Aerial Surveys of Endangered Whales in the Beaufort Sea, Fall 2002 – 2004

OCS Study
MMS 2005-037

U.S. Department of the Interior
Minerals Management Service
Alaska Outer Continental Shelf Region

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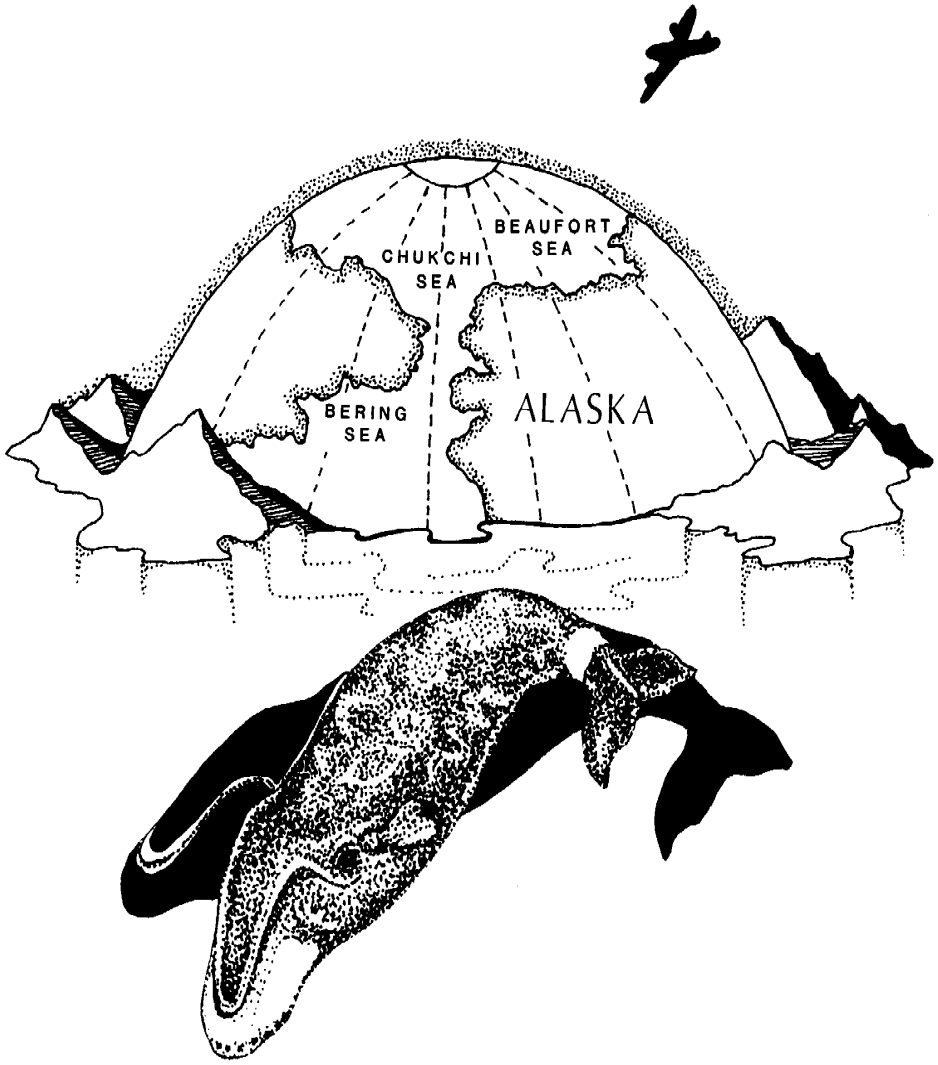
By Charles Monnett and Stephen D. Treacy
MMS Bowhead Whale Aerial Survey Project



U.S. Department of the Interior
Minerals Management Service
Alaska OCS Region

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ABSTRACT

This report describes field activities and data analyses for aerial surveys of bowhead whales conducted during Fall 2002 (22 August - 7 October), Fall 2003 (1 September - 19 October), and Fall 2004 (1 September – 18 October) in the Beaufort Sea, between 140 °W. and 156 °W. longitudes south of 72°N. latitude.

During Fall 2002, general ice cover during September and October was the 5th-mildest open-water season (1953-2002). A total of 27 survey flights were attempted. There were 74 sightings for a total of 83 bowhead whales counted during Fall 2002. Additionally, 645 beluga whales, 97 bearded seals, 618 ringed seals, and 11 polar bears were observed during 98.6 hours of survey effort that included 60.0 hours on randomized transects.

During Fall 2003, general ice cover during September and October was relatively light. A total of 28 survey flights were attempted. There were 146 sightings for a total of 245 bowhead whales counted. Additionally, 444 beluga whales, 26 bearded seals, 301 ringed seals, and 45 polar bears were observed during 76.3 hours of survey effort that included 40.0 hours on randomized transects.

During Fall 2004, general ice cover during September and October was very light. A total of 29 survey flights were attempted. There were 238 sightings for a total of 496 bowhead whales counted. Additionally, 447 beluga whales, 93 bearded seals, 2896 ringed seals, and 55 polar bears were observed during 115.9 hours of survey effort that included 66.0 hours on randomized transects.

In 2002, 2003 and 2004 the respective axes of bowhead whale sightings were: East Region 21.9 km, 31.8 km, and 26.2 km; and West Region 41.9 km, 34.4 km and 26.0 km. Means were compared with combined data for other years and comparisons indicated that bowhead whales were closer to shore in the East Region in 2002 and 2004, and the West Region in 2004 than in previous years. Mean values for both Regions in all 3 years were within the respective 25th – 75th quartile ranges for all years (1982-2001).

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I. INTRODUCTION

In 1953, the Outer Continental Shelf Lands Act (OCSLA) (43 USC 1331-1356) charged the Secretary of the Interior with the responsibility for administering minerals exploration and development of the OCS. The Act empowered the Secretary to formulate regulations so that its provisions might 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) as the administrative agency responsible for leasing submerged Federal lands and the Conservation Division of the U.S. Geological Survey for classification and evaluation of submerged Federal lands and regulation of exploration and production. In 1982, the Minerals Management Service (MMS) assumed these responsibilities.

To provide information used in environmental impact statements and environmental assessments under the National Environmental Policy Act of 1969 (42 USC 4321-4347), and to assure protection of marine mammals under the Marine Mammal Protection Act of 1972 (16 USC 1361-1407) and the Endangered Species Act (ESA) of 1973 (16 USC 1531-1543), BLM funded numerous studies involving acquisition and analysis of marine mammal and other environmental data.

In June 1978, BLM entered into an ESA Section 7 consultation with NMFS. 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. The NMFS determined that insufficient information existed to conclude whether the proposed Beaufort Sea sale was or was not likely to jeopardize the continued existence of bowhead and gray whales. In August 1978, NMFS recommended studies to BLM that would fill the information needs identified during the Section 7 consultation. Subsequent biological opinions for leasing and exploration in the Beaufort Sea (Sales 71, 87, and 97) and the 1988 Arctic Region Biological Opinion (ARBO), used for Beaufort and Chukchi Sea sales (Sales 124, 126, 144, and 170), recommended continuing studies of whale distribution and OCS-industry effects on bowhead whales (USDOC, NOAA, NMFS, 1982, 1983, 1987, 1988) and monitoring of bowhead whale presence during periods when geophysical exploration and drilling are occurring. The current ARBO, issued by NMFS in 2001 for leasing and exploration in the Beaufort Sea, also recommends that whale distribution studies during the fall migration continue, along with acoustic monitoring studies to describe the impact of exploration activities on the migration path of bowhead whales in the Beaufort Sea.

Following several years when drilling was limited to the period 1 November through 31 March (USDOI, MMS, 1979), a variable 2-month seasonal-drilling restriction on fall exploratory activity in the joint Federal/State Beaufort Sea sale area was implemented. The period of restriction would vary depending on bowhead whale presence, and "this determination would require development of a monitoring program. . .." (USDOI, MMS, 1982). Subsequently, MMS (Alaska OCS Region) adopted an endangered whale-monitoring plan that required aerial surveys. The Diapir Field Sale 87 Notice of Sale (NOS) (1984) states 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 (Sales 97, 124, 144, and 170) did not include a seasonal drilling restriction but the NOS for each contained an Information to Lessees clause that "MMS intends to continue its area wide endangered whale monitoring program in the Beaufort Sea during exploration activities" (USDOI, MMS, 1988, 1991, 1996, 1998). Information gathered is used to help determine the extent, if any, of adverse effects on the species.

From 1979 to 1987, the MMS (formerly BLM) funded annual monitoring of endangered whales in arctic waters under Interagency Agreements with the Naval Ocean Systems Center and through subcontracts to SEACO, Inc. On 15 April 1987, a proposal for MMS scientists to conduct aerial surveys of endangered

whales was approved by the Associate Director for Offshore Minerals Management. The MMS uses agency personnel to perform fieldwork and reporting activities for the Beaufort Sea on an annual basis. The goals of the ongoing project for monitoring endangered whales are to:

1. Define the annual fall migration of bowhead whales, significant inter-year differences, and long-term trends in the distance from shore and water depth at which whales migrate;

2. Monitor temporal and spatial trends in the distribution, relative abundance, habitat, and behaviors (especially feeding) of endangered whales in arctic waters;

3. Provide real-time data to MMS and NMFS on the general progress of the fall migration of bowhead whales across the Alaskan Beaufort Sea, for use in protection of this Endangered Species;

4. Provide an objective wide-area context for management interpretation of the overall fall migration of bowhead whales and site-specific study results;

5. Record and map beluga whale distribution and incidental sightings of other marine mammals; and

6. Determine seasonal distribution of endangered whales in other planning areas of interest to MMS.

II. METHODS AND MATERIALS

A. Study Area

The annual survey program has been based on a design of random field transects within established geographic blocks overlapping or near Chukchi and Beaufort Sea sale areas offshore of Alaska. The present study, which was focused on the fall bowhead whale migrations during 2002-2004, included Beaufort Sea Survey Blocks 1 through 12 (Figure 1) between 140°W. and 157°W. longitude south of 72°N. latitude.

A large-scale Beaufort Gyre moves waters clockwise from the Canadian Basin westward in the deeper offshore regions. Nearshore surface currents tend to follow local wind patterns and bathymetry, moving from the east in winter, with an onshore component, and to the west in summer, with an offshore component (Brower et al., 1988). There is recent evidence for the existence of two regimes or climate states for arctic atmospheric-ice-ocean circulation. Based on analysis of modeled sea level and ice motion, wind-driven motion in the Arctic was found to alternate between anticyclonic and cyclonic circulation, with each regime persisting for 5-7 years (Proshutinsky and Johnson, 1997; Johnson et al., 1999).

In the Beaufort Sea, landfast ice forms during the fall and may eventually extend up to 50 kilometers (km) offshore by the end of winter (Norton and Weller, 1984). The pack ice, which includes multiyear ice averaging 4 meters (m) in thickness, with pressure ridges up to 50 m thick (Norton and Weller, 1984), becomes contiguous with the new and fast ice in late fall—effectively closing off the migration corridor to westbound bowhead whales. From early November to mid-May, the Beaufort Sea normally remains almost totally covered by ice considered too thick for whales to penetrate. In mid-May, a recurring flaw lead can form just seaward of the stable fast ice, followed by decreasing ice concentrations (LaBelle et al., 1983) and large areas of open water in summer.

Local weather patterns affect the frequency and effectiveness of all marine aerial surveys. The present study area is in the arctic climate zone, with mean temperatures at the Alaskan Beaufort Sea coast communities of Barrow, Lonely, Oliktok, and Barter Island from -0.9°C to -0.1°C during September and from -9.7°C to -8.5°C during October. Precipitation in these communities occurred an average of 10 to 34 percent of the time during September (snow with some rain) and 13 to 43 percent during October (almost all snow), with the heaviest precipitation at Barrow and Barter Island during both months. Fog (without precipitation) reduces visibility approximately 11 to 19 percent of the time during September and 6 to 8 percent of the time during October. Mean wind speed in the same communities is from 5 to 6 m per second during September and 5 to 7 m per second during October (Brower et al., 1988).

Sea state is another environmental factor affecting visibility during aerial surveys. Surface waters in the Beaufort Sea are driven primarily by wind. Ocean waves are generally from northerly or easterly directions during September and October, during which time the ice pack continues to limit fetch. Because of the pack ice, significant wave heights are reduced by a factor of 4 from heights that would otherwise be expected during the open-water season. Wave heights greater than 0.5 m occurred in 23.9 to 38.9 percent of observations during September and 14.1 to 37.4 percent during October, with the greater percentage of larger waves (>0.5 m) reported for the eastern third of the study area during both months. Wave heights greater than 3.5 m are not reported within the study area during September or October (Brower, 1988).

The study area contains sufficient zooplankton to support some feeding by bowhead whales. The availability of zooplankton during the fall would be expected to vary between years, geographic locations, and water depths in response to ambient oceanographic conditions. In September 1985 and 1986, average zooplankton biomass in the Alaskan Beaufort Sea east of 144°W. longitude was highest south of the 50-m isobath in subsurface water (LGL Ecological Research Associates, Inc., 1987).

B. Equipment

The survey aircraft was a de Havilland Twin Otter Series 300 (call sign: N321EA). The aircraft was equipped with two medium-size bubble windows behind the cabin bulkhead and one on the aft starboard side that afforded complete trackline viewing. The pilot and copilot seats provided good forward and side viewing. Each observer was issued a hand-held clinometer (Suunto) for measuring the angle of inclination to the sighting location of endangered whales. Observers and pilots were linked to common communication systems, and commentary could be recorded. The aircraft's maximum time aloft under normal survey load was extended to approximately 8 hours (hr) through the use of a supplemental onboard fuel tank.

A portable Gateway Solo 5100 SE laptop computing system was used aboard the aircraft to store and analyze flight and observational data. The computer system was connected to a local Garmin III Global Positioning System (GPS) with external aircraft antenna. A custom moving-map program developed by MMS project personnel in Visual Basic permitted surveyors to view the aircraft's trackline in real time.

Onboard safety equipment included an impact-triggered emergency locator transmitter installed in the aircraft, a 6-person Switlik Search and Rescue Life Raft equipped with a portable Personal Locator Beacon and desalination pump, a portable ICOM A3 Sport aircraft-band transceiver, an emergency Magellan 3000 GPS, White dry suits, and emergency flight helmets.

A Windstream Flight System was used for satellite-tracking the project aircraft over the Alaskan Beaufort Sea. The OAS obtained current flight information in the form of maps for visual tracking of the survey aircraft. As a backup, we used an Iridium phone system as needed for communicating our position to OAS. In addition to these flight-following systems, the onboard transponder was set at a discrete identification code for radar tracking by air-traffic-control personnel.

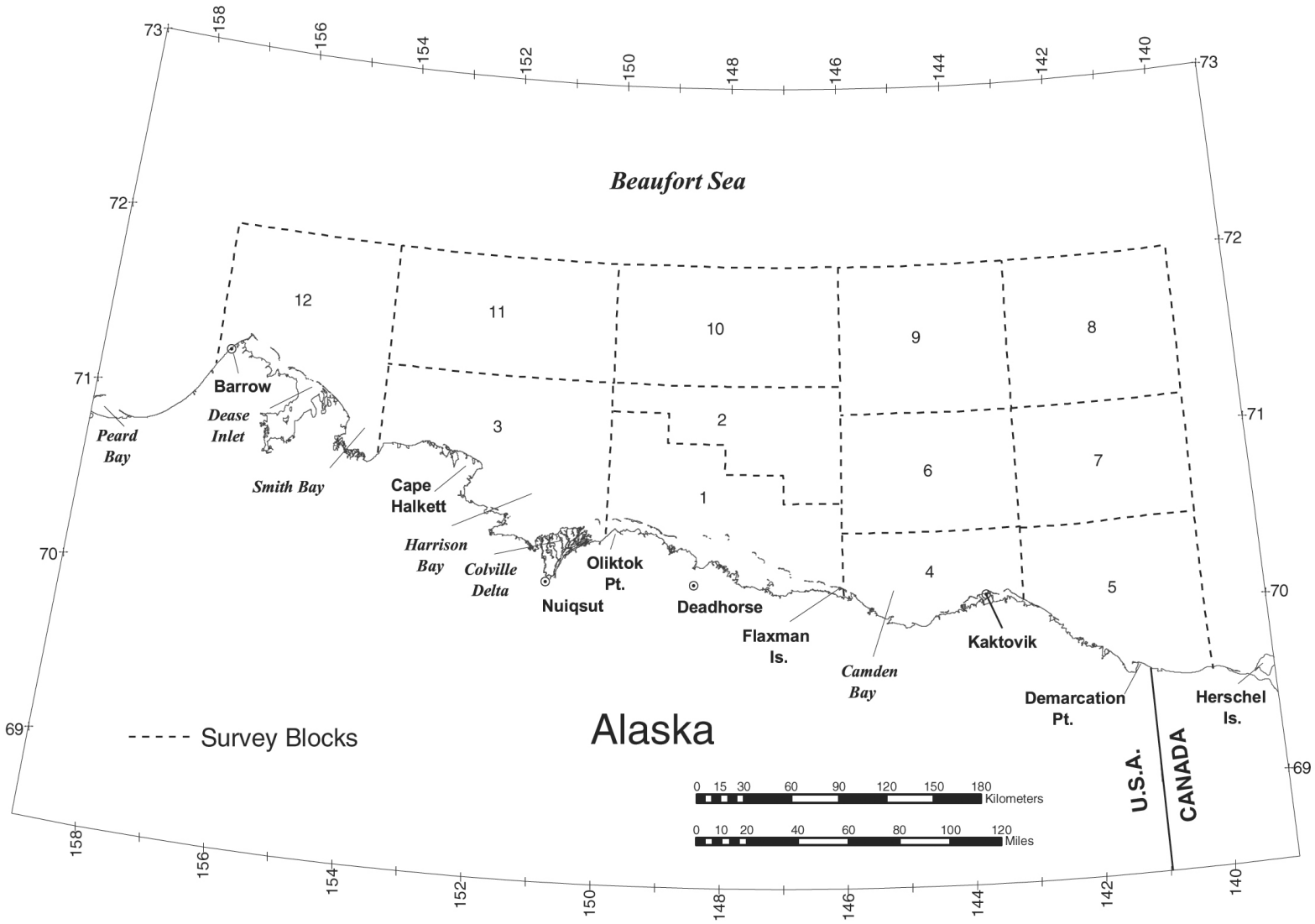

Figure 1 – Study Area Showing Survey Blocks

C. Aerial-Survey Design

Aerial surveys were based out of Deadhorse, Alaska, from 20 August through 10 October during 2002; from 30 August through 20 October during 2003; and from 30 August through 20 October during 2004. Field schedules were designed to monitor the progress of fall bowhead migrations across the Alaskan Beaufort Sea. All bowhead (and beluga) whales observed were recorded, along with incidental sightings of other marine mammals. Particular emphasis was placed on regional surveys to assess large-area shifts in the migration pathway of bowhead whales and on the coordination of effort and management of data necessary to support seasonal offshore-drilling and seismic-exploration regulations.

Daily flight patterns were based on sets of unique transect grids computer-generated for each survey block. Transect grids were derived by dividing each survey block into sections 30 minutes of longitude across. One of the minute marks along the northern edge of each section was selected at random then connected by a straight line to a similarly selected endpoint along the southern edge of that same section. This procedure was followed for all sections of that survey block. These transect legs were then connected alternately at their northernmost or southernmost ends to produce one continuous flight grid within each survey block. The use of random-transect grids is a requirement for subsequent analyses of the bowhead migration corridor based on line-transect theory (Cochran, 1963).

The selection of the survey blocks to be flown on a given day was nonrandom, based primarily on criteria such as reported or observed weather conditions over the study area and the level of offshore oil industry activity in various areas. Weather permitting, the project attempted to distribute effort fairly evenly east-to-west across the entire study area. It also used a semimonthly flight-hour goal for each survey block allocated proportionately for survey blocks east of 154°W. longitude and semimonthly time periods based on relative abundance of bowhead whales as determined from earlier fall migrations (1979-1986). Such allocations, detailed in our Project Management Plan (USDOI, MMS, 2001), greatly favor survey coverage in inshore Survey Blocks 1 through 7 and 11 (Figure 1), since bowheads were rarely sighted north of these blocks in previous surveys. The purpose of these survey-effort allocations was to increase the sample size (n) of whale sightings within the primary migration corridor, thus increasing the power of statistical analysis within these inshore blocks. Only data from random-transect legs were used to analyze the migration axis, using a line-transect model.

D. Survey-Flight Procedures

During a typical flight, a “search” leg was flown to the target survey block, beginning a series of random-“transect” legs (above) joined together by “connect” legs, followed by a search leg back to Deadhorse. Surveys generally were flown at a target altitude of 458 m. Weather permitting, this altitude was maintained in order to maximize visibility and to minimize potential disturbance to marine mammals. Flights were normally aborted when cloud ceilings were consistently less than 305 m or the wind force was consistently above Beaufort 4.

Port observers included a Primary Observer, whose field of vision through a bubble window included the trackline directly below the aircraft to the horizon, the Pilot, and an occasional secondary observer-visitor, stationed aft at a flat window. Starboard observers included a Data Recorder-Observer, whose field of vision through a bubble window was particularly focused on guarding the trackline, as well as a Team Leader and a second Pilot, who were alternately stationed at an aft bubble window and the copilot’s seat. A clinometer was used to measure the angle of inclination to each sighting of endangered whales when the initial sighting location was abeam of the aircraft.

When bowheads were encountered while surveying a transect line, the aircraft sometimes diverted from transect for brief (<10-minute) periods and circled the whales to observe behavior, obtain better estimates of their numbers, and determine whether calves were present. Any new sightings of whales made while circling were not counted as “on transect.” Likewise, sightings made while en route to transect grids were counted as “on search”.

E. Data Entry

A customized computer data-entry form developed by MMS project personnel was used to record all data in database format (Access 97). A multi-columnar data table permitted several entries of sighting and position-update data to be logged and edited simultaneously. The data-entry form is menu-driven, facilitating entry of a complete data sequence for sightings of whales. These data included date, time, latitude, longitude, altitude, aircraft heading, reason for entry, species, total number, observer, swim direction (magnetic), clinometer angle, calf number, behavior, sighting cue, predominant size, habitat, swim speed, repeat sighting, and response to aircraft. Reduced data sequences were used when recording other marine mammals. Position-update data on sky conditions, visual impediments, visibility left and right, percent ice coverage, ice type, and wind force were entered at sightings, turning points, when changes in environmental conditions were observed, and otherwise within 10-minute intervals. Entries were simultaneously printed out in hard copy.

The behavior, swim speed, and swim direction for observed whales represent what the pod as a whole was doing at the time it was first sighted. Behaviors were entered into one of 15 categories as noted on previous surveys. These categories—breaching, cow-calf association, diving, feeding, flipper-slapping, log playing, mating, milling, resting, rolling, spy-hopping, swimming, tail-slapping, thrashing, and underwater blowing—are defined in Table 1. Swimming speed was subjectively estimated by observing the time it took a whale to swim one body length. An observed swimming rate of one body length per minute corresponded to an estimated speed of 1 km/hr. One body length per 30 seconds was estimated at 2 km/hr, and so on. Swimming speed was recorded by relative category (i.e., still, 0 km/hr; slow, 0-2 km/hr; medium, 2-4 km/hr; or fast, >4 km/hr). Likewise, whale size was estimated relatively as calf (length less than half of accompanying adult), immature, adult, or large adult. Swim direction was initially recorded in magnetic degrees, using the aircraft's compass.

Wind force was recorded according to the Beaufort scale outlined in *Piloting, Seamanship, and Small Boat Handling* (Chapman, 1971). Ice type was identified using terminology presented in Naval Hydrographic Office Publication Number 609 (USDOD, Navy, 1956). Average ice cover over a 1-2 km lateral distance from the aircraft was estimated as a single percentage, regardless of ice type.

F. General Data Analyses

Preliminary field data analysis was performed by a computer program—developed by MMS project personnel—that provided daily summations of marine mammals observed, plus calculation of time and distance on transect legs, connect legs, and general search portions of the flight. This analysis program provided options for editing the data file, calculating summary values, and printing various flight synopses.

Tables showing the number of survey hours flown for individual days, half-months, months, or survey blocks were subject to decimal-rounding errors and may or may not add up to the grand total shown for the entire field season. For greatest accuracy and consistency, the total survey hours shown in tables was calculated separately from the cumulative total minutes flown over the entire field season.

The water depth at each bowhead sighting in the 1982-2004 database was derived from the International Bathymetric Chart of the Arctic Ocean (IBCAO) containing grid cells 2.5 km square (website http://www.ngdc.noaa.gov/mgg/bathymetry/arctic/arctic.html. Selected isobaths (10 m, 20 m, 30 m, 40 m, 50 m, 60 m, 100 m, 500 m, 1,000 m, 1,500 m, 2,000 m, 2,500 m, 3,000 m, and 3,500 m), also derived from IBCAO data, were included in Figure 2 for visual reference.

The maps in this report were prepared with application software (ArcView 3.2a) based on Universal Transverse Mercator Zone 6 (central meridian =147°W. longitude, reference latitude 0.00000, false easting 500000.00000, false northing 0.00000, spheroid = GRS 80, scale factor = 0.99960). The natural coastline was adopted from the State of Alaska, Department of Natural Resources.

Sea-ice concentrations were derived from the Beaufort Sea Ice Analysis provided by the National Ice Center in Suitland, Maryland. The Beaufort Sea Ice Analysis shows average ice concentrations over the prior 2- to 3-day period based on visual, infrared, and synthetic-aperture-radar satellite imagery combined with reconnaissance, ship, and shore observations, including sea-ice observations made by the project. Polygons of ice concentrations in the Beaufort Sea bracketing the field seasons were downloaded from the National Ice Center Internet web site for the western Arctic (http://www.natice. noaa.gov) and imported into ArcView. Total sea-ice concentrations, regardless of ice type, were edited from these polygons and specially coded to distinguish 0-percent, 1- to 19-percent, 20- to 39-percent, 40- to 59-percent, 60- to 79-percent, 80- to 94-percent, or 95- to 100-percent ice cover.

Survey effort and observed bowhead distribution were plotted semimonthly over the Beaufort Sea study area. Overall fall sightings of beluga whales, as well as incidental sightings of other marine mammals, were depicted on separate maps. Common and scientific names used for marine mammals in this report are taken from Rice (1998).

Overall, whale sightings were shown on distribution maps and entered into relative-abundance analyses, regardless of the type of survey leg (transect, search, or connect) being conducted or the prevailing environmental conditions (sea state, ice cover, etc.) when the sightings were made. As with previous reports in this series (Treacy, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000, and 2002a and 2002b), same-day repeat sightings or sightings of dead marine mammals were not included in summary analyses or maps. Where tables and figures exclude certain data, such exclusions are indicated in the captions.

Table 1
Operational Definitions of Observed Whale Behaviors

Behavior	Definition
Breaching	Whale(s) launching upwards such that half to nearly all of the body is above the surface before falling back into the water, usually on its side, creating an obvious splash.
Cow-Calf	Calf nursing; cow-calf pairs swimming within 20 m of each other.
Diving	Whale(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.
Feeding	Whale(s) diving repeatedly in a fixed general area, sometimes with mud streaming from the mouth and/or defecation observed upon surfacing. Feeding behavior is further defined as synchronous diving and surfacing or echelon-formations at the surface with swaths of clearer water behind the whale(s), or as surface swimming with mouth agape
Flipper-Slapping	Whale(s) floating on side, striking the water surface with pectoral flipper one or many times; usually seen within groups or when the slapping whale is touching another whale.
Log-Playing	Whale(s) milling or thrashing about in association with a floating log.
Mating	Ventral-ventral orienting of two whales, often with one or more other whales present to stabilize the mating pair. Mating is often seen within a group of milling whales. Pairs may appear to hold each other with their pectoral flippers and may entwine their tails.
Milling	Whales moving slowly at the surface in close proximity (within 100 m) to other whales, often with varying headings. Also one whale slowly changing its heading.
Resting	Whale(s) floating at the surface with head, or head and back exposed, showing no movement; more commonly observed in heavy-ice conditions than in open water.
Rolling	Whale(s) rotating on the longitudinal axis, sometimes associated with mating.
Spy-Hopping	Whale(s) extending head vertically out of the water such that up to one-third of the body, including the eye, is above the surface.
Swimming	Whale(s) proceeding forward through the water propelled by tail pushes.
Tail-Slapping	Whale(s) floating horizontally or head-downward in the water, waving tail back and forth above the water and striking the water surface; usually seen in group situations.
Thrashing	Whale(s) exhibiting rapid flexure or gyration in the water.
Underwater-Blowing	Whale(s) exhaling while submerged, thus creating a visible bubble.

G. Analysis of the Bowhead Whale Migration Corridor

The corridor used by bowhead whales during their fall migration was analyzed by the mean distance from shore to whales sighted on randomized transects. The analyses presented here were completed using *Statistica*™ StatSoft, Version 5.1 and ArcView 3.2a. The mean distances from shore for bowhead sightings in 2002, 2003, and 2004 were compared with combined data from other years (1982-2001) using the nonparametric Mann-Whitney *U*-test. The nonparametric test was used for these data because distributions generally did not fit assumptions of the two-sample *t*-test. When assumptions of the t-test are seriously violated, as in this case where variances and samples sizes are not equal, the Mann-Whitney test may be much more powerful (Hodges and Liehman, 1956; Zar, 1984).

The present analyses provide biological information needed to test the following null hypotheses recommended by an initial planning workshop:

Ho_1: The axis of the fall migration of bowhead whales will not be altered during periods of increased OCS oil and gas development activities in the Alaskan Beaufort Sea.

Ho_2: Changes in bowhead migration patterns are not related to OCS oil and gas development activity.

To determine the usefulness of these analyses for detecting differences in distance from shore between years, a preliminary power analysis was performed (Treacy, 1998).

H. Sighting-Rate and Relative-Occurrence Maps

Maps of raw sighting points can give a misleading visual impression when survey effort is unequal. Because survey effort was unequal across our study area, due primarily to environmental conditions, a graphic method that adjusts for discontinuities in effort was desired. First, a grid matrix was superimposed across the study area using a Geographic Information System (ArcView, Version 3.2a). The matrix, consisting of approximately equilateral grid cells sized 5' latitude by 15' longitude, was considered appropriate to the data, simple to query, and visually easy to interpret. Bowhead sighting rates were calculated as the number of sightings per unit effort (SPUE) for each grid cell (5' latitude by 15' longitude) while on northerly-southerly transect. The index of relative occurrence of particular behaviors was calculated as the number of individual whales per unit effort (WPUE). The unit of effort for sighting-rate and relative occurrence maps was the number of kilometers (km) flown. Calculated rates were color-coded for quick visual comparison.Oceanographic Regions

To define the migration axis, a separate file was created for bowhead whale sightings made while on random transects, regardless of distance from the transect line. Distance from shore of bowhead whale sightings made during random transect aerial surveys in the Alaskan Beaufort Sea was analyzed for two regions (Figure 2), the boundaries of which correspond roughly to oceanographic patterns and the offshore-extent of sampling.

Oceanographic patterns common to waters offshore northern Alaska are reviewed in Moore and DeMaster (1997). In brief, cold saline Bering Sea water and warm fresh Alaskan coastal water enter the Alaskan 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 Sea water has been traced at least as far east as Barter Island (~143°W.), but the Alaskan coastal water mixes with ambient surface waters as it moves eastward and is not clearly identifiable east of Prudhoe Bay (~147-148°W.). Therefore, the delineation between West-East regions for this analysis occurs at 148°W., based upon association with general patterns for these water masses.

The northern extent of each region is based upon survey effort. For example, the East Region extends from 140°W. to 148°W. and from the shore north to 71°10' N., except between 146°W. and 148°W. where the region extends to 71°20'N. The northern boundary for this region corresponds with boundaries of

survey blocks 6, 7 and 2 (Figure 1): blocks with sufficient survey effort to support analyses (Treacy, 1997: Table 11). The West Region extends from 148°W. to 156°W. and from the shore north to 72°N., except between 148°W and 150°W. where the region extends to 71°20'N. due to the layout of Block 2. The eastern boundary (140°W.) is simply the easternmost longitude of the survey blocks. The western cutoff at 156°W. limits the analysis to bowheads seen in the Alaskan Beaufort Sea and avoids the influence of Barrow Canyon on bowhead depth distribution.

The shoreline used for this analysis was 'normalized' from the actual Beaufort Sea shoreline to provide a standardization of distance-from-shore measures regardless of the mapping software being used to depict the distribution data. The 'normalized' shoreline was derived by connecting, with straight lines, eleven points at various shoreline or barrier islands locations across Alaska's North Slope between 156°W. and 140°W (Figure 2). The points used to 'normalize' the shoreline are as follows:

71.317°N., 156.000°W.
70.883°N., 153.900°W.
70.917°N., 153.115°W.
70.817°N., 152.200°W.
70.430°N., 151.000°W.
70.550°N., 150.167°W.
70.450°N., 147.950°W.
69.967°N., 144.700°W.
70.150°N., 143.250°W.
69.650°N., 141.000°W.
69.617°N., 140.000°W.

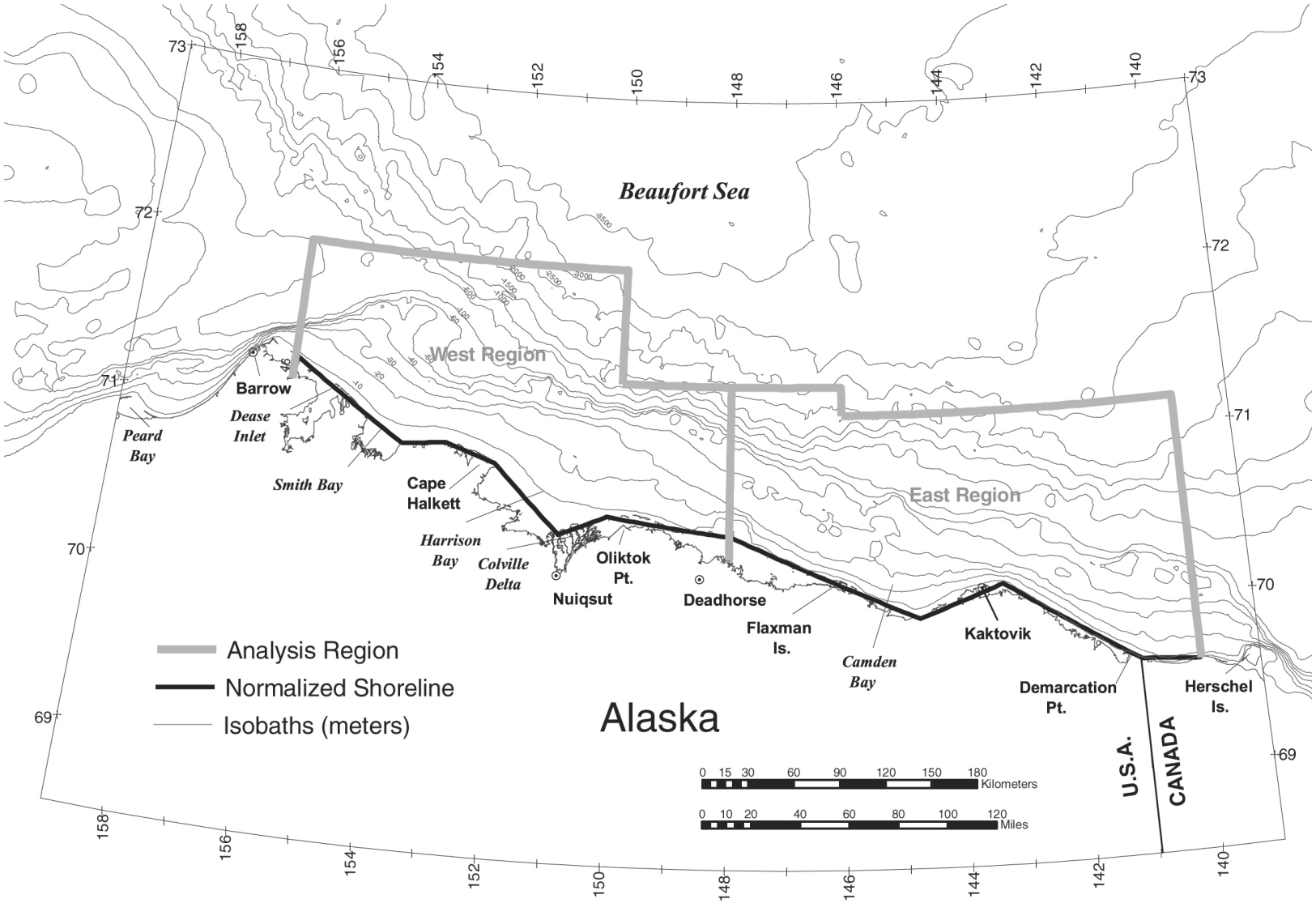

Figure 2 – East and West Regions Showing a Normalized Shoreline and selected IBCAO Isobaths

III. RESULTS

A. Fall 2002

1. Environmental Conditions

Sea-ice coverage in the Alaskan Beaufort Sea (Appendix A-2002) was relatively light overall during the survey period in 2002. By 30 August most of the study area was either ice-free or less than 10% ice. Subsequently, the study area was ice-free, or nearly so, during September and through at least 4 October. By 14 October, heavier offshore ice was closer to shore in only the most eastern blocks. By that date, lighter, but variable concentrations of shore-fast ice had formed along the coastline between Barrow and Canada. Ice percentages and sea states at each sighting of endangered whales are shown in Appendix B-2002 (Table B-2002).

2. Survey Effort

The fall field season was from 22 August 2002 through 7 October 2002. There were 27 flights, of which 11 were in August, 13 were in September and 3 were in October. Daily totals of kilometers and hours flown per survey flight during this period are shown in Table 2. A total of 23,253 km of surveys were flown in 98.64 hrs in the study area at an average speed of 235.73 km/hr. The average survey flight was 861.22 km, with over-ocean flight distances ranging from 0 km to 1,415 km. A total of 13,768 km of random-transect lines were flown in 60 hrs at an average transect speed of 229.5 km/hr. These random transects constituted 59.2 % of the total kms flown and 60.8 % of the total flight hours. Survey-flight lines are shown by semimonthly period in Figure 3 through Figure 6.

Table 2
Aerial-Survey Effort in the Beaufort Sea, 22 August-7 October 2002, by Survey Flight

Day	Flight No	Transect (km)	Connect (km)	Search (km)	Total (km)	Transect (hr)	Total (hr)
22-Aug	1	884	113	352	1349	4.19	5.62
23-Aug	2	794	22	79	894	3.35	3.78
23-Aug	3	337	18	27	382	1.4	1.58
24-Aug	4	685	113	528	1326	3	5.6
25-Aug	5	672	143	424	1239	2.92	5.42
26-Aug	6	1023	111	246	1379	4.28	5.87
27-Aug	7	1133	71	81	1285	4.95	5.58
28-Aug	8	819	147	449	1415	3.5	5.78
29-Aug	9	0	0	107	107	0	0.43
30-Aug	10	771	137	229	1137	3.42	5.18
31-Aug	11	900	41	380	1321	3.95	5.6
2-Sep	12	78	0	188	267	0.38	1.05
4-Sep	13	572	141	73	786	2.53	3.57
5-Sep	14	900	188	213	1301	4.02	5.65
6-Sep	15	581	158	447	1186	2.48	5.02
9-Sep	16	0	0	71	71	0	0.3
10-Sep	17	671	171	438	1280	2.93	5.52
11-Sep	18	816	221	108	1144	3.52	4.88
12-Sep	19	713	133	498	1343	3.02	5.55
13-Sep	20	506	126	467	1099	2.13	4.58
14-Sep	21	0	0	257	257	0	0.97
21-Sep	22	0	0	391	391	0	1.68
27-Sep	23	135	27	84	247	0.58	1.05
30-Sep	24	0	0	436	436	0	1.62
3-Oct	25	0	0	475	475	0	1.78
4-Oct	26	0	0	0	0	0	0
7-Oct	27	778	100	257	1136	3.45	4.98
Semimonthly Effort Summary							
22-31 Aug		8,018	916	2,902	11,834	35	50.44
1-15 Sep		4,837	1,138	2,760	8,734	21	37.09
16-30 Sep		135	27	911	1,074	1	4.35
1-7 Oct		778	100	732	1,611	3	6.76
TOTAL		13,768	2181	7,305	23,253	60	98.64

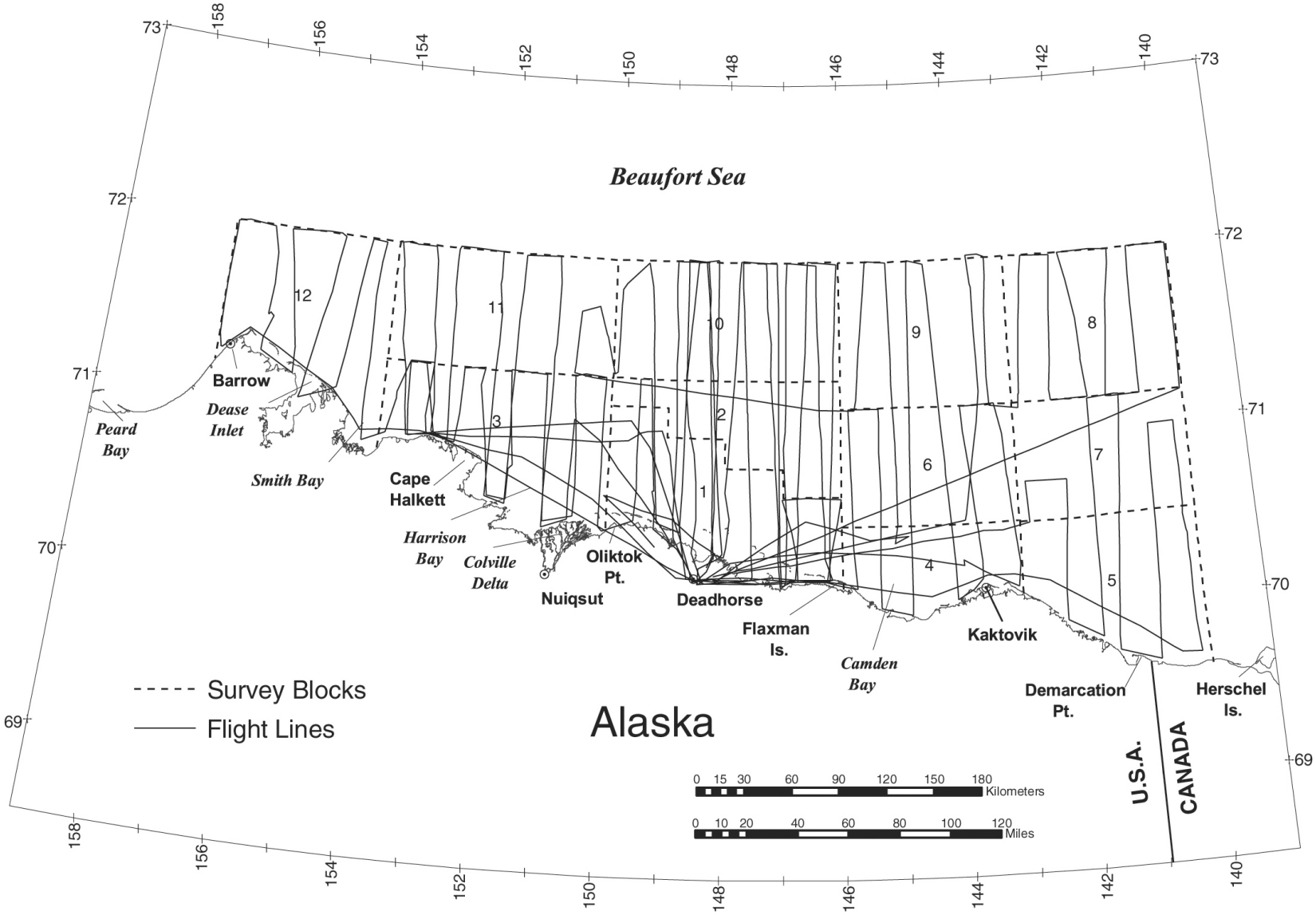

Figure 3 – Combined Flight Tracks, 22 – 31 August 2002

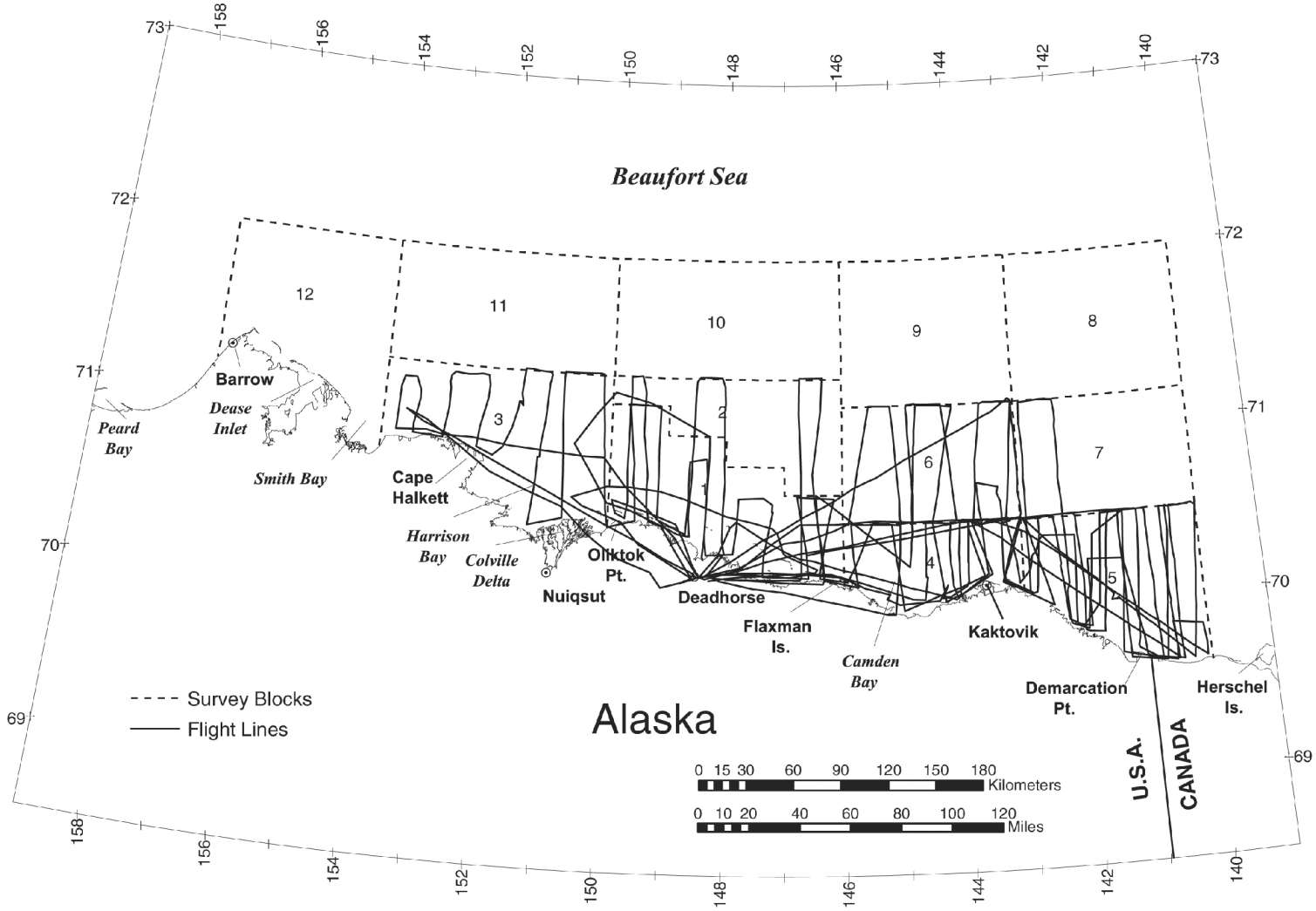

Figure 4 – Combined Flight Tracks, 1-15 September 2002

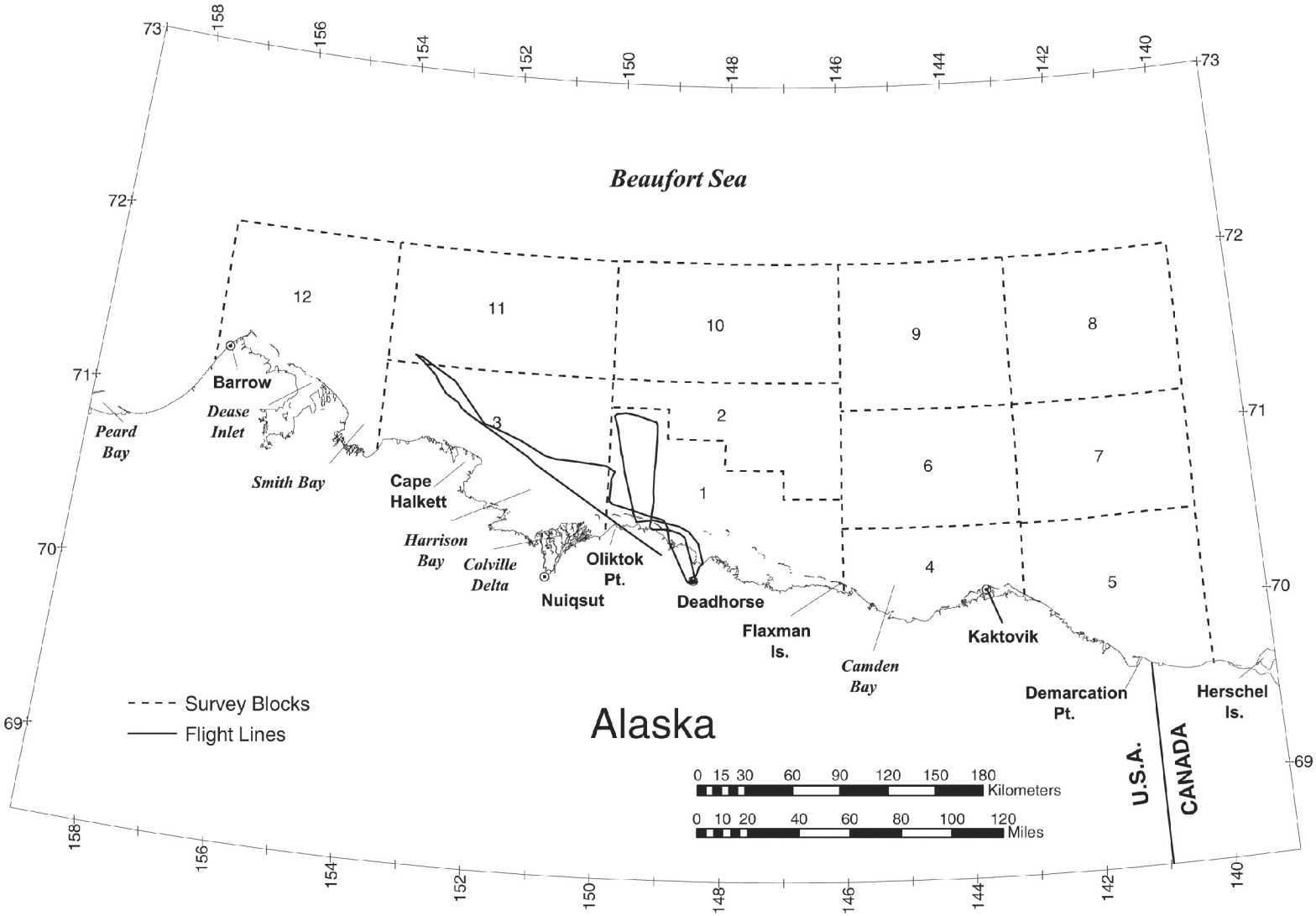

Figure 5 – Combined Flight Tracks, 16 – 30 September 2002

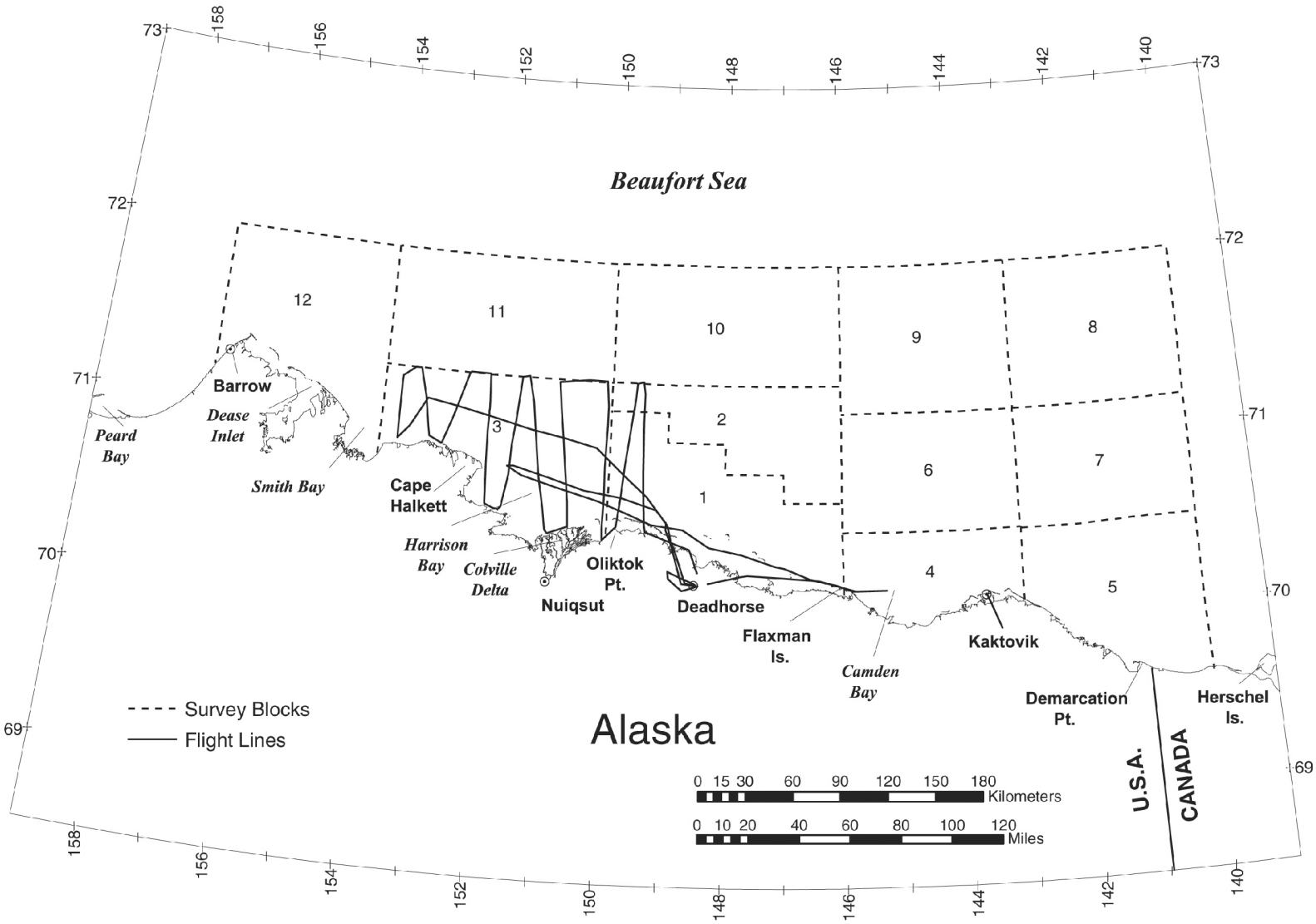

Figure 6 – Combined Flight Tracks, 1-7 October 2002

Table 3
Summary of Marine Mammal Sightings, 22 August-7 October 2002, by Survey Flight

(number of sightings/number of animals)

Day	Flight No	Bowhead Whale	Gray Whale	Beluga Whale	Unidentified Cetacean	Bearded Seal	Ringed Seal	Pacific Walrus	Unidentified Pinniped	Polar Bear (PB)	PB Tracks (no bear)
22-Aug	1	1/1	0	13/27	0	0	0	0	0	0	0
23-Aug	2	0	0	9/26	0	0	0	0	0	0	0
23-Aug	3	0	0	6/12	0	0	0	0	0	0	0
24-Aug	4	1/1	0	7/14	0	0	2/2	0	0	0	0
25-Aug	5	4/5	0	6/159	0	2/3	1/1	2/14	0	0	0
26-Aug	6	8/8	0	12/22	0	0	3/5	0	1/50	0	0
27-Aug	7	0	0	15/34	0	0	0	0	0	0	0
28-Aug	8	0	0	20/58	0	0	5/5	0	1/2	0	0
29-Aug	9	0	0	0	0	0	0	0	0	0	0
30-Aug	10	2/2	0	5/59	0	0	0	0	0	1/1	0
31-Aug	11	0	0	30/66	0	0	1/3	0	0	0	0
2-Sep	12	0	0	0	0	0	0	0	0	0	0
4-Sep	13	1/1	0	0	0	1/1	0	0	0	0	0
5-Sep	14	15/19	0	9/26	0	8/8	49/508	0	1/2	0	0
6-Sep	15	6/7	0	9/16	0	16/26	8/12	0	0	0	0
9-Sep	16	0	0	0	0	0	0	0	0	0	0
10-Sep	17	5/7	0	4/7	0	20/26	11/13	0	1/1	2/2	0
11-Sep	18	3/3	0	12/21	0	6/6	10/11	0	0	0	0
12-Sep	19	2/2	0	28/86	0	10/10	16/27	0	1/1	1/2	0
13-Sep	20	6/6	0	2/10	0	8/10	15/23	0	0	2/2	0
14-Sep	21	0	0	0	0	0	0	0	0	0	0
21-Sep	22	3/3	0	0	0	0	0	0	1/1	0	0
27-Sep	23	1/1	0	0	1/1	1/1	0	0	0	0	0
30-Sep	24	0	0	0	0	0	0	0	0	0	0
3-Oct	25	0	0	0	0	0	0	0	0	1/1	2
4-Oct	26	0	0	0	0	0	0	0	0	0	0
7-Oct	27	16/17	0	1/2	1/1	0	2/8	0	0	1/3	0
Total Semimonthly Sightings											
22-31 Aug		16/17	0	123/477	0	2/3	12/16	2/14	2/52	1/1	0
1-15 Sep		38/45	0	64/166	0	69/87	109/594	0	3/4	5/6	0
16-30 Sep		4/4	0	0	1/1	1/1	0	0	1/1	0	0
1-7 Oct		16/17	0	1/2	1/1	0	2/8	0	0	2/4	2
TOTAL		74/83	0	158/645	2-Feb	72/97	123/618	2/14	6/57	8/11	2

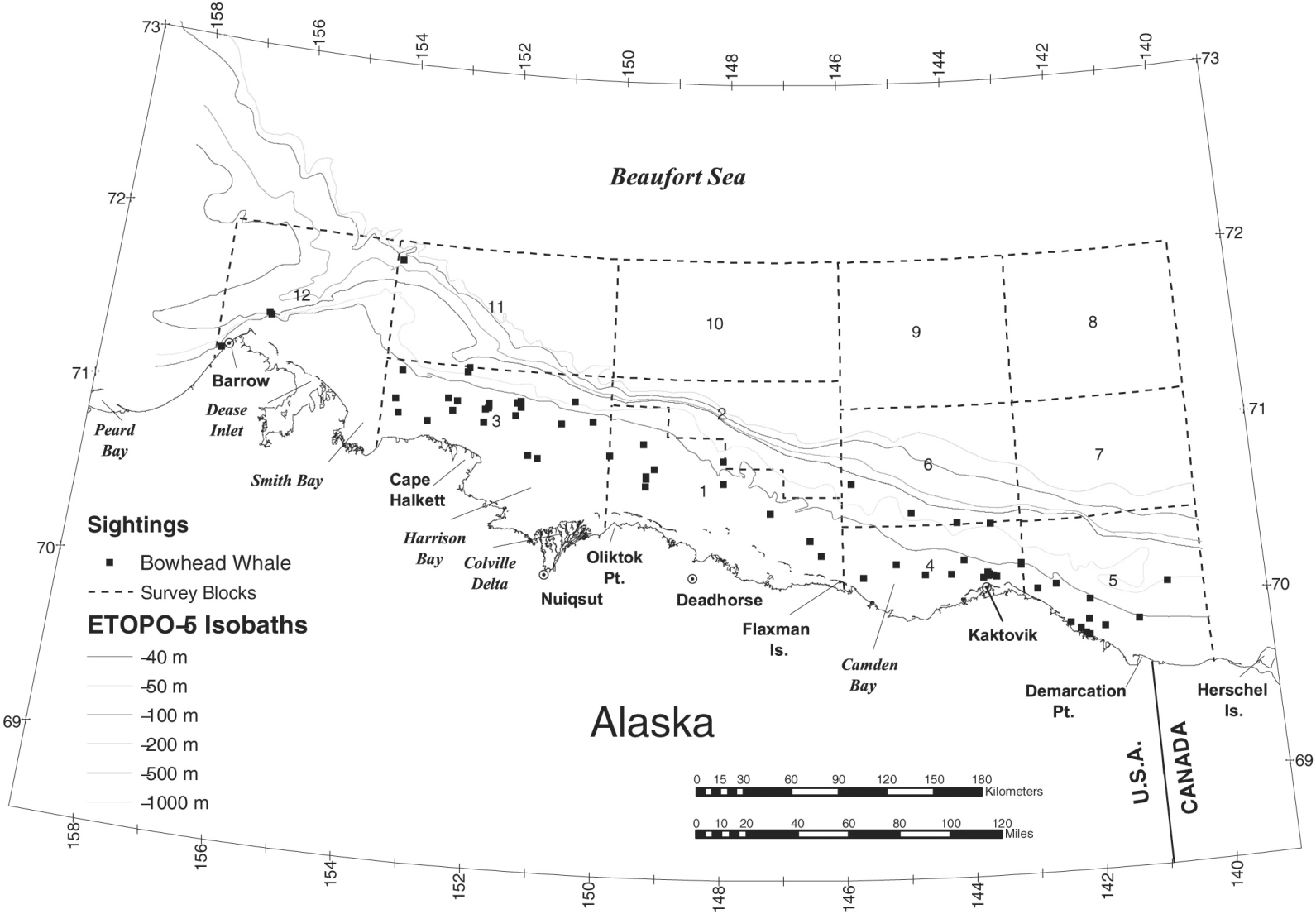

Figure 7 – Map of Bowhead Whale Sightings, Fall 2002

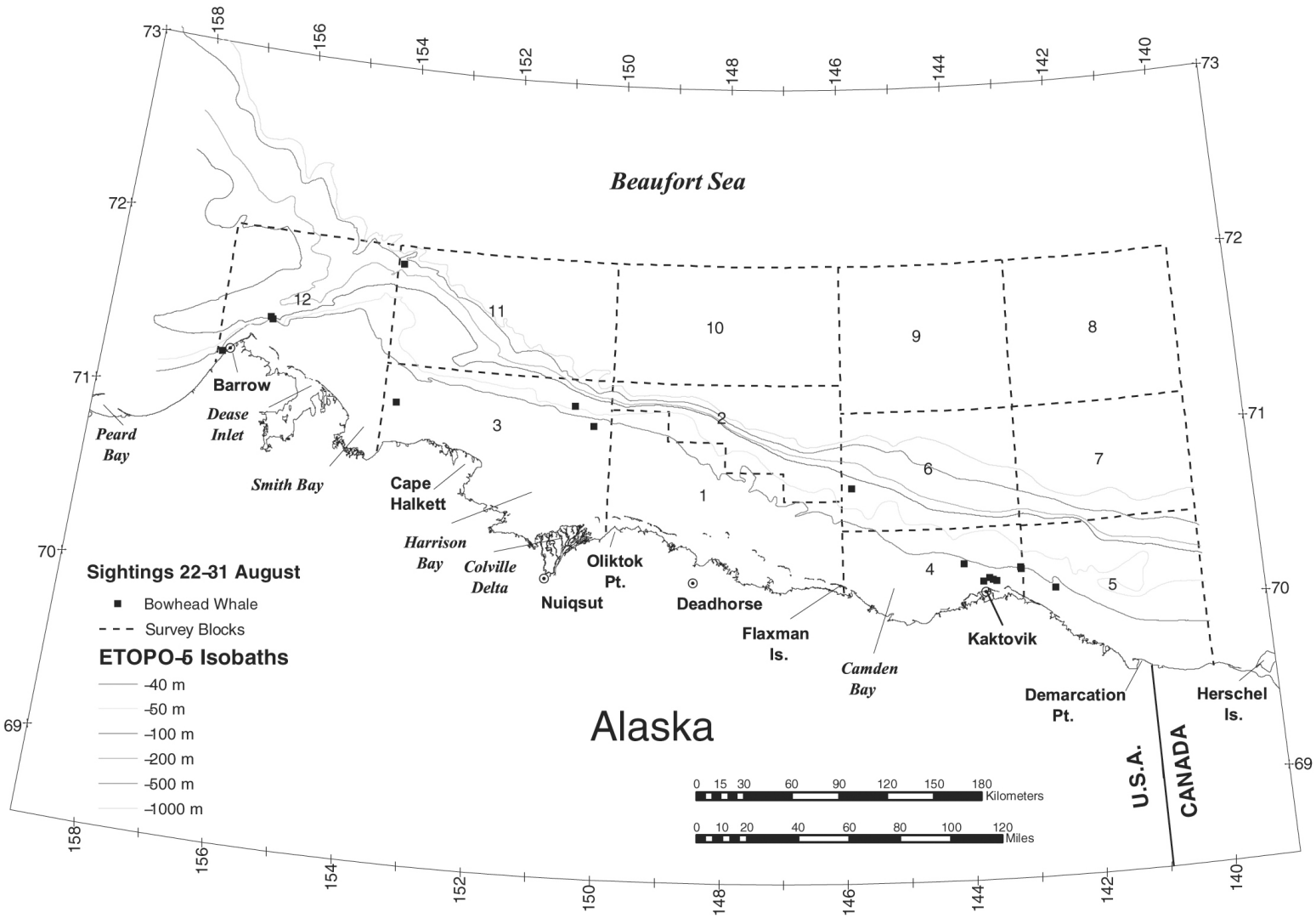

Figure 8 – Map of Bowhead Whale Sightings, 22-31 August 2002

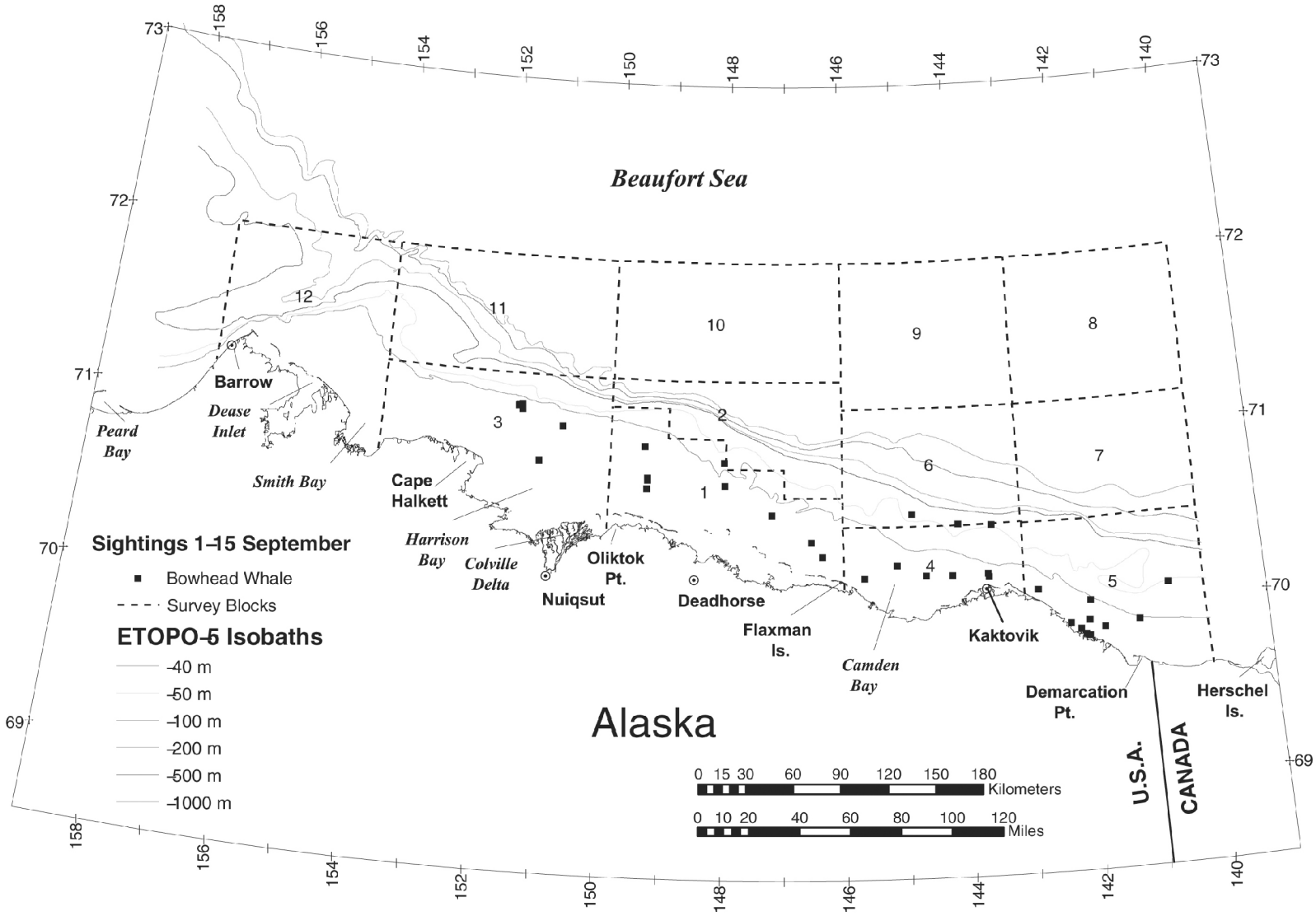

Figure 9 – Map of Bowhead Whale Sightings 1-15 September 2002

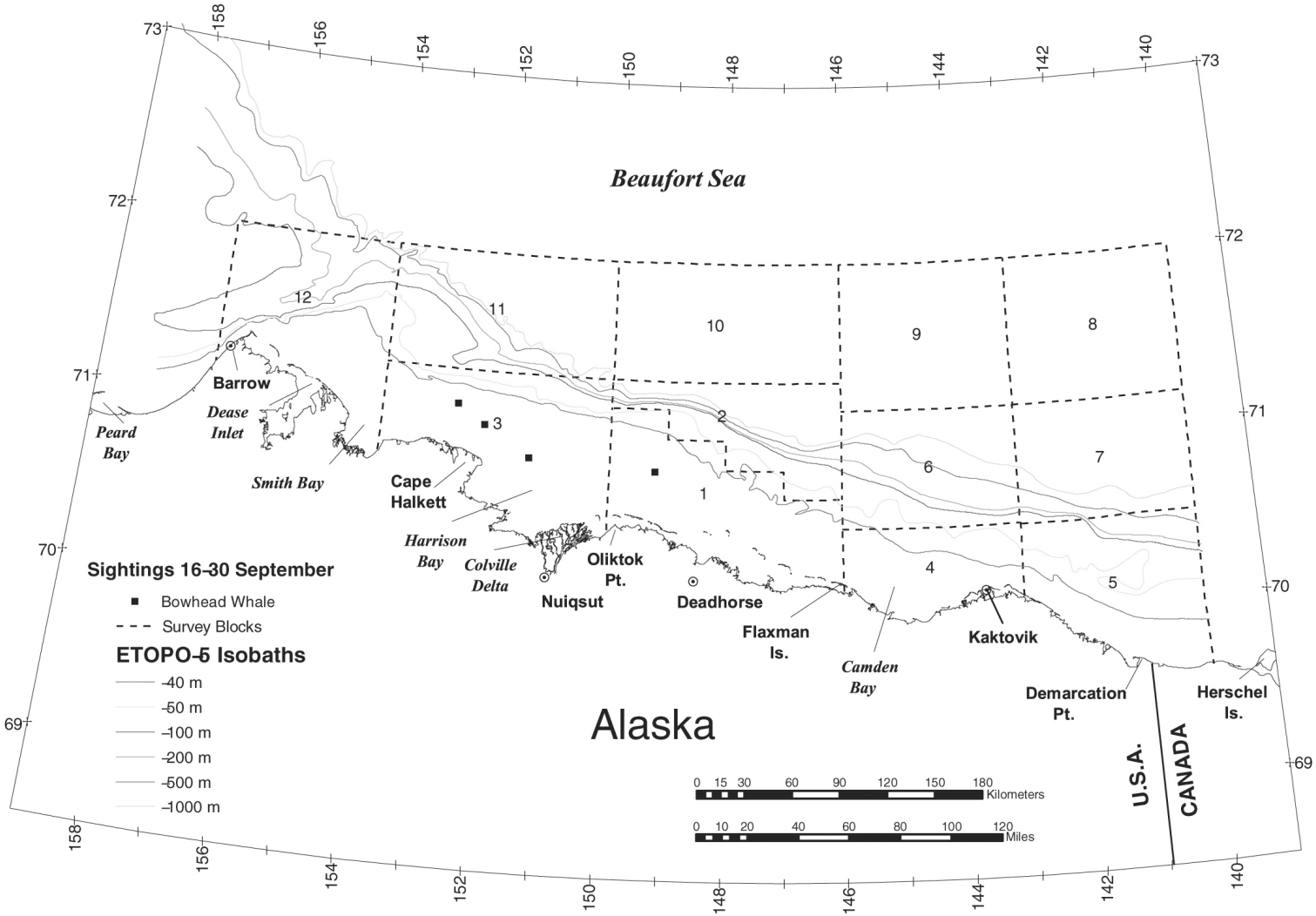

Figure 10 – Map of Bowhead Whale Sighting 16-30 September

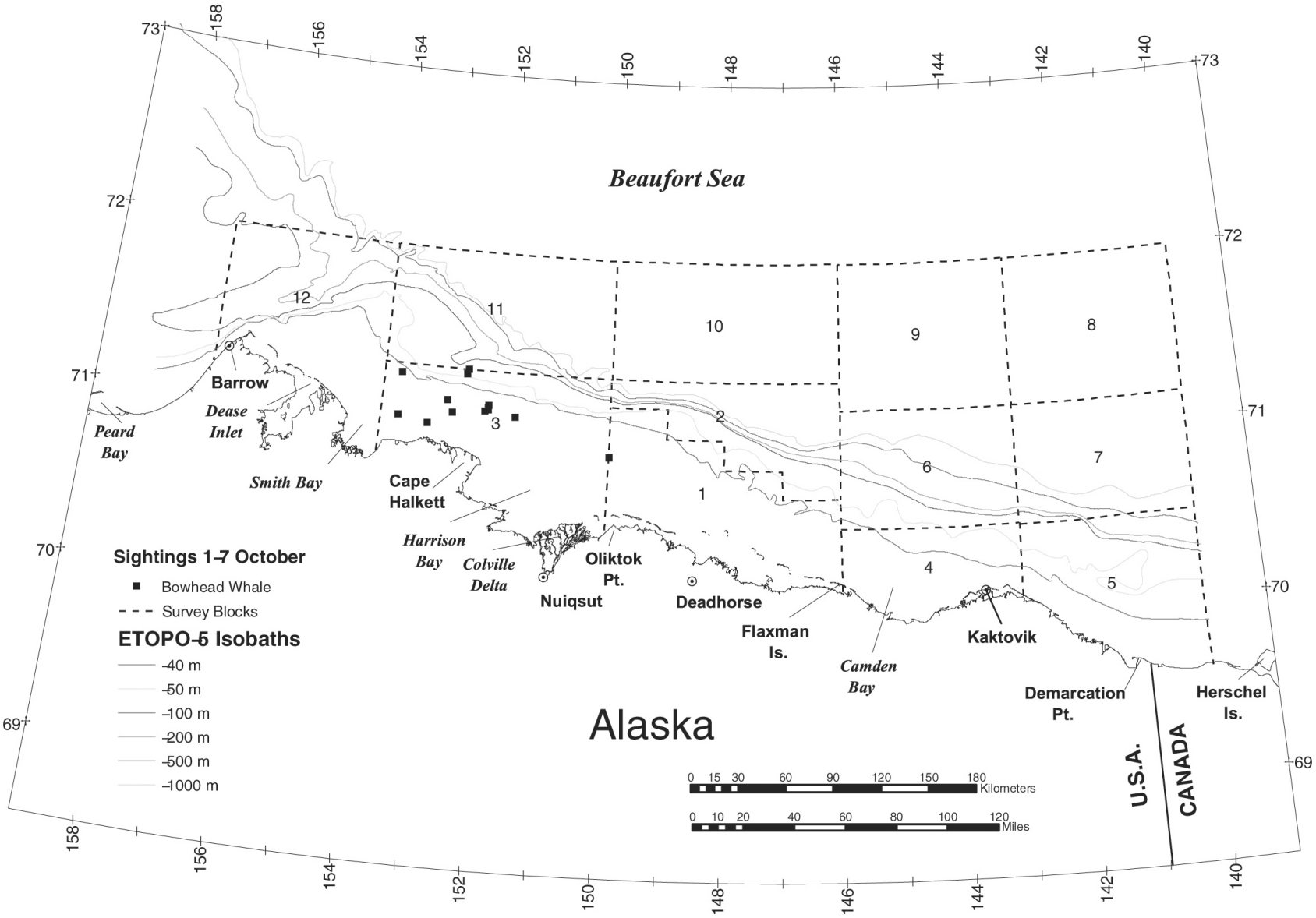

Figure 11 – Map of Bowhead Whale Sightings 1-7 October 2002

3. Bowhead Whale (Balaena mysticetus) Observations

a. Sighting Summary:

Seventy-four sightings were made for a total of 83 bowhead whales observed during Fall-2002 surveys in the study area (Table 3). Relatively widespread survey coverage between 140°W. and 158°W. longitudes showed bowhead whales distributed throughout the survey area (Figure 7). Two of the 83 whales were identified as calves (Appendix B-2002: Table B-2002), resulting in a seasonal calf ratio (number calves/total whales) of 0.0241. Locations of observations of bowhead whales are shown by semi-monthly period in Figure 8-Figure 11.

b. Sighting Rates:

In Fall 2002, bowheads were seen at low densities from Barrow to Canada. Sighting rates were relatively low (Figure 12) with whales generally traveling as singles and no group larger than 2 observed during the survey. (Appendix B-2002, Table B-2002).

c. Habitat Associations:

In addition to general ice coverage for arctic waters during Fall 2002 (Appendix A-2002), the percentage of ambient ice cover visible from the aircraft at each bowhead sighting (Appendix B-2002: Table B-2002) was summarized. Of the 83 bowheads counted over the field season, 62 whales (75%) were sighted in open water, 14 (17%) whales were observed in 1-5% sea ice, and 7 (8%) were counted in 6-10% sea ice (Table 4).

Table 4
Semimonthly Summary of Bowhead Whales Observed,
By Percent Ice Cover Present at Sighting Location, Fall 2002

% Ice Cover	22-31 Aug	1-15 Sep	16-30 Sep	1-7 Oct	Total
0	4 (24%)	37 (82%)	4 (100%)	17 (100%)	62 (75%)
1-5	6 (35%)	8 (18%)	0	0	14 (17%)
6-10	7 (41%)	0	0	0	7 (8%)
TOTAL	17 (100%)	45 (100%)	4 (100%)	17 (100%)	83 (100%)

Table 5
Semimonthly Summary of Bowhead Whales Observed, by Behavioral Category, Fall 2002

Behavior	22-31 Aug	1-15 Sep	16-30 Sep	1-7 Oct	Total
Dive	1 (6%)	2 (4%)	0	1 ((6%)	4 (5%)
Feed	1 (6%)	3 (7%)	1 (25%)	0	5 (6%)
Log Play	0	2 (4%)	0	0	2 (2%)
Mill	0	0	0	3 (18%)	3 (4%)
Rest	3 (18%)	5 (11%)	0	0	8 (10%)
Swim	12 (70%)	33 (74%)	3 (75%)	13 (76%)	61 (73%)
TOTAL	17 (100%)	45 (100%)	4 (100%)	17 (100%)	83 (100%)

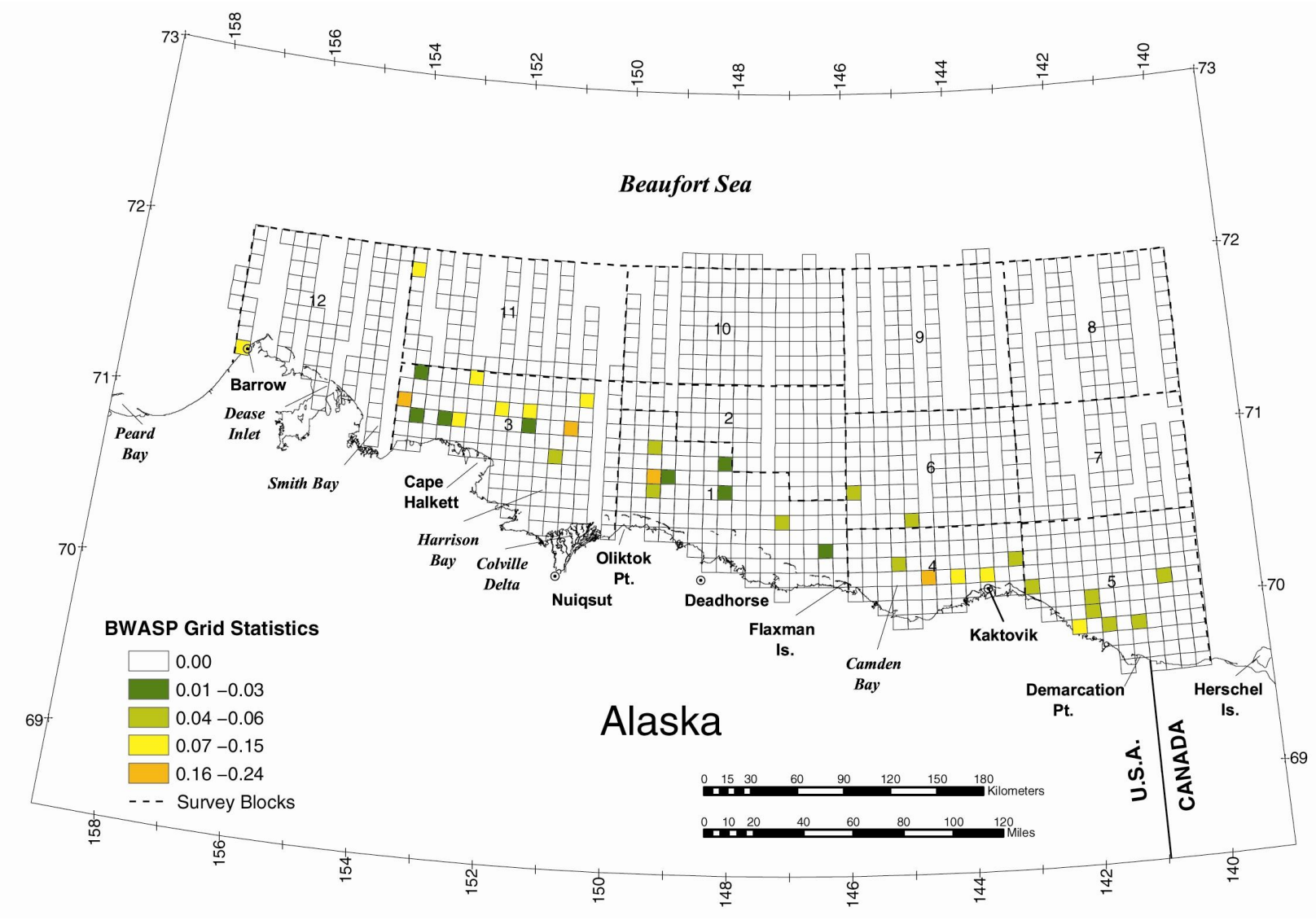

Figure 12 – Count Rates of Bowhead Whales on Transect, Fall 2002 (Bowhead Whales/km surveyed)

d. Behaviors

Behaviors of the 83 bowhead whales observed during Fall 2002, are summarized in Table 5. Most whales (73%) were swimming when observed. Five whales (6%) were seen feeding on survey transects and locations of these observations, and others of milling whales, are shown on Figure 13. These behaviors are defined in Table 1.

Sudden overt changes (e.g., an abrupt dive, course diversion, or cessation of behavior ongoing) in whale behavior were looked for. No bowheads were observed for which responses to the survey aircraft were noted.

e. Distance from Shore

Distances from shore of Fall-2002 bowhead whale sightings made on transect were measured using ArcGIS as the distance due north of a normalized shoreline. This mean distance was 21.9 km (*SD* = 10.9) in the East Region, and 41.9 km (*SD* = 21.4) in the West Region (Figure 14).

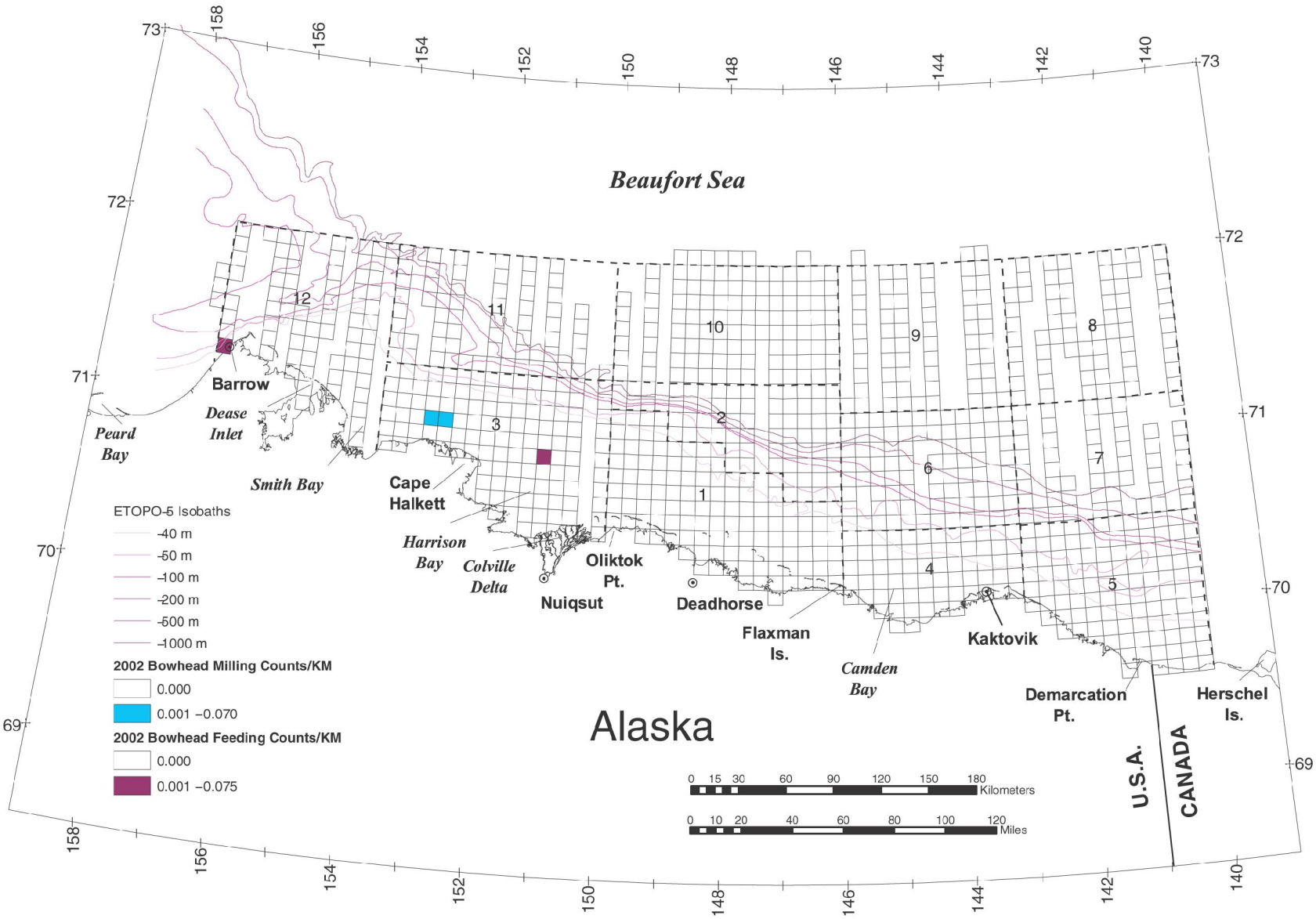

Figure 13 – Fall 2002 Counts of Feeding and Milling Bowhead Whales Per Unit Effort (km) – on Transect

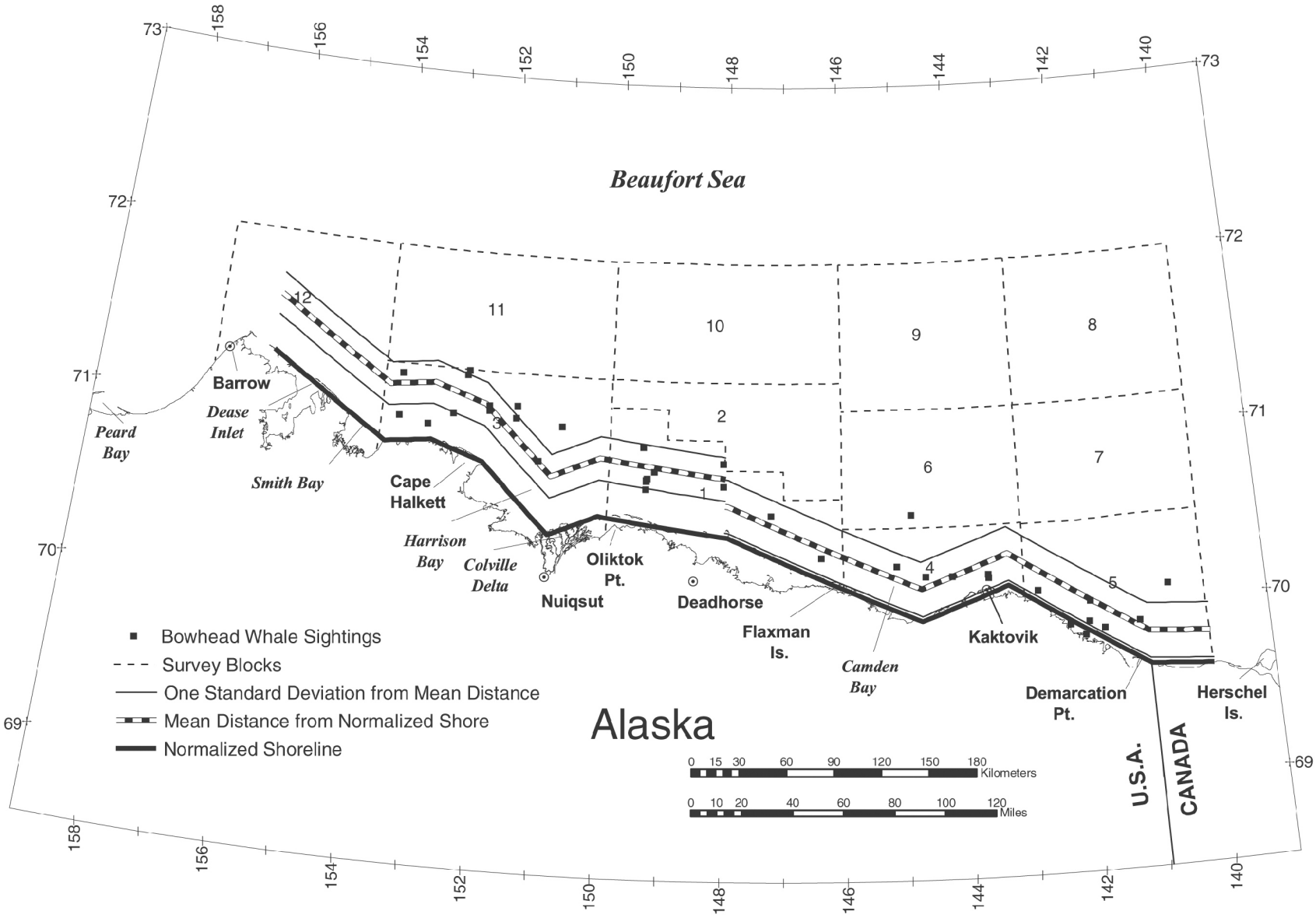

Figure 14 – Bowhead Whale Sightings on Transect Fall 2002 Showing Mean Distance from a Normalized Shoreline

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B. FALL 2003 RESULTS

1. Environmental Conditions

Sea-ice coverage in the Alaskan Beaufort Sea (Appendix A-2003) was relatively light overall during the entire survey period in 2003. A broad area of ice-free water extended from Barrow to eastern Camden Bay by late-August, with concentrations of < 20% sea-ice extending in a band up to 50 km wide along the coastline to eastward of Herschel Island. Moderate sea-ice persisted in the northeast corner of the study area (Blocks 7 and 8), and northward, throughout the survey. Extensive open water remained from Barrow to Camden Bay until the end of the survey, with gradually thickening ice extending eastward on 17 October. A band of shore-fast ice formed along much of the coastline and in bays and inlets during the first week of October. Ice percentages and sea states at each sighting of endangered whales are shown in Appendix B-2003 (Table B-2003).

2. Survey Effort

The 2003 bowhead survey was conducted from 1 September - 19 October. There were 28 flights, of which 22 were in September and 6 were in October. Daily totals of kilometers and hours flown per survey flight during this period are shown in Table 6. A total of 17,600 km of surveys were flown in 76.32 hrs in the study area at an average speed of 230.6 km/hr. The average survey flight was 628.6 km, with over-ocean flight distances ranging from 0 km to 1,393 km. A total of 8,970 km of random-transect lines were flown in 40.0 hrs at an average transect speed of 224.3 km/hr. These random transects constituted 51 % of the total kms flown and 52.4 % of the total flight hours. Survey-flight lines are shown by semimonthly period in Figure 15 through Figure 18.

Table 6
Aerial-Survey Effort in the Beaufort Sea, 1 September-19 October 2003, by Survey Flight

Day	Flight No	Transect (km)	Connect (km)	Search (km)	Total (km)	Transect (hr)	Total (hr)
1-Sep	1	0	0	270	270	0	1.15
3-Sep	2	648	175	123	946	2.9	4.52
5-Sep	3	0	0	270	270	0	1.17
6-Sep	4	509	192	271	973	2.25	4.47
7-Sep	5	782	145	331	1,257	3.4	5.35
8-Sep	6	225	34	308	566	1.07	2.48
9-Sep	7	275	98	180	553	1.17	2.32
11-Sep	8	0	0	154	154	0	0.6
13-Sep	9	0	0	3	3	0	0.02
14-Sep	10	87	0	330	416	0.38	1.67
15-Sep	11	84	0	449	532	0.37	2.18
16-Sep	12	572	95	410	1,077	2.53	4.73
17-Sep	13	0	0	139	139	0	0.78
19-Sep	14	863	64	219	1,145	3.78	5
20-Sep	15	623	75	167	864	2.77	3.95
21-Sep	16	522	96	278	895	2.35	4.07
22-Sep	17	0	0	27	27	0	0.1
24-Sep	18	20	0	403	422	0.08	1.6
25-Sep	19	0	0	98	98	0	0.5
27-Sep	20	18	0	250	269	0.08	1.05
28-Sep	21	543	185	339	1,067	2.47	4.83
29-Sep	22	806	109	187	1,101	3.53	4.75
2-Oct	23	885	232	238	1,354	3.75	5.7
3-Oct	24	505	51	553	1,109	2.18	4.45
9-Oct	25	0	0	0	0	0	0
11-Oct	26	0	0	85	85	0	0.32
13-Oct	27	725	229	440	1,393	3.17	5.93
19-Oct	28	278	81	256	615	1.23	2.63
Semimonthly Effort Summary							
1-15 Sep		2,610	644	2,689	5,940	12	25.93
16-30 Sep		3,967	624	2,517	7,104	18	31.36
1-15 Oct		2,115	512	1,316	3,941	9	16.4
16-19 Oct		278	81	256	615	1	2.63
TOTAL		8,970	1861	6,778	17,600	40	76.32

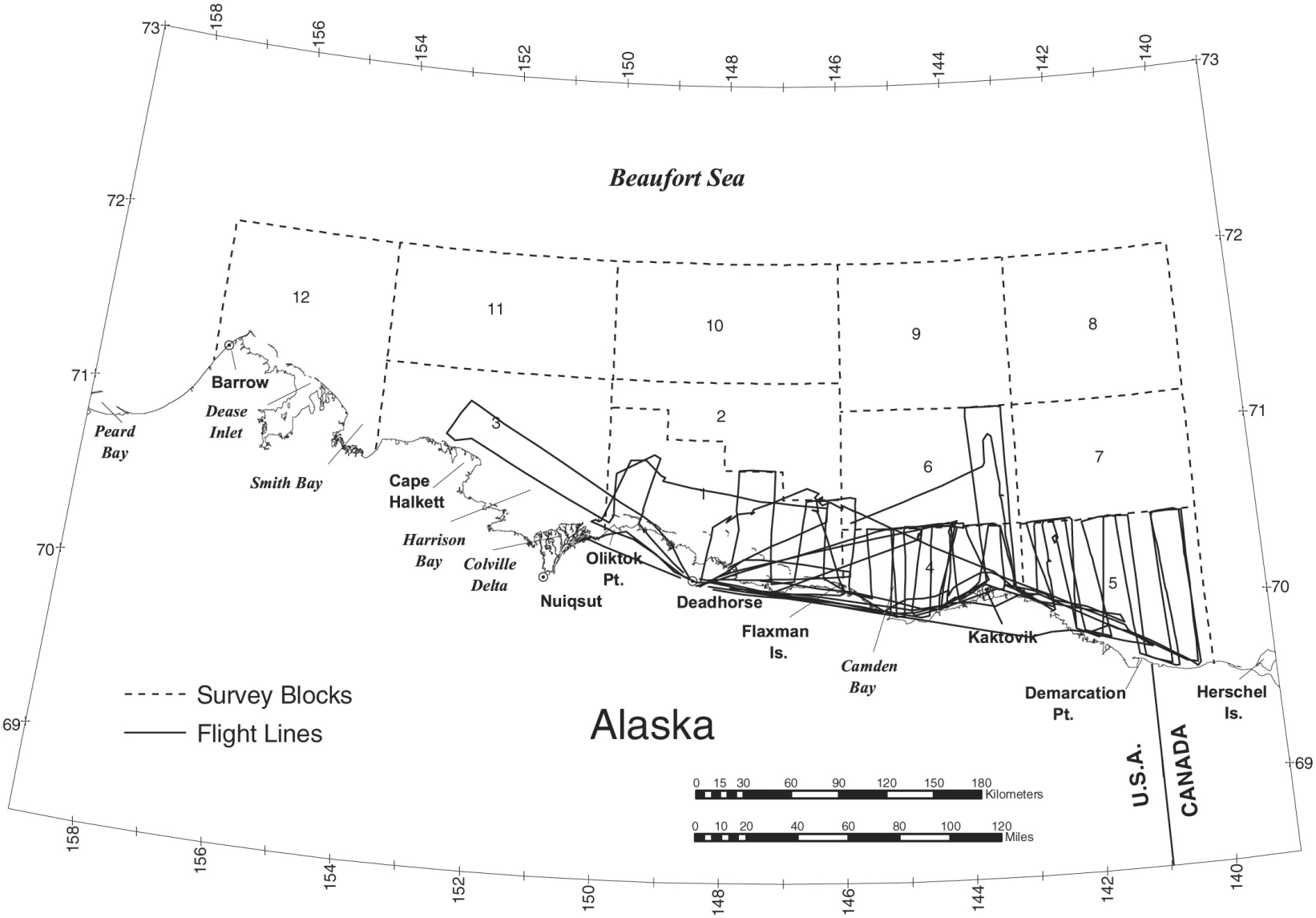

Figure 15 – Combined Flight Tracks, 1 – 15 September 2003

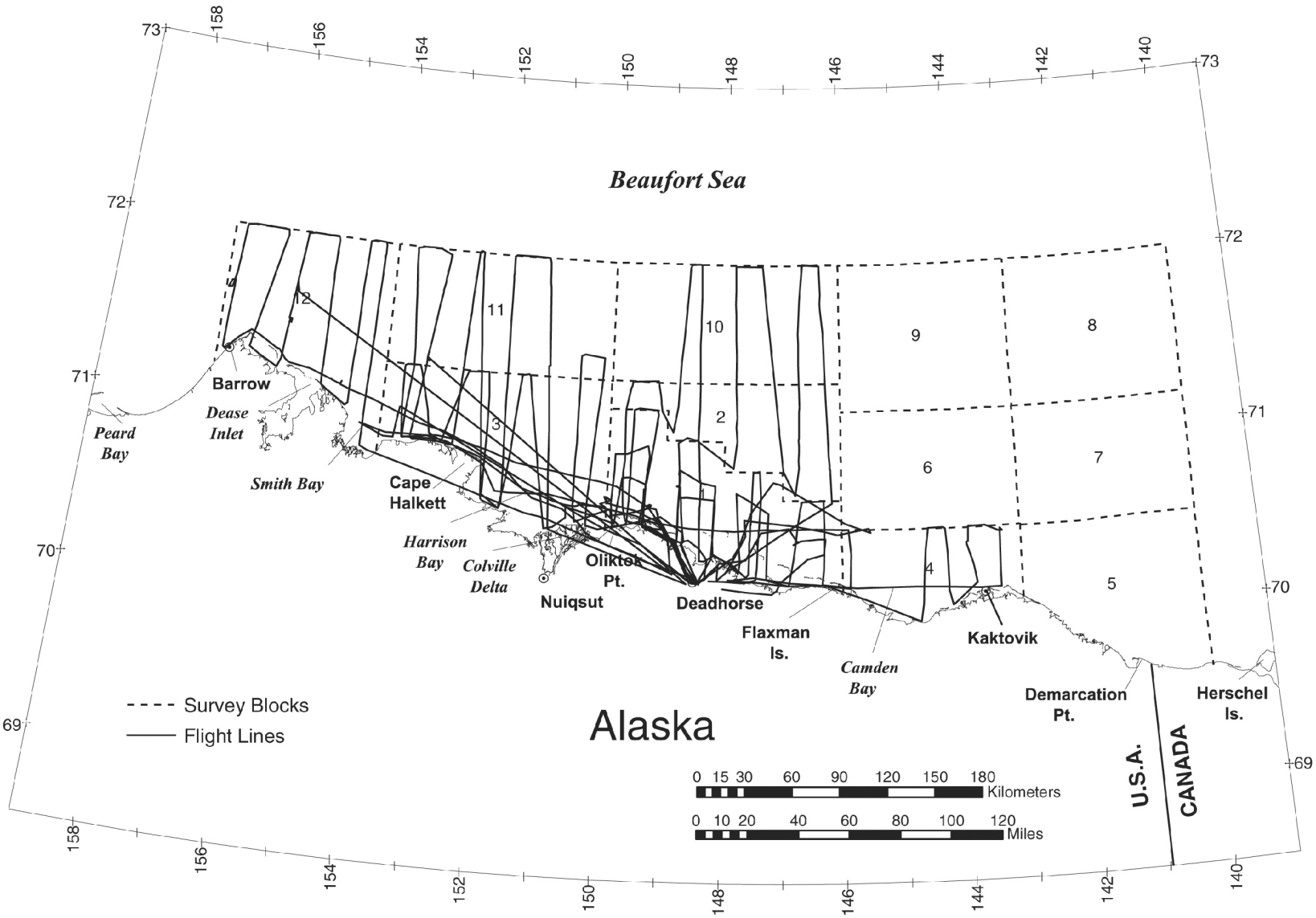

Figure 16 – Combined Flight Tracks, 16-30 September 2003

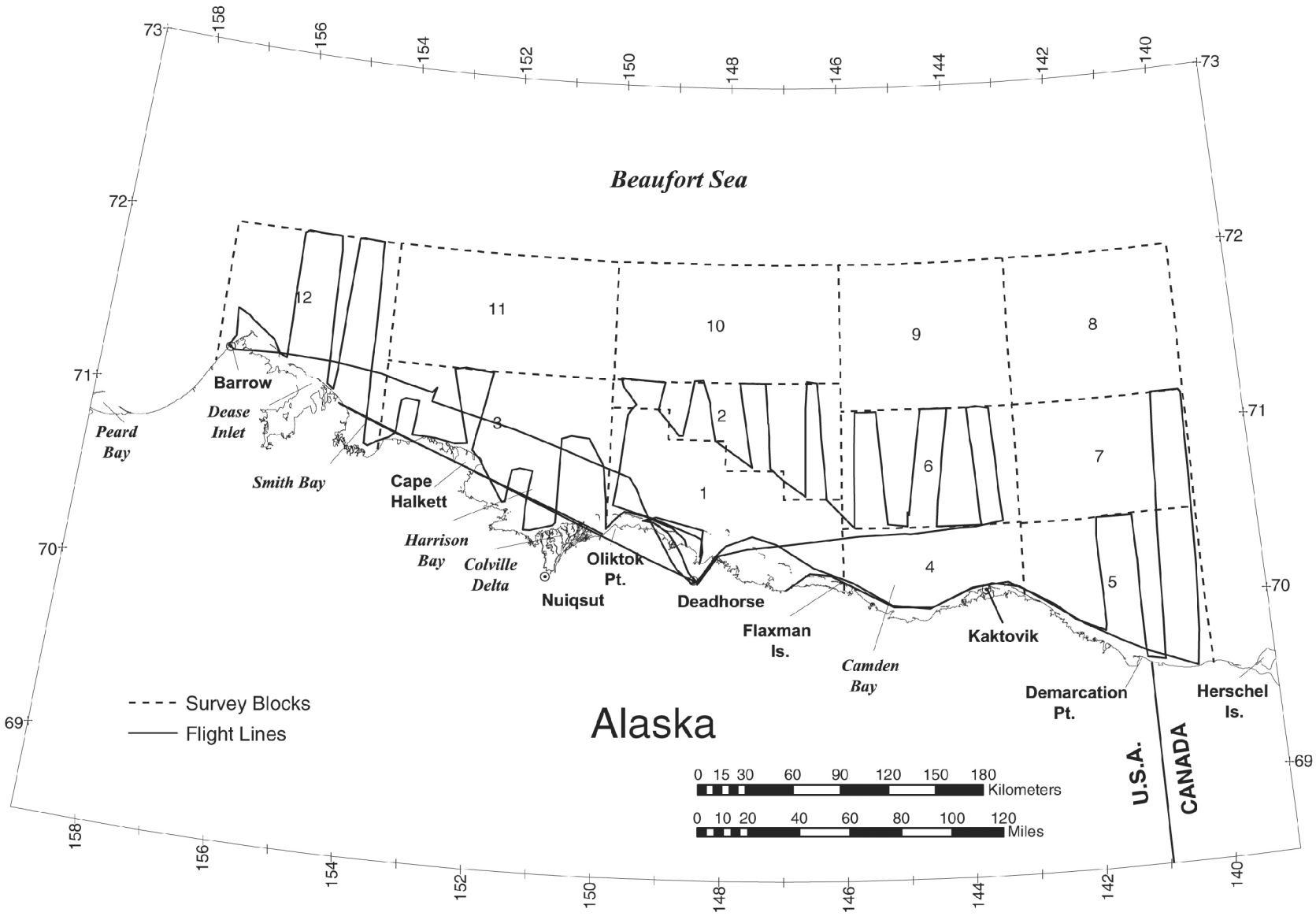

Figure 17 – Combined Flight Tracks, 1-15 October 2003

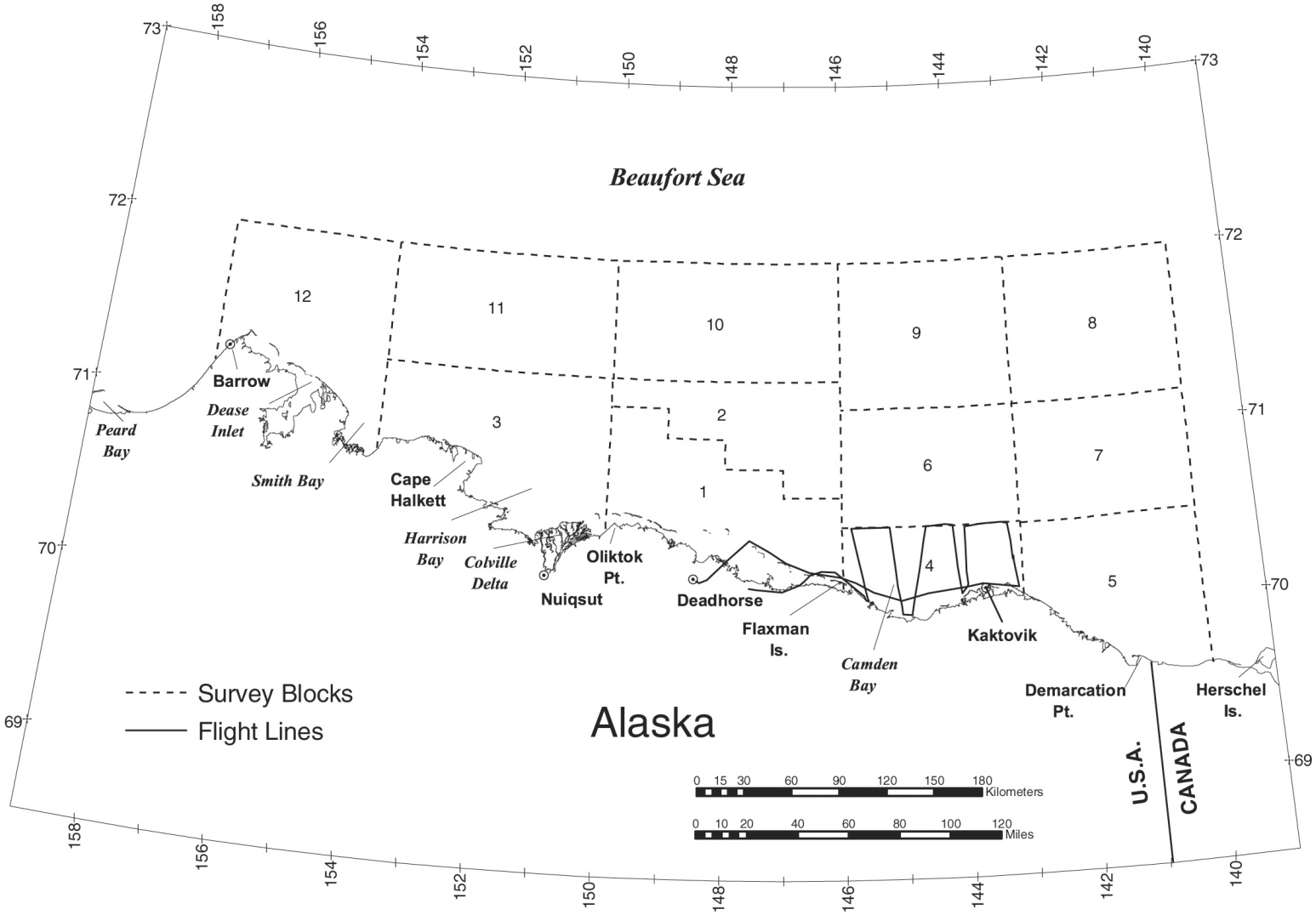

Figure 18 – Combined Flight Tracks, 16-19 October 2003

Table 7
Summary of Marine mammal Sightings, 1 September-19 October 2003, by Survey Flight
(number of sightings/number of animals)

Day	Flight No	Bowhead Whale	Gray Whale	Beluga Whale	Unidentified Cetacean	Bearded Seal	Ringed Seal	Pacific Walrus	Unidentified Pinniped	Polar Bear (PB)	PB Tracks (no bear)
1-Sep	1	0	0	0	0	0	0	0	0	5/14	0
3-Sep	2	3/4	0	4/6	0	5/5	10/55	0	2/4	4/12	0
5-Sep	3	4/5	0	0	0	0	0	0	0	0	0
6-Sep	4	14/17	0	0	0	0	7/23	0	1/1	2/3	0
7-Sep	5	4/8	0	13/84	0	5/5	44/96	0	3/3	2/2	0
8-Sep	6	2/3	0	1/2	0	4/4	19/41	0	2/2	2/4	0
9-Sep	7	7/10	0	0	0	3/3	12/39	0	0	0	0
11-Sep	8	0	0	0	0	0	0	0	0	1/1	0
13-Sep	9	0	0	0	0	0	0	0	0	0	0
14-Sep	10	0	0	0	0	0	0	0	0	0	0
15-Sep	11	4/4	0	0	0	0	0	0	0	1/3	0
16-Sep	12	12/13	0	20/55	0	3/4	1/2	0	0	1/1	0
17-Sep	13	2/4	0	0	0	0	0	0	0	0	0
19-Sep	14	10/10	0	38/98	0	3/4	15/39	0	0	1/5	0
20-Sep	15	33/58	0	11/17	0	0	0	0	2/2	0	0
21-Sep	16	37/92	0	1/1	2/2	1/1	1/5	0	1/1	0	0
22-Sep	17	0	0	0	0	0	0	0	0	0	0
24-Sep	18	0	0	0	0	0	0	0	1/2	0	0
25-Sep	19	0	0	0	0	0	0	0	0	0	0
27-Sep	20	0	0	0	0	0	0	0	0	0	0
28-Sep	21	9/12	0	1/2	1/1	0	0	0	0	0	0
29-Sep	22	1/1	0	28/90	1/1	0	1/1	0	4/63	0	0
2-Oct	23	3/3	0	25/88	1/2	0	0	0	2/2	0	0
3-Oct	24	0	0	1/1	0	0	0	0	1/1	0	1
9-Oct	25	0	0	0	0	0	0	0	0	0	0
11-Oct	26	0	0	0	0	0	0	0	0	0	0
13-Oct	27	1/1	0	0	0	0	0	0	0	0	0
19-Oct	28	0	0	0	0	0	0	0	0	0	0
Total Semimonthly Sightings											
1-15 Sep		38/51	0	18/92	0	17/17	92/254	0	8/10	17/39	0
16-30 Sep		104/190	0	99/263	4/4	7/9	18/47	0	8/68	2/6	0
1-15 Oct		4/4	0	26/89	1/2	0	0	0	3/3	0	1
16-19 Oct		0	0	0	0	0	0	0	0	0	0
TOTAL		146/245	0	140/444	5/6	24/26	110/301	0	19/81	19/45	1

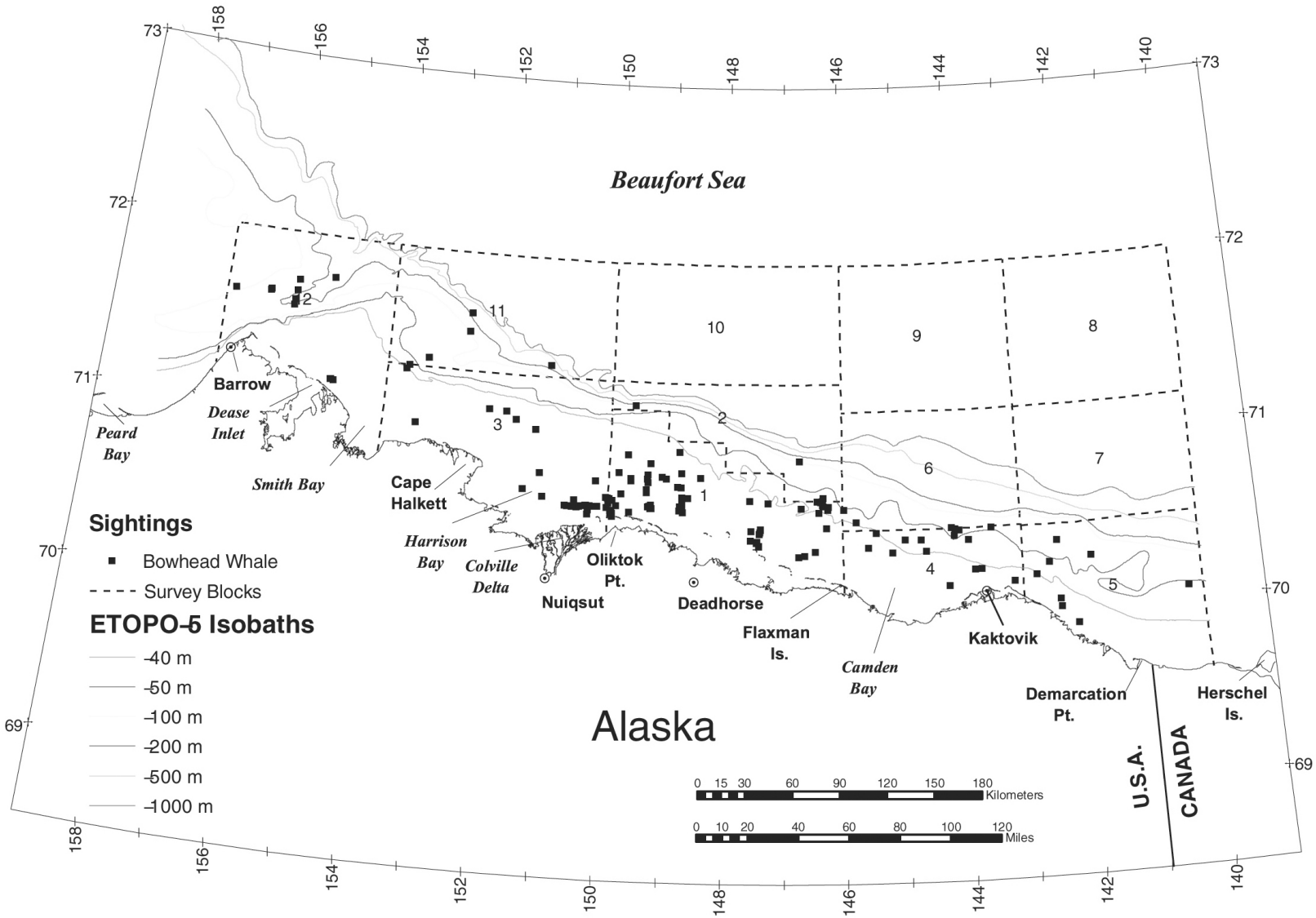

Figure 19 – Map of Bowhead Whale Sightings, Fall 2003

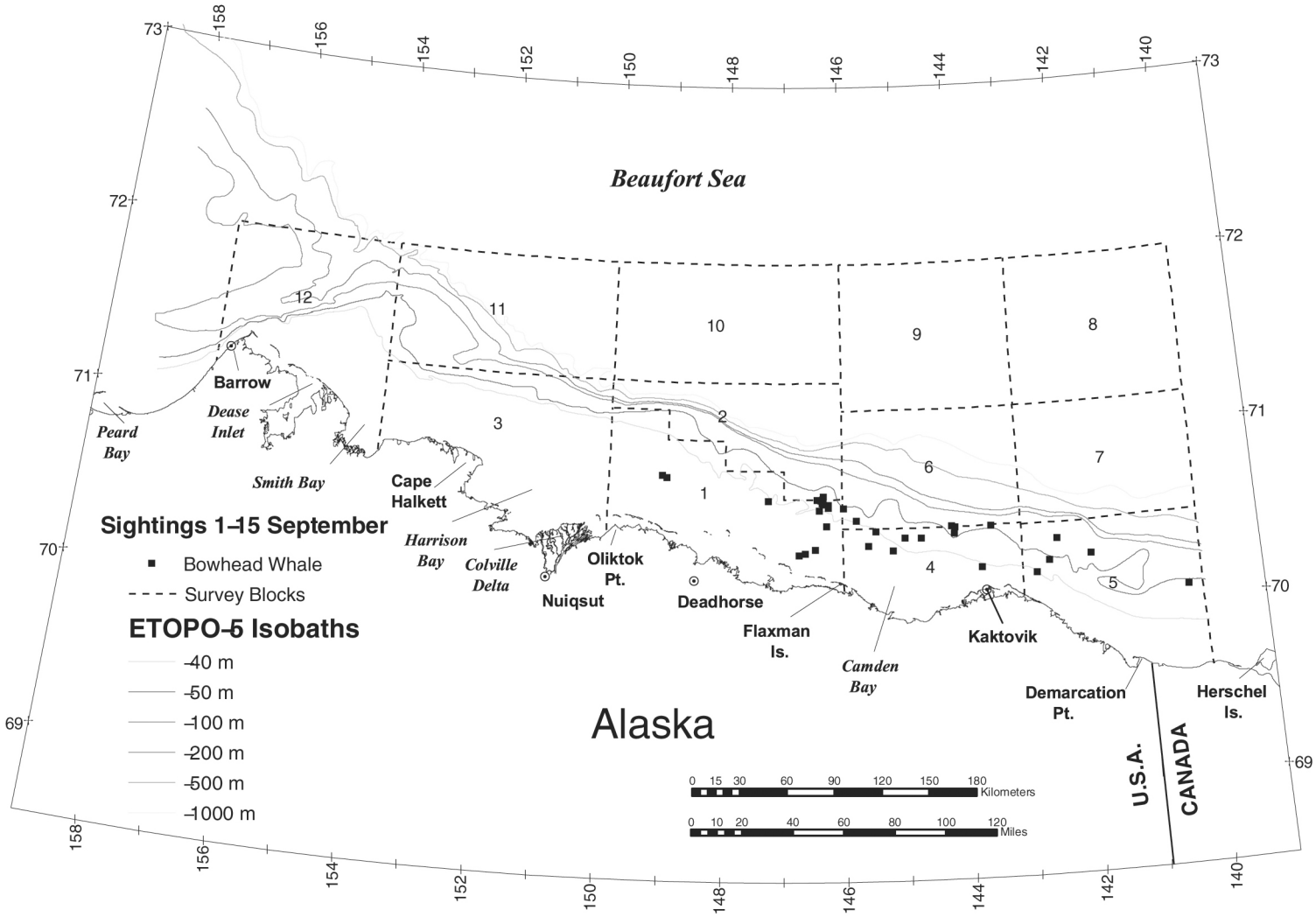

Figure 20 – Map of Bowhead Whale Sightings, 1-15 September 2003

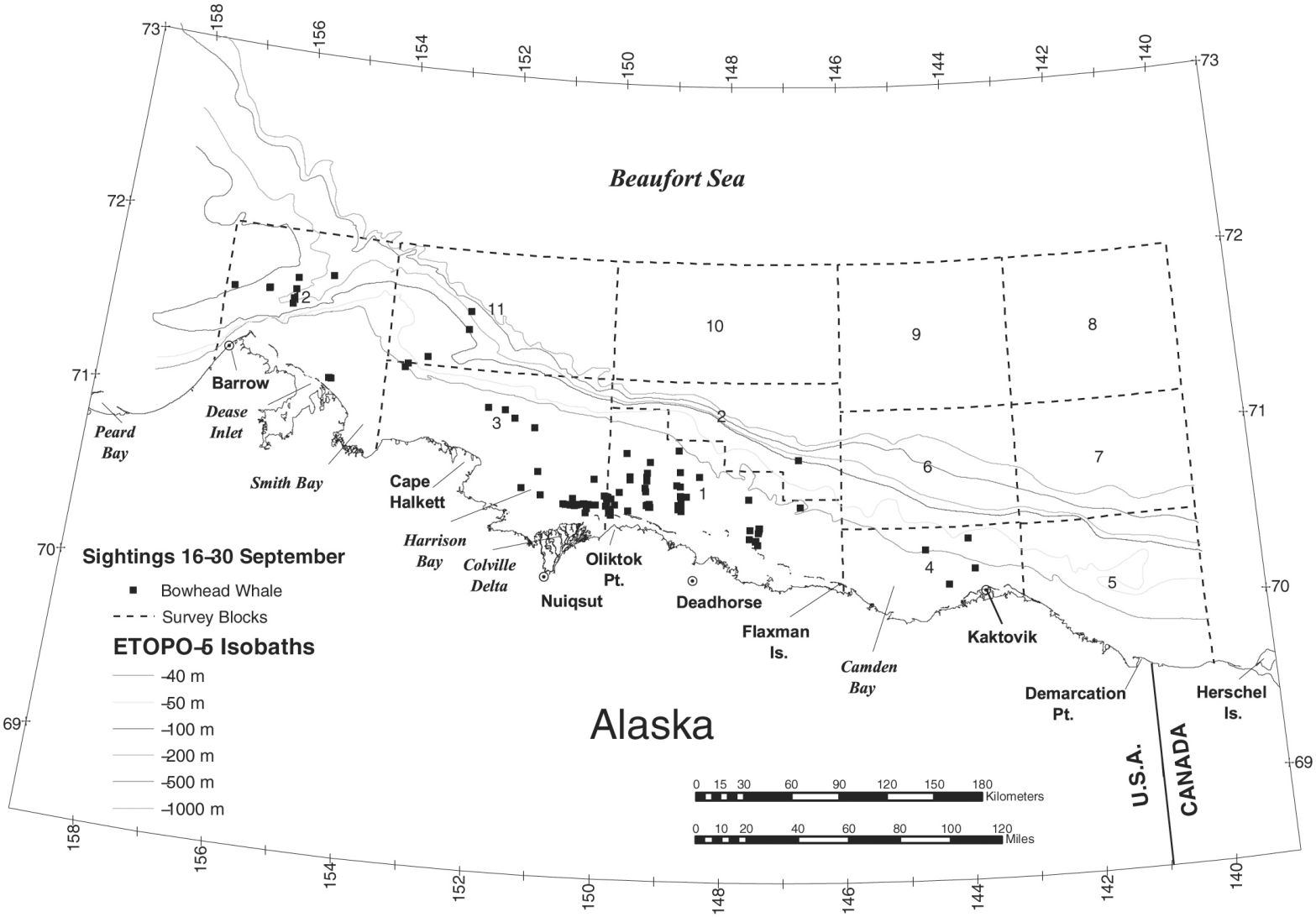

Figure 21 – Map of Bowhead Whale Sightings, 16-30 September, 2003

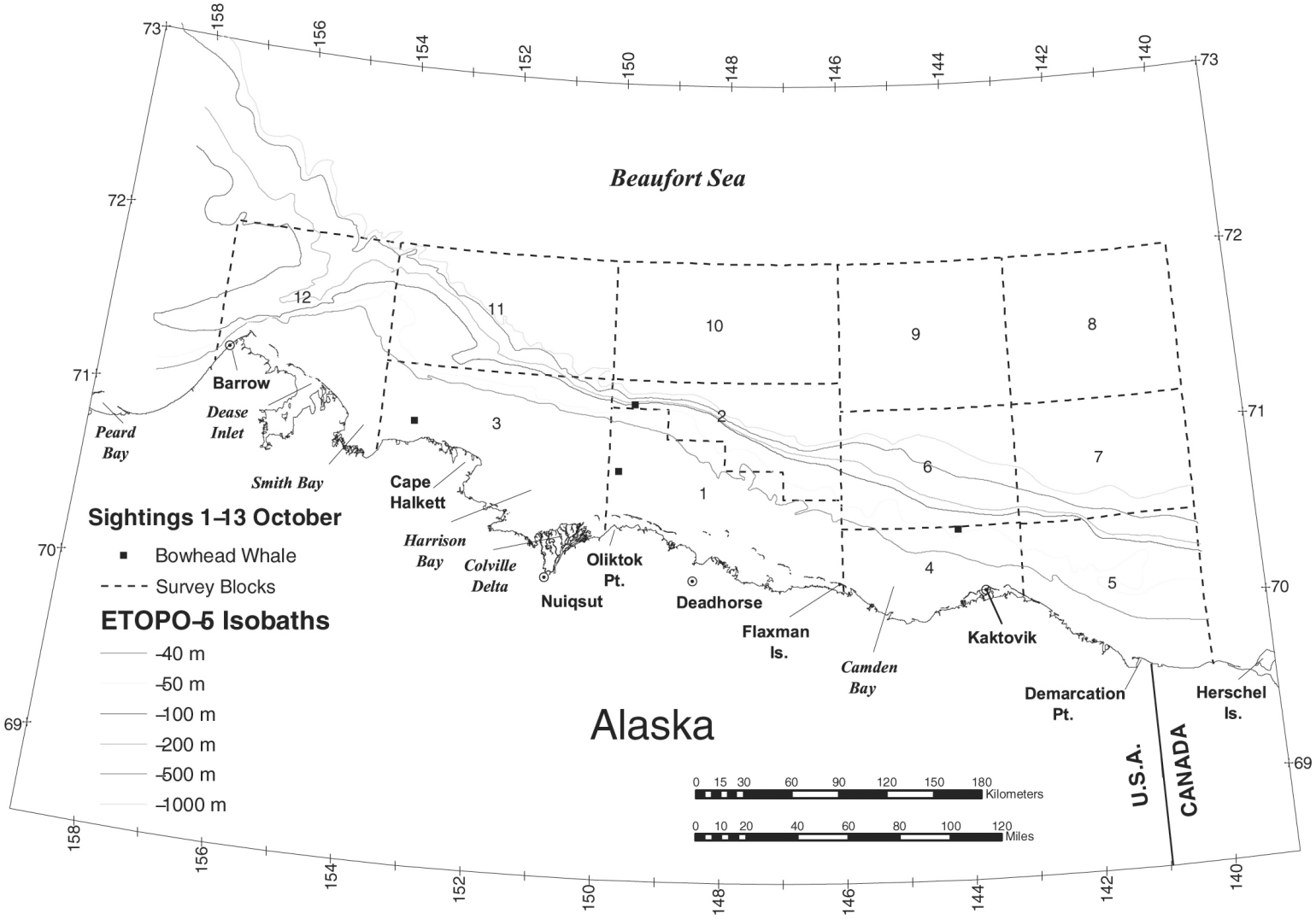

Figure 22 – Map of Bowhead Whale Sightings, 1-13 October, 2003

3. Bowhead Whale (Balaena mysticetus) Observations

a. Sighting Summary:

One hundred forty- six sightings were made for a total of 245 bowhead whales observed during Fall-2003 surveys in the study area (Table 7). Relatively widespread survey coverage between 140°W. and 158°W. longitudes showed bowhead whales widely distributed on the continental shelf south of the 1000 m. isobath (Figure 19). One of the 245 whales was identified as a calf (Appendix B-2003: Table B-2003), resulting in a seasonal calf ratio (number calves/total whales) of 0.004. Locations of observations of bowhead whales are shown by semi-monthly period in Figure 20-Figure 22.

b. Sighting Rates:

In Fall 2003, bowheads were seen at varying densities from Barrow to Canada (Figure 23). Moderate concentrations were observed on transect > 30 km NE of Barrow and near Oliktok Point. The largest groups were observed off transect and were of whales milling near Oliktok Point on 20-21 September. Many whales were milling in that area in late-September (Figure 24) and groups of 8, 9, 10, and 15 whales were observed. However, none of the milling whales were observed on transect (Appendix B-2003, Table B-2003).

c. Habitat Associations:

In addition to general ice coverage for arctic waters during Fall 2003 (A-2003), the percentage of ambient ice cover visible from the aircraft at each bowhead sighting (Appendix B-2003: Table B-2-2003) was summarized. Table 8). Ninety-seven percent of the whales observed (238) were in open water. The remainder were in < 20% ice cover.

Table 8
Semimonthly Summary of Bowhead Whales Observed,
By Percent Ice Cover Present at Sighting Location, Fall 2003

% Ice Cover	1-15 Sep	16-30 Sep	1-15 Oct	Total
0	44 (86%)	190 (100%)	4 (100%)	238 (97%)
1-5	4 (8%)	0	0	4 (2%)
6-10	1 (2%)	0	0	1 (0%)
11-20	2 (4%)	0	0	2 (1%)
TOTAL	51 (100%)	190 (100%)	4 (100%)	245 (100%)

Table 9
Semimonthly Summary of Bowhead Whales Observed, by Behavioral Category, Fall 2003

Behavior	1-15 Sep	16-30 Sep	1-15 Oct	Total
Breach	1 (2)	2 (1%)	0	3 (1%)
Dive	0	5 (3%)	0	5 (2%)
Feed	2 (4%)	0	0	2 (1%)
Mill	0	75 (39%)	0	75 (31%)
Rest	4 (8%)	8 (4%)	0	12 (5%)
Spy Hop	1 (2%)	0	0	1 (0%)
Swim	43 (84%)	99 (52%)	4 (100%)	146 (60%)
Tail Slap	0	1 (1%)	0	1 (0%)
TOTAL	51	190	4	245

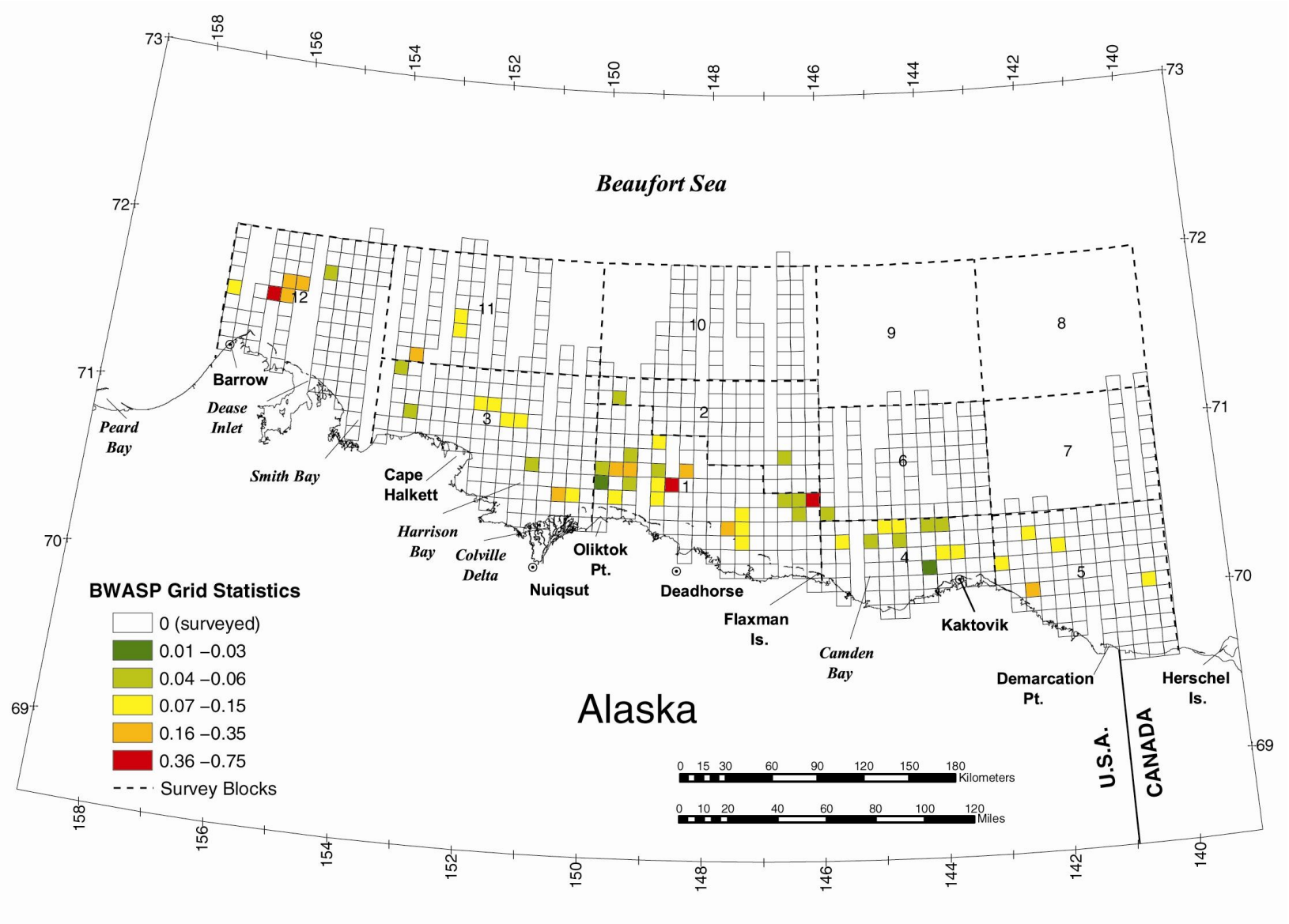

Figure 23 – Count Rates of Bowhead Whales on Transect, Fall 2003

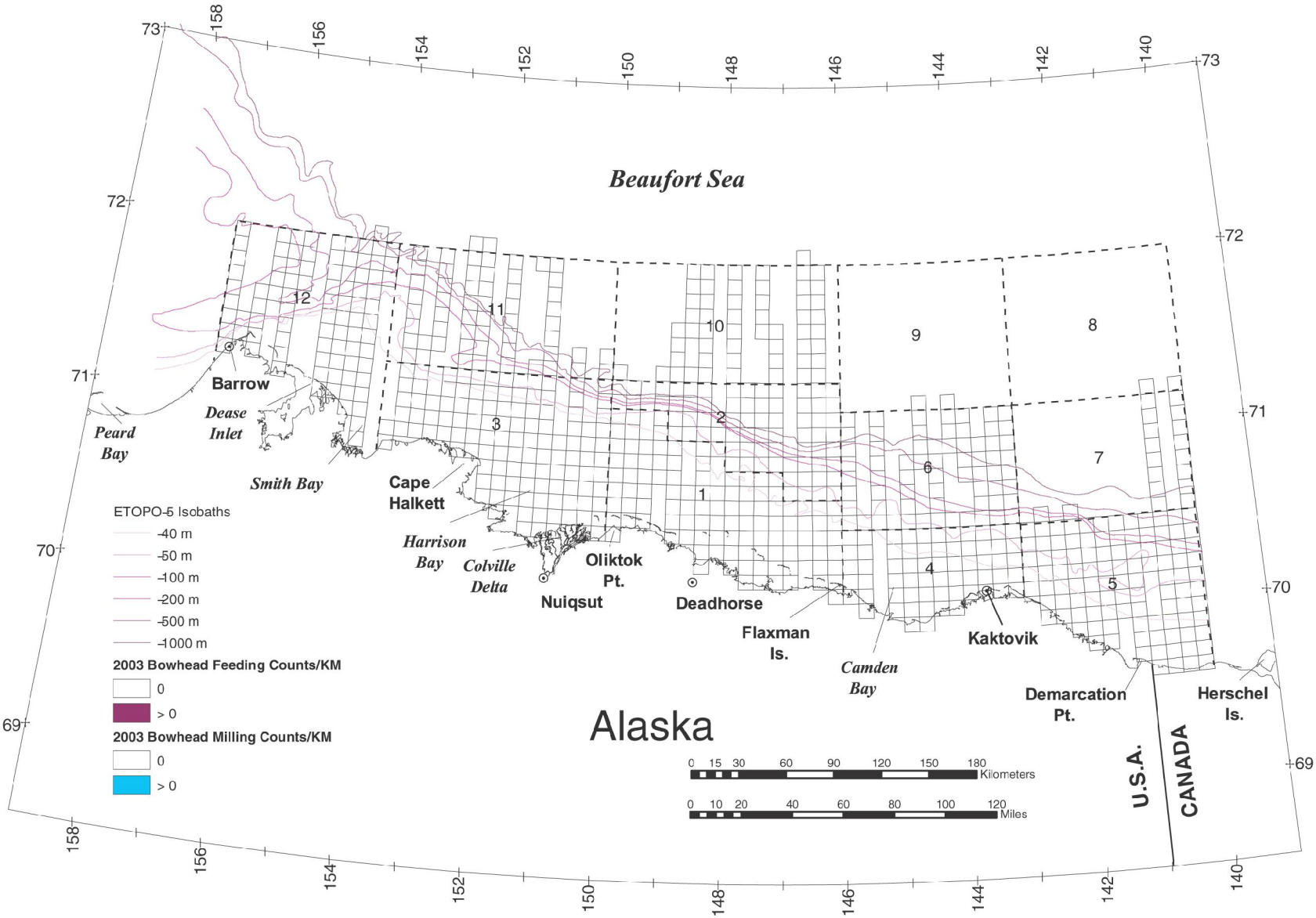

Figure 24 – Fall 2003 Counts of Feeding and Milling Bowhead Whales Per Unit Effort (km) – on Transect

d. Behaviors:

Of 245 bowhead whales observed during 2003, 146 (60%) were swimming (ie. traveling forward in an apparently deliberate manner), and 75 (31%) were milling. Semimonthly summaries of these and other behaviors observed during 2003 are in Table 9.

Sudden overt changes (e.g., an abrupt dive, course diversion, or cessation of behavior ongoing) in whale behavior were looked for. No bowheads were observed for which responses to the survey aircraft were noted.

e. Distance from Shore:

The mean distance from shore for bowhead whales observed on transect during Fall 2003 was 31.8 km (*SD* = 18.2) in the East Region, and 34.4 km (*SD* = 19.7) in the West Region (Fig. 25).

f. Aggregations of Bowhead Whales West of Northstar Development:

Concentrations of milling whales were seen nearshore north and northwest of Oliktok Pt., approximately 40-80 km west of Northstar Development, on September 20-21, 2003 (Fig. 21, Appendix B-2003). Survey observations suggests that possibly as many as several hundred whales were present in that area during those days.

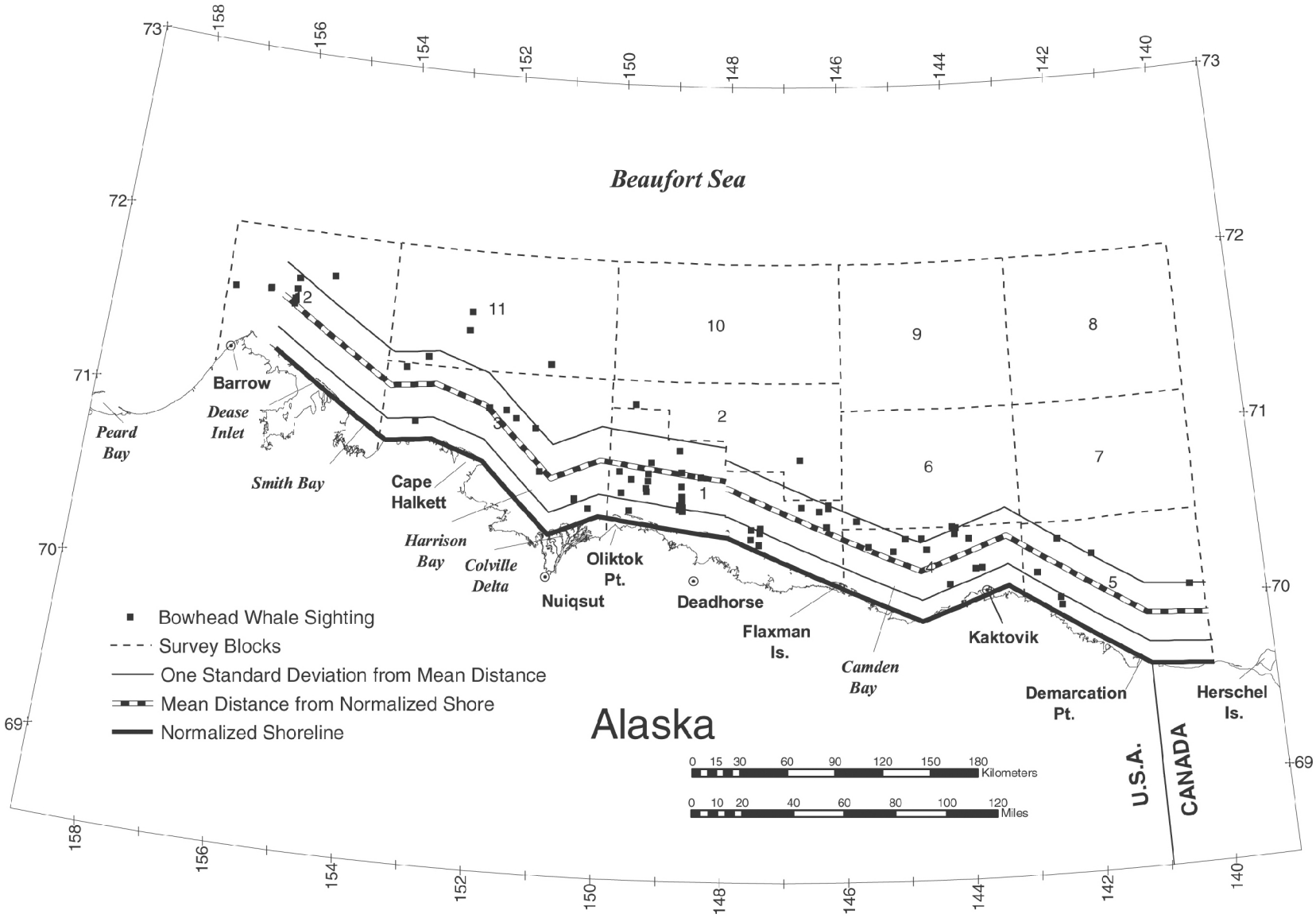

Figure 25 – Bowhead Whale Sightings on Transect Fall 2003 Showing Mean Distance from a Normalized Shoreline.

C. FALL 2004 RESULTS

4. Environmental Conditions

General sea-ice coverage in the Alaskan Beaufort Sea (Appendix A-2004) was very light during the 2004 survey. The study area was essentially ice free, except for a small area of moderate ice cover in the extreme NE corner (Block 9), from the beginning of the survey on 1 September until after 4 October. Shorefast ice began forming in bays and inlets at the end of September. By mid-October a band approximately 20 – 40 km wide had formed from Barrow to Canada. At the end of the survey (19 October), extensive ice free and light-ice (< 30%) waters still existed from Barrow to Canada. Ice percentages and sea states at each sighting of endangered whales are shown in Appendix B-2004 (Table B-2004).

5. Survey Effort

The 2004 bowhead survey was conducted from 1 September -18 October.. There were 29 flights, of which 22 were in September and 7 were in October. Daily totals of kilometers and hours flown per survey flight during this period are shown in Table 10. A total of 25,865 km of surveys were flown in 115.86 hours in the study area at an average speed of 223.3 km/hr. The average survey flight was 891.9 km, with over-ocean flight distances ranging from 110 km to 1,547 km. A total of 14,113 km of random-transect lines were flown in 66.0 hours at an average transect speed of 213.8 km/hr. These random transects constituted 54.5 percent of the total kilometers flown and 57.0 percent of the total flight hours. Survey-flight lines are shown by semimonthly period in Figure 26 through Figure 29.

Table 10
Aerial-Survey Effort in the Beaufort Sea, 1 September-18 October 2004, by Survey Flight

Day	Flight No	Transect (km)	Connect (km)	Search (km)	Total (km)	Transect (hr)	Total (hr)
1-Sep	1	0	0	144	144	0	0.57
2-Sep	2	232	55	538	824	1.05	3.42
4-Sep	3	0	0	493	493	0	1.92
5-Sep	4	603	25	615	1,243	2.77	5.33
6-Sep	5	926	215	278	1,419	4.13	6.55
7-Sep	6	208	60	547	815	1.03	3.58
8-Sep	7	772	185	215	1,172	3.45	5.18
9-Sep	8	841	90	230	1,161	3.68	5.17
10-Sep	9	780	190	167	1,137	3.47	5.13
11-Sep	10	0	0	110	110	0	0.37
13-Sep	11	585	63	384	1,031	2.87	4.65
14-Sep	12	428	55	418	902	2.2	4.75
16-Sep	13	903	90	555	1,547	4.73	7.25
17-Sep	14	0	0	134	134	0	0.48
18-Sep	15	572	69	508	1,149	2.92	5.42
19-Sep	16	510	52	179	741	2.65	3.55
21-Sep	17	518	122	167	807	2.32	3.25
22-Sep	18	990	142	114	1,246	4.4	5.45
24-Sep	19	716	87	371	1,173	3.13	5.32
26-Sep	20	699	161	472	1,332	3.15	6.55
28-Sep	21	280	77	223	579	1.25	2.43
29-Sep	22	532	135	77	744	2.42	3.4
1-Oct	23	813	155	236	1,204	3.63	5.45
2-Oct	24	15	0	451	466	0.07	1.82
10-Oct	25	332	79	360	772	1.5	3.22
15-Oct	26	557	98	581	1,236	2.45	5.47
16-Oct	27	46	0	252	298	0.18	1.17
17-Oct	28	890	224	357	1,471	4.05	6.63
18-Oct	29	365	87	63	515	1.63	2.38
Semimonthly Effort Summary							
1-15 Sep		5,375	938	4,139	10,451	25	46.62
16-30 Sep		5,720	935	2,800	9,452	27	43.1
1-15 Oct		1,717	332	1,628	3,678	8	15.96
16-18 Oct		1,301	311	672	2,284	6	10.18
TOTAL		14,113	2516	9,239	25,865	66	115.86

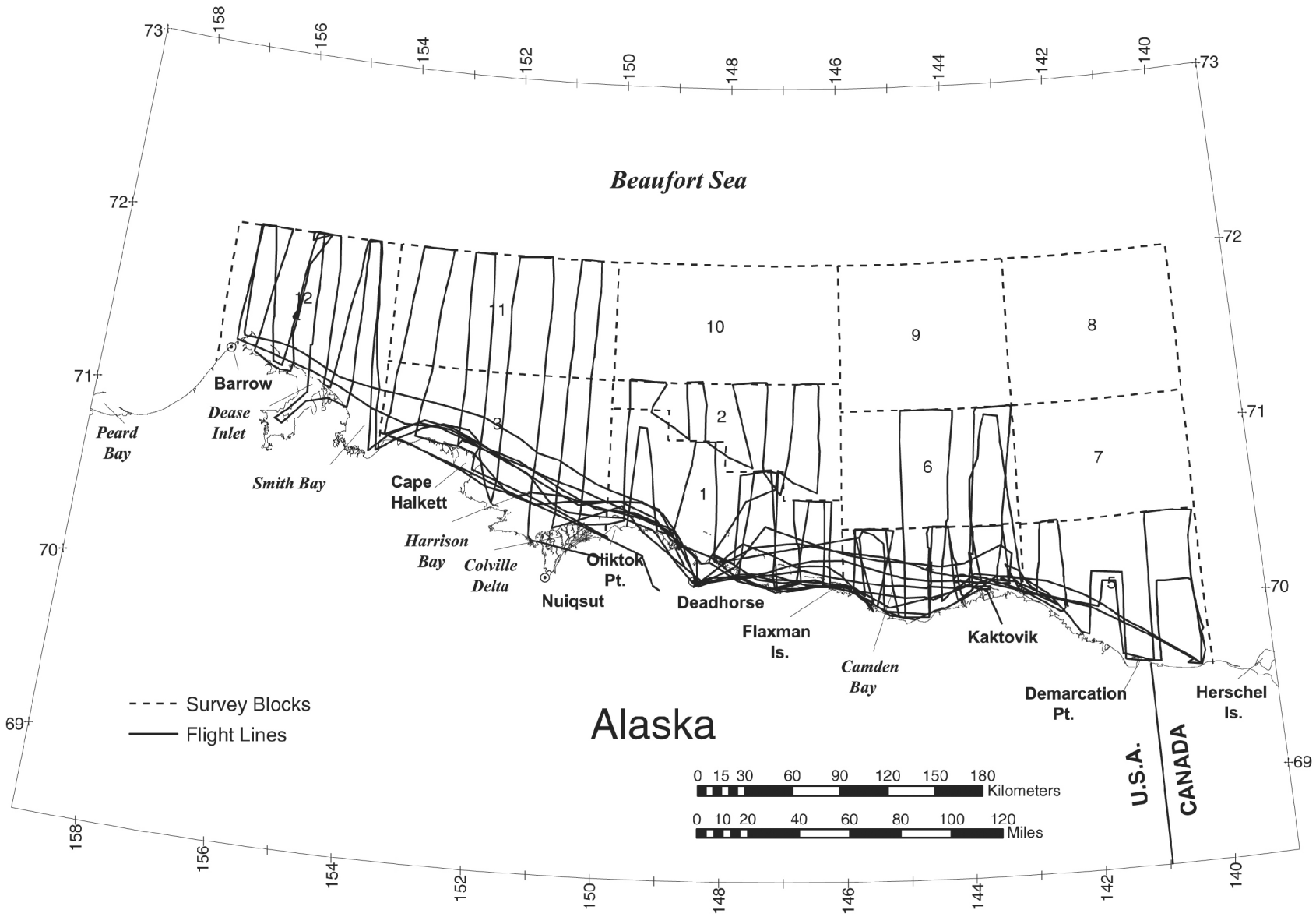

Figure 26 – Combined Flight Tracks, 1 – 15 September 2004

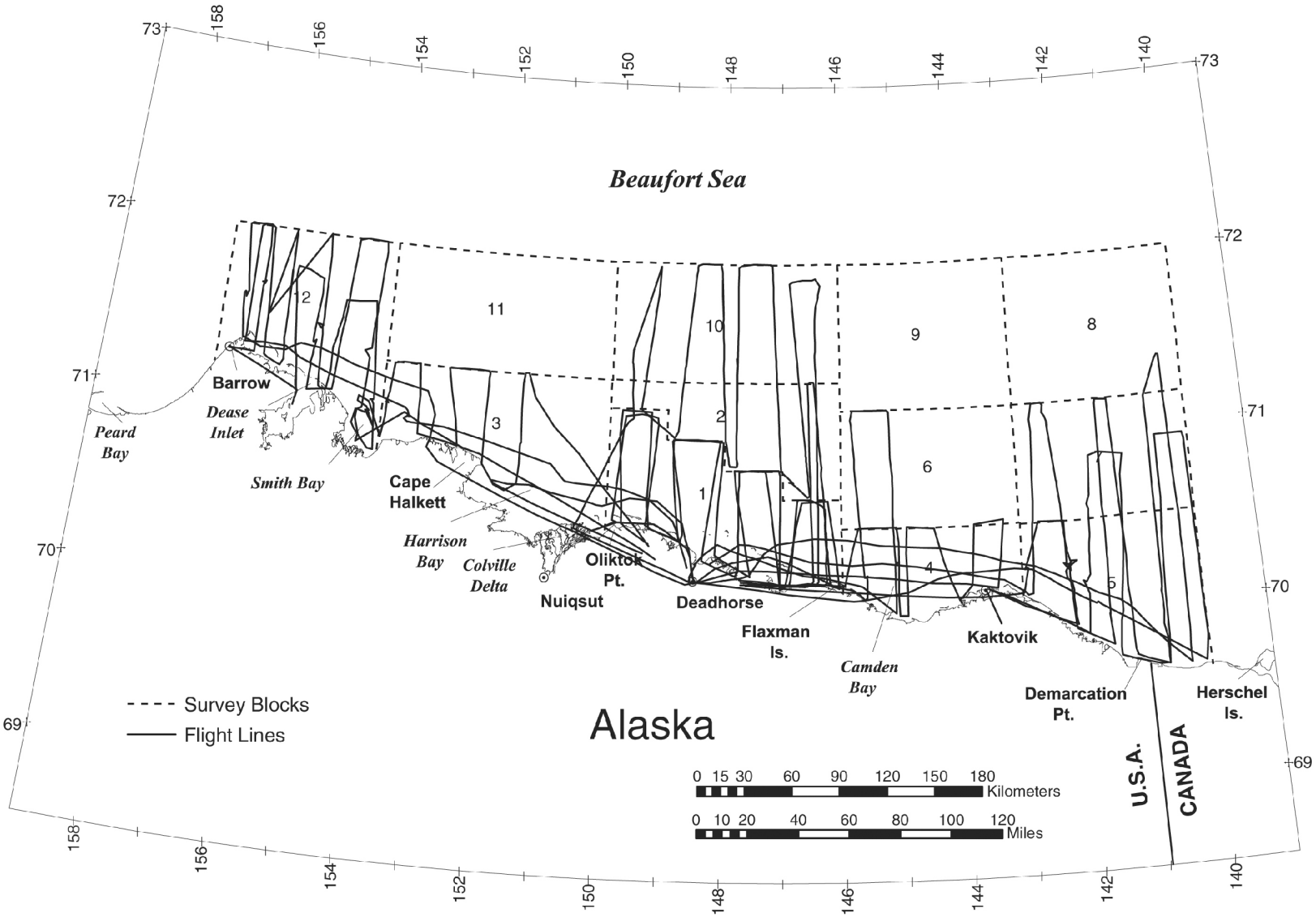

Figure 27 – Combined Flight Tracks, 16-30 September 2004

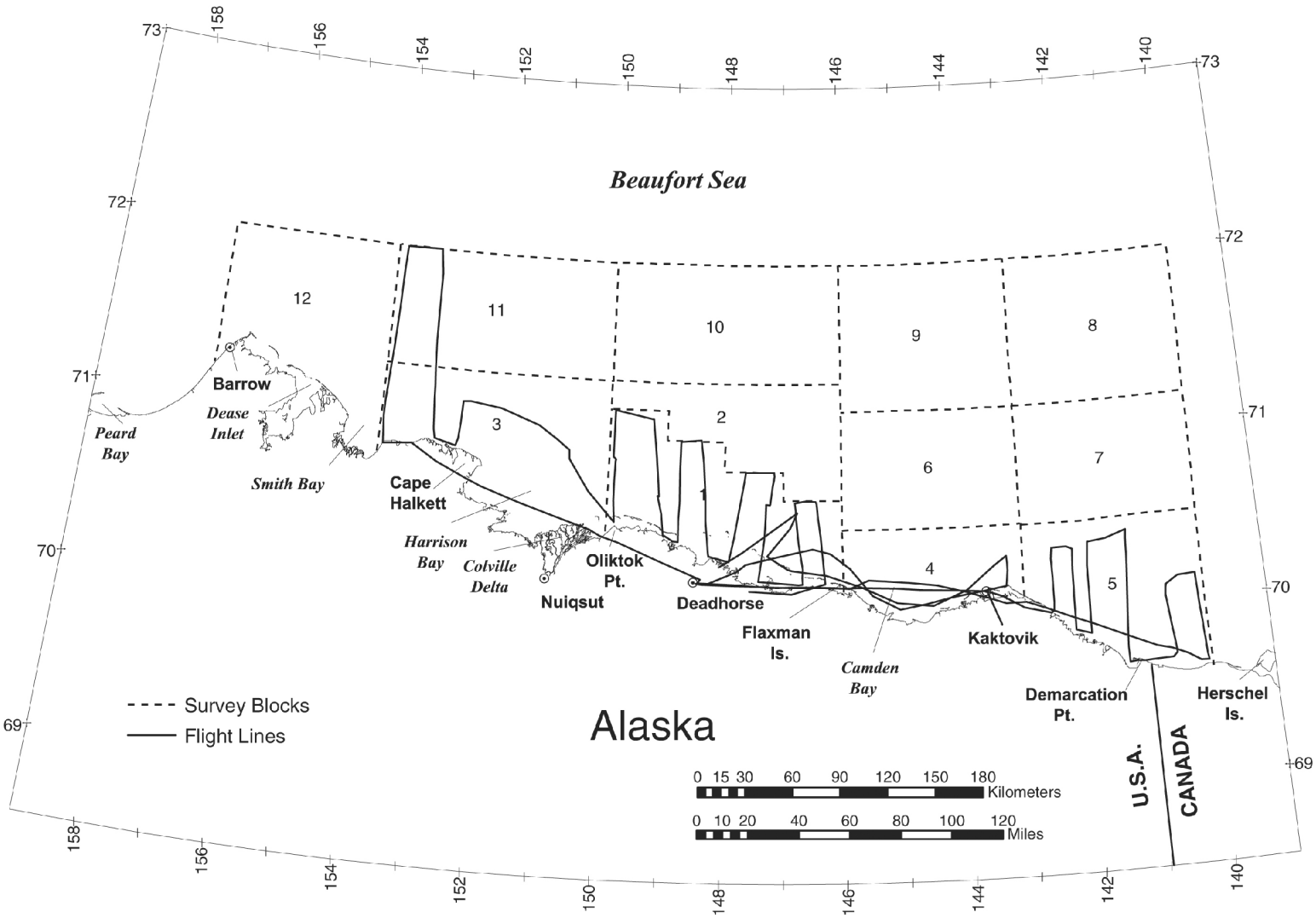

Figure 28 – Combined Flight Tracks, 1-15 October 2004

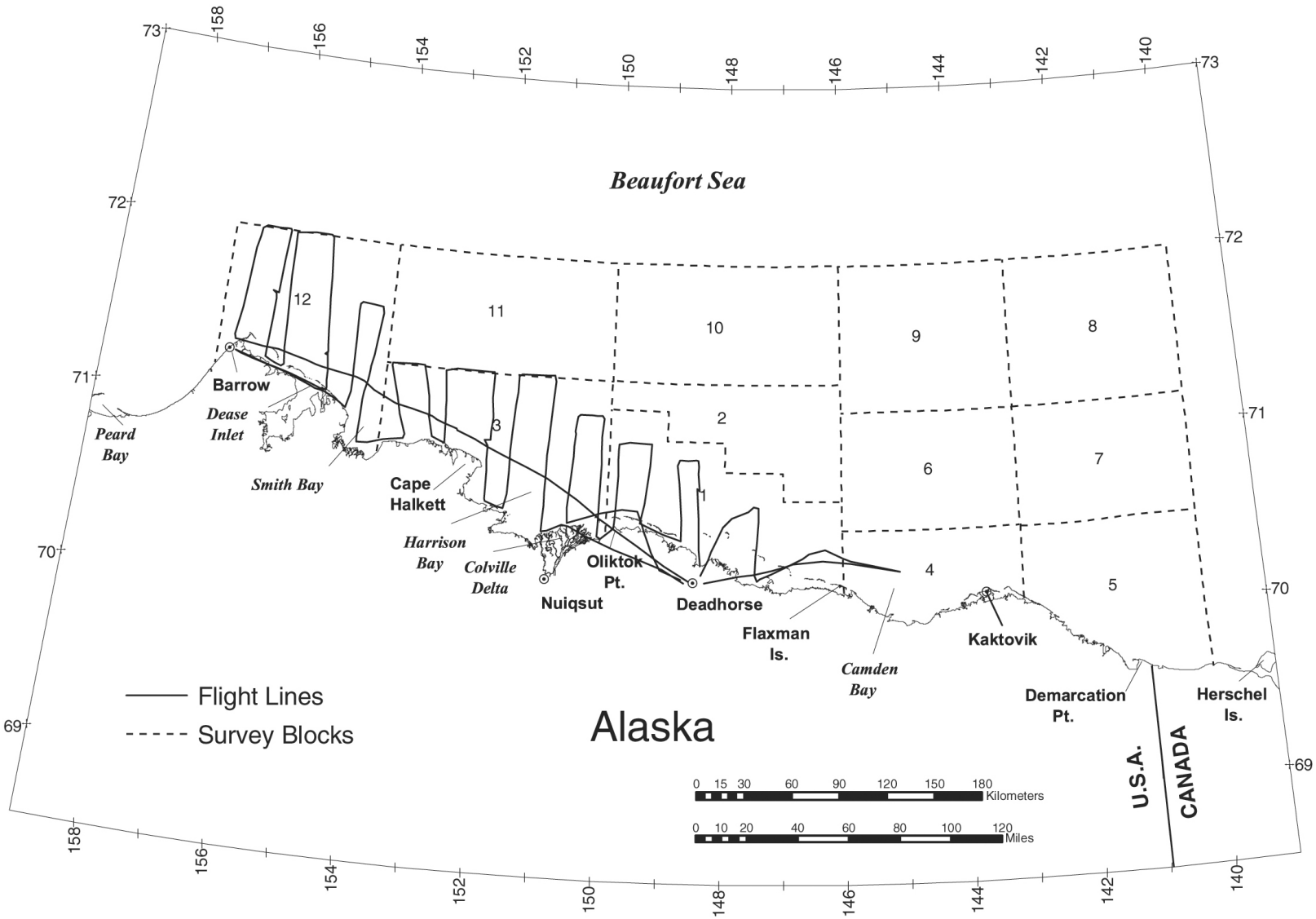

Figure 29 – Combined Flight Tracks, 16 – 18 October 2004

Table 11
Summary of Marine Mammal Sightings, 1 September-18 October 2004, by Survey Flight
(number of sightings/number of animals)

Day	Flight No	Bowhead Whale	Gray Whale	Beluga Whale	Unidentified Cetacean	Bearded Seal	Ringed Seal	Pacific Walrus	Unidentified Pinniped	Polar Bear (PB)	PB Tracks (no bear)
1-Sep	1	0	0	0	0	0	0	0	0	0	0
2-Sep	2	6/9	0	0	0	0	2/2	0	0	0	0
4-Sep	3	0	0	0	0	0	0	0	0	2/3	0
5-Sep	4	12/20	0	13/20	0	6/6	40/141	4/4	0	0	0
6-Sep	5	5/8	0	6/12	1/1	3/3	170/480	0	0	12/15	0
7-Sep	6	7/9	0	0	0	3/3	58/265	0	0	8/9	0
8-Sep	7	3/3	0	1/1	0	0	5/9	0	0	2/2	0
9-Sep	8	4/5	0	2/67	0	0	5/6	0	0	0	0
10-Sep	9	1/3	0	44/160	2/2	1/1	8/34	0	0	1/1	0
11-Sep	10	0	0	0	0	0	0	0	0	1/1	0
13-Sep	11	6/14	0	20/80	1/1	0	4/9	2/12	1/2	0	0
14-Sep	12	28/41	0	3/4	2/2	10/14	60/330	0	0	6/12	0
16-Sep	13	33/70	0	19/37	1/1	14/18	53/546	0	0	3/3	0
17-Sep	14	0	0	0	0	0	0	0	0	0	0
18-Sep	15	27/154	0	1/1	0	2/3	15/16	0	0	2/2	0
19-Sep	16	10/12	0	0	0	4/28	16/67	0	0	1/1	1
21-Sep	17	4/5	0	0	0	1/1	2/2	0	0	1/1	0
22-Sep	18	0	0	5/53	0	4/4	88/601	0	0	1/1	0
24-Sep	19	18/31	0	2/4	0	1/1	20/22	0	0	0	0
26-Sep	20	34/50	0	2/2	2/2	3/3	46/328	0	0	0	0
28-Sep	21	0	0	0	0	0	0	0	0	0	0
29-Sep	22	2/2	0	0	1/1	0	1/8	0	0	0	0
1-Oct	23	5/7	0	0	0	5/7	11/26	0	1/1	1/1	0
2-Oct	24	0	0	0	0	0	0	0	0	1/1	0
10-Oct	25	0	0	0	0	1/1	3/5	0	0	0	0
15-Oct	26	12/12	0	0	0	0	0	0	0	0	0
16-Oct	27	0	0	0	0	0	0	0	0	0	0
17-Oct	28	21/41	0	3/6	0	0	0	0	1/1	1/2	0
18-Oct	29	0	0	0	0	0	0	0	0	0	0
Total Semimonthly Sightings											
1-15 Sep		72/112	0	89/344	6/6	23/27	352/1276	6/16	1/2	32/43	0
16-30 Sep		128/324	0	29/97	4/4	29/58	241/1590	0	0	8/8	1
1-15 Oct		17/19	0	0	0	6/8	14/31	0	1/1	2/2	0
16-18 Oct		21/41	0	3/6	0	0	0	0	1/1	1/2	0
TOTAL		238/496	0	121/447	10/10	58/93	607/2896	6/16	3/4	43/55	1

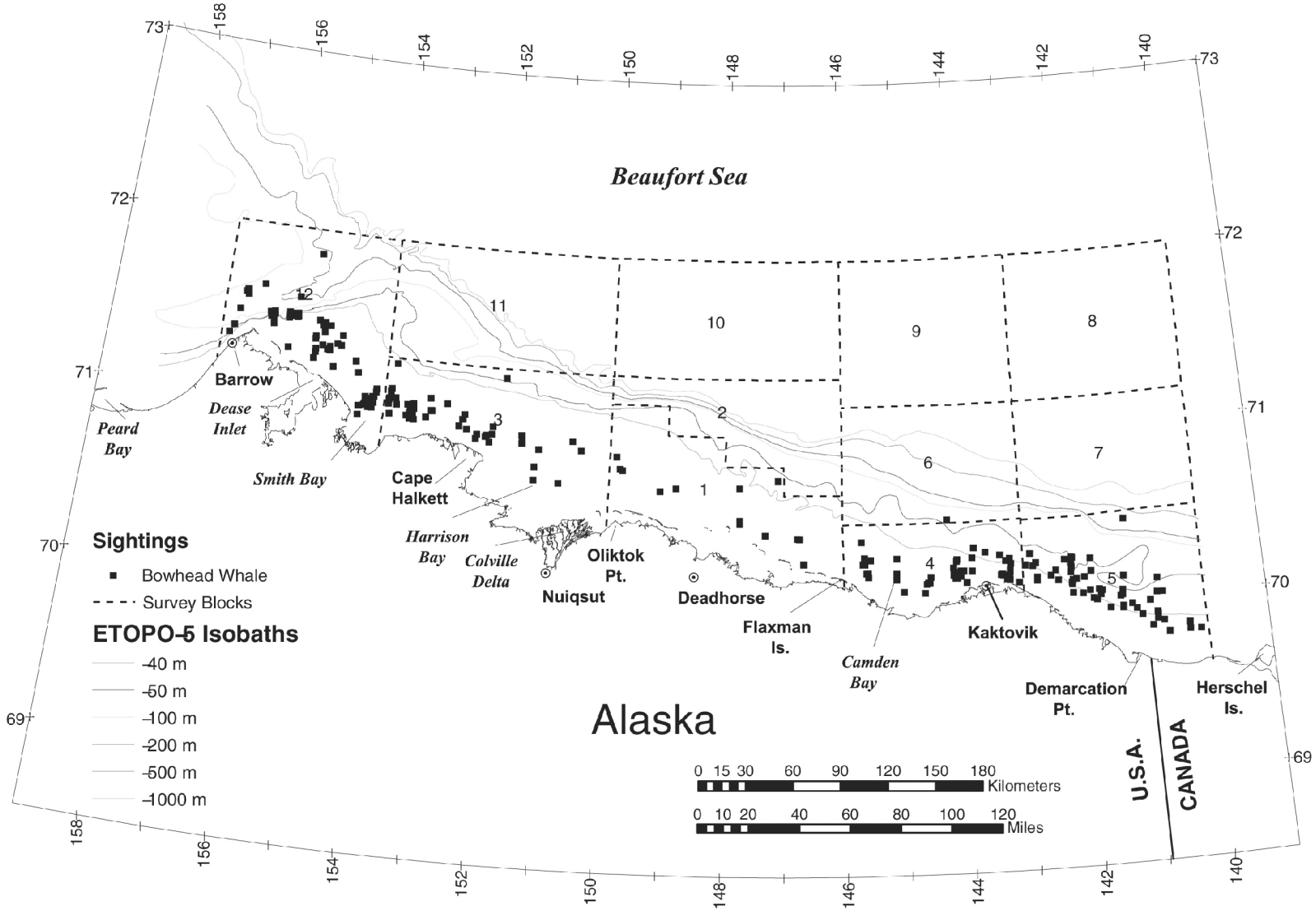

Figure 30 – Map of Bowhead Whale Sightings, Fall 2004

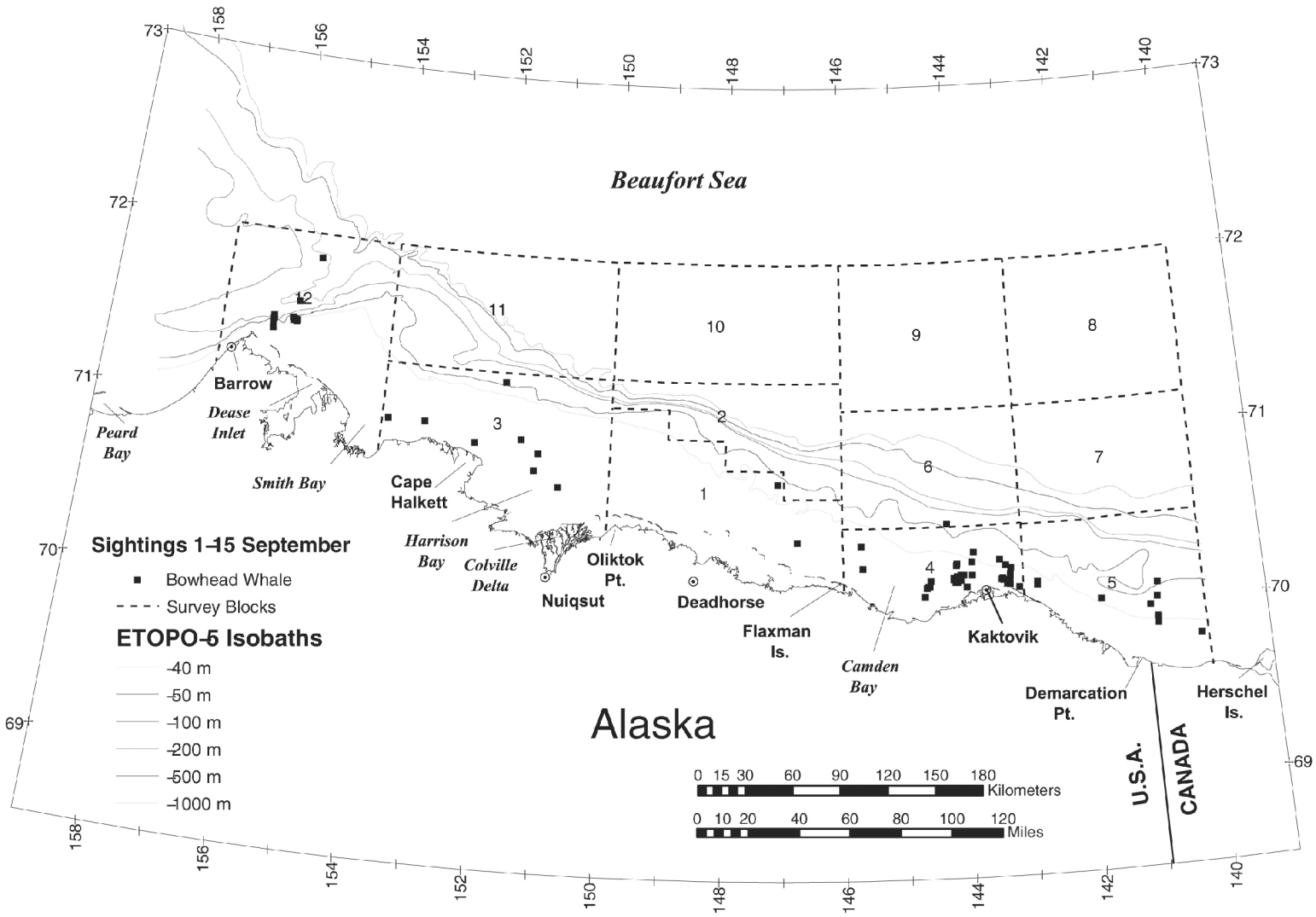

Figure 31 – Map of Bowhead Whale Sighting, 1-15 September 2004

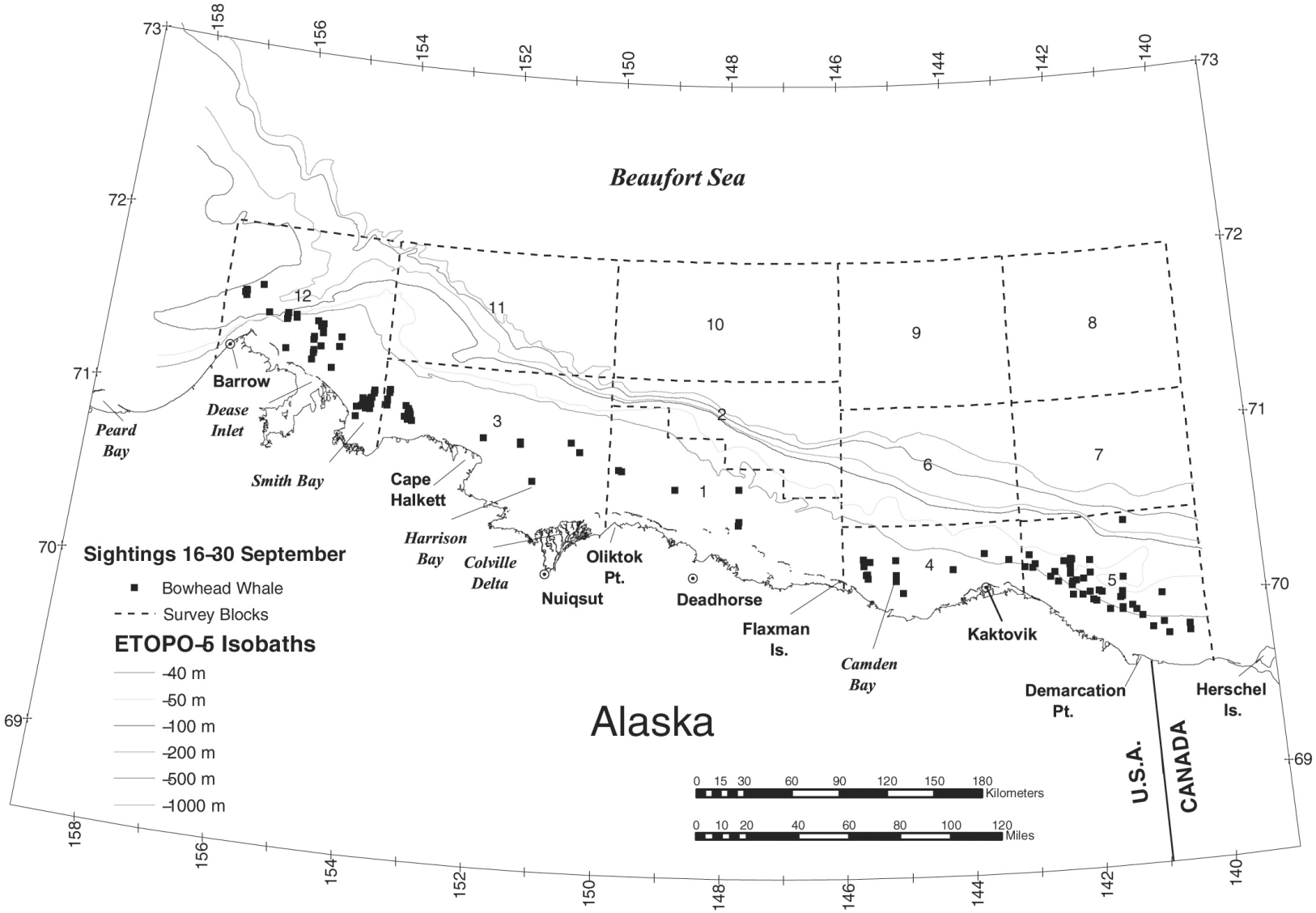

Figure 32 – Map of Bowhead Whale Sightings, 16-30 September 2004

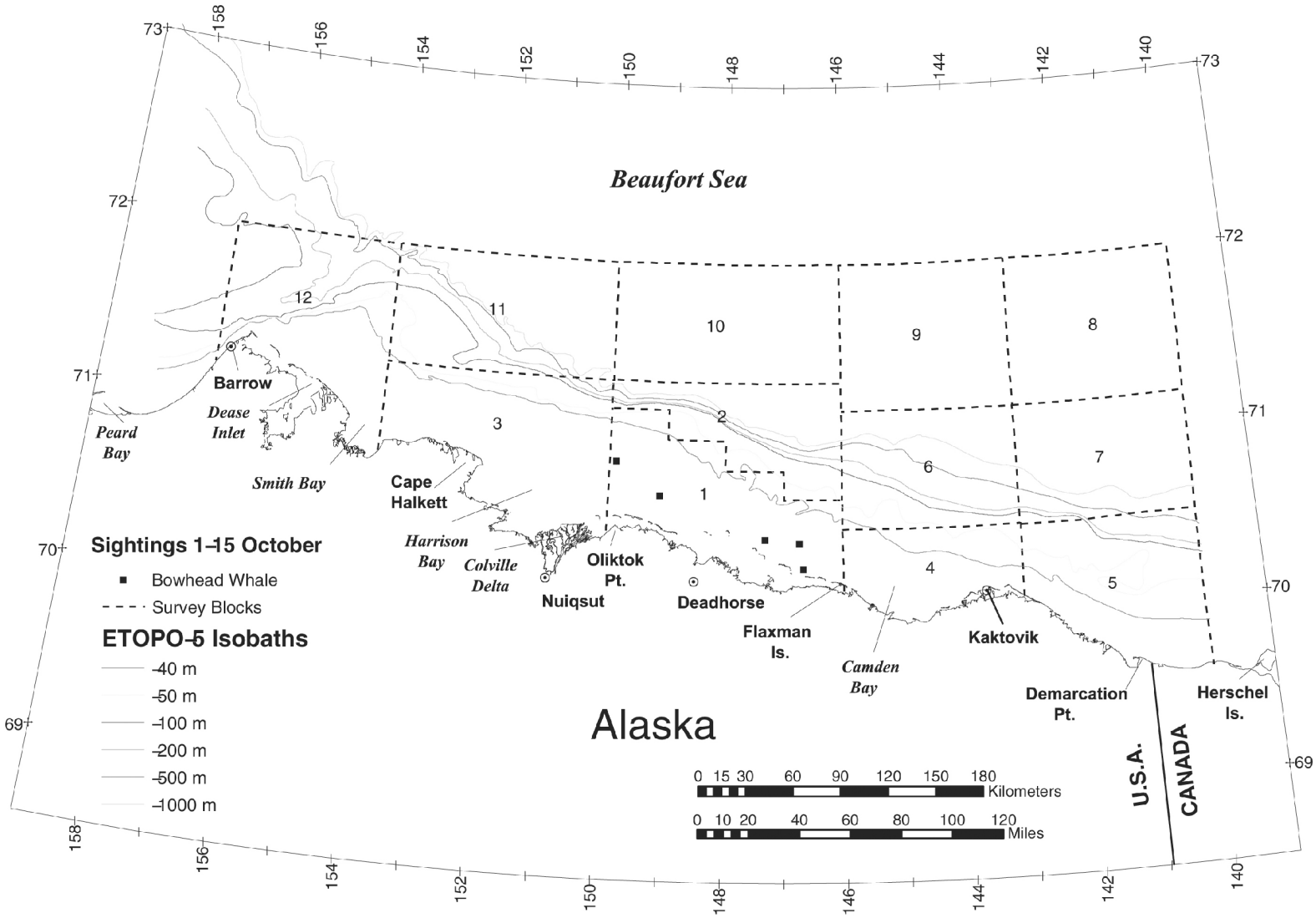

Figure 33 – Map of Bowhead Whale Sightings, 1-15 October 2004

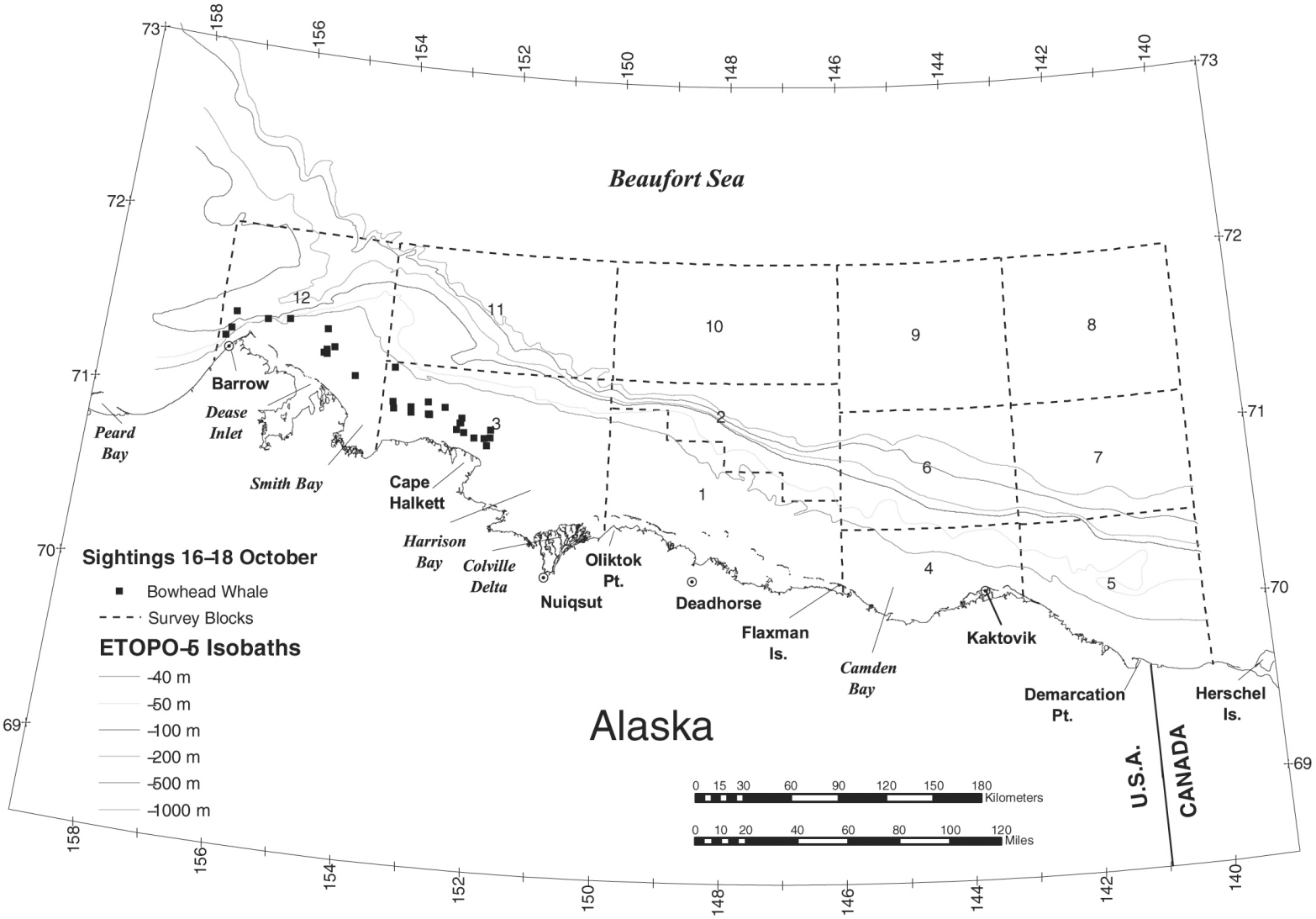

Figure 34 – Map of Bowhead Whale Sightings, 16-18 October 2004

6. Bowhead Whale (Balaena mysticetus) Observations

a. Sighting Summary:

Two hundred thirty-eight sightings were made for a total of 496 bowhead whales observed during Fall-2004 surveys in the study area (Table 11). Relatively widespread survey coverage between 140°W. and 158°W. longitudes showed abundant bowhead whales,on the continental shelf mostly shoreward of the 40 m. isobath (Figure 30). Twenty-two of the 496 whales were identified as calves (Appendix B-2004: Table B-2004), resulting in a seasonal calf ratio (number calves/total whales) of 0.0444. Locations of observations of bowhead whales are shown by semi-monthly period in Figures Figure 31-Figure 34.

b. Sighting Rates:

In September 2004, bowhead sighting rates were high in all southern blocks except Block 1 (Figure 35). Concentrations of whales were seen east of Kaktovik, north of Smith Bay and north of Dease Inlet. Sighting rates were highest during the second half of September. Seventy whales were seen, mostly east of Kaktovik in Block 5, on 16 September. On 18 September, 154 whales were seen in western Block 3 and Block 12. Seven groups ranging in size from 10-45 were seen north of Dease inlet or near Smith Bay on 18 September (Appendix 2004-B: Table B-2004).

c. Habitat Associations:

In addition to general ice coverage for arctic waters during Fall 2004 (Appendix A-2004), the percentage of ambient ice cover visible from the aircraft at each bowhead sighting (Appendix B-2004: Table B-2004) was summarized. Of the 496 bowheads counted over the field season, 456 whales (91%) were sighted in open water. Twenty whales (4%) were seen in dense ice coverage (91-100%) on 17 October. The remaining whales were seen in intermediate ice coverage (Table 12).

Table 12
Semimonthly Summary of Bowhead Whales Observed,
By Percent Ice Cover Present at Sighting Location, Fall 2004

% Ice Cover	1-15 Sep	16-30 Sep	1-15 Oct	16-17 Oct	Total
0	112 (100%)	324 (100%)	17 (88%)	3 (7%)	456 (91%)
1-5	0	0	0	1 (2%)	1 (0%)
11-20	0	0	0	6 (15%)	6 (2%)
21-30	0	0	1 (6%)	2 (5%)	3 (1%)
31-40	0	0	0	1 (2%)	1 (0%)
41-50	0	0	0	6 (15%)	6 (2%)
51-60	0	0	1 (6%)	0	1 (0%)
71-80	0	0	0	2 (5%)	2 (0%)
91-100	0	0	0	20 (49%)	20 (4%)
TOTAL	112 (100%)	324 (100%)	19 (100%)	41 (100%)	496 (100%)

Table 13
Semimonthly Summary of Bowhead Whales Observed, by Behavioral Category, Fall 2004

Behavior	1-15 Sep	16-30 Sep	1-15 Oct	16-17 Oct	Total
Breach	5 (4%)	5 (2%)	0	0	10 (2%)
Cow with Calf	0	0	0	2 (5%)	2 (0%)
Dive	1 (1%)	3 (1%)	4 (21%)	1 (2%)	9 (2%)
Feed	29 (26%)	115 (35%)	0	0	144 (29%)
Mill	15 (13%)	34 (10%)	0	1 (2%)	50 (10%)
Rest	1 (1%)	0	0	26 (64%)	27 (5%)
Swim	61 (55%)	166 (52%)	15 (79%)	11 (27%)	253 (52%)
Tail Slap	0	1 (0%)	0	0	1 (0%)
TOTAL	112 (100%)	324 (100%)	19 (100%)	41 (100%)	496 (100%)

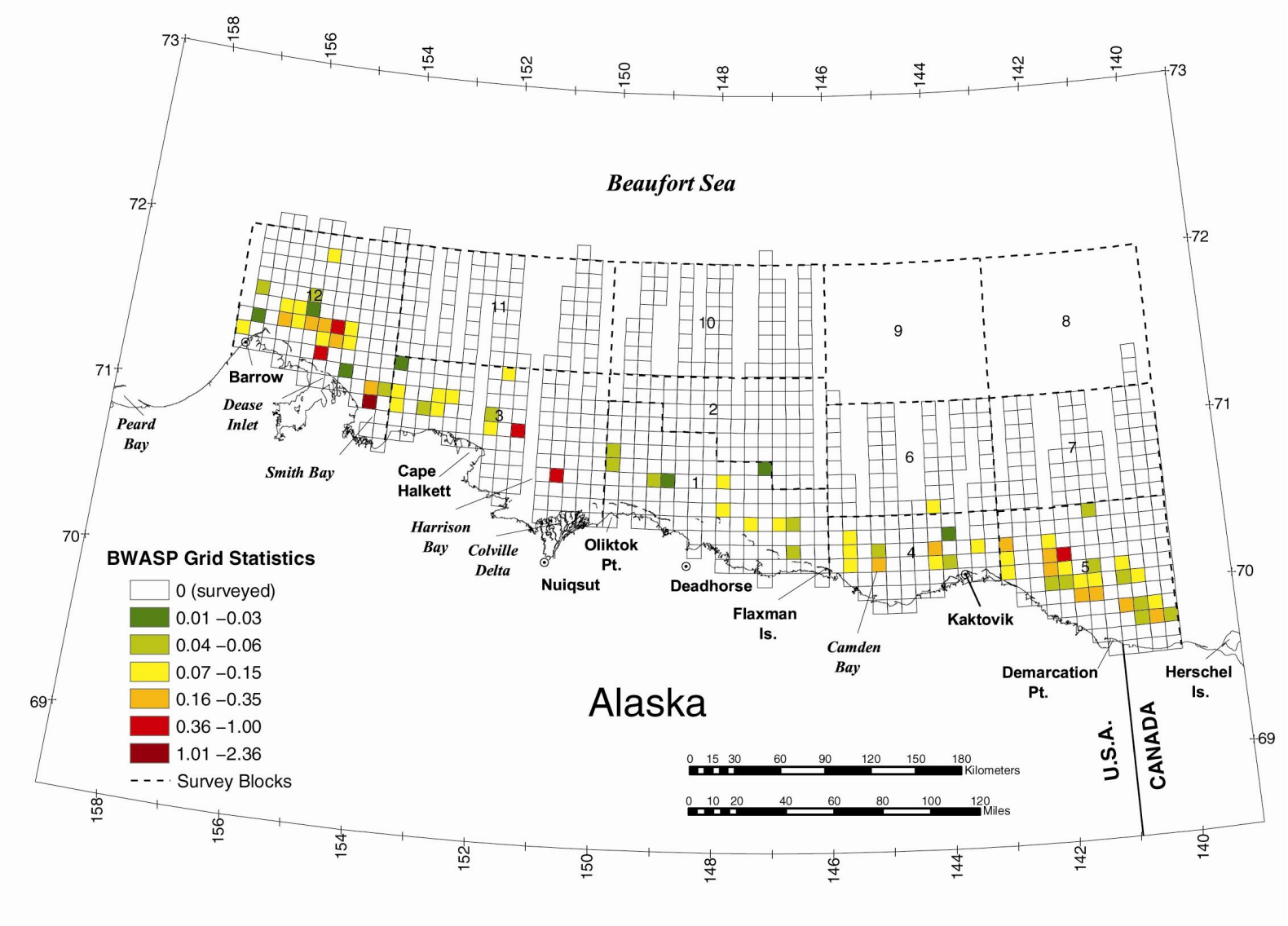

Figure 35 – Count Rates of Bowhead Whales on Transect, Fall 2004

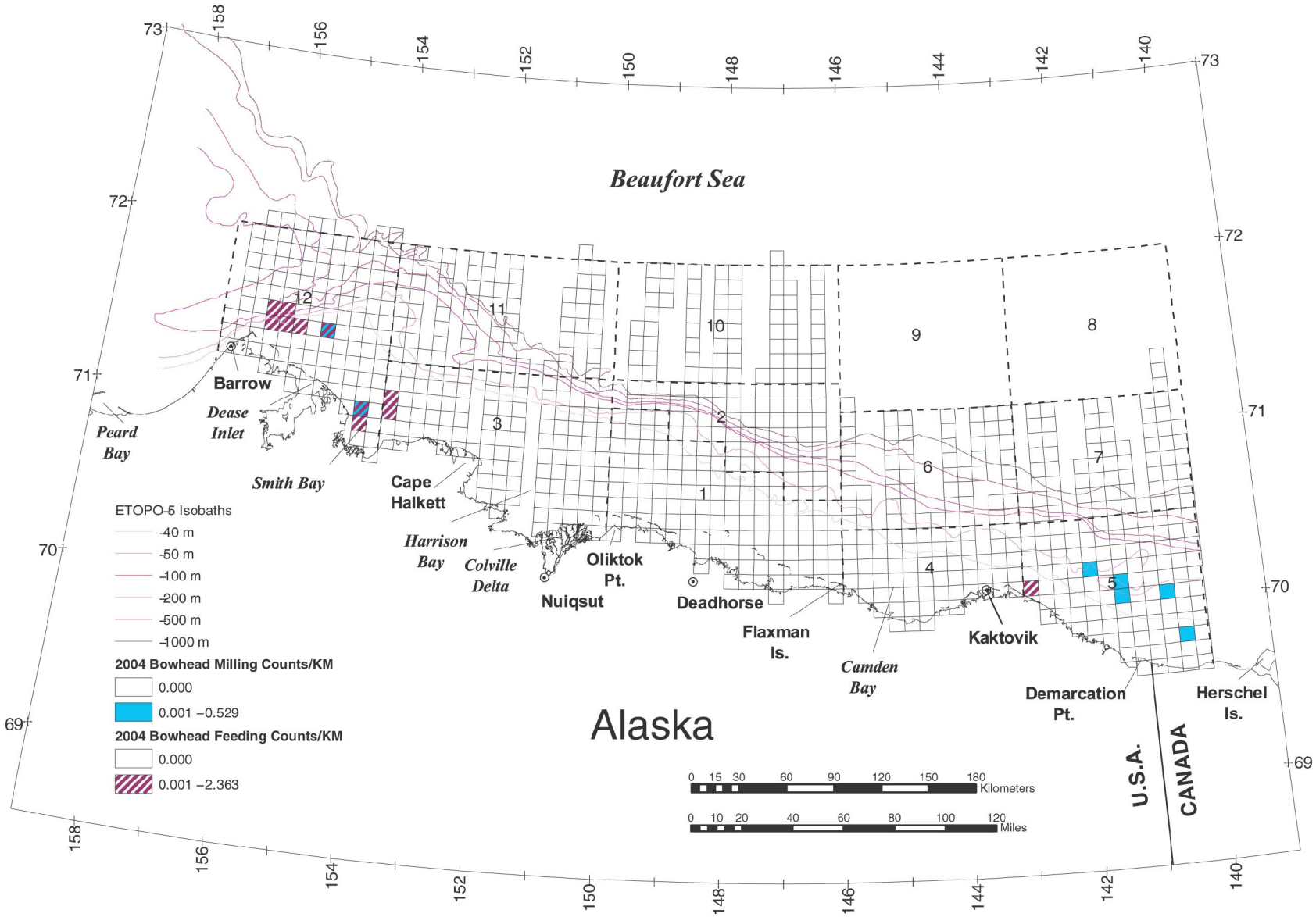

Figure 36 – Fall 2004 Counts of Feeding and Milling Bowhead Whales Per Unit Effort (km) – on Transect

d. Behaviors:

During Fall 2004, 253 bowhead whales (52%) were swimming, 144 (29%) were feeding, 50 (10%) were milling, and 27 (5%) were resting. Locations of feeding and milling whales observed on transects are shown on Figure 36. These, and other behaviors, are summarized in Table 13 and defined in Table 1.

Sudden overt changes (e.g., an abrupt dive, course diversion, or cessation of behavior ongoing) in whale behavior were looked for. No bowheads were observed for which responses to the survey aircraft were noted.

e. Distance from Shore:

The mean distance from shore for bowhead whales observed on transect during Fall 2004 was 26.2 km (SD = 12.9) in the East Region, and 26.0 km (SD = 11.9) in the West Region (Figure 37).

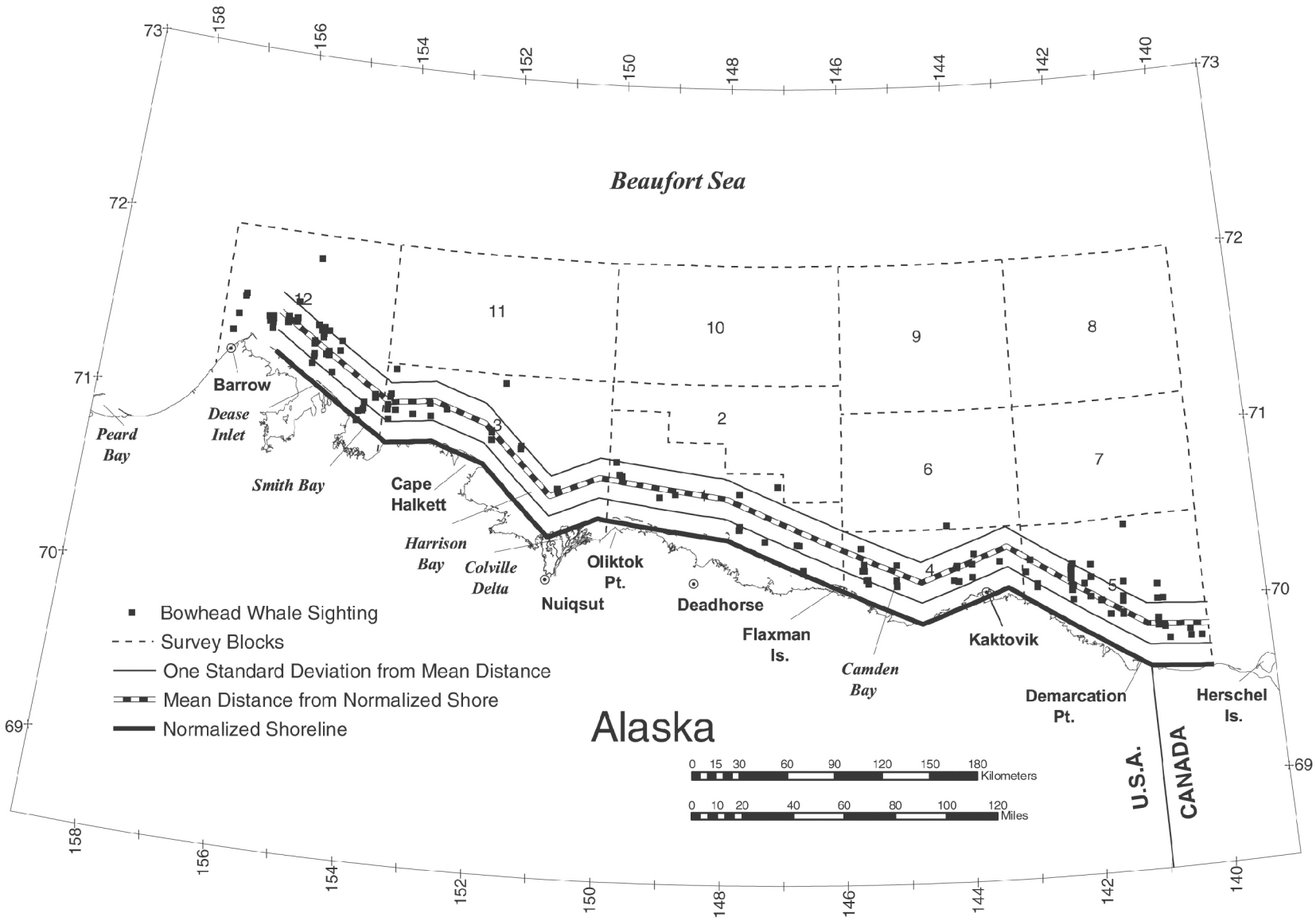

Figure 37 – Bowhead Whale Sightings on Transect Fall 2004
Showing Mean Distance from a Normalized Shoreline

D. DISTRIBUTION OF MIGRATING BOWHEAD WHALES RELATIVE TO SHORE, 2002-2004

In order to evaluate whether there were significant differences in the axis of bowhead whale observations during 2002-2004, estimates of mean distance of sightings from a normalized shoreline were compared with comparable data from previous years (1982-2001). The mean distance from shore during previous years for bowhead whales was 39.6 km (*SD* = 27.6) in the East Region, and 36.2 km (*SD* = 21.7) in the West Region. The 25th – 75th quartile range for 1982-2001 was: East Region = 21.0-43.3 km; West Region = 20.2-47.1 km.

1. Distance from Shore during 2002:

Bowhead whales in the Eastern Region were on average closer to shore than in previous years (21.9 km versus 39.6 km; $Z = 3.70$, $p < 0.0003$. Bowheads in the Western Region were not significantly different among years (41.9 km versus 36.2 km; $Z = -1.59$, $p > 0.11$.

2. Distance from Shore during 2003:

Distances from shore of bowhead whales in both the Eastern and Western Regions during 2003 were not significantly different from previous years (East Region: 31.8 km versus 39.6 km; $Z = 0.91$, $p > 0.36$; West Region: 34.4 km versus 36.2 km; $Z = 0.41$, $p > 0.68$.

3. Distance from Shore during 2004:

Bowhead whales in both the Eastern and Western Regions were closer to shore during 2004 than in previous years (East Region: 26.2 km versus 39.6 km, $Z = 4.36$, $p < 0.00002$; West Region: 26.0 km versus 36.2 km, $Z = 3.38$, $p < 0.0008$).

The mean values for both regions in all three years were within the respective 25th – 75th quartile ranges for all years (1982-2001).

E. OTHER MARINE MAMMAL OBSERVATIONS

Observations of beluga whales, bearded seals, ringed seals, walrus, and polar bears are summarized in Appendices B-2002, B-2003, and B-2004. Respective observations are plotted in Appendices C-2002, C-2003, and C-2004. Not all species were seen in each year. No gray whales were seen during surveys in 2002-2004.

IV. DISCUSSION

A. Conclusions

The axis of the annual fall migration by bowhead whales in the Eastern and Western Alaska Beaufort Sea (2002-2004) was compared with similar data from the 20 years between 1982-2001. It was found that the axis of migration tended to lie relatively close to shore in 5 of the 6 comparisons made. This tendency is consistent with the fact that 2002, 2003, and 2004 were all mild ice years and bowheads tend to be found in waters nearer the shoreline in such years (see Treacy 2002 for discussion). Observations indicated that bowheads showed considerable tendency to feed or mill in groups near shore during 2002 and 2004, but not in 2003. The axis of fall migration for both Eastern and Western Regions in all 3 years was within the respective 25th – 75th quartile ranges derived for all years (1982-2001).

B. Management Use of Real-Time Field Information

The MMS issues various types of permits to industry for gas and oil exploration, including vessel geophysical permits for on-water exploration using an array of deep-seismic airguns; vessel geological-geophysical permits for shallow-seismic exploration using an airgun; on-ice geophysical permits using VIBROSEIS technology; both vessel and on-ice geological permits for obtaining core samples; and permits to drill for gas and oil.

During the years 2002-2004, there were no seismic programs in Federal waters in Alaska. The requirements for monitoring and scientific studies have, in some cases, doubled the cost of the seismic program. In general, to prevent potential operational effects on subsistence whaling, any geophysical-vessel explorations permitted during the fall follow stringent restrictions—including a provision to stop seismic operations when whales are visible from the vessel—as the bowhead whale migration progresses through the area of operations. For any explorations that occur during the fall, daily summaries of survey information are transferred from the field to Anchorage for use by MMS Resource Evaluation and by NMFS in implementing area-wide permit restrictions on high-energy seismic operations during the whale migration.

Development drilling occurred at Northstar throughout 2002-2004. Development drilling is not allowed to penetrate into the Northstar reservoir except when there is solid ice around Northstar Island. During the open-water and broken ice periods, development drilling is completed to the intermediate casing point and the wells are re-entered and drilling completed to the production interval once solid ice develops. In late October 2001, production commenced from the Northstar Project. Production reached the facility capacity in early 2002. Development drilling is continuing at Northstar with the same restriction addressed above. In general, during any fall drilling operations, daily summaries of field information from this survey, and other arctic surveys being conducted concurrently, are transferred by the MMS Team Leader to MMS Field Operations in Anchorage. The MMS and NMFS review daily reports to determine the distribution patterns of bowheads in the vicinity of oil-and-gas-industry activities and the timing of the bowhead whale migration, especially the “end of the migration” past any drill sites.

The sighting data are typically used by area management groups to monitor the progress of the overall fall migration of bowhead whales across the Alaskan Beaufort Sea and to determine the position of their overall migratory corridor relative to shore. The data are also provided to other MMS studies and to industry-sponsored site-specific studies investigating the potential effects of industry activity on marine mammals. Project ice and weather data were also transmitted daily to the National/Naval Ice Center and National Weather Service for use in ground-truthing satellite imagery.

C. Management Use of Interannual Monitoring

The MMS bowhead whale monitoring began in 1979 and has continued every year up to the present. While some aspects of this study have been updated from time to time, the data recorded have remained remarkably parallel (especially data from 1982-2004), thus permitting many one-to-one comparisons between years. Such continuous, long-term, wide-area, aerial monitoring of a large whale migration is indeed unique.

In addition to the use of real-time information by both MMS and NMFS when documenting the progress of endangered bowhead whales past offshore drilling and seismic exploration operations (see Section VI.A. above), the project has been helpful to managers in other ways. Some notable examples are:

- providing raw data to all parties (MMS, Western Geophysical, NMFS, ARCO Alaska, Inc., and Alaska Eskimo Whaling Commission (AEWC)) at an Oil/Whalers Agreement Post Season Meeting on 18 December 1990 to determine whether the Fall 1990 bowhead migration had been temporarily blocked due to seismic exploration activities;
- providing all parties with annual reports from which data were subsequently cited in a declaration to a lawsuit in 1993 (AEWC et al. vs. Dr. Nancy Foster et al., Civil Action No. 93-1629 HHG) on the effects of Kuvlum drilling and seismic exploration operations on the bowhead migration corridor;
- providing upstream, offshore, and downstream sighting-and-effort data in order to enhance sample sizes of many site-specific studies looking at the potential effects of oil-industry activity on bowhead whale migrations;
- documenting geographic areas, especially migration corridors and feeding areas, used annually by bowhead whales. Such data from previous surveys continue to be used by MMS in writing Environmental Impact Statements and Environmental Assessments and in interpreting the results of site-specific studies.
- performing an analysis of the distances from shore to bowhead sightings relative to general sea ice severity.

The NMFS Administrator, Alaska Region, (letter dated 22 December 1998) commended MMS information support to NMFS: “The BWASP has provided a critical element in our ability to evaluate the effects of development in the Beaufort Sea on the bowhead whale. Additionally, the Minerals Management Service has demonstrated the flexibility and willingness to allow this program to compliment and extend project-specific monitoring required for authorizations under the Marine Mammal Protection Act (Incidental Harassment Authorizations). The combined information of these efforts has greatly extended our knowledge and facilitated conflict avoidance agreements. These agreements have allowed oil and gas activities to go forward while minimizing interference with traditional Native subsistence hunting. We have found BWASP statistical analysis and data presentation to be very useful in assessing potential impacts within the Beaufort Sea.”

D. Field Coordination and Other Information Support

During the field seasons, we coordinated with AEWC, Barrow, Alaska; Whalers Communication Center, Deadhorse, Alaska; NMFS, Anchorage, Alaska; and NSB, Department of Wildlife Management, Barrow, Alaska.

Selected BWASP information-support activities during calendar years 2002-2004 included:

- providing data to and coordinating with scientists and subsistence whalers in support of the MMS study “Bowhead Whale Feeding in the Eastern Alaskan Beaufort Sea: Update of Scientific and Traditional Information”;
- providing data to and coordinating with scientists in support of the MMS study “Analysis of Covariance of Human Activities and Sea Ice in Relation to Fall Migrations of Bowhead Whales”;
- providing data to and coordinating with scientists in support of the BLM Northwest National Petroleum Reserve-Alaska Integrated Activity Plan/Environmental Impact Assessment;
- providing data to and coordinating with BLM and MacTec, Inc. in support of the BLM Alpine Satellite Development Plan/Environmental Impact Assessment;
- providing data to Shell Oil Co., Geomatics Department, for use in developing computer analytical systems;

- presenting “Monitoring the Distribution of Arctic Whales” at the Alaska Region Information Transfer Meeting, Anchorage Alaska (March 11, 2003);
- presenting “Monitoring the Distribution of Arctic Whales” at the Alaska Region Information Update Meeting, Barrow, Alaska (March 14, 2003);
- participating in annual interagency evaluations (with NMFS, NSB, AEWC) on BP Exploration (Alaska)’s site-specific planned and reported monitoring of marine mammals near seismic and Northstar pre-production operations;
- providing a PDF versions of the reports “Aerial Surveys of Endangered Whales in the Beaufort Sea, Fall 2000” and “Aerial Surveys of Endangered Whales in the Beaufort Sea, Fall 2001” to Environmental Studies Program Information System (http://mmspub.mms.gov:81/espis);
- providing requested maps of bowhead whale distribution to various MMS EIS writers;
- permitting BWASP data to be used in a site-specific analysis estimating potential takes of whales by the construction and operation of the planned Liberty Island project;

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APPENDIX A-2002: FALL2002 ICE-CONCENTRATION MAPS – ALASKAN BEAUFORT SEA

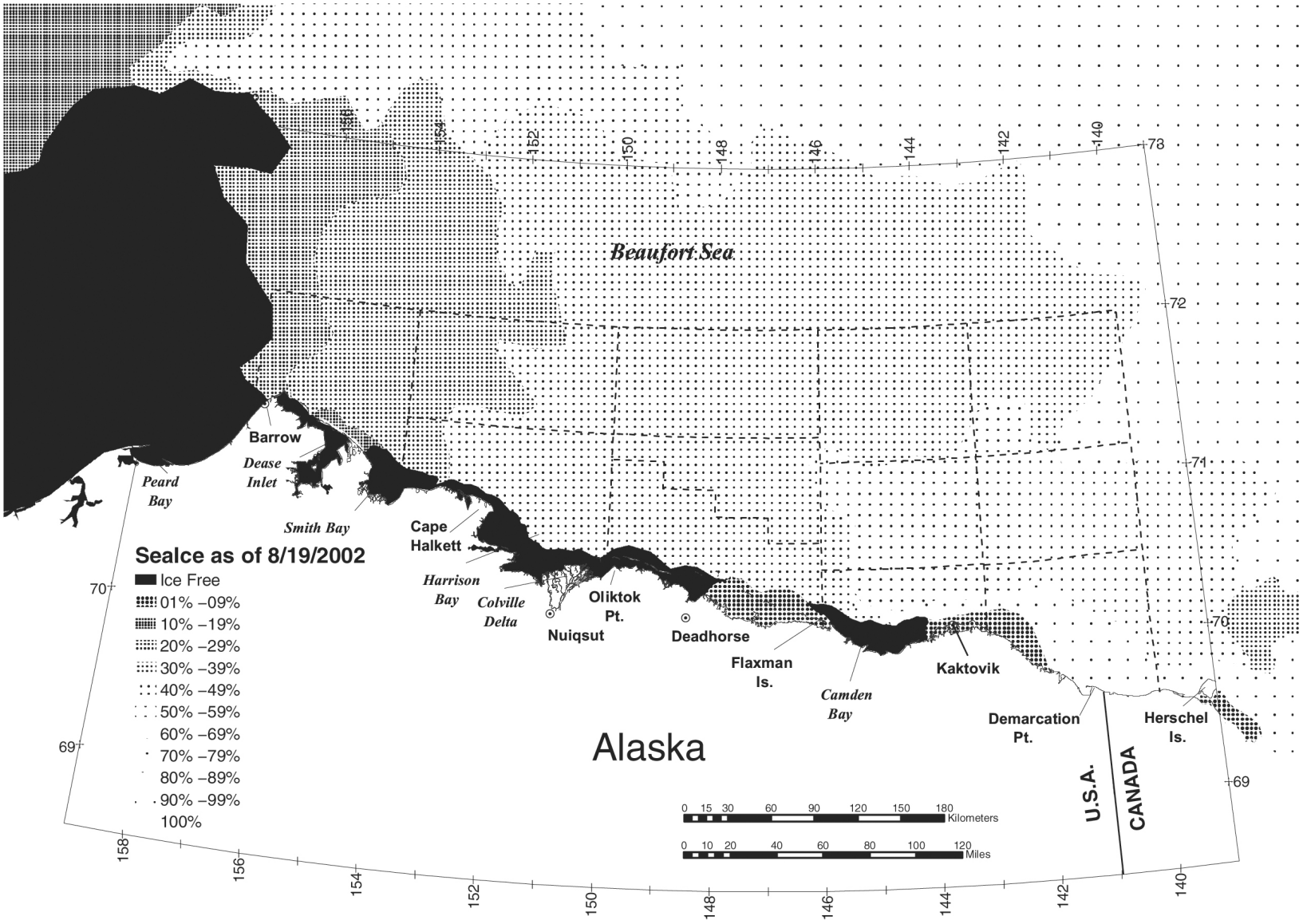

Figure 38 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 19 August 2002

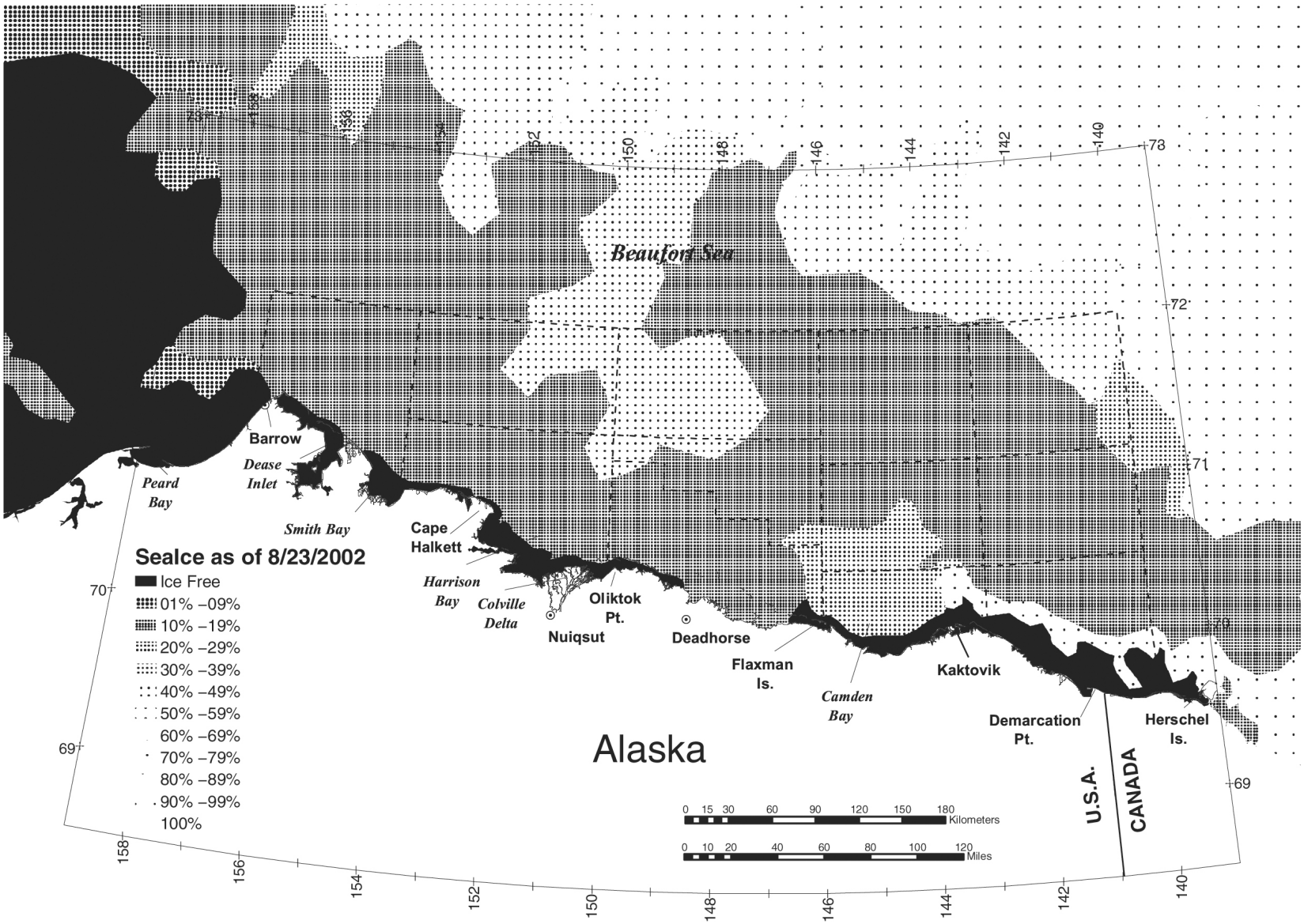

Figure 39 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 23 August 2002

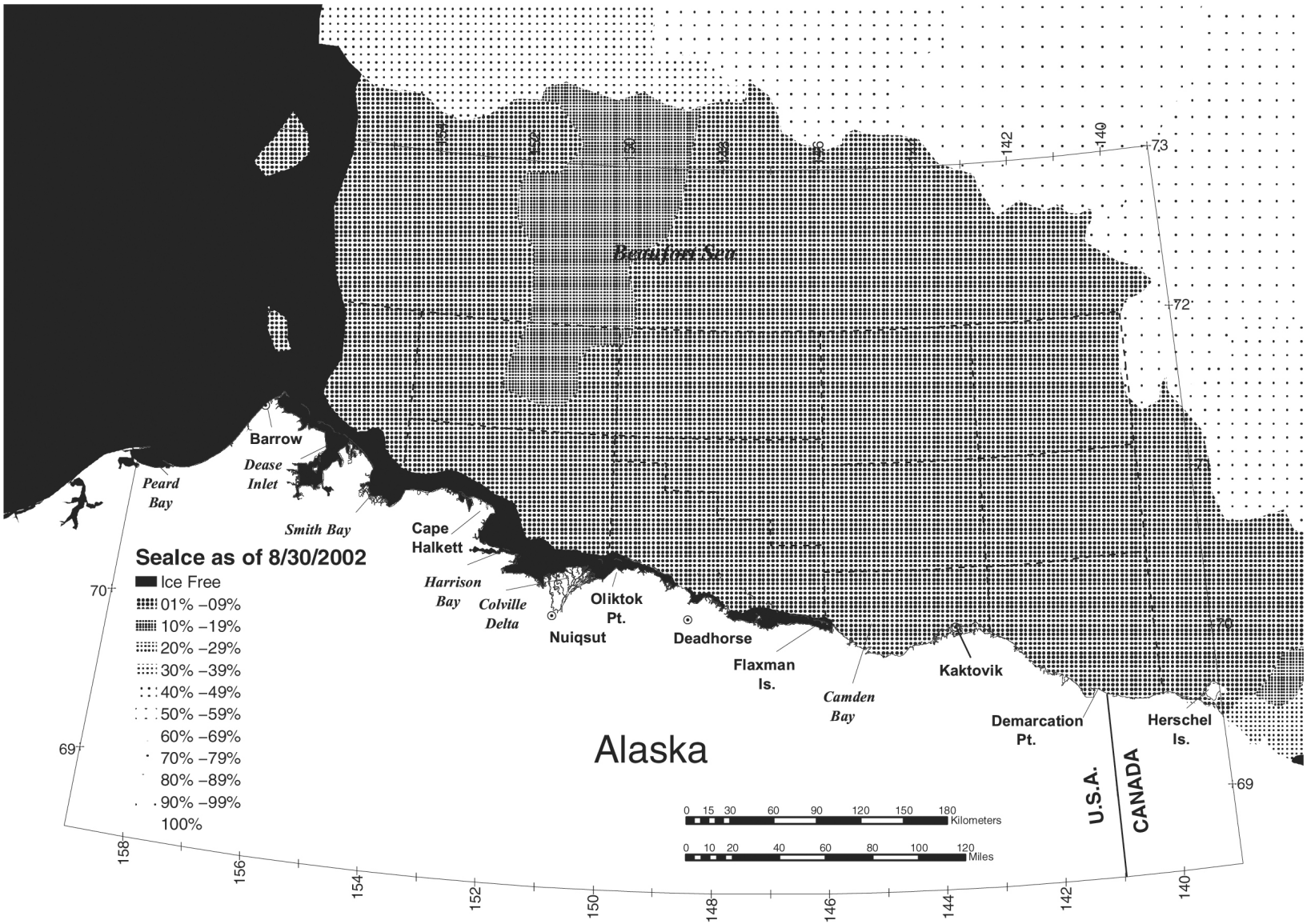

Figure 40 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 30 August 2002

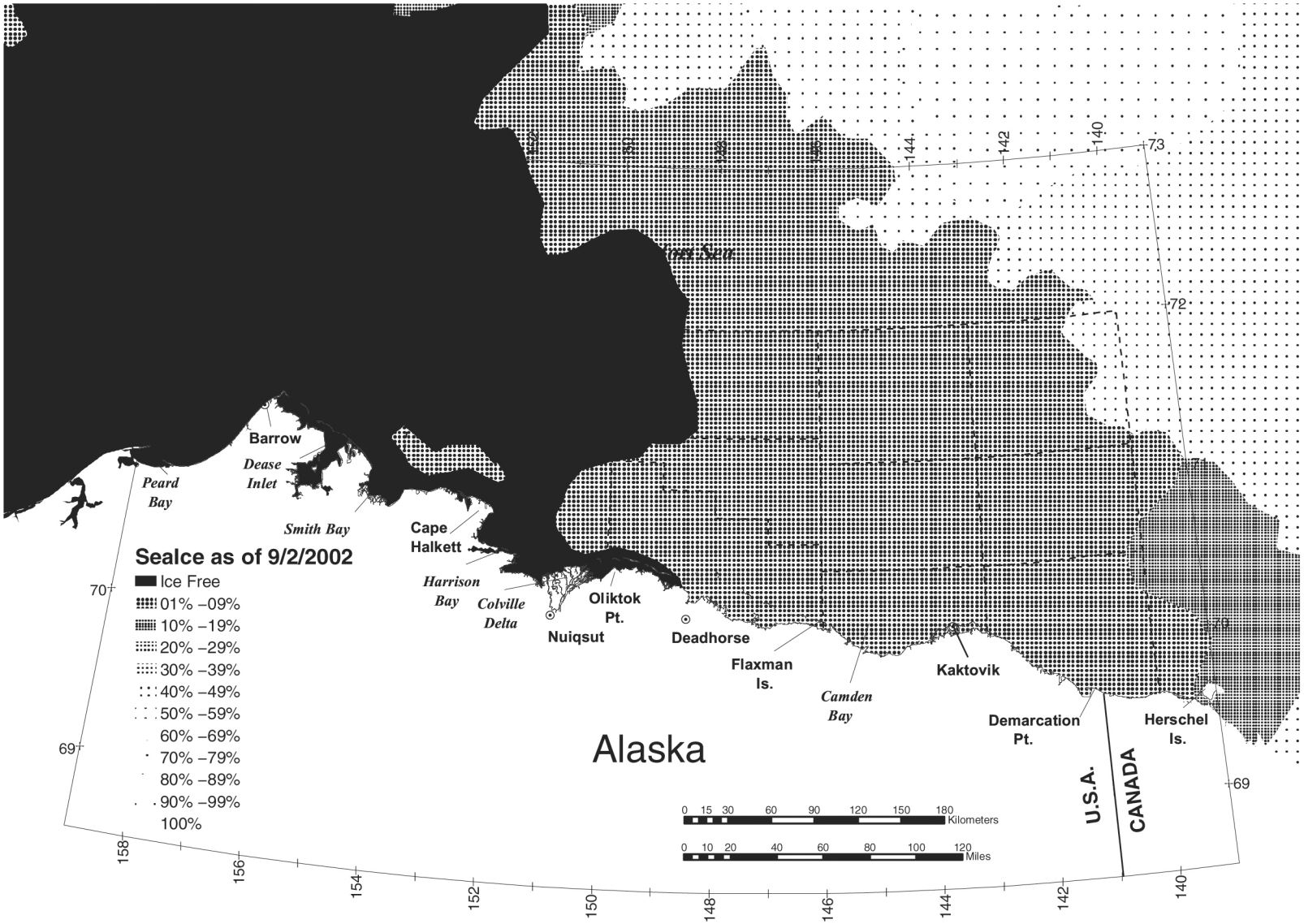

Figure 41 – Map of Concentrations in the Alaskan Beaufort Sea, 2 September 2002

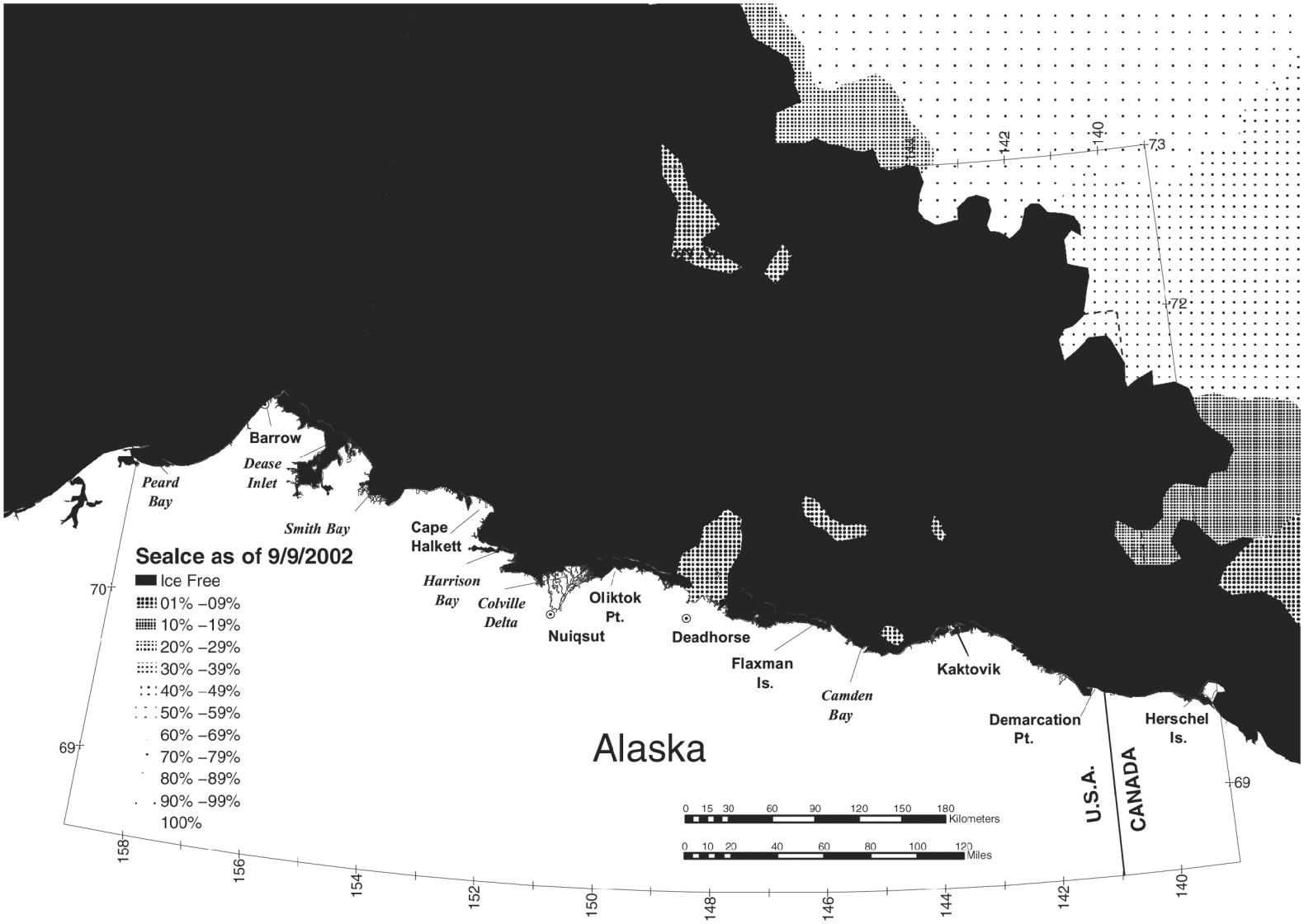

Figure 42 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 9 September 2002

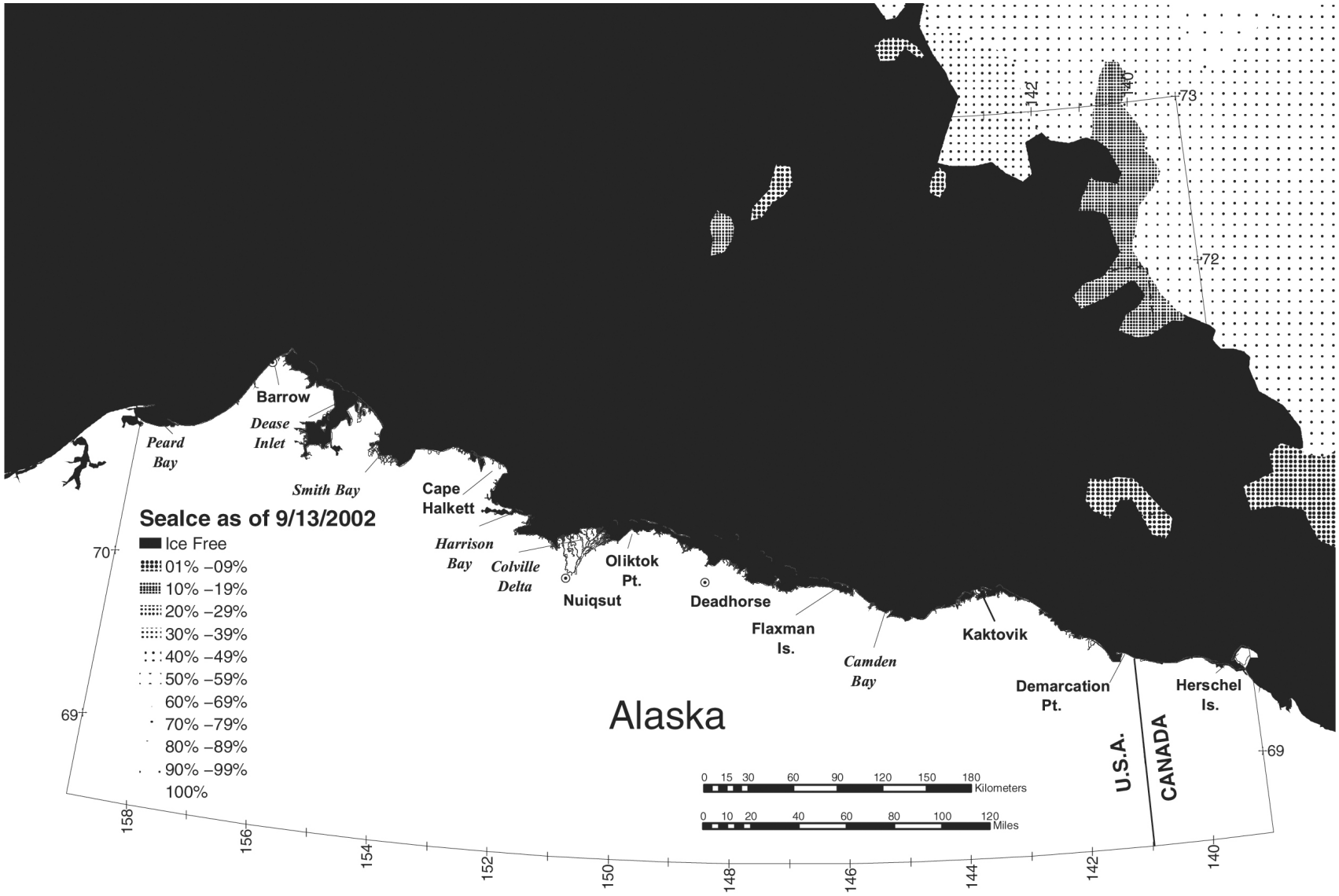

Figure 43 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 13 September 2002

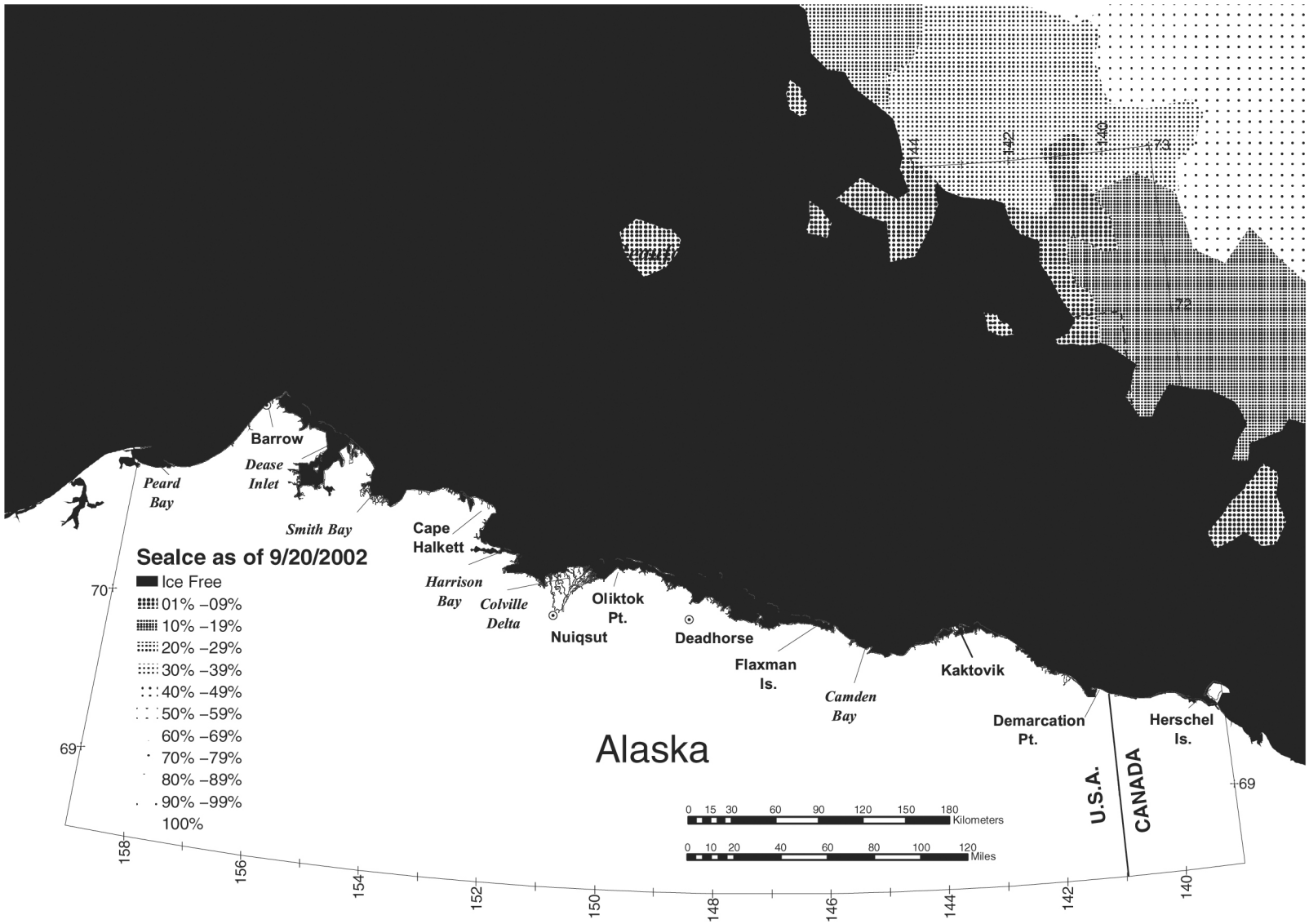

Figure 44 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 20 September 2002

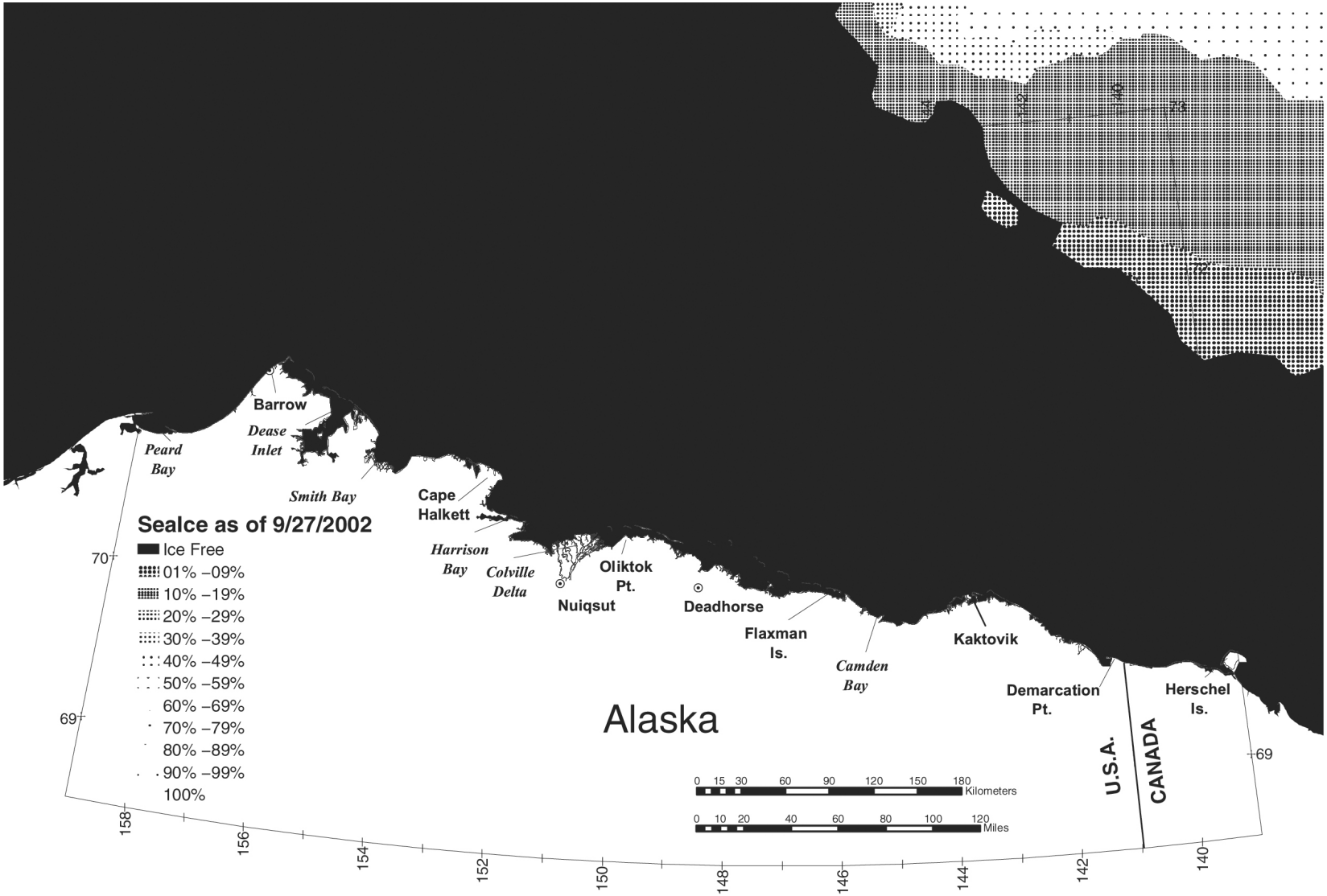

Figure 45 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 27 September 2002

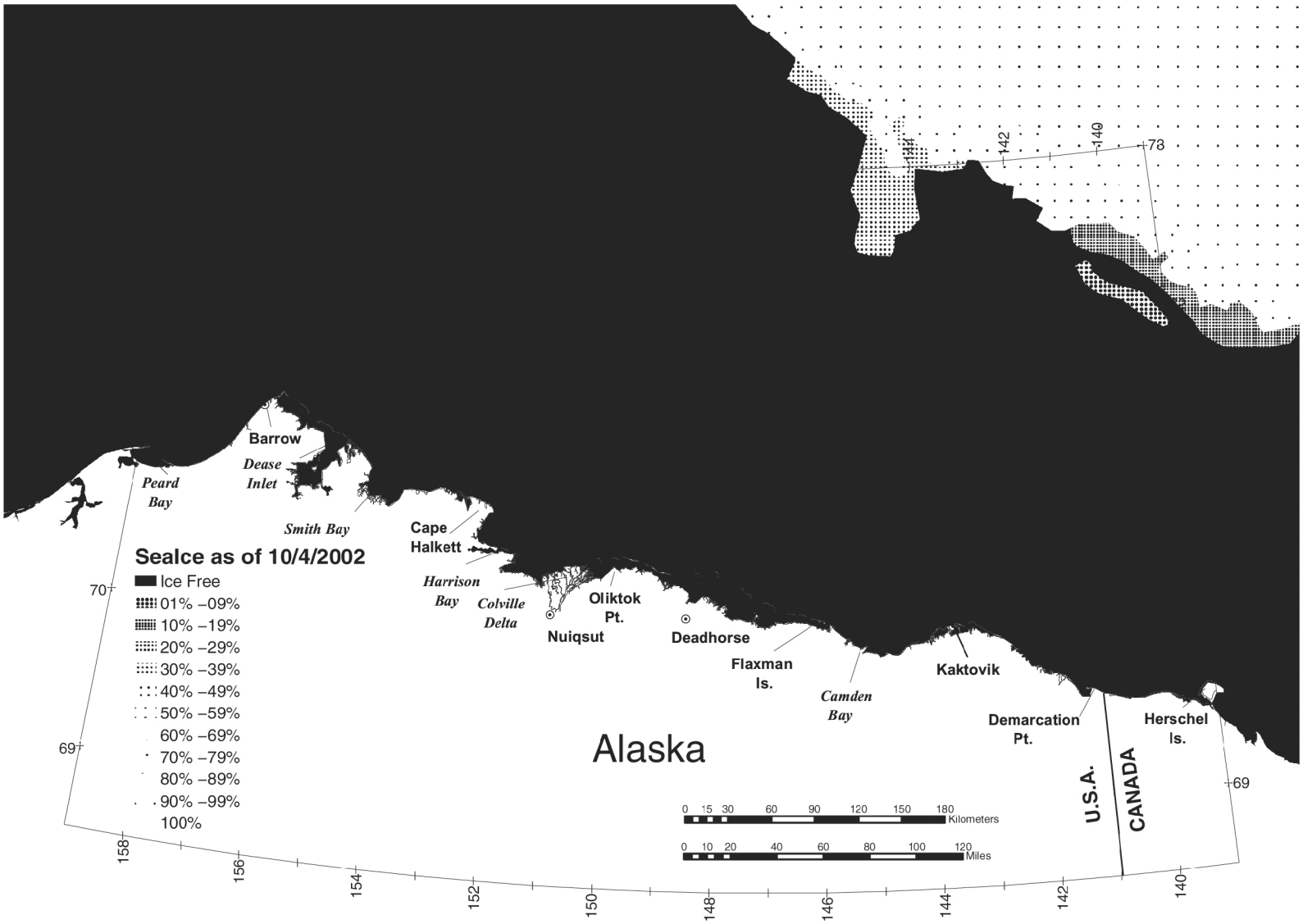

Figure 46 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 4 October 2002

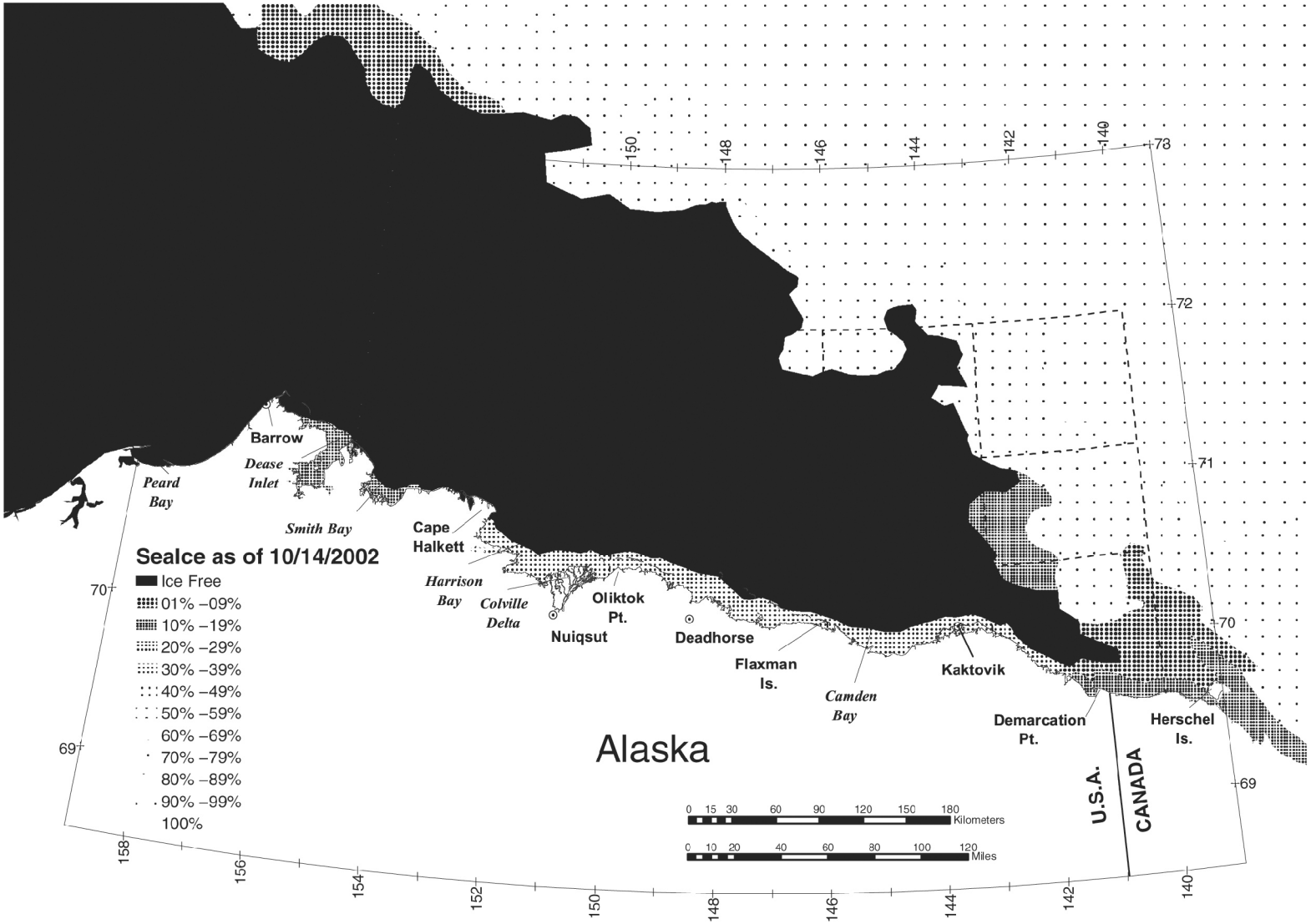

Figure 47 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 14 October 2002

APPENDIX A-2003: FALL2004 ICE-CONCENTRATION MAPS – ALASKAN BEAUFORT SEA

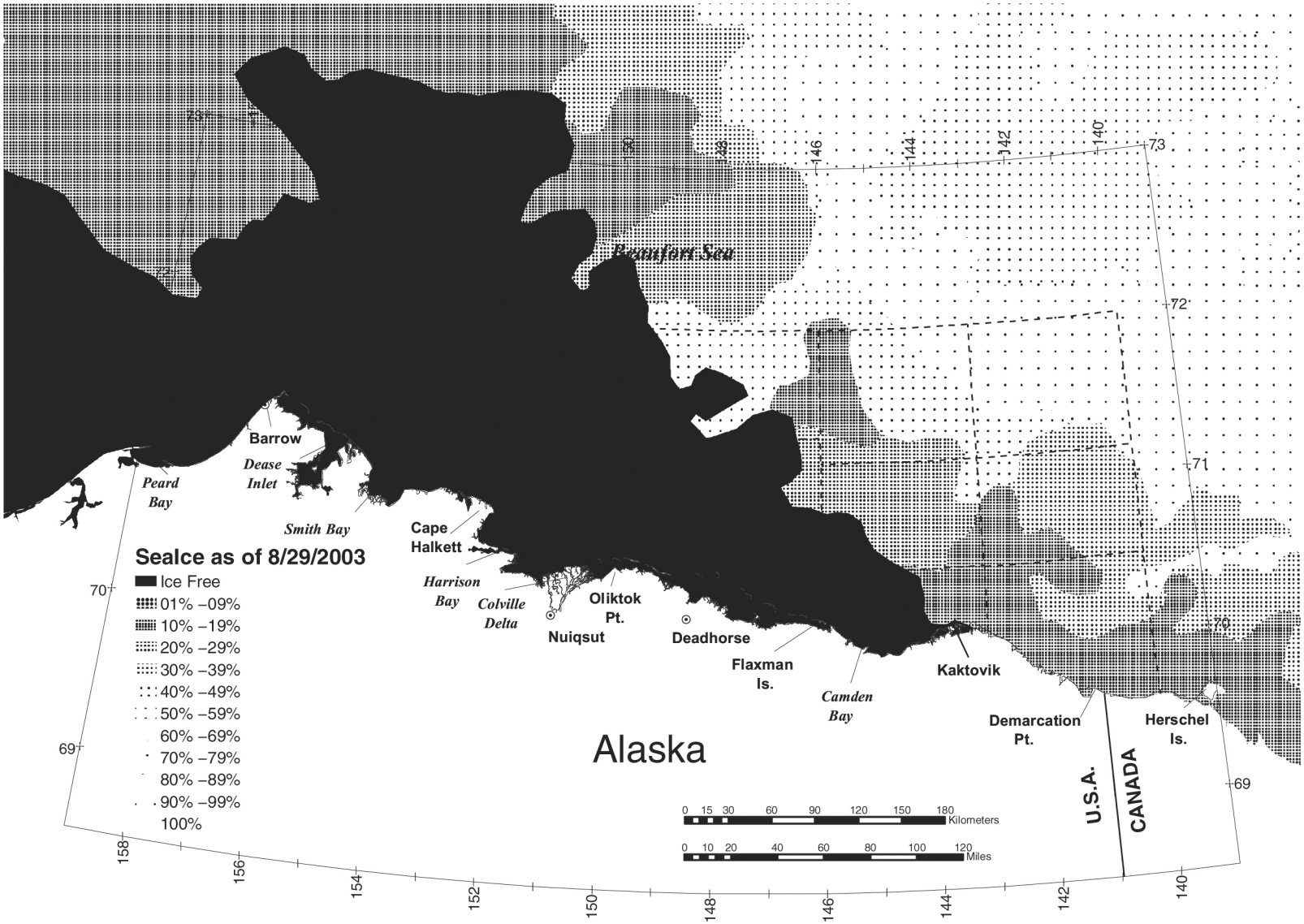

Figure 48 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 29 August 2003

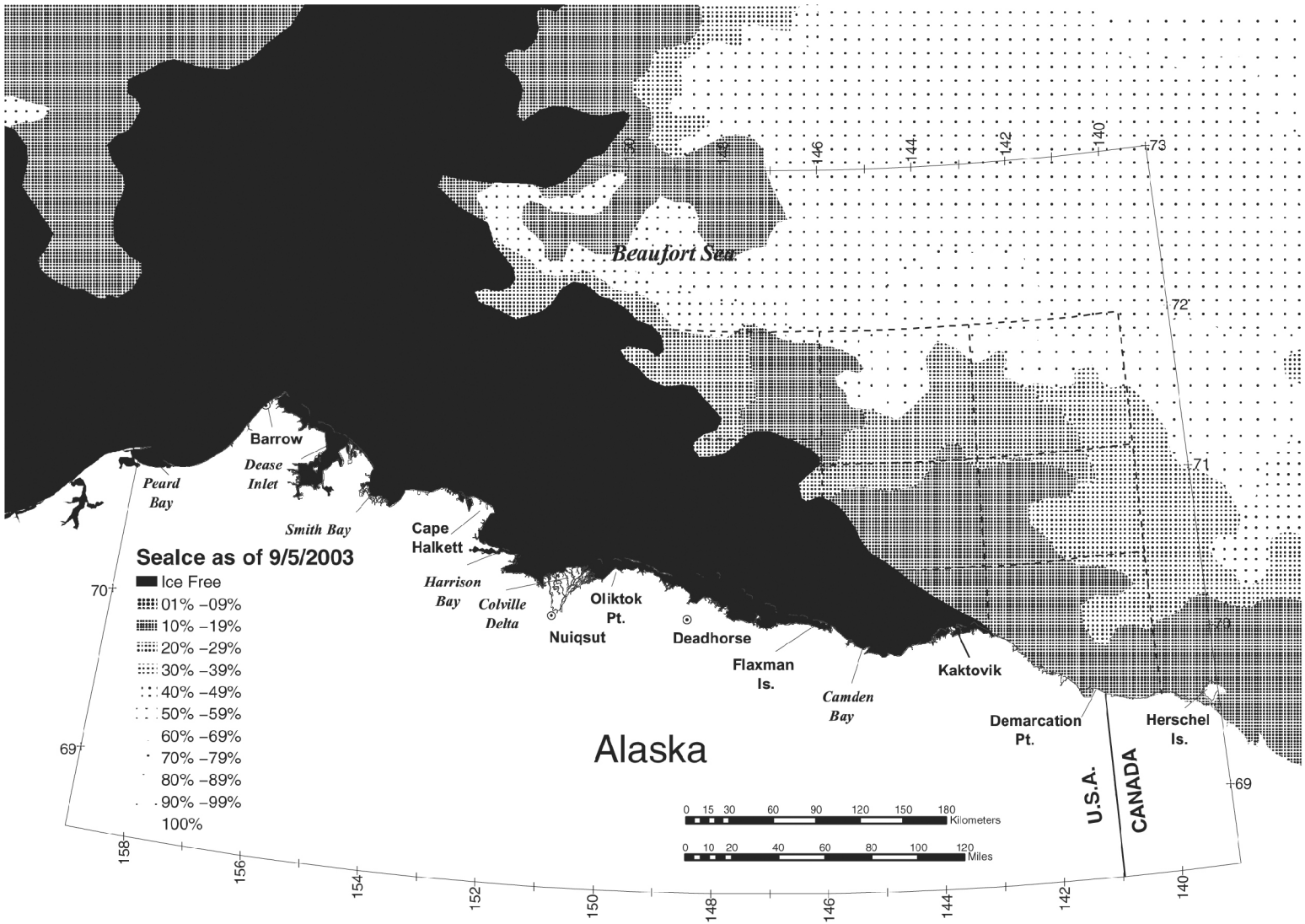

Figure 49 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 5 September 2003

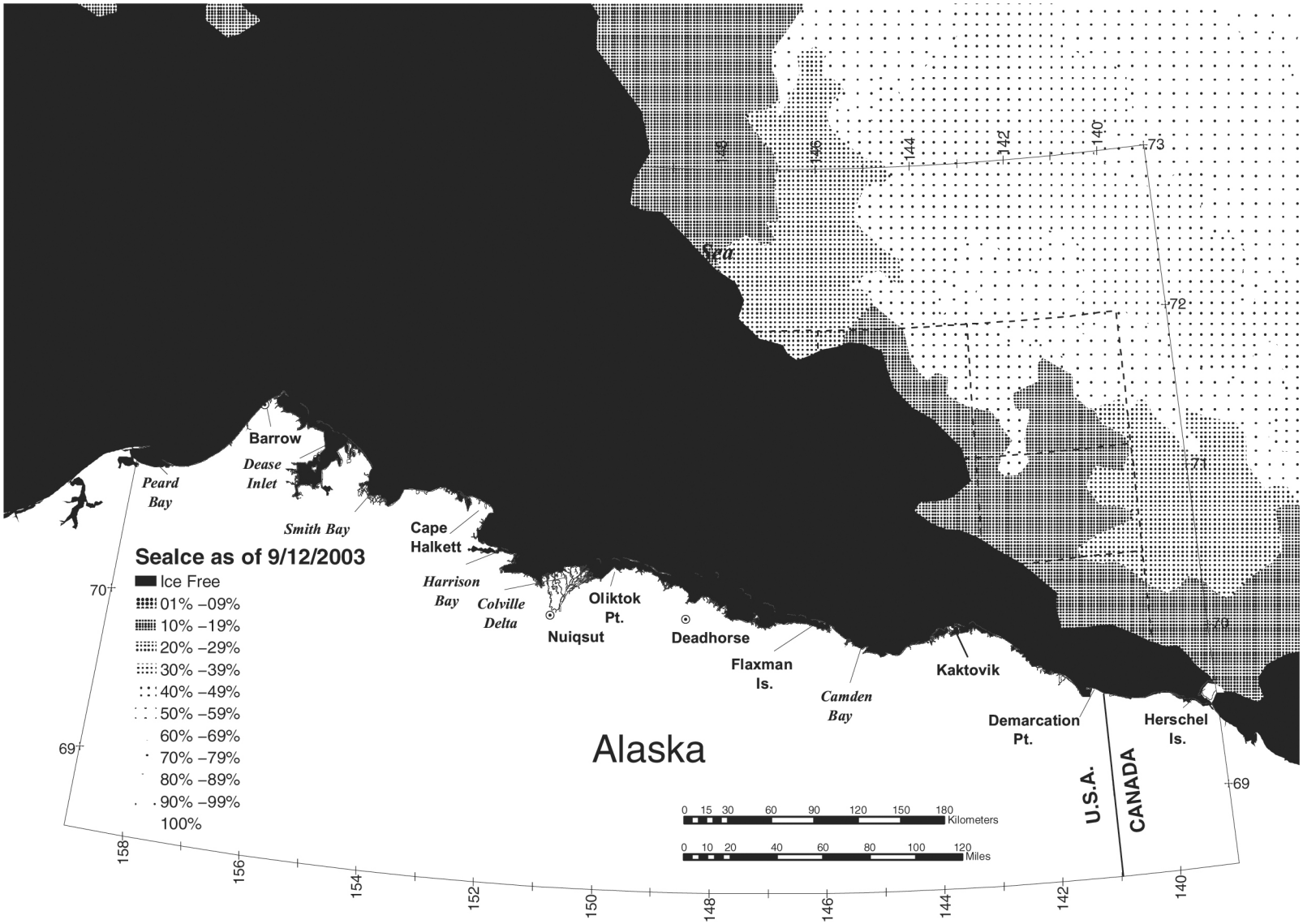

Figure 50 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 12 September 2003

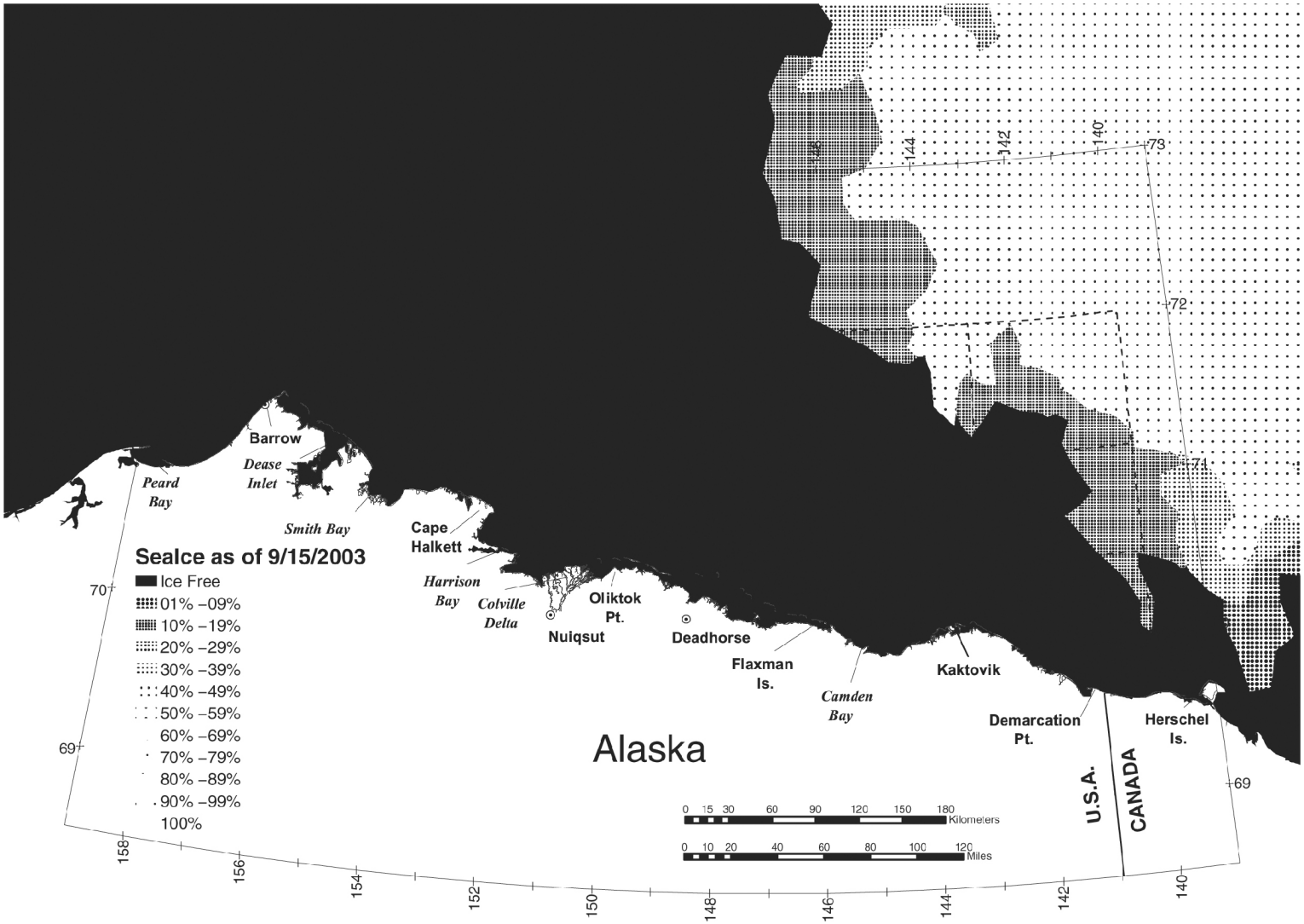

Figure 51 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 15 September 2003

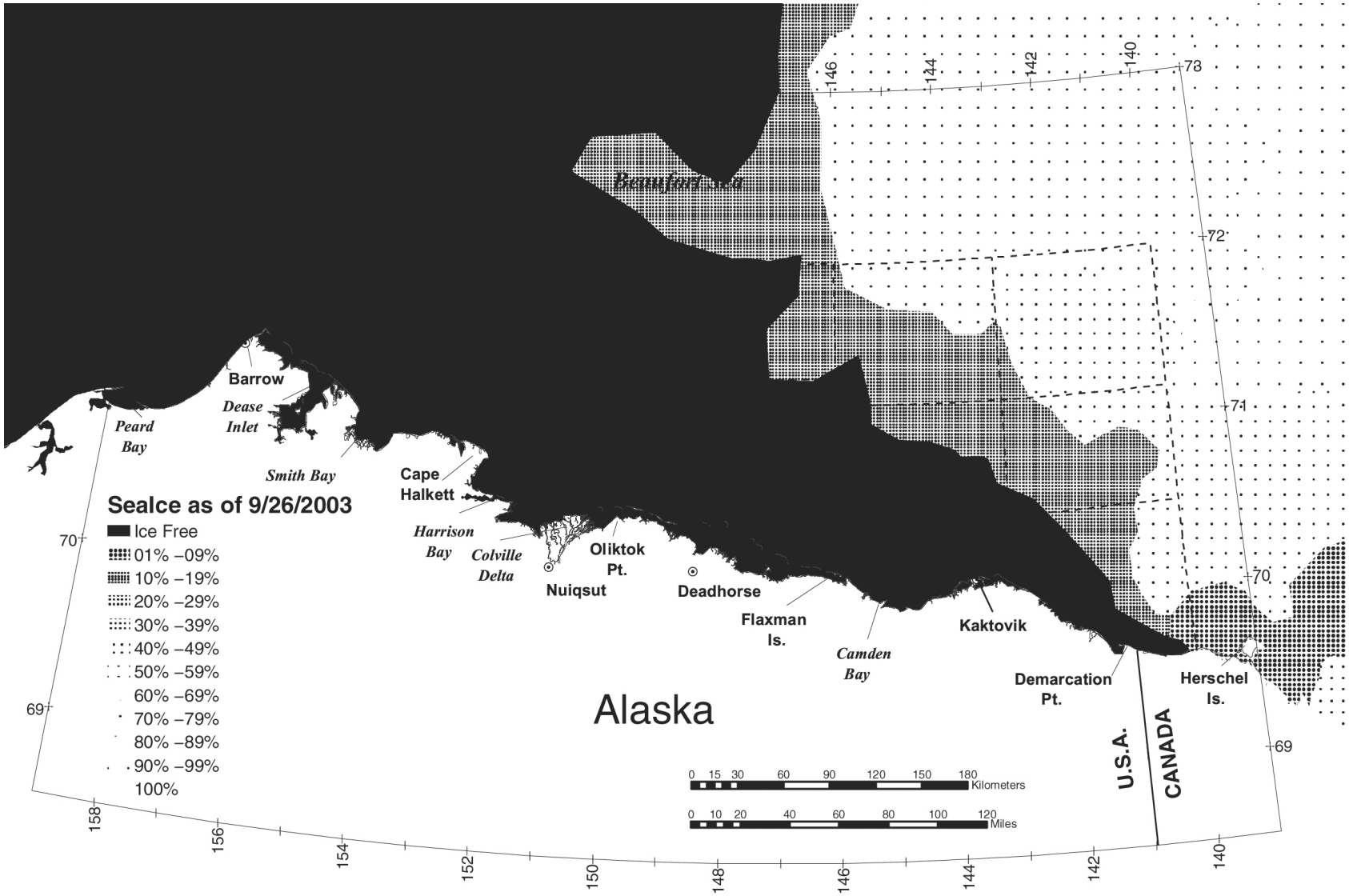

Figure 52 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 26 September 2003

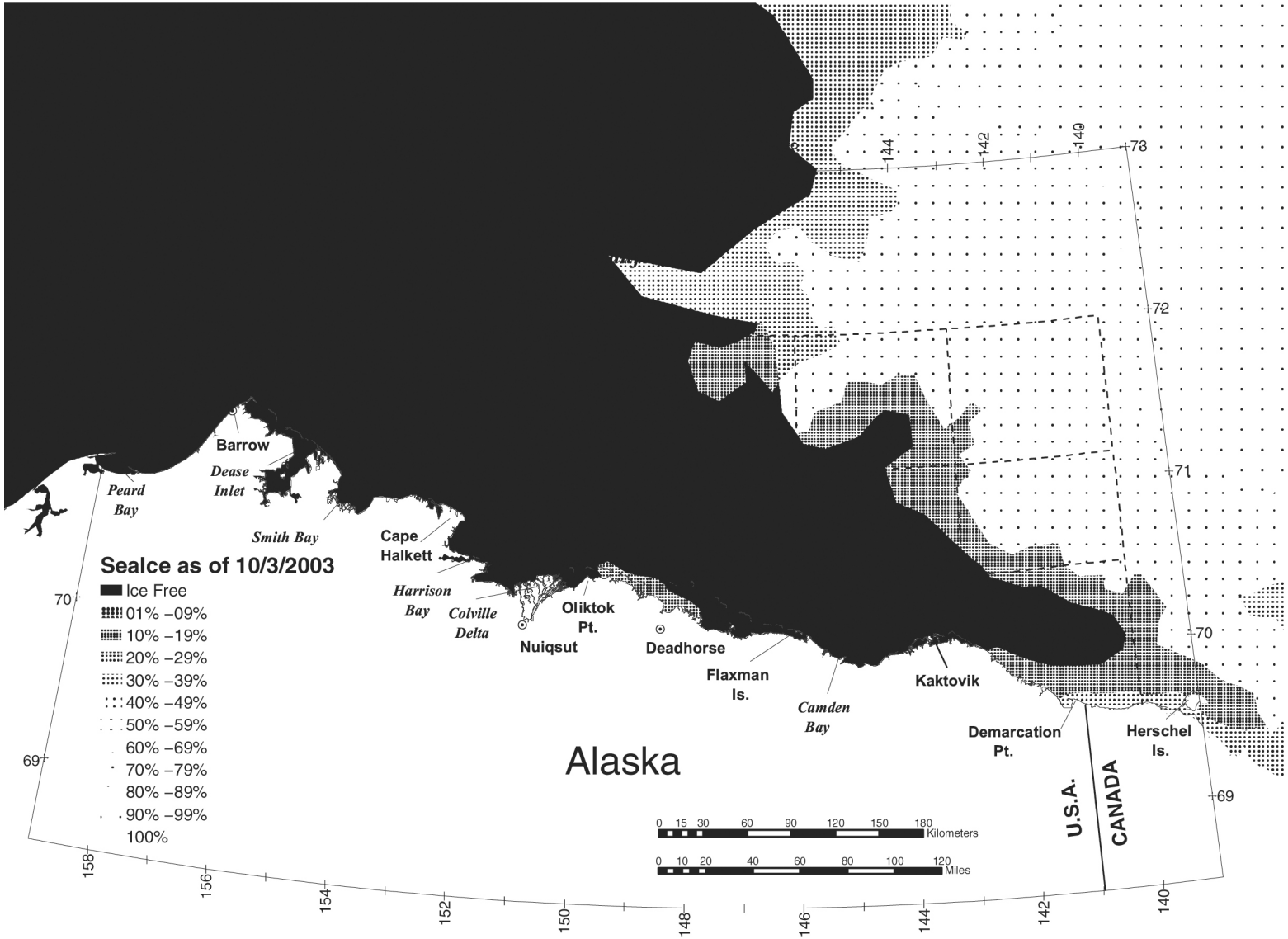

Figure 53 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 3 October 2003

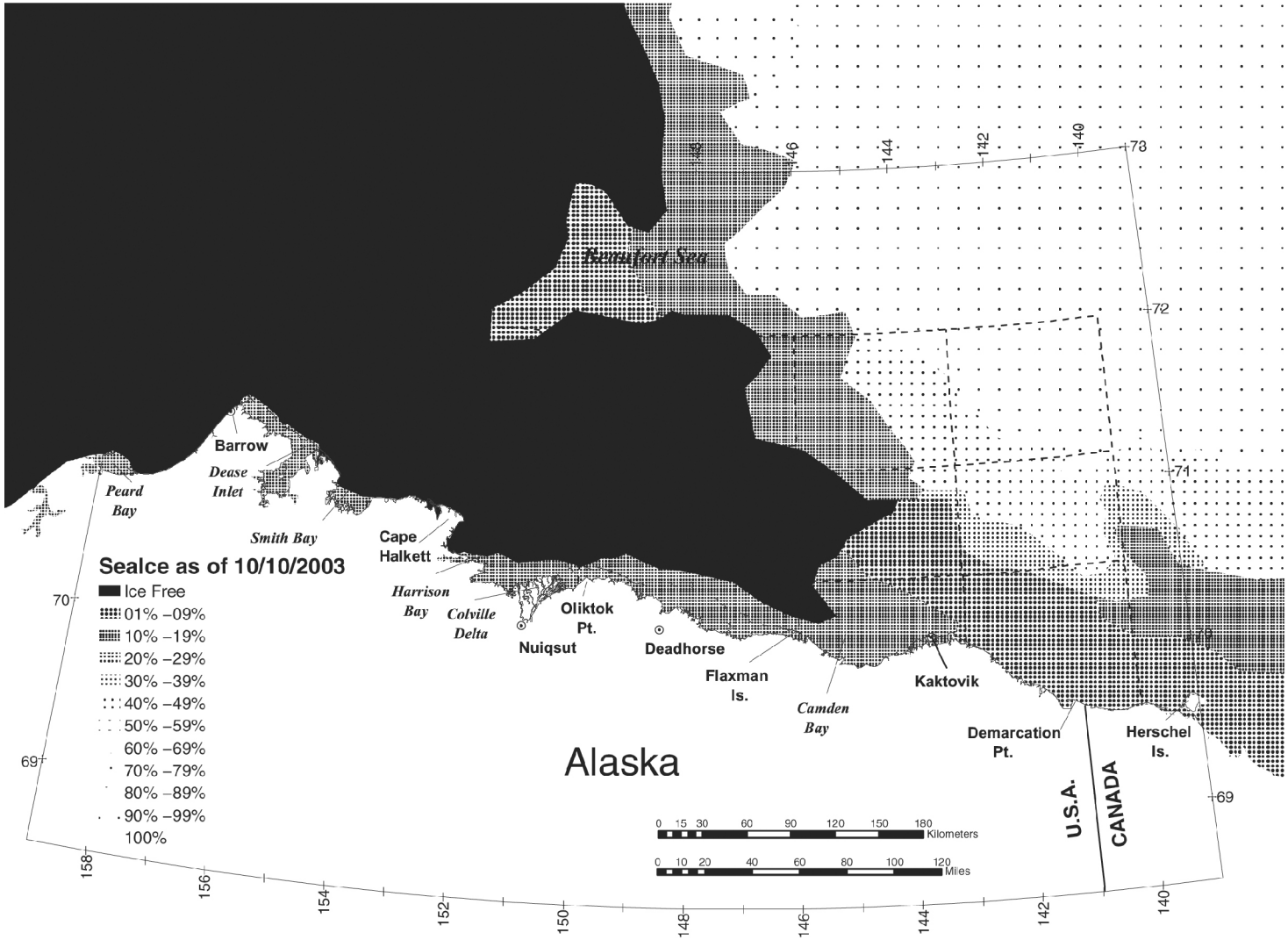

Figure 54 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 10 October 2003

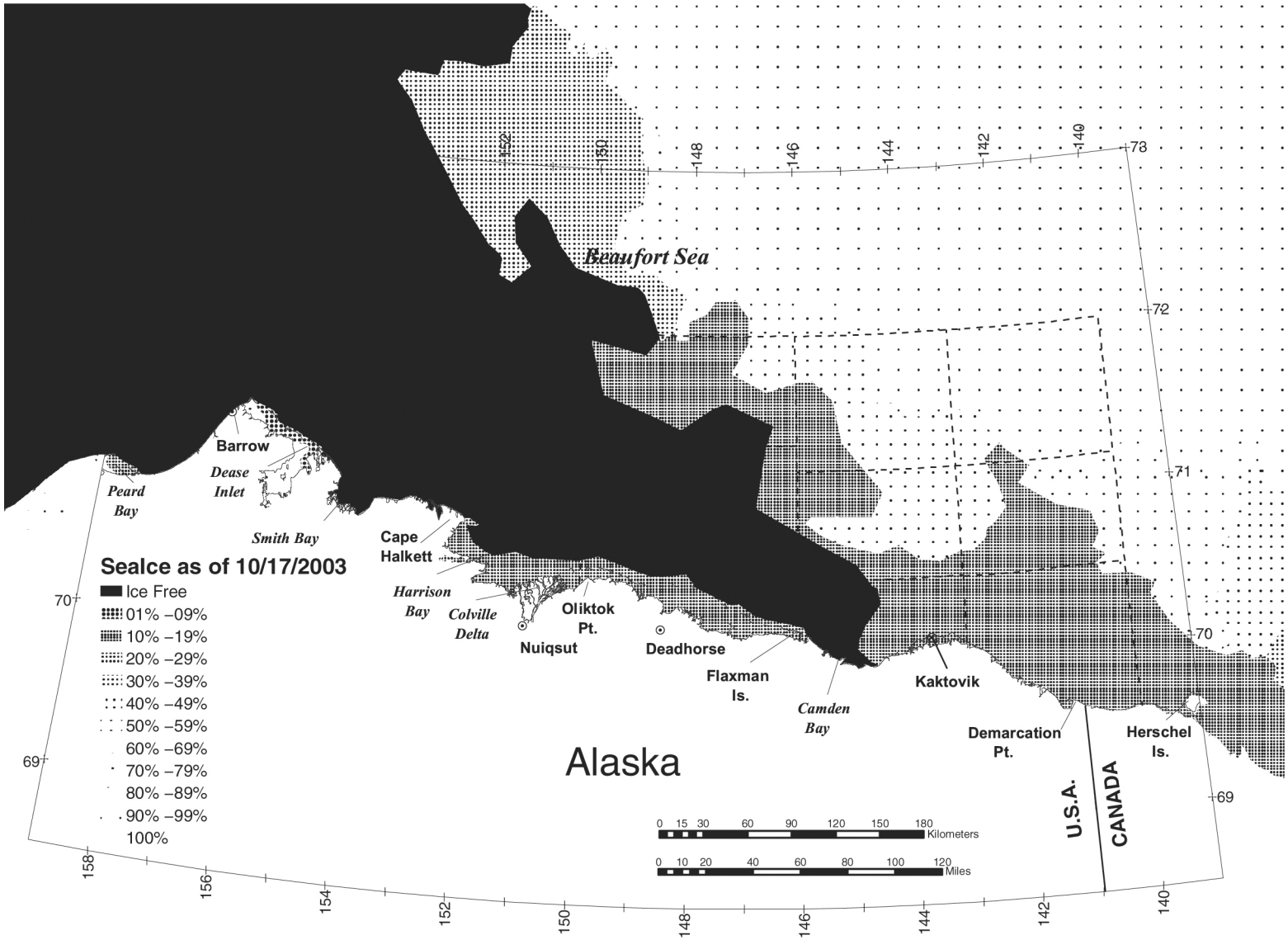

Figure 55 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 17 October 2003

APPENDIX A-2004: FALL2004 ICE-CONCENTRATION MAPS – ALASKAN BEAUFORT SEA

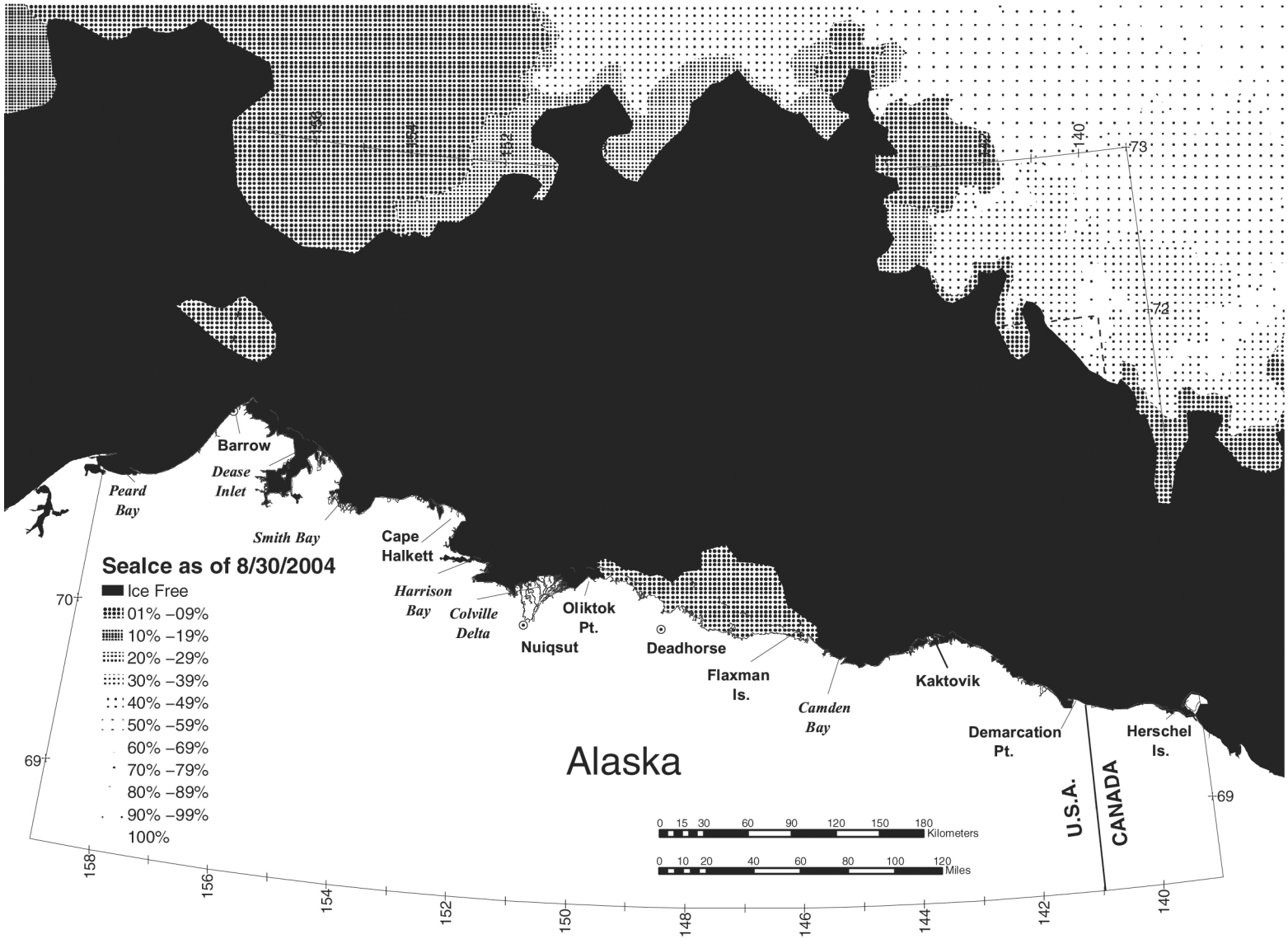

Figure 56 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 30 August 2004

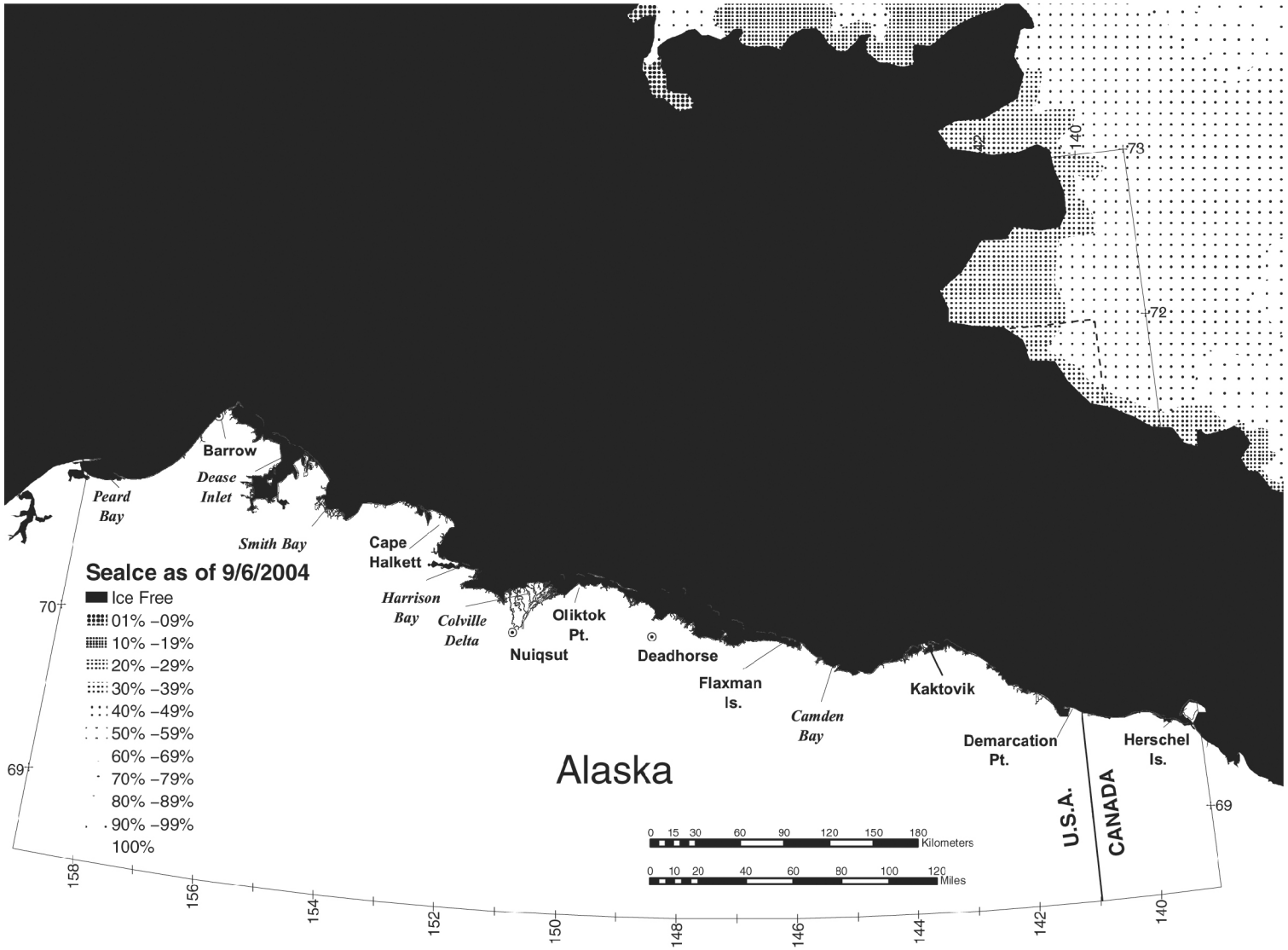

Figure 57 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 6 September 2004

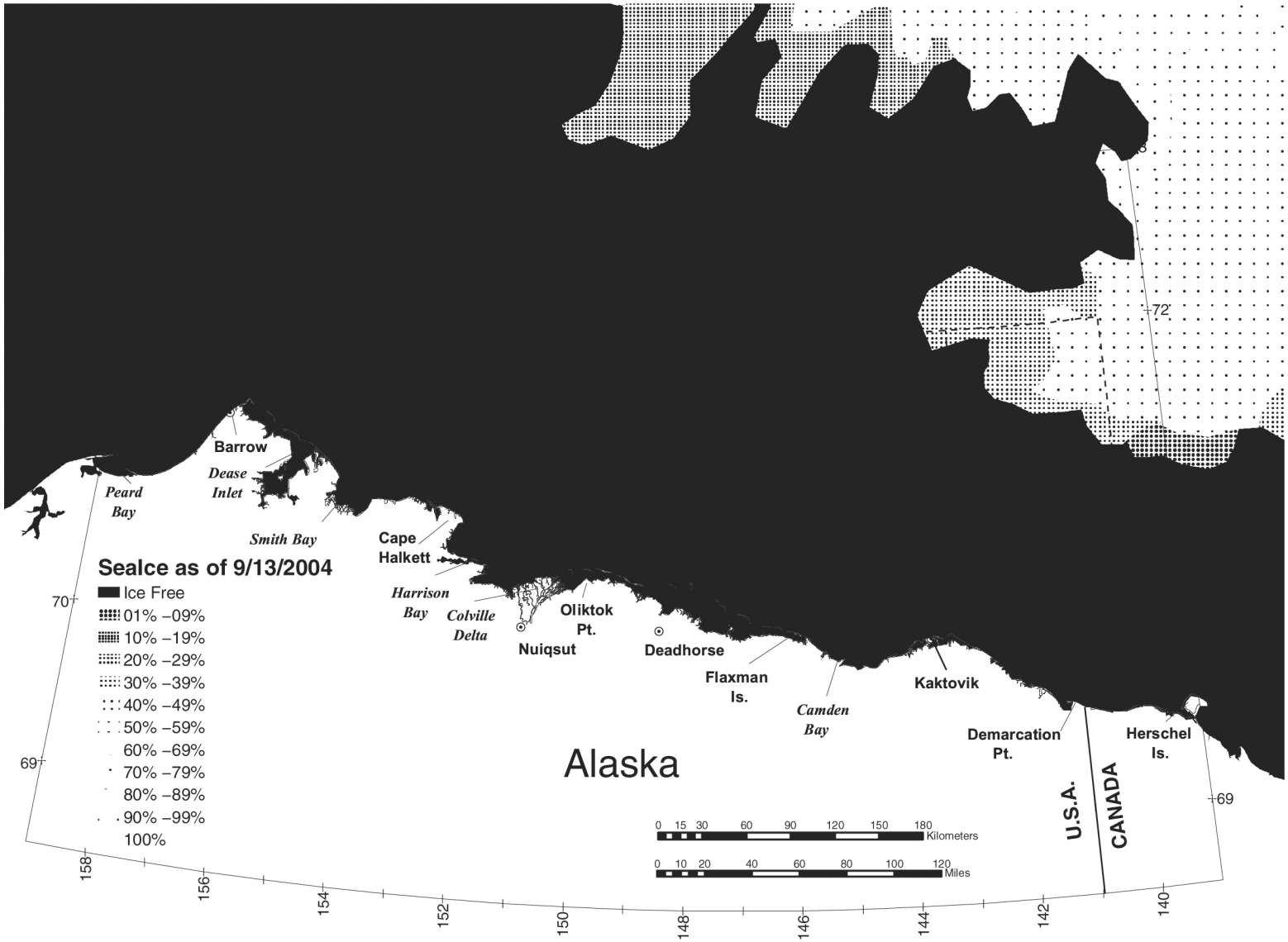

Figure 58 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 13 September 2004

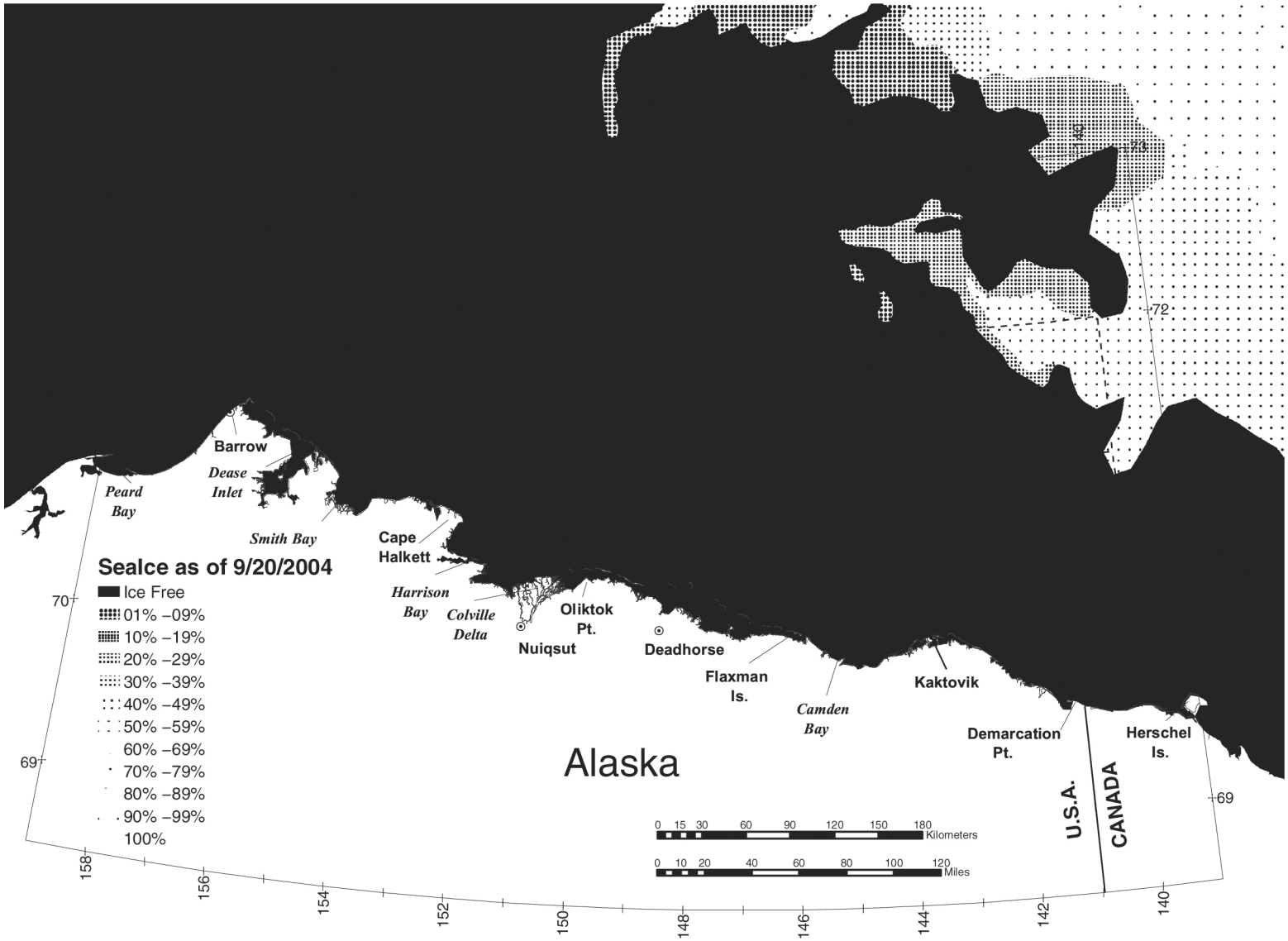

Figure 59 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 20 September 2004

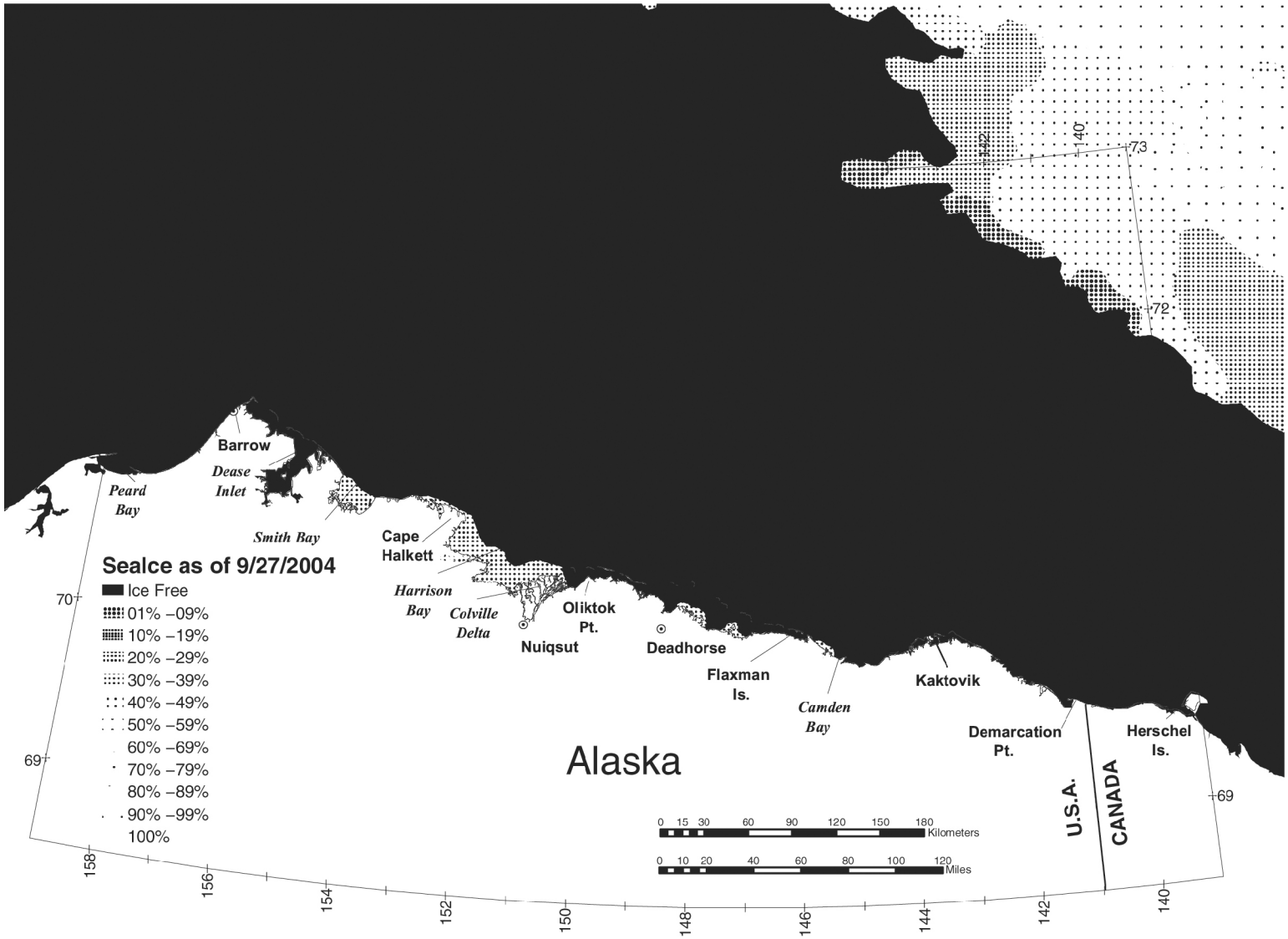

Figure 60 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 27 September 2004

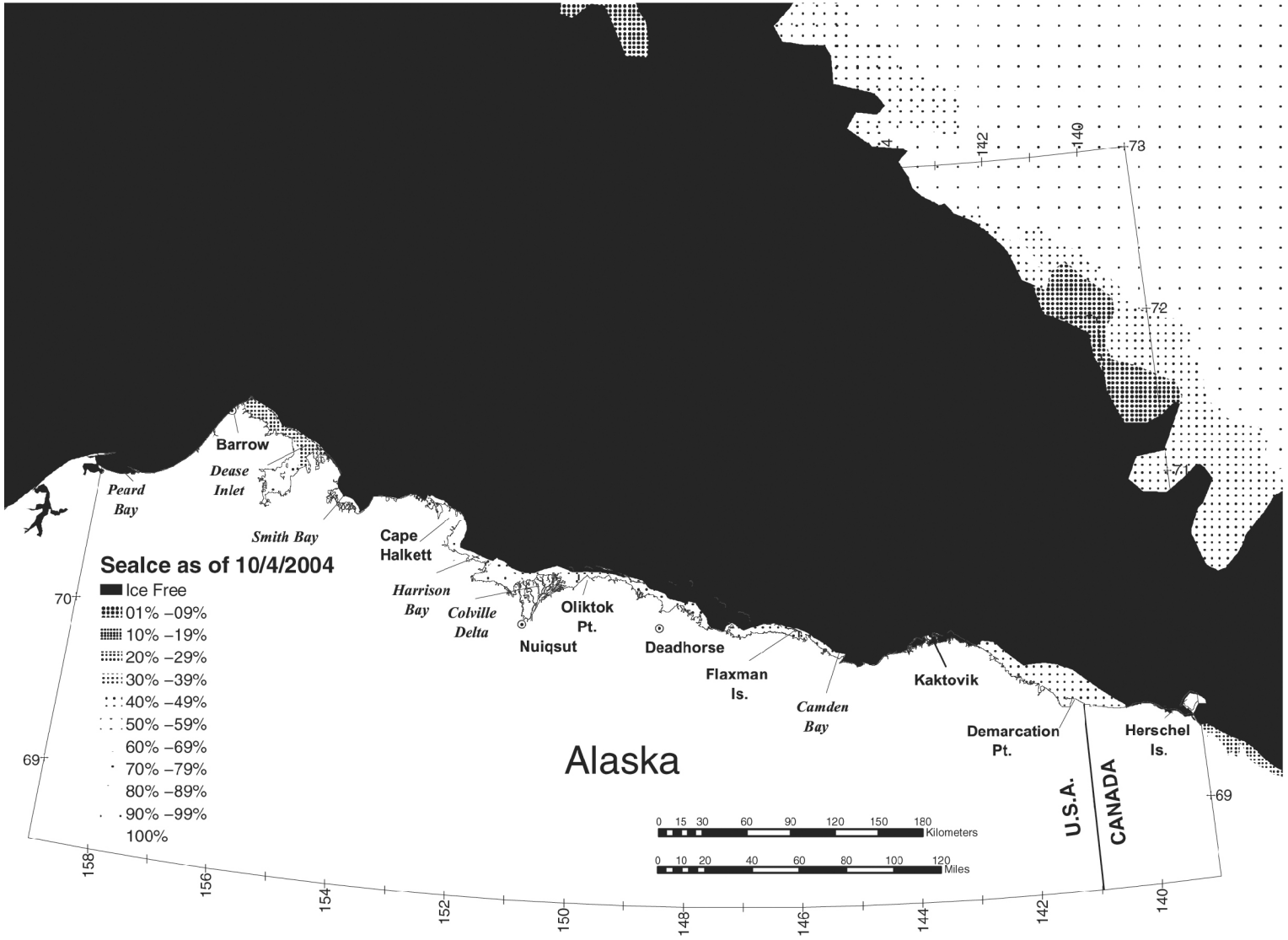

Figure 61 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 4 October 2004

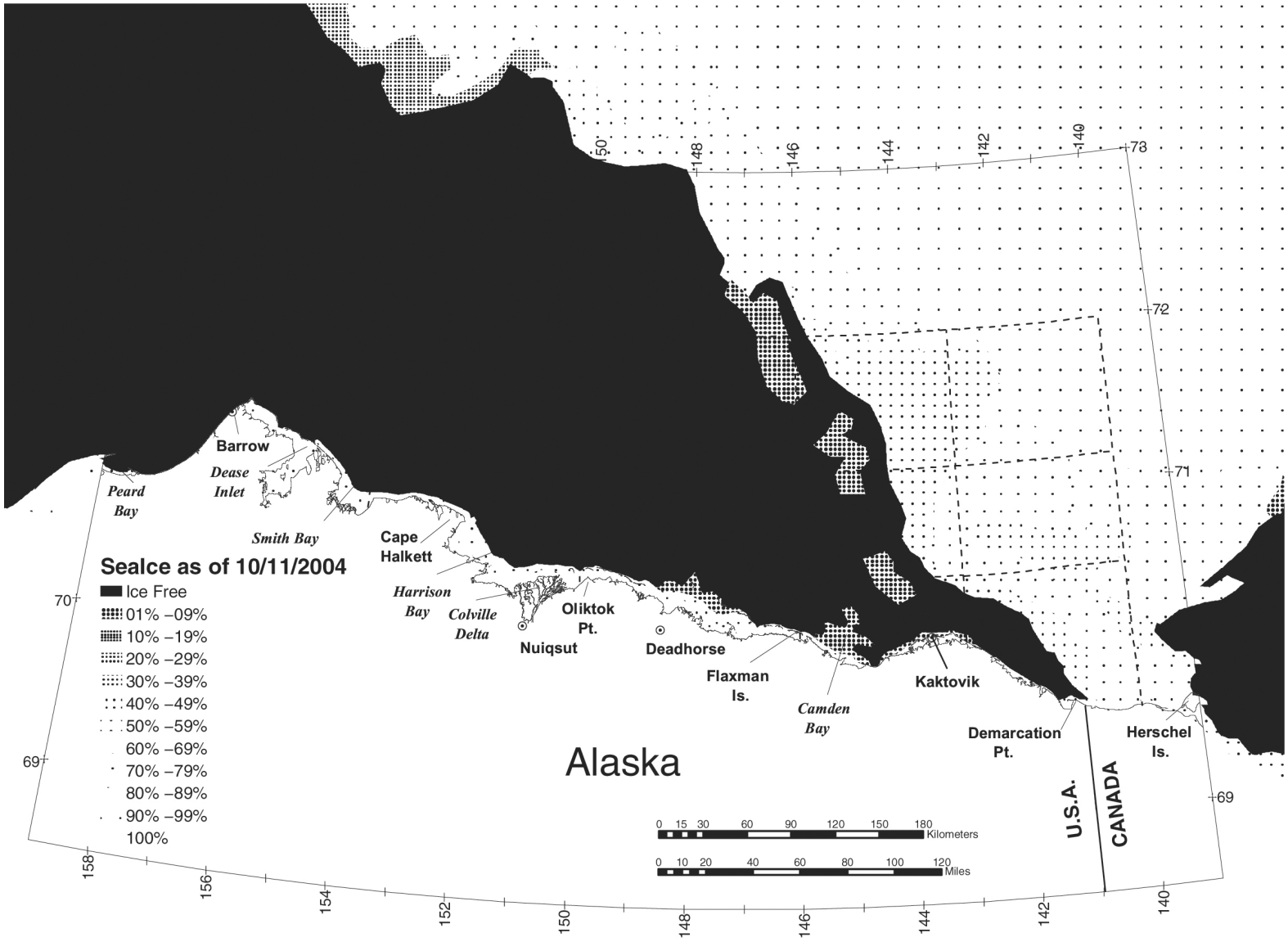

Figure 62 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 11 October 2004

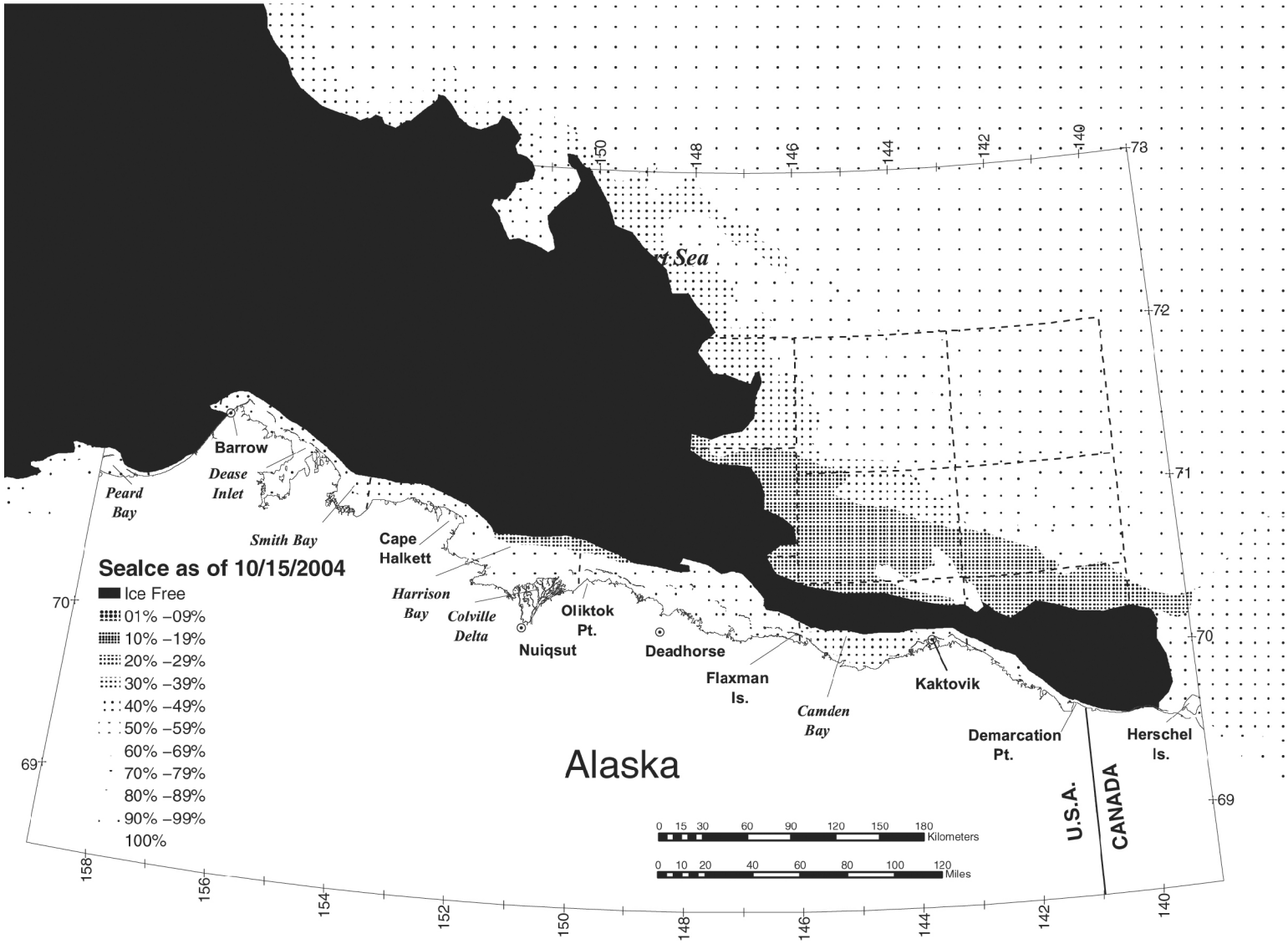

Figure 63 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 15 October 2004

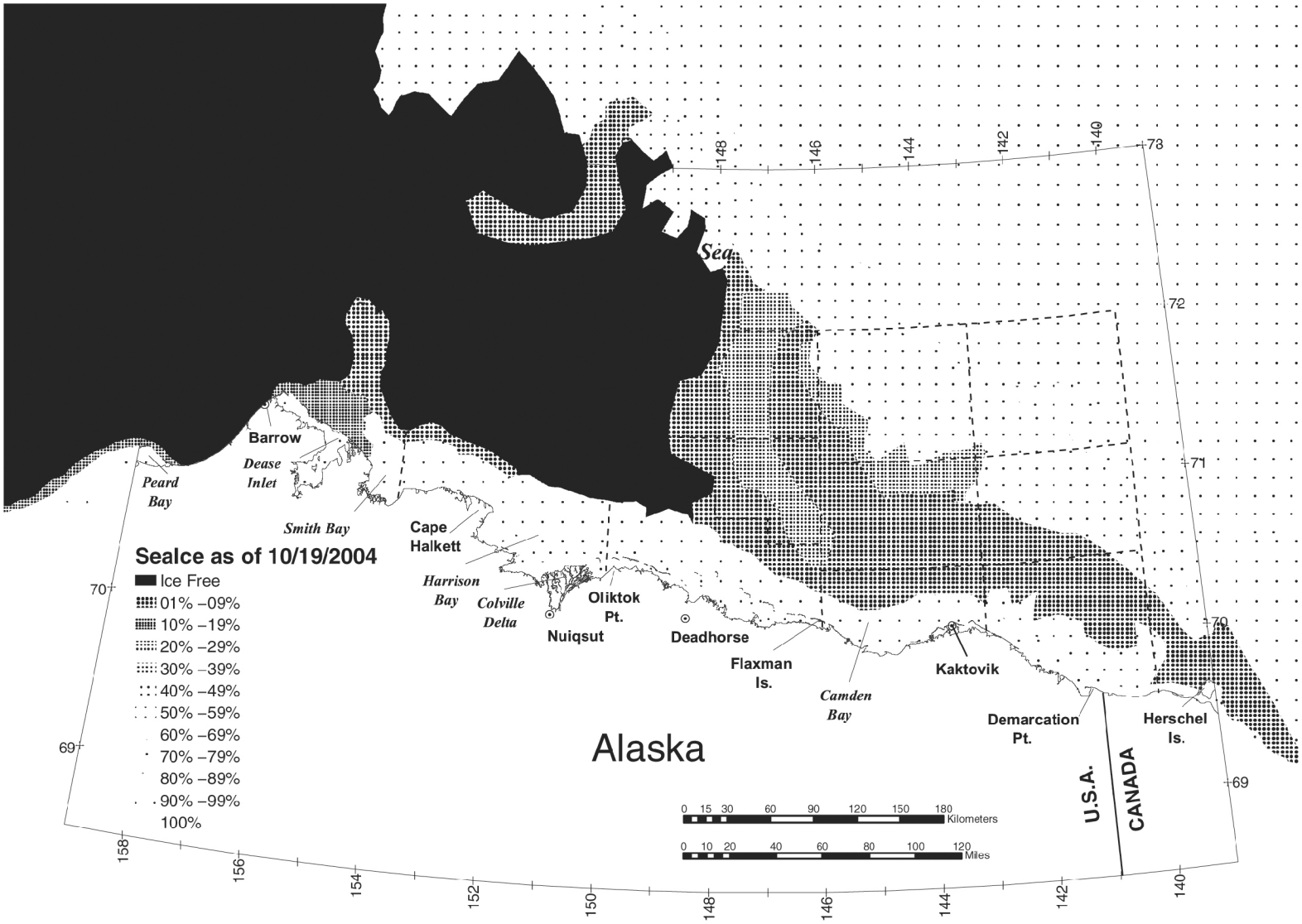

Figure 64 – Map of Ice Concentrations in the Alaskan Beaufort Sea, 19 October 2004

APPENDIX B-2002: FALL 2002 BOWHEAD WHALE SIGHTING DATA

Table B-2002
Selected sighting Data for Bowhead Whales Observed, Fall 2002

Flight No	Day	Total Whales	No of Calves	Latitude	Longitude	Behavior	Compass Heading	Ice (%)	Wind Force
1	22-Aug	1	0	71º53.7'	153º54.1'	swim	60º	5	3
4	24-Aug	1	0	70º07.9'	142º28.0'	rest	270º	2	2
5	25-Aug	1	0	71º16.2'	156º55.0'	feed	240º	0	1
5	25-Aug	1	0	71º30.2'	156º09.6'	swim	360º	0	2
5	25-Aug	2	0	71º29.5'	156º07.4'	swim	330º	0	2
5	25-Aug	1	0	71º06.9'	153º46.3'	swim	240º	5	2
6	26-Aug	1	0	70º17.7'	143º58.2'	dive	300º	10	2
6	26-Aug	1	0	70º12.7'	143º33.2'	swim	270º	10	2
6	26-Aug	1	0	70º12.1'	143º29.7'	swim	270º	10	2
6	26-Aug	1	0	70º11.6'	143º26.3'	swim	270º	10	2
6	26-Aug	1	0	70º15.1'	143º01.3'	swim	150º	10	2
6	26-Aug	1	0	70º15.7'	143º01.4'	swim	150º	10	2
6	26-Aug	1	0	70º11.6'	143º39.4'	swim	160º	1	1
6	26-Aug	1	0	70º44.6'	145º50.1'	rest	30º	10	2
10	30-Aug	1	0	71º04.1'	150º18.5'	swim	240º	1	5
10	30-Aug	1	0	71º10.6'	150º38.7'	rest	70º	5	5
13	4-Sep	1	0	70º34.7'	147º13.1'	swim	320º	5	5
14	5-Sep	2	0	71º08.9'	151º39.0'	swim	90º	0	3
14	5-Sep	1	0	71º08.9'	151º37.1'	swim	120º	0	3
14	5-Sep	1	0	71º09.1'	151º38.4'	swim	20º	0	3
14	5-Sep	2	1	71º07.7'	151º35.0'	feed	310º	0	3
14	5-Sep	2	0	71º09.6'	151º35.2'	swim	30º	0	3
14	5-Sep	1	0	70º50.7'	151º14.4'	feed	20º	0	4
14	5-Sep	2	1	71º02.9'	150º51.8'	swim	125º	1	3
14	5-Sep	1	0	71º02.9'	150º51.8'	swim	110º	1	3
14	5-Sep	1	0	70º57.3'	149º25.1'	swim	250º	5	2
14	5-Sep	1	0	70º46.6'	149º21.3'	dive	165º	0	2
14	5-Sep	1	0	70º46.1'	149º21.3'	swim	240º	0	2
14	5-Sep	1	0	70º45.8'	149º21.3'	rest	135º	0	2
14	5-Sep	1	0	70º43.0'	149º21.8'	rest	255º	0	2
14	5-Sep	1	0	70º52.2'	148º02.0'	swim	290º	1	1
14	5-Sep	1	0	70º44.6'	148º01.5'	dive	360º	1	1
15	6-Sep	1	0	70º30.5'	144º03.6'	swim	60º	0	3
15	6-Sep	1	0	70º30.5'	144º03.6'	swim	65º	0	3
15	6-Sep	1	0	70º01.9'	141º55.0'	swim	90º	0	4
15	6-Sep	1	0	69º52.4'	142º06.3'	rest	210º	1	2
15	6-Sep	2	0	70º29.8'	143º29.9'	log play	0º	0	3
15	6-Sep	1	0	70º34.4'	144º50.0'	swim	245º	0	3
17	10-Sep	1	0	70º05.7'	140º36.9'	swim	255º	0	2
17	10-Sep	1	0	70º13.2'	143º35.1'	swim	245º	0	3

Flight No	Day	Total Whales	No of Calves	Latitude	Longitude	Behavior	Compass Heading	Ice (%)	Wind Force
17	10-Sep	1	0	70º12.1'	143º34.5'	swim	245º	0	3
17	10-Sep	2	0	70º13.0'	144º11.3'	swim	250º	0	2
17	10-Sep	2	0	70º13.2'	144º37.5'	swim	240º	0	4
18	11-Sep	1	0	70º25.3'	146º32.9'	swim	100º	0	2
18	11-Sep	1	0	70º17.0'	145º06.4'	swim	150º	0	2
18	11-Sep	1	0	70º20.3'	146º21.7'	swim	240º	0	3
19	12-Sep	1	0	69º55.1'	141º57.3'	rest	240º	0	1
19	12-Sep	1	0	69º54.5'	142º16.1'	swim	120º	0	1
20	13-Sep	1	0	70º12.7'	145º39.6'	swim	230º	0	2
20	13-Sep	1	0	69º54.1'	141º08.3'	rest	120º	0	2
20	13-Sep	1	0	69º52.5'	141º42.4'	swim	300º	0	2
20	13-Sep	1	0	69º49.9'	141º58.2'	swim	275º	0	2
20	13-Sep	1	0	69º50.5'	142º01.5'	swim	240º	0	2
20	13-Sep	1	0	70º06.7'	142º46.2'	swim	265º	0	3
22	21-Sep	1	0	71º01.6'	152º12.6'	swim	290º	0	4
22	21-Sep	1	0	71º08.0'	152º41.8'	swim	310º	0	4
22	21-Sep	1	0	70º51.4'	151º24.2'	feed	360º	0	4
23	27-Sep	1	0	70º48.9'	149º13.2'	swim	60º	0	2
27	7-Oct	1	0	70º52.9'	149º59.7'	swim	290º	0	4
27	7-Oct	1	0	71º06.1'	152º11.7'	swim	255º	0	3
27	7-Oct	1	0	71º06.1'	152º11.7'	swim	320º	0	3
27	7-Oct	1	0	71º06.1'	152º11.7'	swim	255º	0	3
27	7-Oct	1	0	71º08.7'	152º51.7'	swim	240º	0	5
27	7-Oct	1	0	71º02.2'	153º42.1'	swim	270º	0	4
27	7-Oct	1	0	71º16.6'	153º42.3'	swim	270º	0	6
27	7-Oct	1	0	71º00.3'	153º11.0'	mill	0º	0	4
27	7-Oct	2	0	71º04.7'	152º45.6'	mill	0º	0	4
27	7-Oct	1	0	71º18.1'	152º33.5'	swim	240º	0	3
27	7-Oct	1	0	71º19.6'	152º32.3'	swim	240º	0	3
27	7-Oct	1	0	71º08.2'	152º08.5'	swim	210º	0	2
27	7-Oct	1	0	71º07.4'	152º08.6'	swim	210º	0	2
27	7-Oct	1	0	71º07.1'	152º08.6'	swim	160º	0	2
27	7-Oct	1	0	71º06.6'	152º08.6'	swim	120º	0	2
27	7-Oct	1	0	71º04.8'	151º39.8'	dive	240º	0	3

APPENDIX B-2003: FALL 2003 BOWHEAD WHALE SIGHTING DATA

Table B-2003
Selected sighting Data for Bowhead Whales Observed, Fall 2003

Flight No	Day	Total Whales	No of Calves	Latitude	Longitude	Behavior	Compass Heading	Ice (%)	Wind Force
2	3-Sep	1	0	70º18.0'	141º50.8'	swim	230º	5	2
2	3-Sep	1	0	70º12.8'	142º46.2'	swim	330º	1	1
2	3-Sep	2	0	70º15.7'	143º40.8'	swim	270º	0	2
3	5-Sep	1	0	70º47.8'	149º05.7'	breach	240º	0	6
3	5-Sep	2	0	70º47.2'	149º01.1'	swim	0º	0	6
3	5-Sep	1	0	70º39.5'	147º16.4'	swim	30º	0	5
3	5-Sep	1	0	70º37.4'	146º15.0'	swim	0º	0	3
4	6-Sep	1	0	70º38.6'	146º20.8'	swim	260º	0	5
4	6-Sep	2	0	70º38.3'	146º20.1'	swim	220º	0	5
4	6-Sep	3	0	70º37.0'	145º59.1'	swim	300º	0	5
4	6-Sep	1	0	70º29.5'	143º29.7'	rest	240º	0	6
4	6-Sep	1	0	70º27.5'	144º07.4'	swim	160º	0	4
4	6-Sep	1	0	70º29.6'	144º06.3'	swim	180º	0	4
4	6-Sep	1	0	70º26.4'	144º57.3'	rest	60º	0	4
4	6-Sep	1	0	70º24.0'	145º34.5'	rest	240º	0	4
4	6-Sep	1	0	70º30.8'	146º16.8'	swim	30º	0	4
4	6-Sep	1	0	70º37.1'	146º14.9'	swim	250º	0	3
4	6-Sep	1	0	70º38.2'	146º14.7'	swim	240º	0	4
4	6-Sep	1	0	70º40.1'	146º20.5'	swim	150º	0	4
4	6-Sep	1	0	70º41.1'	146º20.0'	swim	120º	0	4
4	6-Sep	1	0	70º39.9'	146º25.9'	swim	240º	0	4
5	7-Sep	2	0	70º04.6'	140º15.7'	swim	270º	20	1
5	7-Sep	1	0	70º30.0'	144º09.5'	swim	240º	0	1
5	7-Sep	3	0	70º21.6'	146º38.8'	swim	340º	0	1
5	7-Sep	2	0	70º21.1'	146º44.9'	feed	140º	0	1
6	8-Sep	1	0	70º23.9'	142º24.0'	rest	220º	10	2
6	8-Sep	2	1	70º16.6'	142º32.6'	swim	260º	1	2
7	9-Sep	1	0	70º23.0'	146º28.5'	swim	225º	0	6
7	9-Sep	1	0	70º28.9'	145º26.5'	swim	170º	0	4
7	9-Sep	2	0	70º26.3'	144º40.8'	swim	220º	0	2
7	9-Sep	1	0	70º22.3'	145º09.8'	spy hop	350º	0	2
7	9-Sep	1	0	70º32.7'	145º46.1'	swim	60º	0	6
7	9-Sep	3	0	70º39.7'	146º22.4'	swim	215º	0	6
7	9-Sep	1	0	70º36.2'	146º24.0'	swim	341º	0	6
11	15-Sep	1	0	69º55.3'	142º07.6'	swim	290º	0	2
11	15-Sep	1	0	70º03.9'	142º23.9'	swim	310º	0	3
11	15-Sep	1	0	70º01.4'	142º23.4'	swim	110º	0	3
11	15-Sep	1	0	70º11.0'	143º08.1'	swim	60º	0	5
12	16-Sep	1	0	71º11.6'	154º56.2'	swim	100º	0	5
12	16-Sep	1	0	71º11.8'	154º58.6'	swim	150º	0	5
12	16-Sep	1	0	71º11.8'	154º58.8'	swim	320º	0	5

Flight No	Day	Total Whales	No of Calves	Latitude	Longitude	Behavior	Compass Heading	Ice (%)	Wind Force
12	16-Sep	1	0	71º38.1'	156º52.1'	swim	250º	0	3
12	16-Sep	1	0	71º39.4'	156º13.9'	swim	90º	0	4
12	16-Sep	1	0	71º39.0'	156º14.1'	swim	260º	0	4
12	16-Sep	1	0	71º35.1'	155º47.2'	swim	160º	0	5
12	16-Sep	2	0	71º36.9'	155º46.7'	swim	260º	0	5
12	16-Sep	1	0	71º40.0'	155º45.8'	swim	80º	0	5
12	16-Sep	1	0	71º40.0'	155º45.8'	swim	0º	0	5
12	16-Sep	1	0	71º43.8'	155º44.8'	swim	80º	0	4
12	16-Sep	1	0	71º46.1'	155º07.1'	swim	350º	0	4
13	17-Sep	2	0	70º26.0'	147º28.2'	swim	300º	0	5
13	17-Sep	2	0	70º26.2'	147º27.4'	swim	330º	0	5
14	19-Sep	1	0	70º36.9'	149º17.3'	tail slap	150º	0	5
14	19-Sep	1	0	70º37.7'	149º18.3'	swim	240º	0	5
14	19-Sep	1	0	70º38.1'	149º16.5'	swim	240º	0	5
14	19-Sep	1	0	70º36.9'	149º15.8'	swim	35º	0	5
14	19-Sep	1	0	70º37.6'	149º19.9'	swim	280º	0	5
14	19-Sep	1	0	70º45.6'	150º14.4'	swim	260º	0	4
14	19-Sep	1	0	71º22.8'	153º17.6'	breach	270º	0	1
14	19-Sep	1	0	71º33.1'	152º36.5'	swim	150º	0	1
14	19-Sep	1	0	71º39.4'	152º35.5'	swim	0º	0	1
14	19-Sep	1	0	71º07.1'	151º50.9'	swim	300º	0	2
14	19-Sep	1	0	71º23.7'	151º07.1'	dead	0º	0	1
15	20-Sep	2	0	70º33.7'	149º55.8'	swim	270º	0	3
15	20-Sep	2	0	70º34.8'	149º56.1'	swim	0º	0	3
15	20-Sep	1	0	70º35.6'	149º56.6'	swim	0º	0	3
15	20-Sep	9	0	70º35.8'	149º58.3'	mill	0º	0	3
15	20-Sep	10	0	70º35.8'	149º58.3'	mill	0º	0	3
15	20-Sep	1	0	70º38.2'	150º35.2'	swim	60º	0	2
15	20-Sep	1	0	70º38.7'	150º35.2'	rest	170º	0	2
15	20-Sep	1	0	70º35.6'	150º21.0'	swim	260º	0	2
15	20-Sep	1	0	70º35.4'	149º38.6'	dive	280º	0	2
15	20-Sep	1	0	70º46.0'	149º37.6'	swim	300º	0	3
15	20-Sep	2	0	70º46.2'	149º37.5'	swim	240º	0	3
15	20-Sep	1	0	70º52.2'	149º17.4'	swim	150º	0	3
15	20-Sep	1	0	70º45.8'	149º20.2'	swim	250º	0	3
15	20-Sep	1	0	70º47.0'	149º20.5'	swim	250º	0	3
15	20-Sep	1	0	70º43.3'	149º21.7'	swim	290º	0	3
15	20-Sep	1	0	70º35.9'	148º43.9'	swim	240º	0	2
15	20-Sep	1	0	70º37.2'	148º44.3'	swim	240º	0	2
15	20-Sep	2	0	70º39.1'	148º44.5'	swim	60º	0	3
15	20-Sep	3	0	70º39.3'	148º44.5'	swim	210º	0	3
15	20-Sep	1	0	70º40.9'	148º44.9'	swim	270º	0	2
15	20-Sep	2	0	70º44.3'	148º45.7'	swim	270º	0	3
15	20-Sep	1	0	70º44.6'	148º49.1'	swim	330º	0	3
15	20-Sep	1	0	70º44.6'	148º49.1'	swim	210º	0	3

Flight No	Day	Total Whales	No of Calves	Latitude	Longitude	Behavior	Compass Heading	Ice (%)	Wind Force
15	20-Sep	1	0	70º56.3'	148º48.1'	swim	260º	0	4
15	20-Sep	1	0	70º47.6'	148º25.9'	dive	0º	0	4
15	20-Sep	1	0	70º26.7'	147º33.9'	swim	260º	0	4
15	20-Sep	2	0	70º29.9'	147º33.6'	swim	240º	0	4
15	20-Sep	1	0	70º30.5'	147º24.1'	swim	250º	0	4
15	20-Sep	1	0	70º30.4'	147º24.2'	swim	210º	0	4
15	20-Sep	1	0	70º29.6'	147º24.6'	swim	250º	0	4
15	20-Sep	1	0	70º28.8'	147º24.9'	swim	70º	0	4
15	20-Sep	1	0	70º24.8'	147º25.7'	swim	340º	0	4
15	20-Sep	1	0	70º24.8'	147º25.7'	swim	50º	0	4
16	21-Sep	3	0	70º37.4'	149º52.5'	swim	350º	0	2
16	21-Sep	6	0	70º38.1'	150º00.5'	swim	350º	0	2
16	21-Sep	2	0	70º40.0'	150º03.0'	mill	0º	0	2
16	21-Sep	2	0	70º40.0'	150º01.2'	swim	260º	0	2
16	21-Sep	3	0	70º39.7'	149º59.5'	mill	0º	0	2
16	21-Sep	4	0	70º39.2'	149º56.2'	mill	210º	0	2
16	21-Sep	1	0	70º39.2'	149º56.2'	mill	210º	0	2
16	21-Sep	15	0	70º36.7'	150º01.6'	mill	0º	0	2
16	21-Sep	5	0	70º36.9'	150º11.7'	mill	30º	0	2
16	21-Sep	1	0	70º36.9'	150º15.0'	swim	340º	0	2
16	21-Sep	6	0	70º36.9'	150º17.0'	mill	0º	0	2
16	21-Sep	8	0	70º36.9'	150º19.3'	mill	0º	0	2
16	21-Sep	1	0	70º37.0'	150º21.2'	swim	0º	0	2
16	21-Sep	4	0	70º37.0'	150º23.2'	mill	0º	0	2
16	21-Sep	1	0	70º37.1'	150º23.6'	swim	280º	0	2
16	21-Sep	2	0	70º37.1'	150º24.0'	swim	60º	0	2
16	21-Sep	2	0	70º36.9'	150º28.0'	mill	0º	0	2
16	21-Sep	1	0	70º36.5'	150º30.5'	swim	330º	0	2
16	21-Sep	2	0	70º36.4'	150º33.0'	mill	0º	0	2
16	21-Sep	1	0	70º36.4'	150º37.5'	swim	70º	0	2
16	21-Sep	1	0	70º36.6'	150º42.6'	swim	20º	0	2
16	21-Sep	1	0	70º36.7'	150º44.9'	swim	30º	0	2
16	21-Sep	1	0	70º39.2'	151º08.6'	breach	0º	0	2
16	21-Sep	1	0	70º41.3'	151º28.9'	swim	270º	0	2
16	21-Sep	1	0	71º18.6'	153º40.0'	swim	260º	0	4
16	21-Sep	1	0	71º19.8'	153º37.2'	rest	0º	0	4
16	21-Sep	1	0	71º07.4'	152º08.9'	rest	250º	0	2
16	21-Sep	1	0	71º04.6'	151º40.1'	rest	250º	0	1
16	21-Sep	1	0	71º01.7'	151º19.2'	rest	0º	0	1
16	21-Sep	1	0	70º47.1'	151º12.5'	rest	250º	0	1
16	21-Sep	4	0	70º34.2'	150º21.6'	mill	0º	0	1
16	21-Sep	1	0	70º41.5'	149º47.6'	dive	270º	0	2
16	21-Sep	2	0	70º47.0'	149º37.6'	rest	0º	0	2
16	21-Sep	1	0	70º42.2'	149º21.2'	dive	0º	0	2
16	21-Sep	1	0	70º36.4'	148º47.3'	dive	250º	0	2

Flight No	Day	Total Whales	No of Calves	Latitude	Longitude	Behavior	Compass Heading	Ice (%)	Wind Force
16	21-Sep	1	0	70º37.9'	148º47.2'	swim	310º	0	2
16	21-Sep	2	0	70º40.8'	148º39.0'	swim	240º	0	3
21	28-Sep	1	0	70º54.9'	149º41.6'	swim	150º	0	2
21	28-Sep	2	0	70º48.4'	149º20.0'	swim	360º	0	4
21	28-Sep	1	0	70º49.1'	148º45.8'	swim	270º	0	5
21	28-Sep	1	0	70º40.1'	147º35.2'	swim	270º	0	5
21	28-Sep	1	0	70º37.5'	146º42.2'	swim	260º	0	5
21	28-Sep	1	0	70º25.8'	143º52.9'	swim	155º	0	5
21	28-Sep	2	0	70º15.5'	143º47.2'	swim	270º	0	6
21	28-Sep	1	0	70º10.4'	144º13.6'	swim	65º	0	7
21	28-Sep	2	0	70º22.5'	144º35.9'	swim	180º	0	7
22	29-Sep	1	0	70º53.7'	146º43.8'	swim	60º	0	2
23	2-Oct	1	0	70º29.1'	144º01.9'	swim	60º	0	3
23	2-Oct	1	0	71º11.6'	149º35.4'	swim	90º	0	2
23	2-Oct	1	0	70º48.7'	149º50.0'	swim	50º	0	2
27	13-Oct	1	0	71º00.7'	153º25.0'	swim	60º	0	3

APPENDIX B-2004: FALL 2004 BOWHEAD WHALE SIGHTING DATA

Table B-2004
Selected sighting Data for Bowhead Whales Observed, Fall 2004

Flight No	Day	Total Whales	No of Calves	Latitude	Longitude	Behavior	Compass Heading	Ice (%)	Wind Force
2	2-Sep	1	0	70º11.7'	144º32.7'	swim	320º	0	6
2	2-Sep	1	0	69º59.0'	140º55.4'	swim	275º	0	4
2	2-Sep	2	0	70º02.6'	141º43.9'	swim	260º	0	5
2	2-Sep	1	0	70º09.8'	144º33.8'	swim	15º	0	5
2	2-Sep	3	0	70º09.8'	144º35.4'	mill	0º	0	5
2	2-Sep	1	0	70º09.4'	144º36.6'	swim	335º	0	5
4	5-Sep	2	0	71º30.5'	156º07.4'	swim	240º	0	3
4	5-Sep	3	0	71º29.8'	156º07.2'	feed	0º	0	3
4	5-Sep	1	0	71º29.6'	156º07.2'	swim	270º	0	3
4	5-Sep	4	0	71º28.5'	156º07.2'	feed	0º	0	3
4	5-Sep	1	0	71º26.4'	156º06.7'	swim	340º	0	3
4	5-Sep	1	0	71º36.6'	155º42.3'	swim	185º	0	3
4	5-Sep	1	0	71º30.0'	155º43.1'	feed	0º	0	3
4	5-Sep	4	0	71º29.9'	155º42.2'	feed	0º	0	3
4	5-Sep	1	0	71º29.9'	155º45.6'	feed	170º	0	3
4	5-Sep	1	0	71º30.7'	155º47.2'	swim	270º	0	3
4	5-Sep	1	0	71º52.1'	155º24.5'	swim	80º	0	2
4	5-Sep	1	0	71º01.2'	153º15.5'	swim	250º	0	2
5	6-Sep	1	0	70º09.9'	142º46.2'	swim	240º	0	2
5	6-Sep	1	0	70º08.8'	142º46.3'	feed	320º	0	2
5	6-Sep	3	0	70º18.2'	143º22.7'	swim	75º	0	2
5	6-Sep	1	0	70º17.7'	143º50.8'	dead	0º	0	2
5	6-Sep	1	0	70º31.1'	144º14.5'	breach	240º	0	3
5	6-Sep	2	1	70º25.7'	146º46.6'	swim	60º	0	3
6	7-Sep	1	0	69º47.9'	140º08.4'	swim	60º	0	2
6	7-Sep	1	0	69º47.9'	140º08.4'	swim	60º	0	2
6	7-Sep	1	0	70º06.5'	140º47.0'	swim	245º	0	4
6	7-Sep	1	0	70º01.6'	140º48.0'	swim	255º	0	3
6	7-Sep	1	0	69º55.0'	140º49.1'	swim	100º	0	3
6	7-Sep	2	0	69º54.2'	140º49.2'	swim	220º	0	3
6	7-Sep	2	0	69º52.7'	140º49.5'	swim	80º	0	3
7	8-Sep	1	0	70º15.1'	143º11.9'	swim	225º	0	3
7	8-Sep	1	0	70º12.4'	144º09.3'	swim	40º	0	3
7	8-Sep	1	0	70º45.4'	147º06.3'	swim	90º	0	4
8	9-Sep	2	0	70º47.4'	151º18.8'	feed	180º	0	3
8	9-Sep	1	0	70º55.4'	152º21.8'	rest	360º	0	3
8	9-Sep	1	0	71º01.0'	153º54.0'	feed	0º	0	2
8	9-Sep	1	0	71º16.8'	151º53.9'	swim	300º	0	3
9	10-Sep	3	0	70º42.4'	150º53.0'	swim	270º	0	3
11	13-Sep	2	0	70º53.4'	151º15.5'	breach	270º	0	3

Flight No	Day	Total Whales	No of Calves	Latitude	Longitude	Behavior	Compass Heading	Ice (%)	Wind Force
11	13-Sep	1	0	70º57.8'	151º34.0'	swim	180º	0	3
11	13-Sep	1	0	70º57.8'	151º34.0'	swim	270º	0	3
11	13-Sep	2	0	71º29.8'	155º42.4'	feed	180º	0	3
11	13-Sep	2	0	71º30.1'	155º45.2'	feed	0º	0	3
11	13-Sep	6	0	71º30.2'	155º42.5'	feed	0º	0	3
12	14-Sep	1	0	70º06.3'	144º38.7'	swim	270º	0	1
12	14-Sep	1	0	70º09.4'	143º56.6'	swim	240º	0	1
12	14-Sep	1	0	70º11.6'	144º02.5'	mill	0º	0	1
12	14-Sep	1	0	70º11.1'	144º05.8'	mill	0º	0	1
12	14-Sep	1	0	70º11.1'	144º07.9'	mill	0º	0	1
12	14-Sep	3	0	70º12.1'	144º09.3'	mill	0º	0	1
12	14-Sep	1	0	70º13.0'	144º06.1'	swim	300º	0	1
12	14-Sep	1	0	70º13.5'	144º02.0'	swim	270º	0	1
12	14-Sep	1	0	70º13.5'	143º59.4'	swim	270º	0	1
12	14-Sep	1	0	70º09.9'	143º16.1'	swim	270º	0	1
12	14-Sep	1	0	70º09.7'	143º13.2'	dive	270º	0	1
12	14-Sep	1	0	70º10.2'	143º13.6'	swim	270º	0	1
12	14-Sep	3	1	70º10.7'	143º16.1'	mill	0º	0	1
12	14-Sep	3	0	70º11.3'	143º19.4'	mill	0º	0	1
12	14-Sep	2	0	70º11.5'	143º21.9'	swim	270º	0	1
12	14-Sep	3	0	70º11.8'	143º20.2'	swim	270º	0	1
12	14-Sep	1	0	70º12.3'	143º13.0'	breach	279º	0	1
12	14-Sep	1	0	70º12.9'	143º12.5'	feed	0º	0	1
12	14-Sep	1	0	70º12.5'	143º12.9'	breach	270º	0	1
12	14-Sep	2	0	70º08.6'	143º04.2'	feed	270º	0	1
12	14-Sep	1	0	70º16.2'	143º16.9'	swim	210º	0	1
12	14-Sep	1	0	70º21.2'	143º48.6'	swim	240º	0	1
12	14-Sep	1	0	70º13.3'	143º51.0'	swim	240º	0	1
12	14-Sep	1	0	70º12.1'	144º04.6'	swim	240º	0	1
12	14-Sep	2	0	70º16.8'	144º06.5'	swim	260º	0	1
12	14-Sep	2	0	70º17.4'	144º05.7'	swim	270º	0	1
12	14-Sep	2	1	70º24.2'	145º42.1'	swim	30º	0	1
12	14-Sep	1	0	70º16.6'	145º40.7'	swim	260º	0	1
13	16-Sep	1	0	70º19.5'	143º37.1'	swim	250º	0	1
13	16-Sep	1	0	70º17.0'	143º12.9'	swim	250º	0	1
13	16-Sep	2	0	70º14.9'	142º47.0'	swim	250º	0	1
13	16-Sep	1	0	70º11.8'	142º27.4'	swim	250º	0	1
13	16-Sep	1	0	70º08.4'	142º06.9'	swim	250º	0	1
13	16-Sep	2	0	70º04.3'	141º45.0'	mill	0º	0	1
13	16-Sep	1	0	70º03.9'	141º42.3'	swim	250º	0	1
13	16-Sep	2	1	70º01.5'	141º24.3'	swim	240º	0	1
13	16-Sep	1	0	69º58.5'	141º13.5'	dive	290º	0	1
13	16-Sep	1	0	69º56.8'	141º09.5'	swim	290º	0	1
13	16-Sep	1	0	69º54.6'	141º04.2'	swim	290º	0	1
13	16-Sep	1	0	69º50.4'	140º54.8'	swim	290º	0	1

Flight No	Day	Total Whales	No of Calves	Latitude	Longitude	Behavior	Compass Heading	Ice (%)	Wind Force
13	16-Sep	2	0	69º48.1'	140º18.9'	mill	0º	0	1
13	16-Sep	1	0	69º50.3'	140º18.8'	swim	310º	0	1
13	16-Sep	2	0	70º01.7'	140º42.8'	mill	0º	0	1
13	16-Sep	1	0	69º51.9'	140º43.5'	swim	270º	0	1
13	16-Sep	3	0	69º57.3'	141º22.9'	swim	330º	0	1
13	16-Sep	9	0	69º58.0'	141º22.6'	swim	330º	0	1
13	16-Sep	1	0	70º01.9'	141º22.5'	swim	310º	0	1
13	16-Sep	4	2	70º03.4'	141º22.1'	mill	0º	0	1
13	16-Sep	2	0	70º08.2'	141º20.4'	mill	0º	0	1
13	16-Sep	1	0	70º27.5'	141º15.5'	swim	280º	0	1
13	16-Sep	10	3	70º15.0'	141º52.1'	mill	0º	0	1
13	16-Sep	2	1	70º10.7'	141º52.2'	mill	0º	0	1
13	16-Sep	3	0	70º08.8'	141º59.3'	swim	270º	0	1
13	16-Sep	1	0	70º04.2'	141º54.3'	swim	270º	0	1
13	16-Sep	1	0	70º08.1'	142º10.6'	swim	280º	0	1
13	16-Sep	2	1	70º14.7'	142º11.3'	swim	240º	0	1
13	16-Sep	1	0	70º12.5'	142º11.7'	swim	240º	0	1
13	16-Sep	2	0	70º15.7'	142º10.0'	swim	240º	0	1
13	16-Sep	2	0	70º15.9'	142º10.9'	swim	250º	0	1
13	16-Sep	2	0	70º14.5'	144º09.5'	swim	240º	0	1
13	16-Sep	3	0	70º17.9'	145º32.7'	swim	270º	0	1
15	18-Sep	1	0	70º56.4'	152º12.0'	swim	80º	0	3
15	18-Sep	1	0	70º59.9'	153º28.1'	swim	150º	0	2
15	18-Sep	1	0	71º00.2'	153º32.7'	swim	0º	0	2
15	18-Sep	2	0	71º01.0'	153º36.3'	mill	0º	0	2
15	18-Sep	1	0	71º02.0'	153º32.4'	mill	0º	0	2
15	18-Sep	12	2	71º01.9'	153º29.8'	feed	0º	0	2
15	18-Sep	10	0	71º02.7'	153º31.3'	feed	0º	0	2
15	18-Sep	11	0	71º03.0'	153º31.8'	feed	0º	0	2
15	18-Sep	3	0	71º03.8'	153º32.9'	swim	120º	0	2
15	18-Sep	3	1	71º04.8'	153º35.6'	mill	0º	0	2
15	18-Sep	3	0	71º30.3'	156º11.5'	feed	0º	0	4
15	18-Sep	2	0	71º29.1'	155º51.4'	feed	0º	0	3
15	18-Sep	2	0	71º30.0'	155º51.4'	swim	240º	0	3
15	18-Sep	3	0	71º31.1'	155º51.4'	feed	0º	0	3
15	18-Sep	1	0	71º31.1'	155º51.4'	dead	0º	0	3
15	18-Sep	1	0	71º31.1'	155º51.4'	dead	0º	0	3
15	18-Sep	4	0	71º29.0'	155º11.8'	feed	0º	0	2
15	18-Sep	11	0	71º28.0'	155º14.2'	swim	330º	0	2
15	18-Sep	5	0	71º29.7'	155º18.1'	swim	330º	0	2
15	18-Sep	2	0	71º27.0'	155º11.8'	swim	330º	0	2
15	18-Sep	2	0	71º25.9'	155º11.6'	mill	0º	0	2
15	18-Sep	2	0	71º22.0'	154º52.2'	swim	300º	0	2
15	18-Sep	2	0	71º25.4'	154º51.5'	swim	320º	0	2
15	18-Sep	3	0	71º05.8'	154º21.0'	swim	250º	0	1

Flight No	Day	Total Whales	No of Calves	Latitude	Longitude	Behavior	Compass Heading	Ice (%)	Wind Force
15	18-Sep	18	0	71º03.5'	154º21.3'	feed	0º	0	1
15	18-Sep	1	0	71º03.0'	154º21.9'	swim	250º	0	1
15	18-Sep	2	0	71º02.6'	154º25.9'	mill	0º	0	1
15	18-Sep	45	0	70º59.4'	154º27.0'	feed	0º	0	1
15	18-Sep	2	0	70º42.8'	151º18.7'	feed	0º	0	1
16	19-Sep	1	0	70º11.2'	145º06.9'	swim	250º	0	1
16	19-Sep	2	0	70º11.4'	145º06.9'	breach	250º	0	1
16	19-Sep	1	0	70º13.1'	145º06.9'	swim	250º	0	1
16	19-Sep	1	0	70º13.3'	145º06.9'	swim	300º	0	1
16	19-Sep	1	0	70º18.4'	145º06.6'	swim	190º	0	2
16	19-Sep	1	0	70º18.8'	145º39.1'	dive	240º	0	1
16	19-Sep	1	0	70º16.6'	145º38.7'	swim	260º	0	1
16	19-Sep	1	0	70º13.5'	145º36.9'	swim	240º	0	1
16	19-Sep	1	0	70º13.6'	145º35.4'	swim	245º	0	1
16	19-Sep	2	1	70º12.2'	145º35.1'	breach	240º	0	1
17	21-Sep	1	0	70º48.3'	149º49.9'	swim	245º	0	3
17	21-Sep	1	0	70º30.7'	147º45.5'	swim	240º	0	3
17	21-Sep	1	0	70º31.9'	147º45.4'	swim	240º	0	3
17	21-Sep	2	1	70º42.9'	147º45.6'	swim	230º	0	3
19	24-Sep	1	0	70º13.8'	142º49.7'	swim	270º	0	2
19	24-Sep	1	0	70º10.2'	142º32.2'	swim	185º	0	2
19	24-Sep	1	0	70º08.5'	142º25.1'	swim	150º	0	2
19	24-Sep	1	0	70º03.3'	142º01.2'	swim	245º	0	2
19	24-Sep	2	1	70º01.4'	141º51.1'	swim	230º	0	2
19	24-Sep	1	1	70º00.9'	141º48.2'	swim	240º	0	2
19	24-Sep	1	0	69º47.9'	140º39.4'	swim	150º	0	2
19	24-Sep	3	0	69º57.8'	141º35.3'	swim	240º	0	4
19	24-Sep	1	0	70º03.7'	142º11.0'	swim	220º	0	4
19	24-Sep	2	1	70º06.8'	142º11.5'	swim	210º	0	4
19	24-Sep	2	1	70º07.3'	142º11.6'	swim	220º	0	4
19	24-Sep	1	0	70º10.8'	142º12.1'	swim	240º	0	4
19	24-Sep	3	0	70º14.0'	142º12.2'	swim	220º	0	4
19	24-Sep	4	0	70º15.2'	142º18.1'	swim	220º	0	4
19	24-Sep	2	1	70º18.1'	142º52.3'	swim	80º	0	4
19	24-Sep	1	0	70º18.1'	142º52.3'	swim	70º	0	4
19	24-Sep	3	0	70º14.1'	142º57.5'	swim	270º	0	4
19	24-Sep	1	0	70º07.0'	144º59.8'	swim	240º	0	3
20	26-Sep	1	0	71º17.3'	154º34.6'	dead	0º	0	2
20	26-Sep	1	0	71º21.3'	155º12.0'	swim	270º	0	2
20	26-Sep	1	0	71º19.1'	155º48.5'	swim	330º	0	2
20	26-Sep	1	0	71º35.9'	156º40.4'	swim	225º	0	3
20	26-Sep	2	0	71º36.7'	156º39.3'	swim	225º	0	3
20	26-Sep	1	0	71º36.7'	156º38.7'	swim	225º	0	3
20	26-Sep	3	0	71º35.1'	156º38.2'	swim	225º	0	3
20	26-Sep	2	0	71º39.2'	156º21.6'	swim	330º	0	2

Flight No	Day	Total Whales	No of Calves	Latitude	Longitude	Behavior	Compass Heading	Ice (%)	Wind Force
20	26-Sep	1	0	71º29.9'	155º41.7'	swim	280º	0	3
20	26-Sep	1	0	71º31.0'	155º42.0'	swim	210º	0	3
20	26-Sep	1	0	71º24.3'	155º20.5'	swim	240º	0	2
20	26-Sep	1	0	71º23.2'	155º20.3'	swim	150º	0	2
20	26-Sep	1	0	71º19.9'	155º18.9'	swim	290º	0	2
20	26-Sep	1	0	71º18.8'	155º19.2'	swim	290º	0	2
20	26-Sep	5	0	71º16.6'	155º20.1'	swim	90º	0	2
20	26-Sep	1	0	71º14.5'	154º58.2'	swim	70º	0	2
20	26-Sep	1	0	71º08.8'	154º09.8'	swim	250º	0	2
20	26-Sep	1	0	71º07.7'	154º09.7'	swim	250º	0	2
20	26-Sep	1	0	71º06.1'	154º13.1'	dive	250º	0	2
20	26-Sep	1	0	71º06.2'	154º11.8'	swim	270º	0	2
20	26-Sep	1	0	71º02.5'	154º26.9'	swim	280º	0	2
20	26-Sep	1	0	71º02.4'	154º13.4'	swim	0º	0	2
20	26-Sep	4	0	71º02.4'	154º17.3'	feed	0º	0	2
20	26-Sep	1	0	71º03.6'	154º16.1'	swim	170º	0	2
20	26-Sep	1	0	71º05.5'	154º14.1'	swim	220º	0	2
20	26-Sep	1	0	71º04.1'	154º12.4'	swim	220º	0	2
20	26-Sep	1	0	71º04.3'	153º55.5'	swim	250º	0	3
20	26-Sep	1	0	71º05.9'	153º55.6'	feed	230º	0	3
20	26-Sep	1	0	71º06.3'	153º55.3'	swim	120º	0	3
20	26-Sep	1	0	71º08.6'	153º54.0'	tail slap	210º	0	3
20	26-Sep	1	0	71º09.7'	153º53.6'	swim	250º	0	3
20	26-Sep	1	0	70º55.1'	151º33.3'	swim	190º	0	4
20	26-Sep	6	0	70º56.1'	151º33.1'	swim	30º	0	4
20	26-Sep	1	0	70º56.8'	150º40.4'	swim	260º	0	3
20	26-Sep	1	0	70º53.8'	150º31.2'	swim	230º	0	3
22	29-Sep	1	0	70º42.4'	148º51.5'	swim	270º	0	3
22	29-Sep	1	0	70º47.8'	149º47.1'	breach	360º	0	3
23	1-Oct	2	0	70º52.5'	149º53.6'	swim	240º	0	4
23	1-Oct	1	0	70º41.2'	149º07.8'	dive	270º	0	5
23	1-Oct	2	0	70º26.8'	147º19.4'	swim	270º	0	3
23	1-Oct	1	0	70º16.9'	146º40.7'	swim	290º	0	3
23	1-Oct	1	0	70º25.4'	146º44.5'	swim	240º	0	3
26	15-Oct	1	0	71º21.3'	156º52.5'	swim	240º	0	3
26	15-Oct	1	0	71º24.0'	156º48.0'	swim	350º	0	3
26	15-Oct	1	0	71º29.7'	156º44.7'	swim	260º	0	5
26	15-Oct	1	0	71º28.8'	156º10.7'	swim	100º	60	2
26	15-Oct	1	0	71º29.9'	155º47.5'	dive	190º	0	4
26	15-Oct	1	0	71º22.5'	154º56.6'	swim	210º	0	4
26	15-Oct	1	0	71º04.3'	153º47.3'	swim	40º	0	2
26	15-Oct	1	0	71º18.2'	153º50.1'	dive	0º	0	5
26	15-Oct	1	0	71º03.6'	153º28.9'	dive	230º	30	2
26	15-Oct	1	0	71º01.6'	152º36.7'	swim	80º	0	4
26	15-Oct	1	0	71º01.6'	152º36.3'	swim	180º	0	6

Flight No	Day	Total Whales	No of Calves	Latitude	Longitude	Behavior	Compass Heading	Ice (%)	Wind Force
26	15-Oct	1	0	71º03.2'	152º35.0'	swim	100º	0	4
28	17-Oct	8	0	70º54.6'	152º07.3'	rest	0º	97	O
28	17-Oct	1	0	70º57.0'	152º20.9'	rest	340º	97	O
28	17-Oct	1	0	70º57.0'	152º20.9'	rest	0º	97	O
28	17-Oct	8	0	70º58.4'	152º32.1'	rest	0º	97	O
28	17-Oct	1	0	70º59.3'	152º40.0'	rest	0º	97	O
28	17-Oct	1	0	71º03.5'	153º09.1'	rest	300º	80	1
28	17-Oct	1	0	71º03.6'	153º10.1'	swim	120º	80	1
28	17-Oct	1	0	71º05.3'	153º29.4'	mill	120º	95	1
28	17-Oct	1	0	71º06.5'	153º48.6'	rest	330º	5	1
28	17-Oct	2	1	71º13.6'	154º31.0'	cow with calf	60º	20	1
28	17-Oct	2	0	71º28.2'	155º06.0'	swim	200º	20	1
28	17-Oct	1	0	71º21.3'	155º04.1'	swim	230º	40	2
28	17-Oct	1	0	71º20.4'	155º03.9'	rest	150º	0	2
28	17-Oct	2	0	71º20.0'	155º03.9'	rest	220º	30	2
28	17-Oct	1	0	71º20.2'	155º06.8'	dive	220º	0	2
28	17-Oct	2	0	71º07.7'	153º11.8'	rest	0º	45	1
28	17-Oct	2	0	71º03.6'	153º10.3'	swim	150º	50	1
28	17-Oct	1	0	71º06.4'	152º53.8'	swim	130º	0	1
28	17-Oct	1	0	71º00.0'	152º04.5'	swim	240º	20	2
28	17-Oct	2	0	70º57.4'	152º04.6'	swim	220º	50	2
28	17-Oct	1	0	70º57.0'	152º10.5'	swim	220º	20	2

APPENDIX C-2002: 2002 Sightings Maps – Other Marine Mammals

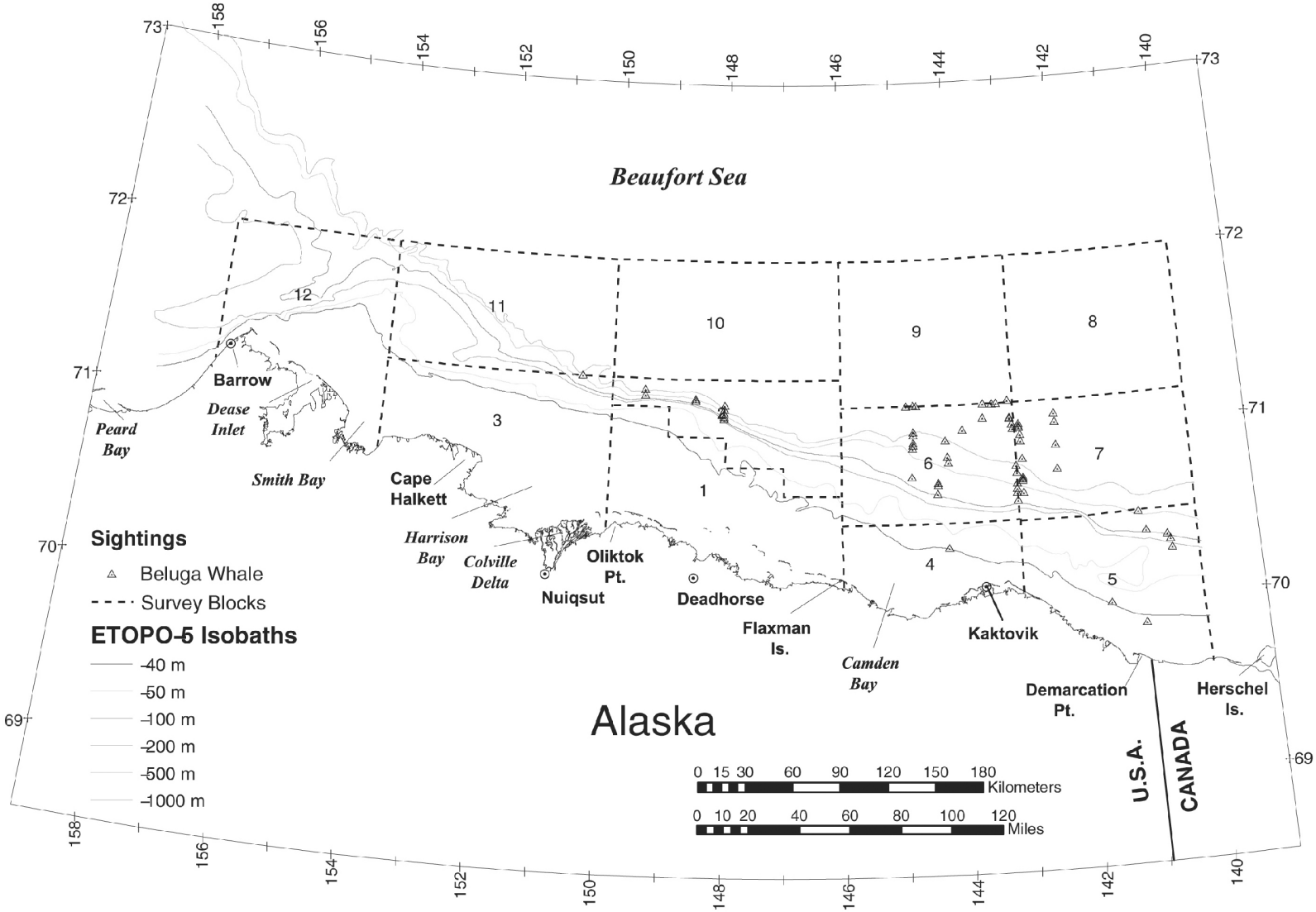

Figure 65 – Map of Beluga Whale Sightings, Fall 2002

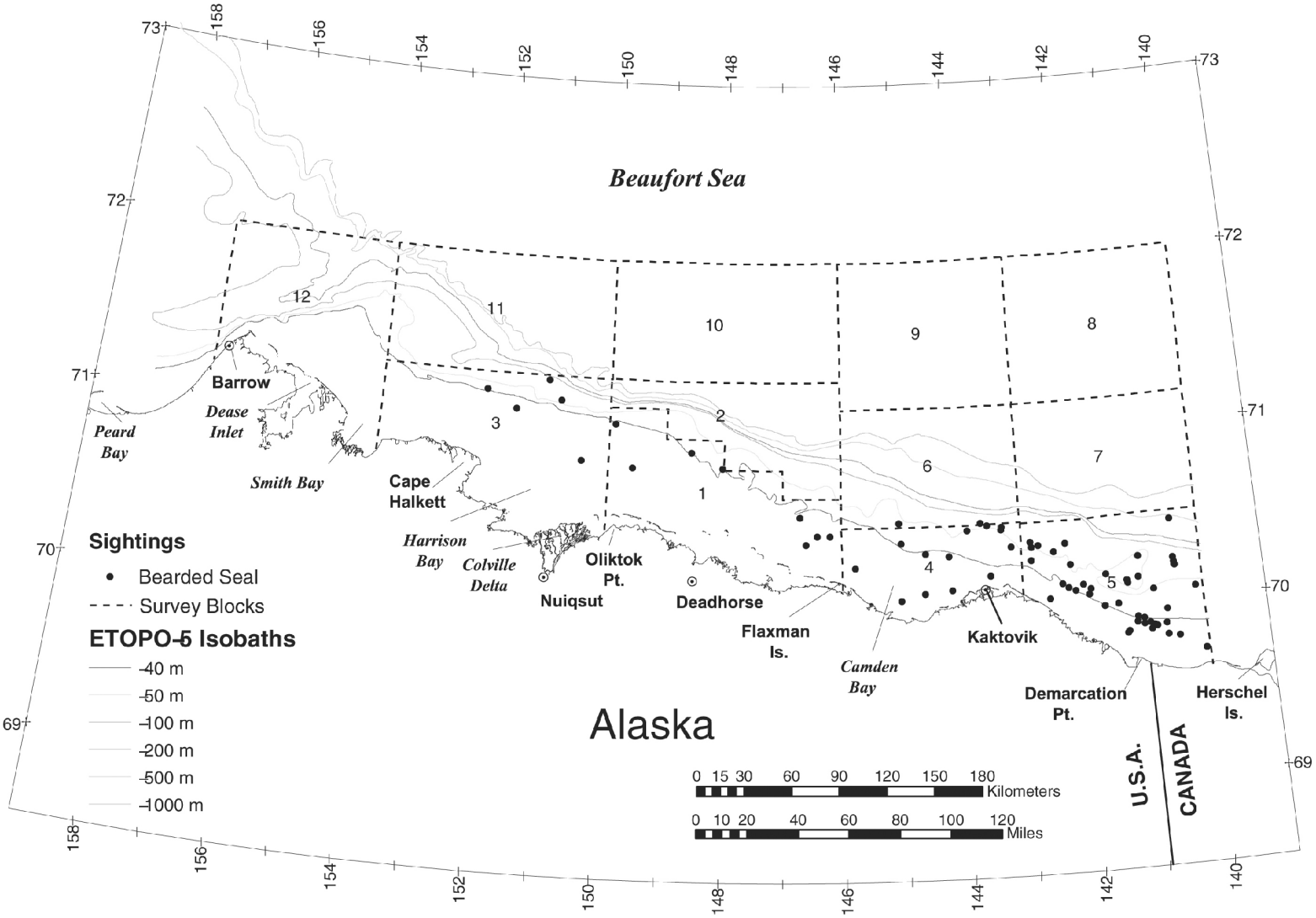

Figure 66 – Map of Bearded Seal Sightings, Fall 2002

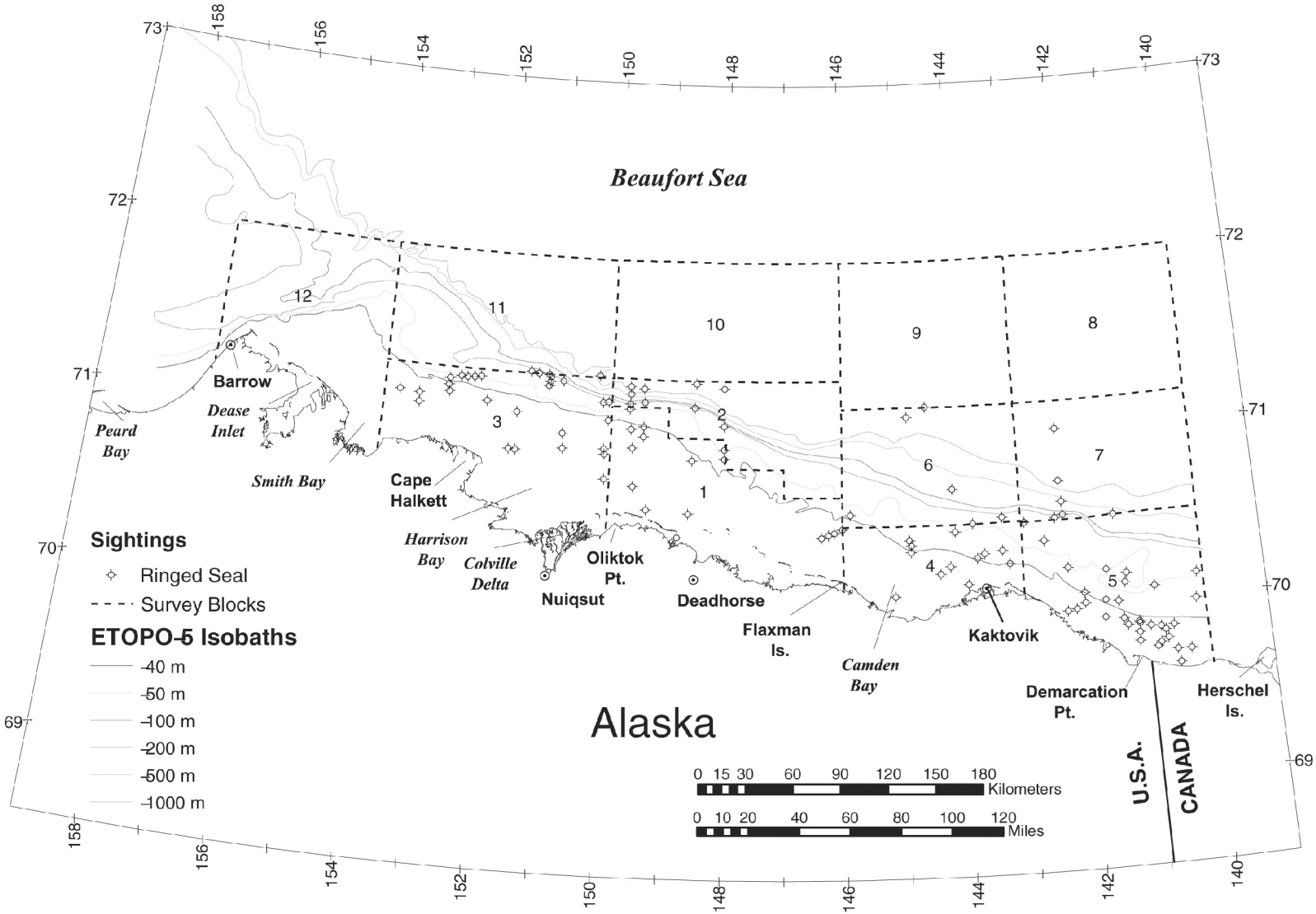

Figure 67 – Map of Ringed Seal Sightings, Fall 2002

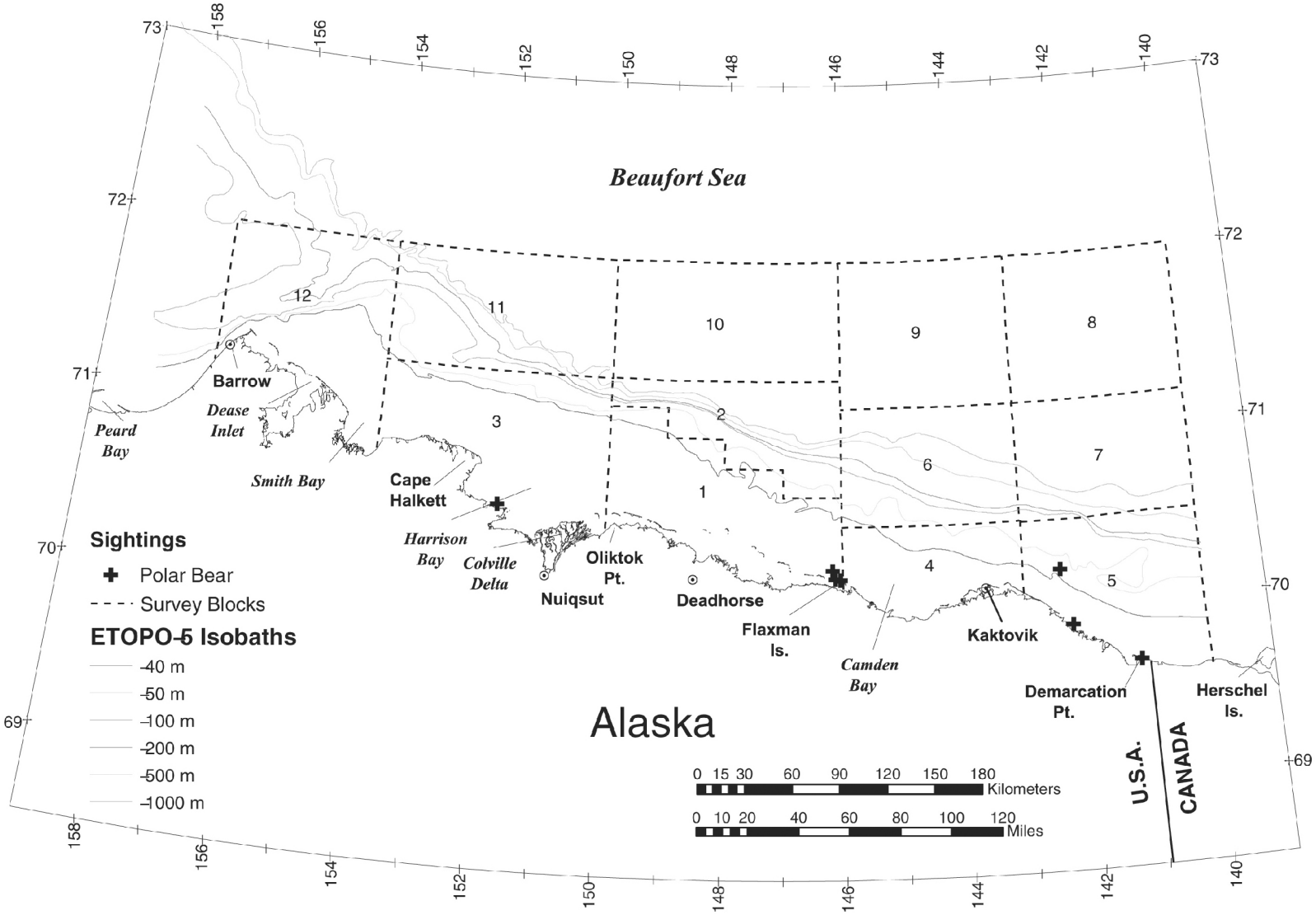

Figure 68 – Map of Polar Bear Sightings, Fall 2002

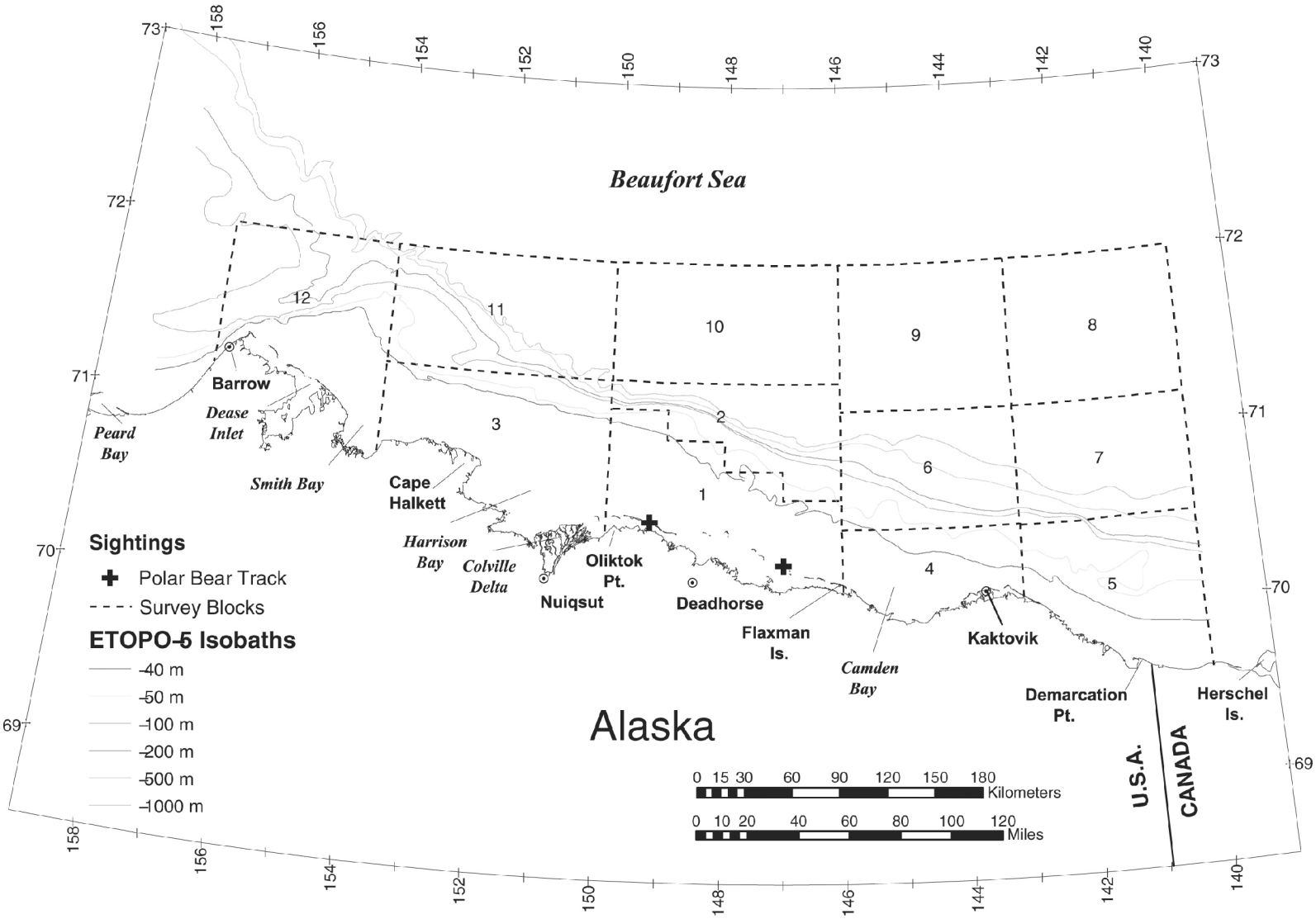

Figure 69 – Map of Polar Bear Tracks, Fall 2002

APPENDIX C-2003: 2003 Sightings Maps – Other Marine Mammals

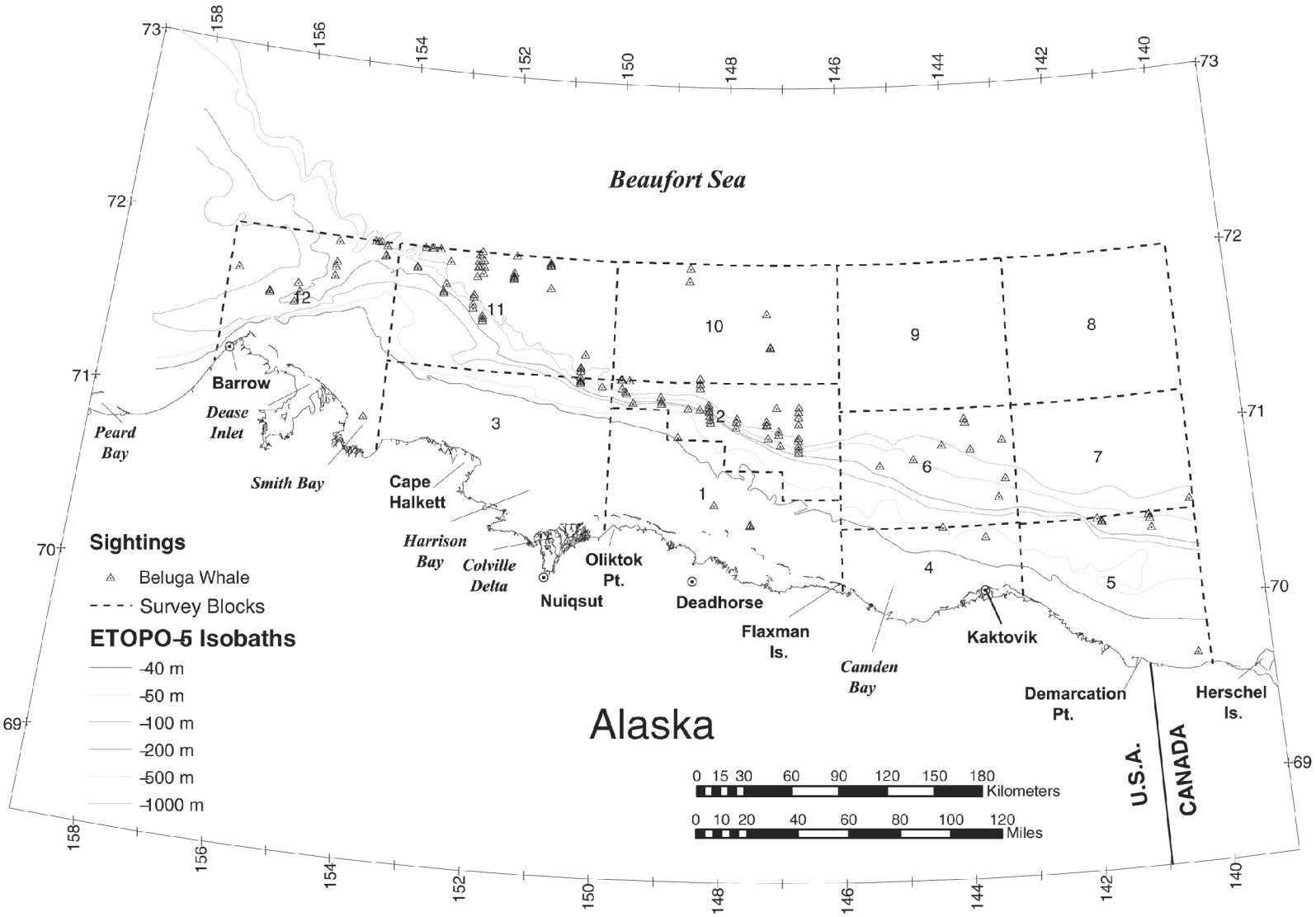

Figure 70 – Map of Beluga Whale Sightings, Fall 2003

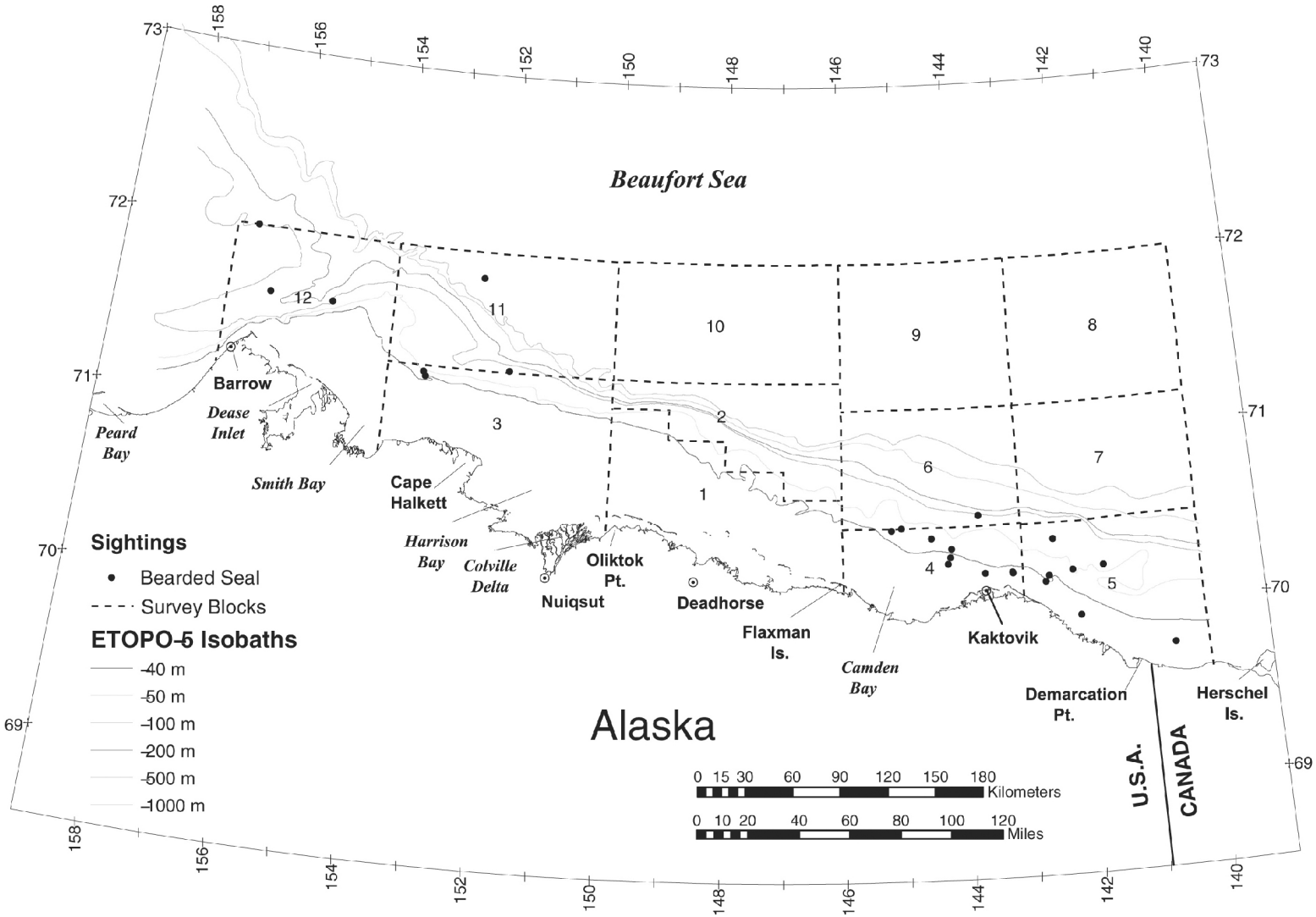

Figure 71 – Map of Bearded Seal Sightings, Fall 2003

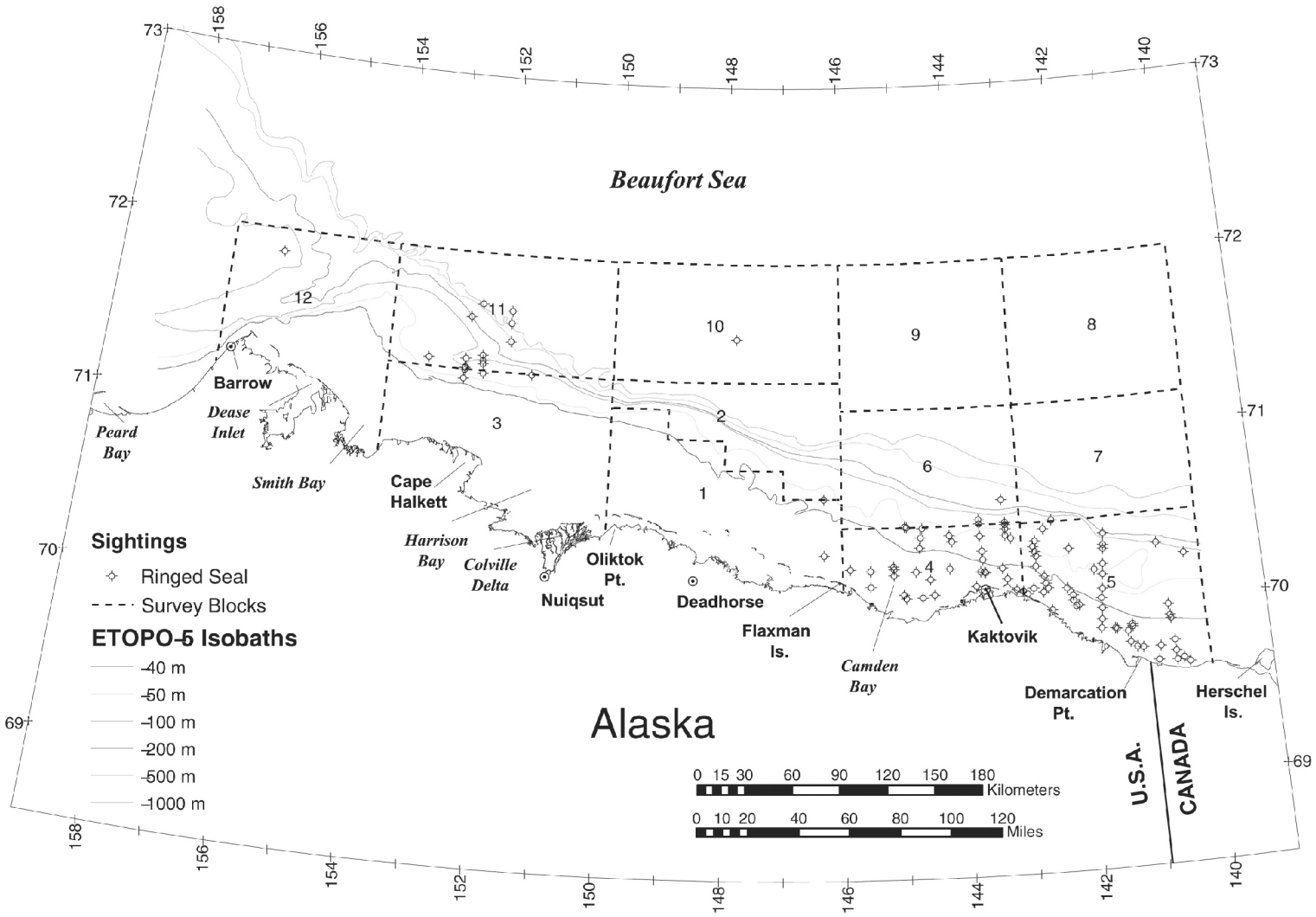

Figure 72 – Map of Ringed Seal Sightings, Fall 2003

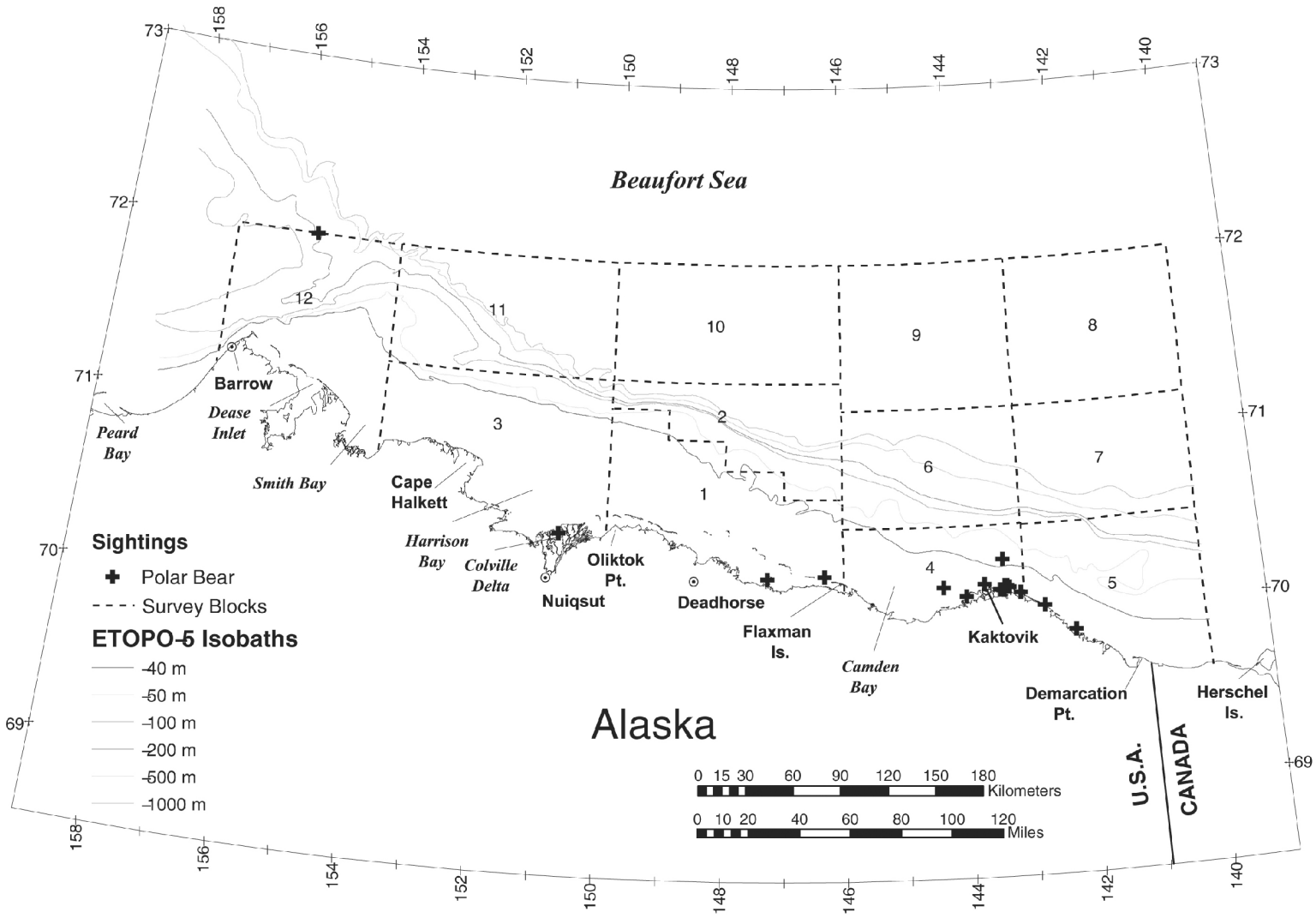

Figure 73 – Map of Polar Bear Sightings, Fall 2003

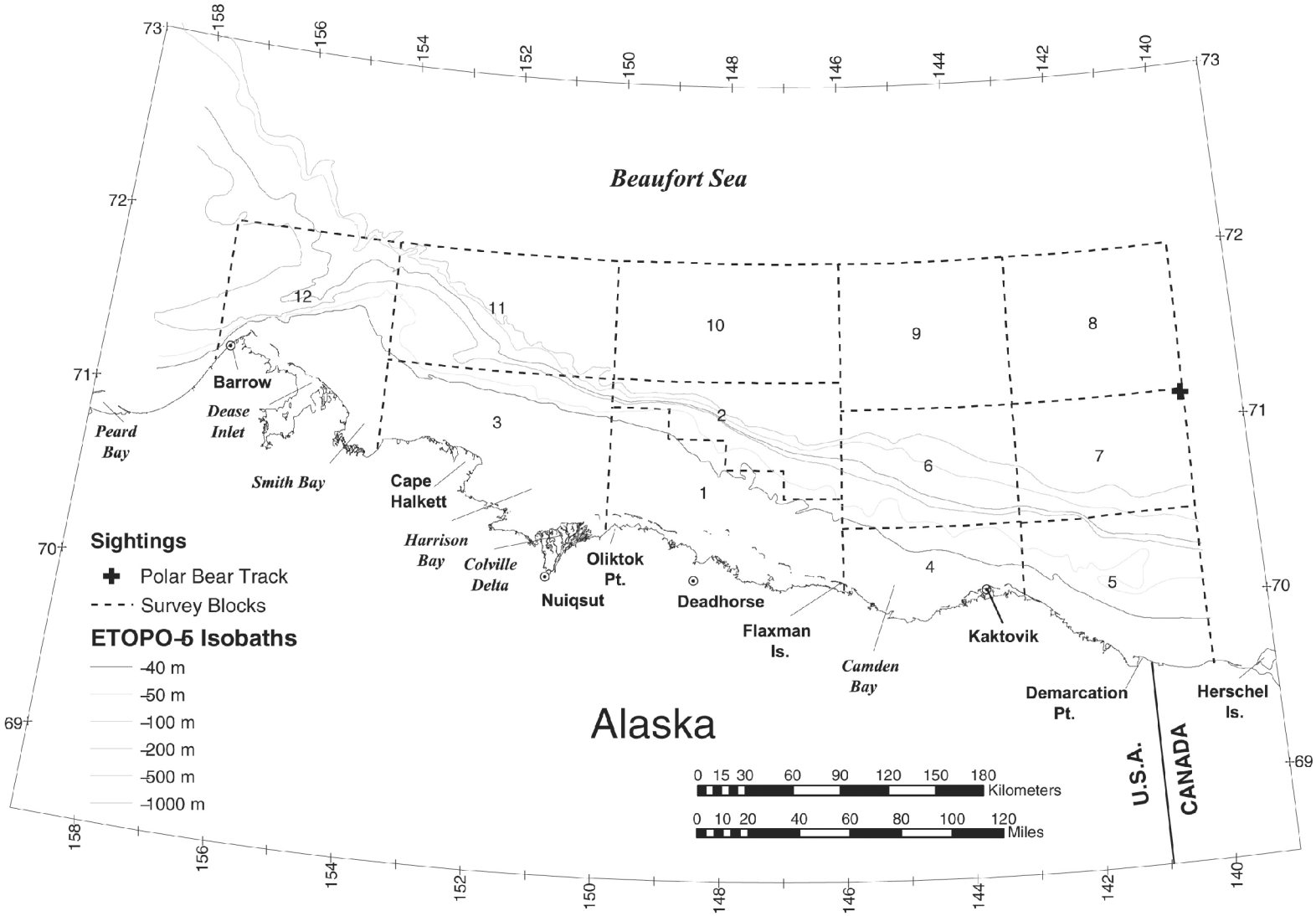

Figure 74 – Map of Polar Bear Tracks, Fall 2003

APPENDIX C-2004: 2004 Sightings Maps – Other Marine Mammals

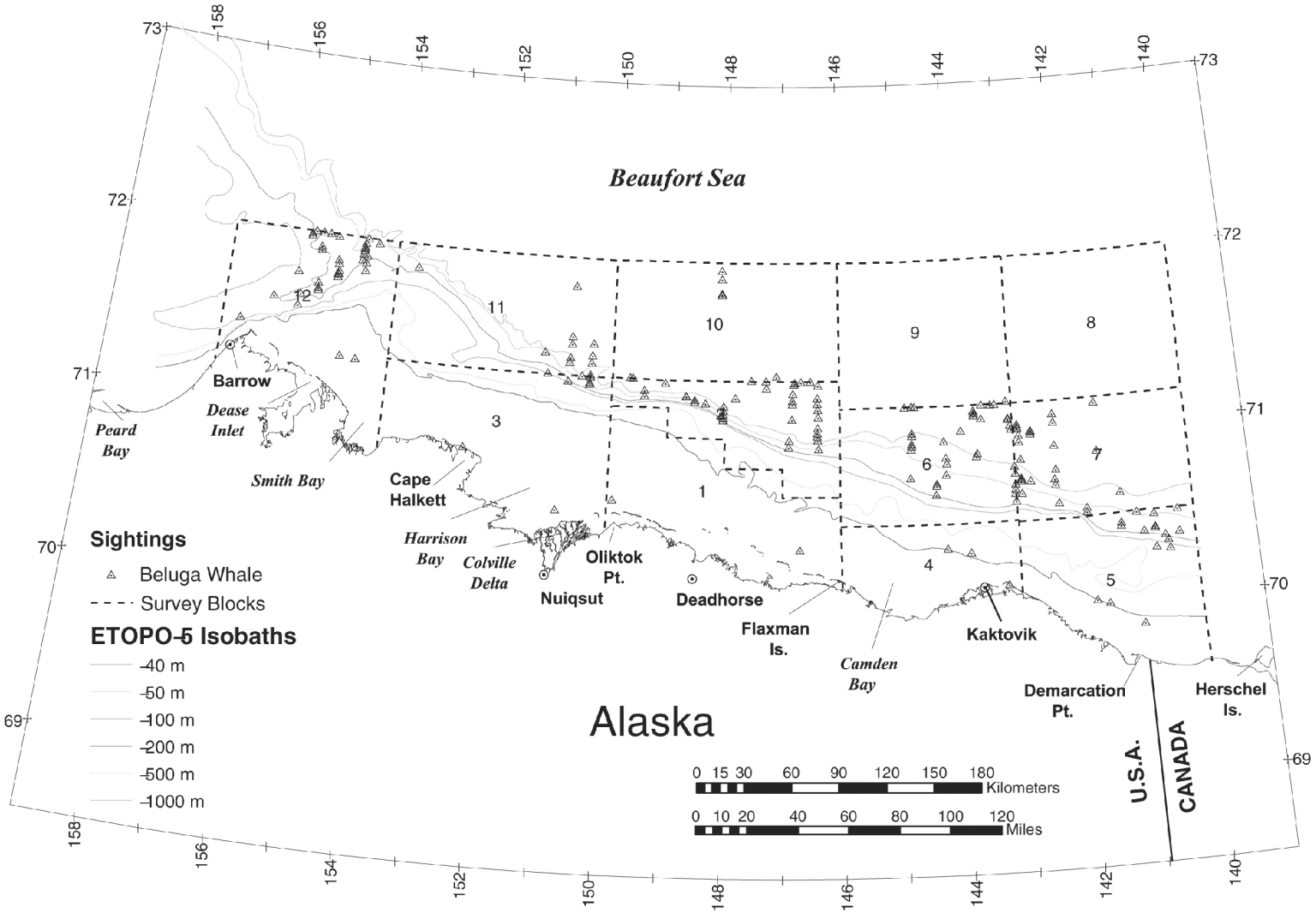

Figure 75 – Map of Beluga Whale Sightings, Fall 2004

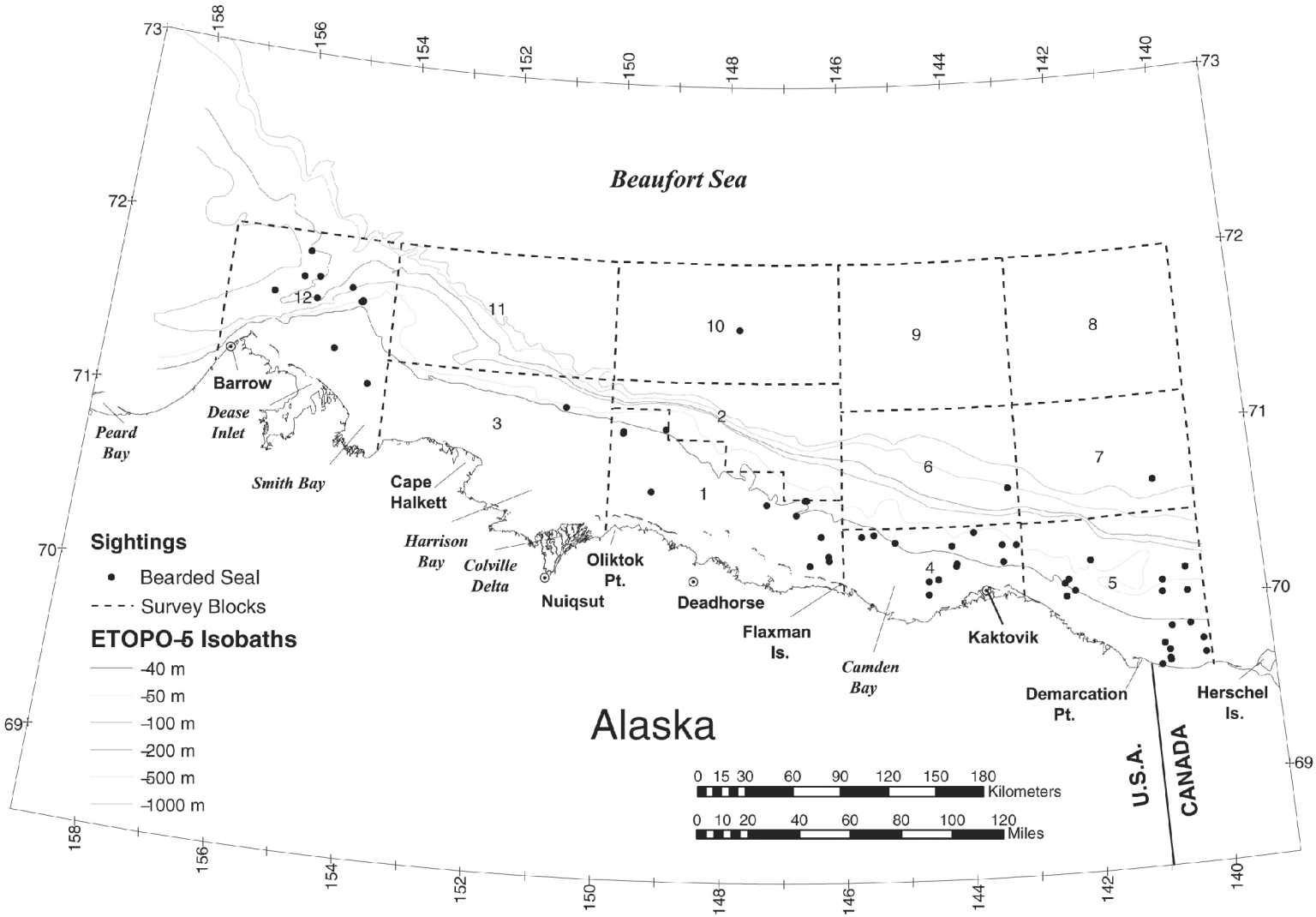

Figure 76 – Map of Bearded Seal Sightings, Fall 2004

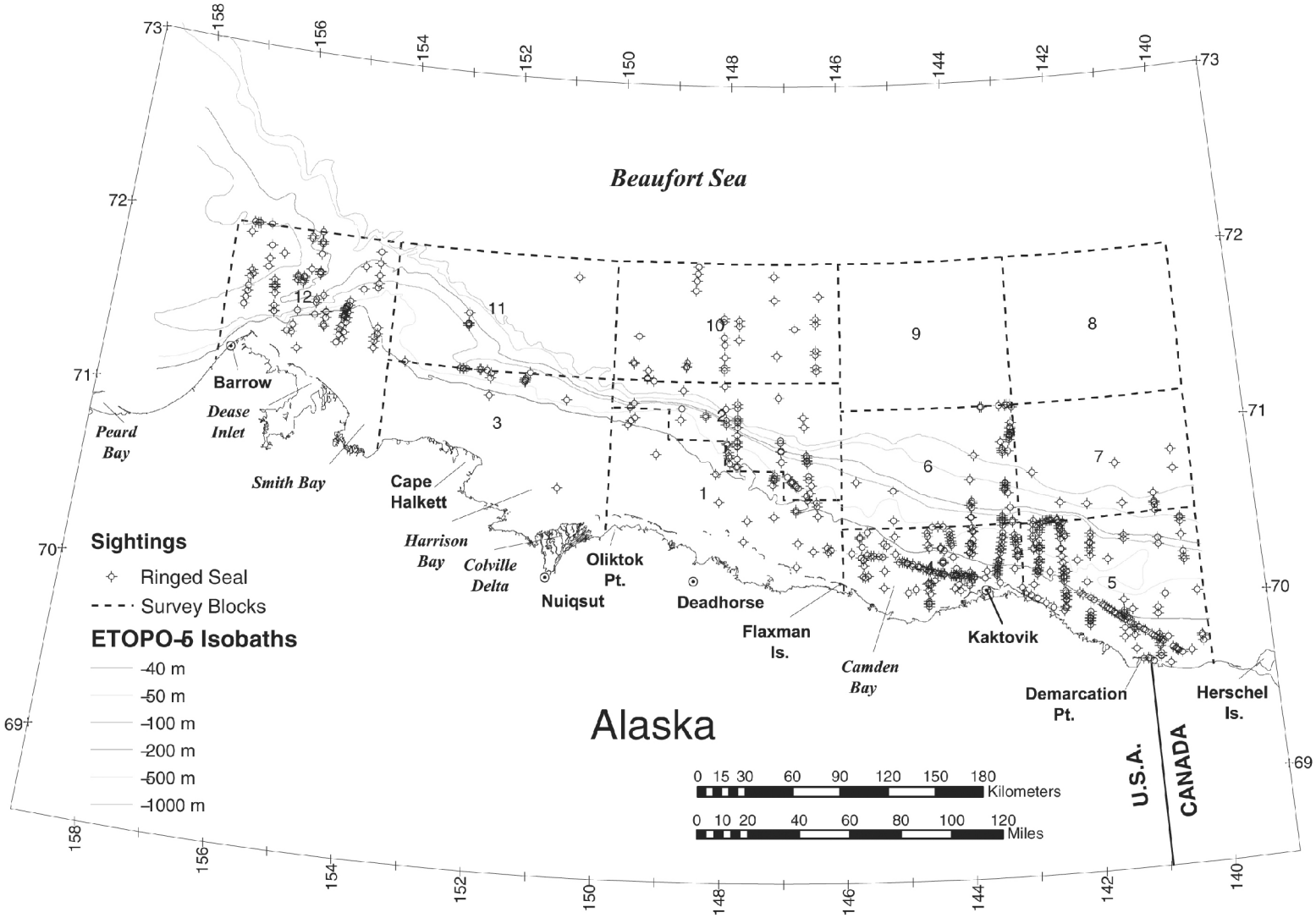

Figure 77 – Map of Ringed Seal Sightings, Fall 2004

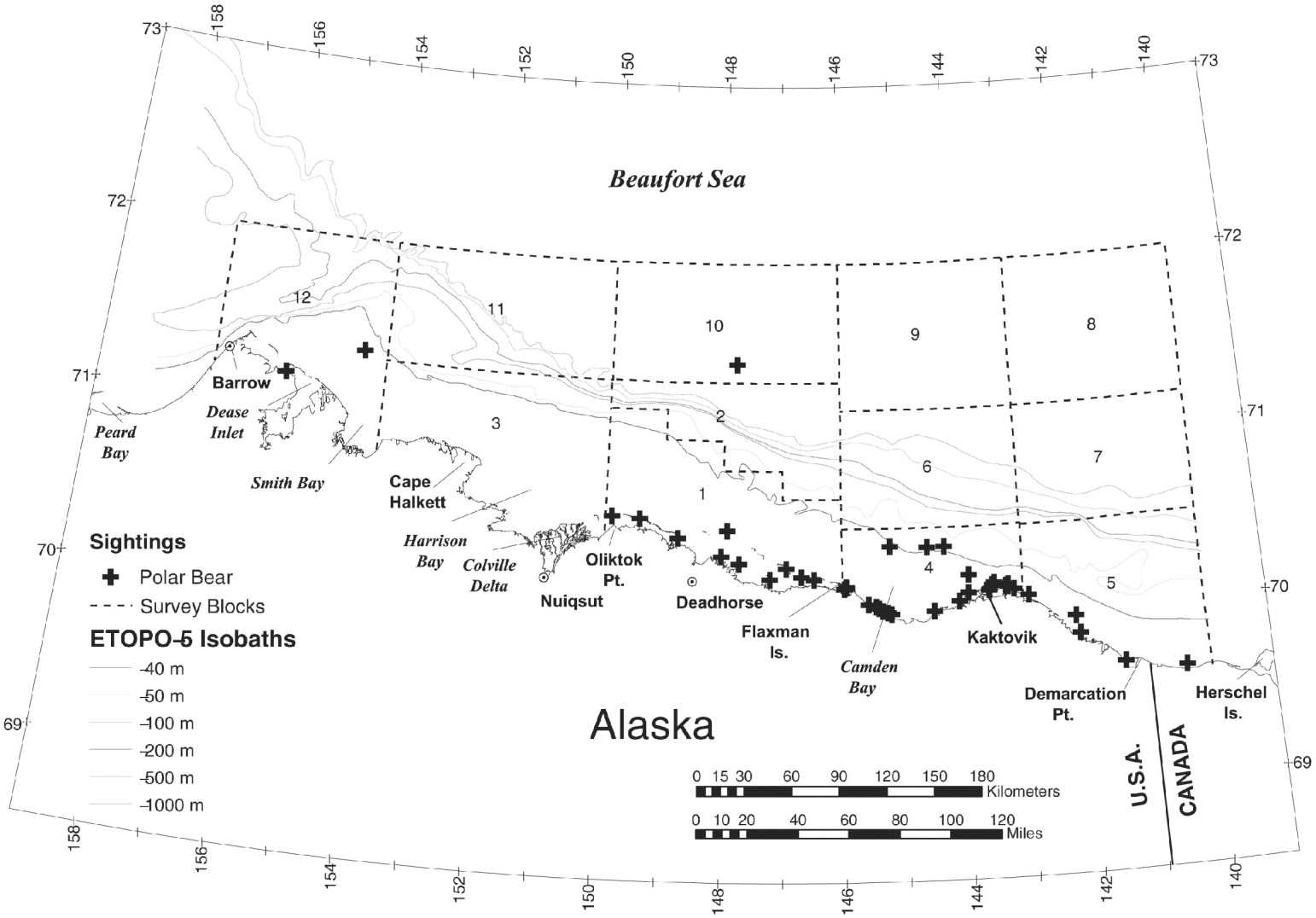

Figure 78 – Map of Polar Bear Sightings, Fall 2004

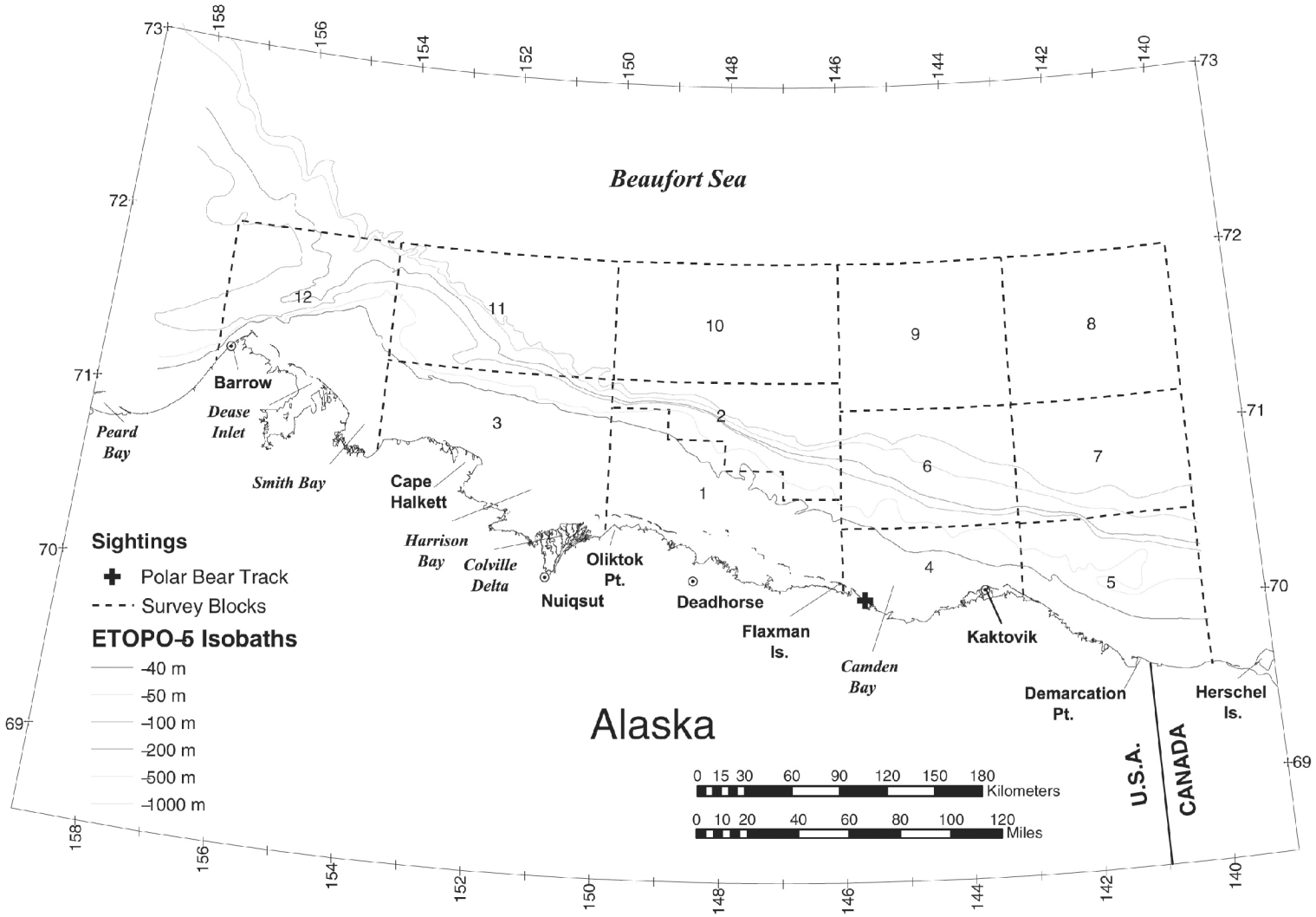

Figure 79 – Map of Polar Bear Tracks, Fall 2004

APPENDIX D: GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND INITIALISMS

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND INITIALISMS

AEWC	Alaska Eskimo Whaling Commission
ANOVA	analysis of variance
BLM	Bureau of Land Management
BWASP	Bowhead Whale Aerial Survey Project
CI	confidence interval
e.g.	for example
ESA	Endangered Species Act
FR	Federal Register
GPS	Global Positioning System
hr	hour
HSD	“honestly significant difference” (Tukey statistical test)
i.e.	that is
k	number of samples
km	kilometer
m	meter
MMS	Minerals Management Service
n	sample size
NOAA	National Oceanic and Atmospheric Administration
NOS	Notice of Sale
NMFS	National Marine Fisheries Service
nm	nautical mile
NSB	North Slope Borough
OAS	Office of Aircraft Services
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
p	probability
SD	standard deviation
SPUE	sightings per unit effort (sighting rate)
trSI	transect sightings
USC	U.S. Code
USDOC	U.S. Department of Commerce
USDOD	U.S. Department of Defense
USDOI	U.S. Department of the Interior
WPUE	whales per unit effort (index of relative abundance or occurrence)

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 U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Royalty Management Program** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.