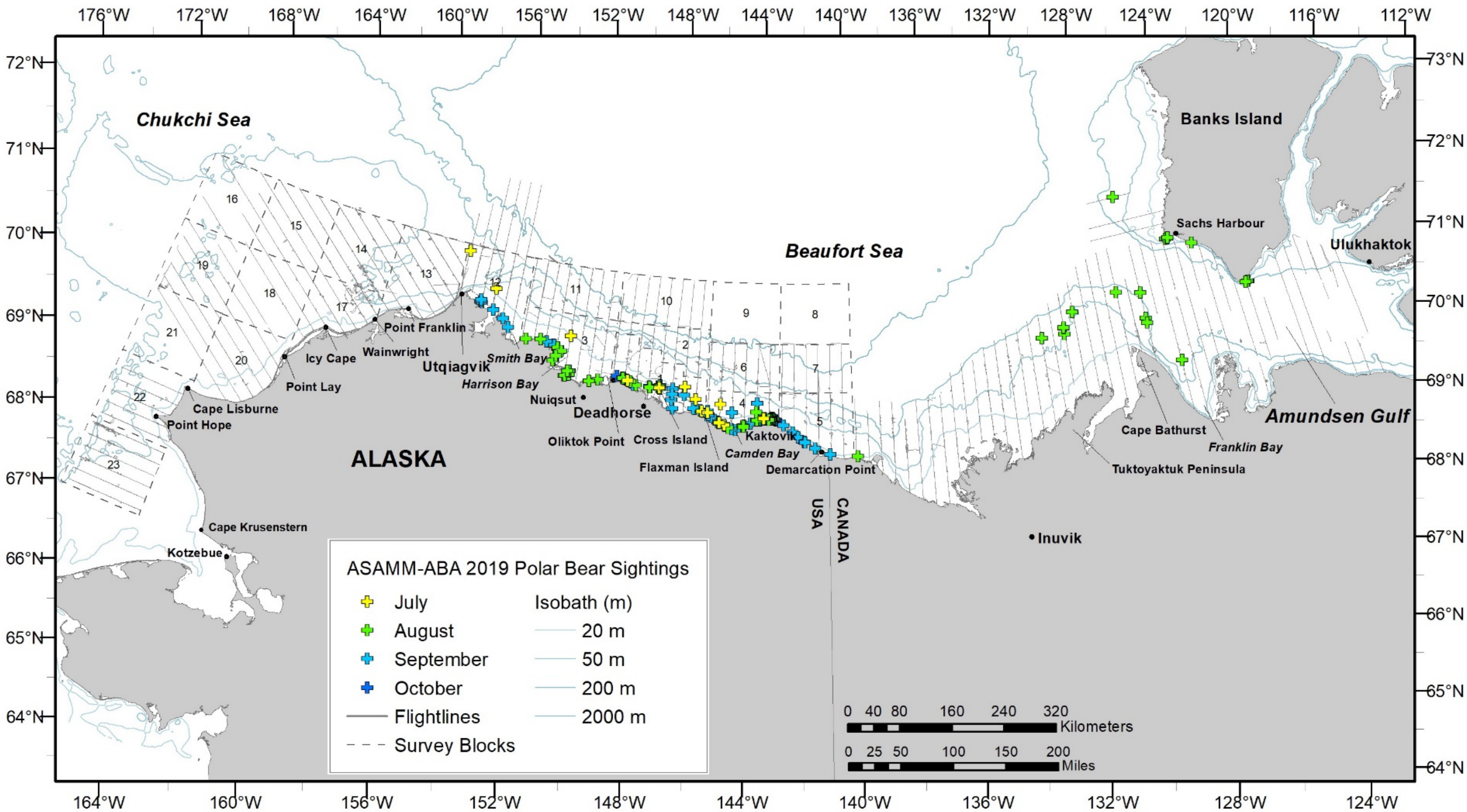


Figure 49. ASAMM 2019 polar bear sightings in the ASAMM and ABA study areas, all survey modes, plotted monthly, with transect, CAPs, search, circling, and FGF effort, July-October. Deadhead flight tracks are not shown.

revised total number, and the revised total was still considered an underestimate. In 2019, there were nine opportunities to photograph Cross Island. Although the entire island was not photographed on any of those dates, final group size estimates increased each time based on post-flight 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.

This page intentionally left blank.

Dead Marine Mammals

There were 116 sightings of 116 unique dead marine mammals in the ASAMM and ABA study areas in 2019 (Table 13); several carcasses were resighted multiple times. Most (76%) of the carcasses were observed in the eastern Chukchi Sea. Twenty-six of the carcasses were cetaceans, including bowhead whales (n_s = 11; n_i = 11), gray whales (n_s = 8; n_i = 8), unidentified cetaceans (n_s = 5; n_i = 5), one humpback whale, and one beluga. Eighty-five of the carcasses observed were walruses and two carcasses were unidentified pinnipeds. Two carcasses were in advanced states of decomposition and not identifiable beyond "marine mammal" and one carcass was a pile of bones and unidentifiable beyond "object". Fifty-eight of the carcasses were observed in open water, 56 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 and Alaska Marine Advisory Panel (all sightings), NMFS (cetaceans and ice seals) and USFWS (walruses).

Table 13. ASAMM 2019 dead marine mammal sightings in the ASAMM and ABA study areas during transect, search, and circling survey modes, in chronological order, 2 July-29 October.

Flight No.	Date	Latitude (°N)	Longitude (°W)	Species	No. Individuals	Habitat
202	3-Jul-19	71.915	155.398	walrus	1	open water
205	7-Jul-19	67.935	168.113	walrus	1	open water
206	11-Jul-19	71.744	153.940	walrus	1	open water
206	11-Jul-19	71.588	154.410	walrus	1	open water
206	11-Jul-19	71.799	154.410	walrus	1	open water
206	11-Jul-19	69.324	163.226	gray whale	1	beach
206	11-Jul-19	69.812	163.007	walrus	1	beach
206	11-Jul-19	69.809	163.003	walrus	1	beach
206	11-Jul-19	69.824	163.022	walrus	1	beach
206	11-Jul-19	70.090	162.520	bowhead whale	1	beach
208	13-Jul-19	71.186	161.631	gray whale	1	open water
2	21-Jul-19	70.117	143.786	unid object	1	barrier island
213	23-Jul-19	70.328	161.610	walrus	1	open water
213	23-Jul-19	70.822	158.329	walrus	1	beach
213	23-Jul-19	70.854	157.917	walrus	1	beach
213	23-Jul-19	70.859	157.846	walrus	1	beach
213	23-Jul-19	70.873	157.779	walrus	1	beach
214	27-Jul-19	71.108	167.553	gray whale	1	open water
223	19-Aug-19	70.970	130.909	small unid pinniped	1	broken floes
408	21-Aug-19	71.264	129.399	unid pinniped	1	broken floes
18	21-Aug-19	70.694	145.850	bowhead whale	1	open water
19	22-Aug-19	70.884	153.860	bowhead whale	1	beach
21	26-Aug-19	71.494	154.401	walrus	1	open water
22	27-Aug-19	70.656	149.425	bowhead whale	1	open water
23	28-Aug-19	70.510	150.653	bowhead whale	1	bay or lagoon
23	28-Aug-19	71.471	153.993	walrus	1	open water
231	30-Aug-19	71.036	158.054	bowhead whale	1	open water
231	30-Aug-19	71.037	157.274	walrus	1	beach
25	30-Aug-19	70.471	145.366	bowhead whale	1	open water
25	30-Aug-19	70.691	145.354	walrus	1	open water
231	30-Aug-19	71.526	157.364	walrus	1	open water
232	31-Aug-19	68.927	164.548	walrus	1	open water
232	31-Aug-19	69.535	163.145	walrus	1	beach
232	31-Aug-19	69.582	163.146	walrus	1	beach
232	31-Aug-19	69.624	163.146	walrus	1	beach
232	31-Aug-19	69.626	163.143	walrus	1	beach
232	31-Aug-19	70.016	162.637	walrus	1	beach

Flight No.	Date	Latitude (°N)	Longitude (°W)	Species	No. Individuals	Habitat
232	31-Aug-19	70.070	162.552	walrus	1	beach
232	31-Aug-19	70.743	159.775	unid cetacean	1	beach
232	31-Aug-19	70.876	159.162	unid cetacean	1	beach
232	31-Aug-19	70.819	158.327	walrus	1	beach
232	31-Aug-19	70.823	158.111	walrus	1	beach
232	31-Aug-19	70.838	157.985	walrus	1	beach
232	31-Aug-19	70.866	157.820	walrus	1	beach
234	5-Sep-19	70.563	160.317	bowhead whale	1	beach
234	5-Sep-19	71.137	162.411	walrus	1	open water
234	5-Sep-19	71.367	157.528	walrus	1	open water
234	5-Sep-19	71.211	156.971	beluga	1	beach
237	8-Sep-19	70.513	162.490	walrus	1	open water
237	8-Sep-19	70.809	163.646	walrus	1	open water
237	8-Sep-19	70.431	163.875	walrus	1	open water
237	8-Sep-19	70.416	163.761	walrus	1	open water
237	8-Sep-19	70.400	163.689	walrus	1	open water
237	8-Sep-19	70.184	162.916	walrus	1	open water
33	9-Sep-19	69.952	142.440	bowhead whale	1	beach
35	17-Sep-19	71.344	155.398	walrus	1	open water
36	18-Sep-19	67.073	166.762	unid marine mammal	1	open water
242	21-Sep-19	67.691	164.403	humpback whale	1	beach
242	21-Sep-19	68.312	166.417	unid cetacean	1	beach
243	22-Sep-19	68.621	166.746	walrus	1	open water
246	25-Sep-19	70.907	158.755	walrus	1	barrier island
246	25-Sep-19	70.820	158.324	walrus	1	beach
246	25-Sep-19	70.841	157.958	walrus	1	beach
246	25-Sep-19	70.875	157.774	walrus	1	beach
246	25-Sep-19	70.879	157.757	walrus	1	beach
246	25-Sep-19	70.977	157.422	unid cetacean	1	beach
246	25-Sep-19	71.050	157.249	gray whale	1	beach
247	26-Sep-19	71.077	162.179	walrus	1	open water
247	26-Sep-19	71.326	161.370	walrus	1	open water
247	26-Sep-19	70.943	160.168	gray whale	1	open water
247	26-Sep-19	71.563	160.642	walrus	1	open water
247	26-Sep-19	71.902	161.953	walrus	1	open water
40	27-Sep-19	71.309	151.838	bowhead whale	1	open water
41	28-Sep-19	69.663	140.908	bowhead whale	1	open water
248	28-Sep-19	71.948	155.804	walrus	1	open water
248	28-Sep-19	71.775	157.347	walrus	1	open water
250	1-Oct-19	71.781	159.830	walrus	1	open water

Flight No.	Date	Latitude (°N)	Longitude (°W)	Species	No. Individuals	Habitat
250	1-Oct-19	71.550	158.164	walrus	1	open water
250	1-Oct-19	71.628	158.516	walrus	1	open water
250	1-Oct-19	71.660	156.884	walrus	1	open water
45	5-Oct-19	70.804	160.367	walrus	1	open water
252	5-Oct-19	70.625	162.109	walrus	1	open water
253	7-Oct-19	71.569	160.667	walrus	1	open water
254	8-Oct-19	71.322	151.906	walrus	1	open water
256	10-Oct-19	69.530	163.144	walrus	1	beach
256	10-Oct-19	69.549	163.146	walrus	1	beach
256	10-Oct-19	69.578	163.149	walrus	1	beach
256	10-Oct-19	69.624	163.148	walrus	1	beach
256	10-Oct-19	69.632	163.138	walrus	1	beach
256	10-Oct-19	69.695	163.099	walrus	1	beach
256	10-Oct-19	69.691	163.100	walrus	1	beach
256	10-Oct-19	69.697	163.108	walrus	1	beach
256	10-Oct-19	70.136	162.550	walrus	1	open water
256	10-Oct-19	70.524	160.313	walrus	1	beach
256	10-Oct-19	70.861	159.266	walrus	1	beach
256	10-Oct-19	70.876	159.161	gray whale	1	beach
256	10-Oct-19	70.885	159.029	walrus	1	beach
256	10-Oct-19	70.903	158.880	walrus	1	beach
256	10-Oct-19	70.909	158.759	walrus	1	beach
256	10-Oct-19	70.819	158.327	walrus	1	beach
256	10-Oct-19	70.818	158.201	walrus	1	beach
256	10-Oct-19	70.874	157.772	walrus	1	beach
256	10-Oct-19	70.921	157.596	walrus	1	beach
256	10-Oct-19	71.035	157.279	walrus	1	beach
257	13-Oct-19	71.736	154.961	walrus	1	open water
257	13-Oct-19	71.995	155.804	walrus	1	open water
258	14-Oct-19	71.548	156.395	walrus	1	open water
258	14-Oct-19	71.878	154.393	walrus	1	open water
259	15-Oct-19	70.103	166.748	walrus	1	open water
259	15-Oct-19	70.099	169.090	unid cetacean	1	open water
260	17-Oct-19	68.568	168.264	gray whale	1	open water
260	17-Oct-19	68.101	168.459	unid marine mammal	1	open water
260	17-Oct-19	68.092	167.963	walrus	1	open water
265	24-Oct-19	71.110	161.480	gray whale	1	open water
265	24-Oct-19	71.872	159.292	walrus	1	open water
267	26-Oct-19	69.768	166.212	walrus	1	open water

Accomplishments and Outreach

Data from ASAMM 2019 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 2019).
- 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, NOAA Alaska Regional Office, Alaska Department of Fish and Game (ADF&G), NSB, BLM, USGS, USFWS, AEWC, NPRB, Fisheries and Oceans Canada, Eco49, UW, WHOI, Duke, UAF, and ConocoPhillips 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, University of Washington Polar Science Center, and Eco49.
- Daily reports specific to the effort on the coastal transect in Harrison Bay and near Point Lonely were shared with ConocoPhillips and BOEM.
- All Level A stranding forms (117 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 2019 included:

- Meeting with the NSB Search and Rescue to familiarize them with our project.
- 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.
- Attending Science and Job Fair in Nuiqsut as guest of ConocoPhillips.

Data for determining observer field of view (FOV) from a Twin Otter survey aircraft and additional data from the Aero Commander survey aircraft were collected to define the general field of view from ASAMM survey aircraft bubble windows.

Marine mammal photos taken by ASAMM personnel in 2019 were shared with interested parties in federal, state, and local governments (including NOAA, BOEM, NSB, ADF&G, USFWS, and USGS), academia, media, and non-governmental organizations.

Media efforts were coordinated through NOAA and BOEM Public Affairs Offices. Eight blog posts were posted to the NOAA AFSC website throughout the 2019 field season. Media interest in the ASAMM project was very high in 2019, due to the gray whale Unusual Mortality Event and the unusual bowhead whale fall migration. ASAMM was featured or prominently cited in more than a dozen articles (Appendix C).

ASAMM provided subsets of the 1982-2018 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 BOEM, NOAA Alaska Regional Office, PMEL, USFWS, Duke University, UAF, and NSB.

Results from the 2019 ASAMM field season were presented at several venues, including:

Berchok, C. 2020. Aerial Surveys of Arctic Marine Mammals (ASAMM). Presentation: US-Russia Area V Marine Mammal Meetings, Anchorage, AK, January 2020.

Berchok, C. 2020. Aerial Surveys of Arctic Marine Mammals (ASAMM). Presentation: DBO workshop, Seattle, WA, January 2020.

Brower, A., A. Willoughby, J. Clarke, M. Ferguson, C. Accardo, L. Barry, S. Hanlan and R. Hardee. 2020. Bowhead Whale Calf Nurseries in the Canadian Beaufort Sea, August 2019. Poster: Alaska Marine Science Symposium, Anchorage, AK, January, 2020.

Clarke, J., M. Ferguson, A. Brower, and A. Willoughby, C. Accardo, L. Barry, L. Ganley, S. Hanlan, R. Hardee, R. Holt, K. Jackson, and N. Metheny. 2020. The Summer of ABA, ASAMM Bowhead Whale Abundance. Poster: Alaska Marine Science Symposium, Anchorage, AK, January, 2020.

Ferguson, M.C., J.L. Clarke, A.A. Brower and A.L. Willoughby. 2019. Where were the whales in the Chukchi Sea in 2019?: A view from the sky. Alaska Eskimo Whaling Commission, October 28-30, 2019.

Ferguson, M.C., J.L. Clarke, A.A. Brower and A.L. Willoughby. 2019. Where were the whales in the Beaufort Sea in 2019?: More views from the sky. Alaska Eskimo Whaling Commission, October 28-30, 2019.

Ferguson, M.C., J.L. Clarke, A.A. Brower and A.L. Willoughby. 2019. Where were the belugas in 2019?: The view from the sky. Alaska Beluga Whale Committee, November 13-14, 2019.

Ferguson, M.C., J.T. Clarke, A.A. Brower, and A.L. Willoughby. 2020. Aerial Surveys of Arctic Marine Mammals (ASAMM). Presentation: DBO Workshop, Seattle, WA, January, 2020.

Ferguson, M.C., J.T. Clarke, A.A. Brower, and A.L. Willoughby. 2020. Aerial Surveys of Arctic Marine Mammals (ASAMM): Key Accomplishments. Presentation: Listening Session, Utqiaġvik, AK, January, 2020.

Ferguson, M.C., J.T. Clarke, A.A. Brower, and A.L. Willoughby. 2020. Aerial Surveys of Arctic Marine Mammals (ASAMM). Presentation: U.S./Russia Marine Mammal Working Group, Anchorage, AK, January, 2020.

Willoughby, A. J. Clarke, A. Brower, M. Ferguson, L. Barry, R. Hardee, S. Hanlan, N. Metheny, and H. Foley. 2020. A Yarn of Wayward Whales in the Eastern Chukchi and Eastern Beaufort Seas, 2019. Poster: Alaska Marine Science Symposium, Anchorage, AK, January, 2020.

A complete listing of publications, posters, and oral presentations from the ASAMM project from 2019 (not included in Clarke et al. 2019) to 2020 is included in Appendix C, and ASAMM contributions to the scientific community are included in Appendix F.

This page intentionally left blank.

DISCUSSION

Unique Observations in 2019

- Aerial surveys conducted in August in the eastern and western Beaufort Sea and Amundsen Gulf specifically to collect data to estimate population abundance for the Western Arctic stock of bowhead whales were seamlessly integrated with ASAMM surveys.
- The bowhead whale fall distribution in the western Beaufort Sea was farther from shore and in deeper water than any previous light ice year since 1982.
- No bowhead whales were seen in fall in the eastern Chukchi Sea.
- Bowhead whale feeding behavior was rarely observed in the western Beaufort Sea (1% of all bowhead whales observed).
- Bowhead whale calf ratios and sighting rates were extremely low in summer and very high in fall in the ASAMM study area; calf ratio in the Canadian Beaufort Sea in August was much higher than calf ratios reported by Harwood et al. (2010) for 2007-2009.
- Gray whales were nearly completely absent from shallow (≤35 m depth) nearshore waters in the northeastern Chukchi Sea, and continued to use areas farther from shore in deeper water. Relative abundance decreased compared to 2018 but was similar to some previous years 2009-2017.
- Fifteen gray whales were observed on a single day in the Canadian Beaufort Sea, representing the highest number of gray whales ever documented in this area per day or per year.
- Gray whale calf counts, calf ratios, and calf sighting rates in the eastern Chukchi Sea decreased for the third year in a row, continuing to mirror calf count trends noted during the gray whale northbound migration along the California coast.
- Photographs of gray whales were collected in the eastern Chukchi Sea, from which relative body condition may be assessed to provide valuable information to the ongoing investigation of the gray whale unusual mortality event (UME) declared in late May 2019.
- Humpback whales, fin whales, and minke whales were observed on Herald Shoal (block 19) for the first time since surveys commenced in the eastern Chukchi Sea in 2009.
- Fin whales were visually detected farther north than any previously recorded sightings in the Pacific Arctic.
- The beluga sighting rate in the western Beaufort Sea in fall was the second highest recorded since 1989.
- In collaboration with ConocoPhillips, aerial surveys of coastal transects in Harrison Bay and near Point Lonely were conducted 18 times from July to August with no negative impact to normal ASAMM survey effort.
- Polar bear sighting rates in the western Beaufort Sea in summer were higher than any previous year since summer surveys commenced in 2012; sighting rates in fall were second only to 2017.
- Eleven bowhead whale carcasses were recorded, representing the highest number of bowhead whale carcasses annually since standardized ASAMM carcass reporting methods began in 2009. More bowhead whale carcasses were sighted in the western

Beaufort Sea in 2019 than in 2009-2018 combined. Eight gray whale carcasses were recorded in 2019, second only to 2012 when 13 carcasses were documented.

Summary

Sea ice conditions in the ASAMM study area in 2019 were similar to conditions observed in most recent years. Sea ice was largely absent from the northeastern Chukchi Sea study area by mid-July and absent from the western Beaufort Sea by early August. Low cloud ceilings, fog, and high sea state, caused by large expanses of relatively warm water overlaid by colder air temperatures, were often encountered in 2019, but did not adversely affect overall survey effort.

Total and on-effort survey hours from July to October 2019 were greater than other years with equivalent field periods (2012-2018) (Figure 50) due to the addition of a third survey aircraft during the ABA surveys. Total survey hours without the third aircraft were 557 in 2019, which still exceeds total effort in 2012-2018. Broad-scale aerial surveys were conducted in the western Beaufort Sea during summer (July-August) for the eighth consecutive year. Due to poor survey conditions, surveys were not conducted for three consecutive days in early July, mid-July and early September 2019. Since 2012, there have been relatively few instances when ASAMM surveys were not possible during extended periods. In 2013, the partial federal government shutdown in the first half of October 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 ASAMM study area, combined with the flexibility of having survey teams based at different locations and using aircraft with the ability 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 fourth consecutive year. In 2019, 622 km were flown on effort in this small area; the four-year average is 568 km on effort per year. Sightings have included 1 beluga (2018), 1 harbor porpoise (2017), several small unidentified pinnipeds (2016-2019), and polar bears (2016-2019).

Surveys were conducted on the coastal transect in Harrison Bay, between Atigaru Point and Fish Creek, and near Point Lonely on 18 occasions. This collaboration, between BOEM, NOAA, and Conoco-Phillips, is an example of successful use of research assets already in place, eliminating the need for an additional dedicated survey team. Furthermore, the consistency of survey protocols in the short coastal sections with those used to survey the larger ASAMM study area allows seamless integration of datasets. The ASAMM database provides a context within which to interpret results from the short coastal sections.

Bowhead whales in the ASAMM study area were distributed from 140°W to 161.2°W in 2019. Sighting rates in the western Beaufort Sea in 2019 were low in July and August, increased in September, and decreased slightly in October (Figure 51B). The overall sighting rate in the

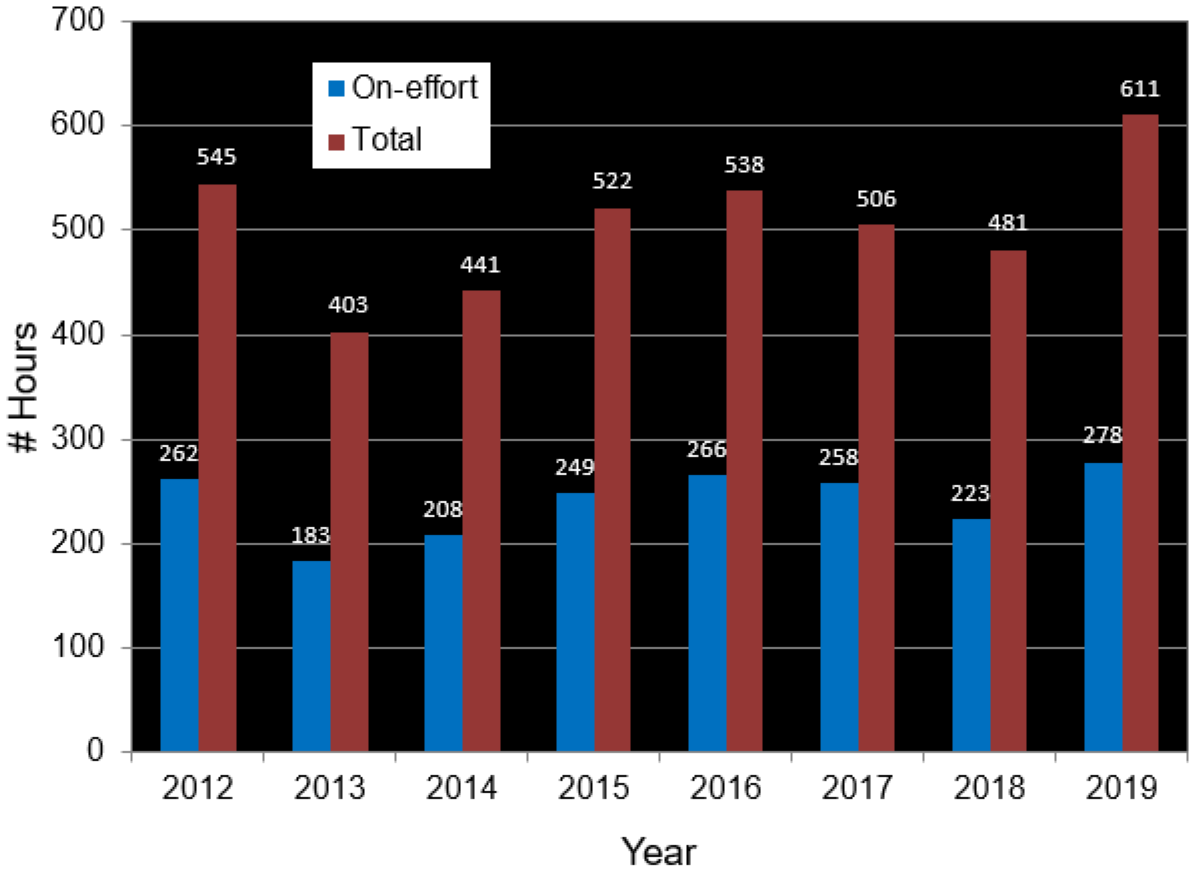


Figure 50. ASAMM on-effort and total survey hours, July-October pooled, 2012-2019.

western Beaufort Sea in summer 2019 was 0.005 (WPUE), which is the third lowest summer sighting rate since surveys commenced in 2012. Survey coverage in the western Beaufort Sea in summer 2019 was temporally and geographically similar to survey coverage in 2012-2018 (Figure 52A), but bowhead whale distribution was farther from shore than in previous years (Figure 52B). Sighting rates in the eastern Chukchi Sea in 2019 were the lowest recorded since 2012 (Figure 51A).

Years with combined lowest sighting rates in summer (2012, 2018, 2019) in the western Beaufort Sea also shared the same pattern of lower sighting rates in August compared to July and September (Figure 51B). All other years (2013-2017) had lower sighting rates in July that increased in August, substantially in some years. Bowhead whales sighted in the western Beaufort Sea in July likely include whales that never migrate farther east and whales that are still en route to the eastern Beaufort Sea. The lower sighting rates in August 2012, 2018, and 2019 may indicate that a greater majority of bowhead whales remained longer in the eastern Beaufort Sea and Amundsen Gulf in those years, perhaps due to better foraging opportunities. Information on bowhead whale occurrence in the eastern Beaufort Sea in summer 2012 and 2018 is limited due to lack of survey effort. In August 2019, however, surveys were conducted in the eastern Beaufort Sea and Amundsen Gulf, concurrent with surveys conducted in the western Beaufort Sea, as part of the ABA effort (Appendix I). This allows direct comparison of sighting

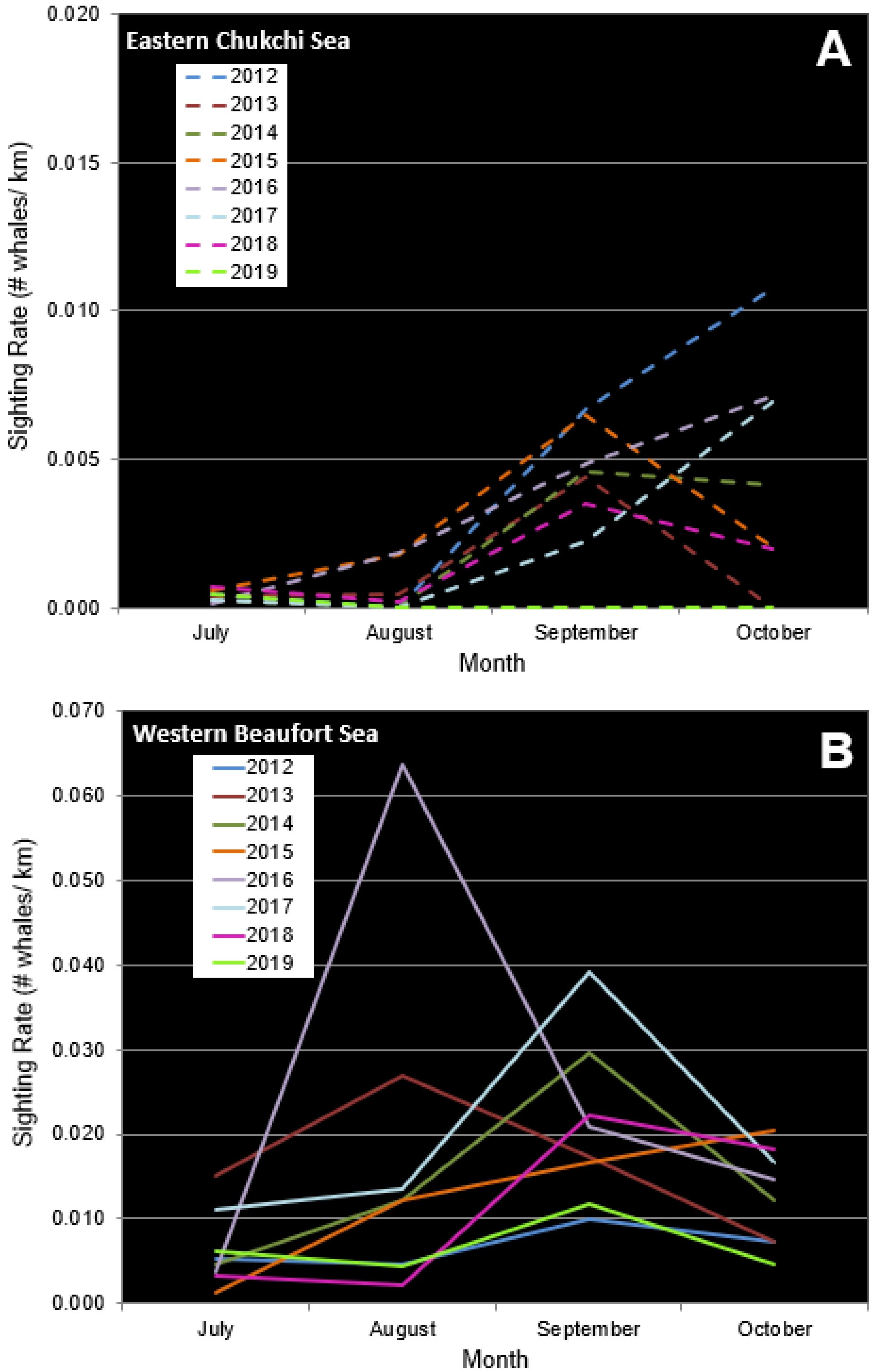


Figure 51. ASAMM bowhead whale on-effort monthly sighting rates (WPUE; sightings from primary observers only) in the eastern Chukchi (A) and western Beaufort (B) seas, July-October, 2012-2019.

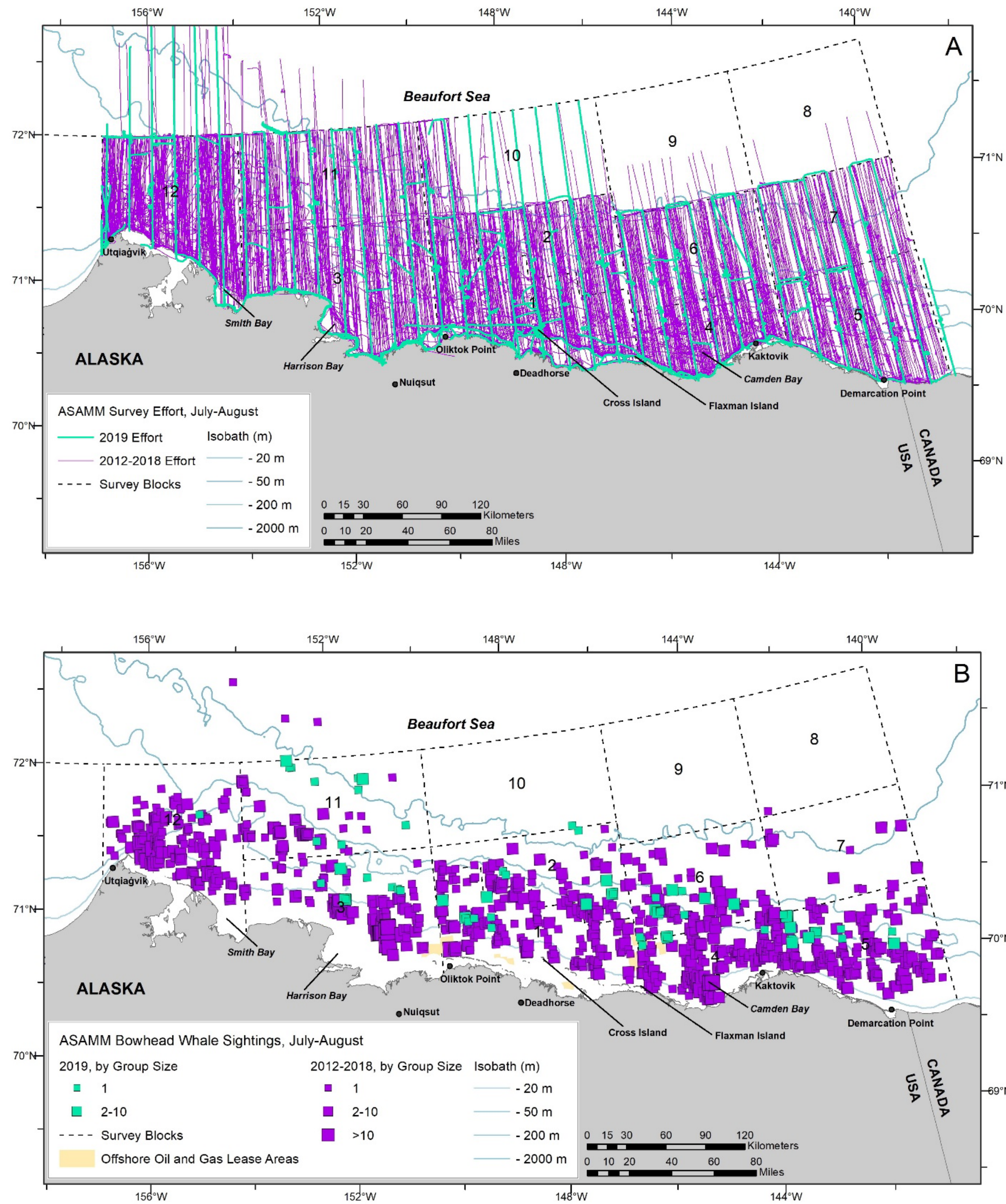


Figure 52. ASAMM 2012-2018 and 2019 summer (July-August) survey effort and bowhead whale sightings from transect, CAPs, search, circling, and FGF survey modes. A: survey effort. B: bowhead whale sightings, by group size. Includes all sightings by primary and secondary observers.

rates across most of the summer range of Western Arctic bowhead whales. Sighting rates were over three times higher in Amundsen Gulf (WPUE 0.0200) and over six times higher in the eastern Beaufort Sea (WPUE 0.0349) in August 2019 compared to those in the western Beaufort Sea (WPUE 0.0056), indicating that the easternmost part of the bowhead whale summer range was more attractive to bowhead whales in 2019. Citta et al. (2015) used satellite tag data from 2006 to 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. Three bowhead whales with satellite tags applied in summer 2017 remained in the Canadian Beaufort Sea until mid-September 2018.

Comparing bowhead whale distribution in summer 2019 in the northeastern Chukchi Sea to any previous year from 2009 to 2018 (Figure 53) is difficult because survey effort in the northeastern Chukchi Sea was negligible in August due to the geographic shift to the Beaufort Sea and Amundsen Gulf for ABA surveys. Only two sightings of two bowhead whales were made in July 2019, and zero sightings in August 2019. Bowhead whale use of offshore areas in the Chukchi Sea in summer in previous years 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 was noticeably different from the general distribution observed in past years with light sea ice cover (Figure 20), especially west of 150°W. This difference is not related to survey effort because ASAMM achieved extensive coverage of the western Beaufort Sea, generally in good weather conditions. Except for whales observed on 29 October north of Deadhorse, bowhead whales were significantly ($P < 0.0001$) farther from shore compared to previous ice years. A comparison of sighting rates per depth zone illustrates the extent of the difference (Figure 54). Bowhead whale sighting rates per depth zone in fall 2019 in the far western Alaskan Beaufort Sea (154°W-157°W) were very low compared to 2009-2018 (Figure 54B); whales were seen only in the 51-200 m and 201-2000 m depth zones. In the central-eastern Alaskan Beaufort Sea (140°W-154°W), sighting rates were highest in the 21-50 m and 51-200 m depth zones (Figure 54A). Sighting rates in fall in the far western Alaskan Beaufort Sea (154°W-157°W) for all depth zones combined were lower than in any previous year from 2009-2018.

The difference in bowhead whale fall distribution was also noted by subsistence whalers from Kaktovik, Nuiqsut, and Utqiaġvik (C. George, North Slope Borough Department of Wildlife Management, pers comm. to J. Clarke, 6 March 2020). Whalers from Kaktovik had a successful fall hunt, landing all three of their 2019 strikes, but traveled much farther than normal to land two of their whales. The village of Nuiqsut, with fall whaling based on Cross Island, had four strikes for fall 2019 and landed three of them. Nuiqsut whalers also traveled farther than usual to find whales, particularly west of Cross Island, where hunters reported that whales were swimming north instead of west. The impact of the abnormal fall bowhead whale distribution was especially strong in Utqiaġvik. Utqiaġvik had 16 strikes for fall 2019, and fall whaling commenced on 25 September. Whalers ventured up to 90 km offshore for over 6 weeks in search of bowhead whales but saw only gray whales. A flight conducted by the AEWC on 15

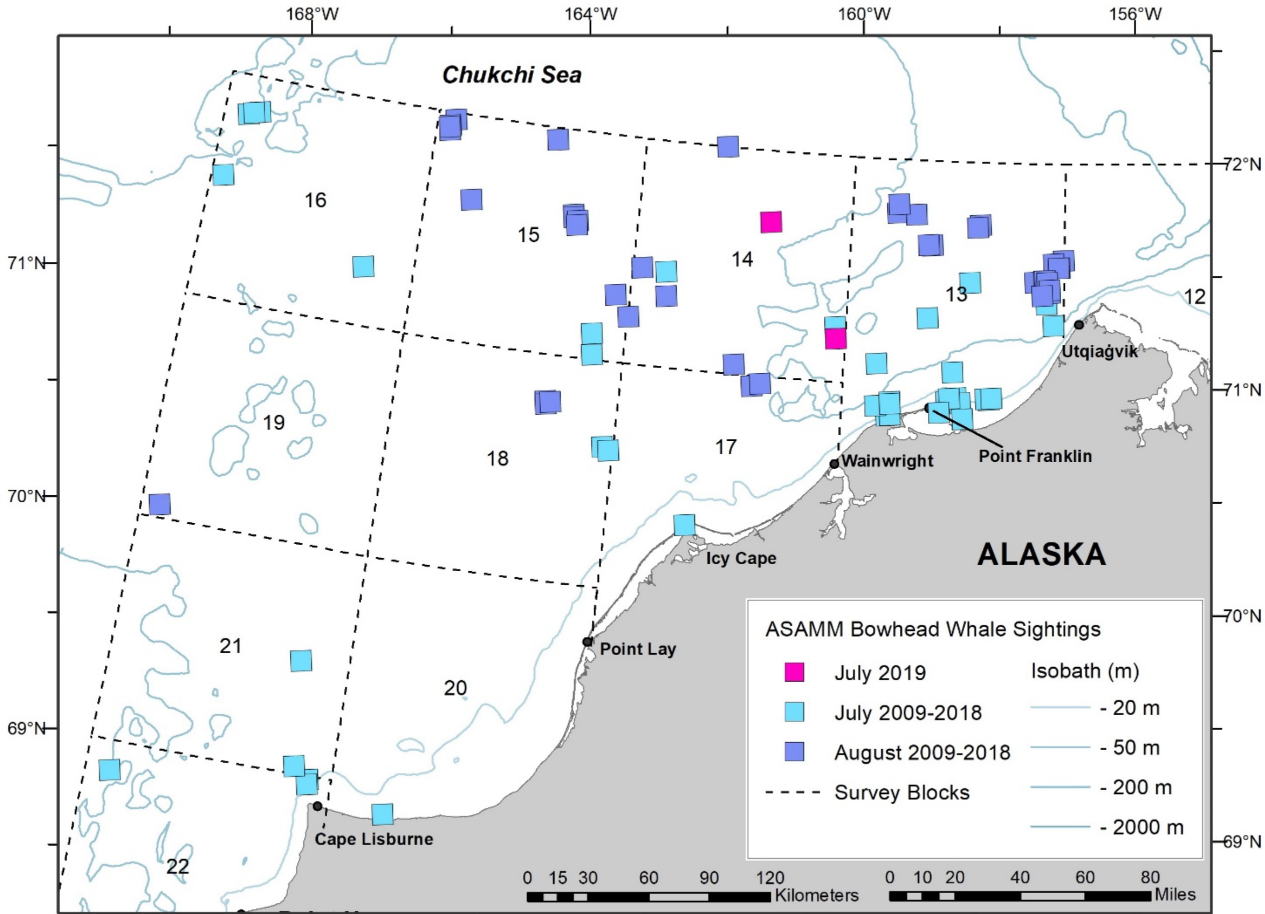
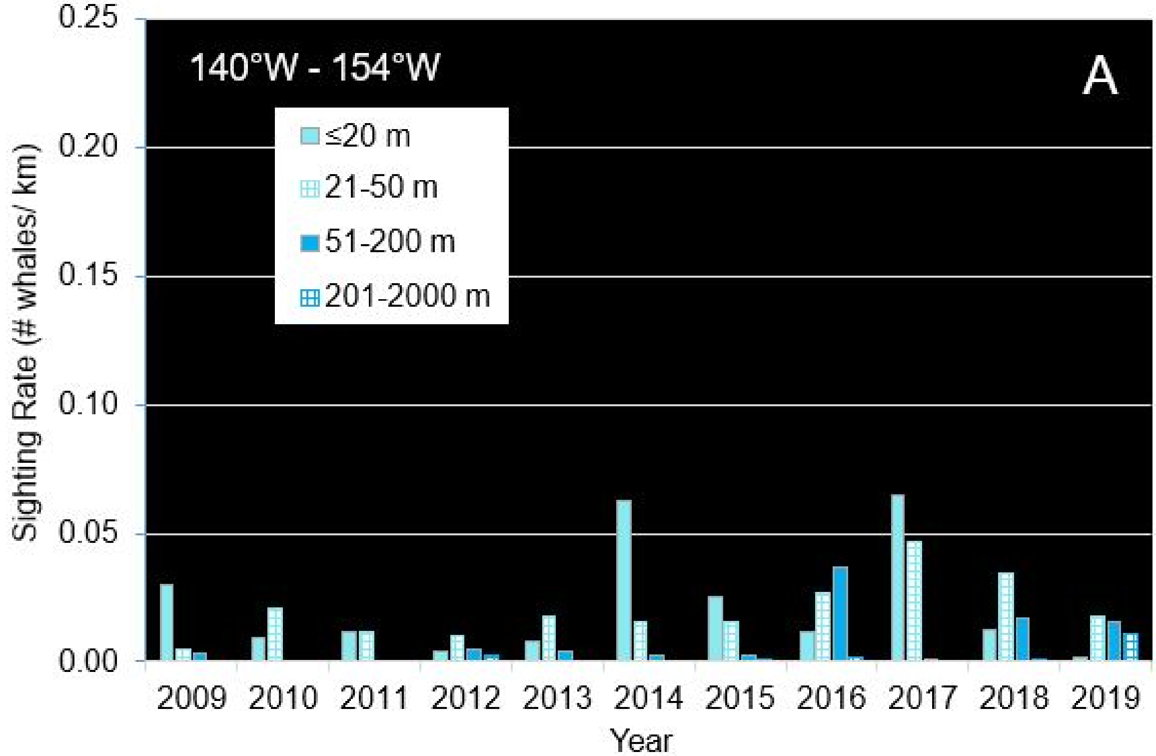


Figure 53. ASAMM bowhead whale distribution in the northeastern Chukchi Sea, transect, CAPs, search, circling, and FGF survey modes, summer (July and August), 2009-2018, and 2019.



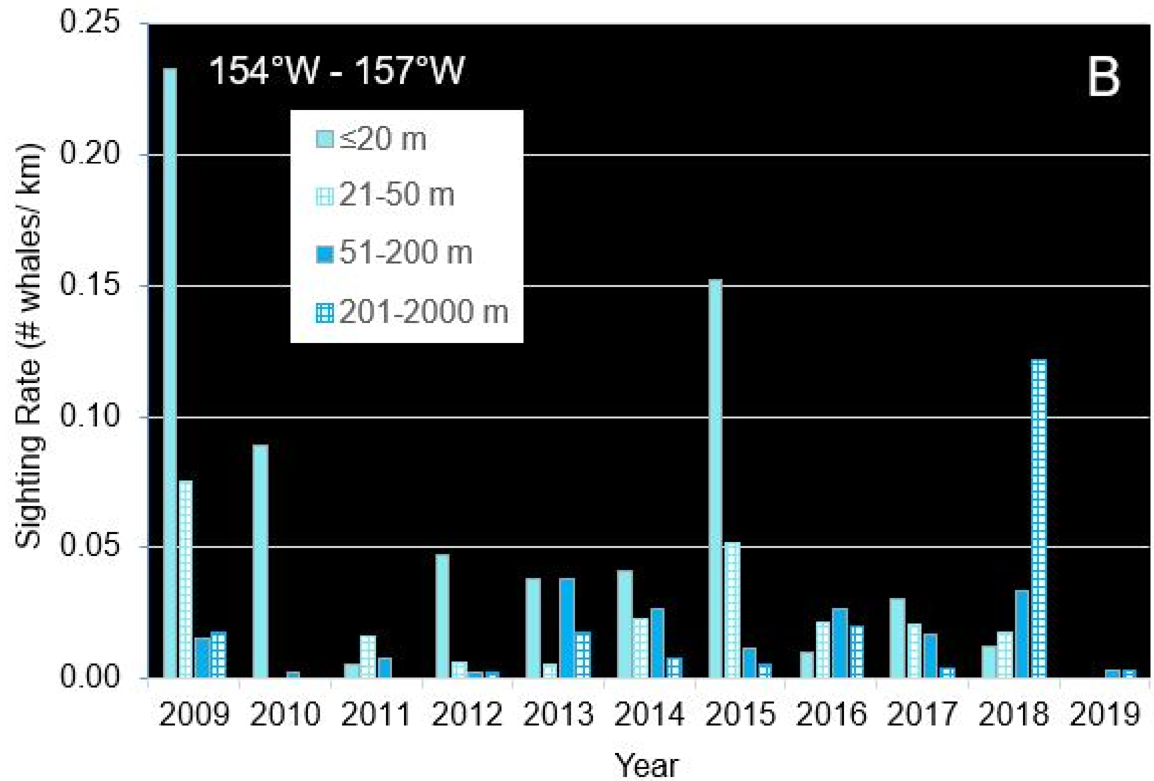


Figure 54. ASAMM bowhead whale on-effort annual sighting rates (WPUE; sightings from primary observers only) per depth zone, fall (September-October pooled) 2009-2019. A: central-eastern Alaskan Beaufort Sea (140°W-154°W). B: far western Alaskan Beaufort Sea (154°W-157°W).

November extended approximately 75 km east and west of Point Barrow and 37 km offshore, and no bowhead whales were seen. Finally, on 16 November, Utqiaġvik took one bowhead. This is the latest known date for a bowhead whale harvest in Utqiaġvik; the previous date was late October.

The anomalous bowhead whale distribution in fall 2019 was ecologically perplexing, with real-world implications to the subsistence whaling communities of northern Alaska. Impacts to these communities included increased financial burden, due to higher fuel costs for scouting at greater distances from the villages, and greater dedication of time which limited the opportunity to pursue other subsistence hunting activities. The greater distances traveled increased risks to each whaling crew, particularly later in fall when weather conditions become more unpredictable. Finally, the unsuccessful subsistence hunt in Utqiaġvik means the very real potential for food shortages, as the community will have to increase reliance either on other subsistence foods or on non-subsistence foods, which are expensive and difficult to obtain.

The area east of Point Barrow is a well-documented bowhead whale feeding area in years when upwelling winds create conditions conducive to 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 of bowhead whales (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 2019. Conditions for the formation of krill traps occurred in fall 2019 (Figure 17), but large bowhead whale aggregations were not seen. Bowhead whale feeding behavior was noted on only one day, in late October.

The underlying causes for the anomalous bowhead whale distribution in fall 2019 are unknown. In addition to the record low summer and winter sea ice extents, other extreme environmental variables were recorded, including warmer surface air temperatures, warmer sea surface temperatures, lower snow cover, thawing permafrost, and decreased sea ice thickness (Richter-Menge et al. 2019), which undoubtedly affected primary and secondary productivity, transport from the Bering Sea, and freshwater runoff. 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 2019, but the lack of bowhead whales in the area indicate that relatively few krill were present and feeding opportunities were suboptimal in fall 2019. Based on daily and seasonally-averaged indices from 2009-2015 derived from acoustic observations of krill, Okkonen et al. (2020) inferred that late-summer krill biomasses were relatively high in the krill trap when mid-summer winds over the Chukchi Sea were southerly and late-summer winds over the Beaufort shelf were weak. Conversely, krill biomasses were relatively low when mid-summer winds over the Chukchi were weak and late-summer winds over the Beaufort shelf were easterly and strong. Okkonen et al. (2020) also speculated that the krill trap east of Point Barrow may diminish in importance to bowhead whales during the fall migration based on the increasing trend in easterly wind speeds over the Beaufort region. Whether the bowhead whale distribution in fall 2019 is a “one-off” and unlikely to happen again or if it represents a new normal is also not known.

Bowhead whales were not seen in the northeastern Chukchi Sea in fall 2019, despite >12,000 km of effort. This is the first year since aerial surveys in the Chukchi Sea started in 2009 that no bowhead whales were seen in September or October. In past years, bowhead whales generally used a broad migratory corridor heading southwest across the northeastern Chukchi Sea, with little use of the nearshore area between Icy Cape and Cape Lisburne (Figure 20). Results from satellite telemetry (Citta et al. 2018; Quakenbush et al. 2010a, 2013) and passive acoustics (Hannay et al. 2013) corroborate use of a broad migratory path. The location of bowhead whales in the Chukchi Sea in fall 2019 is unknown. Either they migrated much farther north than normal, beyond the ASAMM study area northern boundary and therefore were not detectable during aerial surveys, or the migration was substantially delayed. There was one ASAMM survey conducted 110 km north of the normal ASAMM study area in late October and no bowhead whales were seen. However, the offshore distribution of bowhead whales in the western Beaufort Sea in fall 2019 suggests an offshore migration in the northeastern Chukchi Sea as well. There were no satellite-tagged bowhead whales in fall 2019, but paths of some satellite-tagged bowhead whales from previous years have been north of the ASAMM study area (Citta et al. 2018).

Similar to other metrics provided in this report, the spatial model predictions of bowhead whale distribution during fall in the western Beaufort Sea were considerably farther offshore in 2019 compared to 2000-2018. The models predicted the median offshore distance for bowhead whales in 2019 to be 50.9 km in the East region and 48.7 km in the West region, compared to 25.5-31.1 km and 20.2-25.4 km, respectively, for September-October 2000-2018 (Clarke et al. 2019).

The 2019 bowhead whale calf ratio (number of calves/number of total whales on effort) in the ASAMM study area in summer was similar to summer bowhead whale calf ratios in many previous years (Figure 55). Bowhead whale calf ratio in fall alone and summer and fall combined were higher in 2019 than in any previous year recorded in ASAMM. 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 to 2007. Calf distribution was 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 (0.0022 CPUE) and 2013 (0.0020 CPUE) (Clarke et al. 2018a). Calf sighting rate in 2019 was intermediate between the very high CPUEs in 2017, 2016, and 2013 and the very low CPUEs in 2012, 2014, 2018, and 2015 (Figure 56). Calf sighting rate in the eastern Beaufort Sea and Amundsen Gulf was quite high (0.0055 CPUE). 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. Body condition, rate of survival, and reproduction are likely related to the overall reduction of summer sea ice, increased

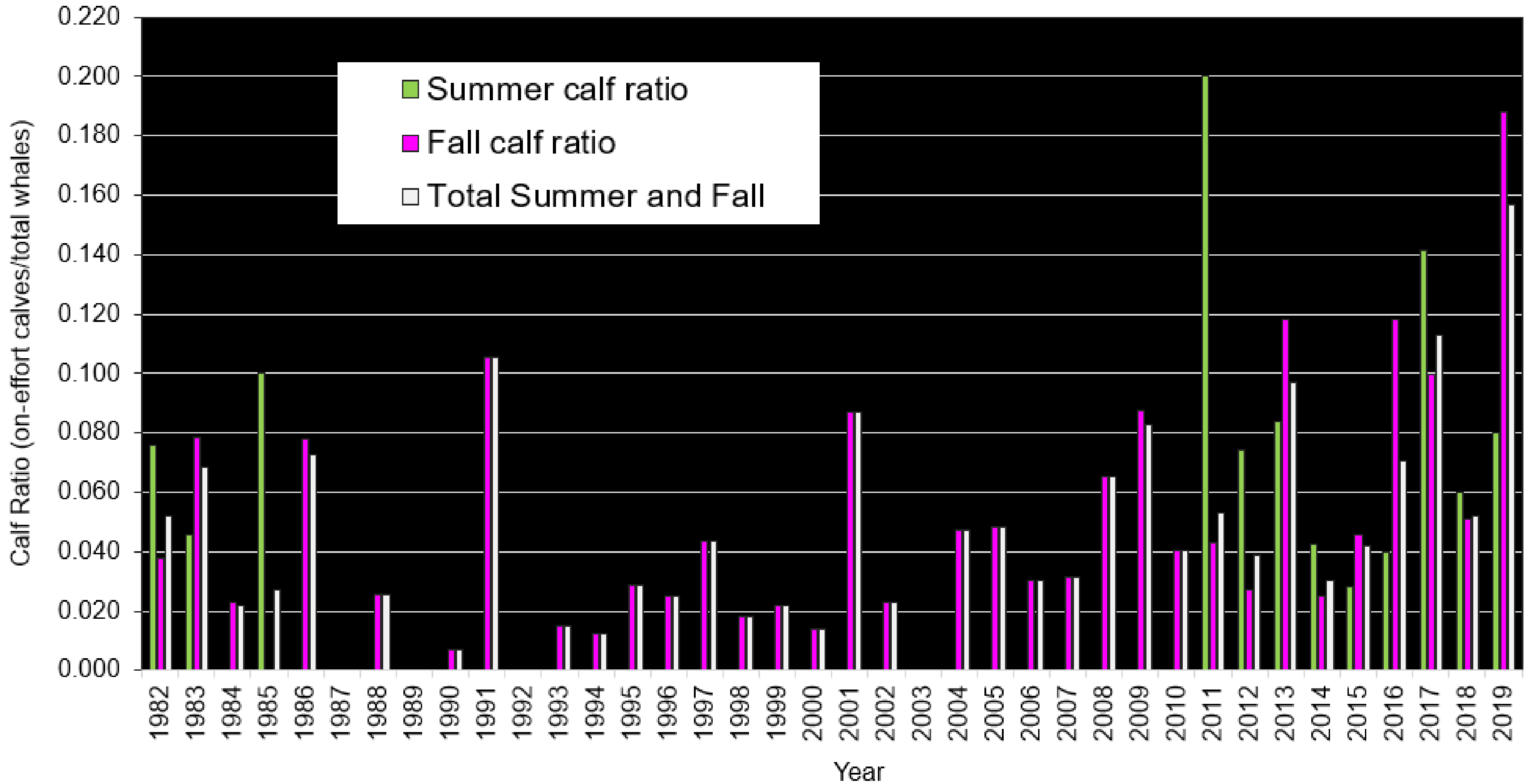


Figure 55. ASAMM bowhead whale annual calf ratios (number of bowhead whale calves on effort per number of total bowhead whales on effort), in summer (July-August pooled), fall (September-October pooled), and summer and fall combined, 1982-2019. Ratios are for the ASAMM study area and do not include whales seen north of 72°N or east of 140°W.

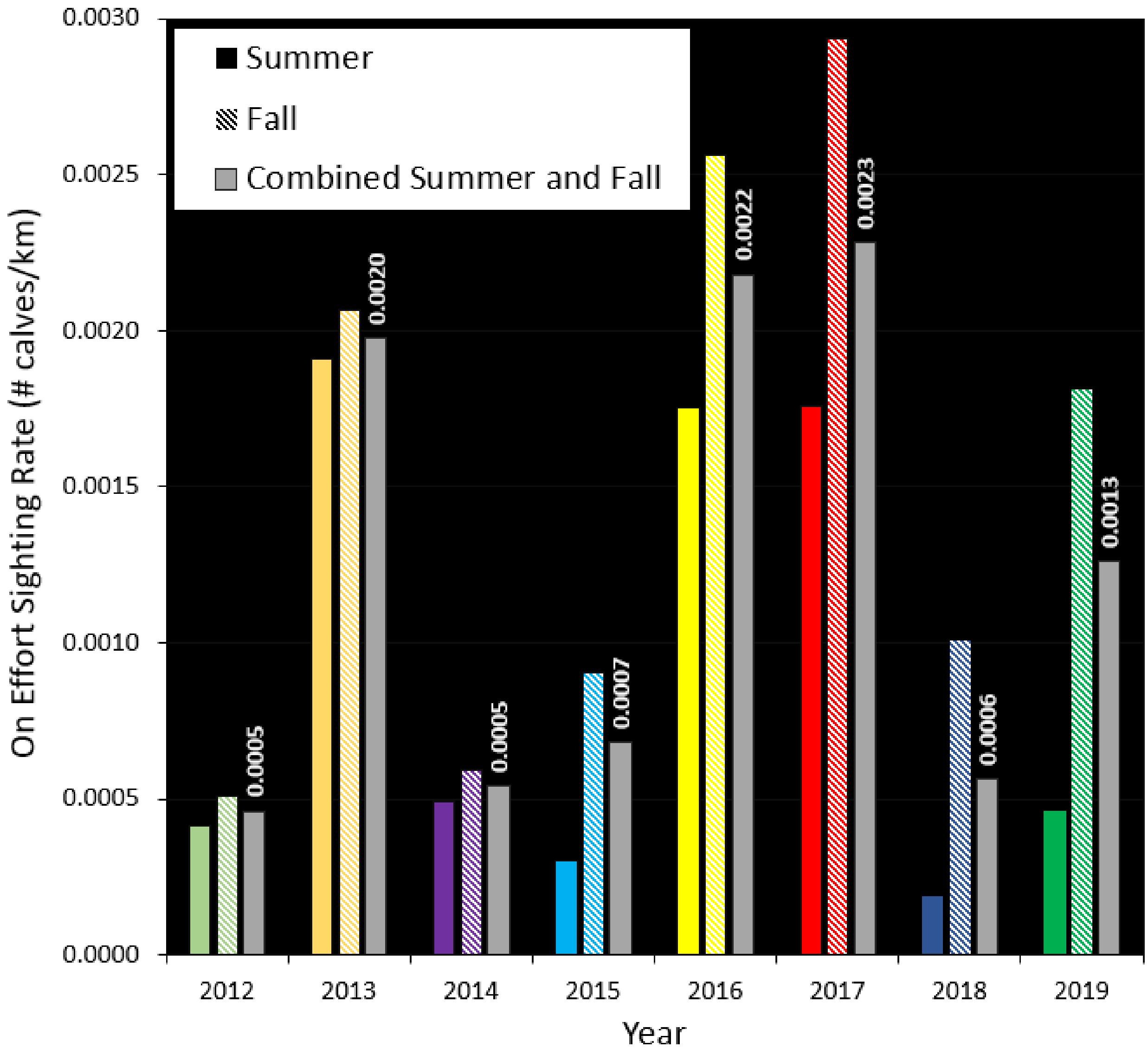


Figure 56. ASAMM bowhead whale on-effort annual calf sighting rates (CPUE; number of bowhead whale calves on effort per km on effort; sightings from primary observers only), western Beaufort Sea, summer (July-August pooled), fall (September-October pooled), and summer and fall combined, 2012-2019.

duration of open water, changes in upwelling potential, and higher primary productivity (Harwood et al. 2015).

The ASAMM study area was extended eastward to include the eastern Beaufort Sea and Amundsen Gulf in August 2019, specifically to collect line transect data suitable for estimating Western Arctic bowhead whale abundance. This effort, termed ASAMM Bowhead Abundance (ABA), represented the first time aerial surveys were used to collect data specifically for estimating bowhead whale abundance. Despite sub-optimal weather conditions during the first half of the survey period, ABA ultimately was extremely successful. Bowhead whales were observed from 119°W to 152°W, with areas of highest sighting rates in Franklin Bay, offshore of the Tuktoyaktuk Peninsula, and northeast of Herschel Island (Appendix I). Distribution and relative abundance in the eastern Beaufort Sea in August 2019 shared similarities with results from aerial surveys conducted there in August 2007-2009 (Harwood et al. 2010), including aggregations near Herschel Island that were observed in all years. However, there were notable differences as well. Harwood et al. (2010) found that most bowhead whales used waters 20-50 m deep near the Tuktoyaktuk Peninsula in 2007-2009, while the areas of highest relative density near the Tuktoyaktuk Peninsula in 2019 were farther from shore and in deeper water (51-2000 m deep). The difference in distribution is likely due to several factors, including but not limited to prey availability and the presence of offshore seismic exploration in 2007-2009 and absence of offshore seismic exploration in 2019. Harwood et al. (2010) sighted a total of 10 calves within their study area (128°W to 141°W) for a combined 2007-2009 calf ratio of 3% (10 calves/ 334 total whales), while the calf ratio in the same area during ABA was 23% (51 calves/ 219 total whales, on effort). The difference in calf numbers is likely due, at least in part, to the number of calves ABA detected during brief circling initiated after an initial sighting was recorded, which is standard protocol during ASAMM and ABA surveys, while Harwood et al. (2010) used strip transect methods that did not include any circling. Analysis of ABA bowhead whale data for stock abundance estimates is currently underway.

Gray whale habitat preference in the northeastern Chukchi Sea continues to be seasonally and annually variable. Distribution in 2019 appeared similar to that observed from 2015 to 2018, with an even greater preference for the area northwest of Wainwright out to ~120 km offshore. In the northeastern Chukchi Sea in 2019, gray whales preferred waters 51-200 m deep in summer (July-August) and 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 100 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 and northern part of block 17. Sighting rates in block 13 were fairly consistent from 2014 to July 2017, but dramatically decreased in August 2017 and remained low though 2019 (Figure 57A). Gray whale occurrence in block 13 was almost non-existent in 2018 and 2019 in every month. Sighting rates in block 14 in 2015-2019 were higher than sighting rates in that block in most months in 2009-2014 (Figure 57B). The 2015-2017 increase in gray whale relative occurrence in block 14 did not coincide with a decrease in relative occurrence in block 13 until August 2017. Block 17 relative occurrence was particularly high in July 2018, representing the highest sighting rate recorded in any month for these three survey blocks (Figure 57C).

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

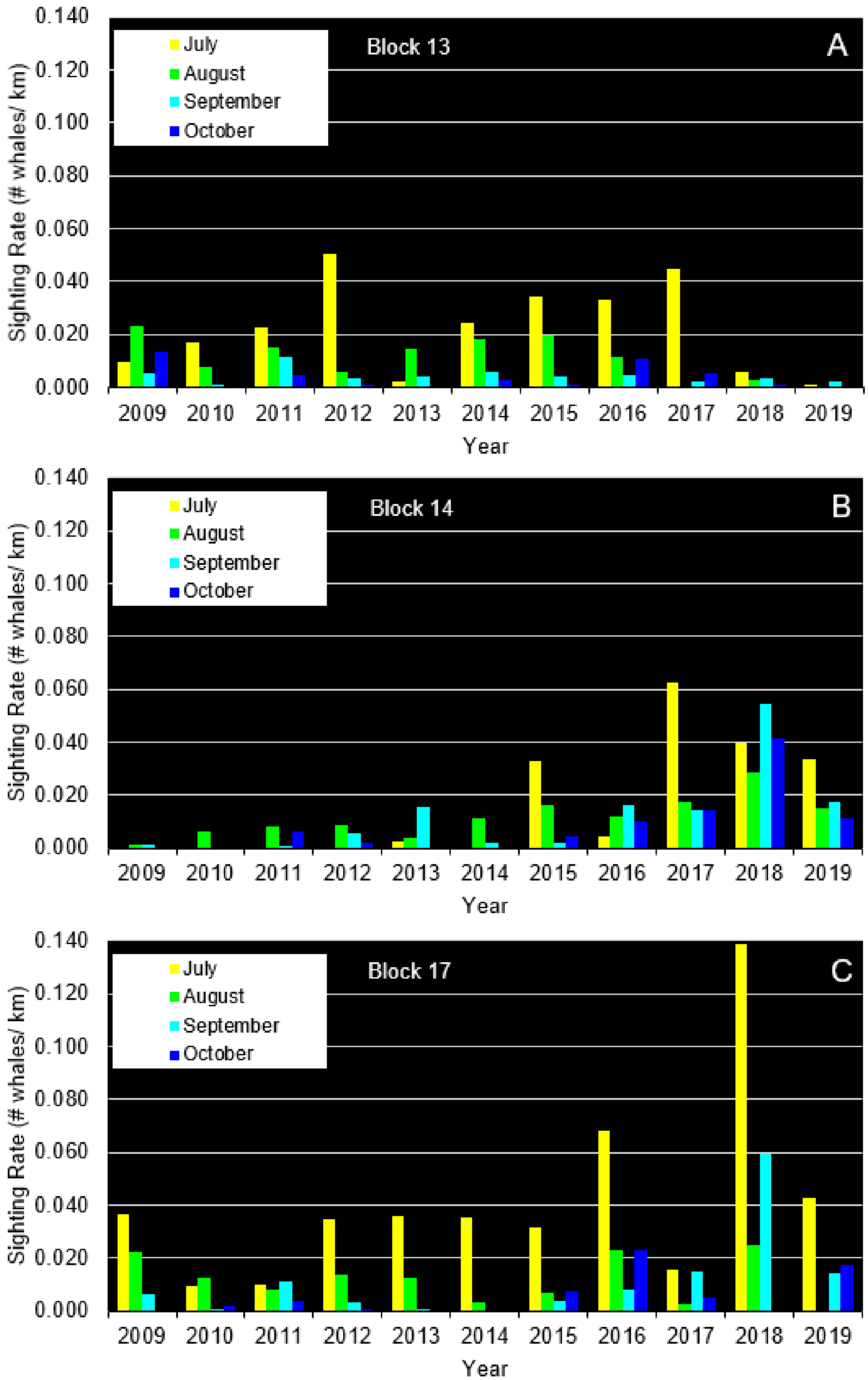


Figure 57. ASAMM gray whale on-effort annual sighting rates (WPUE; sightings from primary observers only) per depth zone in the northeastern Chukchi Sea, July-October pooled, 2009 to 2019. A: block 13. B: block 14. C: block 17. Sighting rates of zero were removed from the graph for clarity.

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, 2013, 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 58A). From 2016 to 2019, summer sighting rates were highest in the 51-200 m depth zone (2016-2017), similar across all depth zones (2018), or highest in the 36-50 m depth zone (2019). In fall, sighting rates were highest in the 51-200 m depth zone in 2013, 2016, and 2018 (Figure 58B). Sighting rates were especially high in fall 2018 compared to 2009-2017 and 2019. Sighting rates in shallow (≤35 m depth) nearshore areas were zero in summer and fall 2019.

Gray whale use of the southcentral Chukchi Sea also varied 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 59). 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 were 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 2019 compared to July 2014-2018, decreased considerably in August before increasing in fall (Figure 29B). For the third straight year (2017-2019), sighting rates decreased from July to August-October in the southcentral Chukchi Sea (Figure 60); in 2014-2016, sighting rates increased between July and August-October.

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. Gray whale sighting rate for July through October in the northeastern Chukchi Sea (blocks 13, 14, and 17 combined) decreased considerably in 2019 after increasing steadily since 2013 (Figure 61). Changing hydrographic conditions or earlier sea ice melt may be altering ecosystem processes that lead to the location of high-density patches of amphipods in the eastern Chukchi Sea.

The current best estimate of the eastern North Pacific (ENP) gray whale population is an all-time high of 26,960 (CV = 0.050) (Durban et al. 2017), based on a census conducted in 2015-2016. While the population appears stable (Carretta et al. 2019), population estimates in the last 30 years have varied from the current high 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

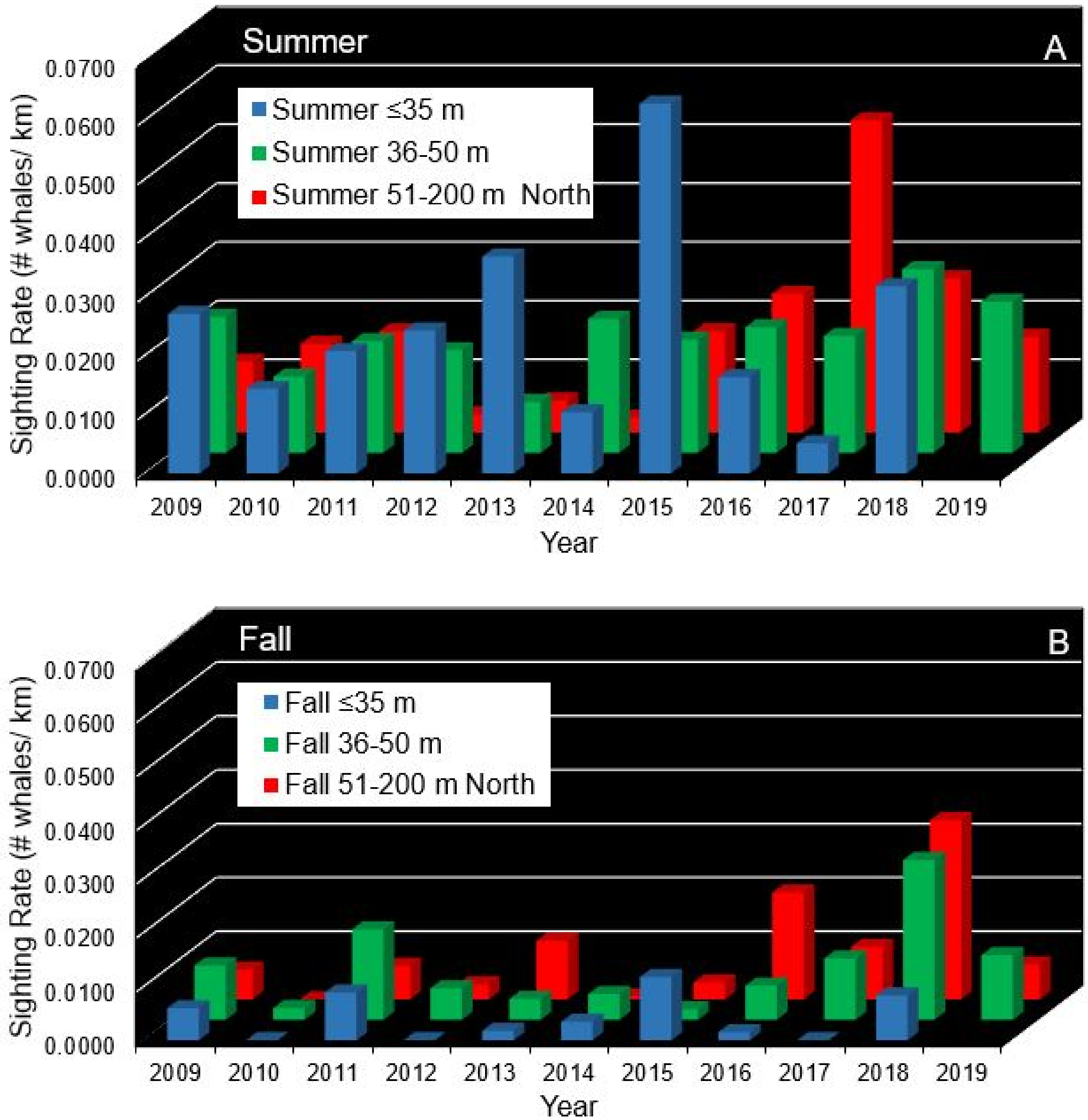


Figure 58. ASAMM gray whale on-effort annual sighting rates (WPUE; sightings from primary observers only), per season per depth zone, in the northeastern Chukchi Sea (blocks 13, 14, and 17 combined), 2009-2019. A: summer (July-August pooled). B: fall (September-October pooled).

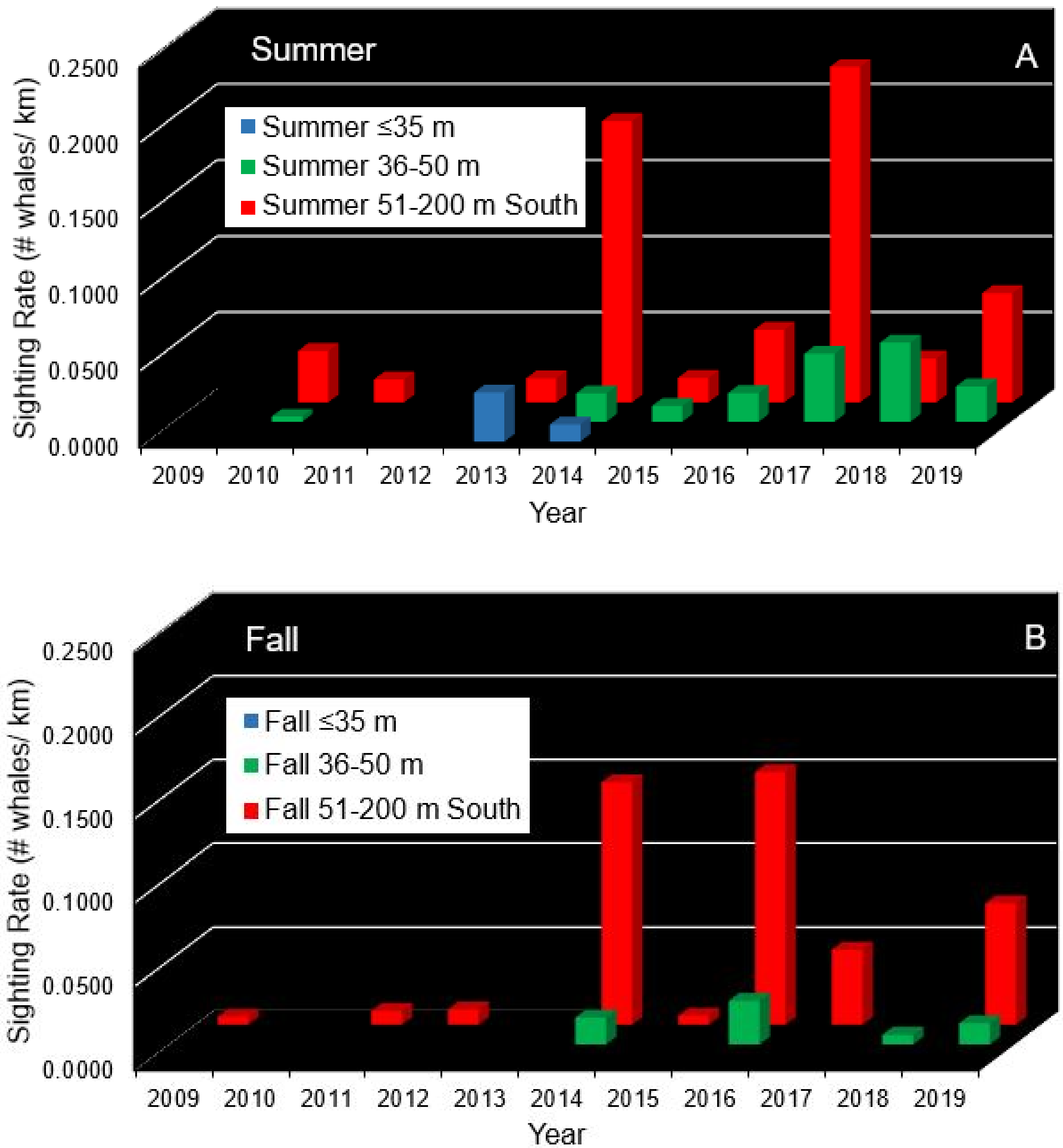


Figure 59. ASAMM gray whale on-effort annual sighting rates (WPUE; sightings from primary observers only), per season per depth zone, in the southcentral Chukchi Sea subarea (blocks 22 and 23 combined), 2009-2019. A: summer (July-August pooled). B: fall (September-October pooled). Sighting rates of zero were removed from the graph for clarity.

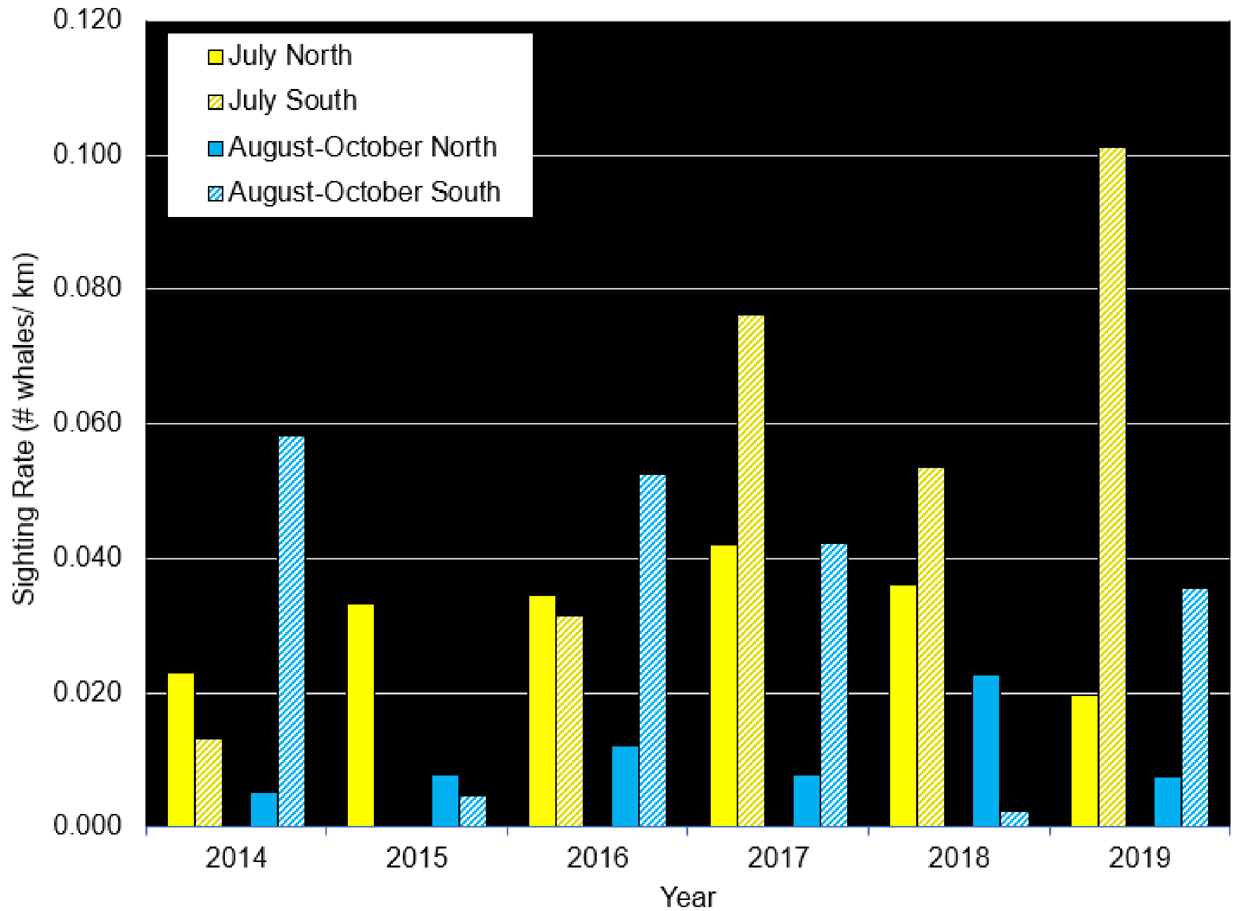


Figure 60. ASAMM gray whale on-effort annual sighting rates (WPUE; sightings from primary observers only) in the northeastern Chukchi Sea (North, blocks 13, 14, and 17 combined) and southcentral Chukchi Sea (South, blocks 22 and 23 combined), July and August-October pooled, 2014 to 2019. Sighting rates of zero were removed from the graph for clarity.

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 and other anthropogenic influences.

The fifteen gray whales sighted in the eastern Beaufort Sea in mid-August (Appendix I) represent the greatest number of gray whales observed in any one day or year in that area. Brower et al. (2015) and Willoughby et al. (2020a) summarized gray whale sightings in the Beaufort Sea from 1933 to 2019, including three gray whales sighted northeast of Cape Bathurst in September 2014 (Iwahara et al. 2016). Systematic surveys are rarely conducted in the eastern Beaufort Sea, so the annual occurrence of gray whales there is largely unknown. Gray whales are also rarely observed in the western Beaufort Sea, which is the presumed migration path that gray whales would take between the northeastern Chukchi Sea and the eastern Beaufort Sea, despite ASAMM surveys conducted there each summer from 2012 to 2019. Most gray whales

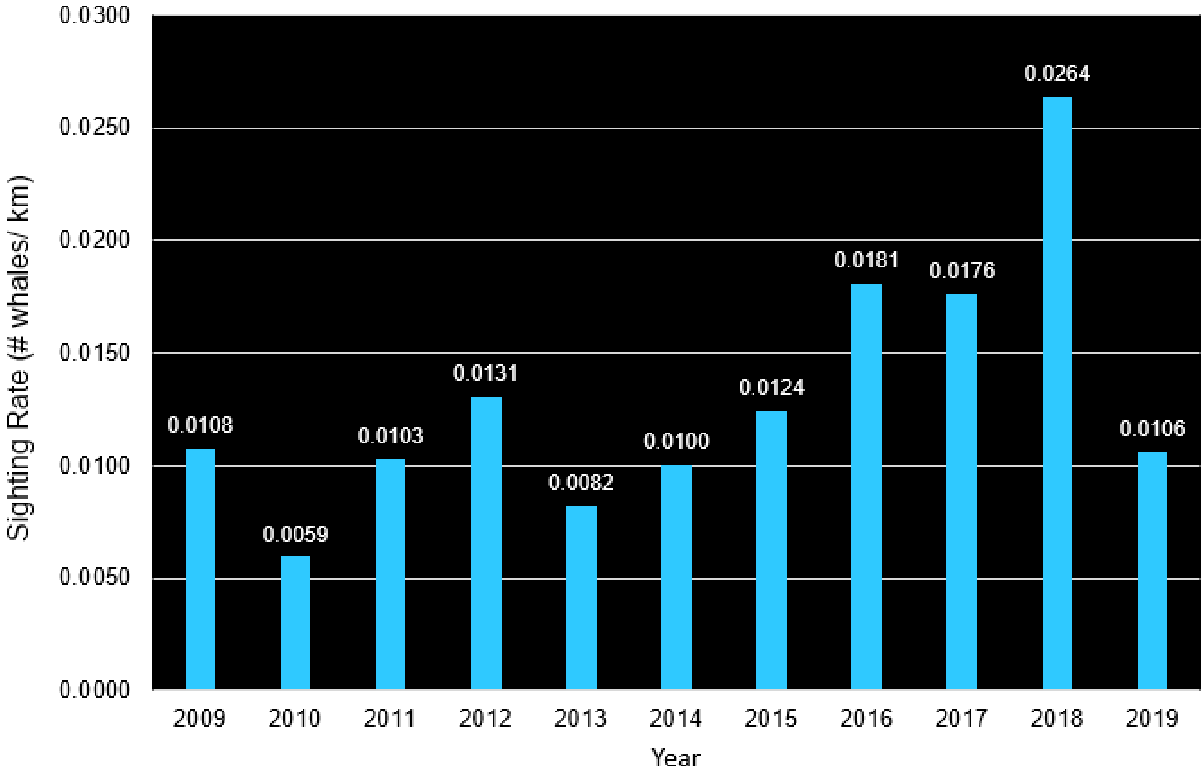


Figure 61. ASAMM gray whale annual on-effort sighting rates (WPUE; sightings from primary observers only) in the northeastern Chukchi Sea (blocks 13, 14, and 17 combined), July-October pooled, 2009-2019.

sighted in the eastern Beaufort Sea were in an area that is upwelling favorable (Williams and Carmack 2008) where ampeliscid amphipods predominate (Conlan et al. 2019).

The importance of the northeastern Chukchi Sea to gray whale calves has persisted 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 (67°-72°N, 154°-169°W) has been inconsistent among years. Gray whale calves have been seen in 17 of the 22 years that ASAMM aerial surveys have been conducted in the region with some regularity (1982-1991, 2008-2019); sightings of more than one gray whale calf per year were recorded in only 12 of the 22 years (Clarke et al. 1989, 2012, 2013a, 2014, 2018b, 2019). Relatively few gray whale calves were seen on effort in the eastern Chukchi Sea in 2019 compared to 2009-2018; sighting rates were lower only in 2009 and 2010 (Figure 62). Gray whale calf sighting rate in 2019 was 0.0005 CPUE, which was lower than the sighting rate for all years from 2012 to 2018. Calf sighting rate was very low in 2019 in all months in blocks 13, 14, and 17 (Figure 63), particularly compared to sighting rates for all gray whales (Figure 57).

July remained the month when most gray whale calves were seen, although survey effort in the northeastern Chukchi Sea in August was limited due to the eastward shift in geographic survey coverage for ABA. Weaning likely takes place in late summer or early fall (Sumich 1986);

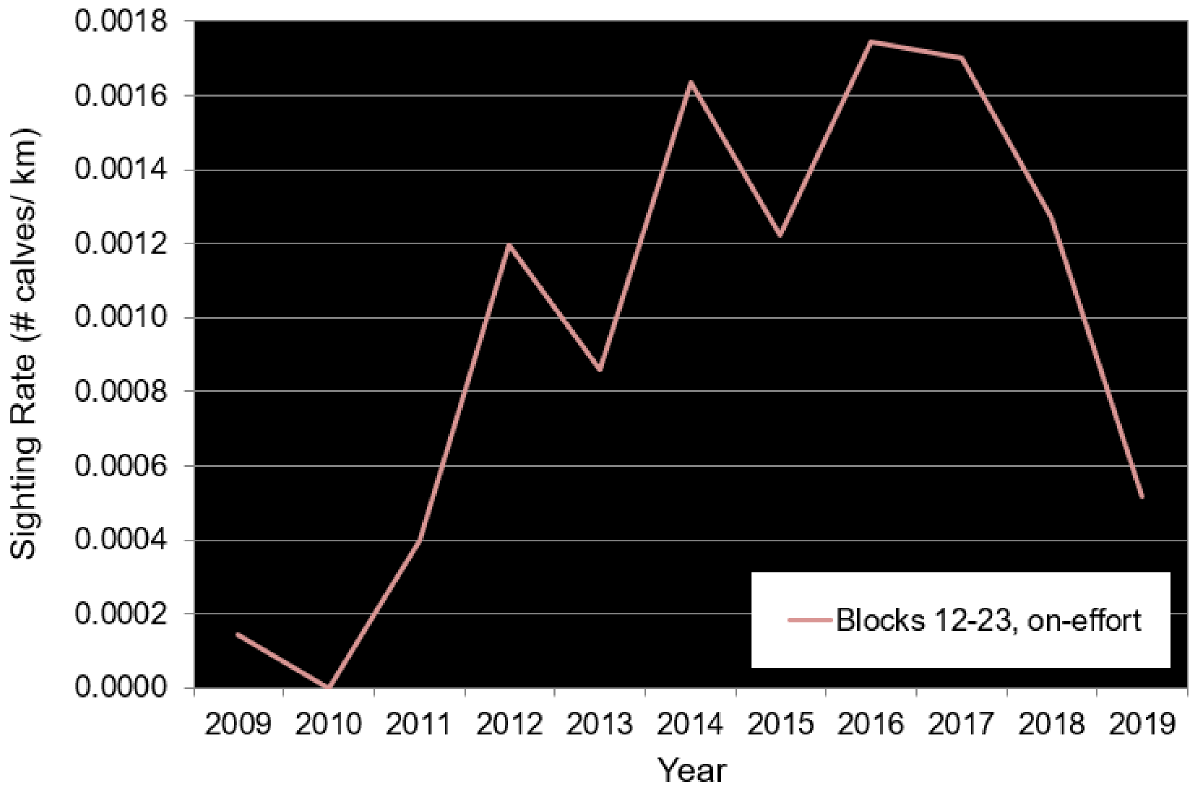


Figure 62. ASAMM gray whale on-effort annual calf sighting rates (CPUE; sightings from primary observers only), blocks 12-23 combined, 2009-2019.

therefore, all gray whales identified during ASAMM as calves based on appreciably 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. 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 2018; Weller and Perryman 2019) and off the southern California coast by the Los Angeles Chapter of the American Cetacean Society (American Cetacean Society, Los Angeles Chapter 2020) (Figure 64). In all three areas, calf counts peaked in 2016, and decreased in 2017 and 2018; the decrease in calf count was also noted in 2019 in the eastern Chukchi Sea and off the southern California coast. Calf counts may have been related to favorable foraging conditions from 2011 to 2016, resulting in higher reproductive success.

In response to the declaration of a gray whale UME in spring 2019 (USDOC, NOAA, NMFS 2019), ASAMM made a concerted effort to collect images of gray whales in the eastern Chukchi Sea in 2019. These images were taken obliquely through an openable side window on the Commander aircraft, and are not directly comparable to images obtained from belly port cameras and unmanned aerial vehicles elsewhere in the gray whale range. However, these images represent a visual means of assessing relative body condition of gray whales at the farthest extreme of their annual summer migration to feeding grounds. The gray whale UME assessment

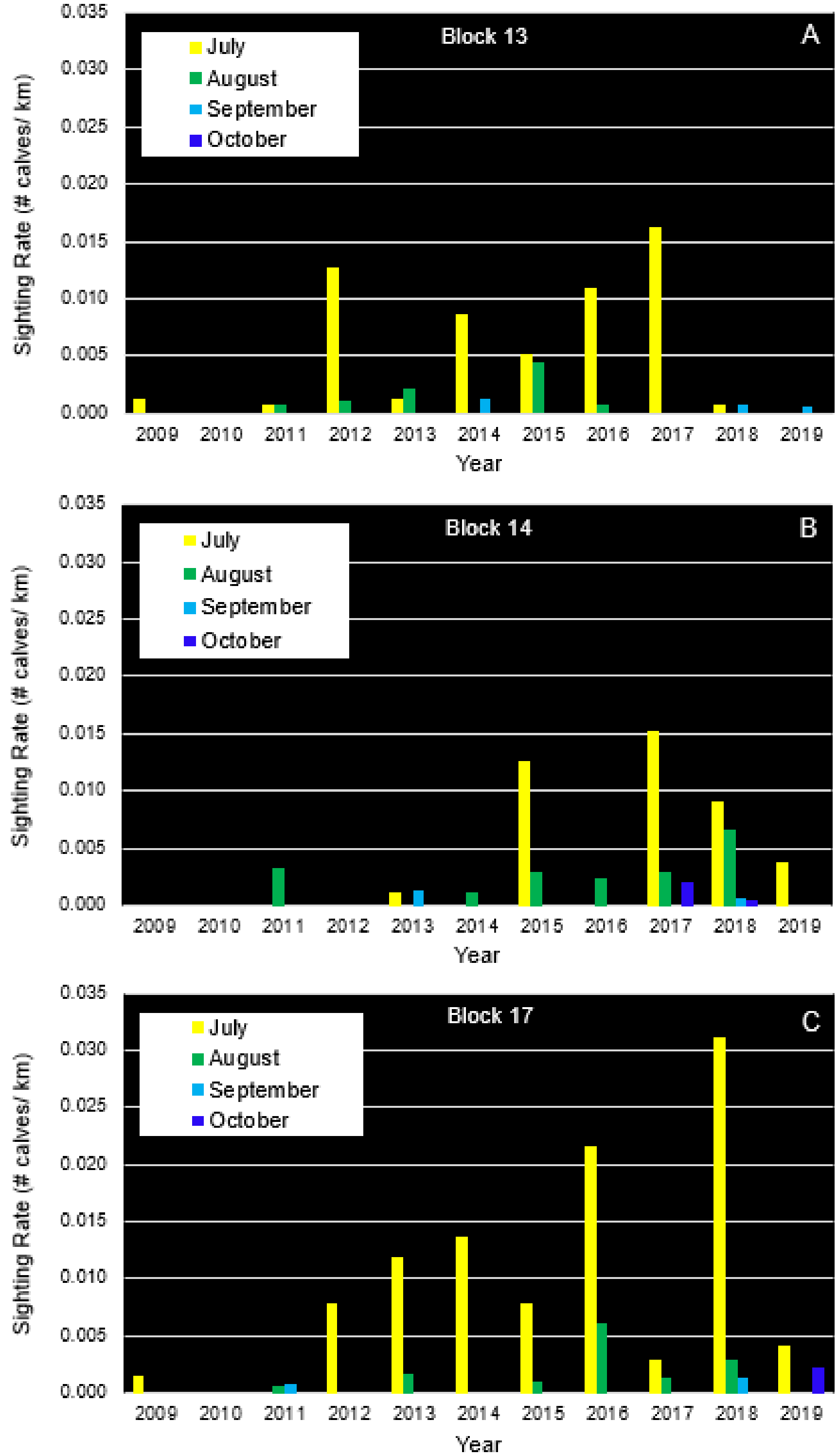


Figure 63. ASAMM gray whale on-effort annual calf sighting rates (CPUE; sightings from primary observers only) in the northeastern Chukchi Sea, July-October pooled, 2009 to 2019. A: block 13. B: block 14. C: block 17. Sighting rates of zero were removed from the graph for clarity.

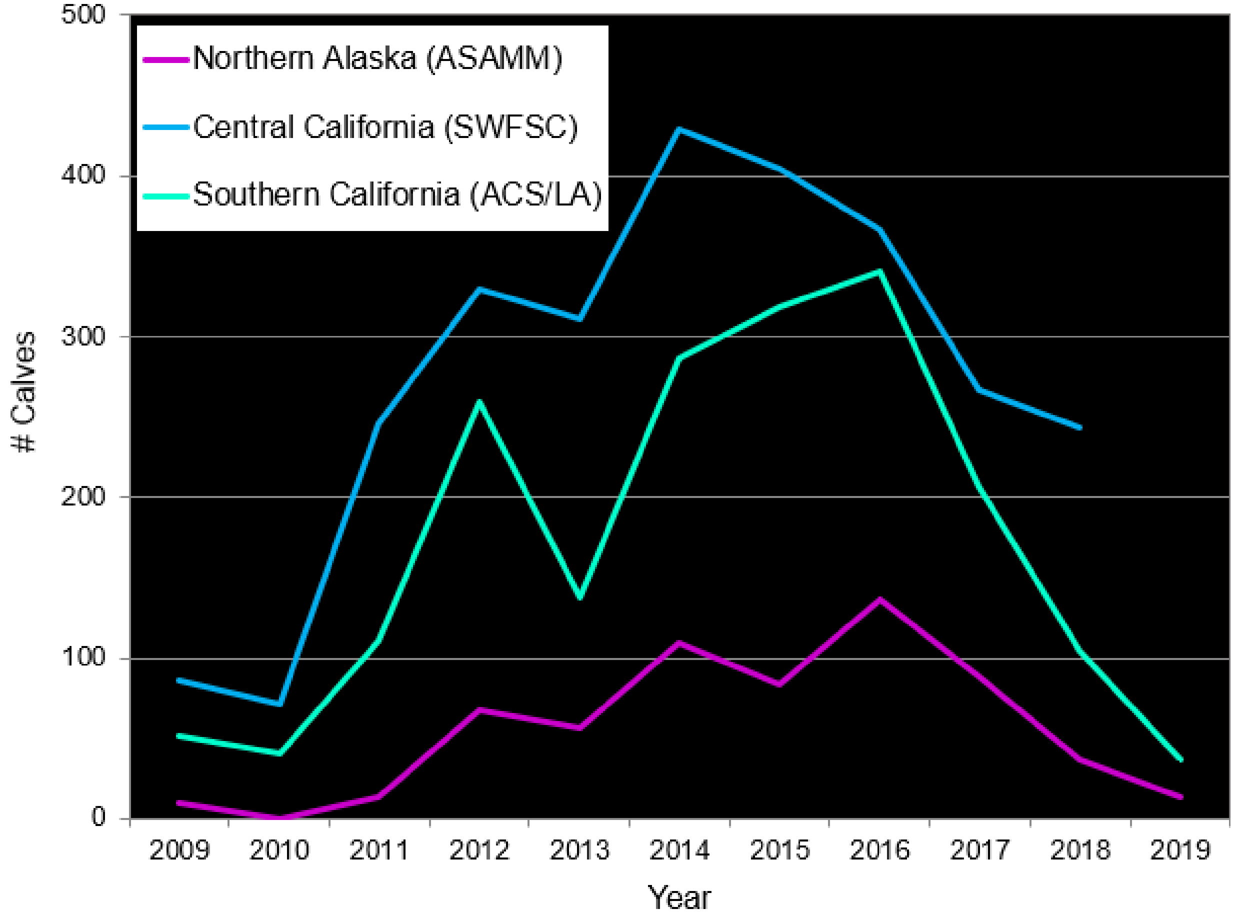


Figure 64. ASAMM gray whale annual calf counts in the eastern Chukchi Sea off northern Alaska, summer and fall 2009-2019, American Cetacean Society/ Los Angeles (ACS/LA) northbound calf counts off southern California, spring 2009-2019, and Southwest Fisheries Science Center (SWFSC) northbound calf counts off central California, spring 2009-2018. Calf counts from central California in 2019 are not available from SWFSC.

team, after viewing several example images, has determined that an in-depth review of photos taken by ASAMM will indeed be useful. Body condition will be scored based on prescribed body features and scoring will be conducted independently by several subject matter experts. This review is ongoing.

In 2014, the ASAMM study area expanded to include regular surveys from July through October in block 23 (67°-68°N, 166°-169°W), 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 2019, gray whales were sighted in this benthic hotspot from early July through mid-October. Humpback and fin whales were also sighted in this area, but gray whales were spatially and temporally segregated from the balaenopterids until late September. Gray whales were observed in western and northwestern block 23 in July and August, while humpback and fin whales observed in the central area of block 23 in July.

Spatial segregation between gray whales and balaenopterids in the southern Chukchi Sea has been observed by ASAMM in previous years as well (Figure 65). Distributions of large whales in the southcentral Chukchi Sea are likely related to water masses (including Alaska Coastal Water [ACW], Bering Shelf Water [BSW], Anadyr Water [AW], and Bering Shelf Anadyr Water [BSAW]), 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, and these prey aggregations appear to be related to water mass clusters (Eisner et al. 2013). Gray whales in the benthic hotspot were in an area characterized by colder, saltier, higher nutrient BSW at the surface. In contrast, humpback and fin whales were primarily found in areas characterized by warmer, less saline, lower nutrient ACW_{highS} at the surface; ACW_{highS} has higher salinity than ACW_{lowS} but lower salinity than BSW (Eisner et al. 2013). Areas where large whales were seen were all characterized by nutrient rich BSAW at the bottom. Prey assemblages differed between the ACW_{highS}/BSAW water mass, where fish abundance was relatively high, and the BSW/BSAW water mass, where fish abundance was quite low; both water masses were characterized by relatively high abundance of large zooplankton. Humpback whales and fin whales are known to prey on small schooling fish, euphausiids, and copepods. Gray whales feed on benthic organisms, like ampeliscid amphipods, which were not sampled during Eisner et al. (2013), but are also known to feed pelagically on mysids, cumaceans, euphausiids, and fish and arthropod larvae (Brower et al. 2018a). Overall, the relationship between gray whales and balaenopterid whale distribution in the southcentral Chukchi Sea and preferred prey assemblages/water masses appears strong. Analysis of data from the DBO transect may reveal even more specific oceanographic and biological parameters that may have influenced gray whale and other large whale distributions and densities in 2014-2019.

Beluga distribution in the ASAMM study area in 2019 remained similar to the distribution observed since 1982 (Figure 38). 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 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 BS, 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

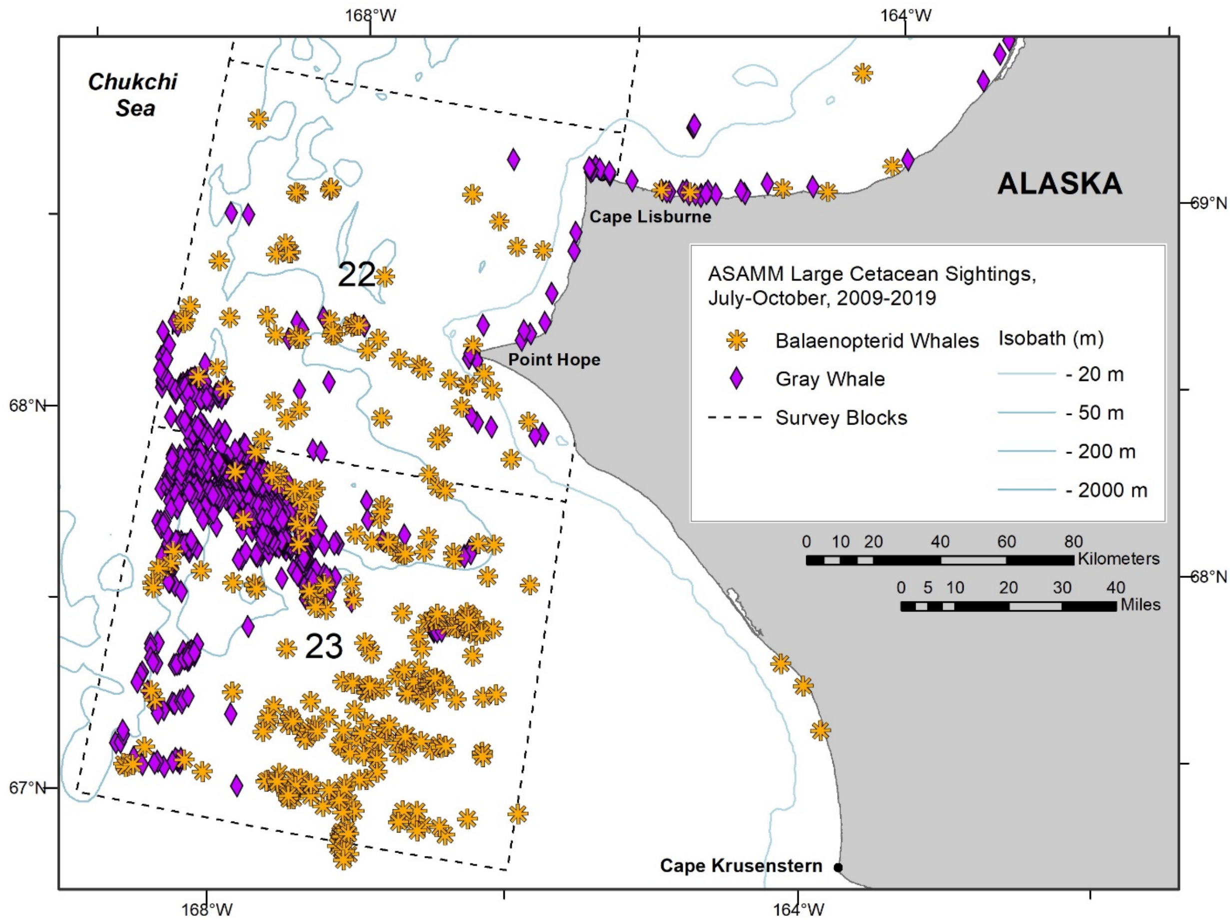


Figure 65. ASAMM gray and balaenopterid whale distribution (transect, CAPs, search and circling modes) in the southcentral Chukchi Sea, July-October, 2009-2019. Balaenopterid whales include humpback, fin, and minke whales.

distribution and relative abundance within the ASAMM study area. The beluga sighting rate in the western Beaufort Sea was much higher in July 2019 compared to July 2012-2018, with August to October 2019 sighting rates comparable to past years (Figure 66A). The 2019 fall beluga sighting rate in the western Beaufort Sea was higher than all previous years except 2015 (Figure 66B).

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, it is likely that the relationship between belugas and sea ice cover in the western Beaufort Sea reflected differences between the two periods in the geographic distribution of sea ice rather than the geographic distribution or habitat affinity of belugas, suggesting that sea ice may not be a good habitat indicator for belugas in this region.

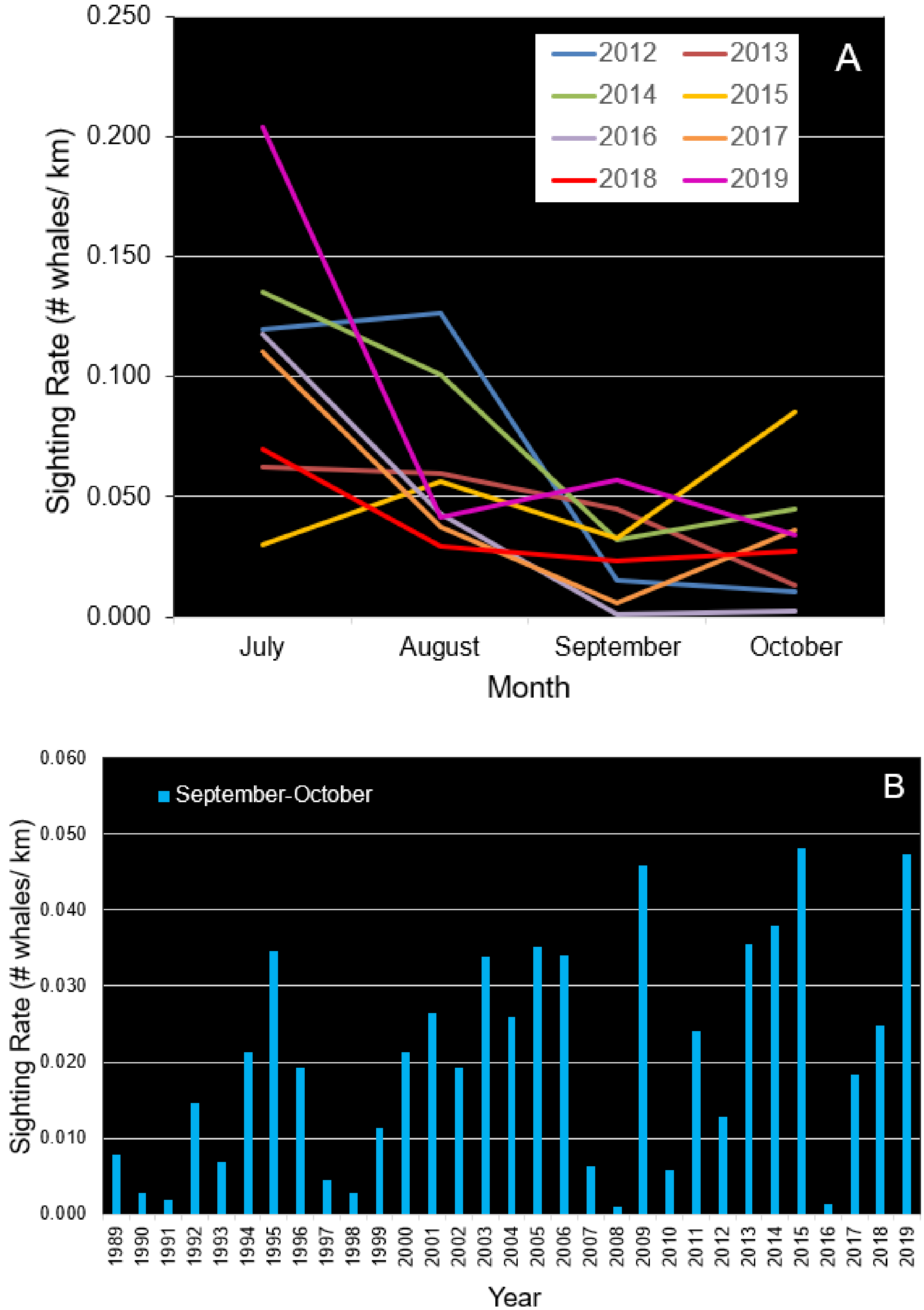


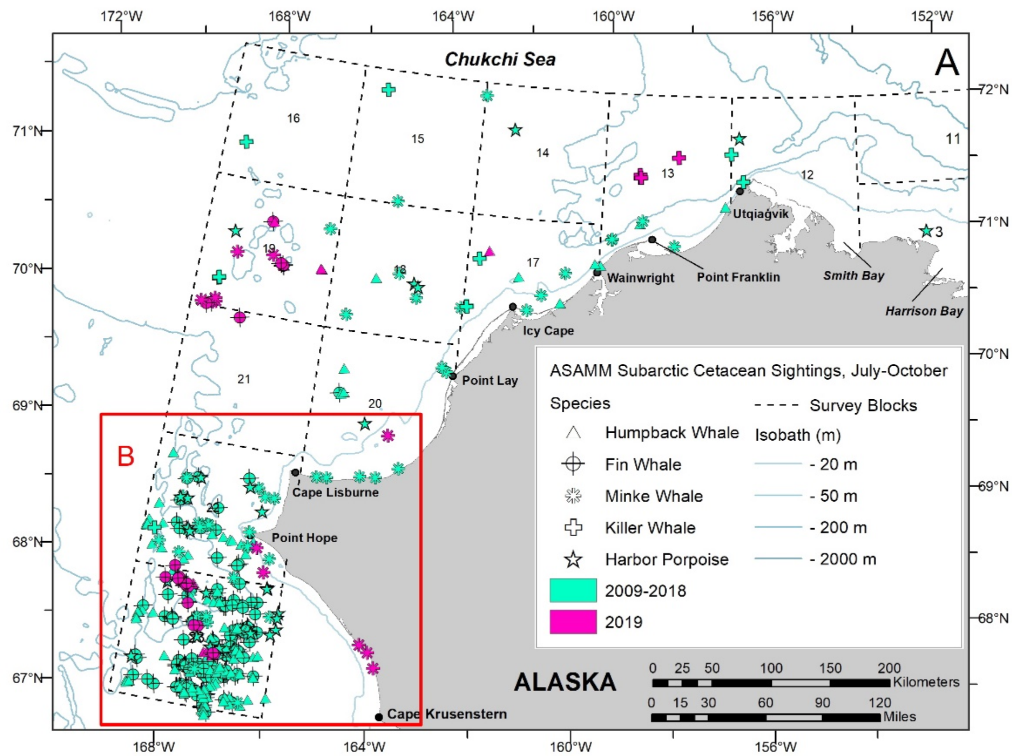
Figure 66. ASAMM beluga on-effort annual sighting rates (WPUE; sightings from primary observers only), 1989-2019. A: monthly sighting rates in the western Beaufort Sea (140°W-157°W), 2012-2019. B: fall (September-October pooled) sighting rates in the western Beaufort Sea, 1989-2019.

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 2019 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 2019 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 2009-2018, most observations of these species in 2019 were in the southcentral Chukchi Sea but humpback, fin, and minke whales were also seen farther north on Herald Shoal in the northeastern Chukchi Sea (Figure 67). Killer whales were also seen in the northeastern Chukchi Sea in 2019.

Humpback whales have been frequently encountered in the northeastern Chukchi Sea since 2009 (Clarke et al. 2013b; Brower et al. 2018a, 2019) (Figures 67 and 68). Sighting rates were particularly high in July and September 2018 (Figure 69A). 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 were the most frequently observed balaenopterid cetacean in the eastern Chukchi Sea from 2009 to 2019 (Brower et al. 2019) (Figure 68). Highest fin whale sighting rates were in September 2014, July and September 2018, and October 2019 (Figure 69B). 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



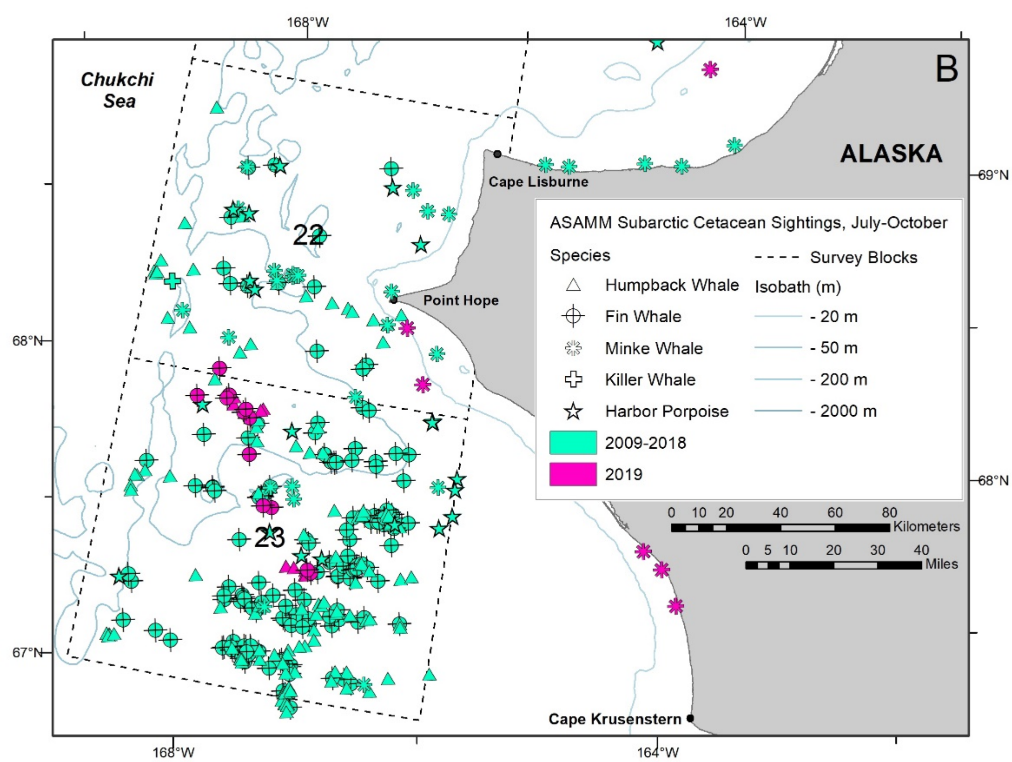


Figure 67. ASAMM subarctic cetacean distribution (transect, CAPs, search and circling modes), July-October, 2009-2019. A: eastern Chukchi Sea. B: southcentral Chukchi Sea.

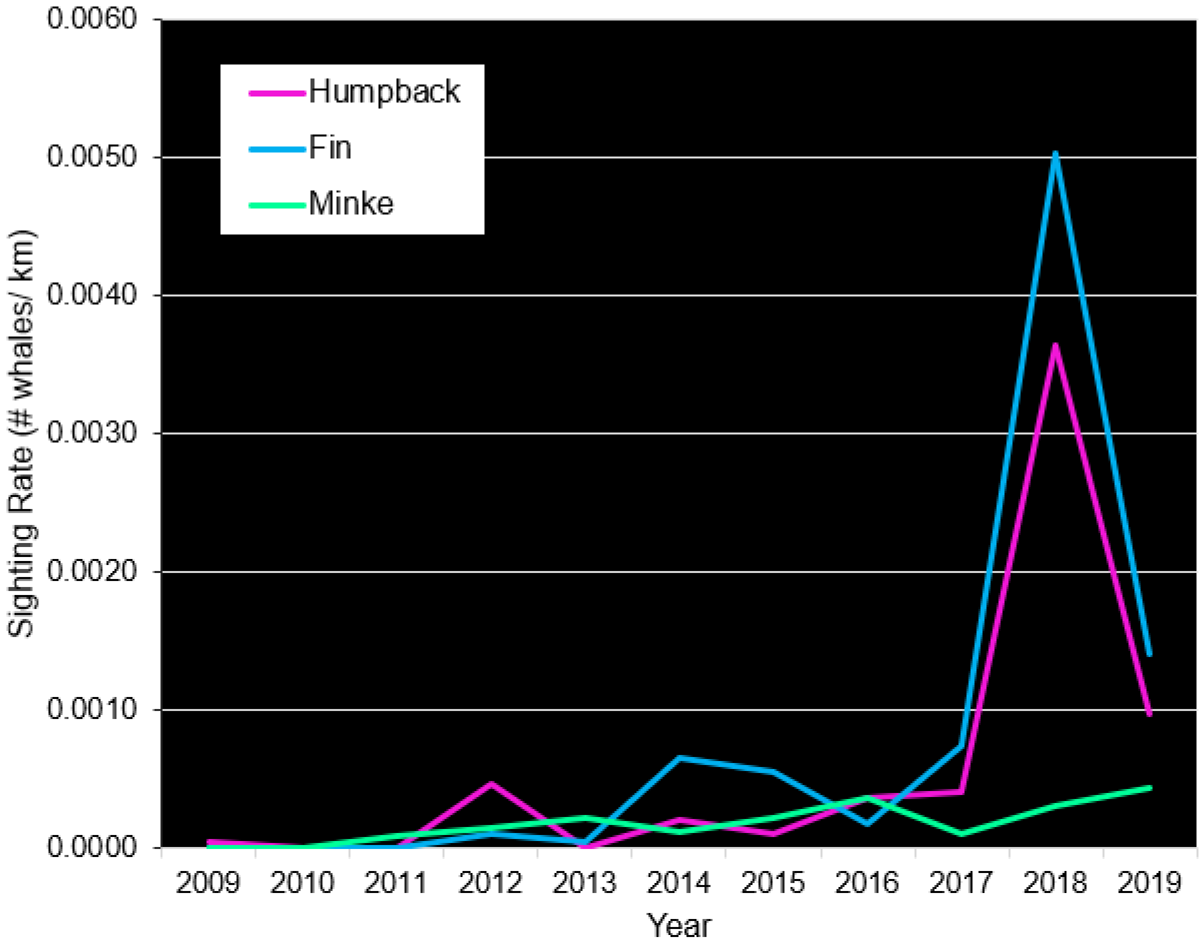


Figure 68. ASAMM subarctic cetacean on-effort annual sighting rates (WPUE; sightings from primary observers only), eastern Chukchi Sea, 2009-2019.

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). Fin whales observed in July, September, and October 2019 represent the farthest north visual detections in the Pacific Arctic (Willoughby et al. 2020a) (Figure 67A).

This is the ninth consecutive year that ASAMM has documented minke whales in the northeastern Chukchi Sea (Clarke et al. 2012, 2013a, 2014, 2015a, 2017a, b, 2018b, 2019; Brower et al. 2018a), although minke whales remain the least commonly observed balaenopterid species (Figures 67 and 68). The highest sighting rate for minke whales occurred in August 2016 (Figure 69C) when nine minke whales were recorded during ASAMM surveys in the eastern Chukchi Sea. 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

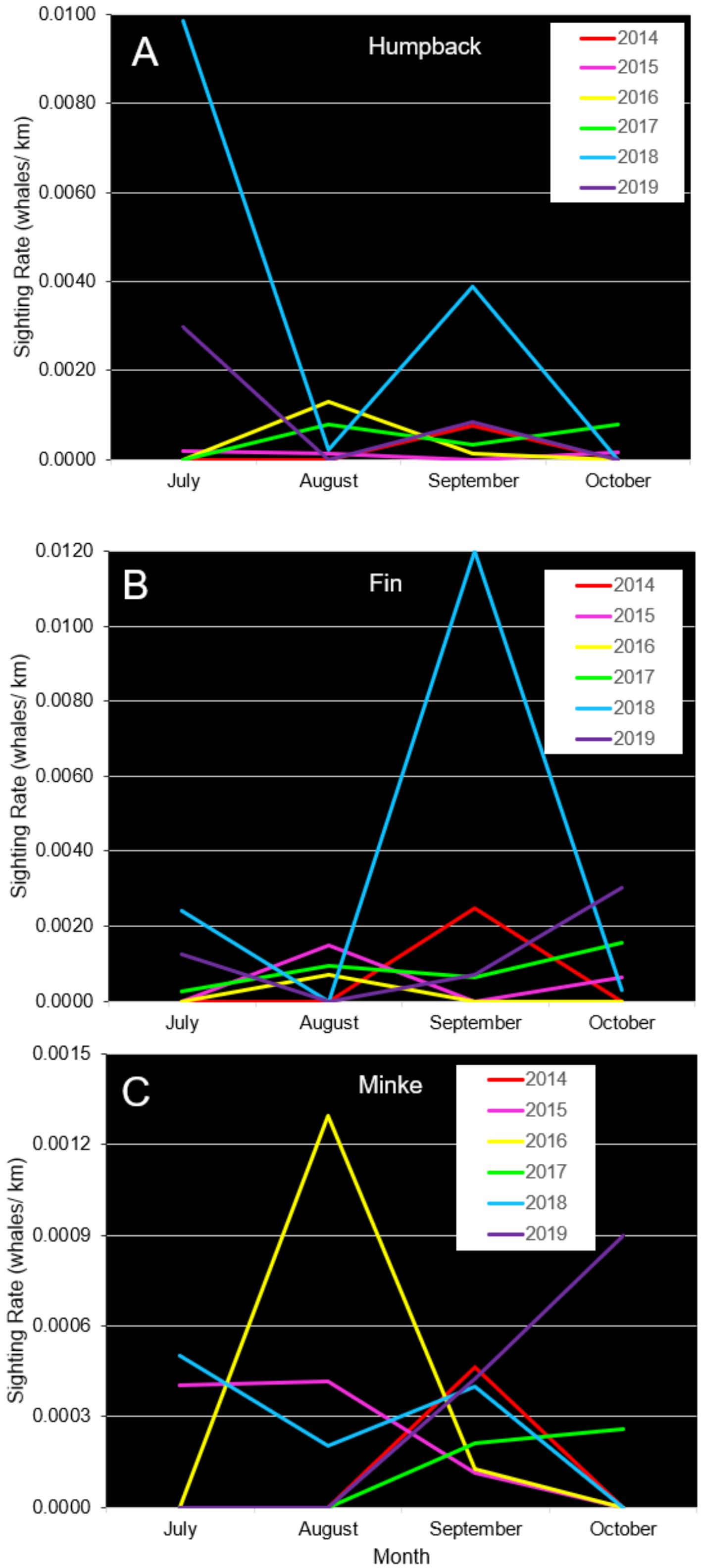
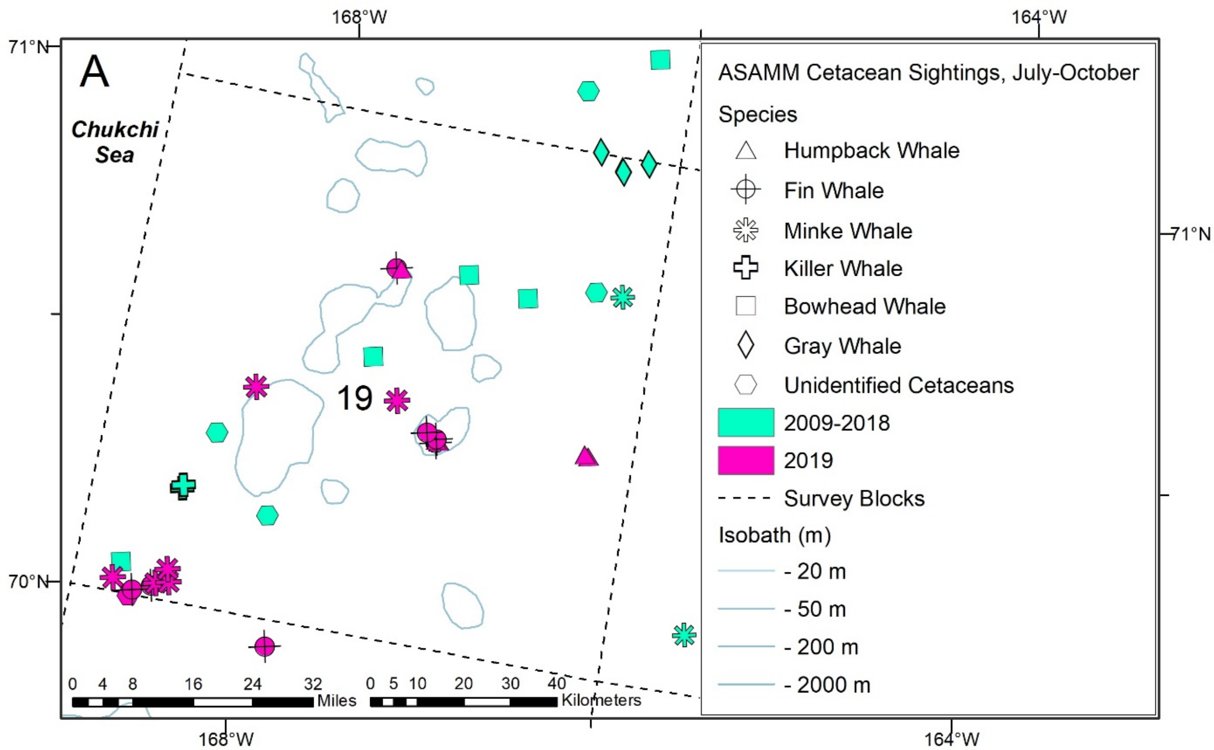


Figure 69. ASAMM subarctic cetacean on-effort monthly sighting rates (WPUE; sightings from primary observers only), northeastern Chukchi Sea, 2014-2019. A: Humpback whales. B: Fin whales. C: Minke whales. Note that sighting rate axes differ.

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

Humpback, fin, and minke whales were frequently seen near one another, particularly in the southern Chukchi Sea near a well-documented benthic hotspot. In 2019, these three species were also sighted near one another near Herald Shoal. Although feeding by humpback, fin, and minke whales is not always detected during ASAMM surveys, it is likely that foraging opportunities are the main reason large whales migrate to the Chukchi Sea. ASAMM documented several indicators that humpback and fin whales were feeding in the Chukchi Sea from 2014 to 2019, including lunge feeding, expanded throat grooves, water streaming from mouth, bubbles, defecation, and many animals with short surfacing bouts in a small area. In some years, balaenopterid whales were seen near gray whales but often balaenopterid whales are segregated from gray whales both spatially and temporally. Balaenopterid whales feed on pelagic euphausids, copepods, 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). Eisner et al. (2013) described pelagic fish and zooplankton species assemblages in relation to water mass characteristics in the southern and central Chukchi Sea. In that analysis, water mass cluster group "F", characterized by ACW_{highS} at the surface and BSAW on the bottom, were found in both the southcentral and central Chukchi Sea, closely overlying where humpback, fin, and minke whales were sighted in 2019. 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).

From 2009 to 2018, very few whales were sighted during ASAMM surveys in the Herald Shoal area (ASAMM block 19) (Figure 70A), despite >10,000 km of survey effort (Figure 70B). Bowhead and gray whales were occasionally sighted in the area, but large cetacean sighting rates were low each year except 2016 (Figure 71A). Only one balaenopterid whale (a minke whale in September 2016; Clarke et al. 2017b) was sighted in block 19. In 2019, however, balaenopterids were sighted in block 19 on four of the five ASAMM surveys that traversed the area from late July through mid-October. In total, 26 humpback, fin, and minke whales were sighted in block 19 and nearby in block 21. Sighting rates, using balaenopterid whales and kilometers on effort, in 2019 were 12.5 times higher than in any previous year (Figure 71B). The underlying reasons why balaenopterid whales were regularly using an area of the eastern Chukchi Sea in 2019 that they had previously not been known to use are not understood, but likely include changes in current transport, water mass properties or sources, rate of primary and secondary production, and continuing decline of sea ice, factors which were anomalous in 2019 (Richter-Menge et al. 2019).



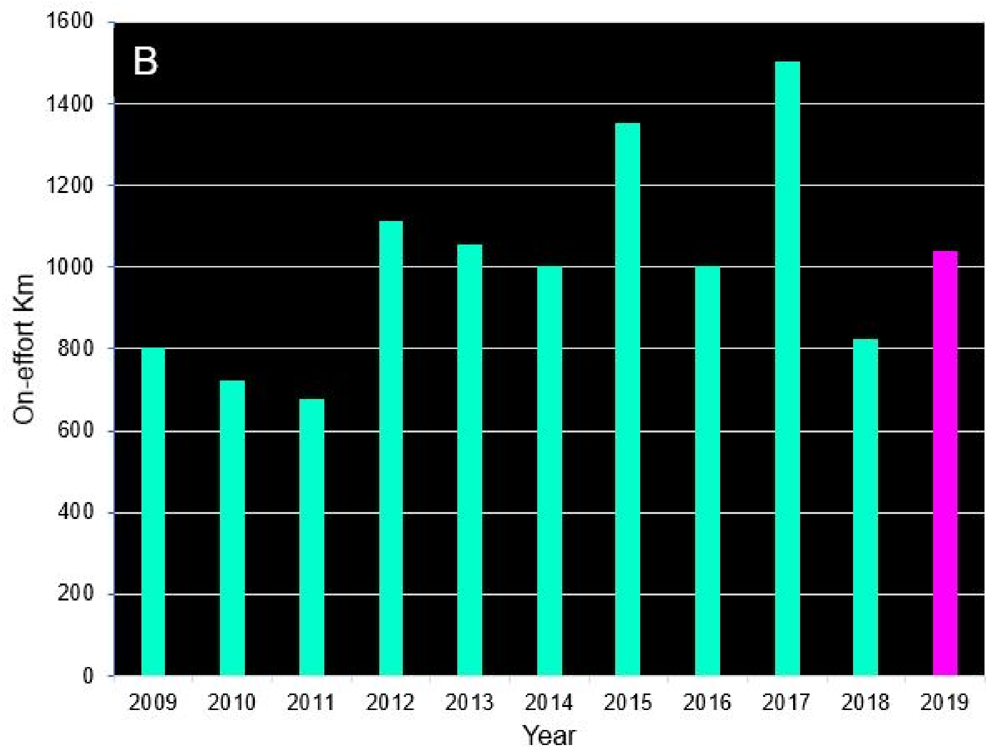


Figure 70. ASAMM large cetacean distribution (all sightings, transect, CAPs, search and circling modes) (A), and annual on-effort kilometers (B) near Herald Shoal (block 19), July-October, 2009-2019.

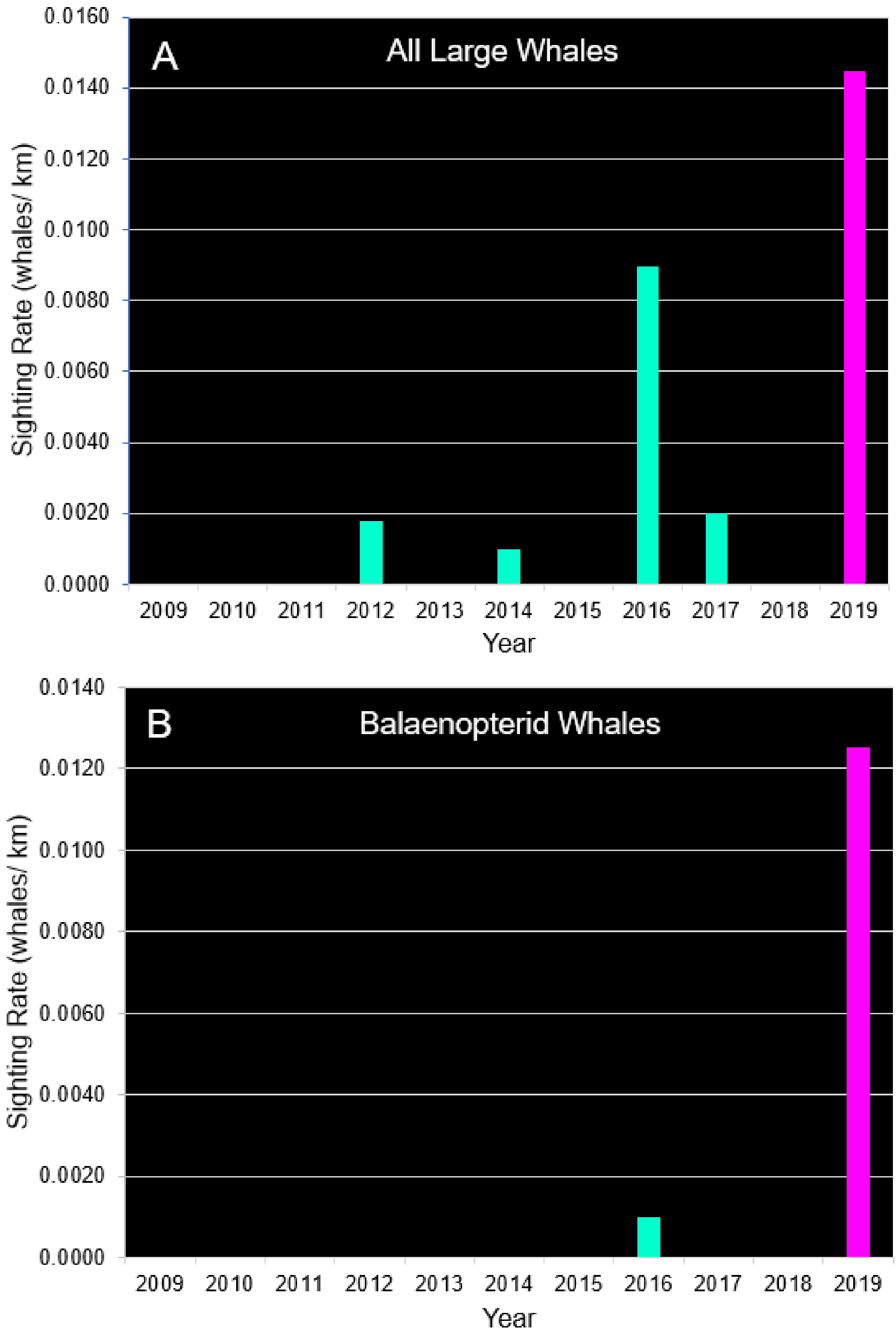


Figure 71. ASAMM large cetacean sighting rates (WPUE: sightings from primary observers only), block 19 (Herald Shoal), July-October, 2009-2019. A: All large whales combined. B: Balaenopterids only.

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 in the eastern Chukchi Sea in 2012 (Clarke et al. 2013a), 2016 (Clarke et al. 2017b), 2017 (Clarke et al. 2018a), and 2018 (Clarke et al. 2019) 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). Review of ASAMM bowhead whale and gray whale carcass imagery indicates that killer whales played a key role in mortality for carcasses documented from 2009 to 2019. ASAMM documented 44 bowhead whale carcasses from 2009 to 2019, of which 24 (55%) had injuries consistent with killer whale predation. In the western Beaufort Sea, bowhead whale carcasses documented in 2019 ($n_i = 8$) equaled those of the previous 10 years (2009-2018) combined ($n_i = 8$). Four of the bowhead whale carcasses in the western Beaufort Sea in 2019 had injuries consistent with killer whale predation, compared to three in 2009-2018 (Willoughby et al. 2020c). Images were collected for 56 of the 60 gray whale carcasses documented by ASAMM from 2009 to 2019. Forty-one of the photographed gray whales had injuries consistent with killer whale predation; killer whale predation was photo-documented every year except 2010 and 2011. Eight gray whale carcasses were documented in 2019, of which six were attributed to killer whale predation; this was the second highest total per year (tied with 2018) for killer whale predated carcasses, after 2012 ($n_i = 12$) (Willoughby et al. 2020b). 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. 2018b). 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 and Aerts 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 were not 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). Whiting et al. (2020) unexpectedly recorded harbor porpoises in Kotzebue Sound and near Sealing Point (Cape Krusenstern) from January to early March 2015.

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 July 2019 and persisted until at least 21 September. The estimated number of walruses at the Point Lay haulout varied considerably over the 2.5 months of use in 2019, similar to what was documented in previous years (Figure 72). 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 2019 was again historically low (National Snow and Ice Data Center 2019).

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 considerably 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,

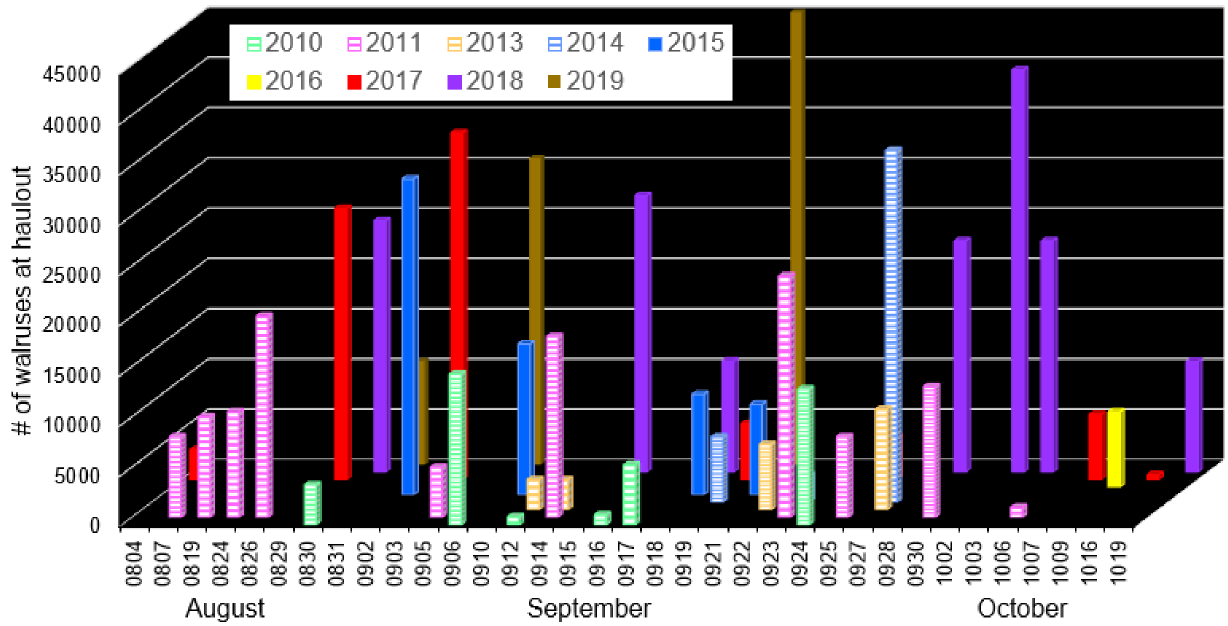


Figure 72. ASAMM walrus group size estimates by month and day (e.g., 0804 is 4 August) and year at coastal haulouts near Point Lay, 2010-2019. Walruses hauled out near Icy Cape but not at Point Lay in 2009; walruses did not haul out at any location along the northeastern Chukchi Sea coastline in 2012.

and 2018 also showed large fluctuations in group sizes (Figure 72). 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.

Sighting rates (number of pinnipeds per km) of unidentified pinnipeds and small unidentified pinnipeds combined, excluding seals observed on coastal haulouts, were moderately high in summer in the western Beaufort Sea and relatively low in fall in the western Beaufort and eastern Chukchi seas in 2019 compared to previous years (Figure 73). ASAMM surveys prioritize cetaceans so some pinnipeds may not be recorded in areas of high cetacean density, which likely negatively affects sighting rates.

The distribution of pinnipeds in 2019 was similar to observed distributions in previous years (Clarke et al. 2011a, d, 2012, 2013a, 2014, 2015a, 2017a, b, 2018a, 2019). Most pinnipeds were within the 200 m isobath in the ASAMM study area (Figures 47 and 48), which is also where the majority of satellite-tagged ringed, spotted, and bearded seals were found in July-October from 2012 to 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).

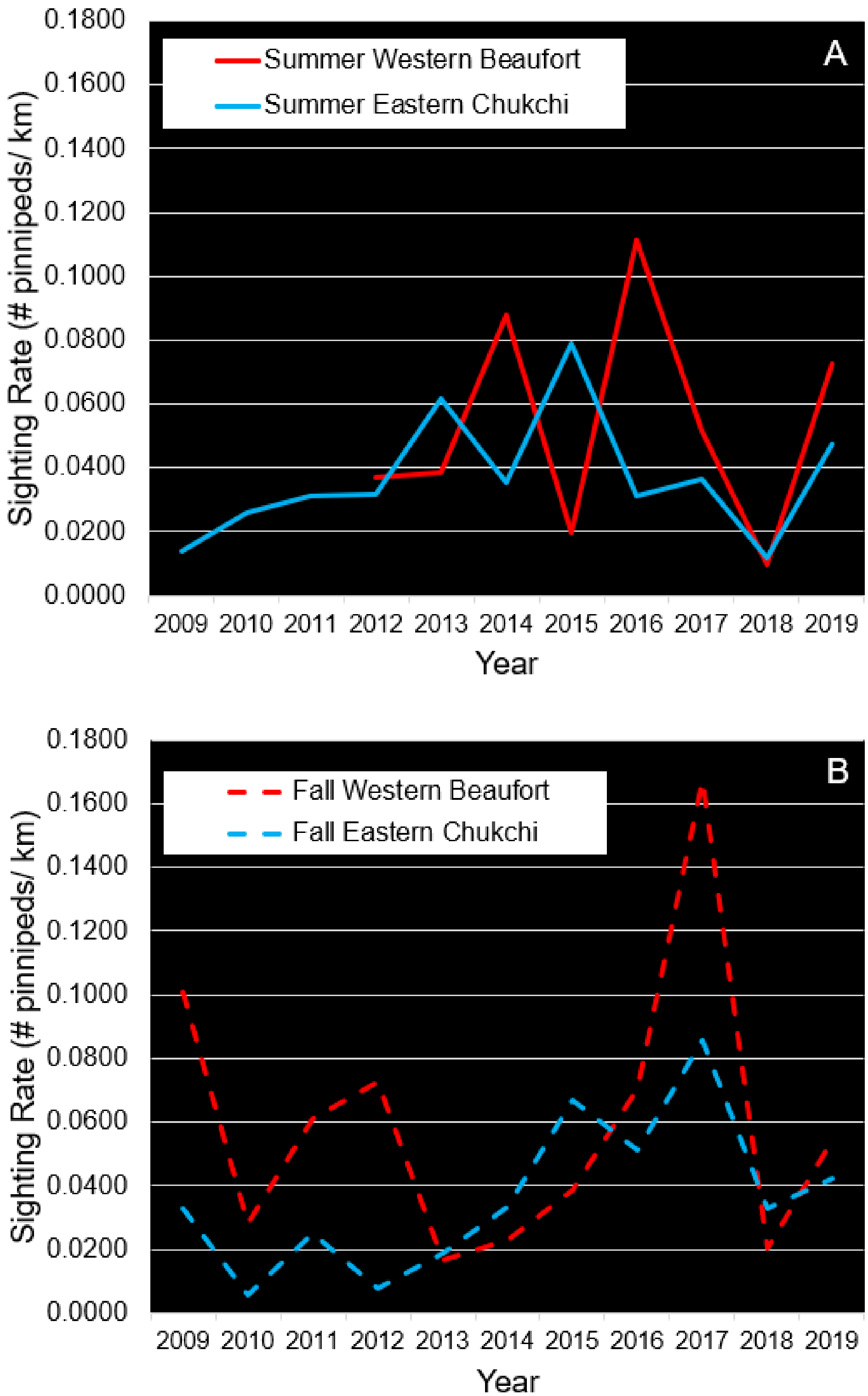


Figure 73. ASAMM unidentified pinniped and small unidentified pinniped (combined) annual sighting rates (PPUE; sightings from primary observers only) in the eastern Chukchi and western Beaufort seas, 2009-2019. A: summer (July-August pooled). B: fall (September-October pooled). Excludes pinnipeds observed at onshore haulouts.

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 photo 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).

Adult bearded seals are one of the few non-walrus pinnipeds that can be identified during ASAMM surveys due to their characteristic large body-to-head ratio. Adult bearded seals were observed scattered in the western Alaskan Beaufort Sea from July to October 2019. Several (n_i = 17) bearded seals were observed near Herald Shoal in mid and late October 2019 (Figure 48), in the same area where subarctic cetaceans had been seen in July and September 2019. The oceanographic conditions that made this area attractive to subarctic cetaceans in summer 2019 may have also made this area more attractive to bearded seals, who forage on shrimp, crabs, clams, cod, and sculpin.

Polar bear sighting rates in the western Beaufort Sea in summer 2019 were the highest recorded since 2012, the year that summer surveys began, and sighting rates in fall 2019 were second only to fall 2017 sighting rates (Figure 74). Polar bear sighting rates were positively impacted by the addition, in 2017, of a coastal transect in the western Beaufort Sea, and by the extension of transects south of the barrier islands into block 1a in 2016. 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. Polar bears use sea ice as a platform to hunt ringed and bearded seals. Most 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).

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

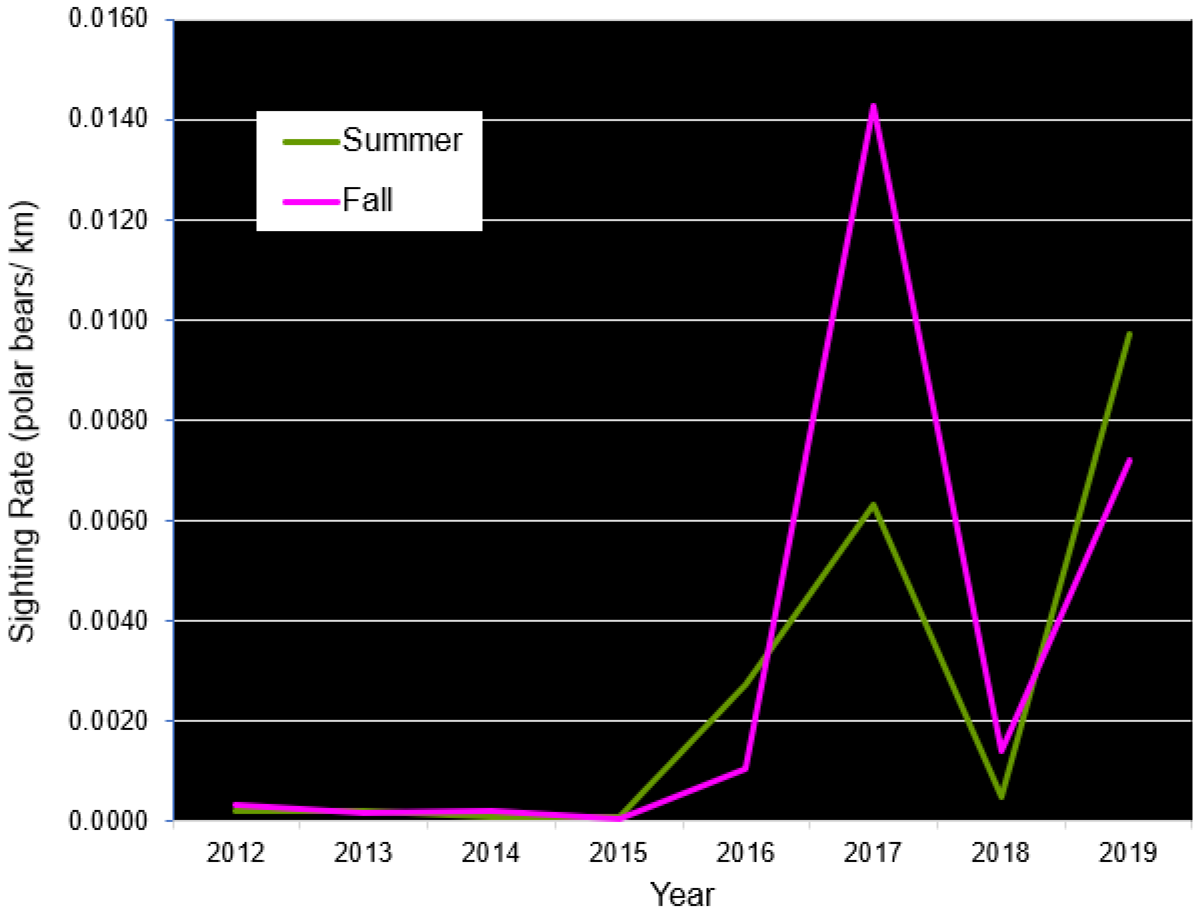


Figure 74. ASAMM polar bear annual sighting rates (PPUE; sightings from primary observers only) in the western Beaufort Seas, summer and fall, 2012-2019. Includes sightings and effort on all transects, including coastal.

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 in 2018, 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 ≥335 m. By comparison, aerial surveys conducted to assess polar bear abundance are often flown at lower altitudes (60 m) and slower speeds (100 kts) 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 transect effort). Many factors affect ASAMM polar bear data: amount of coastal survey effort per month and year, weather conditions during ASAMM surveys at known congregation 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, 2012, and 2019 (National Snow and Ice Data Center 2007, 2012, 2019). 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 (1982-2019) 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 2019).

Management Use of Interannual Monitoring

This BOEM-sponsored marine mammal monitoring study began in 1979 and continued through field work in 2019. While some aspects of this study have been updated, the data collected have remained remarkably consistent (especially data from 1982 to 2019), 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, 2018a, 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; Angliss et al. 2018; Stimmelmayr et al. 2018) to better understand, manage, and conserve arctic resources.

ASAMM data are valuable to addressing near real-time management concerns and aid in future planning. Reliable and current data are a recommended approach for resource management agencies, including NOAA, BOEM and the Department of Defense, to make management decisions about future anthropogenic activities in this region during summer and fall.

LITERATURE CITED

Aagaard, K. 1984. The Beaufort Undercurrent. Pp. 47-71. *In:* P.W. Barnes, D.M. Schell, and E. Reimnitz (eds.), *The Alaskan Beaufort Sea: Ecosystems and Environment*. Academic Press.

Aars, J., T.A. Marques, S.T. Buckland, M. Andersen, S. Belikov, A. Boltunov, and Ø. Wiig. 2009. Estimating the Barents Sea polar bear subpopulation size. *Marine Mammal Science* 25(1): 35-52.

Aerts, L.A.M., A.E. McFarland, B.H. Watts, K.S. Lomac-MacNair, P.E. Seiser, S.S. Wisdom, A.V. Kirk and C.A. Schudel. 2013. Marine mammal distribution and abundance in an offshore sub-region of the northeastern Chukchi Sea during the open-water season. *Continental Shelf Research.* DOI:org/10.1016/j.csr.2013.04.020.

Alaska Department of Fish and Game. 2019. http://www.adfg.alaska.gov/index.cfm?adfg=marinemammalprogram.bowhead (accessed 24 February 2019).

American Cetacean Society, Los Angeles Chapter. 2020. https://acs-la.org/volunteer/gray-whale-census-behavior-project/ (accessed 9 March 2020).

Angliss, R.P., M.C. Ferguson, P. Hall, V. Helker, A. Kennedy, and T. Sformo. 2018. Comparing manned aerial surveys to unmanned aerial surveys for cetacean monitoring in the Arctic: methods and operational results and recommendations. *Journal of Unmanned Vehicle Systems* 6(3): 109-127.

Ashjian, C.J., S.R. Braund, R.G. Campbell, J.C. George, J. Kruse, W. Maslowski, S.E. Moore, C.R. Nicolson, S.R. Okkonen, B.F. Sherr, et al. 2010. Climate Variability, Oceanography, Bowhead Whale Distribution, and Inupiat Subsistence Whaling Near Barrow, Alaska. *Arctic* 63(2): 179-194.

Atwood, T.C., E. Peacock, M.A. McKinney, K. Lillie, R. Wilson, D.C. Douglas, S. Miller, P. Terletzky. 2016. Rapid environmental change drives increased land use by an arctic marine predator. *PLoS ONE* 11(6): e0155932. DOI: 10.1371/journal.pone.0155932

Baldassarre, D.T. 2020. What's the deal with birds? Scientific Journal of Research and Reviews. DOI: 10:33552/SJRR.2020.02.000540.

Barrett-Lennard, L.G., C.O. Matkin, J.W. Durban, E.L. Saulitis, and D. Ellifrit. 2011. Predation on gray whales and prolonged feeding on submerged carcasses by transient killer whales at Unimak Island, Alaska. *Marine Ecology Progress Series* 421: 229-241.

Battaile, B.C., C.V. Jay, M.S. Udevitz, and A.S. Fischbach. 2017. Evaluation of a method using survey counts and tag data to estimate the number of Pacific walruses (Odobenus rosmarus divergens) using a coastal haulout in northwestern Alaska. *Polar Biology*. DOI: 10.1007/s00300-016-2060-5.

Bisson, L.N., H.J. Reider, H.M. Patterson, M. Austin, J.R. Brandon, T. Thomas, and M. Bourdon. 2013. Marine mammal monitoring and mitigation during exploratory drilling by Shell in the Alaskan Chukchi and Beaufort seas, July-November 2012: Draft 90-Day Report. Prepared for Shell Offshore, Inc., and National Marine Fisheries Service, Office of Protected Resources. Available from: http://www.nmfs.noaa.gov/pr/pdfs/permits/shell_90dayreport_draft2012.pdf.

Bivand, R. and N. Lewin-Koh. 2019. maptools: Tools for Reading and Handling Spatial Objects. R package version 0.9-9. Available from: https://CRAN.R-project.org/package=maptools.

Bivand, R. and C. Rundel. 2019. rgeos: Interface to Geometry Engine - Open Source ('GEOS'). R package version 0.5-2. Available from: https//CRAN.R-project.org/package=rgeos.

Bivand, R., T. Keitt, and B. Rowlingson. 2019. rgdal: Bindings for the 'Geospatial' Data Abstraction Library. R package version 1.4-8. Available from: https://CRAN.R-project.org/package=rgdal.

Bivand, R.S., E.J. Pebesma, and V. Gomez-Rubio. 2013. *Applied Spatial Data Analysis with R, Second Edition*. Springer, NY. Available from: http://www.asdar-book.org/.

Bluhm, B., K.O. Coyle, B. Konar, and R. Highsmith. 2007. High gray whale relative abundances associated with an oceanographic front in the south-central Chukchi Sea. *Deep Sea Research Part II: Topical Studies in Oceanography* 54(23-26): 2919-2933.

Boveng, P.L., J.L. Bengtson, T.W. Buckley, M.F. Cameron, S.P. Dahle, B.P. Kelly, B.A. Megrey, J.E. Overland, and N.J. Williamson. 2009. Status review of the spotted seal (*Phoca largha*). U.S. Dep. Commer., NOAA Technical Memorandum NMFS-AFSC-200. 153 pp.

Brower, A.A, J.T Clarke, and M.C. Ferguson. 2018a. Increased sightings of subArctic cetaceans in the eastern Chukchi Sea, 2008–2016: population recovery, response to climate change, or increased survey effort? *Polar Biology*. DOI: 10.1007/s00300-018-2257-x.

Brower, A., M. Ferguson, S. Schonberg, S. Jewett, and J. Clarke. 2017. Gray whale distribution relative to benthic invertebrate biomass and abundance: northeastern Chukchi Sea, 2009-2012. *Deep-Sea Research II*: *Topical Studies in Oceanography* 144: 156-174.

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.

Brower, A., J. Clarke, and M. Ferguson. 2015. Gray Whale Occurrence in the Beaufort Sea. Poster: Alaska Marine Science Symposium, Anchorage, AK, January 2015.

Brower, W.A., R.G. Baldwin, C.N. Williams, J.L. Wise, and L.D. Leslie. 1988. Climatic atlas of the outer continental shelf waters and coastal regions of Alaska, Volume III. OCS Study MMS 87-0013. USDOI, MMS, Alaska OCS Region. 524 pp.

Brueggeman, J. 2010. Marine mammal surveys at the Klondike and Burger survey areas in the Chukchi Sea during the 2009 open water season. Prepared for ConocoPhillips, Inc., Shell Exploration and Production Company, and Statoil USA E&P, Inc.

Buckland, S.T. 2001. *Introduction to Distance Sampling: Estimating Abundance of Biological Populations.* Oxford University Press. 432 pp.

Campbell R., D. Yurick, and N. Snow. 1988. Predation on Narwhals, *Monodon monoceros*, by killer whales, *Orcinus orca*, in the Eastern Canadian Arctic. *The Canadian Field-Naturalist* 102: 689–696.

Carmack, E.C. and R.W. MacDonald. 2002. Oceanography of the Canadian Shelf of the Beaufort Sea: a Setting for Marine Life. *Arctic* 55 (Supp. 1): 29-45.

Carretta J.V., K.A. Forney, E.M. Oleson, D.W. Weller, A.R. Lang, J. Baker, M.M. Muto, B. Hanson, A.J. Orr, H. Huber, et al. 2019. U.S. Pacific marine mammal stock assessments: 2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-617. 377 pp.

Christman, C.L. and L.M. Aerts. 2015. Harbor porpoise (Phocoena phocoena) sightings from shipboards surveys in the Chukchi Sea during summer and fall, 2008-2014. Abstract at the Alaska Marine Science Symposium, Anchorage, AK, January 2015.

Christman, C.L., J.J. Citta, L.T. Quakenbush, J.T. Clarke, B.H. Rone, R.A. Shea, M.C. Ferguson, and M.P. Heide-Jørgensen. 2013. Presence and behavior of bowhead whales (*Balaena mysticetus*) in the Alaskan Beaufort Sea in July 2011. *Polar Biology* 36(12): 1851-1856.

Citta, J.J., S.R. Okkonen, L.T. Quakenbush, W. Maslowski, R, Osinski, J.C. George, R.J. Small, H. Brower, Jr., M.P. Heide-Jørgensen, and L.A. Harwood. 2018. Oceanographic characteristics associated with autumn movements of bowhead whales in the Chukchi Sea. *Deep Sea Research Part II: Topical Studies in Oceanography* 152: 121-131. doi.org/10.1016/j.dsr2.2017.03.009.

Citta, J.J., L.T. Quakenbush, S.R. Okkonen, M.L. Druckenmiller, W. Maslowski, J. Clement-Kinney, J.C. George, H. Brower, R.J. Small, C.J. Ashjian, et al. 2015. Ecological characteristics of core-use areas used by Bering-Chukchi-Beaufort (BCB) bowhead whales, 2006-2012. *Progress in Oceanography* 136: 201-222.

Clark, C.W., C.L. Berchok, S.B. Blackwell, D.E. Hannay, J. Jones, D. Ponirakis, and K.S. Stafford. 2015. A year in the acoustic world of bowhead whales in the Bering, Chukchi and Beaufort seas. *Progress in Oceanography* 136: 223-240.

Clarke, J.T., A.A. Brower, C.L. Christman, and M.C. Ferguson. 2014. Distribution and relative abundance of marine mammals in the northeastern Chukchi and western Beaufort seas, 2013. Annual Report, OCS Study BOEM 2014-018. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA. 330 pp,

Clarke, J.T., A.A. Brower, M.C. Ferguson, A.S. Kennedy, and A.L. Willoughby. 2015a. Distribution and relative abundance of marine mammals in the eastern Chukchi and western Beaufort seas, 2014. Annual Report, OCS Study BOEM 2015-040. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA. 411 pp.

Clarke, J.T., A.A. Brower, M.C. Ferguson, and A.L. Willoughby. 2017a. Distribution and relative abundance of marine mammals in the eastern Chukchi and western Beaufort seas, 2015. Annual Report, OCS Study BOEM 2017-019. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA. 426 pp.

Clarke, J.T., A.A. Brower, M.C. Ferguson, and A.L. 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. Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA. 462 pp.

Clarke, J.T., A.A. Brower, M.C. Ferguson, and A.L. Willoughby. 2018a. 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. 464 pp.

Clarke, J.T., A.A. Brower, M.C. Ferguson, and A.L. Willoughby. 2019. Distribution and relative abundance of marine mammals in the eastern Chukchi and western Beaufort seas, 2018. Annual Report, OCS Study BOEM 2019-021. Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA. 451 pp.

Clarke, J.T., C.L. Christman, A.A. Brower, and M.C. Ferguson. 2012. Distribution and relative abundance of marine mammals in the Alaskan Chukchi and Beaufort seas, 2011. OCS Study BOEM 2012-009. Report from National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, for U.S. Bureau of Ocean Energy Management. 344 pp.

Clarke, J.T., C.L. Christman, A.A. Brower, and M.C. Ferguson. 2013a. 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. 349 pp.

Clarke, J.T., C.L. Christman, A.A. Brower, M.C. Ferguson, and S.L. Grassia. 2011a. Aerial surveys of endangered whales in the Beaufort Sea, fall 2010. OCS Study BOEMRE 2011-035. Report from National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, for U.S. Bureau of Ocean Energy Management, Regulation and Enforcement. 119 pp.

Clarke, J.T., C.L. Christman, M.C. Ferguson, and S.L. Grassia. 2011b. Aerial surveys of endangered whales in the Beaufort Sea, fall 2006-2008. OCS Study BOEMRE 2010-042. Report from National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, for U.S. Bureau of Ocean Energy Management, Regulation and Enforcement. 229 pp.

Clarke, J.T., C.L. Christman, M.C. Ferguson, S.L. Grassia, and A.A. Brower. 2011c. Aerial surveys of endangered whales in the Beaufort Sea, fall 2009. OCS Study BOEMRE 2010-040. Report from National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, for U.S. Bureau of Ocean Energy Management, Regulation and Enforcement. 92 pp.

Clarke, J.T., M.C. Ferguson, A.A. Brower, and A.L Willoughby. 2018c. Bowhead whale calves in the western Beaufort Sea, 2012-2017. Paper SC/67b/AWMP3 presented to the IWC Scientific Committee, April 2018 (unpublished), Bled, Slovenia.

Clarke, J.T., M.C. Ferguson, C.L. Christman, S.L. Grassia, A.A. Brower, and L.J. Morse. 2011d. Chukchi offshore monitoring in drilling area (COMIDA), distribution and relative abundance of marine mammals: Aerial Surveys. OCS Study BOEMRE 2011-06. Report from National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, for U.S. Bureau of Ocean Energy Management, Regulation and Enforcement. 286 pp.

Clarke, J.T., M.C. Ferguson, C. Curtice, and J. Harrison. 2015b. 8. Biologically important areas for cetaceans within U.S. waters – Arctic Region. *Aquatic Mammals* 41(1): 94-103. DOI: 10.1578/AM.41.1.2015.94.

Clarke, J.T., M.C. Ferguson, A.L. Willoughby, and A.A. Brower. 2018b. Bowhead whale and beluga distributions, sighting rates, and habitat associations in the western Beaufort Sea, summer and fall 2009-2016, with a retrospective comparison to 1982-1991. *Arctic* 71(2): 115-136.

Clarke, J., A. Kennedy, and M. Ferguson. 2016. Bowhead and gray whale distributions, sighting rates, and habitat associations in the eastern Chukchi Sea, summer and fall 2009-15, with a retrospective comparison to 1982-91. *Arctic* 69(4): 359-378.

Clarke, J.T., S.E. Moore, and D.K. Ljungblad. 1989. Observations on gray whale (*Eschrichtius robustus*) utilization patterns in the northeastern Chukchi Sea, July-October 1982-87. *Canadian Journal of Zoology* 67: 2646-2654.

Clarke, J., K. Stafford, S. Moore, B. Rone, L. Aerts, and J. Crance. 2013b. Subarctic cetaceans in the southern Chukchi Sea: evidence of recovery or response to a changing ecosystem. *Oceanography* 26(4): 136–149.

Conlan, K.E., E.A. Hendrycks, and A.E. Aitken. 2019. Dense ampeliscid bed on the Canadian Beaufort Shelf: an explanation for species patterns. *Polar Biology* 42: 195-215.

Conn, P.B., E.E. Moreland, E.V. Regehr, E.L. Richmond, M.F. Cameron, and P.L Boveng. 2016. Using simulation to evaluate wildlife survey design: polar bears and seals in the Chukchi Sea. *Royal Society Open Science* 3: 150561. Dx.doi.org/10.1098/rsos.150561.

Crance, J.L., C.L. Berchok, J. Bonnel, and A.M. Thode. 2015. Northeasternmost record of a North Pacific fin whale (*Balaenoptera physalus*) in the Alaskan Chukchi Sea. *Polar Biology* 38(10): 1767-1773.

Delarue, J., B. Martin, X. Mouy, J. MacDonnell, D. Hannay, N.E. Chorney, and J. Vallarta. 2011. Chukchi Sea joint acoustic monitoring program. Chapter 5 *In*: D.W. Funk, C.M. Reiser, D.S. Ireland, R. Rodrigues, and W.R. Koski (eds.), Joint monitoring program in the Chukchi and Beaufort seas, 2006–2010. LGL Alaska Draft Report P1213-1, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Research, Ltd., for Shell Offshore, Inc. and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 592 pp. plus appendices.

Druckenmiller, M.L., J.J. Citta, M.C. Ferguson, J.T. Clarke, J.C. George, and L. Quackenbush. 2017. Trends in sea-ice cover within bowhead whale habitats in the Western Arctic. *Deep-Sea Research II* 152: 95-107.

Dunn, P.K. and G.K. Smith. 2005. Series evaluation of Tweedie exponential dispersion model densities. *Statistics and Computing* 15: 267-280.

Durban, J.W, D.W. Weller, and W.L. Perryman. 2017. Gray whale abundance estimates from shore-based counts off California in 2014/2015 and 2015/2016. Paper SC/A17/GW/06 presented to the International Whaling Commission.

Eastman, R. and S.G. Warren. 2010. Interannual variations of arctic cloud types in relation to sea ice. *Journal of Climate* 23: 4216-4232.

Eisner, L., N. Hillgruber, E. Martinson, and J. Maselko. 2013. Pelagic fish and zooplankton species assemblages in relation to water mass characteristics in the northern Bering and southeast Chukchi seas. *Polar Biology* 36:87-113.

Endangered Species Act of 1973, as amended. 16 USC 1531-1543.

ESRI. 2014. Available from: https://www.esri.com.

Ferguson, M.C. and J.T. Clarke. 2018a. Update on analysis of ASAMM 2016 data to derive a "minimum population estimate" for the Bering-Chukchi- Beaufort bowhead whale stock. Paper SC/67b/AWMP16 presented to the IWC Scientific Committee, April 2018 (unpublished), Bled, Slovenia.

Ferguson, M.C., R.P. Angliss, A. Kennedy, B. Lynch, A. Willoughby, V. Helker, A.A. Brower, and J.T. Clarke. 2018b. Performance of manned and unmanned aerial surveys for estimating arctic cetacean density and associated uncertainty. *Journal of Unmanned Vehicle Systems* 6(3): 128-154.

Ferguson, M.C., J.M. Waite, C. Curtice, J.T. Clarke, and J. Harrison. 2015. 7. Biologically important areas for cetaceans within U.S. waters – Aleutian Islands and Bering Sea Region. *Aquatic Mammals* 41(1): 79-93.

Friday, N.A., P.J. Clapham, C.L. Berchok, J.L. Crance, A.N. Zerbini, B.K. Rone, A.S. Kennedy, P.J. Stabeno, J.M. Napp, and A. Spear. 2016. Arctic whale ecology study (ARCWEST): Use of the Chukchi Sea by endangered baleen and other whales (westward extension of the BOWFEST). AKC 108. Report from the National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA for the Bureau of Ocean Energy Management. 27 pp.

Garland, E.C., C.L. Berchok, and M. Castellote. 2015. Temporal peaks in beluga whale (Delphinapterus leucas) acoustic detections in the northern Bering, northeastern Chukchi, and western Beaufort Seas: 2010–2011. *Polar Biology* 38: 747-754.

Gavrilchuk, K., V. Lesage, C. Ramp, R. Sears, M. Bérubé, S. Bearhop, and G. Beauplet. 2014. Trophic niched partitioning among sympatric baleen whale species following the collapse of groundfish stocks in the Northwest Atlantic. *Marine Ecology Progress Series* 497: 285-301.

George, J.C., M.L. Druckenmiller, K.L. Laidre, and R. Suydam. 2015. Western Arctic bowhead whale body condition and links to summer sea ice and upwelling in the Beaufort Sea. *Progress in Oceanography* 136: 250-262.

George, J.C., L.M. Philo, K. Hazard, D. Withrow, G.M. Carroll, and R. Suydam. 1994. Frequency of killer whale (*Orcinus orca*) attacks and ship collisions based on scarring on bowhead whales (*Balaena mysticetus*) of the Bering-Chukchi-Beaufort seas stock. *Arctic* 47(3): 246-255.

George, J.C., G. Sheffield, D.J. Reed, B. Tudor, R. Stimmelmayr, B.R. Person, T. Sformo, and R. Suydam. 2017. Frequency of injuries from line entanglements, killer whales, and ship strikes on Bering-Chukchi-Beaufort Seas bowhead whales. *Arctic* 70(1): 37-46.

Givens, G.H., S.L. Edmondson, J.C. George, R. Suydam, R.A. Charif, A. Rahaman, D. Hawthorne, B. Tudor, R.A. DeLong, and C.W. Clark. 2013. Estimate of 2011 Abundance of the Bering-Chukchi-Beaufort Seas Bowhead Whale Population. Paper SC/65a/BRG01 presented to the International Whaling Commission Scientific Committee.

Givens, G.H., J.A. Hoeting and L. Beri. 2010. Factors that influence aerial line transect detection of Bering-Chukchi-Beaufort seas bowhead whales. *Journal of Cetacean Research and Management* 11(1): 9-16.

Givens, G.H., J.A. Mocklin, L. Vate Brattström, B.J. Tudor, W.R. Koski, J.C. George, J.E. Zeh, and R. Suydam. 2017. Survival rate and 2011 abundance of Bering-Chukchi-Beaufort seas bowhead whales from photo-identification data over three decades. Paper SC/67a/AWMP09 presented to the IWC Scientific Committee, May 2017. 23 pp.

Grebmeier, J.M., B.A. Bluhm, L.W. Cooper, S. Danielson, K. Arrigo, A.L. Blanchard, J.T. Clarke, R.H. Day, K.E. Frey, R.R. Gradinger, et al. 2015. Ecosystem characteristics and processes facilitating persistent macrobenthic biomass hotspots and associated benthivory in the Pacific Arctic. *Progress in Oceanography* 136: 92-114.

Hamilton, C.D., K.M. Kovacs, and C. Lydersen. 2018. Individual variability in diving, movement and activity patterns of adult bearded seals in Svalbard, Norway. *Scientific Reports* 8: 16988. DOI:10.1038/s41598-018-35306-6.

Hannay, D.E., J. Delurue, X. Mouy, B.S. Martin, D. Leary, J.N. Oswald and J. Vallarta. 2013. Marine mammal acoustic detections in the northeastern Chukchi Sea, September 2007-July 2011. *Continental Shelf Research* 67: 127-146.

Harwood, L.A., J. Auld, A. Joynt and S.E. Moore. 2010. Distribution of bowhead whales in the SE Beaufort Sea during late summer, 2007-2009. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/111. iv + 22 p.

Harwood, L.A., T.G. Smith, and J.C. Auld. 2012. Fall migration of ringed seals (*Phoca hispida*) through the Beaufort and Chukchi Seas, 2001-02. *Arctic* 65(1): 35-44.

Harwood, L.A., T.G. Smith, J.C. George, S.J. Sandstrom, W. Walkusz, and G.J. Divoky. 2015. Change in the Beaufort Sea ecosystem: Diverging trends in body condition and/or production in five marine vertebrate species. *Progress in Oceanography* 136: 263-273.

Hashagen, K.A., G.A. Green, and B. Adams. 2009. Observations of humpback whales, *Megaptera novaeangliae*, in the Beaufort Sea, Alaska. *Northwestern Naturalist* 90: 160-162.

Hauser, D.D.W., K.L. Laidre, S.L. Parker-Stetter, J. K. Horne, R.S. Suydam, and P.R. Richard. 2015. Regional diving behavior of Pacific Arctic beluga whales *Delphinapterus leucas* and possible associations with prey. *Marine Ecology Progress Series* 541: 245-264.

Hauser, D.D.W., K.L. Laidre, K.M. Stafford, H.L. Stern, R.S. Suydam, and P.R. Richard. 2016. Decadal shifts in autumn migration timing by Pacific Arctic beluga whales are related to delayed annual sea ice formation. *Global Change Biology.* DOI: 10.1111/gcb.13564

Hauser, D.D.W., K.L. Laidre, H.L. Stern, S.E. Moore, R.S. Suydam, and P.R. Richard. 2017. Habitat selection by two beluga whale populations in the Chukchi and Beaufort seas. *PLoS ONE* 12(2): e0172755.

Hauser, D.D.W., K.L. Laidre, H.L. Stern, R.S. Suydam, and P.R. Richard. 2018. Indirect effects of sea ice loss on summer-fall habitat and behaviour for sympatric populations of an Arctic marine predator. *Diversity and Distributions*. DOI: 10.1111/ddi.12722

Hauser, D.D.W., K.L. Laidre, R.S. Suydam, and P.R. Richard. 2014. Population-specific home ranges and migration timing of Pacific Arctic beluga whales (*Delphinapterus leucas*). *Polar Biology* 37: 1171-1183.

Higdon, J.W. and S.H Ferguson. 2009. Loss of Arctic sea ice causing punctuated change in sightings of killer whales (*Orcinus orca*) over the past century. *Ecological Applications* 19: 1365–1375.

Higdon, J.W. and S.H. Ferguson. 2011. Reports of humpback and minke whales in the Hudson Bay Region, Eastern Canadian Arctic. *Northeastern Naturalist* 18(3): 370-377.

Highsmith, R.C. and K.O. Coyle. 1992. Productivity of arctic amphipods relative to gray whale energy requirements. *Marine Ecology Progress Series* 83: 141-150.

Hijmans, R.J. 2020. raster: Geographic Data Analysis and Modeling. R package version 3.0.2. Available from: http://CRAN.R-project.org/package=raster.

Hill, P.S. and D.P. DeMaster. 1999. Alaska marine mammal stock assessments, 1999. U.S. Dep. Commer., NOAA Tech. Memo. NMFSAFSC-110. 166 p.

Hodges, J.L. and E.L. Lehmann. 1956. The efficiency of some nonparametric competitors of the *t*-test. *Annals of Mathematical Statistics* 27: 324-335.

Houghton, J.P., D.A. Segar, and J.E. Zeh. 1984. Beaufort Sea Monitoring Program: Proceedings of a workshop (September 1983) and sampling design recommendations. Beaufort Sea Monitoring Program Workshop, Anchorage, Alaska.

Iwahara, Y., A. Fujiwara, K. Ito, K. Kazushi, and Y. Mitani. 2016. Gray whale sightings in the Canadian Beaufort Sea, September 2014. *Polar Science* 10: 173-176.

Jakobsson, M., R. Macnab, L. Mayer, R. Anderson, M. Edwards, J. Hatzky, H. W. Schenke, and P. Johnson. 2008. An improved bathymetric portrayal of the Arctic Ocean: Implications for ocean modeling and geological, geophysical and oceanographic analyses. *Geophysical Research Letters*, DOI: 10.1029/2008GL033520.

Jakobsson, M., L.A. Mayer, B. Coakley, J.A. Dowdeswell, S. Forbes, B. Fridman, H. Hodnesdal, R. Noormets, R. Pedersen, M. Rebesco, et al. 2013. The International Bathymetric Chart of the Arctic Ocean (IBCAO) Version 3.0, *Geophysical Research Letters.* DOI: 10.1029/2012GL052219.

Jefferson, T.A., C.R. Weir, R.C. Anderson, L.T. Ballance, R.D. Kenney, and J.J. Kiszka. 2014. Global distribution of Risso's dolphin Grampus griseus: A review and critical evaluation. *Mammal Review* 44:56–68.

Jeffries, M. O., J. A. Richter-Menge and J. E. Overland, Eds. 2012: Arctic Report Card 2012, http://www.arctic.noaa.gov/reportcard.

Johnson, M.A., A.Y. Proshutinsky, and I.V. Polyakov. 1999. Atmospheric patterns forcing two regimes of arctic circulation: a return to anticyclonic conditions? *Geophysical Research Letters* 26: 1621-1624.

KCS. 2013. Oriana version 4.02. Kovach Computing Services. Anglesey, Wales. Available from: http://www.kovcomp.com.

Koski, W.R. and G.W. Miller. 2009. Habitat use by different size classes of bowhead whales in the central Beaufort Sea during late summer and autumn. *Arctic* 62(2): 137-150.

Koski, W.R., G.W. Millier, and R.A. Davis. 1988. The potential effects of tanker traffic on the bowhead whale in the Beaufort Sea. LGL Report No. TA 839. Report from LGL Ltd, King City, Ontario, Canada. 161 pp.

Kovacs, K.M., C. Lydersen, J.E. Overland, and S.E. Moore. 2011. Impacts of changing sea-ice conditions on Arctic marine mammals. *Marine Biodiversity* 41: 181-194.

Kuletz, K.J., M.C. Ferguson, B. Hurley, A.E. Gall, E.A. Labunski, and T.C. Morgan. 2015. Seasonal spatial patterns in seabird and marine mammal distribution in the eastern Chukchi and western Beaufort seas: Identifying biologically important pelagic areas. *Progress in Oceanography* 136: 175-200.

Laake, J.L., A.E. Punt, R. Hobbs, M. Ferguson, D. Rugh, J. Breiwick. 2012. Gray whale southbound migration surveys 1967-2006: an integratged re-analysis. *Journal of Cetacean Research Management* 12(3): 287-306.

LaBelle, J.C., J.L. Wise, R.P. Voelker, R.H. Schulze, and G.M. Wohl. 1983. *Alaska Marine Ice Atlas*. Arctic Environmental Information and Data Center, University of Alaska, Anchorage, AK. 302 pp.

Laidre, K.L. and M.P. Heide-Jørgensen. 2012. Spring partitioning of Disko Bay, West Greenland, by Arctic and Subarctic baleen whales. ICES *Journal of Marine Science* 69(7): 1226-1233.

Laidre, K.L., M.P. Heide-Jørgensen, P. Heagerty, A. Cossio, B. Bergstrom, and M. Simon. 2010. Spatial associations between large baleen whales and their prey in West Greenland. *Marine Ecology Progress Series* 402: 269-284.

Ljungblad, D.K., S.E. Moore, J.T. Clarke, and J.C. Bennett. 1987. Distribution, abundance, behavior and bioacoustics of endangered whales in the Alaskan Beaufort and Eastern Chukchi seas, 1979-86. OCS Study MMS 87-0039. Anchorage, AK: USDOI, MMS, Alaska OCS Region. 391 pp.

Lowry, L.F., V.N. Burkanov, K.J. Frost, M.A. Simpkins, R. Davis, D.P. DeMaster, R. Suydam, and A. Springer. 2000. Habitate use and habitat selection by spotted seals (*Phoca largha*) in the Bering Sea. *Canadian Journal of Zoology* 78: 1959-1971.

Lowry, L.F., K.J. Frost, R. Davis, D.P. DeMaster, and R.S. Suydam. 1998. Movements and behavior of satellite-tagged spotted seals (*Phoca largha*) in the Bering and Chukchi Seas. *Polar Biology* 19: 221-230.

Lowry, L.F., M.C.S. Kingsley, D.D.W. Hauser, J. Clarke, and R. Suydam. 2017. Aerial Survey Estimates of Abundance of the Eastern Chukchi Sea Stock of Beluga Whales (*Delphinapterus leucas*) in 2012. *Arctic*. 70(3): 273-286.

Maher, W.J. 1960. Recent records of the California grey whale (*Eschrichtius glaucus*) along the north coast of Alaska. *Arctic* 13(4): 257-265.

Maloney, E.S. (ed). 2006. *Chapman piloting and seamanship*, 65th edition. New York: Sterling Publishing Company, Inc. 927 pp.

Manly, B.F.J., V.D. Moulton, R.E. Elliott, G.W. Miller, and W.J. Richardson. 2007. Analysis of covariance of fall migrations of bowhead whales in relation to human activities and environmental factors, Alaskan Beaufort Sea: phase I, 1996-1998. OCS study 2005-033; LGL Report TA2799-3. Report from LGL Ltd, King City, Ontario, and WEST Inc., Cheyenne, Wyoming, for U.S. Minerals Management Service, Anchorage, Alaska. 128 pp.

Marine Mammal Protection Act of 1972. 16 USC 1361-1407.

McClintock, B.T., E. Moreland, J.M. London, S.P. Dahle, G.M. Brady, E.L. Richmond, K.M. Yano, and P.L. Boveng. 2015. Quantitative assessment of species identification in aerial transect surveys for ice-associated seals. *Marine Mammal Science* 31(3): 1057-1076.

McKinney, M.A., T.C. Atwood, S.J. Iverson, E. Peacock. 2017. Temporal complexity of southern Beaufort Sea polar bear diets during a period of increasing land use. *Ecosphere* 8(1): e01633. DOI: 10.1002/ecs2.1633.

Mocklin, J.A., D.J. Rugh, S.E. Moore, and R.P. Angliss. 2011. Using aerial photography to investigate evidence of feeding by bowhead whales. *Marine Mammal Science.* DOI: 10.1111/j.1748-7692.2011.00518.x.

Monnett, C. and S.D. Treacy. 2005. Aerial surveys of endangered whales in the Beaufort Sea, fall 2002-2004. OCS Study MMS 2005-037. Anchorage, AK: USDOI, MMS, Alaska OCS Region. 153 pp.

Moore, S.E. 2000. Variability of cetacean distribution and habitat selection in the Alaskan Arctic, autumn 1982-91. *Arctic* 53(4): 448-460.

Moore, S.E. 2016. Is it 'boom times' for baleen whales in the Pacific Arctic region? *Biology Letters* 12: 20160251.

Moore, S.E. and J.T. Clarke. 1992. Distribution, abundance and behavior of endangered whales in the Alaskan Chukchi and western Beaufort seas, 1991: with a review 1982-91. OCS Study MMS 92-0029. 126 pp plus appendices.

Moore, S.E. and D.P. DeMaster. 1998. Cetacean habitats in the Alaskan Arctic. *Journal of Northwest Atlantic Fishery Science* 22: 55-69.

Moore, S.E. and R.R. Reeves. 1993. Distribution and movement. Chapter 9. *In*: J.J. Burns, J.J. Montague and C.J. Cowles (eds.), *The Bowhead Whale*. Special Publication No. 2, The Society for Marine Mammalogy, Lawrence, Kansas.

Moore, S.E., J.M. Grebmeier, and J.R. Davies. 2003. Gray whale distribution relative to forage habitat in the northern Bering Sea: current conditions and retrospective summary. *Canadian Journal of Zoology* 81: 734-742.

Moore, S.E., K.M. Stafford, H. Melling, C. Berchok, O. Wiig, K.M. Kovacs, C. Lydersen, and J. Richter-Menge. 2012. Comparing marine mammal acoustic habitats in Atlantic and Pacific sectors of the High Arctic: year-long records from Fram Strait and the Chukchi Plateau. *Polar Biology* 35: 475-480.

Moore, S.E., J.M. Waite, N.A. Friday, and T. Honkalehto. 2002. Cetacean distribution and relative abundance on the central-eastern and southeastern Bering Sea shelf with reference to oceanographic domains. *Progress in Oceanography* 55: 249-261.

Muto, M.M., V.T. Helker, R.P. Angliss, B.A. Allen, P.L. Boveng, J.M. Breiwick, M.F. Cameron, P.J. Clapham, S.P. Dahle, M.E. Dahlheim, et al. 2018. Alaska marine mammal stock assessments, 2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFSAFSC-378, 383 pp.

National Environmental Policy Act of 1969. 42 USC 4321-4347.

National Snow and Ice Data Center. 2007. Arctic sea ice shatters all previous record lows. Press Release, 1 October 2007. Cooperative Institute for Research in Environmental Sciences at the University of Colorado at Boulder. Available from: http://nsidc.org/news/press/2007_seaiceminimum/20071001_pressrelease.html.

National Snow and Ice Data Center. 2008. Arctic sea ice down to second-lowest extent; likely record low volume. Press Release, 2 October 2008. Cooperative Institute for Research in Environmental Sciences at the University of Colorado at Boulder. Available from: https://nsidc.org/news/newsroom/20081002_seaice_pressrelease.html.

National Snow and Ice Data Center. 2009. Arctic sea ice extent remains low: 2009 sees third-lowest mark. Press Release, 6 October 2009. Cooperative Institute for Research in Environmental Sciences at the University of Colorado at Boulder. Available from: http://nsidc.org/news/press/20091005_minimumpr.html.

National Snow and Ice Data Center. 2010. Arctic sea ice falls to third-lowest extent; downward trend continues. Press Release, 4 October 2010. Cooperative Institute for Research in Environmental Sciences at the University of Colorado at Boulder. Available from: http://nsidc.org/news/press/20101004_minimumpr.html.

National Snow and Ice Data Center. 2011. Arctic sea ice continues decline, reaches second-lowest level. Press Release, 4 October 2011. Cooperative Institute for Research in Environmental Sciences at the University of Colorado at Boulder. Available from: http://nsidc.org/news/press/20111004_minimumpr.html.

National Snow and Ice Data Center. 2012. Arctic sea ice shatters previous low records; Antarctic sea ice edges to record high. Press Release, 2 October 2012. Cooperative Institute for Research in Environmental Sciences at the University of Colorado at Boulder. Available from: http://nsidc.org/news/press/20121002_MinimumPR.html.

National Snow and Ice Data Center. 2013. Arctic sea ice avoids last year's record low; Antarctic sea ice edges out last year's high. Press Release, 3 October 2013. Cooperative Institute for Research in Environmental Sciences at the University of Colorado at Boulder. Available from: http://nsidc.org/news/press/2013_minimum_final.html.

National Snow and Ice Data Center. 2014. Arctic sea ice continues low; Antarctic ice hits a new high. Press Release, 7 October 2014. Cooperative Institute for Research in Environmental Sciences at the University of Colorado at Boulder. Available from: http://nsidc.org/news/newsroom/archive/201410.

National Snow and Ice Data Center. 2015. Arctic sea ice extent settles at fourth lowest in the satellite record. Press Release, 6 October 2015. Cooperative Institute for Research in Environmental Sciences at the University of Colorado at Boulder. Available from: http://nsidc.org/news/newsroom/PR_2015meltseason.

National Snow and Ice Data Center. 2016a. 2016 ties with 2007 for second lowest Arctic sea ice minimum. Press Release, 15 September 2016. Cooperative Institute for Research in Environmental Sciences at the University of Colorado at Boulder. Available from: http://nsidc.org/news/newsroom/2016-ties-2007-second-lowest-arctic-sea-ice-minimum.

National Snow and Ice Data Center. 2016b. Arctic sea ice settles at 2nd lowest minimum and 5th lowest September. Press Release, 5 October 2016. Cooperative Institute for Research in Environmental Sciences at the University of Colorado at Boulder. Available from: http://nsidc.org/news/newsroom/arctic-sea-ice-settles-2nd-lowest-minimum-and-5th-lowest-september.

National Snow and Ice Data Center. 2017. Arctic sea ice 2017: Tapping the brakes in September 2017, Arctic Sea Ice News & Analysis, October 2017. Available from: https://nsidc.org/arcticseaicenews/2017/10/.

National Snow and Ice Data Center. 2018. Arctic summer 2018: September extent ties for sixth lowest, Arctic Sea Ice News & Analysis, October 8, 2018. Available from: https://nsidc.org/arcticseaicenews/2018/10/september-extent-ties-for-sixth-lowest/

National Snow and Ice Data Center. 2019. 2019 Arctic sea ice minimum is second lowest. Available from: https://earthobservatory.nasa.gov/images/145641/2019-arctic-sea-ice-minimum-is-second-lowest

NMML/RACE/PMEL. 2014. Arctic Whale Ecology Study (ARCWEST)/Chukchi Acoustics, Oceanography, and Zooplankton Study-extension (CHAOZ-X), 2014 Cruise Report. Submitted to BOEM under Interagency Agreement Number M12PG00021 (AKC 108).

Norton, D. and G. Weller. 1984. The Beaufort Sea: background, history, and perspective. Pp 3-22 *In:* P.W. Barnes, D.M. Schell, and E. Reimnitz (eds.), *The Alaskan Beaufort Sea: Ecosystems and Environment*. Academic Press.

O'Corry-Crowe, G., A.R. Mahoney, R. Suydam, L. Quakenbush, A. Whiting, L. Lowry, and L. Harwood. 2016. Genetic profiling links changing sea-ice to shifting beluga whale migration patterns. *Biology Letters* 12: 20160404.

Okkonen, S.P., C.J. Ashjian, R.G. Campbell, and P. Alatalo. 2020. Krill diel vertical migration: A diagnostic for variability of wind forcing over the Beaufort and Chukchi Seas. *Progress in Oceanography* 181. https://doi.org/10.1016/j.pocean.2020.102265.

Okkonen, S.P., C.J. Ashjian, R.G. Campbell, J.T. Clarke, S.E. Moore, and K.D. Taylor. 2011. Satellite observations of circulation features associated with a bowhead whale feeding 'hotspot' near Barrow, Alaska. *Remote Sensing of Environment* 115: 2168-2174.

Okkonen, S.R., J.T. Clarke, and R.A. Potter. 2017. Relationships between high river discharge, upwelling events, and bowhead whale (*Balaena mysticetus*) occurrence in the central Alaskan Beaufort Sea. *Deep-Sea Research II*: *Topical Studies in Oceanography* 152: 195-202.

Outer Continental Shelf Lands Act of 1953, as amended in 1978. 43 USC 1331-1356 and 1801-1866.

Pebesma, E.J. and R.S. Bivand. 2005. Classes and methods for spatial data in R. *R News 5 (2)*. Available from: http://cran.r-project.org/doc/Rnews/.

Proshutinsky, A.Y. and M.A. Johnson. 1997. Two circulation regimes of the wind-driven Arctic Ocean. *Journal of Geophysical Research* 102(C6): 12493-12514.

Proshutinsky, A., D. Dukhovskoy, M-L. Timmermans, R. Krishfield, and J.L. Bamber. 2015. Arctic circulation regimes. *Philosophical Transactions of the Royal Society* 373*:* 20140160.

Quakenbush, L.T., J.J. Citta, J.C. George, R.J. Small, and M.P. Heide-Jørgensen. 2010a. Fall and winter movements of bowhead whales (*Balaena mysticetus*) in the Chukchi Sea and within a potential petroleum development area. *Arctic* 63(3): 289-307.

Quakenbush, L.T., R.J. Small, and J.J. Citta. 2010b. Satellite tracking of western Arctic bowhead whales. Study prepared by the Alaska Department of Fish and Game for the Bureau of Ocean Energy Management, Regulation and Enforcement. OCS Study BOEMRE 2010-033.

Quakenbush, L.T., R.J. Small, and J.J. Citta. 2013. Satellite tracking of bowhead whales: movements and analysis from 2006 to 2012. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Alaska Outer Continental Shelf Region, Anchorage, AK. OCS Study BOEM 2013-01110. 60 pp plus appendices.

R Core Team. 2019. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available from: http://www.R-project.org/.

Real Statistics Using Excel Resource Pack. 2020. http://www.real-statistics.com/

Rice, D.W. 1998. *Marine Mammals of the World: Systematics and Distribution*. Special Publication Number 4. The Society for Marine Mammalogy. 231 pp.

Richard, P.R., A.R. Martin, and J.R. Orr. 2001. Summer and autumn movements of belugas of the eastern Beaufort Sea stock. *Arctic* 54(3): 223-236.

Richter-Menge, J., M.O. Jeffries, and J.E. Overland, Eds. 2011. Arctic Report Card 2011, http://www.arctic.noaa.gov/reportcard.

Richter-Menge, J., M.L. Druckenmiller, and M. Jeffries, Eds. 2019. Arctic Report Card 2019, http://www.arctic.noaa.gov/reportcard.

Satterthwaite-Phillips, D., C. Krenz, G. Gray, and L. Dodd. 2016. Iñuuniałiqput Iḷiḷugu Nunaŋ̣ ŋ̣uanun (Documenting Our Way of Life with Mapping). Northwest Arctic Borough subsistence mapping project. Volume 4. Available from: http://www.nwabor.org/wp-content/uploads/6-Chapter-4-Coastal-and-Marine-Species-IEAs.pdf.

Schick, R.S. and D.L. Urban. 2000. Spatial components of bowhead whale (*Balaena mysticetus*) distribution in the Alaskan Beaufort Sea. *Canadian Journal of Fisheries and Aquatic Sciences* 57: 2193-2200.

Schonberg, S.V., J.T. Clarke, and K.H. Dunton. 2014. Distribution, abundance, biomass and diversity of benthic infauna in the northeast Chukchi Sea, Alaska in relation to environmental variables and marine mammal predators. *Deep Sea Research Part II* 102: 144-163.

Seger, K.D. and J.L. Miksis-Olds. 2019. Acoustic documentation of temperate odontocetes in the Bering and Chukchi Seas. *Marine Mammal Science*, DOI: 10.1111.MMS.12577.

Shelden, K.E.W., J.A. Mocklin, K.T. Goetz, D.J. Rugh, L. Vate Brattström, and N.A. Friday. 2017. Late summer distribution of cetaceans near Barrow, Alaska: Results from aerial surveys conducted during the Bowhead Whale Feeding Ecology Study, 2007-11. *Marine Fisheries Review* 79(2):1-22.

Shelden, K.E.W., D.J. Rugh, B.A. Mahoney, and M.E. Dahlheim. 2003. Killer whale predation on belugas in Cook Inlet, Alaska: implications for a depleted population. *Marine Mammal Science* 19(3): 529-544.

Simmonds, I., C. Burke, and K. Keay. 2008. Arctic climate change as manifest in cyclone behavior. *Journal of Climate* 21: 5777-5796.

Smultea, M.A., M. Blees, M. Larson, J. Cate, S. Simpson, C.E. Bacon, and D. Steckler. 2014. Visual and passive acoustic marine mammal monitoring in northern U.S. and international Chukchi Sea open waters in summer-fall 2013. Poster presented at the Alaska Marine Science Symposium, Anchorage, AK, 20-24 January 2014.

Stafford, K.M. 2018. Increasing detections of killer whales (Orcinus orca) in the Pacific Arctic. *Marine Mammal Science*, DOI: 10.1111/MMS.12551.

Stafford, K.M., M.C. Ferguson, D.D.W. Hauser, S.R. Okkonen, C.L. Berchok, J.J. Citta, H.T. Clarke, E.C. Garland, J. Jones, and R.S. Suydam. 2017. Beluga whales in the western Beaufort Sea: Current state of knowledge on timing, distribution, habitat use and environmental drivers. *Deep-Sea Research II*: *Topical Studies in Oceanography* 152: 182-194.

Stafford, K.M., S.R. Okkonen, and J.T. Clarke. 2013. Correlation of a strong Alaska Coastal Current with the presence of beluga whales *Delphinapterus leucas* near Barrow, Alaska. *Marine Ecology Progress Series* 474: 287-297.

Stafford, J.M., G. Wendler, and J. Curtis. 2000. Temperature and precipitation of Alaska: 50 year trend analysis. *Theoretical and Applied Climatology* 67: 33-44.

Stimmelmayr, R., George, J.C., A. Willoughby, J. Clarke, M. Ferguson, G. Sheffield, K. Stafford, A. Von Duyke, T. Sformo, B. Person, L. Sousa, B. Tudor, and R. Suydam. 2018. 2017 health report for the Bering-Chukchi-Beaufort seas bowhead whales – preliminary findings. Paper SC/67b/AWMP8 presented to the IWC Scientific Committee, April 2018 (unpublished), Bled, Slovenia.

Sumich, J.L. 1986. Growth in young gray whales (*Eschrichtius robustus*). *Marine Mammal Science* 2(2): 145-152.

Suydam, R.S. 2009. Age, growth, reproduction, and movements of beluga whales (*Delphinapterus leucas*) from the eastern Chukchi Sea. Ph.D. dissertation, University of Washington.

Suydam, R.S. and J.C. George. 1992. Recent sightings of harbour porpoises, *Phocoena phocoena*, near Point Barrow, Alaska. *The Canadian Field-Naturalist* 106: 489-492.

Suydam, R.S., L.F. Lowry, K.J. Frost, G.M. O’Corry-Crowe, and D. Pikok, Jr. 2001. Satellite tracking of eastern Chukchi Sea beluga whales in the Arctic Ocean. *Arctic* 54(3): 237-243.

Thomas, T. and W.R. Koski. 2011. Chukchi Sea nearshore aerial surveys. Chapter 4 *In*: D.W. Funk, C.M. Reiser, D.S. Ireland, R. Rodrigues, and W.R. Koski (eds.), Joint monitoring program in the Chukchi and Beaufort seas, 2006–2010. LGL Alaska Draft Report P1213-1, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Research, Ltd., for Shell Offshore, Inc. and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 592 pp. plus Appendices.

Thomson, J., Y. Fan, S. Stammerjohn, J. Stopa, W.E. Rogers, F. Girard-Ardhuin, F. Arduin, H. Shen, W. Perrie, H. Shen, et al. 2016. Emerging trends in the sea state of the Beaufort and Chukchi seas. Ocean Modelling 105: 1-12.

Treacy, S.D. 1988. Aerial surveys of endangered whales in the Beaufort Sea, fall 1987. OCS Study MMS 88-0030. Anchorage, AK: USDOI, MMS, Alaska OCS Region. 141 pp.

Treacy, S.D. 1989. Aerial surveys of endangered whales in the Beaufort Sea, fall 1988. OCS Study MMS 89-0033. Anchorage, AK: USDOI, MMS, Alaska OCS Region. 101 pp.

Treacy, S.D. 1990. Aerial surveys of endangered whales in the Beaufort Sea, fall 1989. OCS Study MMS 90-0047. Anchorage, AK: USDOI, MMS, Alaska OCS Region. 104 pp.

Treacy, S.D. 1991. Aerial surveys of endangered whales in the Beaufort Sea, fall 1990. OCS Study MMS 91-0055. Anchorage, AK: USDOI, MMS, Alaska OCS Region. 107 pp.

Treacy, S.D. 1992. Aerial surveys of endangered whales in the Beaufort Sea, fall 1991. OCS Study MMS 92-0017. Anchorage, AK: USDOI, MMS, Alaska OCS Region. 92 pp.

Treacy, S.D. 1993. Aerial surveys of endangered whales in the Beaufort Sea, fall 1992. OCS Study MMS 93-0023. Anchorage, AK: USDOI, MMS, Alaska OCS Region. 135 pp.

Treacy, S.D. 1994. Aerial surveys of endangered whales in the Beaufort Sea, fall 1993. OCS Study MMS 94-0032. Anchorage, AK: USDOI, MMS, Alaska OCS Region. 132 pp.

Treacy, S.D. 1995. Aerial surveys of endangered whales in the Beaufort Sea, fall 1994. OCS Study MMS 95-0033. Anchorage, AK: USDOI, MMS, Alaska OCS Region. 116 pp.

Treacy, S.D. 1996. Aerial surveys of endangered whales in the Beaufort Sea, fall 1995. OCS Study MMS 96-0006. Anchorage, AK: USDOI, MMS, Alaska OCS Region. 120 pp.

Treacy, S.D. 1997. Aerial surveys of endangered whales in the Beaufort Sea, fall 1996. OCS Study MMS 97-0016. Anchorage, AK: USDOI, MMS, Alaska OCS Region. 115 pp.

Treacy, S.D. 1998. Aerial surveys of endangered whales in the Beaufort Sea, fall 1997. OCS Study MMS 98-0059. Anchorage, AK: USDOI, MMS, Alaska OCS Region. 143 pp.

Treacy, S.D. 2000. Aerial surveys of endangered whales in the Beaufort Sea, fall 1998-1999. OCS Study MMS 2000-066. Anchorage, AK: USDOI, MMS, Alaska OCS Region. 135 pp.

Treacy, S.D. 2002a. Aerial surveys of endangered whales in the Beaufort Sea, fall 2000. OCS Study MMS 2002-014. Anchorage, AK: USDOI, MMS, Alaska OCS Region. 111 pp.

Treacy, S.D. 2002b. Aerial surveys of endangered whales in the Beaufort Sea, fall 2001. OCS Study MMS 2002-061. Anchorage, AK: USDOI, MMS, Alaska OCS Region. 117 pp.

Tweedie, M.C.K. 1984. An index which distinguishes between some important exponential families. Pp. 579-604. *In*: J.K. Ghosh and J. Roy (eds.), *Statistics: Applications and New Directions*. Proceedings of the Indian Statistical Institute Golden Jubilee International Conference. Calcutta: Indian Statistical Institute.

USDOC, NOAA, NMFS. 1982. Endangered Species Act, Section 7 Consultation - Biological Opinion, Oil and Gas Lease Sale 71 (Diapir Field). 19 May 1982. Washington, D.C.

USDOC, NOAA, NMFS. 1983. Endangered Species Act, Section 7 Consultation - Biological Opinion, Oil and Gas Leasing and Exploration - Diapir Field Lease Offering (Sale 87). 19 December 1983. Washington, D.C.

USDOC, NOAA, NMFS. 1987. Endangered Species Act, Section 7 Consultation - Biological Opinion, Oil and Gas Leasing and Exploration - Beaufort Sea Sale 97. 20 May 1987. Washington, D.C.

USDOC, NOAA, NMFS. 1988. Endangered Species Act, Section 7 Consultation - Biological Opinion, Oil and Gas Leasing and Exploration - Arctic Region. 23 November 1988. Washington, D.C.

USDOC, NOAA, NMFS. 2008. Endangered Species Act, Section 7 Consultation – Biological Opinion, Oil and Gas Leasing and Exploration Activities in the U.S. Beaufort and Chukchi Sea, Alaska. 17 July 2008. Washington, D.C.

USDOC, NOAA, NMFS. 2013. Endangered Species Act, Section 7 Consultation – Biological Opinion, Oil and Gas Leasing and Exploration Activities in the U.S. Beaufort and Chukchi Sea, Alaska; and Authorization of Small Takes under the Marine Mammal Protection Act. 23 April 2013.

USDOC, NOAA, NMFS. 2015. Endangered Species Act, Section 7(a)(2) Biological Opinion and Section 7(a)(4) Conference Report – Lease Sale 193 Oil and Gas Exploration Activities, Chukchi Sea, Alaska. 4 June 2015.

USDOC, NOAA, NMFS. 2018a. Endangered Species Act, Section 7(a)(2) Biological Opinion – Liberty Oil and Gas Development and Production Plan Activities, Beaufort Sea, Alaska. 31 July 2018.

USDOC, NOAA, NMFS. 2018b. Available from: https://www.fisheries.noaa.gov/alaska/marine-mammal-protection/aerial-surveys-arctic-marine-mammals

USDOC, NOAA, NMFS. 2019. Available from: https://www.fisheries.noaa.gov/feature-story/noaa-fisheries-declares-elevated-west-coast-gray-whale-strandings-unusual-mortality

USDOD, Navy, Naval Hydrographic Office. 1956. Aerial Ice Reconnaissance and Functional Glossary of Ice Terminology. Hydrographic Office Publication No. 609. 14 pp.

USDOI, MMS. 1979. State of Alaska, Department of Natural Resources; Federal/State Joint Beaufort Sea Oil and Gas Lease Sale BF, 7 November 1979 (44 FR 64752).

USDOI, MMS. 1984. Outer Continental Shelf, Diapir Field, Oil and Gas Lease Sale 87, 23 July 1984 (49 FR 29726).

USDOI, MMS. 1988. Outer Continental Shelf, Beaufort Sea, Oil and Gas Lease Sale 97, 12 February 1988 (53 FR 4356).

USDOI, MMS. 1996. Outer Continental Shelf Beaufort Sea Oil and Gas Lease Sale 144, 16 August 1996 (61 FR 42682).

USDOI, MMS. 2008a. Outer Continental Shelf Chukchi Sea Oil and Gas Lease Sale 193, 2 January 2008 (73 FR 209).

USDOI, MMS. 2008b. Aerial surveys of endangered whales in the Beaufort Sea, fall 2005. OCS Study MMS 2008-023. Anchorage, AK: USDOI, MMS, Alaska OCS Region. 96 pp.

U.S. National Ice Center. 2019. Available from: http://www.natice.noaa.gov/.

Ver Hoef, J.M. and P.L. Boveng. 2007. Quasi-Poisson vs. negative binomial regression: how should we model overdispersed count data? *Ecology* 88(11): 2766-2772.

Walsh, J.E. 2008. Climate of the Arctic marine environment. *Ecological Applications* 18(2): Supplement S3-S22.

Weller, D.W. and W.L. Perryman. 2019. Eastern north Pacific gray whale calf production estimates 1994-2018. Paper SC/68A/CMP/17 presented to the IWC Scientific Committee, May 2019 (unpublished), Nairobi, Kenya.

Wendler, G., B. Moore, and K. Galloway. 2014. Strong temperature increase and shrinking ice in Arctic Alaska. *The Open Atmospheric Science Journal* 8: 7-15.

Wendler, G., M. Shulski, and B. Moore. 2009. Changes in the climate of the Alaskan North Slope and the ice concentration of the adjacent Beaufort Sea. *Theoretical and Applied Climatology* 99: 67–74.

Whiting, A., M. Castellote, R.J. Small, K.J. Frost, and R. Suydam. 2020. Unexpected mid-winter presence of harbor porpoises (*Phocoena phocoena*) in Kotzebue Sounds, Alaska. *Marine Mammal Science* 36: 354-358.

Williams, W.J. and E.C. Carmack. 2008. Combined effect of wind-forcing and isobath divergence on upwelling at Cape Bathurst, Beaufort Sea. *Journal of Marine Research* 66: 645-663.

Willoughby, A.L., M.C. Ferguson, J.T. Clarke, and A.A Brower. 2018a. First photographic match of an anomalously white gray whale (*Eschrichtius robustus*) in the northeastern Chukchi Sea, Alaska, and off Baja California, Mexico. *Aquatic Mammals,* 44(1): 7-12.

Willoughby, A.L., J. Clarke, A. Brower, M. Ferguson, L. Barry, R. Hardee, S. Hanlan, N. Metheny, and H. Foley. 2020a. A yarn of wayward whales in the eastern Chukchi and eastern Beaufort seas, 2019. Poster: Alaska Marine Science Symposium, Anchorage, AK, January, 2020.

Willoughby, A.L., R. Stimmelmayr, A.B. Brower, J.T. Clarke, and M.C. Ferguson. 2020b. Gray whale carcasses in the eastern Chukchi Sea, 2009-2019. Paper presented to the International Whaling Commission Scientific Committee, May 2020 (virtual meeting).

Willoughby, A.L., R. Stimmelmayr, A.B. Brower, J.T. Clarke, and M.C. Ferguson. 2020c. Bowhead whale carcasses in the eastern Chukchi and western Beaufort seas, 2009-2019. Paper presented to the International Whaling Commission Scientific Committee, May 2020 (virtual meeting).

Willoughby, A., M. Ferguson, J. Clarke, A. Brower, C. Accardo, L. Barry, V. Beaver, M. Foster, S. Hanlan, K. Pagan, C. Sims, K. Vale-Vasilev. 2018b. Photo-identification of Gray Whales in the eastern Chukchi Sea, Summer and Fall 2017. Poster presented at the Alaska Marine Science Symposium, Anchorage, AK, January 2018.

Witteveen, B.H. and K.M. Wynne. 2016. Trophic niche partitioning and diet composition of sympatric fin (*Balaenoptera physalus*) and humpback whales (*Megaptera novaeangliae*) in the Gulf of Alaska revealed through stable isotope analysis. *Marine Mammal Science* 32(4): 1319-1339.

Wood, S.N. 2017. *Generalized Additive Models: An Introduction with R* (2nd Edition). Chapman and Hall/CRC.

Wood, K.R., N.A. Bond, S.L. Danielson, J.E. Overland, S.A. Salo, P.J. Stabeno, and J. Whitefield. 2015. A decade of environmental change in the Pacific Arctic region. *Progress in Oceanography* 136: 12-31.

Wood, S.N., M.V. Bravington, and S.L. Hedley. 2008. Soap film smoothing. *Journal of the Royal Statistical Society: Series B* 70: 931-955.

Young, J.K., B.B. Black, J.T. Clarke, S.V. Schonberg, and K.H. Dutton. 2017. Abundance, biomass and caloric content of Chukchi Sea bivalves and association with Pacific walrus (*Odobenus rosmarus divergens*) relative density and distribution in the northeastern Chukchi Sea. *Deep-Sea Research II*: *Topical Studies in Oceanography* 144: 125-141.

Zar, J.H. 1984. *Biostatistical Analysis*. Englewood Cliffs, N.J., Prentice Hall, Inc. 620 pp.

Zongker, D. 2006. Chicken chicken chicken: chicken chicken. *Annals of Improbable Research* 12(5): 16-21.

APPENDIX A: 2019 ICE CONCENTRATION MAPS

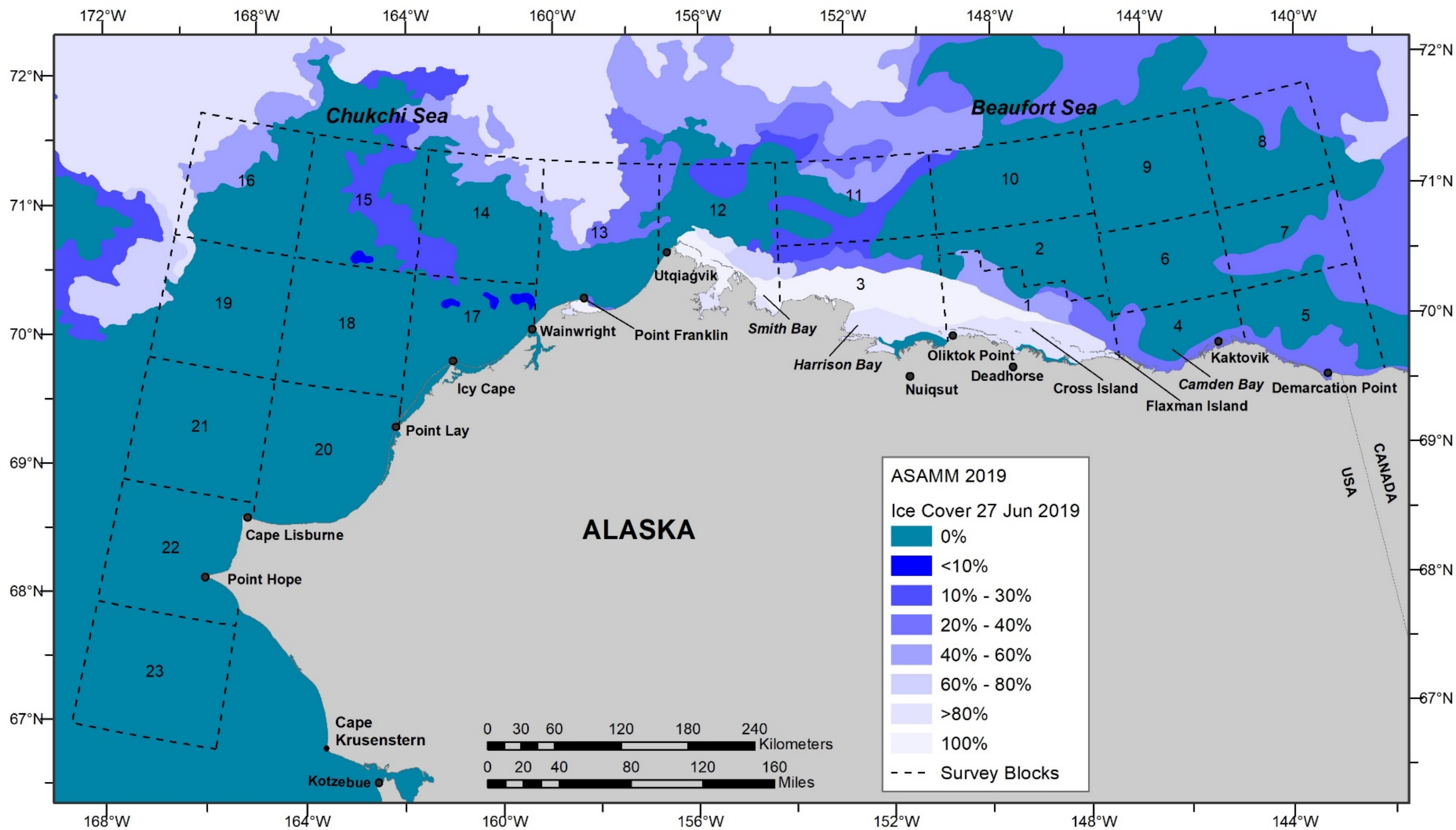


Figure A-1. Ice concentrations in the eastern Chukchi and western Beaufort seas, 27 June 2019. Sea ice information was obtained from the National Ice Center (U.S. National Ice Center 2019).

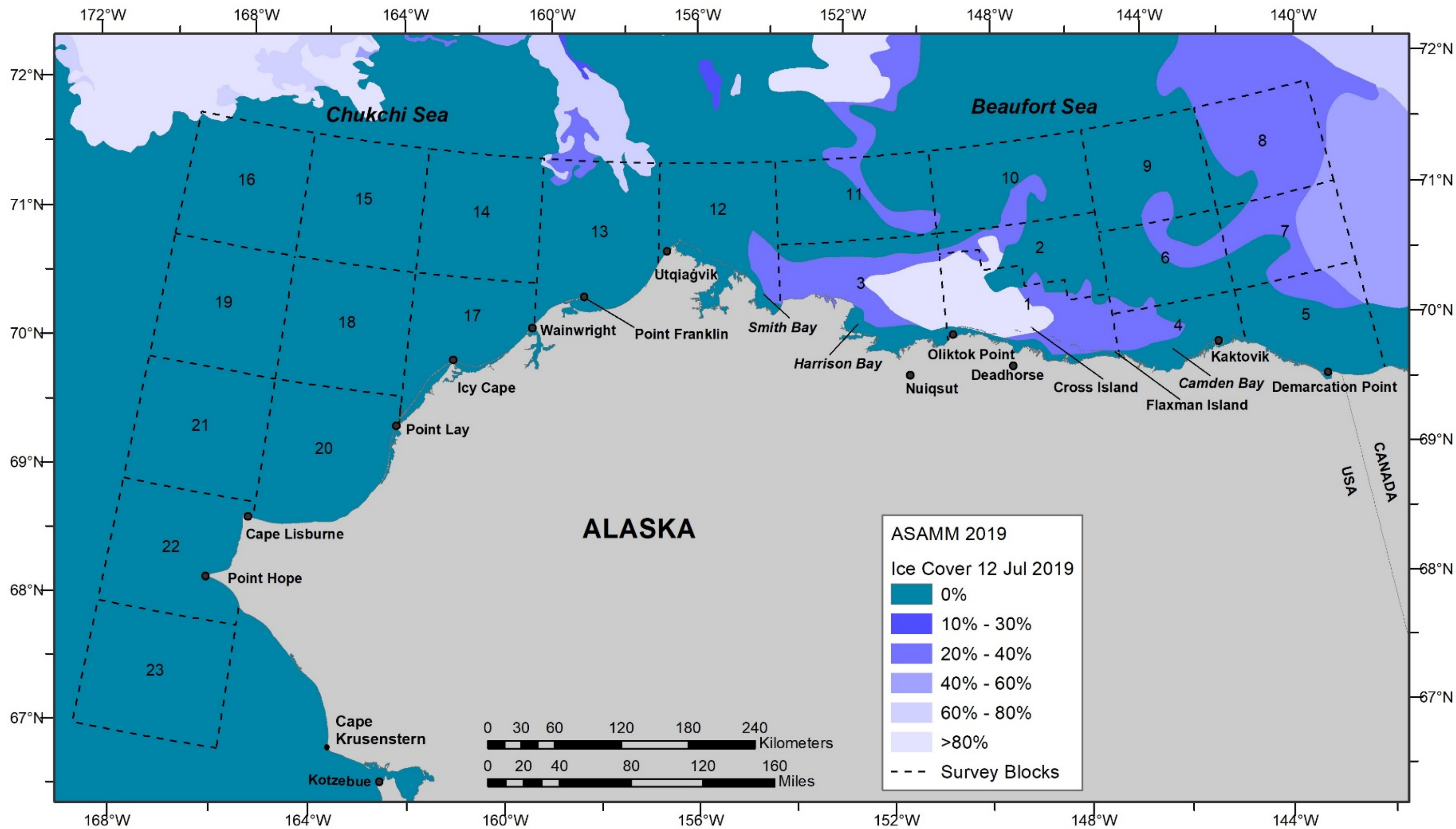


Figure A-2. Ice concentrations in the eastern Chukchi and western Beaufort seas, 12 July 2019. Sea ice information was obtained from the National Ice Center (U.S. National Ice Center 2019).

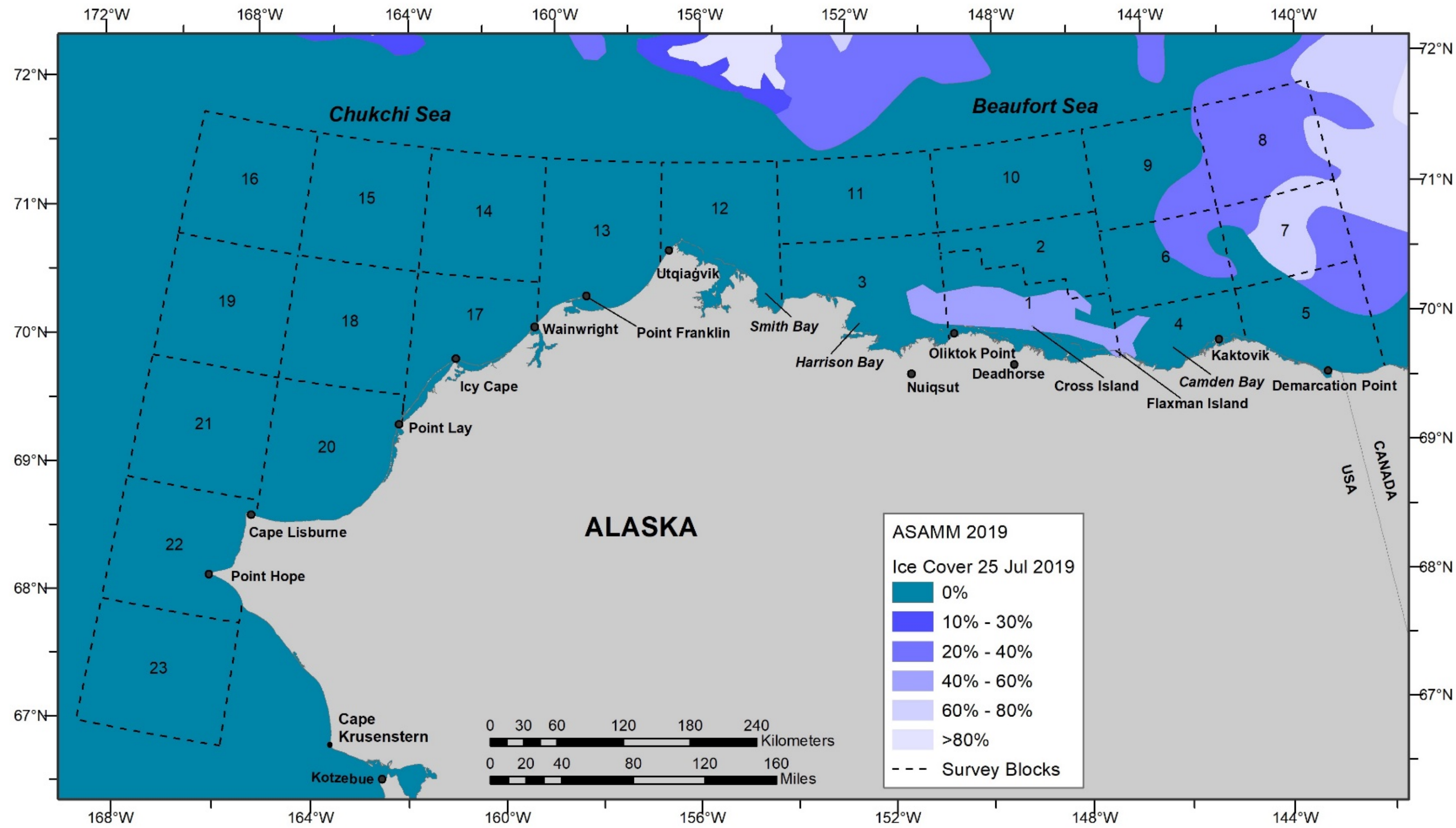


Figure A-3. Ice concentrations in the eastern Chukchi and western Beaufort seas, 25 July 2019. Sea ice information was obtained from the National Ice Center (U.S. National Ice Center 2019).

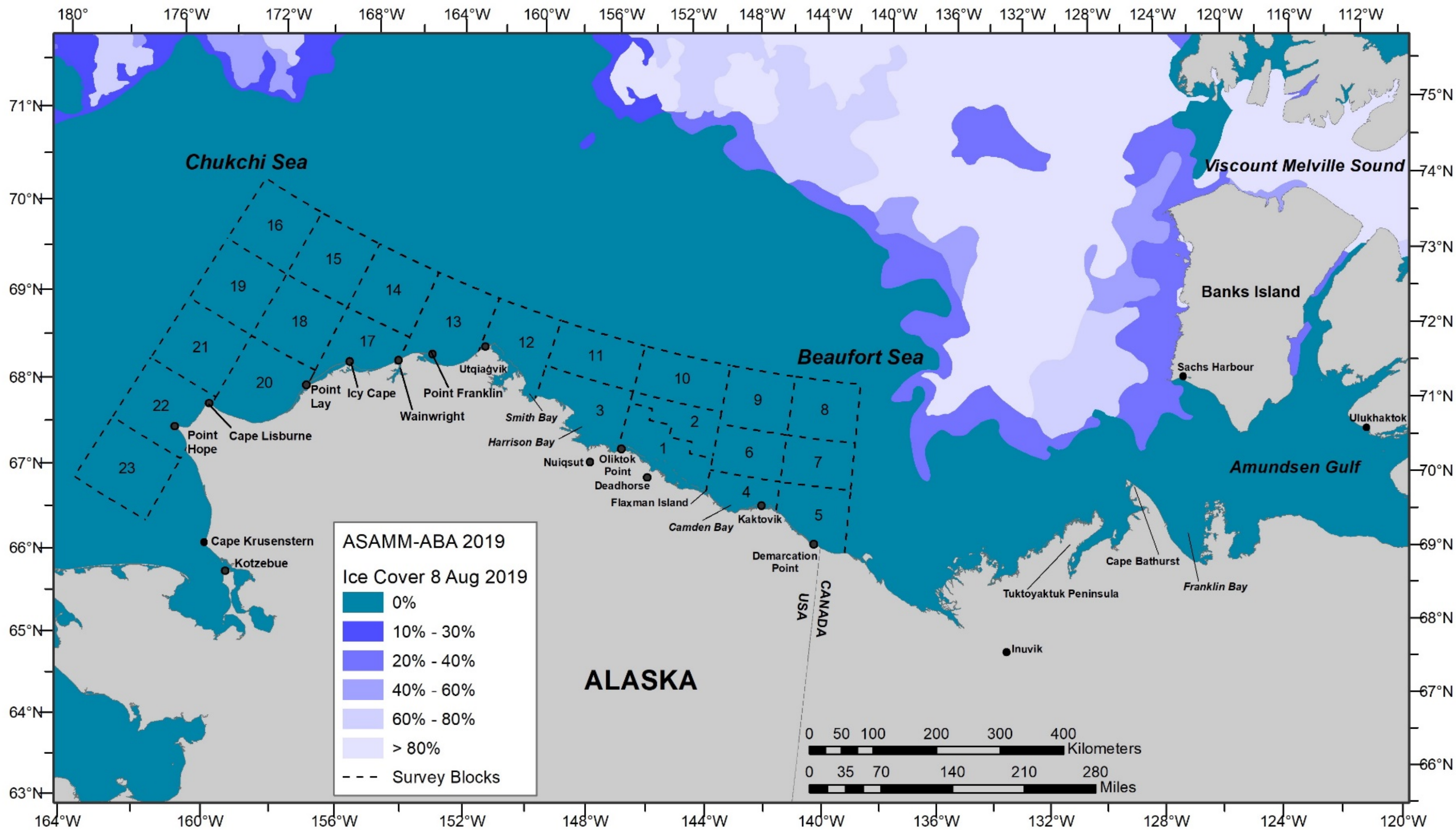


Figure A-4. Ice concentrations in the eastern Chukchi, western and eastern Beaufort seas, and Amundsen Gulf, 8 August 2019. Sea ice information was obtained from the National Ice Center (U.S. National Ice Center 2019).

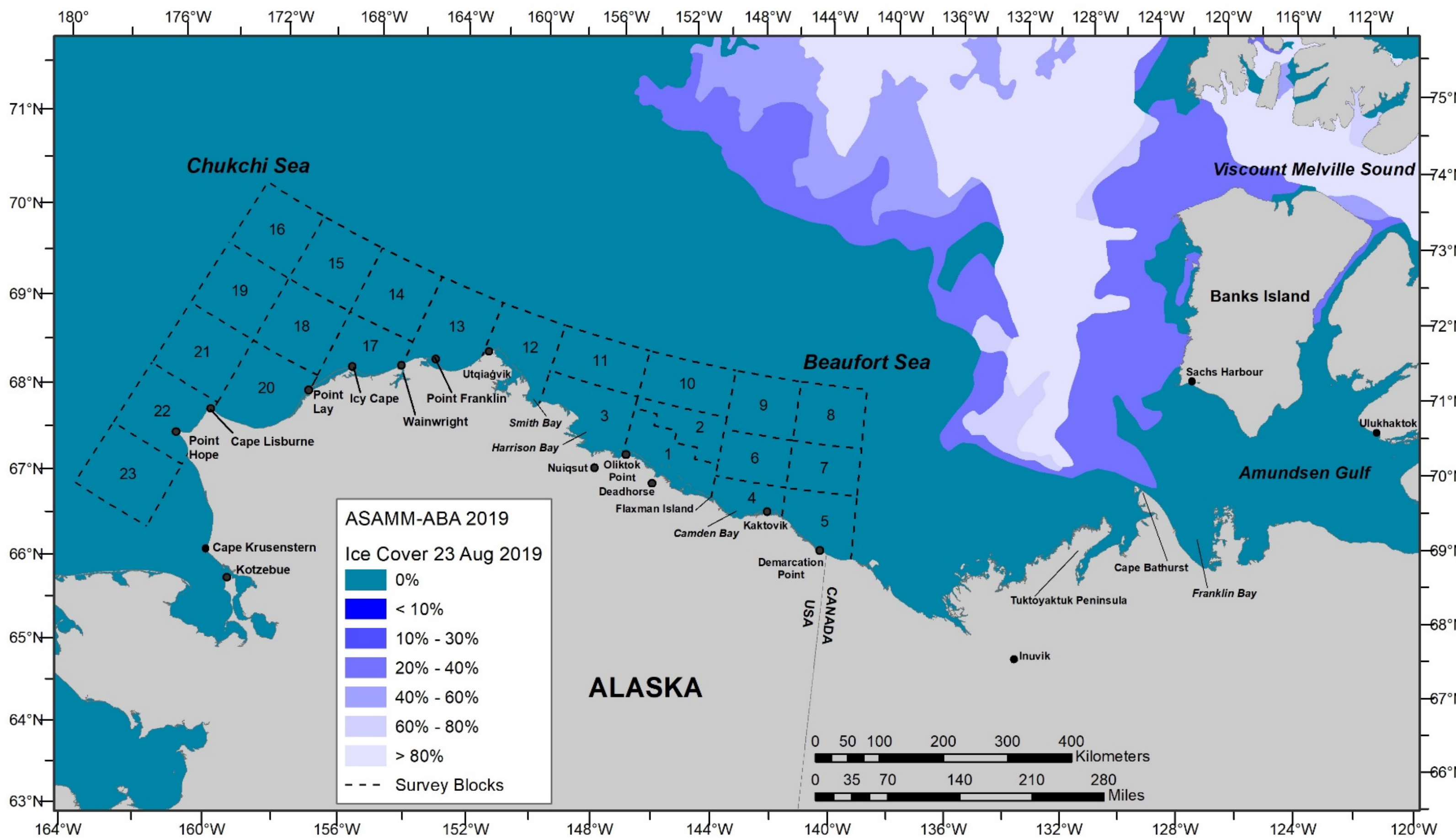


Figure A-5. Ice concentrations in the eastern Chukchi, western and eastern Beaufort seas, and Amundsen Gulf, 23 August 2019. Sea ice information was obtained from the National Ice Center (U.S. National Ice Center 2019).

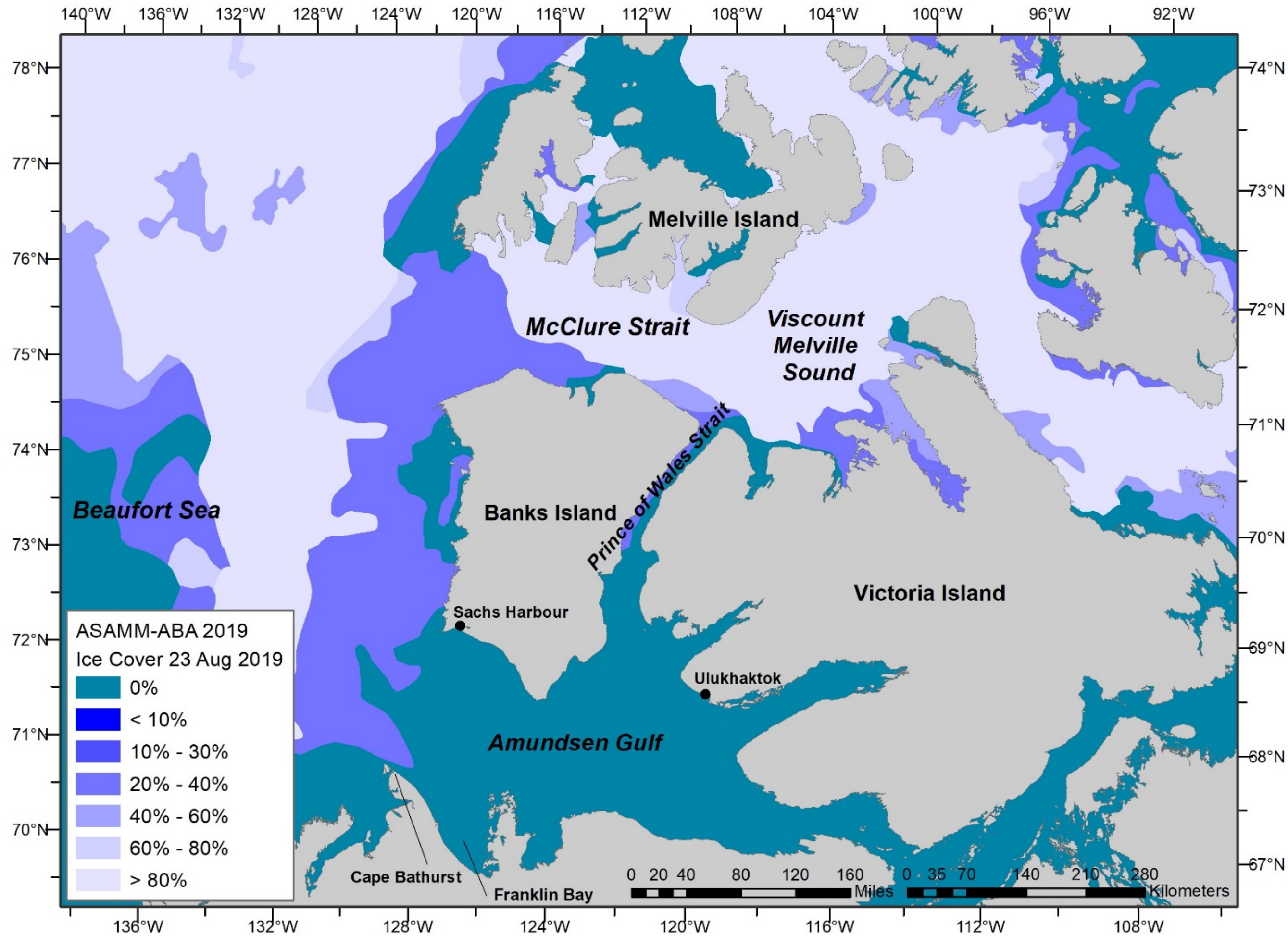


Figure A-6. Ice concentrations in Prince of Wales Strait, Viscount Melville Sound, M'Clure Strait and west of Banks Island, 23 August 2019. Sea ice information was obtained from the National Ice Center (U.S. National Ice Center 2019).

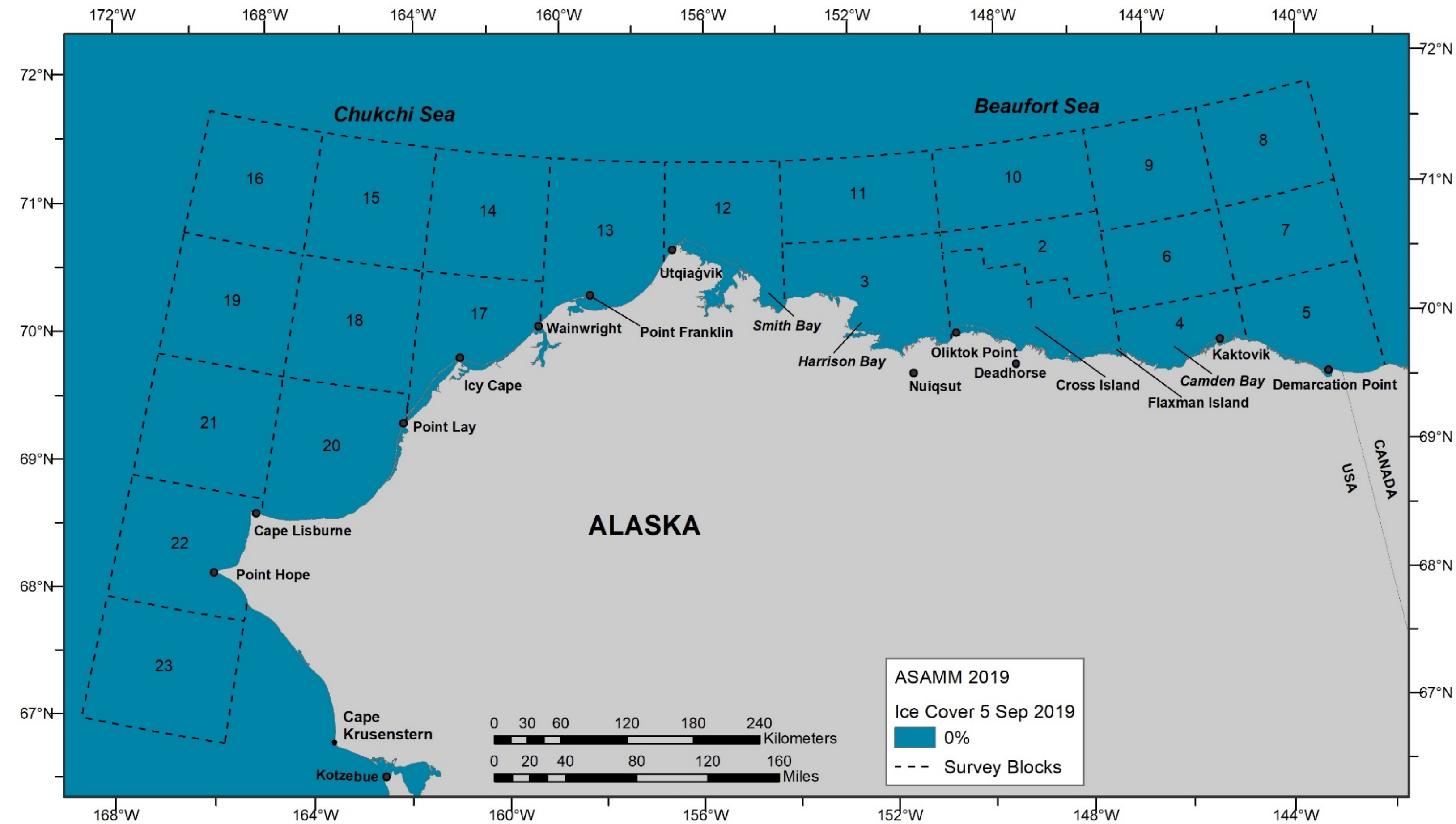


Figure A-7. Ice concentrations in the eastern Chukchi and western Beaufort seas, 5 September 2019. Sea ice information was obtained from the National Ice Center (U.S. National Ice Center 2019).

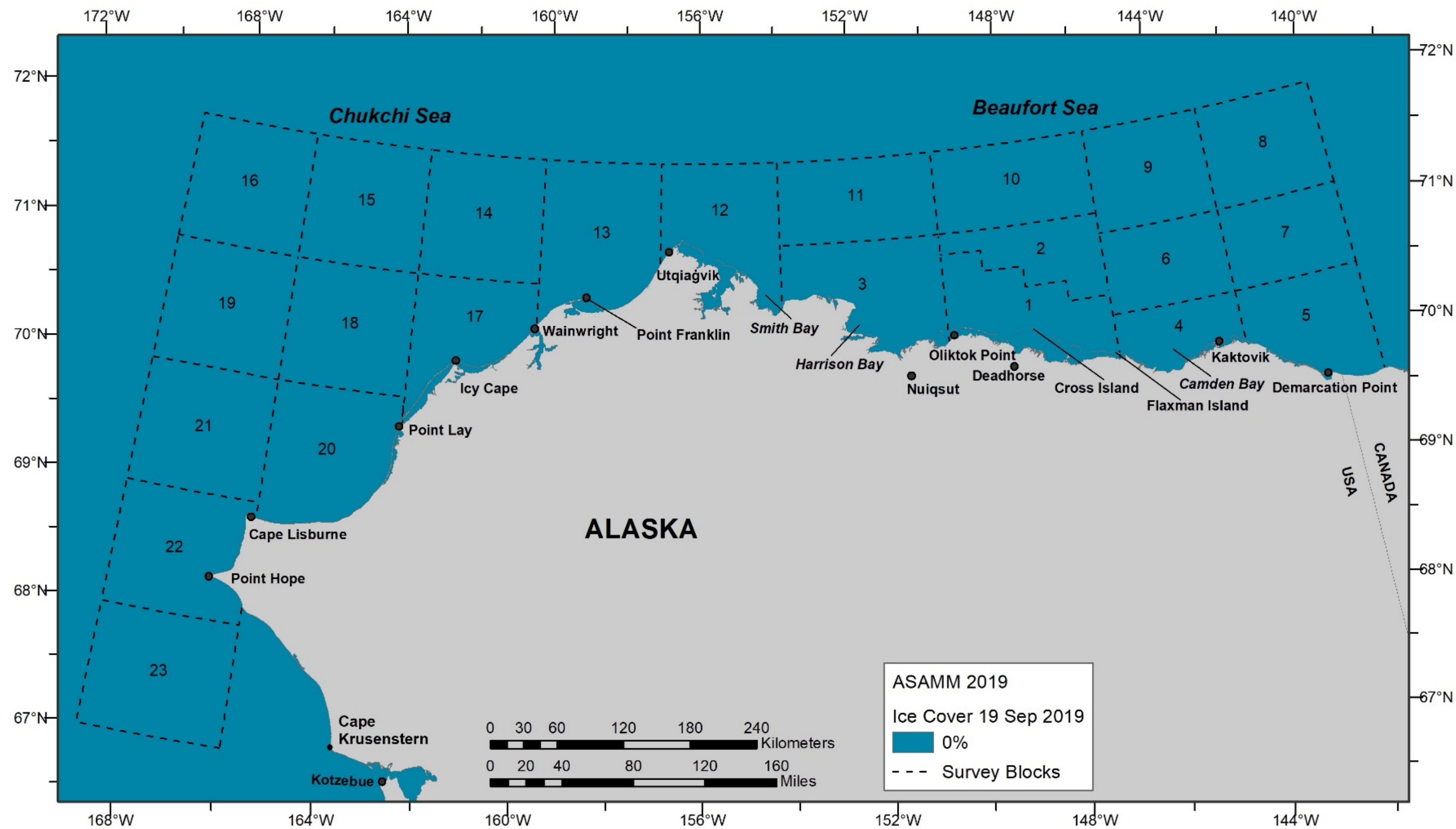


Figure A-8. Ice concentrations in the eastern Chukchi and western Beaufort seas, 19 September 2019. Sea ice information was obtained from the National Ice Center (U.S. National Ice Center 2019).

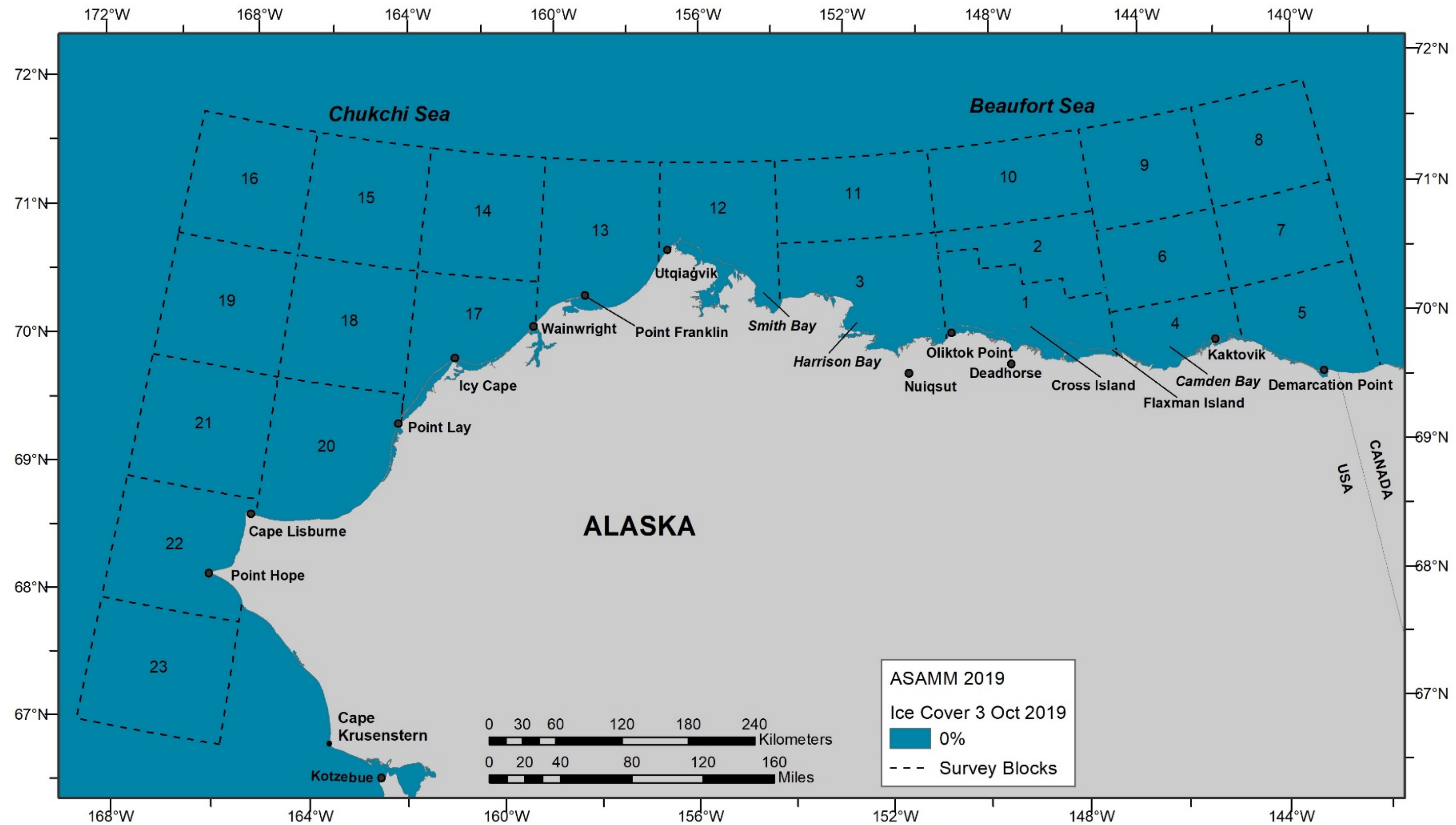


Figure A-9. Ice concentrations in the eastern Chukchi and western Beaufort seas, 3 October 2019. Sea ice information was obtained from the National Ice Center (U.S. National Ice Center 2019).

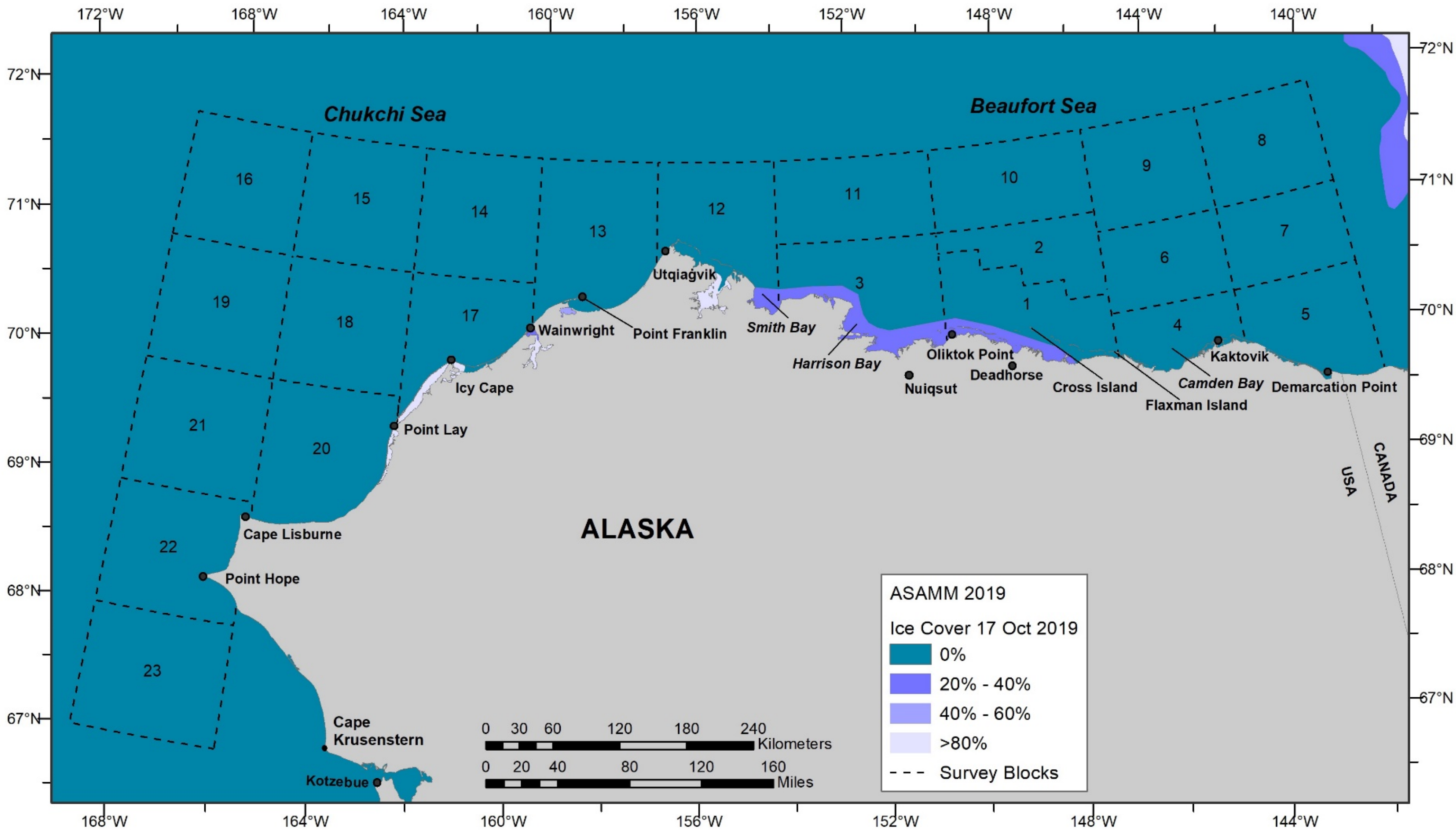


Figure A-10. Ice concentrations in the eastern Chukchi and western Beaufort seas, 17 October 2019. Sea ice information was obtained from the National Ice Center (U.S. National Ice Center 2019).

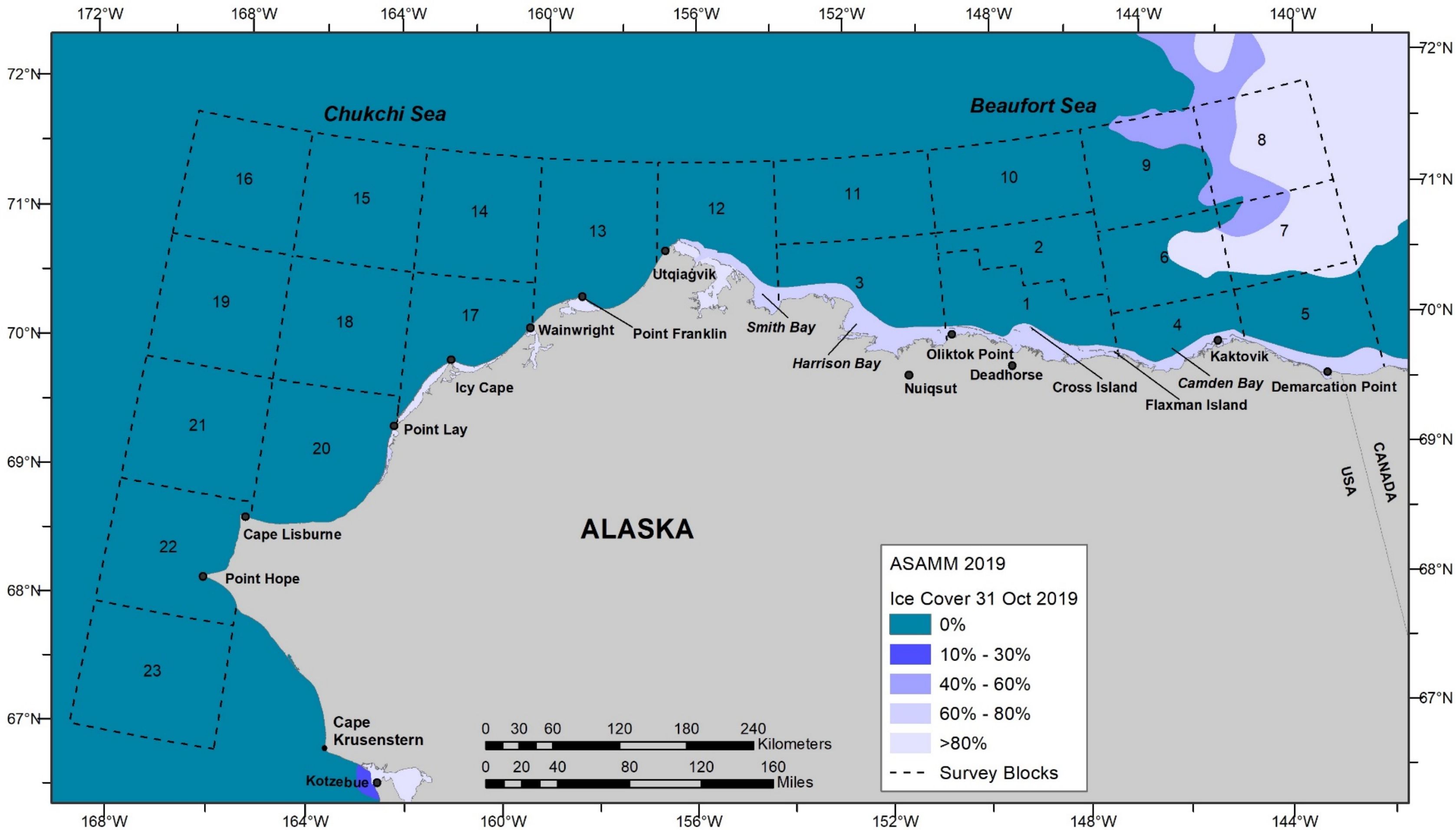


Figure A-11. Ice concentrations in the eastern Chukchi and western Beaufort seas, 31 October 2019. Sea ice information was obtained from the National Ice Center (U.S. National Ice Center 2019).

APPENDIX B: 2019 DAILY FLIGHT SUMMARIES

This page intentionally left blank.

2 July 2019, Flight 201

Flight was a complete survey of transects 1, 3, 5, and 7, and the coastal transect from Point Franklin to Point Barrow. Survey conditions included partly cloudy to overcast skies, 1 km to unlimited visibility, with fog, glare, haze, low ceilings, and precipitation, and Beaufort 1-4 sea states. Sea ice was 0-98% broken floe and pack ice in the area surveyed. Sightings included bowhead whales (including one carcass), gray whales, belugas (including 10 calves), walruses, and small unidentified pinnipeds. The bowhead whale carcass was a resight of a carcass that was previously sighted in 2018 during flight 214 on 30 July, flight 218 on 8 August, and flight 222 on 19 August.

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	7/2/2019 15:01	71.723	158.784	beluga	swim	4	0	13
201	7/2/2019 16:27	72.001	162.477	gray whale	feed	1	0	0
201	7/2/2019 17:14	71.192	160.127	bowhead whale	rest	1	0	14
201	7/2/2019 17:38	70.830	158.397	gray whale	rest	1	0	13
201	7/2/2019 17:48	70.815	158.203	bowhead whale	dead	1	0	13
201	7/2/2019 18:01	71.066	157.220	beluga	rest	150	10	13

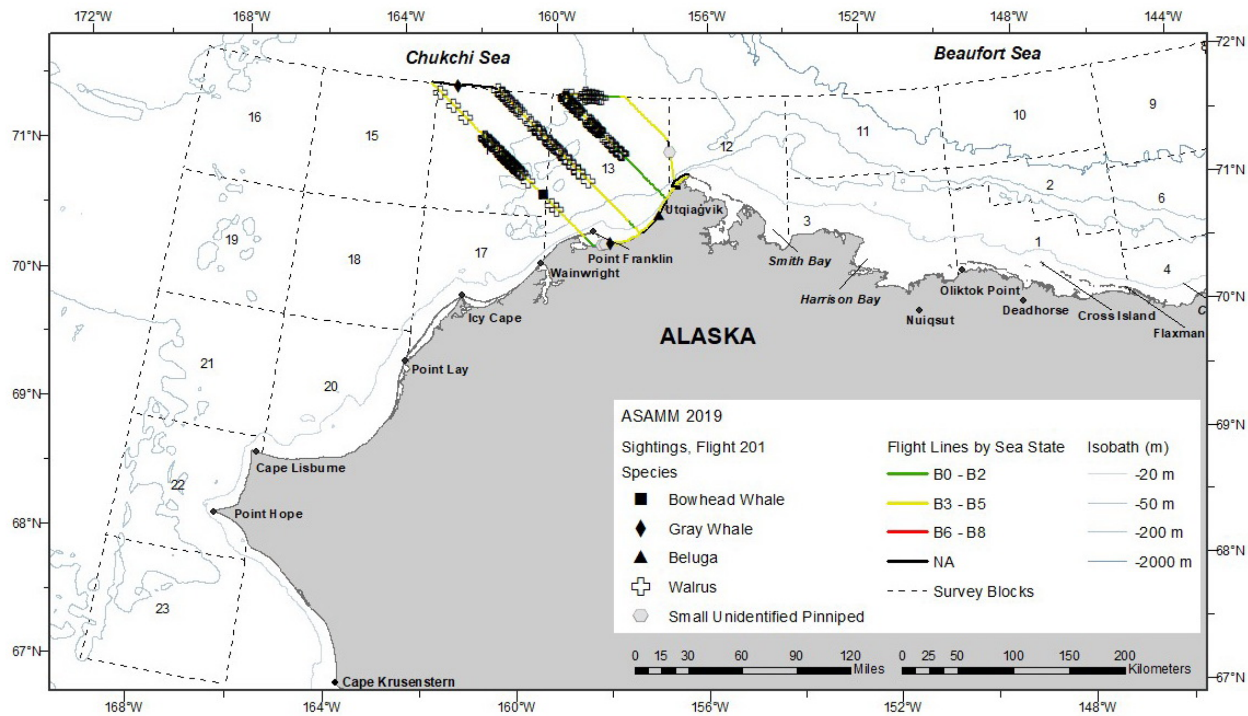


Figure B-1. Flight 201 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

This page intentionally left blank.

3 July 2019, Flight 202

Flight was a complete survey of transect 130 and partial survey of transects 2, 4, 6, 131, 132, and 133. Survey conditions included overcast skies, 0 km to unlimited visibility, with fog, glare, low ceilings, and precipitation, and Beaufort 0-5 sea states. Sea ice was 0-60% broken floe in the area surveyed. Sightings included bowhead whales, belugas (including three 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
202	7/3/2019 13:05	71.685	161.135	bowhead whale	swim	1	0	14
202	7/3/2019 15:03	71.407	156.424	beluga	swim	1	0	12
202	7/3/2019 15:03	71.406	156.418	beluga	swim	1	0	12
202	7/3/2019 15:15	71.466	155.885	beluga	swim	1	0	12
202	7/3/2019 15:15	71.469	155.887	beluga	swim	5	1	12
202	7/3/2019 15:16	71.473	155.896	beluga	swim	9	2	12
202	7/3/2019 15:16	71.476	155.883	beluga	swim	2	0	12
202	7/3/2019 15:16	71.480	155.916	beluga	swim	42	0	12
202	7/3/2019 15:41	71.702	155.413	beluga	swim	2	0	12
202	7/3/2019 16:19	71.652	154.916	bowhead whale	rest	1	0	12
202	7/3/2019 16:28	71.801	154.876	beluga	swim	3	0	12
202	7/3/2019 16:28	71.815	154.900	beluga	swim	5	0	12

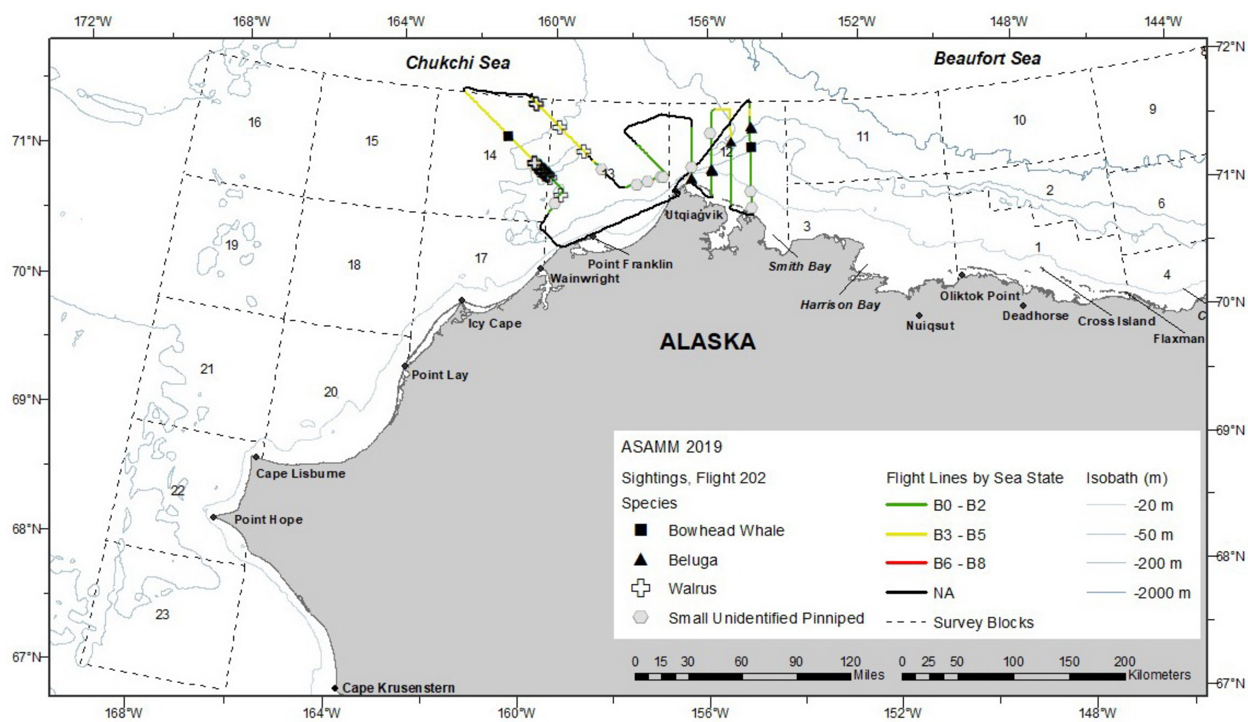


Figure B-2. Flight 202 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

4 July 2019, Flight 203

Flight was a complete survey of transects 110, 111, 112, and 113, partial survey of transect 114, and the coastal transect from Harrison Bay to east of Smith Bay. Survey conditions included partly cloudy skies, <1 km to unlimited visibility, with glare, haze, and low ceilings, and Beaufort 1-5 sea states. Sea ice was 0-75% broken floe in the area surveyed. Sightings included belugas (including 16 calves), 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
203	7/4/2019 9:59	71.110	144.921	beluga	mill	2	1	6
203	7/4/2019 10:00	71.091	144.936	beluga	swim	1	0	6
203	7/4/2019 10:00	71.082	144.929	beluga	rest	1	0	6
203	7/4/2019 10:01	71.076	144.931	beluga	swim	1	0	6
203	7/4/2019 10:02	71.040	144.889	beluga	swim	1	0	6
203	7/4/2019 10:02	71.040	144.934	beluga	swim	2	1	6
203	7/4/2019 10:02	71.029	144.910	beluga	swim	1	0	6
203	7/4/2019 10:03	70.996	144.916	beluga	swim	1	0	6
203	7/4/2019 10:03	70.987	144.886	beluga	swim	1	0	6
203	7/4/2019 10:04	70.963	144.898	beluga	rest	1	0	6
203	7/4/2019 10:05	70.923	144.889	beluga	swim	1	0	6
203	7/4/2019 10:05	70.921	144.922	beluga	swim	1	0	6
203	7/4/2019 10:06	70.918	144.915	beluga	swim	3	0	6
203	7/4/2019 10:06	70.887	144.920	beluga	swim	2	1	6
203	7/4/2019 10:07	70.884	144.909	beluga	swim	1	0	6
203	7/4/2019 10:07	70.882	144.926	beluga	mill	6	0	6
203	7/4/2019 10:07	70.873	144.934	beluga	mill	12	0	6
203	7/4/2019 10:29	70.142	144.940	beluga	swim	2	0	4
203	7/4/2019 11:00	70.787	145.398	beluga	swim	1	0	6
203	7/4/2019 11:00	70.791	145.424	beluga	swim	2	0	6
203	7/4/2019 11:00	70.795	145.421	beluga	swim	1	0	6
203	7/4/2019 11:04	70.912	145.426	beluga	swim	2	0	6
203	7/4/2019 11:06	70.981	145.397	beluga	swim	1	0	6
203	7/4/2019 11:25	70.928	145.914	beluga	swim	1	0	6
203	7/4/2019 11:26	70.922	145.916	beluga	mill	3	0	6
203	7/4/2019 12:23	71.007	146.411	beluga	swim	1	0	2
203	7/4/2019 12:23	71.014	146.421	beluga	swim	1	0	2
203	7/4/2019 12:24	71.040	146.394	beluga	swim	1	0	2
203	7/4/2019 12:24	71.055	146.393	beluga	swim	1	0	2
203	7/4/2019 12:26	71.108	146.393	beluga	swim	3	1	2
203	7/4/2019 12:31	71.280	146.422	beluga	rest	1	0	2
203	7/4/2019 12:49	71.025	146.918	beluga	swim	9	0	2
203	7/4/2019 12:49	71.021	146.891	beluga	swim	7	0	2
203	7/4/2019 12:49	71.009	146.939	beluga	swim	1	0	2
203	7/4/2019 12:50	70.994	146.918	beluga	swim	1	0	2

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
203	7/4/2019 12:50	70.990	146.896	beluga	swim	2	0	2
203	7/4/2019 12:50	70.987	146.922	beluga	swim	2	0	2
203	7/4/2019 12:50	70.985	146.903	beluga	swim	5	2	2
203	7/4/2019 12:50	70.982	146.930	beluga	swim	2	0	2
203	7/4/2019 12:50	70.979	146.901	beluga	swim	12	3	2
203	7/4/2019 12:50	70.977	146.922	beluga	swim	2	1	2
203	7/4/2019 12:50	70.965	146.908	beluga	swim	2	0	2
203	7/4/2019 12:51	70.960	146.881	beluga	swim	1	0	2
203	7/4/2019 12:51	70.953	146.914	beluga	swim	1	0	2
203	7/4/2019 12:51	70.940	146.890	beluga	swim	1	0	2
203	7/4/2019 12:51	70.936	146.885	beluga	swim	4	0	2
203	7/4/2019 12:51	70.928	146.901	beluga	swim	1	0	2
203	7/4/2019 12:52	70.919	146.902	beluga	swim	1	0	2
203	7/4/2019 12:53	70.877	146.918	beluga	swim	1	0	2
203	7/4/2019 12:53	70.873	146.927	beluga	swim	5	0	2
203	7/4/2019 12:53	70.867	146.920	beluga	swim	7	1	2
203	7/4/2019 12:53	70.859	146.886	beluga	swim	9	2	2
203	7/4/2019 12:54	70.846	146.899	beluga	swim	3	0	2
203	7/4/2019 12:54	70.832	146.895	beluga	swim	4	0	2
203	7/4/2019 12:54	70.826	146.894	beluga	swim	2	1	2
203	7/4/2019 12:54	70.826	146.918	beluga	swim	6	0	2
203	7/4/2019 12:54	70.823	146.916	beluga	swim	8	2	2
203	7/4/2019 12:55	70.801	146.932	beluga	swim	4	0	2

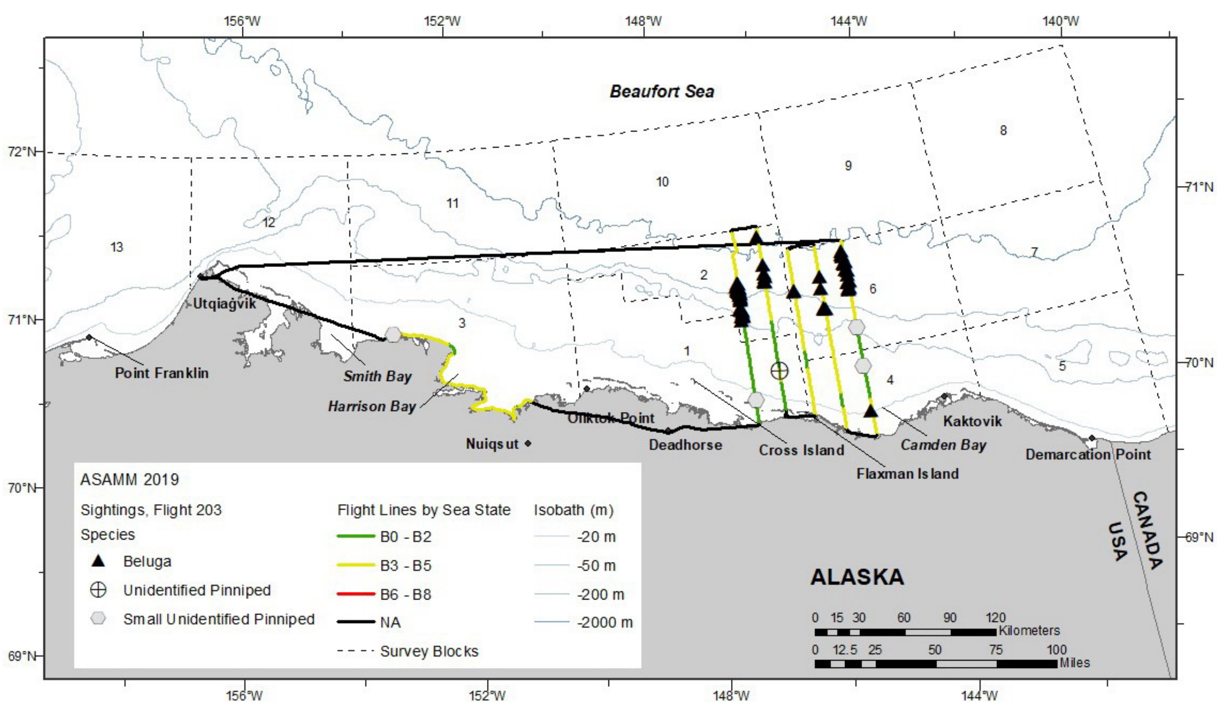


Figure B-3. Flight 203 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

6 July 2019, Flight 204

Flight was a complete survey of transect 134, partial survey of transect 8, and search effort dedicated to photographing gray whales to assess body condition. Survey conditions included partly cloudy skies, unlimited visibility, with glare, and Beaufort 2-6 sea states. Sea ice was 0-5% broken floe in the area surveyed. Sightings included gray whales (including five calves), belugas (including one calf), walruses, 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
204	7/6/2019 11:39	71.018	160.273	gray whale	swim	1	0	14
204	7/6/2019 11:48	71.117	160.598	gray whale	feed	3	1	14
204	7/6/2019 11:48	71.117	160.606	gray whale	feed	1	0	14
204	7/6/2019 11:51	71.119	160.688	gray whale	feed	2	1	14
204	7/6/2019 11:52	71.126	160.696	gray whale	feed	2	1	14
204	7/6/2019 12:03	71.131	160.714	gray whale	feed	1	0	14
204	7/6/2019 12:03	71.129	160.739	gray whale	feed	2	0	14
204	7/6/2019 12:09	71.228	161.012	gray whale	feed	1	0	14
204	7/6/2019 12:19	71.294	161.205	gray whale	feed	1	0	14
204	7/6/2019 12:19	71.287	161.270	gray whale	feed	1	0	14
204	7/6/2019 12:48	71.274	161.410	gray whale	feed	1	0	14
204	7/6/2019 12:55	71.271	161.315	gray whale	feed	1	0	14
204	7/6/2019 13:00	71.285	161.227	gray whale	feed	1	0	14
204	7/6/2019 13:02	71.285	161.277	gray whale	feed	1	0	14
204	7/6/2019 13:05	71.274	161.284	gray whale	feed	1	0	14
204	7/6/2019 13:07	71.241	161.324	gray whale	feed	1	0	14
204	7/6/2019 13:08	71.258	161.350	gray whale	feed	1	0	14
204	7/6/2019 13:18	71.221	161.103	gray whale	feed	2	1	14
204	7/6/2019 13:24	71.233	160.953	gray whale	feed	1	0	14
204	7/6/2019 13:26	71.225	160.946	gray whale	feed	1	0	14
204	7/6/2019 13:29	71.177	160.964	gray whale	feed	1	0	14
204	7/6/2019 13:31	71.202	161.063	gray whale	feed	1	0	14
204	7/6/2019 13:32	71.200	161.083	gray whale	feed	1	0	14
204	7/6/2019 13:35	71.169	160.995	gray whale	feed	1	0	14
204	7/6/2019 13:40	71.130	160.748	gray whale	feed	1	0	14
204	7/6/2019 13:43	71.126	160.661	gray whale	feed	1	0	14
204	7/6/2019 13:45	71.115	160.587	gray whale	feed	1	0	14
204	7/6/2019 13:46	71.127	160.562	gray whale	feed	1	0	14
204	7/6/2019 13:50	71.055	160.738	gray whale	feed	2	0	14
204	7/6/2019 14:46	71.678	156.906	beluga	swim	2	1	12
204	7/6/2019 15:01	71.256	156.878	gray whale	breach	2	1	12
204	7/6/2019 15:01	71.271	156.888	gray whale	rest	2	0	12

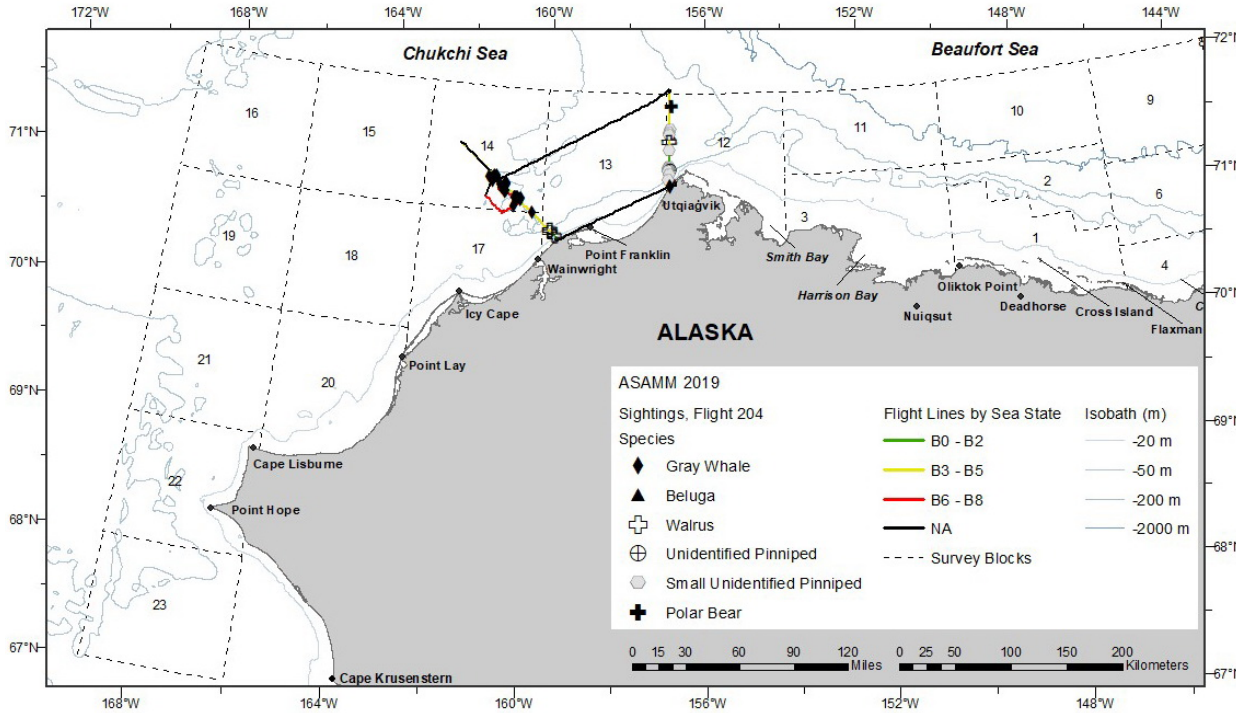


Figure B-4. Flight 204 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Feeding gray whale with mud plume observed approximately 100 km northwest of Point Franklin, Alaska, Flight 204, 6 July 2019.

7 July 2019, Flight 205

Flight was a complete survey of transects 33, 34, and 35, and partial survey of transect 36. Survey conditions included clear skies, 5 km to unlimited visibility, with glare and haze, and Beaufort 1-2 sea states. There was no sea ice in the area surveyed. Sightings included gray whales (including one calf), humpback whales (including one calf), fin whales, 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
205	7/7/2019 11:19	67.919	168.348	gray whale	feed	1	0	23
205	7/7/2019 11:19	67.932	168.356	gray whale	feed	2	0	23
205	7/7/2019 11:23	67.924	168.471	gray whale	rest	2	1	23
205	7/7/2019 11:23	67.929	168.478	gray whale	rest	1	0	23
205	7/7/2019 11:27	67.931	168.626	gray whale	rest	1	0	23
205	7/7/2019 11:27	67.929	168.647	gray whale	feed	1	0	23
205	7/7/2019 11:27	67.912	168.651	gray whale	feed	1	0	23
205	7/7/2019 11:27	67.932	168.669	gray whale	feed	2	0	23
205	7/7/2019 11:30	67.919	168.654	gray whale	swim	1	0	23
205	7/7/2019 11:34	67.907	168.701	gray whale	feed	1	0	23
205	7/7/2019 11:34	67.927	168.701	gray whale	feed	1	0	23
205	7/7/2019 11:34	67.916	168.711	gray whale	feed	1	0	23
205	7/7/2019 11:34	67.926	168.714	gray whale	rest	1	0	23
205	7/7/2019 11:34	67.917	168.719	gray whale	feed	1	0	23
205	7/7/2019 11:34	67.919	168.723	gray whale	feed	1	0	23
205	7/7/2019 11:37	67.932	168.752	gray whale	feed	1	0	23
205	7/7/2019 11:51	67.768	168.092	gray whale	rest	1	0	23
205	7/7/2019 11:52	67.758	168.079	gray whale	feed	1	0	23
205	7/7/2019 11:56	67.767	168.035	gray whale	feed	1	0	23
205	7/7/2019 11:56	67.773	167.998	gray whale	feed	1	0	23
205	7/7/2019 11:56	67.767	167.999	gray whale	feed	1	0	23
205	7/7/2019 11:56	67.752	167.987	gray whale	feed	2	0	23
205	7/7/2019 11:56	67.750	167.980	gray whale	feed	1	0	23
205	7/7/2019 11:56	67.747	167.975	gray whale	feed	2	0	23
205	7/7/2019 11:56	67.750	167.968	gray whale	rest	1	0	23
205	7/7/2019 11:57	67.746	167.952	gray whale	feed	1	0	23
205	7/7/2019 11:57	67.758	167.944	gray whale	rest	1	0	23
205	7/7/2019 11:57	67.757	167.933	gray whale	rest	1	0	23
205	7/7/2019 12:06	67.759	167.939	gray whale	rest	1	0	23
205	7/7/2019 12:07	67.764	167.942	gray whale	rest	1	0	23
205	7/7/2019 12:08	67.749	168.001	gray whale	feed	2	0	23
205	7/7/2019 12:10	67.756	167.988	gray whale	feed	2	0	23
205	7/7/2019 12:11	67.764	168.009	gray whale	feed	1	0	23
205	7/7/2019 12:12	67.769	168.040	gray whale	feed	1	0	23
205	7/7/2019 12:13	67.770	168.046	gray whale	rest	1	0	23
205	7/7/2019 12:14	67.773	168.082	gray whale	rest	1	0	23

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
205	7/7/2019 13:00	67.606	167.540	fin whale	swim	2	0	23
205	7/7/2019 13:05	67.607	167.616	fin whale	swim	1	0	23
205	7/7/2019 13:20	67.591	168.617	gray whale	feed	1	0	23
205	7/7/2019 13:22	67.597	168.661	gray whale	feed	4	0	23
205	7/7/2019 13:22	67.598	168.666	gray whale	rest	1	0	23
205	7/7/2019 13:32	67.427	168.702	gray whale	feed	1	0	23
205	7/7/2019 13:32	67.415	168.697	gray whale	rest	1	0	23
205	7/7/2019 13:36	67.378	168.635	gray whale	feed	3	0	23
205	7/7/2019 13:39	67.390	168.684	gray whale	feed	1	0	23
205	7/7/2019 13:39	67.380	168.660	gray whale	feed	2	0	23
205	7/7/2019 13:54	67.425	167.334	humpback whale	dive	1	0	23
205	7/7/2019 13:55	67.425	167.269	humpback whale	feed	4	1	23
205	7/7/2019 13:59	67.423	167.166	humpback whale	rest	2	0	23
205	7/7/2019 13:59	67.409	167.162	humpback whale	swim	1	0	23
205	7/7/2019 13:59	67.408	167.152	humpback whale	swim	1	0	23
205	7/7/2019 14:03	67.418	167.113	fin whale	mill	2	0	23

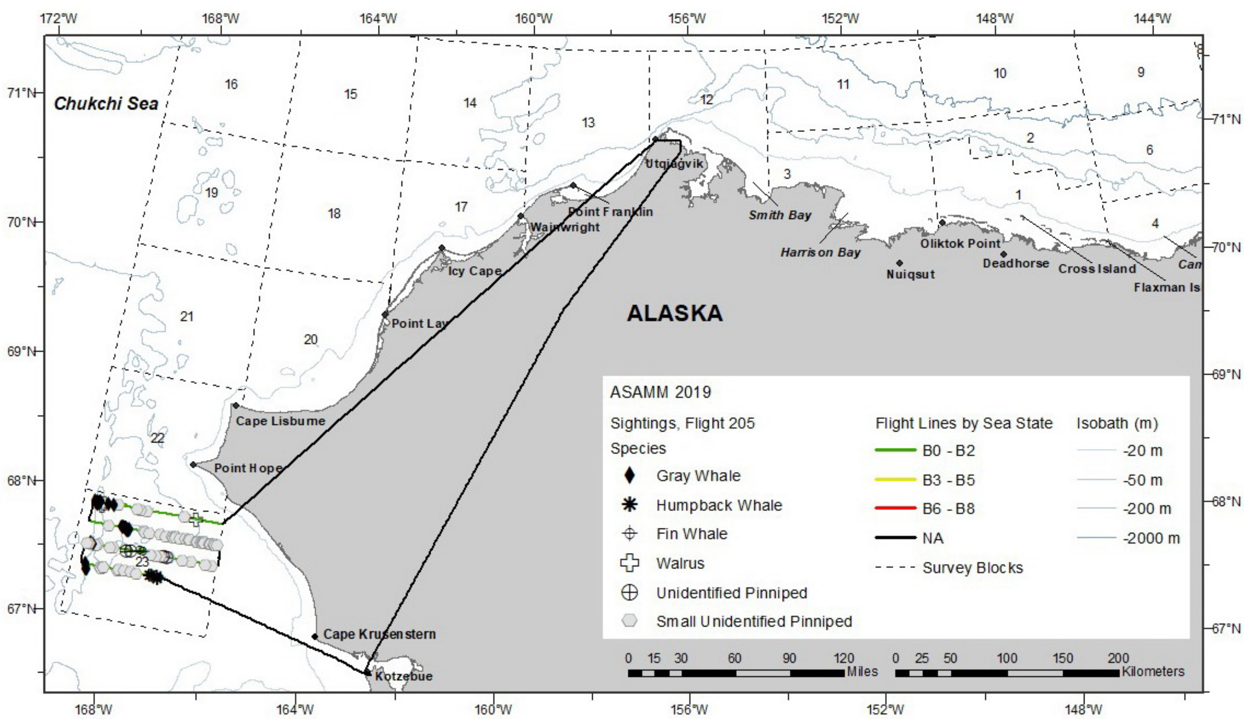


Figure B-5. Flight 205 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

11 July 2019, Flight 206

Flight was a complete survey of transects 127, 128, and 129, and the coastal transect from 80 km south of Point Lay to Wainwright. Survey conditions included partly cloudy skies, 3 km to unlimited visibility, with glare and low ceilings, and Beaufort 1-5 sea states. Sea ice was 0-50% broken floe in the area surveyed. Sightings included one bowhead whale carcass, gray whales (including one carcass), belugas (including five calves), bearded seals, and small unidentified pinnipeds. One haulout of approximately 700 small unidentified pinnipeds was observed on a barrier island south 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
206	7/11/2019 11:36	71.796	153.430	beluga	swim	3	0	11
206	7/11/2019 11:36	71.803	153.417	beluga	swim	2	0	11
206	7/11/2019 11:37	71.810	153.410	beluga	swim	3	1	11
206	7/11/2019 11:39	71.897	153.418	beluga	rest	1	0	11
206	7/11/2019 11:40	71.925	153.446	beluga	swim	1	0	11
206	7/11/2019 11:40	71.930	153.433	beluga	swim	1	0	11
206	7/11/2019 11:50	71.931	153.916	beluga	swim	1	0	11
206	7/11/2019 11:50	71.929	153.916	beluga	swim	1	0	11
206	7/11/2019 11:51	71.921	153.867	beluga	swim	1	0	11
206	7/11/2019 11:51	71.920	153.909	beluga	swim	7	0	11
206	7/11/2019 11:51	71.913	153.876	beluga	swim	3	0	11
206	7/11/2019 11:51	71.911	153.893	beluga	rest	1	0	11
206	7/11/2019 12:15	71.147	153.910	beluga	swim	1	0	3
206	7/11/2019 12:58	71.732	154.466	beluga	swim	3	0	12
206	7/11/2019 13:04	71.914	154.438	beluga	swim	1	0	12
206	7/11/2019 13:05	71.923	154.429	beluga	swim	2	0	12
206	7/11/2019 13:06	71.950	154.431	beluga	swim	2	0	12
206	7/11/2019 13:06	71.957	154.374	beluga	swim	3	0	12
206	7/11/2019 13:06	71.961	154.408	beluga	swim	1	0	12
206	7/11/2019 13:06	71.966	154.378	beluga	swim	2	0	12
206	7/11/2019 13:06	71.968	154.391	beluga	swim	10	3	12
206	7/11/2019 13:07	71.989	154.434	beluga	mill	2	1	12
206	7/11/2019 14:32	69.324	163.226	gray whale	dead	1	0	20
206	7/11/2019 15:05	70.090	162.520	bowhead whale	dead	1	0	17
206	7/11/2019 15:10	70.182	162.366	gray whale	swim	1	0	17

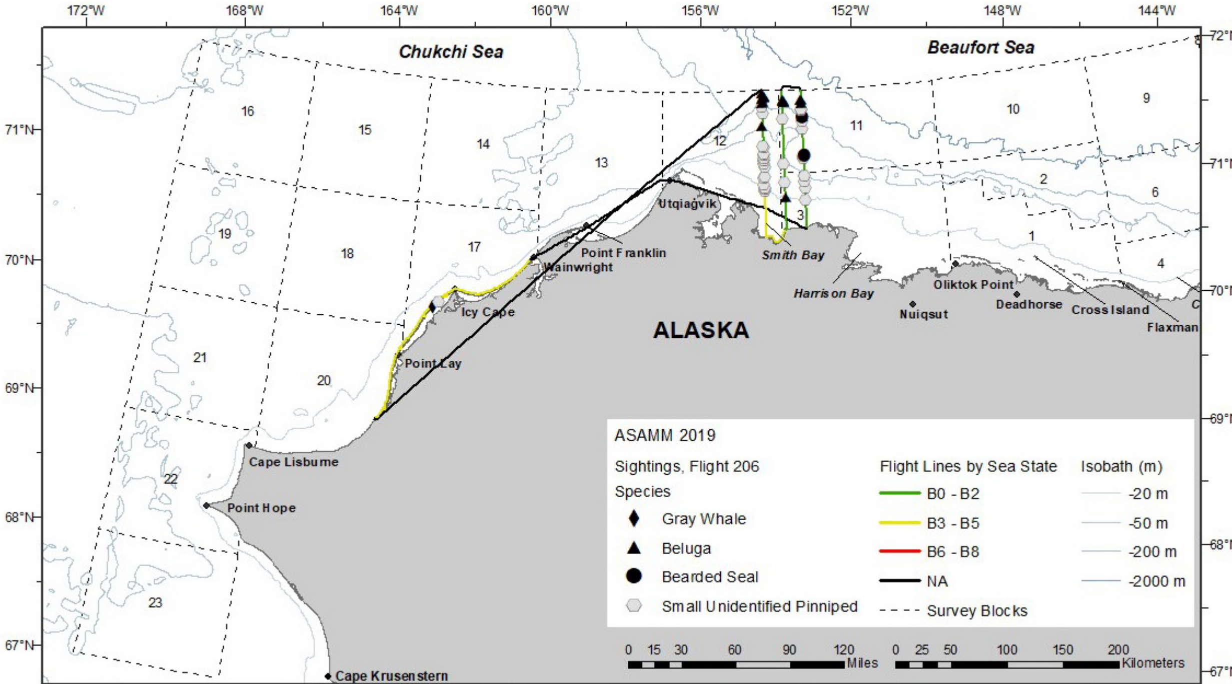


Figure B-6. Flight 206 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

12 July 2019, Flight 207

Flight was a complete survey of transects 123, 124, 125, and 126, and the coastal transect in Harrison Bay and east of Smith Bay. A focal group follow session was conducted on three bowhead whales for 2.8 hours. Survey conditions included clear to partly cloudy skies, unlimited visibility, with glare, and Beaufort 0-5 sea states. Sea ice was 0-75% broken floe in the area surveyed. Sightings included bowhead whales (including one calf), belugas (including 55 calves), unidentified cetaceans, 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
207	7/12/2019 11:24	71.734	152.943	beluga	swim	1	0	11
207	7/12/2019 11:24	71.741	152.932	beluga	swim	2	0	11
207	7/12/2019 11:24	71.755	152.950	beluga	swim	1	0	11
207	7/12/2019 11:25	71.764	152.922	beluga	swim	3	2	11
207	7/12/2019 11:25	71.777	152.898	beluga	swim	1	0	11
207	7/12/2019 11:25	71.788	152.899	beluga	swim	1	0	11
207	7/12/2019 11:25	71.790	152.897	beluga	swim	1	0	11
207	7/12/2019 11:26	71.798	152.922	beluga	mill	45	3	11
207	7/12/2019 11:26	71.801	152.891	beluga	mill	2	1	11
207	7/12/2019 11:26	71.820	152.897	beluga	dive	1	0	11
207	7/12/2019 11:27	71.865	152.916	beluga	swim	1	0	11
207	7/12/2019 11:28	71.871	152.919	beluga	swim	1	0	11
207	7/12/2019 11:29	71.932	152.890	beluga	swim	2	1	11
207	7/12/2019 11:30	71.941	152.911	beluga	swim	1	0	11
207	7/12/2019 11:30	71.947	152.877	bowhead whale	swim	1	0	11
207	7/12/2019 11:30	71.949	152.914	bowhead whale	swim	1	0	11
207	7/12/2019 11:32	71.944	152.900	beluga	swim	1	0	11
207	7/12/2019 11:36	71.995	152.989	bowhead whale	swim	3	0	11
207	7/12/2019 16:40	71.984	152.425	beluga	swim	1	0	11
207	7/12/2019 16:40	71.977	152.409	beluga	swim	1	0	11
207	7/12/2019 16:41	71.971	152.416	beluga	swim	1	0	11
207	7/12/2019 16:42	71.933	152.406	beluga	swim	3	1	11
207	7/12/2019 16:42	71.920	152.366	beluga	swim	1	0	11
207	7/12/2019 16:47	71.842	152.378	bowhead whale	swim	1	0	11
207	7/12/2019 16:49	71.816	152.330	beluga	swim	2	0	11
207	7/12/2019 16:49	71.806	152.310	beluga	swim	4	0	11
207	7/12/2019 16:50	71.774	152.409	beluga	swim	1	0	11
207	7/12/2019 16:50	71.768	152.360	beluga	swim	10	2	11
207	7/12/2019 16:50	71.763	152.399	beluga	mill	4	0	11
207	7/12/2019 16:52	71.710	152.365	beluga	swim	3	1	11
207	7/12/2019 16:53	71.680	152.360	beluga	swim	2	0	11
207	7/12/2019 16:54	71.654	152.434	beluga	swim	2	0	11
207	7/12/2019 16:54	71.646	152.408	beluga	swim	2	1	11
207	7/12/2019 16:54	71.638	152.356	beluga	swim	2	0	11

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
207	7/12/2019 16:55	71.619	152.348	beluga	swim	10	1	11
207	7/12/2019 16:56	71.567	152.357	beluga	swim	2	0	11
207	7/12/2019 16:56	71.559	152.413	beluga	swim	2	0	11
207	7/12/2019 16:56	71.555	152.414	beluga	swim	2	1	11
207	7/12/2019 16:58	71.494	152.360	beluga	swim	6	0	11
207	7/12/2019 16:59	71.480	152.455	beluga	swim	200	20	11
207	7/12/2019 16:59	71.474	152.442	beluga	swim	6	0	11
207	7/12/2019 17:07	71.375	152.472	unid cetacean	swim	1	0	11
207	7/12/2019 17:15	71.147	152.387	bowhead whale	swim	1	0	3
207	7/12/2019 17:52	71.223	151.897	bowhead whale	swim	1	0	3
207	7/12/2019 17:52	71.238	151.963	bowhead whale	swim	2	0	3
207	7/12/2019 18:01	71.432	151.894	beluga	swim	2	0	11
207	7/12/2019 18:01	71.456	151.902	beluga	swim	2	0	11
207	7/12/2019 18:02	71.459	151.860	beluga	swim	1	0	11
207	7/12/2019 18:02	71.462	151.901	beluga	swim	1	0	11
207	7/12/2019 18:02	71.464	151.891	beluga	mill	3	0	11
207	7/12/2019 18:02	71.467	151.915	beluga	swim	4	1	11
207	7/12/2019 18:02	71.488	151.913	beluga	swim	4	0	11
207	7/12/2019 18:03	71.520	151.891	beluga	swim	1	0	11
207	7/12/2019 18:04	71.545	151.921	beluga	swim	1	0	11
207	7/12/2019 18:05	71.577	151.908	beluga	swim	1	0	11
207	7/12/2019 18:07	71.637	151.903	beluga	swim	1	0	11
207	7/12/2019 18:07	71.640	151.919	beluga	swim	1	0	11
207	7/12/2019 18:07	71.641	151.907	beluga	swim	2	0	11
207	7/12/2019 18:07	71.651	151.899	beluga	swim	2	1	11
207	7/12/2019 18:07	71.660	151.921	beluga	swim	5	1	11
207	7/12/2019 18:08	71.670	151.875	beluga	swim	1	0	11
207	7/12/2019 18:08	71.704	151.904	beluga	swim	2	0	11
207	7/12/2019 18:09	71.738	151.903	beluga	mill	2	0	11
207	7/12/2019 18:10	71.750	151.921	beluga	swim	3	1	11
207	7/12/2019 18:11	71.807	151.875	beluga	swim	1	0	11
207	7/12/2019 18:12	71.814	151.966	beluga	swim	8	4	11
207	7/12/2019 18:12	71.816	151.893	beluga	swim	1	0	11
207	7/12/2019 18:16	71.905	151.933	beluga	swim	3	0	11
207	7/12/2019 18:17	71.922	151.853	beluga	swim	6	1	11
207	7/12/2019 18:18	71.950	151.927	beluga	swim	1	0	11
207	7/12/2019 18:18	71.960	151.863	beluga	swim	2	0	11
207	7/12/2019 18:24	71.982	151.412	beluga	swim	1	1	11
207	7/12/2019 18:24	71.980	151.404	beluga	swim	1	0	11
207	7/12/2019 18:24	71.976	151.410	beluga	swim	1	0	11
207	7/12/2019 18:24	71.968	151.397	beluga	swim	1	0	11
207	7/12/2019 18:24	71.968	151.406	beluga	swim	4	2	11
207	7/12/2019 18:25	71.938	151.415	beluga	swim	2	0	11
207	7/12/2019 18:25	71.931	151.352	beluga	swim	4	0	11
207	7/12/2019 18:25	71.926	151.390	beluga	swim	9	3	11

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
207	7/12/2019 18:25	71.924	151.433	beluga	swim	2	0	11
207	7/12/2019 18:26	71.911	151.371	beluga	swim	3	0	11
207	7/12/2019 18:26	71.895	151.406	beluga	swim	2	1	11
207	7/12/2019 18:27	71.869	151.362	beluga	swim	1	0	11
207	7/12/2019 18:27	71.864	151.376	beluga	swim	2	0	11
207	7/12/2019 18:28	71.844	151.428	bowhead whale	swim	1	0	11
207	7/12/2019 18:28	71.835	151.338	bowhead whale	dive	3	1	11
207	7/12/2019 18:34	71.785	151.403	beluga	swim	2	1	11
207	7/12/2019 18:34	71.764	151.444	bowhead whale	swim	1	0	11
207	7/12/2019 18:34	71.762	151.407	beluga	swim	1	0	11
207	7/12/2019 18:35	71.751	151.400	beluga	swim	1	0	11
207	7/12/2019 18:37	71.729	151.389	beluga	swim	2	1	11
207	7/12/2019 18:40	71.651	151.392	beluga	swim	1	0	11
207	7/12/2019 18:40	71.622	151.434	beluga	swim	2	0	11
207	7/12/2019 18:42	71.561	151.349	beluga	swim	7	0	11
207	7/12/2019 18:42	71.552	151.428	beluga	swim	1	0	11
207	7/12/2019 18:44	71.497	151.398	beluga	swim	3	0	11
207	7/12/2019 18:45	71.479	151.378	beluga	swim	6	0	11
207	7/12/2019 18:45	71.468	151.275	unid cetacean	breach	1	0	11
207	7/12/2019 18:45	71.463	151.405	beluga	swim	3	0	11
207	7/12/2019 18:47	71.408	151.403	beluga	swim	14	3	11

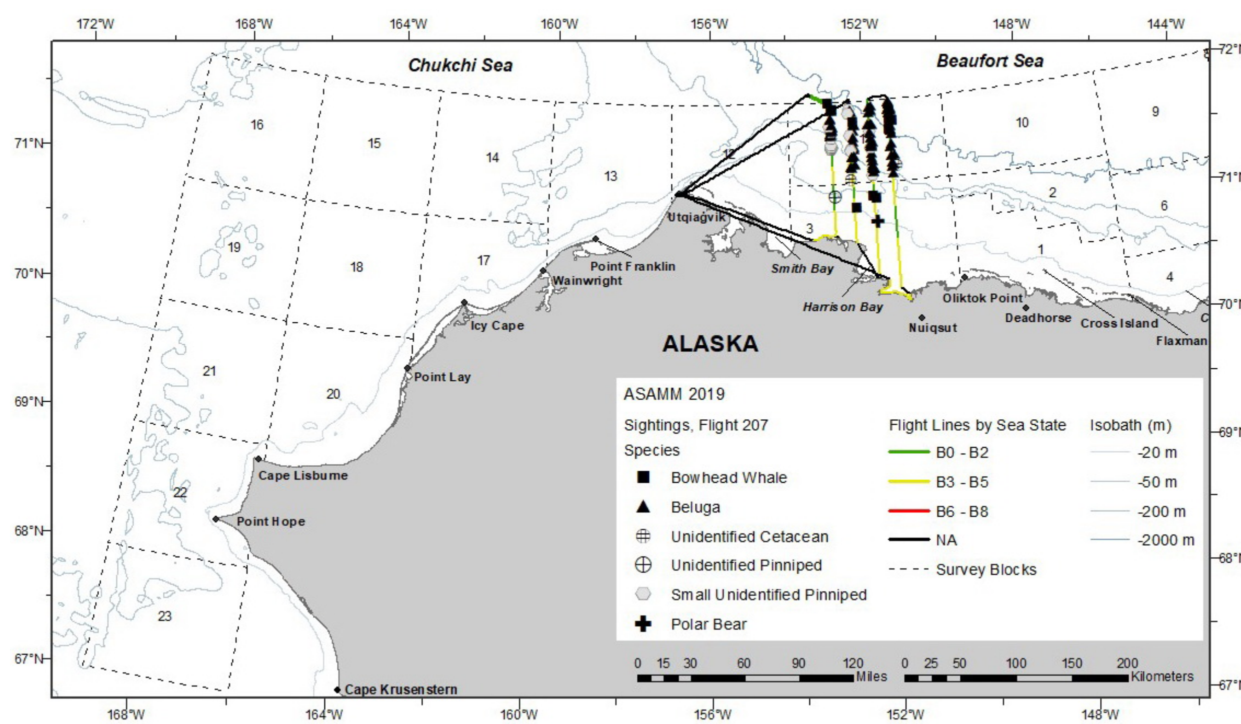


Figure B-7. Flight 207 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

This page intentionally left blank.

13 July 2019, Flight 208

Flight was a complete survey of transect 9, partial survey of transect 11, and search effort dedicated to photographing gray whales to assess body condition. Survey conditions included partly cloudy skies, <1 km to unlimited visibility, with glare and low ceilings, and Beaufort 2-3 sea states. There was no sea ice in the area surveyed. Sightings included gray whales (including one carcass), 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
208	7/13/2019 9:54	70.834	160.456	gray whale	swim	1	0	17
208	7/13/2019 10:01	70.872	160.506	gray whale	swim	1	0	17
208	7/13/2019 10:01	70.853	160.566	gray whale	swim	2	0	17
208	7/13/2019 10:01	70.859	160.561	gray whale	swim	1	0	17
208	7/13/2019 10:08	70.868	160.495	gray whale	feed	7	0	17
208	7/13/2019 10:09	70.861	160.626	gray whale	swim	2	0	17
208	7/13/2019 10:13	70.901	160.618	gray whale	feed	2	0	17
208	7/13/2019 10:19	70.901	160.580	gray whale	feed	1	0	17
208	7/13/2019 10:20	70.867	160.454	gray whale	feed	2	0	17
208	7/13/2019 10:21	70.871	160.489	gray whale	feed	1	0	17
208	7/13/2019 10:22	70.871	160.451	gray whale	feed	2	0	17
208	7/13/2019 10:23	70.870	160.453	gray whale	feed	1	0	17
208	7/13/2019 10:23	70.872	160.459	gray whale	feed	4	0	17
208	7/13/2019 10:31	70.974	160.974	gray whale	swim	1	0	17
208	7/13/2019 10:36	71.025	161.102	gray whale	feed	1	0	14
208	7/13/2019 10:36	71.029	161.128	gray whale	feed	1	0	14
208	7/13/2019 10:36	71.029	161.138	gray whale	feed	1	0	14
208	7/13/2019 10:36	71.030	161.151	gray whale	feed	1	0	14
208	7/13/2019 10:39	71.034	161.038	gray whale	feed	1	0	14
208	7/13/2019 10:40	71.037	161.034	gray whale	feed	1	0	14
208	7/13/2019 10:42	71.041	161.065	gray whale	feed	1	0	14
208	7/13/2019 10:50	71.186	161.631	gray whale	dead	1	0	14
208	7/13/2019 10:54	71.224	161.761	gray whale	feed	1	0	14

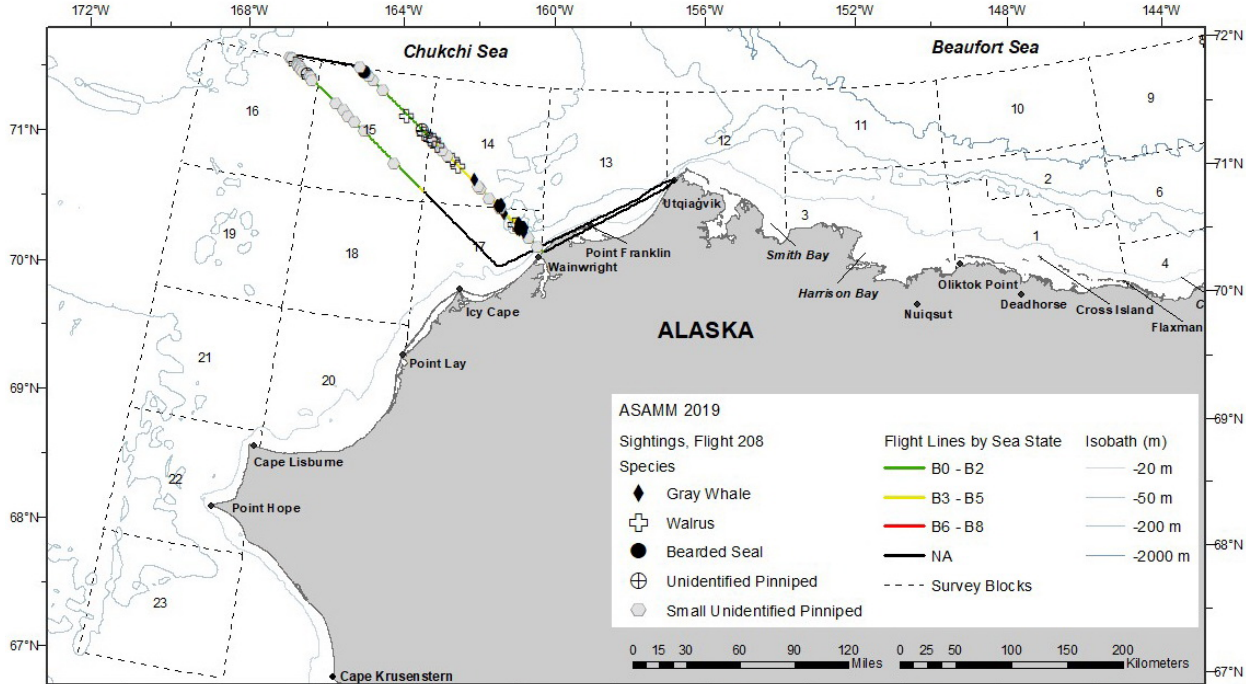


Figure B-8. Flight 208 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

17 July 2019, Flight 209

Flight was complete survey of transects 6 and 10. Survey conditions included partly cloudy to overcast skies, <1 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 gray whales (including two calves), one unidentified cetacean, 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
209	7/17/2019 13:28	71.954	162.118	unid cetacean	unknown	1	0	14
209	7/17/2019 13:50	71.997	162.235	gray whale	feed	2	0	14
209	7/17/2019 15:11	71.002	161.847	gray whale	feed	1	0	14
209	7/17/2019 15:11	71.003	161.834	gray whale	feed	3	0	14
209	7/17/2019 15:14	70.996	161.850	gray whale	feed	1	0	17
209	7/17/2019 15:16	70.965	161.765	gray whale	feed	1	0	17
209	7/17/2019 15:24	70.866	161.265	gray whale	feed	5	0	17
209	7/17/2019 15:35	70.660	160.674	gray whale	rest	4	2	17

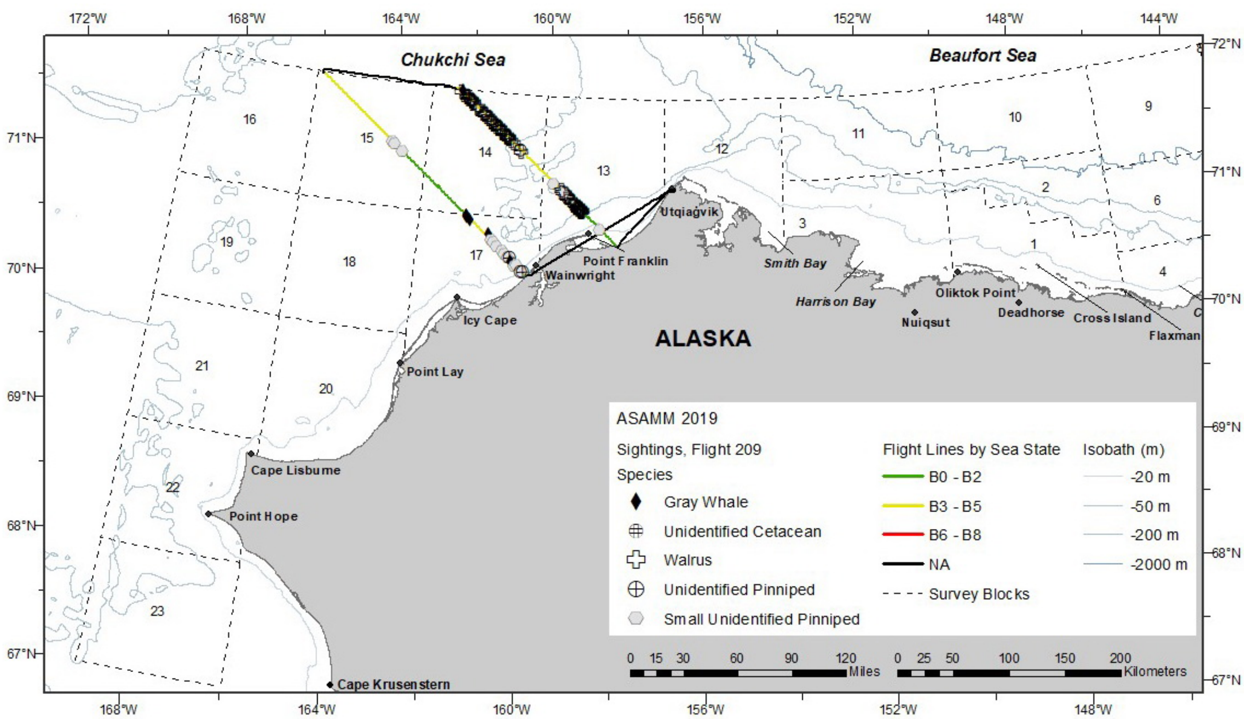


Figure B-9. Flight 209 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

This pair of gray whale cow-calf pairs was sighted approximately 20 km west of Wainwright, Alaska, Flight 209, 17 July 2019.

This page intentionally left blank.

18 July 2019, Flight 210

Flight was a partial survey of transects 3 and 7 and negligible portion of transect 5. Survey conditions included overcast skies, 0-10 km visibility, with low ceilings, and Beaufort 3-7 sea states. Sea ice was 0-5% broken floe in the area surveyed. Sightings included one gray whale carcass and walruses. The gray whale carcass was a resight of a carcass previously sighted on flight 208 on 13 July 2019.

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	7/18/2019 10:31	71.375	157.573	gray whale	dead	1	0	13

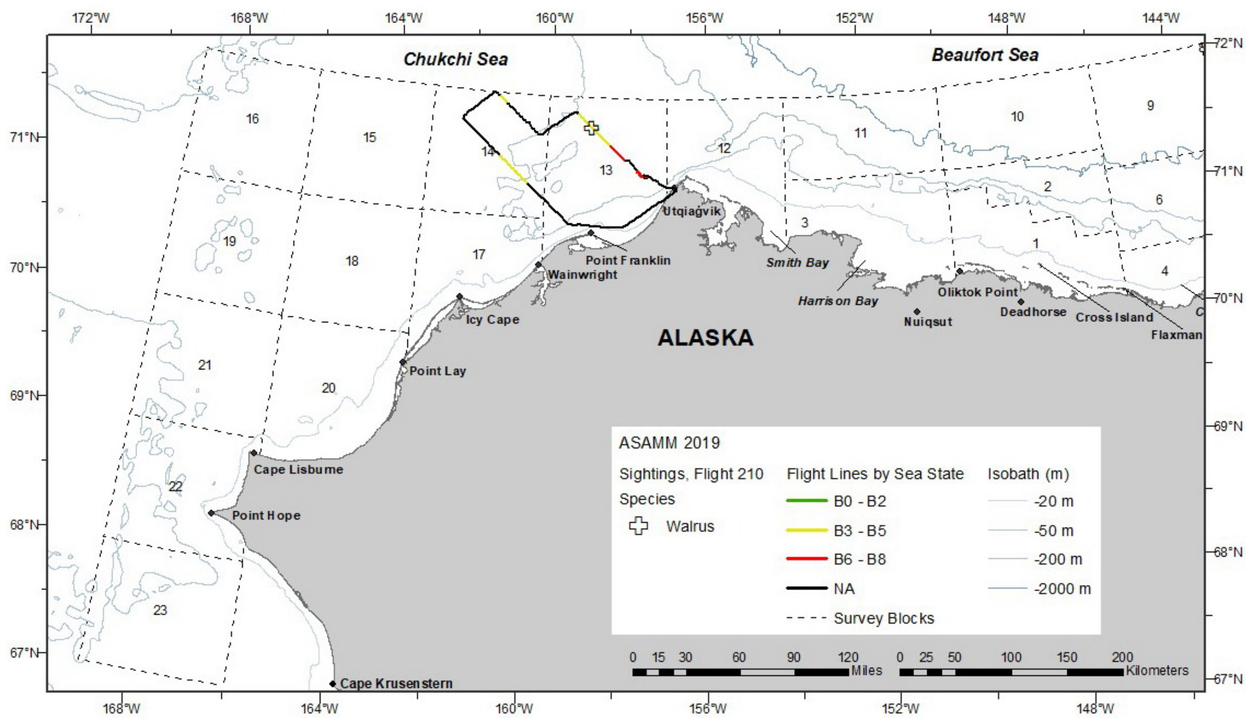


Figure B-10. Flight 210 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

19 July 2019, Flight 1

Flight was a complete survey of transects 116, 117, 118, and 119, and partial survey of transects 120 and 121. Survey conditions included partly cloudy to overcast skies, <1 km to unlimited visibility, with fog, glare, haze, low ceilings, and precipitation, and Beaufort 1-5 sea states. Sea ice was 0-70% broken floe in the area surveyed. Sightings included bowhead whales, belugas (including 15 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	7/19/2019 15:36	71.092	147.877	beluga	swim	2	0	2
1	7/19/2019 15:36	71.108	147.908	beluga	swim	2	1	2
1	7/19/2019 15:37	71.137	147.884	beluga	swim	1	0	2
1	7/19/2019 15:37	71.147	147.909	beluga	swim	1	0	2
1	7/19/2019 15:38	71.179	147.931	beluga	swim	1	0	2
1	7/19/2019 15:39	71.195	147.893	beluga	swim	1	0	2
1	7/19/2019 15:39	71.207	147.887	beluga	swim	1	0	2
1	7/19/2019 15:40	71.225	147.888	beluga	swim	2	0	2
1	7/19/2019 15:40	71.245	147.903	beluga	swim	2	1	2
1	7/19/2019 15:40	71.246	147.876	beluga	swim	2	1	2
1	7/19/2019 15:50	71.279	148.406	beluga	swim	1	0	2
1	7/19/2019 15:51	71.233	148.414	beluga	swim	11	2	2
1	7/19/2019 15:52	71.223	148.407	beluga	swim	2	0	2
1	7/19/2019 15:52	71.209	148.396	beluga	swim	1	0	2
1	7/19/2019 15:52	71.201	148.397	beluga	swim	1	0	2
1	7/19/2019 15:53	71.180	148.404	beluga	mill	3	0	2
1	7/19/2019 16:53	71.233	148.910	beluga	swim	2	1	2
1	7/19/2019 17:09	71.250	149.419	beluga	swim	1	0	2
1	7/19/2019 17:30	70.619	149.406	beluga	swim	2	1	1
1	7/19/2019 17:51	70.961	149.878	bowhead whale	swim	2	0	1
1	7/19/2019 18:17	71.227	149.895	beluga	swim	10	4	2
1	7/19/2019 18:17	71.228	149.901	beluga	swim	2	0	2
1	7/19/2019 18:17	71.234	149.909	beluga	swim	12	3	2
1	7/19/2019 18:18	71.244	149.909	beluga	swim	4	1	2
1	7/19/2019 18:20	71.320	149.904	beluga	rest	1	0	2
1	7/19/2019 18:21	71.346	149.890	beluga	swim	1	0	10

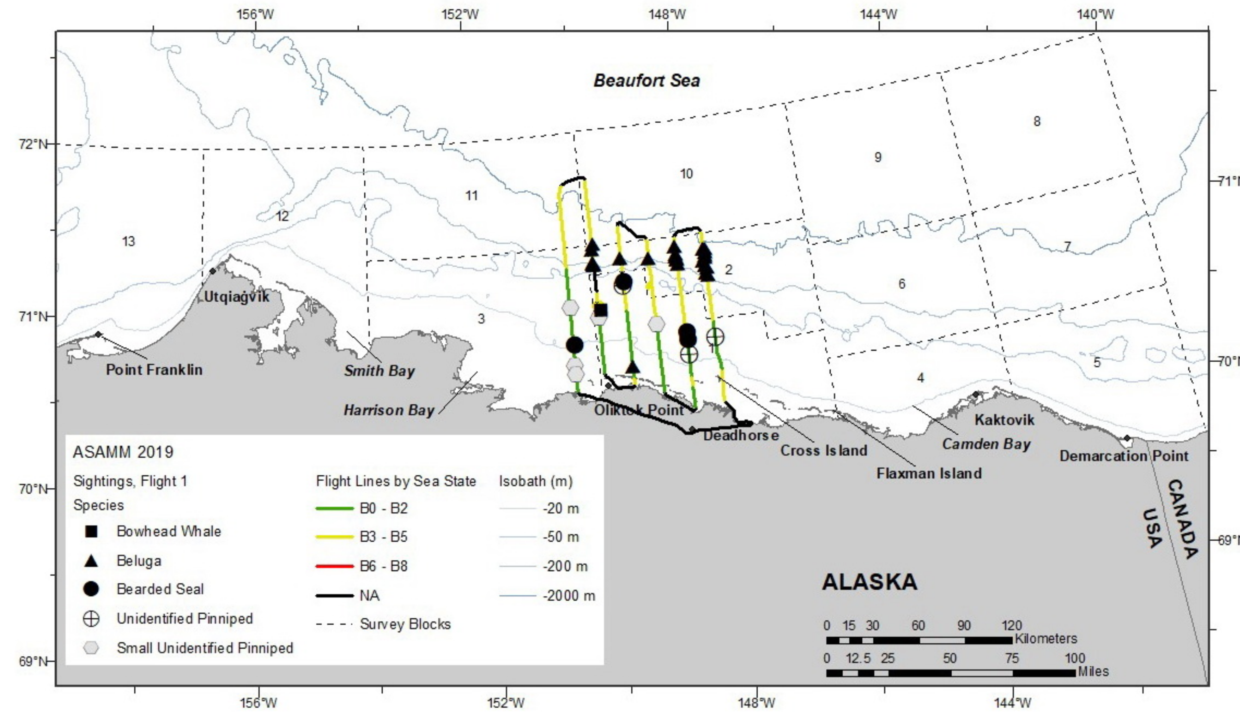


Figure B-11. Flight 1 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

This page intentionally left blank.

21 July 2019, Flight 211

Flight was a complete survey of transects 1, 2, and 3, and partial survey of transects 5 and 134. Survey conditions included overcast skies, 0 km to unlimited visibility, with fog, glare, haze, low ceilings, and precipitation, and Beaufort 1-4 sea states. Sea ice was 0-25% broken floe in the area surveyed. Sightings included one beluga, 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
211	7/21/2019 15:52	71.759	158.901	beluga	rest	1	0	13

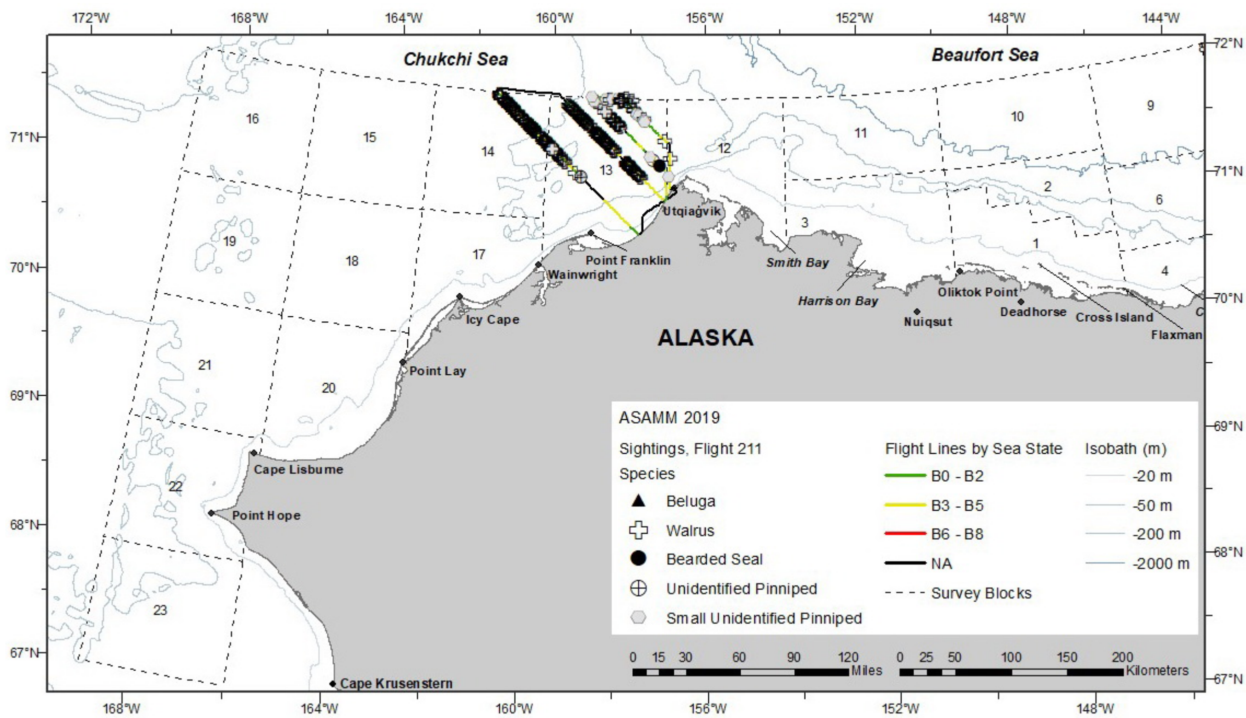


Figure B-12. Flight 211 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

21 July 2019, Flight 2

Flight was a partial survey of transects 106, 107, and 108. A focal group follow session was conducted on a bowhead whale cow-calf pair for 1.6 hours. Survey conditions included overcast skies, <1-10 km visibility, with glare, low ceilings, and precipitation, and Beaufort 2-5 sea states. Sea ice was 0-30% broken floe in the area surveyed. Sightings included bowhead whales (including four calves), belugas (including eight calves), one bearded seal, 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
2	7/21/2019 10:23	70.474	142.905	bowhead whale	swim	2	1	5
2	7/21/2019 10:25	70.480	142.891	bowhead whale	swim	1	0	5
2	7/21/2019 10:26	70.467	142.899	bowhead whale	swim	4	2	5
2	7/21/2019 10:27	70.469	142.905	bowhead whale	swim	2	0	5
2	7/21/2019 10:37	70.473	142.918	bowhead whale	SAG	2	0	5
2	7/21/2019 10:38	70.517	142.919	beluga	swim	2	1	7
2	7/21/2019 10:38	70.540	142.898	beluga	swim	1	0	7
2	7/21/2019 10:39	70.558	142.901	beluga	mill	4	2	7
2	7/21/2019 10:40	70.581	142.917	beluga	rest	1	0	7
2	7/21/2019 10:41	70.616	142.898	beluga	swim	2	1	7
2	7/21/2019 10:41	70.619	142.898	beluga	swim	2	1	7
2	7/21/2019 10:41	70.621	142.908	beluga	swim	1	0	7
2	7/21/2019 10:42	70.656	142.923	beluga	swim	2	1	7
2	7/21/2019 10:42	70.670	142.916	beluga	swim	1	0	7
2	7/21/2019 10:47	70.822	142.904	beluga	rest	4	2	7
2	7/21/2019 11:42	70.580	143.909	beluga	dive	1	0	6
2	7/21/2019 11:43	70.629	143.913	bowhead whale	swim	2	1	6

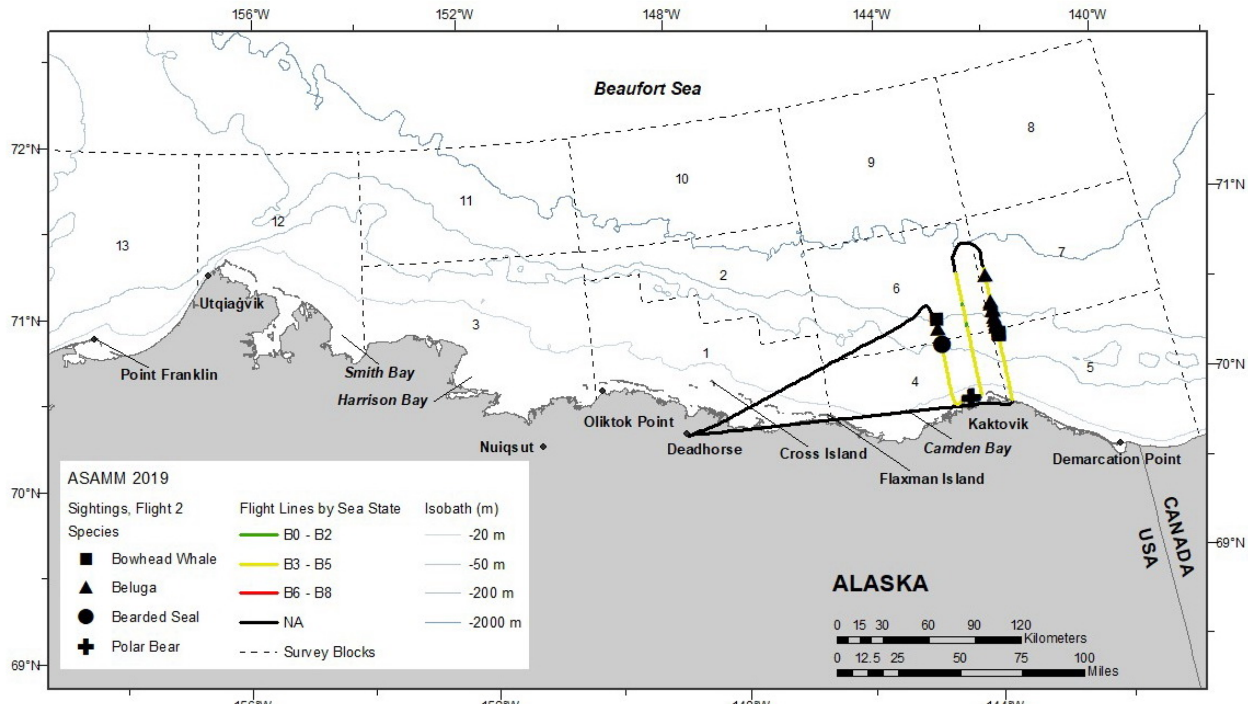


Figure B-13. Flight 2 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Two surface active bowhead whales observed belly to belly and rolling at the water's surface approximately 50 km northeast of Kaktovik, Alaska, Flight 2, 21 July 2019.

Bowhead whale cow-calf pair that were the subject of a focal group follow session, Flight 2, 21 July 2019.

22 July 2019, Flight 212

Flight was a partial survey of transects 129, 131, 132, and 133, and the coastal transect in Harrison Bay and east of Smith Bay. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited of visibility, with glare, haze, and low ceilings, and Beaufort 1-4 sea states. There was no sea ice in the area surveyed. Sightings included one walrus, unidentified pinnipeds, one small unidentified pinniped, and one polar bear.

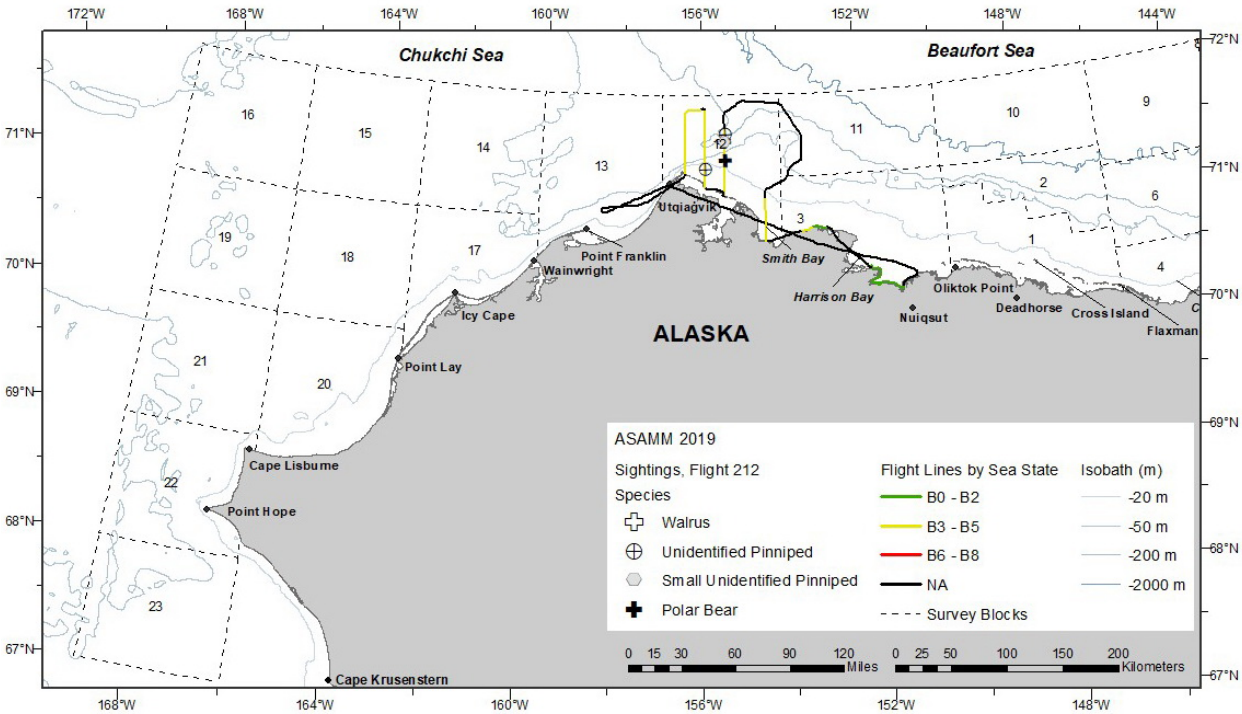


Figure B-14. Flight 212 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

22 July 2019, Flight 3

Flight was a partial survey of transects 110, 111, 112, 113, 114, and 115. Survey conditions included partly cloudy to overcast skies, <1 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 1-3 sea states. Sea ice was 0-50% broken floe in the area surveyed. Sightings included bowhead whales (including three calves), belugas (including 37 calves), bearded seals, 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
3	7/22/2019 10:08	70.623	144.950	bowhead whale	swim	1	0	6
3	7/22/2019 10:13	70.690	144.882	beluga	mill	5	1	6
3	7/22/2019 10:17	70.821	144.944	beluga	swim	1	0	6
3	7/22/2019 10:18	70.837	144.916	beluga	swim	1	0	6
3	7/22/2019 10:25	70.877	145.388	beluga	swim	2	1	6
3	7/22/2019 10:25	70.872	145.410	beluga	swim	4	1	6
3	7/22/2019 10:25	70.864	145.431	beluga	rest	2	1	6
3	7/22/2019 10:26	70.850	145.408	beluga	swim	1	0	6
3	7/22/2019 10:26	70.846	145.405	beluga	swim	1	0	6
3	7/22/2019 10:26	70.840	145.403	beluga	swim	3	1	6
3	7/22/2019 10:26	70.832	145.405	beluga	swim	2	1	6
3	7/22/2019 10:28	70.773	145.470	bowhead whale	breach	1	0	6
3	7/22/2019 10:37	70.693	145.527	bowhead whale	swim	2	0	6
3	7/22/2019 10:39	70.673	145.486	bowhead whale	swim	2	0	6
3	7/22/2019 10:40	70.680	145.436	bowhead whale	swim	1	0	6
3	7/22/2019 10:41	70.676	145.423	bowhead whale	swim	1	0	6
3	7/22/2019 11:14	70.640	145.887	beluga	swim	1	0	6
3	7/22/2019 11:15	70.661	145.901	beluga	swim	1	0	6
3	7/22/2019 11:17	70.717	145.871	beluga	swim	3	0	6
3	7/22/2019 11:17	70.728	145.890	beluga	swim	3	1	6
3	7/22/2019 11:22	70.898	145.877	beluga	swim	1	0	6
3	7/22/2019 11:23	70.909	145.903	beluga	swim	1	0	6
3	7/22/2019 11:23	70.915	145.933	beluga	swim	4	0	6
3	7/22/2019 11:23	70.921	145.945	beluga	swim	1	0	6
3	7/22/2019 11:24	70.940	145.961	beluga	swim	1	0	6
3	7/22/2019 11:24	70.941	145.885	beluga	rest	1	0	6
3	7/22/2019 11:24	70.945	145.898	beluga	rest	2	1	6
3	7/22/2019 11:25	70.979	145.885	beluga	rest	1	0	6
3	7/22/2019 11:25	70.985	145.917	beluga	rest	1	0	6
3	7/22/2019 11:25	70.991	145.936	beluga	swim	1	0	6
3	7/22/2019 11:26	71.002	145.901	beluga	rest	8	0	6
3	7/22/2019 11:26	71.009	145.931	beluga	rest	1	0	6
3	7/22/2019 11:26	71.020	145.933	beluga	rest	4	2	6
3	7/22/2019 11:28	71.069	145.927	beluga	rest	1	0	6
3	7/22/2019 11:28	71.075	145.912	beluga	rest	1	0	6
3	7/22/2019 11:28	71.078	145.922	beluga	rest	1	0	6

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
3	7/22/2019 11:28	71.081	145.897	beluga	rest	1	0	6
3	7/22/2019 11:28	71.085	145.929	beluga	swim	1	0	6
3	7/22/2019 11:29	71.097	145.932	beluga	rest	6	1	6
3	7/22/2019 11:29	71.108	145.890	beluga	rest	5	1	6
3	7/22/2019 11:30	71.143	145.853	beluga	rest	1	0	6
3	7/22/2019 11:30	71.156	145.871	beluga	swim	4	0	6
3	7/22/2019 11:39	71.310	146.397	beluga	swim	2	0	2
3	7/22/2019 11:39	71.309	146.407	beluga	swim	15	0	2
3	7/22/2019 11:48	70.993	146.407	beluga	rest	1	0	2
3	7/22/2019 11:48	70.988	146.423	beluga	rest	1	0	2
3	7/22/2019 11:48	70.984	146.409	beluga	rest	1	0	2
3	7/22/2019 11:49	70.978	146.402	beluga	rest	1	0	2
3	7/22/2019 11:49	70.951	146.446	beluga	rest	1	0	2
3	7/22/2019 11:50	70.946	146.423	bowhead whale	rest	2	1	2
3	7/22/2019 12:08	70.956	146.414	beluga	swim	2	1	2
3	7/22/2019 12:12	70.849	146.350	bowhead whale	rest	2	1	2
3	7/22/2019 12:12	70.847	146.324	bowhead whale	swim	1	0	2
3	7/22/2019 12:50	70.724	146.913	beluga	swim	2	0	2
3	7/22/2019 12:51	70.728	146.909	beluga	swim	5	0	2
3	7/22/2019 12:53	70.808	146.916	bowhead whale	swim	2	1	2
3	7/22/2019 13:00	70.895	146.864	beluga	rest	1	0	2
3	7/22/2019 13:00	70.903	146.886	beluga	rest	6	0	2
3	7/22/2019 13:00	70.909	146.936	beluga	dive	1	0	2
3	7/22/2019 13:00	70.912	146.879	beluga	rest	1	0	2
3	7/22/2019 13:02	70.965	146.899	beluga	rest	2	1	2
3	7/22/2019 13:02	70.971	146.929	beluga	rest	1	0	2
3	7/22/2019 13:02	70.977	146.926	beluga	swim	1	0	2
3	7/22/2019 13:03	71.000	146.902	beluga	rest	1	0	2
3	7/22/2019 13:03	71.008	146.927	beluga	swim	4	1	2
3	7/22/2019 13:03	71.013	146.894	beluga	swim	2	1	2
3	7/22/2019 13:04	71.039	146.897	beluga	rest	13	2	2
3	7/22/2019 13:04	71.043	146.911	beluga	rest	1	0	2
3	7/22/2019 13:05	71.058	146.922	beluga	swim	2	1	2
3	7/22/2019 13:05	71.063	146.905	beluga	rest	3	1	2
3	7/22/2019 13:05	71.068	146.907	beluga	swim	2	1	2
3	7/22/2019 13:05	71.073	146.900	beluga	swim	12	3	2
3	7/22/2019 13:05	71.081	146.904	beluga	swim	5	2	2
3	7/22/2019 13:10	71.250	146.918	beluga	rest	3	0	2
3	7/22/2019 13:11	71.273	146.925	beluga	swim	2	1	2
3	7/22/2019 13:12	71.294	146.900	beluga	swim	1	0	2
3	7/22/2019 13:12	71.313	146.835	bowhead whale	swim	1	0	2
3	7/22/2019 13:16	71.353	146.952	bowhead whale	swim	1	0	10
3	7/22/2019 13:17	71.316	147.125	beluga	rest	1	0	2
3	7/22/2019 13:17	71.368	147.158	beluga	swim	7	2	10
3	7/22/2019 13:19	71.340	147.389	beluga	swim	2	0	10

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
3	7/22/2019 13:21	71.281	147.406	beluga	swim	2	0	2
3	7/22/2019 13:24	71.168	147.414	beluga	swim	2	1	2
3	7/22/2019 13:24	71.156	147.413	beluga	rest	2	1	2
3	7/22/2019 13:24	71.151	147.422	beluga	rest	1	1	2
3	7/22/2019 13:26	71.107	147.402	beluga	rest	2	1	2
3	7/22/2019 13:26	71.102	147.404	beluga	mill	3	0	2
3	7/22/2019 13:26	71.097	147.430	beluga	rest	1	0	2
3	7/22/2019 13:26	71.090	147.397	beluga	swim	2	1	2
3	7/22/2019 13:27	71.063	147.422	beluga	rest	1	0	2
3	7/22/2019 13:28	71.033	147.397	beluga	rest	1	1	2
3	7/22/2019 13:28	71.028	147.386	beluga	rest	1	0	2
3	7/22/2019 13:28	71.022	147.463	beluga	rest	1	0	2
3	7/22/2019 13:29	71.016	147.385	beluga	rest	6	1	2
3	7/22/2019 13:29	71.010	147.428	beluga	rest	1	0	2
3	7/22/2019 13:29	71.005	147.400	beluga	rest	2	1	2
3	7/22/2019 13:29	71.002	147.435	beluga	rest	1	0	2
3	7/22/2019 13:30	70.955	147.426	beluga	swim	11	0	2

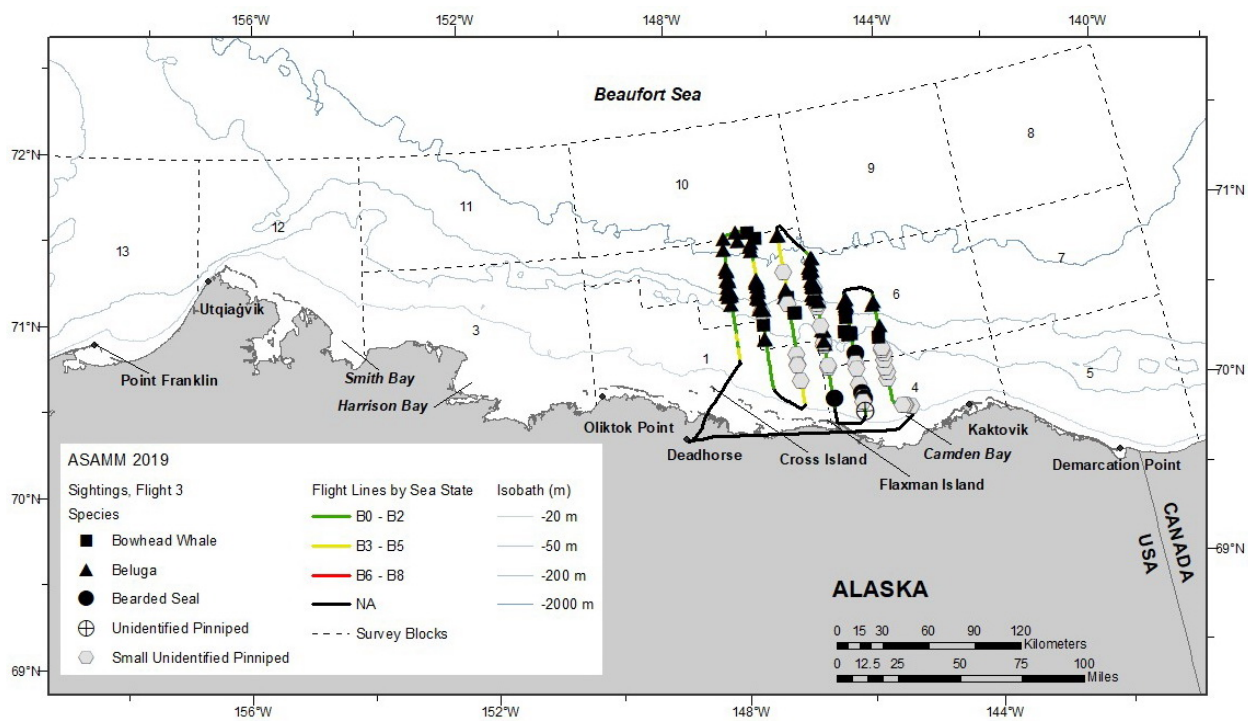


Figure B-15. Flight 3 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Bowhead whale cow-calf pair subsurface in the central Alaskan Beaufort Sea, Flight 3, 22 July 2019.

23 July 2019, Flight 213

Flight was a partial survey of transects 12 and 14, and the coastal transect from Icy Cape to Point Barrow. Survey conditions included partly cloudy to overcast skies, 0-10 km visibility, with haze and low ceilings, and Beaufort 2-5 sea states. There was no sea ice in the area surveyed. Sightings included one bowhead whale carcass, one humpback whale, one unidentified pinniped, and small unidentified pinnipeds. The bowhead whale carcass was originally sighted in 2018 on flight 214 on 30 July, flight 218 on 8 August, and flight 222 on 19 August, and resighted in 2019 during flight 201 on 2 July and flight 256 on 10 October. A haulout of approximately 250 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
213	7/23/2019 10:21	70.733	162.526	humpback whale	swim	1	0	17
213	7/23/2019 13:17	70.827	158.189	bowhead whale	dead	1	0	13

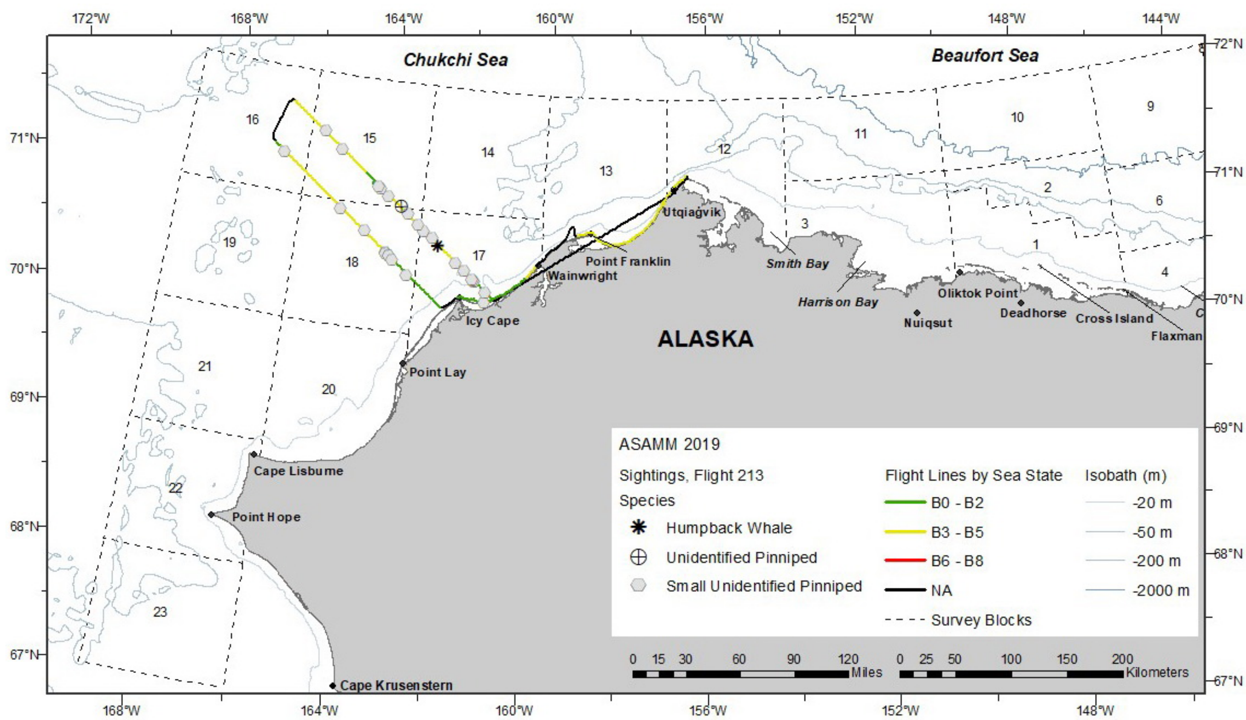


Figure B-16. Flight 213 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Humpback whale sighted swimming approximately 90 km west of Wainwright, Alaska, Flight 213, 23 July 2019.

This page intentionally left blank.

25 July 2019, Flight 4

Flight was the coastal transect from east of Smith Bay to Kaktovik. Survey conditions included clear, partly cloudy, and overcast skies, 0-5 km visibility, with glare, haze (smoke from fires), and low ceilings, and Beaufort 1-6 sea states. Sea ice was 0-35% broken floe in the area surveyed. Sightings included polar bears.

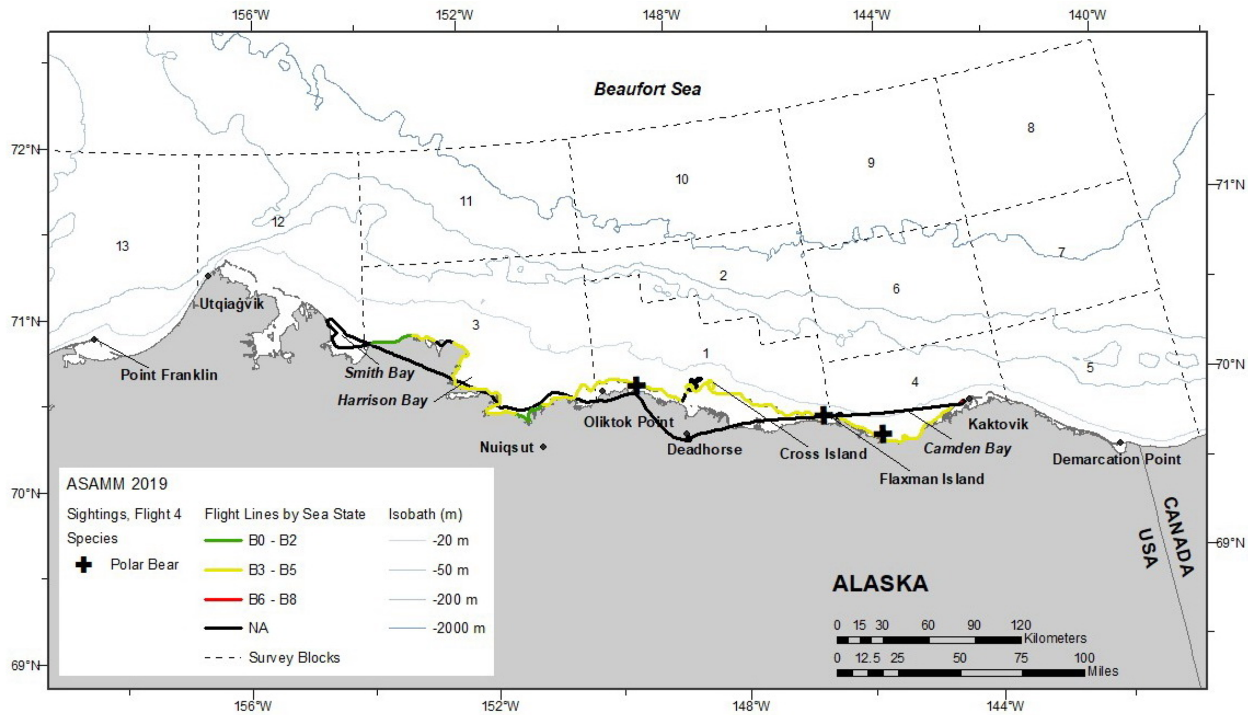


Figure B-17. Flight 4 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

27 July 2019, Flight 214

Flight was a complete survey of transect 18 and partial survey of transect 16. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare, haze, and low ceilings, and Beaufort 3-4 sea states. There was no sea ice in the area surveyed. Sightings included one gray whale carcass, humpback whales, fin whales, 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
214	7/27/2019 15:29	70.423	166.254	humpback whale	feed	2	0	19
214	7/27/2019 15:31	70.425	166.277	humpback whale	dive	1	0	19
214	7/27/2019 15:51	70.715	167.533	fin whale	swim	2	0	19
214	7/27/2019 15:57	70.715	167.502	humpback whale	swim	2	0	19
214	7/27/2019 16:37	71.108	167.553	gray whale	dead	1	0	16

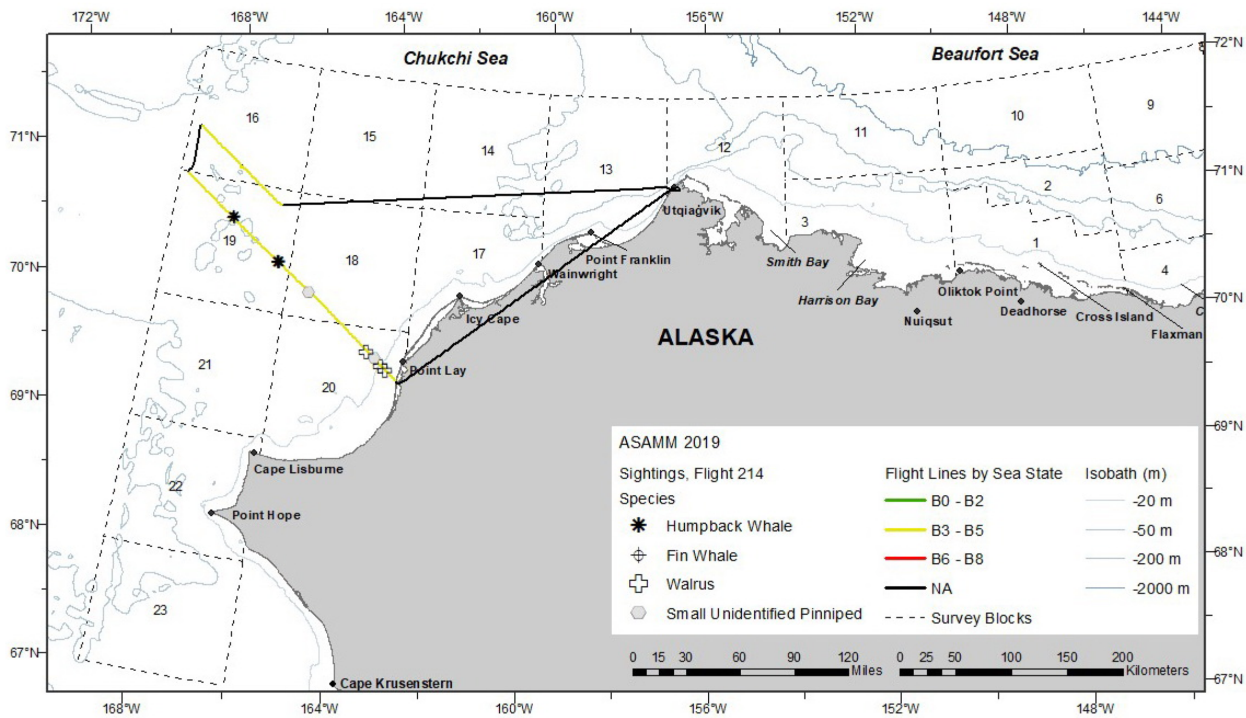


Figure B-18. Flight 214 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

One of two fin whales sighted swimming approximately 275 km west of Wainwright, Flight 214, 27 July 2019. These are the farthest north visually detected fin whales in the Pacific Arctic.

This page intentionally left blank.

27 July 2019, Flight 5

Flight was a partial survey of transects 133 and 134. Survey conditions included overcast skies, 0 to 5 km visibility, with low ceilings and precipitation, and Beaufort 2-3 sea states. There was no sea ice in the area surveyed. There were no marine mammal sightings.

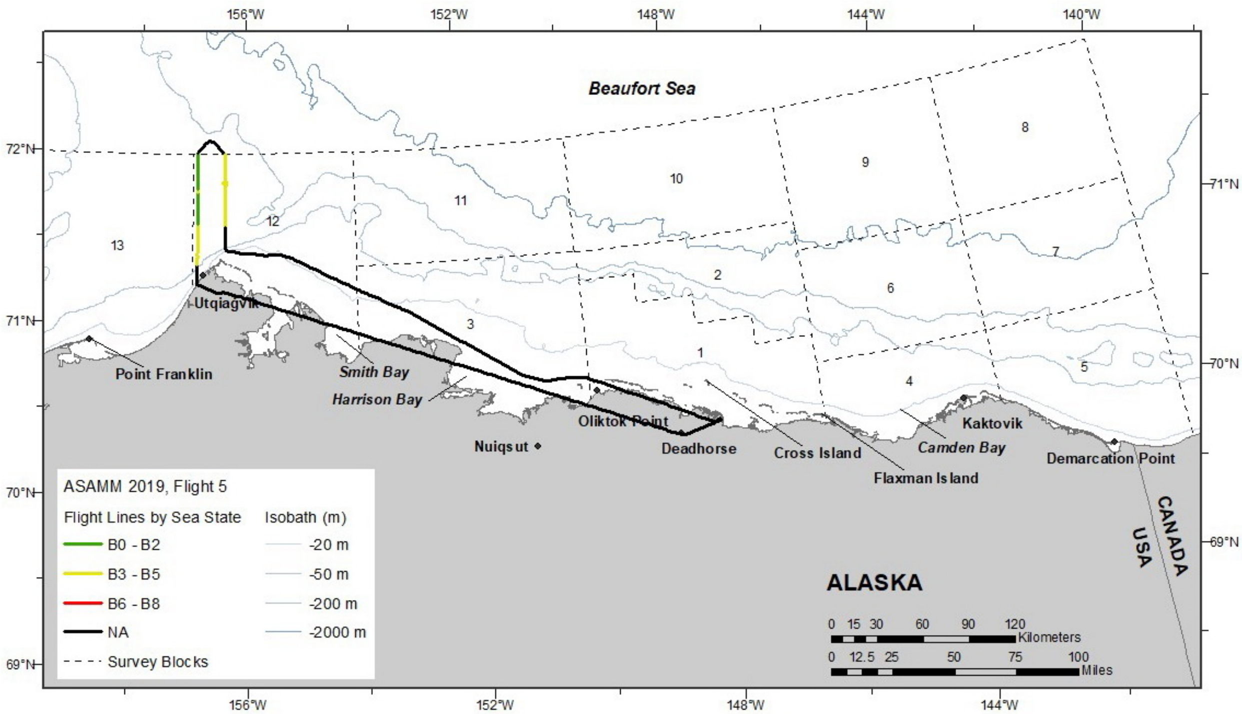


Figure B-19. Flight 5 survey track, depicted by sea state.

30 July 2019, Flight 6

Flight was a complete survey of transects 101, 102, 103, 104, 105, and 106. Survey conditions included partly cloudy skies, unlimited visibility, with glare, and Beaufort 1-4 sea states. Sea ice was 0-1% broken floe in the area surveyed. Sightings included bowhead whales, belugas (including 41 calves), small unidentified cetaceans, bearded seals, 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
6	7/30/2019 10:40	70.329	140.402	beluga	rest	1	0	5
6	7/30/2019 10:40	70.336	140.421	beluga	swim	3	1	5
6	7/30/2019 10:40	70.341	140.440	beluga	rest	1	0	5
6	7/30/2019 10:41	70.364	140.421	beluga	swim	1	0	5
6	7/30/2019 10:46	70.515	140.477	beluga	swim	19	0	7
6	7/30/2019 10:54	70.709	140.377	beluga	rest	1	0	7
6	7/30/2019 10:54	70.728	140.420	beluga	swim	1	0	7
6	7/30/2019 10:54	70.740	140.443	beluga	swim	1	0	7
6	7/30/2019 10:55	70.744	140.414	beluga	rest	1	0	7
6	7/30/2019 10:55	70.766	140.405	beluga	swim	1	0	7
6	7/30/2019 10:55	70.773	140.388	beluga	swim	1	0	7
6	7/30/2019 10:56	70.777	140.430	beluga	swim	1	0	7
6	7/30/2019 11:01	70.957	140.392	beluga	dive	2	1	7
6	7/30/2019 11:03	71.006	140.393	beluga	swim	2	1	7
6	7/30/2019 11:03	71.018	140.408	beluga	swim	4	0	7
6	7/30/2019 11:03	71.022	140.408	beluga	swim	2	0	7
6	7/30/2019 11:09	71.180	140.548	beluga	swim	1	1	8
6	7/30/2019 11:09	71.179	140.551	beluga	swim	1	0	8
6	7/30/2019 11:12	71.180	140.766	beluga	swim	1	0	8
6	7/30/2019 11:18	71.016	140.906	beluga	rest	1	0	7
6	7/30/2019 11:24	70.826	140.885	beluga	swim	1	0	7
6	7/30/2019 11:31	70.672	140.932	beluga	swim	1	0	7
6	7/30/2019 11:31	70.669	140.934	beluga	swim	1	0	7
6	7/30/2019 11:37	70.509	140.919	beluga	swim	5	2	7
6	7/30/2019 11:37	70.507	140.921	beluga	swim	4	0	7
6	7/30/2019 11:42	70.336	140.955	beluga	swim	2	0	5
6	7/30/2019 11:47	70.196	140.880	beluga	swim	1	0	5
6	7/30/2019 11:52	70.026	140.916	beluga	swim	1	0	5
6	7/30/2019 11:52	70.025	140.891	beluga	rest	1	0	5
6	7/30/2019 12:04	69.638	140.912	beluga	swim	1	0	5
6	7/30/2019 15:04	70.147	141.367	beluga	swim	3	1	5
6	7/30/2019 15:04	70.147	141.345	beluga	swim	2	0	5
6	7/30/2019 15:05	70.170	141.391	beluga	swim	4	1	5
6	7/30/2019 15:05	70.179	141.411	beluga	swim	1	0	5
6	7/30/2019 15:05	70.179	141.401	beluga	swim	24	3	5
6	7/30/2019 15:05	70.185	141.424	beluga	swim	4	0	5

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
6	7/30/2019 15:05	70.185	141.405	beluga	swim	3	0	5
6	7/30/2019 15:06	70.201	141.434	beluga	swim	12	0	5
6	7/30/2019 15:11	70.381	141.388	beluga	swim	2	1	5
6	7/30/2019 15:12	70.383	141.387	beluga	swim	2	1	5
6	7/30/2019 15:12	70.401	141.383	beluga	swim	1	0	5
6	7/30/2019 15:12	70.410	141.431	beluga	swim	1	0	5
6	7/30/2019 15:13	70.416	141.432	beluga	swim	1	0	5
6	7/30/2019 15:14	70.476	141.414	beluga	dive	1	0	5
6	7/30/2019 15:19	70.633	141.392	beluga	swim	1	0	7
6	7/30/2019 15:20	70.645	141.428	beluga	swim	3	1	7
6	7/30/2019 15:23	70.771	141.472	small unid cetacean	swim	2	0	7
6	7/30/2019 15:26	70.858	141.421	beluga	swim	1	0	7
6	7/30/2019 15:30	70.986	141.435	beluga	swim	1	0	7
6	7/30/2019 15:44	71.076	141.862	beluga	swim	1	0	7
6	7/30/2019 15:44	71.069	141.896	beluga	swim	1	0	7
6	7/30/2019 15:44	71.065	141.909	beluga	swim	1	0	7
6	7/30/2019 15:50	70.868	141.904	beluga	swim	2	1	7
6	7/30/2019 15:52	70.804	141.893	beluga	swim	3	1	7
6	7/30/2019 15:53	70.777	141.880	beluga	swim	1	0	7
6	7/30/2019 15:53	70.770	141.906	beluga	swim	1	0	7
6	7/30/2019 15:54	70.761	141.896	beluga	swim	2	1	7
6	7/30/2019 15:54	70.757	141.877	beluga	rest	1	0	7
6	7/30/2019 15:54	70.751	141.927	beluga	swim	2	1	7
6	7/30/2019 15:54	70.743	141.931	beluga	swim	1	0	7
6	7/30/2019 15:54	70.738	141.850	beluga	mill	6	0	7
6	7/30/2019 15:55	70.731	141.917	beluga	swim	1	0	7
6	7/30/2019 15:55	70.724	141.877	beluga	swim	5	2	7
6	7/30/2019 15:55	70.709	141.877	beluga	swim	1	0	7
6	7/30/2019 15:55	70.706	141.888	beluga	swim	5	0	7
6	7/30/2019 15:55	70.702	141.908	beluga	swim	1	0	7
6	7/30/2019 15:56	70.699	141.901	beluga	rest	1	0	7
6	7/30/2019 15:56	70.695	141.911	beluga	swim	7	0	7
6	7/30/2019 15:56	70.692	141.922	beluga	swim	8	4	7
6	7/30/2019 15:56	70.681	141.922	beluga	swim	1	0	7
6	7/30/2019 15:56	70.677	141.881	beluga	swim	1	0	7
6	7/30/2019 15:56	70.670	141.917	beluga	swim	4	1	7
6	7/30/2019 15:57	70.650	141.884	beluga	swim	2	0	7
6	7/30/2019 15:57	70.644	141.931	beluga	swim	1	0	7
6	7/30/2019 15:58	70.634	141.877	beluga	rest	1	0	7
6	7/30/2019 16:00	70.559	141.946	beluga	swim	1	0	7
6	7/30/2019 16:00	70.553	141.904	beluga	mill	2	1	7
6	7/30/2019 16:00	70.547	141.911	beluga	swim	1	0	7
6	7/30/2019 16:00	70.544	141.896	beluga	swim	9	0	7
6	7/30/2019 16:01	70.539	141.922	beluga	swim	3	0	7
6	7/30/2019 16:01	70.533	141.915	beluga	swim	2	1	7

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
6	7/30/2019 16:01	70.526	141.906	beluga	swim	2	0	7
6	7/30/2019 16:01	70.520	141.925	beluga	swim	1	0	7
6	7/30/2019 16:01	70.515	141.877	beluga	swim	2	0	7
6	7/30/2019 16:02	70.504	141.918	beluga	swim	1	0	7
6	7/30/2019 16:07	70.336	141.927	beluga	swim	1	0	5
6	7/30/2019 16:09	70.268	141.898	beluga	swim	1	0	5
6	7/30/2019 16:10	70.222	141.906	beluga	swim	3	0	5
6	7/30/2019 16:11	70.213	141.890	beluga	swim	1	0	5
6	7/30/2019 16:11	70.201	141.926	beluga	swim	2	0	5
6	7/30/2019 16:11	70.196	141.915	beluga	swim	3	1	5
6	7/30/2019 16:12	70.155	141.898	beluga	swim	1	0	5
6	7/30/2019 16:13	70.148	141.915	beluga	swim	19	4	5
6	7/30/2019 16:32	70.053	142.406	beluga	swim	1	0	5
6	7/30/2019 16:34	70.105	142.398	beluga	swim	2	0	5
6	7/30/2019 16:34	70.115	142.388	beluga	swim	2	1	5
6	7/30/2019 16:34	70.124	142.390	beluga	swim	3	1	5
6	7/30/2019 16:35	70.129	142.421	beluga	swim	6	2	5
6	7/30/2019 16:35	70.130	142.410	beluga	swim	2	0	5
6	7/30/2019 16:35	70.137	142.378	beluga	swim	2	0	5
6	7/30/2019 16:41	70.350	142.412	beluga	swim	1	0	5
6	7/30/2019 16:41	70.351	142.405	beluga	swim	2	1	5
6	7/30/2019 16:47	70.549	142.412	beluga	swim	2	1	7
6	7/30/2019 16:57	70.876	142.399	beluga	swim	1	0	7
6	7/30/2019 17:00	70.972	142.452	beluga	swim	2	0	7
6	7/30/2019 17:00	70.979	142.380	beluga	swim	4	1	7
6	7/30/2019 17:00	70.981	142.403	beluga	swim	2	0	7
6	7/30/2019 17:01	71.008	142.396	beluga	swim	2	1	7
6	7/30/2019 17:05	71.155	142.421	beluga	swim	2	1	7
6	7/30/2019 17:06	71.178	142.470	beluga	swim	1	0	8
6	7/30/2019 17:07	71.185	142.542	beluga	swim	1	0	8
6	7/30/2019 17:08	71.193	142.624	beluga	swim	2	0	8
6	7/30/2019 17:32	70.489	142.959	bowhead whale	swim	1	0	5
6	7/30/2019 17:37	70.393	142.888	bowhead whale	mill	2	0	5
6	7/30/2019 17:42	70.316	142.918	bowhead whale	swim	1	0	5
6	7/30/2019 17:42	70.314	142.898	bowhead whale	swim	1	0	5
6	7/30/2019 17:42	70.314	142.899	bowhead whale	swim	1	0	5
6	7/30/2019 17:42	70.289	142.920	bowhead whale	mill	2	0	5
6	7/30/2019 17:43	70.269	142.866	beluga	mill	2	0	5

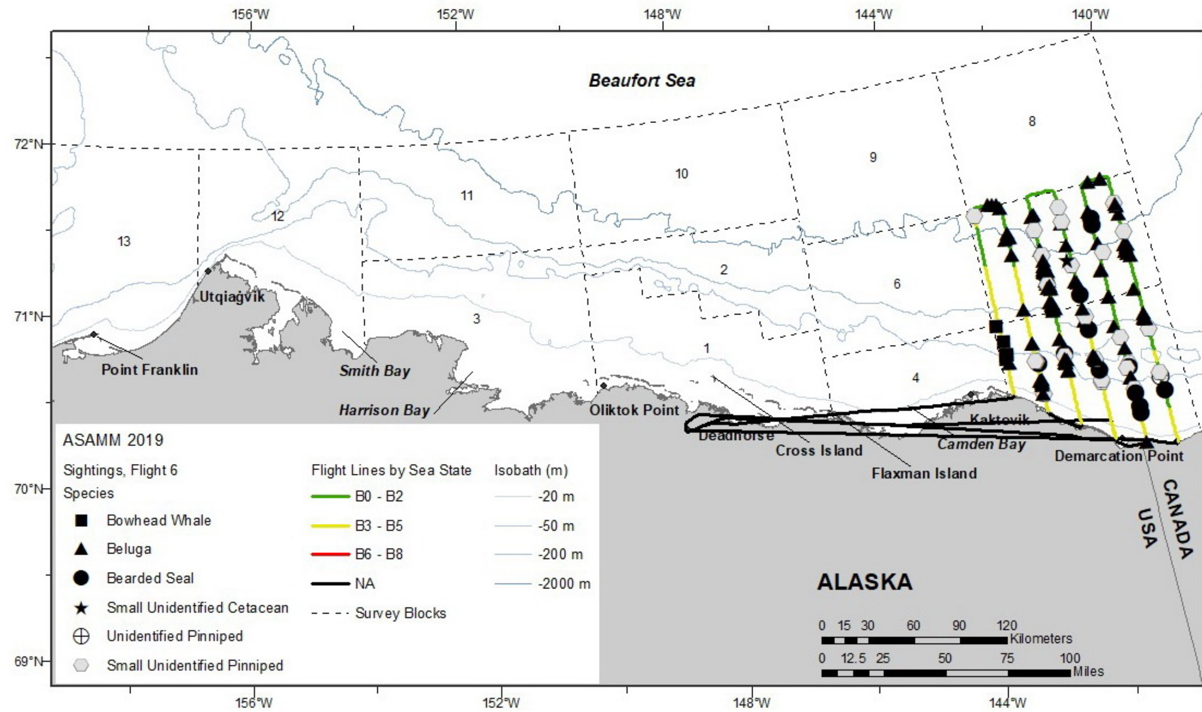


Figure B-20. Flight 6 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

31 July 2019, Flight 7

Flight was a complete survey of transects 107, 108, 109, 110, 111, 112, 113, 114, 115, and 116. Survey conditions included partly cloudy to overcast skies, 1 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 1-4 sea states. Sea ice was 0-1% broken floe in the area surveyed. Sightings included belugas (including four calves), one unidentified cetacean, bearded seals, 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
7	7/31/2019 10:29	70.625	144.394	beluga	rest	1	0	6
7	7/31/2019 10:58	70.276	143.924	beluga	swim	1	0	4
7	7/31/2019 11:32	71.088	143.353	unid cetacean	dive	1	0	6
7	7/31/2019 11:50	70.719	143.408	beluga	rest	1	0	6
7	7/31/2019 11:50	70.717	143.410	beluga	rest	1	0	6
7	7/31/2019 11:50	70.713	143.437	beluga	rest	1	0	6
7	7/31/2019 11:50	70.713	143.378	beluga	rest	1	0	6
7	7/31/2019 11:50	70.705	143.431	beluga	rest	2	0	6
7	7/31/2019 11:51	70.691	143.469	beluga	rest	1	0	6
7	7/31/2019 12:07	70.211	143.397	beluga	swim	2	0	4
7	7/31/2019 12:08	70.174	143.395	beluga	swim	1	0	4
7	7/31/2019 14:43	70.859	145.399	beluga	rest	1	0	6
7	7/31/2019 15:12	70.722	145.983	beluga	swim	22	2	6
7	7/31/2019 16:32	70.886	146.870	beluga	swim	1	0	2
7	7/31/2019 16:51	70.270	146.901	beluga	rest	1	0	1
7	7/31/2019 17:21	70.936	147.403	beluga	rest	1	0	2
7	7/31/2019 17:23	71.018	147.380	beluga	swim	2	1	2
7	7/31/2019 17:24	71.035	147.428	beluga	swim	3	1	2
7	7/31/2019 17:25	71.100	147.400	beluga	swim	2	0	2
7	7/31/2019 17:40	71.251	147.933	beluga	swim	1	0	2
7	7/31/2019 17:40	71.250	147.923	beluga	swim	1	0	2
7	7/31/2019 17:40	71.230	147.883	beluga	swim	1	0	2
7	7/31/2019 17:41	71.223	147.908	beluga	swim	1	0	2
7	7/31/2019 17:58	70.660	147.879	beluga	swim	2	0	1

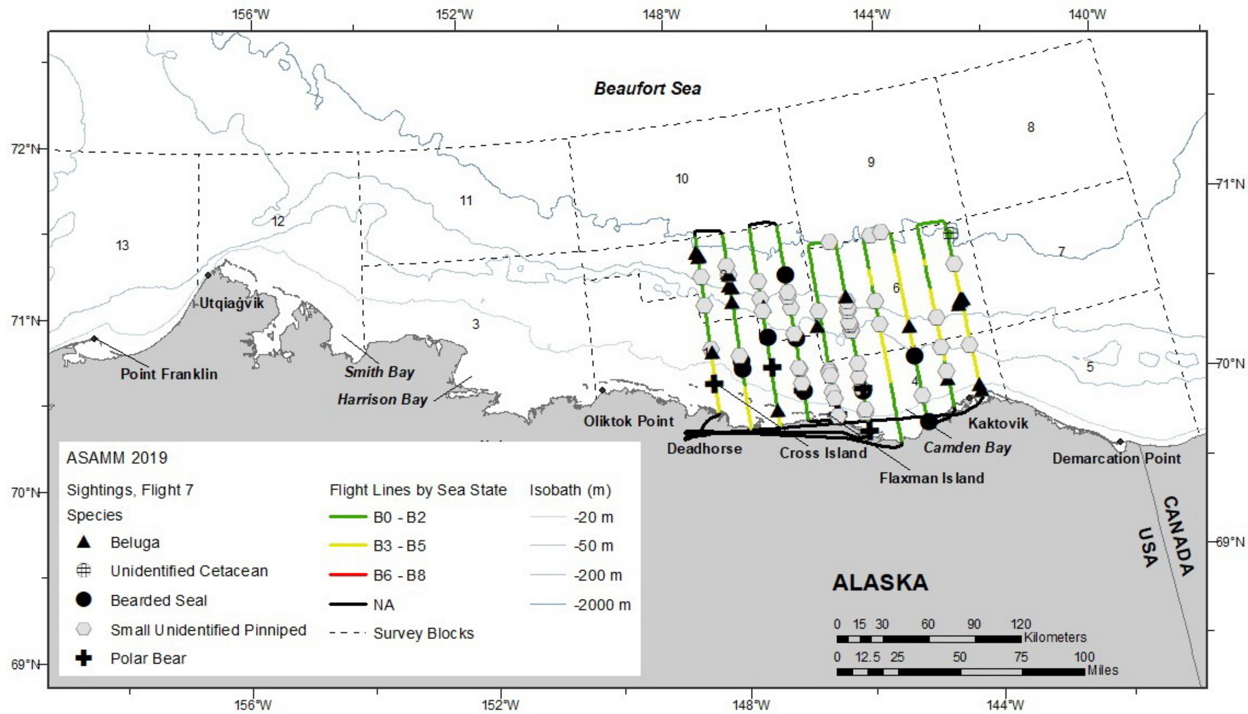


Figure B-21. Flight 7 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

2 August 2019, Flight 215

Flight was a search survey dedicated to photographing gray whales to assess body condition. Survey conditions included partly cloudy skies, 5-10 km visibility, with glare, and Beaufort 3-4 sea states. There was no sea ice in the area surveyed. Sightings included gray whales, 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
215	8/2/2019 14:58	71.067	159.595	beluga	rest	1	0	13
215	8/2/2019 14:59	71.064	159.784	beluga	swim	1	0	13
215	8/2/2019 15:13	70.924	161.126	gray whale	feed	1	0	17
215	8/2/2019 15:22	70.917	161.141	gray whale	feed	1	0	17
215	8/2/2019 15:26	70.931	161.190	gray whale	feed	6	0	17
215	8/2/2019 15:27	70.935	161.179	gray whale	feed	1	0	17
215	8/2/2019 15:35	70.965	161.198	gray whale	feed	1	0	17
215	8/2/2019 15:38	70.981	161.256	gray whale	feed	6	0	17
215	8/2/2019 15:45	70.996	161.273	gray whale	feed	3	0	17
215	8/2/2019 15:49	71.002	161.247	gray whale	feed	1	0	14
215	8/2/2019 15:51	71.006	161.178	gray whale	feed	1	0	14
215	8/2/2019 15:54	71.002	161.180	gray whale	feed	2	0	14
215	8/2/2019 16:00	71.027	161.210	gray whale	feed	3	0	14
215	8/2/2019 16:09	71.043	161.072	gray whale	feed	2	0	14
215	8/2/2019 16:11	71.038	161.082	gray whale	feed	2	0	14
215	8/2/2019 16:14	71.052	161.079	gray whale	feed	1	0	14
215	8/2/2019 16:15	71.044	161.077	gray whale	feed	2	0	14
215	8/2/2019 16:21	71.007	161.029	gray whale	feed	6	0	14

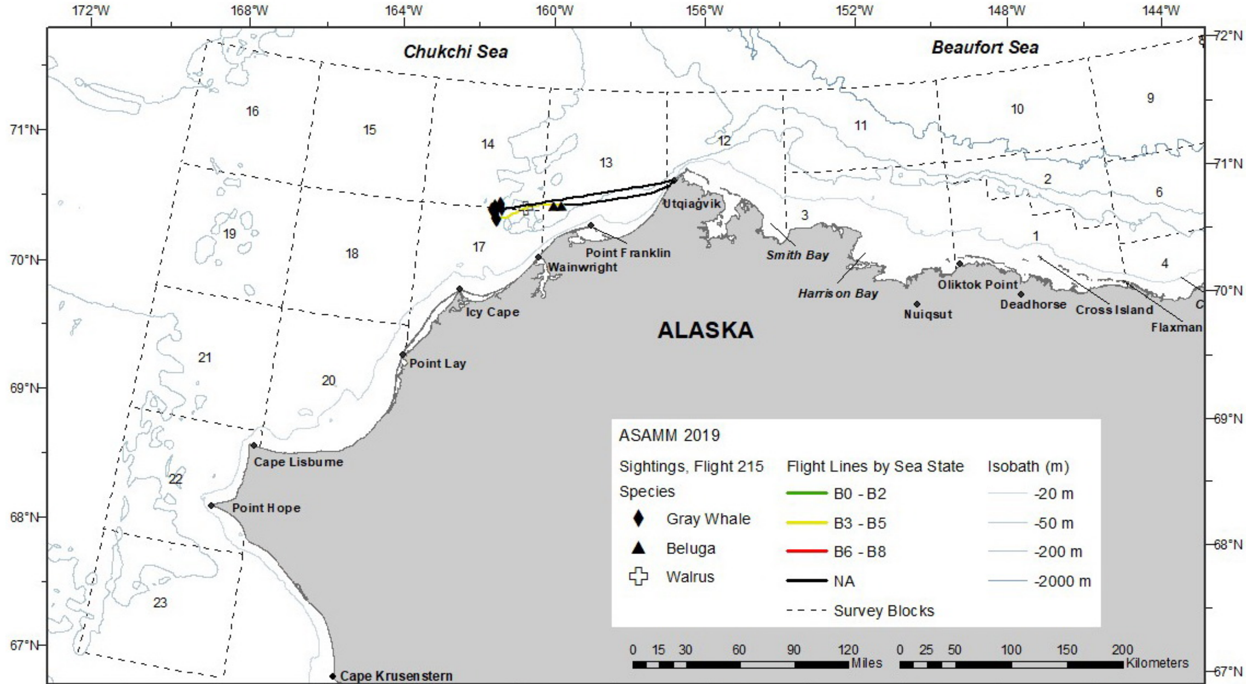


Figure B-22. Flight 215 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

This page intentionally left blank.

2 August 2019, Flight 8

Flight was the coastal transect from east of Smith Bay to Oliktok Point and search survey inside the barrier islands in block 1. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare and low ceilings, and Beaufort 2-3 sea states. There was no sea ice in the area surveyed. Sightings included one small unidentified pinniped and polar bears.

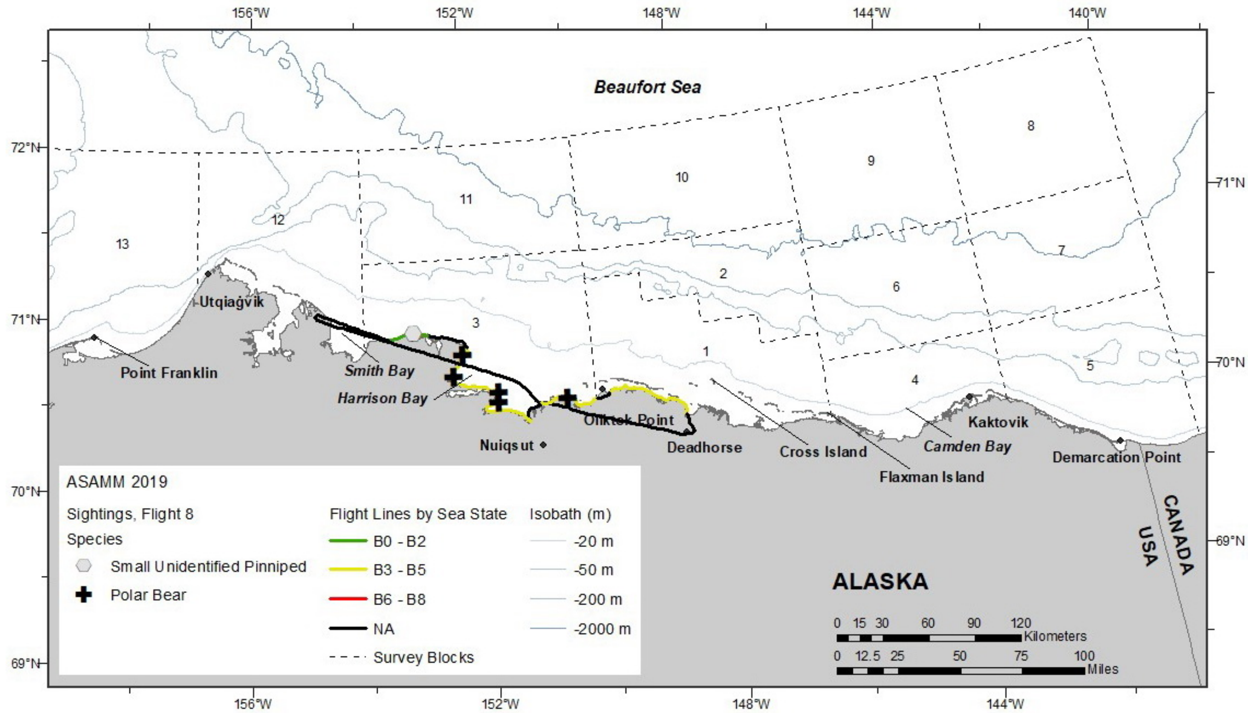


Figure B-23. Flight 8 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

4 August 2019, Flight 9

Flight was a search survey dedicated to photographing gray whales to assess body condition. Survey conditions included partly cloudy skies, 1-10 km of visibility, with glare, low ceilings, and precipitation, and Beaufort 2-4 sea states. There was no sea ice in the area surveyed. Sightings included gray 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
9	8/4/2019 15:54	70.905	161.274	gray whale	feed	1	0	17
9	8/4/2019 15:58	70.927	161.231	gray whale	feed	2	0	17
9	8/4/2019 16:02	70.915	161.382	gray whale	feed	2	0	17
9	8/4/2019 16:04	70.920	161.411	gray whale	feed	1	0	17
9	8/4/2019 16:07	70.929	161.505	gray whale	rest	2	0	17
9	8/4/2019 16:21	70.797	161.474	gray whale	feed	1	0	17
9	8/4/2019 16:25	70.757	161.214	gray whale	feed	1	0	17
9	8/4/2019 16:27	70.748	161.187	gray whale	dive	1	0	17
9	8/4/2019 16:29	70.763	161.218	gray whale	feed	1	0	17
9	8/4/2019 16:29	70.762	161.236	gray whale	feed	1	0	17
9	8/4/2019 16:33	70.741	161.124	gray whale	dive	1	0	17
9	8/4/2019 16:33	70.744	161.130	gray whale	feed	1	0	17
9	8/4/2019 16:36	70.743	161.098	gray whale	feed	1	0	17
9	8/4/2019 16:37	70.746	161.110	gray whale	feed	1	0	17
9	8/4/2019 16:40	70.747	161.089	gray whale	feed	6	0	17
9	8/4/2019 16:44	70.755	161.089	gray whale	feed	1	0	17

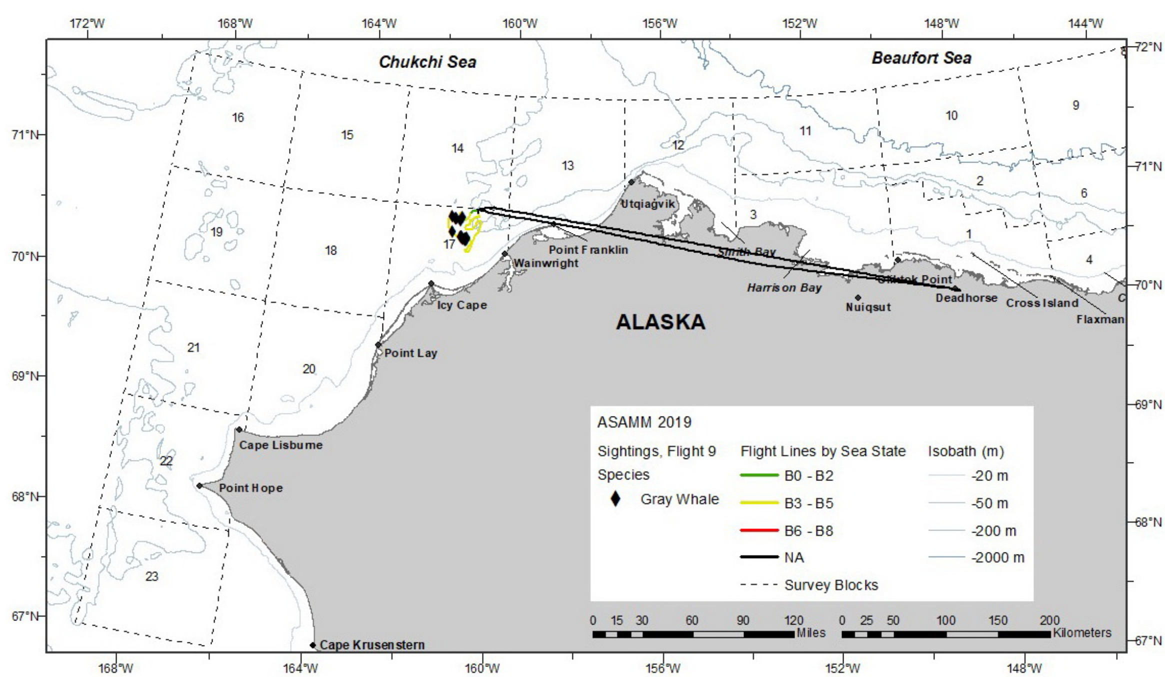


Figure B-24. Flight 9 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

5 August 2019, Flight 10

Flight was a complete survey of transects BCB117, BCB118, and BCB119, and partial survey of transects BCB120, BCB121, BCB122, and BCB123. Survey conditions included clear, partly cloudy, and overcast skies, 0 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 1-3 sea states. There was no sea ice in the area surveyed. Sightings included one beluga, 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
10	8/5/2019 9:24	71.094	148.414	beluga	swim	1	0	2

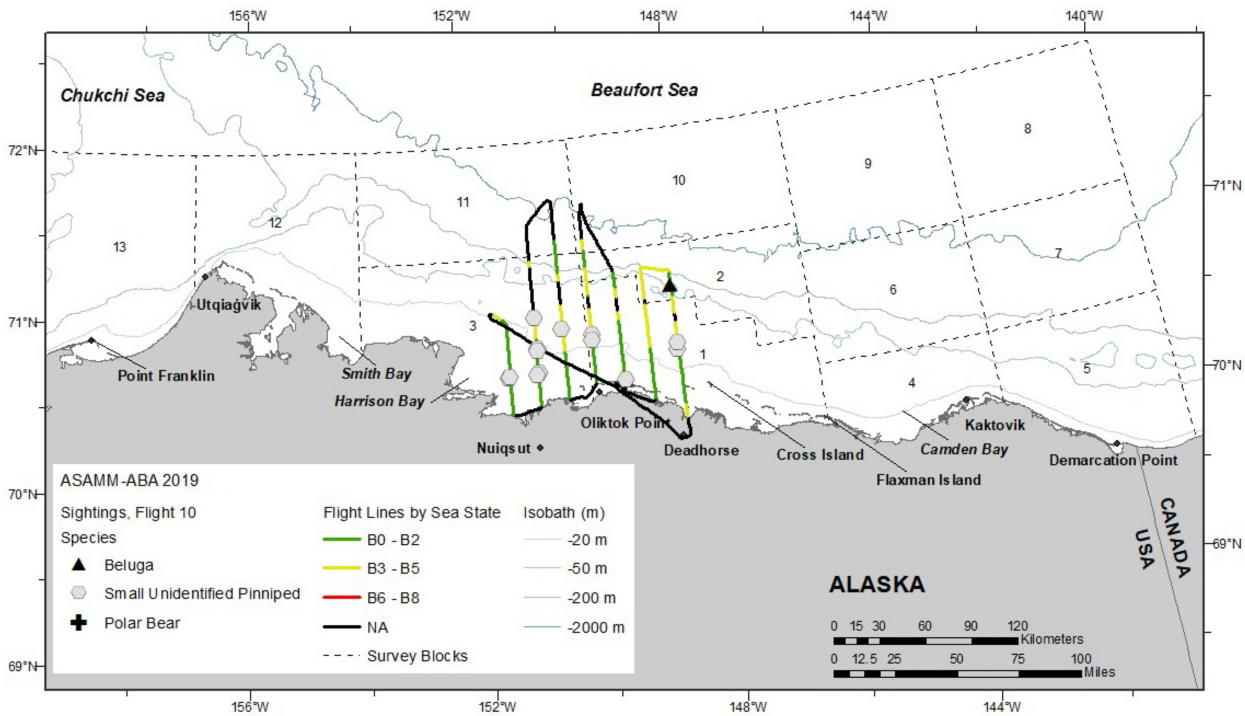


Figure B-25. Flight 10 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

6 August 2019, Flight 11

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

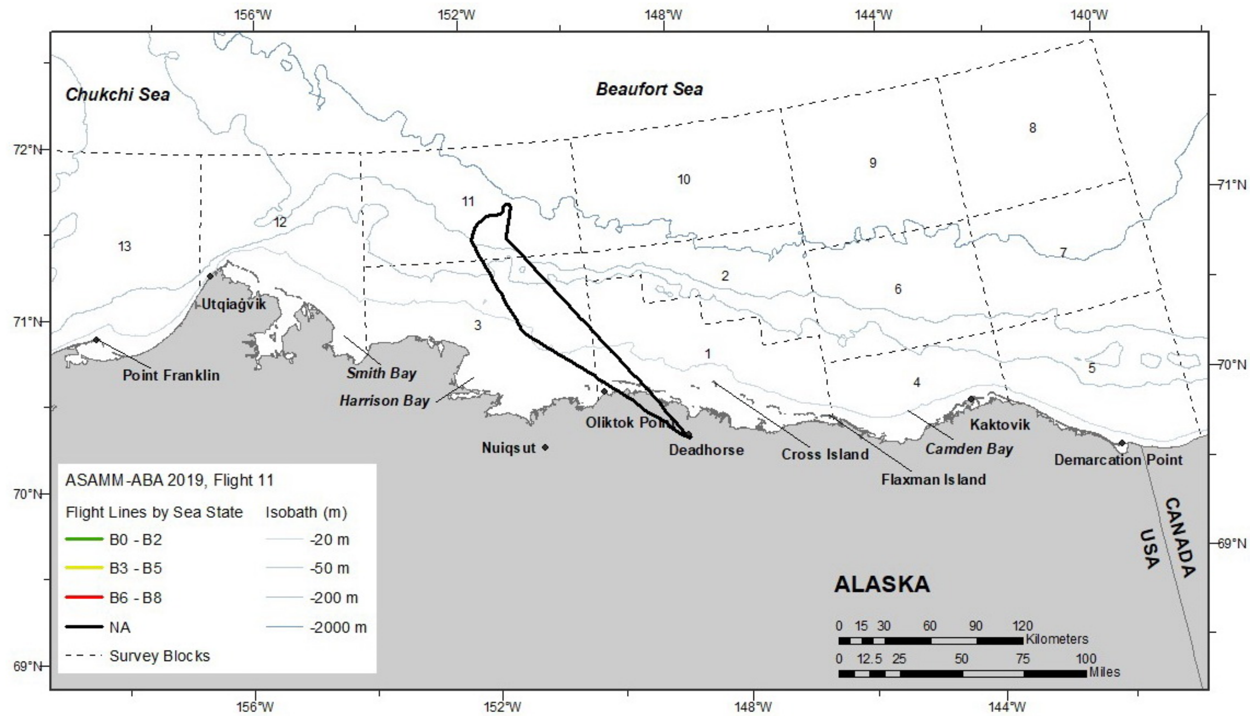


Figure B-26. Flight 11 survey track, depicted by sea state.

8 August 2019, Flight 216

Flight was a partial survey of transects BCB435, BCB436, BCB437, BCB438, and BCB439. Survey conditions included clear skies, 2 km to unlimited visibility, with glare and low ceilings, and Beaufort 3-6 sea states. There was no sea ice in the area surveyed. Sightings included belugas (including two 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
216	8/8/2019 13:50	69.355	137.907	beluga	swim	2	1	0
216	8/8/2019 14:36	69.036	136.905	beluga	swim	35	0	0
216	8/8/2019 14:37	69.079	136.861	beluga	swim	5	0	0
216	8/8/2019 14:37	69.086	136.876	beluga	swim	2	0	0
216	8/8/2019 14:38	69.091	136.898	beluga	swim	3	0	0
216	8/8/2019 14:38	69.093	136.889	beluga	swim	2	0	0
216	8/8/2019 14:38	69.100	136.903	beluga	swim	1	0	0
216	8/8/2019 14:38	69.104	136.893	beluga	swim	1	0	0
216	8/8/2019 14:42	69.232	136.912	beluga	swim	1	0	0
216	8/8/2019 14:43	69.265	136.911	beluga	swim	4	0	0
216	8/8/2019 14:43	69.272	136.899	beluga	swim	2	0	0
216	8/8/2019 14:53	69.633	136.908	beluga	swim	2	1	0
216	8/8/2019 14:54	69.664	136.880	beluga	swim	1	0	0
216	8/8/2019 15:04	69.614	136.426	beluga	swim	1	0	0

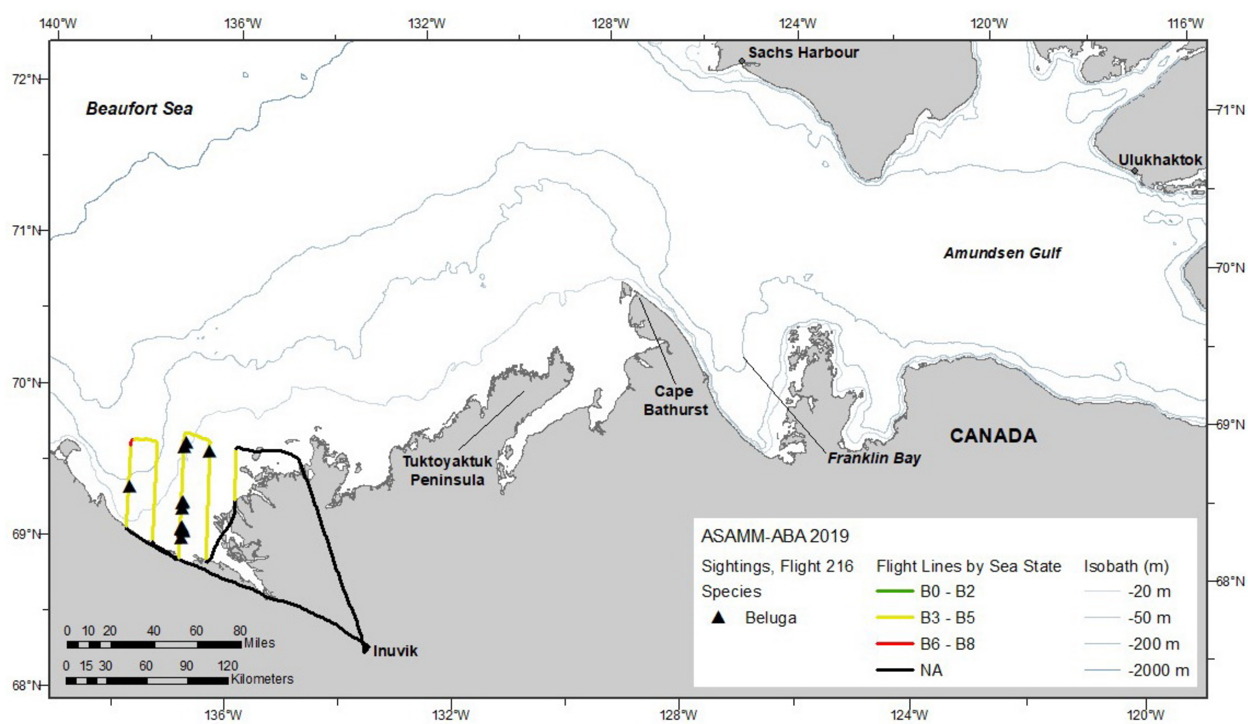


Figure B-27. Flight 216 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

8 August 2019, Flight 401

Flight was a partial survey of transects BCB402, BCB403, and BCB404. Survey conditions included partly cloudy skies, 0 km to unlimited visibility, with glare and low ceilings, and Beaufort 4-6 sea states. Sea ice was 0-20% broken floe in the area surveyed. There were no marine mammal sightings.

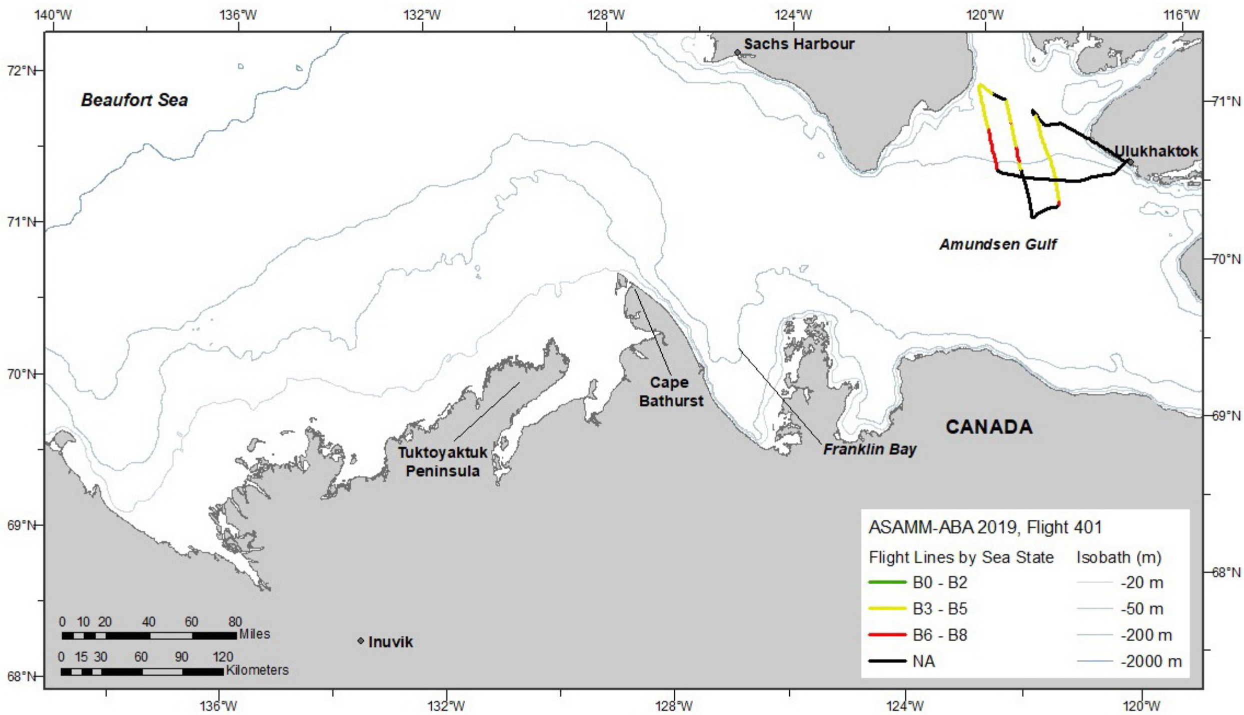


Figure B-28. Flight 401 survey track, depicted by sea state.

Ulukhaktok-based ABA survey team and Twin Otter survey aircraft just prior to their transit from Inuvik to Ulukhaktok on 6 August 2019. (L to R) Mark Vanonen, Amelia Brower, Rachel Hardee, Andre Martineau, Lisa Barry, and Chantelle Callaway.

9 August 2019, Flight 217

Flight was a deadhead flight with nominal search effort. Survey conditions included clear skies, <1 km visibility, with fog, and Beaufort 1 sea state. There was no sea ice in the area surveyed. Sightings included bowhead whales and belugas (including two 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
217	8/9/2019 14:22	70.334	123.856	bowhead whale	swim	1	0	0
217	8/9/2019 14:23	70.340	123.887	beluga	swim	2	1	0
217	8/9/2019 14:26	70.344	123.889	beluga	swim	4	1	0
217	8/9/2019 14:30	70.328	123.887	bowhead whale	swim	1	0	0
217	8/9/2019 14:33	70.338	123.887	bowhead whale	swim	1	0	0

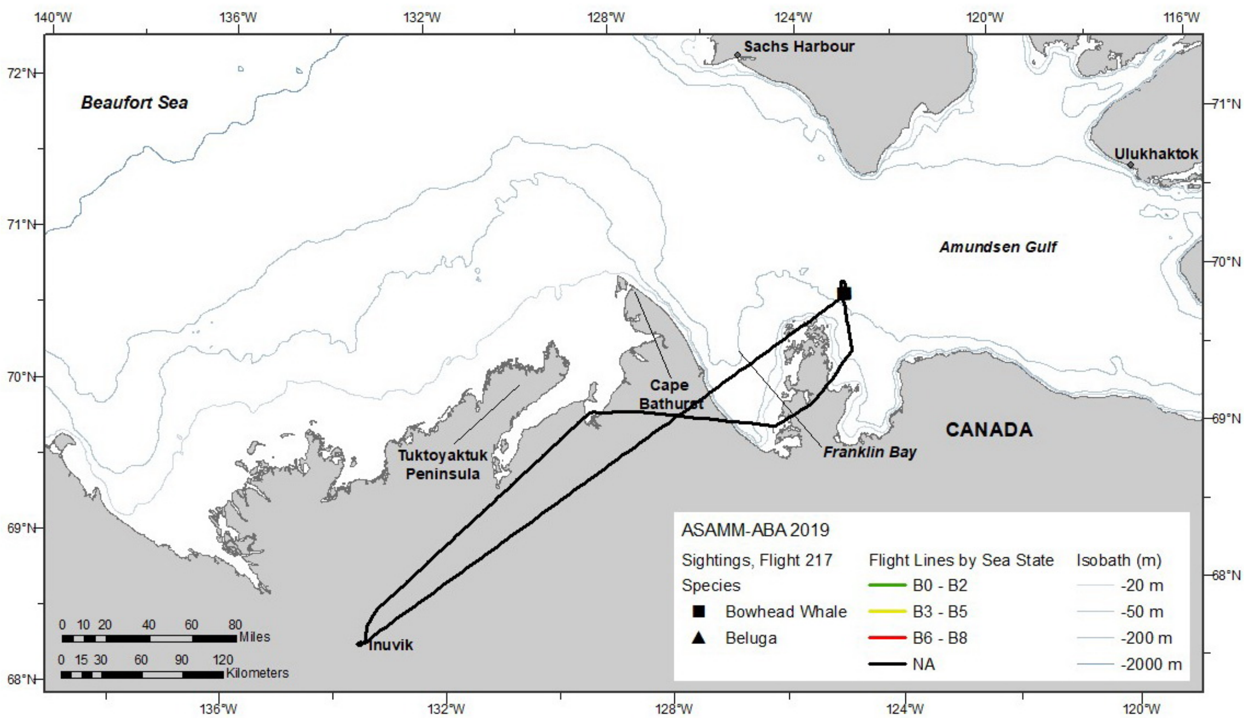


Figure B-29. Flight 217 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Widespread fog encountered on Flight 217, 9 August 2019.

This bowhead was one of three sighted through the fog north of Franklin Bay, Northwest Territories, Canada, on Flight 217, 9 August 2019.

9 August 2018, Flight 402

Flight was a partial survey of transect BCB401 and negligible effort on BCB404. Survey conditions included partly cloudy to overcast skies, 0-10 km visibility, with glare and low ceilings, and Beaufort 1-4 sea states. There was no sea ice in the area surveyed. Sightings included belugas (including four 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
402	8/9/2019 13:29	70.674	118.899	beluga	swim	1	0	0
402	8/9/2019 13:33	70.553	118.927	beluga	swim	7	0	0
402	8/9/2019 13:34	70.529	118.923	beluga	swim	1	0	0
402	8/9/2019 13:34	70.519	118.900	beluga	swim	2	1	0
402	8/9/2019 13:38	70.388	118.891	beluga	swim	1	0	0
402	8/9/2019 13:42	70.265	118.917	beluga	swim	1	0	0
402	8/9/2019 13:43	70.219	118.890	beluga	swim	1	0	0
402	8/9/2019 13:49	70.028	118.918	beluga	swim	3	1	0
402	8/9/2019 13:49	70.021	118.884	beluga	swim	1	0	0
402	8/9/2019 13:50	70.016	118.899	beluga	swim	1	0	0
402	8/9/2019 13:50	70.008	118.921	beluga	swim	1	0	0
402	8/9/2019 13:51	69.956	118.924	beluga	swim	1	0	0
402	8/9/2019 13:52	69.944	118.913	beluga	swim	2	1	0
402	8/9/2019 13:52	69.932	118.938	beluga	mill	3	0	0
402	8/9/2019 13:55	69.860	118.921	beluga	swim	1	0	0
402	8/9/2019 13:58	69.819	119.201	beluga	mill	70	0	0
402	8/9/2019 14:14	69.976	120.393	beluga	swim	3	0	0
402	8/9/2019 14:17	70.055	120.426	beluga	swim	1	0	0
402	8/9/2019 14:17	70.056	120.425	beluga	swim	2	1	0

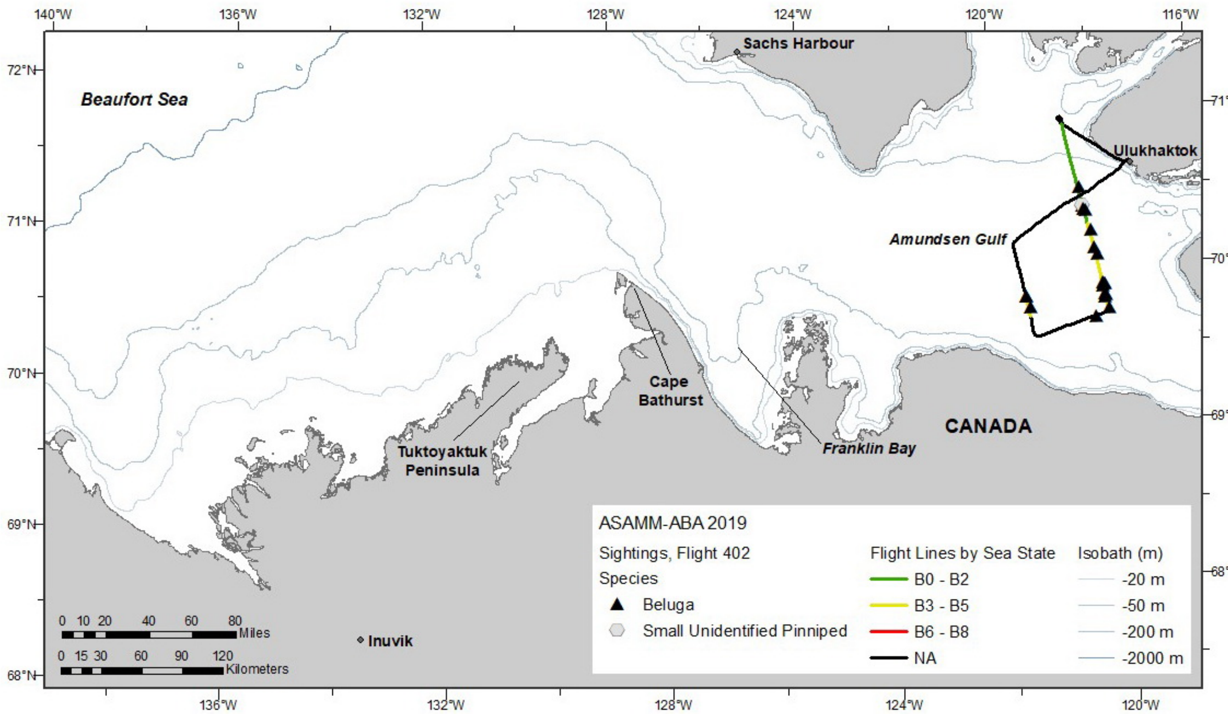


Figure B-30. Flight 402 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

11 August 2019, Flight 12

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

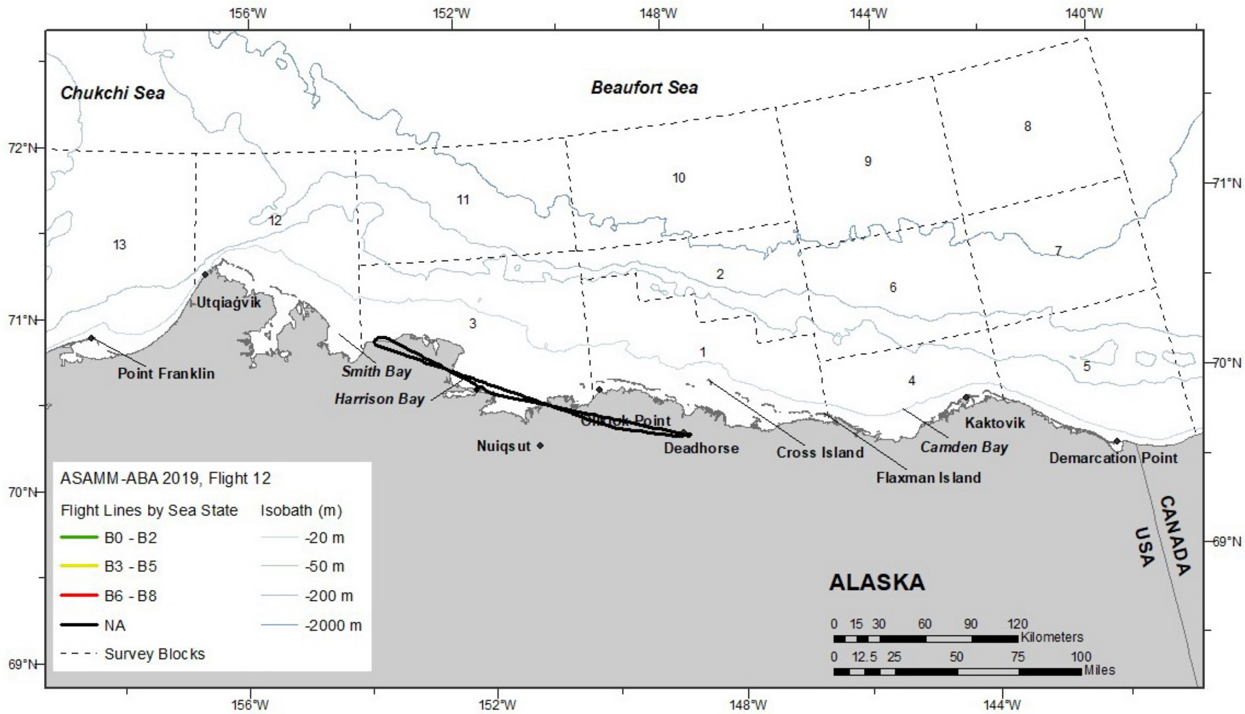


Figure B-31. Flight 12 survey track, depicted by sea state.

11 August 2019, Flight 403

Flight was a partial survey of transects BCB401, BCB402, and BCB403. Survey conditions included partly cloudy to overcast skies, 0-10 km visibility, with glare and low ceilings, and Beaufort 3-6 sea states. There was no sea ice in the area surveyed. Sightings included one bowhead whale and 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
403	8/11/2019 13:08	69.735	119.392	bowhead whale	swim	1	0	0
403	8/11/2019 13:13	69.795	119.412	beluga	swim	1	0	0

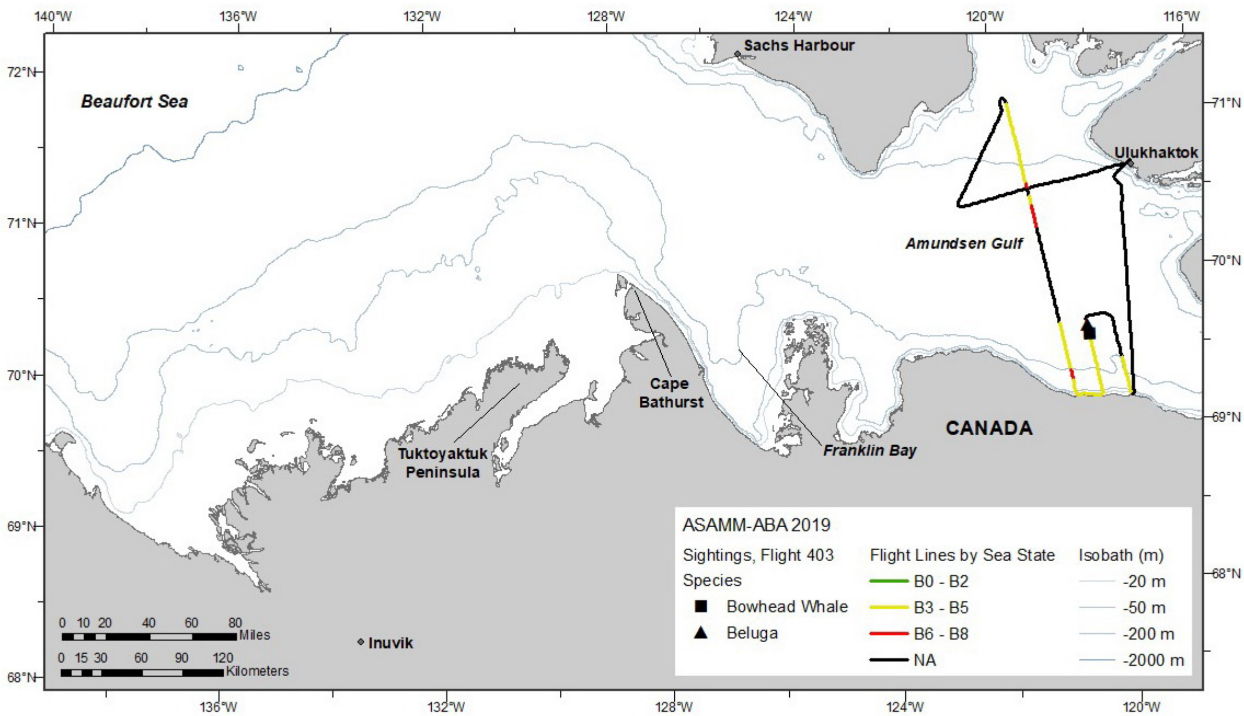


Figure B-32. Flight 403 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

12 August 2019, Flight 218

Flight was a partial survey of transects BCB435, BCB436, BCB437, BCB438, and BCB439. Survey conditions included partly cloudy to overcast 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 bowhead whales (including five calves), belugas (including two 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
218	8/12/2019 15:27	69.668	137.887	bowhead whale	rest	1	0	0
218	8/12/2019 15:27	69.669	137.894	bowhead whale	rest	2	0	0
218	8/12/2019 15:27	69.673	137.886	bowhead whale	rest	1	0	0
218	8/12/2019 15:27	69.682	137.932	bowhead whale	swim	1	0	0
218	8/12/2019 15:27	69.688	137.924	bowhead whale	swim	1	0	0
218	8/12/2019 15:28	69.695	137.919	bowhead whale	swim	1	0	0
218	8/12/2019 15:28	69.700	137.926	bowhead whale	swim	1	0	0
218	8/12/2019 15:28	69.702	137.921	bowhead whale	swim	1	0	0
218	8/12/2019 15:28	69.719	137.934	bowhead whale	swim	1	0	0
218	8/12/2019 15:30	69.716	137.961	bowhead whale	mill	3	2	0
218	8/12/2019 15:32	69.704	137.905	bowhead whale	feed	2	1	0
218	8/12/2019 15:36	69.696	137.922	bowhead whale	mill	2	0	0
218	8/12/2019 15:38	69.696	137.931	bowhead whale	dive	1	0	0
218	8/12/2019 15:38	69.695	137.930	bowhead whale	dive	1	0	0
218	8/12/2019 15:40	69.696	137.869	bowhead whale	swim	2	1	0
218	8/12/2019 15:43	69.673	137.909	bowhead whale	swim	1	0	0
218	8/12/2019 15:43	69.677	137.882	bowhead whale	rest	1	0	0
218	8/12/2019 15:44	69.668	137.886	bowhead whale	rest	1	0	0
218	8/12/2019 15:44	69.668	137.891	bowhead whale	rest	1	0	0
218	8/12/2019 15:45	69.696	137.918	bowhead whale	rest	1	0	0
218	8/12/2019 15:45	69.694	137.925	bowhead whale	rest	1	0	0
218	8/12/2019 15:45	69.687	137.921	bowhead whale	swim	1	0	0
218	8/12/2019 15:46	69.675	137.880	bowhead whale	swim	1	0	0
218	8/12/2019 15:46	69.661	137.850	bowhead whale	swim	1	0	0
218	8/12/2019 15:47	69.663	137.879	bowhead whale	rest	1	0	0
218	8/12/2019 15:47	69.668	137.874	bowhead whale	rest	1	0	0
218	8/12/2019 15:47	69.669	137.862	bowhead whale	rest	1	0	0
218	8/12/2019 15:47	69.665	137.854	bowhead whale	swim	1	0	0
218	8/12/2019 15:53	69.710	137.876	bowhead whale	swim	2	1	0
218	8/12/2019 16:09	69.743	137.382	beluga	swim	2	0	0
218	8/12/2019 16:15	69.562	137.400	beluga	swim	1	0	0
218	8/12/2019 16:20	69.395	137.391	beluga	swim	1	0	0
218	8/12/2019 16:20	69.390	137.398	beluga	swim	1	0	0
218	8/12/2019 16:24	69.273	137.423	beluga	rest	1	0	0
218	8/12/2019 16:24	69.259	137.411	beluga	swim	2	1	0

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
218	8/12/2019 16:24	69.255	137.408	beluga	rest	1	0	0
218	8/12/2019 16:25	69.239	137.386	beluga	swim	1	0	0
218	8/12/2019 16:59	69.604	136.903	beluga	swim	1	0	0
218	8/12/2019 17:02	69.718	136.897	beluga	swim	1	0	0
218	8/12/2019 17:05	69.801	136.920	beluga	swim	1	0	0
218	8/12/2019 17:05	69.808	136.935	beluga	swim	1	0	0
218	8/12/2019 17:05	69.828	136.916	beluga	swim	1	0	0
218	8/12/2019 17:06	69.836	136.907	beluga	rest	1	0	0
218	8/12/2019 17:06	69.851	136.915	beluga	swim	2	1	0
218	8/12/2019 17:07	69.864	136.895	beluga	rest	1	0	0
218	8/12/2019 17:20	69.539	136.393	beluga	swim	1	0	0
218	8/12/2019 17:27	69.328	136.410	beluga	swim	1	0	0

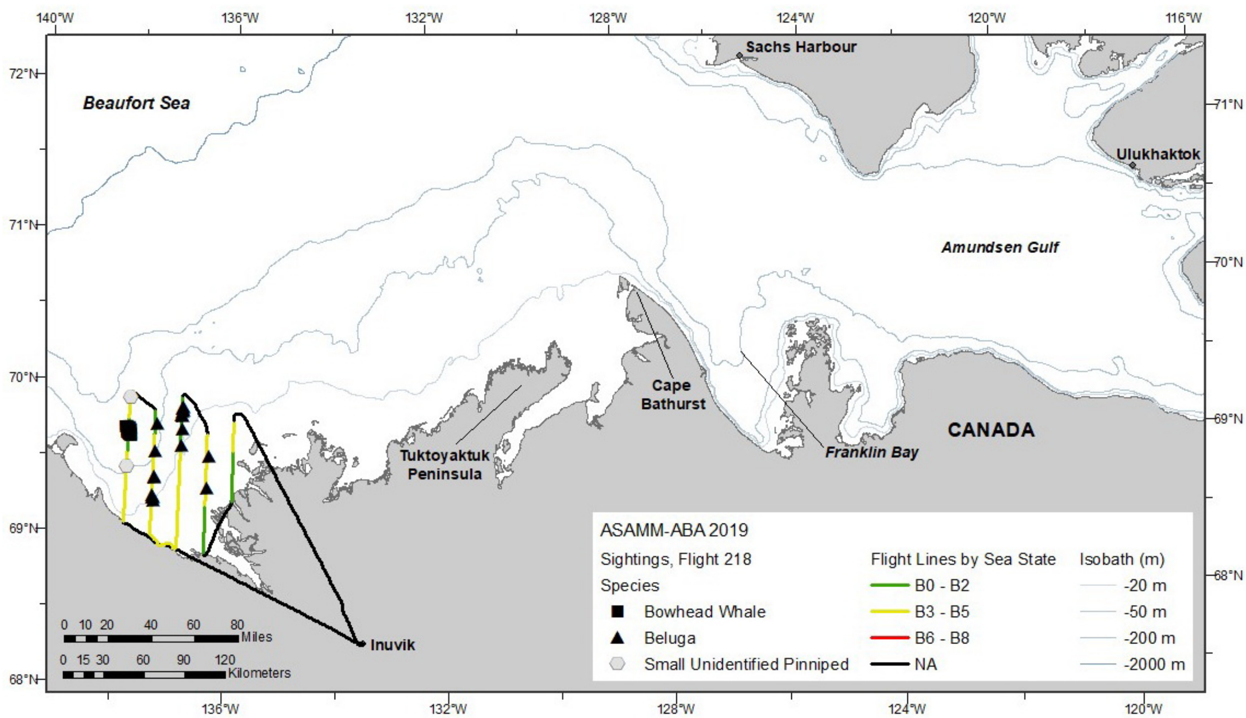


Figure B-33. Flight 218 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Bowhead whale cow-calf pair sighted swimming approximately 230 km northwest of Inuvik, Northwest Territories, Canada, Flight 218, 12 August 2019.

This page intentionally left blank.

12 August 2019, Flight 13

Flight was a complete survey of transects BCB107, BCB108, BCB112, and BCB113, and partial survey of transects BCB116 and BCB117. Survey conditions included partly cloudy to overcast skies, 1-10 km visibility, with glare, haze, and low ceilings, and Beaufort 2-7 sea states. There was no sea ice in the area surveyed. Sightings included one bowhead whale, belugas, 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
13	8/12/2019 14:08	70.416	143.403	bowhead whale	swim	1	0	4
13	8/12/2019 14:17	70.631	143.395	beluga	swim	1	0	6
13	8/12/2019 14:18	70.647	143.412	beluga	swim	1	0	6
13	8/12/2019 14:18	70.650	143.405	beluga	swim	1	0	6
13	8/12/2019 14:18	70.653	143.412	beluga	swim	1	0	6
13	8/12/2019 14:23	70.822	143.551	beluga	swim	1	0	6
13	8/12/2019 14:23	70.820	143.591	beluga	swim	1	0	6
13	8/12/2019 14:23	70.823	143.581	beluga	swim	1	0	6
13	8/12/2019 14:24	70.861	143.599	beluga	swim	1	0	6
13	8/12/2019 14:25	70.898	143.642	beluga	swim	1	0	6
13	8/12/2019 14:25	70.901	143.632	beluga	swim	1	0	6
13	8/12/2019 14:25	70.905	143.629	beluga	swim	1	0	6
13	8/12/2019 14:27	70.945	143.672	beluga	swim	2	0	6
13	8/12/2019 14:27	70.947	143.667	beluga	swim	1	0	6
13	8/12/2019 14:27	70.949	143.673	beluga	swim	1	0	6
13	8/12/2019 14:50	70.783	143.904	beluga	swim	1	0	6
13	8/12/2019 14:50	70.781	143.938	beluga	swim	1	0	6
13	8/12/2019 15:48	70.911	145.934	beluga	swim	1	0	6

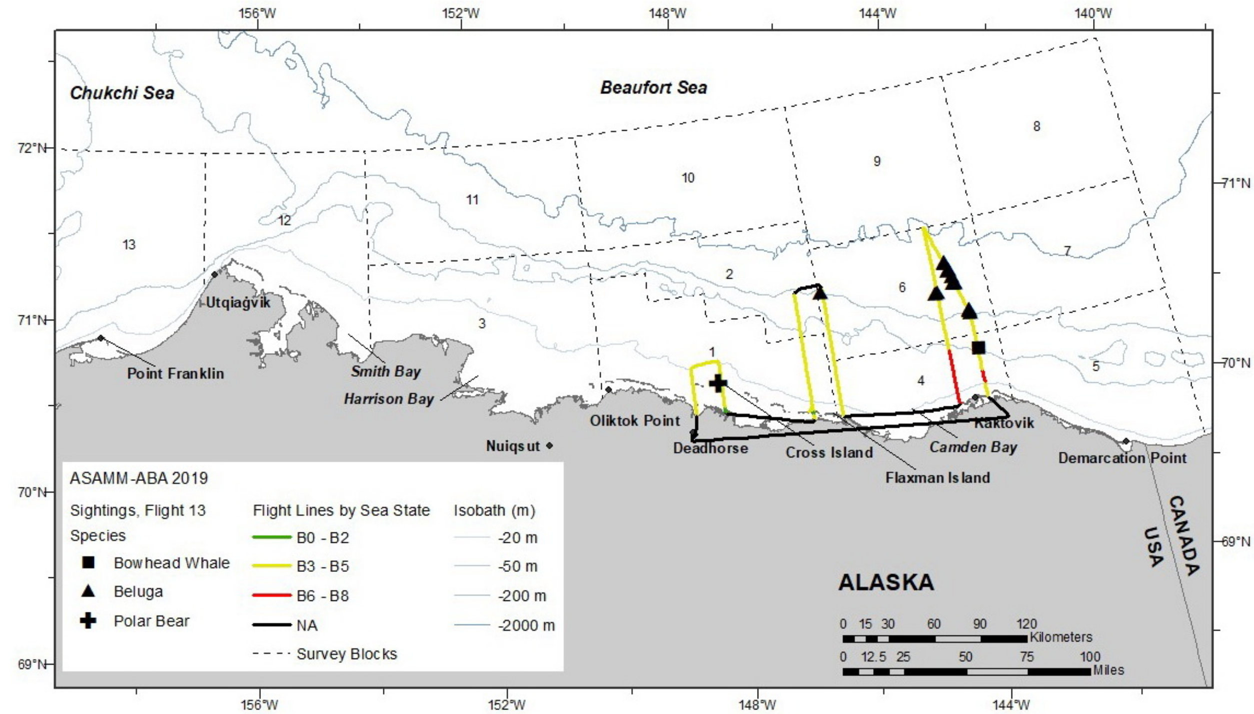


Figure B-34. Flight 13 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

13 August 2019, Flight 219

Flight was a partial survey of transects BCB442 and BCB443. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with fog and glare, and Beaufort 1-2 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales (including one calf), belugas, one unidentified cetacean, 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
219	8/13/2019 11:22	69.857	139.940	bowhead whale	rest	1	0	0
219	8/13/2019 11:27	69.946	139.901	bowhead whale	swim	1	0	0
219	8/13/2019 11:29	69.984	139.921	bowhead whale	swim	1	0	0
219	8/13/2019 11:32	69.987	139.881	bowhead whale	swim	2	1	0
219	8/13/2019 11:53	69.831	139.423	unid cetacean	unknown	1	0	0
219	8/13/2019 12:03	69.683	139.423	beluga	swim	1	0	0
219	8/13/2019 12:05	69.613	139.423	beluga	swim	2	0	0
219	8/13/2019 12:05	69.611	139.424	beluga	swim	1	0	0
219	8/13/2019 12:06	69.598	139.436	beluga	swim	1	0	0
219	8/13/2019 12:06	69.577	139.429	beluga	swim	1	0	0
219	8/13/2019 12:06	69.574	139.413	beluga	dive	1	0	0

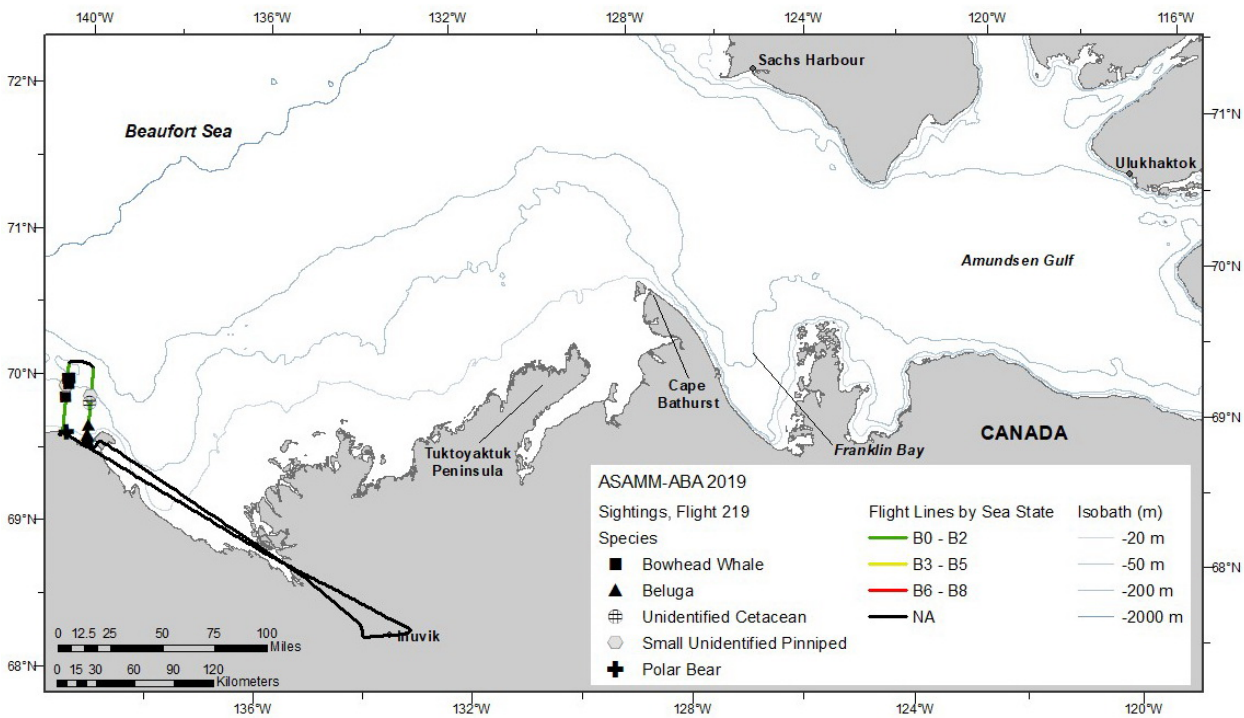


Figure B-35. Flight 219 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

13 August 2019, Flight 404

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

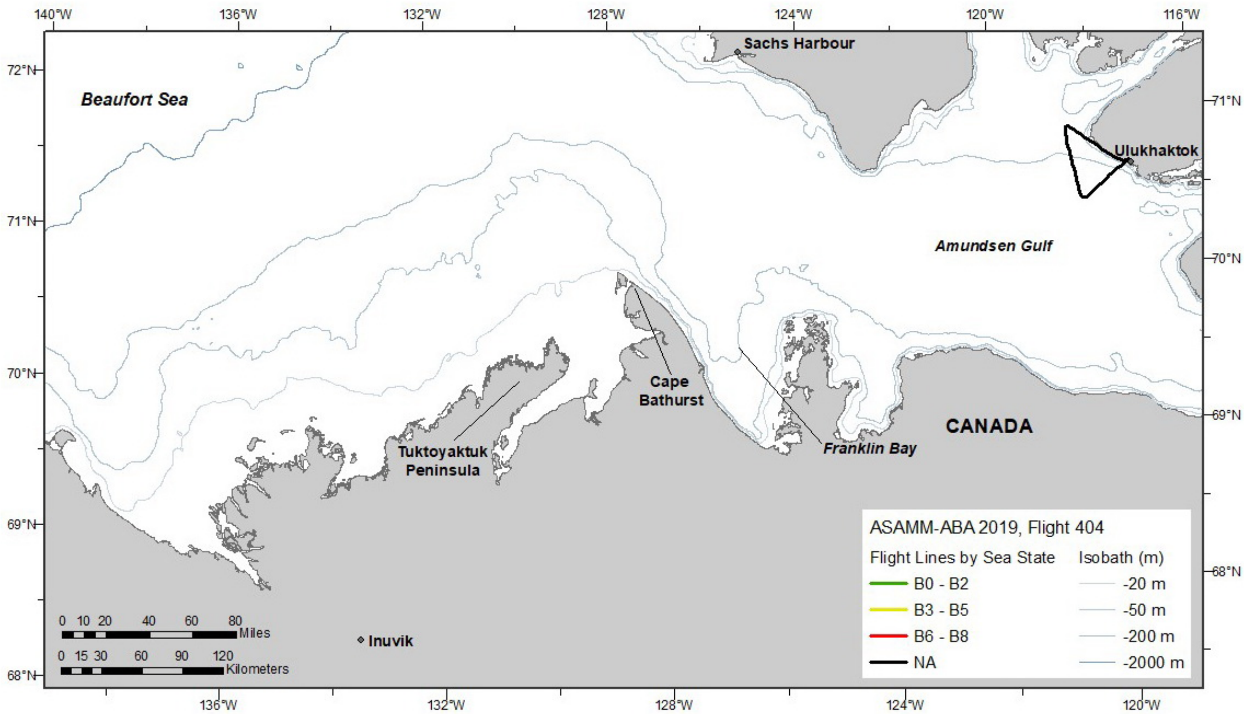


Figure B-36. Flight 404 survey track, depicted by sea state.

14 August 2019, Flight 220

Flight was a partial survey of transects BCB418, BCB419, and BCB420. Survey conditions included clear, partly cloudy, and overcast skies, <1 km to unlimited visibility, with fog, glare, low ceilings, and precipitation, and Beaufort 0-5 sea states. Sea ice ranged from 0-60% broken floe in the area surveyed. Sightings included bowhead whales (including two calves) and belugas (including two 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
220	8/14/2019 14:25	70.495	128.386	beluga	swim	1	0	0
220	8/14/2019 14:26	70.541	128.428	beluga	swim	1	0	0
220	8/14/2019 14:26	70.555	128.410	beluga	rest	1	0	0
220	8/14/2019 14:27	70.558	128.410	beluga	rest	1	0	0
220	8/14/2019 14:27	70.570	128.438	beluga	swim	3	0	0
220	8/14/2019 14:28	70.610	128.399	beluga	rest	1	0	0
220	8/14/2019 14:31	70.700	128.411	beluga	swim	1	0	0
220	8/14/2019 14:32	70.737	128.426	beluga	swim	2	1	0
220	8/14/2019 14:34	70.785	128.414	bowhead whale	dive	1	0	0
220	8/14/2019 14:40	70.868	128.411	bowhead whale	rest	1	0	0
220	8/14/2019 15:10	71.240	127.926	beluga	swim	2	1	0
220	8/14/2019 15:20	70.884	127.907	bowhead whale	swim	1	0	0
220	8/14/2019 15:27	70.820	127.911	bowhead whale	mill	2	0	0
220	8/14/2019 15:27	70.815	127.912	bowhead whale	mill	2	0	0
220	8/14/2019 15:27	70.793	127.925	bowhead whale	rest	1	0	0
220	8/14/2019 15:29	70.747	127.853	bowhead whale	breach	1	0	0
220	8/14/2019 15:29	70.744	127.872	bowhead whale	swim	1	0	0
220	8/14/2019 15:29	70.741	127.886	bowhead whale	breach	1	0	0
220	8/14/2019 15:29	70.740	127.941	bowhead whale	swim	1	0	0
220	8/14/2019 15:30	70.739	127.870	bowhead whale	swim	1	0	0
220	8/14/2019 15:30	70.744	127.875	bowhead whale	swim	1	0	0
220	8/14/2019 15:30	70.745	127.887	bowhead whale	swim	1	0	0
220	8/14/2019 15:31	70.735	127.883	bowhead whale	breach	1	0	0
220	8/14/2019 15:31	70.736	127.875	bowhead whale	swim	2	0	0
220	8/14/2019 15:34	70.800	127.890	bowhead whale	mill	3	0	0
220	8/14/2019 15:34	70.795	127.911	bowhead whale	rest	1	1	0
220	8/14/2019 15:39	70.820	127.922	bowhead whale	swim	1	0	0
220	8/14/2019 15:43	70.818	127.939	bowhead whale	swim	1	0	0
220	8/14/2019 15:46	70.799	127.915	bowhead whale	swim	1	0	0
220	8/14/2019 15:46	70.811	127.911	bowhead whale	swim	1	0	0
220	8/14/2019 15:49	70.771	127.969	bowhead whale	swim	1	0	0
220	8/14/2019 15:51	70.741	127.921	bowhead whale	breach	1	0	0
220	8/14/2019 15:51	70.747	127.902	bowhead whale	swim	1	0	0
220	8/14/2019 15:53	70.758	127.925	bowhead whale	swim	1	0	0
220	8/14/2019 15:53	70.751	127.916	bowhead whale	swim	1	0	0
220	8/14/2019 15:55	70.738	127.915	bowhead whale	swim	1	0	0

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
220	8/14/2019 15:55	70.741	127.913	bowhead whale	tail slap	2	0	0
220	8/14/2019 15:59	70.735	127.902	bowhead whale	swim	1	0	0
220	8/14/2019 16:02	70.711	127.888	bowhead whale	rest	1	0	0
220	8/14/2019 16:05	70.678	127.790	bowhead whale	breach	1	0	0
220	8/14/2019 16:37	70.499	127.361	bowhead whale	swim	1	0	0
220	8/14/2019 16:38	70.513	127.342	bowhead whale	swim	1	0	0
220	8/14/2019 16:38	70.514	127.441	bowhead whale	swim	1	0	0
220	8/14/2019 16:38	70.522	127.402	bowhead whale	dive	1	0	0
220	8/14/2019 16:38	70.530	127.454	bowhead whale	swim	1	0	0
220	8/14/2019 16:39	70.545	127.435	bowhead whale	swim	1	0	0
220	8/14/2019 16:41	70.531	127.452	bowhead whale	swim	1	0	0
220	8/14/2019 16:41	70.540	127.457	bowhead whale	rest	1	0	0
220	8/14/2019 16:42	70.530	127.437	bowhead whale	swim	1	0	0
220	8/14/2019 16:43	70.527	127.447	bowhead whale	swim	1	0	0
220	8/14/2019 16:43	70.522	127.444	bowhead whale	rest	1	0	0
220	8/14/2019 16:43	70.514	127.437	bowhead whale	swim	1	0	0
220	8/14/2019 16:44	70.520	127.428	bowhead whale	rest	1	0	0
220	8/14/2019 16:44	70.519	127.413	bowhead whale	swim	1	0	0
220	8/14/2019 16:47	70.502	127.382	bowhead whale	rest	1	0	0
220	8/14/2019 16:50	70.489	127.338	bowhead whale	feed	2	0	0
220	8/14/2019 16:52	70.506	127.355	bowhead whale	rest	1	0	0
220	8/14/2019 16:56	70.547	127.428	bowhead whale	swim	1	0	0
220	8/14/2019 16:57	70.541	127.431	bowhead whale	rest	1	0	0
220	8/14/2019 17:01	70.526	127.464	bowhead whale	rest	1	1	0

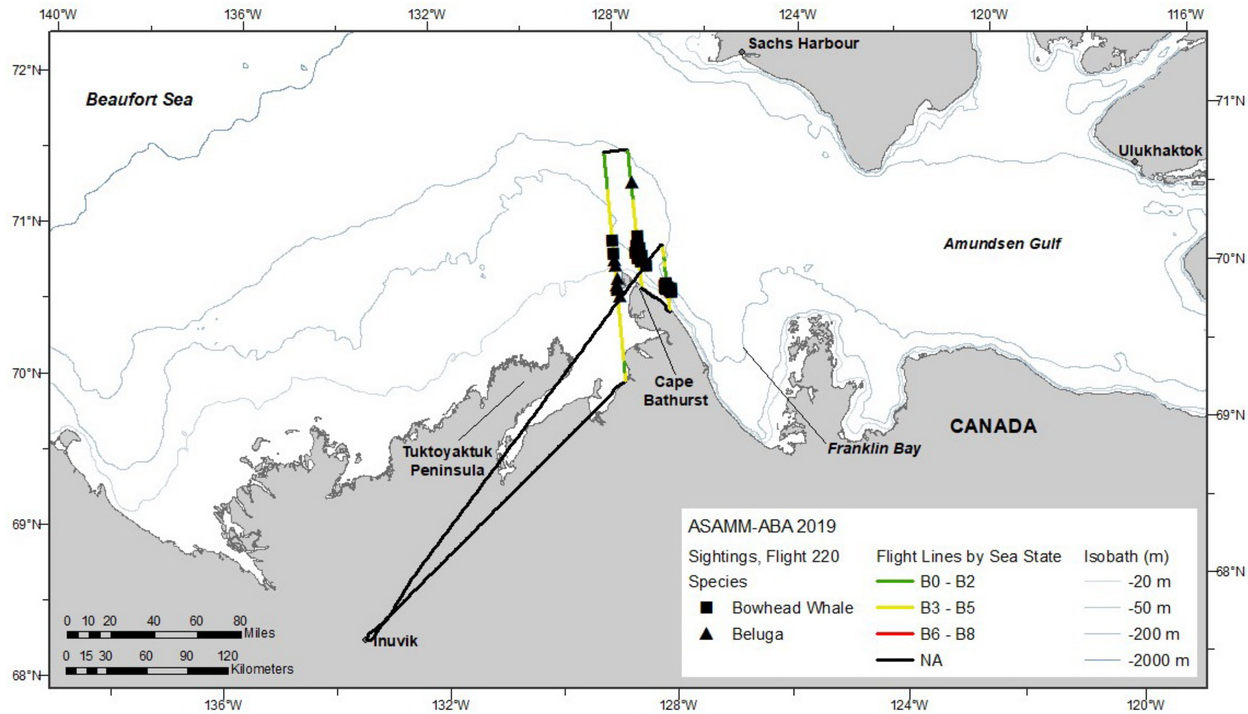


Figure B-37. Flight 220 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Bowhead whales sighted approximately 15 km northeast of Cape Bathurst, Northwest Territories, Canada, Flight 220, 14 August 2019.

14 August 2019, Flight 14

Flight was an attempt to conduct a series of field-of-view transects associated with a terrestrial target south of Deadhorse to estimate field-of-view from the survey aircraft. Low ceilings and rain prevented completion of the field-of-view trials. There were no marine mammal sightings.

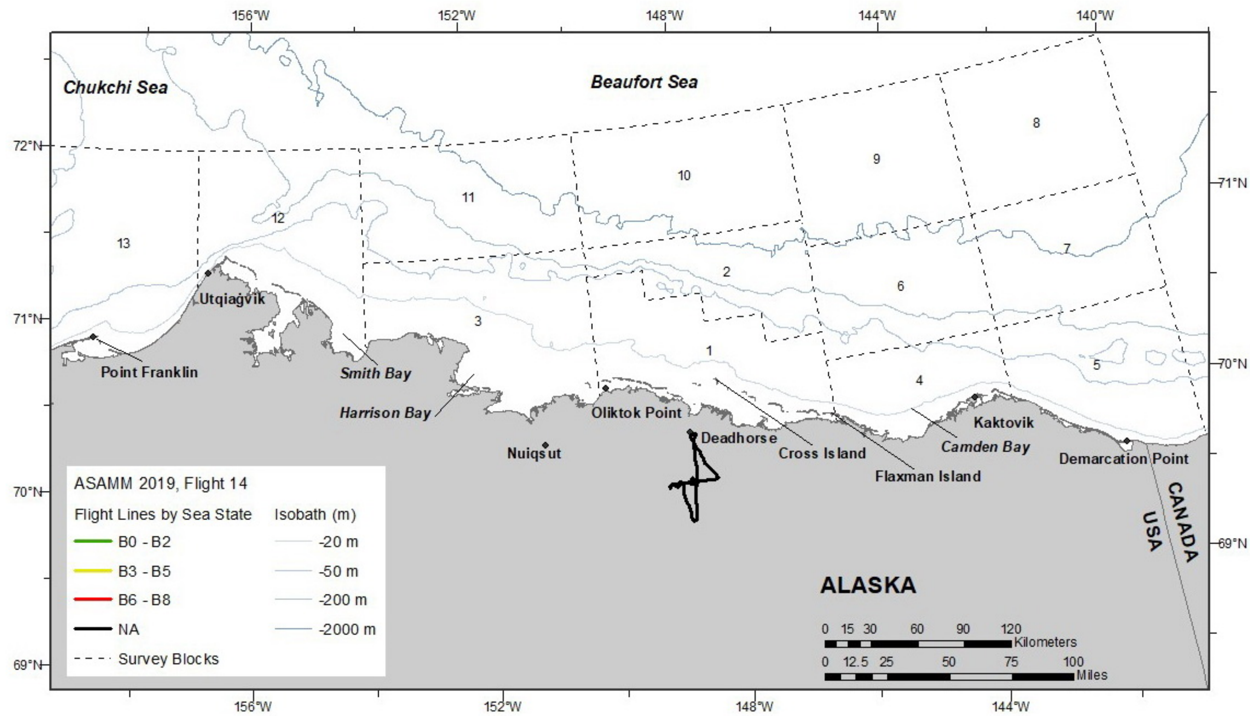


Figure B-38. Flight 14 survey track, depicted by sea state.

15 August 2019, Flight 15

Flight was nominal effort on transect BCB126, the coastal transect from Smith Bay to Harrison Bay, and search effort in survey blocks 1 and 3. Survey conditions included 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 belugas 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
15	8/15/2019 15:27	70.901	152.778	beluga	swim	1	0	3
15	8/15/2019 15:27	70.901	152.771	beluga	swim	1	0	3

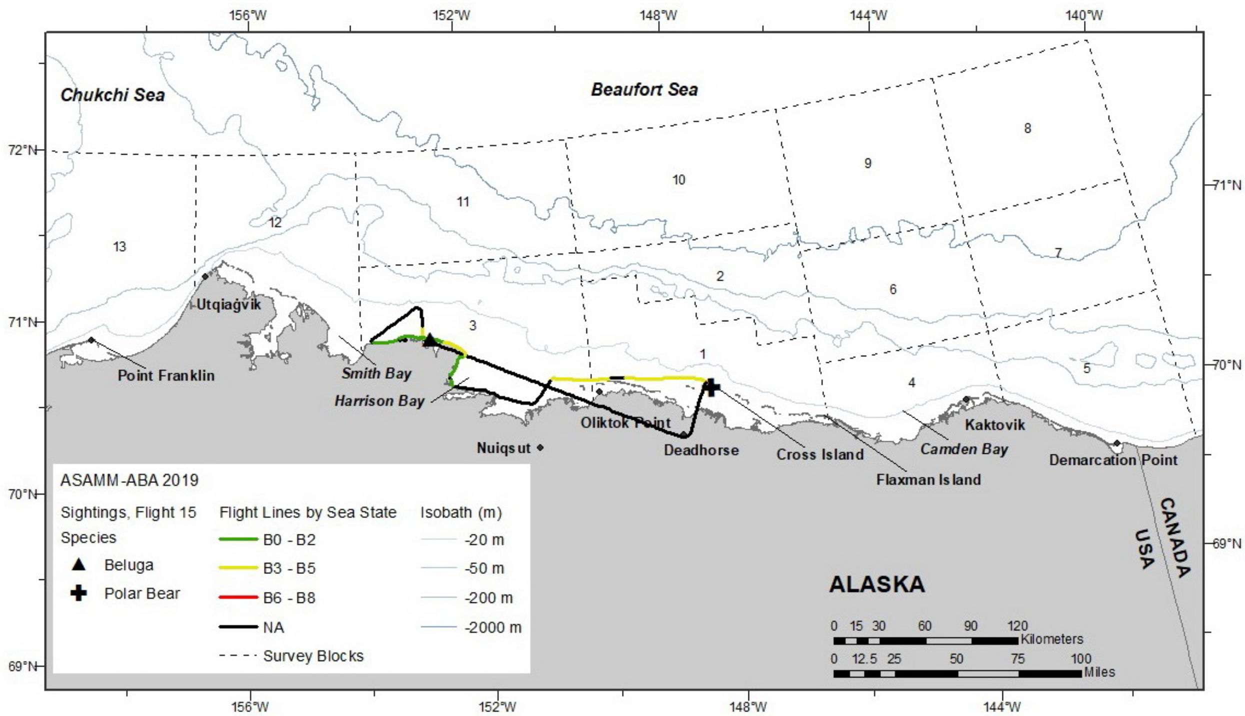


Figure B-39. Flight 15 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

15 August 2019, Flight 405

Flight was a partial survey of transects BCB402, BCB410, and BCB411. 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 bowhead whale, one beluga, 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
405	8/15/2019 11:03	69.690	123.333	bowhead whale	swim	1	0	0
405	8/15/2019 11:39	69.489	123.931	beluga	swim	1	0	0

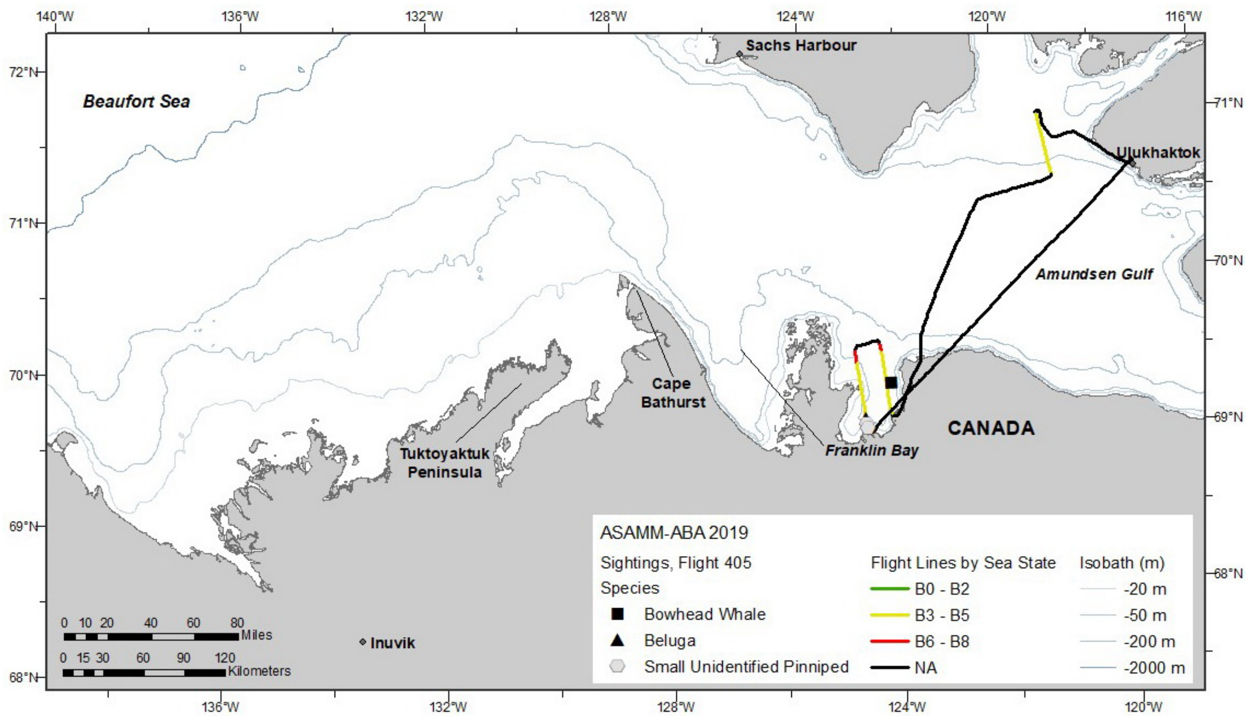


Figure B-40. Flight 405 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

16 August 2019, Flight 221

Flight was a partial survey of transects BCB412, BCB413, BCB414, and BCB415, and nominal effort on BCB417. 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. Sea ice was 0-10% broken floe ice in the area surveyed. Sightings included one bowhead whale, belugas (including seven calves), 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
221	8/16/2019 15:13	71.297	125.893	beluga	swim	1	0	0
221	8/16/2019 15:13	71.307	125.902	beluga	swim	1	0	0
221	8/16/2019 15:14	71.310	125.865	beluga	swim	1	0	0
221	8/16/2019 15:14	71.313	125.907	beluga	swim	2	0	0
221	8/16/2019 15:14	71.316	125.902	beluga	swim	1	0	0
221	8/16/2019 15:14	71.318	125.910	bowhead whale	swim	1	0	0
221	8/16/2019 15:16	71.337	125.918	beluga	rest	1	0	0
221	8/16/2019 15:16	71.350	125.890	beluga	swim	2	1	0
221	8/16/2019 15:19	71.451	125.911	beluga	rest	1	0	0
221	8/16/2019 15:19	71.455	125.903	beluga	swim	1	0	0
221	8/16/2019 15:36	71.959	125.704	beluga	rest	4	0	0
221	8/16/2019 15:47	71.732	125.422	beluga	swim	1	0	0
221	8/16/2019 15:47	71.726	125.410	beluga	rest	1	0	0
221	8/16/2019 15:53	71.528	125.424	beluga	swim	1	0	0
221	8/16/2019 15:54	71.508	125.402	beluga	swim	2	1	0
221	8/16/2019 15:55	71.466	125.403	beluga	swim	1	0	0
221	8/16/2019 15:56	71.435	125.424	beluga	swim	4	0	0
221	8/16/2019 16:04	71.187	125.398	beluga	swim	4	0	0
221	8/16/2019 16:16	71.356	124.937	beluga	swim	1	0	0
221	8/16/2019 16:16	71.362	124.920	beluga	swim	2	0	0
221	8/16/2019 16:32	71.851	124.860	beluga	rest	1	0	0
221	8/16/2019 16:58	71.090	124.393	beluga	swim	1	0	0
221	8/16/2019 16:59	71.079	124.419	beluga	swim	1	0	0
221	8/16/2019 17:00	71.046	124.402	beluga	swim	1	0	0
221	8/16/2019 17:00	71.041	124.400	beluga	swim	1	0	0
221	8/16/2019 17:00	71.039	124.382	beluga	swim	1	0	0
221	8/16/2019 17:00	71.022	124.395	beluga	swim	1	0	0
221	8/16/2019 17:00	71.020	124.405	beluga	swim	1	0	0
221	8/16/2019 17:00	71.017	124.407	beluga	dive	1	0	0
221	8/16/2019 17:01	71.006	124.406	beluga	swim	2	1	0
221	8/16/2019 17:01	71.001	124.415	beluga	swim	1	0	0
221	8/16/2019 17:01	70.984	124.412	beluga	swim	2	1	0
221	8/16/2019 17:01	70.984	124.420	beluga	swim	1	0	0
221	8/16/2019 17:02	70.980	124.430	beluga	swim	1	0	0
221	8/16/2019 17:02	70.973	124.409	beluga	swim	2	1	0
221	8/16/2019 17:04	70.896	124.416	beluga	swim	1	0	0

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
221	8/16/2019 17:04	70.892	124.419	beluga	swim	1	0	0
221	8/16/2019 17:06	70.842	124.405	beluga	swim	2	1	0
221	8/16/2019 17:07	70.812	124.430	beluga	swim	2	1	0

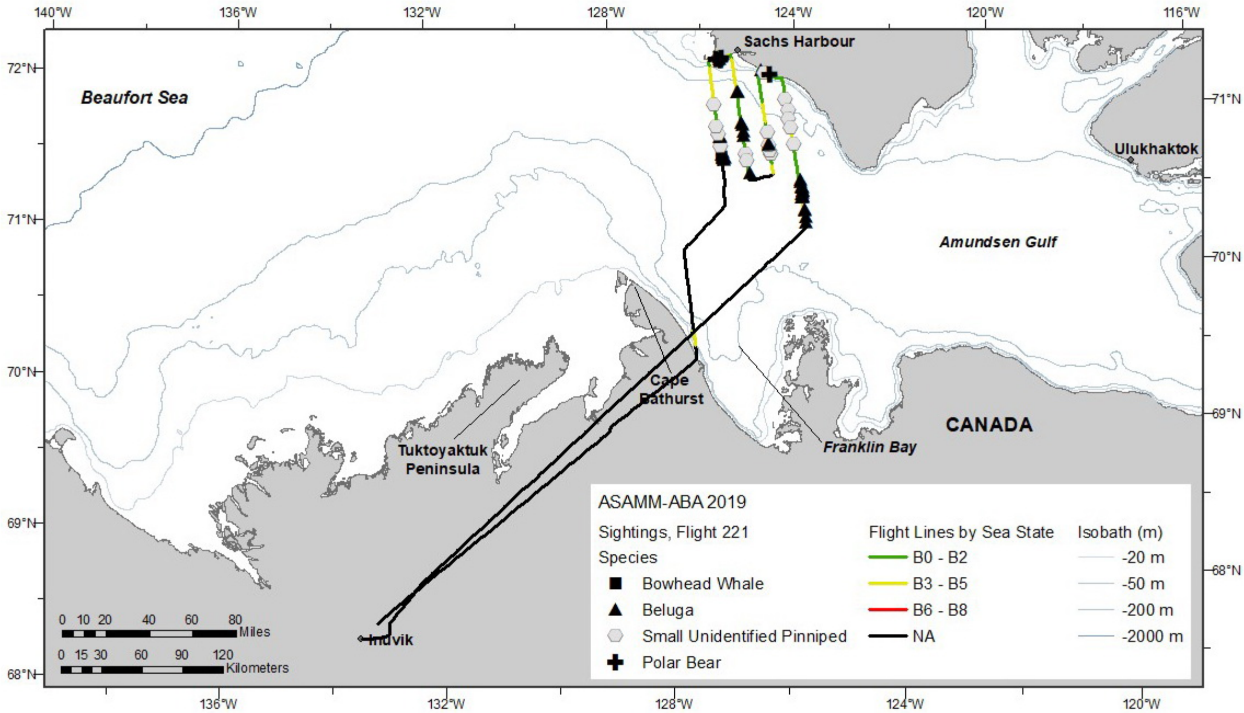


Figure B-41. Flight 221 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

This page intentionally left blank.

16 August 2019, Flight 16

Flight was the coastal transect in Harrison Bay. Survey conditions included overcast skies, 0-5 km visibility, with low ceilings, and Beaufort 3-5 sea states. There was no sea ice in the area surveyed. Sightings included polar bears.

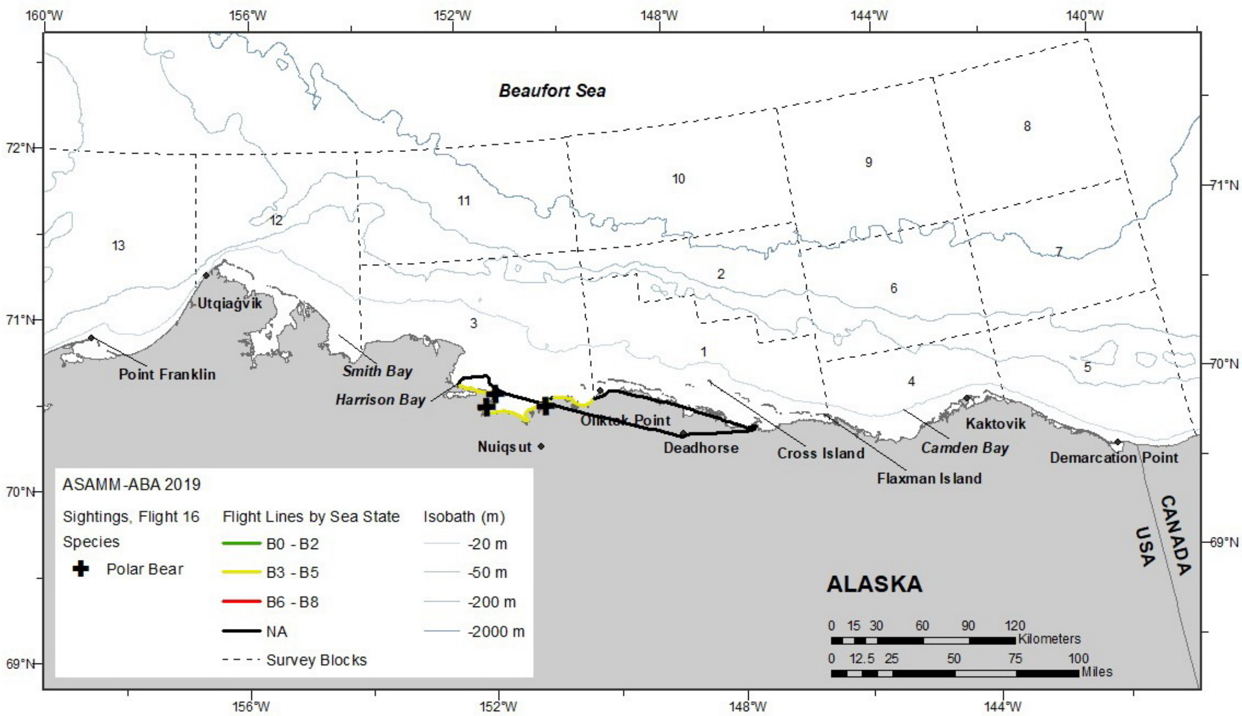


Figure B-42. Flight 16 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

17 August 2019, Flight 222

Flight was a complete survey of transects BCB405 and BCB406. Survey conditions were clear, partly cloudy, and overcast skies, 3 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 2-5 sea states. Sea ice was 0-2% broken floe ice in the area surveyed. Sightings included one bowhead whale, belugas (including 11 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
222	8/17/2019 9:31	69.876	121.427	beluga	swim	1	0	0
222	8/17/2019 9:31	69.879	121.428	beluga	swim	1	0	0
222	8/17/2019 9:32	69.920	121.433	beluga	swim	1	0	0
222	8/17/2019 9:32	69.930	121.420	beluga	swim	1	0	0
222	8/17/2019 9:32	69.931	121.404	beluga	swim	1	0	0
222	8/17/2019 9:33	69.941	121.409	beluga	swim	2	1	0
222	8/17/2019 9:34	69.974	121.406	beluga	swim	2	1	0
222	8/17/2019 9:34	69.979	121.439	beluga	swim	1	0	0
222	8/17/2019 9:34	69.989	121.396	beluga	swim	1	0	0
222	8/17/2019 9:34	69.995	121.416	beluga	swim	2	1	0
222	8/17/2019 9:34	69.997	121.414	beluga	swim	1	0	0
222	8/17/2019 9:34	70.004	121.418	beluga	swim	1	0	0
222	8/17/2019 9:35	70.005	121.416	beluga	swim	2	1	0
222	8/17/2019 9:35	70.007	121.432	beluga	swim	1	0	0
222	8/17/2019 9:35	70.013	121.439	beluga	swim	1	0	0
222	8/17/2019 9:35	70.029	121.410	beluga	mill	3	0	0
222	8/17/2019 9:35	70.032	121.432	beluga	swim	4	0	0
222	8/17/2019 9:36	70.049	121.484	beluga	mill	20	0	0
222	8/17/2019 9:37	70.075	121.518	beluga	unknown	3	0	0
222	8/17/2019 9:37	70.084	121.397	beluga	rest	1	0	0
222	8/17/2019 9:38	70.112	121.396	beluga	swim	1	0	0
222	8/17/2019 9:39	70.148	121.439	beluga	swim	2	1	0
222	8/17/2019 9:39	70.160	121.450	beluga	swim	1	0	0
222	8/17/2019 9:39	70.165	121.418	beluga	swim	1	0	0
222	8/17/2019 9:40	70.175	121.431	beluga	swim	1	0	0
222	8/17/2019 9:41	70.203	121.410	beluga	swim	1	0	0
222	8/17/2019 9:43	70.274	121.460	beluga	unknown	2	0	0
222	8/17/2019 9:43	70.286	121.400	beluga	swim	2	1	0
222	8/17/2019 9:45	70.357	121.395	beluga	swim	1	0	0
222	8/17/2019 9:46	70.372	121.453	beluga	swim	1	0	0
222	8/17/2019 9:46	70.373	121.390	beluga	swim	1	0	0
222	8/17/2019 9:49	70.468	121.374	beluga	unknown	1	0	0
222	8/17/2019 9:49	70.475	121.378	beluga	swim	1	0	0
222	8/17/2019 9:50	70.497	121.410	beluga	swim	3	0	0
222	8/17/2019 9:51	70.539	121.411	beluga	swim	1	0	0

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
222	8/17/2019 9:52	70.570	121.421	beluga	swim	1	0	0
222	8/17/2019 9:52	70.579	121.414	beluga	swim	1	0	0
222	8/17/2019 9:53	70.599	121.423	beluga	swim	1	0	0
222	8/17/2019 9:53	70.620	121.435	beluga	swim	1	0	0
222	8/17/2019 10:02	70.901	121.415	beluga	swim	1	0	0
222	8/17/2019 10:02	70.905	121.422	beluga	swim	1	0	0
222	8/17/2019 10:03	70.944	121.404	beluga	swim	1	0	0
222	8/17/2019 10:29	71.167	120.931	bowhead whale	rest	1	0	0
222	8/17/2019 10:50	70.540	120.911	beluga	swim	1	0	0
222	8/17/2019 10:51	70.537	120.913	beluga	swim	1	0	0
222	8/17/2019 10:53	70.467	120.933	beluga	swim	1	0	0
222	8/17/2019 10:55	70.399	120.909	beluga	swim	1	0	0
222	8/17/2019 10:56	70.363	120.903	beluga	swim	2	1	0
222	8/17/2019 10:56	70.363	120.917	beluga	mill	2	1	0
222	8/17/2019 10:59	70.261	120.929	beluga	swim	1	0	0
222	8/17/2019 10:59	70.257	120.922	beluga	swim	1	0	0
222	8/17/2019 11:00	70.227	120.887	beluga	swim	1	0	0
222	8/17/2019 11:00	70.227	120.944	beluga	swim	1	0	0
222	8/17/2019 11:00	70.220	120.904	beluga	swim	1	0	0
222	8/17/2019 11:01	70.185	120.935	beluga	swim	1	0	0
222	8/17/2019 11:03	70.132	120.945	beluga	swim	1	0	0
222	8/17/2019 11:03	70.126	120.909	beluga	swim	1	0	0
222	8/17/2019 11:03	70.123	120.899	beluga	swim	1	0	0
222	8/17/2019 11:04	70.108	120.949	beluga	swim	1	0	0
222	8/17/2019 11:07	70.005	120.902	beluga	swim	1	0	0
222	8/17/2019 11:07	69.999	120.921	beluga	swim	2	1	0
222	8/17/2019 11:07	69.992	120.910	beluga	swim	2	1	0
222	8/17/2019 11:08	69.971	120.912	beluga	swim	1	0	0
222	8/17/2019 11:09	69.944	120.910	beluga	swim	2	1	0
222	8/17/2019 11:09	69.938	120.900	beluga	swim	1	0	0
222	8/17/2019 11:09	69.929	120.915	beluga	rest	1	0	0
222	8/17/2019 11:10	69.918	120.900	beluga	swim	1	0	0
222	8/17/2019 11:10	69.918	120.904	beluga	swim	1	0	0
222	8/17/2019 11:10	69.915	120.918	beluga	swim	1	0	0

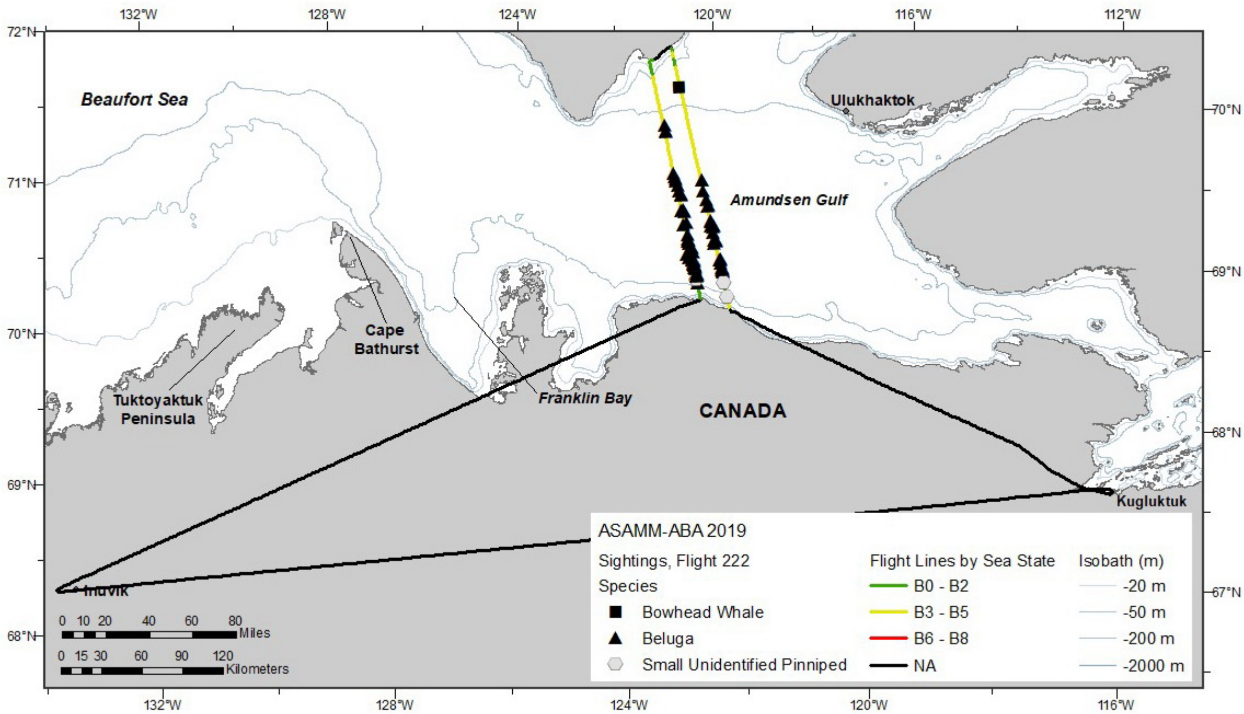


Figure B-43. Flight 222 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Inuvik-based survey team during a refueling stop in Kugluktuk, Nunavut, Canada, during Flight 222, 17 August 2019. (L to R) Jake Creglow, Jake Turner, Suzie Hanlan, Amy Willoughby, and Corey Accardo.

17 August 2019, Flight 17

Flight was a complete survey of transects 36, 37, and 38, and partial survey of transects 33, 34, and 35. Survey conditions included partly cloudy skies, 3-10 km visibility, with glare and haze, and Beaufort 2-5 sea states. There was no sea ice in the area surveyed. High sea states and low ceilings prevented survey effort in the western Beaufort Sea. Sightings included gray whales 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
17	8/17/2019 14:19	67.580	168.566	gray whale	swim	1	0	23
17	8/17/2019 15:02	67.925	168.812	gray whale	feed	1	0	23
17	8/17/2019 15:02	67.934	168.818	gray whale	feed	1	0	23
17	8/17/2019 15:05	67.925	168.816	gray whale	feed	1	0	23
17	8/17/2019 15:07	67.900	168.738	gray whale	feed	2	0	23

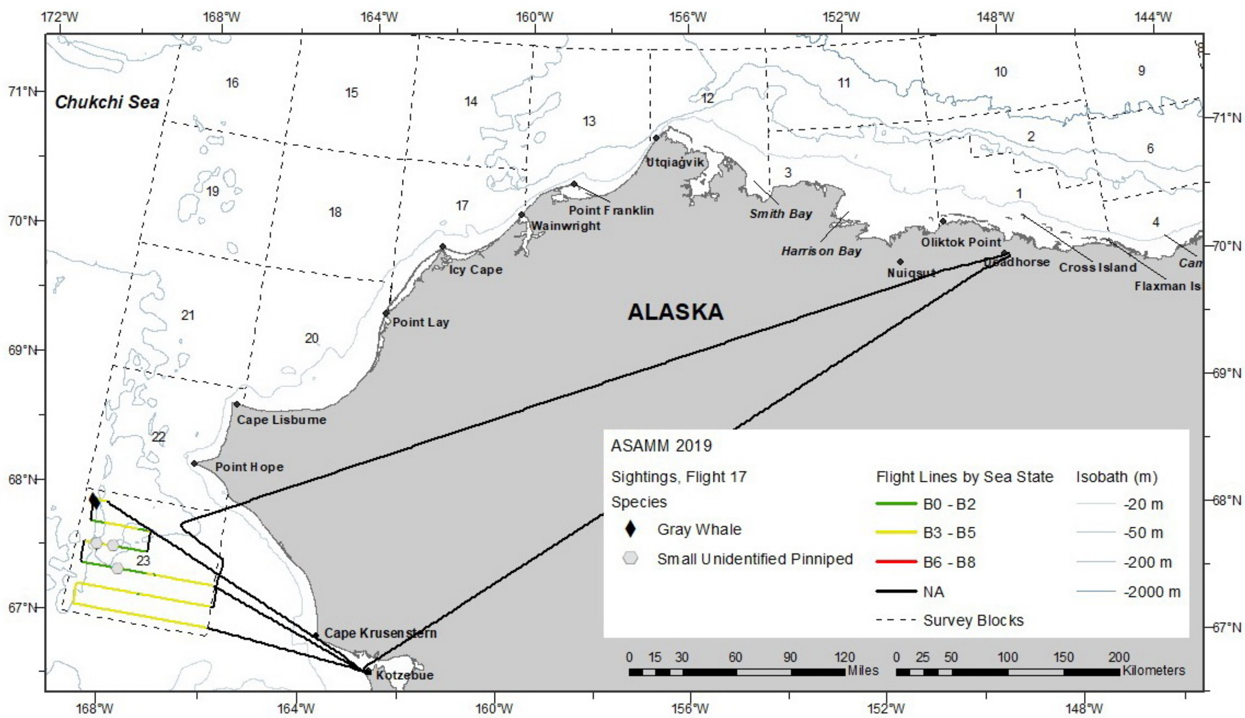


Figure B-44. Flight 17 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

19 August 2019, Flight 223

Flight was a complete survey of transects BCB423 and BCB424, and partial survey of transects BCB425 and BCB426. Survey conditions were partly cloudy to overcast skies, 0 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 0-4 sea states. Sea ice was 0-90% broken floe in the area surveyed. Sightings included bowhead whales, belugas (including one calf), 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
223	8/19/2019 10:04	70.231	129.922	beluga	mill	6	0	0
223	8/19/2019 10:17	70.634	129.911	beluga	swim	1	0	0
223	8/19/2019 10:19	70.722	129.932	beluga	swim	1	0	0
223	8/19/2019 10:38	71.331	129.888	beluga	swim	1	0	0
223	8/19/2019 10:44	71.516	129.941	beluga	swim	1	0	0
223	8/19/2019 10:45	71.534	129.929	beluga	swim	1	0	0
223	8/19/2019 10:45	71.560	129.900	beluga	swim	2	1	0
223	8/19/2019 10:46	71.567	129.923	beluga	swim	2	0	0
223	8/19/2019 10:47	71.619	129.920	beluga	swim	1	0	0
223	8/19/2019 10:48	71.656	129.908	beluga	swim	1	0	0
223	8/19/2019 10:52	71.786	129.905	beluga	swim	1	0	0
223	8/19/2019 10:52	71.788	129.935	beluga	swim	1	0	0
223	8/19/2019 10:53	71.791	129.921	beluga	swim	1	0	0
223	8/19/2019 11:18	71.215	130.400	bowhead whale	rest	2	0	0
223	8/19/2019 11:20	71.181	130.419	bowhead whale	swim	1	0	0
223	8/19/2019 11:31	70.906	130.405	beluga	rest	1	0	0
223	8/19/2019 11:31	70.904	130.411	beluga	rest	1	0	0
223	8/19/2019 11:31	70.895	130.439	beluga	swim	1	0	0
223	8/19/2019 11:35	70.760	130.414	beluga	swim	1	0	0
223	8/19/2019 11:45	70.451	130.407	beluga	swim	1	0	0
223	8/19/2019 11:49	70.299	130.406	beluga	swim	1	0	0
223	8/19/2019 14:26	70.589	130.882	beluga	swim	1	0	0
223	8/19/2019 14:36	70.924	130.918	beluga	swim	1	0	0
223	8/19/2019 14:37	70.965	130.919	bowhead whale	rest	2	0	0
223	8/19/2019 14:56	71.347	130.918	beluga	swim	1	0	0
223	8/19/2019 14:58	71.396	130.925	beluga	swim	1	0	0
223	8/19/2019 15:02	71.539	130.927	beluga	swim	1	0	0
223	8/19/2019 15:29	70.768	131.416	bowhead whale	swim	1	0	0
223	8/19/2019 15:30	70.763	131.424	bowhead whale	rest	1	0	0
223	8/19/2019 15:30	70.761	131.430	bowhead whale	rest	1	0	0

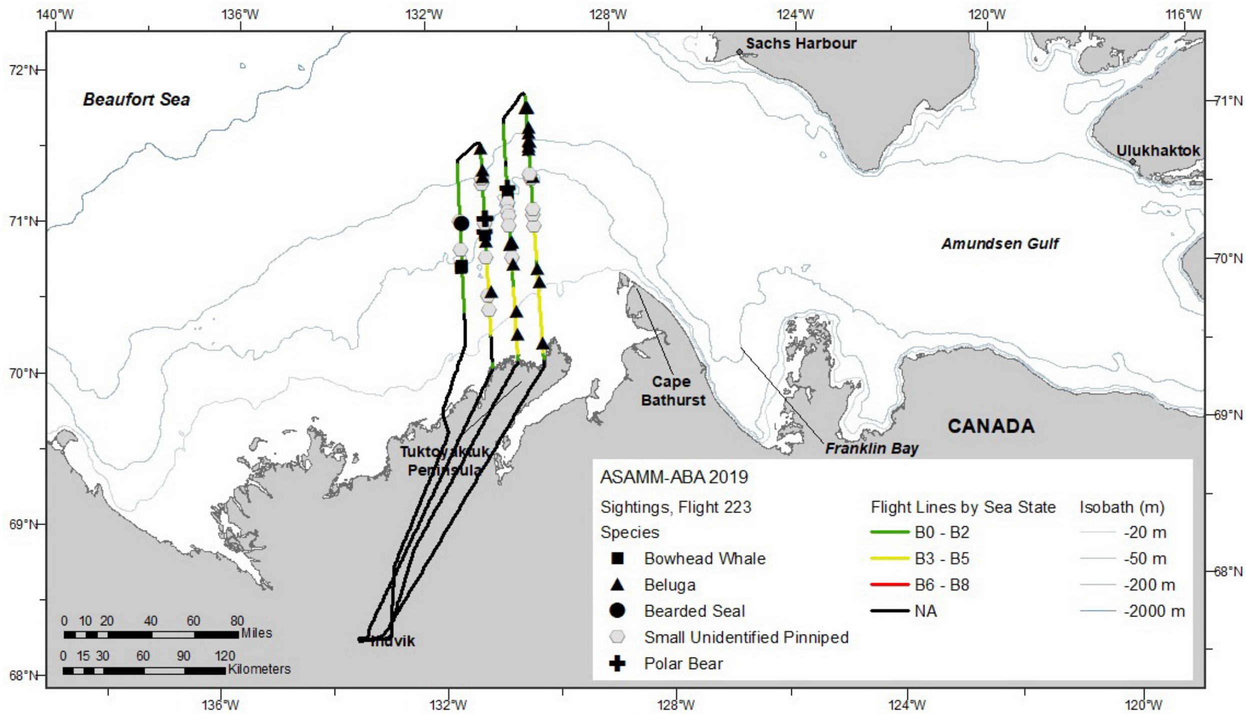


Figure B-45. Flight 223 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Polar bear with a tasty meal (unidentified pinniped), sighted approximately 120 km north of the Tuktoyaktuk Peninsula, Northwest Territories, Canada, Flight 223, 19 August 2019.

19 August 2019, Flight 406

Flight was a complete survey of transects BCB430, BCB431, BCB432, and partial survey of transects BCB429 and BCB433. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with fog, glare, haze, low ceilings, and precipitation, and Beaufort 1-4 sea states. Sea ice was 0-25% broken floe in the area surveyed. Sightings included bowhead whales (including eight calves), belugas (including six calves), 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
406	8/19/2019 10:02	70.092	134.914	beluga	rest	2	1	0
406	8/19/2019 10:03	70.126	134.953	beluga	mill	30	0	0
406	8/19/2019 10:07	70.267	134.910	bowhead whale	log play	1	0	0
406	8/19/2019 10:16	70.498	134.927	beluga	swim	2	1	0
406	8/19/2019 10:39	70.789	134.393	beluga	swim	1	0	0
406	8/19/2019 10:41	70.731	134.412	bowhead whale	swim	1	0	0
406	8/19/2019 10:44	70.726	134.449	bowhead whale	swim	1	0	0
406	8/19/2019 10:45	70.738	134.426	bowhead whale	swim	1	0	0
406	8/19/2019 10:47	70.736	134.428	bowhead whale	swim	1	0	0
406	8/19/2019 10:49	70.680	134.397	bowhead whale	swim	2	1	0
406	8/19/2019 11:00	70.376	134.434	bowhead whale	swim	1	0	0
406	8/19/2019 11:07	70.247	134.385	bowhead whale	swim	1	0	0
406	8/19/2019 11:10	70.137	134.391	bowhead whale	breach	1	0	0
406	8/19/2019 13:45	70.091	133.902	bowhead whale	swim	2	1	0
406	8/19/2019 13:48	70.115	133.918	bowhead whale	swim	1	0	0
406	8/19/2019 13:53	70.186	133.920	bowhead whale	swim	1	0	0
406	8/19/2019 14:06	70.555	133.928	bowhead whale	rest	1	0	0
406	8/19/2019 14:06	70.560	133.931	bowhead whale	rest	1	1	0
406	8/19/2019 14:40	70.794	133.405	bowhead whale	rest	1	0	0
406	8/19/2019 14:43	70.751	133.421	bowhead whale	swim	3	1	0
406	8/19/2019 14:43	70.748	133.412	beluga	swim	2	1	0
406	8/19/2019 14:44	70.737	133.444	bowhead whale	swim	2	1	0
406	8/19/2019 14:48	70.686	133.431	bowhead whale	swim	3	0	0
406	8/19/2019 14:52	70.600	133.392	bowhead whale	swim	1	0	0
406	8/19/2019 14:56	70.562	133.407	bowhead whale	swim	2	1	0
406	8/19/2019 15:00	70.455	133.399	bowhead whale	swim	1	0	0
406	8/19/2019 15:01	70.441	133.414	bowhead whale	swim	2	0	0
406	8/19/2019 15:02	70.419	133.383	bowhead whale	swim	2	1	0
406	8/19/2019 15:05	70.360	133.391	bowhead whale	swim	2	1	0
406	8/19/2019 15:07	70.339	133.412	bowhead whale	swim	1	0	0
406	8/19/2019 15:07	70.332	133.411	beluga	swim	1	0	0
406	8/19/2019 15:12	70.184	133.476	beluga	swim	1	0	0
406	8/19/2019 15:12	70.178	133.408	beluga	swim	2	1	0
406	8/19/2019 15:12	70.177	133.413	beluga	swim	2	1	0
406	8/19/2019 15:12	70.170	133.406	beluga	swim	1	0	0

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
406	8/19/2019 15:13	70.163	133.399	beluga	swim	1	0	0
406	8/19/2019 15:13	70.159	133.421	beluga	swim	5	1	0
406	8/19/2019 15:15	70.091	133.408	beluga	swim	1	0	0
406	8/19/2019 15:24	69.801	133.395	beluga	swim	1	0	0
406	8/19/2019 15:25	69.781	133.406	beluga	swim	1	0	0
406	8/19/2019 15:29	69.632	133.389	beluga	swim	1	0	0
406	8/19/2019 15:29	69.629	133.409	beluga	swim	1	0	0
406	8/19/2019 15:58	70.116	132.909	bowhead whale	swim	1	0	0

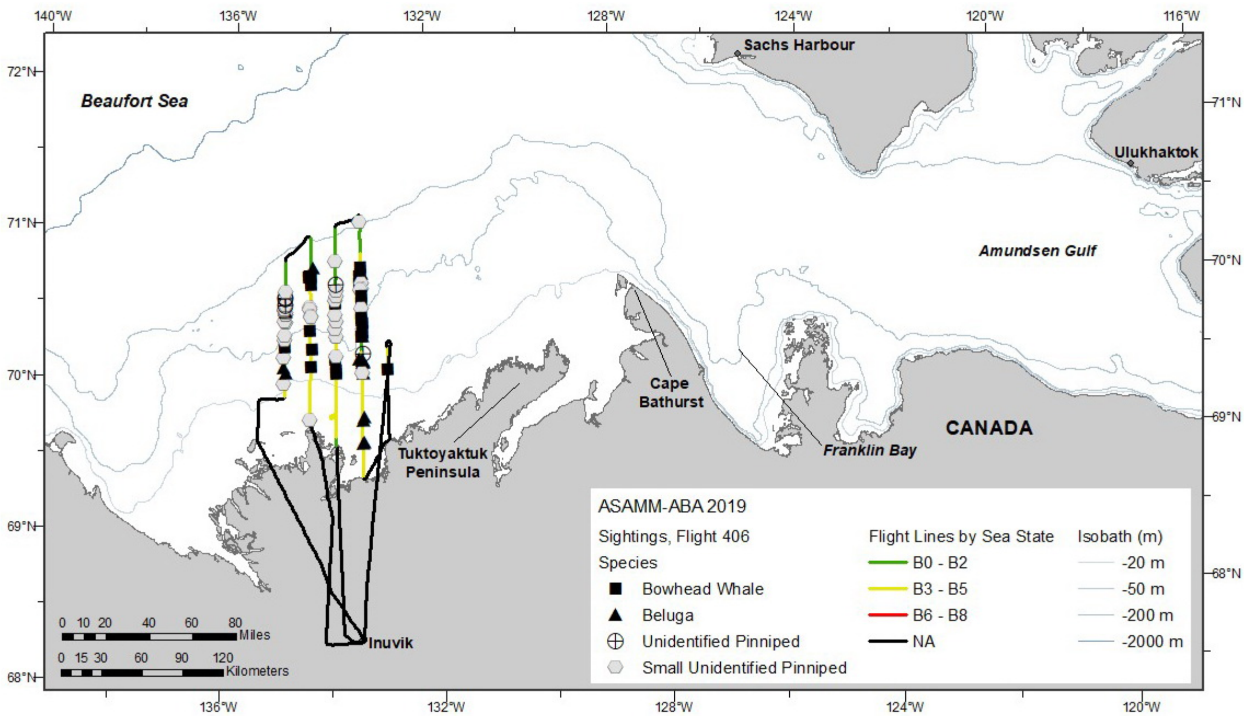


Figure B-46. Flight 406 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

20 August 2019, Flight 224

Flight was a complete survey of transect BCB416, and partial survey of transects BCB412, BCB413, BCB414, BCB415, and BCB417. Survey conditions were partly cloudy to overcast skies, 1 km to unlimited visibility, with fog, glare, and low ceilings, and Beaufort 1-3 sea states. Sea ice was 0-40% broken floe ice in the area surveyed. Sightings included bowhead whales, belugas (including 18 calves), one unidentified cetacean, 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
224	8/20/2019 9:13	70.344	124.387	beluga	swim	1	0	0
224	8/20/2019 9:14	70.387	124.402	bowhead whale	swim	1	0	0
224	8/20/2019 9:14	70.390	124.401	bowhead whale	swim	3	0	0
224	8/20/2019 9:21	70.494	124.405	beluga	rest	1	0	0
224	8/20/2019 9:23	70.552	124.419	beluga	swim	1	0	0
224	8/20/2019 9:23	70.555	124.414	beluga	swim	1	0	0
224	8/20/2019 9:23	70.555	124.405	beluga	swim	1	0	0
224	8/20/2019 9:24	70.574	124.402	beluga	swim	1	0	0
224	8/20/2019 9:24	70.575	124.403	beluga	swim	1	0	0
224	8/20/2019 9:24	70.594	124.449	beluga	swim	1	0	0
224	8/20/2019 9:26	70.639	124.410	beluga	swim	1	0	0
224	8/20/2019 9:28	70.715	124.453	beluga	swim	1	0	0
224	8/20/2019 9:29	70.732	124.438	beluga	swim	1	0	0
224	8/20/2019 9:29	70.738	124.414	beluga	swim	1	0	0
224	8/20/2019 9:40	70.811	124.911	beluga	swim	2	1	0
224	8/20/2019 9:40	70.806	124.927	beluga	swim	1	0	0
224	8/20/2019 9:40	70.802	124.911	beluga	swim	1	0	0
224	8/20/2019 9:40	70.794	124.927	beluga	swim	1	0	0
224	8/20/2019 9:40	70.784	124.923	beluga	swim	2	0	0
224	8/20/2019 9:41	70.780	124.930	beluga	swim	1	0	0
224	8/20/2019 9:41	70.773	124.898	beluga	mill	2	0	0
224	8/20/2019 9:41	70.758	124.942	beluga	swim	1	0	0
224	8/20/2019 9:41	70.751	124.922	beluga	swim	1	0	0
224	8/20/2019 9:42	70.738	124.920	beluga	swim	1	0	0
224	8/20/2019 9:43	70.703	124.890	beluga	swim	1	0	0
224	8/20/2019 9:43	70.694	124.889	beluga	swim	1	0	0
224	8/20/2019 9:43	70.687	124.938	beluga	swim	2	1	0
224	8/20/2019 9:44	70.668	124.909	beluga	swim	1	0	0
224	8/20/2019 9:44	70.656	124.907	beluga	dive	1	0	0
224	8/20/2019 9:45	70.653	124.924	beluga	rest	3	1	0
224	8/20/2019 9:45	70.640	124.904	beluga	swim	1	0	0
224	8/20/2019 9:47	70.585	124.888	bowhead whale	mill	5	0	0
224	8/20/2019 10:32	70.046	125.419	beluga	swim	1	0	0
224	8/20/2019 10:33	70.078	125.399	bowhead whale	swim	1	0	0
224	8/20/2019 10:37	70.147	125.402	beluga	swim	1	0	0

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
224	8/20/2019 10:37	70.156	125.399	beluga	swim	1	0	0
224	8/20/2019 10:51	70.618	125.425	beluga	swim	1	0	0
224	8/20/2019 10:51	70.621	125.422	beluga	swim	1	0	0
224	8/20/2019 10:52	70.627	125.405	beluga	swim	1	0	0
224	8/20/2019 10:52	70.628	125.407	beluga	swim	1	0	0
224	8/20/2019 10:52	70.632	125.402	beluga	swim	1	0	0
224	8/20/2019 10:52	70.637	125.408	bowhead whale	swim	1	0	0
224	8/20/2019 10:54	70.651	125.392	beluga	swim	1	0	0
224	8/20/2019 10:54	70.651	125.393	beluga	swim	1	0	0
224	8/20/2019 10:54	70.656	125.427	beluga	swim	1	0	0
224	8/20/2019 10:54	70.656	125.432	beluga	swim	1	0	0
224	8/20/2019 10:56	70.705	125.459	beluga	swim	1	0	0
224	8/20/2019 10:56	70.713	125.442	beluga	swim	1	0	0
224	8/20/2019 10:58	70.778	125.436	beluga	swim	1	0	0
224	8/20/2019 10:59	70.793	125.394	beluga	swim	1	0	0
224	8/20/2019 11:00	70.844	125.411	beluga	swim	1	0	0
224	8/20/2019 11:00	70.846	125.404	beluga	swim	1	0	0
224	8/20/2019 11:00	70.848	125.415	beluga	swim	1	0	0
224	8/20/2019 11:01	70.868	125.434	beluga	swim	1	0	0
224	8/20/2019 11:03	70.937	125.438	beluga	swim	2	0	0
224	8/20/2019 11:07	71.062	125.478	beluga	unknown	1	0	0
224	8/20/2019 11:09	71.138	125.400	beluga	swim	1	0	0
224	8/20/2019 11:15	71.120	125.957	unid cetacean	unknown	1	0	0
224	8/20/2019 11:21	71.109	125.918	beluga	swim	1	0	0
224	8/20/2019 11:22	71.069	125.925	beluga	swim	1	0	0
224	8/20/2019 11:22	71.048	125.895	beluga	swim	1	0	0
224	8/20/2019 11:22	71.046	125.891	beluga	swim	1	0	0
224	8/20/2019 11:23	71.038	125.903	beluga	swim	1	0	0
224	8/20/2019 11:23	71.036	125.912	beluga	rest	1	0	0
224	8/20/2019 11:24	70.987	125.899	beluga	swim	4	1	0
224	8/20/2019 11:24	70.982	125.878	beluga	swim	2	0	0
224	8/20/2019 11:25	70.979	125.940	beluga	mill	2	1	0
224	8/20/2019 11:25	70.961	125.909	beluga	swim	1	0	0
224	8/20/2019 11:26	70.941	125.934	beluga	swim	1	0	0
224	8/20/2019 11:26	70.941	125.935	beluga	swim	1	0	0
224	8/20/2019 11:26	70.938	125.928	beluga	swim	1	0	0
224	8/20/2019 11:27	70.904	125.919	beluga	swim	1	0	0
224	8/20/2019 11:28	70.873	125.900	beluga	swim	1	0	0
224	8/20/2019 11:28	70.868	125.894	beluga	swim	1	0	0
224	8/20/2019 11:30	70.792	125.920	beluga	swim	1	0	0
224	8/20/2019 11:31	70.760	125.927	beluga	swim	2	0	0
224	8/20/2019 11:32	70.728	125.873	beluga	swim	1	0	0
224	8/20/2019 11:33	70.723	125.906	beluga	swim	1	0	0
224	8/20/2019 11:34	70.679	125.925	beluga	rest	1	0	0
224	8/20/2019 11:35	70.661	125.906	beluga	swim	1	0	0

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
224	8/20/2019 11:35	70.657	125.901	beluga	swim	1	0	0
224	8/20/2019 11:35	70.653	125.888	beluga	swim	1	0	0
224	8/20/2019 11:35	70.649	125.903	beluga	swim	1	0	0
224	8/20/2019 11:35	70.647	125.941	beluga	swim	1	0	0
224	8/20/2019 11:36	70.617	125.918	beluga	swim	1	0	0
224	8/20/2019 11:36	70.617	125.918	beluga	swim	1	0	0
224	8/20/2019 11:36	70.610	125.917	beluga	swim	1	0	0
224	8/20/2019 11:38	70.541	125.894	beluga	swim	2	0	0
224	8/20/2019 11:38	70.539	125.887	beluga	swim	1	0	0
224	8/20/2019 11:38	70.537	125.891	beluga	swim	1	0	0
224	8/20/2019 11:41	70.471	125.968	bowhead whale	unknown	1	0	0
224	8/20/2019 11:47	70.375	125.837	beluga	unknown	1	0	0
224	8/20/2019 11:48	70.359	125.888	beluga	swim	1	0	0
224	8/20/2019 11:48	70.347	125.874	bowhead whale	swim	1	0	0
224	8/20/2019 11:52	70.325	125.949	bowhead whale	swim	1	0	0
224	8/20/2019 11:53	70.321	125.887	bowhead whale	mill	5	0	0
224	8/20/2019 11:53	70.311	125.906	bowhead whale	swim	1	0	0
224	8/20/2019 11:58	70.299	125.854	bowhead whale	dive	1	0	0
224	8/20/2019 11:58	70.291	125.863	bowhead whale	feed	1	0	0
224	8/20/2019 12:13	69.872	125.921	bowhead whale	rest	2	0	0
224	8/20/2019 12:17	69.858	125.889	beluga	rest	1	0	0
224	8/20/2019 12:17	69.856	125.926	beluga	rest	1	0	0
224	8/20/2019 15:27	70.091	126.447	bowhead whale	swim	1	0	0
224	8/20/2019 15:31	70.148	126.415	bowhead whale	mill	2	0	0
224	8/20/2019 15:34	70.208	126.352	bowhead whale	swim	2	0	0
224	8/20/2019 15:37	70.218	126.451	bowhead whale	rest	1	0	0
224	8/20/2019 15:40	70.282	126.414	bowhead whale	rest	2	0	0
224	8/20/2019 15:43	70.302	126.432	bowhead whale	rest	1	0	0
224	8/20/2019 15:43	70.311	126.431	beluga	swim	1	0	0
224	8/20/2019 15:43	70.316	126.418	bowhead whale	rest	1	0	0
224	8/20/2019 15:46	70.345	126.449	bowhead whale	rest	1	0	0
224	8/20/2019 15:47	70.364	126.417	bowhead whale	breach	1	0	0
224	8/20/2019 15:50	70.402	126.396	bowhead whale	swim	1	0	0
224	8/20/2019 15:51	70.426	126.390	bowhead whale	mill	2	0	0
224	8/20/2019 15:52	70.435	126.382	bowhead whale	rest	1	0	0
224	8/20/2019 15:55	70.461	126.444	bowhead whale	swim	1	0	0
224	8/20/2019 15:56	70.471	126.404	beluga	swim	9	0	0
224	8/20/2019 15:57	70.489	126.410	beluga	swim	1	0	0
224	8/20/2019 15:57	70.491	126.406	beluga	swim	1	0	0
224	8/20/2019 15:57	70.500	126.491	bowhead whale	unknown	4	0	0
224	8/20/2019 15:57	70.502	126.502	bowhead whale	unknown	1	0	0
224	8/20/2019 15:57	70.507	126.386	bowhead whale	dive	1	0	0
224	8/20/2019 16:00	70.535	126.402	beluga	swim	1	0	0
224	8/20/2019 16:00	70.546	126.535	bowhead whale	unknown	2	0	0
224	8/20/2019 16:00	70.555	126.388	beluga	swim	1	0	0

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
224	8/20/2019 16:00	70.556	126.490	bowhead whale	unknown	2	0	0
224	8/20/2019 16:01	70.568	126.537	bowhead whale	unknown	2	0	0
224	8/20/2019 16:01	70.569	126.568	bowhead whale	unknown	1	0	0
224	8/20/2019 16:02	70.605	126.443	beluga	swim	1	0	0
224	8/20/2019 16:04	70.679	126.413	beluga	swim	1	0	0
224	8/20/2019 16:05	70.691	126.400	beluga	mill	2	0	0
224	8/20/2019 16:05	70.694	126.407	beluga	mill	2	1	0
224	8/20/2019 16:05	70.696	126.405	beluga	swim	8	0	0
224	8/20/2019 16:05	70.699	126.409	beluga	swim	6	0	0
224	8/20/2019 16:05	70.701	126.398	beluga	mill	2	0	0
224	8/20/2019 16:05	70.704	126.414	bowhead whale	swim	1	0	0
224	8/20/2019 16:13	70.938	126.417	beluga	swim	1	0	0
224	8/20/2019 16:14	70.986	126.381	beluga	swim	3	0	0
224	8/20/2019 16:17	71.066	126.414	beluga	swim	30	0	0
224	8/20/2019 16:17	71.078	126.418	beluga	swim	5	1	0
224	8/20/2019 16:17	71.079	126.431	beluga	swim	1	0	0
224	8/20/2019 16:17	71.080	126.368	beluga	mill	3	0	0
224	8/20/2019 16:17	71.090	126.430	beluga	swim	2	1	0
224	8/20/2019 16:17	71.090	126.417	beluga	swim	1	0	0
224	8/20/2019 16:17	71.092	126.402	beluga	swim	1	0	0
224	8/20/2019 16:18	71.099	126.408	beluga	swim	2	1	0
224	8/20/2019 16:18	71.113	126.411	beluga	swim	1	0	0
224	8/20/2019 16:18	71.116	126.426	beluga	swim	1	0	0
224	8/20/2019 16:18	71.116	126.430	beluga	mill	6	0	0
224	8/20/2019 16:18	71.120	126.435	beluga	mill	6	0	0
224	8/20/2019 16:19	71.134	126.434	beluga	swim	1	0	0
224	8/20/2019 16:19	71.138	126.403	beluga	swim	1	0	0
224	8/20/2019 16:20	71.167	126.398	beluga	swim	1	0	0
224	8/20/2019 16:20	71.182	126.401	beluga	swim	2	0	0
224	8/20/2019 16:20	71.186	126.408	beluga	swim	2	1	0
224	8/20/2019 16:21	71.191	126.413	beluga	swim	1	0	0
224	8/20/2019 16:21	71.206	126.389	beluga	swim	1	0	0
224	8/20/2019 16:21	71.216	126.425	beluga	swim	2	1	0
224	8/20/2019 16:21	71.220	126.420	beluga	swim	1	0	0
224	8/20/2019 16:23	71.266	126.423	beluga	swim	1	0	0
224	8/20/2019 16:25	71.342	126.430	beluga	swim	2	1	0
224	8/20/2019 16:27	71.385	126.417	beluga	swim	2	1	0
224	8/20/2019 16:27	71.384	126.403	beluga	swim	1	0	0
224	8/20/2019 16:30	71.484	126.413	beluga	swim	1	0	0
224	8/20/2019 16:30	71.503	126.433	beluga	swim	2	0	0
224	8/20/2019 16:32	71.538	126.410	beluga	rest	1	0	0
224	8/20/2019 16:32	71.555	126.439	beluga	swim	1	0	0
224	8/20/2019 16:32	71.559	126.434	beluga	swim	16	0	0
224	8/20/2019 16:32	71.562	126.419	beluga	mill	4	1	0
224	8/20/2019 16:34	71.611	126.395	beluga	swim	1	0	0

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
224	8/20/2019 16:35	71.658	126.427	beluga	swim	2	0	0
224	8/20/2019 16:35	71.665	126.373	beluga	swim	1	0	0
224	8/20/2019 16:36	71.679	126.447	beluga	swim	1	0	0
224	8/20/2019 16:36	71.686	126.425	beluga	swim	1	0	0
224	8/20/2019 16:37	71.697	126.426	beluga	swim	1	0	0
224	8/20/2019 16:39	71.767	126.412	beluga	rest	1	0	0
224	8/20/2019 16:51	71.944	126.928	beluga	swim	1	0	0
224	8/20/2019 16:51	71.936	126.911	beluga	swim	1	0	0
224	8/20/2019 16:52	71.908	126.933	beluga	swim	1	0	0
224	8/20/2019 16:52	71.886	126.912	beluga	swim	1	0	0
224	8/20/2019 16:53	71.876	126.908	beluga	swim	1	0	0
224	8/20/2019 16:54	71.847	126.901	beluga	swim	1	0	0
224	8/20/2019 16:54	71.835	126.913	beluga	swim	1	0	0
224	8/20/2019 16:54	71.824	126.895	beluga	swim	2	0	0
224	8/20/2019 16:54	71.820	126.893	beluga	swim	1	0	0
224	8/20/2019 16:55	71.790	126.917	beluga	swim	1	0	0
224	8/20/2019 16:56	71.787	126.894	beluga	mill	7	1	0
224	8/20/2019 16:56	71.780	126.887	beluga	swim	2	0	0
224	8/20/2019 16:58	71.697	126.928	beluga	swim	1	0	0
224	8/20/2019 17:01	71.604	126.921	beluga	swim	2	0	0
224	8/20/2019 17:07	71.432	126.907	beluga	swim	2	1	0
224	8/20/2019 17:09	71.357	126.896	beluga	swim	3	1	0
224	8/20/2019 17:09	71.346	126.900	beluga	swim	1	0	0
224	8/20/2019 17:09	71.343	126.909	beluga	swim	1	0	0
224	8/20/2019 17:09	71.340	126.914	beluga	swim	1	0	0
224	8/20/2019 17:09	71.340	126.898	beluga	swim	1	0	0
224	8/20/2019 17:11	71.305	126.894	beluga	swim	2	0	0
224	8/20/2019 17:11	71.292	126.893	beluga	swim	1	0	0
224	8/20/2019 17:12	71.265	126.907	beluga	swim	1	0	0
224	8/20/2019 17:13	71.221	126.905	beluga	swim	1	0	0
224	8/20/2019 17:17	71.114	126.920	beluga	swim	1	0	0
224	8/20/2019 17:17	71.108	126.899	beluga	swim	1	0	0
224	8/20/2019 17:20	71.016	126.908	beluga	swim	2	1	0
224	8/20/2019 17:20	71.001	126.894	beluga	swim	1	0	0

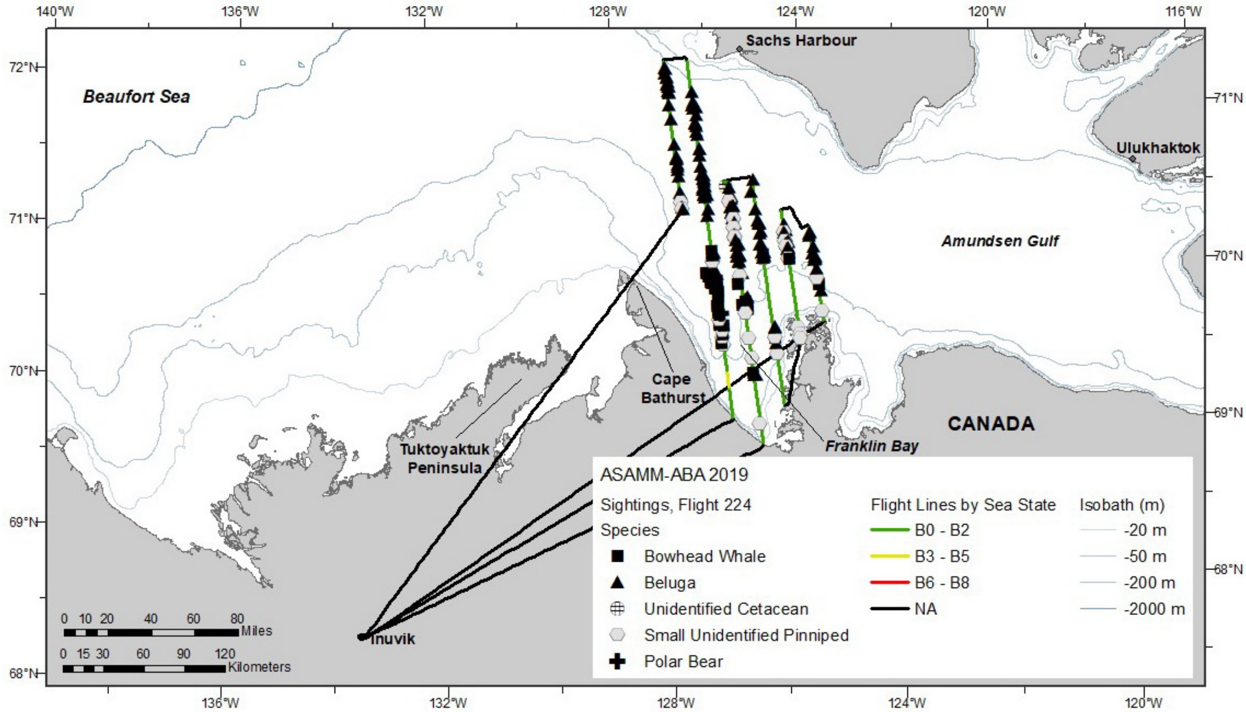


Figure B-47. Flight 224 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Five milling bowhead whales sighted approximately 130 km east of Cape Bathurst, Northwest Territories, Canada, Flight 224, 20 August 2019. The white peduncle and tail on the whale in the upper right indicate that that whale is likely an older individual.

This page intentionally left blank.

20 August 2019, Flight 407

Flight was a partial survey of transect BCB422. Survey conditions included partly cloudy skies, 0 km to unlimited visibility, with low ceilings, and Beaufort 2-3 sea states. There was no sea ice in the area surveyed. Sightings included belugas 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
407	8/20/2019 8:44	70.368	129.430	beluga	swim	1	0	0
407	8/20/2019 8:45	70.380	129.437	beluga	swim	1	0	0
407	8/20/2019 8:46	70.422	129.393	beluga	swim	1	0	0
407	8/20/2019 8:49	70.520	129.428	beluga	swim	1	0	0
407	8/20/2019 8:50	70.556	129.445	beluga	swim	1	0	0

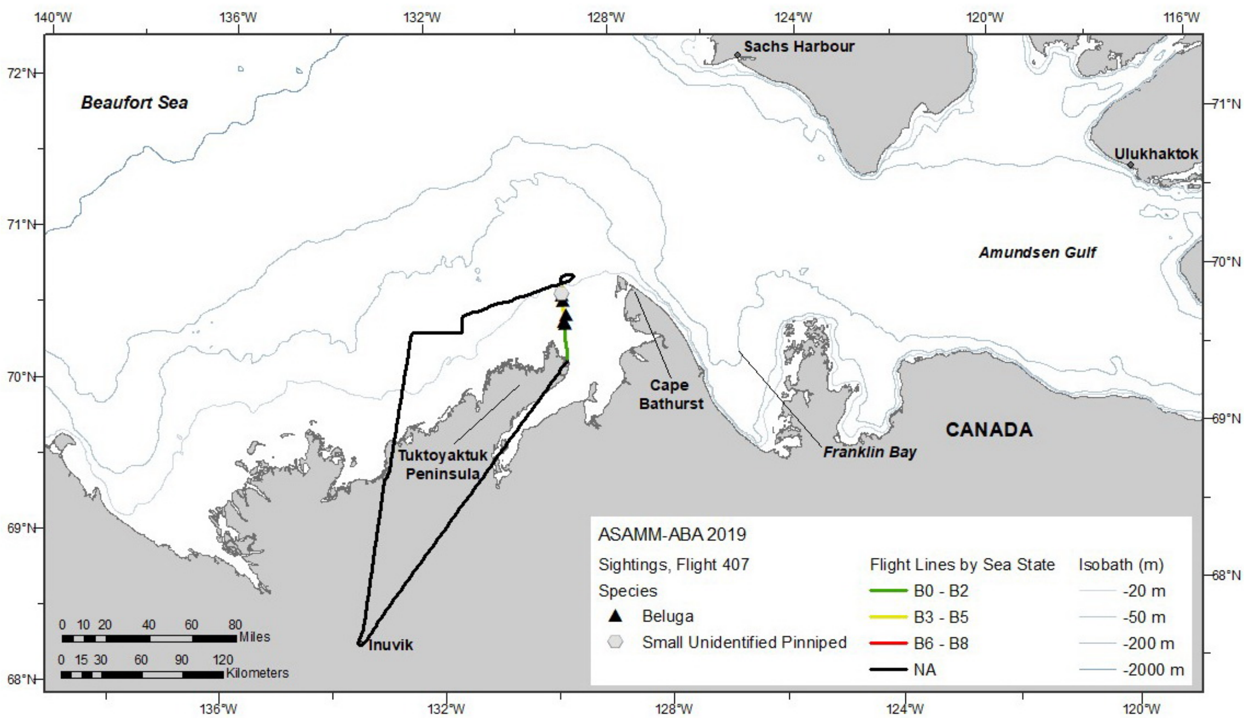


Figure B-48. Flight 407 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

21 August 2019, Flight 225

Flight was a complete survey of transects BCB434 and BCB435, and partial survey of transects BCB437, BCB438, BCB439, and BCB440. Survey conditions were clear, partly cloudy, and overcast skies, 0 km to unlimited visibility, with fog, glare, and low ceilings, and Beaufort 1-4 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales (including 13 calves), belugas (including three 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
225	8/21/2019 9:21	69.807	138.397	bowhead whale	swim	1	0	0
225	8/21/2019 9:24	69.812	138.378	bowhead whale	swim	2	1	0
225	8/21/2019 9:30	69.979	138.416	bowhead whale	rest	2	1	0
225	8/21/2019 9:35	69.987	138.434	bowhead whale	swim	2	1	0
225	8/21/2019 9:38	70.020	138.407	bowhead whale	rest	2	1	0
225	8/21/2019 9:42	70.091	138.408	bowhead whale	mill	3	2	0
225	8/21/2019 9:57	70.099	138.398	bowhead whale	rest	2	1	0
225	8/21/2019 9:57	70.101	138.406	bowhead whale	rest	2	1	0
225	8/21/2019 9:57	70.103	138.390	bowhead whale	rest	2	0	0
225	8/21/2019 9:59	70.099	138.420	bowhead whale	rest	1	1	0
225	8/21/2019 10:01	70.107	138.392	bowhead whale	rest	1	0	0
225	8/21/2019 10:03	70.122	138.368	bowhead whale	swim	1	0	0
225	8/21/2019 10:03	70.121	138.347	bowhead whale	swim	1	0	0
225	8/21/2019 10:06	70.117	138.292	bowhead whale	rest	1	0	0
225	8/21/2019 10:14	70.015	137.921	bowhead whale	rest	2	1	0
225	8/21/2019 10:18	69.940	137.897	bowhead whale	swim	1	0	0
225	8/21/2019 10:18	69.937	137.900	bowhead whale	rest	2	1	0
225	8/21/2019 10:24	69.823	137.912	bowhead whale	swim	2	0	0
225	8/21/2019 10:30	69.698	137.909	beluga	swim	1	0	0
225	8/21/2019 10:31	69.659	137.920	beluga	swim	1	0	0
225	8/21/2019 10:48	69.338	137.399	beluga	swim	1	0	0
225	8/21/2019 10:53	69.497	137.396	beluga	swim	2	1	0
225	8/21/2019 10:53	69.503	137.402	beluga	swim	1	0	0
225	8/21/2019 10:53	69.506	137.413	beluga	swim	1	0	0
225	8/21/2019 10:53	69.508	137.427	beluga	swim	1	0	0
225	8/21/2019 10:53	69.510	137.407	beluga	swim	1	0	0
225	8/21/2019 10:53	69.510	137.424	beluga	swim	1	0	0
225	8/21/2019 10:54	69.541	137.427	beluga	swim	1	0	0
225	8/21/2019 10:54	69.543	137.423	beluga	swim	2	0	0
225	8/21/2019 10:54	69.546	137.426	beluga	swim	2	0	0
225	8/21/2019 10:54	69.549	137.427	beluga	swim	1	0	0
225	8/21/2019 10:55	69.556	137.410	beluga	swim	1	0	0
225	8/21/2019 10:55	69.560	137.440	beluga	swim	1	0	0
225	8/21/2019 10:55	69.564	137.388	beluga	swim	1	0	0
225	8/21/2019 10:56	69.593	137.431	beluga	rest	1	0	0
225	8/21/2019 10:59	69.691	137.423	beluga	rest	1	0	0

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
225	8/21/2019 10:59	69.716	137.403	beluga	dive	1	0	0
225	8/21/2019 11:00	69.719	137.412	beluga	swim	1	0	0
225	8/21/2019 11:00	69.724	137.419	beluga	swim	2	1	0
225	8/21/2019 11:08	69.983	137.408	beluga	dive	1	0	0
225	8/21/2019 11:09	70.022	137.443	beluga	swim	1	0	0
225	8/21/2019 11:09	70.023	137.406	beluga	swim	1	0	0
225	8/21/2019 11:09	70.031	137.420	beluga	swim	1	0	0
225	8/21/2019 11:11	70.092	137.395	beluga	swim	1	0	0
225	8/21/2019 11:19	70.340	137.401	bowhead whale	swim	1	0	0
225	8/21/2019 11:19	70.348	137.395	bowhead whale	swim	1	1	0
225	8/21/2019 11:28	70.333	136.865	bowhead whale	rest	1	0	0
225	8/21/2019 11:28	70.331	136.912	bowhead whale	unknown	1	0	0
225	8/21/2019 11:36	70.170	136.927	beluga	swim	3	0	0
225	8/21/2019 11:37	70.160	136.922	beluga	swim	1	0	0
225	8/21/2019 11:41	70.032	136.880	beluga	swim	1	0	0
225	8/21/2019 11:41	70.027	136.893	beluga	swim	1	0	0
225	8/21/2019 14:21	69.972	135.416	beluga	swim	1	0	0
225	8/21/2019 14:27	70.145	135.343	beluga	swim	2	0	0
225	8/21/2019 14:39	70.516	135.402	bowhead whale	swim	2	1	0
225	8/21/2019 14:56	70.759	135.391	beluga	swim	1	0	0
225	8/21/2019 14:56	70.759	135.427	beluga	swim	1	0	0
225	8/21/2019 14:57	70.763	135.421	beluga	swim	1	0	0
225	8/21/2019 14:57	70.768	135.407	beluga	swim	1	0	0
225	8/21/2019 14:57	70.777	135.428	beluga	swim	1	0	0
225	8/21/2019 15:04	70.664	135.891	beluga	swim	1	0	0
225	8/21/2019 15:04	70.661	135.930	beluga	swim	1	0	0
225	8/21/2019 15:04	70.657	135.893	beluga	swim	1	0	0
225	8/21/2019 15:05	70.648	135.904	beluga	swim	2	0	0
225	8/21/2019 15:11	70.449	135.921	beluga	swim	2	1	0
225	8/21/2019 15:11	70.436	135.942	bowhead whale	swim	1	0	0
225	8/21/2019 15:22	70.221	135.923	beluga	swim	1	0	0
225	8/21/2019 15:22	70.211	135.902	beluga	swim	1	0	0
225	8/21/2019 15:24	70.156	135.943	beluga	swim	2	0	0
225	8/21/2019 15:30	69.963	135.901	beluga	swim	1	0	0
225	8/21/2019 15:35	69.786	135.917	beluga	swim	1	0	0

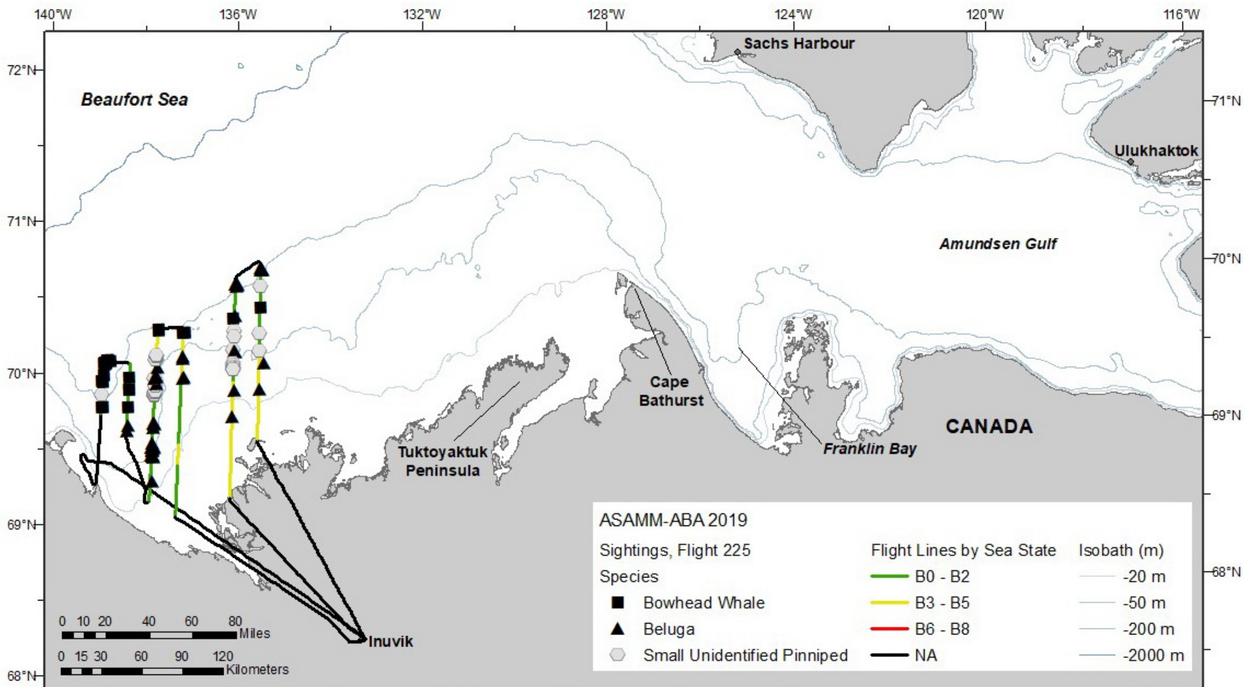


Figure B-49. Flight 225 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

This page intentionally left blank.

21 August 2019, Flight 18

Flight was a complete survey of transects BCB109, BCB110, BCB111, BCB112, BCB113, BCB116, and BCB124, partial survey of transects BCB114, BCB115, BCB122, and BCB123, and the coastal transect in Harrison Bay. Survey conditions included clear, partly cloudy, and overcast skies, <1-10 km visibility, with fog, glare, haze, low ceilings, and precipitation, and Beaufort 1-3 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales (including one carcass), belugas (including one calf), walruses, bearded seals, 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
18	8/21/2019 10:06	70.865	146.923	beluga	swim	1	0	2
18	8/21/2019 10:21	70.921	147.406	beluga	swim	9	0	2
18	8/21/2019 10:21	70.910	147.404	beluga	swim	1	0	2
18	8/21/2019 10:23	70.864	147.405	beluga	swim	2	0	2
18	8/21/2019 10:26	70.757	147.407	beluga	swim	12	0	1
18	8/21/2019 10:30	70.643	147.413	beluga	swim	24	0	1
18	8/21/2019 10:32	70.568	147.413	beluga	swim	1	0	1
18	8/21/2019 11:09	70.741	147.897	beluga	mill	17	0	1
18	8/21/2019 12:27	71.035	151.896	bowhead whale	swim	1	0	3
18	8/21/2019 12:28	71.017	151.904	bowhead whale	swim	1	0	3
18	8/21/2019 12:29	71.023	151.899	bowhead whale	swim	2	0	3
18	8/21/2019 12:30	71.023	151.877	bowhead whale	swim	1	0	3
18	8/21/2019 12:31	71.025	151.907	bowhead whale	swim	2	0	3
18	8/21/2019 12:32	71.027	151.892	bowhead whale	swim	1	0	3
18	8/21/2019 14:46	71.008	144.400	beluga	swim	1	0	6
18	8/21/2019 14:46	70.999	144.410	beluga	swim	1	0	6
18	8/21/2019 14:46	70.995	144.425	beluga	swim	2	0	6
18	8/21/2019 14:46	70.993	144.401	beluga	swim	1	0	6
18	8/21/2019 14:47	70.988	144.419	beluga	swim	2	0	6
18	8/21/2019 14:47	70.987	144.403	beluga	swim	1	0	6
18	8/21/2019 14:47	70.976	144.410	beluga	swim	1	0	6
18	8/21/2019 14:55	70.708	144.477	bowhead whale	swim	2	0	6
18	8/21/2019 15:00	70.597	144.395	beluga	swim	1	0	6
18	8/21/2019 15:11	70.216	144.398	beluga	swim	1	0	4
18	8/21/2019 15:11	70.209	144.401	beluga	swim	1	0	4
18	8/21/2019 15:11	70.204	144.419	beluga	swim	1	0	4
18	8/21/2019 15:11	70.198	144.420	beluga	swim	2	0	4
18	8/21/2019 15:12	70.193	144.403	beluga	swim	1	0	4
18	8/21/2019 15:12	70.187	144.396	beluga	swim	4	0	4
18	8/21/2019 15:28	70.185	144.901	beluga	swim	5	0	4
18	8/21/2019 15:33	70.345	144.884	beluga	swim	2	0	4
18	8/21/2019 15:34	70.380	144.897	beluga	swim	1	0	4
18	8/21/2019 15:41	70.621	144.868	beluga	rest	1	0	6
18	8/21/2019 15:46	70.787	144.906	bowhead whale	rest	1	0	6

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
18	8/21/2019 15:49	70.806	145.112	bowhead whale	swim	3	0	6
18	8/21/2019 16:18	70.059	145.400	beluga	swim	1	0	4
18	8/21/2019 16:41	70.694	145.850	bowhead whale	dead	1	0	6
18	8/21/2019 16:51	70.858	145.893	beluga	swim	1	0	6
18	8/21/2019 16:54	70.949	145.964	beluga	swim	2	0	6
18	8/21/2019 16:54	70.948	145.978	beluga	swim	2	1	6
18	8/21/2019 16:54	70.931	145.994	beluga	swim	1	0	6

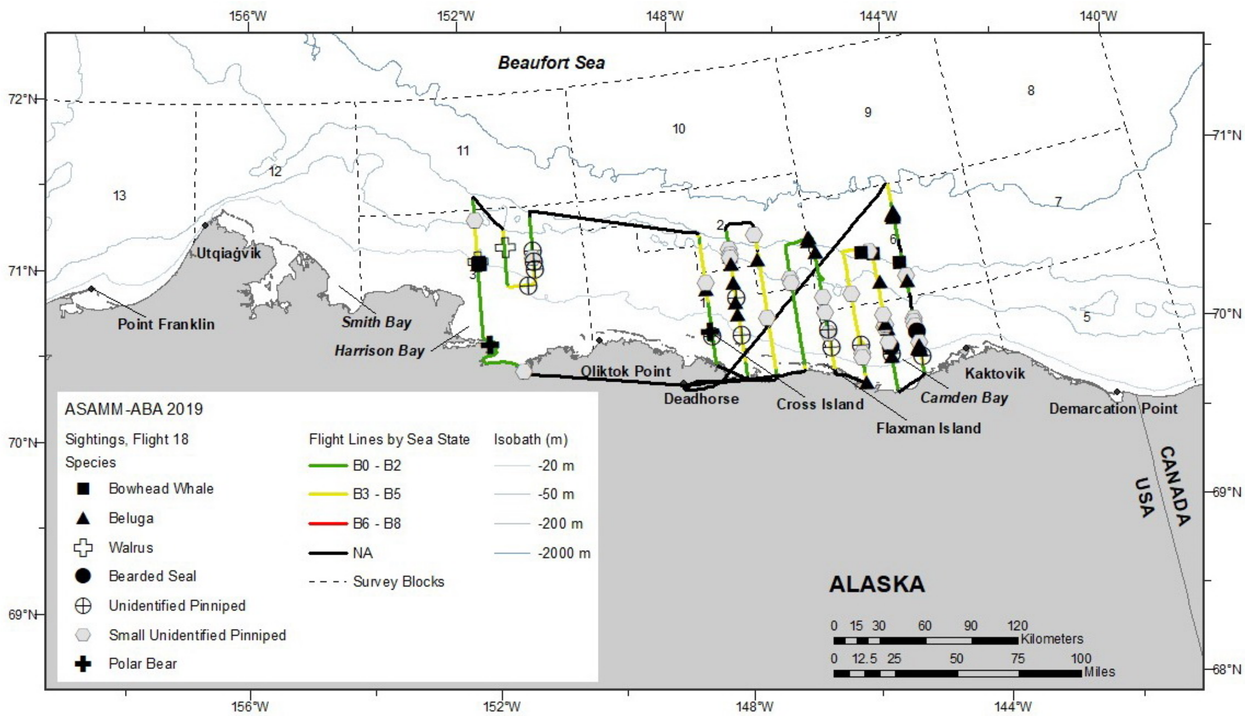


Figure B-50. Flight 18 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

21 August 2019, Flight 408

Flight was a complete survey of transects BCB421, BCB422, BCB428, and BCB429, and partial survey of transects BCB426 and BCB427. Survey conditions included clear, partly cloudy, and overcast skies, 5 km to unlimited visibility, with glare, and Beaufort 1-5 sea states. Sea ice was 0-80% broken floe in the area surveyed. Sightings included bowhead whales (including six calves), gray whales (including one calf), belugas (including one calf), 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
408	8/21/2019 8:53	70.394	128.935	beluga	swim	2	0	0
408	8/21/2019 9:00	70.592	128.904	beluga	swim	1	0	0
408	8/21/2019 9:00	70.608	128.900	beluga	swim	1	0	0
408	8/21/2019 9:01	70.631	128.913	beluga	swim	1	0	0
408	8/21/2019 9:01	70.641	128.935	beluga	swim	2	0	0
408	8/21/2019 9:08	70.857	128.904	beluga	rest	1	0	0
408	8/21/2019 9:27	71.290	128.911	bowhead whale	rest	1	0	0
408	8/21/2019 9:27	71.290	128.901	bowhead whale	mill	3	1	0
408	8/21/2019 9:29	71.282	128.932	bowhead whale	rest	1	1	0
408	8/21/2019 9:37	71.453	128.881	bowhead whale	swim	1	0	0
408	8/21/2019 9:50	71.763	128.892	beluga	swim	1	0	0
408	8/21/2019 9:54	71.886	128.914	beluga	swim	1	0	0
408	8/21/2019 9:57	71.980	128.937	beluga	swim	1	0	0
408	8/21/2019 10:04	71.870	129.391	beluga	swim	1	0	0
408	8/21/2019 10:04	71.870	129.381	beluga	swim	1	0	0
408	8/21/2019 10:05	71.851	129.465	beluga	swim	1	0	0
408	8/21/2019 10:06	71.813	129.414	bowhead whale	swim	1	0	0
408	8/21/2019 10:21	71.367	129.397	bowhead whale	rest	2	1	0
408	8/21/2019 10:36	71.039	129.414	bowhead whale	rest	1	0	0
408	8/21/2019 10:39	70.999	129.404	beluga	swim	1	0	0
408	8/21/2019 10:58	70.398	129.419	beluga	swim	1	0	0
408	8/21/2019 13:38	70.540	132.909	beluga	swim	1	0	0
408	8/21/2019 13:39	70.587	132.895	bowhead whale	swim	2	1	0
408	8/21/2019 13:43	70.677	132.888	bowhead whale	swim	2	1	0
408	8/21/2019 13:45	70.698	132.913	bowhead whale	swim	1	0	0
408	8/21/2019 13:48	70.732	132.903	bowhead whale	swim	1	0	0
408	8/21/2019 13:48	70.739	132.914	gray whale	feed	1	0	0
408	8/21/2019 13:53	70.771	132.895	gray whale	feed	1	0	0
408	8/21/2019 13:56	70.796	132.827	gray whale	feed	2	0	0
408	8/21/2019 13:58	70.783	132.820	gray whale	feed	1	0	0
408	8/21/2019 14:06	71.007	132.986	bowhead whale	feed	4	0	0
408	8/21/2019 14:07	71.018	132.907	bowhead whale	swim	3	1	0
408	8/21/2019 14:07	71.026	132.896	bowhead whale	swim	1	0	0
408	8/21/2019 14:14	71.054	132.925	beluga	swim	1	0	0
408	8/21/2019 14:36	70.879	132.396	beluga	swim	1	0	0

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
408	8/21/2019 14:36	70.875	132.395	beluga	swim	1	0	0
408	8/21/2019 14:36	70.873	132.408	bowhead whale	swim	2	0	0
408	8/21/2019 14:40	70.808	132.425	bowhead whale	dive	1	0	0
408	8/21/2019 14:45	70.624	132.383	bowhead whale	swim	1	0	0
408	8/21/2019 14:48	70.578	132.434	bowhead whale	swim	1	0	0
408	8/21/2019 14:54	70.434	132.415	bowhead whale	dive	1	0	0
408	8/21/2019 15:10	69.944	132.407	beluga	swim	1	0	0
408	8/21/2019 15:31	70.083	131.903	beluga	swim	1	0	0
408	8/21/2019 15:31	70.086	131.917	beluga	swim	1	0	0
408	8/21/2019 15:35	70.222	131.899	beluga	swim	2	0	0
408	8/21/2019 15:38	70.320	131.946	gray whale	swim	3	1	0
408	8/21/2019 15:45	70.312	131.931	gray whale	feed	2	0	0
408	8/21/2019 15:48	70.408	131.914	gray whale	feed	1	0	0
408	8/21/2019 15:55	70.476	131.976	gray whale	swim	4	0	0
408	8/21/2019 15:58	70.461	131.963	bowhead whale	swim	1	0	0
408	8/21/2019 16:06	70.557	131.767	bowhead whale	rest	1	0	0
408	8/21/2019 16:07	70.538	131.633	bowhead whale	swim	1	0	0
408	8/21/2019 16:13	70.377	131.405	beluga	swim	2	1	0
408	8/21/2019 16:25	70.011	131.410	beluga	swim	1	0	0

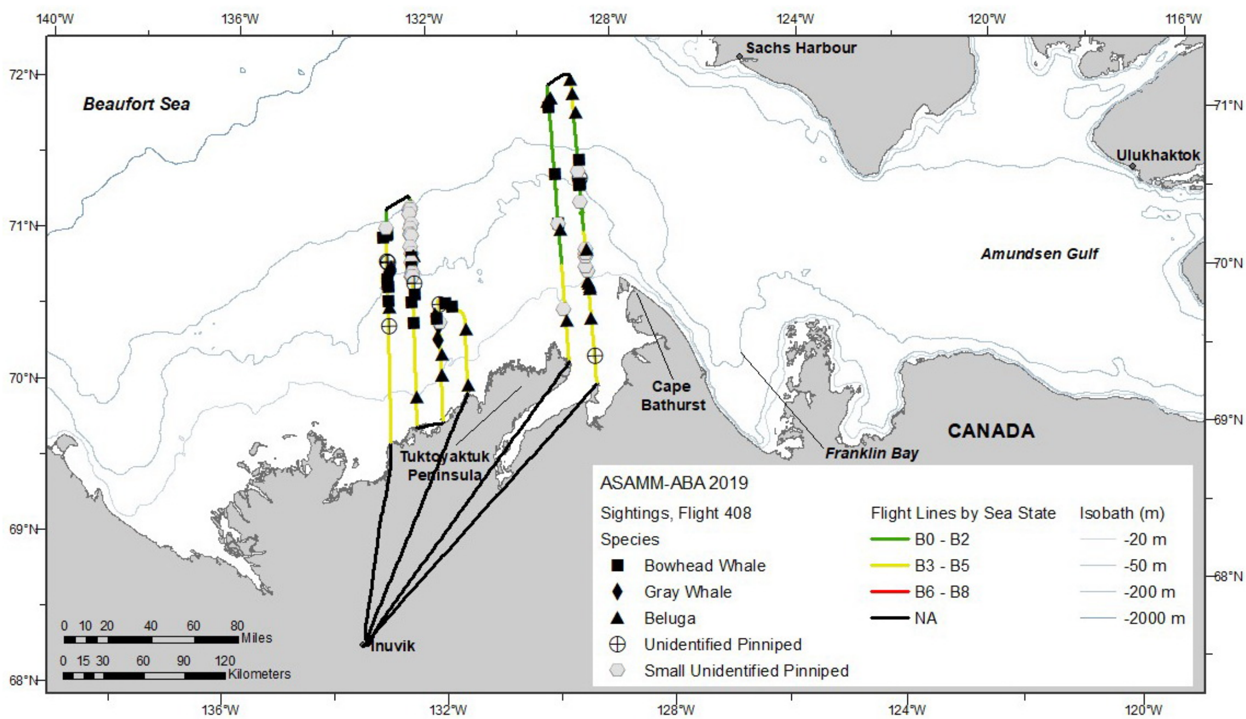
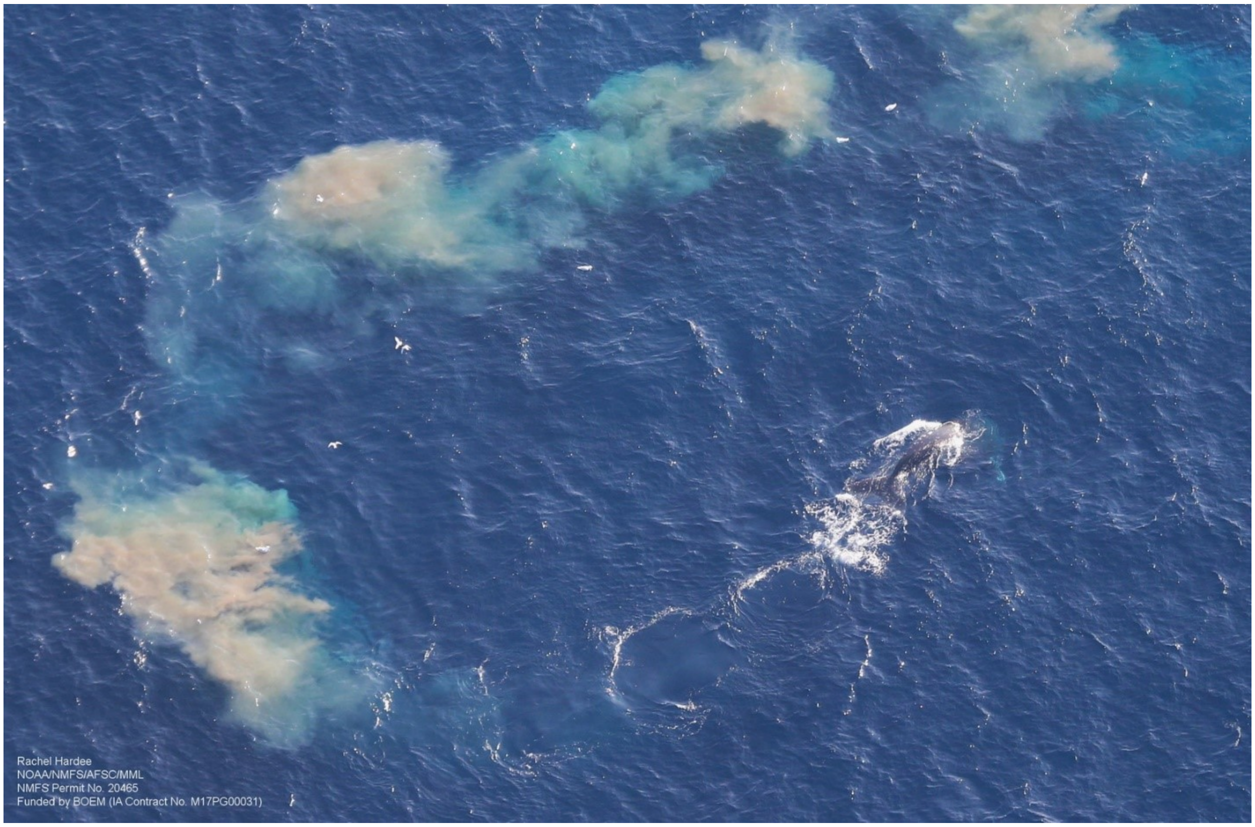


Figure B-51. Flight 408 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.



One of 15 gray whales sighted in two groups north of the Tuktoyaktuk Peninsula, Northwest Territories, Canada, Flight 408, 21 August 2019.

This page intentionally left blank.

22 August 2019, Flight 226

Flight was a complete survey of transects BCB101 and BCB102, and partial survey of transects BCB441, BCB442, and BCB443. Survey conditions included overcast skies, 0 km to unlimited visibility, with fog, low ceilings, and precipitation, and Beaufort 2-4 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales (including four calves), belugas (including two 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
226	8/22/2019 10:43	69.845	140.916	beluga	swim	1	0	5
226	8/22/2019 10:45	69.898	140.901	beluga	rest	1	0	5
226	8/22/2019 10:47	69.959	140.917	beluga	swim	1	0	5
226	8/22/2019 10:47	69.976	140.921	beluga	swim	1	0	5
226	8/22/2019 10:48	69.976	140.908	beluga	swim	1	0	5
226	8/22/2019 10:52	70.122	140.931	bowhead whale	mill	4	0	5
226	8/22/2019 10:57	70.204	140.899	bowhead whale	swim	1	0	5
226	8/22/2019 11:09	70.529	140.919	beluga	swim	1	0	7
226	8/22/2019 11:11	70.614	140.928	beluga	swim	2	0	7
226	8/22/2019 11:11	70.615	140.928	beluga	swim	1	0	7
226	8/22/2019 11:11	70.617	140.929	beluga	swim	1	0	7
226	8/22/2019 11:12	70.629	140.931	beluga	swim	1	0	7
226	8/22/2019 11:12	70.635	140.927	beluga	swim	1	0	7
226	8/22/2019 11:12	70.641	140.925	beluga	swim	1	0	7
226	8/22/2019 11:13	70.667	140.899	beluga	swim	2	1	7
226	8/22/2019 11:16	70.767	140.919	beluga	swim	1	0	7
226	8/22/2019 11:17	70.793	140.918	beluga	swim	1	0	7
226	8/22/2019 11:17	70.798	140.924	beluga	swim	2	0	7
226	8/22/2019 11:39	69.993	140.398	beluga	swim	1	0	5
226	8/22/2019 12:03	69.766	139.911	beluga	swim	2	1	0
226	8/22/2019 12:09	69.995	139.892	bowhead whale	mill	3	1	0
226	8/22/2019 12:15	70.070	139.906	bowhead whale	swim	1	0	0
226	8/22/2019 12:21	70.237	139.917	beluga	swim	1	0	0
226	8/22/2019 12:21	70.248	139.930	beluga	swim	1	0	0
226	8/22/2019 12:21	70.251	139.908	beluga	swim	1	0	0
226	8/22/2019 12:22	70.264	139.904	beluga	swim	1	0	0
226	8/22/2019 12:22	70.267	139.931	beluga	swim	1	0	0
226	8/22/2019 12:23	70.314	139.919	beluga	swim	1	0	0
226	8/22/2019 12:24	70.326	139.915	beluga	swim	1	0	0
226	8/22/2019 12:39	70.045	139.438	bowhead whale	swim	1	0	0
226	8/22/2019 12:46	69.894	139.406	bowhead whale	swim	1	0	0
226	8/22/2019 12:58	69.820	138.904	bowhead whale	unknown	1	0	0
226	8/22/2019 12:58	69.821	138.891	bowhead whale	rest	2	1	0
226	8/22/2019 13:04	69.858	138.929	bowhead whale	rest	1	0	0
226	8/22/2019 13:04	69.862	138.928	bowhead whale	mill	2	2	0
226	8/22/2019 13:07	69.897	138.972	bowhead whale	swim	1	0	0

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
226	8/22/2019 13:15	70.131	138.893	beluga	mill	2	0	0
226	8/22/2019 13:15	70.136	138.889	beluga	swim	3	0	0
226	8/22/2019 13:15	70.146	138.901	beluga	swim	1	0	0
226	8/22/2019 13:15	70.149	138.915	beluga	swim	1	0	0

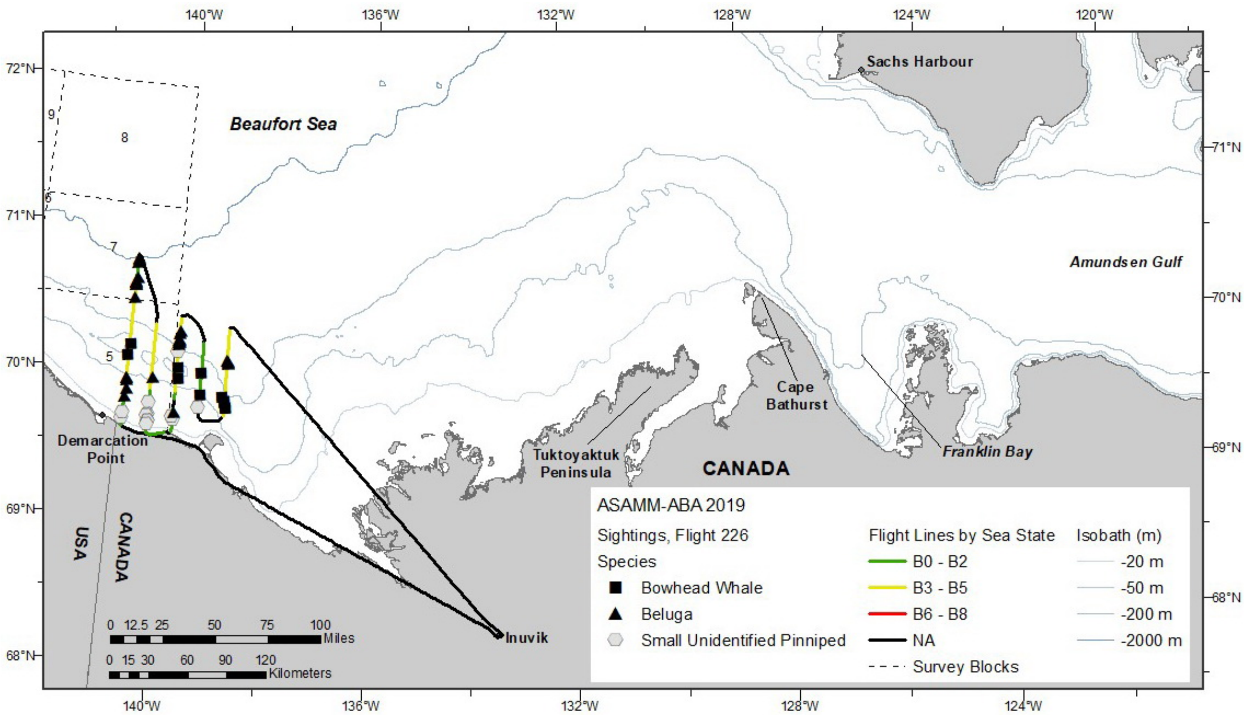


Figure B-52. Flight 226 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

This page intentionally left blank.

22 August 2019, Flight 19

Flight was a complete survey of transect BCB125, partial survey of transects BCB126, BCB127, and BCB128, and the coastal transect from Smith Bay to Harrison Bay. Survey conditions included 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. Sightings included one bowhead whale carcass 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
19	8/22/2019 14:36	70.884	153.860	bowhead whale	dead	1	0	3

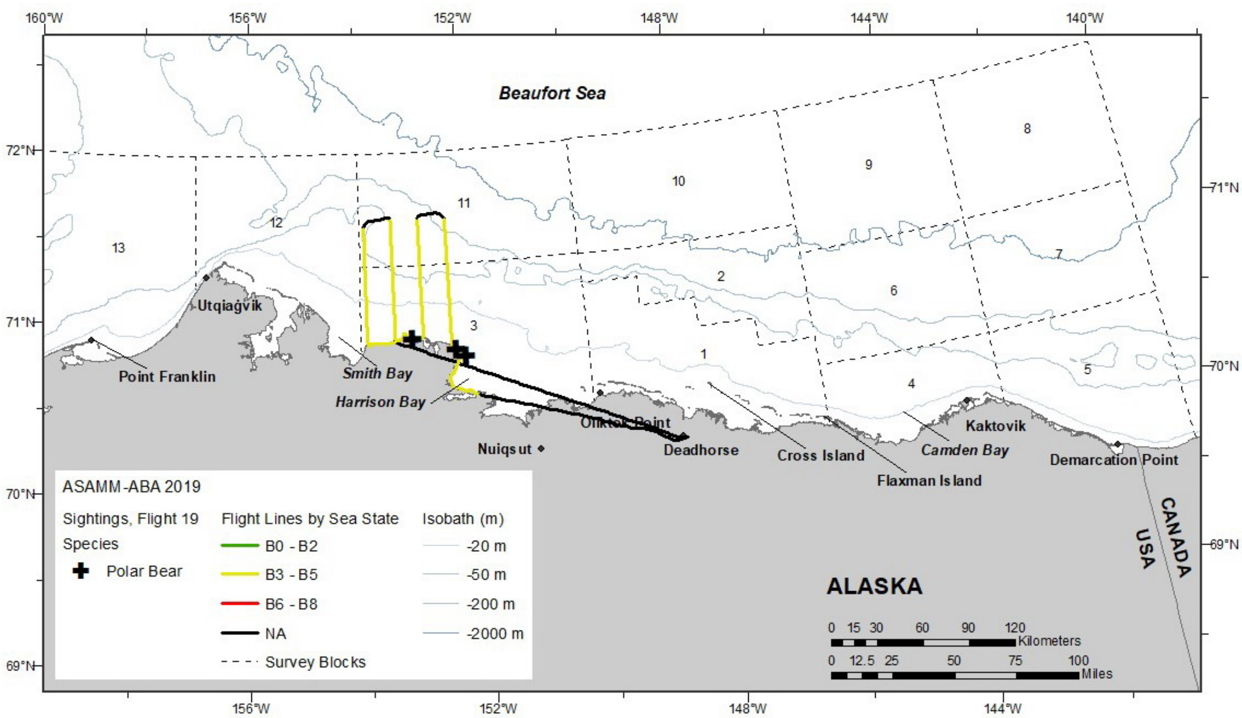


Figure B-53. Flight 19 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

22 August 2019, Flight 409

Flight was a complete survey of transects BCB430 and BCB431, partial survey of transect BCB432, and a series of field-of-view transects with a terrestrial target north of Inuvik, Northwest Territories, Canada to estimate field-of-view from the survey aircraft. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with low ceilings, and Beaufort 1-3 sea states. Sea ice was 0-1% broken floe in the area surveyed. Sightings including bowhead whales (including eight calves), belugas (including one calf), unidentified cetaceans, 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
409	8/22/2019 9:05	69.763	133.419	beluga	swim	1	0	0
409	8/22/2019 9:15	70.073	133.405	beluga	swim	1	0	0
409	8/22/2019 9:25	70.410	133.411	bowhead whale	log play	5	0	0
409	8/22/2019 9:26	70.417	133.367	bowhead whale	rest	1	0	0
409	8/22/2019 9:35	70.519	133.419	bowhead whale	rest	4	2	0
409	8/22/2019 9:42	70.587	133.392	bowhead whale	rest	1	1	0
409	8/22/2019 9:44	70.597	133.414	bowhead whale	swim	1	1	0
409	8/22/2019 9:45	70.630	133.383	unid cetacean	unknown	1	0	0
409	8/22/2019 9:51	70.673	133.349	bowhead whale	swim	2	0	0
409	8/22/2019 9:51	70.674	133.388	bowhead whale	unknown	2	0	0
409	8/22/2019 9:58	70.736	133.401	bowhead whale	swim	1	1	0
409	8/22/2019 10:05	70.804	133.411	bowhead whale	swim	1	0	0
409	8/22/2019 10:10	70.819	133.439	bowhead whale	swim	1	0	0
409	8/22/2019 10:13	70.824	133.414	bowhead whale	swim	1	0	0
409	8/22/2019 10:16	70.870	133.508	bowhead whale	swim	1	0	0
409	8/22/2019 10:22	71.071	133.435	beluga	swim	1	0	0
409	8/22/2019 10:30	71.027	133.924	beluga	swim	2	1	0
409	8/22/2019 10:43	70.651	133.793	bowhead whale	swim	4	0	0
409	8/22/2019 10:47	70.543	133.889	bowhead whale	swim	2	1	0
409	8/22/2019 10:52	70.430	133.858	bowhead whale	swim	1	0	0
409	8/22/2019 10:52	70.423	133.895	bowhead whale	mill	2	1	0
409	8/22/2019 10:57	70.384	133.898	bowhead whale	rest	1	0	0
409	8/22/2019 11:10	70.019	133.900	beluga	swim	1	0	0
409	8/22/2019 11:11	69.992	133.912	beluga	swim	1	0	0
409	8/22/2019 11:22	69.624	133.915	beluga	swim	1	0	0
409	8/22/2019 11:23	69.616	133.913	beluga	swim	1	0	0
409	8/22/2019 11:32	69.841	134.407	beluga	swim	1	0	0
409	8/22/2019 11:32	69.848	134.396	beluga	swim	1	0	0
409	8/22/2019 11:33	69.881	134.402	unid cetacean	swim	1	0	0
409	8/22/2019 11:41	69.978	134.395	beluga	swim	1	0	0
409	8/22/2019 11:42	70.017	134.408	beluga	swim	1	0	0
409	8/22/2019 11:42	70.019	134.414	beluga	swim	1	0	0
409	8/22/2019 11:43	70.026	134.408	beluga	swim	2	0	0
409	8/22/2019 11:52	70.328	134.409	bowhead whale	swim	2	1	0

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
409	8/22/2019 11:57	70.400	134.498	bowhead whale	swim	2	0	0
409	8/22/2019 12:00	70.491	134.401	bowhead whale	swim	1	0	0
409	8/22/2019 12:03	70.534	134.402	bowhead whale	swim	1	0	0

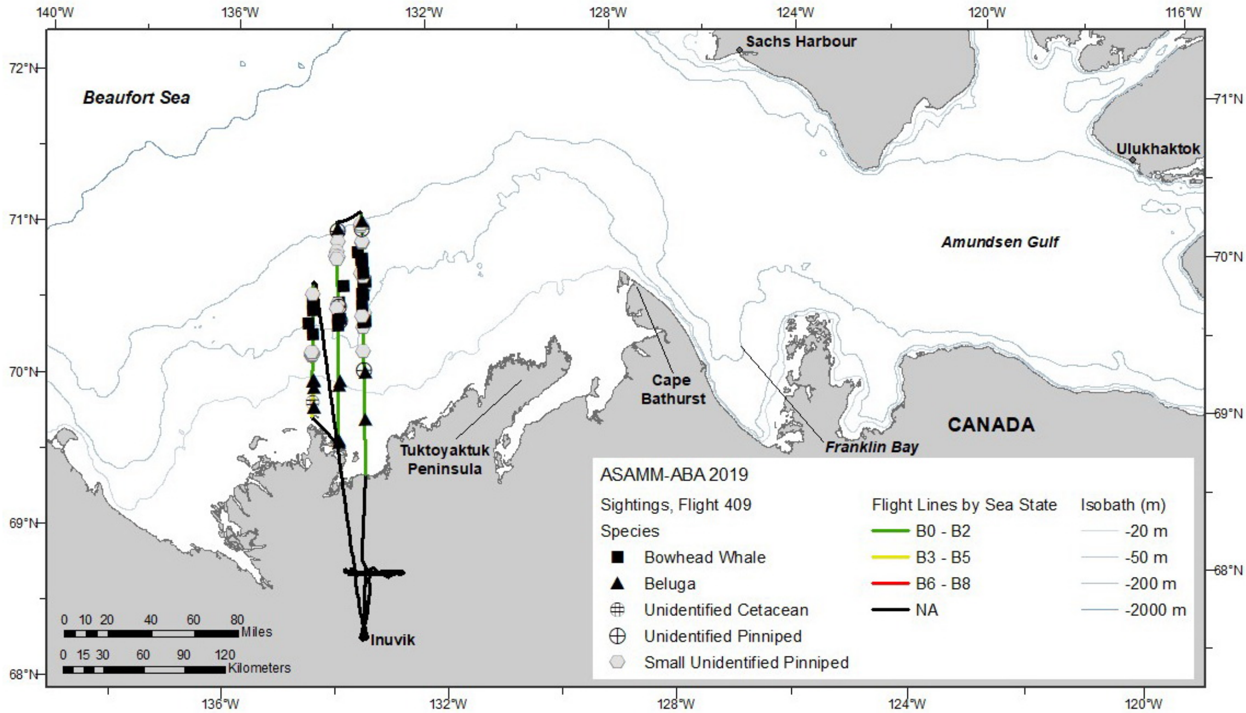


Figure B-54. Flight 409 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

23 August 2019, Flight 227

Flight was a partial survey of transect BCB424 and nominal effort on transect BCB425. Survey conditions included overcast skies, 0-5 km visibility, with low ceilings, and Beaufort 3-5 sea states. There was no sea ice in the area surveyed. There were no marine mammal sightings.

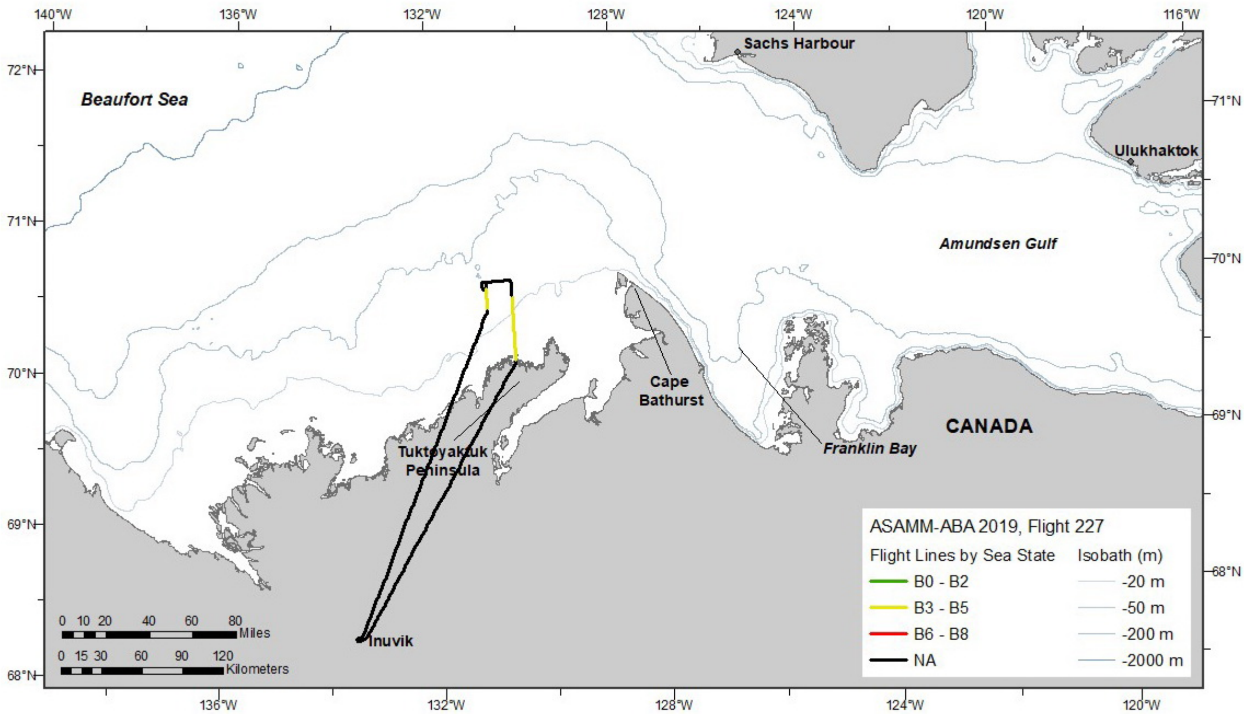


Figure B-55. Flight 227 survey track, depicted by sea state.

23 August 2019, Flight 410

Flight was a partial survey of transects BCB433, BCB434, BCB436, and BCB437. Survey conditions included 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 bowhead whales, 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
410	8/23/2019 8:36	69.880	136.407	beluga	swim	1	0	0
410	8/23/2019 8:50	70.325	136.749	bowhead whale	mill	3	0	0
410	8/23/2019 8:52	70.372	136.896	beluga	swim	1	0	0
410	8/23/2019 9:10	69.809	136.925	bowhead whale	swim	1	0	0
410	8/23/2019 9:37	69.985	135.421	bowhead whale	breach	1	0	0

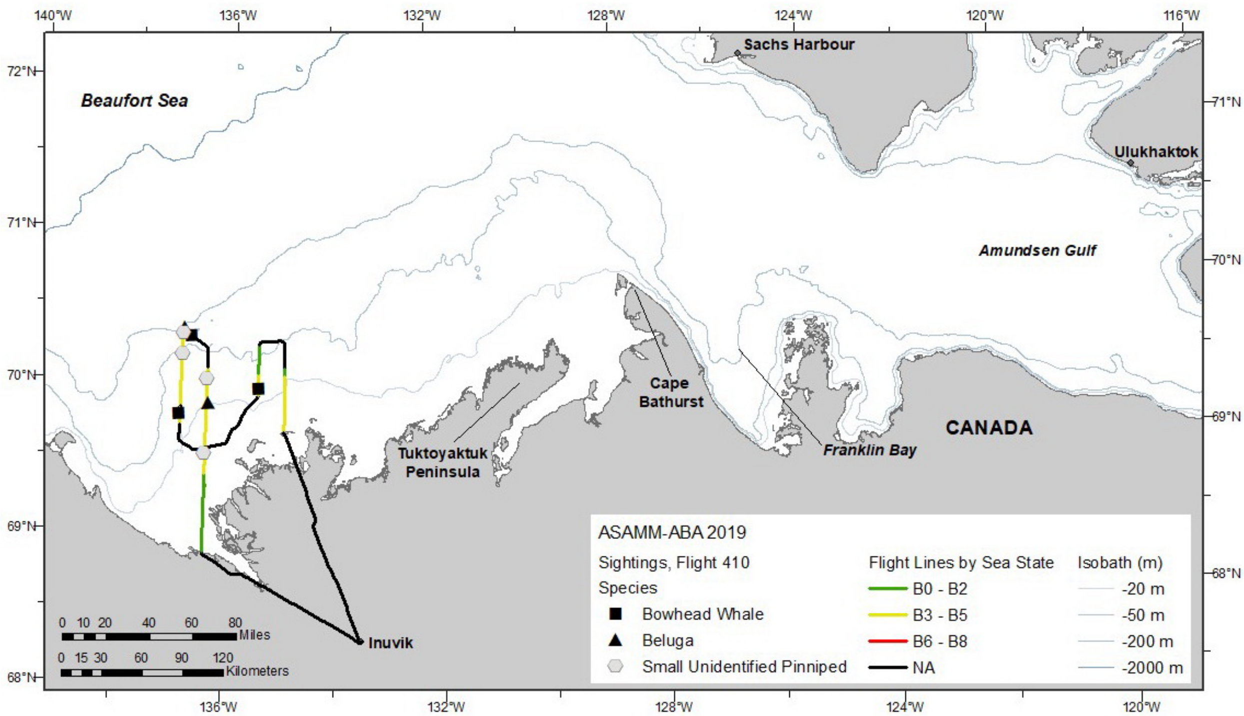


Figure B-56. Flight 410 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

25 August 2019, Flight 228

Flight was a complete survey of transects BCB418, BCB492, and BCB493, and partial survey of transect BCB420. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with fog, glare, low ceilings, and precipitation, and Beaufort 1-5 sea states. Sea ice was 0-70% broken floe ice in the area surveyed. Sightings included bowhead whales, belugas, 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
228	8/25/2019 14:47	71.682	128.411	beluga	swim	1	0	0
228	8/25/2019 14:50	71.769	128.415	beluga	swim	1	0	0
228	8/25/2019 15:16	72.180	127.684	beluga	swim	1	0	0
228	8/25/2019 16:03	72.354	128.244	beluga	swim	1	0	0
228	8/25/2019 16:03	72.346	128.254	beluga	swim	1	0	0
228	8/25/2019 16:07	72.353	128.607	beluga	swim	1	0	0
228	8/25/2019 16:39	71.486	127.411	beluga	swim	2	0	0
228	8/25/2019 16:41	71.448	127.421	beluga	swim	1	0	0
228	8/25/2019 16:41	71.422	127.398	bowhead whale	rest	1	0	0
228	8/25/2019 16:45	71.330	127.386	bowhead whale	swim	1	0	0
228	8/25/2019 16:53	71.161	127.409	beluga	swim	3	0	0
228	8/25/2019 17:07	70.721	127.412	beluga	rest	1	0	0
228	8/25/2019 17:15	70.443	127.405	beluga	swim	1	0	0
228	8/25/2019 17:17	70.377	127.499	beluga	swim	3	0	0

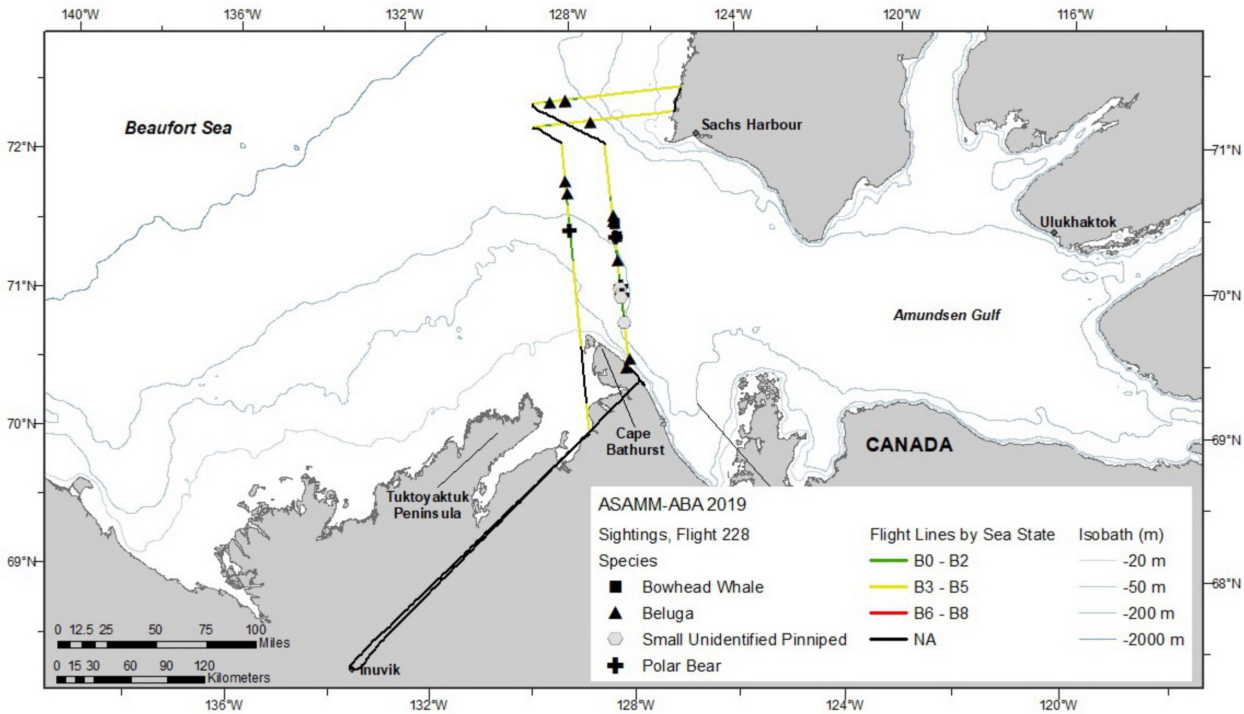


Figure B-57. Flight 228 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

This page intentionally left blank.

25 August 2019, Flight 20

Flight was a partial survey of transects BCB103, BCB104, BCB105, and BCB106, and the coastal transect from approximately 25 km east of Kaktovik to Camden Bay. Survey conditions included partly cloudy and overcast skies, 0-10 km visibility, with fog, glare, haze, low ceilings, and precipitation, and Beaufort 2-5 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales, one beluga, 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
20	8/25/2019 15:46	70.304	141.896	bowhead whale	swim	1	0	5
20	8/25/2019 15:55	70.240	141.911	bowhead whale	swim	1	0	5
20	8/25/2019 16:28	70.320	142.406	bowhead whale	swim	2	0	5
20	8/25/2019 16:29	70.323	142.380	bowhead whale	swim	1	0	5
20	8/25/2019 16:34	70.297	142.551	bowhead whale	swim	1	0	5
20	8/25/2019 16:35	70.299	142.573	bowhead whale	swim	2	0	5
20	8/25/2019 17:09	70.044	144.428	beluga	dive	1	0	4

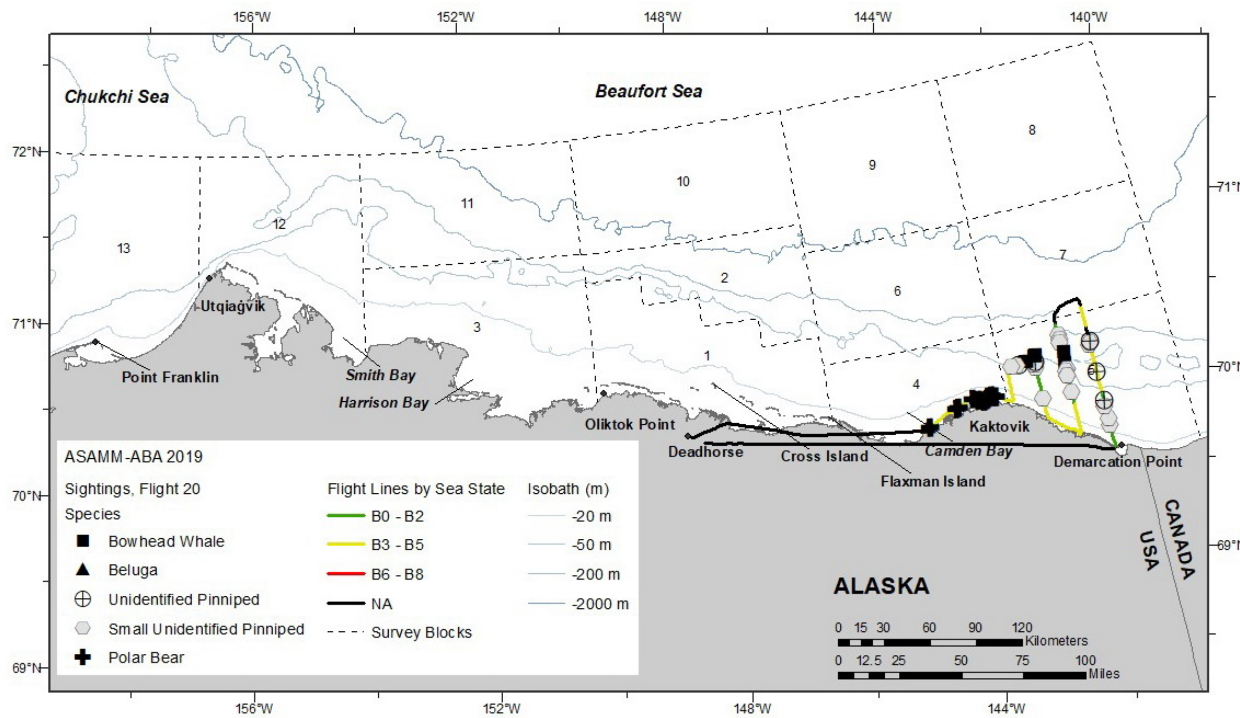


Figure B-58. Flight 20 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

25 August 2019, Flight 411

Flight was a complete survey of transect BCB439, and partial survey of transects BCB436, BCB437, BCB438, BCB440, and BCB441. 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. There was no sea ice in the area surveyed. Sightings included bowhead whales (including four 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
411	8/25/2019 10:43	69.645	138.421	bowhead whale	swim	2	1	0
411	8/25/2019 10:49	69.460	138.403	beluga	swim	1	0	0
411	8/25/2019 11:20	69.678	137.898	bowhead whale	swim	2	1	0
411	8/25/2019 11:20	69.682	137.921	bowhead whale	swim	1	0	0
411	8/25/2019 11:24	69.685	137.925	bowhead whale	swim	1	0	0
411	8/25/2019 11:26	69.711	137.930	bowhead whale	swim	1	0	0
411	8/25/2019 11:28	69.695	137.901	bowhead whale	swim	1	0	0
411	8/25/2019 11:29	69.730	137.893	bowhead whale	swim	2	1	0
411	8/25/2019 11:30	69.744	137.918	bowhead whale	swim	1	0	0
411	8/25/2019 11:35	69.804	137.888	bowhead whale	swim	1	0	0
411	8/25/2019 11:40	69.877	137.898	bowhead whale	SAG	3	0	0
411	8/25/2019 11:43	69.903	137.920	bowhead whale	swim	1	0	0
411	8/25/2019 11:48	69.955	137.851	bowhead whale	swim	2	1	0
411	8/25/2019 12:13	69.869	137.413	bowhead whale	swim	1	0	0
411	8/25/2019 12:51	68.941	136.920	beluga	swim	1	0	0

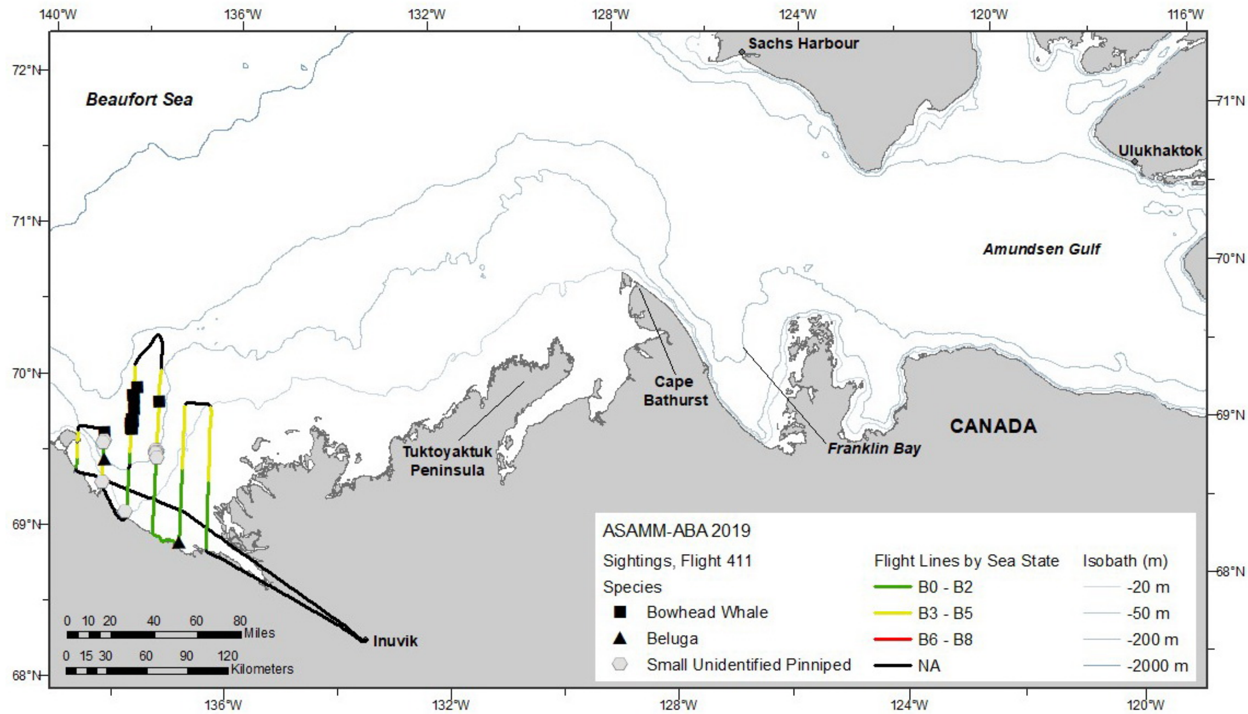


Figure B-59. Flight 411 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

26 August 2019, Flight 229

Flight was a partial survey of transects BCB408, BCB409, BCB410, and BCB411. 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. There was no sea ice in the area surveyed. Sightings included belugas, 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
229	8/26/2019 11:38	70.726	122.922	beluga	swim	1	0	0
229	8/26/2019 11:40	70.645	122.940	beluga	swim	1	0	0
229	8/26/2019 11:46	70.473	122.917	beluga	swim	1	0	0
229	8/26/2019 11:47	70.441	122.913	beluga	rest	1	0	0
229	8/26/2019 11:47	70.427	122.948	beluga	swim	1	0	0
229	8/26/2019 11:48	70.406	122.912	beluga	swim	1	0	0
229	8/26/2019 11:48	70.397	122.909	beluga	swim	1	0	0
229	8/26/2019 11:48	70.396	122.908	beluga	swim	2	0	0
229	8/26/2019 11:48	70.388	122.930	beluga	swim	2	0	0
229	8/26/2019 11:48	70.387	122.916	beluga	swim	1	0	0
229	8/26/2019 11:49	70.381	122.927	beluga	swim	4	0	0
229	8/26/2019 11:49	70.374	122.909	beluga	swim	1	0	0
229	8/26/2019 11:49	70.370	122.904	beluga	swim	1	0	0
229	8/26/2019 11:50	70.333	122.936	beluga	swim	1	0	0
229	8/26/2019 12:06	70.047	122.934	beluga	swim	1	0	0
229	8/26/2019 12:28	70.460	123.408	beluga	swim	1	0	0
229	8/26/2019 12:30	70.524	123.393	beluga	swim	1	0	0
229	8/26/2019 12:30	70.525	123.396	beluga	swim	1	0	0
229	8/26/2019 12:30	70.529	123.389	beluga	swim	1	0	0
229	8/26/2019 12:35	70.687	123.404	beluga	swim	1	0	0
229	8/26/2019 12:35	70.699	123.424	beluga	swim	3	0	0
229	8/26/2019 12:39	70.825	123.414	beluga	swim	5	0	0
229	8/26/2019 12:42	70.916	123.433	beluga	swim	1	0	0
229	8/26/2019 13:22	71.014	123.916	beluga	swim	1	0	0

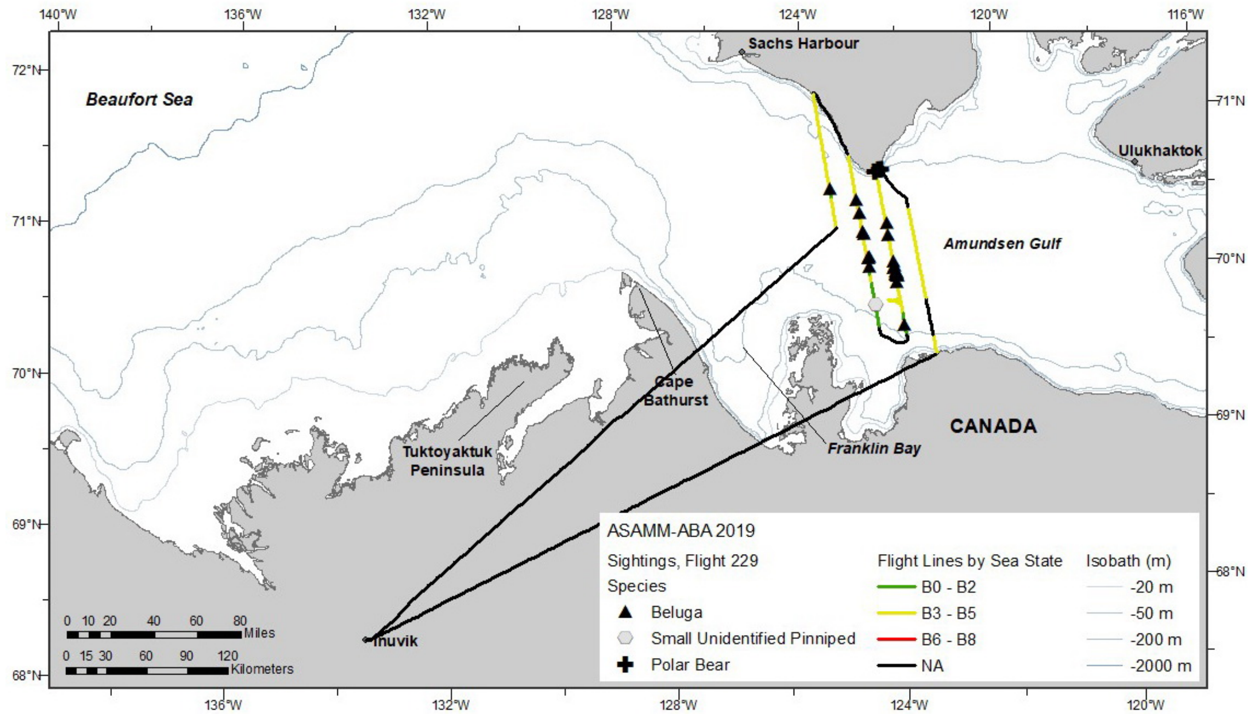


Figure B-60. Flight 229 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

This page intentionally left blank.

26 August 2019, Flight 21

Flight was a complete survey of transects BCB129, BCB131, BCB132, BCB133, and BCB134, and partial survey of transect BCB130. Survey conditions included partly cloudy to overcast skies, 2-10 km visibility, with glare, haze, low ceilings, and precipitation, and Beaufort 2-6 sea states. There was no sea ice in the area surveyed. Sightings included one beluga, one walrus, 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
21	8/26/2019 17:40	71.313	156.914	beluga	swim	1	0	12

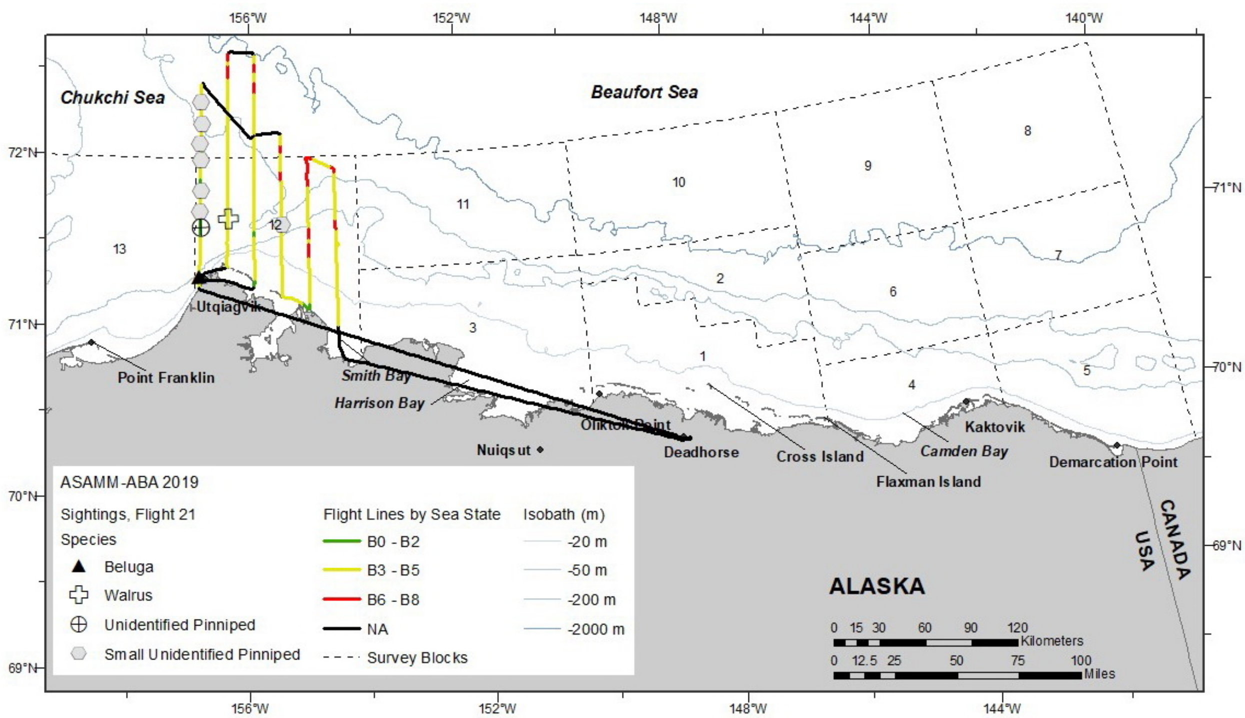


Figure B-61. Flight 21 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

26 August 2019, Flight 412

Flight was a complete survey of transect BCB440 and BCB441, and partial survey of transects BCB435, BCB436, and BCB437. Survey conditions included overcast skies, 0 km to unlimited visibility, with fog, glare, low ceilings, and precipitation, and Beaufort 2-5 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales (including 11 calves), belugas (including one calf), 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
412	8/26/2019 12:30	69.525	138.908	beluga	swim	1	0	0
412	8/26/2019 12:30	69.526	138.907	beluga	swim	1	0	0
412	8/26/2019 12:31	69.531	138.895	beluga	swim	1	0	0
412	8/26/2019 12:31	69.535	138.913	beluga	swim	2	1	0
412	8/26/2019 12:33	69.619	138.905	beluga	swim	1	0	0
412	8/26/2019 12:40	69.828	138.930	bowhead whale	swim	1	0	0
412	8/26/2019 12:43	69.864	138.941	bowhead whale	swim	1	0	0
412	8/26/2019 12:45	69.854	138.908	bowhead whale	swim	1	0	0
412	8/26/2019 12:52	70.043	138.916	bowhead whale	swim	1	0	0
412	8/26/2019 12:57	70.093	138.891	bowhead whale	mill	3	0	0
412	8/26/2019 12:58	70.089	138.892	bowhead whale	mill	3	2	0
412	8/26/2019 13:00	70.107	138.877	beluga	swim	1	0	0
412	8/26/2019 13:01	70.132	138.878	bowhead whale	swim	2	1	0
412	8/26/2019 13:04	70.153	138.909	beluga	swim	1	0	0
412	8/26/2019 13:05	70.192	138.902	beluga	swim	4	0	0
412	8/26/2019 13:18	70.261	138.394	beluga	swim	1	0	0
412	8/26/2019 13:21	70.139	138.383	bowhead whale	swim	2	1	0
412	8/26/2019 13:24	70.115	138.415	bowhead whale	swim	1	1	0
412	8/26/2019 13:30	70.068	138.359	bowhead whale	breach	1	0	0
412	8/26/2019 13:38	69.935	138.436	bowhead whale	mill	2	1	0
412	8/26/2019 13:41	69.921	138.462	bowhead whale	swim	1	0	0
412	8/26/2019 13:41	69.919	138.458	bowhead whale	mill	2	1	0
412	8/26/2019 13:45	69.893	138.408	bowhead whale	swim	1	0	0
412	8/26/2019 13:45	69.893	138.397	bowhead whale	mill	2	2	0
412	8/26/2019 13:53	69.875	138.422	bowhead whale	rest	1	1	0
412	8/26/2019 14:06	69.643	138.419	bowhead whale	swim	2	1	0
412	8/26/2019 14:07	69.619	138.412	bowhead whale	swim	1	0	0
412	8/26/2019 14:08	69.617	138.426	bowhead whale	swim	1	0	0
412	8/26/2019 14:11	69.619	138.408	bowhead whale	swim	1	0	0
412	8/26/2019 14:58	70.457	136.663	bowhead whale	swim	1	0	0

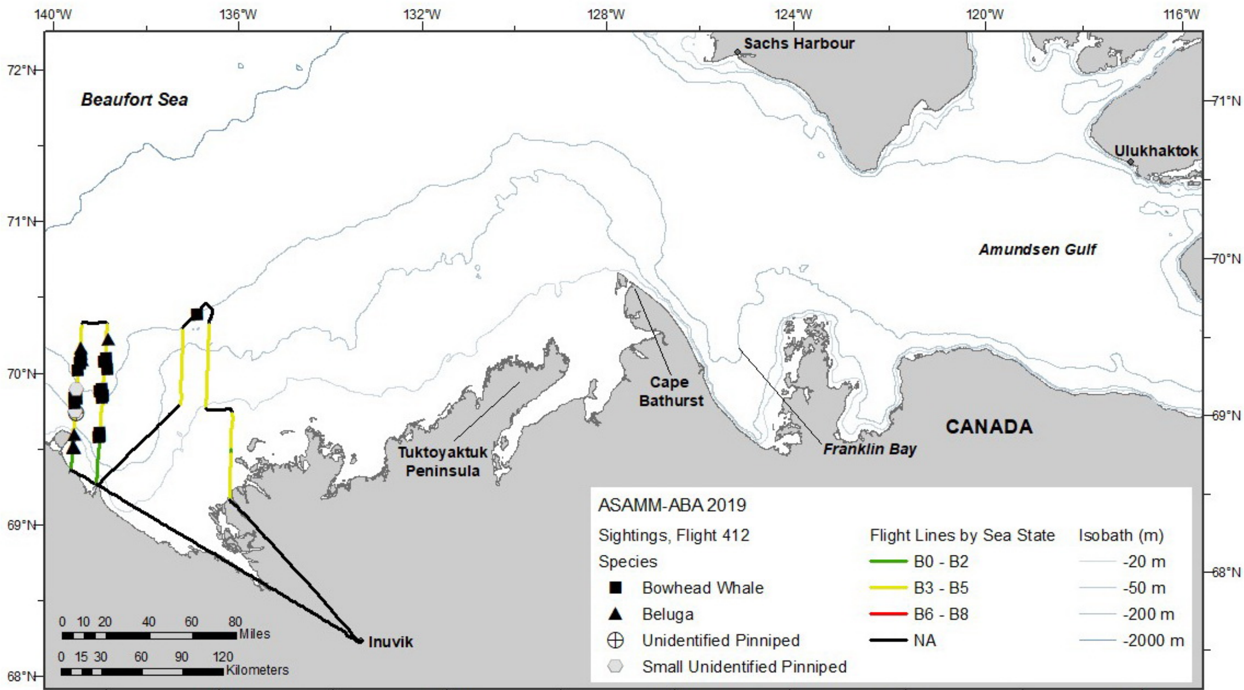


Figure B-62. Flight 412 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

This page intentionally left blank.

27 August 2019, Flight 230

Flight was a partial survey of transects BCB419, BCB422, and BCB490. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare and low ceilings, and Beaufort 0-5 sea states. Sea ice was 0-90% broken floe ice in the area surveyed. Sightings included bowhead whales (including one calf), belugas (including one calf), unidentified pinnipeds, 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
230	8/27/2019 8:35	70.834	129.408	beluga	swim	2	1	0
230	8/27/2019 8:37	70.894	129.427	beluga	swim	1	0	0
230	8/27/2019 10:18	71.359	127.911	beluga	swim	1	0	0
230	8/27/2019 10:23	71.220	127.903	bowhead whale	swim	1	0	0
230	8/27/2019 10:33	70.930	127.935	bowhead whale	rest	1	0	0
230	8/27/2019 10:37	70.901	127.934	bowhead whale	rest	1	0	0
230	8/27/2019 10:41	70.850	127.896	bowhead whale	rest	2	1	0

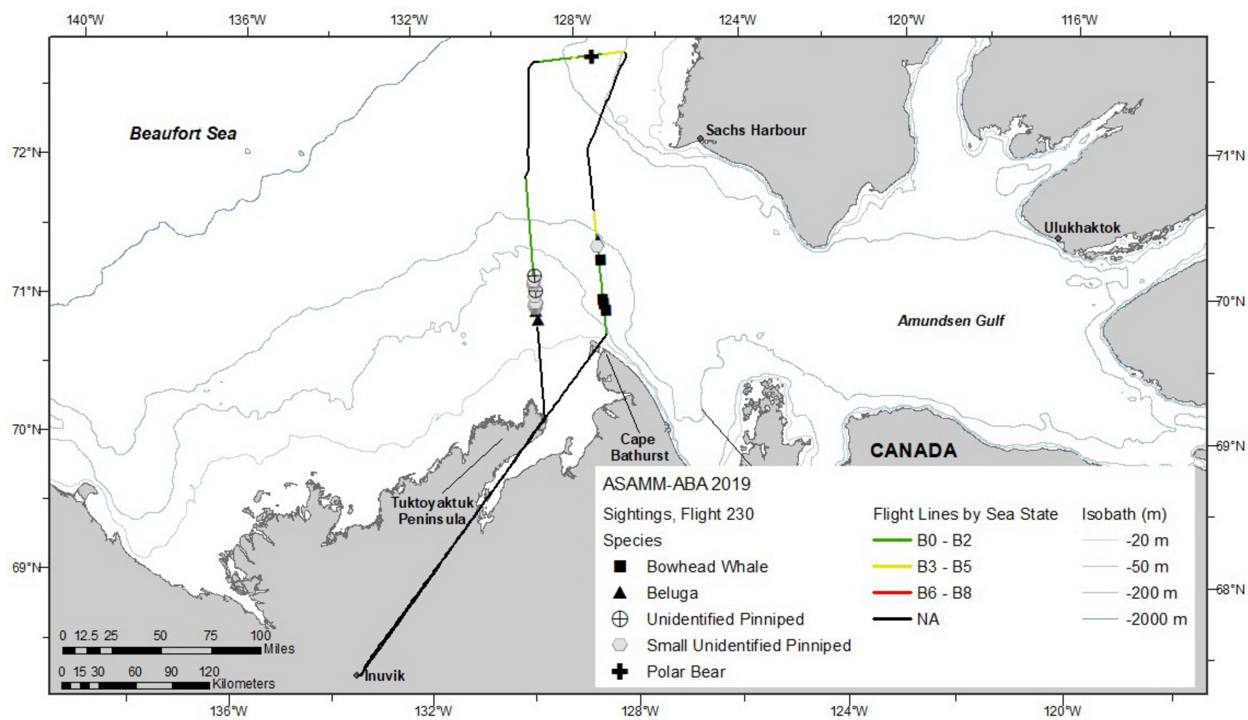


Figure B-63. Flight 230 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

27 August 2019, Flight 22

Flight was a complete survey of transects BCB117, BCB118, BCB119, BCB120, and BCB121. Survey conditions included partly cloudy to overcast 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 bowhead whales (including one carcass), belugas (including two calves), one unidentified cetacean, one bearded seal, 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
22	8/27/2019 14:49	70.738	148.917	bowhead whale	swim	1	0	1
22	8/27/2019 14:53	70.809	148.905	bowhead whale	swim	1	0	1
22	8/27/2019 14:54	70.813	148.885	beluga	swim	2	1	1
22	8/27/2019 15:18	70.968	149.398	beluga	rest	2	1	1
22	8/27/2019 15:22	70.827	149.444	bowhead whale	swim	2	0	1
22	8/27/2019 15:22	70.821	149.428	bowhead whale	swim	1	0	1
22	8/27/2019 15:25	70.798	149.382	bowhead whale	swim	1	0	1
22	8/27/2019 15:30	70.656	149.425	bowhead whale	dead	1	0	1
22	8/27/2019 16:07	71.239	149.915	beluga	swim	2	0	2
22	8/27/2019 16:07	71.246	149.893	beluga	swim	6	0	2
22	8/27/2019 16:07	71.247	149.910	beluga	swim	1	0	2
22	8/27/2019 16:12	71.417	149.872	beluga	swim	2	0	10
22	8/27/2019 16:15	71.515	149.869	unid cetacean	unknown	1	0	10
22	8/27/2019 16:30	71.498	150.485	bowhead whale	swim	1	0	11
22	8/27/2019 16:42	71.258	150.411	beluga	swim	1	0	3
22	8/27/2019 17:16	70.815	149.253	bowhead whale	breach	1	0	1
22	8/27/2019 17:23	70.949	148.951	bowhead whale	swim	2	0	1
22	8/27/2019 17:32	71.111	148.538	bowhead whale	swim	1	0	2
22	8/27/2019 17:37	71.083	148.489	bowhead whale	breach	1	0	2

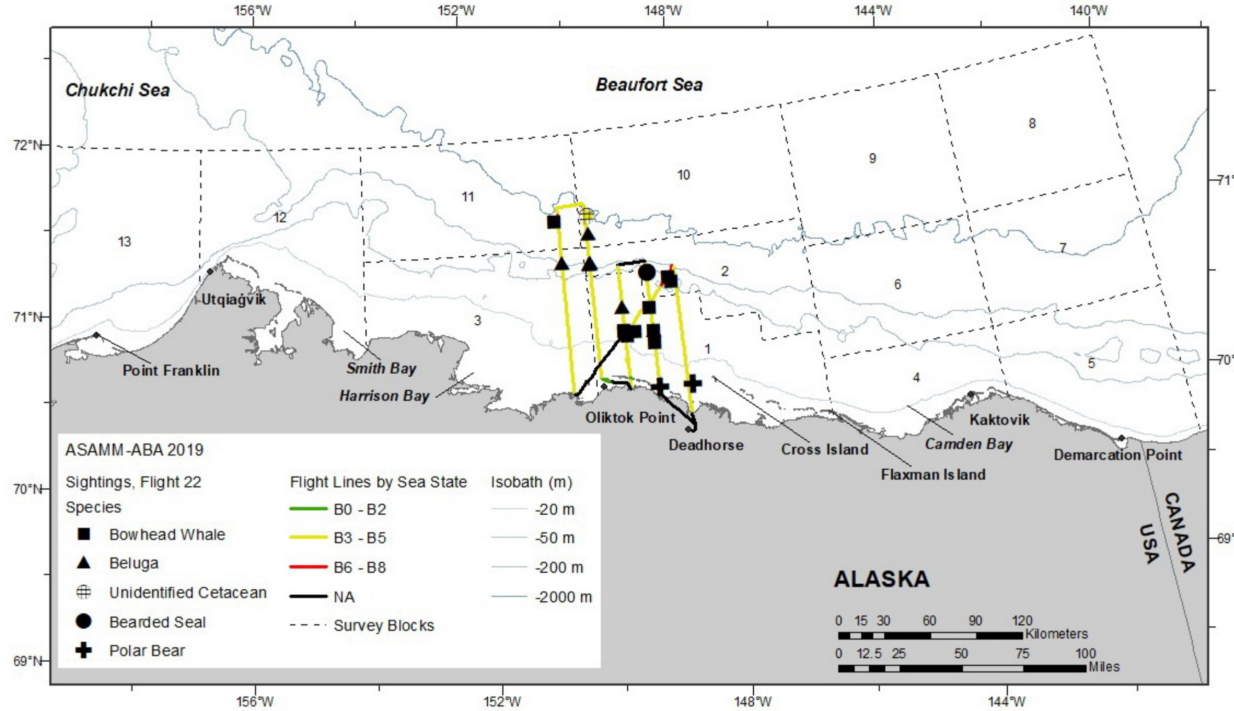


Figure B-64. Flight 22 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Sequence showing bowhead whale breaching approximately 80 km northwest of Cross Island, Alaska, Flight 22, 27 August 2019.

27 August 2019, Flight 413

Flight was a partial survey of transects BCB424, BCB425, and BCB427. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare and low ceilings, and Beaufort 1-3 sea states. Sea ice was 0-95% broken floe in the area surveyed. Sightings included bowhead whales (including two calves), belugas (including one calf), 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
413	8/27/2019 8:45	70.384	131.895	bowhead whale	swim	2	1	0
413	8/27/2019 8:54	70.662	131.911	beluga	swim	1	0	0
413	8/27/2019 8:54	70.677	131.939	bowhead whale	swim	1	0	0
413	8/27/2019 9:00	70.768	131.915	bowhead whale	swim	1	0	0
413	8/27/2019 9:04	70.789	131.892	bowhead whale	swim	1	0	0
413	8/27/2019 9:09	70.822	131.859	bowhead whale	swim	5	1	0
413	8/27/2019 9:13	70.814	131.903	beluga	swim	1	0	0
413	8/27/2019 9:14	70.841	131.915	bowhead whale	swim	1	0	0
413	8/27/2019 9:59	70.912	130.898	bowhead whale	swim	1	0	0
413	8/27/2019 10:06	70.794	130.934	beluga	swim	2	1	0
413	8/27/2019 10:08	70.728	130.914	beluga	swim	1	0	0
413	8/27/2019 10:09	70.723	130.924	beluga	swim	1	0	0
413	8/27/2019 10:32	70.544	130.440	beluga	swim	1	0	0
413	8/27/2019 10:35	70.655	130.436	beluga	swim	1	0	0
413	8/27/2019 10:42	70.855	130.410	beluga	swim	1	0	0

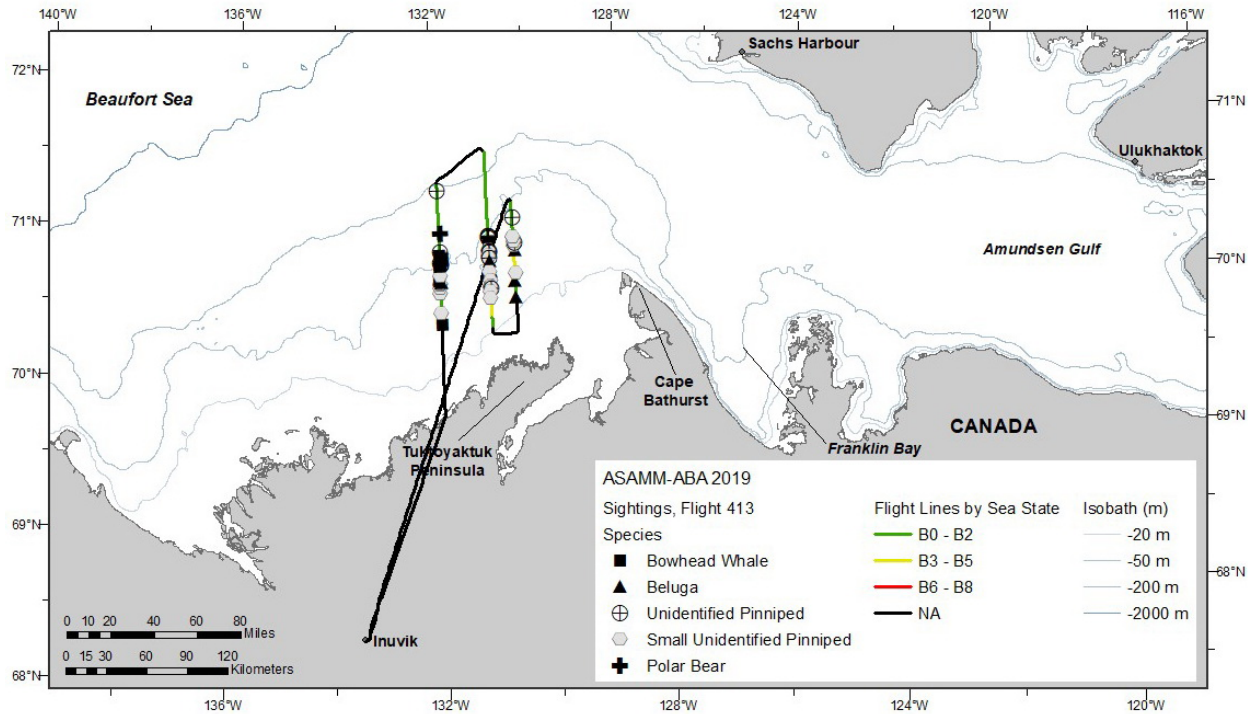


Figure B-65. Flight 413 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Inuvik-based aerial survey teams and aircraft, 27 August 2019.
L to R: Clearwater Air Commander N690AX, Lisa Barry, Amelia Brower, Suzie Hanlan, Rachel Hardee, Corey Accardo, Amy Willoughby, Jake Creglow, Jake Turner, Alex de Boer, Mark Vanonen, and Kenn Borek Twin Otter C-GCKB. Photo by Lisa Barry.

This page intentionally left blank.

28 August 2019, Flight 23

Flight was a complete survey of transects 127 and 128, and the coastal transect from Deadhorse to Smith Bay. Survey conditions included partly cloudy to overcast skies, <1 km to unlimited visibility, with glare, haze, and low ceilings, and Beaufort 1-4 sea states. There was no sea ice in the area surveyed. Sightings included one bowhead whale carcass, belugas, 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
23	8/28/2019 16:25	70.510	150.653	bowhead whale	dead	1	0	3
23	8/28/2019 18:07	71.839	153.909	beluga	rest	1	0	11
23	8/28/2019 18:14	72.006	153.610	beluga	swim	3	0	0
23	8/28/2019 18:15	72.007	153.569	beluga	swim	1	0	0
23	8/28/2019 18:15	72.013	153.553	beluga	swim	2	0	0
23	8/28/2019 18:15	72.015	153.508	beluga	swim	1	0	0
23	8/28/2019 18:15	72.014	153.482	beluga	rest	1	0	0
23	8/28/2019 18:15	72.014	153.462	beluga	swim	1	0	0
23	8/28/2019 18:15	72.014	153.454	beluga	swim	1	0	0

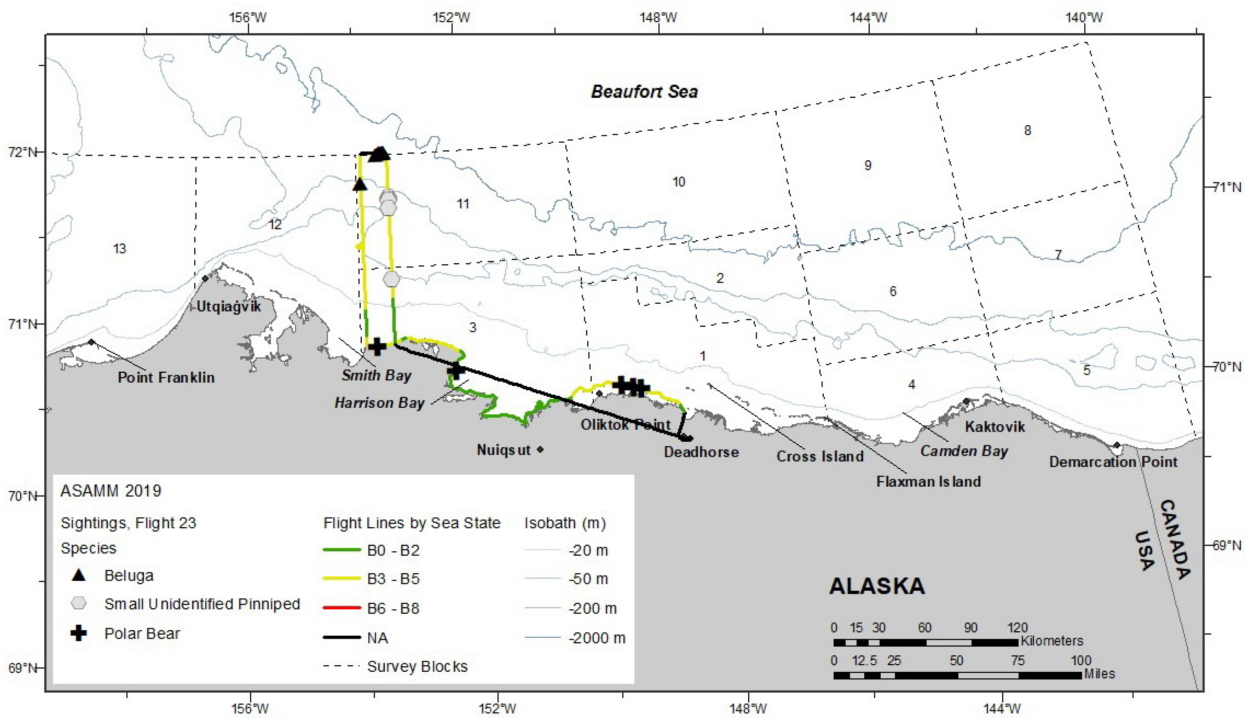


Figure B-66. Flight 23 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

29 August 2019, Flight 24

Flight was a complete survey of transects 123, 124, 125, and 126. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare, haze, low ceilings, and precipitation, and Beaufort 1-3 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales, belugas (including six calves), one walrus, 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
24	8/29/2019 11:12	71.711	152.897	beluga	swim	1	0	11
24	8/29/2019 11:12	71.715	152.894	beluga	swim	3	0	11
24	8/29/2019 11:13	71.720	152.909	beluga	swim	3	0	11
24	8/29/2019 11:13	71.723	152.889	beluga	swim	7	1	11
24	8/29/2019 11:13	71.726	152.908	beluga	swim	2	1	11
24	8/29/2019 11:13	71.729	152.895	beluga	swim	3	0	11
24	8/29/2019 11:13	71.732	152.920	beluga	swim	1	0	11
24	8/29/2019 11:13	71.735	152.908	beluga	swim	2	1	11
24	8/29/2019 11:13	71.737	152.889	beluga	swim	1	0	11
24	8/29/2019 11:13	71.738	152.909	beluga	swim	1	0	11
24	8/29/2019 11:13	71.741	152.914	beluga	swim	1	0	11
24	8/29/2019 11:13	71.744	152.919	beluga	swim	1	0	11
24	8/29/2019 11:13	71.748	152.892	beluga	swim	2	0	11
24	8/29/2019 11:24	71.995	152.552	beluga	swim	2	1	11
24	8/29/2019 11:32	71.783	152.384	beluga	swim	1	0	11
24	8/29/2019 11:42	71.435	152.423	bowhead whale	swim	1	0	11
24	8/29/2019 11:44	71.434	152.437	beluga	swim	1	0	11
24	8/29/2019 12:36	71.402	151.890	bowhead whale	swim	1	0	11
24	8/29/2019 12:39	71.453	151.937	beluga	swim	1	0	11
24	8/29/2019 12:39	71.457	151.890	beluga	swim	1	0	11
24	8/29/2019 12:39	71.460	151.916	beluga	swim	1	0	11
24	8/29/2019 12:40	71.474	151.927	beluga	swim	1	0	11
24	8/29/2019 12:40	71.477	151.909	beluga	swim	1	0	11
24	8/29/2019 12:41	71.497	151.882	beluga	swim	3	0	11
24	8/29/2019 12:41	71.500	151.904	beluga	swim	1	0	11
24	8/29/2019 12:42	71.529	151.919	beluga	swim	1	0	11
24	8/29/2019 12:42	71.534	151.877	beluga	swim	2	0	11
24	8/29/2019 12:42	71.543	151.907	beluga	rest	1	1	11
24	8/29/2019 12:42	71.548	151.877	beluga	swim	1	0	11
24	8/29/2019 12:42	71.554	151.884	beluga	swim	1	0	11
24	8/29/2019 12:42	71.557	151.910	beluga	swim	1	0	11
24	8/29/2019 12:46	71.687	151.885	beluga	mill	5	0	11
24	8/29/2019 12:50	71.798	151.898	beluga	swim	2	1	11
24	8/29/2019 12:50	71.803	151.915	beluga	swim	1	0	11
24	8/29/2019 12:50	71.808	151.912	beluga	rest	1	0	11
24	8/29/2019 12:50	71.814	151.893	beluga	rest	1	0	11

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
24	8/29/2019 13:01	71.976	151.445	beluga	swim	1	0	11
24	8/29/2019 13:01	71.970	151.455	beluga	swim	1	0	11
24	8/29/2019 13:11	71.628	151.441	beluga	swim	1	0	11
24	8/29/2019 13:15	71.508	151.428	beluga	mill	2	0	11
24	8/29/2019 13:15	71.500	151.422	beluga	swim	1	0	11
24	8/29/2019 13:15	71.493	151.428	beluga	swim	1	0	11
24	8/29/2019 13:25	71.163	151.402	bowhead whale	swim	1	0	3

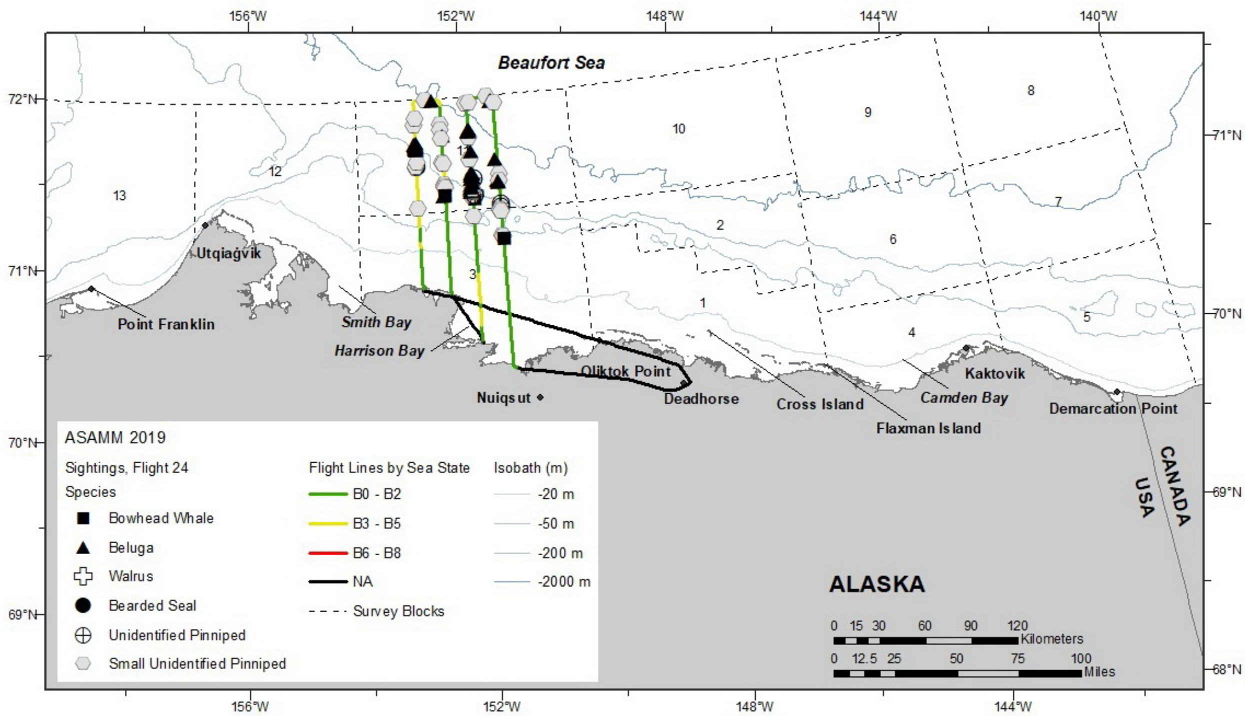


Figure B-67. Flight 24 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

30 August 2019, Flight 231

Flight was a complete survey of transects 1, 2, 3, 5, and 7. Survey conditions included partly cloudy to overcast skies, 2 km to unlimited visibility, with glare, haze, and low ceilings, and Beaufort 1-4 sea states. There was no sea ice in the area surveyed. Sightings included one bowhead whale carcass, gray whales, killer whales, 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
231	8/30/2019 13:41	71.167	160.137	gray whale	feed	3	0	14
231	8/30/2019 15:22	71.036	158.054	bowhead whale	dead	1	0	13
231	8/30/2019 16:00	71.534	158.251	killer whale	mill	2	0	13

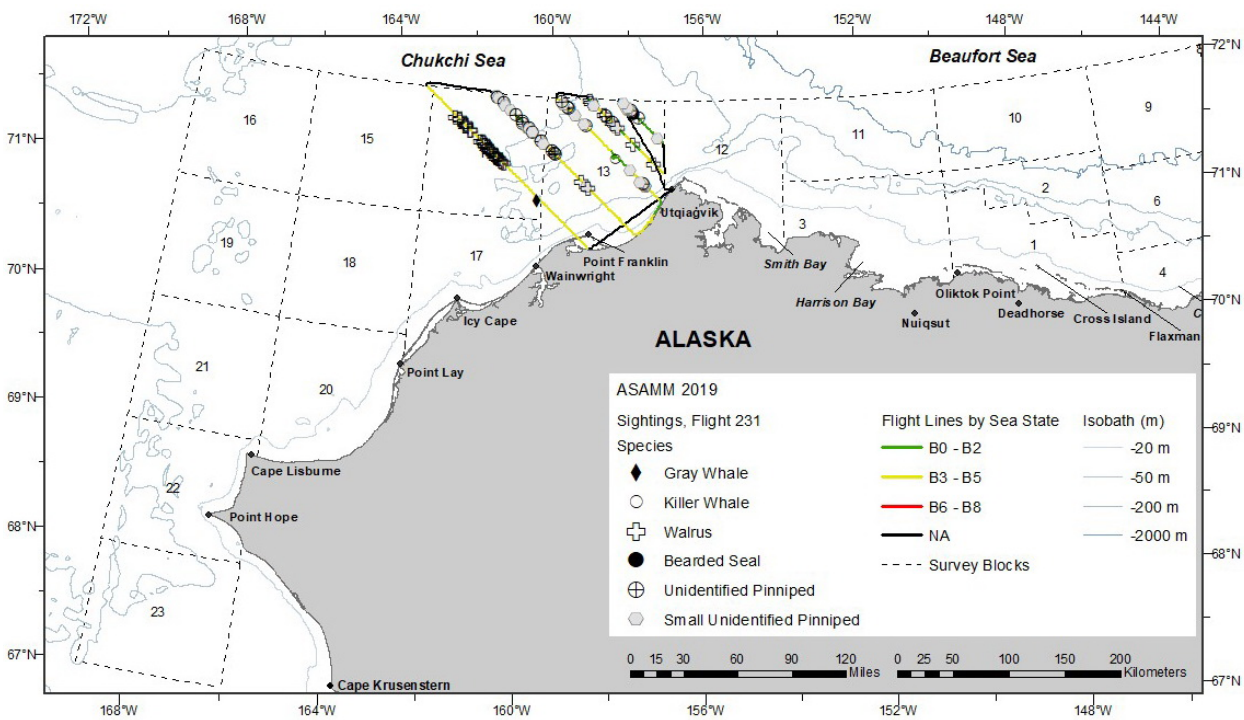
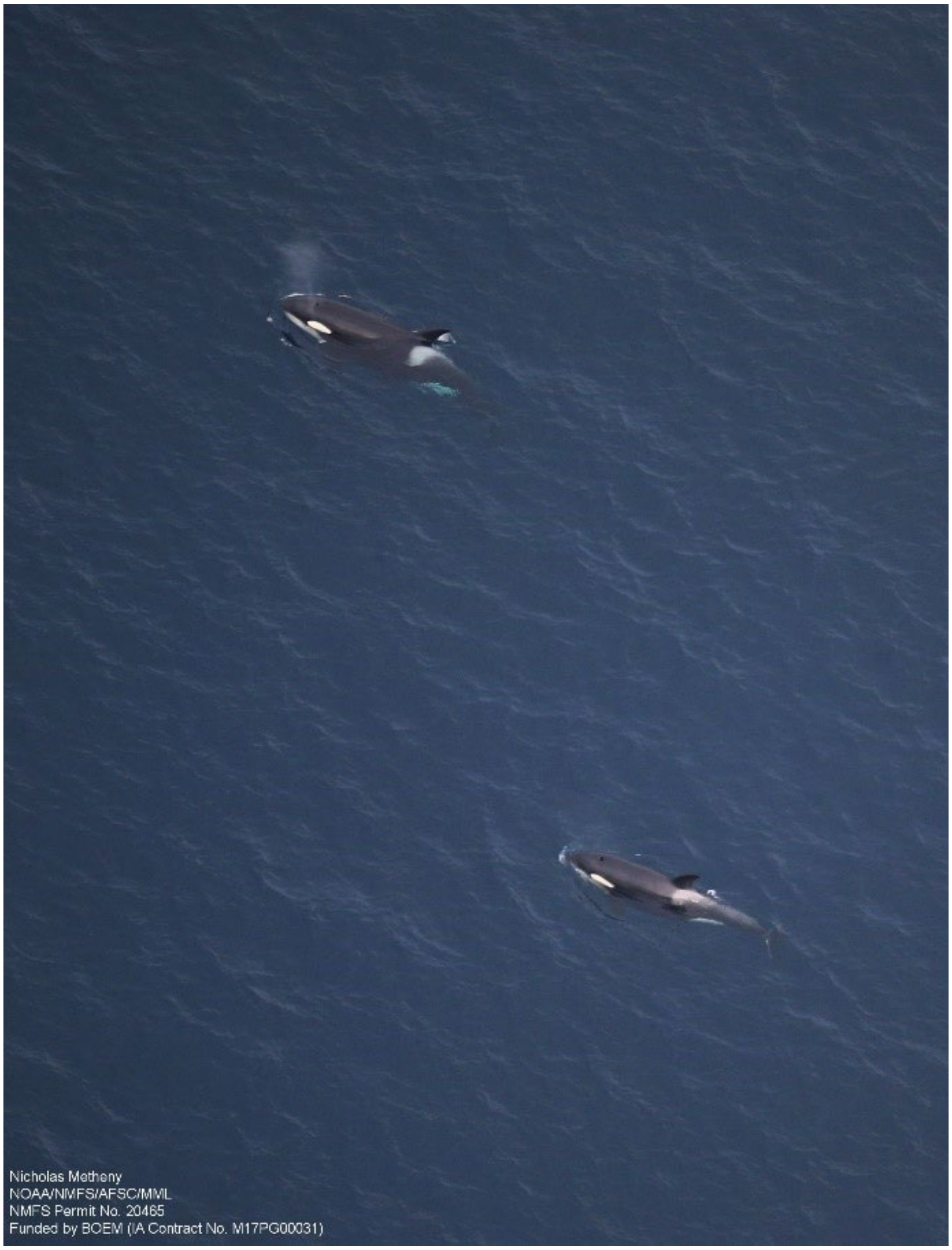


Figure B-68. Flight 231 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.



A pair of killer whales observed approximately 60 km northwest of Utqiaġvik, Alaska, Flight 231, 30 August 2019.

30 August 2019, Flight 25

Flight was a complete survey of transects 105, 106, 107, 108, 109, 110, 111, and 112, and the coastal transect from east of Camden Bay to approximately 30 km west of Camden Bay. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare, haze, low ceilings, and precipitation, and Beaufort 1-4 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales (including one carcass), belugas (including six calves), 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
25	8/30/2019 10:01	70.739	143.927	beluga	swim	1	0	6
25	8/30/2019 10:06	70.896	143.910	beluga	rest	1	0	6
25	8/30/2019 10:06	70.920	143.894	beluga	swim	1	0	6
25	8/30/2019 10:06	70.922	143.909	beluga	swim	2	1	6
25	8/30/2019 10:07	70.928	143.934	beluga	swim	1	0	6
25	8/30/2019 10:07	70.936	143.910	beluga	swim	1	0	6
25	8/30/2019 10:07	70.937	143.902	beluga	rest	2	1	6
25	8/30/2019 10:07	70.945	143.895	beluga	swim	1	0	6
25	8/30/2019 10:08	70.982	143.930	beluga	swim	1	0	6
25	8/30/2019 10:09	70.992	143.923	beluga	swim	1	0	6
25	8/30/2019 10:11	71.056	143.946	beluga	swim	1	0	6
25	8/30/2019 10:13	71.118	143.926	beluga	rest	1	0	6
25	8/30/2019 10:13	71.124	143.887	beluga	swim	1	0	6
25	8/30/2019 10:16	71.173	143.693	beluga	swim	1	0	9
25	8/30/2019 10:17	71.159	143.529	beluga	swim	2	0	6
25	8/30/2019 10:29	70.800	143.427	beluga	swim	1	0	6
25	8/30/2019 10:42	70.339	143.412	beluga	swim	1	0	4
25	8/30/2019 10:42	70.337	143.399	beluga	swim	1	0	4
25	8/30/2019 10:42	70.330	143.407	beluga	swim	1	0	4
25	8/30/2019 10:42	70.331	143.405	beluga	swim	1	0	4
25	8/30/2019 11:11	70.643	142.909	beluga	swim	1	0	7
25	8/30/2019 11:14	70.748	142.890	beluga	swim	1	0	7
25	8/30/2019 11:33	71.146	142.406	beluga	swim	1	0	7
25	8/30/2019 11:44	70.742	142.401	beluga	swim	1	0	7
25	8/30/2019 11:49	70.593	142.401	beluga	swim	1	0	7
25	8/30/2019 11:51	70.502	142.421	beluga	swim	1	0	7
25	8/30/2019 15:01	70.778	144.395	beluga	rest	1	0	6
25	8/30/2019 15:06	70.930	144.405	beluga	swim	1	0	6
25	8/30/2019 15:06	70.935	144.412	beluga	swim	2	1	6
25	8/30/2019 15:08	70.990	144.406	beluga	swim	1	0	6
25	8/30/2019 15:08	70.993	144.407	beluga	swim	2	0	6
25	8/30/2019 15:12	71.149	144.425	beluga	swim	1	0	6
25	8/30/2019 15:16	71.167	144.761	beluga	dive	1	0	9
25	8/30/2019 15:20	71.091	144.891	beluga	swim	1	0	6
25	8/30/2019 15:24	70.926	144.898	beluga	swim	2	0	6

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
25	8/30/2019 15:25	70.894	144.883	beluga	swim	1	0	6
25	8/30/2019 15:25	70.891	144.892	beluga	swim	1	0	6
25	8/30/2019 15:26	70.886	144.912	beluga	swim	1	0	6
25	8/30/2019 15:26	70.880	144.908	beluga	swim	2	0	6
25	8/30/2019 15:26	70.880	144.927	beluga	swim	1	0	6
25	8/30/2019 15:29	70.764	144.905	beluga	swim	1	0	6
25	8/30/2019 16:10	70.471	145.366	bowhead whale	dead	1	0	4
25	8/30/2019 16:15	70.504	145.431	bowhead whale	swim	1	0	6
25	8/30/2019 16:20	70.479	145.414	bowhead whale	swim	1	0	4
25	8/30/2019 16:22	70.497	145.386	bowhead whale	swim	2	0	4
25	8/30/2019 16:22	70.498	145.380	bowhead whale	swim	1	0	4
25	8/30/2019 16:39	70.855	145.328	beluga	rest	1	0	6
25	8/30/2019 16:42	70.880	145.422	beluga	swim	2	1	6
25	8/30/2019 16:42	70.888	145.424	beluga	swim	1	0	6
25	8/30/2019 16:42	70.892	145.387	beluga	swim	1	0	6
25	8/30/2019 16:45	70.986	145.413	beluga	swim	3	1	6
25	8/30/2019 16:46	70.993	145.424	beluga	swim	4	0	6
25	8/30/2019 16:59	71.059	145.886	beluga	swim	2	1	6
25	8/30/2019 17:00	71.033	145.871	beluga	swim	1	0	6
25	8/30/2019 17:15	70.509	145.909	bowhead whale	swim	1	0	6
25	8/30/2019 17:17	70.528	145.930	bowhead whale	swim	1	0	6
25	8/30/2019 17:19	70.467	145.905	bowhead whale	swim	1	0	4

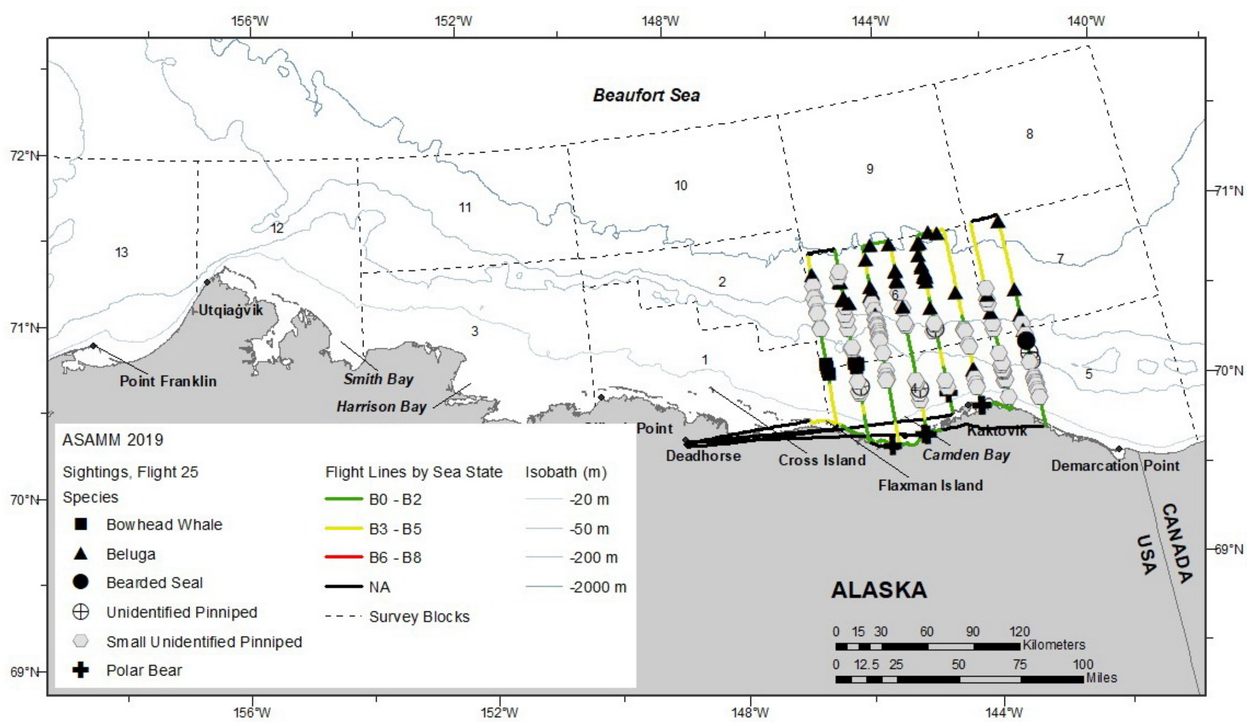


Figure B-69. Flight 25 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

31 August 2019, Flight 232

Flight was a complete survey of transects 28, 29, 30, 31, and 32, and the coastal transect from Cape Lisburne to south of Utqiaġvik. Survey conditions included clear, partly cloudy, and overcast skies, 5 km to unlimited visibility, with glare, haze, and low ceilings, and Beaufort 2-7 sea states. There was no sea ice in the area surveyed. Sightings included one beluga, unidentified cetaceans (including two carcasses), walruses, one unidentified pinniped, and small unidentified pinnipeds. Three walrus haulouts, estimated at 8,000, 1,750, and 11,000 walruses, were observed on a barrier island west of Point Lay. Two small unidentified pinniped haulouts, estimated at 200 and 1,000 individuals, were 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
232	8/31/2019 11:27	68.451	167.037	unid cetacean	unknown	1	0	22
232	8/31/2019 15:50	69.014	163.885	beluga	swim	1	0	20
232	8/31/2019 17:21	70.743	159.775	unid cetacean	dead	1	0	13
232	8/31/2019 17:30	70.876	159.162	unid cetacean	dead	1	1	13

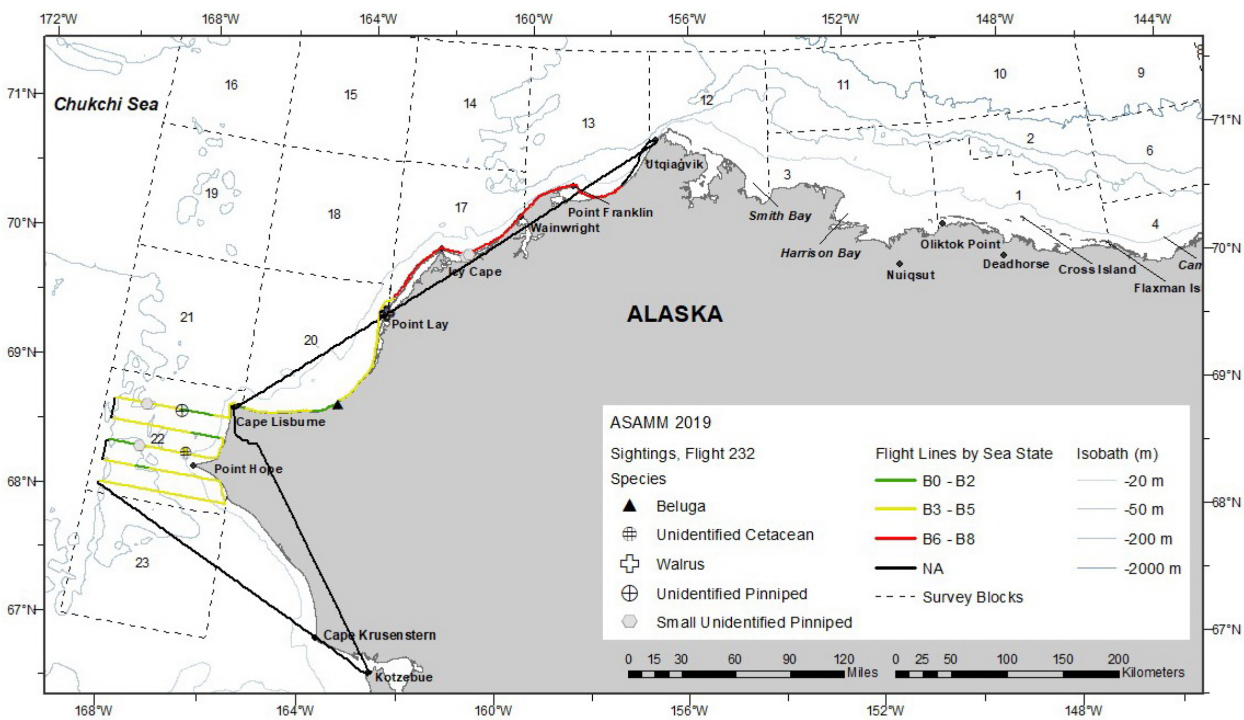


Figure B-70. Flight 232, survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

31 August 2019, Flight 26

Flight was a partial survey of transects 121 and 122. Survey conditions included overcast skies, 0-5 km visibility, with low ceilings, and Beaufort 4-6 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
26	8/31/2019 9:22	71.084	150.896	bowhead whale	swim	1	0	3
26	8/31/2019 9:23	71.067	150.774	bowhead whale	swim	1	0	3
26	8/31/2019 9:23	71.057	150.728	bowhead whale	swim	1	0	3
26	8/31/2019 9:23	71.055	150.724	bowhead whale	swim	1	0	3

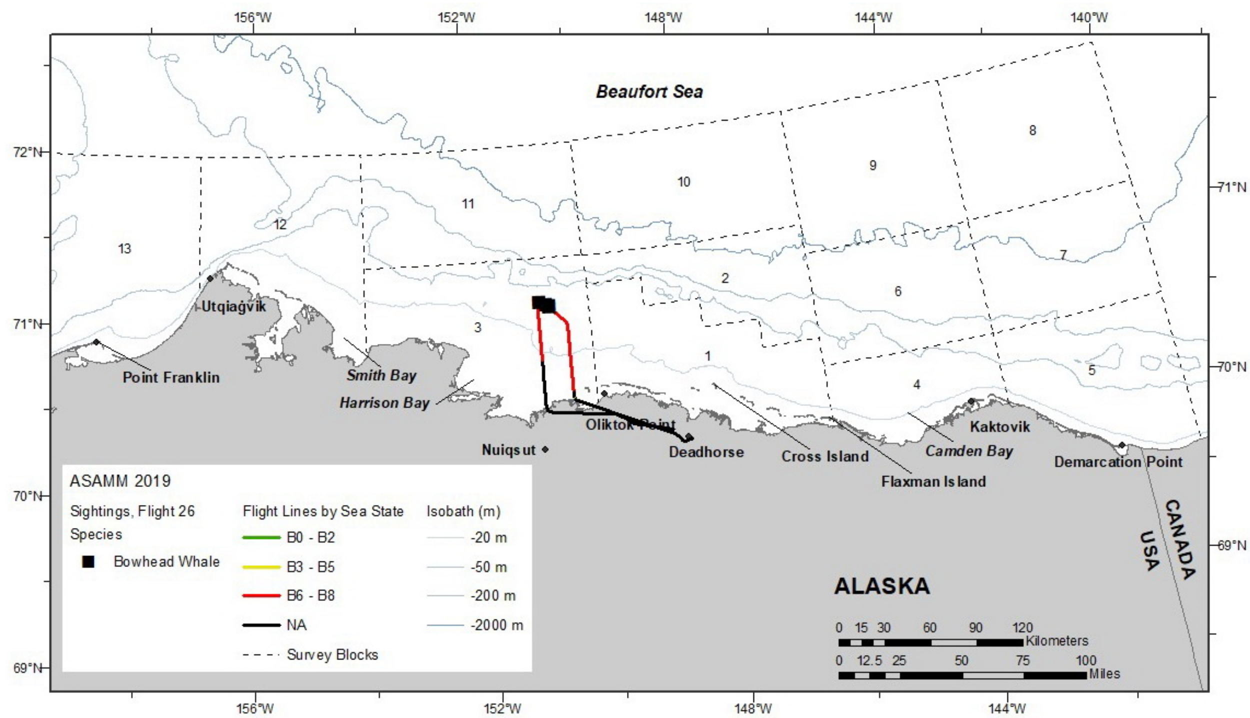


Figure B-71. Flight 26 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

2 September 2019, Flight 233

Flight was a partial survey of transects 6, 8, and 10. Survey conditions included partly cloudy skies, 0-10 km visibility, with fog, glare, haze, and low ceilings, and Beaufort 2-4 sea states. There was no sea ice in the area surveyed. Sightings included gray whales, 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
233	9/2/2019 17:22	71.055	160.369	gray whale	feed	1	0	14
233	9/2/2019 17:28	71.106	160.613	gray whale	swim	3	0	14
233	9/2/2019 17:28	71.108	160.647	gray whale	feed	3	0	14
233	9/2/2019 17:38	71.138	160.726	gray whale	feed	1	0	14
233	9/2/2019 17:45	71.278	161.068	gray whale	feed	1	0	14
233	9/2/2019 17:46	71.274	161.072	gray whale	feed	1	0	14
233	9/2/2019 18:49	71.161	157.097	gray whale	feed	3	0	13
233	9/2/2019 18:52	71.158	157.099	gray whale	feed	1	0	13

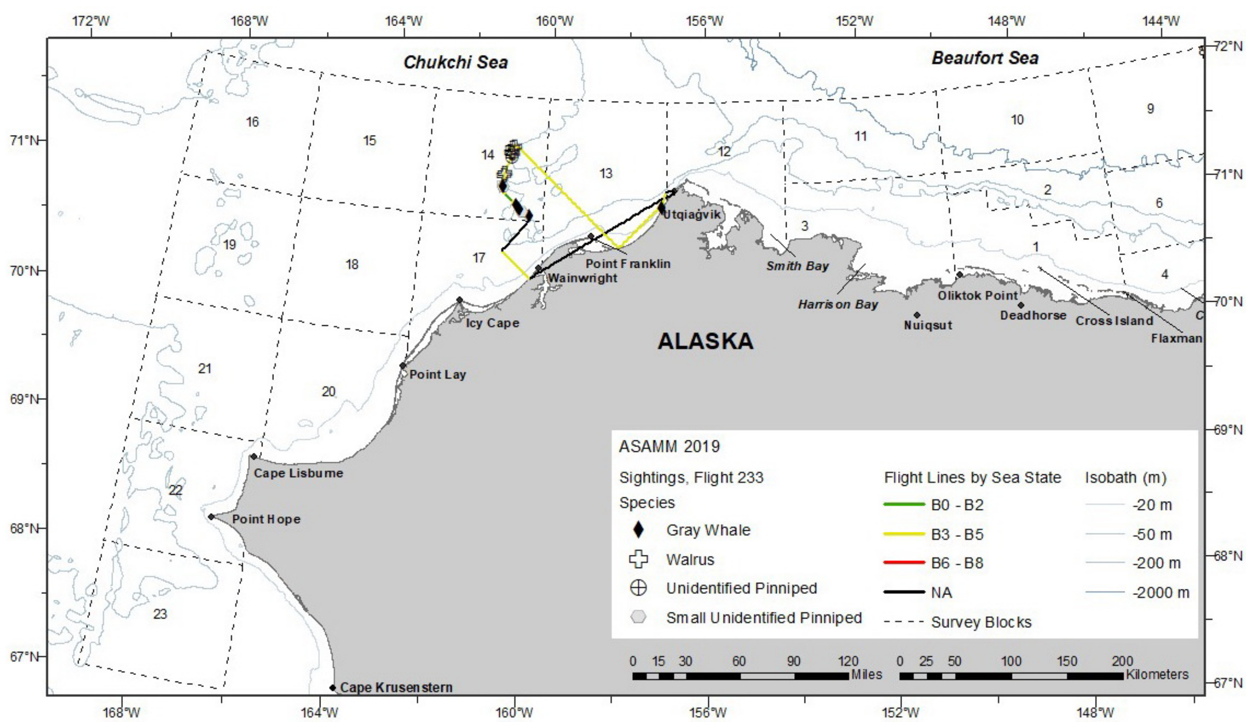


Figure B-72. Flight 233 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

2 September 2019, Flight 27

Flight was the coastal transect survey from east of Smith Bay to Deadhorse. Survey conditions included partly cloudy skies, 2-10 km visibility, with glare, haze, and low ceilings, and Beaufort 3-6 sea states. There was no sea ice in the area surveyed. Sightings included one bowhead whale carcass and polar bears. The bowhead carcass was a resight of a carcass that was previously sighted during flight 23 on 28 August 2019.

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	9/2/2019 17:11	70.512	150.637	bowhead whale	dead	1	0	3

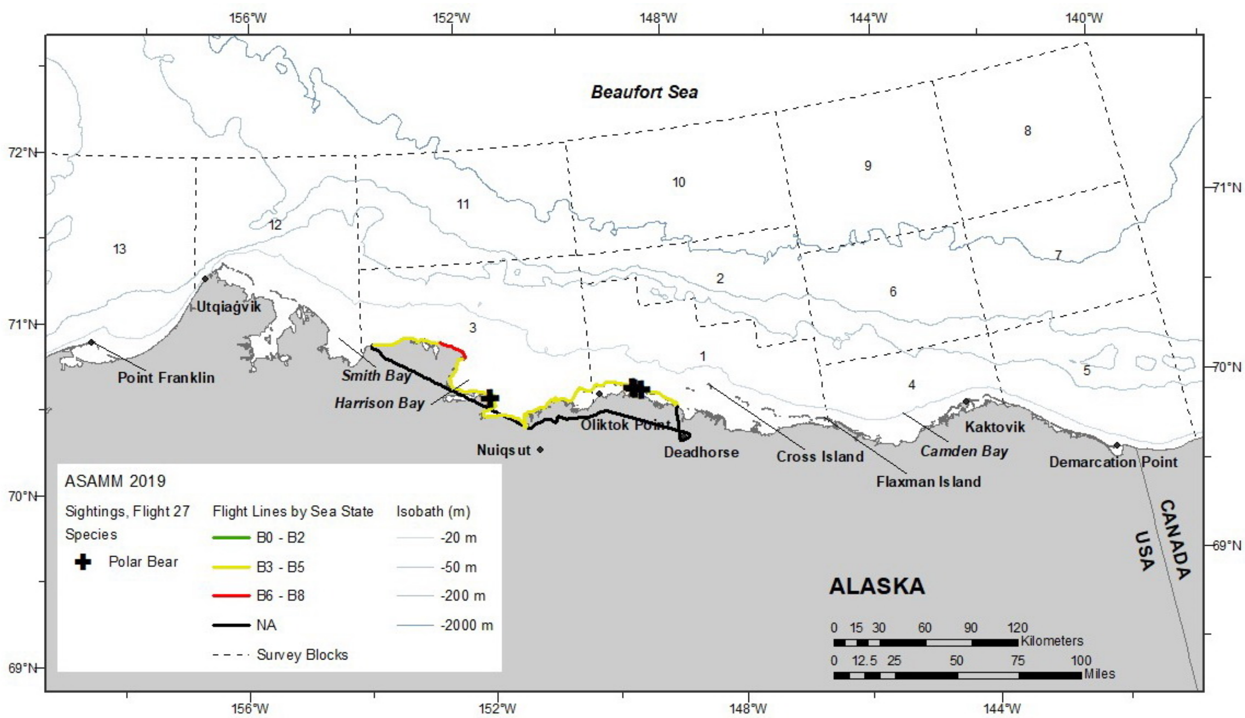


Figure B-73. Flight 27 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

3 September 2019, Flight 28

Flight was complete survey of transects 121 and 122, and partial survey of transects 113, 114, 115, and 116. Survey conditions included clear to partly cloudy skies, <1 km to unlimited visibility, with fog, glare, and haze, and Beaufort 1-4 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales, belugas (including four calves), one bearded seal, 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
28	9/3/2019 13:10	70.666	146.384	bowhead whale	swim	1	0	1
28	9/3/2019 13:13	70.716	146.386	bowhead whale	swim	1	0	2
28	9/3/2019 13:21	70.944	146.421	beluga	rest	2	1	2
28	9/3/2019 13:22	70.966	146.405	beluga	rest	1	0	2
28	9/3/2019 13:34	70.984	146.900	beluga	rest	1	0	2
28	9/3/2019 13:35	70.980	146.890	beluga	rest	5	2	2
28	9/3/2019 13:35	70.974	146.925	beluga	swim	3	0	2
28	9/3/2019 13:35	70.967	146.913	beluga	swim	4	0	2
28	9/3/2019 14:12	70.449	147.405	beluga	rest	2	1	1
28	9/3/2019 14:21	70.742	147.382	bowhead whale	swim	1	0	1
28	9/3/2019 14:21	70.747	147.393	bowhead whale	log play	3	0	1
28	9/3/2019 14:31	70.774	147.416	bowhead whale	swim	1	0	1
28	9/3/2019 14:31	70.782	147.399	bowhead whale	mill	3	0	1
28	9/3/2019 15:05	70.969	147.823	bowhead whale	swim	1	0	2
28	9/3/2019 15:11	70.897	147.920	bowhead whale	swim	1	0	2
28	9/3/2019 15:11	70.892	147.932	bowhead whale	swim	1	0	2
28	9/3/2019 15:11	70.894	147.935	bowhead whale	swim	1	0	2
28	9/3/2019 15:11	70.900	147.929	bowhead whale	swim	1	0	2
28	9/3/2019 15:12	70.879	147.882	bowhead whale	swim	4	0	2
28	9/3/2019 17:15	71.176	150.901	bowhead whale	swim	1	0	3
28	9/3/2019 17:24	71.411	150.894	beluga	swim	1	0	11
28	9/3/2019 17:24	71.421	150.872	beluga	swim	1	0	11
28	9/3/2019 17:26	71.473	150.943	beluga	swim	6	0	11
28	9/3/2019 17:27	71.483	150.958	beluga	swim	14	0	11
28	9/3/2019 17:27	71.480	150.958	beluga	swim	9	0	11
28	9/3/2019 17:32	71.620	150.910	beluga	swim	1	0	11
28	9/3/2019 17:32	71.623	150.877	beluga	swim	1	0	11
28	9/3/2019 17:32	71.627	150.904	beluga	swim	1	0	11
28	9/3/2019 17:33	71.645	150.882	beluga	swim	1	0	11
28	9/3/2019 18:12	71.165	150.409	bowhead whale	swim	1	0	3
28	9/3/2019 18:14	71.179	150.386	bowhead whale	swim	1	0	3
28	9/3/2019 18:15	71.169	150.423	bowhead whale	swim	1	0	3
28	9/3/2019 18:15	71.184	150.426	bowhead whale	swim	1	0	3
28	9/3/2019 18:18	71.162	150.458	bowhead whale	swim	1	0	3

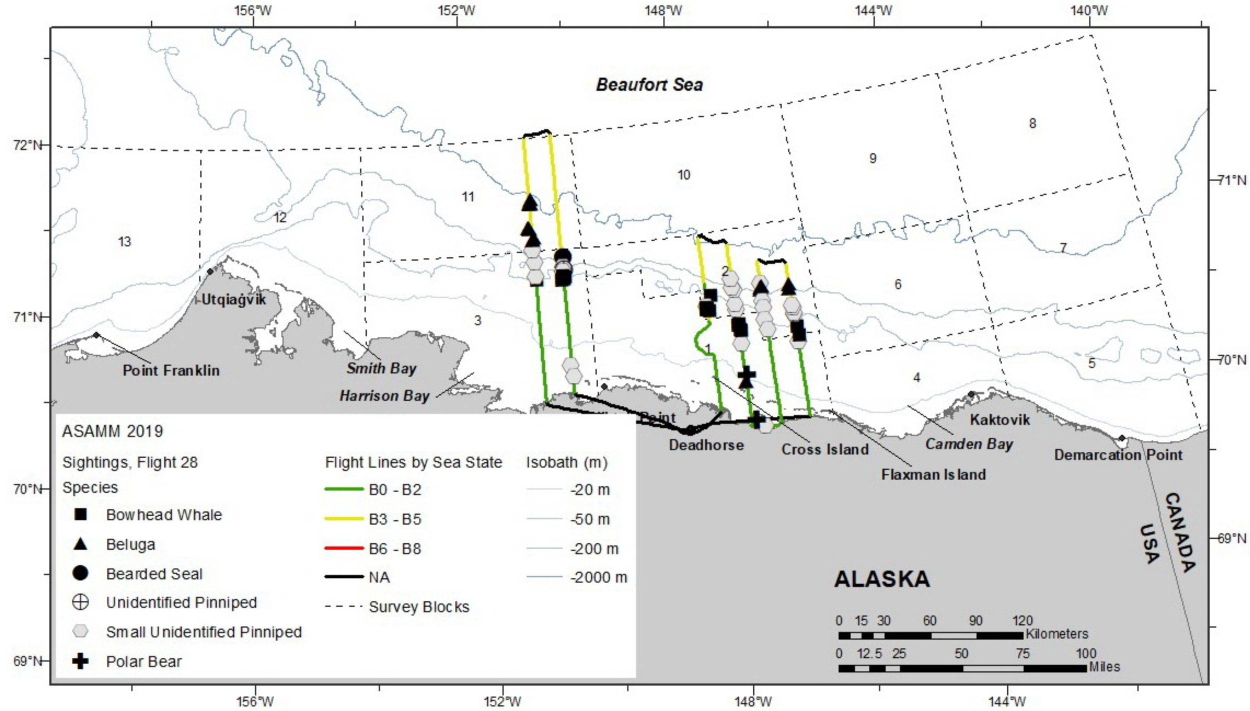


Figure B-74. Flight 28 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

4 September 2019, Flight 29

Flight was a complete survey of transects 118, 119, and 120, and partial survey of transect 117. Survey conditions included partly cloudy to overcast skies, 3 km to unlimited visibility, with glare and precipitation, and Beaufort 1-3 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales, belugas (including three 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
29	9/4/2019 11:04	71.309	149.398	beluga	swim	2	1	2
29	9/4/2019 11:04	71.298	149.430	beluga	swim	1	0	2
29	9/4/2019 11:07	71.211	149.412	bowhead whale	dive	1	0	2
29	9/4/2019 11:07	71.208	149.378	bowhead whale	swim	5	0	2
29	9/4/2019 11:54	71.081	148.890	bowhead whale	breach	1	0	2
29	9/4/2019 12:09	71.215	148.416	beluga	swim	2	1	2
29	9/4/2019 12:09	71.207	148.361	beluga	swim	3	0	2
29	9/4/2019 12:09	71.205	148.407	beluga	swim	1	0	2
29	9/4/2019 12:10	71.199	148.407	beluga	swim	1	0	2
29	9/4/2019 12:10	71.198	148.400	beluga	swim	11	0	2
29	9/4/2019 12:10	71.198	148.392	beluga	swim	7	0	2
29	9/4/2019 12:10	71.192	148.383	beluga	swim	6	0	2
29	9/4/2019 12:10	71.189	148.409	beluga	swim	3	1	2
29	9/4/2019 12:10	71.184	148.428	beluga	swim	4	0	2
29	9/4/2019 12:16	70.980	148.395	bowhead whale	swim	1	0	1
29	9/4/2019 12:16	70.973	148.340	bowhead whale	swim	1	0	1
29	9/4/2019 12:16	70.965	148.244	bowhead whale	swim	3	0	1

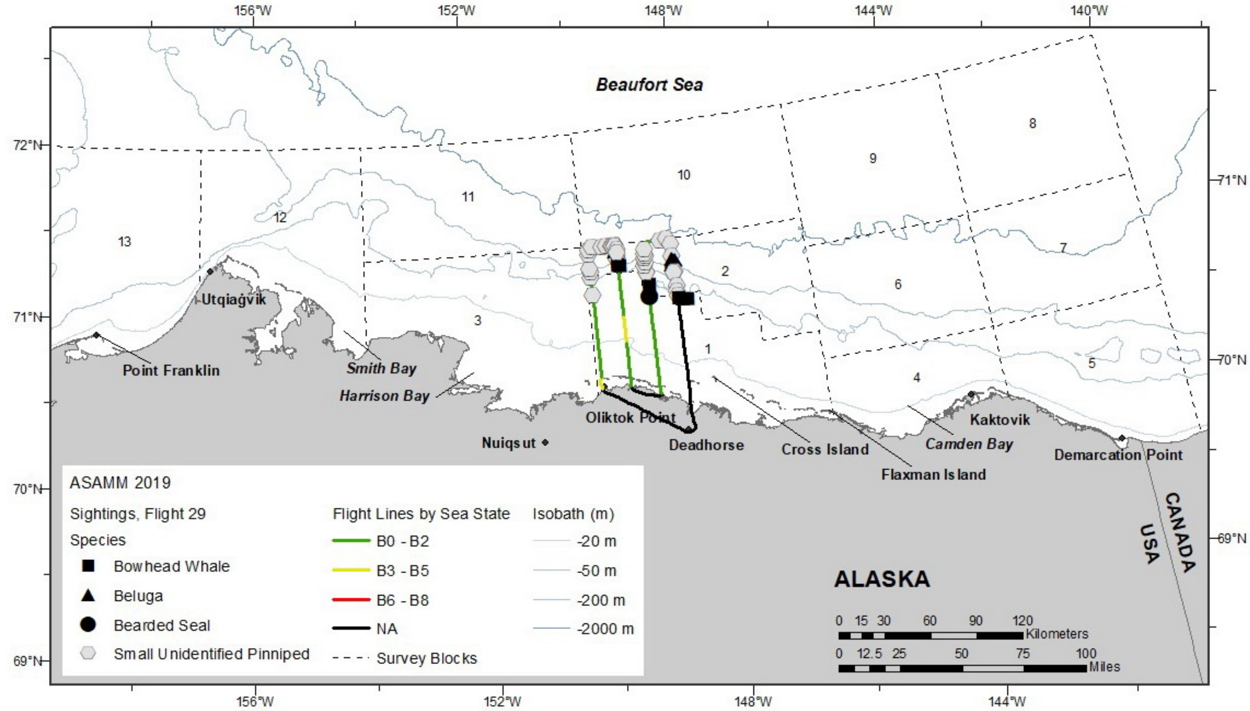


Figure B-75. Flight 29 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

5 September 2019, Flight 234

Flight was a complete survey of transects 1, 2, 3, 4, 6, 8, and 10. Survey conditions included partly cloudy skies, 3 km to unlimited visibility, with glare, haze, and low ceilings, and Beaufort 2-5 sea states. There was no sea ice in the area surveyed. Sightings included two bowhead whale carcasses, gray whales, belugas (including one carcass), one unidentified cetacean, walruses, unidentified pinnipeds, and small unidentified pinnipeds. One bowhead carcass was a resight of a carcass that was previously sighted during flight 231 on 30 August 2019.

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
234	9/5/2019 12:47	70.563	160.317	bowhead whale	dead	1	0	17
234	9/5/2019 13:01	70.800	161.208	gray whale	feed	3	0	17
234	9/5/2019 13:02	70.788	161.194	gray whale	feed	1	0	17
234	9/5/2019 13:13	70.943	161.633	beluga	swim	1	0	17
234	9/5/2019 13:13	70.952	161.657	gray whale	feed	3	0	17
234	9/5/2019 13:13	70.950	161.674	gray whale	feed	1	0	17
234	9/5/2019 13:14	70.966	161.687	gray whale	feed	1	0	17
234	9/5/2019 13:20	70.994	161.862	gray whale	feed	2	0	17
234	9/5/2019 14:58	71.273	161.173	gray whale	feed	1	0	14
234	9/5/2019 15:01	71.223	161.078	gray whale	rest	1	0	14
234	9/5/2019 15:05	71.227	161.076	gray whale	feed	2	0	14
234	9/5/2019 15:12	71.124	160.615	gray whale	feed	1	0	14
234	9/5/2019 15:15	71.065	160.619	gray whale	feed	3	0	14
234	9/5/2019 16:40	71.977	162.201	gray whale	feed	1	0	14
234	9/5/2019 16:41	71.977	162.343	unid cetacean	unknown	1	0	14
234	9/5/2019 18:27	71.512	158.960	bowhead whale	dead	1	0	13
234	9/5/2019 19:44	71.211	156.971	beluga	dead	1	0	12

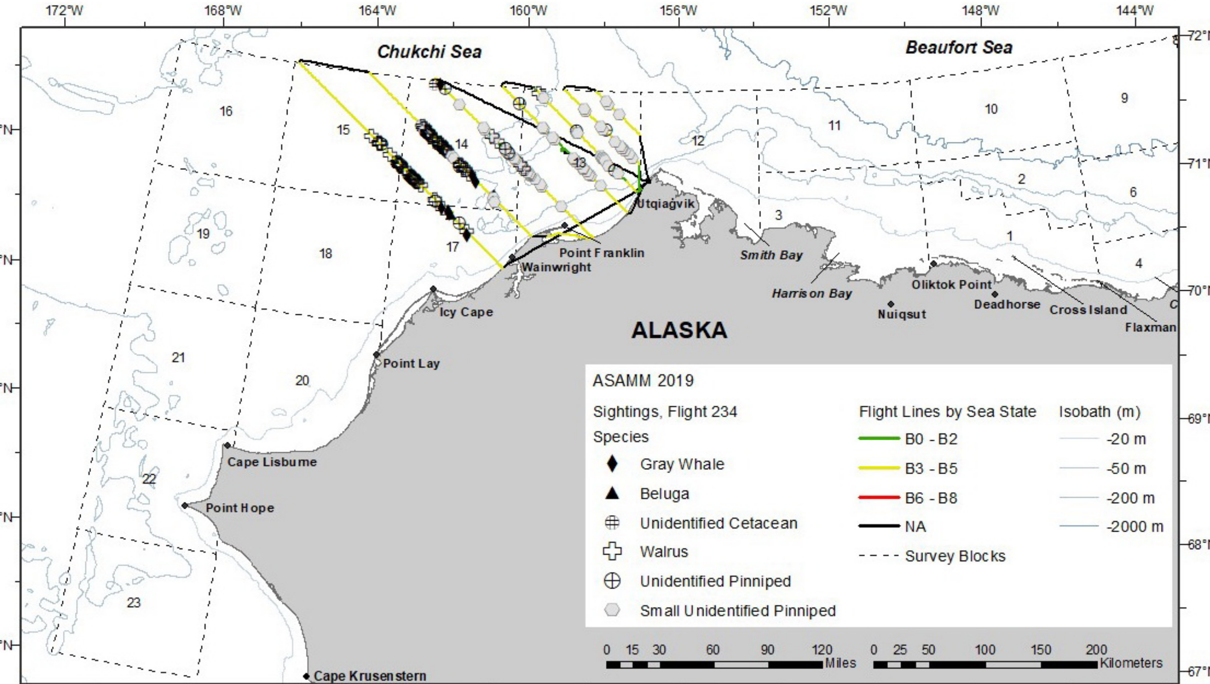


Figure B-76. Flight 234 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

5 September 2019, Flight 30

Flight was a complete survey of transects 131, 132, 133, and 134, partial survey of transect 117, and the coastal transect from west of Smith Bay to the western edge of Harrison Bay. Survey conditions included partly cloudy skies, <1 km to unlimited visibility, with fog and glare, and Beaufort 1-3 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales (including one calf and one carcass), belugas (including seven calves), one walrus, one bearded seal, unidentified pinnipeds, small unidentified pinnipeds, and polar bears. The bowhead carcass was a resight of a carcass that was previously sighted during flight 19 on 22 August 2019.

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	9/5/2019 16:49	71.536	156.874	beluga	swim	1	0	12
30	9/5/2019 17:04	72.016	156.547	bowhead whale	tail slap	1	0	0
30	9/5/2019 17:05	72.027	156.526	bowhead whale	swim	1	0	0
30	9/5/2019 17:11	71.997	156.473	bowhead whale	swim	1	0	12
30	9/5/2019 17:16	71.994	156.377	bowhead whale	swim	2	1	12
30	9/5/2019 19:01	71.592	155.895	beluga	swim	1	0	12
30	9/5/2019 19:01	71.592	155.911	beluga	swim	1	0	12
30	9/5/2019 19:01	71.596	155.897	beluga	swim	1	0	12
30	9/5/2019 19:01	71.598	155.892	beluga	swim	1	0	12
30	9/5/2019 19:01	71.615	155.908	bowhead whale	swim	1	0	12
30	9/5/2019 19:04	71.626	155.889	beluga	mill	24	3	12
30	9/5/2019 19:04	71.626	155.897	beluga	mill	22	4	12
30	9/5/2019 19:26	71.728	155.395	bowhead whale	rest	1	0	12
30	9/5/2019 19:32	71.655	155.381	bowhead whale	swim	1	0	12
30	9/5/2019 20:19	70.878	153.907	bowhead whale	dead	1	0	3

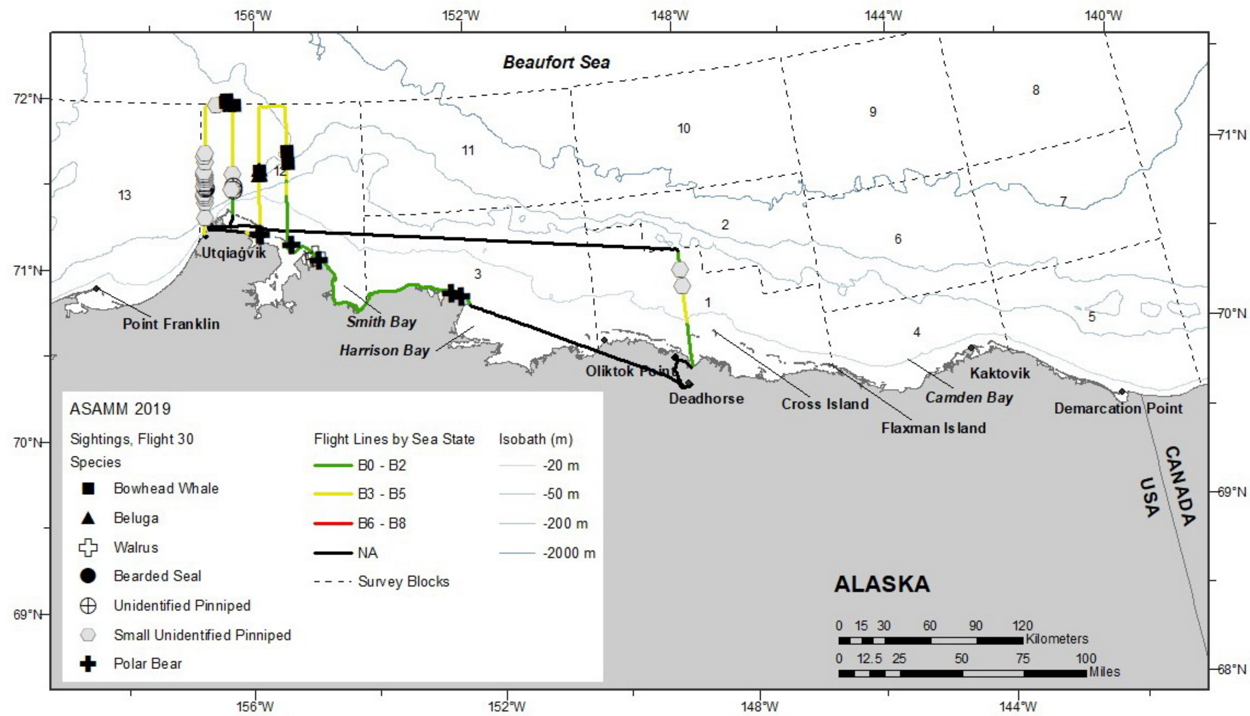


Figure B-77. Flight 30 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

6 September 2019, Flight 235

Flight was a partial survey of transects 17 and 19, and search survey near Point 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 fin whales, humpback whales, walruses, and small unidentified pinnipeds. Three walrus haulouts, estimated at 1,500, 4,000, and 25,000 walruses, were observed on a barrier island west of Point Lay.

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
235	9/6/2019 15:13	70.399	167.130	fin whale	swim	2	0	19
235	9/6/2019 15:15	70.402	167.113	humpback whale	swim	1	0	19
235	9/6/2019 15:15	70.404	167.128	humpback whale	swim	1	0	19
235	9/6/2019 15:19	70.406	167.130	fin whale	swim	1	0	19
235	9/6/2019 15:23	70.416	167.190	fin whale	swim	2	0	19

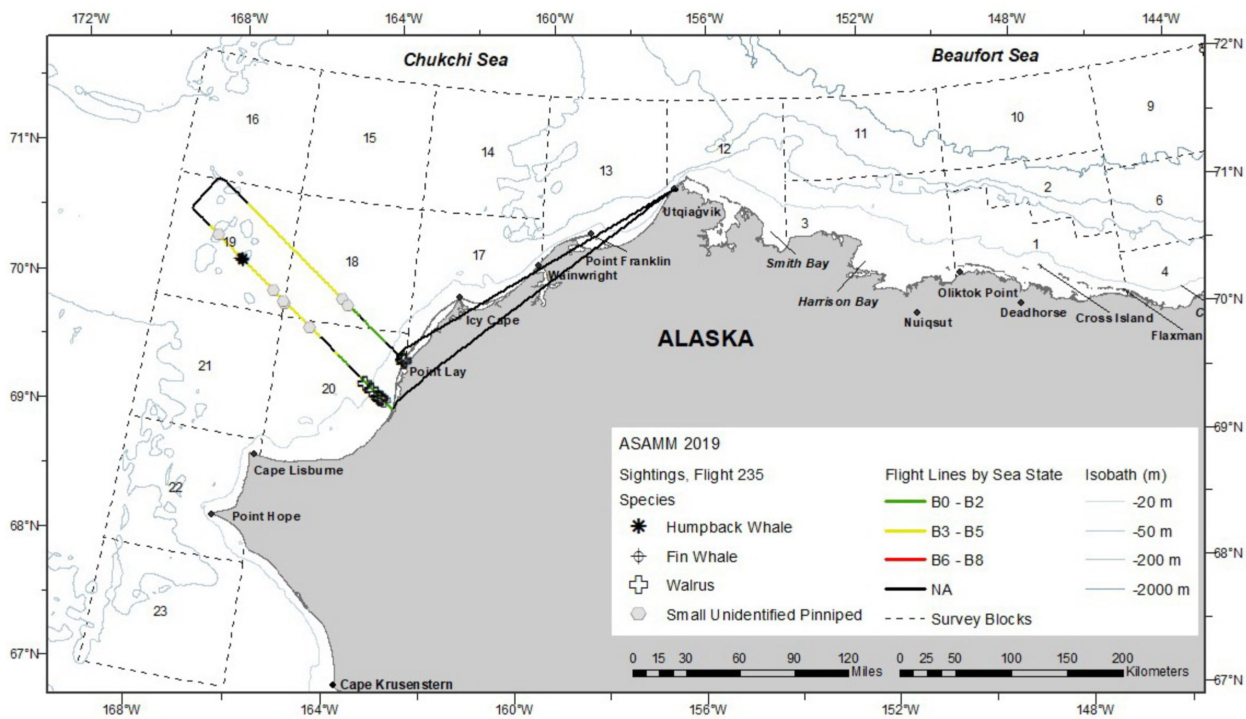


Figure B-78. Flight 235 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

7 September 2019, Flight 236

Flight was a partial survey of transect 11. Survey conditions included partly cloudy skies, 0 km to unlimited visibility, with glare, haze, and low ceilings, and Beaufort 2 sea state. There was no sea ice in the area surveyed. Sightings included walruses and small unidentified pinnipeds.

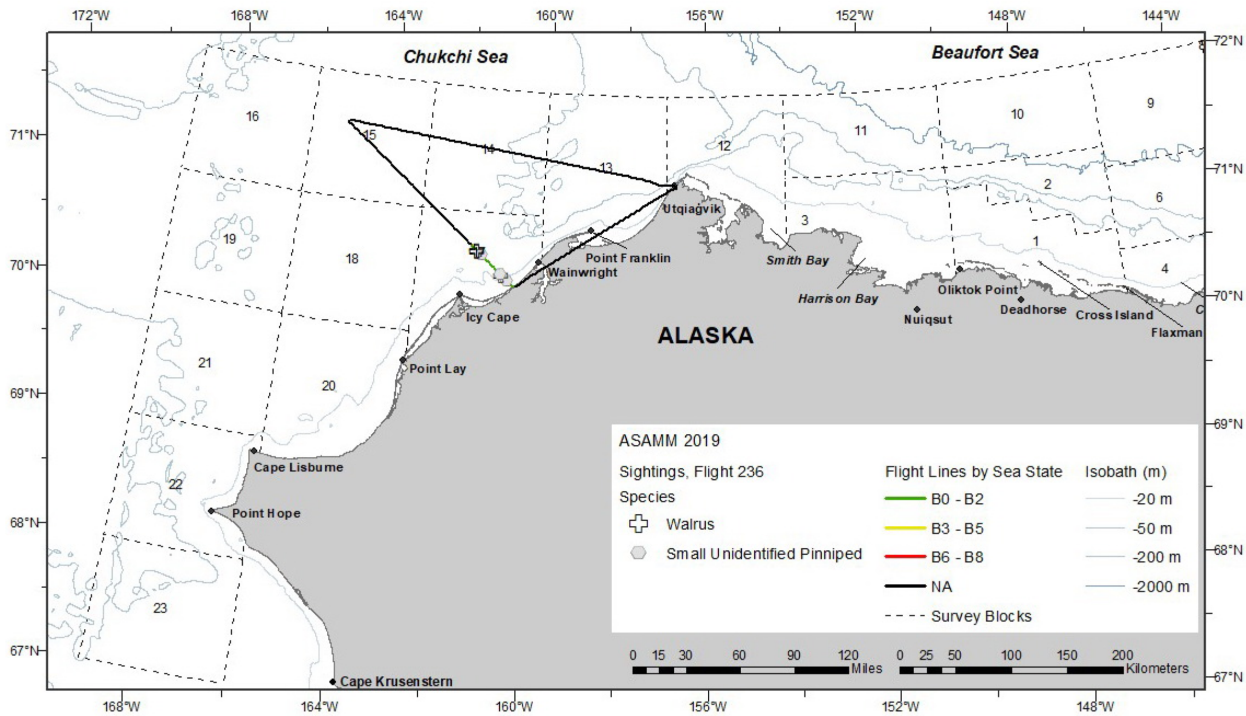


Figure B-79. Flight 236 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

7 September 2019, Flight 31

Flight was a series of field-of-view transects associated with a terrestrial target south of Deadhorse, Alaska, to collect data to refine estimates of the field of view from observer windows in the Commander aircraft. Survey conditions included partly cloudy skies, unlimited visibility, and no visual impediments. There were no marine mammal sightings.

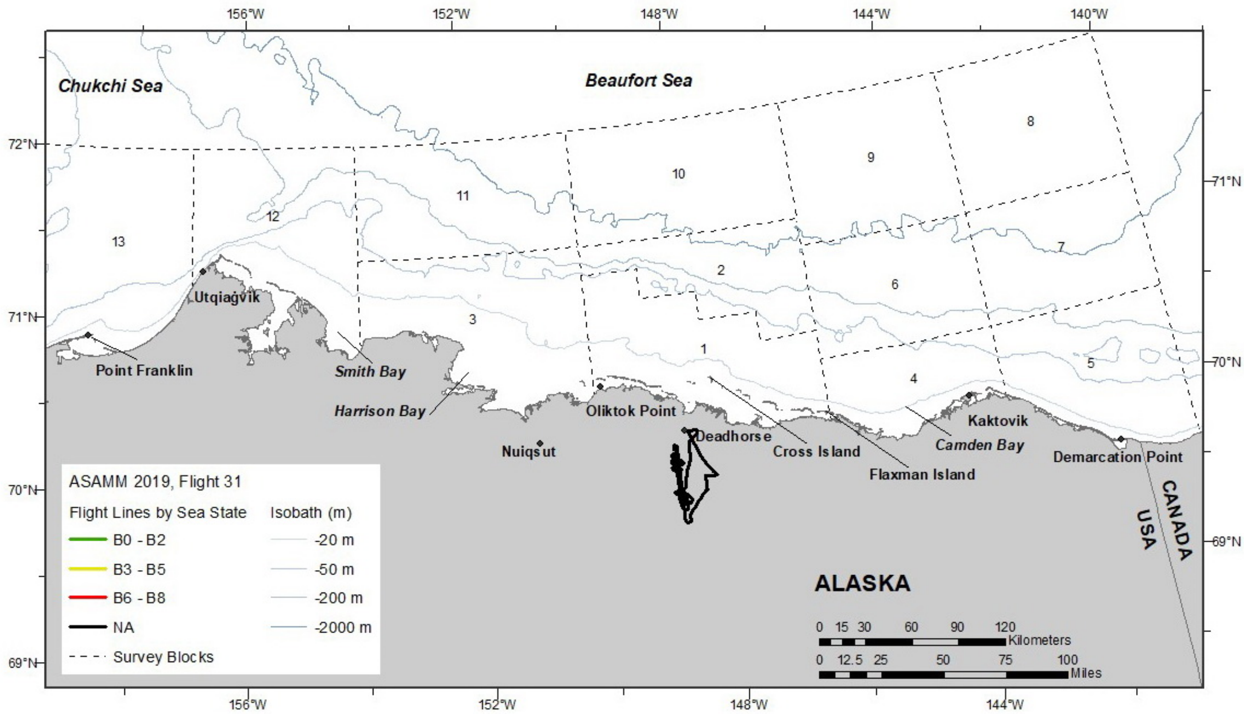


Figure B-80. Flight 31 survey track, depicted by sea state.

8 September 2019, Flight 237

Flight was a partial survey of transects 5, 13, and 15. Survey conditions included partly cloudy to overcast skies, <1 km to unlimited visibility, with fog, glare, haze, low ceilings, and precipitation, and Beaufort 2-4 sea states. There was no sea ice in the area surveyed. Sightings included walruses, one unidentified pinniped, and small unidentified pinnipeds.

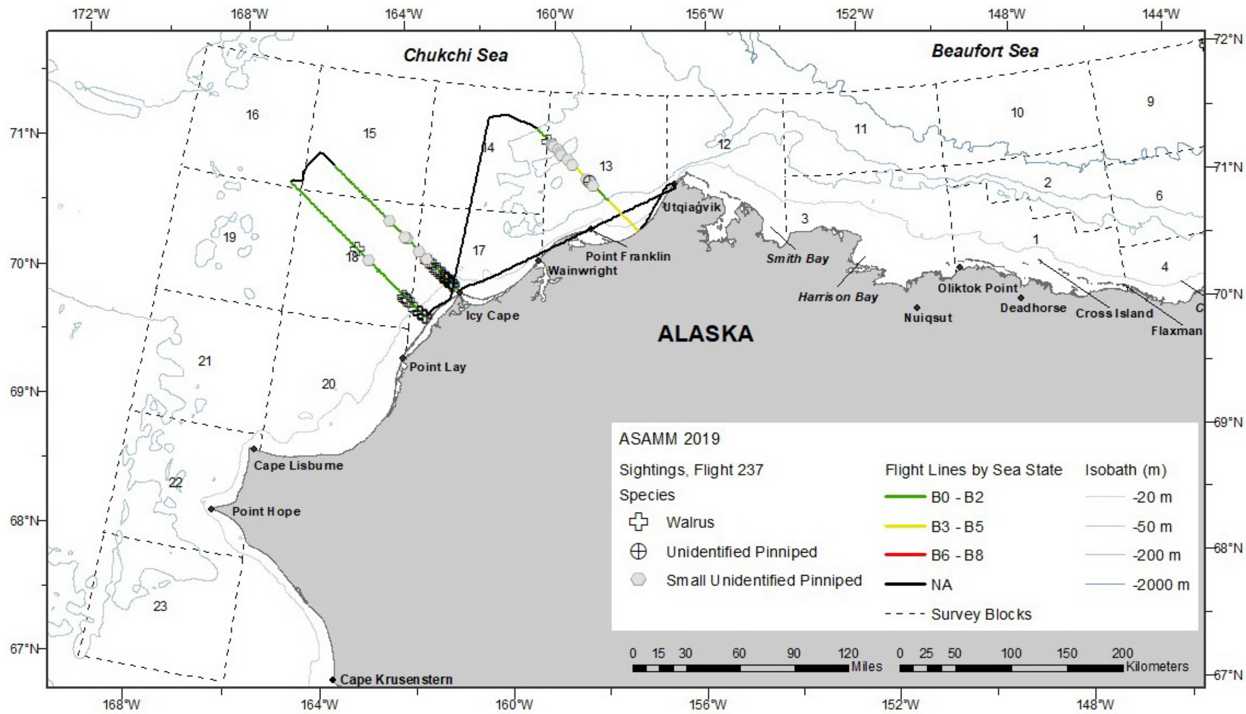


Figure B-81. Flight 237 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

This page intentionally left blank.

8 September 2019, Flight 32

Flight was a complete survey of transects 125, 126, 127, and 128, and the coastal transect in Harrison Bay. Survey conditions included clear, partly cloudy, and overcast skies, 1 km to unlimited visibility, with glare and precipitation, and Beaufort 1-4 sea states. There was no sea ice in the area surveyed. Sightings included belugas (including one calf), one bearded seal, unidentified pinnipeds, small unidentified pinnipeds, and one polar bear. One haulout, of approximately 25 small unidentified pinnipeds, was observed on a barrier island in Harrison Bay.

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
32	9/8/2019 10:08	71.910	153.919	beluga	swim	1	0	11
32	9/8/2019 10:10	71.966	153.878	beluga	swim	1	0	11
32	9/8/2019 10:10	71.980	153.925	beluga	swim	1	0	11
32	9/8/2019 10:10	71.992	153.875	beluga	swim	1	0	11
32	9/8/2019 10:31	71.474	153.409	beluga	swim	19	0	11
32	9/8/2019 10:32	71.458	153.393	beluga	swim	1	0	11
32	9/8/2019 10:32	71.454	153.390	beluga	swim	3	1	11
32	9/8/2019 11:19	71.761	152.920	beluga	swim	1	0	11
32	9/8/2019 11:20	71.800	152.916	beluga	swim	1	0	11
32	9/8/2019 11:20	71.810	152.903	beluga	rest	1	0	11
32	9/8/2019 11:20	71.812	152.898	beluga	rest	1	0	11
32	9/8/2019 11:21	71.825	152.920	beluga	swim	1	0	11

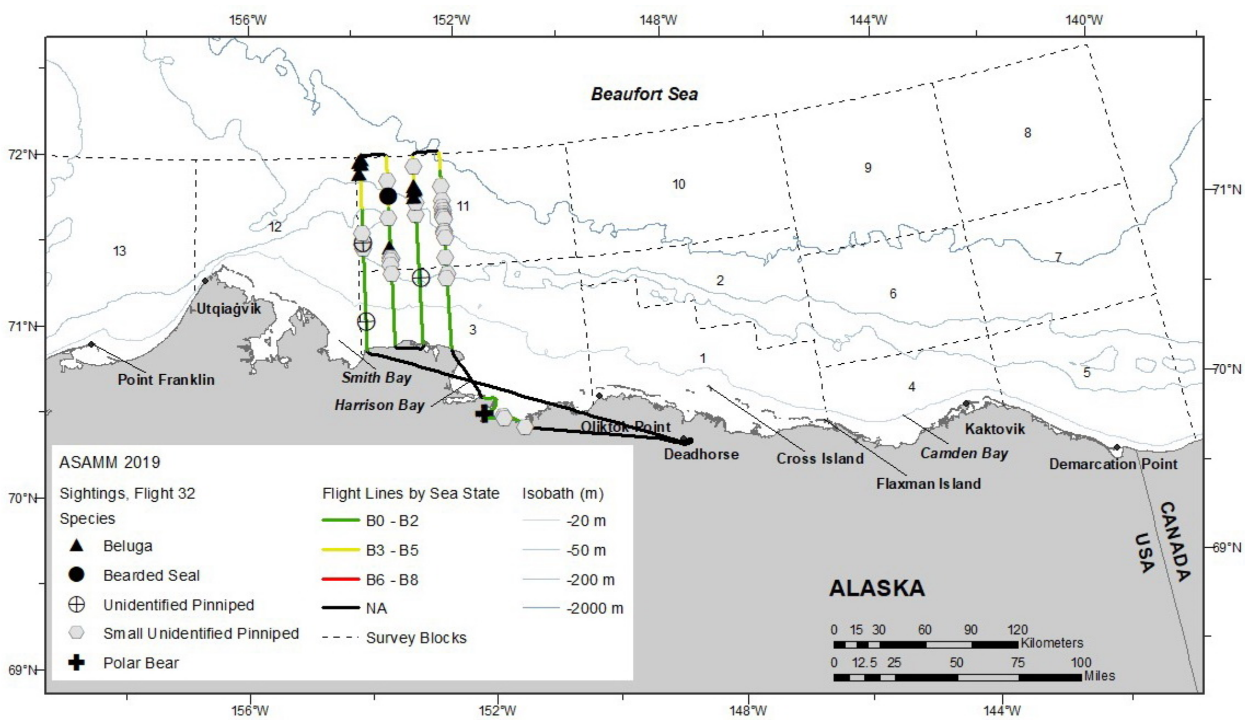


Figure B-82. Flight 32 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

9 September 2019, Flight 33

Flight was a complete survey of transects 101 and 102, and the coastal transect from Demarcation Bay to approximately 50 km east of Kaktovik and from approximately 50 km west of Kaktovik to approximately 50 km east of Cross Island. Survey conditions included clear to partly cloudy skies, unlimited visibility, with glare, and Beaufort 0-3 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales (including 12 calves and one carcass), unidentified cetaceans, bearded seals, 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
33	9/9/2019 10:17	69.792	140.353	unid cetacean	swim	1	0	5
33	9/9/2019 10:27	69.911	140.447	bowhead whale	swim	1	0	5
33	9/9/2019 10:35	70.158	140.412	bowhead whale	rest	3	1	5
33	9/9/2019 10:40	70.271	140.374	bowhead whale	swim	1	0	5
33	9/9/2019 11:30	70.566	140.931	bowhead whale	swim	2	1	7
33	9/9/2019 11:40	70.419	141.012	bowhead whale	swim	2	0	5
33	9/9/2019 11:47	70.414	140.879	bowhead whale	.	2	1	5
33	9/9/2019 11:47	70.408	140.864	bowhead whale	.	1	0	5
33	9/9/2019 11:48	70.382	140.872	bowhead whale	.	2	1	5
33	9/9/2019 11:48	70.380	140.874	bowhead whale	.	1	0	5
33	9/9/2019 11:52	70.392	140.843	bowhead whale	swim	2	1	5
33	9/9/2019 11:53	70.379	140.863	bowhead whale	swim	2	1	5
33	9/9/2019 11:53	70.392	140.838	bowhead whale	swim	1	0	5
33	9/9/2019 11:57	70.413	140.876	bowhead whale	swim	2	1	5
33	9/9/2019 11:57	70.406	140.857	bowhead whale	swim	1	0	5
33	9/9/2019 11:58	70.407	140.849	bowhead whale	swim	1	0	5
33	9/9/2019 11:58	70.418	140.863	bowhead whale	swim	2	1	5
33	9/9/2019 11:59	70.413	140.882	bowhead whale	swim	2	1	5
33	9/9/2019 12:00	70.386	140.858	bowhead whale	swim	2	1	5
33	9/9/2019 12:01	70.413	140.855	bowhead whale	swim	1	0	5
33	9/9/2019 12:03	70.403	140.874	bowhead whale	swim	1	1	5
33	9/9/2019 12:15	70.046	140.842	bowhead whale	swim	2	1	5
33	9/9/2019 12:19	70.024	140.919	bowhead whale	swim	1	0	5
33	9/9/2019 12:23	69.948	140.903	bowhead whale	swim	1	0	5
33	9/9/2019 12:23	69.942	140.981	bowhead whale	swim	2	0	5
33	9/9/2019 12:24	69.938	140.955	bowhead whale	swim	1	0	5
33	9/9/2019 12:29	69.889	140.906	unid cetacean	dive	1	0	5
33	9/9/2019 13:00	69.952	142.440	bowhead whale	dead	1	0	5

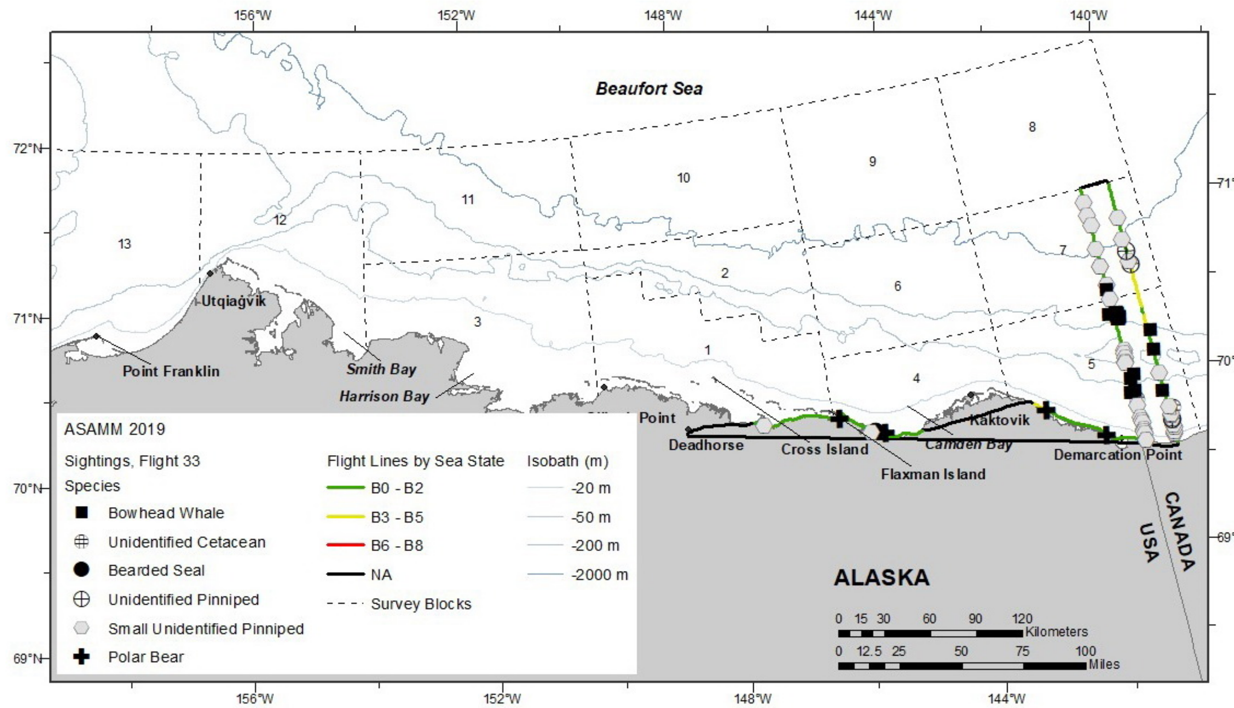


Figure B-83. Flight 33 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Bowhead whale cow-calf pair sighted approximately 110 km north of Demarcation Bay, Alaska, Flight 33, 9 September 2019.

Four polar bears (and two gulls) associated with a bowhead whale carcass sighted approximately 50 km southeast of Kaktovik, Alaska, Flight 33, 9 September 2019.

This page intentionally left blank.

10 September 2019, Flight 34

Flight was a complete survey of transects 110, 111, 112, and 113. Survey conditions included partly cloudy to overcast skies, 3 km to unlimited visibility, with glare and precipitation, and Beaufort 2-4 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales (including two calves), belugas (including eight calves), unidentified cetaceans, bearded seals, 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
34	9/10/2019 9:28	70.417	144.950	bowhead whale	swim	3	1	4
34	9/10/2019 9:41	70.739	144.970	bowhead whale	log play	1	0	6
34	9/10/2019 9:48	70.823	144.827	unid cetacean	swim	1	0	6
34	9/10/2019 9:52	70.839	144.801	unid cetacean	swim	1	0	6
34	9/10/2019 9:56	70.866	144.835	bowhead whale	tail slap	2	1	6
34	9/10/2019 10:03	70.946	144.904	beluga	rest	1	1	6
34	9/10/2019 10:03	70.962	144.922	beluga	swim	1	0	6
34	9/10/2019 10:04	70.972	144.912	beluga	swim	1	0	6
34	9/10/2019 10:04	70.982	144.881	beluga	swim	1	0	6
34	9/10/2019 10:16	71.088	145.373	beluga	swim	1	0	6
34	9/10/2019 10:16	71.085	145.401	beluga	swim	1	0	6
34	9/10/2019 10:17	71.078	145.418	beluga	swim	1	0	6
34	9/10/2019 10:22	70.908	145.393	bowhead whale	swim	1	0	6
34	9/10/2019 10:25	70.859	145.414	bowhead whale	swim	4	0	6
34	9/10/2019 11:30	71.176	145.906	unid cetacean	swim	1	0	9
34	9/10/2019 11:44	71.313	146.425	beluga	swim	1	0	2
34	9/10/2019 11:44	71.306	146.370	beluga	swim	1	0	2
34	9/10/2019 11:44	71.300	146.380	beluga	swim	1	0	2
34	9/10/2019 11:45	71.290	146.387	beluga	swim	1	0	2
34	9/10/2019 11:45	71.289	146.426	beluga	swim	4	2	2
34	9/10/2019 11:45	71.284	146.424	beluga	swim	3	1	2
34	9/10/2019 11:45	71.278	146.410	beluga	swim	6	2	2
34	9/10/2019 11:46	71.227	146.403	beluga	rest	1	0	2
34	9/10/2019 11:47	71.217	146.393	beluga	swim	3	0	2
34	9/10/2019 11:48	71.185	146.423	beluga	rest	1	0	2
34	9/10/2019 11:48	71.170	146.426	beluga	swim	7	1	2
34	9/10/2019 11:48	71.159	146.421	beluga	swim	1	0	2
34	9/10/2019 11:48	71.156	146.415	beluga	swim	1	0	2
34	9/10/2019 11:49	71.149	146.398	beluga	swim	1	0	2
34	9/10/2019 11:49	71.146	146.395	beluga	swim	3	1	2
34	9/10/2019 11:56	70.884	146.563	unid cetacean	swim	1	0	2
34	9/10/2019 11:58	70.871	146.540	bowhead whale	swim	1	0	2
34	9/10/2019 11:59	70.876	146.467	bowhead whale	swim	2	0	2
34	9/10/2019 12:02	70.868	146.423	bowhead whale	swim	2	0	2
34	9/10/2019 12:06	70.857	146.413	bowhead whale	swim	1	0	2

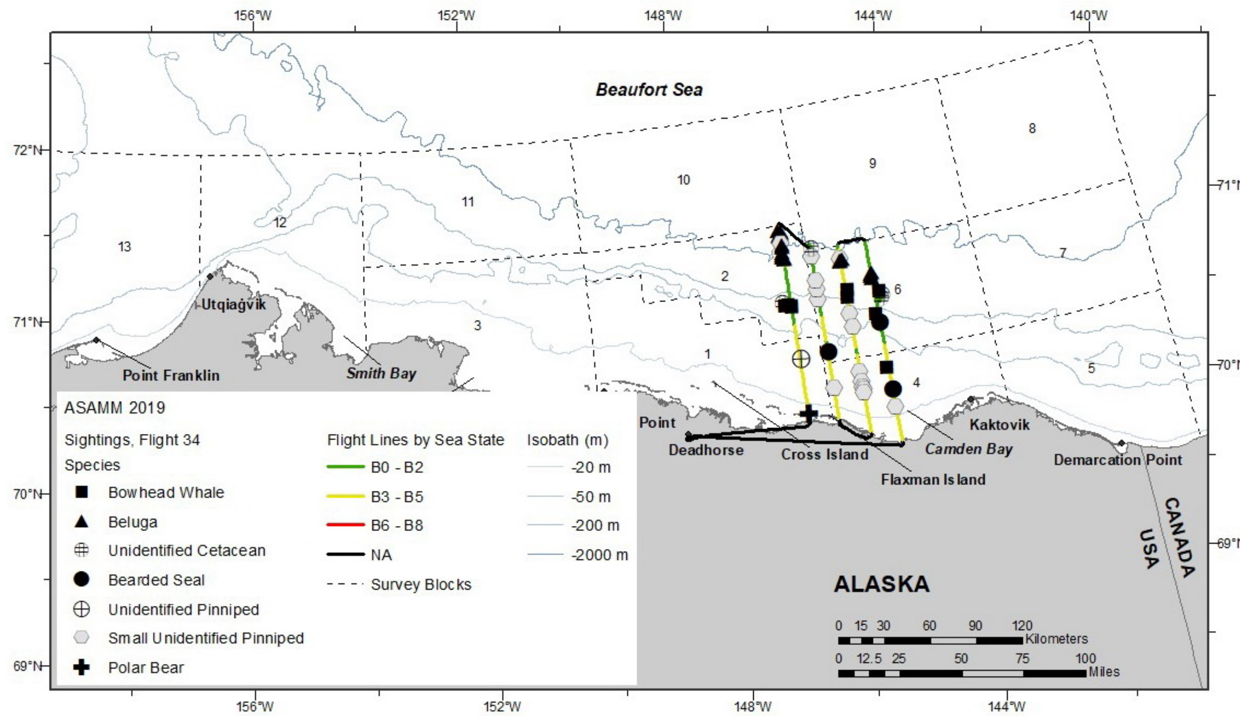


Figure B-84. Flight 34 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Bowhead whale playing with a log approximately 85 km northwest of Kaktovik, Alaska, Flight 34, 10 September 2019.

This tail-slapping bowhead whale was presumed to be a female because there was a calf nearby. The duo was sighted approximately 95 km northwest of Kaktovik, Alaska, Flight 34, 10 September 2019.

14 September 2019, Flight 238

Flight was a complete survey of transects 129, 130, and 131, and partial survey of transect 132. Survey conditions included partly cloudy to overcast skies, 0-5 km visibility, with low ceilings, and Beaufort 2-5 sea states. There was no sea ice in the area surveyed. Sightings included belugas (including two 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
238	9/14/2019 14:45	71.653	154.411	beluga	rest	2	1	12
238	9/14/2019 15:05	71.808	154.893	beluga	swim	1	0	12
238	9/14/2019 15:05	71.798	154.901	beluga	swim	2	1	12
238	9/14/2019 15:05	71.793	154.903	beluga	swim	1	0	12

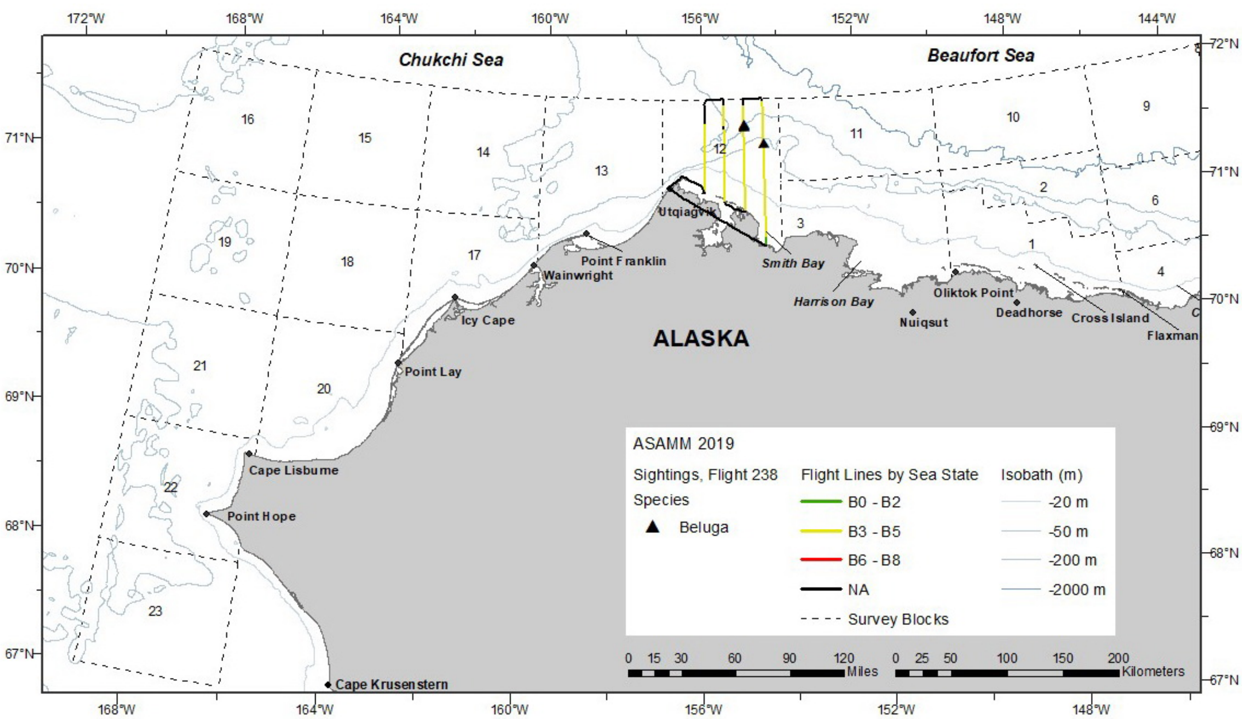


Figure B-85. Flight 238 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

17 September 2019, Flight 239

Flight was a complete survey of transects 2, 3, 4, 5, 7, and 9. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare, haze, low ceilings, and precipitation, and Beaufort 1-4 sea states. There was no sea ice in the area surveyed. Sightings included gray whales, one beluga, killer whales (including two calves), 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	9/17/2019 9:36	71.002	161.064	gray whale	rest	1	0	14
239	9/17/2019 9:42	71.022	161.149	gray whale	feed	1	0	14
239	9/17/2019 11:23	71.176	160.078	gray whale	feed	1	0	14
239	9/17/2019 14:47	71.873	160.081	beluga	swim	1	0	14
239	9/17/2019 15:30	71.393	159.161	killer whale	mill	8	1	13
239	9/17/2019 15:45	71.374	159.153	killer whale	mill	3	1	13
239	9/17/2019 15:46	71.374	159.137	killer whale	mill	2	0	13

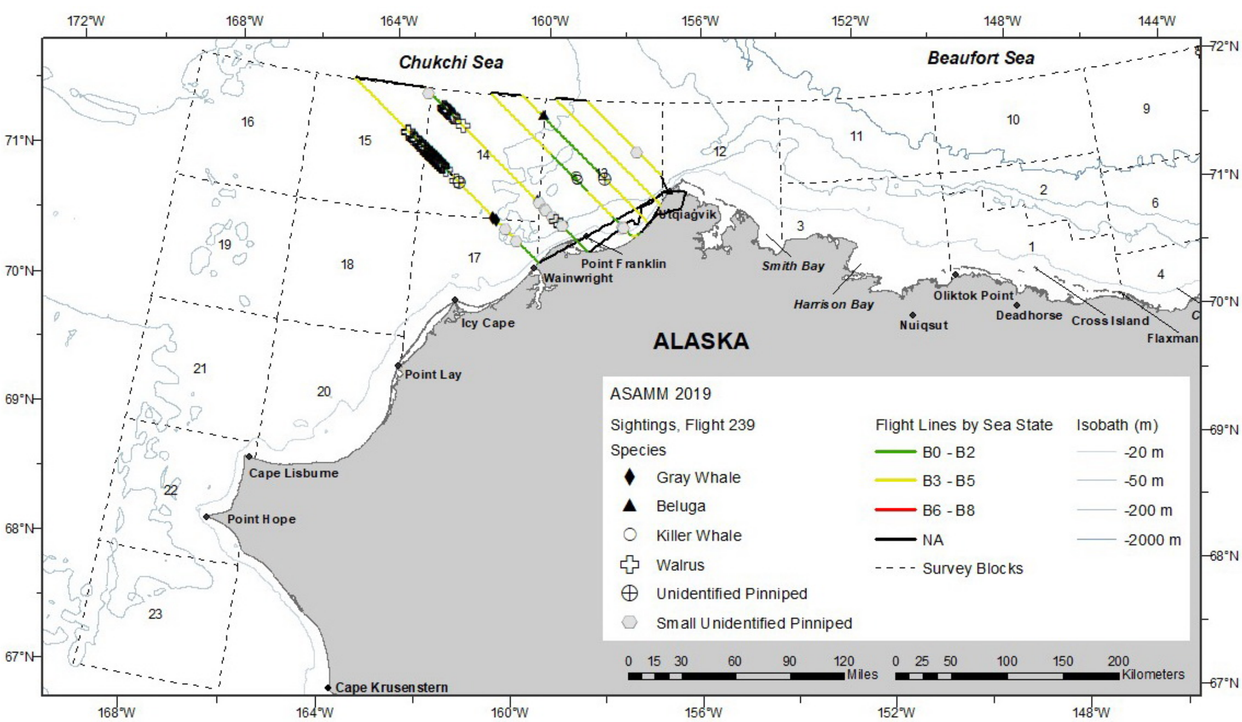


Figure B-86. Flight 239 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

One of thirteen killer whales sighted approximately 85 km west of Utqiaġvik, Alaska, Flight 239, 17 September 2019.

17 September 2019, Flight 35

Flight was a complete survey of transects 128, 129, 130, and 131. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with low ceilings and precipitation, and Beaufort 2-5 sea states. There was no sea ice in the area surveyed. Sightings included one small unidentified pinniped.

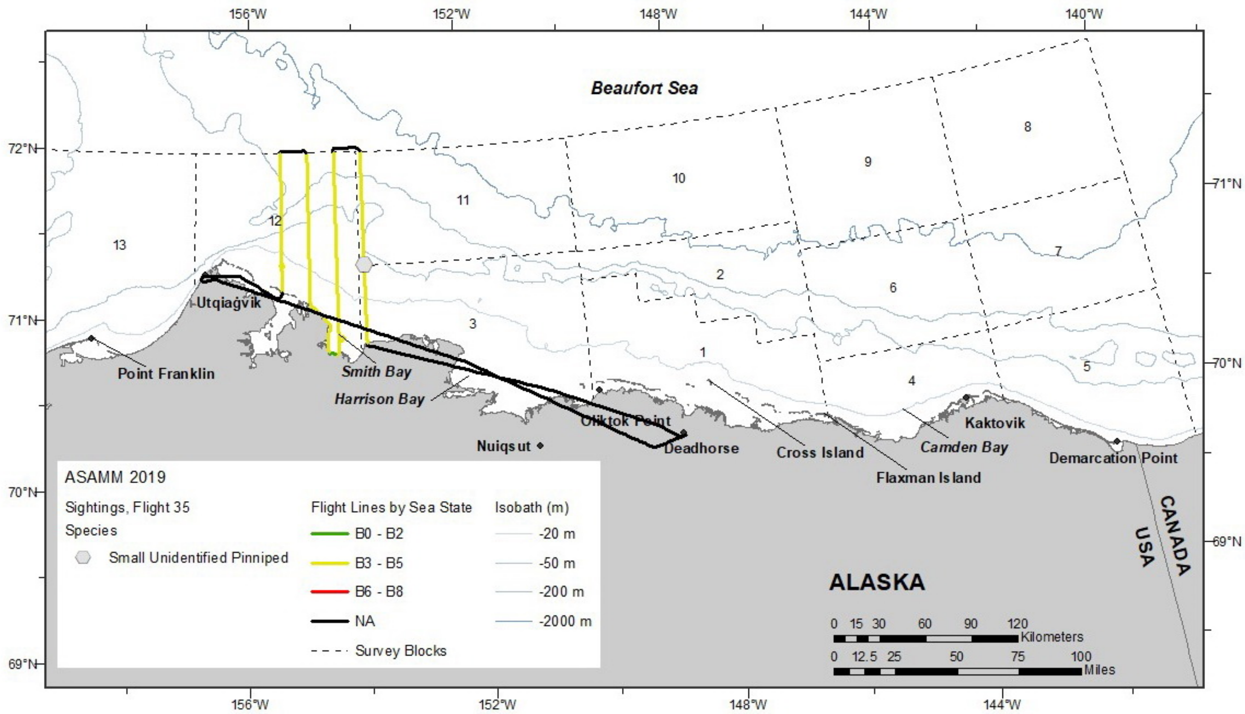


Figure B-87. Flight 35 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

18 September 2019, Flight 240

Flight was a partial survey of transects 10, 12, and 134. Survey conditions included partly cloudy to overcast skies, <1-10 km 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 unidentified cetacean 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
240	9/18/2019 12:49	71.254	164.696	unid cetacean	swim	1	0	15

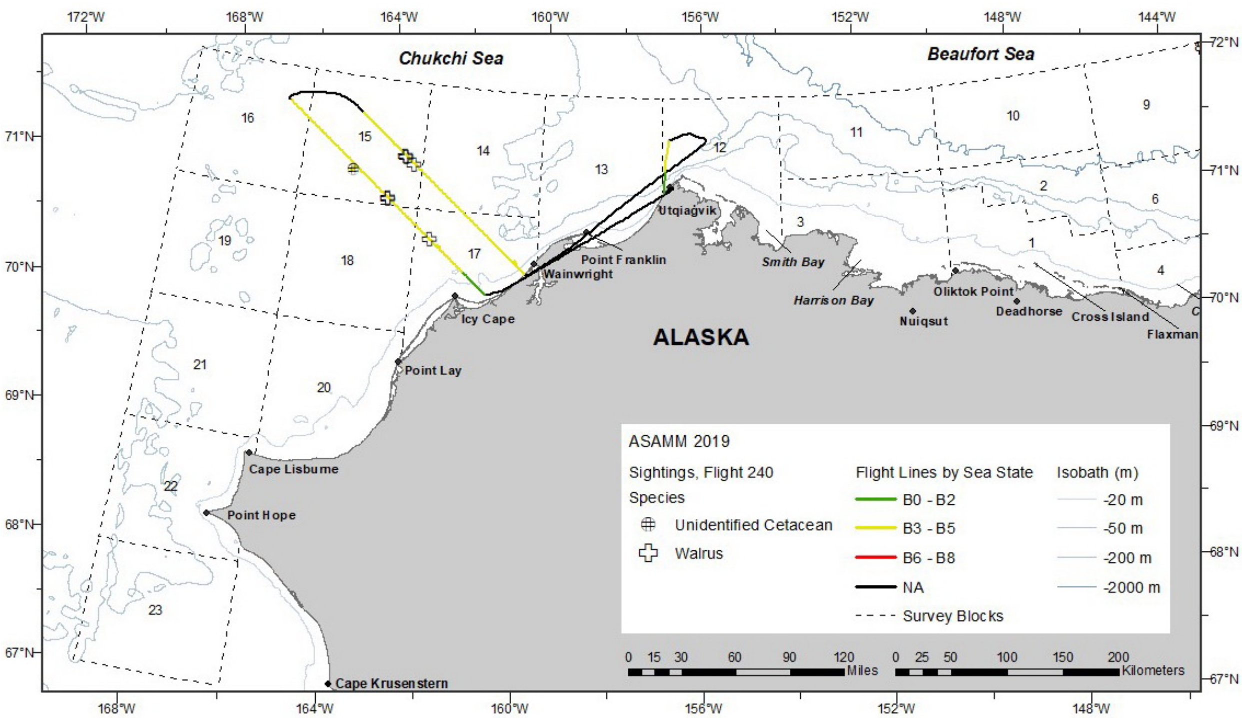


Figure B-88. Flight 240 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

18 September 2018, Flight 36

Flight was a complete survey of transects 33, 34, 37, and 38. Survey conditions included partly cloudy skies, 2 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 gray whales (including two calves), fin whales, unidentified cetaceans, small unidentified pinnipeds, and one unidentified marine mammal carcass.

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	9/18/2019 11:36	67.913	168.178	gray whale	feed	4	1	23
36	9/18/2019 11:40	67.911	168.210	gray whale	feed	5	1	23
36	9/18/2019 11:47	67.922	168.261	gray whale	feed	2	0	23
36	9/18/2019 11:54	67.922	168.358	gray whale	swim	1	0	23
36	9/18/2019 11:56	67.921	168.357	fin whale	swim	1	0	23
36	9/18/2019 11:57	67.919	168.396	gray whale	feed	2	0	23
36	9/18/2019 12:12	67.746	168.783	gray whale	swim	1	0	23
36	9/18/2019 12:23	67.687	167.970	unid cetacean	swim	1	0	23
36	9/18/2019 12:23	67.730	167.968	unid cetacean	swim	1	0	23
36	9/18/2019 12:23	67.715	167.960	unid cetacean	swim	1	0	23
36	9/18/2019 12:27	67.757	167.929	unid cetacean	swim	1	0	23
36	9/18/2019 12:31	67.759	167.860	unid cetacean	swim	1	0	23
36	9/18/2019 12:36	67.764	167.815	fin whale	swim	1	0	23
36	9/18/2019 12:43	67.729	167.340	unid cetacean	swim	1	0	23
36	9/18/2019 12:49	67.722	166.766	unid cetacean	swim	2	0	23

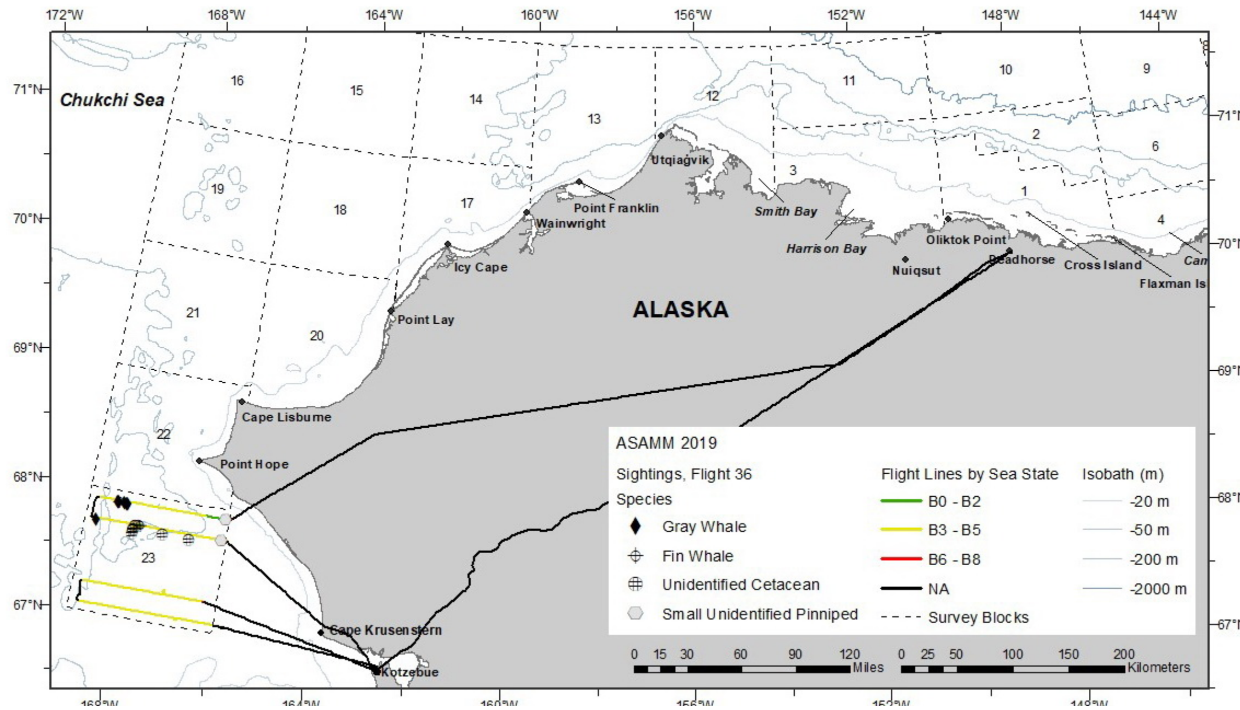


Figure B-89. Flight 36 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

20 September 2019, Flight 241

Flight was a complete survey of transects 1, 124, 125, 132, and 133, partial survey of transects 126 and 134, and the coastal transect in Harrison Bay. Survey conditions included partly cloudy to overcast skies, <1 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 3-5 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales, belugas, one unidentified cetacean, 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	9/20/2019 11:11	71.203	151.924	bowhead whale	swim	2	0	3
241	9/20/2019 11:19	71.335	151.826	bowhead whale	swim	1	0	11
241	9/20/2019 11:24	71.486	151.906	beluga	rest	1	0	11
241	9/20/2019 11:24	71.491	151.925	beluga	swim	1	0	11
241	9/20/2019 11:24	71.504	151.900	beluga	swim	1	0	11
241	9/20/2019 11:25	71.514	151.868	beluga	swim	2	0	11
241	9/20/2019 11:25	71.531	151.935	beluga	swim	2	0	11
241	9/20/2019 11:25	71.535	151.923	beluga	swim	1	0	11
241	9/20/2019 11:25	71.535	151.901	beluga	rest	1	0	11
241	9/20/2019 11:25	71.540	151.895	beluga	rest	1	0	11
241	9/20/2019 11:25	71.543	151.903	beluga	swim	1	0	11
241	9/20/2019 11:26	71.547	151.932	beluga	swim	2	0	11
241	9/20/2019 11:26	71.552	151.897	beluga	rest	1	0	11
241	9/20/2019 11:26	71.557	151.876	beluga	swim	1	0	11
241	9/20/2019 11:26	71.565	151.875	beluga	rest	1	0	11
241	9/20/2019 11:27	71.581	151.894	beluga	swim	1	0	11
241	9/20/2019 11:30	71.703	151.864	unid cetacean	dive	1	0	11
241	9/20/2019 11:42	71.936	151.903	beluga	swim	1	0	11
241	9/20/2019 11:42	71.936	151.892	beluga	swim	1	0	11
241	9/20/2019 11:42	71.945	151.897	beluga	swim	1	0	11

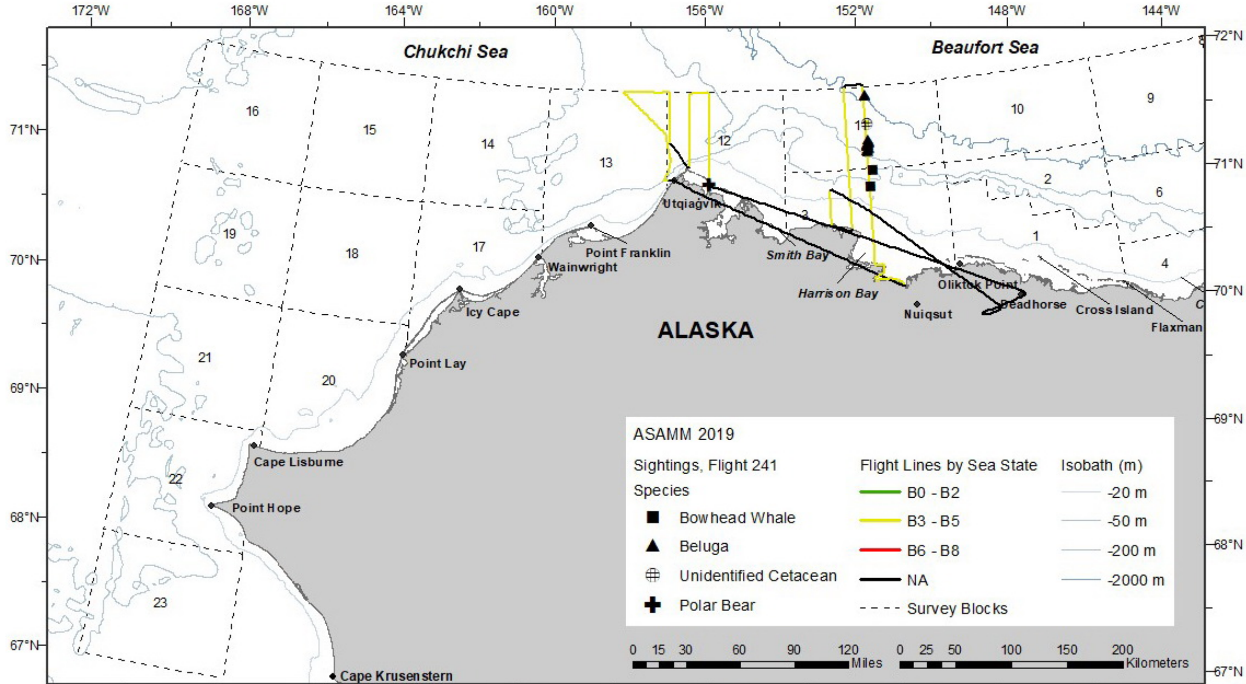


Figure B-90. Flight 241 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

21 September 2019, Flight 242

Flight was a complete survey of transect 21, partial survey of transects 18 and 19, search effort near Point Lay, and the coastal transect from Point Hope to Cape Krusenstern. Survey conditions included clear to partly cloudy skies, 0 km to unlimited visibility, with fog, glare, low ceilings, and precipitation, and Beaufort 1-3 sea states. There was no sea ice in the area surveyed. Sightings included one humpback whale carcass, minke whales, one unidentified cetacean carcass, walruses, and small unidentified pinnipeds. Two walrus haulouts, estimated at 10,000 and 35,000 walruses, were observed on a barrier island west of Point Lay.

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
242	9/21/2019 12:45	70.466	167.390	minke whale	swim	1	0	19
242	9/21/2019 14:16	69.251	164.285	minke whale	swim	1	0	20
242	9/21/2019 16:40	67.691	164.403	humpback whale	dead	1	0	0
242	9/21/2019 17:13	68.312	166.417	unid cetacean	dead	1	0	22

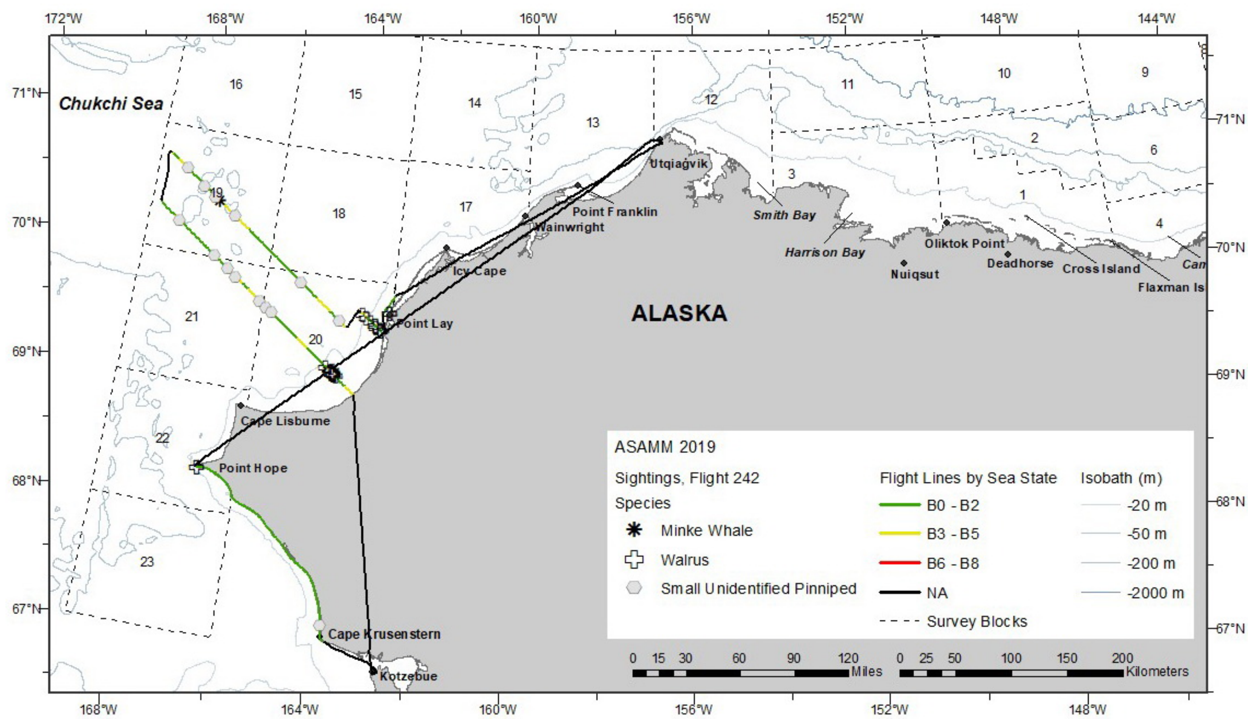


Figure B-91. Flight 242 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

22 September 2019, Flight 243

Flight was a complete survey of transects 28, 29, 30, and 31, and search effort east of Point Hope. Survey conditions included partly cloudy skies, unlimited visibility, with glare, and Beaufort 2-5 sea states. There was no sea ice in the area surveyed. Sightings included one minke whale and one unidentified cetacean carcass. The unidentified cetacean carcass was originally observed during flight 242 on 21 September 2019 and was intentionally relocated for further documentation.

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	9/22/2019 15:32	68.263	166.650	minke whale	swim	1	0	22
243	9/22/2019 15:50	68.308	166.419	unid cetacean	dead	1	0	22

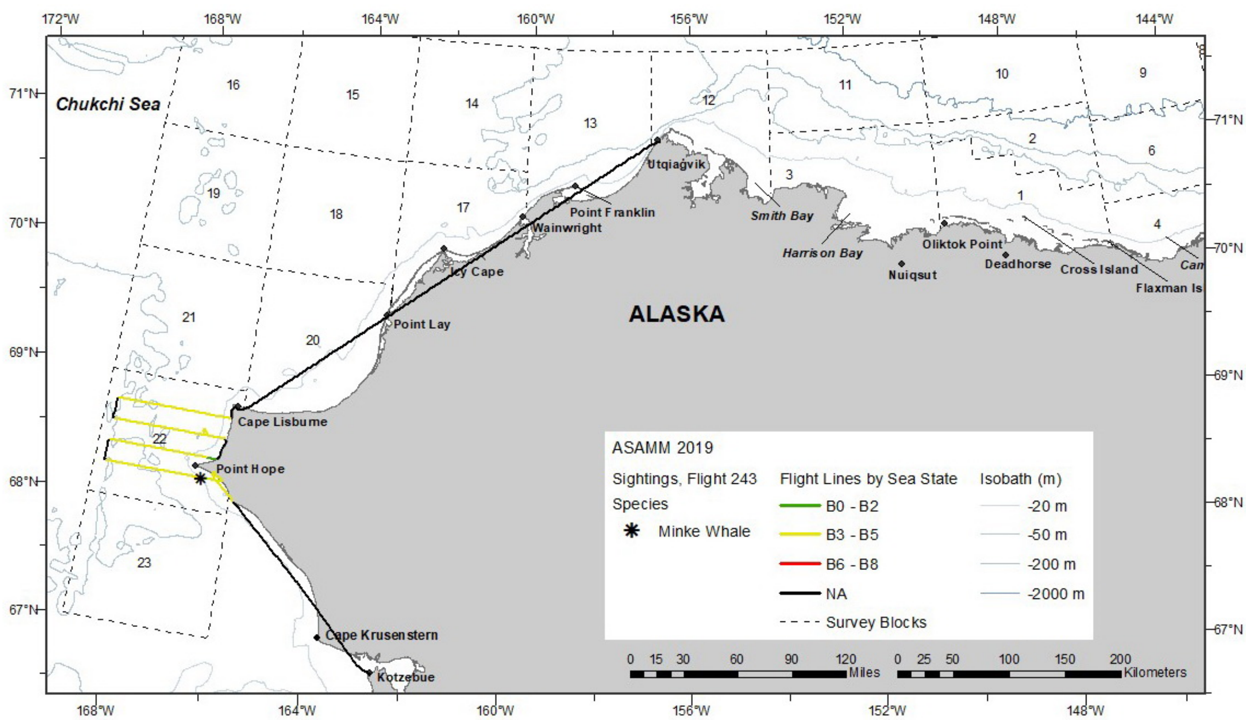


Figure B-92. Flight 243 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

23 September 2019, Flight 244

Flight was a complete survey of transect 33, partial survey of transects 32, 126, 127, 128, and 129, and the coastal transect between Smith Bay and Harrison Bay. 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, gray whales, humpback whales, belugas (including one calf), 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
244	9/23/2019 10:47	67.919	167.773	humpback whale	mill	2	0	23
244	9/23/2019 10:47	67.913	167.794	humpback whale	mill	3	0	23
244	9/23/2019 10:59	67.916	168.035	humpback whale	swim	1	0	23
244	9/23/2019 11:04	67.917	168.197	gray whale	feed	1	0	23
244	9/23/2019 11:11	67.921	168.246	gray whale	feed	1	0	23
244	9/23/2019 11:14	67.918	168.392	gray whale	swim	1	0	23
244	9/23/2019 11:17	67.928	168.425	gray whale	feed	1	0	23
244	9/23/2019 11:22	67.936	168.506	gray whale	feed	2	0	23
244	9/23/2019 11:25	67.916	168.603	gray whale	swim	2	0	23
244	9/23/2019 11:25	67.929	168.630	gray whale	feed	1	0	23
244	9/23/2019 11:25	67.935	168.630	gray whale	mill	2	0	23
244	9/23/2019 11:25	67.934	168.642	gray whale	feed	2	0	23
244	9/23/2019 16:58	71.424	152.902	bowhead whale	swim	2	0	11
244	9/23/2019 17:20	71.858	153.395	beluga	swim	2	1	11
244	9/23/2019 17:21	71.848	153.405	beluga	swim	1	0	11
244	9/23/2019 18:10	71.431	153.910	bowhead whale	swim	1	0	11

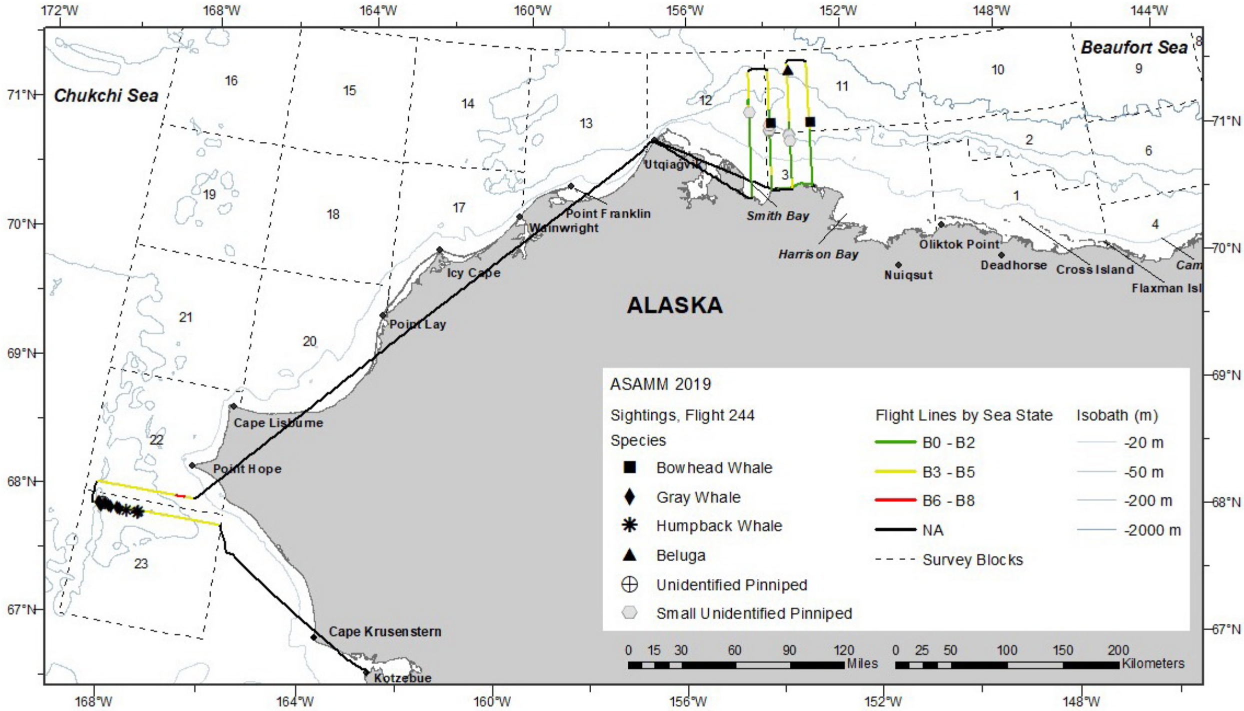


Figure B-93. Flight 244 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

24 September 2019, Flight 245

Flight was a partial survey of transects 110, 111, 113, 114, 115, 116, 119, 120, 121, 122, and 123. 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. There was no sea ice in the area surveyed. Sightings included bowhead whales (including two calves), belugas, 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
245	9/24/2019 11:26	71.448	150.919	beluga	swim	1	0	11
245	9/24/2019 12:42	70.973	149.878	bowhead whale	rest	2	1	1
245	9/24/2019 15:11	70.382	144.885	bowhead whale	swim	1	0	4
245	9/24/2019 15:24	70.789	144.910	bowhead whale	rest	1	1	6
245	9/24/2019 15:33	70.995	144.912	beluga	swim	3	0	6
245	9/24/2019 15:41	70.902	145.416	beluga	dive	1	0	6
245	9/24/2019 15:42	70.892	145.390	beluga	swim	1	0	6
245	9/24/2019 15:42	70.891	145.381	beluga	swim	1	0	6
245	9/24/2019 15:45	70.791	145.405	bowhead whale	rest	1	0	6
245	9/24/2019 16:00	70.418	145.377	bowhead whale	swim	1	0	4

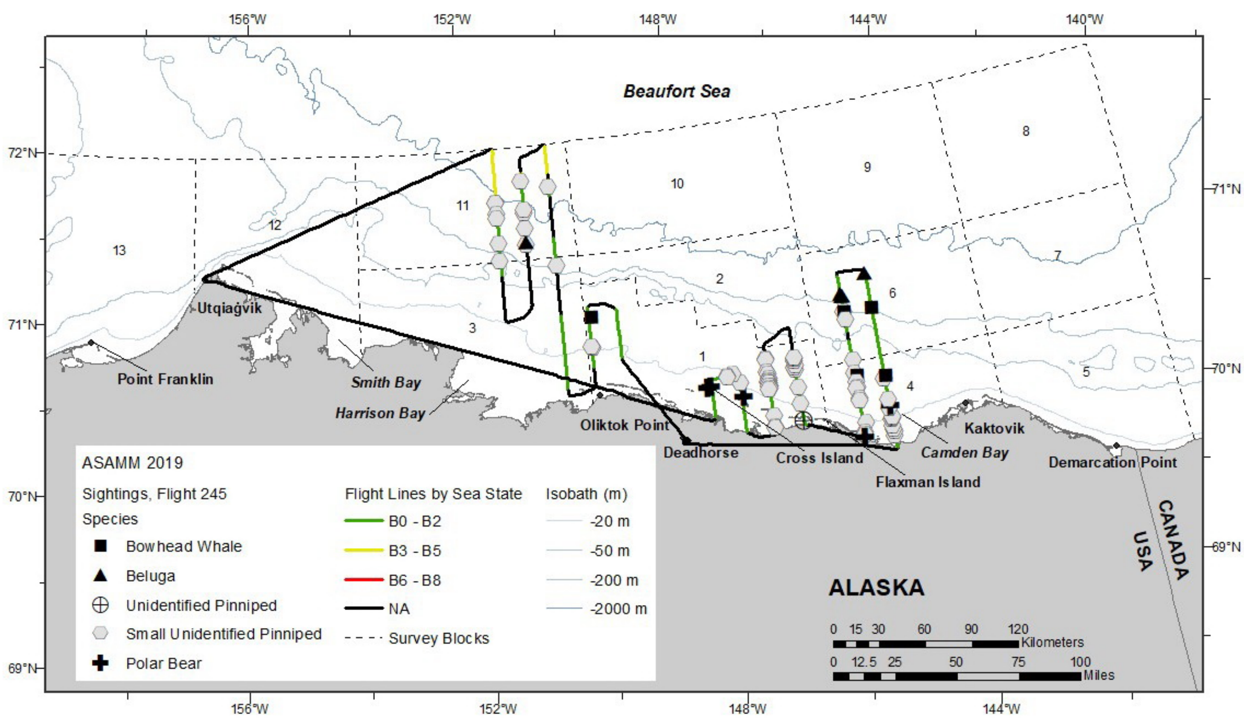
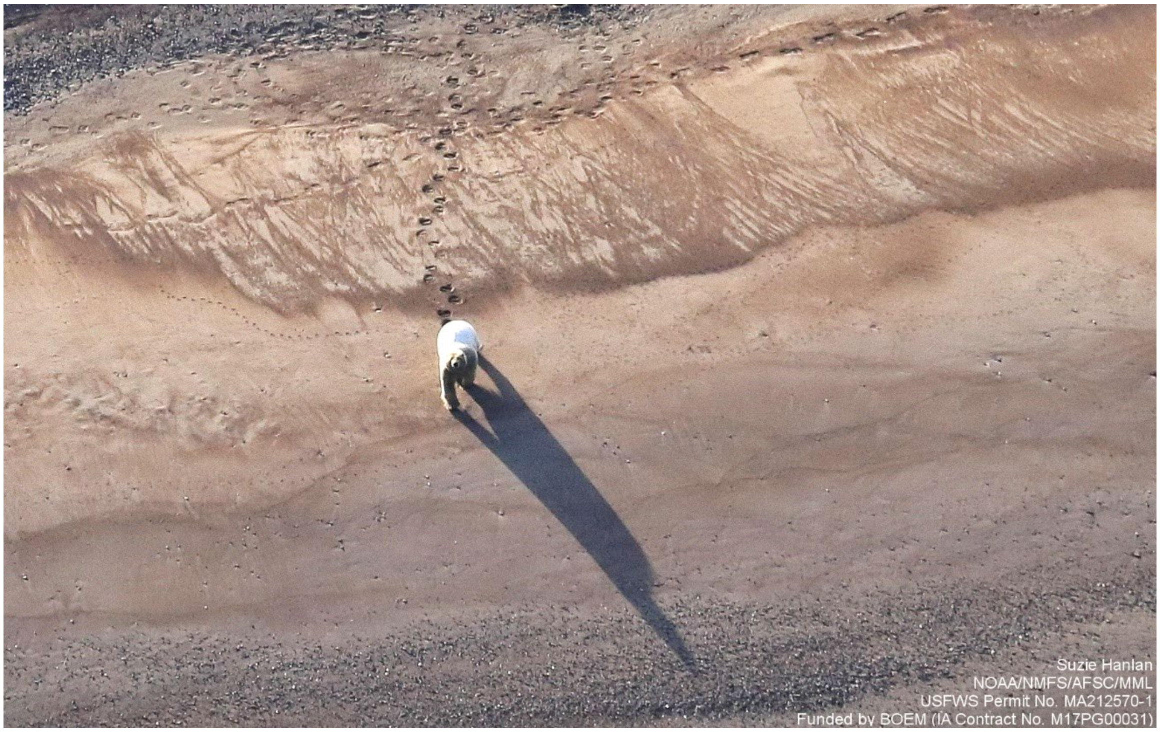


Figure B-94. Flight 245 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Bowhead whale cow-calf pair (cow is upper left, deep subsurface), approximately 50 km north of Oliktok Point, Alaska, Flight 245, 24 September 2019.

Bowhead whale with white on the trailing edge of its fluke, approximately 95 km northeast of Cross Island, Alaska, Flight 245, 24 September 2019.



One of several polar bears sighted on Cross Island, Alaska, Flight 245, 24 September 2019.

This page intentionally left blank.

24 September 2019, Flight 37

Flight was a partial survey of transects 107, 108, 109, 110, 111, and 112, and nominal effort on transect 118. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with fog, glare, and low ceilings, and Beaufort 1-3 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales (including two calves), belugas (including three calves), bearded seals, 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	9/24/2019 9:59	70.957	145.875	beluga	swim	1	0	6
37	9/24/2019 9:59	70.963	145.878	beluga	swim	1	0	6
37	9/24/2019 10:41	70.756	144.941	beluga	swim	1	0	6
37	9/24/2019 10:42	70.761	144.904	beluga	swim	2	1	6
37	9/24/2019 10:42	70.784	144.890	beluga	swim	1	0	6
37	9/24/2019 11:13	70.628	144.425	bowhead whale	swim	2	1	6
37	9/24/2019 11:29	70.640	143.909	bowhead whale	swim	2	1	6
37	9/24/2019 11:29	70.643	143.902	bowhead whale	swim	1	0	6
37	9/24/2019 11:30	70.653	143.937	beluga	swim	9	0	6
37	9/24/2019 11:37	70.657	143.903	beluga	swim	1	0	6
37	9/24/2019 11:37	70.661	143.922	beluga	swim	1	0	6
37	9/24/2019 11:37	70.666	143.930	beluga	swim	2	0	6
37	9/24/2019 11:37	70.670	143.879	beluga	swim	1	0	6
37	9/24/2019 11:37	70.680	143.888	beluga	swim	1	0	6
37	9/24/2019 11:38	70.694	143.929	beluga	swim	8	1	6
37	9/24/2019 11:38	70.705	143.893	beluga	swim	4	0	6
37	9/24/2019 11:41	70.794	143.881	beluga	swim	1	0	6
37	9/24/2019 11:42	70.833	143.907	beluga	swim	1	0	6
37	9/24/2019 11:43	70.862	143.884	beluga	swim	1	0	6
37	9/24/2019 11:46	70.942	143.924	beluga	swim	1	0	6
37	9/24/2019 11:50	71.097	143.897	beluga	swim	1	0	6
37	9/24/2019 11:50	71.098	143.922	beluga	swim	3	1	6
37	9/24/2019 12:04	70.929	143.424	beluga	swim	1	0	6
37	9/24/2019 12:06	70.869	143.418	beluga	swim	1	0	6
37	9/24/2019 12:06	70.863	143.428	beluga	swim	1	0	6
37	9/24/2019 12:06	70.858	143.426	beluga	swim	1	0	6
37	9/24/2019 12:11	70.705	143.434	beluga	swim	1	0	6
37	9/24/2019 12:11	70.705	143.385	beluga	swim	1	0	6
37	9/24/2019 12:11	70.697	143.404	beluga	swim	1	0	6
37	9/24/2019 12:11	70.694	143.419	beluga	swim	1	0	6
37	9/24/2019 12:12	70.662	143.393	beluga	swim	1	0	6
37	9/24/2019 12:12	70.659	143.441	beluga	swim	1	0	6
37	9/24/2019 12:20	70.395	143.408	bowhead whale	breach	1	0	4
37	9/24/2019 12:25	70.213	143.436	bowhead whale	other	1	0	4
37	9/24/2019 12:44	70.273	143.881	bowhead whale	swim	2	0	4
37	9/24/2019 12:44	70.273	143.911	bowhead whale	swim	2	0	4

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
37	9/24/2019 12:44	70.278	143.907	bowhead whale	rest	1	0	4
37	9/24/2019 12:50	70.309	143.927	bowhead whale	swim	2	0	4
37	9/24/2019 12:54	70.302	143.906	bowhead whale	swim	1	0	4

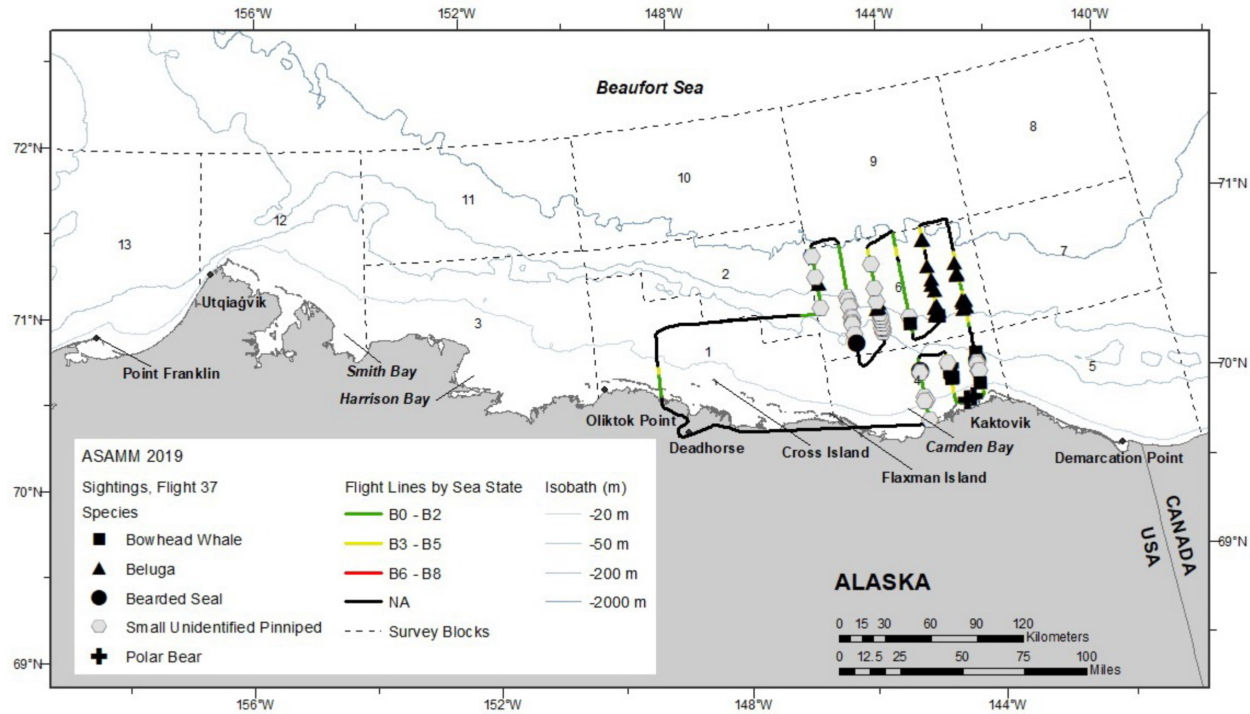


Figure B-95. Flight 37 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Cow-calf pair seen during Flight 37, 24 September 2019, approximately 55 km northwest of Kaktovik, Alaska. The light gray flukes of the calf can be seen submerged to the left of the cow. Also note the distinctive white mark on the cow's back near the right shoulder.

25 September 2019, Flight 246

Flight was nominal effort on transect 8 and the coastal transect from south of Point Franklin to south of Utqiaġvik. Survey conditions included partly cloudy skies, 2-10 km of 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 (including one calf and one carcass), one unidentified cetacean carcass, 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
246	9/25/2019 14:11	70.879	159.171	gray whale	feed	5	1	13
246	9/25/2019 14:49	70.977	157.422	unid cetacean	dead	1	0	13
246	9/25/2019 14:53	71.050	157.249	gray whale	dead	1	0	13

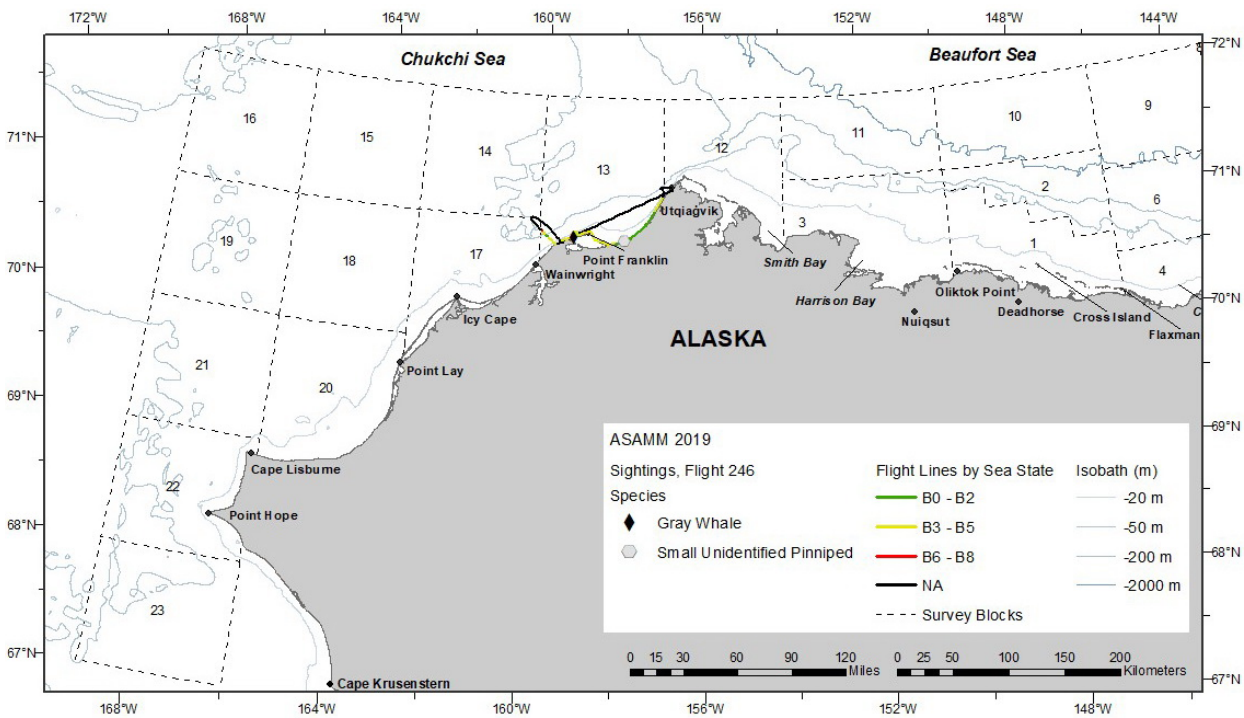


Figure B-96. Flight 246 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

This page intentionally left blank.

25 September 2019, Flight 38

Flight was a partial survey of transects 103, 104, 105, and 106, and the coastal transect from approximately 20 km east of Kaktovik to Deadhorse. Survey conditions included partly cloudy to overcast skies, 0-10 km visibility, with glare, ice on the window, low ceilings, and precipitation, and Beaufort 2-5 sea states. Sea ice was 0-5% grease/new ice in the area surveyed. Sightings included bowhead whales (including two calves), belugas, one small unidentified pinniped, polar bears, and one unidentified marine mammal.

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	9/25/2019 15:12	70.537	141.341	beluga	swim	1	0	7
38	9/25/2019 15:16	70.669	141.360	beluga	swim	1	0	7
38	9/25/2019 15:19	70.771	141.408	beluga	swim	1	0	7
38	9/25/2019 15:43	70.113	141.965	bowhead whale	swim	1	0	5
38	9/25/2019 15:47	70.104	141.893	bowhead whale	swim	2	0	5
38	9/25/2019 15:48	70.083	141.894	bowhead whale	swim	2	1	5
38	9/25/2019 16:26	70.557	142.417	bowhead whale	swim	1	1	7
38	9/25/2019 16:35	70.602	142.404	beluga	swim	1	0	7

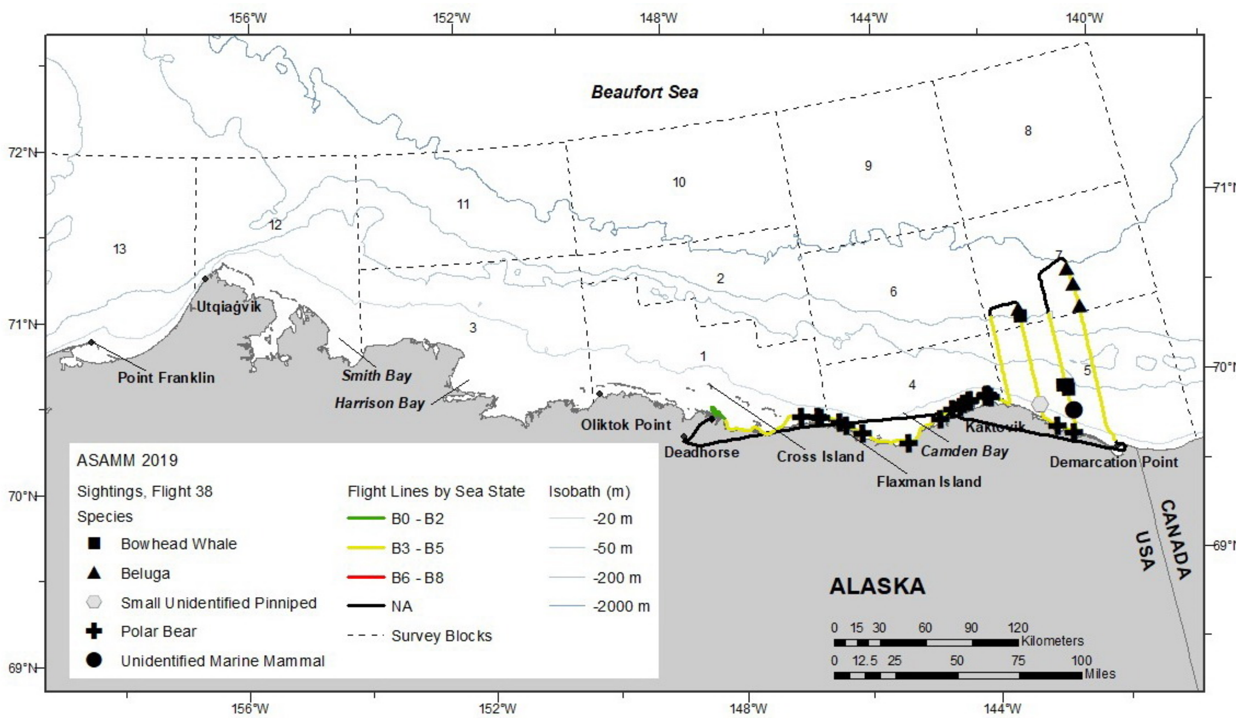


Figure B-97. Flight 38 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

26 September 2019, Flight 247

Flight was a complete survey of transects 2, 3, 4, 6, 8, and 10. Survey conditions included clear, partly cloudy, and overcast skies, 2 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 1-5 sea states. There was no sea ice in the area surveyed. Sightings included gray whales (including one carcass), belugas, one unidentified cetacean, 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
247	9/26/2019 10:28	70.953	161.668	beluga	swim	1	0	17
247	9/26/2019 12:09	71.266	161.239	gray whale	feed	1	0	14
247	9/26/2019 12:09	71.273	161.198	gray whale	swim	1	0	14
247	9/26/2019 12:09	71.269	161.198	gray whale	feed	1	0	14
247	9/26/2019 12:10	71.258	161.185	gray whale	feed	1	0	14
247	9/26/2019 12:20	71.249	161.125	gray whale	feed	1	0	14
247	9/26/2019 12:22	71.258	161.128	gray whale	feed	1	0	14
247	9/26/2019 12:32	71.061	160.494	gray whale	feed	1	0	14
247	9/26/2019 12:36	70.963	160.196	gray whale	feed	1	0	17
247	9/26/2019 12:42	70.943	160.168	gray whale	dead	1	0	17
247	9/26/2019 15:04	72.043	162.078	gray whale	feed	1	0	0
247	9/26/2019 15:06	72.039	162.156	gray whale	rest	1	0	0
247	9/26/2019 15:07	72.036	162.202	gray whale	feed	1	0	0
247	9/26/2019 16:15	71.397	157.685	beluga	swim	1	0	13
247	9/26/2019 16:16	71.404	157.694	beluga	swim	1	0	13
247	9/26/2019 16:16	71.417	157.739	beluga	swim	1	0	13
247	9/26/2019 16:17	71.435	157.753	beluga	mill	3	0	13
247	9/26/2019 16:54	71.914	158.780	unid cetacean	swim	1	0	13

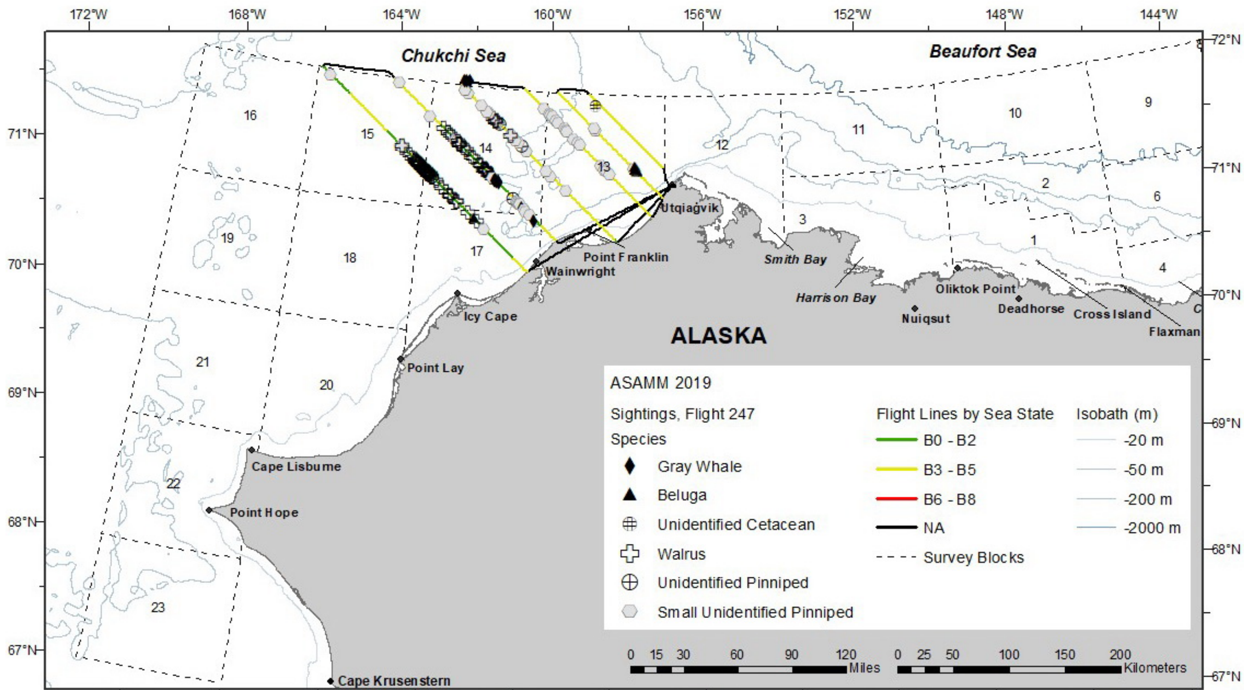


Figure B-98. Flight 247 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

This page intentionally left blank.

26 September 2019, Flight 39

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

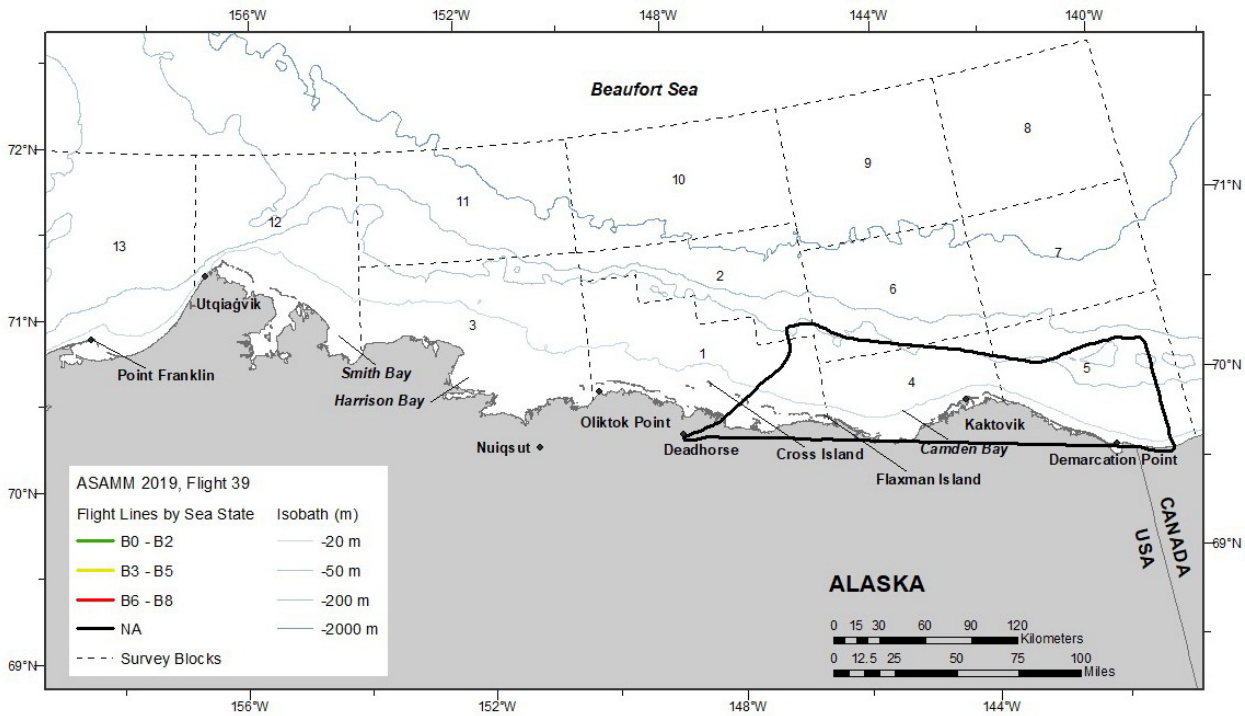


Figure B-99. Flight 39 survey track, depicted by sea state.

27 September 2019, Flight 40

Flight was a complete survey of transects 126, 127, 128, 129, 130, and 131, partial survey of transects 124 and 125, and the coastal transect from Smith Bay to Deadhorse. Survey conditions included clear, partly cloudy, and overcast skies, 1 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 bowhead whales (including one calf and two carcasses), belugas (including 11 calves), one unidentified pinniped, small unidentified pinnipeds, and polar bears. One bowhead carcass was a resight of a carcass previously sighted during flight 23 on 28 August 2019 and flight 27 on 2 September 2019.

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	9/27/2019 10:17	71.309	151.838	bowhead whale	dead	1	1	3
40	9/27/2019 10:28	71.495	151.868	bowhead whale	swim	2	1	11
40	9/27/2019 10:34	71.640	151.897	beluga	swim	2	1	11
40	9/27/2019 10:34	71.651	151.881	beluga	swim	2	1	11
40	9/27/2019 10:35	71.657	151.886	beluga	swim	4	0	11
40	9/27/2019 10:35	71.685	151.934	beluga	swim	2	0	11
40	9/27/2019 10:50	71.442	152.390	beluga	swim	1	0	11
40	9/27/2019 11:52	71.818	152.913	beluga	swim	1	0	11
40	9/27/2019 11:52	71.836	152.918	beluga	swim	2	1	11
40	9/27/2019 11:53	71.859	152.909	beluga	swim	10	1	11
40	9/27/2019 11:53	71.868	152.907	beluga	swim	5	2	11
40	9/27/2019 11:53	71.875	152.897	beluga	swim	7	1	11
40	9/27/2019 11:53	71.878	152.916	beluga	swim	12	3	11
40	9/27/2019 11:54	71.891	152.900	beluga	swim	2	0	11
40	9/27/2019 11:54	71.897	152.904	beluga	swim	150	0	11
40	9/27/2019 11:54	71.897	152.893	beluga	swim	12	1	11
40	9/27/2019 11:55	71.916	152.852	beluga	swim	1	0	11
40	9/27/2019 17:19	70.508	150.650	bowhead whale	dead	1	0	3

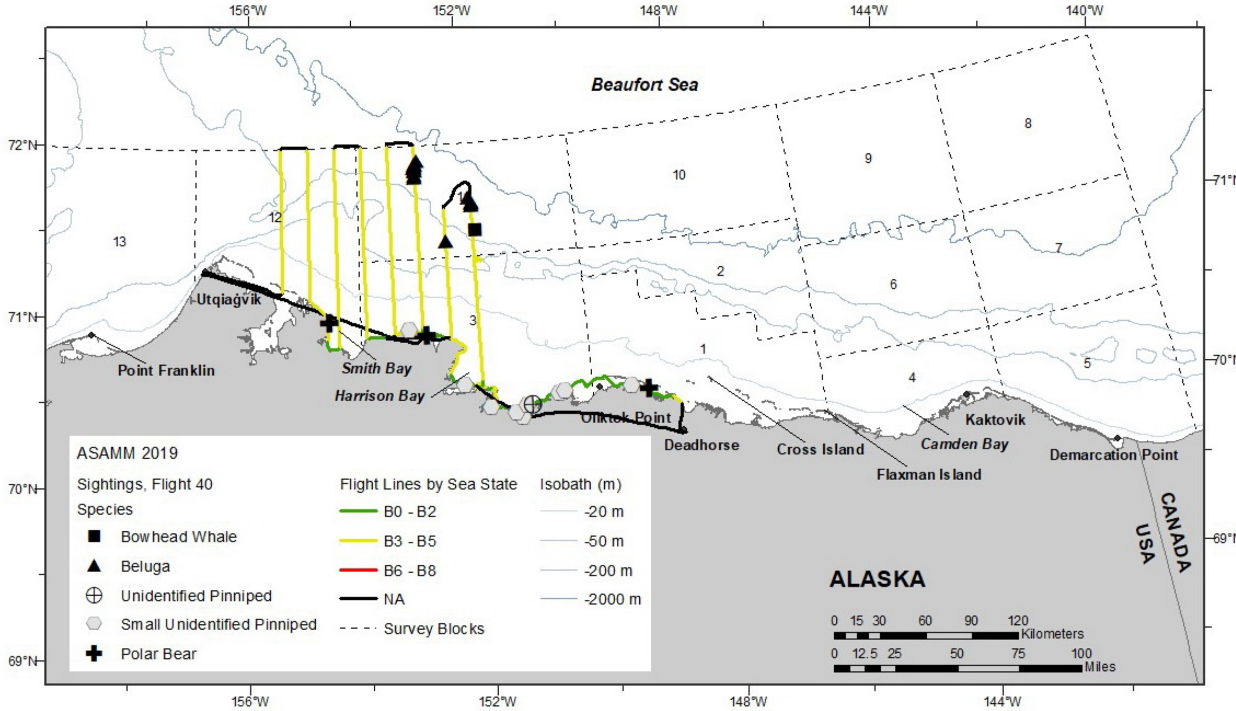


Figure B-100. Flight 40 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

28 September 2019, Flight 248

Flight was a complete survey of transects 1, 112, 132, 133, and 134, and partial survey of transects 113, 114, 115, 116, 117, 118, 119, and 120. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with fog, glare, low ceilings, and precipitation, and Beaufort 2-4 sea states. There was no sea ice in the area surveyed. Sightings included belugas, walruses, 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
248	9/28/2019 13:30	71.359	148.421	beluga	swim	2	0	10

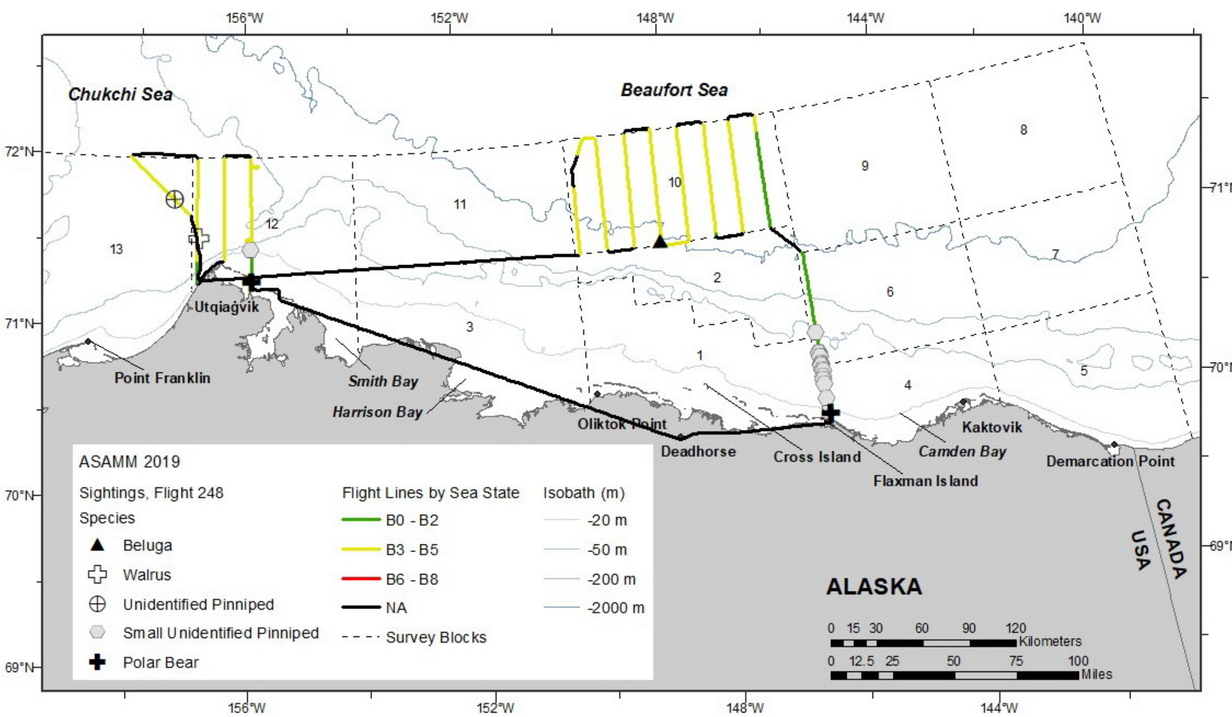


Figure B-101. Flight 248 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

ASAMM teams will do just about anything to take advantage of good weather days, including pushing a stalled fuel truck out of the plane's way so they were able to commence part two of Flight 248, 28 September 2019.

28 September 2019, Flight 41

Flight was a complete survey of transects 101, 102, 114, 115, 116, 117, 118, 119, 120, partial survey of transect 113, and the coastal transect from approximately 12 km east of Demarcation Bay to approximately 30 km east of Kaktovik. Survey conditions included clear, partly cloudy, and overcast skies, 2 km to unlimited visibility, with glare and precipitation, and Beaufort 1-3 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales (including three calves and one carcass), one gray whale, belugas (including two calves), one unidentified cetacean, 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
41	9/28/2019 9:23	70.976	149.904	bowhead whale	swim	3	1	1
41	9/28/2019 9:23	70.987	149.904	bowhead whale	swim	1	0	1
41	9/28/2019 9:36	71.245	149.906	beluga	swim	1	0	2
41	9/28/2019 9:36	71.245	149.890	beluga	mill	3	1	2
41	9/28/2019 9:36	71.250	149.900	beluga	rest	1	0	2
41	9/28/2019 9:36	71.255	149.894	beluga	swim	1	0	2
41	9/28/2019 9:36	71.256	149.923	beluga	swim	1	0	2
41	9/28/2019 9:36	71.263	149.904	beluga	swim	1	0	2
41	9/28/2019 9:57	70.890	149.367	bowhead whale	swim	1	0	1
41	9/28/2019 10:39	71.220	148.934	beluga	swim	2	0	2
41	9/28/2019 10:39	71.236	148.928	beluga	swim	1	0	2
41	9/28/2019 10:47	71.325	148.391	beluga	swim	2	0	2
41	9/28/2019 10:47	71.324	148.412	beluga	swim	3	0	2
41	9/28/2019 10:51	71.187	148.421	beluga	swim	1	0	2
41	9/28/2019 10:51	71.186	148.418	beluga	mill	2	0	2
41	9/28/2019 10:53	71.135	148.426	beluga	swim	1	0	2
41	9/28/2019 10:59	70.944	148.449	bowhead whale	swim	2	1	1
41	9/28/2019 11:47	70.702	147.747	unid cetacean	breach	1	0	1
41	9/28/2019 11:58	71.082	147.937	bowhead whale	swim	1	0	2
41	9/28/2019 12:02	71.120	147.917	beluga	swim	1	0	2
41	9/28/2019 12:02	71.121	147.911	beluga	swim	1	0	2
41	9/28/2019 12:02	71.125	147.893	beluga	swim	1	0	2
41	9/28/2019 12:02	71.131	147.928	beluga	swim	1	0	2
41	9/28/2019 12:15	71.242	147.427	beluga	swim	1	0	2
41	9/28/2019 12:22	71.027	147.395	beluga	swim	1	0	2
41	9/28/2019 12:25	70.939	147.423	bowhead whale	dive	2	1	2
41	9/28/2019 13:16	70.926	146.901	gray whale	swim	1	0	2
41	9/28/2019 13:33	71.233	146.906	beluga	swim	1	0	2
41	9/28/2019 13:51	70.980	146.399	bowhead whale	swim	1	0	2
41	9/28/2019 16:41	70.528	140.394	beluga	swim	1	0	7
41	9/28/2019 16:43	70.594	140.433	beluga	swim	1	0	7
41	9/28/2019 17:19	70.712	140.901	beluga	swim	1	0	7
41	9/28/2019 17:20	70.670	140.909	beluga	swim	1	0	7

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
41	9/28/2019 17:21	70.635	140.898	beluga	swim	2	1	7
41	9/28/2019 17:22	70.607	140.902	beluga	swim	1	0	7
41	9/28/2019 17:24	70.551	140.876	beluga	swim	3	0	7
41	9/28/2019 17:24	70.534	140.924	beluga	swim	1	0	7
41	9/28/2019 17:27	70.451	140.888	beluga	swim	1	0	5
41	9/28/2019 17:43	69.912	140.884	bowhead whale	swim	2	0	5
41	9/28/2019 17:55	69.663	140.908	bowhead whale	dead	1	0	5

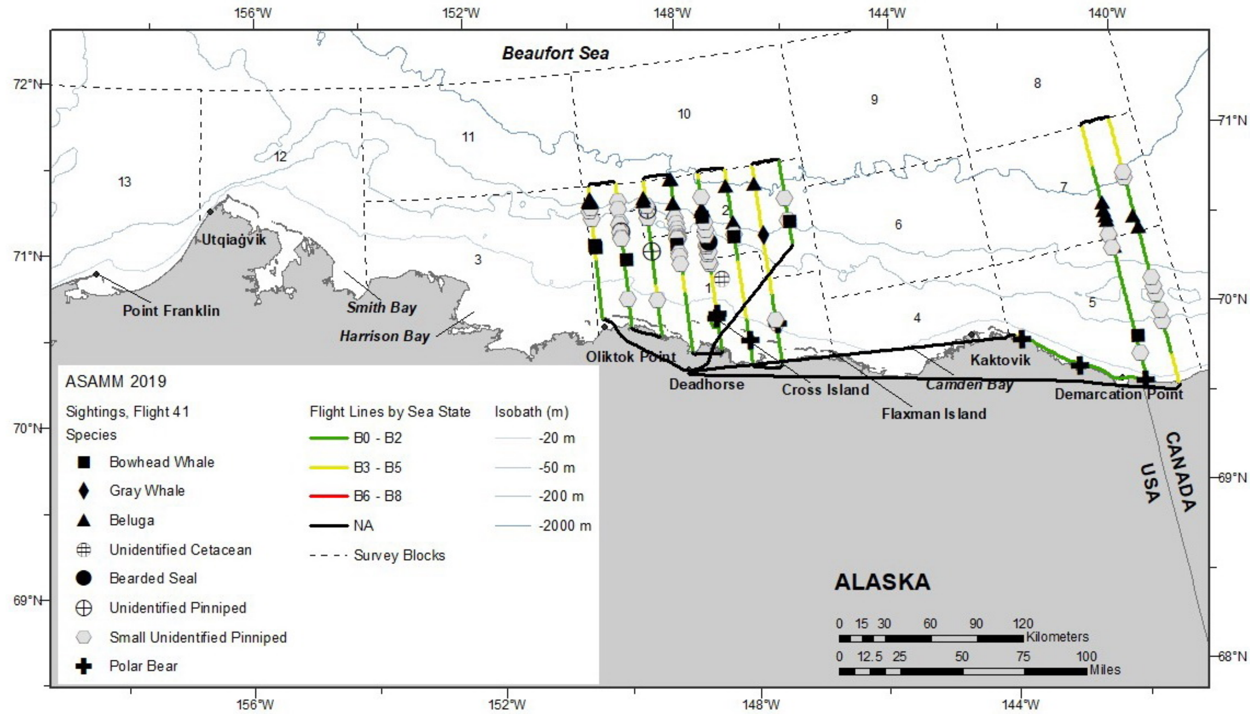
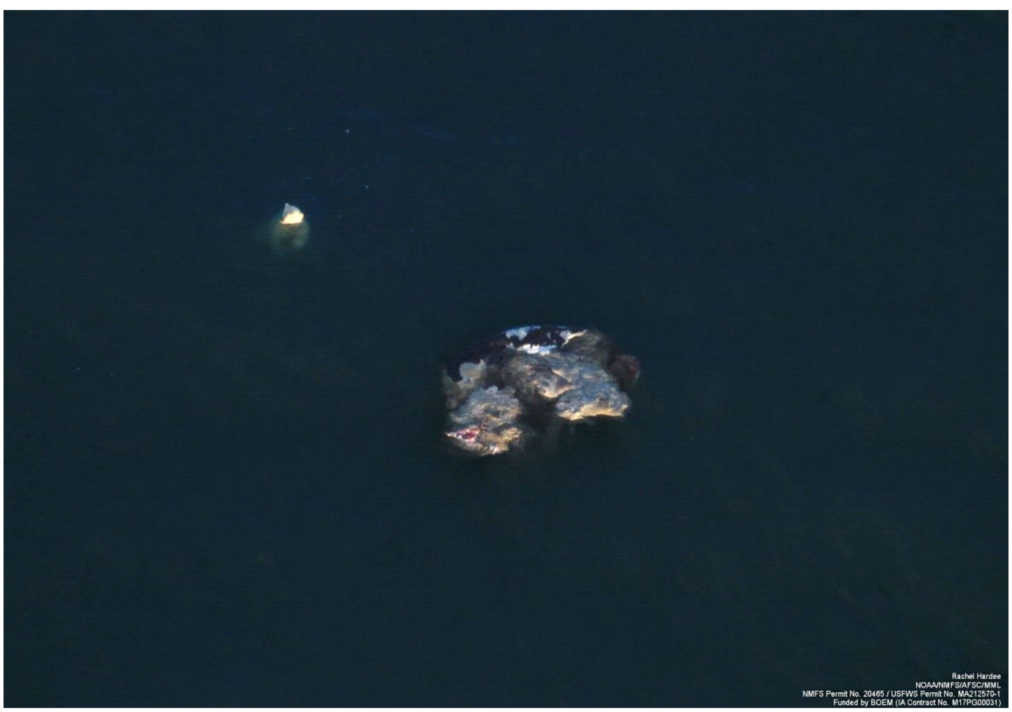


Figure B-102. Flight 41 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Polar bears sighted resting on Cross Island, Alaska, Flight 41, 28 September 2019.



Polar bear sighted swimming next to a bowhead whale carcass, Flight 41, 28 September 2019.

29 September 2019, Flight 249

Flight was a partial survey of transects 11 and 13. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with fog, glare, low ceilings, and precipitation, and Beaufort 2-5 sea states. There was no sea ice in the area surveyed. Sightings included one walrus, one unidentified pinniped, and small unidentified pinnipeds.

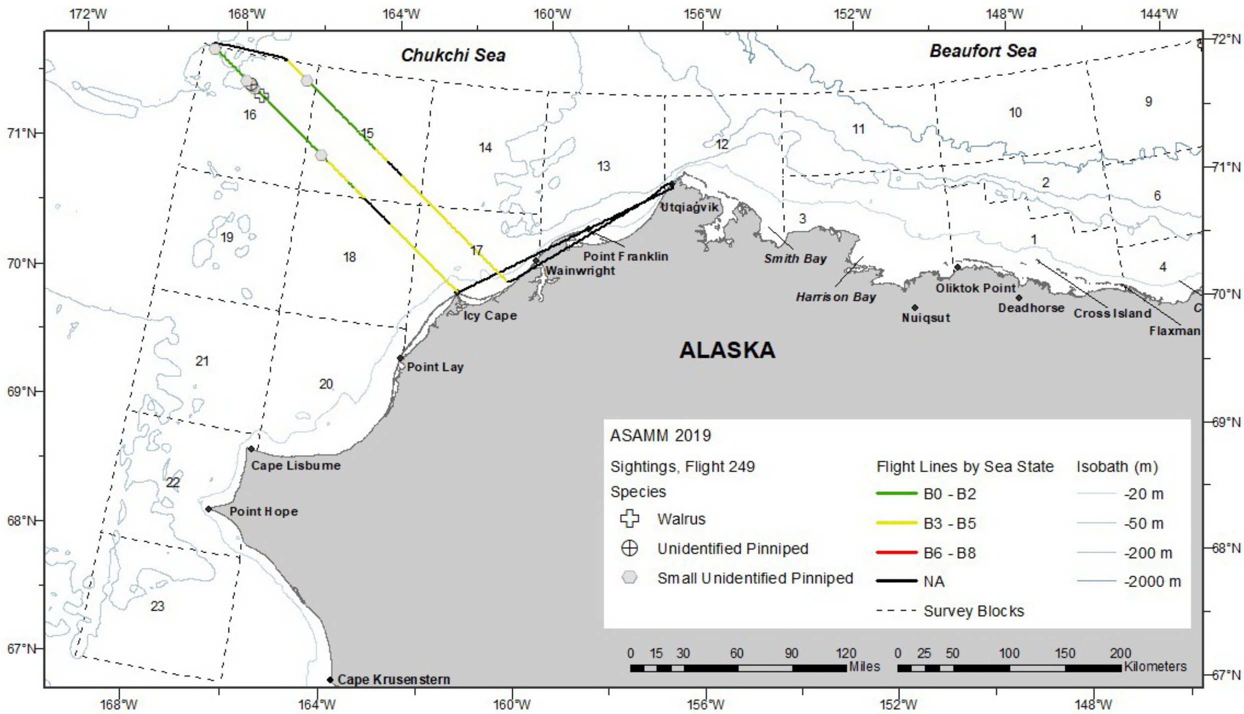


Figure B-103. Flight 249 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

29 September 2019, Flight 42

Flight was a complete survey of transects 107 and 108, and partial survey of transects 103, 104, 105, and 106. Survey conditions included partly cloudy to overcast skies, unlimited visibility, with glare, and Beaufort 2-5 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales (including 10 calves), belugas (including three 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
42	9/29/2019 11:15	70.656	141.396	beluga	swim	1	0	7
42	9/29/2019 11:21	70.484	141.605	bowhead whale	swim	1	0	5
42	9/29/2019 11:21	70.483	141.615	bowhead whale	swim	1	0	5
42	9/29/2019 11:21	70.490	141.628	bowhead whale	swim	1	1	5
42	9/29/2019 11:29	70.514	141.885	beluga	swim	1	0	7
42	9/29/2019 11:29	70.527	141.904	beluga	swim	2	0	7
42	9/29/2019 11:30	70.534	141.915	beluga	swim	2	1	7
42	9/29/2019 11:30	70.538	141.887	beluga	swim	1	0	7
42	9/29/2019 11:30	70.538	141.910	beluga	swim	1	0	7
42	9/29/2019 11:31	70.570	141.940	beluga	swim	1	0	7
42	9/29/2019 11:31	70.573	141.927	beluga	swim	6	0	7
42	9/29/2019 11:31	70.580	141.942	beluga	swim	4	0	7
42	9/29/2019 11:31	70.583	141.915	beluga	swim	1	0	7
42	9/29/2019 11:31	70.586	141.933	beluga	swim	1	0	7
42	9/29/2019 11:31	70.589	141.881	beluga	swim	1	0	7
42	9/29/2019 11:31	70.592	141.931	beluga	swim	3	0	7
42	9/29/2019 11:31	70.594	141.940	beluga	swim	1	0	7
42	9/29/2019 11:31	70.597	141.885	beluga	swim	1	0	7
42	9/29/2019 11:31	70.599	141.942	beluga	swim	1	0	7
42	9/29/2019 11:46	71.057	141.900	beluga	swim	2	0	7
42	9/29/2019 11:57	71.062	142.402	beluga	swim	2	0	7
42	9/29/2019 11:57	71.059	142.402	beluga	swim	1	0	7
42	9/29/2019 12:09	70.644	142.374	beluga	swim	1	0	7
42	9/29/2019 12:09	70.639	142.398	beluga	swim	1	0	7
42	9/29/2019 12:09	70.633	142.369	beluga	swim	2	0	7
42	9/29/2019 12:09	70.631	142.389	beluga	swim	1	0	7
42	9/29/2019 12:10	70.628	142.401	beluga	swim	1	0	7
42	9/29/2019 12:10	70.624	142.390	beluga	swim	1	0	7
42	9/29/2019 12:10	70.622	142.369	beluga	swim	1	0	7
42	9/29/2019 12:10	70.617	142.374	beluga	swim	1	0	7
42	9/29/2019 12:10	70.614	142.366	beluga	swim	1	0	7
42	9/29/2019 12:10	70.611	142.379	beluga	swim	1	0	7
42	9/29/2019 12:10	70.607	142.427	beluga	swim	14	2	7
42	9/29/2019 12:11	70.576	142.398	beluga	swim	9	0	7
42	9/29/2019 12:11	70.570	142.400	beluga	swim	2	0	7
42	9/29/2019 12:11	70.565	142.421	beluga	swim	2	0	7

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
42	9/29/2019 12:12	70.535	142.342	bowhead whale	breach	2	1	7
42	9/29/2019 12:25	70.609	142.871	beluga	swim	2	0	7
42	9/29/2019 12:32	70.837	142.895	beluga	swim	2	0	7
42	9/29/2019 12:32	70.837	142.900	beluga	swim	1	0	7
42	9/29/2019 12:32	70.838	142.935	beluga	swim	1	0	7
42	9/29/2019 12:33	70.870	142.888	beluga	swim	1	0	7
42	9/29/2019 12:33	70.871	142.880	beluga	swim	1	0	7
42	9/29/2019 12:40	71.110	142.926	beluga	swim	1	0	7
42	9/29/2019 13:02	70.641	143.398	bowhead whale	swim	2	1	6
42	9/29/2019 13:03	70.630	143.408	bowhead whale	swim	1	0	6
42	9/29/2019 13:08	70.600	143.399	bowhead whale	swim	2	1	6
42	9/29/2019 13:15	70.546	143.349	bowhead whale	swim	1	0	6
42	9/29/2019 13:22	70.409	143.331	bowhead whale	swim	1	0	4
42	9/29/2019 13:27	70.369	143.425	bowhead whale	swim	1	0	4
42	9/29/2019 13:54	70.461	143.906	bowhead whale	swim	1	0	4
42	9/29/2019 14:03	70.636	143.907	bowhead whale	swim	2	1	6
42	9/29/2019 14:06	70.656	143.907	bowhead whale	swim	3	2	6
42	9/29/2019 14:06	70.657	143.922	bowhead whale	swim	1	0	6
42	9/29/2019 14:06	70.660	143.910	bowhead whale	rest	1	0	6
42	9/29/2019 14:07	70.650	143.918	bowhead whale	swim	3	2	6
42	9/29/2019 14:13	70.654	143.951	bowhead whale	swim	1	1	6
42	9/29/2019 14:17	70.746	143.877	beluga	swim	1	0	6
42	9/29/2019 14:17	70.748	143.929	beluga	swim	1	0	6

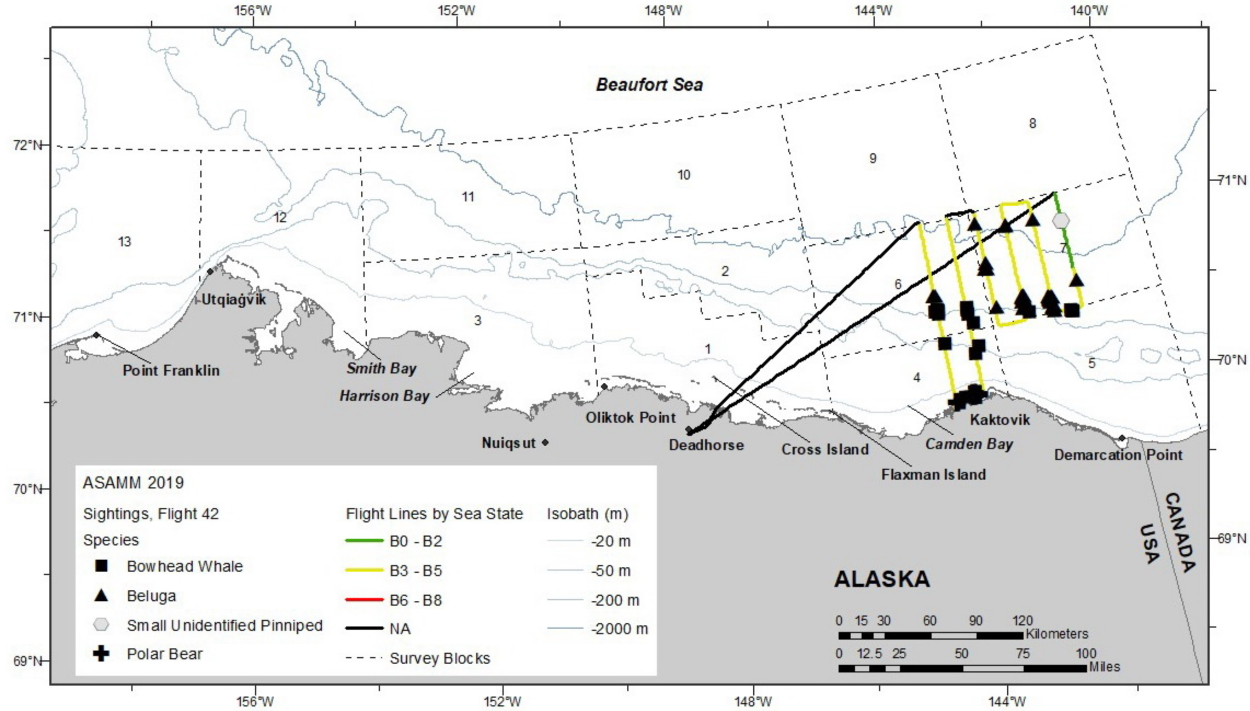
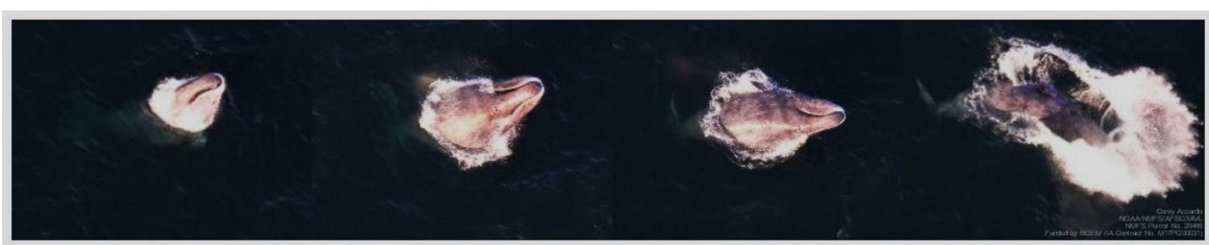


Figure B-104. Flight 42 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Bowhead whale cow-calf pair sighted approximately 70 km northeast of Kaktovik, Alaska, Flight 42, 29 September 2019.

Bowhead whale cow-calf pair sighted approximately 60 km north of Kaktovik, Alaska, Flight 42, 29 September 2019. The calf (water disturbance in left of photo) is beginning a breach (see next photo for the series), and the cow is well-marked with several scars.



Sequence showing breaching bowhead whale calf, sighted approximately 60 km north of Kaktovik, Alaska, Flight 42, 29 September 2019.

30 September 2019, Flight 43

Flight was a complete survey of transects 109, 110, and 111, and partial survey of transects 103, 104, 105, and 106. Survey conditions included partly cloudy to overcast skies, 2 km to unlimited visibility, with fog, glare, haze, low ceilings, and precipitation, and Beaufort 2-5 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales (including one calf), belugas (including one calf), one bearded seal, 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
43	9/30/2019 10:35	70.103	141.952	bowhead whale	swim	1	0	5
43	9/30/2019 10:35	70.099	141.946	bowhead whale	swim	2	1	5
43	9/30/2019 11:43	70.051	144.381	beluga	swim	1	0	4
43	9/30/2019 12:01	70.703	144.403	beluga	swim	2	1	6
43	9/30/2019 12:05	70.821	144.409	beluga	swim	8	0	6
43	9/30/2019 12:05	70.843	144.415	beluga	swim	1	0	6
43	9/30/2019 12:06	70.854	144.418	beluga	swim	1	0	6
43	9/30/2019 12:06	70.858	144.399	beluga	swim	1	0	6
43	9/30/2019 12:06	70.860	144.404	beluga	swim	1	0	6
43	9/30/2019 12:06	70.867	144.413	beluga	swim	1	0	6
43	9/30/2019 12:07	70.908	144.434	beluga	swim	1	0	6
43	9/30/2019 12:07	70.914	144.405	beluga	swim	1	0	6
43	9/30/2019 12:24	71.009	144.928	beluga	swim	2	0	6
43	9/30/2019 13:26	70.895	145.393	beluga	swim	1	0	6
43	9/30/2019 13:26	70.900	145.384	beluga	swim	1	0	6
43	9/30/2019 13:26	70.902	145.394	beluga	swim	2	0	6
43	9/30/2019 13:28	70.963	145.415	beluga	swim	1	0	6
43	9/30/2019 13:28	70.968	145.403	beluga	swim	1	0	6
43	9/30/2019 13:28	70.968	145.424	beluga	swim	1	0	6
43	9/30/2019 13:29	70.998	145.428	beluga	swim	1	0	6
43	9/30/2019 13:29	71.014	145.415	beluga	swim	1	0	6
43	9/30/2019 13:29	71.015	145.406	beluga	rest	1	0	6
43	9/30/2019 13:29	71.017	145.395	beluga	rest	1	0	6
43	9/30/2019 13:29	71.019	145.390	beluga	rest	1	0	6
43	9/30/2019 13:29	71.022	145.392	beluga	rest	1	0	6
43	9/30/2019 13:30	71.024	145.423	beluga	swim	2	0	6
43	9/30/2019 13:30	71.030	145.398	beluga	rest	1	0	6
43	9/30/2019 13:30	71.035	145.423	beluga	swim	1	0	6

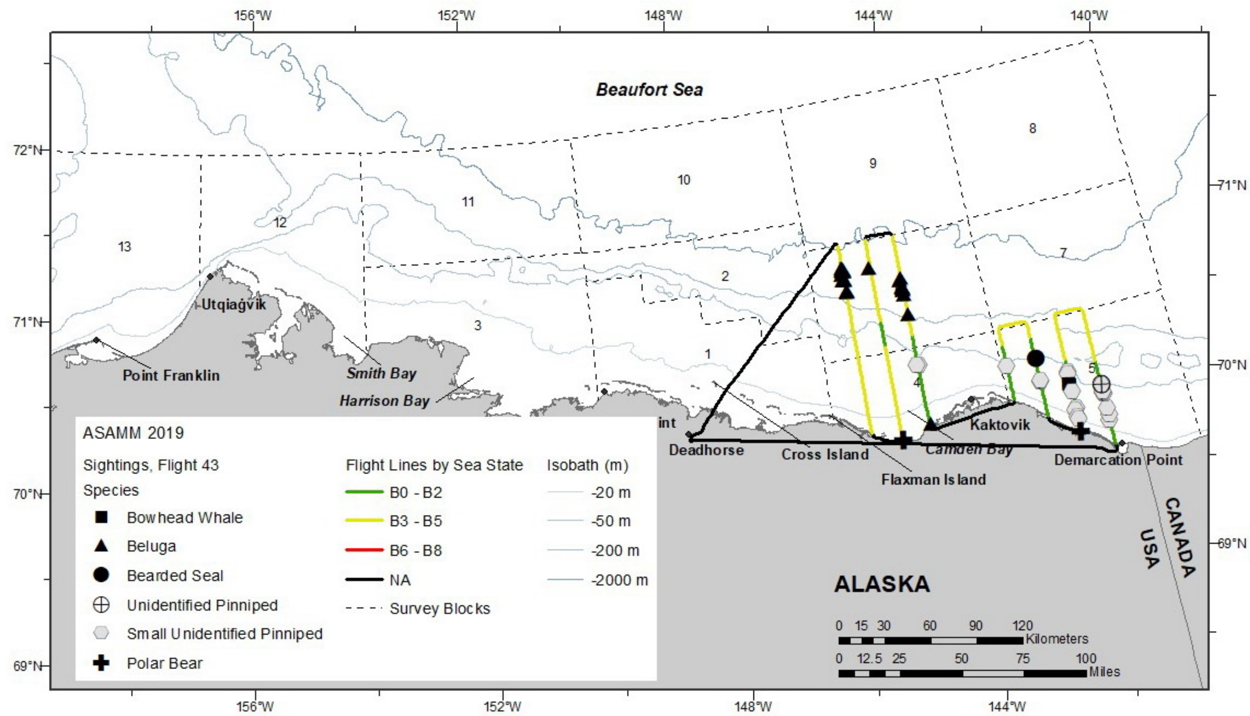


Figure B-105. Flight 43 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

This page intentionally left blank.

1 October 2019, Flight 250

Flight was a complete survey of transects 2, 3, and 4, and partial survey of transects 5 and 134. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare and low ceilings, and Beaufort 2-3 sea states. There was no sea ice in the area surveyed. Sightings included walruses, bearded seals, unidentified pinnipeds, and small unidentified pinnipeds.

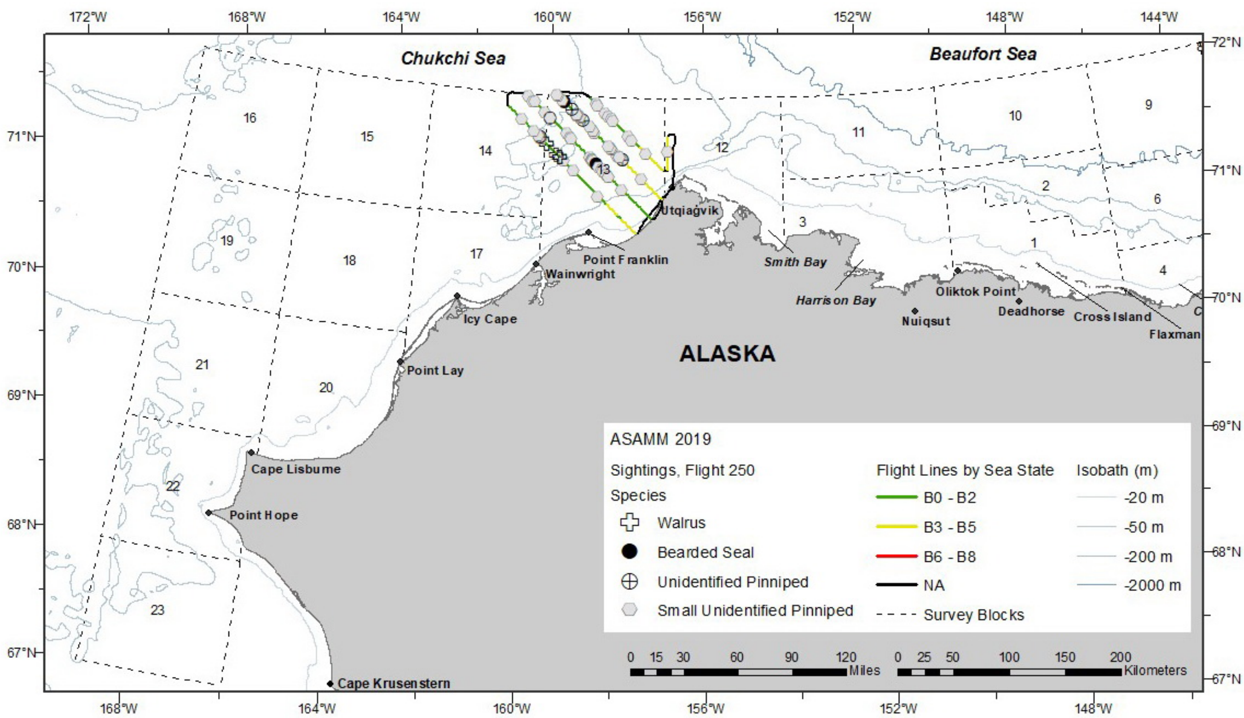


Figure B-106. Flight 250 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

3 October 2019, Flight 251

Flight was a complete survey of transects 129, 130, 131, 133, and 134, and partial survey of transect 132. Survey conditions included partly cloudy to overcast skies, 1 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 belugas (including six 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
251	10/3/2019 13:51	71.853	154.404	beluga	swim	2	0	12
251	10/3/2019 13:51	71.860	154.404	beluga	swim	2	0	12
251	10/3/2019 13:51	71.861	154.414	beluga	swim	1	0	12
251	10/3/2019 13:51	71.864	154.411	beluga	swim	16	5	12
251	10/3/2019 13:51	71.864	154.396	beluga	swim	1	0	12
251	10/3/2019 13:51	71.866	154.397	beluga	swim	1	0	12
251	10/3/2019 13:52	71.889	154.425	beluga	swim	1	0	12
251	10/3/2019 13:52	71.903	154.412	beluga	swim	1	0	12
251	10/3/2019 13:52	71.908	154.411	beluga	swim	1	0	12
251	10/3/2019 13:52	71.918	154.399	beluga	swim	1	0	12
251	10/3/2019 14:00	71.983	154.893	beluga	swim	3	0	12
251	10/3/2019 16:01	71.761	156.899	beluga	swim	1	0	12
251	10/3/2019 16:04	71.653	156.881	beluga	swim	2	1	12
251	10/3/2019 16:05	71.628	156.929	beluga	swim	1	0	12

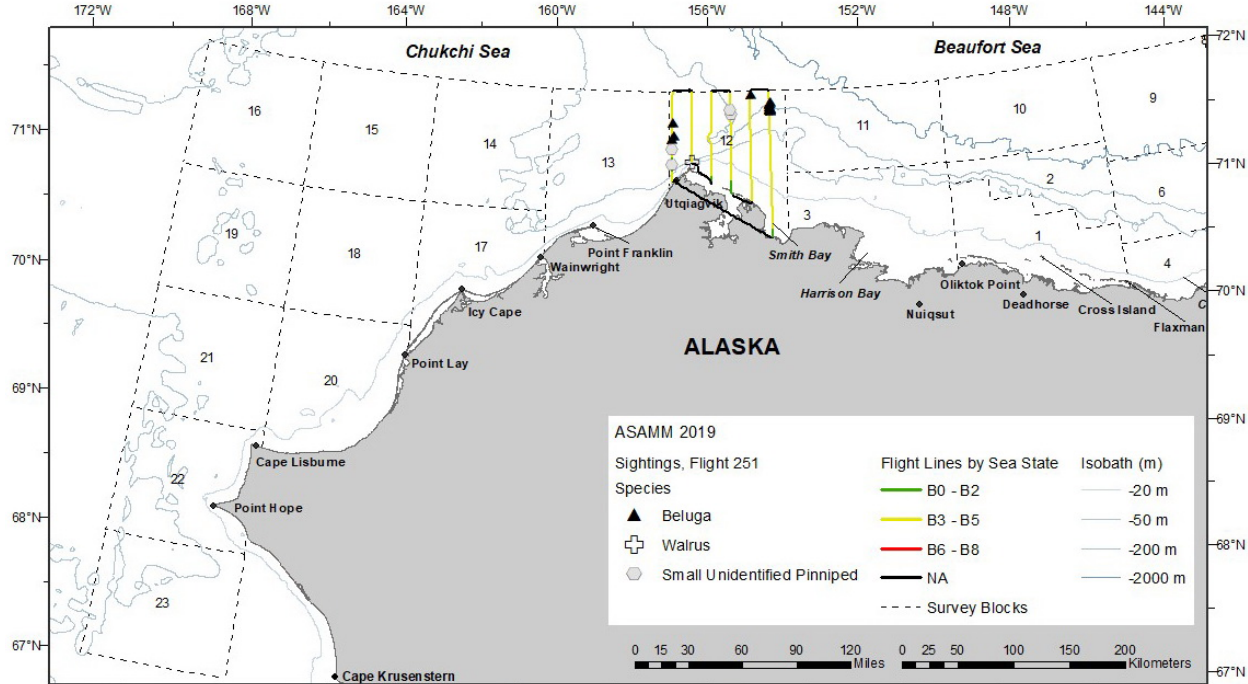


Figure B-107. Flight 251 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

3 October 2019, Flight 44

Flight was a partial survey of transects 120, 121, 122, 123, 124, and 125, and the coastal transect from east of Smith Bay to Cross Island. Survey conditions included partly cloudy to overcast skies, <1 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 belugas, 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
44	10/3/2019 13:13	71.428	151.950	beluga	mill	10	0	11

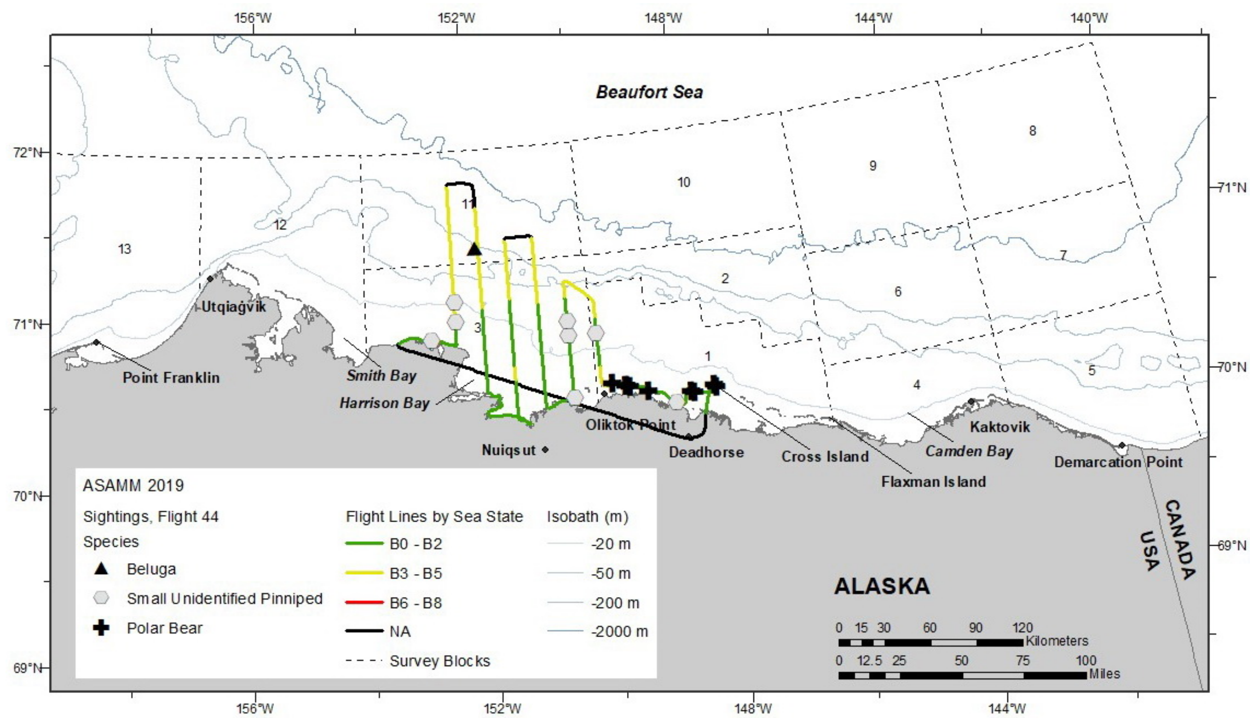


Figure B-108. Flight 44 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

5 October 2019, Flight 252

Flight was a partial survey of transects 12 and 14, and search effort near Point Lay. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with fog, glare, low ceilings, and precipitation, and Beaufort 2-6 sea states. There was no sea ice in the area surveyed. Sightings included walruses and small unidentified pinnipeds.

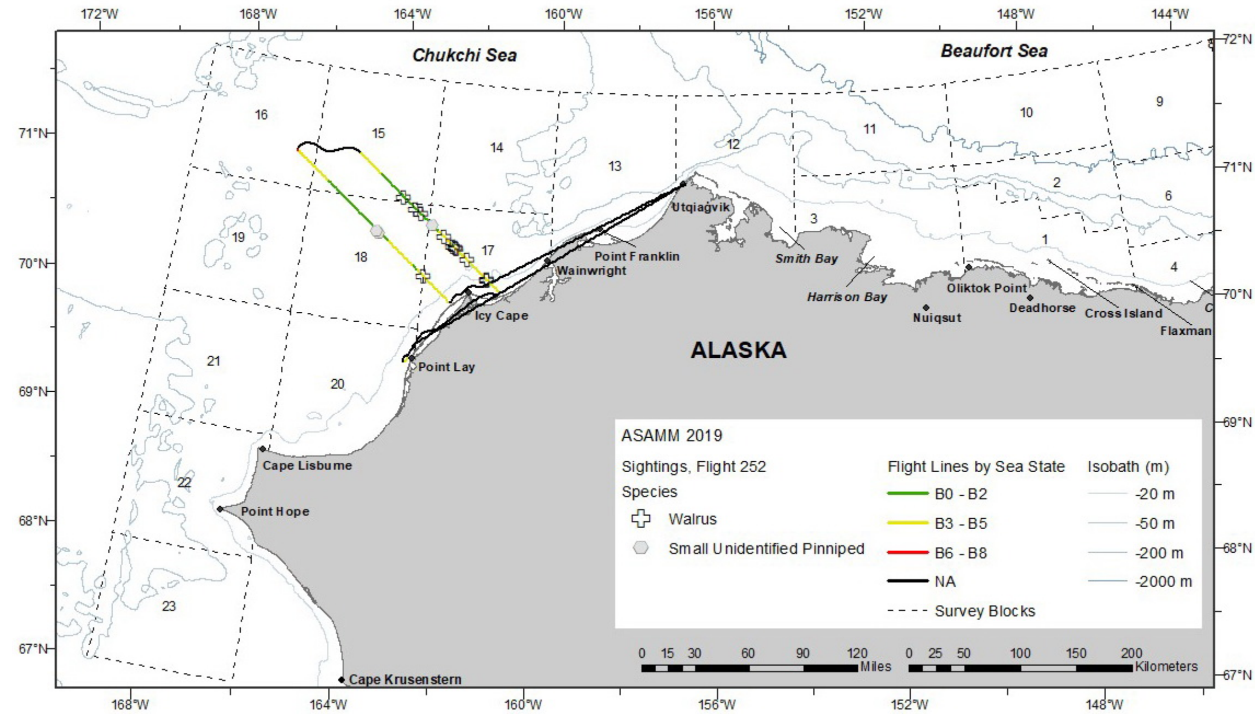


Figure B-109. Flight 252 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

5 October 2019, Flight 45

Flight was a partial survey of transects 9 and 10, and the coastal transect from Harrison Bay to east of Smith Bay. Survey conditions included partly cloudy to overcast skies, <1 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 gray whales (including one calf), walruses, 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
45	10/5/2019 11:53	70.864	160.606	gray whale	feed	1	0	17
45	10/5/2019 11:55	70.881	160.610	gray whale	feed	2	0	17
45	10/5/2019 11:55	70.889	160.618	gray whale	feed	2	1	17
45	10/5/2019 12:00	70.880	160.680	gray whale	feed	1	0	17
45	10/5/2019 12:00	70.877	160.687	gray whale	feed	1	0	17
45	10/5/2019 13:15	70.797	161.149	gray whale	feed	1	0	17
45	10/5/2019 13:17	70.797	161.172	gray whale	swim	1	0	17

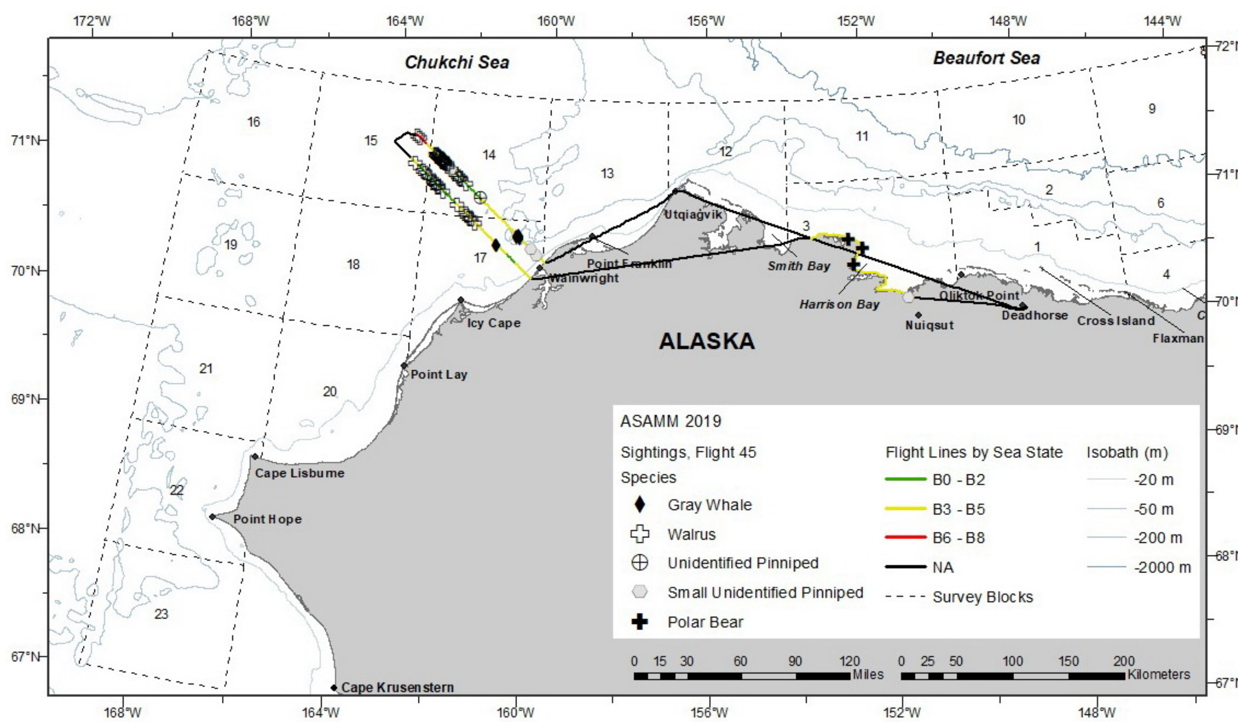


Figure B-110. Flight 45 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Gray whale sighted approximately 40 km northwest of Wainwright, Alaska, Flight 45, 5 October 2019.

7 October 2019, Flight 253

Flight was a complete survey of transects 6 and 8, and partial survey of transect 4. 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. There was no sea ice in the area surveyed. Sightings included gray whales, 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
253	10/7/2019 12:43	71.107	160.635	gray whale	swim	1	0	14
253	10/7/2019 12:54	71.234	161.108	gray whale	feed	1	0	14
253	10/7/2019 12:54	71.235	161.122	gray whale	feed	2	0	14
253	10/7/2019 12:57	71.240	161.137	gray whale	feed	1	0	14
253	10/7/2019 12:57	71.246	161.130	gray whale	feed	2	0	14
253	10/7/2019 12:59	71.245	161.243	gray whale	feed	1	0	14
253	10/7/2019 13:04	71.241	161.148	gray whale	feed	1	0	14
253	10/7/2019 13:04	71.245	161.144	gray whale	feed	1	0	14
253	10/7/2019 13:06	71.237	161.125	gray whale	feed	1	0	14
253	10/7/2019 13:08	71.227	161.098	gray whale	feed	1	0	14
253	10/7/2019 13:11	71.274	161.239	gray whale	feed	1	0	14
253	10/7/2019 13:14	71.274	161.243	gray whale	feed	1	0	14

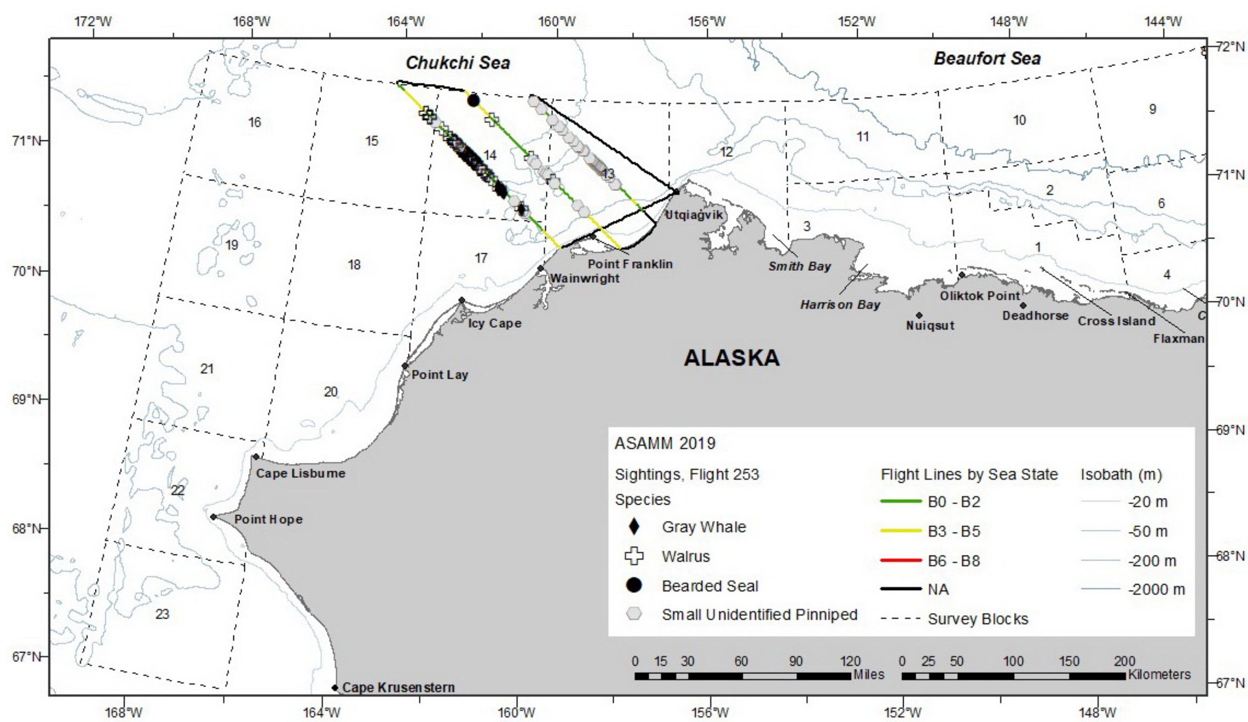


Figure B-111. Flight 253 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

7 October 2019, Flight 46

Flight was a partial survey of transects 124, 126, 127, and 128, and the coastal transect and search effort from east of Smith Bay to inside the barrier islands north of Deadhorse. Survey conditions included partly cloudy skies, 3 km to unlimited visibility, with glare, ice on the window, low ceilings, and precipitation, and Beaufort 2-6 sea states. There was no sea ice in the area surveyed. Sightings included small unidentified pinnipeds.

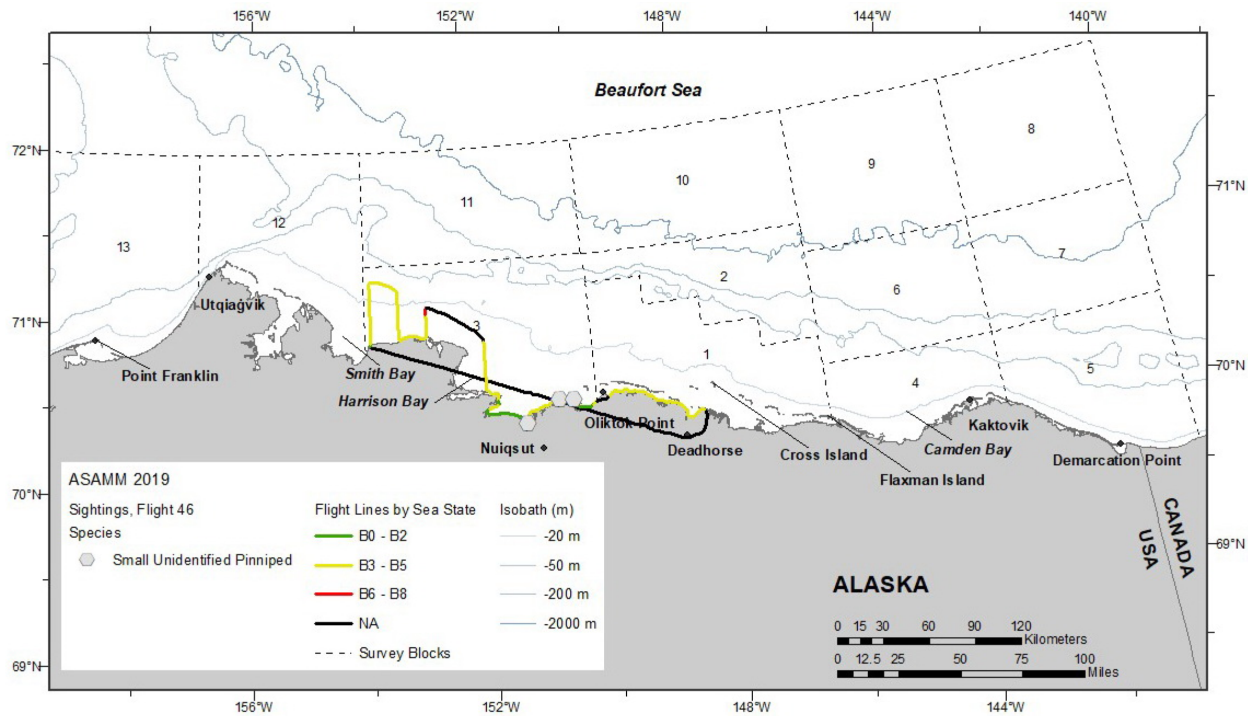


Figure B-112. Flight 46 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

8 October 2019, Flight 254

Flight was a complete survey of transects 121, 122, 123, and 124. Survey conditions included partly cloudy to overcast skies, 1 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 2-4 sea states. Sea ice was 0-20% grease/new ice in the area surveyed. Sightings included bowhead whales, belugas (including two 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
254	10/8/2019 13:27	71.528	151.897	beluga	rest	1	0	11
254	10/8/2019 14:57	71.078	150.867	bowhead whale	swim	1	0	3
254	10/8/2019 15:08	71.294	150.867	bowhead whale	swim	1	0	3
254	10/8/2019 15:13	71.428	150.875	beluga	swim	1	0	11
254	10/8/2019 15:14	71.452	150.968	beluga	swim	1	0	11
254	10/8/2019 15:14	71.456	150.934	beluga	swim	1	0	11
254	10/8/2019 15:15	71.477	150.946	beluga	swim	1	0	11
254	10/8/2019 15:26	71.858	150.903	beluga	rest	1	0	11
254	10/8/2019 15:26	71.870	150.896	beluga	swim	1	0	11
254	10/8/2019 15:26	71.883	150.886	beluga	swim	1	0	11
254	10/8/2019 15:40	71.831	150.382	beluga	rest	4	1	11
254	10/8/2019 15:40	71.826	150.399	beluga	swim	1	0	11
254	10/8/2019 15:40	71.823	150.387	beluga	rest	3	1	11
254	10/8/2019 15:50	71.507	150.423	beluga	swim	1	0	11
254	10/8/2019 15:50	71.498	150.404	beluga	swim	1	0	11
254	10/8/2019 15:50	71.489	150.395	beluga	swim	1	0	11
254	10/8/2019 15:51	71.470	150.399	beluga	swim	1	0	11
254	10/8/2019 15:51	71.464	150.384	beluga	swim	1	0	11
254	10/8/2019 15:51	71.463	150.414	beluga	swim	1	0	11
254	10/8/2019 15:52	71.443	150.415	beluga	swim	1	0	11
254	10/8/2019 15:52	71.439	150.430	beluga	swim	2	0	11
254	10/8/2019 15:52	71.429	150.382	beluga	swim	1	0	11
254	10/8/2019 15:52	71.425	150.401	beluga	swim	1	0	11
254	10/8/2019 15:52	71.421	150.403	beluga	rest	1	0	11
254	10/8/2019 15:53	71.408	150.403	beluga	swim	1	0	11
254	10/8/2019 15:54	71.378	150.384	beluga	swim	1	0	11
254	10/8/2019 15:54	71.376	150.382	beluga	swim	2	0	11
254	10/8/2019 15:54	71.368	150.398	beluga	swim	4	0	11
254	10/8/2019 15:54	71.364	150.405	beluga	swim	1	0	11
254	10/8/2019 15:54	71.359	150.387	beluga	swim	6	0	11
254	10/8/2019 15:55	71.353	150.410	beluga	swim	2	0	11
254	10/8/2019 15:57	71.288	150.371	beluga	swim	2	0	3

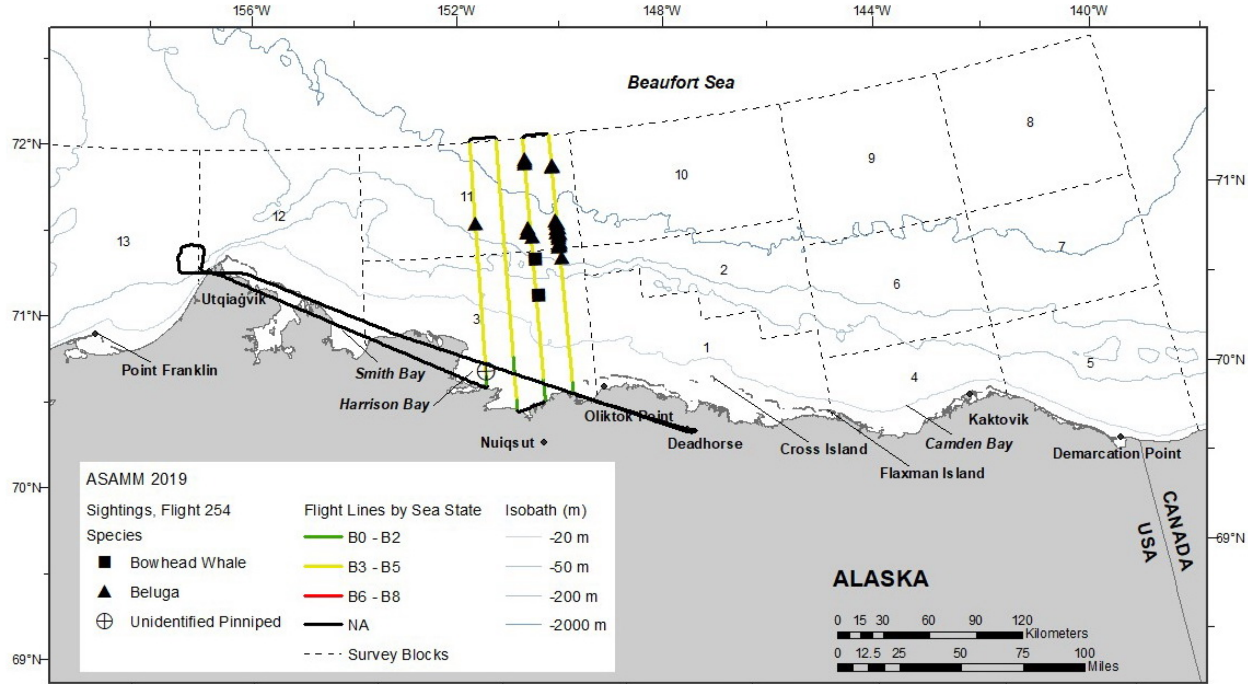


Figure B-113. Flight 254 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

8 October 2019, Flight 47

Flight was a complete survey of transects 101, 102, 103, 104, 112, and 113, and partial survey of transect 114. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare, ice on window, low ceilings, and precipitation, and Beaufort 2-4 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales (including one calf), belugas (including one calf), 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
47	10/8/2019 11:16	70.580	140.922	beluga	swim	1	0	7
47	10/8/2019 11:16	70.571	140.909	beluga	swim	1	0	7
47	10/8/2019 11:16	70.568	140.924	beluga	swim	1	0	7
47	10/8/2019 11:35	69.937	140.868	bowhead whale	swim	1	0	5
47	10/8/2019 13:14	70.105	141.879	bowhead whale	swim	1	0	5
47	10/8/2019 15:51	70.987	145.890	beluga	swim	1	0	6
47	10/8/2019 16:10	71.096	146.409	beluga	swim	1	0	2
47	10/8/2019 16:10	71.092	146.391	beluga	swim	2	1	2
47	10/8/2019 16:10	71.089	146.375	beluga	swim	1	0	2
47	10/8/2019 16:15	70.924	146.378	bowhead whale	swim	2	1	2
47	10/8/2019 17:00	70.670	146.905	bowhead whale	SAG	5	0	2

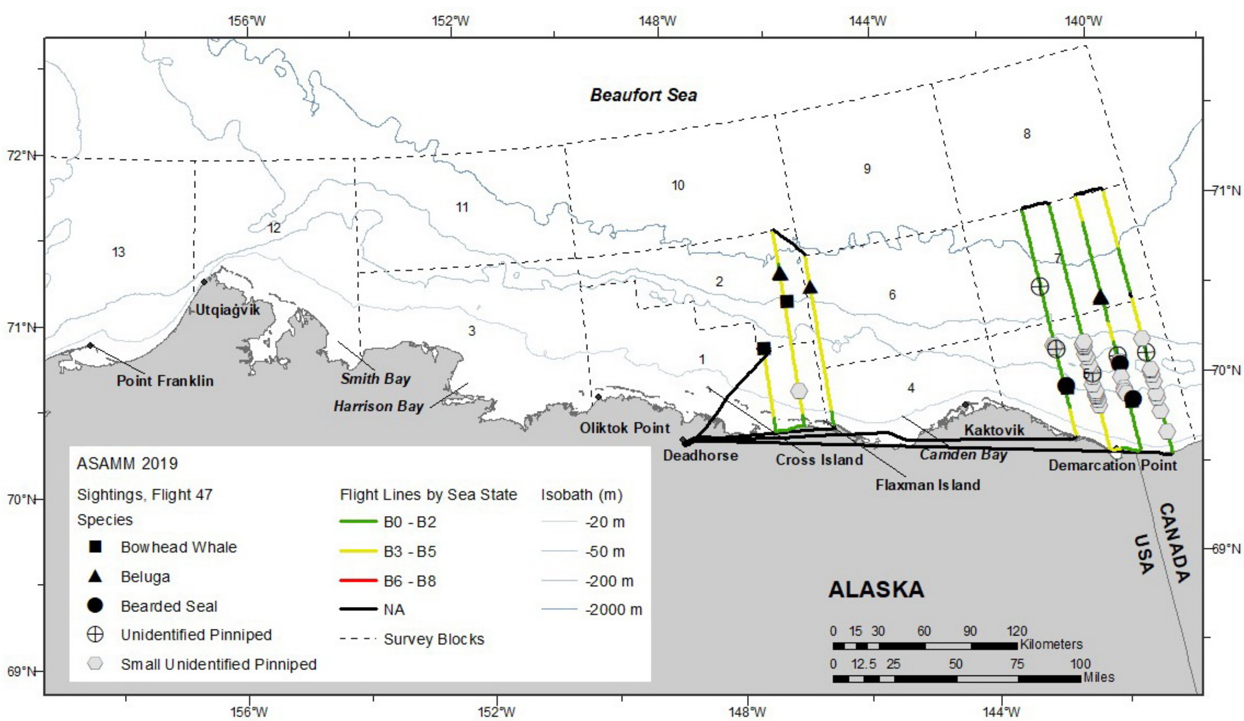


Figure B-114. Flight 47 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Bowhead whale cow-calf pair sighted approximately 80 km northeast of Cross Island, Alaska, Flight 47, 8 October 2019.

Bowhead whale Surface Active Group (SAG) sighted approximately 40 km northeast of Cross Island, Alaska, Flight 47, 8 October 2019. In this photo, the white chins of the whales are visible in the upper right corner.

9 October 2019, Flight 255

Flight was a partial survey of transects 125, 126, 127, and 128. 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 bowhead whales, belugas (including one 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
255	10/9/2019 12:47	71.507	152.344	bowhead whale	swim	1	0	11
255	10/9/2019 12:52	71.499	152.318	bowhead whale	swim	1	0	11
255	10/9/2019 13:01	71.616	152.407	beluga	swim	2	0	11
255	10/9/2019 13:01	71.627	152.381	beluga	swim	3	1	11
255	10/9/2019 13:01	71.629	152.416	beluga	swim	1	0	11
255	10/9/2019 13:01	71.638	152.392	beluga	rest	3	0	11
255	10/9/2019 13:02	71.639	152.421	beluga	swim	1	0	11
255	10/9/2019 13:10	71.930	152.405	beluga	swim	1	0	11
255	10/9/2019 13:10	71.930	152.430	beluga	swim	1	0	11
255	10/9/2019 13:11	71.933	152.407	beluga	swim	1	0	11
255	10/9/2019 13:11	71.934	152.396	beluga	rest	1	0	11
255	10/9/2019 13:24	71.788	152.870	beluga	swim	1	0	11
255	10/9/2019 13:24	71.785	152.888	beluga	swim	1	0	11
255	10/9/2019 13:41	71.616	153.413	bowhead whale	swim	1	0	11

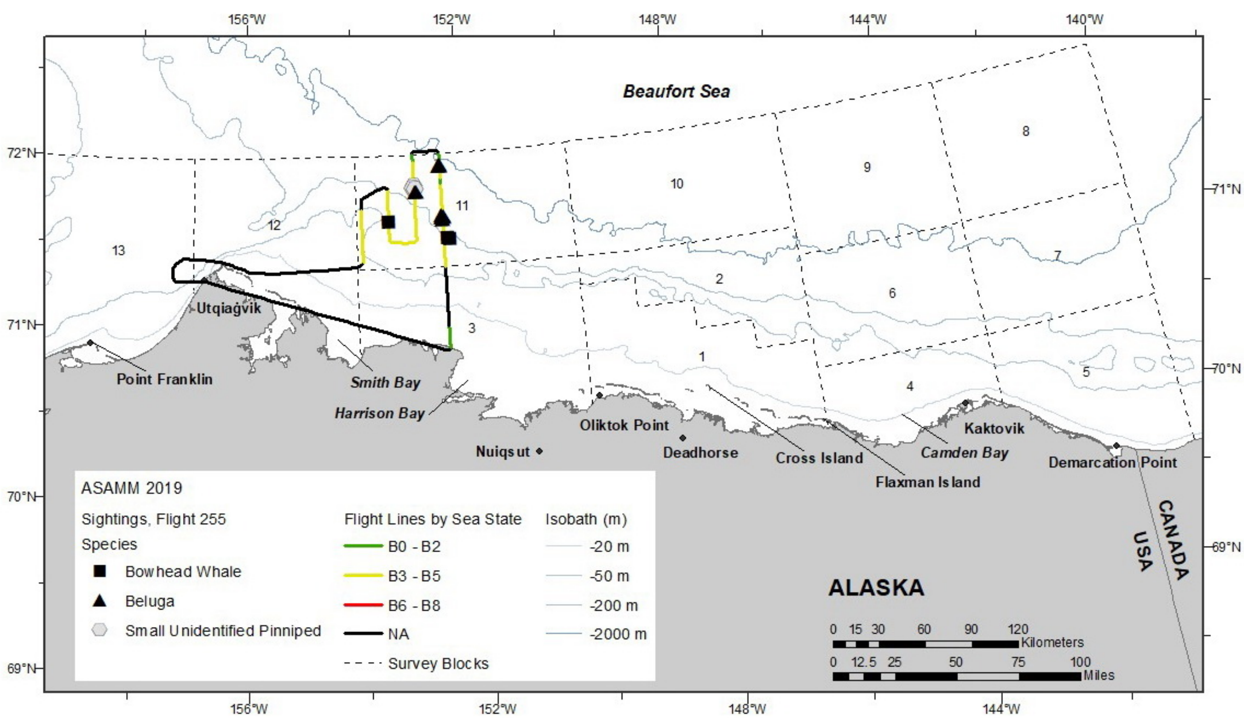


Figure B-115. Flight 255 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

9 October 2019, Flight 48

Flight was a partial survey of transects 105, 106, 107, 108, 109, 110, 111, 115, 116, and 117. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with fog, glare, low ceilings, and precipitation, and Beaufort 1-3 sea states. There was no sea ice in the area surveyed. Sightings included bowhead whales (including one calf), belugas, bearded seals, 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
48	10/9/2019 13:00	70.251	143.368	bowhead whale	swim	1	0	4
48	10/9/2019 14:12	70.458	144.921	beluga	swim	1	0	4
48	10/9/2019 14:12	70.457	144.929	beluga	swim	2	0	4
48	10/9/2019 14:42	70.415	145.406	bowhead whale	swim	2	1	4

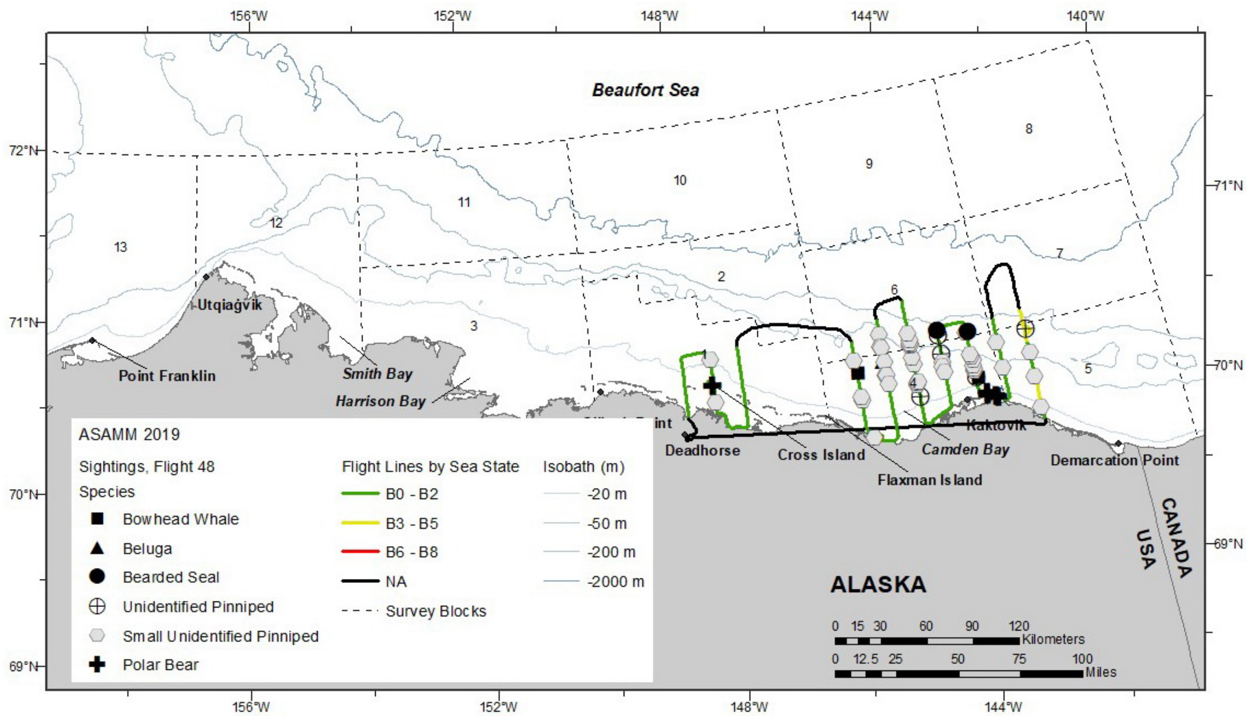


Figure B-116. Flight 48 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

10 October 2019, Flight 256

Flight was the coastal transect from Cape Lisburne to Utqiaġvik. 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% grease/new ice in the area surveyed. Sightings included two bowhead whale carcasses, two gray whale carcasses, walruses, one unidentified pinniped, and small unidentified pinnipeds. One of the bowhead whale carcasses was a resight of a carcass that was previously observed during flight 234 on 5 September 2019. The other bowhead carcass was a resight of a carcass that was originally sighted in 2018, and again during flight 201 and 213 on 2 and 23 July 2019, respectively. One gray whale carcass was a resight of a carcass that was previously sighted during flight 246 on 25 September 2019. Two haulouts, of approximately 150 and 200 small unidentified pinnipeds, were observed on barrier islands east and west 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
256	10/10/2019 17:28	70.547	160.254	bowhead whale	dead	1	0	17
256	10/10/2019 17:44	70.876	159.161	gray whale	dead	1	0	13
256	10/10/2019 18:00	70.816	158.193	bowhead whale	dead	1	0	13
256	10/10/2019 18:11	70.993	157.380	gray whale	dead	1	0	13

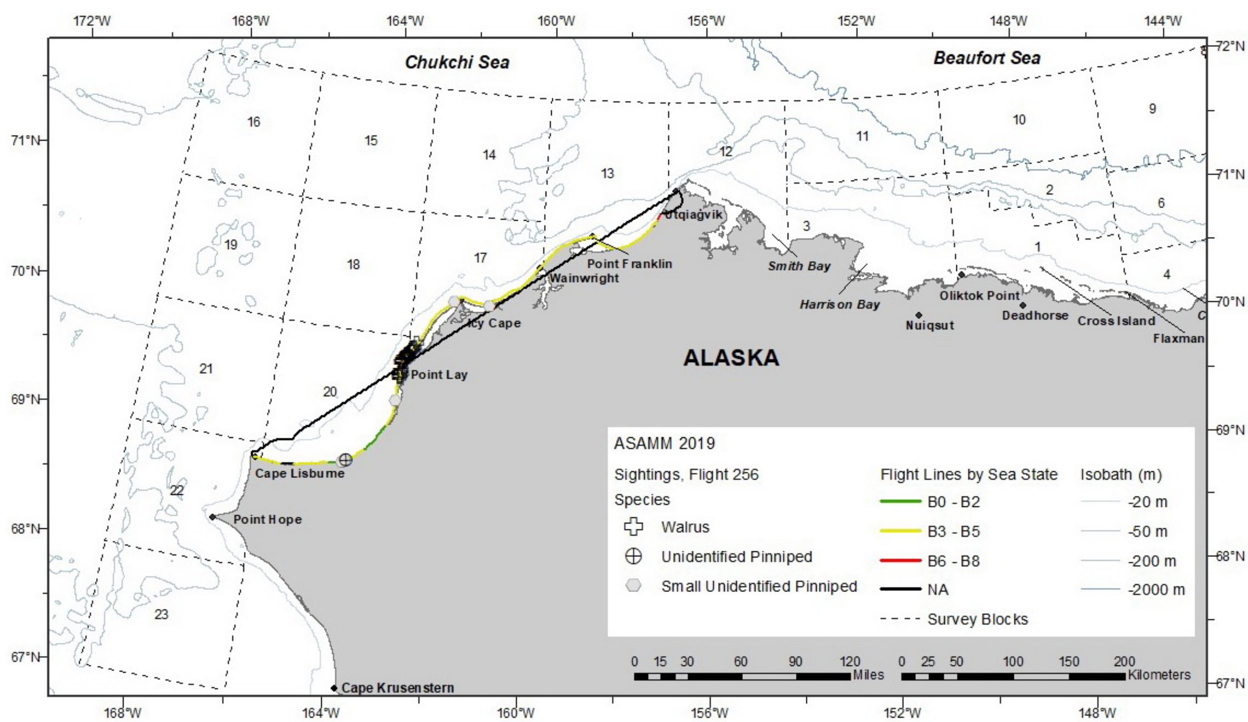


Figure B-117. Flight 256 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

This page intentionally left blank.

10 October 2019, Flight 49

Flight was a partial survey of transects 119, 120, and 128, and the coastal transect from approximately 25 km east of Smith Bay to Oliktok Point. Survey conditions included partly cloudy skies, 1 km to unlimited visibility, with glare and low ceilings, and Beaufort 2-6 sea states. Sea ice ranged 0-75% grease/new ice in the area surveyed. Sightings included small unidentified pinnipeds and one polar bear.

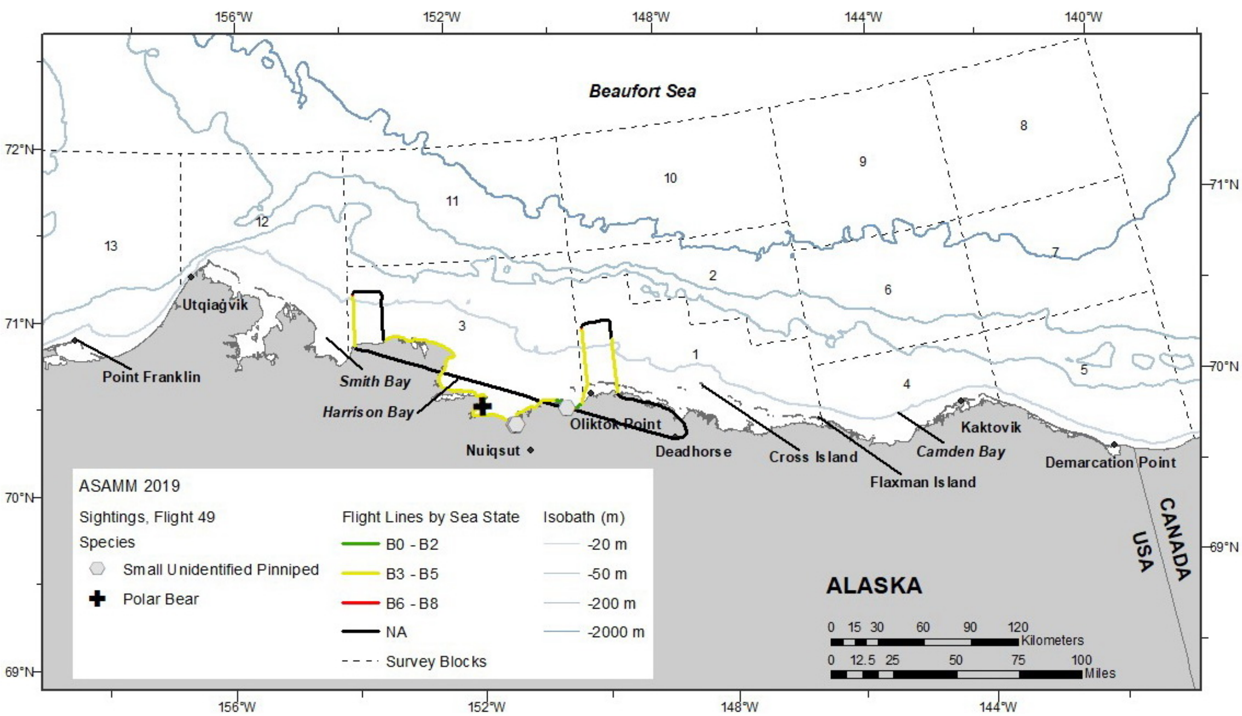


Figure B-118. Flight 49 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

Polar bears hanging out at the bone pile on Cross Island, Alaska, Flight 49, 10 October 2019.

13 October 2019, Flight 257

Flight was a complete survey of transect 129, and partial survey of transects 130, 131, and 132. Survey conditions included clear to partly cloudy skies, 0 km to unlimited visibility, with fog, glare, low ceilings, and precipitation, and Beaufort 2-6 sea states. Sea ice observed ranged from 0-98% grease/new ice in the area surveyed. Sightings included one bowhead whale, belugas, and unidentified cetaceans (including one 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
257	10/13/2019 12:48	71.708	154.896	bowhead whale	swim	1	0	12
257	10/13/2019 13:46	71.922	155.903	beluga	swim	9	0	12
257	10/13/2019 13:55	71.663	155.906	unid cetacean	swim	2	1	12

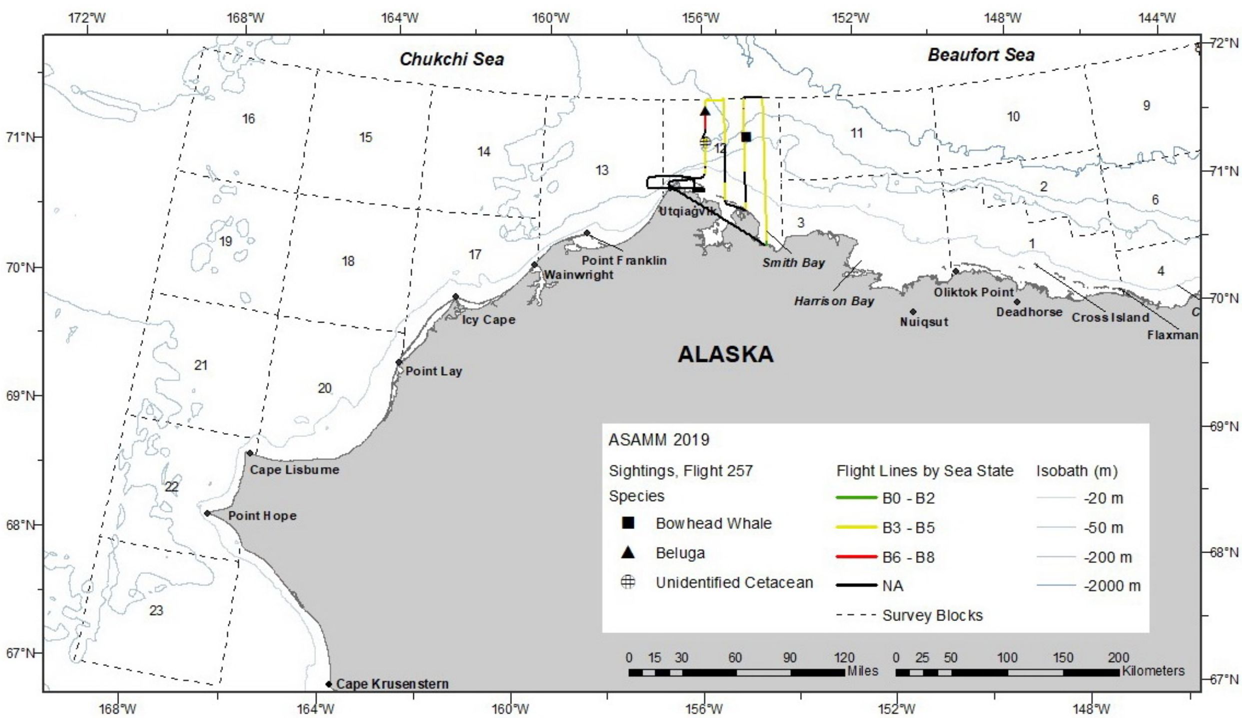


Figure B-119. Flight 257 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

14 October 2019, Flight 258

Flight was a complete survey of transects 127, 128, 129, 130, and 131, and partial survey of transect 133. Survey conditions included clear, partly cloudy, and overcast skies, 1 km to unlimited visibility, with glare and low ceilings, and Beaufort 2-6 sea states. Sea ice was 0-40% grease/new ice in the area surveyed. Sightings included bowhead whales (including one calf) and belugas (including one 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
258	10/14/2019 12:11	71.941	153.390	beluga	swim	4	1	11
258	10/14/2019 12:11	71.940	153.414	beluga	swim	20	0	11
258	10/14/2019 12:16	71.784	153.422	bowhead whale	swim	2	1	11
258	10/14/2019 12:58	70.939	153.868	beluga	feed	3	0	3
258	10/14/2019 13:19	71.690	153.866	bowhead whale	swim	1	0	11
258	10/14/2019 13:26	71.893	153.903	beluga	swim	1	0	11
258	10/14/2019 13:27	71.897	153.899	beluga	swim	1	0	11
258	10/14/2019 13:27	71.905	153.895	beluga	swim	2	0	11
258	10/14/2019 13:27	71.907	153.914	beluga	swim	1	0	11
258	10/14/2019 13:27	71.909	153.884	beluga	swim	1	0	11

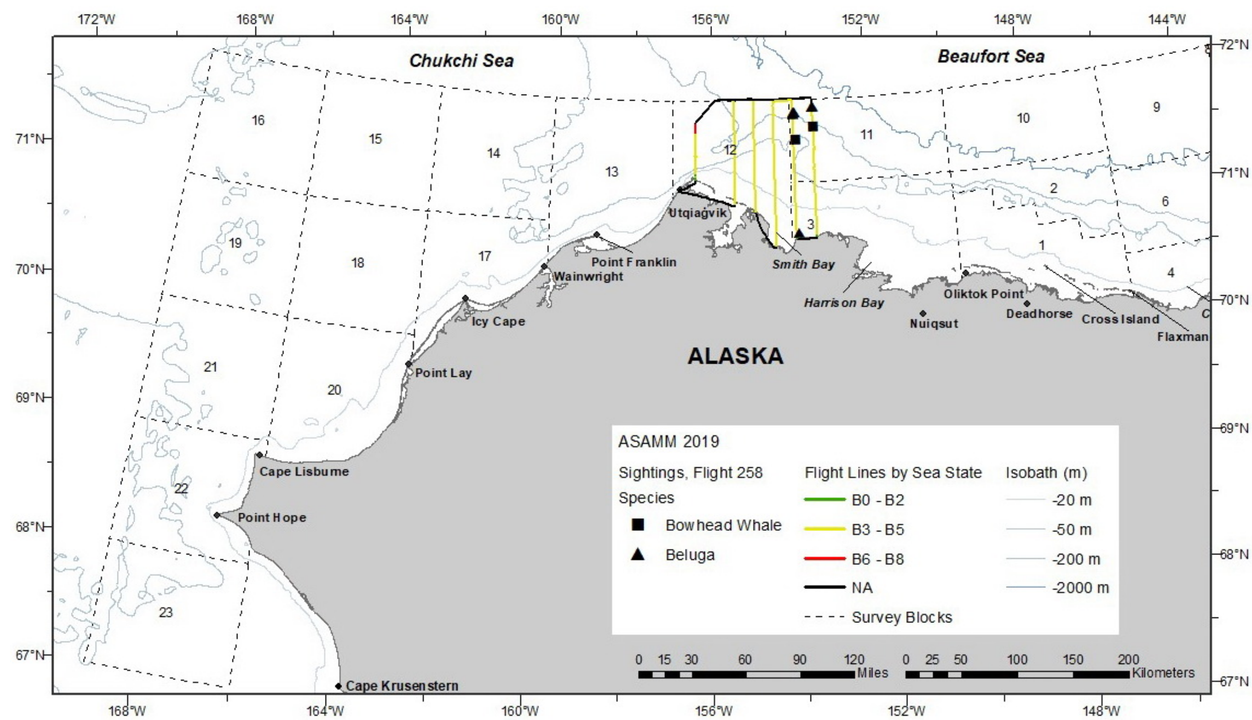


Figure B-120. Flight 258 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

15 October 2019, Flight 259

Flight was a complete survey of transects 20, 21, 22, and 23. Survey conditions included clear skies, unlimited visibility, with glare, and Beaufort 1-5 sea states. There was no sea ice in the area surveyed. Sightings included fin whales, minke whales, unidentified cetaceans (including one carcass), walruses, bearded seals, 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
259	10/15/2019 12:22	70.441	168.198	minke whale	swim	1	0	19
259	10/15/2019 12:50	70.027	168.559	fin whale	mill	3	0	19
259	10/15/2019 12:57	70.034	168.537	minke whale	swim	1	0	19
259	10/15/2019 12:58	70.041	168.466	minke whale	mill	2	0	19
259	10/15/2019 13:02	70.064	168.487	minke whale	swim	1	0	19
259	10/15/2019 13:10	69.955	167.867	fin whale	swim	1	0	21
259	10/15/2019 17:11	70.000	168.673	unid cetacean	unknown	2	0	19
259	10/15/2019 17:20	70.013	168.659	fin whale	swim	1	0	19
259	10/15/2019 17:20	70.029	168.778	minke whale	swim	1	0	19
259	10/15/2019 17:28	70.099	169.090	unid cetacean	dead	1	0	0

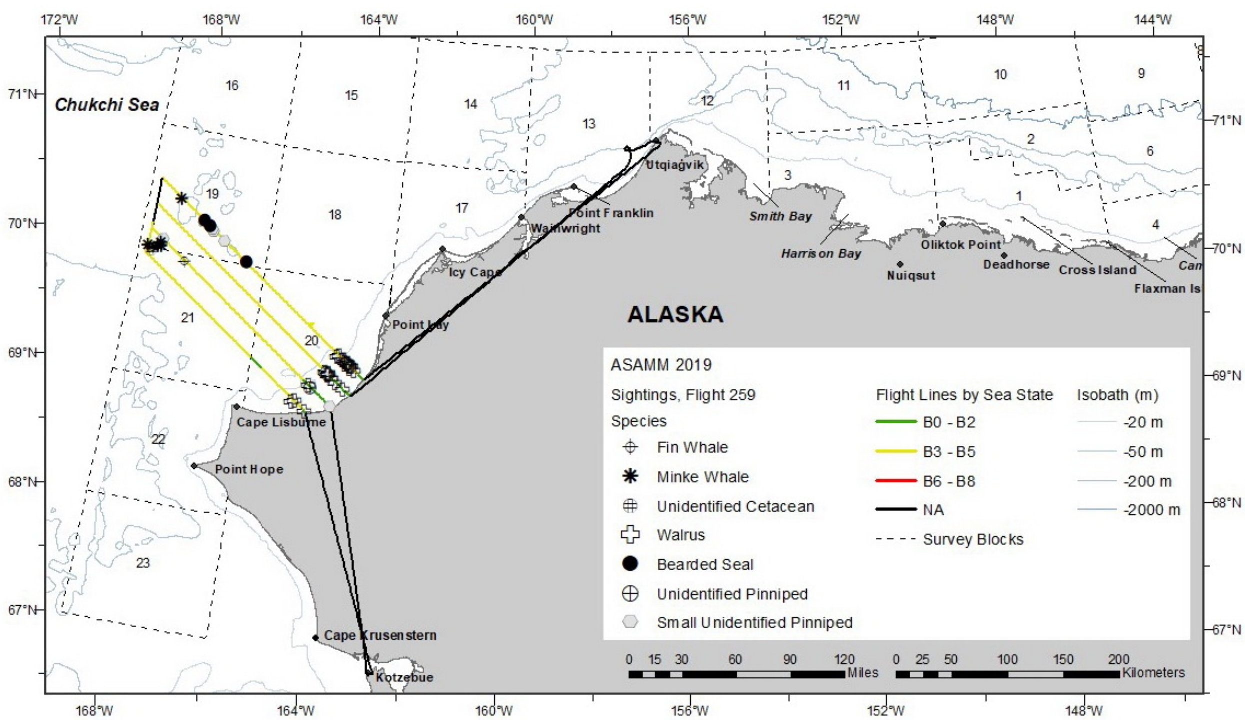


Figure B-121. Flight 259 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

17 October 2019, Flight 260

Flight was a complete survey of transects 29, 30, 31, and 32, and the coastal transect from southeast of Point Hope to Cape Krusenstern. Survey conditions included clear, partly cloudy, and overcast skies, 3 km to unlimited visibility, with glare and precipitation, and Beaufort 1-5 sea states. There was no sea ice in the area surveyed. Sightings included gray whales (including one carcass), fin whales, minke whales, unidentified pinnipeds, 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
260	10/17/2019 14:14	68.568	168.264	gray whale	dead	1	0	22
260	10/17/2019 14:24	68.599	168.756	gray whale	swim	1	0	22
260	10/17/2019 15:46	68.024	168.211	fin whale	mill	3	0	22
260	10/17/2019 16:16	68.088	166.430	minke whale	swim	1	0	22
260	10/17/2019 16:54	67.652	164.318	minke whale	swim	1	0	0
260	10/17/2019 17:08	67.601	164.141	minke whale	swim	1	0	0
260	10/17/2019 17:11	67.488	163.982	minke whale	swim	1	0	0

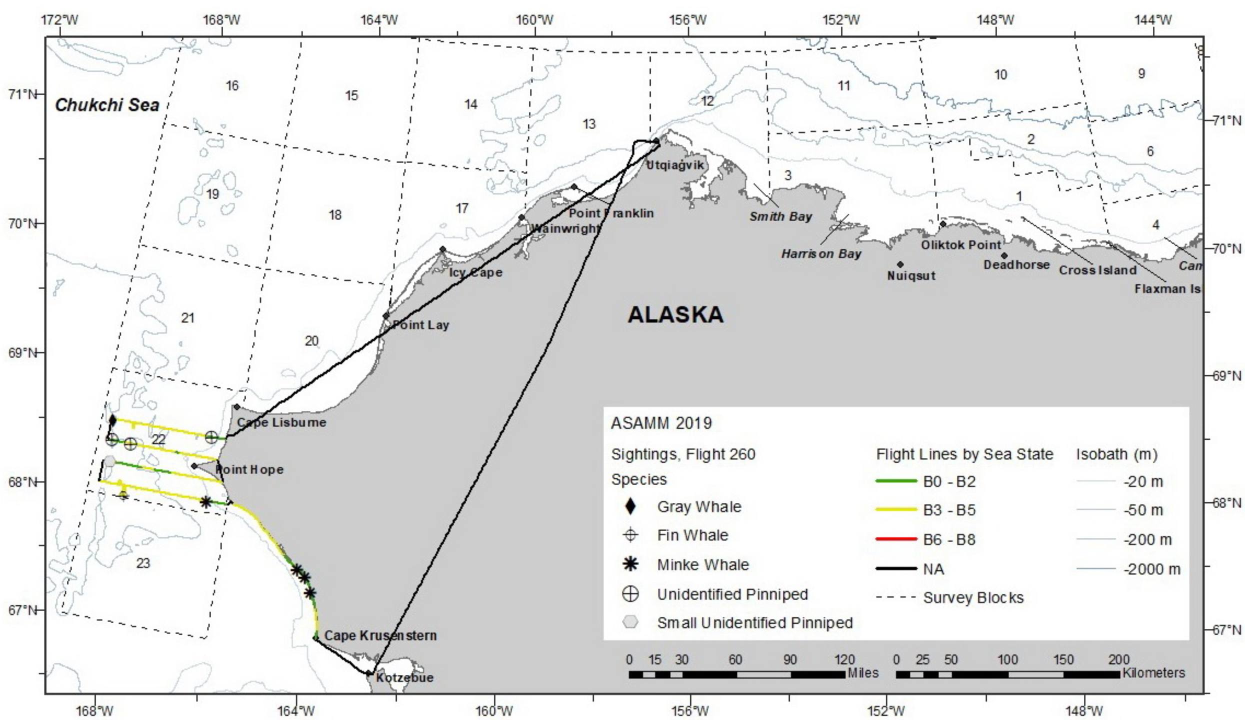


Figure B-122. Flight 260 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

18 October 2019, Flight 261

Flight was a complete survey of transects 33 and 34, and a partial survey of transects 35, 36, and 38. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with glare and precipitation, and Beaufort 2-6 sea states. There was no sea ice in the area surveyed. Sightings included gray whales (including one calf), fin whales (including one calf), one humpback whale, 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
261	10/18/2019 12:25	67.882	167.872	fin whale	mill	4	1	23
261	10/18/2019 12:35	67.897	167.933	fin whale	mill	4	0	23
261	10/18/2019 12:42	67.908	167.916	fin whale	mill	2	0	23
261	10/18/2019 13:06	67.906	168.064	gray whale	feed	1	0	23
261	10/18/2019 13:10	67.911	168.372	gray whale	feed	2	0	23
261	10/18/2019 13:10	67.914	168.387	gray whale	feed	1	0	23
261	10/18/2019 13:10	67.916	168.389	gray whale	feed	1	0	23
261	10/18/2019 13:10	67.908	168.419	gray whale	feed	1	0	23
261	10/18/2019 13:11	67.930	168.470	gray whale	swim	1	0	23
261	10/18/2019 13:11	67.918	168.477	gray whale	rest	1	0	23
261	10/18/2019 13:11	67.928	168.497	gray whale	swim	1	0	23
261	10/18/2019 13:11	67.914	168.542	gray whale	feed	1	0	23
261	10/18/2019 13:12	67.917	168.604	gray whale	rest	1	0	23
261	10/18/2019 13:12	67.922	168.617	gray whale	dive	1	0	23
261	10/18/2019 13:14	67.918	168.606	gray whale	dive	1	0	23
261	10/18/2019 13:15	67.907	168.549	gray whale	feed	1	0	23
261	10/18/2019 13:16	67.910	168.597	gray whale	feed	1	0	23
261	10/18/2019 13:17	67.930	168.498	gray whale	feed	1	0	23
261	10/18/2019 13:18	67.914	168.487	gray whale	swim	1	0	23
261	10/18/2019 13:19	67.912	168.476	gray whale	feed	1	0	23
261	10/18/2019 13:20	67.916	168.481	gray whale	rest	1	0	23
261	10/18/2019 13:22	67.904	168.405	gray whale	feed	1	0	23
261	10/18/2019 13:23	67.918	168.412	gray whale	feed	2	0	23
261	10/18/2019 13:24	67.921	168.430	gray whale	swim	1	0	23
261	10/18/2019 13:25	67.912	168.373	gray whale	feed	3	0	23
261	10/18/2019 13:25	67.907	168.367	gray whale	feed	1	0	23
261	10/18/2019 13:26	67.900	168.338	gray whale	feed	1	0	23
261	10/18/2019 13:30	67.910	168.326	gray whale	feed	1	0	23
261	10/18/2019 13:31	67.901	168.307	gray whale	swim	1	0	23
261	10/18/2019 13:31	67.901	168.287	gray whale	feed	1	0	23
261	10/18/2019 13:31	67.902	168.279	gray whale	feed	1	0	23
261	10/18/2019 13:31	67.902	168.275	gray whale	feed	1	0	23
261	10/18/2019 13:33	67.898	168.199	gray whale	rest	1	0	23
261	10/18/2019 13:34	67.904	168.192	gray whale	feed	2	0	23
261	10/18/2019 13:37	67.909	168.056	gray whale	feed	1	0	23
261	10/18/2019 13:37	67.910	168.058	gray whale	rest	1	0	23

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
261	10/18/2019 13:40	67.911	168.015	gray whale	swim	1	0	23
261	10/18/2019 13:41	67.939	168.046	humpback whale	swim	1	0	23
261	10/18/2019 13:42	67.944	168.085	fin whale	swim	1	0	23
261	10/18/2019 13:44	67.932	168.098	fin whale	swim	2	0	23
261	10/18/2019 13:47	67.909	168.104	gray whale	feed	1	0	23
261	10/18/2019 13:48	67.936	168.124	gray whale	swim	1	0	23
261	10/18/2019 13:49	67.939	168.151	gray whale	feed	1	0	23
261	10/18/2019 13:52	67.929	168.437	gray whale	swim	2	0	23
261	10/18/2019 13:53	67.923	168.437	gray whale	swim	1	0	23
261	10/18/2019 13:53	67.920	168.423	gray whale	feed	2	0	23
261	10/18/2019 13:53	67.933	168.452	gray whale	feed	1	0	23
261	10/18/2019 13:54	67.936	168.462	gray whale	swim	1	0	23
261	10/18/2019 13:54	67.931	168.464	gray whale	swim	1	0	23
261	10/18/2019 13:55	67.924	168.490	gray whale	feed	1	0	23
261	10/18/2019 13:55	67.941	168.487	gray whale	swim	1	0	23
261	10/18/2019 13:58	67.923	168.581	gray whale	rest	1	0	23
261	10/18/2019 13:58	67.929	168.573	gray whale	swim	1	0	23
261	10/18/2019 13:59	67.935	168.619	gray whale	feed	1	0	23
261	10/18/2019 14:01	67.924	168.694	gray whale	swim	1	0	23
261	10/18/2019 14:02	67.884	168.734	gray whale	feed	1	0	23
261	10/18/2019 14:03	67.931	168.716	gray whale	feed	1	0	23
261	10/18/2019 14:03	67.909	168.729	gray whale	swim	1	0	23
261	10/18/2019 14:12	67.779	168.514	gray whale	feed	1	0	23
261	10/18/2019 16:48	67.426	167.147	fin whale	swim	1	0	23
261	10/18/2019 17:03	67.424	168.393	gray whale	feed	1	0	23
261	10/18/2019 17:03	67.421	168.421	gray whale	feed	2	0	23
261	10/18/2019 17:03	67.401	168.426	gray whale	feed	1	0	23
261	10/18/2019 17:03	67.421	168.431	gray whale	feed	1	0	23
261	10/18/2019 17:03	67.419	168.438	gray whale	feed	1	1	23
261	10/18/2019 17:03	67.407	168.439	gray whale	feed	1	0	23
261	10/18/2019 17:03	67.405	168.449	gray whale	feed	2	0	23
261	10/18/2019 17:03	67.424	168.469	gray whale	feed	1	0	23
261	10/18/2019 17:06	67.389	168.482	gray whale	swim	1	0	23
261	10/18/2019 17:07	67.384	168.510	gray whale	rest	1	0	23
261	10/18/2019 17:07	67.386	168.498	gray whale	swim	1	0	23
261	10/18/2019 17:09	67.403	168.430	gray whale	feed	1	0	23
261	10/18/2019 17:09	67.407	168.427	gray whale	feed	2	0	23
261	10/18/2019 17:10	67.404	168.454	gray whale	feed	1	0	23
261	10/18/2019 17:11	67.405	168.421	gray whale	feed	1	0	23
261	10/18/2019 17:13	67.426	168.403	gray whale	feed	1	0	23
261	10/18/2019 17:13	67.427	168.397	gray whale	feed	1	0	23
261	10/18/2019 17:13	67.426	168.392	gray whale	feed	1	0	23
261	10/18/2019 17:13	67.426	168.390	gray whale	feed	1	0	23
261	10/18/2019 17:13	67.417	168.391	gray whale	feed	1	0	23
261	10/18/2019 17:13	67.421	168.416	gray whale	feed	1	0	23

Flight No.	Date/Time (AK Local)	Latitude ºN	Longitude ºW	Species	Behavior	Group Size	Calf No.	Block
261	10/18/2019 17:13	67.421	168.418	gray whale	feed	1	0	23
261	10/18/2019 17:13	67.422	168.419	gray whale	rest	1	0	23
261	10/18/2019 17:13	67.423	168.419	gray whale	feed	1	0	23
261	10/18/2019 17:13	67.425	168.419	gray whale	feed	1	0	23
261	10/18/2019 17:14	67.427	168.417	gray whale	feed	1	0	23
261	10/18/2019 17:14	67.423	168.402	gray whale	feed	1	0	23
261	10/18/2019 17:14	67.422	168.431	gray whale	swim	1	0	23
261	10/18/2019 17:15	67.429	168.413	gray whale	feed	1	0	23
261	10/18/2019 17:15	67.424	168.389	gray whale	feed	1	0	23
261	10/18/2019 17:16	67.438	168.389	gray whale	feed	1	0	23
261	10/18/2019 17:17	67.450	168.381	gray whale	feed	1	0	23
261	10/18/2019 17:18	67.417	168.422	gray whale	feed	1	0	23
261	10/18/2019 17:20	67.409	168.426	gray whale	feed	1	0	23
261	10/18/2019 17:20	67.409	168.426	gray whale	swim	1	0	23
261	10/18/2019 17:20	67.410	168.426	gray whale	swim	1	0	23
261	10/18/2019 17:24	67.426	168.390	gray whale	swim	1	0	23

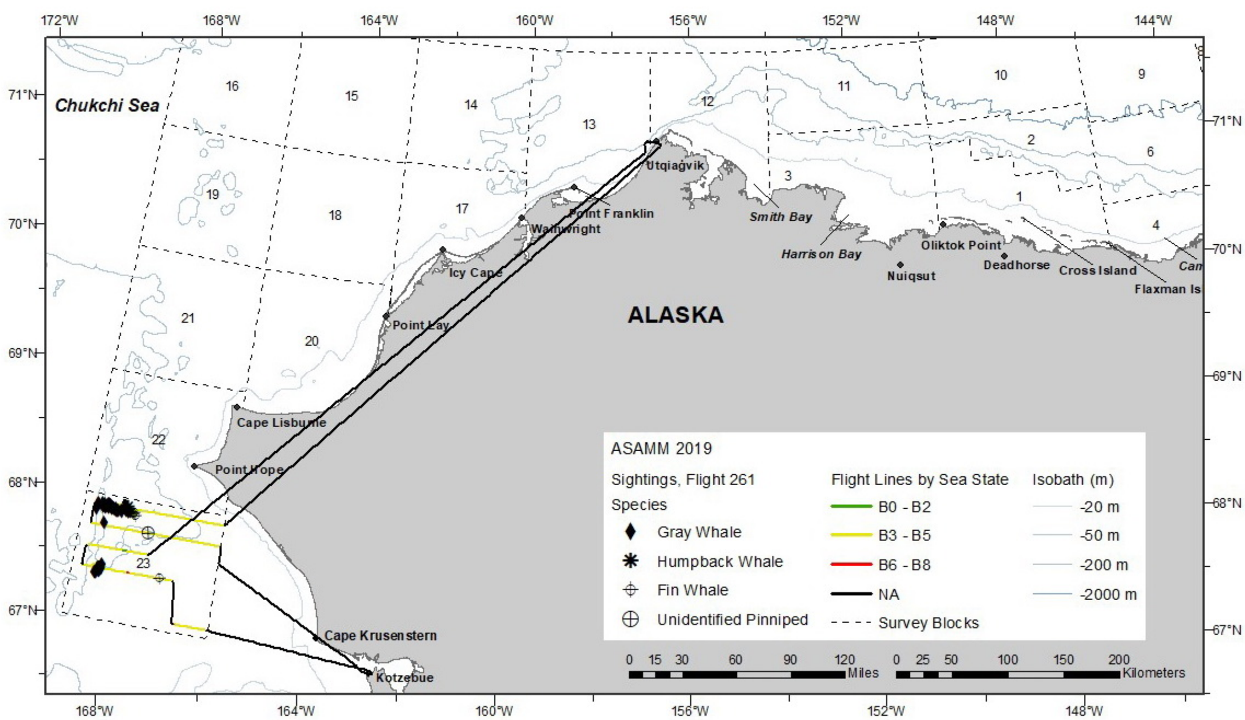


Figure B-123. Flight 261 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

20 October 2019, Flight 262

Flight was a partial survey of transect 5, and the coastal transect from east of Point Franklin to south of Utqiaġvik. Survey conditions included partly cloudy skies, 1 km to unlimited visibility, with fog, glare, and low ceilings, and Beaufort 2-5 sea states. There was no sea ice in the area surveyed. Sightings included one gray whale carcass, one unidentified pinniped, and one small unidentified pinniped. The gray whale carcass was a resight of a carcass that was previously sighted on during flight 246 on 25 September 2019 and flight 256 on 10 October 2019.

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
262	10/20/2019 16:03	70.994	157.381	gray whale	dead	1	0	13

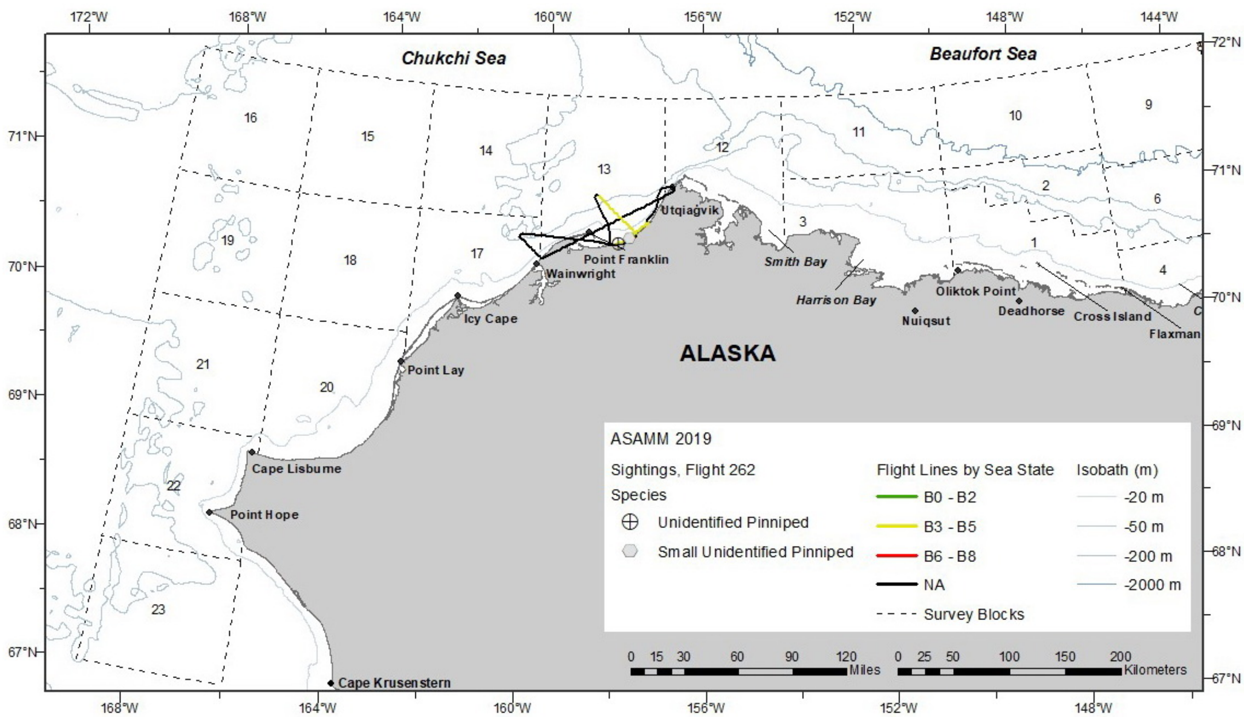


Figure B-124. Flight 262 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

22 October 2019, Flight 263

Flight was a complete survey of transects 121, 122, 125, and 127, partial survey of transects 126 and 128, and the coastal transect in Harrison Bay and east of Smith Bay. Survey conditions included partly cloudy to overcast skies, 0 km to unlimited visibility, with fog, glare, low ceilings, and precipitation, and Beaufort 0-4 sea states. Sea ice was 0-99% grease/new ice and broken floe ice in the area surveyed. Sightings included bowhead whales (including one calf), belugas (including three calves), one walrus, 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
263	10/22/2019 11:42	71.468	153.889	bowhead whale	swim	1	0	11
263	10/22/2019 12:24	71.312	153.392	bowhead whale	feed	2	1	3
263	10/22/2019 13:36	71.750	152.403	beluga	swim	11	3	11
263	10/22/2019 13:36	71.749	152.398	beluga	swim	1	0	11
263	10/22/2019 13:39	71.642	152.396	beluga	swim	1	0	11
263	10/22/2019 13:40	71.612	152.403	beluga	rest	1	0	11
263	10/22/2019 13:40	71.610	152.425	beluga	rest	1	0	11
263	10/22/2019 13:40	71.609	152.408	beluga	rest	1	0	11
263	10/22/2019 14:55	71.339	150.902	beluga	swim	1	0	11
263	10/22/2019 14:55	71.350	150.905	beluga	swim	1	0	11
263	10/22/2019 14:55	71.350	150.883	beluga	swim	1	0	11
263	10/22/2019 14:55	71.355	150.895	beluga	swim	2	0	11
263	10/22/2019 14:55	71.356	150.922	beluga	swim	1	0	11
263	10/22/2019 14:56	71.362	150.921	beluga	swim	1	0	11
263	10/22/2019 15:36	71.367	150.394	beluga	swim	1	0	11
263	10/22/2019 15:37	71.361	150.403	beluga	swim	1	0	11
263	10/22/2019 15:37	71.354	150.428	beluga	swim	2	0	11
263	10/22/2019 15:37	71.345	150.397	beluga	swim	1	0	11

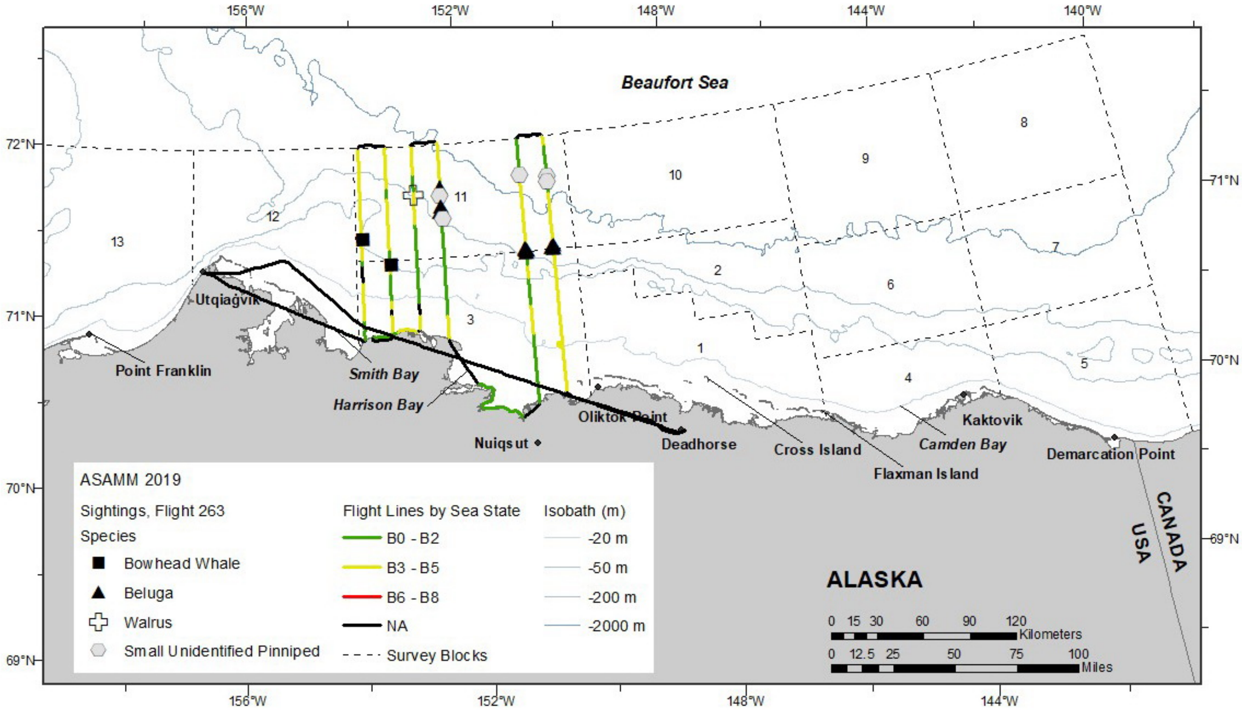


Figure B-125. Flight 263 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

23 October 2019, Flight 264

Flight was a complete survey of transects 110, 112, 113, 114, and 116, and partial survey of transects 111 and 117. Survey conditions included clear, partly cloudy, and overcast skies, 1 km to unlimited visibility, with glare, low ceilings, and precipitation, and Beaufort 0-6 sea states. Sea ice was 0-99% grease/new ice and broken floe in the area surveyed. Sightings included bowhead whales (including one calf), belugas, one unidentified cetacean, 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
264	10/23/2019 12:22	71.106	146.908	beluga	swim	2	0	2
264	10/23/2019 12:26	70.968	146.922	beluga	rest	1	0	2
264	10/23/2019 12:26	70.962	146.921	beluga	rest	1	0	2
264	10/23/2019 12:26	70.959	146.930	beluga	rest	1	0	2
264	10/23/2019 12:26	70.953	146.905	beluga	rest	1	0	2
264	10/23/2019 12:27	70.949	146.918	beluga	swim	1	0	2
264	10/23/2019 12:27	70.944	146.889	beluga	swim	1	0	2
264	10/23/2019 12:27	70.925	146.873	beluga	swim	1	0	2
264	10/23/2019 12:42	70.451	147.007	unid cetacean	swim	1	0	1
264	10/23/2019 13:11	70.420	146.383	beluga	swim	1	0	1
264	10/23/2019 13:30	71.054	146.390	beluga	swim	1	0	2
264	10/23/2019 13:45	71.149	145.898	beluga	swim	1	0	6
264	10/23/2019 13:49	71.042	145.890	beluga	rest	1	0	6
264	10/23/2019 13:52	70.935	145.879	beluga	rest	1	0	6
264	10/23/2019 14:51	71.108	145.428	beluga	rest	1	0	6
264	10/23/2019 14:51	71.110	145.407	beluga	rest	1	0	6
264	10/23/2019 14:51	71.116	145.422	beluga	rest	1	0	6
264	10/23/2019 15:03	70.987	144.914	beluga	rest	1	0	6
264	10/23/2019 15:04	70.980	144.927	beluga	swim	5	0	6
264	10/23/2019 15:04	70.969	144.918	beluga	rest	1	0	6
264	10/23/2019 15:06	70.900	144.850	beluga	rest	1	0	6
264	10/23/2019 17:14	70.532	147.892	bowhead whale	swim	1	0	1
264	10/23/2019 17:17	70.589	147.890	bowhead whale	swim	2	1	1

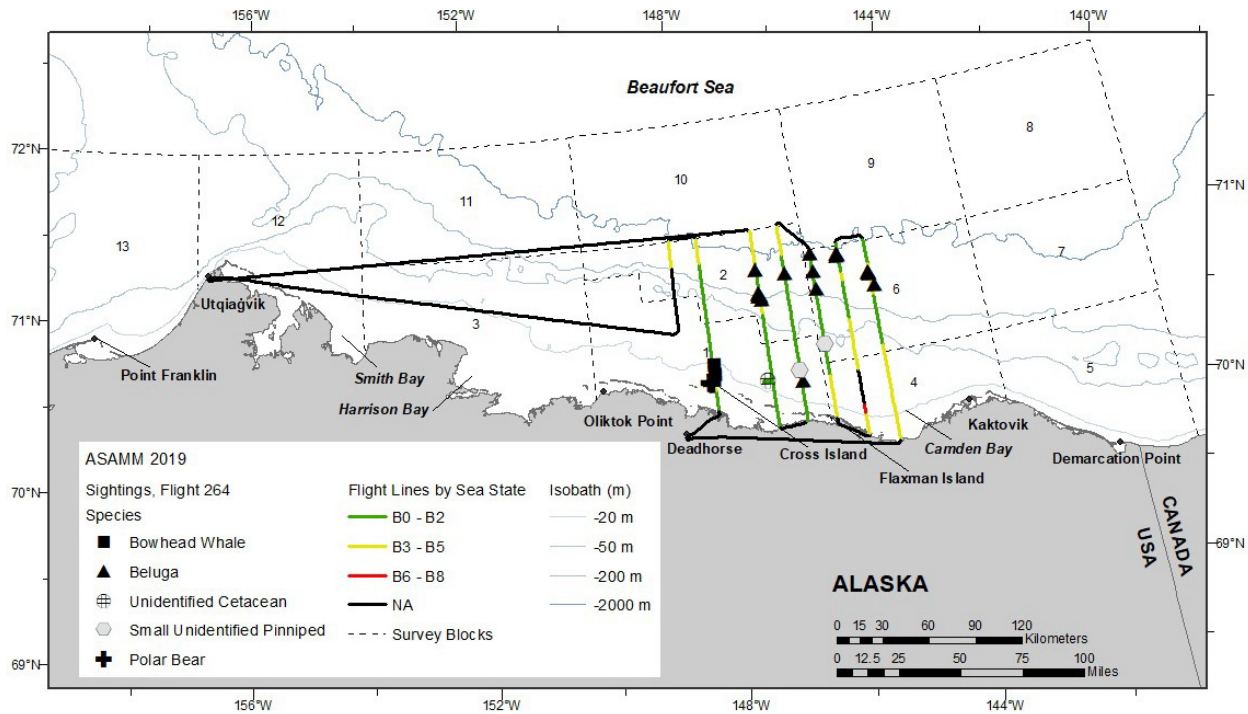


Figure B-126. Flight 264 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

This page intentionally left blank.

24 October 2019, Flight 265

Flight was a complete survey of transects 1 and 9, and a partial survey of transects 2, 3, 4, and 7. Survey conditions included partly cloudy skies, 0 km to unlimited visibility, with fog, glare, low ceilings, and precipitation, and Beaufort 2-7 sea states. There was no sea ice in the area surveyed. Sightings included gray whales (including one carcass), belugas (including two calves), 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
265	10/24/2019 11:44	70.916	160.755	gray whale	feed	1	0	17
265	10/24/2019 11:56	71.110	161.480	gray whale	dead	1	0	14
265	10/24/2019 13:17	71.479	161.148	beluga	rest	2	0	14
265	10/24/2019 13:18	71.463	161.119	beluga	rest	2	0	14
265	10/24/2019 13:18	71.467	161.105	beluga	rest	7	0	14
265	10/24/2019 13:18	71.467	161.102	beluga	rest	8	0	14
265	10/24/2019 13:18	71.466	161.101	beluga	rest	3	0	14
265	10/24/2019 14:44	71.435	157.773	beluga	swim	1	0	13
265	10/24/2019 14:44	71.428	157.785	beluga	swim	2	0	13
265	10/24/2019 14:44	71.425	157.794	beluga	swim	2	1	13
265	10/24/2019 14:44	71.421	157.751	beluga	swim	2	1	13

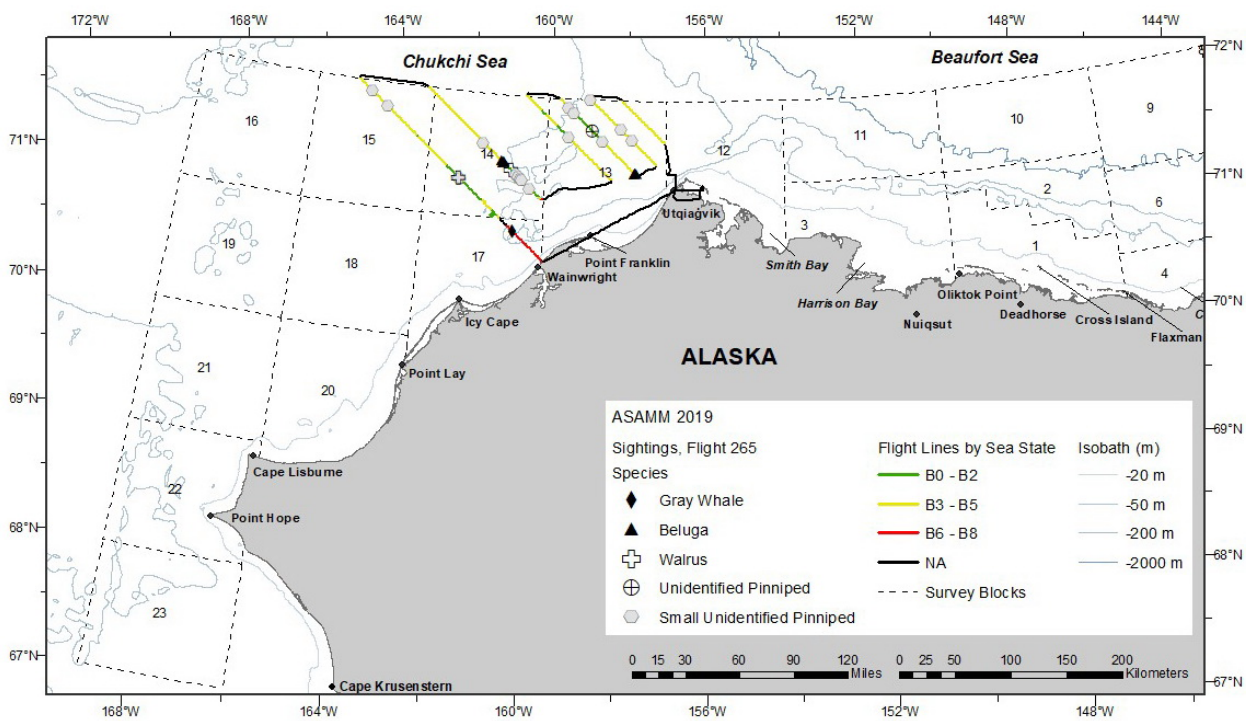


Figure B-127. Flight 265 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

25 October 2019, Flight 266

Flight was a partial survey of transects 129, 130, 131, 132, 133, and 134. Transects 129, 130, 131, and 132 were extended to 73°N. Survey conditions included partly cloudy to overcast skies, <1 km to unlimited visibility, with glare and precipitation, and Beaufort 1-8 sea states. There was no sea ice in the area surveyed. Sightings included belugas (including one 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
266	10/25/2019 11:36	72.225	155.895	beluga	swim	1	0	0
266	10/25/2019 11:36	72.226	155.890	beluga	swim	1	0	0
266	10/25/2019 11:36	72.226	155.887	beluga	swim	1	0	0
266	10/25/2019 11:36	72.233	155.901	beluga	swim	1	0	0
266	10/25/2019 11:37	72.260	155.884	beluga	swim	2	1	0
266	10/25/2019 12:38	71.914	154.923	beluga	swim	8	0	12
266	10/25/2019 12:38	71.917	154.930	beluga	swim	10	0	12
266	10/25/2019 12:38	71.919	154.940	beluga	swim	10	0	12
266	10/25/2019 12:40	71.989	154.931	beluga	swim	1	0	12
266	10/25/2019 12:41	72.005	154.904	beluga	swim	1	0	0
266	10/25/2019 12:41	72.010	154.892	beluga	swim	1	0	0
266	10/25/2019 12:41	72.013	154.896	beluga	swim	2	0	0
266	10/25/2019 12:41	72.013	154.892	beluga	swim	2	0	0
266	10/25/2019 12:41	72.015	154.925	beluga	swim	1	0	0

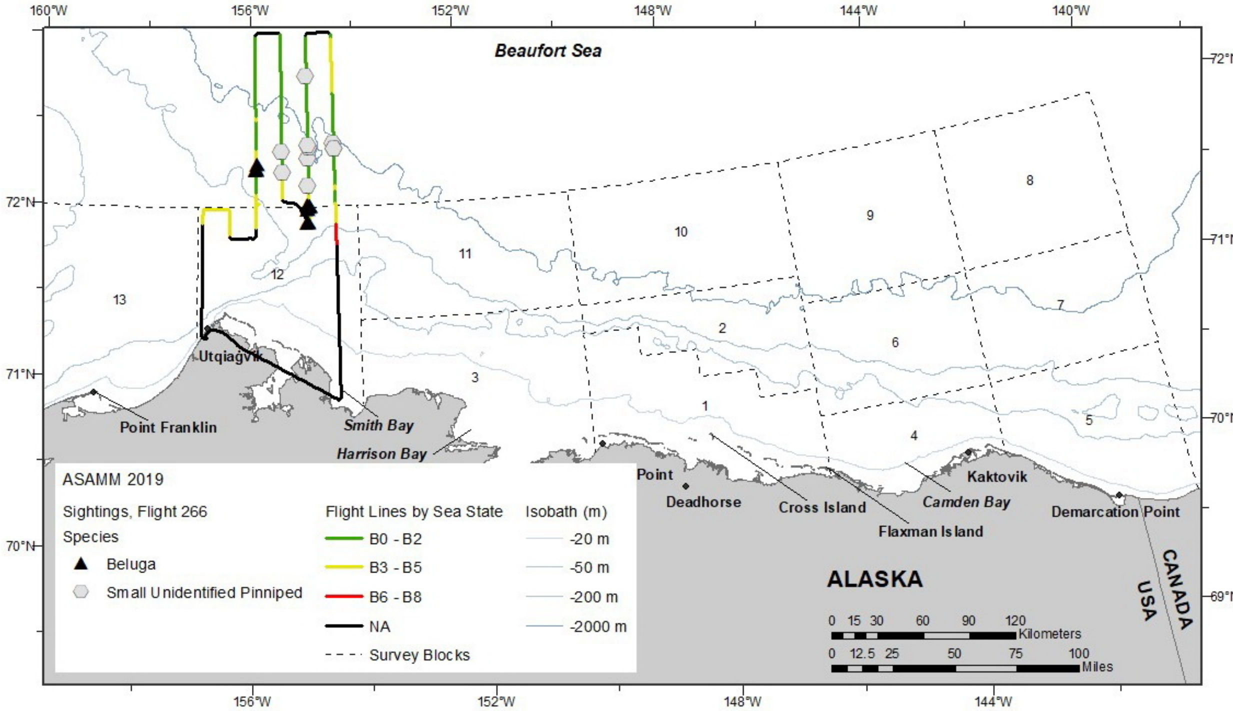


Figure B-128. Flight 266 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

26 October 2019, Flight 267

Flight was a complete survey of transect 21, and a partial survey of transects 19, 20, and 22. Survey conditions included clear, partly cloudy, and overcast skies, 3 km to unlimited visibility, with glare and precipitation, and Beaufort 2-4 sea states. Sea ice was 0-5% grease/new ice in the area surveyed. Sightings included one beluga, one walrus, 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
267	10/26/2019 12:17	69.092	163.706	beluga	swim	1	0	20

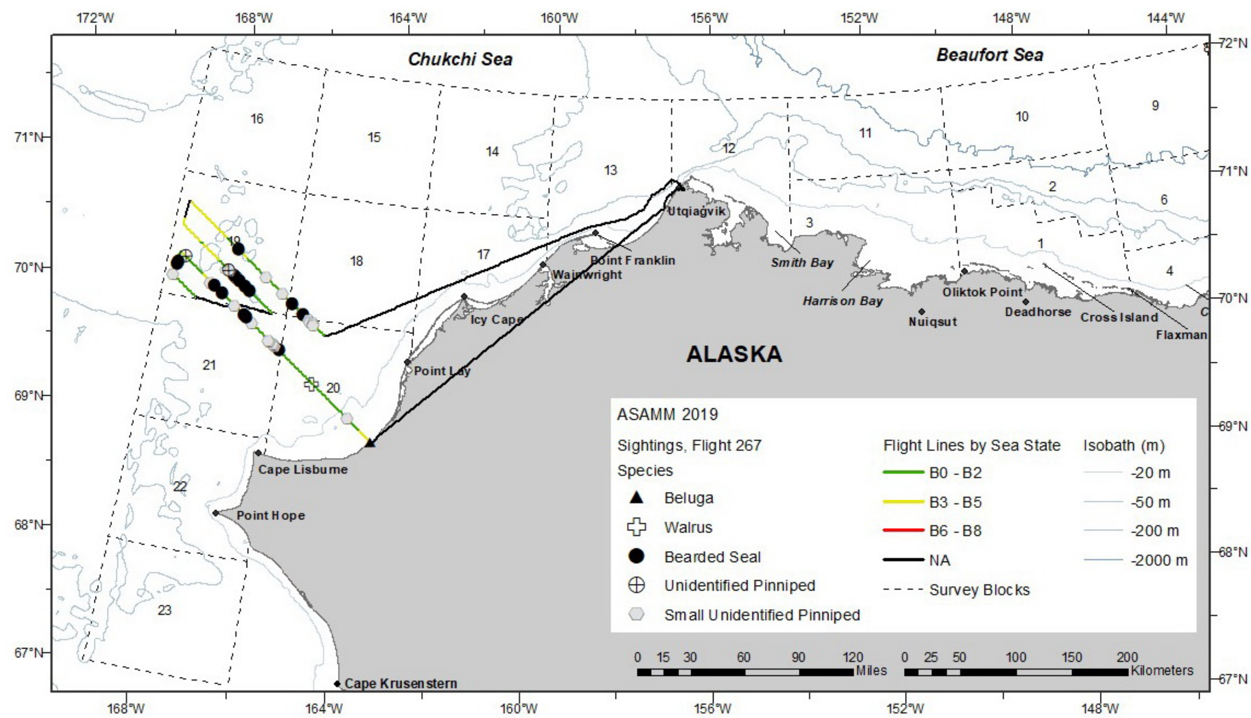


Figure B-129. Flight 267 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

28 October 2019, Flight 268

Flight was a complete survey of transects 109, 110, 111, and 112, and search effort approximately 10 km offshore from west of Camden Bay to east of Deadhorse. Survey conditions included partly cloudy to overcast skies, unlimited visibility, and Beaufort 1-3 sea states. Sea ice was 0-95% grease/new ice in the area surveyed. Sightings included 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
268	10/28/2019 16:05	71.009	145.406	beluga	swim	1	0	6
268	10/28/2019 16:05	71.013	145.385	beluga	swim	1	0	6

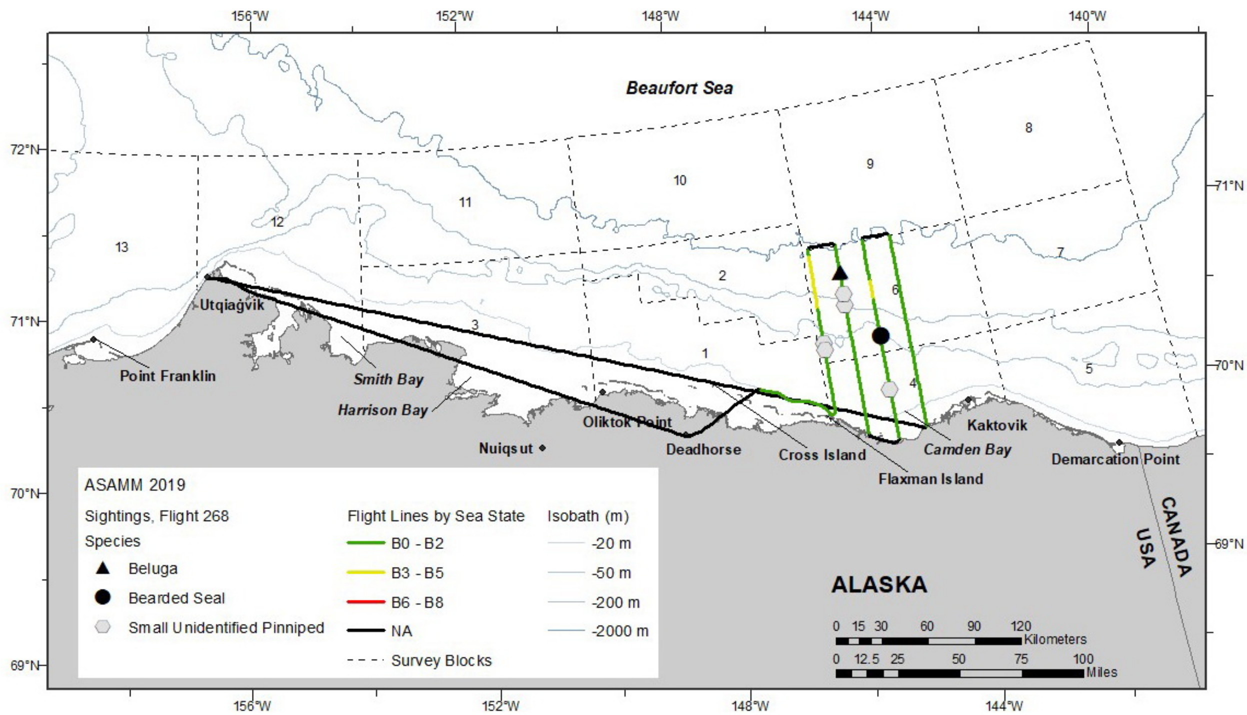


Figure B-130. Flight 268 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.

29 October 2019, Flight 269

Flight was a complete survey of transects 113, 114, 115, and 116, partial survey of transects 117, 118, 119, and 120, and the coastal transect in Harrison Bay and east of Smith Bay. Survey conditions included clear, partly cloudy, and overcast skies, 2 km to unlimited visibility, with fog and glare, and Beaufort 0-3 sea states. Sea ice was 0-99% broken floe, new, and grease ice in the area surveyed. Sightings included bowhead whales (including eight calves), belugas (including one calf), one unidentified cetacean, bearded seals, 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
269	10/29/2019 11:52	70.981	146.402	beluga	swim	1	1	2
269	10/29/2019 11:52	70.983	146.420	beluga	swim	1	0	2
269	10/29/2019 11:55	71.095	146.406	beluga	swim	1	0	2
269	10/29/2019 12:10	71.214	146.898	beluga	swim	1	0	2
269	10/29/2019 12:16	70.999	146.840	beluga	swim	15	0	2
269	10/29/2019 12:16	70.994	146.824	beluga	swim	20	0	2
269	10/29/2019 12:58	70.626	147.342	bowhead whale	swim	2	1	1
269	10/29/2019 13:03	70.623	147.262	bowhead whale	swim	1	0	1
269	10/29/2019 13:10	70.711	147.372	bowhead whale	swim	2	1	1
269	10/29/2019 13:59	70.653	147.923	bowhead whale	mill	2	0	1
269	10/29/2019 14:11	70.496	147.826	bowhead whale	swim	1	0	1
269	10/29/2019 14:32	70.532	148.388	bowhead whale	rest	1	0	1
269	10/29/2019 14:39	70.697	148.404	unid cetacean	swim	1	0	1
269	10/29/2019 14:47	70.837	148.604	bowhead whale	swim	2	1	1
269	10/29/2019 14:53	70.741	148.893	bowhead whale	swim	1	0	1
269	10/29/2019 14:58	70.643	148.815	bowhead whale	swim	1	0	1
269	10/29/2019 15:00	70.659	148.715	bowhead whale	mill	2	1	1
269	10/29/2019 15:06	70.604	148.942	bowhead whale	swim	1	0	1
269	10/29/2019 15:09	70.596	148.920	bowhead whale	swim	1	0	1
269	10/29/2019 15:25	70.725	149.436	bowhead whale	rest	1	0	1
269	10/29/2019 15:27	70.758	149.337	bowhead whale	swim	1	0	1
269	10/29/2019 15:36	70.925	149.385	bowhead whale	swim	1	0	1
269	10/29/2019 15:38	70.943	149.271	bowhead whale	swim	2	1	1
269	10/29/2019 15:40	70.927	149.248	bowhead whale	swim	2	1	1
269	10/29/2019 15:40	70.925	149.251	bowhead whale	swim	2	1	1
269	10/29/2019 15:42	70.919	149.354	bowhead whale	swim	1	0	1
269	10/29/2019 15:51	71.041	149.891	bowhead whale	mill	2	1	1
269	10/29/2019 15:52	71.036	149.903	bowhead whale	swim	1	0	1

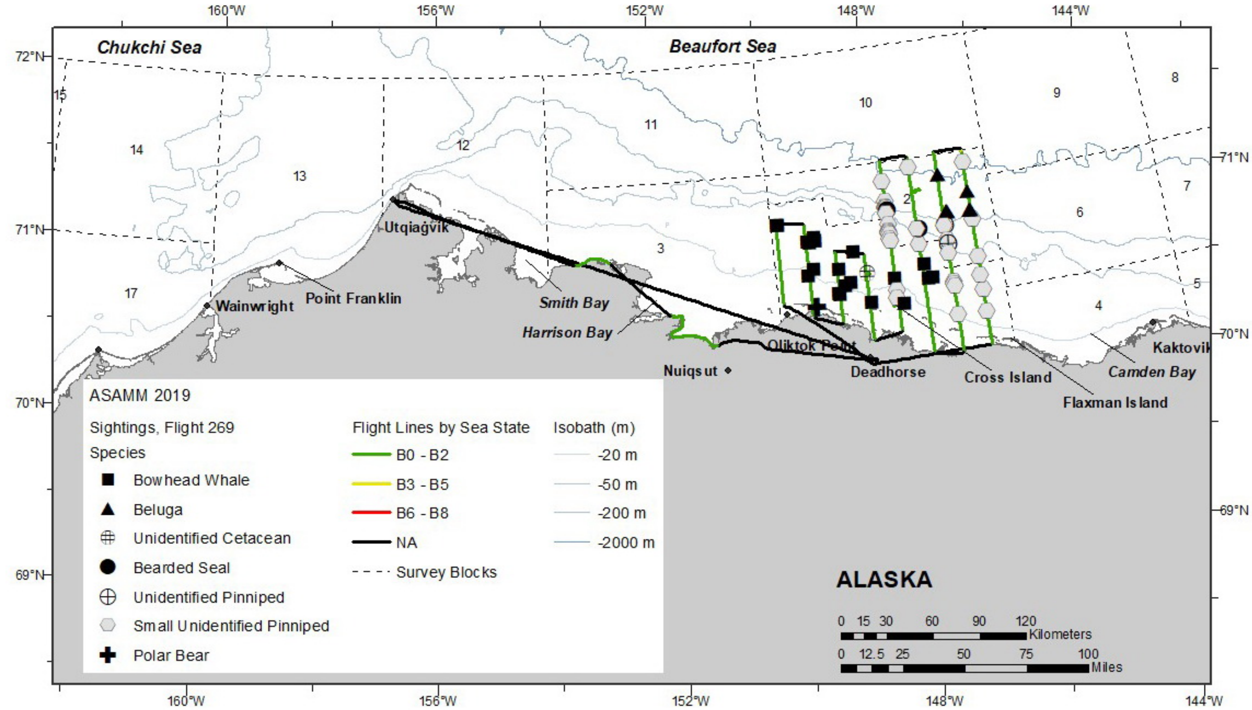
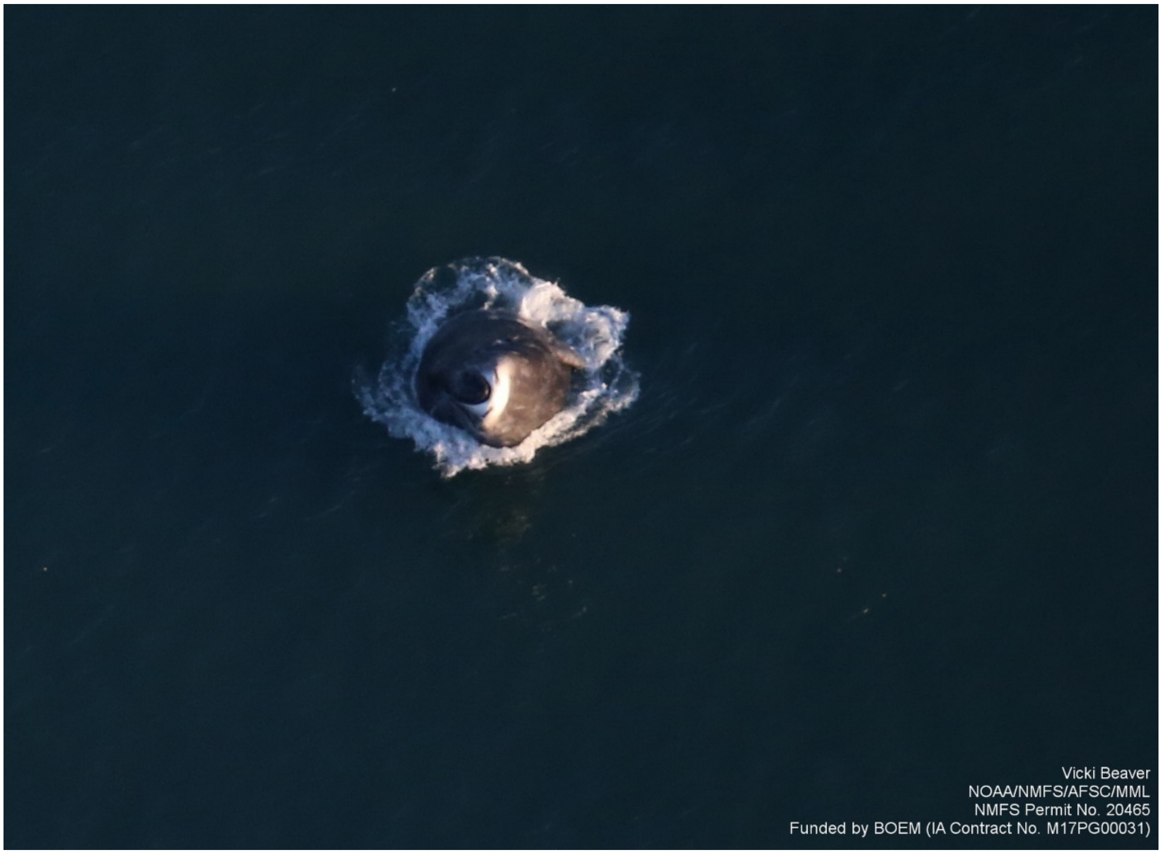


Figure B-131. Flight 269 survey track, depicted by sea state, and all marine mammal sightings, excluding carcasses.



This unique perspective is not often photographed – as a bowhead whale calf exits the water at the beginning of a breach, the tip of its rostrum and small white chin patch are clearly evident.

APPENDIX C: PUBLICATIONS, POSTERS, PRESENTATIONS AND MEDIA OUTREACH FROM ASAMM, SPRING 2019-SPRING 2020

List of Publications, Posters, and Presentations

Includes material published or produced since the 2018 ASAMM report.

2019

Brower, A.A., J.T. Clarke, A.L. Willoughby, and M.C. Ferguson. 2019. Changes in Gray Whale Foraging Occurrence in the Eastern Chukchi Sea, 2009-2018. Poster: World Marine Mammal Conference, Barcelona, Spain, December 2019.

Clarke, J., A. Brower, M. Ferguson, and A. Willoughby. 2019. Distribution and relative abundance of marine mammals in the eastern Chukchi and western Beaufort Seas, 2018. Annual report, OCS Study BOEM 2019-021. Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC, Seattle, WA 98115-6349.

Ferguson, M.C., J.T. Clarke, A.A. Brower, A.L. Willoughby. 2019. Where Were the Whales in the Chukchi Sea in 2019? A View from the Sky. Presentation: Alaska Eskimo Whaling Commission, Anchorage, AK, October 2019.

Ferguson, M.C., J.T. Clarke, A.A. Brower, A.L. Willoughby. 2019. Where Were the Whales in the Beaufort Sea in 2019? More Views from the Sky. Presentation: Alaska Eskimo Whaling Commission, Anchorage, AK, October 2019.

Givens, G.H., M.C. Ferguson, J.T. Clarke, A. Willoughby, A. Brower, and R. Suydam. 2019. Abundance of the Eastern Chukchi Sea stock of beluga whales, 2012-2017. SC/68a/ASI/09 presented at the International Whaling Commission Scientific Committee Meetings, Nairobi, Kenya, May 2019. 15 pp.

Willoughby, A.L., M.C. Ferguson, R. Stimmelmayr, J.T. Clarke, and A.A. Brower. 2019. Killer Whale Predation on Bowhead Whales in the Pacific Arctic – on the Rise? Poster: World Marine Mammal Conference, Barcelona, Spain, December 2019.

2020

Brower, A.A., A. Willoughby, J. Clarke, M. Ferguson, C. Accardo, L. Barry, S. Hanlan, and R. Hardee. 2020. Bowhead Whale Calf Nurseries in the Canadian Beaufort Sea, August 2019. Poster: Alaska Marine Science Symposium, Anchorage, AK, January, 2020.

Clarke, J.T., M. Ferguson, A. Brower, A. Willoughby, C. Accardo, L. Barry, L. Ganley, S. Hanlan, R. Hardee, R. Holt, K. Jackson, and N. Methany. 2020. The Summer of ABA. Poster: Alaska Marine Science Symposium, Anchorage, AK, January, 2020.

Clarke, J.T. 2020. ASAMM Whale Survey Update. Presentation: Preview of Ecological and Economic Conditions, May 2020. Virtual Workshop.

Ferguson, M.C. 2020. Bering-Chukchi-Beaufort Seas bowhead whale (Balaena mysticetus) abundance estimate from the 2019 aerial line-transect survey. Paper SC/68B/ASI/09 presented to the International Whaling Commission Scientific Committee, May 2020.

Ferguson, M.C. J.T. Clarke, A.A. Brower, and A.L. Willoughby. 2020. Aerial Surveys of Arctic Marine Mammals (ASAMM) Key Accomplishments. Presentation: Arctic Cetacean Listening Session, Utqiaġvik, AK, January 2020.

Stimmelmayr, R., J.C. George, J. Clarke, M. Ferguson, A. Willoughby, A. Brower, G. Sheffield, K. Stafford, G. Givens, A. Von Duyke, T. Sformo, B. Person, L. Sousa, and R. Suydam. 2020. 2018-2019 health report for the Bering-Chukchi-Beaufort Seas bowhead whales – preliminary findings. Paper SC/68b/ASW presented to the International Whaling Commission Scientific Committee, May 2020.

Willoughby, A.L., J. Clarke, A. Brower, M. Ferguson, L. Barry, R. Hardee, S. Hanlan, N. Methany, and H. Foley. 2020. A Yarn of Wayward Whales in the Eastern Chukchi and Eastern Beaufort Seas, 2019. Poster: Alaska Marine Science Symposium, Anchorage, AK, January, 2020.

Willoughby, A.L., R. Stimmelmayr, A.A. Brower, J.T. Clarke, and M.C. Ferguson. 2020. Bowhead whale carcasses in the eastern Chukchi and western Beaufort seas, 2009-2019. Paper presented to the International Whaling Commission Scientific Committee, May 2020.

Willoughby, A.L., R. Stimmelmayr, A.A. Brower, J.T. Clarke, and M.C. Ferguson. 2020. Gray whale carcasses in the eastern Chukchi Sea, 2009-2019. Paper SC/68B/ASW/02 presented to the International Whaling Commission Scientific Committee, May 2020.

Snapshots of ASAMM-related Media Outreach

Gray whale die off, bowhead whale population estimates are focus of annual NOAA survey

Gray whales feeding (Photo from NOAA)

By Grant Robinson | Posted: Fri 3:56 PM, Jul 26, 2019

ANCHORAGE (KTUU) - An annual survey of arctic marine mammals dating back four decades continues this summer with a focus on identifying the population size of bowhead whales and understanding the feeding behavior of gray whales.

The National Oceanic and Atmospheric Administration's Aerial Surveys of Arctic Marine Mammals project started in 1979 and has created a long-term data set for tracking changes of marine life in the Arctic.

For the first time in its history, the 2019 survey will expand into Canadian waters to determine a new abundance estimate of the Western Arctic population of bowhead whales.

Bowhead whales are an endangered species and are a staple of subsistence life for Alaska Native communities. The last abundance estimate of the species estimated the population at 16,820.

"If you compare that to the size at the end of commercial whaling which was in the mid 1900s, that population got down to about 1,000 or 3,000 animals," said Megan Ferguson, marine ecologist with NOAA. "So this population has really rebounded just over the course of the last 50 years or so."

Two groups of researchers will be stationed in the Arctic. Ferguson is with a group based in Deadhorse. Another group is based in Utqiagvik.

High Country News

FOR PEOPLE WHO CARE ABOUT THE WEST

Scientists struggle to find reasons behind gray whale deaths

Some researchers think the whales are starving, but the cause of death may be far more complicated.

Helen Santoro | NEWS | Aug. 15, 2019

Scientists are monitoring the lives of grey whales in the Chukchi Sea to determine if the deaths could be part of a larger trend as animals struggle to adapt to climate change.

Nicholas Metheny/NOAA/NMFS Permit No. 20465

On July 2, around a thousand feet above the Chukchi Sea, Megan Ferguson sat with two scientists in the back of a small propeller plane. Bounded on the east by Point Barrow, Alaska, and on the west by Wrangle Island, north of Russia, the Chukchi serves as the summer feeding ground for hundreds of gray whales. This year, a disconcerting number of them are not completing their journey north. Along the West Coast of Mexico, the United States and Canada, at least 193 dead animals have washed ashore — the most in two decades.

The plane cut through clouds and fog, curving around Alaska's northwestern coast as the research team searched for the 90,000-pound creatures. Through the overcast, a scientist at a side window spotted a gray whale. She opened the window, aimed her camera and photographed it, while Ferguson, a co-leader of an Alaska Fisheries Science Center research team,jotted down its location and behavior. By tracking the whales' numbers, physical condition and eating patterns over a four-month period, the team can compare them to those of other gray whales in different areas. Ideally, that will help them uncover what is happening to this species.

So far, the cause of the die-offs remains a mystery, though theories include starvation from lack of food, or a disease that mimics chronic wasting disease. Teams of scientists are investigating what the casualties mean for the gray whale population as a whole. But some also fear that the deaths could be part of a larger trend as

Something killed 121 gray whales this summer. Scientists are scrambling to find out what

Elizabeth Weise, USA TODAY Published 5:02 p.m. ET Sept. 18, 2019 | **Updated 7:23 p.m. ET Sept. 18, 2019**

Something killed 121 gray whales this spring and summer, and scientists are struggling to find out what it was.

The dead giants of the ocean washed up on West Coast beaches (https://usatoday.com/story/news/2019/05/16/whats-killing-grey-whales-they-swim-up-west-coast-alaska/3669039002/)as they finished their annual epic migration to their winter feeding grounds between Alaska and Russia. Many were emaciated and appeared to be starving.

The near-final death count, (https://fisheries.noaa.gov/national/marine-life-distress/2019-gray-whale-unusual-mortality-event-along-west-coast) tallied this week, makes this the second-worst year on record for gray whales, which were hunted almost to extinction in the late 1800s. It could represent as much as 10% of the species' total population.

"I wouldn't be surprised if our team comes across other carcasses," said Megan Ferguson, a fisheries biologist with the Cetacean Assessment and Ecology Program of the National Marine Fisheries Service.

She and her team are flying aerial surveys (https://www.fisheries.noaa.gov/science-blog/2019-aerial-surveys-arctic-marine-mammals-post-2) out of Deadhorse, Alaska, observing whales in their feeding grounds in the Bering and Chukchi seas.

"We're taking photographs of the gray whales to assess their body condition," she said.

Only once before – in 2000 – have scientists seen a larger number of these marine mammals die during their long migration. That year, 131 of the whales washed up on shores from California to Alaska.

Research teams are working to understand why so many have been found dead and what it means for the species as a whole.

"Your immediate tendency is to look at the food supply, because of the fact that so many are emaciated," said John Calambokidis, a cetacean expert with Cascadia Research in Olympia, Washington, a nonprofit organization that focuses on whale research. "But we don't know enough to be able to say what the cause is yet."

Whalers in Utqiaġvik can't remember hunting this late without landing a bowhead

By **Nathaniel Herz, Alaska's Energy Desk - Anchorage** - October 25, 2019

Three bowhead whales swim in the Beaufort Sea in July, 2019. (Photo by Kate Pagan / National Marine Fisheries Service)

Each fall, captains from Alaska's northernmost community, Utqiaġvik, drive their powerboats 10 to 20 miles offshore to hunt whales. And usually, by this point in the season, successful crews have towed dead bowheads back to town, divided up the meat and shared it with friends and family, who eat it through the winter until the whales return on their spring migration.

But this year, a month into the fall hunt in Utqiaġvik, the bowheads still haven't shown up.

0:00 / 3:49

Whaling crews have not landed a single one, which some residents say is unprecedented for a town that last fall captured nearly 20. And federal scientists say their airborne surveys have shown bowheads much farther offshore than their usual range.

Also unprecedented are this year's temperatures: It was the warmest May through September on record in Utqiaġvik, and there's never been less ice offshore in the combined Chukchi and Beaufort seas at this point in the year, according to Rick Thoman, a climatologist with the Alaska Center for Climate Assessment and Policy. And some in the village think the environmental changes are connected to the whales' behavior.

Rick Thoman
@AlaskaWx

Now the lowest #seaice extent of record so late in the autumn for the combined Beaufort & Chukchi Seas from @NSIDC data. Some ice now forming in protected areas on North Slope coast. Chukchi

HOURLY NEWS
LISTEN LIVE Play Live Radio
PLAYLIST

npr DONATE

Environment And Energy Collaborative

No Bowhead Sightings Yet For Alaskan Whalers. Some Blame Climate Change

October 29, 2019 · 12:00 PM ET

NATHANIEL HERZ

FROM ALASKA PUBLIC MEDIA

Utqiagvik whalers use many traditional tools, including the sealskin boat, or umiak, during the spring hunt.

Ravenna Koenig/Alaska's Energy Desk

inside climate news

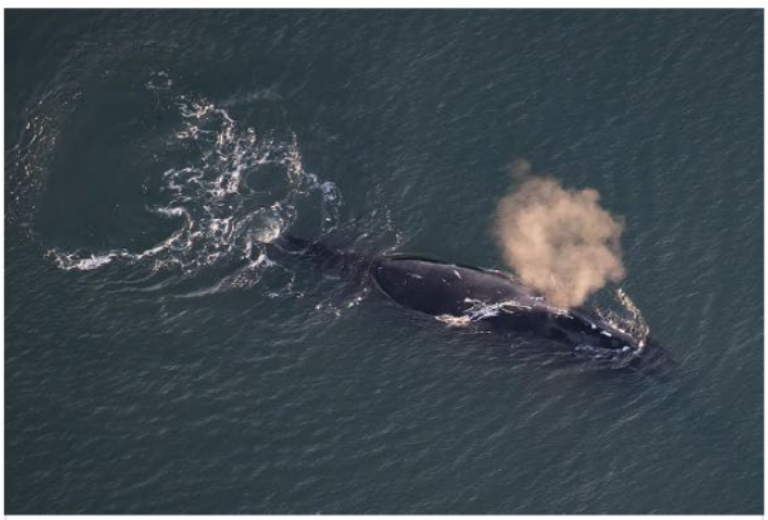
A Pulitzer Prize-winning, non-profit, non-partisan news organization dedicated to covering climate change, energy and the environment.

Alaska's Big Whale Mystery: Where Are the Bowheads?

As the Arctic struggles with climate extremes, the bowhead migration is two months late. If whales don't arrive soon, "we're going to go hungry," one hunter said.

BY SABRINA SHANKMAN Follow @shankman

NOV 1, 2019



A bowhead whale spotted by observers on Oct. 29, 2019. Normally, thousands of the whales would be moving along Alaska's northern coast in October, but that hasn't happened this year. Credit: Vicki Beaver/NOAA/NMFS/AFSC/MML via BOEM

In October, as the hours of daylight dwindle and the residents of Utqiagvik prepare for winter, the bowhead whales make their annual migration. Roughly 17,000 whales depart

ANCHORAGE DAILY NEWS

Rural Alaska

Utqiagvik whalers still hope to land a bowhead as season wanes

Author: **Shady Grove Oliver, Arctic Sounder** Updated: 15 hours ago Published 1 day ago

The iconic whale bone arch is photographed on Sept. 23, 2015, in Utqiagvik. (Erik Hill / ADN)

UTQIAGVIK -- The start of November has come and gone, and still, Utqiaġvik whalers have no bowheads to show for the season.

“Last year, I killed my whale on the 29th of October. That’s a week and a half ago. But, also, that was one of the last whales killed. So, we were done whaling by the 29th last year,” said captain Chucky Hopson. "I’ve never gone into November whaling and not one whale has been landed yet — not that I remember.”

The Arctic Sounder

Season nears end with no whales yet for Utqiagvik

November 9th, 2019 | **Shady Grove Oliver** print email

While Utqiagvik crews have seen some whales in the waters near town, they weren't able to land a single one. - *Qaiyaan Harcharek*

The start of November has come and gone and still, Utqiaġvik whalers have no bowheads to show for the season.

"Last year, I killed my whale on the 29th of October. That's a week and a half ago. But, also, that was one of the last whales killed. So, we were done whaling by the 29th last year," said Captain Chucky Hopson. "I've never gone into November whaling and not one whale has been landed yet — not that I remember."

The fall whaling season is a critical time for crews across the North Slope who rely on their catches to put away food for the winter.

Nuiqsut and Kaktovik whalers landed bowheads in late August and early September, which is typical for the area. The whales usually make their way over to Utqiaġvik next, with the strongest whaling happening in late September and early October.

But this year, September passed and October passed and while Utqiaġvik crews have seen some whales in the waters near town, they weren't able to land a single one.

"When we first started the season, we were going out every day in the dark. We'd take off in the dark and come home in the dark. In September, we were doing 14-hour days in the water, looking for whales. We weren't really spotting any. I mean, some people were, but we were chasing pretty much whales with no blows. We weren't seeing the blows at all," Hopson said. "We were seeing the whales once or twice."

Biologists track the annual patterns of the bowhead migration and have been doing so for four decades, through the Aerial Surveys of Arctic Marine Mammals program, or ASAMM.

"We have 40 years of perspective to look at this problem from," said biologist Megan Ferguson.

http://www.thearcticsounder.com/article/1945season_nears_end_with_no_whales_yet_for

The Arctic Sounder

No whales in sight as fall season nears end

November 15th 3:15 pm | **Shady Grove Oliver** print email

The sun is waning on the Utqiaġvik horizon. But still, some whaling captains and their crews are pushing through the final days of light in the hopes they'll be able to land a single bowhead for the community.

"(Next week) we're going to be at zero daylight; the sun's going to set and we're not going to see it again. At that point, it will just be too hard to try to continue hunting," said Little Whaler Captain Frederick Brower.

He's been going out on the water for weeks now, hoping for a catch and like all other whalers in town, has come up empty.

"The information that we received of the thousands of bowhead whales in eastern Canada kind of confirms that they're just not stopping where they traditionally stopped in Utqiaġvik and just bypassed us, which this season, is just beyond our reach," he said. "Even if we tried on a nice day, going 40 miles out there is getting into some heavy seas, 1,000 feet deep or more and the waves just get too big to do anything and become unsafe to try and tow a whale back in."

As the Sounder reported last week, scientists with the Aerial Surveys of Arctic Marine Mammals program, or ASAMM, have been tracking the annual migrations of the bowheads for decades. This year, their data showed the whales on track in July and August. But then, in September, something changed.

"We started off the season going where we typically would go at that time of year, which would be easterly — east of Utqiaġvik anywhere between 20 and 30 miles. Usually, the distance we try to go is how long it would take to tow a whale back so it doesn't spoil towing it in," said Brower.

Crews have about 12 hours to get the whale to shore before it begins to turn, as the inside of the carcass is still hot, but lacking blood flow. That means they can only go so far to look for whales if they want to bring them back in good shape.

The crews went out to the east, but didn't find any whales.

"Through that timeframe, we were getting reports from ASAMM," he said. "By then, there were still no whale sightings and it was determined that the whales that they were spotting through that aerial survey were still in the Camden Bay area, between Kaktovik and Prudhoe Bay. So, a lot of the whaling captains and the whalers were kind of going off of that data, but they're only seeing so many whales."

Megan Ferguson, a biologist with ASAMM, said while they were seeing some whales, their distribution wasn't in line with their normal migration patterns.

"In particular, September in the Beaufort Sea is one month and region where we have a snapshot of the bowhead whale distribution every single year since 1979," she said.

In areas where there would normally be a lot of bowheads, there were only a few. That left scientists and whalers wondering where they'd gone.

ANCHORAGE DAILY NEWS

Rural Alaska

Utqiagvik finally celebrates first successful bowhead hunt of season

Author: **Shady Grove Oliver, Arctic Sounder** Updated: November 20, 2019
Published November 20, 2019

A whaling crew heads out of Utqiagvik onto the sea ice toward open water to begin their bowhead whale hunt on April 17, 2016. (Marc Lester / ADN)

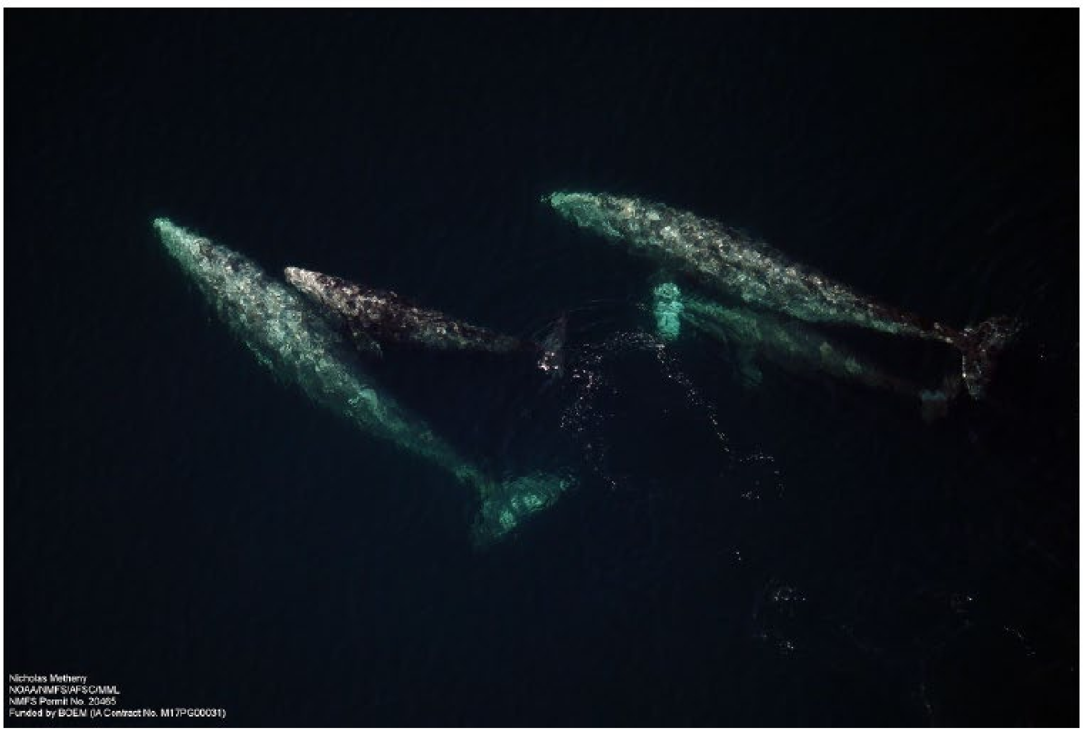
"Yay Hey Hey!" The cheer went up in town, on social media and out on the water Nov. 16 when Panigiuq Crew landed the first whale of the season for Utqiagvik, later than many people can remember ever bringing one in before.

NOAA FISHERIES

Investigation of West Coast Gray Whale Strandings Continues as Whales Head South for the Winter

January 21, 2020

Central California survey counts migrating whales for new population assessment.



Gray whales roam Arctic waters off Alaska in summer, searching for food. Credit: ASAMM/AFSC. Funded by BOEM IAA No. M11PG00033.

CALIFORNIA

As gray whale migration reaches its peak, scientists fear another unexplained die-off

A dead gray whale on Limantour Beach on May 23, 2019, in Point Reyes Station, Calif. Scientists fear a repeat of whale die-offs this year after the deaths of three of the creatures. (Justin Sullivan / Getty Images)

By SUSANNE RUST, ROSANNA XIA

JAN. 24, 2020 | 5 AM

CARMEL, Calif. — As California gray whales wind their way south along North America's Pacific coast — from their feeding grounds in the Arctic to their spring destination in the secluded lagoons of Mexico's Baja Peninsula — researchers from Alaska to Mexico are watching, worried about another year of unexplained die-offs.

So far, at least three whales have died on the southbound journey, according to a spokesman at the U.S. National Oceanic and Atmospheric Administration. And there are unconfirmed reports of strandings in Mexico.

https://www.latimes.com/california/story/2020-01-24/gray-whale-migration-deaths-california-alaska-oceans

Gray whales a little late in coming to Monterey Bay this year

Gray whale migration seems a little later this year

Gray whale migration typically peaks in the bay around mid-January, bit numbers are only now beginning to tick upwards now. (Monterey Bay Whale Watch / Gowhales.com)

By AMANDA HEIDT | newsroom@montereyherald.com |
PUBLISHED: January 30, 2020 at 2:37 p.m. | UPDATED: January 30, 2020 at 2:37 p.m.

https://www.montereyherald.com/2020/01/30/gray-whales-a-little-late-in-coming-to-monterey-bay-this-year/#:~:text=MONTEREY%20%E2%80%94%20The%20unusually%20slow%20trickle,now%20beginning%20to%20tick%20upward.

LIVING OCEANS

Scientists Count Gray Whales Following Unusual Spate of Deaths Last Spring

By Danielle Venton Feb 3

Gray whales feed in Arctic waters off Alaska in the summer and swim south in the winter to rear their young. *(ASAMM/AFSC)*

It's one of the great migrations on the planet. Each winter, gray whales swim south from the Arctic to Mexico to rear their calves before turning around in spring and heading north again.

Since the late 1800s, when commercial whaling declined, the giants have made a remarkable comeback, thanks to the Marine Mammal Protection Act and other regulations. Amid the rebound, however, scientists spotted a troubling spate of gray whale deaths last year, the most

NOAA FISHERIES

2019 Aerial Surveys of Arctic Marine Mammals - Post 1

July 15, 2019

Each year we conduct aerial surveys of the northern and western coasts of Alaska, in the Beaufort and Chukchi seas.

)ne of ASAMM's survey aircraft takes to the skies!

Velcome to the 41st consecutive field season for the Aerial Surveys of Arctic Marine Mammals ASAMM) project! Every year since 1979, ASAMM has conducted line-transect aerial surveys ff the northern and western coasts of Alaska, in the Beaufort and Chukchi seas. A long-term lataset like this is extraordinary because it is both rare and ecologically invaluable. Exact survey dates and boundaries have varied over time, but the study goals, general survey area, and survey methods have remained remarkably similar. This year is particularly noteworthy because ASAMM will be extending its range to include Canadian waters in the eastern Beaufort Sea and Amundsen Gulf during August to collect data for a new estimate of the abundance of

NOAA FISHERIES

2019 Aerial Surveys of Arctic Marine Mammals - Post 2

July 15, 2019

Each year we conduct aerial surveys of the northern and western coasts of Alaska, in the Beaufort and Chukchi seas.

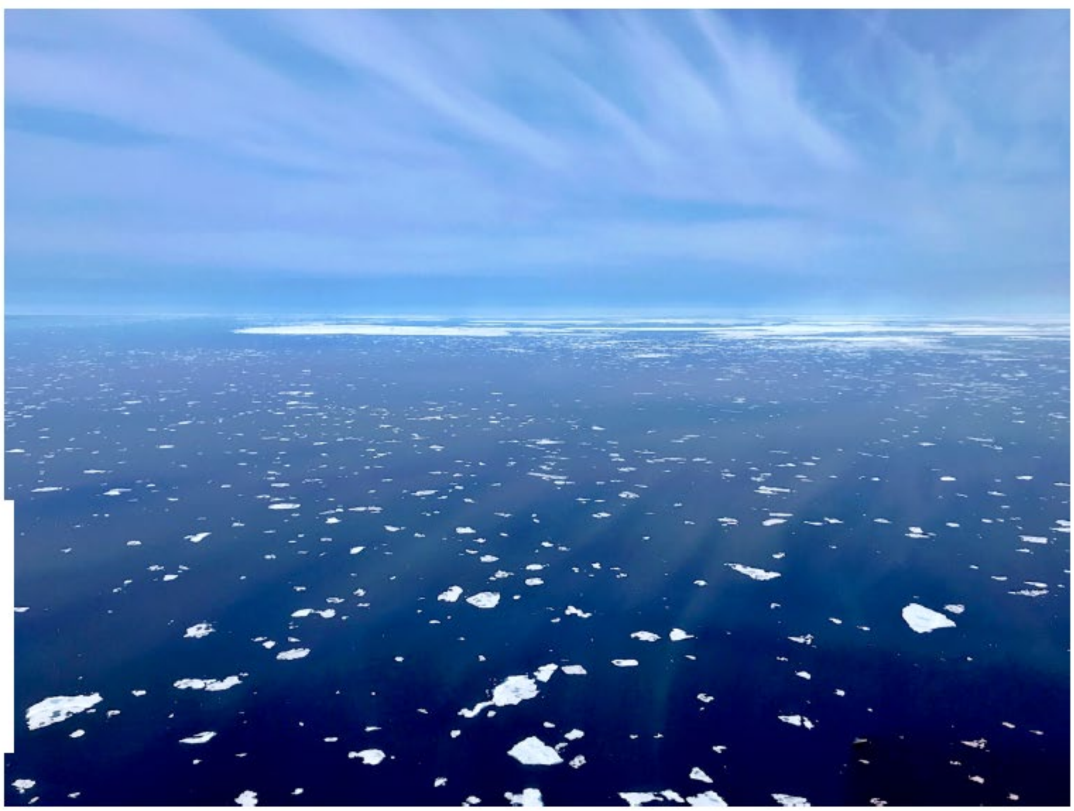
This photo, taken in 2016, is of a mother and calf gray whale. The mother at top, with an open mouth.

NOAA FISHERIES

2019 Aerial Surveys of Arctic Marine Mammals - Post 3

July 23, 2019

Each year we conduct aerial surveys of the northern and western coasts of Alaska, in the Beaufort and Chukchi seas.



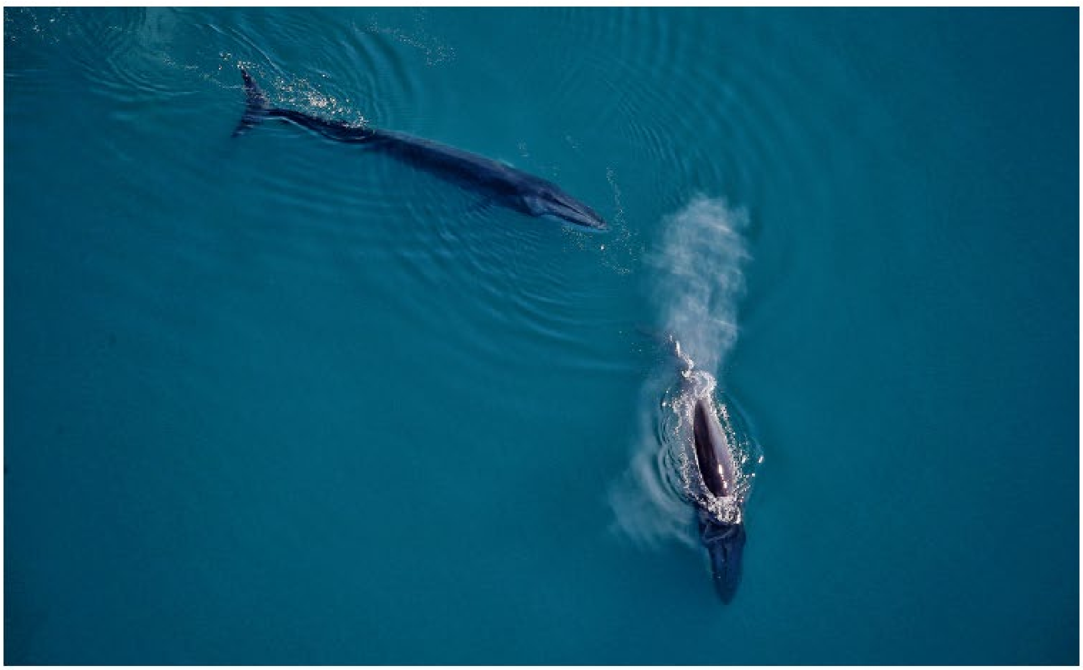
On this particular day in mid-July, we had very calm seas and mostly sunny skies: a recipe for near perfect sighting conditions.

NOAA FISHERIES

2019 Aerial Surveys of Arctic Marine Mammals - Post 4

August 02, 2019

Each year we conduct aerial surveys of the northern and western coasts of Alaska, in the Beaufort and Chukchi seas.



These fin whales were sighted in early July 2019, in the southern Chukchi Sea region of our survey area. Notice the white chin and jawline on the right side of the head. A fin whale exhibits an asymmetrical head coloration; the left side is dark, while the right side is light.

The Utqiaġvik-based aerial team is continuing their surveys in the eastern Chukchi Sea. On a survey in late July, the team saw a subarctic whale species farther north in the Pacific Arctic

NOAA FISHERIES

2019 Aerial Surveys of Arctic Marine Mammals - Post 5

September 10, 2019

A tale of wayward whales.

The tundra flashing its amazing cape of autumn colors.

For three weeks in August this year, our Aerial Surveys of Arctic Marine Mammals teams did something a little different. This year we were tasked to come up with an abundance estimate

2019 Aerial Surveys of Arctic Marine Mammals - Post 6

October 11, 2019

How many bowhead whales are in the Bering-Chukchi-Beaufort (BCB) stock? This year the ASAMM team got the very special chance to help answer this question!

A Bering-Chukchi-Beaufort Bowhead whale surfaces for air.

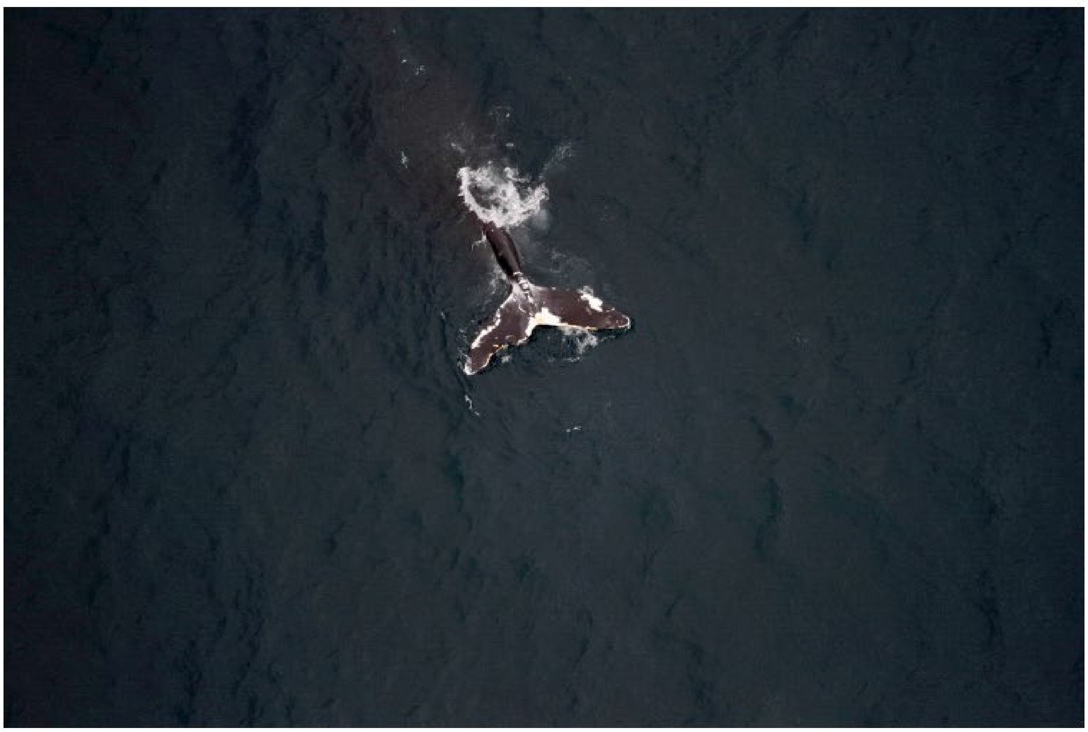
The International Whaling Commission (IWC) requires a population abundance estimate to be submitted for the BCB bowhead whale stock every 10 years. In years past, the scientific and

NOAA FISHERIES

2019 Aerial Surveys of Arctic Marine Mammals - Post 7

October 25, 2019

Aerial surveys for whales offer a vastly different view compared to boat-based surveys.



The peduncle and flukes of this bowhead whale depict scars of at least one previous entanglement in fishing or crabbing gear. This whale was photographed by ASAMM in 2016, and images from 2016 were matched (with very high confidence) to images of the same whale from 1985; the entanglement scars were already evident in 1985. From these photos we have learned that (1) this whale was entangled in fishing gear (likely commercial, because commercial fishing and crabbing are most common in the overlapping geographical

NOAA FISHERIES

2019 Aerial Surveys of Arctic Marine Mammals - Post 8

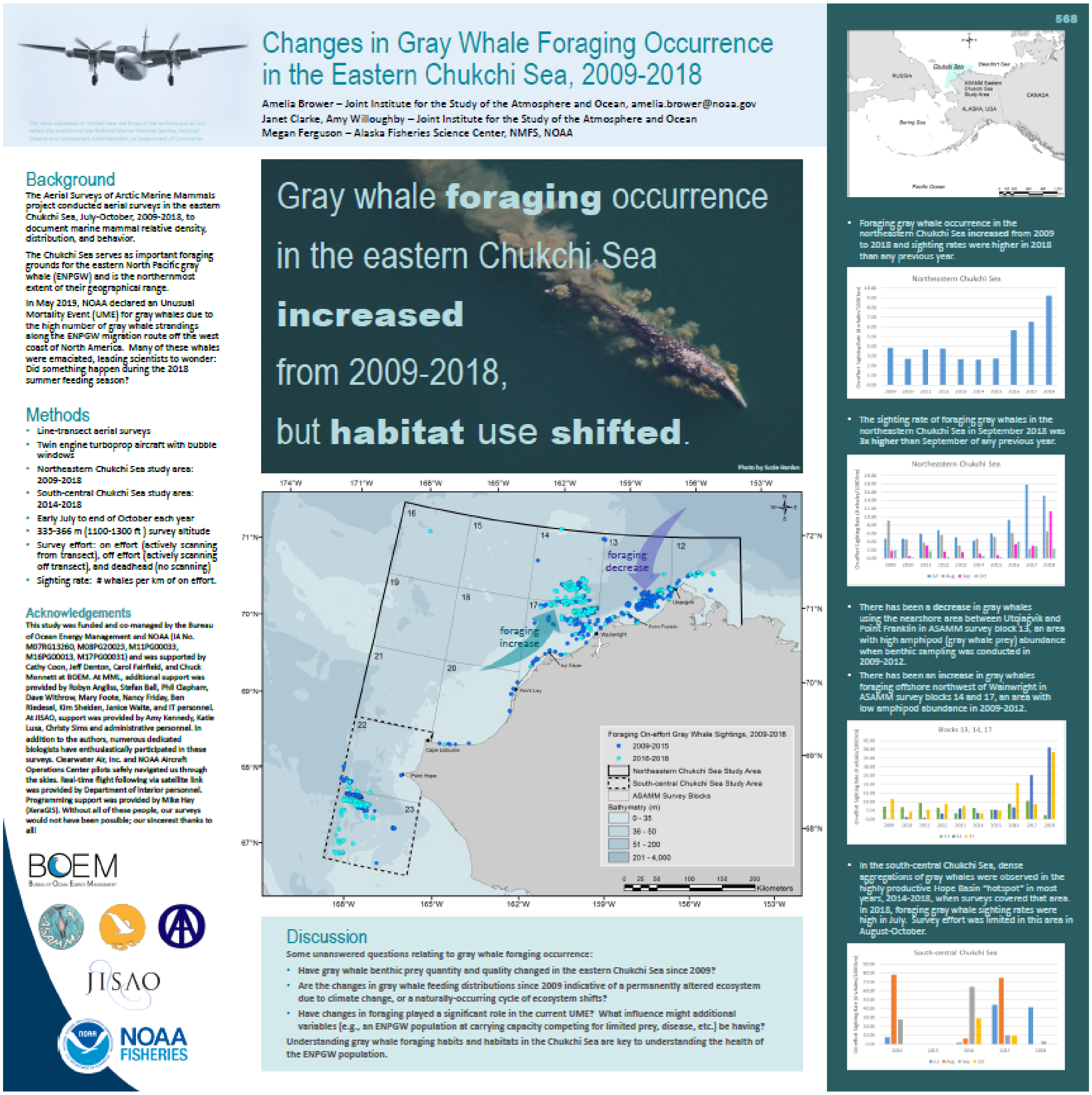
November 07, 2019

Beautiful Beaufort Polar Bears

Six polar bears wallowing in the sand.

The main focus of the Aerial Surveys of Arctic Marine Mammals (ASAMM) project may be bowhead whales, but the "MM" (Marine Mammal) part of the project name is also taken very seriously. This season is a good example of why we record sightings of all marine mammals and compare them to previous years. Bears, bears, and more bears! More specifically, polar bears!

ASAMM Poster Presentations



Killer whale predation on bowhead whales in the Pacific Arctic – on the rise?

Amy Willoughby - Joint Institute for the Study of the Atmosphere and Ocean, amy.willoughby@noaa.gov
Megan Ferguson - Alaska Fisheries Science Center, NMFS, NOAA
Raphaela Stimmelmayr - Department of Wildlife Management, North Slope Borough
Janet Clarke and **Amelia Brower** - Joint Institute for the Study of the Atmosphere and Ocean

Introduction

Imagery and sighting data on bowhead whale (*Balaena mysticetus*) carcasses from a decade (2009–2018) of aerial surveys in the eastern Chukchi and western Beaufort seas were investigated to determine cause of death. The Aerial Surveys of Arctic Marine Mammals (ASAMM) project provides information on distribution, behavior, and relative density of marine mammals, including bowhead whales and their only natural predator, killer whales (*Orcinus orca*). Conducted annually, July–October, these surveys offer consistent information on floating and beach-cast bowhead whale carcasses.

Methods

- Line-transect aerial surveys flown in De Havilland Twin Otters and Turbo Commanders at 305–457 m survey altitudes
- Canon EOS 7D or 1DX DSLR camera, Canon 100–400 m lens
- Bowhead whale carcass sighting rates were calculated using sightings during all survey modes (on effort) except deadhead, when no sighting or environmental data are recorded.
- Carcass imagery was evaluated by the North Slope Borough's (NSB) wildlife veterinarian and senior wildlife biologist. Cause of death were categorized in four ways:

1. **Mortal injuries consistent with killer whale predation** when imagery contained visual evidence such as large semi-circular tissue defects to the head, body, and appendages; evisceration of abdomen; skin and blubber peeled away from body (flensed); tongue missing or damaged; tissue fraying around mouth, on pectoral flippers, or flukes; or fresh rake marks.
2. **Suspect killer whale predation** when an injury was typical of that from killer whales, but evidence was insufficient to definitively assign killer whale predation.
3. **Aboriginal subsistence hunting** based on timing of hunting activity, proximity to a whale reported as struck with harvest equipment but not retained (a "struck and lost" whale), image review, or physical examination of the carcass.
4. **Could not be determined** when the carcass was either too decomposed, lacked visible external injuries, lacked injuries sufficient for positively determining cause of death, or poor image quality.

Acknowledgements

Funding for, and co-management of the ASAMM project were provided by the Bureau of Ocean Energy Management Alaska Region under an Interagency Agreements M07RG13260, M11PG00033, M16PG00013, and M17PG00031 with the Alaska Fisheries Science Center, and supported by Cathy Coon, Jeffrey Denton, Carol Fairfield, and Chuck Monnett (CORs). At the Marine Mammal Laboratory, additional support was provided by Robyn Angliss, Phillip Clapham, Mary Foote, Nancy Friday, Ben Hou, Stuart Pascua, Monte Pascual, Kim Shelden, Janice Waite, and Rebecca White. At JISAO, support was provided by Amy Kennedy, Katie Luxa, Christy Sims, and administrative personnel. At NSB, thank you to Craig George for his assistance reviewing bowhead whale images. We give additional gratitude to the field biologists who collected these data; NOAA Aircraft Operations Center and Clearwater Air, Inc., pilots and mechanics for keeping ASAMM airborne; the Bureau of Land Management and Aviation Management Division (DOI) for real-time flight following; and Mike Hay (Xera GIS) for providing our programing support.

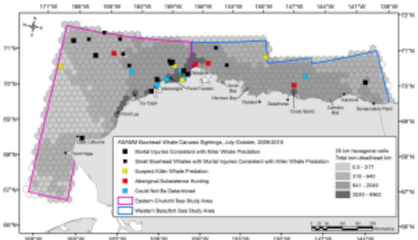


Figure 1. ASAMM bowhead whale carcass sightings by likely cause of death, 2009–2018.

- 33 bowhead carcasses were documented in July–October, 2009–2018.
- Cause of death was determined for 22 (66.6%) carcasses.
- 18 carcasses had injuries consistent with killer whale predation.
  - four per year in 2016 and 2018,
  - three in 2013 (including one calf/yearling),
  - two per year in 2012 and 2015 (including one calf/yearling) and,
  - one per year in 2010 and 2017 (a calf/yearling).
- Four carcasses, two in 2015 and one each in 2013 and 2018, were likely whales struck and lost during aboriginal subsistence hunting.

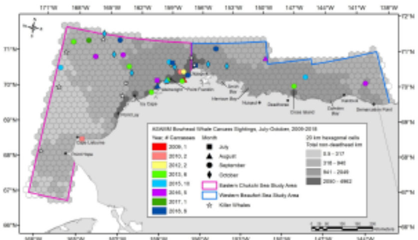


Figure 2. ASAMM study areas, total non-deadhead survey effort, and bowhead whale carcass and killer whale sightings, by month and year.

- Highest number of carcasses was observed in 2015, followed by 2013 and 2018, and 2016.
- More bowhead carcass sightings in the eastern Chukchi Sea study area compared to the western Beaufort Sea study area, cannot be accounted for by differences in survey effort between the two.
- In both study areas, more carcass sightings occurred in September than in other survey months.

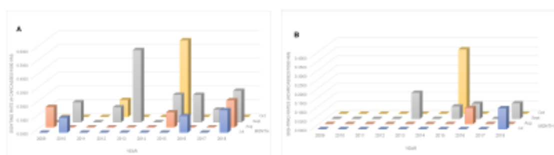


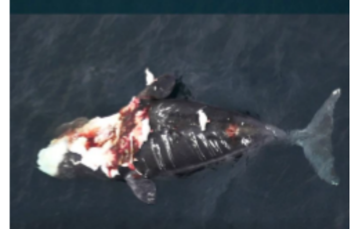
Figure 3. Bowhead Whale Carcass Sighting Rate: # carcasses per 1000 km flown on effort, by month and year. A) Sighting rates of bowhead whale carcasses in the eastern Chukchi Sea study area. B) Sighting rates of bowhead whale carcasses in the western Beaufort Sea study area.

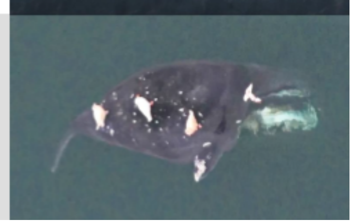
- When survey areas and years are combined, September had the most survey effort and highest carcass sighting rate.
- The maximum monthly sighting rate in any given year and region occurred in October 2015 in both the eastern Chukchi Sea and western Beaufort Sea study areas.

Conclusion

- Prior to 2012, no killer whales were sighted within the study area during aerial surveys conducted as far back as the 1980s.
- Killer whale annual occurrence is highly variable and killer whale sightings are rare during ASAMM surveys.
- Sea ice reduction during summer and fall may allow killer whales to hunt in previously inaccessible areas.
- More carcasses in the eastern Chukchi Sea study area may be due to killer whales frequenting the eastern Chukchi Sea more often than the western Beaufort Sea.
- Continued monitoring and documentation of bowhead whale mortality, including killer whale predation, is needed for assessing the status of the Bering-Chukchi-Beaufort bowhead whale stock and the ecological impacts of a changing Arctic.

New and robust evidence of killer whale predation on bowhead whales in the Pacific Arctic.





Bowhead Whale Calf Nurseries in the Canadian Beaufort Sea, August 2019

Amelia Brower[1,3], Amy Willoughby[2,3], Janet Clarke[2,3], Megan Ferguson[3], Corey Accardo[4], Lisa Barry[4], Suzie Hanlan[4], Rachel Hardee[4]

1 Joint Institute for the Study of the Atmosphere and Ocean/UW, NOAA Fisheries, amelia.brower@noaa.gov
2 Joint Institute for the Study of the Atmosphere and Ocean/UW, NOAA Fisheries
3 Alaska Fisheries Science Center/NOAA Fisheries
4 Ocean Associates, Inc.

NOAA FISHERIES

INTRODUCTION

- New and unique aerial survey!
- Designed to estimate the population abundance of the Western Arctic stock of bowhead whales (*Balaena mysticetus*).
- Alaskan & Canadian Beaufort seas & Amundsen Gulf.
- Aerial Surveys of Arctic Marine Mammals (ASAMM) project and the new survey, ASAMM Bowhead Abundance (ABA).

METHODS

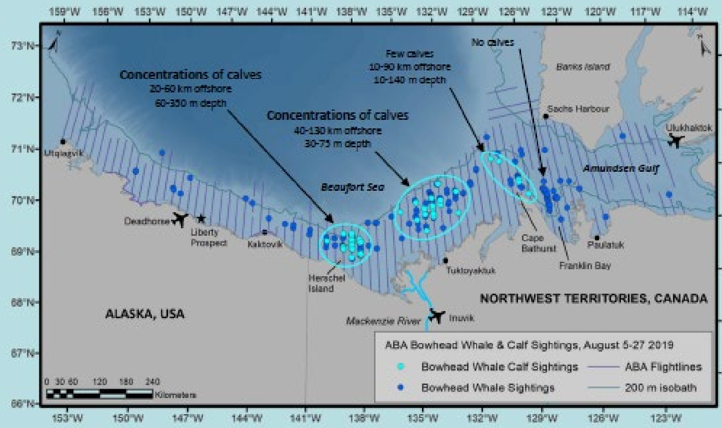
- Line-transect aerial survey
- 5-27 August 2019
- 2 Turbo Commander and 1 Twin Otter aircraft with bubble windows
- Survey effort:
  - on effort (actively scanning from transect)
  - off effort (actively scanning off transect)
  - deadhead (no scanning)

Acknowledgements

This study was a joint endeavor with BOEM, NOAA, the North Slope Borough, Department of Fisheries and Oceans Canada, Fisheries Joint Management Committee Canada, and Inuvialuit Game Council. Funding and co-management came from BOEM and NOAA (IA No. M17PG00031). At BOEM, Cathy Coon and Richard Raymond supported the project. At AFSC, additional support was provided by Robyn Angliss, Phil Clapham, Mary Foote, Nancy Friday, Kim Shelden, Janice Waite, and IT personnel. At JISAO, support was provided by Katie Luua, Colleen Marquist, Christy Sims, and administrative personnel. Aircraft support was provided by Clearwater Air, Inc. (Contract No. 01SPC00102) Director of Operations Andy Harcombe, pilots Jake Creglow and Jake Turner, and mechanic Chris Creglow; and Kenn Borek Air Ltd. (Contract No. 140D0819C0004) Client Services Manager Joel Conrad, pilots Chantelle Calloway, Alex de Boer, and Mark Vanonen, and mechanics William Allen and Andre Martineau who all collaborated to safely navigate us through the skies. Real-time flight following via satellite link was provided by Department of Interior and Kenn Borek Air personnel. Programming support was provided by Mike Hay (XeraGIS). Without all of these people, our surveys would not have been possible; our sincerest thanks to all!

JISAO BOEM xeragis Fisheries and Oceans Canada FJMC

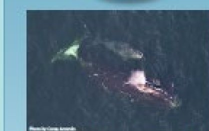
Bowhead whale calf occurrence in the **Canadian Beaufort Sea** in 2019 was concentrated in **two nurseries**.



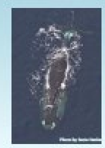
Calves were sighted with cows, by themselves without an adult, and in groups of one cow with two calves or multiple cows and calves together.

The high concentration of calves relative to other areas surveyed suggests these areas served as nurseries.

317 bowhead whales on effort; of these, 54 (17%) were calves.



Four cows that had calves with them were large individuals with white on their flukes and peduncles, suggesting they were older individuals.



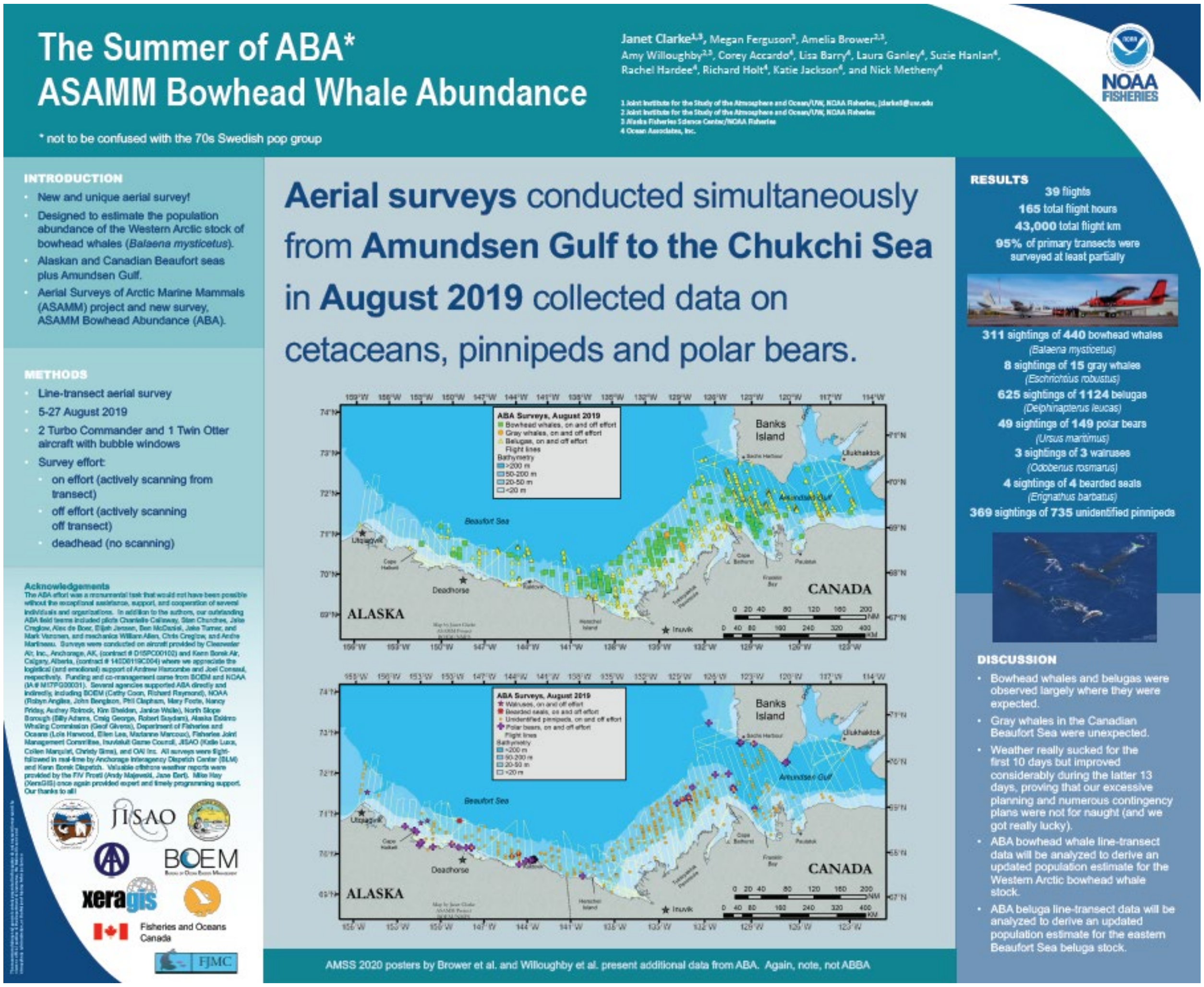
One cow with mud on head, suggesting she had been feeding at the ocean floor.

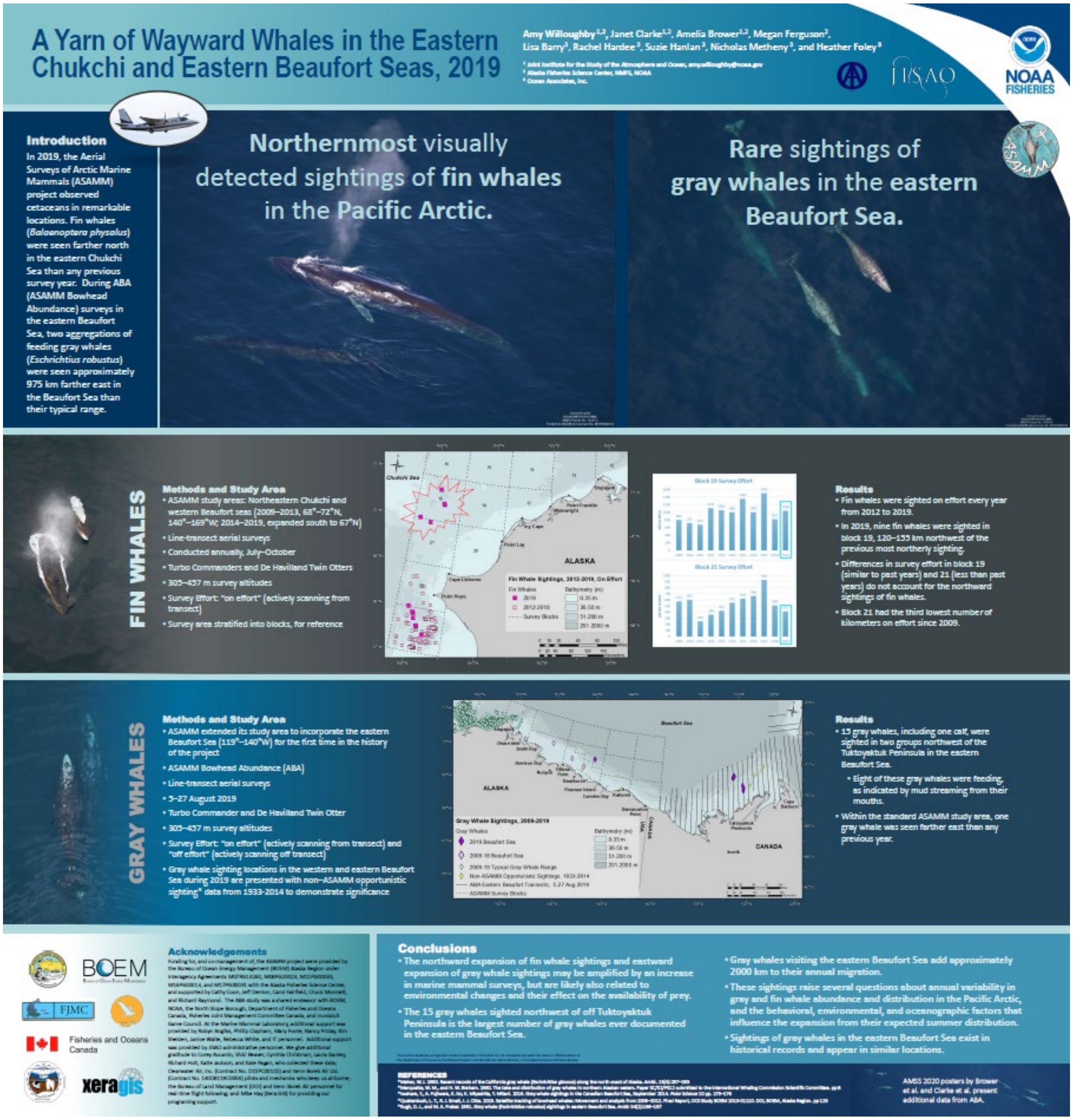
DISCUSSION

Bowhead whales migrate each spring to feed in the Canadian Beaufort Sea, primarily from the Mackenzie River Plume to near Cape Bathurst. The two nurseries were located in these prime bowhead whale foraging areas.

During aerial surveys conducted in the 1980s and 2007-2009, bowhead whale cow-calf pairs were also sighted on the shelf near Herschel Island and Tuktoyaktuk. Franklin Bay and Amundsen Gulf lacked calf sightings during all survey periods.

AMSS 2020 posters by Brower et al. and Clarke et al. present additional data from ABA.


The Summer of ABA*
ASAMM Bowhead Whale Abundance
* not to be confused with the 70s Swedish pop group
Janet Clarke[1,3], Megan Ferguson[3], Amelia Brower[2,3], Amy Willoughby[2,3], Corey Accardo[4], Lisa Barry[4], Laura Ganley[4], Suzie Hanlan[4], Rachel Hardee[4], Richard Holt[4], Katie Jackson[4], and Nick Metheny[4]
NOAA FISHERIES
INTRODUCTION
New and unique aerial survey!
Designed to estimate the population abundance of the Western Arctic stock of bowhead whales (Balaena mysticetus).
Alaskan and Canadian Beaufort seas plus Amundsen Gulf.
Aerial Surveys of Arctic Marine Mammals (ASAMM) project and new survey, ASAMM Bowhead Abundance (ABA).
METHODS
Line-transect aerial survey
5-27 August 2019
2 Turbo Commander and 1 Twin Otter aircraft with bubble windows
Survey effort:
on effort (actively scanning from transect)
off effort (actively scanning off transect)
deadhead (no scanning)
Acknowledgements
JISAO
BOEM
Fisheries and Oceans Canada
FJMC
Aerial surveys conducted simultaneously from Amundsen Gulf to the Chukchi Sea in August 2019 collected data on cetaceans, pinnipeds and polar bears.
ABA Surveys, August 2019
Bowhead whales, on and off effort
Gray whales, on and off effort
Belugas, on and off effort
Flight lines
Bathymetry
Banks Island
Beaufort Sea
Amundsen Gulf
CANADA
ALASKA
Deadhorse
Inuvik
Ulukhaktok
Walruses, on and off effort
Bearded seals, on and off effort
Unidentified pinnipeds, on and off effort
Polar bears, on and off effort
RESULTS
39 flights
165 total flight hours
43,000 total flight km
95% of primary transects were surveyed at least partially
311 sightings of 440 bowhead whales (Balaena mysticetus)
8 sightings of 15 gray whales (Eschrichtius robustus)
625 sightings of 1124 belugas (Delphinapterus leucas)
49 sightings of 149 polar bears (Ursus maritimus)
3 sightings of 3 walruses (Odobenus rosmarus)
4 sightings of 4 bearded seals (Erignathus barbatus)
369 sightings of 735 unidentified pinnipeds
DISCUSSION
Bowhead whales and belugas were observed largely where they were expected.
Gray whales in the Canadian Beaufort Sea were unexpected.
Weather really sucked for the first 10 days but improved considerably during the latter 13 days, proving that our excessive planning and numerous contingency plans were not for naught (and we got really lucky).
ABA bowhead whale line-transect data will be analyzed to derive an updated population estimate for the Western Arctic bowhead whale stock.
ABA beluga line-transect data will be analyzed to derive an updated population estimate for the eastern Beaufort Sea beluga stock.
AMSS 2020 posters by Brower et al. and Willoughby et al. present additional data from ABA. Again, note, not ABBA


A Yarn of Wayward Whales in the Eastern Chukchi and Eastern Beaufort Seas, 2019
Amy Willoughby[1,2], Janet Clarke[1,2], Amelia Brower[1,2], Megan Ferguson[2], Lisa Barry[3], Rachel Hardee[3], Suzie Hanlan[3], Nicholas Metheny[3], and Heather Foley[3]
NOAA FISHERIES
Introduction
In 2019, the Aerial Surveys of Arctic Marine Mammals (ASAMM) project observed cetaceans in remarkable locations. Fin whales (Balaenoptera physalus) were seen farther north in the eastern Chukchi Sea than any previous survey year. During ABA (ASAMM Bowhead Abundance) surveys in the eastern Beaufort Sea, two aggregations of feeding gray whales (Eschrichtius robustus) were seen approximately 975 km farther east in the Beaufort Sea than their typical range.
Northernmost visually detected sightings of fin whales in the Pacific Arctic.
Rare sightings of gray whales in the eastern Beaufort Sea.
FIN WHALES
Methods and Study Area
• ASAMM study areas: Northeastern Chukchi and western Beaufort seas (2009–2013, 68°–72°N, 140°–169°W; 2014–2019, expanded south to 67°N)
• Line-transect aerial surveys
• Conducted annually, July–October
• Turbo Commanders and De Havilland Twin Otters
• 305–457 m survey altitudes
• Survey Effort: "on effort" (actively scanning from transect)
• Survey area stratified into blocks, for reference
Chukchi Sea
ALASKA
Fin Whale Sightings, 2012-2019, On Effort
Block 19 Survey Effort
Block 21 Survey Effort
Results
• Fin whales were sighted on effort every year from 2012 to 2019.
• In 2019, nine fin whales were sighted in block 19, 120–155 km northwest of the previous most northerly sighting.
• Differences in survey effort in block 19 (similar to past years) and 21 (less than past years) do not account for the northward sightings of fin whales.
• Block 21 had the third lowest number of kilometers on effort since 2009.
GRAY WHALES
Methods and Study Area
• ASAMM extended its study area to incorporate the eastern Beaufort Sea (119°–140°W) for the first time in the history of the project
• ASAMM Bowhead Abundance (ABA)
• Line-transect aerial surveys
• 5–27 August 2019
• Turbo Commander and De Havilland Twin Otter
• 305–457 m survey altitudes
• Survey Effort: "on effort" (actively scanning from transect) and "off effort" (actively scanning off transect)
• Gray whale sighting locations in the western and eastern Beaufort Sea during 2019 are presented with non–ASAMM opportunistic sighting* data from 1933-2014 to demonstrate significance
Beaufort Sea
ALASKA
CANADA
Gray Whale Sightings, 2009-2019
Results
• 15 gray whales, including one calf, were sighted in two groups northwest of the Tuktoyaktuk Peninsula in the eastern Beaufort Sea.
• Eight of these gray whales were feeding, as indicated by mud streaming from their mouths.
• Within the standard ASAMM study area, one gray whale was seen farther east than any previous year.
BOEM
FJMC
Fisheries and Oceans Canada
xeragis
Acknowledgements
Conclusions
• The northward expansion of fin whale sightings and eastward expansion of gray whale sightings may be amplified by an increase in marine mammal surveys, but are likely also related to environmental changes and their effect on the availability of prey.
• The 15 gray whales sighted northwest of off Tuktoyaktuk Peninsula is the largest number of gray whales ever documented in the eastern Beaufort Sea.
• Gray whales visiting the eastern Beaufort Sea add approximately 2000 km to their annual migration.
• These sightings raise several questions about annual variability in gray and fin whale abundance and distribution in the Pacific Arctic, and the behavioral, environmental, and oceanographic factors that influence the expansion from their expected summer distribution.
• Sightings of gray whales in the eastern Beaufort Sea exist in historical records and appear in similar locations.
REFERENCES
AMSS 2020 posters by Brower et al. and Clarke et al. present additional data from ABA.

APPENDIX D: CETACEAN AGGREGATION PROTOCOLS (CAPS)

Cetacean Aggregation Protocols (CAPs)

Adapted from Version 21, 15 August 2019

Background

During all ASAMM surveys, when surveying aggregations of large cetaceans (bowhead, gray, humpback, fin, and minke whales), 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 species 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.***

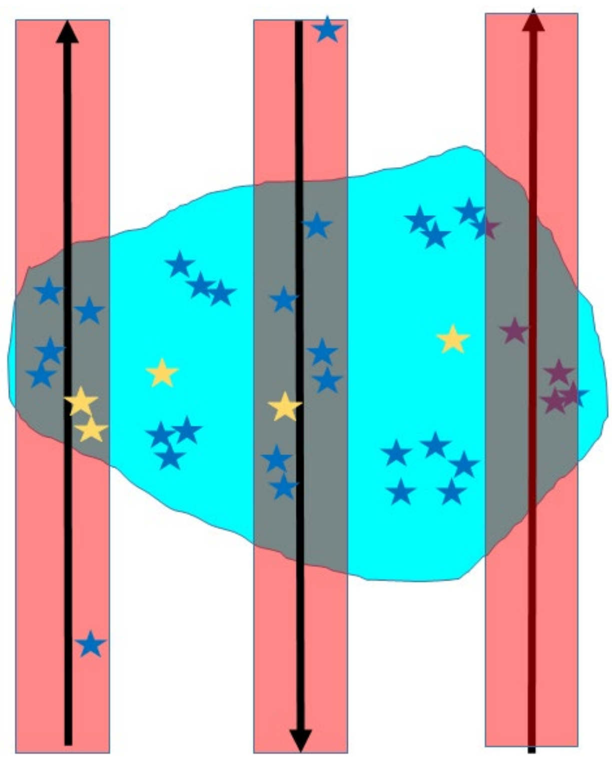


Figure D-1. A cetacean sighting comprises all whales within 5 body lengths of each other. The final group size estimate for a sighting can be updated to incorporate additional animals detected near the initial detection (e.g., within ~ 5 body lengths of the cetaceans that were initially sighted). An 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 sightings on circling:

- Sightings on circling are low priority and should not compromise the team's ability to accurately record sightings on transect. For example, it might be a good idea to not enter sightings 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 sightings on transect.
- Do not enter any sightings on circling that are located on fresh transect and have a chance of being sighted from transect.
- Sightings on circling located inside the circle can be recorded.
- Sightings 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 sightings 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 sighting 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.

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)

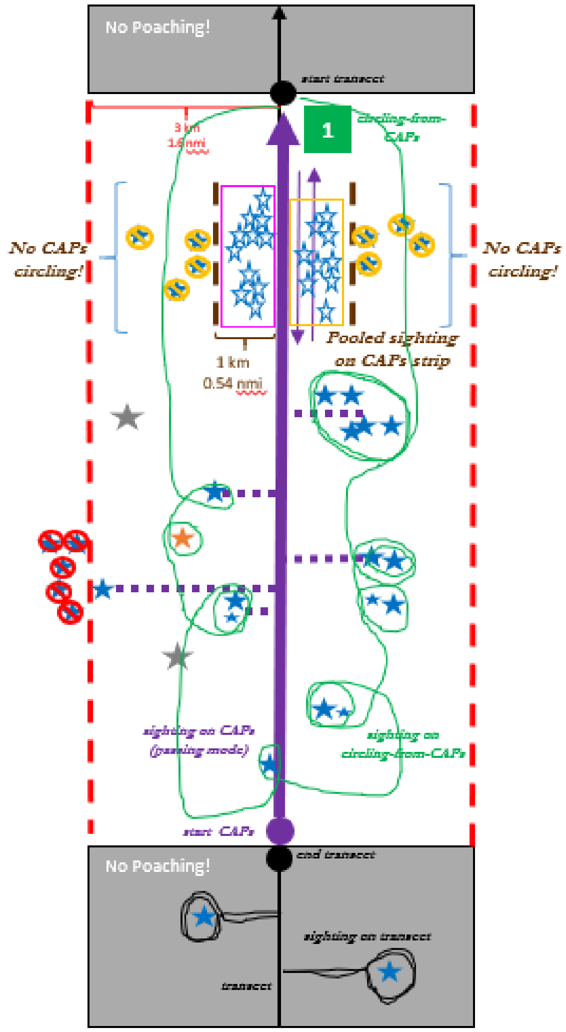


Figure D-2. Black: transect and circling-from-transect, surveyed using standard ASAMM protocols, from bottom to top of figure. Purple: CAPs passing mode effort (solid line) and perpendicular distances to sightings (dotted lines). Magenta and yellow boxes: CAPs strip effort in extremely high-density area, 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.

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.

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 sightings 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

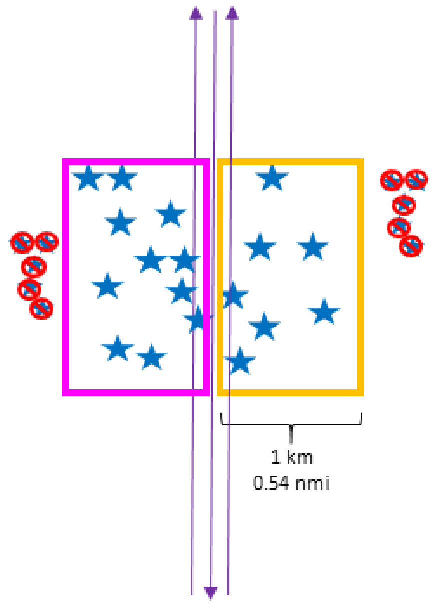


Figure D-3. Schematic of CAPs strip mode. During CAPs passing mode, if sighting density precludes the ability to enter a new sighting record for each sighting, survey the high-density area using strip-transect methods. Make three passes through the area (depicted by adjacent purple arrows but actually 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.

sighting on search, mop up the relevant sightings 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 of the original effort and sightings on transect located perpendicular to the CAPs segment should be identified and changed to deadhead events (see example in Figure D-4). The data recorder can make a note saying where transect effort should end and deadhead effort should begin so that the data editor can make the necessary edits during post-flight processing. During final data editing, be sure that there is a note near the beginning of the deadhead section that reads, “backtracking to begin CAPs”. It is

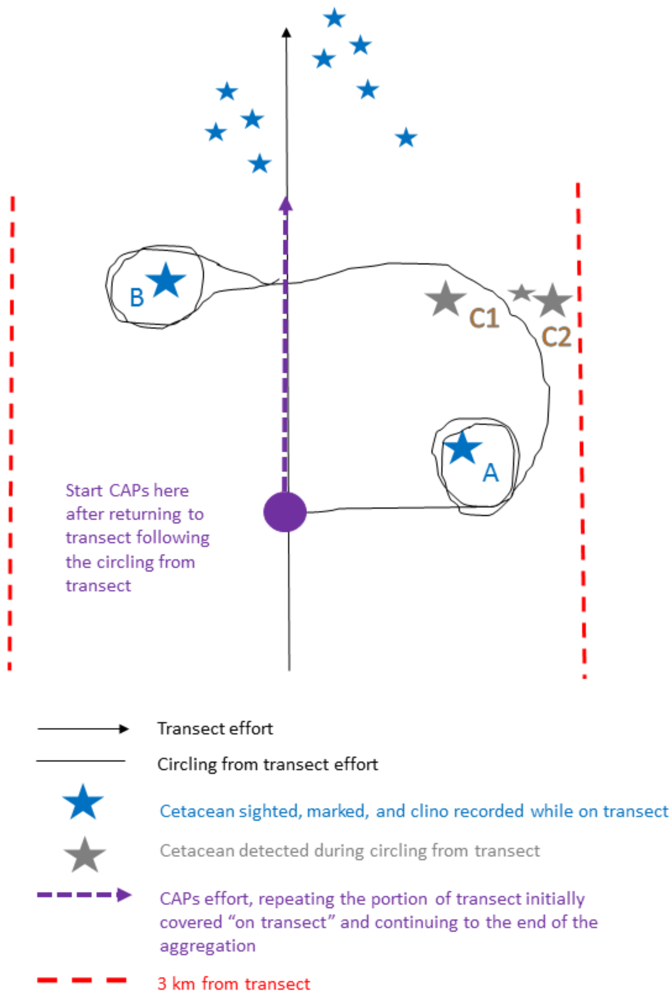


Figure D-4. Schematic illustrating "backtracking" to start CAPs. Cetaceans A and B were detected from the transect at approximately the same time. Cetacean A was marked with a clinometer; the aircraft continued on the transect to mark and record the clinometer for B before diverting to circle from transect. 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 were not within 5 body lengths of A or B, they cannot be combined with the group size estimates for the transect sightings and should not be recorded. 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 that all of the original effort and sightings on transect located perpendicular to the CAPs segment should be identified and changed to deadhead events.

unusual for ASAMM to have deadhead effort in the middle of bowhead aggregations, so this note should help explain the situation to data users.

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 bear 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:

- A sighting 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 sightings 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, calf 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 sighting-on-CAPs passing locations during CAPs circling to increase your chances of finding animals. Depending on the time passed since marking the sighting on CAPs passing, the separation of sightings, and other factors, it might be possible to gather additional info for the sighting on CAPs passing sighting during CAPs circling. If there is confidence that a sighting on CAPs passing was resighted during CAPs circling, enter the resight as a sighting on CAPs circling and, post-flight, and make a note in the sighting on CAPs passing stating what sighting on CAPs circling it corresponds to. If a sighting is found during CAPs circling in the general vicinity of a sighting on CAPs passing, but there is not very high confidence that the exact same sighting was relocated during CAPs circling, enter it as a sighting on CAPs circling; no additional notation needed.

There is interest in beluga presence in the eastern Beaufort Sea and Amundsen Gulf and a value in knowing whether a lack of beluga sightings recorded during CAPs was due to there being zero sightings of belugas during CAPs or if it was due to the team not recording belugas that were sighted during CAPs. Therefore, at the end of CAPs circling and right before the start transect or deadhead, make an environmental update to record presence or absence of belugas during the CAPs session. In the notes for the environmental update, state either "zero belugas sighted during CAPs session" or "~X # of belugas sighted during CAPs session", and note the approximate number of belugas (keep it simple, e.g., <5, 5-25, >25, >100, etc.).

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 high-use-area (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.

This page intentionally left blank.

APPENDIX E: 2019 SIGHTING RATE TABLES AND FIGURES

Table E-1. ASAMM 2019 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. ASAMM study area. NA – surveys were not conducted. Minor discrepancies within the table are due to rounding error.

	July				August				Summer			
BLOCK	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
1	815	1	2	0.0025	828	3	4	0.0048	1,643	4	6	0.0037
1a	101	0	0	0.0000	148	0	0	0.0000	249	0	0	0.0000
2	749	5	8	0.0107	268	1	1	0.0037	1,017	6	9	0.0089
3	1,018	3	4	0.0039	1,804	2	3	0.0017	2,822	5	7	0.0025
4	700	0	0	0.0000	727	2	3	0.0041	1,428	2	3	0.0021
5	528	7	10	0.0189	489	5	9	0.0184	1,017	12	19	0.0187
6	886	4	6	0.0068	753	4	5	0.0066	1,639	8	11	0.0067
7	484	0	0	0.0000	183	0	0	0.0000	668	0	0	0.0000
8	1	0	0	0.0000	0	0	0	NA	2	0	0	0.0000
9	2	0	0	0.0000	0	0	0	NA	2	0	0	0.0000
10	56	0	0	0.0000	36	0	0	0.0000	92	0	0	0.0000
11	484	7	11	0.0227	591	3	3	0.0051	1,076	10	14	0.0130
12	963	1	1	0.0010	530	0	0	0.0000	1,493	1	1	0.0007
13	1,178	0	0	0.0000	546	0	0	0.0000	1,725	0	0	0.0000
14	781	2	2	0.0026	205	0	0	0.0000	985	2	2	0.0020
15	500	0	0	0.0000	8	0	0	0.0000	508	0	0	0.0000
16	167	0	0	0.0000	0	0	0	NA	167	0	0	0.0000
17	491	0	0	0.0000	145	0	0	0.0000	636	0	0	0.0000
18	195	0	0	0.0000	0	0	0	NA	195	0	0	0.0000
19	149	0	0	0.0000	0	0	0	NA	149	0	0	0.0000
20	137	0	0	0.0000	183	0	0	0.0000	320	0	0	0.0000
21	0	0	0	NA	0	0	0	NA	0	0	0	NA
22	0	0	0	NA	516	0	0	0.0000	516	0	0	0.0000
23	416	0	0	0.0000	476	0	0	0.0000	891	0	0	0.0000
Total	**10,803**	**30**	**44.0000**	**0.0041**	**8,435**	**20**	**28.0000**	**0.0033**	**19,238**	**50**	**72.0000**	**0.0037**

	September				October				Fall			
BLOCK	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
1	1,172	13	23	0.0196	883	16	22	0.0249	2,055	29	45	0.0219
1a	198	0	0	0.0000	175	0	0	0.0000	373	0	0	0.0000
2	724	12	21	0.0290	557	1	2	0.0036	1,280	13	23	0.0180
3	1,728	3	4	0.0023	2,125	3	4	0.0019	3,852	6	8	0.0021
4	815	12	17	0.0209	584	1	1	0.0017	1,399	13	18	0.0129
5	1,095	18	29.5	0.0269	464	2	2	0.0043	1,560	20	32	0.0202
6	1,100	15	26	0.0236	677	0	0	0.0000	1,778	15	26	0.0146
7	653	3	5	0.0077	310	0	0	0.0000	963	3	5	0.0052
8	1	0	0	0.0000	0	0	0	NA	1	0	0	0.0000
9	2	0	0	0.0000	2	0	0	0.0000	4	0	0	0.0000
10	559	0	0	0.0000	2	0	0	0.0000	561	0	0	0.0000
11	1,309	3	4	0.0031	1,198	5	6	0.0050	2,507	8	10	0.0040
12	1,978	4	5	0.0025	1,311	1	1	0.0008	3,289	5	6	0.0018
13	1,980	0	0	0.0000	1,220	0	0	0.0000	3,201	0	0	0.0000
14	1,091	0	0	0.0000	729	0	0	0.0000	1,821	0	0	0.0000
15	851	0	0	0.0000	277	0	0	0.0000	1,128	0	0	0.0000
16	183	0	0	0.0000	20	0	0	0.0000	203	0	0	0.0000
17	698	0	0	0.0000	454	0	0	0.0000	1,152	0	0	0.0000
18	402	0	0	0.0000	153	0	0	0.0000	555	0	0	0.0000
19	347	0	0	0.0000	543	0	0	0.0000	889	0	0	0.0000
20	306	0	0	0.0000	725	0	0	0.0000	1,031	0	0	0.0000
21	56	0	0	0.0000	356	0	0	0.0000	412	0	0	0.0000
22	536	0	0	0.0000	426	0	0	0.0000	962	0	0	0.0000
23	579	0	0	0.0000	391	0	0	0.0000	970	0	0	0.0000
Total	**18,362**	**83**	**134.5000**	**0.0073**	**13,583**	**29**	**38.0000**	**0.0028**	**31,944**	**112**	**172.5000**	**0.0054**

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.

Table E-2. ASAMM 2019 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. ASAMM study area. Minor discrepancies within the table are due to rounding error.

	July				August				Summer			
DEPTH ZONE	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
157°W-169°W												
0-35 m	792	0	0.0000	0.0000	687	0	0.0000	0.0000	1,479	0	0.000	0.0000
36-50 m	2,068	1	1.0000	0.0005	768	0	0.0000	0.0000	2,837	1	1.000	0.0004
51-200 m N	993	1	1.0000	0.0010	420	0	0.0000	0.0000	1,413	1	1.000	0.0007
51-200 m S	161	0	0.0000	0.0000	203	0	0.0000	0.0000	363	0	0.000	0.0000
154°W-157°W												
0-20 m	267	0	0.0000	0.0000	102	0	0.0000	0.0000	369	0	0.000	0.0000
21-50 m	142	0	0.0000	0.0000	97	0	0.0000	0.0000	239	0	0.000	0.0000
51-200 m	492	1	1.0000	0.0020	285	0	0.0000	0.0000	777	1	1.000	0.0013
201-2,000 m	62	0	0.0000	0.0000	46	0	0.0000	0.0000	108	0	0.000	0.0000
140°W-154°W												
0-20 m	1,390	0	0.0000	0.0000	1,920	1	2.0000	0.0010	3,310	1	2.000	0.0006
21-50 m	1,648	5	7.0000	0.0042	1,877	8	10.0000	0.0053	3,525	13	17.000	0.0048
51-200 m	970	13	20.0000	0.0206	995	9	13.0000	0.0131	1,965	22	33.000	0.0168
201-2,000 m	1,330	5	8.0000	0.0060	839	2	3.0000	0.0036	2,168	7	11.000	0.0051
>2,000 m	416	4	6.0000	0.0144	99	0	0.0000	0.0000	515	4	6.000	0.0117
Total	**10,731**	**30**	**44.000**	**0.0041**	**8,337**	**20**	**28.000**	**0.0034**	**19,068**	**50**	**72.000**	**0.0038**

	September				October				Fall			
DEPTH ZONE	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
157°W-169°W												
0-35 m	1,182	0	0.0000	0.0000	1,376	0	0.0000	0.0000	2,558	0	0.000	0.0000
36-50 m	3,746	0	0.0000	0.0000	2,612	0	0.0000	0.0000	6,358	0	0.000	0.0000
51-200 m N	1,743	0	0.0000	0.0000	1,030	0	0.0000	0.0000	2,772	0	0.000	0.0000
51-200 m S	355	0	0.0000	0.0000	276	0	0.0000	0.0000	631	0	0.000	0.0000
154°W-157°W												
0-20 m	521	0	0.0000	0.0000	283	0	0.0000	0.0000	804	0	0.000	0.0000
21-50 m	345	0	0.0000	0.0000	239	0	0.0000	0.0000	583	0	0.000	0.0000
51-200 m	943	3	4.0000	0.0042	609	1	1.0000	0.0016	1,552	4	5.000	0.0032
201-2,000 m	171	1	1.0000	0.0059	181	0	0.0000	0.0000	352	1	1.000	0.0028
140°W-154°W												
0-20 m	2,277	0	0.0000	0.0000	2,057	8	9.0000	0.0044	4,334	8	9.000	0.0021
21-50 m	2,417	38	62.0000	0.0256	1,980	13	18.0000	0.0091	4,398	51	80.000	0.0182
51-200 m	1,555	23	33.0000	0.0212	1,130	6	8.0000	0.0071	2,685	29	41.000	0.0153
201-2,000 m	1,976	18	34.5000	0.0175	1,236	1	2.0000	0.0016	3,213	19	36.500	0.0114
>2,000 m	1,059	0	0.0000	0.0000	497	0	0.0000	0.0000	1,556	0	0.000	0.0000
Total	**18,289**	**83**	**134.500**	**0.0074**	**13507**	**29**	**38.000**	**0.0028**	**31,796**	**112**	**172.500**	**0.0054**

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, except for block 1a.

Table E-3. ASAMM 2019 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. ASAMM study area. NA – surveys were not conducted. Minor discrepancies within the table are due to rounding error.

	July				August				Summer			
BLOCK	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
12	963	2	4.000	0.0042	530	0	0.0000	0.0000	1,493	2	4.000	0.0027
13	1,178	1	1.000	0.0008	546	0	0.0000	0.0000	1,725	1	1.000	0.0006
14	781	18	26.000	0.0333	205	1	3.0000	**0.0147**	985	19	29.000	0.0294
15	500	0	0.000	0.0000	8	0	0.0000	0.0000	508	0	0.000	0.0000
16	167	0	0.000	0.0000	0	0	0.0000	NA	167	0	0.000	0.0000
17	491	11	21.000	0.0428	145	0	0.0000	0.0000	636	11	21.000	0.0330
18	195	0	0.000	0.0000	0	0	0.0000	NA	195	0	0.000	0.0000
19	149	0	0.000	0.0000	0	0	0.0000	NA	149	0	0.000	0.0000
20	137	0	0.000	0.0000	183	0	0.0000	0.0000	320	0	0.000	0.0000
21	0	0	0.000	NA	0	0	0.0000	NA	0	0	0.000	NA
22	0	0	0.000	NA	516	0	0.0000	0.0000	516	0	0.000	0.0000
23	416	32	42.000	0.1010	476	2	3.0000	0.0063	891	34	45.000	0.0505
Total	**4,977**	**64**	**94.0000**	**0.0189**	**2,608**	**3**	**6.0000**	**0.0023**	**7,584**	**67**	**100.000**	**0.0132**

	September				October				Fall			
BLOCK	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
12	1,978	0	0.0000	0.0000	1,311	0	0.000	0.0000	3,289	0	0.000	0.0000
13	1,980	1	5.0000	0.0025	1,220	0	0.000	0.0000	3,201	1	5.000	0.0016
14	1,091	17	21.0000	0.0192	729	7	9.000	0.0110	1,821	24	30.000	0.0210
15	851	0	0.0000	0.0000	277	0	0.000	0.0000	1,128	0	0.000	0.0000
16	183	0	0.0000	0.0000	20	0	0.000	0.0000	203	0	0.000	0.0000
17	698	5	10.0000	0.0143	454	6	8.000	0.0176	1,152	11	18.000	0.0156
18	402	0	0.0000	0.0000	153	0	0.000	0.0000	555	0	0.000	0.0000
19	347	0	0.0000	0.0000	543	0	0.000	0.0000	889	0	0.000	0.0000
20	306	0	0.0000	0.0000	725	0	0.000	0.0000	1,031	0	0.000	0.0000
21	56	0	0.0000	0.0000	356	0	0.000	0.0000	412	0	0.000	0.0000
22	536	0	0.0000	0.0000	426	1	1.000	0.0023	962	1	1.000	0.0010
23	579	15	28.0000	0.0483	391	24	27.784	0.0711	970	39	55.784	0.0575
Total	**9,005**	**36**	**62.0000**	**0.0069**	**6,605**	**37**	**44.7838**	**0.0068**	**15,611**	**73**	**106.7838**	**0.0068**

Does not include one sighting of one gray whale in September in block 2.
Total transect effort (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.

Table E-4. ASAMM 2019 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. ASAMM study area. Minor discrepancies within the table are due to rounding error.

	July				August				Summer			
DEPTH ZONE	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
157°W-169°W												
0-35 m	792	2	2.0000	0.0025	687	0	0.0000	0.0000	1,479	2	2.000	0.0014
36-50 m	2,068	27	44.0000	0.0213	768	1	1.0000	0.0013	2,837	28	45.000	0.0159
51-200 m N	993	12	20.0000	0.0201	420	1	3.0000	0.0071	1,413	13	23.000	0.0163
51-200 m S	161	21	24.0000	0.1494	203	1	2.0000	0.0099	363	22	26.000	0.0716
154°W-157°W												
0-20 m	267	1	2.0000	0.0075	102	0	0.0000	0.0000	369	1	2.000	0.0054
21-50 m	142	1	2.0000	0.0141	97	0	0.0000	0.0000	239	1	2.000	0.0084
51-200 m	492	0	0.0000	0.0000	285	0	0.0000	0.0000	777	0	0.000	0.0000
201-2,000 m	62	0	0.0000	0.0000	46	0	0.0000	0.0000	108	0	0.000	0.0000
140°W-154°W												
0-20 m	1,390	0	0.0000	0.0000	1,920	0	0.0000	0.0000	3,310	0	0.000	0.0000
21-50 m	1,648	0	0.0000	0.0000	1,877	0	0.0000	0.0000	3,525	0	0.000	0.0000
51-200 m	970	0	0.0000	0.0000	995	0	0.0000	0.0000	1,965	0	0.000	0.0000
201-2,000 m	1,330	0	0.0000	0.0000	839	0	0.0000	0.0000	2,168	0	0.000	0.0000
>2,000 m	416	0	0.0000	0.0000	99	0	0.0000	0.0000	515	0	0.000	0.0000
TOTAL	**10,731**	**64**	**94.0000**	**0.0088**	**8,337**	**3**	**6.0000**	**0.0007**	**19,068**	**67**	**100.0000**	**0.0052**

	September				October				Fall			
DEPTH ZONE	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	Whales	WPUE
157°W-169°W												
0-35 m	1,182	1	5.0000	0.0042	1,376	0	0.0000	0.0000	2,558	1	5.000	0.0020
36-50 m	3,746	13	20.0000	0.0053	2,612	14	18.0000	0.0069	6,358	27	38.000	0.0060
51-200 m N	1,743	7	9.0000	0.0052	1,030	7	9.0000	0.0087	2,772	14	18.000	0.0065
51-200 m S	355	15	28.0000	**0.0789**	276	16	17.7838	0.0643	631	31	45.784	0.0725
154°W-157°W												
0-20 m	521	0	0.0000	0.0000	283	0	0.0000	0.0000	804	0	0.000	0.0000
21-50 m	345	0	0.0000	0.0000	239	0	0.0000	0.0000	583	0	0.000	0.0000
51-200 m	943	0	0.0000	0.0000	609	0	0.0000	0.0000	1,552	0	0.000	0.0000
201-2,000 m	171	0	0.0000	0.0000	181	0	0.0000	0.0000	352	0	0.000	0.0000
140°W-154°W												
0-20 m	2,277	0	0.0000	0.0000	2,057	0	0.0000	0.0000	4,334	0	0.000	0.0000
21-50 m	2,417	0	0.0000	0.0000	1,980	0	0.0000	0.0000	4,398	0	0.000	0.0000
51-200 m	1,555	1	1.0000	0.0006	1,130	0	0.0000	0.0000	2,685	1	1.000	0.0004
201-2,000 m	1,976	0	0.0000	0.0000	1,236	0	0.0000	0.0000	3,213	0	0.000	0.0000
>2,000 m	1,059	0	0.0000	0.0000	497	0	0.0000	0.0000	1,556	0	0.000	0.0000
TOTAL	**18,289**	**37**	**63.0000**	0.0034	**13,507**	**37**	**44.7838**	0.0033	31,796	74	107.7838	0.0034

Total transect effort (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.

Table E-5. ASAMM 2019 on-effort (transect and CAPs passing) kilometers (Km), humpback whale on-effort sightings (primary observers only), and humpback whale sighting rate (WPUE = humpback whales per km surveyed) per depth zone per month. ASAMM study area. NA – surveys were not conducted. Minor discrepancies within the table are due to rounding error.

	July				August				Summer			
DEPTH ZONE	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
157°W-169°W												
0-35 m N	792	0	0.0000	0.0000	614	0	0.0000	0.0000	1,406	0	0.000	0.0000
0-35 m S	0	0	0.0000	NA	73	0	0.0000	0.0000	73	0	0.000	0.0000
36-50 m	2,068	7	12.0000	0.0058	768	0	0.0000	0.0000	2,836	7	12.000	0.0042
51-200 m N	993	0	0.0000	0.0000	420	0	0.0000	0.0000	1,413	0	0.000	0.0000
51-200 m S	161	0	0.0000	0.0000	203	0	0.0000	0.0000	364	0	0.000	0.0000
TOTAL	**4,014**	**7**	**12.0000**	**0.0030**	**2,078**	**0**	**0.0000**	**0.0000**	**6,092**	**7**	**12.000**	**0.0020**

	September				October				Fall			
DEPTH ZONE	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
157°W-169°W												
0-35 m N	1,121	0	0.0000	0.0000	1,347	0	0.0000	0.0000	2,468	0	0.000	0.0000
0-35 m S	61	0	0.0000	0.0000	29	0	0.0000	0.0000	90	0	0.000	0.0000
36-50 m	3,746	0	0.0000	0.0000	2,612	0	0.0000	0.0000	6,358	0	0.000	0.0000
51-200 m N	1,743	0	0.0000	0.0000	1,030	0	0.0000	0.0000	2,772	0	0.000	0.0000
51-200 m S	355	3	6.0000	0.0169	276	0	0.0000	0.0000	631	3	6.000	0.0095
TOTAL	**7,025**	**3**	**6.0000**	**0.0009**	**5,294**	**0**	**0.0000**	**0.0000**	**12,320**	**3**	**6.000**	**0.0005**

Total transect effort (Km) may differ from values in Tables 3 because effort between barrier islands and the mainland was included in the sighting rate per depth zone analysis.

Table E-6. ASAMM 2019 on-effort (transect and CAPs passing) kilometers (Km), fin whale on-effort sightings (primary observers only), and fin whale sighting rate (WPUE = fin whales per km surveyed) per depth zone per month. ASAMM study area. NA – surveys were not conducted. Minor discrepancies within the table are due to rounding error.

	July				August				Summer			
DEPTH ZONE	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
157°W-169°W												
0-35 m N	792	0	0.0000	0.0000	614	0	0.0000	0.0000	1,406	0	0.000	0.0000
0-35 m S	0	0	0.0000	NA	73	0	0.0000	0.0000	73	0	0.000	0.0000
36-50 m	2,068	3	5.0000	0.0024	768	0	0.0000	0.0000	2,836	3	5.000	0.0018
51-200 m N	993	0	0.0000	0.0000	420	0	0.0000	0.0000	1,413	0	0.000	0.0000
51-200 m S	161	0	0.0000	0.0000	203	0	0.0000	0.0000	364	0	0.000	0.0000
TOTAL	**4,014**	**3**	**5.0000**	**0.0012**	**2,078**	**0**	**0.0000**	**0.0000**	**6,092**	**3**	**5.000**	**0.0008**

	September				October				Fall			
DEPTH ZONE	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
157°W-169°W												
0-35 m N	1,121	0	0.0000	0.0000	1,347	0	0.0000	0.0000	2,468	0	0.000	0.0000
0-35 m S	61	0	0.0000	0.0000	29	0	0.0000	0.0000	90	0	0.000	0.0000
36-50 m	3,746	3	5.0000	0.0013	2,612	3	5.0000	0.0019	6,358	6	10.000	0.0016
51-200 m N	1,743	0	0.0000	0.0000	1,030	0	0.0000	0.0000	2,772	0	0.000	0.0000
51-200 m S	355	0	0.0000	0.0000	276	3	11.0000	0.0398	631	3	11.000	0.0174
TOTAL	**7,025**	**3**	**5.0000**	**0.0007**	**5,294**	**6**	**16.0000**	**0.0030**	**12,320**	**9**	**21.000**	**0.0017**

Total transect effort (Km) may differ from values in Tables 3 because effort between barrier islands and the mainland was included in the sighting rate per depth zone analysis.

Table E-7. ASAMM 2019 on-effort (transect and CAPs passing) kilometers (Km), minke whale on-effort sightings (primary observers only), and minke whale sighting rate (WPUE = minke whales per km surveyed) per depth zone per month. ASAMM study area. NA – surveys were not conducted. Minor discrepancies within the table are due to rounding error.

	July				August				Summer			
DEPTH ZONE	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
157°W-169°W												
0-35 m N	792	0	0.0000	0.0000	614	0	0.0000	0.0000	1,406	0	0.000	0.0000
0-35 m S	0	0	0.0000	NA	73	0	0.0000	0.0000	73	0	0.000	0.0000
36-50 m	2,068	0	0.0000	0.0000	768	0	0.0000	0.0000	2,836	0	0.000	0.0000
51-200 m N	993	0	0.0000	0.0000	420	0	0.0000	0.0000	1,413	0	0.000	0.0000
51-200 m S	161	0	0.0000	0.0000	203	0	0.0000	0.0000	364	0	0.000	0.0000
TOTAL	**4,014**	**0**	**0.0000**	**0.0000**	**2,078**	**0**	**0.0000**	**0.0000**	**6,092**	**0**	**0.000**	**0.0000**

	September				October				Fall			
DEPTH ZONE	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**	**Km**	**Sightings**	**Whales**	**WPUE**
157°W-169°W												
0-35 m N	1,121	2	2.0000	0.0018	1,347	1	1.0000	0.0007	2,468	3	3.000	0.0012
0-35 m S	61	0	0.0000	0.0000	29	0	0.0000	0.0000	90	0	0.000	0.0000
36-50 m	3,746	1	1.0000	0.0003	2,612	1	1.0000	0.0004	6,358	2	2.000	0.0003
51-200 m N	1,743	0	0.0000	0.0000	1,030	0	0.0000	0.0000	2,772	0	0.000	0.0000
51-200 m S	355	0	0.0000	0.0000	276	0	0.0000	0.0000	631	0	0.000	0.0000
TOTAL	**7,025**	**3**	**3.0000**	**0.0004**	**5,294**	**2**	**2.0000**	**0.0004**	**12,320**	**5**	**5.000**	**0.0004**

Total transect effort (Km) may differ from values in Tables 3 because effort between barrier islands and the mainland was included in the sighting rate per depth zone analysis.

Table E-8. ASAMM 2019 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. ASAMM study area. NA – surveys were not conducted. Minor discrepancies within the table are due to rounding error.

	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	815	3	5	0.0061	828	6	58	0.0701	1,643	9	63	0.0384
1a	101	0	0	0.0000	148	0	0	0.0000	249	0	0	0.0000
2	749	111	323	0.4313	268	8	23	0.0860	1,017	119	346	0.3404
3	1,018	1	1	0.0010	1,804	3	3	0.0017	2,822	4	4	0.0014
4	700	4	6	0.0086	727	15	24	0.0330	1,428	19	30	0.0210
5	528	41	127	0.2406	489	6	6	0.0123	1,017	47	133	0.1308
6	886	69	158	0.1782	753	49	64	0.0850	1,639	118	222	0.1354
7	484	75	175	0.3612	183	17	20	0.1091	668	92	195	0.2920
8	1	0	0	0.0000	0	0	0	0.0000	2	0	0	0.0000
9	2	0	0	0.0000	0	0	0	NA	2	0	0	0.0000
10	56	1	1	0.0177	36	1	2	0.0558	92	2	3	0.0325
11	484	99	492	1.0156	591	39	63	0.1065	1,076	138	555	0.5158
12	963	19	94	0.0976	530	1	1	0.0019	1,493	20	95	0.0636
13	1,178	3	155	0.1315	546	0	0	0.0000	1,725	3	155	0.0899
14	781	0	0	0.0000	205	0	0	0.0000	985	0	0	0.0000
15	500	0	0	0.0000	8	0	0	0.0000	508	0	0	0.0000
16	167	0	0	0.0000	0	0	0	NA	167	0	0	0.0000
17	491	0	0	0.0000	145	0	0	0.0000	636	0	0	0.0000
18	195	0	0	0.0000	0	0	0	NA	195	0	0	0.0000
19	149	0	0	0.0000	0	0	0	NA	149	0	0	0.0000
20	137	0	0	0.0000	183	1	1	0.0055	320	1	1	0.0031
21	0	0	0	NA	0	0	0	NA	0	0	0	NA
22	0	0	0	NA	516	0	0	0.0000	516	0	0	0.0000
23	416	0	0	0.0000	476	0	0	0.0000	891	0	0	0.0000
Total	**10,803**	**426**	**1537**	**0.1423**	**8,435**	**146**	**265**	**0.0314**	**19,238**	**572**	**1,802**	**0.0937**

	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	1,172	0	0	0.0000	883	1	1	0.0011	2,055	1	1	0.0005
1a	198	0	0	0.0000	175	0	0	0.0000	373	0	0	0.0000
2	724	51	118	0.1630	557	18	53	0.0952	1,280	69	171	0.1336
3	1,728	0	0	0.0000	2,125	2	5	0.0024	3,852	2	5	0.0013
4	815	1	1	0.0012	584	2	3	0.0051	1,399	3	4	0.0029
5	1,087	1	1	0.0009	464	0	0	0.0000	1,551	1	1	0.0006
6	1,100	66	93	0.0845	677	12	16	0.0236	1,778	78	109	0.0613
7	653	52	95	0.1454	310	3	3	0.0097	963	55	98	0.1017
8	1	0	0	0.0000	0	0	0	0.0000	1	0	0	0.0000
9	2	0	0	0.0000	2	0	0	0.0000	4	0	0	0.0000
10	559	1	2	0.0036	2	0	0	0.0000	561	1	2	0.0036
11	1,309	53	280	0.2139	1,198	63	128	0.1068	2,507	116	408	0.1627
12	1,978	11	57	0.0288	1,311	18	71	0.0541	3,289	29	128	0.0389
13	1,980	4	6	0.0030	1,220	4	7	0.0057	3,201	8	13	0.0041
14	1,091	1	1	0.0009	729	5	22	0.0302	1,821	6	23	0.0126
15	851	0	0	0.0000	277	0	0	0.0000	1,128	0	0	0.0000
16	183	0	0	0.0000	20	0	0	0.0000	203	0	0	0.0000
17	698	2	2	0.0029	454	0	0	0.0000	1,152	2	2	0.0017
18	402	0	0	0.0000	153	0	0	0.0000	555	0	0	0.0000
19	347	0	0	0.0000	543	0	0	0.0000	889	0	0	0.0000
20	306	0	0	0.0000	725	1	1	0.0014	1,031	1	1	0.0010
21	56	0	0	0.0000	356	0	0	0.0000	412	0	0	0.0000
22	536	0	0	0.0000	426	0	0	0.0000	962	0	0	0.0000
23	579	0	0	0.0000	357	0	0	0.0000	936	0	0	0.0000
Total	**18353**	**243**	**656**	**0.0357**	**13,549**	**129**	**310**	**0.0229**	**31,902**	**372**	**966**	**0.0303**

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.

Table E-9. ASAMM 2019 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. ASAMM study area. Minor discrepancies within the table are due to rounding error.

	July				August				Summer			
DEPTH ZONE	**Tr Km**	**Tr Sightings**	**Tr Whales**	**WPUE**	**Tr Km**	**Tr Sightings**	**Tr Whales**	**WPUE**	**Tr Km**	**Tr Sightings**	**Tr Whales**	**WPUE**
157°W-169°W												
0-35 m	792	1	150	0.1895	687	1	1	0.0015	1,479	2	151	0.1021
36-50 m	2,068	0	0	0.0000	768	0	0	0.0000	2,837	0	0	0.0000
51-200 m N	993	2	5	0.0050	420	0	0	0.0000	1,413	2	5	0.0035
51-200 m S	161	0	0	0.0000	203	0	0	0.0000	363	0	0	0.0000
154°W-157°W												
0-20 m	267	2	2	0.0075	102	0	0	0.0000	369	2	2	0.0054
21-50 m	142	5	59	0.4166	97	1	1	0.0103	239	6	60	0.2512
51-200 m	492	3	6	0.0122	285	0	0	0.0000	777	3	6	0.0077
201-2,000 m	62	9	27	0.4353	46	0	0	0.0000	108	9	27	0.2505
140°W-154°W												
0-20 m	1,390	4	5	0.0036	1,920	4	4	0.0021	3,310	8	9	0.0027
21-50 m	1,648	23	88	0.0534	1,877	26	88	0.0469	3,525	49	176	0.0499
51-200 m	970	79	431	0.4441	995	11	19	0.0191	1,965	90	450	0.2290
201-2,000 m	1,330	254	660	0.4964	839	99	148	0.1765	2,168	353	808	0.3727
>2,000 m	416	44	104	0.2499	99	4	4	0.0406	515	48	108	0.2098
TOTAL	**10,731**	**426**	**1537**	**0.1432**	**8,337**	**146**	**265**	**0.0318**	**19,068**	**572**	**1802**	**0.0945**

	September				October				Fall			
DEPTH ZONE	**Tr Km**	**Tr Sightings**	**Tr Whales**	**WPUE**	**Tr Km**	**Tr Sightings**	**Tr Whales**	**WPUE**	**Tr Km**	**Tr Sightings**	**Tr Whales**	**WPUE**
157°W-169°W												
0-35 m	1,182	0	0	0.0000	1,376	1	1	0.0007	2,558	1	1	0.0004
36-50 m	3,746	3	3	0.0008	2,605	5	22	0.0084	6,351	8	25	0.0039
51-200 m N	1,743	4	6	0.0034	1,030	4	7	0.0068	2,772	8	13	0.0047
51-200 m S	355	0	0	0.0000	250	0	0	0.0000	605	0	0	0.0000
154°W-157°W												
0-20 m	521	0	0	0.0000	283	0	0	0.0000	804	0	0	0.0000
21-50 m	345	1	2	0.0058	239	0	0	0.0000	583	1	2	0.0034
51-200 m	943	3	47	0.0499	609	13	39	0.0640	1,552	16	86	0.0554
201-2,000 m	171	7	8	0.0469	181	5	32	0.1768	352	12	40	0.1138
140°W-154°W												
0-20 m	2,277	1	1	0.0004	2,057	1	3	0.0015	4,334	2	4	0.0009
21-50 m	2,417	0	0	0.0000	1,980	3	4	0.0020	4,398	3	4	0.0009
51-200 m	1,555	25	72	0.0463	1,130	4	4	0.0035	2,685	29	76	0.0283
201-2,000 m	1,968	178	481	0.2445	1,236	87	187	0.1512	3,204	265	668	0.2085
>2,000 m	1,059	21	36	0.0340	497	6	11	0.0221	1,556	27	47	0.0302
TOTAL	**18,281**	**243**	**656**	**0.0359**	**13,473**	**129**	**310**	**0.0230**	**31,754**	**372**	**966**	**0.0304**

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, except for block 1a.

APPENDIX F: ASAMM CONTRIBUTIONS TO THE SCIENTIFIC COMMUNITY, 2008-Spring 2020

The Aerial Surveys of Arctic Marine Mammals (ASAMM) project is important 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 utilized to generate species-specific estimates of the number of animals that may be affected by future anthropogenic activities that are proposed to occur in the ASAMM study area during summer and fall. This information is utilized as best available information by multiple agencies, included BOEM, NOAA, USFSW, and USDOD, to fulfill the agencies' obligations under the NEPA, MMPA, and ESA. Without current, reliable data, 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 important 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 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 crucial 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

	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
ADFG		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.

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 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 crucial 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, 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.

PUBLISHED PAPERS USING ASAMM/BWASP/COMIDA DATA (ALPHABETIZED):

Angliss, R.P., M.C. Ferguson, P. Hall, V. Helker, A. Kennedy, and T. Sformo. 2018. Comparing manned to unmanned aerial surveys for cetacean monitoring in the Arctic: Methods and operational results. *Journal of Unmanned Vehicle Systems.* doi.org/10.1139/juvs-2018-0001.

Battaile, B.C., C.V. Jay, M.S. Udevitz, A.S. Fischbach. 2017. Evaluation of a method using survey counts and tag data to estimate the number of Pacific walruses (*Odobenus rosmarus divergens*) using a coastal haulout in northwestern Alaska. *Polar Biology.* DOI 10.1007/s00300-016-2060-5.

Brower, A., M. Ferguson, S. Schonberg, S. Jewett, and J. Clarke. 2017. Gray whale distribution relative to benthic invertebrate biomass and abundance: northeastern Chukchi Sea, 2009-2012. *Deep-Sea Research II.* DOI 10.1016/j.dsr2.2016.12.007.

Brower, A.A., J.T. Clarke, and M.C. Ferguson. 2018. Increased sightings of subarctic cetaceans in the eastern Chukchi Sea, 2008-2016: population recovery, response to climate change, or increased effort? *Polar Biology.* DOI 10.1007/s00300-018-2257-x.

Calambokidis, J., G. Steiger, C. Curtice, J. Harrison, M.C. Ferguson, E. Becker, M. DeAngelis, and S.M. Van Parijs. 2015. Biologically Important Areas for cetaceans within U.S. waters: West Coast region. *Aquatic Mammals* 41(1): 39-53.

Christman, C., J. Citta, L. Quakenbush, J. Clarke, B. Rone, R. Shea, M. Ferguson and M. Heide-Jørgensen. 2013. Presence and behavior of bowhead whales (*Balaena mysticetus*) in the Alaskan Beaufort Sea in July 2011. *Polar Biology* 36(12): 1851-1856. DOI 10.1007/s00300-013-1395-4.

Clarke, J., K. Stafford, S. Moore, B. Rone, L. Aerts, and J. Crance. 2014. Subarctic cetaceans in the southern Chukchi Sea: evidence of recovery or response to a changing ecosystem. *Oceanography* 24(4):46-59.

Clarke, J.T., M.C. Ferguson, C. Curtice, and J. Harrison. 2015. Biologically Important Areas for cetaceans within the U.S. waters: Arctic region. *Aquatic Mammals* 41(1):94-103.

Clarke, J., A. Kennedy, and M. Ferguson. 2016. Bowhead and gray whale distributions, sighting rates, and habitat associations in the eastern Chukchi Sea, summer and fall 2009-15, with a retrospective comparison to 1982-91**.** *Arctic* 69(4):359-377.

Clarke, J.T., M.C. Ferguson, A.L. Willoughby, and A.A. Brower. 2018. Bowhead whale and beluga distributions, sighting rates, and habitat associations in the western Beaufort Sea, summer and fall 2009-2016, with a retrospective comparison to 1982-1991. *Arctic* 71(2): 115-138.

Druckenmiller, M.L., J.J. Citta, M.C. Ferguson, J.T. Clarke, J.C. George, and L. Quakenbush. 2017. Trends in sea-ice cover within bowhead whale habitats in the Western Arctic. *Deep-Sea Research II.* DOI 10.1016/j.dsr2.2017.10.017.

Edwards, E.F., C. Hall, T.J. Moore, C. Sheredy, and J.V. Redfern. 2015. Global distribution of fin whales *Balaenoptera physalus* in the post-whaling era (1980-2012). *Mammal Review* 45:197-214.

Ferguson, M. 2012. Quantifying spatial characteristics of the Bowhead Whale Aerial Survey Project (BWASP) survey design. *Journal of Cetacean Research and Management* 12(1): 39-44.

Ferguson, M. and J. Clarke. 2013. Estimates of detection probability for BWASP bowhead whale, gray whale, and beluga sightings collected from Twin Otter and Aero Commander aircraft, 1989 to 2007 and 2008 to 2011. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-AFSC-261. 52 p.

Ferguson, M.C., R.P. Angliss, A. Kennedy, B. Lynch, A. Willoughby, V.T. Helker, A.A. Brower, and J.T. Clarke. 2018. Performance of manned and unmanned aerial surveys to collect visual data and imagery for estimating arctic cetacean density and uncertainty. *Journal of Unmanned Vehicle Systems.* doi.org/10.1139/juvs-2018-0002.

Ferguson, M.C., C. Curtice, and J. Harrison. 2015. Biologically Important Areas for cetaceans within U.S. waters: Gulf of Alaska region. *Aquatic Mammals* 41(1): 65-78.

Ferguson, M.C., C. Curtice, J. Harrison, and S.M. Van Parijs. 2015. Biologically Important Areas for marine mammals within U.S. waters: Overview and rationale. *Aquatic Mammals* 41(1):2-16.

Ferguson, M.C., J. Waite, C. Curtice, J.T. Clarke, and J. Harrison. 2015. Biologically Important Areas for cetaceans within U.S. waters: Aleutian Islands and Bering Sea region. *Aquatic Mammals* 41(1):79-93.

Givens, G.H., J.A. Hoeting, and L. Beri. 2009. Factors that influence aerial line transect detection of Bering-Chukchi-Beaufort Seas bowhead whales. *Journal of Cetacean Research and Management* 11(1): 9-16.

Grebmeier, J.M., B.A. Bluhm, L.W. Cooper, S. Danielson, K.Arrigo, A.L. Blanchard, J.T. Clarke, R.H. Day, K.E. Frey, R.R. Gradinger, M. Kedra, B. Konar, K.J. Kuletz, S.H. Lee, J.R. Lovvorn, B.L. Norcross, and S.R. Okkonen. 2015. Ecosystem characteristics and processes facilitating persistent macrobenthic biomass hotspots and associated benthivory in the Pacific Arctic. *Progress in Oceanography*. DOI 10.1016/j.pocean.2015.05.006.

Kuletz, K.J., M.C. Ferguson, B. Hurley, A.E. Gall, E.A. Labunski, and T.C. Morgan. 2015. Seasonal spatial patterns in seabird and marine mammal distribution in the eastern Chukchi and western Beaufort seas: Identifying biologically important pelagic areas. *Progress in Oceanography*. DOI 10.1016/j.pocean.2015.05.012.

Lowry, L.F., M.C.S. Kingsley, D.D.W. Hauser, J. Clarke, and R. Suydam. 2017. Aerial survey estimates of abundance of the Eastern Chukchi Sea stock of beluga whales (*Delphinapterus leucas*) in 2012. *Arctic* 70(3):273-286. doi.org/10.14430/arctic4667.

Mannocci, L., A. Boustany, J. Roberts, D. Dunn, P. Halpin, D. Palacios, S. Viehman, J. Moxley, J. Cleary, H. Bailey, S. Bograd, E. Becker, B. Gardner, J. Hartog, E. Hazen, M. Ferguson, K. Forney, B. Kinlan, M. Oliver, C. Perretti, V. Ridoux, S. Teo, and A. Winship. 2017. Temporal resolutions in species distribution models of highly mobile marine animals: Recommendations for ecologists and managers. *Diversity Distribution* 23:1098–1109. DOI 10.1111/ddi.12609.

Muto, M.M., V.T. Helker, R.P. Angliss, B.A. Allen, P.L. Boveng, J.M. Breiwick, M.F. Cameron, P.J. Clapham, S.P. Dahle, M.E. Dahlheim, B.S. Fadely, M.C. Ferguson, L.W. Fritz, R.C. Hobbs, Y.V. Ivashchenko, A.S. Kennedy, J.M. London, S.A. Mizroch, R.R. Ream, E.L.

Richmond, K.E.W. Shelden, R.G. Towell, P.R. Wade, J.M. Waite, and A.N. Zerbini. 2016. Alaska marine mammal stock assessments, 2015. U.S. Dep. Commer., NOAA Tech. Memo. NMFSAFSC-323, 300 p. DOI 10.7289/V5/TM-AFSC-323.

Muto, M.M., V.T. Helker, R.P. Angliss, B.A. Allen, P.L. Boveng, J.M. Breiwick, M.F. Cameron, P.J. Clapham, S.P. Dahle, M.E. Dahlheim, B.S. Fadely, M.C. Ferguson, L.W. Fritz, R.C. Hobbs, Y.V. Ivashchenko, A.S. Kennedy, J.M. London, S.A. Mizroch, R.R. Ream, E.L. Richmond, K.E.W. Shelden, R.G. Towell, P.R. Wade, J.M. Waite, and A.N. Zerbini. 2017. Alaska marine mammal stock assessments, 2016. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-355, 366 p. DOI 10.7289/V5/TM-AFSC-355.

Okkonen, S., C. Ashjian, R. Campbell, J. Clarke, S. Moore and K. Taylor. 2011. Satellite observations of circulation features associated with a bowhead whale feeding 'hotspot' near Barrow, Alaska. *Remote Sensing of Environment* 115: 2168-2174.

Okkonen, S., J. Clarke, and R. Potter. 2017. Relationship between high river discharge, upwelling events, and bowhead whale (*Balaena mysticetus*) occurrence in the central Alaskan Beaufort Sea. *Deep Sea Research II.* DOI 10.1016/j.dsr2.2016.11.015.

Schonberg, S., J. Clarke and K. Dunton. 2013. Distribution, abundance, biomass and diversity of benthic infauna in the northeast Chukchi Sea, Alaska: Relation to environmental variables and marine mammals. *Deep Sea Research Part II: Topical Studies in Oceanography.* DOI 10.1016/j.dsr2.2013.11.004.

Smith, M.A., M.S. Goldman, E.J. Knight, and J.J. Warrenchuk. 2017. *Ecological Atlas of the Bering, Chukchi, and Beaufort Seas*. 2nd edition. Audubon Alaska, Anchorage, AK.

Stafford, K., S. Okkonen, and J. Clarke. 2013. Correlation of a strong Alaska Coastal Current with the presence of beluga whales (*Delphinapterus leucas)* near Barrow, Alaska. *Marine Ecology Progress Series* 474: 287-297.

Stafford, K.M., M.C. Ferguson, D.D.W. Hauser, S.T. Okkonen, C.L. Berchok, J.J. Citta, J.T. Clarke, E.C. Garland, J. Jones, and R.S. Suydam. 2016. Beluga whales in the western Beaufort Sea: current state of knowledge on timing, distribution, habitat use and environmental drivers. *Deep-Sea Research II*. DOI 10.1016/j.dsr2.2016.11.017.

Willoughby, A.L., M.C. Ferguson, J.T. Clarke, and A.A Brower. 2018. First photographic match of an anomalously white gray whale (*Eschrichtius robustus*) in the northeastern Chukchi Sea, Alaska, and off Baja California, Mexico. *Aquatic Mammals* 44(1): 7-12. DOI 10.1578/AM.44.1.2018.7.

Young, J.K., B.A. Black, J.T. Clarke, S.V. Schonberg, and K.H. Dunton. 2017. Abundance, biomass and caloric content of Chukchi Sea bivalves and association with Pacific walrus (*Odobenus rosmarus divergens*) relative density and distribution in the northeastern Chukchi Sea. *Deep-Sea Research II* 144: 125-141. DOI 10.1016/j.dsr2.2017.04.017.

ASAMM Annual Reports, USFWS Permit Reports, International Whaling Commission Papers, and Alaska Fisheries Science Center Quarterly Reports (Alphabetized):

Brower, A., J. Clarke, M. Ferguson, C. Christman and C. Sims. 2012. Aerial surveys of Arctic marine mammals project: preliminary results from the 2012 field season. Alaska Fisheries Science Center Quarterly Report Jul-Aug-Sep.

Brower, A. 2013. Gray whale calf occurrence in the Alaskan Arctic, summer and fall 2013, with comparisons to previous years. Alaska Fisheries Science Center Quarterly Report Oct-Nov-Dec.

Brower, A. and B. Rone. 2015. Annual report for activities conducted by the National Marine Mammal Laboratory under Federal Fish and Wildlife Permit MA212570-0 in calendar year 2014. Prepared by the National Marine Mammal Laboratory (NMFS) for U.S. Fish and Wildlife Service. 11 pp.

Brower, A. and B. Rone. 2015. Annual report for activities conducted by the National Marine Mammal Laboratory under Federal Fish and Wildlife Permit MA212570-1 in calendar year 2015. Prepared by the Marine Mammal Laboratory (NMFS) for U.S. Fish and Wildlife Service. 10 pp.

Brower, A. and B. Rone. 2016. Annual report for activities conducted by the National Marine Mammal Laboratory under Federal Fish and Wildlife Permit MA212570-1 in calendar year 2016. Prepared by the Marine Mammal Laboratory (NMFS) for U.S. Fish and Wildlife Service. 13 pp.

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.

Brower, A. and J. Waite. 2019. Annual report for activities conducted by the National Marine Mammal Laboratory under Federal Fish and Wildlife Permit MA212570-1 in calendar year 2018. Prepared by the Marine Mammal Laboratory (NMFS) for U.S. Fish and Wildlife Service. 11 pp.

Brower, A. and J. Waite. 2020. Annual report for activities conducted by the National Marine Mammal Laboratory under Federal Fish and Wildlife Permit MA212570-1 in calendar year 2019. 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.

Christman, C. and B. Rone. 2012. Annual report for activities conducted by the National Marine Mammal Laboratory under Federal Fish and Wildlife Permit MA212570-0 in calendar year 2011. Prepared by the National Marine Mammal Laboratory (NMFS) for U.S. Fish and Wildlife Service. 16 pp.

Christman, C. and B. Rone. 2013. Annual report for activities conducted by the National Marine Mammal Laboratory under Federal Fish and Wildlife Permit MA212570-0 in calendar year 2012. Prepared by the National Marine Mammal Laboratory (NMFS) for U.S. Fish and Wildlife Service. 13 pp.

Christman, C. and B. Rone. 2013. Annual report for activities conducted by the National Marine Mammal Laboratory under Federal Fish and Wildlife Permit MA212570-0 in calendar year 2013. Prepared by the National Marine Mammal Laboratory (NMFS) for U.S. Fish and Wildlife Service. 10 pp.

Clarke, J. 2009. Chukchi Offshore Monitoring in Drilling Area, 2008. Prepared for NMML-NMFS and MMS-Alaska. 15 pp.

Clarke, J. 2010. Chukchi Offshore Monitoring in Drilling Area, 2009. Prepared for NMML-NMFS and MMS-Alaska. 26 pp.
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.
Clarke, J. and M. Ferguson. 2010. Aerial surveys for bowhead whales in the Alaskan Beaufort Sea: BWASP update 2000-2009 with comparisons to historical data. SC/62/BRG14 presented at the International Whaling Commission Scientific Committee Meetings, Morocco, June 2010. 11 pp.
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.
Clarke, J., C. Christman, A.A. Brower, M.C. Ferguson and S.L. Grassia. 2011. Aerial Surveys of Endangered Whales in the Beaufort Sea, fall 2010. OCS Study BOEMRE 2011-035. Annual report, OCS Study BOEMRE 2011-035. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC, Seattle, WA 98115-6349. 119 pp.
Clarke, J., C. Christman, M. Ferguson and S. Grassia. 2011. Aerial surveys of endangered whales in the Beaufort Sea, fall 2006-2008. Final report, OCS Study BOEMRE 2011-042. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC, Seattle, WA 98115-6349. 240 pp.
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.

Clarke, J., A. Brower, M. Ferguson, A. Kennedy, and A. Willoughby. 2015. Distribution and relative abundance of marine mammals in the eastern Chukchi and western Beaufort Seas, 2014. Annual report, OCS Study BOEM 2015-0040. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC, Seattle, WA 98115-6349.

Clarke, J., M. Ferguson, A. Brower, A. Willoughby, and C. Sims. 2016. Occurrence of humpback, fin, and minke whale in the eastern Chukchi Sea, 2008-2015: population recovery, response to climate change, or increased effort? Alaska Fisheries Science Center Quarterly Report Jan-Feb-Mar 2016.

Clarke, J., A. Brower, M. Ferguson, and A. Willoughby. 2017a. Distribution and relative abundance of marine mammals in the eastern Chukchi and western Beaufort Seas, 2015. Annual report, OCS Study BOEM 2017-019. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC, Seattle, WA 98115-6349.

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., A. Brower, M. Ferguson, and A. 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/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/67b/AWMP3 presented to the IWC Scientific Committee, April 2018 (unpublished), Bled, Slovenia.

Clarke, J., A. Brower, M. Ferguson, and A. Willoughby. 2019. Distribution and relative abundance of marine mammals in the eastern Chukchi and western Beaufort Seas, 2018. Annual report, OCS Study BOEM 2019-021. Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC, Seattle, WA 98115-6349.

Ferguson, M.C. 2020. Bering-Chukchi-Beaufort Seas bowhead whale (*Balaena mysticetus*) abundance estimate from the 2019 aerial line-transect survey. Paper SC/68B/ASI/09 presented to the International Whaling Commission Scientific Committee, May 2020.

Ferguson, M., J. Clarke, R. Angliss, J. Bengtson, A. Brower, J. Citta, P. Clapham, P. Conn, K. Forney, C. George, and G. Givens. 2018. Bering-Chukchi-Beaufort bowhead whale abundance estimation survey workshop report. SC/67b/AWMP16 presented at the International Whaling Commission Scientific Committee Meetings, Slovenia, April 2018. 23 pp.

Fischbach, A.S., A.A. Kochnev, J.L. Garlich-Miller, and C.V. Jay. 2016. Pacific walrus coastal haulout database, 1852-2016 – Background report: U.S. Geological Survey Open-File Report 2016-1108, 27 p. DOI 10.3133/ofr20161108.

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.

Givens, G.H., M.C. Ferguson, J.T. Clarke, A. Willoughby, A. Brower, and R. Suydam. 2019. Abundance of the Eastern Chukchi Sea stock of beluga whales, 2012-2017. SC/68a/ASI/09 presented at the International Whaling Commission Scientific Committee Meetings, Nairobi, Kenya, May 2019. 15 pp.

National Marine Mammal Laboratory. 2009. Annual Report for Permit No. 782-1719-09: 1 July 2008 – 30 June 2009. Submitted to the National Marine Fisheries Service Office of Protected Resources. 33 pp.

National Marine Mammal Laboratory. 2010. Annual Report for Permit No. 782-1719-09: 1 July 2009 – 30 June 2010. Submitted to the National Marine Fisheries Service Office of Protected Resources. 38 pp.

National Marine Mammal Laboratory. 2011. Annual Report for Permit No. 782-1719-09: 1 July 2010 to 24 April 2011. Submitted to the National Marine Fisheries Service Office of Protected Resources. 29 pp.

National Marine Mammal Laboratory. 2012. Annual Report for Permit No. 14245: 25 April 2011 to 30 April 2012. Submitted to the National Marine Fisheries Service Office of Protected Resources. 50 pp.

National Marine Mammal Laboratory. 2013. Annual Report for Permit No. 14245: 1 May 2012 to 30 April 2013. Submitted to the National Marine Fisheries Service Office of Protected Resources. 60 pp.

National Marine Mammal Laboratory. 2014. Annual Report for Permit No. 14245: 1 May 2013 to 30 April 2014. Submitted to the National Marine Fisheries Service Office of Protected Resources.

National Marine Mammal Laboratory. 2015. Annual Report for Permit No. 14245: 1 May 2014 to 30 April 2015. Submitted to the National Marine Fisheries Service Office of Protected Resources.

National Marine Mammal Laboratory. 2016. Annual Report for Permit No. 14245: 1 May 2015 to 30 April 2016. Submitted to the National Marine Fisheries Service Office of Protected Resources.

National Marine Mammal Laboratory. 2017. Annual Report for Permit No. 14245: 1 May 2016 to 30 April 2017. Submitted to the National Marine Fisheries Service Office of Protected Resources.

National Marine Mammal Laboratory. 2018. Annual Report for Permit No. 20465: 1 June 2017 to 31 May 2018. Submitted to the National Marine Fisheries Service Office of Protected Resources.

National Marine Mammal Laboratory. 2019. Annual Report for Permit No. 20465: 1 June 2018 to 31 May 2019. Submitted to the National Marine Fisheries Service Office of Protected Resources.

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, B. Tudor, and R. Suydam. 2018. 2017 health report for the Bering-Chukchi-Beaufort seas bowhead whales – preliminary findings. Paper SC/67b/AWMP8 presented to the IWC Scientific Committee, April 2018, Bled, Slovenia. 25 pp.

Stimmelmayr, R., J.C. George, J. Clarke, M. Ferguson, A. Willoughby, A. Brower, G. Sheffield, K. Stafford, G. Givens, A. Von Duyke, T. Sformo, B. Person, L. Sousa, and R. Suydam. 2020. 2018-2019 health report for the Bering-Chukchi-Beaufort Seas bowhead whales – preliminary findings. Paper SC/68b/ASW presented to the International Whaling Commission Scientific Committee, May 2020.

Willoughby, A.L., J.T. Clarke, M.C. Ferguson, R. Stimmelmayr, and A.A. Brower. 2018. Bowhead whale carcasses in the eastern Chukchi and western Beaufort seas, 2009-2017. Paper SC/67b/AWMP2 presented to the IWC Scientific Committee, April 2018 (unpublished), Bled, Slovenia. 10 pp.

Willoughby, A.L., R. Stimmelmayr, A.A. Brower, J.T. Clarke, and M.C. Ferguson. 2020. Bowhead whale carcasses in the eastern Chukchi and western Beaufort seas, 2009-2019. Paper presented to the International Whaling Commission Scientific Committee, May 2020.

Willoughby, A.L., R. Stimmelmayr, A.A. Brower, J.T. Clarke, and M.C. Ferguson. 2020. Gray whale carcasses in the eastern Chukchi Sea, 2009-2019. Paper SC/68B/ASW/02 presented to the International Whaling Commission Scientific Committee, May 2020.

VENUES WHERE ASAMM RESULTS WERE PRESENTED (ALPHABETIZED):

Alaska Beluga Whale Committee Workshop, Anchorage, AK. 2012, 2016, 2017, 2019. Presentations (4).

Alaska Eskimo Whaling Commission, Anchorage, AK, 2019 (2).

Alaska Marine Science Symposium, Anchorage, AK. 2009-2020. Presentations (2), posters (50).

American Cetacean Society, Monterey, CA. 2008. Poster.

Applied Physics Lab, Polar Science Center, Seattle, WA. 2016. Presentation.

Arctic Cetacean Listening Session, Utqiaġvik, AK. 2020. 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, 2018, 2020. Presentations (4).

Distributed Biological Observatory Data Workshops, Seattle, WA. 2014, 2016, 2017, 2020. Presentations (4).

Duke University, Marine Geospatial Ecology Lab, Durham, NC. 2017. Presentation.

International Whaling Commission Scientific Committee Meeting, Morocco. 2010. Reports (2).

International Whaling Commission Scientific Committee Meeting, Slovenia. 2018. Reports (4).

Inter-American Tropical Tuna Commission Workshop, La Jolla, CA, 2016. Presentation.

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).

Preview of Ecological and Economic Conditions. 2018 and 2019. Presentations (2)

Society for Marine Mammalogy, 2009, 2011, 2015, 2019. Presentation (1), posters (4).

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 Nunaŋ̱ ŋ̱ 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.

April 2019: Stephanie Grassia (JISAO) requested minke sightings, 2010-2018, for inclusion in a manuscript on minke whale acoustic detections.

October 2019: Ben Sullender (Audubon Alaska) requested 2015-2017 flightlines for use in comments to be provided to the USCG related to the Arctic Port Access Route Study.

October 2019: Alan Springer requested a bowhead whale distribution map that had been published in newspaper article.

October 2019: Kate Savage (Gray Whale UME team) requested map of gray whale sightings from 2019, 2009-2015, and 2016-2018.

November 2019: Steve Okkonen (UAF) requested bowhead whale sighting data from 2015-2019 to supplement data share previously

January 2020: Vicki Cornish (MMC) requested map showing bowhead whale sightings in relation to proposed location of Qilak LNG north of Point Thomson, AK.

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 2011-2019 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.

2015-2019: 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.
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 Beaufort and Chukchi Seas, Alaska, during 2010.
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.
BOEM, Alaska OCS Region: Chukchi Sea Planning Area, Shell Gulf of Mexico, Inc., Shell Revised Chukchi Sea Exploration Plan, Burger Prospect: Posey Area Blocks 6714, 6762, 6764, 6812, 6912, 6915, Chukchi Seal 193, 2011.
BOEM, Office of Leasing and Environment, Alaska OCS Region: Beaufort Sea Planning Area, Shell Offshore, Ic., 2012 Revised Outer Continental Shelf Lease Exploration Plan, Camden Bay, Beaufort Sea, Alaska, Flaxman Island Blocks 6559, 6610 and 6658, Beaufort Lease Sales 195 and 202, 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.
BOEM, Office of Environment, Alaska OCS Region: SAExploration Inc., Colville River Delta 2014, 3D Geophysical Seismic Survey, Beaufort Sea, Alaska, 2014.
BOEM, Office of Environment, Alaska OCS Region: BP Exploration (Alaska) Inc., 2014 Liberty Ancillary Activities, Shallow Geohazard Seismic Survey, Beaufort Sea, Alaska, 2014.
BOEM, Office of Environment, Alaska OCS Region: BP Exploration (Alaska) Inc., North Prudhoe Bay 2014 OBS, Geophysical Seismic Survey, Beaufort Sea, Alaska, 2014.
BOEM, Office of Environment, Alaska OCS Region: SAExploration 2014 Geophysical Seismic Survey, Beaufort Sea, Alaska, 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.
SAExploration: 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, 2015.
Shell Gulf of Mexico, Inc.: Application for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with planned exploration drilling activities during 2015, Chukchi Sea, Alaska.
Shell Gulf of Mexico, Inc.: Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska, Environmental Assessment. Burger Prospect: Posey Area Blocks 6714, 6762, 6764, 6812, 6912, 6915, Revision 2, 2015.
BOEM, Alaska OCS Region: Chukchi Sea Oil and Gas Lease Sale 193 Environmental Impact Statement, Final, First Supplemental and Second Supplemental, 2015.
Hilcorp Alaska: Incidental Harassment Authorization request for the non-lethal harassment of marine mammals during the Liberty Unit geohazard surveys, Beaufort Sea, Alaska, 2015.
Shell Gulf of Mexico, Inc.: Application for Incidental Harassment Authorization for the non-lethal taking of whales and seals in conjunction with a planned ice overflight survey program in the Chukchi and Beaufort Seas, Alaska, May 2015-April 2016.
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.
Fairweather LLC: Application for Incidental Harassment Authorization for 2016 anchor retrieval program, Chukchi and Beaufort Seas, Alaska.
Quintillion Subsea Operations, LLC: Application for the Incidental Harassment Authorization for the Taking of Marine Mammals in Conjunction with Proposed Alaska Phase of the Quintillion Subsea Project, 2016.
Hilcorp Alaska: Incidental Harassment Authorization request for non-lethal harassment of marine mammals during Liberty Island construction, Beaufort Sea, Alaska, 2017.
NOAA-OPR: Effects of Oil and Gas Activities in the Arctic Ocean. Final Environmental Impact Statement, 2016.
Quintillion Subsea Operations, LLC: Application for the Incidental Harassment Authorization for the Taking of Marine Mammals in Conjunction with the Quintillion Subsea Operations Cable Project, 2017.
BOEM, Alaska OCS Region. Environmental Assessment, Eni US Operating Company, Inc., OCS Lease Exploration Plan Harrison Bay Block 6423 Unit – Leases OCS-Y-1753, OCS-Y-1754, and OCS-Y-1757, 2017.
SAExploration, Inc.: Application for the Incidental Harassment Authorization for the Taking of Marine Mammals in Conjunction with the SAExploration Proposed 3D Seismic Survey Beaufort Sea, Alaska, 2017.
Hilcorp Alaska, LLC: Petition for promulgation of regulations and request for letter of authorization pursuant to section 101(a)(5)(A) of the Marine Mammal Protection Act for the taking of marine mammals incidental to construction and installation of the Liberty drilling and production island, Foggy Island Bay, Beaufort Sea, Alaska, 2018.

BOEM, Alaska OCS Region: Final Environmental Impact Statement, Liberty Development and Production Plan, 2018.

PRESS RELEASES AND NEWS ARTICLES (ALPHABETICAL):

Accardo, C. 2019. "2019 Aerial Surveys of Arctic Marine Mammals – Post 6." NOAA Fisheries Blog Post. Oct 11, 2019.

Baier, C. "Sentinels of Change: Gray whales in the Arctic." AFSC News. March 29, 2016. http://www.afsc.noaa.gov/News/Sentinel_change_gray_whales.htm

Barry, L. 2019. "2019 Aerial Surveys of Arctic Marine Mammals – Post 2." NOAA Fisheries Blog Post. Jul 15, 2019.

Barry. L. 2019. "2019 Aerial Surveys of Arctic Marine Mammals – Post 5." NOAA Fisheries Blog Post. Sep 10, 2019.

Barry, L., and N. Methany. 2019. "2019 Aerial Surveys of Arctic Marine Mammals – Post 4." NOAA Fisheries Blog Post. Aug 2, 2019.

Beaver, V. 2019. "2019 Aerial Surveys of Arctic Marine Mammals – Post 8." NOAA Fisheries Blog Post. Nov 7, 2019.

Boddy, J. "Drones can take scientists to strange new places-like inside whale snot." Popular Science. May 2, 2018.

BOEM. 2013. Partnerships in Science: Research on the Alaska OCS. BOEM Ocean Science Vol. 10 (2). April-May-June. http://www.boem.gov/Ocean-Science-2013-Apr-May-Jun/

Brower, A. 2017. "2017 Aerial Surveys of Arctic Marine Mammals – Post 1" NOAA Fisheries Blog Post. Jul 27, 2017.

Brower, A. 2017. Evidence for the earliest "krill trap" on record in the western Beaufort Sea. ASAMM blog, August 1, 2017. https://www.afsc.noaa.gov/Science_blog/ASAMM_1.htm.

Brower, A. 2018. "2018 Aerial Surveys of Arctic Marine Mammals – Post 1." NOAA Fisheries Blog Post. Sep 11, 2018.

Brower, A., A. Willoughby, N. Brandt Turner, and C. Accardo. 2018. "2018 Aerial Surveys of Arctic Marine Mammals – Post 2." NOAA Fisheries Blog Post. Sep 18, 2018.

Clarke, J. 2017. The kids are alright – bowhead calves in the Alaskan Arctic. ASAMM blog, September 28, 2017. https://www.afsc.noaa.gov/Science_blog/ASAMM_4.htm.

David. "Whale Watching – and More – from a Twin Commander". Flight Levels Online. November 12, 2015. http://flightlevelsonline.com/2015/fall-2015/whale-watching-and-more-from-a-twin-commander/

Dawicki, S. "NOAA Northeast Aerial Marine Mammal Team Flies Alaskan Skies." NOAA Fisheries. October 22, 2012.

DeMarban, A. "Bowhead whale deaths mystify observers." Alaska Dispatch News. Oct 9, 2015.

DeMarban, A. "Bowhead whales, dwellers of icy seas, enjoy steady growth off Alaska in the age of climate change." Anchorage Daily News. May 13, 2018.

Dunham, M. "Gray Whale Baby Boom is Noted in Alaska and California." Anchorage Daily News. August 2, 2012.

Feidt, A. "Researchers Describe 'Jaw-Dropping' Whale Survey Near Point Hope." APRN Alaska Public Media. November 26, 2012.

Ferguson, M. 2019. "2019 Aerial Surveys of Arctic Marine Mammals – Post 1." NOAA Fisheries Blog Post. Jul 15, 2019.

Heidt, A. “Gray whales a little late in coming to Monterey Bay this year.” Monterey Herald. Jan 30, 2020.
Heimbuch, H. “Chukchi Sea Whale Sightings Wow Researchers.” The Arctic Sounder. December 14, 2012.
Herz, N. “Whalers in Utqiagvik can’t remember hunting this late without landing a bowhead.” Alaska’s Energy Desk. Oct 25, 2019.
Herz, N. “A month into Utqiagvik’s whaling season, none have been landed.” Alaska’s Energy Desk – Anchorage. Oct 25, 2019.
Herz, N. “No Bowhead Sightings Yet for Alaskan Whalers. Some Blame Climate Change.” NPR. Oct 29, 2019.
Hickey, H. “Whales, Ships More Common Through Bering Strait.” University of Washington. 2013. http://www.washington.edu/news/2014/02/26/whales-ships-more-common-through-bering-strait/
Joling, D. 2008. “Nine polar bears seen in open ocean.” Anchorage Daily News. August 22, 2008.
Joling, D. 2012. “Whale Surveys Spot Killer Whales in Alaska Arctic.” Juneau Empire. September 11, 2012.
Joling, D. 2012. “Large Groups of Orcas Sighted in Arctic Ocean off Alaska.” Anchorage Daily News. November 26, 2012.
Joling, D. 2014. “Estimated 35,000 Walrus Come Ashore in Northwest Alaska.” Alaska Dispatch News. September 10, 2015.
Joling, D. 2014. “35,000 Walrus Come Ashore as Arctic Sea Ice Retreats.” The Christian Science Monitor. October 1, 2014.
Joling, D. 2014. “Estimated 35,000 walrus come ashore in Northwest Alaska.” Alaska Dispatch News. September 10, 2015.
Joling, D. 2018. “Thousands of Pacific walruses again herd up on Alaska Coast.” Anchorage Daily News. Sep 13, 2018.
Matheson, F. and M. Ferguson. 2013. “NOAA Scientists Document New Walrus Haulout in Alaskan Arctic.” NOAA Fisheries Press Release. http://www.afsc.noaa.gov/NMML/cetacean/research/Walrus-ASAMM2013.php
NOAA Fisheries. 2013. BOEM Funding and NOAA Science Keep an Eye on Marine Mammals in the Arctic. July 29, 2013. http://www.nmfs.noaa.gov/stories/2013/07/7_29_13aerial_surveys_arctic_marine_mammals.html
NOAA Fisheries. 2018. Performance of manned and unmanned aerial surveys to collect visual data and imagery for estimating Arctic cetacean density and associated uncertainty, Ferguson et al. Science Connect Issue 3. https://content.govdelivery.com/accounts/USNOAAFISHERIES/bulletins/2086dcf
NOAA Fisheries. 2020. Investigation of West Coast gray whale strandings continues as whales head south for winter. Jan 21, 2020. https://www.fisheries.noaa.gov/feature-story/investigation-west-coast-gray-whale-strandings-continues-whales-head-south-winter
NOAA Fisheries. 2019. Alaska Region Marine Mammal Stranding Network, Fall/Winter 2019 Newsletter. Nov 4, 2019. Mahoney, B., Savage, K., Kuletz, K., Snyder, J., Jensen, A., Wright, S., Kumar, S., Gann, D., Belovarac, J., Auletta, J., and Rouse, N.

https://www.fisheries.noaa.gov/resource/document/alaska-region-marine-mammal-stranding-network-newsletters
NSB Department of Wildlife Management. 2012. New and Interesting this Summer. The Towline Vol 4 (2). Fall 2012.
Oliver, Shady Grove. “Researchers eye marine mammals in offshore surveys.” The Arctic Sounder. August 11, 2017.
Oliver, Shady Grove. “Utqiagvik whalers still hope to land a bowhead as season wanes.” Anchorage Daily News. Nov 7, 2019.
Oliver, Shady Grove. “Season nears end with no whales yet for Utqiagvik.” The Arctic Sounder. Nov 9, 2019.
Oliver, Shady Grove. “No whales in sight as fall season nears end.” The Arctic Sounder. Nov 15, 2019.
Oliver, Shady Grove. “Utqiagvik finally celebrates first successful bowhead hunt of season.” Anchorage Daily News. Nov 20, 2019
Pagan, K. 2019. “2019 Aerial Surveys of Arctic Marine Mammals – Post 3.” NOAA Fisheries Blog Post. Jul 23, 2019.
Robinson, G. “Gray whale dies off, bowhead whale population estimates are focus of annual NOAA survey.” Anchorage KTUU. July 26, 2019.
Rosen, Y. 2014. “Biologists Spot Huge Gathering of Walruses on Beach Near Point Lay.” Alaska Dispatch News. September 30, 2014.
Rosen, Y. 2016. “Walrus congregation in Northwest Alaska apparently short-lived this year.” Alaska Dispatch News. October 12, 2016.
Rust, S. and Xia, R. “As gray whale migration reaches its peak, scientist fear another unexplained die-off.” Los Angeles Times. Jan 24, 2020.
Santoro, H. “Scientists struggle to find reasons behind gray whale deaths.” High Country News. Aug 15, 2019.
Shankman, S. “Alaska’s Big Whale Mystery: Where Are the Bowheads?” Inside Climate News. Nov 1, 2019.
Sims, C. 2017. Some days are diamonds, some days are stone. ASAMM blog, August 31, 2017. https://www.afsc.noaa.gov/Science_blog/ASAMM_3.htm.
Speegle, J. 2013. “NOAA’s Aerial Surveys of Arctic Marine Mammals: No One Flies Where These Scientists Fly.” NOAA Fisheries Press Release. August 2, 2012.
Speegle, J. 2013. “NOAA’s Aerial Surveys of Arctic Marine Mammals Photograph Walrus Haulout Site – Scientists Call Behavior a New Phenomenon.” NOAA Fisheries News Release. September 30, 2013.
http://alaskafisheries.noaa.gov/newsreleases/2013/walrushaulout093013.htm
Venton, D. “Scientists Count Gray Whales Following Unusual Spate of Deaths Last Spring.” KQED Science. Feb 3, 2020.
Walrus coastal haulout media teleconference, 1 October 2014. Organized by Julie Speegle. Scientists interviewed: Megan Ferguson (NOAA), Joel Garlich-Miller (USFWS), and Chad Jay (USGS).
*NOAA’s most popular Facebook and Instagram posts ever resulted from ASAMM’s photos of the 2014 walrus haulout at Point Lay. The Facebook photo reached 700,000 people and the Instagram post had over 1,000 “likes.”
Weise, E. 2019. “Something killed 121 gray whales this summer. Scientists are scrambling to find out what.” USA Today. Sep 18, 2019.

Willoughby, A. 2017. A gray whale in Peard Bay, ASAMM-Chukchi Flight on 28 July 2017. ASAMM blog, August 16, 2017. https://www.afsc.noaa.gov/Science_blog/ASAMM_2.htm.
Willoughby, A. 2017. Belugas – the "where's Waldo?" of the ASAMM study area. ASAMM blog, October 17, 2017. https://www.afsc.noaa.gov/Science_blog/ASAMM_5.htm.
Willoughby, A. 2019. "2019 Aerial Surveys of Arctic Marine Mammals – Post 7." NOAA Fisheries Blog Post. Oct 25, 2019.

PAPERS IN REVIEW (ALPHABETICAL):

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.*
Clarke, J.T., M.C. Ferguson, A.A. Brower, and A.L. Willoughby. Baby boom for western Arctic bowhead whales? *Paper in prep.*
Ferguson et al. Ecological variation in the western Beaufort Sea. *In review.*
Ferguson et al. Anomalous bowhead whale distribution and migration across the western Beaufort Sea during autumn 2019. *Paper in prep.*
Ferguson et al. Observer Field of View during Aerial Surveys: variability, uncertainty, and power analyses. *Paper in prep.*
Givens, G.H., M.C. Ferguson, J.T. Clarke, A. Willoughby, A. Brower, and R. Suydam. Abundance of the Eastern Chukchi Sea Stock of Beluga Whales, 2012-2017. *In review.* Arctic.
Lowry et al. Distribution, Abundance, Harvest, and Status of Western Alaska Beluga Whale, Delphinapterus leucas, Stocks. *In review.*
Willoughby, A.L., M.C. Ferguson, R. Stimmelmayr, J.T. Clarke, and A.A. Brower. Killer whale predation on bowhead whales in the Pacific Arctic – on the rise? *In review.* Polar Biology.

This page intentionally left blank.

APPENDIX G: ASAMM FIELD OF VIEW EFFORTS, 2018 and 2019

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 an observer's field of view. Perception bias refers to animals that are available to be seen, but an observer fails 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 spent at greater depths where they are invisible to an aerial observer (Laake and Borchers 2004). ASAMM collected behavioral data using Focal Group Follow (FGF) protocols, which are described in Clarke et al. (2019). In addition, the amount of time that an observer has to detect an available object must also be known (Laake and Borchers 2004). 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. Eyesight and target familiarity may also lead to perception bias, but these factors are considered here to the extent that they influence the *farthest* distance at which an object can be detected under *ideal* conditions. Numerous other variables that influence perception bias 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 and 2019 field seasons, the ASAMM project collected data to estimate the dimensions of the fields of view for each type of survey aircraft used. This effort was a continuation of initial FOV flights conducted in summer and fall 2017 (Clarke et al. 2018) and January 2018, and incorporated important refinements based on lessons learned from those flights. This appendix documents ASAMM's 2018 and 2019 FOV field methods, analytical methods, and results.

Field Methods

Two types of aircraft were flown during 2018 and 2019, a De Havilland Twin Otter and Turbo Commander. To estimate FOV, each type of aircraft flew short, predetermined transects located at designated distances from stationary targets on land. The targets were located in areas of relatively low air traffic (>18 km from any airport) to minimize distractions and maximize safety. The ideal target is symmetrical, so that it appears the same regardless of viewing direction, and not extremely reflective because that could result in time-in-view estimates that are biased high. Transects were located on relatively flat terrain that did not interfere with target visibility.

ASAMM's previous FOV trials indicated that targets disappeared under the wing or in the exhaust from Turbo Commander engines when transects were flown farther than 750 m perpendicular distance at altitudes ≤457 m (≤1500 ft) AGL, and this biased 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 457 m perpendicular distance. Furthermore, to maintain the target in the aft FOV until it disappears due to distance, the Turbo Commander must fly at an altitude of approximately 610 m (2000 ft) AGL or higher. Therefore, for consistency, all FOV trials for both types of aircraft were conducted at 610 m AGL. Cloud ceilings needed to be high enough to not affect visibility of the target at distance; if low ceilings impeded detection of the target, FOV trials ceased and the aircraft either returned to base or commenced offshore survey effort if survey conditions were acceptable.

Due to different bases of operations, the Twin Otter used a different target than the Turbo Commander. The Twin Otter's target was a small cabin with a black and white roof (Figure G-1) located approximately 60 km north of Inuvik, Northwest Territories, Canada, at 68.8°N, 133.3°W (the coordinates in degrees, decimal minutes are 68°45.29'N, 133°20.86'W). The Turbo Commander's target was a tight cluster of Conex boxes (Figure G-2) located between the Dalton Highway and Franklin Bluffs, approximately 34 km south of Deadhorse, Alaska, at 69.9°N, 148.7°W (69°54.84'N, 148°43.85'W).

ASAMM typically conducts surveys between 305 m (1000 ft) and 457 m altitude. A large bowhead whale is approximately 18.2 m (60 ft) long, although often the whale's total length is not visible to an aerial observer upon initial detection. An 18.2-m object viewed from 305 m will appear to be the same size as a 36.5-m (120-ft) object viewed from 610 m (Figure G-3). The apparent size of each FOV target at 610 m altitude was roughly the size of a sighting cue for a bowhead whale at typical ASAMM survey altitude. The footprint of the two large ochre and one large light blue Conex boxes in the Franklin Bluffs target (Figure G-2), measured on the ground, was 9.7 m x 12.2 m (32 ft x 40 ft). The footprint of the small cabin used for the Twin Otter target was approximately 4.6 m x 6.1 m (15 ft x 20'), estimated from aerial images.

Transects were located 500 m and 2000 m from the target (Figure G-4). Transects were all centered on the target. Coordinates of each waypoint in degrees, decimal minutes are provided in Tables G-1 and G-2. Each transect was long enough that the observer could not see the target at the beginning and end of each transect. Based on previous 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.

Transects were generated along four axes: north/south, east/west, northwest/southeast, and northeast/southwest (Figure G-3). For each orientation, there was one set of transects on each side of the target. A "set" of transects consisted of transects located 500 m and 2000 m perpendicular to the target. For example, there was one set of north/south transects located

Figure G-1. Aerial view of the cabin located approximately 60 km north of Inuvik, Northwest Territories, Canada, used for the ASAMM Twin Otter FOV target in August 2019.

Figure G-2. Aerial view of the Conex boxes located along the Sagavanirktok River, between the Dalton Highway and Franklin Bluffs south of Deadhorse, Alaska, used for the ASAMM Turbo Commander FOV target in September 2018 and 2019.

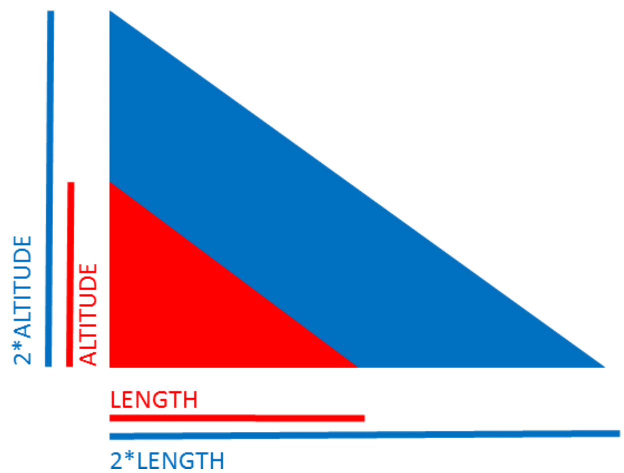


Figure G-3. The height and length of a right triangle (a triangle with one 90° angle) scale directly in proportion with each other. Therefore, an 18.2 m bowhead whale viewed from 305 m altitude will appear to be the same length as a 36.5 m target viewed from 610 m altitude.

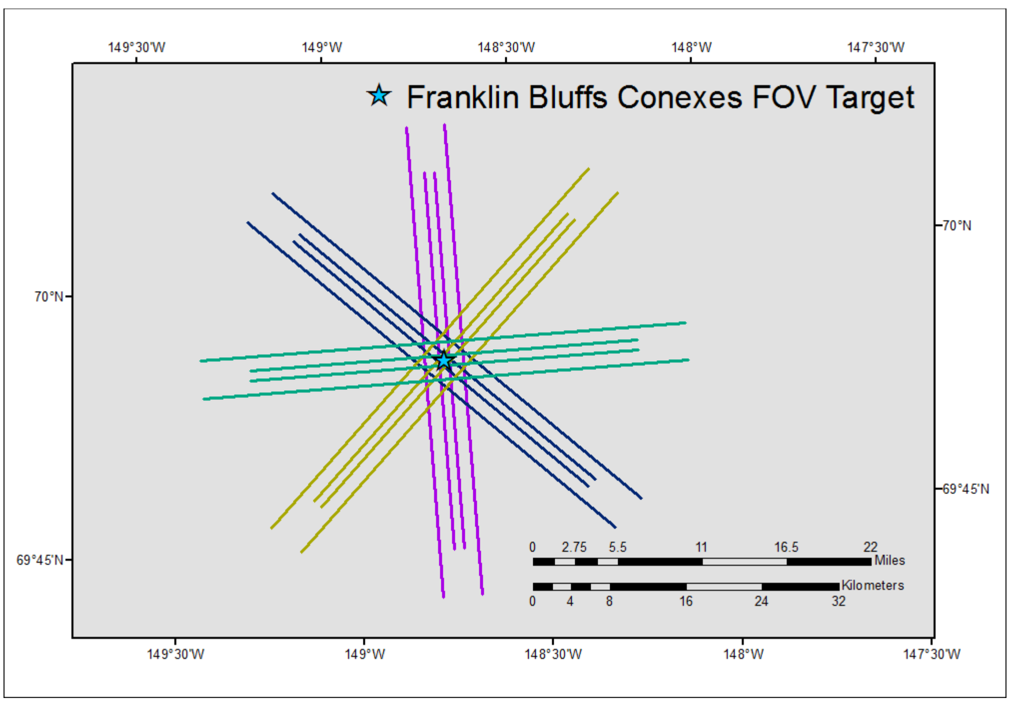


Figure G-4. Sample FOV transect design, showing the FOV target and transects oriented north/south, east/west, northwest/southeast, and northeast/southwest. A "set" of transects consisted of transects located 500 m and 2000 m perpendicular to the target. There were two sets of transects for each transect orientation. Only one set of transects was flown during a single FOV flight to minimize variability in environmental effects that affect detectability.

Table G-1. Twin Otter FOV transect waypoints (degrees, decimal minutes) flown during the FOV flight in August 2019. These transects were oriented along an east/west axis and centered on a cabin north of Inuvik, Northwest Territories, Canada. The transect name for all transects on one side of the target ends in either 1 or 2, and the name for transects on the opposite side of the target ends in either 1x or 2x.

ID	Latitude Degrees	Latitude Decimal Minutes	Longitude Degrees	Longitude Decimal Minutes
500EW1	68	45.530	-132	58.611
500EW2	68	45.530	-133	43.113
2000EW1	68	46.307	-132	47.466
2000EW2	68	46.307	-133	54.258
500EW1x	68	44.992	-132	58.620
500EW2x	68	44.992	-133	43.104
2000EW1x	68	44.155	-132	47.520
2000EW2x	68	44.155	-133	54.204

Table G-2. Turbo Commander FOV transect waypoints (degrees, decimal minutes) flown during FOV flights in September 2018 and 2019. These transects were oriented along an east/west axis and centered on a cluster of three Conex boxes near Franklin Bluffs, Alaska. The transect name for all transects on one side of the target ends in either 1 or 2, and the name for transects on the opposite side of the target ends in either 1x or 2x.

ID	Latitude Degrees	Latitude Decimal Minutes	Longitude Degrees	Longitude Decimal Minutes
500EW1	69	55.067	-148	12.548
500EW2	69	55.067	-149	15.152
2000EW1	69	55.848	-148	4.698
2000EW2	69	55.848	-149	23.002
500EW1x	69	54.529	-148	12.562
500EW2x	69	54.529	-149	15.138
2000EW1x	69	53.697	-148	4.765
2000EW2x	69	53.697	-149	22.935

east of the target and one set of north/south transects located west of the target. The survey team chose the transect configuration that minimized the effects of crabbing due to crosswinds at the altitude of the aircraft and optimized viewing conditions for each observer, left and right, during the same trial.

Transects were flown at typical ASAMM survey speed, approximately 213 km/hr (115 kts).

For each aircraft type, one entire set of transects for a given transect orientation was flown two times for each observer, in order to collect replicate data that could be used to estimate uncertainty. The exact details on the order in which transects were flown are documented in the database; an example is provided in Table G-3. To complete the entire experiment with one pair of observers in one aircraft, each observer needed to sight the target during eight transects: two perpendicular distances (500 m and 2000 m), two replicates, and each side of the plane (SOP, left and right). It took approximately 8 minutes to complete one transect and line up for the next transect. For flight planning, we estimated that 16 transects at 8 minutes per transect would take 128 minutes (~2 hrs) at the target site, plus time to transit between the target and the airport. The data recorder entered data into a specialized component of the ASAMM survey program.

Data collected for each transect included: 1) time and position (latitude, longitude, altitude) at which the target was first clearly visible; 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 Twin Otter target was defined to be clearly visible when the black and white pattern on the roof could be differentiated. “Clearly visible” for the Turbo Commander target was defined as when the Conex boxes appeared as separate structures. The notes field in the database was used to consistently label the transect distance (“500m” or “2000m”) and orientation (EW) 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 or as conditions changed throughout each flight.

For this experiment, the element of surprise was not necessary because the goal was to estimate the field of view under ideal conditions. The ability to accurately and precisely record the times and locations described above was most important. Perception bias will be computed using other methods (see Appendix D). To maximize the accuracy and precision in the data, 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 it was no longer considered clearly visible, using the target-specific definitions above. The observer did not scan the field of view like they would during a survey because that likely introduces additional measurement error into the data. The observer tried to maintain typical survey posture in the window while on transect because head position affects the field of view.

Table G-3. Sample FOV transect order. Blue cells indicate that observers switched sides of plane (SOP).

Trial #		Observer ID	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

Analytical Methods

All analyses were conducted in R version 3.6.1, using packages lme4, RLRsim, ggplot2, tidyverse, and dplyr.

In a standard distance sampling analysis, time in view (TIV) on the transect or at a designated left-truncation distance is the relevant parameter for estimating availability bias. TIV typically increases linearly with viewing distance. Due to the short viewing distance near the aircraft and the considerable variability in FOV data, viewing distance was estimated as a linear model based on perpendicular distance (*pdist*) (Figure G-5).

Preliminary analyses suggested that viewing distance varied among observers. Only two observers flew in the Twin Otter; therefore, a linear model with only fixed effects for observer ID was used for that aircraft. Numerous observers flew ASAMM surveys and five observers flew FOV trials in the Turbo Commander; therefore, observer ID was incorporated as a random effect for the Turbo Commander models.

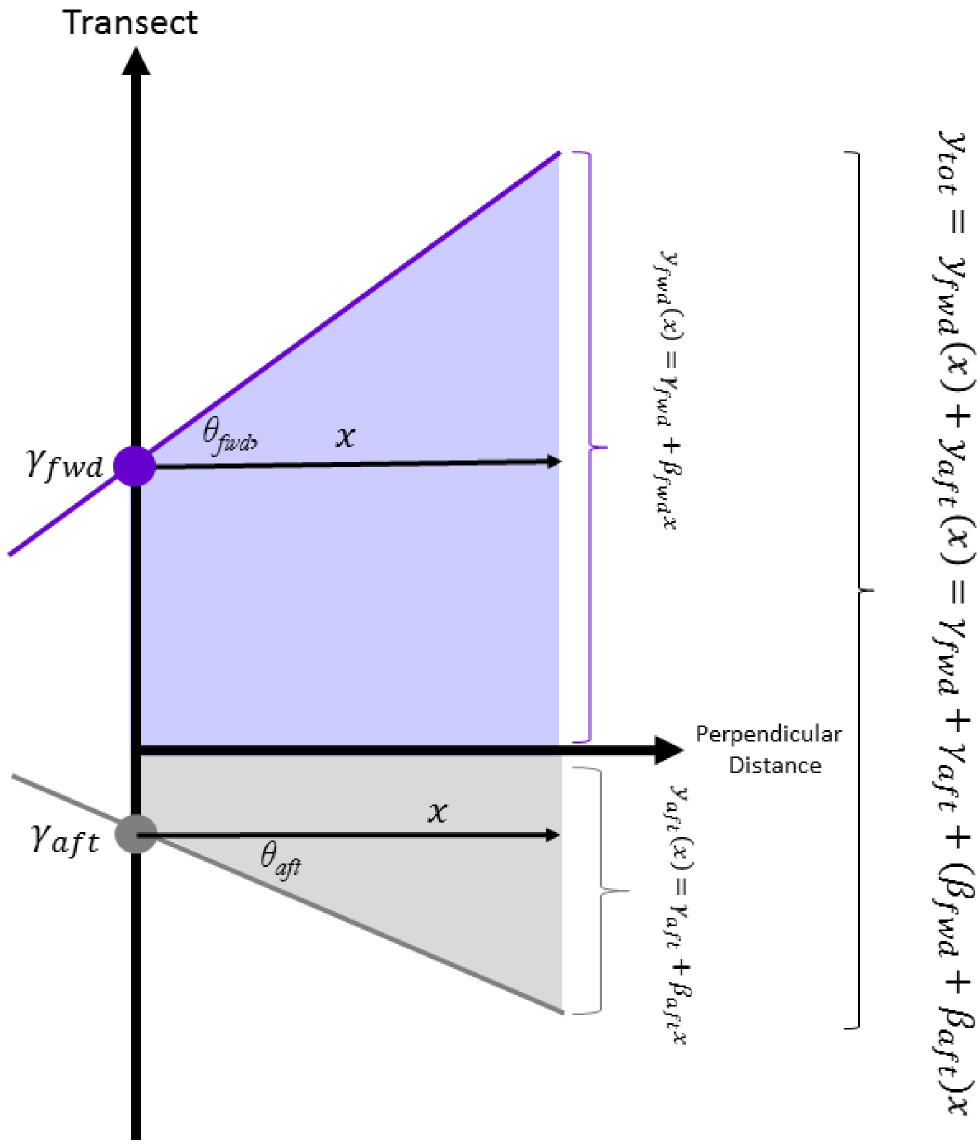


Figure G-5. Schematic representation of simple linear models for estimating parameters defining the forward (fwd), aft, and total (tot) field of view. y=viewing distance. γ=intercept. θ=viewing angle. β=slope. x=perpendicular distance.

The left and right windows in the Twin Otter were identical, so data from both sides of the aircraft were pooled to estimate a single field of view for each observer. In the Turbo Commander, the left window differed slightly from the right window. For the Turbo Commander, separate analyses were conducted for the left and right fields of view.

Previous authors (e.g., Robertson et al. 2015; Ganley et al. 2019) created linear fixed effects models for forward and aft FOVs separately, enabling estimation of the forward and aft angles and intercepts (Figure G-5). We constructed separate models for total (the sum of forward and aft) viewing distance and for forward viewing distance alone. The former allow comparison of these ASAMM results with those from Robertson et al. (2015) and Ganley et al. (2019). The forward field of view is the relevant parameter for deriving an availability bias correction factor for ASAMM data because sightings initially detected in the aft field of view are considered to have been "missed" by ASAMM primary observers.

For the random effects models to converge, it was necessary to scale *pdist* using the following transformation, which was computed separately for each aircraft:

$pdist.scl_{h,l} = \frac{(pdist_{h,l} - \overline{pdist_l})}{\sigma_{pdist_l}}$ (1)

Where
h: waypoint
l: SOP (used only for the Turbo Commander; both sides were pooled for the Twin Otter)
$\overline{pdist_l} = \frac{1}{n_l}\sum_{h \in l} pdist_{h,l}$
n_l: number of waypoints for SOP l
σ_{pdist_l}: standard deviation among *pdist* values for SOP l.

Because Eqn (1) is not a linear transformation, it was not possible to use the models based on *pdist.scl* to estimate forward and aft angles.

TURBO COMMANDER

Preliminary investigation of the Turbo Commander FOV data suggested that observer ID did not affect the slopes of the lines for either total or forward field of view; therefore, a random effect for observer ID was incorporated only into the intercepts of each model. The linear mixed effects model of viewing distance was estimated as:
$y_{i,k,l} = \gamma_l + \alpha_{obs,l}[i] + \beta_{pdist.scl,l} * pdist.scl_{i,k,l} + \varepsilon_{i,k,l}$ (3)

$\beta_{pdist.scl,l}$: fixed effect of *pdist.scl* on slope for SOP l
$\alpha_{obs,l}[i] \sim N(0, \sigma^2_{obs,l})$

$$\varepsilon_{i,k,l} \sim N(0, \sigma^2_{resid,l})$$

One observer flew FOV trials in the Turbo Commander in both 2018 and 2019. Preliminary investigation of the results for this observer suggested that her fields of view from both windows were quite different each year. This could be due to differences in environmental conditions between the trial periods that could not be controlled for. Therefore, this observer's data from 2019 was incorporated into the model as a "new" observer.

TWIN OTTER

For the Twin Otter, the linear model of viewing distance was estimated as:

$y_{i,k} = \gamma_i + \beta_{pdist.scl,i} * pdist.scl_{i,k} + \varepsilon_{i,k}$ (2)
y: viewing distance (m)
i: observer ID
k: replicate
γ_i: intercept

$\beta_{pdist.scl,i}$: fixed effect of *pdist.scl* on slope for observer i
$\varepsilon_{\,i,k} \sim N(0, \sigma^2_{resid})$

Models were evaluated to determine whether model assumptions were met using QQ plots of residuals and binned random effects, and plots of fitted versus residual values.

Predictions and bootstrapped 95% prediction intervals were created for a new observer based on the parameterized fixed (Eqn 2) and mixed effects (Eqn 3) models. To transform *pdist* to *pdist.scl* for the prediction analysis, Eqn (1) with $\overline{pdist_l}$ and σ_{pdist_l} derived from the field data were used.

Results

Results for the models of total field of view and forward field of view are presented below.

Twin Otter

One FOV flight was flown with two ASAMM observers over the black and white-roofed cabin near Inuvik (Figure G-1) on 22 August 2019. Survey conditions included partly cloudy to overcast skies, with unlimited visibility and no impediments to visibility. All trials were conducted at a constant speed of ~213 km/hr.

The bootstrap predictions for the distance (m) and time (sec) defining the total field of view for each Twin Otter observer at various distances perpendicular to the target are shown in Tables G-4 and G-5, respectively.

The relationship between total viewing distance and perpendicular distance from the target differed between observers, exhibiting a slightly positive slope for one observer (RH) and a negative slope for the other observer (LB) (Figure G-6).

The bootstrap predictions for the distance (m) and time (sec) defining the forward field of view for each Twin Otter observer at various distances perpendicular to the target are shown in Tables G-6 and G-7, respectively.

The relationship between forward viewing distance and perpendicular distance from the target differed between observers, exhibiting a positive slope for one observer (RH) and essentially a horizontal line for the other observer (LB) (Figure G-7).

Table G-4. Twin Otter total field of view, measured in distance (m), for observers LB and RH at 0 m, 100 m, 500 m, and 2000 m perpendicular to the target, based on bootstrap predictions.

	Observer ID = LB				Observer ID = RH			
	0 m	100 m	500 m	2000 m	0 m	100 m	500 m	2000 m
2.50%	2890	2905	2978	2872	4131	4170	4233	4141
Median	3493	3482	3461	3344	4767	4754	4725	4618
Mean	3496	3489	3461	3355	4766	4758	4730	4625
97.50%	4122	4066	3965	3887	5387	5360	5242	5118

Table G-5. Twin Otter total field of view, measured in time (sec), for observers LB and RH at 0 m, 100 m, 500 m, and 2000 m perpendicular to the target, based on bootstrap predictions.

	Observer ID = LB				Observer ID = RH			
	0 m	100 m	500 m	2000 m	0 m	100 m	500 m	2000 m
2.50%	48.8	49.1	50.3	48.5	69.8	70.5	71.6	70.0
Median	59.0	58.9	58.5	56.5	80.6	80.4	79.9	78.1
Mean	59.1	59.0	58.5	56.7	80.6	80.4	80.0	78.2
97.50%	69.7	68.7	67.0	65.7	91.0	90.6	88.6	86.5

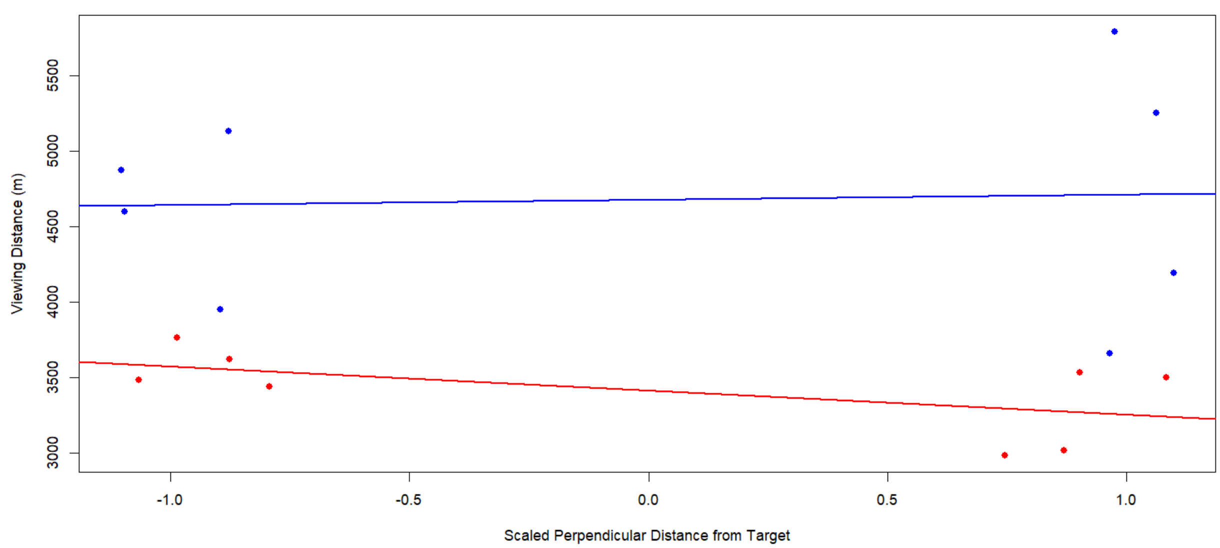


Figure G-6. Predicted total viewing distance (m) for RH (blue) and LB (red) in the Twin Otter as a function of scaled perpendicular distance from the target. The scaled distance of -1.0 corresponds to the 500-m transect; and the scaled distance of 1.0 corresponds to the 2000-m transect.

Table G-6. Twin Otter forward field of view, measured in distance (m), for observers LB and RH at 0 m, 100 m, 500 m, and 2000 m perpendicular to the target, based on bootstrap predictions.

	Observer ID = LB				Observer ID = RH			
	0 m	100 m	500 m	2000 m	0 m	100 m	500 m	2000 m
2.50%	1026	1058	1208	1420	2071	2112	2249	2445
Median	1478	1493	1558	1776	2519	2532	2595	2826
Mean	1479	1494	1554	1779	2521	2536	2596	2821
97.50%	1903	1896	1883	2169	2954	2956	2948	3187

Table G-7. Twin Otter forward field of view, measured in time (sec), for observers LB and RH at 0 m, 100 m, 500 m, and 2000 m perpendicular to the target, based on bootstrap predictions.

	Observer ID = LB				Observer ID = RH			
	0 m	100 m	500 m	2000 m	0 m	100 m	500 m	2000 m
2.50%	17.4	17.9	20.4	24.0	35.0	35.7	38.0	41.3
Median	25.0	25.2	26.3	30.0	42.6	42.8	43.9	47.8
Mean	25.0	25.2	26.3	30.1	42.6	42.9	43.9	47.7
97.50%	32.2	32.1	31.8	36.7	49.9	50.0	49.8	53.9

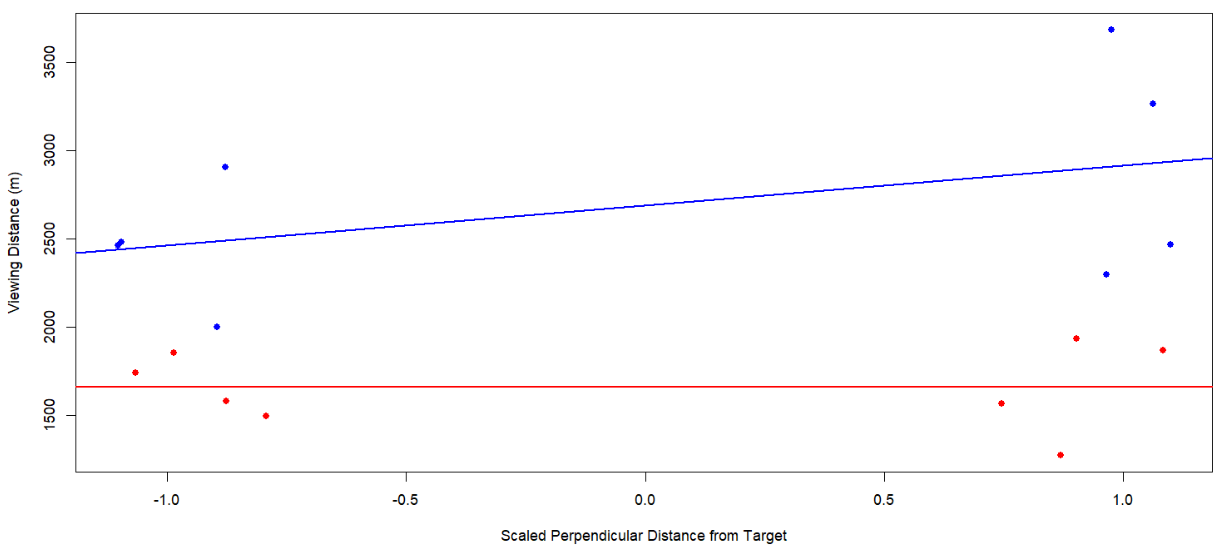


Figure G-7. Predicted forward viewing distance (m) for RH (blue) and LB (red) in the Twin Otter as a function of scaled perpendicular distance from the target. The scaled distance of -1.0 corresponds to the 500-m transect; and the scaled distance of 1.0 corresponds to the 2000-m transect.

TURBO COMMANDER

FOV flights were flown with a total of five ASAMM observers over the Franklin Bluffs target on 18 and 19 September 2018, and 7 September 2019. Survey conditions during the flights in 2018 included clear skies, unlimited visibility, and no impediments to visibility. Survey conditions during the flight in 2019 included partly cloudy skies, unlimited visibility, and no visual impediments. 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 a constant speed of ~213 km/hr.

Although there was variability in the total 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 (Figure G-8; Tables G-8 and G-9). Furthermore, bootstrap predictions and 95% confidence intervals confirmed that there was higher uncertainty in estimated field of view for the mixed effects model (Eqn 3) with observer ID as a random effect compared to a fixed effect model based only on perpendicular distance to target.

Parameter estimates from the linear mixed models were relatively similar for the left and right sides of the plane (Table G-10).

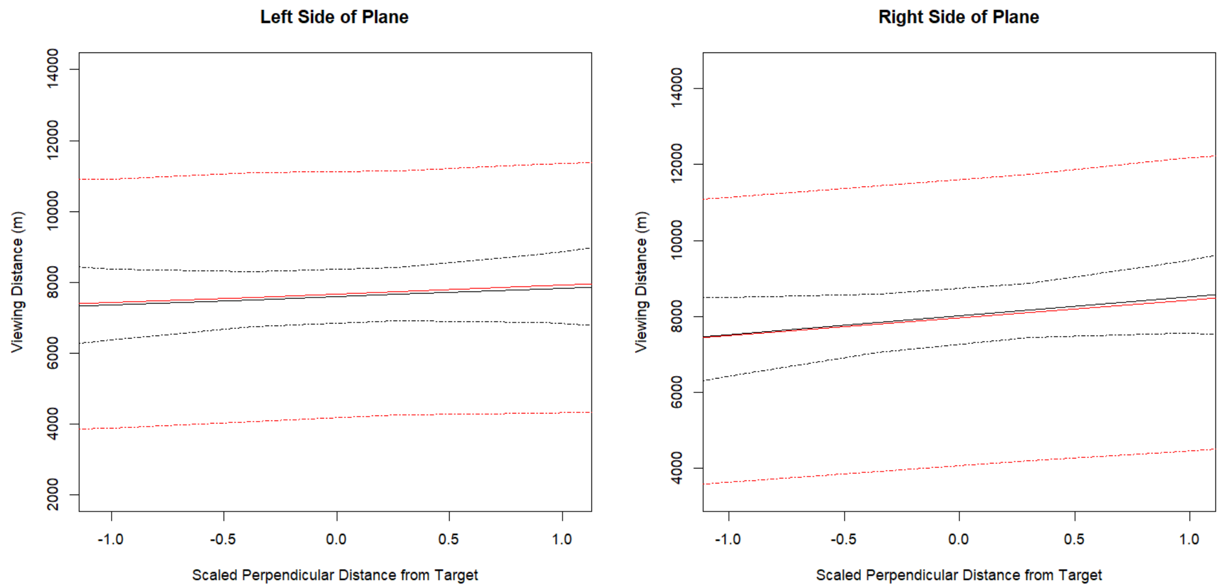


Figure G-8. Predicted total (sum of forward and aft) viewing distance (m) for a new observer seated in the left and right sides of the Turbo Commander, as a function of scaled perpendicular distance from the target. Black = bootstrap predictions and 95% confidence intervals based on a linear fixed effects models with perpendicular distance as the only predictor. Red = bootstrap predictions and 95% confidence intervals for the linear mixed effects models (Eqn 3) with observer ID as a random effect.

Table G-8. Turbo Commander total field of view, measured in distance (m), for left and right sides of the plane at 0 m, 100 m, 500 m, and 2000 m perpendicular to the target, based on bootstrap predictions.

	Left Side of Plane				Right Side of Plane			
	0 m	100 m	500 m	2000 m	0 m	100 m	500 m	2000 m
2.50%	3729	3770	3890	4300	3346	3396	3633	4446
Median	7279	7303	7416	7936	7175	7239	7486	8418
Mean	7274	7304	7427	7888	7185	7246	7492	8413
97.50%	10797	10826	10920	11333	10895	10943	11133	12155

Table G-9. Turbo Commander total field of view, measured in time (sec), for left and right sides of the plane at 0 m, 100 m, 500 m, and 2000 m perpendicular to the target, based on bootstrap predictions.

	Left Side of Plane				Right Side of Plane			
	0 m	100 m	500 m	2000 m	0 m	100 m	500 m	2000 m
2.50%	63.0	63.7	65.7	72.7	56.6	57.4	61.4	75.2
Median	123.0	123.4	125.4	134.1	121.3	122.4	126.5	142.3
Mean	122.9	123.5	125.5	133.3	121.4	122.5	126.6	142.2
97.50%	182.5	183.0	184.6	191.6	184.2	185.0	188.2	205.5

Table G-10. Parameter estimates for the linear mixed models of total viewing distance for the left and right sides of the Turbo Commander.

	Left Side of Plane		Right Side of Plane	
	Estimate	Standard Deviation	Estimate	Standard Deviation
Fixed Effects				
γ	7588.4	724.1	8001.5	723.2
$\beta_{pdist.scl}$	237.8	170.5	465.0	118.7
Random Effects				
α_{obs}	--	1726.0	--	1748.0
ε	--	816.8	--	569.0

Similar to the models for total field of view, the models for forward field of view showed that the target remained in view longer from the 2000-m transect compared to the 500-m transect and that there was variability among observers (Figure G-9; Tables G-11 and G-12). Furthermore, bootstrap predictions and 95% confidence intervals confirmed that there was higher uncertainty in estimated field of view for the mixed effects model (Eqn 3) with observer ID as a random effect compared to a fixed effect model based only on perpendicular distance to target. Parameter estimates from the linear mixed models were relatively similar for the left and right sides of the plane (Table G-13).

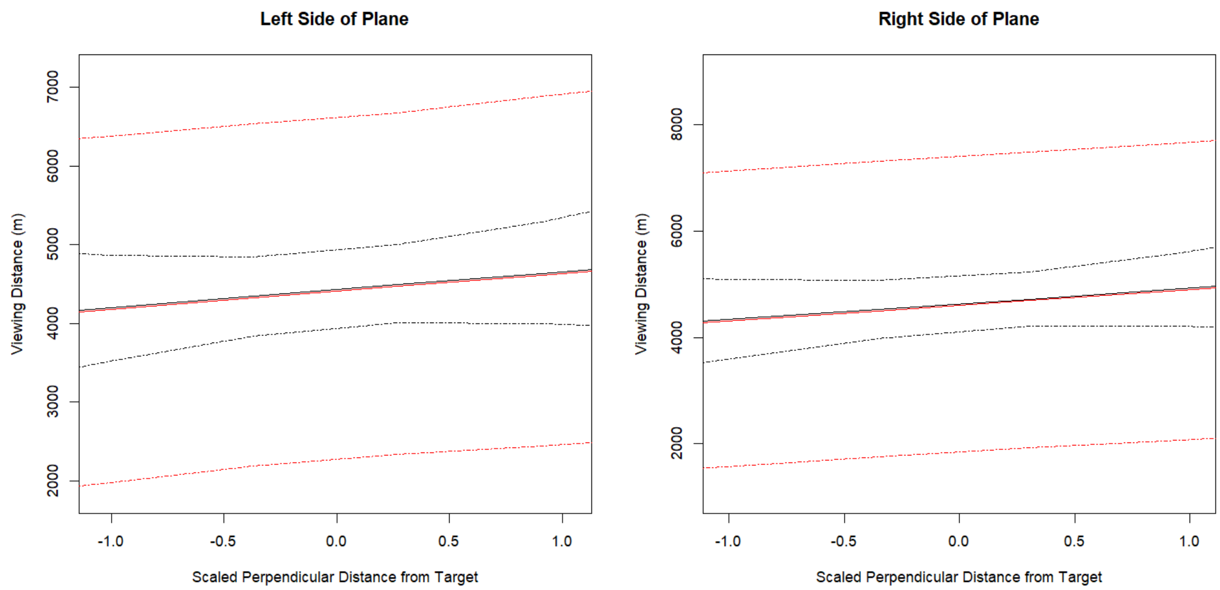


Figure G-9. Predicted forward viewing distance (m) for a new observer seated in the left and right sides of the Turbo Commander, as a function of scaled perpendicular distance from the target. Black = bootstrap predictions and 95% confidence intervals based on a linear fixed effects models with perpendicular distance as the only predictor. Red = bootstrap predictions and 95% confidence intervals for the linear mixed effects models (Eqn 3) with observer ID as a random effect.

Table G-11. Turbo Commander forward field of view, measured in distance (m), for left and right sides of the plane at 0 m, 100 m, 500 m, and 2000 m perpendicular to the target, based on bootstrap predictions.

	Left Side of Plane				Right Side of Plane			
	0 m	100 m	500 m	2000 m	0 m	100 m	500 m	2000 m
2.50%	1798	1831	1978	2445	1405	1436	1561	2062
Median	4017	4039	4155	4575	4099	4145	4305	4910
Mean	4035	4064	4181	4618	4109	4148	4305	4893
97.50%	6242	6277	6378	6887	6933	6971	7129	7656

Table G-12. Turbo Commander forward field of view, measured in time (sec), for left and right sides of the plane at 0 m, 100 m, 500 m, and 2000 m perpendicular to the target, based on bootstrap predictions.

	Left Side of Plane				Right Side of Plane			
	0 m	100 m	500 m	2000 m	0 m	100 m	500 m	2000 m
2.50%	30.4	31.0	33.4	41.3	23.7	24.3	26.4	34.9
Median	67.9	68.3	70.2	77.3	69.3	70.1	72.8	83.0
Mean	68.2	68.7	70.7	78.1	69.4	70.1	72.8	82.7
97.50%	105.5	106.1	107.8	116.4	117.2	117.8	120.5	129.4

Table G-13. Parameter estimates for the linear mixed models of forward viewing distance for the left and right sides of the Turbo Commander.

	Left Side of Plane		Right Side of Plane	
	Estimate	Standard Deviation	Estimate	Standard Deviation
Fixed Effects				
γ	4430.2	442.2	4635.9	538.40
$\beta_{pdist.scl}$	221.8	117.6	297.52	92.68
Random Effects				
α_{obs}	--	1045.8	--	1299.9
ε	--	563.6	--	444.4

Acknowledgments

Special thanks to the ASAMM observers and pilots who enthusiastically flew racetracks around stationary objects on the tundra to their hearts' content 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, Alexander De Boer, Carol Fairfield, Megan Ferguson, Marjorie Foster, Laura Ganley, Rachel Hardee, Griffin Kellar, Suzie Hanlan, Andy Harcombe, Ben McDaniel, Robert McPhie, Jesse Munday, Kate Pagan, Jake Turner, Markku Vanonen, and Amy Willoughby. We also thank Laura Ganley and Sarah Converse for providing analytical expertise and sample computer code for analyzing the FOV data.

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. 464 pp.

Ganley, L.C., S. Brault, and C.A. Mayo. 2019. What we see is not what there is: estimating North Atlantic right whale *Eubalaena glacialis* local abundance. *Endangered Species Research* 38:101-113.

Laake, J.L. and D.L. Borchers. 2004. Methods for incomplete detection at distance zero. Pp. 108-189. *In:* S.T. Buckland, D.R. Anderson, K.P. Burnham, J.L. Laake, D.L. Borchers, and L. Thomas (eds.), *Advanced Distance Sampling: Estimating abundance of biological populations*. Oxford University Press.

Robertson, F.C., W.R. Koski, J.R. Brandon, T.A. Thomas, and A.W. Trites. 2015. Correction factors account for the availability of bowhead whales exposed to seismic operations in the Beaufort Sea. *Journal of Cetacean Research and Management* 15: 35-44.

APPENDIX H: SAFETY and LOGISTICS PLAN, 2019

Aerial Surveys of Arctic Marine Mammals and ASAMM Bowhead Abundance Safety and Logistics Plan 29 June 2019 (updated 31 July 2019)

The Aerial Surveys of Arctic Marine Mammals (ASAMM) and ASAMM Bowhead Abundance (ABA) projects are co-managed by BOEM and the Alaska Fisheries Science Center (AFSC, NOAA Fisheries), conducted by AFSC, and funded by BOEM and NOAA. The ASAMM study area covers the eastern Chukchi and western Beaufort seas, from 140° to 169°W, 67° to 72°N, and the ABA study area covers the eastern and western Beaufort Sea shelf and Amundsen Gulf from 117° to 158°W (Figure H-1). The 2019 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). The Utqiaġvik team will be in the field from 1 July until 2 August (when that team relocates to Inuvik for ABA) and from 28 August until the end of the field season in late October, and the Deadhorse team will be in the field from 18 July – 11 October. Lodging in Utqiaġvik will be provided by the King Eider Inn, and lodging in Deadhorse will be provided by Brooks Range Camp. 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.

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 health services. 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 British Petroleum. 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

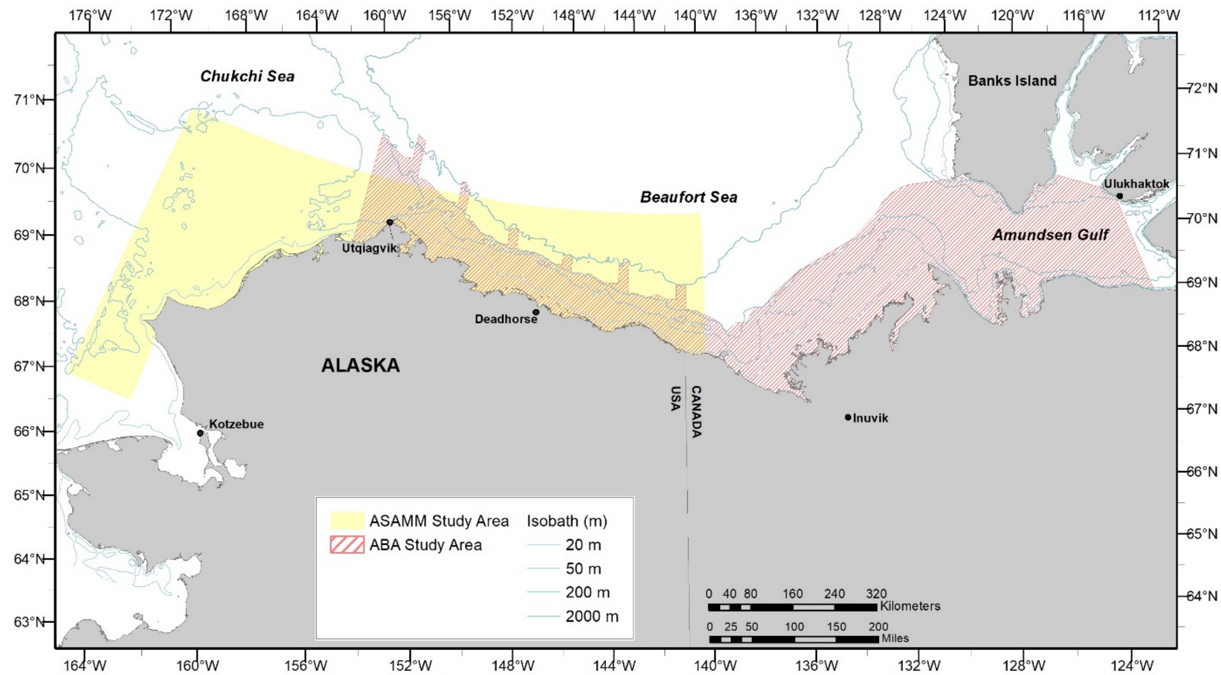


Figure 1. ASAMM and ABA study areas, 2019.

year; they are located on oilfield lease land, and their phone number is 907 659 5239. Access to the facility is via the Central Check Point gate, beyond which oil field security will provide an escort to MCC. 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

Emergency Support Services at the ABA Bases of Operations

ABA will be conducted in August only, and will operate from Deadhorse, Alaska, and Inuvik and Ulukhaktok, Northwest Territories, Canada (Figure H-1). Information specific to Deadhorse remains the same as outlined above. ABA teams will be based in Inuvik from 4-28 August and in Ulukhaktok from 6-28 August. Lodging in Inuvik will be provided by Capitol Suites and lodging in Ulukhaktok will be provided by the Arctic Char Inn. One Turbo Commander, operated by Clearwater Air, Inc., will reposition from Utqiaġvik to Inuvik and will be available to ABA under an exclusive use contract for the duration of the ABA field season. One Twin

Otter, operated by Kenn Borek Air, Inc., will be stationed in Ulukhaktok and will be available to ABA under an exclusive use contract for the duration of the ABA field season.

Primary emergency support services in Inuvik include Inuvik Fire Department (867 777 2222), the Royal Canadian Mounted Police (867 777 1111), and the Inuvik Regional Hospital. The hospital provides emergency clinic and urgent care in the Beaufort Delta Region of the Northwest Territories. It is open for emergencies 24 hours a day. It is located at 286-289 Mackenzie Road, and the phone number is 867 777 8000. Medical assistance in Ulukhaktok will be handled by the Ulukhaktok Health Services, located at Block 10, Lot 13. The clinic is open Monday-Friday, 0830-1700, but can be reached after hours by phone 867 396 3111. The Northwest Territories Health and Social Services Authority is responsible for any emergency air evacuations.

Inuvik is 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 Yellowknife or Edmonton. There is a territorial hospital in Yellowknife and a provincial hospital in Edmonton, both of which provide emergency services 24 hours a day:

Stanton Territorial Hospital	University of Alberta Hospital
550 Byrne Road	8440 112 Street NW
Yellowknife, NT X1A 2N1	Edmonton, AB T6G 2B7
867 669 4111	780 407 8822

Aviation Safety Protocols

The ASAMM and ABA aviation safety protocols are based on training, emergency preparedness, flight following, and reporting, as detailed below.

Training

Each person flying on ASAMM and ABA 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 2019 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 2019 season will include Turbo Commander and Twin Otter (twin turbine, high fixed-wing) aircraft. The Commanders were used during previous ASAMM field seasons. The Twin Otter aircraft has been used for surveys and cargo logistics throughout the Canadian Arctic. The Clearwater Air Pilots in Command have an average of over 8,500 hrs flying experience and considerable experience flying small aircraft in arctic Alaska. The Ken Borek Pilot in Command has over 10,000 hours experience flying Twin Otters in remote areas of Canada and Greenland. All PICs also conduct a comprehensive Flight Risk

Assessment (Figure H-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 and ABA 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, personal locator beacon, portable marine and aviation band transceivers, satellite 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.

Risk Assessment Template.xlsx

Clearwater Air — **Multi-Engine IFR**

Flight Risk Assessment

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 H-2. Example pre-flight Risk Assessment completed prior to every ASAMM and ABA survey flight.

Every survey flight will be satellite-tracked in real-time by the Automated Flight Following (AFF) system via SpiderTracks (Clearwater Air) or SkyTrac (Ken Borek). 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 2013-2018, the aviation dispatchers from the Alaska Fire Service, Bureau of Land Management, will provide real-time flight following assistance to the project. Kenn Borek Air Dispatch will provide additional real-time flight following for the Twin Otter.

Aviation Safety Reporting

Two types of safety reporting mechanisms may be used by ASAMM and ABA personnel: SAFECOM reporting is a tool that is maintained by the Department of Interior, and Clearwater Air and Kenn Borek each have their own Safety Management System in place. ASAMM and

ABA 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.

Kenn Borek has an extensive Emergency Response Manual that details company policy, responsibilities, communication, categories of accidents and incidents, accident report forms, and more. The Manual is proprietary to Kenn Borek, contact Joel Consaul (jconsaul@borekair.com) for additional information.

During an ASAMM or ABA 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; signaling devices), ASAMM and ABA 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 local 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 and ABA projects do not provide firearms and no personal observer firearms are allowed on the survey aircraft. Clearwater Air and Kenn Borek pilots may use their discretion regarding whether they bring personal firearms onto the plane. Some of the lodging facilities allow firearms but with special considerations or restrictions. Pilots will inquire prior to the field season as to firearms rules.

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 and ABA team have 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 and ABA provide field personnel with access to a Bear Awareness and Defense Training Manual on the survey laptops.

In Utqiaġvik and Ulukhaktok, 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 and Arctic Char Inn managers usually hear the latest on if/where bears are present. If ASAMM or ABA personnel think a bear has gone undocumented, they will report it to the local law enforcement authorities.

Brown bears are year-round residents in Deadhorse and Inuvik, and are frequently seen. Walking around Deadhorse is frowned upon, due to the bear presence, industrial activity, and truck traffic in the area. Walking in Inuvik is acceptable but all ABA team members are encouraged to be vigilant and aware of their surroundings at all times. Polar bears are rarely sighted in Deadhorse or Inuvik, are far less habituated to human activity, and may be far more aggressive than resident brown bears. If ASAMM or ABA personnel observe any bears anywhere in Deadhorse or Inuvik, they will immediately report the sighting to local law enforcement authorities.

Contact Information

ASAMM Project Management maintains an updated list of emergency contact information for all NOAA employees and contractors participating in ASAMM and ABA surveys. Additional emergency contact information is provided in the ASAMM and ABA master contact list, which is distributed to all ASAMM and ABA personnel.

APPENDIX I – ASAMM BOWHEAD ABUNDANCE (ABA) SURVEYS

Background

The Western Arctic bowhead whale stock is hunted for subsistence by Alaska Natives. The most recent population abundance estimate for this stock is approximately 17,000, derived from a 2011 ice-based survey (Givens et al. 2017). The International Whaling Commission (IWC) sets the aboriginal subsistence quota for BCB bowhead whales, requiring a new population abundance estimate every 10 years. Based on IWC rules, a new abundance estimate is required by spring 2021.

From 1978 through 2011, ice-based surveys conducted during spring near Point Barrow, Alaska, reliably provided data needed to estimate the abundance of BCB bowhead whales. Deteriorating spring sea ice conditions in the Arctic have increased the risks, and lowered the chances of success, of conducting ice-based surveys. Forecasted changes in Arctic climate are likely to exacerbate this trend. Photo-identification data also have been used successfully to estimate BCB bowhead whale abundance in a mark-recapture framework, but analyzing imagery for this type of analysis is time intensive, typically resulting in a minimum 3-year lag between when the imagery are collected and a new abundance estimate is finalized.

In spring 2018, NOAA convened a workshop to discuss, in-depth, if and how ASAMM surveys could be adapted to collect the data needed to estimate BCB bowhead whale abundance. As a result of that workshop, several new protocols were introduced and successfully tested in summer and fall 2018. In August 2019, ASAMM Bowhead Abundance (ABA) surveys were conducted. ABA is a collaboration between NOAA, BOEM, NSB, and Canadian colleagues in the Department of Fisheries and Oceans Canada (DFO), Inuvialuit Game Council (IGC), and Fisheries Joint Management Committee (FJMC).

The objective of ABA was to apply ASAMM line-transect methodology to survey the Beaufort Sea shelf and Amundsen Gulf, with additional transects west of Pt. Barrow, west of Banks Island, and possibly in Viscount Melville Sound (VMS), within a three-week period in August. The spatial and temporal scope were chosen to coincide with the time period when the majority of the BCB bowhead whale stock is believed to be located in a region that could be effectively surveyed using aerial line-transect methods.

Study Area and Survey Priorities

For the purposes of this appendix, the ABA study area extended from 118°W-158°W (Figure I-1) (Note: in the main body of the report, references to the ABA study area was limited to the subset of data collected between 118°W-140°W). The primary study area extended from west of Point Barrow to the eastern part of Amundsen Gulf (118°W–158°W), encompassed approximately 253,000 km^2, and consisted of 80 transects. Secondary survey areas, with predefined transects, were located in Viscount Melville Sound and west of Banks Island.

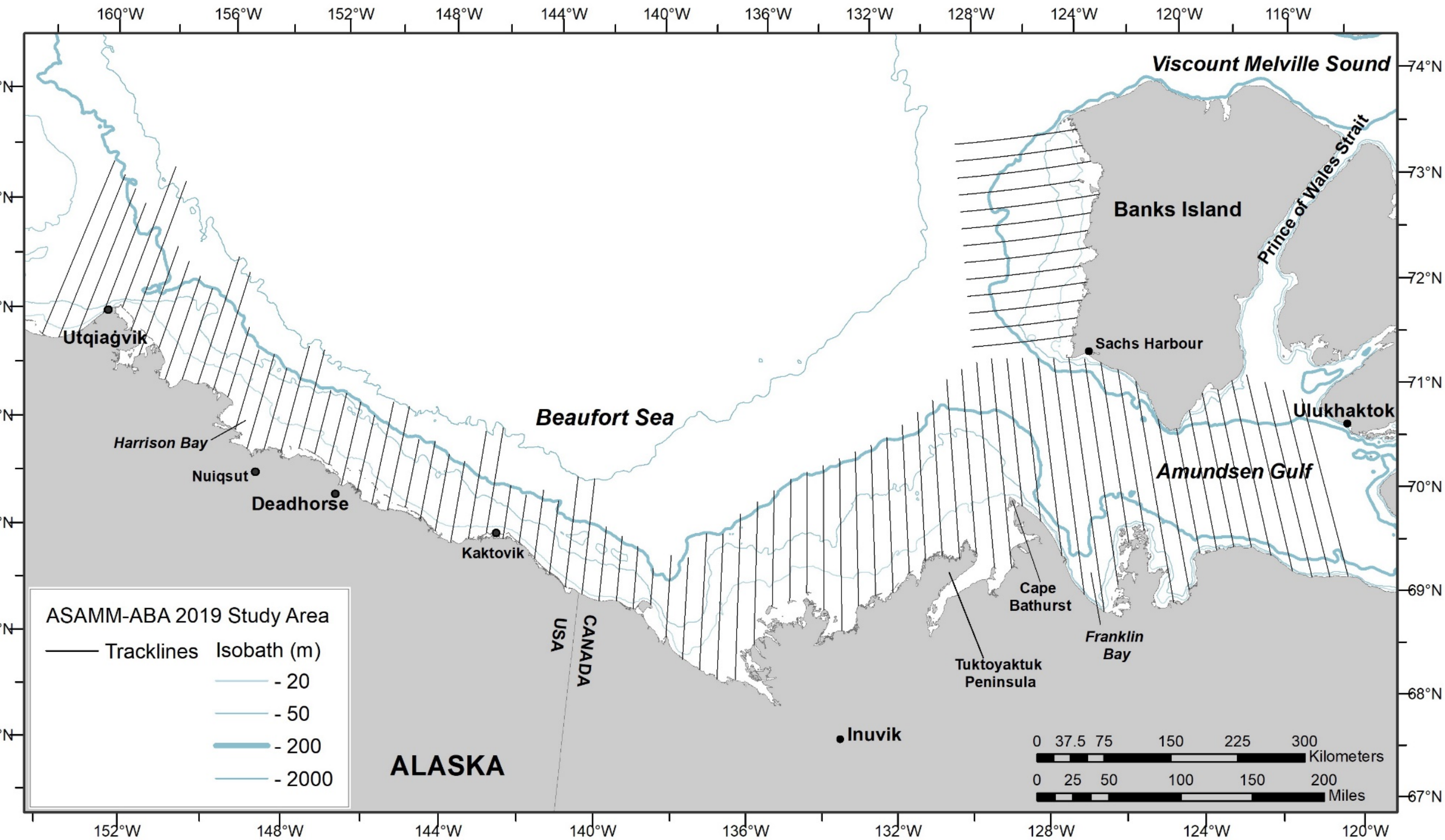


Figure I-1. ABA study area, transects, and bathymetry.

Surveying transects was the highest priority during ABA. ABA transects covered the area from shore to the 200-m isobath to encompass the area in which most bowheads were expected to occur in August, based on whaling records, previous aerial surveys and tagging data, and traditional knowledge (Figure I-1). A few transects in the western Beaufort Sea extended to the 2,000-m isobaths to confirm that the full extent of the whales' range was surveyed. Transects were designed to be perpendicular to dominant bathymetric gradients. Primary transects to be flown during ABA were oriented north-south. Secondary transects west of Banks Island were oriented east-west.

Field Methods and Preliminary Analyses

Survey protocols were identical to those used during ASAMM with very few exceptions. Survey teams were based in Deadhorse, AK, to cover the western Beaufort and easternmost Chukchi seas (~140°W–158°W), and in Inuvik and Ulukhaktok, Northwest Territories, Canada, to cover the eastern Beaufort Sea and Amundsen Gulf (117°W–140°W). During ABA, there was no survey team based in Utqiaġvik, AK.

Inuvik and Ulukhaktok are on Mountain Daylight Time (MDT), which is two hours earlier than Alaska Daylight Time (AKDT). All survey laptops remained on AKDT time, resulting in the time data being recorded in AKDT, to maintain continuity with the ASAMM historical database and facilitate analyses of the full ABA study area.

Bowhead whales had priority over other species during ABA. Data collection on other species continued when it did not impact bowhead whale data collection.

ABA received approval from the Inuvialuit Game Council and the Joint Game Management Committee to conduct surveys in the Inuvialuit Settlement Region. Additional permits were not required.

Sighting rate analysis was conducted on two spatial scales in the ABA study area. Sighting rates 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, were calculated for bowhead whales. Sighting rates for depth zones were calculated for bowhead whales, gray whales, and belugas. Depth zones were divided into three subareas: western Beaufort Sea (140°W–158°W), eastern Beaufort Sea (127°W–140°W) and Amundsen Gulf (117°W–127°W). Depth zone sighting rate analysis did not include any data north of 72°N. On-effort km (transect and CAPs passing) and sightings (primary observers only; transect and CAPs-adjusted) were used for sighting rate analyses.

Results

The ABA field season commenced 3 August 2019 and ended 29 August 2019. Two days at the beginning and two days at the end of the field season were required to mobilize field teams in Canada, including relocating the Utqiaġvik-based team to Inuvik and back again. One day at the beginning of the field season was also dedicated to a pre-survey orientation for the two Canada-based survey teams. Survey flights were conducted from 5 to 27 August (Table I-1). There were

Table I-1. ABA aerial survey effort in chronological order, 5-27 August 2019, by survey flight. 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.

Day	Flight No.	On-Effort (km)	Off-Effort (km)	CAPs circling (km)	FGF (km)	FOV (km)	Deadhead (km)	Total (km)	On-Effort (hrs)	Total (hrs)
5 Aug	10	538	39	0	0	0	444	1,021	2.4	4.1
6 Aug	11	0	0	0	0	0	436	436	0.0	1.3
8 Aug	401	178	20	0	0	0	261	459	0.8	2.0
8 Aug	216	352	43	0	0	0	485	881	1.6	3.4
9 Aug	217	0	43	0	0	0	967	1,009	0.0	3.0
9 Aug	402	159	3	0	0	0	282	445	0.8	1.9
11 Aug	12	0	0	0	0	0	444	444	0.0	1.3
11 Aug	403	230	33	0	0	0	533	796	1.1	3.2
12 Aug	13	400	136	0	0	0	405	941	1.8	3.7
12 Aug	218	449	37	80	0	0	511	1,077	2.0	4.2
13 Aug	404	0	0	0	0	0	152	152	0.0	0.6
13 Aug	219	112	45	0	0	0	642	798	0.5	2.7
14 Aug	220	325	30	150	0	0	730	1,236	1.5	4.9
15 Aug	405	160	26	0	0	0	635	820	0.8	3.3
15 Aug	15	93	114	0	0	0	369	576	0.4	2.1
16 Aug	16	127	2	0	0	0	321	449	0.6	1.6
16 Aug	221	364	48	0	0	0	940	1,352	1.7	4.7
17 Aug	222	375	18	0	0	0	1,640	2,032	1.7	6.4
19 Aug	406	610	106	0	0	0	940	1,655	2.8	7.1
19 Aug	223	621	53	0	0	0	1,079	1,753	2.9	6.5
20 Aug	407	58	0	0	0	0	645	703	0.3	2.6
20 Aug	224	904	149	0	0	0	1,586	2,639	4.2	9.8
21 Aug	408	909	200	0	0	0	942	2,051	4.3	8.8
21 Aug	225	648	151	0	0	0	935	1,734	3.0	7.0
21 Aug	18	942	137	0	0	0	709	1,788	4.2	7.3
22 Aug	409	449	138	0	0	549	593	1,729	2.1	7.6
22 Aug	226	413	76	0	0	0	779	1,268	1.9	4.7
22 Aug	19	398	25	0	0	0	380	803	1.8	3.1
23 Aug	410	287	37	0	0	0	468	792	1.3	3.3
23 Aug	227	63	2	0	0	0	552	616	0.3	2.0
25 Aug	411	495	103	0	0	0	525	1,123	2.3	4.8
25 Aug	228	600	14	0	0	0	797	1,411	2.7	5.2

Day	Flight No.	On-Effort (km)	Off-Effort (km)	CAPs circling (km)	FGF (km)	FOV (km)	Deadhead (km)	Total (km)	On-Effort (hrs)	Total (hrs)
25 Aug	20	274	135	0	0	0	458	867	1.2	3.3
26 Aug	229	434	32	0	0	0	1,094	1,560	2.0	5.4
26 Aug	412	403	114	0	0	0	566	1,083	1.9	4.8
26 Aug	21	727	57	0	0	0	734	1,517	3.2	5.8
27 Aug	230	280	35	0	0	0	912	1,227	1.3	4.3
27 Aug	413	308	53	0	0	0	679	1,041	1.4	4.3
27 Aug	22	492	174	0	0	0	132	798	2.2	3.5
Total		14,177	2,428	230	0	549	25,702	43,082	65.0	165.6

39 ABA survey flights, including 11 by the Deadhorse-based team, 15 by the Inuvik-based team, and 13 by the Ulukhaktok-based team. Not included in this total were two of the surveys conducted by the Deadhorse-based team during 5-27 August, one to the southern Chukchi Sea and one to specifically collect data on Field of View (Appendix G).

Over 43,000 km were flown during 165.6 hours in the ABA study area (Figure I-2). A total of 14,177 km was flown on effort (transect and CAPs passing) during 65 hours; there was no effort on CAPs strip. Ninety-five percent of primary transects were surveyed wholly or partially at least once; 54 of the 80 primary transects were surveyed completely. Three transects in the eastern Chukchi Sea and one transect in Amundsen Gulf were not surveyed at all. Portions of three secondary transects southwest of Banks Island were surveyed, but effort off central and northern Banks Island and in Viscount Melville Sound was not possible due to weather and fuel restrictions. Sixty percent of total survey kilometers were flown on deadhead. The high amount of deadhead was due in large part to the unavoidable transits over land between Inuvik and the survey area (Figure I-2). On nine 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 all three survey teams on five days.

Survey effort during ABA was impacted by poor weather conditions and the unavailability of aviation fuel in Ulukhaktok after 15 August. Survey conditions during the first half of the ABA survey period were abysmal. Strong winds, high sea states, and poor visibility severely limited effort, and only 54.4 hours (33% of total effort) were flown in the first 14 days. Several surveys from 5 to 18 August consisted of long transits searching in vain for suitable survey conditions. Survey conditions improved dramatically from 19 to 27 August, when 67% of total effort was completed.

On 15 August, Transport Canada informed one of the ABA aircraft contractors that aviation fuel in Ulukhaktok, Paulatuk, and Sachs Harbour was available only for emergency services and scheduled charter flights. The Ulukhaktok-based survey team relocated to Inuvik for the remainder of ABA. Pre-season flight planning incorporated contingencies to address potential lack of fuel in Paulatuk and Sachs Harbour, but the restriction of fuel in Ulukhaktok negatively

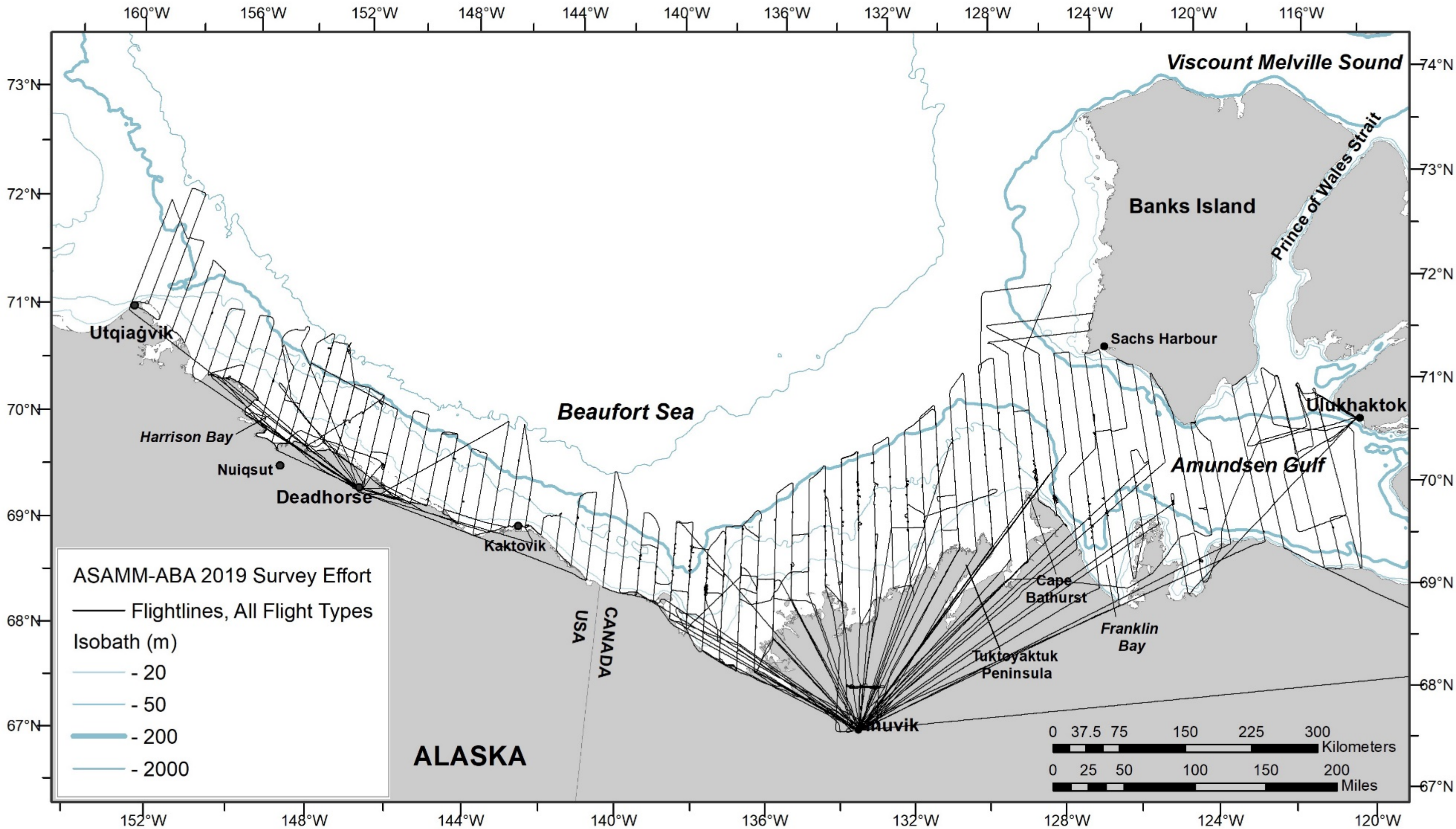


Figure I-2. Survey coverage in the ABA study area, including transect, CAPs, circling, search, and deadhead, 5-27 August 2019.

impacted surveys in eastern Amundsen Gulf. The lack of fuel in Ulukhaktok also squashed any possibility of surveying in Viscount Melville Sound or off northern Banks Island.

Most surveys were conducted in areas completely lacking sea ice (Figure A–4), including most of Amundsen Gulf and the western Beaufort Sea. Sea ice (10–40%) in the primary study area remained offshore between Franklin Bay and the Tuktoyaktuk Peninsula. The area west of Banks Island, McClure Strait, and Viscount Melville Sound retained heavier sea ice cover throughout August.

BOWHEAD WHALES

During the 2019 ABA surveys, 311 sightings of 440 bowhead whales of the BCB stock were observed in the ABA study area during transect, CAPs, search and circling modes (Figure I-3). Sightings were distributed from 119°W to 152°W. Bowhead whale sightings in Amundsen Gulf were primarily in Franklin Bay. In the eastern Beaufort Sea, bowhead whales were sighted near Cape Bathurst and offshore of the Tuktoyaktuk Peninsula in Northwest Territories, Canada, and north of Herschel Island in Yukon Territory, Canada. Bowhead whale distribution in Canada was similar to that found in August 2007–2009 by Harwood et al. (2010) and shared some similarities with aggregation areas identified by Harwood et al. (2017) using satellite tag data. However, bowhead whales were not seen in shallow waters close to the Tuktoyaktuk Peninsula and only one whale was seen in Darnley Bay. Relatively few bowhead whales were observed in the western Beaufort Sea, particularly west of 152°W, or in eastern Amundsen Gulf.

Most bowhead whales observed during ABA were swimming (55%, $n_i = 242$), followed by resting (19%, $n_i = 84$), milling (13%, $n_i = 58$), feeding (2%, $n_i = 9$), and diving (2%, $n_i = 8$). 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. In a few instances, whales recorded as swimming had mud on their heads, indicating that feeding near the sea floor had occurred at some time prior to the sighting. Feeding and milling behaviors were observed primarily in Franklin Bay and north of Herschel Island (Figure I-4). Nineteen whales were recorded exhibiting display behaviors, including breaches (11 whales), log play (6 whales), and tail slaps (2 whales). A group of three whales were recorded as surface active (SAG, surface active group). Behavior was recorded as unknown for 17 whales, likely because the sightings were too far away to determine a behavior.

Mean vector bowhead whale swim direction during ABA was 208°T but headings were scattered in several directions (Rayleigh $Z = 1.441$, $P = 0.237$, 120 observations). Mean vector swim directions varied between the eastern Beaufort Sea and Amundsen Gulf (203°T) and western Beaufort Sea (267°T), with headings in all directions.

Sixty-four bowhead whale calves were seen, all in the eastern Beaufort Sea and western Amundsen Gulf (~127°W–140°W), mainly concentrated west of the Tuktoyaktuk Peninsula and in Mackenzie Canyon (Figure I-5). Most calves ($n_i = 36$, 56%) were sighted after circling was initiated and likely would not have been observed if circling had not commenced. Calves were observed with adult bowhead whales that were swimming, resting, milling, and feeding. Calf

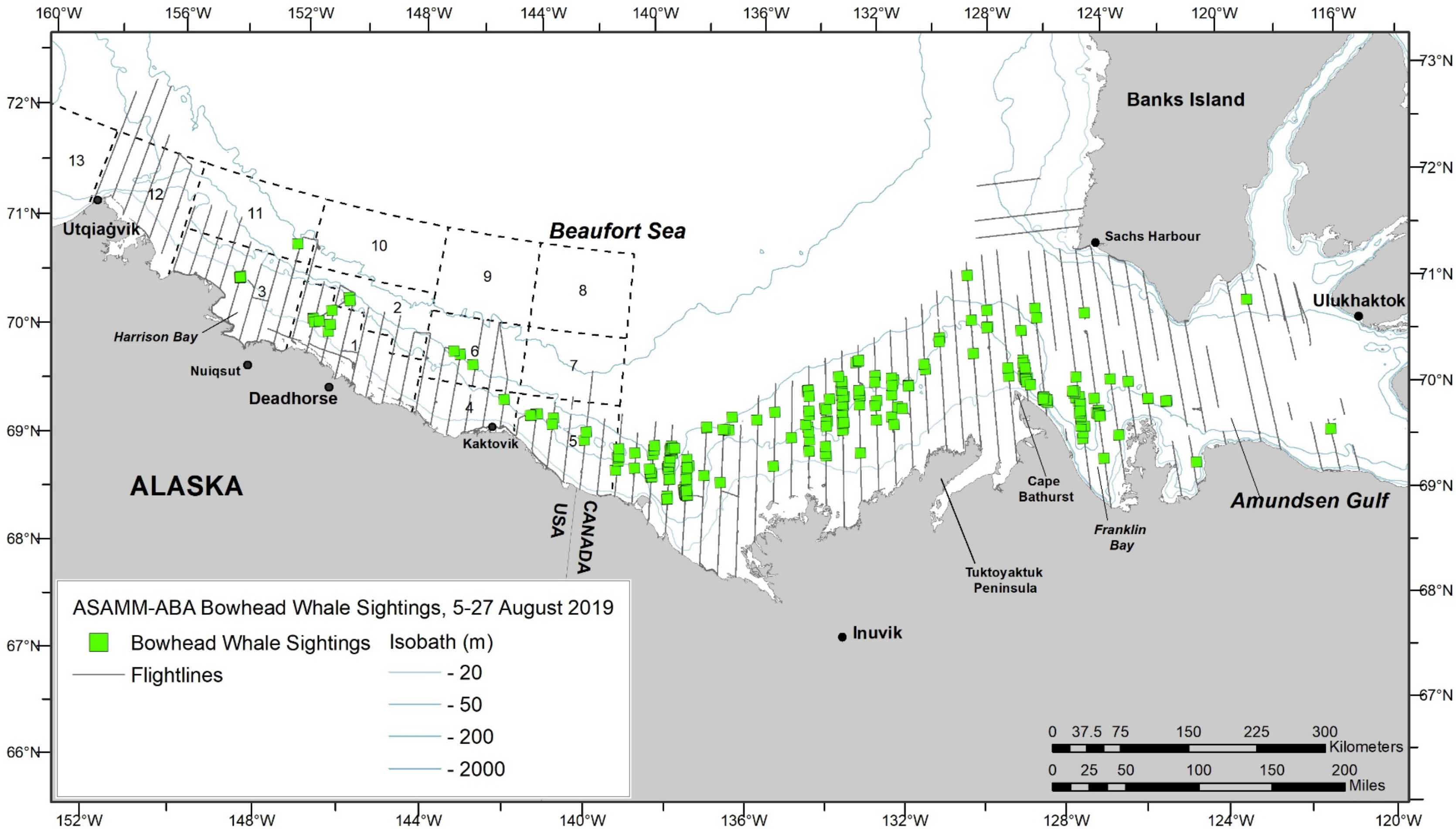


Figure I-3. Bowhead whale sightings in the ABA study area, all survey modes, 5-27 August 2019.

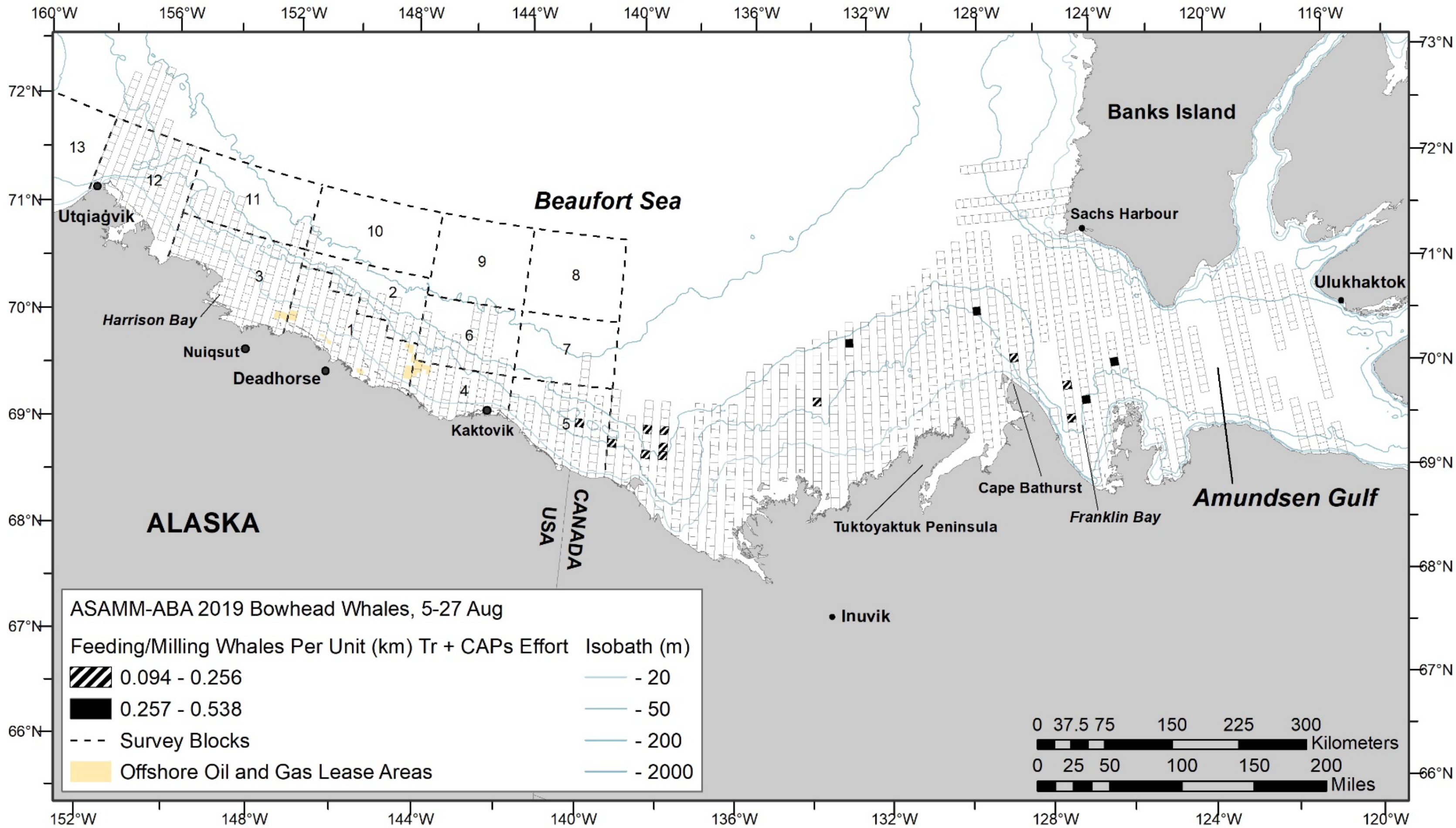


Figure I-4. Bowhead whale on-effort feeding and milling sighting rates (WPUE; sightings from primary observers only) in the ABA study area, 5-27 August. Empty cells indicate sighting rates of zero. Transect and CAPs survey effort were not conducted in areas without cell outlines.

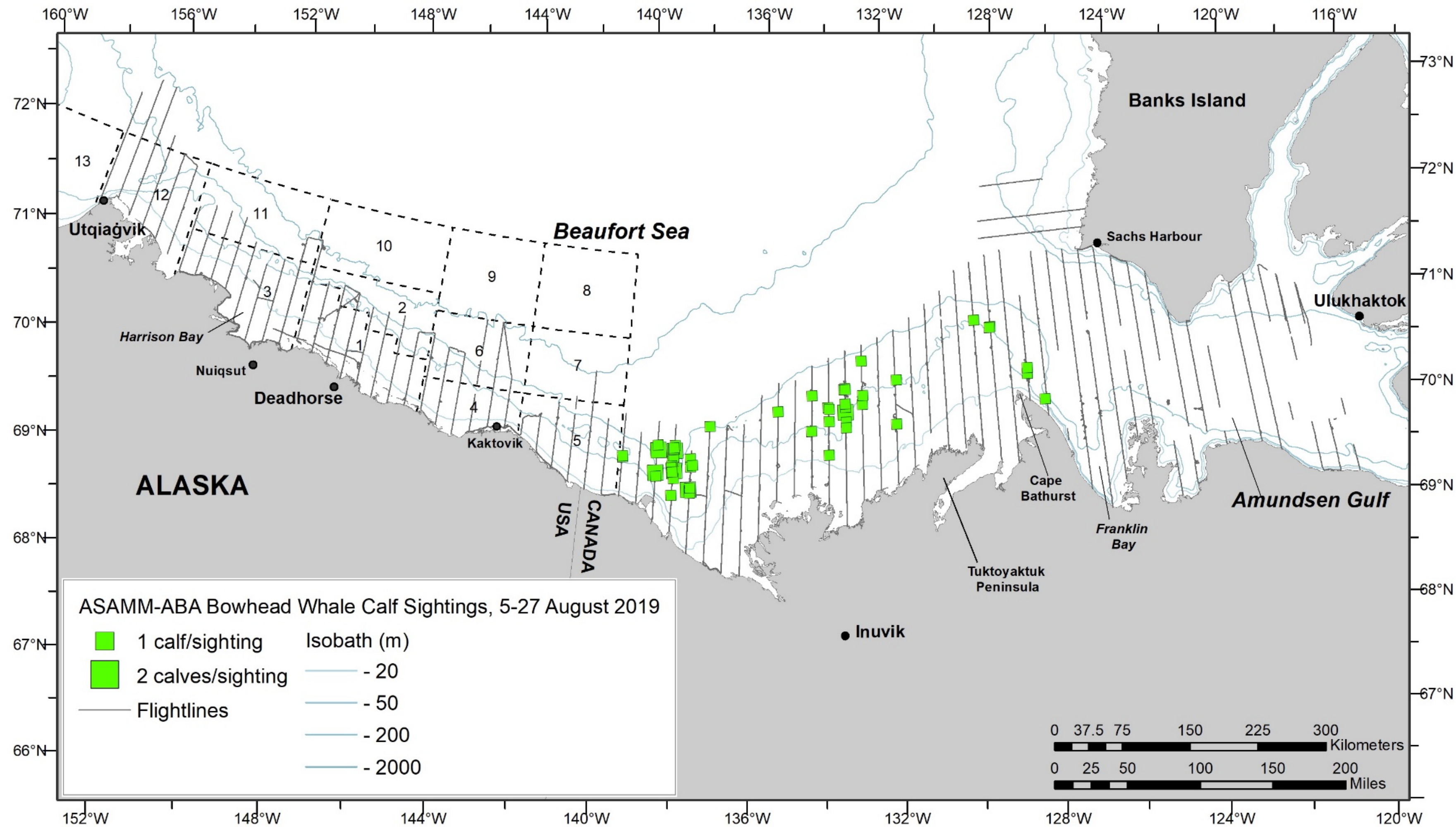


Figure I-5. Bowhead whale calf sightings in the ABA study area, all survey modes, 5-27 August 2019.

behavior usually mirrored that of the accompanying adult, but calves were also observed breaching, rolling, playing with logs, and flipper slapping. On three occasions, one adult whale was sighted with two similarly-sized calves in very close proximity (e.g., less than one body length apart). Fourteen calves were sighted without a closely associated adult, although in some of those cases ($n_i = 5$) adult whales were in the general vicinity.

Survey teams tried to note whenever noticeably large whales were observed, based either on size relative to other whales or extensive white coloration on the tail and peduncle. Thirty-one large bowhead whales were noted, and were found primarily in two areas, Franklin Bay and between the Tuktoyaktuk Peninsula and Herschel Island. Fifty-five percent ($n_i = 17$) of large whales were seen during a single survey on 20 August in Franklin Bay. Five of the large whales were cows with calves. In the eastern Beaufort and Amundsen Gulf (east of 140°W), large bowhead whales were observed in deeper water (median depth = 208 m) than other bowhead whales (median depth 94 m; $Z = 2.566$, $P = 0.0103$). Large bowhead whales were also found to be in deeper Beaufort shelf and Amundsen Gulf habitats by Koski et al. (1988), Koski and Miller (2009), and Harwood et al. (2017).

Bowhead whales were seen on effort (transect and CAPs-adjusted) from 119.3°W to 152°W. There were 213 sightings of 317 bowhead whales on effort by primary observers in the ABA study area, ranging from one whale per sighting ($n_s = 120$) to 5 whales per sighting ($n_s = 3$). Highest fine-scale sighting rates (WPUE, 5-km grid) in the ABA study area were in Franklin Bay, offshore of the Tuktoyaktuk Peninsula, and northeast of Herschel Island (Figure I-6). Sighting rates per depth zone were highest in the 51–200 m depth zone in the western Beaufort Sea (0.0126 WPUE) and eastern Beaufort Sea (0.0779 WPUE), and in the 201–2,000 m depth zone in Amundsen Gulf (0.0224 WPUE) (Figure I-7). Overall sighting rate was highest in the eastern Beaufort (0.0349 WPUE) and lowest in the western Beaufort (0.0056 WPUE).

GRAY WHALES

Eight sightings of 15 gray whales were observed in the ABA study area during transect, CAPs, search, and circling modes (Figure I-8). All gray whales were observed on a single day (21 August) east-northeast of the Tuktoyaktuk Peninsula. Gray whales were observed in two clusters, both of which were near bowhead whales (Figure I-9). Gray whales in both clusters were observed feeding ($n_i = 8$), evidenced by the presence of well-formed mud plumes. Seven gray whales were swimming. One gray whale calf was seen. Sighting rate was highest in the 21-50 m depth zone (0.0036 WPUE). Gray whale sightings during ABA represent the highest number of gray whales observed on any one day or single year in the eastern Beaufort Sea (Brower et al. 2015; Iwahara et al. 2016; Willoughby et al. 2020).

BELUGAS

There were 625 sightings of 1,124 belugas in the ABA study area during transect, CAPs, search, and circling modes (Figure I-8). Stock identity is unknown but, based on analyses by Hauser et al. (2014), most belugas seen in the eastern Beaufort Sea and Amundsen Gulf were likely of the Eastern Beaufort stock. Belugas were distributed from 118.8°W to 157°W, although there were very few sightings west of 150°W.

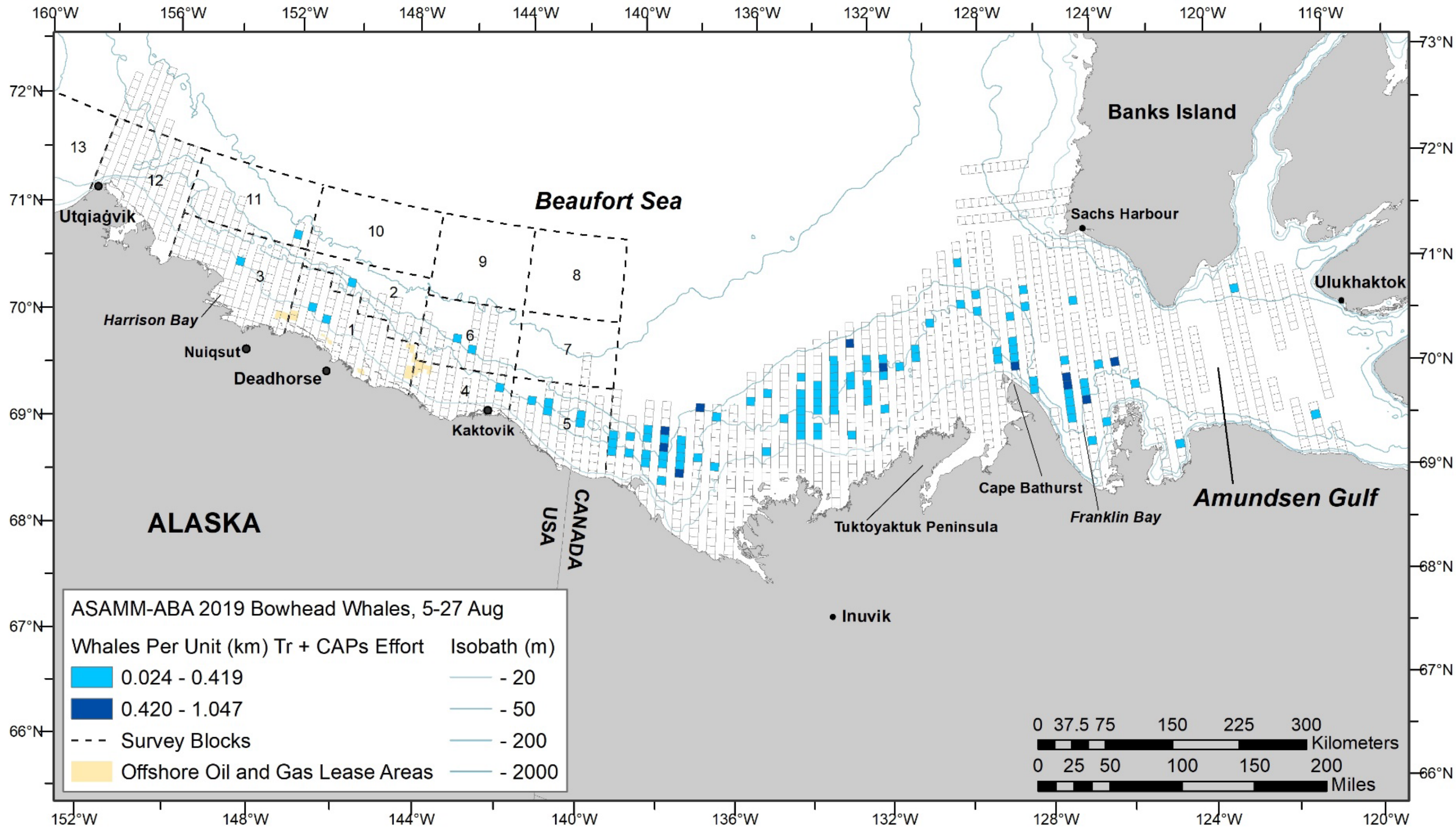


Figure I-6. Bowhead whale on-effort sighting rates (WPUE; sightings from primary observers only) in the ABA study area, 5-27 August 2019. Empty cells indicate sighting rates of zero. Transect and CAPs survey effort were not conducted in areas without cell outlines.

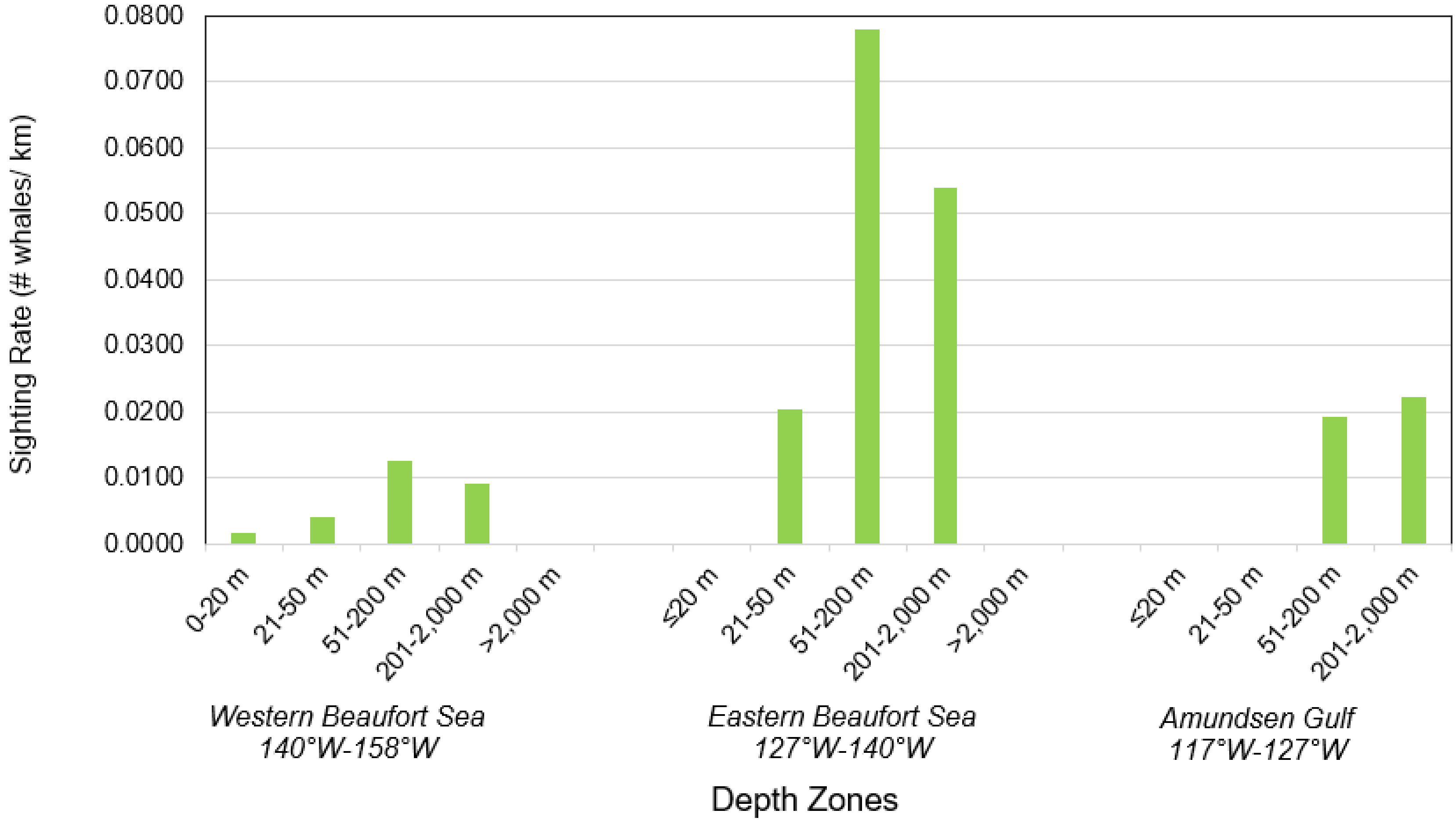


Figure I-7. Bowhead whale on-effort sighting rates (WPUE; sightings from primary observers only) per depth zone in the ABA study area, 5-27 August. Sighting rates of zero were removed from the graph for clarity.

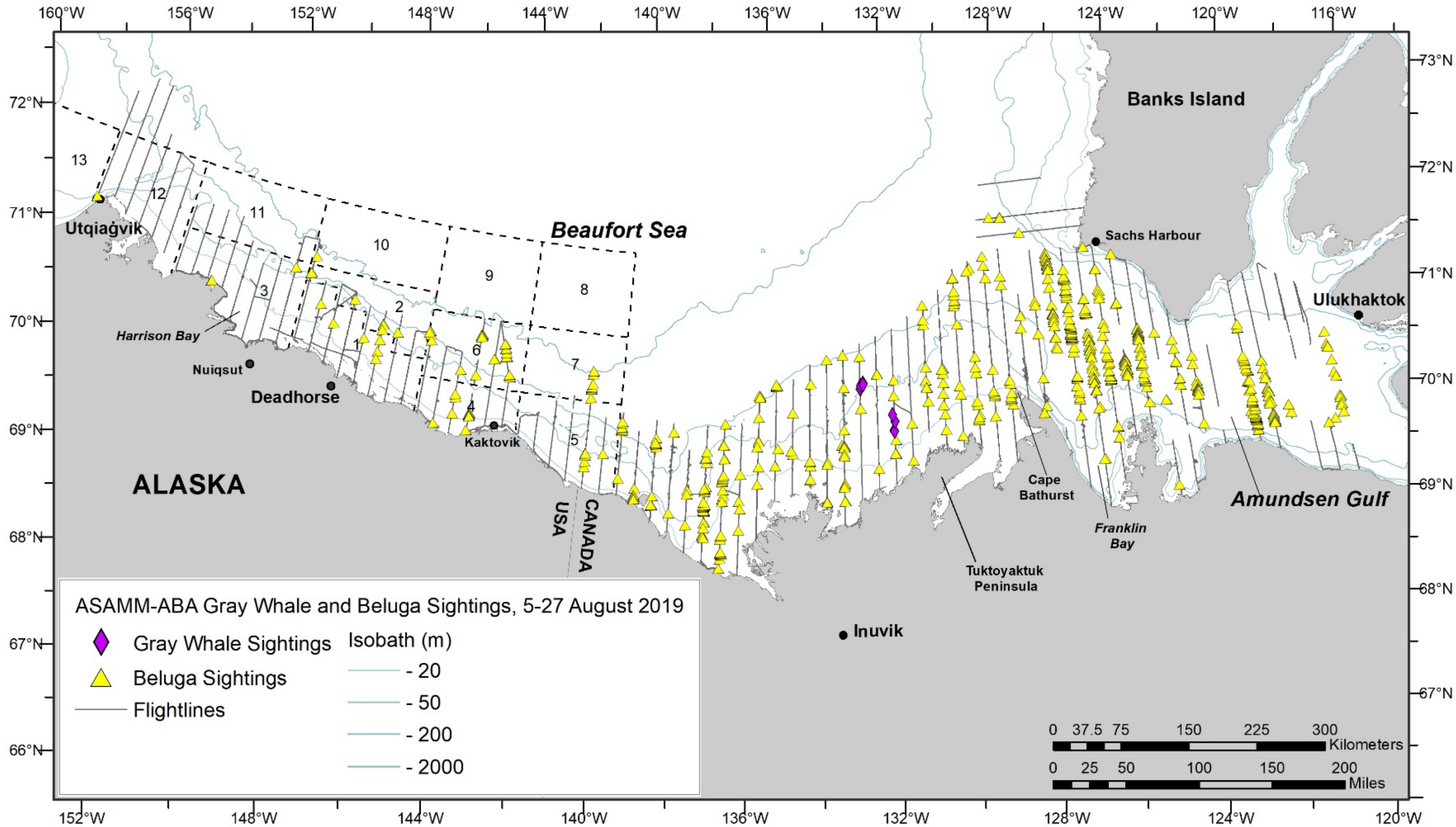


Figure I-8. Gray whale and beluga sightings in the ABA study area, all survey modes, 5-27 August 2019.

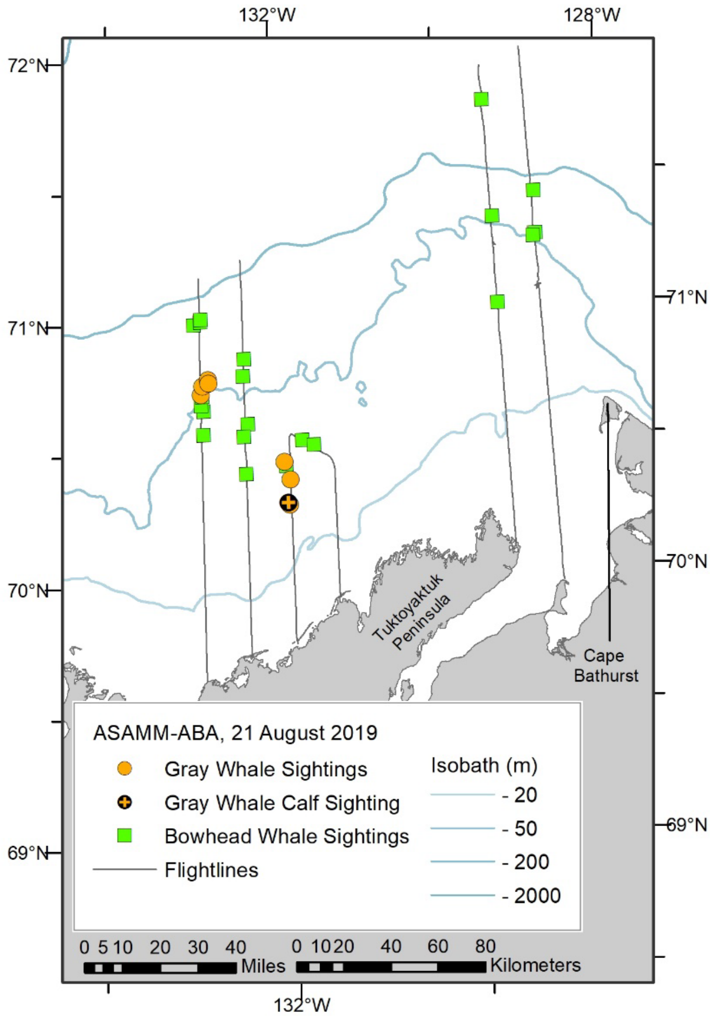


Figure I-9. Bowhead and gray whale sightings, eastern Beaufort Sea, 21 August 2019.

Most belugas (78%) in the ABA study area were swimming. Swim direction was westerly in Amundsen Gulf (263°T, Rayleigh Z = 18.126, P < 0.0001, 273 observations), the eastern Beaufort Sea (285°T, Z = 9.863, P < 0.0001, 197 observations), and the western Beaufort Sea (287°T, Z = 4.093, P = 0.0170, 64 observations).

Beluga group size ranged from 1 (n_s = 466) to 70 (n_s = 1) in the ABA study area. Sixty-eight beluga calves were seen. Calf numbers were likely under-reported because circling was not initiated on beluga sightings.

Highest fine-scale sighting rates (WPUE, 5-km grid) for belugas in the ABA study area were in Amundsen Gulf, offshore of the Tuktoyaktuk Peninsula, and offshore of Deadhorse, AK (Figure I-10). Sighting rates per depth zone were highest in the 201-2,000 m depth zone in the western

Beaufort Sea (0.1152 WPUE), eastern Beaufort Sea (0.0743 WPUE), and Amundsen Gulf (0.2717 WPUE) (Figure I-11). Overall sighting rate was highest in Amundsen Gulf (0.0722 WPUE) and lowest in the western Beaufort (0.0363 WPUE).

Polar Bears

There were 49 sightings of 149 polar bears in the ABA study area during transect, CAPs, search, and circling modes (Figure I-12). In the western Beaufort Sea, polar bears were sighted on shore or on barrier islands, with the greatest numbers of polar bears observed near Kaktovik and Cross Island, AK. Several polar bears were sighted during coastal transect surveys that were flown 1 km offshore. In the eastern Beaufort Sea, polar bears were sighted on shore only on Banks Island; note that the coastal transect did not extend to the eastern Beaufort Sea so there was far less opportunity to observe polar bears on shore compared to the western Beaufort Sea. In the eastern Beaufort Sea, polar bears were also sighted offshore in areas of broken floe sea ice. A few offshore polar bears were swimming, but most were on ice. Three bears were observed at kill sites.

Pinnipeds

There were 3 sightings of 3 walruses in the ABA study area during transect, CAPs, search and circling modes (Figure I-13); all three walruses were in the western Beaufort Sea. There were 4 sightings of 4 bearded seals in the ABA study area during transect, CAPs, search and circling modes; 3 of the bearded seals were in the western Beaufort Sea and 1 bearded seal was sighted in the eastern Beaufort Sea. There were 369 sightings of 735 unidentified and small unidentified pinnipeds in the ABA study area during transect, CAPs, search and circling modes. Most unidentified pinnipeds were seen from western Amundsen Gulf (~124°W) to the western Beaufort Sea (~152°W). Pinnipeds were disproportionately seen in depths >20 m.

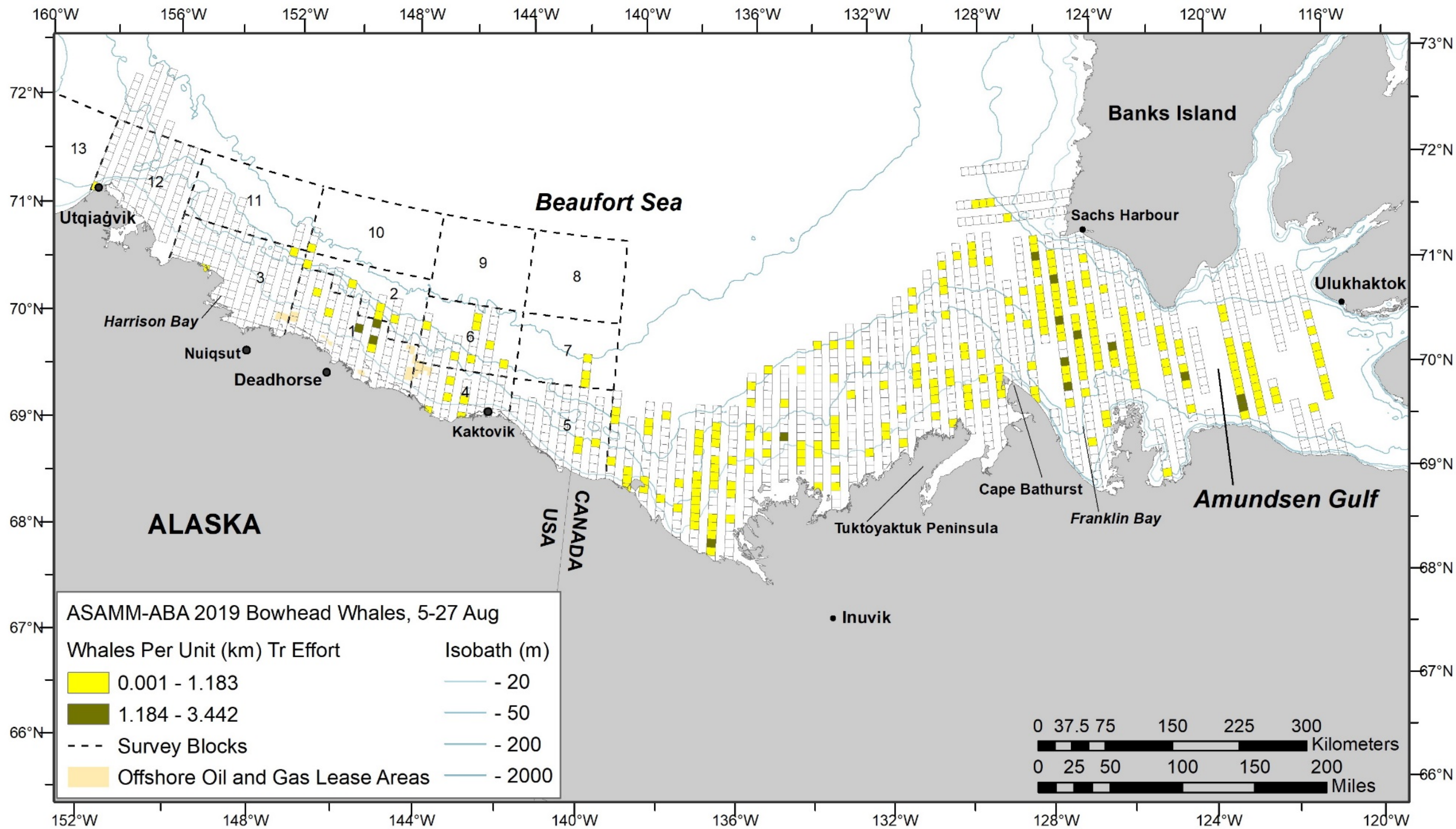


Figure I-10. Beluga on-effort sighting rates (WPUE; sightings from primary observers only) in the ABA study area, 5-27 August 2019. Empty cells indicate sighting rates of zero. Transect effort was not conducted in areas without cell outlines.

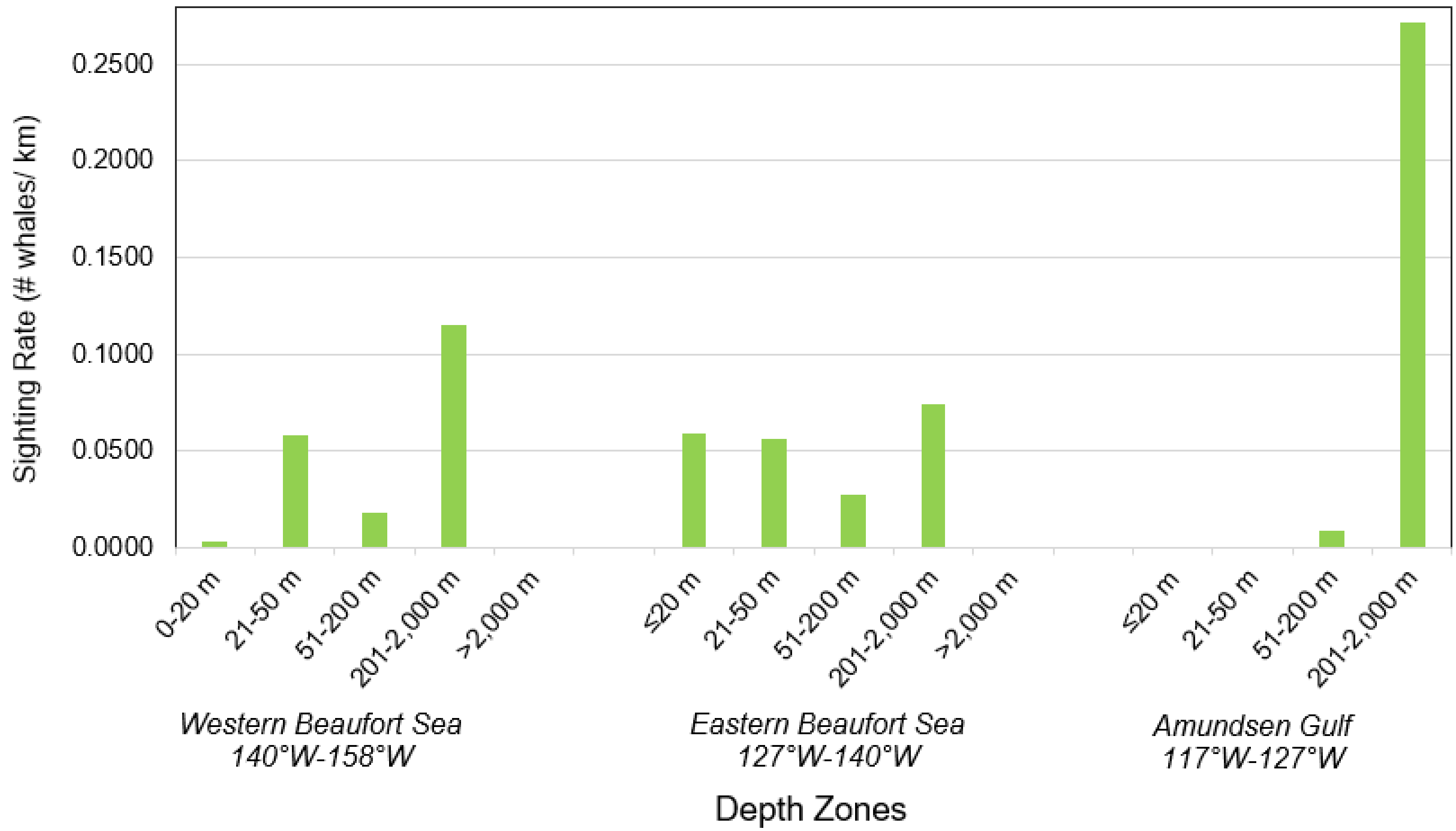


Figure I-11. Beluga on-effort sighting rates (WPUE; sightings from primary observers only) per depth zone in the ABA study area, 5-27 August. Sighting rates of zero were removed from the graph for clarity.

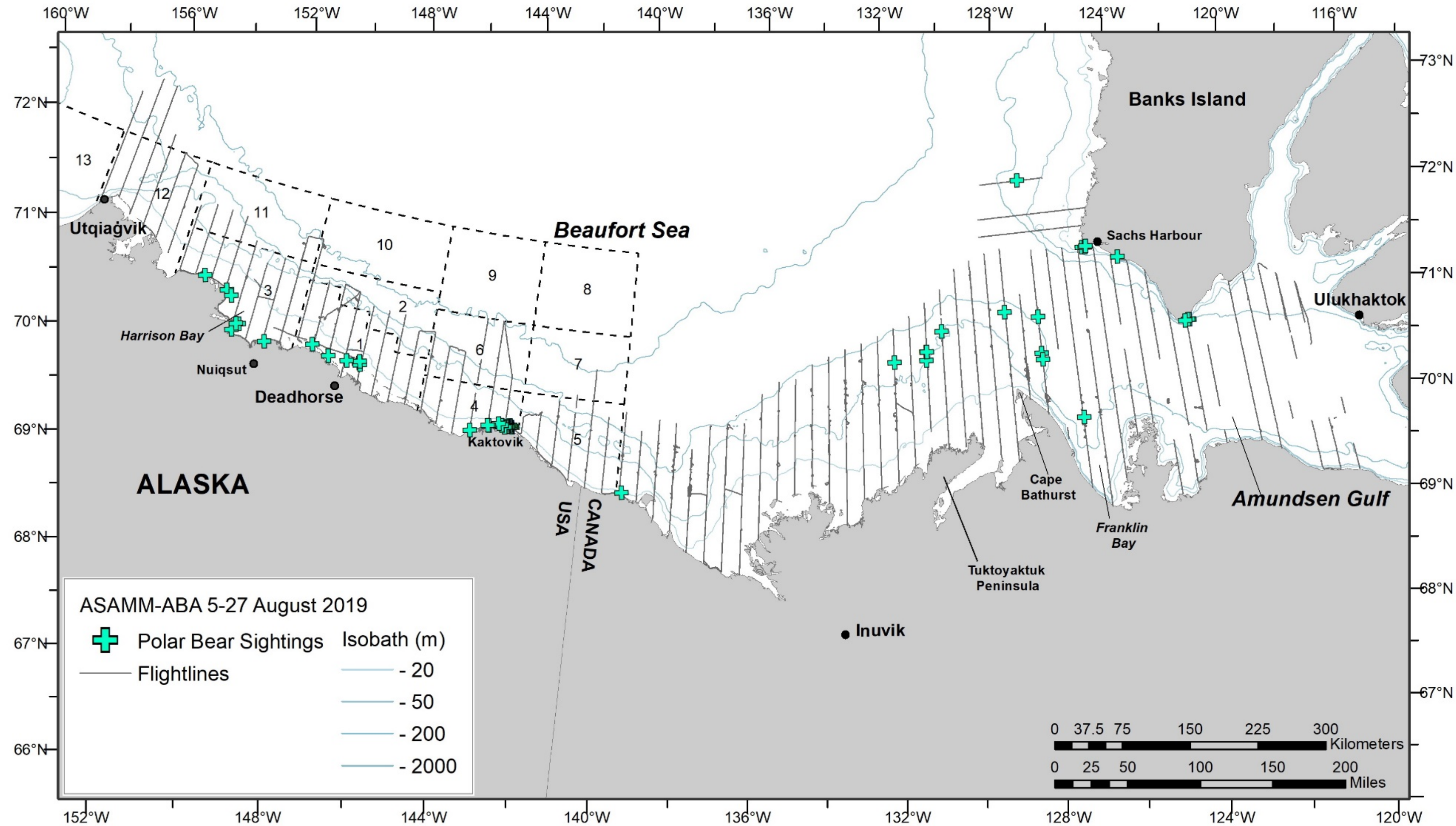


Figure I-12. Polar bear sightings in the ABA study area, all survey modes, 5-27 August 2019.

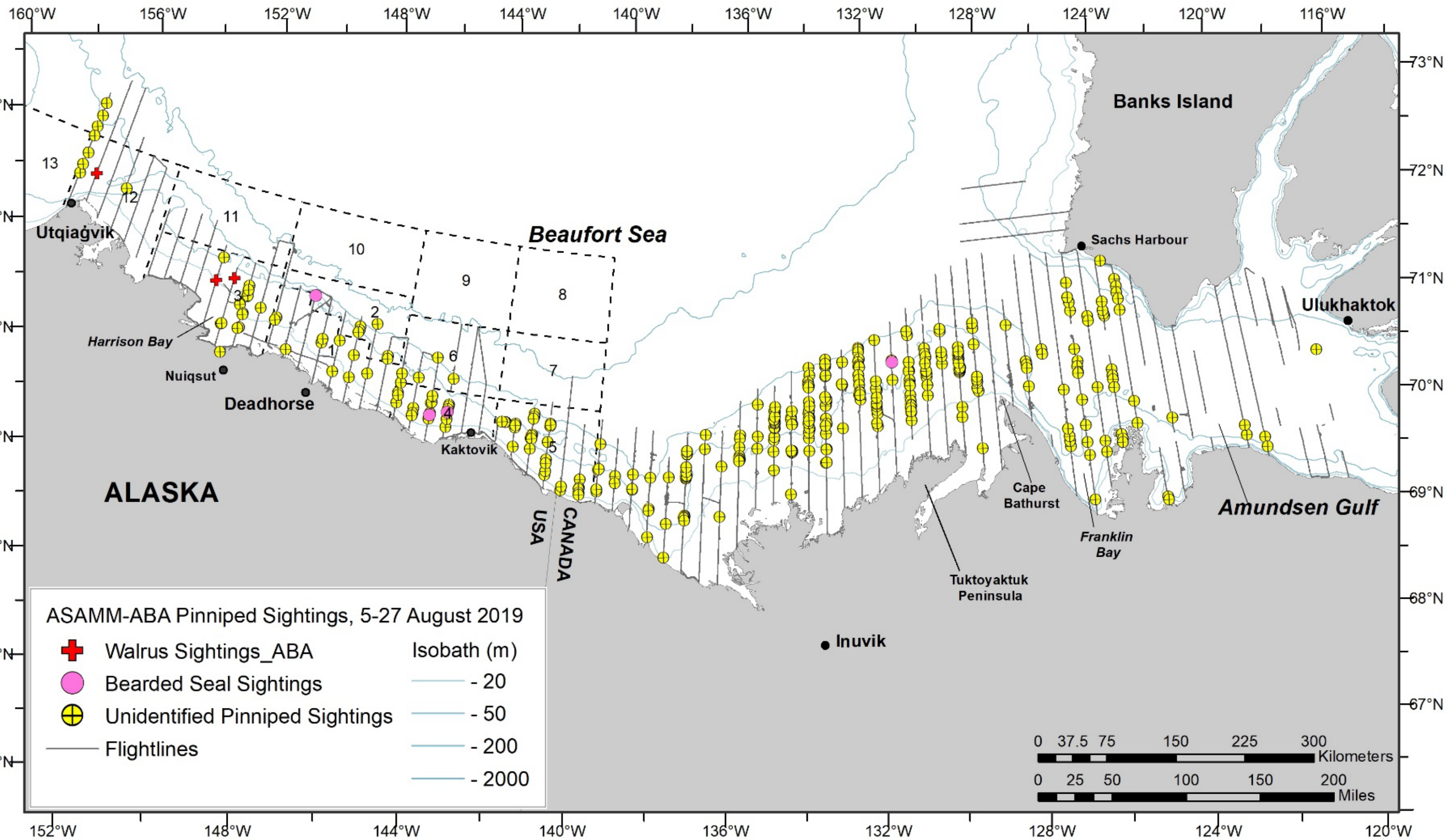


Figure I-13. Pinniped sightings in the ABA study area, all survey modes, 5-27 August 2019.

Acknowledgments

The ABA effort was a monumental task that would not have been possible without the exceptional assistance, support, and cooperation of several individuals and organizations. Our outstanding ABA field teams included team leaders Amelia Brower, Janet Clarke, Megan Ferguson, Katie Jackson, and Amy Willoughby; observers Corey Accardo, Lisa Barry, Laura Ganley, Suzie Hanlan, Rachel Hardee, Richard Holt, and Nick Metheny; pilots Chantelle Callaway, Stan Churches, Jake Creglow, Alex De Boer, Elijah Jensen, Ben McDaniel, Jake Turner, and Mark Vanonen; and mechanics William Allen, Chris Creglow, and Andre Martineau. Surveys were conducted on aircraft provided by Clearwater Air, Inc., Anchorage, AK, and Kenn Borek Air, Calgary, Alberta, in collaboration with Aklak Air, Inuvik, Northwest Territories, where we appreciated the logistical (and emotional) support of Andrew Harcombe and Joel Consaul, respectively. Hangar and other aircraft support services were provided by Aklak Air. Several agencies and companies supported ABA directly and indirectly, including BOEM (Cathy Coon, Richard Raymond), NOAA (Robyn Angliss, Ben Hou, Audrey Rotrock, Kim Shelden, Janice Waite), NSB (Billy Adams, Craig George, Geof Givens, Robert Suydam), AEWC, DFO (Lois Harwood, Ellen Lea, Lisa Loseto, Marianne Marcoux, Shannon MacPhee), FJMC, and IGC, JISAO (Katie Luxa, Collen Marquist, Christy Sims), and OAI, Inc. All surveys were flight followed in real-time by Anchorage Interagency Dispatch Center (BLM) and Kenn Borek Dispatch. Valuable offshore weather reports were provided by the F/V Frosti (Andy Majewski, Jane Eert). Our thanks to all!

Literature Cited

Brower, A., J. Clarke, and M. Ferguson. 2015. Gray Whale Occurrence in the Beaufort Sea. Poster: Alaska Marine Science Symposium, Anchorage, AK, January 2015.

Givens, G.H., S.L. Edmondson, J.C. George, R. Suydam, R.A. Charif, A. Rahaman, D. Hawthorne, B. Tudor, R.A. DeLong, and C.W. Clark. 2016. Horvitz-Thompson whale abundance estimation adjusting for uncertain recapture, temporal availability variation, and intermittent effort. *Environmetrics* 27:134-146.

Harwood, L.A., J. Auld, A. Joynt, and S.E. Moore. 2010. Distribution of bowhead whales in the SE Beaufort Sea during late summer, 2007-2009. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/111. iv + 22 p.

Harwood, L.A., L.T. Quakenbush, R.J. Small, J.C. George, J. Pokiak, C. Pokiak, M.P. Heide-Jørgensen, E.V. Lea, and H. Brower. 2017. Movements and inferred foraging by bowhead whales in the Canadian Beaufort Sea during August and September, 2006-12. *Arctic* 70(2): 161-176.

Hauser, D.D.W., K.L. Laidre, R.S. Suydam, and P.R. Richard. 2014. Population-specific home ranges and migration timing of Pacific Arctic beluga whales (*Delphinapterus leucas*). *Polar Biology* 37: 1171-1183.

Iwahara, Y., A. Fujiwara, K. Ito, K. Kazushi, and Y. Mitani. 2016. Gray whale sightings in the Canadian Beaufort Sea, September 2014. *Polar Science* 10: 173-176.

Koski, W.R., G.W. Miller, and R.A. Davis. 1988. The potential effects of tanker traffic on the bowhead whale in the Beaufort Sea. Environmental Studies 58. Report from LGL Limited, King City, Ontario, for the Department of Indian Affairs and Northern Development, Hull, Quebec. 50pp. NTIS MIC-90 -045 52.

Koski, W.R. and G.W. Miller. 2009. Habitat use by different size classes of bowhead whales in the central Beaufort Sea during late summer and autumn. *Arctic* 62(2): 137-150.

Willoughby, A., J. Clarke, A. Brower, M. Ferguson, L. Barry, R. Hardee, S. Hanlan, N. Metheny, and H. Foley. 2020. A yarn of wayward whales in the eastern Chukchi and Eastern Beaufort Seas, 2019. Poster: Alaska Marine Science Symposium, Anchorage, AK, January 2020.

This page intentionally left blank.

APPENDIX J: ASAMM GIS PROJECTIONS

For calculating distance from shore in APFU

FOR THE CHUKCHI: "CENTRAL_MERIDIAN", -163.0

PROJCS["Chukchi Equidistant Conic",GEOGCS["GCS_North_American_1983",DATUM["D_North_American_1983",SPHEROID["GRS_1980",6378137.0,298.257222101]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.0174532925199433]],PROJECTION["Equidistant_Conic"],PARAMETER["False_Easting",0.0],PARAMETER["False_Northing",0.0],PARAMETER["Central_Meridian",-163.0],PARAMETER["Standard_Parallel_1",68.5],PARAMETER["Standard_Parallel_2",71.5],PARAMETER["Latitude_Of_Origin",70.0],UNIT["Meter",1.0]]

FOR BEAUFORT AK AND ABUNDANCE WEST: "CENTRAL_MERIDIAN", -148.0

PROJCS["Beaufort Equidistant Conic",GEOGCS["GCS_North_American_1983",DATUM["D_North_American_1983",SPHEROID["GRS_1980",6378137.0,298.257222101]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.0174532925199433]],PROJECTION["Equidistant_Conic"],PARAMETER["False_Easting",0.0],PARAMETER["False_Northing",0.0],PARAMETER["Central_Meridian",-148.0],PARAMETER["Standard_Parallel_1",70.5],PARAMETER["Standard_Parallel_2",71.5],PARAMETER["Latitude_Of_Origin",71.0],UNIT["Meter",1.0]]

FOR ABUNDANCE CENTRAL: "CENTRAL_MERIDIAN", -132.0

PROJCS["Abundance Central Equidistant Conic",GEOGCS["GCS_North_American_1983",DATUM["D_North_American_1983",SPHEROID["GRS_1980",6378137.0,298.257222101]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.0174532925199433]],PROJECTION["Equidistant_Conic"],PARAMETER["False_Easting",0.0],PARAMETER["False_Northing",0.0],PARAMETER["Central_Meridian",-132.0],PARAMETER["Standard_Parallel_1",69.5],PARAMETER["Standard_Parallel_2",71.5],PARAMETER["Latitude_Of_Origin",70.5],UNIT["Meter",1.0]]

FOR ABUNDANCE EAST: "CENTRAL_MERIDIAN", -126.0 (VISCOUNT MELVILLE SOUND)

PROJCS["Abundance East Equidistant Conic",GEOGCS["GCS_North_American_1983",DATUM["D_North_American_1983",SPHEROID["GRS_1980",6378137.0,298.257222101]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.0174532925199433]],PROJECTION["Equidistant_Conic"],PARAMETER["False_Easting",0.0],PARAMETER["False_Northing",0.0],PARAMETER["Central_Meridian",-126.0],PARAMETER["Standard_Parallel_1",70.5],PARAMETER["Standard_Parallel_2",73.5],PARAMETER["Latitude_Of_Origin",72.0],UNIT["Meter",1.0]]

Data Frames in the annual maps

ASAMM (CHUKCHI, AK BEAUFORT):
Because this is just for cartographic purposes, UTM is retained and has been used since 2007.
NAD_1983_UTM_Zone_5N
Authority: Custom
Projection: Transverse_Mercator
False_Easting: 500000.0
False_Northing: 0.0
Central_Meridian: -154.0
Scale_Factor: 0.9996
Latitude_Of_Origin: 70.0
Linear Unit: Meter (1.0)
Geographic Coordinate System: GCS_North_American_1983
Angular Unit: Degree (0.0174532925199433)
Prime Meridian: Greenwich (0.0)
Datum: D_North_American_1983
  Spheroid: GRS_1980
    Semimajor Axis: 6378137.0
    Semiminor Axis: 6356752.314140356
    Inverse Flattening: 298.257222101

ABA (BEAUFORT THROUGH CANADA):

Abundance Central Equidistant Conic
Authority: Custom
Projection: Equidistant_Conic
False_Easting: 0.0
False_Northing: 0.0
Central_Meridian: -132.0
Standard_Parallel_1: 69.5
Standard_Parallel_2: 71.5
Latitude_Of_Origin: 70.5
Linear Unit: Meter (1.0)
Geographic Coordinate System: GCS_North_American_1983
Angular Unit: Degree (0.0174532925199433)
Prime Meridian: Greenwich (0.0)
Datum: D_North_American_1983
  Spheroid: GRS_1980
    Semimajor Axis: 6378137.0
    Semiminor Axis: 6356752.314140356
    Inverse Flattening: 298.257222101

ALL SURVEY AREAS (CHUKCHI THROUGH CANADA):

AllSurveyAreas Equidistant Conic
Authority: Custom
Projection: Equidistant_Conic
False_Easting: 0.0
False_Northing: 0.0
Central_Meridian: -142.0
Standard_Parallel_1: 68.5
Standard_Parallel_2: 71.5
Latitude_Of_Origin: 70.0
Linear Unit: Meter (1.0)
Geographic Coordinate System: GCS_North_American_1983
Angular Unit: Degree (0.0174532925199433)
Prime Meridian: Greenwich (0.0)
Datum: D_North_American_1983
  Spheroid: GRS_1980
    Semimajor Axis: 6378137.0
    Semiminor Axis: 6356752.314140356
    Inverse Flattening: 298.257222101

FLIGHTLINES_19.GDB\FLTLN_BYGRID_ASAED:

Flightlines are in a single feature class so have to be one projection. Therefore this equidistant conic covers Chukchi to VMS/Amundsen Gulf.
"Central_Meridian",-142.0
PROJCS["AllSurveyAreas Equidistant Conic",GEOGCS["GCS_North_American_1983",DATUM["D_North_American_1983",SPHEROID["GRS_1980",6378137.0,298.257222101]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.0174532925199433]],PROJECTION["Equidistant_Conic"],PARAMETER["False_Easting",0.0],PARAMETER["False_Northing",0.0],PARAMETER["Central_Meridian",-142.0],PARAMETER["Standard_Parallel_1",68.5],PARAMETER["Standard_Parallel_2",71.5],PARAMETER["Latitude_Of_Origin",70.0],UNIT["Meter",1.0]]

MISCELLANEOUS OTHER PROJECTION INFO
When getting actual locations of sightings (XofWhale, YofWhale) the plane's location is projected to the UTM zone that it falls within before calculating direction and distance to actual location. The projection of the new location point is removed before writing the coordinates to the table.

APPENDIX K: BELLY PORT CAMERA (BPC)

Background

To address perception bias, ASAMM collected images from a downward-facing camera mounted in one of the survey aircraft from July to October, 2018–2019. Perception bias refers to the animals within the observers' field of view and available to be seen that are not detected. Belly port camera (BPC) imagery serves as an independent observer and will be used to develop correction factors for perception bias directly beneath the aircraft. BPC imagery is the best way to correct for perception bias for ASAMM observers onboard Turbo Commanders because that aircraft has neither the space nor the window configuration for independent observers. Teams assigned to the aircraft with the BPC were responsible for the camera equipment on and off the plane, imagery management and storage, QA/QC, and photo analysis. For complete BPC protocols, see Clarke et al. (2019).

After BPC imagery was analyzed, a cross-analysis compared BPC sightings to ASAMM observer data, and ASAMM observer data to BPC imagery. This information is necessary to estimate the probability that ASAMM observers onboard Turbo Commanders would detect a cetacean that was available to be seen directly beneath the aircraft.

Field Methods

Perception bias correction factors are needed to derive a new population estimate for the Western Arctic bowhead whale stock. For this reason, bowhead whales and other large cetaceans were the focus of BPC imagery collection (Figures K-1 and K-2). The aircraft outfitted with the BPC was located with the survey team most likely to encounter large cetaceans. In 2018 and 2019, BPC missions operated out of Utqiaġvik from 1 to 18 July and 11 to 30 October, which offered extra data collection opportunities before and after dedicated Beaufort Sea surveys. From 19 July to 10 October in 2018 and 2019, BPC images were collected by teams surveying the Beaufort Sea.

Results

Photo analysis of BPC imagery is a timely undertaking, requiring approximately 45 minutes to analyze 100 images. To expedite the analysis process, images with >50% ice cover were excluded from analysis. In 2018, sea ice cover in the Beaufort Sea study area was heavy from July into early September, limiting the number of BPC imagery collection flights. No BPC images were collected from 9 August to 6 September 2018. Images were collected during 32 flights in 2018 (Table K-1). Sea ice cover was not an issue in 2019, and images were collected during 58 flights (Table K-1).

Photo analysis of BPC images collected in 2018 was finalized in September 2019 and finalized in April 2019 for images collected in 2019 (Table K-1).

Figure K-1. Belly port camera image of a bowhead whale, collected in 2018.

Figure K-1. Belly port camera image of a bowhead whale cow-calf pair and a singleton, collected in 2019.

Table K-1. ASAMM results for 2018 BPC imagery and 2019 BPC imagery. “No.” is an abbreviation for “number”.

	2018	2019*	Total
No. BPC Collection Flights/Analyzed	32/32	58/54	90/86
No. Images Collected	167,862	309,628	477,490
No. Images On Transect or Search	110,366	224,954	335,320
No. Subset Images Viewed‡	33,519	73,382	106,901
No. Images with Cetacean Sightings	116	476	592
No. of Cetacean Sightings/Individuals†	161/178	610/812	771/990
No. Bowhead Whale Sightings/Individuals†	18/15	67/69	85/84
No. Gray Whale Sightings/Individuals†	8/9	19/18	27/27
No. Fin Whale Sightings/Individuals†	0/0	0/0	0/0
No. Humpback Whale Sightings/Individuals†	1/1	0/0	1/1
No. Unidentified Whale Sightings/Individuals†	1/1	1/1	2/2
No. Beluga Sightings/Individuals	133/153	522/612	655/765

‡ Subset images represent the number of images viewed, corresponding to every third image collected.

† Individuals account for the first sighting of an individual whale (i.e., an individual whale may appear in more than one image but that whale is counted only once).

This page intentionally left blank.

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.