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# Bowhead and Beluga Distribution and Abundance Aerial Survey Field Report, 2025

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## AFSC Processed Report

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# **Bowhead and Beluga Distribution and Abundance Aerial Survey Field Report, 2025**

by

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## Abstract

The Western Arctic stock of bowhead whales (also known as the Bering-Chukchi-Beaufort [BCB] population of bowhead whales, *Balaena mysticetus*) is a critical subsistence resource for U.S. Alaska Native Iñupiat communities and is listed as endangered under the U.S. Endangered Species Act. To satisfy International Whaling Commission (IWC) mandates requiring updated abundance estimates at least once every 10 years, the Alaska Fisheries Science Center (NOAA Fisheries) conducted a large-scale aerial line-transect survey from 28 July to 24 August 2025. The Beaufort Sea stock of beluga whales (*Delphinapterus leucas*) is of critical importance to Canadian Inuvialuit communities. Because this stock overlaps with the bowhead population during the summer, this survey collected the data needed to assess both the BCB bowhead population and the Beaufort Sea beluga population.

Collaboratively executed with the Alaska's North Slope Borough, the Alaska Eskimo Whaling Commission, and Canadian partners (the Department of Fisheries and Oceans, Fisheries Joint Management Committee, and Inuvialuit Game Council), the survey encompassed the eastern Chukchi Sea, the Alaskan and Canadian Beaufort seas, and Amundsen Gulf. Despite anomalous and persistent sea ice in the eastern Beaufort Sea, the team successfully surveyed 89% of the planned 15,116 km of transect effort. High quality sighting conditions were observed during most of the survey, with 84% of effort conducted in Beaufort Sea State scale of three or less.

Excluding duplicate transect effort (2,699 km), the total on-effort distance on transects (including transect and cetacean aggregation passing modes) was 11,883 km in 2025. A total of 1,177 marine mammal sightings (3,212 animals) were recorded, including 200 bowhead whale sightings (332 animals) and 783 beluga whale (*Delphinapterus leucas*) sightings (2,377 animals). In 2025, bowhead whale observations decreased compared to 2019, which recorded 311 sightings of 440 individuals. Conversely, beluga whale sightings saw a substantial increase over 2019 levels, which previously documented 625 sightings of 1,124 animals. While the 2025 bowhead and beluga counts represent a change in raw sightings compared to 2019, this variance may be attributable to differences in survey design, sea ice extent, and sighting conditions between the two study years rather than a change in population abundance. The distribution of beluga whale sightings in 2025 was similar to 2019. However, unlike in 2019, bowhead whale distribution in 2025 was concentrated nearshore in the Beaufort Sea, likely driven by heavy offshore ice concentrations. Additionally, expanded survey effort in the northern Amundsen Gulf identified whale presence in areas not sampled in 2019, more fully delineating the species' summer range.

While spatial data confirm the continued importance of nearshore habitat, comprehensive abundance estimates incorporating availability and perception bias derived from Field of View (FOV) trials are anticipated for release in 2026. These results will provide the scientific basis for the continued management and sustainable subsistence harvest of the BCB population of bowhead whales.



## Acknowledgments

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## Introduction

The Western Arctic stock of bowhead whales (also known as the Bering-Chukchi-Beaufort [BCB] population of bowhead whales, *Balaena mysticetus*) is designated as endangered under the U.S. Endangered Species Act and serves as a critical subsistence resource for numerous Alaska Native coastal communities. Similarly, the Beaufort Sea stock of beluga whales (*Delphinapterus leucas*) is of vital importance to Canadian Inuvialuit communities. With documented lifespans potentially surpassing 200 years for bowheads (George et al. 1999), the management of this long-lived species faces compounding challenges as the Arctic undergoes rapid, unprecedented climate change.

To support the renewal of harvest quotas, the International Whaling Commission (IWC) requires updated abundance estimates at least once every decade. To fulfill this regulatory requirement, the Alaska Fisheries Science Center (AFSC) within NOAA Fisheries conducted the first aerial survey specifically designed to cover the Alaska and Canadian Beaufort Sea and Amundsen Gulf in 2019. This effort resulted in abundance estimates of 17,175 (CV: 0.237; 95% CI: 10,793 - 27,330) bowhead whales (Ferguson et al. 2022) and 41,648 beluga whales (*Delphinapterus leucas*) (CV: 0.125) (Ferguson et al. in review). A concurrent ice-based visual/acoustic survey of bowhead whales was conducted in the spring of 2019, yielding an estimate of 14,025 (95% CI: 8,964-21,942; CV: 0.228; Givens et al. 2023). Ice-based surveys for BCB bowhead whales are the traditional method accepted by IWC; the similarity between the two estimates provided validation for the use of aerial line-transect methods.

The 2025 Bowhead and Beluga Distribution and Abundance Aerial Survey was conducted through a broad partnership between NOAA Fisheries, Alaska's North Slope Borough, University of Washington's Cooperative Institute for Climate, Ocean, & Ecosystem Studies, the Alaska Eskimo Whaling Commission, and Canadian partners (the Department of Fisheries and Oceans, Fisheries Joint Management Committee, and Inuvialuit Game Council, and local Hunter and Trapper Committees). The primary objective of this survey was to collect line-transect aerial data to generate updated abundance estimates for both BCB bowhead and Beaufort Sea beluga whales. By utilizing a survey design that leverages the summer spatial overlap of both species, the study efficiently gathered data to inform future trend analyses. These findings will ultimately assist the International Whaling Commission in ensuring that subsistence quotas remain sustainable for Iñupiat and Inuvialuit communities.

Here, we present summary results and scope of our 2025 survey. The 2025 survey targeted the same general geographical areas that were flown during the 2019 survey. While spatial distributions are presented here, formal abundance estimates, incorporating availability and perception biases, for the BCB bowhead whale population are currently in development and are not anticipated until mid-2027. Assuming that the data collected in 2025 yields an estimate of abundance that is accepted by the IWC Scientific Committee as being appropriate for management, the next estimate of abundance will be due to IWC in 2035 and the next abundance survey is planned for 2032 to meet that deadline.

## Methods

### Study Area and Survey Design

The 2025 study area encompassed the eastern Chukchi Sea, Alaska and Canadian Beaufort seas, and Amundsen Gulf. The allocation of survey effort was specifically designed to

- Maintain consistency with the 2019 bowhead whale abundance survey protocols (Clarke et al. 2020, Ferguson et al. 2022) to maximize comparability across surveys and to use protocols that have already been reviewed and accepted by the IWC Scientific Committee.
- Account for potential effort loss due to inclement weather and transit requirements between transects and home bases.
- Ensure uniform sampling coverage across the entire study area.
- Optimize available flight hours within the designated survey window.

While the 2025 survey area remained largely consistent with the 2019 survey, several strategic adjustments were made to the transect lines:

- Offshore Extensions: Transect lines were extended to the 1,500 m isobath to ensure full coverage of potential bowhead whale habitat. An exception to this was the region between 126°W and 132°W, where shallow depths persist far offshore and lines reach their maximum logistically feasible distance. These extensions were based on 2019 data showing bowhead whale presence at the offshore limits of previous transects, particularly in the eastern Beaufort Sea.
- Eastern and Northern Expansion: In the eastern Beaufort Sea, lines were extended east to 117°W longitude and north into Viscount Melville Sound to approximately 72°N latitude.
- Chukchi Sea Expansion: In the Chukchi Sea, transects were extended west to 160°W longitude.
- Spatial Exclusions: To manage logistical constraints and avoid potential overlap with other Canadian bowhead stocks, transects off the western coast of Banks Island and north of Viscount Melville Sound were removed.

Transect allocation was conducted using Distance software (version 7.2; Thomas et al. 2010) and the R package *dssd* (version 1.0.3; Marshall 2025) within the R statistical environment (version 4.5.0; R Core Team 2025). Parallel transect lines, oriented approximately north-to-south and nearly perpendicular to the coastline, were allocated proportional to the area of three strata: the Western Beaufort Sea, the eastern Beaufort Sea, and Amundsen Gulf (Table 1, Fig. 1).

The survey design included 87 transect lines (1-39 in the Western Beaufort Sea Stratum, 40-74 in the Eastern Beaufort Sea Stratum, and 75-87 in the Amundsen Gulf Stratum) (Fig. 1). To maintain consistency with Ferguson et al. (2022), lines were spaced 19 km apart. This design encompassed 15,116 km of planned transect effort (Table 1), with the primary objective of surveying each line at least once.

Table 1. --Proposed transect effort and total effort (distance and time) per study stratum planned within the study area of the 2025 Bowhead and Beluga Distribution and Abundance Aerial Survey.

Region	Transect Effort (km)	Total Effort (km)	Transect Time (hr)	Total Time (hr)
W Beaufort Sea	5,063	12,982	23.8	60.9
E Beaufort Sea	7,554	19,369	35.5	90.9
Amundsen Gulf	2,499	6,408	11.7	30.1
<b>Total</b>	<b>15,116</b>	<b>38,759</b>	<b>71.0</b>	<b>182.0</b>

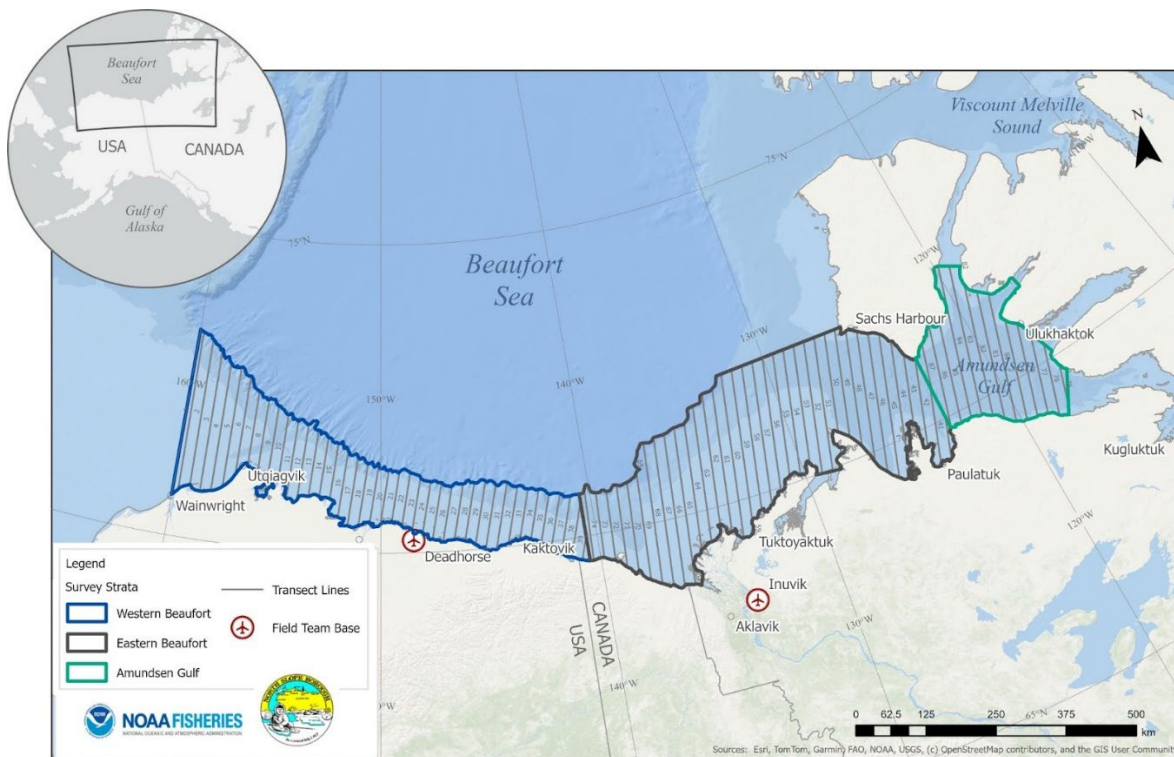


Figure 1. -- Map of study area and proposed survey tracklines within each stratum for the 2025 Bowhead and Beluga Distribution and Abundance Aerial Survey.

## Aircraft Configuration and Survey Protocol

Aerial surveys were scheduled from 28 July to 24 August 2025 using three de Havilland DHC-6 Twin Otter aircraft. However, persistent poor weather precluded flights after 22 August, which marked the final day of operations. Logistically, one aircraft was based in Deadhorse, Alaska, USA, while the remaining two operated out of Inuvik, Northwest Territories (NWT), Canada (Fig. 1). The target survey parameters were maintained at an altitude of 396 m (1,300 ft) and a groundspeed of 213 km/h (115 kts). All aircraft were configured with large bubble windows on both the port and starboard sides to optimize downward and forward visibility. Additionally, the Deadhorse-based aircraft featured an opening flat window, facilitating the collection of opportunistic oblique imagery.

Each survey platform was manned by a dedicated field team (Team A in Deadhorse; Teams B and C in Inuvik). Each team was composed of a science crew (team lead/data recorder and two primary observers) and an aviation crew (pilot-in-command, second-in-command, and a mechanic). The science and aviation personnel collaborated closely to ensure mission success while prioritizing safety and operational efficiency.

Daily flight planning was a joint effort between team leads and pilots, accounting for local weather, short- and long-term forecasts, and logistical constraints. The Inuvik-based teams coordinated specifically to deconflict flight paths and ensure each transect was covered at least once during the season.

The selection of daily transects was dictated by

- Meteorological Conditions: Prioritizing areas with acceptable visibility, sea states, and cloud ceilings.
- Subsistence Coordination: Avoiding active hunting areas to minimize community disturbance.
- Effort Distribution: Tracking the location of recent surveys to ensure uniform coverage.
- Ice Concentration: Adjusting for shifting ice densities that might influence whale distribution.
- Team Deconfliction: Maintaining safe separation between survey aircraft.

During each flight, the data recorder utilized custom-built, menu-driven software to log observations into a laptop computer interfaced with a Global Positioning System (GPS). The system automatically recorded time and position data (latitude, longitude, and altitude) at 30-second intervals and upon every manual entry. Environmental and viewing conditions were

updated every 5 minutes or whenever a change in conditions occurred. Recorded parameters included

- Beaufort Sea State scale: Wind force scale ranging from 0 to 12.
- Visibility Range: Perpendicular visibility on each side of the aircraft categorized as < 1 km, 1–2 km, 2–3 km, 3–5 km, 5–10 km, or unlimited.
- Sky Conditions: Categorized as clear, partly cloudy, or overcast.
- Sea Ice Concentration: Estimated percentage of ice cover on each side of the aircraft.
- Visibility Impediments: Specific factors affecting observation, such as glare, fog, haze, precipitation, window icing, or low ceilings.

Primary observers scanned for marine mammals using the naked eye. When a sighting was positioned abeam (perpendicular to the aircraft), declination angles from the horizon were measured using handheld Suunto clinometers. A "sighting" or "group" was defined as all individuals of the same species located within five body lengths of one another; consequently, a group could consist of one or more animals. Upon recording the initial clinometer angle, most bowhead whale sightings were circled to

- Confirm species identification.
- Obtain a final, accurate group size estimate.
- Identify the presence of calves.
- Determine primary behavior.

Sightings that could not be positively identified to species were recorded at the lowest possible taxonomic level (e.g., "unidentified cetacean"). The database maintained both initial and final group size estimates; if group size could not be determined with certainty, high or low estimates were recorded.

Data were collected across seven distinct survey modes (Table 2). With the exception of "Deadhead" and "FOV" (Field of View) modes, observers remained on active survey effort, and all sighting and environmental data were recorded. Standard line-transect survey protocols (Buckland et al. 2001) were strictly followed until bowhead whale encounter rates exceeded the observers' capacity to accurately log individual locations and clinometer angles. In these high-density areas, the team transitioned to specific aggregation protocols (detailed in the following section).

Table 2. --Description of survey modes, or effort types, used during the 2025 Bowhead and Beluga Distribution and Abundance Aerial Survey.

Effort Type	Description
Transect	Used when on transect to conduct systematic survey effort along a prescribed line.
Circling-transect	Used when the survey is diverted away from transect effort to circle a sighting.
CAPs passing	Used when the data recorder can no longer keep up with recording sightings in transect mode.
CAPs circling	Used when circling sightings over areas that were initially surveyed during CAPs passing.
Search	Used during any non-deadhead, non-transect, or non-CAPs effort.
Deadhead	Used when the survey flight has just begun before the transect has been reached, when the aircraft is over land, when visibility is zero (e.g., transiting above cloud cover with no downward visibility), during transits between transects and at the end of a flight.
FOV	Used when conducting Field of View effort.

### Cetacean Aggregation Protocols

Cetacean Aggregation Protocols (CAPs) were implemented when the density of bowhead whale sightings on a transect exceeded the observers' capacity to mark, record accurate clinometer angles for, and circle every individual sighting. This protocol ensured that encounter rates remained accurate without overwhelming the observers or losing the primary line-transect integrity.

CAPs were conducted in two distinct phases:

1. **CAPs passing:** The aircraft continued along the transect line at standard speed and altitude. Observers recorded all bowhead whale sightings within a 3 km strip of the transect to establish a reliable encounter rate. Crucially, no circling was conducted during this phase to maintain the "passing" effort.
2. **CAPs circling:** The aircraft passed the high-density patch of bowhead whales and returned to the area covered during the passing phase to circle the previously marked groups. During this second phase, the crew collected a full suite of data, including final group size, calf presence, and behavioral observations.

## Field of View Trials

Aerial line-transect survey data are inherently subject to availability bias, which occurs when animals on or near the trackline remain undetected because they are submerged or outside of the observers' active field of view (e.g., positioned too far fore or aft of the aircraft). To correct for this bias, it is necessary to quantify the "time-in-view", which is the period of time an observer has to detect a target while it is available at the surface. To determine this parameter, each survey aircraft conducted at least two dedicated FOV calibration flights during the 2025 season, one at 610 m (2,000 ft) and one at 396 m (1,300 ft). The 610 m flight was performed to maintain comparability with 2019 data, as the Turbo Commander used in that survey required a higher altitude to prevent targets from being obscured by the wings or lost in the engine jetwash. Since the 2025 survey utilized different aircraft, the second flight at 396 m was conducted to ensure the FOV data matched the actual 2025 survey altitude.

For each aircraft, two transects (one 500 m and one 2,000 m from the target) for a given transect orientation were flown two times in order to collect replicate data that could be used to estimate uncertainty. To complete the entire experiment, each observer needed to sight the target during eight transects: two perpendicular distances from the target (500 m and 2,000 m), two replicates, and on each side of the plane (SOP, left and right) (Table 3).

Two stationary land-based targets were used during the FOV survey (Fig. 2); the Deadhorse target consisted of two CONEX boxes and the Inuvik target was a cabin. To ensure standardization, a target was only defined as "visible" when specific features could be resolved: the Conex boxes had to appear as two distinct structures, or the black-and-white pattern on the cabin roof had to be clearly differentiated. Each observer manually marked the exact onset and offset times when the target was clearly resolvable. These data will be used to calculate the mean time-in-view, which is a critical component for correcting availability bias in the final bowhead whale abundance estimates.

Table 3. -- Sample FOV transect order. Gray cells indicate that observers switched sides of the plane (SOP).

Trial	Direction (e.g., N/S)	Observer	SOP	Transect Distance (m)
1	N	A	R	500
2	S	B	L	500
3	N	A	R	500
4	S	B	L	500
5	N	B	R	500
6	S	A	L	500
7	N	B	R	500
8	S	A	L	500
9	N	B	R	2,000
10	S	A	L	2,000
11	N	B	R	2,000
12	S	A	L	2,000
13	N	A	R	2,000
14	S	B	L	2,000
15	N	A	R	2,000
16	S	B	L	2,000



Figure 2. -- Aerial view of the Field of View (FOV) targets used during the 2025 Bowhead and Beluga Distribution and Abundance Aerial Survey. Left: CONEX boxes south of Deadhorse, Alaska, USA. Right: cabin located approximately 60 km north of Inuvik, Northwest Territories, Canada.

## Camera Systems

To estimate transect detection probability for the observers (perception bias), each of the three survey aircraft were equipped with downward pointing camera(s).

### Western Beaufort Sea Stratum

The aircraft that surveyed the western Beaufort Sea was equipped with an array of cameras that were mounted in an open-air port in the belly of the aircraft (Fig. 3). The array included three Phase One iXM-GS120 color cameras that were fitted with Schneider-Kreuznach RS 110 mm lenses. The color cameras were designed to capture high-resolution images of objects moving rapidly in environments that are highly dynamic. Each color camera was paired with a FLIR A6750sc SLS thermal camera also designed to operate at high speeds for fast-moving objects. The paired color and thermal cameras were mounted with the center cameras pointed downward at nadir and the side cameras angled at 21 degrees in order to create side-to-side overlap between images. When surveying at a target altitude of 396 m (1,300 ft) and a target speed of 115 knots, the combined swath coverage underneath the plane from all three color cameras was approximately 501 m (1,644 ft) with images at a resolution of 1.25 cm/pixel.

An Applanix POS AVX 210 Inertial Navigation System (INS) was integrated with the camera system to collect the aircraft's location, altitude, and attitude. The INS data and image metadata were collected for each color and thermal image pair and stored in a JSON file. Image collection was managed by [KAMERA](#) (the Knowledge-Guided Image Acquisition Manager and Archiver), which was developed by Kitware, Inc., in conjunction with NOAA's Marine Mammal Laboratory as an open-source software platform to collect, manage, and analyze images. The KAMERA operator used a graphical user interface to start and stop image collections, adjust camera settings, and set collection rates. Images were collected at a rate to create front-to-back overlap between images based on the aircraft's altitude and speed, and collections occurred continuously during survey effort on each flight. All camera system data were processed on multiple graphical processing units and then saved to a network attached storage device.



Figure 3. -- View of the mounted camera array from underneath the aircraft showing UV, color (RGB), and thermal cameras from left to right. The UV cameras were disabled for this project.

### Eastern Beaufort Sea and Amundsen Gulf Strata

Both Twin Otters based in Inuvik had a Nikon Z8 camera with a 20 mm lens installed in the open-air belly port of the aircraft (Fig. 4). The Nikon Z8, which is a ~ 45.7 megapixel mirrorless camera equipped with a full-frame (36 × 24 mm) sensor, was connected to an Nikon MC-36 intervalometer which was used to start and stop the camera and control the image capture rate (set at every 2 seconds). A custom-built logging system was also developed and used to log GPS and inertial measurement unit (IMU) data (i.e., roll, pitch, heading/yaw) at a rate of approximately 1 Hz which will later be linked to the image metadata based on the date and time (Fig. 4). With an SD card inserted before startup, the logging system created a CSV file that contained the aircraft's altitude, position, and attitude.

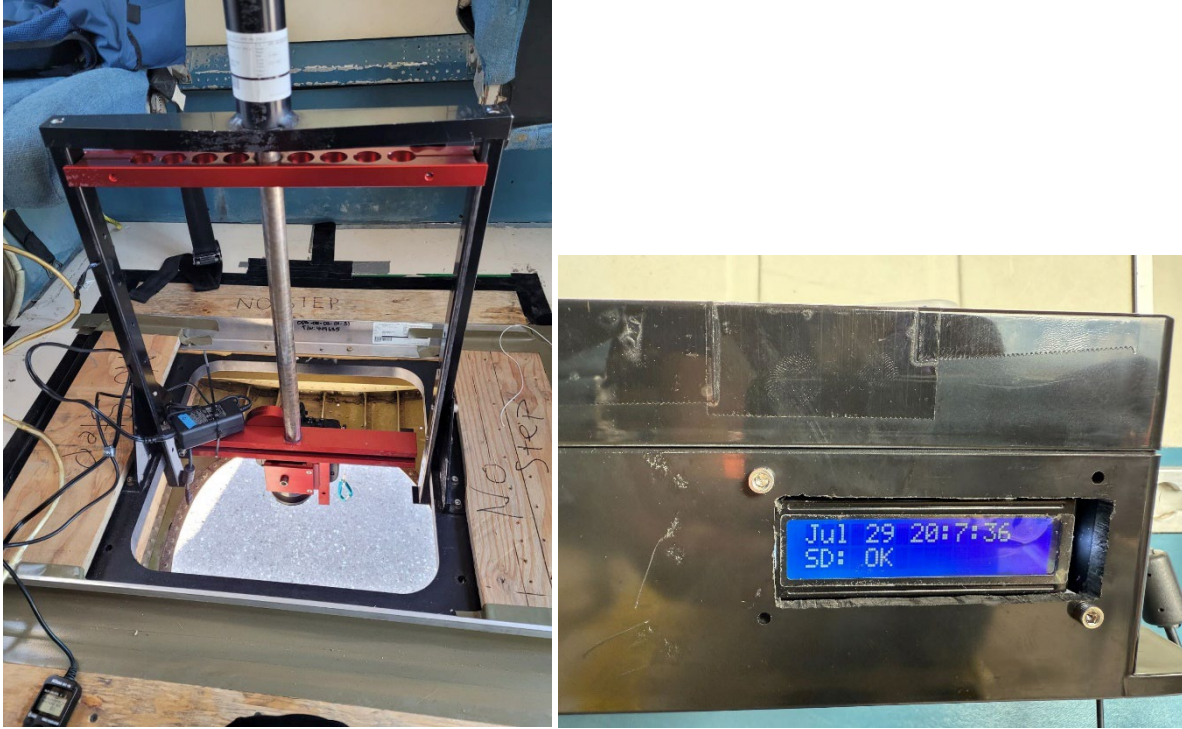


Figure 4. -- Left: View of the mounted camera from inside the aircraft showing the Nikon Z8 secured on the crossbar. The camera was lowered into the belly of the aircraft once over water, and the intervalometer on the lower left of the image was used to control camera operation and image capture rate. Right: Logging system used to record GPS and IMU data from the aircraft.

## Results

### Survey Effort

Between 28 July and 22 August 2025, the field teams conducted 35 survey flights, totaling approximately 230 flight hours (Tables 4 and 5). Team A (Deadhorse, AK) completed 13 flights, while Teams B and C (Inuvik, NWT) each completed 11 flights (Table 4). Eight of these flights included calibration passes over land to support FOV analyses. Environmental factors, specifically heavy sea ice and high sea states, frequently necessitated the truncation of transect lines at their northernmost extents (Table 4).

Across all effort types, the teams covered a distance of over 48,000 km (Table 5, Fig. 5). The majority of this distance was recorded as deadhead effort (27,503.8 km, 127.9 hr), a result of the transit requirements from Inuvik, which is situated approximately 120 km inland from the Arctic coast (Fig. 1). Search effort was implemented once and CAPs was initiated three times throughout

the duration of the survey (Table 5). The survey resulted in 14,582.3 km (69.5 hr) of effort conducted on-transect (transect and CAPs passing mode; Table 5, Fig. 6). A small portion of the transect effort (2,699.0 km, 12.7 hr) was considered duplicate transect effort that occurred when some lines were resurveyed due to high sea states (> 4) or high ice concentrations (> 50%) during the initial attempt to survey the transect (Fig. 7). As a result, total transect coverage dropped to 11,883 km once accounting for duplicate effort. Despite periodically challenging sea states and ice conditions, 93% of the western Beaufort Sea, 83% of the eastern Beaufort Sea, and 99% of the Amundsen Gulf planned transects were successfully surveyed. In total, 89% of the planned transect effort (13,491 of 15,116 km) was successfully surveyed. Unsurveyed portions of transects were primarily concentrated in the northern sections of the eastern Beaufort Sea, where heavy sea ice persisted throughout the season.

In total, 84% of the transect effort was conducted in Beaufort Sea State scale of three or less (Table 6, Fig. 8), which are considered preferred sighting conditions. Similarly, 83% of the transect effort occurred in areas where the average ice concentration was < 50% (Table 7, Fig. 9). Satellite data revealed that while ice concentrations diminished in the western Beaufort Sea and Amundsen Gulf as the season progressed, the eastern Beaufort Sea remained characterized by persistent, high-density sea ice (Fig. 10).

Table 4. --Descriptions of each flight conducted during the 2025 Bowhead and Beluga Distribution and Abundance Survey. Flights 101-113 were completed by Team A based in Deadhorse Alaska, USA, while flights 201-211 and 301-311 were completed by Teams B and C, respectively, both based in Inuvik, NWT, Canada. Days on which no flights were attempted were due to high winds, low ceilings, or precipitation.

Date	Flight	Description
28 July	201	Partial survey of transects 40, 48, 84, and 86. Low ceilings and fog precluded additional transect effort
31 July	101	Complete survey of transects 17 and 18, and a partial survey of transects 19-21. Partial transects were truncated due to low ceilings.
1 August	102	Partial survey of transects 7-10. Transects were truncated offshore due to thick and extensive low clouds.
	202	Complete survey of transects 85-87, and a partial survey of transect 84. Parts of lines 85-87 were surveyed in sea states 5-6 and were later resurveyed when time allowed. Transect 84 was attempted but was aborted due to low clouds.
	301	Complete survey of transects 72-74.

2 August	203	Complete survey of transects 75-78.
	302	Partial survey of transects 83 and 84. Transects were truncated due to high sea states.
3 August	103	Complete survey of transects 11-15.
	204	Nearly complete survey of transects 70-71. The last 15 km of transect 71 was precluded by heavy ice.
	303	Complete survey of transect 41, and a partial survey of transects 80-82. Transects were truncated due to fog and high sea states.
8 August	104	Complete survey of transects 28-35.
	205	Calibration survey over land for the field-of-view analysis.
	304	Calibration survey over land for the field-of-view analysis.
9 August	206	Partial survey of transect 42. Parts of transects 80-83 that were previously flown in high sea states were resurveyed in better conditions.
	305	Partial survey of transects 66-69. Transects were truncated due to heavy ice and fog.
11 August	105	Complete survey of transects 22-27.
12 August	106	Complete survey of transects 4 and 16.
	207	Partial survey of transects 64-65. Heavy ice precluded surveying ~30 nm on the northern part of each line.
13 August	107	Complete survey of transects 36-39.
	208	Partial survey of transects 51-54. Heavy ice prevented surveying the northern parts of the transects.
	306	Partial survey of transects 58-61. Transects were truncated due heavy ice and fog.
14 August	209	Nearly complete survey of transects 62-63. Surveying the northern part of each transect was precluded due to heavy ice.
	307	Partial survey of transects 64-69 and 56-57. Transects were truncated due to heavy ice.
15 August	108	Complete survey of transects 5 and 6, and a partial survey of transects 3, 7, 8, and 9.
17 August	109	Partial survey of transect 17 which was truncated due to thick low ceilings. A calibration survey over land was also conducted for the field-of-view analysis.

18 August	110	Calibration survey over land for the field-of-view analysis.
	308	Partial survey of transects 55-58. Transects were truncated due to fog and heavy ice.
19 August	111	Complete survey of transects 17, 19, and 20, and a partial survey of transect 21. The partial survey was to complete a segment of transect that was missed previously. We also conducted a calibration survey for the field-of-view analysis.
20 August	309	Calibration survey over land for the field-of-view analysis.
21 August	112	Calibration survey over land for the field-of-view analysis.
	210	Partial survey of transects 43-45. High winds prevented surveying the northern sections of the transects. An attempt was made to resurvey the northern part of transect 84 but high winds prevented conducting effort in sea states less than 5.
	310	Complete survey of transects 47 and 48, and a partial survey of transects 46, 49, 50, and 55. Ice cover was patchy and some sections of transects were flown in heavy (>50%) ice. Transect 55 was truncated due to fog. Transect 46 was truncated due to high (Beaufort 6 and 7) sea states. Transects 49 and 50 were truncated due to fuel reserves.
22 August	113	Partial survey of transects 1-3. Offshore ends of transects were truncated due to thick and extensive low ceilings.
	211	An attempt was made to resurvey the northern part of transects 59-60 but fog and heavy ice impacted visibility. A calibration survey over land was also conducted for the field-of-view analysis.
	311	Partial survey of transects 42, 43 and 84-87 to fill in gaps of transects that were previously surveyed under poor conditions.

Table 5. --Total distance and survey time conducted by effort type during the 2025 Bowhead and Beluga Distribution and Abundance Aerial Survey.

Effort Type	Total Distance (km)	Total Time (hr)
Transect*	14,557.3	69.5
Circling on transect	1,917.4	11.6
CAPs passing	25.0	0.1
CAPs circling	147.5	0.8
Search	10.5	0.1
Deadhead	27,503.8	127.9
FOV	4,202.3	19.7
<b>Total</b>	<b>48,363.8</b>	<b>229.7</b>

\*Transect effort includes 2,699 km of duplicate effort as some transects were resurveyed to ensure data integrity when poor environmental conditions compromised visibility during the primary attempt.

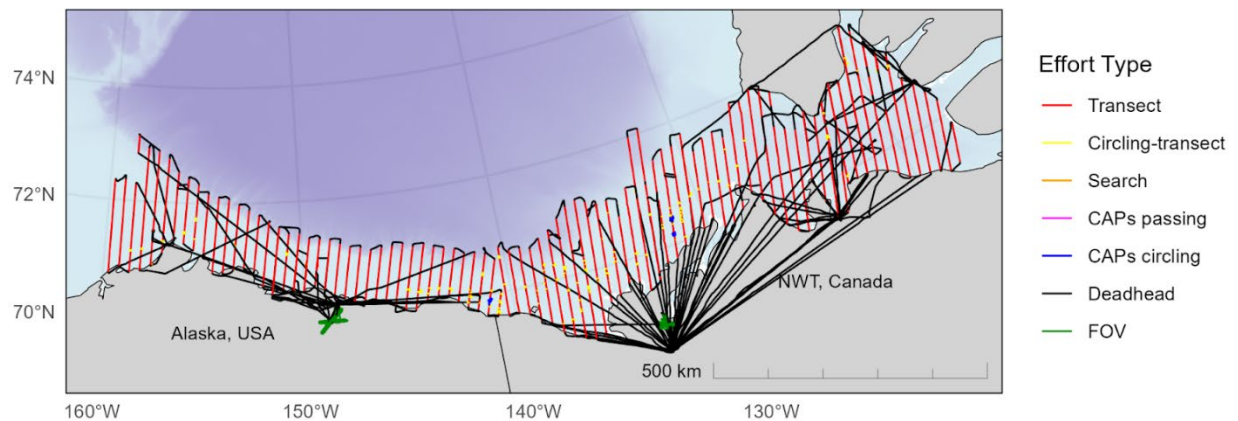


Figure 5. -- Effort types used during the 2025 Bowhead and Beluga Distribution and Abundance Aerial Survey. Note that CAPs passing mode is obscured by CAPs circling.

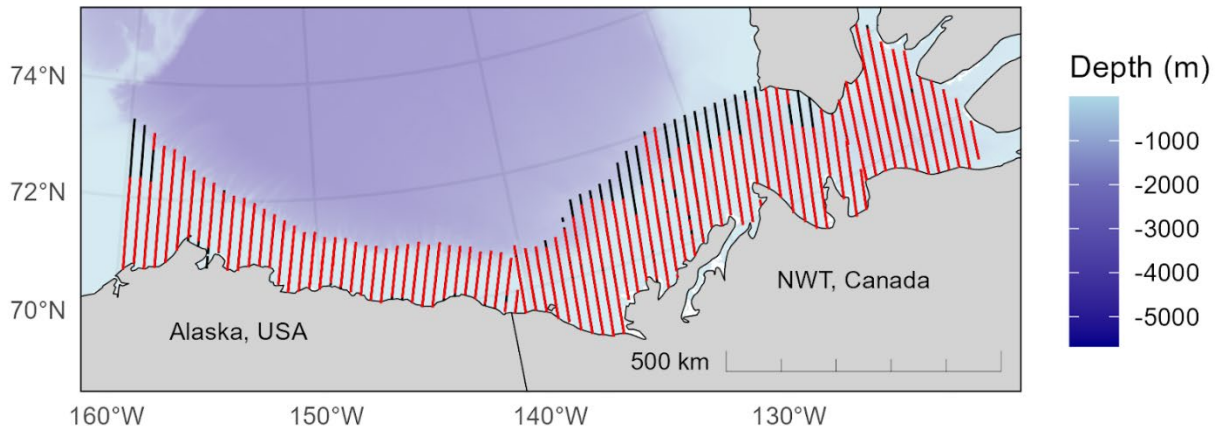


Figure 6. -- Planned (black) and actual (red) transect effort conducted during the 2025 Bowhead and Beluga Distribution and Abundance Aerial Survey.

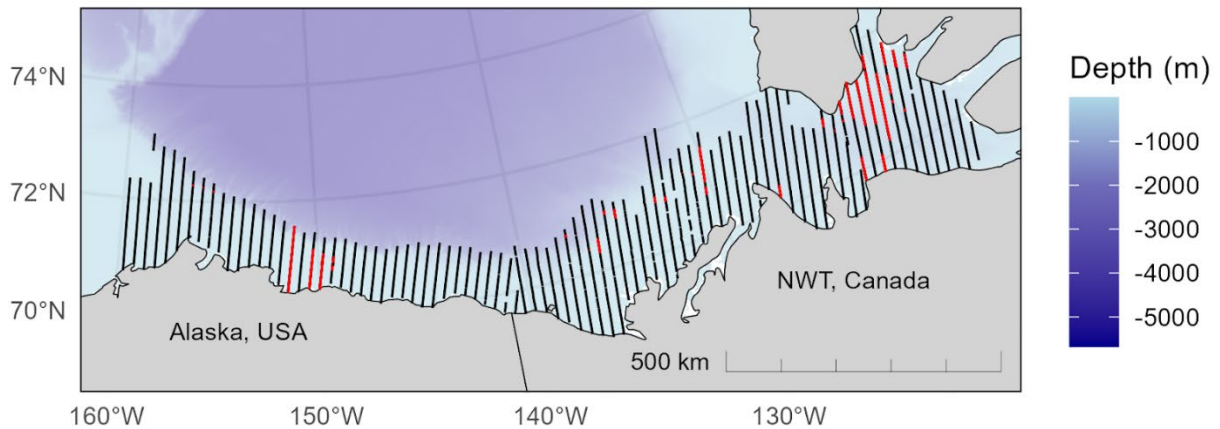


Figure 7. -- Actual transect effort (black) flown during the 2025 Bowhead and Beluga Distribution and Abundance Aerial Survey with sections of transects flown more than once shown in red.

Table 6. --Transect survey effort flown by Beaufort Sea State scale during the 2025 Bowhead Distribution and Abundance Aerial Survey.

Beaufort Sea State	Transect Effort (km)*
B0 glassy, <1 kt	275.3
B1 ripples, 1-3 kt	3,550.5
B2 small waves, 4-6 kt	5,243.9
B3 scattered caps, 7-10 kt	3,160.2
B4 numerous caps, 11-16 kt	1,421.5
B5 many caps, 17-21 kt	691.1
B6 all caps, 22-27 kt	202.2
B7 breaking waves, 28-33 kt	12.6
<b>Total</b>	<b>14,557.3</b>

\*Includes some duplicated effort due to transects being flown more than once.

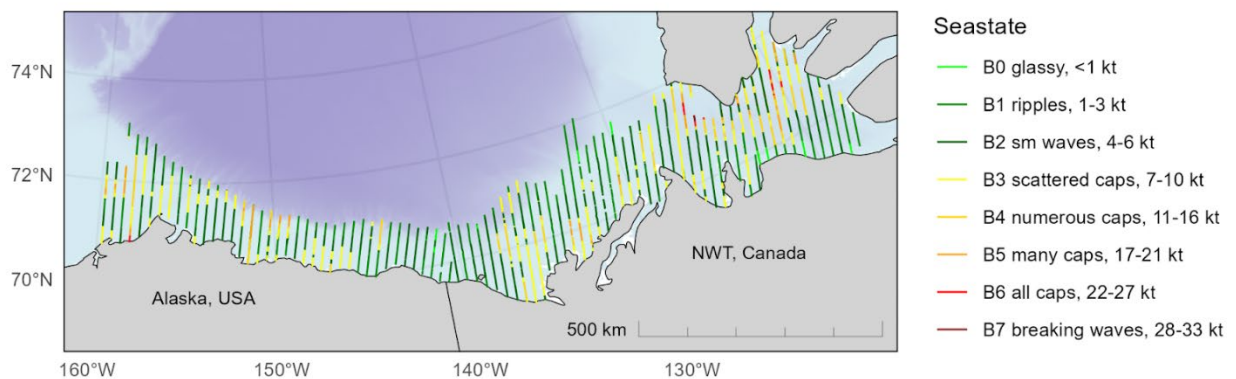


Figure 8. -- Sea states encountered during the 2025 Bowhead and Beluga Distribution and Abundance Aerial Survey.

Table 7. --Transect survey effort flown by sea ice concentration during the 2025 Bowhead and Beluga Distribution and Abundance Aerial Survey.

Ice Conc. (%)	Transect Effort (km)
0-10	6,585.5
10-20	3,228.3
20-30	1,613.0
30-40	759.0
40-50	650.7
50-60	781.3
60-70	444.6
70-80	413.1
80-90	61.9
90-100	19.9
<b>Total</b>	<b>14,557.3</b>

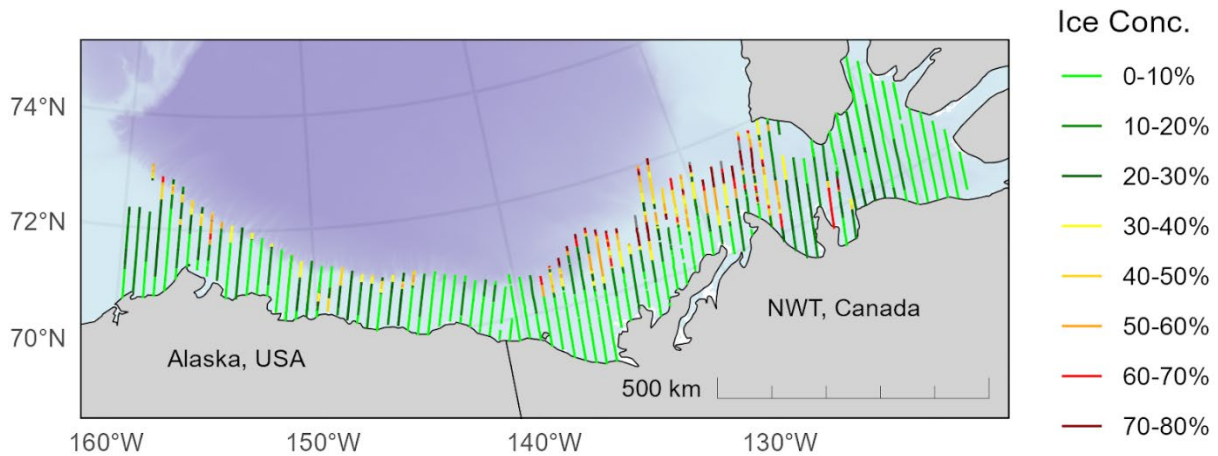


Figure 9. -- Average sea ice concentration encountered during the 2025 Bowhead and Beluga Distribution and Abundance Aerial Survey.

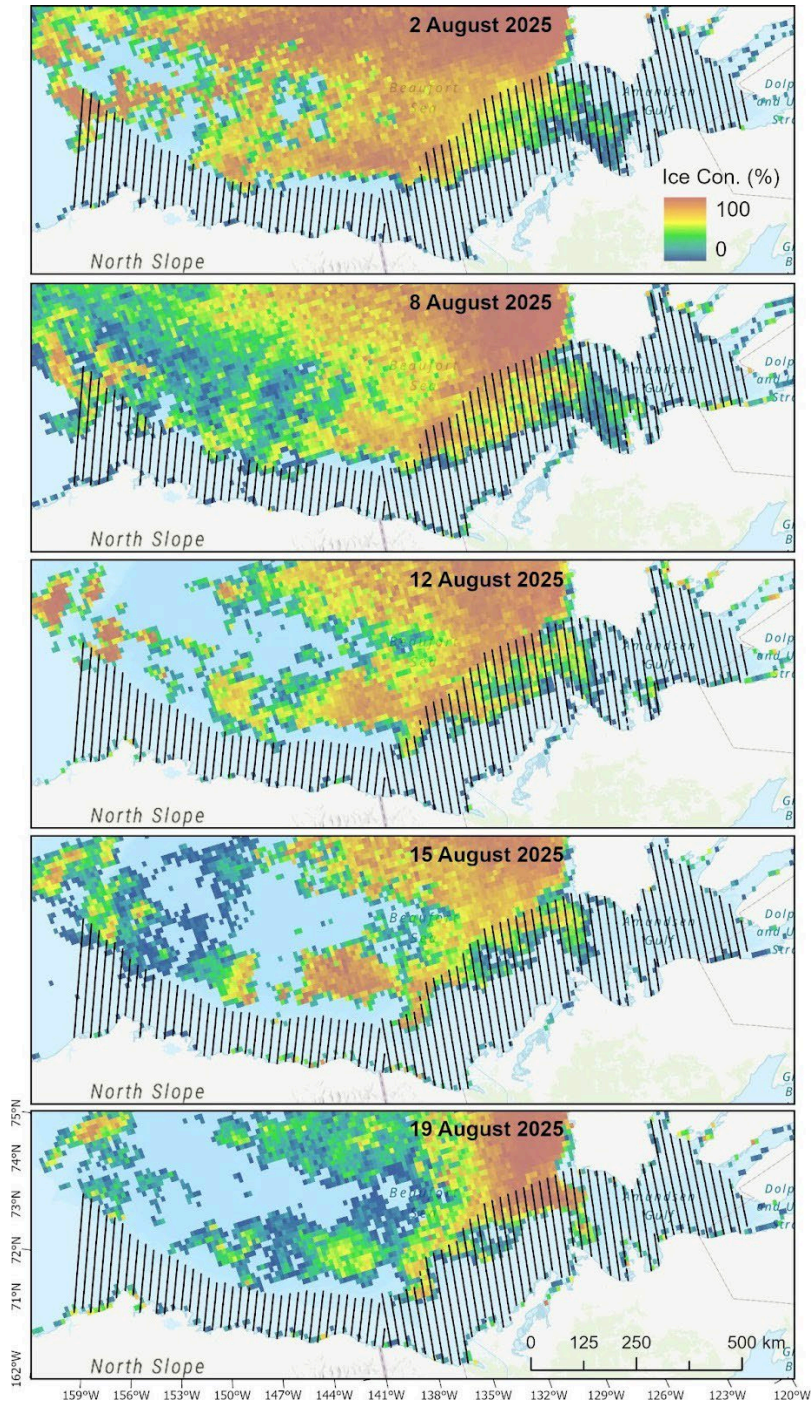


Figure 10. -- Advanced Microwave Scanning Radiometer sea-ice concentration data with a 6.25 km resolution from the University of Bremen ([https://data.seaice.uni-bremen.de/amsr2/asi\\_daygrid\\_swath/n6250/netcdf/2025/](https://data.seaice.uni-bremen.de/amsr2/asi_daygrid_swath/n6250/netcdf/2025/)), for five of the survey days during the 2025 Bowhead and Beluga Distribution and Abundance Aerial Survey. Planned transect lines are shown in black.

## Sightings

During the 2025 survey, a total of 1,177 sightings comprising 3,212 individual animals were recorded (Table 8). Bowhead and beluga whales were the most frequently encountered species, accounting for 200 sightings (332 animals) and 783 sightings (2,377 animals), respectively (Table 8, Figs. 11-12). With the exception of one gray whale, all marine mammal observations occurred while the teams were on-effort.

Due to the implementation of CAPs, the raw bowhead whale counts in Table 8 include some duplicate sightings from the "passing" and "circling" phases. Table 9 delineates these sightings by effort type; the actual number of individuals present in high-density areas likely falls between the totals recorded during the CAPs passing and CAPs circling modes.

In addition to the primary target species, several other cetacean species were documented: three humpback whale sightings (5 animals), eight gray whale sightings (11 animals), and a single minke whale sighting (1 animal) (Table 8, Fig. 13). Pinniped observations were also frequent throughout the study area including: two bearded seal sightings (3 animals), 29 walrus sightings (291 animals), and 142 unidentified small or otherwise unspecified pinnipeds (183 animals) (Table 8, Fig. 14). Additionally, two polar bears were observed during the survey period.

Table 8. -- Number of sightings and total number of animals by species seen on all effort types during the Bowhead and Beluga Distribution and Abundance Aerial Survey, with exceptions denoted by asterisk(s). Unid. = unidentified.

<b>Species</b>	<b>No. Sightings</b>	<b>No. Animals</b>
Bowhead whale*	200	332
Beluga whale	783	2,377
Gray whale**	8	11
Humpback whale	3	5
Minke whale	1	1
Unid. cetacean	7	7
Bearded seal	2	3
Walrus	29	291
Small unid. pinniped	100	123
Unid. pinniped	42	60
Polar bear	2	2
<b>Total</b>	<b>1,177</b>	<b>3,212</b>

\*Includes some duplicate sightings, see Table 9.

\*\*One gray whale carcass was recorded while searching off effort and an additional sighting (1 animal) was recorded during CAPs circling.

Table 9. --Number of bowhead whale sightings and animals recorded by effort type during the 2025 Bowhead and Beluga Distribution and Abundance Aerial Survey. Note that several of the bowhead whales recorded during CAPs passing and CAPs circling are duplicates. See section on Cetacean Aggregation Protocols for additional details.

<b>Effort Type</b>	<b>No. Sightings</b>	<b>No. Animals</b>
Transect	144	211
Circling-transect	15	37
CAPs circling	31	61
CAPs passing	10	23
<b>Total</b>	<b>200</b>	<b>332</b>

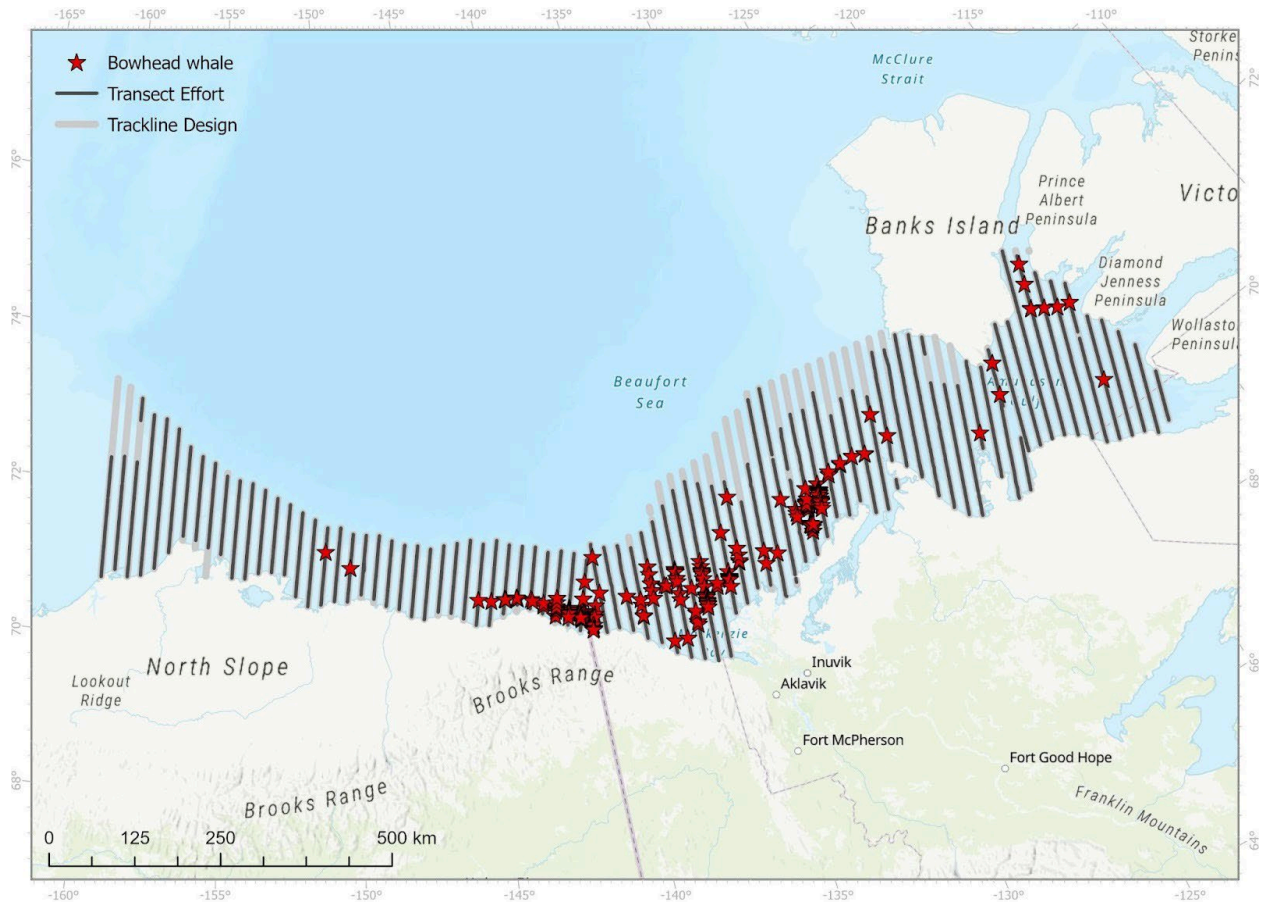


Figure 11. -- Bowhead whale sightings (red stars) and transect effort (black lines) during the 2025 Bowhead and Beluga Distribution and Abundance Aerial Survey.

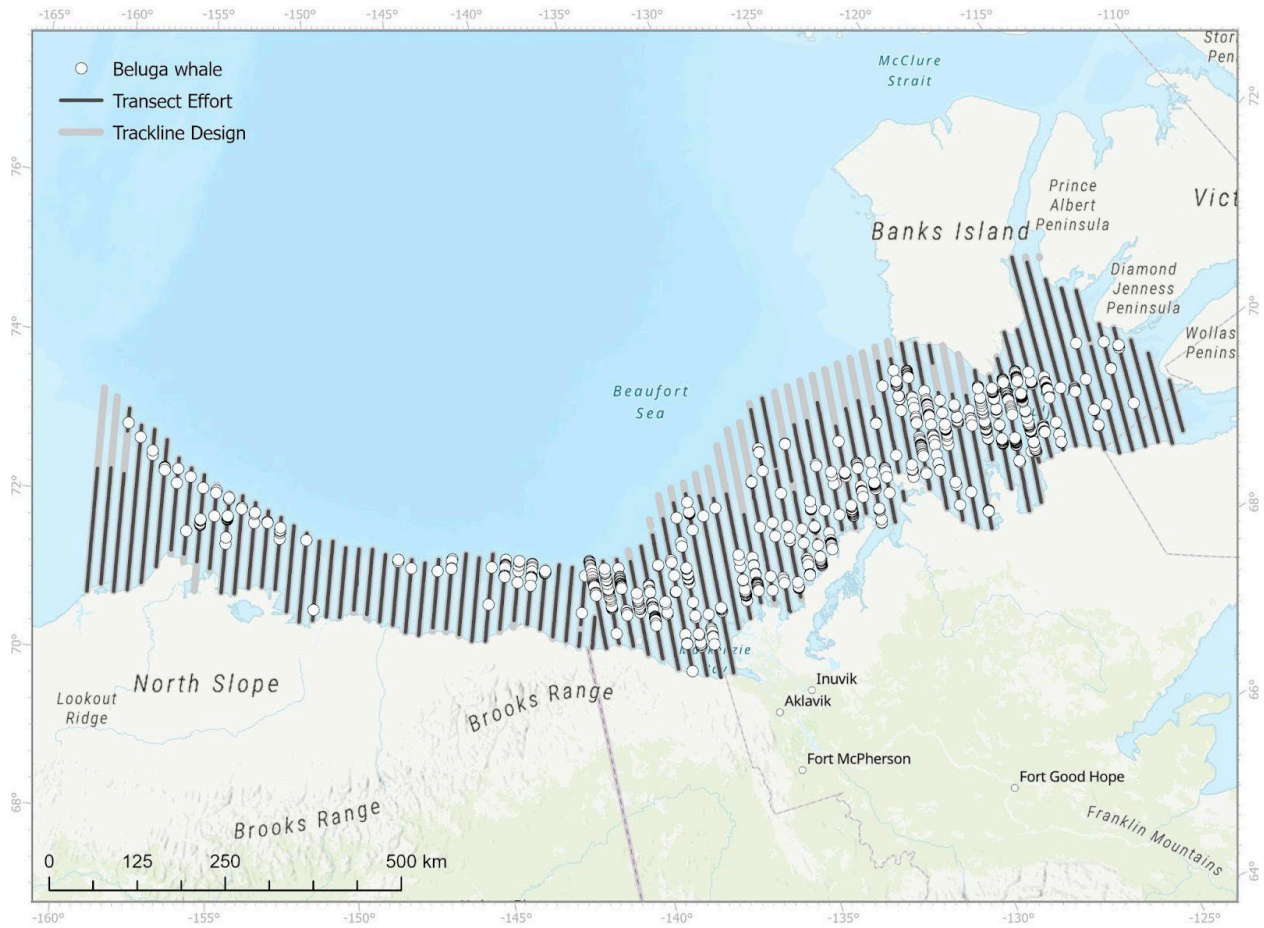


Figure 12. -- Beluga whale sightings (white circles) and transect effort (black lines) during the 2025 Bowhead and Beluga Distribution and Abundance Aerial Survey.

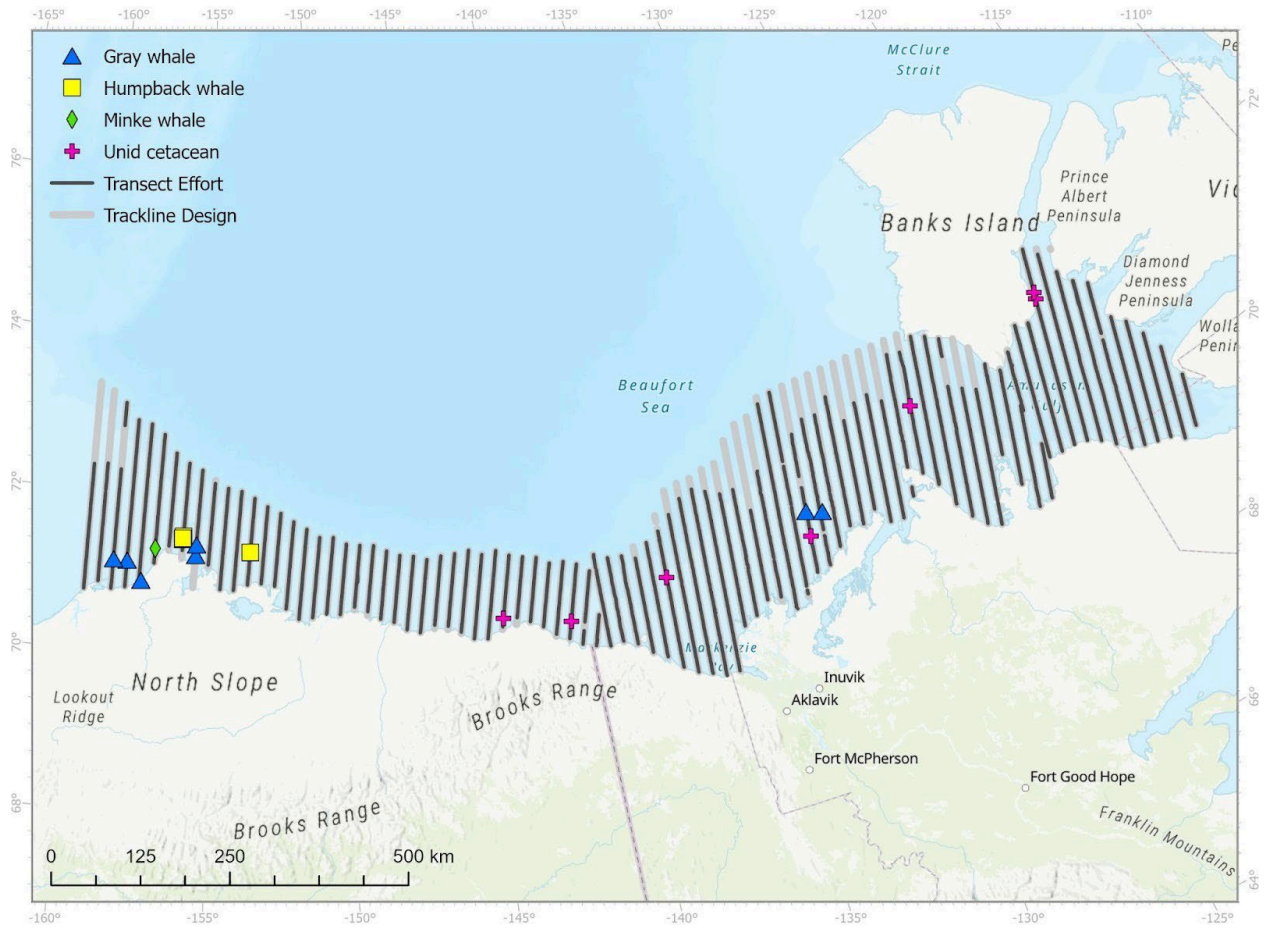


Figure 13. -- Other cetacean sightings and transect effort (black lines) during the 2025 Bowhead and Beluga Distribution and Abundance Aerial Survey.

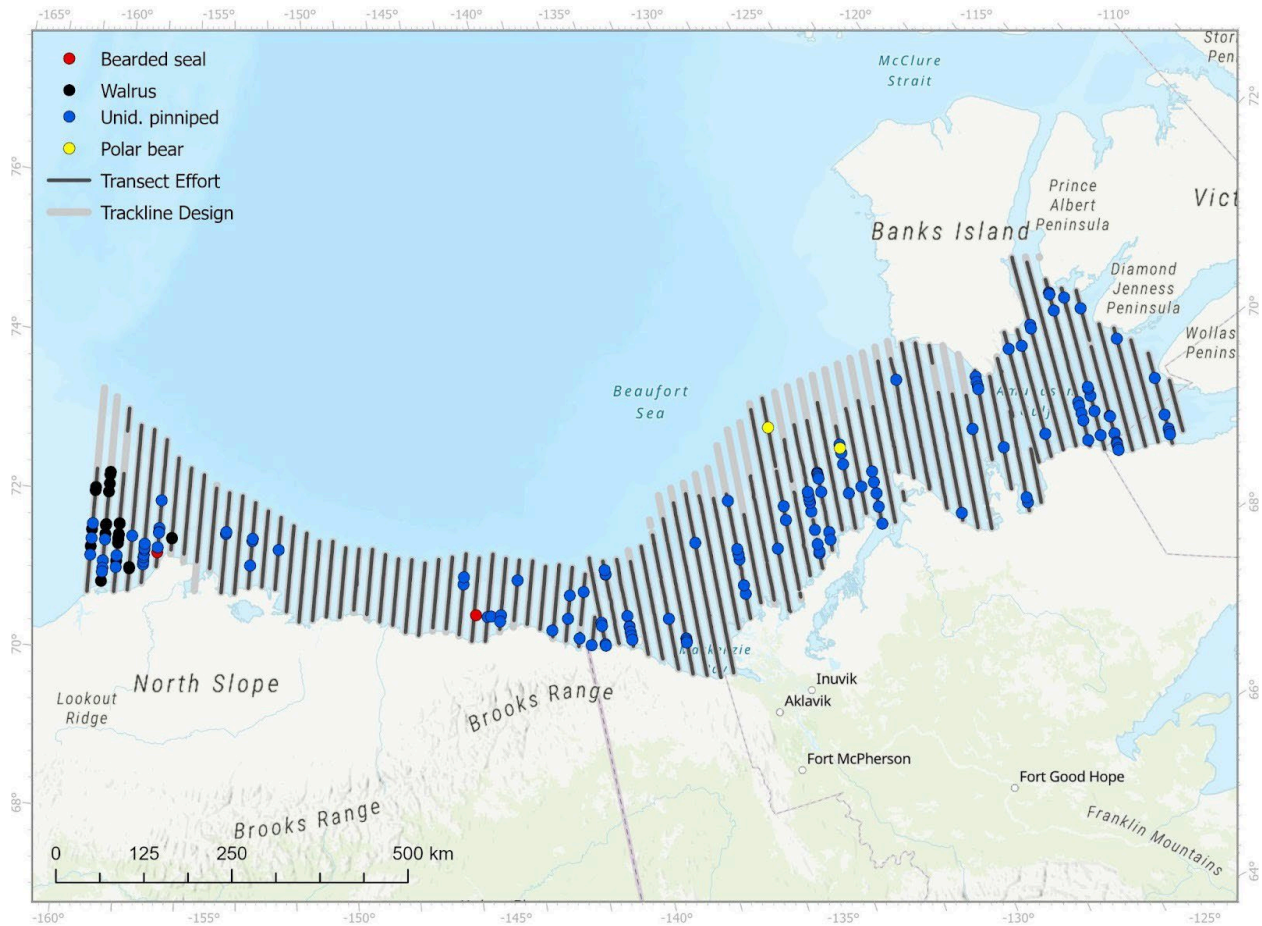


Figure 14. -- Pinniped and polar bear sightings overlaid on survey effort (black lines) during the 2025 Bowhead and Beluga Distribution and Abundance Aerial Survey.

## Camera Imagery

### Western Beaufort Sea Stratum

Images were collected from six cameras mounted in the belly port of the Twin Otter stationed in Deadhorse, Alaska. The number of files collected varied by flight and ranged from 11 to just over 10,000 (Table 9) per camera and file type. Throughout the entire survey, over 180,000 color (RGB), thermal (IR), and metadata (json) files were collected for a total volume of just over 4 terabytes. Fewer files were generally collected on flights that also included a calibration survey over land.

Table 9. --Number of files collected by flight for each mounted camera used by the aircraft that surveyed the western Beaufort Sea (Team A). Summary includes files for the center, left, and right cameras by file type (i.e., color image [RGB], thermal image [IR], and metadata [json]).

Flight	Center RGB	Center IR	Center json	Left RGB	Left IR	Left json	Right RGB	Right IR	Right json
101	4,681	4,681	4,683	4,681	4,680	4,681	4,681	4,681	4,682
102	4,993	4,993	4,994	4,983	4,991	4,993	4,993	4,991	4,993
103	9,646	9,652	9,655	9,645	9,647	9,655	9,646	9,648	9,655
104	10,092	10,102	10,103	10,092	10,102	10,102	10,092	10,099	10,102
105	5,238	5,238	5,237	5,238	5,236	5,237	5,238	5,238	5,237
106	3,428	3,428	3,428	3,428	3,427	3,428	3,428	3,428	3,428
107	6,503	6,511	6,514	6,503	6,514	6,515	6,503	6,509	6,515
108	5,015	5,022	5,022	5,014	5,023	5,022	5,024	5,023	5,022
109*	149	160	159	150	160	159	150	160	159
110*	1,449	1,450	1,448	1,449	1,450	1,449	1,449	1,450	1,449
111*	3,923	3,932	3,933	3,923	3,930	3,933	3,923	3,929	3,933
112*	11	12	11	11	12	11	11	12	11
113	4,961	4,970	4,968	4,961	4,969	4,968	4,961	4,967	4,969
<b>Total</b>	<b>60,089</b>	<b>60,151</b>	<b>60,155</b>	<b>60,078</b>	<b>60,141</b>	<b>60,153</b>	<b>60,099</b>	<b>60,135</b>	<b>60,155</b>

\*Flight included a calibration survey over land for the field-of-view analysis.

### Eastern Beaufort Sea and Amundsen Gulf Strata

Across the two survey aircraft based in Inuvik, NWT, Canada (Teams B and C), the number of images collected ranged from 4 to 11,719 (Table 10). Fewer images were collected on flights that included a calibration survey over land. Flight 201 was the first survey flight of the season (28 July 2025) and was the only flight to occur before the two camera systems were installed in the belly port of the aircraft. As a result, no imagery was collected during flight 201. In total, 50,713 and 61,537 images were collected by cameras installed in the two Twin Otters, respectively (Table 10).

Table 10. -- Number of images collected by stationary cameras installed in the two Twin Otters (Teams B and C) stationed in Inuvik, NWT, Canada during the 2025 Bowhead and Beluga Distribution and Abundance Aerial Survey.

Team B		Team C	
Flight	No. Images	Flight	No. Images
201	No Camera	301	4,335
202	5,686	302	2,900
203	7,041	303	7,747
204	3,786	304*	4
205*	143	305	9,857
206	7,897	306	7,209
207	4,984	307	9,593
208	6,864	308	2,975
209	3,764	309*	3
210	7,433	310	11,719
211*	3,115	311	5,231
<b>Total</b>	<b>50,713</b>	<b>Total</b>	<b>61,573</b>

\*Flight included a calibration survey over land for the field-of-view analysis.

## Discussion

The 2025 Bowhead and Beluga Distribution and Abundance Aerial Survey successfully surveyed 89% of the planned transect effort, providing a critical decadal update for the management of the BCB bowhead whale population. Despite the presence of anomalous sea ice -- which remained a persistent feature in the eastern Beaufort Sea -- the high completion rate across the western Beaufort Sea and Amundsen Gulf strata should provide a robust dataset for subsequent abundance modeling.

Sea ice conditions within the study area were anomalous compared to previous survey years, such as 2019, when sea ice was largely absent from the region (Clarke et al. 2020). In contrast to the recent trend of ice-free summers, sea ice was a persistent feature throughout the entire 2025 field season. While spatial concentrations gradually decreased in the western Beaufort Sea and Amundsen Gulf, ice persisted in the eastern Beaufort Sea; these conditions likely played an

important role in the observed distribution and aggregation patterns of at least bowhead whales. To mitigate the impact of heavy sea ice on sightability, we attempted to repeat several transects when ice cover diminished. However, in most cases, reduced sea ice coincided with higher Beaufort Sea States, which also hindered visibility. The impact of these two variables will be further examined during abundance analyses.

Compared to the 2019 survey, the distribution of bowhead whales in 2025 generally remained latitudinally consistent. However, bowhead whales in the Beaufort Sea were generally located closer to the shoreline than in previous years. Although a nearshore shift in prey is a possible driver, the apparent distribution may be confounded by observation bias, as high sea ice concentrations farther offshore negatively impact the probability of detecting whales. In contrast to 2019, a higher number of bowhead whales were recorded in the northern region of Amundsen Gulf in 2025. However, this change is primarily attributed to the expanded survey area. In 2025, transect lines were extended farther north into areas that remained unsurveyed in 2019. While both years aimed to cover Viscount Melville Sound, a region bordering Banks Island to the north and is known for its ecological importance for bowhead and beluga whales, the area was ultimately excluded due to its extreme remoteness, high operational costs, and safety concerns. Nevertheless, the documentation of bowhead whales in the Prince of Wales Strait, which serves as the primary corridor to Viscount Melville Sound, underscores the high likelihood that both species utilize habitats further north of the current survey area.

The total number of bowhead whale sightings and individuals documented during the 2025 survey was lower than the totals recorded in 2019 (Clarke et al. 2020). Across all effort types, there were a total of 200 bowhead whale sightings comprising 332 individuals in 2025, compared to 311 sightings of 440 individuals in 2019 (Clark et al. 2020). Contrary to bowhead whales, the distribution of beluga whales was similar in both years, with 2025 having a higher number of sightings and individuals (783 sightings of 2,377 animals) than in 2019 (625 sightings of 1,124 animals). While the 2025 counts represent a decrease in raw sightings, this variance may be attributable to differences in study area design, sea ice concentrations, and sighting conditions between the two study years rather than actual changes in population abundance. Detailed analyses, incorporating detection probability and environmental covariates, are required to determine if these differences represent a statistically significant shift in whale density or availability.

Data analyses will continue throughout 2026, incorporating corrections for availability and perception bias derived from the FOV trials. Final abundance estimates, which are essential for the renewal of IWC harvest quotas, are anticipated for release by mid-2027.

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