AD-A158 946 AERIAL SURVEYS OF ENDANGERED WHALES IN THE NORTHERN BERING EASTERN CHUKCH..(U) NAVAL OCEAN SYSTEMS CENTER SAN DIEGO CA D K LJUNGBLAD ET AL. JUN 85 NOSC/TR-1046 1/4

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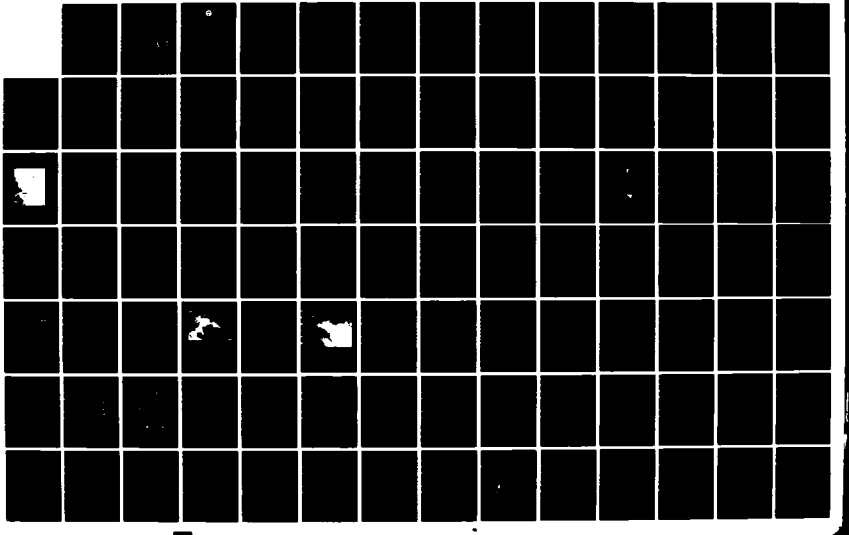

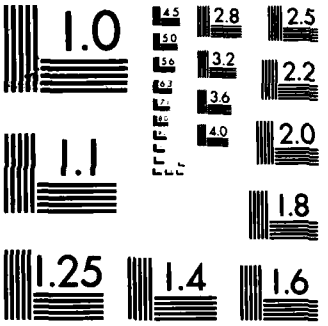

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Technical Report 1046
June 1985

AERIAL SURVEYS OF ENDANGERED WHALES IN THE NORTHERN BERING, EASTERN CHUKCHI, AND ALASKAN BEAUFORT SEAS, 1984: WITH A SIX YEAR REVIEW, 1979-1984

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

Naval Ocean Systems Center
San Diego, California 92152-5000

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ADMINISTRATIVE INFORMATION

The work discussed in this report was done during the period of mid-April to October 1984 under the sponsorship of the Minerals Management Service, Alaska, OCS Region, U.S. Department of Interior.

Released by
L. W. Bivens, Head
Biological Services Branch

Under authority of
H. O. Porter, Head
Biosciences Division

ACKNOWLEDGEMENTS

We wish to acknowledge the professional assistance of those people who contributed to our safe and successful season. At the Office of Aircraft Services (OAS), U. S. Department of Interior, Anchorage, Alaska, we cite the safe and persevering performance of pilots Carsten Anderson, Gary Candee, Dale Moore, and John Warren, and the OAS maintenance and administrative staffs. At Minerals Management Service (MMS) we appreciate the advice and support of Cleve Cowles, Jerry Imm, Jerome Montague, and Tim Sullivan. The dedicated field service of observers Edith Barrowclough, David Nelson, and Richard O'Hara of SEACO, Inc. contributed invaluably to our efforts.

Jean Killian and Doris Malley of the graphics department of the Naval Ocean Systems Center (NOSC) assisted in compiling the report. Ron Scheidt supplied satellite imagery from the National Weather Service, U. S. Department of Commerce. Jeanne Cole and Barbara McAvoy of SEACO, Inc. typed numerous drafts. Richard O'Hara assisted invaluably with data acquisition and compilation, and construction of flight tracks. Bruce Krogman and Ronald Sonntag of Analytical Software, Inc. provided density estimates. Review of this document and helpful comments were provided by Jim Keene and Steve Swartz of SEACO, Inc., Forrest Wood of the NOSC, Byron Morris of the National Marine Fisheries Service (NMFS), Douglas Chapman of the Marine Mammal Commission and Jerome Montague, Gary Wheeler, and Debbie Johnston of MMS.

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UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b RESTRICTIVE MARKINGS
2a SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
2b DECLASSIFICATION/DOWNGRADING SCHEDULE	
4 PERFORMING ORGANIZATION REPORT NUMBER(S) NOSC TR 1046	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a NAME OF PERFORMING ORGANIZATION Naval Ocean Systems Center 6b OFFICE SYMBOL (if applicable)	7a NAME OF MONITORING ORGANIZATION
6c ADDRESS (City, State and ZIP Code) San Diego, CA 92152-5000	7b ADDRESS (City, State and ZIP Code)
8a NAME OF FUNDING/SPONSORING ORGANIZATION Minerals Management Service Department of Interior 8b OFFICE SYMBOL (if applicable)	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER OCS Study: MMS, 85-0018
8c ADDRESS (City, State and ZIP Code) Washington, DC 20350	10 SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO / PROJECT NO / TASK NO / WORK UNIT NO

11 TITLE (Include Security Classification)
AERIAL SURVEYS OF ENDANGERED WHALES IN THE NORTHERN BERING, EASTERN CHUKCHI AND ALASKAN BEAUFORT SEAS, 1984; WITH A SIX YEAR REVIEW, 1979-1984

12 PERSONAL AUTHOR(S)
D.K. Ljungblad (NOSC), S.E. Moore, J.T. Clarke, D.R. VanSchoik, and J.C. Bennet (SEACO, Inc.)

13a TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Final	FROM Apr 84 TO Oct 84	June 1985	315

16 SUPPLEMENTARY NOTATION

17 COSATI CODES			18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)		
FIELD	GROUP	SUB-GROUP	Endangered Whales	Migration	Behavior
			Alaska	Population	Density
			North Slope	Habits	
			Bering, Chukchi, Beaufort Seas		

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

Aerial surveys and acoustic recordings of bowhead whales and, secondarily, other marine mammals were made from mid-April through mid-May and from mid-July through October 1984 in the northern Bering, eastern Chukchi, and Alaskan Beaufort Seas. Survey results and observations on bowhead distribution, relative abundance, migration patterns, general behavior, and sound production for spring and fall seasons are presented. Presented here also are survey results and observations on gray whale distribution, relative abundance, and general behavior. Incidental sightings of all marine mammals are reported.

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT	21 ABSTRACT SECURITY CLASSIFICATION	
[X] UNCLASSIFIED UNLIMITED [X] SAME AS RPT [ ] DTIC USERS	UNCLASSIFIED	
22a NAME OF RESPONSIBLE INDIVIDUAL D.K. Ljundblad	22b TELEPHONE (Include Area Code) (619) 225-2359	22c OFFICE SYMBOL Code 514

DD FORM 1473, 84 JAN

83 APR EDITION MAY BE USED UNTIL EXHAUSTED
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EXECUTIVE SUMMARY

This report summarizes the 1984 investigations of the distribution, abundance, migration, habitats, and behavior of endangered whales in the northern Bering, eastern Chukchi, and Alaskan Beaufort Seas. Aerial transect and search surveys were flown in a specially modified Grumman Goose in the study region from 24 April through 10 May and from 17 July through 23 October. Overall, 217 sightings of 617 bowhead whales (Balaena mysticetus) were made on 82 flights. In spring, 237 bowhead whales were seen on 13 flights. Two bowheads were seen in the Bering Sea between St. Lawrence Island and Cape Prince of Wales in late April. In April and May, 61 bowheads were seen in or near the nearshore lead in the Chukchi Sea, and 174 were found roughly along 71°30' N in the western Beaufort Sea. The timing and route of the observed spring migration were typical of 1979 to 1983 findings. Belukha whales (Delphinapterus leucas) were observed preceding and following the bowhead migration in spring.

Twenty-one sightings of 51 gray whales (Eschrichtius robustus) were made in the northern Bering Sea and the northeastern Chukchi Sea in July. Most grays (71 percent) appeared to be feeding; their swimming direction was not significantly clustered about any heading. One bowhead carcass was seen beached near Cape Lisburne.

In fall, 153 sightings of 380 bowheads were made during August, September, and October. Two bowheads were seen in the Canadian Beaufort Sea in August, but fewer bowheads (n = 19) were seen in the eastern Alaskan Beaufort Sea in August 1984 than in the two previous years (n = 145, 1982; n = 59, 1983). Whales seen in August maintained headings in all directions and exhibited some social behaviors. In September and October, bowhead distribution (n = 359) across the Alaskan Beaufort Sea was roughly along and inside the continental shelf break at water depths between 5 and 466 m, as in past years. On 22, 24, and 28 September, large groups (n = 45 to 50) of feeding whales were seen near 71°24' N, 155°34' W over a 110 km^2 area, yielding high WPUE (whales per unit effort) on those days. The peak migration period, when WPUE were consistently high, extended from 21 September through 17 October. Five bowhead calves were seen during the fall, and a gross annual recruitment rate (GARR) of 5/380 or 1.32-percent was calculated. Observed bowhead behaviors were tabulated by two-week intervals, with swimming and feeding the most commonly noted. Two bowhead carcasses were seen; one sighted with a polar bear in the Beaufort Sea and one floating near Cape Halkett.

An additional aircraft was dedicated to the Beaufort Sea from 15 August to 3 October to conduct controlled experiments with bowhead whales and seismic survey vessels. Data were supplied daily to these researchers to advise them of bowhead distribution and movements.

One hundred fifteen gray whales were seen in the northeastern Chukchi Sea between 8 August and 11 October. The majority of these (79 percent) appeared to be feeding between Icy Cape and Barrow. Belukha whales, some groups with calves, were seen in the Beaufort and northeastern Chukchi Seas throughout fall. Polar bears were seen throughout the fall season, and one was seen feeding on a bowhead carcass. Most walrus were seen in the Chukchi Sea in August before the ice moved offshore. Ringed and bearded seals were seen throughout the fall season.

ACRONYMS AND ABBREVIATIONS

ADFG	Alaska Department of Fish and Game
AM	Amplitude Modulated
AMP	A Mapping Package
BE	Belukha Whale
BH	Bowhead Whale
BS	Bearded Seal
CT	Unidentified Cetacean
FM	Frequency Modulated
GARR	Gross Annual Recruitment Rate
GNS	Global Navigation System
GW	Gray Whale
IDL	International Date Line
MMS	Minerals Management Service
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
NOSC	Naval Ocean Systems Center
NTIS	National Technical Information Service
OCS	Outer Continental Shelf
PN	Unidentified Pinniped
PR	Polar Bear
RS	Ringed Seal
s.d.	Standard Deviation
USGS	United States Geological Survey
WPUE	Whales Per Unit Effort
WS	Walrus

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INTRODUCTION

The Naval Ocean Systems Center (NOSC), San Diego, California, has been funded by the Alaska Outer Continental Shelf (OCS) area office of the Minerals Management Service (MMS), U.S. Department of the Interior, since 1979 to conduct aerial surveys of endangered whales and other marine mammals in the northern Bering (above 63° N), eastern Chukchi, and Alaskan Beaufort Seas. As part of its responsibilities under the OCS Lands Act, National Environmental Policy Act, Marine Mammal Protection Act, and Endangered Species Act, MMS has continued this work as an extension of previous studies (Ljungblad et al., 1980; Ljungblad, 1981; Ljungblad et al., 1982, 1983, 1984a). Results of these studies will be useful to MMS in preparing environmental impact statements and in making decisions relative to leasing, exploring, and developing of the Alaskan OCS.

The bowhead whale (Balaena mysticetus) has been the principal species investigated over the past five years. Historically, bowheads had a nearly circumpolar distribution north of 60° N. However, a long history of exploitation seriously reduced the number of whales in each of five geographically separate stocks (Breiwick et al., 1981). The western Arctic stock, now estimated by the International Whaling Commission to contain 3,871 ± 254 whales (Chapman, 1984), is the population monitored in this study.

Gray whales (Eschrichtius robustus) have also been investigated during this study. Principal areas surveyed are the summer feeding grounds in the northern Bering Sea and eastern Chukchi Sea (Bogoslovskaya et al., 1981; Nerini, 1984). This population is now estimated to number 17,577 ± 2,364 whales (Reilly et al., 1983).

This report is a summary of 1984 field results on regional surveys of bowhead whale distribution, relative abundance, migration, and behavior in accordance with the objectives as outlined below. Gray whale distribution and relative abundance are also reported, as well as incidental information on all other marine mammals seen. Synthesis and comparison of 1984 data with the results of previous years are provided in a brief conclusion section at the end of the report. A flight track and descriptive caption for each flight are presented in Appendix A. The distribution of 1984 survey effort and observed densities of bowhead and gray whales with comparisons to 1979 through 1983 are presented in Appendix B.

Objectives

The primary objectives of the 1984 surveys, as stated in the Inter-Agency Agreement Statement of Work, were to:

- Determine seasonal distribution, migration routes, relative abundance, and habitat characteristics of endangered whales in or near existing and proposed federal lease sales in the northern Bering, Chukchi, and Beaufort Seas
- Derive estimates and indicators of relative and/or absolute abundance of endangered whales in these areas
- Describe behavioral characteristics of endangered whales observed in these areas
- Deploy sonobuoys to detect sounds produced by whales, to be used as additional indices of whale presence in these areas
- Obtain distributional information on nonendangered marine mammal sightings incidental to other investigations
- Consult and coordinate field activities with other Federal Agencies, state or local government organizations, or other endangered species researchers to maximize productivity of this study and minimize conflict with other resource uses

An additional research team and additional aircraft were dedicated for the period 15 August through 3 October 1984 in the Beaufort Sea to:

- Conduct controlled bowhead whale-seismic exploration experiments in cooperation with active geophysical vessels to assess possible disturbance caused by geophysical seismic exploration and related activities
- Obtain and analyze recordings of bowhead and geophysical seismic exploration sounds

In conjunction with the primary survey objectives, correlated objectives specific to the fall season were to:

- Summarize daily survey efforts and conditions
- Provide daily reports on bowhead distribution, behavior, movement, and habitat

These reports were provided to the government officials regulating seasonal offshore drilling and geophysical exploration, e.g., National Marine Fisheries Service (NMFS), MMS, and to the aforementioned research team monitoring the interaction between the bowhead whales and the geophysical boats. The reader is

directed to Ljungblad et al. (1985, in preparation) for a complete report of results on the bowhead whale-seismic exploration experiments and monitoring effort.

METHODS AND MATERIALS

Study Area and Aerial Survey Procedures

The study area included the Bering Sea north of St. Lawrence Island (63° N), the Chukchi Sea east of the International Date Line (IDL, 168°58' W), and the Alaskan Beaufort Sea from Pt. Barrow east to 140° W and offshore to 72° N. This study area was divided into survey blocks (Figure 1) suitable to line transect surveys (one or, with favorable conditions, two blocks could be surveyed completely on one flight).

Two types of aerial surveys were utilized to accomplish the objectives listed:

1. Line transect surveys were flown in survey blocks to determine distribution and estimate relative and absolute abundance. Coverage of no less than 10 percent of the total area of each block was planned. Line transect is one available survey method from which statistical inferences can be made, provided the starting and turning points of the line are selected randomly (Cochran, 1963). Survey blocks were divided into sections that were 30 minutes of longitude or 10 minutes of latitude wide, and each section divided into 10 equal segments. Starting and/or turning points were chosen within each section by selecting two numbers from a random numbers' table and matching them to the numbered segments. A transect line was then drawn between the two segments. The same procedure was followed for each section of the survey block, and all transect lines were then linked together with connecting lines at top and bottom.

2. Search surveys were flown into areas of maximum probability of sighting whales and did not follow a preset paradigm. The exact routes of search surveys were dependent upon previous patterns of whale sightings (i.e., number, heading, swimming speed), weather, sea state, and ice conditions. Search surveys were flown to locate whales, observe their behavior, follow migrating groups or individuals, record waterborne sounds, and when transiting to a new base of operations.

The year was divided into three seasons: spring (April, May), summer (July), and fall (August, September, October). Bases of operation were Nome, Kotzebue, Pt. Barrow, and Deadhorse, Alaska.

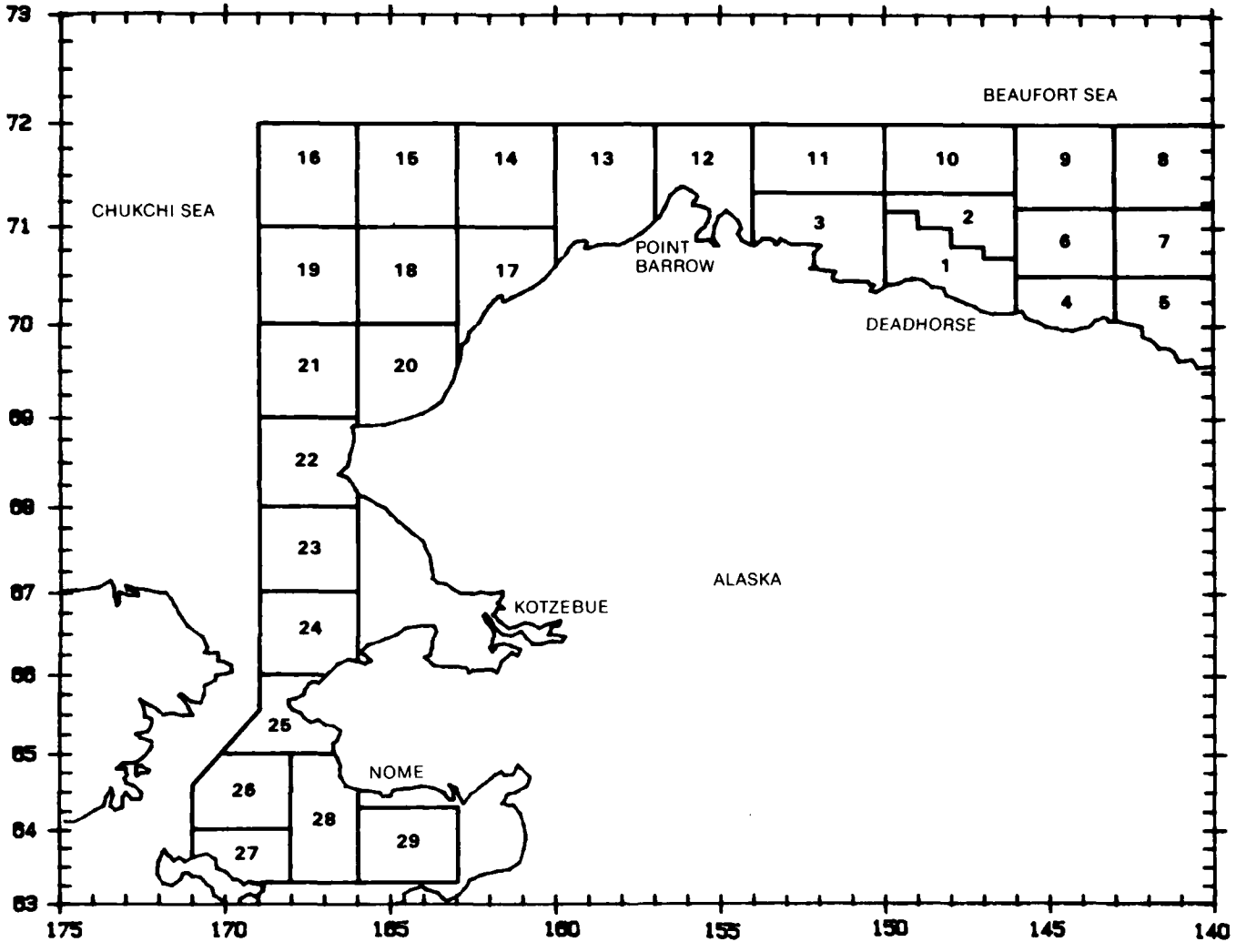


Figure 1. Study area and transect blocks.

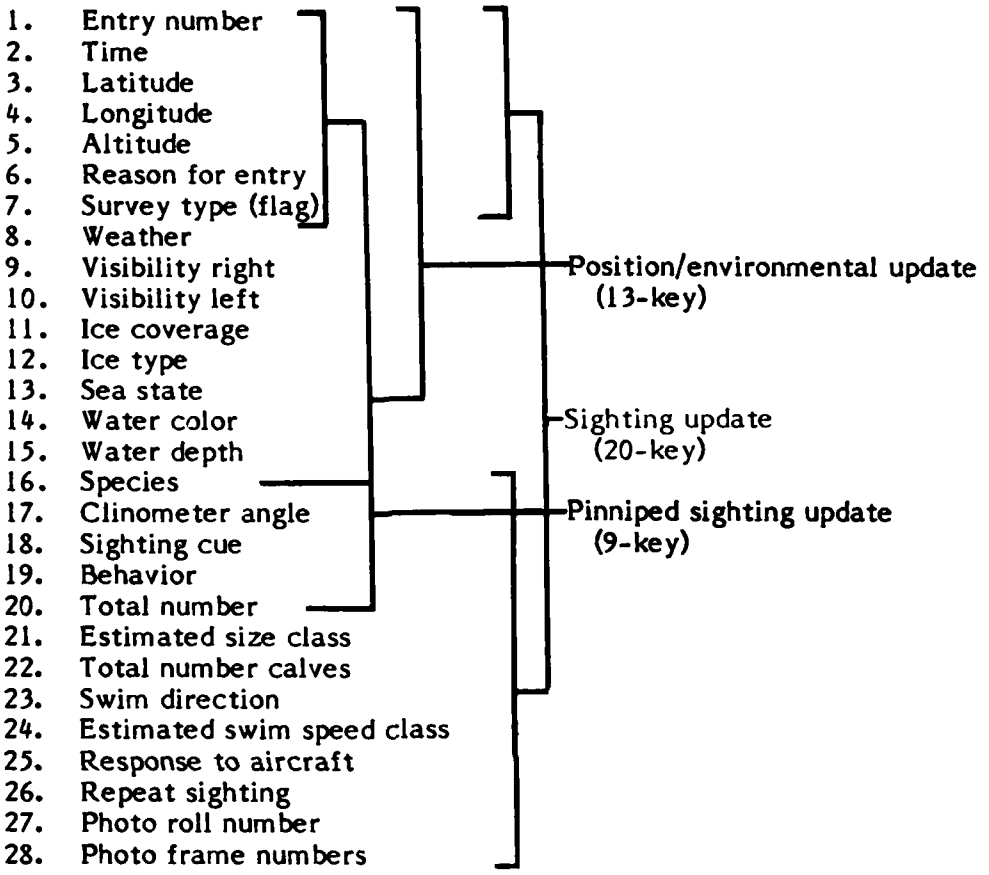
Equipment, Data Collection, and Analyses

The aircraft used for the surveys was a Grumman Turbo Goose model G21G with a call sign of N780 provided by the Office of Aircraft Services, U.S. Department of Interior, Anchorage. The aircraft was equipped with a Global Navigation System (GNS) 500 that provided continuous position updating (0.6 km/survey hour, precision) and transect turning point programming. Surveys were flown at 100 m to 458 m altitude, at speeds of 222 to 296 km/hr. Higher altitudes were maintained when weather permitted maximum visibility. The aircraft's maximum time aloft was 6.5 hrs.

The aircraft cockpit was outfitted with four seats, each of which afforded excellent visibility through large side windows. A long rectangular window behind the cockpit provided good visibility for an observer-recorder, while the observer-navigator and a third observer occupied the seats behind the pilot and co-pilot. During line transect surveys the observer-navigator moved to the co-pilot's seat for a better vantage point. The pilots acted as limited observers. Each observer was provided with a clinometer to take angles on all whale sightings abeam of the aircraft to provide a measure of animal distance from the survey track. All observers and the pilots were linked into the same communication system, and commentary on the aircraft could be recorded.

A portable computing system (Hewlett-Packard 85) was used aboard the aircraft to store and later analyze the flight data. The computer was interfaced to the GNS for automatic input of entry number, time, latitude, and longitude, and to the radar altimeter for precise input of altitude. One of four different data entry formats was selected on the computer depending on the reason for entry. Whenever possible, a 28-key entry format was used when whales were seen (Table 1). An abbreviated 20-key sighting update format was used when several whales were sighted within a short period of time. An even shorter rapid sighting update (9-key format) was used in extremely high density areas to avoid lumping sightings. A position update 13-key format, including data on weather, visibility, ice coverage, and sea state, was entered at turning points, when environmental conditions changed, or, in the absence of sighting data, every 10 minutes. Sea state was recorded according to the Beaufort scale outlined in Chapman (1971). Ice type was identified using terminology presented in the Naval Hydrographic Office (1956), and ice coverage was estimated in percent.

Table 1. Data entry sequence on portable flight computer.



Sonobuoys, passive listening systems that contain hydrophone arrays, and VHF transmitters, were dropped near whales whenever possible in an attempt to collect acoustic data. Models AN/SSQ-57A and AN/SSQ-41B with frequency responses of 10 Hz to 20 kHz and 10 Hz to 6 kHz, respectively, were used. Sonobuoys are designed to be dropped from the aircraft and their descent is slowed by means of a rotochute or parachute. Once in contact with water, the unit is energized by a saltwater-activated battery. At that time the roto/parachute assembly is jettisoned and the hydrophone array drops to a preselected depth of 18.2 or 91.4 m. The 18.2 m depth setting is most commonly used. The sounds picked up by the hydrophones are then amplified and transmitted to a VHF broadband receiver aboard the aircraft. This output is recorded on a Nagra IV SJ recorder that has a frequency response of within 2 dB from 25 Hz to 10 kHz, at a recording speed of 9.5 cm/s. This recorder has two channels,

permitting simultaneous recording of the waterborne sounds and the observers' verbal comments.

Attempts were made to photograph as many bowhead whales as possible. Still photographs were made with hand-held 35-mm cameras (Olympus OM-1) with 210-mm or 230-mm lenses using ASA 64 or ASA 200 film at as fast a shutter speed as possible. The altitude of the aircraft and the photograph roll and frame number were noted and stored on the computer. When a calf and its assumed mother (cow) were in the same frame, the size of the calf relative to the cow was measured from projected images to provide an index of the calf size.

Bowhead, gray, and belukha whale distribution was plotted by survey season and, in fall, by month. An index of relative abundance was derived as whales per unit effort (WPUE; unit effort = one hour survey time) per survey block. Bowhead and gray whale density estimates were derived using strip transect methodologies and are presented in Appendix B. Migration timing was analysed as WPUE/date and habitat preference by WPUE/ice class or WPUE/depth regime. Directionality of whale headings was analyzed using Rayleigh's test (Batschelet, 1972). Statistical comparison (Mann-Whitney U or Student's-t) and correlation tests (Spearman's rank) were used as appropriate (Zar, 1974).

Bowhead behaviors were classified by means of operational definitions (Table 2). Behaviors were grossly catalogued into two types for purposes of discussion: migratory behaviors, which included swimming and diving; and social behaviors (typically observed in groups) such as milling, feeding, mating, calf-nurturing, resting, and displaying. Displays included breaches, spy-hops, tail and flipper-slaps, rolls, and underwater blows. 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/min corresponded to an estimated speed of 1 km/hr, one body length/30s 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, immature, adult, or large adult, respectively) rather than on an absolute scale as in past years.

In compliance with condition B.4-6 of permit No. 459 to "take" endangered marine mammals, any sudden overt change in whale behavior observed coincident with the arrival of the survey aircraft was recorded (and later reported) as "response to aircraft," although it was impossible to determine the specific

Table 2. Operational definitions of observed bowhead whale behaviors.

MIGRATORY:	
Swimming	Forward movement through the water propelled by tail pushes; performed individually or as part of a group.
Diving	Change of swimming direction or body orientation relative to the water surface resulting in submergence; may or may not be accompanied by lifting of the tail out of the water; performed individually or as part of a group.
SOCIAL:	
Milling	Whales swimming slowly near one another in close proximity (within 100 m) at the water surface.
Feeding	Whale/whales diving repetitively in usually cloudy water often accompanied by mud streaming from the mouth and defecation upon surfacing; nearly synchronous diving and surfacing have been noted as have echelon formation surface feeding with swaths of clearer water noted behind the whales and open mouth surface swimming (Würsig et al., 1982).
Mating	Ventral-ventral orientation of a pair of whales often with at least one other whale present to stabilize the mating couple; often within a group of milling whales; pairs appear to hold each other with their pectoral flippers and may entwine their tails.
Cow-Calf	Calf nursing; calf swimming within 20 m of an adult.
Resting	Whale/whales at the surface with head, or head and back exposed, showing no movement; more commonly observed in heavy ice conditions than in open water.
Displaying:	
Rolling	Whale rotating on longitudinal axis, sometimes associated with mating.
Flipper-Slapping	Whale on its side striking the water surface with its pectoral flipper one or many times; usually seen in groups, sometimes when slapping whale is touching another whale.
Tail-Slapping	Whale hanging horizontally or vertically in the water with tail out of water waving back and forth striking the water surface; usually seen in groups.
Spy-Hopping	Whale rising vertically from the water such that the head and up to one-third of the body, including the eye, is exposed; usually seen in groups.
Breaching	Whale exiting vertically from the water such that half to nearly all of the body is exposed then falling back into the water, usually on its side, creating a large splash and presumably some sounds.
Underwater Blow	Exhalation of breath while submerged creating a visible bubble.

stimulus for the behavioral change. Such changes included abrupt dives, sudden course diversion or cessation of behavior ongoing at first sighting.

RESULTS AND DISCUSSION

Spring (24 April to 10 May)

Survey Effort, Rationale, and Sighting Summary

Fifty-four and one-half hours of survey were flown in the spring season, with 21 percent (11.5 hrs) of this effort in the northern Bering Sea, 62 percent (33.7 hrs) in the eastern Chukchi Sea and 17 percent (9.3 hrs) in the Alaskan Beaufort Sea (Table 3, Figure 2). Transect surveys were conducted on most (77 percent, n = 10) flights. Unlike other years, search surveys were flown only during transits to new bases of operations (Nome, Kotzebue, Pt. Barrow). These search survey-transits (Appendix A: Flights 4, 7, and 9) investigated general ice conditions and bowhead distribution in the nearshore lead. Inclement weather prevented flights on five days.

The overall flight plan was to sample onshore and offshore blocks to determine the presence and distribution of bowheads migrating through the area. In the Chukchi and Beaufort Seas, it was generally accepted that the nearshore lead between Pt. Hope to and northeast of Pt. Barrow was the primary migration route, but relatively little was known about the possible spring offshore migration route through the Chukchi Sea. Thus, offshore blocks in the Chukchi Sea were targeted for investigation.

Three transect surveys and one search survey-transit were flown in the northern Bering Sea, an effort comparable to 1983 but less than in 1980, 1981, and 1982 (see Table 28). Two bowheads were seen in the Bering Sea north of St. Lawrence Island, but no large concentrations of whales were found such as those seen in 1980 and 1981.

Five transect surveys and two search survey-transits were flown in the Chukchi Sea. This constitutes more effort than in other years, especially offshore, as past efforts have been limited to search surveys of the nearshore lead. All bowheads in the Chukchi Sea (n = 61) were seen either near Cape Prince of Wales (n = 7), or in the nearshore lead between Cape Thompson and Pt. Barrow (n = 54).

Table 3. Summary of flight effort, spring 1984.

Flight	Date	Sea	Transect Length[1] (km)	Search Length[2] (km)	Connect Length[3] (km)	Total Length (km)	Time on Transect (hr:min)	Total Time (hr:min)	WPUE (whales /hr)
1	24 April	Bering	460	277	55	792	1:56	3:17	0.00
2	26 April	Bering	633	313	165	1,111	2:37	4:33	0.44
3	27 April	Bering	585	238	87	910	2:21	3:43	0.00
4	29 April	Chukchi	0	482	0	482	0:00	2:16	3.04
5	29 April	Chukchi	441	832	35	1,308	1:38	5:02	5.20
6	1 May	Chukchi	433	343	119	895	1:53	3:40	0.00
7	3 May	Chukchi	0	1,068	0	1,068	0:00	4:14	0.00
8	4 May	Chukchi	547	337	94	978	2:40	4:34	0.65
9	5 May	Chukchi	0	992	0	992	0:00	4:25	2.94
10	6 May	Chukchi	903	209	73	1,185	3:51	5:03	1.00
11	7 May	Beaufort	536	179	111	826	2:22	3:36	5.83
12	8 May	Beaufort	765	377	112	1,254	3:03	5:40	27.18
13	10 May	Chukchi	662	371	40	1,073	2:44	4:30	1.33
Bering Sea Total			1,678	828	307	2,813	6:54	11:33	0.17
Chukchi Sea Total			2,986	4,634	361	7,981	12:46	33:44	1.78
Beaufort Sea Total			1,301	556	223	2,080	5:25	9:16	18.82
TOTAL			5,965	6,018	891	12,874	25:05	54:33	4.35*

1. Total length of all transect legs
2. Total length of transit to and from survey blocks and/or new bases of operation
3 Total length of legs which connect transect legs
*Average WPUE for spring 1984

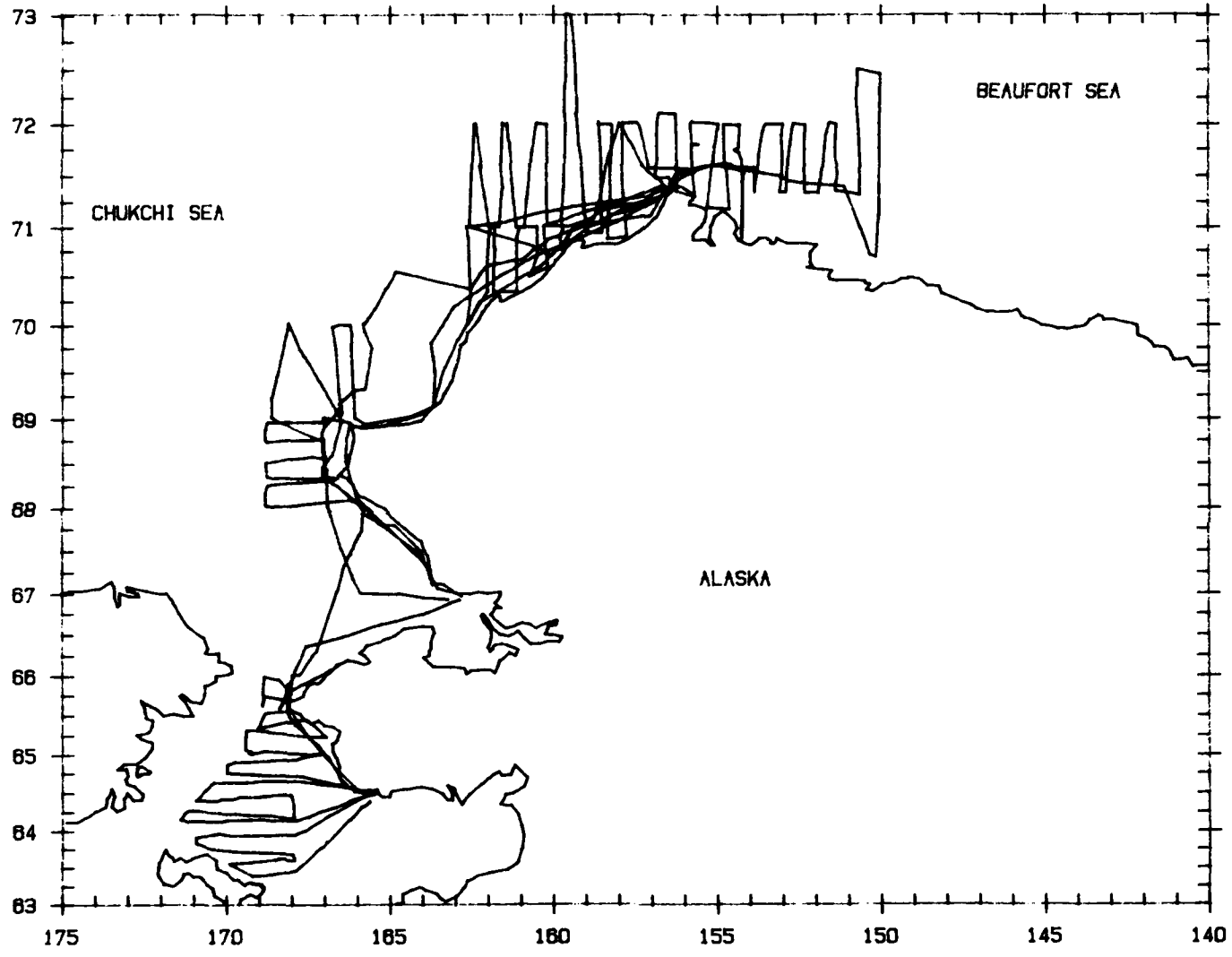


Figure 2. Composite flight track from 13 flights, spring 1984.

Two transect surveys were flown in the Beaufort Sea as far east as 150° W, representing less effort than in past years. As in past years, transects near Pt. Barrow were truncated so as not to overfly whaling or ice-based whale census camps. Results were similar to those of previous years, as bowheads (n = 174) were found in or near the nearshore lead east of Pt. Barrow.

Survey Conditions Summary

In April and early May survey conditions were good. Weather was clear or high overcast, winds slight (< 20 km/hr), and temperatures well below freezing. Sea states were generally low (Beaufort 00 to 02), except over wide (>1 km) leads and open water areas where sea states as high as Beaufort 05 were encountered. From 5 May to 13 May, temperatures and wind speeds rose, and fog reduced visibility on flights (Appendix A: Flights 9, 11, 12, and 13). Altitude was reduced to as low as 100 m on 8 May (Appendix A: Flight 12) to maintain visibility.

Pre-survey information about March and early April ice conditions was available from satellite imagery analysis (i.e., Figure 3; Scheidt, personal communication[1]). In March the ice edge was south of 60° N. The northern Bering Sea had 80- to 100-percent coverage of broken annual ice. There was open water along the Soviet coast south of the Chukotski Peninsula to near the Bering Strait and the Siberian coast north of the Bering Strait. There were some cracks and leads near polynyas in the Chukchi Sea. In early April, the coastal northern Bering Sea was open, but the central portions were still covered with over 90-percent annual and new ice. The Chukchi Sea was congested with cracked ice, except for an open water lead between Cape Lisburne and Pt. Barrow. The Beaufort Sea was ice covered except for a recurring lead stretching from about 50 km north of Pt. Barrow east to about 152° W.

In late April, coverage of 95- to 99-percent mixed annual and new ice was observed between St. Lawrence Island and the Bering Strait, with almost open (<10 percent ice) water west of it. This open water began about 50 km north of the village of Gambell and extended west across the International Date Line (IDL). There was over 80-percent ice coverage east of St. Lawrence Island and in outer Norton Sound. Shorefast ice 10 to 15 km wide was noted around St. Lawrence,

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1. Ron Scheidt, National Environmental Satellite Service, National Weather Service, NOAA, Department of Commerce, Anchorage, AK 99513.

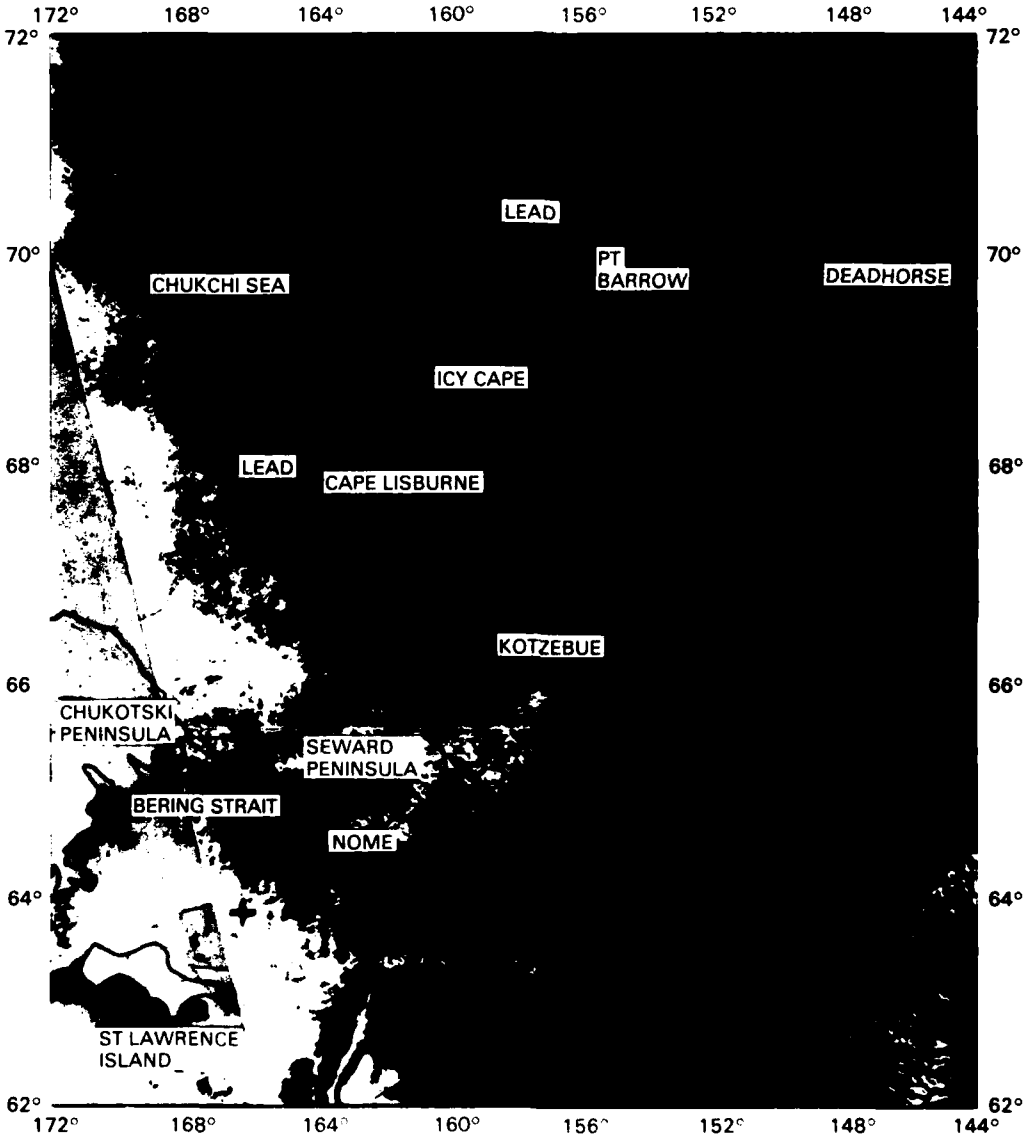

Figure 3. Satellite imagery of ice coverage in the Chukchi and Beaufort Seas on 19 March 1984.

King, and the Diomede Islands and around the Seward Peninsula. Similar ice conditions have been observed in the northern Bering Sea each year since 1981.

Most coastal areas in the Chukchi Sea less than 40 m deep (i.e., Kotzebue Sound) were covered by solid shorefast ice. Ninety- to 99-percent broken floe ice extended north of the Bering Strait to 66°30' N and east to 167° W, with intermittent cracks from 66°30' N through outer Kotzebue Sound to the Pt. Hope area. There was a polynya, 90 percent filled with new ice, south of Cape Thompson and Pt. Hope. This polynya forms annually in early spring (Carleton, 1980), sometimes stretching as far east as Kivalina, and is the southern terminus of the nearshore lead which extends to Pt. Barrow. Offshore of the polynya and shorefast ice, 90-percent coverage of cracked floe ice predominated. The cracks ran east-west south of Pt. Hope, and north-south between Pt. Hope and Cape Lisburne, parallel to the shore (southwest-northeast) north of Cape Lisburne, and east-west north of Pt. Barrow. This is probably caused by current and wind-induced shear. Fewer cracks were noted with distance from shore. Bowheads could possibly migrate through this ice, although there have been few sightings in such heavy ice.

The extent and width of the nearshore lead between Cape Thompson and Pt. Barrow varied throughout early May. On 3 May, the lead stretched from Cape Thompson to Cape Lisburne. North of Pt. Hope it approximately followed the 40 m isobath. New grease ice covered half of the lead as nights were cold (as low as -17° C) and winds calm (< 20 km/hr). Between 5 and 7 May, the lead extended unbroken from Cape Lisburne to Pt. Barrow (Figure 4), and was of variable width, generally 0.5 to 2.0 km wide. By 7 May, however, the nearshore lead southwest of Pt. Barrow had closed again and only occasional cracks and small openings existed through 10 May. Overall the nearshore lead immediately west of Pt. Barrow was closed on more days than it was open between 1 and 10 May. The offshore cracked floe ice gradually became more broken, but the shorefast ice remained unchanged in distribution and coverage (100 percent) in early May.

The nearshore lead east of Pt. Barrow generally followed 71°30' N in the Beaufort Sea and increased in width at 156° W from 1 to 2 km on 6 May, to 8 to 12 km on 8 May. The Beaufort Sea oil lease areas west of 150° W remained covered 100 percent by ice. The areas east of 150° W and south of 71° N appeared to be covered 100 percent by ice, although there were no flights into that area.

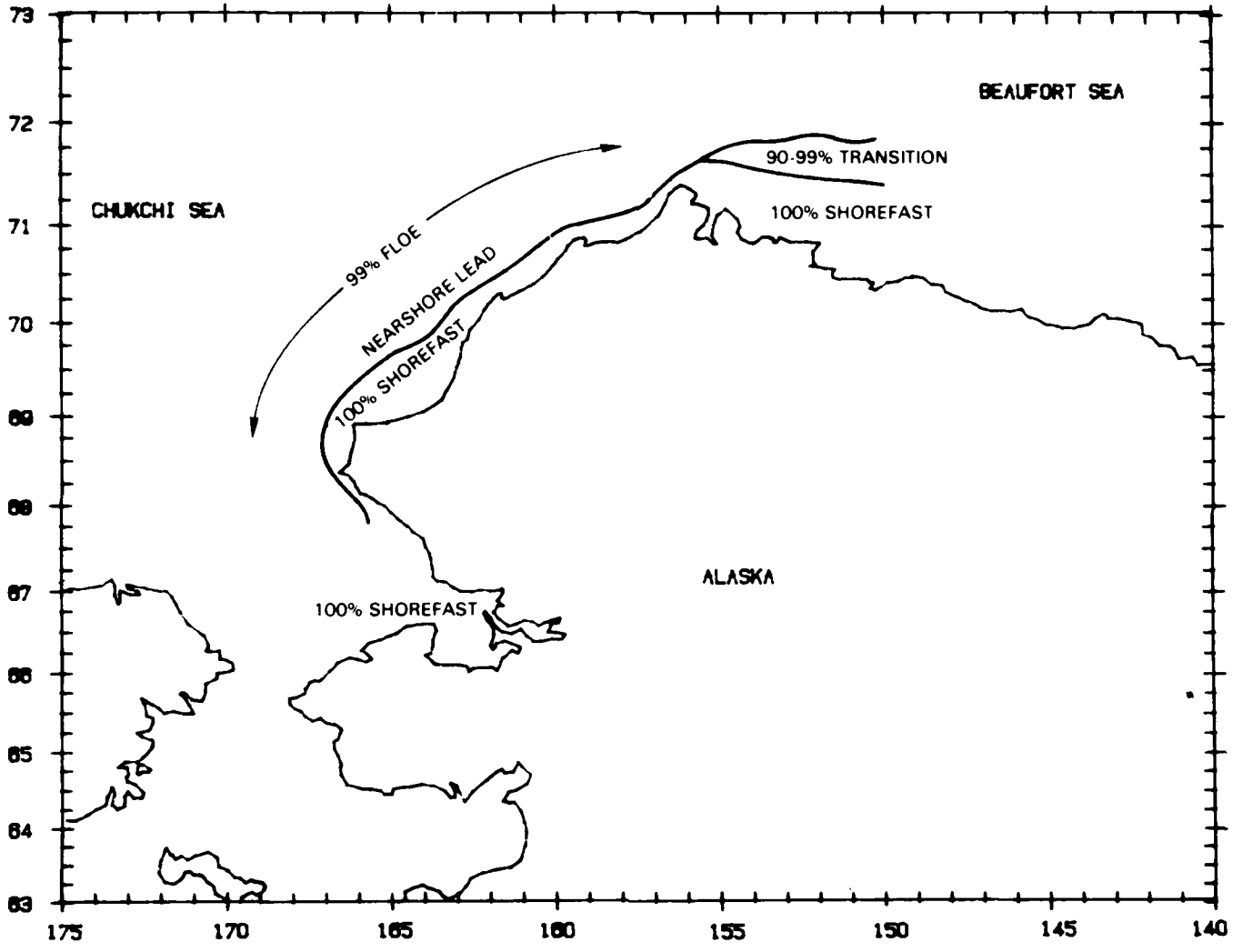

Figure 4. Schematic representation of ice conditions in the Chukchi and Beaufort Seas in early May 1984.

Bowhead Whale (Balaena mysticetus)

Distribution and Relative Abundance

Sixty-four sightings of 237 bowheads were made during the spring season: one sighting of two whales in the Bering Sea, 27 sightings of 61 whales in the Chukchi Sea and 36 sightings of 174 whales in the Beaufort Sea (Table 4, Figure 5). Bowheads in the northern Bering and southern Chukchi Seas were just north and due south of the Bering Strait. In the northern Chukchi and western Beaufort Seas, bowheads were seen in the nearshore lead system with the exception of four whales in a polynya and one ice track near Cape Thompson, and three ice tracks northwest of Pt. Hope. Ice tracks are oval-shaped holes produced by bowheads when they break through ice as they surface to breathe (Ljungblad et al., 1983).

Bowhead abundance indices in the Chukchi Sea were highest just north of the Bering Strait in block 25 where WPUE was 2.18, between Pt. Hope and Cape Lisburne in blocks 21 and 22 where WPUE was 2.93 and 6.64, respectively; and southwest of Pt. Barrow in block 13 where the WPUE was 1.08 (Table 5, Figure 6). Each of these blocks incorporates shoreline promontories where ice conditions are often heavy, sometimes blocking the lead system. Whales often must swim through an area where the major lead system narrows. Similarly in the Beaufort Sea, observed WPUE was highest in block 12 (20.91); this area incorporates the Pt. Barrow peninsula where the lead often closes, and compares to 14.17 in block 11.

Migration Route, Timing, and Habitat Relationships

The spring migration route in the northern Bering Sea appeared to pass west of St. Lawrence Island as bowheads were regularly sighted from the village of Gambell (Mate, personal communication[2]). From there, whales swam north through the Bering Strait and north-northeast to the Kivalina-Cape Thompson area. Most whales appeared to follow the nearshore lead through the northeastern Chukchi Sea to Pt. Barrow. East of Pt. Barrow, bowheads were found predominantly in the nearshore lead, although a few were sighted in the ponds and

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2. Bruce Mate, Oregon State University, Marine Science Center, Newport, OR 97365.

Table 4. Summary of sightings (number of sightings/number of animals), spring 1984.

Flight	Date	Bowhead	Belukha	Bearded Seal	Ringed Seal	Walrus	Unidentified Pinniped	Polar Bear
1	24 April	0	0	7/10	0	3/17	3/4	0
2	26 April	1/2	5/44	6/6	0	3/72	1/1	0
3	27 April	0	1/3	3/5	3/3	18/336	2/2	0
4	29 April	4/7	2/15	1/1	0	1/2	2/2	0
5	29 April	9/26	8/174	14/40	1/1	0	0	0
6	1 May	0	1/50	10/30	1/1	0	0	0
7	3 May	0	8/39	7/9	3/4	0	0	0
8	4 May	1/3	10/225	17/20	4/8	0	0	3/3
9	5 May	6/13	19/412	14/60	5/7	0	0	0
10	6 May	4/5	7/261	5/6	6/9	1/1	2/2	0
11	7 May	8/21	5/61	2/4	1/1	0	0	0
12	8 May	29/154	1/22	1/3	4/8	1/1	0	1/4
13	10 May	2/6	6/36	1/1	3/4	0	0	1/2
	TOTAL	64/237	73/1342	88/195	31/46	27/429	10/11	5/9

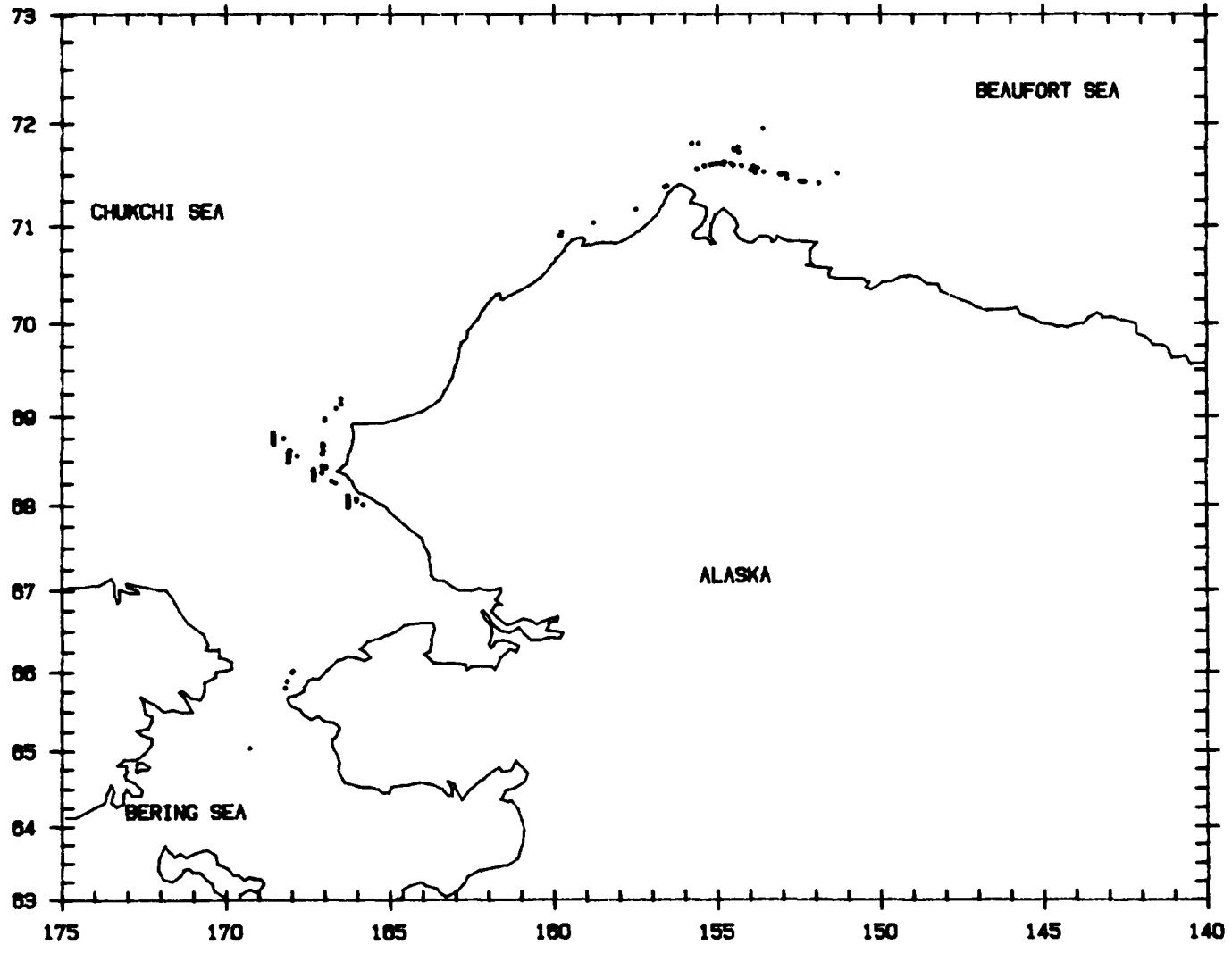

Figure 5. Distribution of 64 sightings (•) of 237 bowheads and four bowhead ice tracks (I), spring 1984.

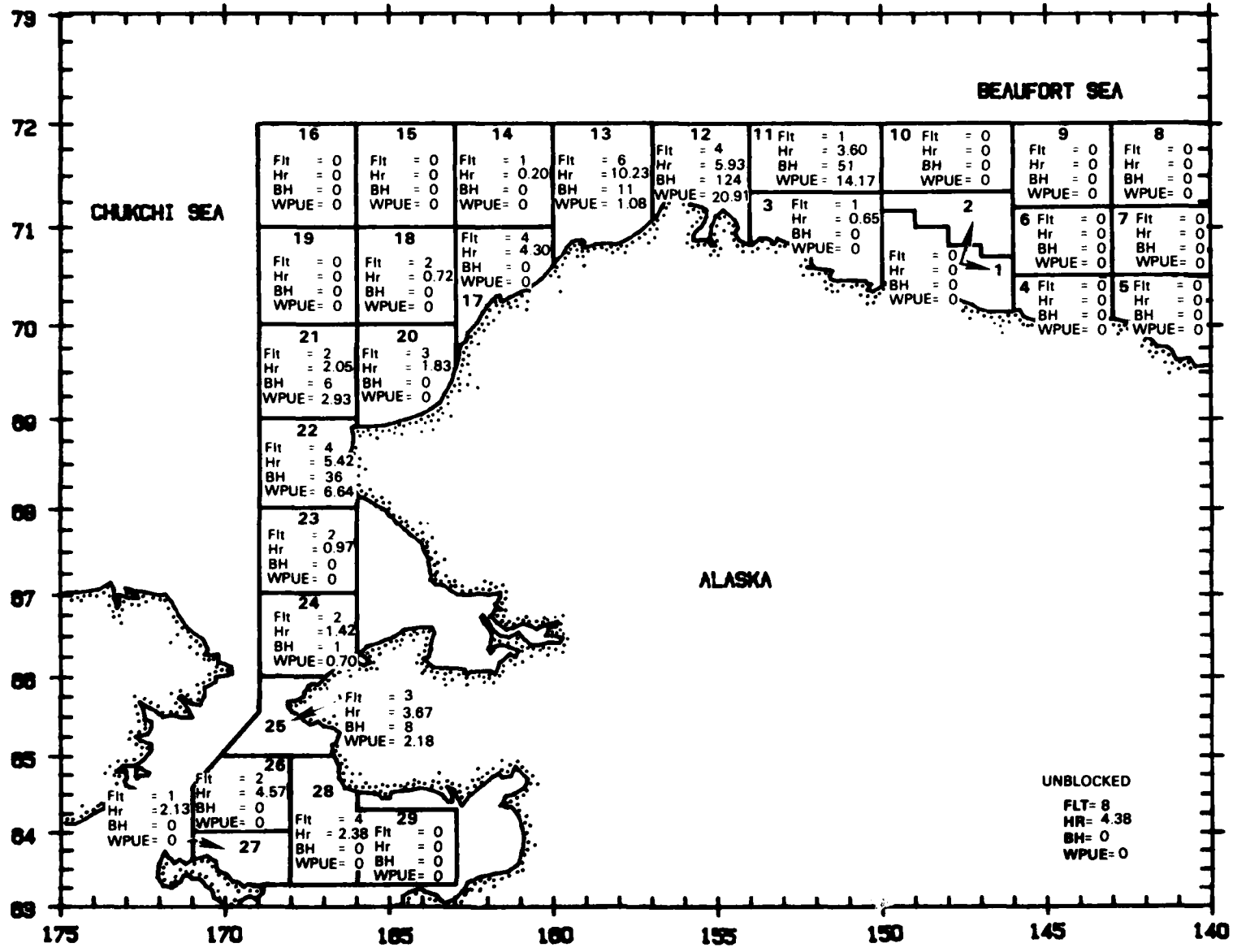

Figure 6. Relative abundance of bowheads: whales per unit effort (WPUE) by block, spring 1984.

Table 5. Relative abundance of bowheads: whales per unit effort (WPUE) by block, spring 1984.

Block	Flights*	Hours	Bowheads	WPUE
3	1	0.65	0	0.00
11	1	3.60	51	14.17
12	4	5.93	124	20.91
13	6	10.23	11	1.08
14	1	0.20	0	0.00
17	4	4.30	0	0.00
18	2	0.72	0	0.00
20	3	1.83	0	0.00
21	2	2.05	6	2.93
22	4	5.42	36	6.64
23	2	0.97	0	0.00
24	2	1.42	1	0.70
25	3	3.67	8	2.18
26	2	4.57	0	0.00
27	1	2.13	0	0.00
28	4	2.38	0	0.00
Unblocked	8	4.38	0	0.00
TOTAL	-	54.45	237	4.35

*Flight is any traverse of a block.

cracks north of main lead. Whales passing through the lead were found near (within 200 m of) the ice edge.

Interpretation of results from ice-based census camps and aerial surveys by this project and by NMFS indicated that the migration past Pt. Barrow was underway in late April. Observed migration events are discussed below chronologically in an attempt to review the timing of the bowhead spring migration.

The first whales were acoustically detected and one was seen, by the ice-based census camps off Pt. Barrow, on 19 April (Albert et al., 1984; Clark, personal communication[3]). The ice-based census camps reported a "small pulse" of whales on 27 and 28 April. A small WPUE peak (4.52; Figure 7) was noted by this project during a search survey-transit to Barrow on 29 April (Appendix A: Flight 5). Tracks in the ice, possibly made by bowheads, were seen on surveys

3. Chris Clark, Rockefeller University, Tyrrell Road, Millbrook, NY 12545.

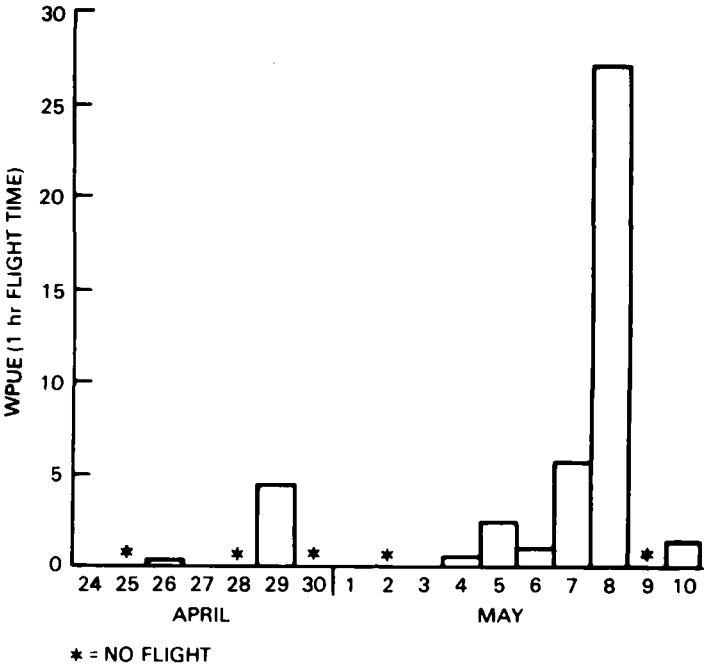

Figure 7. Bowhead whales per unit effort (WPUE) by date, spring, 1984.

conducted by the NMFS prior to their first whale sighting on 30 April (Nerini, personal communication[4]). Efforts at the ice-based census camps were hampered by poor ice conditions, and few sightings were reported between 28 April and 5 May (Albert et al., 1984). On 5 May, the NMFS survey team saw seven bowheads, while sounds were heard at the acoustics facility at the ice-based census camp. On 6 May, five bowheads were sighted southwest of Pt. Barrow (Appendix A: Flight 10). On 7 May, 21 bowheads were seen in block 12 (Appendix A: Flight 11), while 35 bowheads were sighted from the ice-based census camps during a five-hour period. The largest WPUE peak (27.16) in spring 1984 occurred on 8 May east of Pt. Barrow (Table 4, Figure 7). This coincides with NMFS peak of 116 whales seen on the same day. The nearshore lead closed on 10 May ending that pulse of sightings. The interval between pulses observed near Barrow by the ice-based census camp and by aerial surveys (27 or 29 April to 8 May) of 9 to 11 days is comparable to intervals found in previous years (see Table 29).

4. Mary Nerini, National Marine Fisheries Service, NOAA, 7600 Sand Point Way, Seattle, WA 98115.

Bowhead migratory swimming direction was significantly clustered about mean headings in both the Chukchi and Beaufort Seas (Figure 8). In the Chukchi Sea there was clustering around the mean heading of 030° T ($z = 13.82$, $p \leq 0.001$) and 81 percent of all headings were in the north quadrant, indicating little meandering or socializing along this section of the spring migration route. In the Beaufort Sea there was clustering around the mean heading of 092° T ($z = 34.02$, $p \leq 0.001$) and all recorded headings were easterly.

During the spring migration, bowheads were found in leads, cracks, and ponds in ice coverage that ranged from 1 to 90 percent. Of the 64 sightings, 31 (49 percent) were in 1 to 50 percent ice coverage in the nearshore lead near Barrow, nine (14 percent) were in 70 percent coverage, six (9 percent) were in 80 percent coverage, 10 (16 percent) were in 90 percent coverage, six (9 percent) were in 95 percent coverage and two (3 percent) were in 99 percent coverage.

The two bowheads sighted in the Bering Sea were in water 49 m deep, while those in the Chukchi Sea were in water 7 to 38 m deep ($\bar{x} = 25.11$ m, s.d. = 8.53 m, n = 27). Whales in the nearshore lead between Pt. Hope and Cape Lisburne were in 18 to 37 m deep water, and those in the nearshore lead between Wainwright and Pt. Barrow were in water 7 to 38 m deep.

Bowheads in the Beaufort Sea, with the exception of one, were sighted in water 28 to 183 m deep ($\bar{x} = 67.97$ m, s.d. = 93.77 m, n = 36). Whales in the nearshore lead east of Pt. Barrow were in water 18 to 55 m deep, while those in the transition ice north of the lead were in water 35 to 183 m deep. The exception was the easternmost-sighted whale (at 71°31.0' N, 151°20.6' W; Appendix A: Flight 12) which was sighted near the northern edge of the transition ice in 585 m deep water.

Behavior and Sound Production

Fifty-seven percent of all bowheads were migratory (Table 6). Of those, 98 percent were moving slowly (less than 2 km/hr) and 2 percent were moving at medium speeds (2 to 4 km/hr). As previously noted, swimming direction was significantly clustered in both the Beaufort and Chukchi Seas (Figure 8). In the Chukchi Sea, resting (3 percent), milling (10 percent), possible mating (11 percent), cow-calf (6 percent), and display (5 percent) behaviors were observed. The displaying (slaps) whales were seen near Cape Thompson (block 22) on 29 April (Appendix A: Flight 5). In the Beaufort Sea, swimming (53 percent), milling (9 percent), and displays (37 percent) were the most frequent behaviors

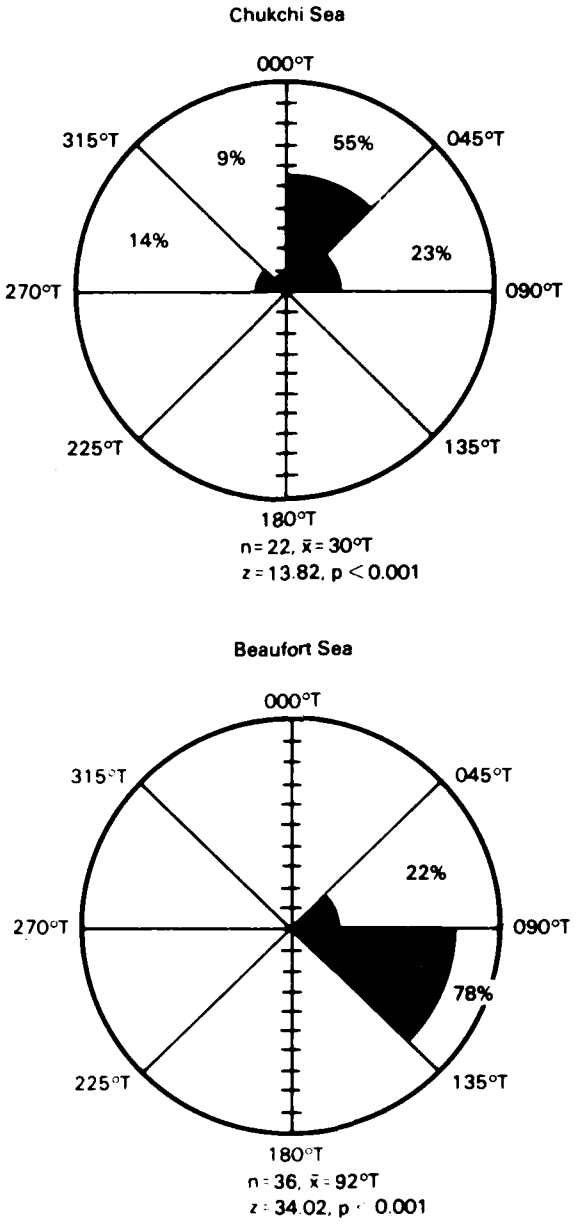

Figure 8. Bowhead swimming direction analysis by sea, spring 1984. Numbers in 45° octants represent percentage of whales exhibiting headings within that range.

Table 6. Observed bowhead behavior by sea, spring 1984.

	Bering Sea, No.(%)	Chukchi Sea, No.(%)	Beaufort Sea, No.(%)	Total, No.(%)
MIGRATORY				
Swim	2(100)	35(58)	93(53)	130(55)
Dive	0(0)	3(5)	2(1)	5(2)
SOCIAL				
Rest	0(0)	2(3)	0(0)	2(1)
Mill	0(0)	6(10)	15(9)	21(9)
Mate	0(0)	7(11)	0(0)	7(3)
Cow-Calf	0(0)	4(6)	0(0)	2(1)
	0(0)	3(5)	64(37)	67(28)
NONE RECORDED	0(0)	1(2)	0(0)	1(0)
TOTAL	2(100)	61(100)	174(100)	237(100)

seen. The displaying whales were seen just east of Pt. Barrow (71°31' to 71°48' N; 152°53' to 155°48' W), among groups of three to ten whales in the large bowhead aggregations seen on 7 and 8 May (Appendix A: Flights 11 and 12).

A group of 15 bowheads, partially covered with, and sometimes streaming, mud from their bodies, was seen in the nearshore lead east of Pt. Barrow between 154° W and 155° W on 8 May. The overall behavior (milling with repeated dives) of these whales resembled feeding (Table 2). This was the first time such behavior has been seen in spring.

Bowheads were often encountered in groups during the spring migration. Whenever an initial sighting was investigated, additional whales were seen. Groups of two to 15 whales were seen even though relatively little effort was expended in circling sightings to wait for other whales to surface. The average group size (for sightings of two or more animals) for the spring season was 4.93 (s.d. = 3.16, n = 44), which is larger than other years (Ljungblad et al., 1984a). The group size in the Beaufort Sea ($\bar{x}$ = 6.11, s.d. = 3.40, n = 27) was higher than in the Chukchi Sea ($\bar{x}$ = 3.12, s.d. = 1.41, n = 16; t = 3.33, $p \leq 0.001$). This is the opposite of 1983 when relatively large groups were found in the Chukchi Sea (Ljungblad et al., 1984a). Equal numbers (10) of solitary whales were seen in the Chukchi and Beaufort Seas.

One nursing cow-calf pair was the only bowheads that appeared to respond to the aircraft during the spring season. The pair was inadvertently overflown at 335 m altitude at which time the calf ceased nursing, and the pair swam toward and dived under the ice (Appendix A: Flight 9).

Sonobuoys were dropped six times on four dates in an attempt to record or monitor an area for bowhead sounds (Table 7). Two bowhead calls were recorded from whales swimming through 85 percent floe ice south of the Bering Strait on 26 April (Appendix A: Flight 2). These were the only bowhead sounds recorded in spring. The best recordings were of belukha calls as these whales swam within 100 m of the sonobuoy on 6 May. Bearded seal calls were recorded on most dates.

Recruitment

Two calves were seen among a total of 237 bowheads resulting in a Gross Annual Recruitment Rate (GARR = calves/total whales observed including calves) of 0.84 percent. Both calves were observed on 5 May near Cape Lisburne (Appendix A: Flight 9). One was nursing when first observed. This calf-sighting rate was similar to that in other spring seasons, but lower than during fall seasons. Calves may be difficult to see due to their relatively small size, or they may be segregated temporally or spatially during the spring migration (Braham et al., 1980).

The two calves were less than half the size of their associated cows (0.44 and 0.39) as measured from slides taken with hand-held 35-mm cameras (see Methods section). These ratios are larger than that in the single sample (0.36) from 1982 (Table 31).

Table 7. Summary of sonobuoy drops, spring 1984.

Date	Type	Lat(N)	Long(W)	Subject Species
26 Apr	57A	65°01.3'	169°22.6'	Bowhead
4 May	57A	68°56.6'	167°01.8'	Bowhead, Belukha
	57A	68°18.8'	166°59.7'	Bowhead
6 May	57A	71°01.8'	158°59.1'	Belukha, Bearded Seal
	57A	71°03.9'	158°32.2'	Belukha
8 May	57A	71°33.5'	13°48.0'	Bearded Seal

Other Species

Belukha Whale (Delphinapterus leucas)

Belukha whales (73 sightings of 1,342 whales) and belukha ice tracks were seen throughout the Bering, Chukchi, and Beaufort Seas in coastal as well as offshore areas (Figure 9). Belukhas were not found north of the nearshore lead in the Beaufort Sea, however, even though there were sufficient holes and cracks in the offshore ice.

Belukha whales were sighted ahead of, north of, and with bowheads. They were usually sighted whenever bowheads were seen, but rarely vice versa. Belukhas usually arrive at Pt. Barrow one to two weeks earlier than bowheads by using smaller holes in the ice (Braham et al., 1984). As in previous years (Ljungblad et al., 1984a), the distribution of the two species was partially segregated east of Pt. Barrow, with belukhas commonly seen further north than bowheads.

Pinnipeds

Pinnipeds, including 88 sightings of 195 bearded seals (Erignathus barbatus), 31 sightings of 46 ringed seals (Phoca hispida), 27 sightings of 429 walrus (Odobenus rosmarus), and 10 sightings of 11 unidentified pinnipeds, were seen throughout the Bering, Chukchi, and Beaufort Seas, usually on cracked or floe ice or along the nearshore leads. Seals were unidentified if they dived suddenly in response to the aircraft.

One usual sighting was made of 42 bearded seals together along a crack north of Pt. Barrow (Appendix A: Flight 9). Bearded seals were usually sighted alone or in pairs.

Walrus were sighted mainly in the Bering Sea. Two sightings of lone walrus were noted north of Pt. Barrow. One was closely surrounded by polar bear tracks but was apparently unharmed. There were no sightings of large groups of walrus near Pt. Barrow as in other spring seasons. Otherwise, all pinniped distributions and behaviors were similar to those seen in past years.

Polar Bear (Ursus maritimus)

Four polar bears were seen on floe ice in the Chukchi Sea, at 68°52.6' N, 168°51.4' W; 68°10.8' N, 168°52.5' W, 68°00.6' N, 168°38.2' W (Appendix A: Flight 8) and 71°35.5' N, 162°16.7' W (Appendix A: Flight 13). Each of these sightings was made near cracks on otherwise 99-percent coverage floe ice. One bear was

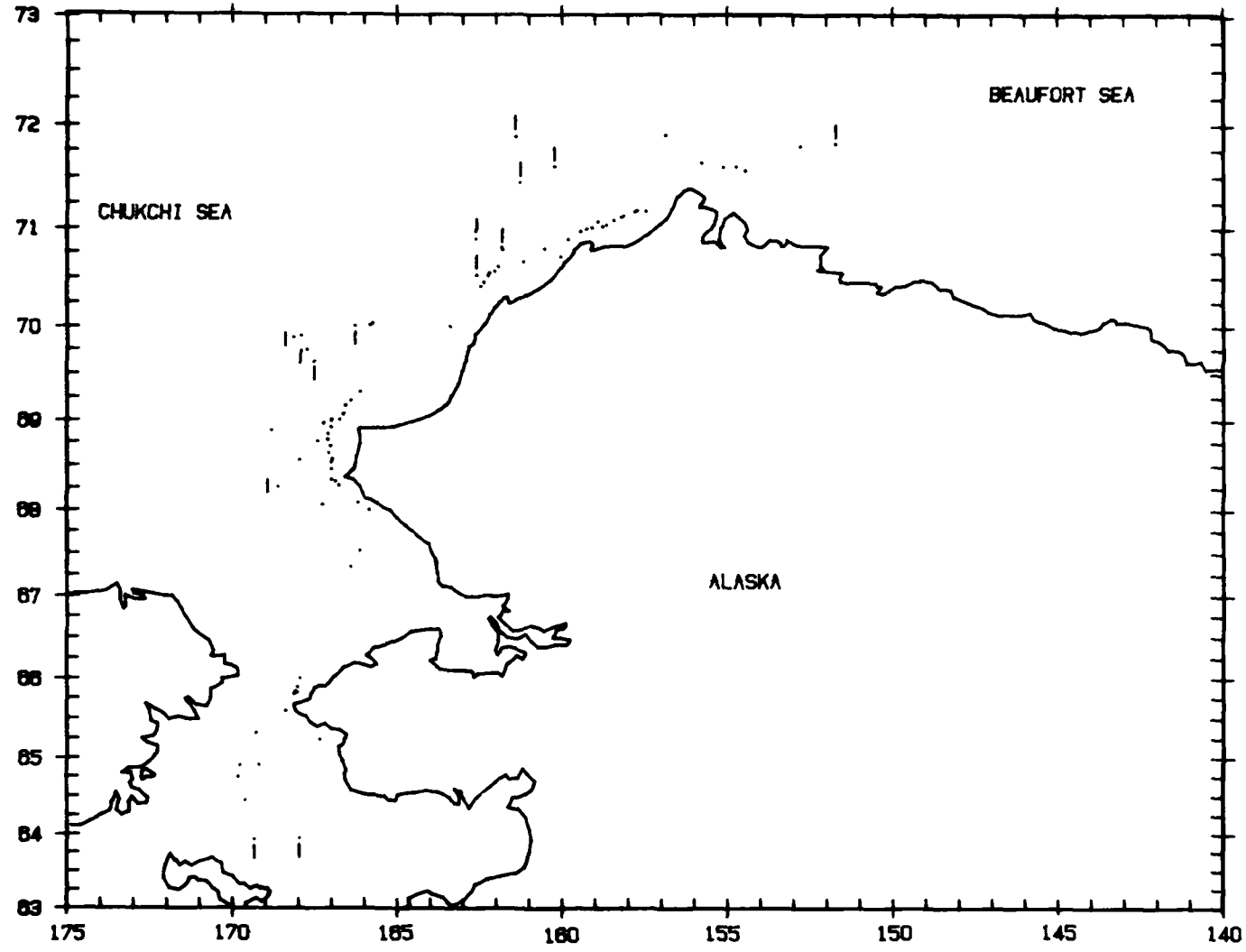

Figure 9. Distribution of 73 sightings (•) of 1,342 belukha whales and 12 ice tracks (I), spring 1984.

seen in the Beaufort Sea, at 71° 34.4' N, 154°02.2' W (Appendix A: Flight 12). This sighting was along the nearshore lead. No polar bears were seen in the Bering Sea.

Summer (17 July to 31 July)

Survey Effort, Rationale, and Sighting Summary

Thirty-two and one-third hours of surveys were flown in July, with 10 percent (3.3 hrs) of this effort in the northern Bering Sea, 48 percent (15.6 hrs) in the northeastern Chukchi Sea, and 42 percent (13.4 hrs) in the Alaskan Beaufort Sea (Table 8, Figure 10). This effort represents more coverage of the Alaskan Beaufort and northeastern Chukchi Seas than in recent years, but considerably less coverage of the northern Bering Sea (see Table 36). Search surveys were flown only when transect surveys were aborted due to poor weather, or during transits to a new base of operations. Inclement weather, mostly rain and fog, prevented flying on seven of the 15 days.

Survey effort was allocated to the offshore regions of the eastern Alaskan Beaufort Sea in July to investigate the timing and location of earliest bowhead arrival in these waters. In the northern Bering and northeastern Chukchi Seas, surveys were designed to investigate gray whale distribution and relative abundance in nearshore and offshore waters.

One transect survey was flown in the northern Bering Sea. Gray whales were seen along the eastern boundary of the Chirikov Basin (Appendix A: Flight 16) as in past years. Persistent low fog, drizzle, and rain prevented surveys over much of the Chirikov Basin where gray whales have been routinely observed each year since 1980 (Moore et al., 1984a). Three transect and one search surveys were flown and grays were seen nearshore in the northeastern Chukchi Sea. Four transect and one search surveys were flown in the Beaufort Sea, with belukhas the only cetaceans seen.

Survey Conditions Summary

Weather conditions in July were generally poor. Low ceilings, fog, and rain blanketed the western and northern Alaskan coast for much of this period, forcing some transect surveys to be truncated or aborted. Most summer surveys were flown in overcast or foggy weather, often with precipitation.

Table 8. Summary of flight effort, summer 1984.

Flight	Date	Sea	Transect Length[1] (km)	Search Length[2] (km)	Connect Length[3] (km)	Total Length (km)	Time on Transect (hr:min)	Total Time (hr:min)	WPUE (Whales/ hr)
14	17 July	Beaufort	482	281	88	851	1:52	3:17	0.00
15	18 July	Beaufort/ Chukchi	0	1,219	0	1,219	0	1:22	0.00
								3:19	3.01
16	21 July	Bering	539	125	115	779	1:56	3:19	7.27
17	25 July	Beaufort	857	455	69	1,381	3:02	5:00	0.00
18	27 July	Beaufort	284	158	87	529	1:04	2:05	0.00
19	28 July	Beaufort/ Chukchi	772	420	81	1,273	3:04	1:41	0.00
								3:22	3.56
20	29 July	Chukchi	609	445	94	1,148	2:10	4:20	1.16
21	30 July	Chukchi	773	294	139	1,206	2:47	4:38	0.00
Total Bering Sea			539	125	115	779	1:56	3:19	7.23
Total Chukchi Sea			1,382	739	233	2,354	4:57	15:39	1.73
Total Beaufort Sea			2,395	2,533	325	5,253	10:02	13:25	0.00
TOTAL			4,316	3,397	673	8,386	15:55	32:23	1.58*

1. Total length of all transect legs
2. Total length of transit to and from survey blocks and/or new bases of operation
3. Total length of legs which connect transect legs

*Average WPUE for summer 1984

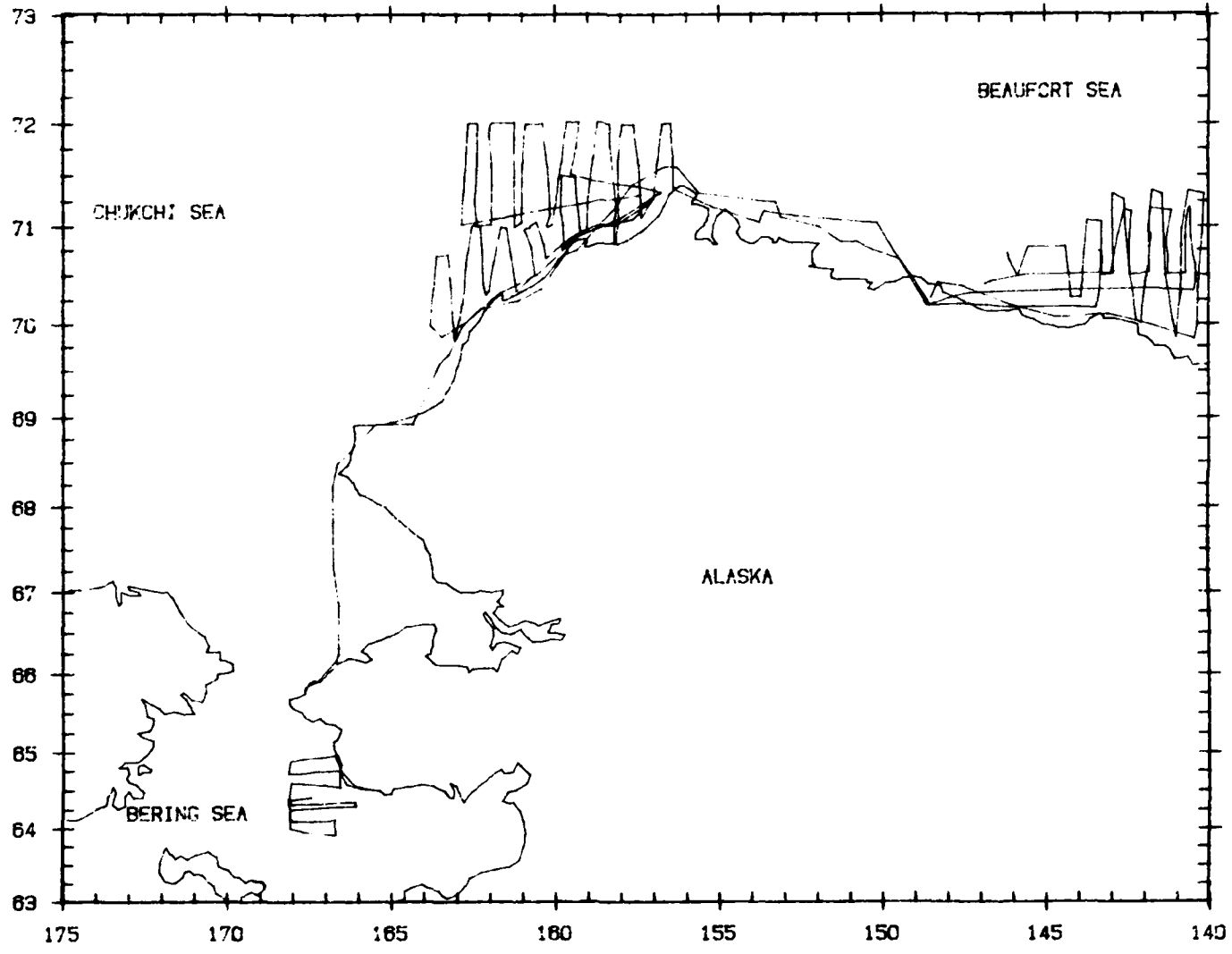

Figure 10. Composite flight track from eight flights, summer 1984.

Ice in the Alaskan Beaufort Sea and northeastern Chukchi Sea remained nearshore in mid-July (Figure 11). On 17 and 18 July, 90- to 95-percent broken ice coverage extended to the barrier islands in the Alaskan Beaufort Sea, with 30-to 60-percent coverage between the islands and the shoreline. In the northeastern Chukchi Sea, heavy ice coverage (>90 percent) was observed along the coast to Wainwright. Ice coverage was 60 to 90 percent between Wainwright and Icy Cape, diminishing to less than 1 percent south of Icy Cape. On 31 July, open water extended to Icy Cape. Ice coverage ranged from 1 to 60 percent between Icy Cape and Wainwright, and from 60 to 70 percent between Wainwright and Barrow.

Sea state ranged from Beaufort 00 to 05 on all summer surveys, with 00 to 03 the most common conditions encountered.

Bowhead Whale

One bowhead carcass was seen on 18 July (Appendix A: Flight 15) on the beach north of Cape Lisburne (68°55' N, 165°22' W). The decomposing whale, subjectively estimated to be 13 m long, was lying on its left side. The cause of death could not be ascertained.

Gray Whale (Eschrichtius robustus)

Distribution and Relative Abundance

Twenty-one sightings of 51 gray whales were made in the Chukchi and Bering Seas in July (Table 9, Figure 12). Twenty-four whales, including one cow-calf pair (Appendix A: Flight 16), were seen in the northern Bering Sea and 27 grays were seen in the Chukchi Sea. Areas of greatest concentration were block 28 (WPUE = 7.50) in the Bering Sea and blocks 22, 23, and 13 in the Chukchi Sea where WPUE was 21.21, 6.98 and 2.51, respectively (Table 10). Whales in blocks 22 and 23 were approximately 7 to 50 km south of Pt. Hope while those in block 13 were nearshore (< 25 km) south of Pt. Barrow.

Three gray whale carcasses were seen, two on the beach between Cape Beaufort and Cape Lisburne (68°56' N, 164°15' W; 68°55' N, 165°22' W), and one on shore approximately 35 km south of Cape Lisburne (68°30' N, 166°30' W) on 18 July (Appendix A: Flight 15). All carcasses appeared to be partially decomposed and one had attracted a grizzly bear. The cause of death could not be ascertained.

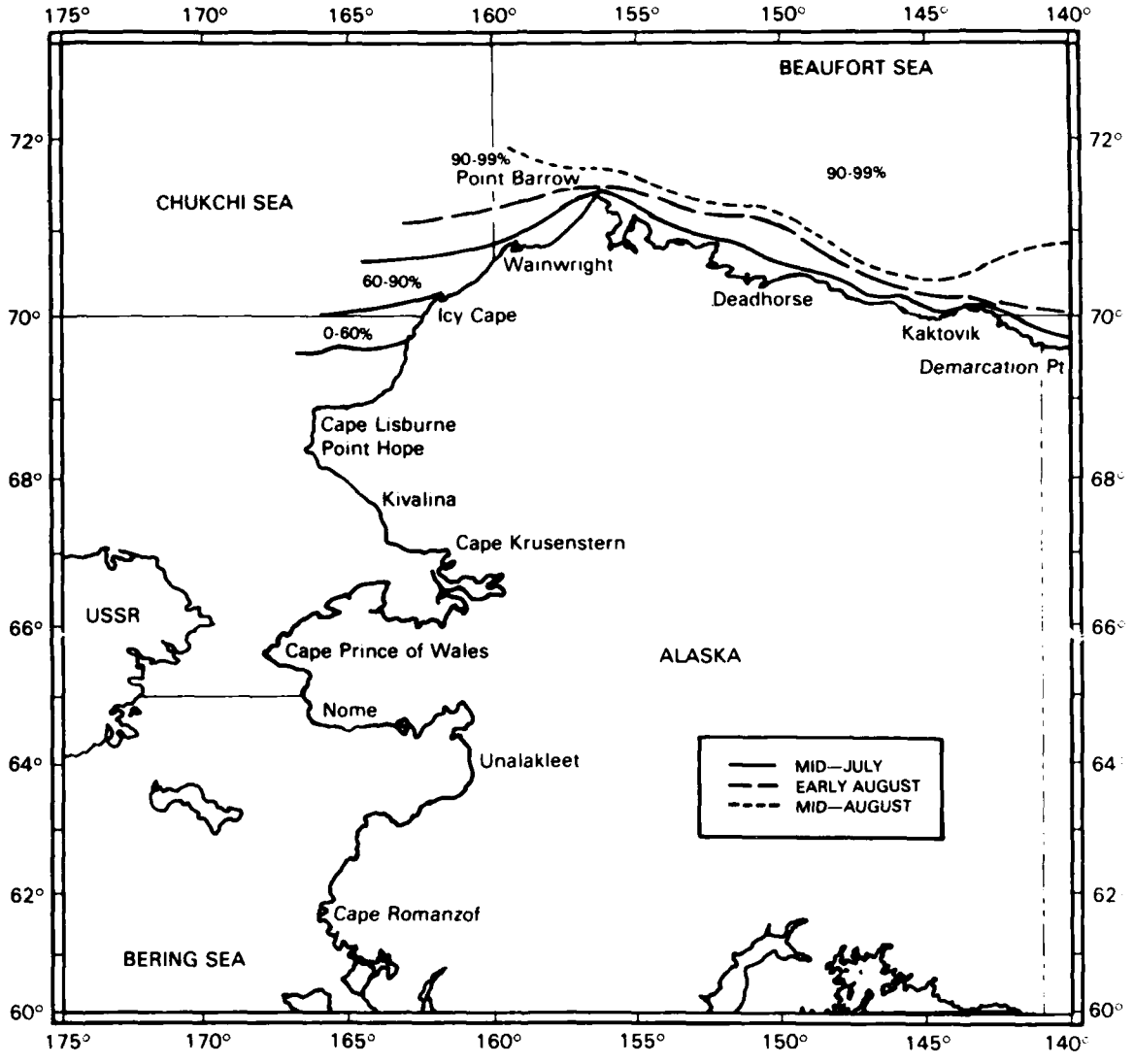

Figure 11. Schematic representation of ice conditions in the Chukchi and Beaufort Seas, mid-July to mid-August 1984.

Table 9. Summary of sightings (number of sightings/number of animals), summer 1984.

Flight	Date	Bowhead	Belukha	Gray Whale	Bearded Seal	Ringed Seal	Walrus	Unidentified Pinniped	Polar Bear
14	17 July	0	6/30	0	1/1	0	0	2/2	0
15	18 July	(1D)	(2D)	2/10(3D)	1/1	0	2/34(32D)	0	0
16	21 July	0	0	9/24	0	0	(5D)	0	0
17	25 July	0	2/9	0	0	1/1	0	3/4	0
18	27 July	0	0	0	3/3	0	0	1/1	0
19	28 July	0	0	5/12	0	0	4/12	1/1	1/1
20	29 July	0	0	5/5	0	0	13/75	3/3	0
21	30 July	0	0	0	8/9	0	11/176	2/2	1/1
Total		0	8/39	21/51	13/14	1/1	30/297	12/13	2/2
		(1D)	(2D)	(3D)			(37D)		

(D) = Dead.

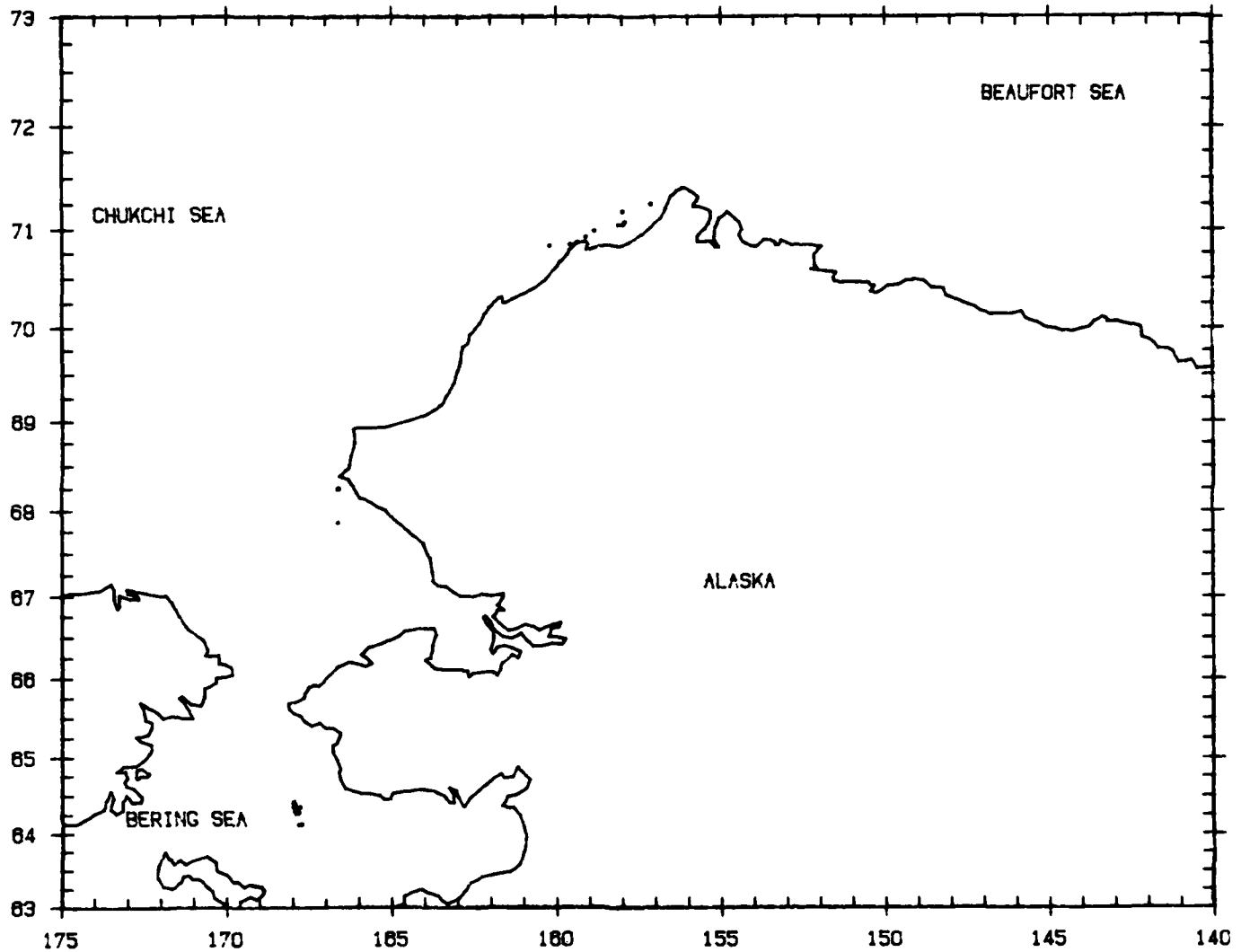

Figure 12. Distribution of 21 sightings (•) of 51 gray whales, summer 1984.

Table 10. Relative abundance of gray whales: whales per unit effort (WPUE) by block, summer 1984.

Block	Flights*	Hours	Gray Whales	WPUE
1	5	1.42	0	0.00
2	1	0.03	0	0.00
3	2	1.35	0	0.00
4	3	1.72	0	0.00
5	2	2.03	0	0.00
6	3	1.50	0	0.00
7	2	3.63	0	0.00
8	1	0.52	0	0.00
12	2	1.43	0	0.00
13	4	6.37	16	2.51
14	1	3.23	0	0.00
17	2	3.07	1	0.33
18	1	0.50	0	0.00
20	2	0.87	0	0.00
22	1	0.33	7	21.21
23	1	0.43	3	6.98
24	1	0.60	0	0.00
28	1	3.20	24	7.50
Unblocked	1	0.12	0	0.00
Total/Average		32.35	51	1.58

*Flight is any traverse of a block.

Habitat Relationships

Gray whales were seen approximately 0.5 to 120 km from shore in water 18 to 51 m deep ($\bar{x}$ = 28.33, s.d. = 9.86, n = 21). Gray whales were seen in open water (70 percent, n = 36), in 1 to 10 percent ice coverage (20 percent) and in 10-to 30-percent coverage (10 percent). Ten percent of whales seen in open water were found within 5 km of an ice field of 40- to 90-percent broken floe ice.

Behavior

Gray whales were either feeding (71 percent), or swimming (25 percent), or involved in cow-calf behaviors (4 percent) (Table 11). Feeding was inferred any time a whale was seen with a mud plume. Mud plumes, billows of sediment brought to the surface by whales feeding on infaunal prey, are excellent sighting cues and as such may positively bias data toward "feeding" whales. Eighty-four percent (n = 20) of whales seen in the northern Bering Sea and 59 percent (n = 16)

Table 11. Observed gray whale behavior by sea, summer 1984.

	Bering Sea No.(%)	Chukchi Sea No.(%)	**Total** No.(%)
BEHAVIOR:			
Swim	2(8)	11(41)	13(25)
Feed	20(84)	16(59)	36(71)
Cow-Calf	2(8)	0(0)	2(4)
TOTAL	24	27	51

of those in the Chukchi Sea were feeding. These feeding ratios are higher than those observed in past years (Moore et al., 1984a).

Gray whales exhibited headings in all directions, with no significant clustering about any direction in either the northern Bering Sea ($z = 1.07$, $n = 9$, $p \leq 0.5$) nor northeastern Chukchi Sea ($z = 1.19$, $n = 12$, $p \leq 0.5$).

Average group size for all gray whales was 4.33 (s.d. = 1.11, n = 9). Grays were found in slightly larger groups in the northern Bering ($\bar{x} = 4.75$, s.d. = 4.86, n = 4) than in the Chukchi Sea ($\bar{x} = 4.00$, s.d. = 2.00, n = 5), but this difference was not significiant ($t = 0.3176$, $df = 7$, $p \leq 0.38$). Feeding gray whale groups ($\bar{x} = 4.83$, s.d. = 3.97, n = 6) were also slightly larger than groups of swimming whales ($\bar{x} = 4.00$, s.d. = 1.41, n = 2), but this difference also was not significant ($t = 0.2781$, $df = 6$, $p \leq 0.3951$).

Other Species

Belukha Whale

Eight sightings of 39 belukha whales were made in summer (Figure 13). Groups consisting primarily of cows with calves were seen on 17 July (Appendix A: Flight 14) in the eastern Alaskan Beaufort Sea. All other sightings were of singles or small groups of adult whales. Results of aerial surveys for belukha whales in the Soviet arctic (Kleinenberg et al., 1964; Gurevich, 1980) suggests that sexual and age-class segregation becomes more distinct in belukha populations from mid to late July at the end of the main calving/mating season.

One belukha carcass was seen on 18 July (Appendix A: Flight 15) along the Chukchi coast between Icy Cape and Cape Lisburne (69°35.0' N, 163°25.0' W). The cause of death could not be ascertained.

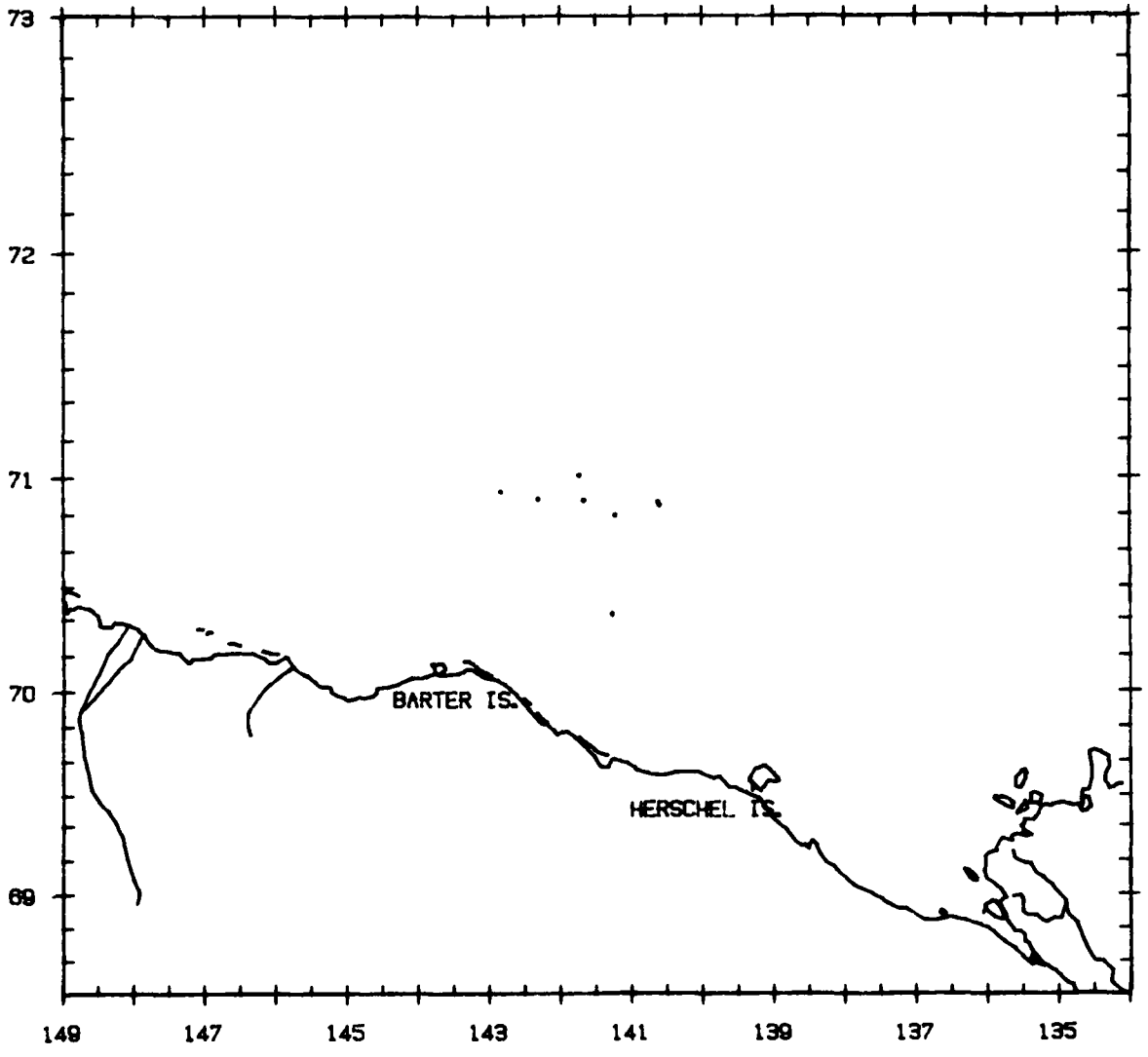

Figure 13. Distribution of eight sightings (·) of 39 belukha whales, summer 1984.

Unidentified Cetacean

One unidentified cetacean carcass was seen onshore southwest of Icy Cape (69°15.0' N, 163°30.0' W) on 18 July (Appendix A: Flight 15). The carcass was too decomposed to allow identification.

Fourteen bearded seals, one ringed seal, 297 walrus, and 13 unidentified pinnipeds were seen in summer. Pinnipeds that reacted suddenly to the aircraft often could not be positively identified. Additionally, 37 walrus carcasses were seen along the beach between Wainwright and Pt. Hope.

Pinnipeds

Fourteen bearded seals, one ringed seal, 297 walrus, and 13 unidentified pinnipeds were seen in summer. Pinnipeds that reacted suddenly to the aircraft often could not be positively identified. Additionally, 37 walrus carcasses were seen along the beach between Wainwright and Pt. Hope.

Polar Bear

Two polar bears were seen on the ice in the northeastern Chukchi Sea in late July. The first was seen at 71°02.7' N, 159°39.6' W on 28 July (Appendix A: Flight 19) near Wainwright; the second was seen at 71°24.0' N, 157°22.1' W on 30 July (Appendix A: Flight 21) approximately 100 km due west of Barrow.

Fall (1 August to 23 October)

Survey Effort, Rationale, and Sighting Summary

Two hundred fifty-two hours were flown in the fall, with 86 percent (216 hrs) of this effort in the Beaufort Sea and 14 percent (36 hrs) in the Chukchi Sea (Table 12). Thirty-six percent (89.1 hrs) of the total flight time was flown in August (Figure 14A), 34 percent (86.7 hrs) in September (Figure 14B), and 30 percent (76.2 hrs) in October (Figure 14C; Table 13).

Surveys in the Beaufort Sea were scheduled to cover all areas equally, but restrictive weather and lengthy transit time to some blocks altered planned coverage. Transit times to the westernmost Chukchi Sea blocks from Deadhorse or Pt. Barrow were particularly long and not all blocks could be surveyed within the allocated flight hours. First priority was given to coastal blocks, with blocks furthest offshore given lower priority. The shifting ice edge or 20- to 40-m isobath was flown enroute to or from scheduled blocks.

Flight	Date	Sea	Transect Length (km)	Search Length (km)	Connect Length (km)	Total Length (km)	Time on Transect (hr:min)	Total Time (hr:min)	WPUE (Whales/ hr)	Species*
22	1 Aug	Beaufort	442	746	44	1232	1:37	4:29	0	-
23	2 Aug	Beaufort	616	521	201	1338	2:19	5:03	0	-
24	5 Aug	Beaufort	0	539	0	539	0	2:02	0	-
25	6 Aug	Beaufort	561	357	179	1097	2:12	4:19	0	-
26	7 Aug	Beaufort	798	493	152	1443	3:06	5:37	0.36	BH
27	8 Aug	Chukchi	109	735	0	844	0:25	3:16	4.29	GW
28	10 Aug	Chukchi	785	436	124	1345	2:54	4:59	0	-
29	11 Aug	Beaufort	434	222	72	728	1:46	2:57	0	-
30	13 Aug	Beaufort	511	650	40	1201	1:57	4:35	0	-
31	14 Aug	Beaufort	710	235	90	1035	2:47	4:03	0	-
32	15 Aug	Beaufort	365	458	79	902	1:27	3:36	0.28	BH
33	16 Aug	Beaufort	364	545	87	996	1:33	4:14	3.07	BH
34	18 Aug	Beaufort	1112	70	100	1282	4:14	4:53	0	-
35	20 Aug	Beaufort	865	62	95	1022	3:22	3:59	0	-
36	21 Aug	Beaufort	123	261	53	437	0:29	1:43	0	-
37	23 Aug	Beaufort	0	174	0	174	0	0:43	0	-
38	24 Aug	Beaufort	0	766	0	766	0	2:57	0	-
39	26 Aug	Beaufort	993	227	37	1257	3:50	4:51	0	-
40	27 Aug	Beaufort	894	484	82	1460	3:28	5:39	0	-
41	28 Aug	Beaufort	0	487	0	487	0	1:55	0	-
42	29 Aug	Beaufort	702	347	169	1218	2:41	4:39	1.08	BH
43	30 Aug	Chukchi	356	558	34	948	1:19	3:30	0	-
44	31 Aug	Chukchi	721	509	103	1333	2:45	5:05	3.74	GW
45	6 Sep	Beaufort	101	102	42	245	0:26	1:02	1.94	BH
46	7 Sep	Beaufort	547	85	103	735	2:15	3:01	0.66	BH
47	7 Sep	Beaufort	487	97	144	728	1:42	2:37	0	-
48	11 Sep	Beaufort	352	969	41	1362	1:18	5:03	0.79	BH
49	12 Sep	Beaufort	81	212	0	293	0:19	1:10	0	-
50	13 Sep	Beaufort	600	165	135	900	2:34	3:51	0.78	BH
51	14 Sep	Beaufort	403	145	123	671	1:36	2:36	1.54	BH
52	15 Sep	Beaufort	388	514	88	990	1:30	3:51	0.52	BH
53	16 Sep	Beaufort	259	435	107	801	1:01	3:08	0	-
54	17 Sep	Beaufort	393	235	123	751	1:32	2:55	0	-
55	18 Sep	Beaufort	708	409	173	1290	2:59	5:27	1.10	BH
56	20 Sep	Beaufort	589	266	94	949	2:12	3:32	0	-
57	21 Sep	Beaufort	0	119	0	119	0	0:32	5.66	BH
58	21 Sep	Beaufort	763	510	58	1331	2:59	5:12	2.50	BH
59	22 Sep	Beaufort	389	600	61	1050	1:48	4:51	8.35	BH
		Chukchi	161	38	22	221	:45	1:01		
60	23 Sep	Beaufort	810	323	158	1301	3:07	5:00	0.40	BH

REPRODUCED AT GOVERNMENT EXPENSE

-	21 Sep	Beaufort	-	119	0	119	0	0:52	5.66	BH
58	21 Sep	Beaufort	763	510	58	1331	2:59	5:12	2.50	BH
59	22 Sep	Beaufort	389	600	61	1050	1:48	4:51	8.35	BH
		Chukchi	161	38	22	221	:45	1:01		
60	23 Sep	Beaufort	810	333	158	1301	3:07	5:00	0.40	BH
61	24 Sep	Beaufort	0	603	0	603	0	2:48	6.98	BH
		Chukchi	890	326	107	1326	3:26	4:39	9.40	GW
62	25 Sep	Beaufort	976	461	283	1720	3:37	6:23	0.31	BH
63	26 Sep	Beaufort	727	750	100	1577	2:50	6:09	10.73	BH
64	27 Sep	Beaufort	1020	162	124	1306	4:00	5:08	0	-
65	28 Sep	Beaufort	0	618	90	708	0	2:34	7.41	BH
		Chukchi	567	430	68	1065	2:16	4:11	0	GW
66	2 Oct	Beaufort	0	346	0	346	0	1:25	0.63	BH
		Chukchi	0	74	0	74	0	0:10	0	GW
67	3 Oct	Beaufort	252	777	69	1098	1:02	4:31	2.65	BH
68	4 Oct	Beaufort	0	345	0	345	0	1:30	0.25	BH
		Chukchi	411	192	76	679	1:36	2:30	0	GW
69	5 Oct	Beaufort	859	71	111	1041	3:39	4:26	0.45	BH
70	9 Oct	Beaufort	896	407	113	1416	3:48	6:01	3.82	BH
71	10 Oct	Beaufort	586	775	58	1419	2:24	5:48	0.17	BH
72	11 Oct	Beaufort	258	580	40	878	1:06	4:34	2.69	BH
		Chukchi	614	158	90	862	2:37	2:52	1.62	GW
73	13 Oct	Beaufort	702	76	156	934	2:59	3:58	0.25	BH
74	14 Oct	Beaufort	452	272	124	848	2:00	3:46	1.86	BH
75	15 Oct	Beaufort	370	70	70	510	1:32	2:06	2.90	BH
		Chukchi	158	32	46	236	:40	1:00		
76	16 Oct	Beaufort	680	117	143	940	2:37	3:37	0.27	BH
		Chukchi	0	15	0	15	0	:04		
77	17 Oct	Beaufort	528	479	83	1090	2:09	4:26	2.19	BH
		Chukchi	0	33	0	33	0	:08		
78	19 Oct	Beaufort	876	44	165	1085	3:43	4:36	0.43	BH
79	20 Oct	Beaufort	1087	55	209	1351	4:30	5:36	1.25	BH
80	21 Oct	Beaufort	372	66	64	502	1:37	3:23	0	-
		Chukchi	322	33	59	414	1:26	0:40		
81	22 Oct	Beaufort	377	4	55	436	1:34	2:09	0.47	BH
		Chukchi	381	123	86	590	1:35	2:08	0	GW
82	23 Oct	Beaufort	812	133	211	1156	3:23	4:49	0	-
Beaufort Sea Total				28177	20051	5121	53349	112:36	215:45	
Chukchi Sea Total			5475	3692	815	9982	21:44	36:13		
Total				33,652	23,783	5,936	63,331	134:20	251:58	

*Species: BH=Bowhead Whale; GW=Gray Whale.

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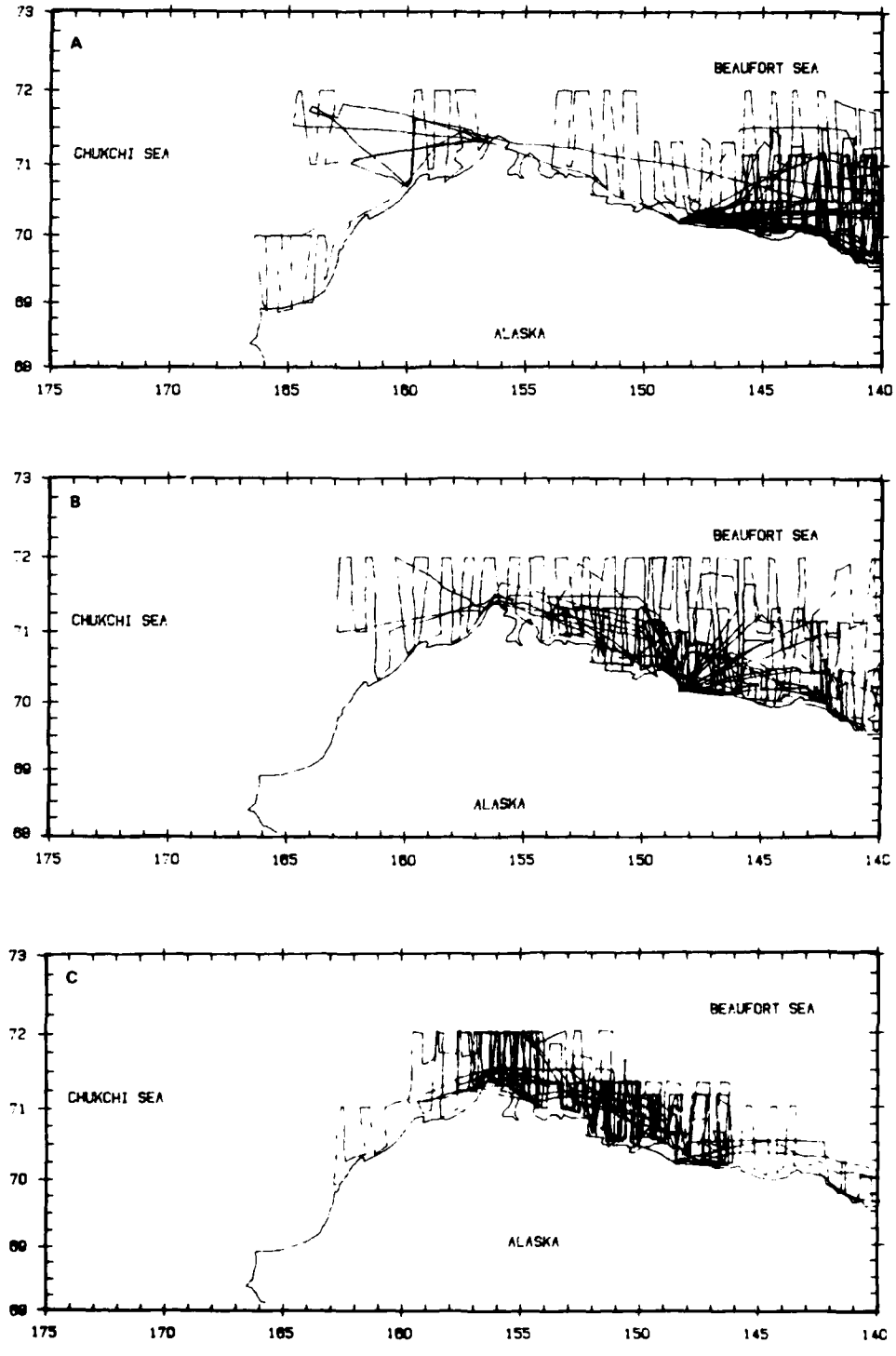

Figure 14. Composite flight tracks, fall 1984: 23 flights in August (A); 21 flights in September (B); and 17 flights in October (C).

Table 13. Monthly summary of flight effort, fall 1984.

	AUG	SEP	OCT	TOTAL
Total Flight Effort				
Total Transect Length (km)	11,461	11,211	10,980	33,652
Total Connect Length (km)	9,882	8,584	5,277	23,743
Total Search Length (km)	1,741	2,154	2,041	5,936
Total Time on Transect (hr:min)	44:11	44:12	45:57	134:20
Total Flight Time (hr:min)	89:04	86:41	76:13	251:58
No. Flights (days)	23	20	17	60
Unacceptable Weather (days)	7	9	6	22
Aircraft Maintenance (days)	1	1	0	2

Survey effort and area coverage in the Beaufort Sea was similar to that in 1982 (Ljungblad et al., 1983), but somewhat less than that completed in 1983 (Ljungblad et al., 1984a). The effort in the Chukchi Sea, investigating gray whale distribution and relative abundance in nearshore and offshore waters, as well as bowhead migration timing, was also less than that in 1982 and 1983, but greater than that flown in 1979 to 1981. Surveys were not flown on eight days in August, 10 in September, and six in October due to poor weather or aircraft maintenance requirements (Table 13).

The distribution of bowheads in the Beaufort and Chukchi Seas in 1984 was similar to past years with two principle exceptions: bowheads were not seen offshore in early August along the Alaskan-Canadian border as they were in 1982 and 1983 (Ljungblad et al., 1983, 1984); and a large aggregation of whales (n = 45 to 50) was seen feeding east of Pt. Barrow in late September. In October, bowheads were sighted from Kay Point in Canada (138°20' W) across the Beaufort Sea and into the northeastern Chukchi Sea.

Survey Conditions Summary

Survey conditions in early August were poor. Low ceilings and fog prevented flying on four days and unacceptable visibility caused transects to be

truncated or aborted on five occasions. The weather improved during the latter half of August, although heavy fog and snow flurries over the entire Beaufort Sea coast in late August precluded flying on three days and forced truncated transect surveys and low altitude search surveys on four days.

Weather in early September was very poor. No flights were attempted until 6 September due to persistent freezing drizzle, heavy fog, and snow flurries extending from Barrow east to Canada. By mid-September the weather had improved and survey conditions were good. In late September the weather was generally optimal for surveys with clear or high overcast, unlimited visibility, and nearly calm winds and seas (Beaufort 00 to 01).

October weather conditions were variable but generally good in the Beaufort Sea until 21 October, when high winds prevailed. Conditions in the Chukchi Sea, which was mostly ice-free, were poor with visibility reduced due to snow or fog, and high winds which created high sea states (up to Beaufort 07).

There was heavy-ice coverage in the Beaufort and northeastern Chukchi Seas throughout August (Figure 11). In the Beaufort Sea, there was 5 km of open water north of Pt. Barrow and greater than 90-percent ice coverage in Smith Bay and Prudhoe Bay; Harrison Bay and Camden Bay had less than 10-percent ice coverage on 1 August. Open water extended from shore to the barrier islands east and west of Prudhoe Bay. Ice conditions in the Beaufort Sea remained almost unchanged through mid-August, with the exception of more open water north and east of Barter Island (Figure 11). In early August the ice field in the Chukchi Sea was approximately 70 km offshore of Wainwright and about 2 km offshore at Pt. Barrow. By mid-August, the ice field in the northeastern Chukchi Sea began about 5 km northwest of Barrow with open water to the south.

In late August the ice moved further offshore, especially in the Chukchi Sea. On 30 August, the open water corridor north and west of Barrow was about 33 km wide. The heavy-ice edge (>90 percent) extended east-west along 71°30' N (Figure 15). In the Beaufort Sea the heavy-ice edge was 40 to 50 km offshore between Barter Island and Harrison Bay, increasing to ≥ 100 km offshore east and west of those two respective areas. Nearshore, the ice fluctuated with wind and current, varying between 5- to 50-percent broken floe coverage.

Strong easterly winds started blowing on 9 September, pushing the heavy ice in the Beaufort Sea offshore. By 13 September the ice edge was along 71°10' N east of 151° W (Figure 16). Due to continuous easterly winds, much of the Beaufort Sea was relatively ice-free north to almost 72° N, from 17 September to

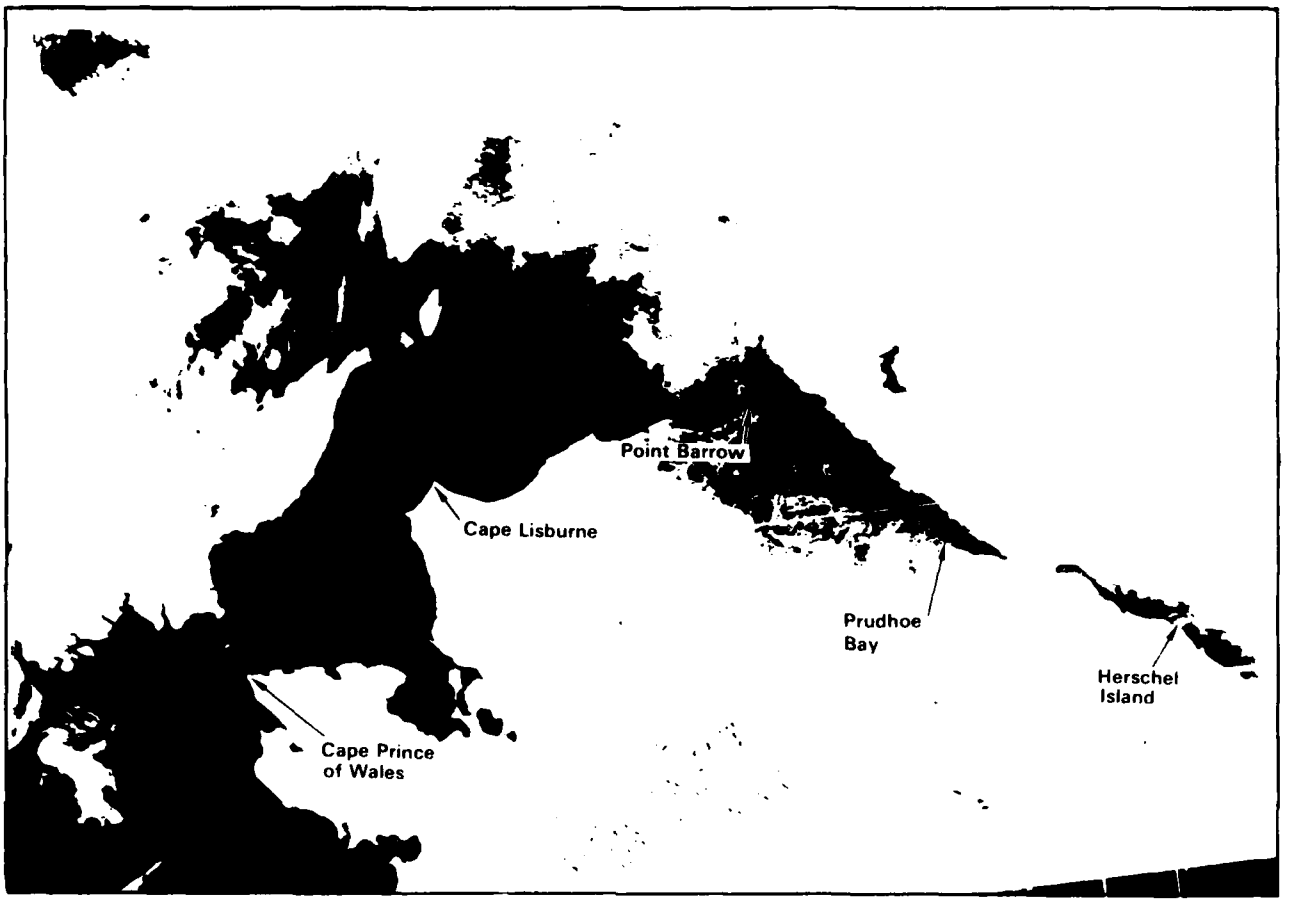

Figure 15. Satellite imagery of ice coverage in the Chukchi and Beaufort Seas on 31 August 1984.

2 October. The eastern Chukchi Sea was also ice-free during this period north to at least 72° N except for a narrow (5- to 10-km wide) strip of less than 50-percent coverage which extended west to at least 165° W along 71°30' N from Pt. Barrow. A satellite photograph on 23 September (Figure 17) and a schematic representation (Figure 18A) depict late September ice conditions.

Freeze-up in the Beaufort Sea began on 2 October and continued beyond 23 October (Figure 18B). Grease ice formed in shallow areas by 2 October and was consolidated by wind, so that there was 1 to 10 km of shorefast ice on 3 October. Up to 90-percent grease ice extended from the 20-to 40-m isobath from 30 to 100 km offshore in the Beaufort Sea on 4 October. By mid-October there was 90-percent coverage east of 153° W and over 99 percent along the beaches inside the 15-m isobath.

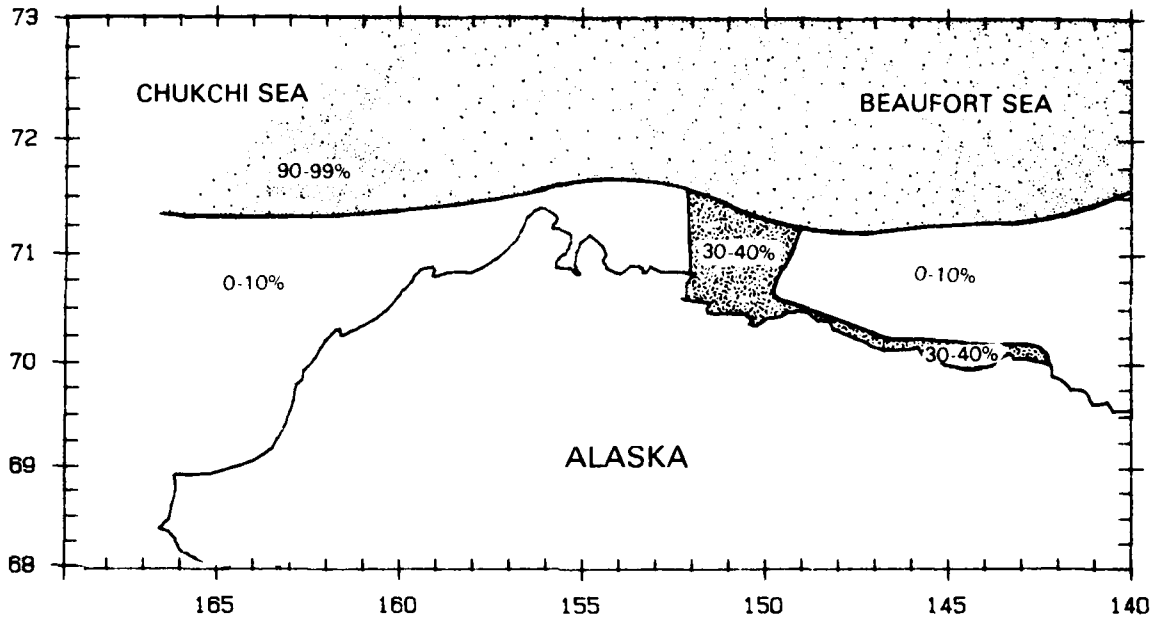

Figure 16. Schematic representation of ice conditions in the Chukchi and Beaufort Seas, mid-September 1984.

A nearshore lead centered along the 20- to 30-m isobath stretched between Pt. Barrow and the U.S.-Canadian border in the latter half of October, with 100-percent shorefast ice inshore of it and over 90-percent broken new ice offshore of it. It was possibly influenced by currents from the Chukchi Sea or by winds from the south which blew on 15 and 16 October. The lead width was about 5 km at 148° W northeast of Prudhoe Bay on 19 October and was last observed on 23 October.

Ice in the Chukchi Sea formed parallel to the beach in early October and moved progressively southeast toward it during the month. Shorefast ice formed inside the 10-m isobath by 11 October, but was soon blown offshore. New ice had moved to within 50 km of the beach at Pt. Franklin on 23 October.

Bowhead Whale

Distribution and Relative Abundance

One hundred fifty-three sightings of 380 bowheads were made during the fall season (Table 14, Figure 19). Twenty-one bowheads were seen in August between 140° W and 141°30' W offshore to 70°25' N (Figure 19A), but whales were not found along or outside the shelf break as in August 1982 and 1983 (Ljungblad et al., 1983, 1984a). Few surveys (9 percent of August flight effort) were flown north of 71°10' N, thus some offshore whales may have gone undetected.

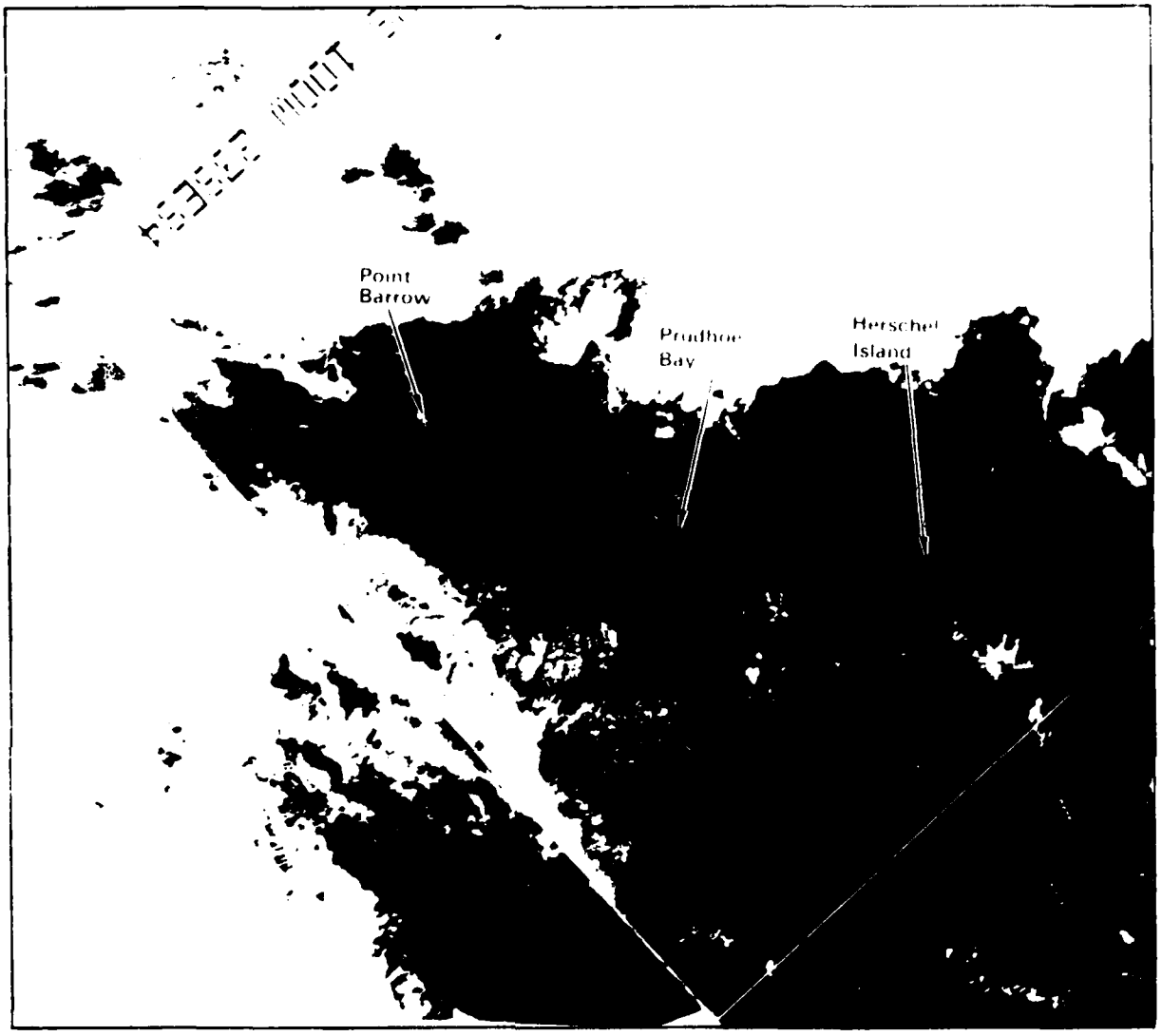

Figure 17. Satellite imagery of ice coverage in the Chukchi and Beaufort Seas on 23 September 1984.

In September, 260 bowheads were sighted in the Beaufort Sea from 138° W to 156°22' W, with sightings centered along and offshore of the 20-m isobath within 100 km of shore. There was little flight effort in offshore blocks (8,9,10,11) after 27 September as emphasis shifted to onshore areas to address industry concerns. It is possible that some whales passed offshore in late September undetected by surveys. An aggregation of 45 to 50 feeding bowheads was repeatedly sighted near Pt. Barrow between 22 and 28 September (Appendix A: Flights 59, 61, 65). Seven bowheads were sighted in the Chukchi Sea in September, north and west of Pt. Barrow (Appendix A: Flight 59, 61, 65).

Table 12. Summary of flight effort, fall 1984.

Flight	Date	Sea	Transect Length (km)	Search Length (km)	Connect Length (km)	Total Length (km)	Time on Transect (hr:min)	Total Time (hr:min)	WPUE (Whales/ hr)	Species*
22	1 Aug	Beaufort	442	746	44	1232	1:37	4:29	0	-
23	2 Aug	Beaufort	616	521	201	1338	2:19	5:03	0	-
24	5 Aug	Beaufort	0	539	0	539	0	2:02	0	-
25	6 Aug	Beaufort	561	357	179	1097	2:12	4:19	0	-
26	7 Aug	Beaufort	798	493	152	1443	3:06	5:37	0.36	BH
27	8 Aug	Chukchi	109	735	0	844	0:25	3:16	4.29	GW
28	10 Aug	Chukchi	785	436	124	1345	2:54	4:59	0	-
29	11 Aug	Beaufort	434	222	72	728	1:46	2:57	0	-
30	13 Aug	Beaufort	511	650	40	1201	1:57	4:35	0	-
31	14 Aug	Beaufort	710	235	90	1035	2:47	4:03	0	-
32	15 Aug	Beaufort	365	458	79	902	1:27	3:36	0.28	BH
33	16 Aug	Beaufort	364	545	87	996	1:33	4:14	3.07	BH
34	18 Aug	Beaufort	1112	70	100	1282	4:14	4:53	0	-
35	20 Aug	Beaufort	865	62	95	1022	3:22	3:59	0	-
36	21 Aug	Beaufort	123	261	53	437	0:29	1:43	0	-
37	23 Aug	Beaufort	0	174	0	174	0	0:43	0	-
38	24 Aug	Beaufort	0	766	0	766	0	2:57	0	-
39	26 Aug	Beaufort	993	227	37	1257	3:50	4:51	0	-
40	27 Aug	Beaufort	894	484	82	1460	3:28	5:39	0	-
41	28 Aug	Beaufort	0	487	0	487	0	1:55	0	-
42	29 Aug	Beaufort	702	347	169	1218	2:41	4:39	1.08	BH
43	30 Aug	Chukchi	356	558	34	948	1:19	3:30	0	-
44	31 Aug	Chukchi	721	509	103	1333	2:45	5:05	3.74	GW
45	6 Sep	Beaufort	101	102	42	245	0:26	1:02	1.94	BH
46	7 Sep	Beaufort	547	85	103	735	2:15	3:01	0.66	BH
47	7 Sep	Beaufort	487	97	144	728	1:42	2:37	0	-
48	11 Sep	Beaufort	352	969	41	1362	1:18	5:03	0.79	BH
49	12 Sep	Beaufort	81	212	0	293	0:19	1:10	0	-
50	13 Sep	Beaufort	600	165	135	900	2:34	3:51	0.78	BH
51	14 Sep	Beaufort	403	145	123	671	1:36	2:36	1.54	BH
52	15 Sep	Beaufort	388	514	88	990	1:30	3:51	0.52	BH
53	16 Sep	Beaufort	259	435	107	801	1:01	3:08	0	-
54	17 Sep	Beaufort	393	235	123	751	1:32	2:55	0	-
55	18 Sep	Beaufort	708	409	173	1290	2:59	5:27	1.10	BH
56	20 Sep	Beaufort	589	266	94	949	2:12	3:32	0	-
57	21 Sep	Beaufort	0	119	0	119	0	0:32	5.66	BH
58	21 Sep	Beaufort	763	510	58	1331	2:59	5:12	2.50	BH
59	22 Sep	Beaufort	389	600	61	1050	1:48	4:51	8.35	BH

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53	16 Sep	0	0	0	2/3	2/2	0	3/4	0
54	17 Sep	0	3/22	0	0	0	0	3/3	0
55	18 Sep	6/6 (1D)	3/8	0	3/3	3/3	0	4/7	1/1
56	20 Sep	0	5/42	0	0	0	0	1/1	0
57	21 Sep	2/3	0	0	0	0	0	0	0
58	21 Sep	10/13	2/6	0	2/2	1/1	0	7/7	0
59	22 Sep	8/49	10/126	0	3/3	2/3	1/1	6/8	0
60	23 Sep	2/2	2/10	0	1/1	0	0	0	0
61	24 Sep	6/52	1/1	7/70	23/32	11/19	8/11	26/56	0
62	25 Sep	2/2	5/20	0	0	2/2	0	18/21	0
63	26 Sep	21/66	1/5	0	2/4	0	0	4/6	0
64	27 Sep	0	6/29	0	2/4	1/1	0	5/5	0
65	28 Sep	6/50	1/10	0	1/1	0	5/118	3/3	0
66	2 Oct	1/1	0	0	0	0	0	0	0
67	3 Oct	8/12	0	0	0	0	0	0	0
68	4 Oct	1/1	0	0	0	0	2/2	1/1	0
69	5 Oct	2/2	2/5	0	0	0	0	3/3	0
70	9 Oct	15/23	23/56	0	1/1	0	0	10/11	0
71	10 Oct	1/1	2/3	0	2/2	2/2	0	17/24	0
72	11 Oct	12/20	22/91	6/12	17/20	0	1/1	14/15	0
73	13 Oct	1/1	1/15	0	1/1	0	0	6/6	0
74	14 Oct	6/7	2/8	0	0	0	0	0	0
75	15 Oct	5/9	3/8	0	0	0	0	1/1	0
76	16 Oct	1/1	2/2	0	0	0	0	0	0
77	17 Oct	6/10	0	0	0	0	0	1/1	0
78	19 Oct	2/2(1D)	0	0	3/3	0	0	4/5	0
79	20 Oct	3/7	11/37	0	0	0	0	0	0
80	21 Oct	0	1/1	0	0	0	0	0	1/2
82	22 Oct	1/2	1/1	0	0	0	0	0	0
83	23 Oct	0	0	0	0	0	0	3/4	2/4
August		13/21	37/90	16/33	81/93	71/95	28/179	94/109	8/12
September		75/260	63/471	7/70	47/61	41/68	14/130	98/139	3/4
October		65/99	70/227	6/12	24/27	2/2	3/3	60/71	3/6
Total		153/380 (2D)	170/788	29/115	152/181	114/165	45/312 (2D)	252/319	14/22

(D)=Dead.

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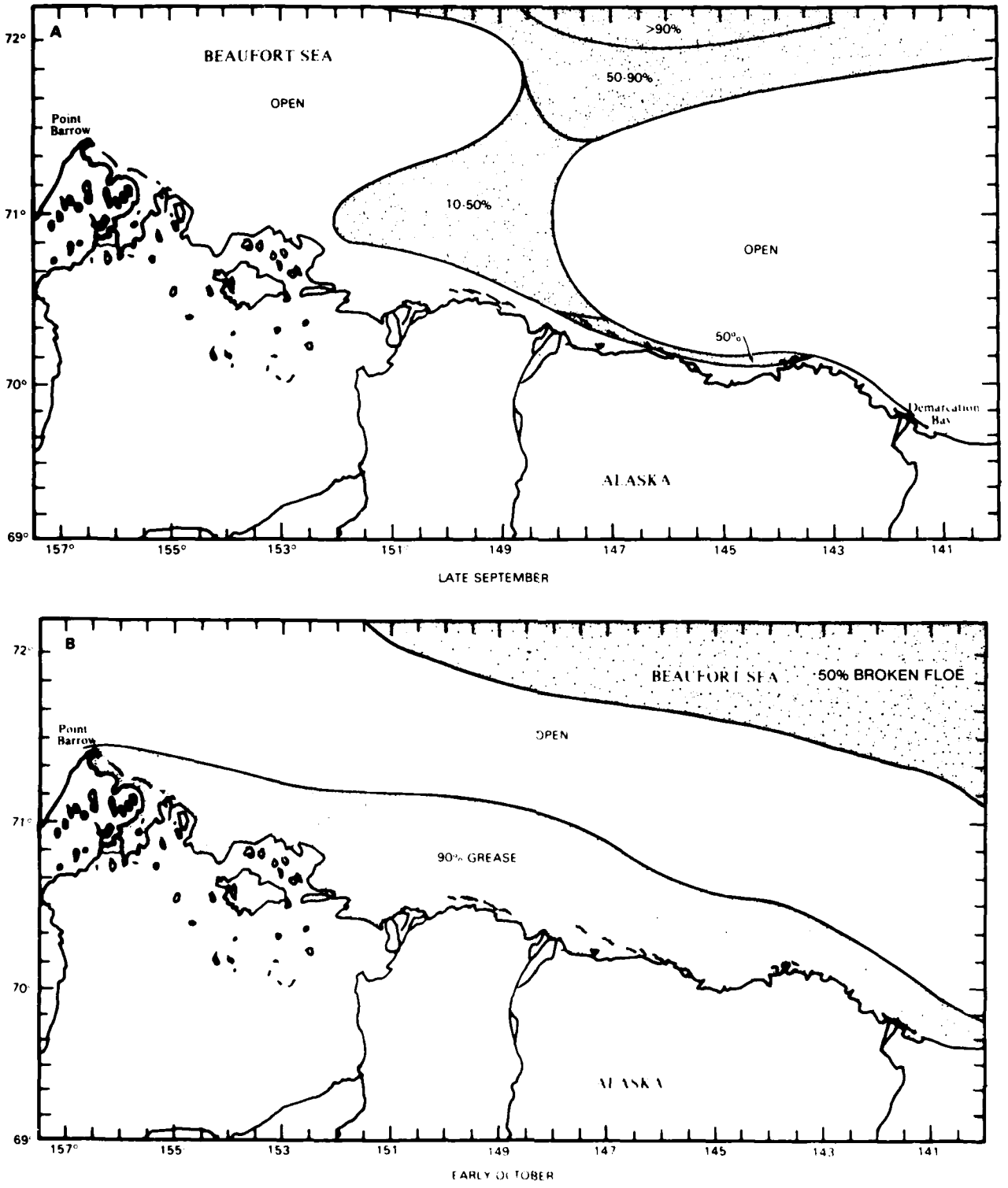


Figure 18. Schematic representation of ice conditions in the Chukchi and Beaufort Seas: late September 1984 (A); early October 1984 (B).

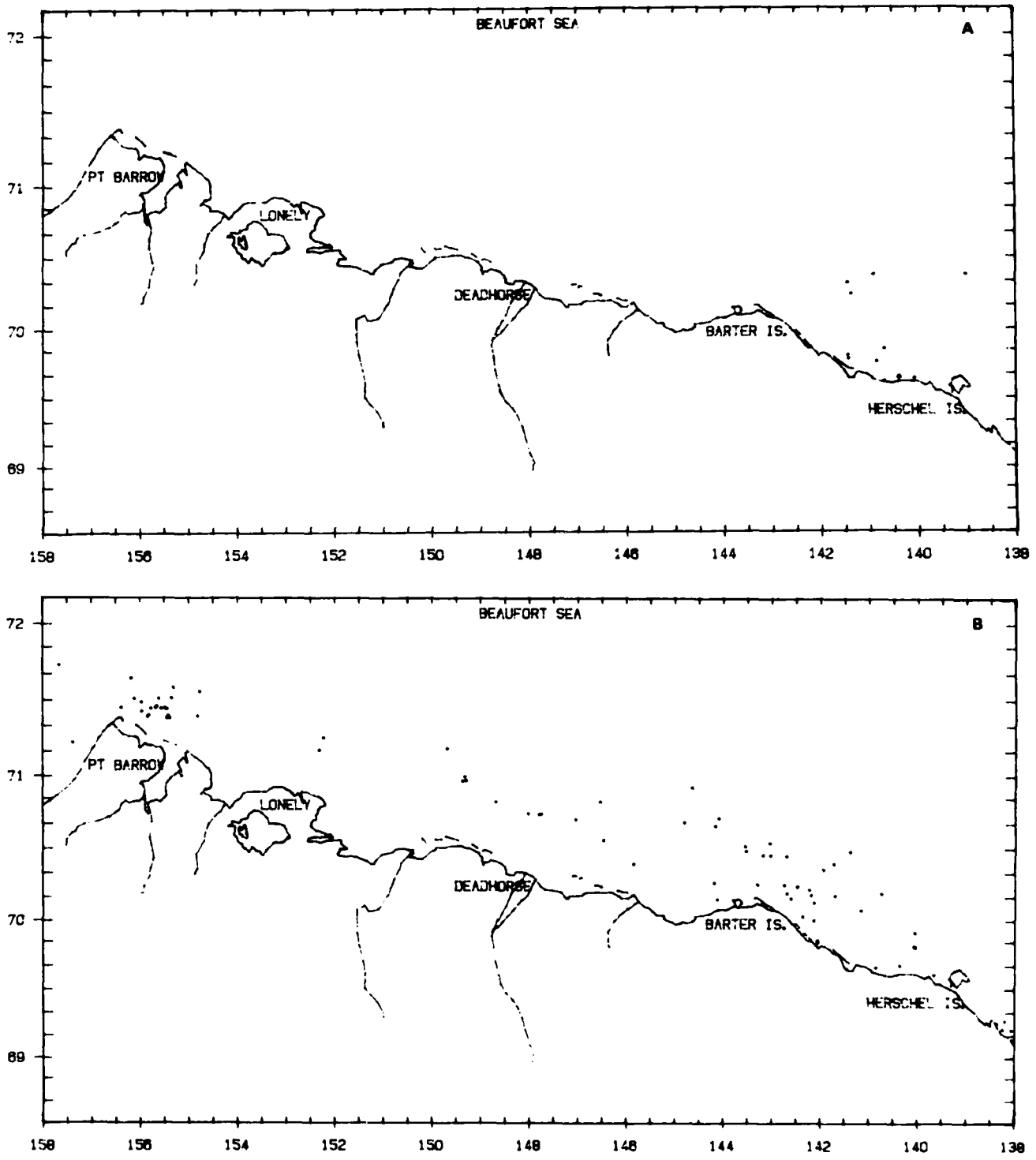
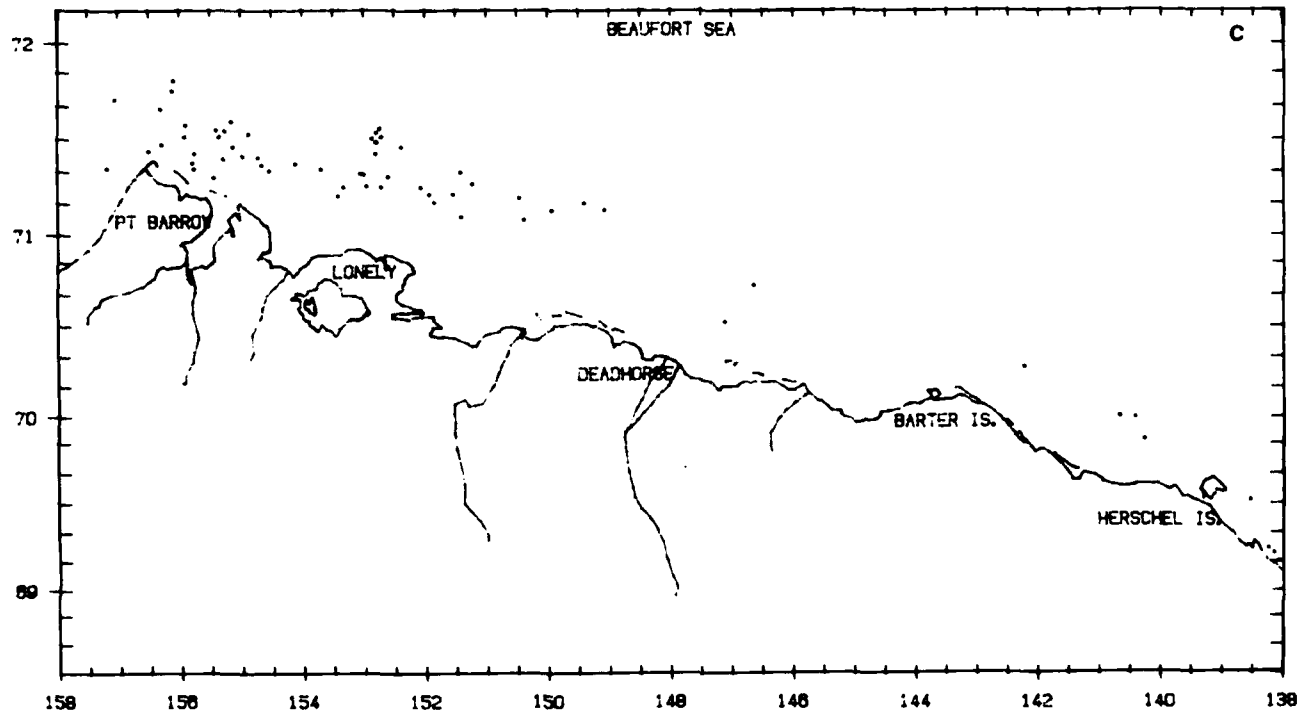


Figure 19. Distribution of 153 sightings (·) of 380 bowheads, fall 1984: August (A); September (B); October (C); Total (D).



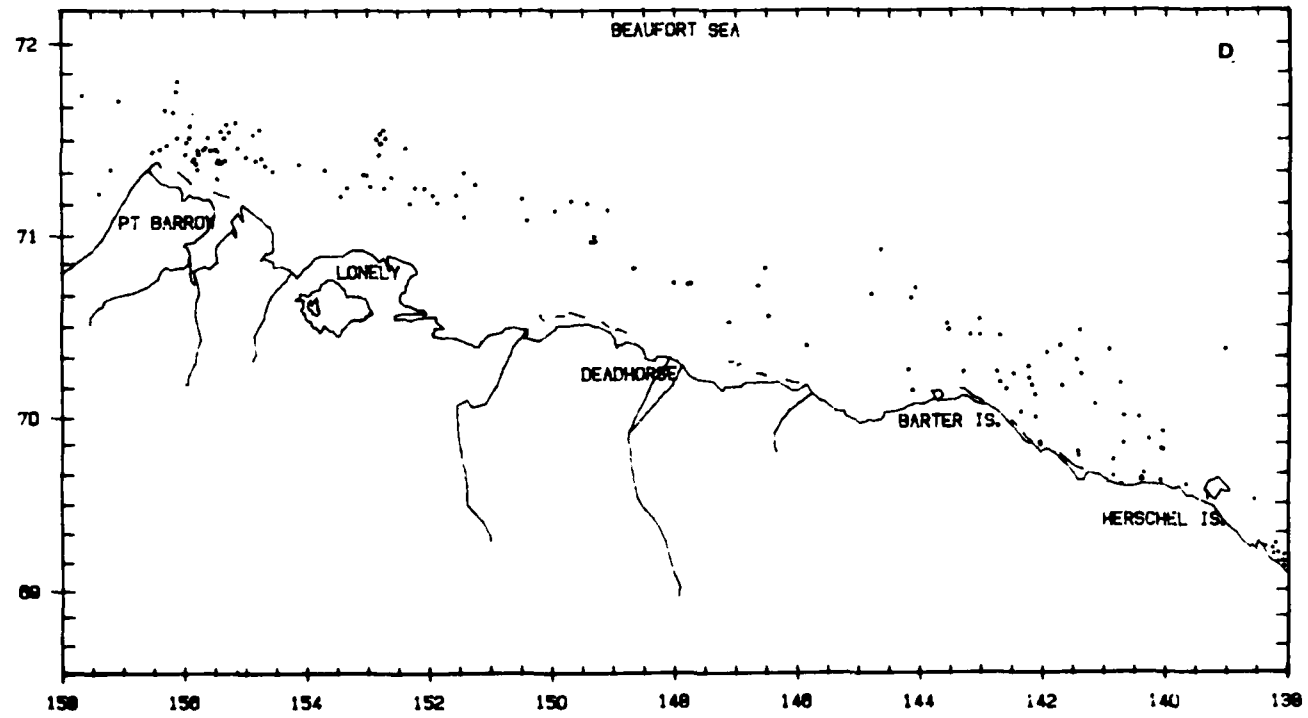


Figure 19. (Continued).

In October, 99 bowheads were sighted in the Beaufort Sea along and seaward of the 20-m isobath between 138° W and 156°18' W. Ten whales were sighted in the Chukchi Sea north and west of Pt. Barrow. (Appendix A: Flights 72, 75, 81).

The number of flights, total flight hours, number of bowheads seen and whales seen per unit effort (WPUE) were calculated for each block by month (Table 15, Figure 20). In addition to calculated WPUE, blocks were roughly classified bathymetrically as shallow (under 50 m), transitional (50 to 2,000 m), or deep (over 2,000 m). The highest bowhead WPUE in August occurred in block 5 (1.16). Highest WPUE in September was in blocks 5 (3.28) and 12 (26.76), and in October in blocks 11 (3.86) and 12 (2.17).

Migration Route, Timing, and Habitat Relationships

The observed fall bowhead migration route across the Alaskan Beaufort Sea was centered roughly along the continental shelf break (Figure 19D). The observed migration period extended from 7 September to 20 October. Bowheads were seen in the Alaskan Beaufort Sea earlier than 7 September (16 and 29 August, 6 September), but were not seen swimming in a westerly direction until that date. The last bowhead seen in the Alaskan Beaufort Sea was at 71°22.6' N, 155°47.0' W on 20 October (Appendix A: Flight 79). No bowheads were seen on a transect survey of block 12 on 21 and 22 October, nor on surveys of blocks 1 and 3 on 23 October, indicating that the majority of the migration was probably past.

Several WPUE peak periods were noted during the fall season (Figure 21). There was no peak migration period in the offshore zones in August and early September, although a relatively high WPUE was noted nearshore in block 5 on 16 August. The largest WPUE occurred between 22 and 28 September as a result of the sighting and resighting of large (n = 45 to 50) aggregations of bowheads feeding northeast of Pt. Barrow (Appendix A: Flights 59, 61, and 65). A lesser peak WPUE period occurred in early to mid-October (Appendix A: Flights 67, 70, 72, 74, and 75) when bowheads were seen as far east as 137°50' W and as far west as 157°10' W.

Bowhead swimming direction was not significantly clustered around a mean heading in August (Figure 22). Swimming direction in the Beaufort Sea was significantly clustered about mean headings in September (202° T) and October (226° T), resulting in a combined heading of 211° T for the fall season. In the Chukchi Sea, swimming direction was not significantly clustered around a mean

Table 15. Relative abundance of bowheads: whales per unit effort (WPUE) by block by month, fall 1984.

Block No.	Depth Regime	August				September				October				Total			
		Flts	Hrs	BH	WPUE	Flts	Hrs	BH	WPUE	Flts	Hrs	BH	WPUE	Flts	Hrs	BH	WPUE
1	Shallow	17	9.32	0	-	22	16.58	11	0.66	13	13.53	2	0.15	52	39.43	13	0.33
2	Transition	3	2.15	0	-	9	4.25	3	0.71	3	4.15	3	0.72	15	10.55	6	0.57
3	Shallow	3	3.40	0	-	7	11.20	1	0.09	8	19.22	22	1.14	18	33.82	23	0.68
4	Shallow	15	12.28	0	-	11	5.83	15	2.57	2	2.28	0	-	28	20.39	15	0.74
5	Shallow	13	16.40	19	1.16	8	8.53	28	3.28	2	2.93	4	1.37	23	27.86	51	1.83
6	Transition	7	8.20	0	-	8	4.80	8	1.67	1	1.87	0	-	16	14.87	8	0.54
7	Transition	9	10.23	0	-	7	3.67	0	-	0	0.00	0	-	16	13.90	0	-
8	Deep	3	3.23	0	-	1	1.50	0	-	0	0.00	0	-	4	4.73	0	-
9	Deep	3	3.18	0	-	3	3.48	0	-	0	0.00	0	-	6	6.66	0	-
10	Deep	0	0.00	0	-	3	4.67	0	-	0	0.00	0	-	3	4.67	0	-
11	Transition	1	2.48	0	-	5	4.77	2	0.42	5	4.40	17	3.86	11	11.65	19	1.63
12	Shallow	5	1.02	0	-	3	5.53	148	26.76	12	17.02	37	2.17	20	23.57	185	7.85
13	Shallow	4	6.02	0	-	2	4.82	2	0.41	5	5.82	5	0.86	11	16.66	7	0.42
14	Transition	3	2.13	0	-	2	2.97	0	-	1	0.08	0	-	6	5.18	0	-
15	Transition	2	2.20	0	-	0	0.00	0	-	0	0.00	0	-	2	2.20	0	-
16	Transition	0	0.00	0	-	0	0.00	0	-	0	0.00	0	-	0	0.00	0	-
17	Shallow	3	1.07	0	-	2	0.68	0	-	1	1.92	0	-	6	3.67	0	-
18	Transition	1	0.10	0	-	0	0.00	0	-	0	0.00	0	-	1	0.10	0	-
19	Transition	0	0.00	0	-	0	0.00	0	-	0	0.00	0	-	0	0.00	0	-
20	Shallow	1	3.63	0	-	0	0.00	0	-	0	0.00	0	-	1	3.63	0	-
21	Transition	0	0.00	0	-	0	0.00	0	-	0	0.00	0	-	0	0.00	0	-
22	Shallow	0	0.00	0	-	0	0.00	0	-	0	0.00	0	-	0	0.00	0	-
Total Shallow		61	53.14	19	0.36	55	53.17	205	3.86	43	62.72	70	1.12	159	169.03	294	1.74
Total Transition		28	27.49	0	-	31	20.46	13	0.63	10	10.50	20	1.90	67	58.45	33	0.56
Total Deep		6	6.41	0	-	7	9.65	0	-	0	0	0	-	13	16.06	0	-
Total Canada		2	2.01	2	1.00	2	3.40	42	12.35	2	3.00	9	3.00	6	8.41	53	6.30
Grand Total		97	89.05	21	0.24	95	86.68	260	3.00	55	76.22	99	1.30	245	251.95	380	1.51

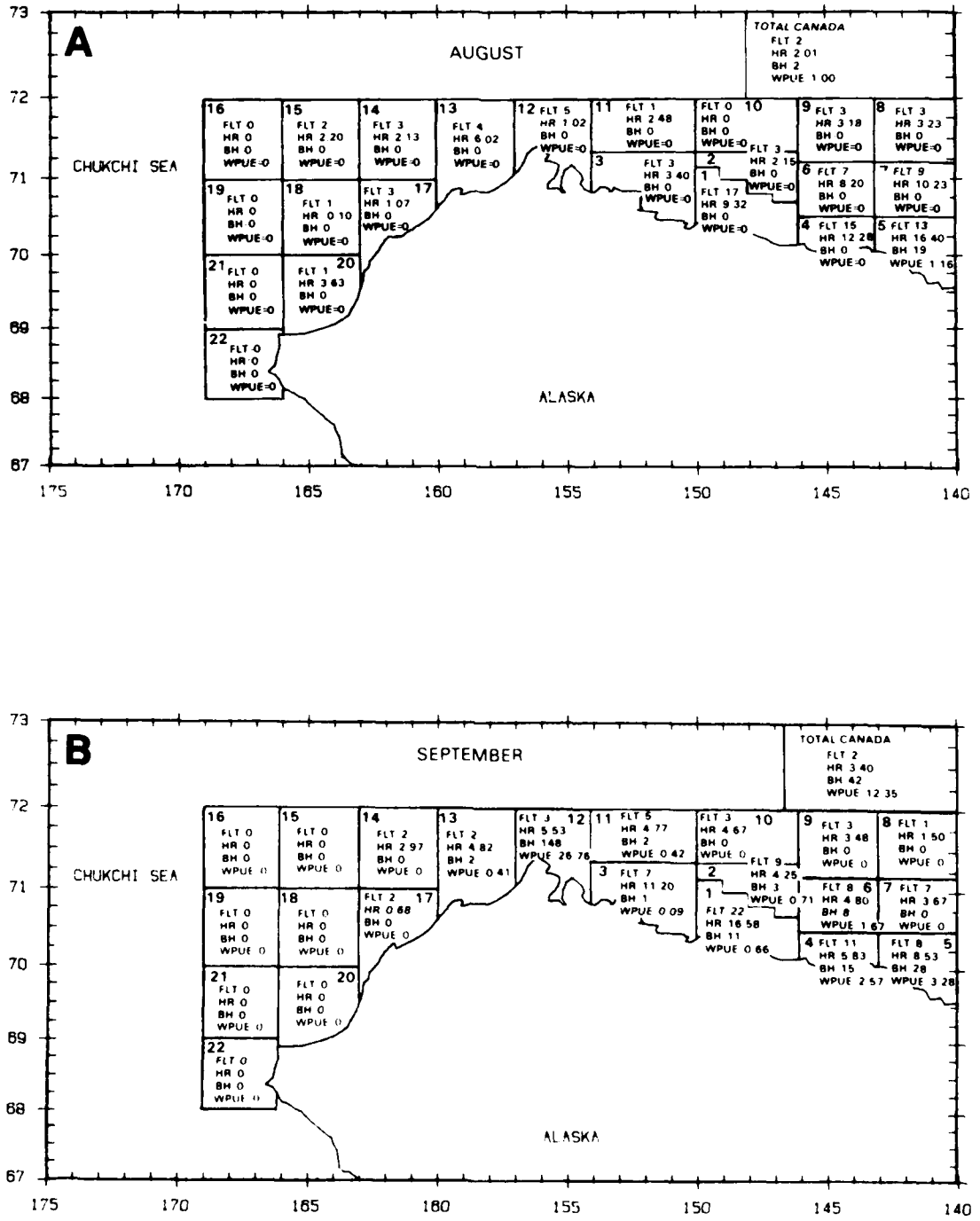
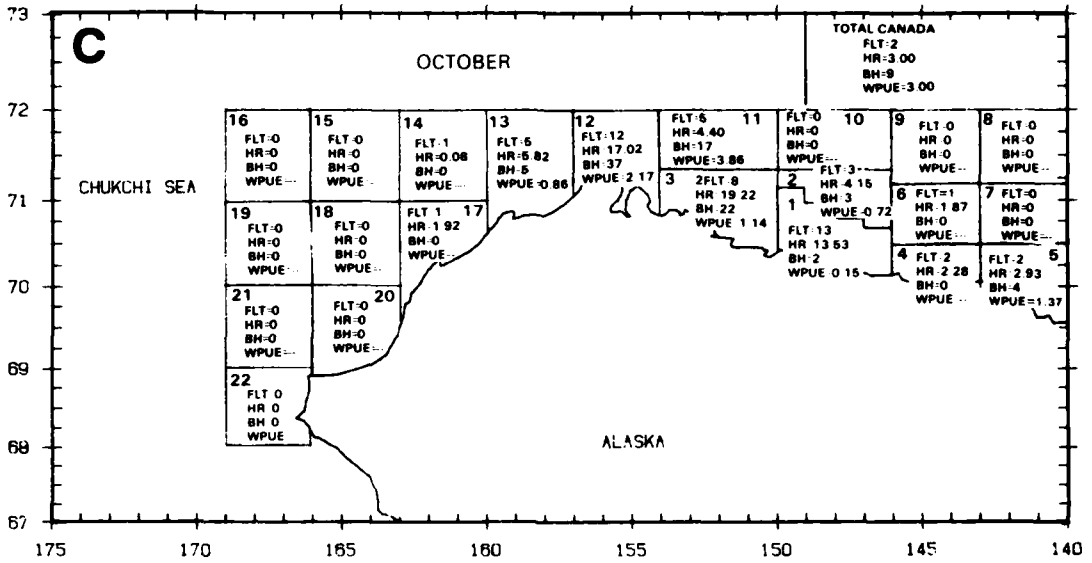


Figure 20. Relative abundance of bowhead whales by block, fall 1984: August (A); September (B); October (C); Total (D).



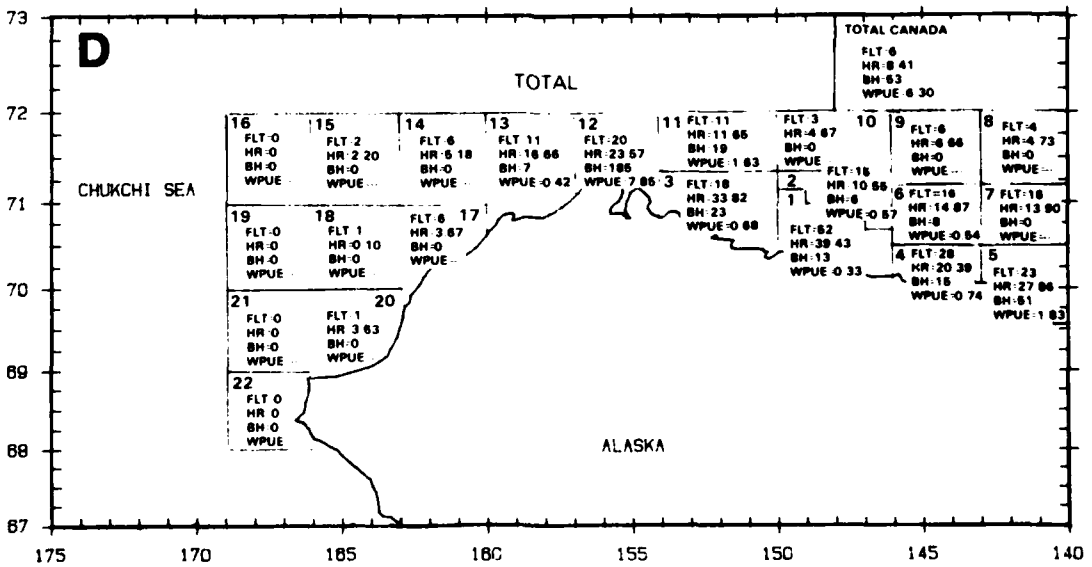


Figure 20. (Continued).

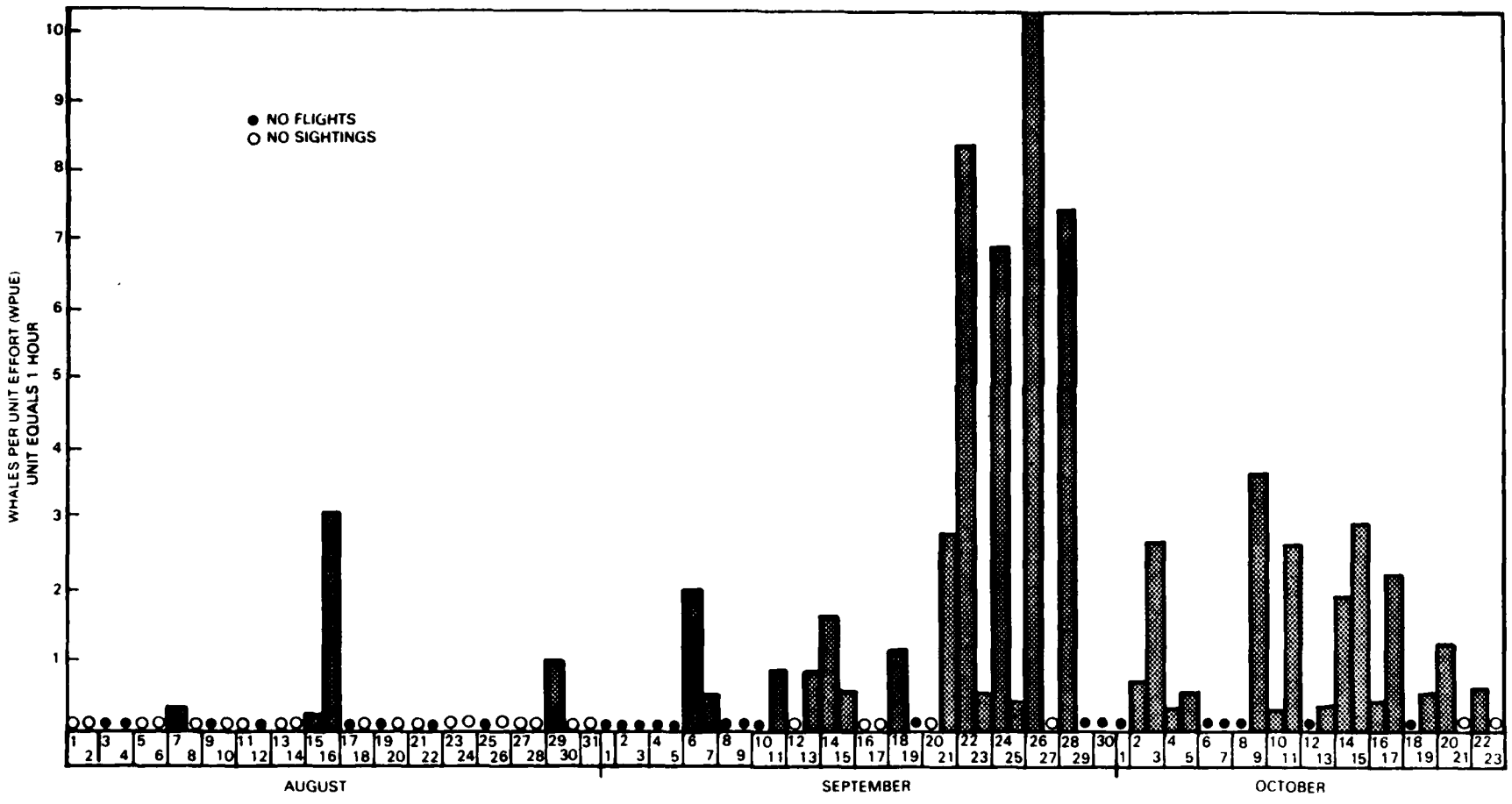


Figure 21. Bowhead whales per unit effort (WPUE) by date, fall 1984.

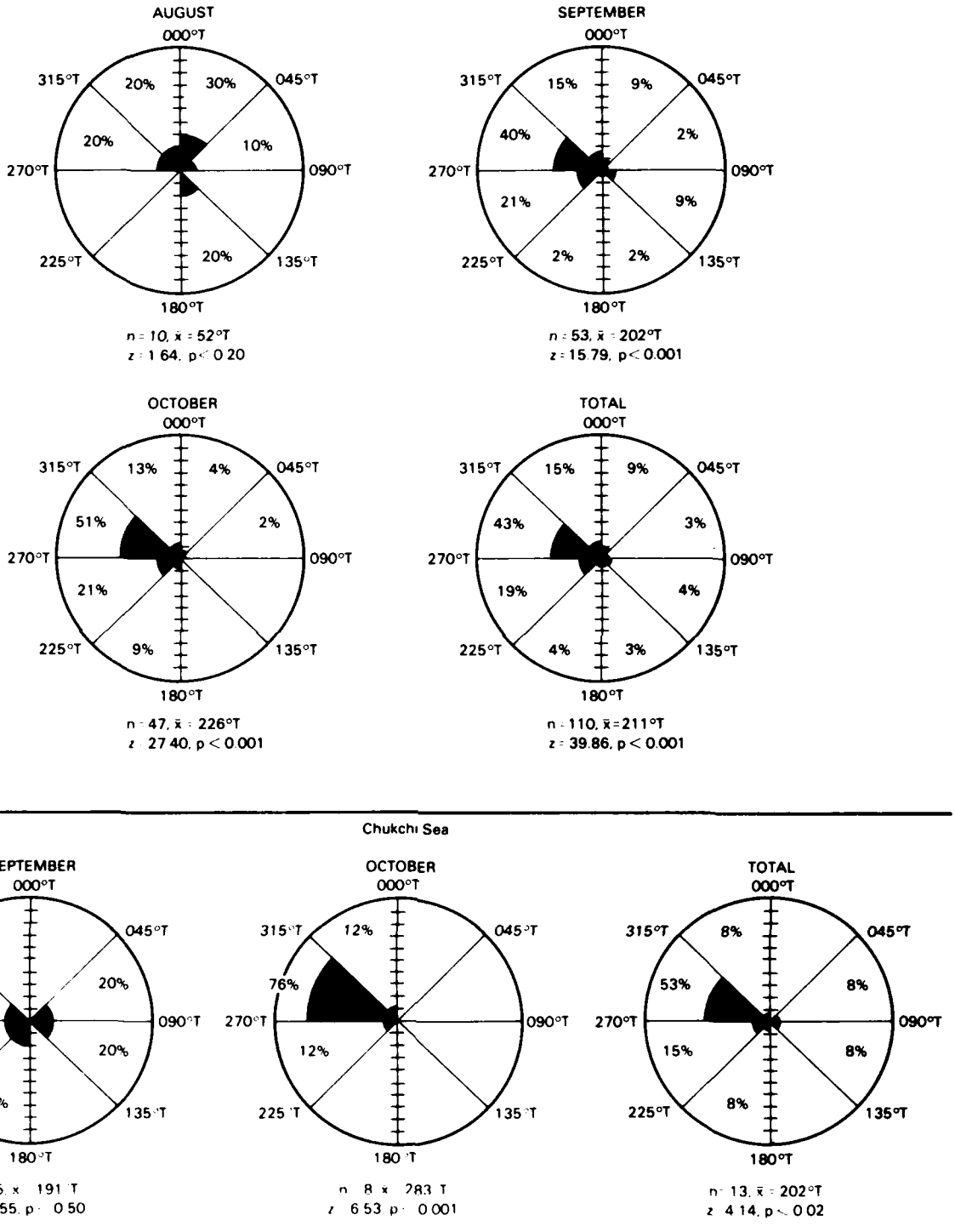


Figure 22. Bowhead swimming direction analysis, fall 1984.

heading in September but was in October (283° T), for an overall mean heading of 202° T.

Bowheads were found disproportionately in light-ice coverage (74 percent, n = 282) as most whales (64 percent, n = 243) were seen nearshore in mid- to late September when the Beaufort Sea was relatively ice-free (Table 16). Few bowheads (10 percent, n = 38) were found in August and early September when ice coverage was heavy. Perpendicular distance to whale sightings decreased with ice coverage, although not significantly ($r^2 = 0.18$, $p \leq 0.10$), thus ability to sight whales in heavier ice may bias these findings. Bowheads seemed to actively avoid contact with ice, as they were seen swimming around ice floes rather than diving under them. Similar avoidance has been noted in the past (Ljungblad et al., 1984a; Würsig et al., 1984). The only exception was on 10 October when one bowhead broke through heavy (99 percent) new ice to surface for a single breath.

Bowheads were found in shallow (0 to 50 m) and transitional (50 to 2,000 m) water depths throughout fall (Table 17). Mean depth for all sightings was 38.29 m (s.d. = 57.41 m) with most whales (91 percent, n = 347) in shallow water. The deepest sighting (529 m) was on 7 August in the Canadian Beaufort Sea.

Behavior and Sound Production

Thirty-seven-percent (n = 141) of all whales seen were swimming or diving, and 6 percent (n = 24) were resting (Table 18). More (39 percent, n = 148) bowheads were seen feeding in 1984 than in any previous year. Feeding whales were seen in three areas: east of Demarcation Bay (Appendix A: Flight 33); east of Kay Point, Canada (Appendix A: Flight 63); and east of Pt. Barrow (Appendix A: Flights 59, 61 and 65). The largest (n = 45-50) aggregations of feeding whales were seen near Pt. Barrow on three separate days over a six day period. On 22 September, three groups were seen near 71°23' N, 155°23' W within 3 to 5 km of one another. The largest group of 20 consisted of subgroups of two or three animals. The second and third groups, estimated at 11 and 13, respectively, were just west of the first group and consisted of single adults and a few juveniles in small groups of two to four. Subgroups of two to four whales exhibited synchronous diving and surfacing in muddied water. Displays (flipper and tail slaps, underwater blows, rolls, and spy hops) and social behaviors were also noted. The whales seemed to be water-column and bottom-feeding, and numerous birds, probably old squaws, Clangula hyemalis, were attracted to the sediment stirred up by the whales. Some of the whales surfaced with mud on their backs or

Table 16. Number (No.) and percent (%) of bowheads found in each ice coverage class, fall 1984.

Ice Coverage (%)	1-15 Aug No.	(%)	16-31 Aug No.	(%)	1-15 Sep No.	(%)	16-30 Sep No.	(%)	1-23 Oct No.	(%)	Total No.	(%)
0-10	0		12	(67)	13	(76)	234	(96)	23	(24)	282	(74)
11-20	0		0		2	(12)	6	(2)	3	(3)	11	(3)
21-30	0		2	(11)	0		1	(1)	1	(1)	4	(1)
31-40	0		0		2	(12)	0		17	(17)	19	(5)
41-50	1	(33)	1	(6)	0		2	(1)	12	(11)	16	(4)
51-60	2	(67)	0		0		0		2	(2)	4	(1)
61-70	0		0		0		0		1	(1)	1	(0)
71-80	0		0		0		0		7	(7)	7	(2)
81-90	0		0		0		0		25	(26)	25	(7)
91-100	0		3	(16)	0		0		8	(8)	11	(3)
TOTAL	3		18		17		243		99		380	

Table 17. Bimonthly summary of depths at bowhead sightings, fall 1984.

	1-15 Aug No.(%)	16-31 Aug No.(%)	1-15 Sep No.(%)	16-30 Sep No.(%)	1-23 Oct No.(%)	Total No.(%)
Shallow (0-50 m)	0	18(100)	14(82)	230(95)	85(86)	347(91)
Transition (50-2,000 m)	3(100)	0	3(18)	13(5)	14(14)	33(9)
Deep (over 2,000 m)	0	0	0	0	0	0
TOTAL	3	18	17	243	99	380

Table 18. Bimonthly bowhead behavior, fall 1984.

	1-15 Aug No.(%)	16-31 Aug No.(%)	1-15 Sep No.(%)	16-30 Sep No.(%)	1-23 Oct No.(%)	Total No.(%)
MIGRATORY						
Swim	2(67)	8(44)	13(76)	46(19)	60(61)	129(34)
Dive	0	0	4(24)	2(1)	6(6)	12(3)
SOCIAL						
Rest	1(33)	1(6)	0	7(3)	15(15)	24(6)
Feed	0	8(44)	0	138(57)	2(2)	148(39)
Mill	0	0	0	46(19)	0	46(12)
Cow-Calf	0	0	0	4(1)	6(6)	10(3)
Display	0	1(6)	0	0	10(10)	11(3)
TOTAL	3(1)	18(5)	17(4)	243(64)	99(26)	380

rostrums. About an hour after the initial sighting, whales were relocated at the same positions, but group size and behavior had changed. The second and most northerly group, originally estimated at 11 individuals, now consisted of seven animals that were dispersed and swimming steadily towards the southerly group which had increased from 13 to at least 17. There were 24 whales seen where the first group of 20 had been seen, but their behavior had not changed.

Feeding bowheads were sighted in the same area on 24 September, when a group of 15 whales was seen at 71°27' N, 155°40' W, with a second and larger group of 31 whales about 7 km to the west at 71°29' N, 155°57' W. Both groups exhibited feeding and social behaviors, as well as numerous displays, similar to those seen two days earlier. Whale movement between groups was again noted. The two separate groups formed a single large group of 70 whales (as observed by the crew aboard the aircraft monitoring bowhead whale and geophysical ship interactions), and whales were seen continuously swimming toward and joining this group from the west, while others left the group swimming east over a 70 minute period. No calves were seen.

Feeding bowheads east of Pt. Barrow were last seen on 28 September when 52 whales were seen in four groups in the area of 71°27' N, 155°28' W. They were observed only long enough to confirm group numbers and behavior. As on the two previous days of observation, no calves were seen in any group.

Breaching bowheads, other than those seen with feeding whales, were seen on four dates during the fall migration (29 August, 9, 14, and 17 October; Appendix A: Flights 42, 70, 74, and 77). The adult whale seen on 29 August breached at least twice, then tail-slapped for more than two minutes before resting at the surface. The breaching display on 9 October was north of Pt. Lonely near 71°30' N, 152°50' W and included at least eight adult bowheads. They were in an open water area approximately 20 km^2, which was oriented north-south and surrounded by 50-percent new ice. Nearly all breachers slapped their tails (up to 32 times in succession). Six other bowheads were observed swimming through the same area at slow (estimated < 2 km/hr) speeds interspersed among, and apparently unaffected by, the breachers. On 14 and 17 October, lone whales were seen breaching in 1-and 50-percent ice, respectively.

Most bowheads (67 to 88 percent, n = 237) swam at slow (< 2 km/hr) speeds in August and September (Table 19). In October, more whales were observed swimming at medium (30 percent, n = 29) and fast (>4 km/hr) speeds. No similar trend was noted in previous years.

Fewer (5 percent, n = 18) bowheads were judged to respond to the aircraft this year (Table 20) than in past years (Ljungblad et al., 1982, 1983, 1984a). The mean altitude at which bowheads responded to the aircraft (200 m), was significantly lower than the mean altitude during all other sightings (373 m, $t = 3.77$, $p \leq 0.001$). Positive responses were all from singles or pairs, except for one group of four that included a calf.

Fourteen AN SSQ-57A sonobuoys were dropped during the fall season (Table 21). Good recordings of bowhead whale sounds were obtained on 24 September and 3 and 9 October (Appendix A: Flights 61, 67, and 70). Bowhead calls were aurally (i.e., subjective listening) analyzed as in past years (Ljungblad et al., 1983, 1984a) and placed into simple or complex moan categories (Table 22). Simple moans are tonal, frequency modulated (FM) sounds often with harmonic structure and usually in the 20 Hz to 2 kHz frequency band. Simple moans were classified to five categories based upon temporal frequency modulation as follows:

FM_1 up = ascending frequency modulation

FM_2 down = descending frequency modulation

FM_3 constant = no discernable frequency modulation

FM_4 inflect = combined ascending and descending frequency modulation

FM_5 high = short calls starting above 800 Hz

Table 19. Bimonthly summary of bowhead swimming speeds, fall 1984.

	1-15 Aug No.(%)	16-31 Aug No.(%)	1-15 Sep No.(%)	16-30 Sep No.(%)	1-23 Oct No.(%)	Total No.(%)
Still 0 km/hr	1(33)	5(29)	--	13(5)	22(23)	41(11)
Slow 2 km/hr	2(67)	12(71)	13(87)	210(88)	39(41)	276(73)
Medium 2-4 km/hr	--	--	2(13)	16(7)	29(30)	47(12)
Fast 4 km/hr	--	--	--	1(0)	6(6)	7(2)
Unknown	--	1	2	3	3	9(2)
TOTAL	3	18	17	243	99	380

Complex moans are amplitude modulated (AM) sounds. Amplitude modulation may be rapid resulting in well-defined components (Watkins, 1967), or slow, resulting in non-uniform and varied component structure. Two categories of complex moans aurally recognized on the basis of frequency content are:

- AM_1 growl = low frequency calls with energy primarily below 1 kHz
- AM_2 trumpet = high frequency calls with energy primarily between 500 Hz and 4 kHz

Growls can (and do) grade into trumpets with a shift in frequency.

Occasionally simple or complex moans exhibited both FM and AM components. Aurally these calls sounded "complex" and were so categorized for the purpose of this initial analysis. The sound categories presented here are comparable to those reported by Würsig et al., (1982) for bowhead sounds recorded in the Canadian Beaufort Sea.

Of a sound sample containing 99 discrete calls, 77 percent were simple moans and 23 percent were complex moans. The four most common call types were inflect (28 percent), up (25 percent), growl (22 percent) and down (21 percent). These ratios are roughly comparable to those recorded in past fall seasons (Moore et al., 1984b). Most call samples were small ($\leq$30), and as yet no biological significance may be assigned to any of the call types.

Table 20. Bimonthly summary of bowhead whale response to aircraft, fall 1984.

	1-15 Aug No.(%)	16-31 Aug No.(%)	1-15 Sep No.(%)	16-30 Sep No.(%)	1-23 Oct No.(%)	Total No.(%)
Positive	2(67)	0	4(24)	1(1)	11(11)	18(5)
Negative	1(33)	18(100)	13(76)	242(99)	88(89)	362(95)
Total	3	18	17	243	99	380

Table 21. Summary of sonobuoy drops, fall 1984.

Date	Lat (N)	Long (W)	Species	Background
27 Aug	70°23.0'	140°30.3'	Belukha	Ambient
11 Sep	69°48.0'	140°02.0'	Bowhead	Seismic
18 Sep	71°00.3'	149°19.1'	Bowhead	Ambient
21 Sep	70°10.6'	141°37.2'	Bowhead	Seismic
22 Sep	71°23.5'	155°22.9'	Bowhead	Seismic
24 Sep	71°28.2'	155°53.1'	Bowhead	Ambient
24 Sep	71°14.2'	157°39.6'	Gray	Ambient
26 Sep	69°36.0'	139°34.6'	Bowhead	Ambient
3 Oct	69°23.1'	138°20.9'	Bowhead	Ambient
9 Oct	71°15.7'	152°43.9'	Bowhead	Industrial
9 Oct	71°30.8'	152°52.2'	Bowhead	Ambient
11 Oct	71°21.9'	157°09.9'	Bowhead	Seismic
17 Oct	71°05.8'	151°25.3'	Bowhead	Ambient
20 Oct	71°34.4'	154°18.6'	None	Seismic

Recruitment

Five calves were sighted during the 1984 fall migration (Table 23), which yielded a GARR (5 calves/380 whales) of 1.32 percent. Extensive effort was not expended circling over whale groups to search for calves, thus GARR may be biased downward. The crew studying the interaction between seismic vessels and bowheads spent hours studying group composition and dynamics, and sighted 16 calves among 325 total animals (Ljungblad et al., 1985, in preparation). This yields a GARR of 4.92 percent, and a combined GARR of 2.98 percent for the two aircraft.

Table 22. Results of initial aural analysis of bowhead calls recorded in fall 1984. No.(%) = Number (percent).

Date	Sample Duration[1]	No. of Whales	Call Rate[2]	General Behavior	Up No.(%)	Down No.(%)	Const. No.(%)	Inflect. No.(%)	Growl No.(%)	Trumpet No.(%)	Total No.	Noise	Comment
11 Sep	14"	4	0.04	swimming diving				2(100)			2	airgun aircraft	Faint calls
18 Sep	7"	4	0.64	resting swimming				14(78)	4(22)		18	aircraft	Faint calls
21 Sep	18"	3	0.24	swimming milling	8(62)	4(31)		1(7)			13	airgun static	Faint calls
24 Sep	10"	50	0.04	swimming feeding	4(21)	7(37)	2(11)	1(5)	5(26)		19	static	Spy-hop, tail-slap
26 Sep	6"	7	0.0	milling							0	aircraft static	
3 Oct	6"	8	0.62	resting swimming	11(37)	6(20)		5(17)	8(26)		30		Faint calls; whales near 50% ice
9 Oct	5"	3	1.13	resting swimming	2(12)	4(24)		5(29)	5(29)	1(6)	17		Faint Belukha
11 Oct	17"	2	0.0	resting							0	engine	Belukha calls
17 Oct	4"	1	0.0	swimming							0	distant airgun	small, light bowhead
TOTAL	87"				25(25)	21(21)	2(2)	28(28)	22(22)	1(1)	99		

1. Sample duration in minutes

2. Call rate = $\frac{\text{No. calls/No. whales}}{\text{sample duration}}$

Gray Whale

Distribution and Relative Abundance

Twenty-nine sightings of 115 gray whales were made in the northeastern Chukchi Sea in fall (Figure 23). With the exception of two sightings (of three animals) on 31 August, all gray whales were sighted within 50 km of the coastline between Icy Cape and Pt. Barrow. Ninety-seven gray whales (84 percent) were seen in block 13 yielding the highest WPUE, 5.82; the WPUE in block 17 was 3.27 (Table 24).

Habitat Relationships

Most gray whales (93 percent, n = 107) were seen in areas of light-ice coverage (0-20 percent ice), although often within 5 to 10 km of heavy ice. In October, seven gray whales (6 percent) were seen in 80-percent ice. Water depth at gray whale sightings ranged from 7 to 44 m ($\bar{x}$ = 29.72 m, s.d. = 11.52 m, n = 29).

Behavior

Gray whales were feeding (79 percent, n = 91) or swimming (21 percent, n = 24) (Table 25). Whales seen in blocks 12, 13, and 14 were predominantly feeding, but the majority (92 percent, n = 11) of those seen in block 17 were swimming south (125° T to 215° T).

Average group size for all gray whales in fall 1984 was 8.82 (s.d. = 9.62, n = 11; Table 26). As in summer, feeding whales were generally found in larger groups ($\bar{x}$ = 10.50, s.d. = 10.76, n = 8) than swimming grays ($\bar{x}$ = 4.33, s.d. = 4.04, n = 3), but the difference was not significant (t = 0.9414, df = 9, $p \leq 0.37$). There also was no significant difference in group size of those whales seen during summer and those seen in the Chukchi in fall (t = 1.3297, df = 18, $p \leq 0.10$).

In August, gray whale swimming direction was significantly clustered about the mean heading of 201° T (z = 3.97, n = 9, $p \leq 0.02$). In late September and October there was no significant clustering about any mean heading (z = 2.12, n = 9, $p \geq 0.20$). Gray whales seen in the northeastern Chukchi Sea from August to mid-October may have alternated feeding with migrating southwestward. When all gray whale headings (summer and fall included) in the northeastern Chukchi Sea were lumped for analysis there was significant clustering about the mean heading of 210° T (z = 4.54, n = 30, $p \leq 0.01$).

Table 23. Summary of bowhead calf sightings, fall 1984.

Date	Flt	Lat (N)	Long (W)	Heading (Mag)	Behavior
21 Sep	58	70°23.9'	141°42.7'	030°	swimming close to cow
26 Sep	63	71°27.2'	143°00.8'	220°	swimming alone
15 Oct	75	71°24.5'	154°42.9'	--	swimming in group of 4
17 Oct	77	71°19.8'	151°25.5'	220°	swimming in group of 3
22 Oct	81	71°07.6'	159°42.1'	210°	swimming close to cow

Gray and bowhead whales were found within 28 km of each other in the northeastern Chukchi Sea on two occasions (Appendix A: Flights 61 and 72), but they may be ecologically isolated by a number of factors, including depth (Sergeant, 1974). Gray whales in the northeastern Chukchi Sea were found in significantly shallower water ($x = 29.72$ m, s.d. = 11.52 m, $n = 29$) than bowheads ($x = 56.54$, s.d = 39.30, $n = 13$; $t = 3.41$, $p \leq 0.01$). They may also be temporally isolated. Gray whales were found as far north as 71°24' N, 156°33' W in the northeastern Chukchi Sea in late summer (28, 29 July, and 8, 31 August). On 24 September, bowheads were seen in the Chukchi Sea 28 km northwest of the northernmost gray whales found at 71°14' N, 157°45' W (Appendix A: Flight 61). On 11 October, bowheads were again seen in the Chukchi Sea approximately 28 km northwest of the northernmost gray whales at 71°12' N, 157°45' W (Appendix A: Flight 72). On October 22, two bowheads were seen offshore in block 13, but no gray whales were seen (Appendix A: Flight 81). It was assumed that the gray whales previously found near Pt. Barrow had begun their southward migration just prior to the arrival of the bowheads. Lack of survey effort due to poor flying conditions along the Chukchi coast (blocks 17, 18, 20) in October could not confirm this.

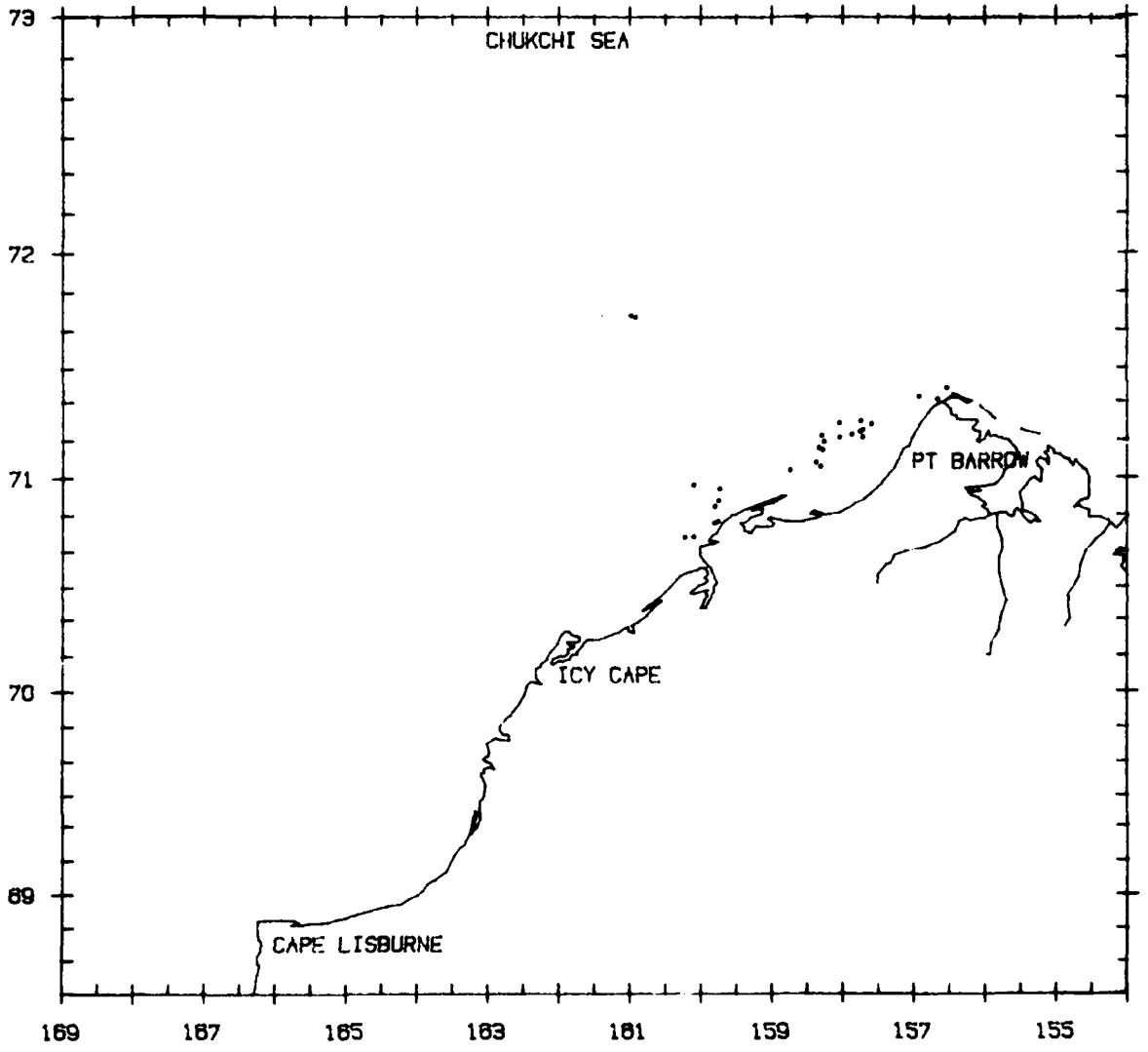


Figure 23. Distribution of 29 sightings (·) of 115 gray whales, fall 1984.

Table 24. Relative abundance of gray whales: whales per unit effort (WPUE) by block, fall 1984.

Block	Flights*	Hours**	Gray Whales	WPUE
12	20	23.57	3	0.13
13	11	16.66	97	5.82
14	6	5.18	3	0.58
15	2	2.20	0	0.00
17	6	3.67	12	3.27
18	1	0.10	0	0.00
20	1	3.63	0	0.00
TOTAL		55.01	115	2.09

*Flight is any traverse of a block.

**Hours do not sum to total survey time reported elsewhere (Table 13) due to flights in other blocks.

Table 25. Summary of gray whale behavior by block, fall 1984.

Block	Feeding No.(%)	Swimming No.(%)	Total No.(%)
12	2 (67)	1 (33)	3 (3)
13	85 (88)	12 (12)	97 (84)
14	3 (100)	0 (0)	3 (3)
17	1 (8)	11 (92)	12 (10)
TOTAL	91 (79)	24 (21)	115 (100)

Table 26. Gray whale group size analysis, fall 1984.

Group Size*	Feeding	Swimming	Total
$\bar{x}$	10.50	4.33	8.82
s.d.	10.76	4.04	9.62
No.	8	3	11
No. of solitary whales	7	11	18
No. of sightings	14	15	29

*Groups of two or more whales.

Other Species

Belukha Whale

Belukha whale distribution during the fall migration was generally north of the bowhead distribution (Figure 24). Less overlap occurred between the two species' distributions than during the spring migration when both migrated along nearly the same route and were often sighted together. There may be some ecological isolation (Sergeant, 1974) as belukhas are odontocetes and utilize larger prey, such as Arctic cod and squid. They also dive to 300 m and feed on benthic organisms (Wood and Evans, 1979).

The belukha and bowhead migration appeared to temporally coincide. Belukha whale headings were nonsystematic until September when there was significant clustering about the mean heading of 204° T ($z = 15.62$, $p \leq 0.001$). Belukhas sighted in October both east and west of Pt. Barrow maintained a westerly heading along the ice edge ($x = 218°T$, $z = 34.83$, $p \leq 0.001$).

The majority of belukhas (67 percent, $n = 531$) were seen swimming, and 16.8 percent ($n = 132$) of the whales were judged to be calves or immature.

Pinnipeds

Ringed and bearded seals were seen throughout the Beaufort Sea, especially in Harrison Bay, during the fall season. One hundred sixty-five ringed seals were seen: 53 (32 percent) in open water, 62 (37 percent) in 1- to 69-percent ice coverage and 50 (31 percent) in heavy ice ($\geq$70 percent) coverage. Of the 181 bearded seals seen, 88 (49 percent) were in open water, 64 (35 percent) were in 1 to 69-percent ice coverage and 29 (16 percent) were in heavy ice coverage. All seals ($n = 665$) were either swimming or resting (on the ice), and 48 percent ($n = 319$) could not be positively identified.

Three hundred and twelve walrus were seen from 8 August to 11 October (Table 27). Solitary animals or groups of two and three were often sighted in the water. Many ($n = 101$) were near or just west of Pt. Barrow (at approximately 71°20' N, 157°20' W) on the remnants of the winter ice. Six walrus were seen east of Pt. Barrow in the Beaufort Sea. There were few groups of walrus and no group had more than 100 animals.

Polar Bear

Twenty-two polar bears were seen between 8 August and 23 October. Five polar bears were seen in the Beaufort Sea in August; three were seen on

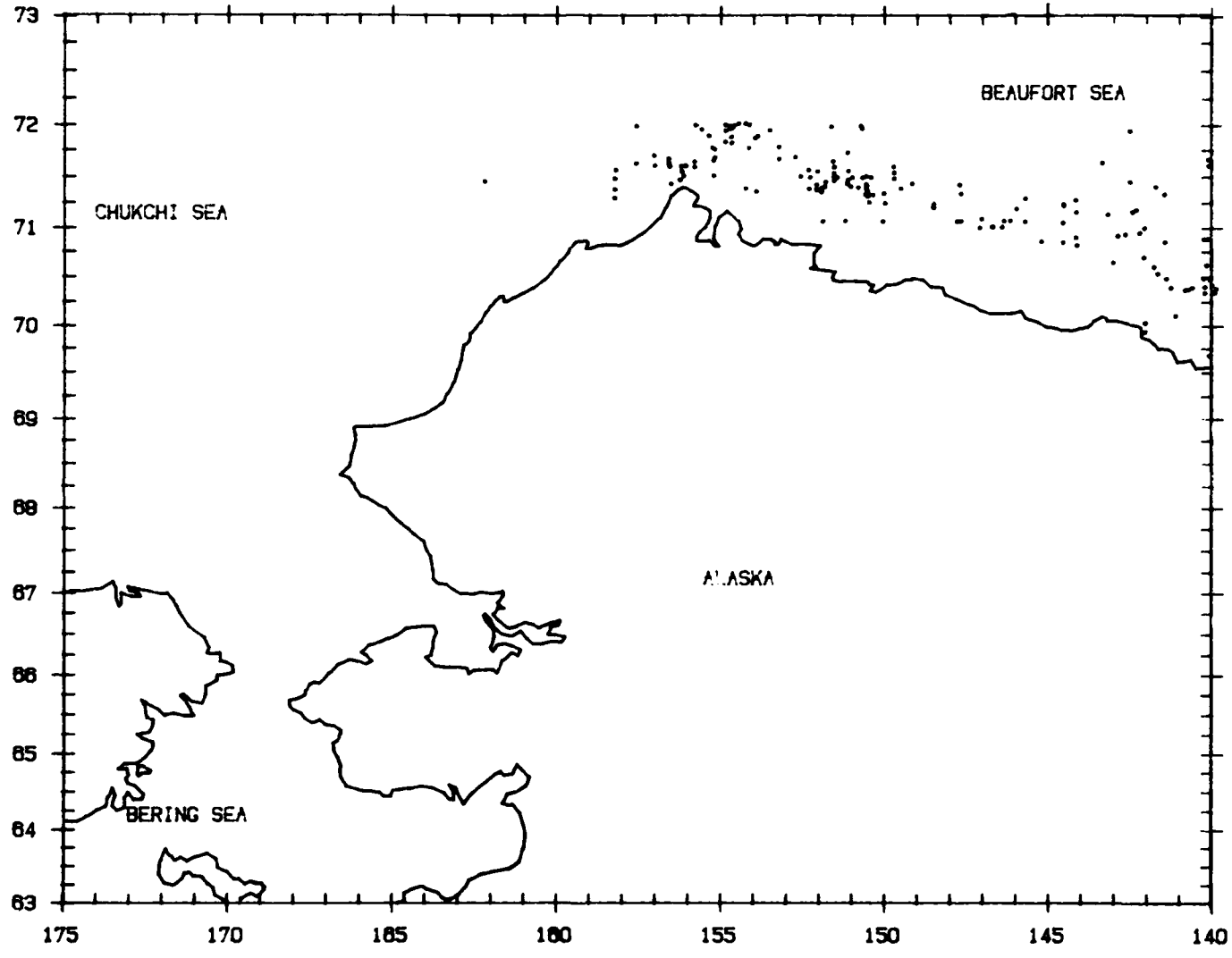


Figure 24. Distribution of 170 sightings (•) of 788 belukha whales, fall 1984.

Table 27. Summary of walrus sightings, fall 1984.

Date	Flt	Estimated Number	Latitude(N)	Longitude(W)
8 Aug	27	1	71°20.9'	157°13.7'
		1	71°17.4'	158°03.0'
		1	71°14.2'	159°25.2'
		1	71°11.7'	160°21.4'
		1	71°35.7'	159°38.2'
		25	71°28.7'	157°16.1'
30 Aug	43	3	71°19.0'	157°46.8'
		12	71°18.3'	157°58.4'
		1	71°09.8'	160°42.4'
		1	71°48.6'	164°22.6'
		35*	71°22.0'	157°32.8'
		1	71°19.9'	156°59.2'
31 Aug	44	1	71°24.8'	157°20.6'
		35*	71°25.8'	157°29.9'
		10	71°26.6'	157°37.2'
		1	71°24.1'	162°23.6'
		25	71°22.0'	162°18.0'
		1	70°58.6'	160°54.7'
		1	70°59.3'	159°46.3'
		2	71°03.9'	159°46.3'
		1	71°07.9'	159°45.2'
		6	71°50.9'	159°40.4'
		1	71°33.3'	159°12.1'
		1	71°10.9'	159°08.0'
		1	71°06.1'	159°06.5'
		4	71°10.9'	158°50.7'
		4	71°11.4'	158°16.2'
		2	71°02.6'	157°51.1'
22 Sep	59	1	71°47.3'	154°46.8'
24 Sep	61	1	71°26.2'	156°24.0'
		1	71°22.0'	157°18.3'
		2	71°13.0'	159°20.6'
		2	71°50.2'	159°43.6'
		1	71°10.3'	159°39.5'
		1	71°11.2'	160°10.4'
		1	71°49.1'	159°22.5'
		2	71°28.4'	157°31.4'
28 Sep	65	1	71°40.1'	162°16.0'
		1	71°42.5'	162°16.7'
		100*	71°47.0'	162°49.6'
		15	71°30.1'	162°52.2'
		1	71°22.4'	155°48.7'
4 Oct	68	1	71°16.2'	154°59.3'
		1	71°30.1'	155°46.9'
11 Oct	72	1	71°38.8'	154°01.4'
TOTAL		312		

*Approximate position of large aggregations.

26 August: one at 71°43.7' N, 145°45.2' W, approximately 185 km offshore and two, a sow and small cub, at 70°42.1' N, 143°51.5' W, approximately 68 km due north of Barter Island (Appendix A: Flight 39). Two more bears were seen on 27 August at 71°23.1' N, 140°52.7' W, approximately 175 km northeast of Barter Island (Appendix A: Flight 40).

Seven bears were seen in August in the northeastern Chukchi Sea. The first was sighted at 71°25.5' N, 159°40.4' W on 1 August, approximately 120 km west of Barrow (Appendix A: Flight 22). Three bears were seen on 30 August: the first at 71°11.5' N, 160°17.2' W; the second two, a sow and cub, at 71°43.0' N, 163°43.6' W, approximately 270 km northwest of Barrow (Appendix A: Flight 43). Three bears were seen on 31 August: two at a kill site at 71°45.0' N, 161°15.0' W and one, swimming underwater, at 71°45.6' N, 163°50.0' W, approximately 275 km northwest of Barrow (Appendix A: Flight 44).

Four bears were seen in September, all in the Beaufort Sea. One bear was seen at 70°23.9' N, 142°20.2' W on 6 September (Appendix A: Flight 45). Two bears, a sow and cub, were seen on 13 September at 71°02.1' N, 145°14.0' W (Appendix A: Flight 50). On 18 September one bear was seen north of Flaxman Island (70°32.5' N, 146°36.3' W) feeding on the carcass of an small (estimate 6m) bowhead (Appendix A: Flight 55). Photographs showed that the jaw, head and ano-genital area of the bowhead had been eaten.

Six bears were seen in mid-October. Two bears were seen northwest of Pt. Barrow (71°58.9' N, 157°05.2' W) on 21 October (Appendix A: Flight 80). Four were seen on 23 October, one at 71°09.1' N, 153°20.3' W, and three (including two cubs) at 70°59.2' N, 150°41.9' W (Appendix A: Flight 82).

CONCLUSIONS AND REVIEW, 1979-1984

This section represents a review and synthesis of data gathered on aerial surveys of endangered whales conducted between 1979 and 1984. Efforts and results have appeared separately in annual reports finalized as NOSC technical documents or technical reports (Ljungblad, 1981; Ljungblad et al., 1980, 1982, 1983, 1984a). Here, the 1984 results are compared to a five-year summary (1979-1983) presented in Ljungblad et al. (1984a).

The objectives and methods of data collection and analysis have remained similar throughout all years with the exception of the use of a microcomputer aboard the aircraft since 1982 to record and later analyse data. Bowhead and gray whales have been the principal species studied over the years due to their endangered status, and are the only species addressed in this review. Sightings of all other marine mammals may be referenced in the annual reports.

This review is presented by species following the seasonal format of the field efforts: spring (April, May); summer (July); fall (August, September, October). Retaining this format resulted in 30 flights being excluded from review, including 13 flights in the Beaufort Sea in June 1980 during which 16 bowheads were seen, four flights in the northern Bering Sea in November 1980 during which 134 gray whales were seen, and 13 flights in the northern Bering Sea in June 1981 during which 152 gray whales were seen. The objectives for each season are briefly stated prior to presentation of the summary data.

BOWHEAD WHALE

Spring (April, May)

The primary objectives of spring aerial surveys have been to determine the distribution and timing of the bowhead migration, and to derive relative and/or absolute abundance estimates in or near proposed or existing federal lease areas. Bowhead behavior and sound production have been summarily recorded in association with these efforts.

Survey Effort and Conditions

A total of 487.8 survey hours have been flown in spring since 1979 with 43 percent (210.6 hrs) of this effort in the Beaufort Sea, 24 percent (116.6 hrs) in the Chukchi Sea, and 33 percent (160.6 hrs) in the northern Bering Sea (Table 28).

Table 28. Summary of hours of flight effort by sea, spring 1979-1984.

	1979	1980	1981	1982	1983	1984	Total	(%)
Bering Sea	-	21:28	93:10	28:19	6:08	11:33	160:38	(33)
Chukchi Sea	12:06	24:02	17:18	19:31	9:52	33:44	116:33	(24)
Beaufort Sea	29:15	29:25	54:50	40:13	47:39	9:16	210:38	(43)
TOTAL	41:21	74:55	165:18	88:03	63:39	54:33	487:49	(100)

The annual timing and extent of surveys in each sea has varied somewhat with extant ice conditions, MMS requirements, and input from the expanding data base. Until 1983, most effort was comprised of search surveys directed toward finding and observing migrating bowheads. In 1983 and 1984, effort shifted to transect surveys in the northeastern Chukchi and western Beaufort Seas to better define bowhead distribution and temporal abundance during the spring migration.

Spring ice conditions ranged from 80- to 100-percent coverage in all seas each year. Annual open water areas were found north of Gambell on St. Lawrence Island, north and south of Cape Prince of Wales, and as part of a recurring nearshore lead system extending from Cape Thompson to and around Pt. Barrow (Figure 4). In the Beaufort Sea, this lead system degenerated to over 90-percent ice coverage by 152°00' W and was no longer recognizable as a distinct lead. Examination of satellite imagery over the last four years (1981 to 1984) indicates that ice breaks up at these locations in March or April and that these areas remain relatively open throughout the spring.

Spring weather conditions were generally good. The predominant heavy ice coverage lowered the sea state to as low as 00 to 04 in most areas.

Distribution and Density

There were 955 sightings of 2,842 bowheads made over the six spring seasons (Figure 25). Bowhead spring distribution generally corresponds to open water areas that develop annually during ice breakup. The plotted distribution for 1979 through 1984 corresponds well with that reported in Braham et al. (1980) for spring bowhead sighting data collected between 1974 and 1979.

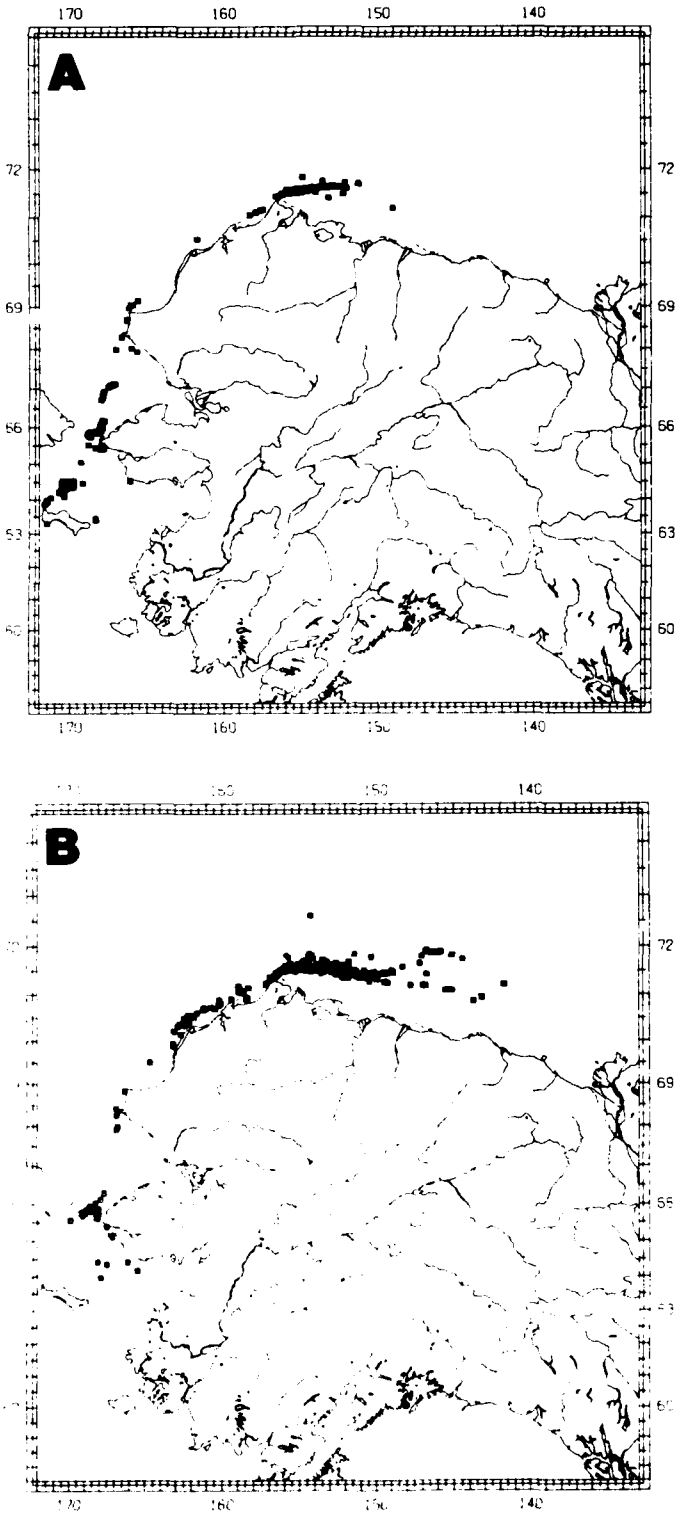


Figure 25. Distribution of 955 sightings (□) representing 2,842 bowheads plotted by month, spring 1979-1984: April (A); May (B).

The distribution of 237 bowheads seen in 1984 (Figure 5) was comparable to previous springs, with the exception of two whales seen south of the Bering Strait on 26 April (Appendix A: Flight 2), four whales and one bowhead ice track found near Cape Thompson on 29 April (Appendix A: Flight 5), and 19 whales seen along the northern edge of the lead north of Pt. Barrow on 7 May (Appendix A: Flight 11). Additionally, bowheads were regularly sighted in April, from the village of Gambell, St. Lawrence Island, and two whales were seen west of the nearshore lead near Cape Lisburne ((69°34.4' N, 167°48.2' W and 69°07.2' N, 167°29.6' W) by Alaska Department of Fish and Game (ADFG) researchers in 1984.

Highest annual bowhead densities have been calculated for regions* north of St. Lawrence Island, north of Cape Prince of Wales, the coastal area between Kivalina and Cape Lisburne, and northeast of Pt. Barrow (Figure 26). In 1984, higher densities were calculated in the Beaufort Sea for subregions A3 (0.269 whales/nmi^2), A4 (0.359 whales/nmi^2), and B4 (0.114 whales/nmi^2) than for any previous spring (Appendix B: Table B-2). Although these densities are nearly twice those calculated for these subregions in prior years, they are only about half that of the highest density calculated for the Chukchi Sea (0.666 whales/nmi^2, region 12) or the northern Bering Sea (0.722 whales/nmi^2, region 6) in 1980 and 1981, respectively.

Annual variation in observed bowhead distribution and density may be due to differences in survey effort and temporal/spatial variability in whale concentrations. Bowheads typically migrate in aggregations or pulses (Braham et al., 1980; Bruggeman, 1982) in spring, thus survey results are dependent upon the relative timing of the migration and the sampling effort. Bowheads were never seen in existing or proposed Beaufort Sea Federal lease areas (subregions: B1-3, C1-4, D1-4) as these areas usually remain covered by shorefast ice through May.

Migration Timing and Habitat Relationships

The bowhead spring migration coincides with the first "deterioration" of solid floe ice in the Bering Sea (Fay, 1974). Bowhead daily abundance indices were highest on 29 April (WPUE = 4) and 8 May (WPUE = 27) in 1984. The timing of these peaks, with a nine-day interval between them, is similar to that found in

*Regions depicted are those used for density calculation since 1981. Please see Appendix B, Methods, for a description of their derivation.

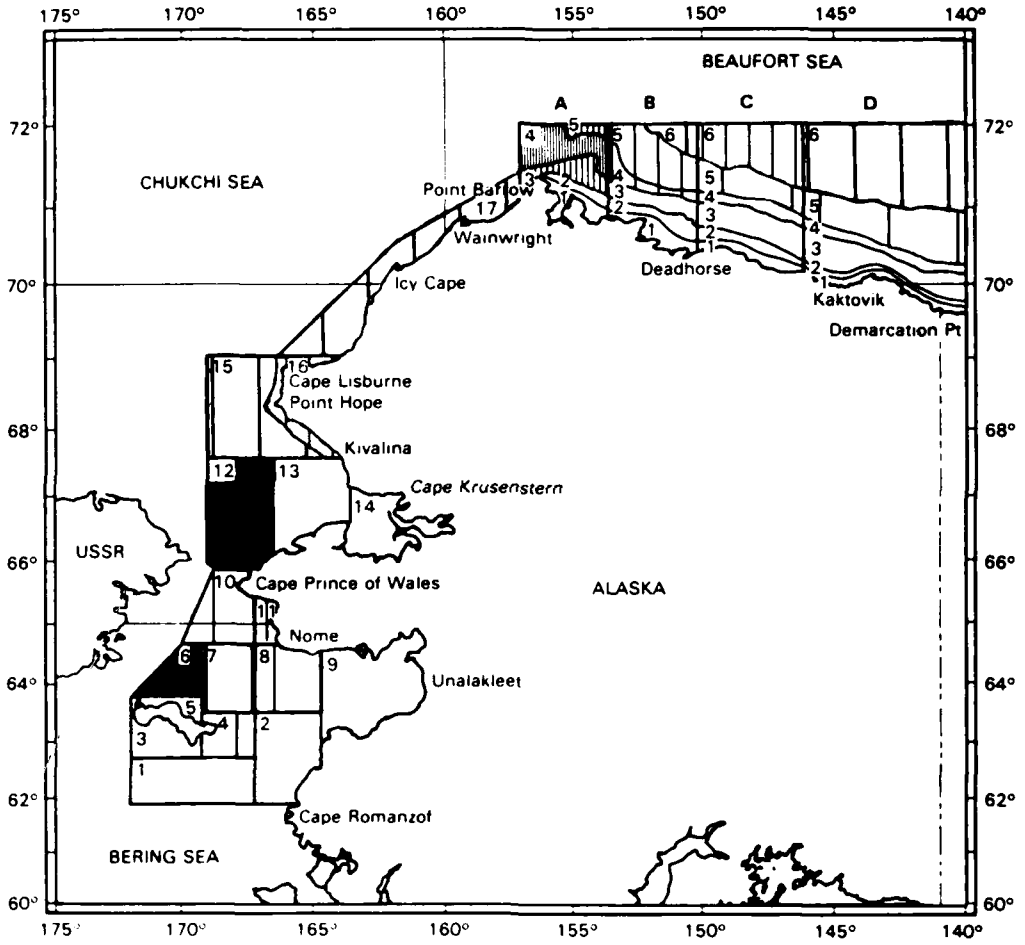


Figure 26. Highest annual bowhead densities/region, spring 1979-1984. Shading varies from white (representing 0 density) to black (representing 0.722 whales/nmi^2 density). Data based on annual subregional densities presented in Table B-2.

past years, with the exception of 1980 (Table 29). Peaks in temporal and geographic abundance indices along the migration may be related to wind-driven fluctuations in ice conditions near coastal promontories and the Bering Strait. In 1984, WPUE peaks were calculated for blocks near Cape Prince of Wales (WPUE = 2.18), between Pt. Hope and Cape Lisburne (WPUE = 6.64) and northeast of Pt. Barrow (WPUE = 20.91). The nearshore lead from Cape Lisburne to Pt. Barrow is alternately ice-free and ice-bound throughout April and May. Such temporary ice blockages may delay migratory progress and influence local temporal abundance estimates. The clearest evidence of ice influence on migratory timing was observed in 1980 when heavy-ice blocked the Bering Strait for nearly three weeks and WPUE peaks were approximately 20 days later than those reported for any other year.

Bowheads migrate through restricted open water areas in predominantly ice covered seas throughout the spring. Whales have been seen in 10- to 98-percent ice coverage since 1979, with the majority (approximately 70 percent) of sightings in 70-percent ice coverage.

This was the first year swimming direction was significantly clustered about a mean heading (030° T) in the Chukchi Sea, but significant clustering around 092° T in the Beaufort Sea is similar to that observed in past years (Ljungblad et al., 1984a).

Behavior and Sound Production

Bowhead behaviors observed during the 1984 spring migration were similar to past years, as most whales (57 percent, n = 135) were migrating (Table 30). More whales were seen displaying than in other years, especially in the Beaufort Sea just east of Pt. Barrow (37 percent, n = 64). Mud-covered whales, which behaved as if feeding, were noted in the same general area. Although a recent report suggests bowheads may actively feed in the northern Bering Sea in spring (Hazard and Lowry, 1984), bowheads are generally thought to feed little during the spring migration (Lowry and Burns, 1980; Marquette et al., 1982). The observation of mud-covered whales near Pt. Barrow indicates that bowheads may sample the bottom for prey and perhaps feed opportunistically, at intervals along the migration route.

A cow-calf pair was the only whales that reacted noticeably to the aircraft during the spring migration, a much lower rate (<1 percent) of potential disturbance than in other years (13 percent in 1982, 41 percent in 1983).

Table 29. Timing of pulses during bowhead spring migration past Pt. Barrow, as determined by WPUE/date, 1979 - 1984.

Year	First Pulse	Interval (days)	Second Pulse
1979	2 May	8	10 May
1980	22 May	7	29 May
1981	1 May	8	9 May
1982	4 May	9	13 May
1983	2 May	8	10 May
1984	29 April	9	8 May

Only two sounds were recorded near two whales seen in the northern Bering Sea in spring 1984. This is a much smaller sample than that recorded in 1982 (n = 759) or 1983 (n = 385) (Moore et al., 1984b). The small sample size was due to little flight effort devoted to remaining near sonobuoys to make recordings.

Recruitment

The 1984 GARR of 0.84-percent was the highest for any spring season. There were no calves seen in 1979, 1981, or 1983; and calculated GARR was 0.45-percent and 0.75-percent in 1980 and 1982, respectively. There is some evidence of age-class segregation in the bowhead migration, with cows and calves not seen at Barrow until late May or June (Braham et al., 1980). Thus, the low GARRs in spring may be the result of not encountering cow-calf groups due to the timing and placement of survey effort.

The two calves seen in the spring were less than half the size of their associated cows (0.44 and 0.39). These ratios (see Methods section) are larger than the single sample (0.36) from May 1982, but similar to the weighted mean of August and September ratios (0.42, n = 60) (Table 31).

Fall (August-October)

Survey Effort and Conditions

A total of 1,378.7 hours of survey effort has been flown in fall since 1979 with 86 percent (1,184.4 hrs) of this effort in the Beaufort Sea, 10 percent

Table 30. Summary of bowhead behavior in the Bering, Chukchi and Beaufort Seas, spring 1979 - 1984.

Behavior	Year	Bering Sea No.(%)	Chukchi Sea No.(%)	Beaufort Sea No.(%)	Total No.(%)
MIGRATORY					
Swim	1979	-	-	17(100)	17
	1980	0(0)	9(33)	54(44)	63
	1981	0(0)	18(56)	140(68)	158
	1982	3(100)	23(39)	137(69)	163
	1983	3(100)	19(90)	143(74)	165
	1984	2(100)	35(58)	93(53)	130
	Total	8(5)	104(52)	584(64)	696(55)
Dive	1980	0(0)	16(59)	62(50)	78
	1981	2(4)	2(6)	38(19)	42
	1982	0(0)	13(22)	11(6)	24
	1983	0(0)	0(0)	18(9)	18
	1984	0(0)	3(5)	2(1)	5
	Total	2(1)	34(17)	131(14)	167(13)
SOCIAL					
Rest	1980	77(83)	0(0)	5(4)	82
	1981	14(26)	12(38)	9(4)	35
	1982	0(0)	16(27)	16(8)	32
	1984	0(0)	2(3)	0(0)	2
	Total	91(59)	30(15)	30(3)	151(12)
Mill	1980	12(13)	0(0)	0(0)	12
	1982	0(0)	2(3)	21(11)	23
	1984	0(0)	6(10)	15(9)	21
	Total	12(8)	8(47)	36(4)	56(4)
Mate	1981	26(49)	0(0)	0(0)	26
	1982	0(0)	3(5)	9(5)	12
	1983	0(0)	2(10)	24(12)	26
	1984	0(0)	7(11)	0(0)	7
	Total	26(17)	12(6)	33(4)	71(6)
Cow-Calf	1980	0(0)	2(8)	4(2)	6
	1982	0(0)	2(3)	2(1)	4
	1984	0(0)	4(6)	0(0)	4
	Total	0(0)	8(4)	6(1)	14(1)
Display	1980	4(4)	0(0)	0(0)	4
	1981	11(21)	0(0)	18(9)	29
	1982	0(0)	0(0)	3(2)	3
	1983	0(0)	0(0)	8(4)	8
	1984	0(0)	3(5)	64(37)	67
	Total	15(10)	3(1)	93(10)	111(9)

Table 31. Calf/cow size ratio summary, spring 1981-1984.

Year	Month	n	$\bar{x}$	s.d.	Range	Source
1981	Sep	1	0.48	-	-	Ljungblad et al., 1982
1982	May	1	0.36	-	-	Ljungblad et al., 1983
1982	Aug, Sep	42	0.41	-	.33-.45	Davis et al., 1983
1982	Aug, Sep	9	0.47	.06	.39-.57	Ljungblad et al., 1983
1983	Aug, Sep	7	0.44	.03	.40-.48	Cubbage et al., 1984
1983	Sep	1	0.45	-	-	Ljungblad et al., 1984a
1984	May	2	0.42	.04	.39-.44	This report

(145.1 hrs) in the Chukchi Sea, and 4 percent (49.2 hrs) in the northern Bering Sea (Table 32). The 1984 effort was roughly comparable to that of 1982 and 1983. From 1979 to 1981, surveys were flown primarily in the Beaufort Sea with little time spent in the Chukchi Sea. Surveys were flown in the northern Bering Sea only in August 1981 and October 1980.

In 1984, ice coverage in the Beaufort and Chukchi Seas was generally heavy throughout August (70 to 90 percent); it became and remained light (10 percent) throughout September, and began to build again with the first new ice observed on 2 October 1984. These conditions are similar to those encountered in 1979, 1981, and 1982. In 1980 and 1983, ice coverage remained heavy (60 to 90 percent) in the Beaufort and northeastern Chukchi Seas throughout the fall.

Fall 1984 weather conditions in the Beaufort Sea were generally poor in August and early September. Many surveys had to be curtailed or aborted due to fog and/or precipitation. Conditions improved by mid-September, and were generally good throughout October. In the Chukchi Sea, weather conditions were usually poor throughout the fall with fog and precipitation reducing visibility on portions of most flights. These conditions were similar to those encountered in the Chukchi Sea in previous years.

Distribution and Density

There were 813 sightings of 1,573 bowheads made over six fall seasons (Figure 27). The monthly distribution of 380 bowheads seen in 1984 (Figure 19) is

Table 32. Summary of hours of flight effort by sea, fall 1979-1984.

	1979	1980	1981	1982	1983	1984	Total	(%)
Bering Sea	0	34:05	14:39	0	00:31	0	49:15	(4)
Chukchi Sea	5:15	15:56	12:18	25:10	52:28	34:00	145:07	(10)
Beaufort Sea	187:04	184:41	145:58	214:10	234:35	217:58	1184:26	(86)
TOTAL	192:19	234:42	172:55	239:20	287:34	251:58	1378:48	(100)

similar to that of past years. Bowheads have been found in August east of 146° W in the Alaskan Beaufort Sea; in 1984 all whales in August were east of 142° W. In September, whales were found across the Beaufort Sea, generally along the continental shelf break, and into the northern coastal Chukchi Sea. In October, whales were again found along the shelf break across the Beaufort Sea, with more seen west of 150° W and in the northeastern Chukchi Sea than in September.

Highest annual bowhead densities were calculated for 1979-1984 for subregions D5 (0.015 whales/nmi^2) in August, subregion A2 (0.266 whales/nmi^2) in September, and subregion B3 (0.169 whales/nmi^2) in October (Figure 28). The unusually high densities calculated for subregions A2 (0.266 whales/nmi^2), A3 (0.176 whales/nmi^2), and A4 (0.139 whales/nmi^2) in September 1984 were the result of recurrent sightings of feeding bowheads near Pt. Barrow between 22 and 28 September. Highest densities calculated for these subregions between 1979 and 1983 ranged from 0.0 to 0.029 whales/nmi^2. Prior to 1984, highest bowhead density in September had been calculated for subregion C3 (0.078 whales/nmi^2).

Migration Timing and Habitat Relationships

The timing and character of the fall bowhead migration across the Alaskan Beaufort Sea may be related to the extent of ice coverage and its effect on prey productivity and resultant bowhead feeding opportunities. Ice coverage limits primary, and, therefore, secondary productivity (i.e., bowhead food) by deflecting and diffusing incident light (Schell et al., 1982). The trend, described for five years of data, was for migrations in light-ice years to be longer, to result in a higher and later WPUE, and to be comprised of more feeding whales than

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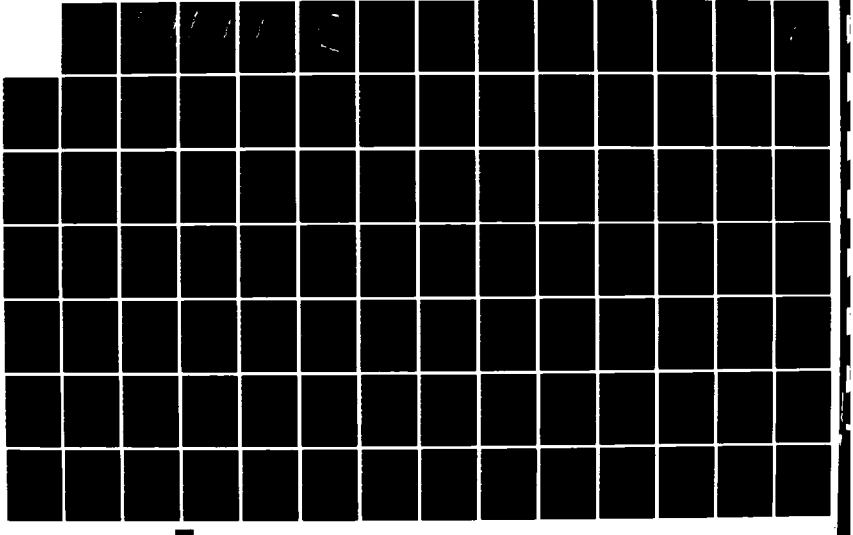

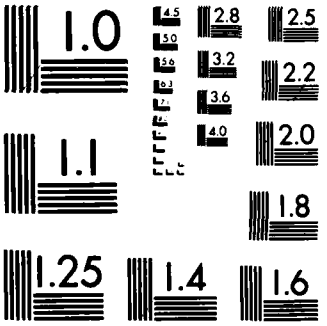

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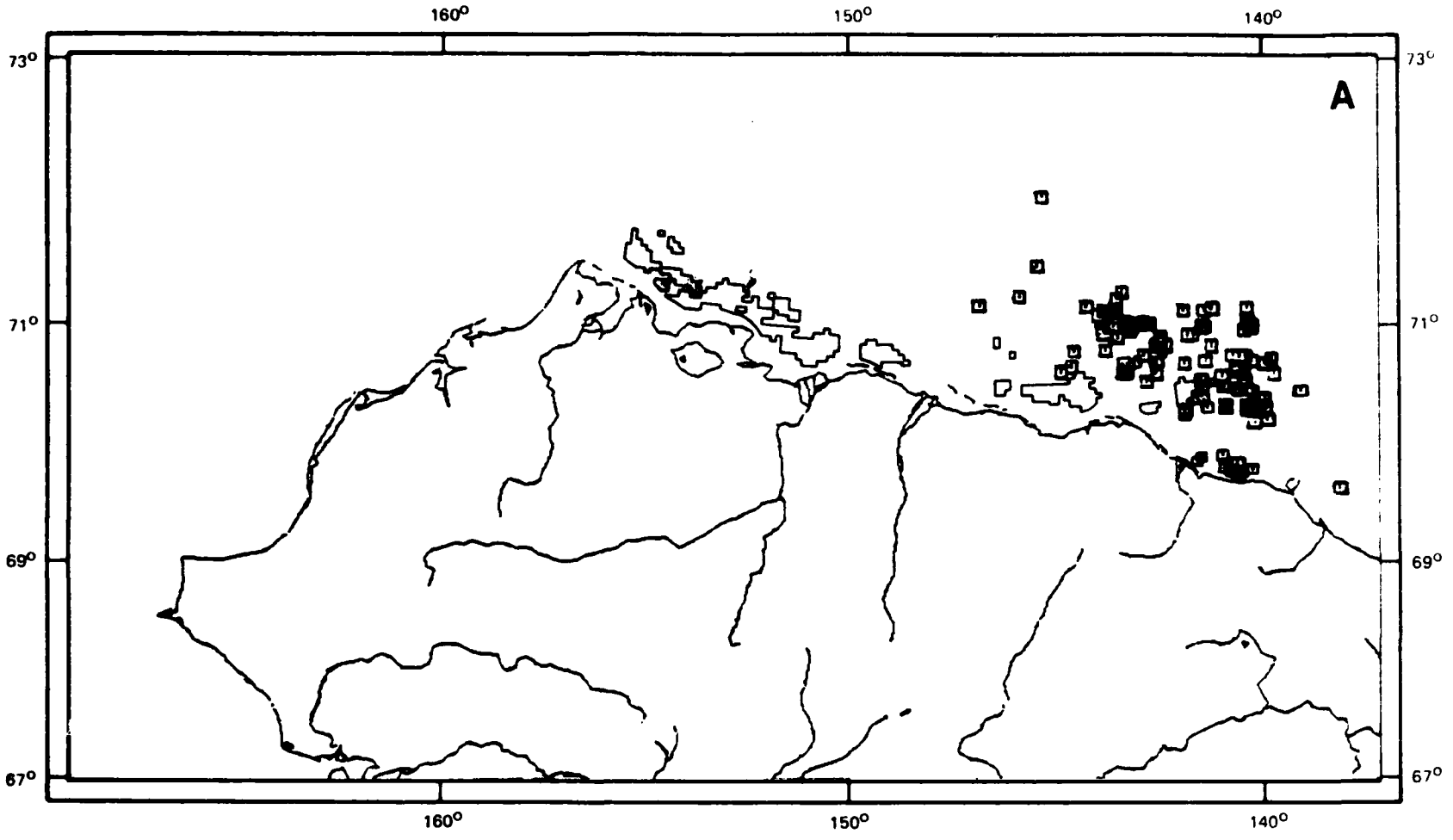

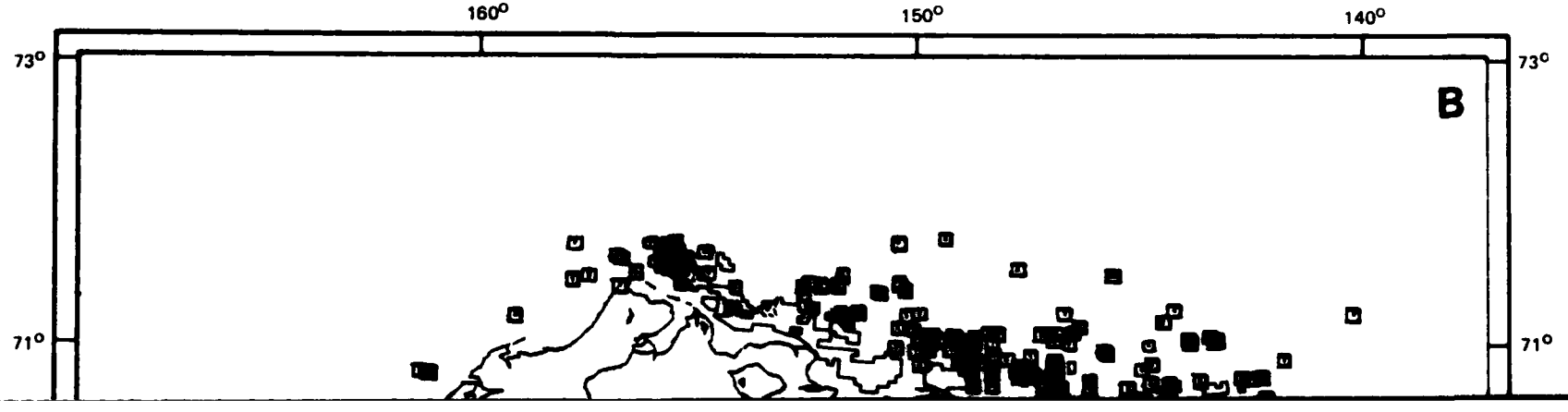

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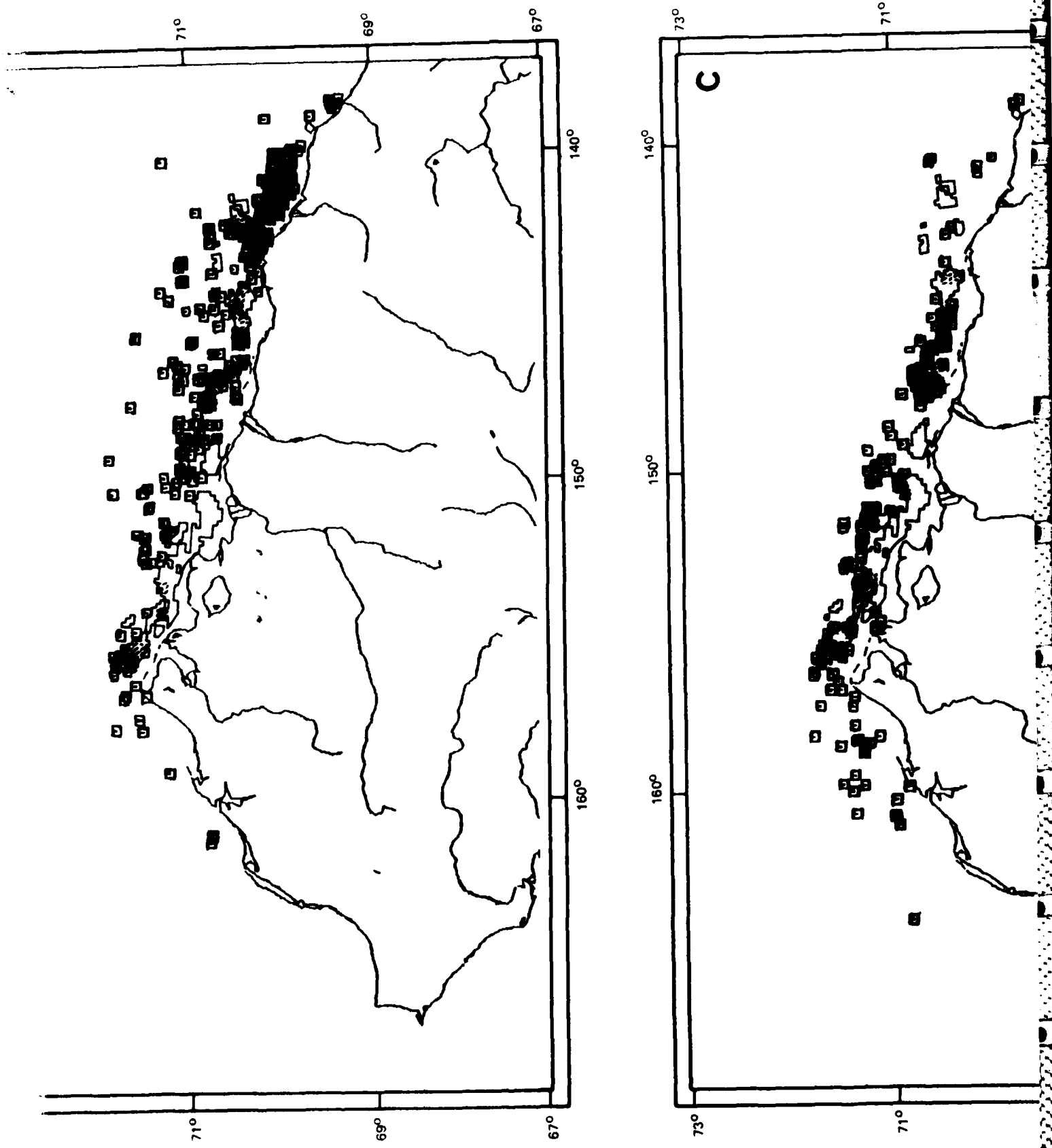

Figure 27. Distribution of 813 (□) sightings of 1,573 bowheads plo
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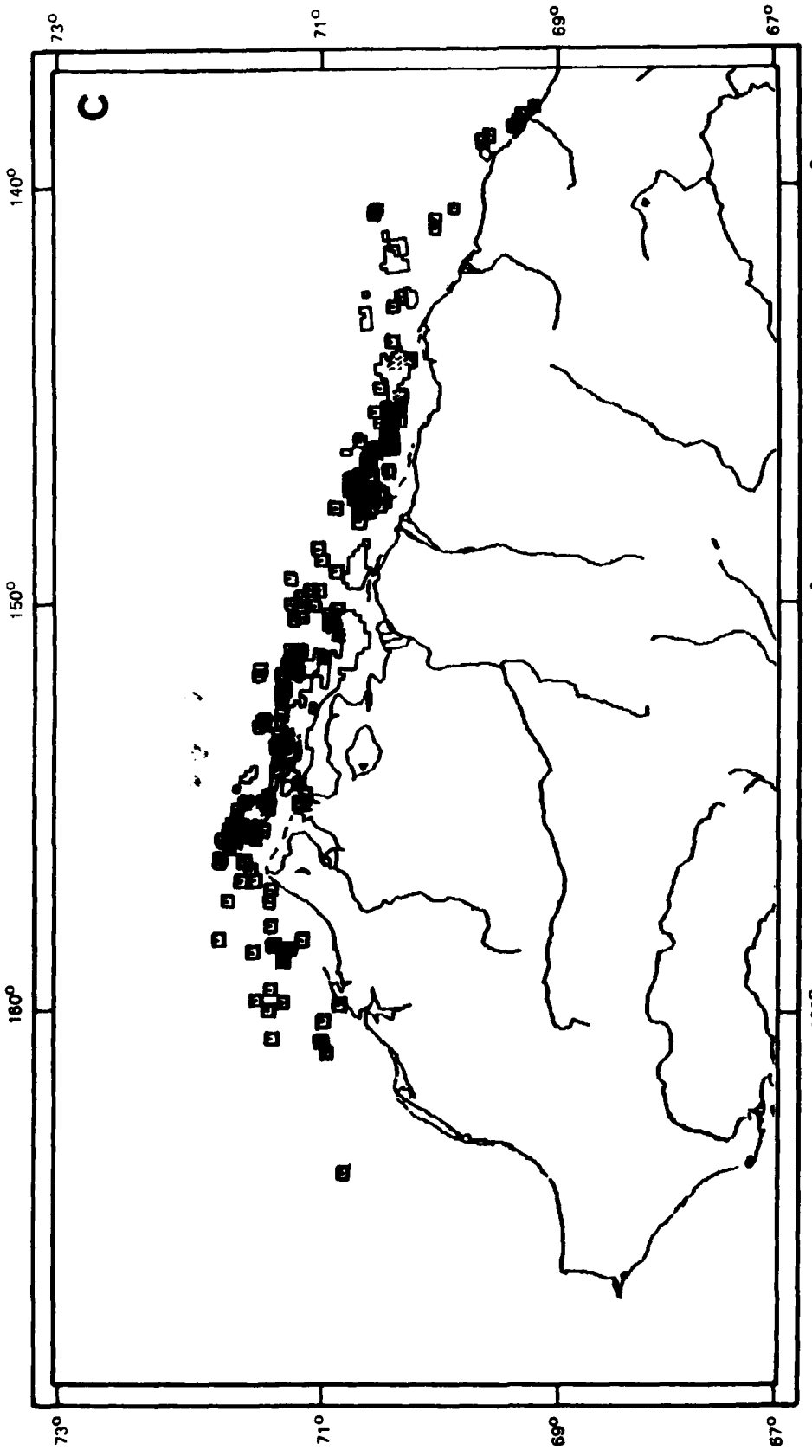

ution of 813 (□) sightings of 1,573 bowheads plotted by month, gust (A); September (B); October (C). Outlined areas depict n Diapir Field Planning Area of the Alaskan Beaufort Sea.

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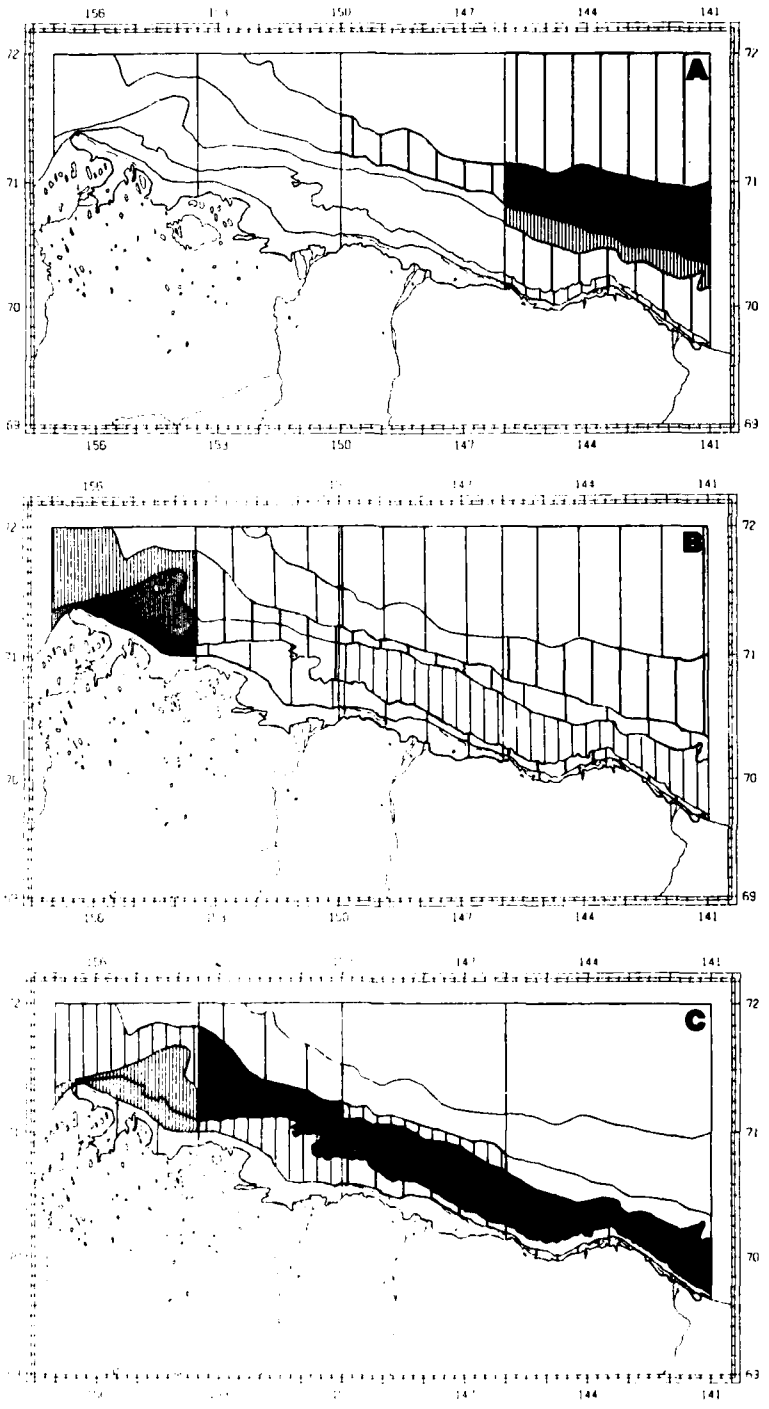


Figure 28. Highest annual bowhead densities/region calculated by month, fall 1979-1984. Shading varies from white (representing 0 density) to black representing: 0.015 whales/nmi^2, August (A); 0.266 whales/nmi^2, September (B); 0.169 whales/nmi^2, October (C). Data based on annual subregional densities presented in Tables B-3 through B-8.

migrations in heavy-ice years (Ljungblad et al., 1984b). As previously noted, the ice conditions encountered in 1984 were most like those of 1979, 1981, and 1982 (termed light-ice years in Ljungblad et al., 1984b).

The 1984 bowhead migration extended from 7 September to 20 October, a time period (44 days) identical to that observed in 1983 and similar to that found since 1981 (Table 33). Migratory period is determined by the date that bowheads are observed swimming in a predominantly westerly direction (initiation), and the date that the last whale is seen in the Beaufort Sea (termination), thus its calculation is effort dependent. Since 1979, zero to 11 surveys have been flown after the termination date; since 1981, zero to three surveys have been conducted after the last whale sighting.

Table 33. Summary of average September ice coverage, bowhead migration timing, peak WPUE date, and number of feeding bowheads in the Alaskan Beaufort Sea, fall 1979 - 1984.

	1979	1980	1981	1982	1983	1984
Average September Ice Coverage	0/10 - 1/10	6/10 - 9/10	0/10 - 1/10	0/10	6/10 - 9/10	0/10 - 1/10
Migration: Period Length (Days)	20 Aug - 20 Oct (61)	4 Sep - 9 Oct (35)	7 Sep - 20 Oct (43)	2 Sep - 17 Oct (45)	3 Sep - 17 Oct (44)	7 Sep - 20 Oct (44)
WPUE: Peak	7.33	1.25	15.75	23.60	1.86	10.73
Date	14 Oct	18 Sep	28 Sep	16 Sep	24 Sep	26 Sep
Feeding Bowheads No. Whales (% all whales)	50(25)	5(11)	41(14)	108(22)	14(8)	148(39)

The relatively high (10.73) and late WPUE peak date (26 September) and the high incidence of feeding observed (n = 148, 39 percent) in 1984 all correspond to migratory characteristics expected in light-ice years (Ljungblad et al., 1984b). The differences in average migration period, peak WPUE, and percentage of feeding whales in light-ice years (48 days, 14.35, 25 percent) and heavy-ice years (40 days, 1.55, 9.5 percent) were not statistically significant (1.25, t 2.41, $p \leq 0.10$) and should be considered trends only.

Behavior and Sound Production

A greater proportion of bowheads (39 percent) was seen feeding in 1984, more than in any previous fall or in any other light-ice year (Table 34). As in past years, the highest proportion of feeding whales was seen in mid- to late September. Migratory behaviors were seen less often (38 percent) in 1984 than in past years when swimming and diving represented 4 to 85 percent of all behaviors. Six percent of all whales seen were resting, similar to the situation in 1982 (8 percent) and 1983 (7 percent), less than that in 1981 (18 percent), but greater than that in 1979 (1 percent) and 1980 (0 percent). Ratios of cow-calf (3 percent) and display (3 percent) behaviors were generally similar to past years except 1983 when more cow-calf (9 percent) and display (14 percent) behaviors were recorded.

Fewer bowhead calls were recorded in 1984 (n = 99) than in 1982 (n = 2,044) or 1983 (n = 775), but call-type ratios were very similar to those recorded during previous fall seasons (Moore et al., 1984b). As in spring, the small call sample size recorded in fall is likely the result of little effort directed toward remaining near a sonobuoy to record sounds.

Recruitment

Calves have been seen from August through October, resulting in recruitment estimates ranging from 1.3 to 7.6, and an overall estimate of 3.2 (Table 35). The 1984 recruitment estimate (1.3) was lower than that calculated for all other fall seasons, but similar to the 1981 (1.7) estimate.

The variation in bimonthly and yearly recruitment estimates may be due to age class segregation within the population. Segregation into bowhead age classes in the eastern Beaufort Sea has been demonstrated via photogrammatic length frequency studies (Cubbage et al., 1984; Davis et al., 1983). Different age classes were found in different locations each year. Chapman (1984) noted that to derive an accurate GARR, given the existence of segregation, all components of the population must be sampled and then combined, weighed by the number of whales comprising each component. The GARR provided here was not corrected for such segregation, because the component(s) of the population sampled is not known with certainty for any year. Thus, the derived GARR (Table 35) represents only the observed portion of the bowhead population in the Alaskan Beaufort Sea during the stated time period.

Table 34. Bimonthly summary of bowhead behavior, fall 1979-1984.

Behavior	Year	1-15 Aug	16-31 Aug	1-15 Sep	16-30 Sep	1-23 Oct	Total (%)
Swim	1979	--	4	2	6	57	69 (50)
	1980	--	--	7	5	2	14 (31)
	1981	--	2	38	70	19	129 (51)
	1982	64	7	5	77	29	182 (37.5)
	1983	27	8	6	37	16	94 (55)
	1984	2	8	13	46	60	129 (34)
	Total	**93**	**29**	**71**	**241**	**183**	**617 (42)**
Dive	1979	--	3	0	3	7	13 (9)
	1980	--	--	0	17	8	25 (54)
	1981	--	0	5	20	8	33 (13)
	1982	5	3	4	16	3	31 (6.5)
	1983	2	0	4	5	1	12 (7)
	1984	0	0	4	2	6	12 (3)
	Total	**7**	**6**	**17**	**63**	**33**	**126 (8)**
Rest	1979	--	0	0	0	2	2 (1)
	1980	--	--	0	0	0	0 (0)
	1981	--	0	17	22	6	45 (18)
	1982	18	7	2	5	8	40 (8)
	1983	8	0	3	1	0	12 (7)
	1984	1	1	0	7	15	24 (6)
	Total	**27**	**8**	**22**	**35**	**31**	**123 (8)**
Feed	1979	--	0	0	43	7	50 (36)
	1980	--	--	5	0	0	5 (11)
	1981	--	0	8	22	11	41 (16)
	1982	0	0	23	85	0	108 (22)
	1983	4	0	0	0	10	14 (8)
	1984	0	8	0	138	2	148 (39)
	Total	**4**	**8**	**36**	**288**	**30**	**366 (25)**
Mill	1982	12	12	7	50	0	81 (17)
	1984	0	0	0	46	0	46 (12)
	Total	**12**	**12**	**7**	**96**	**0**	**127 (9)**
Cow-Calf	1979	--	0	0	0	4	4 (3)
	1980	--	--	0	0	2	2 (4)
	1981	--	0	0	2	2	4 (2)
	1982	8	6	6	0	2	22 (4.5)
	1983	0	2	4	4	6	16 (9)
	1984	0	0	0	4	6	10 (3)
	Total	**8**	**8**	**10**	**10**	**22**	**58 (4)**
Display	1979	--	0	0	0	1	1 (1)
	1980	--	--	0	0	0	0 (0)
	1981	--	0	0	0	0	0 (0)
	1982	0	2	7	12	1	22 (4.5)
	1983	8	0	7	7	2	24 (14)
	1984	0	1	0	0	10	11 (3)
	Total	**8**	**3**	**14**	**19**	**14**	**58 (4)**
*Total	1979	--	7	2	52	78	139
	1980	--	--	12	22	12	46
	1981	--	2	68	136	46	252
	1982	107	37	54	245	43	486
	1983	49	10	24	54	35	172
	1984	3	18	17	243	99	380
	Total	**159**	**74**	**177**	**752**	**313**	**1475 (100)**

*Behavior was not recorded for 98 whales: 58 in 1979; 36 in 1981; and 4 in 1982. (--) = no sightings.

Table 35. Sightings and estimated Gross Annual Recruitment Rate (GARR)* of bowhead calves by two-week interval, fall 1979-1984.

Year	1-15 Aug	16-31 Aug	1-15 Sep	16-30 Sep	1-23 Oct	Total
1979	0	0	0	0	6 (3.9)	6 (2.5)
1980	0	0	0	0	1 (8.3)	1 (2.2)
1981	-	0	1 (3.2)	1 (1.1)	1 (2.0)	3 (1.7)
1982	5 (4.6)	6 (16.2)	4 (7.4)	7 (2.8)	1 (2.2)	23 (4.7)
1983	2 (4.1)	1 (10.0)	3 (12.5)	3 (5.6)	4 (11.4)	13 (7.6)
1984	0	0	0	2 (0.8)	3 (3.0)	5 (1.3)
TOTAL	7 (4.2)	7 (9.3)	8 (5.4)	13 (1.7)	16 (3.9)	51 (3.2)

*GARR = Number calves/total number bowheads

GRAY WHALE

Summer (July)

The primary objectives of summer aerial surveys have been to determine the distribution, relative abundance, and behavior of gray whales in the northern Bering Sea and the southern and coastal Chukchi Sea. Secondarily, surveys were conducted in the Beaufort Sea to search for bowhead whales and/or assess ice conditions.

Survey Effort and Conditions

A total of 209.8 survey hours has been flown in summer since 1980* with 26 percent (54.8 hrs) of this effort in the Beaufort Sea, 30 percent (63.5 hrs) in the Chukchi Sea, and 44 percent (91.5 hrs) in the northern Bering Sea (Table 36). In 1980, search surveys directed toward finding bowhead whales were flown mostly in the Beaufort and northeastern Chukchi Sea. Since 1981, transect and/or search surveys have been flown in the Bering, Chukchi, and Beaufort Seas. Since 1982, surveys have begun on or after 10 July.

*There were no summer surveys flown in 1979.

Table 36. Summary of hours of flight effort by sea, summer 1980-1984.

	1980	1981	1982	1983	1984	Total	(%)
Bering Sea	1:39	32:48	31:13	22:33	3:19	91:32	(44)
Chukchi Sea	8:23	20:22	15:04	4:03	15:39	63:31	(30)
Beaufort Sea	36:09	2:10	1:21	1:45	13:25	54:50	(26)
TOTAL	46:11	55:20	47:38	28:21	32:23	209:53	(100)

Summer ice conditions ranged from open water in the northern Bering and southern Chukchi Seas to over 90-percent coverage in the Beaufort Sea. In the northern Chukchi Sea (north of 70° N), ice conditions often changed dramatically during this period. In general, heavy-ice (>90 percent) coverage was found nearshore between Barrow and Wainwright through mid-July, diminishing to about 70 percent by 31 July. Between Wainwright and Icy Cape, ice coverage ranged from 90 to 60 percent in mid-July, diminishing by 31 July to open water north to Icy Cape and 50- to 70-percent coverage to Wainwright. In the Beaufort Sea, nearshore (< 10 km) areas were often ice free, while offshore coverage ranged from 70 to 90 percent throughout the month.

Sea states encountered on surveys in the northern Bering and southern Chukchi Seas ranged from 00 to 06, with 01 to 03 conditions the most common. Surveys were terminated when Beaufort 05 to 06 conditions persisted.

Fog and rain dominated summer weather conditions. Due to temperature fluctuations over land and ice, and/or recently ice-free water, low fog often caused surveys to be truncated or aborted.

Distribution and Density

There were 707 sightings of 1,594 gray whales made over five seasons (Figure 29). The distribution of 51 whales observed in 1984 (Figure 12) was similar to, but not comprehensive of, that found in previous years due to weather limited survey effort of the Chirikov Basin. Gray whale distribution generally corresponds to areas where dense amphipod beds have been found, such as the northcentral Bering Sea and coastal St. Lawrence Island (Rice and Wolman, 1971; Zimushko and Ivashin, 1979; Nerini, 1984; Oliver et al., 1984). The distribution extends to areas

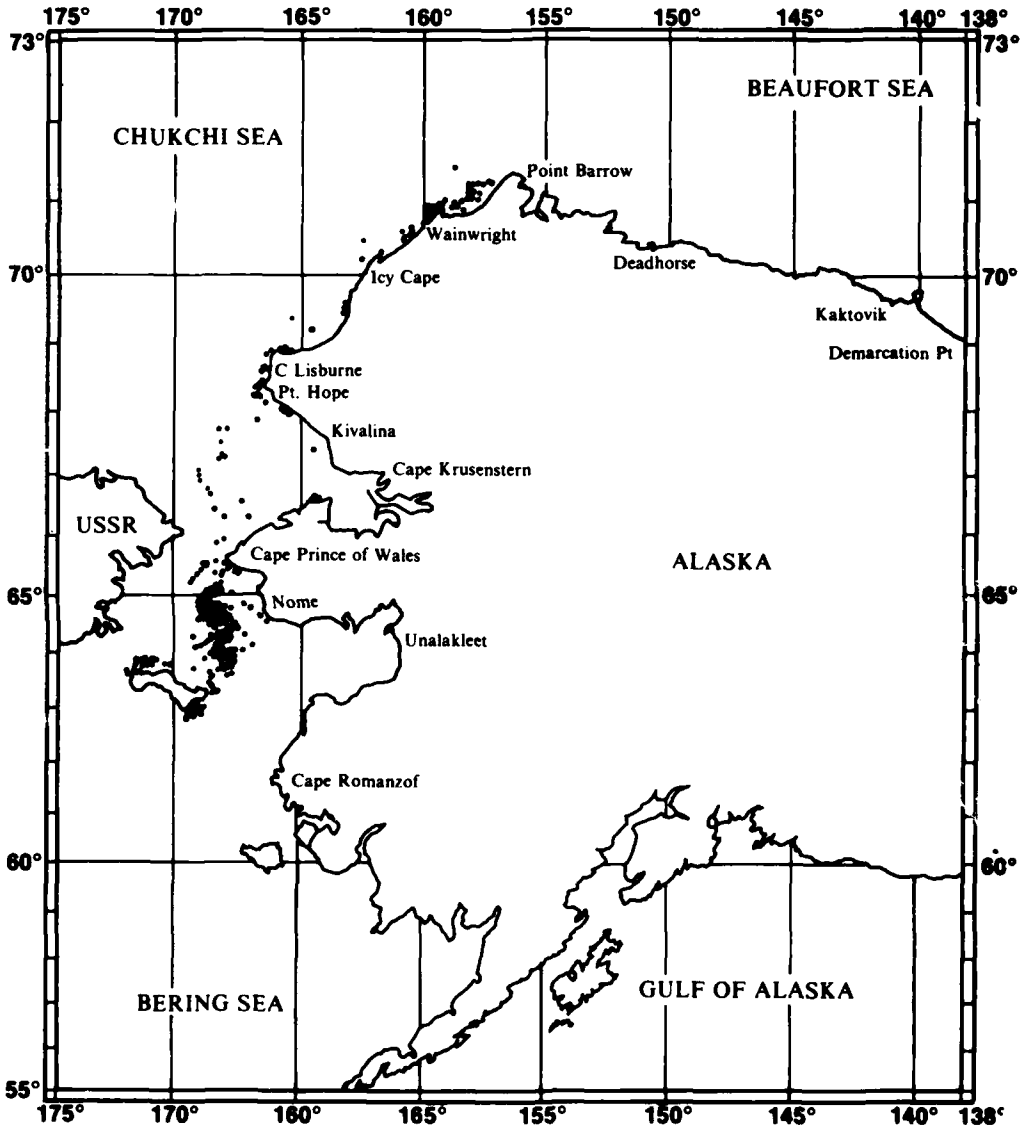


Figure 29. Distribution of 707 sightings (•) representing 1,594 gray whales, summer 1980-1984.

where such amphipod assemblages might occur, such as along the relatively narrow coastal Chukchi shelf. Although gray whale feeding grounds have been documented along the western coastal Bering and Chukchi Seas (Bogoslovskaya et al., 1981), none has been reported along the eastern coasts of these seas (Stoker, 1981).

Highest annual gray whale density was calculated for regions 3 (0.317 whales/nmi^2), 6 (0.243 whales/nmi^2), 7 (0.347 whales/nmi^2), 10 (0.495 whales/nmi^2), 16 (0.206 whales/nmi^2), and 17 (0.430 whales/nmi^2) (Figure 30). Highest density in 1984 was calculated for region 16 contrasting with past seasons when peak densities were calculated for the northern Bering Sea (regions 3, 6, 7, and 10). The limited survey coverage of the northern Bering Sea probably accounts for this divergence, since high (0.105 to 0.495 whales/nmi^2) gray whale densities have been routinely observed there each year since 1981 (Moore et al., 1984a).

Habitat Relationships and Behavior

As in past years, gray whales were seen from 0.5 to 120 km from shore in water 28.3 m, 9.9 s.d. deep, and, in the northeastern Chukchi Sea, in ice coverage to 30 percent. A higher percentage of grays was seen feeding in 1984 (71 percent, n = 36) more than in any previous year when 20 to 45 percent of all whales was observed with mud plumes (Moore et al., 1984a). Conversely, fewer whales (25 percent vs. 42 percent to 80 percent) were noted as swimming in 1984. As in past years, gray whale swimming direction was not significantly clustered about any direction.

The only gray whale calf seen in 1984 was with the group of 24 whales seen in block 28 on 21 July (Appendix A: Flight 16) resulting in an estimated GARR of 2 percent. Since 1980, the number of calves seen in July has ranged from zero to 19 (Table 37). Notably, only one calf was seen in the Bering Sea in 1983, when over 40 times (n = 1,005) the number of grays was observed as in 1984. There is some evidence that gray whales may maintain patterns of age-class segregation such as those observed in breeding lagoons (Jones and Swartz, 1984) and along the migration route (Poole, 1984; Herzing and Mate, 1984) while on the northern feeding grounds (Moore et al., 1984a). The best example of such segregation was the count of 18 calves among 121 gray whales seen along the northeastern Chukchi coast in 1982. Segregation of cow-calf pairs on the northern range may influence the calf count in any one survey year, and result in a biased GARR estimate if all portions of the population are not sampled (Chapman, 1984).

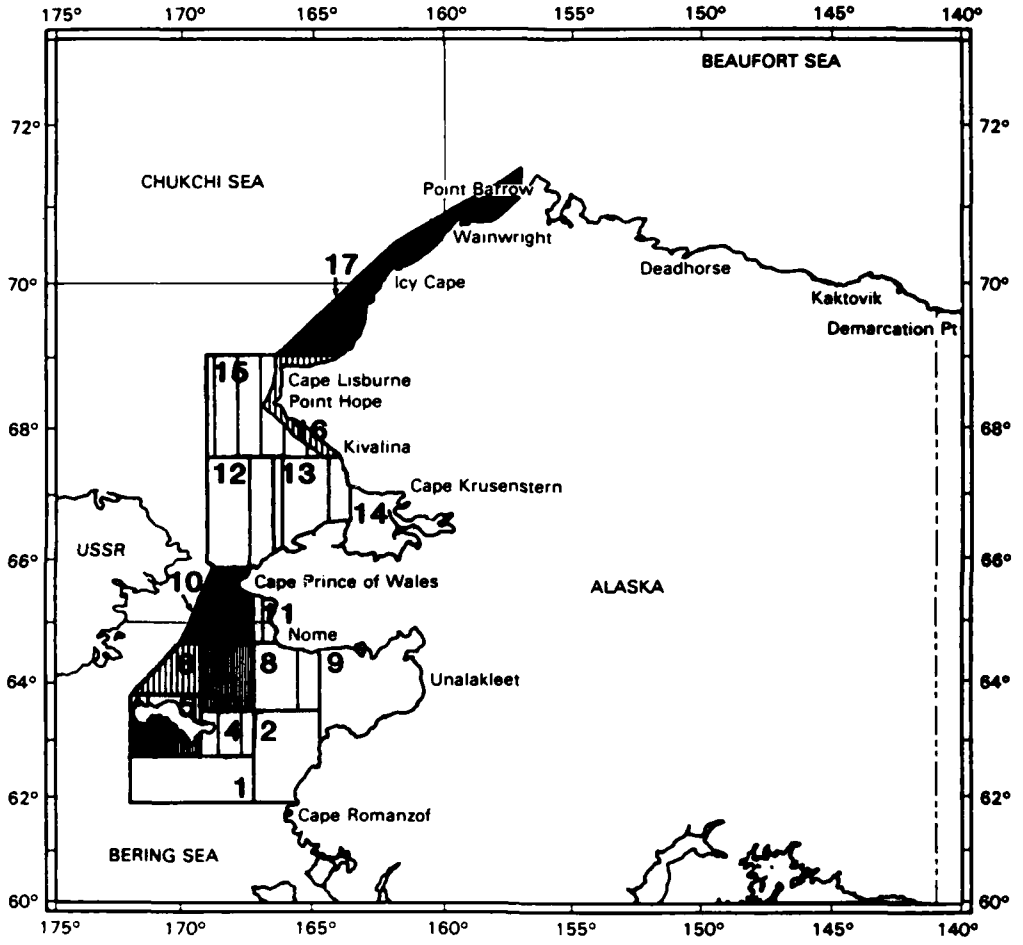


Figure 30. Highest annual gray whale densities/region, summer 1980-1984. Shading varies from white (representing 0 density) to black (representing 0.495 whales/nmi^2). Densities presented here from Table B-12.

Table 37. Number of gray whale calves/total number of gray whales (c/gw) and estimated recruitment (GARR) by sea, summer 1980-1984.

Year	Bering Sea c/gw (GARR)	Chukchi Sea c/gw (GARR)	Total c/gw (GARR)
1980	-	0/10 (0)	0/10 (0)
1981	0/84 (0)	4/102 (4)	4/186 (2)
1982	1/200 (0.5)	18/121 (15)	19/321 (6)
1983	1/1005 (0.1)	0/21 (0)	1/1026 (0.1)
1984	1/24 (4)	0/27 (0)	1/51 (2)
TOTAL	3/1313 (0.2)	22/281 (8)	25/1594 (2)

*GARR = number calves/total number of gray whales including calves
- = no surveys flown

Fall (August - October)

Distribution and Relative Abundance

Three hundred forty-five gray whales have been seen in fall since 1980 with 47 percent (n = 162) in the Bering Sea, 52.7 percent (n = 182) in the Chukchi Sea and 0.3 percent (n = 1) in the Beaufort Sea (Table 38). In October 1980 and August 1981, surveys were flown and gray whales seen in the northern Bering Sea. Since 1982, all fall surveys have been conducted in the Beaufort and northeastern Chukchi Sea (Table 32).

Gray whale fall distribution ranged from the southeast coast of St. Lawrence Island and the Chirikov Basin in the northern Bering Sea through the northeast Chukchi Sea to Pt. Barrow (Figure 31). In August, grays were seen along the southeast coast of St. Lawrence Island, in the Chirikov Basin between 167° W and 170° W, just north of the Bering Strait, and in the northeastern Chukchi Sea along the coast between Icy Cape and Pt. Barrow (Figure 31A). One whale, seen in the Canadian Beaufort Sea (70°29' N, 131°14' W) in August 1980 (Rugh and Fraker, 1981), was not plotted in Figure 31A. In September (1982-84), grays were seen in the northeastern Chukchi Sea between Wainwright and Barrow (Figure 31B). In October, grays were found in the Chirikov Basin, the southern Chukchi Sea north of the Bering Strait and along the Seward Peninsula, and in the northeastern Chukchi Sea along the coast between Pt. Hope and Pt. Barrow (Figure 31C). The distribution of 115 grays in the northeastern Chukchi Sea found in 1984 (Figure 23)

Table 38. Summary of gray whale sightings by month and sea, fall 1980-1984.

Year	Bering Sea	Chukchi Sea	Beaufort Sea	Total
1980				
Aug	0	0	1*	1
Sep	0	0	0	0
Oct	116	6	0	122
Total 1980	116	6	1	123
1981				
Aug	46	9	0	55
Sep	0	0	0	0
Oct	0	0	0	0
Total 1981	46	9	0	55
1982				
Aug	0	0	0	0
Sep	0	18	0	18
Oct	0	8	0	8
Total 1982	0	26	0	26
1983				
Aug	0	14	0	14
Sep	0	2	0	2
Oct	0	10	0	10
Total 1983	0	26	0	26
1984				
Aug	0	33	0	33
Sep	0	70	0	70
Oct	0	12	0	12
Total 1984	0	115	0	115
Final Totals				
Aug	46	56	1	103 (30 %)
Sep	0	90	0	90 (26 %)
Oct	116	36	0	152 (44 %)
Total	162 (47)	182 (52.7)	1 (0.3)	345 (100 %)

*Canadian Beaufort Sea; Rugh and Fraker, 1981.

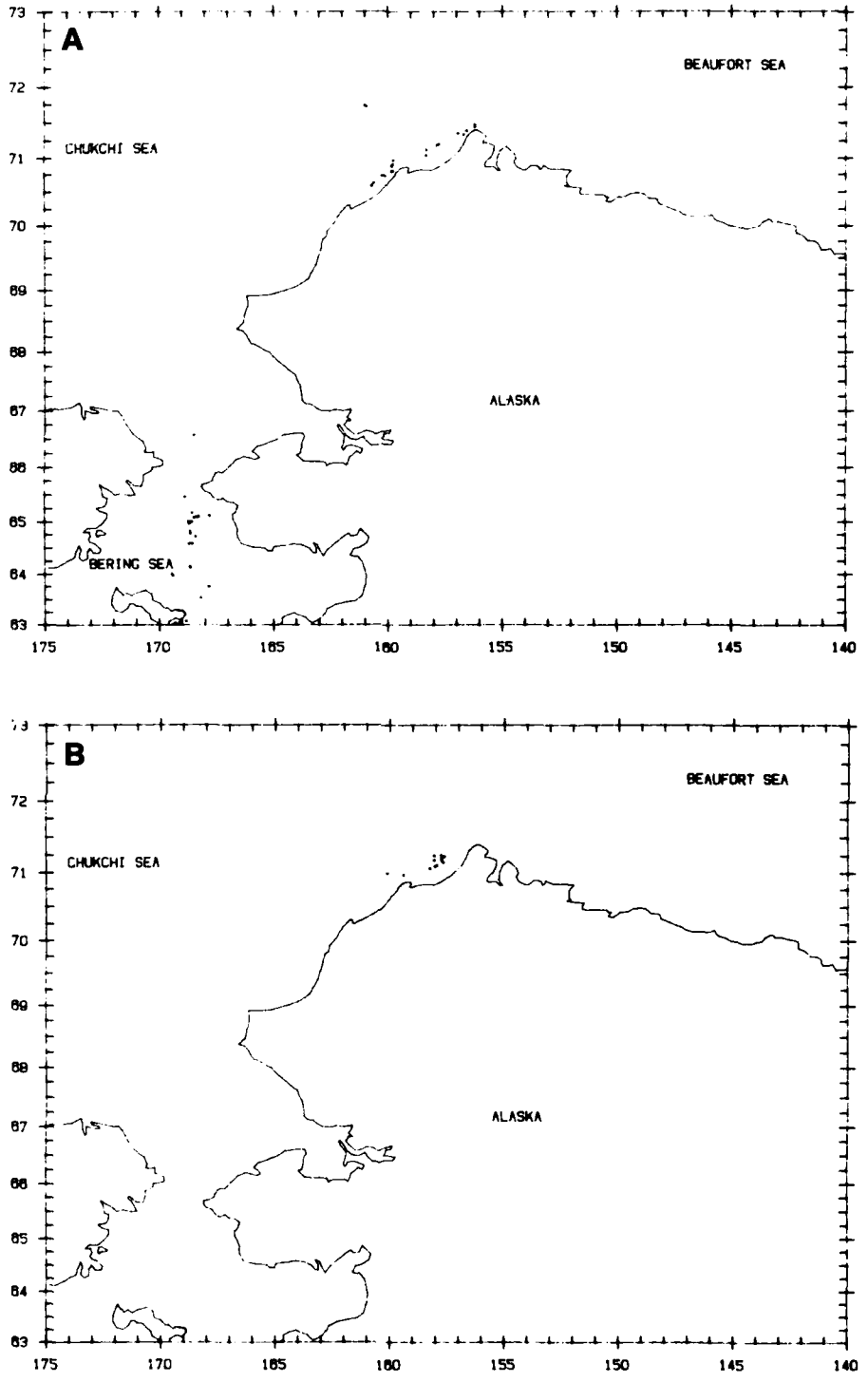
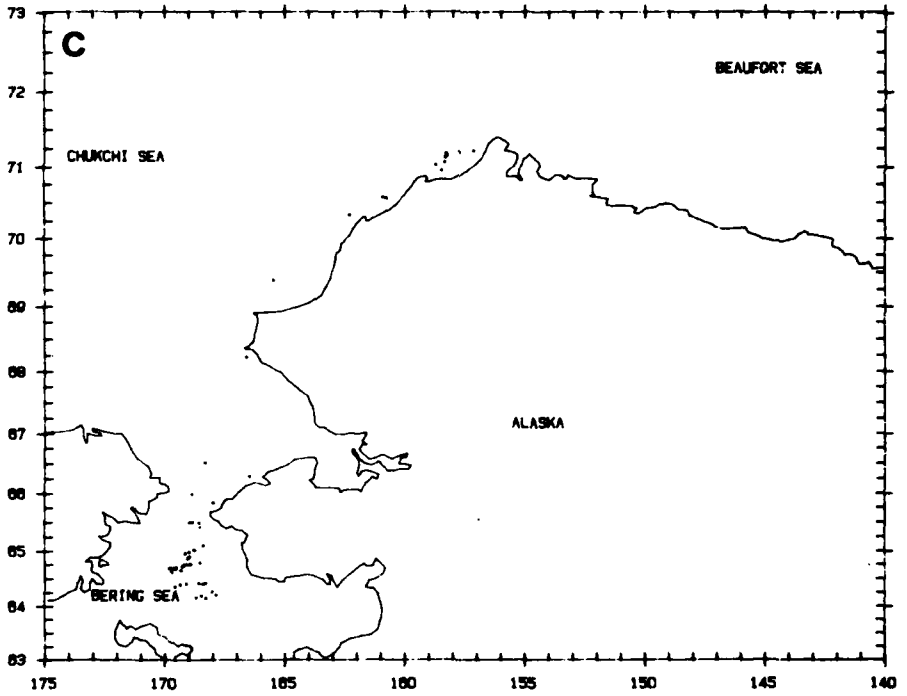


Figure 31. Distribution of 151 sightings (•) of 344 gray whales plotted by month, fall 1980-1984: August (A); September (B); October (C); Total (D). One whale seen in the Canadian Beaufort Sea (70°29' N, 131°14' W) in August 1980 is not plotted (Rugh and Fraker, 1981).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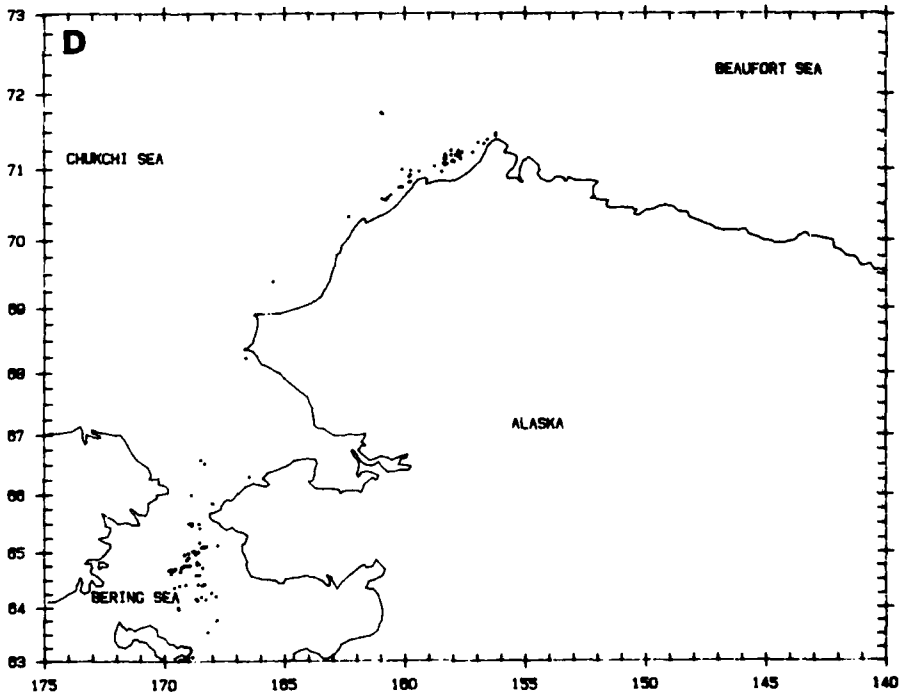
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was similar to that observed in 1982 and 1983, except for three whales seen feeding approximately 158 km northwest of Barrow on 31 August (Appendix A: Flight 44).

The highest gray whale relative abundance in the Chukchi Sea was calculated for block 13 (WPUE = 3.3), with lesser WPUE calculated for blocks 12 (WPUE = 1.82) and 17 (WPUE = 1.20) (Table 39). In the northern Bering Sea, relative abundance was highest in block 26 (17.45), with lesser values calculated for blocks 25 (7.55) and 27 (5.97). In 1984, the highest relative abundance of grays was found in coastal blocks 13 (WPUE = 5.82) and 17 (WPUE = 3.27) (Table 24).

Table 39. Relative abundance of gray whales (WPUE) by block, fall 1980-1984. (--) = no effort.

Month	Aug		Sept		Oct		Total	
Block	No.	(WPUE)	No.	(WPUE)	No.	(WPUE)	No.	(WPUE)
12	16	(1.82)	0		0		16	(1.82)
13	18	(2.49)	88	(9.45)	15	(0.75)	121	(3.30)
14	3	(1.41)	0		0		3	(0.24)
15	0		--		0		0	
17	16	(2.99)	2	(0.63)	3	(0.28)	21	(1.20)
18	0		--		0		0	
20	0		--		5	(0.63)	5	(0.43)
21	--		--		0		0	
22	--		--		7	(1.93)	7	(1.93)
23	--		--		0		0	
24	3	(1.20)	--		2	(1.21)	5	(1.20)
25	12	(3.35)	--		38	(12.50)	50	(7.55)
26	17	(20.48)	--		80	(16.91)	97	(17.45)
27	4	(5.97)	--		--		4	(5.97)
28	6	(1.71)	--		2	(1.48)	8	(1.65)

Monthly WPUE values decreased from August to October, except in blocks 13 and 25. In block 13, WPUE was 2.49 in August, 9.45 in September, and 0.75 in October. The drop in relative abundance between September and October corresponds with reports that gray whales begin their fall migration from summer feeding grounds in mid-October (Berzin, 1984; Braham, 1984). In block 25, WPUE was 3.35 in August and 12.5 in October. This increase also may be attributed to migratory timing of southbound gray whales passing through the Bering Strait in October.

Habitat Relationships and Behavior

Gray whales were seen from 0.5 to 158 km from shore, in water 10 to 52 m deep. In 1984, most whales (97 percent, n = 112) were found within 50 km of shore between Icy Cape and Pt. Barrow, in water 11 to 51 m deep. Most gray whales (82 percent, n = 283) were seen in open water. Of those whales seen with ice, 71 percent (n = 44) were in 1- to 30-percent coverage, 9 percent (n = 6) were in 31- to 69-percent coverage and 20 percent (n = 12) were in 70-percent ice coverage. In 1984, 25 whales (22 percent) were in open water, 69 (60 percent) were in 1-to 5-percent ice coverage, 13 (11 percent) were in 10- to 30-percent coverage, and 8 (7 percent) were in 80-percent coverage.

Gray whales were feeding (53 percent, n = 183), swimming (39.1 percent, n = 135), resting (4.9 percent, n = 17), milling (2.3 percent, n = 8) or involved in cow-calf behaviors (0.7 percent, n = 2). In 1984, feeding whales were found in larger groups ($\bar{x}$ = 10.50, s.d. = 10.76, n = 8) than swimming grays ($\bar{x}$ = 4.33, s.d. = 4.04, n = 3), but this difference was not significant.

REFERENCES

Albert, T.F., R.B. Dronenburg and J.C. George. An overview of studies being conducted by the North Slope Borough (Alaska) that pertain to the bowhead whale, Balaena mysticetus. Int. Whal. Comm. SC/36/PS12. 12 pp. 1984.

Batschelet, E. Recent statistical methods for orientation data. pp 61-41, In: Animal Orientation and Navigation, S.R. Galler, K. Schmidt-Koenig, G.J. Jacobs and R.E. Bellevue (eds.), NASA, Washington, D.C. 360 pp. 1972.

Berzin, A.A. Soviet studies on the distribution and numbers of the gray whale in the Bering and Chukchi Seas from 1968 to 1982. pp. 409-419, In: The Gray Whale, M.L. Jones, S. L. Swartz and J.S. Leatherwood (eds.), Academic Press, Inc., San Francisco, CA. 600 pp. 1984.

Bogoslovskaya, L.S., L.M. Votrogov and T.N. Semenova. Feeding habits of gray whales off Chukotka. Rep. Int. Whale Comm. 31:507-510. 1981.

Braham, H.W. Distribution and migration of gray whales in Alaska. pp. 249-266, In: The Gray Whale, M.L. Jones, S.L. Swartz and J.S. Leatherwood (eds.), Academic Press, Inc., San Francisco, CA. 600 pp. 1984.

Braham, H.W., M.A. Fraker and B.D. Krogman. Spring migration of the western arctic population of bowhead whales. Mar. Fish. Rev. 42 (9-10): 36-46. 1980.

Braham, H.W., B.D. Krogman and G.M. Carroll. Bowhead and white whale migration, distribution and abundance in the Bering, Chukchi and Beaufort Seas, 1975-78. NOAA Technical Report NMFS SSRF-778, 39 pp. 1984.

Breiwick, J.M., E.D. Mitchell and D.G. Chapman. Estimated initial population size of the Bering Sea stock of bowhead whale (Balaena mysticetus): an iterative method. U.S. Fish. Bull. 78(4): 843-853. 1981.

Brueggeman, J.J. Early spring distribution of bowhead whales in the Bering Sea. J. Wild. Manage. 46(4): 1036-1044. 1982.

Carleton, A.M. Polynya development in Cape Thompson-Point Hope region, Alaska. Arc. Alp. Res. 12: 205-214. 1980.

Chapman, C.F. Piloting, Seamanship and Small Boat Handling. Hearst Books, New York, 640 pp. 1971.

Chapman, D.G. Estimates of net recruitment of Alaska bowhead whales and of risk associated with various levels of kill. Rep. Int. Whal. Comm. 34:469-471. 1984.

Cochran, W.G. Sampling Techniques. J. Wiley, New York, 413 pp. 1963.

Cubbage, J.C., J. Calambokidis and D.J. Rugh. Bowhead whale length measured through stereophotogrammetry. Cascadia Research Collective for National Marine Mammal Laboratory, NMFS, NOAA, Seattle, WA. 71 pp. 1984.

Davis, R.A., W.R. Koski and G.W. Miller. Preliminary assessment of the length-frequency distribution and gross annual reproduction rate of the western arctic bowhead whale as determined with low-level aerial photography, with comments on life history. Report by LGL Ecol. Res. Assoc., Inc., for National Marine Mammal Laboratory, NMFS, NOAA, Seattle, WA. 90 pp. 1983.

Fay, F. The role of ice in the ecology of marine mammals of the Bering Sea. pp 383-400, In: Oceanography of the Bering Sea, D.W. Hood and E.S. Kelly (eds.), University of Alaska Institute of Marine Sciences, Fairbanks. 623 pp. 1974.

Gurevich, V.S. Worldwide distribution and migration patterns of the white whale (Beluga), Delphinapterus leucas. Rep. Int. Whal. Comm., 30:465-480. 1980.

Hazard, K.W. and L.F. Lowry. Benthic prey in a bowhead whale from the northern Bering Sea. Arctic 37(2):166-168. 1984.

Herzing, D.L. and B.R. Mate. Gray Whale (Eschrichtius robustus) migrations along the Oregon coast, 1978-81. pp 289-307, In: The Gray Whale, M.L. Jones, S.L. Swartz and J.S. Leatherwoods (eds.), Academic Press, Inc., San Francisco, CA. 600 pp. 1984.

Jones, M.L. and S.L. Swartz. Demography and phenology of gray whales and evaluation of whale watching activities in Laguna San Ignacio, Baja California Sur, Mexico. pp 309-374, In: The Gray Whale, M.L. Jones, S.L. Swartz and J.S. Leatherwood (eds.), Academic Press, Inc., San Francisco, CA. 600 pp. 1984.

Kleinenberg, S.E., A.V. Yablokov, V.M. Bel'kovich and M.N. Tarasevich. Belukha. Opyt Monograficheskogo issledovaniya vida. (Beluga Delphinapterus leucas): Investigation of the species. Akademiya Nauk, S.S.S.R., Inst. Morgologii Zhivotnykh im A.N. Severtsova Izdatel'stvo Nauka, Moscow, 456 pp. Translated from Russian. Israel Program for Scien. Transl., Jerusalem, No. 1923. 1969, 376 pp. 1964.

Ljungblad, D.K. Aerial surveys of endangered whales in the Beaufort Sea, Chukchi Sea, and northern Bering Sea. NOSC TD 449 for Alaska OCS Office MMS, 302 pp. June 1981.

Ljungblad, D.K., S.E. Moore and D.R. Van Schoik. Aerial surveys of endangered whales in the Beaufort, Chukchi and northern Bering Seas, 1982. NOSC TD 605 for Alaska OCS Office MMS, 382 pp. June 1983.

Ljungblad, D.K., S.E. Moore and D.R. Van Schoik. Aerial surveys of endangered whales in the northern Bering, eastern Chukchi and Alaskan Beaufort Seas, 1983: with a five-year review 1979-1983. NOSC TR 955 for Alaska OCS Office MMS, 356 pp. June 1984 (1984a).

Ljungblad, D.K., S.E. Moore and D.R. Van Schoik. Seasonal patterns of distribution, abundance, migration and behavior of the western Arctic stock of bowhead whales, Balaena mysticetus in Alaskan Seas. Int. Whal. Comm. SC/36/PS1, 23 pp. 1984b.

Ljungblad, D.K., S.E. Moore, D.R. Van Schoik and C.S. Winchell. Aerial surveys of endangered whales in the Beaufort, Chukchi and northern Bering Seas. NOSC TD 486 for Alaska OCS Office MMS, 374 pp. March 1982.

Ljungblad, D.K., M.F. Platter-Rieger and F.S. Shipp, Jr. Aerial surveys of bowhead whales, North Slope, AK. NOSC TD 314 for Alaska OCS Office MMS, 188 pp. February 1980.

Ljungblad D.K., B. Würsig, S.L. Swartz and J.M. Keene. Observations on the behavior of the bowhead whale, Balaena mysticetus, in the presence of an operating seismic exploration vessel in the Alaskan Beaufort Sea. NOSC report for Alaska OCS Office MMS. 1985, in preparation.

Lowry, L.F. and J.J. Burns. Foods utilized by bowhead whales near Barter Island, Alaska, Autumn 1979. Mar. Fish. Rev. 42 (9-10): 88-91. 1980.

Marquette, W.M., H.W. Braham, M.K. Nerini and R.V. Miller. Bowhead whale studies, Autumn 1980-Spring 1981: harvest, biology and distribution. Rep. Int. Whal. Comm. 32:357-370. 1982.

Moore, S.E., D.K. Ljungblad and D.R. Van Schoik. Annual patterns of gray whale (Eschrichtius robustus) distribution, abundance and behavior in the northern Bering and eastern Chukchi Seas, 1980-1983. Int. Whal. Comm. SC/36/PS2, 10 pp. 1984a.

Moore, S.E., D.K. Ljungblad and D.R. Schmidt. Ambient, industrial and biological sounds recorded in the northern Bering, eastern Chukchi and Alaskan Beaufort Seas during the seasonal migrations of the bowhead whale (Balaena mysticetus), 1979-1982. Final Report for: U.S. MMS; prepared by SEACO, Inc., 104 pp. 1984b.

Naval Hydrographic Office. Aerial Ice Reconnaissance and Functional Glossary of Ice Terminology. Hydrographic Office Publication Number 609, 14 pp. 1956.

Nerini, M.K. A review of gray whale (Eschrichtius robustus) feeding ecology. pp 423-450, In: The Gray Whale, M.L. Jones, S.L. Swartz and J.S. Leatherwood (eds.), Academic Press, San Francisco, CA. 600 pp. 1984.

Oliver, J.S., P.N. Slattery, M.A. Silberstein, and E.F. O'Connor. Gray whale feeding on dense ampeliscid amphipod communities near Bamifield, British Columbia. Can. J. Zool. 62(1):41-49. 1984.

Poole, M.M. Migration corridors of gray whales (Eschrichitus robustus) along the Central California coast, 1980-82. pp 389-407, In: The Gray Whale, M.L. Jones, S.L. Swartz and J.S. Leatherwood (eds.), Academic Press, Inc., San Francisco, CA. 600 pp. 1984.

Reilly, S.B., D.W. Rice and A.A. Wolman. Population assessment of the gray whale, Eschrichtius robustus, from California shore censuses, 1967-80. U.S. Fish. Bull. 81(2): 267-281. 1983.

Rice, D.W. and A.A. Wolman. The life history and ecology of the gray whale (Eschrichtius robustus). Am. Soc. Mammal. Spec. Publ. No. 3. 142 pp. 1971.

Rugh, D.J. and M.A. Fraker. Gray whale sightings in the eastern Beaufort Sea. Arctic 34(2):186-187. 1981.

Schell, D.M., P.J. Ziemann, D.M. Parrish, K.H. Danton and E.J. Brown. Foodweb and nutrient dynamics in nearshore Alaska Beaufort Sea waters. pp 327-499, In: Other Continental Shelf Environmental Assessment Program, Vol. 25. 500 pp. 1982.

Sergeant, D.E. Ecological isolation in some cetacea. Contribution to Symposium on Marine Mammals, International Theological Congress, Moscow. 18 pp. 1974.

Stoker, S. Benthic invertebrate macrofauna of the eastern Bering/Chukchi continental shelf. pp 1066-1091, In: The eastern Bering Sea shelf: Oceanography and Resources, Volume 2, D.W. Hood and J.A. Colder (eds.), Univ. of Wash. Press, Seattle, WA. 1339 pp. 1981.

Watkins, W.A. The harmonic interval: fact or artifact in special analysis of pulse trains. pp 15-43, In: Marine Bioacoustics, W.N. Tavolga (ed.), Permangion Press, New York. 353 pp. 1967.

Wood, F.G. and W.E. Evans. Adaptiveness and ecology of echolocation in toothed whales. pp 381-4267, In: Animal Sonar Systems, R.G. Bushnel and J.F. Fish (eds.), Plenum Press, New York, 1135 pp. 1979.

Würsig, B., C.W. Clark, E.M. Dorsey, M.A. Fraker, and R.S. Payne. Normal behavior of bowheads. pp 33-143, In: Behavior, Disturbance Responses and Feeding of Bowhead Whales (Balaena mysticetus) in the Beaufort Sea, 1980-1981, W.J. Richardson (ed.), report by LGL Ecol. Res. Assoc., Inc. for Bureau of Land Management, 455 pp. 1982.

Würsig, B., E.M. Dorsey, M.A. Fraker, R.F. Payne, W.J. Richardson and R.S. Wells. Behavior of bowhead whales, Balaena mysticetus, swimming in the Beaufort Sea: surfacing, respiration and dive characteristics. Can. J. Zool. 62: 1910-1921. 1984.

Zar, S.H. Biostatistical Analysis. Prentice Hall, Inc. Englewood Cliffs, NJ. 620 pp. 1974.

Zimushko, V.V. and M.V. Ivashin. Some results of Soviet investigations and whaling of gray whales (Eschrichtius robustus, Lilljeborg, 1861). Rep. Int. Whal. Comm. 30:237-246. 1979.

APPENDIX A

AERIAL SURVEY FLIGHT CAPTIONS, SURVEY TRACKS AND SIGHTING SUMMARIES, 1984

CONTENTS

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INTRODUCTION

This appendix consists of flight tracks 1 through 82, which depict aerial surveys flown over the northern Bering, eastern Chukchi, and Alaskan Beaufort Seas between mid-April and mid-October 1984. Each flight is represented by a caption describing the flight's objectives, survey conditions and sightings, as well as survey track, with all marine mammal sightings plotted. Each symbol on the flight track/sighting charts represents one sighting of one or more animals. Additionally, summary information on bowhead and gray whale sightings is presented beneath the flight caption in the tabularized format:

T#/C#	Total number of whales/total number of calves seen		
LAT/LONG	Location (latitude N/longitude W) in degrees, minutes, and tenths of minutes		
DIS	Perpendicular distance from the aircraft in meters (altitude x cotangent clinometer angle)		
CUE	Sighting cue:		
	BO = Body	MP = Mud Plumes	
	BW = Blow	DY = Display	
	SP = Splash		
BEH	Behavior:		
	SW = Swim	DY = Display	SH = Spyhop
	DI = Dive	MT = Mate	TS = Tail-Slap
	RE = Rest	FE = Feed	BR = Breach
	MI = Mill	CC = Cow-Calf	NA = None
			DE = Dead
HDG	Heading in magnetic degrees		
ICE	Ice coverage in percent		
SS	Sea State (Beaufort scale)		
DEPTH	Depth in meters		

A dash (-) indicates data were not recorded.

A seasonal summary of all marine mammal sightings by species provides an overview of sighting data for the 1984 field season (Table A-1). Species abbreviations used in flight track keys are listed in Table A-1.

METHODS

Maps were prepared using a series of computer programs consisting of BASIC subroutines implemented on a Hewlett-Packard (HP 85) microcomputer connected to a HP 7470A printer/plotter. The coastlines for each map, digitized on a HP 9111A graphics tablet, were formatted to examine the principal study areas (i.e., northern Bering Sea, eastern Chukchi Sea, and the Alaskan Beaufort Sea). As a result, a comparison of flight tracks for a given study area can be made on a visual basis over the period of the field season to evaluate ongoing patterns of the animal distribution and aircraft coverage. Each map shows the flight track as a line drawn through position updates recorded on the aircraft computer system. Each animal sighting is marked with a species symbol on the flight track plot. Additional summary information provided by the computer log is reflected in the flight captions and was used as a double check on total number of sightings of bowhead whales and the distances traveled on transect legs.

Table A-1. Seasonal summary of all marine mammal sightings* by species.

Species	Abr**	Spring	Summer	Fall	Total
Bowhead Whale	BH	64/237	0/0	153/380	217/617
(Balaena mysticetus)			(1D)	(2D)	(3D)
Belukha Whale	BE	73/1342	8/39	170/788	251/2169
(Delphinapterus leucas)			(2D)		(2D)
Gray Whale	GW	0/0	21/51	29/115	50/166
(Eschrichtius robustus)			(3D)		(3D)
Unidentified Cetacean	CT	0/0	0/0	0/0	0/0
			(1D)		(1D)
Bearded Seal	BS	88/195	13/14	152/181	253/390
(Erignathus barbatus)					
Ringed Seal	RS	31/46	1/1	114/165	146/212
(Phoca hispida)					
Walrus	WS	27/429	30/297	45/312	102/1038
(Odobenus rosmarus)			(37D)	(2D)	(39D)
Unidentified Pinniped	PN	10/11	12/13	252/319	274/343
Polar Bear	PR	5/9	2/2	14/22	21/33
(Ursus maritimus)					

*The figures shown under the seasons represent the number of sightings/the number of individuals sighted during that period.

**Abbreviations listed are those used in flight track legends.

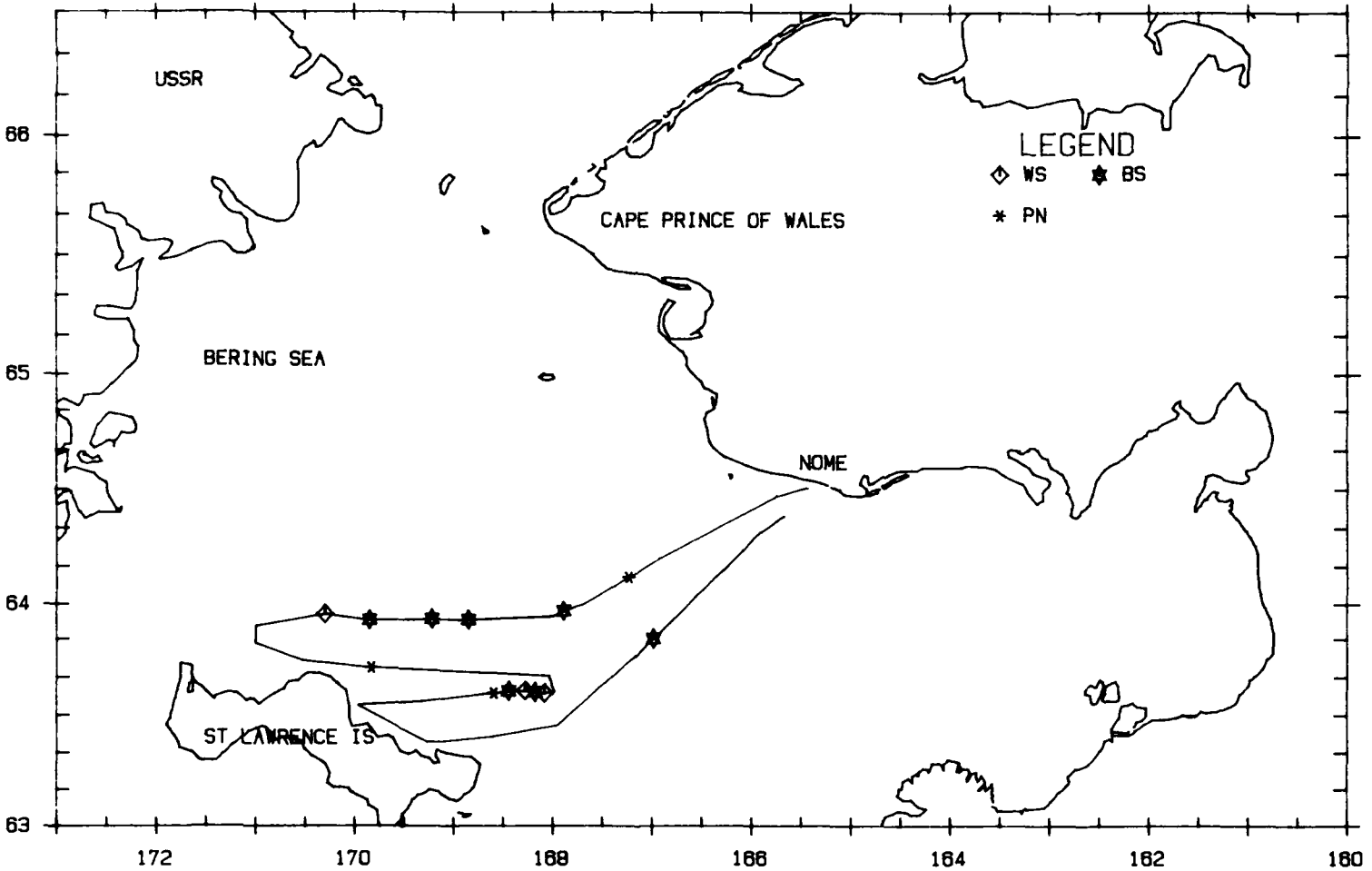
D = Dead.

FLIGHT CAPTIONS, SURVEY TRACKS, AND SIGHTINGS SUMMARY

SPRING

Flight 1: 24 April 1984

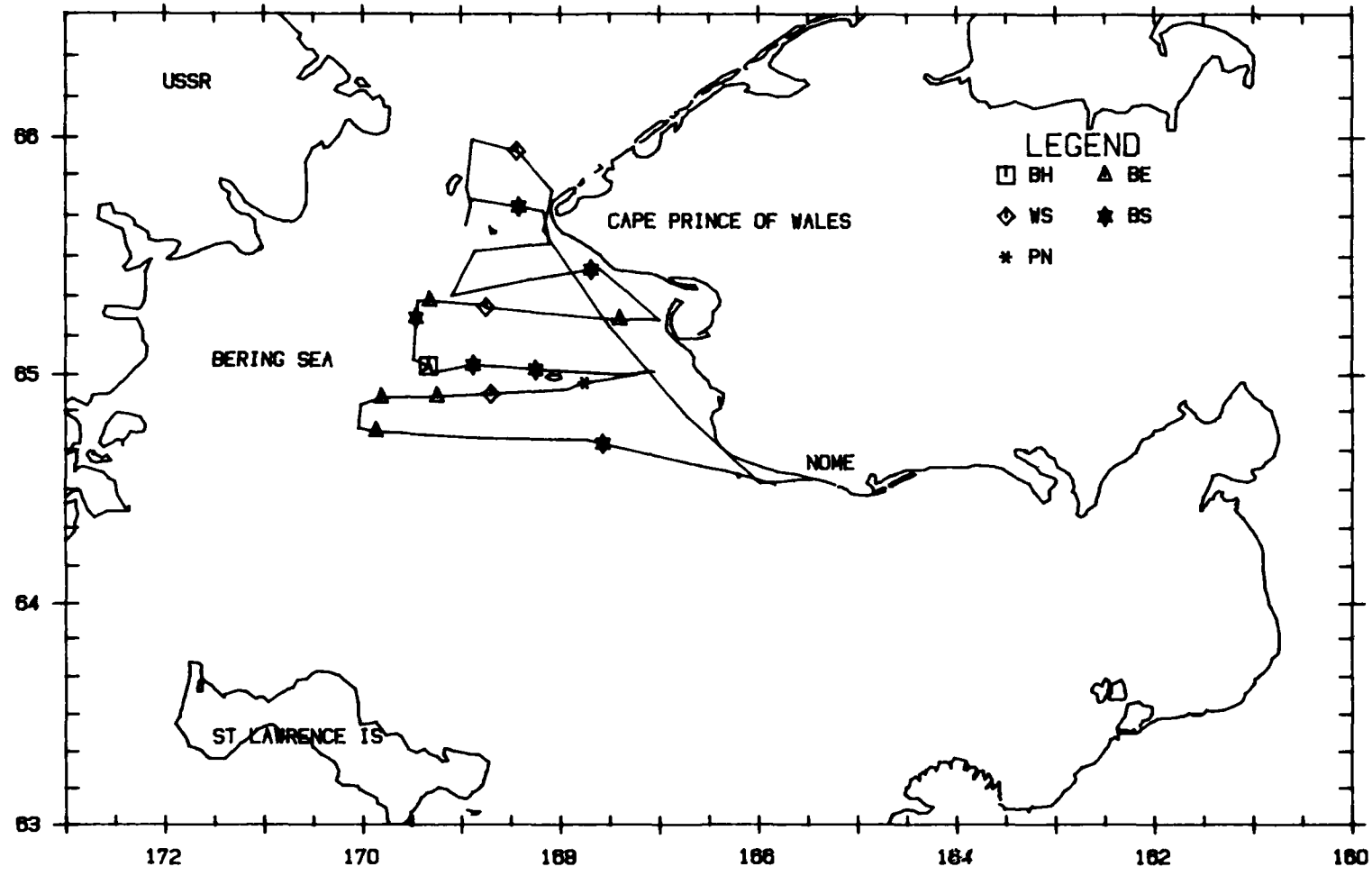
Flight was a transect survey of block 27 northeast of St. Lawrence Island. Weather was clear or high overcast with unlimited visibility. Ice coverage was 90 percent to 100 percent new and grease ice except for a 10 to 15 km wide strip of 100 percent shorefast first-year floe ice around St. Lawrence Island. Sea state was Beaufort 00 and 01. Walrus, bearded seals, and unidentified pinnipeds were seen.


USSR
BERING SEA
CAPE PRINCE OF WALES
NOME
ST LAWRENCE IS
LEGEND
WS
BS
PN
66
65
64
63
172
170
168
166
164
162
160

Flight 2: 26 April 1984

Flight was a transect survey of block 25 and the northern two legs of block 26 in the northern Bering Sea. Weather was clear with unlimited visibility. Ice coverage was 80 percent to 100 percent mixed broken first-year floe and new ice. Sea state varied with ice coverage from Beaufort 00 to 02. Two bowheads were observed west of King Island swimming north. Belukha whales, walrus, bearded seals, and unidentified pinnipeds were seen. One sonobuoy was dropped and two bowhead calls, bearded seals, and ambient sounds were recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
2/0	65°02.4'	169°20.0'	528	BW	SW	330	85	B0	49


USSR
CAPE PRINCE OF WALES
BERING SEA
NOME
ST LAWRENCE IS
LEGEND
BH
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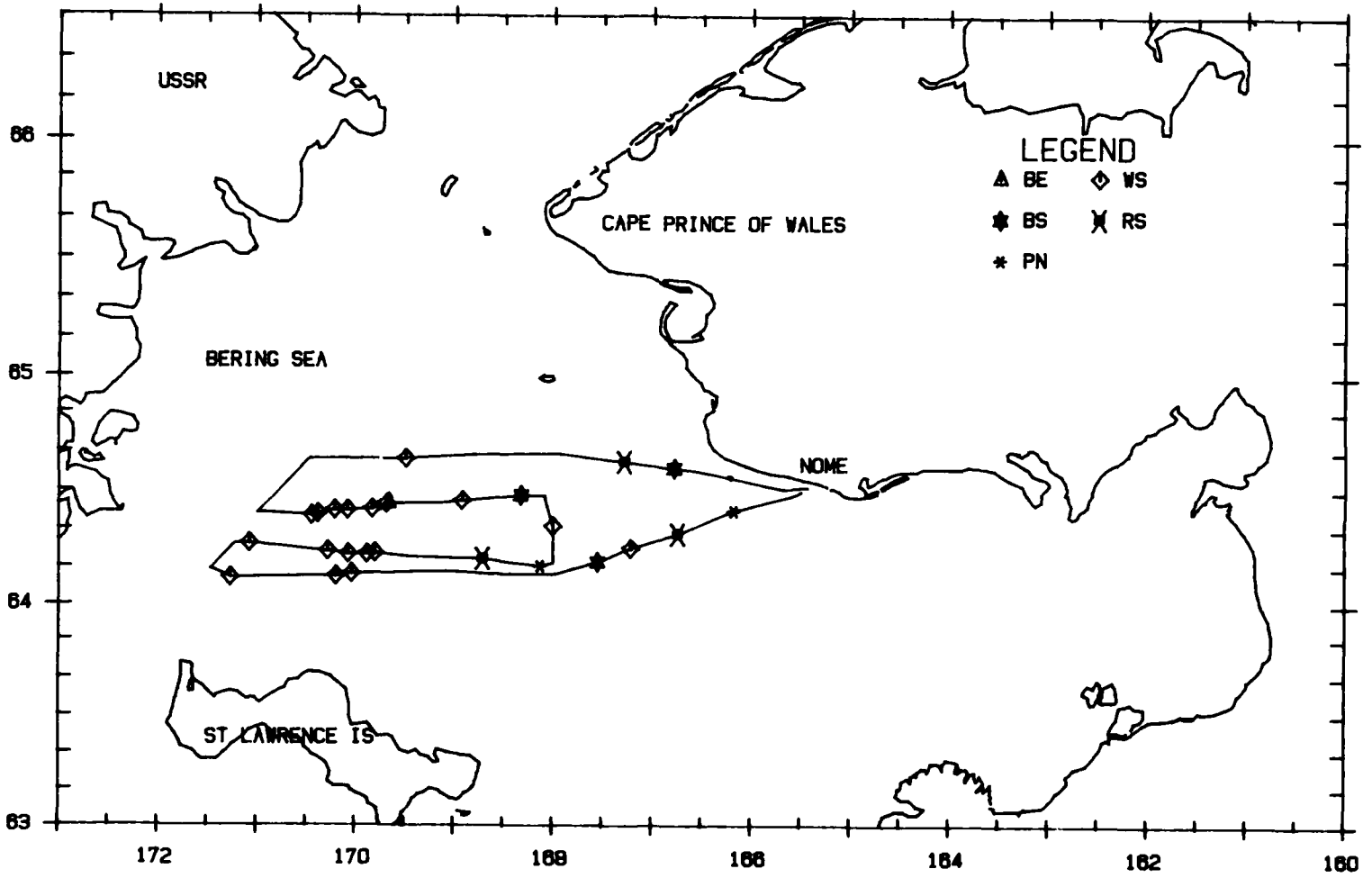
172
170
168
166
164
162
160

Flight 3: 27 April 1984

Flight was a transect survey of four legs of block 26 between St. Lawrence Island and the Bering Strait. Weather was overcast with unlimited visibility. Ice coverage varied from 99 percent broken floe in mid Bering Sea and 80 percent new ice in eastern portions to nearly open water along the IDL. Sea state also varied, from Beaufort 01 in heavy ice to Beaufort 05 in the open water. Belukha whales, walrus, bearded seals, ringed seals, and unidentified pinnipeds were seen.


USSR
CAPE PRINCE OF WALES
BERING SEA
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ST LAWRENCE IS
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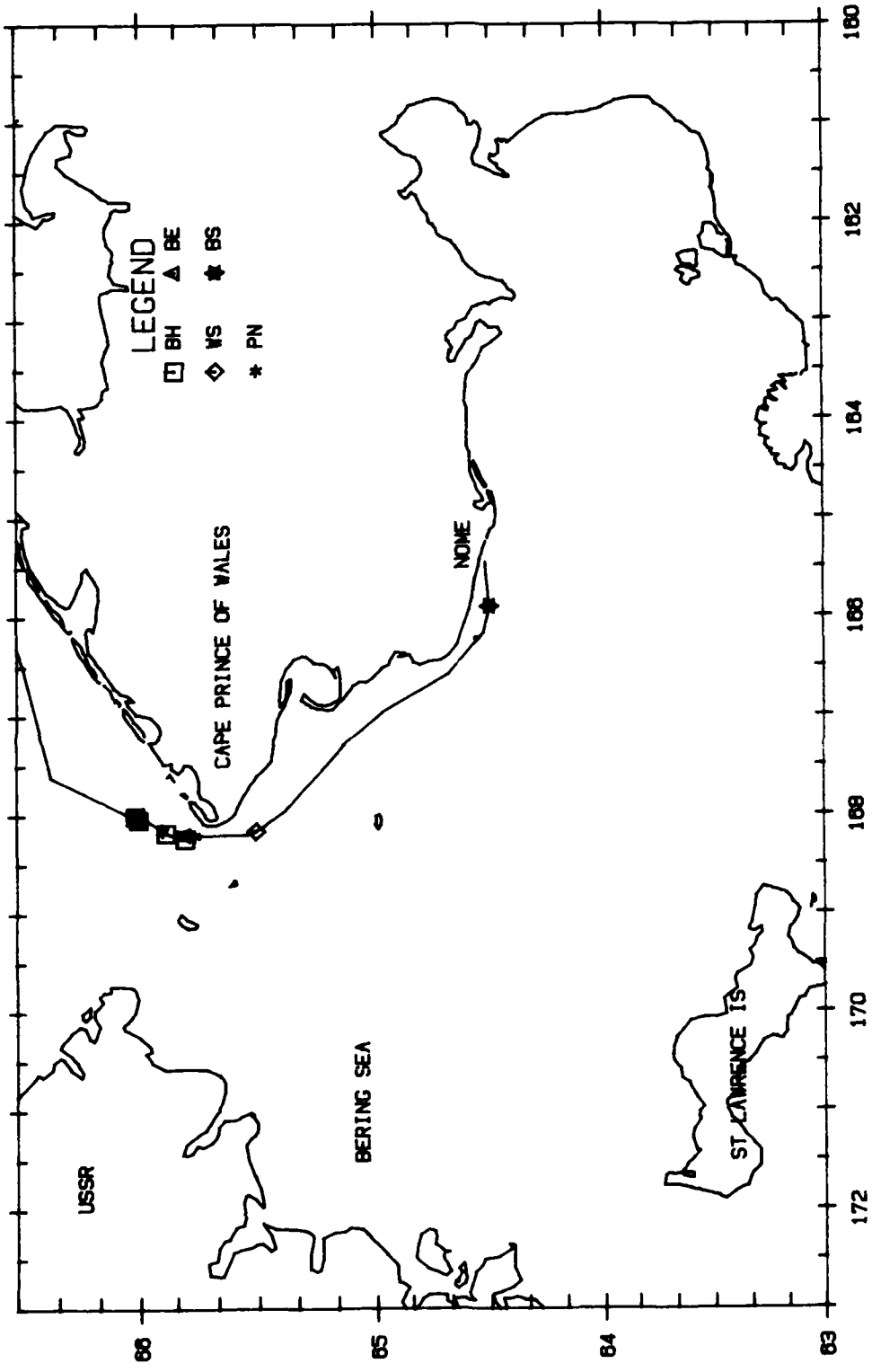
Flight 4: 29 April 1984

Flight was a search survey-transit from Nome to Kotzebue around Cape Prince of Wales. Weather was high overcast with unlimited visibility. Ice coverage was 90 percent new ice along the Seward Peninsula in the Bering Sea and over 98 percent broken floe ice in the Chukchi Sea. Sea state varied from Beaufort 01 to 02. Seven bowheads were sighted north of the Bering Strait swimming generally north. Belukha whales, walrus, bearded seals, and unidentified pinnipeds were also seen. Pinnipeds were seen on trackline not shown on the accompanying chart.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	65°47.8'	168°14.0'	--	SP	SW	360	80	B0	18
4/0	65°52.5'	168°10.4'	--	BO	MT	360	80	B0	18
1/0	65°59.9'	168°00.0'	--	BO	SW	360	80	B0	18
1/0	66°00.2'	168°02.4'	--	BO	SW	30	80	B0	35


LEGEND
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CAPE PRINCE OF WALES
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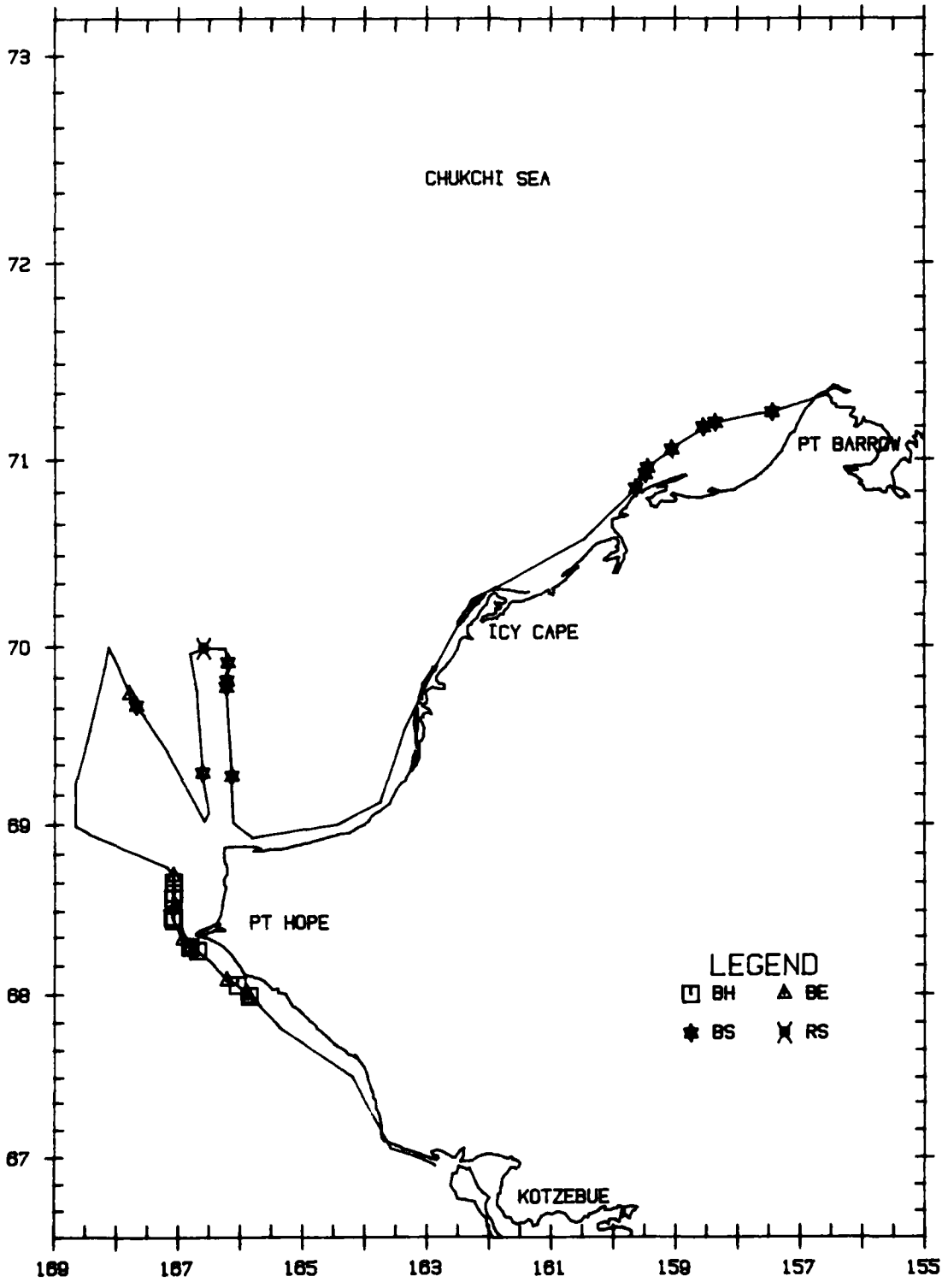
Flight 5: 29 April 1984

Flight was a transit from Kotzebue to Pt. Barrow and a transect survey of the eastern half of block 21. Weather was high overcast with unlimited visibility. Ice coverage was over 95 percent cracked floe and 100 percent shorefast ice. Sea state was Beaufort 00 to 01. Twenty-six bowheads were sighted from northwest and southeast of Pt. Hope generally swimming along the shorefast lead. Belukha whales, bearded seals, and a ringed seal were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
3/0	67°59.3'	165°50.8'	--	BO	SL	270	70	B2	18
1/0	68°03.2'	166°02.4'	--	BO	SW	260	70	B2	26
1/0	68°15.2'	166°41.0'	1097	BW	SW	300	70	B2	18
1/0	68°16.5'	166°48.7'	1506	BW	SW	260	70	B2	18
3/0	68°25.6'	167°04.5'	--	SP	MI	330	70	B2	24
5/0	68°26.7'	167°05.6'	--	BO	MI	340	70	B2	24
7/0	68°34.6'	167°05.1'	--	BO	SW	340	70	B2	33
2/0	68°36.4'	167°04.3'	--	BO	RE	--	70	B2	35
3/0	68°40.2'	167°04.5'	--	BO	SW	340	70	B2	35


CHUKCHI SEA
PT BARROW
ICY CAPE
PT HOPE
KOTZEBUE
LEGEND
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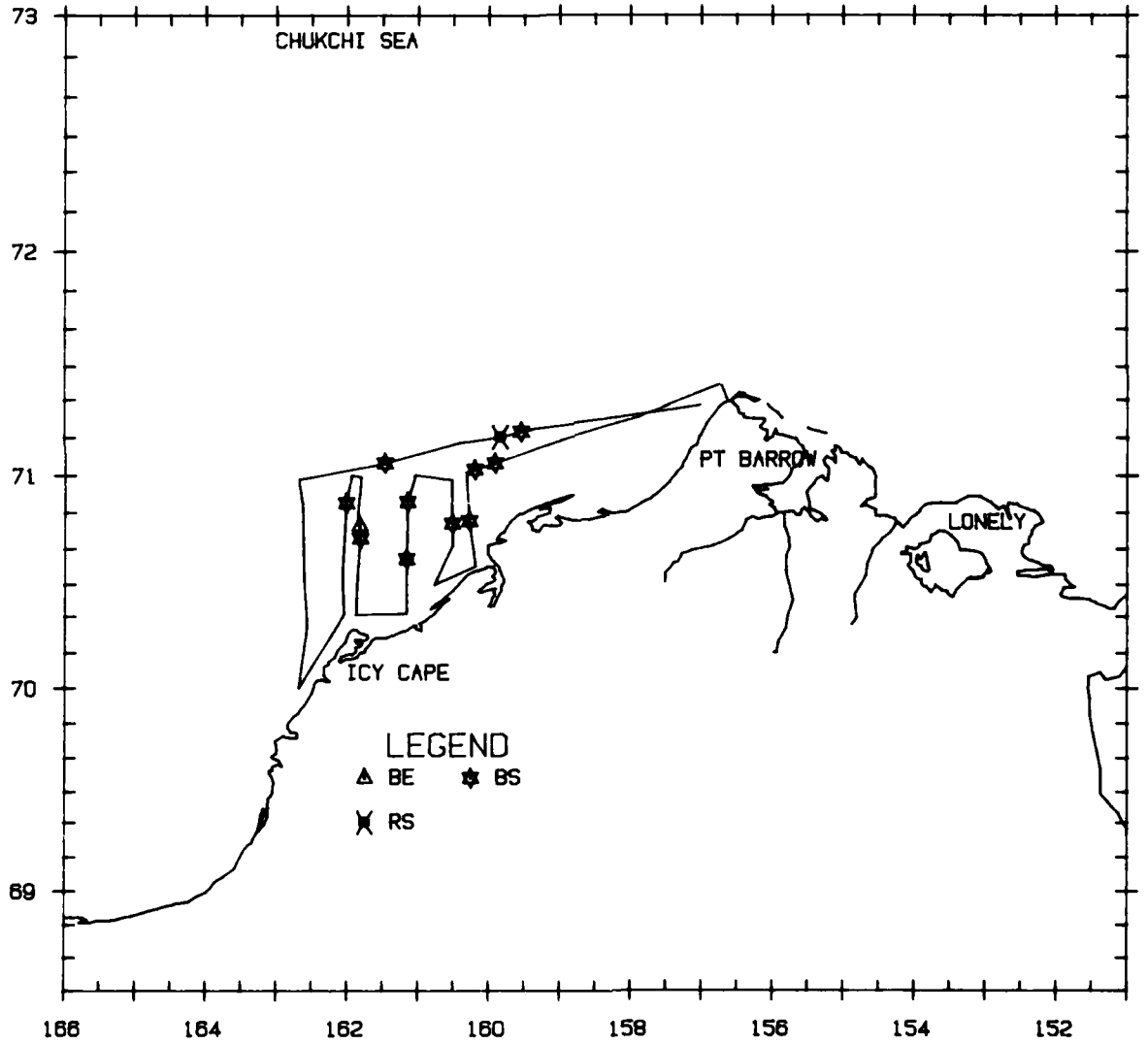
Flight 6: 1 May 1984

Flight was a transect survey of block 17 north of Icy Cape. Weather was clear with unlimited visibility. Ice coverage was over 99 percent floe ice with new ice filling cracks. Sea state was Beaufort 00. Belukha whales, bearded seals, and a ringed seal were seen.


CHUKCHI SEA
PT BARROW
LONELY
ICY CAPE
LEGEND
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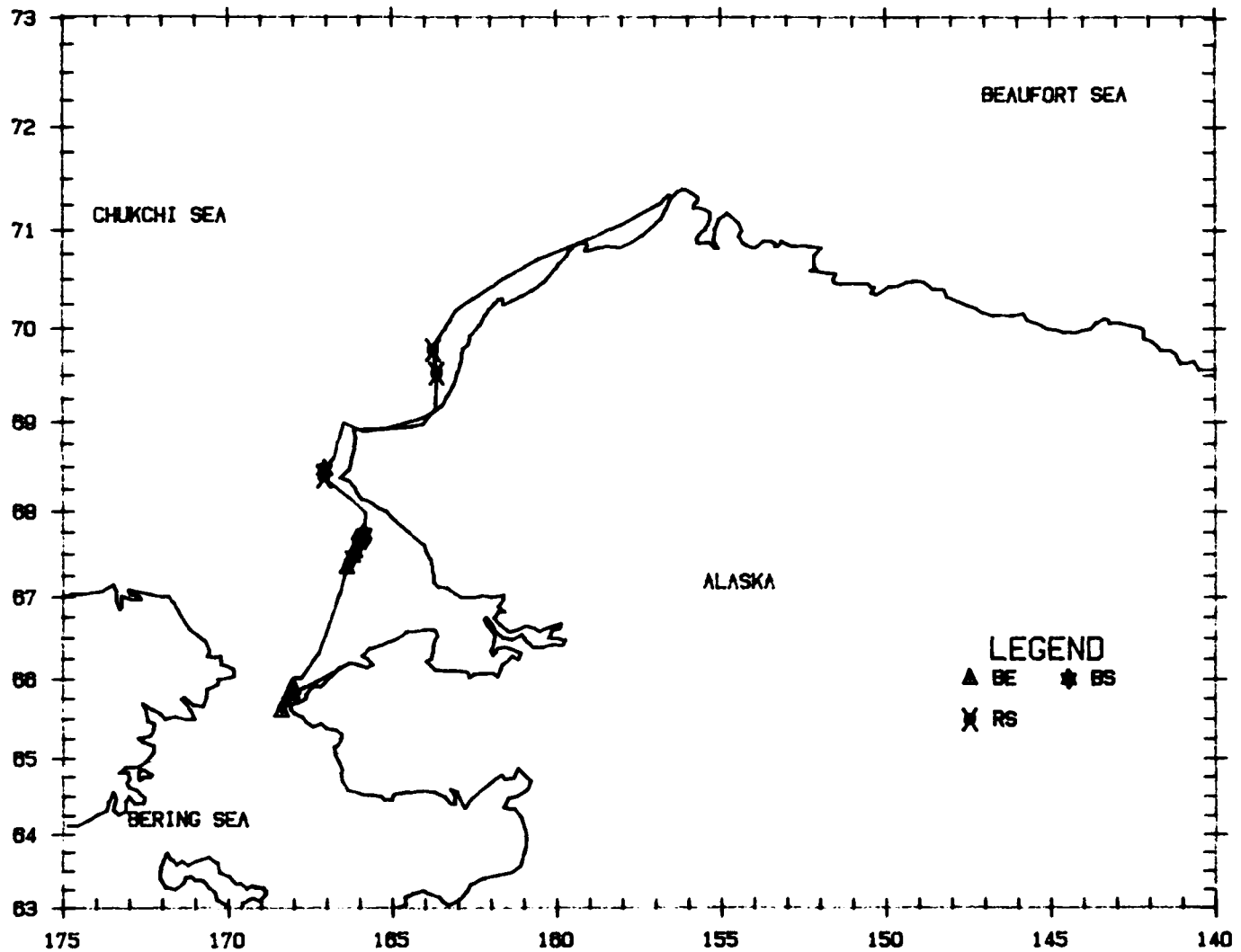
Flight 7: 3 May 1984

Flight was a search survey-transit from Pt. Barrow to the Bering Strait and into Kotzebue. Weather was clear with unlimited visibility. Ice coverage was 99 percent floe with Beaufort 00 sea state. Belukha whales and bearded and ringed seals were seen.


BEAUFORT SEA
CHUKCHI SEA
ALASKA
BERING SEA
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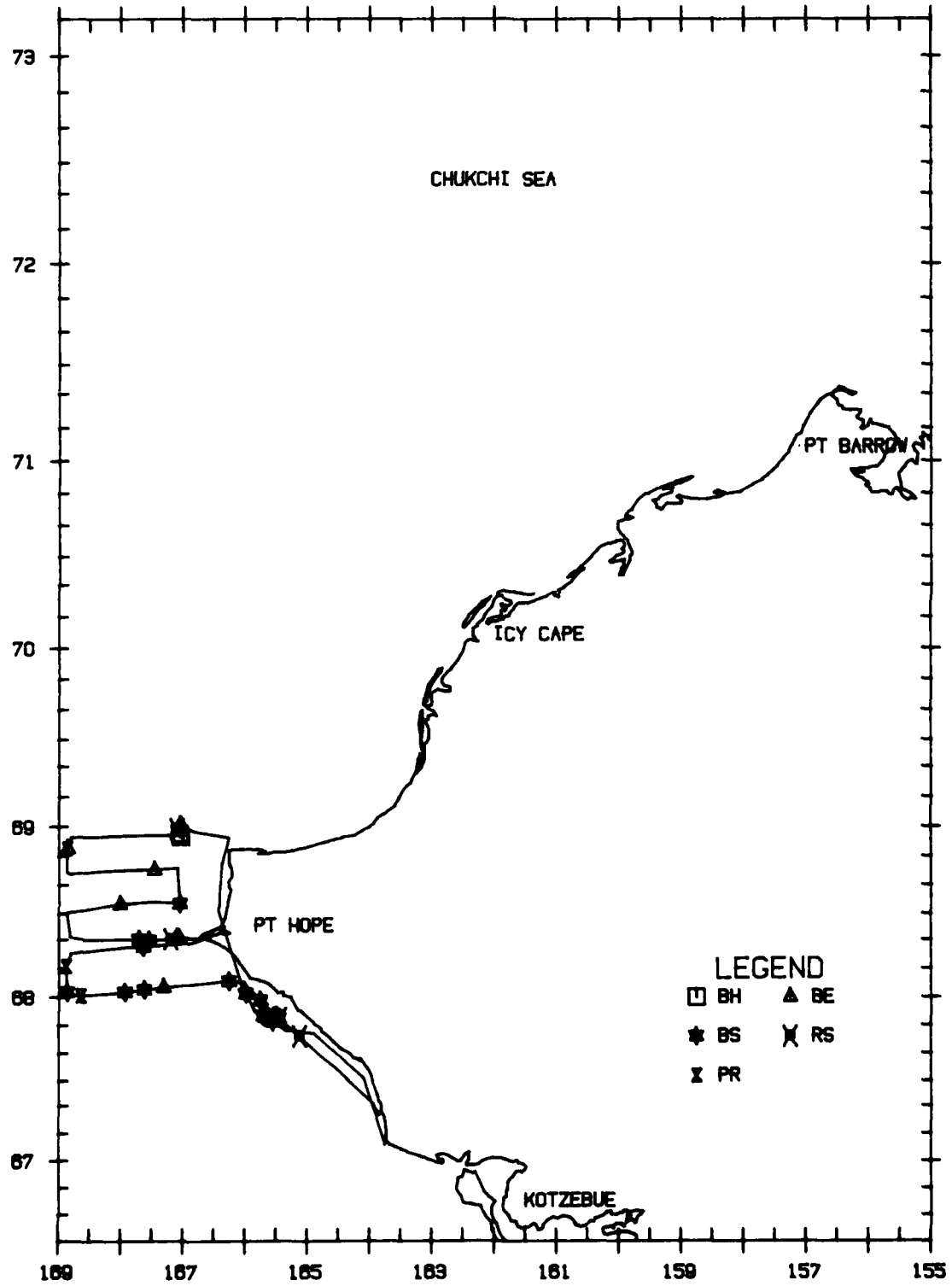
Flight 8: 4 May 1984

Flight was a transect survey of block 22 west of Pt. Hope. Weather was clear with unlimited visibility. Ice coverage was over 90 percent floe ice with north-south cracks in ice. Sea state was Beaufort 00 to 01. Three bowheads were seen northwest of Pt. Hope possibly mating. Belukha whales, polar bears, bearded seals, and ringed seals were also seen. Three sonobuoys were dropped.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
3/0	68°57.6'	167°02.6'	--	BO	MT	--	95	B1	37


CHUKCHI SEA
PT BARROW
ICY CAPE
PT HOPE
KOTZEBUE
LEGEND
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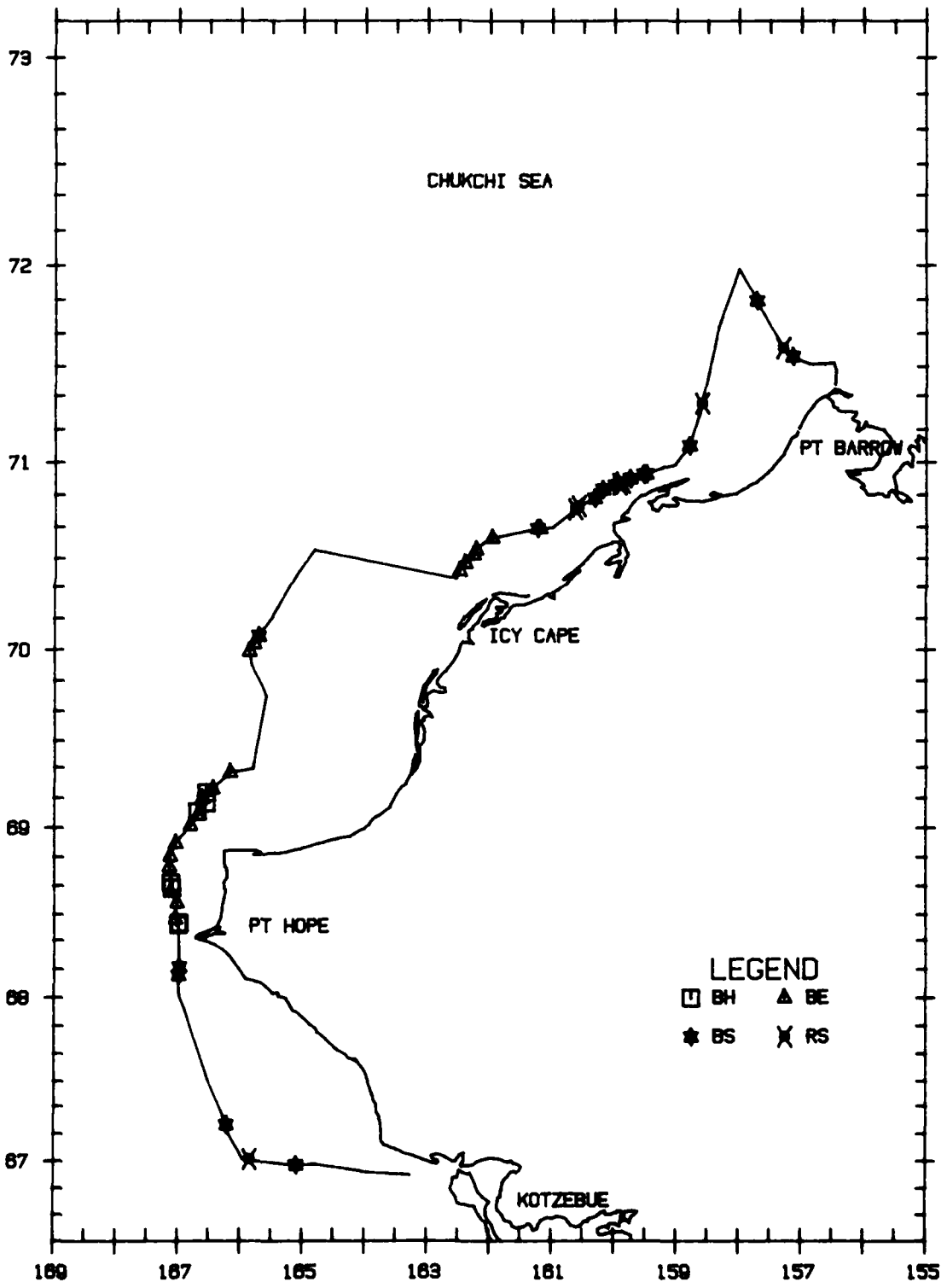
Flight 9: 5 May 1984

Flight was a search survey-transit from Kotzebue to Pt. Barrow. Weather was clear with unlimited visibility except for light fog near Pt. Barrow. Ice coverage was 99 percent floe except the nearshore lead from Pt. Hope to Pt. Barrow which was up to 2 km wide and 90 percent filled with new/grease ice. Sea state was Beaufort 00 to 01. Thirteen bowheads, including two calves, were seen swimming in the nearshore lead from Pt. Hope to north of Cape Lisburne. Belukha whales and bearded and ringed seals were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	68°25.3'	166°59.5'	--	BO	DI	350	90	B1	18
2/0	68°41.1'	167°06.5'	787	BO	DI	360	90	B1	35
4/1	68°39.4'	167°05.7'	--	BW	SW	360	90	B1	35
2/1	69°05.4'	166°40.8'	--	BO	CC	--	90	B1	24
2/0	69°08.2'	166°32.1'	--	BO	SW	340	90	B1	24
2/0	69°11.7'	166°31.8'	--	BO	SW	320	90	B1	29


CHUKCHI SEA
PT BARROW
ICY CAPE
PT HOPE
KOTZEBUE
LEGEND
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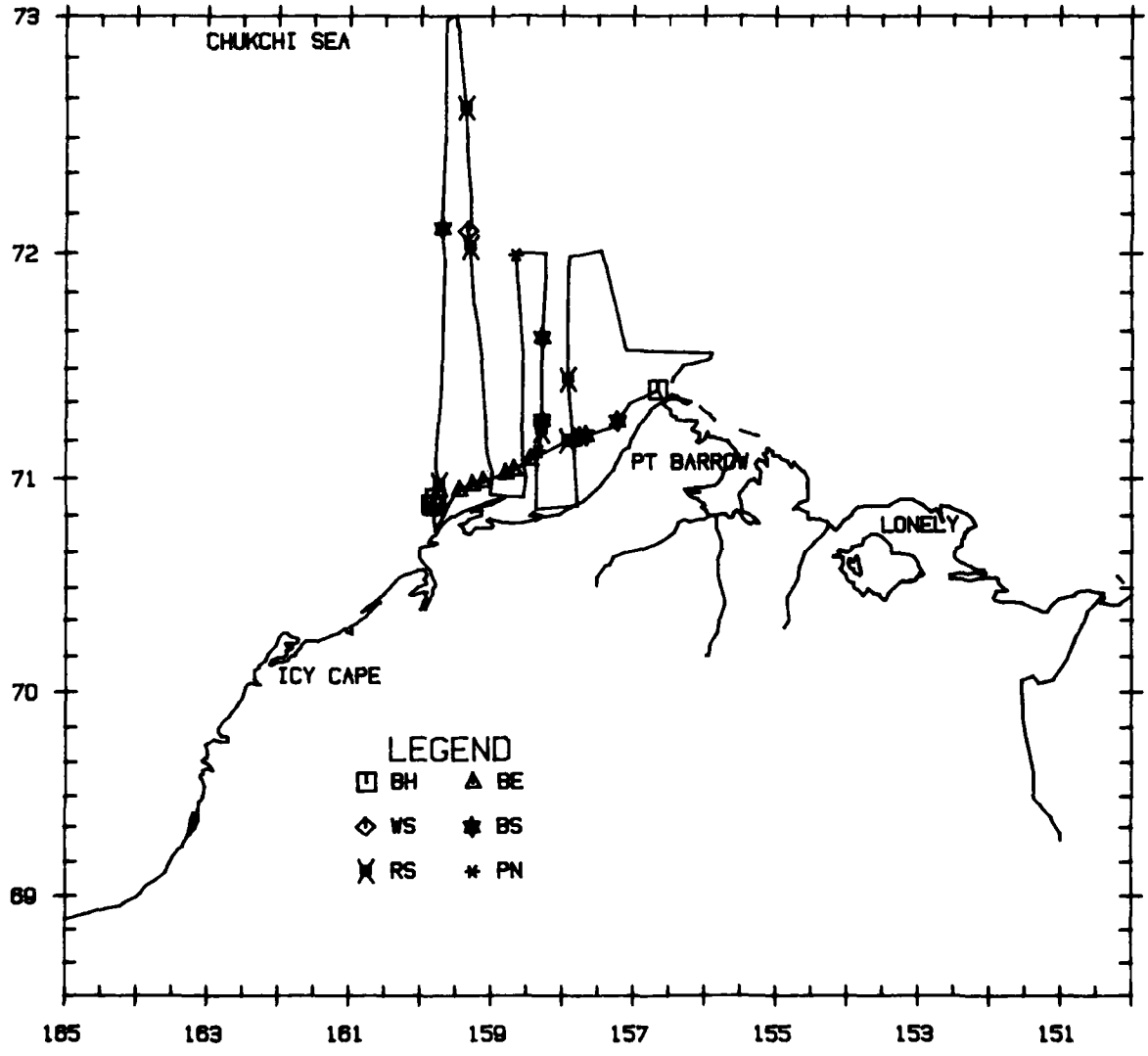
Flight 10: 6 May 1984

Flight was a transect survey of block 13 west of Pt. Barrow and an ice reconnaissance to 73° N. Weather was clear or high overcast with unlimited visibility. Ice coverage was 100 percent shorefast shoreward of the nearshore lead and 99 percent floe seaward. The nearshore lead was 1 to 2 km wide and about half filled with new/grease ice. Sea state was Beaufort 00 to 01. Four bowheads were sighted between Icy Cape and Pt. Barrow and one was seen north of Pt. Barrow swimming in the nearshore lead. Belukha whales, bearded and ringed seals, unidentified pinnipeds, and a walrus were also seen. Two sonobuoys were dropped.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°23.2'	156°38.9'	974	SP	SW	30	99	B1	7
1/0	70°53.1'	159°48.4'	138	BW	SW	30	95	B1	26
2/0	70°53.0'	159°50.4'	--	BO	SW	20	95	B1	26
1/0	70°54.9'	159°47.2'	1125	BO	SW	30	95	B1	26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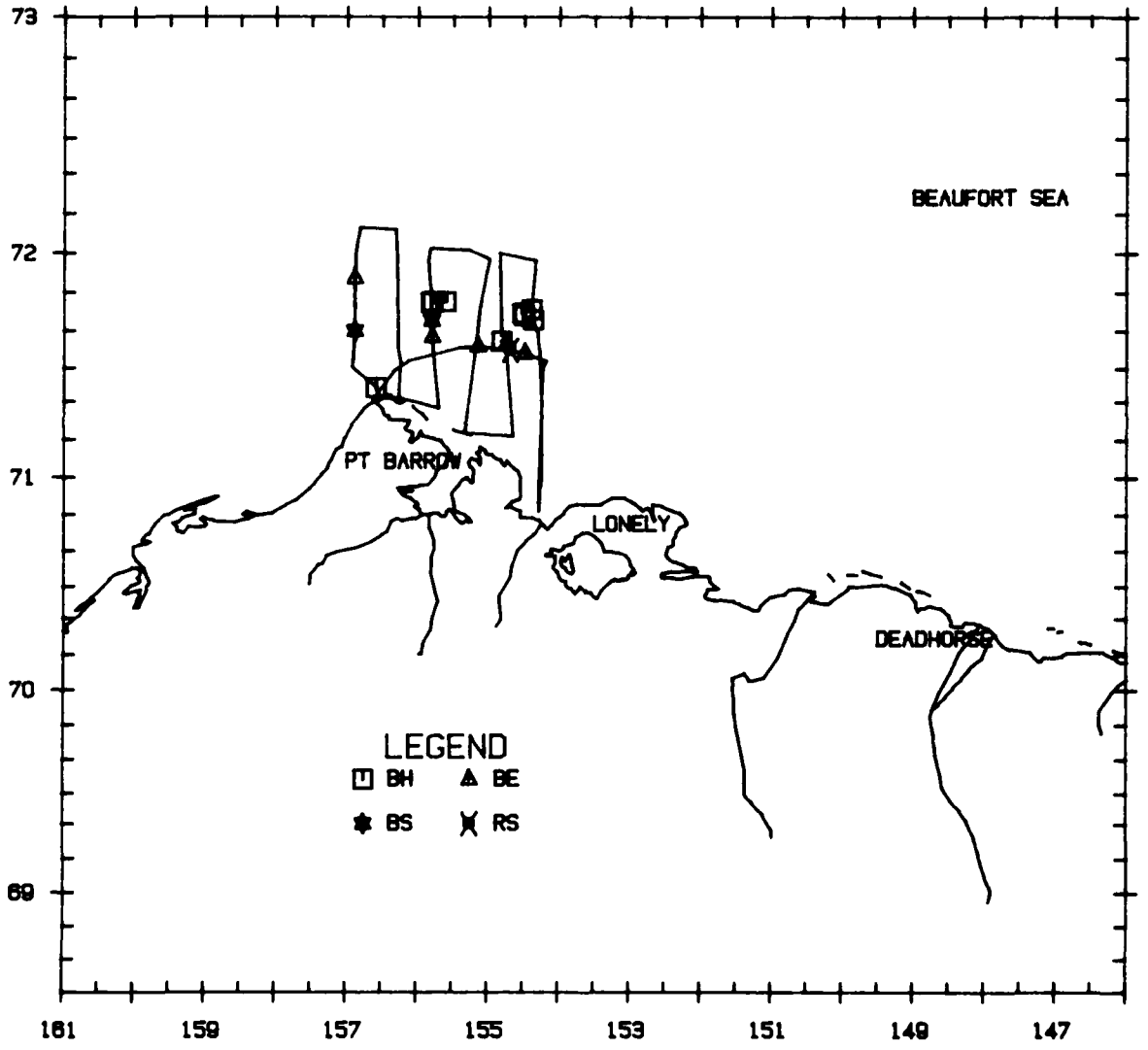
CHUKCHI SEA
PT BARROW
LONELY
ICY CAPE
LEGEND
BH
BE
WS
BS
RS
PN

Flight 11: 7 May 1984

Flight was a transect survey of block 12 north and east of Pt. Barrow. Weather was variable from clear with unlimited visibility in the east to fog with unacceptable visibility in the northwest corner. Ice coverage was 100 percent shorefast floe north to a 4 to 5 km wide nearshore lead which had mixed ice coverage. Immediately north of the nearshore lead was a transition zone of 90 to 99 percent broken floe ice. Its width increased to the east to 20 km wide at 154° W. Sea state was Beaufort 00 except in the lead where it was as high as Beaufort 02. Twenty-one bowheads were seen in the transition ice northeast of Pt. Barrow. Most were swimming east, others were displaying. Belukha whales, bearded seals, and a ringed seal were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
6/0	71°43.0'	154°21.8'	--	BW	SW	80	90	B0	35
4/0	71°44.1'	154°29.7'	--	BW	SW	80	90	B0	35
4/0	71°44.7'	154°31.2'	--	DY	BR	80	90	B0	35
1/0	71°37.3'	154°48.6'	1925	SP	SW	60	50	B1	53
1/0	71°47.7'	155°47.8'	4360	BO	SL	30	25	B1	126
3/0	71°47.7'	155°36.1'	--	BO	BR	30	25	B1	183
1/0	71°47.5'	155°48.7'	--	BW	SW	30	25	B1	126
1/0	71°23.7'	156°35.1'	2901	SP	NA	--	99	BO	7


73
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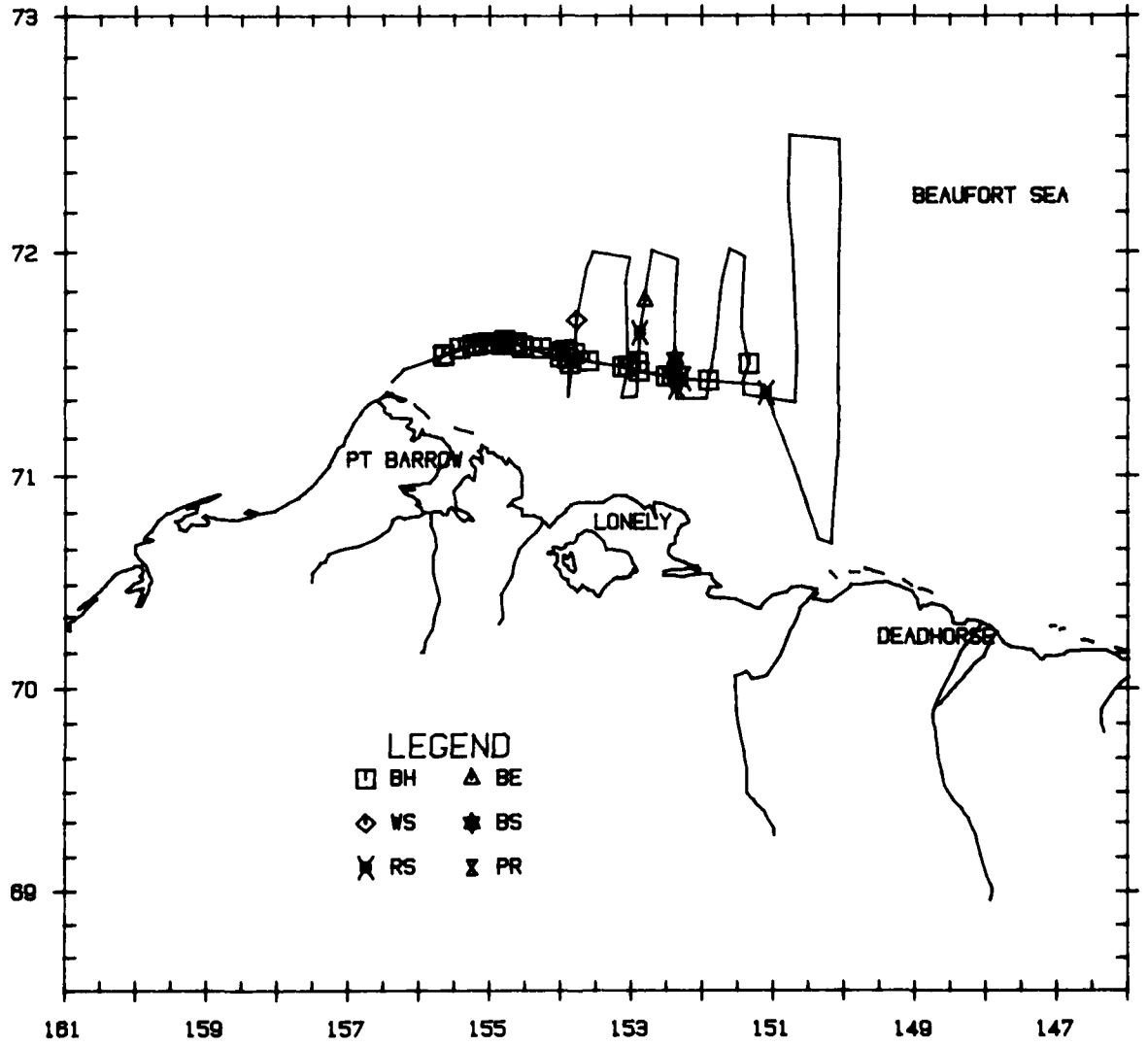
BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
LEGEND
BH
BE
BS
RS

Flight 12: 8 May 1984

Flight was a transect survey of blocks 11 and 3 east of Pt. Barrow. Weather was overcast or low ceiling. Visibility varied from unlimited to 3 km. Ice coverage was 100 percent shorefast inside the 8 to 12 km-wide nearshore lead. There was a transition zone of 90 to 99 percent floe ice north of the near shore lead giving way to 99 percent floe-pack ice. Sea state was Beaufort 01 to 03 in the lead and Beaufort 00 in the ice. One hundred fifty-four bowheads were sighted swimming east and displaying in the nearshore lead and transition ice. Some were covered with mud. Belukha whales, bearded and ringed seals, polar bears, and a walrus were also seen. A sonobuoy was dropped.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
10/0	71°33.6'	155°38.9'	528	DY	SW	40	90	B1	18
5/0	71°33.2'	155°39.7'	--	DY	BR	40	50	B1	18
15/0	71°36.0'	155°14.4'	--	DY	SW	50	50	B1	49
9/0	71°36.6'	154°55.4'	--	DY	BR	50	50	B1	53
2/0	71°37.3'	154°47.3'	--	BO	DI	50	50	B1	53
5/0	71°35.7'	154°32.1'	1089	DY	BR	80	50	B2	40
2/0	71°32.8'	154°00.2'	497	BW	SW	80	50	B3	31
5/0	71°32.5'	153°54.1'	861	DY	BR	70	1	B3	46
6/0	71°31.7'	153°36.3'	--	DY	BR	70	1	B3	55
1/0	71°30.1'	153°07.0'	78	BO	SW	70	1	B3	46
4/0	71°27.5'	152°53.5'	--	DY	BR	80	1	B3	55
4/0	71°26.2'	152°30.2'	--	BO	SW	70	1	B3	51
4/0	71°26.2'	152°25.3'	--	BO	SW	70	1	B3	51
1/0	71°31.0'	151°20.6'	--	BO	SW	60	85	B2	585
1/0	71°25.2'	151°54.7'	--	SP	SW	60	50	B2	51
1/0	71°26.2'	152°21.1'	192	BO	SW	60	25	B2	51
1/0	71°29.9'	152°54.4'	454	BO	SW	60	1	B2	55
1/0	71°30.3'	153°02.9'	4360	SP	SW	60	10	B2	46
6/0	71°33.8'	153°48.2'	--	DY	BR	60	10	B1	46
10/0	71°[illegible]	153°52.3'	--	DY	BR	60	10	B2	46
6/0	71°34.7'	153°55.7'	--	DY	BR	60	1	B2	46
6/0	71°35.2'	154°16.6'	--	BO	SW	60	1	B2	33
3/0	71°35.[illegible]	154°32.6'	713	BO	SW	60	1	B2	40
11/0	71°36.[illegible]	[illegible]	--	BO	SW	60	1	B2	40
2/0	71°36.2'	154°49.7'	--	BO	SW	60	1	B2	53
14/0	71°36.9'	155°00.8'	--	BO	SW	60	1	B2	49
6/0	71°[illegible]	155°[illegible]	--	BO	SW	60	1	B2	49
6/0	71°[illegible]	[illegible]	--	BO	SW	60	1	B2	49
7/0	71°[illegible]	[illegible]	--	BO	SW	60	50	B0	49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BEAUFORT SEA
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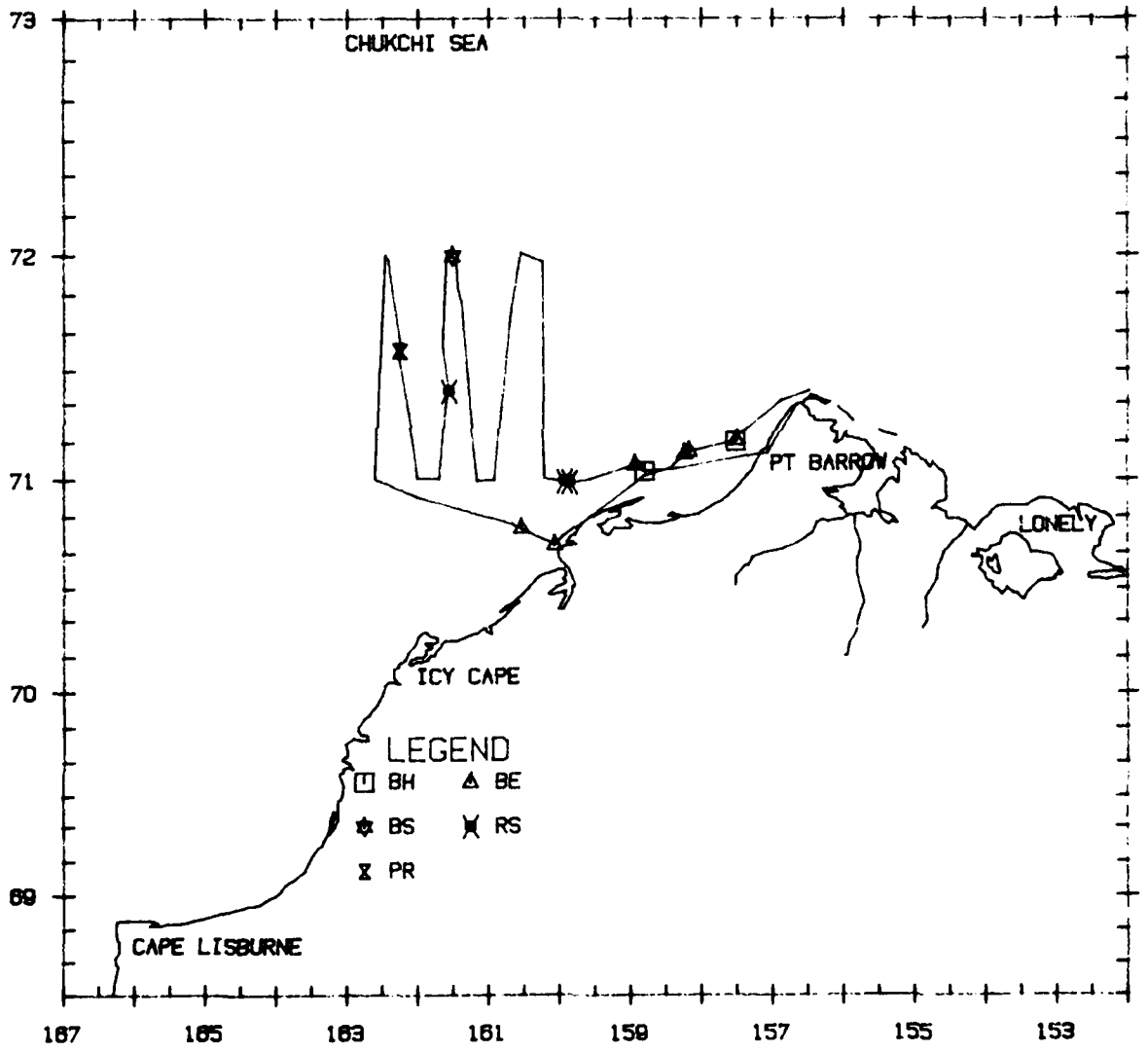
Flight 13: 10 May 1984

Flight was a transect survey of block 14. Weather was low ceiling and fog. Visibility varied from unlimited to 3 km. Ice coverage was 98 percent floe north of the nearshore lead which consisted of only ponds and cracks. The shorefast remained 100 percent. Sea state was Beaufort 01 to 03 in the open water and Beaufort 00 in ice. Six bowheads were sighted southwest of Pt. Barrow swimming northeast. Belukha whales, polar bears, a bearded seal, and ringed seals were also seen. A sonobuoy was dropped.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
4/0	71°02.5'	158°47.9'	--	BO	SW	30	96	B2	26
2/0	71°10.2'	157°30.6'	--	BO	SW	60	95	B2	38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ICY CAPE
CAPE LISBURNE
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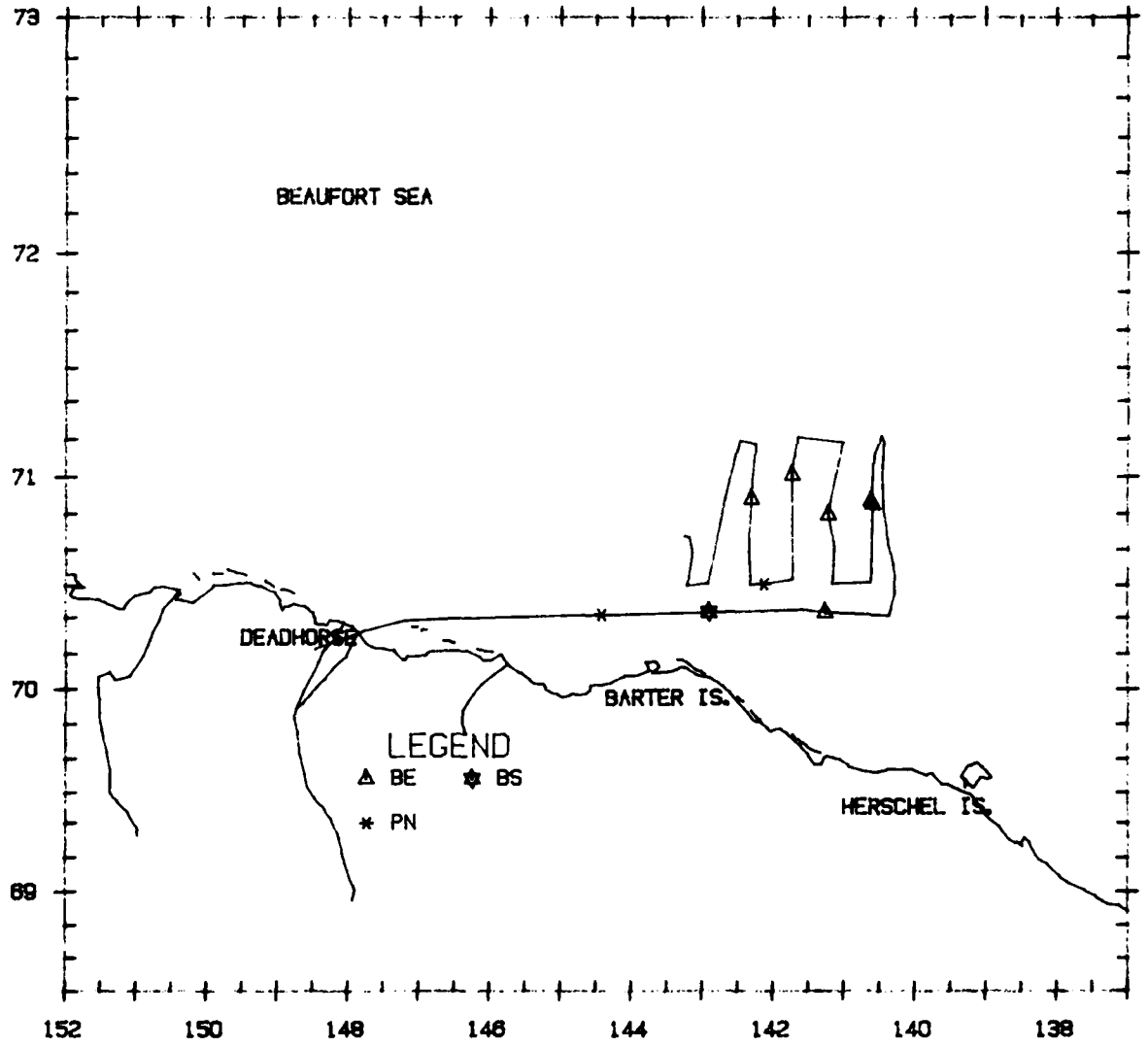
SUMMER

Flight 14: 17 July 1984

Flight was a transect survey of block 7 with a search through blocks 4 and 5 along the 70°20' N line. Weather was overcast with patches of fog resulting in visibility that ranged from unlimited to unacceptable. Ice coverage was 90 to 99 percent broken floe ice with sea state Beaufort 00 to 01. Belukha whales, a bearded seal, and unidentified pinnipeds were seen.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Flight 15: 18 July 1984

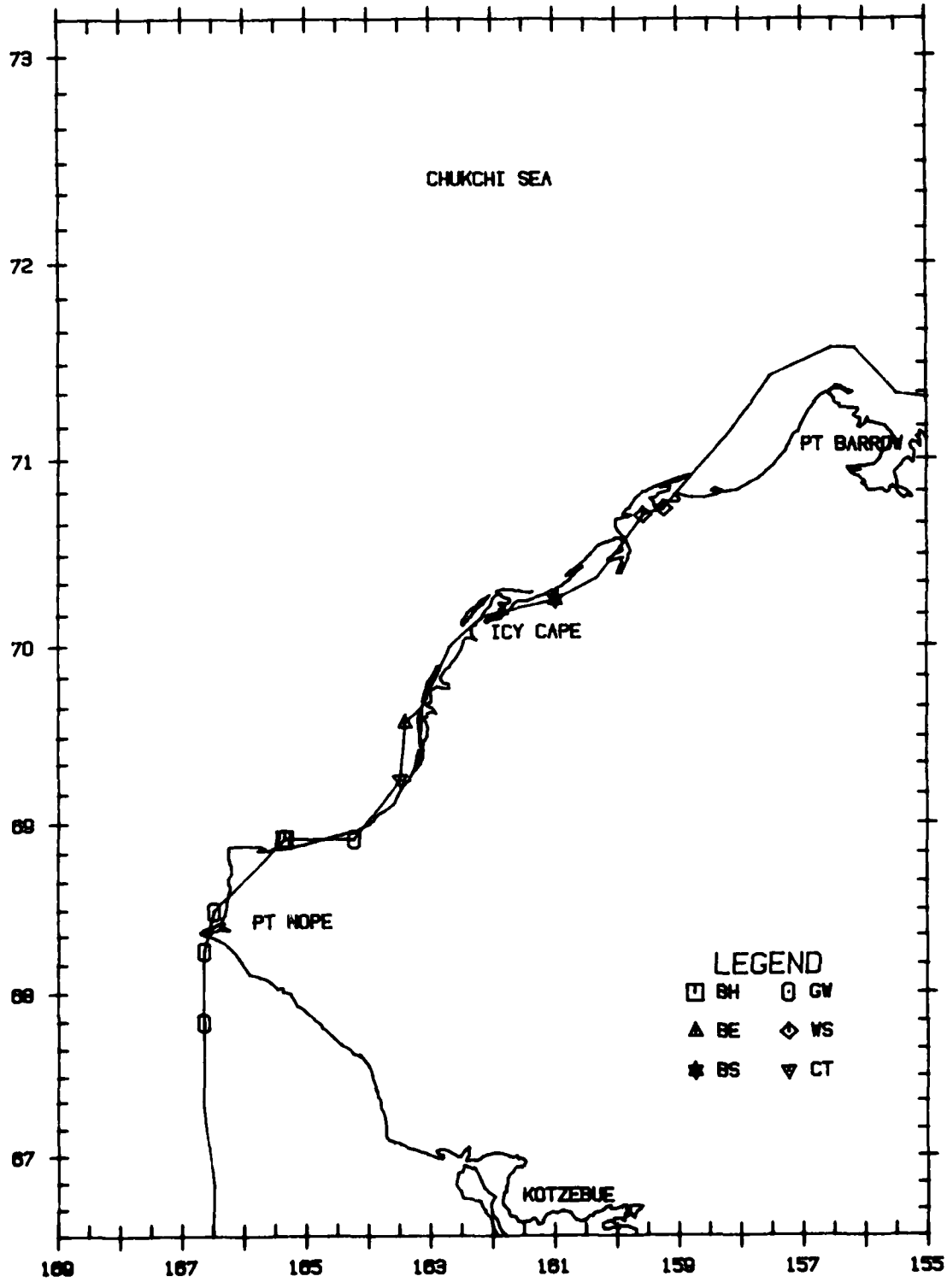
Flight was a coastal search survey from Deadhorse to Nome. Weather was low overcast with rain squalls. Visibility ranged from less than 1 km to unlimited. Ice coverage averaged 95 percent broken floe in the Beaufort Sea, varied from 95 to 60 percent in the northern Chukchi Sea to Icy Cape and diminished to less than 1 percent south of Icy Cape. Sea state was Beaufort 01 in areas of heavy ice and Beaufort 03 to 04 in open water. Walrus were seen in the northern Chukchi Sea and ten gray whales with mud plumes were seen 7 to 50 km south of Pt. Hope. One bowhead, three gray whales, one belukha whale, one unidentified cetacean, and 32 walrus carcasses and bearded seals were seen along the beach between Icy Cape and Pt. Hope.

Bowhead

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	68°55.0'	165°22.0'	90	BO	DE	--	0	B3	--

Gray Whale

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	68°55.0'	164°15.0'	17	BO	DE	--	0	B3	--
1/0	68°55.0'	165°22.0'	90	BO	DE	--	0	B3	--
1/0	68°30.0'	166°30.0'	--	BO	DE	--	0	B4	--
7/0	68°15.0'	166°40.0'	218	MP	FE	170	0	B4	18
3/0	67°50.0'	166°40.0'	377	BO	FE	230	0	B4	51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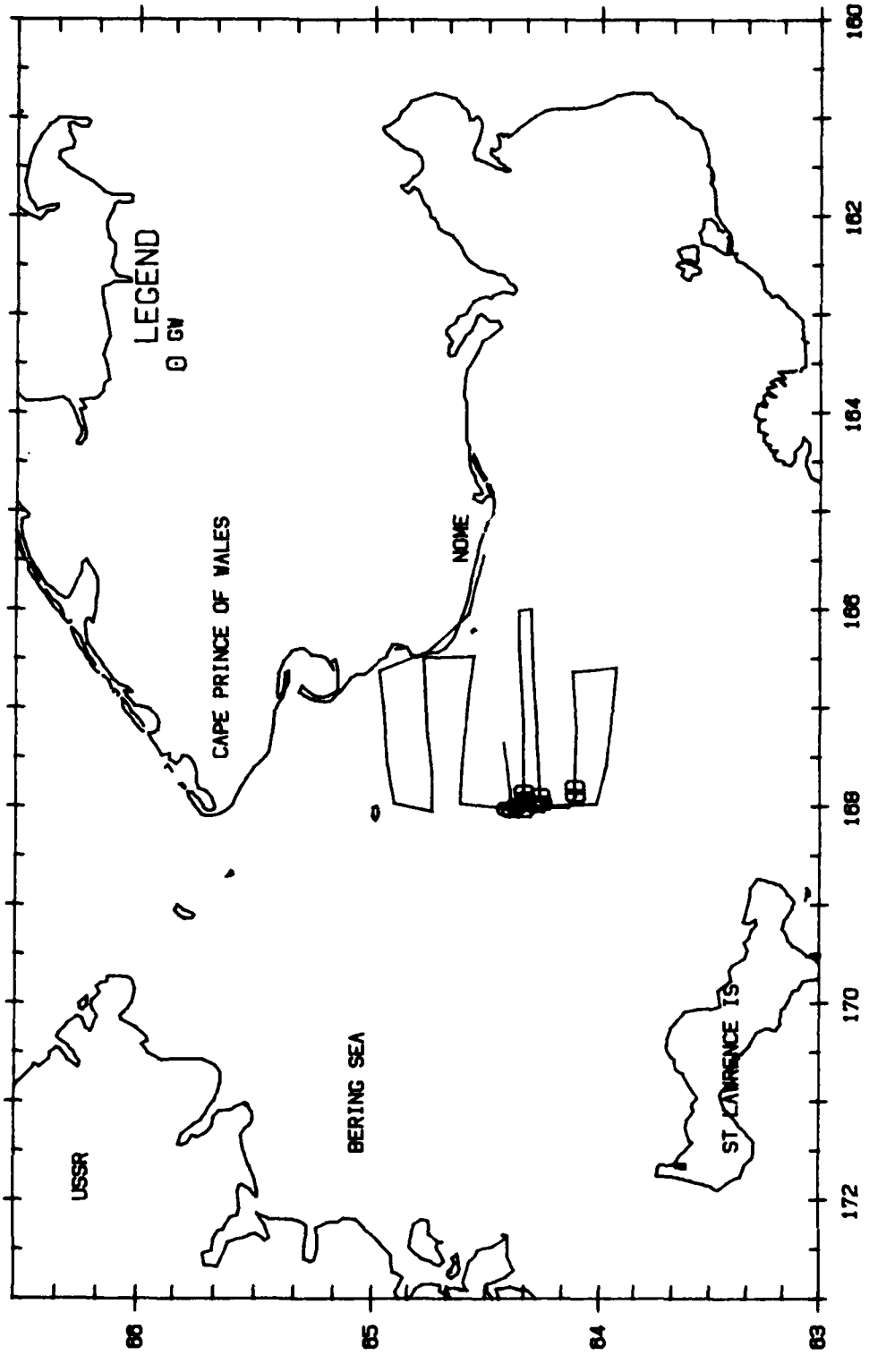
Flight 16: 21 July 1984

Flight was a transect survey in the northern half of block 28. Weather was low overcast with patches of fog. Visibility ranged from unlimited to unacceptable. Dense fog resulted in terminating the survey halfway through the block. Sea state was Beaufort 02. Twenty-four gray whales were seen along the western boundary of the block, including one cow-calf pair. Dead walrus were also seen. One sonobuoy was dropped, but no sounds recorded.

Gray Whale

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
12/0	64°24.6'	168°01.3'	335	MP	FE	330	0	B2	37
3/0	64°22.1'	167°59.4'	--	MP	FE	150	0	B2	33
1/0	64°19.8'	167°55.0'	573	BO	SW	330	0	B2	37
2/0	64°20.2'	167°50.6'	512	MP	FE	330	0	B2	33
1/0	64°15.9'	167°53.0'	372	BO	SW	30	0	B2	37
1/0	64°15.4'	167°57.9'	479	MP	FE	120	0	B2	37
1/0	64°06.5'	167°53.2'	880	MP	FE	330	0	B2	37
1/0	64°06.6'	167°47.9'	985	MP	FE	150	0	B2	37
2/1	64°23.4'	168°02.5'	--	MP	CC	30	0	B2	37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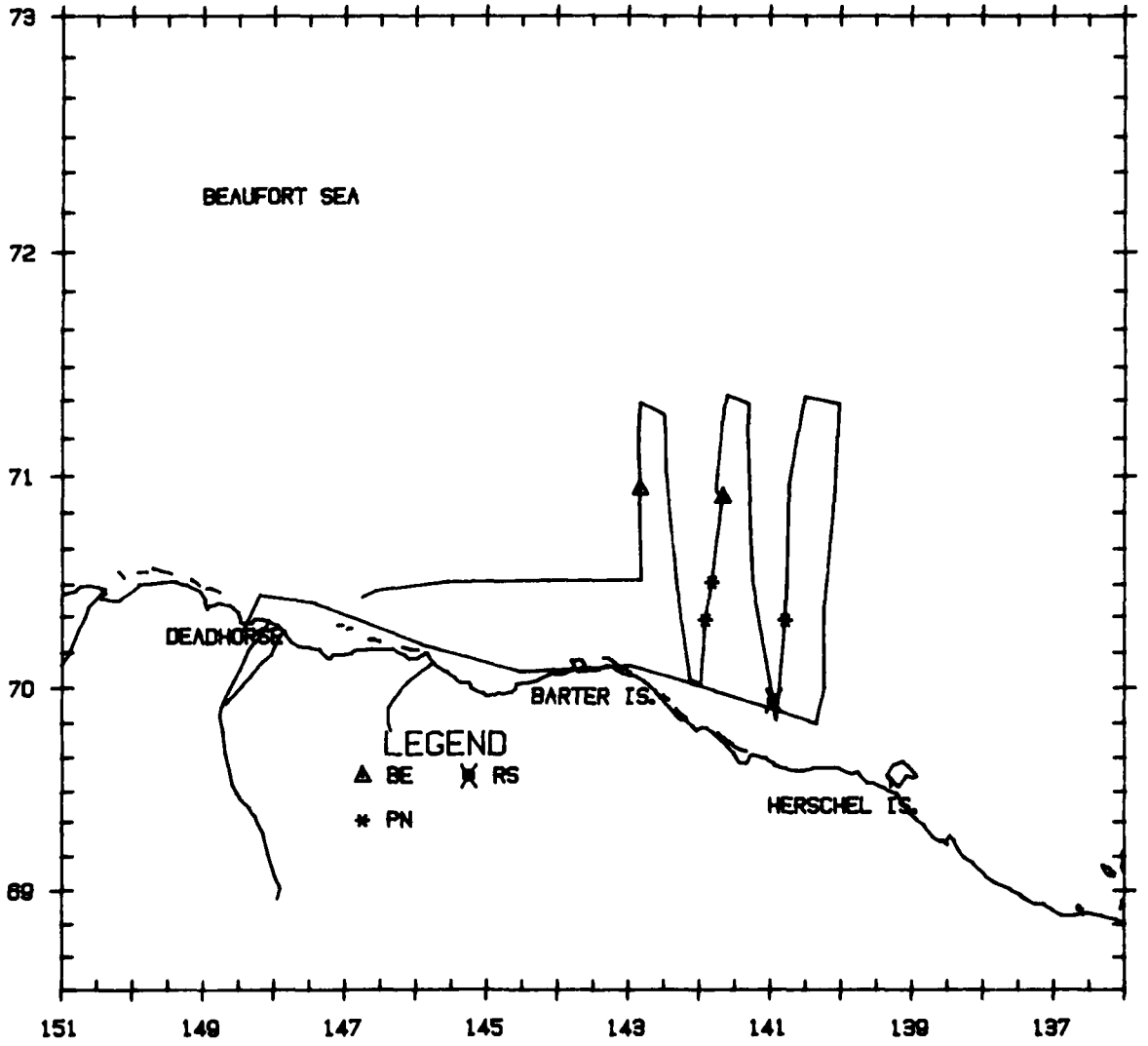
Flight 17: 25 July 1984

Flight was a transect survey in blocks 5, 7, and the southern fifth of block 8, with a search survey through blocks 4 and 6. Weather was clear and visibility unlimited except for a 20 km^2 patch of fog in the southwest corner of block 8. Ice coverage was 95 to 99 percent broken floe in all blocks, and sea state was Beaufort 00. There was a narrow open water channel between the barrier islands and the shoreline where sea state was Beaufort 01. Belukha whales, a ringed seal, and unidentified pinnipeds were seen.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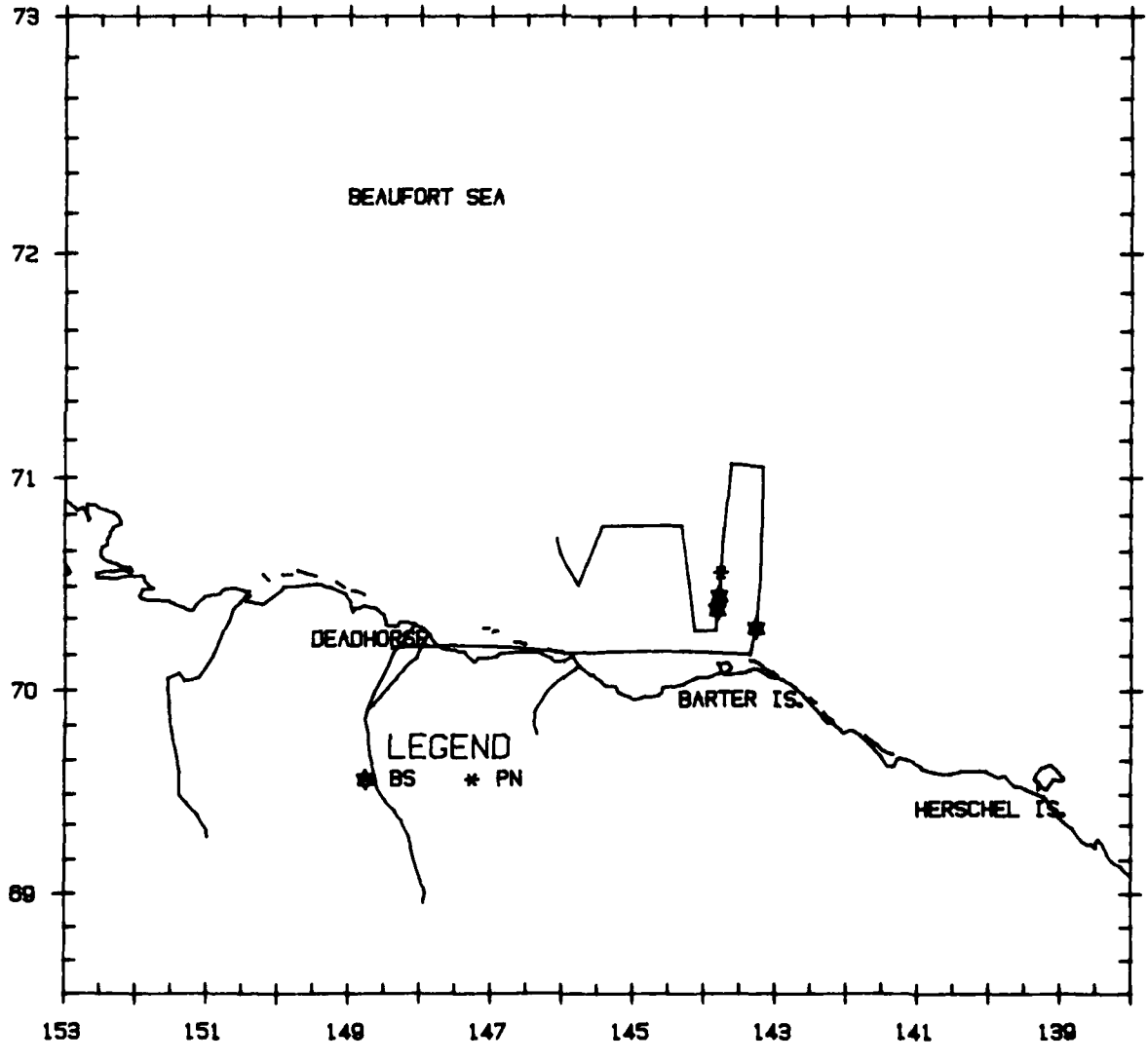
Flight 18: 27 July 1984

Flight was a transect survey of the eastern half of blocks 4 and 6. Low, dense fog caused transect legs to be truncated at their northern and southern boundaries and finally for the survey to be aborted. Weather was partly cloudy with fog over the ice. Ice coverage was 95 to 99 percent broken floe. Sea state was Beaufort 00. There was a narrow 2 km wide open water channel from shore extending approximately 0.5 km north of the barrier islands where sea state was Beaufort 01. Bearded seals and an unidentified pinniped were seen.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HERSCHEL IS.
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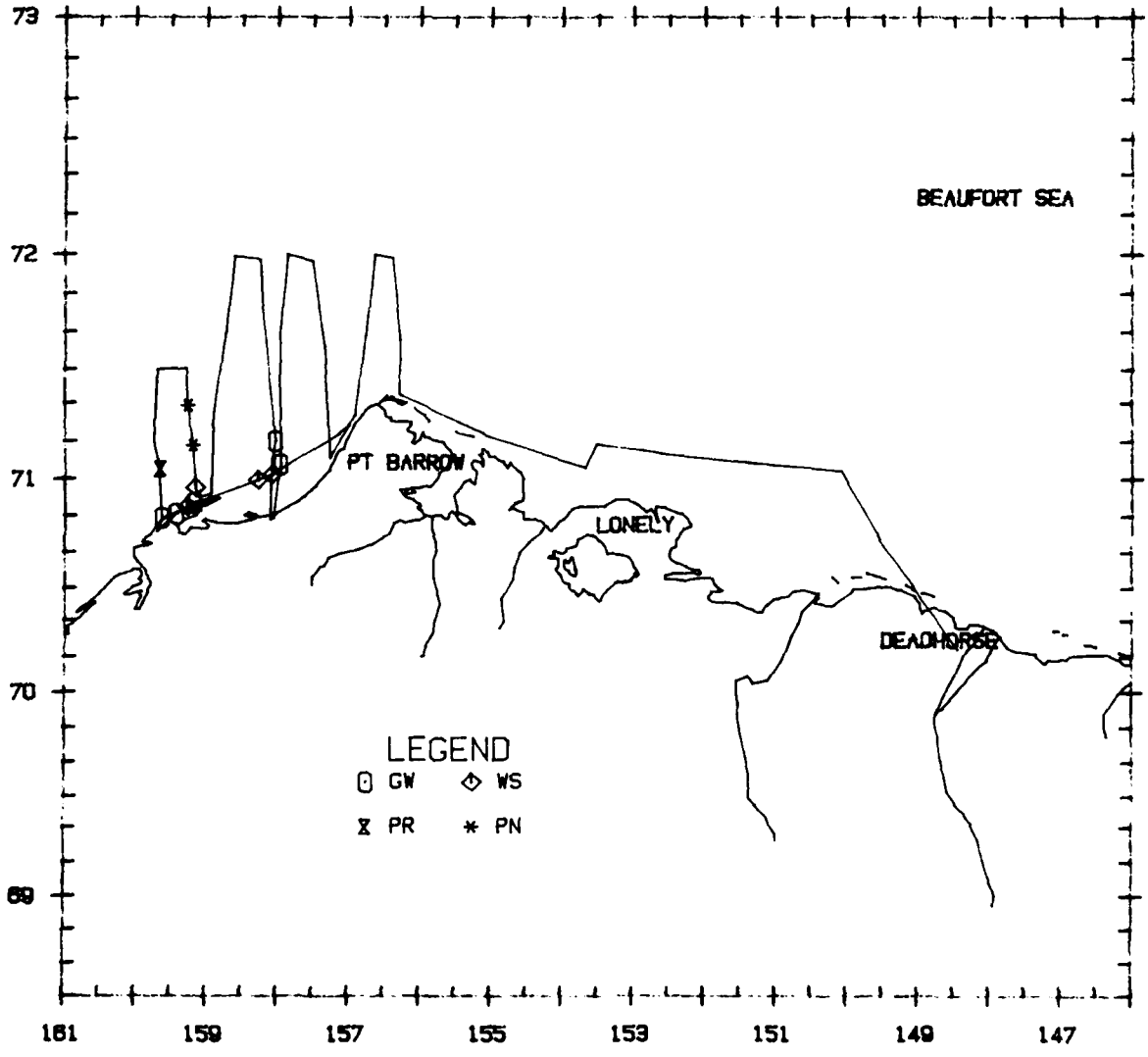
Flight 19: 28 July 1984

Flight was a search survey in the Beaufort Sea enroute to a transect survey of the western third of block 12 and block 13. Weather ranged from partly cloudy to low overcast and fog. Visibility ranged from unlimited to less than 1 km. Transect survey in the northwestern corner of block 13 was aborted due to fog. Ice coverage ranged from 0 to 70 percent within 5 km from shore, but was generally 95 to 99 percent at distances over 5 km from shore. Sea state was Beaufort 00 to 03. Twelve gray whales, walrus, unidentified pinnipeds, and a polar bear were seen.

Gray Whale

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
2/0	71°03.9'	157°57.7'	409	BO	FE	330	25	B1	27
3/0	71°10.1'	158°01.9'	305	BO	SW	180	30	B2	22
5/0	70°49.5'	159°37.7'	323	BO	SW	240	10	B3	18
1/0	70°50.7'	159°25.4'	196	BO	SW	210	5	B2	18
1/0	70°53.7'	159°09.8'	192	BO	SW	350	5	B3	18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BEAUFORT SEA
PT BARROW
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DEADHORSE
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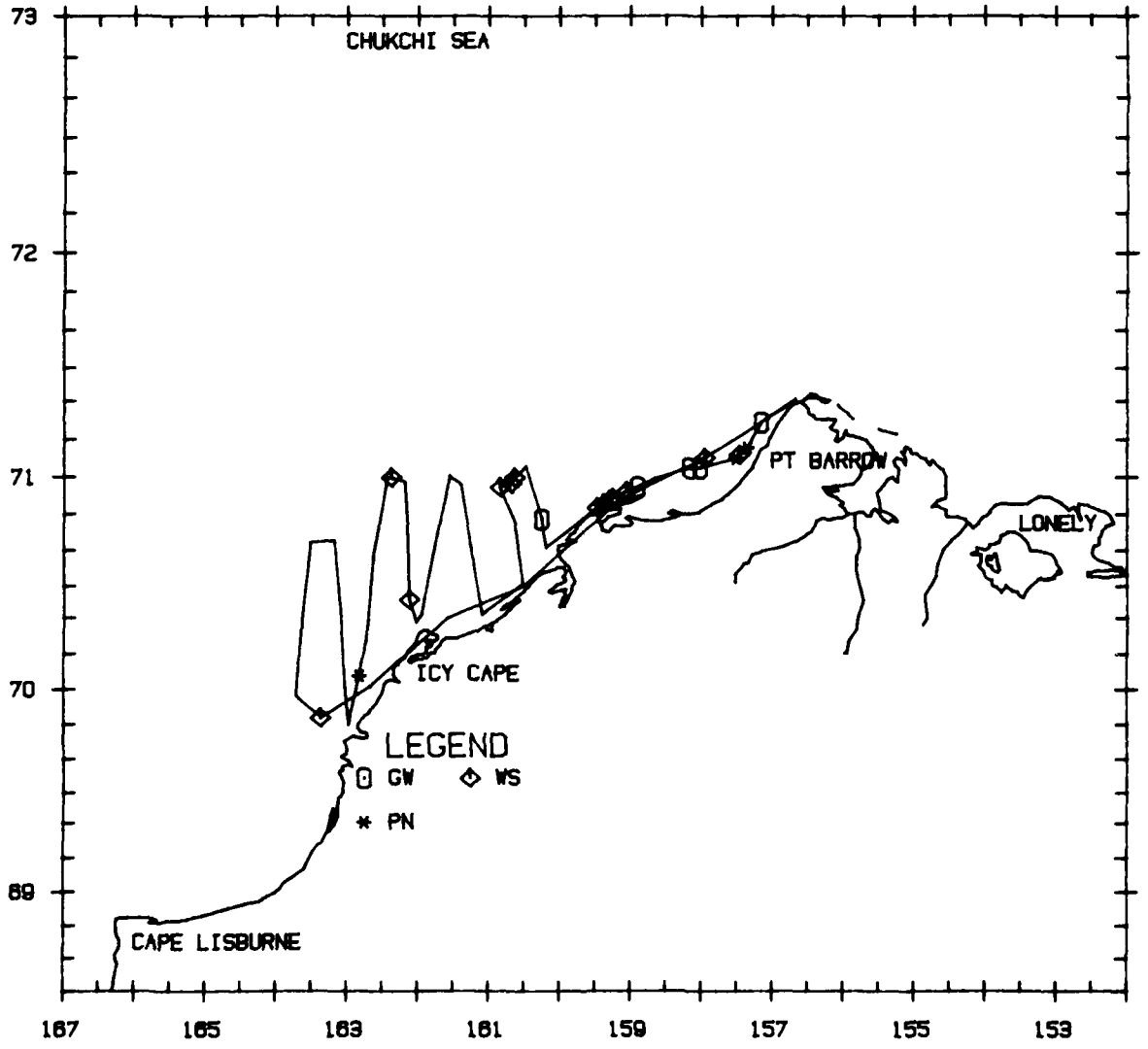
Flight 20: 29 July 1984

Flight was a nearshore search survey enroute to a transect survey of block 17 and the eastern third of block 18. Weather was partly cloudy to overcast with areas of fog. Visibility ranged from unlimited to less than 1 km. Ice coverage ranged from 40 to 90 percent broken floe offshore, with a 1 km open water channel at Barrow, broadening to 20 km west of Peard Bay, and to approximately 70 km west of Wainwright. Sea state ranged from Beaufort 01 to 05. Five gray whales, walrus, and unidentified pinnipeds were seen.

Gray Whale

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°14.4'	157°09.4'	352	BO	SW	40	1	B1	18
1/0	71°02.4'	158°01.0'	368	MP	FE	240	1	B1	20
1/0	71°02.3'	158°09.8'	492	MP	FE	60	1	B1	20
1/0	70°57.2'	158°53.9'	479	MP	FE	210	0	B2	18
1/0	70°48.6'	160°15.2'	562	MP	FE	300	0	B4	22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CHUKCHI SEA
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CAPE LISBURNE
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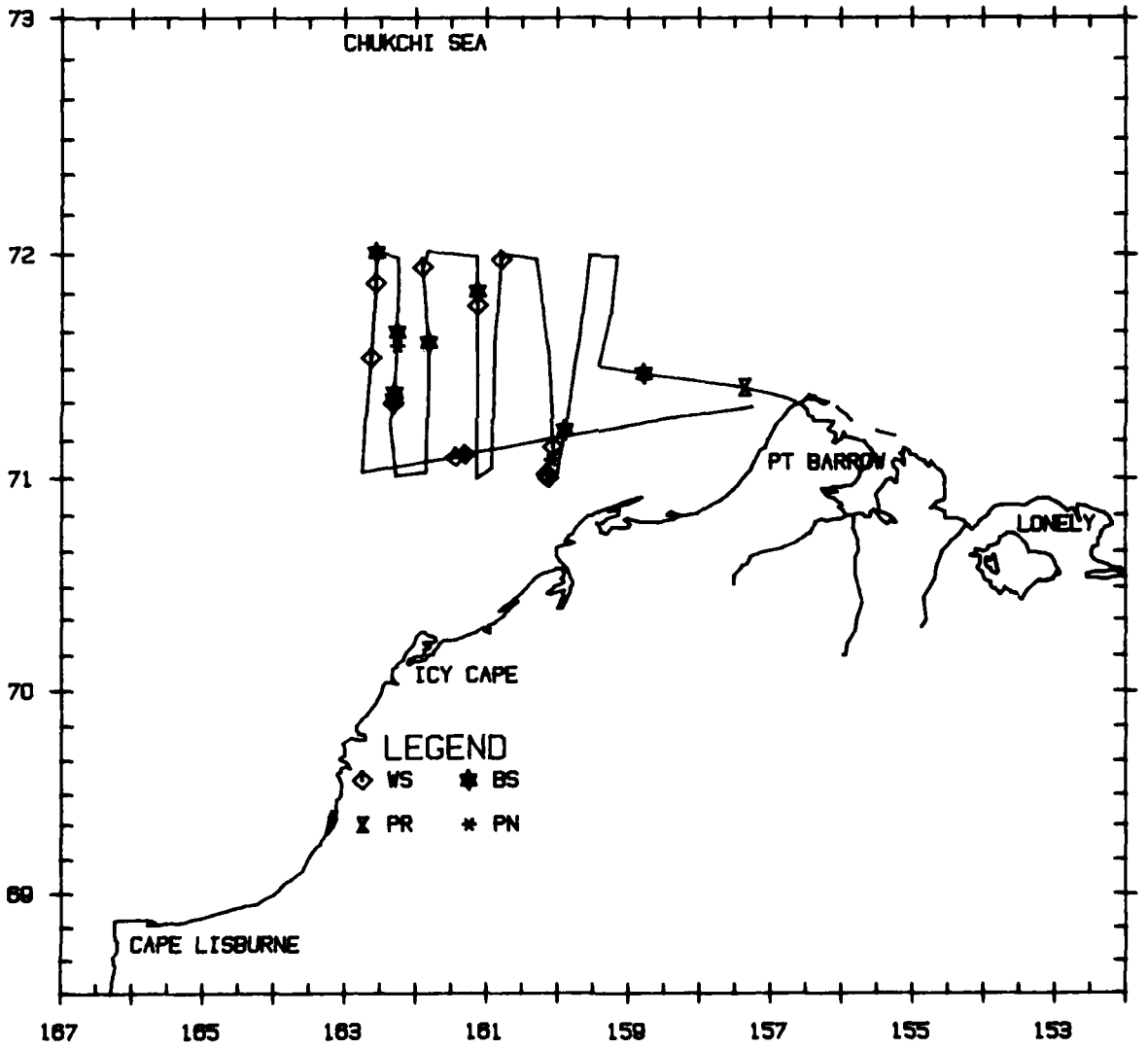
Flight 21: 30 July 1984

Flight was a transect survey of block 14 with a search survey across block 13. Weather was partly cloudy with areas of overcast. Visibility was unlimited. Ice coverage ranged from 90 percent broken floe in the northeastern quadrant to open water in the southwestern quadrant. Sea state ranged from Beaufort 00 to 02. Walrus, bearded seals, unidentified pinnipeds, and a polar bear were seen.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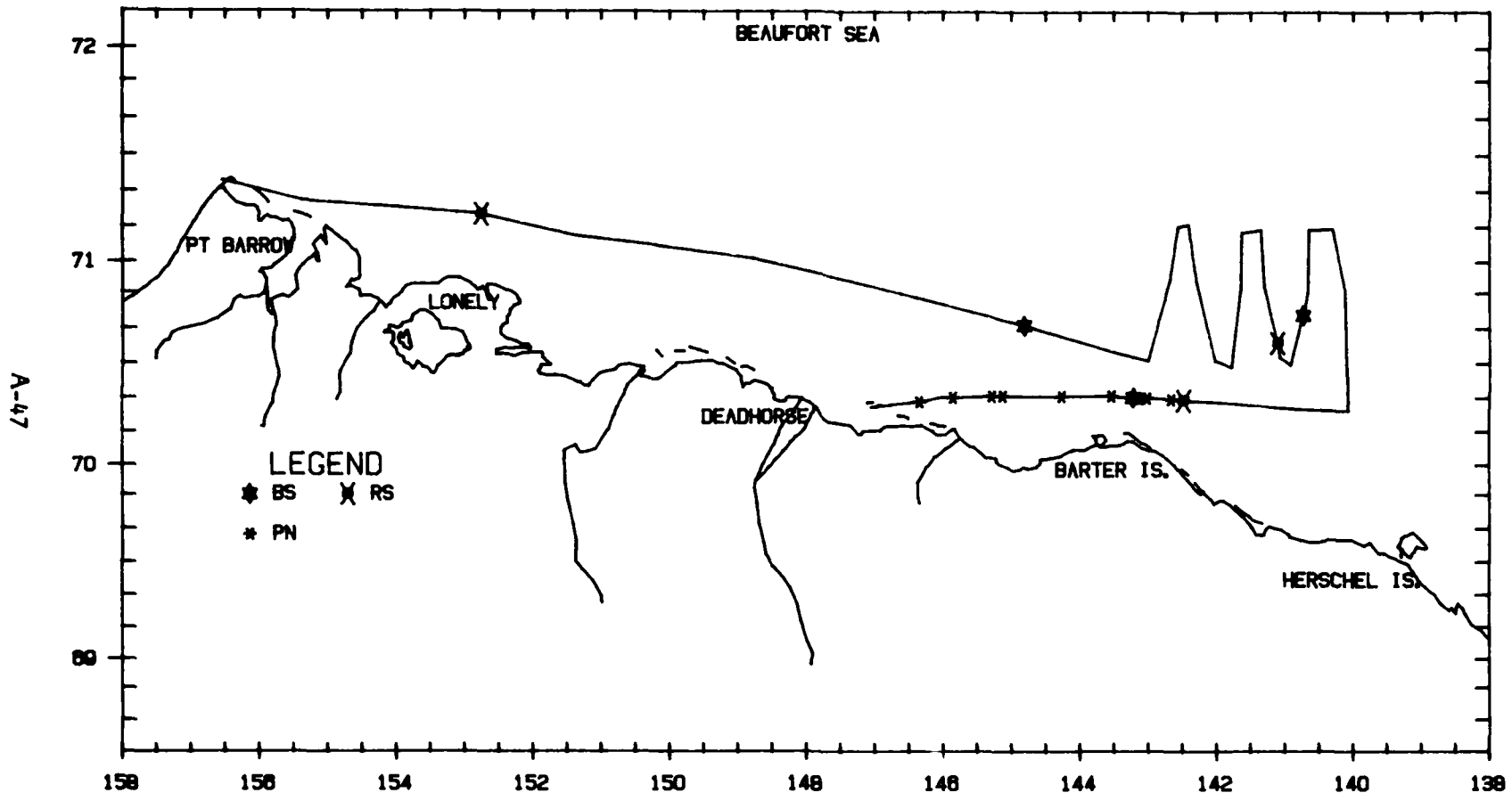
FALL

Flight 22: 1 August 1984

Flight was a search survey across the Alaskan Beaufort Sea and a transect survey of block 7. Weather was partly cloudy with areas of overcast. Visibility was unlimited. Ice coverage ranged from open water nearshore (inside 10 km) to 99 percent in the northern half of block 7. Sea state was Beaufort 00 to 01. Bearded and ringed seals and unidentified pinnipeds were seen.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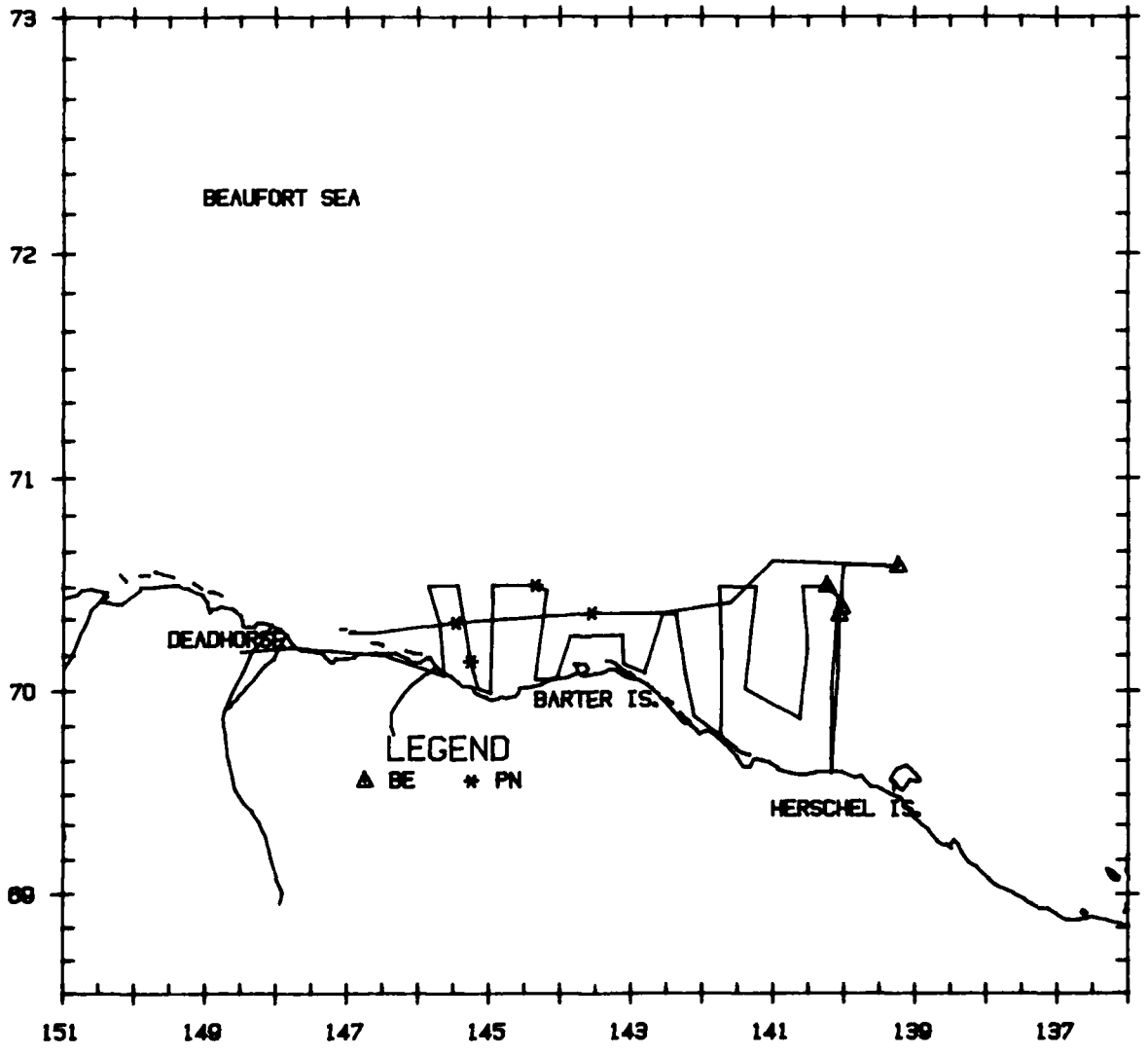
Flight 23: 2 August 1984

Flight was a transect survey in blocks 4 and 5 with a search survey to 70°40' N, 139°20' W, and return to Deadhorse. Weather was overcast with patches of fog and drizzle causing some transect legs to be truncated. Visibility ranged from unlimited to unacceptable. Ice coverage ranged from open water within 5 km of shore to 95 percent at 70°25' N. Sea state was Beaufort 00 to 01. Belukha whales and unidentified pinnipeds were seen.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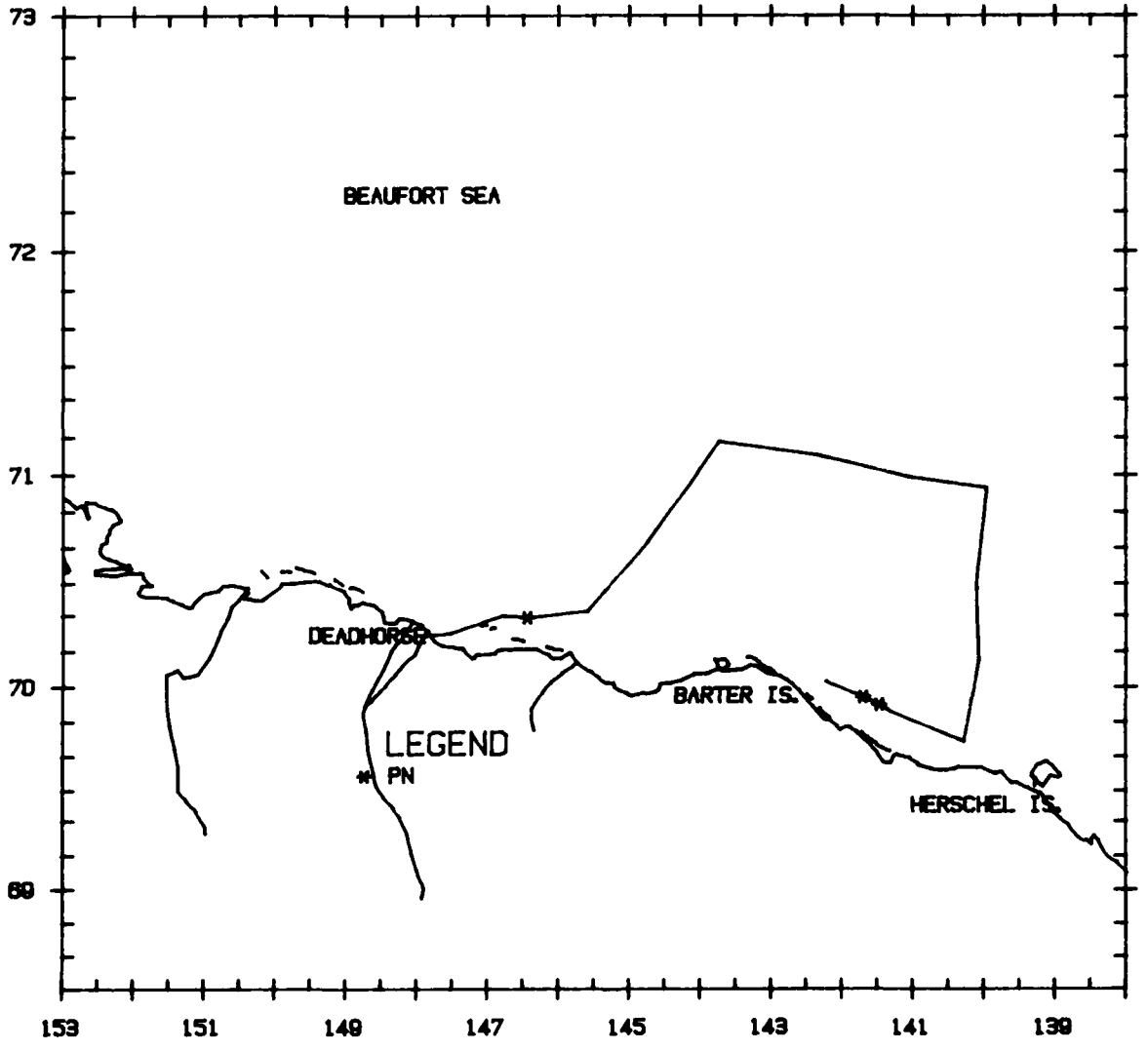
Flight 24: 5 August 1984

Flight was a search survey through blocks 6, 7, and 5 after a transect survey in each block was aborted due to low heavy fog. Weather was low overcast with fog; visibility was generally less than 1 km. Ice coverage was 70 to 95 percent in blocks 6 and 7, 0 to 70 percent in block 5. Sea state was Beaufort 00 to 01. Three unidentified pinnipeds were seen.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LEGEND
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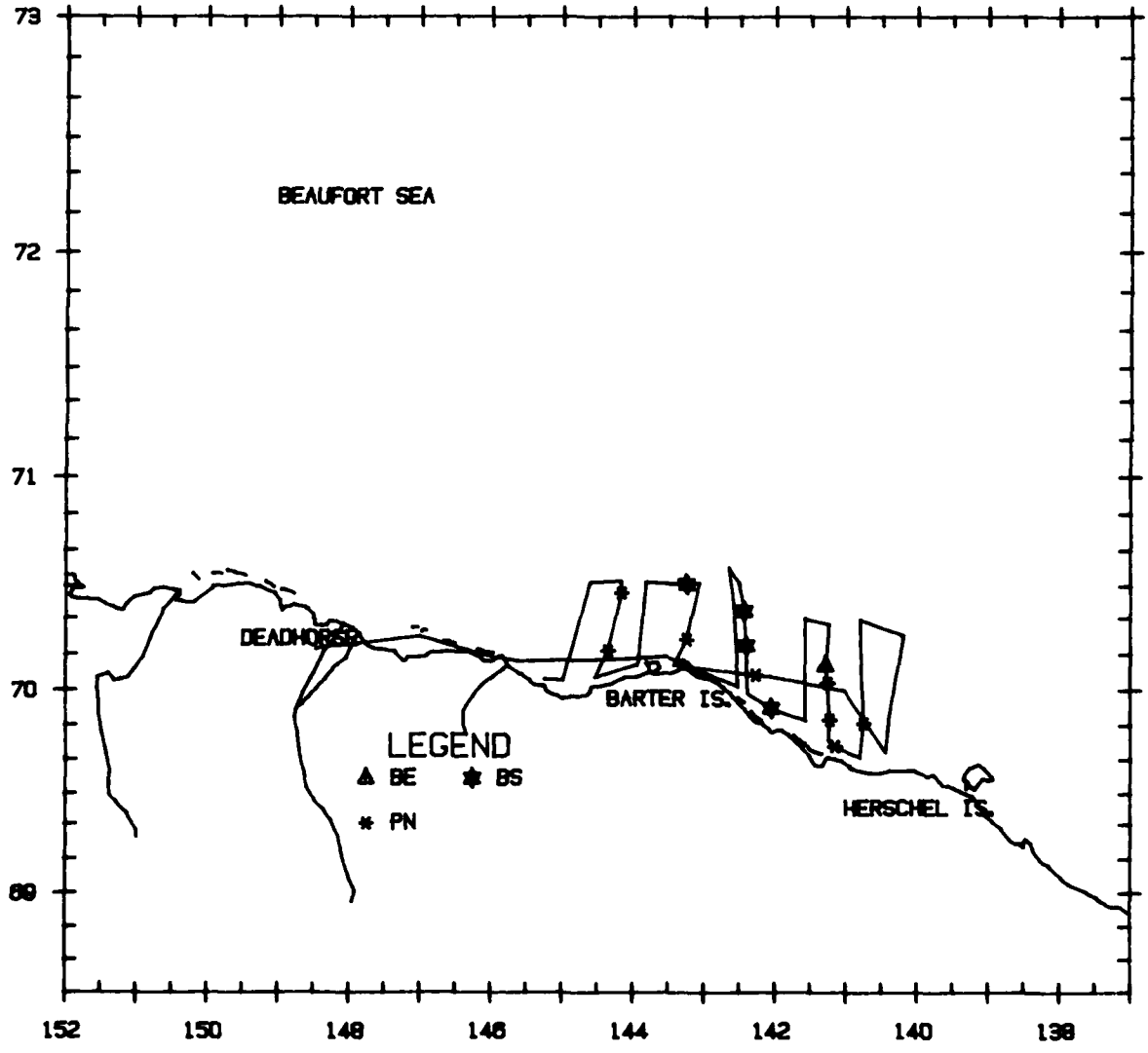
Flight 25: 6 August 1984

Flight was a transect survey of block 5 and the eastern two-thirds of block 4. A transect survey of block 7 was aborted due to fog. Weather was overcast with areas of fog, causing the northern portion of four legs in block 5 to be truncated. Visibility ranged from unlimited to unacceptable. Ice coverage ranged from 0 to 95 percent, but averaged 35 percent in block 4 and 5. Sea state ranged from a Beaufort 00 to 03. Belukha whales, bearded seals, and unidentified pinnipeds were seen.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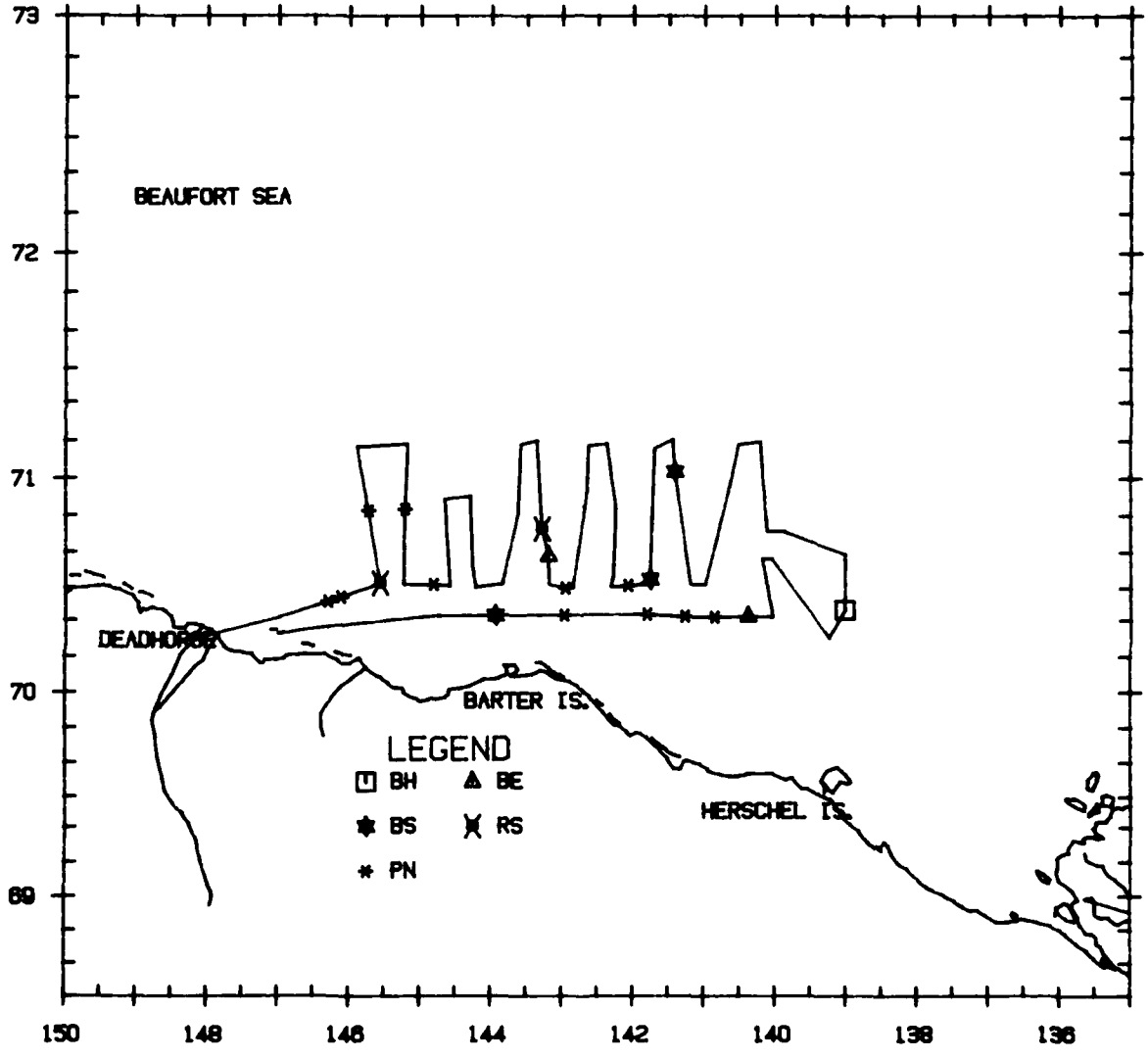
Flight 26: 7 August 1984

Flight was a transect survey in blocks 6 and 7 with a search survey east to 139° W and along the 70°20' N line through blocks 5 and 4. Weather was clear with unlimited visibility except for fog along the northern boundary of block 6. Ice coverage was 0 to 70 percent in blocks 4 and 5, and 70 to 95 percent in blocks 6 and 7. Sea state was Beaufort 00 to 01. Two bowheads were seen in Canadian waters. The whales dove upon approach of the aircraft and were not resighted. Belukha whales, ringed and bearded seals, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
2/0	70°22.6'	139°00.9'	880	BW	SW	120	60	B0	529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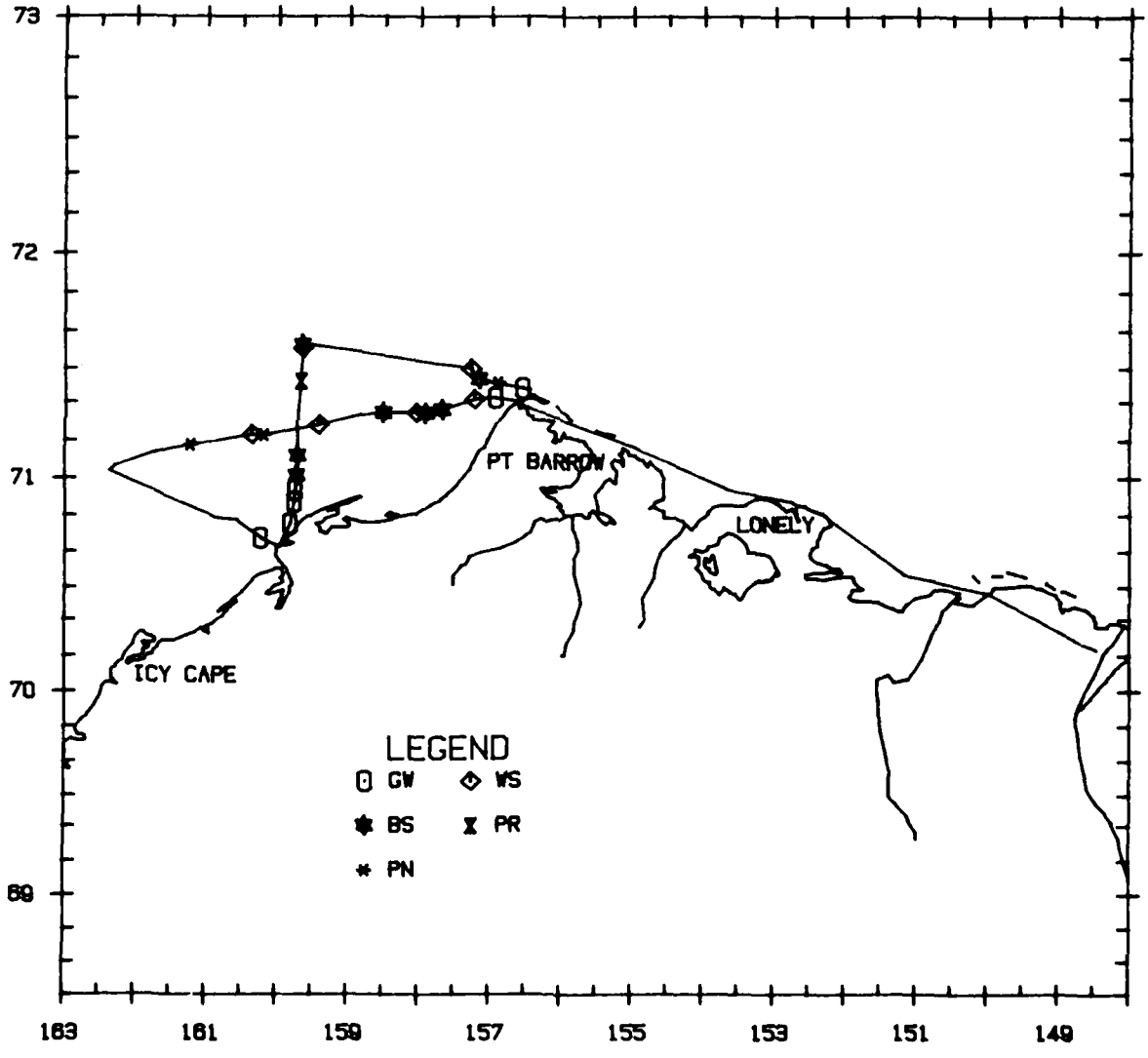
Flight 27: 8 August 1984

Flight was a search survey through block 14 and an aborted transect survey of block 13 (due to failure of the GNS). Weather was clear with unlimited visibility in block 13 and heavy fog with 1 to 3 km visibility in block 14. Ice coverage was 0 to 99 percent broken floe, and sea state was Beaufort 00 to 03. Fourteen gray whales, walrus, bearded seals, unidentified pinnipeds, and one polar bear were seen.

Gray Whale

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°21.3'	156°56.4'	250	SP	FE	200	0	B2	44
9/0	70°43.9'	160°14.2'	--	BW	SW	100	0	B2	18
1/0	70°47.9'	159°49.1'	351	BO	SW	100	0	B2	18
1/0	70°53.9'	159°45.5'	420	BO	SW	--	0	B2	26
1/0	70°57.1'	159°44.7'	288	BO	SW	160	0	B2	35
1/0	71°23.6'	156°33.0'	--	SP	SW	--	80	B1	7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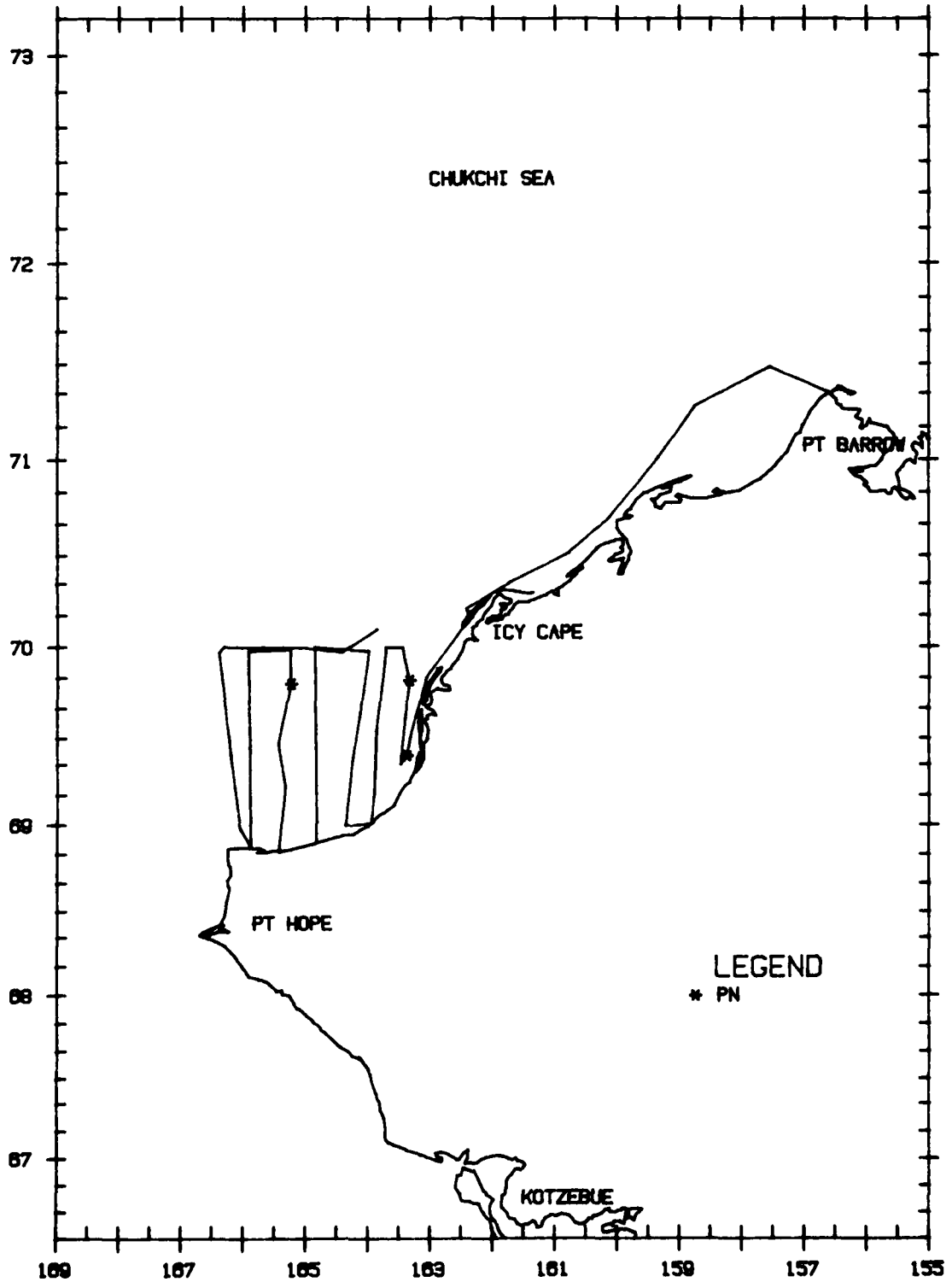
Flight 28: 10 August 1984

Flight was a coastal search of the Chukchi Sea and a transect survey of block 20 and the easternmost leg of block 21. Weather was clear with unlimited visibility. Ice coverage was 0 percent along the coast and in both blocks, and the sea state was Beaufort 03 to 05. Dead walrus and unidentified pinnipeds were seen.


CHUKCHI SEA
PT BARROW
ICY CAPE
PT HOPE
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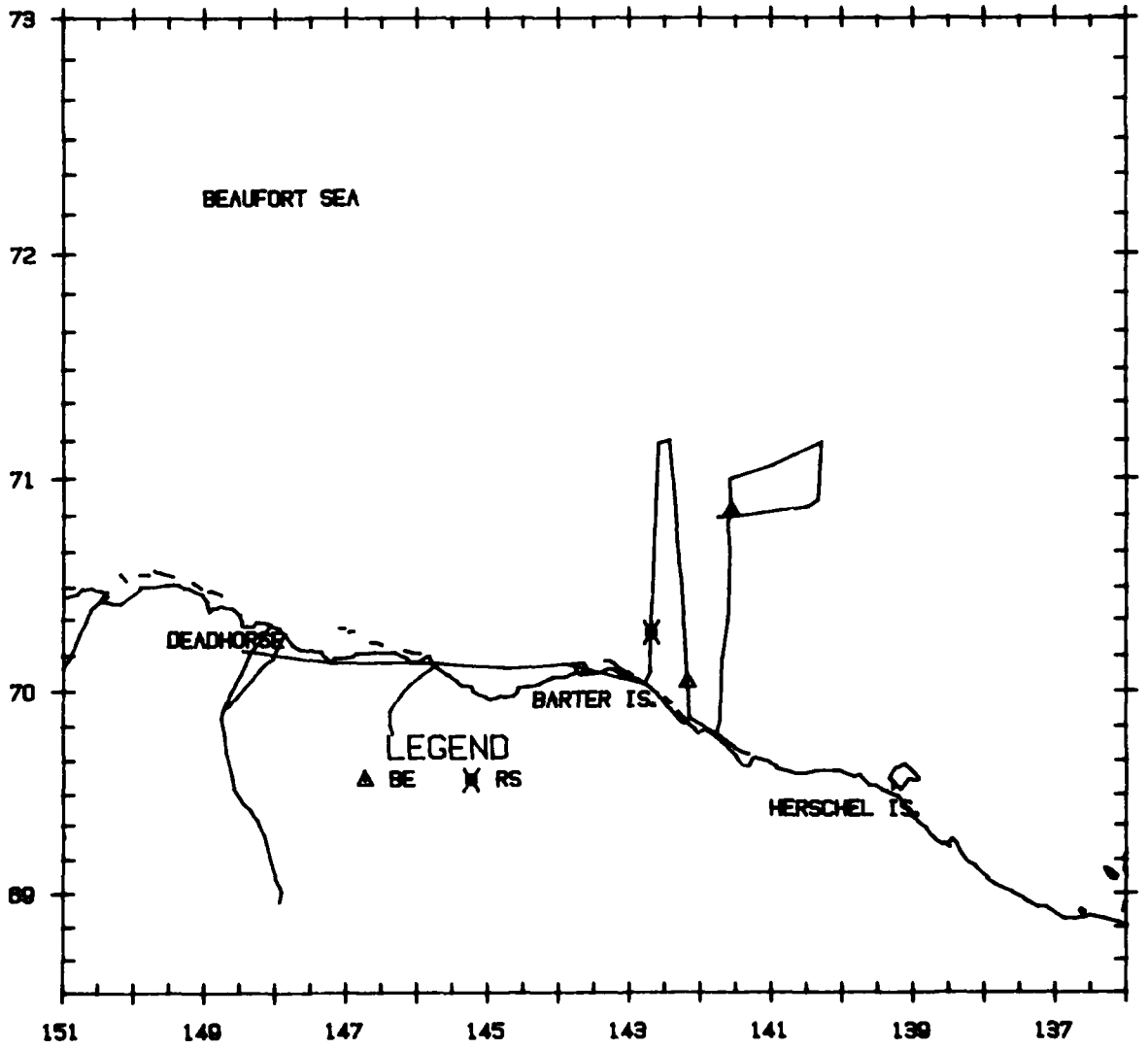
Flight 29: 11 August 1984

Flight was a transect survey of the western half of blocks 5 and 7. Heavy fog and snow flurries caused the survey to be aborted. Visibility was variable from less than 1 km to unlimited. Ice coverage was 0 to 20 percent in the southern half of block 5 and 50 to 99 percent in the rest of block 5 and all of block 7. Sea state was Beaufort 01 to 02 in heavy ice and 05 in open water. Beluga whales and a ringed seal were seen.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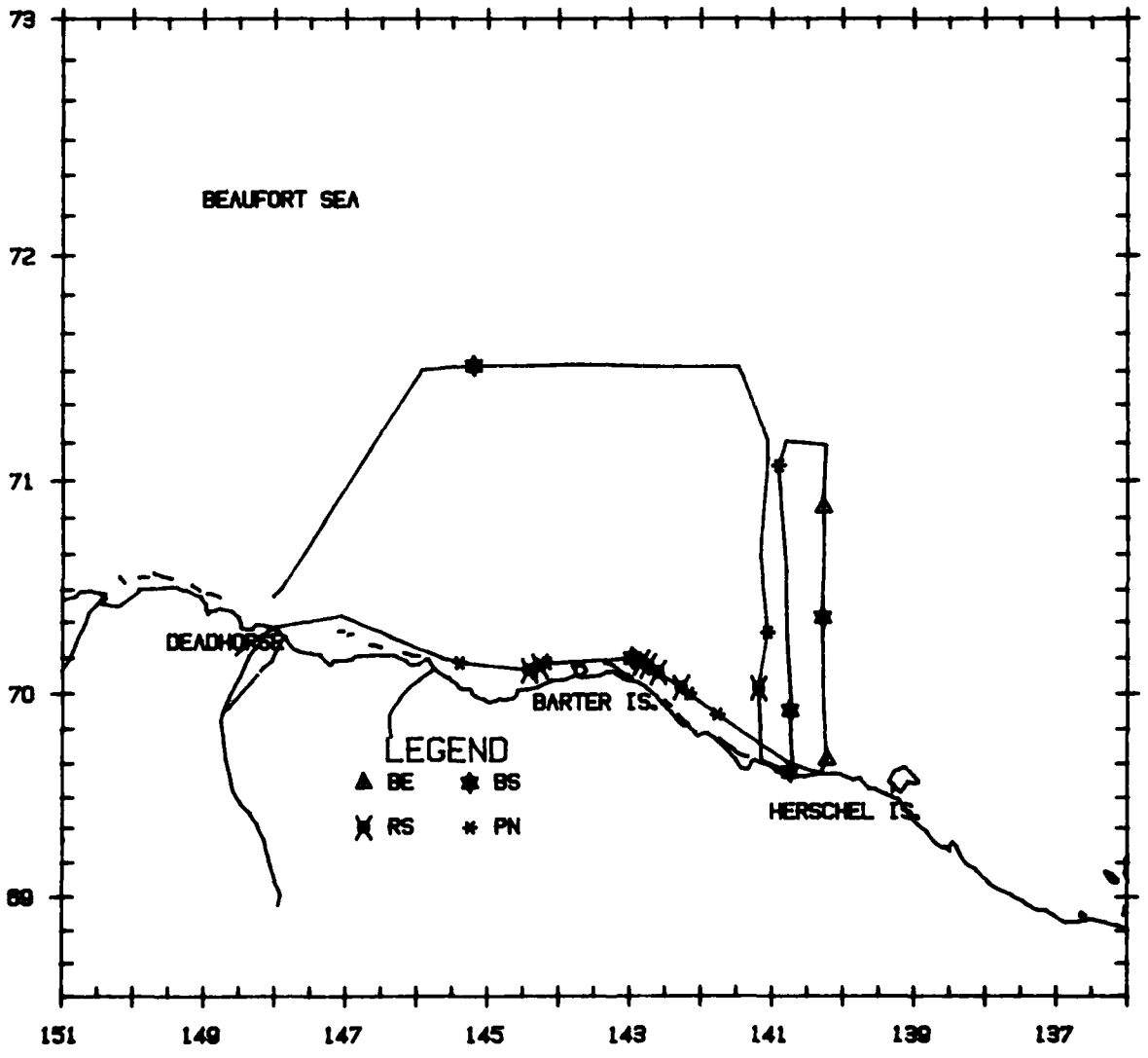
Flight 30: 13 August 1984

Flight was a transect survey of the eastern half of blocks 5 and 7, and a search survey west along 71°30' N. Weather was clear with unlimited visibility. Ice coverage was 0 to 20 percent in the southern third of block 5 and 50 to 99 percent in the rest of block 5, all of block 7 and along 71°30' N. Sea state was Beaufort 00 to 02. Belukha whales, bearded and ringed seals, and unidentified pinnipeds were seen.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BEAUFORT SEA
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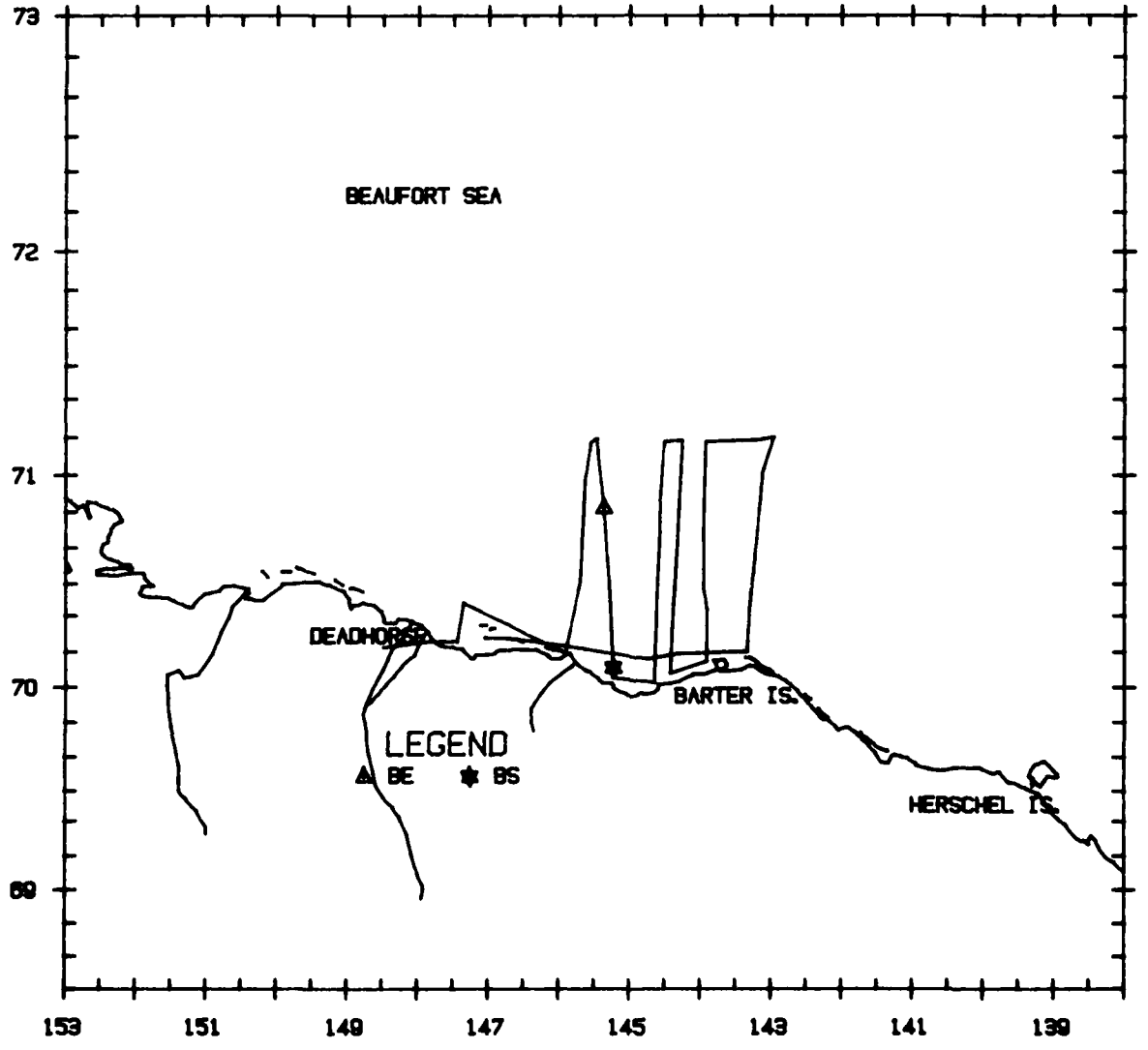
Flight 31: 14 August 1984

Flight was a transect survey of blocks 4 and 6. Weather was overcast with unlimited visibility. Ice coverage was 0 to 80 percent in block 4, 95 to 99 percent in block 6. Sea state was Beaufort 00 to 02. A belukha whale and a bearded seal were seen.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BARTER IS.
HERSCHEL IS.
LEGEND
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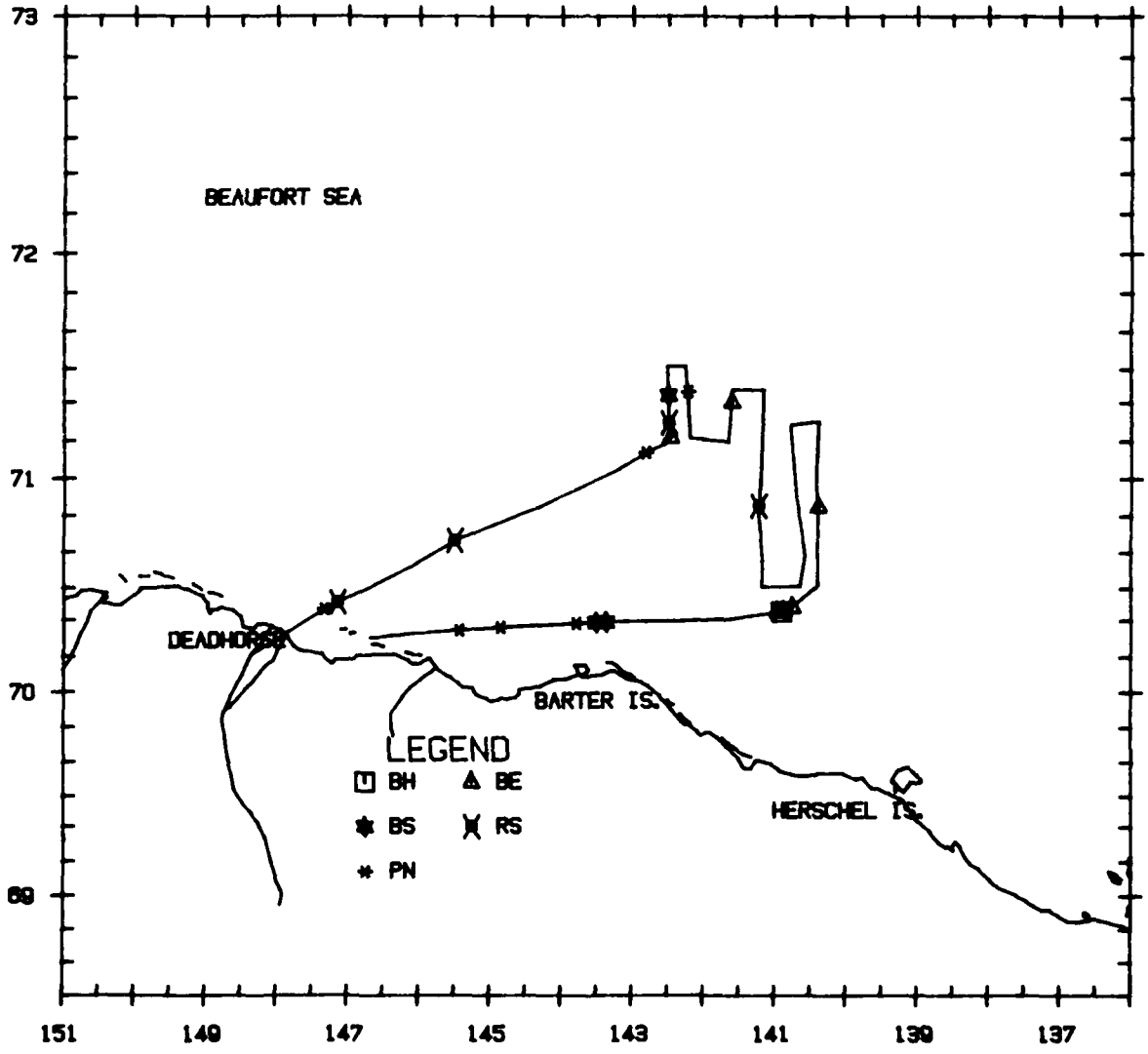
Flight 32: 15 August 1984

Flight was a transect survey of the southern half of block 8 and the eastern half of block 7 and a search survey along 70°20' N. Heavy fog and snow flurries caused transect lines to be truncated. Visibility was variable from less than 1 km to unlimited. Ice coverage was 85 to 99 percent in blocks 7 and 8 and 30 to 50 percent along 70°20' N. Sea state was Beaufort 00 to 02. One resting bowhead was seen. Belukha whales, bearded and ringed seals, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°22.4'	140°54.3'	--	BO	RE	320	50	B1	66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BEAUFORT SEA
DEADHORSE
BARTER IS.
HERSCHEL IS.
LEGEND
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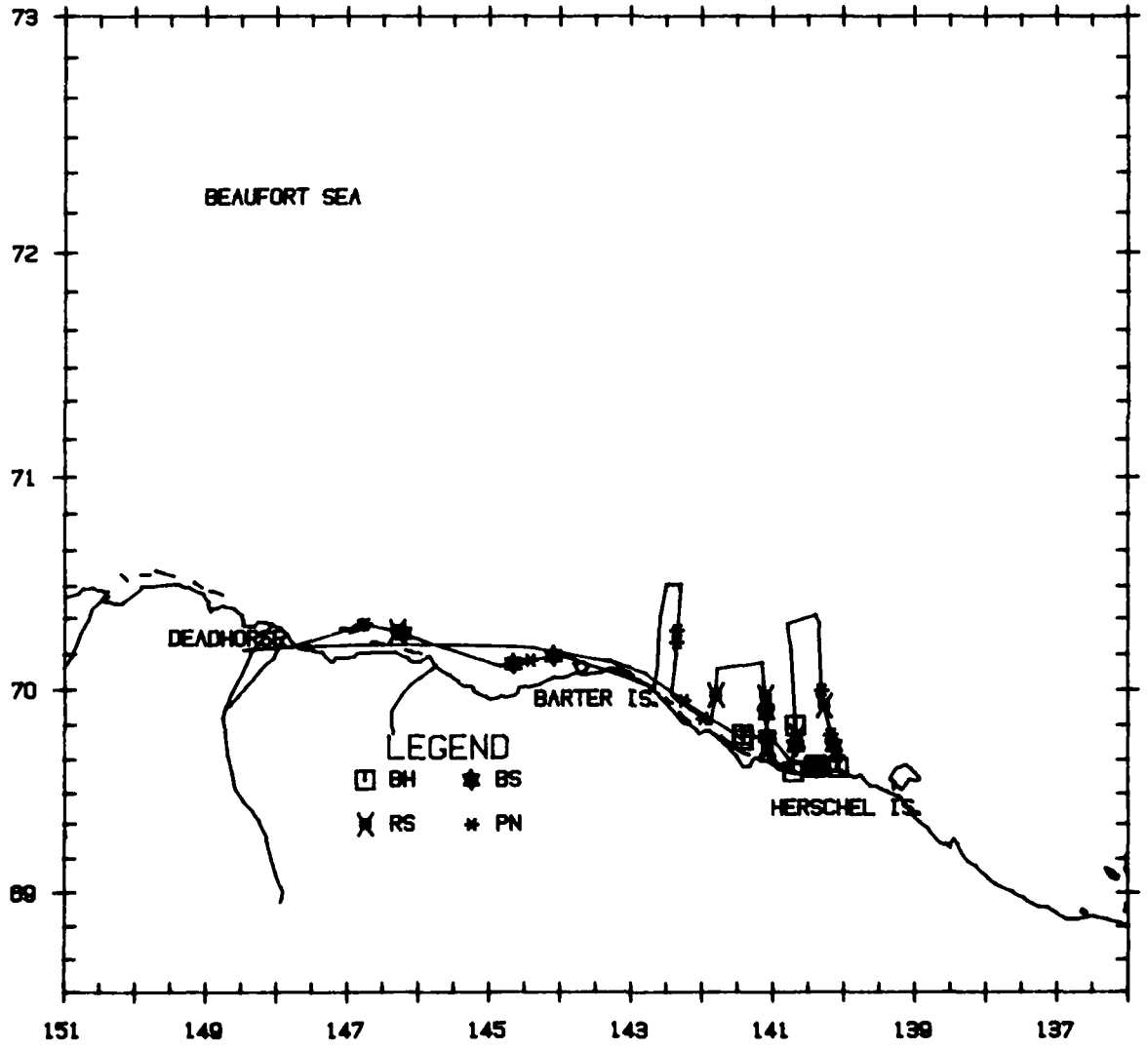
Flight 33: 16 August 1984

Flight was a transect survey of block 5, partially truncated due to heavy fog. Visibility was variable from less than 1 km to unlimited. Ice coverage was 0 to 99 percent and sea state was Beaufort 00. Thirteen bowheads were seen in block 5 and some appeared to be feeding. Bearded and ringed seals, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	69°36.6'	140°42.5'	--	SP	FE	250	1	B0	7
1/0	69°50.2'	140°40.9'	838	BO	RE	120	50	B0	35
1/0	69°37.8'	140°04.3'	528	BO	FE	--	1	B0	16
3/0	69°38.1'	140°22.1'	--	BO	FE	330	1	B0	7
2/0	69°38.0'	140°24.2'	--	BO	FE	330	1	B0	7
1/0	69°38.6'	140°23.1'	--	BO	FE	--	1	B0	7
2/0	69°47.5'	141°25.6'	--	SP	SW	330	1	B0	18
2/0	69°46.1'	141°24.9'	--	BO	SW	280	1	B0	18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BEAUFORT SEA
DEADHORSE
BARTER IS.
HERSCHEL IS.
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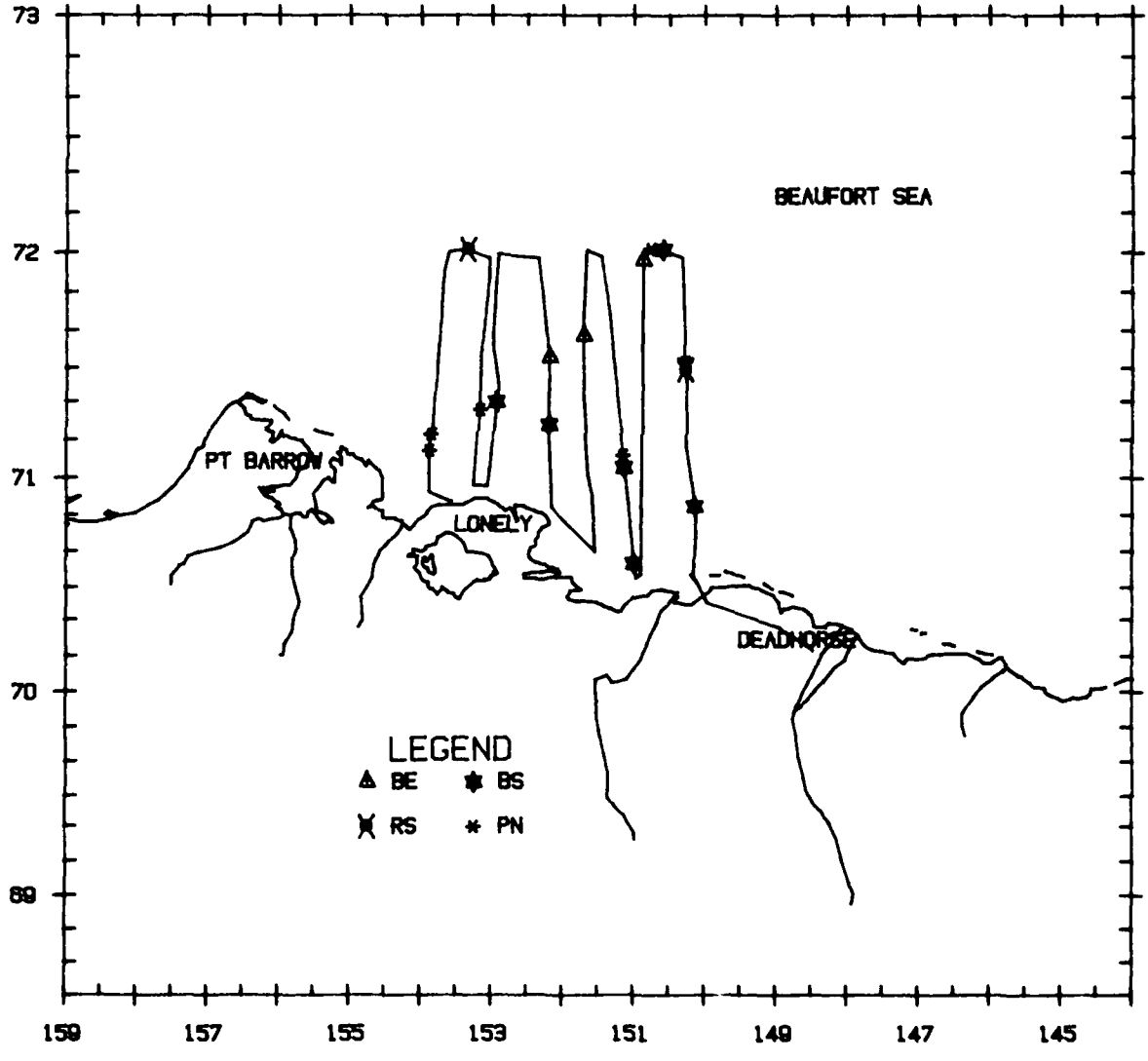
Flight 34: 18 August 1984

Flight was a transect survey of blocks 3 and 11. Weather was clear to overcast and visibility was unlimited. Ice coverage was 0 to 10 percent in the southern half of block 3, and 0 to 50 percent in the rest of 3 and all of block 11. Sea state was Beaufort 00 to 03. Belukha whales, bearded and ringed seals, and unidentified pinnipeds were seen.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BEAUFORT SEA
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AD-A158 946 AERIAL SURVEYS OF ENDANGERED WHALES IN THE NORTHERN BERING EASTERN CHUKCH..(U) NAVAL OCEAN SYSTEMS CENTER SAN DIEGO CA D K LJUNGBLAD ET AL. JUN 85 NOSC/TR-1046 3/4

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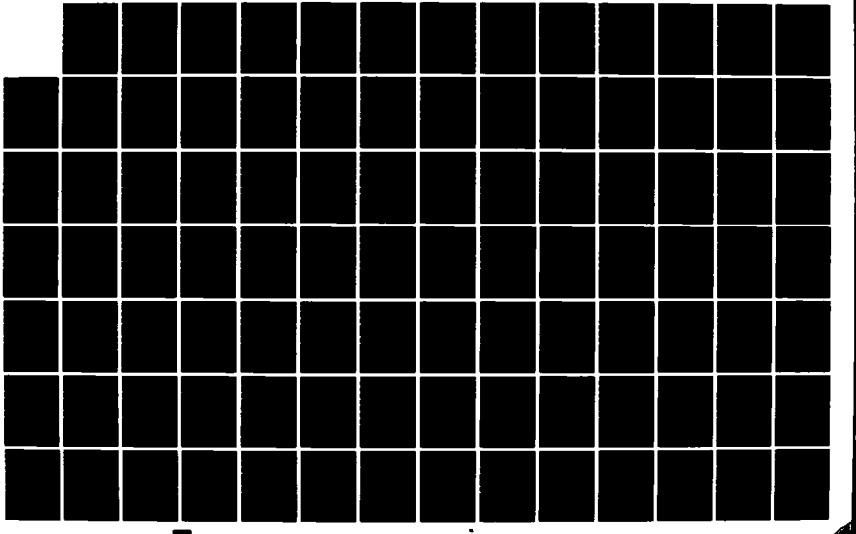
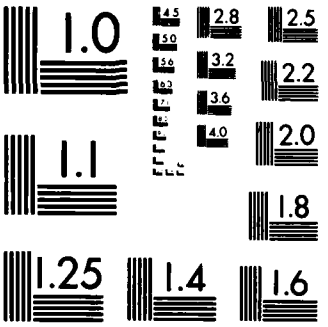
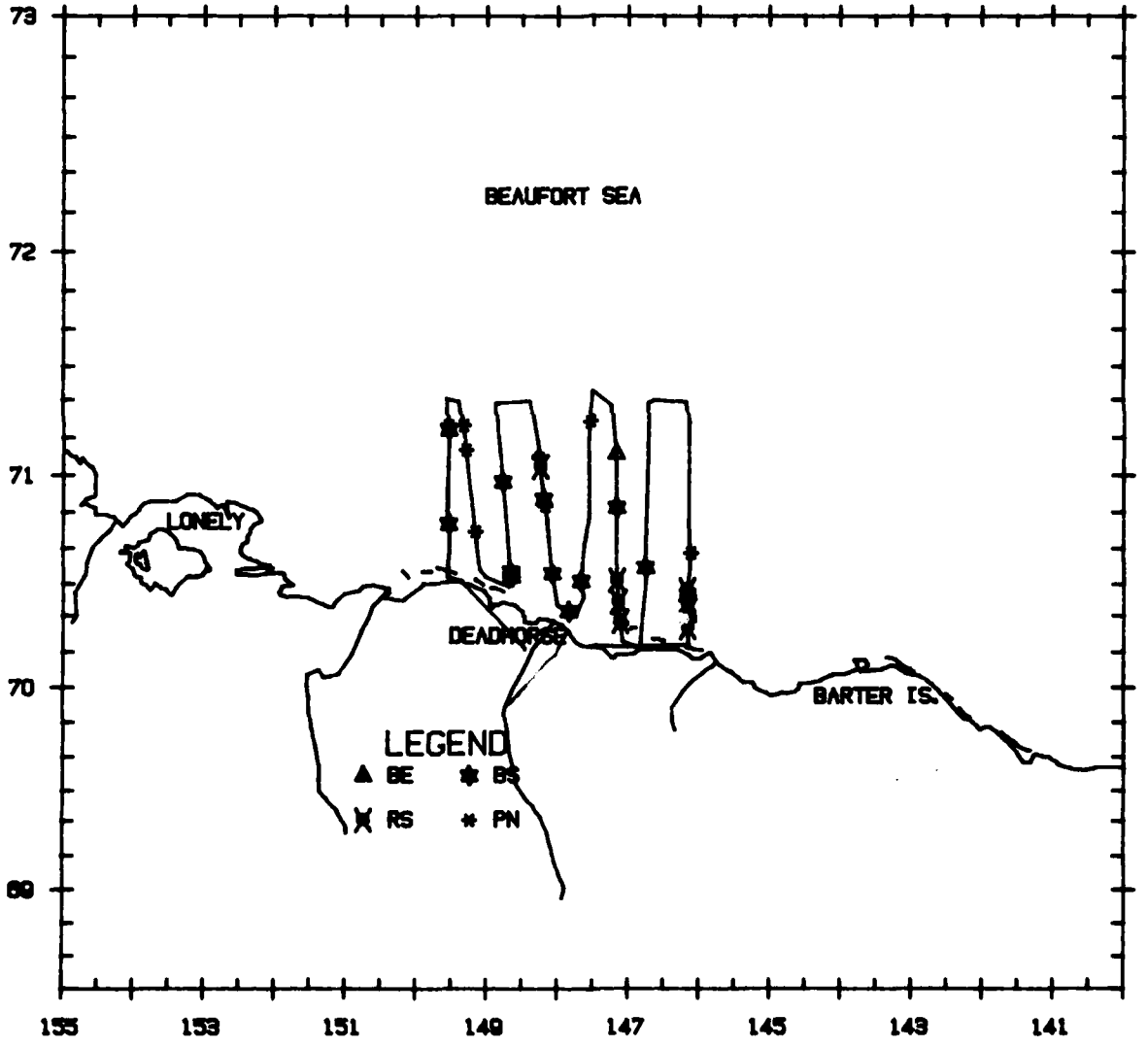




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Flight 35: 20 August 1984

Flight was a transect survey of blocks 1 and 2. Weather was overcast with some fog and visibility was variable from 3 km to unlimited. Ice coverage was 0 to 95 percent in block 1 and 50 to 99 percent in block 2. Sea state was Beaufort 00 to 01. Belukha whales, bearded and ringed seals, and unidentified pinnipeds were seen.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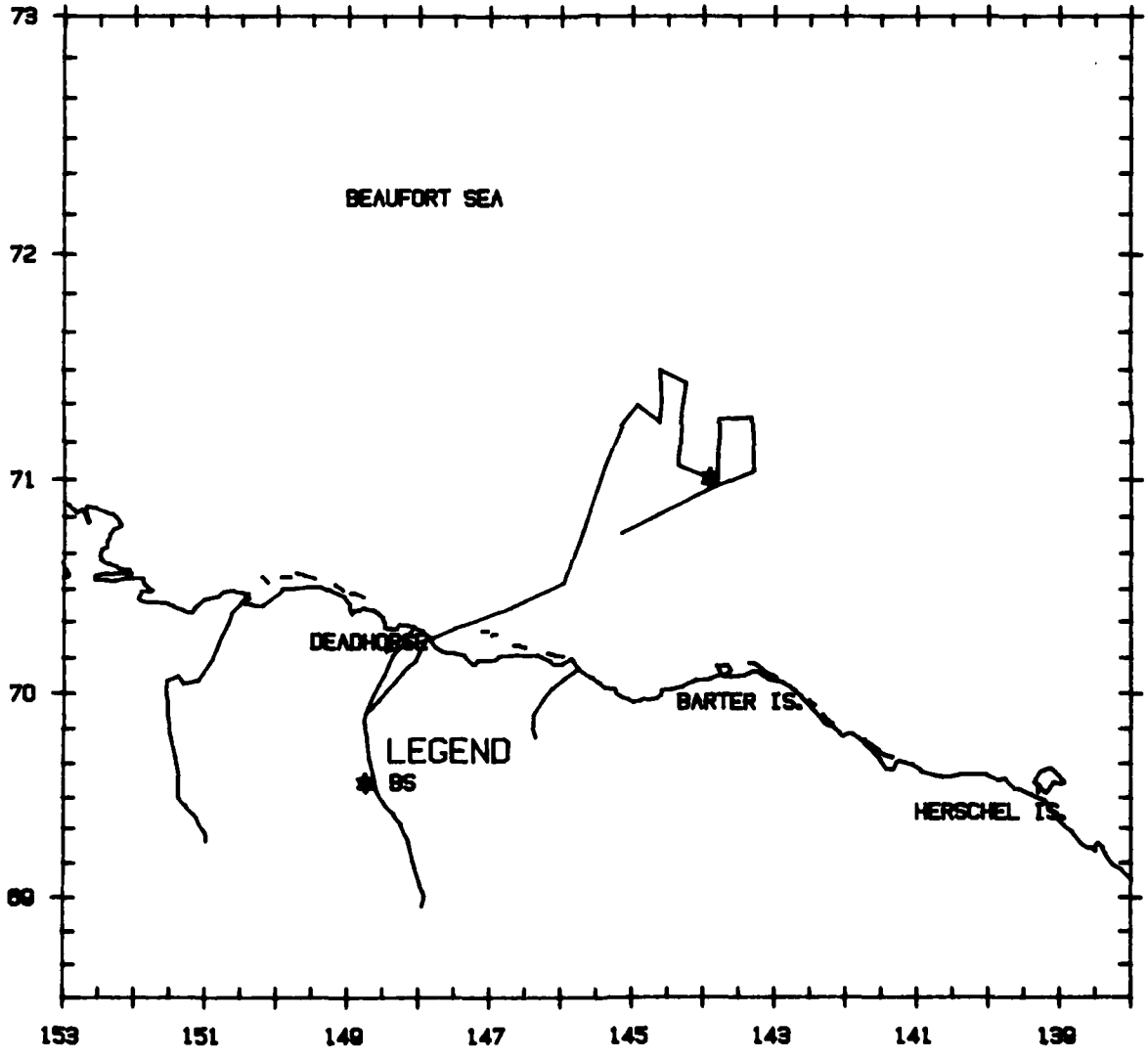
Flight 36: 21 August 1984

Flight was a transect survey of portions of blocks 6 and 9. Heavy fog caused transect lines to be truncated. Visibility was usually less than 1 km. Ice coverage was 95 to 99 percent and sea state was Beaufort 00. Bearded seals were seen.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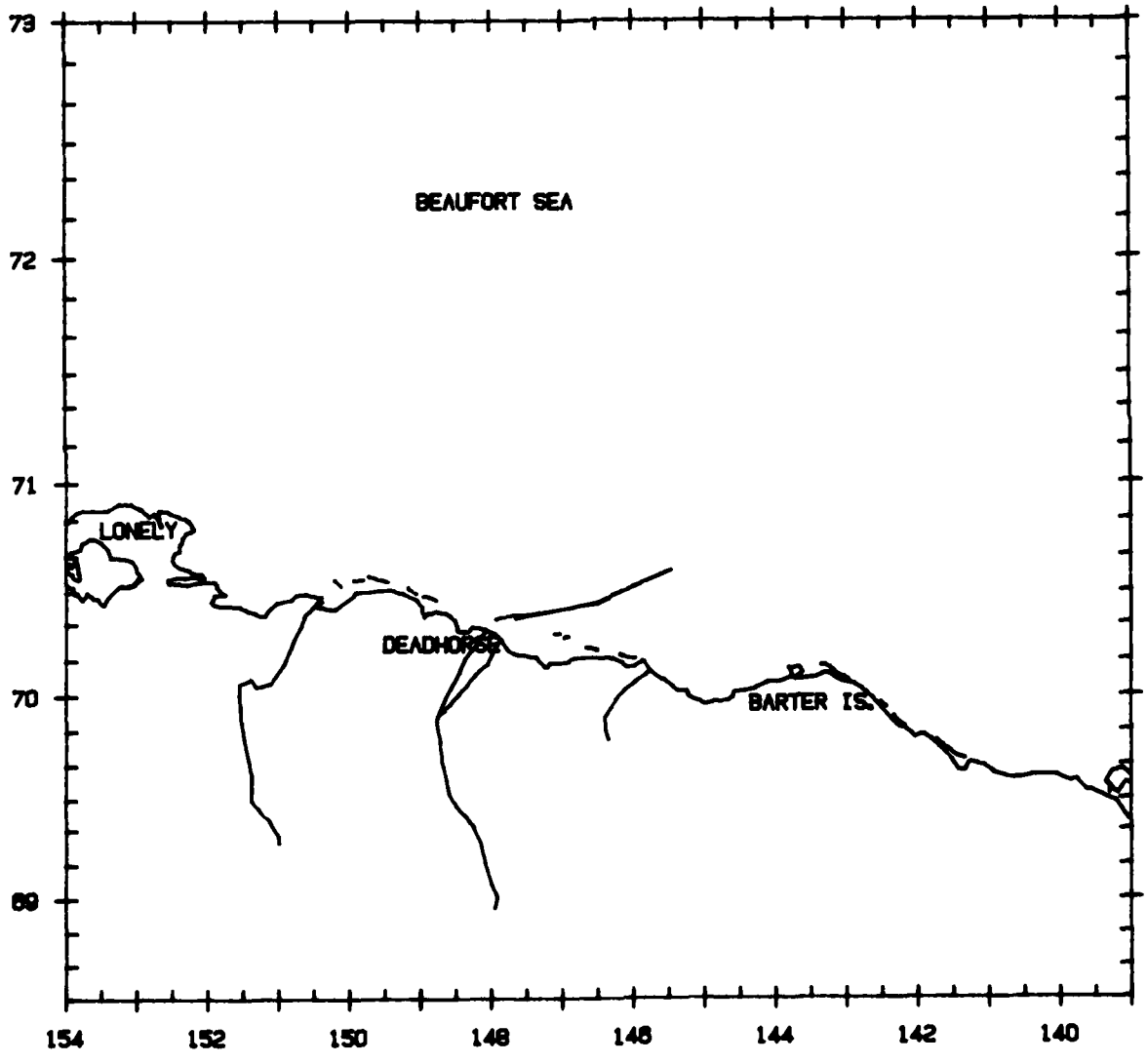
Flight 37: 23 August 1984

Flight was a search survey that was aborted due to heavy fog. Visibility was less than 1 km. Severe icing conditions forced an early return. No animals were seen.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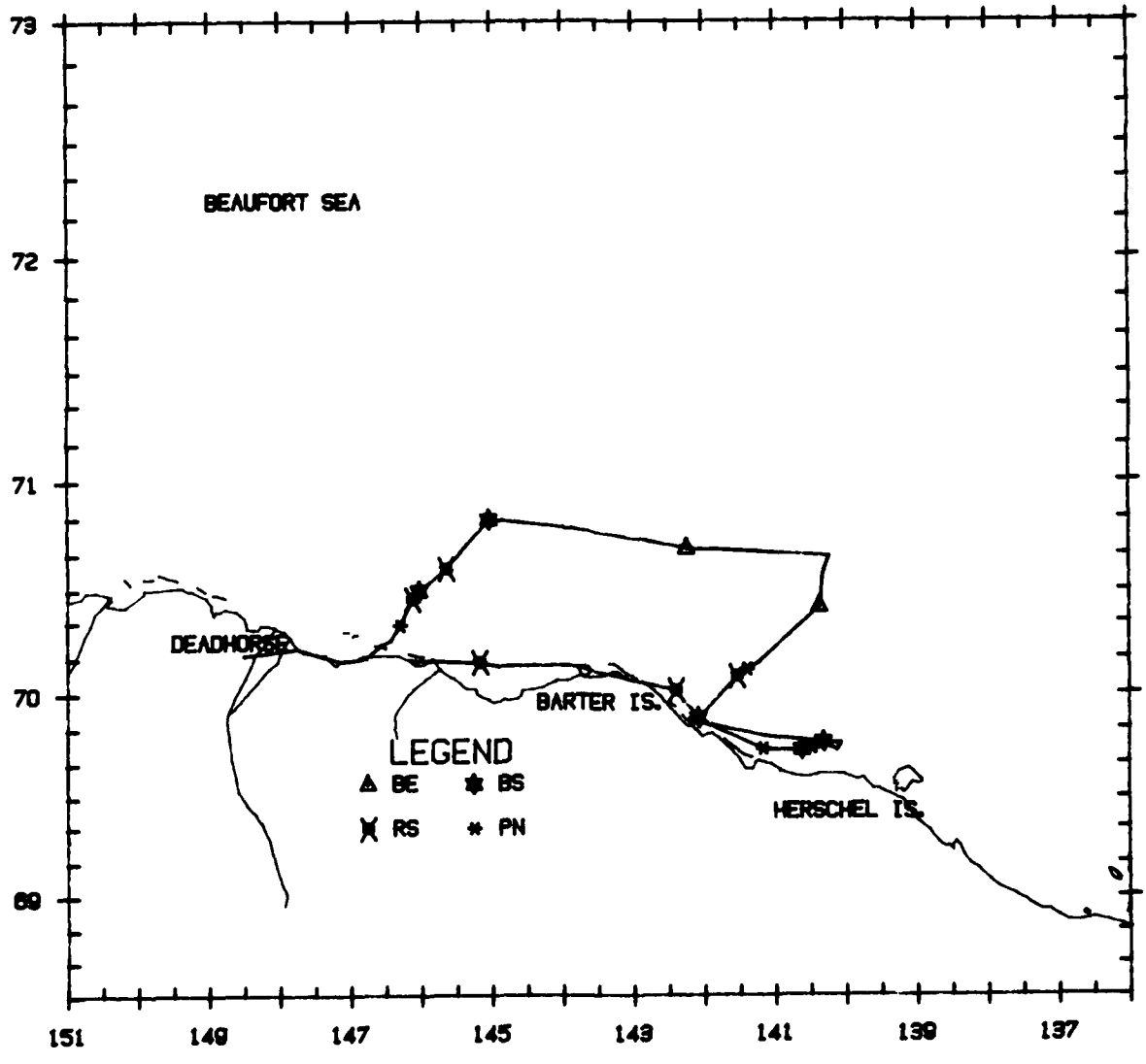
Flight 38: 24 August 1984

Flight was a search survey along 70°50' N. Heavy fog over the entire Beaufort Sea prevented a transect survey from being flown. Visibility was generally less than 1 km. Ice coverage was 90 to 99 percent and sea state was Beaufort 00. Belukha whales, bearded and ringed seals, and unidentified pinnipeds were seen.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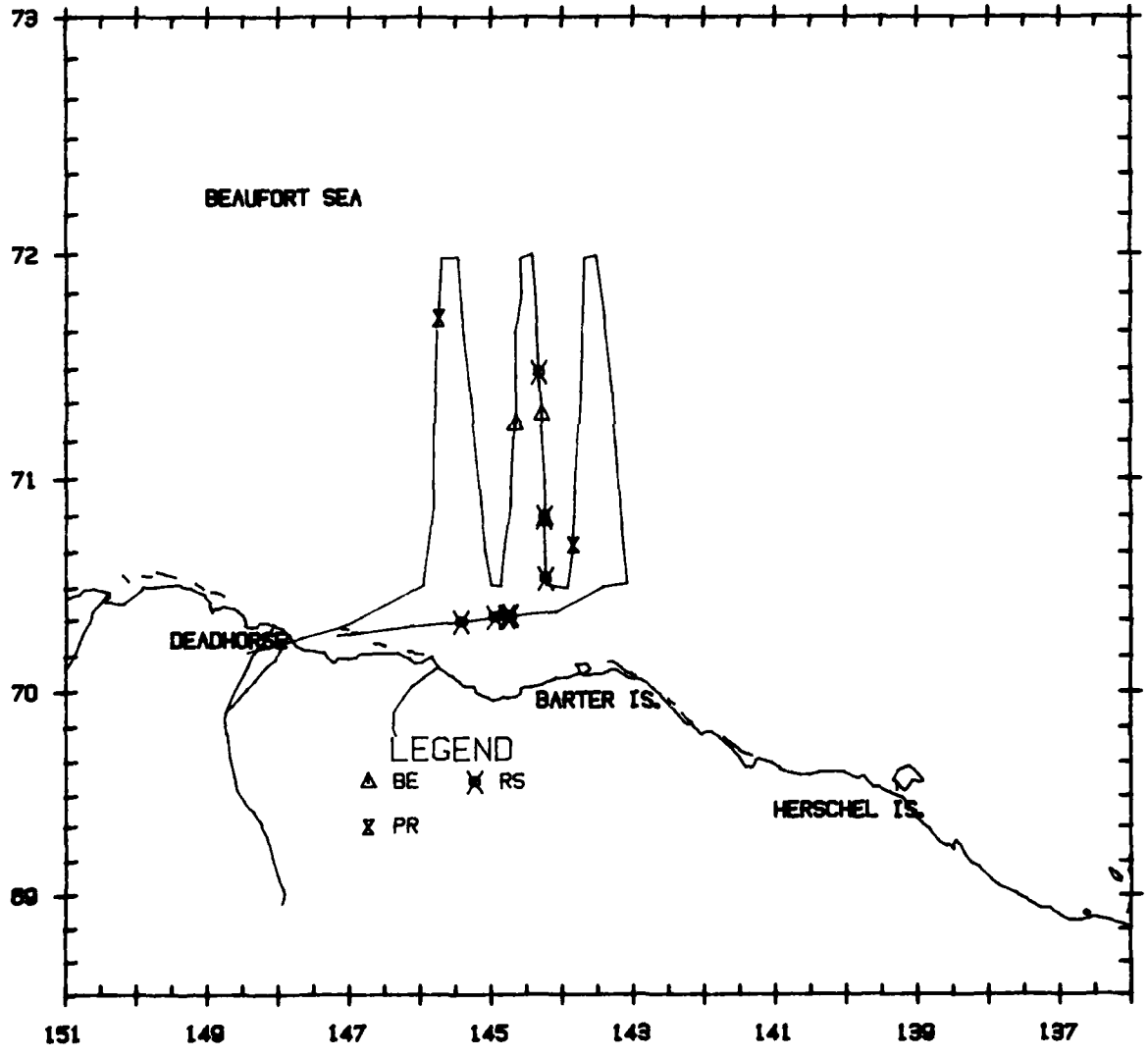
Flight 39: 26 August 1984

Flight was a transect survey of blocks 6 and 9. Weather was generally overcast with some fog and snow flurries. Visibility was variable from 5 km to unlimited. Ice coverage was 90 to 99 percent broken floe and new grease ice, and sea state was Beaufort 00 to 01. Belukha whales, ringed seals, and polar bears were seen.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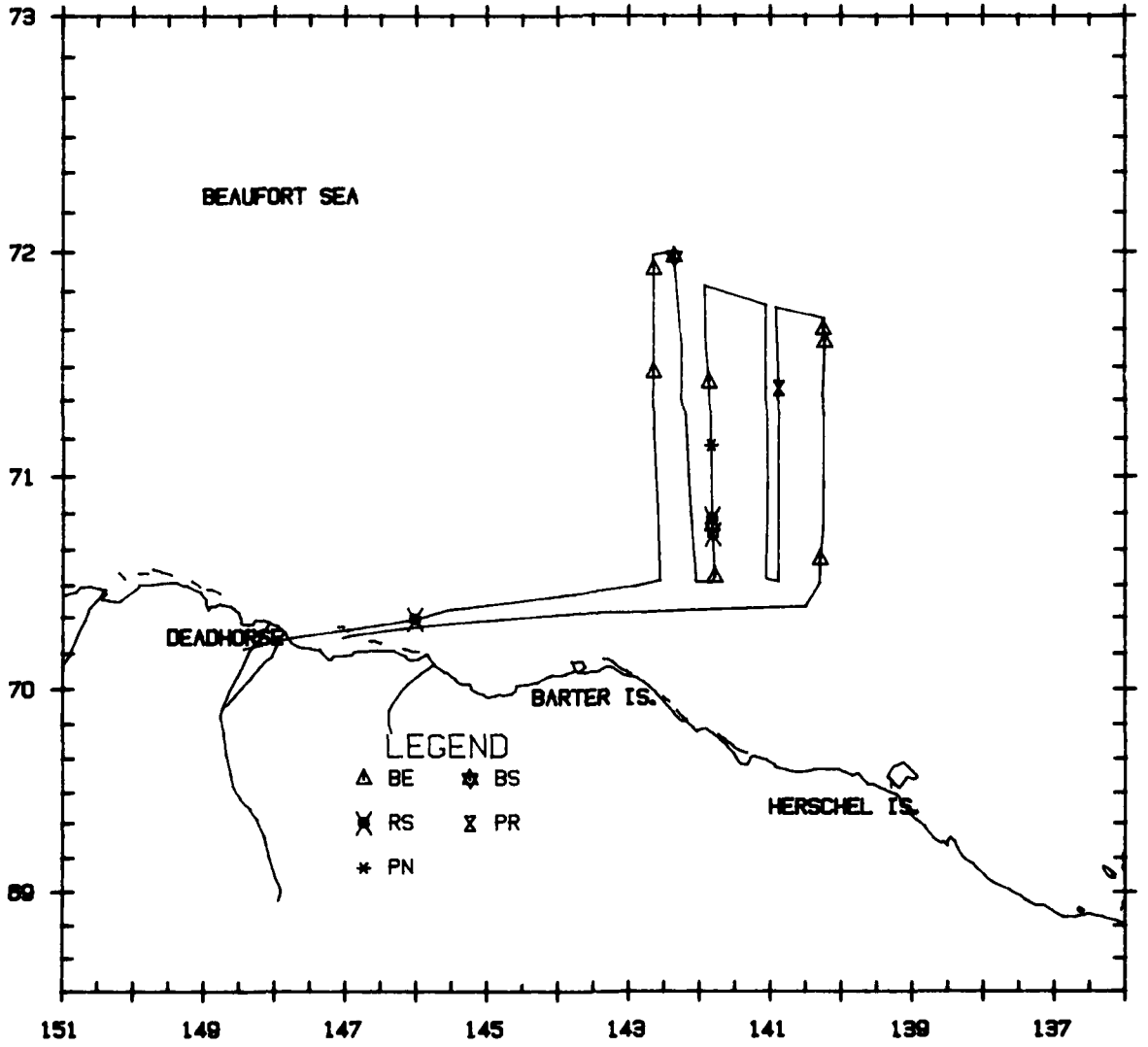
Flight 40: 27 August 1994

Flight was a transect survey of blocks 7 and 8. Weather was clear except for one area of heavy fog in the northeast corner of block 8. Visibility was usually unlimited. Ice coverage was 80 to 99 percent and sea state was Beaufort 00 to 01. Belukha whales, polar bears, bearded and ringed seals, and unidentified pinnipeds were seen.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LEGEND
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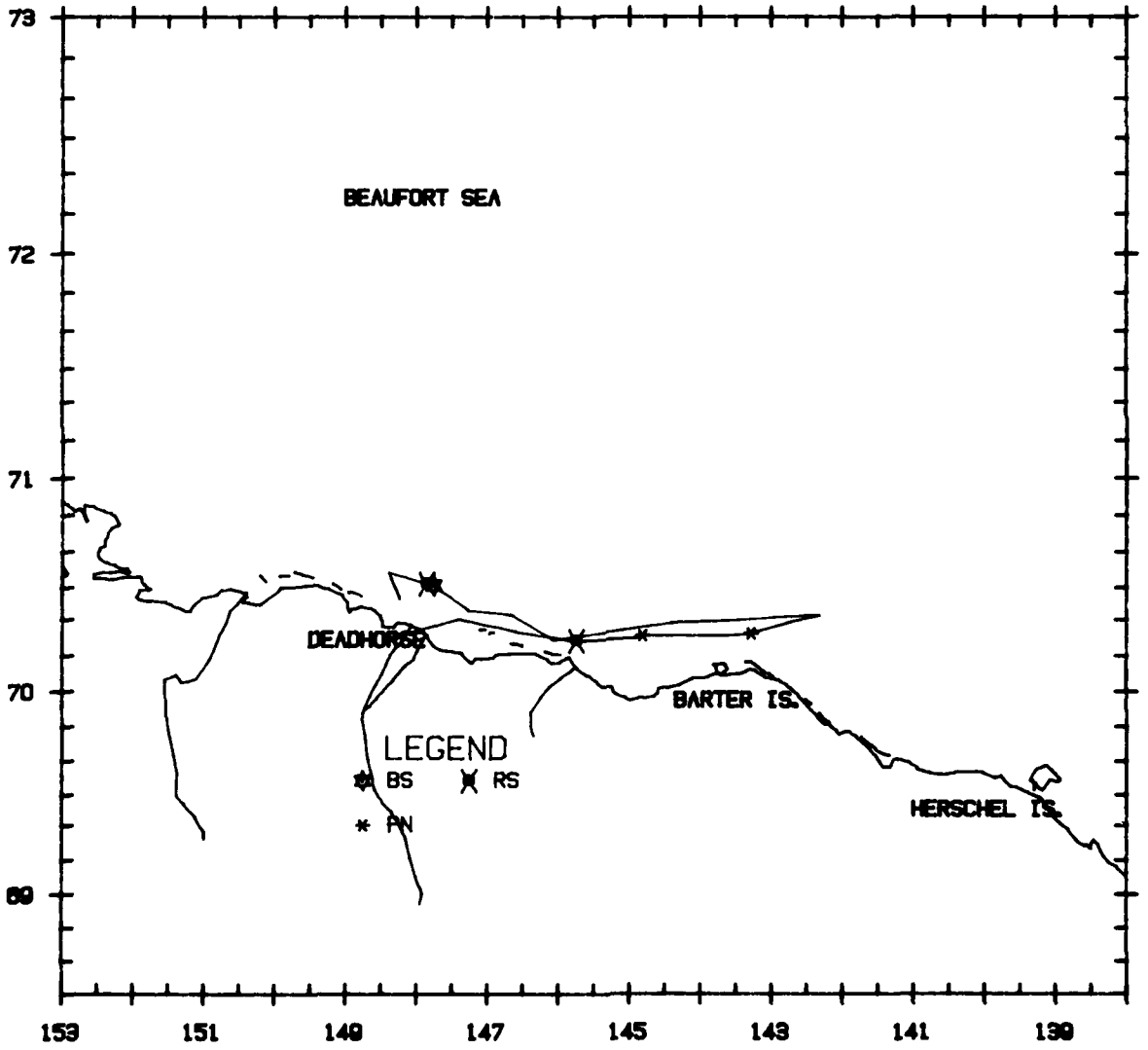
Flight 41: 28 August 1984

Flight was a search survey along the shore. Heavy fog and low ceilings over the entire Beaufort Sea prevented a transect survey from being completed. Visibility was usually less than 1 km. Ice coverage was 0 to 50 percent and sea state was Beaufort 00 to 01. Bearded and ringed seals and unidentified pinnipeds were seen.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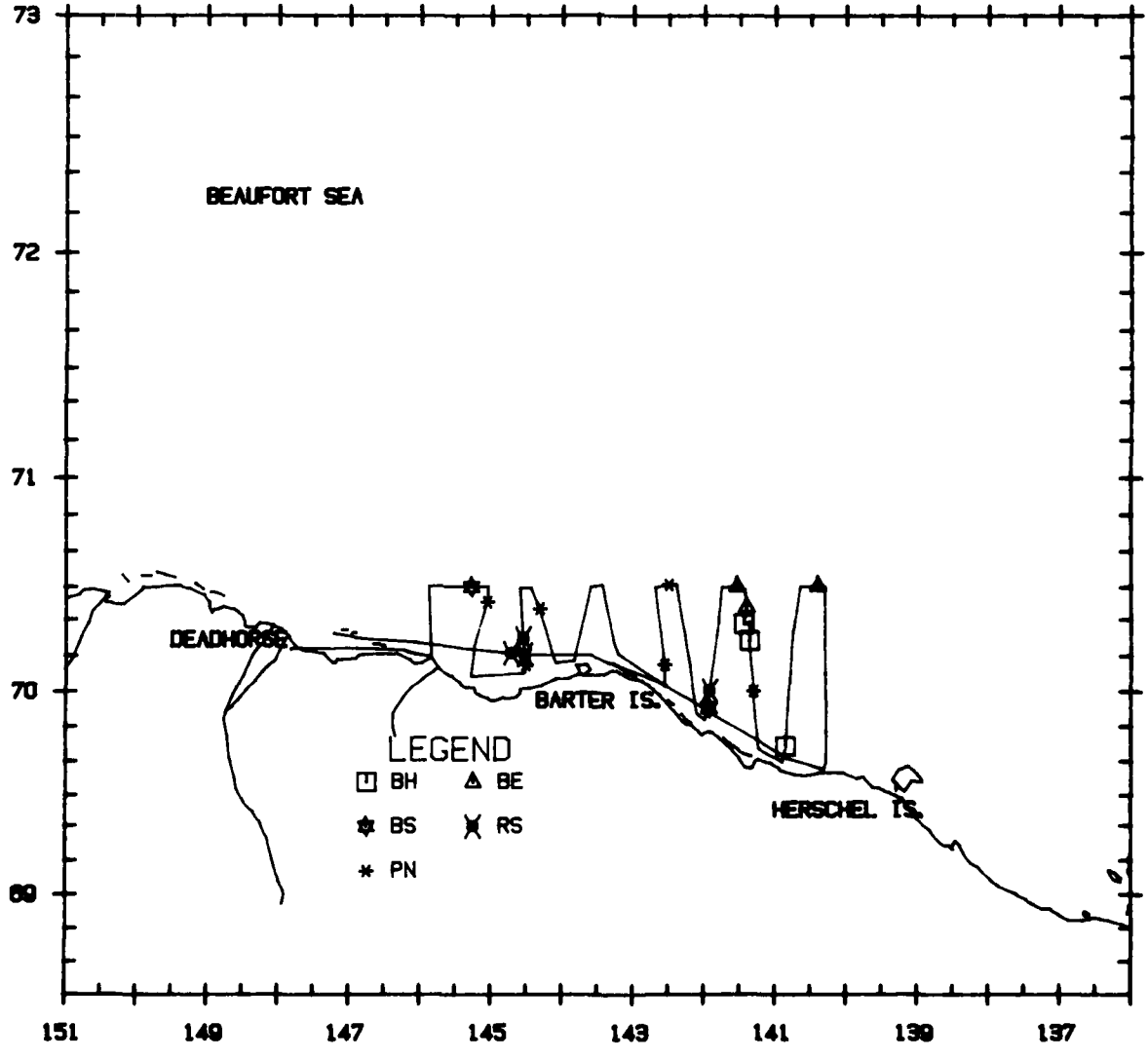
Flight 42: 29 August 1984

Flight was a transect survey of blocks 4 and 5. Weather was overcast to fog, and visibility varied from less than 1 km to unlimited. Ice coverage was 10 to 99 percent and sea state was Beaufort 00 to 01. Five bowheads were seen in block 5, including one seen breaching and tail slapping. Belukha whales, bearded and ringed seals, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°19.1'	141°26.2'	360	SP	BR	--	95	B1	57
2/0	70°14.5'	141°21.6'	363	BO	SW	50	99	B1	53
2/0	69°44.7'	140°50.7'	1031	BO	SW	290	30	B1	24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BEAUFORT SEA
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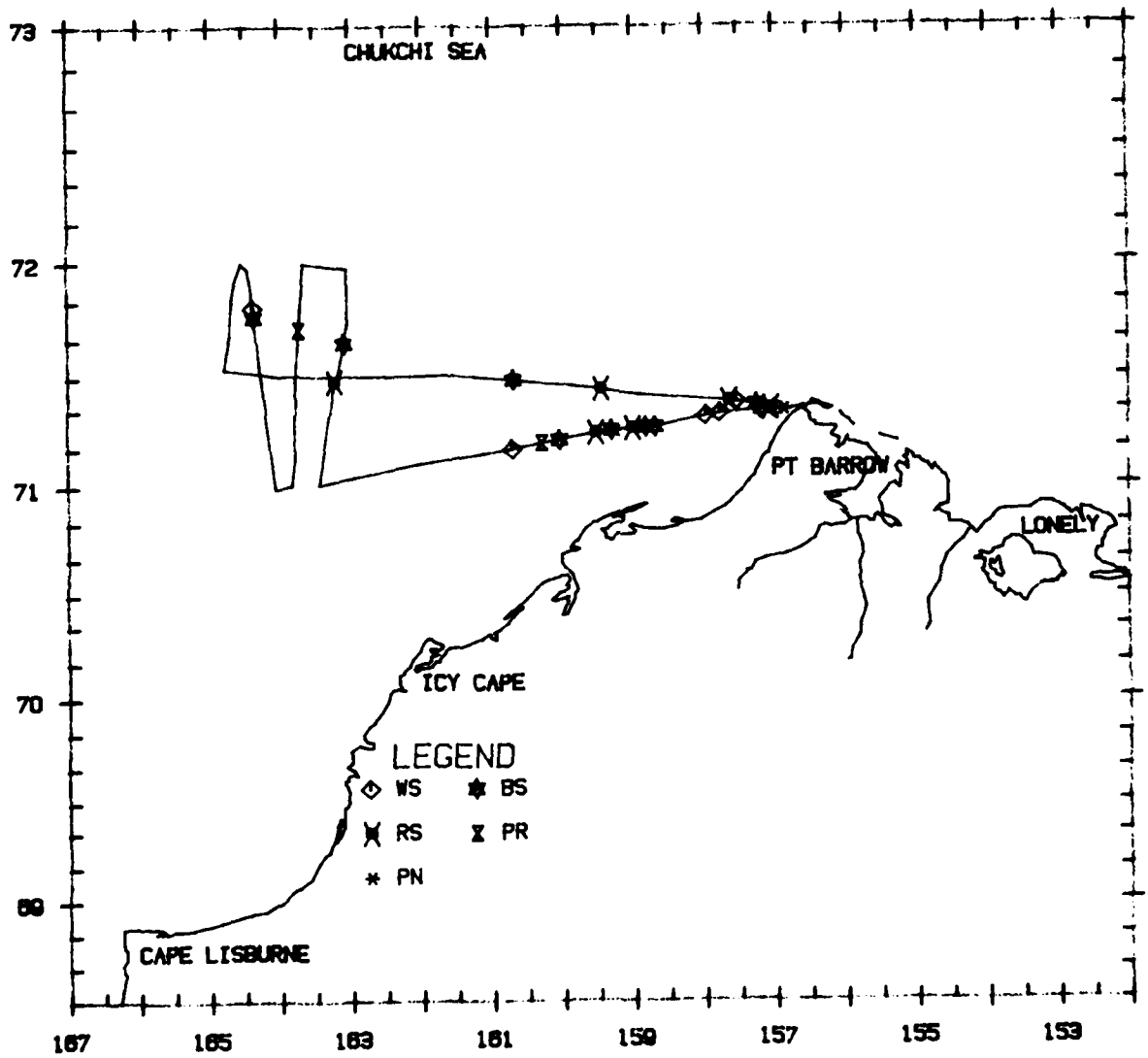
Flight 43: 30 August 1984

Flight was a transect survey of the eastern half of block 15. Heavy fog in the western half caused the survey to be aborted. Visibility was variable from less than 1 km to unlimited. Ice coverage was 0 to 40 percent, and sea state was Beaufort 03 to 04. Walrus, polar bears, bearded and ringed seals, and unidentified pinnipeds were seen.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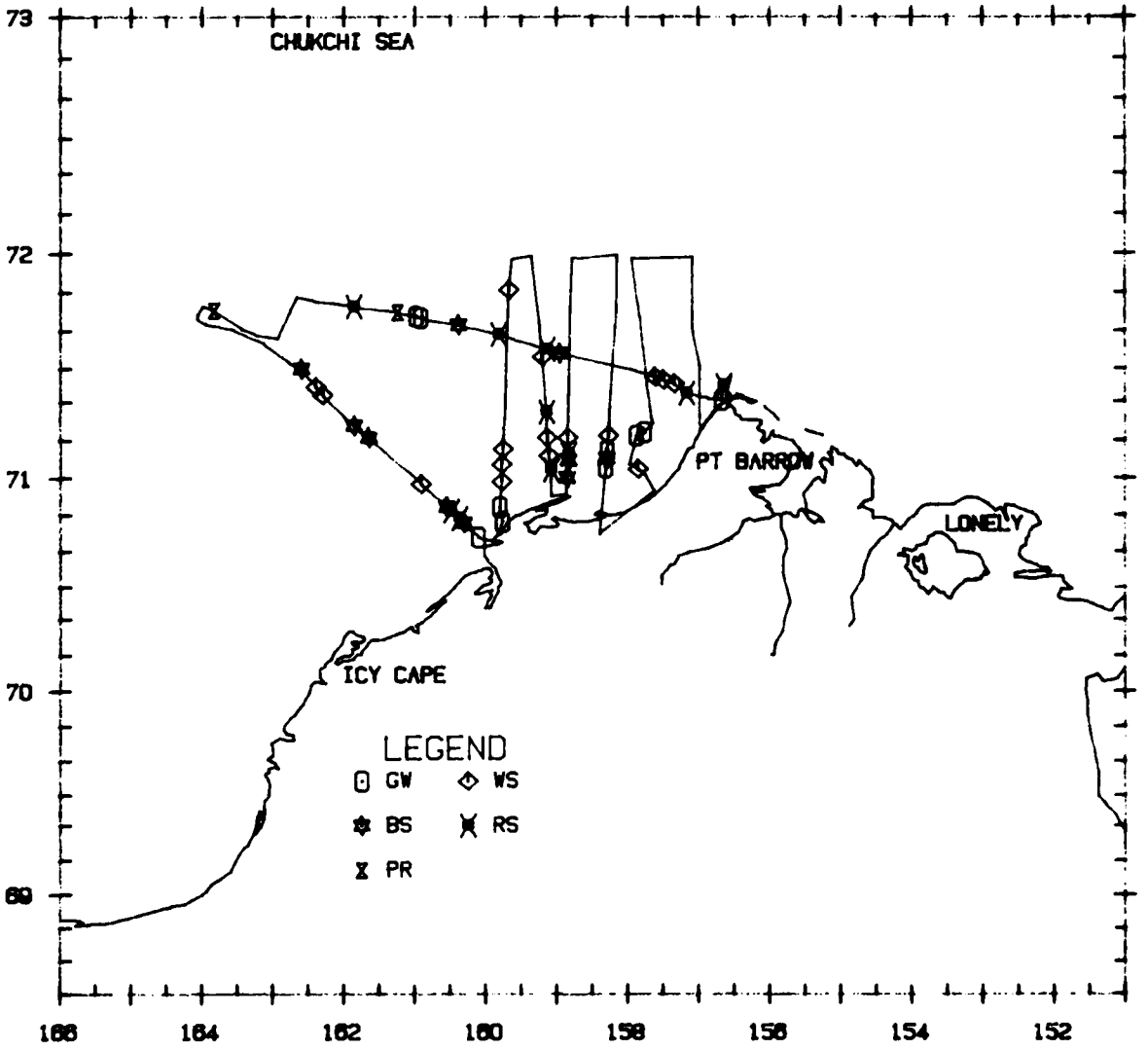
Flight 44: 31 August 1984

Flight was a transect survey of block 13, after heavy fog prevented a survey of block 16 or 18. Weather in block 13 was clear and visibility unlimited. Ice coverage was 0 to 95 percent, and sea state Beaufort 00 to 02. Nineteen gray whales, walrus, bearded and ringed seals, and polar bears were seen.

Gray Whale

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°20.6'	156°40.8'	--	MP	FE	--	0	NA	44
1/0	71°44.0'	160°59.4'	--	MP	FE	80	20	B0	42
2/0	71°43.6'	160°55.4'	--	MP	FE	--	20	B0	42
1/0	70°44.1'	160°06.3'	--	BW	FE	200	0	B2	18
2/0	70°48.3'	159°45.9'	1925	BW	SW	150	0	B2	18
1/0	70°52.4'	159°48.1'	216	BO	SW	180	0	B2	26
1/0	71°07.4'	158°17.4'	--	BW	SW	--	1	B0	20
1/0	71°03.0'	158°18.9'	420	BO	SW	230	1	B0	20
1/0	71°11.4'	157°52.7'	1925	MP	FE	--	0	B1	42
8/0	71°12.3'	157°45.9'	--	MP	FE	--	0	B1	42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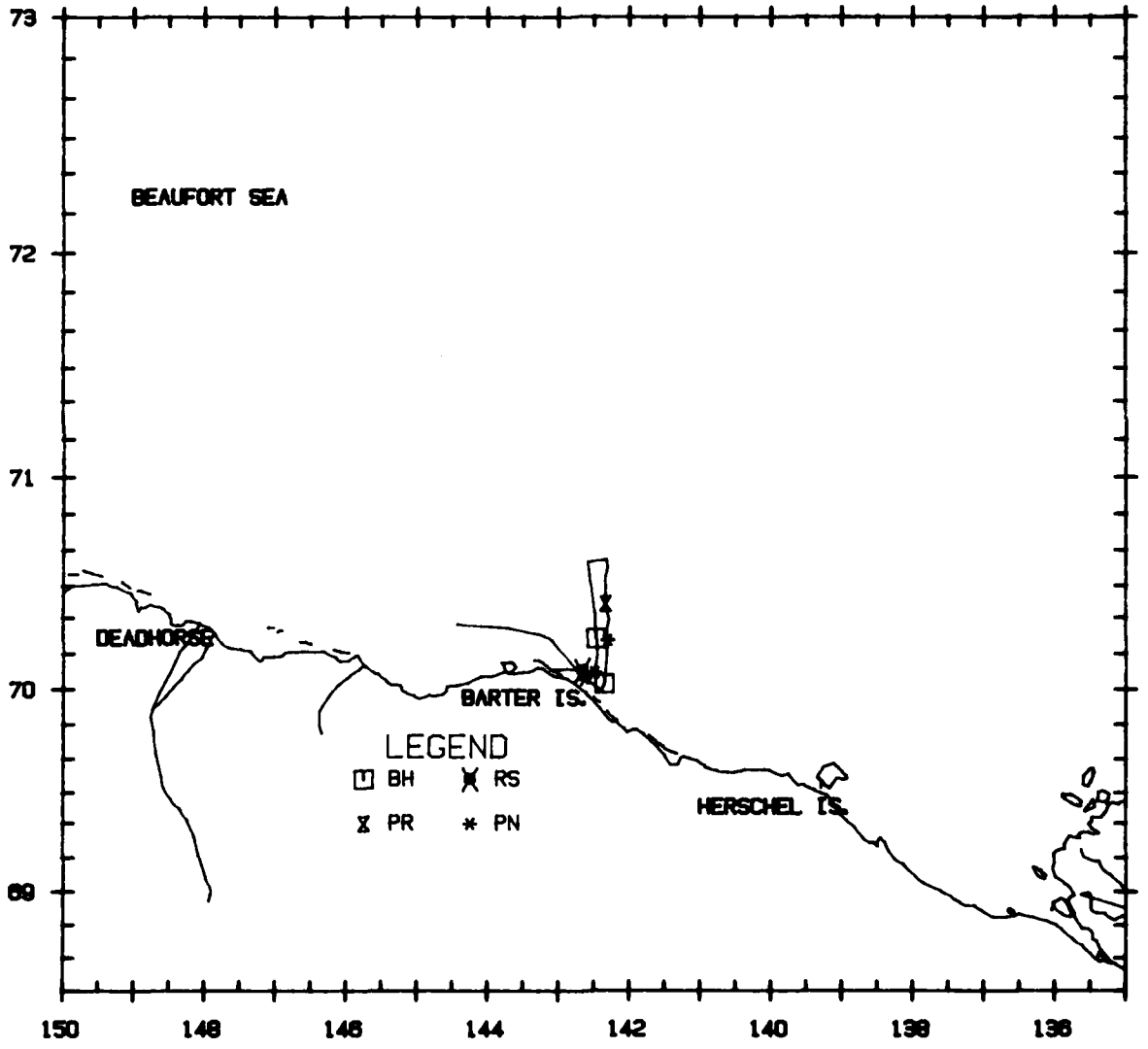
Flight 45: 6 September 1984

Flight was a transect survey of the western third of block 5. Heavy fog, low ceilings, and icing conditions forced the survey to be aborted. Visibility was variable from less than 1 to 3 km. Ice coverage was 0 to 90 percent and sea state was Beaufort 00 to 01. Two bowheads were seen in block 5. Both dove in an apparent response to the aircraft. A ringed seal, a polar bear, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°14.4'	142°28.0'	--	BO	DI	320	1	B1	29
1/0	70°01.8'	142°21.1'	--	SP	DI	250	1	B1	18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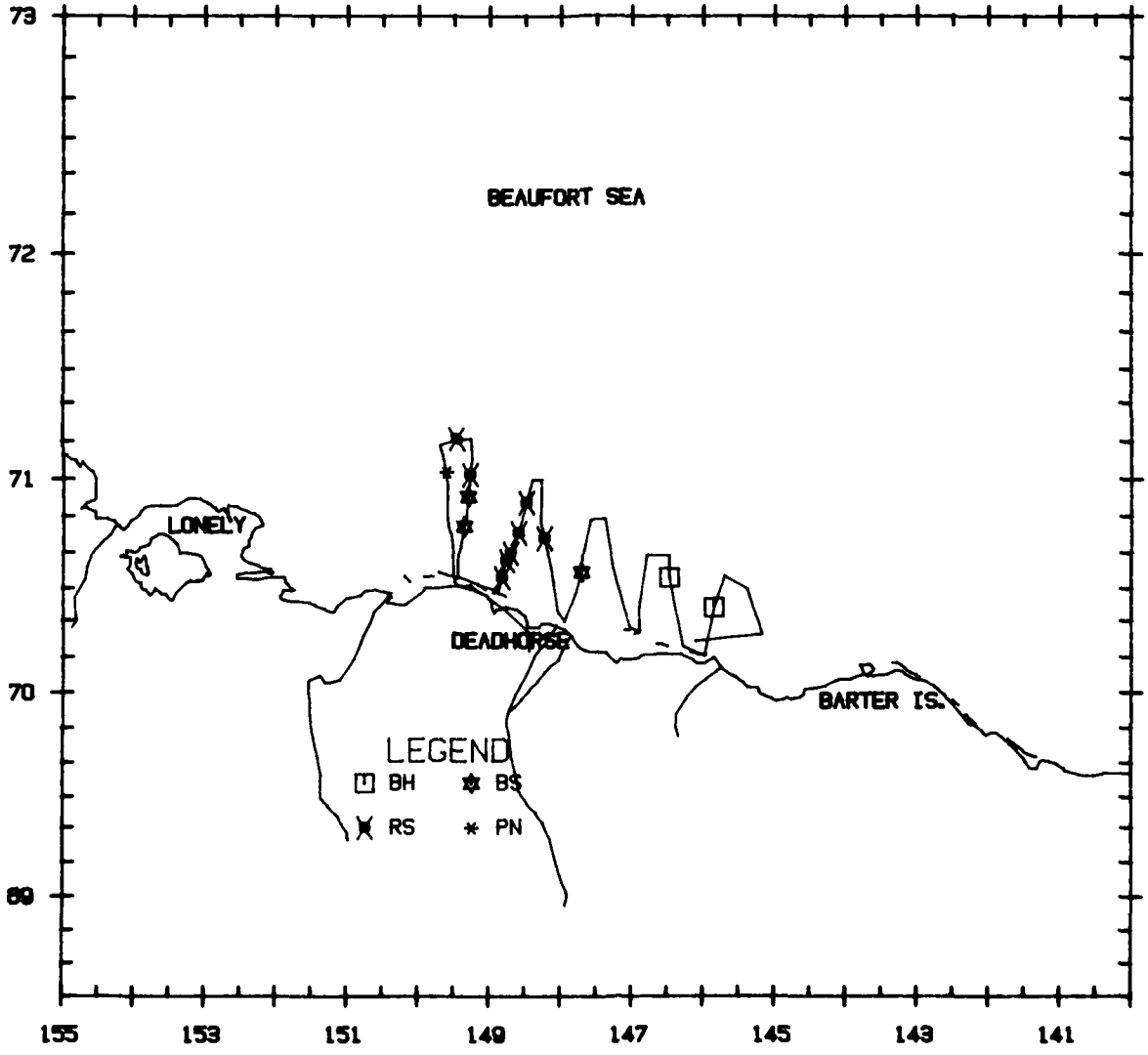
Flight 46: 7 September 1984

Flight was a transect survey of block 1 and one line in block 4. Weather was overcast to foggy and visibility was variable from 1 km to unlimited. Ice coverage was 0 to 90 percent and sea state was Beaufort 00 to 02. Two bowheads were seen; one in each block. Bearded and ringed seals, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°33.3'	146°28.3'	3380	BO	SW	260	40	B2	35
1/0	70°23.7'	145°50.7'	133	BO	SW	350	40	B2	26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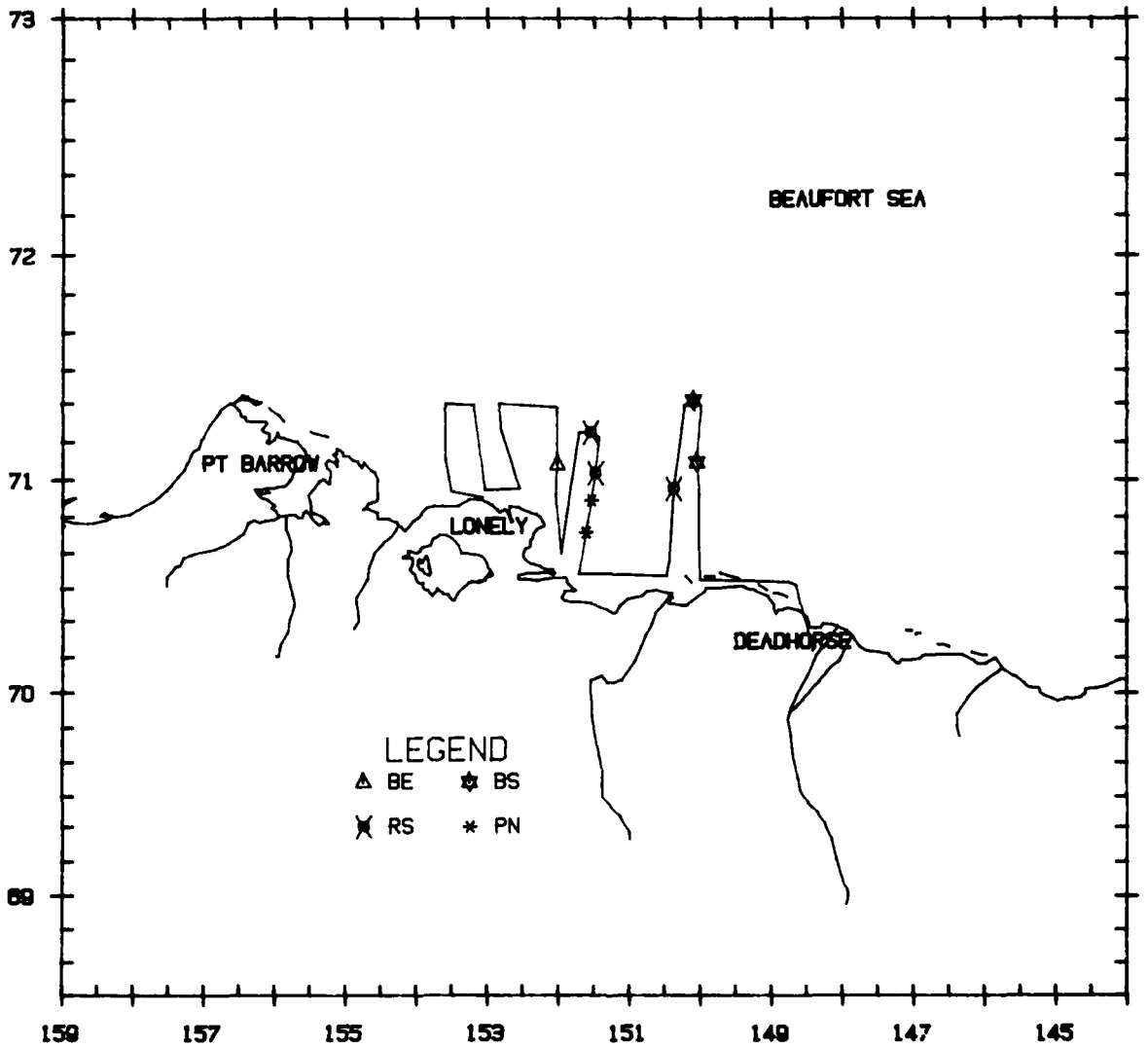
Flight 47: 7 September 1984

Flight was a transect survey of block 3. Weather was overcast and foggy with visibility ranging from 1 to 5 km. Ice coverage was 0 to 40 percent and sea state was Beaufort 00 to 03. Belukha whales, bearded and ringed seals, and unidentified pinnipeds were seen.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BEAUFORT SEA
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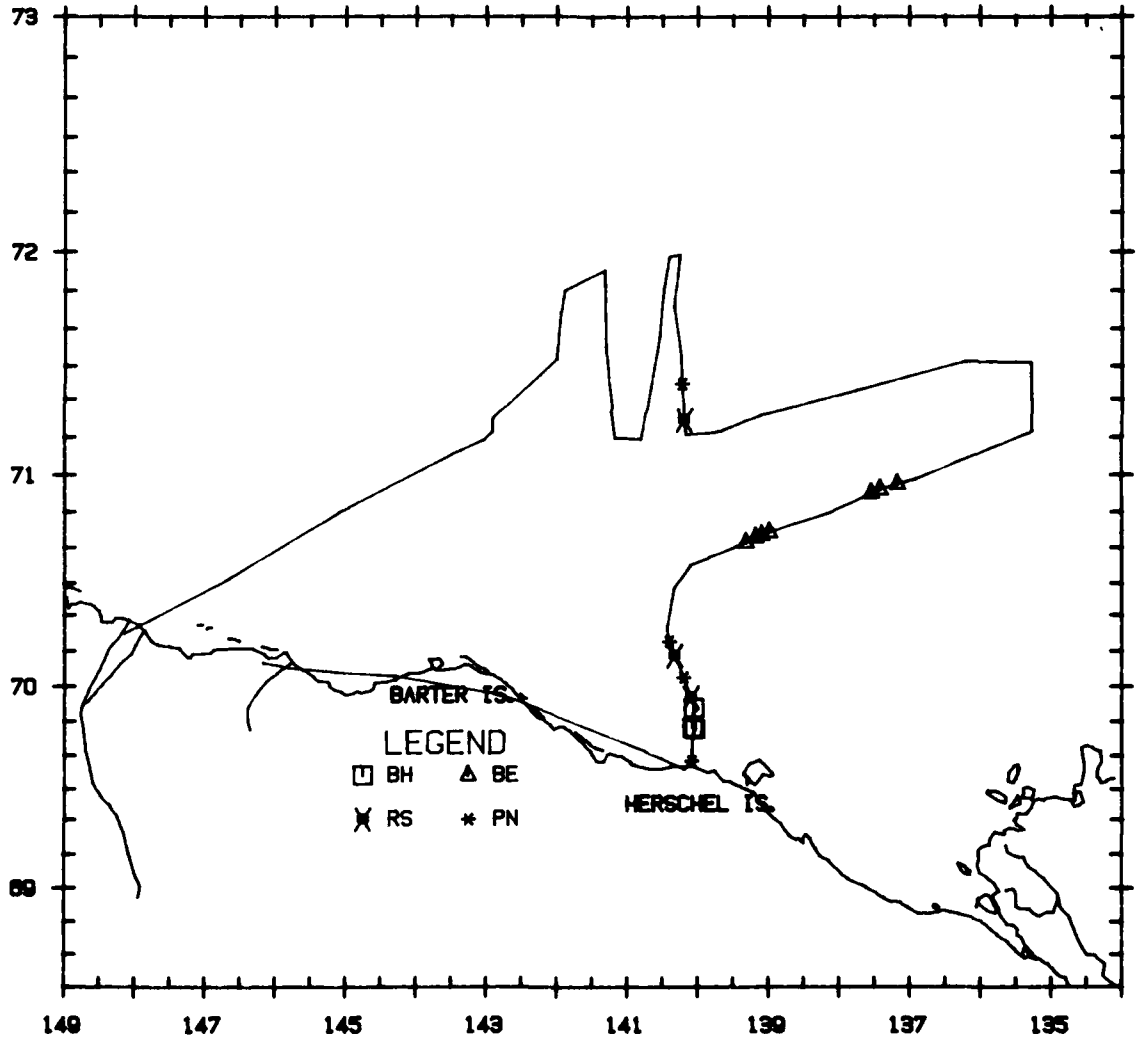
Flight 48: 11 September 1984

Flight was a transect survey of the eastern half of block 8 and a search survey east to determine ice conditions. Weather was heavy fog over most of the Beaufort Sea west of 140° W. To the east, weather was clear with unlimited visibility. Ice coverage was 0 to 98 percent and sea state was Beaufort 00 to 02. Four bowheads were seen in an open pocket in the fog on the eastern edge of block 5. Belukha whales, ringed seals, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
2/0	69°54.0'	140°02.6'	--	SP	DI	315	0	B2	48
1/0	69°48.3'	140°03.9'	--	SP	SW	300	0	B2	29
1/0	69°48.0'	140°02.0'	176	BO	SW	300	0	B2	29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BARTER IS.
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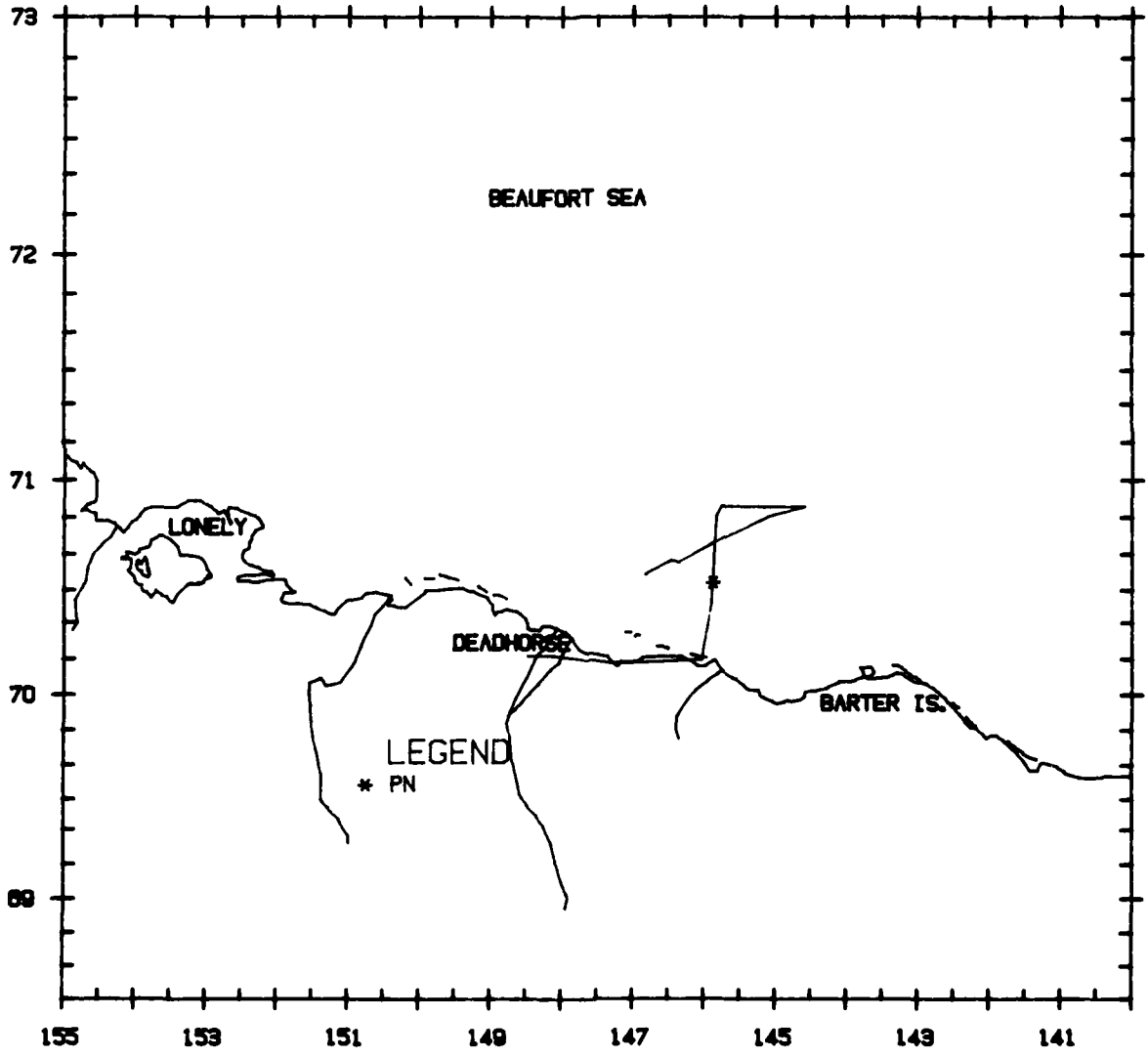
Flight 49: 12 September 1984

Flight was a search survey north to the ice edge at 70°53' N. Heavy fog and snow flurries forced the flight to be aborted. Visibility was usually less than 1 km. Ice coverage south of 70°53' N was generally 0 to 5 percent; north of 70°53', ice coverage was 95 to 99 percent. Sea state was Beaufort 00 to 02. One unidentified pinniped was seen.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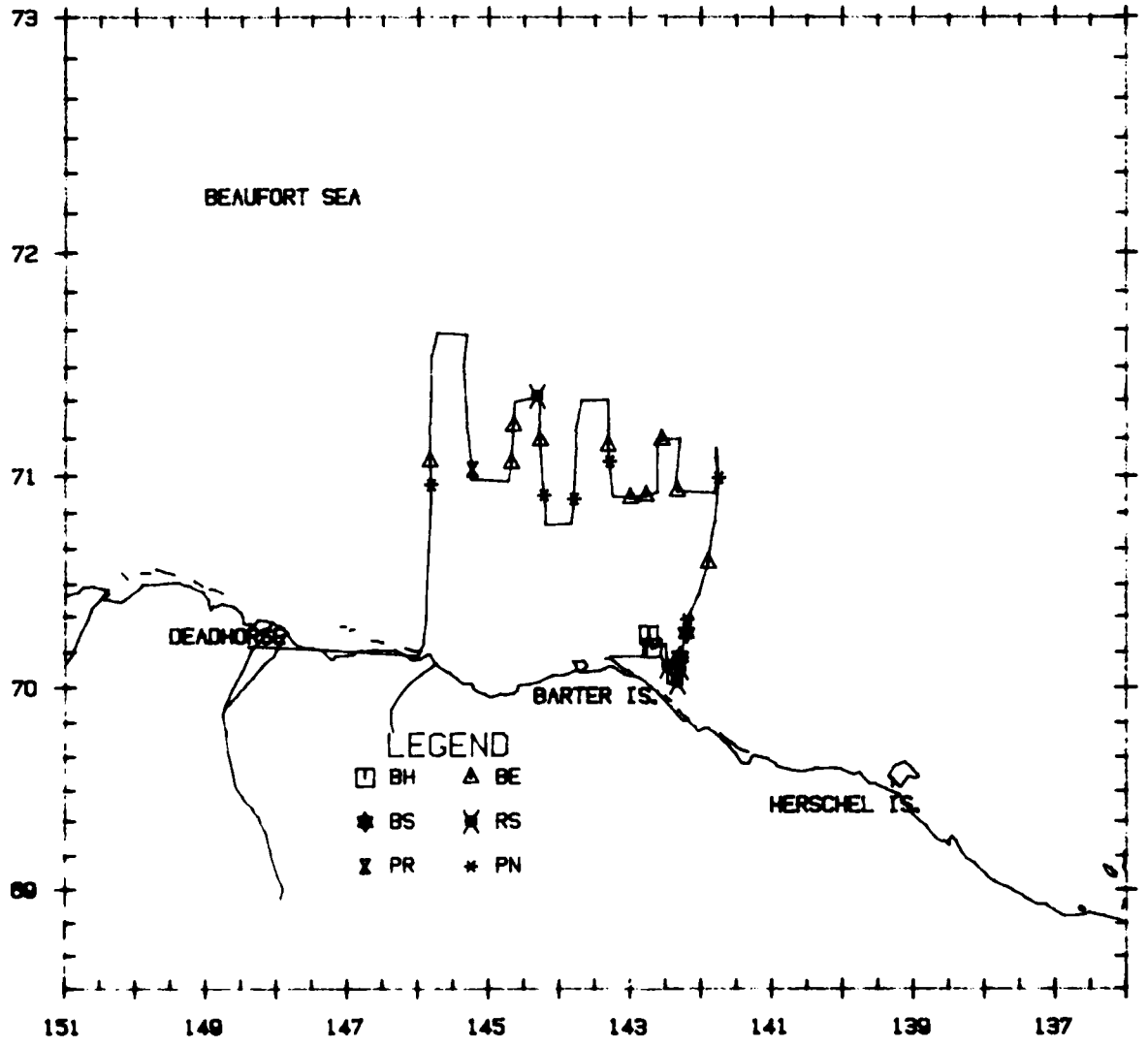
Flight 50: 13 September 1984

Flight was a transect survey through portions of blocks 5, 6, 7, and 9. Heavy fog and low visibility in surrounding areas forced transect lines to be truncated. Ice coverage was 0 to 95 percent and sea state was Beaufort 00 to 01. Three bowheads, including one struck by whalers from the village of Kaktovik, were seen in block 5. Belukha whales, polar bears, bearded and ringed seals, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°11.6'	142°41.4'	--	BW	SW	200	0	B1	22
2/0	70°15.1'	142°44.2'	--	BO	SW	300	0	B1	22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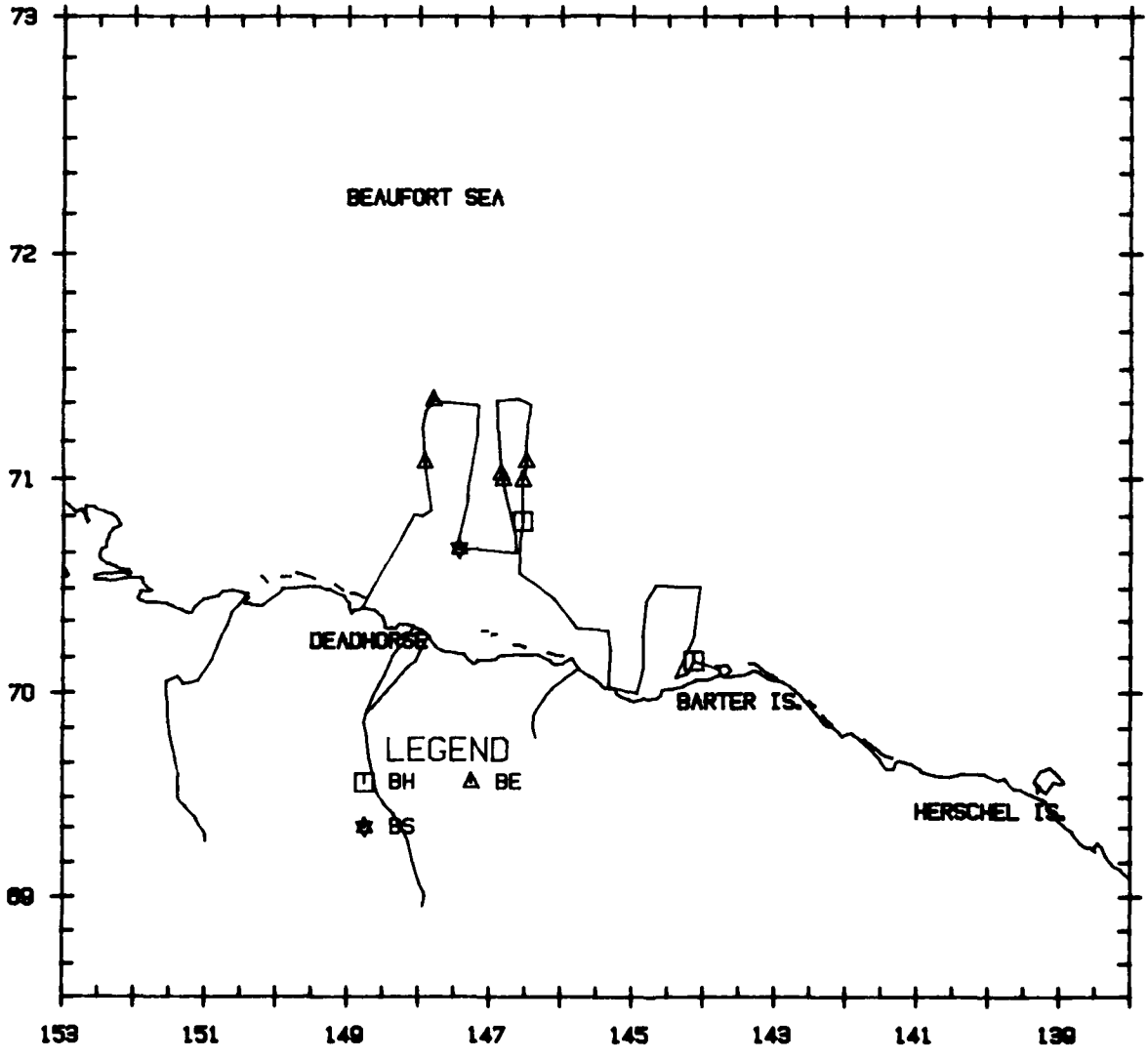
Flight 51: 14 September 1984

Flight was a transect survey of portions of blocks 4 and 2. Heavy fog and low visibility in surrounding areas forced transect lines to be truncated. Ice coverage was 1 to 20 percent in block 4, with a sea state of Beaufort 01 to 02; and 0 to 99 percent in block 2, with a sea state of Beaufort 00 to 02. One bowhead was sighted in block 4 and three bowheads in block 2. Belukha whales and bearded seals were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°09.0'	144°07.5'	--	BO	SW	240	1	B1	11
3/0	70°48.6'	146°32.0'	238	BO	SW	10	1	B2	64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BEAUFORT SEA
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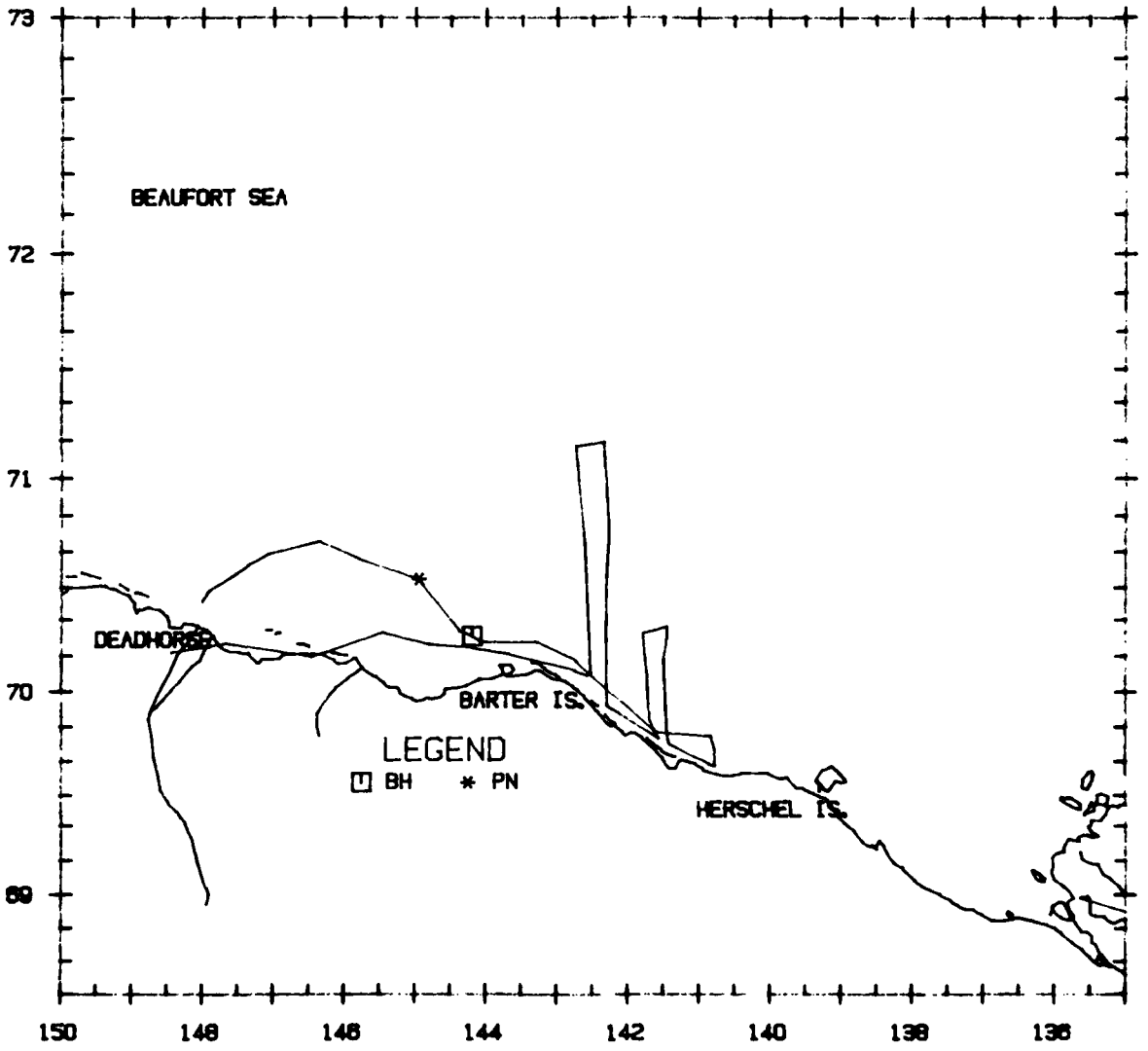
Flight 52: 15 September 1984

Flight was a transect survey of portions of blocks 5 and 7. Weather varied from overcast to low ceiling and fog. Visibility varied from unlimited to unacceptable but was mostly 5 km. Sea state was Beaufort 03 to 05. Ice coverage was 1 to 20 percent. Two bowheads were seen swimming. One unidentified pinniped was also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
2/0	70°15.9'	144°11.3'	--	BO	SW	240	20	B4	37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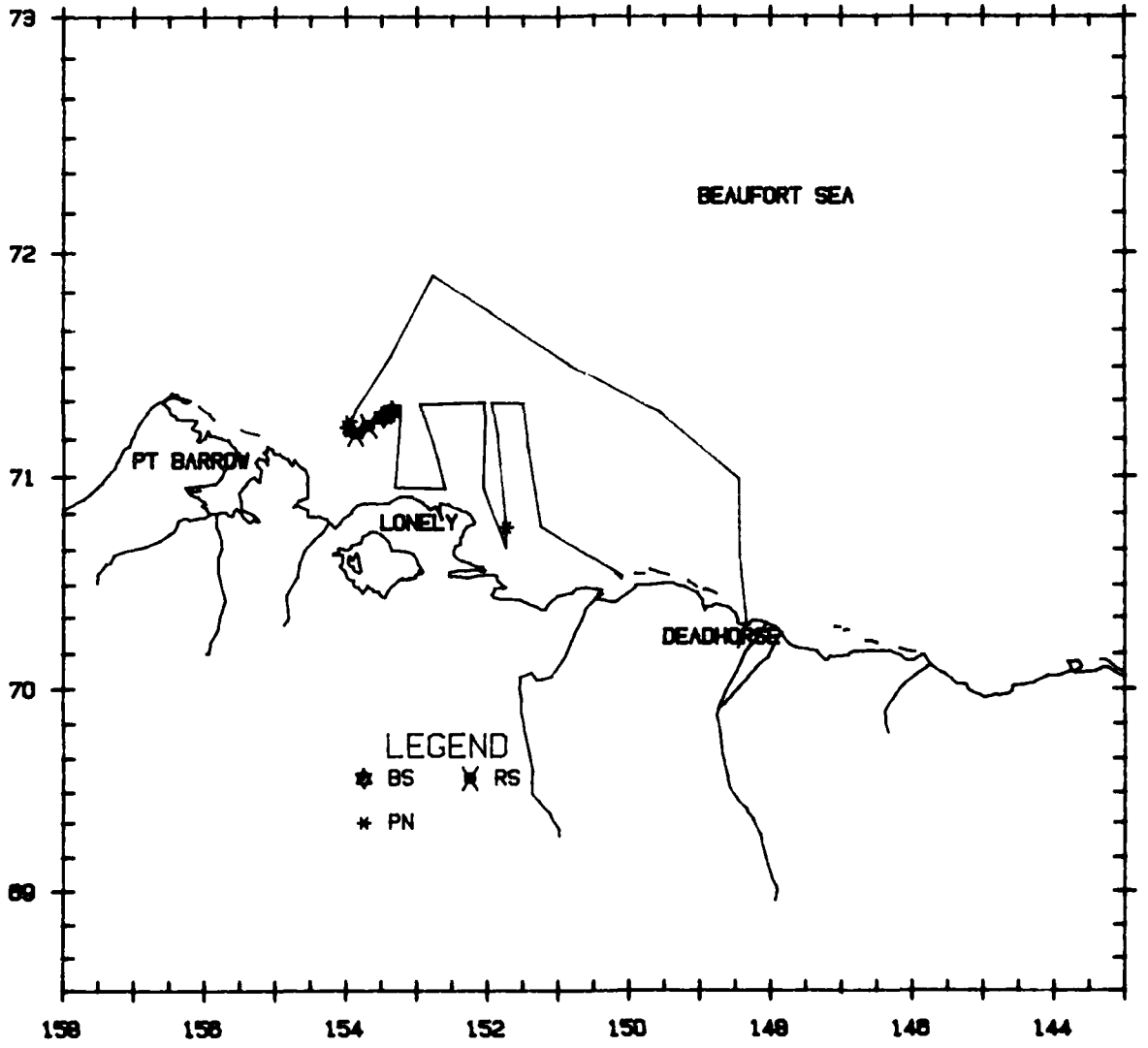
Flight 53: 16 September 1984

Flight was a transect survey of the western half of block 3 after attempting blocks 10 and 11. Weather was fog and overcast. Visibility was generally less than 5 km. Ice coverage varied from 1 to 10 percent nearshore to 90 percent offshore. Sea state was Beaufort 01. Bearded and ringed seals and unidentified pinnipeds were seen.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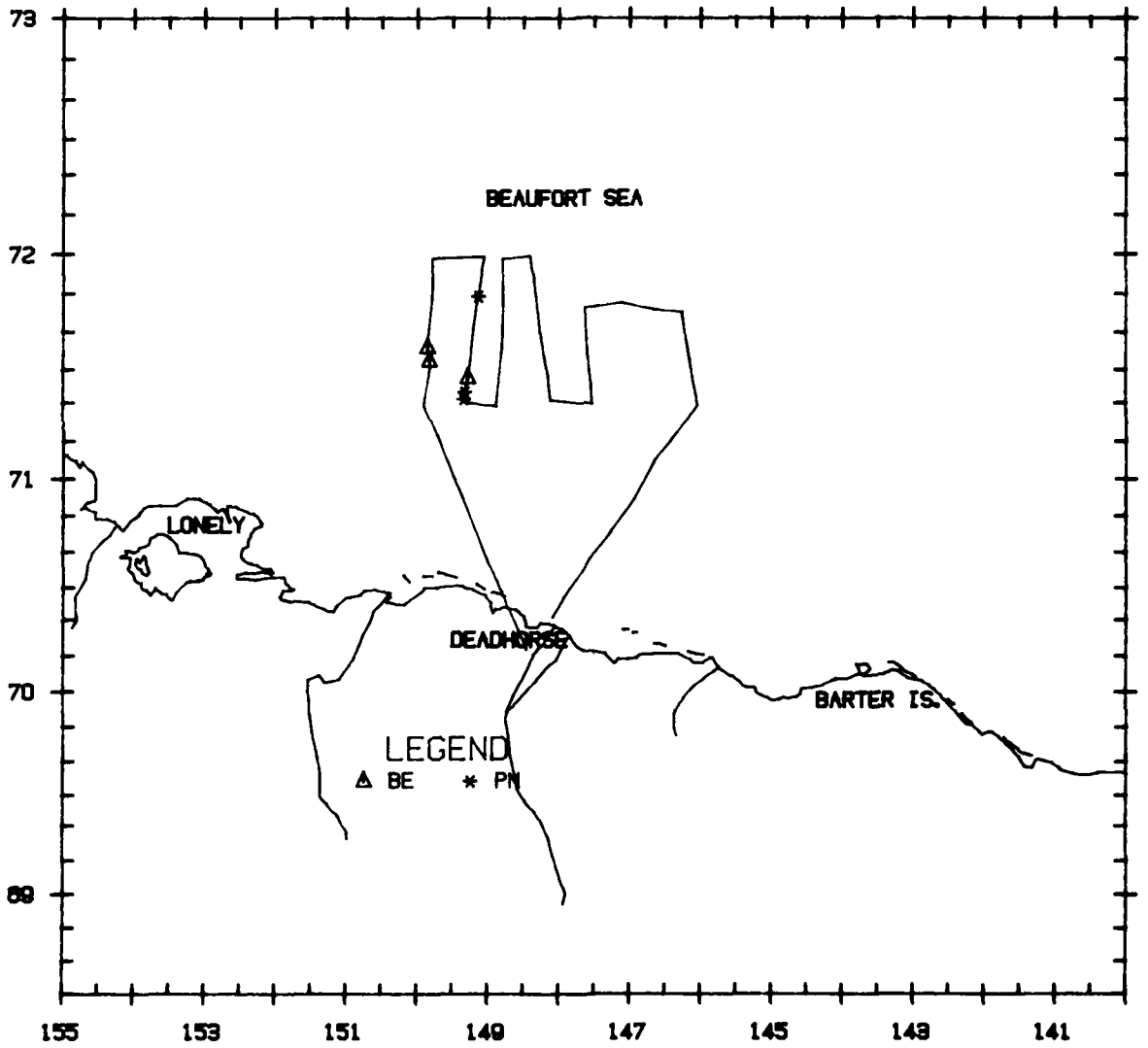
Flight 54: 17 September 1984

Flight was a transect survey of block 10. Weather was clear in the western half and fog in the eastern half. Visibility was unlimited in the west and unacceptable in the east. Ice coverage was 90 to 99 percent broken floe ice. The sea state was Beaufort 01. Belukha whales and unidentified pinnipeds were seen.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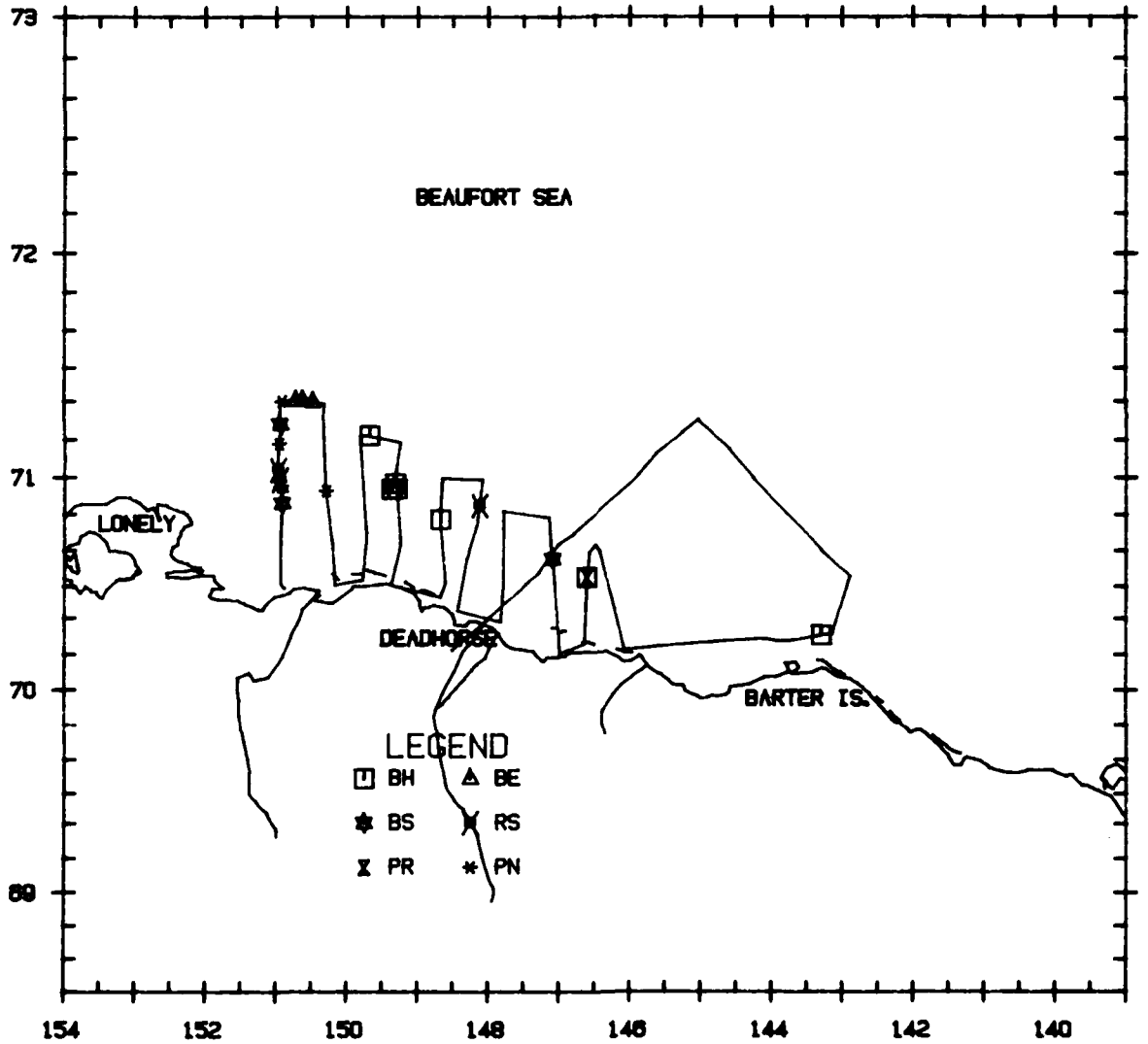
Flight 55: 18 September 1984

Flight was a transect survey of block 1 and the western portion of block 3 after attempting blocks 7, 8, and 5. Weather was clear or overcast with unlimited visibility. Ice coverage varied from open to 90 percent broken floe in the northwest corner of the survey block. Sea state was mostly Beaufort 00 or 01, but ranged up to 03. Six bowheads were seen. Four were swimming west. A polar bear was seen feeding on a small (est. 6 m) bowhead carcass. Belukha whales, bearded and ringed seals, and unidentified pinnipeds were also seen. One sonobuoy was dropped in the vicinity of three bowheads but no bowhead sounds were recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°15.2'	143°17.3'	678	BO	SW	90	0	B3	22
1/0	70°32.5'	146°36.3'	--	BO	DE	--	0	B3	--
1/0	70°48.5'	148°40.4'	1096	BO	RE	90	20	B0	20
1/0	70°56.9'	149°17.4'	1956	BO	SW	240	20	B0	22
1/0	70°58.3'	149°18.8'	--	BO	SW	240	20	B0	22
1/0	70°56.7'	149°21.9'	--	BO	SW	240	10	B0	18
1/0	71°11.0'	149°40.8'	3579	BO	SW	290	50	B0	62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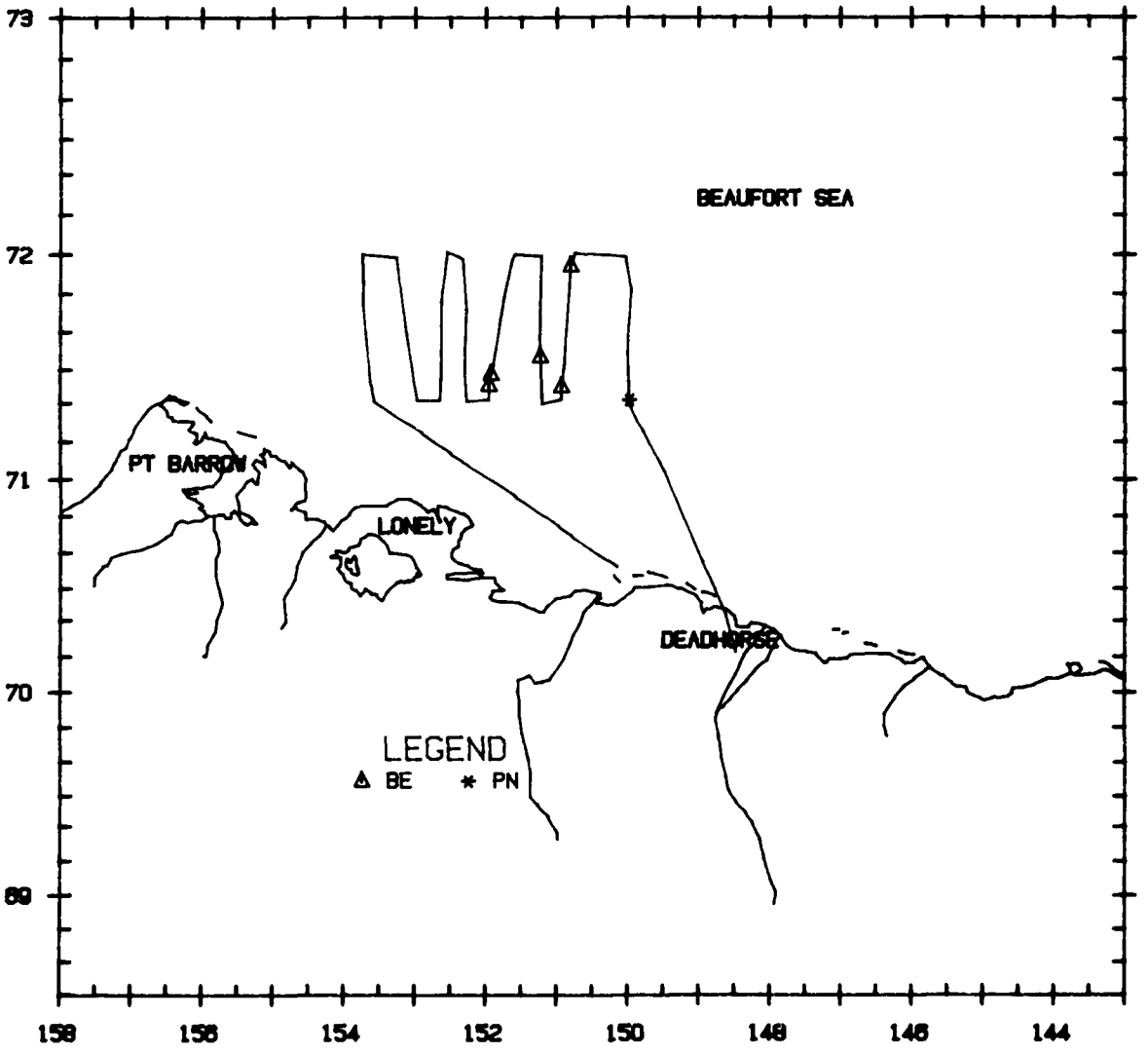
Flight 56: 20 September 1984

Flight was a transect survey of block 11. Weather was clear with unlimited visibility. Ice coverage varied from 90 percent broken floe and new ice in the northeast corner to open in west. Sea state varied with the ice coverage from Beaufort 00 to 03. Belukha whales and unidentified pinnipeds were seen.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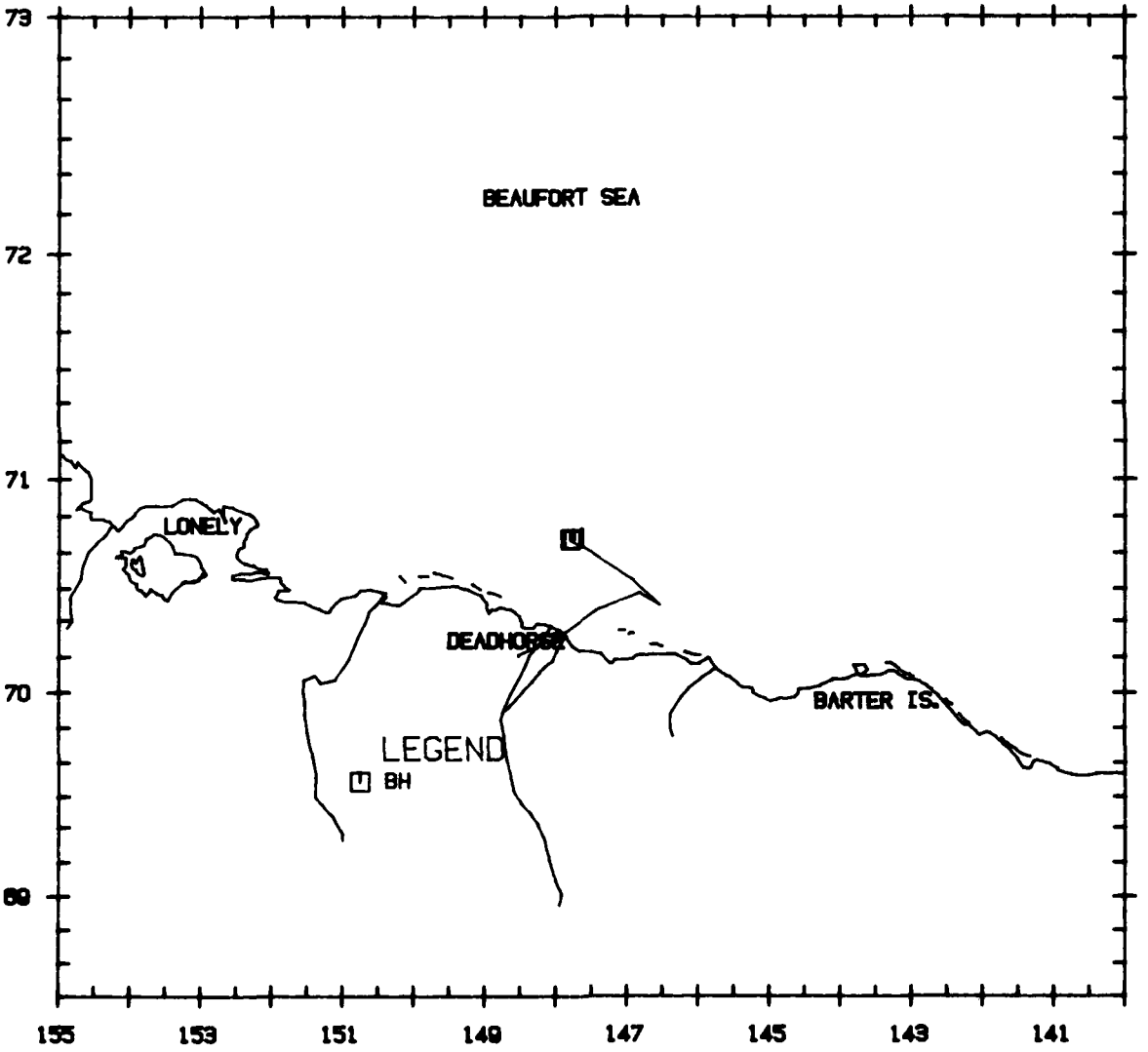
Flight 57: 21 September 1984

Flight was intended as a transect survey of blocks 5 and 7 but was aborted. Weather was high overcast with unlimited visibility. Ice coverage was 0 to 50 percent broken floe. Sea state was Beaufort 01 to 02. Three bowheads were seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°43.5'	147°47.3'	--	BO	SW	260	15	B1	37
2/0	70°43.7'	147°44.8'	--	BO	SW	240	15	B1	37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BEAUFORT SEA
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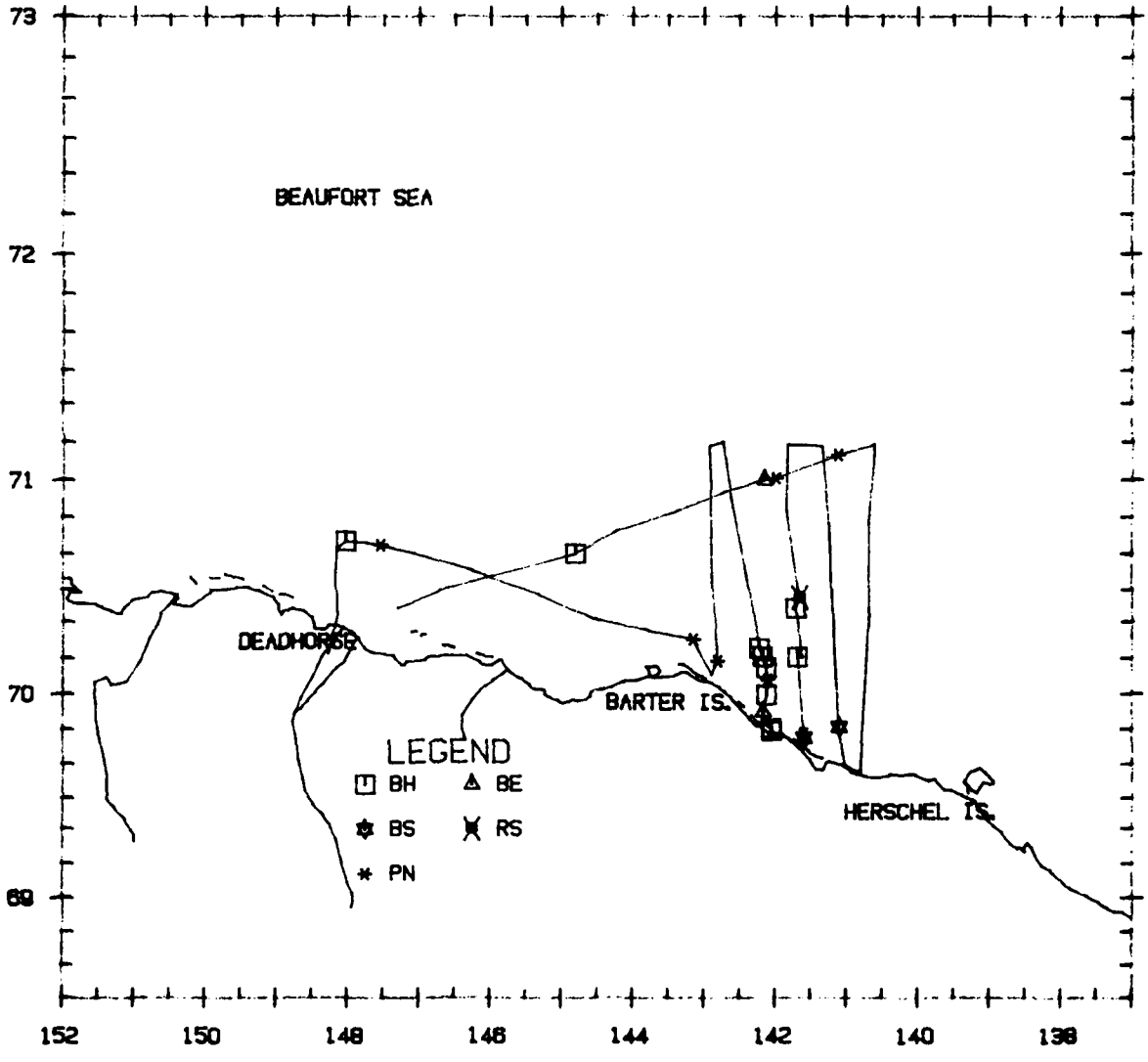
Flight 58: 21 September 1984

Flight was a transect survey of blocks 5 and 7. Weather was overcast with unlimited visibility. Ice coverage was mostly open with patches of 50 percent broken floe along the north edge. Sea state was Beaufort 01 to 02. Thirteen bowheads were seen, mostly nearshore. Belukha whales, bearded and ringed seals, and unidentified pinnipeds were seen. One sonobuoy was dropped but only seismic signals were recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°43.9'	148°01.0'	--	SP	SW	250	1	B1	24
1/0	70°13.0'	142°13.0'	295	BW	DI	200	0	B2	33
3/0	70°10.7'	142°10.3'	383	BO	RE	290	0	B2	33
1/0	70°07.5'	142°07.2'	5401	BO	SW	240	0	B2	26
1/0	70°00.0'	142°06.8'	213	BO	RE	330	0	B2	18
1/0	69°50.5'	142°02.7'	235	BO	SW	70	1	B1	11
1/0	69°49.7'	142°02.4'	310	BO	RE	60	1	B1	11
1/0	70°10.6'	141°41.0'	1361	BO	SW	200	0	B1	40
2/1	70°23.9'	141°42.7'	12659	BO	MI	30	0	B2	60
1/0	70°40.4'	144°48.0'	565	BO	DI	220	0	B2	79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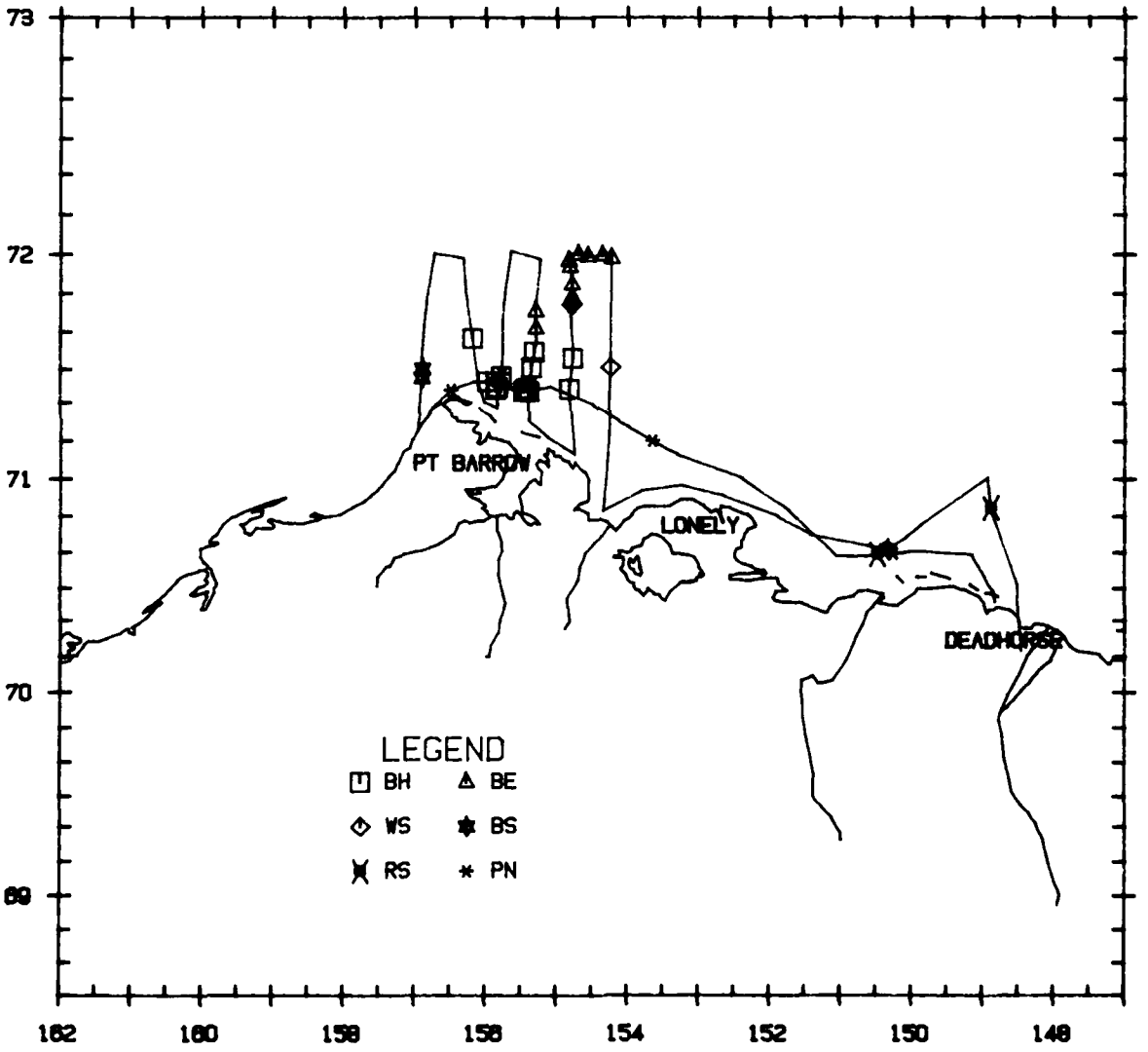
Flight 59: 22 September 1984

Flight was a transect survey of block 12. Weather was overcast with unlimited visibility. Ice coverage was very patchy from 0 to 50 percent but mostly open. Sea state Beaufort 01 to 04. Forty-nine bowheads were seen; most were feeding east of Pt. Barrow. Belukha whales, bearded and ringed seals, walrus, and unidentified pinnipeds were also seen. One sonobuoy was dropped and whale and distant seismic signals were recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°33.2'	154°45.8'	546	SP	SW	210	0	B2	18
1/0	71°23.7'	154°48.6'	1094	BO	SW	220	0	B2	11
20/0	71°23.0'	155°22.8'	--	BW	FE	--	0	B3	9
1/0	71°30.7'	155°20.7'	1895	SP	SW	230	0	B3	18
1/0	71°34.9'	155°18.4'	243	BO	SW	160	0	B3	18
11/0	71°26.8'	155°46.0'	2887	SP	FE	--	0	B3	5
13/0	71°23.6'	155°50.7'	--	BO	FE	--	0	B3	15
1/0	71°38.4'	156°01.5'	585	SP	SW	100	30	B4	123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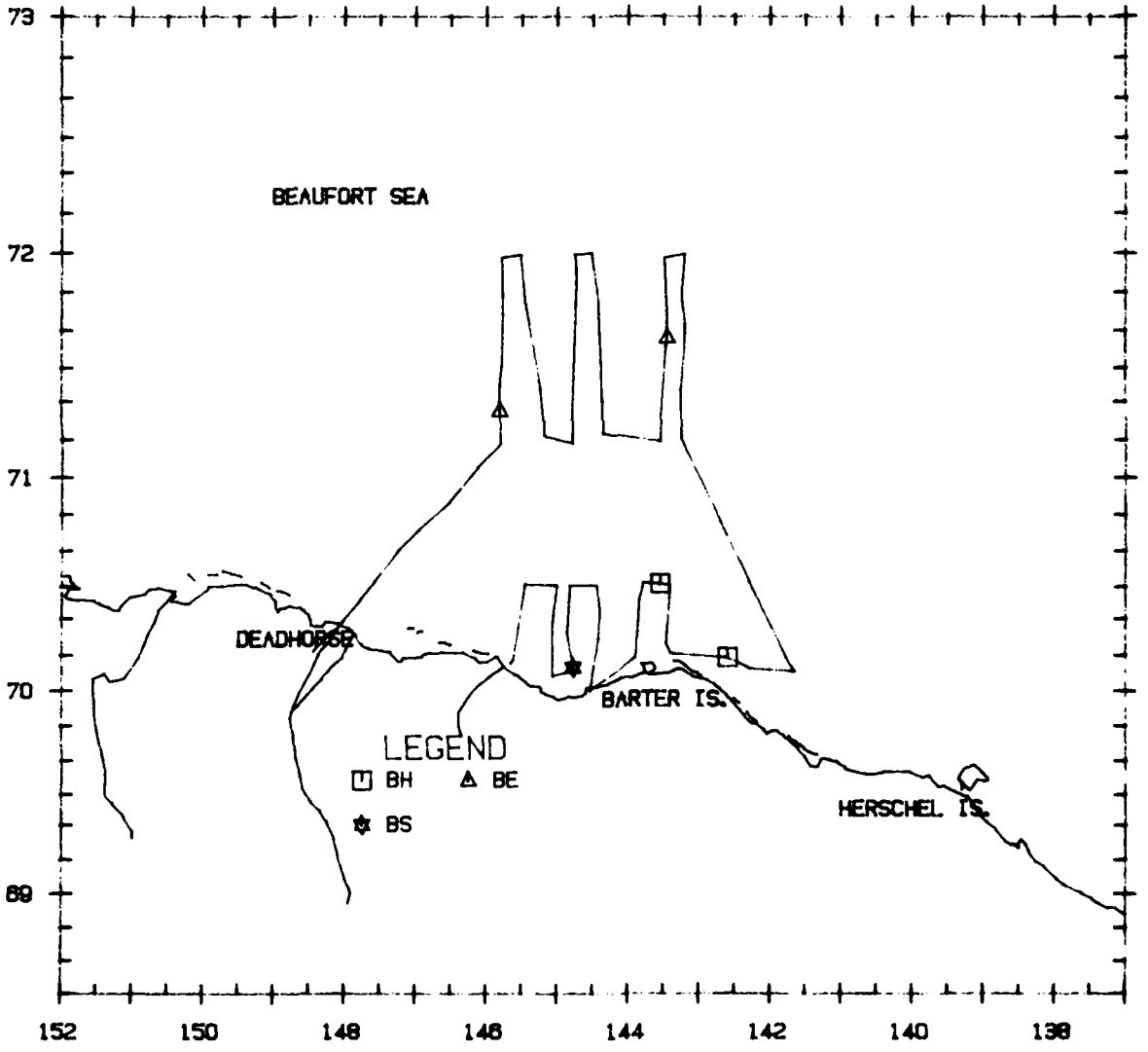
Flight 60: 23 September 1984

Flight was a transect survey of blocks 9 and 4. Weather was clear with unlimited visibility. Ice coverage was over 90 percent broken floe and new ice in the northern half of block 9 but otherwise open. Sea state was Beaufort 01 to 03. Two bowheads were seen near Barter Island. Belukha whales and bearded seals were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°09.4'	142°35.7'	1284	BO	RE	330	2	B2	27
1/0	70°30.9'	143°32.6'	1094	BO	SW	240	0	B3	53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Flight 61: 24 September 1984

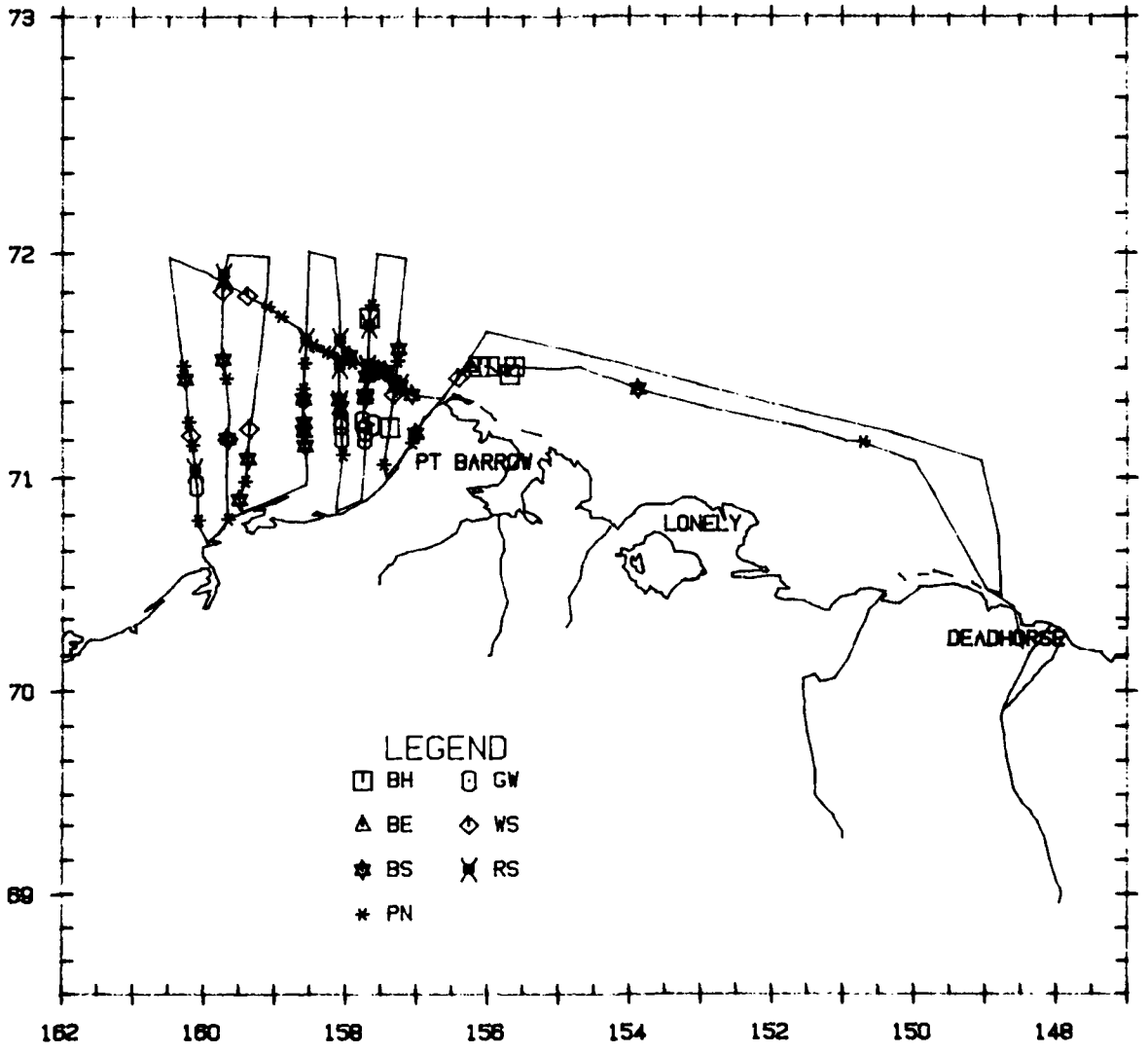
Flight was a transect survey of block 13. Weather was clear or high overcast with unlimited visibility. Ice coverage was open except for patches of 50 percent along the northern edge of the block. Sea state was Beaufort 00 to 03. Fifty bowheads were seen feeding east of Pt. Barrow and two were seen swimming in the Chukchi Sea. Seventy gray whales were seen feeding southwest of Pt. Barrow. Belukha whales, walrus, bearded and ringed seals, and unidentified pinnipeds were also seen.

Bowhead

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°30.6'	155°36.2'	766	BO	SW	230	0	B3	18
15/0	71°27.0'	155°40.4'	--	BO	FE	--	0	B3	5
31/0	71°29.2'	155°57.5'	--	BO	FE	--	0	B3	5
3/0	71°30.6'	156°06.4'	--	BW	SW	210	0	B3	7
1/0	71°13.4'	157°22.0'	276	BO	SW	150	0	B3	38
1/0	71°43.4'	157°39.3'	425	BW	SW	240	2	B2	57

Gray Whale

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
35/0	71°14.9'	157°45.2'	5227	BW	FE	210	2	B2	42
12/0	71°14.1'	157°36.2'	--	MP	FE	210	2	B2	38
14/0	71°12.6'	157°43.1'	508	MP	FE	--	2	B2	42
1/0	71°10.7'	157°43.6'	898	BO	SW	20	2	B2	42
5/0	71°10.8'	158°03.3'	585	MP	FE	150	0	B2	22
1/0	71°14.4'	158°03.2'	321	BO	SW	160	0	B2	22
2/0	70°58.1'	160°06.5'	3037	BW	SW	190	0	B1	44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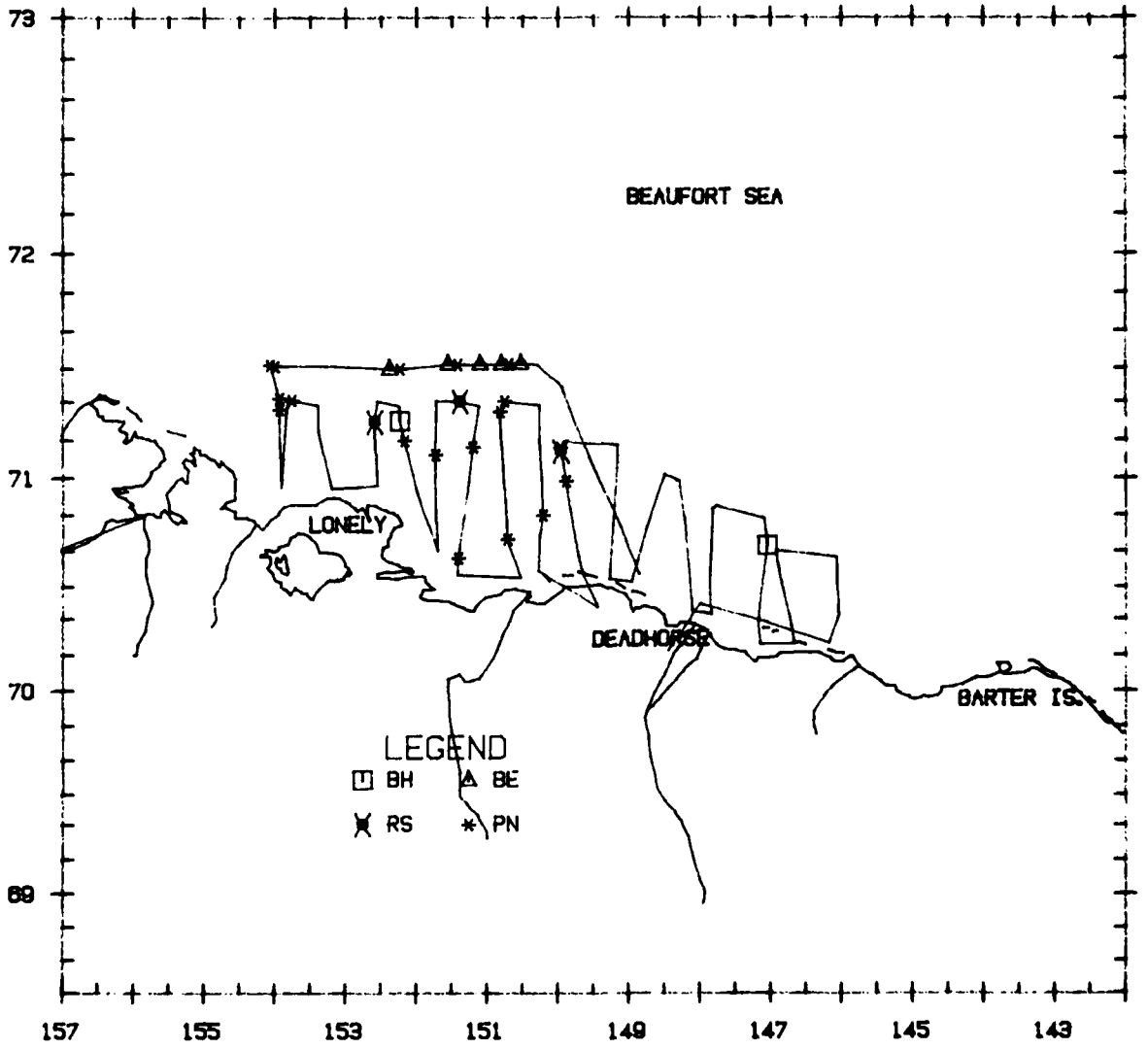
Flight 62: 25 September 1984

Flight was a transect survey of blocks 3 and 1. Weather was high overcast with unlimited visibility. Ice coverage was mostly open with a 20 km wide swath of 30 to 50 percent broken floe ice. Sea state was Beaufort 00 to 01. Two bowheads were seen. Belukha whales, ringed seals, and unidentified pinnipeds were seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°41.5'	147°02.3'	332	BO	SW	200	50	B1	40
1/0	71°15.2'	152°13.0'	5227	BO	SW	330	1	B1	48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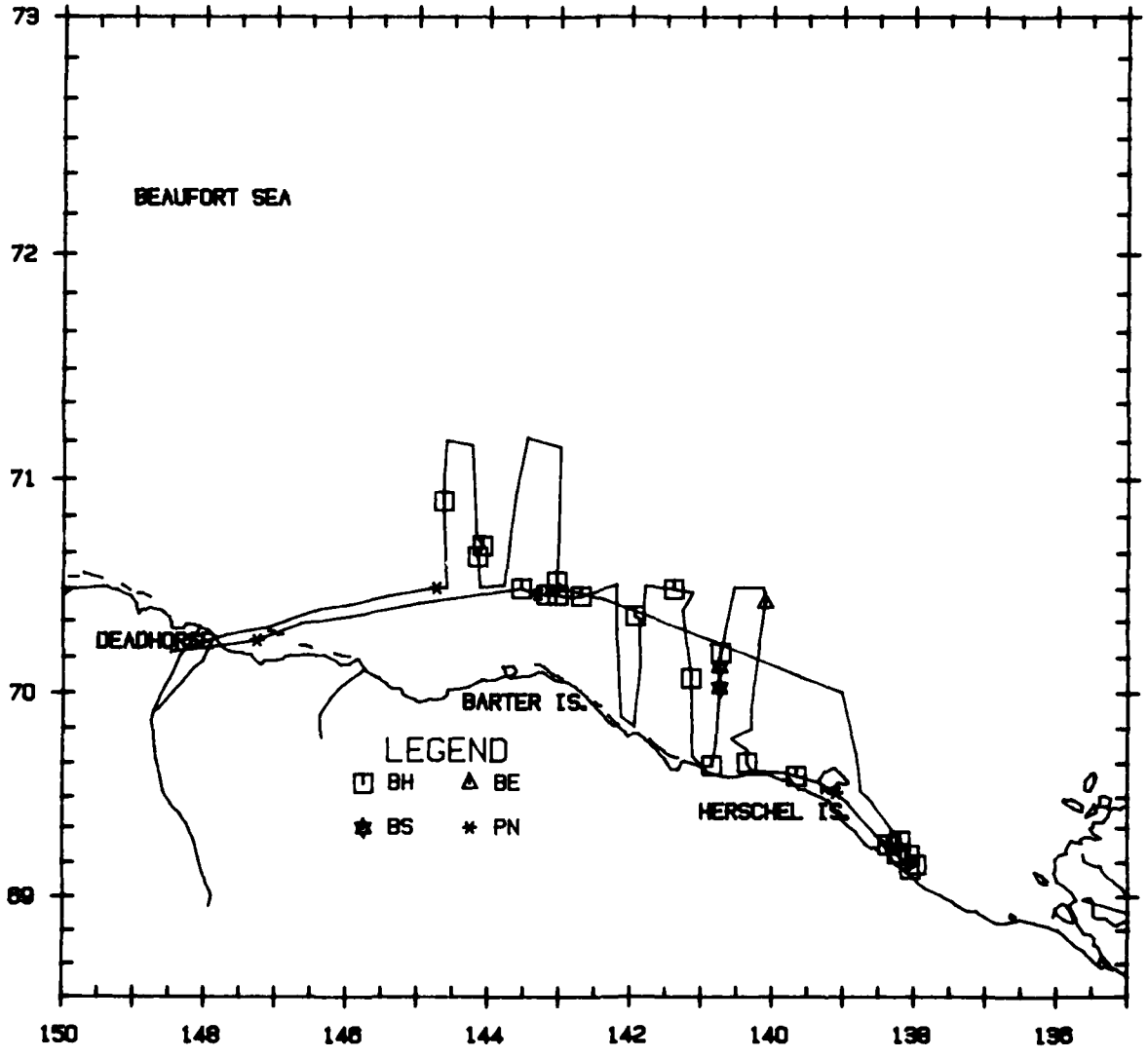
Flight 63: 26 September 1984

Flight was a transect survey of blocks 5 and 6 and a search of coastal Canadian Beaufort Sea. Weather was overcast with unlimited visibility. There was no ice. Sea state was Beaufort 00 to 01. Sixty-six bowheads including one calf were seen. Coastal whales were feeding while those offshore were swimming westerly. Belukha whales, bearded seals, and unidentified pinnipeds were also seen. One sonobuoy was dropped but only ambient sounds recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°29.0'	143°31.6'	1027	BO	SW	60	1	B0	37
8/0	70°27.3'	143°10.1'	--	BO	MI	--	1	B0	37
1/1	70°27.2'	143°00.8'	308	BO	SW	220	1	B0	37
1/0	70°26.9'	142°41.1'	--	SP	SW	270	0	B0	46
1/0	70°21.4'	141°55.2'	--	SP	SW	240	0	B1	60
1/0	70°28.7'	141°22.6'	13532	SP	SW	240	0	B1	68
1/0	70°04.3'	141°08.5'	6540	SP	SW	240	0	B1	40
1/0	69°39.3'	140°50.3'	--	MP	MI	250	0	B0	7
1/0	70°11.4'	140°43.4'	5227	SP	SW	240	0	B0	48
1/0	69°40.2'	140°20.7'	--	SP	SW	-99	0	B1	24
7/0	69°36.3'	139°39.0'	--	BO	MI	--	0	B1	16
6/0	69°15.3'	138°21.4'	--	SP	MI	--	0	B0	7
8/0	69°12.7'	138°13.8'	--	BO	MI	--	0	B0	7
11/0	69°08.2'	138°03.1'	--	BO	MI	--	0	B0	11
6/0	69°09.5'	137°57.6'	--	BO	FE	--	0	B0	18
3/0	69°12.3'	138°03.2'	4206	BO	FE	--	0	B0	27
1/0	69°16.4'	138°11.1'	397	BO	FE	180	0	B0	27
1/0	70°32.3'	143°01.7'	938	SP	SW	230	0	B0	48
2/0	70°39.1'	144°09.2'	3600	SP	SW	300	0	B0	62
3/0	70°42.2'	144°05.0'	--	BO	SW	240	0	B0	73
1/0	70°54.2'	144°38.2'	--	SP	SW	240	0	B0	466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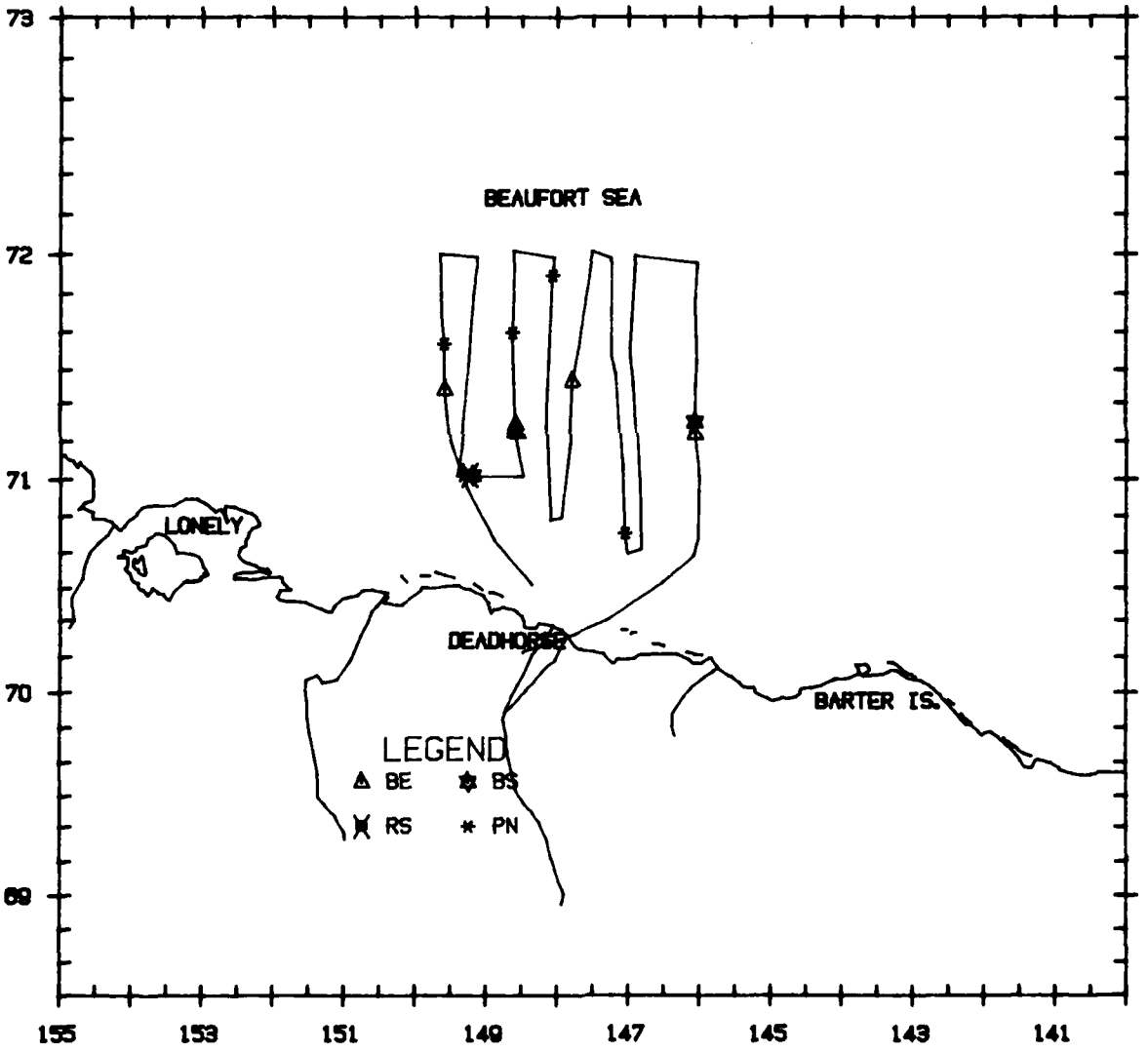
Flight 64: 27 September 1984

Flight was a transect survey of blocks 2 and 10. Weather was low overcast with patchy fog. Visibility was generally 5 km. Ice coverage varied from open in the southwest corner and 90 to 99 percent broken floe along the north edge. Sea state was Beaufort 00 to 01. Belukha whales, bearded and ringed seals, and unidentified pinnipeds were seen.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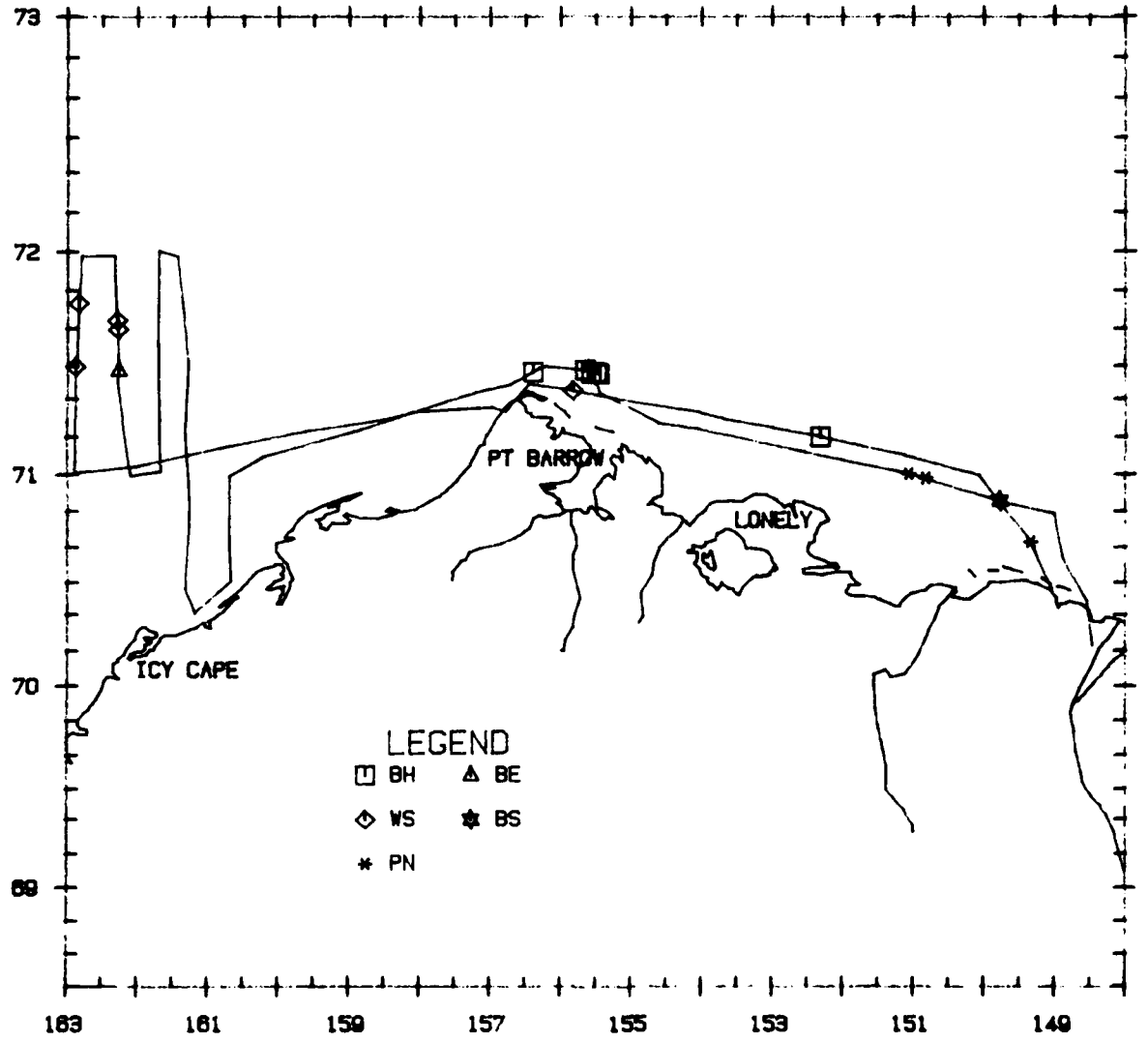
Flight 65: 28 September 1984

Flight was a transect survey of portions of blocks 14 and 17. Weather was low ceiling and patchy fog with reduced visibility in block 17; and high overcast and unlimited visibility in block 14. Block 14 was ice-free and had a sea state of Beaufort 05. Block 17 had ice coverage to 50 percent broken floe and sea state Beaufort 01 to 03. Fifty bowheads were seen; most were feeding east of Pt. Barrow. Belukha whales, bearded seals, walrus, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
24/0	71°26.8'	155°33.3'	--	BO	FE	--	0	B3	5
14/0	71°27.0'	155°28.6'	--	BO	FE	--	0	B3	5
7/0	71°26.7'	155°26.5'	--	BO	FE	--	0	B3	5
3/0	71°27.7'	155°38.6'	--	BO	FE	--	0	B3	5
1/0	71°27.2'	156°22.7'	--	BO	SW	30	0	B3	18
1/0	71°10.2'	152°18.4'	1041	BO	SW	250	1	B3	20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PT BARROW
LONELY
ICY CAPE
LEGEND
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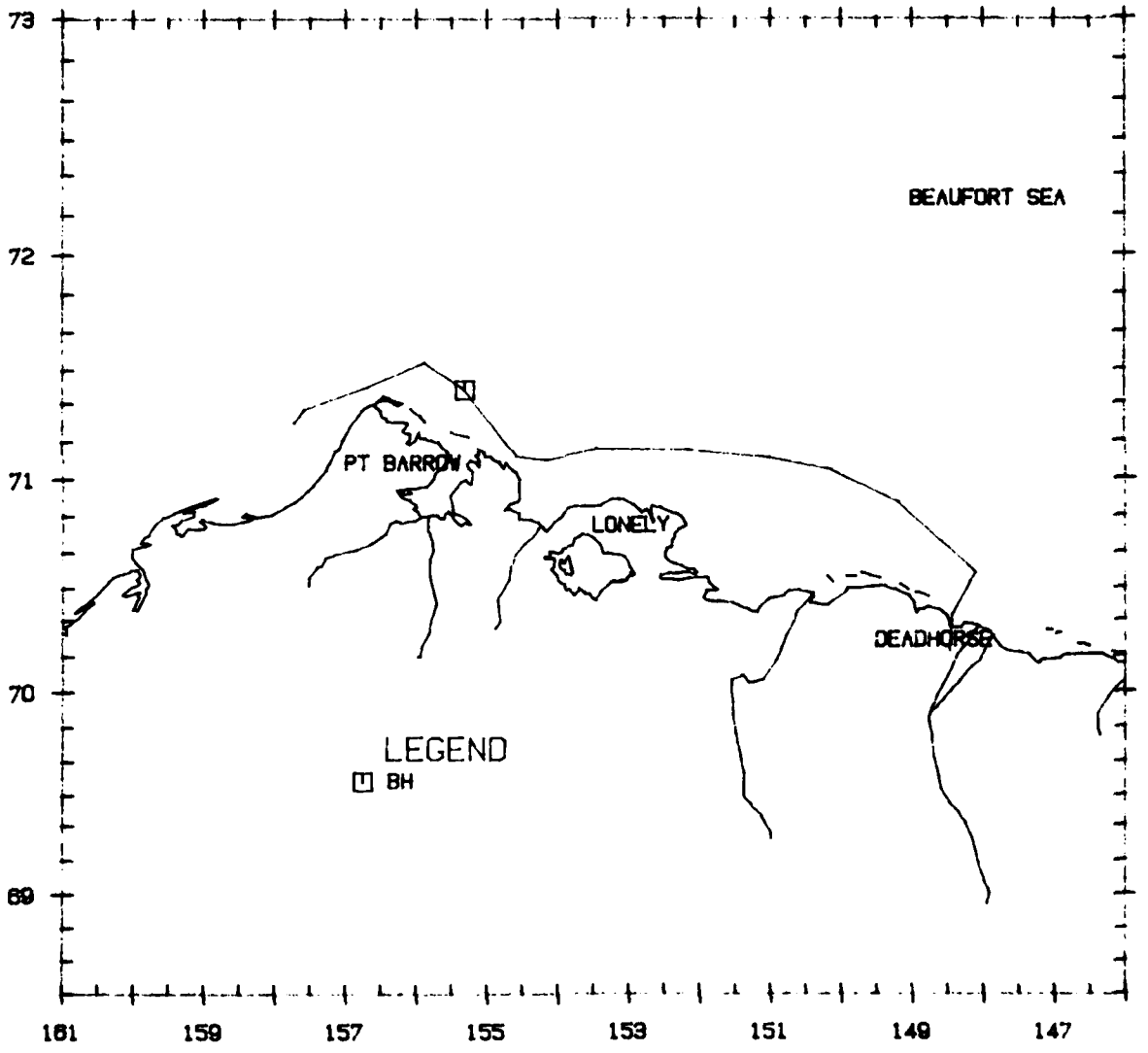
Flight 66: 2 October 1984

Flight was an attempted transect survey of block 17 which was aborted due to high seas. The weather was low overcast with 5 to 10 km visibilty. Ice coverage was open except for about 1 km of shorefast new ice. Sea state was Beaufort 05 to 06. One bowhead was seen east of Pt. Barrow.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°23.7'	155°18.3'	4247	BO	NA	200	0	B5	11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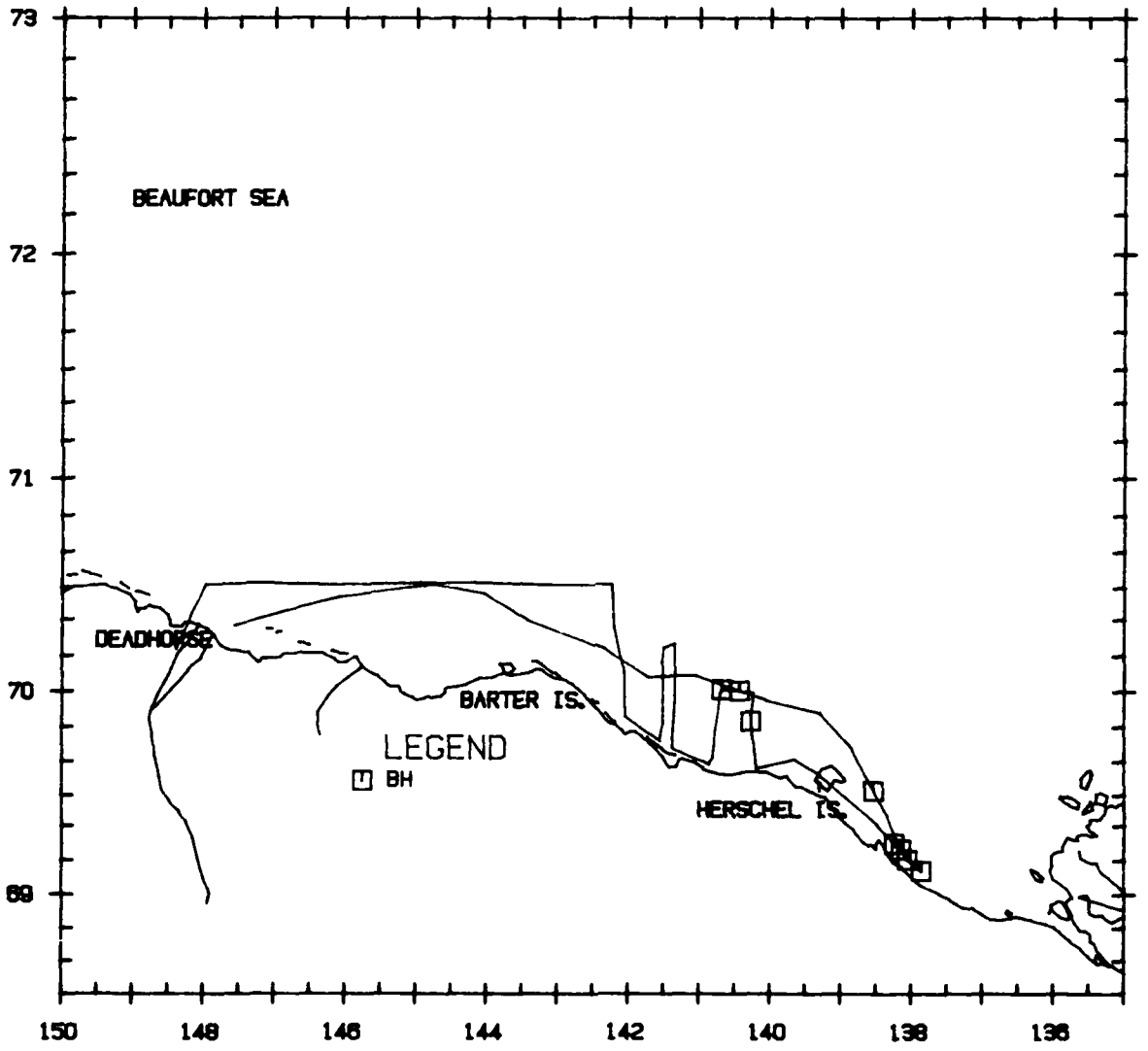
BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
LEGEND
BH

Flight 67: 3 October 1984

Flight was a transect survey of block 5 and a search around Herschel Island, Canada. Weather was low overcast with snow and fog. Visibility was generally 5 to 10 km. Ice coverage varied from open to 100 percent grease ice along the shore. Sea state varied with ice coverage from Beaufort 00 to 05. Twelve bowheads were seen. Most were swimming west. One sonobuoy was dropped and whale sounds recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°00.5'	140°40.7'	--	BO	DI	210	0	B3	49
1/0	70°00.1'	140°25.6'	875	SP	SW	240	0	B3	59
1/0	69°51.5'	140°15.8'	509	BO	SW	210	0	B2	48
4/0	69°14.7'	138°14.2'	704	BO	SW	300	35	B0	18
1/0	69°06.9'	137°51.2'	297	BO	RE	280	80	B0	11
2/0	69°10.1'	138°03.2'	1231	BO	RE	--	80	B0	11
1/0	69°13.0'	138°08.6'	--	BO	RE	--	80	B0	27
1/0	69°31.3'	138°31.8'	718	BO	DI	290	35	B1	37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BEAUFORT SEA
DEADHORSE
BARTER IS.
LEGEND
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HERSCHEL IS.
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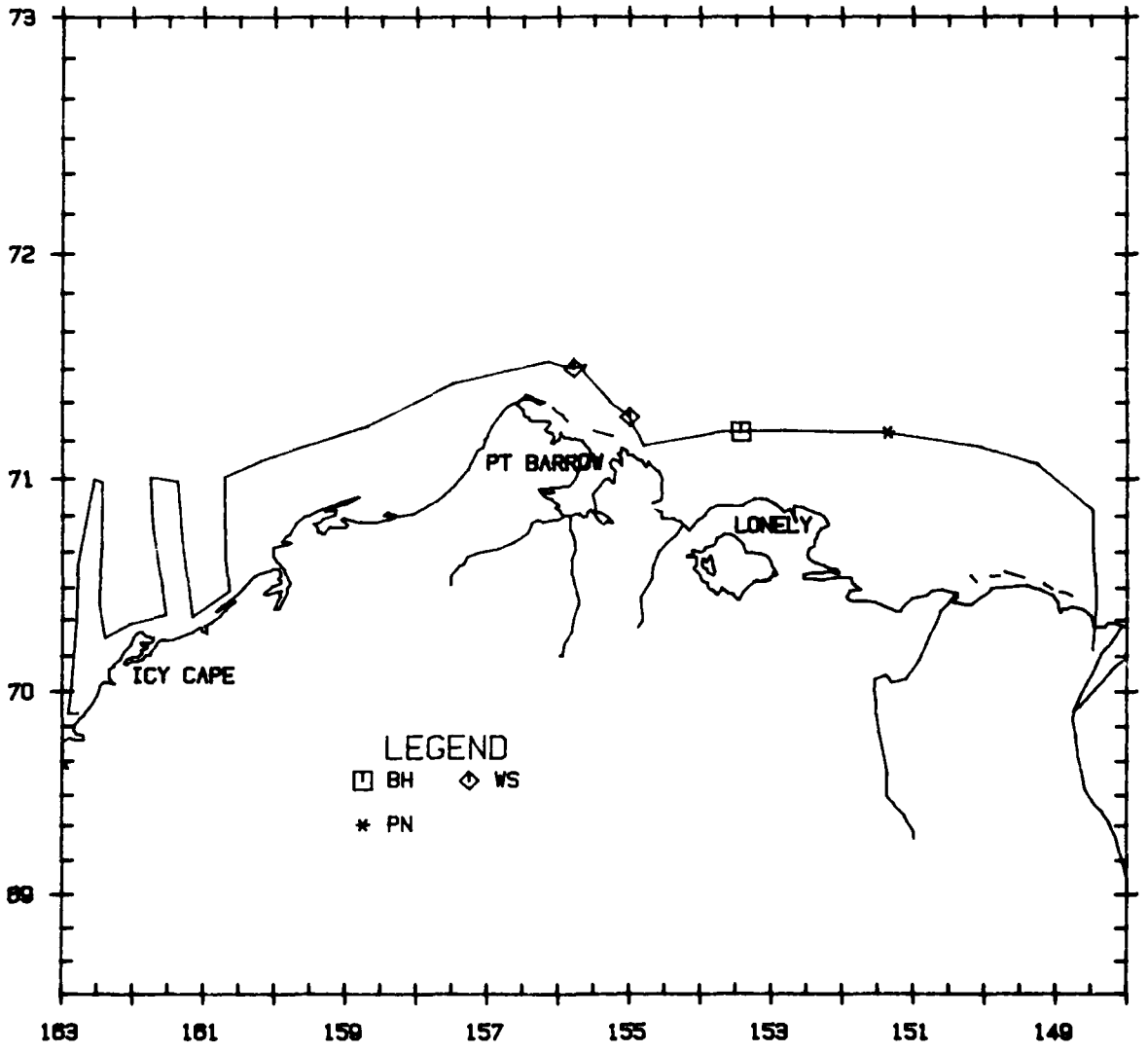
Flight 68: 4 October 1984

Flight was a transect survey of block 17. Weather was low overcast with generally 10 km visibility. Ice coverage was 0 percent in block 17 and 0 to 99 percent grease ice in block 12. Sea state ranged from Beaufort 02 to 05. One bowhead was seen resting in a pond in otherwise 99 percent grease ice. Walrus and an unidentified pinniped were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°12.4'	153°25.8'	204	BO	RE	190	10	B4	22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PT BARROW
LONELY
ICY CAPE
LEGEND
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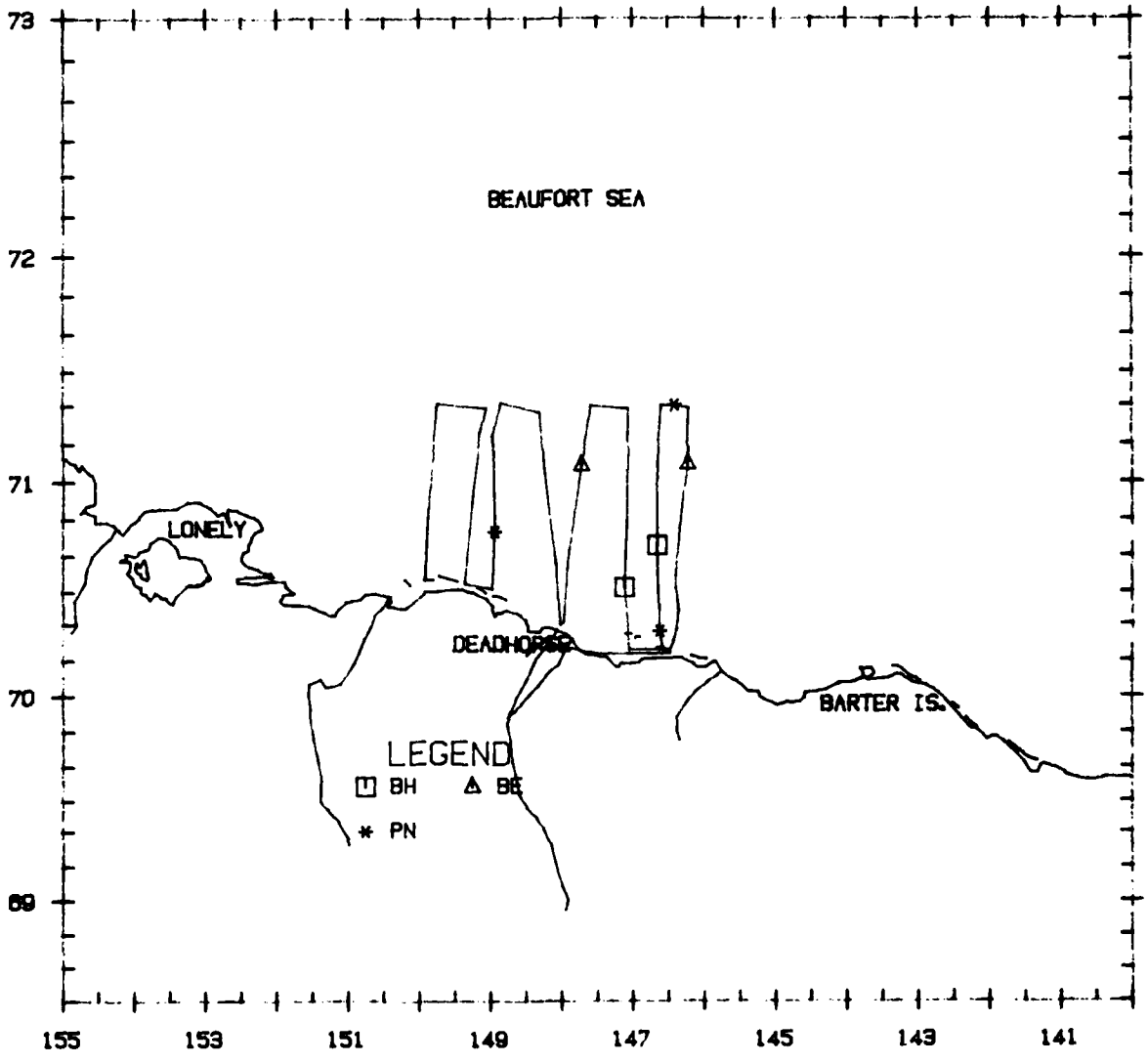
WS
PN

Flight 69: 5 October 1984

Flight was a transect survey of block 1 and 2. Weather was low overcast. Visbility was generally 10 km. Ice coverage was 0 to 99 percent new ice. Sea state was Beaufort 01 to 05. Two bowheads were seen swimming west. Belukha whales and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°43.0'	146°39.0'	--	BO	SW	240	99	B4	51
1/0	70°31.4'	147°06.5'	506	BO	SW	240	90	B2	29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BEAUFORT SEA
LONELY
DEADHORSE
BARTER IS.
LEGEND
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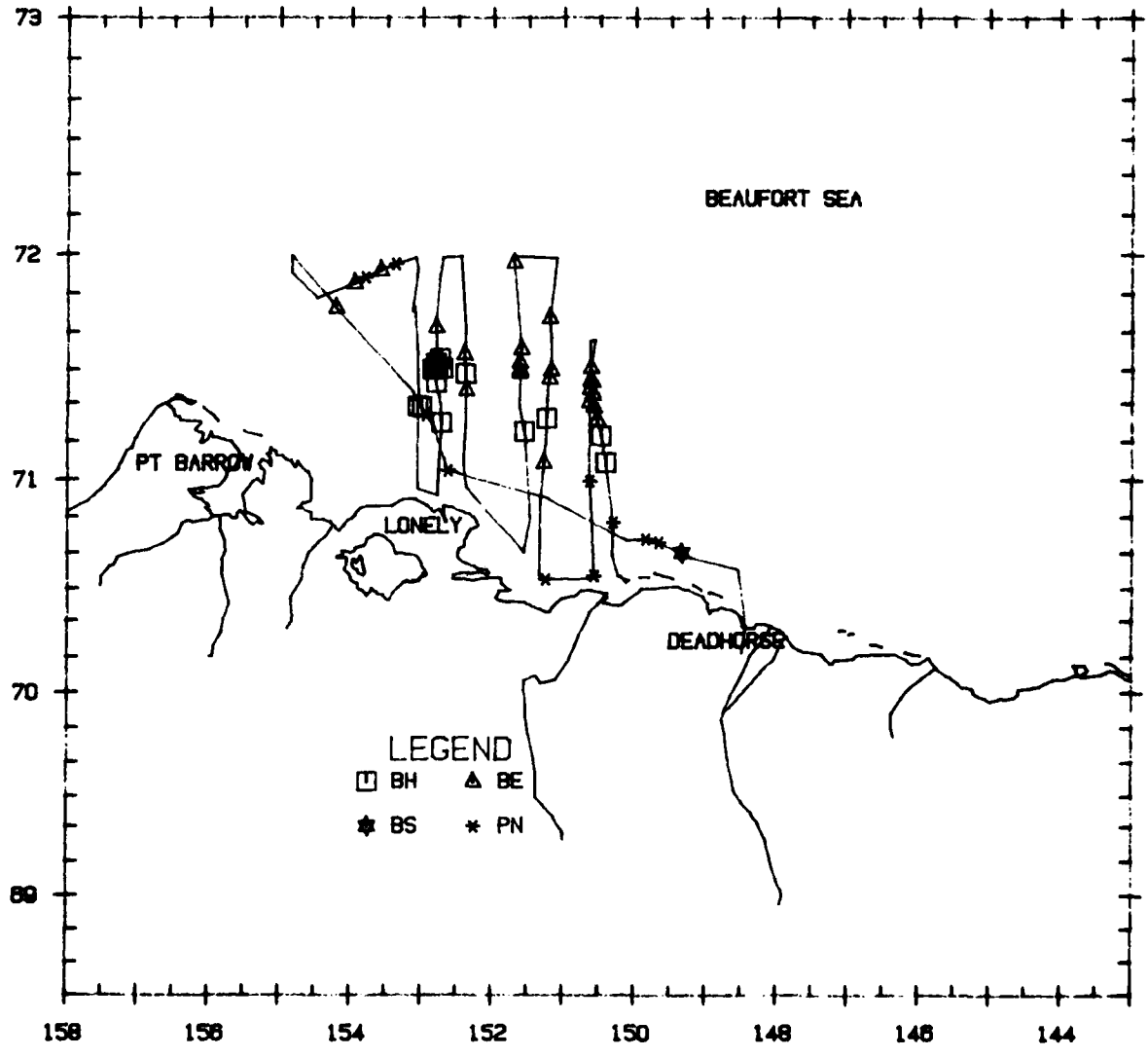
Flight 70: 9 October 1984

Flight was a transect survey of blocks 3 and 11 after attempting block 12. Weather was low overcast with generally unlimited visibility. Ice coverage was 50 to 99 percent new ice. Sea state was Beaufort 01 to 03. Twenty-three bowheads were seen, mostly swimming west. Eight were breaching in an open water area near 90 percent ice coverage. Belukha whales, bearded seals, and unidentified pinnipeds were also seen. Two sonobuoys were dropped and bowhead sounds recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°19.1'	153°00.1'	321	BO	RE	220	85	B1	42
1/0	71°19.3'	153°03.2'	319	BO	SW	270	65	B3	42
1/0	71°15.0'	152°43.2'	1443	BO	RE	--	80	B2	26
1/0	71°25.4'	152°48.2'	2502	BO	SW	260	90	B1	55
2/0	71°28.9'	152°47.7'	--	DY	BR	--	90	B1	55
1/0	71°28.9'	152°47.0'	--	BO	SW	240	90	B1	55
3/0	71°30.2'	152°51.3'	--	DY	BR	--	90	B1	46
1/0	71°31.9'	152°48.1'	--	BO	SW	270	90	B1	46
3/0	71°33.1'	152°44.5'	--	DY	BR	--	90	B1	46
4/0	71°30.5'	152°42.5'	--	BO	SW	240	90	B1	46
1/0	71°27.6'	152°23.0'	239	BO	RE	220	50	B2	51
1/0	71°12.8'	151°32.9'	533	BO	RE	210	85	B1	29
1/0	71°16.1'	151°14.2'	409	BO	RE	210	80	B1	55
1/0	71°11.6'	150°28.5'	84	BO	RE	270	85	B1	51
1/0	71°04.7'	150°24.0'	--	BO	DI	270	85	B1	13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BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
LEGEND
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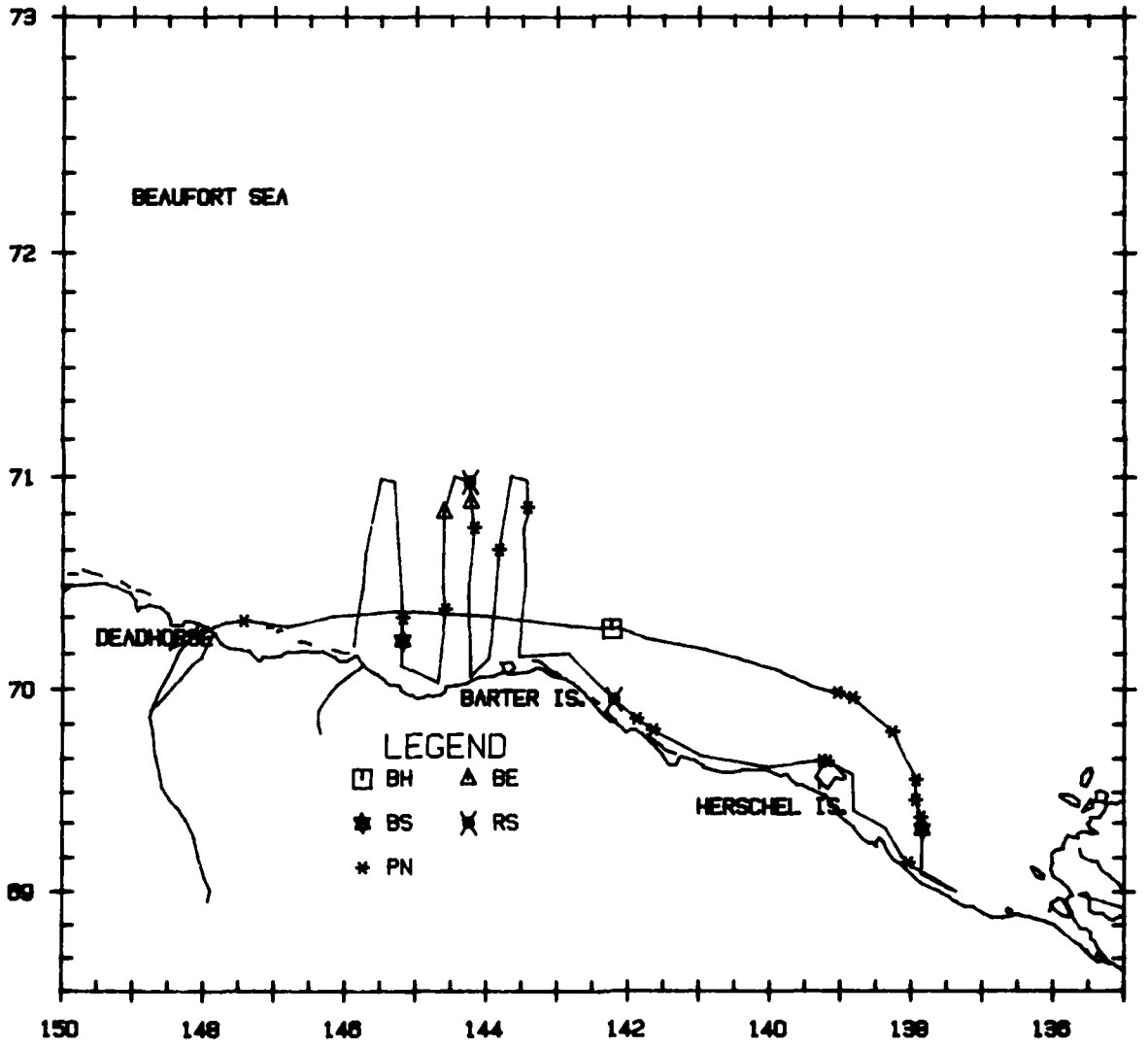
Flight 71: 10 October 1984

Flight was a transect survey of blocks 4 and 6 after a coastal search to 137°W. Weather was low overcast. Visibility was generally 10 km. Ice coverage was 50 to 99 percent new ice. Sea state was Beaufort 00 to 01. One bowhead was seen swimming west. Belukha whales, bearded and ringed seals, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°16.9'	142°13.6'	622	SP	SW	240	50	B0	51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BEAUFORT SEA
DEADHORSE
BARTER IS.
HERSCHEL IS.
LEGEND
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Flight 72: 11 October 1984

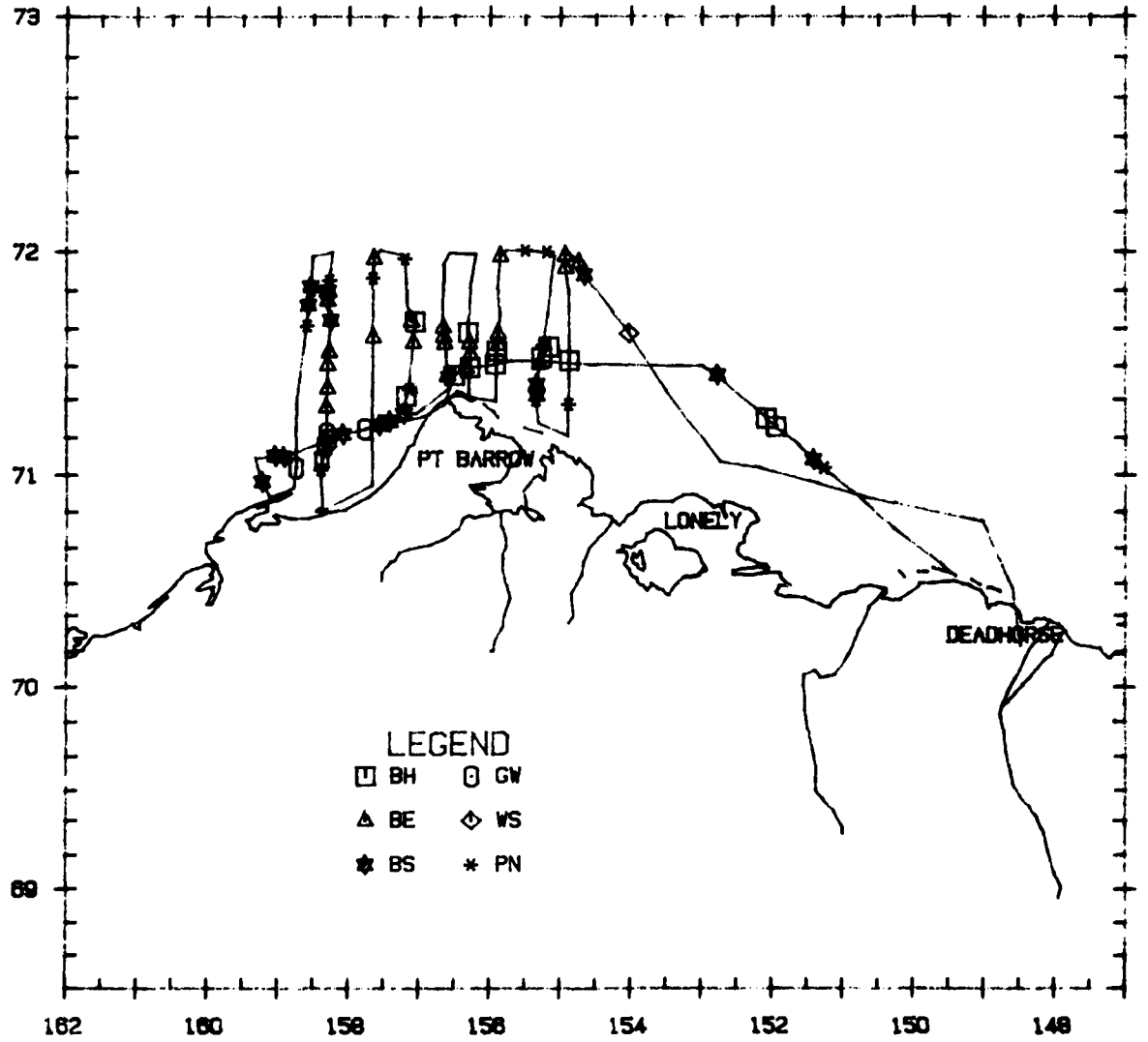
Flight was a transect survey of blocks 12 and 13. Weather was low overcast, snow and icing. Visibility was generally 10 km. Ice coverage varied from open to 99 percent new ice. Sea state was Beaufort 01 to 03. Twenty bowheads were seen swimming west. Twelve gray whales were seen feeding. Belukha whales, bearded seals, walrus, and unidentified pinnipeds were also seen. One sonobuoy was dropped and bowhead and belukha sounds and seismic signals were recorded.

Bowhead

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°31.7'	154°52.2'	215	BO	SW	240	0	B2	18
2/0	71°32.5'	155°15.7'	760	SP	SW	270	0	B2	18
3/0	71°35.4'	155°09.2'	--	BO	SW	240	0	B2	49
1/0	71°34.2'	155°53.8'	303	BO	SW	300	0	B3	18
1/0	71°28.3'	156°16.5'	447	BO	SW	240	0	B0	9
1/0	71°39.1'	156°18.2'	683	BO	SW	270	0	B3	123
2/0	71°21.0'	157°10.4'	674	BO	RE	300	10	B1	90
1/0	71°42.0'	157°03.2'	813	BW	SW	240	0	B2	70
1/0	71°26.3'	156°29.6'	--	BO	SW	240	0	B1	18
1/0	71°30.7'	155°54.6'	1359	BO	SW	240	40	B1	18
5/0	71°15.0'	152°04.1'	334	BO	SW	270	35	B1	20
1/0	71°12.8'	151°56.0'	185	BO	SW	270	35	B1	29

Gray Whale

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°04.1'	158°23.0'	138	MP	FE	30	80	B1	18
5/0	71°07.9'	158°20.5'	--	BO	FE	--	80	B1	20
1/0	71°11.2'	158°18.1'	1867	BO	FE	--	80	B1	22
1/0	71°02.1'	158°44.9'	488	BO	SW	230	0	B2	26
1/0	71°09.6'	158°16.2'	380	BO	SW	180	0	B2	20
3/0	71°12.4'	157°45.4'	292	MP	FE	--	0	B2	42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PT BARROW
LONELY
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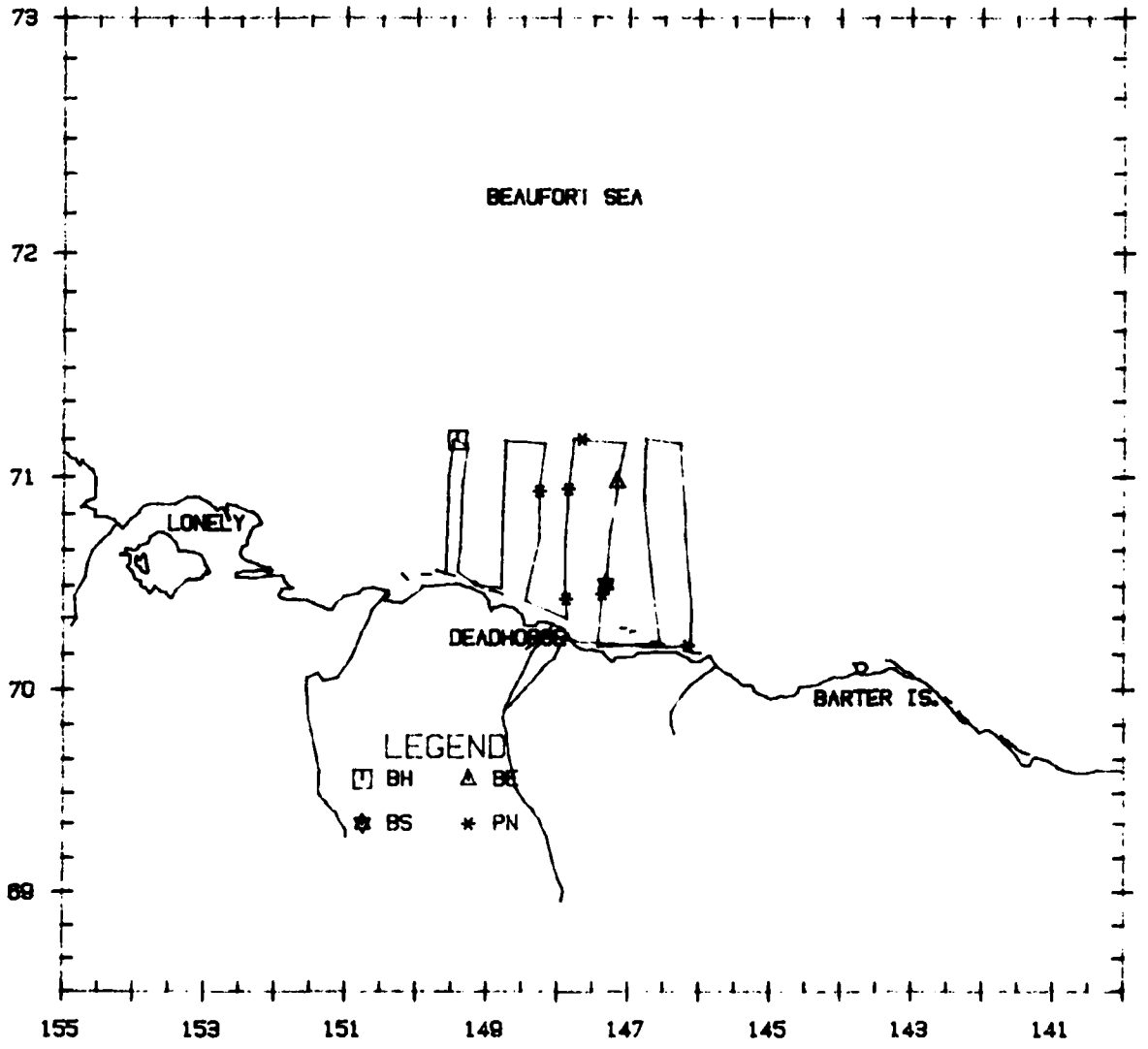
Flight 73: 13 October 1984

Flight was a transect survey of blocks 1 and 2. Weather was low overcast. Visibility was unlimited. Ice coverage was generally over 90 percent new ice. Sea state was Beaufort 00 to 01. One bowhead was sighted swimming west. Belukha whales, bearded seals, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°10.2'	149°24.7'	2104	BO	DI	240	90	B1	62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BEAUFORT SEA
LONELY
DEADHORSE
BARTER IS.
LEGEND
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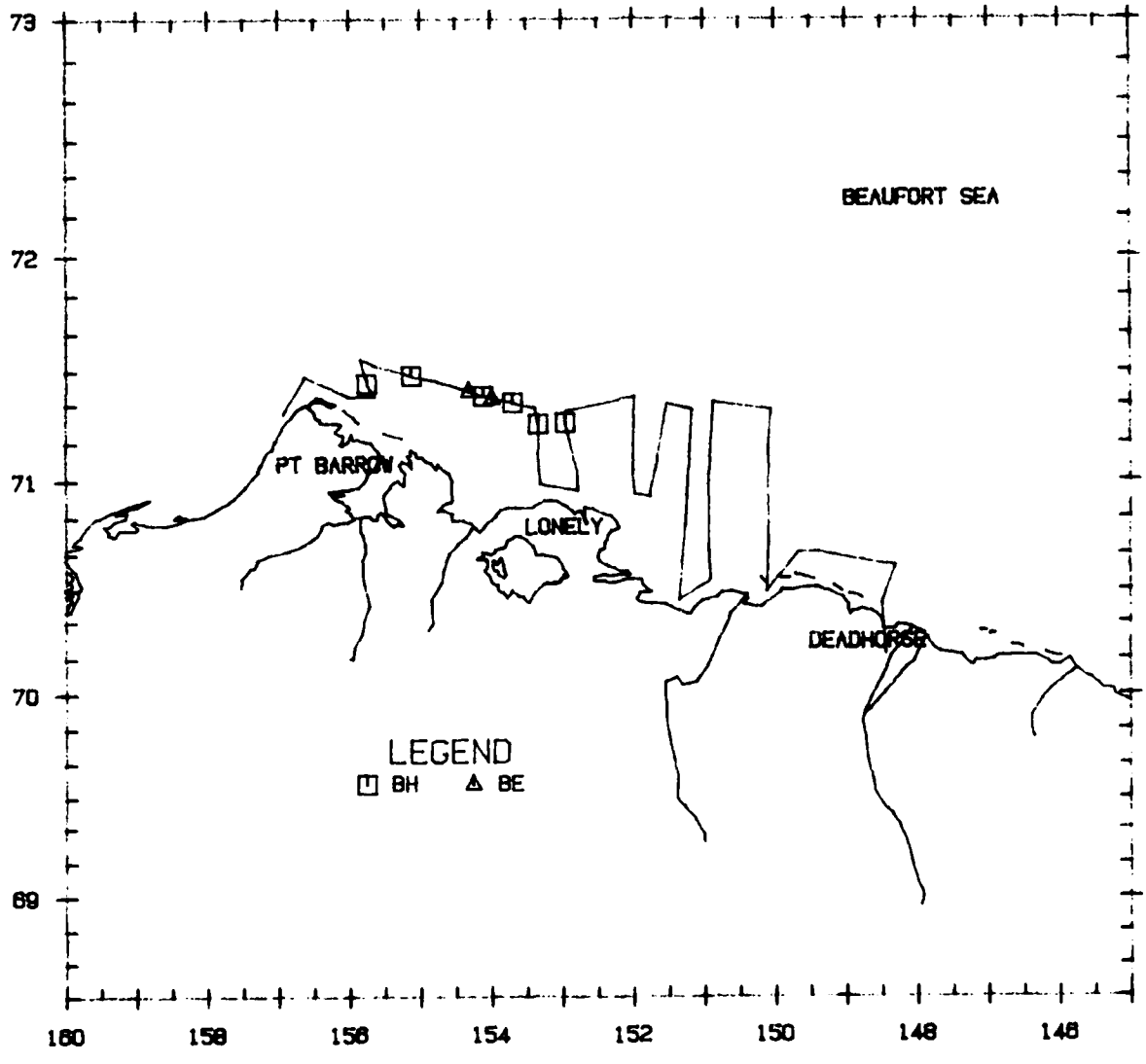
Flight 74: 14 October 1984

Flight was a transect survey of block 3 and a transit to Barrow. Weather was high overcast with unlimited visibility. Ice coverage was 50 to 99 percent new ice with 100 percent shorefast inside the 7 m isobath. Sea state was Beaufort 01 to 05. Seven bowheads were seen. Most were swimming west and one was breaching. Belukha whales were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°15.5'	152°56.9'	--	BO	SW	240	50	B3	42
1/0	71°15.2'	153°19.7'	346	BO	RE	300	90	B1	42
1/0	71°20.8'	153°41.4'	118	BO	DI	330	85	B2	31
2/0	71°22.5'	154°06.2'	--	BO	SW	150	85	B2	24
1/0	71°27.7'	155°07.0'	3916	BW	SW	--	50	B3	13
1/0	71°25.6'	155°44.8'	--	DY	BR	300	1	B5	5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BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
LEGEND
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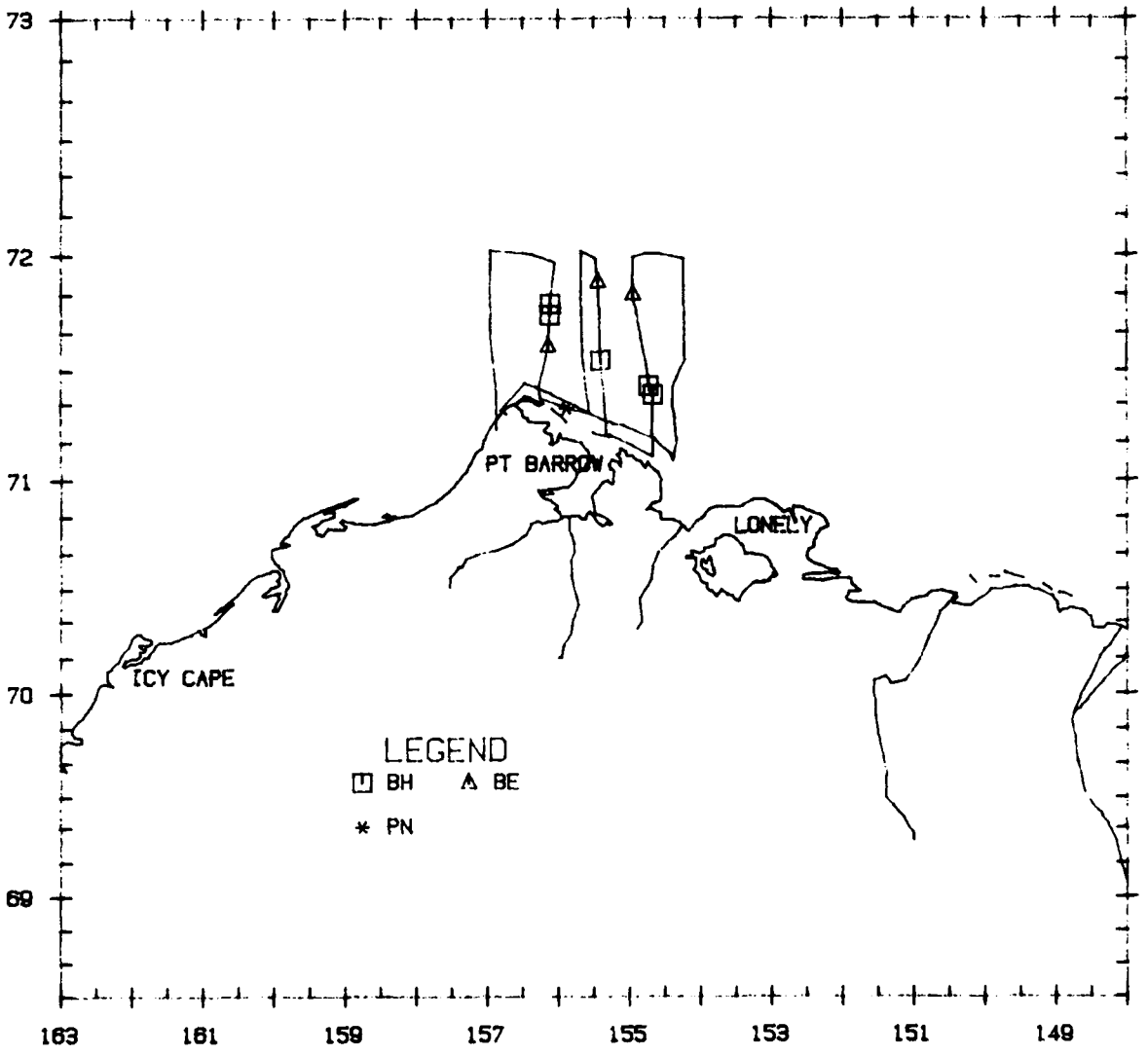
Flight 75: 15 October 1984

Flight was a transect survey of block 12. Weather was low overcast. Visibility was 5 to 10 km. Ice coverage was open to 50 percent new ice. Sea state was Beaufort 01 in ice and up to Beaufort 05 in open water. Nine bowheads, including a calf, were seen. Belukha whales and an unidentified pinniped were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
4/1	71°24.5'	154°42.9'	453	BO	CC	--	50	B3	11
2/0	71°22.2'	154°39.3'	1035	BO	FE	180	60	B2	24
1/0	71°32.8'	155°24.0'	688	BO	SW	300	0	B3	18
1/0	71°44.6'	156°07.0'	347	BO	SW	270	0	B4	68
1/0	71°47.6'	156°06.0'	658	BO	DI	240	0	B4	68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PT BARROW
LONELY
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LEGEND
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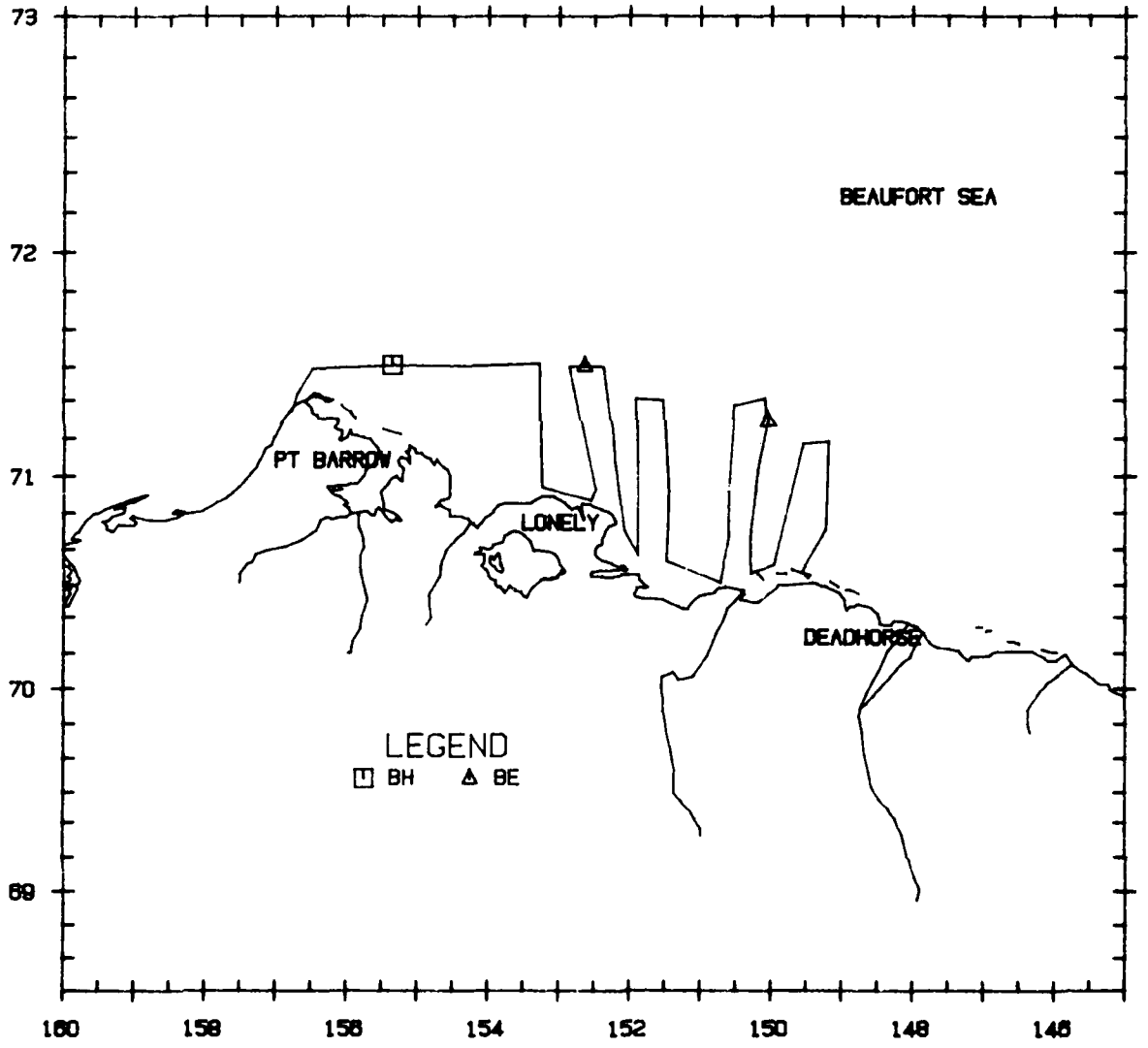
Flight 76: 16 October 1984

Flight was a transect survey of block 3 and portions of block 1. Weather was high overcast with unlimited visibility. Ice coverage was generally 90 percent new. Sea state was Beaufort 01 to 03. One bowhead was sighted swimming west. Belukha whales were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°30.7'	155°21.0'	1536	BO	SW	240	0	B3	18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BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
LEGEND
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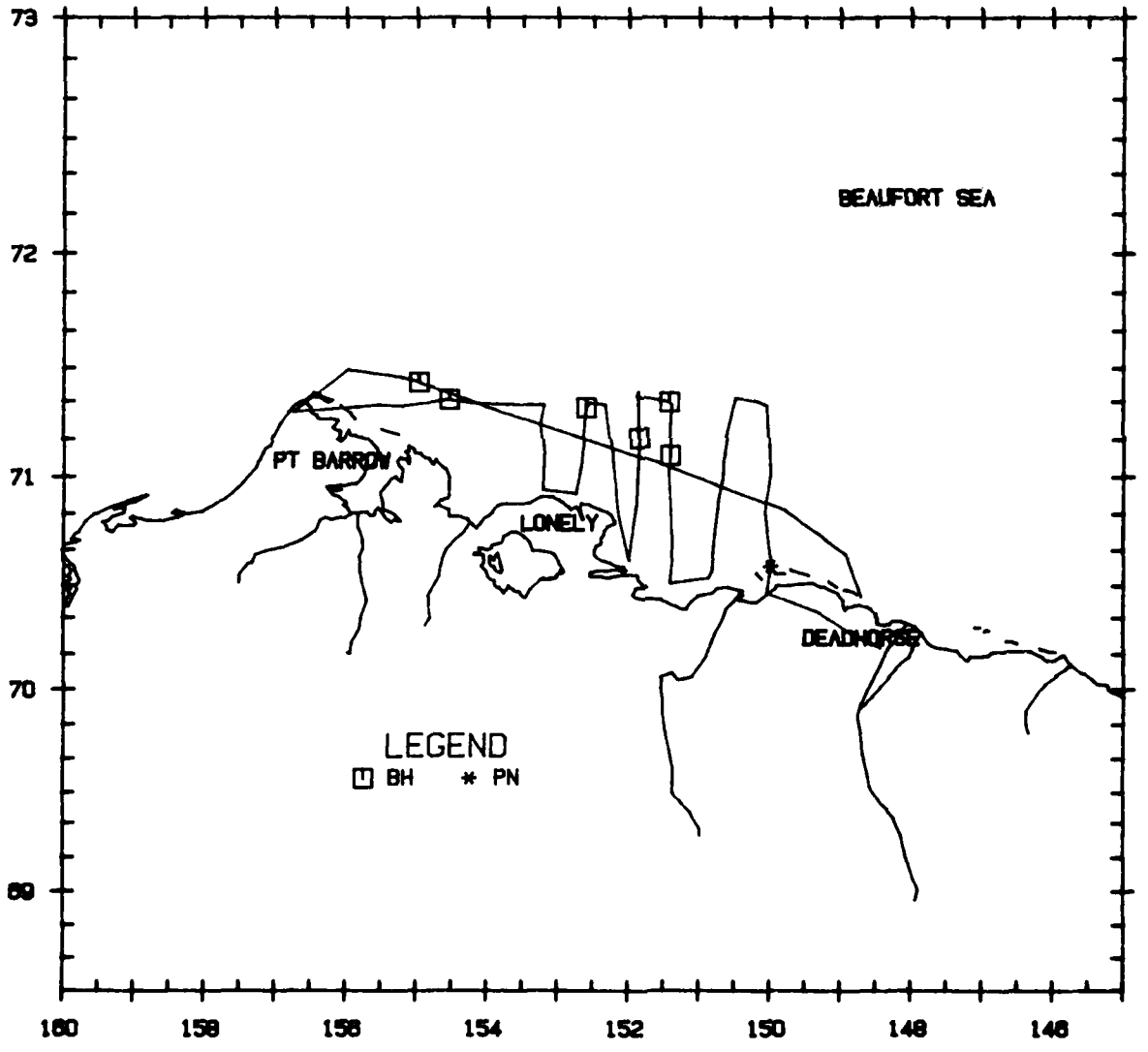
Flight 77: 17 October 1984

Flight was a transect survey of block 3. Weather was high overcast with unlimited visibility. Ice coverage was 50 to 90 percent new ice and open west of 154° W. Sea state was Beaufort 01 in the ice and up to Beaufort 04 in the open water. Ten bowheads including a calf were seen. Most were swimming west and one was seen breaching. An unidentified pinniped was also seen. One sonobuoy was dropped but only ambient sounds recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°05.8'	151°25.3'	527	BO	SW	220	40	B1	11
3/1	71°19.8'	151°25.5'	--	BO	SW	220	20	B2	57
1/0	71°10.4'	151°51.2'	2431	SP	SW	240	30	B2	29
1/0	71°18.4'	152°36.1'	2791	BO	BR	330	50	B2	48
2/0	71°20.4'	154°32.2'	197	BO	SW	270	50	B4	24
2/0	71°24.9'	154°58.0'	1132	BO	SW	260	40	B3	11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BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
LEGEND
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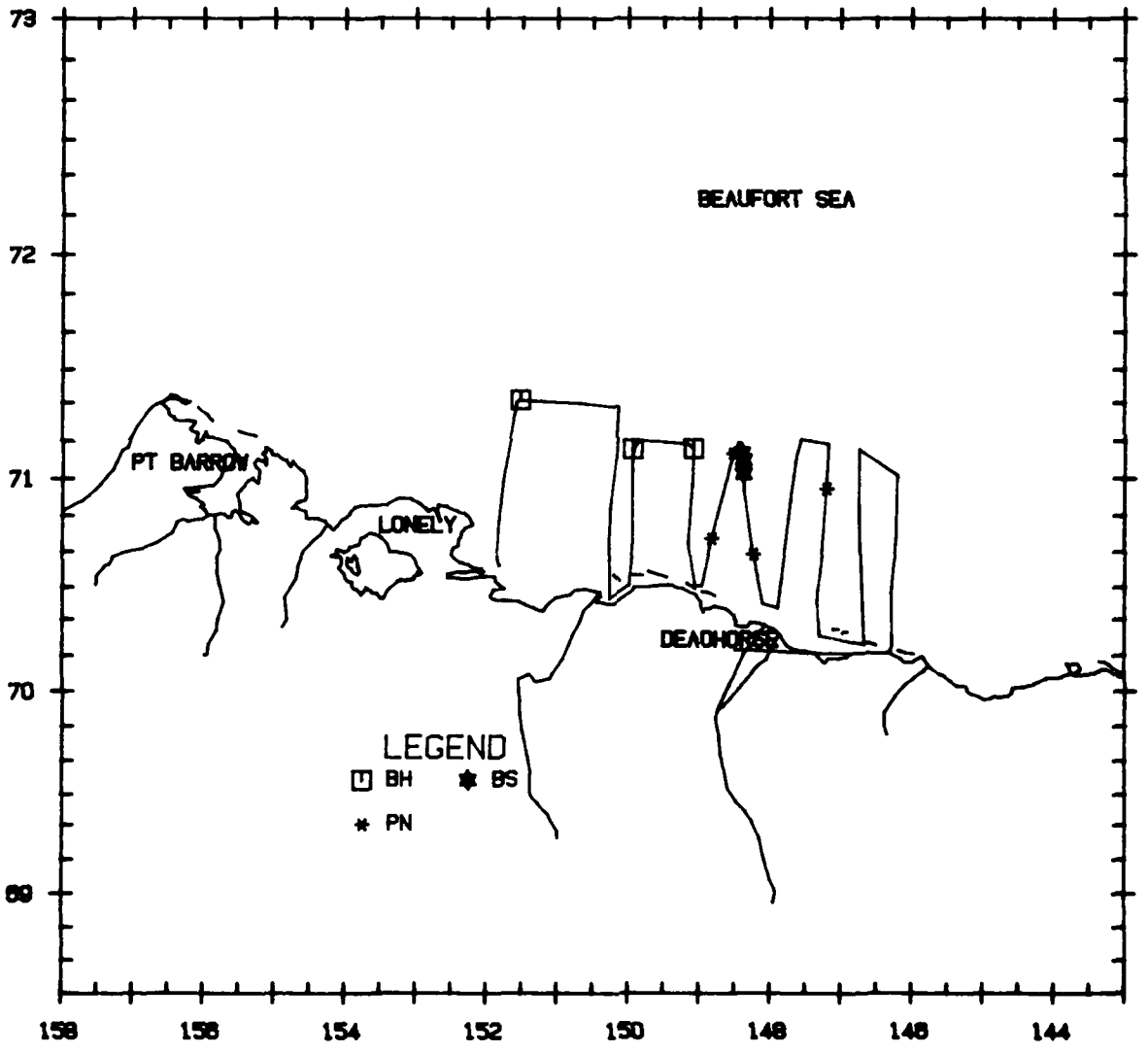
Flight 78: 19 October 1984

Flight was a transect survey of blocks 1 and 2 and portions of block 3. Weather was low overcast with generally 10 km visibility. Ice coverage varied from 50 to 99 percent new. Sea state was Beaufort 00 to 01. Two bowheads and one bowhead carcass were seen. Bearded seals and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°08.0'	149°05.1'	--	BO	RE	180	50	B1	40
1/0	71°07.8'	149°56.4'	--	BO	SW	--	80	B1	38
1/0	71°20.8'	151°31.0'	--	BO	DE	--	85	B1	49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BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
LEGEND
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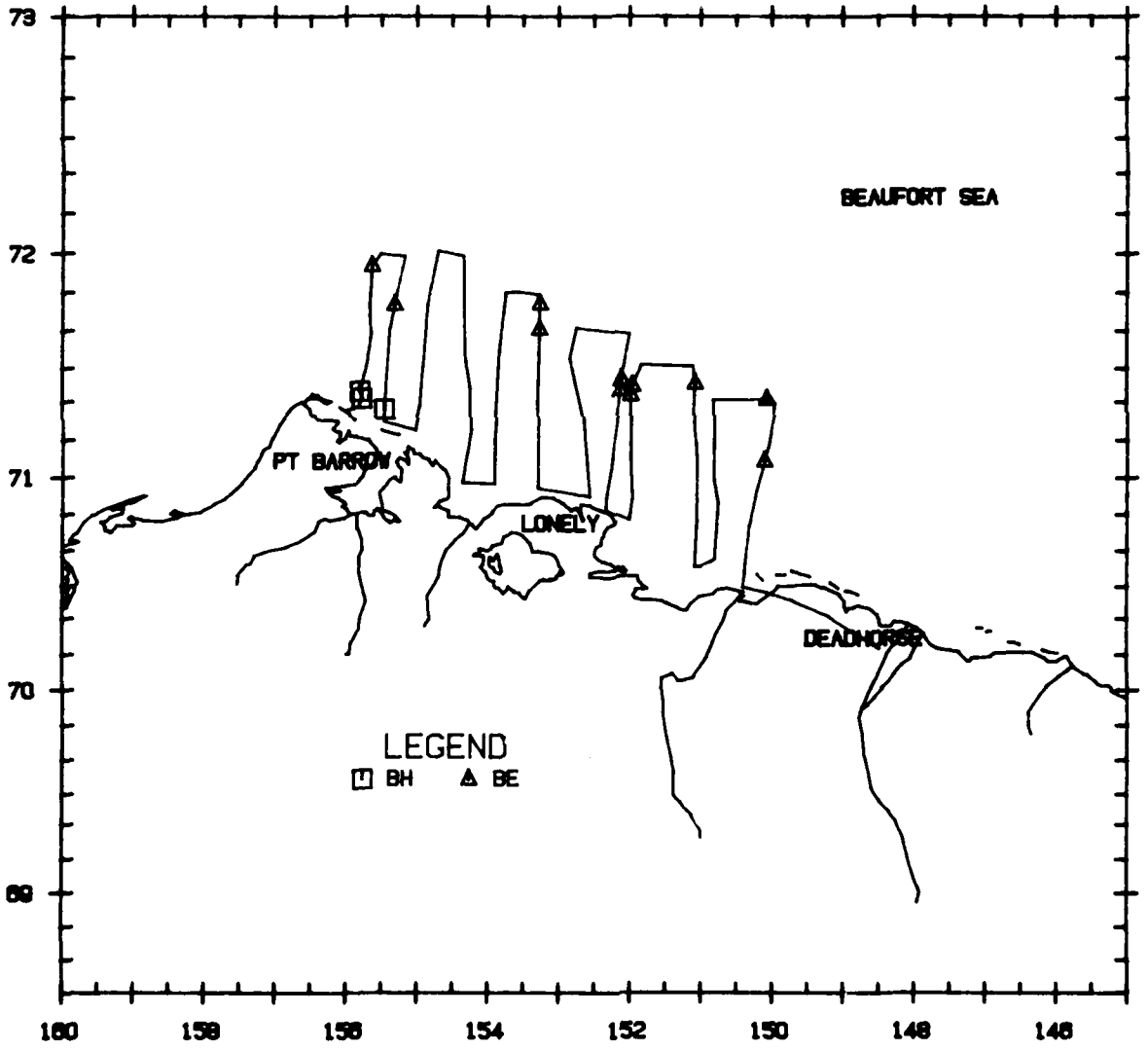
Flight 79: 20 October 1984

Flight was a transect survey of block 3 and portions of blocks 11 and 12. Weather was high overcast with unlimited visibility. Ice coverage was 90 to 99 percent new ice except for an open water area in mid block 12. Sea state was Beaufort 00 to 01 except in the open water where it was up to Beaufort 05. Seven bowheads were seen swimming east of Pt. Barrow. Belukha whales were also seen. One sonobuoy was dropped and seismic sounds recorded.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
3/0	71°18.0'	155°26.3'	248	BO	SW	260	99	B1	9
3/0	71°22.6'	155°47.0'	930	BO	SW	--	99	B2	15
1/0	71°20.8'	155°45.6'	--	BO	SW	30	99	B2	15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BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
LEGEND
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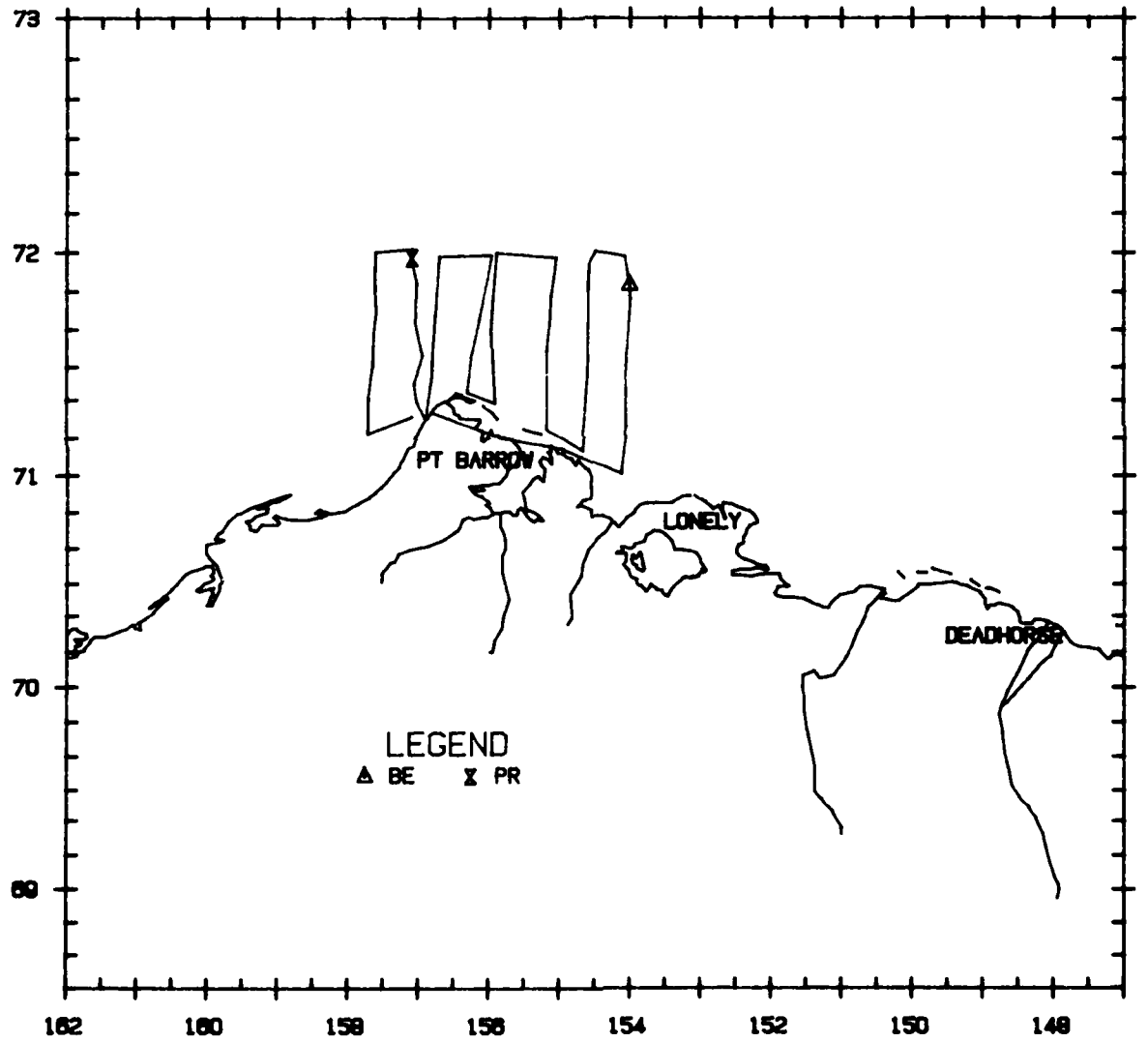
Flight 80: 21 October 1984

Flight was a transect survey of block 12 and portions of block 13. Weather was low overcast with 10 km to unlimited visibility. Ice coverage was 90 to 99 percent new ice with open water in mid block 12. Sea state was Beaufort 01 in ice and up to Beaufort 05 in open water. A belukha whale and polar bears were seen.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PT BARROW
LONELY
DEADHORSE
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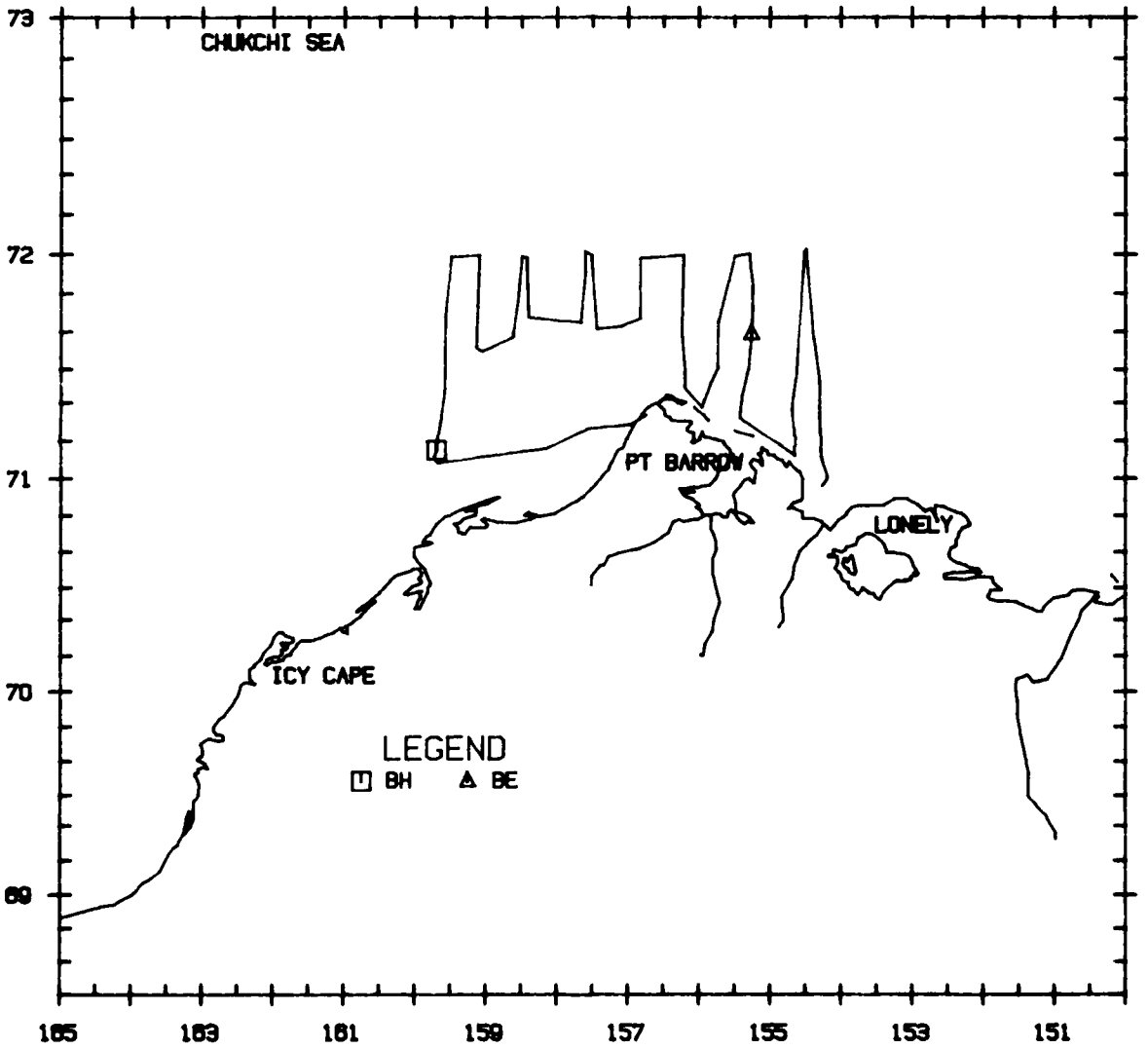
Flight 81: 22 October 1984

Flight was a transect survey of blocks 13 and 12. Weather varied from low overcast with 10 km visibility to clear with unlimited visibility. Ice coverage was 50 to 99 percent new floe except the southern third of block 13 which was open. Sea state was Beaufort 01 to 03 in the ice and up to Beaufort 07 in open water. A bowhead cow-calf pair swimming southwest were seen. A belukha whale was also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
2/1	71°07.6'	159°42.1'	--	BO	SW	210	40	B5	46


CHUKCHI SEA
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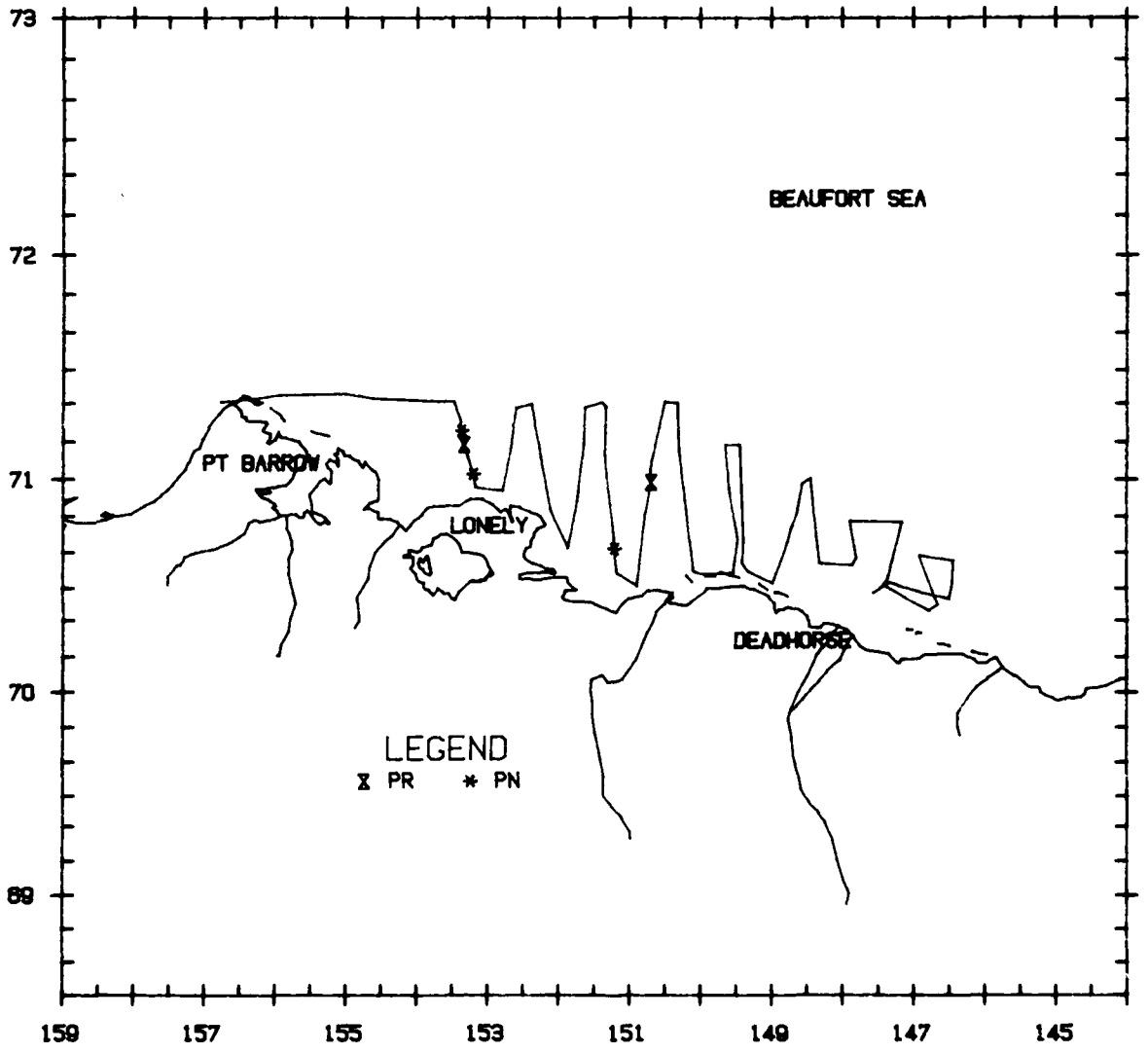
Flight 82: 23 October 1984

Flight was a transect survey of blocks 1 and 2. Weather varied from clear to overcast. Visibility varied from 5 km to unlimited. Ice coverage was 50 to 99 percent new ice in block 3 and 90 to 99 percent new ice in block 1 with 100 percent shorefast inside the 20 m isobath. Sea state was Beaufort 00 to 02. Polar bears and unidentified pinnipeds were seen.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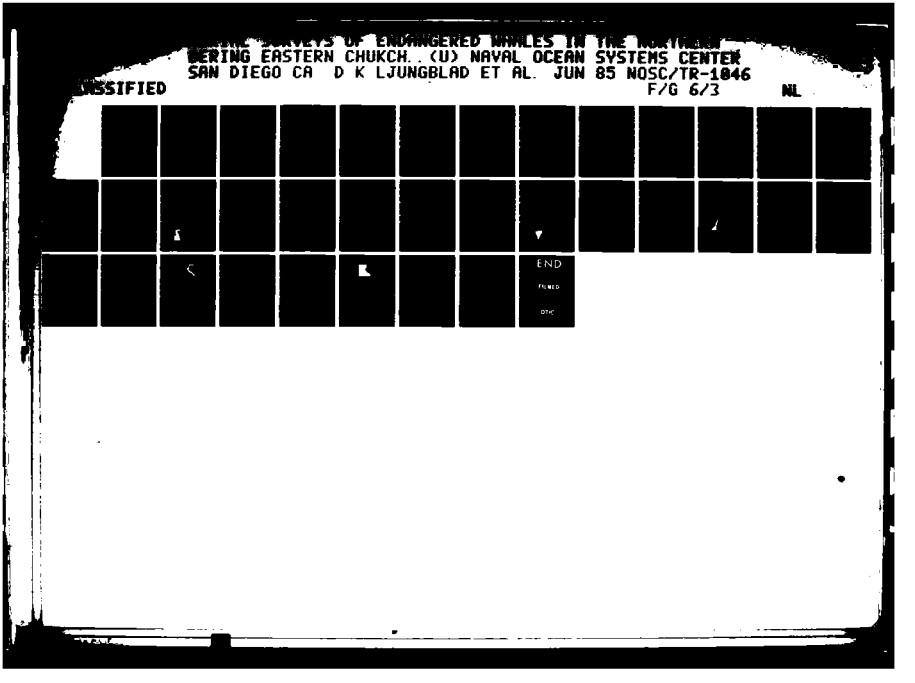
LEGEND
PR
PN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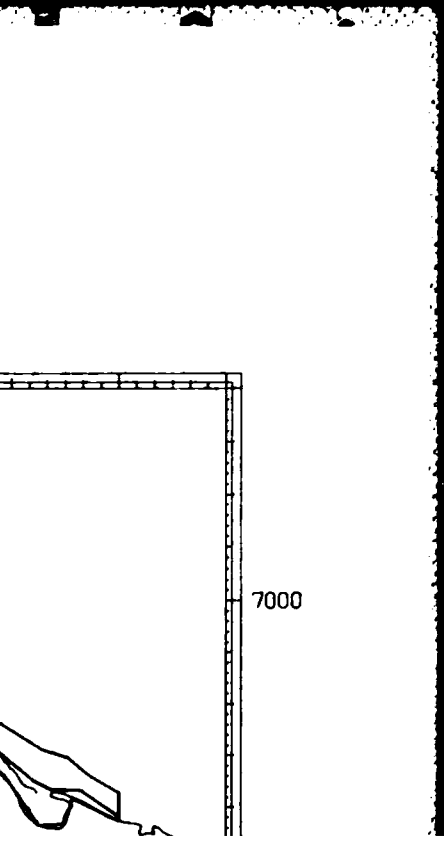
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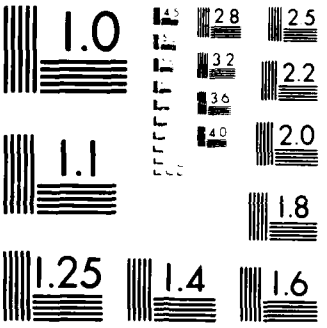

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APPENDIX B

DISTRIBUTION OF 1984 SURVEY EFFORT AND OBSERVED DENSITIES OF BOWHEAD AND GRAY WHALES IN THE ALASKAN BEAUFORT, EASTERN CHUKCHI AND NORTHERN BERING SEAS, WITH COMPARISONS TO 1979 AND 1983.

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INTRODUCTION

The following section presents an analysis of aerial survey data collected during 1984 and a comparison to similarly analyzed data for 1979-1983. The objectives of the analysis were to determine distribution and density of bowhead whales in the Beaufort, Chukchi, and Bering Seas, and distribution and density of gray whales in the Bering and Chukchi Seas. An important component of this analysis was determining the distribution of survey effort.

The Beaufort Sea was treated as one study area bounded by 141°00' W to 157°00' W longitude and 72°00' N latitude to the coastline. The Bering and Chukchi Seas were treated as a second study area. Both study areas were subdivided to more precisely illustrate survey effort and density of animals.

Distribution of survey effort and density of bowhead whales in the Beaufort Sea study area were examined during spring (April-May) and fall (August-October). In the Bering and Chukchi Seas, distribution of survey effort and density of bowhead whales were examined during spring. Distribution of survey effort and density of gray whales in the Bering and Chukchi Seas were examined during summer (July).

METHODS

Map Preparation

Maps were prepared using the computer program AMP, A Mapping Package, consisting of FORTRAN subroutines which can be used for customized plotting applications. AMP was used to plot aerial survey data which resided on file as a series of geographic coordinates (latitude and longitude) associated with time and sightings of whales. Land masses are part of the AMP data base. Depth contours were plotted by reading a separate file of data points prepared for this analysis.

Depth contours were digitized using several reference maps. It was necessary to use more than one map because not all contours were available on any one map. The U.S. Geological Survey Map Open - File 76 - 823, Sheet 1 or 2 was used to digitize the 50 m and greater depth contours, plus all contours shown in the Chukchi Sea except for the 30 m depth contour off the Soviet coastline. The 30 m depth contour off the Soviet coastline and in the Bering Sea was taken from U.S. Department of Commerce map 514, 4th Ed., Apr. 11/81. In the Beaufort Sea, the

10 m, 20 m, and 30 m depth contours were taken from two maps labeled Data from: Geophysical Corp. of Alaska, 1975, NOAA, Department of Commerce Charts, USGS Department of Interior Charts which were additionally labeled as Eastern Beaufort Sea and Western Beaufort Sea.

When the depth contours were merged onto a single data file and plotted, some inconsistencies became apparent. For example, a 30 m depth contour from one map file crossed over the 50 m depth contour from another map file. When this situation occurred, a portion of one of the depth contours was clipped to resolve the inconsistency. Note that portions of the 20 m and 30 m depth contours were clipped near Pt. Barrow, Alaska, and that the 50 m depth contour was clipped near St. Lawrence Island in the Bering Sea.

Data Processing and Quality Control

A computer program was written to screen for bad data values. The chronological order of time was checked. Aerial survey data files were screened for obvious errors in geographic position by plotting separately the course of each daily aerial survey. A computer program was used to calculate flight speeds and distances on a point to point basis, and listings of these values were scanned for suspiciously slow or fast speeds. The listings and maps were compared; errors were flagged and edited and the process was repeated until data files were error-free with respect to these conditions.

Definition of Areas and Methodological Limitations

The total Beaufort Sea study area was divided from east to west based on proximity to oil lease sites (Figure B-1). Region A is west and adjacent to the lease areas extending from 153°30' W to 157°00' W longitude. Region B extends from 150°00' W to 153°30' W longitude, representing the western lease area. Region C extends from 146°00' W to 150°00' W longitude, representing the eastern lease area. And, Region D is east and adjacent to the lease area extending from 141°00' W to 146°00' W longitude.

Depth contours (Figure B-2) were used to stratify the Beaufort Sea from north to south corresponding to water depth. Preliminary analysis of survey data indicated that there was a relationship between water depth and distribution of bowhead whales. Depth contours of 10 m, 20 m, 50 m, 200 m, and 2000 m were selected (Figure B-3).

The stratum from the coastline to 10 m corresponded closely to the area inside the barrier islands (A1, B1, C1, D1A, and D1B) (Figure B-4). Area D1 was divided into D1A and D1B at 143°30' W, which marked the boundary between two areas previously defined for behavioral studies (Figure B-5).

The shelf area was stratified from 10 m to 20 m, 20 m to 50 m, and 50 m to 200 m. Areas A2, B2, C2, D2A and D2B corresponded to the 10 m to 20 m strata. Area D2 was divided similarly to D1. Areas A3, B3, C3, and D3 corresponded to the 20 m and 50 m stratum. Areas A4, B4, C4, and D4 corresponded to the 50 m to 200 m stratum.

Offshelf strata were defined from 200 m to 2000 m and deeper than 2000 m. Areas A5, B5, C5, and D5 corresponded to the 200 m to 2000 m strata. Areas B6, C6, and D6 corresponded to the deeper than 2000 m strata.

The comparatively shallow Bering and Chukchi Seas were not subdivided on the basis of depth contours; rather, regions (Figures B-10 and B-11) were determined based on survey effort and animal distributions.

The digitizer was used to trace region boundaries, which led to a boundary problem termed "splinter error." The technique used to digitize each region was to circumscribe it by tracing the boundary of the region. Thus, when two regions were adjacent, the common boundary would be digitized twice. In fact, a boundary was often digitized more than twice. For example, the boundary between regions A1 and B1 was digitized four times because it served not only as a boundary between regions A1 and B1 but also between the larger regions A and B. A splinter error occurred when one set of points defining a common boundary did not exactly match the second, third, or fourth set of points used to define the same boundary for other regions.

Because of this splinter error problem, a very small percentage of the total area may be shared by two regions or may be left out of a region. For example, because of overlap, a small portion of the Beaufort Sea may have been shared during the analysis of two adjacent regions. Conversely, if two sets of points defining a common boundary diverged slightly, a small portion of the Beaufort Sea could have been left out of the analysis.

The implications of the splinter error problem are small in relation to this study. Statistics reported for each subregion, region, and the total study area are valid, but there may be small discrepancies when the values of subregions are

summed and compared to the values reported for larger regions, e.g., number of survey hours flown, listed in the tables as Survey Time.

Statistics Presented in Tables

Region Area nmi^2. Areas were approximated by straight line integration which contributed to discrepancies between the summation of subregion areas and areas calculated for larger regions. Area calculations are accurate to within about 1 percent of the true area.

Percent of Total Area. The percent of total area was calculated as the region area divided by the sum of all subregion areas; this quantity was then multiplied by 100.

Percent of Area Surveyed. The percent of area surveyed is a relative measure of survey effort expended per survey region. Strip width was defined as one nautical mile. Therefore, the total number of miles flown equalled the total number of square nautical miles surveyed. The percent of total area was calculated as the number of nautical miles surveyed divided by the region area; this quantity was then multiplied by 100.

This technique did not account for overlapping aerial survey strips which result in double counting the area surveyed. Therefore, some areas surveyed may show more than 100 percent coverage.

Survey Time HR:MIN. This is the time in hours and minutes spent surveying an area. Because of splinter errors and rounding errors, the values reported for time spent surveying subregions did not always equal those reported for larger regions.

Percent of Total Time. This is the time in hours and minutes spent surveying a region divided by the sum of survey times reported for each subregion.

Number of Transects Flown. Transects or flight legs were defined as units of survey effort by the aerial survey team. The beginning and ending of transects were further defined by the survey region boundaries. A portion of an aerial survey leg passing over a region was treated as a transect relative to that region. Thus, one transect could be broken into several transects with respect to subregion analyses. For this reason, the sum of the transects based on subregions was greater than the total number of transects reported for the total region.

Number of Bowheads Observed. This indicates the number of bowhead whales observed within one-half nautical mile of either side of the aircraft. Because of

splinter errors, small discrepancies may occur between the sum of the number of whales observed in each subregion, versus the number reported for larger regions.

Density as Number per nmi^2, Variance and Confidence Range. Calculation of density statistics for each stratum followed the method employed by Krogman et al. (1979), which was based on the technique described in Estes and Gilbert (1978):

$$R = y_i / x_i \quad (1)$$

where R = observed density of whales per square nautical mile

y_i = number of whales observed in the ith strip transect

x_i = area of the ith strip transect

$$S_R = (y_i^2/x_i) - R\ y_i\ /(n-1)(\ X_i) \quad (2)$$

where S_R = variance of R

n = number of strip transects

$$C.I. = R\ t_{.05}(2)V\ ^{V}(R) \quad (3)$$

The notation $t_{.05}(2)V$ refers to the critical value of t where alpha ( ) - .05 (1- =.95) based on two tailed test with V degrees of freedom. Degrees of freedom were calculated as the total number of transects minus one.

RESULTS AND DISCUSSION

Results are presented by area, season, and species. Each presentation consists of:

- Table of statistics associated with each region presenting 1984 data
- Figure depicting observed density of whales for each region, 1984
- Summary Table of statistics associated with each region, 1979-1983

Please refer to the table of contents for order of presentation of aerial survey results. Figures and tables are intended to be self explanatory.

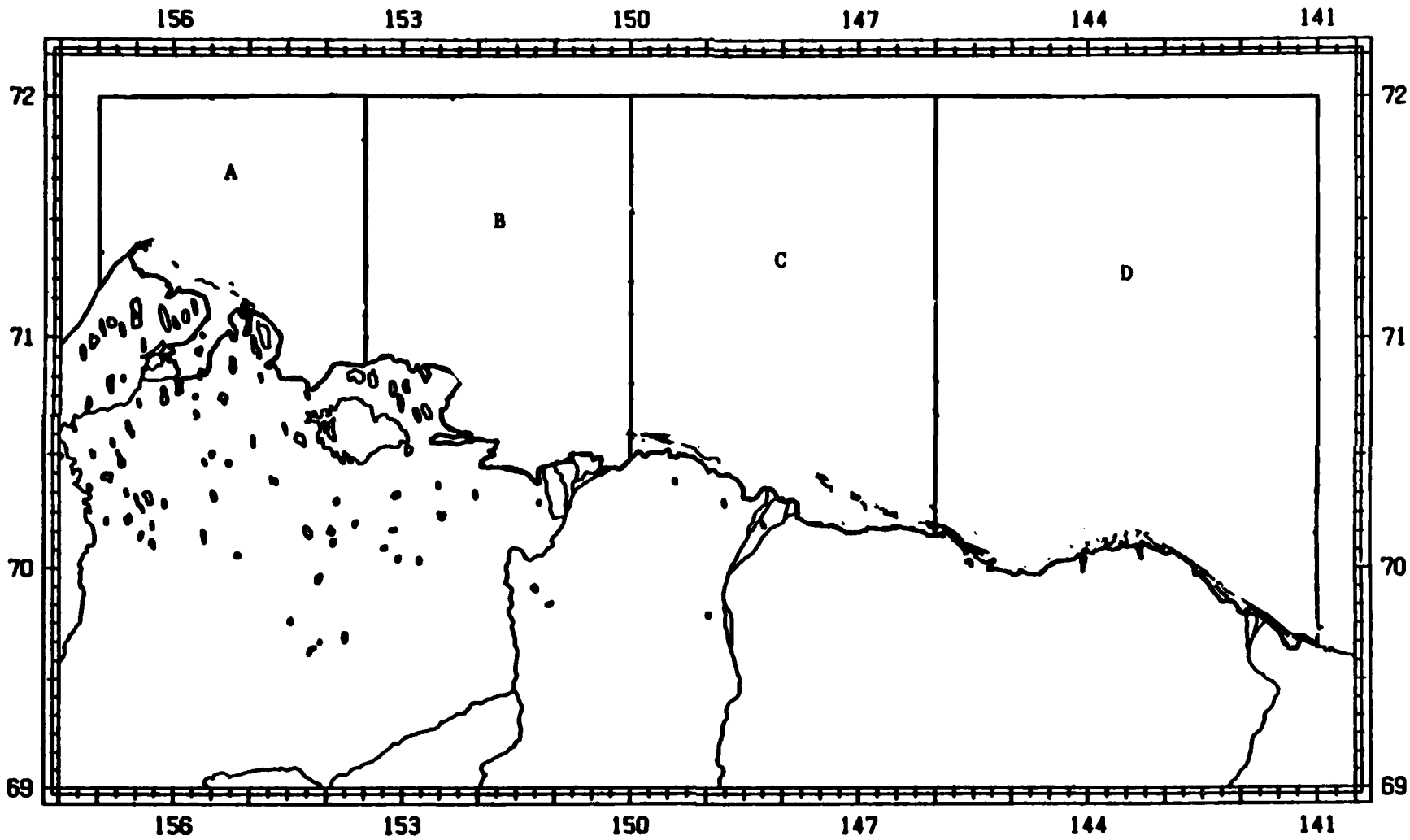


Figure B-1. The Beaufort Sea Study area was divided into four regions: A, B, C, and D.

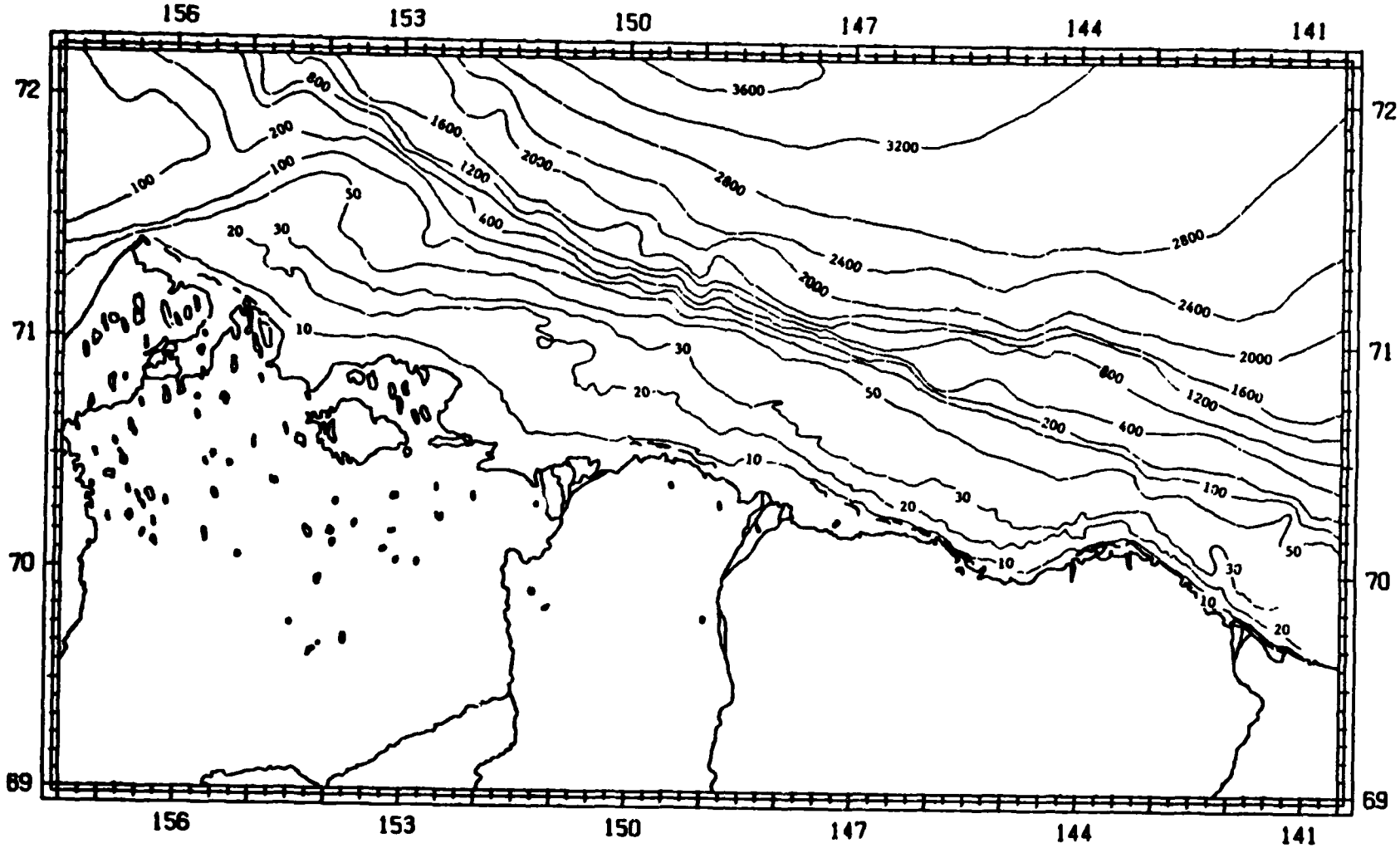


Figure B-2. Beaufort Sea depth contour lines, in meters.

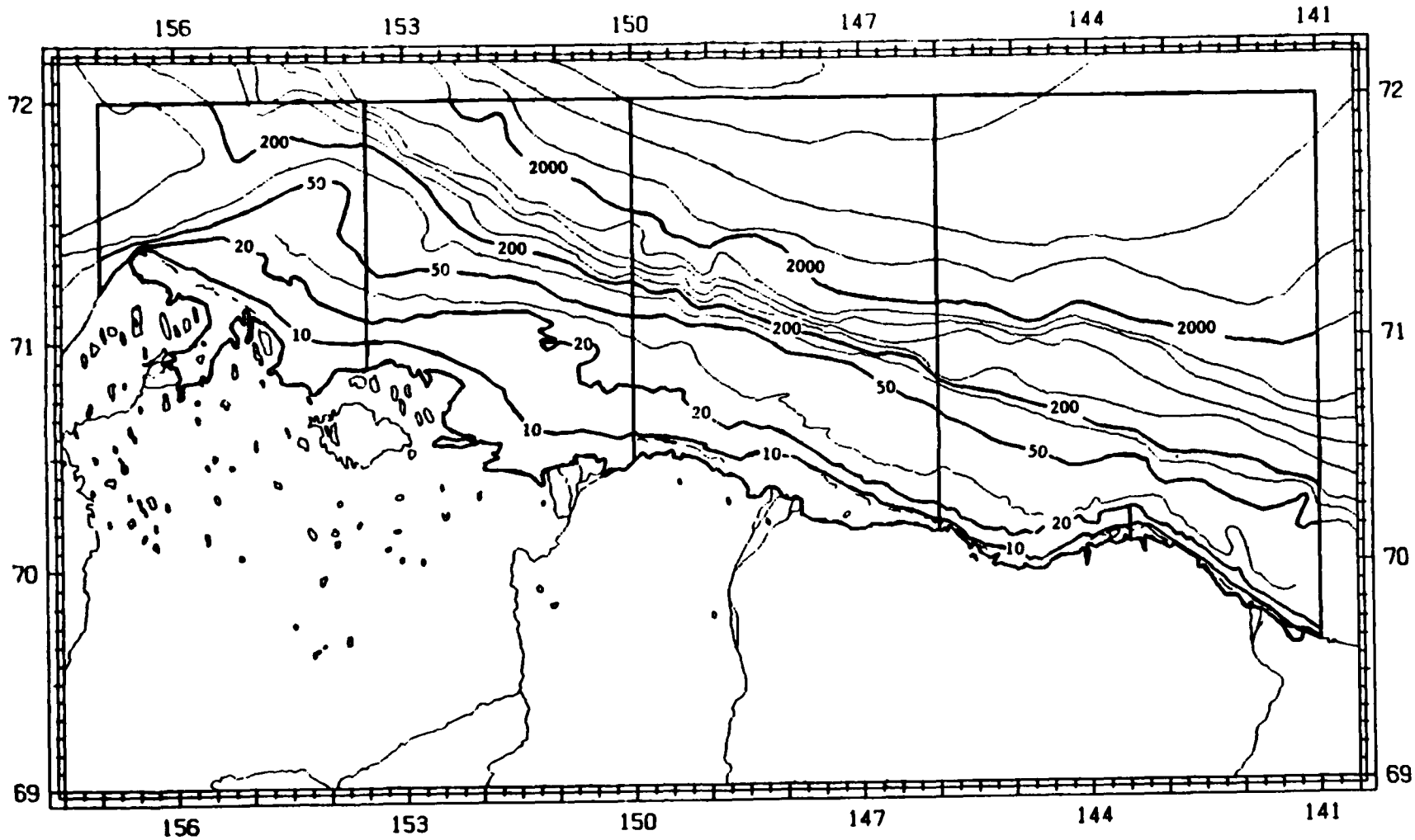


Figure B-3. Map depicting the survey regions in the Beaufort Sea after stratification by contour intervals of 10m, 20m, 50m, 200m, and 2000m.

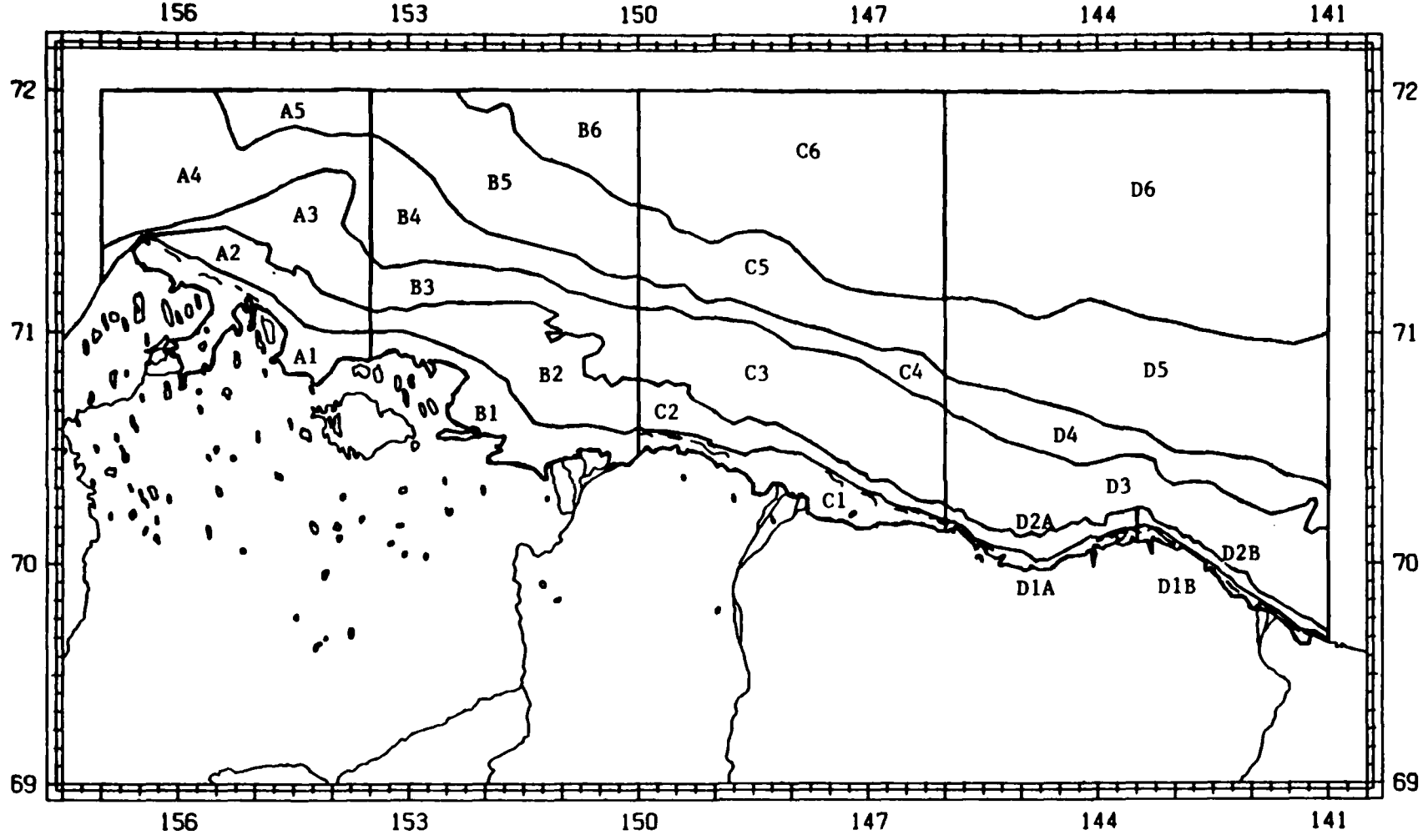
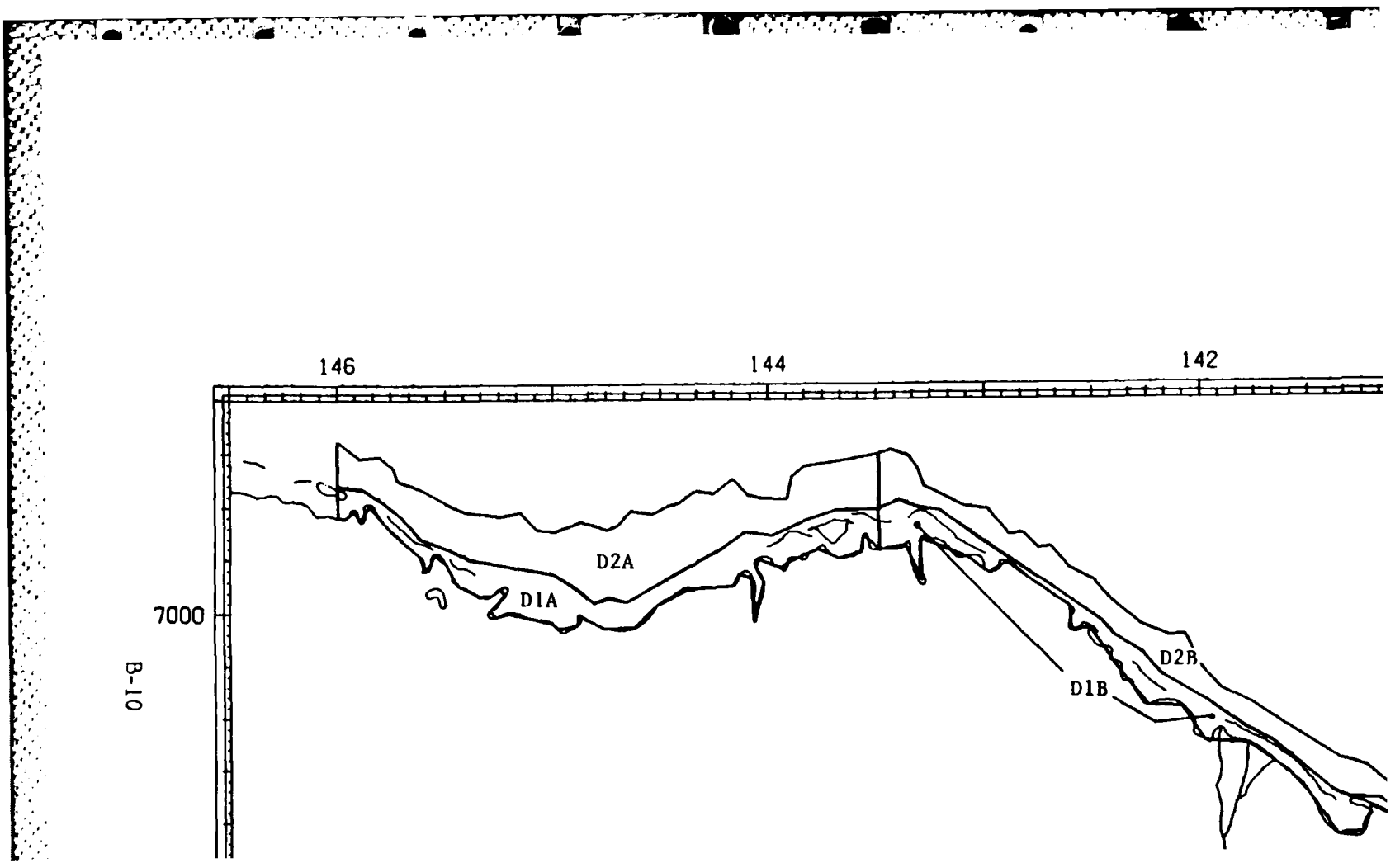


Figure B-4. Map depicting Beaufort Sea stratum names. Strata A1, B1, C1, D1A, and D1B extended from the coast out to the 10 meter depth contour. Strata A2, B2, C2, and D2A, and D2B fell between the 10 and 20 meter depth contours; A3, B3, C3, and D3, fell between the 20 and 50 meter depth contours; etc. Strata D1A, D1B, D2A, and D2B are enlarged in Figure B-5.


146
144
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7000
B-10
D2A
D1A
D2B
D1B

Table B-1. Statistics from aerial surveys of bowhead whales conducted April-May 1984 in the Beaufort Sea. Values for each region were summed where appropriate. Region numbers refer to areas depicted in Figure B-4. The total area of all regions was approximately 29,070 nmi^2. Areas were approximated by straight line integration and thus minor discrepancies exist between the summation of areas of subregions and the area calculated for the total region. Total time spent surveying was approximately 9 hours.

Region Name	Region Area nmi^2	Percent of Total Area	Percent of Area Surveyed	Survey Time HR:MIN	Percent of Total Time	Number Transects Flown	Number Bowheads Observed	Density as Number per nmi^2	Variance ($*10^{-4}$)	Confidence Range of Density
Total	28,609	100.	3.85	8:40	100.00	41	178	0.162	26.5	0.058-0.266
A	3,792	13.	17.18	5:21	61.73	30	161	0.247	72.6	0.073-0.421
A1	654	2.25	7.01	0:23	4.42	11	0	0.0	0.0	0.0-0.0
A2	479	1.65	11.33	0:24	4.62	8	0	0.0	0.0	0.0-0.0
A3	789	2.71	23.60	1:35	18.27	18	50	0.269	116.7	0.041-0.497
A4	1,518	5.22	20.34	2:36	30.00	20	111	0.359	234.1	0.039-0.680
A5	384	1.32	14.63	0:24	4.62	7	0	0.0	0.0	0.0-0.0
B	5,569	19.	8.15	3:21	38.65	14	17	0.037	2.2	0.006-0.069
B1	739	2.54	0.0							
B2	1,079	3.71	2.15	0:11	2.12	3	0	0.0	0.0	0.0-0.0
B3	793	2.73	4.51	0:15	2.88	3	0	0.0	0.0	0.0-0.0
B4	893	3.07	15.66	1:04	12.31	11	16	0.114	25.0	0.003-0.226
B5	1,463	5.03	12.78	1:21	15.58	11	1	0.017	0.2	0.0-0.015
B6	659	2.27	10.29	0:29	5.58	5	0	0.0	0.0	0.0-0.0
C	7,701	27.	0.00							
C1	584	2.02	0.00							
C2	528	1.82	0.00							
C3	1,910	6.57	0.00							
C4	486	1.67	0.00							
C5	1,224	4.21	0.00							
C6	3,070	10.56	0.00							
D	11,625	41.	0.00							
D1A	156	0.55	0.00							
D1B	123	0.42	0.00							
D2A	257	0.88	0.00							
D2B	155	0.53	0.00							

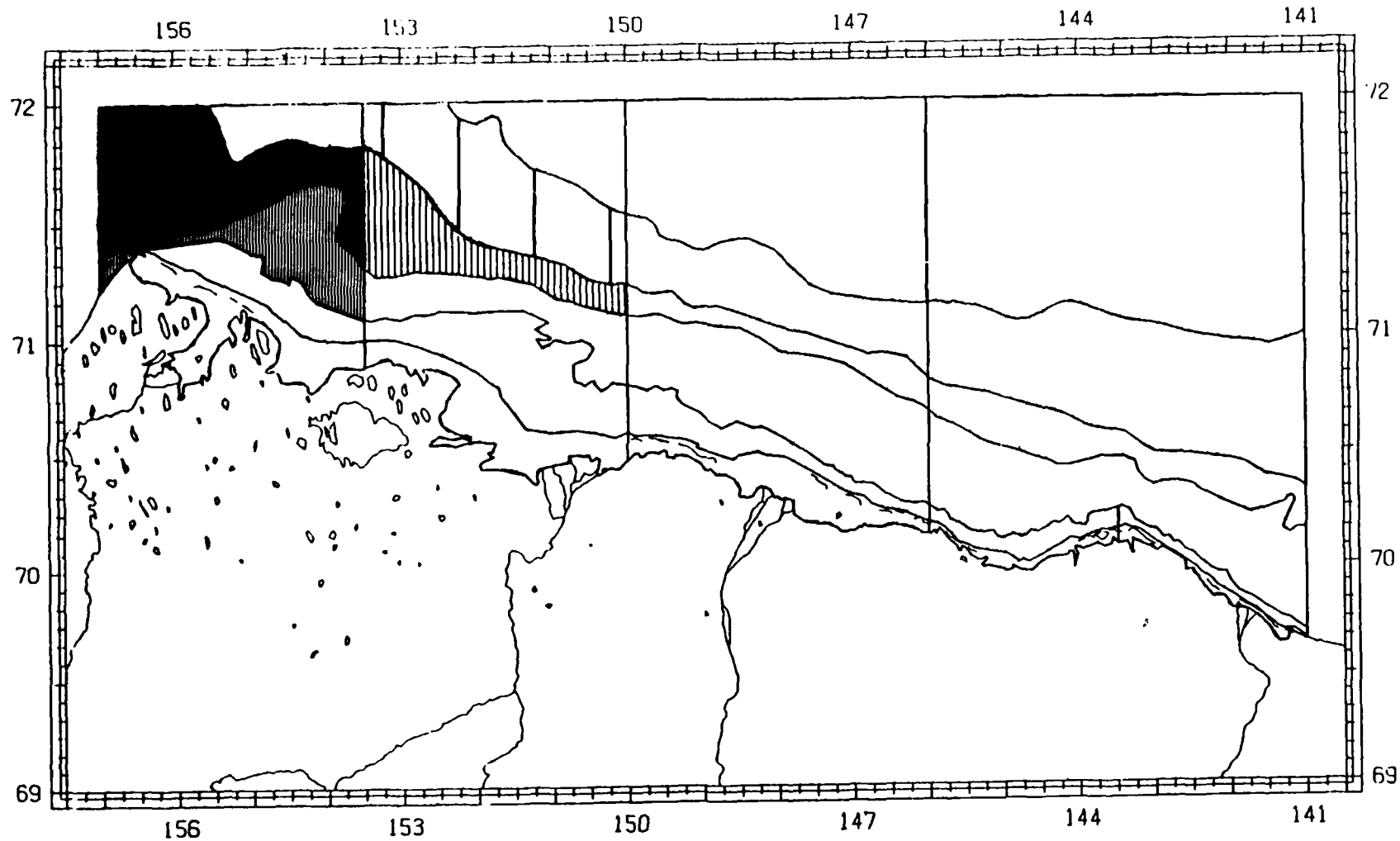


Figure B-6. Shaded regions represent observed densitites of bowhead whales as determined from aerial surveys flown in the Beaufort Sea during April-May 1984. Shading varies from all white (representing 0 density) to all black (representing 0.359 density).

Table B-2. Statistics from aerial surveys of bowhead whales conducted April-May 1979-1983 in the Beaufort Sea.

		1979			1980			1981			1982			1983		
Region Name	Region Area nmi^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per nmi^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per nmi^2	Percent Of Area Surveyed	Number Bowheads Observed	Density as Number Per nmi^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per nmi^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per nmi^2
Total	28,609	8.45	14	0.006	11.18	268	0.084	19.27	271	0.049	17.13	134	0.027	21.51	191	0.031
A	3,792	10.79	14	.034	36.05	175	0.128	33.51	100	0.079	31.15	75	0.063	56.22	122	0.057
A1	654	9.49	0	0.0	12.68	0	0.0	0.74	0	0.0	4.62	0	0.0	5.70	0	0.0
A2	479	13.05	0	0.0	7.13	0	0.0	1.39	0	0.0	7.05	0	0.0	18.24	0	0.0
A3	789	13.58	0	0.0	47.12	58	0.156	83.77	42	0.064	61.67	15	0.031	84.44	44	0.066
A4	1,518	9.88	13	0.087	54.49	117	0.141	38.24	53	0.091	38.81	60	0.102	77.69	78	0.066
A5	384	3.58	0	0.0	12.81	0	0.0	5.07	5	0.256	10.78	0	0.0	42.98	0	0.0
B	5,569	8.41	0	0.0	14.40	58	0.072	38.25	150	0.070	25.24	52	0.037	33.60	69	0.037
B1	739	4.37	0	0.0	6.12	0	0.0	7.57	0	0.0	0.0			0.0		
B2	1,079	19.05	0	0.0	2.35	0	0.0	15.60	0	0.0	9.38	0	0.0	2.93	0	0.0
B3	793	20.46	0	0.0	3.06	0	0.0	16.74	0	0.0	17.44	0	0.0	16.30	0	0.0
B4	893	7.58	0	0.0	42.80	25	0.065	87.22	56	0.072	65.66	29	0.049	76.31	53	0.078
B5	1,463	0.0			22.15	33	0.102	68.10	93	0.093	31.99	22	0.047	58.45	17	0.020
B6	659	0.0			0.00			5.33	1	0.028	16.93	1	0.009	26.29	0	0.0
C	7,701	19.55	0	0.0	7.28	24	0.043	19.38	13	0.009	21.68	7	0.004	15.18	0	0.0
C1	584	80.45	0	0.0	14.90	0	0.0	2.64	0	0.0	11.15	0	0.0	4.82	0	0.0
C2	528	88.28	0	0.0	10.64	0	0.0	15.41	0	0.0	20.23	0	0.0	7.59	0	0.0
C3	1,910	27.51	0	0.0	5.76	0	0.0	12.67	0	0.0	26.36	0	0.0	11.87	0	0.0
C4	486	0.89	0	0.0	10.77	0	0.0	26.95	0	0.0	19.48	0	0.0	16.40	0	0.0
C5	1,224	1.57	0	0.0	9.13	1	0.009	50.94	6	0.010	22.31	3	0.011	30.16	0	0.0
C6	3,070	1.25	0	0.0	4.66	23	0.161	12.90	7	0.018	20.33	4	0.006	15.56	0	0.0
D	11,625	0.26	0	0.0	4.07	11	0.023	5.37	8	0.013	5.58	0	0.0	7.98	0	0.0
D1A	156	0.0			2.31	0	0.0	2.96	0	0.0	0.0			1.78	0	0.0
D1B	123	0.0			0.00			12.26	0	0.0	0.0			1.59	0	0.0
D2A	257	1.26	0	0.0	8.50	0	0.0	2.11	0	0.0	0.0			0.16	0	0.0
D2B	155	0.0			2.33	0	0.0	24.88	0	0.0	1.26	0	0.0	4.82	0	0.0
D3	1,997	0.69	0	0.0	7.30	0	0.0	4.79	0	0.0	5.99	0	0.0	2.81	0	0.0
D4	1,018	0.0			1.64	0	0.0	5.26	0	0.0	6.48	0	0.0	3.17	0	0.0
D5	2,809	0.0			3.16	1	0.011	8.32	7	0.030	4.00	0	0.0	6.98	0	0.0
D6	5,303	0.0			3.65	10	0.052	3.34	1	0.006	6.57	0	0.0	11.37	0	0.0

Table B-3. Statistics from aerial surveys of bowhead whales conducted August 1984 in the Beaufort Sea. Values for each region were summed where appropriate. Region numbers refer to areas depicted in Figure B-4. The total area of all regions was approximately 29,070 nmi^2. Areas were approximated by straight line integration and thus minor discrepancies exist between the summation of areas of subregions and the area calculated for the total region. Total time spent surveying was approximately 58 hours.

Region Name	Region Area nmi^2	Percent of Total Area	Percent of Area Surveyed	Survey Time HR:MIN	Percent of Total Time	Number Transects Flown	Number Bowheads Observed	Density as Number per nmi^2	Variance (*10^{-4})	Confidence Range of Density
Total	28,609	100.	29.09	57:36	100.00	227	7	0.001	0.002	0.000-0.002
A	3,792	13.	6.02	1:36	2.78	12	0	0.0	0.0	0.0-0.0
A1	654	2.25	9.99	0:29	0.84	5	0	0.0	0.0	0.0-0.0
A2	479	1.65	7.65	0:14	0.41	4	0	0.0	0.0	0.0-0.0
A3	789	2.71	9.99	0:32	0.93	10	0	0.0	0.0	0.0-0.0
A4	1,518	5.22	2.39	0:15	0.43	6	0	0.0	0.0	0.0-0.0
A5	384	1.32	2.89	0:06	0.17	1	0	0.0	0.0	0.0-0.0
B	5,569	19.	12.90	4:50	8.39	19	0	0.0	0.0	0.0-0.0
B1	739	2.54	15.10	0:47	1.36	14	0	0.0	0.0	0.0-0.0
B2	1,079	3.71	11.17	0:51	1.48	10	0	0.0	0.0	0.0-0.0
B3	793	2.73	18.38	0:55	1.59	11	0	0.0	0.0	0.0-0.0
B4	893	3.07	10.94	0:39	1.13	7	0	0.0	0.0	0.0-0.0
B5	1,463	5.03	11.84	1:14	2.14	9	0	0.0	0.0	0.0-0.0
B6	659	2.27	10.31	0:24	0.69	6	0	0.0	0.0	0.0-0.0
C	7,701	27.	19.55	10:10	17.65	50	0	0.0	0.0	0.0-0.0
C1	584	2.02	75.85	2:57	5.12	45	0	0.0	0.0	0.0-0.0
C2	528	1.82	55.73	2:03	3.56	35	0	0.0	0.0	0.0-0.0
C3	1,910	6.57	25.89	3:21	5.82	26	0	0.0	0.0	0.0-0.0
C4	486	1.67	15.24	0:30	0.87	10	0	0.0	0.0	0.0-0.0
C5	1,224	4.21	10.29	0:48	1.39	11	0	0.0	0.0	0.0-0.0
C6	3,070	10.56	2.37	0:32	0.93	7	0	0.0	0.0	0.0-0.0
D	11,625	41.	50.57	41:05	71.33	191	7	0.001	0.003	0.0-0.002
D1A	156	0.55	73.66	0:55	1.59	36	0	0.0	0.0	0.0-0.0
D1B	123	0.42	76.38	0:37	1.07	25	0	0.0	0.0	0.0-0.0
D2A	257	0.88	145.02	2:37	4.54	50	0	0.0	0.0	0.0-0.0
D2B	155	0.53	136.68	1:29	2.58	44	2	0.009	0.383	0.0-0.022
D3	1,997	6.87	93.34	13:17	23.06	103	4	0.002	0.027	0.0-0.005
D4	1,018	3.50	67.60	4:52	8.45	76	1	0.001	0.042	0.0-0.006
D5	2,809	9.66	48.94	9:35	16.64	77	0	0.0	0.0	0.0-0.0
D6	5,303	18.24	21.80	7:42	13.37	64	0	0.0	0.0	0.0-0.0

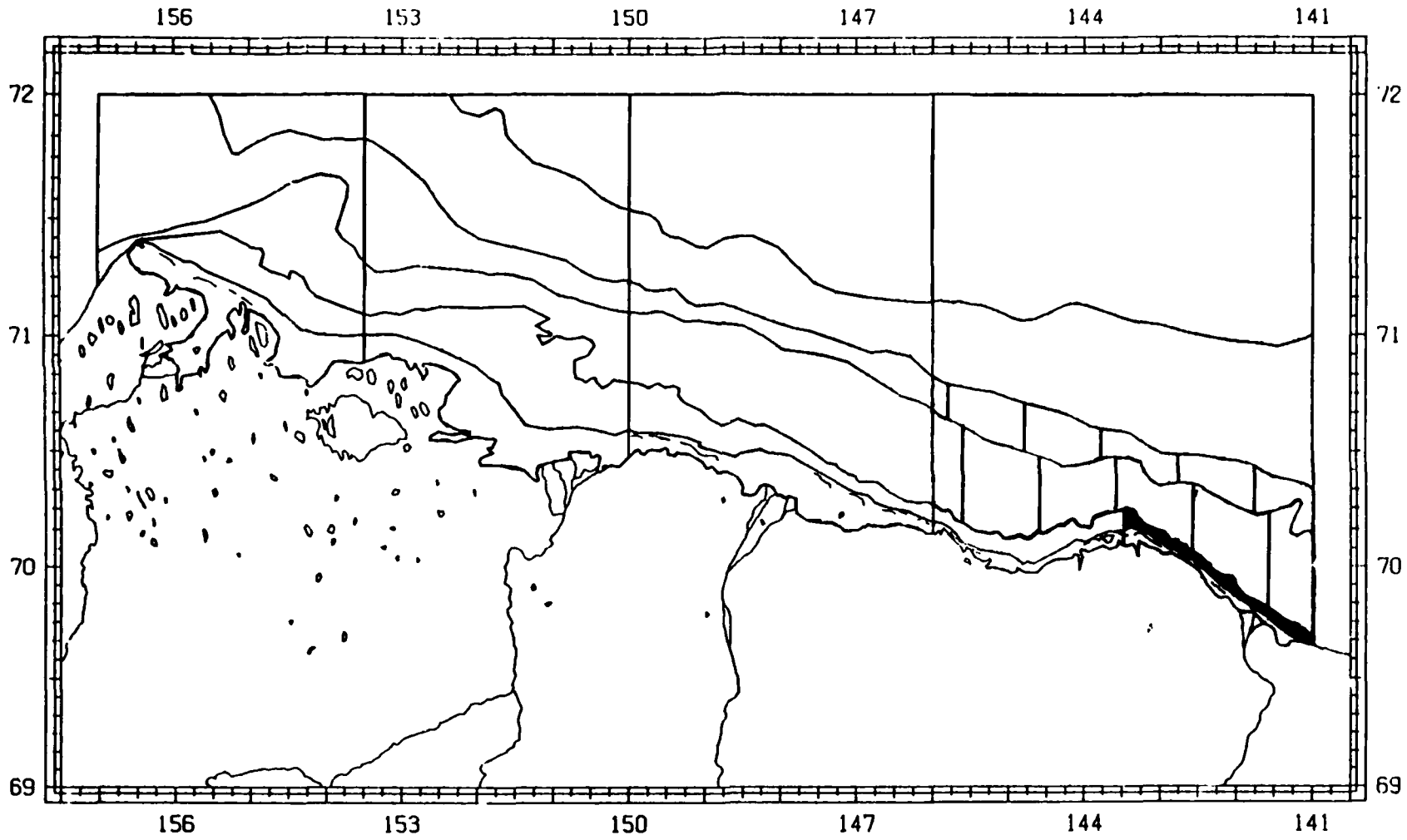


Figure B-7. Shaded regions represent observed densities of bowhead whales as determined from aerial surveys flown in the Beaufort Sea during August 1984. Shading varies from all white (representing 0 density) to all black (representing 0.031 density).

Table B-4. Statistics from aerial surveys of bowhead whales conducted August 1979-1983 in Beaufort Sea.

		1979			1980			1981			1982			1983		
Region Name	Region Area nmi^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per nmi^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per nmi^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per nmi^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per nmi^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per nmi^2
Total	28,609	14.43	7	0.002	8.29	0	0.0	6.66	0	0.0	26.94	79	0.010	36.18	10	0.001
A	3,792	0.0			1.94	0	0.0	5.72	0	0.0	0.0			21.67	0	0.0
A1	654	0.0			3.38	0	0.0	8.20	0	0.0	0.0			24.31	0	0.0
A2	479	0.0			3.37	0	0.0	5.56	0	0.0	0.0			33.17	0	0.0
A3	789	0.0			4.25	0	0.0	9.76	0	0.0	0.0			26.67	0	0.0
A4	1,518	0.0			0.15	0	0.0	4.00	0	0.0	0.0			16.45	0	0.0
A5	384	0.0			0.0			0.0			0.0			11.23	0	0.0
B	5,569	0.0			16.36	0	0.0	7.87	0	0.0	0.0			33.21	0	0.0
B1	739	0.0			36.89	0	0.0	10.96	0	0.0	0.0			38.64	0	0.0
B2	1,079	0.0			31.23	0	0.0	10.22	0	0.0	0.0			65.24	0	0.0
B3	793	0.0			20.23	0	0.0	19.62	0	0.0	0.0			50.90	0	0.0
B4	893	0.0			12.59	0	0.0	6.71	0	0.0	0.0			19.12	0	0.0
B5	1,463	0.0			1.90	0	0.0	2.12	0	0.0	0.0			12.40	0	0.0
B6	659	0.0			0.0			0.0			0.0			15.55	0	0.0
C	7,701	30.37	0	0.0	12.53	0	0.0	9.09	0	0.0	17.77	0	0.0	31.52	1	0.0
C1	584	134.66	0	0.0	32.67	0	0.0	28.30	0	0.0	45.68	0	0.0	65.32	0	0.0
C2	528	68.95	0	0.0	31.04	0	0.0	41.87	0	0.0	22.62	0	0.0	53.72	0	0.0
C3	1,910	54.34	0	0.0	29.67	0	0.0	10.12	0	0.0	24.20	0	0.0	35.07	0	0.0
C4	486	8.69	0	0.0	8.49	0	0.0	2.06	0	0.0	23.77	0	0.0	24.39	0	0.0
C5	1,224	7.83	0	0.0	0.24	0	0.0	2.90	0	0.0	21.41	0	0.0	20.34	1	0.004
C6	3,070	2.58	0	0.0	0.0			2.44	0	0.0	4.68	0	0.0	23.48	0	0.0
D	11,625	15.40	7	0.004	3.45	0	0.0	4.71	0	0.0	54.57	79	0.012	45.28	9	0.002
D1A	156	15.04	0	0.0	11.44	0	0.0	0.0			140.15	0	0.0	36.62	0	0.0
D1B	123	0.0			4.93	0	0.0	3.93	0	0.0	57.24	0	0.0	66.13	0	0.0
D2A	257	111.90	0	0.0	2.85	0	0.0	17.43	0	0.0	109.20	0	0.0	68.66	0	0.0
D2B	155	9.68	0	0.0	8.11	0	0.0	7.22	0	0.0	123.46	0	0.0	57.30	0	0.0
D3	1,997	44.65	0	0.0	17.48	0	0.0	21.82	0	0.0	80.48	0	0.0	65.32	2	0.002
D4	1,018	31.73	4	0.012	0.74	0	0.0	0.0			84.05	3	0.004	55.45	0	0.0
D5	2,809	7.05	3	0.015	0.0			1.83	0	0.0	67.16	72	0.038	53.55	3	0.002
D6	5,303	0.0			0.0			0.0			23.14	4	0.003	28.08	4	0.003

Table B-5. Statistics from aerial surveys of bowhead whales conducted September 1984 in the Beaufort Sea. Values for each region were summed where appropriate. Region numbers refer to areas depicted in Figure B-4. The total area of all regions was approximately 29,070 nmi^2. Areas were approximated by straight line integration and thus minor discrepancies exist between the summation of areas of subregions and the area calculated for the total region. Total time spent surveying was approximately 71 hours.

Region Name	Region Area nmi^2	Percent of Total Area	Percent of Area Surveyed	Survey Time HR:MIN	Percent of Total Time	Number Transects Flown	Number Bowheads Observed	Density as Number per nmi^2	Variance ($*10^{-4}$)	Confidence Range of Density
Total	28,609	100.	33.62	71:28	100.00	300	182	0.019	0.3	0.008-0.030
A	3,792	13.	23.01	8:54	12.45	33	135	0.155	36.7	0.031-0.278
A1	654	2.25	10.38	0:35	0.82	15	0	0.0	0.0	0.0-0.0
A2	479	1.65	31.34	1:45	2.45	17	40	0.266	574.6	0.0-0.775
A3	789	2.71	40.96	3:58	5.55	30	57	0.176	721.7	0.0-0.726
A4	1,518	5.22	17.96	2:11	3.06	21	38	0.139	158.2	0.0-0.402
A5	384	1.32	15.69	0:27	0.63	7	0	0.0	0.0	0.0-0.0
B	5,569	19.	35.23	13:29	18.87	71	0	0.0	0.0	0.0-0.0
B1	739	2.54	31.99	1:46	2.47	30	0	0.0	0.0	0.0-0.0
B2	1,079	3.71	54.11	3:58	5.55	34	0	0.0	0.0	0.0-0.0
B3	793	2.73	51.18	2:43	3.80	32	0	0.0	0.0	0.0-0.0
B4	893	3.07	39.86	2:28	3.45	41	0	0.0	0.0	0.0-0.0
B5	1,463	5.03	21.29	2:05	2.92	20	0	0.0	0.0	0.0-0.0
B6	659	2.27	10.28	0:29	0.68	9	0	0.0	0.0	0.0-0.0
C	7,709	27.	44.76	25:12	35.26	131	11	0.003	0.0	0.001-0.006
C1	584	2.02	78.57	3:53	5.43	75	0	0.0	0.0	0.0-0.0
C2	528	1.82	71.20	2:36	3.64	55	0	0.0	0.0	0.0-0.0
C3	1,910	6.57	72.15	10:05	14.11	75	8	0.006	0.1	0.001-0.011
C4	486	1.67	44.14	1:31	2.12	33	3	0.014	1.3	0.0-0.037
C5	1,224	4.21	27.30	2:21	3.29	31	0	0.0	0.0	0.0-0.0
C6	3,070	10.56	22.21	4:45	6.65	29	0	0.0	0.0	0.0-0.0
D	11,625	41.	28.76	23:51	33.37	115	36	0.011	0.2	0.003-0.019
D1A	156	0.55	31.34	0:20	0.47	15	0	0.0	0.0	0.0-0.0
D1B	123	0.42	27.20	0:21	0.49	8	2	0.060	8.8	0.0-0.130
D2A	257	0.88	42.15	0:47	1.10	23	1	0.009	1.4	0.0-0.034
D2B	155	0.53	75.49	0:56	1.31	31	0	0.0	0.0	0.0-0.0
D3	1,997	6.87	51.64	7:23	10.33	55	14	0.014	0.3	0.002-0.025
D4	1,018	3.50	39.61	2:51	3.99	46	12	0.030	2.8	0.0-0.064
D5	2,809	9.66	27.76	5:29	7.67	42	7	0.009	1.8	0.0-0.036
D6	5,303	18.24	15.40	5:44	8.02	48	0	0.0	0.0	0.0-0.0

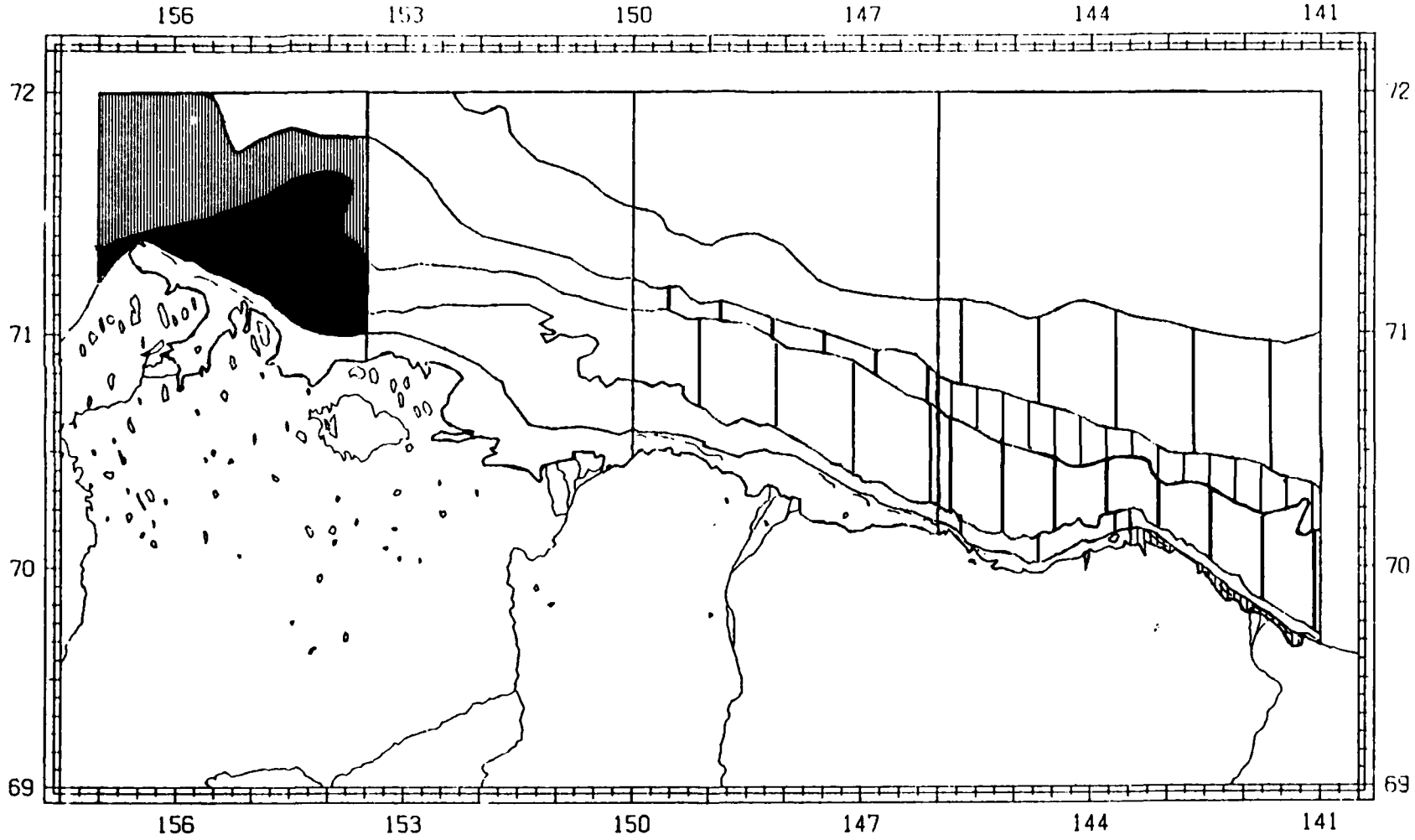


Figure B-8. Shaded regions represent observed densities of bowhead whales as determined from aerial surveys flown in the Beaufort Sea during September 1984. Shading varies from all white (representing 0 density) to all black (representing 0.266 density).

Table B-6. Statistics from aerial surveys of bowhead whales conducted September 1979-1983 in Beaufort Sea.

		1979			1980			1981			1982			1983		
Region Name	Region Area nmi^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per nmi^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per nmi^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per nmi^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per nmi^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per nmi^2
Total	28,609	18.84	5	0.001	28.10	13	0.002	25.23	158	0.022	29.30	120	0.014	46.69	65	0.005
A	3,792	1.58	0	0.0	5.88	0	0.0	1.48	0	0.0	20.81	3	0.004	45.24	14	0.008
A1	654	1.86	0	0.0	12.56	0	0.0	0.98	0	0.0	23.84	0	0.0	40.06	0	0.0
A2	479	7.71	0	0.0	15.72	0	0.0	3.02	0	0.0	33.80	1	0.006	63.68	0	0.0
A3	789	1.48	0	0.0	8.12	0	0.0	4.38	0	0.0	31.85	0	0.0	48.72	11	0.029
A4	1,518	0.0			0.14	0	0.0	0.06	0	0.0	13.44	2	0.010	38.54	3	0.005
A5	384	0.0			0.0			0.0			4.43	0	0.0	47.32	0	0.0
B	5,569	1.28	0	0.0	27.61	0	0.0	12.49	0	0.0	43.90	7	0.003	58.66	21	0.006
B1	739	0.0			47.16	0	0.0	5.26	0	0.0	52.93	0	0.0	47.84	0	0.0
B2	1,079	5.28	0	0.0	51.75	0	0.0	27.66	0	0.0	68.27	4	0.005	51.78	0	0.0
B3	793	1.80	0	0.0	40.71	0	0.0	27.82	0	0.0	63.41	2	0.004	59.92	9	0.019
B4	893	0.0			28.35	0	0.0	13.00	0	0.0	46.94	1	0.002	71.80	8	0.012
B5	1,463	0.0			4.03	0	0.0	1.41	0	0.0	22.95	0	0.0	60.22	3	0.003
B6	659	0.0			0.0			0.0			8.49	0	0.0	53.34	1	0.003
C	7,701	38.33	2	0.001	58.23	6	0.001	36.14	5	0.002	19.01	58	0.40	64.33	10	0.002
C1	584	139.42	0	0.0	190.54	1	0.001	112.97	0	0.0	60.77	0	0.0	97.34	0	0.0
C2	528	78.13	0	0.0	154.06	1	0.001	148.46	0	0.0	46.59	1	0.004	61.87	0	0.0
C3	1,910	72.99	2	0.001	111.24	3	0.001	66.92	5	0.004	37.58	56	0.078	79.74	2	0.001
C4	486	22.13	0	0.0	30.81	0	0.0	11.13	0	0.0	20.85	1	0.010	75.25	2	0.005
C5	1,224	14.47	0	0.0	12.39	0	0.0	0.37	0	0.0	6.54	0	0.0	65.45	4	0.005
C6	3,070	1.45	0	0.0	4.72	0	0.0	0.0			0.46	0	0.0	44.52	2	0.001
D	11,625	19.95	3	0.001	15.42	7	0.004	31.59	153	0.042	30.97	52	0.014	29.59	20	0.006
D1A	156	39.70	0	0.0	65.06	1	0.010	75.12	0	0.0	38.50	0	0.0	17.02	0	0.0
D1B	123	24.07	0	0.0	83.16	0	0.0	71.77	0	0.0	65.79	0	0.0	3.49	0	0.0
D2A	257	140.52	1	0.003	96.88	0	0.0	121.26	0	0.0	46.16	0	0.0	17.16	0	0.0
D2B	155	47.99	0	0.0	78.36	3	0.025	152.46	5	0.021	101.45	0	0.0	17.80	0	0.0
D3	1,997	52.93	1	0.001	45.30	2	0.002	114.76	145	0.063	59.77	48	0.040	32.40	0	0.0
D4	1,018	44.12	0	0.0	5.93	0	0.0	9.21	1	0.011	46.39	0	0.0	58.91	2	0.003
D5	2,809	10.41	1	0.003	5.55	0	0.0	11.81	0	0.0	28.64	0	0.0	46.24	17	0.013
D6	5,303	0.0			1.78	0	0.0	3.99	0	0.0	13.55	4	0.006	14.92	1	0.001

Table B-7. Statistics from aerial surveys of bowhead whales conducted October 1984 in the Beaufort Sea. Values for each region were summed where appropriate. Region numbers refer to areas depicted in Figure B-4. The total area of all regions was approximately 29,070 nmi^2. Areas were approximated by straight line integration and thus minor discrepancies exist between the summation of areas of subregions and the area calculated for the total region. Total time spent surveying was approximately 63 hours.

Region Name	Region Area nmi^2	Percent of Total Area	Percent of Area Surveyed	Survey Time HR:MIN	Percent of Total Time	Number Transects Flown	Number Bowheads Observed	Density as Number per nmi^2	Variance ($*10^{-4}$)	Confidence Range of Density
Total	28,609	100.	28.80	63:20	100.00	258	68	0.008	0.1	0.003-0.014
A	3,792	13.	58.36	18:09	28.66	74	27	0.012	0.1	0.006-0.018
A1	654	2.25	26.86	2:38	4.16	38	0	0.0	0.0	0.0-0.0
A2	479	1.65	78.31	3:00	4.74	37	5	0.013	0.7	0.0-0.030
A3	789	2.71	69.45	4:15	6.71	53	10	0.018	0.5	0.003-0.033
A4	1,518	5.22	57.71	6:29	10.24	53	12	0.014	0.4	0.001-0.026
A5	384	1.32	62.63	1:49	2.87	30	0	0.0	0.0	0.0-0.0
B	5,569	19.	51.83	21:53	34.55	105	36	0.012	0.5	0.0-0.026
B1	739	2.54	52.89	2:58	4.68	62	0	0.0	0.0	0.0-0.0
B2	1,079	3.71	81.61	6:23	10.08	62	1	0.001	0.0	0.0-0.003
B3	793	2.73	90.79	5:26	8.58	65	11	0.015	0.6	0.0-0.030
B4	893	3.07	58.62	4:22	6.89	64	24	0.046	4.2	0.005-0.087
B5	1,463	5.03	23.13	2:31	3.97	36	0	0.0	0.0	0.0-0.0
B6	659	2.27	4.54	0:13	0.34	3	0	0.0	0.0	0.0-0.0
C	7,701	27.	29.75	17:08	27.05	85	4	0.002	0.0	0.001-0.003
C1	584	2.02	59.39	2:43	4.29	54	0	0.0	0.0	0.0-0.0
C2	528	1.82	69.15	2:43	4.29	50	0	0.0	0.0	0.0-0.0
C3	1,910	6.57	54.70	7:40	12.11	52	2	0.002	0.0	0.0-0.004
C4	486	1.67	39.11	1:26	2.26	34	2	0.011	0.6	0.0-0.027
C5	1,224	4.21	23.05	2:08	3.37	33	0	0.0	0.0	0.0-0.0
C6	3,070	10.56	2.00	0:28	0.74	9	0	0.0	0.0	0.0-0.0
D	11,625	41.	6.99	5:57	9.39	21	1	0.001	0.0	0.0-0.003
D1A	156	0.55	5.38	0:04	0.11	4	0	0.0	0.0	0.0-0.0
D1B	123	0.42	3.30	0:02	0.05	1	0	0.0	0.0	0.0-0.0
D2A	257	0.88	14.87	0:17	0.45	8	0	0.0	0.0	0.0-0.0
D2B	155	0.53	40.54	0:28	0.74	7	0	0.0	0.0	0.0-0.0
D3	1,997	6.87	20.36	2:57	4.66	17	1	0.002	0.0	0.0-0.005
D4	1,018	3.50	14.46	1:07	1.76	11	0	0.0	0.0	0.0-0.0
D5	2,809	9.66	5.17	1:02	1.63	11	0	0.0	0.0	0.0-0.0
D6	5,303	18.24	0.00							

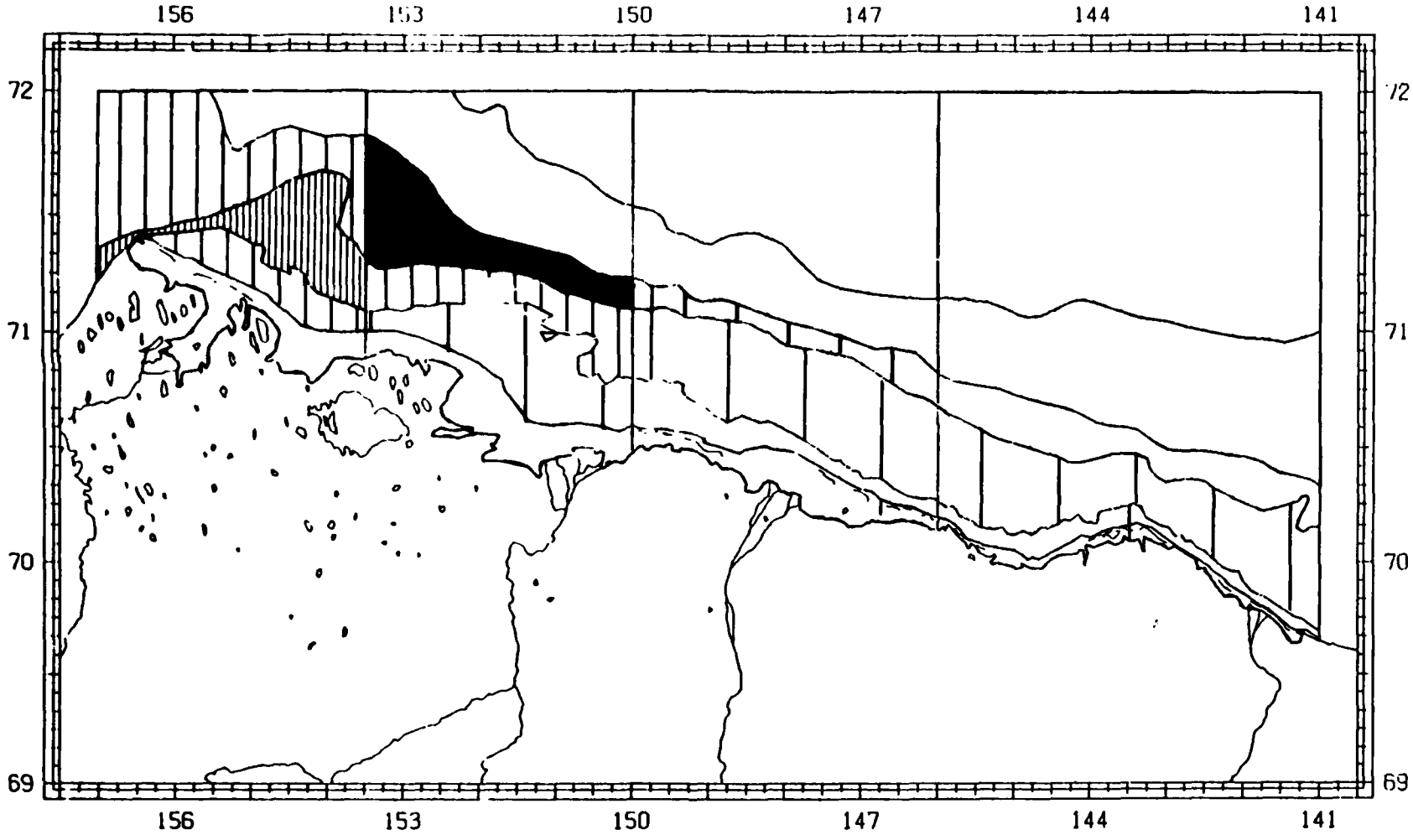


Figure B-9. Shaded regions represent observed densities of bowhead whales as determined from aerial surveys flown in the Beaufort Sea in October 1984. Shading varies from all white (representing 0 density) to all black (representing 0.046 density).

Table B-8. Statistics from aerial surveys of bowhead whales conducted October 1979-1983 in the Beaufort Sea.

		1979			1980			1981			1982			1983		
Region Name	Region Area nmi^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per nmi^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per nmi^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per nmi^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per nmi^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per nmi^2
Total	28,609	24.02	145	0.021	22.24	8	0.001	17.70	46	0.009	14.91	25	0.006	18.87	12	0.002
A	3,792	19.33	5	0.007	14.06	0	0.0	4.92	0	0.0	32.04	11	0.009	43.78	8	0.005
A1	654	6.59	0	0.0	13.12	0	0.0	12.34	0	0.0	15.23	4	0.040	20.67	0	0.0
A2	479	18.86	0	0.0	18.75	0	0.0	11.74	0	0.0	39.58	4	0.021	50.24	0	0.0
A3	739	26.99	1	0.005	32.01	0	0.0	6.39	0	0.0	37.33	1	0.003	43.77	6	0.017
A4	1,513	22.71	4	0.012	7.15	0	0.0	0.0			34.40	2	0.004	51.15	2	0.003
A5	384	10.68	0	0.0	0.0			0.0			28.09	0	0.0	42.49	0	0.0
B	5,569	11.84	41	0.062	44.80	4	0.002	30.14	8	0.005	18.17	10	0.010	26.47	3	0.002
B1	739	0.64	0	0.0	74.43	0	0.0	34.01	0	0.0	7.02	0	0.0	17.69	0	0.0
B2	1,079	23.54	0	0.0	81.18	0	0.0	65.23	0	0.0	12.39	2	0.015	28.83	0	0.0
B3	793	30.52	41	0.169	75.15	4	0.007	59.32	8	0.017	12.57	7	0.070	24.67	3	0.015
B4	893	10.51	0	0.0	41.84	0	0.0	21.86	0	0.0	24.41	0	0.0	33.69	0	0.0
B5	1,463	4.45	0	0.0	8.55	0	0.0	3.85	0	0.0	22.84	1	0.003	24.32	0	0.0
B6	659	0.0			0.0			0.0			27.23	0	0.0	26.96	0	0.0
C	7,701	62.93	81	0.017	34.38	4	0.002	24.84	16	0.008	12.18	1	0.001	14.26	0	0.0
C1	584	258.45	0	0.0	94.01	0	0.0	50.89	0	0.0	25.16	0	0.0	29.11	0	0.0
C2	528	139.58	6	0.008	79.70	0	0.0	67.71	1	0.003	26.33	0	0.0	34.31	0	0.0
C3	1,910	119.69	75	0.033	77.48	4	0.003	58.35	14	0.013	25.82	1	0.002	22.05	0	0.0
C4	486	23.31	0	0.0	22.51	0	0.0	28.93	1	0.007	9.08	0	0.0	14.81	0	0.0
C5	1,224	19.97	0	0.0	5.54	0	0.0	0.53	0	0.0	6.07	0	0.0	10.68	0	0.0
C6	3,070	2.52	0	0.0	0.76	0	0.0	0.0			1.18	0	0.0	4.01	0	0.0
D	11,625	5.65	18	0.027	5.92	0	0.0	11.16	22	0.017	9.52	3	0.003	10.19	1	0.001
D1A	156	3.98	0	0.0	4.96	0	0.0	6.26	0	0.0	14.81	0	0.0	24.19	0	0.0
D1B	123	0.0			0.0			35.17	0	0.0	9.20	0	0.0	8.37	0	0.0
D2A	257	46.27	0	0.0	32.94	0	0.0	36.71	0	0.0	28.50	0	0.0	23.29	0	0.0
D2B	155	0.0			42.15	0	0.0	36.65	0	0.0	15.55	0	0.0	17.01	0	0.0
D3	1,997	16.11	18	0.056	26.12	0	0.0	31.99	22	0.034	27.87	3	0.005	20.96	1	0.002
D4	1,018	8.54	0	0.0	0.81	0	0.0	13.09	0	0.0	13.89	0	0.0	20.04	0	0.0
D5	2,809	1.03	0	0.0	0.0			10.61	0	0.0	4.14	0	0.0	13.45	0	0.0
D6	5,303	0.02	0	0.0	0.0			0.28	0	0.0	3.01	0	0.0	0.93	0	0.0

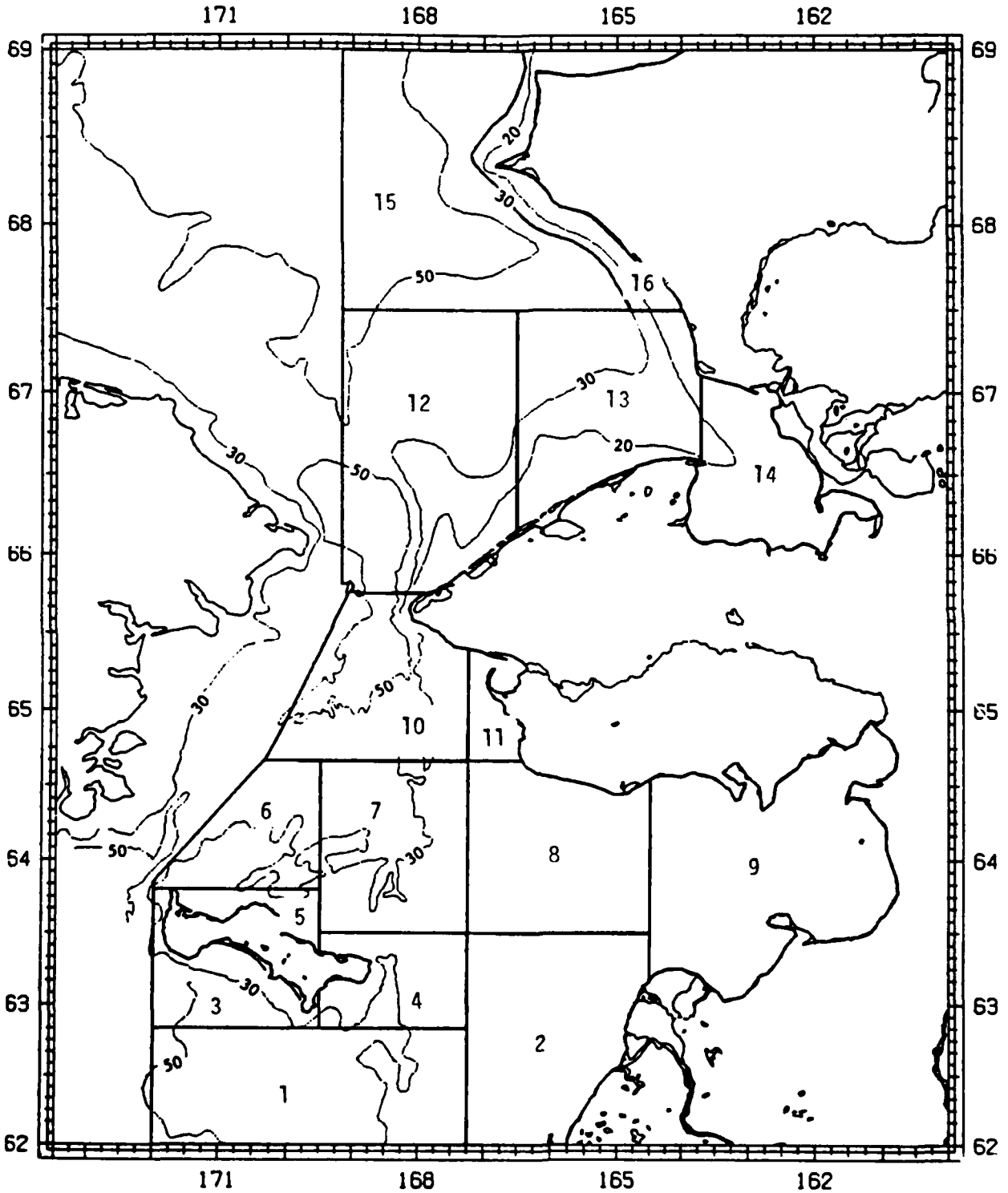
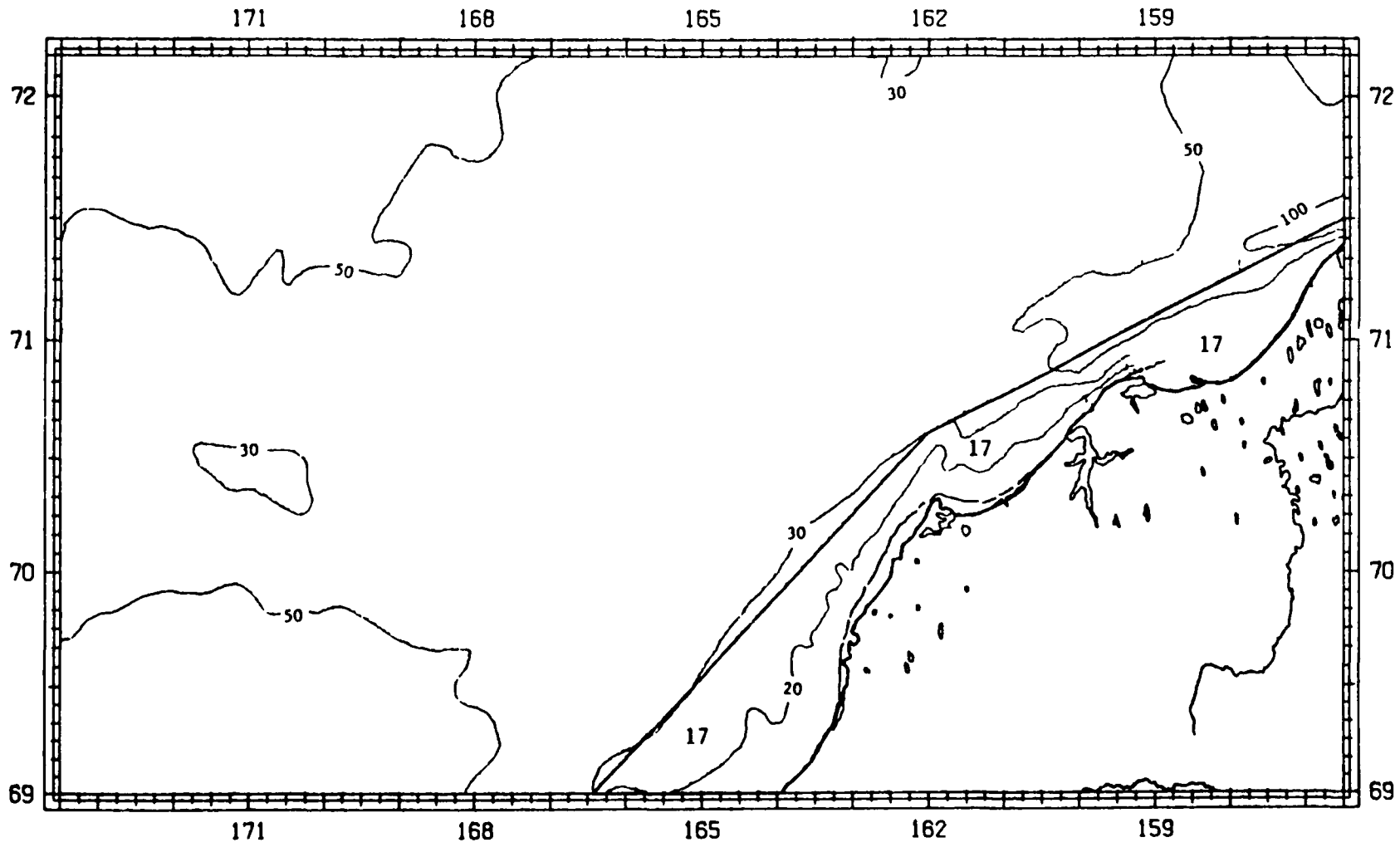


Figure B-10. Map depicting survey areas in relation to depth contours in the Bering and Chukchi Seas.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159
72
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0

Table B-9. Statistics from aerial survey of bowhead whales conducted April-May 1984 in the Bering and Chukchi Seas. Values for each region are summed where appropriate. Region numbers refer to areas depicted in Figure B-10. The total study area was approximately 64,871 nmi^2. Total time spent surveying was approximately 30 hours and 24 minutes.

Region Name	Region Area nmi^2	Percent of Total Area	Percent of Area Surveyed	Survey Time HR:MIN	Percent of Total Time	Number Transects Flown	Number Bowheads Observed	Density as Number per nmi^2	Variance ($*10^{-4}$)	Confidence Range of Density
1	6,542	10.08	0.0							
2	5,550	8.56	0.0							
3	2,011	3.10	0.0							
4	2,211	3.41	2.11	0:19	1.04	3	0	0.0	0.0	0.0-0.0
5	724	1.12	8.86	0:30	1.64	3	0	0.0	0.0	0.0-0.0
6	2,313	3.56	8.65	1:36	5.26	7	0	0.0	0.0	0.0-0.0
7	4,088	6.30	9.29	2:48	9.21	14	0	0.0	0.0	0.0-0.0
8	4,566	7.04	5.11	1:39	5.43	6	0	0.0	0.0	0.0-0.0
9	7,262	11.19	0.0							
10	3,676	5.67	14.20	3:59	13.10	20	2	0.004	0.1	0.0-0.009
11	767	1.18	11.41	0:36	1.97	6	0	0.0	0.0	0.0-0.0
12	6,185	9.53	4.23	2:08	7.02	7	7	0.027	3.3	0.0-0.071
13	4,140	6.38	3.15	0:55	3.02	6	0	0.0	0.0	0.0-0.0
14	2,469	3.81	1.47	0:15	0.82	2	0	0.0		
15	5,767	8.89	9.45	4:20	14.25	23	21	0.039	3.9	0.0-0.080
16	1,504	2.32	27.68	3:22	11.07	18	13	0.031	3.0	0.0-0.068
17	5,096	7.86	21.30	7:57	26.15	34	14	0.013	1.6	0.0-0.038

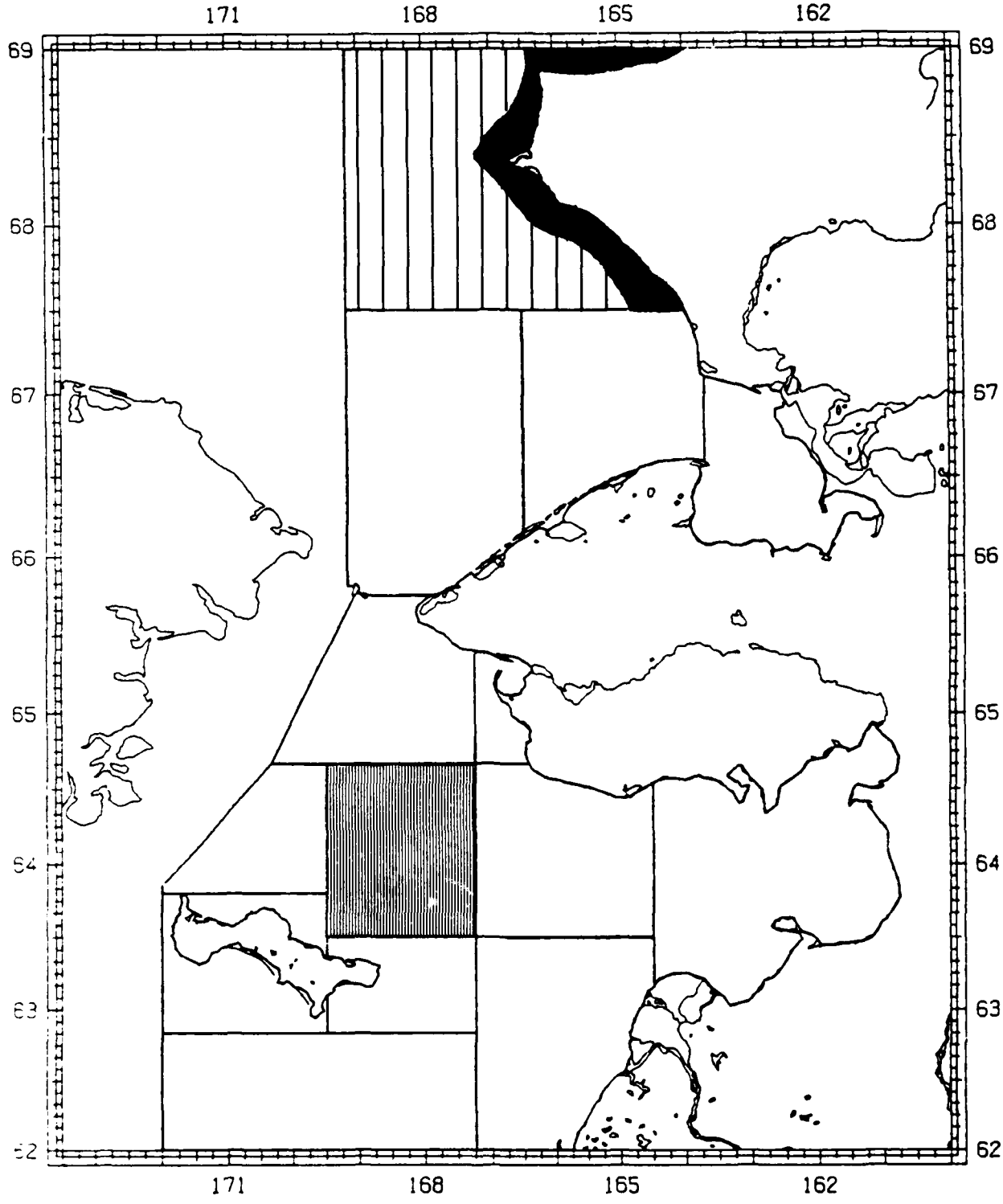

Figure B-12. Shaded regions represent observed densities of bowhead whales as determined from aerial surveys flown in the Bering and Chukchi Seas during April-May 1984. Shading varies from all white (representing 0 density) to all black (representing 0.039 density). Chukchi Sea region 17 is not shown.

Table B-10. Statistics from aerial surveys of bowhead whales conducted April-May 1980-1983 in the Bering and Chukchi Seas.

		1980			1981			1982			1983		
Region Name	Region Area nm^2	Percent Area Surveyed	Number Bowheads Observed	Density Number per nmi^2	Percent Area Surveyed	Number Bowheads Observed	Density Number per nmi^2	Percent Area Surveyed	Number Bowheads Observed	Density Number per nmi^2	Percent Area Surveyed	Number Bowheads Observed	Density Number per nmi^2
1	6,542	0.16	0	0.0	0.26	0	0.0	0.03	0	0.0	0.0		--
2	5,550	2.68	0	0.0	9.18	0	0.0	1.80	0	0.0	0.0		--
3	2,011	2.97	0	0.0	11.83	0	0.0	9.44	0	0.0	0.0		--
4	2,211	3.12	0	0.0	25.45	0	0.0	14.75	1	0.003	0.0		--
5	724	1.64	0	0.0	20.68	0	0.0	12.86	0	0.0	0.0		--
6	2,313	2.73	0	0.0	49.56	828	0.722	9.12	0	0.0	7.15	0	0.0
7	4,088	3.27	4	0.030	38.68	0	0.0	17.20	0	0.0	5.93	2	0.008
8	4,566	14.78	2	0.003	42.19	0	0.0	12.95	0	0.0	2.48	0	0.0
9	7,262	4.31	0	0.0	12.28	0	0.0	3.19	0	0.0	0.0		--
10	3,676	20.24	11	0.015	25.77	2	0.002	21.46	4	0.005	4.83	1	0.006
11	767	35.84	2	0.007	39.38	0	0.0	32.85	0	0.0	5.17	0	0.0
12	6,185	7.57	312	0.666	17.33	28	0.026	9.58	24	0.040	1.89	0	0.0
13	4,140	3.74	0	0.0	0.10	0	0.0	0.0		--	0.0		--
14	2,469	0.00		--	0.00		--	0.0		--	0.0		--
15	5,767	0.35	0	0.0	2.22	0	0.0	2.48	4	0.028	0.81	1	0.021
16	1,504	12.78	0	0.0	5.31	5	0.063	9.82	2	0.014	3.85	10	0.173
17	5,096	16.01	49	0.060	10.18	18	0.035	15.54	7	0.009	9.61	11	0.022

B-11. Statistics from aerial survey of gray whales conducted July 1984 in the Bering and Chukchi Seas. Values for each region are summed where appropriate. Region numbers refer to areas depicted in Figure B-10. The total study area was approximately 64,871 nmi^2. Total time spent surveying was approximately 9 hours and 21 minutes.

Region Name	Region Area nmi^2	Percent of Total Area	Percent of Area Surveyed	Survey Time HR:MIN	Percent of Total Time	Number Transects Flown	Number Grays Observed	Density as Number per nmi^2	Variance ($*10^{-4}$)	Confidence Range of Density
1	6,542	10.08	0.0							
2	5,550	8.56	0.0							
3	2,011	3.10	0.0							
4	2,211	3.41	0.0							
5	724	1.12	0.0							
6	2,313	3.56	0.0							
7	4,088	6.30	3.98	1:25	15.15	11	26	0.160	97.3	0.0-0.380
8	4,566	7.04	3.12	0:59	10.52	8	0	0.0	0.0	0.0-0.0
9	7,262	11.19	0.0							
10	3,676	5.67	1.32	0:20	3.57	3	0	0.0	0.0	0.0-0.0
11	767	1.18	6.58	0:22	3.92	5	0	0.0	0.0	0.0-0.0
12	6,185	9.53	1.05	0:25	4.46	4	0	0.0	0.0	0.0-0.0
13	4,140	6.38	0.88	0:21	3.74	1	0	0.0		
14	2,469	3.81	0.0							
15	5,767	8.89	0.69	0:16	2.85	1	3	0.075		
16	1,504	2.32	3.45	0:25	4.46	4	9	0.173	208.0	0.0-0.632
17	5,096	7.86	13.41	4:48	51.34	29	17	0.025	1.3	0.001-0.048

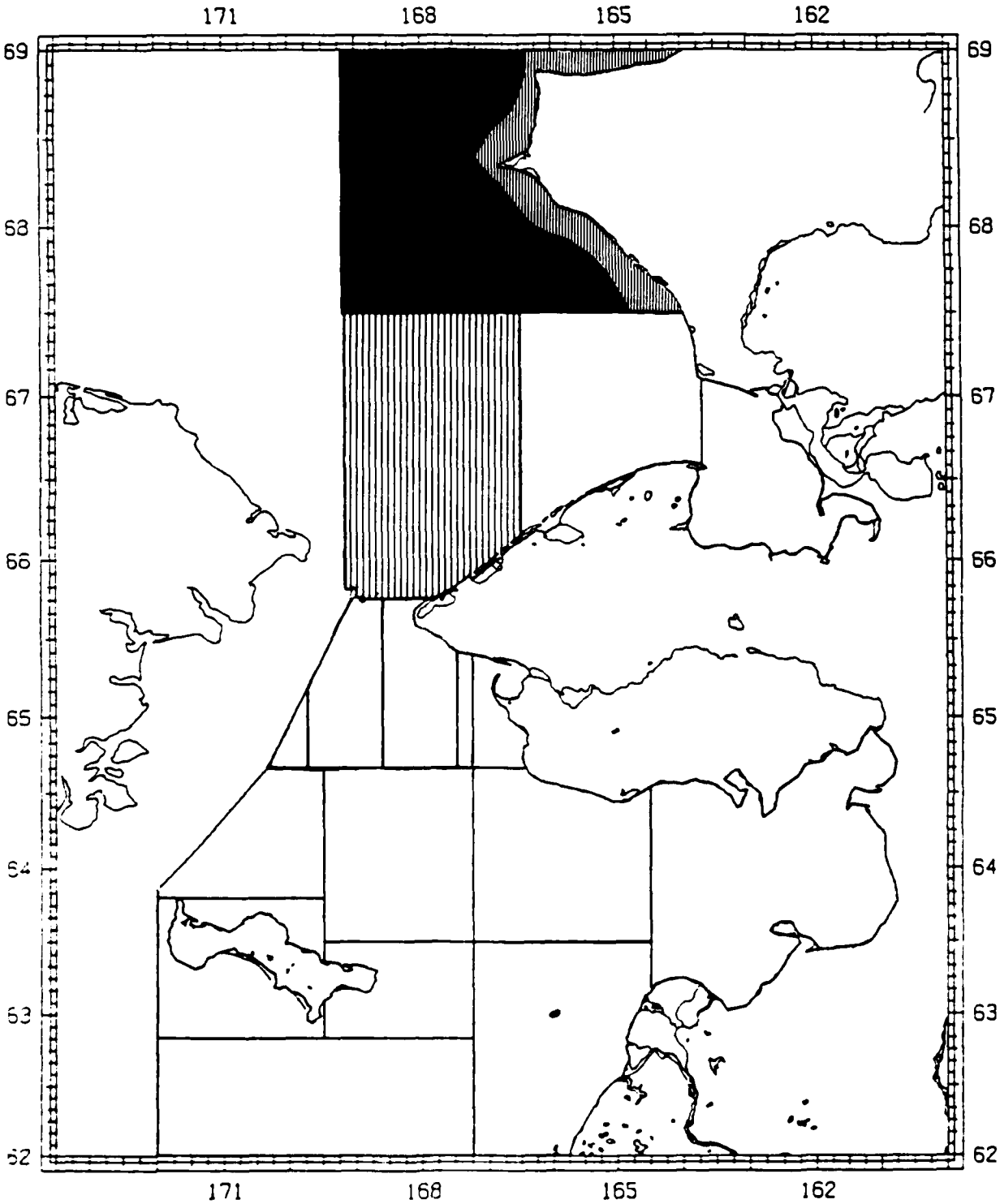

Figure B-13. Shaded regions represent observed densities of gray whales as determined from aerial surveys flown in the Bering and Chukchi/Seas during July 1984. Shading varies from all white (representing 0 density) to all black (representing 0.173 density). Chukchi Sea region is not shown.

Table B-12. Statistics from aerial surveys of gray whales conducted July 1980-1983 in the Bering and Chukchi Seas.

		1980			1981			1982			1983		
Region Name	Region Area nmi^2	Percent Area Surveyed	Number Grays Observed	Density Number per nmi^2	Percent Area Surveyed	Number Grays Observed	Density Number per nmi^2	Percent Area Surveyed	Number Grays Observed	Density Number per nmi^2	Percent Area Surveyed	Number Grays Observed	Density Number per nmi^2
1	6,542	0.0		--	0.0		--	0.11	0	0.0	0.0		--
2	5,550	0.0		--	2.23	0	0.0	0.0		--	1.71	0	0.0
3	2,011	0.0		--	0.0		--	1.73	11	0.317	0.0		--
4	2,211	0.0		--	8.20	0	0.0	17.66	40	0.102	9.56	0	0.0
5	724	0.0		--	0.0		--	22.81	6	0.036	0.0		--
6	2,313	0.0		--	0.0		--	12.18	7	0.025	11.55	65	0.243
7	4,088	0.0		--	10.74	46	0.105	30.55	56	0.045	30.26	429	0.347
8	4,566	0.22	0	0.0	18.21	0	0.0	6.02	1	0.004	6.76	0	0.0
9	7,262	1.39	0	0.0	7.86	0	0.0	0.0		--	2.67	0	0.0
10	3,676	1.23	0	0.0	13.65	14	0.028	23.18	37	0.043	19.00	346	0.495
11	767	3.69	0	0.0	36.54	5	0.018	15.73	0	0.0	5.00	0	0.0
12	6,185	1.52	0	0.0	7.09	9	0.021	13.85	5	0.006	0.62	1	0.026
13	4,140	0.46	0	0.0	10.23	0	0.0	7.30	1	0.003	2.24	4	0.043
14	2,469	0.0		--	8.29	0	0.0	6.05	0	0.0	0.0		--
15	5,767	0.50	0	0.0	4.73	12	0.044	0.0		--	0.46	0	0.0
16	1,504	3.51	4	0.076	25.79	28	0.072	7.75	24	0.206	3.72	6	0.107
17	5,096	3.74	4	0.021	5.02	21	0.082	3.83	84	0.430	3.65	0	0.0

REFERENCES

Estes, J.A., and J.R. Gilbert. Evaluation of an aerial survey of Pacific walruses (Odobenus rosmarus divergens). J. Fish. Res. Board Can. 35: 1130-1140. 1978.

Krogman, B.D., H.W. Braham, R.M. Sonntag, and R.G. Punsley. Early spring distribution, density, and abundance of the Pacific Walrus (Odobenus rosmarus) in 1976. Outer Continental Shelf Environmental Assessment Program Research Unit 14 Final Report, No. R7120804. 1979.

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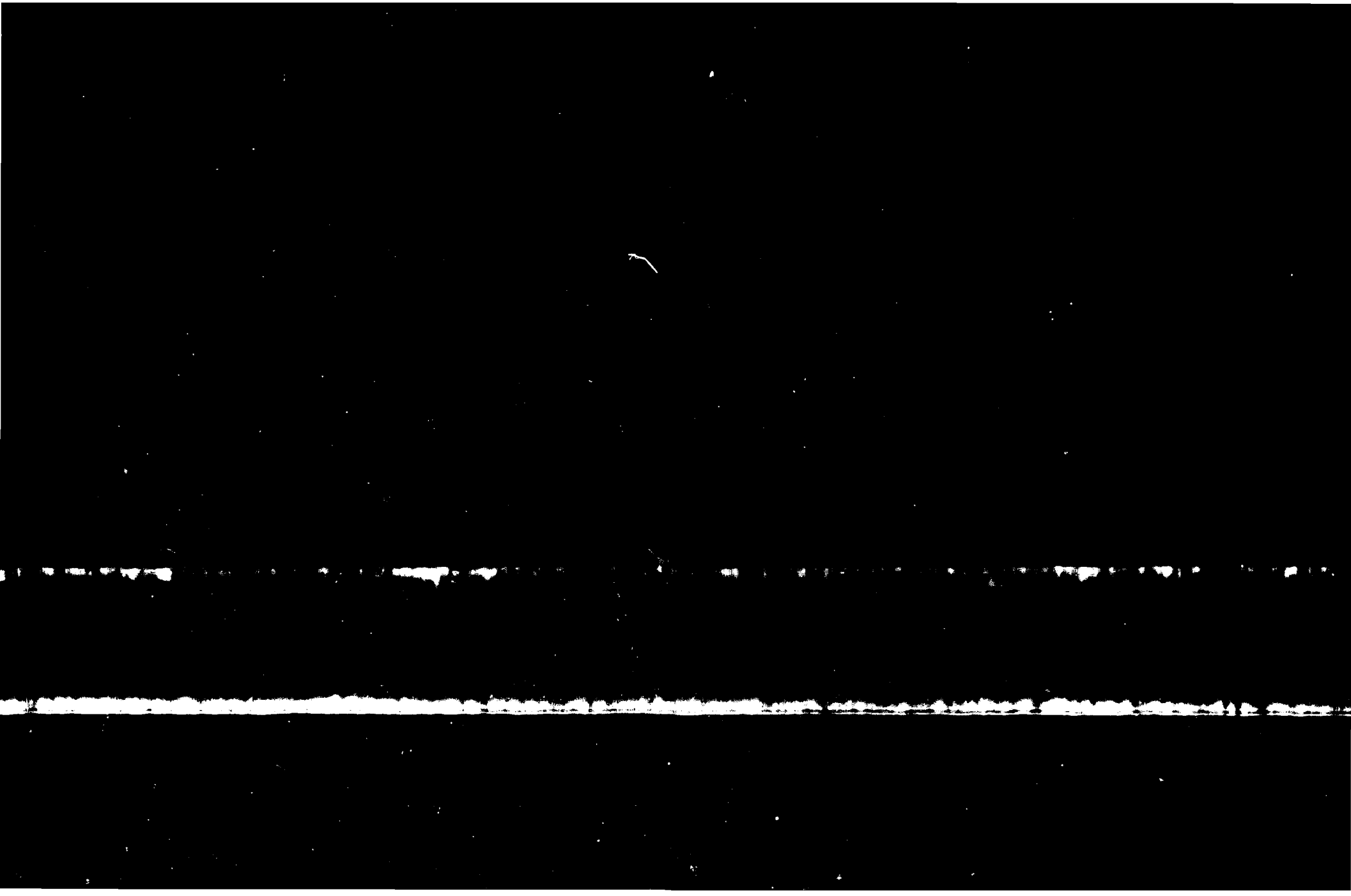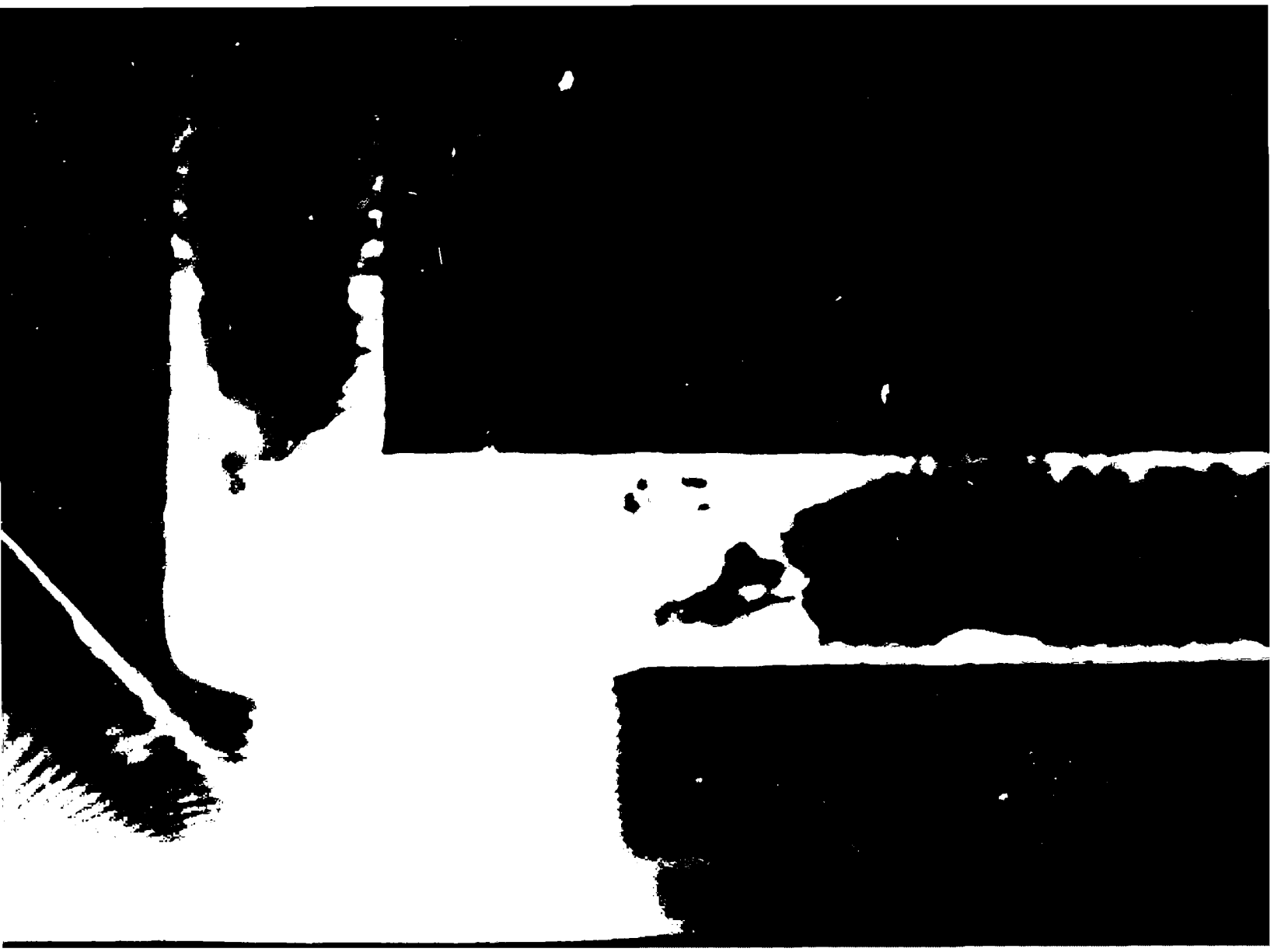
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