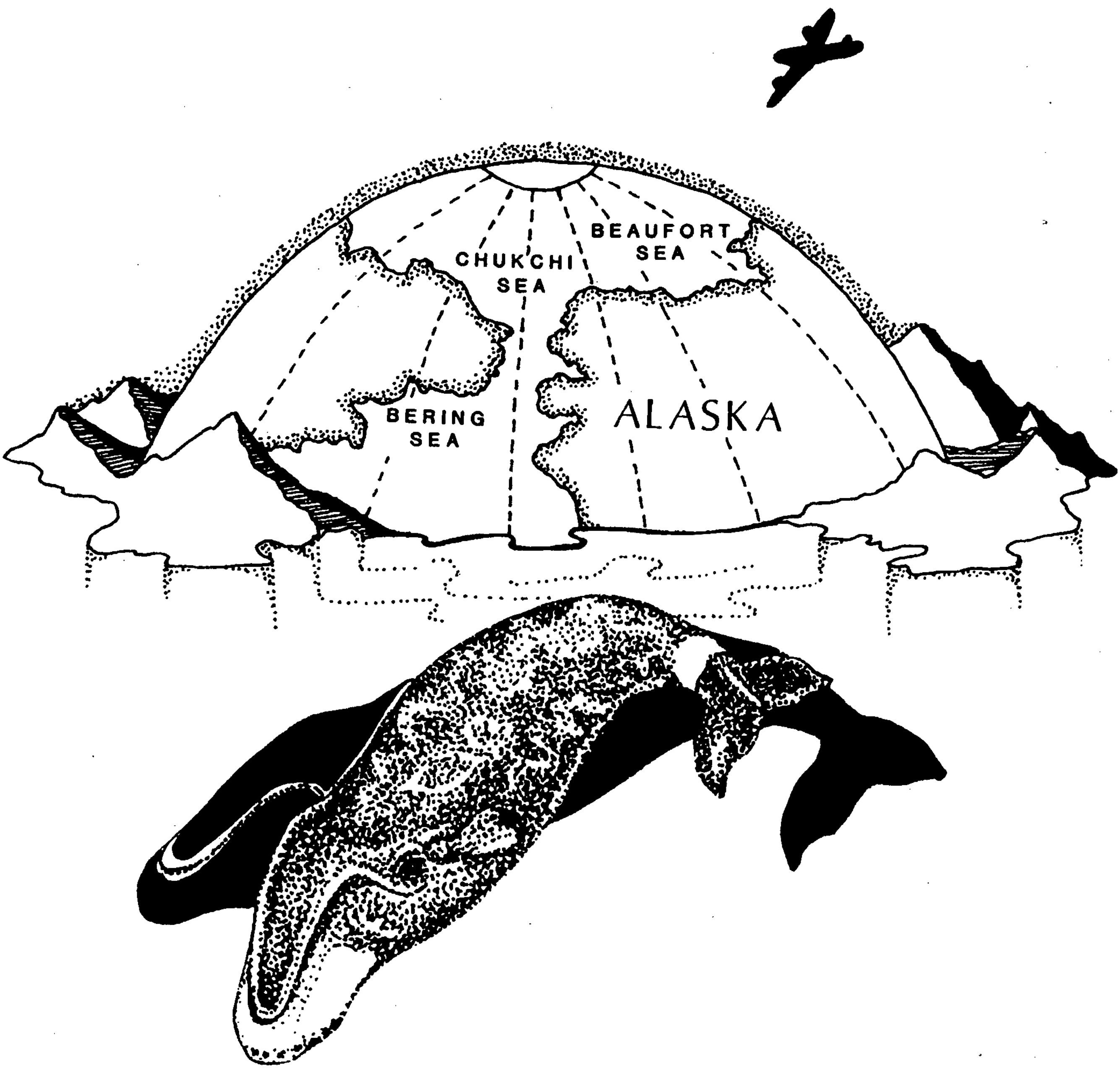
Aerial Surveys of Endangered Whales in the Beaufort Sea, Fall 1997

OCS Study
MMS 98-0059



MMS
U.S. Department of the Interior
Minerals Management Service
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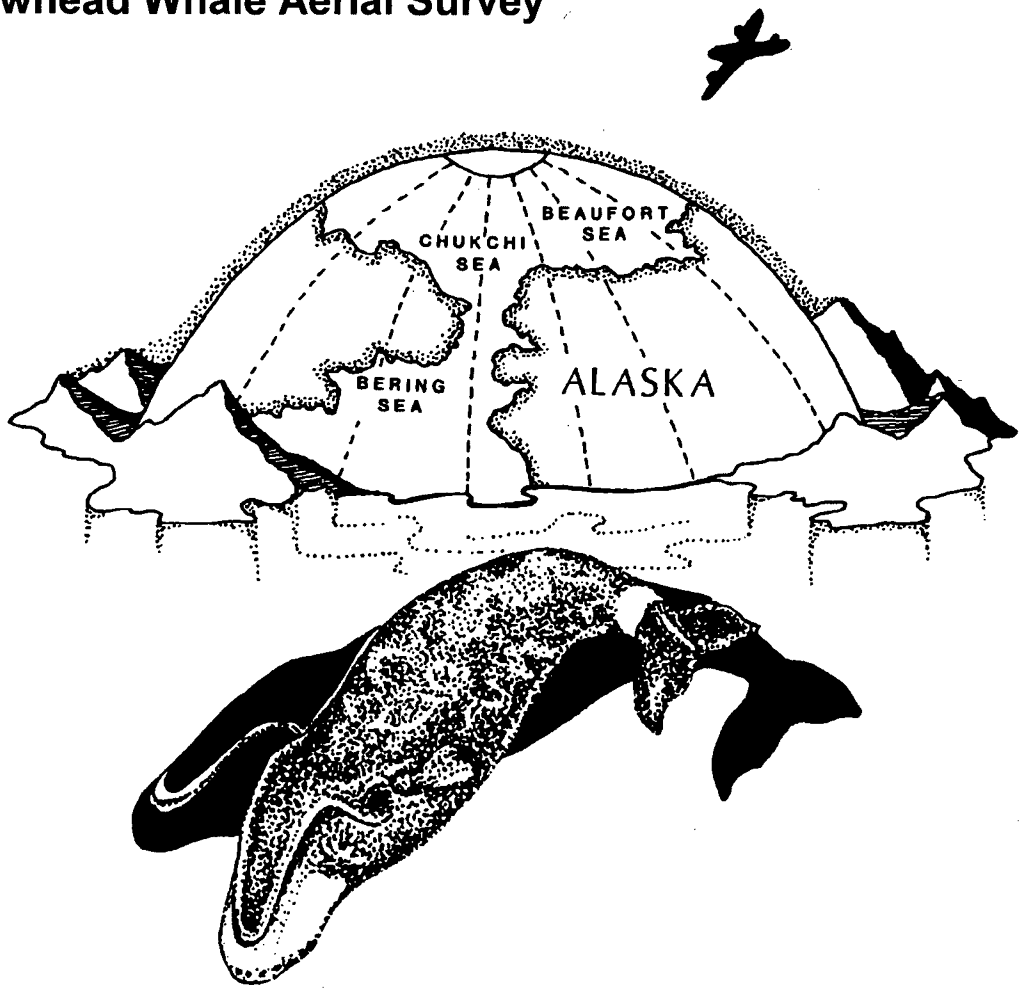
By Stephen D. Treacy, Research Manager
MMS Bowhead Whale Aerial Survey



U.S. Department of the Interior
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Anchorage, Alaska
1998

ABSTRACT

This report describes field activities and data analyses for aerial surveys of bowhead whales conducted between 31 August 1997 and 19 October 1997 in the Beaufort Sea, primarily between 140°W. and 157°W. longitudes south of 72°N. latitude. General ice cover during September and October 1997 was extremely light. The very high number of sightings of bowhead whales (n=437) as well as the very high number of individual bowhead whales counted (n=1,655) likely resulted from favorable open-water conditions along with some repeat counting between days of large aggregations of feeding and/or milling whales that appeared to remain in the same area for several days. The 1,655 bowhead whales, 398 beluga whales, 9 gray whales, 1 unidentified cetacean, 8 bearded seals, 311 ringed seals, 19 unidentified pinnipeds, 50 polar bears, and 8 sets of polar bear tracks were observed during 123.62 hours of survey effort that included 59.27 hours on randomized transects. The initial sighting of bowhead whales in Alaskan waters occurred on 3 September, when 164 bowheads were sighted, of which 129 were feeding when first observed. Of all bowhead whales observed, half (median) had been counted by 2 October. The peak count (mode) of 400 whales also occurred on 2 October. The last sightings of bowhead whales in the primary study area occurred in 80-percent ice in western Blocks 3 and 12 on 18 October, as 95-100% new sea ice concentrations were forming over most of the study area. The relatively small median distances from shore and small median water depths at bowhead sightings in Fall 1997, in both East and West Regions of the study area, are consistent with a tendency for bowheads to migrate closer to shore and in shallower water during years of light general ice cover.

The parametric ANOVA for distance of bowhead whales from shore showed strongly significant differences among years in both oceanographic regions. A preliminary power analysis of the ANOVA (α=0.05, $\beta \leq 0.01$) for distance from shore showed minimum detectable differences of 7.8 km in the East Region of the study area and 9.7 km in the West. The Tukey HSD test of randomized bowhead sightings between years showed that their region-wide migration corridor in Fall 1997 was significantly closer to shore in the East Region, and not significantly different in the West Region, than in 1994 or 1995, years with no offshore seismic exploration or drilling activity during the fall season in the Alaskan Beaufort Sea. Because the water-depth data were highly skewed (skewness=7.441 for the East Region and 9.732 in the West), nonparametric procedures were applied. The Kruskal-Wallis ANOVA of ranks and Mann-Whitney U tests showed significant differences in mean water depth among years and between pairs of years. The potential for performing power analysis (or surrogate power analysis) of these nonparametric tests is being assessed.

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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 the National Marine Fisheries Service (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. After reviewing available information on the two species, 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 Arctic Region sales—including a regional biological opinion; a revised opinion relative to the joint Federal/State lease area; and opinions on Sales 71 (issued in 1982), 87 (issued in 1983), 97 (issued in 1987), and Arctic Region sales (issued in 1988)—recommended continuing studies of whale distribution and OCS-industry effects on bowhead whales (USDOC, NOAA, NMFS, 1982, 1983, 1987, 1988). The Arctic Region Biological Opinion was used by NMFS for subsequent sales in the Beaufort Sea (Sale 124 in 1991 and Sale 144 in 1996). These opinions also requested monitoring of bowhead whale presence during periods when geophysical exploration and drilling are occurring.

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). Three subsequent lease sales in the Beaufort Sea, Sale 97 (1988), Sale 124 (1991), and Sale 144 (1996), have not included a seasonal drilling restriction. The NOS for each of these sales contains an Information to Lessees clause that "MMS intends to continue its areawide endangered whale monitoring program in the Beaufort Sea during exploration activities" (USDOI, MMS, 1988, 1991, 1996). The information gathered will provide additional assistance to 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 (NOSC) 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 field work and reporting activities for the Beaufort Sea on an annual basis. Previous survey reports are available for inspection at the Minerals Management Service, Alaska OCS Region, Resource Center, 949 East 36th Avenue, Anchorage, Alaska 99508-4363.

The present goals of the ongoing program for monitoring endangered whales are to:

1. 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 implementing overall limitations on seasonal drilling and geological/geophysical exploration;

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

3. Provide annual analyses of long-term interyear trends in the median depth (or north-south positioning) of the migration axis of bowhead whales;

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

5. Monitor behaviors, swim directions, dive times, surfacing patterns, and tracklines of selected bowhead whales;

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

7. 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 is based on a design of random field transects within established geographic blocks in and adjacent to Chukchi and Beaufort Sea sale areas offshore of Alaska. The present study, which was focused on the bowhead whale migration from 31 August 1997 to 19 October 1997, included Beaufort Sea Survey Blocks 1 through 12 (Fig. 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).

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 windspeed 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: N302EH). 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

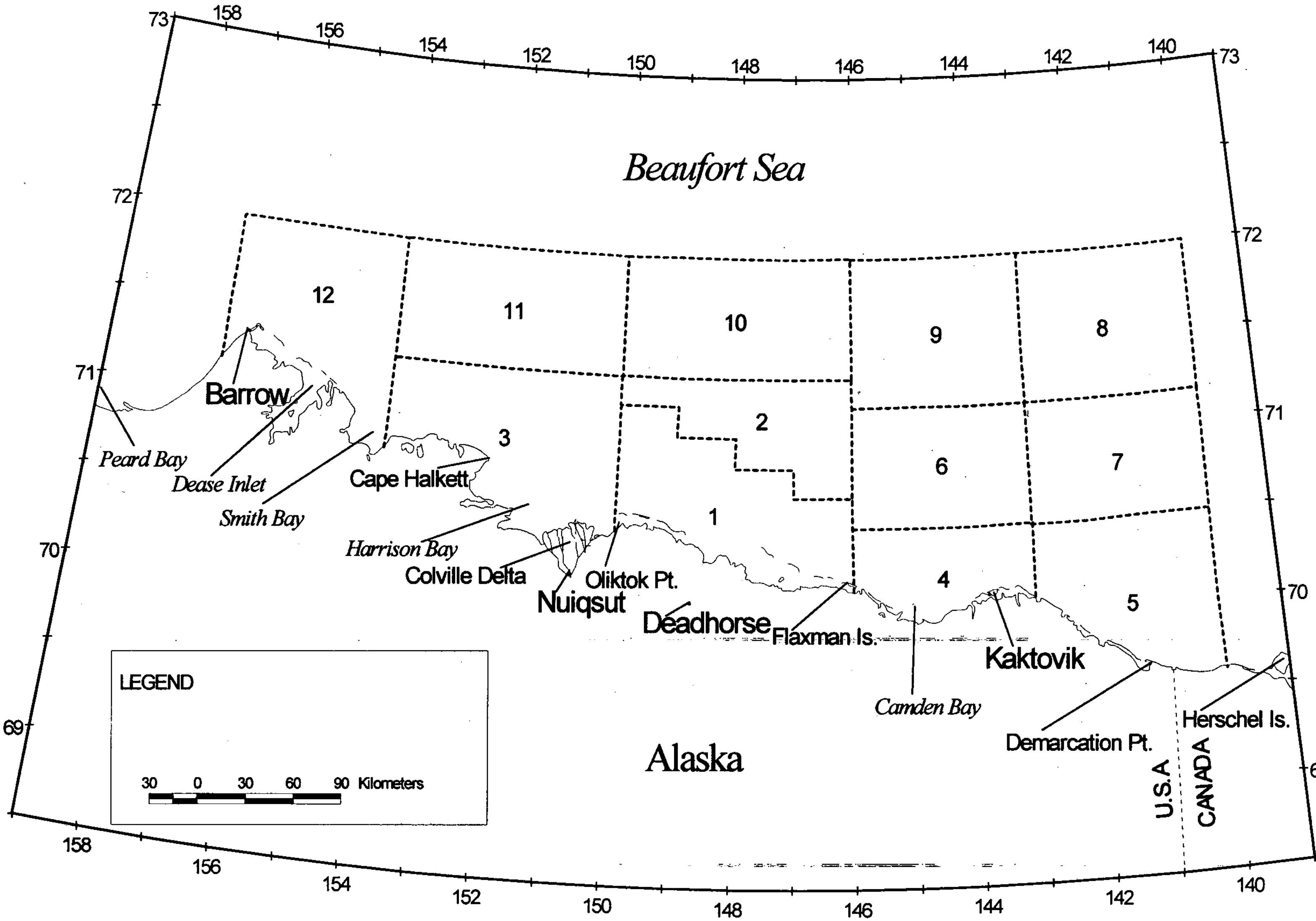


Figure 1. Fall 1997 Study Area Showing Survey Blocks

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.

Avionics included a Flight Management System (FMS) by ARNAV Systems, Inc., part of which was a Global Positioning System (GPS). The FMS 5000, Model GPS-505, is a worldwide satellite-based system that provides continuous position updating (15-m precision) and survey navigation through preprogramming of transect start and end points. Electronic signals from the GPS were converted into an RS 232 serial stream; and data were polled every second for automatic input of time, latitude, longitude, and flight altitude. The GPS altitude (27-m precision) that was used exceeded the accuracy of the radar altimeter (32 m at the target altitude of 458 m). System components required 115-volt alternating current (AC) power, which was supplied by a direct current-AC invertor connected to the aircraft electrical bus.

A portable AST Premium Exec 386SX/20 computing system was used aboard the aircraft to store and analyze flight and observational data. A small, portable Kodak Diconix 150 Plus inkjet printer was used to produce tractor-fed hard copy and to plot onboard flight maps.

Onboard safety equipment included an impact-triggered emergency locator transmitter (ELT) installed in the aircraft, a portable ELT in a 6-person Switlik Search and Rescue Life Raft, a portable aircraft-band transceiver, a portable GPS, cold-water immersion suits, Nomex flight suits, and emergency crash helmets.

Flight-following equipment used during the 1997 field season featured an experimental Radio Determination Satellite System (RDSS), developed by Mobile Datacom Corporation (MDC), that tracked the project aircraft over the Alaskan Beaufort Sea. The RDSS used three toggled patch antennas, two of which were mounted externally on the aft section of the fuselage and one which was installed in the nose of the aircraft for greater radial coverage. Data on latitude, longitude, time, and other parameters were obtained from the aircraft's GPS and broadcast every minute through the patch antennas to a satellite that was stationary over the equator at 87°W. longitude. Real-time satellite signals were relayed to MDC in Clarksburg, Maryland, where OAS queried the RDSS every 15 minutes to obtain current flight-following information. The information was displayed as digital data on a computer screen and in the form of a map for visual tracking of the survey aircraft. When west of the satellite coverage area, an aircraft-band very-high-frequency radio was used to transmit periodic position data to Barrow Flight Service. In addition to RDSS flight following, the onboard transponder was set at a discrete identification code for radar tracking by air-traffic-control personnel.

C. Aerial-Survey Design

Aerial surveys were based out of Deadhorse, Alaska, from 31 August through 19 October 1997. The field schedule was designed to monitor the progress of the Fall 1997 bowhead migration 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 fine-scale shifts in the migration pathway of bowhead whales in this area 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 produced 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 to designate one end of a transect leg. The other endpoint of the transect leg was determined similarly using a separate randomly generated number along the southern edge of the same section. A straight line, representing one transect leg, was drawn between the two points. The same procedure was followed for all sections of the survey block. 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 also uses 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, 1997a), greatly favor survey coverage in inshore Survey Blocks 1 through 7 and 11 (Fig. 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.

Random-transect legs were used for obtaining data to analyze the migration axis, using a line-transect model. Nonrandom surveys were flown to further identify whales and their behaviors when sighted adjacent to a transect line or when in transit to a transect block.

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. This altitude was maintained—when weather permitted—in order to maximize visibility and 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."

E. Data Entry

A computer program developed by project personnel was used to record all data. Time of day was maintained by the computer and recorded at each entry. Greenwich Mean Time, local time, latitude, longitude, and altitude as well as a question list and the main menu selections were shown continuously on the computer monitor. The program is menu-driven, facilitating entry of a complete data sequence for sightings of endangered whales. An abbreviated data-entry format was available whenever several whale pods (the use of the term pod includes sightings of any single animal or group of nearby animals whose respiration patterns appear to be synchronous) were sighted within a short period of time. To avoid lumping of sightings in areas where whales were extremely concentrated, an even shorter rapid-sighting update was used. A position-update format including data on weather, visibility, ice cover, and sea state was entered at turning points, when changes in environmental conditions were observed, and otherwise within 10-minute intervals. All entries were coded to reflect the type of survey being conducted. Table 1 shows the data-entry sequence used in 1997 and the questions used to prompt entry of observational data. All data entered 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 14 categories as noted on previous surveys. These categories—breaching, cow-calf association, diving, feeding, flipper-slapping, log playing,

Table 1
Data-Entry Sequence on the Portable Flight Computer

Sequence	Position Update	Large Whale Sightings	Polar Bear or Belukha Whale Sightings	Other Species
1. Entry number	X	X	X	X
2. Time	X	X	X	X
3. Latitude	X	X	X	X
4. Longitude	X	X	X	X
5. Altitude	X	X	X	X
6. Reason for entry	X	X	X	X
7. Search type	X	X	X	X
8. Species		X	X	X
9. Sighting cue		X		
10. Habitat		X	X	X
11. Behavior		X	X	X
12. Size		X		
13. Total number		X	X	X
14. Calf number		X	X	X
15. Clinometer angle		X		
16. Side of plane		X		
17. Swim direction		X	X	
18. Swim speed		X		
19. Aircraft response		X	X	X
20. Repeat sighting		X		
21. Observer		X	X	
22. Weather	X	X	X	X
23. Visibility right	X	X	X	X
24. Visibility left	X	X	X	X
25. Ice coverage	X	X	X	X
26. Ice type	X	X	X	X
27. Sea state	X	X	X	X
28. Water color	X	X	X	X

mating, milling, resting, rolling, spy-hopping, swimming, tail-slapping, and underwater blowing—are defined in Table 2. 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 and whale size were 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; and calf [length less than half of accompanying adult], immature, adult, or large adult, respectively) rather than on an absolute scale. Swim direction was recorded in the field as a magnetic value, 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 within a few kilometers of the aircraft was estimated as a single percentage, regardless of ice type.

F. General Data Analyses

Preliminary data analysis was performed by a computer program—developed by 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. The analysis program provided options for editing the data file, calculating summary values, and printing various flight synopses.

Application software (Grapher, Golden Software, Inc.) was used to plot daily maps of aircraft tracklines and positions of marine mammals observed. To function as a mapping package, coastlines were mapped using an Altec digitizer; and all points on the maps were based on number of meters north or to one side of a central meridian for Universal Transverse Mercator (UTM) Zone 6.

Tables showing the number of survey hours flown for individual days, half-months, or months 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.

An index of relative abundance was derived as whales per unit effort (WPUE = number of whales counted/hr of survey effort) per survey block for bowheads and belugas. The timing of the 1997 bowhead migration through the study area was analyzed as sightings per unit effort (SPUE = number of sightings counted/hr of survey effort) and WPUE per date. Because chance sightings of a few large groups of whales in a short period of time might produce artificially high WPUE values in certain blocks, values based on at least 4.00 hr of survey effort were distinguished when discussing relative abundance between areas.

The water depth at each bowhead sighting in the 1982-1997 database was derived using a computer program—DEPTH—that assigned a metric depth value averaged over gridded areas (each 3 minutes of latitude by 10 minutes of longitude) in the Beaufort Sea west of 139°W. longitude and south of 72°N. latitude. Values assigned to each grid block were initially subjective and were averaged from depths read from NOAA Provisional Chart 16004.

The maps in this report were prepared with application software (ArcView 3.0) based on UTM 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).

Selected isobaths (60 m, 100 m, 500 m, 1,000 m, 2,000 m, 2,500 m, 3,000 m, and 3,500 m) were included in Figure 2 for visual reference only and were not used in data analyses. A point file of ETOPO5 5-minute gridded elevation data (USDOC, NOAA, National Geophysical Data Center, 1988) was downloaded from the National Geophysical Data Center Internet web site (http://www.ngdc.noaa.gov/mgg/global/etopo5.html). ArcView Spatial Analyst was used with these data to generate isobaths.

Table 2
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; calf swimming within 20 m of an adult.
Diving	Whale(s) changing swim direction or body orientation relative to the water surface, resulting in submergence; may or may not be accompanied by 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	Whale(s) swimming slowly at the surface in close proximity (within 100 m) to other whales, often with varying headings.
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.
Underwater Blowing	Whale(s) exhaling while submerged, thus creating a visible bubble.

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 for the period 26 August through 24 October 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 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. Both effort and marine mammal sightings were included on daily flight 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), 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.

G. Analysis of the Bowhead Whale Migration Corridor

The corridor used by bowhead whales during their fall migration was analyzed between years both by mean distance from shore to the whales sighted on randomized transects as well as mean water depth at random whale sightings.

An analysis protocol specifying the use of median water depth to detect interannual shifts in the bowhead migration route was initially described in Chapters 4.2.3 and 5.3.3 of "Beaufort Sea Monitoring Program Workshop Synthesis and Sampling Design Recommendations" (Houghton, Segar, and Zeh, 1984). Because of the bathymetry of the Alaskan Beaufort Sea, a seaward displacement of the fall-migration route would be represented, via this analysis, as a shift to deeper water and a greater median depth.

Comparing the distance from shore to migrating bowhead whales is another method for detecting shifts in their migratory corridor. Distance from shore is of particular interest to North Slope residents who rely on a successful harvest of whales for subsistence purposes. Subsistence whalers generally agree that the farther offshore whales migrate, the riskier whales are to hunt and the more likely carcasses will spoil before reaching the villages (USDOI, MMS, 1997b).

The present analyses provide biological information needed to test the following null hypotheses recommended by the above 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.

1. 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 and water depth at bowhead whale sightings made during random transect aerial surveys in the

Alaskan Beaufort Sea were analyzed for two regions (Fig. 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 (Fig. 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 (Fig. 1). 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

In past years (e.g., Treacy 1997), water depths at random bowhead whale sightings were analyzed for three regions (Regions I, II and III), with boundaries loosely based on a protocol derived in 1982 to estimate whale density (Ljungblad et al. 1982). Furthermore, prior analyses were completed using DOS-based software specially written for those regions. Conversely, the analyses presented here are for broader regions based upon sampling effort and oceanographic patterns (as described above), and were completed using *Statistica™ StatSoft, Version 5.1*. To insure repeatability of results, central tendency and Mann-Whitney U statistics were derived for the 1982-96 Region II dataset using *Statistica™*, then compared to results generated using the DOS-based software. The results generated using *Statistica™* were identical to results from the specialized DOS-based software.

2. Analysis Protocol: The mean distance from shore at bowhead sightings between years were compared employing an analysis of variance (ANOVA) and the Tukey "honestly significant difference" (HSD) test. The ANOVA tests the hypotheses that all mean distances are equal among years. The Tukey HSD test is a multiple comparison procedure that provides statistical comparison of means for any pair of years (Zar, 1984).

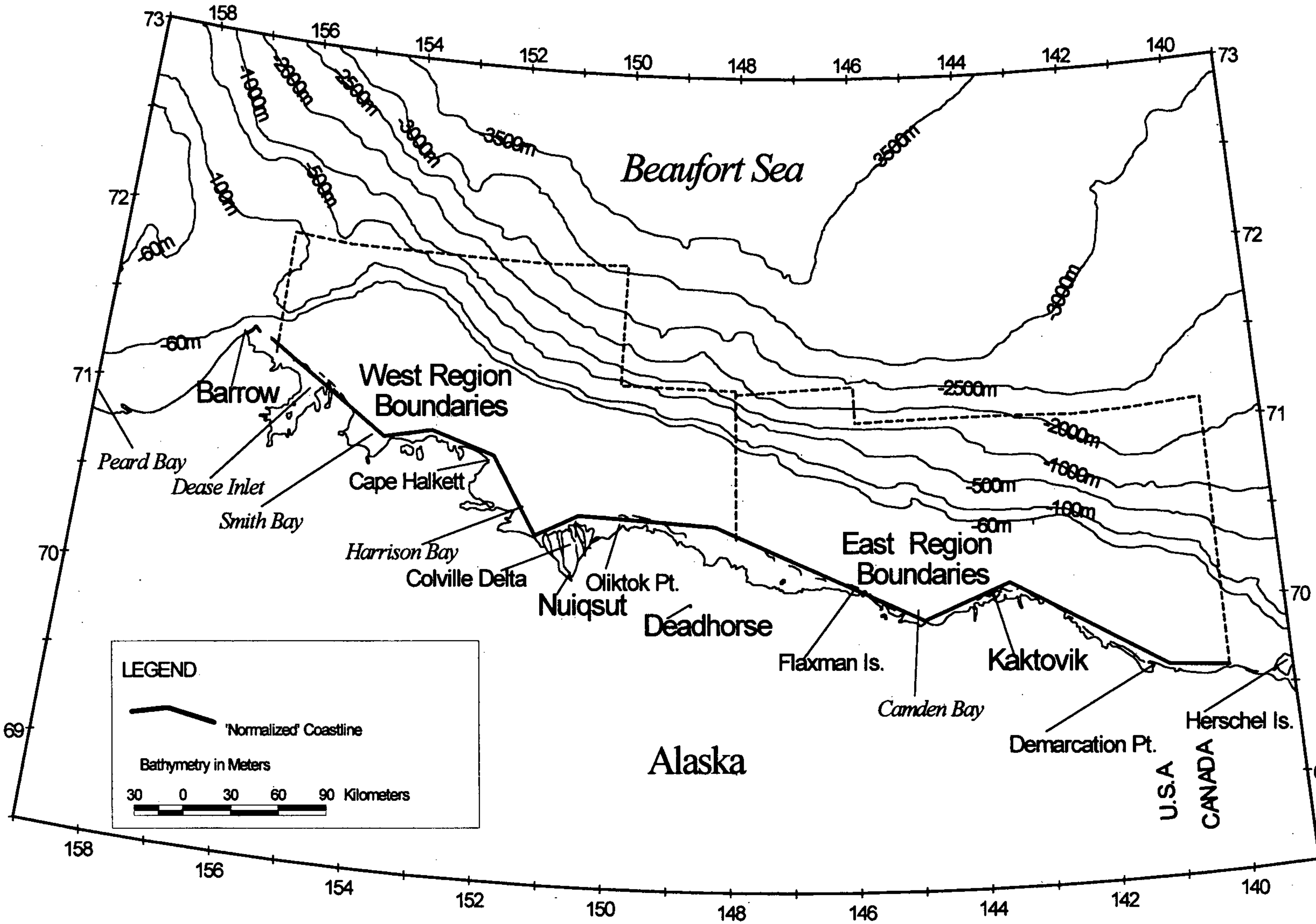


Figure 2. East and West Regions (used in water-depth analyses) and Selected Isobaths

Statistical power is the probability that a test will reject a null hypothesis which is in fact false and should be rejected. The power of the ANOVA to detect differences in distance from shore among mean values was analyzed by region, following the protocol outlined in Zar (1984). Preliminary power was tested at $\alpha=0.05$ and at $\alpha=0.01$ levels of significance. If the number of samples was large (i.e., k=16; $v_1=15$), the graphs of power and sample size in Zar (1984: Fig. B.1) for $\alpha=0.05$ and $\alpha=0.01$ were interpolated. Interpolation resulted in axes values of $\phi=1$ at 0.75 and ∞ at 1.69 for $\alpha=0.05$; $\phi=1$ at 0.44 and ∞ at 1.35 for $\alpha=0.01$. The power analysis presented here should be considered preliminary since subsequent reports will factor in survey effort and autocorrelation as they relate to the number of sightings.

Nonparametric tests were used to analyze water depth at transect sightings, using ranks of data rather than actual measurements. The Kruskal-Wallis (K-W) ANOVA by ranks, which compares ranks when $k>2$, is considered to be 95% as powerful as the parametric ANOVA. When the underlying assumptions of normal distribution and equal variances associated with parametric tests are violated, the K-W may be even more powerful than the parametric ANOVA. The potential for performing power analysis (or surrogate power analysis) of this nonparametric test is being assessed. When the assumption of normal distribution is violated and k=2, the nonparametric Mann-Whitney U may be more powerful than the *t*-test (Zar, 1984).

III. FALL 1997 RESULTS

A. Environmental Conditions

General ice coverage in the Alaskan Beaufort Sea (Figs. 3-11) was extremely light during most of the Fall 1997 surveys. In the last week of August (Fig. 3), the sea ice was mostly north of the study area or was confined to very light (<20%) shore-associated ice from Oliktok Point east into Canada. Throughout the month of September, the study area was entirely free of ice (Figs. 4-7). In early October, a narrow strip of moderate (40-59%) shore-associated ice began forming along the central Beaufort coast (Fig. 8). By 10 October, the shore-associated ice had solidified to heavy ice (60-79%) all along the coastline, and the offshore ice moved into the northeast corner of the study area (Fig. 9). By 17 October (Fig. 10), the shore-fast ice had become near-solid (>94%) while moderate (40-59%) to near-solid (>94%) offshore ice covered most the eastern half of the study area. By 24 October (Fig. 11), the entire study area was covered in near-solid (>94%) ice, except for a small area of open water north of Barrow. Ice percent at each sighting of endangered whales is shown in Appendix A (Table A-1).

Other environmental conditions during Fall 1997 were considered fair for observing whales at or near the surface, permitting 36 flights during that period. High sea states, most notably during mid-September and the first half of October, limited the number of flights or otherwise reduced the ability of observers to spot whales near the surface or at great distances from the transect centerline. Sea states at each sighting of endangered whales are shown in Appendix A (Table A-1). Cloud ceilings over portions of the study area were often lower than the target-survey altitude of 458 m, most notably during early and mid-September.

B. Survey Effort

Daily totals of kilometers and hours flown per survey flight are shown in Table 3. A total of 28,701 km of surveys were flown in 123.62 hours in the study area at an average speed of 232.17 km/hr. The average survey flight was 797.25 km, with flights ranging from 0 km to 1,704 km of over-water survey. Mean survey time per flight was 3.43 hr (SD=2.07, n=36). A total of 13,604 km of random-transect lines were flown in 59.27 hours at an average speed of 229.53 km/hr. These random transects constituted 47.40 percent of the total kilometers flown and 47.95 percent of the total flight hours. The number of flight hours over each survey block is shown in subsequent analyses.

Day-to-day flight tracks are shown in Appendix B. Survey-flight lines are summarized by semimonthly period in Figures 12 through 15.

During the first half of September, survey coverage ranged from 140°W. to 154°W. longitudes, with most of the effort within 70 nautical miles (nm) of shore (Fig. 12). There were 13.98 hours of random transects flown from a total of 32.32 flight hours during this period (Table 3), constituting 23.6 percent and 26.1 percent, respectively, of the total time spent in those effort categories.

During the second half of September, survey coverage ranged from 140°W. to 157°W. longitudes, mostly within 70 nm of shore (Fig. 13). There were 21.00 hours of random transects flown from 42.90 total flight hours during this period (Table 3), constituting 35.4 percent and 34.7 percent, respectively, of the total time spent in those effort categories.

During the first half of October, survey coverage ranged from 140°W. to 157°W. longitudes, mostly within 70 nm of shore (Fig. 14). There were 17.83 hours of random transects flown from 35.28 total flight hours during this period (Table 3), constituting 30.1 percent and 28.5 percent, respectively, of the total time spent in those effort categories.

From 16 through 19 October, survey coverage ranged from 141°W. to 157°W. longitudes, mostly within 70 nm of shore (Fig. 15). There were 6.45 hours of random transects flown from 13.12 total flight hours during this period (Table 3), constituting 10.9 percent and 10.6 percent, respectively, of the total time spent in those effort categories.

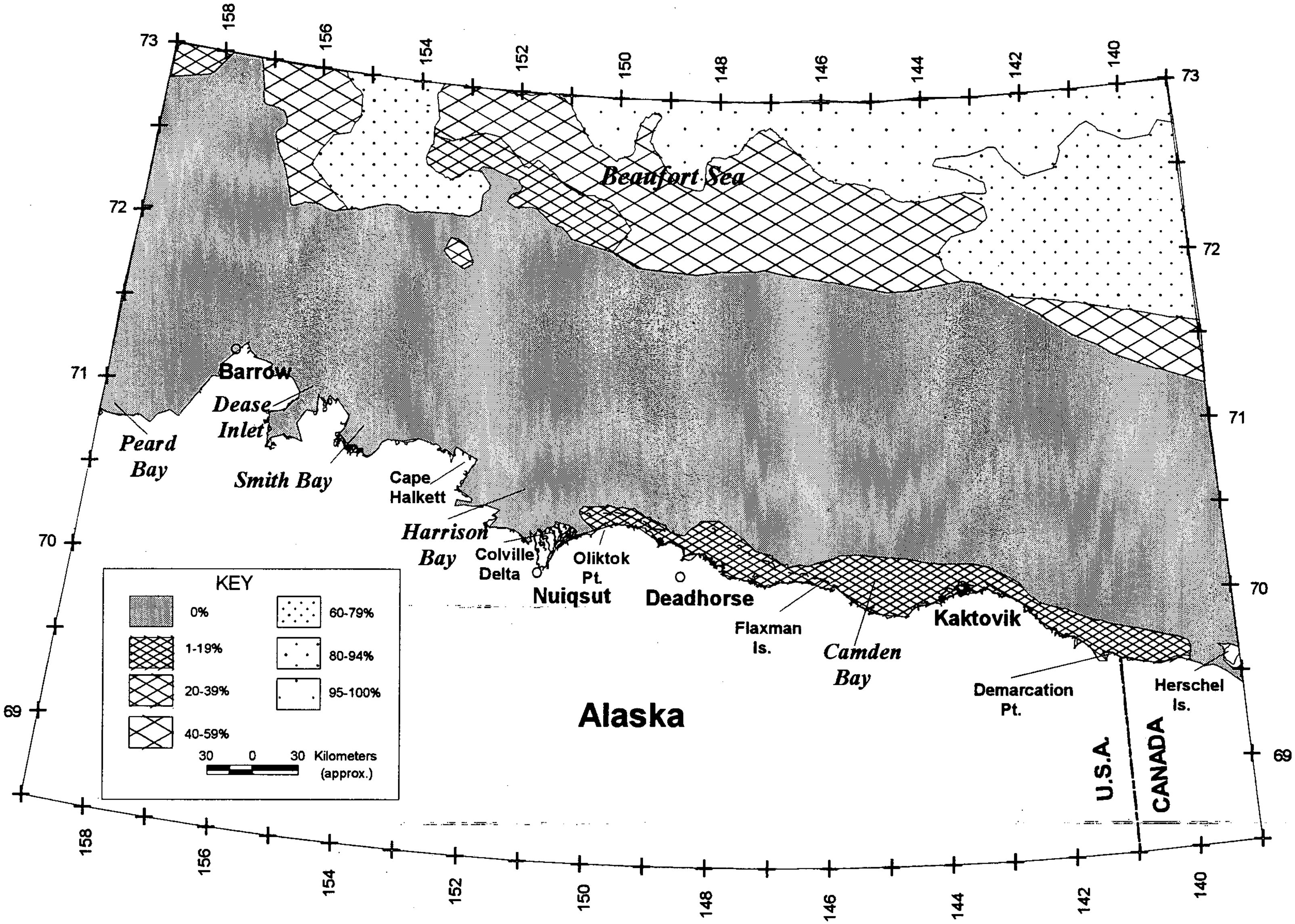


Figure 3. Map of Ice Concentrations in the Beaufort Sea, 26 August 1997

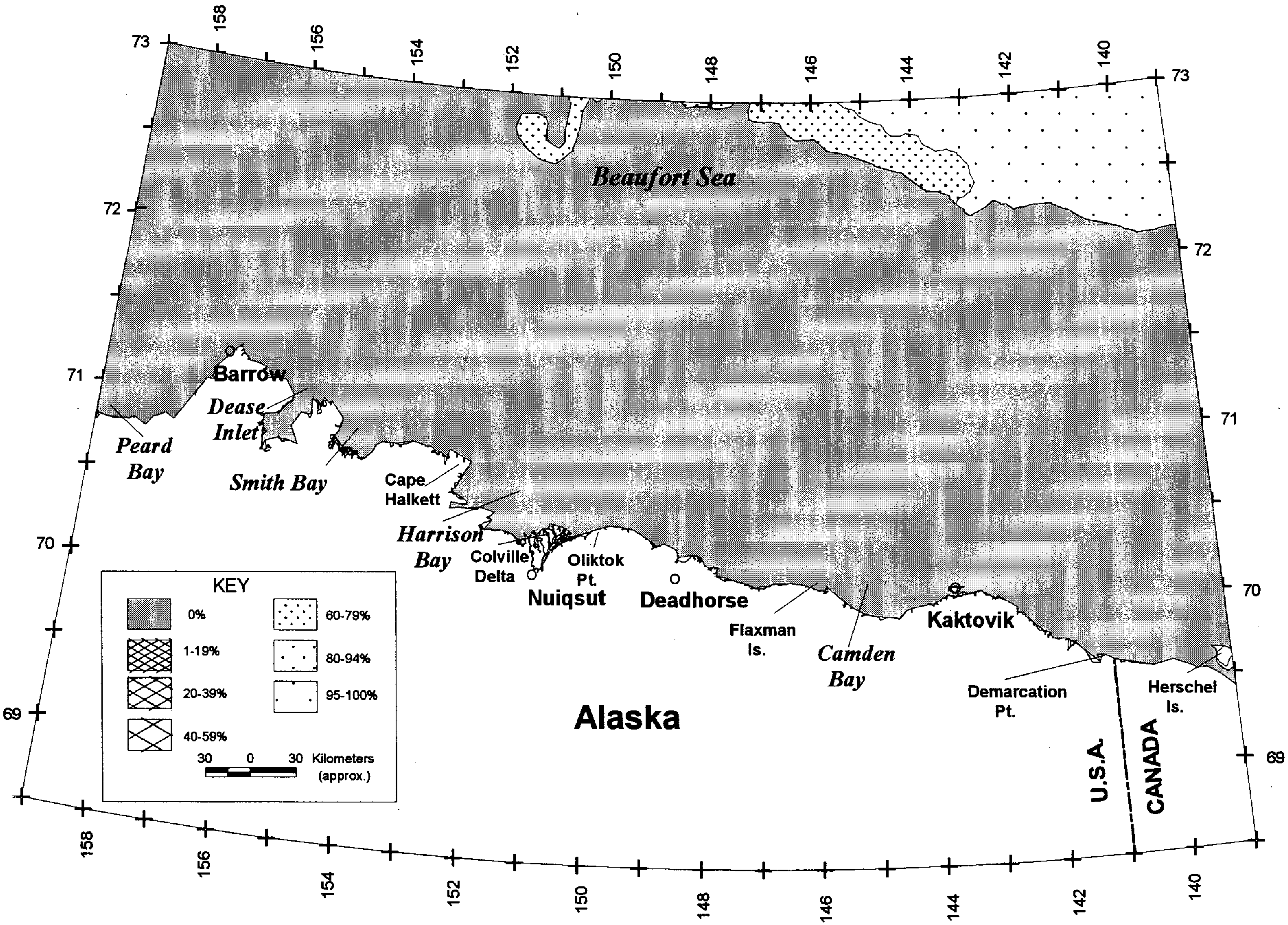


Figure 4. Map of Ice Concentrations in the Beaufort Sea, 5 September 1997

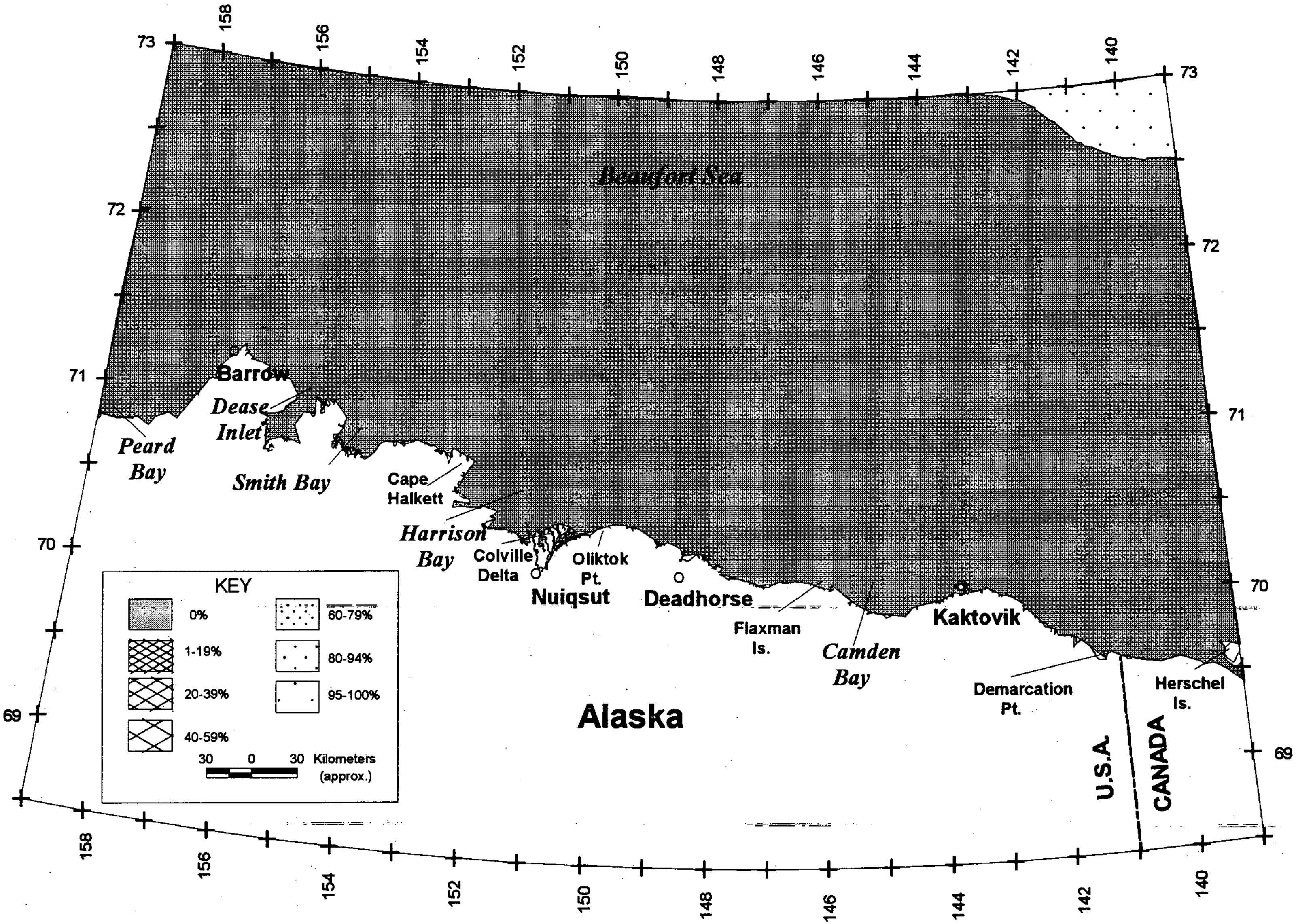


Figure 5. Map of Ice Concentrations in the Beaufort Sea, 12 September 1997

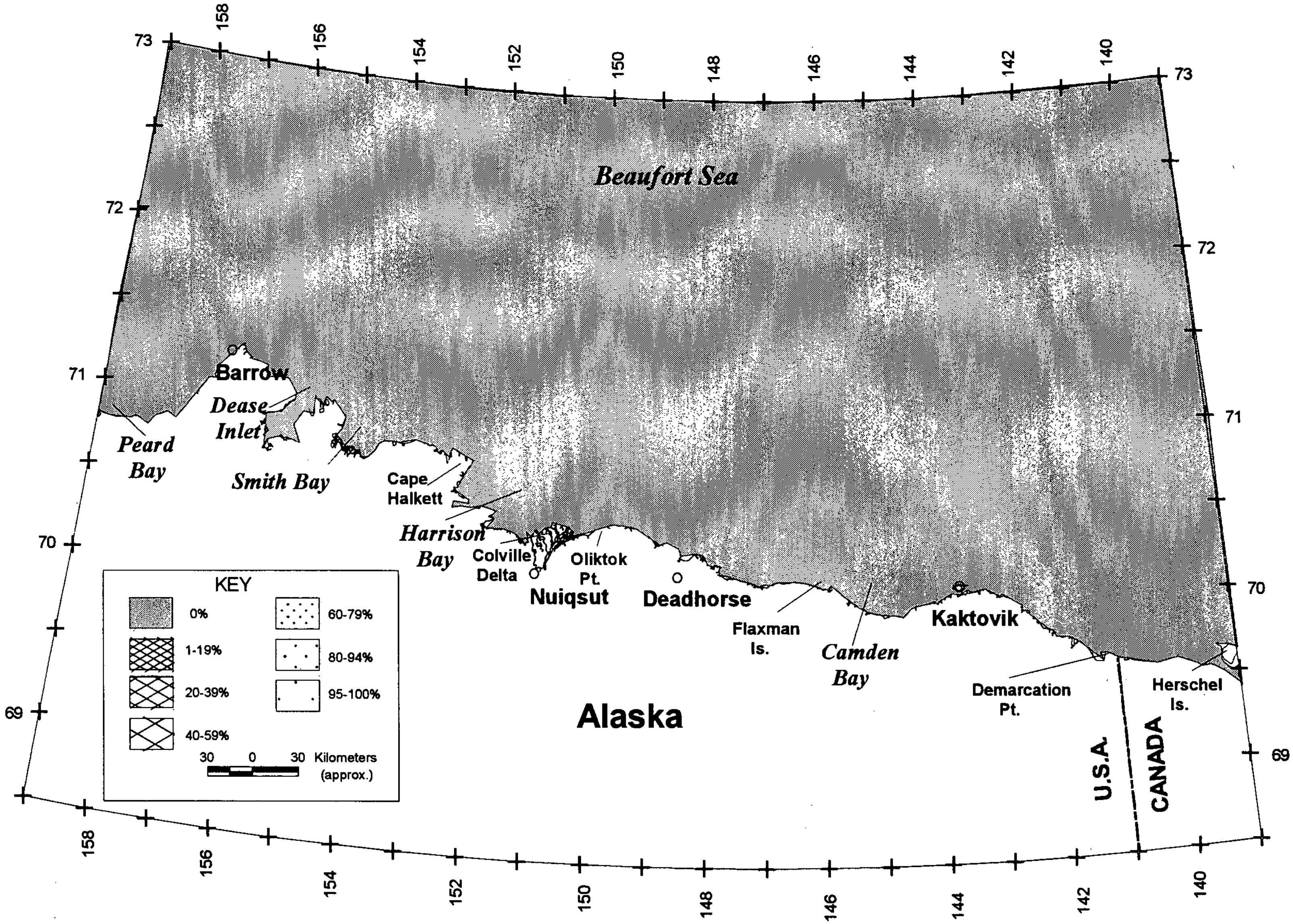


Figure 6. Map of Ice Concentrations in the Beaufort Sea, 19 September 1997

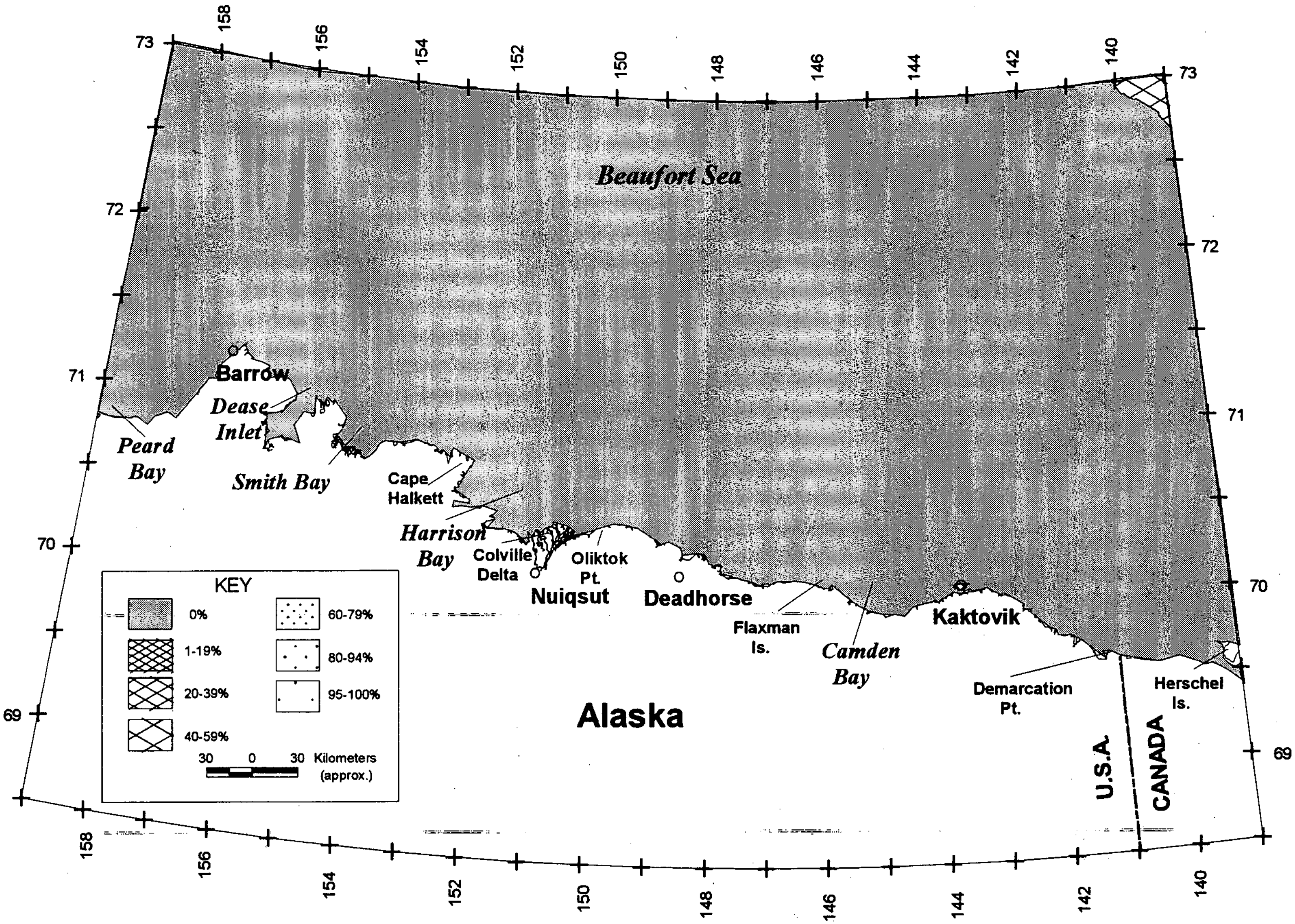


Figure 7. Map of Ice Concentrations in the Beaufort Sea, 26 September 1997

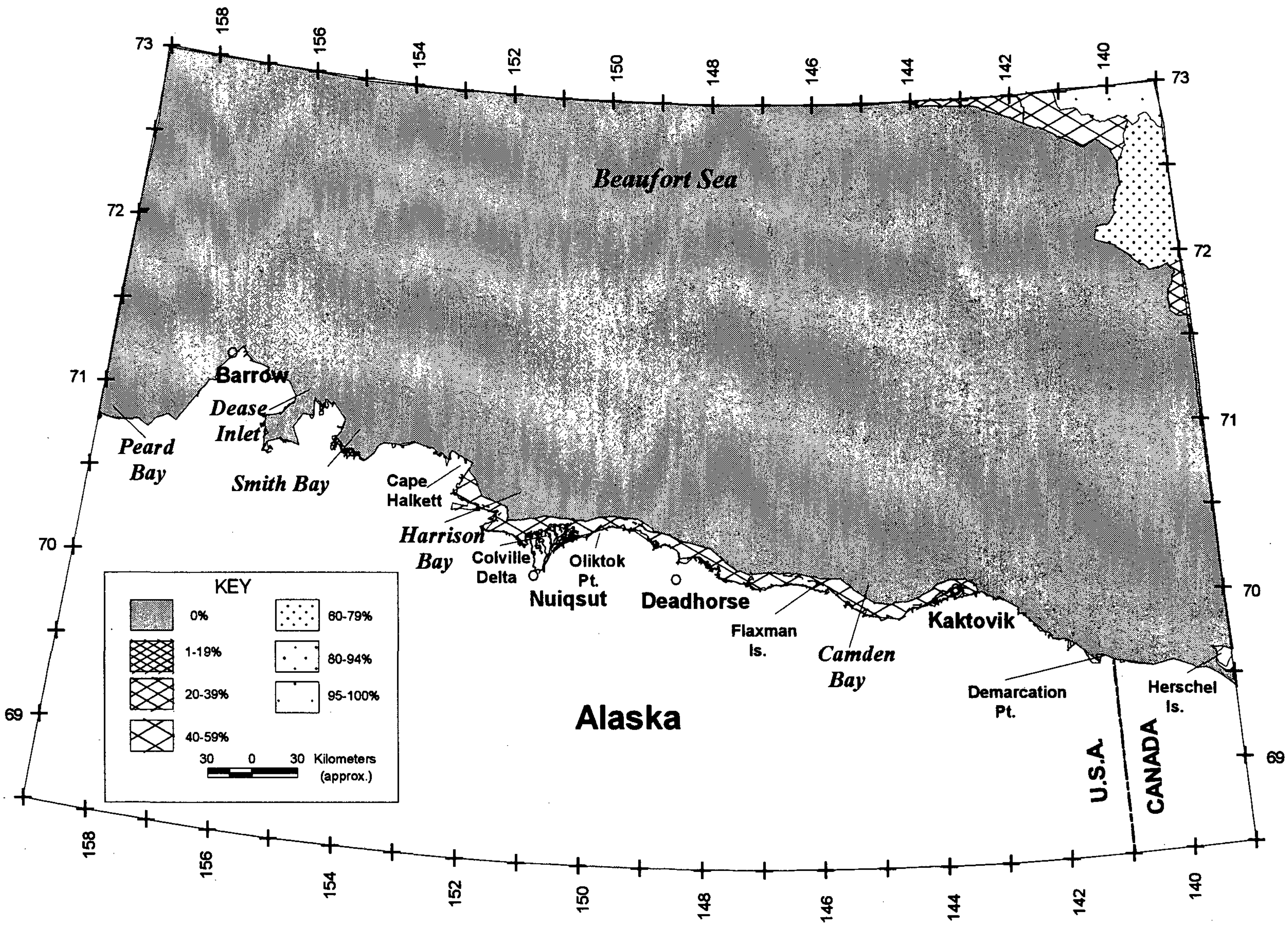


Figure 8. Map of Ice Concentrations in the Beaufort Sea, 2 October 1997

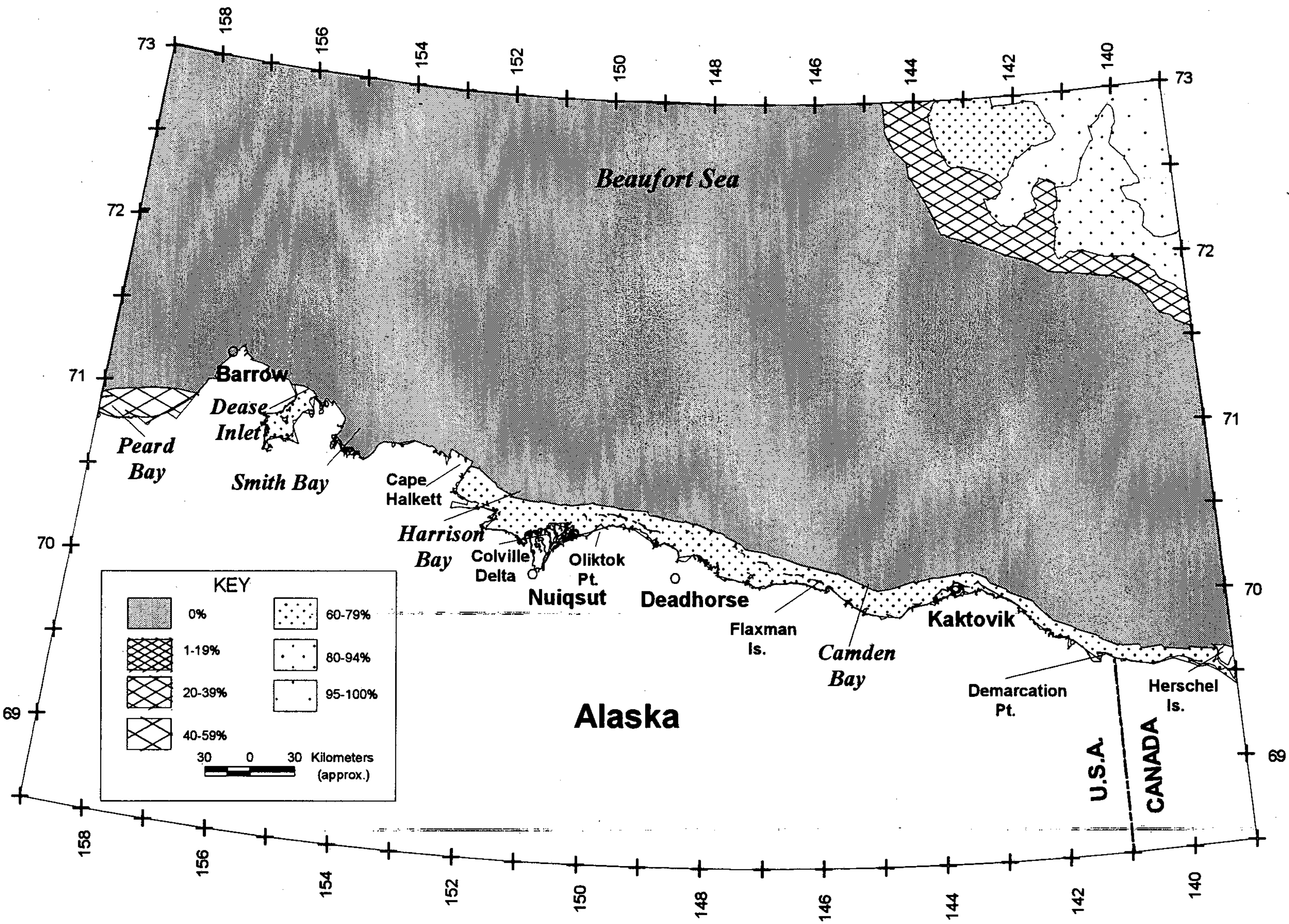


Figure 9. Map of Ice Concentrations in the Beaufort Sea, 10 October 1997

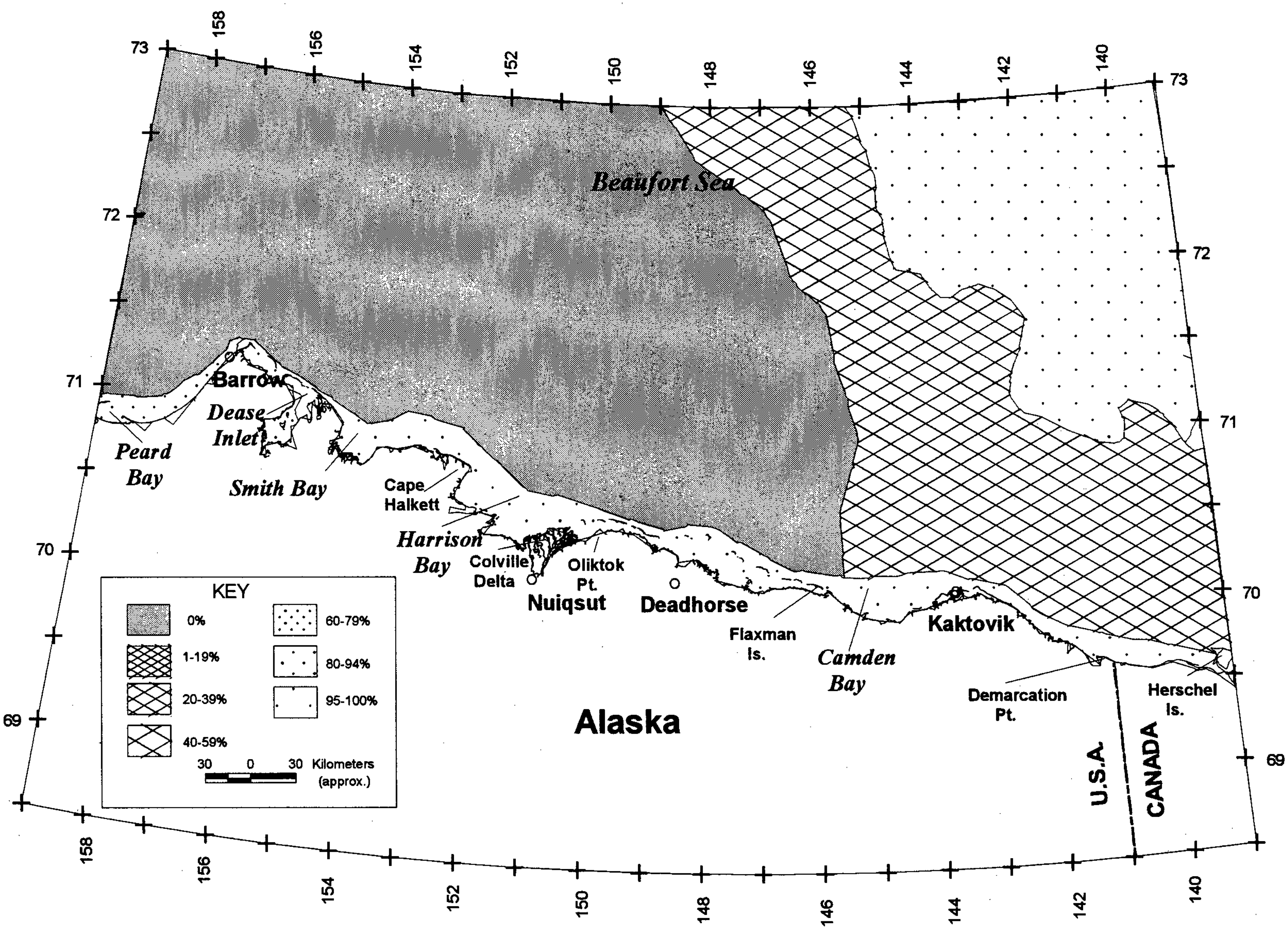


Figure 10. Map of Ice Concentrations in the Beaufort Sea, 17 October 1997

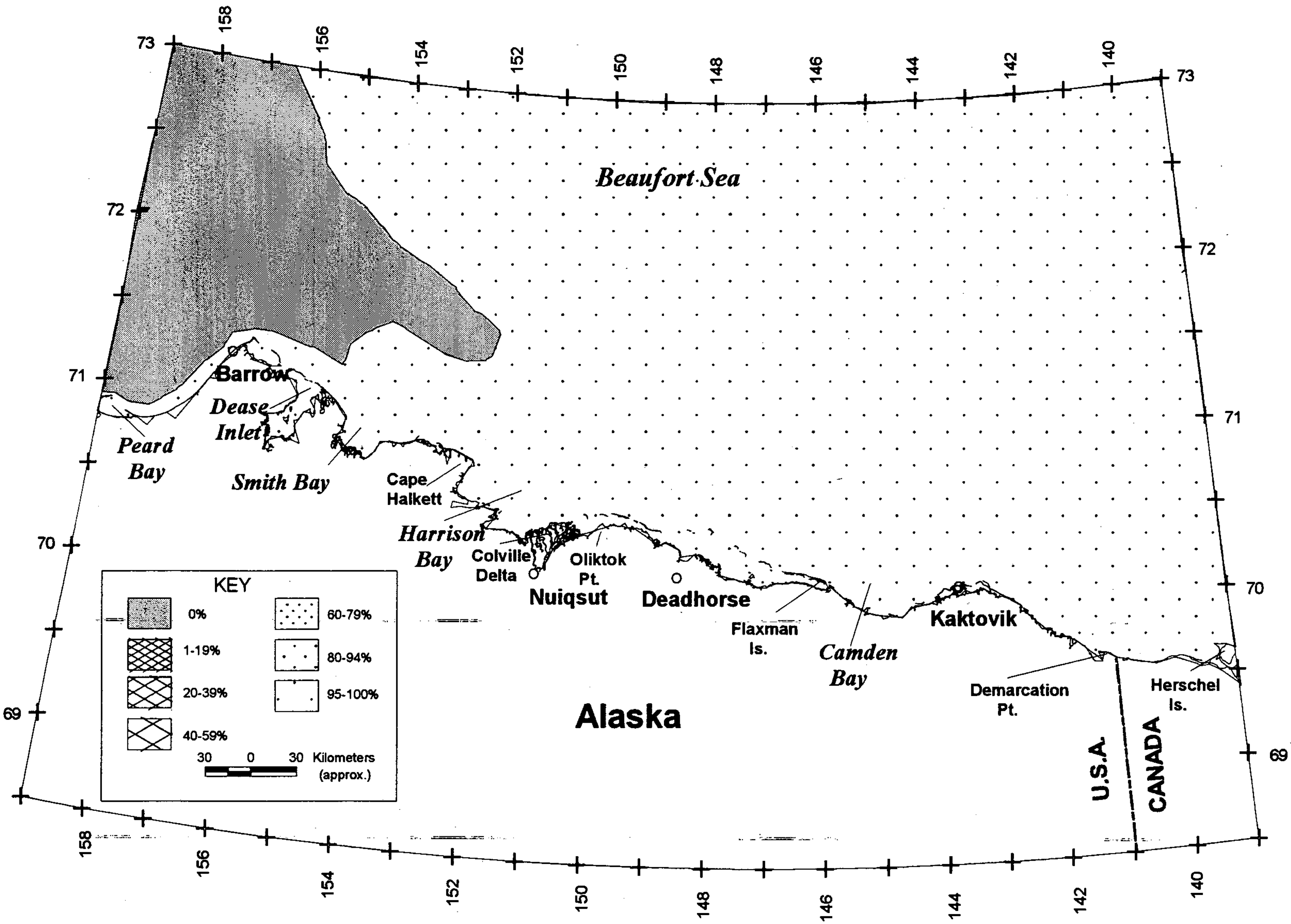


Figure 11. Map of Ice Concentrations in the Beaufort Sea, 24 October 1997

Table 3
Aerial-Survey Effort in the Beaufort Sea, 31 August-19 October 1997, by Survey Flight

Day	Flight No.	Transect (km)	Connect (km)	Search (km)	Total (km)	Transect (hr)	Total (hr)
1 Sep	1	110	0	349	459	0.52	2.20
3 Sep	2	391	42	358	791	1.72	4.00
4 Sep	3	0	0	326	326	0.00	1.73
5 Sep	4	0	0	0	0	0.00	0.00
7 Sep	5	419	45	271	735	1.80	3.13
9 Sep	6	130	19	507	656	0.55	2.53
10 Sep	7	397	53	661	1,111	1.67	4.70
11 Sep	8	0	0	163	163	0.00	0.70
12 Sep	9	1,104	232	368	1,704	4.58	7.00
13 Sep	10	717	91	612	1,420	3.15	6.32
18 Sep	11	195	14	487	696	0.85	3.22
18 Sep	12	261	17	310	588	1.08	2.52
19 Sep	13	0	0	275	275	0.00	1.23
20 Sep	14	345	99	221	665	1.55	2.80
21 Sep	15	679	113	533	1,325	3.05	6.02
22 Sep	16	0	0	175	175	0.00	0.75
25 Sep	17	0	0	486	486	0.00	1.92
25 Sep	18	79	19	355	453	0.32	1.78
26 Sep	19	895	125	450	1,470	3.83	6.18
27 Sep	20	1,035	199	261	1,495	4.52	6.48
28 Sep	21	928	208	330	1,466	4.13	6.25
29 Sep	22	365	161	167	693	1.62	3.02
30 Sep	23	11	0	164	175	0.05	0.73
1 Oct	24	554	130	276	960	2.40	4.03
2 Oct	25	551	94	591	1,236	2.42	5.40
4 Oct	26	355	92	326	773	1.55	3.25
7 Oct	27	707	62	209	978	3.08	4.20
9 Oct	28	0	0	284	284	0.00	1.07

Table 3
Aerial-Survey Effort in the Beaufort Sea, 31 August-19 October 1997, by Survey Flight

Day	Flight No.	Transect (km)	Connect (km)	Search (km)	Total (km)	Transect (hr)	Total (hr)
10 Oct	29	842	176	246	1,264	3.75	5.55
11 Oct	30	600	149	513	1,262	2.60	5.37
12 Oct	31	45	0	174	219	0.18	0.87
14 Oct	32	411	68	864	1,343	1.85	5.55
16 Oct	33	0	0	66	66	0.00	0.27
17 Oct	34	853	131	259	1,243	3.53	5.15
18 Oct	35	513	70	553	1,136	2.28	4.68
19 Oct	36	159	26	537	722	0.63	3.02
Total Semimonthly Effort							
1-15 Sep		3,256	480	3,600	7,336	13.98	32.32
16-30 Sep		4,777	952	4,197	9,926	21.00	42.90
1-15 Oct		4,051	766	3,467	8,284	17.83	35.28
16-19 Oct		1,520	225	1,409	3,154	6.45	13.12
TOTAL		13,604	2,423	12,673	28,701	59.27	123.62

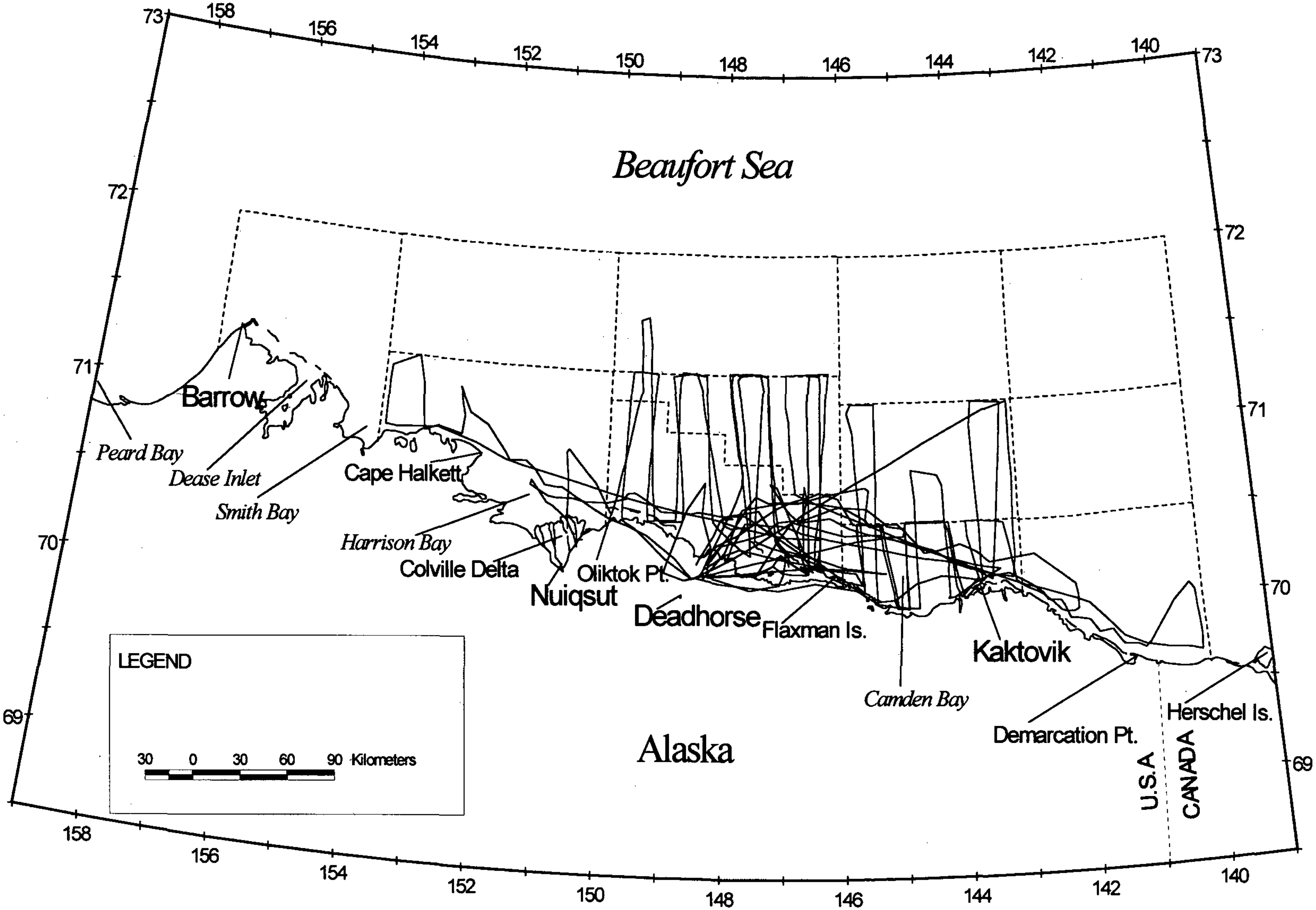


Figure 12. Combined Flight Tracks, 1-15 September 1997

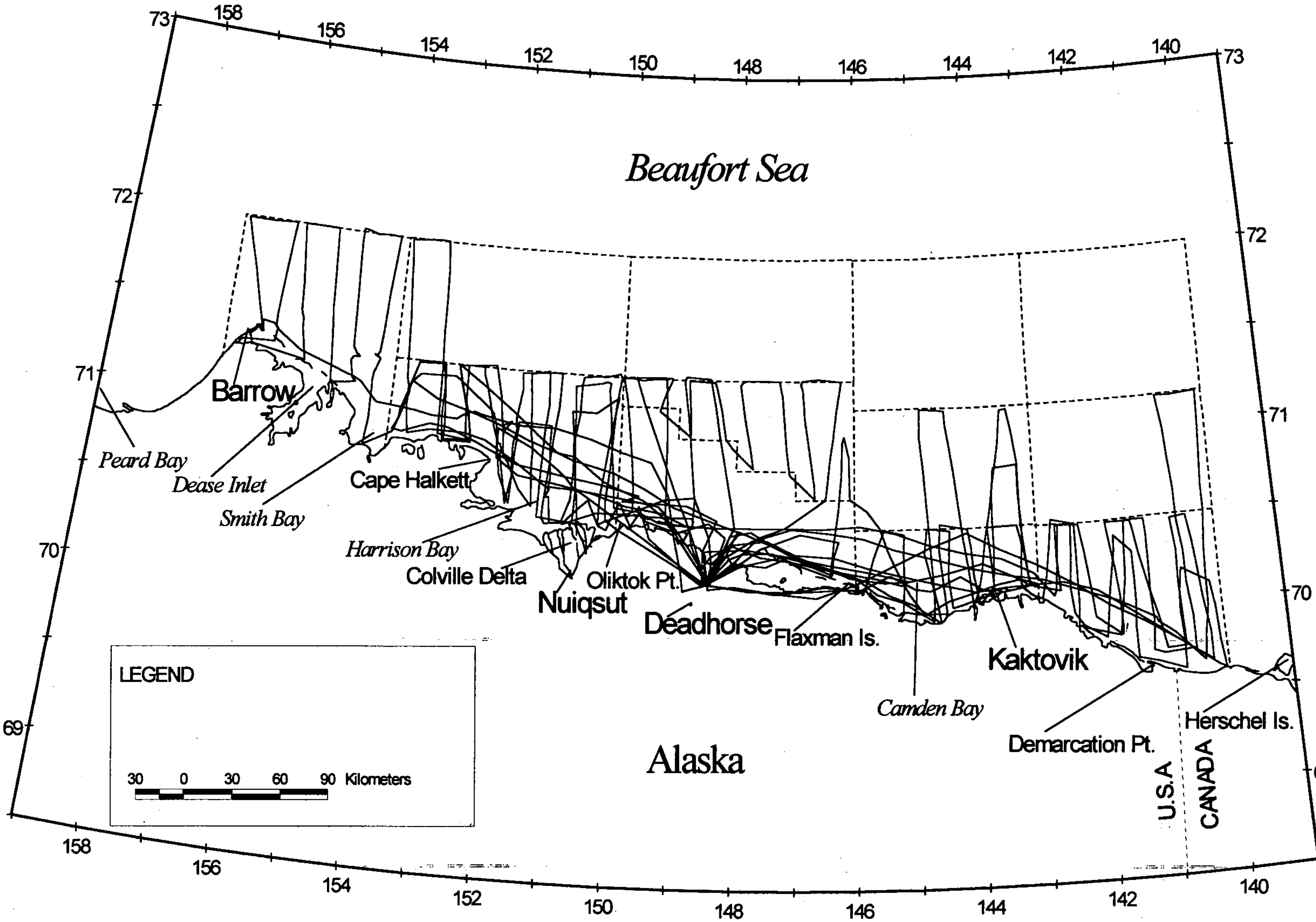


Figure 13. Combined Flight Tracks, 16-30 September 1997

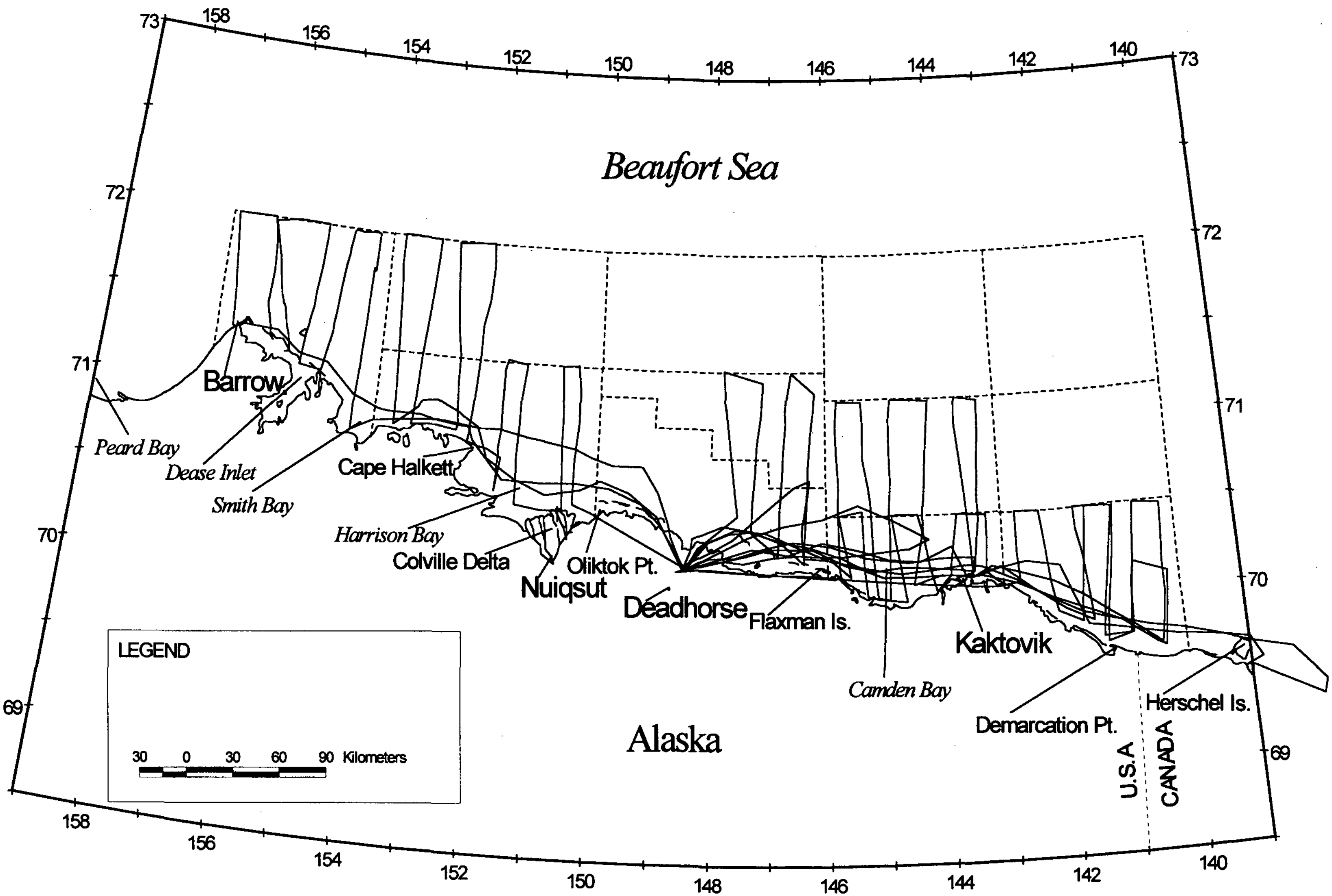


Figure 14. Combined Flight Tracks, 1-15 October 1997

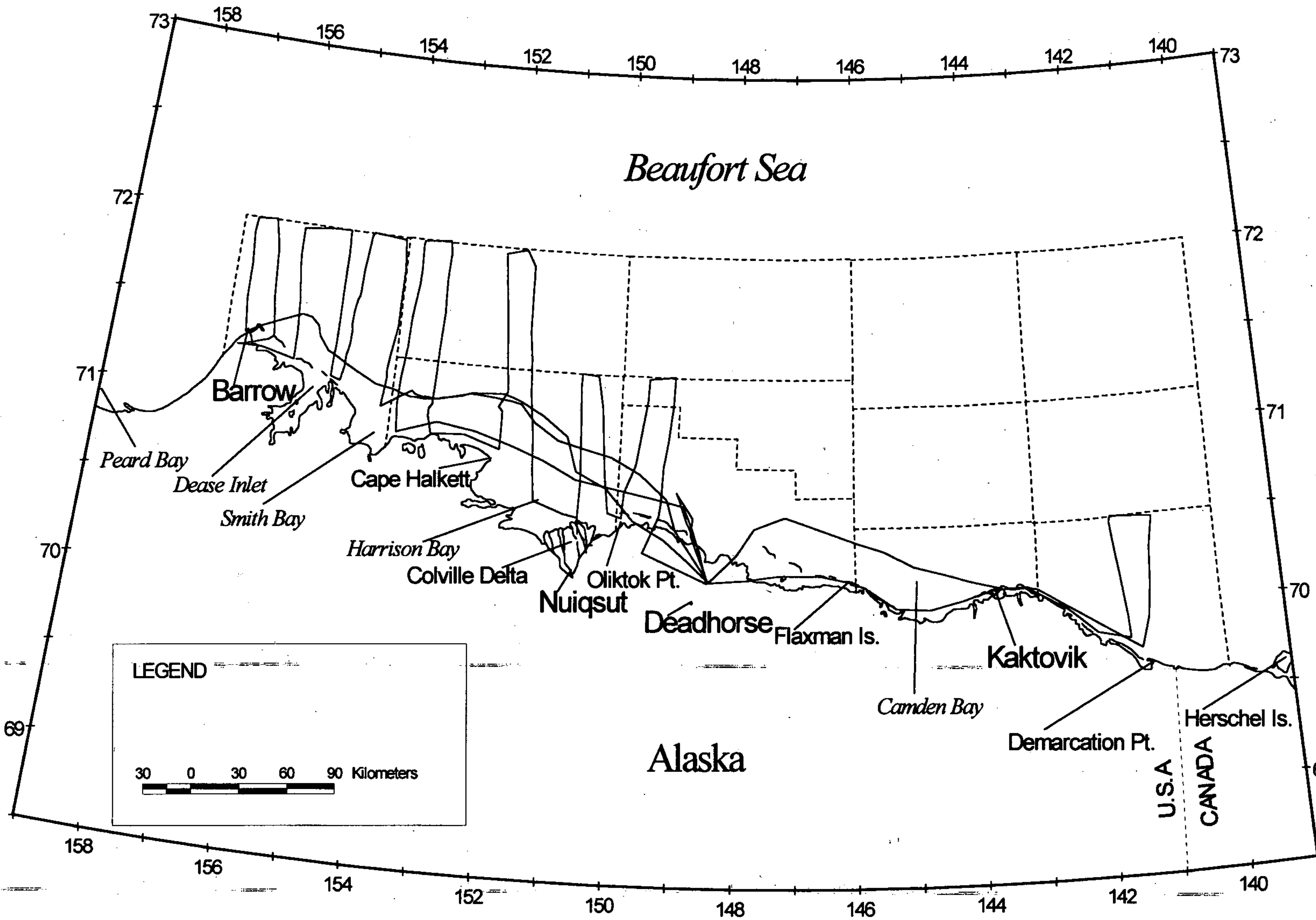


Figure 15. Combined Flight Tracks, 16-19 October 1997

C. Bowhead Whale (*Balaena mysticetus*) Observations

1. Distribution: Four hundred thirty-seven sightings were made for a total of 1,655 bowhead whales observed during Fall-1997 surveys in the study area (Table 4 and Figs. 16-20), not counting definite repeat sightings or dead whales. The very high number of bowheads was likely a result of much unavoidable recounting of large aggregations of feeding and/or milling whales that this year appeared to remain in the same area for several days. Relatively even survey coverage between 140°W. and 157°W. longitudes (Figs. 12-15), resulted in distribution of bowhead whales all across the study area, mostly within 30 nm north of the shoreline (Fig. 20). Seventy-five of the 1,655 whales were identified as calves (Appendix A: Table A-1), resulting in a seasonal calf ratio (number calves/total whales) of 0.045. Daily sightings are shown on individual maps in Appendix B. A semi-monthly analysis follows.

During the first half of September, 105 sightings were made for a total of 318 bowheads (Table 4), with sightings from 142°09.0'W. to 149°40.6'W. longitudes, based on survey coverage between 140°W. and 154°W. longitudes (Fig. 12). The first bowhead in the Alaskan Beaufort Sea was sighted on 3 September at 70°25.7'N. latitude, 147°02.4'W. longitude. Whale pods were concentrated east of Oliktok Point, with notable aggregations of pods between Deadhorse and Flaxman Island and in a narrow band adjacent to shore just east of Kaktovik, within 30 nm north of the shoreline (Fig. 16). Pod sizes ranged from 1 to 70 whales, with a mean of 3.03 (SD=8.97, n=105). Eight bowhead whale calves were observed during this period (Appendix A: Table A-1).

During the second half of September, 147 sightings were made for a total of 333 bowheads (Table 4), with sightings from 140°20.3'W. to 156°40.6'W. longitudes, based on survey coverage between 140°W. and 157°W. longitudes (Fig. 13). Whale pods were distributed fairly evenly east to west across the study area, within 30 nm north of the shoreline (Fig. 17). Pod sizes ranged from 1 to 30 whales, with a mean of 2.27 (SD=4.05, n=147). Six bowhead whale calves were observed during this period (Appendix A: Table A-1).

During the first half of October, 120 sightings were made for a total of 684 bowheads (Table 4), with sightings from 143°01.9'W. to 156°06.7'W. longitudes, based on survey coverage between 140°W. and 157°W. longitudes (Fig. 14). Whale pods were distributed east to west across the study area, with most pods aggregated between Barrow and the Colville Delta, within 30 nm north of the shoreline (Fig. 18). Pod sizes ranged from 1 to 77 whales, with a mean of 5.70 (SD=13.30, n=120). Thirty-five bowhead whale calves were observed during this period (Appendix A: Table A-1).

From 16 through 19 October, 65 sightings were made for a total of 320 bowheads (Table 4), with sightings from 151°30.3'W. to 155°53.5'W. longitudes, based on survey coverage between 141°W. and 157°W. longitudes (Fig. 15). Whale pods were mostly located in tight aggregations between Barrow and the Colville Delta, within 30 nm north of the shoreline (Fig.19). Pod sizes ranged from 1 to 47 whales, with a mean of 4.92 (SD=9.06, n=65). The last bowhead in the Alaskan Beaufort Sea was sighted on 18 October at 71°09.2'N. latitude, 151°46.7'W. longitude. Twenty-six bowhead whale calves were observed during this period (Appendix A: Table A-1).

2. Migration Timing and Relative Abundance: The day-to-day timing of the bowhead whale migration was calculated over the entire study area (Table 5 and Fig. 21) as a daily sighting rate, or sightings per unit effort (SPUE), and an index of relative abundance, or whales per unit effort (WPUE).

Of the 437 sightings of bowhead whale pods, the first whales observed were on 3 September. The data for daily sighting rates showed a fairly level distribution over the field season, with higher values on 4 September (6.94 SPUE), 21 September (10.96 SPUE), 2 October (9.44 SPUE), and 18 October (12.39 SPUE). The last sighting of a bowhead whale was made on 18 October (Table 5 and Fig. 21).

Of the 1,655 individual bowhead whales counted, the data for daily relative abundance show that the midpoint (median) of the bowhead migration in Blocks 1 through 12 (when 50% of all sighted whales had been recorded) occurred on 2 October. The peak relative abundance (mode) of 74.07 WPUE also occurred on 2 October (Table 5 and Fig. 21).

Table 4
Summary of Marine Mammal Sightings, 31 August-19 October 1997, by Survey Flight
(number of sightings/number of animals)

Day	Flight No	Bowhead Whale	Gray Whale	Belukha 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
3 Sep	2	19/164	0	3/29	0	0	8/140	0	0	0	0
4 Sep	3	12/37	0	0	0	0	0	0	0	1/1	0
5 Sep	4	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]
7 Sep	5	0	0	0	0	0	0	0	0	0	0
9 Sep	6	0	0	0	0	0	0	0	0	0	0
10 Sep	7	5/5	0	0	0	0	0	0	1/1	0	0
11 Sep	8	1/1	0	0	0	0	2/6	0	0	0	0
12 Sep	9	34/56	0	10/44	1/1	1/1	1/1	0	0	0	0
13 Sep	10	34/55	0	9/13	0	0	25/105	0	2/11	0	0
18 Sep	11	7/9	0	0	0	0	0	0	0	1/3	0
18 Sep	12	13/13	0	0	0	0	0	0	0	0	0
19 Sep	13	1/1	0	0	0	1/1	1/3	0	0	0	0
20 Sep	14	0	0	0	0	2/4	4/10	0	1/5	0	0
21 Sep	15	66/162	0	11/56	0	0	0	0	0	0	0
22 Sep	16	0	0	0	0	0	0	0	0	0	0
25 Sep	17	4/4	0	0	0	0	0	0	0	0	0
25 Sep	18	9/17	0	0	0	0	0	0	0	0	0
26 Sep	19	5/8	0	0	0	0	2/2	0	1/1	1/1	0
27 Sep	20	30/102	0	14/93	0	0	0	0	0	0	0
28 Sep	21	12/17	0	1/1	0	1/1	0	0	0	0	3
29 Sep	22	0	0	17/42	0	0	0	0	0	0	0

Table 4
Summary of Marine Mammal Sightings, 31 August-19 October 1997, by Survey Flight
(number of sightings/number of animals)

Day	Flight No	Bowhead Whale	Gray Whale	Belukha Whale	Unidentified Cetacean	Bearded Seal	Ringed Seal	Pacific Walrus	Unidentified Pinniped	Polar Bear (PB)	PB Tracks (no bear)
30 Sep	23	0	0	0	0	0	0	0	0	0	0
1 Oct	24	29/173	0	5/8	0	0	2/21	0	0	0	0
2 Oct	25	51/400	3/9	10/66	0	0	1/20	0	1/1	0	0
4 Oct	26	0	0	0	0	0	0	0	0	0	1
7 Oct	27	6/7	0	1/1	0	0	1/1	0	0	0	0
9 Oct	28	1/1	0	0	0	0	0	0	0	0	0
10 Oct	29	27/88	0	0	0	0	0	0	0	0	0
11 Oct	30	1/1	0	0	0	0	0	0	0	1/1	1
12 Oct	31	0/0	0	0	0	0	0	0	0	0	0
14 Oct	32	5/14	0	5/18	0	0	1/2	0	0	2/18	0
16 Oct	33	0	0	0	0	0	0	0	0	0	0
17 Oct	34	7/98	0	3/7	0	1/1	0	0	0	0	0
18 Oct	35	58/222	0	4/20	0	0	0	0	0	0	0
19 Oct	36	0	0	0	0	0	0	0	0	4/26	3
Total Semimonthly Sightings											
1-15 Sep		105/318	0	22/86	1/1	1/1	36/252	0	3/12	1/1	0
16-30 Sep		147/333	0	43/192	0	4/6	7/15	0	2/6	2/4	3
1-15 Oct		120/684	3/9	21/93	0	0	5/44	0	1/1	3/19	2
16-19 Oct		65/320	0	7/27	0	1/1	0	0	0	4/26	3
TOTAL		437/1,655	3/9	93/398	1/1	6/8	48/311	0	6/19	10/50	8

[1] Flight aborted due to weather: did not include over-water survey.

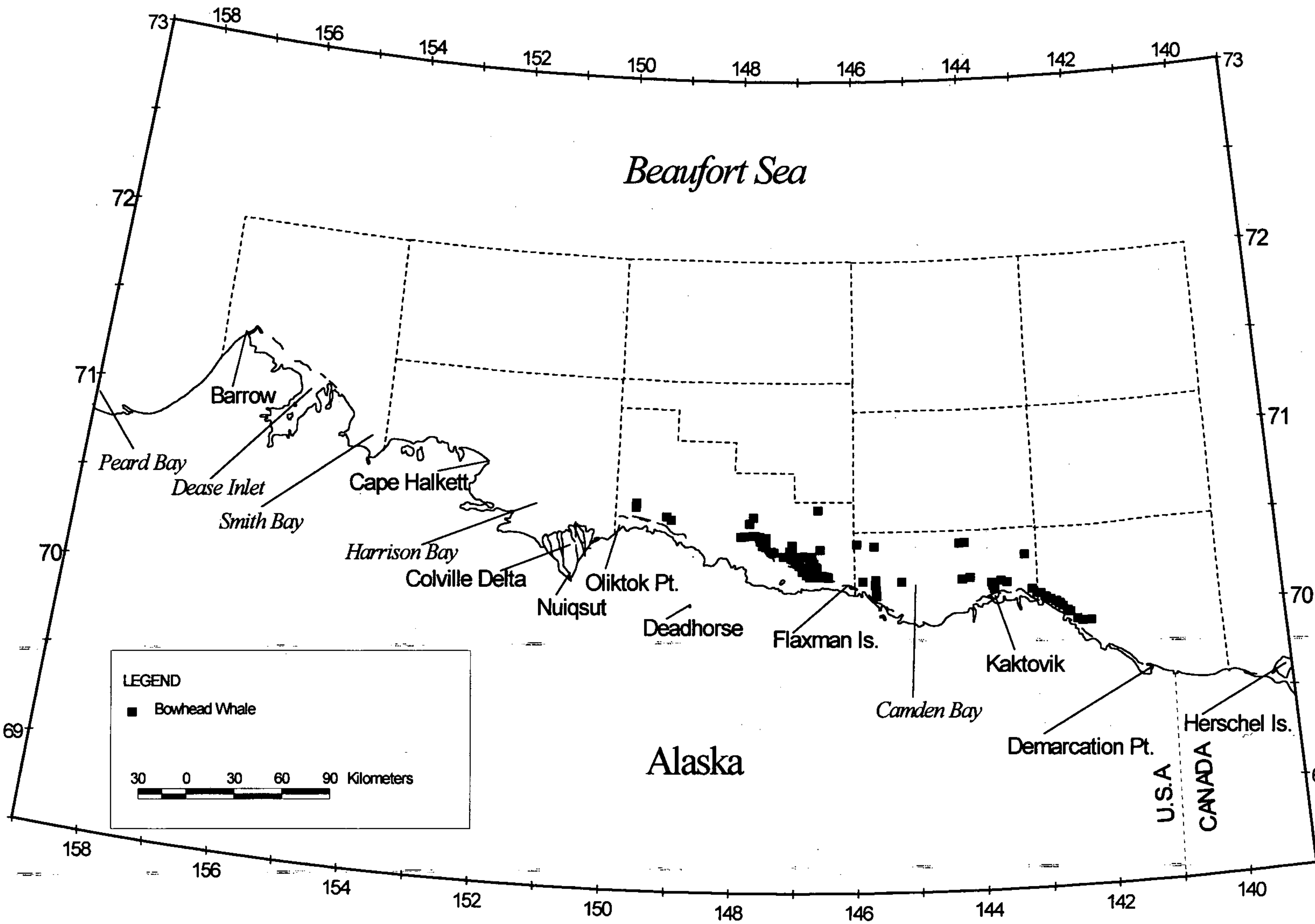


Figure 16. Map of Bowhead Whale Sightings, 1-15 September 1997

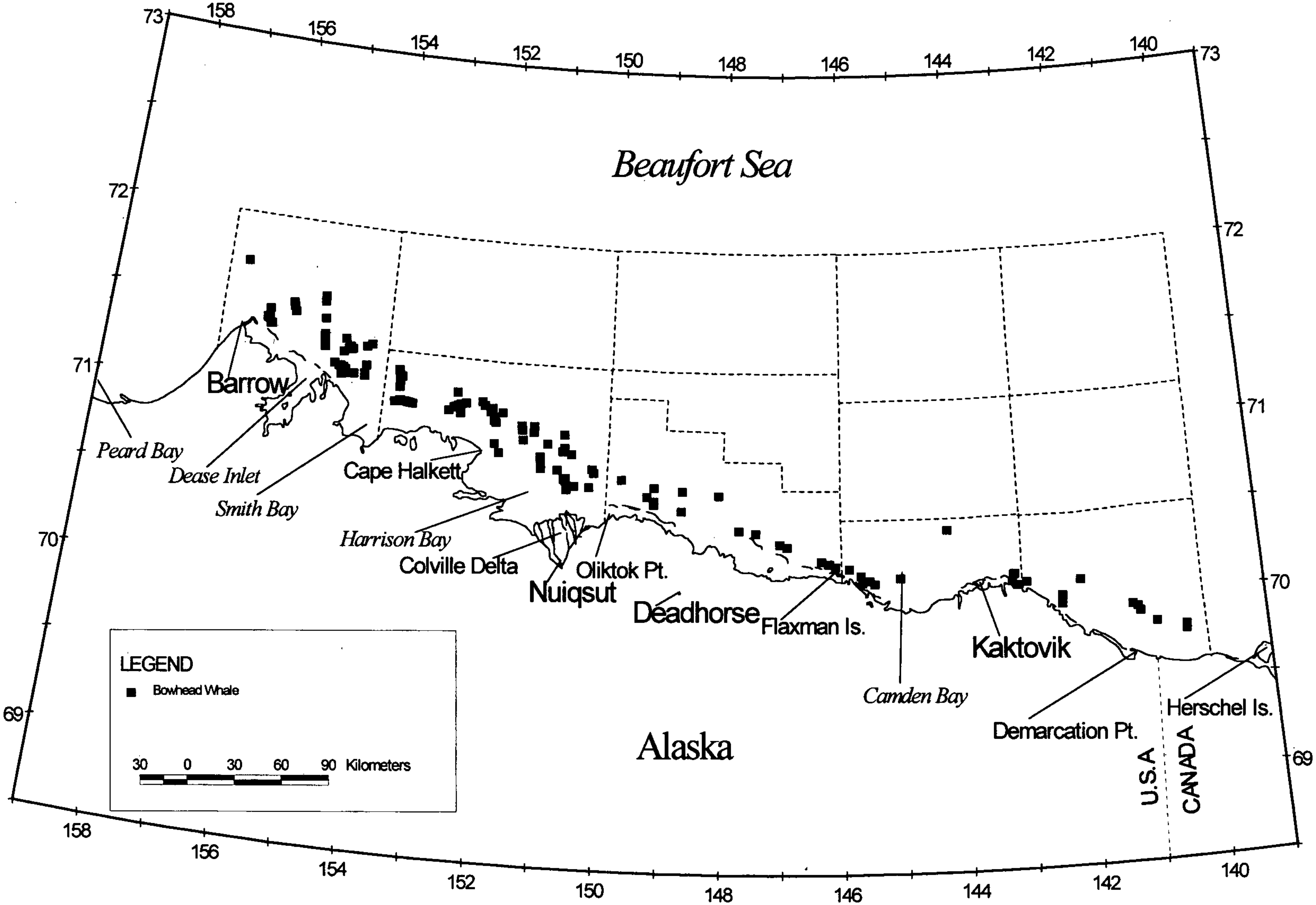


Figure 17. Map of Bowhead Whale Sightings, 16-30 September 1997

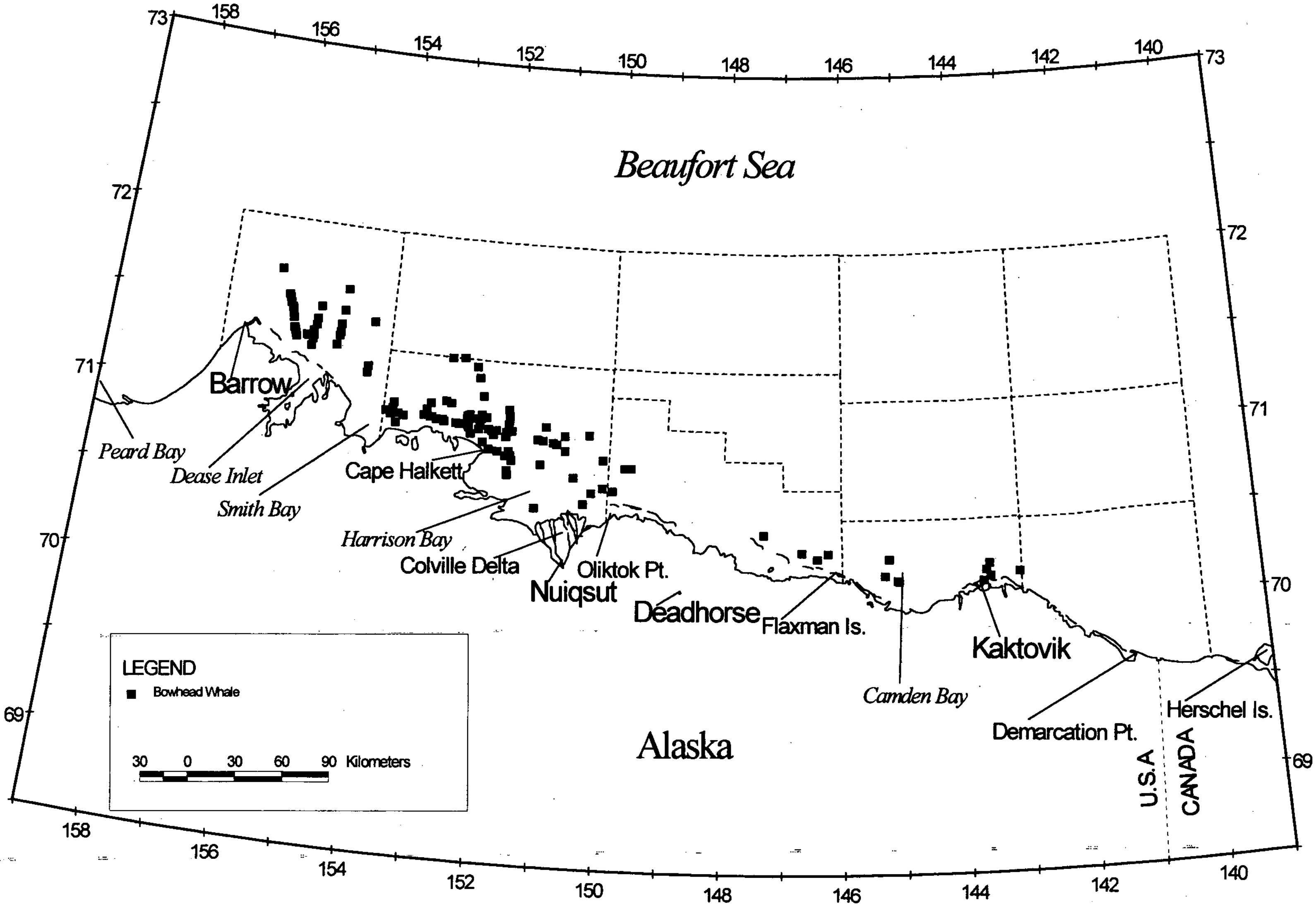


Figure 18. Map of Bowhead Whale Sightings, 1-15 October 1997

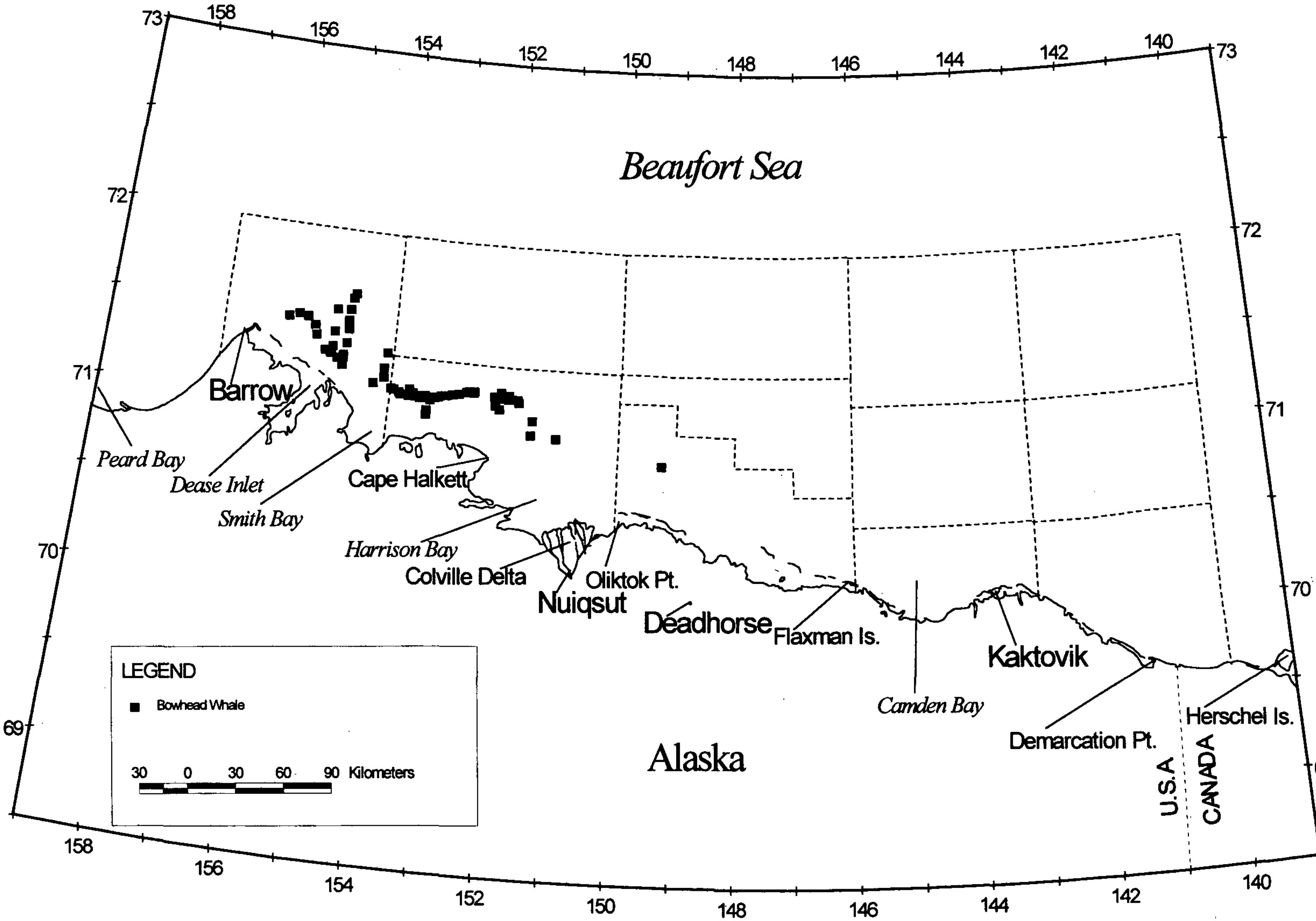


Figure 19. Map of Bowhead Whale Sightings, 16-19 October 1997

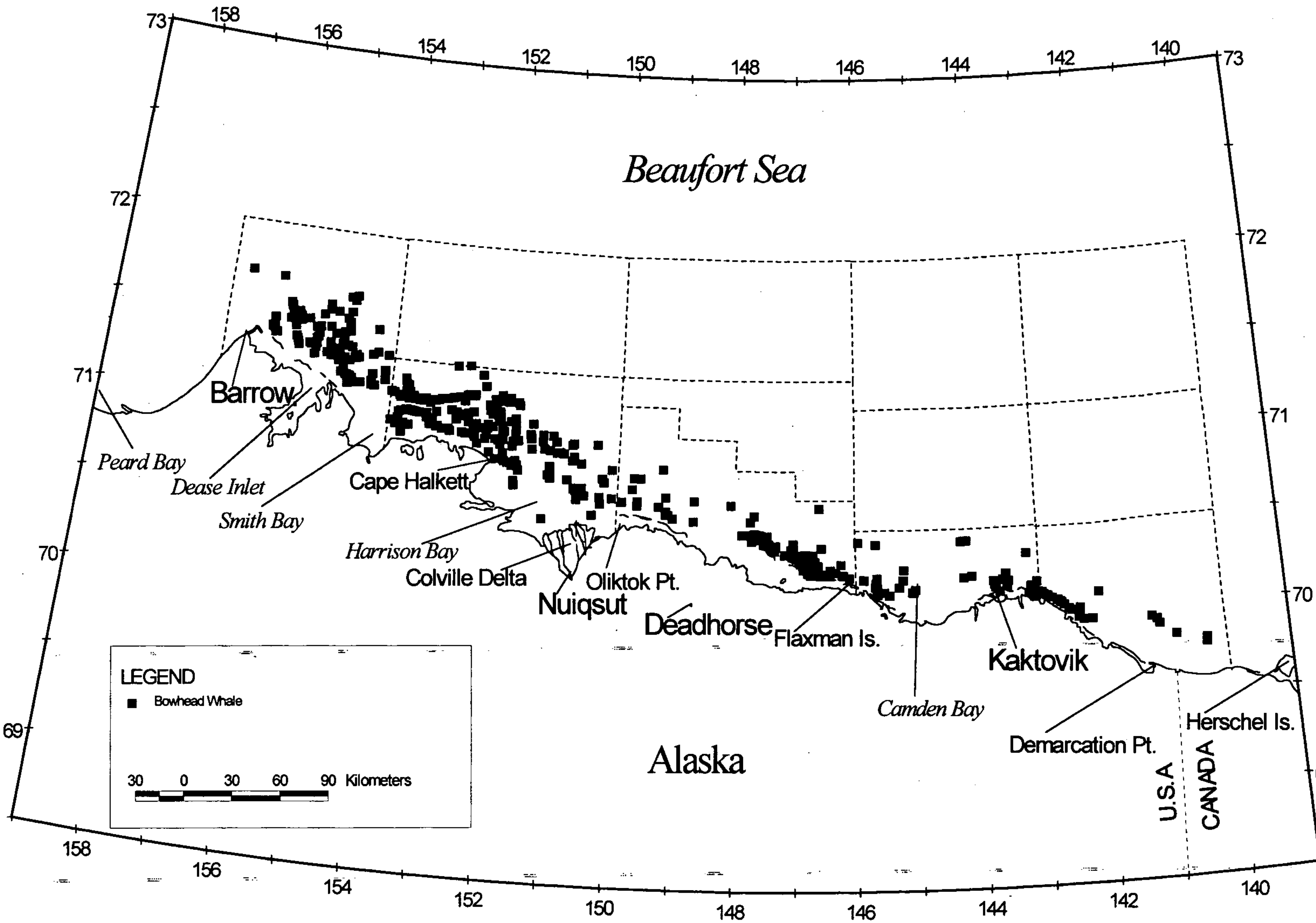


Figure 20. Map of Bowhead Whale Sightings, Fall 1997

Table 5
Number of Sightings and Total Bowhead Whales Observed per Hour,
31 August-19 October 1997, by Flight Day

Day	No. of Sightings	No. of Whales	Survey Time (hr)	Sightings/hr (SPUE)	Whales/hr (WPUE)
1 Sep	0	0	2.20	0.00	0.00
3 Sep	19	164	4.00	4.75	41.00
4 Sep	12	37	1.73	6.94	21.39
5 Sep	[1]	[1]	0.00	[1]	[1]
7 Sep	0	0	3.13	0.00	0.00
9 Sep	0	0	2.53	0.00	0.00
10 Sep	5	5	4.70	1.06	1.06
11 Sep	1	1	0.70	1.42	1.42
12 Sep	34	56	7.00	4.86	8.00
13 Sep	34	55	6.32	5.38	8.70
18 Sep	20	22	5.74	3.48	3.83
19 Sep	1	1	1.23	0.81	0.81
20 Sep	0	0	2.80	0.00	0.00
21 Sep	66	162	6.02	10.96	26.91
22 Sep	0	0	0.75	0.00	0.00
25 Sep	13	21	3.70	3.51	5.68
26 Sep	5	8	6.18	0.81	1.29
27 Sep	30	102	6.48	4.63	15.74
28 Sep	12	17	6.25	1.92	2.72
29 Sep	0	0	3.02	0.00	0.00
30 Sep	0	0	0.73	0.00	0.00
1 Oct	29	173	4.03	7.20	42.93
2 Oct	51	400	5.40	9.44	74.07
4 Oct	0	0	3.25	0.00	0.00
7 Oct	6	7	4.20	1.43	1.67
9 Oct	1	1	1.07	0.93	0.93
10 Oct	27	88	5.55	4.86	15.86
11 Oct	1	1	5.37	0.19	0.19
12 Oct	0	0	0.87	0.00	0.00
14 Oct	5	14	5.55	0.90	2.52

Table 5
Number of Sightings and Total Bowhead Whales Observed per Hour, 31 August-19 October 1997, by Flight Day

Day	No. of Sightings	No. of Whales	Survey Time (hr)	Sightings/hr (SPUE)	Whales/hr (WPUE)
16 Oct	0	0	0.27	0.00	0.00
17 Oct	7	98	5.15	1.36	19.03
18 Oct	58	222	4.68	12.39	47.44
19 Oct	0	0	3.02	0.00	0.00
TOTAL	437	1,655	123.62	3.54	13.39

[1]Flight aborted due to weather: did not include over-water survey.

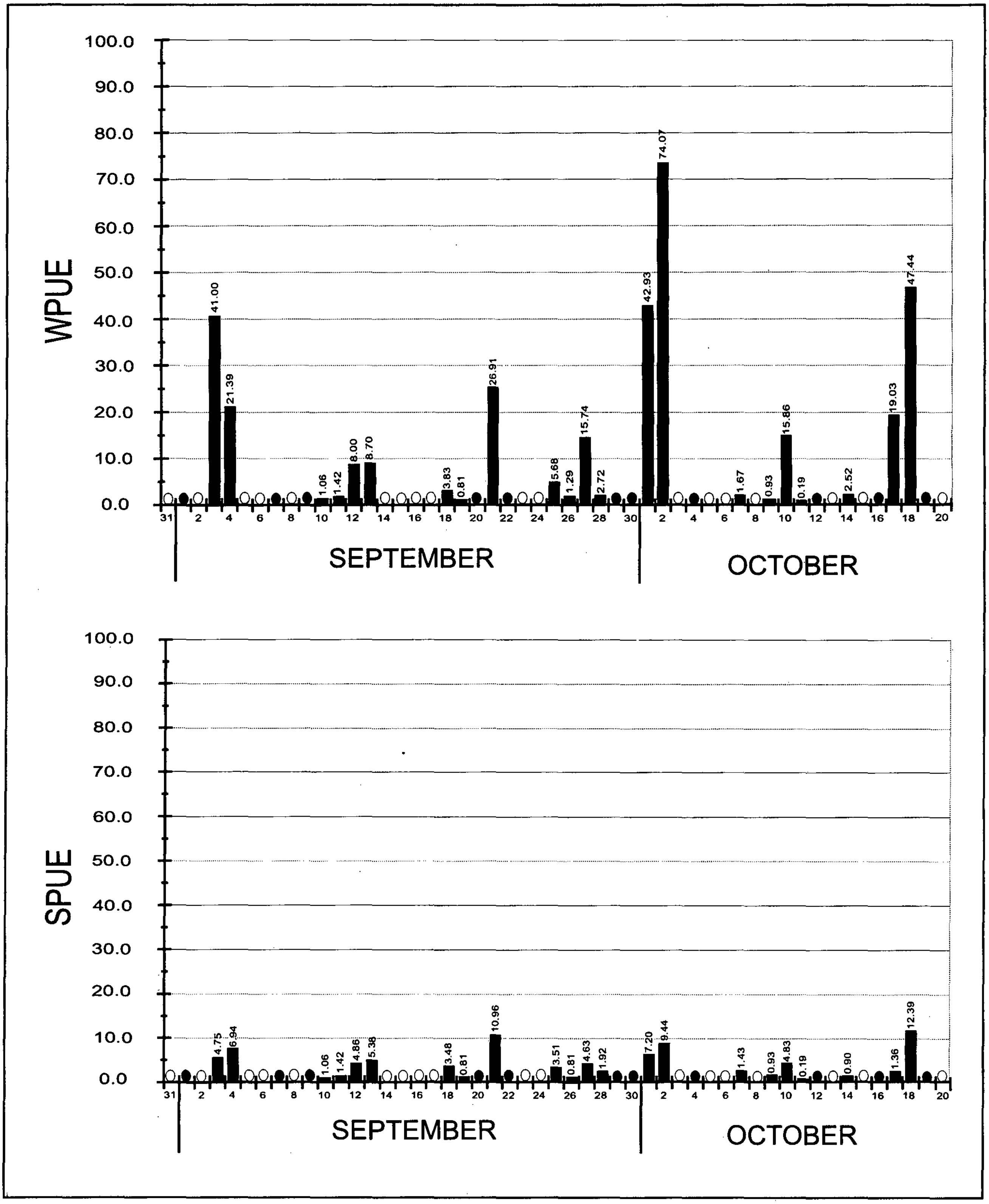


Figure 21. Daily Relative Abundance (WPUE) and Sighting Rate (SPUE) of Bowhead Whales, 31 August - 19 October 1997

(Solid circles indicate days when flights were made during which no bowheads were observed. Open circles indicate days when no flight was made.)

The most prominent differences in pattern between the graph for relative abundance and that for sighting rate occurred on 3 September, 1 October, 2 October, and 18 October (Fig. 21), due to several large pods of whales observed on those days (Appendix A: Table A-1).

Semimonthly relative abundance (WPUE) by survey block (Table 6) showed that bowhead whales were abundant only in coastal survey blocks (Blocks 1, 3, 4, 5, and 12).

3. Habitat Associations: Of 1,655 bowhead whales sighted over the field season (31 August-19 October), 1,641 (99%) were in shallow water (0-50 m deep), 12 (1%) were in waters of transitional depth (51-200 m), and 2 were sighted in deeper water (>200 m) (Table 7). A fuller description of water depth associated with the bowhead migration appears in the water-depth analyses in Section IV.B.

In addition to general ice coverage for arctic waters (Figs. 3-11), the percentage of ice cover visible from the aircraft at each bowhead sighting (Appendix A: Table A-1) was summarized (Table 8). Over the field season, whales were sighted in a wide range of sea-ice concentrations, with 1,452 (88%) sighted in open water (0% sea ice), 91 (5%) in 41- through 50-percent sea ice, 62 (4%) in 91- through 99-percent sea ice, 26 (2%) in 21- through 30-percent sea ice, 23 (1%) in 61- through 70-percent sea ice, and 1 whale in 71- through 80% sea ice. Open water (0% sea ice) predominated throughout September and the first half of October, with heavier ice concentrations prevailing after mid-October (Table 8).

4. Behaviors: Of 1,655 bowhead whales observed during Fall 1997, 679 (41%) were feeding, 470 (28%) swimming (moving forward in an apparently deliberate manner), and 372 (22%) milling when first sighted. Less frequent behaviors included 44 (3%) that were resting, 28 (2%) in cow-calf associations, 20 (1%) diving, 13 (1%) breaching, 8 (1%) slapping the water, 2 spy hopping, and 1 thrashing (Table 9). All behaviors noted are defined in Table 2.

Feeding bowhead whales were observed within approx. 30 nm of shore between 146°W. and 156°W. longitudes. The high percentages of these behaviors noted in Fall 1997 was likely associated with greater availability of prey species in this area, which in turn might have been linked with a band of warmer-than-average sea surface temperatures overlapping the same area during that period (USDOC, NOAA 1997). On 18 October, one group of 40 bowhead whales, observed feeding at 71°33.0' N., 155°03.8' W., further confirmed the importance of the area east of Barrow as an occasional late-fall feeding area (Landino et al., 1994) (Appendix A: Table A-1).

During the 1997 field season, there were no sightings of bowhead whales for which definite responses to the survey aircraft were apparent. Sudden overt changes (e.g., an abrupt dive, course diversion, or cessation of behavior ongoing) in whale behavior were looked for, but none were observed.

D. Other Marine Mammal Observations

1. Gray Whale (*Eschrichtius robustus*): Over the field season, 3 incidental sightings were made for a total of 9 gray whales (Table 4; Appendix B: Flight 25). The whales were sighted on 2 October swimming in open water.

2. Beluga Whale (*Delphinapterus leucas*): Although the study area and survey altitude were designed to record the fall migration of bowhead whales, beluga whales, which undertake a somewhat parallel migration, were always counted. Over the Fall 1997 field season, 93 sightings were made for a total of 398 beluga whales (Table 4) during 123.62 hr of survey effort (Table 3) and a seasonal relative abundance of 3.22 WPUE. Beluga whales were sighted beginning 3 September through 18 October, between 143°W. and 156°W. longitudes, mostly between 30 and 80 nm from shore, south of 72°N. latitude (Fig. 22). Sizes of pods (or close aggregations of pods) ranged from 1 to 30 whales, with a mean of 4.28 (SD=5.27, n=93). Twenty-seven beluga calves were noted for a calf ratio of 0.07. All but two pods of belugas were sighted in open water (0% sea ice).

Table 6
Semimonthly Relative Abundance (WPUE) of Bowhead Whales (BH), by Survey Block, Fall 1997

	1-15 Sep			16-30 Sep			1-15 Oct			16-19 Oct			Total		
Block	Hr	BH	WPUE	Hr	BH	WPUE	Hr	BH	WPUE	Hr	BH	WPUE	Hr	BH	WPUE
1	12.34	267	21.64	8.58	36	4.20	4.98	9	1.81	2.05	1	0.49	27.94	313	11.20
2	3.81	0	0.00	2.83	0	0.00	1.18	0	0.00	0.21	0	0.00	8.03	0	0.00
3	2.47	0	0.00	9.13	167	18.29	8.59	339	39.46	4.02	186	46.26	24.22	692	28.57
4	8.20	33	4.02	6.85	18	2.63	6.00	18	3.00	1.08	0	0.00	22.13	69	3.12
5	1.76	18	19.23	7.91	14	1.77	5.90	0	0.00	1.26	0	0.00	16.82	32	1.90
6	3.17	0	0.00	1.96	0	0.00	2.42	0	0.00	0.01	0	0.00	7.55	0	0.00
7	[1]	[1]	[1]	0.80	0	0.00	[1]	[1]	[1]	[1]	[1]	[1]	0.81	0	0.00
8	[1]	[1]	[1]	0.01	0	0.00	[1]	[1]	[1]	[1]	[1]	[1]	0.01	0	0.00
9	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]
10	0.57	0	0.00	0.17	0	0.00	[1]	[1]	[1]	[1]	[1]	[1]	0.75	0	0.00
11	[1]	[1]	[1]	0.79	0	0.00	1.53	0	0.00	1.31	0	0.00	3.64	0	0.00
12	[1]	[1]	[1]	3.65	98	26.85	3.51	318	90.60	3.10	133	42.90	10.24	549	53.61
12N [2]	[1]	[1]	[1]	0.16	0	0.00	0.18	0	0.00	0.02	0	0.00	0.35	0	0.00
Other Canadian Areas	[1]	[1]	[1]	[1]	[1]	[1]	0.92	0	0.00	[1]	[1]	[1]	0.92	0	0.00
Other Alaskan Areas	[1]	[1]	[1]	0.05	0	0.00	0.08	0	0.00	0.04	0	0.00	0.16	0	0.00
TOTAL	32.32	318	9.84	42.90	333	7.76	35.28	684	19.39	13.12	320	24.39	123.62	1,655	13.39

[1] No survey effort.
[2] Block 12N is between Block 12 and 73°N. latitude.

Table 7
Semimonthly Summary of Bowhead Whales Observed, by Water Depth at Sighting Location, Fall 1997

	1-15 Sep		16-30 Sep		1-15 Oct		16-19 Oct		Total	
Water Depth	No.	%	No.	%	No.	%	No.	%	No.	%
Shallow (0-50 m)	318	100	326	98	677	99	320	100	1,641	99
Transitional (51-200 m)	0	-	7	2	5	1	0	-	12	1
Deep (>200 m)	0	-	0	-	2	-	0	-	2	-
TOTAL	318	100	333	100	684	100	320	100	1,655	100

Table 8
Semimonthly Summary of Bowhead Whales Observed, by Percent Ice Cover Present at Sighting Location, Fall 1997

	1-15 Sep		16-30 Sep		1-15 Oct		16-19 Oct		Total	
% Ice Cover	No.	%	No.	%	No.	%	No.	%	No.	%
0	318	100	333	100	683	100	118	37	1,452	88
1-5	0	-	0	-	0	-	0	-	0	-
6-10	0	-	0	-	0	-	0	-	0	-
11-20	0	-	0	-	0	-	0	-	0	-
21-30	0	-	0	-	0	-	26	8	26	2
31-40	0	-	0	-	0	-	0	-	0	-
41-50	0	-	0	-	0	-	91	29	91	5
51-60	0	-	0	-	0	-	0	-	0	-
61-70	0	-	0	-	0	-	23	7	23	1
71-80	0	-	0	-	1	-	0	-	1	-
81-90	0	-	0	-	0	-	0	-	0	-
91-99	0	-	0	-	0	-	62	19	62	4
TOTAL	318	100	333	100	684	100	320	100	1,655	100

Table 9
Semimonthly Summary of Bowhead Whales Observed, by Behavioral Category, Fall 1997

	1-15 Sep		16-30 Sep		1-15 Oct		16-19 Oct		Total	
Behavior	No.	%	No.	%	No.	%	No.	%	No.	%
Breaching	2	1	0	-	10	1	1	-	13	1
Cow-Calf	0	-	8	2	8	1	12	4	28	2
Diving	0	-	14	4	6	1	0	-	20	1
Feeding	165	52	84	25	299	44	131	41	679	41
Milling	35	11	60	18	224	33	53	17	372	22
Resting	15	5	11	3	6	1	12	4	44	3
Slapping	4	1	3	1	0	-	1	-	8	1
Spy Hopping	0	-	0	-	0	-	2	-	2	-
Swimming	81	25	152	46	129	19	108	34	470	28
Thrashing	0	-	1	1	0	-	0	-	1	-
(not noted)	16	5	0	-	2	-	0	-	18	1
TOTAL	318	100	333	100	684	100	320	100	1,655	100

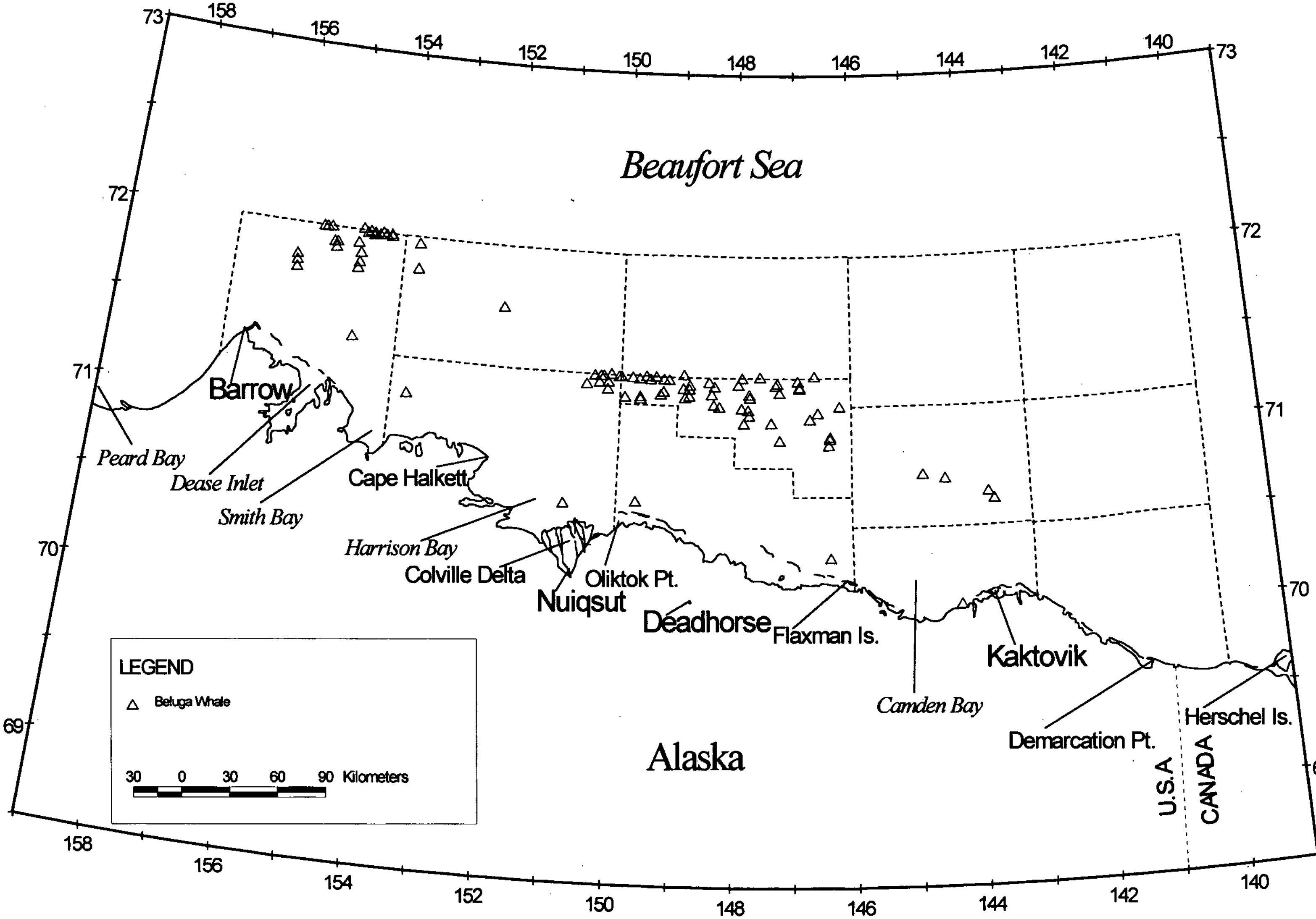


Figure 22. Map of Beluga Whale Sightings, Fall 1997

3. Unidentified Cetaceans: Over the field season, 1 incidental sighting was made for a total of 1 unidentified cetacean (Table 4).

4. Bearded Seal (*Erignathus barbatus nauticus*): Over the field season, 6 incidental sightings were made for a total of 8 bearded seals (Table 4) (Fig. 23). All the bearded seals were in open water (0% sea ice) when sighted.

5. Ringed Seal (*Pusa hispida hispida*): Over the field season, 48 incidental sightings were made for a total of 311 ringed seals (Table 4). Sightings were mostly between 30 and 60 nm from shore (Fig. 24). All but two of the ringed seals were in open water (0% sea ice) when sighted.

6. Walrus (*Odobenus rosmarus divergens*): No walruses were sighted during the study (Table 4).

7. Unidentified Pinnipeds: Over the field season, 6 incidental sightings were made for a total of 19 unidentified pinnipeds (Table 4).

8. Polar Bear (*Ursus maritimus marinus*): Over the field season, 10 incidental sightings were made for a total of 50 polar bears (Table 4). Most of the bears were near Kaktovik (Fig. 25). On 14 October, 15 bears were counted in the vicinity of a whale carcass at 70°08.2' N, 143°143.35.2' W. In addition to the polar bear sightings, 8 sets of polar bear tracks were recorded for which no bear was present (Table 4; Fig. 26).

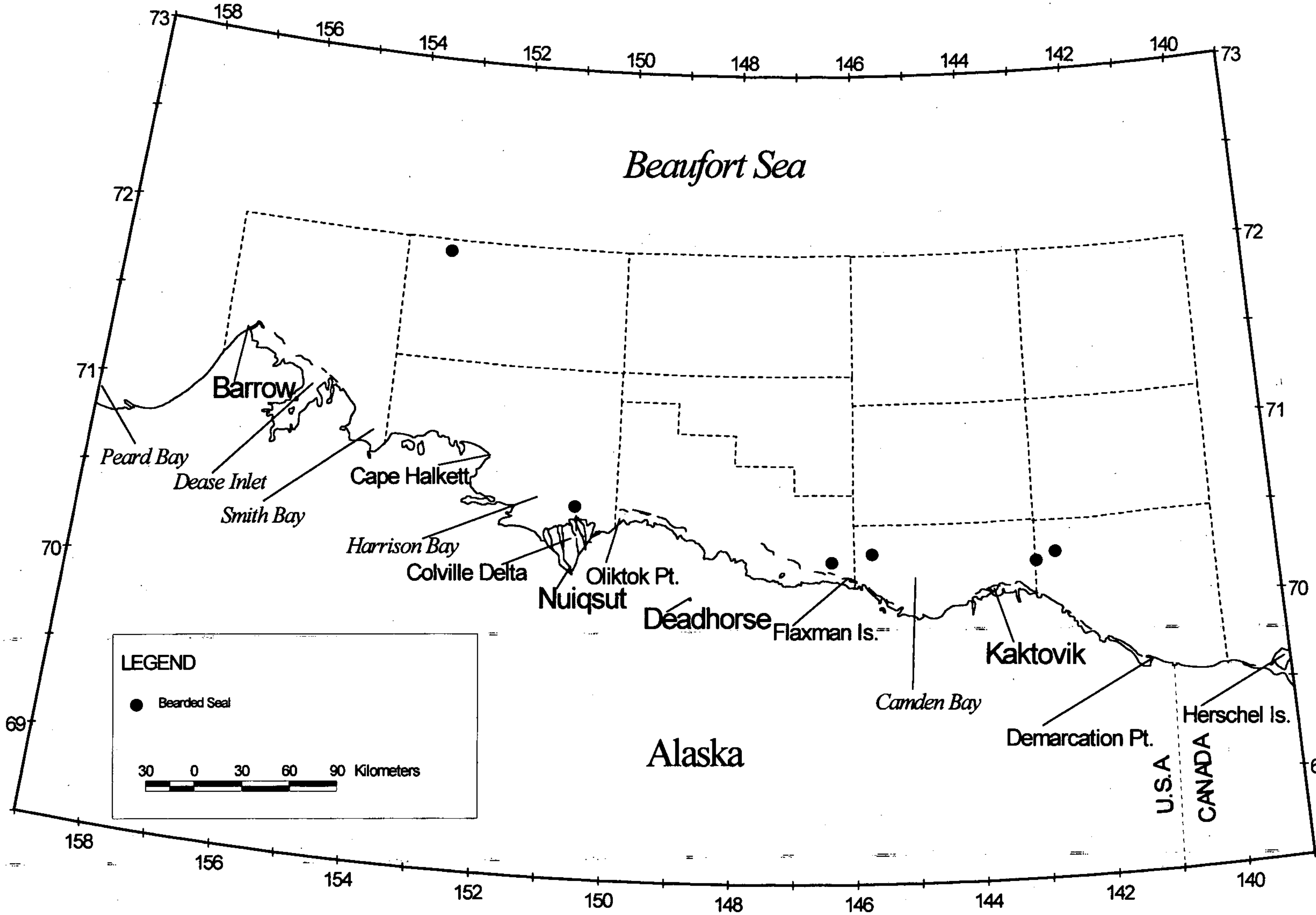


Figure 23. Map of Bearded Seal Sightings, Fall 1997

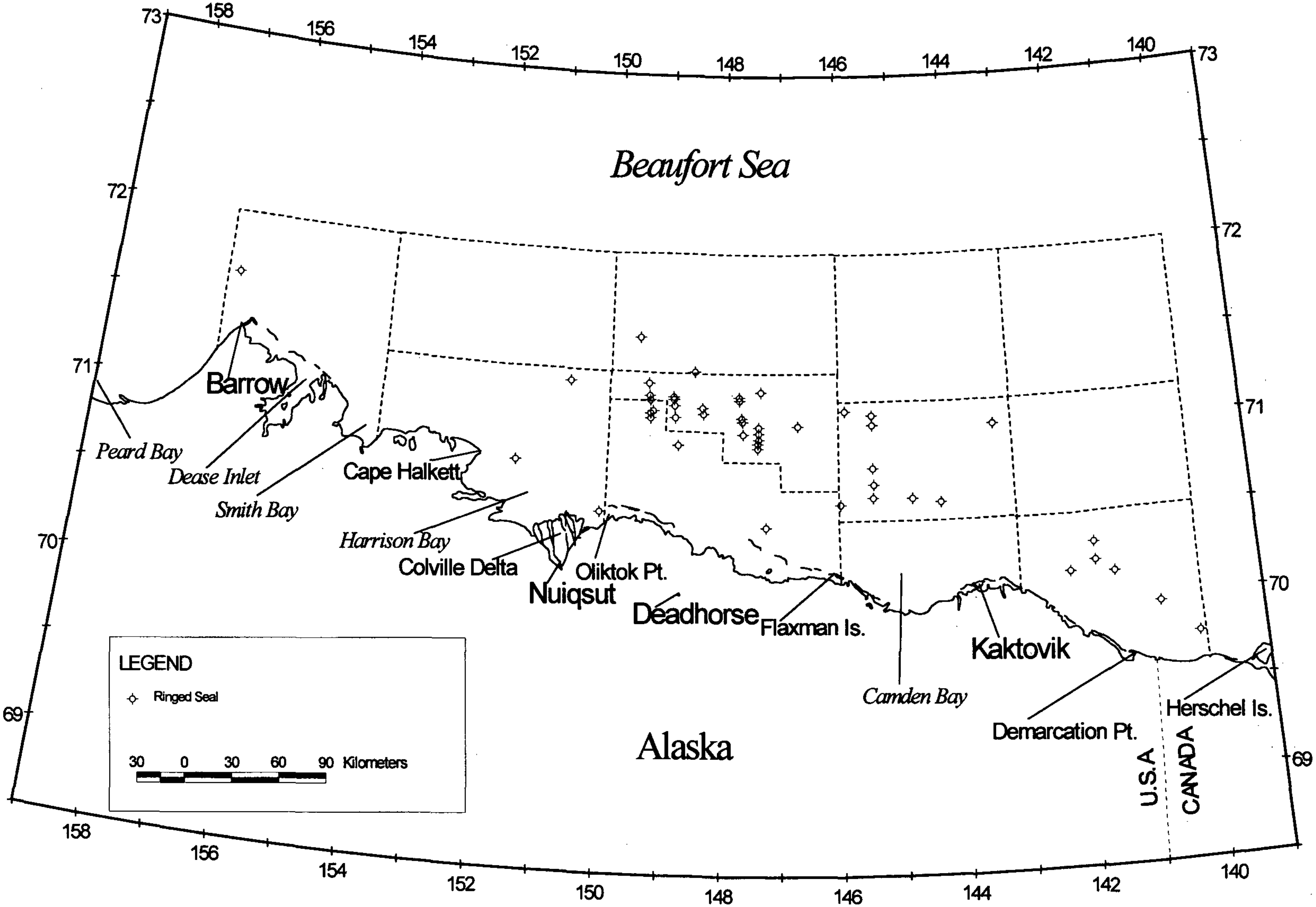


Figure 24. Map of Ringed Seal Sightings, Fall 1997

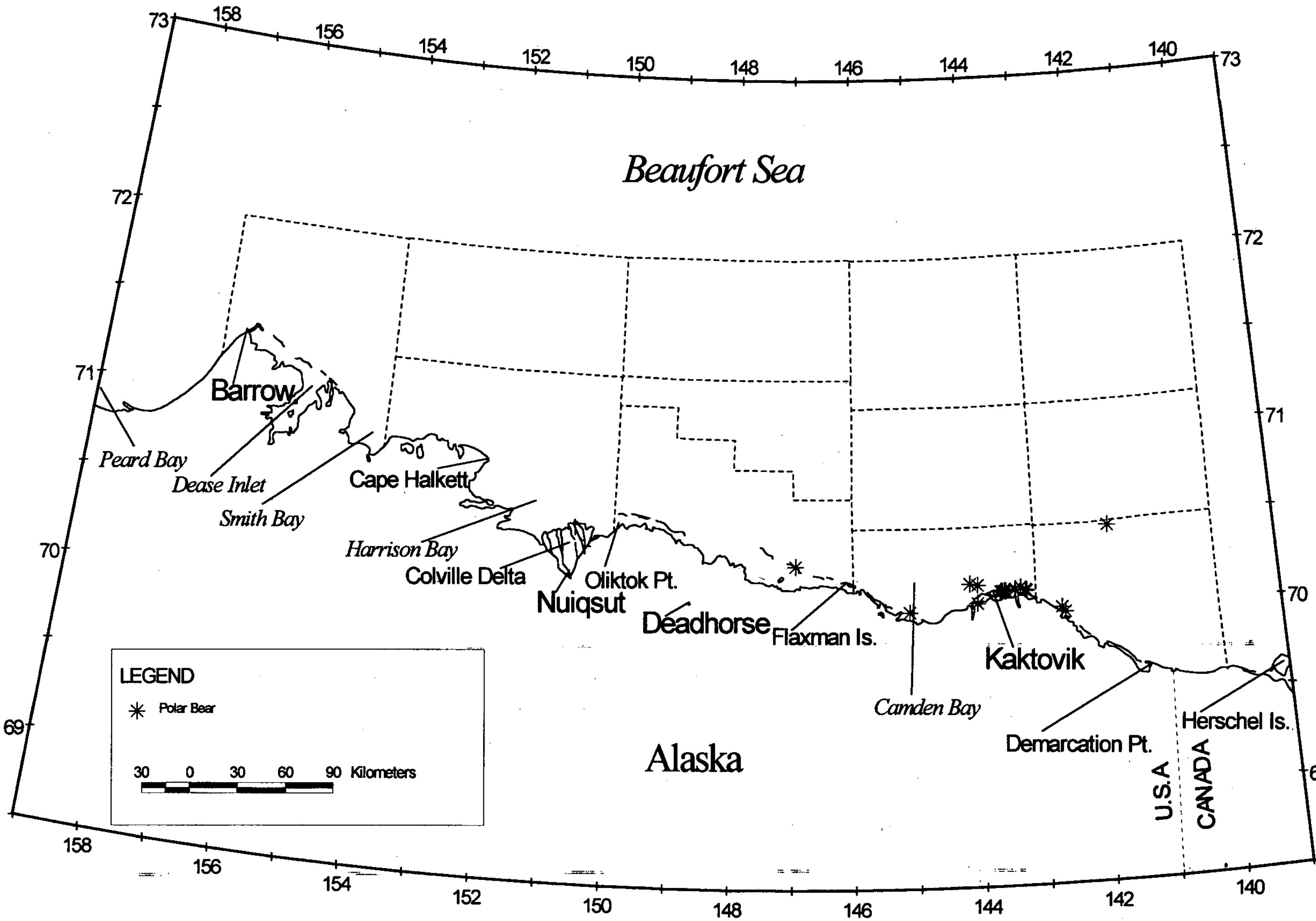


Figure 25. Map of Polar Bear Sightings, Fall 1997

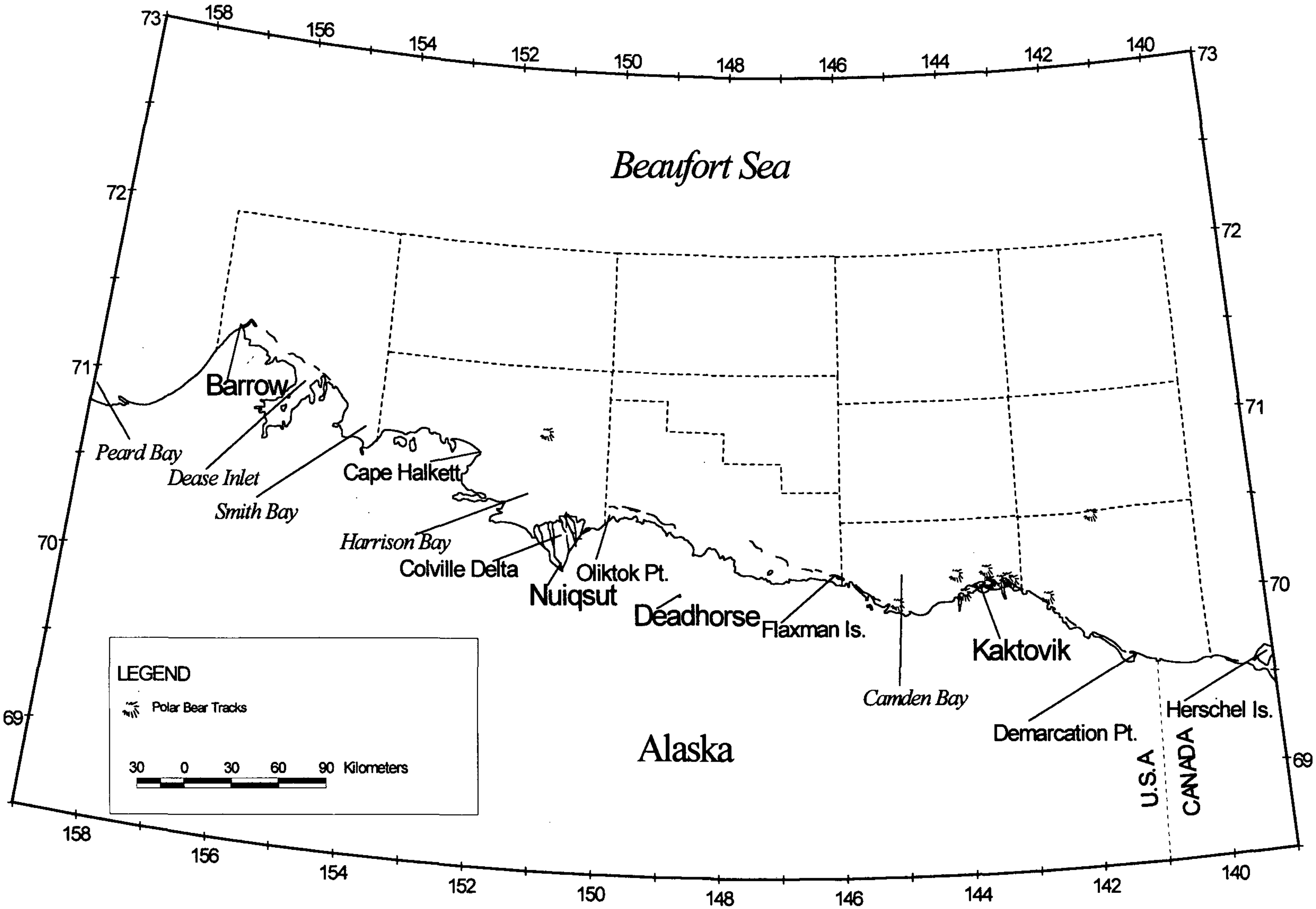


Figure 26. Map of Polar Bear Tracks, Fall 1997

IV. INTERANNUAL RESULTS (1979-1997)

A. Statistical Analyses of the Bowhead Whale Migration Corridor (1982-1997)

1. Central Tendency Statistics - Distance from Shore: Transect data were analyzed over a 16-year period (1982-1997) in two regions of the Alaskan Beaufort Sea (Fig. 2). Annual central tendency statistics for distance of bowhead whales from shore were summarized by year and region (Table 10; Fig. 27).

East Region

The combined data (1982-1997) included 501 transect sightings in the East Region. Mean measures of distance from shore ranged from 15.1 km to 89.7 km. The CI about the mean was widest (>30 km) in 1988 and 1989, both of which had sample sizes less than 10 (Table 10).

West Region

The combined data (1982-1997) included 403 transect sightings in the West Region. Mean measures of distance from shore ranged from 24.8 km to 65.9 km. The CI about the mean was widest (>30 km) in 1985, 1987, 1990, 1991, and 1994, all of which had sample sizes less than 10 (Table 10).

2. Central Tendency Statistics - Water Depth: Transect data were analyzed over a 16-year period (1982-1997) in two regions of the Alaskan Beaufort Sea (Fig. 2). Annual central tendency statistics for water depth at bowhead whale sightings were summarized by year and region (Table 11; Fig. 28).

East Region

The combined data (1982-1997) included 501 transect sightings in the East Region. Annual mean depths ranged from 22.9 m to 915.1 m. The confidence interval (CI) about the mean was widest (>100 m) in 1983, 1988, 1989, and 1991, all of which had less than 20 transect sightings (trSI) (Table 11). The 25^{th} - 75^{th} quartiles about the median were widest apart (>35 m) in 1983, 1989, and 1991 (Fig. 28).

West Region

The combined data (1982-1997) included 403 transect sightings in the West Region. Annual mean depths ranged from 15.7 m to 275.9 m. The CI about the mean was widest (>100 m) in 1983, 1985, 1986, 1991, 1992, and 1995, all but one of which had less than 20 trSI (Table 11). The 25^{th}-75^{th} quartiles about the median were widest apart (>35 m) in 1983, 1985, and 1991 (Fig. 28).

3. Parametric vs. Nonparametric Approach: To determine whether to apply parametric or nonparametric procedures to the bowhead whale sighting data, frequency distributions for both distance from shore and water depth were examined and the skewness was determined.

The frequency distribution for distance of bowheads from shore was nearly symmetrical. Median distances from shore for each region (1982-1997) were only slightly different from the means in most years. The skewness was determined to be only 1.067 for the East Region and 1.019 for the West Region. Therefore normality was assumed for distance measures in each region. Analysis using parametric procedures (ANOVA, power of ANOVA, and Tukey HSD) was considered most appropriate.

The frequency distribution for water depth at bowhead sightings was highly asymmetrical. In general, mean water depths at sightings of bowhead whales were skewed to the deeper (northern) side of the migration axis (median), with cumulative mean values for each region (1982-1997) approximately twice as great (as deep) as the cumulative medians (Table 11). The reason for the differences between the mean and median values is unknown but may simply reflect the increasing gradient of the seafloor farther offshore. The skewness of the data distribution was determined to be 7.441 for the East Region and 9.732 for the West Region. Therefore normality was not assumed for depth measures in either region. Analysis using nonparametric procedures (K-W ANOVA by ranks and Mann Whitney U) was considered most appropriate for water depths at whale sightings.

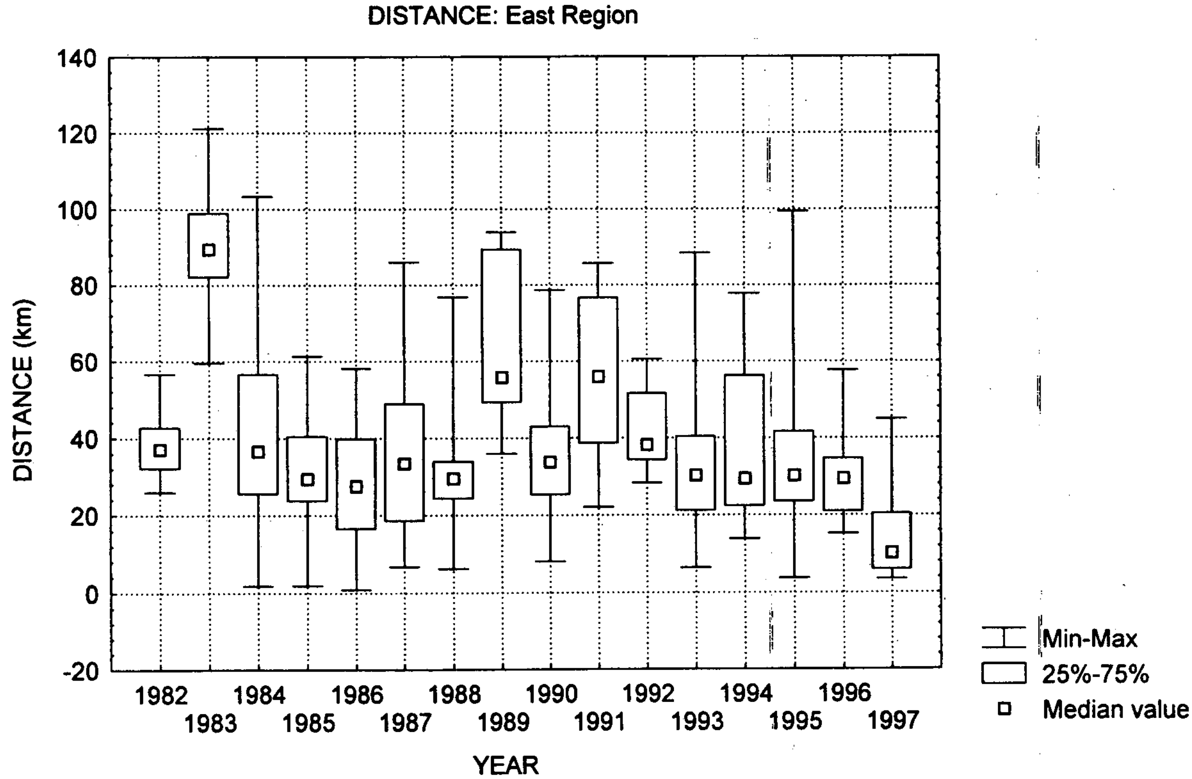
Table 10
Central-Tendency Statistics for Distance from Shore (in kilometers) to Random Sightings of Bowhead Whales (September-October), by Year and Region, 1982-1997

Year	Region	trSI [1]	Median	25th-75th Quartile Range	Mean	SD [2]	CI [3]	Range
1982	East	29	37.2	32.2-42.8	38.2	8.3	35.0-41.4	26.0-56.7
	West	27	40.9	37.6-48.9	43.6	16.4	37.1-50.1	14.6-86.3
1983	East[5]	14	89.5	82.0-98.9	89.7	15.7	80.7-98.8	59.6-121.2
	West[5]	15	53.3	42.3-86.6	62.2	26.3	47.6-76.7	27.4-125.3
1984	East	23	36.6	25.6-56.5	39.7	23.9	29.3-50.0	1.9-103.4
	West	36	46.2	36.8-60.3	45.7	19.1	39.2-52.2	8.9-85.2
1985	East[5]	10	29.5	23.7-40.5	31.8	16.0	20.4-43.3	1.9-61.4
	West[5]	7	50.3	25.9-86.2	53.8	29.2	26.7-80.8	15.4-88.9
1986	East	30	27.6	16.6-39.9	27.8	16.7	21.5-34.0	0.9-58.1
	West[5]	19	38.8	24.7-52.4	39.9	22.8	28.9-50.9	3.7-81.7
1987	East	34	33.4	18.6-49.0	36.2	19.9	29.2-43.1	6.8-86.0
	West[5]	8	29.2	16.7-51.2	32.7	20.2	15.8-49.6	7.3-60.4
1988	East[5]	6	29.6	24.4-34.0	33.4	23.5	8.8-58.0	6.3-76.8
	West[5]	8	64.5	59.2-71.5	65.9	11.2	56.6-75.3	50.8-86.7
1989	East[5]	6	55.8	49.3-89.4	63.4	23.4	38.8-87.9	36.0-93.0
	West[5]	16	37.3	14.5-48.3	33.8	19.6	23.3-44.2	7.5-74.6
1990	East	93	33.8	25.4-43.0	34.5	13.8	31.7-37.4	8.1-78.6
	West[5]	6	35.8	32.4-48.1	42.5	18.5	23.1-62.0	25.8-77.4
1991	East[5]	15	56.0	38.7-76.7	56.7	22.0	44.6-68.9	22.0-85.7
	West[5]	6	46.1	34.2-72.3	51.5	18.8	31.8-71.2	33.7-76.9
1992	East[5]	12	38.2	34.3-51.6	42.5	10.9	35.6-49.4	28.4-60.5
	West[5]	13	61.1	45.1-75.3	59.3	17.2	48.9-69.7	29.9-82.1
1993	East	55	30.3	21.2-40.4	31.9	17.0	27.3-36.5	6.4-88.5
	West	35	25.1	20.4-38.6	29.9	12.7	25.6-34.3	11.8-62.8
1994	East	32	29.5	22.3-56.2	37.2	18.7	30.5-44.0	13.9-77.7
	West[5]	3	23.5	[4]	24.8	11.4	0.0-53.1	14.2-36.8
1995	East	94	30.2	23.5-41.7	33.1	16.4	29.7-36.5	3.8-99.5

Table 10
Central-Tendency Statistics for Distance from Shore (in kilometers) to Random Sightings of Bowhead Whales (September-October), by Year and Region, 1982-1997

Year	Region	trSI [1]	Median	25th-75th Quartile Range	Mean	SD [2]	CI [3]	Range
	West	44	36.5	25.3-51.7	42.9	26.5	34.8-50.9	7.5-118.7
1996	East[5]	13	29.5	20.9-34.6	29.1	11.4	22.2-36.0	15.2-57.6
	West[5]	15	40.6	23.7-55.1	40.8	14.8	32.6-49.1	21.5-64.1
1997	East	35	10.2	5.9-20.4	15.1	11.9	11.0-19.2	3.5-44.9
	West	145	27.5	20.0-36.2	29.2	13.0	27.0-31.3	1.1-65.9
Cumulative	East	501	32.6	21.4-44.4	35.5	20.1	33.7-37.2	0.9-121-2
(1982-97)	West	403	35.7	23.4-49.2	38.2	20.4	36.2-40.2	1.1-125.3

[1] trSI = number of transect sightings.
[2] SD = standard deviation.
[3] CI ≥ 95-percent confidence interval (positive values).
[4] Insufficient sample size.
[5] trSI<20: sample excluded from parametric ANOVA and power analysis.



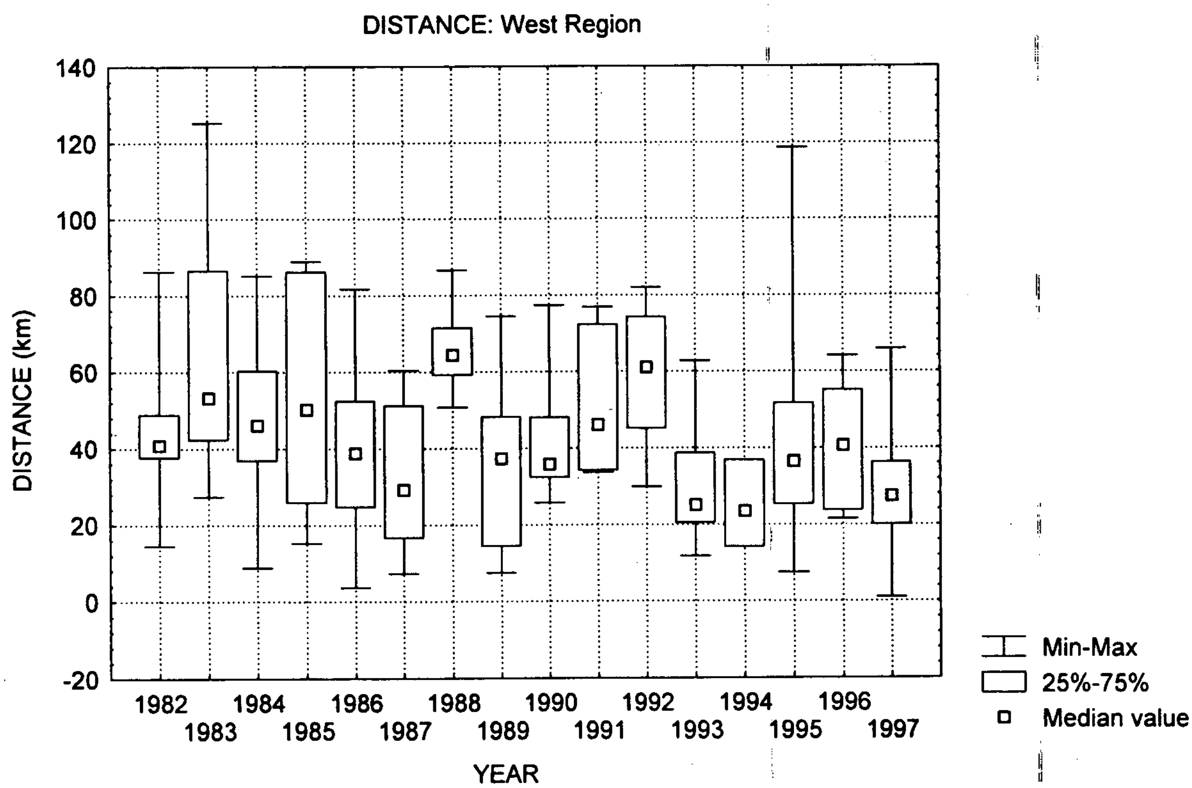


Figure 27. Median Distance from Shore at Random Sightings of Bowhead Whales (September-October), by Year and Region, 1982-1997, showing Quartile and Maximum Ranges

Table 11
Central-Tendency Statistics for Water Depth (in meters) at Random Sightings of Bowhead Whales (September-October), by Year and Region, 1982-1997

Year	Region	trSI [1]	Median	25th-75th Quartile Range	Mean	SD [2]	CI [3]	Range
1982	East	29	40.0	38.0-48.0	41.5	6.5	39.0-44.0	29.0-59.0
	West	27	22.0	18.0-27.0	51.2	92.7	15.0-88.0	11.0-457.0
1983	East[5]	14	810.0	183.0-1,737.0	915.1	737.7	489.0-1,341.0	49.0-2,021.0
	West	15	69.0	29.0-247.0	275.9	581.4	0.0-598.0	18.0-2,323.0
1984	East	23	48.0	33.0-55.0	71.2	103.6	26.0-116.0	18.0-485.0
	West	36	27.0	20.0-51.0	37.8	35.8	26.0-50.0	9.0-221.0
1985	East[5]	10	31.0	31.0-33.0	34.1	11.6	26.0-42.0	18.0-64.0
	West[5]	7	26.0	18.0-177.0	117.7	162.0	0.0-268.0	13.0-457.0
1986	East	30	37.5	22.0-46.0	33.0	14.2	28.0-38.0	9.0-57.0
	West	19	18.0	13.0-31.0	55.4	118.6	0.0-113.0	7.0-519.0
1987	East	34	37.0	29.0-48.0	42.9	33.2	31.0-54.0	15.0-219.0
	West[5]	8	20.0	11.0-25.0	18.4	7.2	12.0-24.0	9.0-26.0
1988	East[5]	6	42.0	37.0-46.0	81.5	106.4	0.0-193.0	24.0-298.0
	West[5]	8	44.0	35.0-54.0	44.8	12.3	34.0-55.0	29.0-62.0
1989	East[5]	6	54.0	44.0-488.0	200.8	237.1	0.0-450.0	40.0-525.0
	West	16	17.0	12.0-19.0	15.7	4.6	13.0-18.0	9.0-24.0
1990	East	93	38.0	33.0-48.0	41.7	28.2	36.0-48.0	15.0-293.0
	West[5]	6	22.0	18.0-31.0	25.0	10.2	14.0-36.0	15.0-42.0
1991	East	15	53.0	48.0-229.0	110.3	90.4	60.0-160.0	35.0-274.0
	West[5]	6	41.0	24.0-172.0	85.0	88.9	0.0-178.0	11.0-221.0
1992	East[5]	12	55.0	47.0-55.0	52.4	4.9	49.0-56.0	44.0-59.0
	West	13	46.0	29.0-51.0	76.7	99.4	17.0-137.0	13.0-329.0
1993	East	55	38.0	26.0-48.0	41.5	29.5	34.0-50.0	9.0-229.0
	West	35	16.0	15.0-18.0	17.7	6.5	16.0-20.0	2.0-38.0
1994	East	32	41.0	30.0-48.0	57.1	102.0	20.0-94.0	22.0-613.0
	West[5]	3	13.0	[4]	16.3	9.5	0.0-40.0	9.0-27.0

Table 11
Central-Tendency Statistics for Water Depth (in meters) at Random Sightings of Bowhead Whales (September-October), by Year and Region, 1982-1997

Year	Region	trSI [1]	Median	25th-75th Quartile Range	Mean	SD [2]	CI [3]	Range
1995	East	94	37.0	33.0-48.0	47.0	72.8	32.0-62.0	9.0-728.0
	West	44	26.0	20.0-34.0	111.9	295.4	22.0-202.0	7.0-1,445.0
1996	East[5]	13	37.0	29.0-40.0	36.0	10.4	30.0-42.0	13.0-51.0
	West	15	24.0	18.0-40.0	30.2	16.4	21.0-39.0	13.0-68.0
1997	East	35	18.0	15.0-29.0	22.9	12.2	19.0-27.0	9.0-53.0
	West	145	16.0	13.0-18.0	20.7	25.6	16.0-25.0	5.0-221.0
Cumulative	East	501	38.0	29.0-49.0	72.1	196.2	55.0-89.0	9.0-2,021.0
(1982-97)	West	403	18.0	15.0-29.0	50.2	162.5	34.0-66.0	2.0-2,323.0

[1] trSI = number of transect sightings.
[2] SD = standard deviation.
[3] CI ≥ 95-percent confidence interval (positive values).
[4] Insufficient sample size.
[5] smaller sample: excluded from K-W test.

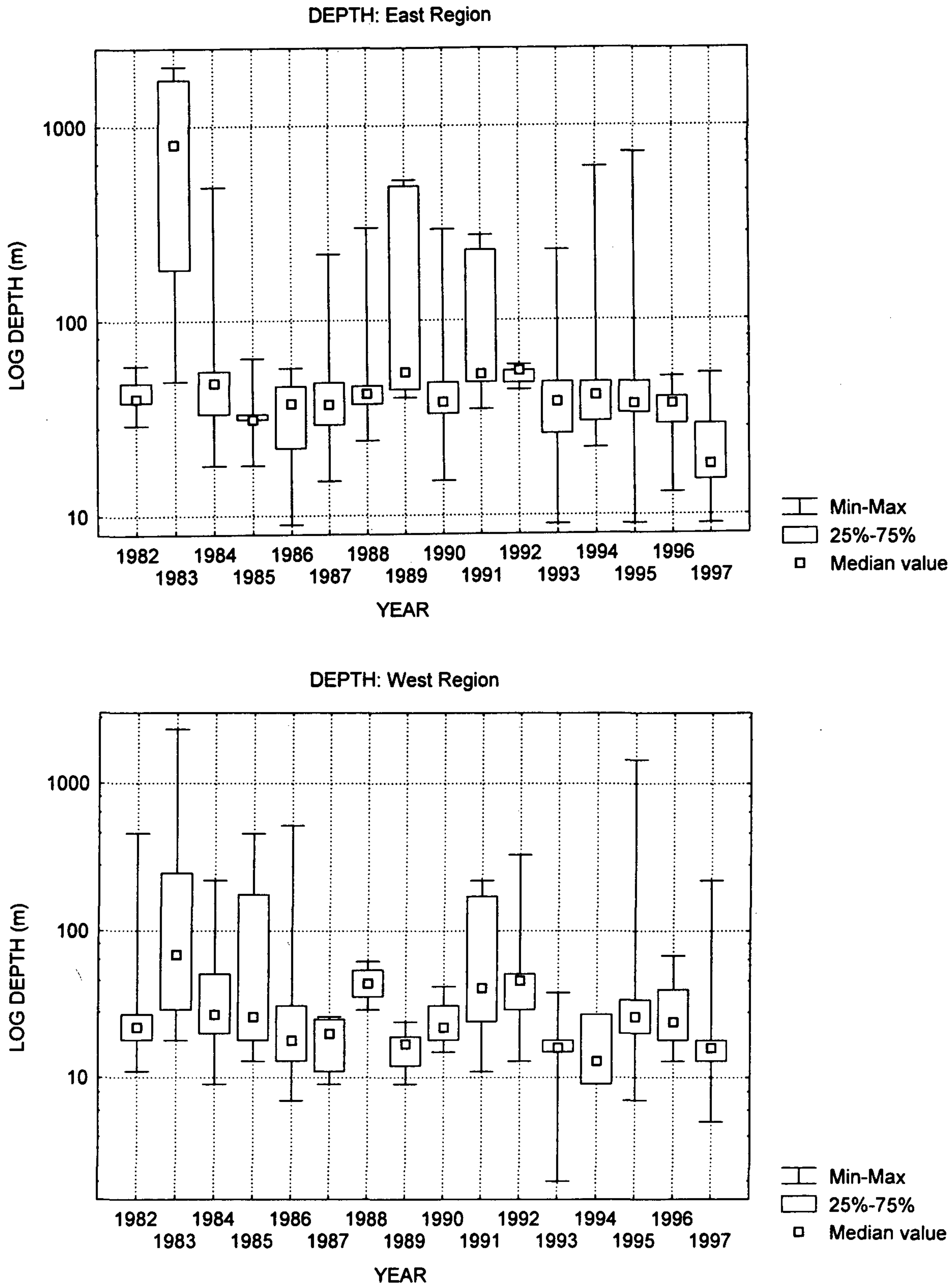


Figure 28. Median Water Depth at Random Sightings of Bowhead Whales (September-October), by Year and Region, 1982-1997, showing Quartile and Maximum Ranges

4. Preliminary ANOVA and Power Analysis - Distance from Shore: The among-year ANOVA and power analyses should be considered preliminary until data are adjusted by survey effort as it relates to the number of transect sightings by year and region. In order to limit the potential influence of survey-effort on the preliminary ANOVA and power analyses performed for this report, it was decided that only those years and regions with the largest sample sizes ($n \geq 20$) should be compared at this time (SAIC, pers. comm.). Results of the preliminary ANOVA showed that mean distances from shore were not equal among years. Preliminary power analyses for ANOVA tests are summarized in Table 12 and discussed by region.

East Region

Years with sample sizes ≥ 20 included in the ANOVA analysis were: 1982, 1984, 1986, 1987, 1990, 1993, 1994, 1995, and 1997. Results of ANOVA of distance-from-shore measures indicate strongly significant differences among years ($F=7.14$, $p<0.001$).

The power of the ANOVA performed on distance-from-shore measures in the East Region was $\phi=2.34$, with only a 1% probability of a Type II error either when $\alpha=0.05$ or when $\alpha=0.01$. Therefore the likelihood of failing to reject the null hypothesis when null is false was considered extremely low for the East Region. The minimum change in distance from shore detectable by the performed ANOVA was 7.80 km.

West Region

Years with sample sizes ≥ 20 included in the ANOVA analysis were: 1982, 1984, 1993, 1995, and 1997. Results of ANOVA of distance-from-shore measures indicate strongly significant differences among years ($F=12.90$, $p<0.001$).

The power of the ANOVA performed on distance-from-shore measures in the West Region was $\phi=3.09$, with only a 1% probability of a Type II error either when $\alpha=0.05$ or when $\alpha=0.01$. Therefore the likelihood of failing to reject the null hypothesis when null is false was considered extremely low for the West Region. The minimum change in distance from shore detectable by the performed ANOVA was 9.69 km.

5. Tukey HSD Test - Distance from Shore: Because the parametric ANOVA showed significant differences among years in both regions, the Tukey HSD test was applied to all transect sightings of bowhead whales over a 16-year period (1982-1997) without exclusions to determine which years were significantly different from each other year.

East Region

The Tukey HSD test showed that in 1983 whales were migrating significantly ($p<0.05$) farther offshore than in any other year except 1989. The data also showed that whales in 1989 and 1991 were significantly farther offshore, and in 1997 were significantly nearer to shore, than for most other years.

West Region

The Tukey HSD test showed that distances from shore in 1983 and 1988 were significantly ($p<0.05$) greater than in 1986, 1987, 1989, 1993, and 1997.

6. Kruskal-Wallis ANOVA by Ranks - Water Depth: The nonparametric K-W ANOVA by ranks was used to compare mean water depths at transect sightings of bowhead whales. The statistical package used to apply the K-W ANOVA by ranks limited the number of samples to ten; therefore the 10 years with the largest sample sizes for each region were included in the analysis.

East Region

The 10 years with larger sample sizes ($n \geq 15$) for the East Region were 1982, 1984, 1986, 1987, 1990, 1991, 1993, 1994, 1995, and 1997. The K-W ANOVA showed that differences in water depths at bowhead sightings among these years were highly significant ($H=68.08$, $p<0.001$).

Table 12
Summary of Power Analysis Statistics for the ANOVA
on Distance from Shore to Random Bowhead Whale Sightings

- **EAST REGION**

source of variation	SS	DF	MS
Total	124404	424	
Among groups	15026	8	1878
Error	109378	416	263

♦ Power

$$\phi = \sqrt{\frac{(9-1)(1878-263)}{9(263)}} = \sqrt{5.46} = 2.34$$

Power at α = 0.05 = 0.99; 1% chance of a Type II error
Power at α = 0.01 = 0.99; 1% chance of a Type II error

♦ Minimum Detectable Difference

$$\delta = \sqrt{\frac{2(9)(263)(2.34)^2}{425}} = \sqrt{60.82} = 7.80km$$

- **WEST REGION**

source of variation	SS	DF	MS
Total	83574	286	
Among groups	3655	4	3655
Error	79919	282	283

♦ Power

$$\phi = \sqrt{\frac{(5-1)(3655-283)}{5(283)}} = \sqrt{9.53} = 3.09$$

Power at α = 0.05 = 0.99; 1% chance of a Type II error
Power at α = 0.01 = 0.99; 1% chance of a Type II error

♦ Minimum Detectable Difference

$$\delta = \sqrt{\frac{2(5)(283)(3.09)^2}{287}} = \sqrt{93.97} = 9.69km$$

West Region

The 10 years with larger sample sizes ($n \geq 13$) for the West Region were 1982, 1983, 1984, 1986, 1989, 1992, 1993, 1995, 1996, and 1997. The K-W ANOVA showed that differences in water depths at bowhead sightings among these years were highly significant ($H=113.59$, $p<0.001$).

7. Mann-Whitney U - Water Depth: Because the nonparametric K-W ANOVA by ranks showed significant differences among years in both regions, the Mann-Whitney U test was applied to all transect sightings of bowhead whales over a 16-year period (1982-1997) without exclusions to determine which years were significantly different from each other year.

East Region

The Mann-Whitney U showed that bowheads in 1983 migrated in water that was significantly ($p<0.05$) deeper than in any other year. Whales in 1997 migrated in water that was significantly shallower than any other year. The data also showed that whales in 1989 and 1991 were in significantly deeper water than most other years.

West Region

The Mann-Whitney U showed that bowheads in 1983 migrated in water that was significantly ($p<0.05$) deeper than all but 4 years. Whales in 1997 migrated in water significantly shallower than all but 5 years. The data also showed that whales in 1989 were in significantly shallower water than for most other years.

B. General Ice Cover (1979-1997)

During September and October (combined) 1997, there were 1,655 bowhead whales observed during 122.17 hr for a relative abundance of 13.55 WPUE in Survey Blocks 1 through 12, with 8.68 WPUE during September and 21.29 WPUE during October (Table 13). The very high relative abundance of bowhead whales during Fall 1997 was likely due to the open-water conditions along with some repeat counting between days of large aggregations of feeding and/or milling whales that appeared to remain in the same area for several days.

The years 1980, 1983, 1988, and 1991 were categorized as having "heavy" ice cover during the navigation season. These 4 years are ranked as having the severest seasonal ice for the years 1979 through 1997 and show distances ranging from 10 to 25 nm between Point Barrow and the five-tenths ice concentration on 15 September (USDOC, NOAA, National Ice Center/USDOD, Navy, Naval Ice Center, 1997).

The years 1984, 1985, and 1992, categorized as having "moderate" ice cover during the open-water season, are ranked next in seasonal ice severity for the years 1979 through 1997 and show distances ranging from 50 to 75 nm between Point Barrow and the five-tenths ice concentration on 15 September (USDOC, NOAA, National Ice Center/USDOD, Navy, Naval Ice Center, 1997).

The years 1979, 1981, 1982, 1986, 1987, 1989, 1990, 1993, 1994, 1995, 1996, and 1997, categorized as having "light" ice cover during the open-water season, are ranked as having the least-severe seasonal ice for the years 1979 through 1997 and show distances ranging from 50 to 185 nm between Point Barrow and the five-tenths ice concentration on 15 September (USDOC, NOAA, National Ice Center/USDOD, Navy, Naval Ice Center, 1997).

The cumulative totals in Table 13 show a low relative abundance of bowhead whales in the primary study area (Survey Blocks 1-12) during September and October (combined) for years of heavy ice cover (0.46 WPUE), a middle-range value for moderate ice years (1.55 WPUE), and a high value for light ice years (2.96 WPUE). The K-W single-factor ANOVA by ranks showed that ice-year categories were significantly related ($p<0.05$) to annual relative abundance.

Although cumulative values for the three ice-year categories (Table 13) and the K-W test ($p \leq 0.009$) suggest a relationship to annual relative abundance, it is clear that WPUE value is not totally dependent on general ice coverage. While the mean WPUE for heavy ice years ($\bar{x}=0.46$, $SD=0.15$, $n=4$) appears separable from

Table 13
Relative Abundance (WPUE) of Bowhead Whales within the Primary Study Area (Survey Blocks 1-12) during September and October[1], by Year and General Ice Coverage, 1979-1997

	September			October			Total (Sep-Oct)		
Year	Hours	BH	WPUE	Hours	BH	WPUE	Hours	BH	WPUE
1979	51.80	60	1.16	79.99	130	1.63	131.79	190	1.44
1980[2]	76.41	30	0.39	50.72	12	0.24	127.13	42	0.33
1981	70.28	231	3.29	46.00	54	1.17	116.28	285	2.45
1982	77.91	283	3.63	35.19	29	0.82	113.10	312	2.76
1983[2]	101.73	72	0.71	41.48	17	0.41	143.21	89	0.62
1984[3]	73.64	216	2.93	63.49	85	1.34	137.13	301	2.19
1985[3]	67.39	52	0.77	58.22	57	0.98	125.61	109	0.87
1986	100.21	65	0.65	51.96	35	0.67	152.17	100	0.66
1987	90.07	61	0.68	77.07	76	0.99	167.14	137	0.82
1988[2]	64.96	21	0.32	55.49	19	0.34	120.45	40	0.33
1989	69.84	141	2.02	38.61	149	3.86	108.45	290	2.67
1990	54.85	401	7.31	41.37	77	1.86	96.22	478	4.97
1991[2]	38.36	9	0.23	51.13	40	0.78	89.49	49	0.55
1992[3]	104.28	63	0.60	90.52	234	2.59	194.80	297	1.52
1993	87.33	217	2.48	77.89	136	1.75	165.22	353	2.14
1994	67.55	183	2.71	53.24	9	0.17	120.79	192	1.59
1995	91.72	413	4.50	19.33	7	0.36	111.05	420	3.78
1996	91.49	108	1.18	32.05	6	0.19	121.96	114	0.93
1997	75.00	651	8.68	47.15	1,004	21.29	122.17	1,655	13.55
Heavy Ice Years[2] (Σ)	281.46	132	0.47	198.82	88	0.44	480.28	220	0.46
Moderate Ice Years[3] (Σ)	245.31	331	1.35	212.23	376	1.77	457.54	707	1.55
Light Ice Years (Σ)	928.05	2,814	3.03	599.85	1,712	2.85	1,526.90	4,526	2.96

[1] After Ljungblad et al. (1987), Moore and Clarke (1992), and Treacy (1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997).
[2] 1980, 1983, 1988, and 1991 were considered years of heavy ice coverage.
[3] 1984, 1985, and 1992 were considered years of moderate ice coverage.

that for moderate ice years ($\bar{x}$=1.53, SD=0.66, n=3), the SD of the mean WPUE for light ice years ($\bar{x}$=3.15, SD=3.51, n=12) overlaps both ice-year categories. Similarly, a nonparametric Tukey-type test (Zar, 1984) for comparing unequal sample sizes showed that while relative abundance of bowheads in light ice years was significantly different ($p<0.05$) from that in heavy ice years, neither of these two categories was significantly different from relative abundance in moderate ice years. A separate comparison of ice concentrations at the location of bowhead sightings (1981-1986) with the observability of whales showed that sighting distance was significantly affected by local ice cover only in 1982 and 1983 (Ljungblad et al., 1987).

General ice cover may also affect the distance from shore and the water depth at which bowhead whales migrate in the fall. The years with heavy and medium ice cover (1980, 1983, 1984, 1985, 1988, 1991, and 1992) account for many of the peak median values on Figures 27 and 28, thereby suggesting that bowheads may migrate farther offshore and in deeper water in icier years. This potential relationship can be seen most clearly in the distance from shore in the West Region (Table 10), where all six of the median distances greater than 42. km ,correspond with these years. The relatively small median distances from shore and small median water depths at bowhead sightings in both regions in Fall 1997 (Tables 10 and 11) are consistent with a tendency for bowheads to migrate closer to shore and in shallower water during years of light general ice cover.

C. Key Results Summary (1979-1997)

- General ice coverage along the northern coast of Alaska during the 1997 navigation season was the seventh -mildest in the Arctic Ocean for the 45 years from 1953 through 1997 (USDOC, NOAA, National Ice Center/USDOD, Navy, Naval Ice Center, 1997).

- The 1997 total of 123.62 survey hours was close to the mean of 127.98 hours (SD=38.10, n=10) for previous MMS surveys (1987-1996).

- The 437 sightings for a total of 1,655 individual bowhead whales in Fall 1997 was the highest number for the 11 MMS project surveys (1987-1997), almost 11 Standard Deviations higher than the mean for previous years ($\bar{x}$=232.30, SD=154.54, n=10). The high count in 1997 likely resulted from favorable open-water conditions along with some repeat counting between days of large aggregations of feeding and/or milling whales that appeared to remain in the same area for several days.

- There were more feeding bowheads in 1997 than in previous years (1987-1996). Feeding bowheads were observed within 30 nm of shore between 146°W. and 156°W. longitudes. The many feeders in Fall 1997 were likely linked to a greater availability of prey species, possibly associated with a narrow band of warmer-than-average sea surface temperatures.

- In 1997, the first bowheads observed were on 3 September. Sighting rates were fairly level over the field season, with higher values on 4 September, 21 September, 2 October, and 18 October. The data on daily relative abundance showed both the midpoint (median) and the peak (mode) of the bowhead migration occurred on 2 October. The last sighting of a bowhead was made on 18 October in 80-percent ice, as 95-100% concentrations of new sea ice were forming over most of the study area.

- The relatively small median distances from shore and small median water depths at bowhead sightings in both regions in Fall 1997 are consistent with a tendency for bowheads to migrate closer to shore and in shallower water during years of light general ice cover.

- The parametric ANOVA for distance from shore showed strongly significant differences among years in both regions.

- Preliminary power analysis of the ANOVA for distance of bowhead whales from shore (α=0.05, $\beta\leq$0.01) showed minimum detectable differences of 7.8 km in the East Region and 9.7 km in the West.

- The parametric Tukey HSD test showed that bowheads in the East Region were migrating farther from shore in 1983 than those in all other years except 1989. Whales in 1989 and 1991 were significantly farther offshore, and whales in 1997 were significantly nearer to shore, than for most other years. In the West Region, whales in 1983 and 1988 were significantly farther offshore than in 1986, 1987, 1989, 1993, and 1997.

- The nonparametric K-W ANOVA by ranks showed that differences in the water depth at which bowhead whales migrated were highly significant among years in each region. The potential for performing power analysis (or surrogate power analysis) of this nonparametric test is being assessed.

- The nonparametric Mann-Whitney U test showed that bowheads in the East Region in 1983 were migrating in water significantly deeper than in any other year; that whales in 1997 were in significantly shallower water than any other year; and that whales in 1989 and 1991 were in significantly deeper water than most other years. In the West Region, bowheads in 1983 and 1989 migrated in water that was significantly deeper than most other years and that whales in 1997 were in significantly shallower water than most other years.

- Other results of the present study are generally within the range of result values from previous MMS-funded endangered-whale monitoring conducted during September and October (1979-1996) in the Beaufort Sea using similar survey methods (Ljungblad et al., 1987; Moore and Clarke, 1992; Treacy, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997).

V. DISCUSSION

A. 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.

In the winter and spring of 1997, there were two over-ice seismic programs in the Beaufort Sea in Federal waters. The programs took place west of Prudhoe Bay (9 January-4 May) and used vibrators as an energy source. There was one marine-seismic program in the central Beaufort Sea during the summer of 1997 (15 July-23 September) using airguns as its seismic source.

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 areawide permit restrictions on high-energy seismic operations during the whale migration.

There were no drilling operations, with associated helicopter and vessel support, in the Beaufort Sea in 1997. 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 distributional 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.

In general, sighting data are used by several 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. Data from previous surveys continue to be used by MMS in writing Environmental Impact Statements (EIS) and Environmental Assessments and in interpreting the results of site-specific studies. Project ice data were also transmitted daily to the U.S. Navy, Naval Ice Center, for their use in ground-truthing satellite imagery.

B. 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 1982-1997), thus permitting many one-for-one comparisons between years. Such continuous, long-term, wide-area, systematic, 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 V.A. above), the project has been helpful to managers in several ways. Some notable examples are: (1) providing raw data to all parties (MMS, Western Geophysical, NMFS, ARCO Alaska, Inc., and 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; (2) 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; (3) providing sighting and effort data to enhance sample sizes of many site-specific studies on the potential effects of oil-industry activity on bowhead whale migrations; and (4) documenting bowhead feeding areas.

When making decisions based on current broad-area monitoring, managers should consider the context in which data are collected and analyzed. Certain key points relevant to the present study, some of which we continue to improve upon, are: (1) the aircraft used in Block 12 prior to Fall 1992 was a modified Grumman Goose rather than a Twin Otter; (2) the area surveyed on a given day is driven more by prevailing sighting conditions than by a rigid sampling paradigm; (3) the sightability of whales is variable depending on the observer and the ambient conditions; (4) the distance of whales from the aircraft, used in certain density calculations, is limited by the accuracy of the clinometer and how effectively it is used; (5) the exclusion of data collected under adverse ambient conditions may decrease some sample sizes below a meaningful level; (6) the geographic positions of sighting events are those of the aircraft, rather than the mammal observed, limited by the accuracy of the aircraft's positioning system; (7) the water depths assigned to sighting events are based on a grid superimposed on a marine navigational chart; (8) the measurement of distance from shore is an imperfect process since Beaufort Sea coastlines are nonlinear; and (9) the present migration-timing analysis treats the Alaskan Beaufort Sea as a single location.

To support future management usages, we anticipate improving our monitoring program by: (1) increasing survey coverage in areas of industrial activity and potential feeding areas; (2) increasing the accuracy of mammal positions (e.g., calculating positions from available data); (3) focusing on parametric analyses of distance from shore (for which we have a power analysis) rather than nonparametric analyses of water depth; (4) comparing migration timing of non-feeding bowheads past a small representative area; (5) addressing the potential for autocorrelation and survey effort on existing analyses (including power analysis); (6) upgrading the bathymetry used to estimate depths at whale sightings; (7) performing a fuller analysis of distance-from-shore and water-depth at bowhead sightings relative to general ice cover; (8) adding other analyses applicable to future management issues; and (9) deleting analyses of limited future relevance.

C. Conclusions

Day-to-day observations showed that many groups of bowhead whales appeared to pause for several days at various sites along the migration route while feeding. Other than these feeding bouts, we saw no indications that the migration was "stopped" this year, including areas near or just east of seismic exploration activities by Western Geophysical.

Oil industry studies, pooling our data with their own site-specific data, have detected localized deflections on the order of 10 to 20 km by bowhead whales in the immediate vicinity of certain types of active seismic exploration (USDOI, MMS, 1997b). Since preliminary power analysis of the ANOVA for distance of bowhead whales from shore (α=0.05, $\beta \leq 0.01$) showed minimum detectable differences of 7.8 km in the East Region and 9.7 km in the West, we should be able to detect any region-wide 10- to 20-km shifts between years that may have derived from localized deflections. The Tukey HSD test of our own randomized bowhead sightings showed that the migration corridor region-wide in Fall 1997 was significantly closer to shore in the East Region, and not significantly different in the West Region, than in 1994 or 1995, years with no offshore seismic exploration or drilling activity during the fall season in the Alaskan Beaufort Sea.

To some extent, general ice cover, which includes shorefast ice, appears to influence the distance from shore and the water depth at which bowhead whales migrate. Insofar as 1997 was the seventh-mildest in the Arctic Ocean over the last 45 years, sea ice this year had little direct effect on the whale migration. However, the relatively small median distances from shore and small median water depths at bowhead sightings in both regions in Fall 1997 are consistent with a tendency for bowheads to migrate closer to shore and in shallower water during years of light general ice cover.

D. Field Coordination and Information Support

During the field season, we coordinated with the Alaska Eskimo Whaling Commission (AEWC), Barrow, Alaska; the BP Exploration (Alaska) Inc. (BPXA) Northstar site-specific aerial survey team; Whalers Communication Center, Deadhorse, Alaska; NMFS, Anchorage, Alaska; and North Slope Borough (NSB), Department of Wildlife Management, Barrow, Alaska. Accompanying the project and actively participating in selected survey flights was Colleen Benner, MMS Oceanographer (Flights 11-13).

Selected BWASP information-support activities during the year included: (1) providing data summaries to various requesting agencies and private-sector organizations, including AEWC, BPXA, and Northstar EIS Development Project; (2) presenting a talk on BWASP to the Polar Research Board; (3) contributing information used in a MMS Focus Sheet "Alaska OCS Region Environmental Studies Program" (April 1997) and on the Internet (http://www.mms.gov/omm/alaska/ess); (4) participating in an evaluation of BPXA's "Proposed Technical Plan for 1997 Northstar Marine Mammal Monitoring Program"; (5) releasing the project Twin Otter and assisting in an emergency medical evacuation from the offshore pack ice; (6) participating as the MMS Regional Aviation Manager in meetings of the Alaska Inter-Agency Aircraft Working Group; (7) helping to redraft portions of the Sale 170 EIS in light of BWASP research findings; (8) presenting a talk on MMS-funded research and monitoring of marine mammal species to the Marine Mammal Commission; (9) providing data to and coordinating with scientists and subsistence whalers in Kaktovik, Alaska, in support of the MMS study "Bowhead Whale Feeding in the Eastern Alaskan Beaufort Sea: Update of Scientific and Traditional Information"; (10) providing BWASP beluga whale sightings in support of the MMS study "Tagging and Satellite Tracking of Bowhead and Belukha Whales"; and (11) contributing text for an article entitled "BWASP Team Involved in Rescue Mission" and "BWASP Flies Again", articles in MMS Today (Vol. 8, Winter 1998).

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APPENDIX A

BOWHEAD WHALE SIGHTING DATA

Table A-1
Selected Sighting Data for Bowhead Whales Observed, Fall 1997
(Page 1 of 21)

Flight No.	Day	Total Whales	No. of Calves	Latitude	Longitude	Sighting Cue	Behavior	Compass Heading	Ice (%)	Sea State	Depth (m)
2	3 Sep	2	0	70°15.1′	146°27.3′	body	swim	240°	0	2	15
2	3 Sep	1	0	70°15.1′	146°44.9′	body	slap	[1]	0	2	9
2	3 Sep	5	0	70°15.0′	146°35.5′	body	mill	[1]	0	2	11
2	3 Sep	10	0	70°15.1′	146°29.1′	body	mill	[1]	0	2	15
2	3 Sep	59	5	70°15.9′	146°42.3′	body	feed	[1]	0	2	9
2	3 Sep	1	0	70°15.6′	146°41.2′	body	[1]	[1]	0	2	9
2	3 Sep	1	0	70°15.4′	146°38.6′	body	swim	270°	0	2	11
2	3 Sep	1	0	70°15.8′	146°47.7′	body	swim	300°	0	2	9
2	3 Sep	1	0	70°15.4′	146°29.9′	body	[1]	[1]	0	2	15
2	3 Sep	2	0	70°13.5′	144°13.4′	blow	swim	190°	0	2	29
2	3 Sep	2	1	70°14.9′	146°26.2′	blow	swim	240°	0	2	9
2	3 Sep	1	0	70°13.5′	145°52.0′	body	swim	240°	0	2	18
2	3 Sep	1	0	70°12.3′	145°39.7′	body	swim	240°	0	2	20
2	3 Sep	2	0	70°14.0′	145°39.2′	body	swim	240°	0	2	20
2	3 Sep	1	0	70°25.2′	145°40.1′	body	swim	210°	0	2	38
2	3 Sep	2	0	70°25.6′	144°15.3′	body	swim	350°	0	1	53
2	3 Sep	1	0	70°25.9′	145°57.8′	body	swim	260°	0	2	37
2	3 Sep	70	0	70°15.6′	146°32.6′	body	feed	[1]	0	2	11
2	3 Sep	1	0	70°25.7′	147°02.4′	body	swim	240°	0	2	18
3	4 Sep	1	0	70°37.4′	146°36.5′	body	swim	260°	0	3	33
3	4 Sep	1	0	70°18.4′	146°49.0′	body	swim	[1]	0	2	15

Table A-1
Selected Sighting Data for Bowhead Whales Observed, Fall 1997
(Page 2 of 21)

Flight No.	Day	Total Whales	No. of Calves	Latitude	Longitude	Sighting Cue	Behavior	Compass Heading	Ice (%)	Sea State	Depth (m)
3	4 Sep	22	1	70°18.4′	146°49.0′	body	feed	[1]	0	2	15
3	4 Sep	1	0	70°18.4′	146°49.0′	body	[1]	[1]	0	2	15
3	4 Sep	4	0	70°18.4′	146°49.0′	body	[1]	[1]	0	2	15
3	4 Sep	1	0	70°17.9′	146°45.4′	body	rest	[1]	0	2	9
3	4 Sep	1	0	70°16.8′	146°43.9′	body	swim	180°	0	2	9
3	4 Sep	1	0	70°32.8′	147°45.3′	body	swim	260°	0	3	13
3	4 Sep	1	0	70°18.2′	146°37.5′	body	swim	230°	0	2	16
3	4 Sep	2	0	70°21.4′	146°58.0′	body	slap	180°	0	2	13
3	4 Sep	1	0	70°34.8′	147°41.5′	body	swim	260°	0	3	18
3	4 Sep	1	0	70°16.8′	146°42.6′	body	swim	270°	0	2	9
7	10 Sep	1	0	70°12.6′	143°35.3′	body	swim	80°	0	4	16
7	10 Sep	1	0	70°12.0′	143°29.6′	blow	swim	120°	0	4	13
7	10 Sep	1	0	70°07.7′	142°57.2′	body	swim	260°	0	4	18
7	10 Sep	1	0	70°13.9′	144°05.5′	body	swim	150°	0	4	29
7	10 Sep	1	0	70°25.8′	144°10.2′	splash	swim	40°	0	4	53
8	11 Sep	1	0	70°25.4′	147°31.6′	body	[1]	[1]	0	2	9
9	12 Sep	1	0	70°04.7′	142°42.2′	body	swim	80°	0	4	18
9	12 Sep	1	0	70°12.1′	143°44.5′	splash	swim	130°	0	4	18
9	12 Sep	1	0	70°20.9′	143°11.0′	body	swim	210°	0	4	46
9	12 Sep	1	0	70°09.3′	143°05.1′	body	swim	60°	0	5	18
9	12 Sep	1	0	70°07.9′	143°00.9′	body	swim	60°	0	5	11

Table A-1
Selected Sighting Data for Bowhead Whales Observed, Fall 1997
(Page 3 of 21)

Flight No.	Day	Total Whales	No. of Calves	Latitude	Longitude	Sighting Cue	Behavior	Compass Heading	Ice (%)	Sea State	Depth (m)
9	12 Sep	1	0	70°06.5′	142°53.0′	body	swim	80°	0	5	18
9	12 Sep	1	0	70°06.3′	142°52.0′	body	swim	40°	0	5	18
9	12 Sep	1	0	69°57.8′	142°17.5′	body	swim	330°	0	5	18
9	12 Sep	1	0	70°04.8′	142°42.7′	body	swim	360°	0	5	18
9	12 Sep	1	0	69°58.5′	142°22.4′	body	swim	290°	0	5	9
9	12 Sep	1	0	70°04.1′	142°39.6′	body	swim	60°	0	4	18
9	12 Sep	2	0	70°03.8′	142°38.5′	body	swim	270°	0	4	18
9	12 Sep	1	0	70°03.0′	142°36.0′	body	swim	260°	0	4	18
9	12 Sep	3	0	70°01.7′	142°31.7′	body	mill	[1]	0	4	9
9	12 Sep	1	0	70°01.0′	142°29.1′	body	swim	260°	0	4	18
9	12 Sep	4	0	70°10.9′	143°43.4′	blow	mill	[1]	0	4	9
9	12 Sep	1	0	70°05.6′	142°47.9′	blow	swim	240°	0	5	18
9	12 Sep	1	0	70°20.9′	146°58.3′	body	rest	[1]	0	2	11
9	12 Sep	2	0	69°57.7′	142°09.0′	splash	breach	[1]	0	5	22
9	12 Sep	1	0	70°09.9′	143°42.3′	body	swim	220°	0	4	9
9	12 Sep	1	0	70°27.0′	147°34.5′	body	rest	270°	0	2	13
9	12 Sep	1	0	70°22.2′	147°03.4′	body	swim	120°	0	2	15
9	12 Sep	4	0	70°20.9′	146°58.3′	body	feed	[1]	0	2	11
9	12 Sep	1	0	70°20.4′	146°56.4′	blow	[1]	[1]	0	2	11
9	12 Sep	1	0	70°19.4′	146°55.1′	body	swim	[1]	0	2	11
9	12 Sep	1	0	70°13.2′	145°13.1′	body	swim	100°	0	4	24

Table A-1
Selected Sighting Data for Bowhead Whales Observed, Fall 1997
(Page 4 of 21)

Flight No.	Day	Total Whales	No. of Calves	Latitude	Longitude	Sighting Cue	Behavior	Compass Heading	Ice (%)	Sea State	Depth (m)
9	12 Sep	7	0	70°16.9′	146°52.4′	blow	feed	[1]	0	2	9
9	12 Sep	1	0	70°24.2′	146°34.2′	blow	swim	200°	0	2	27
9	12 Sep	3	0	70°08.6′	145°38.4′	body	swim	290°	0	4	11
9	12 Sep	2	0	70°09.0′	145°38.5′	body	swim	290°	0	4	18
9	12 Sep	2	0	70°10.6′	145°38.8′	blow	swim	250°	0	4	18
9	12 Sep	1	0	70°18.9′	146°54.9′	body	swim	[1]	0	2	11
9	12 Sep	2	0	70°28.5′	147°35.4′	body	swim	230°	0	2	13
9	12 Sep	2	0	70°13.2′	145°13.1′	body	swim	20°	0	4	24
10	13 Sep	1	0	70°28.8′	147°39.8′	body	swim	180°	0	2	13
10	13 Sep	1	0	70°28.8′	147°41.4′	body	swim	270°	0	2	9
10	13 Sep	1	0	70°28.5′	147°50.2′	body	swim	240°	0	2	9
10	13 Sep	1	0	70°28.4′	147°53.7′	blow	swim	310°	0	2	9
10	13 Sep	3	0	70°37.3′	149°40.6′	body	mill	[1]	0	2	13
10 [2]	13 Sep	1	0	70°20.1′	146°54.7′	body	swim	180°	0	2	11
10	13 Sep	1	0	70°28.2′	147°28.5′	body	swim	240°	0	2	18
10 [2]	13 Sep	1	0	70°21.0′	147°01.3′	body	swim	270°	0	2	15
10 [2]	13 Sep	1	0	70°20.1′	146°54.7′	body	feed	150°	0	2	11
10	13 Sep	2	0	70°27.5′	147°28.5′	blow	feed	[1]	0	2	18
10	13 Sep	1	0	70°26.4′	147°28.7′	body	rest	[1]	0	2	15
10	13 Sep	1	0	70°25.6′	147°28.8′	body	[1]	[1]	0	2	15
10	13 Sep	1	0	70°25.1′	147°28.8′	body	[1]	[1]	0	2	15

Table A-1
Selected Sighting Data for Bowhead Whales Observed, Fall 1997
(Page 5 of 21)

Flight No.	Day	Total Whales	No. of Calves	Latitude	Longitude	Sighting Cue	Behavior	Compass Heading	Ice (%)	Sea State	Depth (m)
10	13 Sep	4	0	70°23.5′	147°23.1′	body	rest	[1]	0	2	9
10	13 Sep	1	0	70°23.2′	147°20.7′	body	swim	[1]	0	2	9
10 [2]	13 Sep	2	0	70°21.3′	147°03.4′	body	[1]	[1]	0	2	15
10 [2]	13 Sep	1	0	70°21.1′	146°42.7′	body	swim	220°	0	2	13
10 [2]	13 Sep	2	0	70°20.6′	146°59.0′	body	[1]	[1]	0	2	11
10	13 Sep	3	0	70°21.9′	147°10.9′	body	swim	270°	0	2	9
10	13 Sep	1	0	70°20.2′	146°43.0′	blow	swim	150°	0	2	15
10	13 Sep	1	0	70°38.7′	149°40.1′	body	swim	30°	0	3	13
10	13 Sep	1	0	70°34.6′	149°09.2′	body	swim	240°	0	3	13
10	13 Sep	1	0	70°33.4′	149°04.5′	blow	swim	270°	0	3	13
10	13 Sep	1	0	70°22.0′	146°50.5′	blow	swim	120°	0	2	13
10	13 Sep	2	0	70°21.7′	146°49.3′	blow	swim	180°	0	2	13
10 [2]	13 Sep	3	0	70°21.9′	146°43.0′	body	mill	[1]	0	2	13
10 [2]	13 Sep	1	0	70°19.9′	146°42.3′	body	slap	220°	0	2	15
10	13 Sep	5	0	70°19.7′	146°40.8′	body	mill	[1]	0	2	15
10	13 Sep	3	1	70°18.5′	146°38.6′	body	rest	[1]	0	2	16
10	13 Sep	1	0	70°21.9′	146°59.4′	body	rest	240°	0	2	13
10	13 Sep	1	0	70°22.9′	147°02.1′	body	rest	250°	0	2	15
10 [2]	13 Sep	1	0	70°20.6′	146°59.0′	body	[1]	[1]	0	2	11
10	13 Sep	2	0	70°23.7′	147°04.4′	body	rest	150°	0	2	15
10	13 Sep	2	0	70°20.7′	146°44.8′	body	mill	[1]	0	2	15

Table A-1
Selected Sighting Data for Bowhead Whales Observed, Fall 1997
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Flight No.	Day	Total Whales	No. of Calves	Latitude	Longitude	Sighting Cue	Behavior	Compass Heading	Ice (%)	Sea State	Depth (m)
11	18 Sep	1	0	70°13.3′	145°52.2′	body	swim	80°	0	5	18
11	18 Sep	1	0	70°13.3′	145°52.2′	body	swim	60°	0	5	18
11	18 Sep	1	0	70°13.3′	145°52.2′	body	rest	60°	0	5	18
11	18 Sep	2	0	70°20.9′	146°55.1′	body	rest	110°	0	5	11
11	18 Sep	2	0	70°08.1′	145°27.0′	body	swim	60°	0	5	16
11	18 Sep	1	0	70°09.2′	145°31.9′	body	swim	30°	0	5	18
11	18 Sep	1	0	70°11.0′	145°40.5′	body	dive	[1]	0	5	11
12	18 Sep	1	0	70°39.6′	150°42.7′	body	rest	240°	0	4	15
12	18 Sep	1	0	70°41.4′	150°43.5′	blow	swim	300°	0	4	15
12	18 Sep	1	0	70°39.8′	150°34.7′	blow	swim	360°	0	5	15
12	18 Sep	1	0	70°41.9′	150°45.8′	splash	swim	360°	0	5	15
12	18 Sep	1	0	70°44.8′	150°52.8′	blow	swim	[1]	0	5	16
12	18 Sep	1	0	70°48.9′	151°11.1′	blow	rest	60°	0	4	16
12	18 Sep	1	0	70°48.6′	151°11.1′	blow	swim	[1]	0	4	16
12	18 Sep	1	0	70°45.0′	151°09.9′	body	swim	30°	0	4	16
12	18 Sep	1	0	70°42.2′	150°43.8′	body	dive	60°	0	4	16
12	18 Sep	1	0	70°45.7′	150°16.5′	splash	swim	340°	0	3	15
12	18 Sep	1	0	70°39.6′	150°19.2′	blow	swim	30°	0	3	18
12	18 Sep	1	0	70°47.6′	151°10.5′	blow	swim	[1]	0	4	16
12	18 Sep	1	0	70°38.4′	150°42.3′	body	dive	[1]	0	4	11
13	19 Sep	1	0	70°32.7′	148°43.1′	body	swim	90°	0	5	11

Table A-1
Selected Sighting Data for Bowhead Whales Observed, Fall 1997
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Flight No.	Day	Total Whales	No. of Calves	Latitude	Longitude	Sighting Cue	Behavior	Compass Heading	Ice (%)	Sea State	Depth (m)
15	21 Sep	1	0	71°22.6′	155°08.8′	body	dive	150°	0	5	18
15	21 Sep	1	0	71°11.7′	154°43.1′	body	swim	90°	0	5	11
15	21 Sep	30	0	71°10.5′	154°39.5′	body	feed	[1]	0	5	11
15	21 Sep	1	0	71°09.9′	154°46.7′	body	rest	160°	0	5	11
15	21 Sep	2	0	71°19.4′	155°07.9′	body	dive	150°	0	5	18
15	21 Sep	4	0	71°02.7′	152°06.0′	splash	swim	10°	0	3	16
15	21 Sep	1	0	71°21.9′	155°08.7′	splash	swim	150°	0	5	18
15	21 Sep	1	0	71°18.6′	154°39.4′	body	swim	150°	0	5	18
15	21 Sep	1	0	71°27.7′	155°10.2′	body	swim	270°	0	5	11
15	21 Sep	2	0	71°33.4′	155°12.5′	body	swim	300°	0	5	57
15	21 Sep	3	0	71°35.1′	155°12.6′	splash	swim	30°	0	5	57
15	21 Sep	1	0	71°31.5′	155°45.6′	body	swim	150°	0	4	24
15	21 Sep	1	0	71°31.0′	155°45.1′	body	swim	60°	0	4	24
15	21 Sep	2	0	71°30.4′	155°44.5′	body	swim	150°	0	4	24
15	21 Sep	1	0	71°21.4′	155°08.6′	body	swim	145°	0	5	18
15	21 Sep	3	0	71°20.2′	154°22.6′	body	swim	280°	0	6	18
15	21 Sep	20	1	70°44.5′	150°14.8′	body	feed	[1]	0	5	18
15	21 Sep	12	0	70°53.4′	151°04.0′	body	feed	330°	0	4	15
15	21 Sep	1	0	71°01.4′	152°37.7′	body	swim	350°	0	5	13
15	21 Sep	1	0	71°11.6′	153°42.3′	splash	swim	350°	0	6	18
15	21 Sep	4	0	71°03.0′	153°48.0′	body	swim	120°	0	6	16

Table A-1
Selected Sighting Data for Bowhead Whales Observed, Fall 1997
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Flight No.	Day	Total Whales	No. of Calves	Latitude	Longitude	Sighting Cue	Behavior	Compass Heading	Ice (%)	Sea State	Depth (m)
15	21 Sep	1	0	71°10.3′	154°22.0′	splash	swim	195°	0	5	15
15	21 Sep	2	0	71°17.5′	154°46.8′	body	swim	130°	0	5	15
15	21 Sep	1	0	71°13.9′	154°21.6′	body	dive	[1]	0	5	16
15	21 Sep	1	0	71°18.7′	154°41.9′	body	swim	90°	0	5	15
15	21 Sep	2	0	71°21.1′	154°17.7′	blow	swim	10°	0	6	24
15	21 Sep	1	0	71°21.9′	154°45.7′	body	swim	140°	0	5	20
15	21 Sep	14	0	71°19.5′	154°41.2′	body	feed	[1]	0	5	15
15	21 Sep	1	0	71°19.5′	154°40.1′	splash	swim	[1]	0	5	15
15	21 Sep	1	0	71°18.8′	154°37.7′	body	swim	150°	0	5	18
15	21 Sep	1	0	71°18.7′	154°38.4′	body	swim	120°	0	5	18
15	21 Sep	1	0	71°19.9′	155°08.0′	body	swim	150°	0	5	18
15	21 Sep	1	0	71°11.2′	154°22.3′	blow	swim	195°	0	5	15
15	21 Sep	1	0	71°25.3′	156°11.2′	body	rest	220°	0	4	9
15	21 Sep	1	0	71°23.6′	156°08.1′	blow	swim	90°	0	5	9
15	21 Sep	1	0	71°12.4′	154°46.2′	body	swim	180°	0	4	15
15	21 Sep	1	0	71°12.6′	154°48.3′	body	swim	[1]	0	4	15
15	21 Sep	1	0	71°12.7′	154°49.1′	body	swim	[1]	0	4	15
15	21 Sep	1	0	71°12.8′	154°50.3′	body	swim	265°	0	4	13
15	21 Sep	1	0	71°10.7′	154°33.9′	splash	swim	220°	0	4	11
15	21 Sep	1	0	71°23.6′	156°06.4′	splash	slap	220°	0	4	9
15	21 Sep	1	0	71°03.6′	153°42.8′	body	swim	210°	0	4	16

Table A-1
Selected Sighting Data for Bowhead Whales Observed, Fall 1997
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Flight No.	Day	Total Whales	No. of Calves	Latitude	Longitude	Sighting Cue	Behavior	Compass Heading	Ice (%)	Sea State	Depth (m)
15	21 Sep	1	0	71°25.6′	156°11.9′	body	dive	[1]	0	4	9
15	21 Sep	1	0	71°43.2′	156°40.6′	splash	dive	[1]	0	6	73
15	21 Sep	1	0	71°28.5′	156°10.1′	body	swim	200°	0	5	9
15	21 Sep	1	0	71°26.0′	156°09.7′	body	rest	180°	0	5	15
15	21 Sep	2	0	71°25.5′	156°09.5′	body	swim	180°	0	5	15
15	21 Sep	1	0	71°25.1′	156°09.3′	body	slap	180°	0	5	15
15	21 Sep	1	0	71°13.4′	154°55.1′	body	dive	[1]	0	4	13
15	21 Sep	2	0	71°03.2′	153°32.1′	body	swim	300°	0	4	18
15	21 Sep	1	0	71°04.9′	152°32.5′	body	slap	150°	0	4	18
15	21 Sep	1	0	71°04.4′	152°38.0′	body	swim	330°	0	4	18
15	21 Sep	4	0	71°03.9′	152°41.1′	splash	mill	[1]	0	4	16
15	21 Sep	1	0	71°03.5′	152°43.6′	body	swim	90°	0	4	16
15	21 Sep	1	0	71°18.4′	155°07.4′	body	dive	120°	0	5	18
15	21 Sep	1	0	71°12.4′	154°45.2′	body	swim	210°	0	4	15
15	21 Sep	2	0	71°28.7′	155°42.6′	blow	swim	360°	0	4	16
15	21 Sep	1	0	71°03.0′	153°28.6′	body	dive	10°	0	4	16
15	21 Sep	1	0	71°03.3′	153°34.2′	body	swim	[1]	0	4	18
15	21 Sep	2	0	71°03.4′	153°35.8′	body	swim	300°	0	4	18
15	21 Sep	2	0	71°03.4′	153°35.8′	body	swim	300°	0	4	18
15	21 Sep	1	0	71°03.4′	153°37.4′	body	swim	200°	0	4	18
15	21 Sep	1	0	71°03.5′	153°39.2′	body	swim	210°	0	4	18

Table A-1
Selected Sighting Data for Bowhead Whales Observed, Fall 1997
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Flight No.	Day	Total Whales	No. of Calves	Latitude	Longitude	Sighting Cue	Behavior	Compass Heading	Ice (%)	Sea State	Depth (m)
15	21 Sep	1	0	71°03.6′	153°41.6′	body	swim	60°	0	4	16
15	21 Sep	2	0	71°02.0′	152°50.4′	splash	swim	340°	0	4	13
15	21 Sep	1	0	71°03.2′	152°45.6′	body	swim	[1]	0	4	16
17	25 Sep	1	0	71°04.6′	152°12.7′	body	swim	210°	0	7	15
17	25 Sep	1	0	71°05.9′	152°15.5′	body	rest	90°	0	7	15
17	25 Sep	1	0	70°51.2′	150°47.8′	body	swim	290°	0	6	9
17	25 Sep	1	0	70°50.4′	150°38.6′	body	swim	360°	0	6	16
18	25 Sep	1	0	70°25.5′	147°26.9′	body	swim	150°	0	5	15
18	25 Sep	2	0	70°09.8′	143°08.1′	blow	swim	250°	0	4	18
18	25 Sep	1	0	70°14.1′	146°06.0′	body	swim	80°	0	4	9
18	25 Sep	3	0	70°15.0′	146°12.1′	body	mill	[1]	0	4	15
18	25 Sep	3	0	70°15.2′	146°13.3′	body	swim	310°	0	4	15
18	25 Sep	2	0	70°16.0′	146°20.3′	body	swim	300°	0	4	15
18	25 Sep	1	0	70°09.9′	145°01.1′	body	swim	230°	0	3	22
18	25 Sep	3	0	70°25.5′	147°26.9′	body	swim	360°	0	5	15
18	25 Sep	1	0	70°16.0′	146°20.3′	body	swim	330°	0	4	15
19	26 Sep	2	1	70°10.0′	143°06.9′	body	cow with calf	275°	0	2	18
19	26 Sep	1	0	70°06.5′	142°01.7′	body	swim	240°	0	2	38
19	26 Sep	3	0	70°08.5′	145°39.1′	body	swim	110°	0	2	11
19	26 Sep	1	0	70°25.8′	144°12.6′	blow	dive	60°	0	3	53
19	26 Sep	1	0	70°21.9′	147°02.2′	body	swim	270°	0	3	15

Flight No.	Day	Total Whales	No. of Calves	Latitude	Longitude	Sighting Cue	Behavior	Compass Heading	Ice (%)	Sea State	Depth (m)
20	27 Sep	2	0	70°59.1′	151°18.8′	body	swim	260°	0	3	18
20	27 Sep	1	0	71°13.0′	153°45.2′	body	swim	240°	0	3	18
20	27 Sep	1	0	71°03.3′	152°41.6′	body	swim	150°	0	3	16
20	27 Sep	1	0	70°38.2′	148°05.0′	splash	swim	180°	0	2	24
20	27 Sep	2	0	71°03.9′	152°04.1′	body	swim	210°	0	3	16
20	27 Sep	25	0	71°01.1′	152°02.1′	body	mill	[1]	0	3	16
20	27 Sep	1	0	70°39.4′	148°42.6′	splash	swim	20°	0	2	18
20	27 Sep	1	0	70°35.7′	149°11.5′	body	dive	270°	0	2	9
20	27 Sep	2	0	70°40.3′	149°11.7′	body	swim	250°	0	2	13
20	27 Sep	2	0	70°42.7′	149°45.6′	splash	swim	250°	0	2	18
20	27 Sep	3	0	70°56.8′	150°47.1′	body	swim	360°	0	2	9
20	27 Sep	1	0	70°57.0′	151°18.9′	body	swim	250°	0	3	18
20	27 Sep	3	1	70°59.3′	151°59.7′	body	cow with calf	210°	0	3	13
20	27 Sep	20	2	70°58.9′	151°32.3′	body	mill	[1]	0	2	16
20	27 Sep	1	0	70°57.5′	151°31.4′	body	swim	210°	0	2	16
20	27 Sep	8	0	70°54.2′	151°29.9′	mud plumes	feed	[1]	0	2	13
20	27 Sep	1	0	70°49.2′	151°54.7′	body	rest	30°	0	2	9
20	27 Sep	1	0	71°11.9′	153°44.4′	splash	swim	240°	0	3	18
20	27 Sep	2	0	70°52.2′	152°00.1′	splash	swim	[1]	0	3	9
20	27 Sep	1	0	71°13.8′	153°45.9′	splash	swim	180°	0	3	18
20 [3]	27 Sep	25	0	71°02.7′	151°53.2′	body	mill	[1]	0	3	-

Table A-1
Selected Sighting Data for Bowhead Whales Observed, Fall 1997
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Flight No.	Day	Total Whales	No. of Calves	Latitude	Longitude	Sighting Cue	Behavior	Compass Heading	Ice (%)	Sea State	Depth (m)
20	27 Sep	1	0	70°59.9′	152°01.6′	body	swim	360°	0	3	13
20	27 Sep	5	0	70°52.4′	150°46.2′	splash	swim	270°	0	2	9
20	27 Sep	1	0	71°10.5′	153°43.8′	splash	swim	240°	0	3	18
20	27 Sep	1	0	71°09.9′	153°43.9′	body	swim	240°	0	3	18
20	27 Sep	1	0	71°08.2′	152°42.5′	splash	swim	220°	0	3	22
20	27 Sep	3	0	71°08.0′	153°43.8′	body	swim	240°	0	3	18
20	27 Sep	1	0	70°41.4′	150°43.7′	splash	swim	285°	0	3	15
20	27 Sep	1	0	70°37.2′	149°18.8′	body	swim	90°	0	2	16
20	27 Sep	8	0	70°34.7′	149°11.6′	splash	mill	[1]	0	2	9
20	27 Sep	1	0	71°11.4′	153°44.1′	splash	swim	260°	0	3	18
21	28 Sep	2	0	69°46.9′	140°20.7′	body	swim	240°	0	3	29
21	28 Sep	1	0	70°07.5′	143°09.7′	body	thrash	[1]	0	3	11
21	28 Sep	1	0	70°06.2′	143°04.8′	body	swim	270°	0	3	11
21	28 Sep	2	0	70°06.9′	142°55.5′	splash	swim	270°	0	3	18
21	28 Sep	1	0	70°01.6′	142°20.8′	splash	swim	280°	0	3	18
21	28 Sep	1	0	69°48.4′	140°20.3′	body	rest	230°	0	3	29
21	28 Sep	1	0	69°50.5′	140°49.2′	body	swim	250°	0	4	37
21	28 Sep	3	1	69°56.0′	141°06.7′	splash	cow with calf	270°	0	4	40
21	28 Sep	1	0	69°57.0′	141°11.8′	body	swim	270°	0	4	40
21	28 Sep	2	0	70°26.4′	147°43.8′	body	swim	290°	0	2	5
21	28 Sep	1	0	69°54.4′	141°04.6′	body	swim	250°	0	4	40

Table A-1
Selected Sighting Data for Bowhead Whales Observed, Fall 1997
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Flight No.	Day	Total Whales	No. of Calves	Latitude	Longitude	Sighting Cue	Behavior	Compass Heading	Ice (%)	Sea State	Depth (m)
21	28 Sep	1	0	69°58.8′	142°21.4′	body	swim	280°	0	3	9
24	1 Oct	1	0	70°31.3′	151°16.1′	body	swim	320°	0	2	5
24	1 Oct	24	0	71°00.6′	152°11.9′	splash	mill	[1]	0	2	16
24	1 Oct	14	1	70°55.0′	152°03.6′	body	mill	[1]	0	2	13
24	1 Oct	64	7	70°48.3′	151°50.2′	body	mill	[1]	0	2	9
24	1 Oct	2	1	70°54.6′	151°50.6′	body	cow with calf	250°	0	2	11
24	1 Oct	10	0	70°56.3′	151°50.0′	body	swim	240°	0	2	13
24	1 Oct	2	0	70°58.8′	151°48.0′	body	swim	210°	0	2	13
24	1 Oct	1	0	71°00.2′	151°47.6′	body	swim	170°	0	2	16
24	1 Oct	1	0	71°01.7′	151°48.0′	body	swim	180°	0	2	16
24	1 Oct	3	0	71°03.8′	151°48.6′	body	mill	180°	0	2	18
24	1 Oct	1	0	70°51.2′	150°47.6′	body	dive	290°	0	2	9
24	1 Oct	2	0	70°56.3′	150°48.4′	body	dive	260°	0	2	9
24	1 Oct	1	0	71°07.6′	152°16.7′	body	swim	330°	0	2	20
24	1 Oct	9	0	70°48.5′	151°44.8′	body	mill	[1]	0	2	11
24	1 Oct	2	0	70°46.1′	151°12.7′	body	swim	300°	0	2	16
24	1 Oct	1	0	71°13.7′	152°21.9′	body	swim	250°	0	3	26
24	1 Oct	1	0	71°17.3′	152°25.6′	body	swim	230°	0	3	29
24	1 Oct	1	0	71°19.9′	152°39.9′	body	swim	150°	0	3	69
24	1 Oct	1	0	71°19.5′	152°52.8′	body	swim	360°	0	3	60
24	1 Oct	1	0	71°02.7′	153°50.2′	body	swim	60°	0	3	13

Table A-1
Selected Sighting Data for Bowhead Whales Observed, Fall 1997
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Flight No.	Day	Total Whales	No. of Calves	Latitude	Longitude	Sighting Cue	Behavior	Compass Heading	Ice (%)	Sea State	Depth (m)
24	1 Oct	1	0	71°00.7′	153°50.8′	body	swim	240°	0	3	13
24	1 Oct	2	0	70°58.6′	153°52.8′	body	swim	260°	0	3	9
24	1 Oct	1	0	70°56.0′	153°46.4′	body	rest	120°	0	2	5
24	1 Oct	4	0	70°59.2′	153°09.3′	[1]	swim	240°	0	2	7
24	1 Oct	2	0	70°54.7′	152°27.4′	body	mill	[1]	0	2	9
24	1 Oct	2	0	70°58.9′	151°08.9′	splash	swim	270°	0	2	18
24	1 Oct	3	0	70°58.7′	152°58.0′	body	mill	[1]	0	2	7
24	1 Oct	1	0	70°38.4′	149°56.0′	body	swim	210°	0	4	11
24	1 Oct	15	0	70°59.5′	153°17.7′	body	feed	[1]	0	2	7
25	2 Oct	12	0	70°58.5′	153°04.2′	body	mill	[1]	0	3	7
25	2 Oct	62	5	71°25.2′	155°22.0′	body	feed	[1]	0	1	18
25	2 Oct	2	0	71°23.9′	154°55.0′	body	swim	270°	0	1	18
25	2 Oct	1	0	71°22.7′	154°55.7′	body	swim	60°	0	1	18
25	2 Oct	1	0	70°56.8′	152°30.1′	body	swim	240°	0	3	7
25	2 Oct	1	0	71°18.2′	155°24.7′	body	rest	90°	0	1	13
25	2 Oct	1	0	71°21.7′	155°23.5′	body	swim	120°	0	1	9
25	2 Oct	2	0	71°23.3′	155°24.2′	body	swim	240°	0	1	9
25	2 Oct	1	0	71°29.4′	155°49.2′	body	swim	270°	0	1	16
25	2 Oct	77	6	71°21.3′	155°29.4′	body	feed	[1]	0	1	9
25	2 Oct	1	0	71°38.4′	154°51.7′	body	swim	260°	0	1	53
25	2 Oct	51	0	71°27.3′	155°21.3′	body	feed	[1]	0	1	18

Table A-1
Selected Sighting Data for Bowhead Whales Observed, Fall 1997
(Page 15 of 21)

Flight No	Day	Total Whales	No. of Calves	Latitude	Longitude	Sighting Cue	Behavior	Compass Heading	Ice (%)	Sea State	Depth (m)
25	2 Oct	20	0	71°31.5′	155°19.0′	slick	mill	[1]	0	1	20
25	2 Oct	1	0	71°34.1′	155°55.2′	body	swim	240°	0	1	221
25	2 Oct	1	0	71°33.1′	155°53.8′	body	swim	270°	0	1	221
25	2 Oct	1	0	71°31.4′	155°52.3′	splash	breach	270°	0	1	24
25	2 Oct	1	0	71°30.0′	155°49.9′	body	swim	180°	0	1	24
25	2 Oct	57	7	71°21.6′	155°31.0′	body	feed	[1]	0	1	15
25	2 Oct	8	1	70°56.5′	152°00.6′	splash	breach	[1]	0	3	13
25	2 Oct	2	0	70°46.4′	149°37.5′	body	swim	60°	0	2	18
25	2 Oct	1	0	70°46.3′	149°43.9′	blow	swim	240°	0	2	15
25	2 Oct	1	0	70°48.8′	150°07.1′	body	rest	270°	0	2	15
25	2 Oct	1	0	70°53.3′	150°56.9′	blow	swim	150°	0	3	15
25	2 Oct	1	0	70°53.7′	151°00.6′	body	swim	70°	0	3	15
25	2 Oct	1	0	70°54.2′	151°11.1′	body	swim	250°	0	3	15
25	2 Oct	2	1	71°26.6′	154°54.9′	body	cow with calf	90°	0	1	18
25	2 Oct	1	0	70°56.5′	151°45.5′	splash	swim	240°	0	3	13
25	2 Oct	4	0	71°31.2′	154°53.3′	body	swim	280°	0	1	33
25	2 Oct	1	0	70°56.3′	152°05.6′	body	swim	190°	0	3	13
25	2 Oct	2	0	70°57.7′	152°40.0′	blow	swim	120°	0	3	9
25	2 Oct	1	0	70°57.9′	152°43.8′	body	swim	70°	0	3	9
25	2 Oct	1	0	71°11.6′	154°22.3′	body	swim	270°	0	2	15
25	2 Oct	4	0	71°13.8′	154°21.6′	body	mill	[1]	0	2	16

Table A-1
Selected Sighting Data for Bowhead Whales Observed, Fall 1997
(Page 16 of 21)

Flight No.	Day	Total Whales	No. of Calves	Latitude	Longitude	Sighting Cue	Behavior	Compass Heading	Ice (%)	Sea State	Depth (m)
25	2 Oct	1	0	71°28.6′	154°19.8′	body	swim	240°	0	2	31
25	2 Oct	2	0	71°20.4′	155°24.1′	body	swim	60°	0	1	13
25	2 Oct	1	0	70°54.5′	151°17.0′	body	swim	240°	0	3	15
25	2 Oct	1	0	70°59.1′	153°45.0′	body	swim	270°	0	3	7
25	2 Oct	10	0	71°19.5′	154°57.8′	body	mill	[1]	0	1	13
25	2 Oct	37	0	70°52.2′	152°14.5′	body	feed	[1]	0	3	7
25	2 Oct	4	0	70°56.5′	152°19.4′	body	swim	240°	0	3	11
25	2 Oct	1	0	70°58.0′	152°56.3′	body	swim	150°	0	3	7
25	2 Oct	1	0	71°28.1′	155°48.3′	body	swim	150°	0	1	16
25	2 Oct	2	0	70°59.1′	153°10.8′	body	swim	80°	0	3	7
25	2 Oct	2	0	70°59.4′	153°53.0′	body	swim	110°	0	3	9
25	2 Oct	1	0	70°59.7′	153°58.0′	body	swim	80°	0	3	9
25	2 Oct	2	0	71°42.3′	156°06.7′	slick	swim	210°	0	3	68
25	2 Oct	1	0	71°20.5′	155°42.1′	body	dive	240°	0	1	9
25	2 Oct	1	0	71°21.5′	155°43.0′	body	swim	150°	0	1	11
25	2 Oct	2	0	71°22.5′	155°44.1′	body	swim	250°	0	1	11
25	2 Oct	6	0	71°23.3′	155°45.3′	body	swim	270°	0	1	11
25	2 Oct	1	0	71°26.6′	155°47.5′	body	swim	240°	0	1	15
27	7 Oct	1	0	70°16.5′	145°12.5′	body	swim	280°	0	5	24
27	7 Oct	1	0	70°14.5′	143°32.1′	splash	swim	230°	0	2	16
27	7 Oct	1	0	70°10.3′	143°31.2′	blow	swim	230°	0	2	16

Table A-1
Selected Sighting Data for Bowhead Whales Observed, Fall 1997
(Page 17 of 21)

Flight No.	Day	Total Whales	No. of Calves	Latitude	Longitude	Sighting Cue	Behavior	Compass Heading	Ice (%)	Sea State	Depth (m)
27	7 Oct	2	0	70°08.6′	143°38.3′	blow	swim	230°	0	3	5
27	7 Oct	1	0	70°18.6′	146°14.4′	blow	swim	180°	0	4	22
27	7 Oct	1	0	70°18.9′	146°40.7′	body	swim	360°	0	5	15
28	9 Oct	1	0	70°16.8′	146°25.4′	body	swim	330°	0	5	15
29	10 Oct	1	0	70°50.1′	152°07.8′	body	dive	330°	0	3	7
29	10 Oct	1	0	71°03.8′	153°11.3′	body	swim	360°	0	5	13
29	10 Oct	1	0	71°01.5′	153°14.9′	body	swim	250°	0	5	9
29	10 Oct	1	0	70°58.6′	153°39.3′	body	swim	100°	0	5	9
29	10 Oct	1	0	70°57.5′	152°31.2′	slick	breach	270°	0	5	9
29	10 Oct	1	0	70°59.5′	152°31.9′	body	swim	60°	0	5	9
29	10 Oct	1	0	71°00.6′	152°32.1′	[1]	swim	230°	0	5	13
29	10 Oct	2	0	71°01.3′	152°16.9′	body	[1]	50°	0	3	16
29	10 Oct	2	0	70°57.8′	152°18.4′	body	mill	70°	0	4	11
29	10 Oct	2	0	71°01.1′	152°29.6′	blow	swim	170°	0	5	13
29	10 Oct	2	0	70°49.6′	151°58.4′	body	rest	360°	0	3	9
29	10 Oct	7	1	70°46.8′	151°43.3′	body	mill	330°	0	3	7
29	10 Oct	1	0	70°41.9′	151°46.8′	body	swim	330°	0	4	5
29	10 Oct	1	0	70°43.3′	151°47.4′	body	swim	250°	0	4	7
29	10 Oct	1	0	70°48.3′	151°45.9′	body	swim	20°	0	4	11
29	10 Oct	38	3	70°49.9′	151°46.9′	body	mill	[1]	0	4	11
29	10 Oct	2	0	70°56.7′	151°44.4′	body	swim	330°	0	4	13

Table A-1
Selected Sighting Data for Bowhead Whales Observed, Fall 1997
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Flight No.	Day	Total Whales	No. of Calves	Latitude	Longitude	Sighting Cue	Behavior	Compass Heading	Ice (%)	Sea State	Depth (m)
29	10 Oct	1	0	70°42.3′	150°37.5′	body	swim	230°	0	5	16
29	10 Oct	1	0	70°56.9′	150°22.9′	splash	swim	270°	0	3	18
29	10 Oct	12	0	71°00.0′	152°17.4′	blow	mill	[1]	0	3	16
29	10 Oct	1	0	70°33.6′	150°25.9′	body	rest	330°	0	3	9
29	10 Oct	1	0	71°04.9′	152°55.5′	body	swim	120°	0	5	11
29	10 Oct	1	0	71°04.3′	152°50.1′	blow	swim	350°	0	5	11
29	10 Oct	1	0	70°39.3′	150°06.4′	body	swim	225°	0	5	16
29	10 Oct	2	1	70°37.4′	150°18.2′	body	cow with calf	170°	0	5	15
29	10 Oct	2	0	70°56.7′	152°09.2′	body	swim	110°	0	5	13
29	10 Oct	1	0	70°59.9′	152°24.8′	body	dive	[1]	0	5	13
30	11 Oct	1	0	70°11.3′	143°01.9′	body	swim	270°	0	3	18
32	14 Oct	6	0	70°08.9′	145°03.2′	body	swim	240°	0	3	18
32	14 Oct	1	0	70°12.3′	143°35.3′	ice tracks	swim	240°	80	2	16
32	14 Oct	2	1	70°25.0′	147°19.9′	body	cow with calf	270°	0	3	15
32	14 Oct	3	0	70°10.8′	145°17.2′	body	swim	240°	0	3	22
32	14 Oct	2	0	70°09.1′	145°04.3′	body	swim	270°	0	3	22
34	17 Oct	2	0	71°03.2′	153°21.2′	body	swim	240°	98	1	16
34	17 Oct	1	0	71°01.7′	153°21.1′	body	swim	240°	98	1	11
34	17 Oct	2	0	71°06.6′	153°17.9′	body	spy hop	340°	0	3	18
34	17 Oct	1	0	70°57.7′	151°31.2′	body	swim	250°	98	1	16
34	17 Oct	1	0	70°49.6′	149°15.1′	splash	breach	250°	0	6	22

Table A-1
Selected Sighting Data for Bowhead Whales Observed, Fall 1997
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Flight No.	Day	Total Whales	No. of Calves	Latitude	Longitude	Sighting Cue	Behavior	Compass Heading	Ice (%)	Sea State	Depth (m)
34	17 Oct	44	7	71°05.6′	152°05.0′	body	feed	[1]	50	2	16
34	17 Oct	47	8	71°06.8′	152°09.3′	body	feed	[1]	50	2	20
35	18 Oct	2	0	71°37.3′	154°47.6′	body	swim	175°	0	3	46
35	18 Oct	5	1	71°08.3′	153°36.0′	body	cow with calf	270°	0	2	2
35	18 Oct	9	0	71°29.9′	154°50.2′	body	mill	210°	0	3	18
35	18 Oct	3	0	71°14.9′	154°52.7′	body	rest	250°	0	3	13
35	18 Oct	1	0	71°17.3′	154°52.6′	body	swim	240°	0	3	16
35	18 Oct	1	0	71°18.3′	154°52.4′	body	swim	240°	0	3	13
35	18 Oct	1	0	71°22.3′	154°50.0′	body	rest	180°	0	3	20
35	18 Oct	3	0	71°27.0′	154°49.5′	body	mill	[1]	0	3	46
35	18 Oct	1	0	71°28.8′	154°50.3′	body	swim	335°	0	3	18
35	18 Oct	2	1	71°33.5′	154°49.8′	body	cow with calf	180°	0	3	46
35	18 Oct	2	0	71°38.9′	154°45.7′	body	swim	10°	0	3	46
35	18 Oct	2	0	71°20.6′	154°06.5′	blow	swim	270°	0	4	26
35	18 Oct	2	0	71°15.5′	154°08.4′	splash	swim	300°	0	4	18
35	18 Oct	7	0	71°12.4′	154°08.0′	body	mill	250°	0	4	18
35	18 Oct	14	0	71°20.7′	155°04.2′	body	swim	[1]	0	2	18
35	18 Oct	3	0	71°09.4′	153°40.0′	body	swim	270°	0	2	16
35	18 Oct	7	1	71°25.6′	155°04.0′	body	swim	240°	0	2	13
35	18 Oct	1	0	71°07.7′	153°30.0′	body	swim	270°	0	2	27
35	18 Oct	1	0	71°07.9′	153°23.2′	body	swim	270°	0	2	27

Table A-1
Selected Sighting Data for Bowhead Whales Observed, Fall 1997
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Flight No.	Day	Total Whales	No. of Calves	Latitude	Longitude	Sighting Cue	Behavior	Compass Heading	Ice (%)	Sea State	Depth (m)
35	18 Oct	5	0	71°07.5′	153°18.7′	body	swim	260°	0	2	18
35	18 Oct	5	1	71°07.5′	153°13.0′	body	swim	240°	70	2	18
35	18 Oct	3	0	71°08.3′	153°06.1′	body	swim	240°	70	2	18
35	18 Oct	4	1	71°08.5′	153°00.3′	body	swim	250°	70	2	18
35	18 Oct	2	0	71°09.3′	152°48.1′	body	swim	240°	70	2	26
35	18 Oct	3	0	71°10.5′	152°38.1′	body	swim	240°	70	2	24
35	18 Oct	2	0	71°10.7′	152°32.4′	body	swim	240°	70	2	24
35	18 Oct	2	1	71°11.1′	152°04.1′	body	cow with calf	60°	70	2	20
35	18 Oct	1	0	71°10.3′	151°55.3′	body	rest	190°	70	2	20
35	18 Oct	1	0	71°09.2′	151°46.7′	splash	slap	210°	70	2	40
35	18 Oct	3	1	71°07.5′	153°49.6′	body	cow with calf	270°	0	2	18
35	18 Oct	3	0	71°08.1′	153°50.8′	body	swim	260°	30	3	16
35	18 Oct	8	0	71°02.5′	151°30.3′	body	mill		99	1	16
35	18 Oct	3	0	71°08.2′	151°45.1′	body	swim	230°	99	1	18
35	18 Oct	1	0	71°09.0′	151°56.1′	body	swim	180°	99	1	20
35	18 Oct	2	0	71°09.2′	152°03.6′	body	rest	330°	99	1	20
35	18 Oct	2	0	71°09.6′	152°10.8′	body	rest	330°	99	1	26
35	18 Oct	4	0	71°10.2′	152°32.9′	body	swim	240°	99	1	24
35	18 Oct	2	0	71°10.2′	152°40.2′	body	swim	230°	99	1	26
35	18 Oct	1	0	71°09.0′	152°54.5′	body	swim	220°	30	4	22
35	18 Oct	2	0	71°07.8′	153°09.4′	splash	swim	240°	30	4	18

Table A-1
Selected Sighting Data for Bowhead Whales Observed, Fall 1997
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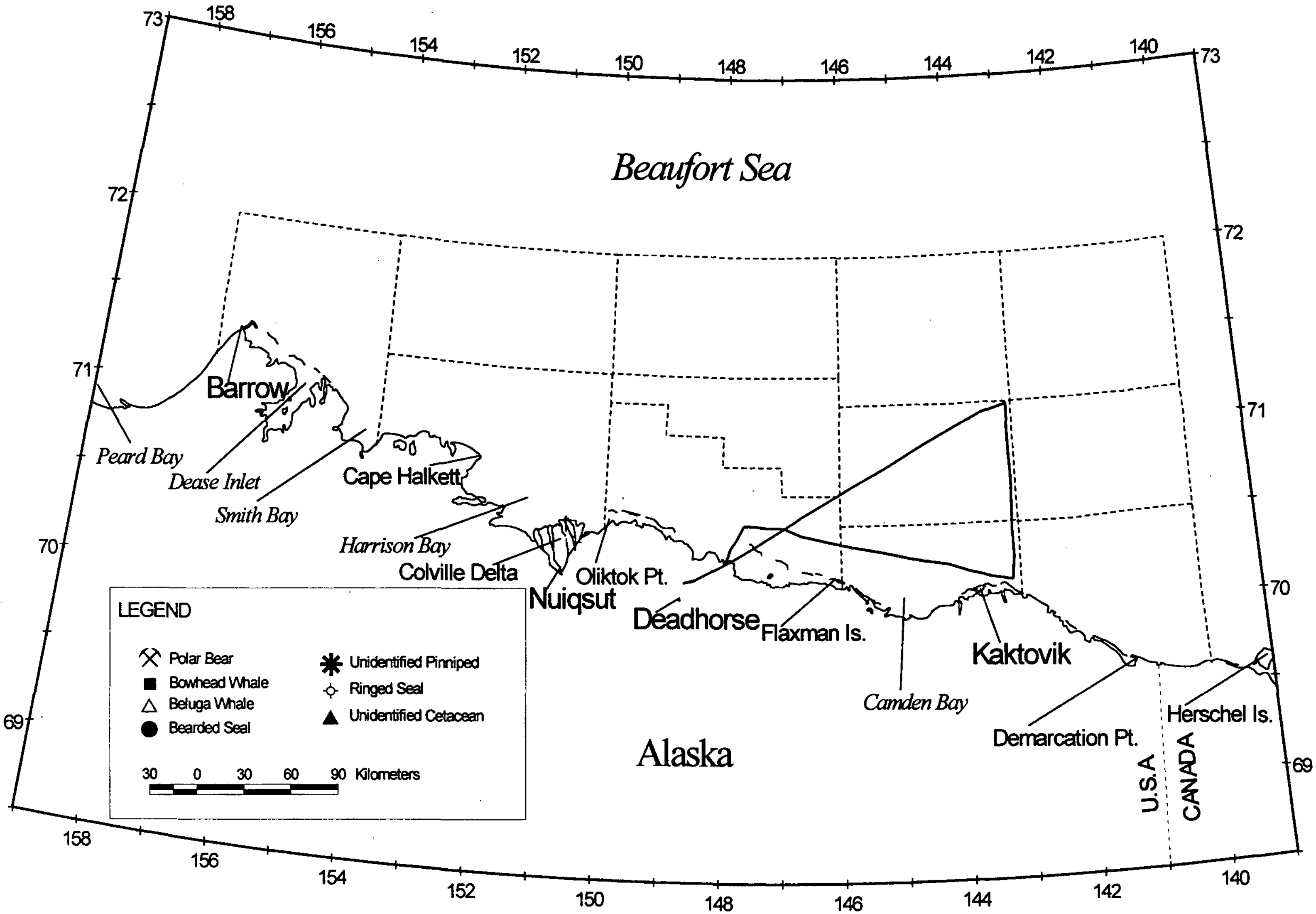
Flight No.	Day	Total Whales	No. of Calves	Latitude	Longitude	Sighting Cue	Behavior	Compass Heading	Ice (%)	Sea State	Depth (m)
35	18 Oct	8	0	71°07.5′	153°17.5′	body	swim	240°	30	4	18
35	18 Oct	1	0	71°07.2′	153°24.3′	body	swim	240°	30	4	27
35	18 Oct	2	0	71°07.1′	153°29.1′	body	swim	250°	30	4	27
35	18 Oct	3	0	71°18.4′	155°05.1′	body	mill	[1]	99	1	18
35	18 Oct	3	0	71°07.3′	153°40.8′	body	swim	250°	30	3	18
35	18 Oct	1	0	70°57.1′	151°05.0′	ice tracks	rest	270°	99	1	18
35	18 Oct	1	0	71°08.8′	153°56.2′	body	swim	230°	30	3	16
35	18 Oct	2	0	71°09.1′	153°59.4′	body	swim	250°	30	3	20
35	18 Oct	1	0	71°10.2′	154°18.4′	splash	swim	255°	30	3	15
35	18 Oct	1	0	71°17.1′	154°58.7′	body	rest	[1]	99	1	16
35	18 Oct	14	0	71°18.5′	155°06.5′	body	mill	[1]	99	1	18
35	18 Oct	1	0	71°19.2′	155°11.9′	body	rest	270°	99	1	16
35	18 Oct	3	0	71°23.9′	155°22.6′	body	swim	130°	99	1	9
35	18 Oct	9	0	71°27.0′	155°25.2′	body	mill	[1]	99	1	18
35	18 Oct	3	0	71°29.5′	155°33.7′	body	swim	[1]	99	1	18
35	18 Oct	1	0	71°30.1′	155°43.2′	body	swim	140°	99	1	24
35 [4]	18 Oct	1	0	71°28.8′	155°53.5′	body	dead	[1]	99	1	18
35	18 Oct	40	4	71°33.0′	155°03.8′	body	feed	[1]	0	2	37
35	18 Oct	2	0	71°07.3′	153°34.3′	body	swim	245°	30	4	2

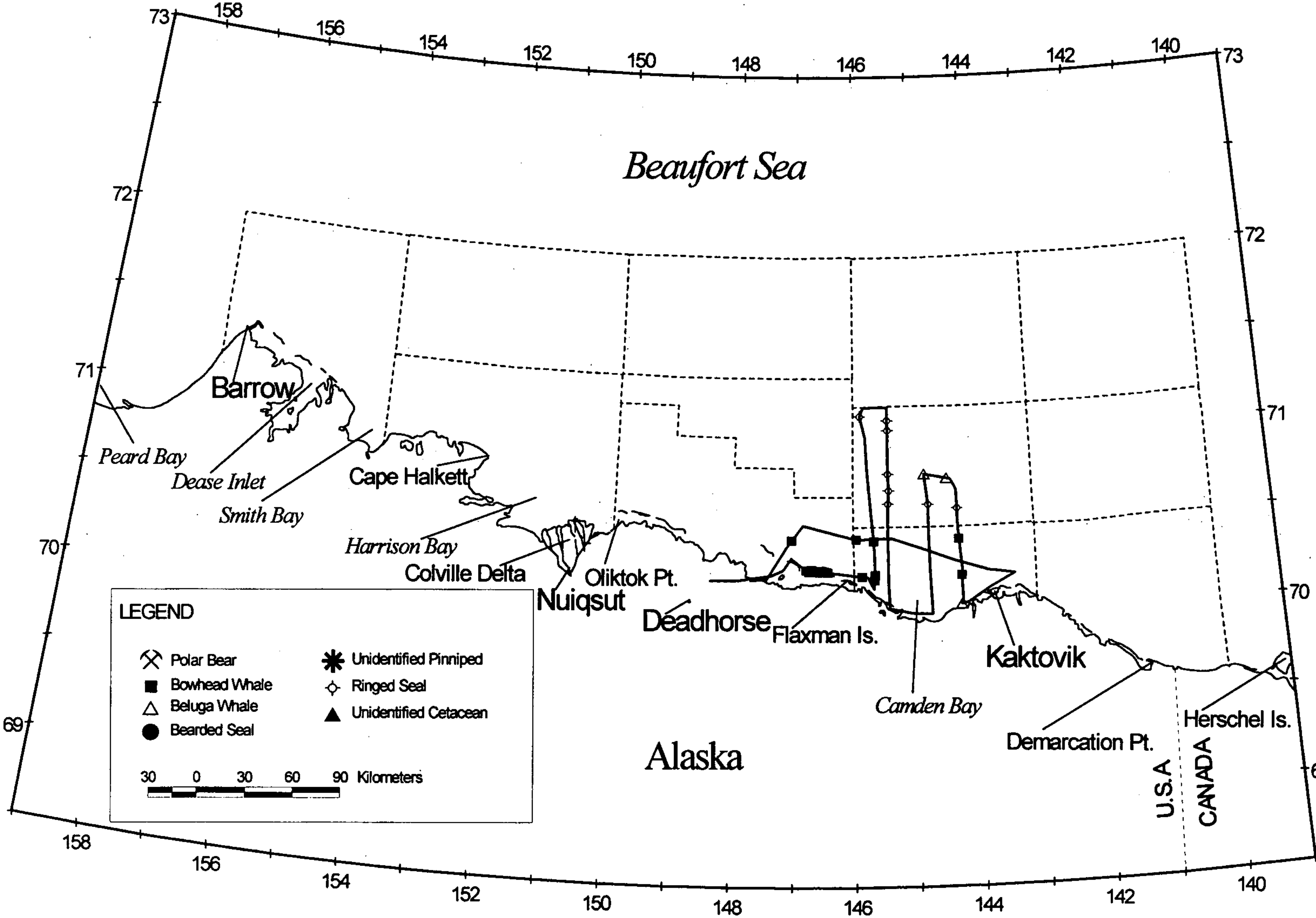
[1] Not recorded.
[2] Possible repeat sighting.
[3] Definite repeat sighting.
[4] Dead whale.

APPENDIX B

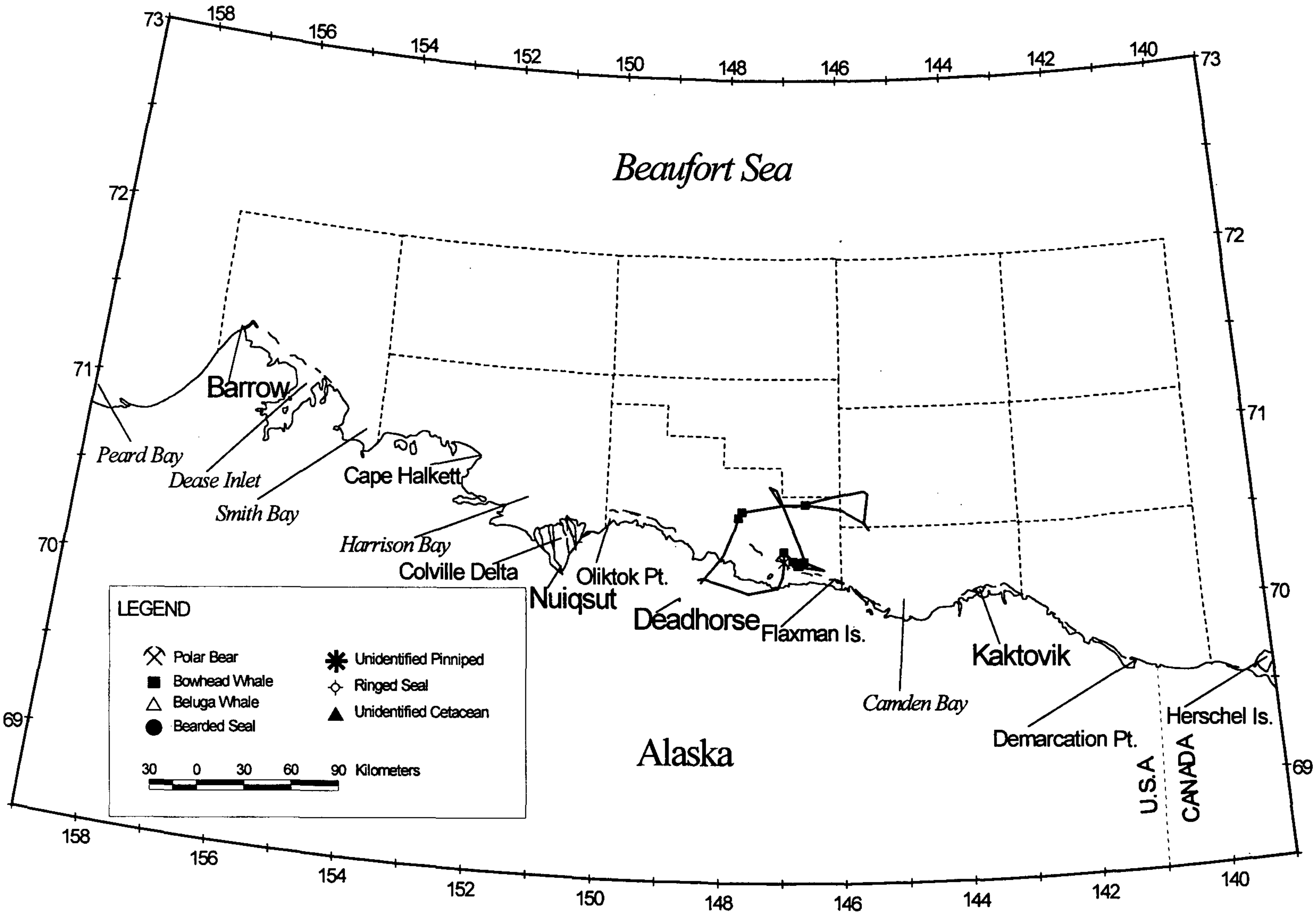
DAILY FLIGHT MAPS



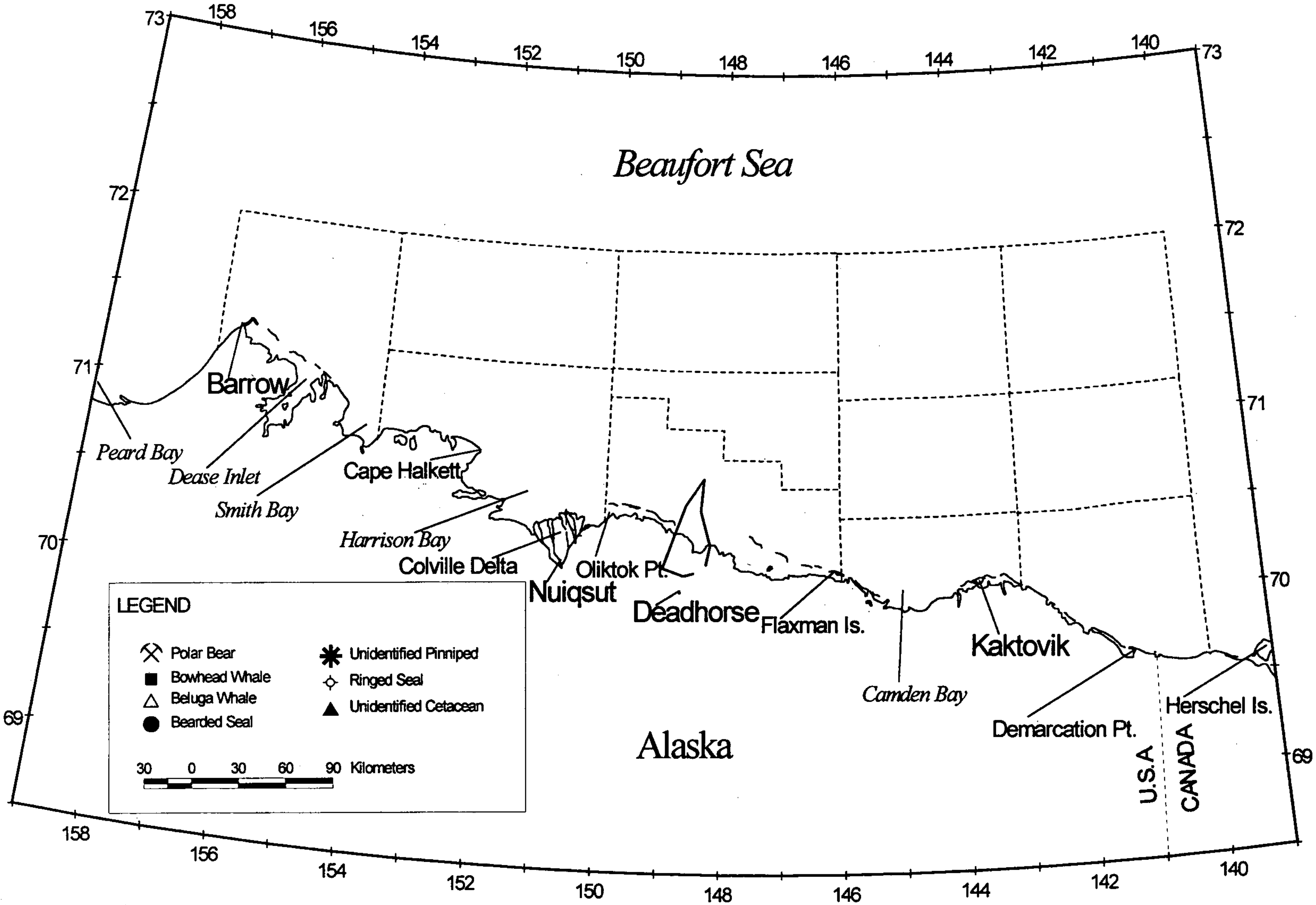
Flight 1. 1 September 1997 Survey Track and Sightings



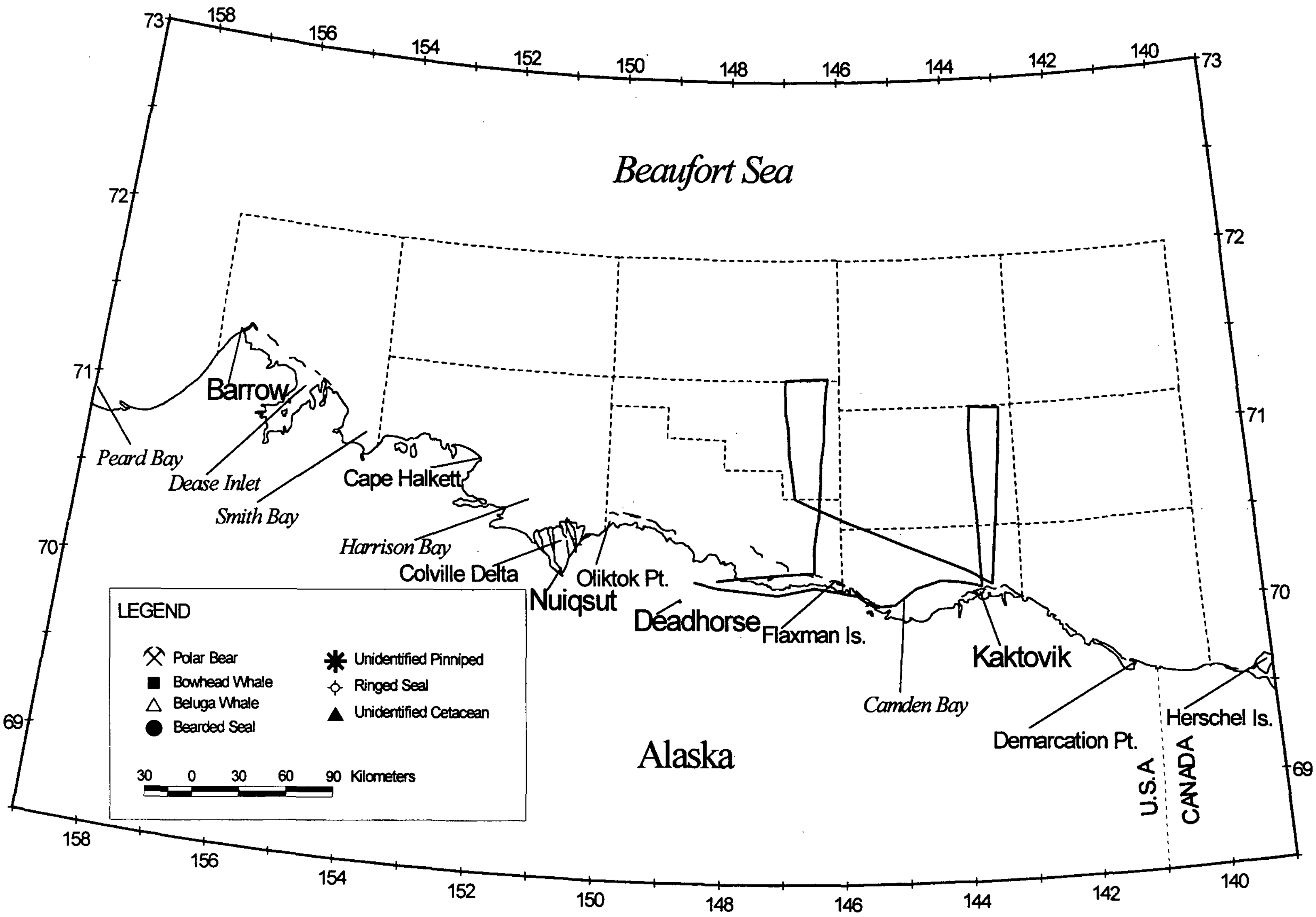
Flight 2: 3 September 1997 Survey Track and Sightings



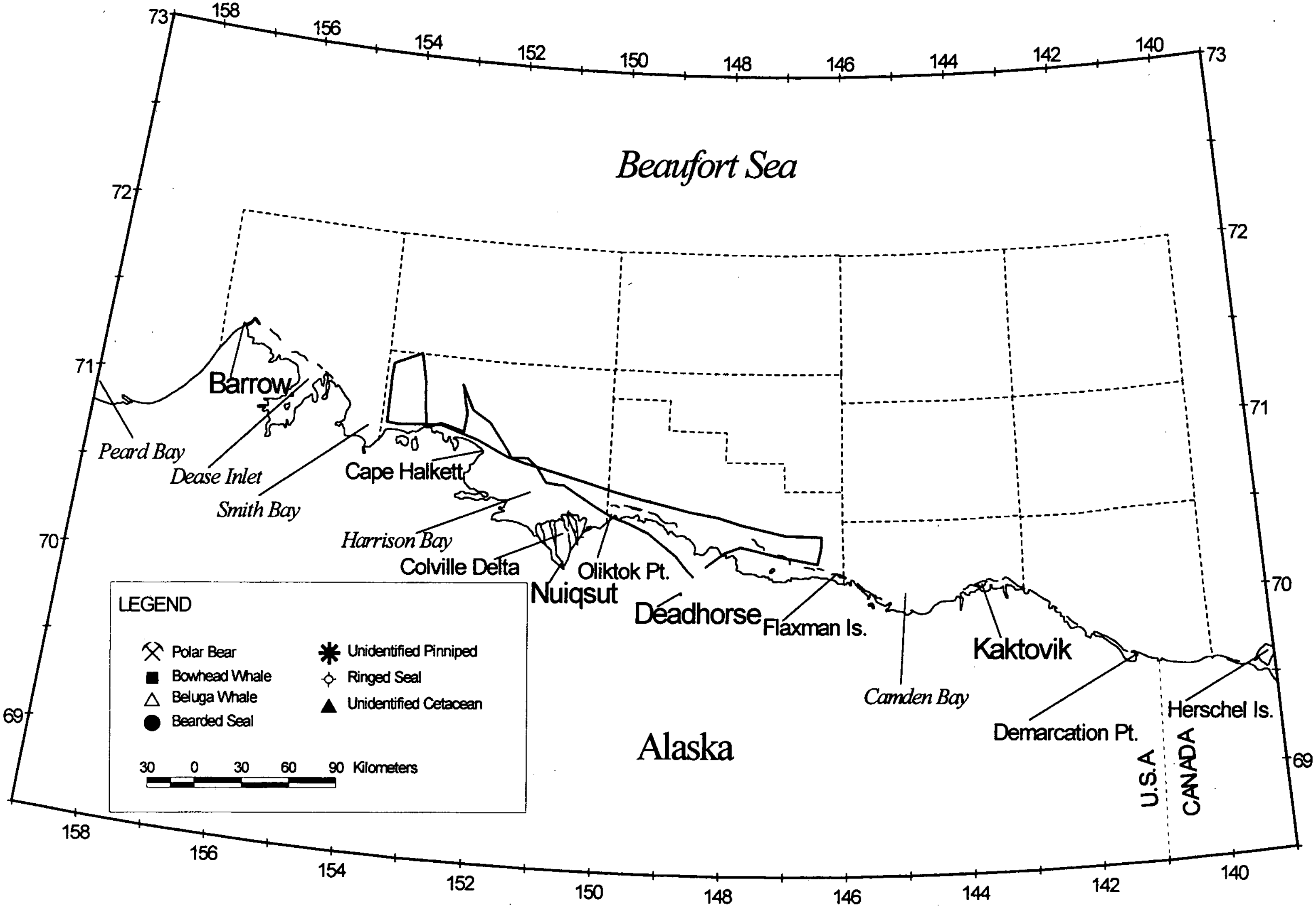
Flight 3: 4 September 1997 Survey Track and Sightings



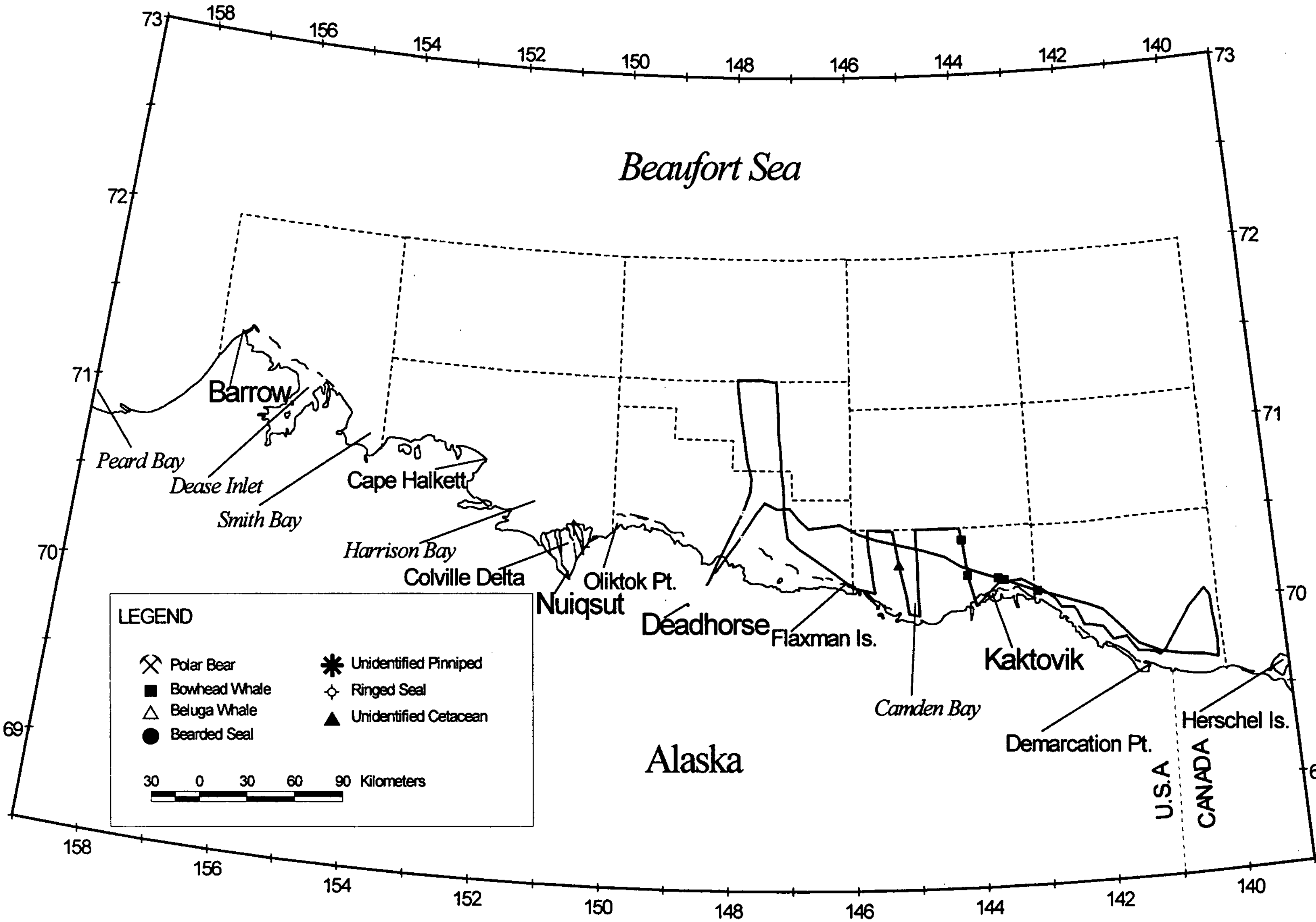
Flight 4: 5 September 1997 Survey Track and Sightings



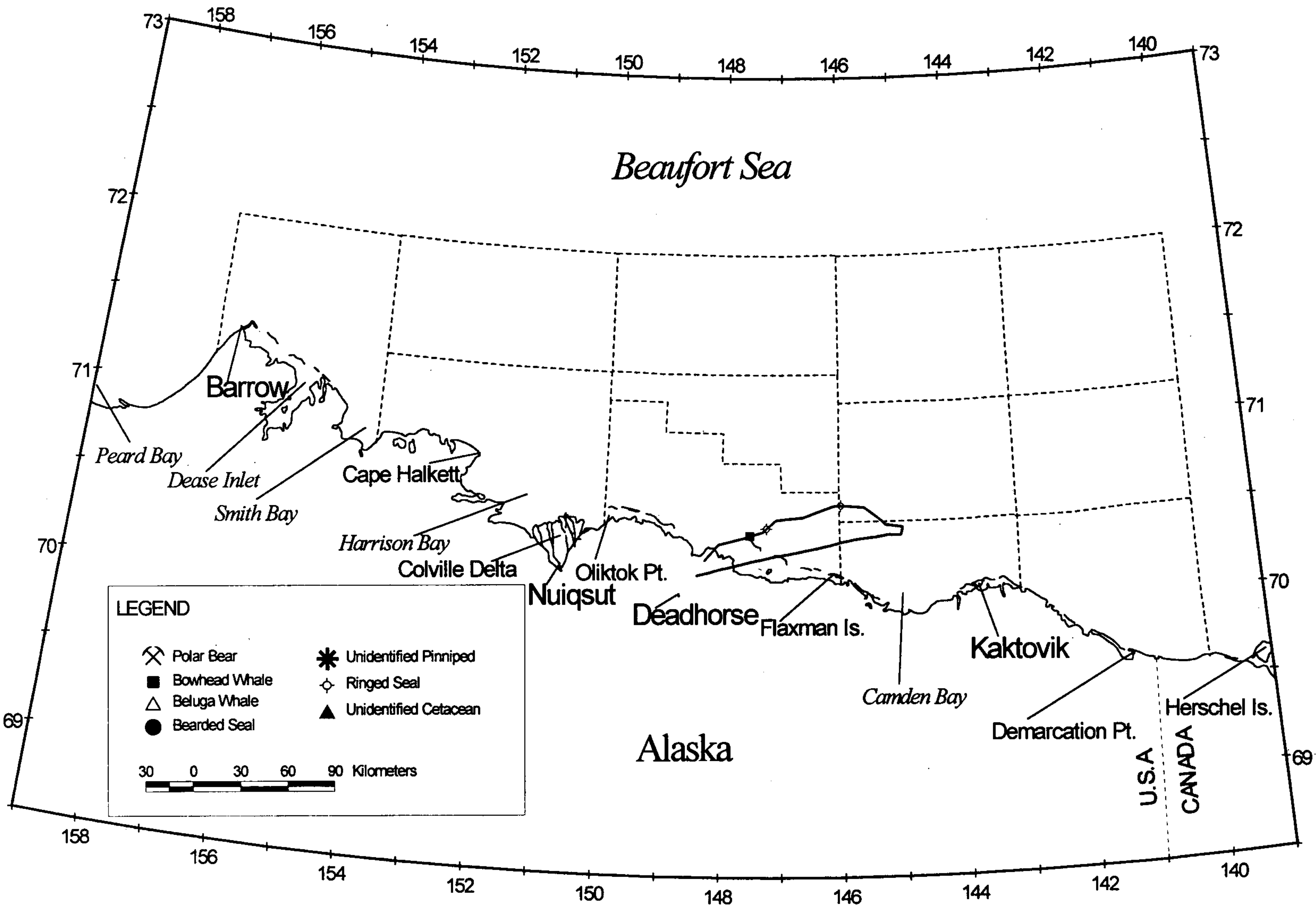
Flight 5: 7 September 1997 Survey Track and Sightings



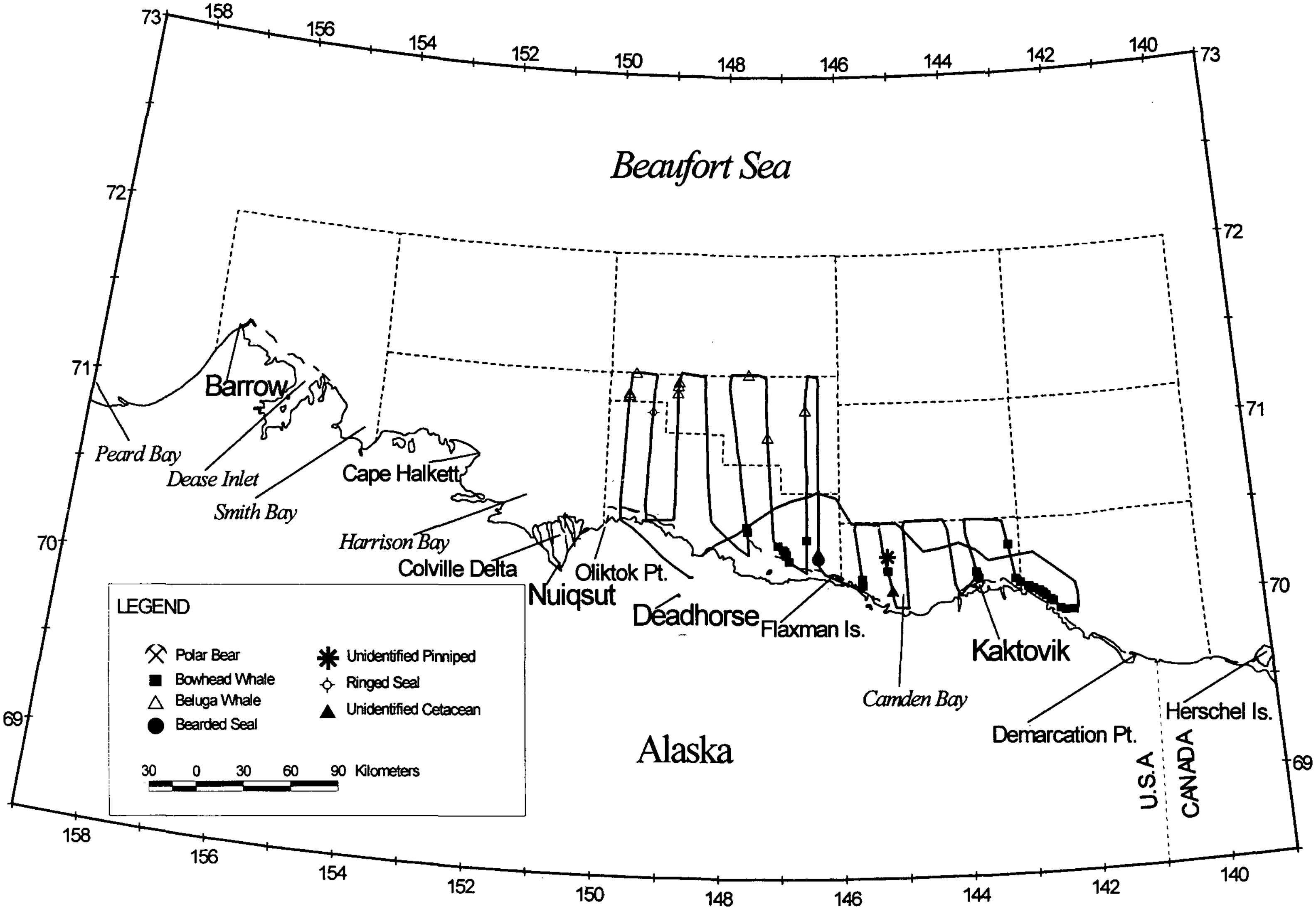
Flight 6: 9 September 1997 Survey Track and Sightings



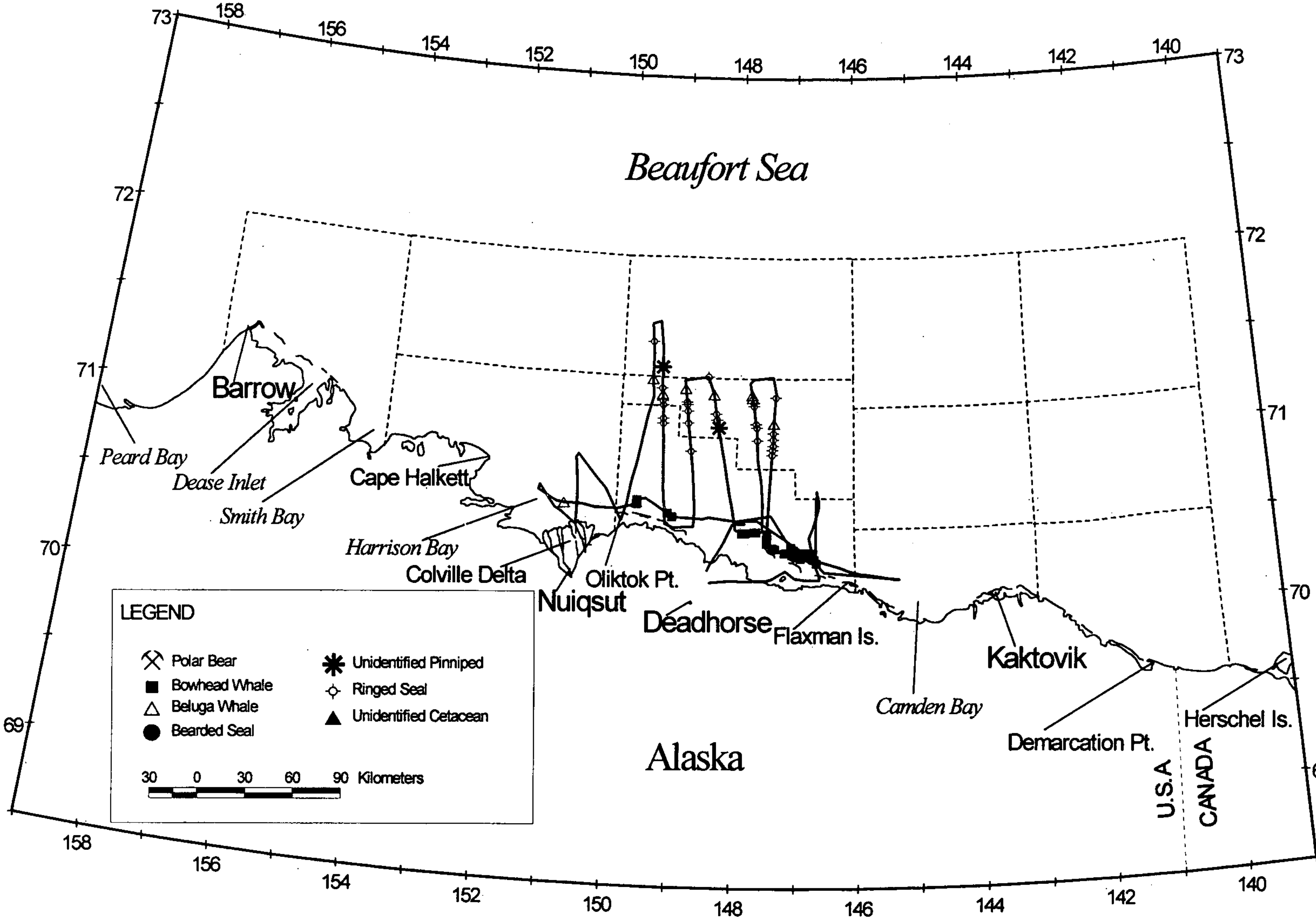
Flight 7: 10 September 1997 Survey Track and Sightings



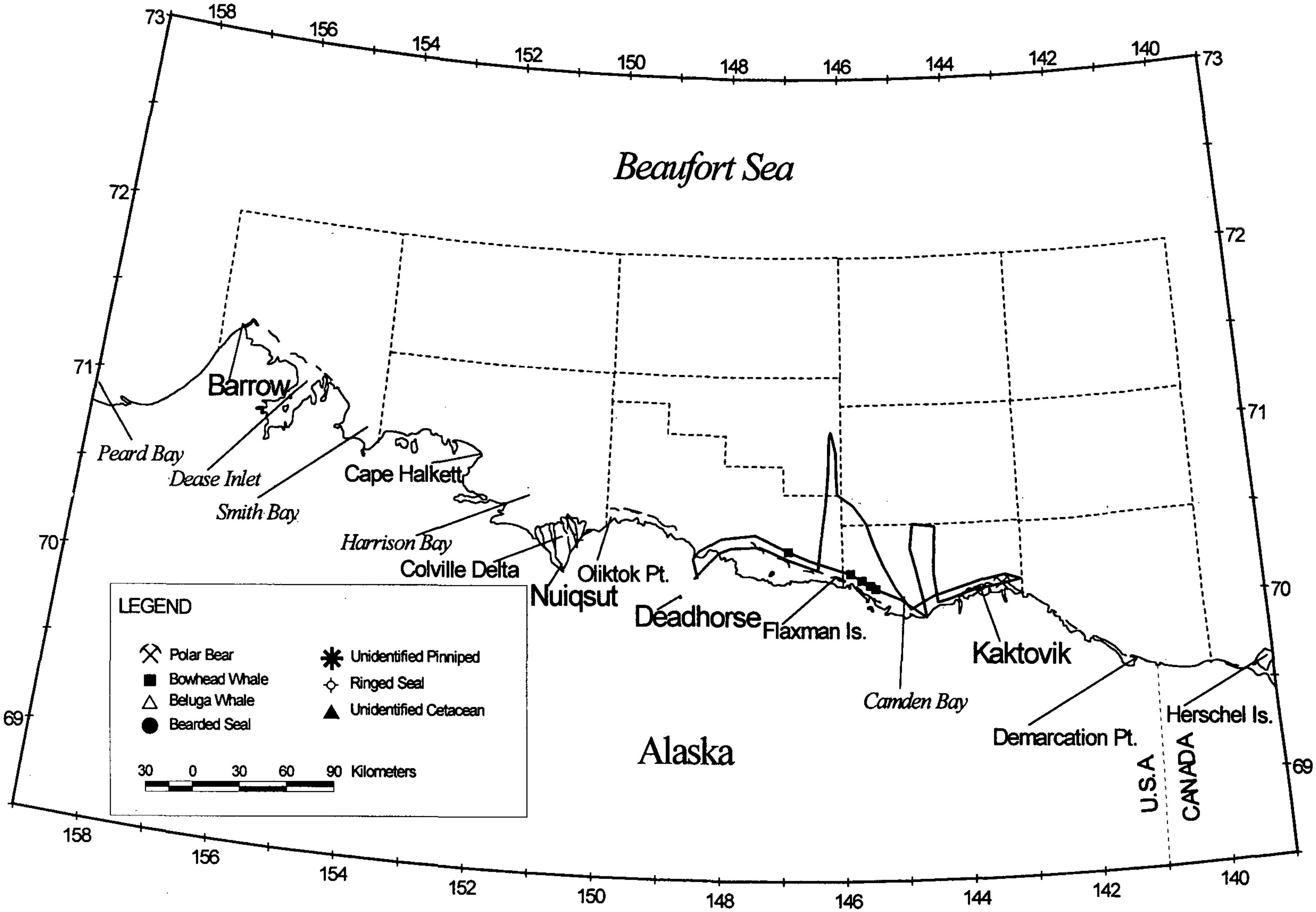
Flight 8: 11 September 1997 Survey Track and Sightings



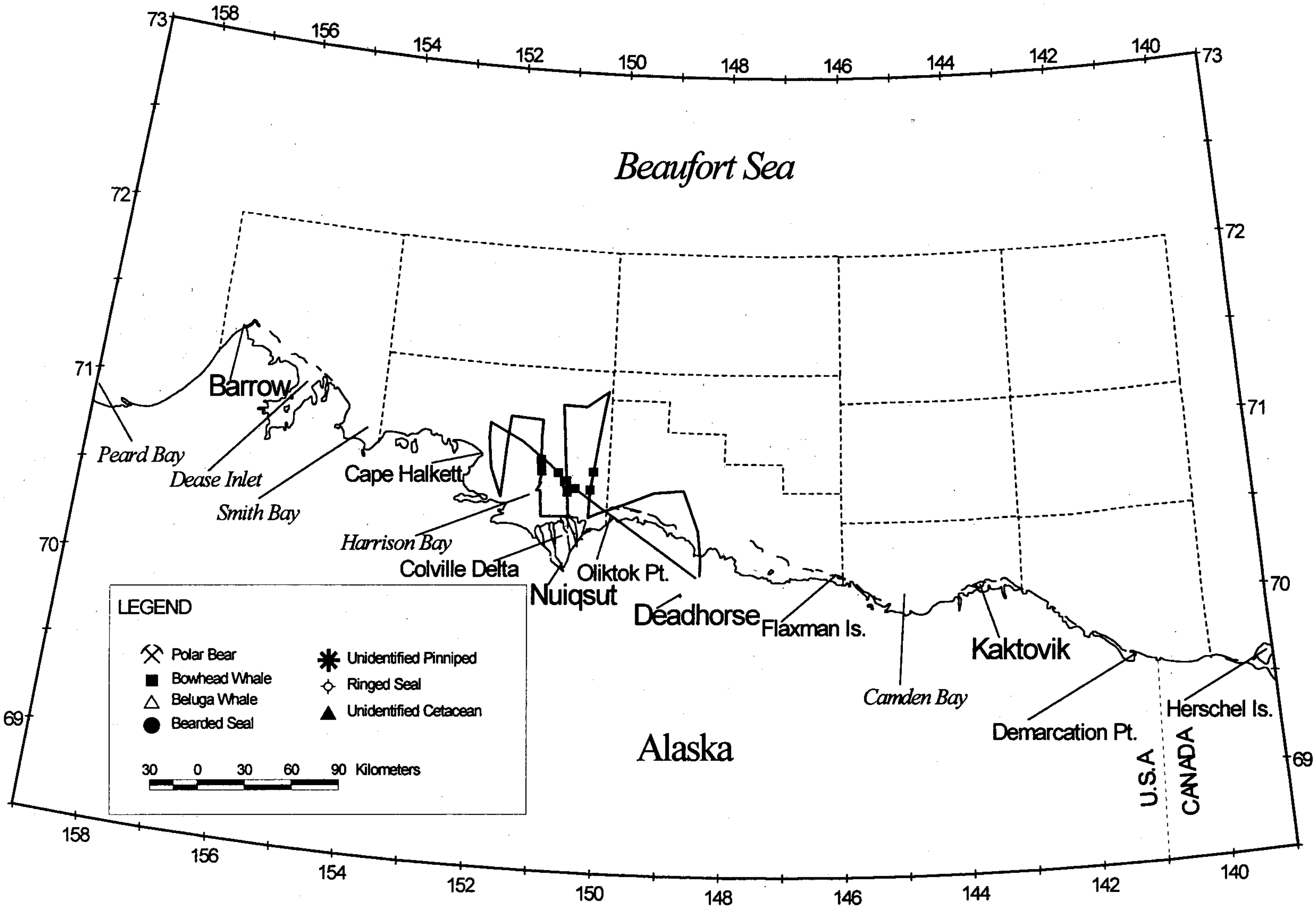
Flight 9: 12 September 1997 Survey Track and Sightings



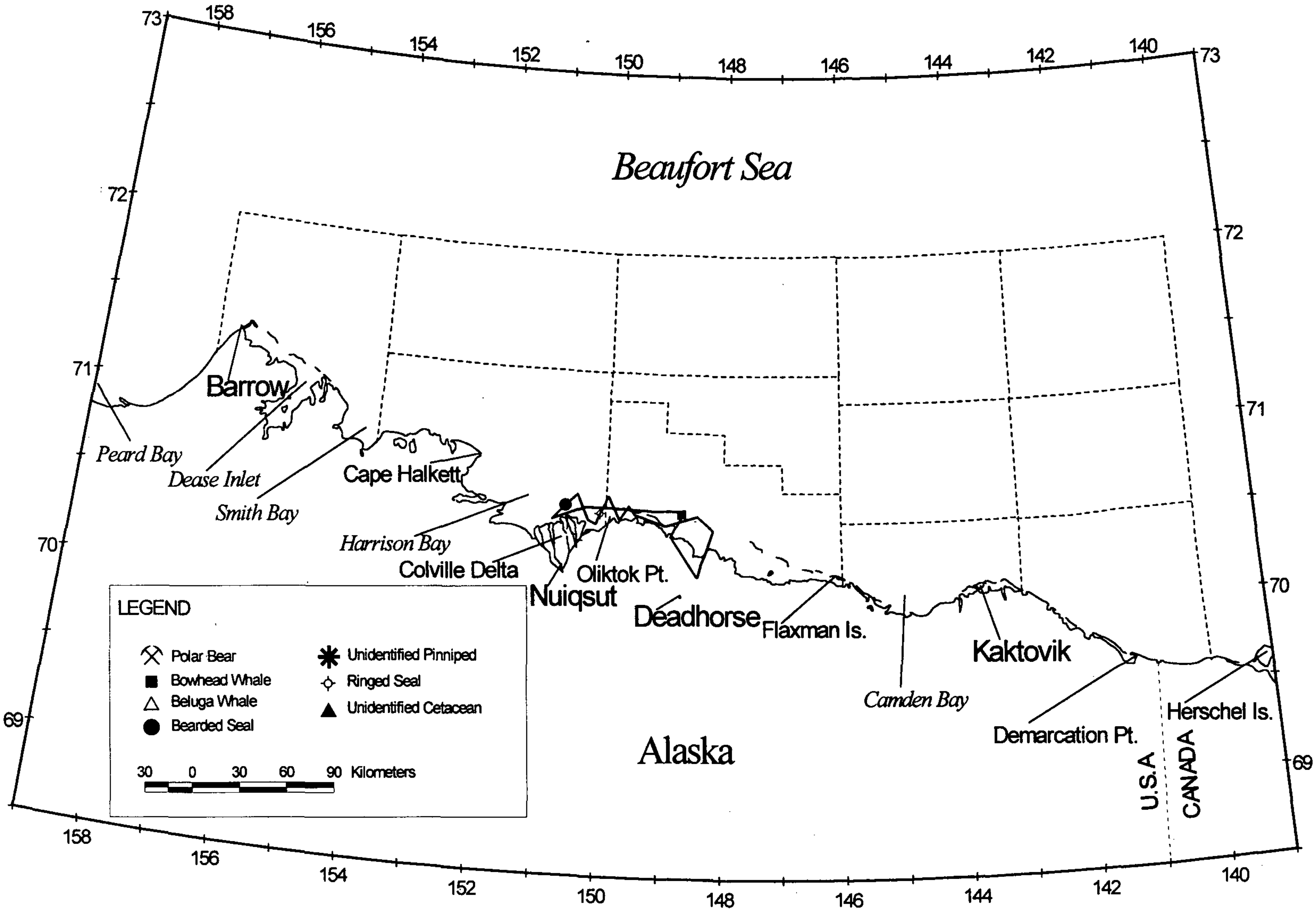
Flight 10: 13 September 1997 Survey Track and Sightings



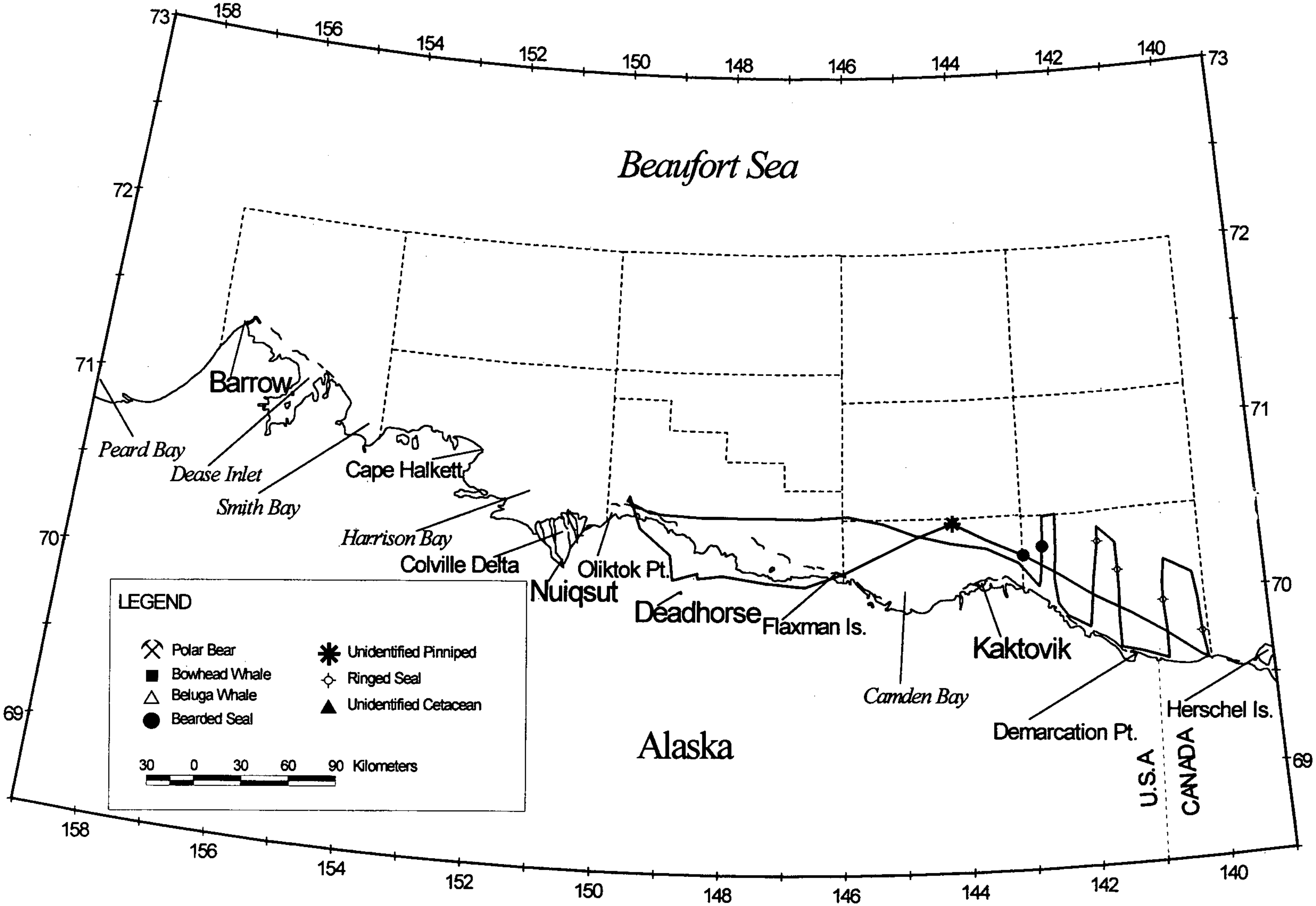
Flight 11: 18 September 1997 Survey Track and Sightings



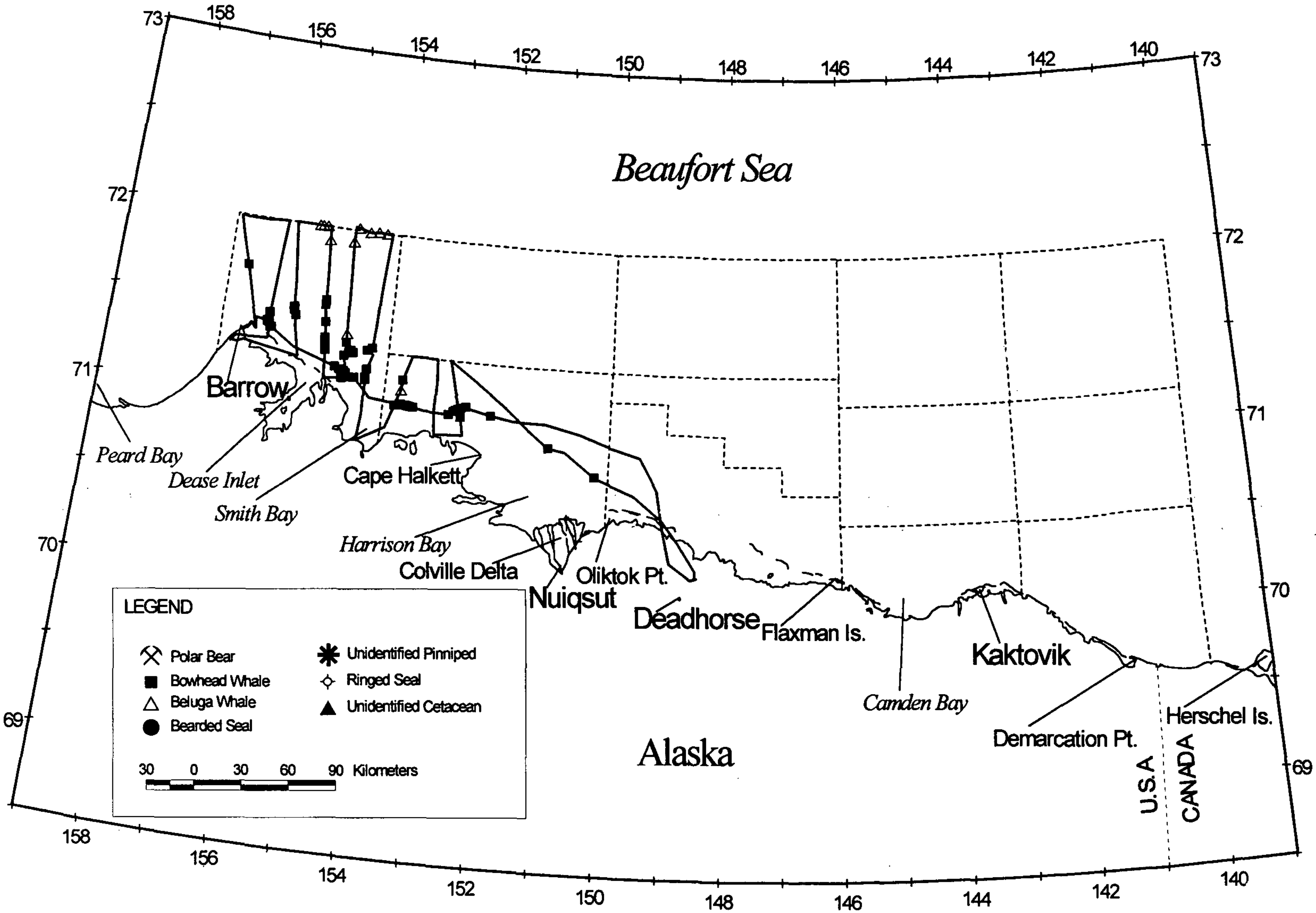
Flight 12: 18 September 1997 Survey Track and Sightings



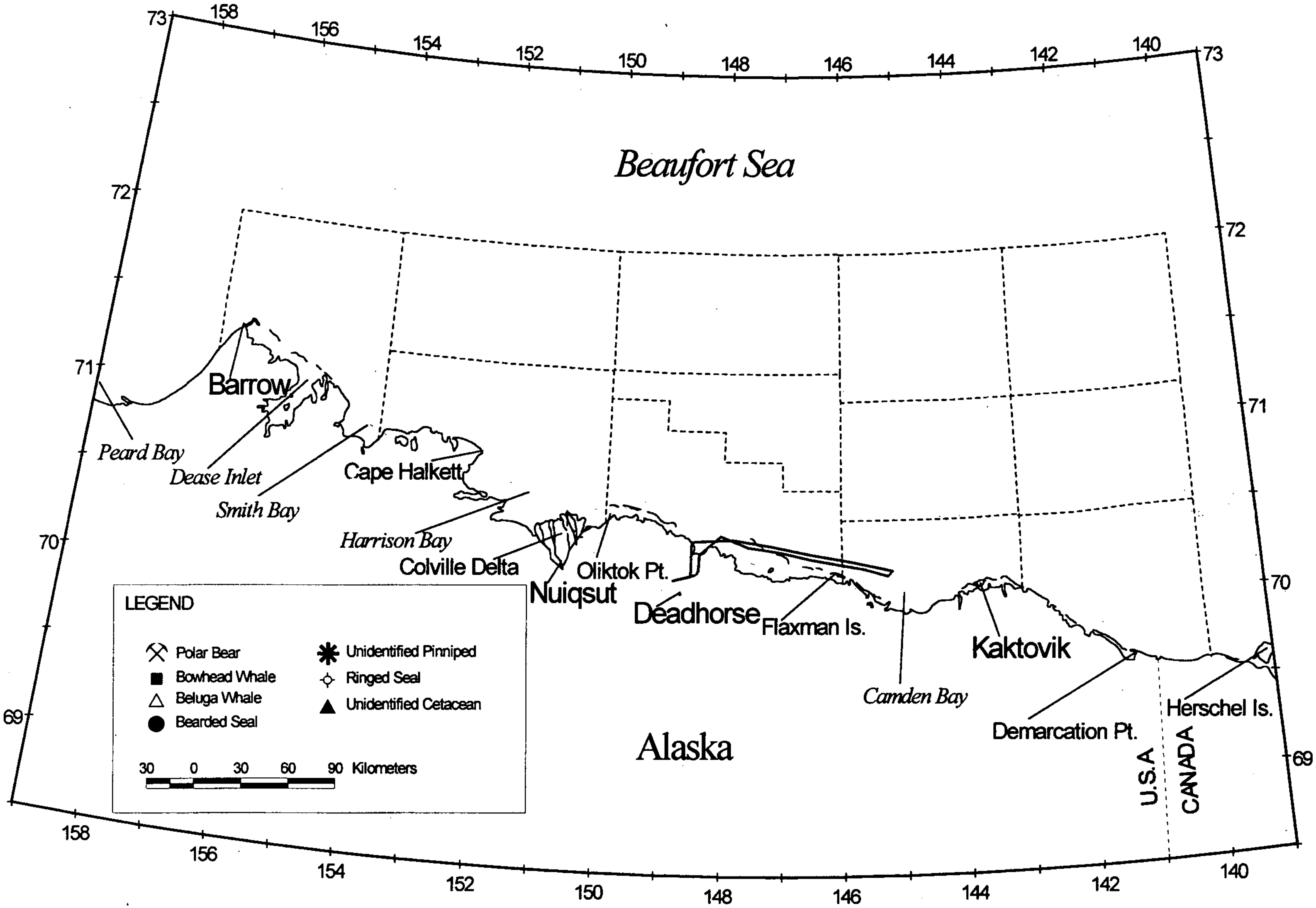
Flight 13: 19 September 1997 Survey Track and Sightings



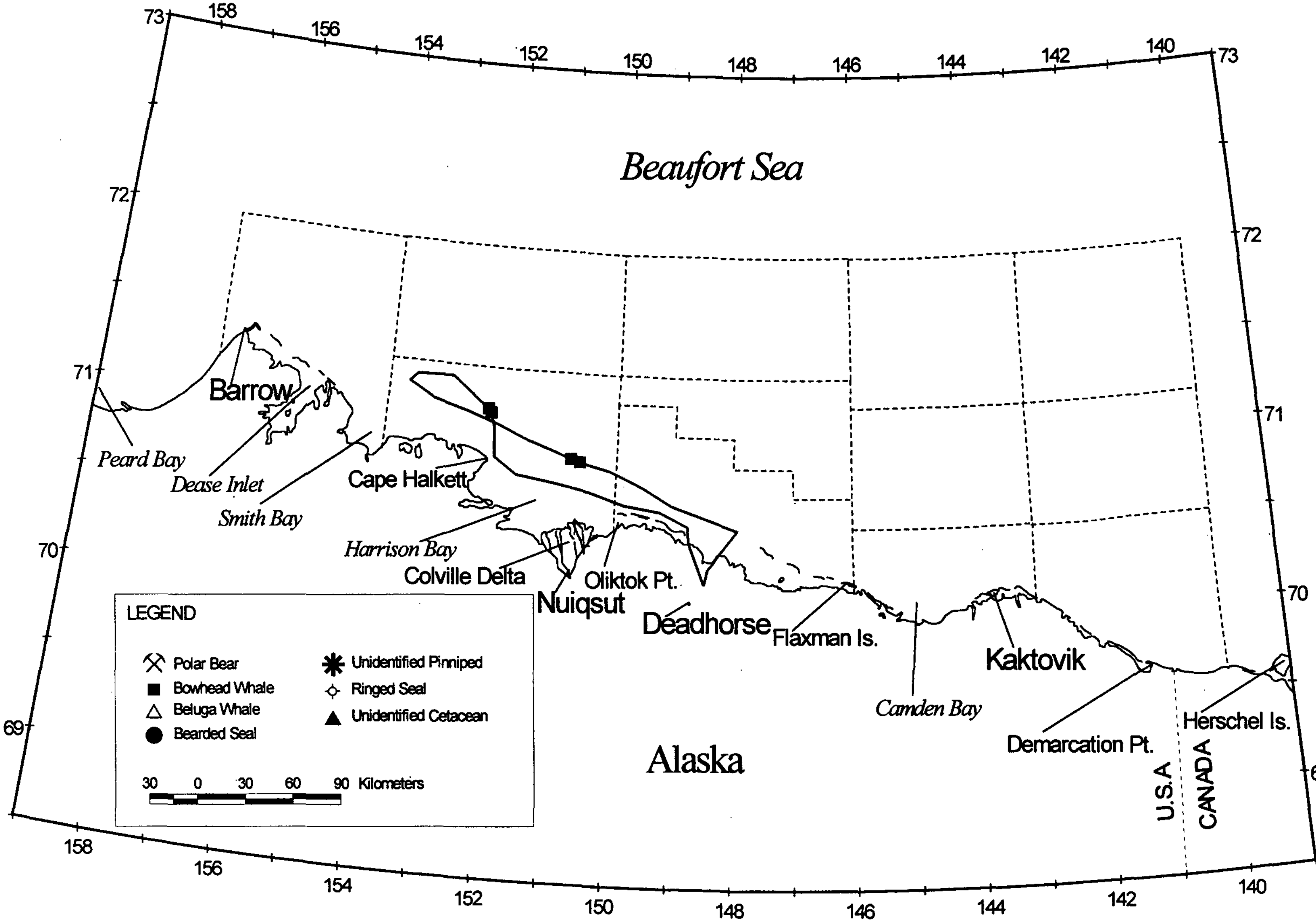
Flight 14: 20 September 1997 Survey Track and Sightings



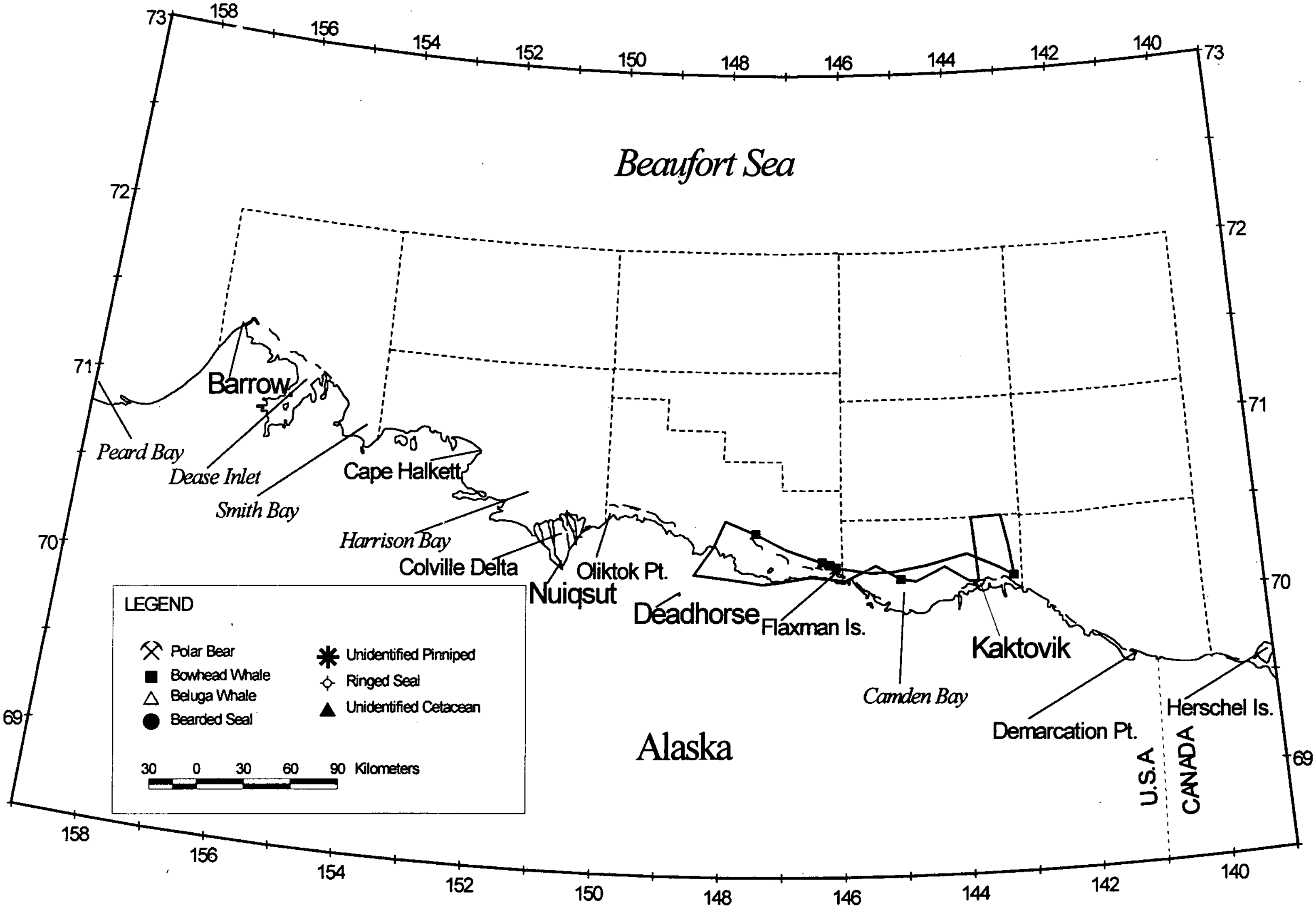
Flight 15: 21 September 1997 Survey Track and Sightings



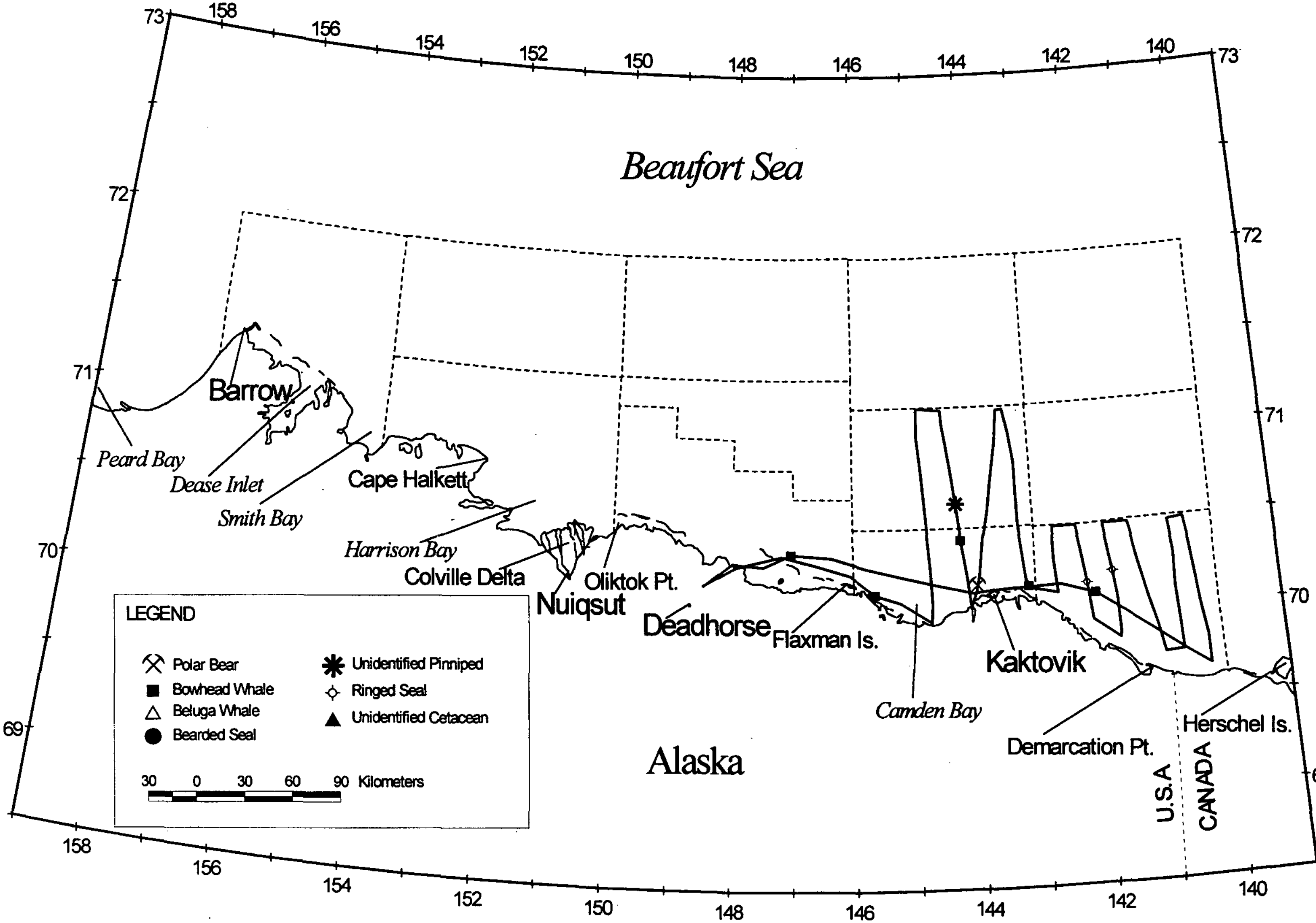
Flight 16: 22 September 1997 Survey Track and Sightings



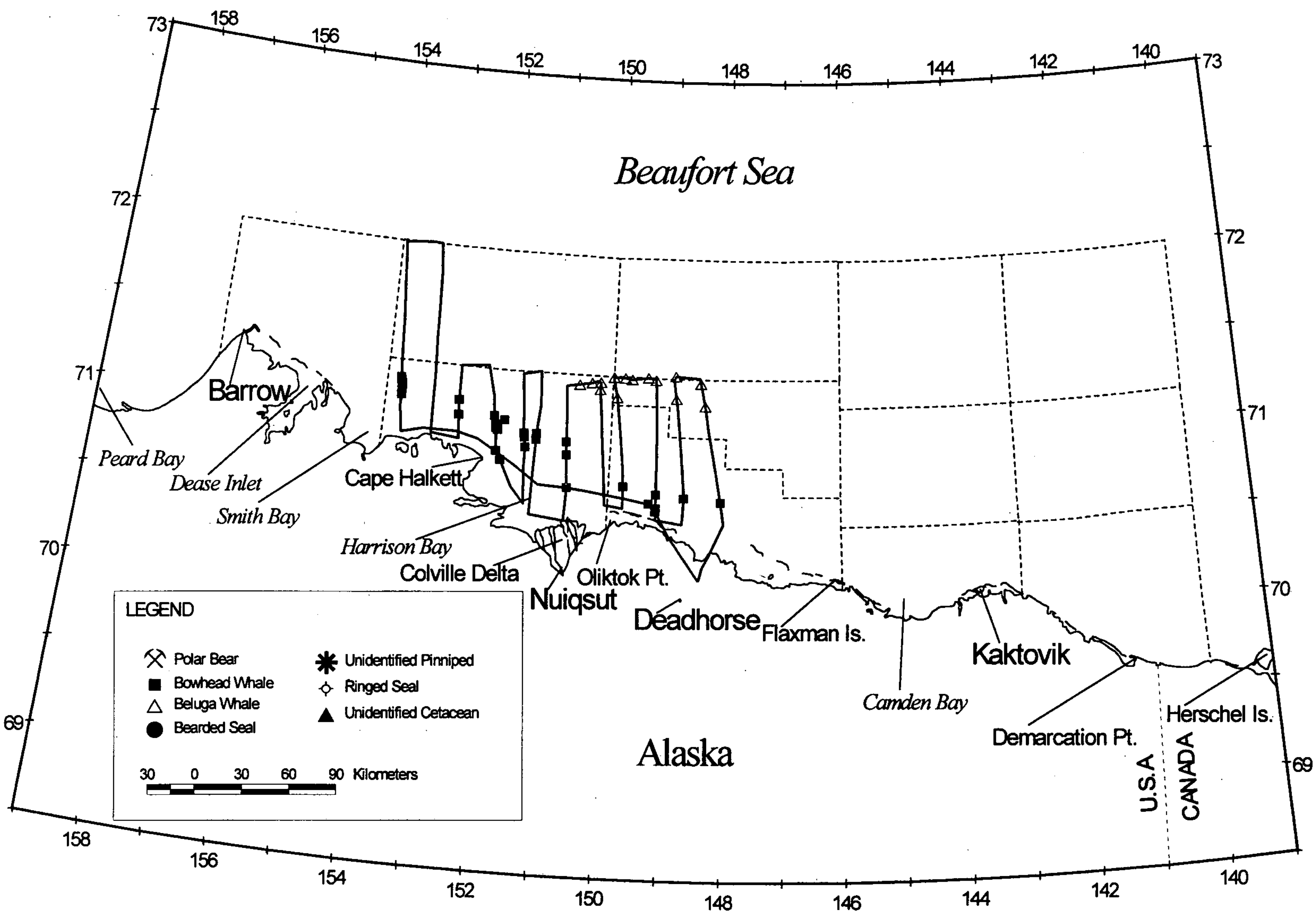
Flight 17: 23 September 1997 Survey Track and Sightings



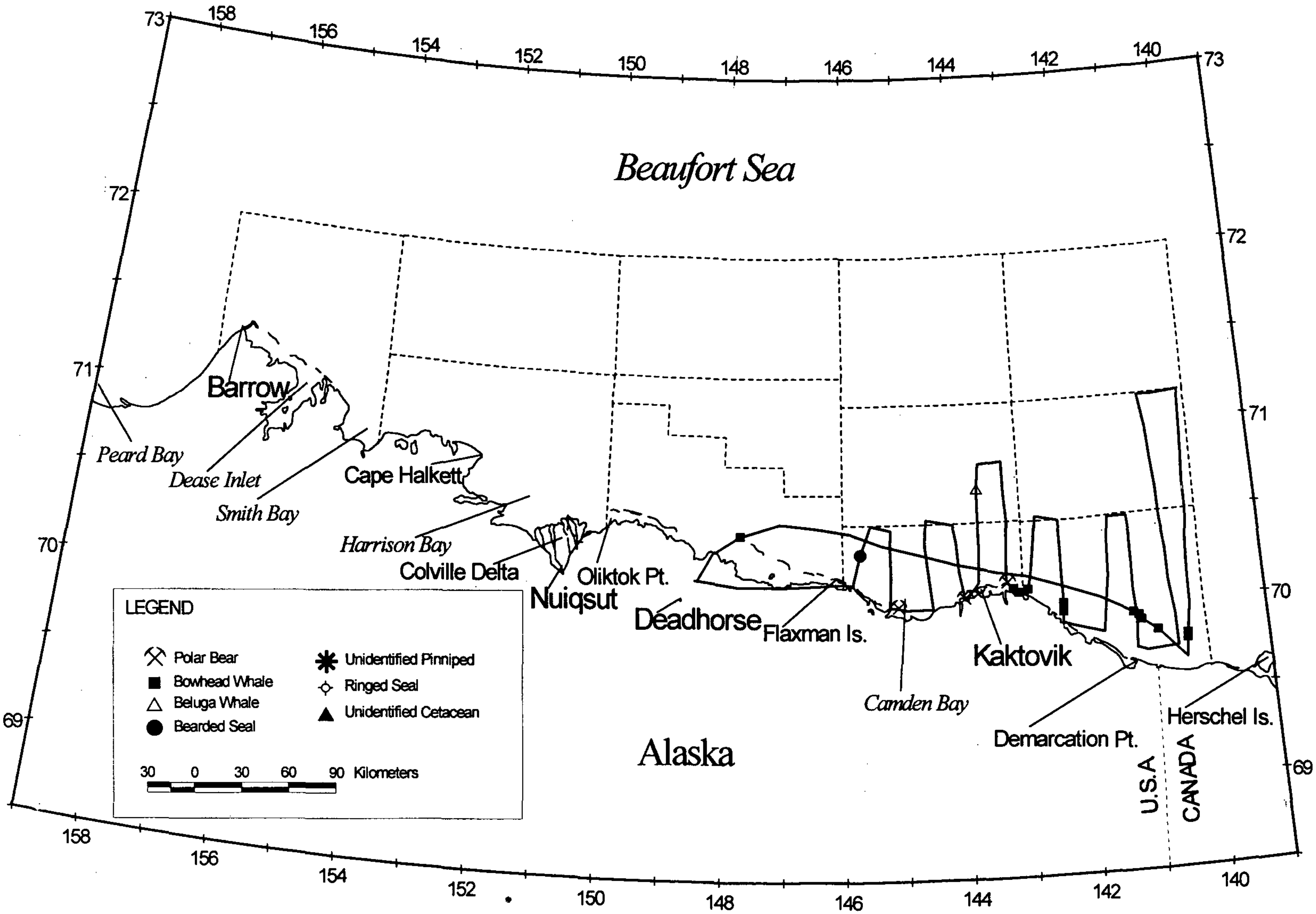
Flight 18: 25 September 1997 Survey Track and Sightings



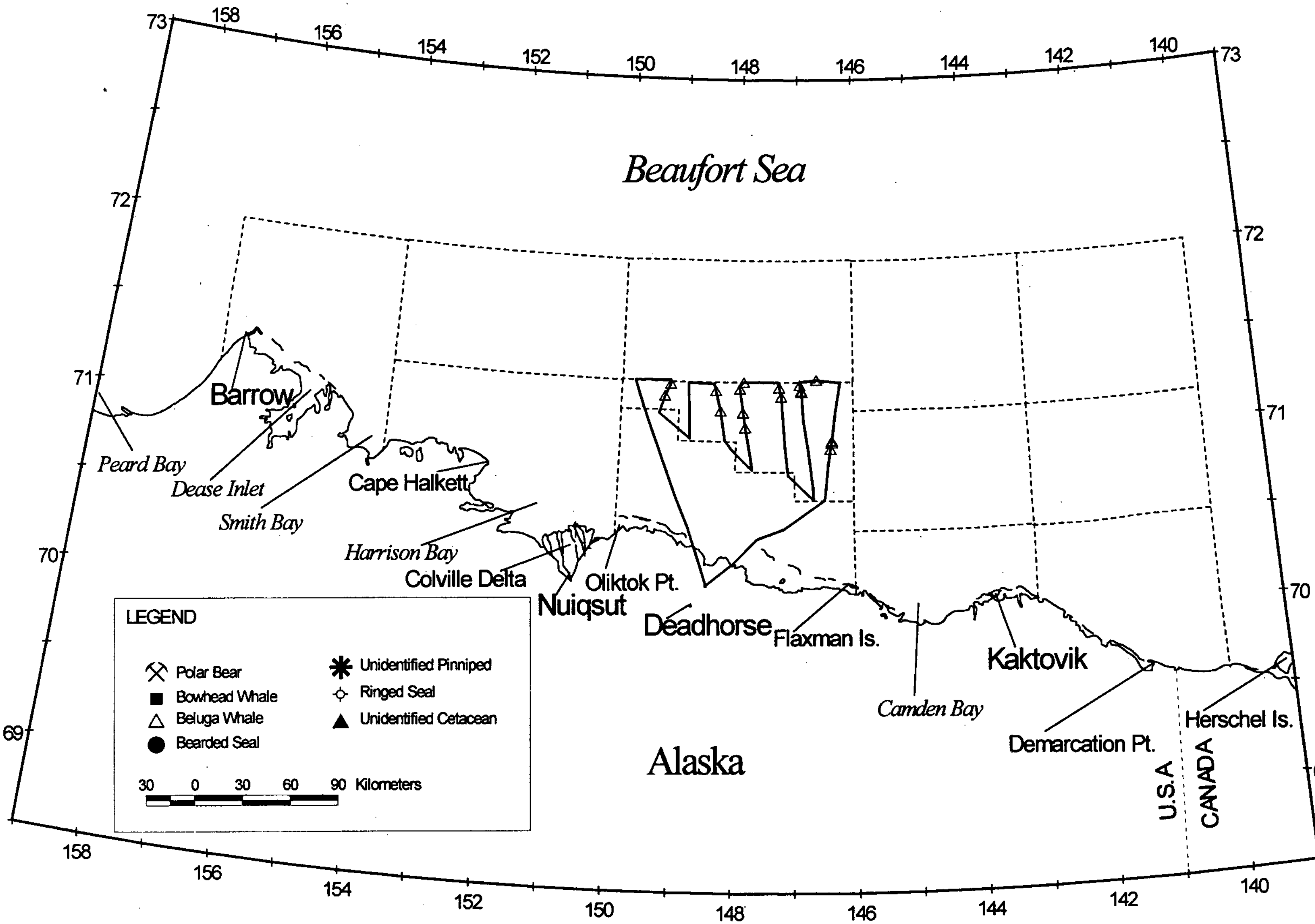
Flight 19: 26 September 1997 Survey Track and Sightings



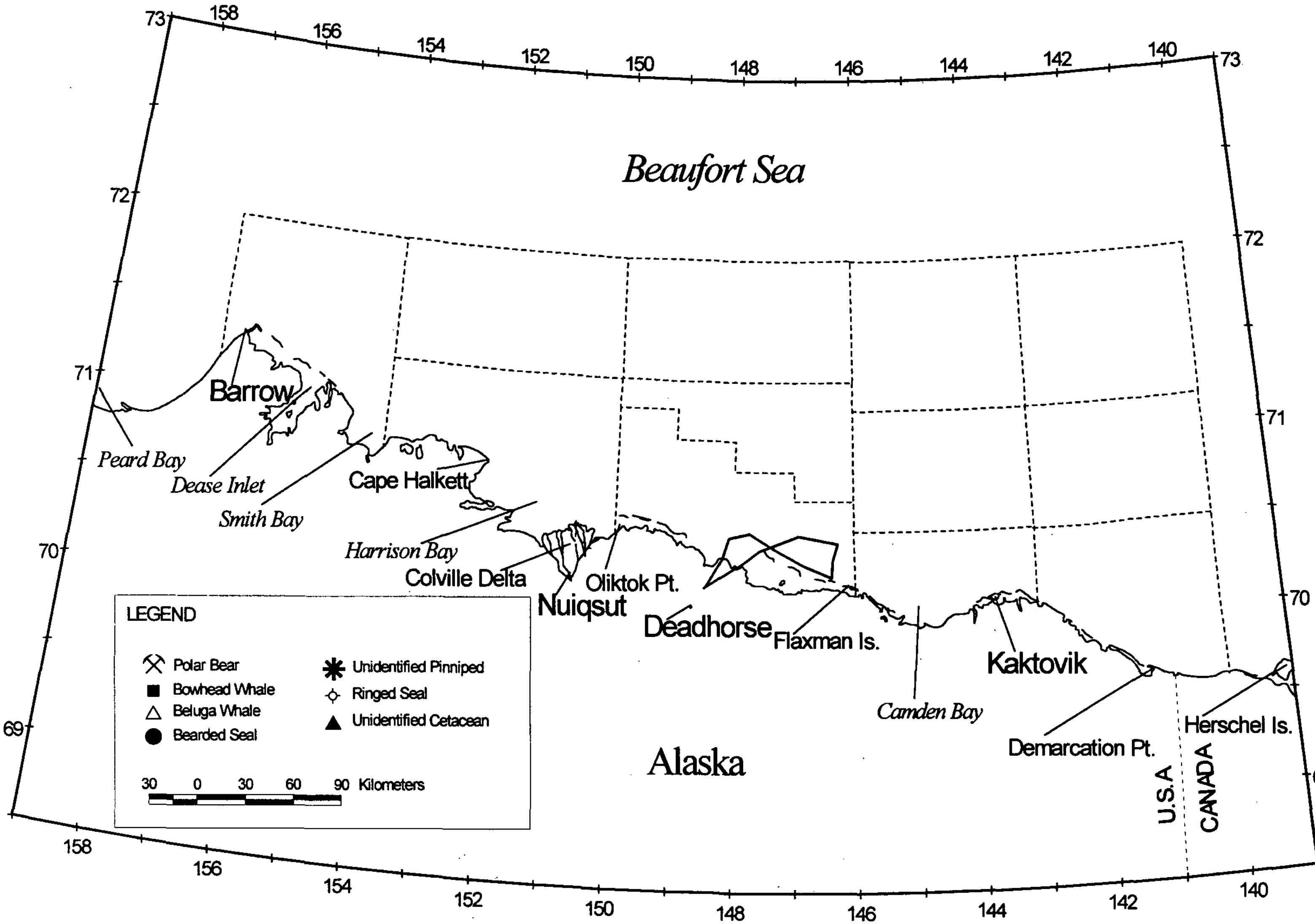
Flight 20: 27 September 1997 Survey Track and Sightings



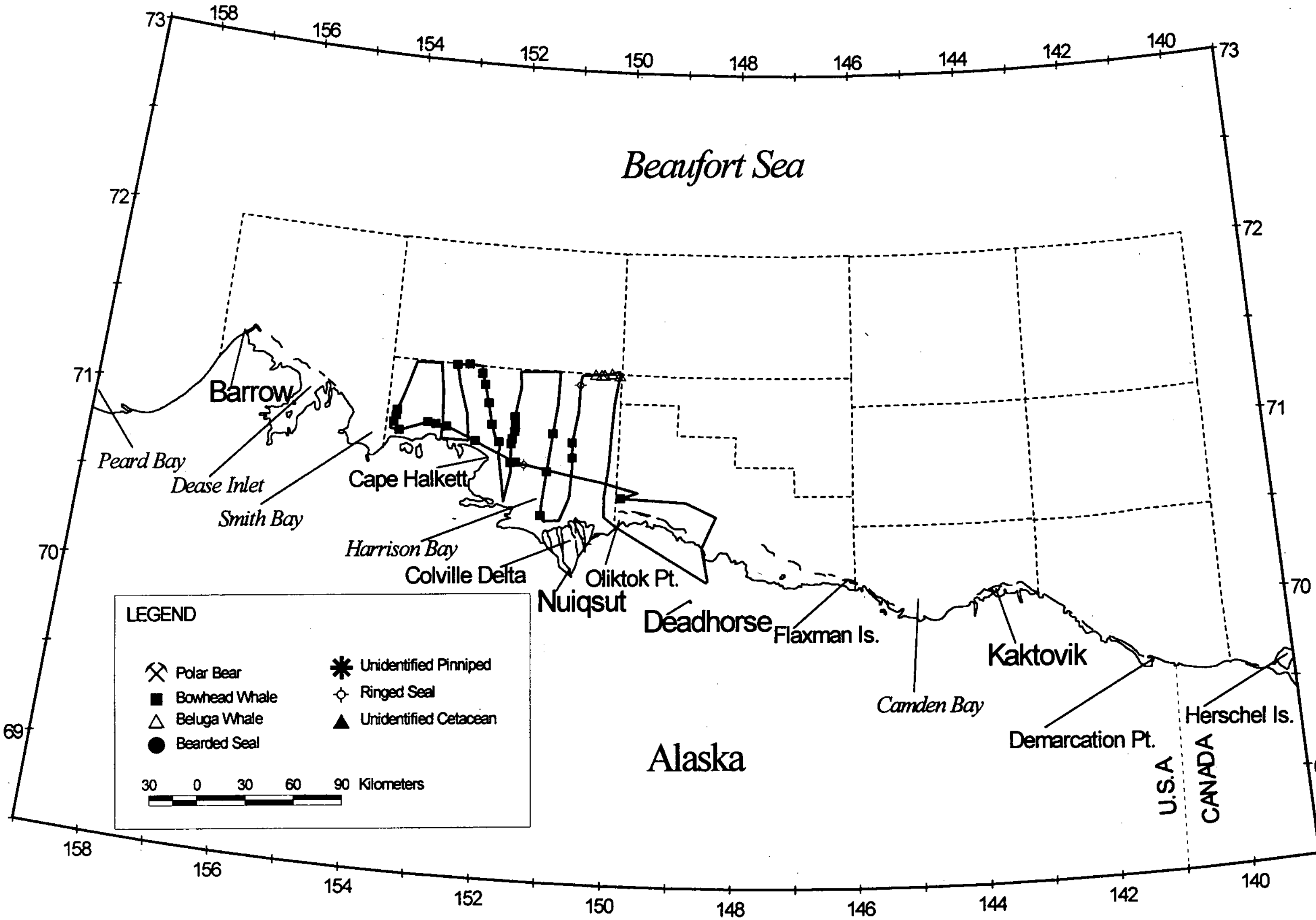
Flight 21: 28 September 1997 Survey Track and Sightings



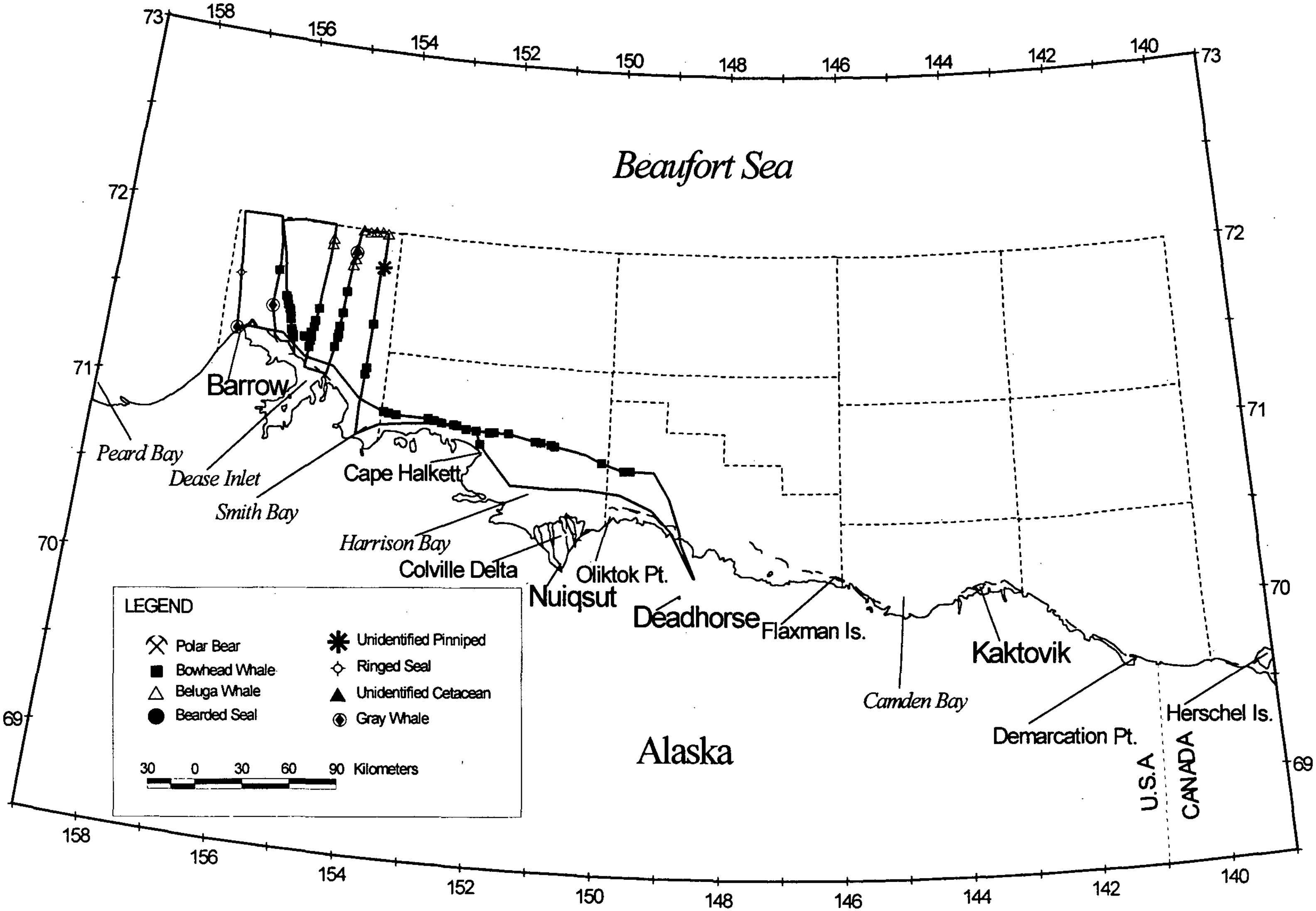
Flight 22: 29 September 1997 Survey Track and Sightings



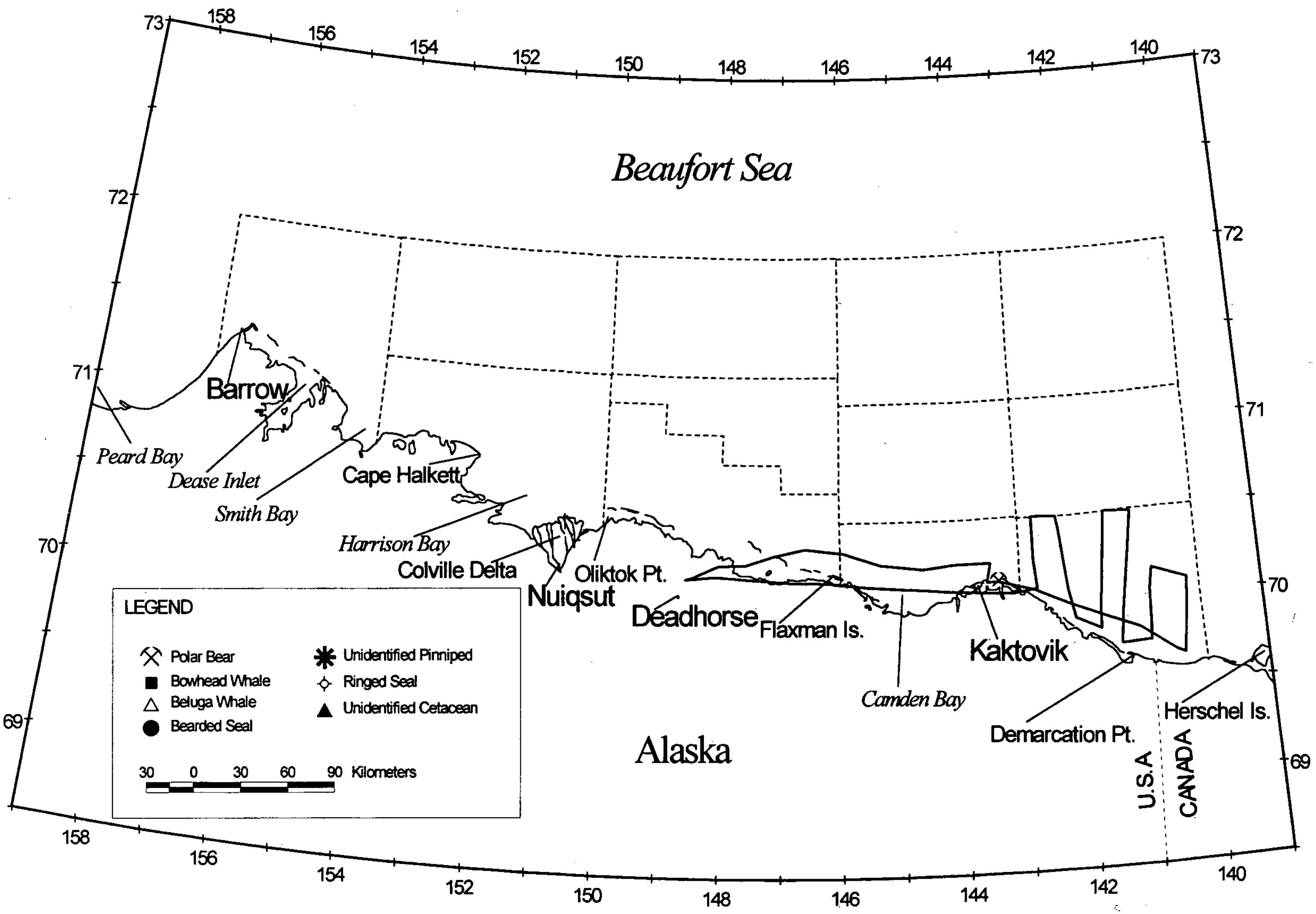
Flight 23: 30 September 1997 Survey Track and Sightings



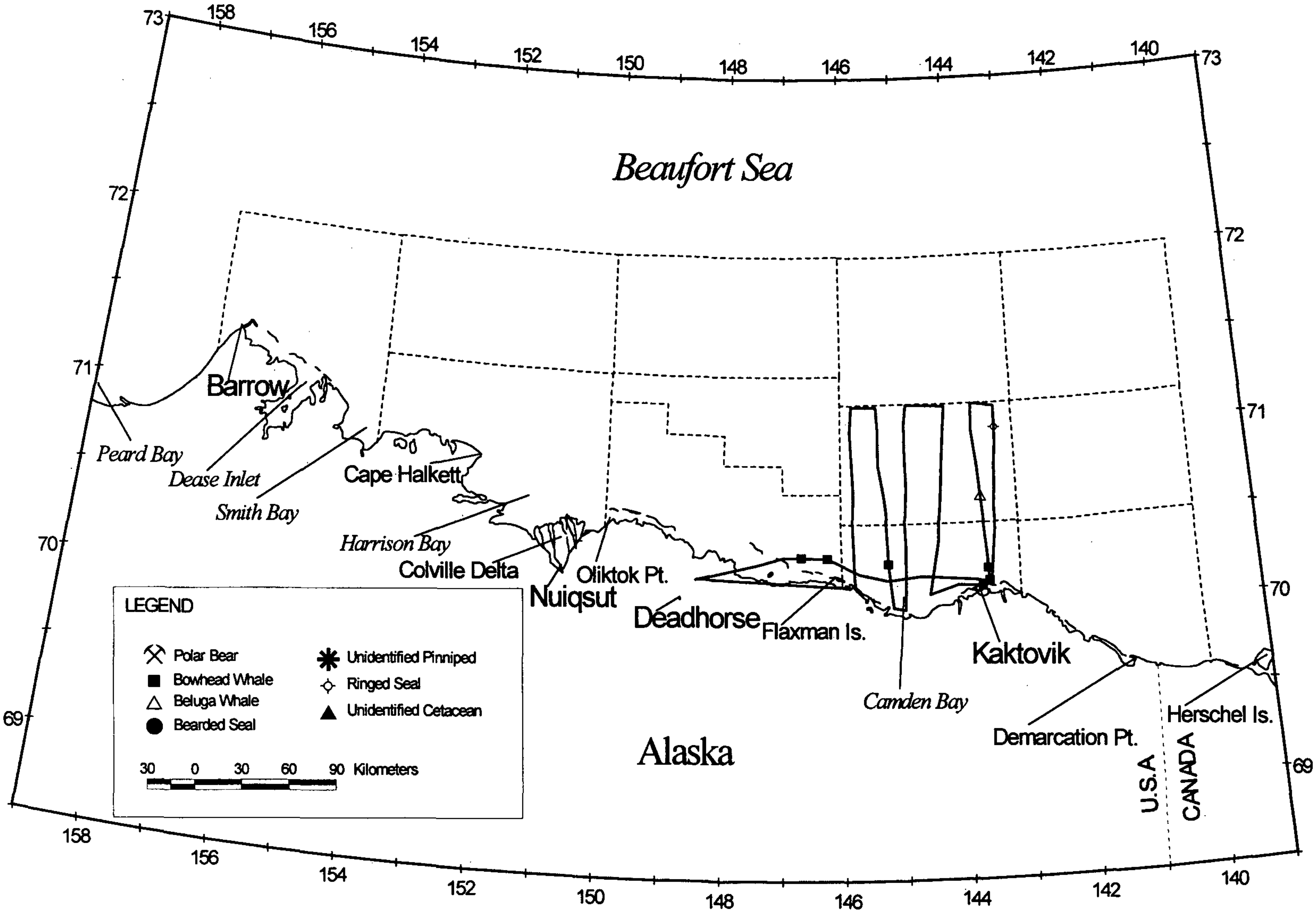
Flight 24: 1 October 1997 Survey Track and Sightings



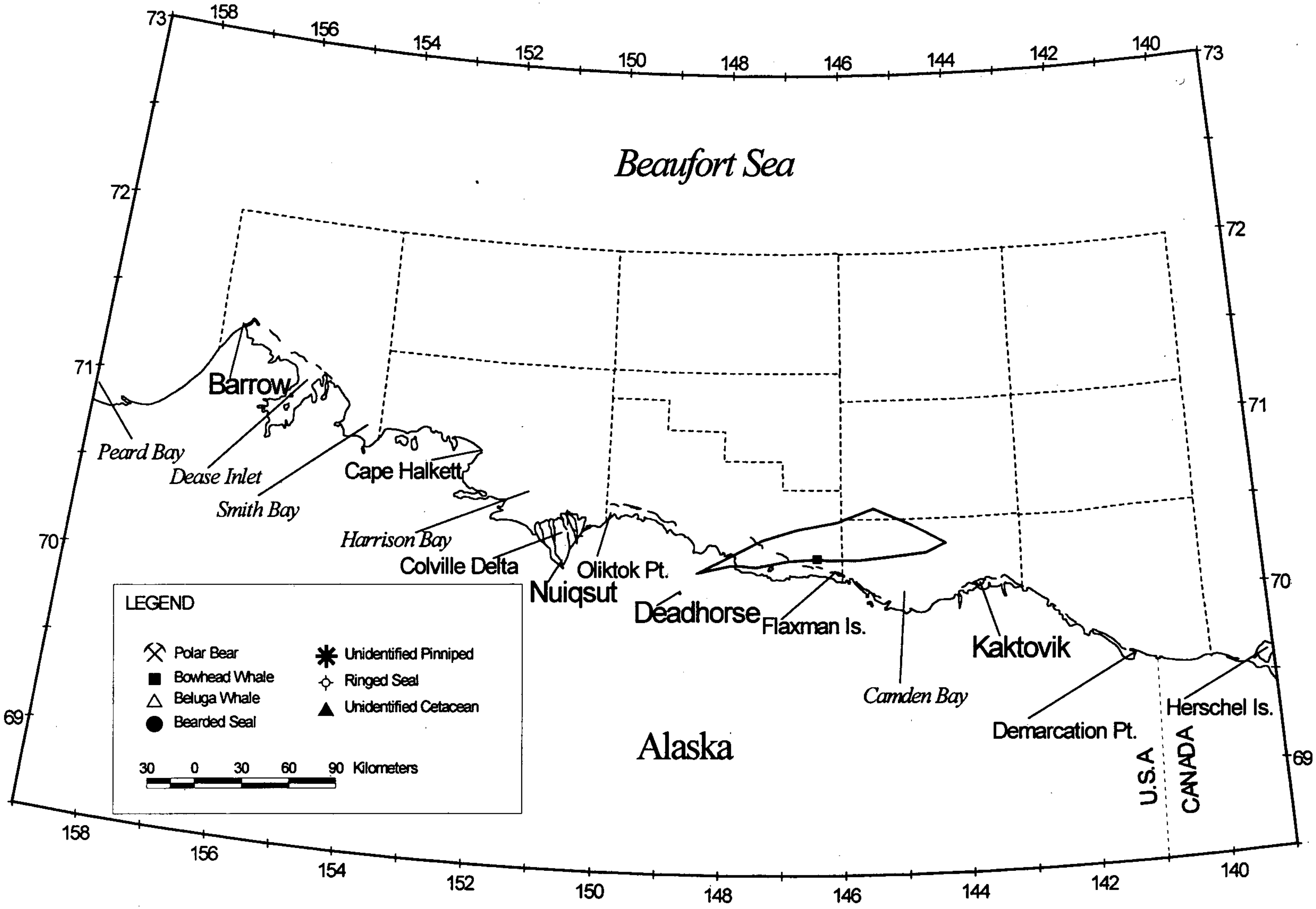
Flight 25: 2 October 1997 Survey Track and Sightings



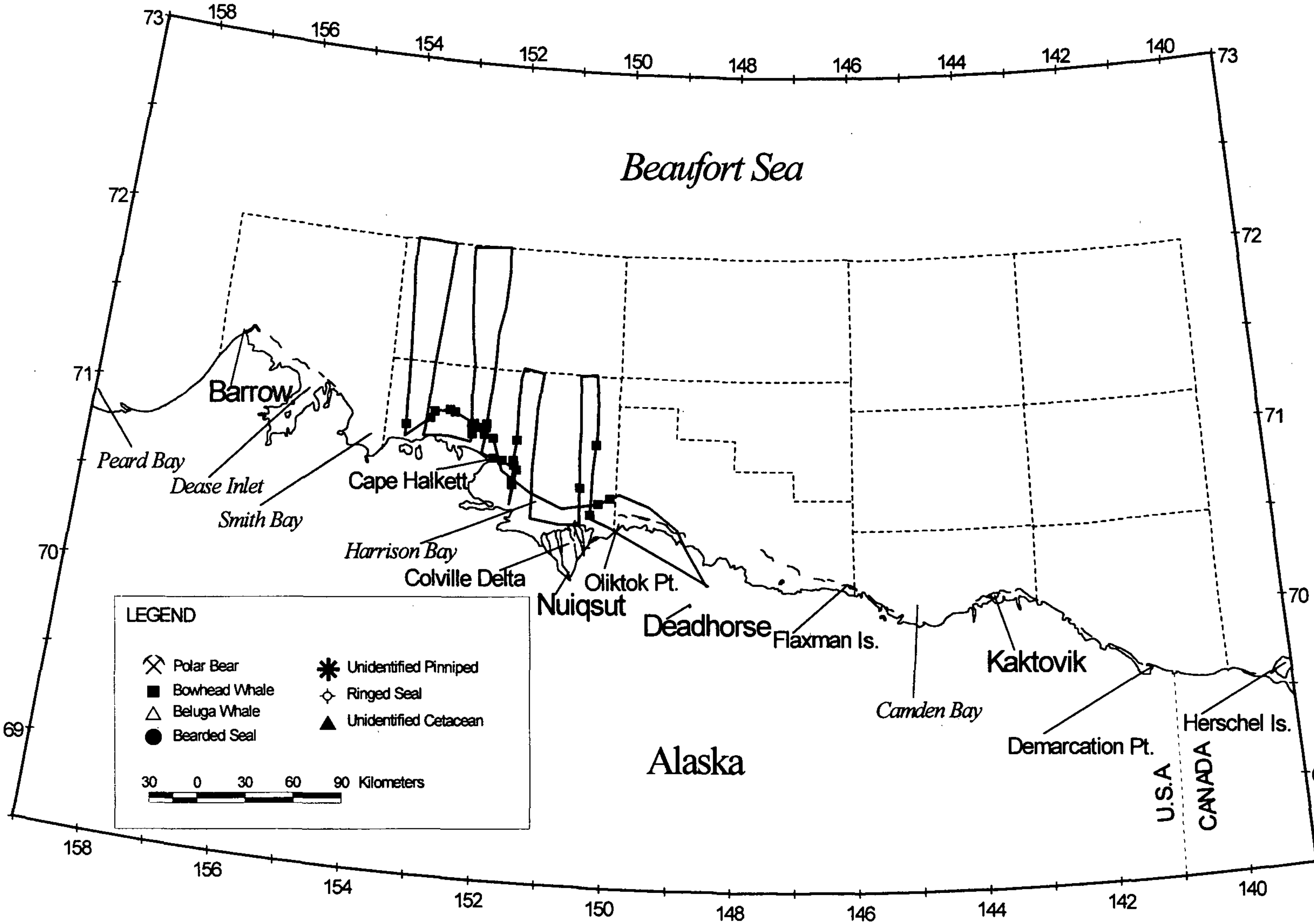
Flight 26: 4 October 1997 Survey Track and Sightings



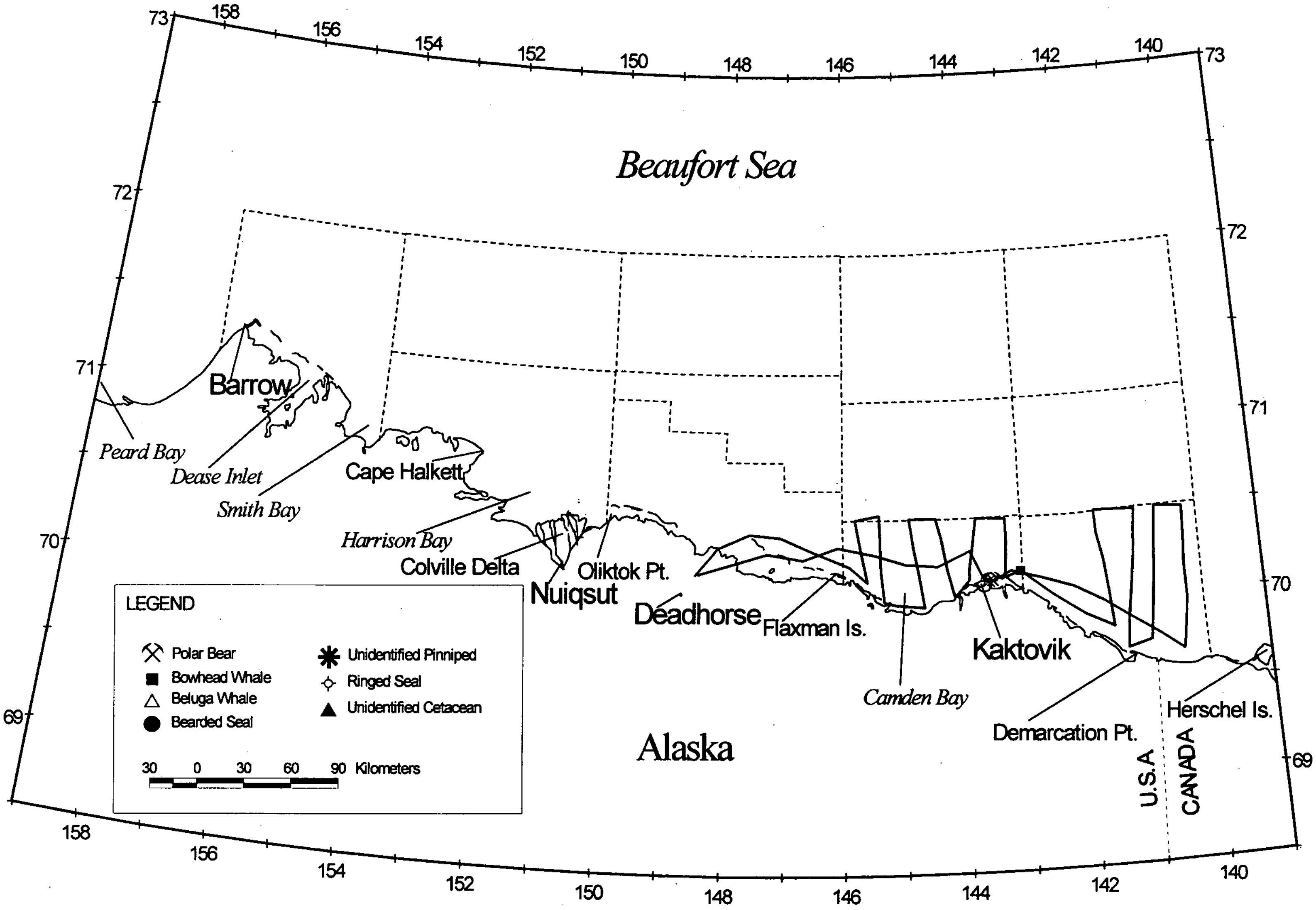
Flight 27: 7 October 1997 Survey Track and Sightings



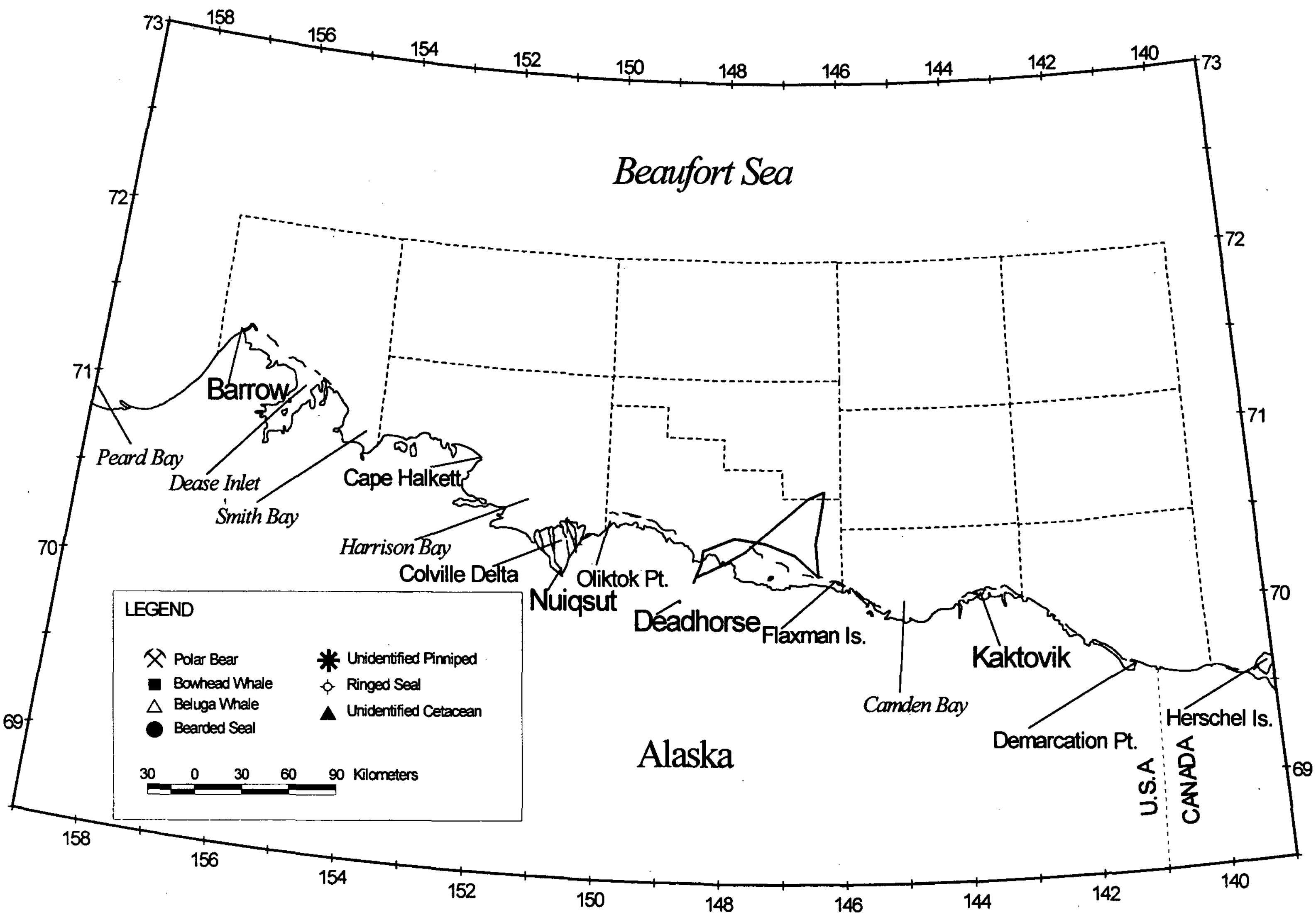
Flight 28: 9 October 1997 Survey Track and Sightings



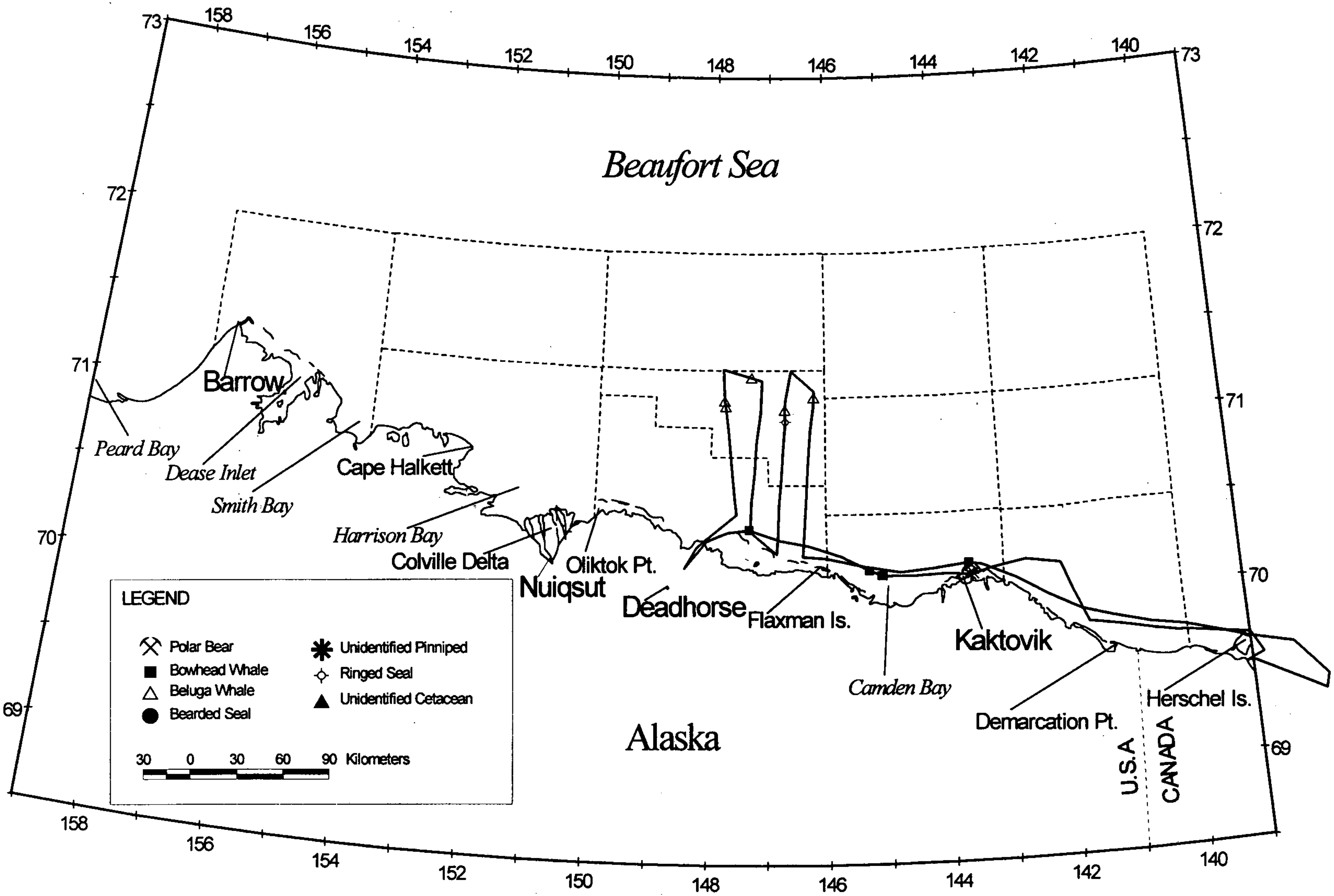
Flight 29: 11 October 1997 Survey Track and Sightings



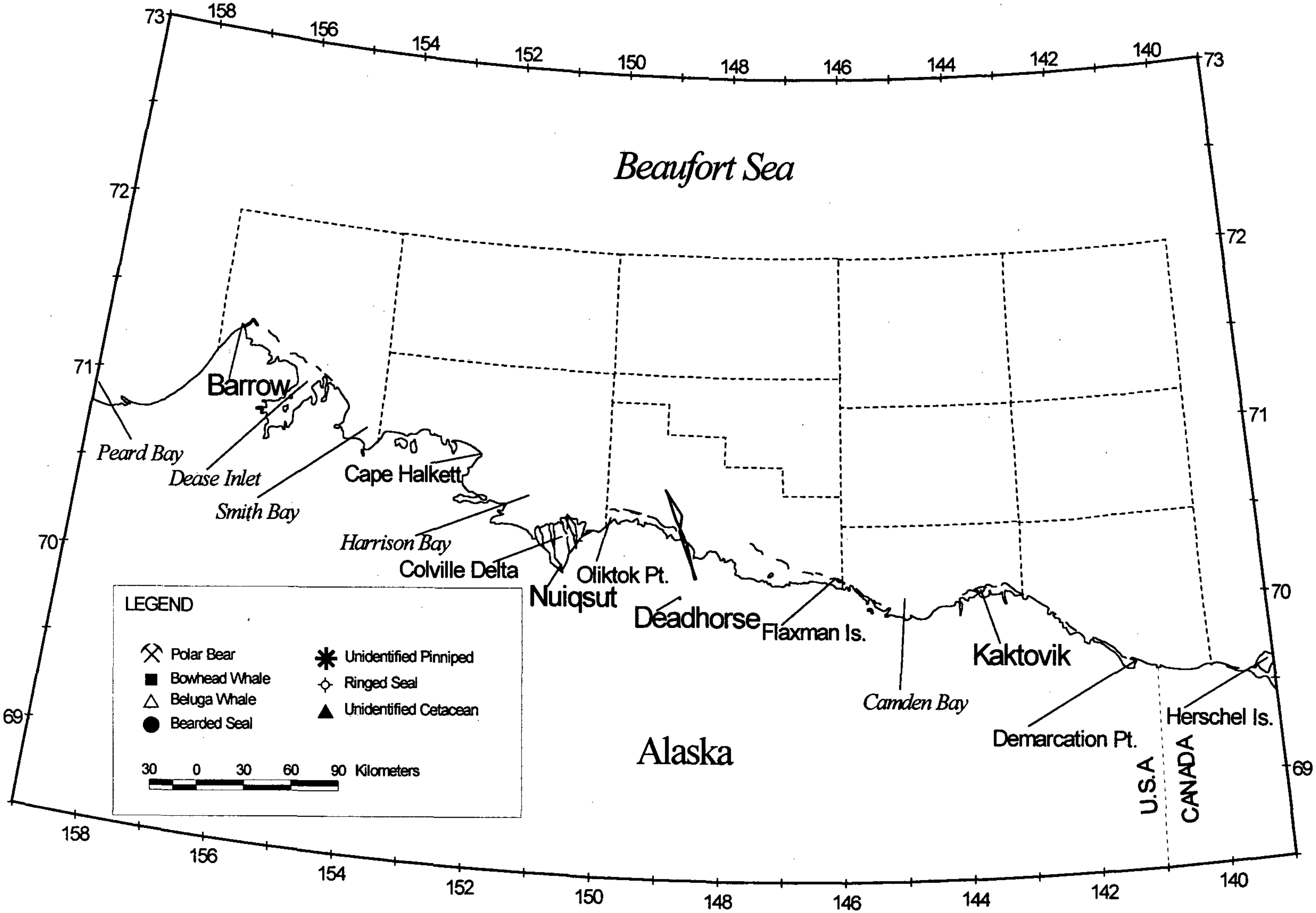
Flight 30: 11 October 1997 Survey Track and Sightings



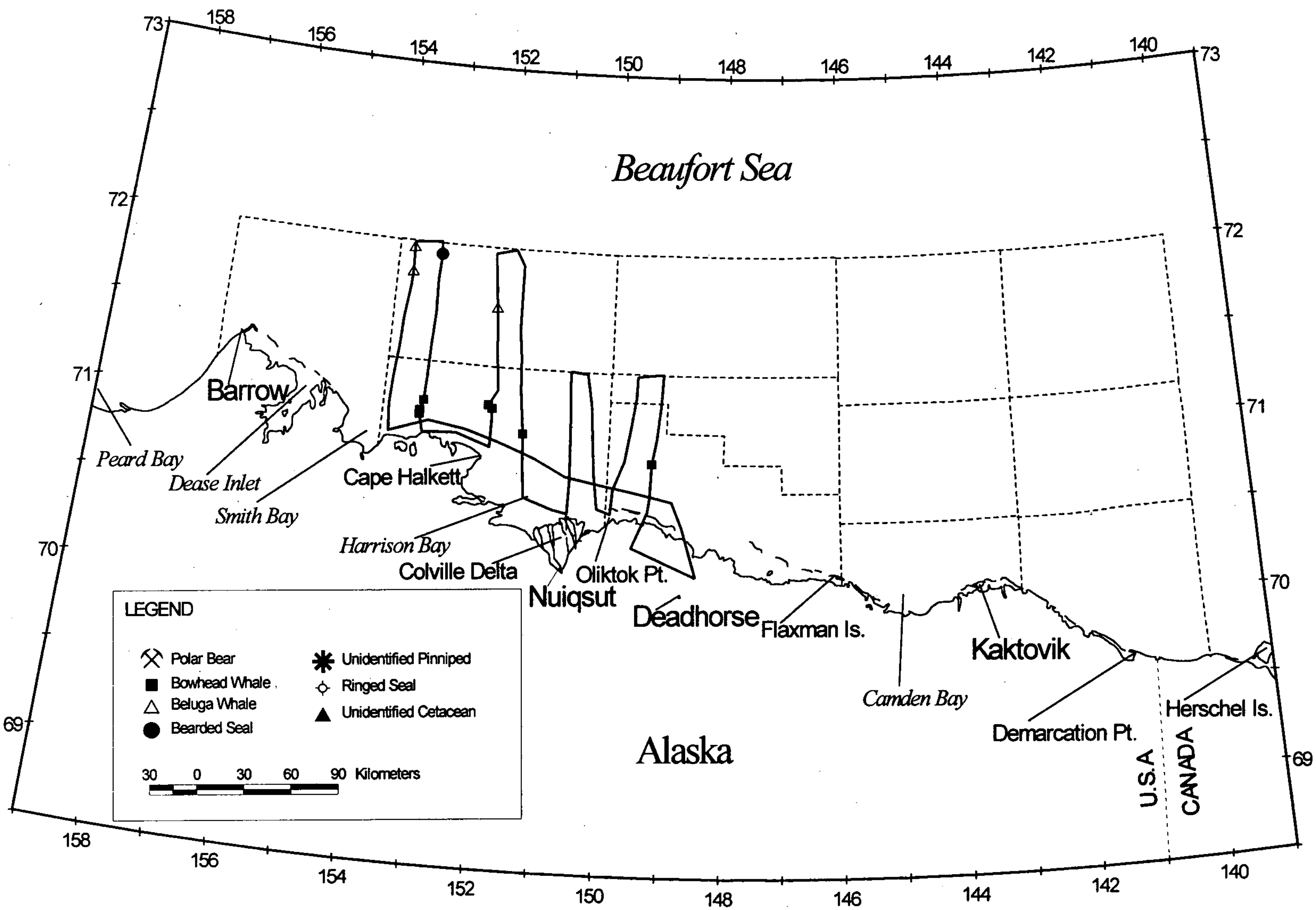
Flight 31: 12 October 1997 Survey Track and Sightings



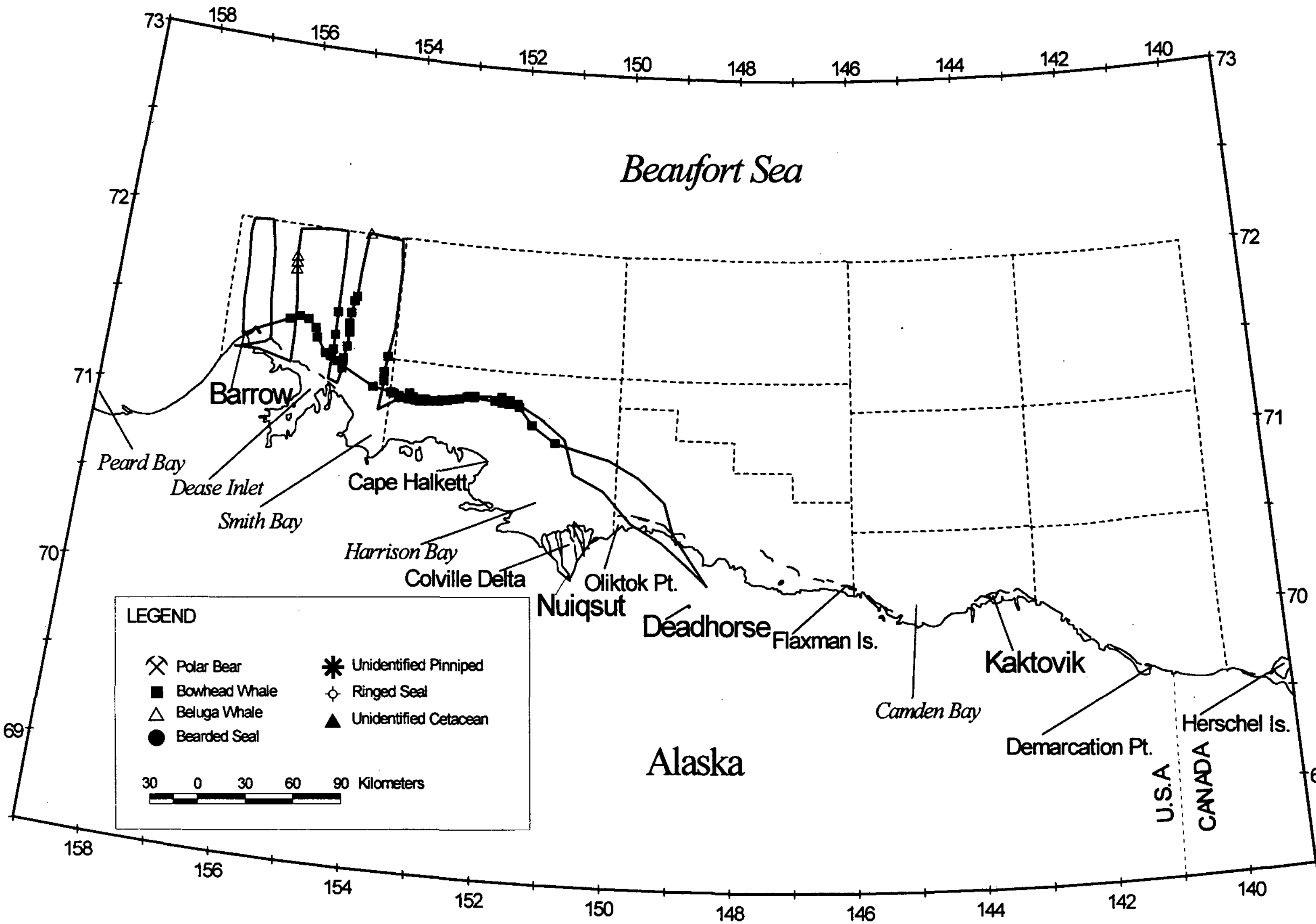
Flight 32: 14 October 1997 Survey Track and Sightings



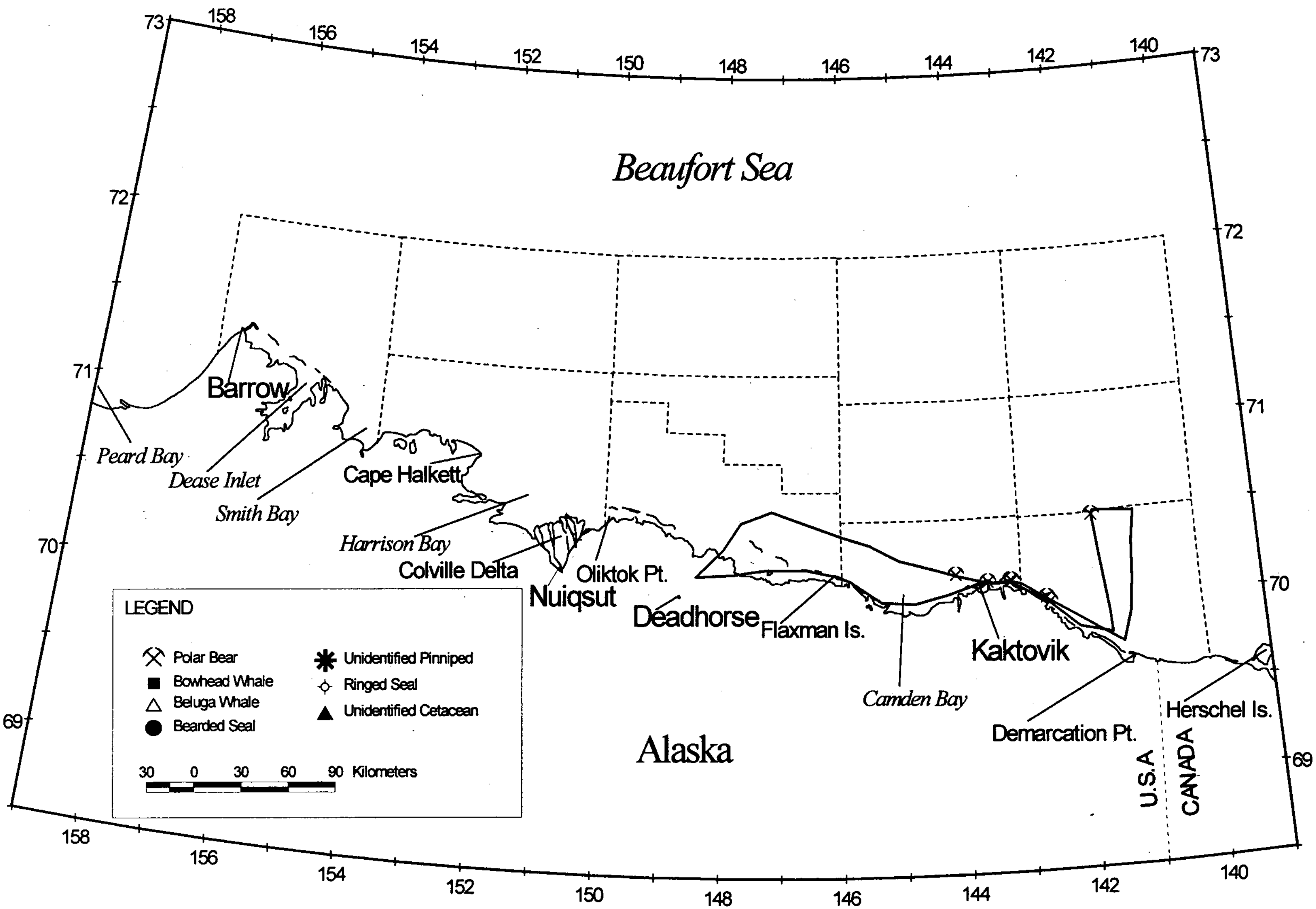
Flight 33: 16 October 1997 Survey Track and Sightings



Flight 34: 17 October 1997 Survey Track and Sightings



Flight 35: 18 October 1997 Survey Track and Sightings



Flight 36: 19 October 1997 Survey Track and Sightings

APPENDIX C

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND INITIALISMS

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND INITIALISMS

AC	alternating current
AEWC	Alaska Eskimo Whaling Commission
ANOVA	analysis of variance
BLM	Bureau of Land Management
BPXA	BP Exploration (Alaska) Inc.
C	Celsius
CI	confidence interval
e.g.	for example
EIS	Environmental Impact Statement
ELT	emergency locator transmitter
ESA	Endangered Species Act
FMS	Flight Management System
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
K-S	Kolmogorov-Smirnov statistical test
m	meter
MDC	Mobile Datacom Corporation
MMS	Minerals Management Service
n	sample size
NOAA	National Oceanic and Atmospheric Administration
NOS	Notice of Sale
NOSC	Naval Ocean Systems Center
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
RDSS	Radio Determination Satellite System
SD	standard deviation
SI	sightings
SPUE	sightings per unit effort (number of whale sightings counted per hour)
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
UTM	Universal Transverse Mercator
WPUE	whales per unit effort (number of whales counted per hour); relative abundance

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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.