Modeling Western Arctic Bowhead Whale High-use Areas in the Western Beaufort Sea, 2000-2013

Megan Ferguson[1], Janet Clarke[2], Amelia Brower[1], Cynthia Christman[1]

[1]National Marine Mammal Laboratory, Alaska Fisheries Science Center, NOAA, Seattle, WA 98115, megan.ferguson@noaa.gov.   [2]Leidos, 4001 N Fairfax Drive, Arlington, VA 22203

ABSTRACT

Characteristics of Western Arctic bowhead whale distribution vary spatially from the Bering to the Chukchi and Beaufort seas, and temporally across seasons. Quantitatively describing the variability in bowhead whale distribution can lead to insights into bowhead whale ecology and can inform conservation and management decisions. The spatial distribution of bowhead whales in the western Beaufort Sea (140°-156°W) in the summer (July and August) and fall (September and October) of 2000 through 2013 was quantitatively assessed using a geographically-explicit model of bowhead whale relative abundance (number of animals per kilometer) based on sightings made during the Aerial Surveys of Arctic Marine Mammals (ASAMM) line-transect surveys and preceding projects. ASAMM is currently funded and co-managed by BOEM and conducted by NMFS. The analysis was restricted to the 2000-2013 ASAMM data because experts believe that a regime shift occurred in the Arctic around 2000-2002. The model was based on a grid with a 5 km x 5 km resolution and incorporated spatial and temporal heterogeneity in bowhead whale group size and survey effort. The model did not account for sighting probabilities, although this is a natural extension that will be built into future models. Bowhead whale high-use areas (HUAs) were identified as the locations of the 30th, 40th, 50th, 60th, and 70th percentiles of predicted bowhead whale relative abundance for each north/south column of 5 km x 5 km grid cells in the study area. For example, the location of the 30th percentile in a specific column of cells referred to the location where 30% of the predicted number of bowhead whales was closer to shore and 70% were farther offshore. The midpoints of all cells corresponding to each percentile were connected across the study area to define linear boundaries across the western Beaufort Sea corresponding to each percentile of the bowhead whale HUA. Interannual variability was evident in bowhead whale sightings in all months; however, some patterns were evident in the analysis pooled across all years. The resulting HUAs were located relatively farther offshore in July. From August through October, the HUAs were nearshore from Dease Inlet to Cape Halkett, and they bordered the barrier islands between Cross and Flaxman islands. The HUAs were relatively far from shore north of Harrison Bay in all months, and north of Camden Bay in every month except August.

Study Area and Field Methods

- **Location**: Western Beaufort Sea (Figure 1)

- **Timing**: Primarily September through October, 2000-2011; July through October, 2012-2013

- **Survey Aircraft and flight profiles**: Line transect aerial surveys for marine mammals were conducted in de Havilland Twin Otter and twin turbine Aero Commander aircraft with bubble windows at 204 km/h and 305-458 m altitude

- **Survey Protocols**: Crew included two primary marine mammal observers, one data recorder who also served as a secondary observer, and two pilots. Data were recorded onto a laptop computer, including automatic updates on the aircraft's latitude, longitude, and altitude. Environmental conditions were recorded every 5 minutes, or whenever conditions changed. All marine mammal sightings were recorded. The highest priority sighting data included species identification, group size estimates, number of calves, angle of declination to sighting from the horizon, behavior, and whether the animals reacted to the survey aircraft. Transect effort was conducted on predetermined, randomly placed transects oriented generally north/south. Search effort was conducted whenever sighting conditions were adequate and the aircraft was not surveying a transect line. The aircraft circled some bowhead whale sightings to better estimate group size and determine whether calves were present. Deadhead effort was assigned to flightlines located over land, shoreward of the barrier islands, or when sighting conditions were poor.

Cynthia Christman
NOAA/NMFS/AFSC/NMML
NMFS Permit No. 14245
Funded by BOEM (IA Contract No. M11PG00033)

Figure 1. ASAMM western Beaufort Sea study area, including survey blocks, isobaths, and offshore oil and gas lease areas

Analytical Methods
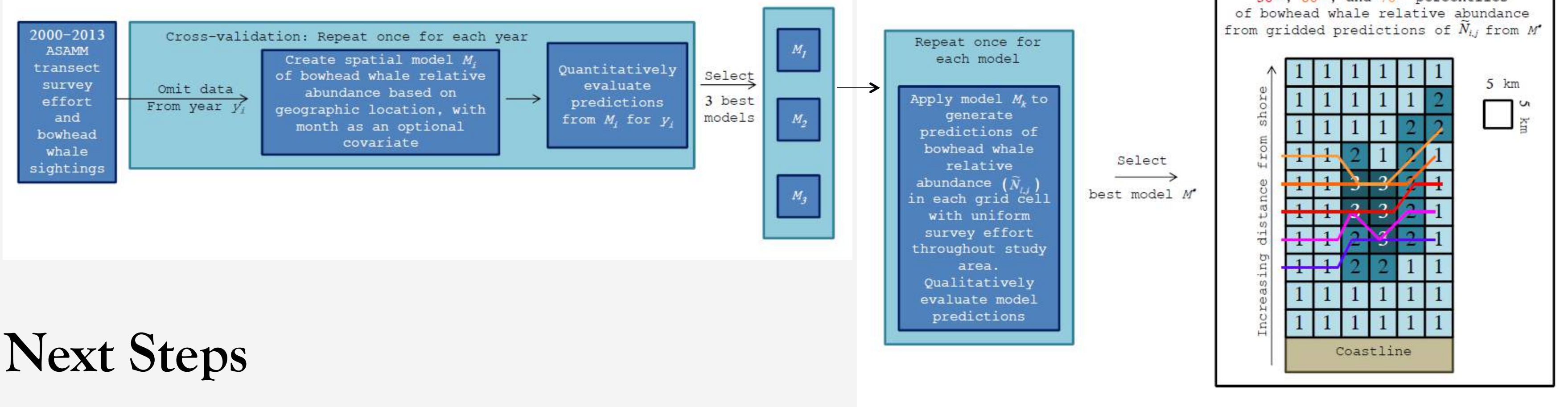
Next Steps

- Incorporate sighting probabilities into the spatial models

- Estimate uncertainty in the spatial model predictions

- Examine interannual variability in the spatial model predictions

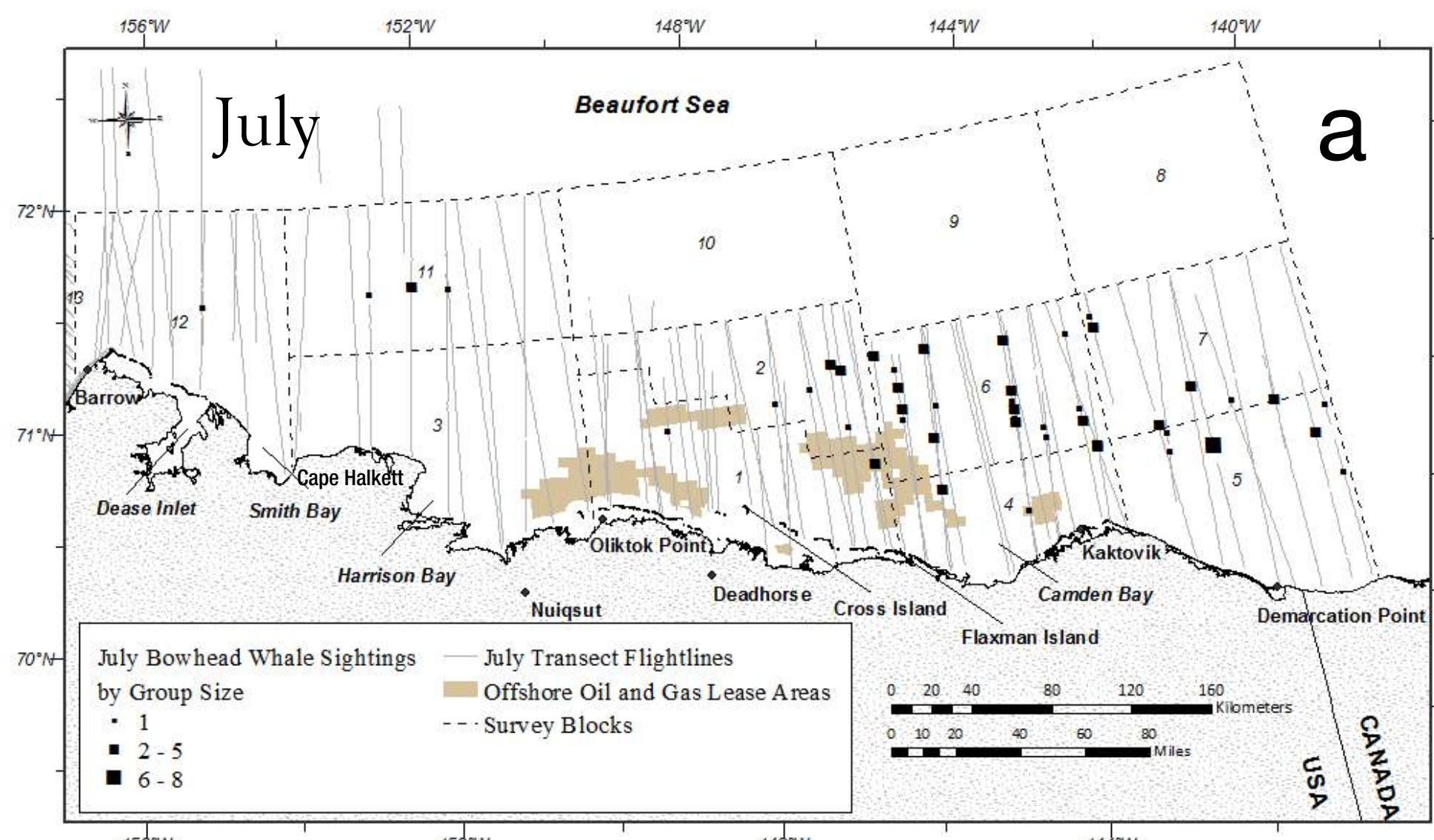## ASAMM Transect Effort and Bowhead Whale Transect Sightings

Predicted Bowhead Whale Relative Abundance and High-use Areas

Figure 2a. The spatial model incorporated a total of 59 bowhead whale sightings made by primary observers on transect in July. All of the July sightings were from 2012 and 2013, and the majority of the sightings were located in the eastern half of the study area. b. The spatial model predicted that the bowhead whale high-use areas were farthest offshore in July. Limited sample size in the western half of the study area provided minimal information for the spatial models in July.
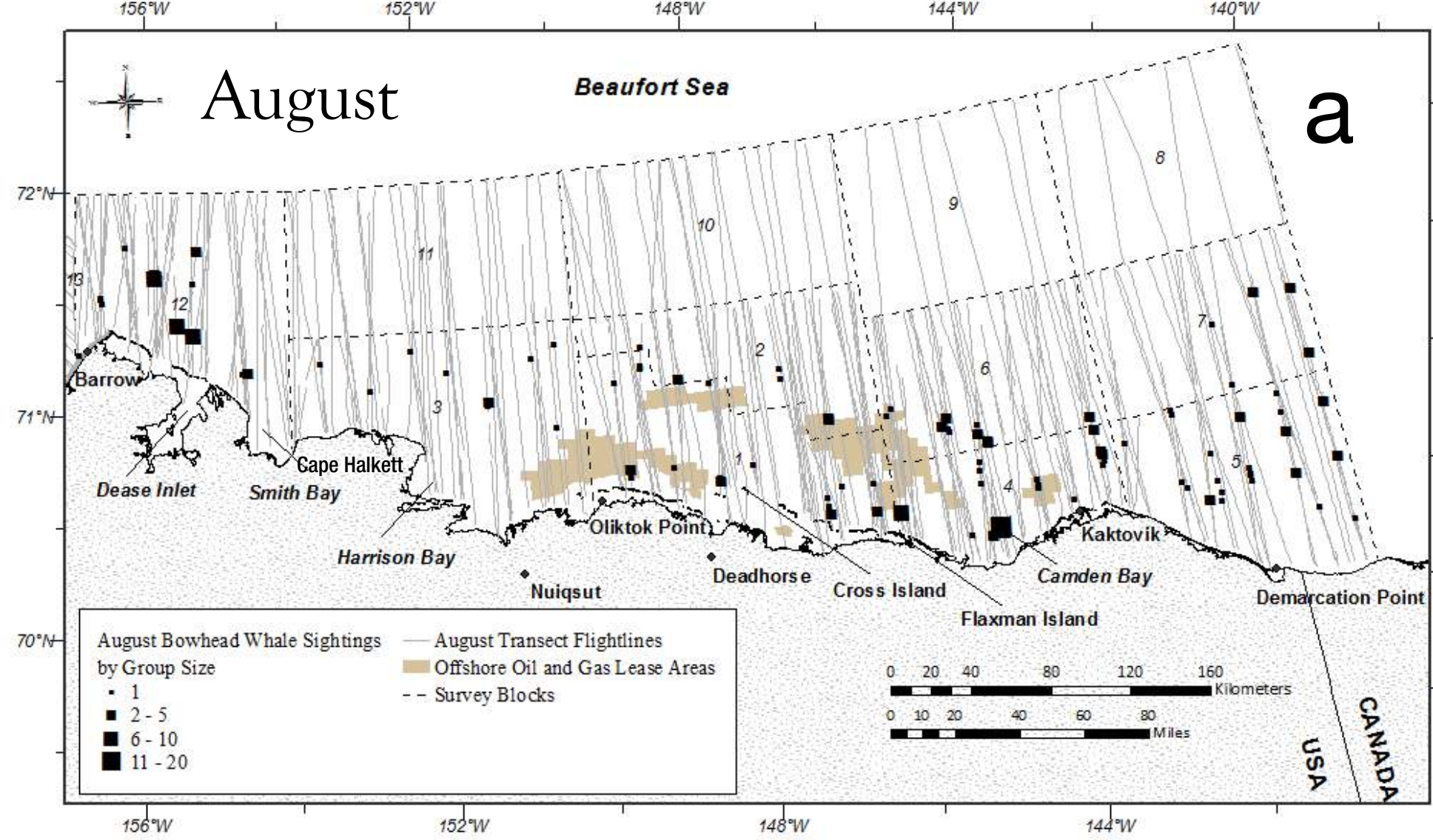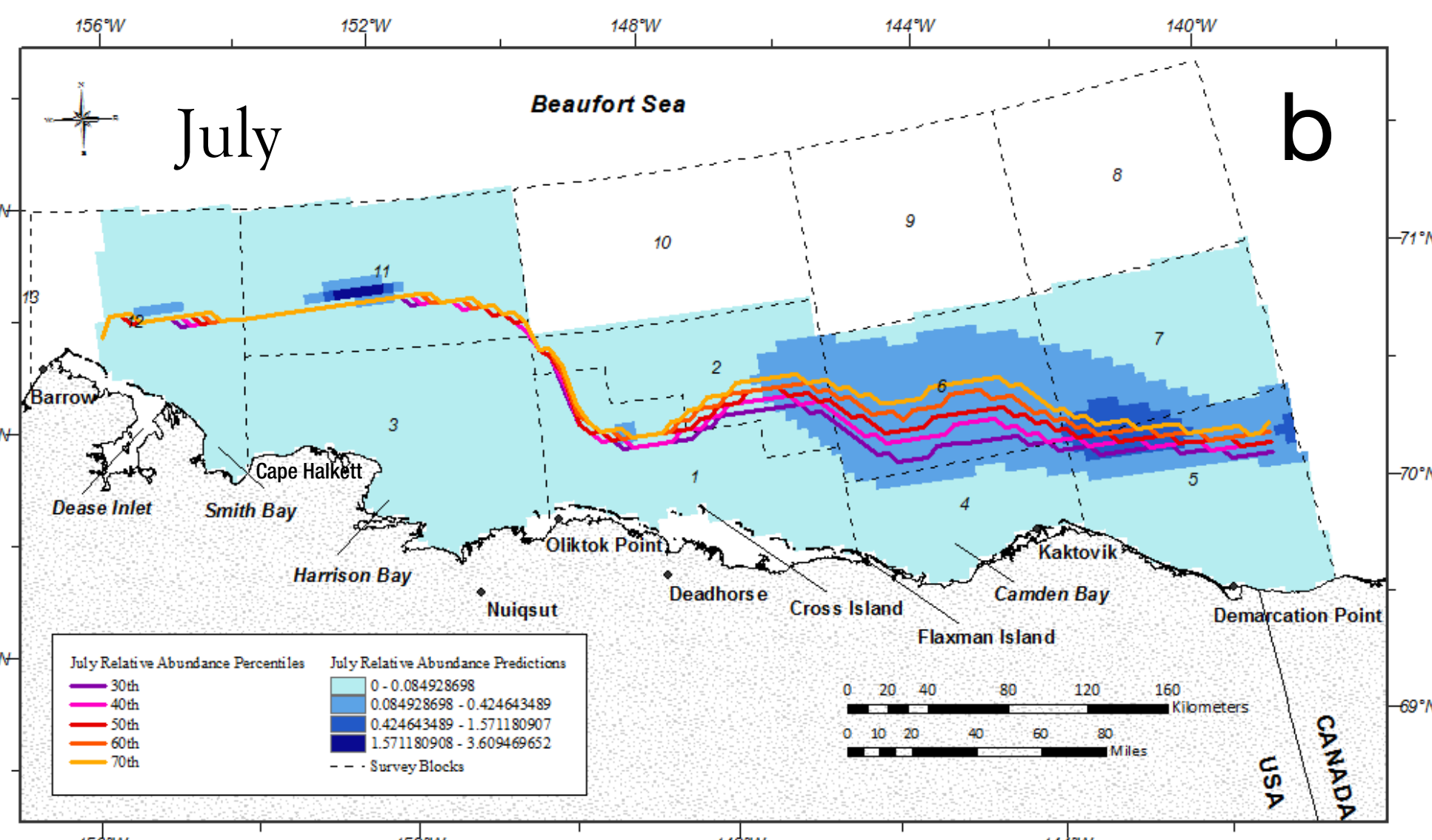

Figure 3a. The spatial model incorporated a total of 125 bowhead whale sightings made by primary observers on transect in August. Most of the August sightings were from 2012 and 2013. b. The spatial model predicted that the bowhead whale high-use areas were located relatively close to shore from Dease Inlet to Cape Halkett, and just outside the barrier islands from Oliktok Point to Flaxman Island. The high relative abundance predictions inside Camden Bay were heavily influenced by two sightings with large group sizes (14 and 20 animals) made on 20 August 2013. The percentile lines extending into Smith Bay are likely due to model misspecification because there were no sightings in the bay.
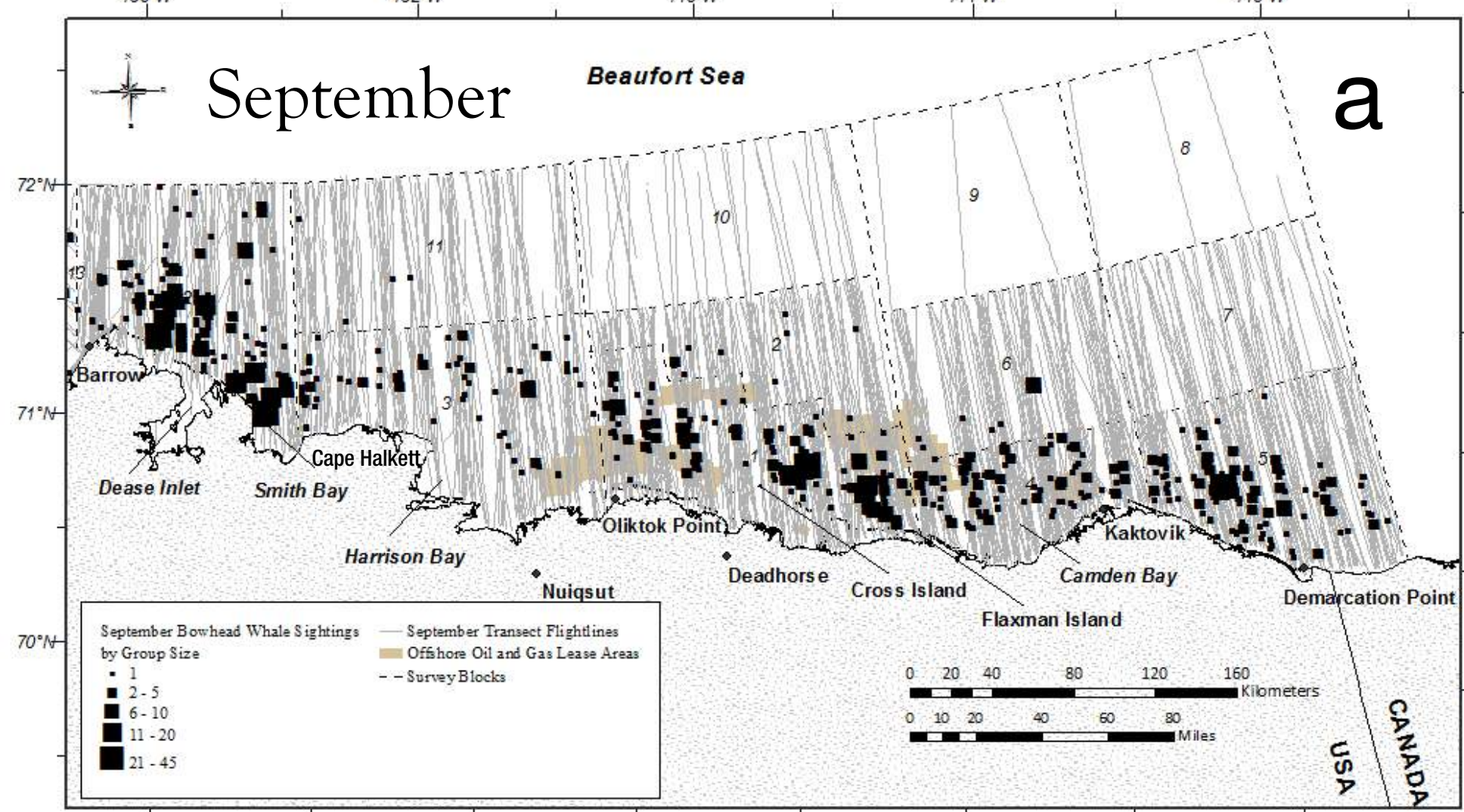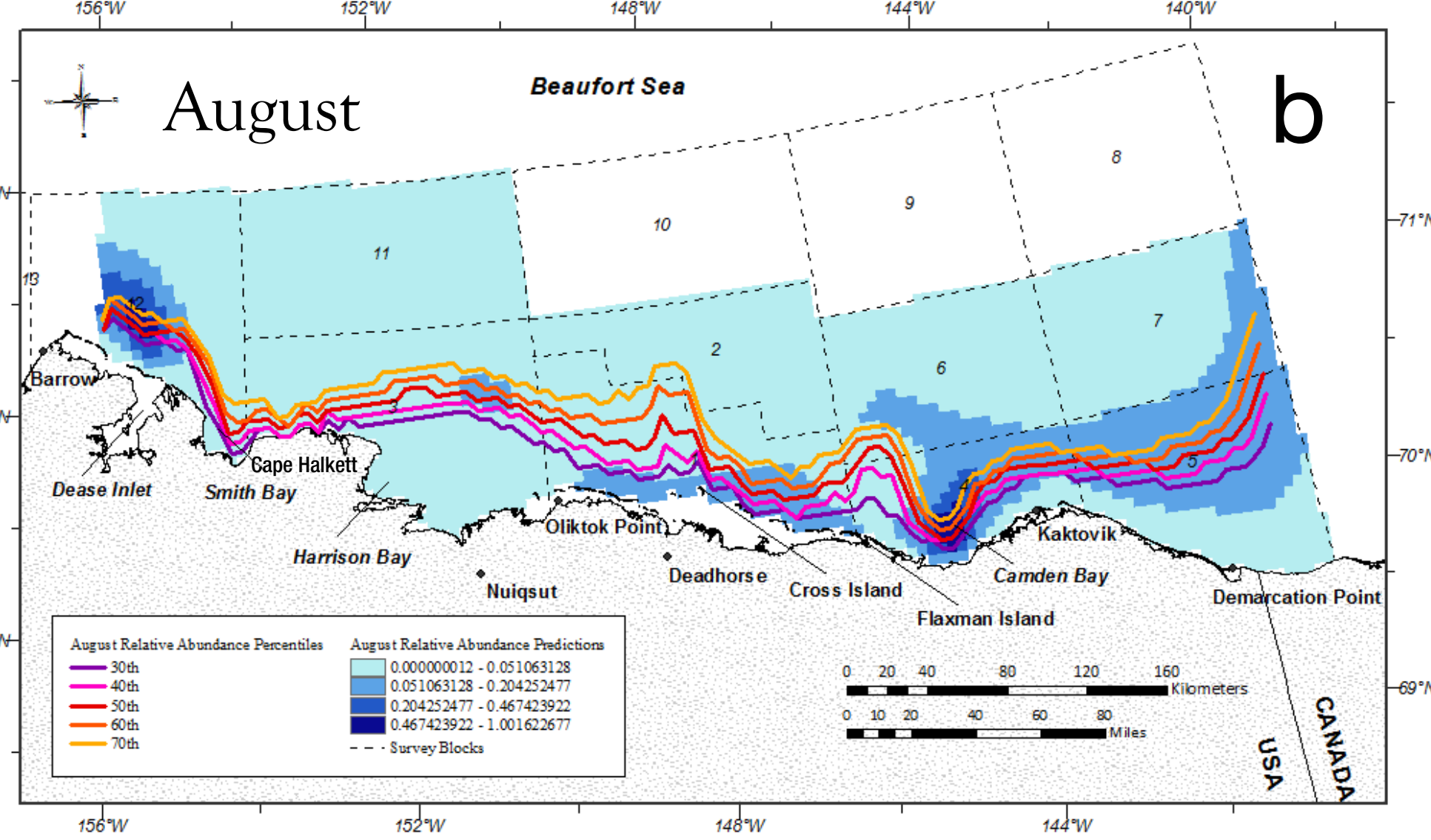

Figure 4a. The spatial model incorporated a total of 643 bowhead whale sightings made by primary observers on transect in September. b. The spatial model predicted that the bowhead whale high-use areas were located relatively close to shore from Dease Inlet to Cape Halkett, and just outside the barrier islands from Oliktok Point to Flaxman Island. The model predicted relatively low abundance in Harrison and Camden bays, and relatively high abundance in the Barrow Canyon area.
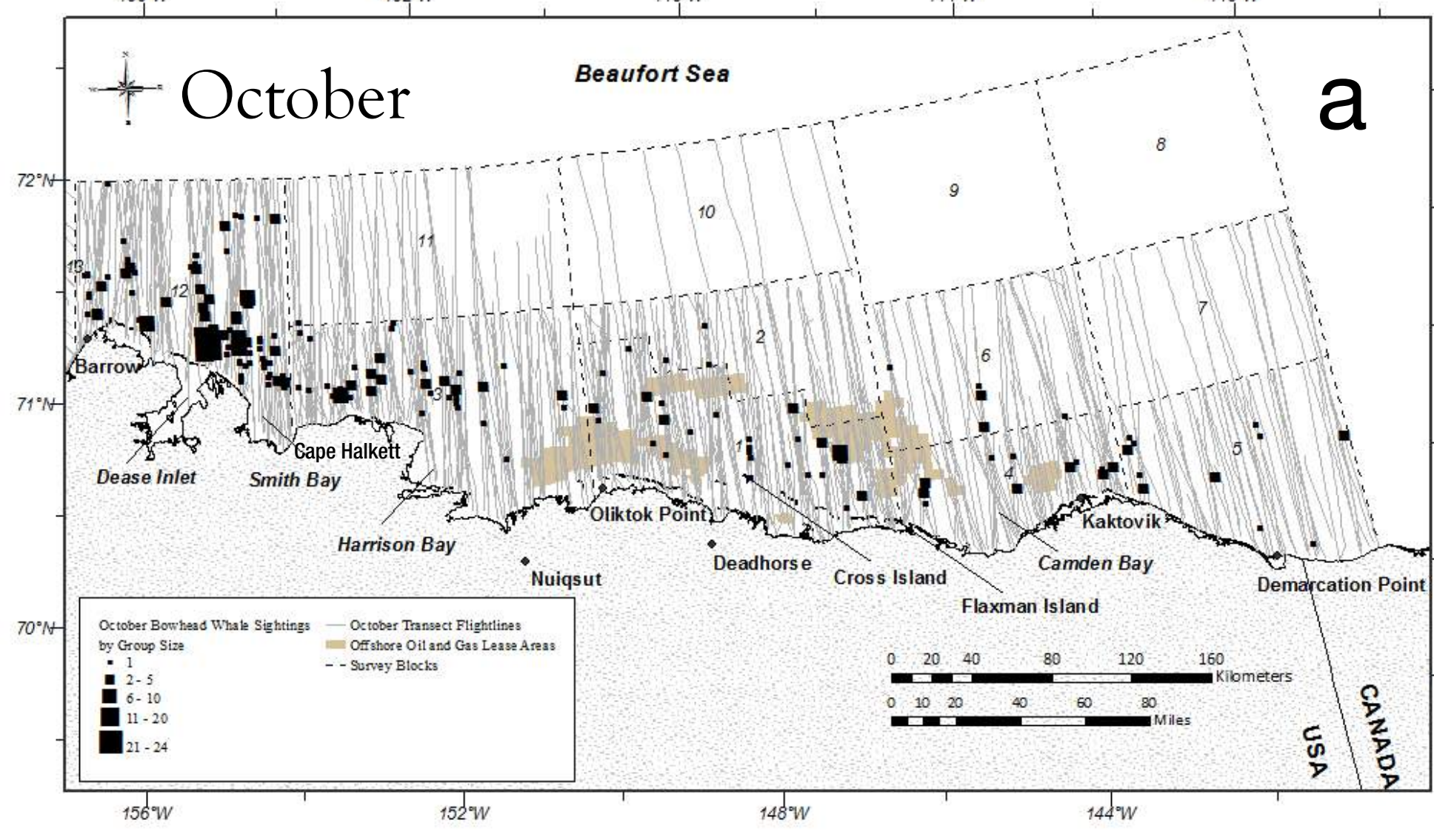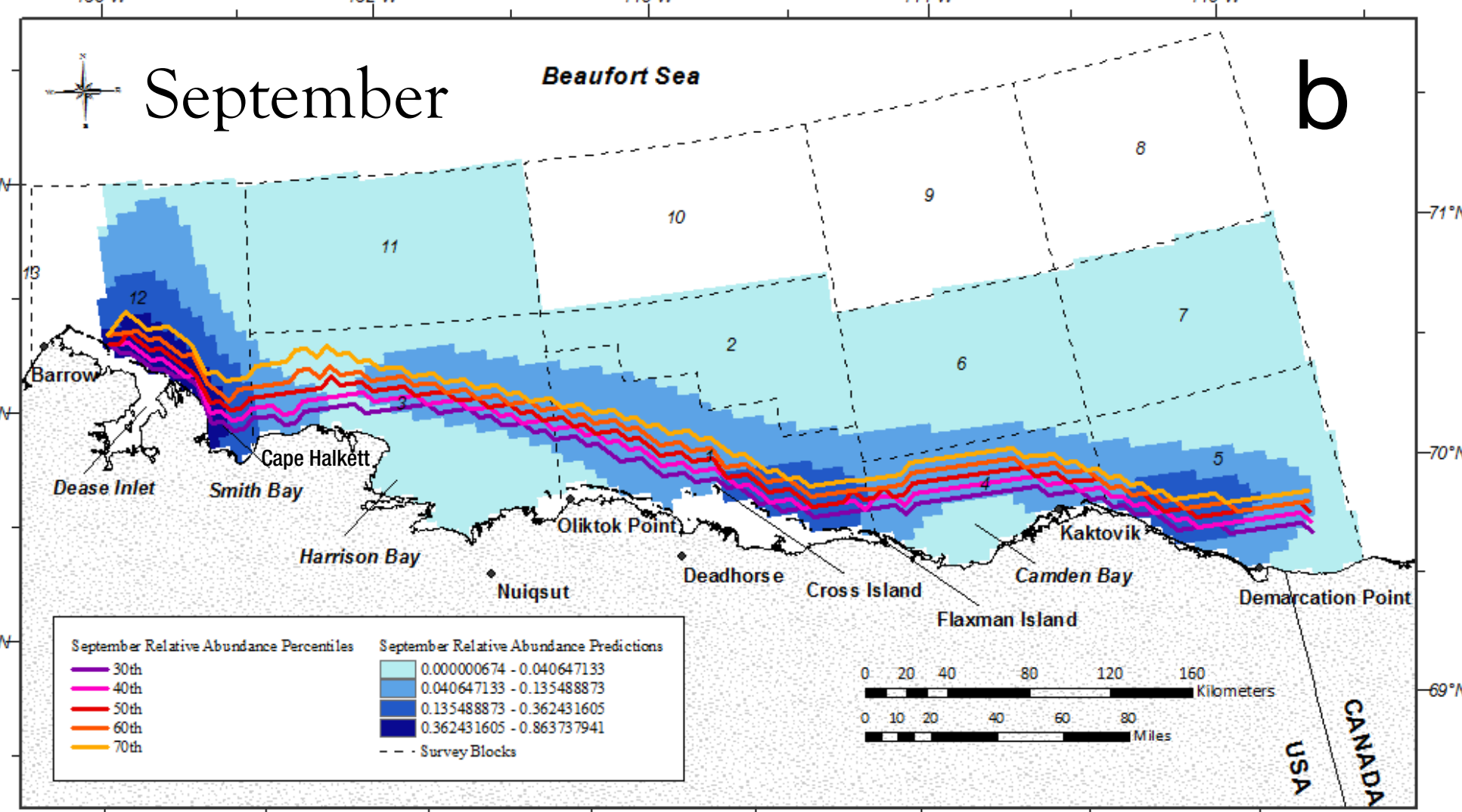

Figure 5a. The spatial model incorporated a total of 279 bowhead whale sightings made by primary observers on transect in October. b. Similar to September, the spatial model predicted that the bowhead whale high-use areas were located relatively close to shore from Dease Inlet to Cape Halkett, and just outside the barrier islands from Cross Island to Flaxman Island. The model predicted relatively low abundance in Harrison and Camden bays.