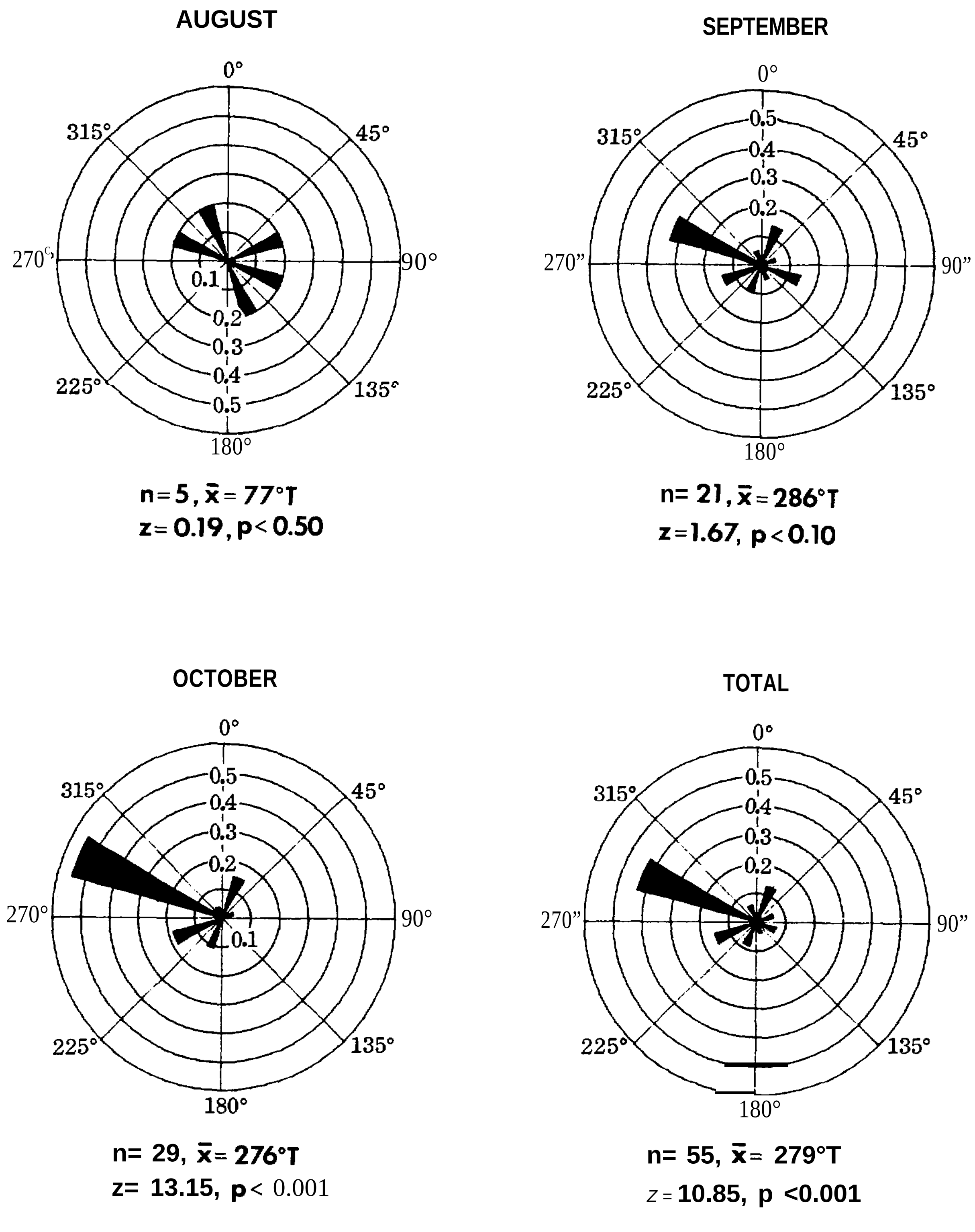


Figure 17. Bowhead swimming direction analysis, fall 1985.

Table 17. Bimonthly summary of bowhead whale response to aircraft, fall 1985.

	1-15 Aug No.(%)	16-31 Aug No.(%)	1-15 Sep No.(%)	16-30 Sep No.(%)	1-23 Oct No.(%)	Total No.(%)
Positive	0	0	3(9)	6(18)	0	9(6)
Negative	9(100)	3(100)	31(91)	27(82)	60(100) 1	30(94)
Total	9	3	34	3 3	60	139

Fewer (6%, n = 9) bowheads were judged to react to the aircraft (Table 17) this year than in all previous years (Ljungblad et al., 1985). The mean altitude at which bowheads responded to the aircraft (409 m) was not significantly lower than the mean altitude for all other sightings (415 m, t = 0.165, p <0.50). positive responses were all from adults, and all but one were from whales in light ice coverage (< 10%). The exception was one bowhead closely associated with another whale, which did not react to the aircraft, in 90 percent ice.

Eleven sonobuoys were dropped during the fall season near bowhead whales or vessels (Table 18). Bowhead whale calls were recorded on 11 September and 23 September onboard the secondary aircraft (N545N) assessing bowhead migration status (Appendix C: Flights C-2 and C-8), and on 25 September, 27 September, and 13 October on board N780 (Appendix A: Flights 46, 48 and 59). Bowhead calls and were aurally analyzed (i.e., subjective listening) as in past years (Ljungblad et al., 1983, 1984a) and placed into simple or complex moan categories. Simple moans were tonal, frequency modulated (FM) sounds often with harmonic structure and usually in the 50 Hz to 2 kHz frequency band. Simple moans were classified to five categories based upon temporal frequency modulation as follows:

FM1 up = ascending frequency modulation
FM2 down = descending frequency modulation
FM3 constant = no discernible frequency modulation
FM4 inflect = combined ascending and descending frequency modulation
FM5 high = short calls starting above 800 Hz

Table 18. Summary of sonobuoydrops, fall 1985.
*Dropped during N545N Surveys (Appendix C)

Date	Latitude (N)	Longitude (W)	Subject
28 Aug	70°20.7'	141043.2’	Vessel
11 Sep*	69°37.8'	140031.7’	Bowhead
13 Sep	70°36.5'	146°36.0'	Bowhead
13 Sep*	70°22.8'	145058.2’	Drillship
13 Sep*	69°38.9'	140050.5’	Bo whead
23 Sep*	69°36.5'	140020.4’	Bowhead
25 Sep	70°26.9'	143045.7’	Bowhead
27 Sep	70°27.1'	143007.7’	Bowhead
1 Ott	71039.41	152°42.9’	Bowhead
5 Ott	70°57.6'	149043.7’	Bowhead
13 Ott	70°48.6'	147058.4’	Bowhead

Complex moans were 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 were

AM 1 growl = low frequency calls with energy primarily below 1 kHz

AM2 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 exhibit both FM and AM components. Aurally these calls sound “complex” and were so categorized for the purpose of this analysis.

To standardize call counts over recording periods of varying duration, a call rate was derived as calls per whale-hour (calls/wh-h) by dividing the number of calls by the duration of the recording period and by the number of bowheads seen within about 10 km (5.4 nmi) of the sonobuoy. A 10-km radius around the sonobuoy was used to derive the possible number of calling whales based upon the Cummings and Holliday (1983) estimate of signal/noise ratios of bowhead calls approaching zero at about 5 to 15 km. Call rate, so derived, is useful only as a relative index of overall calling behavior because its accuracy is dependent on a precise count of the number of whales near enough to the sonobuoy to be recorded. The whale-to-sonobuoy distance will vary somewhat with each location based upon sound propagation loss parameters that are dependent upon environmental factors such as water depth, ice coverage, and sea state (Urick, 1983). To compare call samples recorded near whales involved in a variety of behaviors, a behavioral index was derived by ranking behaviors by their general surface activity level, then multiplying the rank by the number of surfaced whales seen within 10 km of the sonobuoy exhibiting that behavior and dividing by the number of whales. Behaviors were ranked and abbreviated as follows:

0 = resting (RE)
1 = swimming or diving (SW or DV)
2 = milling or mild social (ML or MS)
3 = feeding (FE)
4 = cow/calf association (CC)
5 = active social or play (AS or PL)
6 = display (DY)

These rankings attempted to reflect the relative level of exertion required of the whale involved in the behavior.

Of a sound sample containing 170 discrete calls, 61 percent were simple moans and 39 percent were complex moans (Table 19). The four most common call types were growl (35%), down (25%), up (19%) and inflect (11%). It appears that resting or swimming bowheads produce mostly tonal FM calls, and that complex AM sound production increases with increasing levels of social behavior (Ljungblad et al., 1984; Würsig et al., 1985). This assertion appears to be generally true of the 1985 sound sample. The combined proportion of simple FM calls were greatest on 23 September (77%) when whales were swimming and milling, and on 25 September (87%) when resting and swimming whales were seen. Conversely, complex AM calls were prevalent on 11 September (56%) when whales were resting, feeding and involved in mild social behaviors, and on 27 September (54%) when a sonobuoy was dropped near swimming and mildly social whales that included a cow-calf pair. The relatively high proportion of complex calls (53%) recorded on 13 October, when no

R an bo N N

Date	Sample Duration[1]	No. Whales	General Behavior[2]	Behavior Index	Call Rate 3	Up No. (%)	Down No. (%)	Const No. (%)	Inflect No. (%)	High No. (%)	Growl No. (%)	Trumpet No. (%)	Total No.	Comment
11 Sept[4]	0.72	18	RE/MS/FE	1.7	0.7	1(11)			3(33)		5(56)		9	distant ai rgun noise
23 Sept[4]	0.23	8	SW/ ML	1.5	16.3	14(47)	8(27)			1(3)	7(23)		30	relatively loud ambient noise
25 Sept	0.45	4	RE/S W	0.5	21.1	9(24)	11(29)	3(8)	8(21)	2(5)	5(1 3)		38	water noise
27 Sept	0.33	11	SW/MS/CC	2.1	14.6	8(15)	9(17)	1(2)	4(8)	2(4)	29(54)		53	belukha calls, a/c noise
13 Ott	0.20	6	RE/SW	0.8	33.3	1(2)	14(35)	1(2)	3(8)		14(35)	7(18)	40	95% ice coverage, a/c noise
Total	1.93	47			1.9	33(19)	42(25)	5(3)	18(11)	5(3)	60(35)	7(4)	170	

1) Sample duration in hours

2) Abbreviation Key, p. 58

3) Call rate = $\frac{\text{No. calls/sample duration (h)}}{\text{No. Whales}}$

4) Recordings made on N545N surveys (Appendix C)

Table 20. Summary of bowhead calf sightings, fall 1985.

Date	Flt	Latitude (oN)	Longitude (°W)	Heading (°M)	Behavior
8 Aug	17	70°13.8'	140006.1’	--	resting at surface alone
27 Sept	48	70°26.7'	143006.6’	210	swimming close to cow
27 Sept	48	70°27.1'	143007.7’	340	swimming in group of 3
27 Sept	48	70°27.8'	143014.0’	210	swimming in group of 5
6 Ott	54	71°20.5'	150047.4’	--	resting at surface in group of feeding whales
6 Ott	54	71°20.5'	150047.4’	--	resting at surface in group of feeding whales
6 Ott	54	71°20.5'	150047.4’	--	resting at surface in groups of feeding whales

“social whales” were seen, underscores the difficulty of definitely ascribing call types to behavior; either the whales making the complex calls went unseen, or the assumption that only “social whales” are complex call producers is a shaky one. A regression analysis revealed no significant correlations between call types, nor between behavior index and call types. There was a significant correlation between call rate and the FM2 call type ($r = 0.942$, $p <0.005$, $n = 5$) indicating that as call rate increases more “down” calls are produced. In addition, there was a trend for call rate to be negatively correlated with the number of whales ($r = -0.858$, $p <0.10$, $n = 5$), indicating that a higher call rate may not correspond to relatively more whales (i.e. not all whales seen are calling).

Recruitment

Seven calves were among the total of 139 bowheads seen from the primary aircraft (N780), resulting in a GARR of 5.04 percent (Table 20). This estimate was higher than for any fall except 1982 (Ljungblad et al., 1985). One solitary calf was seen on 8 August (Appendix A: Flight 17). Three calves were seen on 27 September (Appendix A: Flight 48), and 3 calves were seen on 6 October within a group of 18 bowheads presumed to be feeding (Appendix A: Flight 54). The crew aboard the aircraft assessing bowhead migratory status (N545N) sighted 5 calves among 106 whales (Appendix C: Table C-4), yielding a combined GARR of 4.90 percent for the two aircraft. This combined recruitment estimate was nearly identical to the 4.87 estimate calculated for the 1982-85 combined sightings from primary and secondary aircraft surveying for bowheads in the Alaskan Beaufort Sea (Clarke et al., 1986).

Other Species

Belukha Whale

One hundred sixteen sightings of 439 belukhas were made by the primary aircraft (N780), and six sightings of 54 belukhas were made by the secondary aircraft (N545N; Appendix C) in fall (Figure 18). Belukhas were seen both singly and in groups of 2 to 28. The majority of belukhas (98%, n = 483) seen were swimming, and 8.1 percent (n = 40) were judged to be calves.

Belukha whale distribution during the fall was generally north of the bowhead distribution, although there was overlap in near-shore areas. Belukhas were sighted in depths ranging from 5 to 2868 m ($\bar{x}$ = 446.5 m), significantly deeper than depths in which bowheads were sighted ($\bar{x}$ = 56.2 m, t = 5.102, df = 171, p <0.001). Belukha headings were nonsystematic until September when there was significant clustering about a mean heading of 2630T (z = 6.95, p < 0.001). Belukhas sighted in October in both the Beaufort and Chukchi Seas maintained mostly westerly headings ($\bar{x}$ = 2540T, z = 4.46, p < 0.01).

Pinnipeds

Nineteen bearded seals and one ringed seal were seen during the fall, fewer than have been seen in any previous season (Ljungblad, 1981; Ljungblad et al., 1980, 1982, 1983, 1984a, 1985 b). Seventy-one percent (n = 50) of all pinnipeds seen could not be positively identified.

Polar Bear

Six polar bears were seen by the primary aircraft in late September and October. One bear was seen on 25 September, 60 km north of Barter Island at 70036 .3'N, 143°22.9'W (Appendix .4: Flight 46). Two bears were seen on 10 October in the Chukchi Sea; one on 50 percent ice at 71011.8'N, 164021 .5'W, and

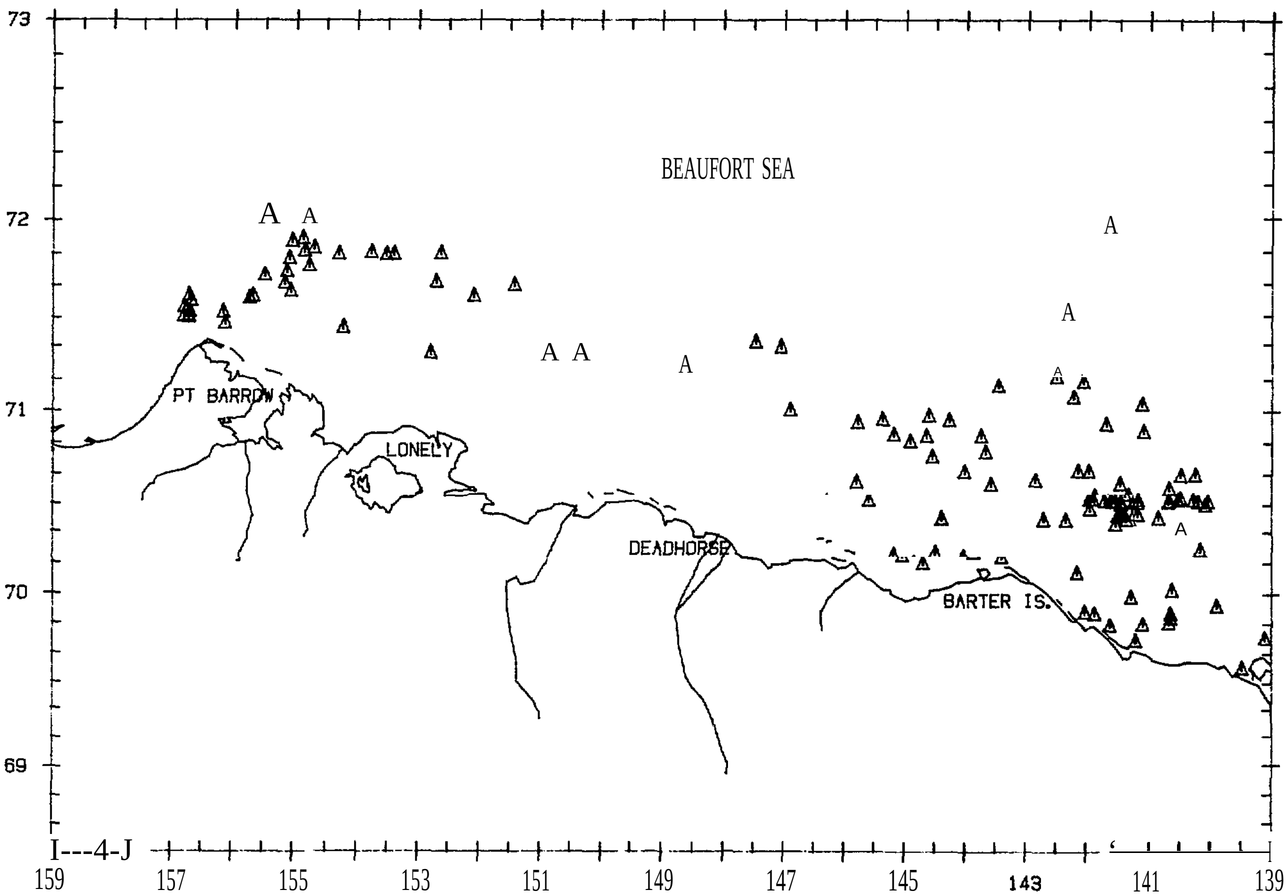


Figure 18. Distribution of 122 sightings of 493 belukha whales, incorporating sightings from both primary and secondary aircrafts, fall 1985.

one on 98 percent ice at 7 1°16.6'N, 16202 1.8'W (Appendix A: Flight 56). Three bears, a sow, and two large cubs were seen in the western Beaufort Sea on 16 October at 71°28.8'N, 154° 16.4'W (Appendix A: Flight 62). The secondary aircraft sighted five bears during September (Appendix C: Flights C-7 and C-9).

CONCLUSIONS AND REVIEW 1979-85

This section represents a review and synthesis of data gathered on aerial surveys of endangered whales conducted from 1979 to 1985. Results of these surveys have appeared in annual reports finalized as NOSC technical documents or technical reports (Ljungblad 1981; Ljungblad et al., 1980, 1982, 1983, 1984a, 1985) and in summary manuscripts presented in the proceedings of the International Whaling Commission (IWC) annual meetings (Ljungblad et al., 1986a, 1986b; Moore et al., 1986a, 1986 b).

The objectives and methods of data collection and analysis on the primary aircraft (N780) have remained similar throughout all years with the exception of the use of a microcomputer aboard the aircraft since 1982 to record and later analyze 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 follows the seasonal format of the field efforts, i.e., summer (June, July) and fall (August, September, October, November). This was the first year since 1979 that surveys were not flown in spring (April, May). A review of six years of spring survey efforts and results was presented in Ljungblad et al. (1985). The objectives for each season are briefly stated prior to presentation of the summary data.

SUMMER (June, 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 Summary

A total of 354.3 survey hours have been flown in summer since 1980, with 32 percent (1 14.6 h) of this effort in the Beaufort Sea, 32 percent (1 12.2 h) in the Chukchi Sea, and 36 percent (127.5 h) in the northern Bering Sea (Table 21). There

Table 21. Summary of of flight effort (hours: minutes) bysea, summer 1980-85.

	1980	1981	1982	1983	1984	1985	Total	(%)
Bering Sea	1:35	63:47	31:20	22:36	3:22	4:50	127:30	(36)
Chukchi Sea	6:54	39:46	13:11	3:23	14:59-	34:01	112:14	(32)
Beau fort Sea	83:55	5:15	1:31	2:10	13:16	8:30	114:37	(32)
TOTAL	92:24	108:48	46:02	28:09	31:37	42:21	354:21	(100)

were no summer surveys flown in 1979, and surveys were conducted in June only in 1980 and 1981. 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, survey shave begun on or after 10 July.

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 coverage (≥90 percent) was found near-shore. between Barrow and Wainwright through mid-July, diminishing to about 70 percent by 3 I July. Between Wainwright and Icy Cape, ice coverage ranged from 90 to 60 percent in mid-July, diminishing to open water to 30 percent at Icy Cape and 50 to 70 percent coverage at Wainwright by 31 July. In the Beaufort Sea, near-shore (≤1 O km) areas were often ice-free, while offshore coverage ranged from 70 to 90 percent throughout the summer.

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. Sea states in the northern Chukchi Sea and Beaufort Sea generally ranged from 00 to 03 throughout the summer due to the dampening influence of the predominant heavy ice coverage.

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.

BOWHEAD WHALE

Distribution

Fifteen sightings of 16 bowheads were made in June 1980. The distribution of whales was roughly from 71°20'N to 71°39'N, between 147°40'W and 141 °15'W (Figure 19). This distribution was probably strongly influenced by nearly continuous pan and shorefast ice coverage (i.e. 99-100%) south of 7 1°20'N. Bowheads were never seen in the Alaskan Beaufort Sea on July surveys.

Habitat Relationships and Behavior

Bowheads seen in June were generally in heavy ice ($\geq$90%), although data on ice type and coverage was not routinely recorded for each sighting in 1980. Depth at bowhead sightings ranged from 2261 m to 3212 m ($\bar{x}$ = 2880 m, 288 s.d.), reflecting the offshore shorefast ice-influenced distribution.

Most whales seen in June were migrating eastward ($\bar{x}$ = 83°T, z = 8.12, $p < 0.001$). Swimming (12%, n = 2) and diving (75%, n = 12) comprised the majority of behaviors seen. One whale was seen breaching (6%) and one whale was resting (6%) during this time period. These behavioral indices are similar to those reported for bowheads migrating through the Alaskan Beaufort Sea in April and May (Ljungblad et al., 1985).

GRAY WHALE

Distribution and Density

Eight hundred fifty-three sightings of 2490 gray whales were made over six survey seasons: 58 sightings of 152 whales were made in June 1981 (Figure 20A), and 795 sightings of 2338 whales were made on surveys conducted in July 1980-85 (Figure 20B). As previously mentioned, surveys were conducted only in the Beaufort Sea in June 1980 and no gray whales were seen there.

The highest annual gray whale density estimates (Figure 21), calculated for the month of July 1980-85, were localized in two areas:

(1) the Chirikov Basin north of Saint Lawrence Island where highest annual densities ranged from 0.360 to 1.70 whales/km^2, and

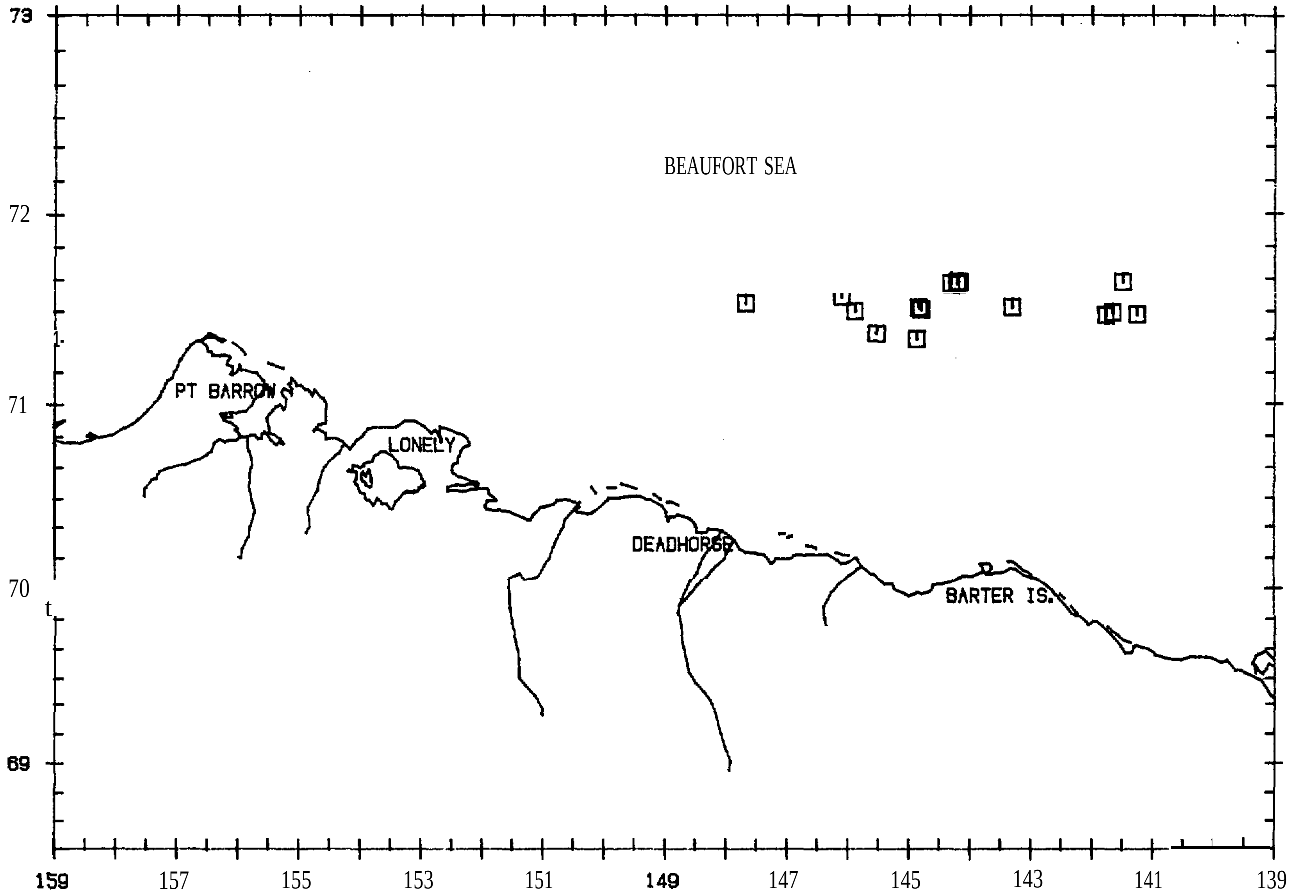


Figure 19. Distribution of 15 sightings of 16 bowhead whales, summer 1979-85 (June 1980).

(2) the coastal Chukchi Sea between Point Hope and Barrow where highest annual densities ranged from 0.261 to 1.47 whales/km^2.

The coastal waters south and east of Saint Lawrence Island supported relatively high densities of gray whales in 1982 (0.350 to 1.087 whales/km 2), the only year that the area was adequately surveyed to support the calculation of density estimates.

Gray whale distribution and highest densities correspond to areas where dense prey assemblages have been documented. The Chirikov Basin, in the north central Bering Sea, and coastal areas of Saint Lawrence Island have been described as primary feeding areas for gray whales (Rice and Wolman, 1971; Zimushko and Ivashin, 1979; Bogoslovskaya et al., 1981). Dense assemblages of benthic amphipods, dominated by the tube-building species Ampelisca macrocephala in the Chirikov Basin and by other more mobile species (eg., Anonyx and Pontoporeia spp.) in shallow waters near Saint Lawrence Island, have been reported (Stoker, 1981; Nerini and Oliver, 1983; Nerini, 1984; Oliver et al., 1984). The prey communities along the coastal Chukchi Sea are not as well documented (Stoker, 1981), but

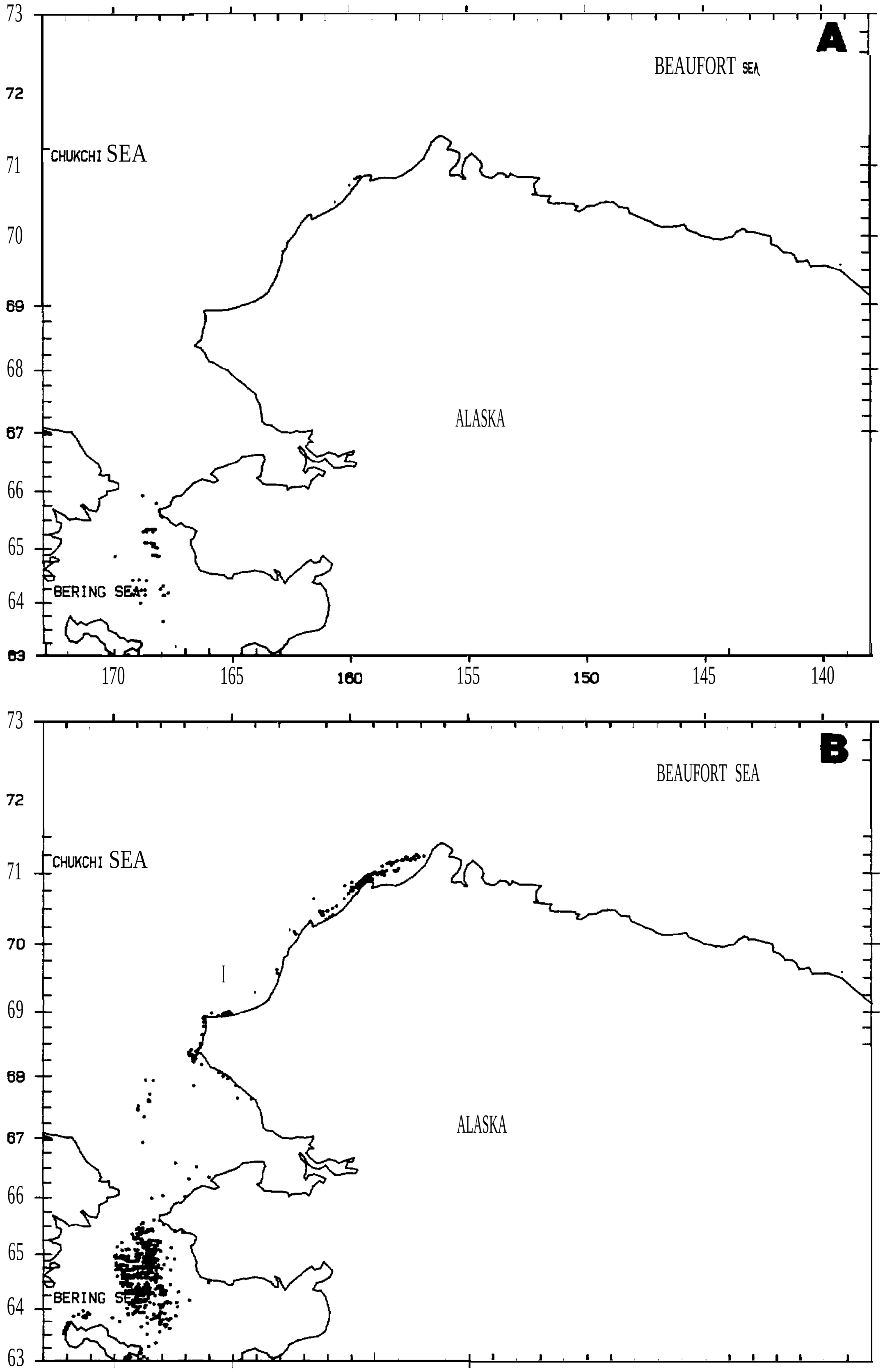


Figure 20. Distribution of 853 sightings of 2490 gray whales, summer 1980-85: 58 sightings of 152 whales, June (A); 795 sightings of 2338 whales, July (B).

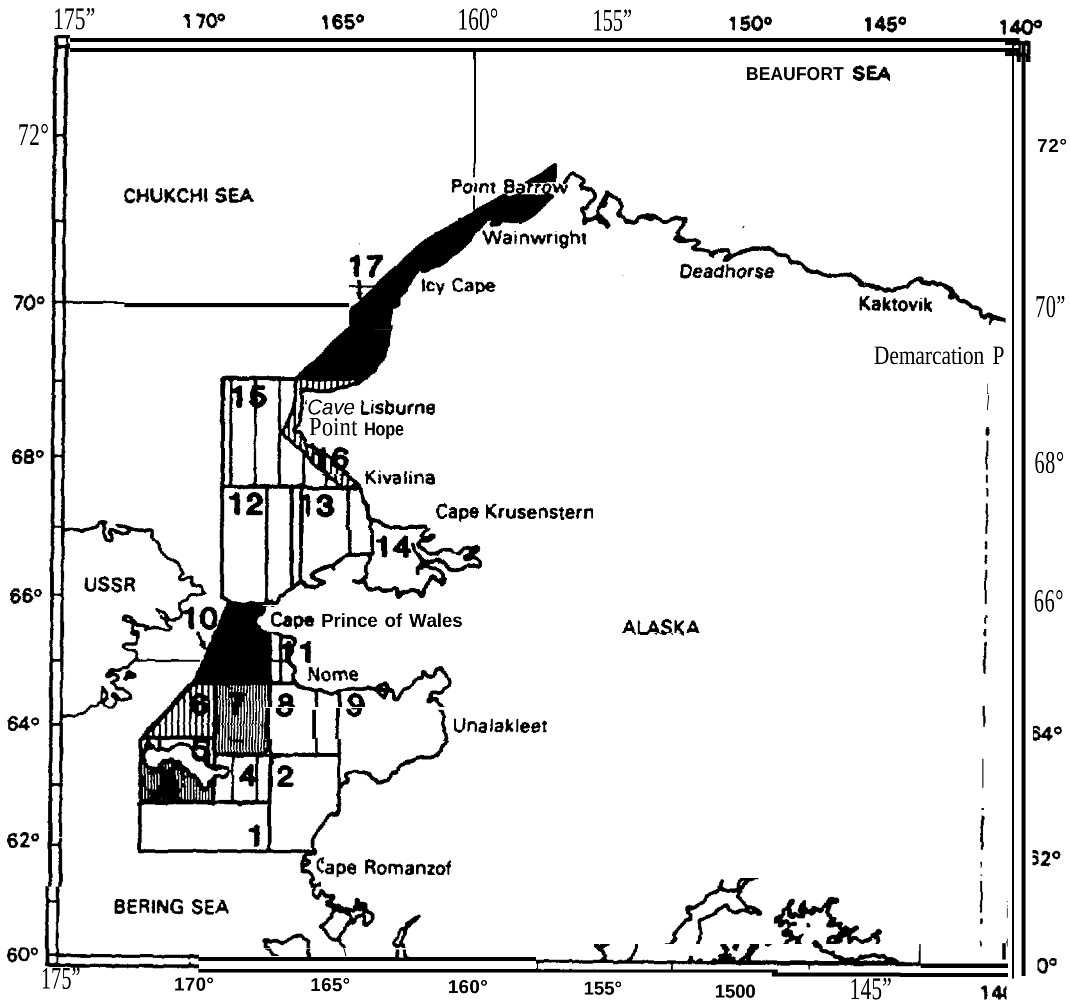


Figure 21. Highest annual gray whale densities/region, summer 1980-84. Shading varies from white (representing O density) to black (representing 0.495 whales/km ^{2}). Densities presented here from Appendix B: Table B-2.

appear to consist of a variety of epibenthic and infaunal species. Benthic communities sampled south of Point Hope (water depth approx. 10-15 m), northeast of Cape Lisburne (water depth approx. 10 m) and southwest of Wainwright (water depth 25-30 m) were of three distinct types (3. Oliver, personal communication). The community south of Point Hope consisted largely of swarms of epibenthic crustaceans (eg. mysids, amphipods, and shrimp) found above a course gravel bottom. The prey assemblage was found by divers sampling an area where four

Table 22. Annual summary of gray whale behavior, summer 1980-85.

	1980	1981	1982	1983	1984	1985	Total	(%)
BEHAVIOR:								
Swim/Dive	18	133	134	499	13	183	980	(39)
Feed	18	190	116	465	36	466	1291	(52)
Rest	0	3	32	57	0	22	114	(5)
Cow-Calf	12	12	38	2	2	34	100	(4)
Display	0	1	1	3	0	0	5	(0.2)
TOTAL	48	339	321	1026	51	705	2490	

gray whales appeared to be feeding and seemed to be very localized, as samples taken nearby but not directly under the feeding whales contained much lower prey densities. The samples collected northeast of Cape Lisburne were dominated by epibenthic isopods (Tectaceps spp.) that perch or crawl across the bottom. The stomach of a gray whale killed by killer whales (Orcinus orca) in this area was full of isopods. Southwest of Wainwright, infaunal amphipod communities similar to those in the Chirikov Basin and epibenthic cumaceans swarming 0.5 to 1 m off the bottom were sampled from areas where gray whales appeared to be feeding. In summary, gray whales feeding along the coastal Chukchi Sea probably forage opportunistically upon a mosaic of localized benthic communities consisting of both infaunal and epibenthic forms (3. Oliver, personal communication). Whales feeding on epibenthic animals probably do not create mud plumes characteristic of whales foraging on infaunal species, thus their feeding may go unrecognized by aerial observers.

Habitat Relationships and Behavior

Gray whales were seen from 0.5 to 140 km from shore in water 7 m to 60 m deep ($\bar{x}$ = 36.7, 8.7 s.d.). Although 97 percent (n = 2415) of all gray whales were seen in open water, whales in the northeastern Chukchi Sea were sometimes found in ice coverage up to 30 percent.

More gray whales seen during summer surveys were feeding (52%, n = 1291) than any other single activity (Table 22). Other behaviors observed included

Table 23. Number of gray whale calves/total number of gray whales (C/GW) and estimated recruitment rate (GARR) by sea, summer 1980-85.

YEAR	Bering Sea C/GW (GARR)	Chukchi Sea C/GW (GARR)	TOTAL C/W (GARR)
1980*	--	6/46(0.13)	6/46(0.13)
1981	1/223(0.005)	5/116(0.04)	6/339(0.02)
1982	1/206(0.005)	18/115(0.15)	19/321(0.06)
1983	1/1005(0.001)	0/21(0)	1/1026(0.001)
1984	1/24(0.04)	0/27(0)	1/51(0.02)
1985	2/477 (O .004)	15/228(0.07)	17/705(0.02)
TOTAL	6/1935(0.003)	44/553(0.08)	50/2488(0.02)

*ERRATUM: Ten sightings of 48 gray whales were recorded in error as 10 gray whales in Ljungblad et al. (1981, p. C-96 and 1985a, p. 94). Twoof the48 gray whales werein the Beaufort Sea.
-- = no surveys flown

swimming (39%, n= 980), resting (5%, n= 114), cow-calf associations (4%, n= 100) and displaying (<1%, n= 5). Swimming direction was not consistently clustered about any heading, indicating little directed movement for summering whales.

Recruitment

Fifty gray whale calves have been seen in the northern Bering and eastern Chukchi Seas since 1980 (Table 23). Annual recruitment estimates (GARR) ranged from 0.1 to 13 percent with an overall GARR of 2.0 percent calculated over six seasons. This overall estimate is similar to the 2.5 percent annual recruitment rate (95% confidence limits = 0.4% to 4.6%) calculated by Reilly (1984), as reviewed by Cooke (1986).

Annual differences in GARR by sea were statistically significant ($X^2 = 128.3$, p&O.001), and seemingly ref lect a partial segregation of cow-calf groups on the northern range as suggested in Moore et al. (1986b). Of the 50 gray whale calves seen since 1980, six were seen among 1935 whales in the Bering Sea and 44 were among the 553 whales in the Chukchi Sea (Table 23). Resultant GARR ranged from 0.001 (1983) to 0.04 (1984) and averaged 0.003 in the northern Bering Sea. In the Chukchi Sea, GARR ranged from 0.0 (1983-84) to 0.15 (1982) and averaged 0.08.

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 was not known with certainty for any year. Thus, the estimates presented in Table 23 represent only the observed ratio of calves to adults, and should be interpreted within the confines of the time periods and regions surveyed.

Relative abundance of gray whale calves (CPUE: calf per unit effort, unit effort = 1 hour survey time) was also significantly higher in the Chukchi Sea (0.39) than in the Bering Sea (0.05, $X^2 = 41.23$, $p < 0.001$; Table 24). Gray whale CPUE values were lowest in 1983 (0.04) and 1984 (0.05), when only one calf was seen per year, and in 1981 (0.06) when six calves were seen with far greater survey effort than in any other year. Relative abundance of gray whale calves was highest in 1980 (0.71), when six calves were seen between Pt. Hope and Cape Lisburne during a coastal survey. Overall, CPUE per block was highest in block 22 in 1980 (7.79), 1981 (0.51) and 1985 (1.55), in block 13 in 1982 (9.92) and in block 26 in 1983 (0.12) and 1984 (2.56). Highest CPUE per block for the Bering Sea was in block 25 (0.1 2). Highest CPUE per block in the Chukchi Sea, and for both seas across all years, was calculated for block 22 (1.27).

Cow-calf segregation has been reported for gray whales on the southern range (Jones and Swartz, 1984), and along their migration route (Rice and Wolman, 1971; Herzing and Mate, 1984; Poole, 1984). Harvest data also indicates that gray whales remain at least partially segregated and generally in coastal waters on the summer range (Blokhin, 1982, 1986; Votrogov and Bogoslovskaya, 1980). In addition, Maher (1960) reported the observation of “three calves with their mothers, and four to six other adults” near Cape Lisburne, and that gray whales taken near Barrow from 1954 to 1959 were either calves (n = 6), lactating females (n = 2), or juveniles (n = 2). Thus, it appears gray whales may maintain patterns of reproductive-class segregation throughout their range.

Although segregation of cow-calf groups on the feeding grounds may be expected as an extension of parturition and migratory segregation it is surprising that such groups, which enter the northern feeding grounds later, were found on the more northerly peripheral feeding area of the coastal Chukchi Sea rather than on the central feeding ground of the northern Bering Sea. Predator avoidance may be a causal factor in such distributional differences. Edwards (1983) reported that

Table 24. Relative abundance of gray whale calves (CPUE) = no. calves/hour of survey effort) by block, summer 1980-85.

Blocks	19s0 Survey Hrs	No. Calves	CPUE	1981 Survey Hrs	No. Calves	CPUE	1982 Survey Hrs	No. Calves	CPUE
Chukchi Sea									
13	0.55	o		1.s5	0		1.31	13	9.92
14	0.00	0		0.00	0		0.00	0	
15	0.00	'3		0.00	0		0.'20	0	
17	0.54	o		?.06	1	'5.49	0.73	0	
18	0.00	0		0.00	0		0.00	0	
19	0.00	0		0.00	0		0.00	0	
20	0.69	0		3.s3	0		0.75	5	6.67
21	0.00	0		0.01	0		0.00	0	
22	0.77	6	7.79	S.89	3	0.51	'2.5s	0	
23	0.43	0		4.29	1	0.23	0.00	o	
24	0.76	o		4.24	0		7.17	0	
unblocked	3.11	0		17.59	0		2.65	0	
Chukchi Sea Subtotal	6.90	6	0.s7	39.76	5	0.13	13.19	Is	1.36
Bering Sea									
23	0.7'2	0		13.24	1	0.0s	6.44	0	
26	0.00	0		2.36	0		5.52	O	
2s	0.2!	0		13.01	0		8.55	1	0.11
29	0.00	0		5.94	0		0.00	o	
unblocked	0.67	0		25.9s	0		4. 46	O	
Bering Sea Subtotal	1.58	0		63.79	1	9.02	31.33	1	0.03
GRAND ToTAL	8.48	6	%71	1'23.55	6	0.06	44.52	19	0.43

Blocks	1983 Survey Hrs'	No. Calves	CPUE	[9s4 Survey Hrs	No. Calves	CPUE	1985 Survey Hrs	No. Calves	CPUE	TOTAL Survey Hrs	No. Calves	CPUE
Chukchi Sea												
13	0.02	0		5.93	o		9.77	7	0.72	19. s3	20	1.01
14	0.00	0		3.12	0		3.2S	0		6.37	0	
15	0.00	0		0.00	0		3.22	0		3.22	0	
17	0.7s	0		3.07	0		3.s1	2	0.52	10.99	3	0.27
1s	0.00	0		0.62	0		2.90	0		3.52	0	
19	0.00	0		0.00	0		0.33	0		0.33	0	
20	0.94	0		0.95	0		2.85	0		10.01	5	0.s0
21	0.00	0		0.00	0		1.91	0		1.92	0	
22	0.39	0		0.31	0		3.s8	6	1.55	11.82	15	1.27
23	0.00	0		0.39	0		0.00	0		5.16	1	0.19
24	0.18	0		0,52	0		0.17	0		13.04	0	
	0.68	0		0,07	0		1.92	0		26. 02	O	
Chukchi Sea Subtotal	3.39	0		14.9s	0		34.01	15	0.44	112.23	44	0.39
Bering Sca												
25	2,54	0		0.14	0		2.46	2	0.s1	25.52	3	0.12
26	8.37	I	0.12	0.39	1	2.56	2.21	0		20.29	2	0.10
27	1.88	o		0.00	0		0.00	0		9.76	0	
29	4.s1	0		2.s1	0		0.16	0		29.85	I	0.03
29	2.54	0		0.00	0		0.00	0		8.48	0	
. . blocked	2.46	0		0.03	0		0.00	0		33.60	O	
Bering Sea Subtotal	22.60	1	0.04	3.37	1	0.30	4..93	2	0.41	127.50	6	0.05
GRAND TOTAL	25.99	I	0.04	1s.35	1	0.05	33.84	17	0.44	Z39. 73	so	0.21

cow-calf moose (Alces alces andersoni) pairs on Isle Royale, Michigan, were found on suboptimal peripheral feeding areas that were wolf-free, while solitary adults and yearling moose were found in the presence of wolves (Canis lupus) in areas of optimal forage. Killer whales (Orcinus orca) are known gray whale predators and have been observed chasing (Ljungblad and Moore, 1983) and killing (Braham et al., 1981) gray whales in the northern Bering Sea. Although killer whales have been reported in low numbers along the coastal Chukchi Sea (Frost et al., 1983), and a group of killer whales was observed to kill and partially devour a small gray whale near Cape Lisburne in July 1984 (J. Oliver, personal communication), it is likely that gray whales encounter fewer killer whales there than in the Bering Sea (Dahlheim, 1981). Intraspecies competition may be a more likely causal factor in relegating cow-calf groups to coastal, or peripheral, feeding areas. An alternate gray whale feeding ground near Bamfield, British Columbia has been reported, and observations made there on the respiration pattern of a "small" (6 m) feeding whale (Oliver et al., 1984). Because killer whales are common in waters near British Columbia (Dahlheim, 1981), intraspecific competitive factors rather than predator avoidance might be important correlations in finding young gray whales there. In summary, gray whale cows with calves may be excluded from, or prefer to stay away from, dense aggregations of adult and sub-adult whales on the central Bering Sea feeding ground and are more often found along the coastal Chukchi Sea.

FALL (August - November)

The primary objectives of fall aerial surveys have been to determine the distribution and timing of the bowhead whale migration, to derive relative and absolute abundance estimates in or near proposed or existing federal lease areas, and to describe bowhead whale general behavior and record underwater sound production.

Survey Effort and Conditions Summary

A total of 1509.8 survey hours has been flown in the fall since 1979, with 88 percent (1325.9 h) of this effort in the Beaufort Sea, 9 percent (1 34.7 h) in the Chukchi Sea, and 3 percent (49.2 h) in the northern Bering Sea (Table 25). There has been considerable variability in survey effort over the years. There was little effort flown in August 1979-81 due to aircraft unavailability and/or its diversion to support other M MS-funded projects. Although surveys were flown each year in

Table 25. Summary of flight effort (hours: minutes) by sea, fall 1979-85.

	1979	1980	1981	1982	1983	1984	1985	Total (%)
Bering Sea	o	33:45	14:43	0	0:42	0	0	49:10(3)
Chukchi Sea	0:48	14:30	11:24	18:56	42:41	31:19	15:06	134:44(9)
Beaufort Sea	171:06	156:49	144:19	204:44	236:29	214:47	197:43	1325:57(88)
TOTAL	171:54	205:04*	170:26	223:40	279:52	246:06	212:49	1509:51

*includes 21:38 flown in November 1980

September, areas covered varied annually. Forexample, in 1979 and 1980 transect surveys were flown primarily near-shore in oil lease areas (blocks 1 and 3), with search surveys flown in blocks 4 and 5. In 1981, September survey efforts were divided between transect surveys in blocks 1 and 3, and behavioral observation surveys (usually in blocks 4, 5, 6 and 7) conducted in an attempt to document significant differences in bowhead whale behaviors when whales were near active geophysical vessels (Fraker et al., 1985). In 1982-85, September transect surveys were generally conductedin blocks 1 through 9 in early September, andin blocks 1 through 14, 17 and 18 from mid-September through mid-October. The termination of fall survey effort in the Beaufort Sea has occurred from 15 to 31 October. In 1980, the last surveyin the Beaufort Sea was flownon 250ctober, but surveys in the northern Bering Sea were continued through 4 November.

Fall ice conditions varied annually, but may be generally regarded as predominantly heavy (70% to 9096), or light (O to 30%) coverage. In light ice years (1979, 1981, 1982, 1984) ice coverage in the Alaskan Beaufort Sea was relatively heavy through early August, became and remained light from mid-August through September, with freeze up commencing in early October. In heavy ice years (1980, 1983) ice coverage remained heavy throughout the fall season. Ice conditions in 1985 did not conform completely to this paradigm, however, as coverage in early and late September was ≤60% in some areas, resulting in average ice coverage for the 1985 season that was intermediate (30% c_ ice c_ 70%) to previous years.

Table 26. Bimonthly summary of bowhead whale sightings (number of sightings/number of whales), fall 1979-85.

YEAR	AUGUST		SEPTEMBER		OCTOBER		TOTAL
	1-15	16-31	1-15	16-30	1-15	16-31	
1979	(o)	(4/7)	2/2	28/58	60/86	27/44	121/197
1980	(o)	(o)	9/12	15/22	8/12	(0)	32/46
1981	(o)	(1/2)	47/63	144/169	43/54	--	235/288
1982	57/108	22/37	23/54	90/247	27/43	(1/1)	222/490
1983	25/49	7/10	19/24	41/54	17/24	(7/11)	116/172
1984	2/3	11/18	12/17	64/243	52/77	(13/22)	154/380
1985	8/9	3/3	13/34	18/33	34/59	(1/1)	77/139
TOTAL	(92/169)	(48/77)	127/206	400/826	241/355	(49/79)	957/1712

(surveys not conducted over entire period)

-- = no surveys conducted

Sea states encountered on fall surveys ranged from 00 to 06, with 01 to 03 conditions the most common. Sea states during heavy ice years generally ranged from 00 to 02 due to the dampening influence of the ice coverage. Fog often caused surveys to be truncated or aborted in August and September when ice conditions changed daily. In October, high winds often curtailed survey efforts.

BOWHEAD WHALE

Distribution, Relative Abundance, and Density

There were 957 sightings of 1712 bowheads made over seven fall seasons (Table 26, Figure 22). The distribution of 139 bowheads seen in 1985 (Figure 11) was similar to, but not comprehensive of, past years.

In August, bowheads have been seen from 0.5 to 180 km from shore between 138°W to 147°W (Figure 22A), with annual variation as follows:

- In 1979, seven whales were seen between 1430W and 144030'W, offshore to 70041'N
- In 1981, two whales were seen near 138°W, at 69033'N

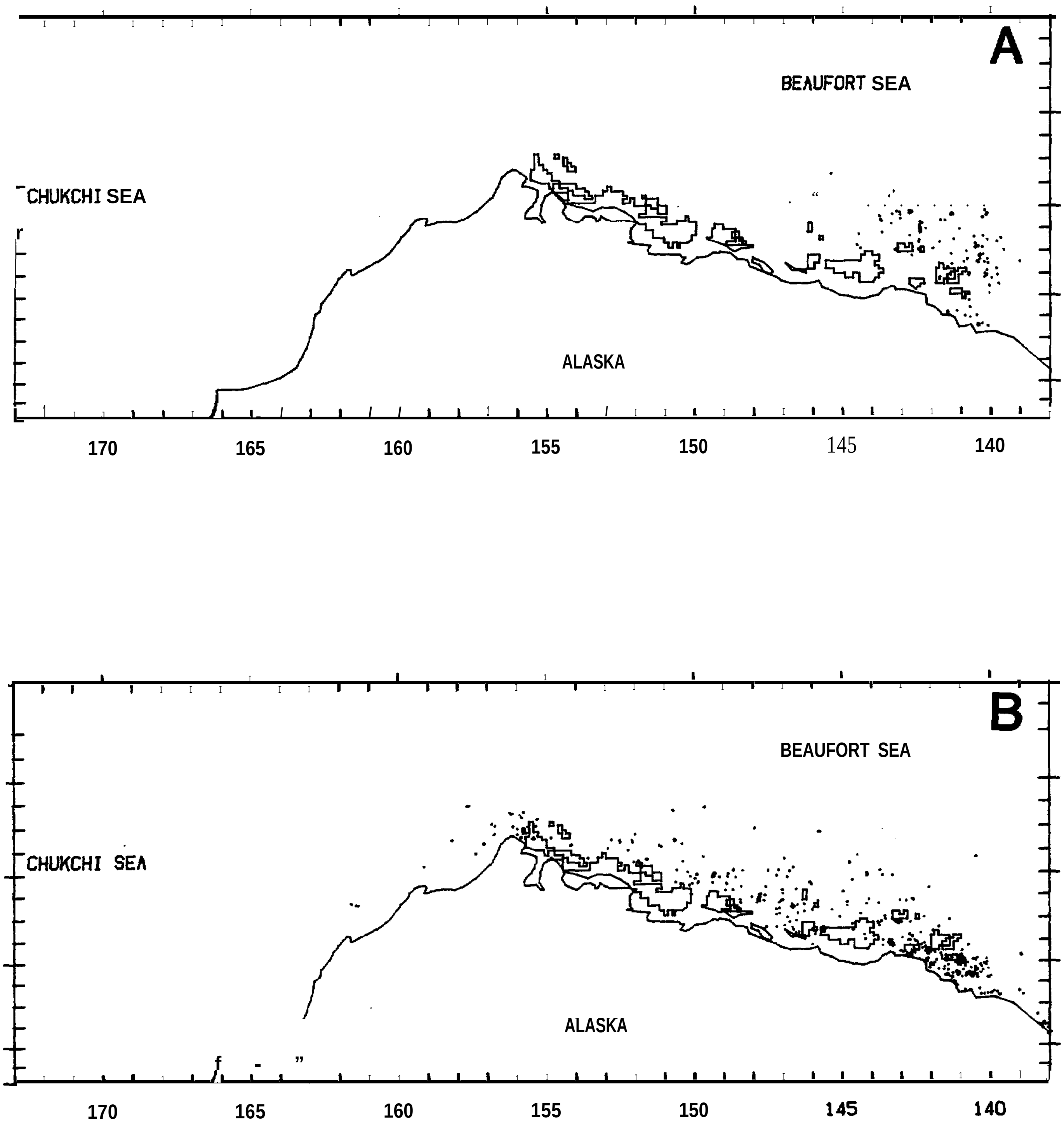


Figure 22. Distribution of 957 sightings of 1712 bowheads plotted by month, fall 1979-85: 140 sightings of 246 whales, August (A); 527 sightings of 1032 whales, September (B)

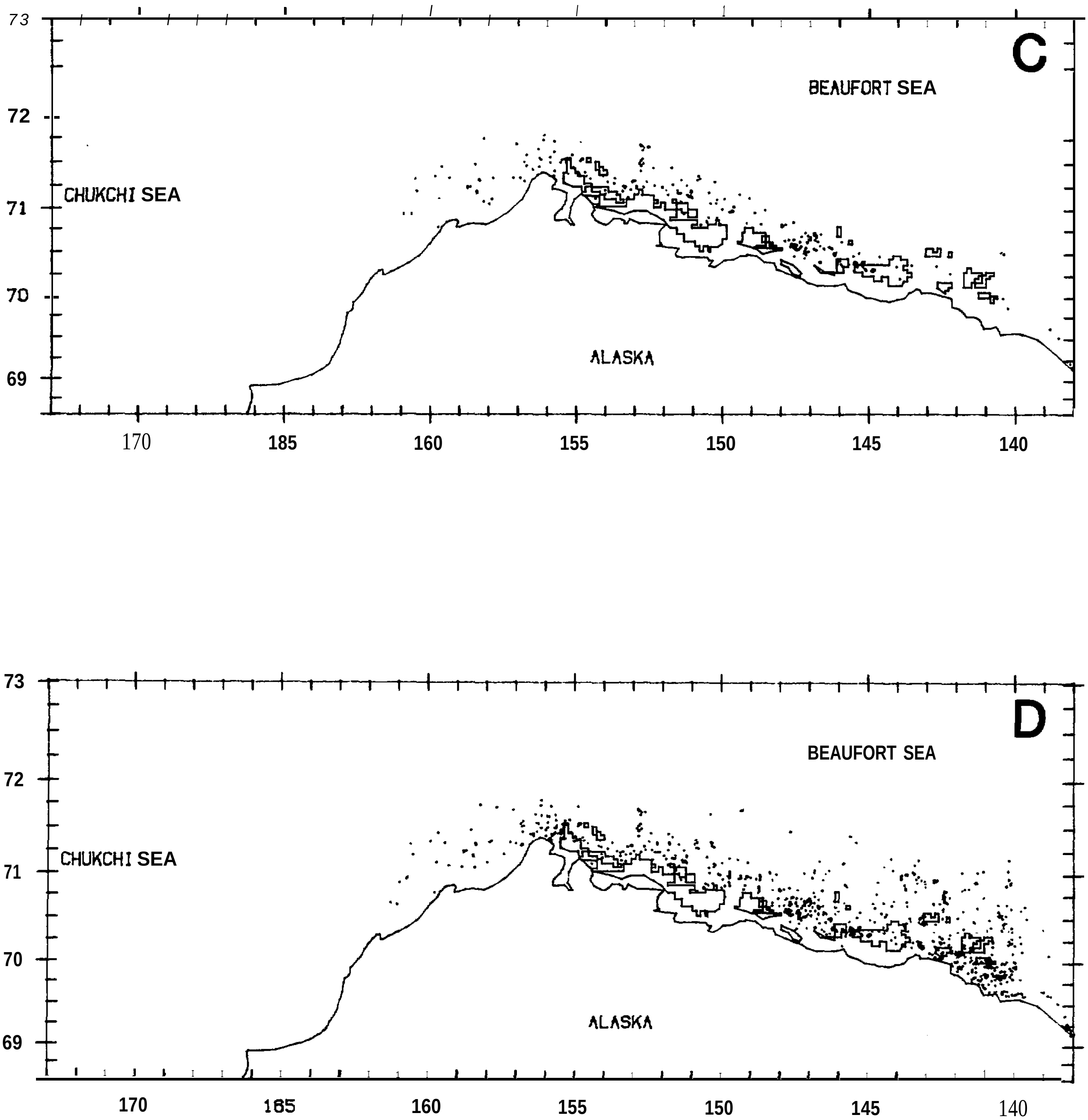


Figure 22 (contd). 290 sightings of 434 whales, October (C); all sightings (D)). Outlined areas depict OCS oil and gas lease areas within the Beaufort Sea Planning Area of the Alaskan Beaufort Sea.

- In 1982, 145 whales were seen between 139°33'W and 145049'W, offshore to 71 °54'N
- In 1983, 59 whales were seen between 139°38'W and 146048'W, offshore to 71°03'N
- In 1984, 21 whales were seen between 1390W and 141°26'W, offshore to 70°23'N
- In 1985, 12 whales were seen from 140°W to 141°56'W, offshore to 70°31'N

As previously mentioned there was little August survey effort in the Beaufort Sea in 1979-81, therefore, bowhead distribution and number are probably under-represented for those years. In 1982-85, August surveys were routinely flown in blocks 1 through 9, and bowheads were seen in all blocks except 1, 3, 4, and 8. Many more whales were seen, and their distribution extended further north and west, in 1982-83 than in 1984-85. In all years since 1982, August bowhead distribution has coincided with only the easternmost boundaries of OCS oil and gas lease areas; generally whales have been seen north, east, or shoreward of lease areas (Figure 22A).

In September, bowheads have been seen across the Alaskan Beaufort Sea generally along the shelf break and into the northeastern Chukchi Sea (Figure 22B), with annual variation as follows:

- In 1979, 60 whales were seen between 140°58'W and 146°33'W, offshore to 70°38'N
- In 1980, 34 whales were seen between 138°45'W and 149043'W, offshore to 70°53'N
- In 1981, 232 whales were seen between 138°16'W and 146°27'W, offshore to 70 °23'N
- In 1982, 301 whales were seen between 139°47'W and 155°37'W, offshore to 71°39'N
- In 1983, 78 whales were seen between 14001 2'W and 16101 4'W, offshore to 71°41'N
- In 1984, 260 whales were seen between 137058'W and 157°39'W, off shore to 71°43'N
- In 1985, 67 whales were seen between 13900 1'W and 146041'W, offshore to 70°40'N

The 1979-81 September survey effort was directed to blocks 1 through 6, and whales were seen in all blocks except 2 and 3. In 1982-85, September surveys were routinely flown in blocks 1 through 13, and occasionally in blocks 14 and 17. Notably, September bowhead distribution extended offshore to about 71°40’N in all years that survey coverage was expanded to include blocks 7 through 13, except in 1985. The 1985 distribution was similar to that observed in 1979-81 when surveys were generally confined to near-shore blocks. In all years, September bowhead distribution has overlapped the boundaries of OCS oil and gas lease areas between 141°W and 150°W, been generally north of the lease areas between 150°W and 155°W, and overlapped the northwesternmost OCS lease areas (Figure 22B).

In October, whales have been found along the shelf break in the Beaufort Sea, with relatively more whales seen west of 1500W and in the northeastern Chukchi Sea than in September (Figure 22C). Annual variation in October bowhead distribution was as follows:

- In 1979, 130 whales were seen between 144°45'W and 155°40'W, offshore to 71°32’N
- In 1980, 12 whales were seen between 144°02’W and 1530 10'W, offshore to 71°18'N
- In 1981, 54 whales were seen between 143°36'W and 153°24'W, offshore to 71°16'N
- In 1982, 44 whales were seen between 138°52'W and 160°34'W, offshore to 71°45'N
- In 1983, 35 whales were seen between 140°24'W and 163°54'W, offshore to 71°44'N
- In 1984, 99 whales were seen between 137°51’W and 159°42'W, offshore to 71°48'N
- In 1985, 60 whales were seen between 147°21'W and 160°29'W, offshore to 71°43'N

As in September, survey efforts in October were expanded to offshore Beaufort Sea, and coastal Chukchi Sea survey blocks (i.e., generally blocks 7 to 18) after 1981. In all years, October coverage included blocks 1 through 6, 11 and 12. Bowheads were seen in all Beaufort Sea survey blocks except 8, 9 and 10; in the Chukchi Sea, whales were seen in blocks 13, 14, 17 and 18. In all years, October bowhead distribution overlapped OCS lease area boundaries east of 150°W, and west of 154°W (Figure 22C).

The annual variation of bowhead relative abundance (WPUE) in the survey blocks (Table 27) reflects the patterns of survey effort and bowhead distribution discussed above. Highest seasonal WPUE was calculated for block 5 in all years except 1984 and 1985. In 1984, highest W PUE was calculated for block 12 where large aggregations of whales were seen feeding that year (Ljungblad et al., 1986a). Highest W PUE in 1985 was also associated with a group of feeding bowheads in block 11. An annual review of the shifts in highest monthly WPUE may be summarized as follows:

- In 1979, bowhead relative abundance was highest in block 6 in August, block 5 in September, and block 3 in October
- In 1980, there were no bowheads seen in August, relative abundance was highest in block 5 in September, and block 2 in October
- In 1981, bowheads were not seen in August, highest abundance was calculated for block 5 in September, and block 4 in October
- In 1982, bowhead relative abundance was highest in block 7 in August, block 5 in September, and block 13 in October
- In 1983, bowhead relative abundance was highest in block 5 in August, block 17 in September, and block 7 in October
- In 1984, bowhead relative abundance was highest in block 5 in August, block 12 in September, and block 11 in October
- In 1985, bowhead relative abundance was highest in block 5 in August, block 4 in September, and block 11 in October

Overall (1979-85), highest abundance indices were calculated for block 7 in August, block 12 in September and block 11 in October. These patterns of change in bowhead distribution and relative abundance over time indicate that whales are generally found somewhat offshore in the eastern Alaskan Beaufort Sea in August, in coastal blocks across the Alaskan Beaufort and northeastern Chukchi Sea in September, and somewhat offshore in the central and western Alaskan Beaufort Sea, and in coastal Chukchi Sea survey blocks in October. Differences in abundance indices calculated for each survey block between years reflect the annual variation in the distribution and timing of whale movements during the migration.

Table 27. Monthly and seasonal relative abundance (WPUE) of bowhead whales by survey block, fall 1979-85. Bold indicates survey blocks with the highest monthly and seasonal WPUE. WPUE = no. whales/hours of survey effort.

1979

	August			September			October			Total		
Block	Hrs	BH	WPUE	Hrs	BH	wPUE	Hrs	BH	wPUE	Hrs	BH	WPUE
1	19.25	0	-	24.33	2	0.08	55.76	88	1.58	99.34	90	0.91
2	2.15	0	-	2.50	0		3.17	0	-	7.82	0	-
3	0.00	0	-	0.65	0		7.36	27	3.67	8.01	27	3.37
4	11.63	0	-	11.39	1	0.09	4.2S	10	2.35	27.27	11	0.40
5	0.00	0	-	5.26	53	10.08	0.00	0	-	5.26	33	10.08
6	5.13	7	1.36	5.47	4	0.73	1.02	0	-	11.62	11	0.95
7	0.00	0	-	1.36	0		0.00	0	-	1.36	0	-
8	0.00	0	-	0.00	0		0.00	0	-	0.00	0	-
9	0.00	0	-	0.00	0		0.00	0	-	0.00	0	-
10	0.36	0	-	0.00	0		0.00	0	-	0.36	0	-
11	0.00	0	-	0.00	0		1.29	0	-	1.29	0	-
12	0.00	0	-	0.42	0		7.14	5	0.70	7.S6	5	0.66
13	0.00	0	-	0.00	0		0.19	0	-	0.19	0	-
14	0.00	0	-	0.00	0		0.00	0	-	0.00	0	-
15	0.00	0	-	0.00	0		0.00	0	-	0.00	0	-
16	0.00	0	-	0.90	0		0.00	0	-	0.00	0	-
17	0.00	0	-	0.00	0		0.00	0	-	0.00	0	-
18	0.00	0	-	0.00	0		0.00	0	-	0.00	0	-
19	0.00	0	-	0.00	0		0.00	0	-	0.00	0	-
20	0.00	0	-	0.00	0		0.00	0	-	0.00	0	-
21	0.00	0	-	0.00	0		0.00	0	-	0.00	0	-
22	0.00	0	-	0.00	0		0.00	0	-	0.00	0	-
23	0.00	0	-	0.00	0		0.00	0	-	0.00	0	-
24	0.00	0	-	0.00	0		0.00	0	-	0.00	0	-
25	0.00	0	-	0.00	0		0.00	0	-	0.00	0	-
26	0.00	0	-	0.00	0		0.00	0	-	0.00	0	-
27	0.00	0	-	0.00	0		0.00	0	-	0.00	0	-
28	0.00	0	-	0.00	0		0.00	0	-	0.00	0	-
29	0.00	0	-	0.00	0		0.90	0	-	0.00	0	-
Block Total	38.52	7	0.18	51.38	60	1.17	80.18	130	1.62	170.08	197	1.16
Total Canada	0.00	0	-	0.00	0		0.00	0	-	0.00	0	-
Total Unblocked	0.00	0	-	0.00	0		1.82	0	-	1.82	0	-
GRAND TOTAL	38.52	7	0.18	>1.38	60	1.17	82.00	130	1.59	171.90	197	1.15

1980

	August			September			October			Total		
Block	Hrs	BH	WP UE	Hrs	BH	wPUE	Hrs	BH	WPUE	Hrs	BH	WPUE
1	7.48	0		38.98	15	0.38	19.55	2	0.10	66.01	17	0.26
2	0.36	0		1.16	0		1.69	2	1.18	3.21	2	0.62
3	7.00	0		12.01	0		20.12	7	0.35	39.53	7	0.18
4	1.46	0		10.75	5	0.-47	3.42	1	0.29	15.63	6	0.38
5	2.98	0		10.01	10	0.99	2.04	0		15.03	10	0.67
6	0.00	0		1.06	0		0.11	0		1.17	0	
7	0.00	0		0.s0	0		0.00	0		0.80	0	
8	0.00	0		0.26	0		0.00	0		0.26	0	
9	0.00	0		0.29	0		0.00	0		0.29	0	
10	0.00	0		0.-57	0		0.18	0		0.75	0	
11	0.51	0		0.12	0		1.67	0		2.30	0	
12	0.00	0		9.00	0		1.94	0		1.94	0	
13	0.00	0		0.00	0		0.50	o		0.50	0	
14	0.00	0		0.00	0		0.00	0		0.00	0	
15	0.00	0		0.00	0		0.00	0		0.00	0	
16	0.00	0		0.00	0		0.00	0		0.00	0	
17	0.00	0		0.00	0		0.58	0		0.58	0	
18	0.00	0		0.00	0		0.00	0		0.00	0	
19	0.00	0		0.00	0		0.00	0		0.00	0	
20	0.00	0		0.90	0		0.69	0		0.69	0	
21	0.00	0		0.00	0		1.85	0		1.85	0	
22	0.00	0		0.00	0		3.82	0		3.82	0	
23	0.00	0		0.00	0		2.32	0		2.32	0	
24	0.00	0		0.00	0		3.59	0		3.59	0	
25	0.00	0		0.00	0		4.25	0		4.25	0	
26	0.00	0		0.00	0		5.83	0		5.s3	o	
28	0.00	0		0.00	0		2.09	0		2.09	0	
29	0.00	0		0.00	0		0.03	0		0.03	0	
Block Total	19.79	0		76.41	30	0.39	76.27	12	0.16	172.47	42	0.24
Total Canada	0.67	0		8.58	4	0.47	0.65	0		9.90	4	0.40
Total Unblocked	0.00	0		0.00	0		1.07	0		1.07	0	-
GRAND TOTAL	20.46	0		84.99	34	0.40	77.99	12	0.15	183.44	46	0.25

Table 27 **(contd).**

1981

Block	August Hrs	August BH	August WPUE	September Hrs	September BH	September WPUE	October Hrs	October BH	October WPUE	Total Hrs	Total BH	Total WPUE
1	6.65	0		23.24	5	0.22	19.01	17	0.89	48.90	22	0.45
2	0.36	0		0.48	0	-	0.30	0	-	1.14	0	-
3	2.98	0		5.34	0	-	13.34	7	0.52	21.66	7	0.32
4	4.22	0		15.67	96	6.13	7.11	30	4.22	27.00	126	4.67
5	1.94	0		30.98	130	6.20	2.98	0		25.90	130	5.02
6	0.00	0		1.44	0	-	1.46	0		2.90	0	
7	0.54	0		1.67	0	-	1.15	0		3.36	0	
8	0.00	0		1.31	0	-	0.00	0		1.31	0	
9	0.00	0		0.12	0	-	0.00	0		0.12	0	
10	0.52	0		0.00	0	-	0.00	0		0.52	0	
11	0.39	0		0.03	0	-	0.28	0		0.70	0	
12	1.86	0		0.00	0	-	0.37	0		2.23	0	
13	1.14	0		0.00	0	-	0.00	0		1.14	0	
14	0.00	0		0.00	0	-	0.00	0		0.00	0	
15	0.00	0		0.00	0	-	0.00	0		0.00	0	
16	0.00	0		0.00	0	-	0.00	0		0.00	0	
17	1.17	0		0.00	0	-	0.00	0		1.17	0	
18	0.00	0		0.00	0	-	0.00	0		0.00	0	
19	0.00	0		0.00	0	-	0.00	0		0.00	0	
20	2.08	0		0.00	0	-	0.00	0		2.08	0	
21	0.00	0		0.00	0	-	0.00	0		0.00	0	
22	0.52	0		0.00	0	-	0.00	0		0.52	0	
23	0.00	0		0.00	0	-	0,00	0		0.00	0	
24	2.39	0		0.00	0	-	0.00	0		2.39	0	
25	3.61	0		0.00	0	-	0.00	0		3.61	0	
26	0.91	0		0.00	0	-	0.00	0		0.91	0	
27	0.63	0		0.00	0	-	0.00	0		0.63	0	
28	3.47	0		0.00	0	-	0.00	0		3.47	0	
29	3.42	0		0.00	0	-	0.00	0		3.42	0	
Block Total	38.80	0		70.28	231	3.29	46.00	54		155.08	285	1.84
Total Canada	3.27	2	0.61	3.17	1	0.32	0.00	0		6.44	3	0.47
Total Unblocked	8.87	0		0.04	0	-	0.00	0		8.91	0	-
GRAND TOTAL	**50.94**	**2**	0.04	73.49	232	3.16	46.00	54	1.17	170.43	288	1.69

1982

Block	August Hrs	August BH	August wPUE	September Hrs	September BH	September WPUE	October Hrs	October BH	October wPUE	Total Hrs	Total BH	Total WPUE
1	9.99	0	-	13.76	94	6.83	5.35	1	0.19	29.10	95	3.26
2	3.70	0	-	2.22	3	1.35	1.21	0		7.13	3	0.42
3	0.00	0	-	14.53	13	0.89	3.63	9	2.48	18.16	22	1.21
4	14.27	0	-	8.58	8	0.93	4.02	0		26.87	8	0.30
5	19.14	16	0.84	14.07	159	11.30	4.27	3	0.70	37.48	178	4.75
6	15.22	43	2.83	5.38	0	-	1.83	0		22.43	43	1.92
7	12.35	75	6.07	3.86	0	-	0.00	0		16.21	75	4.63
8	4.90	0	-	1.55	0	-	0.59	0		7.04	0	-
9	3.73	2	0.54	3.13	4	1.28	0.48	0		7.34	6	0.82
10	0.54	0	-	0.00	0	-	0.43	0		0.97	0	-
11	0.00	0	-	4.56	0	-	5.35	1	0.19	9.91	I	0.10
12	0.00	0	-	4.17	2	0.48	8.01	15	1.87	12.18	17	1.40
13	0.00	0	-	3.58	0	-	4.34	12	2.76	7.92	12	1.52
14	0.00	0	-	0.00	0	-	2.46	1	0.41	2.46	1	0.41
15	0.00	0	-	0.00	0	-	0.12	0		0.12	0	
16	0.00	0	-	0.00	0	-	0.00	0		0.00	0	
17	0.00	0	-	0.00	0	-	3.81	0		3.81	0	
1s	0.00	0	-	0.00	0	-	2.00	0		2.00	0	
19	0,00	0	-	0.00	0	-	0.00	0		0.00	0	
20	0.00	0	-	0.00	0	-	3.40	0		3.40	0	
21	0.00	0	-	0.00	0	-	1.35	0		1.35	0	
22	0.00	0	-	0.00	0	-	0.00	0		0.00	0	
23	0.00	0	-	0.00	0	-	0.00	0		0.00	0	
24	0.00	0	-	0.00	0	-	0.00	0		0.00	0	
25	0.00	0	-	0.00	0	-	0.00	0		0.00	0	
26	0.00	0	-	0.00	0	-	0.00	0		0.00	0	
27	0.00	0	-	0.00	0	-	0.00	0		0.00	0	
28	0.00	0	-	0.00	0	-	0.00	0		0.00	0	
29	0.00	0	-	0.00	0	-	0.00	0		0.00	0	
. Block Total	83.84	136	1.62	79.39	283	3,56	52.65	42	0.80	215.88	461	2.14
Total Canada	1.80	9	5.00	0.37	18	48.65	4.39	2	0.46	6.56	29	4.42
Total Unblocked	0.36	0	-	0.18	0	-	0.70	0		1.24	0	-
GRAND TOTAL	**86.00**	145	**1.69**	79.94	301	3.77	57.74	44	0.76	223.68	490	2.19

Table 27 (contd).

1983

Block	August Hrs	August BH	August WPUE	September Hrs	September BH	September WPUE	October Hrs	October BH	October WPUE	Total Hrs	Total BH	Total WPUE
1	9.82	0	-	17.99	2	0.11	5.77	0	-	33.58	2	0.06
2	2.91	1	0.34	10.34	9	0.87	1.54	0	-	14.79	10	0.68
3	11.96	0	-	13.22	8	0.61	6.13	3	0.49	31.31	11	0.35
4	7.08	0	-	3.33	o	-	3.65	0	-	14.06	0	-
5	12.05	38	3.15	4.91	0	-	1.11	0	-	18.07	38	2.10
6	6.28	0	-	11.29	17	1.51	3.70	1	0.27	21.27	18	0.85
7	13.92	17	1.22	4.20	8	1.90	2.30	5	2.17	20.42	30	1.47
8	4.92	0	-	3.34	0	-	0.00	0	-	8.26	0	-
9	4.45	0	-	2.78	1	0.36	0.00	0	-	7.23	1	0.14
10	5.22	0	-	9.34	2	0.21	0.79	0	-	15.35	2	0.13
11	2.57	0	-	13.10	7	0.53	5.81	0	-	21.48	7	0.33
12	5.49	0	-	10.69	18	1.68	10.74	8	0.74	26.92	26	0.97
13	0.00	0	-	3.28	3	0.91	8.88	13	1.46	12.16	16	1.32
14	0.00	0	-	0.87	0	-	3.95	0	-	4.82	0	-
15	0.00	0	-	0.00	0	-	3.73	0	-	3.73	0	-
16	0.00	0	-	0.00	0	-	0.00	0	-	0.00	0	-
17	0.00	0	-	o.%	3	3.12	4.29	3	0.70	5.25	6	1.14
18	0.00	0	-	0.00	o	-	4.61	2	0.43	4.61	2	0.43
19	0.00	0	-	0.00	0	-	0.37	0	-	0.37	0	-
20	0.00	0	-	0.00	0	-	2.97	0	-	2.97	0	-
21	0.00	0	-	0.00	0	-	1.73	0	-	1.73	0	-
22	0.00	0	-	0.00	0	-	3.60	0	-	3.60	0	-
23	0.00	0	-	0.00	0	-	0.59	0	-	0.59	0	-
24	0.00	0	-	0.00	0	-	0.34	0	-	0.34	0	-
25	0.00	0	-	0.00	0	-	0.51	0	-	0.51	0	-
26	0.00	0	-	0.00	0	-	0.00	0	-	0.00	0	-
27	0.00	0	-	0.00	0	-	0.00	0	-	0.00	0	-
28	0.00	0	-	0.00	0	-	0.18	0	-	0.18	0	-
29	0.00	0	-	0.00	0	-	0.00	0	-	0.00	0	-
Block Total	86.67	56	0.65	109.64	76	0.69	77.29	35	0.45	273.60	169	0.62
Total Canada	0.81	3	3.70	0.00	0	-	0.00	0	-	0.81	3	3.70
Total Unblocked	0.60	0	-	1.27	o	-	3.58	0	-	5.45	0	-
GRAND TOTAL	88.08	59	0.67	110.91	76	0.69	80.87	35	0.43	279.86	172	0.61

1984

Block	August Hrs	August BH	August WPUE	September Hrs	September BH	September WPUE	October Hrs	October BH	October WPUE	Total Hrs	Total BH	Total wPUE
1	9.46	0	-	16.98	10	0.59	13.93	4	0.29	40.37	14	0.35
2	1.88	0	-	3.80	4	1.05	3.81	1	0.26	9.49	5	0.53
3	3.21	0	-	10.94	2	0.18	17.68	22	1.24	31.83	24	0.75
4	12.60	0	-	5.58	15	2.69	1,85	0	-	20.03	15	0.75
5	16.45	19	1.16	8.77	28	3.19	2.91	4	1.37	28.13	51	1.81
6	8.11	0	-	4.64	9	1.94	2.04	0	-	14.79	9	0.61
7	9.73	0	-	3.73	0	-	0.00	0	-	13.46	0	-
8	2.99	0	-	1.53	0	-	0.00	0	-	4.52	0	-
9	2.92	0	-	3.33	0	-	0.00	0	-	6.25	0	-
10	0.06	0	-	4.53	0	-	0.10	0	-	4.69	0	-
11	2.30	0	-	4.17	0	-	5.57	17	3.05	12.04	17	1.41
12	1.01	0	-	5.63	148	26.29	15.58	37	2.37	22.22	185	8.33
13	5.61	0	-	4.76	2	0.42	5.77	5	0.87	16.14	7	0.43
14	2.19	0	-	2.79	0	-	0.11	0	-	5.09	0	-
15	2.14	0	-	0.00	0	-	0.00	0	-	2.14	0	-
16	0.00	0	-	0.00	0	-	0.00	0	-	0.00	0	-
17	1.05	0	-	0.75	0	-	1.90	0	-	3.70	0	-
18	0.33	0	-	0.00	0	-	0.00	0	-	0.33	0	-
19	0.00	0	-	0.00	0	-	0.00	0	-	0.00	0	-
20	3.08	0	-	0.00	0	-	0.00	o	-	3.08	0	-
21	0.41	0	-	0.00	0	-	0.00	0	-	0.41	0	-
22	0.00	0	-	0.00	0	-	0.00	0	-	0.00	0	-
23	0.00	0	-	0.00	0	-	0.00	0	-	0.00	0	-
24	0.00	0	-	0.00	0	-	0.00	0	-	0.00	0	-
25	0.00	0	-	0.00	0	-	0.00	0	-	0.00	0	-
26	0.00	0	-	0.00	0	-	0.00	0	-	0.00	0	-
27	0.00	0	-	0.00	0	-	0.00	0	-	0.00	0	-
28	0.00	0	-	0.00	0	-	0.00	0	-	0.00	0	-
29	0.00	0	-	0.00	0	-	0.00	0	-	0.00	0	-
Block Total	85.53	19	0.22	81.93	218	2.66	71.25	90	1.26	238.71	327	1.37
Total Canada	1.23	2	1.63	2.47	42	17.00	2.43	9	3.70	6.13	53	8.65
Total Unblocked	0.22	0	-	0.37	0	-	0.66	0	-	1.25	0	-
GRAND TOTAL	86.99	21	0.24	84.77	260	3.07	74.34	99	1.33	246.09	380	1.54

Table 27 (contd).

1985

Block	August Hrs	August BH	August WPUE	September Hrs	September BH	September WPUE	October Hrs	October BH	October WPUE	Total Hrs	Total BH	Total WPUE
1	10.67	0	-	13.04	7	0.54	7.97	18	2.26	31.68	25	0.79
2	1.67	0	-	4.16	0		1.75	0	-	7.58	0	
3	0.00	0	-	4.90	0		12.38	5	0.40	17.28	5	0.29
4	16.75	0	-	10.39	23	2.21	6.22	0	-	33.36	23	0.69
5	17.52	11	0.63	10.89	19	1.74	9.16	0	-	37.57	30	0.80
6	7.31	0	-	7.78	3	0.39	2.09	0	-	17.18	3	0.17
7	8.70	1	0.18	7.08	0		2.08	0	-	17.86	1	0.06
8	3.01	0	-	5.33	0		0.06	0	-	8.40	0	
9	0.32	0	-	0.36	0		0.00	0	-	0.68	0	
10	0.16	0	-	0.18	0		0.25	0	-	0.59	0	
11	0.00	0	-	0.19	0		3.00	27	9.00	3.19	27	8.46
12	0.00	0	-	3.08	0		13.25	7	0.53	16.33	7	0.43
13	0.00	0	-	0.00	0		6.40	2	0.31	6.40	2	0.31
14	0.00	0	-	0.00	0		2.09	1	0.48	2.09	1	0.48
15	0.00	0	-	0.00	0		.1.00	0	-	1.00	0	
16	0.00	0	-	0.00	0		0.00	0	-	0.00	0	
17	0.00	0	-	0.00	0		2.69	0	-	2.69	0	
18	0.00	0	-	0.00	0		2.90	0	-	2.90	0	
19	0.00	0	-	0.00	0		0.00	0	-	0.00	0	
20	0.00	0	-	0.00	0		0.00	0	-	0.00	0	
21	0.00	0	-	0.00	0		0.00	0	-	0.00	0	
22	0.00	0	-	0.00	0		0.00	0	-	0.00	0	
23	0.00	0	-	0.00	0		0.00	0	-	0.00	0	
24	0.00	0	-	0.00	0		0.00	0	-	0.00	0	
25	0.00	0	-	0.00	0		0.00	0	-	0.00	0	
26	0.00	0	-	0.00	0		0.00	0	-	0.00	0	
27	0.00	0	-	0.00	0		0.00	0	-	0.00	0	
28	0.00	0	-	0.00	0		0.00	0	-	0.00	0	
29	0.00	0	-	0.00	0		0.00	0	-	0.00	0	
Block Total	66.11	12	0.18	67.38	52	0.77	73.29	60	0.82	206.78	124	0.60
Total Canada	0.91	0	-	2.30	15	6.52	1.96	0	-	5.17	15	2.90
Total Unblocked	0.00	0	-	0.09	0	-	0.78	0	-	0.87	0	-
GRAND TOTAL	67,02	12	0.18	69.77	67	0.96	76.03	60	0.79	212.82	139	0.65

TOTAL

Block	August Hrs	August BH	August WPUE	September Hrs	September BH	September WPUE	October Hrs	October BH	October WPUE	Total Hrs	Total BH	Total WPUE
1	73.32	0		148.32	135	0.91	127.34	130	1.02	348.98	265	0.76
2	13.03	1	0.08	24.66	16	0.65	13.47	3	0.22	51.16	20	0.39
3	25.15	0		61.99	23	0.37	80.64	80	0.99	167.78	103	0.61
4	68.01	0		65.69	148	2.25	30.52	41	1.34	164.22	189	1.15
5	70.08	84	1.20	74.89	399	5.33	22.47	7	0.31	167.44	490	2.93
6	42.05	50	1.19	37.06	33	0.89	12.25	1	0.08	91.36	84	0.92
7	45.24	93	2.06	22.70	8	0.35	5.53	5	0.90	73.47	106	1.44
8	15.82	0	-	13.32	0		0.65	0		29.79	0	
9	11.42	2	0.18	10.01	5	0.50	0.48	0		21.91	7	0.32
10	6.86	0		14.62	2	0.14	1.75	0		23.23	2	0.09
11	5.77	0		22.17	7	0.32	22.97	45	1.96	50.91	52	1.02
12	8.36	0		23.99	168	7.00	57.03	72	1.26	89.38	240	2.69
13	6.74	0		11.62	5	0.43	26.08	32	1.23	44.44	37	0.83
14	2.19	0		3.66	0		8.61	2	0.23	14.46	2	0.14
15	2.14	0		0.00	0		4.85	0		6.99	0	
16	0.00	0		0.00	0		0.90	0		0.00	0	
17	2.22	0		1.71	3	1.75	13.27	3	0.23	17.20	6	0.35
18	0.33	0		0.00	0		9.51	2	0.21	9.84	2	0.20
19	0.00	0		0.00	0		0.37	0		0.37	0	
20	5.16	0		0.00	0		7.06	0		12.22	0	
21	0.41	0		0.00	0		4.93	0		5.34	0	
22	0.52	0		0.00	0		7.42	0		7.94	0	
23	0.00	0		0.00	0		2.91	0		2.91	0	
24	2.39	0		0.00	0		3.93	0		6.32	0	
25	3.61	0		0.00	0		4.76	0		8.37	0	
26	0.91	0		0.00	0		5.83	0		6.74	0	
27	0.63	0		0.00	0		0.00	0		0.63	0	
28	3.47	0		0.00	0		2.27	0		5.74	0	
29	3.42	0		0.00	0		0.03	0		3.45	0	
Block Total	419.26	230	0.55	536.41	952	1.77	476.93	423	0.89	1432.60	1605	1.12
Total Canada	8.69	16	1.84	16.89	80	4.74	9.43	11	1.17	35.01	107	3.06
Total Unblocked	10.05	0	-	1.95	0	-	8.61	0	-	20.61	0	
GRAND TOTAL	438.00	246	0.56	555.25	1032	1.86	494.97	434	0.88	1488.22	1712	1.15

Deriving a density estimate for a particular area is useful when assessing how a portion of a species range is utilized by the population. Bowhead densities were calculated for survey blocks only in 1985. Highest bowhead densities were calculated for block 5 in August (0.001 1 whales/km 2) and September (0.0007 whales/km 2), and block 11 in October (0.0045 whales/km 2). Density estimates have been calculated for bathymetrically defined subregions (see Figure 24) in the Alaskan Beaufort Sea since 1979, as described in Appendix B. Overall (1979-85), highest monthly bowhead density was calculated for subregions D5 in August (O. 130 whales/km 2), subregion A2 in September (0.912 whales/km 2) and subregion B3 in October (0.580 whales/km 2, Figure 23). The relatively high densities calculated for subregions A2 (0.912 whales/km 2), A3(0.604 whales/km 2), and A4 (0.477 whales/km 2) in September 1984 were the result of recurrent sightings of feeding bowheads near I%. Barrow that year (Ljungblad et al., 1986a). Highest densities calculated for these subregions between 1979 and 1985 ranged from 0.0 to 0.099 whales/km 2. Prior to 1984, highest bowhead density in September had been calculated for subregion C3 (0.268 whales/km 2). Subregional density calculations for all years are presented and compared in Appendix B.

Migration Route, Timing, and Habitat Relationships

a. Median Depth Analysis of Migration Route

The fall bowhead migration route passes near or through areas off Alaska's North Slope that are designated for, or currently involved in, oil and gas development (see Figure 22A-D). Recently, concern has focused on the potential offshore displacement of the fall bowhead migration route by OCS oil and gas development activity. It was determined that one means of addressing this concern was to analyze bowhead sighting data for potential shifts in migratory route. A simple statistic was needed to define an axis of the bowhead fall migration route to address the question of potential shifts in the migration route. Median water depth for bowhead sightings made on random north-south line transect surveys was the statistic chosen because it (a) adequately defined the observed migratory axis as the depth contour such that half the sightings were at shallower (or equal) depths and half the sightings were at deeper (or equal) depths (b) is a robust statistic and

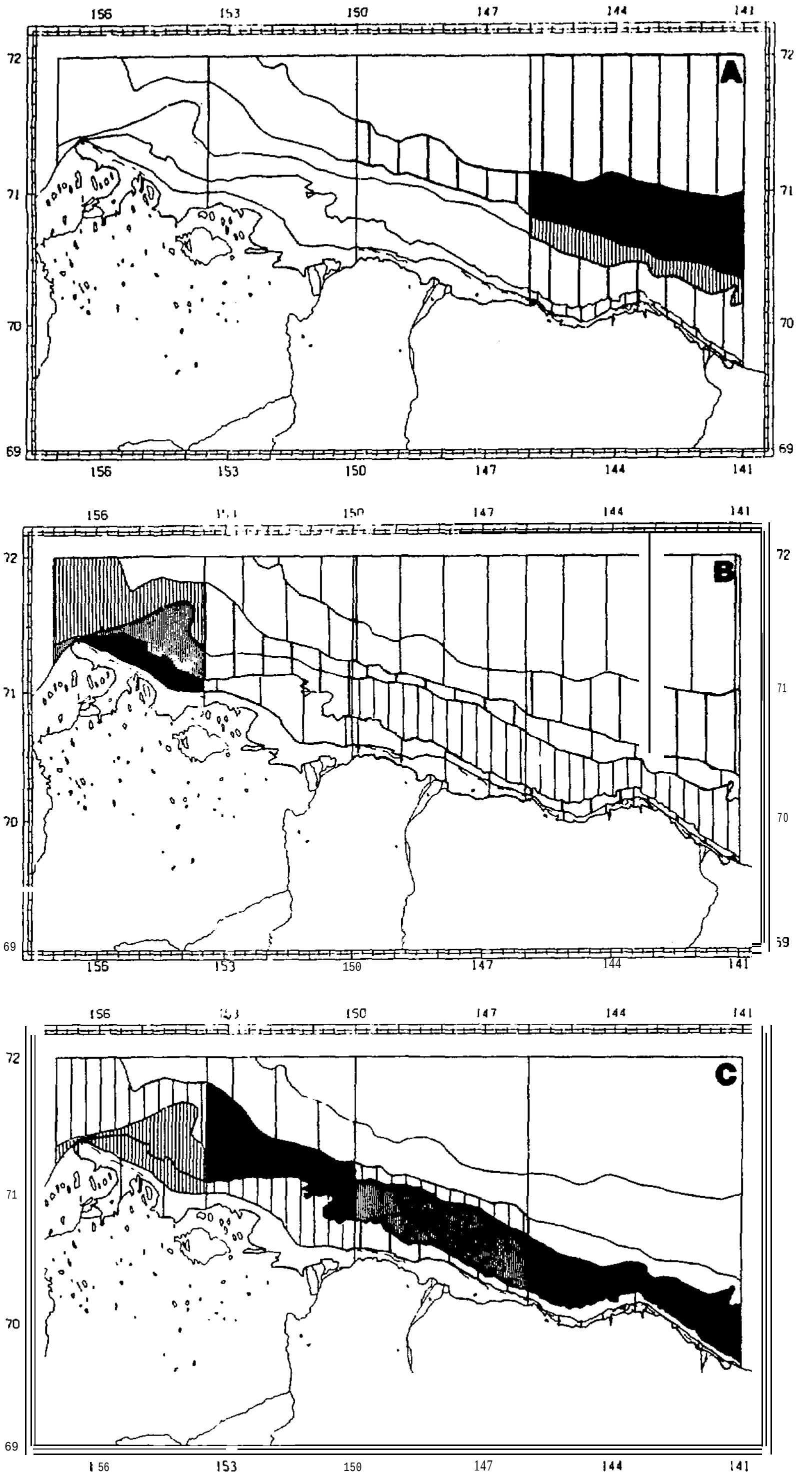


Figure 23. Highest annual bowhead densities/region calculated by month, fall 1979-85. Shading varies from white (representing 0 density) to black representing: 0.130 whales/km^2, August (A); 0.912 whales/km^2, September (B); 0.580 whales/km^2, October (C). Subregional densities presented here from Appendix B: Tables B-4(A), B-6(B) and B-8(C).

as such it is insensitive to unusually large or small depth values, to nonuniform aerial survey coverage, or to skewed distributions of data, and (c) was easy to compute from the existing data base. The analysis protocol specifying the use of median water depth to test for interannual shifts in the bowhead migration route is described in Chapters 4.2.3 and 5.3.3 of "Beaufort Sea Monitoring Program Workshop Synthesis and Sampling Design Recommendations" (Houghton et al., 1984).

The hypotheses tested via median depth analysis was prescribed in Houghton et al. (1984) as:

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

H02: Changes in bowhead migration patterns are not related to OCS oil and gas development activity.

Because of the bathymetry of the Alaskan Beaufort Sea, a seaward displacement of the fall migration route would be represented, via this analysis, as a shift to a deeper median depth.

Median depth at bowhead sightings was analyzed for the Alaskan Beaufort Sea study area between 141°W and 157°W, as well as for each of the four regions (A-D) utilized in density analysis (Figure 24). Region A extended from 153°30'W to 157°00'W, region B from 150°00'W to 153°30'W, region C from 146°00'W to 150 °00'W, and region D extended from 141 °00'W to 146°00'W. The depth at each bowhead sighting in the 1979-85 data base was derived using the computer program DEPTH that assigns a metric depth value to each 5 nmi of latitude by 20 nmi of longitude (approximately 9.25 km x 37 km) segment of the Beaufort Sea between 141°W and 157°W offshore to 72°N. This scaling assigns depth to sighting locations with an accuracy of approximately ± 3.5 m over most of the study area. At the shelf break between 100 m and 1000 m in regions B and C and between 10 m and 100 m at 156 °30'W in region A, the accuracy was approximately ±20 m. Values assigned to each segment were read off NOAA Provisional Chart 16004 when the DEPTH software was written. After depth values for all bowhead sightings were standardized across all years using DEPTH, it was determined that a 5-m shift in depth would correspond roughly to a 2 km displacement.

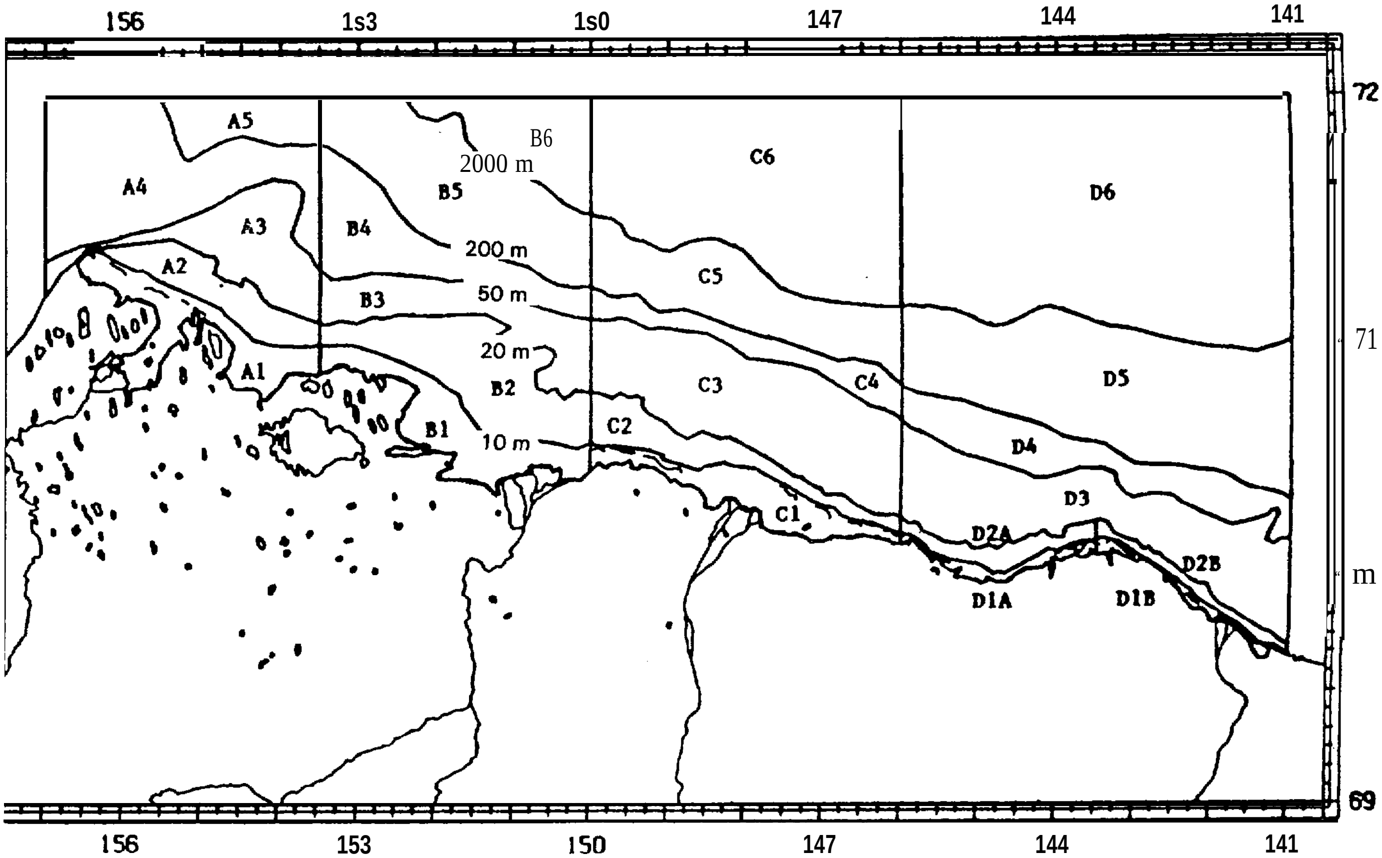


Figure 24. Four regions of the Alaskan Beaufort Sea study area stratified by contour intervals of 10 m, 20 m, 50 m, 200 m, and 2000 m.

The bowhead sighting data base was sorted such that only sightings made on random transect lines were stored onto a separate data file (M EDEPTH 1). Sightings made during search surveys or enroute to survey blocks were omitted from the data file because such sightings do not represent a random sample of depths of all possible sightings. The median depth of sightings rather than of individual whales was used because each sighting represents an independent random observation, a necessary prerequisite to the derivation of confidence intervals for the sample median.

The depth values stored on the MEDEPTH 1 data file were then ranked from lowest to highest values, and a sample median, a 99 percent confidence interval (C.I.) and the overall range of depth values were tabulated for each year.

The 99 percent C.I. was defined as:

$L_1 = X_{C+1}$: lower limit

$L_2 = X_{n-C}$: upper limit

When (2) = 0.01, C is determined from a table of critical values (Zar, 1984; Table B-26) where sample size n > 8. Confidence intervals were calculated at the 1 percent level to reduce the probability of incorrectly asserting that a change in migration route had occurred based on testing any one year to six others. For example, the probability of incorrectly determining a change occurred based on 1 of 5 tests is approximately 23 percent if tested at the 5 percent level, but only about 5 percent if tested at the 1 percent level (Houghton et al., 1984).

Because bowheads seen in the eastern Alaskan Beaufort Sea in August are generally farther offshore than whales seen in September and October and usually show no significant clustering about westerly swimming directions (i.e., are not migrating near-shore), the ME DEPTH 1 data file was sorted such that only bowhead sightings made on random transects in September and October were stored (MEDEPTH2). The MEDEPTH2 depth values were ranked from lowest to highest and a sample median, 99 percent C.I. and overall sample range were tabulated. The MEDEPTH2 data file was then sorted by region (A-D), the values for each region were ranked and the above descriptive statistics were tabulated.

Tests for displacement in the axis of the migration assumed that annual median depths represented a "true" axis. The Mann-Whitney test, a standard test for a shift in median (Zar, 1984), was used to address the question of potential shifts in the axis of the bowhead whale fall migration route. The Mann-Whitney test is a nonparametric procedure performed on ranked samples where U and U' are calculated as:

$$U = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - R_1$$

$$U' = n_1 \; 2 - u$$

where, ‘1 = the smaller of the two samples being compared, if sample sizes are unequal

‘2 = the second sample set

‘1 ▫ sum of the ranks of the n_1 sample

If either U or U' is as great or greater than the tabularized critical value at the chosen level of significance, the difference between the samples is significant. If the size of the smaller sample exceeds 20 or the size of the larger sample exceeds 40, the distribution of U approaches the normal distribution and a Z value is compared to the critical value t_{α} , where Z is calculated as:

$$Z = \frac{|U - \mu U| - 0.5}{\sigma U}$$

1 after μ_U and σ_U have been derived from the sample sizes as:

$$\mu U = \frac{n_1 n_2}{2} \quad ; \quad \sigma U = \sqrt{\frac{n_1 n_2 (N+1)}{12}}$$

A series of Mann-Whitney paired comparisons were made on annual median depths derived from the MEDEPTH2 data file with each year compared to all others such that annual and/or overall shifts in migration route over the 1979-85 study period could be evaluated. Subsequently, a series of paired comparisons were performed for each region (A-D) such that annual variations or potential shifts in median depth could be assessed for these smaller areas.

A total of 268 bowhead sightings have been made during random transect surveys since 1979 (Table 28). The timing and coverage of fall aerial surveys have changed from year to year with resultant shifts in areas surveyed, the amount of effort allotted to transect surveys, and therefore, the number of sightings made while on transect. For example, in 1979 and 1980 transect surveys were conducted primarily in or near the proposed state/federal oil lease areas (Figure 1: blocks 1 and 3), with search surveys flown in blocks 4 and 5. In 1981, attempts were made to conduct both behavioral studies (in blocks 4 and 5) and transect surveys (in blocks 1 and 3) from a single aircraft. The result was that prior to 1982, there was almost no survey effort north of the 200-m isobath, little effort west of 154°W, and relatively few sightings (n = 62, 23%) while on random transect lines. Since 1982, survey efforts have commenced in August (August survey efforts from 1979-81 were somewhat inconsistent) and have included survey blocks 1 through 12 (see Figure 1). As a result, more transect surveys were flown over the entire study area, and relatively more sightings were made while on random transects (n = 206, 77%) from 1982-85.

Table 28. Depth in meters at bowhead whale sightings made while flying random transects over the Alaskan Beaufort Sea, Fall 1979-85. Data was ranked from lowest to highest values. Bold depths indicate whales seen in August.

YEAR	1979	1980	1981	1982	1982	1983	1984	1984	1985
	11	11	15	7	**48**	5	5	29	7
	11	18	15	9	48	**7**	9	31	7
	11	18	13	13	49	18	9	33	9
	18	20	20	13	49	18	11	33	18
	18	20	22	13	49	18	11	35	18
	18	20	22	13	49	40	13	38	20
	18	20	29	18	49	42	15	40	20
	18	27	29	18	51	44	15	40	29
	18	27	33	18	**55**	48	15	40	29
	18	**29**	33	1s	88	48	**18**	40	31
	20	40	35	20	145	49	18	40	38
	27	40	40	20	225	49	18	48	33
	27	(n=12)	46	20	353	53	18	48	46
	27		(n=13)	20	366	**70**	18	48	55
	27			**22**	**366**	**82**	18	49	57
	27			22	366	90	18	51	73
	29			22	366	90	18	51	145
	29			**24**	366	113	**20**	**53**	146
	29			27	439	145	20	55	225
	29			27	549	145	20	55	(n=19)
	29			27	549	154	20	55	
	29			29	**670**	154	**20**	**57**	
	29			31	670	293	**20**	**60**	
	31			31	670	366	**22**	**60**	
	35			35	732	556	**22**	62	
	35			38	732	732	22	64	
	35			38	798	732	26	86	
	38			38	1006	1290	26	102	
	38			38	1222	1290	26	110	
	40			38	1829	1290	27	123	
	40			38	1829	1537	29	466	
	42			38	1848	1902	(n=62)		
	42			38	1848	1829			
	46			38	1857	2005			
	48			40	1873	2043			
	49			40	1884	2122			
	75			40	1884	2444			
	(n=37)			42	1902	2444			
				44	2036	2561			
				44	**2232**	2698			
				48	2799	(n=40)			
					2799				
					2799				
					3293				
					(n=85)				

It should be noted that the depths listed in Table 28 may be different than those published in the NOSC annual reports (Ljungblad, 1981; Ljungblad et al., 1980, 1982-84). The depths published in annual reports prior to 1985 were read off nautical charts, often in the aircraft during the survey. To minimize error and to standardize depth - location assignment across all years, the DEPTH program was run on all data and in some cases caused depth values to change. Also, the sample size, sample median and 99 percent C.I. for the 1982 data cited in Houghton et al. (1984) is discrepant with that published here. Their larger sample size (n = 103) for 1982 September-October sightings is likely the result of using all data in Ljungblad et al. (1983) Appendix A, for which a sighting distance was listed. Sorting data by this method would result in the inclusion of sightings made on other than random transects, since the listing of a sighting distance in the appendix tables is not confined to whales seen on random transect.

The annual median water depth for bowhead sightings on random transect surveys conducted from August through October ranged from 20 m to 150 m (Table 29). Median depths for 1979-81 and 1984-85 data had a narrower 20 m to 31 m range, and 99 percent confidence intervals that overlapped in the 18 to 40 m range. These data correspond to years when few (O to 4) bowhead sightings were made in August. In 1982 and 1983, 34 and six bowhead sightings, respectively, were made in August in relatively deep water (Table 28: bold), resulting in deeper median depths and broader confidence intervals for those years.

Overall, bowheads sighted on random transects in August (n = 48; Figure 25A) were further offshore and, therefore, in deeper water than whales seen during September and October (n = 220; Figure 25 B). These whales were either part of an early offshore migratory component (Ljungblad et al., 1983), or were an extension of the summering population generally thought to be confined to the Canadian Beaufort Sea (Fraker et al., 1980). Because of their offshore distribution, and lack of significant clustering about westerly swimming directions (Ljungblad et al., 1986 b), August bowhead sightings probably do not represent whales likely to be affected by current near-shore OCS development activities and were, therefore, eliminated from subsequent analysis.

The annual median water depth for bowhead sightings on transect surveys conducted in September and October ranged from 20 m to 145 m (Table 30). A plot of annual median depth contours across the Alaskan Beaufort Sea (Figure 26) demonstrates an overlap of the migration route with eastern (approx. 141°W to 147°W) OCS oil and gas lease areas, similar to that depicted in the distribution analysis (see Figure 22). Again, 1979-81 and 1984-85 data were most similar, with a median depth range of 20 to

Table 29. Median, confidence interval and overall range of water depth at bowhead whale sightings in the Alaskan Beaufort Sea, August-October 1979-85.

YEAR	(n)	MEDIAN	C. .(99%)	RANGE
1979	(37)	29 m	20-35 m	11-75 m
1980	(12)	20 m	18-40 m	11-40 m
1981	(13)	29 m	15-40 m	15-46 m
1982	(85)	48 m	38-366 m	7-3293 m
1983	(40)	150 m	49-1290 m	5-2698 m
1984	(62)	29 m	20-40 m	5-466 m
1985	(19)	31 m	18-73 m	7-225 m

29 m and 99 percent confidence interval overlap within 18-40 m. Although the overall median depth for the 1982 sample was 38 m, the 99 percent confidence interval of 22-40 m overlapped that of 1979-81 and 1984 data. The median depth and confidence interval for 1983 data (145 m, 49-732 m) were deeper than that for any other year.

There appeared to be little variation in annual median depth across years 1979-85 as determined by the Mann-Whitney test (Table 31). The only year that was significantly different ($p < 0.001$) from all other years was 1983. The observed migratory route was farther offshore and in deeper water in 1983 than in all other years (Figures 26 and 27). The cause for this one-year difference in migratory route is unclear. Seismic exploration by geophysical vessels has been proposed as a disturbance source that might displace the bowhead migration (Albert, in Houghton et al., 1984). This seems an unlikely cause for the offshore distribution in 1983 however, because geophysical vessels were forced to operate primarily in Canadian waters or were confined to coastal Alaskan waters by the heavy ice conditions prevalent that year. Beaufort Sea ice coverage in 1983 was very heavy, similar to 1980 and to a lesser extent 1985 conditions, but much heavier than conditions in 1982 and 1984. The distribution of bowheads seen on random transects in 1982 and 1984 overlapped that of geophysical vessels, but heavy ice coverage in 1983 confined these vessels to near-shore waters, and there was little or no overlap with the observed bowhead distribution (Figure 28). Although geophysical vessels did not often use their air guns to conduct seismic surveys in 1983 due to the restrictive ice, the ships themselves were generating noise in the near-shore waters. Measurements

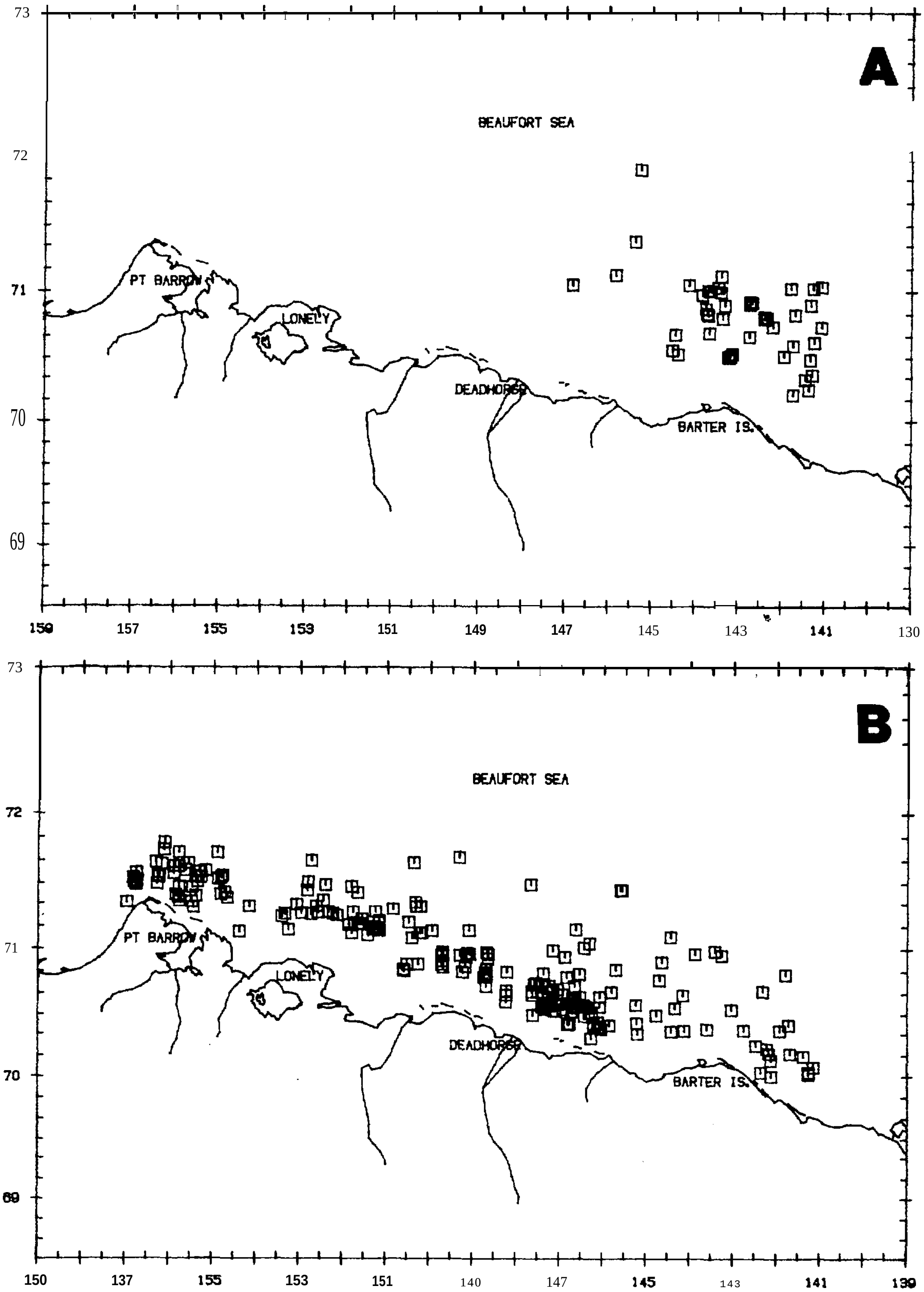


Figure 25. Distributionof bowhead whale sightings on random transect surveysin the Alaskan Beaufort Sea, 1979-85: 48 sightings, August(A); 220 sightings, September-October (B).

Table 30. Median, confidence interval and overall range of water depth at bowhead whale sightings in the Alaskan Beaufort Sea, September-October 1979-85.

YEAR	(n)	MEDIAN	C.I.(99%)	RANGE
1979	(33)	29 m	18-35 m	11-42 m
1980	(12)	20 m	18-40 m	11-40 m
1981	(13)	29 m	15-40 m	15-46 m
1982	(51)	38 m	22-40 m	7-2799 m
1983	(34)	145m	49-732 m	5-2698 m
1984	(60)	28 m	20-40 m	5-466 m
1985	(17)	29 m	9-73 m	7-225 m

Table 31. Results of the Mann-Whitney test for comparisons of median water depth at bowhead sightings in the Alaskan Beaufort Sea, September-October 1979-85. Bold indicates comparisons that were statistically significant.

	1979 (n=33)	1980 (n=12)	1981 (n=13)	1982 (n=51)	1983 (n=34)	1984 (n=60)
1980	U=233 p ≤ 0.50					
1981	U'=220.5 p ≤ 0.50	U=95 p ≤ 0.50				
1982	**U= 1059.5 Z=1.99 p < 0.05**	U=414.5 Z=1.89 p < 0.10	U=409 Z=1.284 p < 0.20			
1983	**U=975.5 Z=5.19 p <0.001**	**U=354 p <0.001**	**U=383.5 p <0.001**	**U'= 1376 Z=4.56 p <0.001**		
1984	U=1117.5 Z=1.02 p ≤ 0.50	U=441 Z=1.22 p ≤ 0.50	U=436 Z=0.66 p ≤ 0.50	U'=1618 Z=0.52 p ≤ 0.50	**U=1656.5 Z=5.00 p <0.001**	
1985 (n=17)	U'=317.5 p ≤ 0.50	U=123 p ≤ 0.50	U=120.5 p ≤ 0.50	U=471.5 Z=0.53 p ≤ 0.50	**U=464 p ≤ 0.001**	U=516.5 Z=0.07 p ≤ 0.50

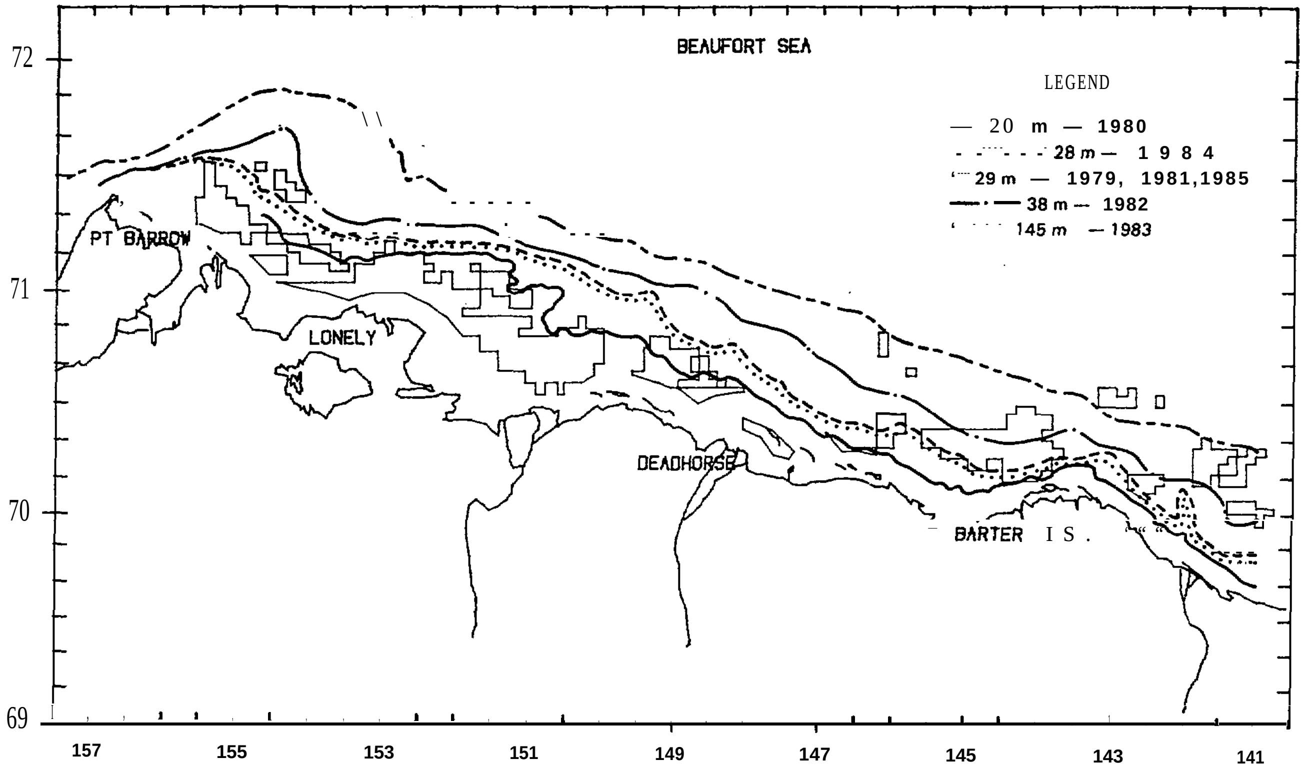


Figure 26. Annual median water depth contours depicting the bowhead migration route across the Alaskan Beaufort Sea September-October 1979-85. Outlined areas depict OCS oil and gas lease areas within the Beaufort Sea Planning Area of the Alaskan Beaufort Sea.

of geophysical vessel peak engine-noise levels in the 100-200 Hz frequency band include 104 dB re 1uPa^2/Hz for a vessel at 1.4 km, 80 dB re 1 uPa^2/Hz for a vessel 38 km away and 78 dB re 1uPa^2/Hz for a vessel 43 km away (Moore et al., 1984). Bowheads have been observed to avoid vessels of a variety of sizes when approached to within 1-4 km, and their avoidance of boats, although seemingly of short duration, has been described as more dramatic and consistent than to any other industrial activity studied (Richardson et al., 1985 b). However, the magnitude of displacement (roughly 45 km) of the 1983 fall migration appears to be greater than that expected if caused by vessel disturbance. Even when bowheads were directly approached by geophysical vessels that were firing their air guns during experimental trials, behavior disturbance was not elicited until the vessels were within about 7.5 km of the whales, and was relatively short term (≤60 bin) (Ljungblad et al., 1986c). Displacement due to oil and gas activities other than vessels also seems unlikely, however, as ice conditions in 1983 forced many such activities to be curtailed.

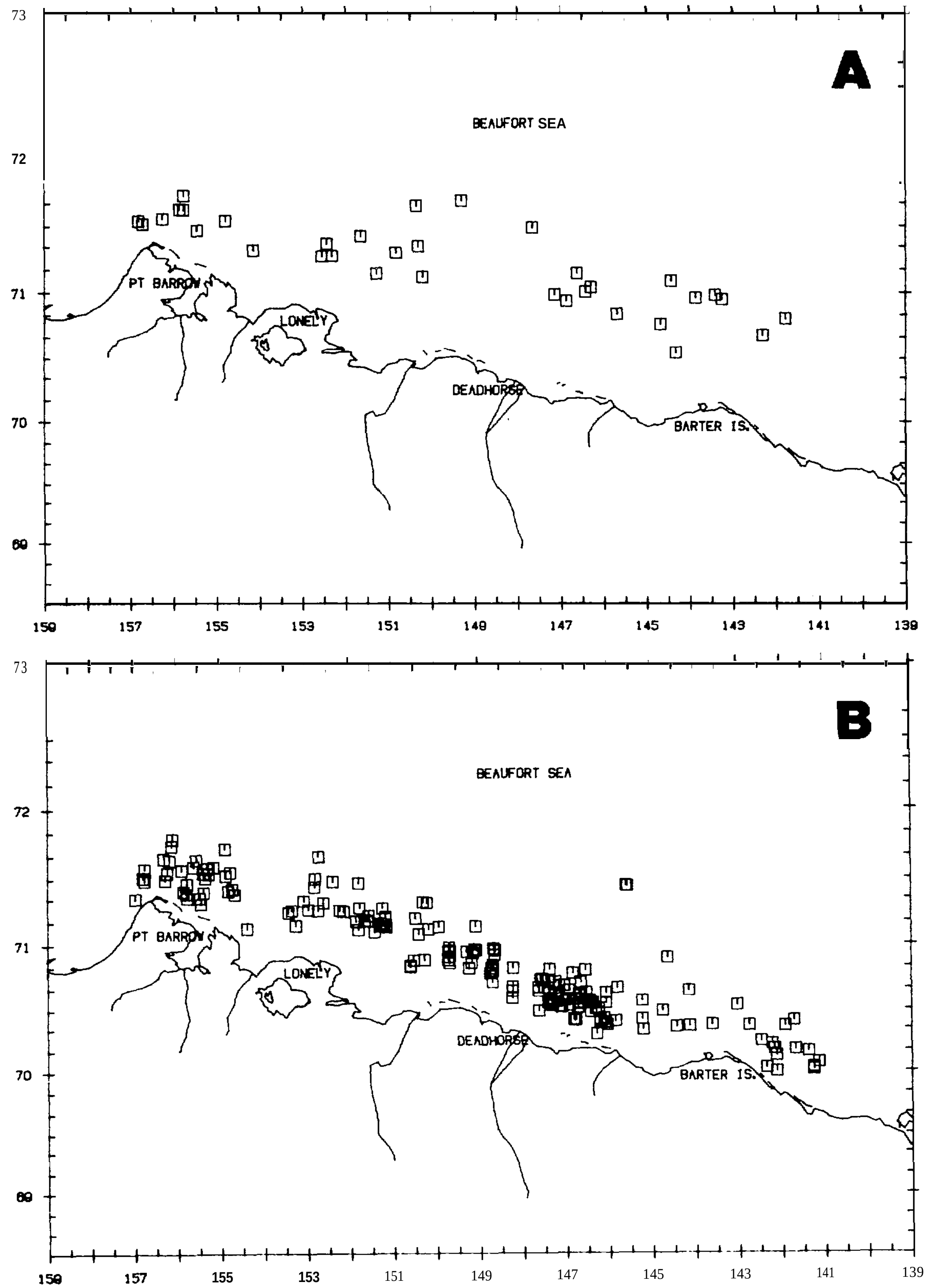


Figure 27. Distribution of 34 bowhead whale sightings, September-October 1983(A), and 186 sightings September-October 1979-82 and 1984-85 (B).

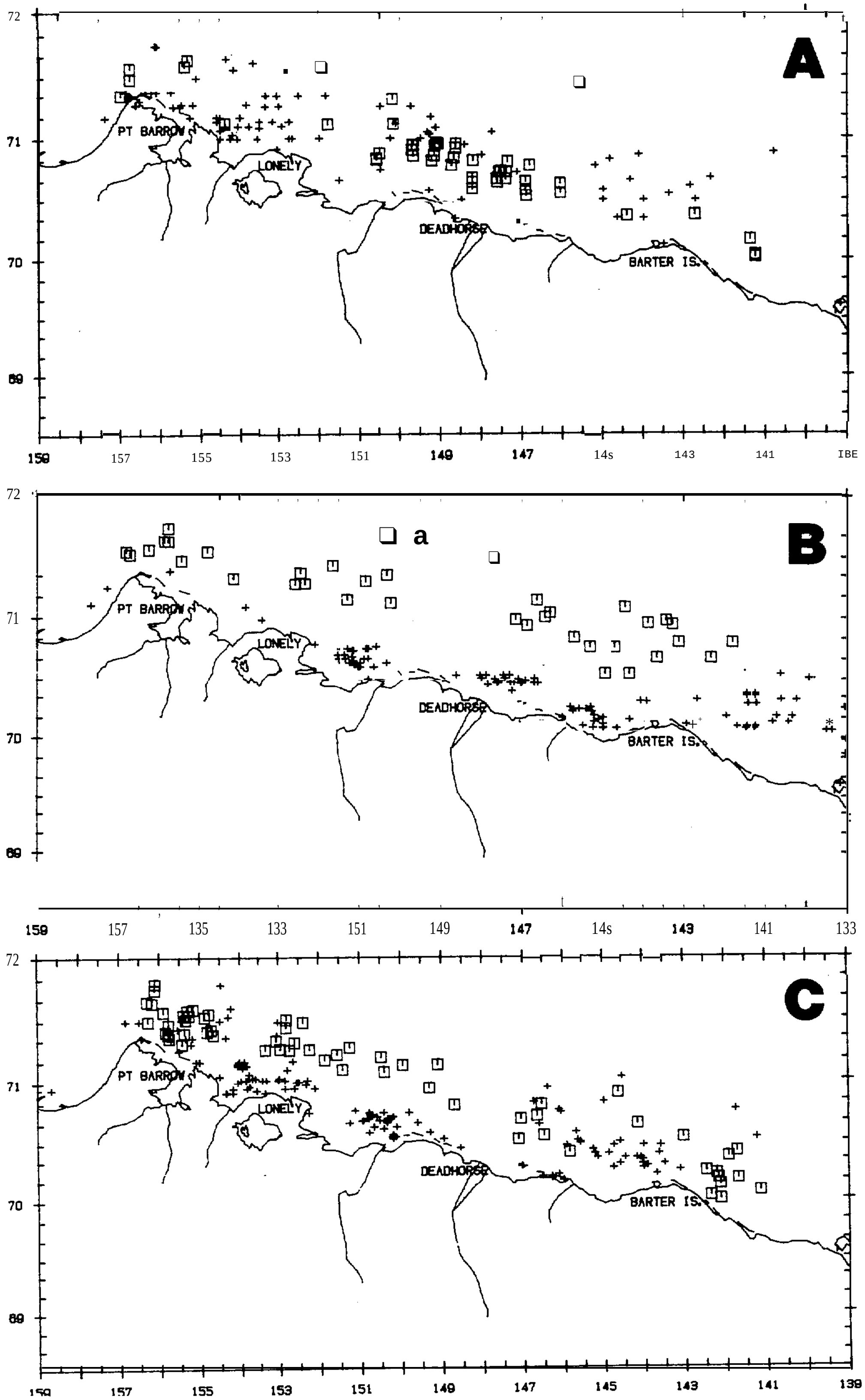


Figure 28. Distribution of bowhead whale sightings (☐) and the daily "morning positions" for geophysical survey vessels (+): 1982(A); 1983(B); and 1984(C). Whale positions represent September-October sightings; vessel locations represent September only as most vessels were either dockside or out of the Alaskan Beaufort Sea by the end of September.

The only other case of significant difference of median depth between years was the 1979 and 1982 samples. The level of significance ($p < 0.05$) was not nearly as great as that for comparisons of any year with 1983 data (Table 31). This observed difference in median depth was probably related to differences in flight effort (i.e. surveys were flown offshore over deeper water in 1982, but not in 1979). When sightings with corresponding depths deeper than 200 m were deleted from the 1982 data ($n = 3$), the resultant median depth for 1982 (33 m) was not significantly different than 1979 ($U = 960.5$, $Z = 1.62$, $p < 0.20$).

The influence of ice coverage on the axis of the bowhead migration, as defined by median depth, appears to be indirectly related to ice effects on productivity. When median depth was related to average ice coverage observed during random transect survey and average ice coverage at random bowhead sightings for the 1981-85 survey seasons (Table 32), neither overall ice coverage nor ice coverage at bowhead sightings were significantly correlated with median depth ($r = 0.240$ and $r = 0.353$ respectively; $p < 0.50$). In other words, ice conditions did not appear to directly affect the annual median depth "axis" of the migration. The influence of heavy ice coverage on the productivity of bowhead prey communities over the continental shelf, however, may have contributed to the offshore distribution of bowheads observed in 1983. Between 1979-84, feeding bowheads were seen along the migration route in significantly shallower water and lighter ice coverage than non-feeding whales (Ljungblad et al., 1986a). Prey abundance depends upon light-dependent primary productivity. Ice deflects and diffuses incident light and in this way limits productivity (Schell et al., 1982). Therefore, 1983 prey abundance in the Alaskan Beaufort Sea may have been relatively low. The resultant lack of feeding opportunities may have had the secondary effect of displacing the migration offshore over deeper water. This suggestion of ice-related effects on bowhead distribution via the impact of ice coverage on productivity is speculative at best as there have been no comprehensive studies to determine this relationship. An alternate suggestion is that during the heavy ice year of 1983, bowheads encountered relatively lighter ice conditions along the 145-m isobath as a result of the effects of prevailing currents and wind on ice coverage. Each spring, an east-west lead system develops along a shear zone in the Beaufort Sea, and most whales are seen in or near this lead (Braham et al., 1980; Ljungblad et al., 1986b). Oceanographic conditions similar to those that influence spring ice habitat may have caused ice conditions along the

Table 32. Median depth, average annual ice coverage and average ice coverage at bowhead sightings, August-October 1981-85. All data from random transect lines only.

	Median Depth(m)	Overall Ice Conditions (%)			Ice Conditions at Sightings (%)			Statistical Comparison of Ice Conditions
		$\bar{x}$	s.d.	n	$\bar{x}$	s.d.	n	
1981	29	74	20	351	68	19	13	$t' = 1.08$, $df = 13$, $p < 0.50$
1982	48	46	36	909	41	37	85	$t' = 1.22$, $df = 143$, $p < 0.50$
1983	150	60	30	976	55	31	40	$t' = 1.26$, $df = 1030$, $p < 0.50$
1984	29	41	64	884	29	35	62	$t' = 2.62$, $df = 123$, $p < 0.01$
1985	31	44	39	433	19	33	19	$t' = 3.81$, $df = 31$, $p < 0.001$
1981-85		51	44	3553	40	37	219	$t = 4.85$, $df = 3837$, $p < 0.001$

145 m isobath to be more broken and/or relatively lighter than elsewhere and so influenced bowhead distribution by providing less restrictive migrating conditions. Although ice coverage at random bowhead sightings in 1983 was not significantly lighter (55%) than average ice coverage observed on random transects (60%, $t = 1.26$, $p < 0.50$; Table 32), subtle differences in ice coverage or make up (i.e., more broken ice) may have gone undetected because environmental data are updated only every 10 minutes (i.e., roughly every 40 km) in lieu of sighting data during random transect surveys. A ≤ 2 km wide lead-type channel of relatively lighter ice coverage, or changing ice composition, would not be definitively described via these methods.

Bowheads may generally prefer areas of relatively lighter ice coverage when migrating, although annual comparisons of overall ice conditions and ice conditions at random sightings did not uniformly support this contention (Table 32). In 1981-83, ice conditions at bowhead sightings were not significantly lighter ($p < 0.50$) than overall ice conditions on random transects. Bowheads were found in significantly lighter ice in 1984 ($t' = 2.62$, $p < 0.01$) and 1985 ($t' = 3.81$, $p < 0.001$), however, than overall conditions for those years. When data were pooled over five seasons (198 1-85), average ice conditions recorded on random transects was significantly heavier (51 %) than ice conditions at random bowhead sightings (40%; $t = 4.85$, $p < 0.001$), indicating that whales may seek out areas of relatively lighter ice during the fall migration.

To assess possible shifts in migration route over smaller areas, the median water depth, 99 percent confidence interval and overall depth range were calculated for each of the 4 regions of the Beaufort Sea study area (Table 33). There were no bowhead sightings while on transect in region A in 1979-81, nor in region D in 1980 due to aforementioned annual variations in flight effort. Annual median water depth in region A ranged from 18 m in 1984 to 113 m in 1983. The 99 percent confidence interval calculated for 1983 (5- 154 m) encompassed that for 1984 (13-22 m). There were too few sightings in region A in 1982 and 1985 to calculate a confidence interval. The shallow median depth observed in region A in 1984 was likely related to sightings of feeding whales there. Bowheads seen feeding northeast of Point Barrow in 1984 were in significantly shallower water than whales feeding elsewhere in the Alaskan Beaufort Sea (Ljungblad et al., 1986a). The relatively deep median depth for the 1983 sample is consistent with the overall offshore distribution of whales discussed earlier, but was not significantly different from any other year (Table 34). In region B, annual median water depth ranged from 13 to 48 m (Table 33). Surprisingly, the median depth found in the 1983 sample was not significantly different than for 1981-85 samples, but was significantly deeper than that of 1979-89 (Table 34). In addition, median depth for 1984 sightings in region B was significantly deeper than those for 1979. As previously mentioned, flight effort extended further north and over deeper water in 1982-85 than in 1979-81. In 1984, depth at sightings in region B ranged from 11 m to 55 m, and in 1979 from 18 m to 29 m, such that the difference in annual median depth between these two years could have been effort dependent. Annual median depth in region C ranged from 24 to 1290 m (Table 33). Bowheads seen in region C in 1983 were in deeper water than whales seen there in any other year (i.e. 1983 sample range did not overlap any other year's range). As a result, the median depth for 1983 (1290 m) was significantly deeper than that for any other year (Table 34). There were no other cases of significant differences in region C. In region D, annual median depth ranged from 33 to 732 m (Table 33). The median depth for 1983 (732 m) was significantly deeper than 1979, 1981 and 1984 data (Table 34). There were no bowhead sightings in region D in 1980 and only one sighting in 1985.

When the 1983 data were omitted, the average median depth was deeper in region A ($\bar{x}$ = 36 m, 16.09 s.d., n = 3) and region D ($\bar{x}$ = 43.40 m, 9.76 s.d., n = 5) than in region B ($\bar{x}$ = 26.50, 13.26 s.d., n = 6) and region C ($\bar{x}$ = 29.17 m, 4.71 s.d.,

Table 33. Median water depth at bowhead whale sightings for four regions of the Alaskan Beaufort Sea, September-October 1979-85. -- = no sightings, *insufficient sample size. All depths given in meters.

A
(153°30'-157°W)

	(n)	MEDIAN	C.I. (99%)	RANGE
1979			- -	
1980			--	
1981				
1982	(6)	49	*	7-145
1983	(9)	113	5-154	5-154
1984	(22)	18	13-22	5-123
1985	(4)	41	*	7-145

B
(150°-153°30'W)

	(n)	MEDIAN	C.I. (99%)	RANGE
1979	(lo)	18	18-29	18-29
1980	(4)	20	*	(20)
1981	(3)	22	*	18-22
1982	(8)	13	9-225	9-225
1983	(9)	48	18-2122	18-2122
1984	(15)	40	18-55	11-55
1985	(3)	46	*	7-225

C
(146°-150°W)

	(n)	MEDIAN	C.I. (99%)	RANGE
1979	(21)	29	27-35	11-40
1980	(8)	27	11-40	11-40
1981	(6)	24	*	15-40
1982	(30)	28	20-38	18-49
1983	(7)	1290	*	90-2698
1984	(9)	38	20-64	20-64
1985	(9)	29	18-38	18-38

D
(141°-146°W)

	(n)	MEDIAN	C.I. (99%)	RANGE
1979	(2)	42	*	(42)
1980			--	
1981	(4)	33	*	29-46
1982	(7)	49	*	40-2799
1983	(9)	732	49-2005	49-2005
1984	(14)	36	18-62	18-466
1985	(1)	57	*	(57)

Table 34. Results of the Mann-Whitney test for comparisons of annual median water depth at bowhead sightings in four regions (A-D) of the Alaskan Beaufort Sea, September-October 1979-85. * = insufficient sample size. Bold indicates comparisons that were statistically significant.

A

	1982 (n=6)	1983 (n=9)	1984 (n=22)
1983	U=30.5 p ≤ 0.50		
1984	U'=96 p ≤ 0.10	U'=I 30.5 p < 0.20	
1985 (n=4)	U=12 p ≤ 0.50	U=22.5 p ≤ 0.50	U=45 p ≤ 0.50

B

	1979 (n=10)	1980 (n=4)	1981 (n=3)	1982 (n=8)	1983 (n=9)	1984 (n=15)
1980	U'=28 p ≤0.50					
1981	U'= 17.5 p ≤ 0.50	U'=8 p ≤ 0.50				
1982	U=50 p ≤ 0.50	U'=20 p ≤ 0.50	U'=15 p ≤ 0.50			
1983	U'=83.5 p <0.001	U=32 p ≤0.005	U=24.5 p < 0.10	U=56.5 p < 0.10 .		
1984	U=119.5 p <0.02	U=48 p ≤ 0.10	U=36 p < 0.20	U=81.5 p < 0.20	U'=91.5 p < 0.20	
1985 (n=3)	U'=20 p ≤ 0.50	U'=8 p ≤ 0.50	U=6 p ≤ 0.50	U'=13.5 p ≤ 0.50	U=17 p ≤ 0.50	U'=23 p ≤ 0.50

C

	1979 (n=21)	1980 (n=8)	1981 (n=6)	1982 (n=30)	1983 (n=7)	1984 (n=9)
1980	U=96.5 p ≤ 0.50					
1981	U=70 p ≤ 0.50	U=24.5 p < 0.50				
1982	U=318 Z=0.05 p ≤ 0.50	U= 136.5 p ≤ 0.50	U=111.5 p ≤0.50			
1983	U'=147 p 40.001	U'=56 p <0.001	U=42 p ≤ 0.002	U'=210 p <0.001		
1984	u:127 p < 0.20	U=51 p < 0.20	U=41 p <0.20	U'=186.5 p < 0.10	U'=63 p <0.001	
1985 (n=9)	U=104.5 p ≤ 0.50	U=39 p ≤ 0.50	U=30 p ≤ 0.50	U=159 p ≤ 0.50	U'=63 p <0,001	U=62 p < 0.10

D

	1979 (n=2)	1981 (n=4)	1982 (n=7)	1983 (n=9)	1984 (n=14)
1981	U'=6 p ≤ 0.50				
1982	U=9 p ≤ 0.50	U=25 p ≤0.05			
1983	U=18 p ≤0.05	U=36 p <0.005	U=44 p ≤ 0.50		
1984	U'=18 p ≤ 0.50	U=30.5 p ≤ 0.50	U'=73 p < 0.10	U'=1 19 p <0.001	
1985	*	*	•	U=8 p ≤ 0.50	U'=10 p ≤ 0.50

n. 6). Region D's average median depth was significantly deeper than region C's ($p < 0.005$) and region B's ($p < 0.02$), indicating that bowheads may migrate along a somewhat deeper isobath in the eastern (141°W to 146°W) Alaskan Beaufort Sea. There were no other instances of inter-regional differences in average median depth indicating that the bowhead migratory corridor may be roughly demarcated by the 20- to 40- meter isobath across the Alaskan Beaufort Sea west of 146°W.

b. Sightings Per Unit Effort **(SPUE) Analysis of Migration Timing and Habitat** Relationships

Each year considerable time has been spent describing interannual differences in the fall bowhead migration with regard to observed distribution, behavior, the timing of whale movements and associated ice conditions. In reviewing the progress that has been achieved since 1979 in describing the migration, one factor that has remained somewhat vague is the interpretation of the term "migration", specifically as it is applied to an aerial survey assessment of its progress. Migration is defined as a seasonal or periodic (mass) movement of animals away from and back to their breeding areas, and typically precedes and follows breeding seasons. Determining annual initiation and termination dates for the bowhead migration via aerial surveys is, by nature of methodological limitations, effort dependent. The criteria used to define the initiation of the migration has been the sighting of one or more adult bowheads swimming in a westerly or northwesterly direction (i.e., 210° -240° M) on two separate surveys within a five-day period. The termination of the migration has been generally defined as the date the last bowhead is seen in the Alaskan Beaufort Sea. These criteria, coupled with annual variation in survey effort, have resulted in migratory periods of varying duration (Table 35). For example, in 1979 the initiation of the migration period was based upon sightings of three whales and one whale swimming in a westerly direction on 20 August and 21 August respectively. Bowheads were next seen in the Alaskan Beaufort Sea on 7 September 1979 (n = 2, swimming west), but were not seen in great numbers until aggregations ($n \geq 20$) of whales were seen near Demarcation Bay on 24 and 26 September 1979. During this period, observed behaviors included feeding and slow westerly swimming. After 26 September, whales were seen west of Demarcation Bay with most whales swimming steadily.

Table 35. Summary of annual bowhead migration period, peak WPUE and date, number (percentage) of feeding bowheads, 5-day SPUE peak and SPUE peak period, average September/October ice coverage, and median depth at bowhead sightings in the Alaskan Beaufort Sea, fall 1979-85.

	1979	1980	1981	1982	1983	1984	1985
Migration Period Length (Days)	20 Aug- 25 Ott (66)	4 Sep- 9 Ott (35)	7 Sep- 20 Ott (43)	2 Sep- 17 Ott (45)	3 Sep- 17 Ott (44)	7 Sep- 20 Ott (44)	22 Sep 20 Ott (29)
WPUE: Peak	7.33	1.25	15.75	23.60	1.86	10.73	5.23
Date	14 Ott	18 Sep	28 Sep	16 Sep	24 Sep	26 Sep	6 Ott
Feeding Bowheads	50(25)	5(1 f)	41(14)	108(22)	14(8)	148(39)	35(25)
SPUE: Peak	2.69	0.61	6.70	2.53	1.35	1.60	0.97
Period	26-30 Sept	11-15 Sept	26-30 Sept	21-25 Sept	16-20 Sept	6-10 Ott	11-15 Ott
Average Sept/Ott Ice Coverage	C1OYO	≥60%	≤10%	0%	>60%	≤10%	>40%
Median Depth	29 m	20 m	29 m	38 m	145 m	28 m	29 m

The last whale seen in the Alaskan Beaufort Sea was on 25 October, although surveys continued through 31 October 1979. In 1980 and 1981, very few surveys were conducted in the Alaskan Beaufort Sea prior to the migration initiation date in early September, so potential whale distribution and movements in August could not be fully described. Since 1982, surveys have been initiated in the Alaskan Beaufort Sea in August, and have extended offshore to 720N. In 1982 and 1983, westerly swimming bowheads were seen in the Alaskan Beaufort Sea as early as 5 August and 2 August respectively. Because these whales were primarily offshore (see Figure 25) and in deep water, it was determined that they would not likely be affected by current near-shore OCS oil and gas activities and, therefore, these sightings were not incorporated in the defined migratory period. In 1984 and 1985, the few bowheads seen in August were relatively near shore in shallow water, as in 1979, but these whales were not swimming west. Therefore, the initiation of the 1984-85 bowhead migrations were in September. Determining the migration termination date was also affected by annual variations in the level and direction of survey effort. In 1980, 9 surveys were flown in the Alaskan Beaufort Sea after the migration termination date. Since 1981, zero to five surveys have been conducted after the last whale sighting. In 1985, the termination of the migration was based upon efforts of three aircraft resulting in no bowhead sightings on two consecutive days. Resultant migratory periods have ranged from 35 to 66 days (Table 35). The 1985 bowhead migration extended from 22 September to 20 October, a shorter time period (29 days) than any previous year.

A description of fall migratory timing was initially based upon WPUE (Ljungblad et al., 1985), but this method was somewhat compromised because group size of feeding whales is significantly larger than that of non-feeding bowheads (Ljungblad et al., 1986a). Therefore, peak WPUE is strongly influenced by the number and timing of whales seen feeding during the migration. In 1985, 25 percent (n = 35) of all whales seen were feeding, and 66 percent (n = 23) of all feeders were seen on 9 September when WPUE was highest (see Figure 13). Similarly, in 1981, 1982 and 1984, peak WPUE was calculated for dates when groups of feeding bowheads were seen. Thus, peak WPUE/date indicates as much about when groups of feeding bowheads were seen during the fall migration as it does about the progress of the migration itself. Therefore, although WPUE/date has been used effectively in describing the progress of the spring bowhead migration (Braham et al., 1984; Ljungblad et al., 1986 b), its utility in defining fall migratory progress is compromised somewhat by whales stopping to feed along the migratory route.

The timing of the observed fall bowhead migration described as the sightings per unit effort (SPUE = no. sightings/hour of survey effort) per five-day time period minimizes bias introduced when the number of whales are used (Figure 29). Sighting rates in August (1979-81) and the latter part of October reflect partial coverage during those time periods. Since 1979, the peak 5-day sighting period has occurred between 11-15 September and 11-15 October (Table 35, Figure 29). Peak 5-day SPUE periods were earlier in years of heavy ice coverage (1980: 11-15 September; 1983: 16-20 September) than in years when ice was light (Table 35). Peak sighting rate was highest (SPUE: 6.70) in 1981 when most September surveys were dedicated to observing bowhead behavior near active geophysical vessels (Fraker et al., 1985).

To analyze the interrelationship of migratory timing, behavioral parameters and habitat relationships as described by average annual September-October ice coverage and median depth, a multiple regression was performed on the data summarized in Table 35. The initiation of the migration was defined as the dependent variable (Y), and peak WPUE, percentage of feeding whales, SPUE peak,

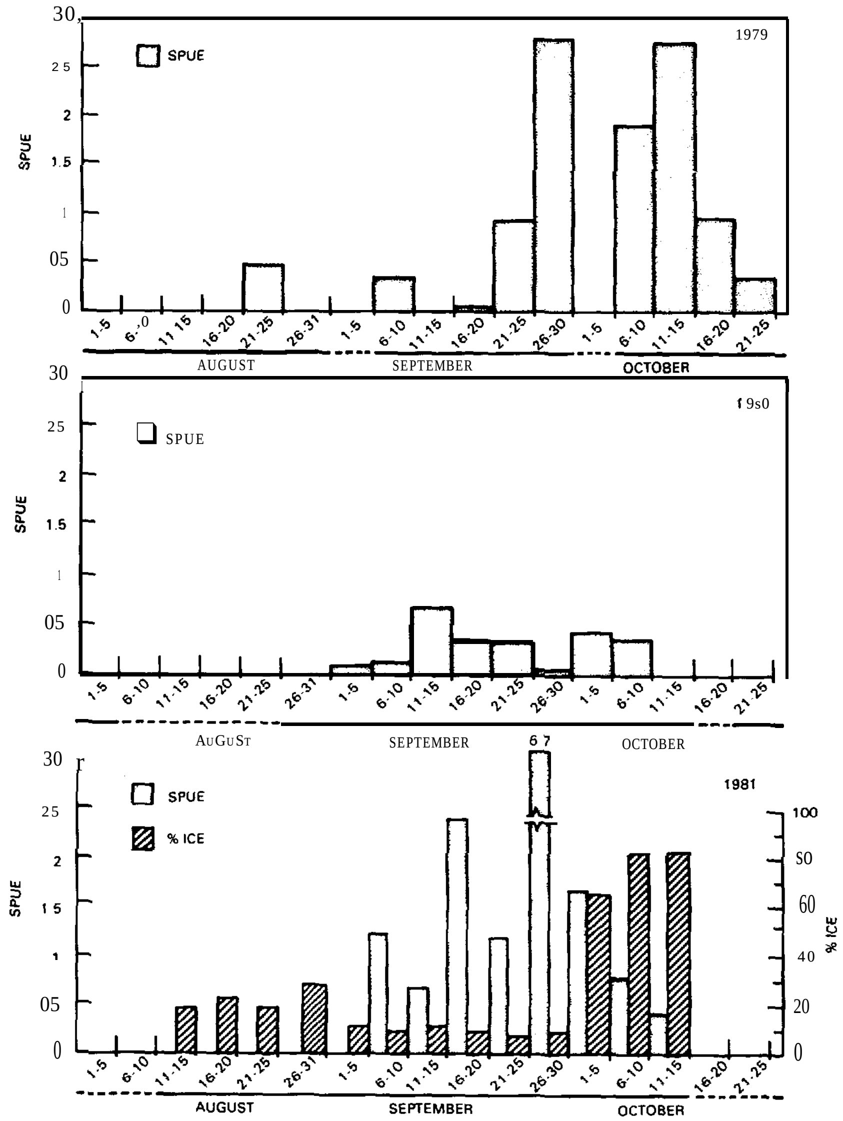


Figure 29. Bowhead whale sightings per unit effort (SPUE = no. sightings/hours of survey effort), and percentage of ice coverage, 1979-85. Ice coverage was not routinely recorded in 1979 and 1980, and therefore not incorporated in this analysis. A solid line (—) appears under periods of survey coverage; a dotted line (---) indicates periods without survey coverage.

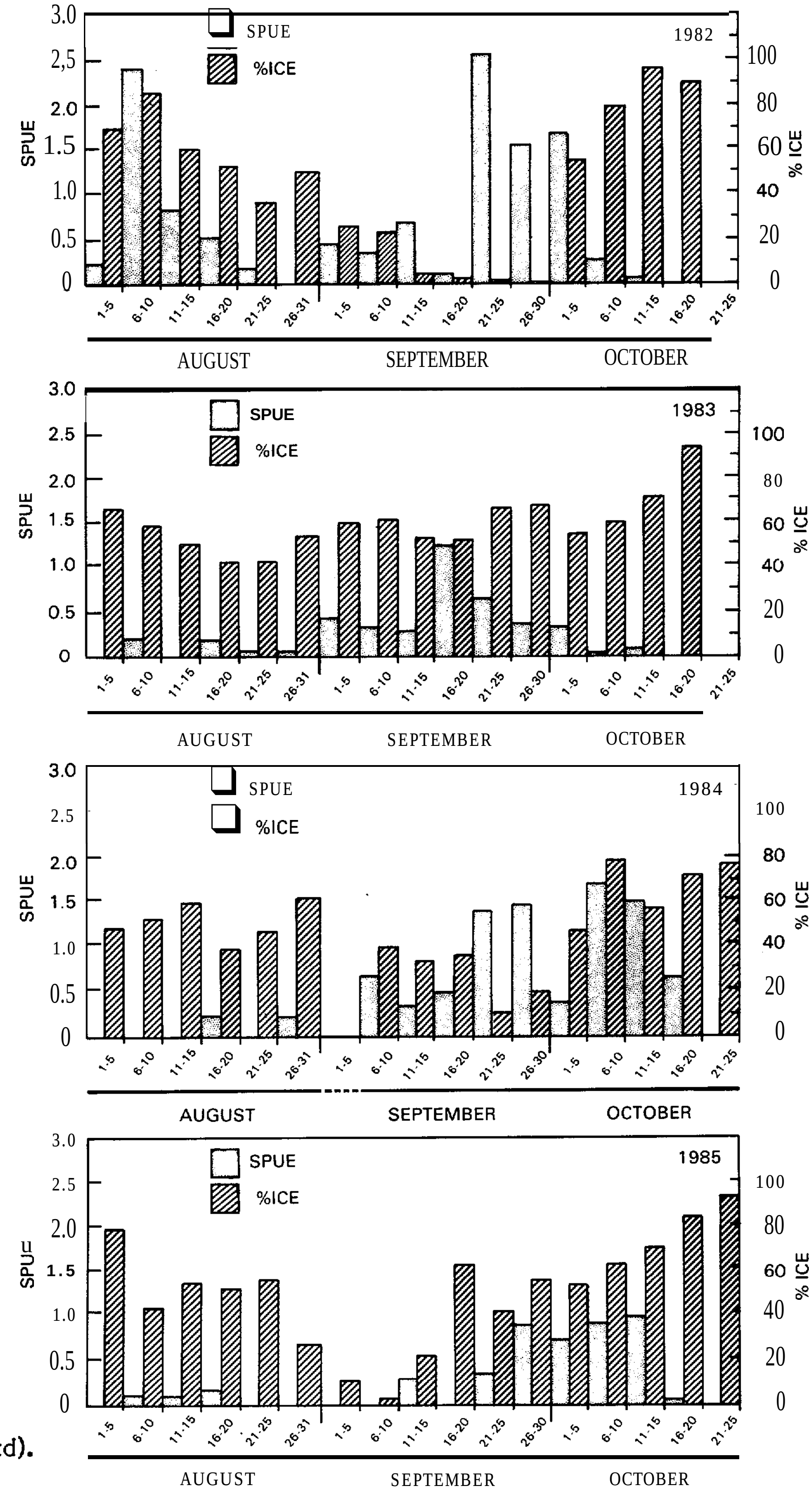


Figure 29 (contd).

Table 36. Matrix of correlation coefficients relating the migration initiation date (Y) to WPUE Peak (x_1), % feeding whales (x2), SPUE peak (x3), SPUE peak period (x4), % ice coverage (x5), and median depth (x6).

		(x_1)	(x_2)	(x3)	(x4)	(X5)	(X6)	(Y)
Peak WPUE	(x_1)	1.0						
% Feeding	(x_2)	0.290	1.0					
Peak SPUE	(x3)	0.561[1])	-0.134	1.0				
SPUE Period	(x4)	0.151	0.763[2])	0.053	1.0			
% Ice	(x5)	-0.849[3])	-0.607[1])	-0.568[1])	-0.408	1.0		
Median Depth	(x6)	-0.316	-0.490	-0.179	-0.356	0.484	1.0	
MIG. Initiation	(Y)	-0.089	0.095	-0.154	0.526	0.272	-0.090	1.0

1) $p < 0.20$
2) $p < 0.05$
3) $p < 0.02$

SPUE peak period, percentage of ice and median depth comprised the independent variables ($x_1 \ldots x_6$). The resultant correlation coefficients are summarized in Table 36. The strongest relationship was the negative correlation of ice coverage with peak WPUE ($r = -0.849$, $p < 0.02$). Ice coverage was also negatively associated with the percentage of feeding whales (r .-0.607, $p < 0.05$) and SPUE peak ($r = -0.568$, $p < 0.05$). As previously mentioned, WPUE is strongly influenced by the observed number of feeding whales, thus, it is not surprising that both WPUE and the percentage of feeding whales are negatively associated with heavy ice coverage, as ice coverage curtails productivity and in this way may limit bowhead feeding opportunities. The percentage of feeding whales was positively associated with peak SPUE period ($r = 0.763$, $p < 0.05$), indicating that in years of lighter ice when more whales are feeding, peak SPUE will be later than in heavy ice years when few whales are feeding. The annual median depth defining the axis of the bowhead migration was negatively associated with all parameters except ice coverage, although none of the relationships were significant (Table 36). The positive association of median depth with ice coverage may indicate that in heavy ice years, such as 1983, the migration proceeds farther offshore in deeper water than in light ice years. This may have indeed been the case in 1980, however, surveys were conducted only in relatively near-shore shallow water that year and whales migrating farther offshore in deeper water may have been missed.

The route, timing, and character of the fall bowhead migration across the Alaskan Beaufort Sea appears to 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 (ie., 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 migrations in heavy- ice years (Ljungblad et al., 1984 b). As previously noted, the ice conditions encountered in 1985 were intermediate to years described as heavy (1980, 1983) or light (1979, 1981-82, 1984) (Ljungblad et al., 1984b). The timing and general character of the 1985 migration was most similar to that observed in 1979 when SPUE was relatively high from 26 September through 15 October. The influence of ice coverage on the fall migration may be indirectly related to the aforementioned effects of ice coverage on prey productivity. Understanding the specific effects of ice coverage on prey productivity in areas where bowheads have been seen feeding may better explain the impact of ice conditions on migratory dynamics.

In general, bowheads were seen each year most often in whatever ice coverage predominated during the latter half of September or first half of October when the majority of migrating whales were observed. Since 1981, 64 percent (n = 939) of all bowheads seen were in open water (i.e., ice coverage < 10%, Table 37). Eighty-five whales (6%) were in light (1 1-30%) ice coverage, 114 whales (8%) were in medium (31-60%) ice coverage and 331 whales (22%) were in relatively heavy (≥60%) ice coverage. These data were not corrected for the potential effects ice coverage may have on the ability of observers to sight surfaced whales.

Probability of Detecting Bowhead Whales During the Fall Migration

The inability of observers to detect whales during aerial surveys will obviously affect distribution, relative abundance, density, and migratory route and timing results. Bowheads are missed by aerial observers either because (a) they are at the surface but go undetected, or (b) they are submerged as the aircraft passes over their location. The sightability of surfaced whales is affected by observer ability and by surface conditions (i.e., sea state and ice coverage). The relative ability of each observer to detect surfaced whales will vary with visual activity, attention span, the ability to withstand fatigue, experience with aerial surveys,

Table 37. Number and percent of bowheads found in each ice coverage class, fall 1981-85. Ice coverage was not routinely recorded in 1979-80.

Ice Coverage (%)	1981 No. (%)	1982 No. (%)	1983 No. (%)	1984 No. (%)	1985 No.(%)	Total No.(%)
o-1o	234(81)	309(63)	46(27)	282(74)	68(49)	939(64)
11-20	9(3)	6(1)	o(o)	11(3)	1(1)	27(2)
21-30	5(2)	8(2)	22(13)	4(1)	19(14)	58(4)
31-40	1(0.5)	12(2)	13(8)	19(5)	3(2)	48(3)
41-50	lo(3)	6(1)	4(2)	16(4)	o(o)	36(3)
51-60	1(0.5)	13(3)	12(7)	4(1)	o(o)	30(2)
61-70	6(2)	29(6) ‘	27(16)	l(o)	1(1)	64(4)
71-80	19(7)	30(6)	23(13)	7(2)	29(21)	108(7)
81-90	3(1)	75(15)	25(14)	25(7)	5(3)	133(9)
91-100	o(o)	2(1)	o(o)	11(3)	13(9)	26(2)
TOTAL	288(100)	490(100)	172(100)	380(100)	139(100)	1469(100)

and seat position or type of window. These factors have not been documented for each observer during bowhead aerial surveys but have been described as having a significant (p <0.03) effect on the outcome of other marine mammal surveys (Leatherwood et al., 1978). Magnusson et al. (1978) described an analysis, mathematically similar to mark-recapture techniques, that provides an estimate of the proportion of whales at the surface that are missed by observers. This method requires three full-time observers, such that two observers can survey independently from the same side of the aircraft. Because aerial surveys for bowheads in the AIaskan Beaufort Sea have not been conductedin this manner, the best approximation of surfaced whales missed by observers maybe that derived for aerial surveys of bowheads in the Canadian Beaufort Sea (Davis et al., 1982). The analysis performed by these researchers indicated that the raw bowhead count by a single observer on one side of the aircraft could be corrected for unseen surfaced whales by dividing that count by 0.685 $\pm$ se. 0.177 (Davis et al., 1982). Because this correction factor applies to sightings, it is potentially biased if large groups of whales are more easily detected than small groups or individuals, and it does not include any correction for submerged whales.

The effect of surface conditions on the sightability of surfaced whales was analyzed by comparing the perpendicular sighting distance of whales from the survey track line (see Figure B-1) to the percentage of ice coverage and sea state at the sighting. All sightings that had a perpendicular sighting distance (i.e. for which a clinometer angle was recorded) were entered into the analysis, ‘regardless of whether the whales were seen during search or line transect surveys. Ice coverage and sea state were not routinely recorded at bowhead sightings in 1979 and 1980, thus, the analysis was performed on 1981-85 data only. Annual correlation coefficients (Table 38) indicated that in 1981, 1984, and 1985 ice coverage did not have a significant effect on sighting distance, but that sighting distance was significantly affected by ice coverage in 1982 ($r = -0.299$, $p < 0.001$) and in 1983 ($r = -0.260$, $p < 0.05$). Ice conditions in the Alaskan Beaufort Sea in 1982 were much lighter than those in 1983, so it is unlikely that similarities in survey conditions effected the results of the annual regressions. Sea state was negatively correlated with sighting distance in all years, but these associated coefficients were not statistically significant. When 1981-85 data were pooled, sighting distance was significantly negatively correlated with ice coverage ($r = -0.224$, $p < 0.001$) and negatively associated with sea state ($r = -0.041$, $p < 0.50$). Because the intercorrelation of ice coverage and sea state for the pooled sample was strong ($r = 0.431$, $p < 0.001$), it is not appropriate to describe a precise regression function using these regression coefficients (Zar, 1984: Section 20.4).

Because the pooled data indicates that ice coverage negatively affects the sightability of surfaced whales, the 0.685 correction factor derived by Davis et al. (1982) may be enhanced if paired comparisons of individual sighting rates could be completed with regard to different ice conditions. Ideally, the results of such a comparison would be the derivation of a series of correction factors weighted by the percentage of extant ice coverage. For example, Davis et al. (1982) noted that the probability of detecting surfaced whales in areas of “extensive pan ice” (i.e. $\geq$ 70% coverage) is high because an observer’s attention can be focused for a “considerable period” on the relatively small, generally calm open water areas. Conversely, ice coverage of 30 to 70% may inhibit an observer’s search pattern and not be sufficient to appreciably dampen high sea states, while calm water with light ice conditions (i.e. $\leq$30%) may facilitate an observer’s search. In the absence of paired tests of sighting rates in a variety of ice conditions, 0.685 remains the best correction estimate for surfaced bowheads that are not detected by any individual observer.

Table 38. Correlation coefficients relating the effects of ice coverage and sea state surface conditions to the perpendicular sighting distance of bowhead whales from the survey track line.

	1981 (n=24)	1982 (n=172)	1983 (n=62)	1984 (n=89)	1985 (n=35)	1981-85 (n=386)
Ice coverage (%)	r = 0.268 p <0.50	r = -0.299 p <0.001	r = -0.260 p <0.05	r = -0.156 p <0.20	r = 0.023 p <0.50	r = -0.224 p <0.001
Sea state	r = -0.380 p <0.10	r = -0.009 p <0.50	r = -0.041 p <0.50	r = -0.082 p <0.50	r = -0.266 p <0.20	r = -0.041 p <0.50

Bowheads spend most of the time underwater. The probability that a whale will be at the surface when its location first comes into visual range may be described as:

$$\frac{s}{s+u} + \frac{t}{s+u} = \frac{s+t}{s+u}$$

Where (s) is the duration of surfacing, (u) is the duration of dives, and (t) is the duration of potential detectability (Eberhardt, 1978). Because only bowheads within 1 km of the survey track line have been considered when calculating bowhead density (see Appendix B), the parameter (t) was calculated as the time taken to travel 1 km at an average survey speed of 240 km/h; (i.e., t = 0.25 min.). Although the 0.25-minute figure seems a reasonable average estimate of duration of potential detectability, variation in survey speed, the potential detection of subsurface bowheads, or the detection of whales after the aircraft has passed their location will all affect the (t) estimate.

The dive and surface profiles of bowhead whales in the Alaskan Beaufort Sea were measured each fall 1981-84 during the course of surveys conducted to assess the effects of geophysical exploration on whale behavior (Fraker et al., 1985; Reeves et al., 1983; Ljungblad et al., 1984b; Ljungblad et al., 1985c). Most whales for which respiratory data were collected during these studies were either milling or feeding, not migrating. Based on the four sets of data, the proportion of time non-calf bowheads remained at the surface ranged from 11% to 18.5%, with an overall average of 13.6% (Table 39). The corresponding detection probabilities were calculated as 0.133 to 0.219, with a 0.160 overall average. Surface and dive times were reported for shallow (< 27-30 m) and relatively deep (30-50 m) water in

Table 39. Calculation of the probability that a bowhead whale will be at the surface and within an observer's field of view while conducting a random transect line.

	SURFACE TIME(S) $\bar{x}$	SURFACE TIME(S) s.d.	SURFACE TIME(S) n	DIVE TIME(U) $\bar{x}$	DIVE TIME(U) s.d.	DIVE TIME(U) n	Prop. of Time at surface	Detection Probability $\frac{S+.25}{S+U}$
A. September 1981								
Non-calves	1.82	0.94	42	13.31	6.81	20	12.0%	0.137
B. September 1982								
Non-calves	1.36	0.59	31	5.98	3.02	6	18.5%	0.219
Water depth								
<27.45 m	1.33	0.67	42	6.83	4.07	19	16.3%	0.194
>27.45 m	1.77	0.81	48			1		
C. September 1983								
Non-calves	1.33	1.10	168	7.11	5.94	59	15.8%	0.187
Water depth								
<30m	1.04	0.63	88	9.08	6.66	27	10.3%	0.127
30-59 m	1.42	0.87	35	4.84	4.86	14	22.7%	0.267
D. September 1984								
Non-calves	1.19	0.87	155	9.61	8.14	30	11.0%	0.133
Water depth								
<30m	0.82	0.57	100	6.90	7.09	17	10.6%	0.139
30-59 m	1.88	0.90	55	13.16	8.32	13	12.5%	0.142
OVERALL AVERAGE								
Non-calves	1.42	0.24	4	9.00	2.81	4	13.6%	0.160
Water depth								
27-30 m	1.06	0.21	3	7.60	1.04	3	12.2%	0.151
30-59 m	1.69	0.20	3	9.00	4.16	2	15.8%	0.181

A. Fraker et al., 1985: Table 3
B. Reeves et al., 1983: Table 9
C. Ljungblad et al., 1984b: Table 11
D. Ljungblad et al., 1985b: Table 1

1982-84. The proportion of time that bowheads in shallow water remained at the surface ranged from 10.3% to 16.3% with a 12.2% three-year average. Corresponding detection probabilities for whales in shallow water ranged from 0.127 to 0.194, with a 0.151 average. The proportion of time that whales in deeper water remained at the surface ranged from 12.5% to 22.7%, with 15.8% average for the two years for which data was available. Detection probabilities for whales in 30-59 m deep water ranged from 0.142 to 0.267, with a two-year O.181 average. Although the proportion of surface time for whales in 30-50 m deep water was longer than for whales in shallower water, these differences were not significant (X^2 = 0.050, p <0.90).

The results presented in Table 39 indicate that bowheads in the Alaskan Beaufort Sea were at the surface 13.6% of the time, and that 16% of the whales within 1 km of a random transect survey leg would be expected to be detectable. Since 1979, an annual average of 137 bowheads have been seen within one kilometer of the aircraft while conducting random transect surveys. When corrected for surfaced whales that are missed by aerial observers (i.e., 137 0.685), this number represents 200 whales. If these 200 whales comprise the component of whales at the surface as the aircraft passes over (i.e., 16%), then on average 1250 whales are actually represented by the annual average of 137 bowheads seen on transect.

Behavior and Sound Production

The proportion of bowhead behaviors observed in 1985 were roughly similar to previous years (Table 40). Migratory behaviors (swimming and diving) comprised 44 percent of all behaviors seen, a lower proportion than 1979-81 and 1983, the same as 1982 and a higher proportion than 1984. The percentage of socializing whales was highest in 1982 (56%), 1984 (63 %), and 1985 (56%). In contrast, Würsig et al. (1985) reported a relatively high socializing rate for bowheads summering in Canadian waters in 1981, relatively low rates of socializing in 1982 and 1984, and an intermediate rate in 1983.

Eleven percent of all whales seen in 1985 were resting, a greater proportion than all years except 1981 (18%; Table 41). Feeding whales comprised 25 percent of the sample, equal to that of the seven-year average. Milling whales comprised 6 percent of the sample. Cow-calf association represented 9 percent of all observations, equal to that in 1982 but greater than all other years. Five percent of all behaviors were displays, a proportion similar to all years except 1983 (14’?40).

Table 40. Proportions of migratory and social bowhead behaviors observed, fall 1979-85.

	1979	1980	1981	1982	1983	1984	1985
Migratory	59	85	64	44	62	37	44
Social	41	15	36	56	38	63	56

When bowhead calls recorded aboard secondary aircraft (Ljungblad et al., 1984b;1985c) were added to fall 1983-84 call samples, the 1985 sample contained fewer calls than any other year analyzed (Table 42). Call rate ranged from 0.9 in 1982, to 11.3 in 1983. The relatively high call rate in 1983 was nearly an orderof magnitude greater than the three-year combined average of 1982, 1984-35 ($\bar{x}$ = 1.3, s.d. = 0.4). Würsig et al. (1985) suggest that the high call rate (45.3) reported for bowheads summering in the Canadian Beaufort Sea in 1982 was the result of recordings made in relatively deep water that year, and state that there was a significant positive correlation between call rate and water depth when five years of data were analysed. No such correlation was found in the 1982-85 Alaskan Beaufort Sea bowhead call data base (r = -0.026, p <0.50, n = 30), although the average water depth at sonobuoy locations was in fact deeper in 1983 (427 m) than in 1984 (36 m) and 1985 (21 m), but shallower than in 1982 (721 m). The underwater propagation of bowhead calls is also affected by sea state and percent of ice cover. There was a weak trend for call rate to increase with increasing ice coverage (r = 0.286, p <0.20, n = 30), and an insignificant negative association of call rate with increasing sea state (r = -.078, p <0.50, n = 30). As previously mentioned, 1983 was a year of heavy ice coverage. The trend for bowhead call rates to be somewhat higher in heavy ice coverage is consistent with the high call rate recorded that year. In addition, 32?6 of all calls recorded in 1983 were “up” calls, a higher percentage than any other year (Table 42). These calls are very similar to “up” calls recorded near southern right whales (Eubalaena glacialis) that Clark (1983) suggests function as long distance “contact” signals that bring whales together. Perhaps bowheads migrating through heavy ice conditions call more often and use “contact” calls to coordinate their movements.

Table 41. Bimonthly summary of bowhead behavior, fall 1979-85.

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)
	1985	5	3	3	17	30	58 (42)
	Total	98	32	74	258	213	675 (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)
	1985	0	0	0	2	1	3 (2)
	Total	7	6	17	65	34	129 (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	3	8	40 (8)
	1983	8	0	3	1	0	12 (7)
	1984	1	1	0	7	15	24 (6)
	1985	2	0	2	5	6	15 (11)
	Total	29	8	24	40	37	138 (9)
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	o	0	0	10	14 (8)
	1984	0	8	0	138	2	148 (39)
	1985	0	0	23	0	12	35 (25)
	Total	4	8	59	288	42	401 (25)
Mill	1982	12	12	7	50	0	81 (17)
	1984	0	0	0	46	0	46 (12)
	1985	0	0	6	2	1	9 (6)
	Total	12	12	13	98	1	136 (8)
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)
	1985	0	0	0	6	6	12 (9)
	Total	8	8	10	16	28	70 (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)
	1985	2	0	0	1	4	7 (5)
	Total	10	3	14	20	18	65 (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
	1985	9	3	34	33	60	139
	Total	168	77	211	785	373	1614 (100)

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

Table 42. Percent of bowhead calls of each category, fall 1982-85.

		CALL TYPE							
		Simple				Complex			
Year	Call Rate	Up %	Down %	Const. %	Inflect %	High %	Growl %	Trumpet %	No. Calls
1982	0.9	20	27	8	17	8	10	10	2012
1983	11.3	32	15	7	18	2	22	4	1194
1984	1.1	21	17	1	23	3	19	16	182
1985	1.9	19	25	3	11	3	35	4	170

All bowhead call types recorded during the falls of 1982-85 were qualitatively very similar to those recorded and quantitatively described for the spring migration (Ljungblad et al., 1982; Clark and Johnson, 1984), and the relative proportions of simple and complex calls were roughly similar each year (Table 42). Simple FM calls comprised 61 to 80 percent of the bowhead fall call sample with a four-year average of 70 percent; conversely, 20 to 39 percent of bowhead calls recorded in fall were complex AM signals with a 30 percent four-year average. This four-year fall proportion of simple/complex calls (70/30) contrasts with two-year spring (52/48; Moore et al., 1984) and five-year summer (87.5/12.5; Würsig et al., 1985) proportions, indicating there may be some seasonal differences to the call types produced. The interpretation of these differences is compromised in several ways. Although the procedures for call categorization have been agreed upon by the different analysts, call samples have largely been reviewed and counted aurally resulting in an inherent reliance on the listener's hearing and subjective judgement. The time and cost of analyzing all recorded sounds via spectral processes have, to date, been prohibitive. Therefore, there is probably some subjective bias to the proportion of calls reported. Secondly, and perhaps more important, are the circumstances (i.e., environmental conditions and/or researcher's motivation) involved in recording data. In spring and fall, sonobuoys were usually dropped near groups of whales, and occasionally when whales were not seen to acoustically monitor an area for whale presence. In summer, sonobuoys were always dropped near whales (Würsig et al., 1985).

Although statistically significant correlations between observed behaviors and call production have not been demonstrated for bowheads, general trends of socializing whales producing higher proportions of complex calls and swimming or resting whales producing mostly tonal FM calls have been reported (Ljungblad et al., 1984a, 1985b; Würsig et al., 1985). Such differences likely result in different proportions of sounds being recorded depending on the behavior of the subject whales that a researcher chooses to drop a sonobuoy near. In addition, variation in sea state and ice conditions will affect the attenuation of each call type somewhat differently, depending on their physical qualities, and therefore, the proportion of calls recorded in the sample.

Because acoustic monitoring is becoming more common in bowhead research (Clark et al., 1985; Clark et al., 1986; Cummings and Holliday, 1983), it is increasingly important that the data recorded be analyzed for differences in call rate, or call type proportions, by season and/or by the number of whales near ($\leq$10 km) the sonobuoy, such that inferences may be drawn from the data. To test for possible correlations, 87 bowhead call samples were tabularized with concomitant behavior, call rate, and the proportion of call types (Table 43). The sample included recordings made in spring (April/May, n = 12), summer (August, n = 51) and fall (September/October, n = 24). Forty-five samples were recorded, usually in August, near whales summering in the Canadian Beaufort Sea (Würsig et al., 1982, 1983, 1984a). Seven August recordings were made either in the eastern Alaskan Beaufort Sea, or within 50 km of the U.S.-Canadian border (Ljungblad et al., 1983, 1984), and were considered "summer" data for this analysis. A behavior index was calculated for the samples as described for the fall 1985 acoustic data (p. 49). For 1980-83 data tabulated from Würsig et al. (1982-84), an average number of whales and average call rate was calculated for samples where ranges were given in the original data. Also, for 1982-83 data transcribed from Würsig et al. (1983-84) the "loud sounds," presumed to be produced by whales $\leq$5 km from the sonobuoy, were used because associated behaviors were listed for these sounds. Call samples were omitted if there were no behavioral observations associated with them.

In spring, call rate ranged from 2.9 to 22.6 ($\bar{x}$ = 9.91, s.d. = 7.23), in summer from 0.0 to 5.49 ($\bar{x}$ = 5.59, s.d. = 9.42), and in fall from 0.0 to 93.1 ($\bar{x}$ = 23.13, s.d. = 26.36). Although the spring and summer call rates were not significantly different ($t' = 1.75$, $p < 0.10$), average fall call rate was significantly higher than spring ($t' = 2.29$, $p < 0.05$) and summer ($t' = 3.17$, $p < 0.005$).

Table 43. Summary of 87 bowhead call samples recorded since 1980, including number of whales, behavior index, call rate, percentage of call types, and number of calls.

Sample No.	Date	No. Whales	Behavior	Behavior Index	Call rate (calls/wh-h)	up (%)	down (%)	const (%)	inflect (%)	high (%)	growl (%)	trumpet (%)	No. Calls
1	26 April 1982	28	RE/MS/SW	0.6	4.6	23	11	0	0	9	46	11	35
2	28 April 1982	8	RE/MS/SW	1.4	10.5	23	19	6	0	0	49	3	31
3	3 May 1982	35	RE/SW	0.9	3.2	42	19	9	7	4	19	0	96
4	4 May 1982	33	SW/MS/AS/DY	2.5	4.8	8	10	4	3	8	47	20	250
5	5 May 1982	11	MS/SW	1.5	19.2	12	15	3	4	2	41	23	127
6	13 May 1982	45	RE/MS/SW/AS	1.2	2.9	22	10	10	3	0	49	6	125
7	14 May 1982	12	SW	1.0	13.6	25	18	11	8	0	34	4	9s
8	30 April 1983	11	MS/AS/SW	2.1	3.6	10	10	0	20	0	40	20	10
9	1 May 1983	10	AS/SW	3.8	6.4	14	29	0	14	0	38	5	21
10	2 May 1983	15	SW/AS	3.7	22.6	51	5	0	3	1	39	1	282
11	4 May 1983	4	SW/AS	3.0	20.2	26	21	0	3	0	50	0	34
12	[0 May 1983	9	SW	1.0	7.3	5	24	3	13	0	55	0	38
13	7 Aug 1980	7	MS	2.0	9.1	26	6	3	0	0	65	0	31
14	22 Aug 1980	14	FE	3.0	1.0	37	45	9	9	0	0	0	11
15	23 Aug 1980	5	FE	3.0	2.6	60	10	0	0	0	30	0	10
16	29 Aug 1980	9	MS	2.0	1.3	14	21	0	58	0	7	0	14
17	5 Aug 19S1	5	SW	1.0	30.5	30	8	12	10	12	2	26	84
18	5 Aug 1981	5	Sw	1.0	13.0	39	0	0	0	15	0	46	13
19	10 Aug 1981	2	RE	0.0	0.0	0	0	0	0	0	0	0	0
20	10 Aug 1981	5	MS	2.0	1.1	0	0	0	0	25	0	75	4
21	18 Aug 1981	10	Sw	1.0	1.4	58	12	2	2	7	7	12	42
22	18 Aug 1981	25	FE	3.0	0.4	37	27	0	0	0	9	27	11
23	18 Aug 1981	25	FE	3.0	0.0	0	0	0	0	0	0	0	0
24	18 Aug 1981	25	FE	3.0	1.1	58	5	2	2	9	21	3	57
25	19 Aug 1981	6	FE	3.0	0.0	0	0	0	0	0	0	0	0
26	19 Aug 1981	6	MS	2.0	1.1	75	0	0	25	0	0	0	4
27	19 Aug 1981	6	MS	2.0	0.5	100	0	0	0	0	0	0	1
28	19 Aug 1981	4	MS	2.0	0.3	100	0	0	0	0	0	0	1
29	23 Aug 1981	6	MS	2.0	2.4	50	30	10	0	10	0	0	10
30	23 Aug 1981	12	AS	5.0	10.1	19	5	2	2	13	31	28	363
31	23 Aug 1981	12	AS	5.0	0.0	0	0	0	0	0	0	0	0
32	24 Aug 1981	12	SW	1.0	0.9	30	40	0	0	10	0	20	10
33	25 Aug 1981	15	SW	1.0	0.5	100	0	0	0	0	0	0	7
34	25 Aug 1981	4	MS	2.0	4.2	100	0	0	0	0	0	0	4
35	25 Aug 1981	4	PL/MS	2.8	1.5	100	0	0	0	0	0	0	1
36	25 Aug 1981	5	SW	1.0	3.7	55	23	0	0	3	16	3	31
37	8 Sep 1981	6	AS	5.0	22.4	8	3	1	0	22	8	58	121
38	8 Aug 1982	6	RE/SW/MS	1.0	17.5	71	5	20	1	0	0	3	98
39	14 Aug 1982	1	Sw	1.0	22.9	57	0	6	12	0	0	25	16
40	14 Aug 1982	3	SW	1.0	6.2	19	12	25	6	0	0	38	16
41	16 Aug 1982	6	Sw	1.0	8.3	7	28	5	7	2	12	39	43
42	19 Aug 1982	9	SW/PL/CC	2.1	3.8	18	14	50	6	0	6	6	49
43	19 Aug 1982	11	SW/MS/CC	1.8	4.0	16	28	18	11	1	17	9	100
44	23 Aug 1982	11	SW/MS/CC	1.9	18.2	17	38	16	16	3	3	7	474
45	24 Aug 1982	8	SW/MS/DY	1.9	4.1	47	0	12	6	6	0	29	17
46	24 Aug 1982	8	Sw	1.0	6.5	36	14	21	20	3	0	6	102
47	24 Aug 1982	4	RE	0.0	1.7	100	0	0	0	0	0	0	6

Table 43 (contd).

Sample No.	Date	No. Whales	Behavior	Behavior Index	Call rate (calls/wh-h)	up (%)	down (%)	const (%)	inflect (%)	high (%)	growl (%)	trumpet (%)	No. Calls
48	31 Aug 1982	1	Sw	1.0	8.8	29	0	0	7	7	0	57	14
49	31 Aug 1982	2	RE/SW	0.5	0.0	0	0	0	0	0	0	0	0
50	9 Aug 1983	12	MS	2.0	0.0	0	0	0	0	0	0	0	0
51	15 Aug 1983	6	SW	1.0	0.2	100	0	0	0	0	0	0	1
52	15 Aug 1983	6	Sw	1.0	1.7	13	10	10	25	0	42	0	31
53	17 Aug 1983	15	MS	2.0	2.3	37	18	18	9	9	9	0	11
54	18 Aug 1983	13	MS/SW	1.5	0.4	40	0	0	20	0	40	0	5
55	22 Aug 1983	6	DY/FE	3.5	2.6	27	27	0	18	10	18	0	11
56	22 Aug 1983	10	RE/SW	0.5	1.0	86	0	0	0	0	7	7	14
57	26 Aug 1983	6	FE	3.0	0.0	0	0	0	0	0	0	0	0
58	7 Aug 1982	10	SW/MS/CC	1.7	2.1	50	30	20	0	0	0	0	10
59	8 Aug 1982	19	SW/MS	1.3	6.1	12	19	13	5	16	22	13	78
60	15 Aug 1982	16	RE/MS/CC	1.9	9.0	34	7	15	4	21	2	17	82
61	16 Aug 1982	14	RE/SW/MS/CC	2.1	5.0	12	3	6	0	12	58	9	41
62	18 Aug 1982	9	MS/DY	2.9	8.2	56	3	35	0	3	3	0	37
63	14 Sep 1982	18	MS	2.0	11.4	17	11	6	10	12	12	32	143
64	15 Sep 1982	32	SW/FE/CC	2.5	8.7	25	22	12	21	4	10	6	277
65	16 Sep 1982	60	SW/MS/FE	1.8	11.3	17	36	6	20	5	10	6	1014
66	24 Sep 1982	133	SW/MS/FE/CC/DY	2.1	3.0	21	19	9	17	12	4	18	330
67	2 Aug 1983	3	SW/DY	4.3	54.9	0	0	0	0	21	50	29	28
68	9 Aug 1983	8	SW/FE/DY	2.6	2.8	0	0	0	0	25	75	0	4
69	12 Sep 1983	14	DY/MS/SW	2.5	28.7	41	17	15	13	2	9	3	523
70	21 Sep 1983	3	SW/CC	3.0	29.6	12	21	0	0	0	67	0	24
71	26 Sep 1983	2	Sw	1.0	65.0	62	15	0	8	0	15	0	13
72	2 Ott 1983	5	CC/SW	3.4	93.1	27	15	1	23	1	30	3	6S4
73	14 Ott 1983	3	SW/DY	2.7	91.7	27	27	0	23	0	23	0	22
74	11 Sep 1984	4	Sw	1.0	2.2	0	0	0	100	0	0	0	2
75	18 Sep 1984	4	Sw	1.0	37.5	0	0	0	78	0	22	0	18
76	21 Sep 1984	3	SWIMS	1.7	14.4	62	31	0	7	0	[illegible]	0	13
77	24 Sep 1984	50	SW/FE	2.8	2.2	21	37	11	5	0	26	0	19
78	26 Sep 1984	7	MS	2.0	0.0	0	0	0	0	0	0	0	0
79	3 Oct 1984	9	RE/SW	0.6	33.3	37	20	0	17	0	26	0	30
80	9 Ott 1984	18	RE/SW/DY	3.1	14.6	16	13	0	18	5	18	30	100
81	11 Ott 1984	2	RE	0.0	0.0	0	0	0	0	0	0	0	0
82	17 Oct 1984	1	Sw	1.0	0.0	0	0	0	0	0	0	0	0
83	11 Sep 1985	18	RE/MS/FE	1.7	0.7	11	0	0	33	0	56	0	9
84	23 Sep 1985	8	MS/SW	1.5	16.3	47	27	0	0	3	23	0	30
85	25 Sep 1985	4	RE/SW	0.5	21.1	24	29	8	21	5	13	0	38
86	27 Sep 1985	11	SW/MS/CC	2.1	14.6	15	17	2	8	4	54	0	53
87	13 Oct 1985	6	RE/SW	0.8	33.3	2	35	2	8	0	35	18	40

Sample No. 13-37: Würsig et al. 1982, Table 5, p. 113

Sample No. 38-47: Würsig et al. 1983, Table 9, "loud sounds", p. 85

Sample No. 48-57: Würsig et al. 1984, Table 6, "loud sounds", p. 82

Table 44. Matrix of correlation coefficients relating number of bowhead whales (Y) to behavior index (x_1), call rate (x2), percentage of call types (x3-x9) and total number of calls (x10). Coefficients represent the results of a multiple regression analysis of the data summarized in Table 43.

		(x_1)	(x_2)	(x3)	(x4)	(x5)	(X6)	(x7)	(X8)	(x9)	(x_{10})	(Y)
avior index	(x_1)	1.0										
rate	(x_2)	0.143	1.0									
calls: up	(x3)	-0.155	-0.070	1.0								
[own	(x4)	0.011	0.167	-0.122	1.0							
:onstant	(x5)	-0.068	-0.076	-0.004	0.212 2)	1.0						
nflect	(X6)	-0.114	0.176	-0.2262)	0.053	-0.043	1.0					
iigh	(x7)	O. 2352).	0.019	-0.211 2)	-0.090	0.009	-0.160	1.0				
calls: growl	(X8)	0.173	0.216 2)	-0.3164)	0.107	-0.173	0.000	0.091	1.0			
rumpet	(x9)	0.088	0.042	-0.212	-0.099	0.002	-0.130	0.5795)	-0.123	1.0		
Calls	(x_{10})	0.195 1)	0. 305 4)	-O. O99	0.2673)	0.144	0.110	0.095	0.047	0.040	1.0	
Whales	(Y)	0.088	-0.163	-0.102	0.222	0.118	0.020	0.143	0.056	0.010	0.4225)	1.0

-i'j--p <0.10 4) p <0.05
2) p <0.05 5) p <0.001
3) p <0.02

A multiple linear regression was performed on the data summarized in Table 43, resulting in several significant correlations (Table 44). The only significant correlation with behavior index was "high" (FM_7) calls (r = 0.235, p <0.05, n . 87), and there was a trend for the number of calls to be greater with higher behavioral indices (r = 0.195, p <0.10, n = 87). Call rate was positively correlated with the number of calls (r = -0.305, p <0.005, n = 87), and with "growl" (AM_1) calls (r = 0.216, p <0.05, n = 87). As in the fall 1985 sample, call rate was positively associated with "down" (FM_2) calls, and negatively associated with the number of whales, but these correlations were not significant. Significant intra-call type correlations were found with "up" (FM 1), "down" (FM 2) and "trumpet" (AM_2) calls. All correlations with "up" calls were negative; the four that were significant were with "inflect" (FM_6) calls (r = 0.226, p <0.05, n = 87), with "high" (FM_7) calls (r = -0.211, p <0.05, n = 87), with "growl" (AM 1) calls (r = -0.316, p < 0.005, n = 87) and with "trumpet" (AM_2) calls (r = -0.212, p <0.05, n = 87). Down calls were significantly correlated with "constant" (FM_5) calls (r = 0.212, p <0.05, n = 87), with the number of calls (r = 0.267, p < 0.02, n = 87), and the number of whales (r = 0.222, p <0.05, n = 87). Trumpets were significantly correlated with “high” (FM7) calls (r = 0.5?9, p < 0.001, n = 87). The number of calls was significantly correlated with the number of whales (r = 0.422, p <0.001, n = 87). These correlations suggest that bowhead calls are in some way interrelated, and not simply a series of discrete events. As Clark (1982) reported for southern right whales, the bowhead call repertoire may be best described as a continuum where certain call types are more common than others, and with some inter-call associations within the repertoire framework.

The occurrence of significant correlation between call types suggests that call production changes with concomitant behavior. The ability to infer something about the number and/or behavior of whales associated with a particular call sample is occluded, however, by the apparent flexibility of bowhead calling behavior and the inability of aerial observers to positively identify and watch calling whales. There was no clear association of call rate with the number of whales nor of their behavior. A review of Table 43 indicates instances where swimming bowheads (i.e., behavior index ▫1.0) produced call rates ranging from 0.2 calls/wh-h to 60 calls/wh-h, while milling whale (behavior index = 2.0) call rate ranged from 0.0 to 11.4 calls/wh-h, and so on. If bowhead and right whale calling strategies are similar, however, certain assumptions about call type proportions may be practical. Clark (1982; 1983) reported that resting right whales produced “up” calls, swimming whales produced “up” and “down” calls, mildly active and fully active whales produced mostly “high” calls with some “growls”, “ups” and "downs", and that sexually active whales produced mostly “growls” and “high” calls with some “up”, “down” and “constant” calls. A researcher at a listening station may infer general activity states, and whether whales are likely grouped, from these associations. For example, a series of “up” calls may indicate lone stationary or swimming whales (note: bowhead “up” calls were negatively associated with all other call types), while a series of “growls” and “trumpets” with interspersed FM calls may indicate a social group of whale near the hydrophore.

Recruitment

Bowhead calves have been seen from August through October, resulting in annual recruitment estimates ranging from 0.01 to 0.08, and an overall estimate of 0.03 (Table 45). The 1985 recruitment estimate (0.05) was the same as that calculated in 1982, and higher than that calculated for all other fall seasons, except 1983 (0.08). The recruitment estimate for 1983 (7.56%) was significantly

Table 45. Sightings and estimated Gross Annual Recruitment Rate (GARR)* of bowhead calves by two-week interval, fall 1979-85.

Year	1-15 Aug	16-31 Aug	1-15 Sep	16-30 Sep	1-24 Oct	Total
1979	0	0	0	0	6(0.05)	6(0.03)
1980	0	0	0	0	1(0.08)	1(0.02)
1981		0	1(0.02)	1(0.01)	1 (0.02)	3(0.01)
1982	5(0.05)	6(0.16)	4(0.07)	7(0.03)	1(0.02)	23(0.05)
1983	2(0.04)	1(0.10)	3(0.12)	3(0.06)	4(0.11)	13(0.08)
1984	0	0	0	2(0.01)	3(0.03)	5(0.01)
1985	0	1(0.09)	0	3(0.09)	3(0.05)	7(0.05)
TOTAL	7(0.04)	8(0.09)	8(0.04)	16(0.02)	19(0.04)	58(0.03)

*GARR · Number calves/total number bowheads

higher than those in 1979 (3.05%; X2 = 6.85, p <0.01), 1981 (1.04%; X2 = 13.54, $p < 0.001$), and 1984 (1.32%; $X^2 = 14.46$, $p < 0.001$), and was also significantly higher than all years (except 1983) combined ($X^2 = 10.12$, $p < 0.001$).

The variation in bimonthly and yearly recruitment estimates may be due to age class segregation within the population. Segregation of bowhead age classes in the eastern Beaufort Sea has been demonstrated via photogrammetric 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 45) represents only the observed portion of the bowhead population in the Alaskan Beaufort Sea during the stated time period.

Table 46. Monthly summary of gray whale sightings (number of sightings/number of whales), fall 1980-85.

	August	September	October	November	TOTAL
1980	0[a]	0	44/125	60/163	104/288
1981	33/55	0	0	0	33/55
1982	0	5/18	6/8	0	11/26
1983	2/14	1/2	6/10	0	9/26
1984	16/33	7/70	6/12	0	29/115
1985	0	0	0	0	0
TOTAL	51/102	13/90	62/155	60/163	186/510

a) 3/3, Canadian Beaufort Sea; Rugh and Fraker, 1981.

GRAY WHALE

Distribution and Relative Abundance

Since 1980, 186 fall sightings of 510 gray whales have been made (Table 46), with 64 percent (n = 328) of all whales in the Bering Sea, and 36 percent (n = 182) in the Chukchi Sea. In October and November 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 northwestern Chukchi Sea.

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 30). In August, grays were seen along the southeast coast of St. Lawrence Island, in the Chirikov Basin between 1670W 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 30A). Three gray whales were seen in the Canadian Beaufort Sea by researchers on the primary aircraft (N780) in August 1980 (Rugh and Fraker, 198 1), but were not plotted in Figure 30A as the sightings were well east of 1390W. In September (1982-84), grays were seen in the northeastern Chukchi Sea between Wainwright and Barrow (Figure 30 B). In

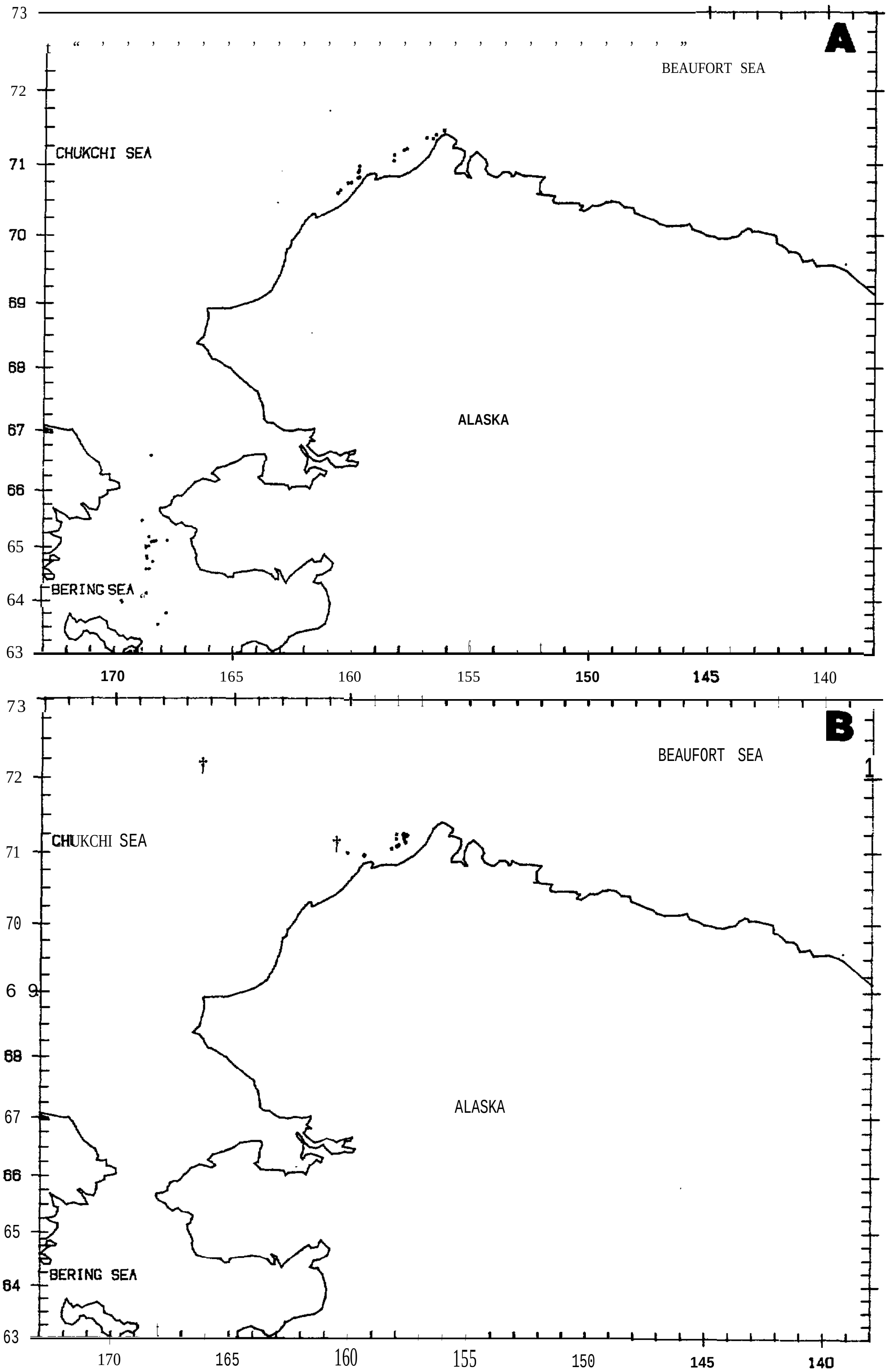
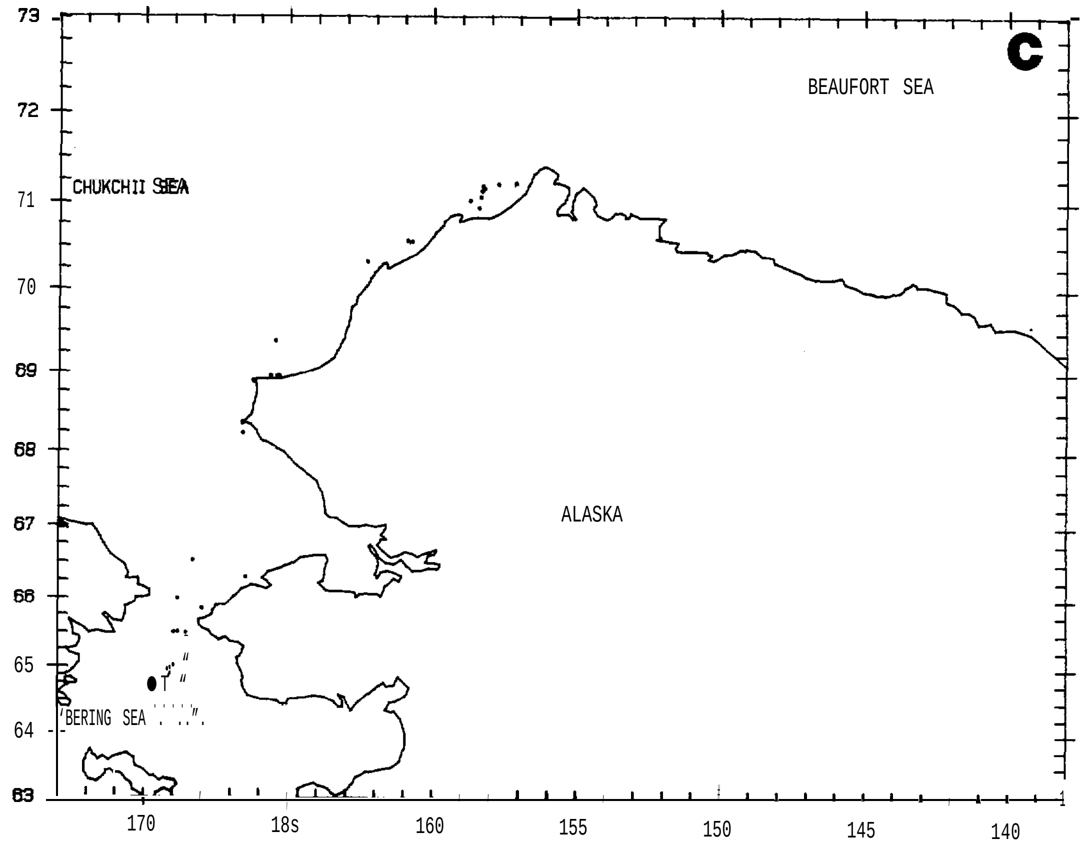


Figure 30. Distribution of 186 sightings of 510 gray whales, fall 1980-85; 51 sightings of 102 whales in August (A); 13 sightings of 90 whales in September (B); (#'September 1985 sightings by USF WS researchers; K. **Frost,** personal communication).



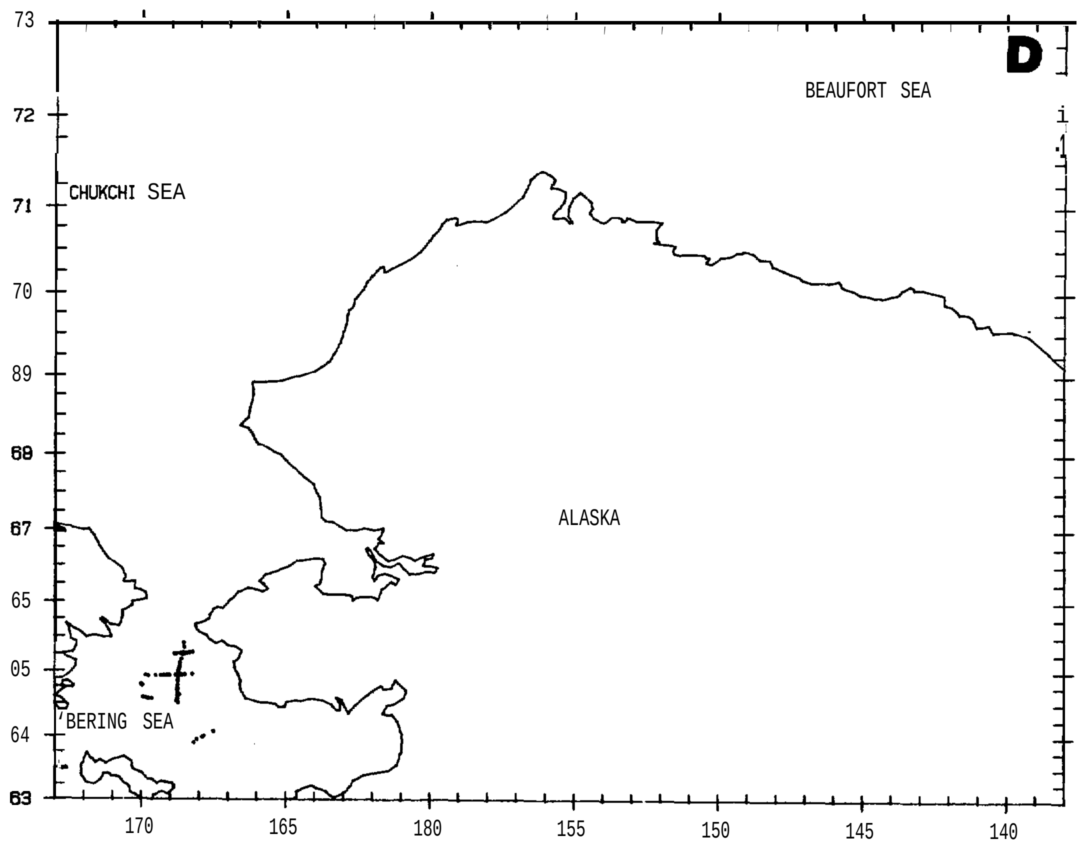


Figure 30(contd). **62 sightings of 155 whales** in October (C)and 60 sightings of 163 whalesin November (D).

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 30 C). In November (1980) all gray whales were seen on surveys conducted in the Chirikov Basin (Figure 30 D).

The only gray whales reported during fall surveys. in 1985 were two seen in September by researchers conducting walrus surveys for USFWS (Figure 2 1B). One whale was seen with three mud plumes on 22 September at 72009 .0'N, 166017.1'W; and one was seen on 25 September" at 7 1°07.2'N, 160033 .8'W. The whale seen on 22 September was approximately 445 km northwest of Barrow, or about twice the distance from Barrow as our farthest offshore sighting of three whales on 31 August 1984.

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 47). In the northern Bering Sea, relative abundance was highest in block 26 (20.46), with lesser values calculated for blocks 25 (10.46) and 27 (1.80).

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 11.84 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

Of the 222 gray whales seen in fall since 1981, 92% (n = 205) were in open water or very light ($\leq$ 10%) ice coverage, 2% (n = 4) were in 11 to 20% ice coverage, 4% (n = 8) were in 71 to 80% coverage and 2% (n = 5) were in 81 to 90% coverage. Grays were found in water from 5 m to 62 m deep ($\bar{x}$ = 38.03, 13.67 s.d.). Whales seen along the shoreline appeared to be in water shallow enough to allow them to rest on the bottom.

Table 47. Relative abundance of gray whales (WPUE) by block, fall 1980-85. (--) = no effort*

Month Block	Aug No. (WPUE)	Sept No. (WPUE)	Ott No. (WPUE)	Nov No.(WPUE)	Total No.(WPUE)
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)	1(1.20)	6 (1.20)
25	12 (3.35)		36 (11.84)	44(19.73)	92 (10.40)
26	17 (20.48)	--	83 (17.55)	106(23.50)	206 (20.46)
27	1 (1.49)	--	--	3(1.94)	4 (1.80)
28	6 (1.71)		4 (2.96)	4(1.27)	14 (1.75)
29	--	--	--	0	0

*does not include whales and effort for: 17 gray whales seen in block 12 and 10 gray whales seen in unblocked areas in August, and 5 gray whales seen in unblocked areas in November.

Recruitment

Only one gray whale calf was seen in the fall over six seasons. On 17 August 1983, a calf was seen among 13 adult whales north of Point Barrow (71°26.6'N, 156°11 .5'W) in 20 percent ice coverage. This was the farthest north a gray whale calf was seen.

Review Summary

1. Bowhead whales were seen in eastern Alaskan and western Canadian Beaufort Sea waters throughout August and mid-September, and were distributed across the Alaskan Beaufort Sea and into the northeastern Chukchi Sea from mid-September through October, 1979-85.
2. The annual variation in bowhead distribution in the Alaskan Beaufort Sea during the 1979-85 fall migration did not appear to be as great as that described for bowheads summering in the Canadian Beaufort Sea between 1980-84 (Richardson et al., 1985a).

3. Bowheads seen in the Alaskan Beaufort Sea in August were generally farther offshore and in deeper water than those seen in September and October.

4. There may be considerable movements of whales back and forth between the Canadian and Alaskan Beaufort Seas prior to the onset of the migration.

5. Ice coverage was negatively associated with bowhead relative abundance as calculated by W PUE ($r = -0.849$, $p \leq 0.02$) and 5-day SPUE peak (-0.568, $p \leq 0.05$). The negative correlation of ice coverage with sighting distance ($r = -0.224$, $p \sim 0.001$) likely influences these results.

6. Although there were some annual variability in observed bowhead whale distribution during the autumn 1979-85 migrations, it appears that except for 1983, the migration route may be roughly demarcated by the 20- to 40- meter isobath, and that the effects of OCS oil and gas development activities on the axis of the bowhead whale migration (as defined by median depth) are slight.

7. Although the 1983 migration route could be said to be displaced offshore compared to other years, it is not likely that this was the result of industrial activities because such activities were curtailed that year. Additionally, the migratory axis since 1983 (i.e. 1984-85) was Similar to years 1979-82. There is little quantitative information available on displacement of large whales by human activities. Although gray whales (*Eschrichtius robustus*) were apparently displaced from a wintering breeding lagoon off Baja California, Mexico by increased ship traffic (Gard, 1974; Reeves, 1977), they returned when ship traffic abated (Bryant et al., 1984). It has been suggested that the gray whale migration has been displaced offshore by human activities, especially in the southern California Bight (Rice, 1965; Dohl and Guess, 1979), but Evans (1982) noted that this potential shift has been documented during a time when the gray whale population appears to be increasing and the apparent shift offshore may be a function of increased population size or other reasons unrelated to disturbance. Cowles et al. (1981) note that gray whales have continued to migrate along the western coast of North America despite increases in vessel traffic and other potentially disturbing activities. Additional instances where human activities have been thought to impact whale distribution include the breeding and feeding areas of north Pacific humpback whales (*Megaptera novaeangliae*) in Hawaii (Norris and Reeves, 1978) and Alaska (Baker et al., 1983) respectively; blue (*Balaenoptera*

musculus) and fin (Balaenoptera physalus) whales in the St. Lawrence river (Macfarlane, 1981); and minke whales (Balaenoptera acutorostrata) off Japan (Nishiwaki and Sasao, 1977). In all of the above cases, however, displacements have not been convincingly demonstrated (all but Bauer and Herran, 1986; reviewedby Richardson, 1983).

8. Based on 1983 results, it is likely that the 1980 migration proceeded farther offshore than aerial surveys were flown that year and went largely undetected.

9. As described in Ljungblad et al. (1986a,c) whales passing through the Alaskan Beaufort Sea stop to feed opportunistically. Feeding whales were seen in shallower water and in lighter ice coverage than whales not feeding, and so the annual availability of prey will influence somewhat the water depth and ice coverage in which whales are found. The lack of quantitative information regarding the effect of ice coverage and/or oceanographic processes along the shelf break (or ice edge) on the distribution of bowheads or their prey somewhat confounds the interpretation of data on bowhead distribution.

10. Bowhead call rate was significantly higher in September-October ($\bar{x}$ = 23.13 calls/wh-h) than in April-May ($\bar{x}$ = 9.91 calls/wh-h; t' . 2.29, $p < 0.05$), or August ($\bar{x}$ = 5.59 calls/wh-h; t' = 3.17, $p < 0.005$). There was a trend for call rates to increase with ice coverage. Bowhead call rate in 1983, a heavy ice year, was nearly an order of magnitude higher than the average of 1982, 1984-85.

11. Gray whale density in summer was greatest each year in the Chirikov Basin (0.360 whales/km^2) north of St. Lawrence Island, and along the coastal Chukchi Sea (0.26 1 whales/km ^{2}).

12. The ratio of gray whale calves to all whales in summer was significantly higher in the Chukchi Sea (44/560 . 0.08) than in the northern Bering Sea (6/1983 = **0.003**; X^2 = 128.3, $p < 0.001$). The relative abundance of gray whale calves was also significantly higher in the Chukchi Sea (0.39 calves/survey hour) than in the northern Bering Sea (0.005 calves/survey hour; X^2 = 41.23, $p < 0.001$) indicating that gray whales maintain patterns of reproductive class segregation on the northern range.

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APPENDIX A

AERIAL SURVEY FLIGHT CAPTIONS, SURVEY TRACKS AND SIGHTING SUMMARIES, 19S5

CONTENTS

INTRODUCTION

This appendix consists of flight tracks 1 through 67, which depict aerial surveys flown over the northern Bering, eastern Chukchi, and Alaskan Beaufort Seas between mid-July and mid-October 1985. Each flight is represented by a survey track, with all marine mammal sightings plotted, and a caption describing the flight's objectives, survey conditions, and sightings. 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	RL = Roll
		DE = Dead	NA = None
HDG	Heading in magnetic degrees		
ICE	Ice coverage in percent		
SS	Sea State (Beaufort scale)		
DEPTH	Depth in meters		

Dashes (-) indicate data were not recorded.

A monthly summary of all marine mammal sightings is provided as an overview of sighting data for the 1985 field season (Table A-1). Species abbreviations used in flight track keys are listed in Table A-1.

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

Species	Abbr**	July	August	September	October	Total
Bowhead Whale (*Balaena mysticetus*)	BH	0/0	11/12	31/67	35/60	77/139
Gray Whale (*Eschrichtius robustus*)	GW	139/705	0/0	0/0	0/0	139/705
Belukha Whale (*Delphinapterus leucas*)	BE	4/37	44/122	41/214	31/103	120/476
Bearded Seal (*Erignathus barbatus*)	BS	28/37	5/5	9/12	2/2	44/56
Ringed Seal (*Phoca hispida*)	RS	14/19	0/0	1/1	0/0	15/20
Walrus (*Odobenus rosmarus*)	WS	96/6352	0/0	0/0	0/0	96/6352
Unidentified Pinniped	PN	46/86	18/22	23/25	3/3	104/136
Polar Bear (*Ursus maritimus*)	PR	0/0	0/0	1/1	3/5	4/6

*The figures shown for each month represent the number of sightings/the number of individuals sighted during that period.

**Abbreviations are those used in flight track legends.

METHODS

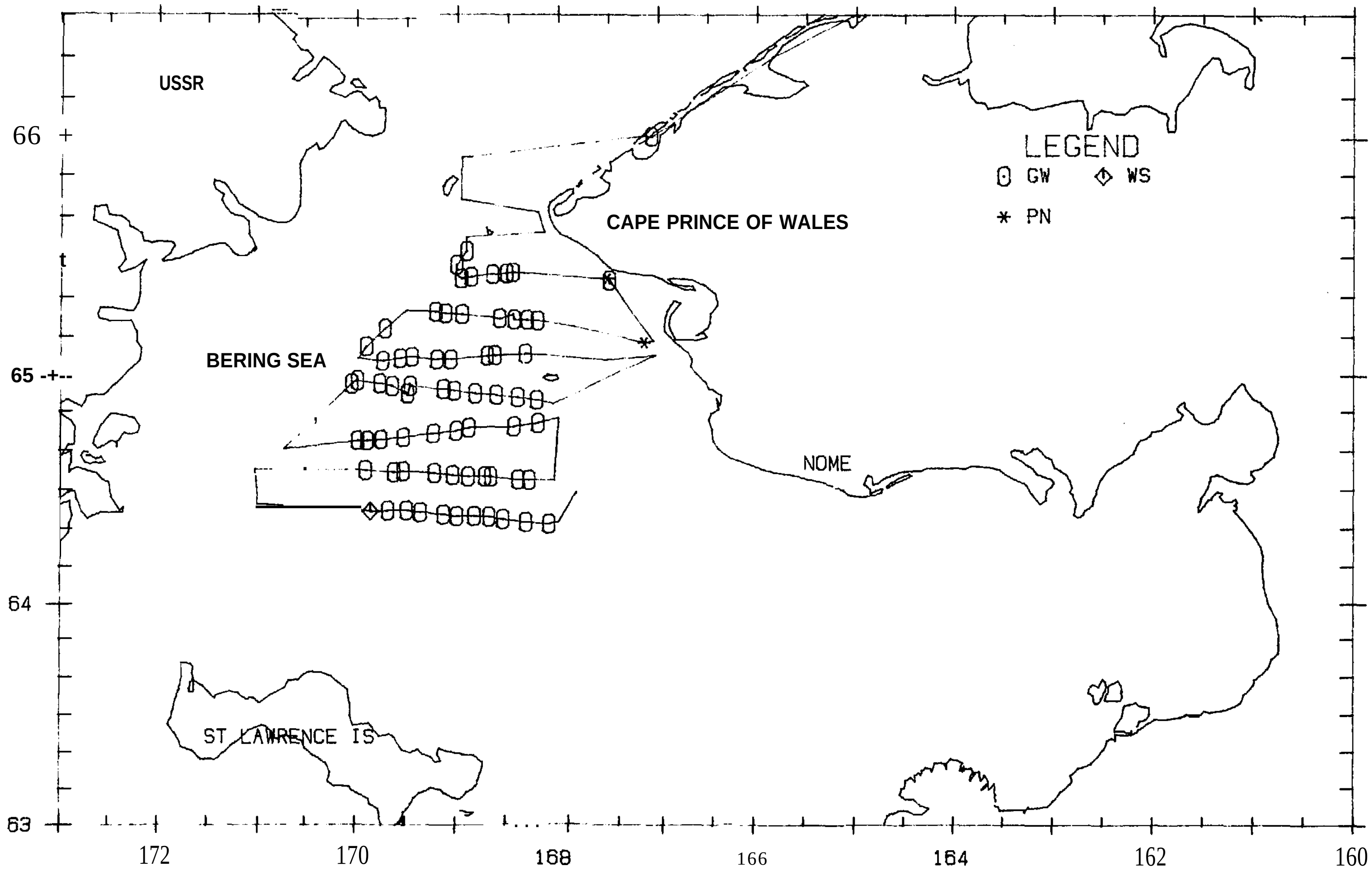
Maps were prepared using a series of computer programs consisting of BASIC subroutines implemented on a Hewlett-Packard (HP 85) microcomputer connected to a HP 7470A printer/plotter. The coastlines for each map, digitized on a HP 9111A graphics tablet, were formatted to examine the principal study areas (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.

SUMMER

Flight 1: 17 July 1985

Flight was a transect survey of blocks 25 and 26. Weather was clear with unlimited visibility. Sea state ranged from Beaufort 02 to 03, and there was no ice. Four hundred seventy-eight gray whales, including 2 calves, were seen. Many were sighted with mud plumes and considered feeding. Unidentified pinnipeds and a walrus were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	66°00.5'	167003.3’		BO	RE	180	o	B1	15
11/0	65°31.5'	168054.0’		BW	FE	--	0	B3	59
9/0	65°28.1'	168059.8’	--	BO	FE		0	B3	59
4/0	65°24.6'	168057.0’		MP	FE	--	0	B3	59
1/0	65°25.0'	168051.3’	--	MP	FE	190	0	B3	59
3/0	65°25.7'	168038.3’	384	MP	FE		0	B3	60’:
3/0	65°26.0'	168030.0’	653	MP	FE	--	0	B3	60
9/0	65°26.2'	168026.2’	384	MP	FE	--	0	B3	60
1/0	65°24.1'	167028.7’	653	BO	SW	270	0	B1	18
8/0	65°14.1'	168011.5’	1027	BW	FE	--	0	B1	40
1 5/0	65°14.3'	168017.9’	--	BO	FE	--	0	B1	40
7/0	65°14.4'	168025.5’	1256	MP	FE	--	0	B1	48
7/0	65°14.7'	168034.1’	357	BW	FE		0	B1	48
4/0	65°15.7'	168°56.6'	981	BW	SW	--	0	B1	55
1/0	65°15.9'	169006.4’	1191	BW	SW	--	0	B1	51
1/0	65°16.3'	169012.2’	1256	MP	FE	170	0	B1	51
1/0	65°12.0'	169042.6’	223	BW	FE	110	0	62	44
3/0	65°07.5'	169053.8’	357	BW	SW	120	0	B2	51
7/0	65°03.8'	169°43.8’	792	BO	FE	--	0	B3	44
4/0	65°04.4'	169033.2’		BW	SW		0	B3	46
4/0	65°04.8'	169026.3’	—	BO	FE		0	B3	46
1/0	65°04.2'	169011.4’	761	BO	SW	10	0	B3	4.6
2/0	65°04.2'	169003.1’	653	BW	SW	180	0	B3	46
1/0	65°05.1'	168041.5’	2594	MP	FE	--	0	B3	49
5/0	65°05.3'	168036.7’	2594	BW	SW	330	0	B3	48
2/0	65°05.7'	168°18.7'	704	BW	SW	--	0	B3	48
1 1/0	64°52.9'	168012.0’	384	BW	FE	--	0	B1	31
8/0	64°53.6'	168023.3’	860	BW	FE		0	B1	42
5/0	64°54.2'	168035.8’	412	BW	FE	--	0	B1	42
1/0	64°54.5'	168048.7’	1981	BW	FE	--	0	B1	48
4/0	64°55.2'	169001.0’	213	BO	RE		0	B1	48
1 0/0	64°55.6'	169007.4’		BW	FE		0	B1	48
125/1	64°56.3'	169027.1’		MP	FE	--	0	B1	46
1 7/0	64°54.5'	169028.8’		BW	FE	--	0	B1	60
5/0	64°56.3'	169038.0’		BW	FE	--	0	B1	46
5/0	64°57.0'	169045.6’	825	BW	FE		0	B1	42
3/0	64°57.7'	169059.0’	--	MP	FE	--	0	B]	42
1/0	64°56.9'	170002.4’	1077	BW	FE		0	B2	42
3/0	64°42.6'	169058.6’	2152	MP	FE	--	0	B3	46
1/0	64°42.7'	169053.0’	825	BW	SW	260	0	B3	46
5/0	64°42.9'	169044.5’	2594	MP	FE	--	0	B3	46
8/0	64°43.4'	169031.1’	653	BO	SW	180	0	B3	46
5/0	64°44.5'	169013.4’	2887	BW	SW	--	0	B3	46
1/0	64°45.1'	168059.8’	508	BO	RE	200	0	B3	46
1/0	64°45.9'	168°52.3’	233	BO	SW	340	0	B3	46
3/0	64°46.3'	168025.3’	320	BO	SW	180	0	B3	44
1/0	64°47.1'	168011.3’	704	BO	FE	55	0	B3	38
4/0	64°32.6'	168016.5’	264	BO	RE		0	B1	37
5/0	64°32.7'	168022.8’	J328	BW	FE	--	0	B1	42
1/0	64°33.4'	168039.1 ‘	1132	BW	SW	--	0	B1	42
6/0	64°33.4'	168042.9’	264	BO	SW	160	0	B1	44
5/0	64°33.4'	168052.8’		60	FE		0	B1	44
8/0	64°33.8'	169°01.8'		MP	FE	--	0	B1	42
5/0	64°34.3'	169012.7’		MP	FE		0	B1	42
7/0	64°34.7'	169031.4’		MP	FE	--	0	B]	44
15/0	64°34.5'	169036.9’	--	BO	FE	--	0	B1	44
2/0	64°35.1'	169054.1’		BW	SW		0	B1	35
1 2/0	64°24.6'	169040.4’		BW	SW	--	0	62	37
8/0	64°24.6'	169029.1’	860	BW	SW		0	02	37
1 2/0	64°24.1'	169020.8’	565	MP	FE	--	0	B2	37
1/0	64°23.6'	169°07.2'	345	BO	SW	--	0	B2	38
1 2/0	64°23.2'	168059.4’		BW	SW	--	0	B2	40
9/0	64°23.2'	168049.0’		BW	SW		0	B2	40
6/0	64°23.0'	168040.1’	--	BW	SW	--	0	B2	40
5/0	64°22.5'	168031.6’	--	BW	SW	--	0	B2	42
14/1	64°21.7'	168018.1’	653	BW	SW		0	B2	37
3/0	64°21.2'	168004.4’	1132	BO	SW		0	B2	37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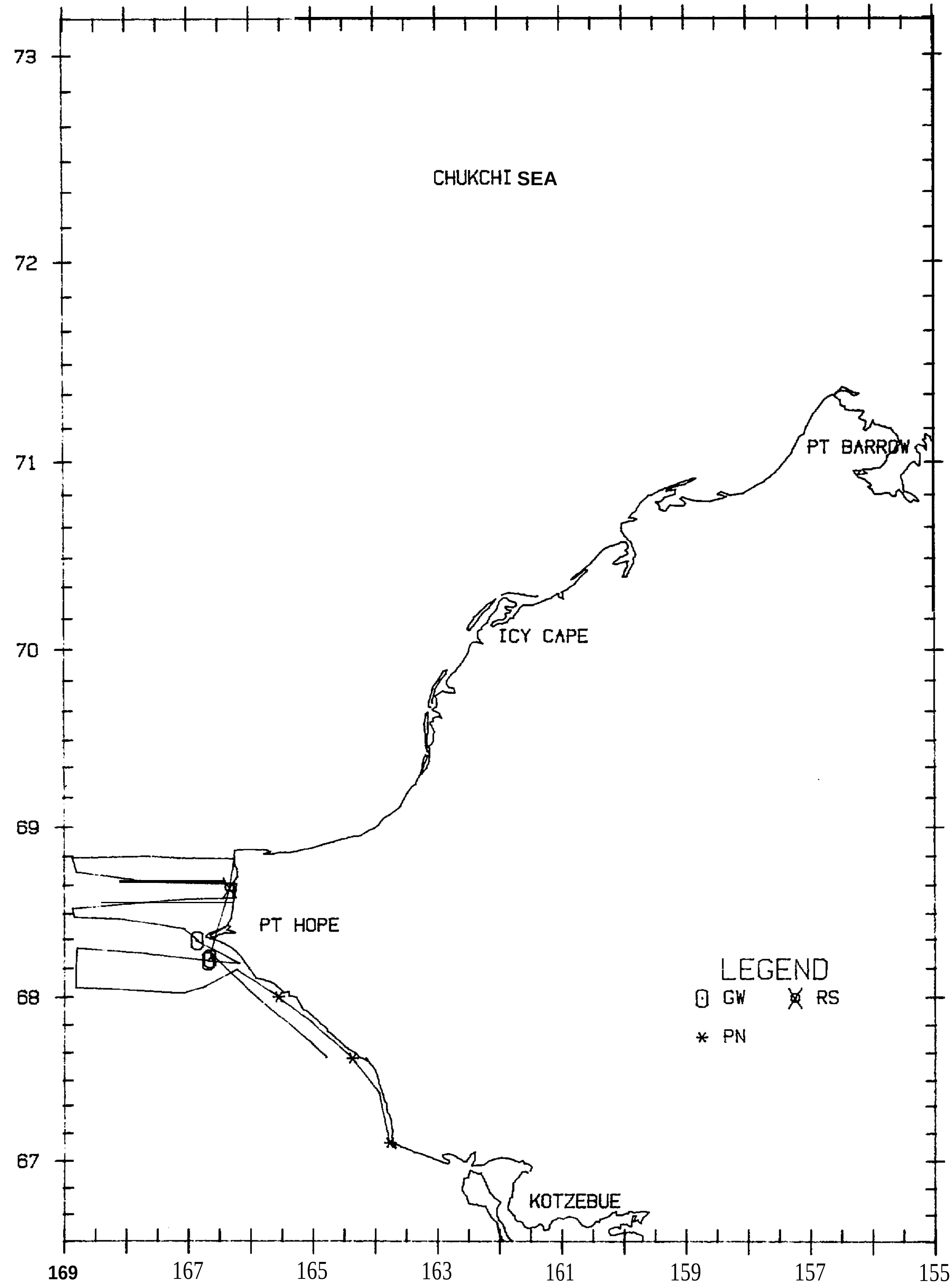
Flight 2: 18 July 1985

Flight was a transect survey of block 22 and a coastal search survey to and from the block. Weather was clear with unlimited visibility. Ice coverage varied from O-to 40-percent broken floe and sea state ranged from Beaufort 01 to 03. Sixteen gray whales, including 5 calves, were seen swimming, feeding, and resting south of Pt. Hope. Ringed seals and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
5/0	68°13.1'	166°41.0'	1981	BW	FE	330	0	B1	33
6/3	68°20.1'	166051.8’	--	BO	CC	--	5	B1	13
5/2	68°13.8'	166039.6’	--	BO	FE	--	0	B2	18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CHUKCHI SEA
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PT HOPE
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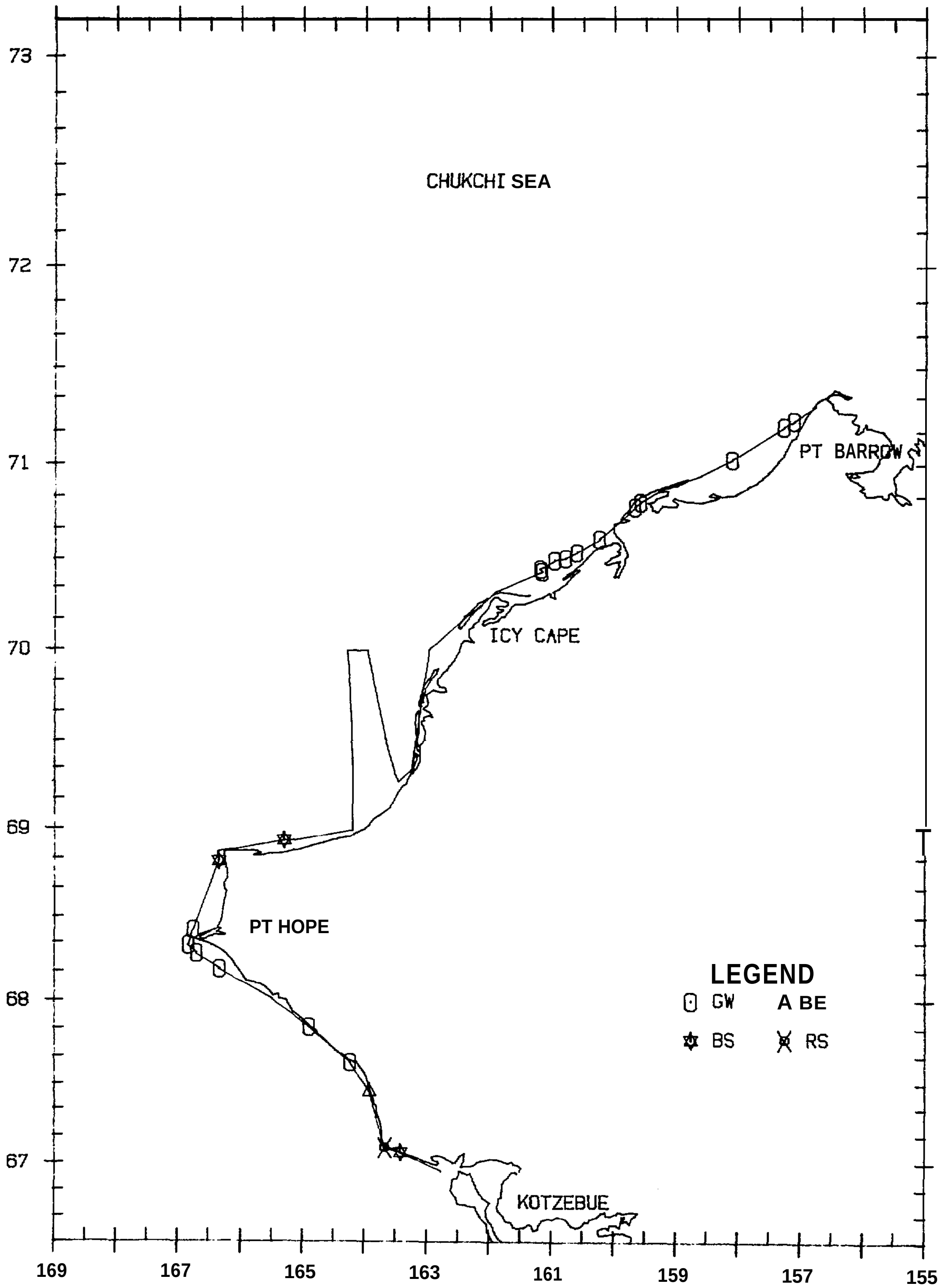
Flight 3: 193Uly 1985

Flight was a transect survey of the eastern one-half of block 20 and a coastal search survey transit to Pt. Barrow. Weather was clear with unlimited visibility. Ice coverage ranged from l-to 50-percent broken floe near-shore to 0 percent offshore in block 20 and sea state varied from Beauf ort 01 near-shore to 04 offshore. In the northern Chukchi Sea, 95 percent broken floe ice existed 100 km offshore at Icy Cape, 60 km offshore at Wainwright and 20 km offshore at Pt. Barrow. Sea state in the near-shore open water corridor was Beaufort 03. Fifty seven gray whales were seen. Seventeen, including one calf, were seen swimming and feeding south of Pt. Hope. The remaining 40, including 4 calves, were seen swimming and feeding along the coast between Icy Cape and Pt. Barrow. Belukhas and bearded and ringed seals were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
2/0	67°37.6'	164°14.2’	457	BO	SW	110	0	B1	5
1/0	67°50.4'	164053.9’	264	BO	DI	250	0	B1	5
6/0	68°10.7'	166°20.4’	--	BO	SW	--	0	63	18
2/0	68°16.1'	166042.4’	--	BO	SW	--	0	B3	18
5/1	68°18.9’	166°50.1’	--	BO	RE	--	0	63	18
1/0	68°24.2'	166°45.5’	585	BO	RE	140	20	B1	13
8/0	70°24.6'	161009.6’	--	BW	FE	--	0	B3	11
9/1	70025.3’	161°10.9’	--	BW	FE	--	0	63	18
3/1	70°28.1'	160°57.4’	--	BO	FE	--	0	B3	18
3/0	70°30.1'	160°46.7’	761	MP	FE	--	0	B3	20
1/0	70°32.0'	160°36.0'	981	BW	SW	180	0	B3	18
1/0	70°36.3'	160°14.2’	253	BO	RE	--	0	B3	18
2/0	70°46.5'	159040.0’	--	BW	SW	180	0	B3	5
6/0	70°48.0'	159034.4’	--	BW	S w	--	0	B3	5
2/0	71°01.4'	158005.8’	457	BO	FE	150	5	B3	20
3/1	71°11.2'	157016.2’	1256	MP	FE	--	5	B3	18
2/1	71°13.0'	157006.5’	176	MP	FE	--	5	B3	18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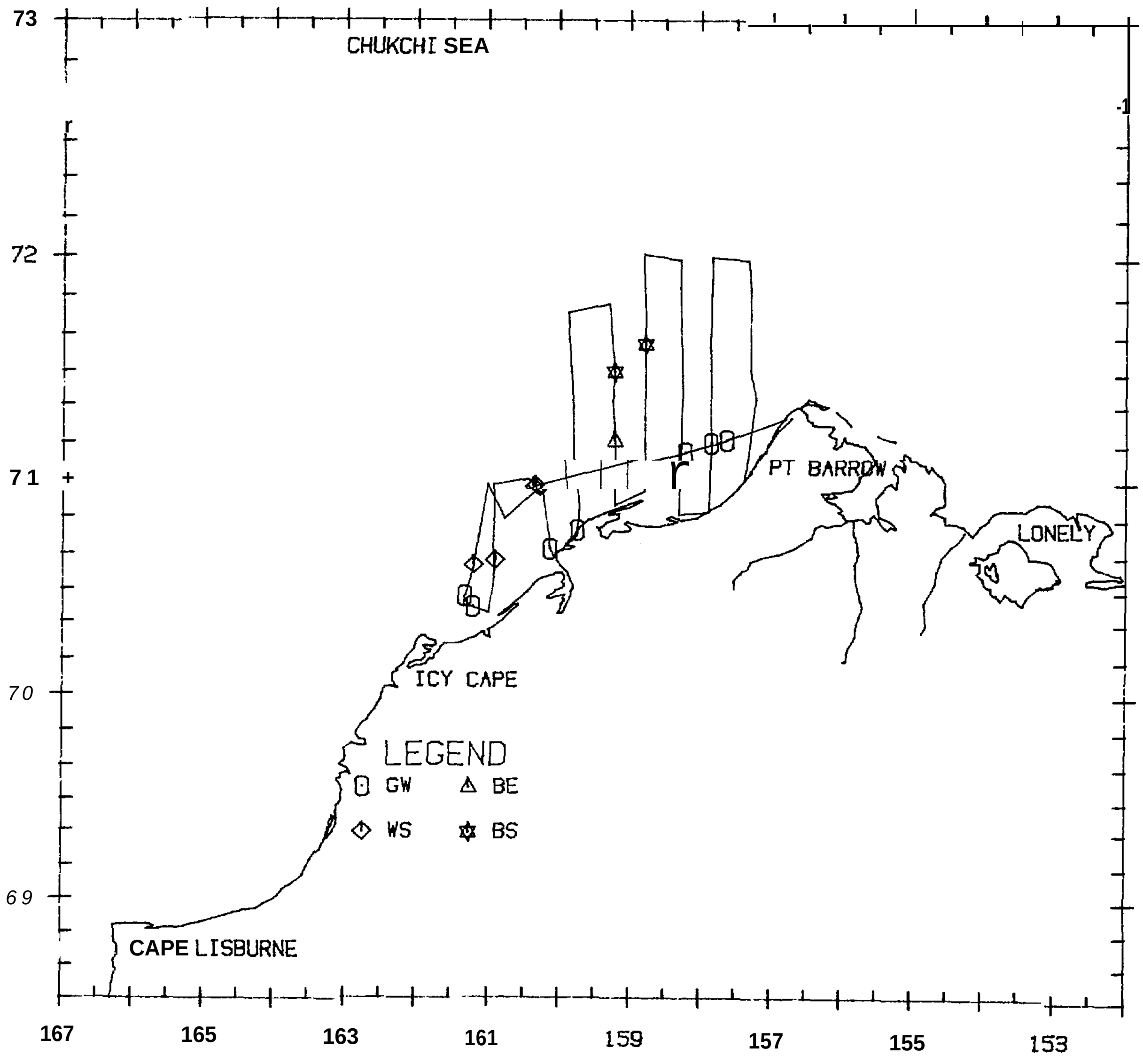
Flight **4:** 20 **July** 1985

Flight was a transect survey of block 13 and the eastern one-half of block 17. Weather was overcast with unlimited visibility, except in the southwestern corner of block 13 where heavy fog prevailed. Ninety-nine percent broken floe ice existed in the northern two-thirds of block 13 and northern half of block 17, and open water existed south of there in the near-shore areas. Sea state ranged from Beaufort 03 in open water areas to 00 in areas with heavy ice. Twelve gray whales were seen swimming and feeding. **Belukhas,** walrus, and bearded seals were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°10.6'	157051.0'	522	BO	SW	20	0	B2	42
1/0	70°47.2'	159'344.1'	--	BO	SW	--	30	B2	18
2/0	70°42.1'	160006.9'	339	BO	SW	350	5	B2	18
5/0	70°24.7'	161012.1'	191	BO	FE	130	0	B3	11
1/0	70°27.6'	161019.3'	238	BO	SW	110	0	B4	18
1/0	71°08.3'	158012.5'	327	BO	FE	210	5	B3	20
1/0	71°11.5'	157037.3'	1138	BW	FE	45	5	B3	38


CHUKCHI SEA
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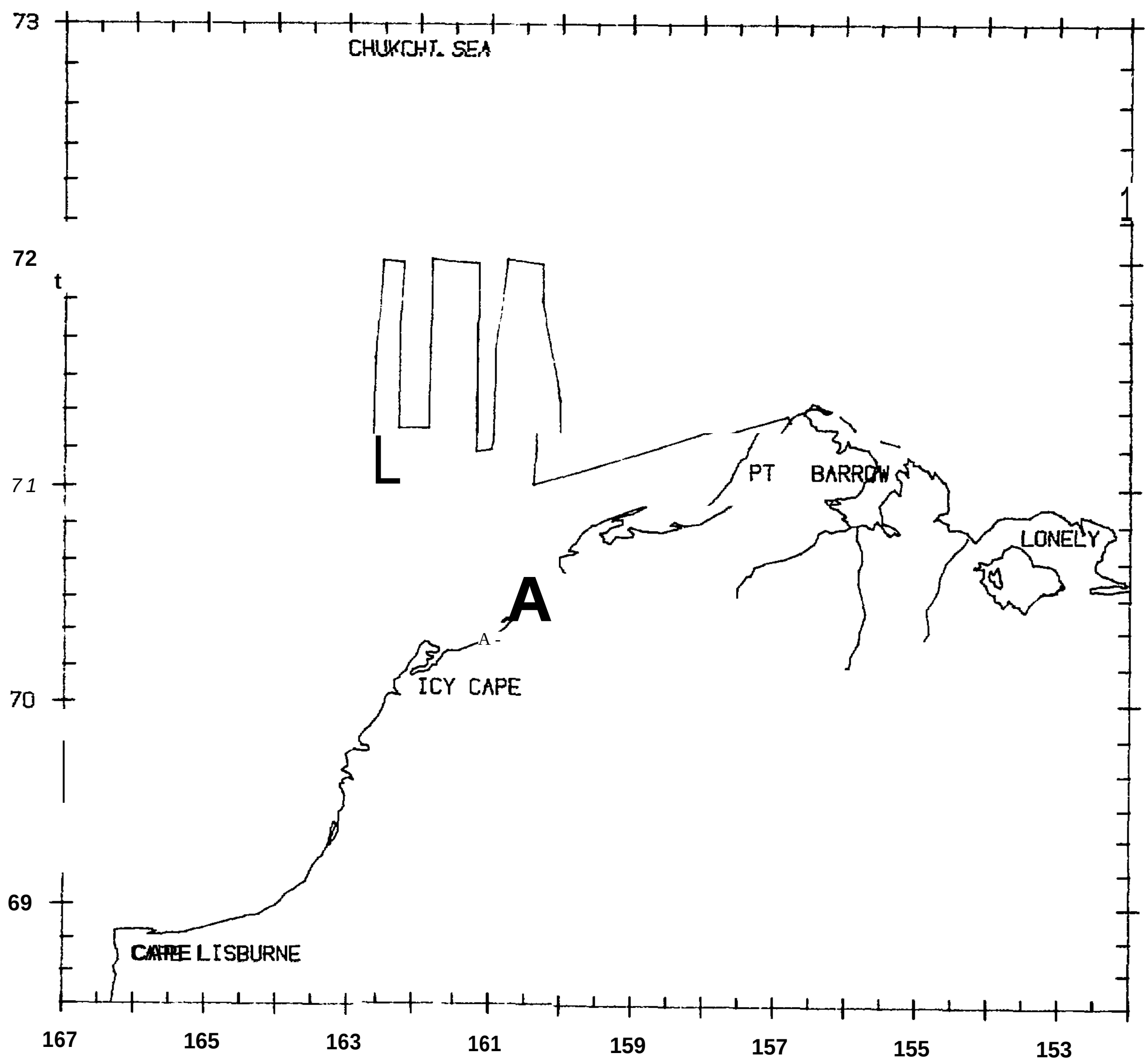
Flight 5: 21 July 1985

Flight was a transect survey of block 14. Weather was clear with unlimited visibility over the ice, and dense fog with unacceptable visibility over open water areas. Sea state in block 14 was Beaufort 00, with 95 to 99 percent broken floe ice coverage. In the near-shore open water corridor, sea state was Beaufort 03. No marine mammals were sighted.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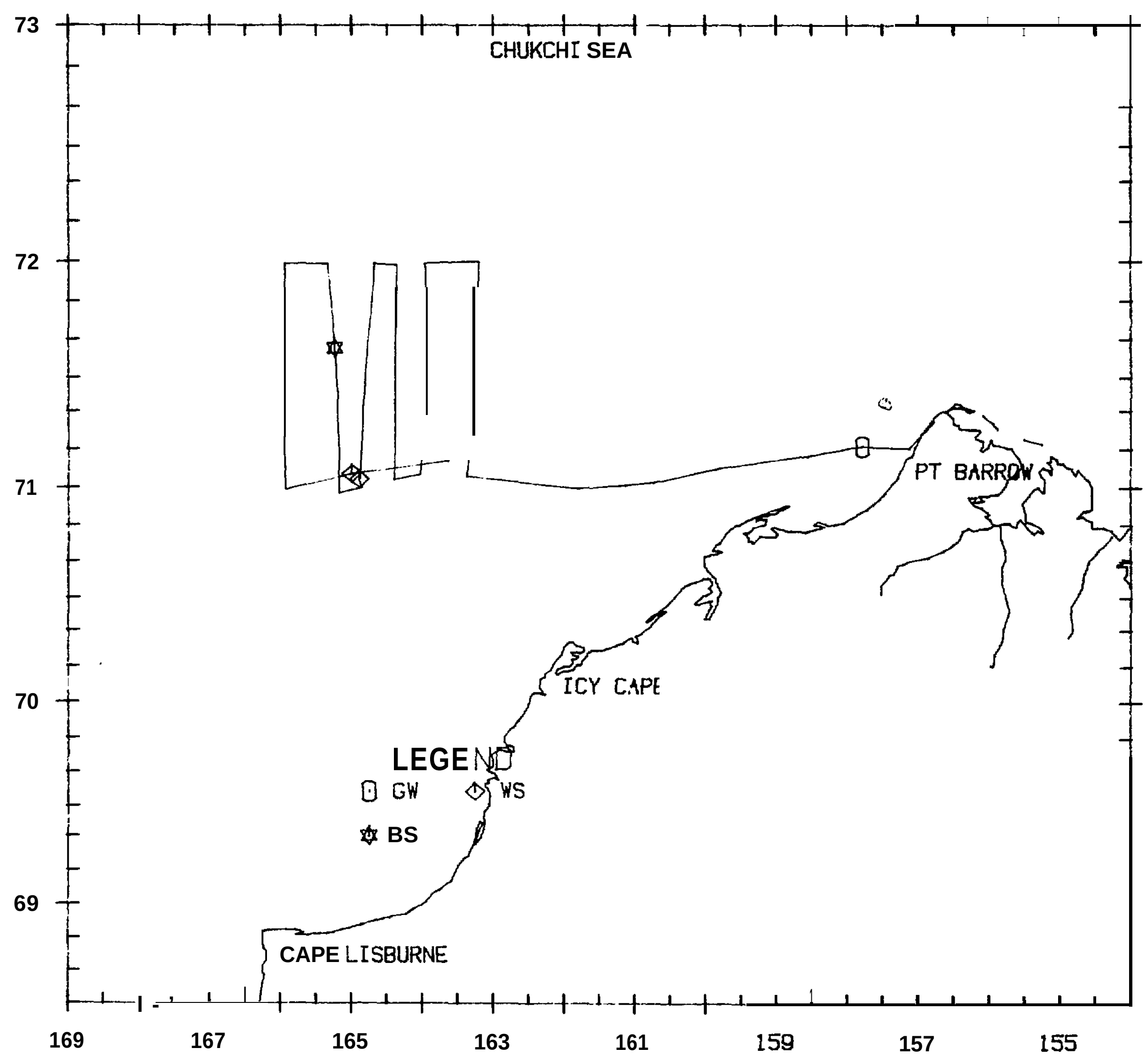
Flight 6: 22 July 1985

Flight was a transect survey of block 15, after dense fog precluded surveying blocks 17 and 18. Weather was clear with unlimited visibility over the ice, and dense fog with unacceptable visibility over open water areas. Block 15 was completely covered with 99 percent broken floe ice. Sea state was Beaufort 00 to 01 in heavy ice areas and Beaufort 03 in the open water corridor. One gray whale was seen feeding. Walrus and a bearded seal were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°10.6'	157046.9'	607	MP	FE	--	10	B1	42



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CHUKCHI SEA
PT BARROW
ICY CAPE
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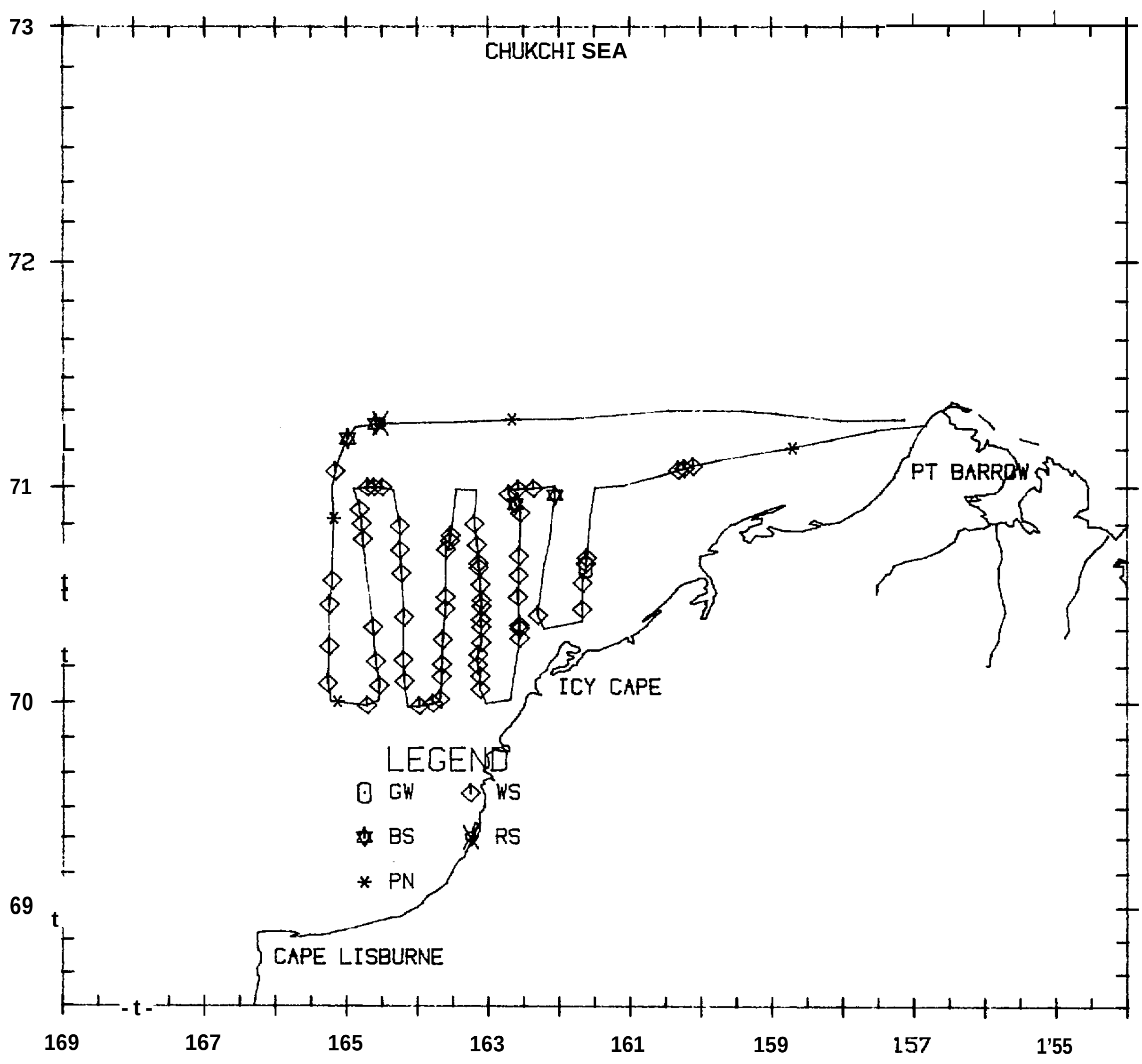
Flight 7: 23 July 1985

Flight was a transect survey of the western one-half of block 17 and all of block 18. Weather was overcast with unlimited visibility. Ice coverage varied from O to 99 percent broken floe in block 17, and O to 60 percent broken floe in block 18. Sea state ranged from Beaufort 02 in open water areas to 00 in heavy ice. Two gray whales were seen feeding. Walrus, bearded and ringed seals, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
2/0	70°38.4'	161°37.7'	1542	BO	FE	240	0	B1	22



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CHUKCHI SEA
PT BARROW
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CAPE LISBURNE
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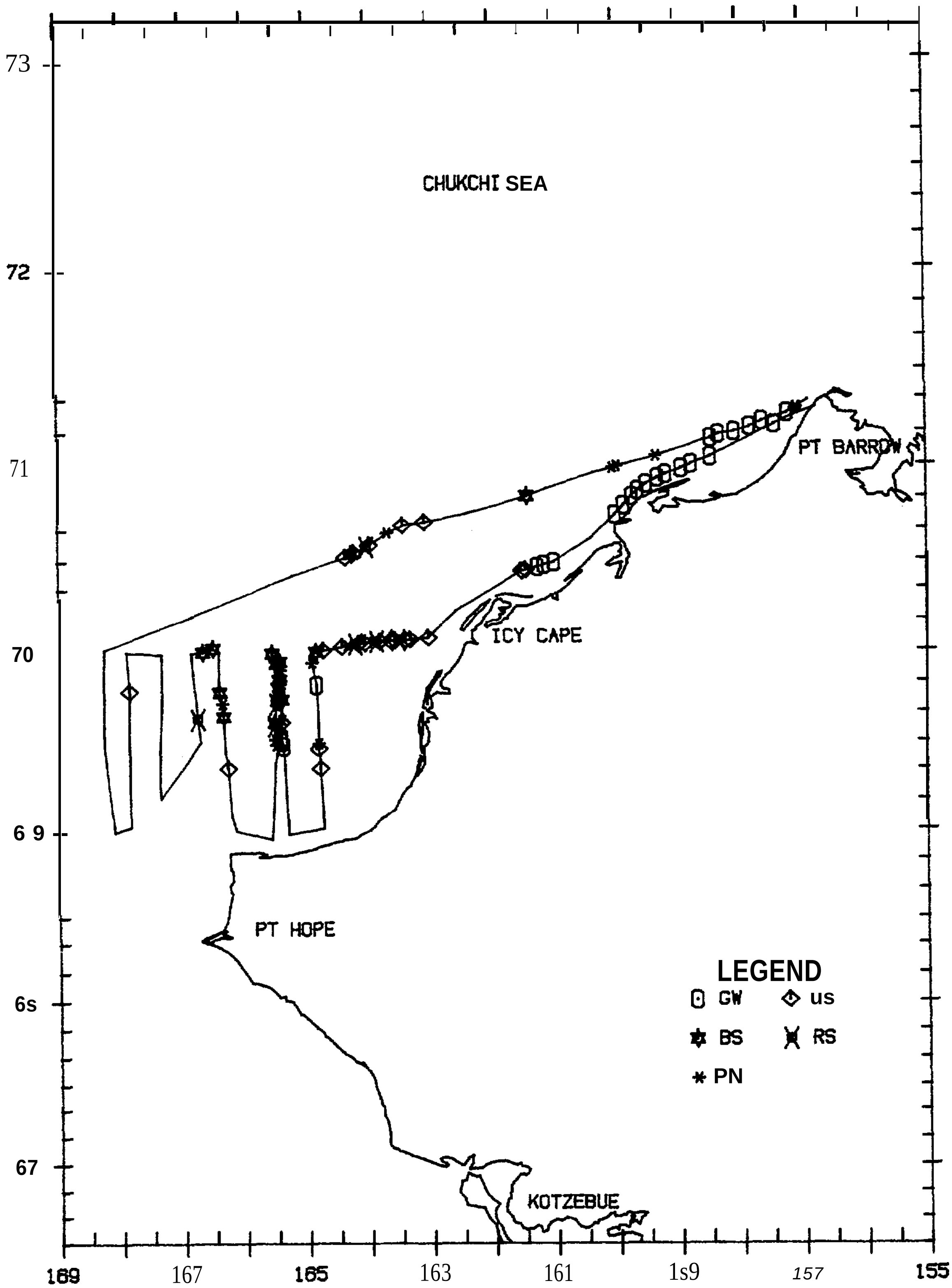
Flight 8: 24 **July** 1985

Flight was a transect survey of the western one-half of block 20 and all of block 21. Weather was mostly clear with unlimited visibility, except in the southeast corner of block 21, where low fog caused transect lines to be truncated. Ice coverage varied from O to 30 percent broken floe near-shore to O percent in offshore areas. Sea state ranged from Beaufort 00 to 01. Seventy-six gray whales were seen along the coastline. Walrus, bearded and ringed seals, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°11.8'	157026.2’	245	MP	FE	--	1	B1	38
2/0	71°02.1'	158028.4’	2274	MP	FE	--	1	B1	18
1/0	71°00.0'	158°47.0'	1314	BW	SW	30	0	B1	18
10/0	70°58.7'	158056.6’	--	BW	FE	--	0	B1	18
3/0	70°56.9'	159011.8’	1496	BW	Sw	30	0	B1	27
2/0	70°55.8'	159019.7’	631	BW	RE	200	0	B1	27
5/0	70053.91	159030.7’	--	BO	Sw	30	0	B1	18
3/0	70°51.9'	159039.0’	1496	BW	SW	--	0	B1	18
4/0	70°50.1'	159°44.8’	993	BW	FE	--	0	B1	26
5/0	70047.41	159°52.8’	--	BO	FE	--	0	B1	18
2/0	70°44.5'	160°01.3’	1707	BW	Sw	--	0	B1	18
4/0	70°28.0'	161°00.4’	6540	BO	FE	--	0	B1	18
4/0	70°27.2'	161010.3’	1328	MP	FE	--	0	B1	18
2/0	70°26.5'	161016.4’	357	BO	RE	--	0	B1	18
1/0	69°49.0'	164°50.8’	1648	BW	SW	--	0	BO	22
1/0	69027.41	165°22.9’	653	BO	RE	30	0	BO	27
3/0	69°31.4'	165024.8’	--	MP	FE	220	0	BO	27
3/0	69°28.8'	165024.6’	--	BW	FE	--	0	BO	27
1/0	71°07.7'	158027.8’	792	BO	Sw	180	0	B1	20
5/0	71°08.9'	158020.1’	898	BW	FE	--	0	B1	20
7/0	71°09.7'	158004.8’	--	MP	FE	--	0	B1	20
4/0	71°11.2'	157049.9’	2353	BW	FE	--	0	B1	42
2/0	71°12.8'	157038.1’	1707	BW	FE	--	0	B1	38
1/0	71°15.3'	157013.8’	728	MP	FE	--	0	B1	35



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CHUKCHI SEA
PT BARROW
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PT HOPE
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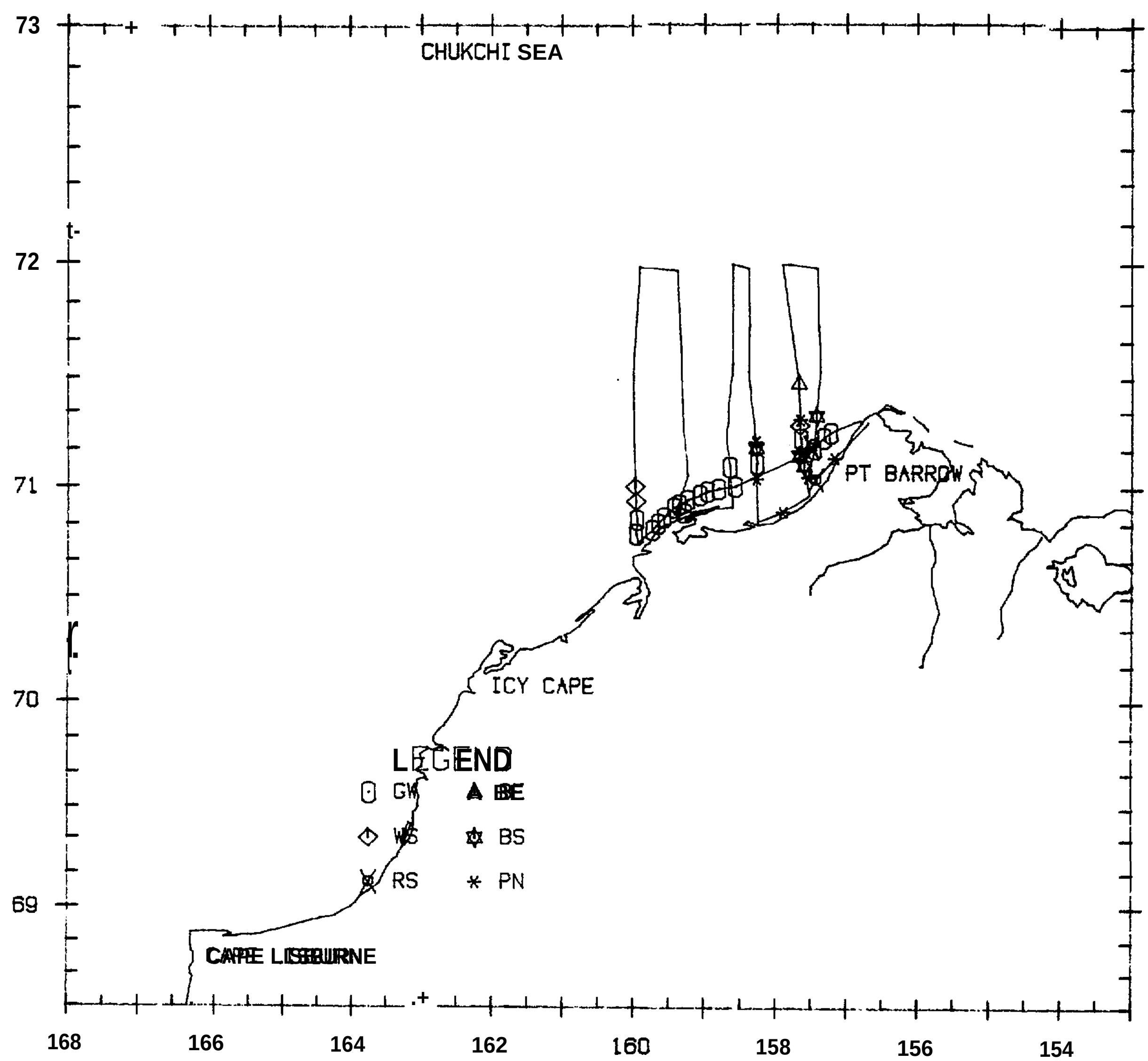
Flight 9: 25 July 1985

Flight was a transect survey of block 13. Weather was mostly overcast with unlimited visibility, with some areas of light patchy fog. Ice coverage was O percent in the southern half of the block and 99 percent broken floe in the northern half. Sea state ranged from Beaufort 00 to 02. Sixty-three gray whales, including five calves, were seen. One belukha, walrus, bearded and ringed seals, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
3/1	71°10.5'	157°28.1'	426	BO	FE	100	0	B1	38
6/2	71°13.1'	157039.7’	1132	BO	FE	--	0	B1	38
6/0	71°06.6'	158°17.0'	1361	MP	FE	--	0	B1	20
1/0	71°05.7'	158039.9’	948	BO	Sw	170	5	B1	20
2/0	70°53.4'	159018.3’	546	BO	RE	30	1	B2	18
8/0	70°51.4'	159°58.1’	1546	BW	Sw	--	0	B1	26
3/0	70°47.4'	159°58.9’	--	BO	Sw	--	0	B1	18
1/0	70°48.7'	159045.0’	792	MP	FE	--	0	B1	18
4/0	70°50.4'	159°40.1'	1077	BW	Sw	190	0	B1	26
1/0	70°52.2'	159034.9’	474	BO	Sw	70	0	B1	18
1/0	70°54.9'	159°26.7’	201	BO	Sw	210	0	B1	18
2/0	70°55.7'	159°22.4’	585	BO	Sw	--	0	B1	37
2/0	70°56.9'	159°15.5'	331	BO	Sw	--	0	B1	27
8/0	70°58.3'	149004.7’	1546	BO	FE	--	0	B1	27
3/0	70°59.2'	158058.4’	1077	BO	FE	--	0	B1	18
4/1	71°00.0'	158°49.0'	2152	BO	SW	--	0	B1	18
2/1	71°00.6'	158°35.1’	--	BO	SW	60	0	B1	18
3/0	71°13.4'	157°20.0’	1707	MP	FE	--	0	B1	18
3/0	71°14.7'	157014.0’	1077	MP	FE	--	0	B1	18



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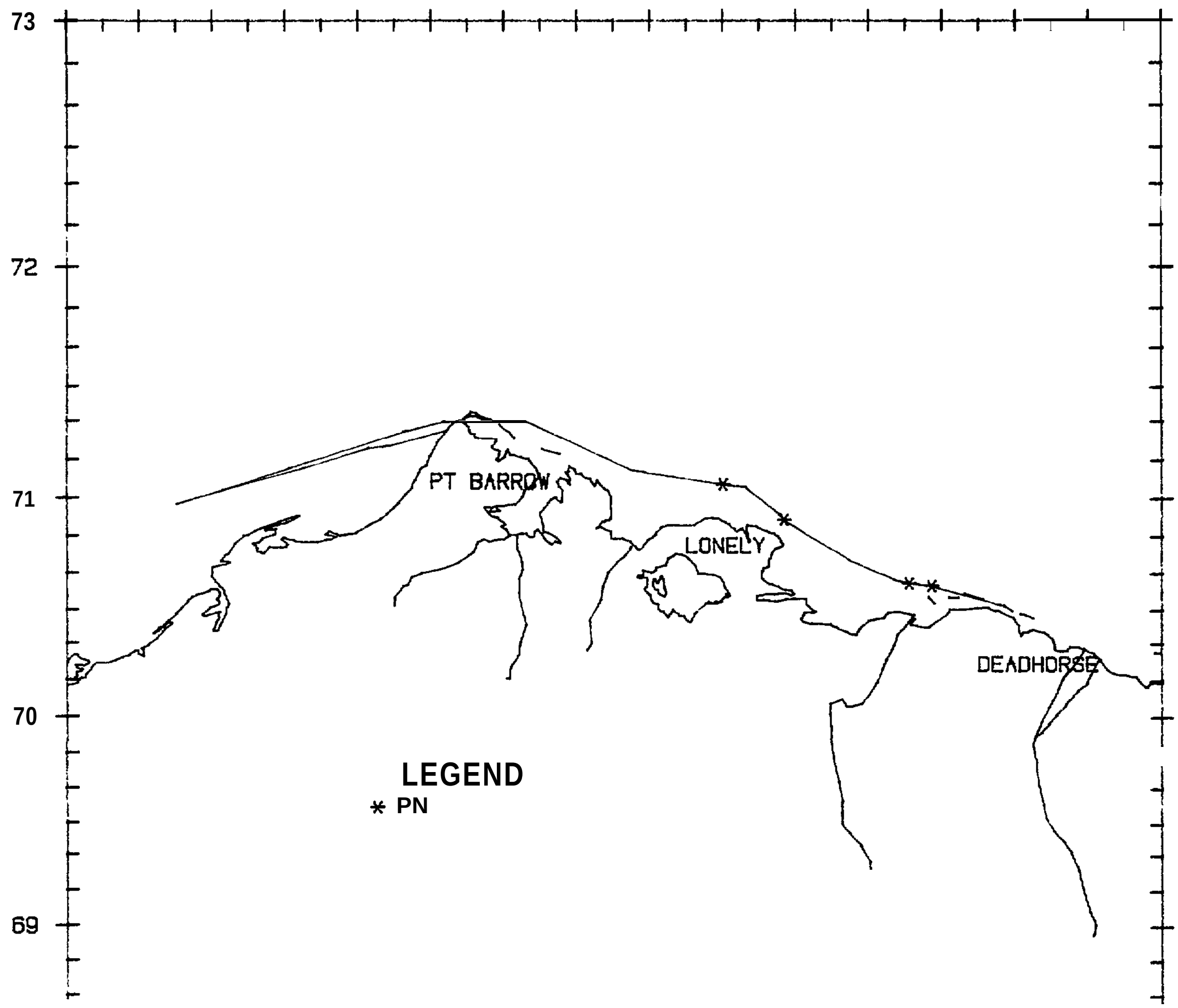
Flight **10:** 26 **July** 1985

Flight was a coastal search survey transit to Deadhorse after heavy fog precluded any surveys in the Chukchi Sea. Weather in the Beaufort Sea was overcast with unlimited visibility. Ice coverage was 10 to 99 percent broken floe and sea state was Beaufort 00 to 01. Unidentified pinnipeds were seen.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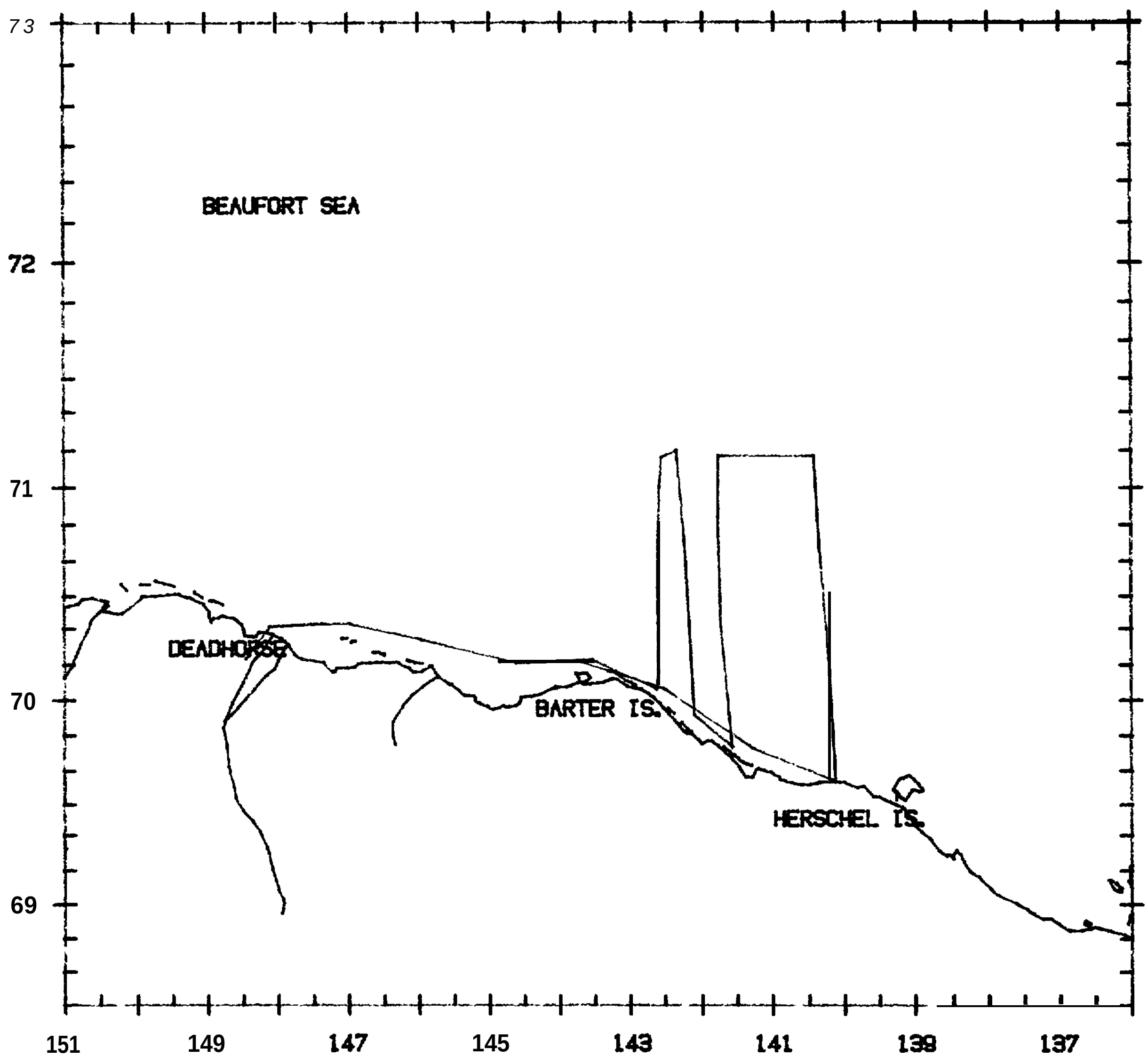
Flight 11: 28 July 1985

Flight was a transect survey of blocks 5 and 7. Weather was generally overcast with unlimited visibility,with some areas of light patchy fog. Ice coverage was 75 to 99 percent broken floe except in Camden Bay, where it was O to 30 percent, and inside the barrier islands, where there was no ice. Sea state was Beaufort 00 to 01. No marine mam reals were sighted.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BEAUFORT SEA
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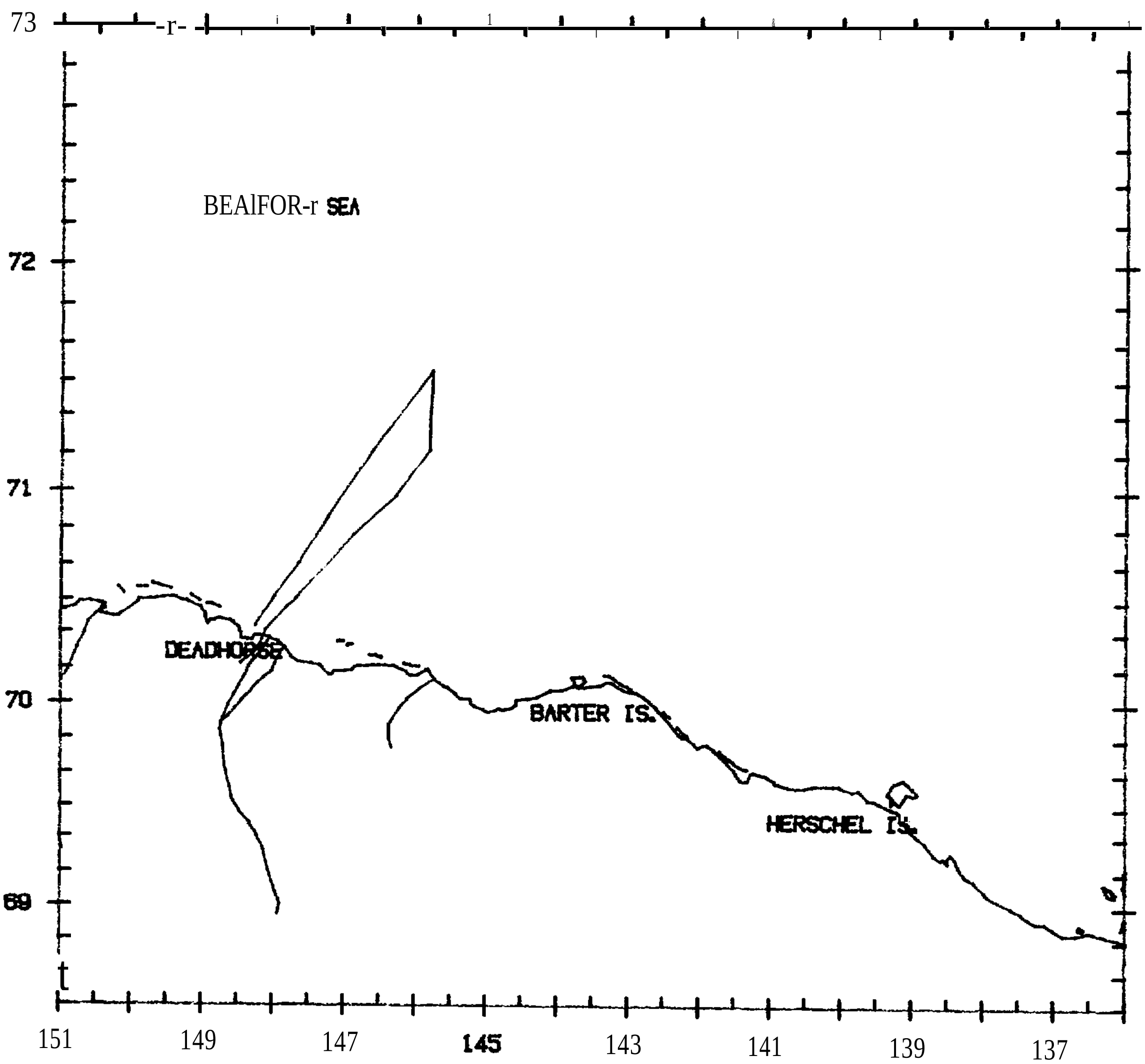
Flight 12: 29 July 1985

Flight wasanaborted transect survey of block 9. Dense, low-lying fog over the entire Alaskan Beaufort Sea prevented flying in any area. Sea state was Beaufort 00, and ice was 99 percent broken floe. No marine mammals were seen.



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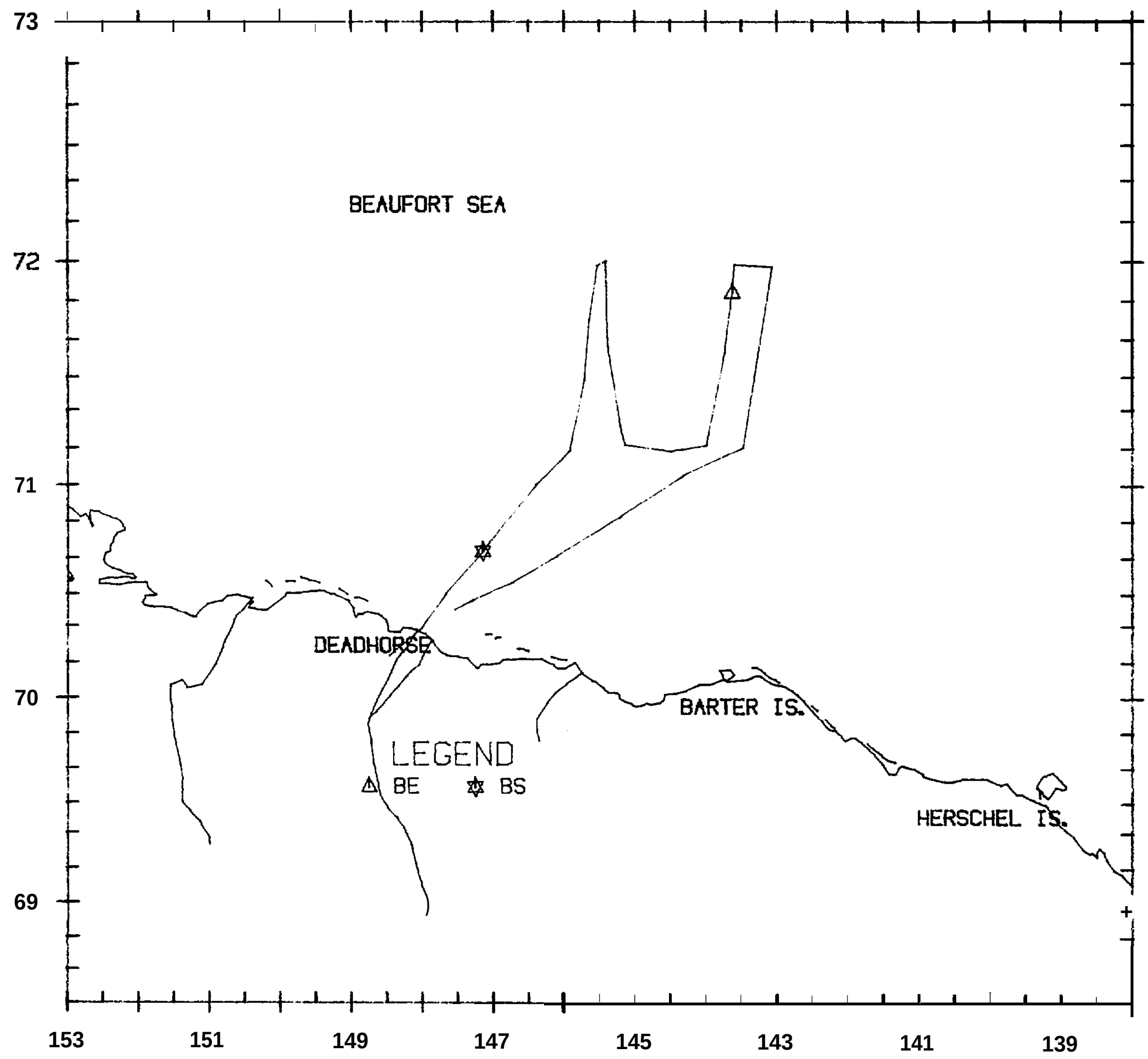
Flight 13: 30 July 1985

Flight was a transect survey of block 9. Weather was clear with unlimited visibility. Ice coverage was 99 percent broken floe and sea state was Beaufort 00. Belukhas and a bearded seal were seen.


BEAUFORT SEA
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HERSCHEL IS.
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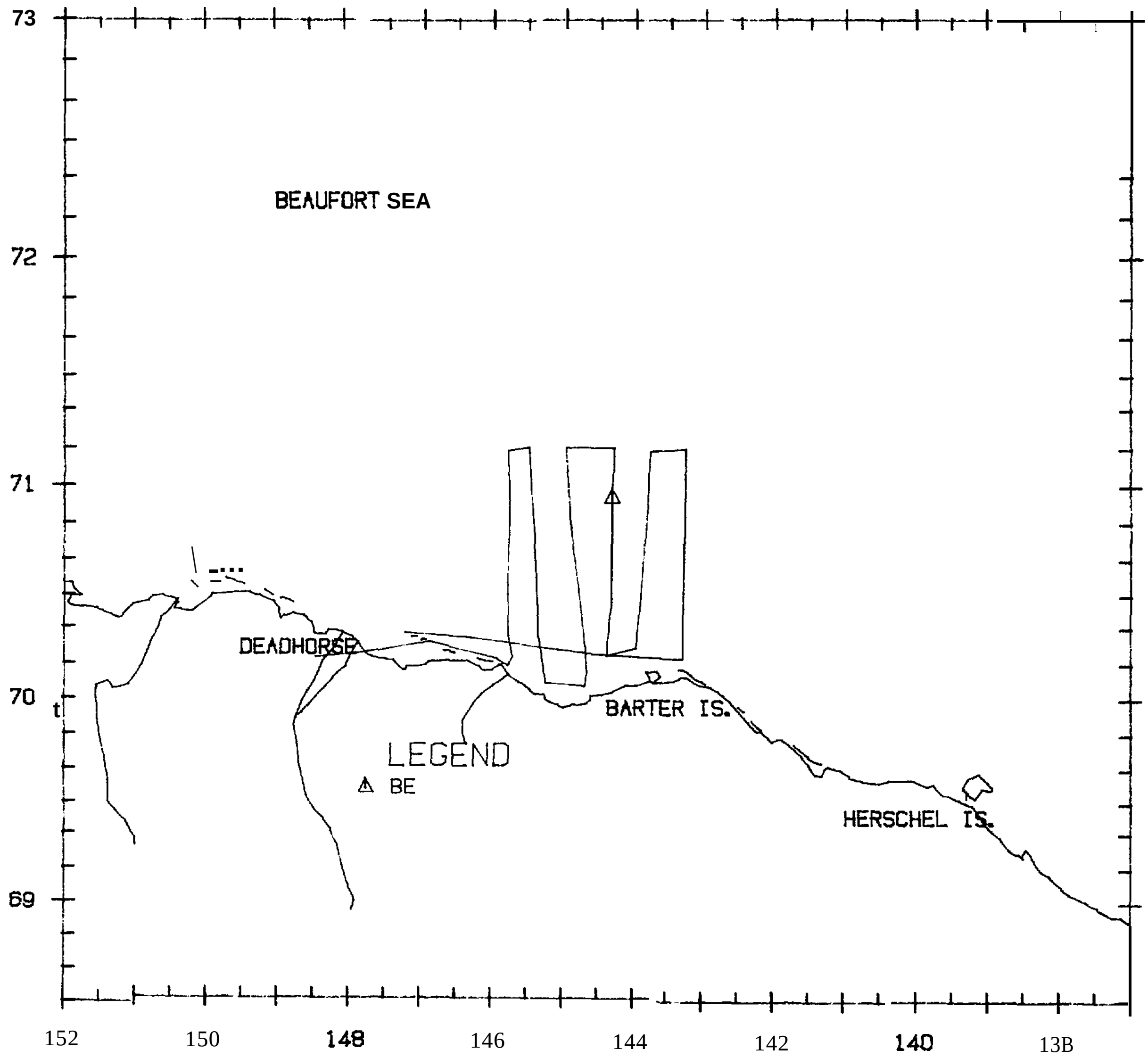
FALL

Flight 14: **2 August 1985**

Flight was a transect survey of blocks 4 and 6. Weather was generally clear with unlimited visibility, except in the southeastern corner of block 4, which was covered by low-lying fog. Ice coverage was 99 percent broken floe in both blocks except inside the barrier islands. Sea state was Beaufort 00 to 01. One belukha was seen.



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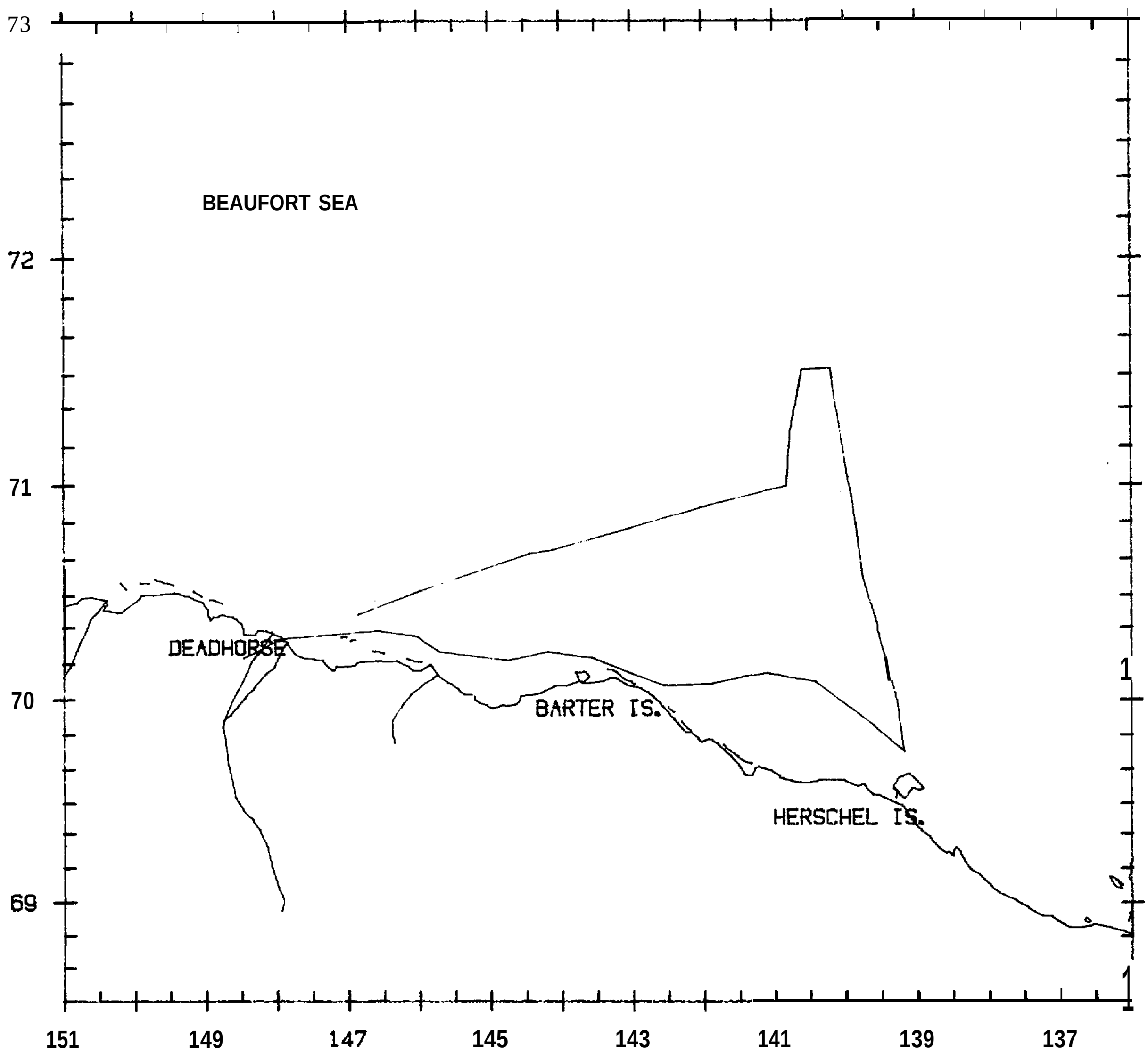
Flight 15: **6 August** 1985

Flight was a search survey east to Herschel Island and a modified transect survey of parts of blocks 7 and 8 to identify ice conditions. Low-lying fog blanketed the Beaufort Sea west of Barter Island, but clear skies existed between Barter and Herschel Islands. Ice coverage in block 5 was O percent north to 70° N, and 30 to 95 percent broken floe north of there. West of Barter Island, 90 percent broken floe ice existed to within 5 km of shore. Sea state was Beaufort 00 in heavy ice areas and Beaufort 04 to 05 in open water areas. No marine mammals were seen.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BEAUFORT SEA
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DEADHORSE
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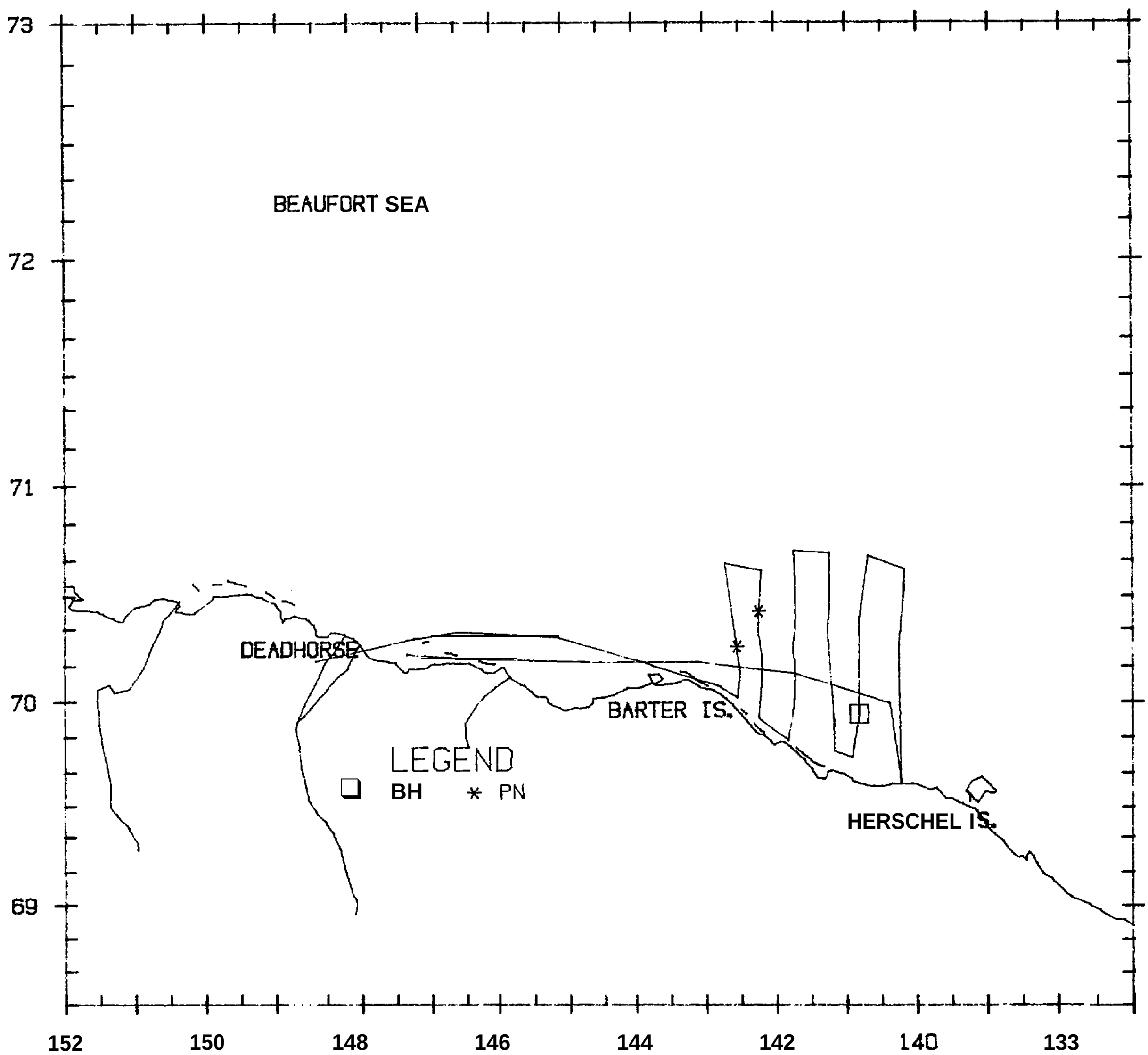
Flight 16: 7 August 1985

Flight was a transect survey of block 5 and the lower one-third of block 7. Weather was hazy, but with generally unlimited visibility. Ninety-f ive percent broken floe ice covered all of block 7 and the northern third of block 5. Sea state was Beaufort 00 in the heavy ice and Beaufort 02 to 03 in open water areas. One small bowhead was seen in block 5 swimming slowly. Unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	69056.7'	140'350.1'	357	BO	SW	290	0	B3	37



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BEAUFORT SEA
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BARTER IS.
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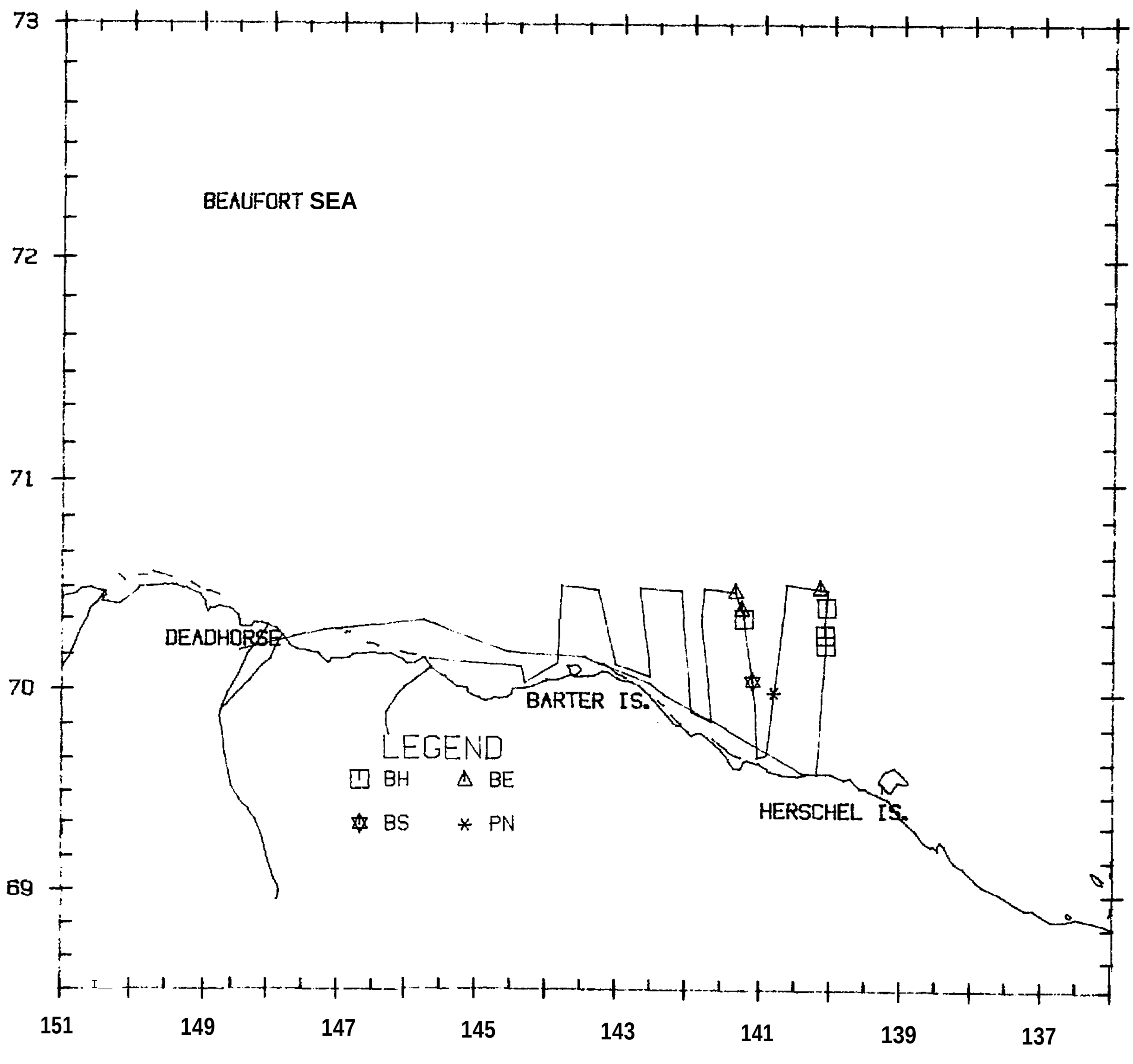
Flight 17: 8 August 1985

Flight was a transect survey of blocks 5 and4. Aircraft mechanical problems forced us to abort the survey in block 4. Weather was overcast and hazy, with generally unlimited visibility. Block 5 was ice-free, except for 10 percent broken floe coverage near-shore. Block 4, except Camden Bay, was 10 to 85 percent covered with ice. Camden Bay was ice-free. Sea state ranged from Beaufort 00 to 03. Four bowheads, including one lone calf and one tail slapping, were seen in block 5. Belukhas, a bearded seal, and an unidentified pinniped were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/1	70°13.8'	140006.1’	295	BO	RE	--	0	B1	62
1/0	70°16.7'	140006.9’	2594	BO	SL	--	0	B1	73
1/0	70°24.3'	140°05.8’	3254	BW	SW	--	0	B1	115
1/0	70°21.1'	141016.7’	398	00	SW	60	0	B1	55



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BEAUFORT SEA
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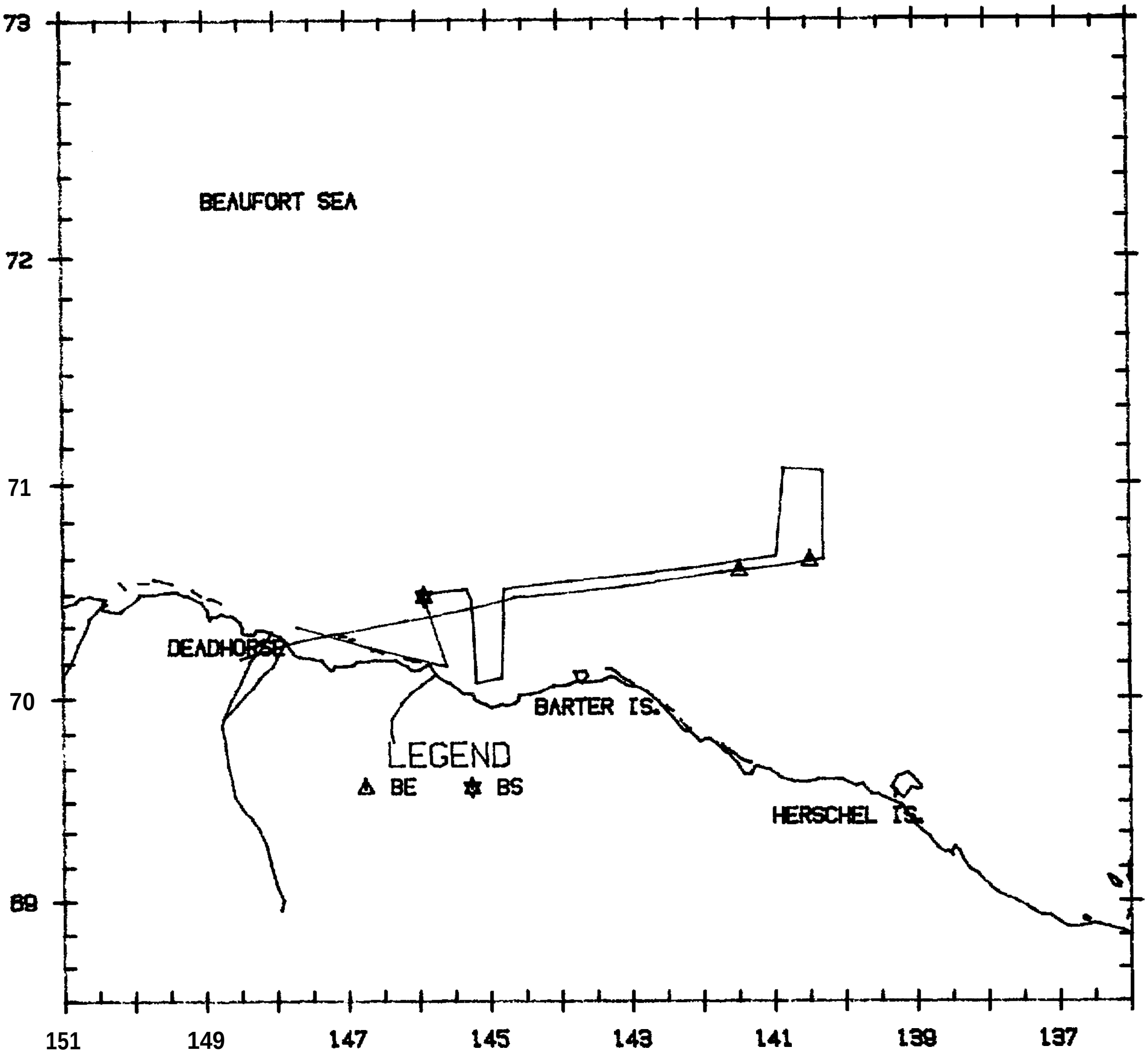
Flight 18: 9 August 1985

Flight was a transect survey of the western one-half of block 4 after low-lying fog prevented a planned survey of blocks 7 and 8. Weather in block 4 was overcast with unlimited visibility. Ice coverage was 10 to 40 percent in the southern two-thirds of the block and 90 to 95 percent in the northern one-third. Sea state was Beaufort 00 to 01. Belukhas and a bearded seal were seen.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BEAUFORT SEA
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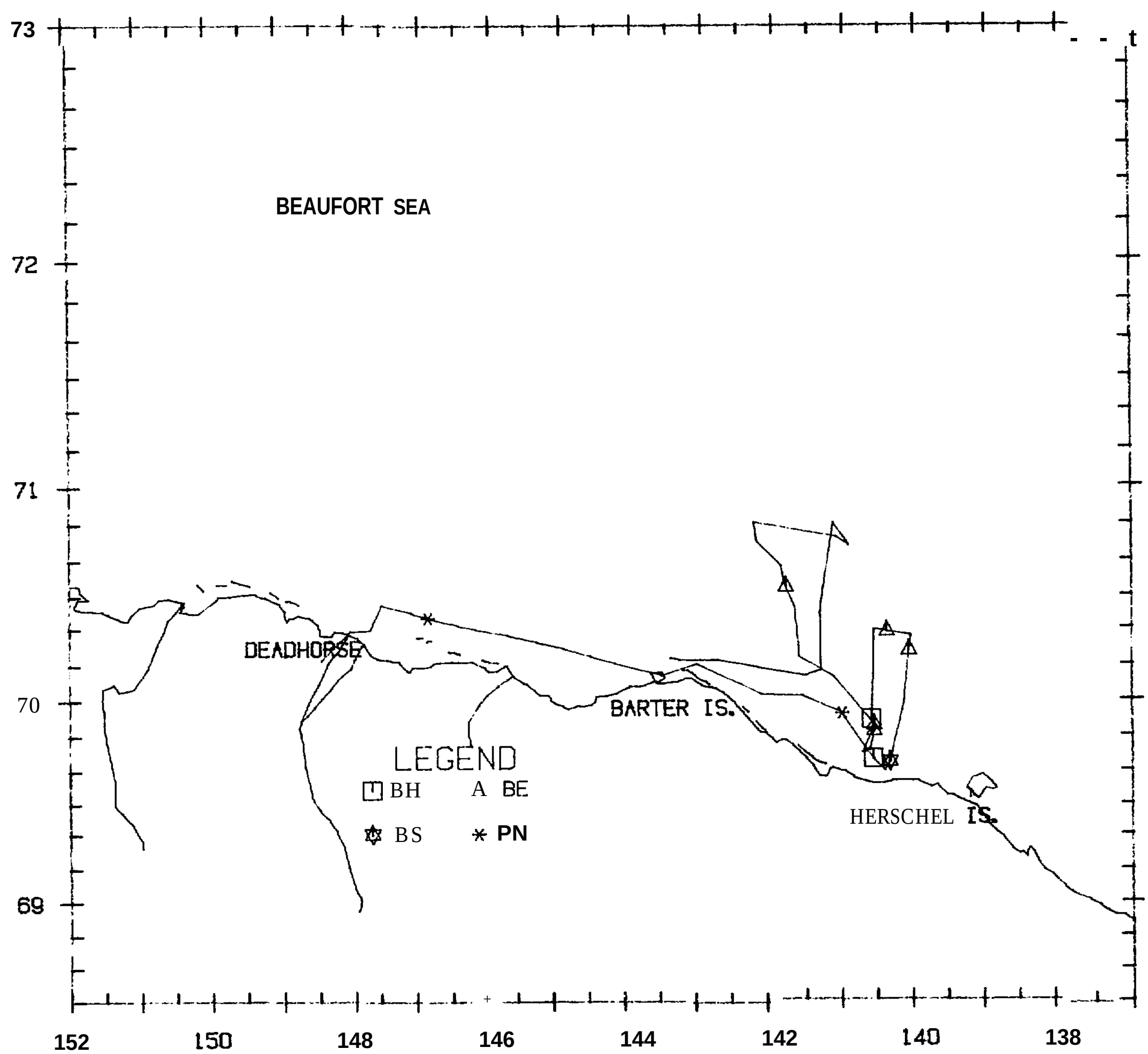
Flight 19: 11 August 1985

Flight was a modified transect survey of blocks 5 and7. Dense, low-lying fog covered nearly all of the Alaskan Beaufort Sea. Visibility varied from unacceptable to 5 km. Ice coverage in block 5 was Opercent and 95 percent in block 7. Sea state ranged from Beaufort 01 to 03. Three bowheadswere seenin block 5. Belukhas, abeardedseal, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	69043.5'	140039.5'	286	BO	RE	110	2	B3	24
2/0	69054.7'	140041.2'	1215	BO	SW	--	0	B3	35



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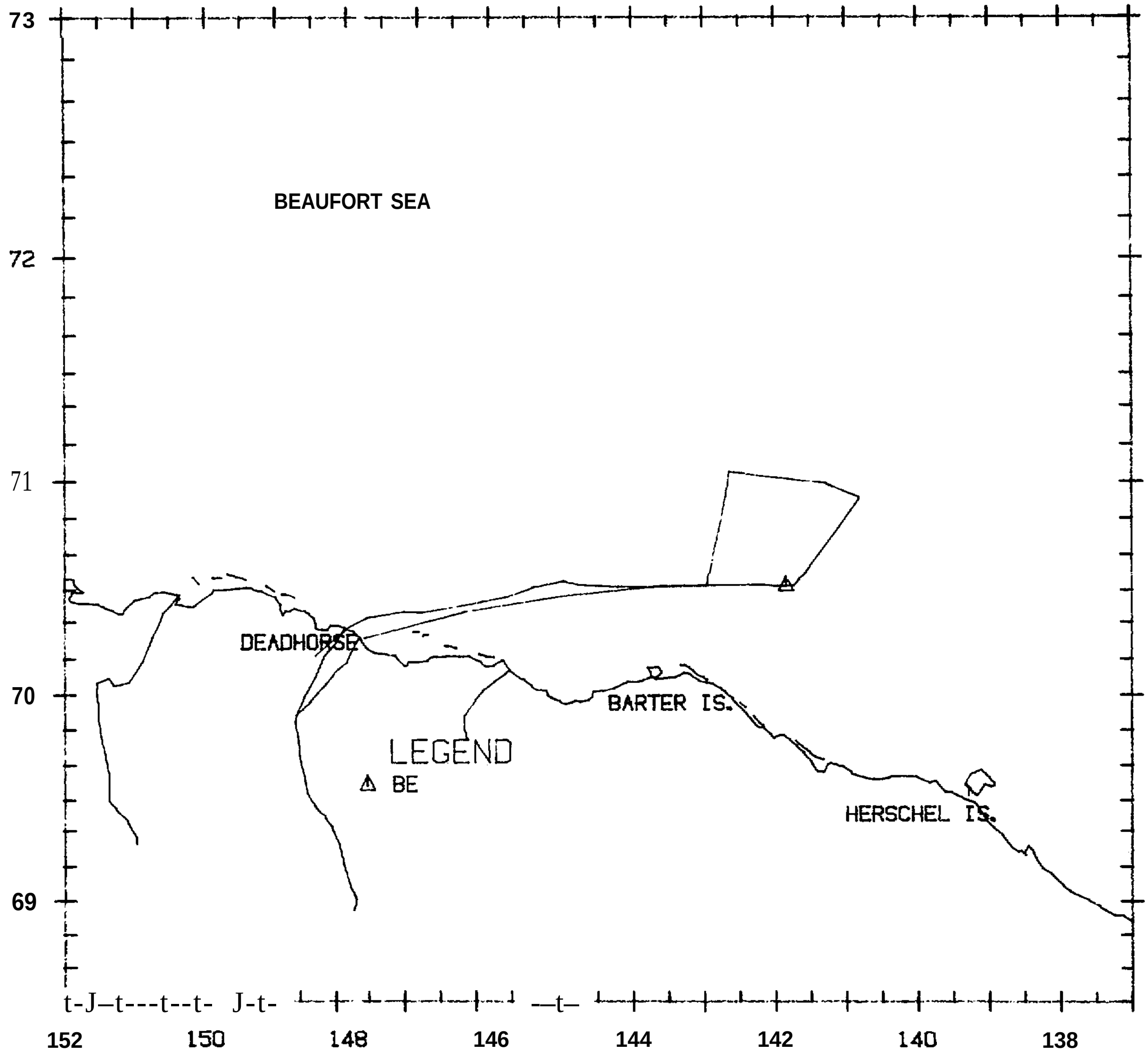
Flight **20:** 12 August 1985

Flight was an aborted transect survey of block 7. Weather was dense, low-lying fog and visibility was unacceptable. Ice coverage in block 7 was 95 to 99 percent broken floe and sea state was Beaufort 00. Belukhas were seen.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BEAUFORT SEA
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BARTER IS.
HERSCHEL IS.
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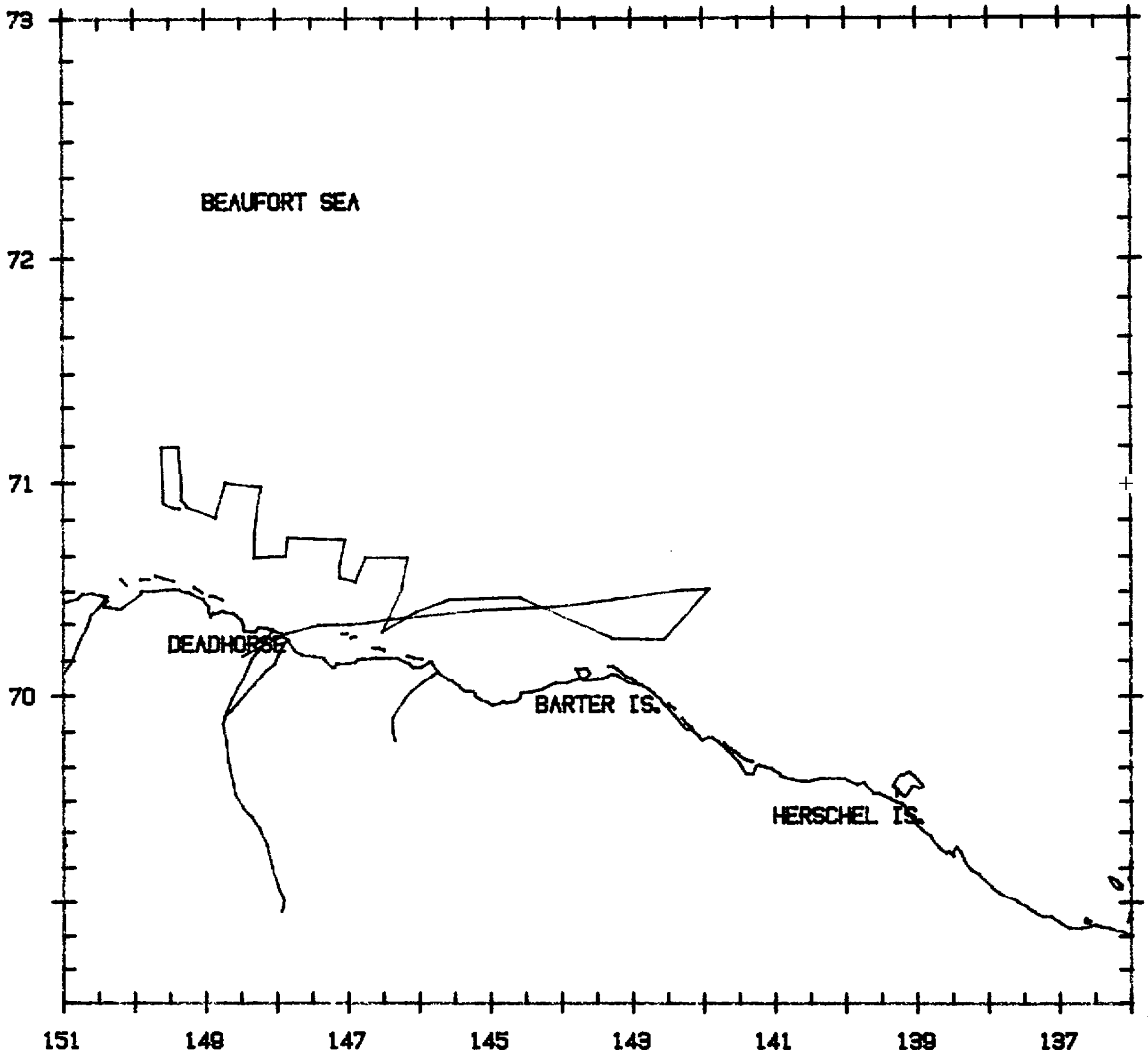
Flight 21: 14 August 1985

Flight was a transect survey of the northern one-half of block 1 after low-lying fog prevented surveys in the eastern Alaskan Beaufort Sea. Weather in block 1 was clear with unlimited visibility in the northern half and heavy fog in the southern half. Ice coverage was 80 to 95 percent broken floe and sea state was Beaufort 00. No marine mammals were seen.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BEAUFORT SEA
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HERSCHEL IS.
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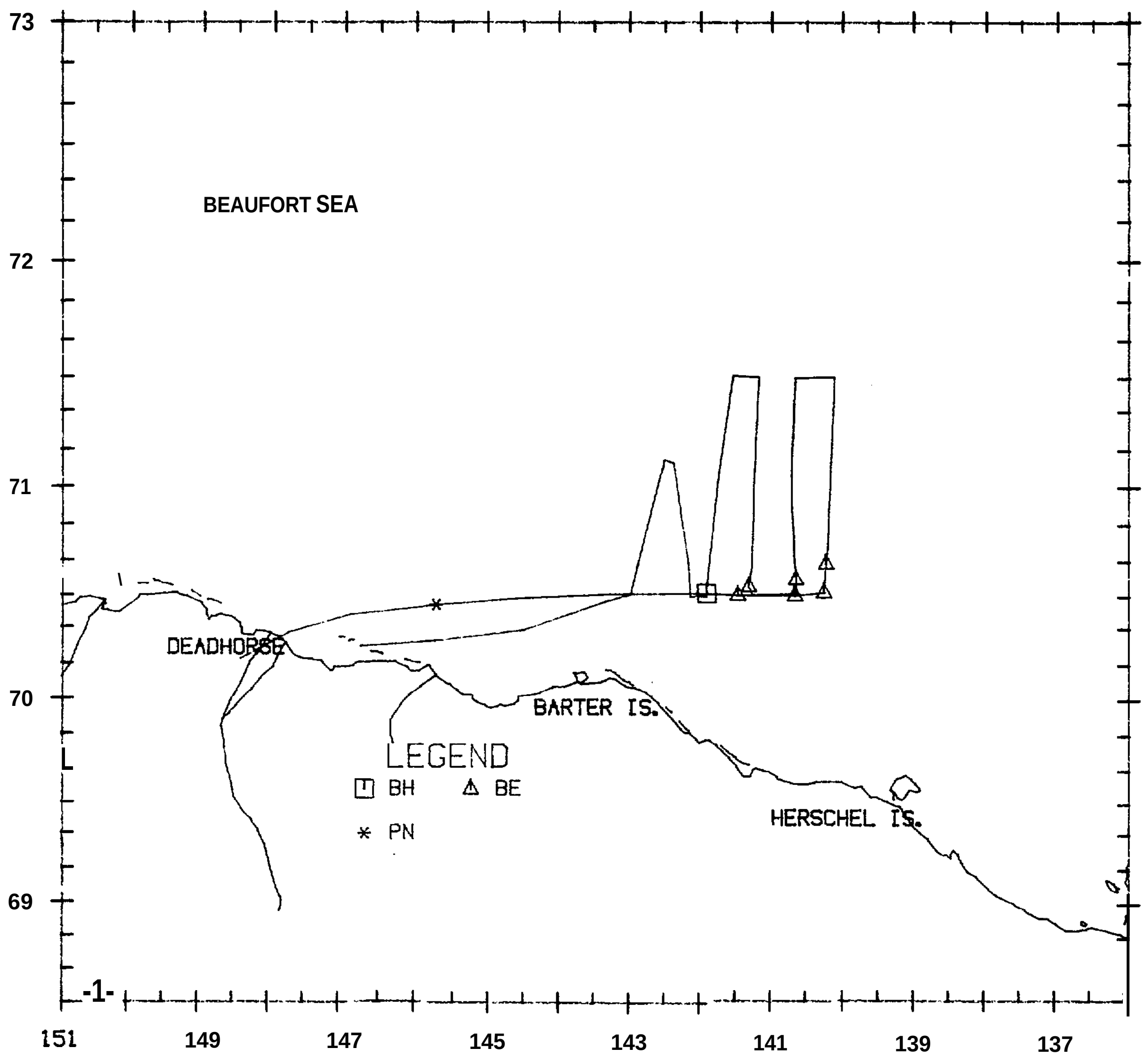
Flight **22:** 15 August 1985

Flight was a transect survey of block 7 and the southern one-half of block 8. Weather was mostly overcast with some patchy fog and visibility was generally unlimited. Ice coverage was O to 10 percent along the southernmost edge of block 7 and 95 to 99 percent in the rest of block 7 and all of block 8. Sea state was Beaufort 00 to 02. One bowhead was seen tail slapping in block 7. Belukhas were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°30.9'	141055.7’	--	BO	SL	--	0	B1	146


BEAUFORT SEA
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DEADHORSE
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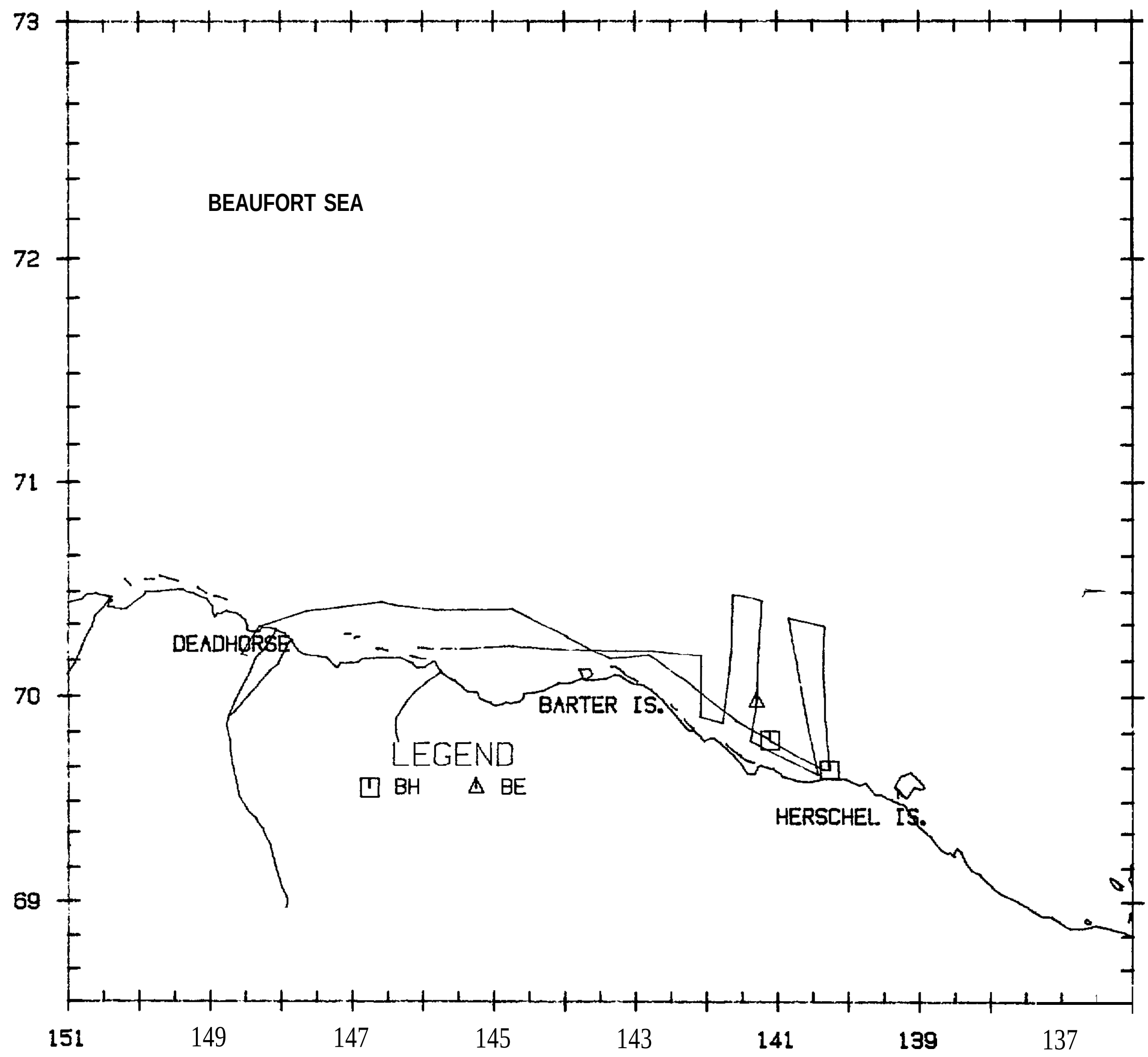
Flight 23: 17 August 1985

Flight was a transect survey of the eastern two-thirds of block 5. Weather was overcast with unlimited visibility in this area. Heavy fog covered the rest of the Alaskan Beaufort Sea. Ice coverage was O to 10 percent broken floe, except along the northernmost edge of block 5. Sea state was Beaufort 01 to 02. Two bowheads were seen swimming. Belukhas were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	69048.0'	141006.1'	--	BO	SW	240	5	B2	22
1/0	69039.5'	I 40015.5'	--	BO	SW	--	2	B2	16



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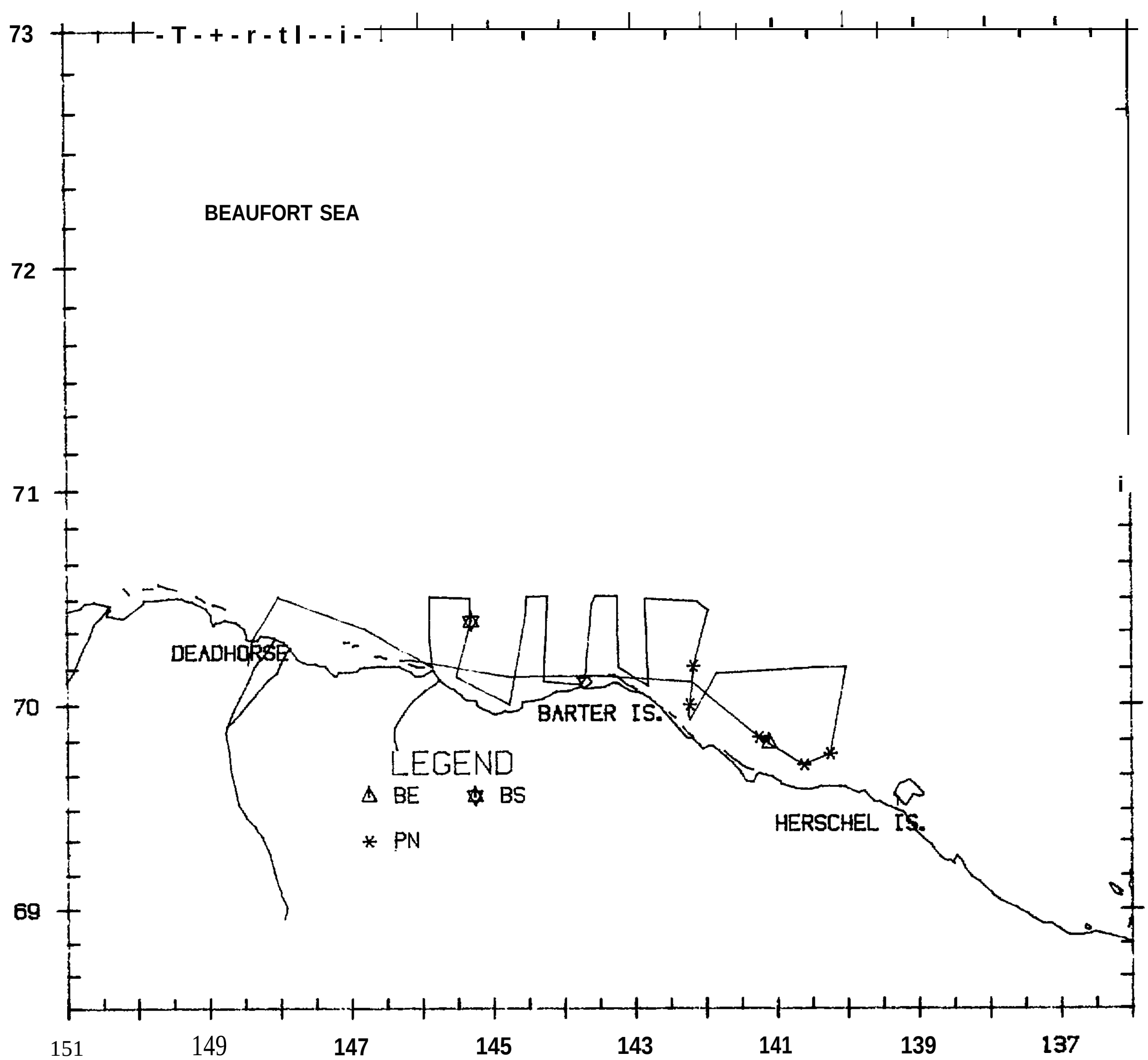
Flight 24: 18 August 1985

Flight was a transect survey of block 4 and the westernmost one-third of block 5 and a search survey to 1400 W. Weather was clear with unlimited visibility. Ice coverage was 10 to 40 percent in the southern two-thirds of block 4 and all of block 5 and 95 to 99 percent in the northern third of block 4. Sea state was Beaufort 00 to 01. Belukhas, bearded seals and unidentified pinnipeds were seen.



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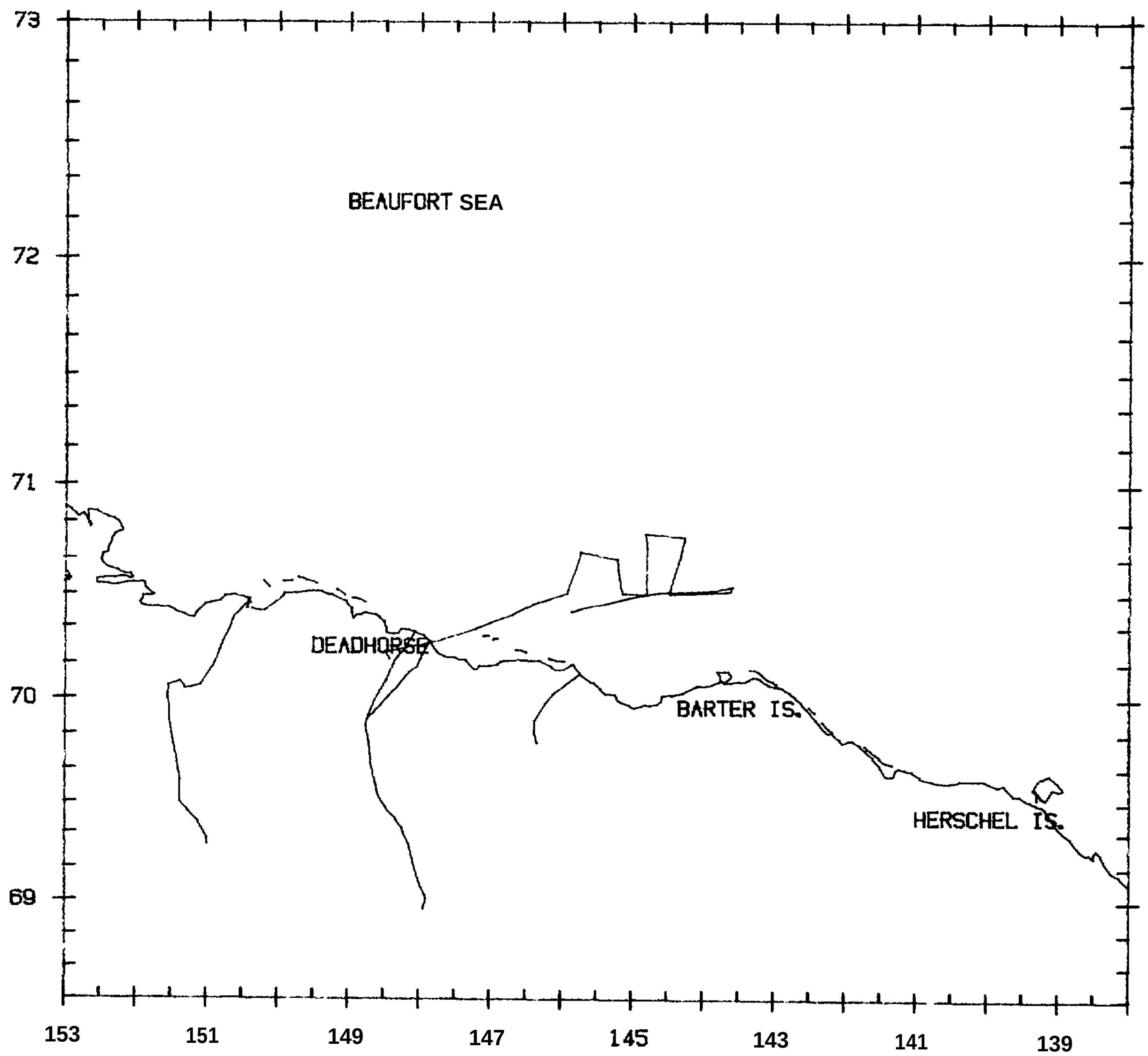
Flight 25: 19 August 1985

Flight wasa modified transect survey of block 6. Heavy fog blanketed the rest of the Alaskan Beaufort Sea. Visibility was variable from 10km to unacceptable. Ice coverage was 95to 99 percent broken floe and sea state was Beaufort 00. No marine mammals were seen.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BEAUFORT SEA
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BARTER IS.
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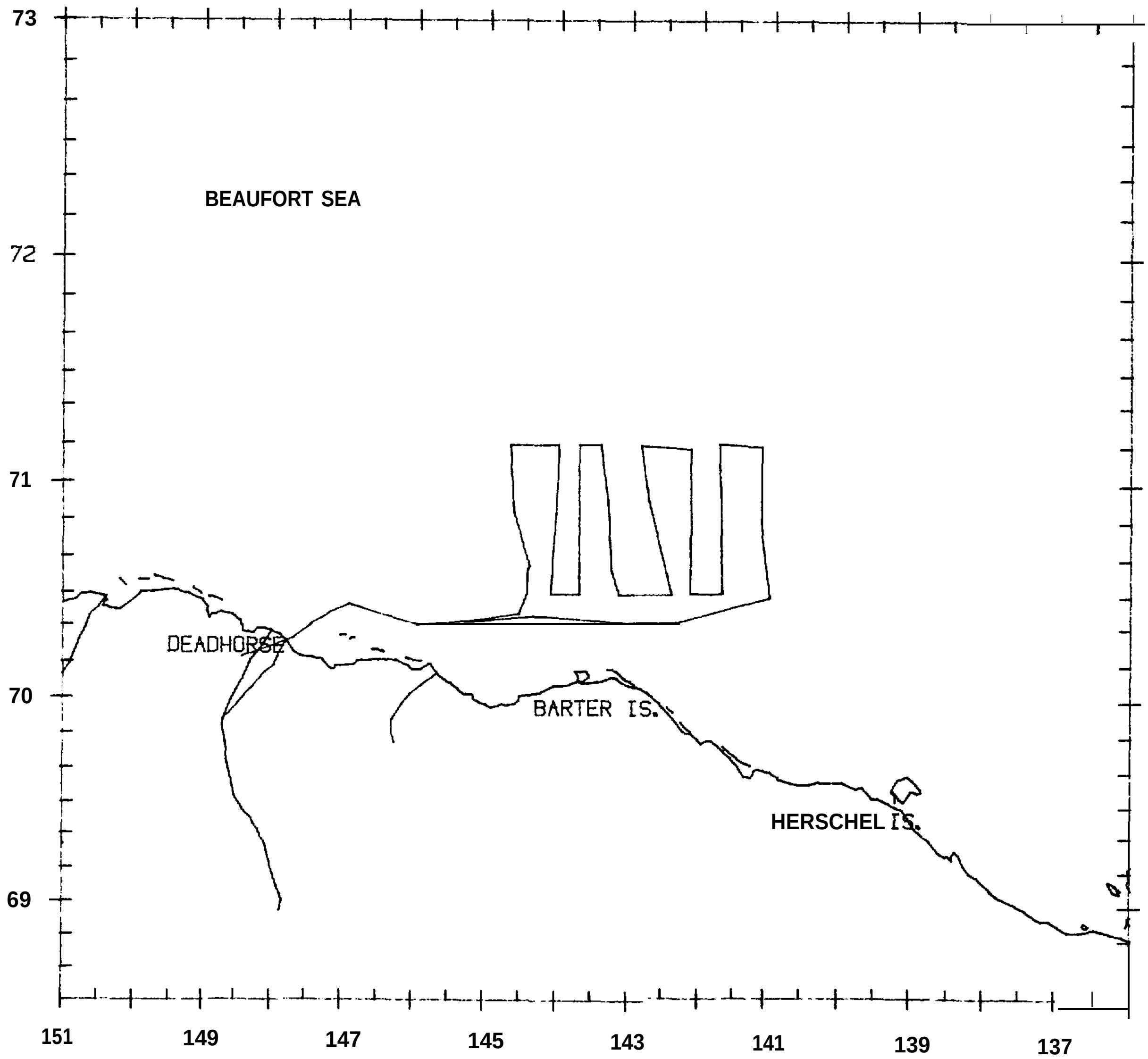
Flight 26: 21 August 19S5

Flight was a transect survey of the eastern two-thirds of block 6 and the western two-thirds of block 7. Weather was clear with unlimited visibility. Ice coverage was 95 to 99 percent in all areas of both blocks except for the southernmost edge, which was ice-free. Sea state was Beaufort 00 in the ice and Beaufort 04 in open water areas.



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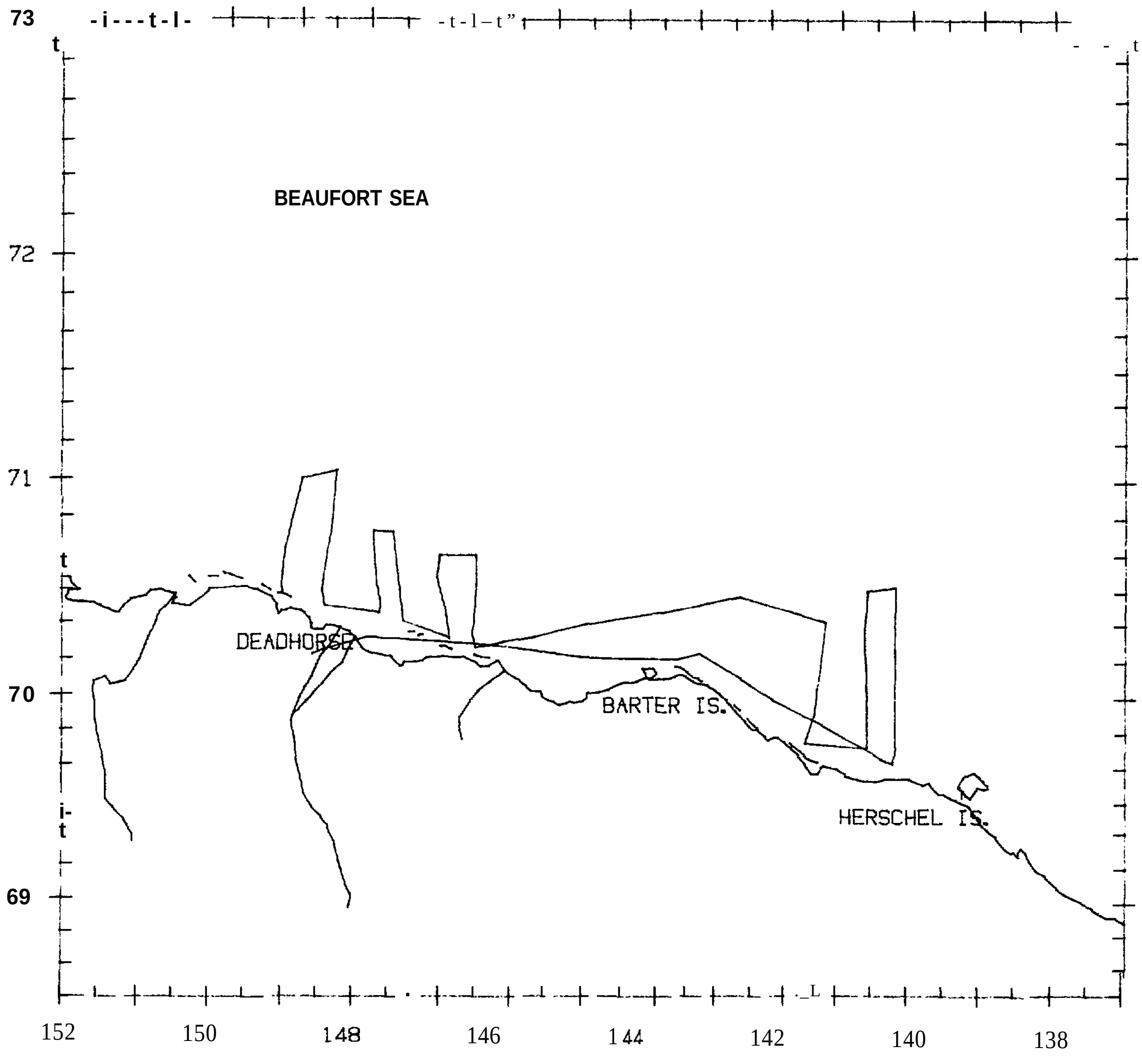
Flight Z?: 24 August 1985

Flight was a transect survey of the eastern one-half of block 5 and the eastern three-quarters of block 1. Weather was clear with unlimited visibility. Ice coverage was O to 10 percent in block 5 and O to 99 percent in block 1. Sea state was Beaufort 05 in block 5 and varied from Beaufort 00 to 02 in block 1. No marine mammals were seen.


BEAUFORT SEA
DEADHORSE
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HERSCHEL IS.
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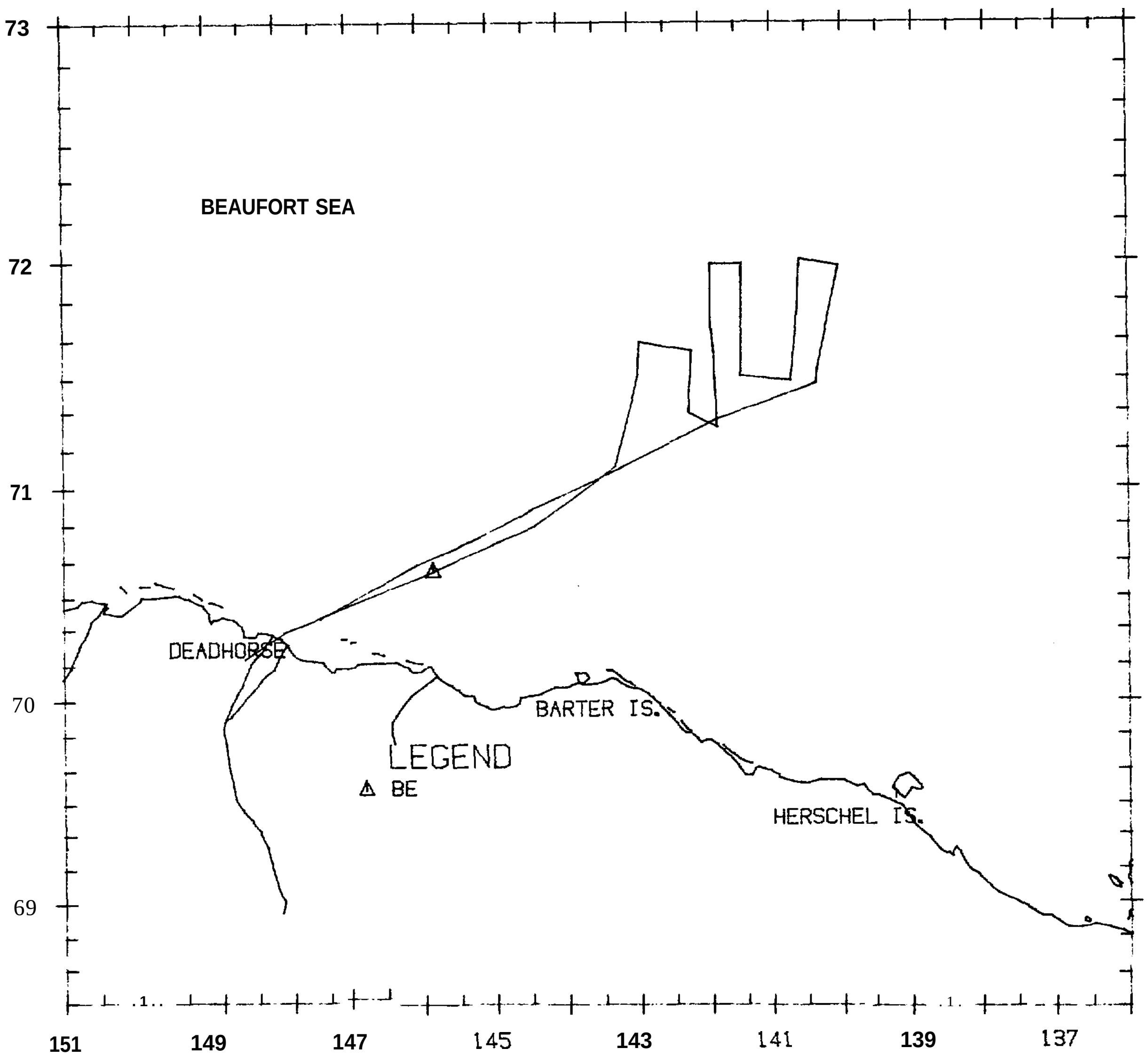
Flight **28:** 25 August 1985

Flight was a modified transect survey of Mock 8. Low-lying fog forced some transect lines to be truncated, but the majority of the block was clear with unlimited visibility. Ninety-nine percent broken floe ice covered the entire block and the sea state was Beaufort 00. One belukha was seen.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BEAUFORT SEA
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HERSCHEL IS.
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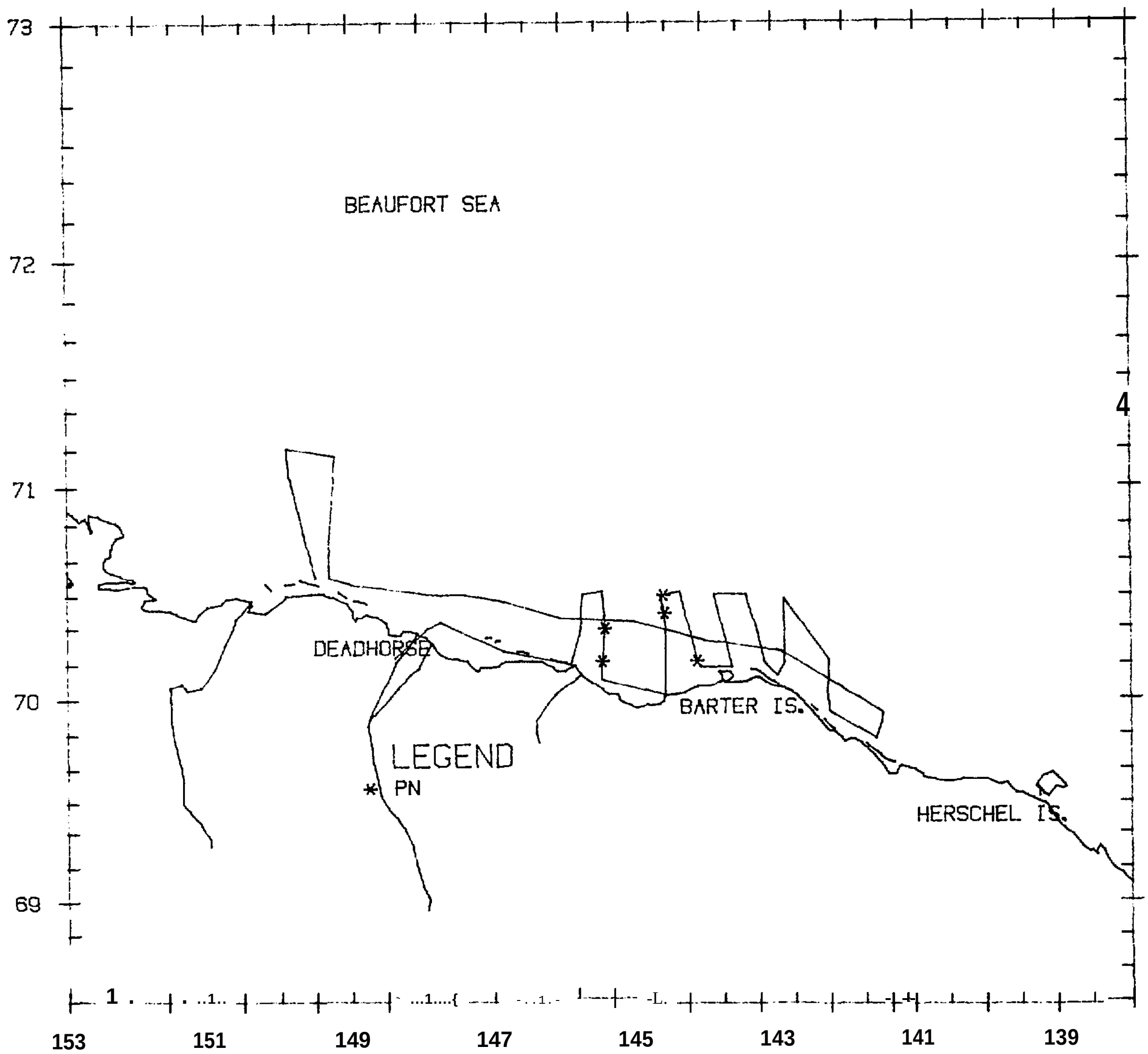
Flight 29: 27 August 1985

Flight was a transect survey of block 4 and parts of blocks 5 and 1. Weather was generally clear with unlimited visibility except in the northern portion of block 5 where low-lying fog existed. Ice coverage in blocks 4 and 5 was O to 10 percent broken floe with sea state ranging from Beaufort 01 to 03. Ice coverage in block 1 varied from O to 95 percent, with sea state ranging from Beaufort 00 to 01. Unidentified pinnipeds were seen.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BEAUFORT SEA
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BARTER IS.
HERSCHEL IS.
LEGEND
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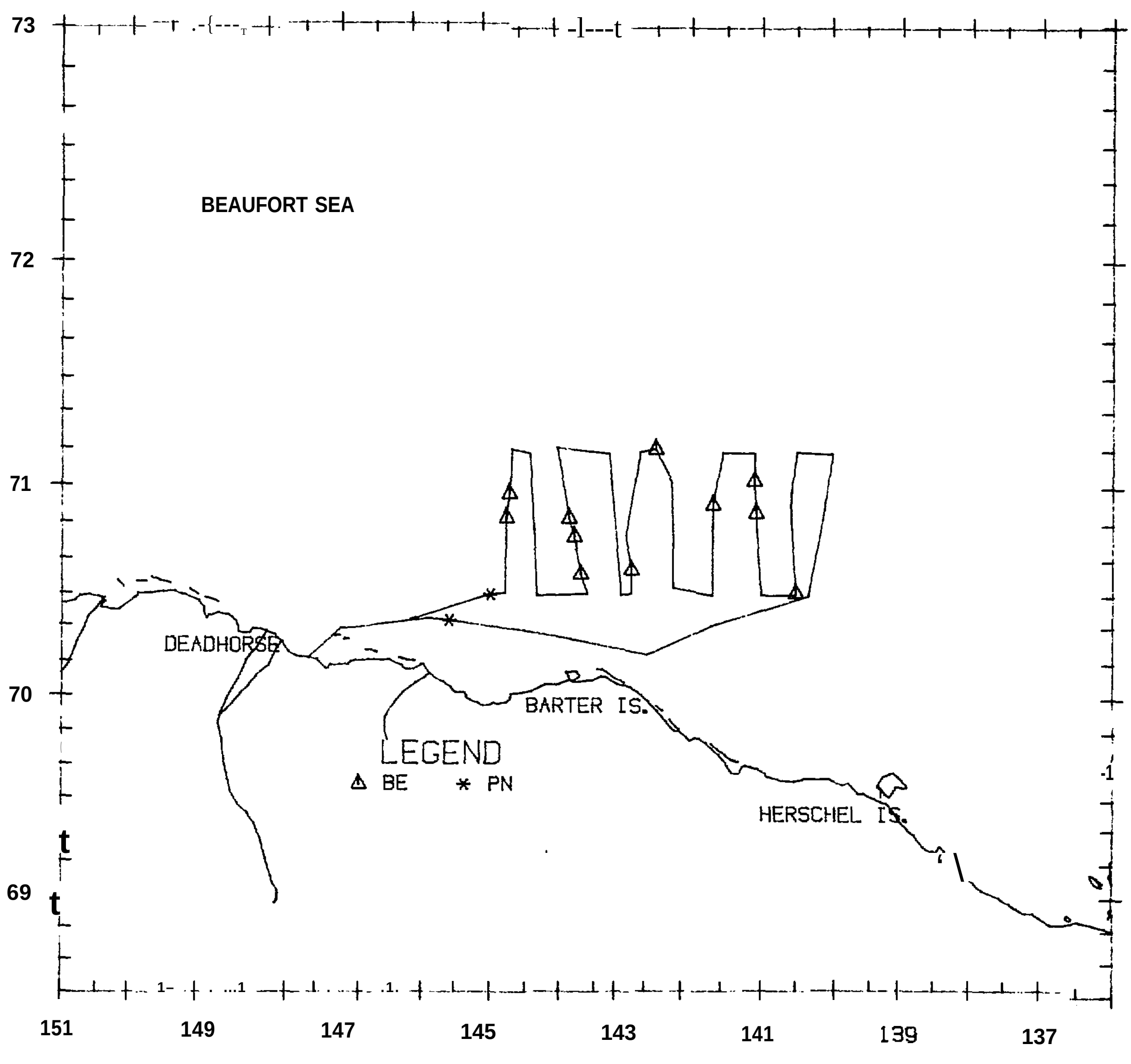
Flight **30:** 28 August 1985

Flight was a transect survey of blocks 7 and 6. Weather was clear with unlimited visibility. Ice coverage was 85 to 99 percent in the northern half of each block and O to 30 percent in the southern half. Sea state was Beaufort 00 in the heavy ice and Beaufort 01 in open water. Belukhas and unidentified pinnipeds were seen.



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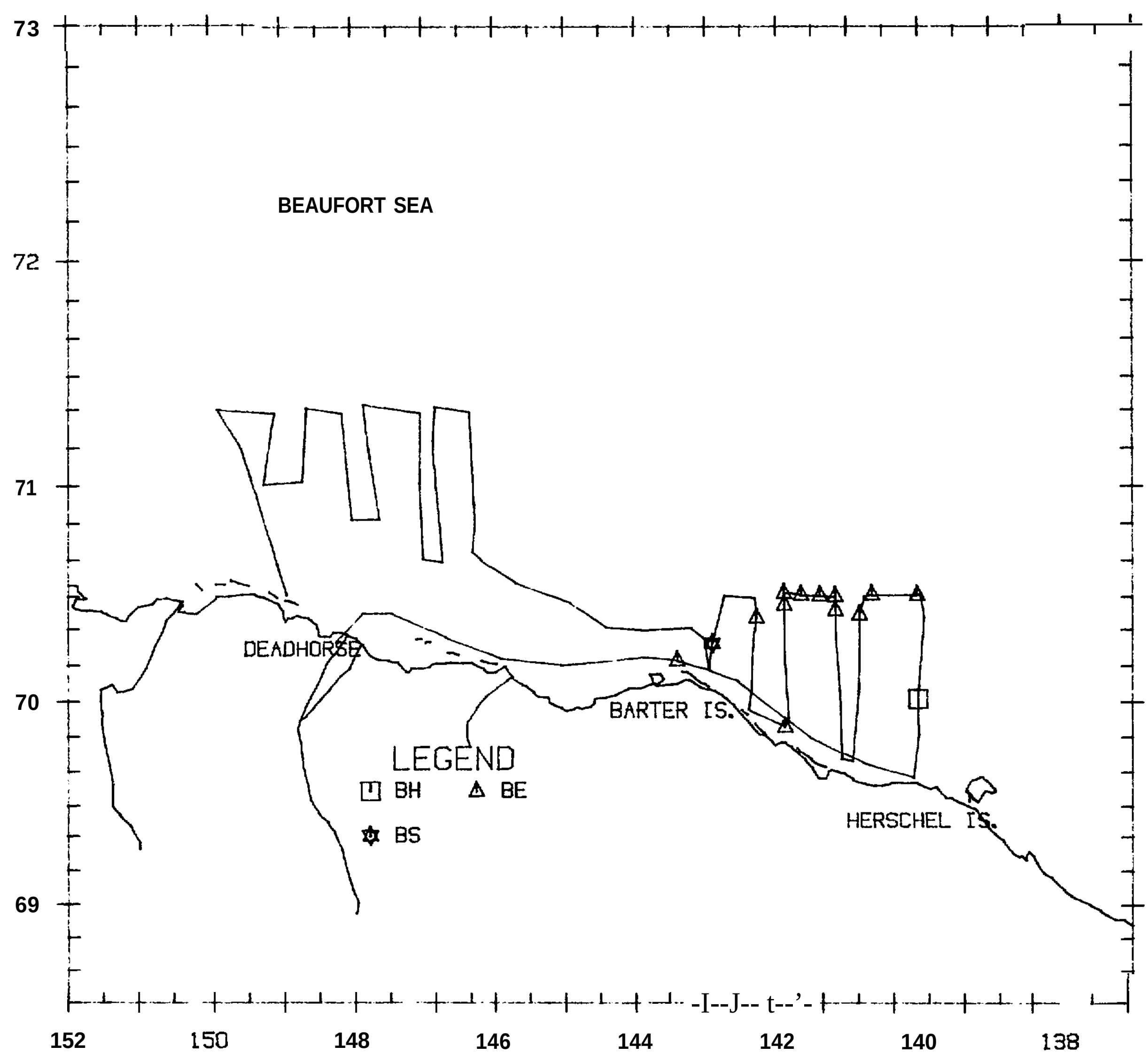
Flight 31: 29 August 1985

Flight was a transect survey of blocks 5 and 2. Weather was generally clear with some patchy fog and visibility varied from 3 km to unlimited. There was no ice in block 5, with a sea state of Beaufort 01. Ice coverage in block 2 was 50 to 99 percent, with a sea state of Beaufort 00 to 01. One bowhead was seen swimming. Belukhas and a bearded seal were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°01.0'	140000.8’	527	BO	SW	45	0	B2	59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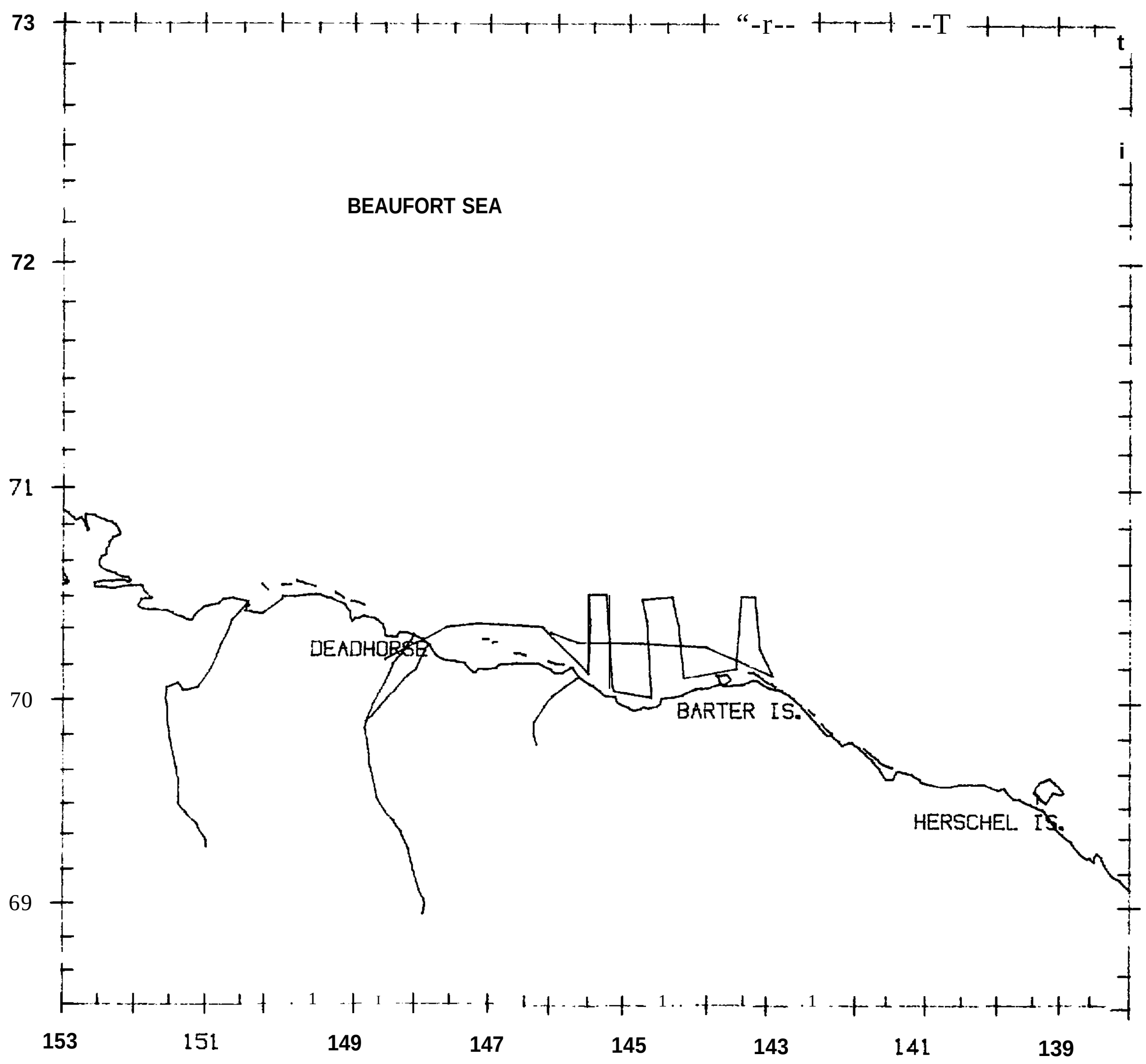
Flight 32: 30 August 1985

Flight was a transect survey of block 4. Weather was overcast with unlimited visibility. Ice coverage was O to 5 percent and sea state was Beaufort 01. No marine mammals were seen.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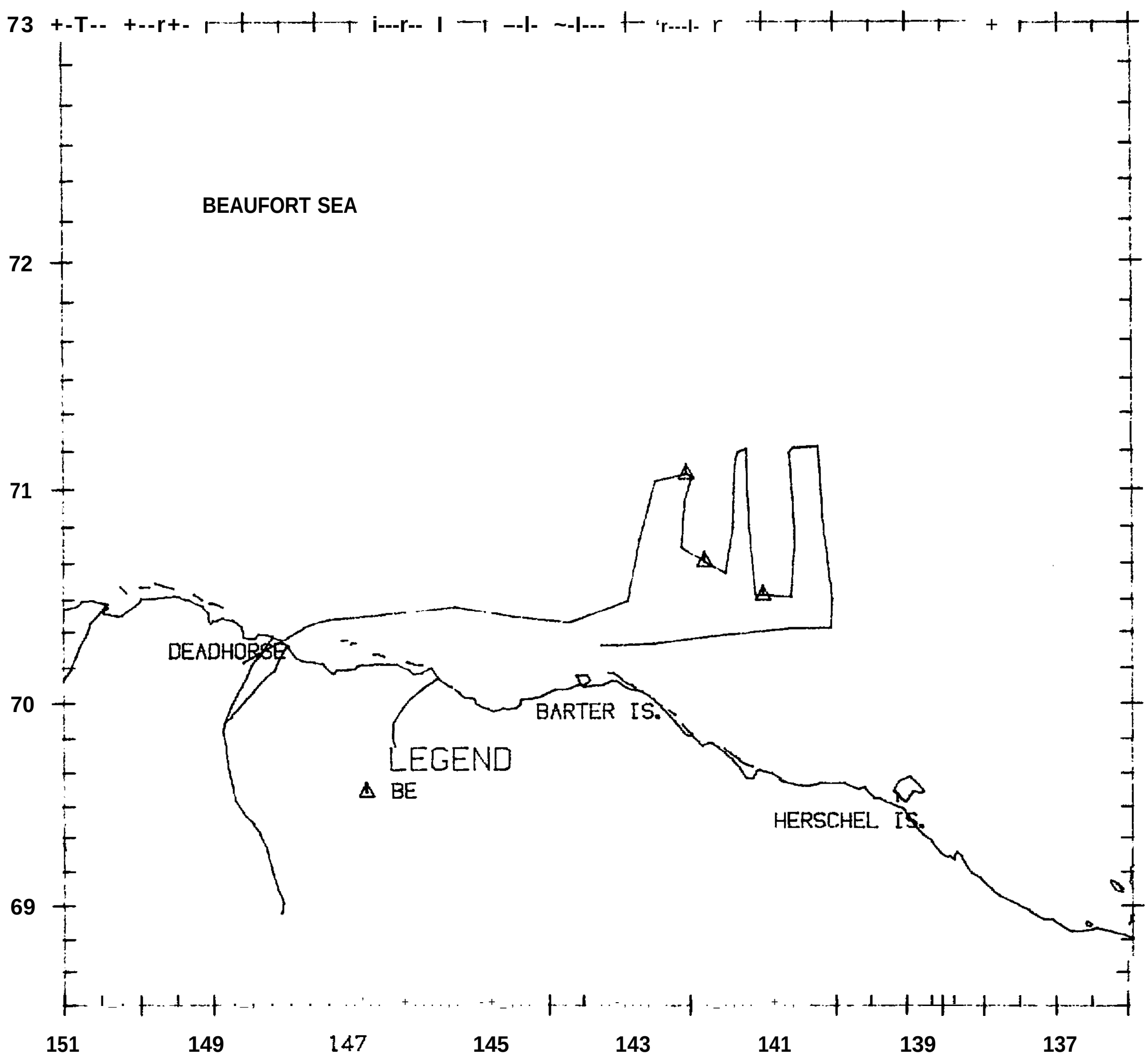
Flight 33: 1 September 1985

Flight was a transect survey of block 7. Heavy fog surrounding the area forced some transect legs to be truncated, as visibility varied from 10 km to unacceptable. Ice coverage was O percent in all but the northernmost areas, where 20 to 50 percent broken floe ice persisted. Sea state was Beaufort 05 to 06. Belukhas were the only marine mammals seen.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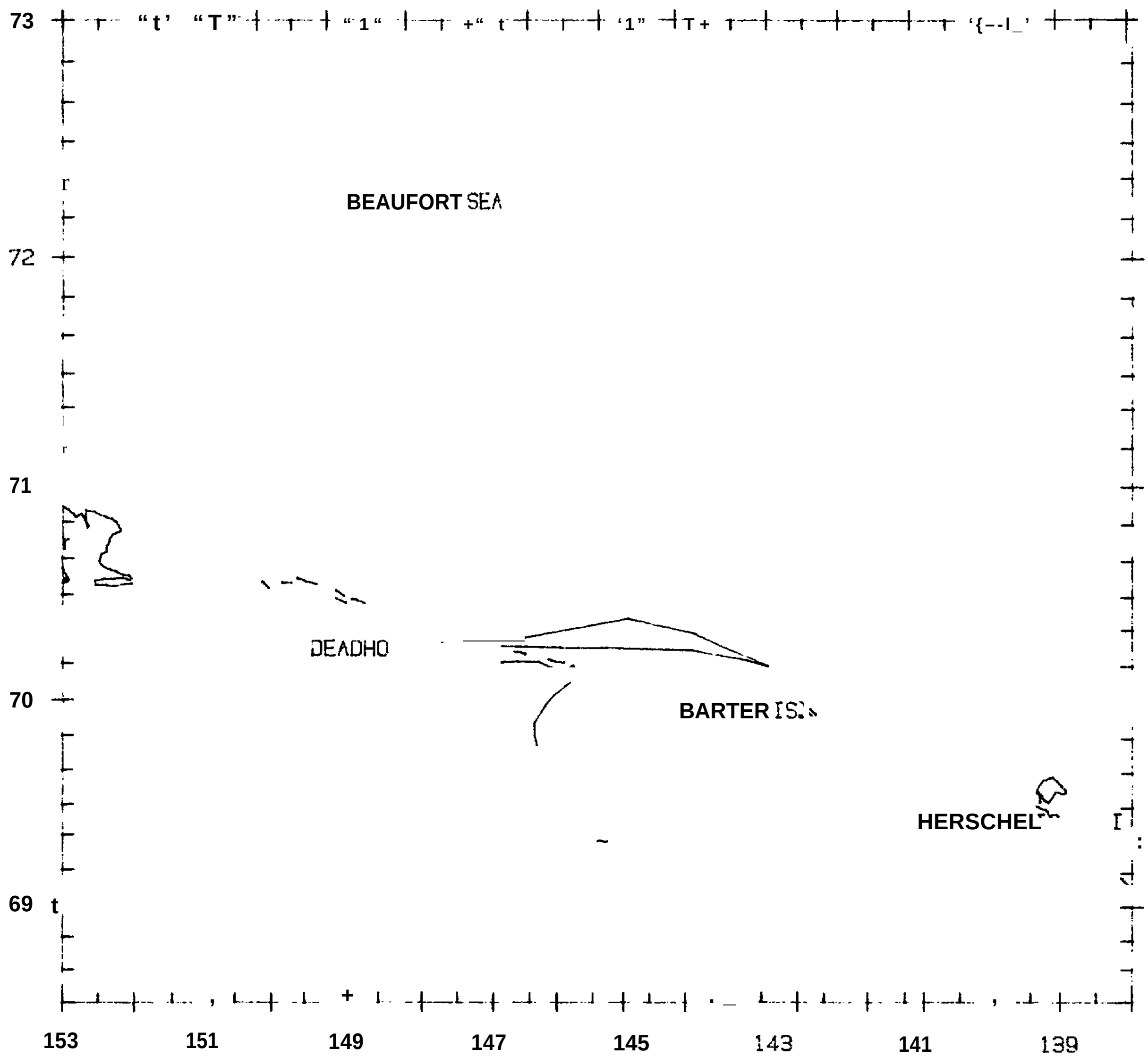
Flight 34: 4 September 1985

Flight was a search survey east to Barter Island. Heavy, low-lying fog covered the Alaskan Beaufort Sea and visibility was unacceptable. Ice coverage along the barrier islands was about 30 percent and sea state was Beaufort 03. No marine mammals were seen.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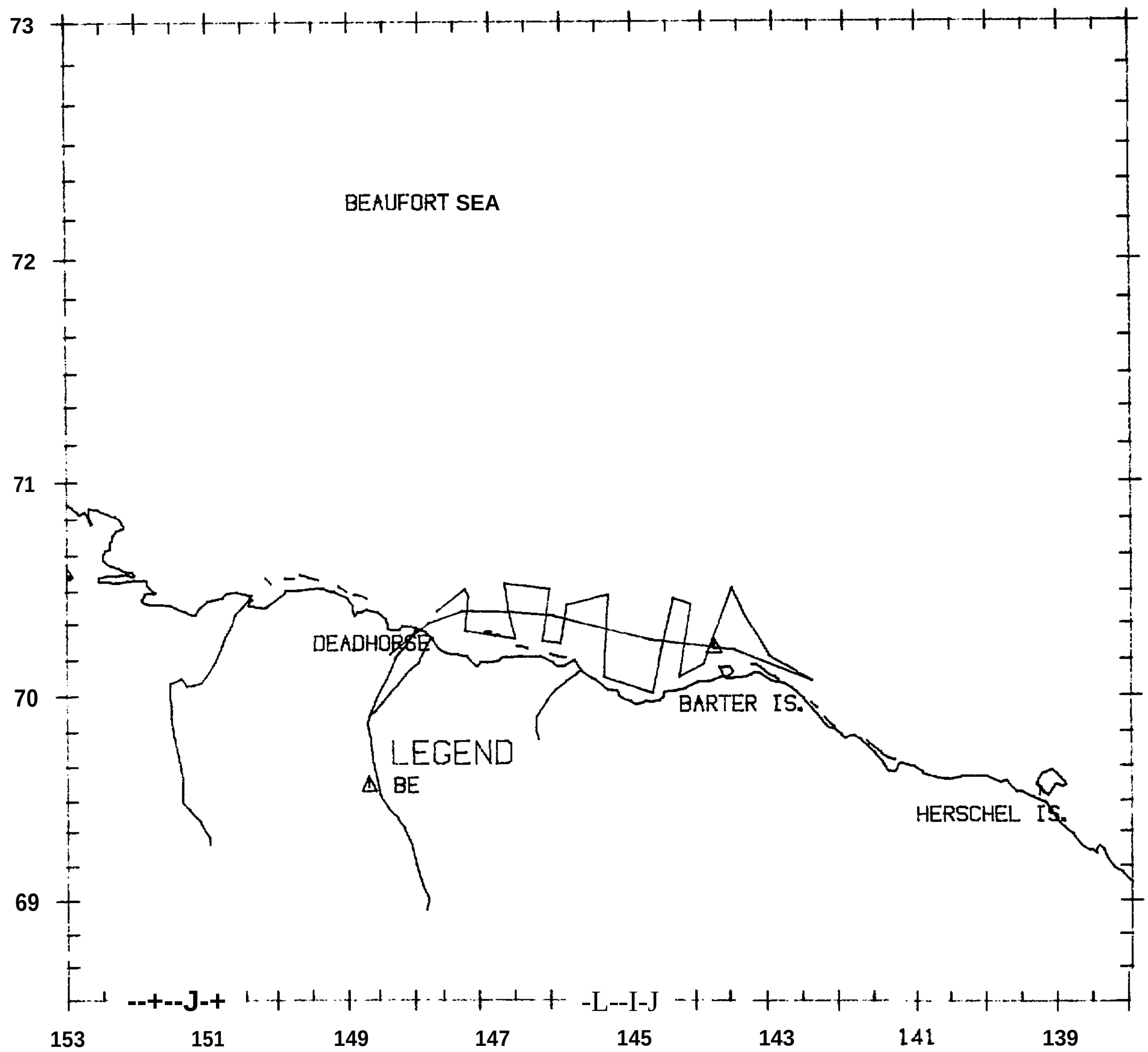
Flight 35: 5 September 1985

Flight was a transect survey of block 4 and the southeast corner of block 1. Heavy fog forced transect legs to be truncated and the survey of block 1 to be aborted. Visibility was variable from 10 km to unacceptable. Ice coverage was O to 5 percent in block 4 and O to 40 percent in block 1. Sea state was Beaufort 02 to 03. One belukha was seen.



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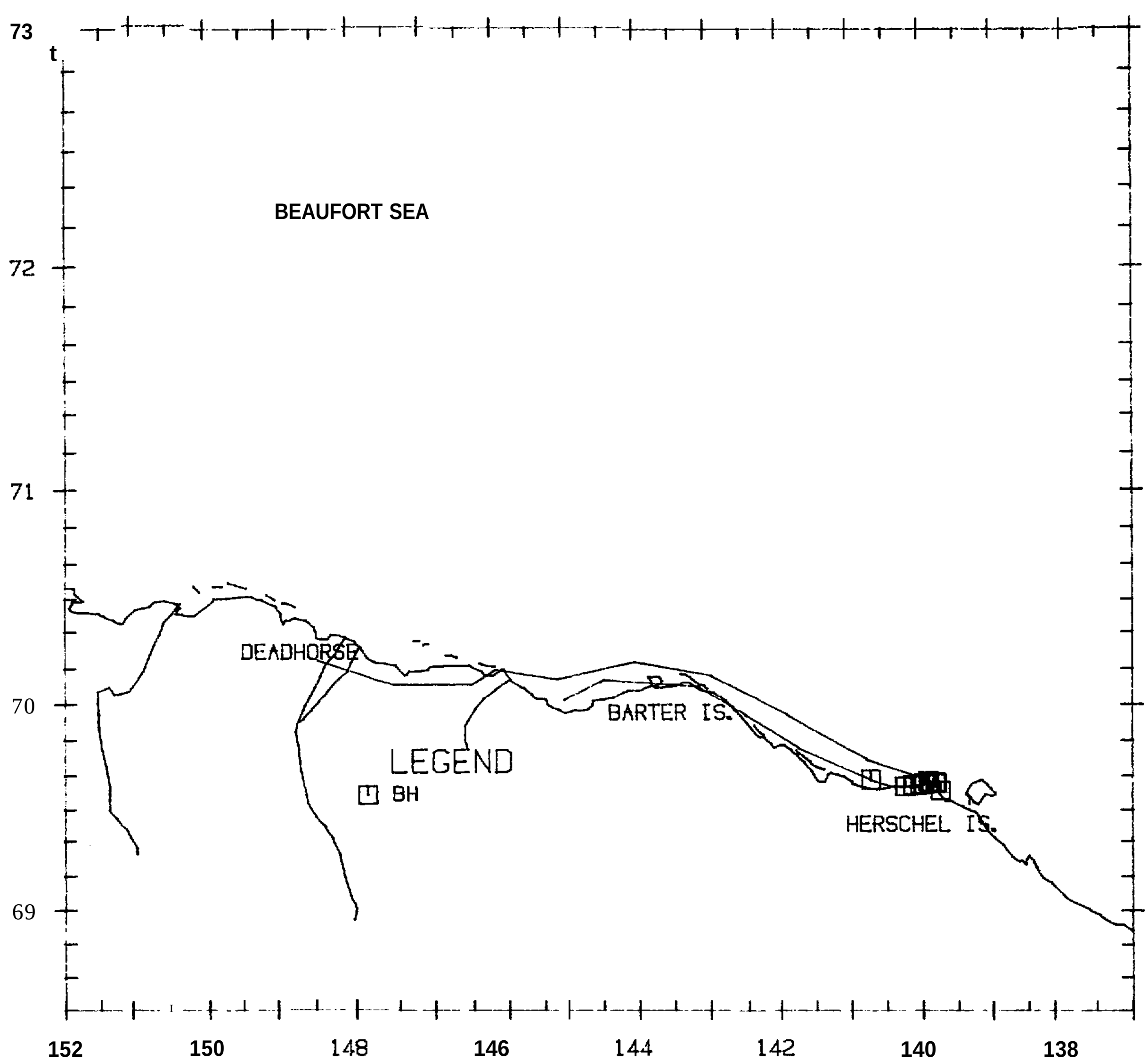
Flight **36:** 9 September 1985

Flight was a search survey east to Herschel Island. Heavy, low-lying fog over the entire Alaskan Beaufort Sea prevented any transect surveys. One open area existed between 1410 W and 1390 W, in which sea state was Beaufort 03 and there was no ice. Twenty-five bowheads were seen there, milling and possibly feeding. No other marine mammals were seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
2/0	69°35.5'	139041.8’	--	BO	RE	--	0	B2	15
3/0	69°37.8'	139045.9’	--	BO	FE	--	0	B2	15
1/0	69°38.2'	139051.9’	--	BO	FE	--	0	B2	15
1/0	69°37.6'	139045.0’	--	BW	FE	--	0	B2	15
2/0	69°37.4'	139055.8’	--	BW	FE	--	0	B2	15
5/0	69°37.1'	139059.2’	--	BO	FE	--	0	B2	15
4/0	69°37.0'	140005.0’	--	BO	FE	--	0	B2	16
5/0	69°36.6'	140011.9’	--	BO	FE	--	0	B2	16
2/0	69°38.7'	140040.7’	--	BO	FE	--	4	B3	7



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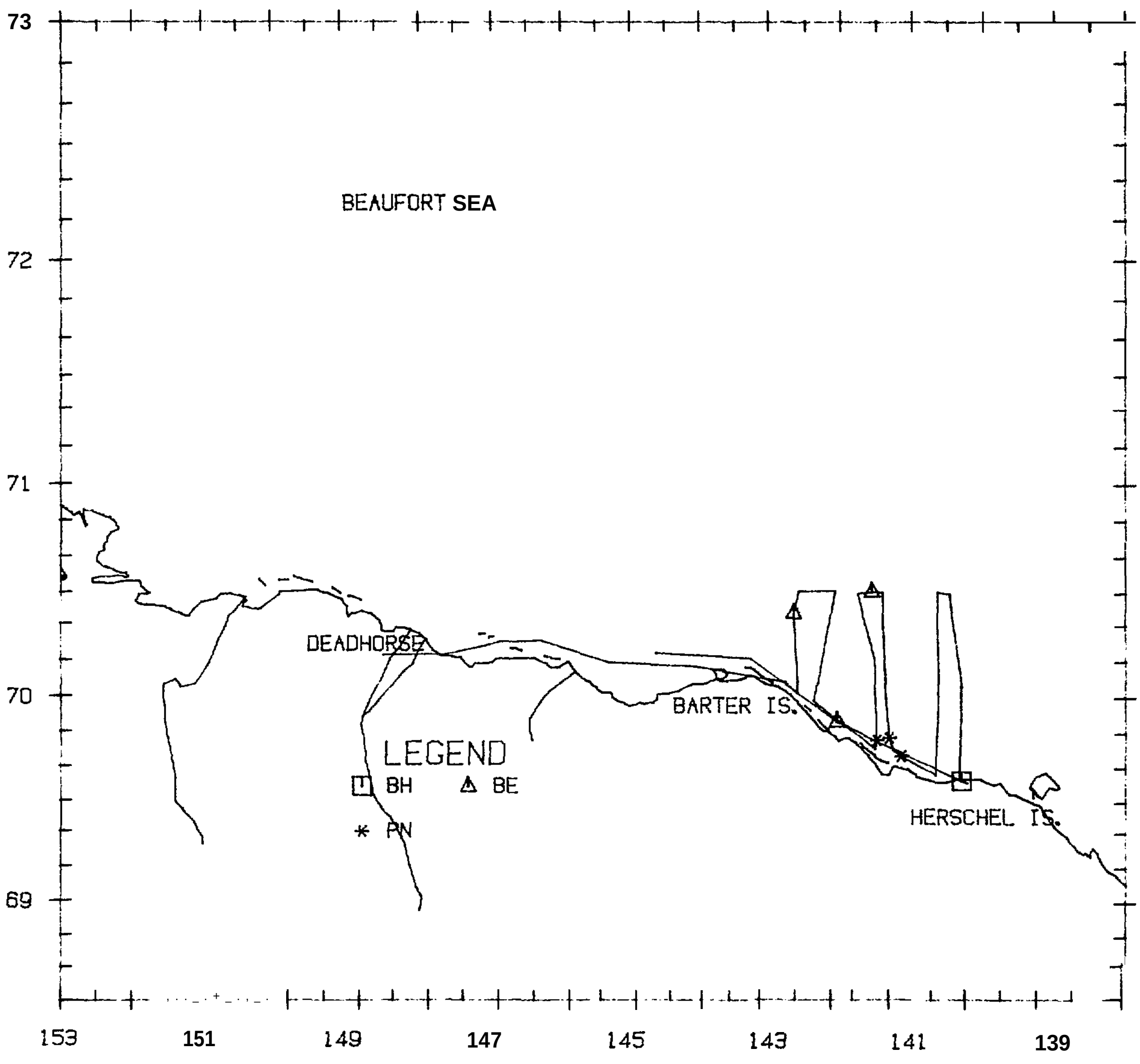
Flight 37: 11 September 1985

Flight was a transect survey of block 5, with a search survey through block 4. Intermittent heavy fog resulted in visibility that ranged from 10 km to unacceptable. Ice coverage was O to 5 percent, and sea state was Beaufort 01 to 02. Three bowheads were seen near-shore east of block 5. Belukhas and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
3/0	69°36.4'	140°17.8'	--	BO	MI	60	0	B2	16



BEAUFORT SEA
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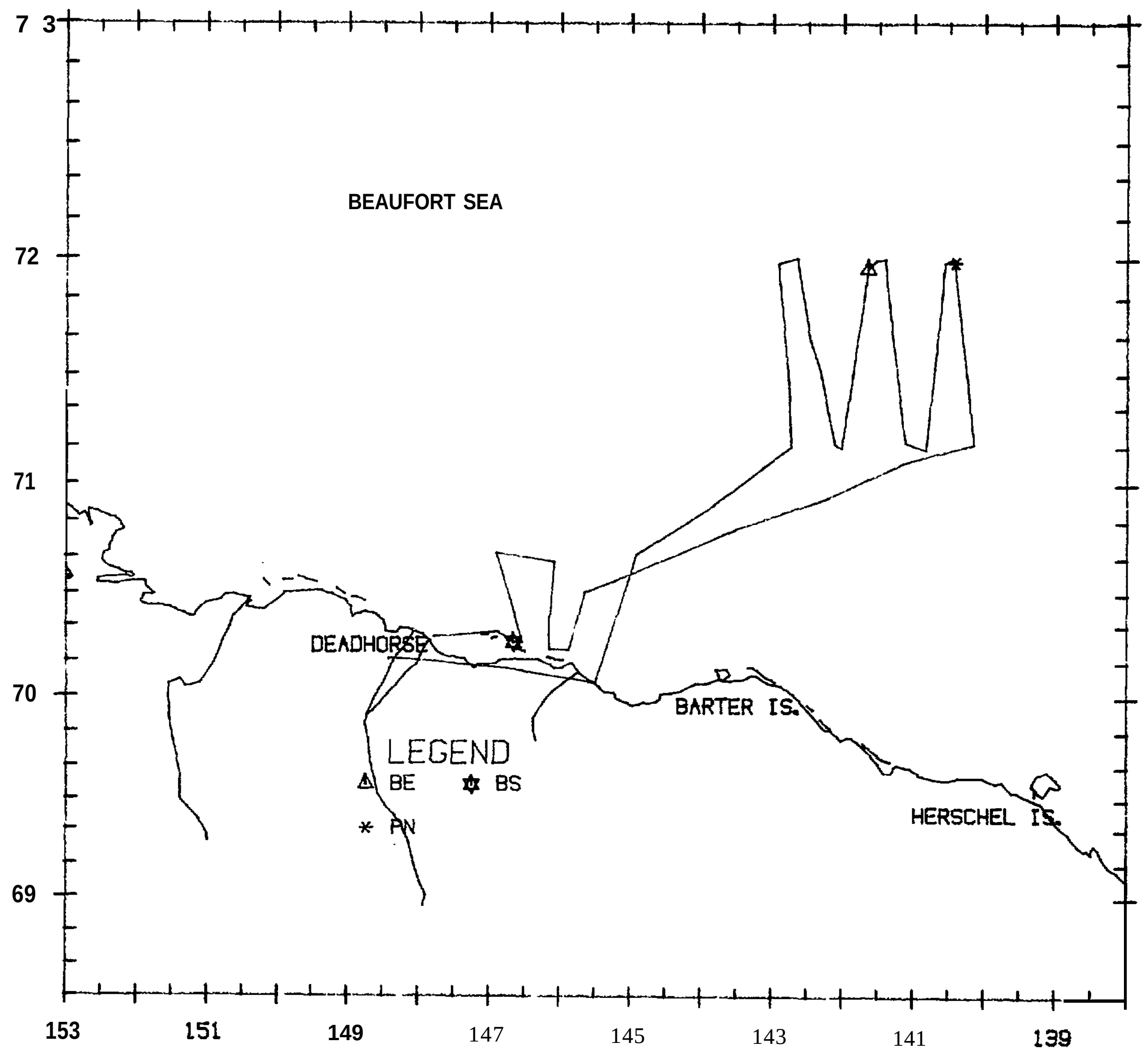
Flight 38: 12 September 1985

Flight was a transect survey of block 8 and one and two survey lines in blocks 4 and 1 respectively. Weather was partly cloudy with an area of low overcast with patchy fog in the northeastern corner of block 8. Visibility ranged from 0.5 km to unlimited. All areas had less than 1 percent ice coverage except the northern half of block 8 where ice coverage ranged from 40 to 99 percent. Sea state was Beaufort 00 to 02. A belukha, bearded seals and unidentified pinnipeds were seen.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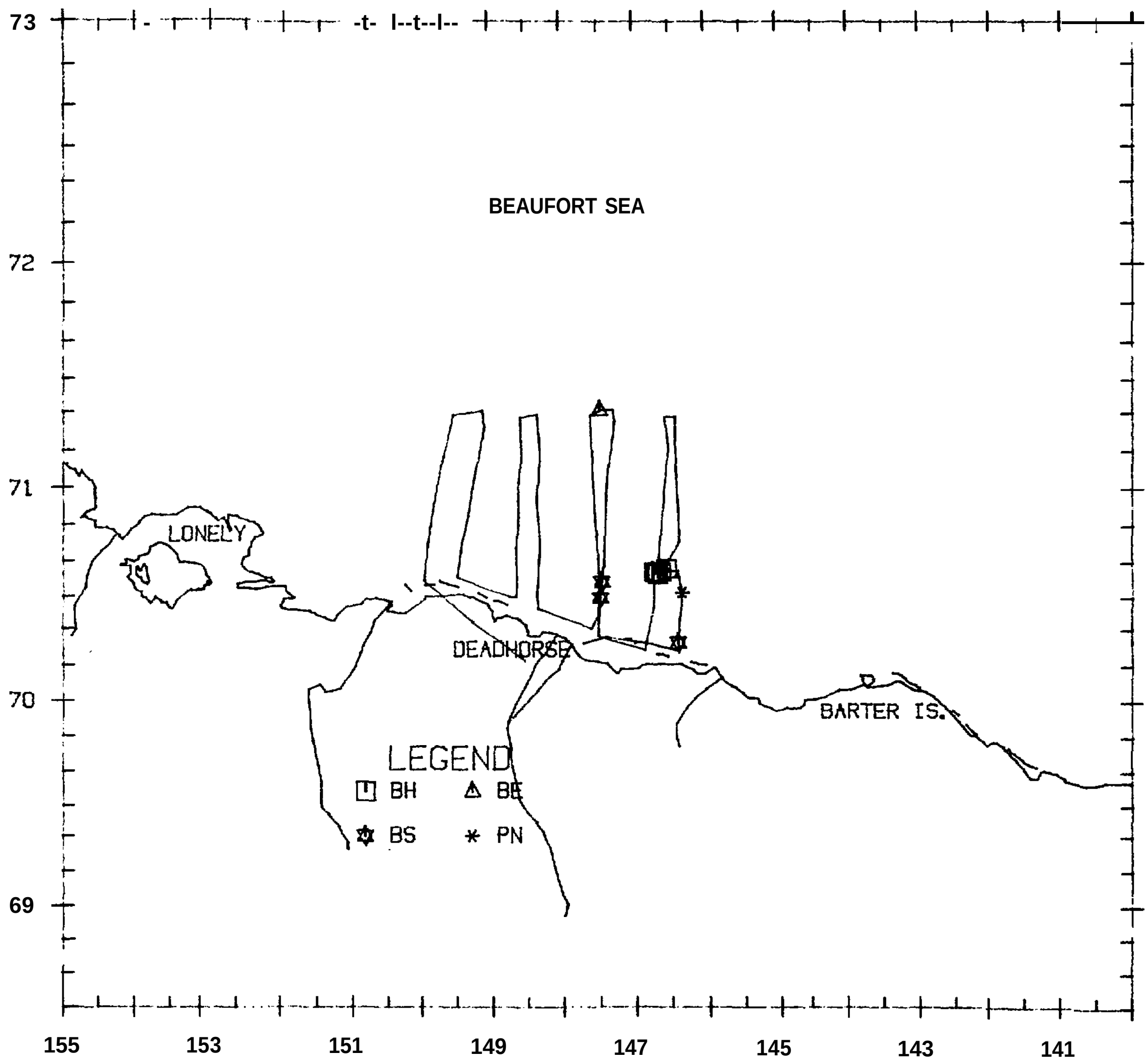
Flight 39: **13 September 1985**

Flight was a transect survey of blocks 1 and 2. Weather was overcast with occasional rain showers. Visibility ranged from 3 km to unlimited, and sea state from Beaufort 01 to 03. Ice coverage ranged from O to 90 percent in block 1, and from 60 to 95 percent in block 2. Six bowheads, a belukha, bearded seals and an unidentified pinniped were seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
3/0	70037.3'	146041.3'	2353	BO	MI	--	0	B2	31
2/0	70036.8'	146038.8'	--	BO	SW	--	0	B2	29
1/0	70°38.3'	146031.2'	--	BW	SW	360	0	B2	29



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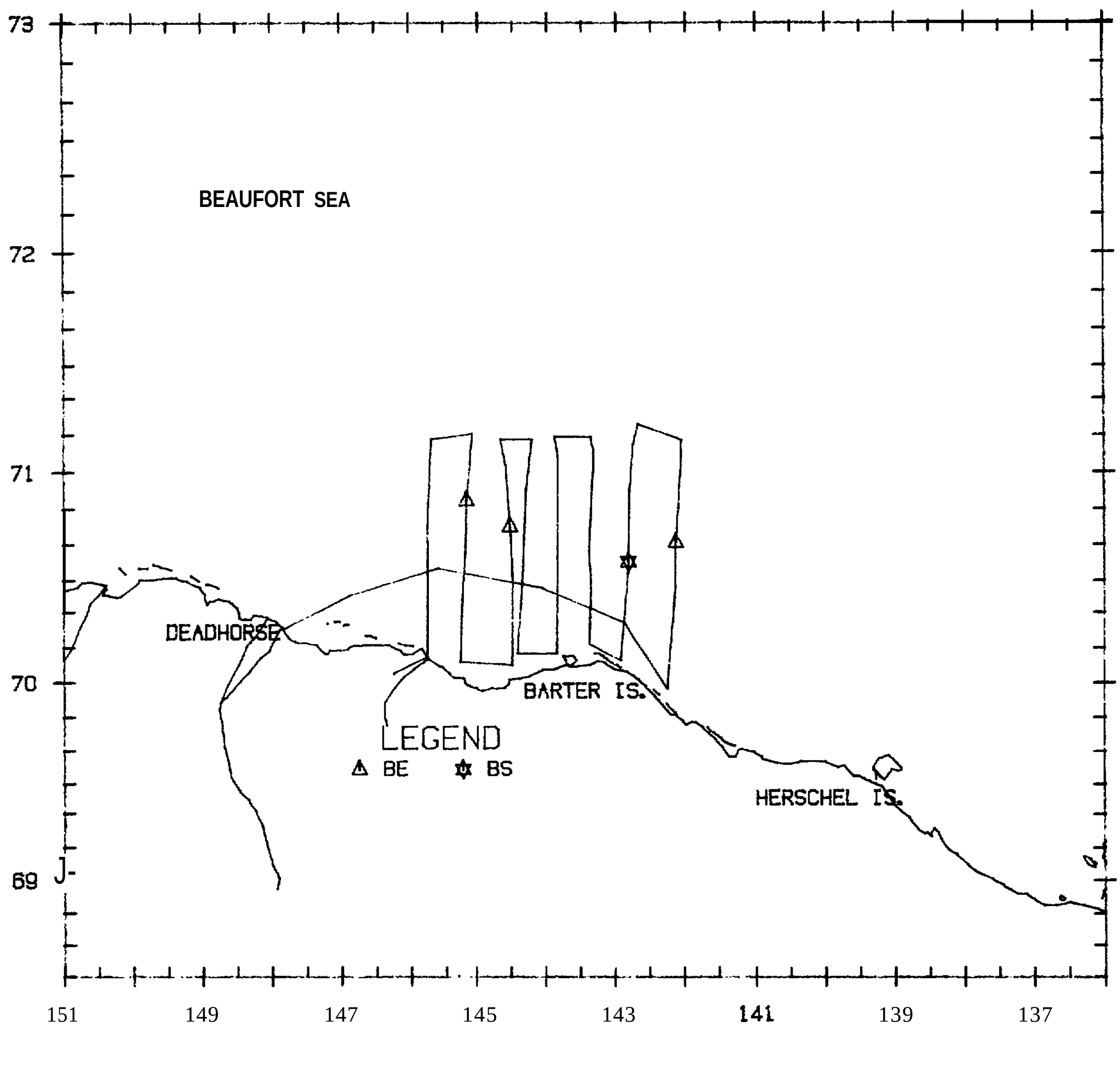
Flight 40: 18 September 1985

Flight was a transect survey of blocks 4 and 6 and the western one-third of blocks 5 and 7. Weather varied from partly cloudy near-shore, to low overcast at the northern extreme of blocks 6 and 7. Visibility ranged from 5 km to unlimited. Ice coverage was 2 to 90 percent in blocks 4 and 5, and 50 to 95 percent in blocks 6 and 7. Sea state was Beaufort 00 to 01. Belukha whales and a bearded seal were seen.



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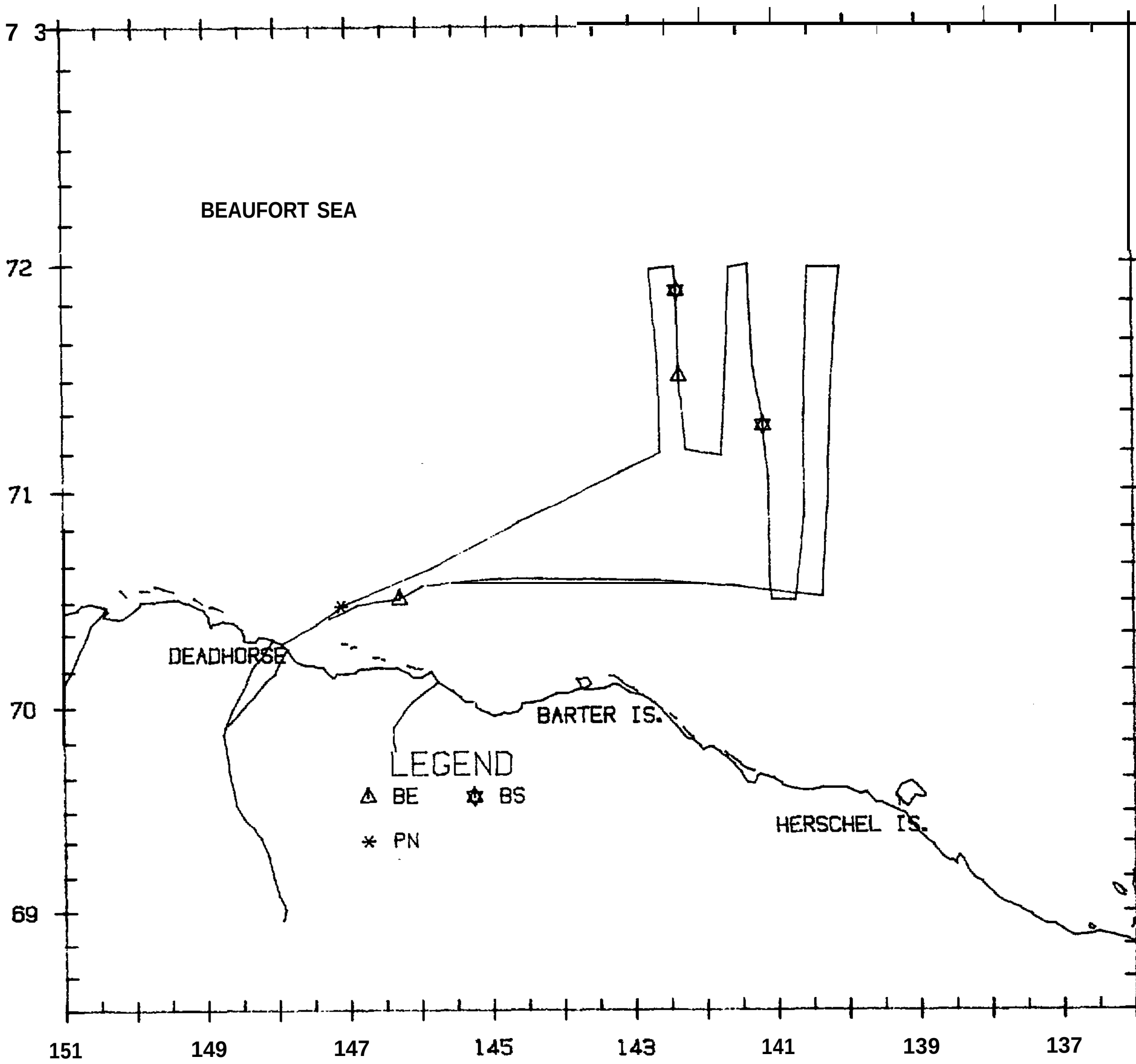
Flight 41: 19 September 1985

Flight was a transect survey of block 8 and the eastern one-half of block 7. Weather was overcast with 5 km to unlimited visibility. Ice coverage ranged from 75 to 95 percent in block 8, and from 5 to 70 percent in block 7. Sea state was Beaufort 00 to 02. Belukha whales, a bearded seal and an unidentified pinniped were seen.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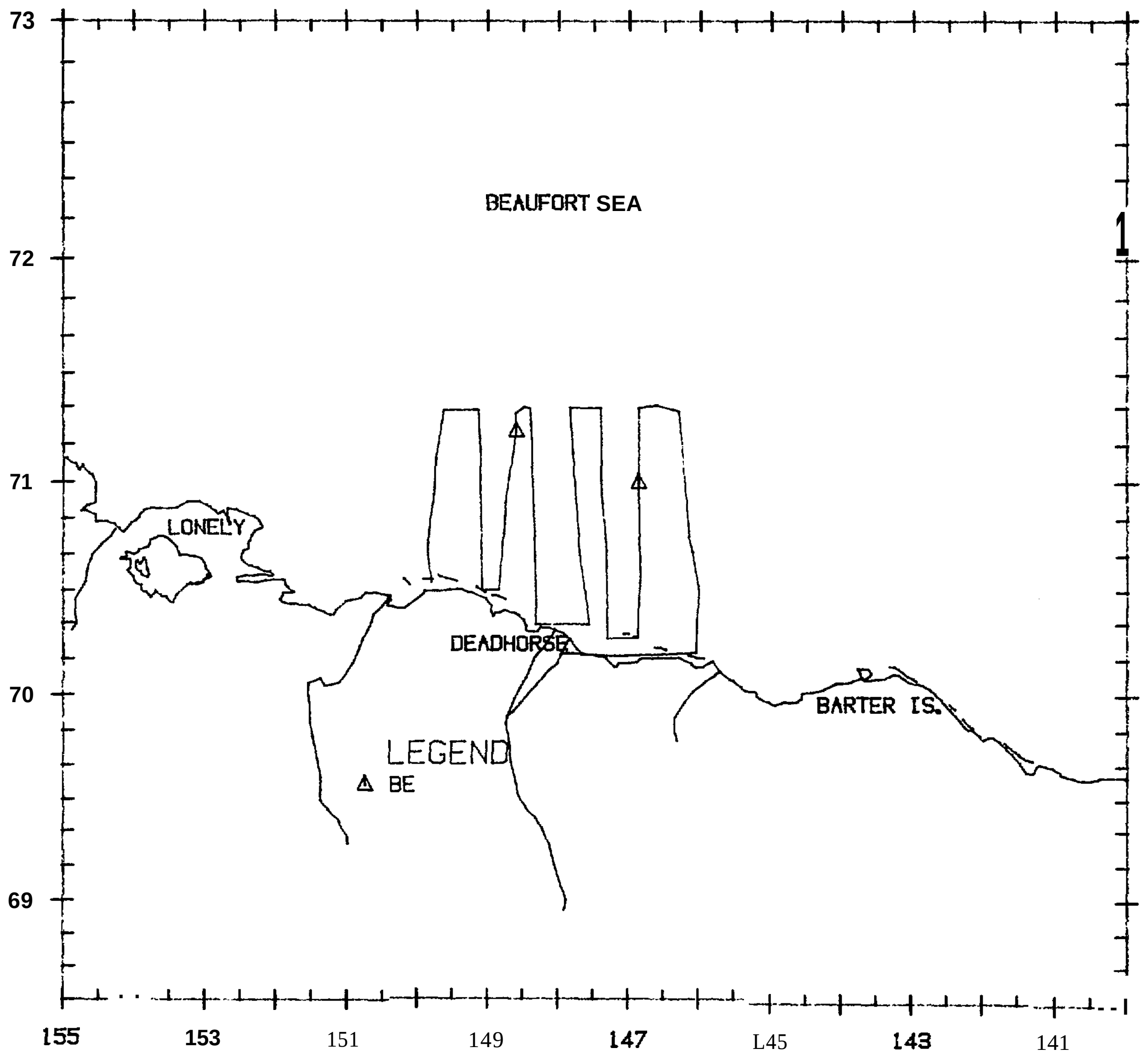
Flight 42: 20 September 1985

Flight was a transect survey of blocks 1 and 2. Weather was low overcast with patches of fog. Visibility ranged from 10km to unacceptable. Ice coverage was O to 75 percent in block 1, and 50 to 80 percent in block 2. Sea state was Beaufort 01 to 05. Belukha whales were the only marine mammals seen.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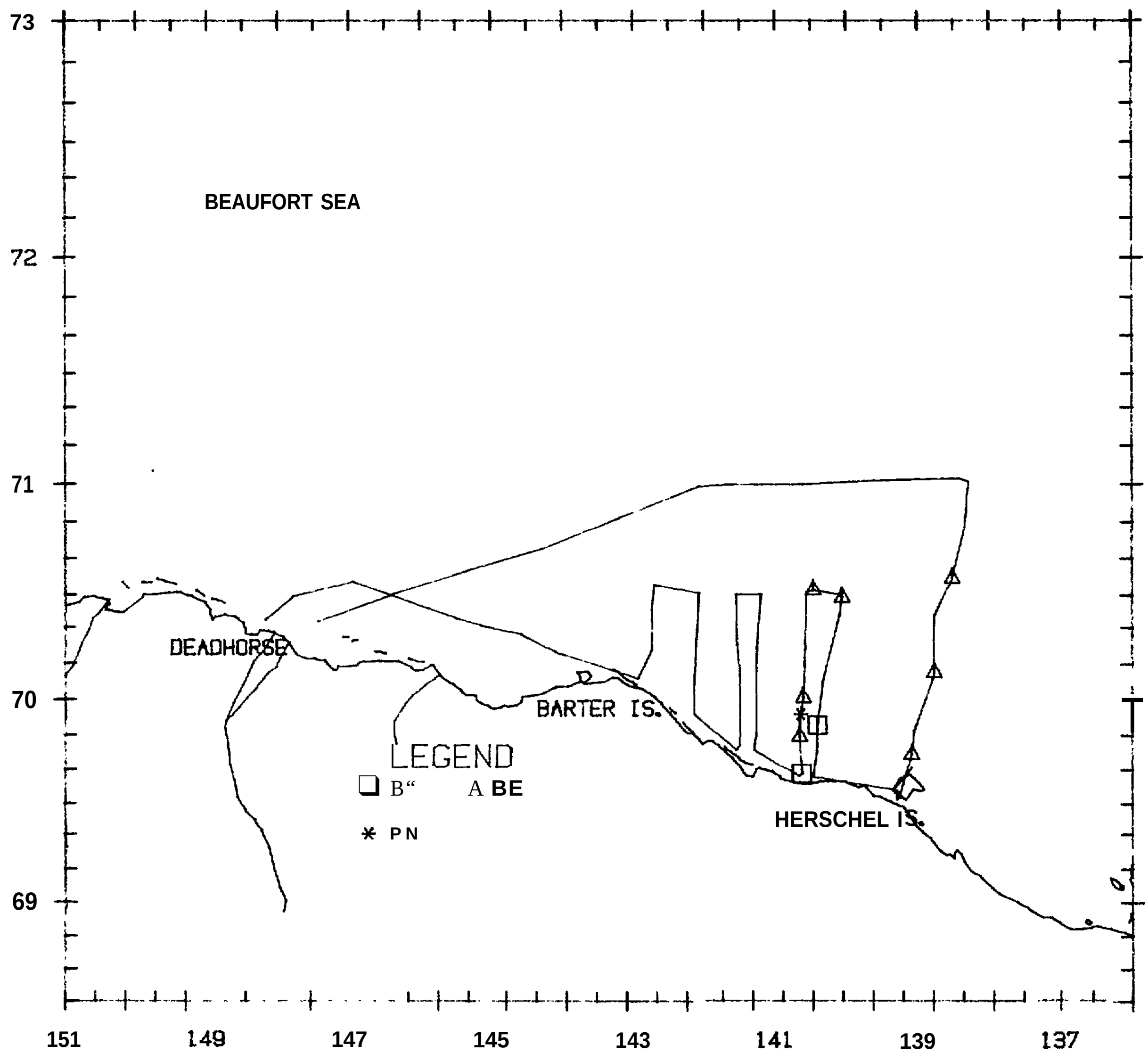
Flight 43: 22 September 1985

Flight was a search survey through block 4, a transect survey of block 5, and a search survey around and north of Herschel Island, then west through block 7. Weather was partly cloudy with some overcast and patchy fog. Visibility was 5 km to unlimited, and sea state was Beaufort 00 to 02. Ice coverage was 5 to 90 percent in blocks 4 and 5, and 40 to 75 percent in block 7. Two bowheads were seen in block 5. Belukha whales and an unidentified pinniped were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	69°39,0'	140°38.0'	761	BO	SW	260	5	BO	7
1/0	69°53.1'	140025.4'	685	BO	SW	270	10	B0	31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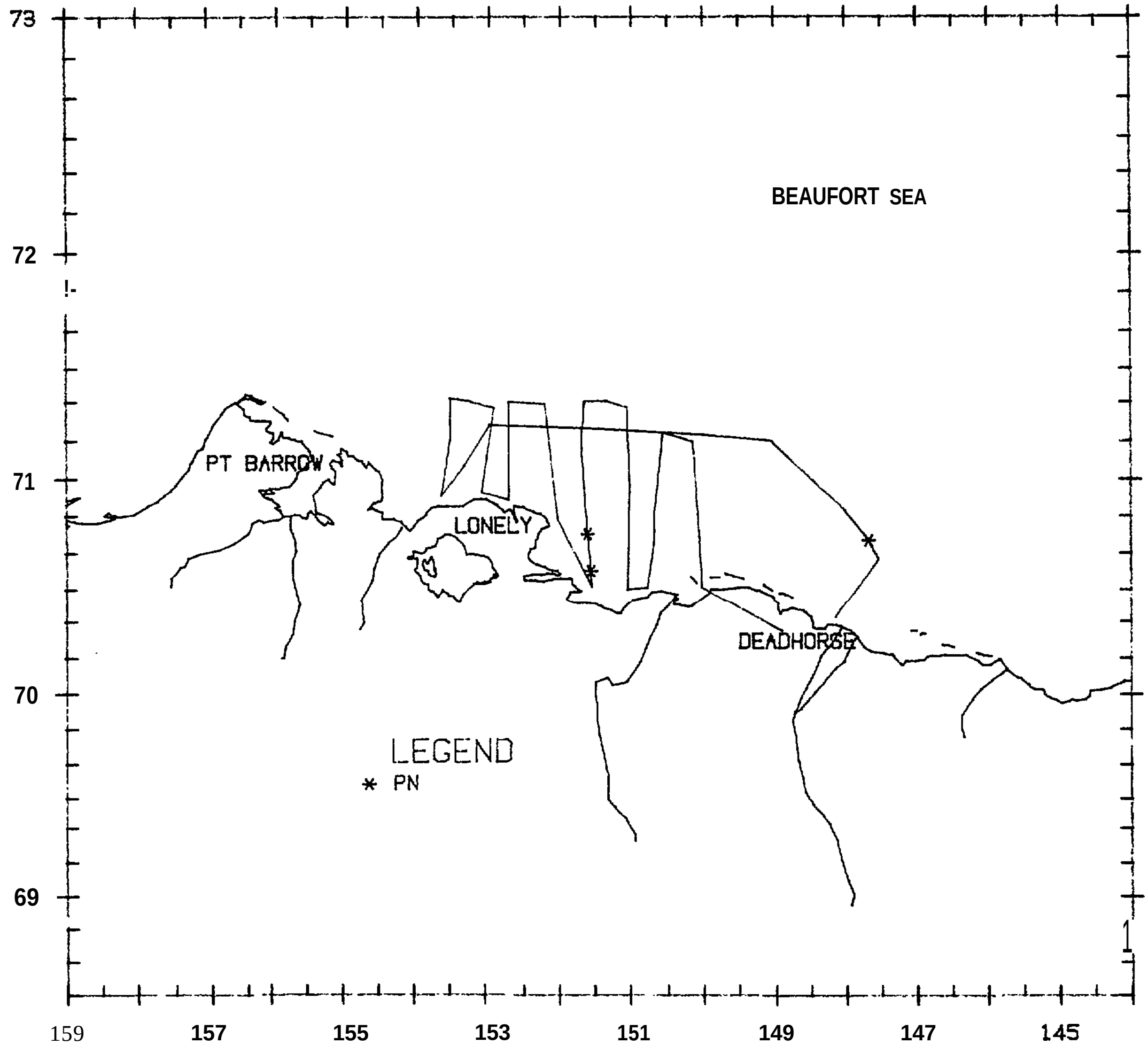
Flight 44: 23 September 1985

Flight was a transect survey of block 3, and a search survey through blocks 1 and 2. Weather was partly cloudy with patches of dense fog that caused the westernmost transect lines to be truncated. Visibility was generally 5 km to unlimited, with localized areas of less than 1 km to unacceptable. Ice coverage was O to 5 percent, and sea state was Beaufort 00 to 04. Unidentified pinnipeds were seen.



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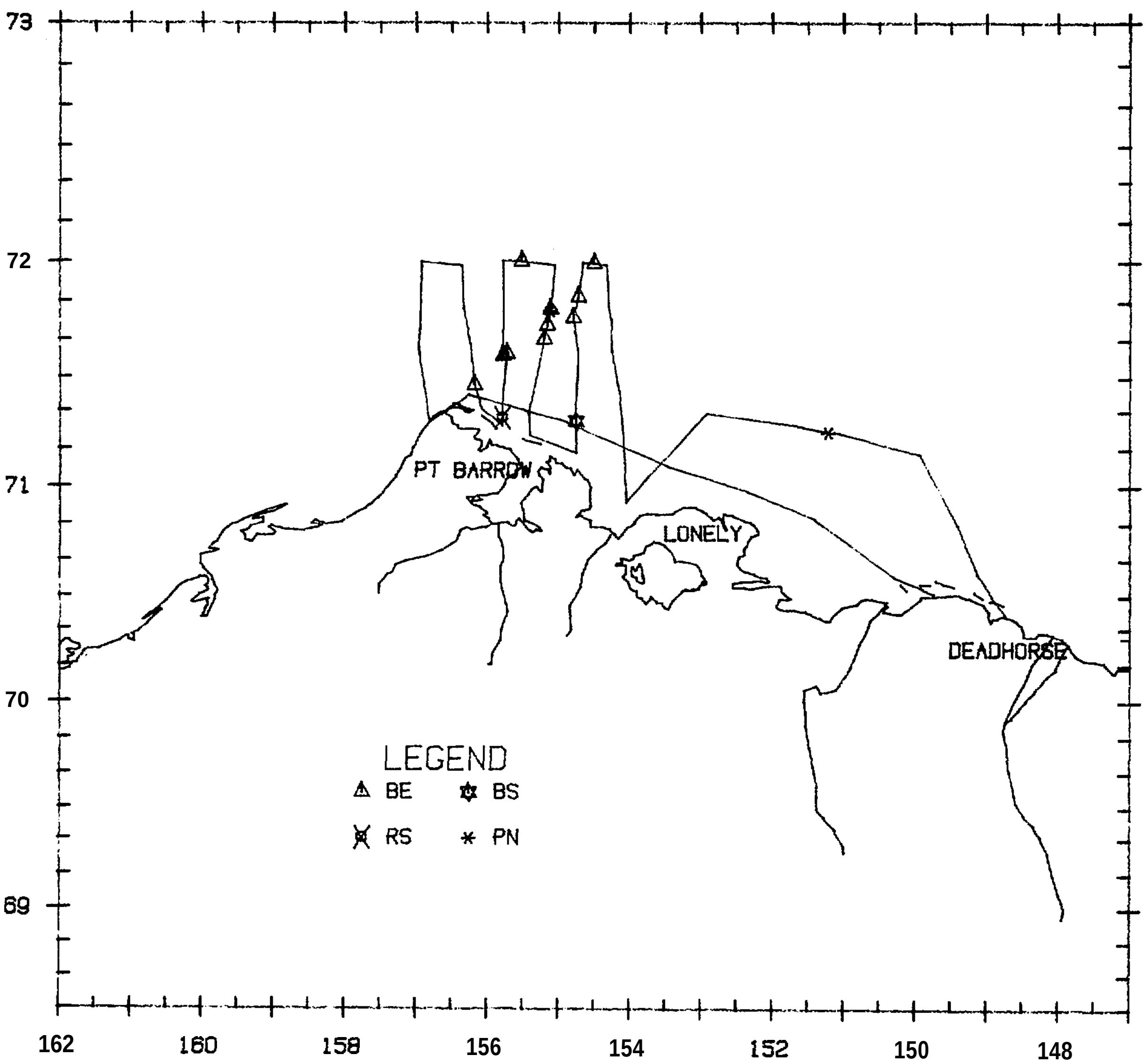
Flight 45: 24 September 1985

Flight was a transect survey of block 12, and a search survey of block 3 and the southwest corner of block 11. Weather ranged from clear to low overcast with patches of fog. Visibility was generally 5km to unlimited, with some areas of less than 1 km. Sea state was Beaufort 00 to 02. Ice coverage was O to 95 percent in block 12, 5 to 25 percent in block 11, and O to 20 percent in block 3. Belukha whales, a bearded seal, a ringed seal, and unidentified pinnipeds were seen.



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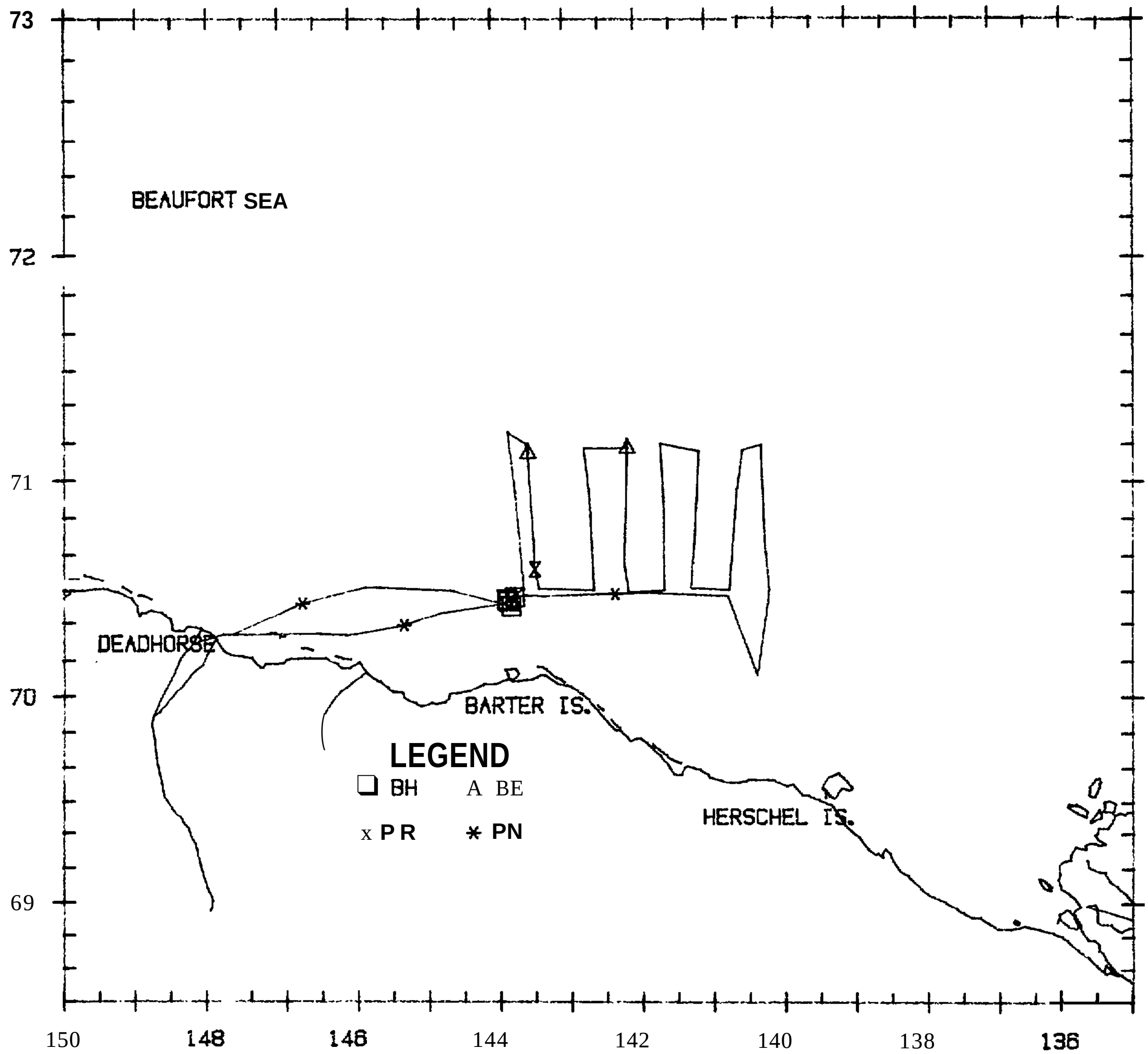
Flight 46: 25 September 1985

Flight was a transect survey of the eastern one-third of block 6, block 7, and a search survey through blocks 4 and 5. Weather ranged from clear to low overcast and fog, with resultant visibility of 3 km to unlimited. Ice coverage was 5 to 90 percent in block 4, and 40 to 90 percent in blocks 5, 6 and 7. Sea state was Beaufort 00 to 02. Seven bowheads were seen in block 4. Belukha whales, a polar bear and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
2/0	70°26.1'	143045.2’	--	BO	DI	90	90	B1	40
1/0	70°26.6'	143046.6’	--	BO	RE	270	90	B1	40
1/0	70°26.5'	143046.2’	--	BO	RE	120	90	B1	40
2/0	70°27.2'	143039.8’	781	BO	SW	270	40	B1	37
1/0	70°24.8'	143043.0’	--	BO	SW	300	35	B1	40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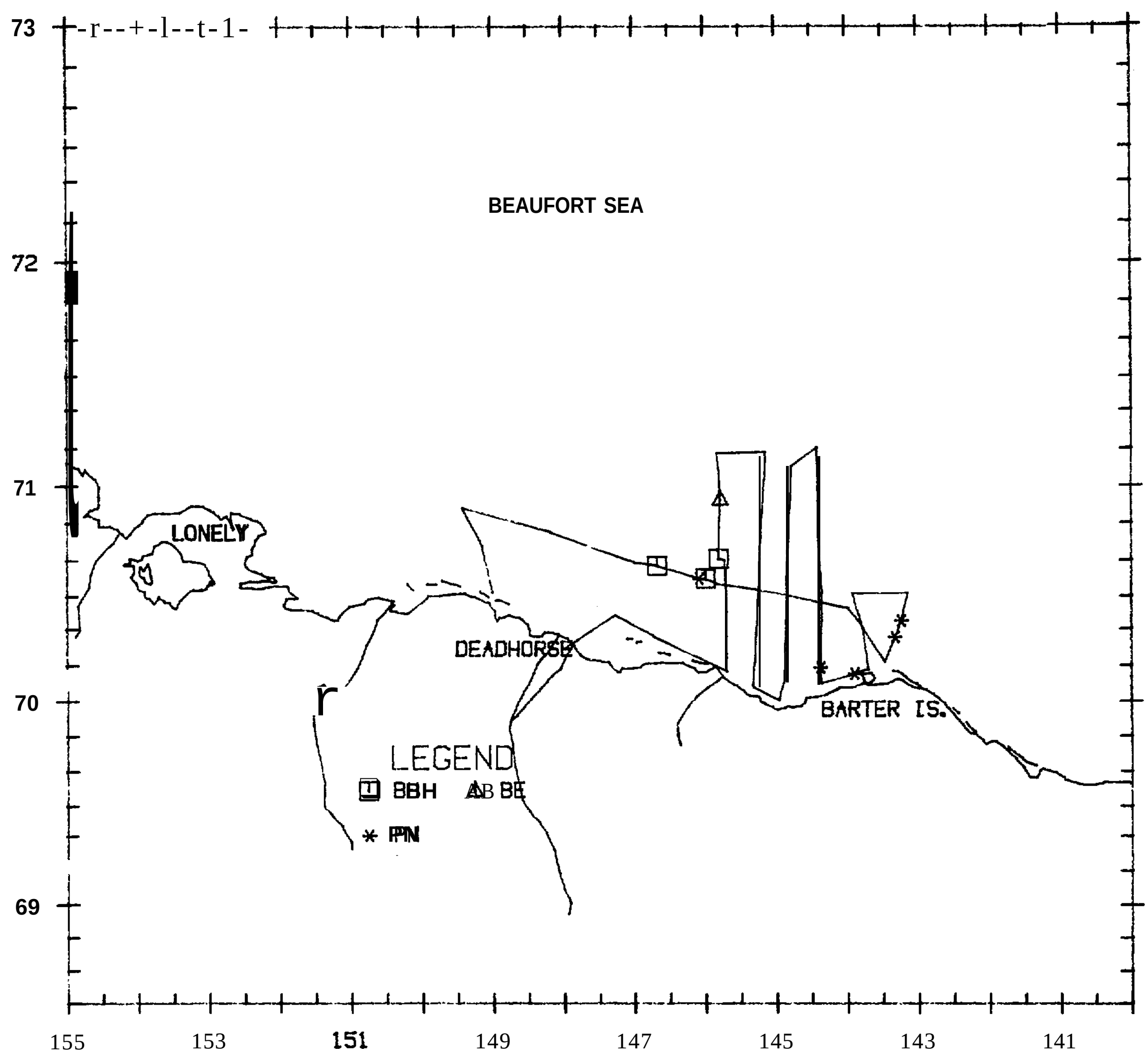
Flight 47: 26 September 1985

Flight was a transect survey of the western two-thirdsof block 6, block 4, anda search survey through block 2. Weather was clear and visibility unlimited. Ice ranged from 5 to 90 percent in block 4, from 40 to 95 percent in block 6 and from 0t05 percent in block 2. Sea state was Beaufort OOto 02. Four towheads, belukhas andunidentified pinnipeds were seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
2/0	70040.5'	145048.0'	1072	BW	SW	240	0	B1	57
1/0	70035.1'	145059.2'	255	BO	SW	30	0	B1	48
1/0	70038.6'	146040.3'	238	SP	Sw	240	0	B2	31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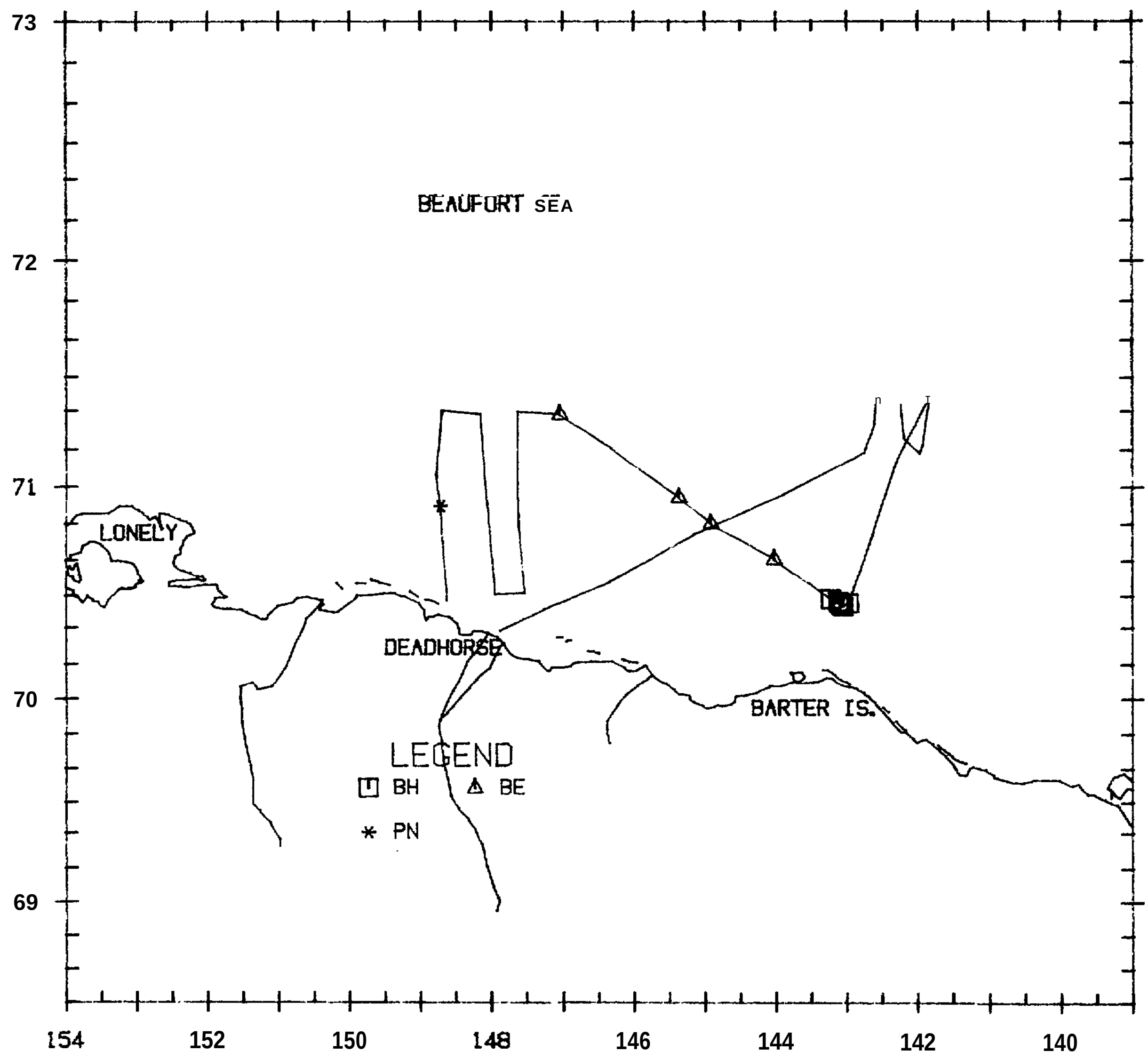
Flight 48: 27 September 1985

Flight was a search survey in blocks 4 and 5 followed by a transect survey in the eastern one-half of blocks 1 and 2, after a transect survey in block 8 was aborted due to fog. Weather was partly cloudy with areas of low fog, and visibility ranged from unlimited to unacceptable. Ice coverage was O to 80 percent in blocks 1, 2,and 4; 30 percent in block 5; and 85 to 90 percent in block 8. Sea state ranged from Beaufort 00 to 03. Nineteen bowheads, including three calves, were seen north of Barter Island. Belukha whales and an unidentified pinniped were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
3/0	70°26.7'	142058.9'	--	BO	RE	180	30	B1	46
3/0	70°26.1'	143005.0'	792	00	ML	330	30	B1	37
2/1	70°26.7'	143006.6'	--	BO	SW	330	30	B1	37
3/1	70°27.1'	143007.7'	--	BO	CC	340	30	B1	37
2/0	70026.57	143°04.8'	--	BO	SW	180	30	B1	37
1/0	70°25.9'	143'303.5'	--	BO	SW	240	30	B1	37
5/1	70°27.8'	143014.0'	981	BO	SW	210	30	B1	37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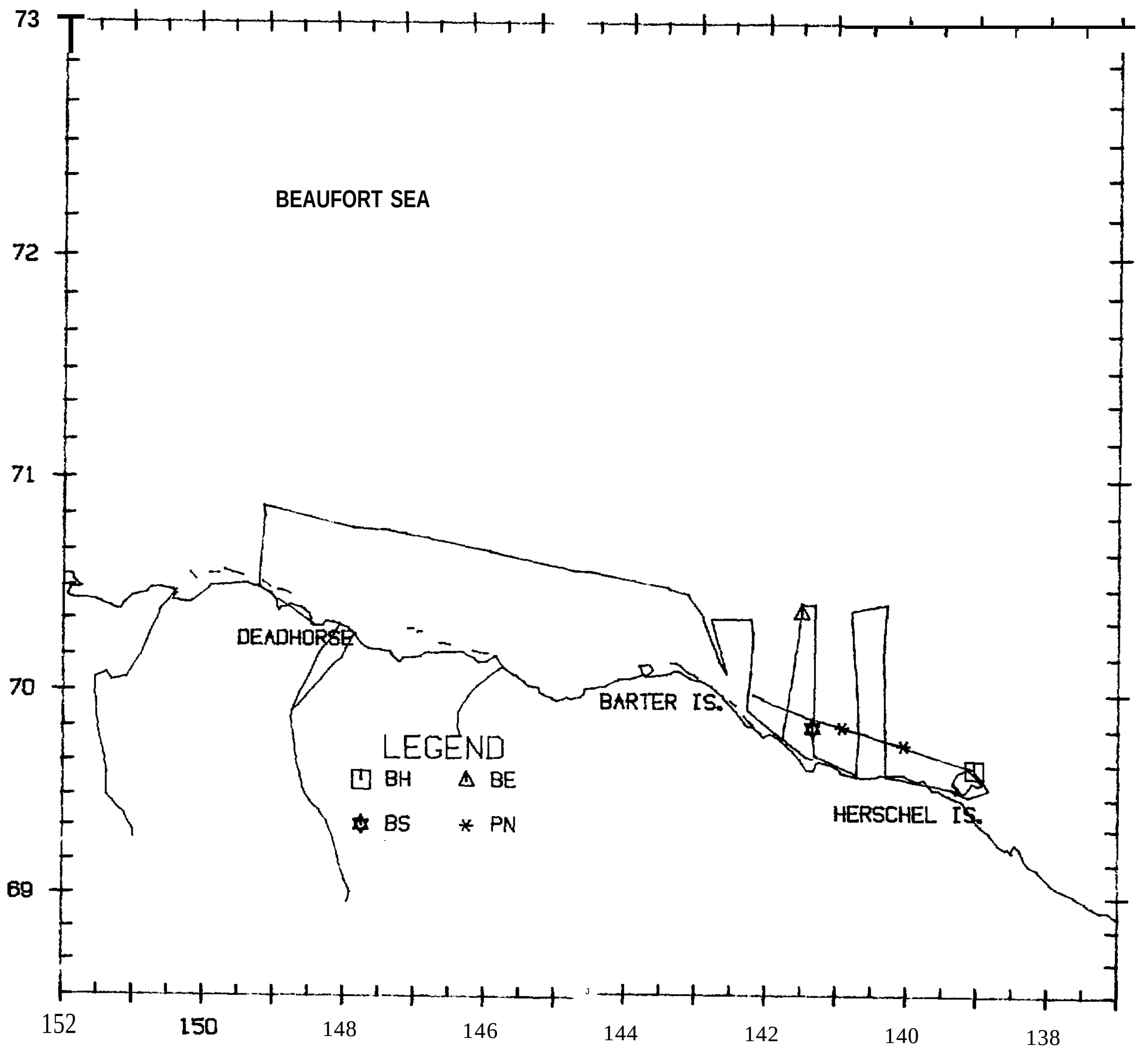
Flight 49: 29 September 1985

Flight was transect survey in block 5 and a search survey to Herschel Island after transect surveys in blocks 1 and 4 were canceled due to heavy low fog. Weather was partly cloudy over most of block 5, with low fog at the northern boundary that caused transect lines to be somewhat truncated. Visibility ranged from 10 km to unacceptable. Ice coverage was 5 to 95 percent, and sea state was Beaufort 00. One bowhead was seen just north of Herschel Island. A belukha whale, a bearded seal, and unidentified pinnipeds were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	69038.5'	139001.4'	898	BW	SW	60	2	B1	16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BARTER IS.
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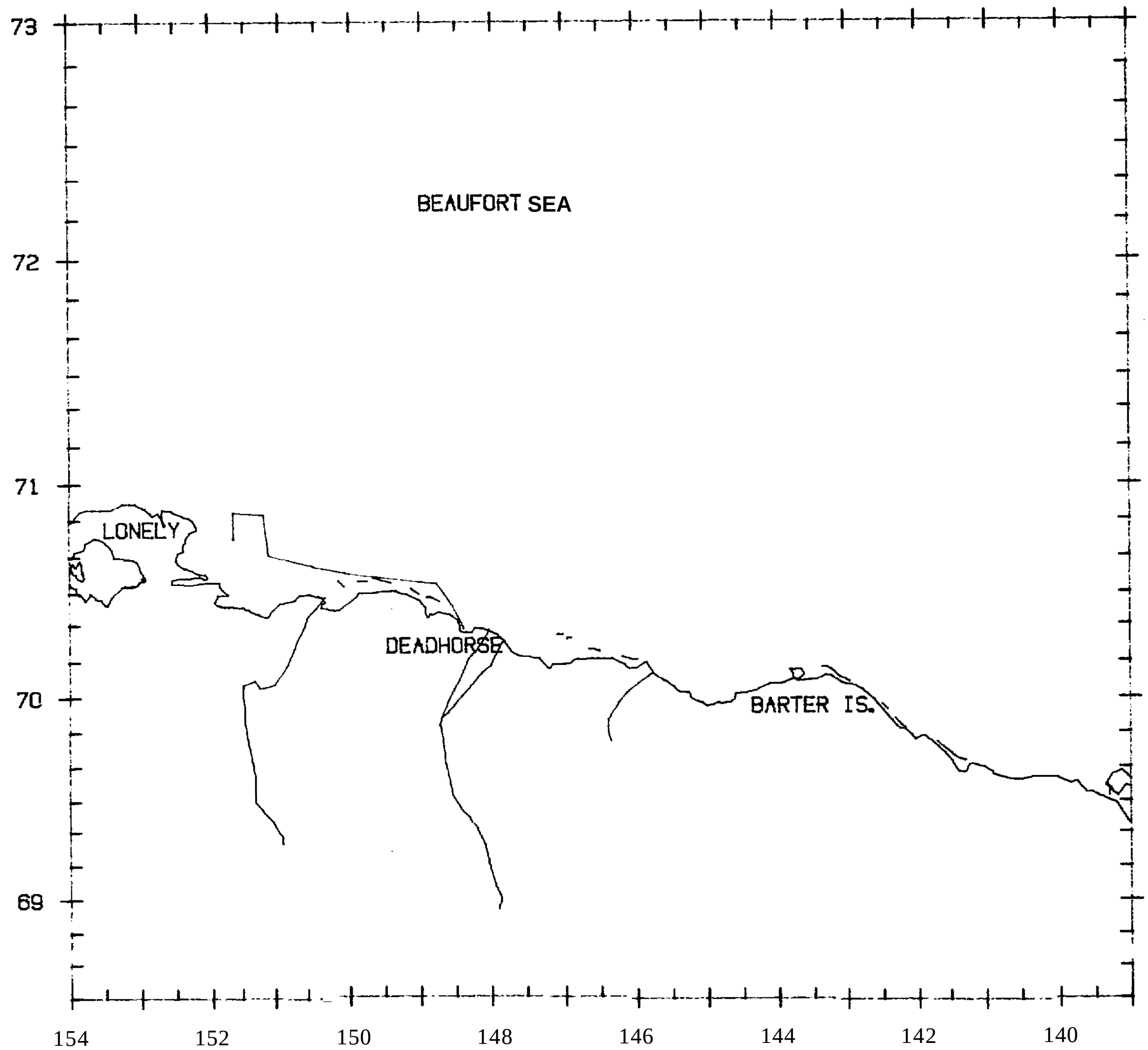
Flight **50: 30** September 1985

Flight was a short search survey in block 1 after a transect survey in block 3 was canceled due to fog and icing conditions. Weather was low overcast with fog and visibility ranged from 3 km to unacceptable. Ice coverage was O to 85 percent and sea state was Beaufort 01 to 02. No marine mammals were seen.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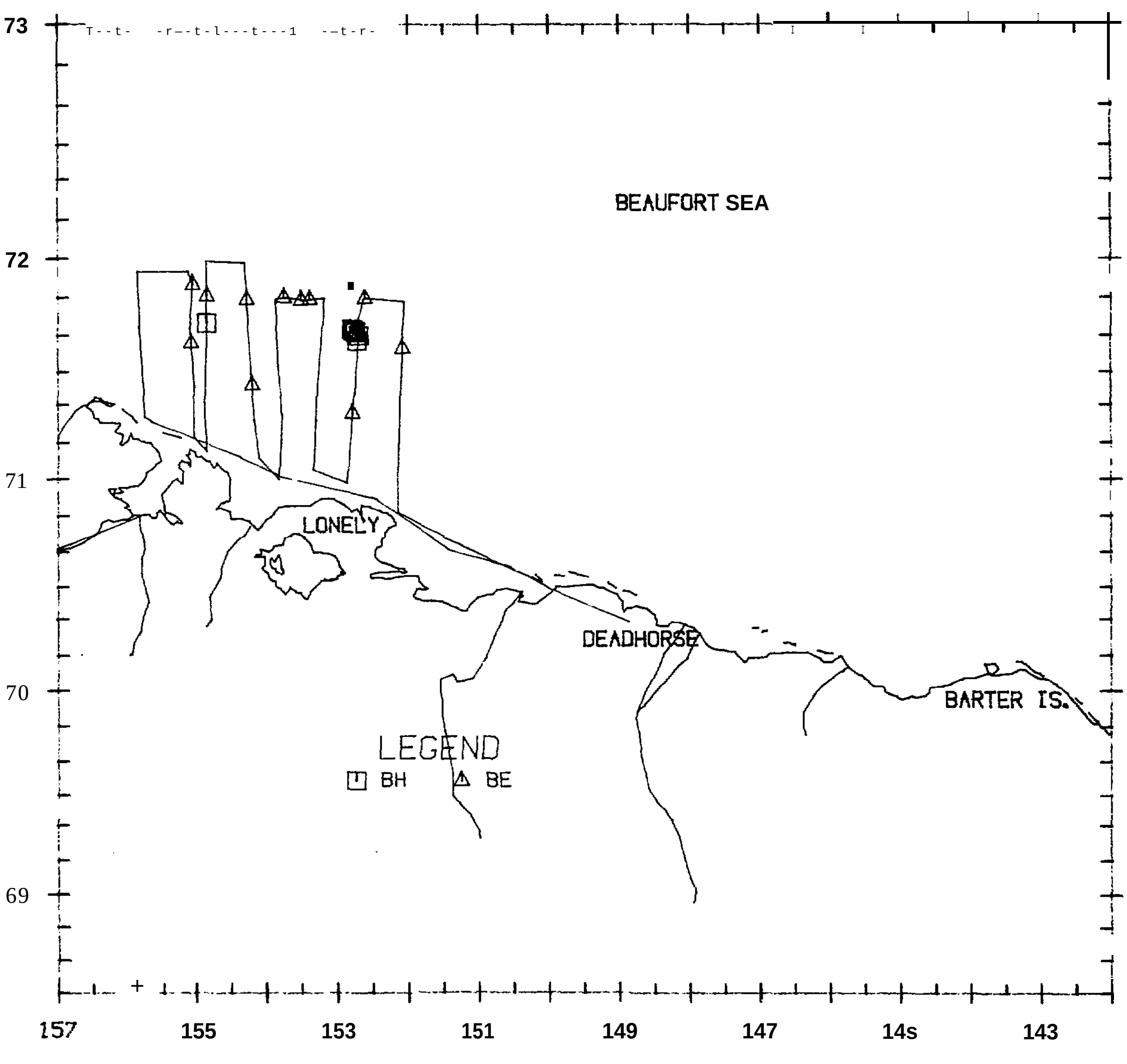
Flight 51: **1 October** 1985

Flight was a transect survey of the eastern two-thirds of block 12 and the western one-half of blocks 3 and 11. Weather varied from low overcast to partly cloudy resulting in visibility that ranged from 1 to 10 km. Ice coverage was O to 95 percent in block 12, 0 to 10 percent in block 3, and 40 to 90 percent in block 11. Sea state was Beaufort 01 to 03. Nine bowheads were seen; eight of them northeast of Lonely. Belukha whales were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°43.3'	154052.4’	853	BO	RE	240	10	B2	73
2/0	71°39.8'	152042.4’	707	BO	SW	240	75	B1	46
1/0	71°38.4'	152044.2’	--	BO	SW	240	75	B1	46
2/0	71°40.7'	152045.6’	618	BO	RE	150/330	75	B1	177
1/0	71°40.9'	152°45.5’	--	BO	RE	210	75	B1	177
1/0	71°41.2'	152°47.5’	--	BO	SW	280	75	B1	177
1/0	71°41.6'	152°48.7’	--	BO	SW	240	75	B1	177



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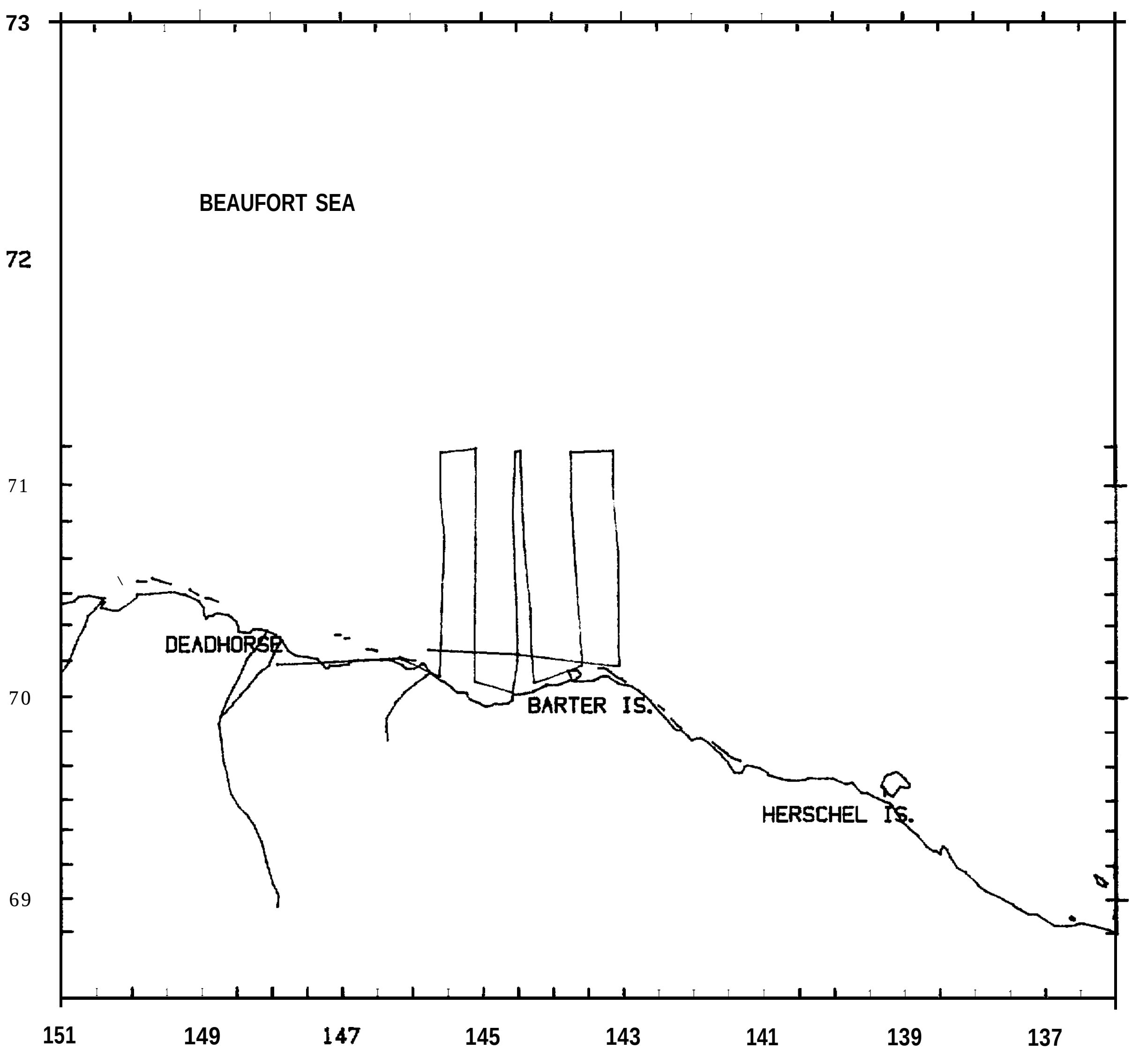
Flight **52:** 3 October 1985

Flight was a transect survey of blocks 4 and 6. Weather was overcast with low ceilings and visibility varied from 3 to 10 km. Ice coverage was 10 to 99 percent broken floe and new grease ice and sea state was Beaufort 00 to 02. No marine mam reals were seen.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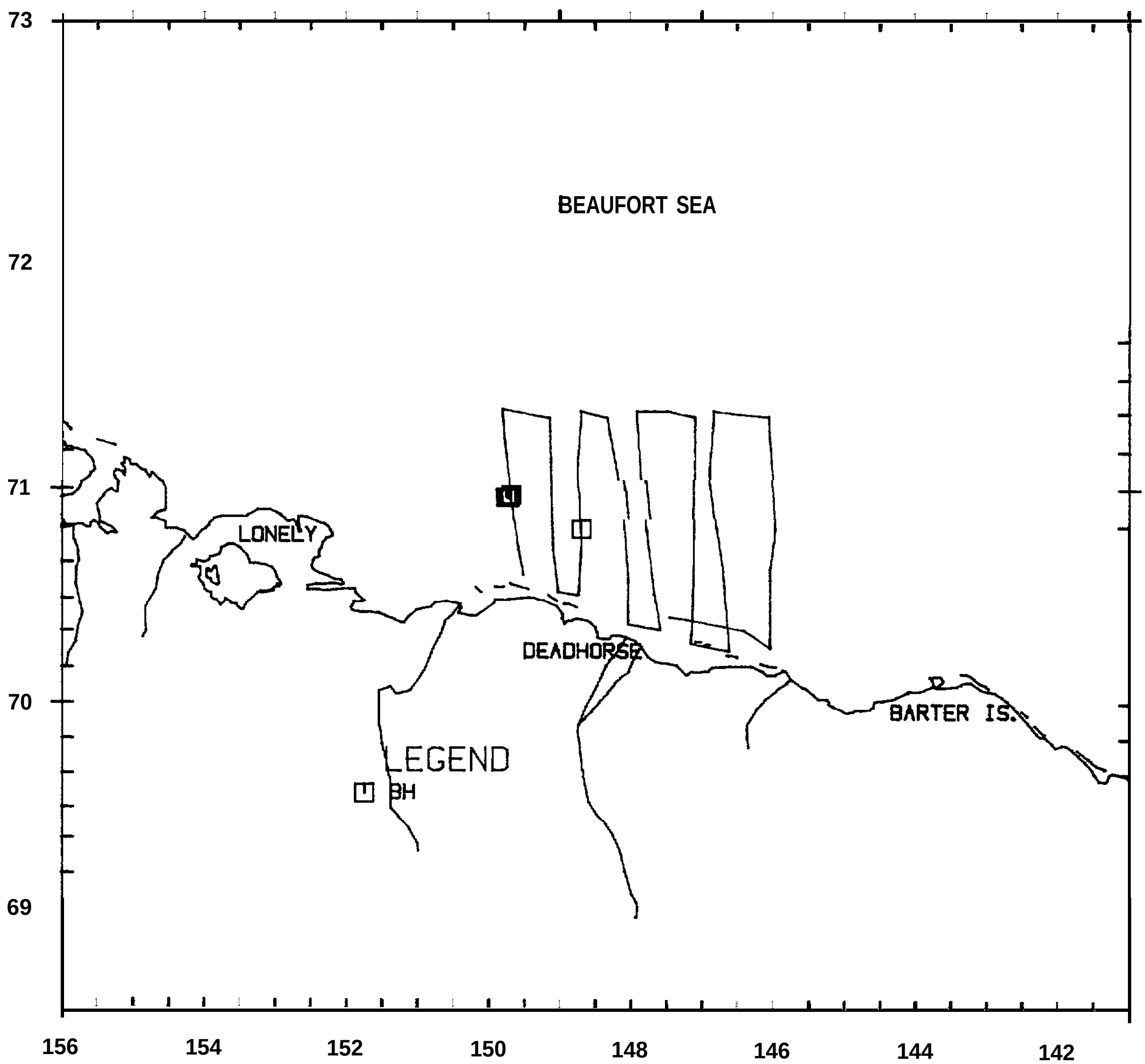
Flight 53: 5 October 1985

Flight was a transect survey of blocks 1 and 2. Weather was clear with unlimited visibility. Ice coverage was 10 to 99 percent broken floe and new grease ice. Sea state was Beaufort 00 to 01. Five bowheads were seen including two that were breaching.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70049.4’	148042.2’	678	BO	SW	240	20	B1	20
1/0	70058.6’	149041.4’	--	BO	BR	240	5	62	20
2/0	70057*91	149043.2'	--	BO	S W	240	5	B2	20
1/0	70057.9'	149045.7’	--	SP	BR	240	5	B2	20


BEAUFORT SEA
LONELY
DEADHORSE
BARTER IS.
LEGEND
BH
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156
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148
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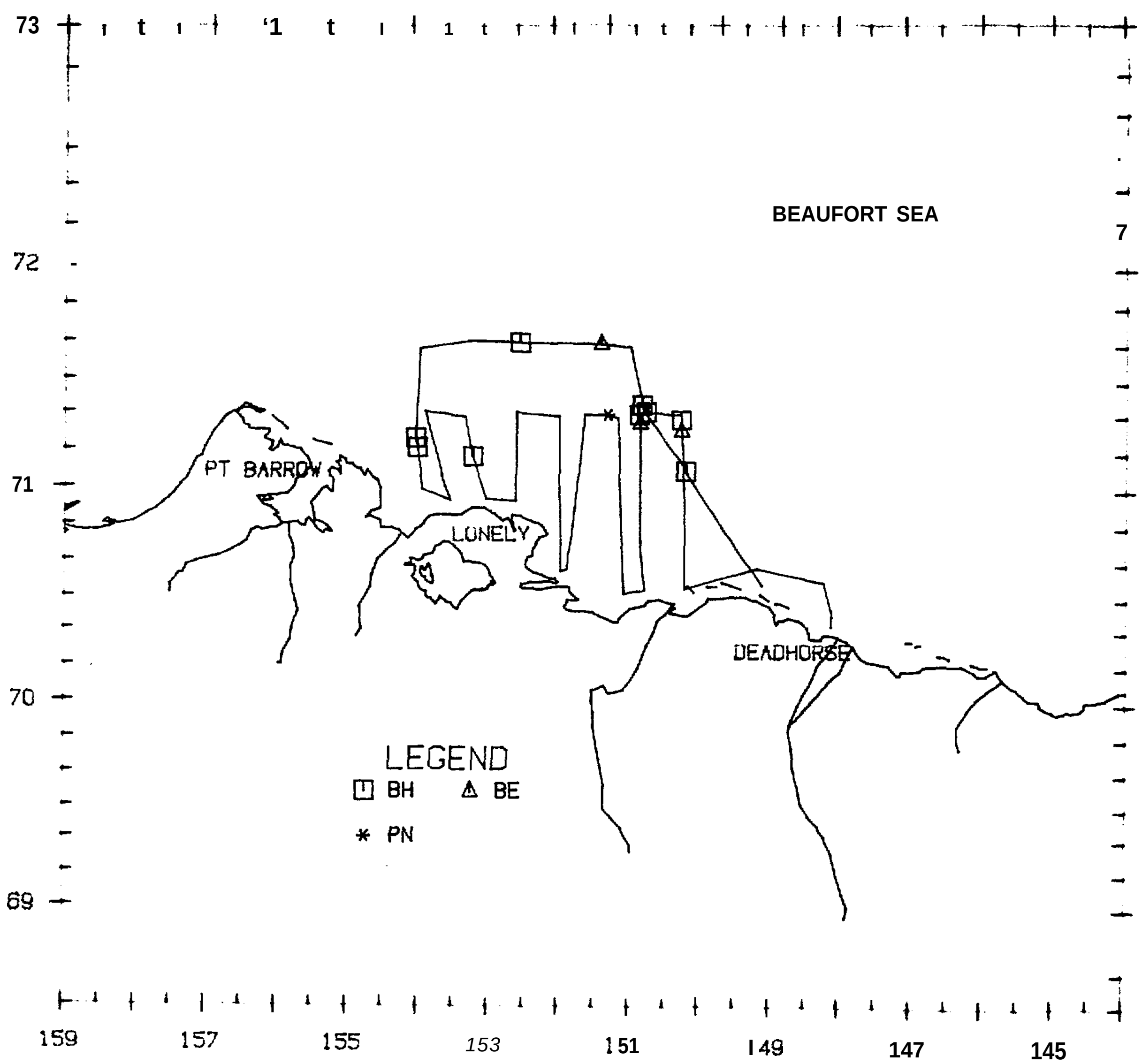
144
142

Flight 54: 6 October 1985

Flight was a transect survey of block 3 and a search survey through block 11. Weather was clear to overcast and visibility was unlimited. Ice coverage in the eastern half of the block was 50 to 99 percent and O to 5 percent in the western half. Sea state was Beaufort 00 to 02. Twenty-six bowheads were seen. One group of eighteen, including three calves, were milling and possibly feeding. Belukhas and one unidentified pinniped were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°18.5'	150017.5’	655	BO	SW	340	70	B1	225
18/3	71°20.5'	150047,4’	--	BO	FE	--	80	B1	595
2/0	71°19.8'	150053.2’	--	BO	SW	240	80	B1	42
1/0	71°08.4'	153014.7’	474	BO	SW	240	0	B2	7
1/0	71°10.7'	15400.16’	--	SP	SL	240	0	B2	9
1/0	71°13.2'	154003.0’	--	DY	SL	--	0	B2	9
1/0	71°40.0'	152034.4’	1132	BO	SW	240	80	B1	373
1/0	71 °04.9'	150013.7’	509	BO	SW	300	85	B1	16


73
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BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
LEGEND
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159
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147
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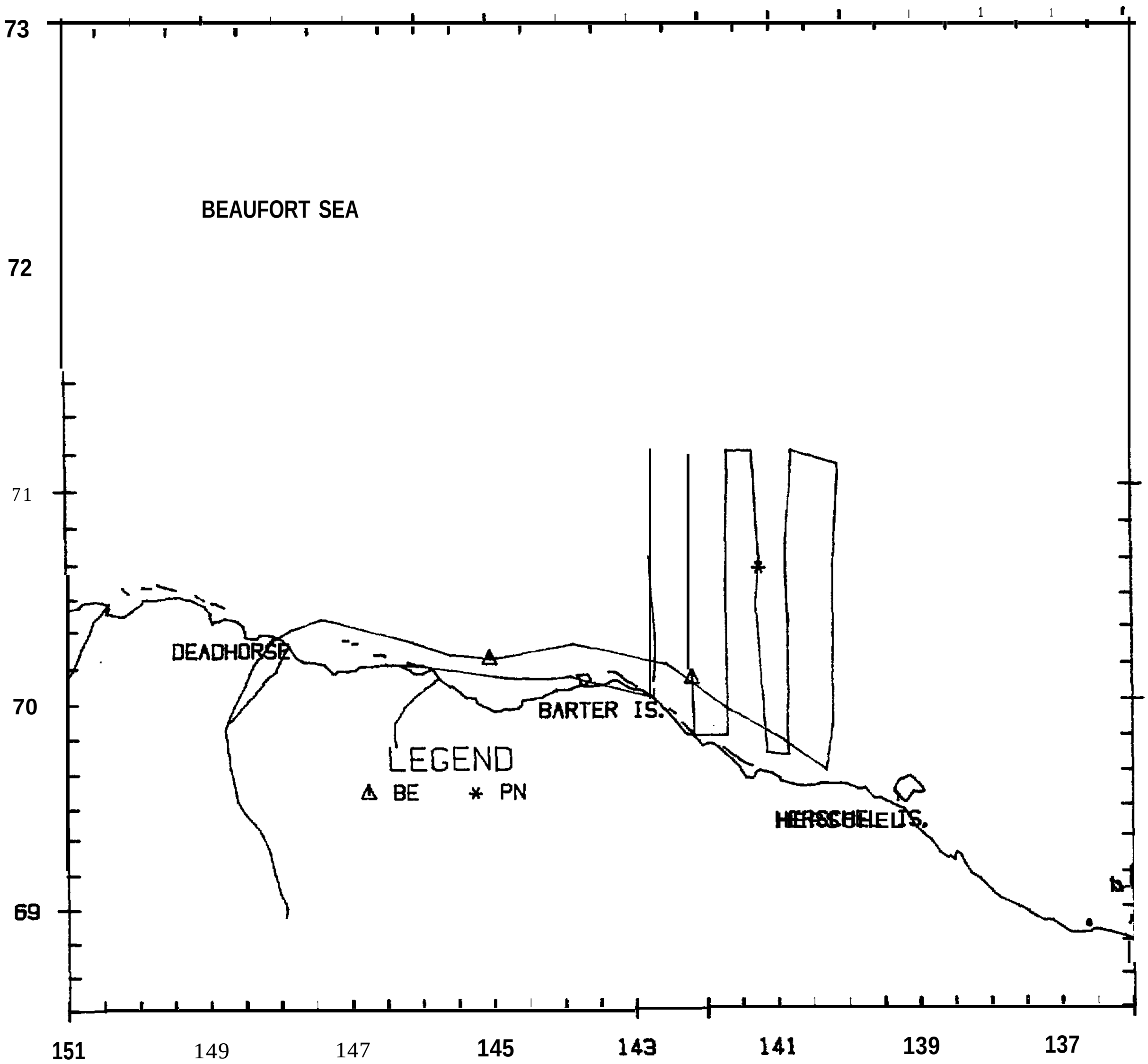
Flight 55: 7 October 1985

Flight was a transect survey of blocks 5 and 7. Weather was overcast with unlimited visibility. Ice coverage in block 5 was 0 to 50 percent with sea state Beauf ort 01. Ice coverage in block 7 was 50 to 95 percent with sea state Beau fort 00 to 01. Belukhas and an unidentified pinniped were seen.



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BEAUFORT SEA
DEADHORSE
BARTER IS.
HERSCHEL IS.
LEGEND
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PN
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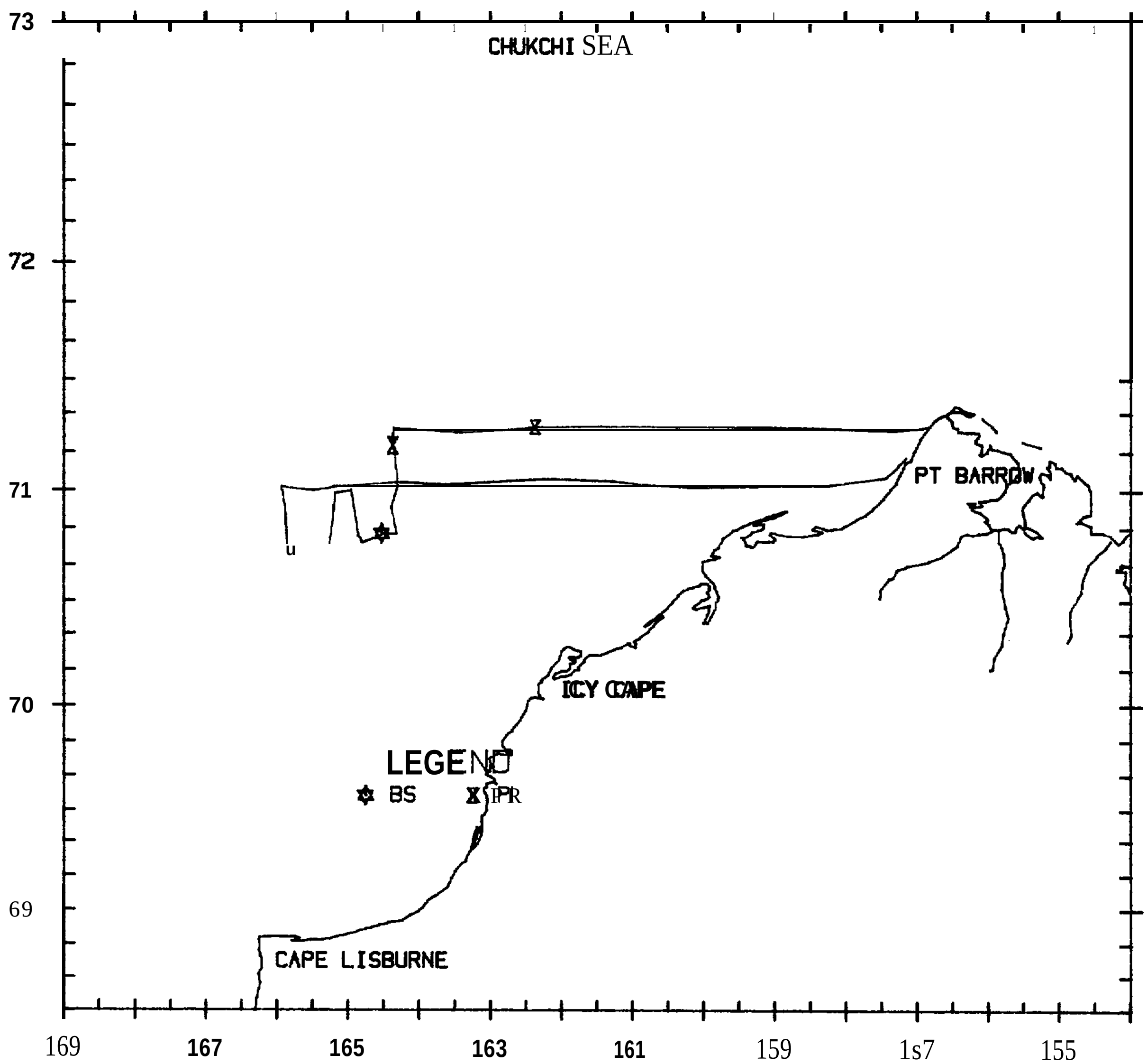
137

Flight **56:** 10 October 1985

Flight was a transect survey of block 18 that was aborted due to low ceilings and fog. Visibility was less than 1 km. Ice coverage *in* the entire area surveyed was variable from O to 99 percent and sea state ranged from Beaufort 00 to 04. One bearded seal and two polar bears were seen.


73
CHUKCHI SEA
72
71
70
69
PT BARROW
ICY CAPE
LEGEND
BS
PR
CAPE LISBURNE
169
167
165
163
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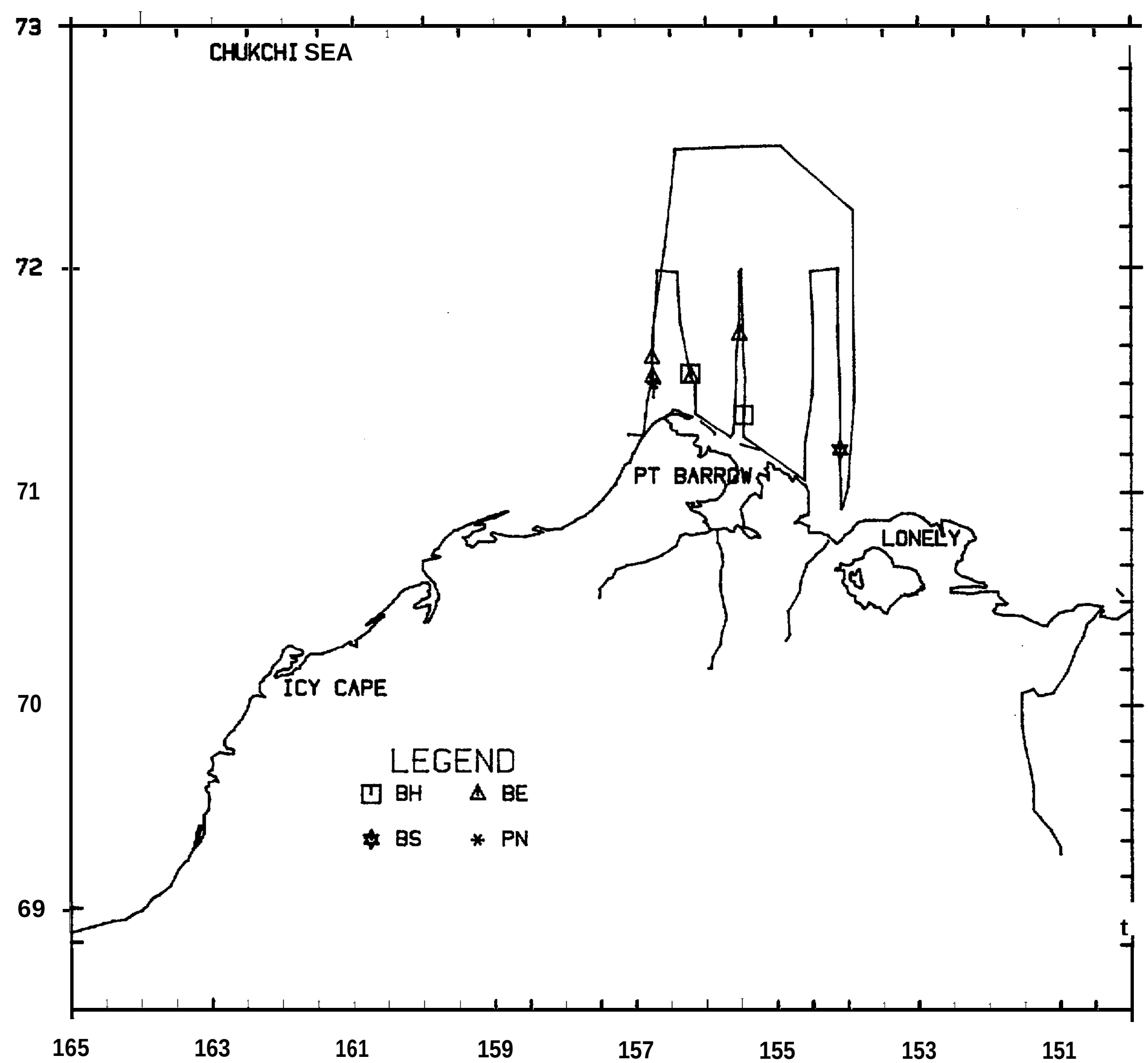
155

Flight 57: 11 October 1985

Flight was a transect survey of block 12 and a search survey north along 72°30'N. Weather was overcast with low ceilings and fog and visibility was 3 to 5 km. Ice coverage in southern half of the block was 10 to 55 percent and 75 to 99 percent in the northern half. Sea state was Beaufort 02 to 04. Two bowheads were seen. Belukhas, a bearded seal and an unidentified pinniped were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71032.8’	156013.2’	200	BO	SW	330	10	B3	7
1/0	71°20.6'	155027.9’	863	BO	MI	30	5	B3	9


73
72
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CHUKCHI SEA
PT BARROW
LONELY
ICY CAPE
LEGEND
BH
BE
BS
PN
165
163
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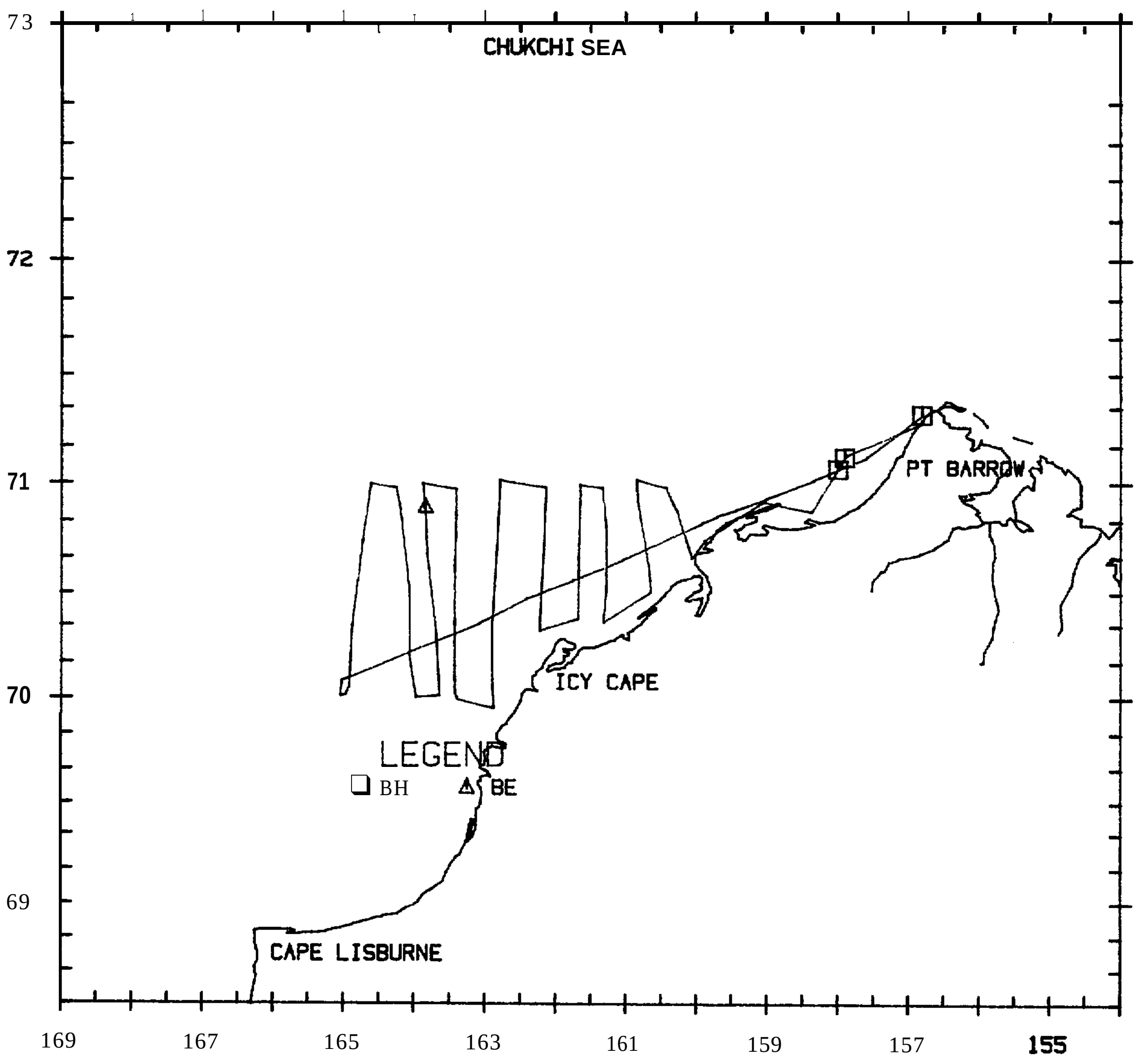
157
155
153
151

Flight 58: **12 October** 1985

Flight was transect survey of block 17andthe eastern one-half of block 18. Weather was overcast with intermittent *snow* squalls. Visibility varied from unacceptable to 10 km. Sea state was Beaufort 04 and there was no ice. Three bowheads and **belukhas** were seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°07.3'	157053.9’	--	BO	SW	060	0	B2	22
1/0	71°04.1'	157059.6’	249		BO DI	--	0	B2	27
1/0	71°18.5'	156°48.0'	--	SP	Sw	190	0	B3	18


73
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167
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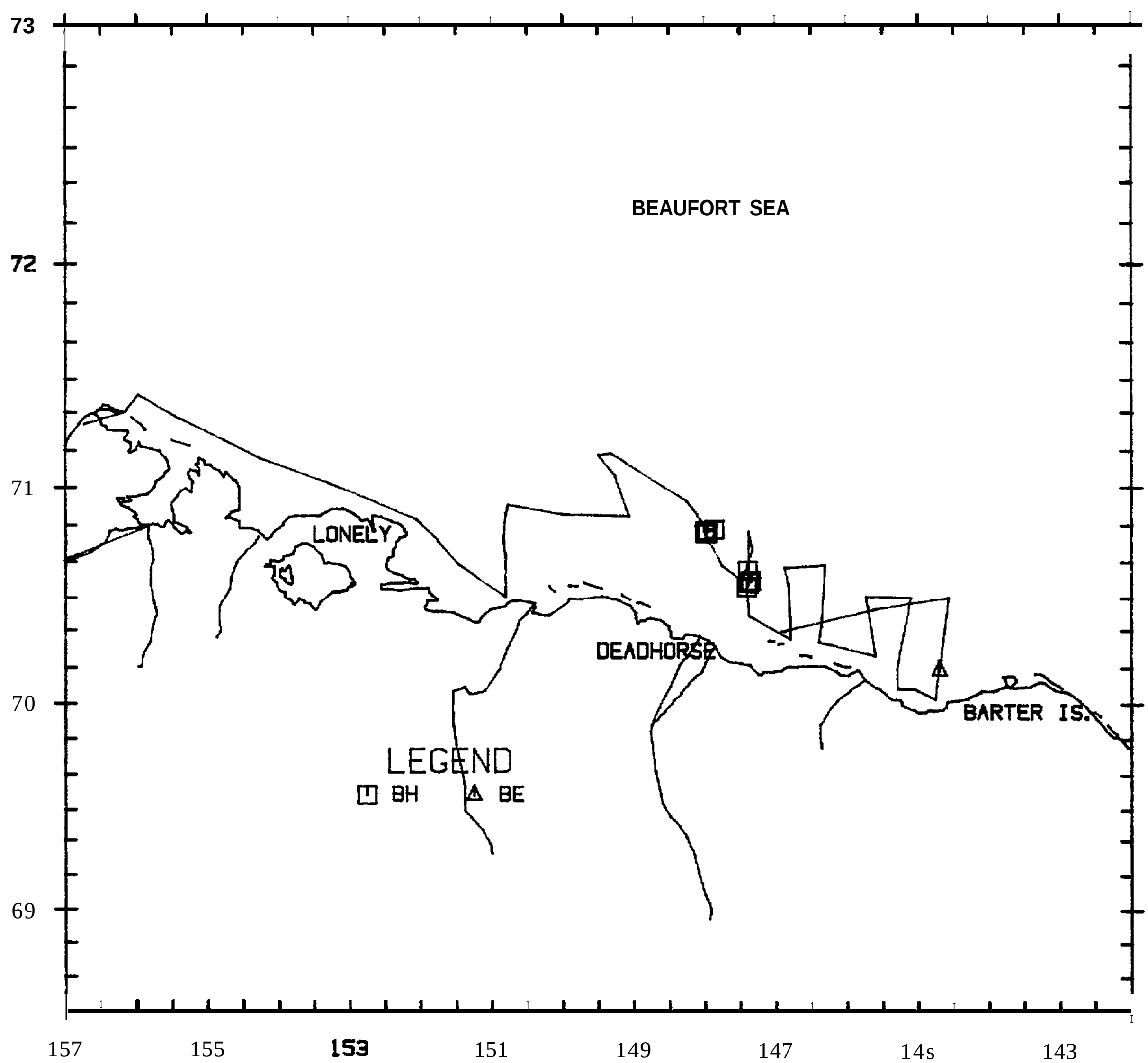
163
161
159
157
155
CHUKCHI SEA
PT BARROW
ICY CAPE
CAPE LISBURNE
LEGEND
BH
BE

Flight **59:** 13 October 1985

Flight was a transect survey of the eastern one-half of block 1 and western one-half of block 4. Weather in these areas was clear with unlimited visibility, although low-lying fog covered the rest of the Alaskan Beaufort Sea. Ice coverage was 90 to 99 percent and sea state varied from Beaufort 00 to 01. Thirteen bowheads were seen, mostly swimming slowly west. One belukha was also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	70°48.3'	147057.4’	--	BW	RE	340	99	BO	38
1/0	70°48.1'	147058.7’	--	BO	SW	210	99	BO	38
2/0	70°49.1'	147051.2’	--	BO	SW	210	95	B0	38
1/0	70°48.9'	147059.2’	--	BO	SW	250	95	B0	38
1/0	70°48.2'	147059.9’	--	BO	SW	250	95	BO	38
1/0	70°38.0'	147023.2’	766	BO	SW	210	99	B0	38
1/0	70034.5’	147°22.4'	1650	BO	SW	210	99	B0	18
4/0	70°35.1'	147020.7’	--	BO	SW	180	99	BO	38
1/0	70°33.5'	147024.2’	--	BO	RE	--	95	B0	18



73
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BEAUFORT SEA
LONELY
DEADHORSE
BARTER IS.
LEGEND
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147
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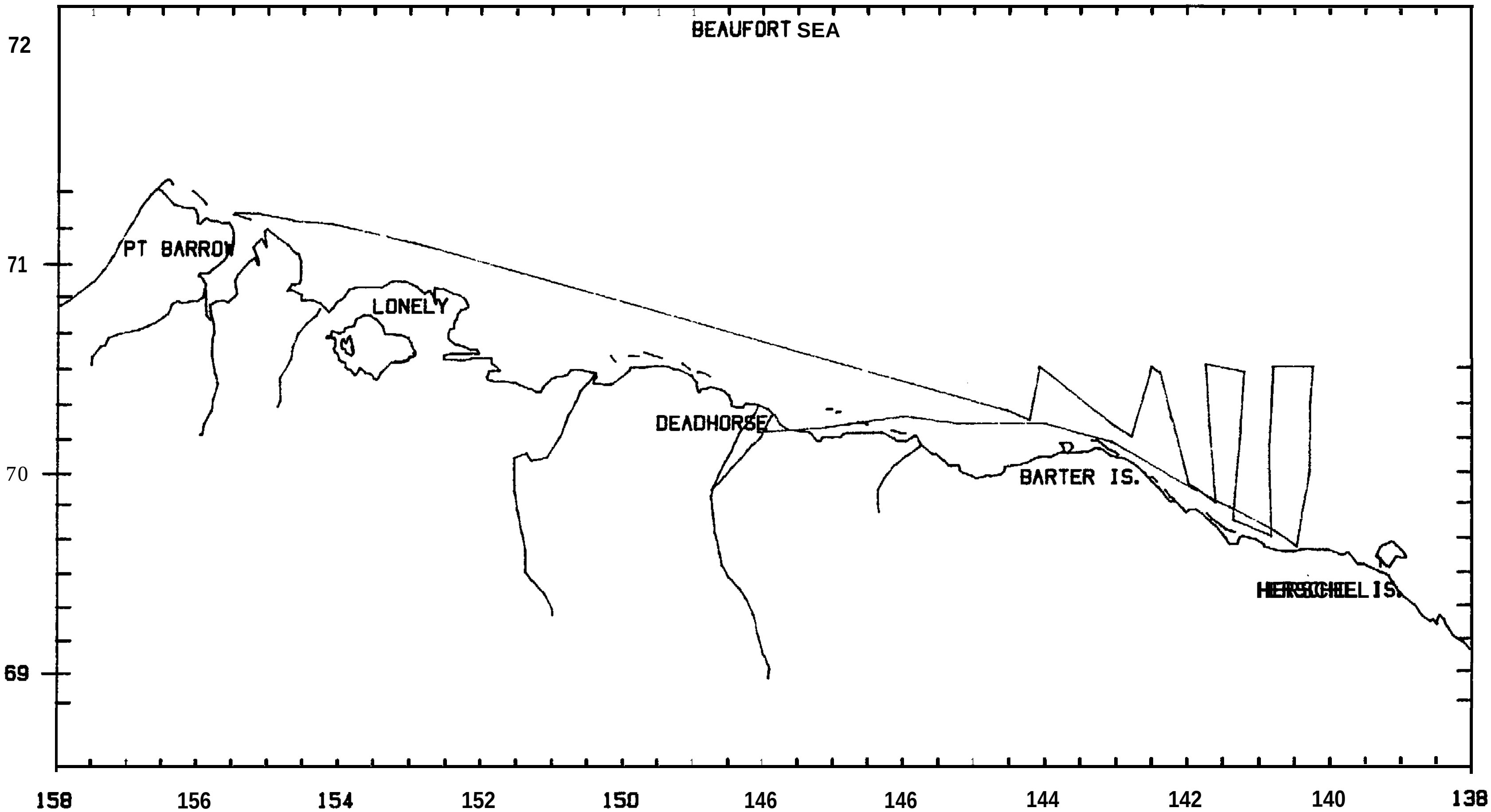
Flight **60:** 14 October 1985

Flight was a transect survey of block 5 and the western one-half of block 4. Weather was overcast with fog and high winds (>50 knots). Visibility varied from 10 km to unacceptable. Ice coverage was 90 to 99 percent and sea state ranged from Beaufort 00 to 03. No marine mammals were seen.


BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
BARTER IS.
HERSCHEL IS.
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158
156
154
152
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146
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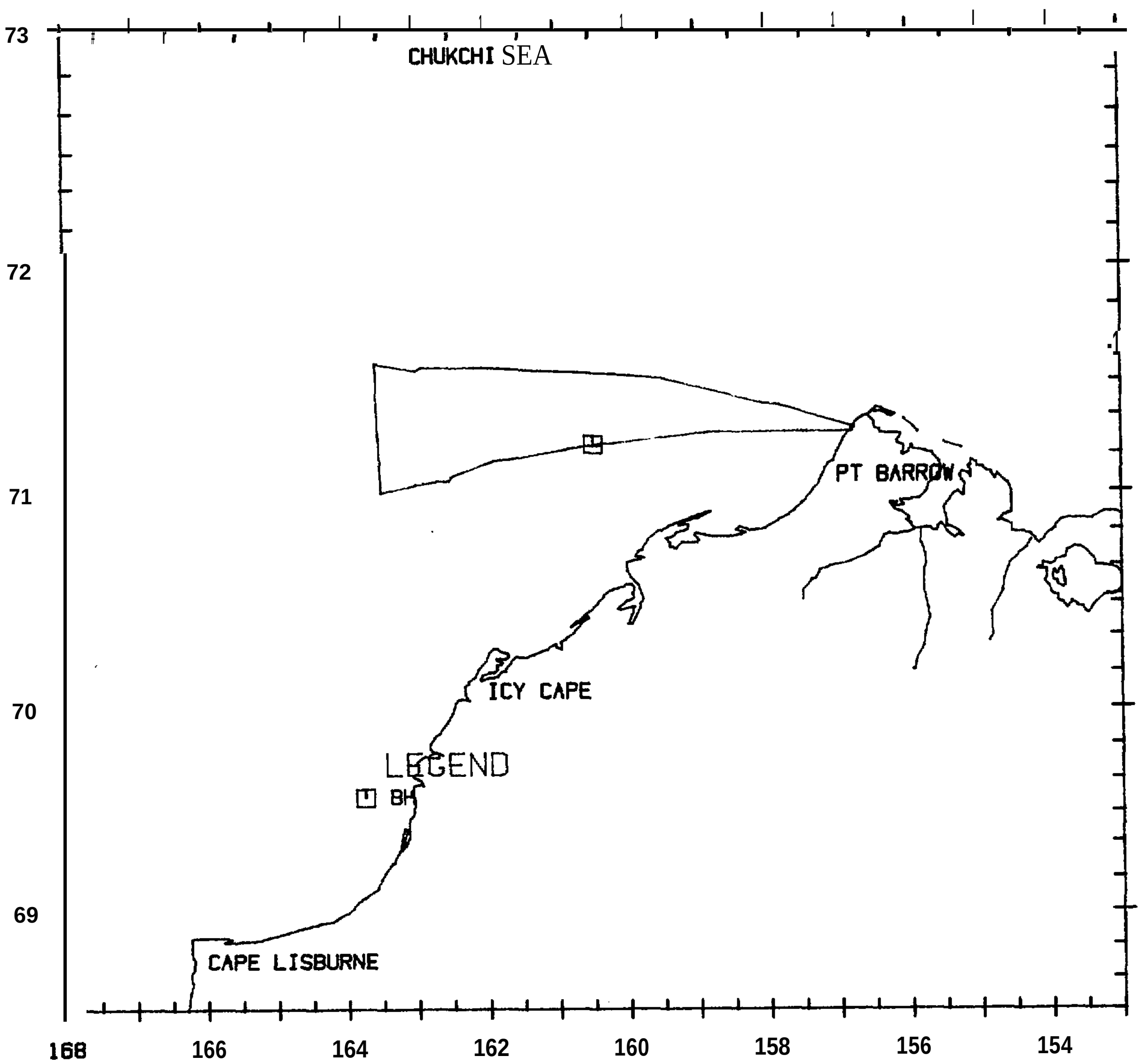
144
142
140
138

Flight 61: 15 October 1985

Flight was a search survey through the northeastern Chukchi Sea after low ceilings and low visibility forced an attempted survey of blocks 18 and 19 to be aborted. Ice coverage varied from O to 99 percent and sea state was Beaufort 00 to 04. One bowhead was seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°12.5'	160°29.2'	240	BO	SW	30	0	B3	37



73
72
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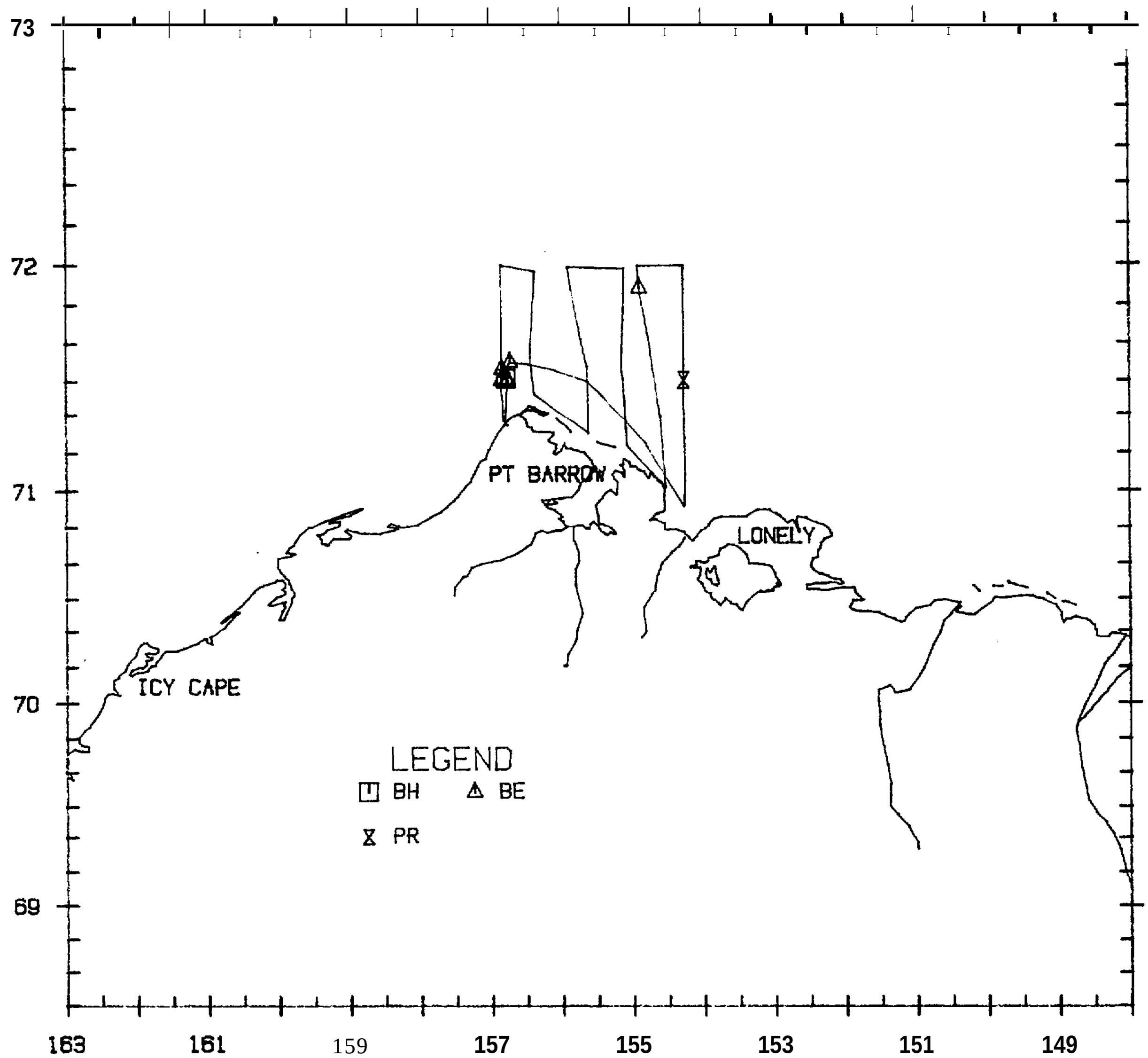
69
CHUKCHI SEA
PT BARROW
ICY CAPE
LEGEND
BH
CAPE LISBURNE
168
166
164
162
160
158
156
154

Flight **62:** 16 October 1985

Flight was a transect survey of block 12. Weather was clear to overcast and visibility was unlimited. Ice coverage varied from O to 95 percent and sea state was Beaufort 00 to 03. One bowhead was seen swimming south. Belukhas and polar bears were also seen.

T#/C#	LAT	LONG	DIS	CUE	BEH	HDG	ICE	SS	DEPTH
1/0	71°30.7'	156°47.0'	333	BO	SW	150	0	B3	145


73
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PT BARROW
LONELY
ICY CAPE
LEGEND
BH
BE
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163
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153
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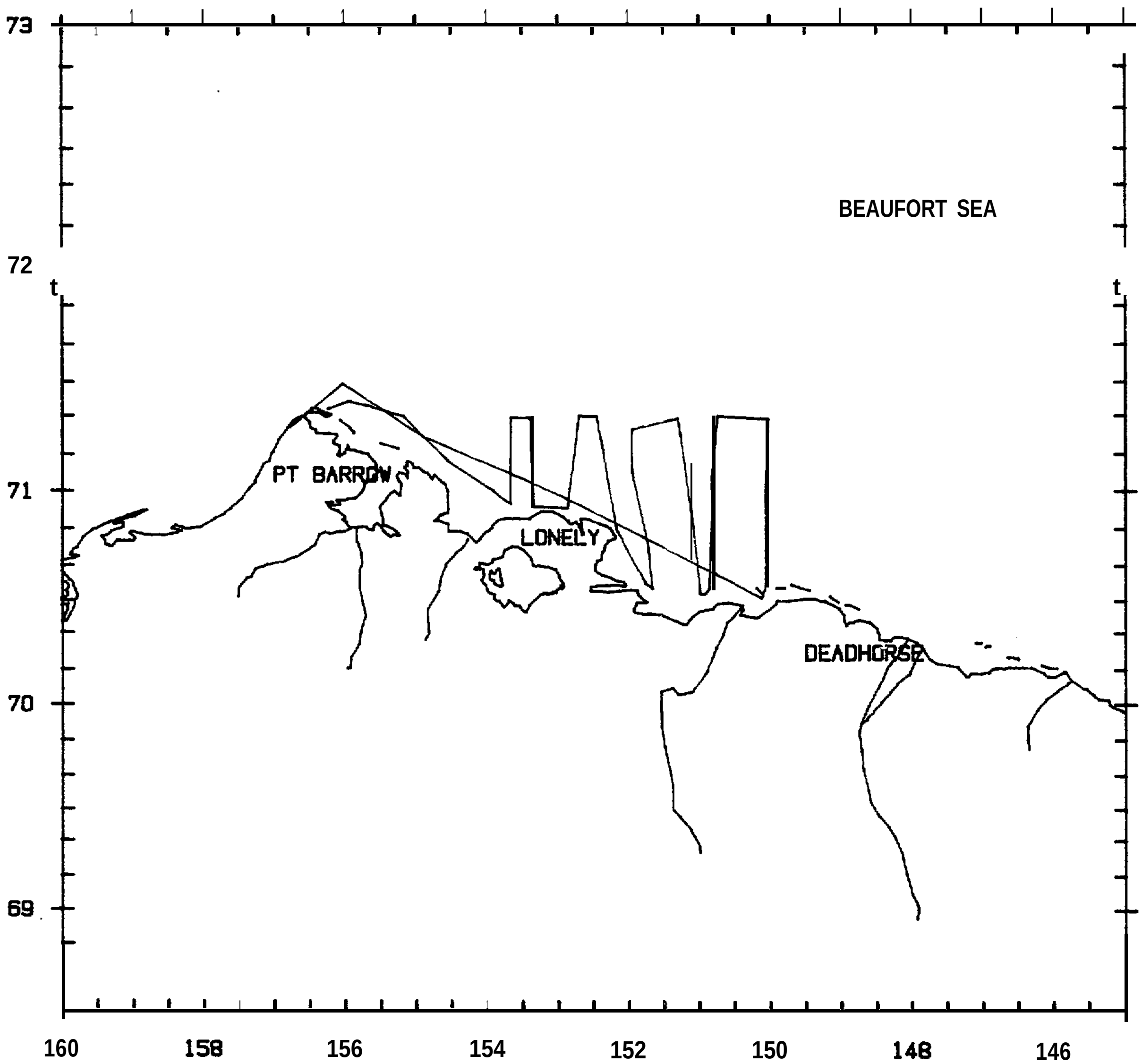
149

Flight 63: 17 October 1985

Flight was a transect survey of block 3. Weather was overcast with visibility varying from 5 km to unlimited. Ice coverage was 95 to 99 percent and sea state ranged from Beaufort 00 to 01. No marine mammals were seen.


73
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BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
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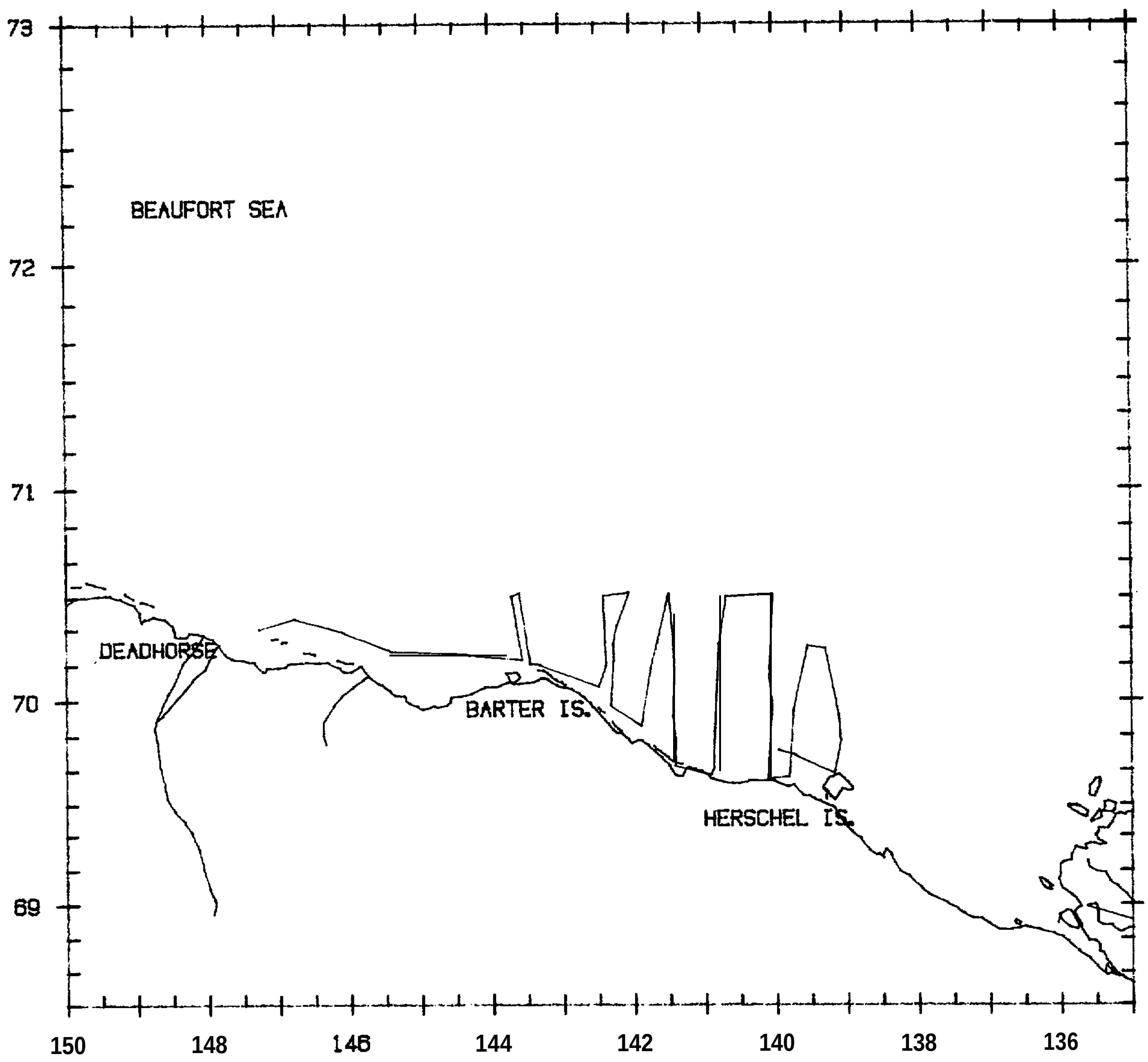
Flight **64:** 19 October 1985

Flight was a transect survey of Canada between 139°W and 1400 W, block 5 and the eastern one-third of block 4. Weather was overcast with fog and visibility varied from less than 1 km near-shore to unlimited offshore. Ice coverage was 99 percent and sea state ranged from Beaufort 00 to 03. No marine mammals were seen.



73
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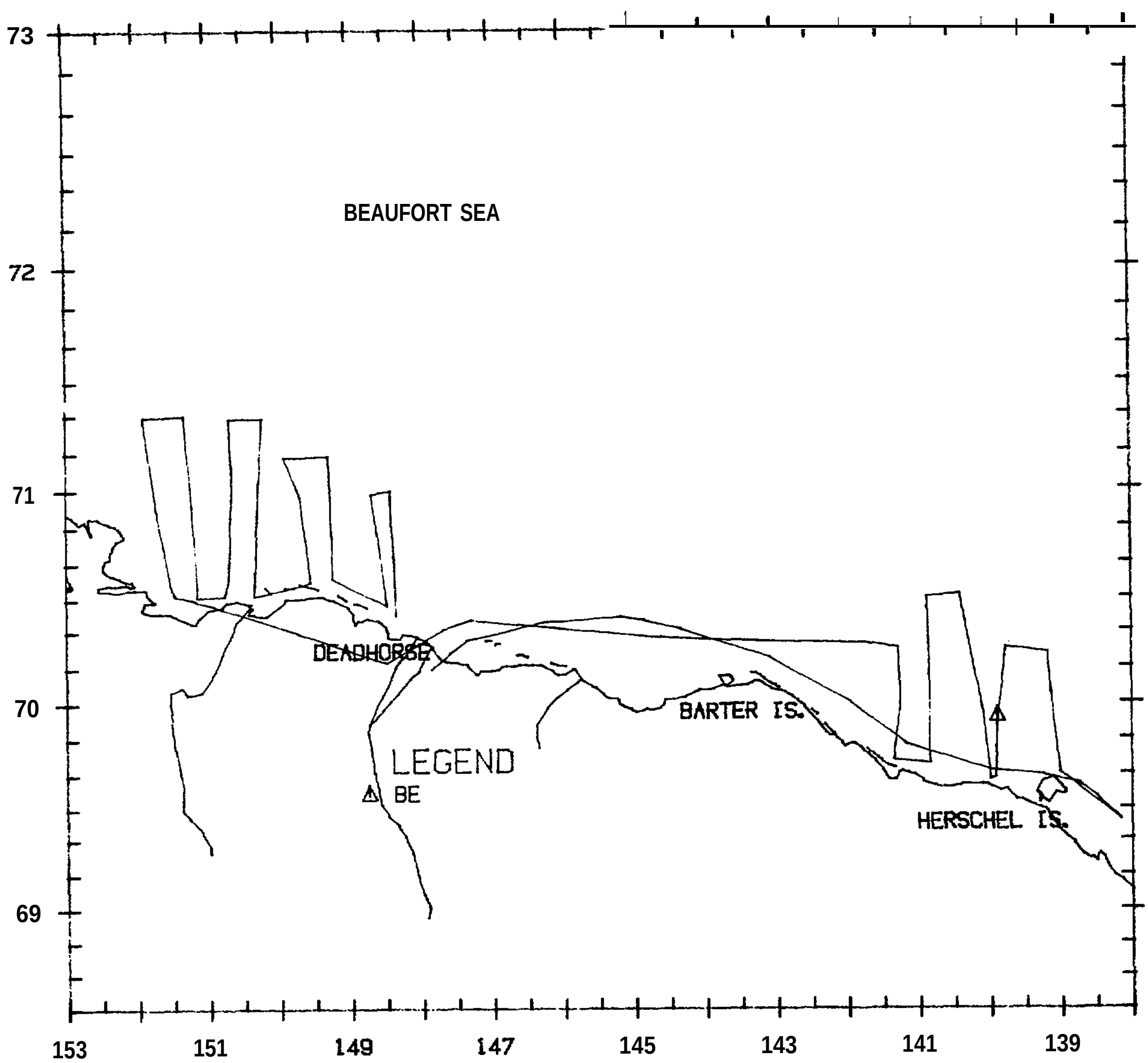
BEAUFORT SEA
DEADHORSE
BARTER IS.
HERSCHEL IS.
150
148
146
144
142
140
138
136

Flight 65: 20 October 1985

Flight was a transect survey of parts of blocks 5, 3 and 1 and a search survey east to 138°10'W. Weather was overcast to clear with unlimited visibility. Ice coverage in all areas was 95 to 99 percent and sea state was Beaufort 00 to 01. Belukhas were seen.


73
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69
BEAUFORT SEA
DEADHORSE
BARTER IS.
HERSCHEL IS.
LEGEND
BE
153
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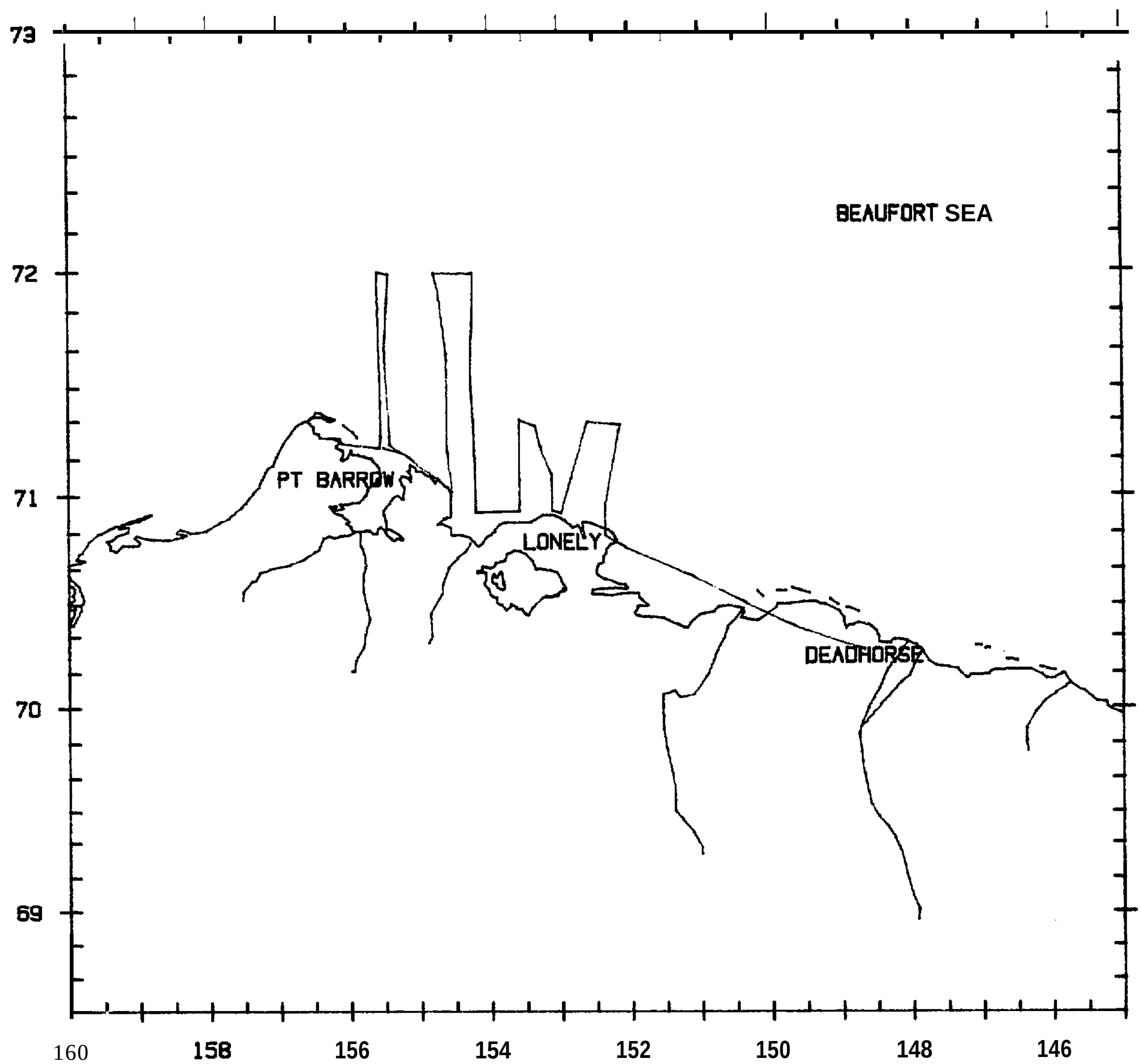
149
147
145
143
141
139

Flight 66: 21 October 1985

Flight was a transect survey of the western one-half of block 3 and the eastern two-thirds of block 12. Weather was partly cloudy and visibility was unlimited. Ice coverage was 95 to 99 percent and sea state was Beaufort 00. No marine mammals were seen.


73
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BEAUFORT SEA
PT BARROW
LONELY
DEADHORSE
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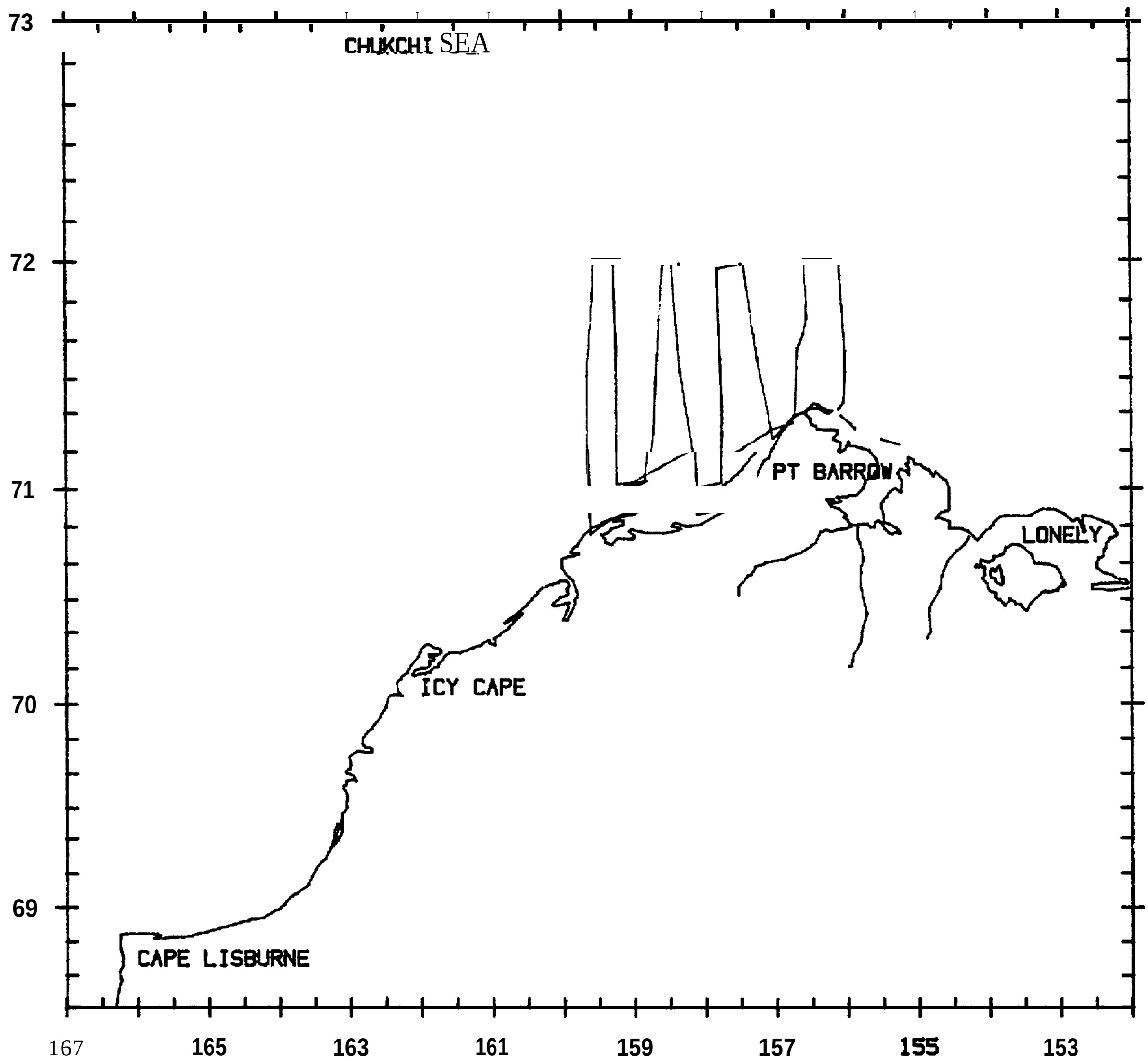
148
146

Flight 67: 23 October 1985

Flight was a transect survey of block 13 and the western one-third of block 12. Weather was overcast and visibility was 5 to 10 km. Ice coverage was 99 percent and sea state was Beaufort 00. No marine mammals were seen.



73
CHUKCHI SEA
72
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PT BARROW
LONELY
70
ICY CAPE
69
CAPE LISBURNE
167
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155
153

APPENDIX B

DISTRIBUTION OF 1985 SURVEY EFFORT AND OBSERVED DENSITIES OF BOWHEAD AND GRAY WHALES IN THE ALASKAN BEAUFORT, EASTERN CHUKCHI AND NORTHERN BERING SEAS, WITH COMPARISONS TO 1979 THROUGH 1984

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Page

FIGURES

TABLES

INTRODUCTION

This appendix presents an analysis of aerial survey data collected during 1985*, and a summary of similarly analyzed data for 1979-84. The objectives of the analysis were to estimate the density of bowhead whales in the Beaufort Sea, and of gray whales in the Chukchi and Bering Seas. Estimating the density of a species provides an evaluation of the relative importance of an area to that group. The density estimate for a particular area is useful when assessing how a portion of a species' range is utilized by the population. Sequential density estimates provide an invaluable tool when determining a population's response to its environment through time.

An important component of this analysis was determining the distribution of survey effort within specific study areas. The Bering and Chukchi Seas were treated as one study area. The Beaufort Sea was treated as a second study area bounded by 141°W to 157°W longitude and 720N latitude to the coastline. Both study areas were subdivided to more precisely illustrate survey effort and density of animals. Distribution of survey effort and density of gray whales in the Bering and Chukchi Seas were examined during summer (July). Distribution of survey effort and density of bowhead whales in the Beaufort Sea study area were examined during fall (August-October).

METHODS

Density Estimates

Estimating population density requires calculating the portion of that population which is never sighted. In order to correctly estimate density of any population, four underlying assumptions must be adhered to. The assumptions are as follows:

- There are no measurement errors and no rounding errors.
- Sightings are independent events.
- Individuals are fixed at an initial sighting position and no individuals are counted twice.
- A sample of the population is collected at random; no individual is biasedly selected during a count (Cox, 1958; Anderson et al., 1976).

*Density estimates for 1985 survey data were also calculated for survey blocks and provided in the report text (Figures 5 and 11).

Two factors inherent in a study of cetaceans that cause an individual to be missed during a count are sightability and submergence. Sightability means an individual may be at the surface but missed by the observer. As the distance increases between the observer and a whale, the chance of sighting the whale decreases (Doi, 1974, 1975). Transect estimators are designed to work in planar situations. Hence, it is the portion of a population surfaced but not sighted that is calculated when estimating population density. Secondly, whales are not sighted because they are submerged. A distinction must be made between whales at the surface but not sighted, and submerged whales that cannot be sighted. Submerged whales are **never** calculated in the population density estimate. These whales represent a source of known but currently unmeasurable error in the total population estimate (Eberhardt et al., 1979). Additional assumptions peculiar to estimating cetacean density that stem from their sightability and submergence characteristics are:

- Only surfaced animals are counted, and density estimates are calculated only for the population of whales not submerged during an observation period.[1]
- The whales' behaviors do **not** change over the period for which an estimate is calculated (i.e., whales maintain the same swimming speeds and dive patterns throughout the migratory period). This assumption is critical, but difficult to satisfy because whales' behaviors do change over the period of migration.
- Observers are equally effective on both sides of the aircraft and in all areas of the sighting sector. This assumption is necessary since each observer's sightings are weighted equally by formulas used in calculating population size. Any deviation from this assumption will cause a negative or downward bias on the final estimate.

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[1]A combined estimate of the population of surfaced and submerged whales can be calculated if a ratio of dive time to surface time is known. This ratio is a correction factor which permits one to adjust the population estimate to incorporate submerged whales. Presently no good correction factor exists for all behavioral situations. Whales seen during the fall in the Beaufort Sea can either be actively migrating, moving slowly, resting or milling and feeding. Although dive-time ratios have been calculated for milling and feeding whales (see Table 39), these ratios may not be appropriate to use as correction factors for migrating whales.

- Group size does not affect detection of whales. A violation of this assumption would cause a negative bias, since some classes of groups would not be sighted. This assumption is probably violated because larger groups are indeed easier to sight and because the larger the group, the higher the probability of having a whale at the surface.
- Whales do not evade the aircraft. This assumption is probably met because the speed of the aircraft is so much greater than that of the whales (ie., the aircraft probably approaches a whale before the whale can evade it by diving).
- Unity of detection occurs on the flight track. All whales are sighted if they are on the transect line. The only whales that an observer fails to sight are those that are some distance away from the survey aircraft (Burnham et al., 1980).

Strip and Line Transect Methodologies. Strip transect and line transect represent two analytical methodologies used to derive density estimates. The fundamental difference between the two is that a strip transect samples a strip defined by boundaries, while line transect samples an area without boundaries. **Both methods sample from a predetermined, randomly selected transect.** The basic formula for strip transect estimators (Hayne, 1949) is as follows:

$$N = \frac{nA}{2\,LH} \quad ,$$

where N is the estimated animal population, n is the number of individuals counted, A is area of strip, L is the transect length, and H is the mean sighting distance. Strip transects have a predetermined strip width, within which the observer is required to be certain of counting all individuals. This method does not utilize a detection function that incorporates sightings to the horizon. Individuals outside the strip are not counted, even if seen. For this reason, strip transect methods are recommended when the species density is high and individual counts are large. Line transect estimators are, conceptually, a strip transect with infinite strip width. Line transect methods use the following formula to estimate density:

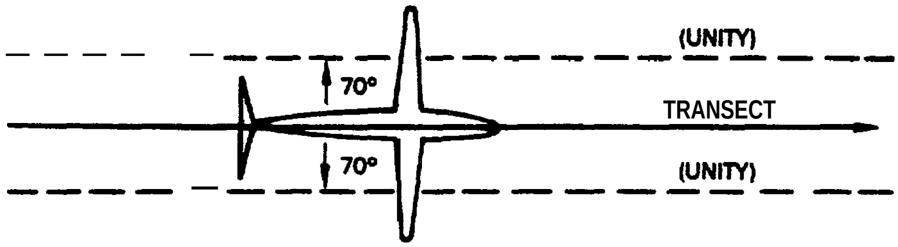
$$D = \frac{n\ f(o)}{2L} \quad ,$$

where D is the estimated density, n is the number of animals sighted while surveying from a transect, f(o) is the normalized detection function or the probability of sighting and animal, and L is the total transect length surveyed. The number of animals sighted and the transect length surveyed are known parameters. The detection function is the probability of sighting a surfaced whale at a known distance from the transect and must be estimated for density to be calculated. It is used to determine the number of animals on the surface that are not seen. As long as sampling is completed as a series of random transects, the detection function f(o), is the critical estimation made. Determining which specific mathematical model best fits the detection function is most easily done by program computer models. TRANSECT (Burnham et al., 1980) is a program inclusive of parametric and non-parametric mathematical models applicable to fitting curves to data consisting of perpendicular distances.

A critical assumption that must be satisfied *to* validate the detection function is unity at the transect line; all individuals that occur on the transect line are counted. This assumption was violated because the aircraft's design prevented searching between clinometer angles of 90° and 70° from the horizon. To compensate, all perpendicular distances were adjusted by subtracting a distance from the transect's centerline to a parallel line drawn by the 700 angle specific for the highest altitude flown. The original assumption of unity is modified to assume unity of sightings at these two parallel lines (Figure B-l). The lines are placed at a position equidistant from the transect line, the distance being the perpendicular distance for a 70° clinometer angle at the highest altitude surveyed.

Previous studies have shown that both the accuracy and precision of line transect estimators ***rely*** on the ability to determine the exact distance of an individual sighting from the transect line. A fundamental problem now arises. The transect line has been transformed to represent two parallel lines determined by a 70° clinometer angle at the highest altitude surveyed. If a sighting occurs at an altitude lower than the altitude used to attain the parallel transect lines, but at a 700 angle, the sighting will occur in a mathematical "blind spot," the blind spot being the area between the two parallel lines. A blind spot confuses any effort to mathematically model the true probability of detecting whales at varying distances from the survey aircraft. A negative bias or underestimation of the true population is the result of a mathematical blind spot.

A.



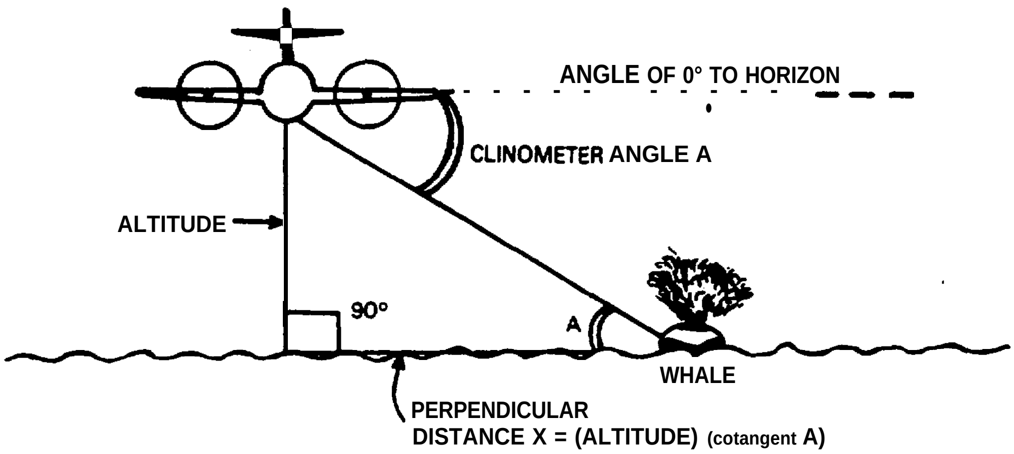


Figure B-1. Due to aircraft design, the assumption of unity at centerline is modified to assume unity at two parallel lines drawn by the 700 angle for the highest altitude flown.

A second method employed by Leatherwood et al. (in press) to compensate for the blind spot beneath the aircraft during line transect analysis, was to replace the parallel-line assumption with a new one that requires all marine mammals to be seen at some fixed perpendicular distance (x_o) from the transect line. The resulting density values experience no aliasing, as introduced by the subtraction method when estimating sightability via the detection function, but nevertheless result in a minimum estimate.

One additional assumption that may be violated is that there are no measurement errors and no rounding errors. Exact sighting angles are difficult to obtain. A deviation of several degrees from the true sighting angle will significantly alter a line transect density estimate.

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 f rem: 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 separately plotting 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

Survey regions in the Bering and Chukchi Seas were determined based on survey effort and animal -distributions (Figures B-2 and B-3). These regions did not conform to survey blocks. The Beaufort Sea study area was divided into four regions from west to east (Figure B-4). Region A extended from 157°00'W to 153°30'W, region B from 153°30'W to 150°00'W, region C from 150 °00'W to 146°00'W, and, region D from 146°00'W to 141°00’W.

Depth contours (Figure B-5) were used to stratify the Beaufort Sea from north to south. Depth contours of 10 m, 20 m, 50 m, 200 m, and 200 m were selected (Figure B-6). The stratum from the coastline to 10 m corresponded closely to the area inside the barrier islands (A 1, B1, C 1, D 1A, and D 1B) (Figure B-7). Area D 1 was divided into DIA and D 1 B at 143030’ W, which marked the boundary between two areas previously defined for behavioral studies (Figure B-8). 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. Of fshelf 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.

A 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 A 1 and B1 was digitized four times because it served not only as a boundary between regions A 1 and B 1 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 km^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 two kilometers (i.e. one kilometer on either side of the aircraft). Therefore, the total number of kilometers flown equalled half the number of square kilometers surveyed. The percent of total area was calculated as the number of square kilometers 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 kilometer 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 km^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 strip transect technique described in Estes and Gilbert (1978):

$$\hat{R} = \Sigma y_i / \Sigma x_i \quad (1)$$

where $\hat{R}$ = observed density of whales per square kilometer

y_i = number of whales observed in the ith strip transect

x_i = area of the ith strip transect

$$S^2_{\hat{R}} = [\Sigma(y_i^2/x_i) - \hat{R}\Sigma y_i] / (n-1)(\Sigma x_i) \quad (2)$$

where $S^2_{\hat{R}}$ = variance of R

n = number of strip transects

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

The notation $t_{.05}(2)V$ refers to the critical value of t where alpha (α) = .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:

- o Table of statistics associated with each region presenting 1985 data
- o Summary table of statistics associated with each region, 1979-1984

Please refer to the table of contents for order of presentation of results.

BERING AND CHUKCHI SEAS STUDY AREA

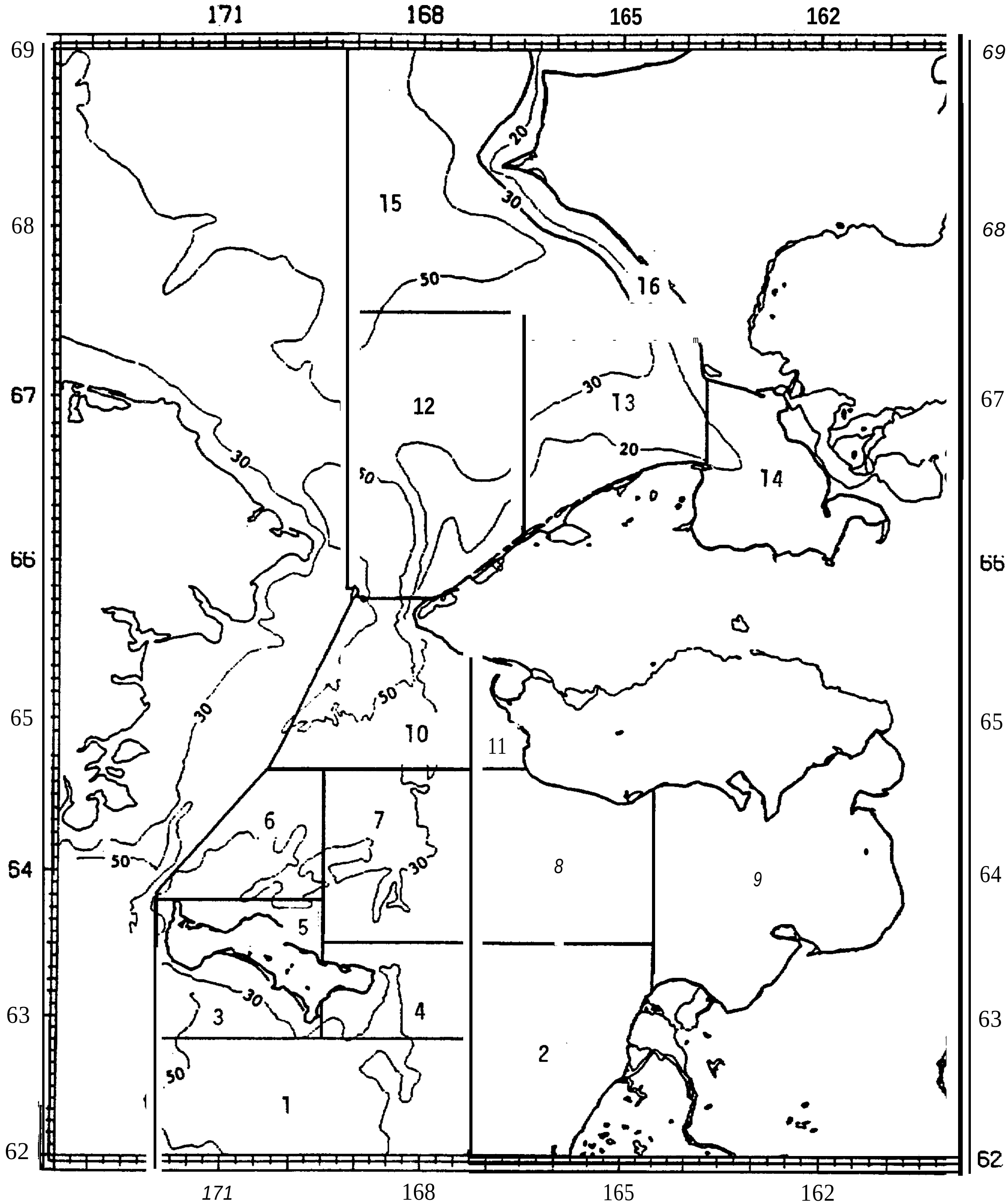


Figure B-2. Map depicting survey regions in relation to depth contours in the Bering and Chukchi Seas.

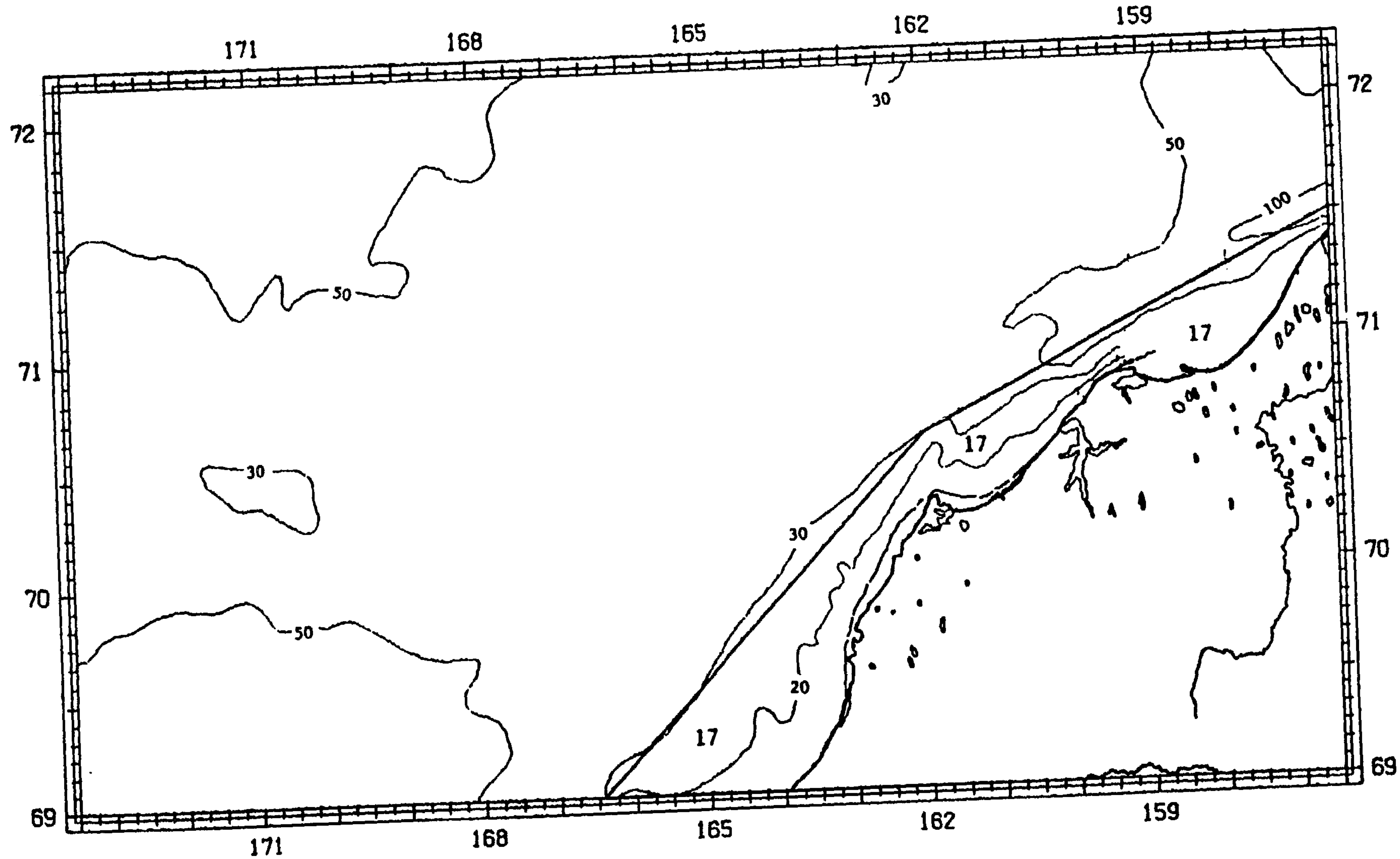


Figure B-3. Map depicting survey region 7 in relation to depth contours in the Chukchi Sea.

Table B-1. Statistics from aerial surveys of gray whales conducted July 1985 in the Bering and Chukchi Seas. Values for each region were summed where appropriate. Region numbers refer to areas depicted in Figures B-2 and B-3.

Region Name	Region Area km2	Percent of Total Area	Percent of Area Surveyed	Survey Time HR:MIN	Percent of Total Time	Number of Transects Flown	Number of Gray Whales Observed	Density as number per km 2	Variance (*10⁴)	Confidence Range of Density
1	22,438	10.08	0.0							
2	19,036	8.56	0.0							
3	6,898	3.10	0.0							
4	7,584	3.41	0.0							
5'	2,483	1.12	0.0							
6	7,933	3.56	3.62	0:29	5.59	2	0	0	0.0	0.0
7	14,021	6.30	2.06	0:29	5.59	2	45	0.160	70.0	0.00- 1.2
8	15,661	7.04	0.0							
9	24,908	11.19	0.0							
10	12,608	5.67	6.70	1:48	20.90	6	71	0.084	11.0	0.00-0.17
11	2,631	1.18	1.64	0:05	0.89	2	0	0.0	0.0	0.0
12	21,214	9.53	0.0							
13	14,200	6.38	0.0							
14	8,468	3.81	0.0							
15	19,780	8.89	5.37	1:51	21.40	7	0	0.0	0.0	0.0
16	5,159	2.32	3.15	0:18	3.54	9	0	0.0	0.0	0.0
17	17,479	7.86	11.61	3:38	42.09	24	8	0.004	0.042	0.00-0.008

Table B-2. Statistics from aerial surveys of gray whales conducted July 1980-1984 in the Bering and Chukchi Seas.

		1980			1981			1982		
Region Name	Region Area km2	Percent Area Surveyed	Number Grays observed	Density Number per km2	Percent Area Surveyed	Number Grays Observed	Density Number per km²	Percent Area Surveyed	Number Grays Observed	Density Number per km2
1	22,438	0.0			0.0		--	0.11	0	0.0
2	19,036	0.0			2.23	0	0.0	0.0		--
3	6,898	0.0			0.0			1.73	11	1.087
4	7,584	0.0		--	8.20	0	0.0	17.66	40	0.350
5	2,483	0.0		--	0.0		--	22.81	6	0.123
6	7,933	0.0			0.0		--	12.18	7	0.086
7	14,021	0.0		--	10.74	46	0.360	30.55	56	0.154
8	15,661	0.22	0	0.0	18.21	0	0.0	6.02	1	0.014
9	24,908	1.39	0	0.0	7.86	0	0.0	0.0		--
10	12,608	1.23	0	0.0	13.65	14	0.096	23.18	37	0.147
11	2,631	3.69	0	0.0	36.54	5	0.062	15.73	0	0.0
12	21,214	1.52	0	0.0	7.09	9	0.072	13. s5	5	0.021
13	14,200	0.46	0	0.0	10.23	0	0.0	7.30	1	0.010
14	8,468	0.0		--	8.29	0	0.0	6.05	0	0.0
15	19,780	0.50	0	0.0	4.73	12	0.151	0.0		--
16	5,159	3.51	4	0.261	25.79	28	0.247	7.75	24	0.707
17	17,479	3.74	4	0.072	5.02	21	0.281	3.83	84	1.475

		1983			1984		
Region Name	Region Area km²	Percent Area Surveyed	Number Grays Observed	Density Number per km²	Percent Area Surveyed	Number Grays Observed	Density Number per km²
1	22,438	0.0		--	0.0		
2	19,036	1.71	0	0.0	0.0		
3	6,898	0.0		--	0.0		
4	7,584	9.56	0	0.0	0.0		
5	2,483	0.0		--	0.0		
6	7,933	11.55	65	0.833	0.0		
7	14,021	30.26	429	1.190	3.98	26	0.549
8	1S,661	6.76	0	0.0	3.12	0	0.0
9	24,908	2.67	0	0.0	0.0		
10	12,608	19.00	346	1.698	1.32	0	0.0
11	2,631	5.00	0	0.0	6.58	0	0.0
12	21,214	0.62	1	0.089	1.05	0	0.0
13	14,200	2.24	4	0.147	0.88	0	0.0
14	8,468	0.0		--	0.0		
15	19,780	0.46	0	0.0	0.69	3	0.257
16	5,159	3.72	6	0.367	3.45	9	0.593
17	17,479	3.65	0	0.0	13.41	17	0.086

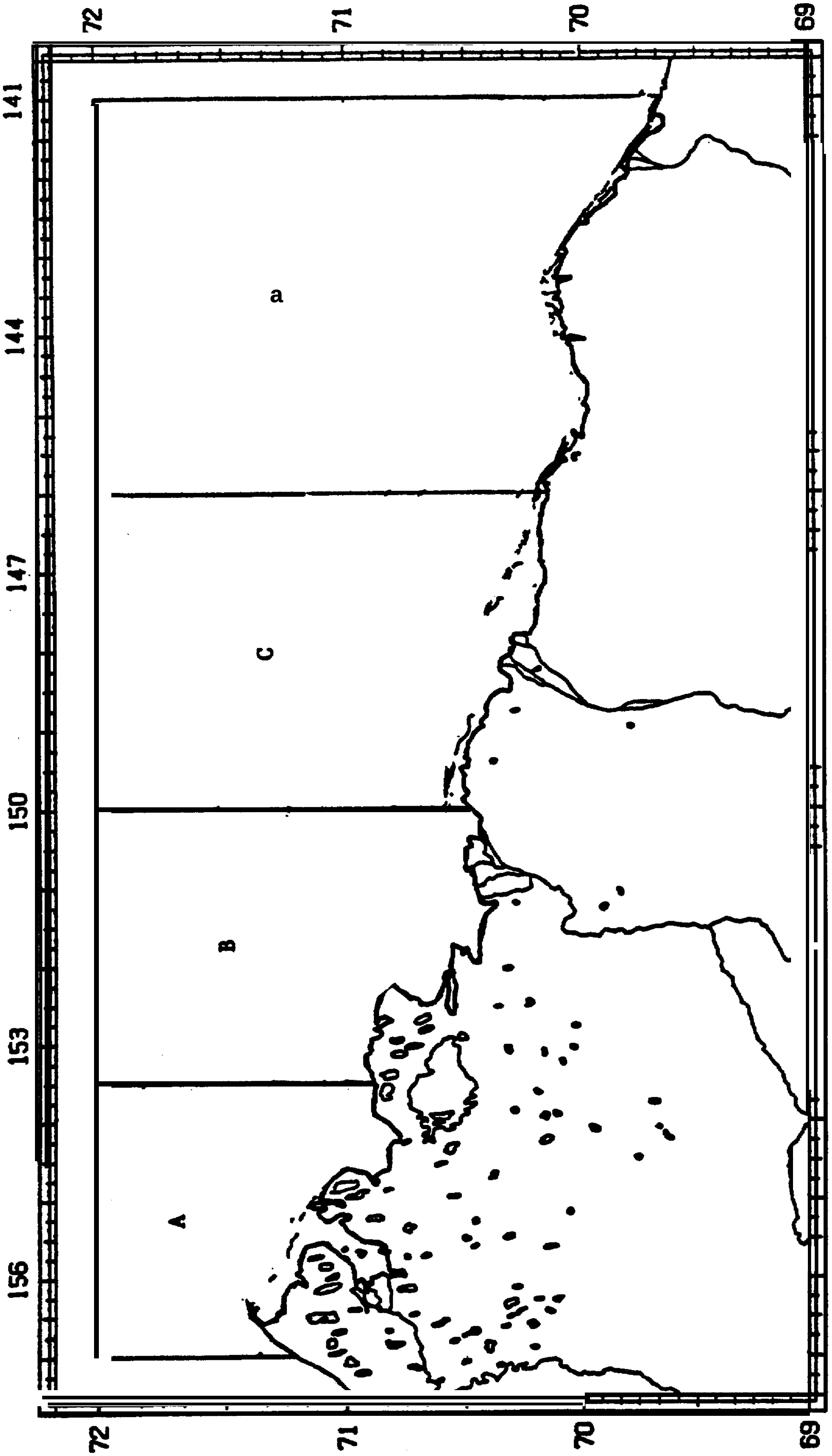


Figure B-4. The Beaufort Sea study area was divided into four regions: A, B, C, and D.

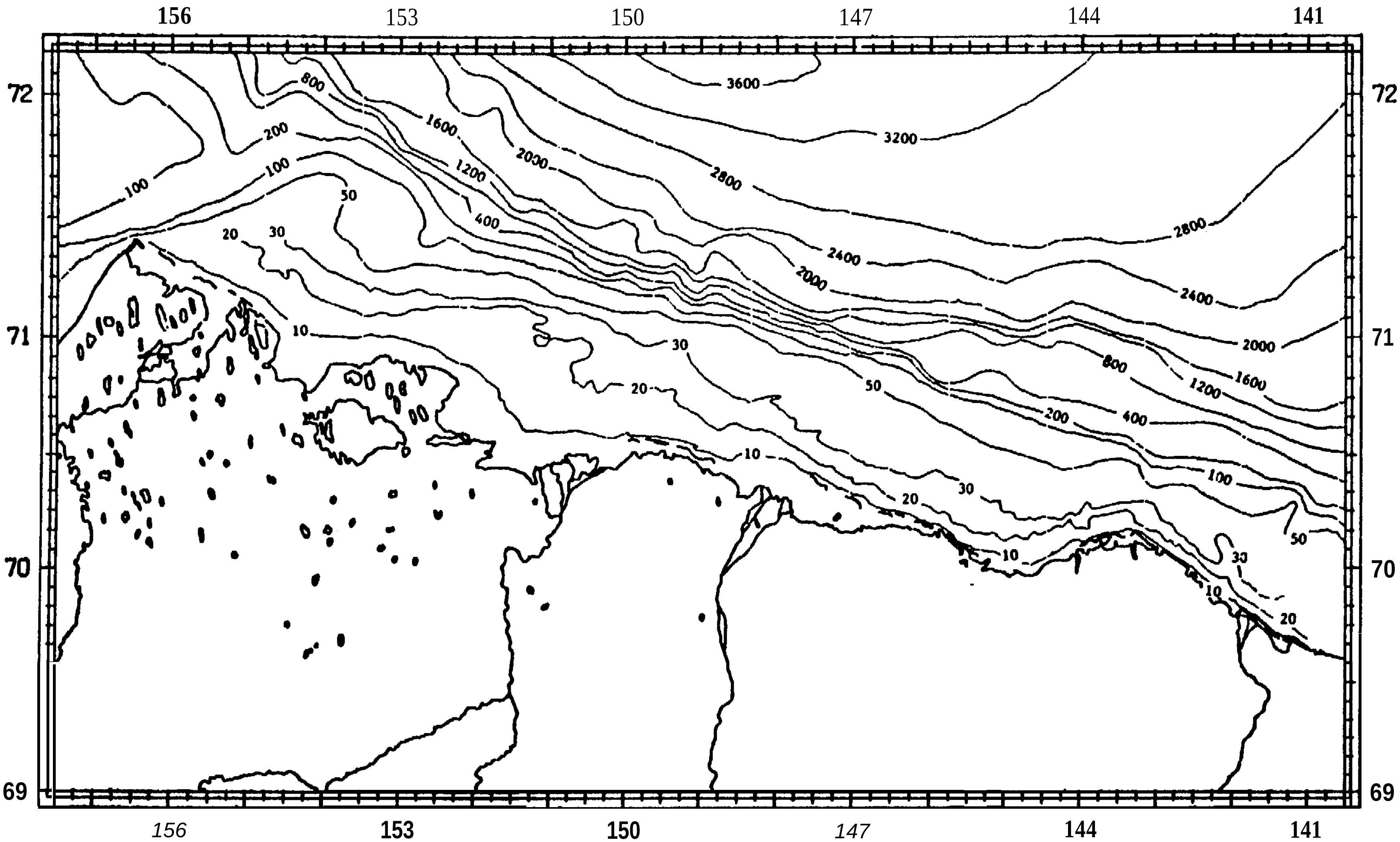


Figure B-5. Beaufort Sea depth contour lines, in meters.

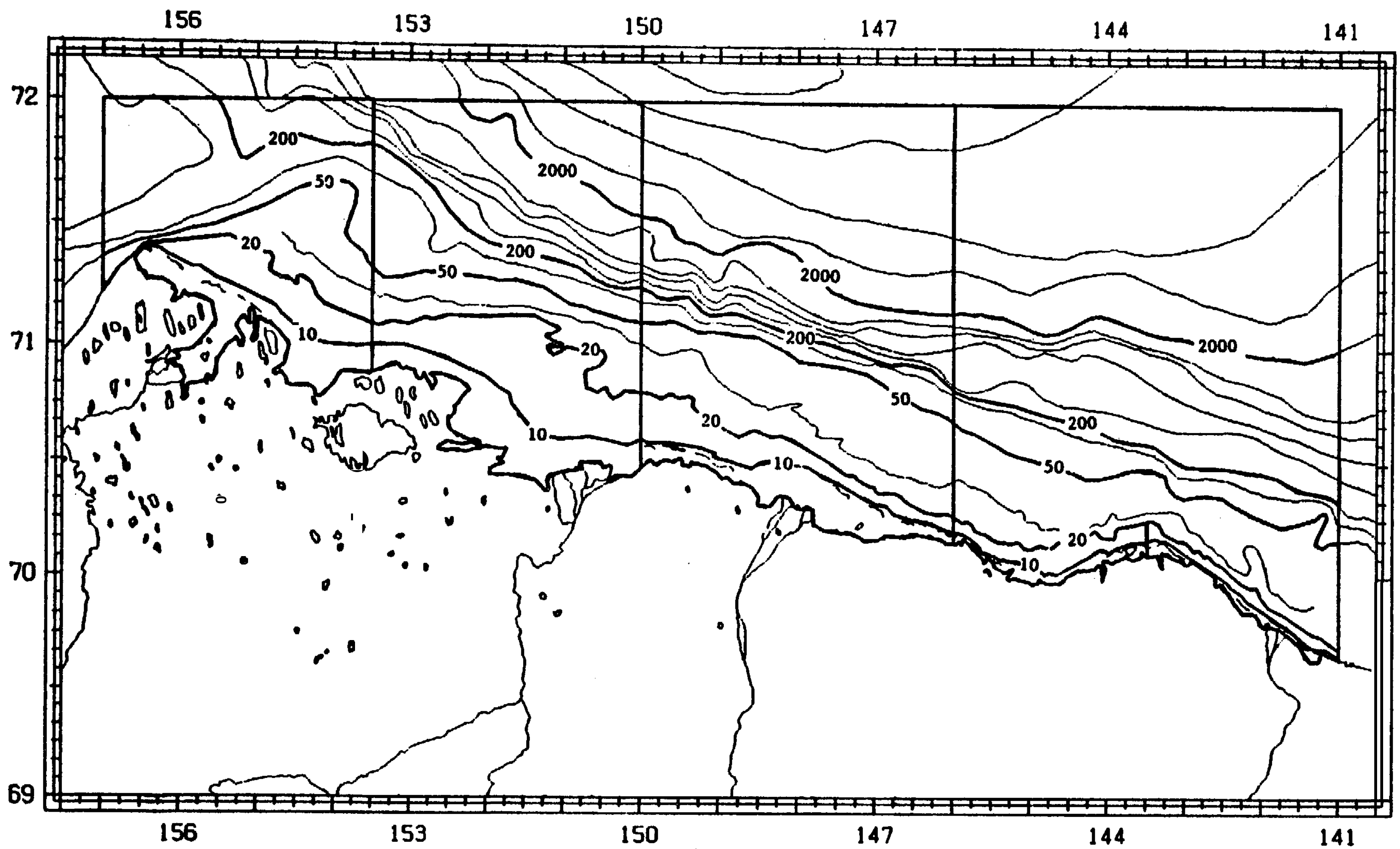


Figure B-6. Map depicting the survey regions in the Beaufort Sea after stratification by contour intervals of 10 m, 20 m, 50 m, 200 m,and 2000 m.

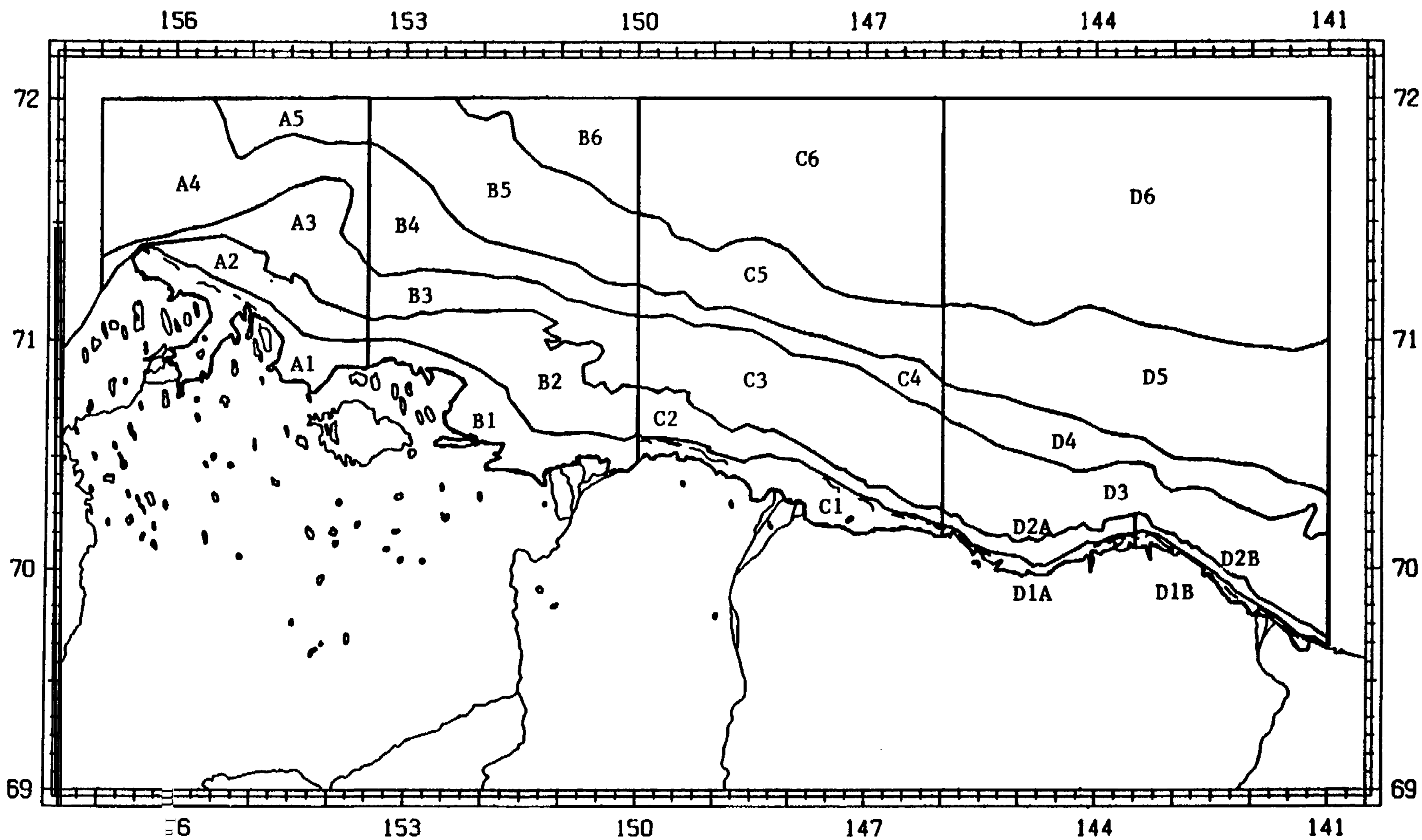


Figure B-7. Map depicting Beaufort Sea stratum names. Strata A1, B1, C1, D1A and D1B extended from the coast out to the 10 meter depth contour. Strata A2, B2, C2, D2A and D2B fell between the 10 and 20 meter depth contours; A3, B3, C3 and D3, fell between the 20 and 50 meter depth contours; etc. Strata D1A, D1B, D2A and D2B are enlarged in Figure B-8.

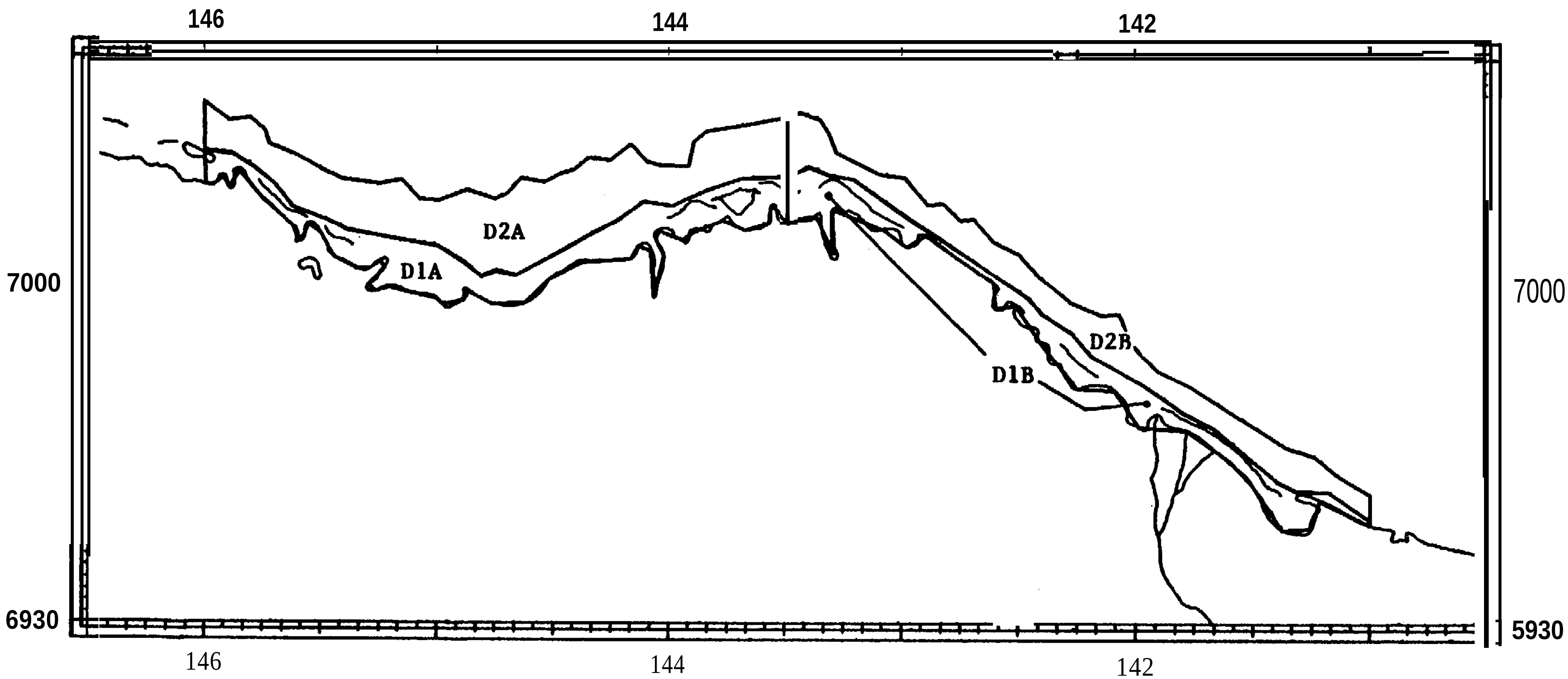


Figure B-8. Map depicting Beaufort Sea strata DIA, D1B, D2A and D2B. Regions D1A and DIB extended from the coast out to the 10 meter depth contour. Regions D2A and D2B extended from the 10 meter to the 20 meter depth contour.

Table B-3. Statistics from aerial surveys of bowhead whales conducted August 1985 in the Beaufort Sea. Values for each region were summed where appropriate. Region numbers refer to areas depicted in Figure B-7.

* The total area of all regions was approximately 101,248 km^2; areas were approximated by straight line integration.

Region Name	Region Area km2	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 km 2	Variance (* 10^{-4})	Confidence Range of Density
Total	*101,248	100.00	11.97	22:37	100.00	298	1	0.0001	0.0001	0.0-0.0003
A										
Al										
A2										
A3										
A4										
A5										
B										
B1										
B2										
03										
B4										
B5										
B6										
c	27,156	27.	7.85	04:00	17.69	61	0	0	0	0
c1	2,086	2.06	1.61	00:03	0.22	3	0	0	0	0
C2	1,809	1*79	10.52	00:23	1.67	9	0	0	0	0
C3	6,482	6.40	17.35	02:08	9.47	23	0	0	0	0
C4	1,803	1.78	14.49	00:29	2.23	14	0	0	0	0
C5	4,252	4.20	9.53	00:44	3.24	8	0	0	0	0
C6	10,724	10.59	1.08	00:13	0.96	4	0	0	0	0
D	41,139	41.	24.28	18:37	82.31	237	1	0.0001	0.0002	0.0-0.0004
D1A	494	0.49	7.04	00:04	0.32	9	0	0	0	0
DIB	428	0.42	0.70	00:00	0.02	3	0	0	0	0
D2A	915	0.90	40.86	00:44	3.25	23	0	0	0	0
D2B	510	0.50	22.01	00:12	0.91	17	0	0	0	0
D3	6,933	6.85	49.78	06:24	28.27	57	0	0	0	0
D4	3,462	3.42	42.05	02:44	12.07	56	1	0.0007	0.0055	0.0-0.0022
D5	9,785	9.66	34.12	06:12	27.41	43	0	0	0	0
D6	18,612	18.38	6.56	02:17	10.06	29	0	0	0	0

Table B-4. Statistics from aerial surveys of bowhead whales conducted August 1979-1984 in the Beauf ort Sea.

Region Name	Region Area km2	1979 Percent of Area Surveyed	1979 Number Bowheads Observed	1979 Density as Number km2	1980 Percent per of Area Surveyed	1980 Number Bowheads Observed	1980 Density as Number per km2	1981 Percent of Area Surveyed	1981 Number Bowheads Observed	1981 Density as Number per km2
Total	101 ,24S	14.43	7	0.007	8.29	0	0.0	6.66	0	0.0
A	13,360	0.0			1.94	0	0.0	5.72	0	0.0
A1	2,361	0.0			3.38	0	0.0	8.20	0	0.0
A2	1,64S	0.0			3.37	0	0.0	5.56	0	0.0
A3	2,688	0.0			4.25	0	0.0	9.76	0	0.0
A4	5,166	0.0			0.15	0	0.0	4.00	0	0.0
AS	I ,497	0.0			0.0			0.0		
B	19,593	0.0			16.36	0	0.0	7.87	0	0.0
B1	2,614	0.0			36. S9	0	0.9	10.96	0	0.0
B2	3,s14	0.0			31.23	0	0.0	10.22	0	0.0
B3	2,739	0.0			20.23	0	0.0	19.62	0	0.0
B4	3,061	0.0			12.59	0	0.0	6.71	0	0.0
B5	5,009	0.0			1.90	0	0.'2	2.12	0	0.0
B6	2,356	0.0			0.0			0.0		
c	27,156	30.37	0	0.0	12.53	0	0.0	9.09	0	0.0
c l	2,086	134.66	0	0.0	32.67	0	0.0	28.30	0	0.0
C2	1,809	68.95	0	0.0	31.04	0	0.0	41. s7	o	0.0
C3	6,482	54.34	0	0.0	29.67	0	0.0	10.12	0	0.0
C4	1,803	8.69	0	0.0	8.49	0	0.0	2.06	0	0.0
C5	4,252	7.33	0	0.0	0.24	0	O.!l	2.90	0	0.0
C6	10,724	2.58	0	0.0	0.0			2.44	0	0.0
D	41,139	15.40	7	0.014	3.45	0	0.0	4.71	0	0.0
D1A	494	15.04	0	0.0	11.44	0	0.0	0.0		
D1B	428	0.0			4.93	0	0.0	3.93	0	0.0
D2A	91.5	111.90	0	0.0	2.S5	0	0.0	17.43	0	0.0
D2B	510	9.68	0	0.0	8.11	0	0.0	7.22	0	0.0
D3	6,933	44.65	0	0.0	17.48	o	0.0	21.82	0	0.0
D4	3,462	31.73	0	0.041	9.74	0	0.0	0.0		
D5	9,785	7.05	3	0.051	0.0			1.83	0	0.0
D6	18,612	0.0			0.0			0.0		

Region Name	Region Area km2	1982 Percent of Area Surveyed	1982 Number Bowheads Observed	1982 Density as Number per km2	1983 Percent of Area Surveyed	1983 Number Bowheads Observed	1983 Density as Number per km 2	1984 Percent of Area Surveyed	1984 Number Bowheads Observed	1984 Density as Number per km2
Total	101,248	26.94	79	0.034	36.18	10	0.003	29.09	7	0.003
A	13,360	0.0			21.67	0	0.0	6.02	0	0.0
A1	2,361	0.0			24.31	0	0.0	9.99	0	0.0
A2	1,648	0.0			33.17	0	0.0	7.65	0	0.0
A3	2,688	0.0			26.67	0	0.0	9.99	0	0.0
A4	5,166	0.0			16.45	0	0.0	2.39	0	0.0
AS	1,497	0.0			11.23	0	0.0	2.S9	0	0.0
B	19,593	0.0			33.21	0	0.0	12.90	0	0.0
B1	2,614	0.0			38.64	0	0.0	15.10	0	0.0
02	3,s14	0.0			65.24	0	0.0	11.17	0	0.0
B3	2,739	0.0			50.90	0	0.0	1s.3s	0	0.0
B4	3,061	0.0			19.12	0	0.0	10.94	0	0.0
B5	5,009	0.0			12.40	0	0.0	11. s4	0	0.0
B6	2,356	'2.0			15.55	0	0.0	10.31	0	0.0
c	27,156	17.77	0	0.0	31 .s2	1	0.0	19.55	0	0.0
C1	2,0S6	45.68	0	0.0	65.32	0	0.0	75.85	0	0.0
C2	1,809	22.62	0	0.0	53.72	0	0.0	55.73	0	0.0
C3	6,482	24.20	0	0.0	35.07	0	0.0	25.89	0	0.0
C4	I ,s03	23.77	0	0.0	24.39	0	0.0	1s.24	0	0.0
C5	4,252	21.41	0	0.0	20.34	1	0.014	10.29	0	0.0
C6	10,724	4.68	0	0.0	23.48	0	0.0	2.37	0	0.0
D	41,139	54.57	79	0.041	45.28	9	0.007	50.57	7	0.003
D1A	494	140.15	0	0.0	36.62	0	0.0	73.66	0	0.0
D1B	42s	57.24	0	0.0	66.13	0	0.0	76.38	0	0.0
D2A	915	109.2'3	0	0.0	6s.66	o	0.9	145.02	0	0.0
D2B	510	123.46	0	0.0	57.30	0	0.0	136.6S	2	0.031
D3	6,933	80.48	0	0.0	65.32	2	0.007	93.34	4	0.007
D4	3,462	84.05	3	0.014	55.45	0	0.0	67.60	1	0.003
D5	9,7s5	67.16	72	0.130	53.55	3	0.007	48.94	0	0.0
D6	1S,612	23.14	4	0.010	28.08	4	0.010	21.80	0	0.0

Table B-5. Statistics from aerial surveys of bowhead whales conducted September 1985 in the Beaufort Sea. Values for each region were summed where appropriate. Region numbers refer to areas depicted in Figure B-7.

*The total area of all regions was approximately 101,2.48 km2; areas were approximated by straight line integration.

Region Name	Region Area km²	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 km 2	Variance (* 10-4)	Confidence Range of Density
Total	*101,248	100.00	14.30	28:58	100.00	326	0	0	0	0
A	13,360	13.	8.68	02:27	8.45	30	0	0	0	0
Al	2,361	2.33	2.61	00:08	0.48	6	0	0	0	0
A2	1,648	1.63	10.71	00:23	1.32	6	0	0	0	0
A3	2,688	2.65	10.31	00:34	1.93	8	0	0	0	0
A4	5,166	5.10	10.05	01:07	3.86	7	0	0	0	0
A5	1,497	1.48	8.31	00:15	0.86	3	0	0	0	0
B	19,593	19.	5.58	02:04	7.12	31	0	0	0	0
B1	2,614	2.58	6.02	00:19	1.09	7	0	0	0	0
B2	3,814	3.77	13.29	01:00	3.44	10	0	0	0	0
B3	2,739	2.71	11.99	00:36	2.07	8	0	0	0	0
B4	3,061	3.02	3.32	00:09	0.52	6	0	0	0	0
B5	5,009	4.93	0.0	00:00	0.00	0	0	0	0	0
B6	2,356	2.33	0.0	00:00	0.00	0	0	0	0	0
c	27,156	27.	15.73	08:38	29.79	109	0	0	0	0
c l	2,086	2.06	9.68	00:25	1.42	14	0	0	0	0
C2	1,809	1.79	28.73	01:05	3.76	24	0	0	0	0
C3	6,482	6.40	30.43	04:10	14.40	24	0	0	0	0
C4	1,803	1.78	24.45	00:52	2.98	19	0	0	0	0
C5	4,252	4.20	21.29	01:42	5.84	19	0	0	0	0
C6	10,724	10.59	2.16	00:24	1.40	9	0	0	0	0
D	41,139	41.	19.34	15:50	54.63	156	0	0	0	0
D1A	494	0.49	4.19	00:03	0.15	6	0	0	0	0
D1B	428	0.42	1.58	00:01	0.05	4	0	0	0	0
D2A	915	0.90	24.99	00:28	1.62	14	0	0	0	0
D2B	510	0.50	22.15	00:13	0.76	13	0	0	0	0
D3	6,933	6.85	30.92	04:17	14.77	31	0	0	0	0
D4	3,462	3.42	25.25	01:48	6.20	28	0	0	0	0
D5	9,785	9.66	24.52	04:47	16.48	32	0	0	0	0
D6	18,612	18.38	11.65	04:14	14.60	28	0	0	0	0

Table B-6. Statistics from aerial surveys of bowhead whales conducted September 1979-1984 in the Beaufort Sea.

		1979			1980			1981		
Region Name	Region Area km2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per km^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per km^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per km^2
Total	101,248	18.84	5	0.003	28.10	13	0.007	25.23	158	0.075
A	13,360	1.58	0	0.0	5.88	0	0.0	1.48	0	0.0
AI	2,361	1.86	0	0.0	12.56	0	0.0	0.98	0	0.0
A2	1,648	7.71	0	0.0	15.72	0	0.0	3.02	0	0.0
A3	2,6.98	1.48	0	0.0	8.12	0	0.0	4.38	0	0.0
A4	5,166	0.0			0.14	0	0.0	0.06	0	0.0
AS	1,497	0.0			0.0			0.0		
B	19,593	1.23	0	0.0	27.61	0	0.0	12.49	0	0.0
B1	2,614	0.0			47.16	0	0 . 0	5.26	0	0.0
B2	3,814	5.28	0	0.0	51.75	0	0.0	27.66	0	0.0
B3	2,739	1.80	0	0.0	40.71	0	0.0	27.82	0	0.0
B4	3,061	0.0			28.35	0	0.0	13.00	0	0.0
B5	5,009	0.0			4.03	0	0.0	1.41	0	0.0
B6	2,356	0.0			0.0			0.0		
c	27,156	38.33	2	0.003	58.23	6	0.003	36.14	5	0.007
c1	2,086	139.42	0	0.0	190.54	1	0.003	112.97	0	0.0
C2	1,809	78.13	0	0.0	154.06	1	0.003	148.46	0	0.0
C3	6,482	72.99	2	0.003	111.24	3	0.003	66.92	5	0.014
C4	1,803	22.13	0	0.0	30.81	0	0.0	11.13	0	0.0
C5	4,252	14.47	0	0.0	12.39	0	0.0	0.37	0	0.0
C6	10,724	1.45	0	0.0	4.72	0	0.0	0.0		
D	41,139	19.95	3	0.003	15.42	7	0.014	31.59	153	0.144
D1A	494	39.79	0	0.0	65.06	1	0.034	75.12	0	0.0
D1B	423	24.07	0	0.0	83.16	0	0.'2	71.77	0	0.0
D2A	915	140.52	1	0.010	96.88	0	0.0	121.26	0	0.0
D2B	510	47.99	0	0.0	78.36	3	0.086	152.46	5	0.072
D3	6,933	52.93	1	0.003	45.30	2	0.007	114.76	145	0.216
D4	3,462	44.12	0	0.0	5.93	0	0.0	9.21	1	0.038
D5	9,785	10.41	1	0.010	5.55	0	0.0	11.81	0	0.0
D6	1S,612	0.0			1.78	0	0.0	3.99	0	0.0

		1982			1983			1984		
Region Name	Region Area km2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per km^2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per km2	Percent of Area Surveyed	Number Bowheads Observed	Density as Number per km^2
Total	101,248	29.30	120	0.048	46.69	65	0.017	33.62	182	0.065
A	13,360	20.81	3	0.014	45.24	14	0.027	23.01	135	0.532
A1	2,361	23.84	0	0.0	40.06	0	0.0	10.3s	0	0.0
A2	1,648	33.80	1	0.021	63.68	0	0.0	31.34	40	0.912
A3	2,688	31.85	0	0.0	48.72	11	0.099	40.96	57	0.604
A4	5,166	13.44	2	0.034	38.54	3	0.017	17.96	38	0.477
AS	1,497	4.43	0	0 . 0	47.32	0	0.0	15.69	0	0.0
B	19,593	43.90	7	0.010	58.66	21	0.021	35.23	0	0.0
B1	2,614	52.93	0	0.0	47.84	0	0.0	31.99	0	0.0
B2	3,814	68,27	4	0.017	51.78	0	0.0	54.11	0	0.0
B3	2,739	63.41	2	0.014	59.92	9	0.065	51.18	0	0.0
B4	3,061	46.94	1	0.007	71.80	8	0.041	39.86	0	0.0
B5	5,009	22.95	0	0.0	60.22	3	0.010	21.29	0	0.0
B6	2,356	8.49	0	0.0	53.34	1	0.010	10.28	0	0.0
c	27,156	19.01	58	1.372	64.33	10	0.007	44.76	11	0.010
c1	2,086	60.77	0	0.0	97.34	0	0.0	78.57	0	0.0
C2	1,809	46.59	1	0.014	61.87	0	0.0	71.20	0	0.0
C3	6,482	37.58	56	0.268	79.74	2	0.003	72.15	8	0.021
C4	1,803	20.85	1	0.034	75.25	2	0.017	44.14	3	0.048
C5	4,252	6.54	0	0.0	65.45	4	0.017	27.30	0	0.0
C6	10,724	0.46	0	0.0	44.52	2	0.003	22.21	0	0.0
D	41,139	30.97	52	0.048	29.59	20	0.021	28.76	36	0.03s
D1A	494	38.50	0	0.0	17.02	0	'3.0	31.34	0	0.0
D1B	428	65.79	0	0.0	3.49	0	0.0	27.10	2	0.206
D2A	915	46.16	0	0.0	17.16	0	0.0	42.15	1	0.031
D2B	510	101.45	0	0.0	17.80	0	0.0	75.49	0	0.0
D3	6,933	59.77	48	0.1?'7	32.40	0	0.0	51.64	14	0.048
D4	3,462	46.39	0	0.0	5s.91	2	0.010	39.61	12	0.103
D5	9,785	28.64	0	0.0	46.24	17	0.045	27.76	7	0.031
D6	18,612	13.55	4	0.021	14.92	1	0.003	15.40	0	0.0

Table B-7. Statistics from aerial surveys of bowhead whales conducted October 1985 in the Beaufort Sea. Values for each region were summed where appropriate. Region numbers refer to areas depicted in Figure B-7.

*The total area of all regions was approximately 101,248 km^2; areas were approximated by straight line integration.

Region Name	Region Area km^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 km^2	Variance (*10^{-4})	Confidence Range of Density
Total	*101,248	100.00	14.58	30:04	100.00	370	10	0.0007	0.0020	0.0-0.0016
A	13,360	13.	32.69	09:17	30.90	104	4	0.0009	0.0012	0.0-0.016
A1	2,361	2.33	10.82	00:32	1.80	20	0	0	0	0
A2	1,648	1.63	44.10	01:34	5.19	21	1	0.0014	0.0145	0.0-0.039
A3	2,688	2.65,	41.84	02:22	7.87	26	0	0	0	0
A4	5,166	5.10	35.64	03:56	13.09	25	3	0.0016	0.0069	0.0-0.003
A5	1,497	1.48	28.01	00:53	2.96	12	0	0	0	0
B	19,593	19.	19.10	07:18	24.29	110	4	0.0011	0.0252	0.0-0.0042
B1	2,614	2.58	18.90	01:01	3.36	22	0	0	0	0
B2	3,814	3.77	38.95	02:48	9.31	31	0	0	0	0
B3	2,739	2.71	39.01	01:57	6.51	30	1	0.0009	0.0075	0.0-0.0027
B4	3,061	3.02	15.36	00:55	3.06	18	0	0	0	0
B5	5,009	4.95	4.47	00:37	2.05	9	3	0.0134	5.4100	0.0-0.0670
B6	2,356	2.33	0.0	00:00	0	0	0	0	0	0
c	27,156	27.	8.96	05:00	16.61	56	2	0.0008	0.0020	0.0-0.0017
c1	2,086	2.06	5.17	00:13	0.71	7	0	0	0	0
C2	1,809	1.79	17.30	00:38	2.12	14	0	0	0	0
C3	6,482	6.40	21.93	02:56	9.77	17	2	0.0014	0.0112	0.0-0.0037
C4	1,803	1.78	10.22	00:22	1.24	9	0	0	0	0
C5	4,252	4.20	7.94	00:42	2.32	7	0	0	0	0
C6	10,724	10.59	0.64	00:08	0.44	2	0	0	0	0
D	41,139	41.	10.26	08:29	28.21	100	0	0	0	0
D1A	494	0.49	1.50	00:01	0.05	1	0	0	0	0
D1B	428	0.42	5.37	00:03	0.17	3	0	0	0	0
D2A	915	0.90	17.06	00:19	1.03	8	0	0	0	0
D2B	510	0.50	13.13	00:09	0.50	8	0	0	0	0
D3	6,933	6.85	25.82	03:37	12.05	27	0	0	0	0
D4	3,462	3.42	21.93	01:29	4.93	25	0	0	0	0
D5	9,783	9.66	12.11	02:22	7.87	18	0	0	0	0
D6	18,612	18.38	1.24	00:29	1.60	9	0	0	0	0

Table B-8. Statistics from aerial surveys of bowhead whales conducted October 1979-1984 in the Beaufort Sea.

Region Name	Region Area km²	1979 Percent of Area Surveyed	1979 Number Bowheads Observed	1979 Density as Number per km 2	1980 Percent of Area Surveyed	1980 Number Bowheads Observed	1980 Density as Number per km2	1981 Percent of Area Surveyed	1981 Number Bowheads Observed	1981 Density as Number per km2
Total	101,284	24.02	145	0.072	22.24	8	0.003	17.70	46	0.031
A	13,360	19.33	5	0.024	14.06	0	0.0	4.92	0	0.0
Al	2,361	6.59	0	0.0	13.12	0	0.0	12.34	0	0.0
AZ	1,648	18.86	0	0.0	18.75	0	0.0	11.74	0	0.0
A3	2, 68a	26.99	1	0.017	32.01	0	0.0	6.39	0	0.0
A4	5,166	22.71	4	0.041	7.15	0	0.0	0.0		
A5	1.497	10.68	0	0.0	0.0			0.0		
B	19,593	11.84	41	0.213	44.2.0	4	0.007	30.14	8	0.017
B1	2,614	0.64	0	.0.0	74.43	0	0.0	34.01	0	0.0
B2	3,s14	23.54	0	0.0	81.18	0	0.0	6S.23	0	0.0
03	2,739	30.52	41	0.580	75.15	4	0.024	59.32	8	0.058
B4	3,061	10.51	0	0.0	41.84	0	0.0	21.86	0	0.0
B5	5,009	4.45	0	0.0	8.55	0	0.0	3.85	0	0.0
06	2,356	0.0			0.0			0.0		
c	27,156	62.93	81	0.058	34.38	4	0.007	24.84	16	0.027
c1	2,086	258.45	0	0.0	94.01	0	0.0	50.89	0	0.0
C2	1,809	139.58	6	0.027	79.79	0	0.0	67.71	1	0.010
C3	6,482	119.69	75	0.113	77.48	4	0.010	58.35	14	0.045
C4	1,803	23.31	0	0.0	22.51	0	0.0	28.93	1	0.024
C5	4,252	19.97	0	0.0	5.54	0	0.0	0.53	0	0.0
C6	10,724	2.52	0	0.0	0.76	0	0.0	0.0		
D	41,139	5.65	18	0.093	5.92	0	0.0	11.16	22	0.058
D1A	494	3.98	0	0.0	4.96	0	0.0	6.26	0	0.0
D1B	423	0.0			0.0			35.17	0	0.0
D2A	915	46.27	0	0.0	32.94	0	0.0	36.71	0	0.0
D2B	510	0.0			42.15	0	0.0	36.65	0	0.0
D3	6,933	16.11	18	0.192	26.12	0	0.0	31.99	22	0.117
D4	3,462	8.54	0	0.0	0.s1	0	0.0	13.09	0	0.0
D5	9,785	1.03	0	0.0	0.0			10.61	0	0.0
D6	1S,612	0.02	0	0.0	0.0			0.28	0	0.0

Region Name	Region Area km2	1982 Percent of Area Surveyed	1982 Number Bowheads Observed	1982 Density as Number per km2	1983 Percent of Area Surveyed	1983 Number Bow'heads Observed	1983 Density as Number per km2	1984 Percent of Area Surveyed	1984 Number Bowheads Observed	1984 Density as Number per km2
Total	101,248	14.91	25	0.021	18.87	12	0.007	28.80	68	0.027
A	13,360	32.04	11	0.031	43.78	8	0.017	58.36	27	0.041
Al	2,361	15.23	4	0.137	20.67	0	0.0	26.86	0	0.0
A2	1,648	39.58	4	0.072	50.24	0	0.0	78.31	5	0.045
A3	2,688	37.33	1	0.010	43.77	6	0.058	69.45	10	0.062
A4	5,166	34.40	2	0.014	51.15	2	0.010	57.71	12	0.048
A5	1,497	28.09	0	0.0	42.49	0	0.0	62.63	0	0.0
B	19,593	18.17	10	0.034	26.47	3	0.007	51.83	36	0.041
B1	2,614	7.02	0	0.0	17.69	0	0.0	52.39	0	0.0
B2	3,'s14	12.39	2	0.051	28.83	0	0.0	81.61	1	0.003
B3	2,739	12.57	7	0.240	24.67	3	0.051	90.79	11	0.051
04	3,061	24.41	0	0.0	33.69	0	0.0	58.62	24	0.158
B5	5,009	22.84	1	0.010	24.32	0	0.0	23.13	0	0.0
B6	2,356	27.23	0	0.0	26.96	0	0.0	4.54	0	0.0
c	27,156	12.18	1	0.003	14.26	0	0.0	29.75	4	0.007
c l	2,086	25.16	0	0.0	29.11	0	0.0	59.39	0	0.0
C2	1,809	26.33	0	0.0	34.31	0	0.0	69.15	0	0.0
C3	6,482	25. s2	1	0.007	22.05	0	0.0	54.70.	2	0.007
C4	1 ,s03	9.08	0	0.0	14.81	0	0.0	39.11	2	0.038
C5	4,252	6.07	0	0.0	10.68	0	0.0	23.05	0	0.0
C6	10,724	1.1s	0	0.0	4.01	0	0.0	2.00	0	0.0
D	41,139	9.52	3	0.010	10.19	1	0.003	6.99	1	0.003
D1A	494	14. s1	0	0.0	24.19	0	0.0	5.38	0	0.0
D1B	42s	9.20	0	0.0	8.37	0	0.0	3.30	0	0.0
D2A	915	2S.50	0	0.0	23.29	0	0.0	1%. s7	0	0.0
D2B	510	1s.55	0	0.0	17.01	0	0.0	40.54	0	0.0
D3	6,933	27.87	3	0.017	20.96	1	0.007	29.36	1	0.007
D4	3,462	13.89	0	0.0	20.04	0	0.0	14.46	0	0.0
D5	9,785	4.14	0	0.0	13.45	0	0.0	5.17	0	0.0
D6	18,612	3.01	0	0.0	0.93	0	0.0	0.00	0	0.0

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APPENDIX C

ASSESSMENT OF BOWHEAD WHALE MIGRATION STATUS, SEPTEMBER 1985

CONTENTS

FIGURES

TABLES

INTRODUCTION

In fall 1985, a secondary aircraft (N545N) was provided by MMS to monitor the location and migration status of bowhead whales in the eastern Alaskan Beaufort Sea. Information on the timing of bowhead movements through the Alaskan Beaufort Sea has become a key element to decision making processes of government official regulating offshore drilling and exploration. Additional tasks of the research team aboard the secondary aircraft included describing the general behavior and sound production of any whales observed. Daily reports of survey effort, survey conditions, and sighting summaries from the secondary aircraft were integrated with reports from the primary aircraft and provided to government officials responsible for regulating offshore drilling and geophysical exploration.

METHODS

The study area and aerial survey procedures utilized by the secondary aircraft were essentially the same as those described for the primary aircraft (see Methods and Materials, p. 3). In general, surveys were concentrated in the southeastern survey blocks (i.e. blocks 4 and 5) in order to intercept the bowhead migration. The survey aircraft was a de-Havilland Series 300 High-Wing Twin Otter (N545N), capable of 9 hours of continuous flight. The aircraft was equipped with bubble windows to enhance viewing, a radar altimeter, and a Global Navigation System (GNS) 500A Series that provided continuous position updates (0.6 km/survey hour, precision). The aircraft and crew of five (pilot, co-pilot, data recorder and two observers) were based at Deadhorse, Alaska, from 7 to 27 September 1985. Data collection and analysis were identical to those techniques used on board the primary survey aircraft (see Methods and Materials, pp. 5-7).

RESULTS

Survey Effort and Sighting Summary

Forty two and three-quarter hours of surveys were flown by the secondary aircraft between 9 and 27 September, with all of the effort taking place in the eastern Alaskan Beaufort Sea (Table C-1, Figure C-l). The majority (97%) of flights were search surveys to assess the bowhead migration status. Bowheads were seen predominantly east of Demarcation Bay near Komakuk Beach, between longitude 1400 W and 1420 W, and offshore to latitude 70° 06'N. One group of bowheads was seen north of Barter Island in late September (Flight C-1 1).

Table C-1. Summary of N545N flight effort, fall 1985.

Flight	Date	Transect Length (km)	Search Length (km)	Connect Length (km)	Total Length (km)	Time on Transect (hr:min)	Total Time (hr:min)	WPUE (whales/hr)
c-1	9 Sept	0	116	0	116	0:00	0:50	0.00
c-2	11 Sept	0	665	0	665	0:00	4:04	4.44
c-3	12 Sept	0	720	0	720	0:00	4:41	5.34
c-4	13 Sept	0	707	0	707	0:00	4:31	2.21
c-5	18 Sept	0	675	0	675	0:00	3:55	0.00
C-6	19 Sept	249	636	36	921	1:29	4:50	0.21
C-7	22 Sept	0	922	0	922	0:00	5:51	2.74
C-8	23 Sept	0	770	0	770	0:00	4:01	1.99
c-9	24 Sept	0	727	0	727	0:00	3:37	2.76
c-lo	25 Sept	0	530	0	530	0:00	3:10	0.63
C-n	27 Sept	0	604	0	604	0:00	3:20	4.80
Total		249	7072	36	7357	1:29	42:50	2.47

OCS Study
MMS 91-0073

North Slope Subsistence Study
Wainwright, 1988 and 1989

Social and Economic Studies

MMS
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NORTH SLOPE SUBSISTENCE STUDY
WAINWRIGHT, 1988 and 1989

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NOTICE

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North Slope Subsistence Study - Wainwright, 1988 and 1989

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I. INTRODUCTION

The North Slope Subsistence Study, sponsored by the Minerals Management Service (MMS), was a three year study of Barrow and Wainwright residents' subsistence harvests. The major focus of the study was to collect harvest and location data for species used in these communities. This report is the second of two annual reports on the findings of the Wainwright research. The first year of Wainwright data collection began on April 1, 1988 and continued through March 31, 1989. Throughout this report, this time period is referred to as "Year One." The second and final year, Year Two, continued from April 1, 1989 through March 31, 1990. In addition to presenting the Year Two data for the first time, this report contains the Year One data. The current presentation of Year One data contains some revisions to the data published in the previous report (S.R. Braund & Associates [SRB&A] and Institute of Social and Economic Research [ISER] 1989b) based on new or corrected information gathered in the course of Year Two data collection.

PURPOSE OF THE PROJECT

As conceived by the MMS, this study had two objectives. "First, to collect, analyze, and report harvest data by species for the North Slope communities of Barrow and Wainwright. A second objective is to provide comprehensive and accurate mapped subsistence ranges for these communities" during the study period (three years in Barrow and two years in Wainwright). The MMS'S data collection goal was to gather "a reliable and accurate measure of yearly and seasonal subsistence harvests for each community by species and location." And, finally, the MMS envisioned "general use area" maps for each community. Thus, the MMS conceived of the mapping portion of this project as having "mapped subsistence range s," subsistence harvest "location s," and mapped "general use areas."

Both of the terms "general use areas" and "subsistence ranges," used in their broader sense, could include the entire area hunted both successfully and unsuccessfully whereas subsistence harvest "location" refers to the more specific area of a successful harvest. Although the most comprehensive mapping of Barrow and Wainwright subsistence would include general use areas/subsistence ranges (entire hunting/gathering area) and harvest locations, the study team did not have the resources to collect, digitize, and analyze both kinds of harvest data and had to focus on the geographic component that best fit into the overall study objectives (see Methodology in Appendix C for a more detailed discussion).

Thus, the study team, in concert with the MMS, chose "successful harvest locations" as the geographic unit of measurement for this study. As hunting and fishing activities that did not result in a harvest were not recorded, this study did not record "subsistence ranges" used in a broader sense to include the entire area hunted either successfully or unsuccessfully. This report presents the findings of the Wainwright study covering the two year period from April 1, 1988 through March 31, 1990.

OVERVIEW OF WAINWRIGHT REPORT

Rather than summarize the study findings, the purpose of this overview is to explain briefly the key topics that are addressed in this report and clarify what this report does not address. Many of these points are discussed more fully in appropriate sections of the report. The study did not attempt to measure hunting effort; only information on successful harvests was recorded. In this report, the term "harvest" refers to a successful harvest.

This study: (1) collected, analyzed and reported harvest data by species for Barrow and Wainwright; and (2) provided mapped subsistence harvest sites for Barrow and Wainwright. This report presents the findings of the Wainwright study covering the two year period from April 1, 1988 through March 31, 1990.

The community of Wainwright was small enough that the study team decided to attempt to include all households in the study, i.e., conducting a census rather than a sample. Of the 124 households in the study in Year One and 119 households in Year Two, 100 households were present in the community for the full two study years. Throughout the report, these 100 households were referred to as the core study households. Data on total community harvests included the harvests of all 124 Year One and 119 Year Two households whereas data on household and per capita means and percentage of households harvesting were based on only the 100 core study households. To include households present for only part of the year in the household and per capita means would have skewed the data, and therefore the part-year households were excluded from these analyses.

Data were collected on subsistence harvests, including the species harvested, quantity harvested, location and date of harvest. (Additional information was collected about each harvest if available, such as the sex of the animal and the number of household members and non-household members participating in the harvest.) Harvest data were statistically processed to produce numeric output on several aspects of subsistence such as average household and per capita harvests per year and monthly harvests by species. These data are presented in tables and charts.

The mapped data were digitized and processed through the North Slope Borough's Geographic Information Systems (GIS) to produce harvest maps. These mapped data represent successful harvest sites only, not the total area hunted.

The study presents data for two years only. Within the two year period, the study examines average harvests for the two years as well as variability between the two years. Although the study provides thorough and representative data on harvests for those two years, longer term trends are not captured. Environmental and/or economic factors can be major influences on the level of subsistence harvests in any given year. Harvest quantities and mapped harvests for these two years reflect environmental constraints on hunting that occurred during this period and thus may underrepresent some species with respect to their importance to Wainwright residents in a broader time perspective. For example, had this study been conducted during a different two year period when sea ice conditions were more (or, alternatively, less) favorable for marine mammal hunting, the findings may have been quite different. Fluctuations in the populations of certain species, variations in their seasonal migrations, ice and storm conditions at sea, summer rainfall and winter snow cover on land are just a few examples of the kinds of environmental conditions that can influence significantly animal population levels, hunters' access to them, and consequently, the subsistence harvest levels of various species.

Constraints of employment and unemployment on hunters also can influence subsistence harvest levels. Modern Wainwright subsistence hunters require some cash for subsistence equipment as well as time for pursuing subsistence activities. Thus, employment/unemployment is a variable in households' subsistence strategies and in their harvest levels. However, this study did not analyze the nature of the relationship between economics and subsistence.

Similarly, there are many sociocultural aspects of subsistence, such as the role of kinship in subsistence and the sharing of subsistence foods, that are culturally very important to the people of Wainwright. However, the study's focus was on quantifiable harvest data and did not address the sociocultural aspects of subsistence in depth.

Although the data on number of animals harvested is presented, the study team also converted the harvests to pounds for the purpose of having a common unit of measurement by which harvest levels of multiple species can be compared and combined. The pounds data represent "usable" weight (rather than the "round" weight of the entire animal) and are based on standardized estimates of usable weight developed for each species by the Alaska Department of Fish and Game (ADF&G). The ADF&G Community Profile Database Catalog (1991 :xxii) refers to this variable as "edible pounds" and defines it as follows:

> Edible .Pounds is a measure of the portion of the kill brought into a household's kitchen for use, representing the usable pounds of the wild resources harvested (sometimes referred to as "usable weight" or "dressed weight"). In general, "edible pounds" is about 70-75 percent of round weight for fish, 60-65 percent of round weight for game, and 20-60 percent of round weight for marine mammals. and it includes bones 'for particular species. It is equivalent to" the weights of domestic meat, fish, and poultry when purchased in a store.

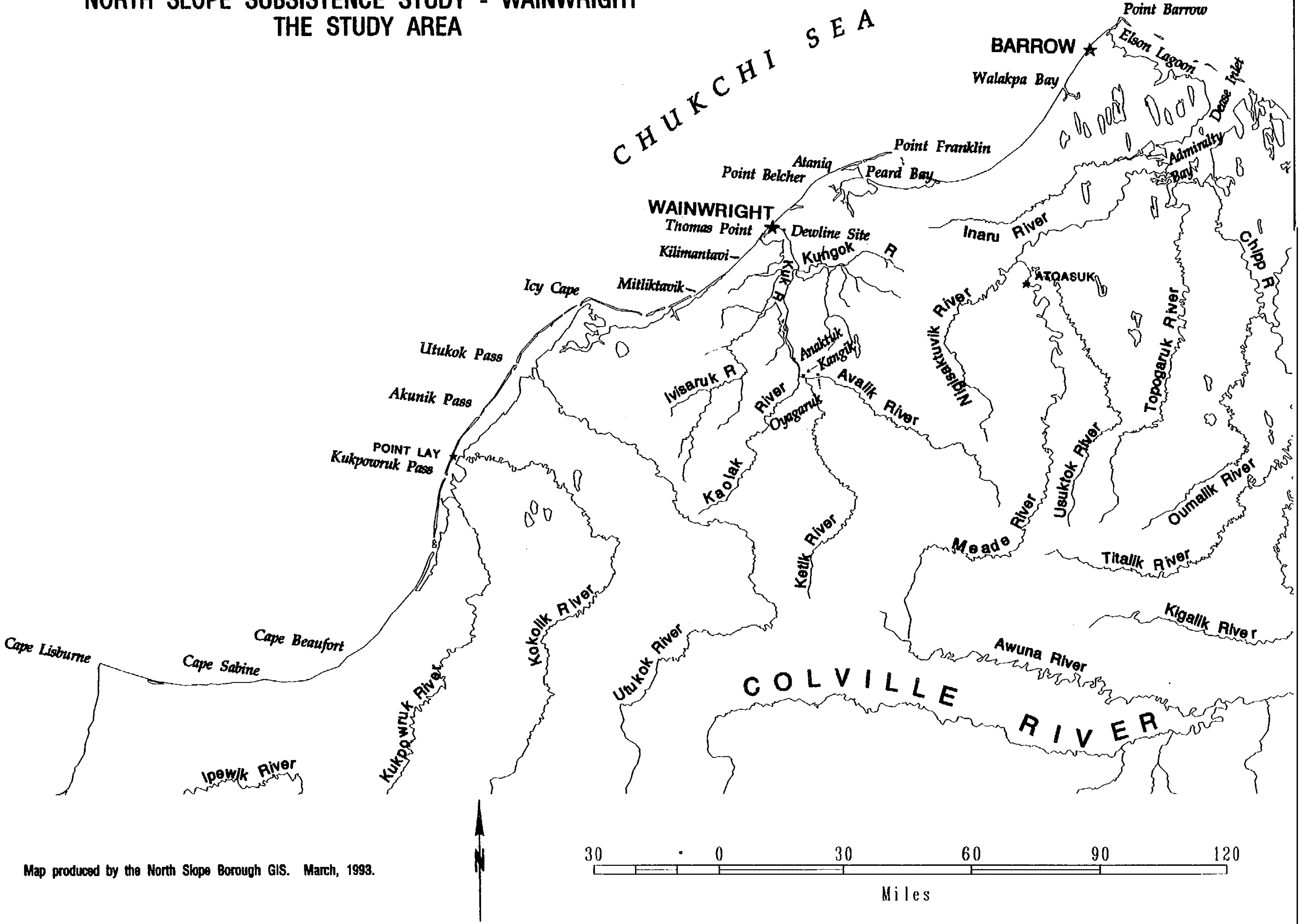
The study team chose to use the same conversion weights as ADF&G where possible to achieve a high level of consistency between the large body of ADF&G research on community subsistence harvests (based on pounds of edible weight harvested) and this study. This study was not designed as a study of consumption, i.e., household reports of how much subsistence food they ate. However, in some cases a discrepancy exists between the amount of an animal that is edible and that which is actually eaten by the typical Wainwright household. For example, the estimates of edible weight for bowhead whale and walrus include all the meat, tongue, *maktak* (skin plus the attached one to two inches of blubber), all the blubber and some of the organs from these animals. Although the blubber is used in a variety of ways, it may not all be eaten by Wainwright residents. Some of the blubber might be trimmed away on the ice. Additionally, in a successful whaling season, large quantities of blubber are sent by successful whaling captains and their crew members to Anaktuvuk Pass, Atqasuk, and other whaling communities on the North Slope that may not have had a successful whaling season. Also, Wainwright residents share large amounts of blubber, meat and *maktak* by sending it to friends and relatives in many different communities, including Fairbanks and Anchorage.

Hence, although our harvest data estimate the total amount of animal product potentially available to eat, in fact not all the product is eaten by Wainwright residents. In the case of these large animals that are widely shared beyond the community, the inclusion of all potentially usable weight has implications for the relative proportions they represent in the overall harvest, particularly when compared to the proportion that smaller species represent (e. g., fish and caribou) for which the usable weight more directly represents the amount actually eaten by Wainwright residents (according to field discussions and observations). Had this study had as its focus Wainwright consumption of subsistence foods, marine mammals (particularly bowhead and walrus) would represent a relatively smaller proportion of the total than is now the case, and terrestrial mammals, birds and fish would represent larger proportions of the total. Therefore, the reader must bear in mind that the harvest quantities presented in this report as usable pounds may not represent the quantities actually consumed by Wainwright residents (mainly in the case of bowhead whale and walrus). This project collected harvest data, not consumption data.

SETTING

The community of Wainwright is situated on the Chukchi Sea coast approximately 100 miles southwest of Point Barrow, the most northerly point in the United States, and 300 miles north of the Arctic Circle (Map 1). The community of Barrow, about 90 miles to the northeast, is both the economic and transportation hub for most North Slope villages, including Wainwright. Wainwright is

MAP 1
NORTH SLOPE SUBSISTENCE STUDY - WAINWRIGHT
THE STUDY AREA



one of eight communities within the North Slope Borough. A North Slope Borough census conducted in Wainwright in 1988 enumerated a population of 502 people living in 127 households (NSB Department of Planning & Community Services 1989).

Wainwright is located at the base of a small peninsula between the Chukchi Sea and the mouth of the Kuk River lagoon system. The Kuk River extends 50 miles inland from Wainwright and, along with its tributaries, provides a travel corridor for Wainwright residents into inland hunting areas. During the summer and fall, the rivers permit boat travel deep into the interior for fishing and hunting the migrating caribou; in the winter and spring months, the frozen rivers provide a trail network and important navigational landmarks for travel by snowmachine in pursuit of furbearing animals, caribou, ptarmigan, and spring geese.

Being situated on the coast allows Wainwright hunters to also exploit the marine environment. Residents hunt marine mammals in the open leads (sections of open water in the otherwise frozen ocean) that form offshore from Wainwright, particularly in the spring when the bowhead whales migrate along the lead system. They also hunt the returning ducks and geese along the leads and the thawing coastline in the spring. When the ocean ice breaks up, hunters drive their boats to the drifting ice floes where the walrus and bearded seals can be found. Thus, Wainwright's location provides local residents with coastal and marine harvest opportunities on the Chukchi Sea, provides access to the unique lagoon habitat adjacent to the townsite, and access to the riparian habitat of the Kuk River and its tributaries as well as the inland tundra, tundra lakes, and mountain' foothills for the mammals, birds, and fish that inhabit or migrate through those areas.

STUDY APPROACH

A full-time, on-site field coordinator organized the collection of comprehensive subsistence data through repeated contacts with study households over the study period. Essential to the study approach were at least two consecutive years of data collection. The variability inherent in subsistence harvest patterns, both seasonally and annually, underscores the importance of this long-term approach. The areas used by Inupiat hunters vary seasonally according to resource distribution patterns and hunter access. Harvest patterns vary from year to year due to environmental conditions, the population status of the targeted resources, as well as social; economic, and cultural influences. Two years of data collection represent a minimum length for this type of study. In two years, one can get a sense of some general patterns and year to year variations. However, two years is too short a period to capture the longer cycles associated with some animal populations and environmental conditions that can and do profoundly affect subsistence harvests. A longer study period would be more desirable in order to capture the variation over time that is inherent in subsistence.

A second essential element of the study approach in Wainwright was the inclusion of all households willing to participate in the study, in contrast with the stratified sampling approach implemented in Barrow (SRB&A and ISER 1993 - Appendix D). In Barrow, the study team foresaw the impossibility of contacting 937 households periodically throughout each study year and therefore applied stratified sampling techniques to obtain a sample of over 100 households to represent the community as a whole. On the other hand, the study team considered Wainwright's estimated 120 to 130 households to be a manageable number to include in the study. The implications of including all Wainwright households in the study, i.e., conducting a census rather than a sample, are discussed in detail in the Methodology (see Appendix C).

During the first year of data collection, the North Slope Borough provided both technical (e. g., Geographic Information Systems mapping) and financial (e.g., local research assistants [RAs] hired through the NSB Mayor's Job Program) support for this project. During Year Two, the NSB continued this support (except for the Mayor's Job Program which was phased out) and also provided supplemental funding for data collection and analysis. This additional funding made possible the continuous field presence in both Wainwright and Barrow, added to the scope of work SRB&A personnel were able to accomplish, and facilitated the data collection and analysis.

DIFFERENCES BETWEEN ANNUAL PROJECT REPORTS

The Wainwright Year One report (SRB&A and ISER 1989b) presented interim results of the first year of data collection in the form of tables, figures, maps and accompanying discussions. The report also described the methods used in this study to collect and process the data. As the final product in this two year study of Wainwright, this report does not focus only on presenting the Year Two data as a sequel to the Year One report, but rather presents Wainwright subsistence in broader terms by emphasizing two year average annual harvests and variability in harvests between the two study years. Extensive use is made of maps, tables and graphics to supplement the discussion of the data. Since publication of the Year One interim report (SRB&A & ISER 1989b), the Year One data have been updated and revised. The correct data are presented in this report, and the data presented in the Year One interim report are no longer valid. The Year One (revised) and Year Two data are appended separately to this report in the form of tables, graphs and maps. Also included in each year's appendix is a narrative report (the Seasonal Round) describing the sequence of harvest activities and related environmental, cultural, and economic events for that year. A third appendix presents the methodology used to conduct this study. Thus, the body of the report concentrates on Wainwright subsistence from a two year perspective, while data on the individual "years and methodological documentation are presented in the appendices.

FORMAT OF THIS REPORT

Following this introduction, the second section of the report (Overview of Wainwright Subsistence) describes the study area and summarizes demographic characteristics of the community, the general annual cycle of harvest activities, a geographic overview of subsistence, as well as community and household harvest levels for the major resource categories. The third section (Wainwright Subsistence Harvests) presents average annual harvest data as well as an examination of year to year variability based on the Year One and Two harvest data. These discussions are organized by major resource group and are species-specific. In the fourth section (Household Variation in Harvest Levels), harvest levels are discussed with regard to socioeconomic characteristics of households. Next, Barrow and Wainwright harvests are