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BELUKHA DISTRIBUTION AND MOVEMENTS OFFSHORE NORTHERN ALASKA IN SPRING AND SUMMER, 1980-84

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ABSTRACT

There were 627 sightings for a total of 9,812 belukhas during 111 aerial surveys flown offshore of northern Alaska in April/May 1980-84. Spring belukha distribution extended from waters north of St. Lawrence Island to leads nearshore in the Chukchi Sea between Point Hope and Point Barrow and east of Point Barrow along ca. 71030'N latitude in the Beaufort Sea. Annual spring sighting rates ranged from 51 whales/survey hour in 1980, a year of persistent heavy ice cover, to 13 whales/survey hour in 1981, a moderate ice year; cumulative (1980-84) spring sighting rate was 24 whales /survey hour. Daily sighting rates oscillated each spring, but annual variation in survey effort precluded comparison of migratory timing among years. Cumulative (1980-84) spring sighting rates in the northern Bering Sea were relatively uniform throughout April and peaked in mid-May; in the eastern Chukchi Sea cumulative sighting rates peaked in early May; and in the Beaufort Sea cumulative rates were relatively uniform through mid-May with peaks

near the end of the month. Cumulative (1980-84) spring swimming direction was significantly clustered about a northeast heading in the northern Bering (a = 38 “T, p < 0.005) and eastern Chukchi Sea (a = 34oT, p << 0.001) and about an easterly heading in the Beaufort Sea (a = 85oT, p << 0.001), as expected during the spring migration. There were 15 sightings for a total of 191 belukhas during 14 surveys in the Beaufort Sea in June 1980, and 19 sightings for a total of 162 whales during 13 surveys in the northern Bering Sea and along the Chukchi coast in June of 1981; surveys were not conducted in June of any other year. There were 156 sightings for a total of 609 belukhas during 138 surveys conducted in July/August 1980-84. There were scattered sightings of belukhas in Norton Sound in 1981 and one in 1983, with only one to three sightings along the Chukchi coast each summer except 1983. Belukhas were distributed across the Beaufort Sea during summers 1982-84, with only 3 sightings there in 1981 and none in 1980. The average depth at belukha sightings collected during random transect surveys ranged from 1615 m to 1931 m, with no significant difference in depth among years 1982-84 (ANOVA F = 0.56, p< 0.50). Peaks in daily summer sighting rates in the Beaufort Sea occurred in mid- and late August, but rates were an order of magnitude lower than in spring. Belukhas in the Beaufort Sea in summer were heading west, although swimming direction clustering was not statistically significant.

INTRODUCTION

Belukhas (*Delphinapterus leucas*) are widely distributed in waters offshore Alaska and the western Canadian arctic. The overall population, estimated at 15,800-18,450 whales, is comprised of five stocks, each with *a* specific summer range: Cook inlet, Bristol Bay, Norton Sound/Yukon Delta, eastern Chukchi Sea and eastern Beaufort Sea (Hazard, 1988). The eastern Beaufort Sea stock is the largest, numbering roughly 11,500- 17,500 whales, and migrates through the Bering, Chukchi and western Beaufort seas each spring enroute to the summer range in eastern Beaufort/Mackenzie Delta waters. The four smaller stocks summer in localized areas along the Alaskan coast (Frost and Lowry, 1990). All but the Cook Inlet stock probably winter along the ice edge in the Bering Sea (Hazard, 1988).

Sightings of belukhas from the eastern Beaufort Sea, eastern Chukchi Sea and Norton Sound/Yukon Delta stocks were collected, incidental to a study of bowhead whales (*Balaena mysticetus*), during aerial surveys conducted offshore of northern Alaska in spring and summer 1980-84. Observed distribution and migration patterns are summarized here to augment coastal records (Frost and Lowry, 1990) and to provide specific information regarding spring and summer migration patterns for the eastern Beaufort Sea stock. Observations of distribution, relative abundance and movement patterns for the eastern Beaufort *Sea* stock during fall 1982-91 are summarized in Clarke, Moore and Johnson (1992).

METHODS

The study area included the Bering Sea north of 62o N latitude, the Chukchi Sea east of the International Date Line (IDL) and the Alaskan Beaufort Sea east to 140° W longitude and offshore to 72o N latitude. Line transect aerial surveys were flown in blocks (Fig. 1) to determine whale distribution, and search surveys were flown along the coast, to open-water leads or polynyas, or to other areas where bowhead whales were expected, to observe behaviors and to follow migrating animals. Surveys were flown at 305-458 m altitude at speeds of 222-296 km/h in a modified *Grumman Turbo Goose* (*G21G*) equipped with a Global Navigation System (GNS) 500 that provided continuous position updating (0.6 km/h, ideally) and transect turning point programming. Although bowhead whales were the species of primary interest, the following data were routinely recorded whenever belukhas were seen: position, number of whales, number of calves (small, grey-coloured whales), and swimming direction. Belukha numbers were estimated to the nearest 10 whales for large groups (> 50 whales) and, when several small groups (2-20 whales) were seen simultaneously, data were sometimes pooled and entered as one sighting. Additional details of survey methods are provided in Ljungblad, Moore and Van Schoik (1986).

Annual survey effort and belukha distribution were plotted for spring (April/May) and summer (July/August) for 1980-84. Surveys were flown in June only in 1980-81, so these data are plotted separately. Belukha migration patterns were inferred for each

season from analyses of daily sighting rate (number of whales/survey hour) and the Rayleigh test for circular distributions applied to observed swimming direction (Zar, 1984).

RESULTS

Spring

There were 111 frights totalling 403.7 survey hours conducted in April/May 1980-84 (Table 1; Fig. 2). Annual survey effort ranged from 136.4 hours in 1981 to 53.2 hours in 1984. Belukha numbers and sighting rate were highest in *1980,* the fewest whales were seen in *1983* although sighting rate was lowest in 1981. Belukha spring distribution ranged from Norton Sound and waters north of St. Lawrence Island through the southern and eastern Chukchi Sea and across the Alaskan Beaufort Seato about 1410 W longitude (Fig. 2). Sightings were concentrated in areas where open water occurs each spring near Bering Strait, in the nearshore lead between Point Hope and Point Barrow, and in the offshore lead northeast of Point Barrow. Surveys were flown west of the nearshore lead in the Chukchi Sea only in 1984, and heavy ice cover (> 95% surface cover) likely impeded sightings there. Similarly, the offshore lead in the Beaufort Sea generally tapers to a series of shear zone cracks east of 150° W longitude (Braham, Fraker and Krogman, 1980), and heavy ice conditions probably contributed to the few spring sightings of belukhas in the eastern Alaskan Beaufort Sea.

Daily sighting rates oscillated each spring, but variation in annual survey effort among the northern Bering, Chukchi and Beaufort seas precluded direct inter-annual comparisons of migration timing (Fig. 3). Peak daily sighting rates occurred in mid- and

late May 1980 in the northern Bering Sea and the Beaufort Sea, respectively; on 10 May 1982 in the Beaufort Sea; on 24 April 1983 in the northern Bering Sea; and on 5 May 1984 in the Chukchi Sea. In 1980 and 1983, sighting rate peaks in the northern Bering Sea were followed 8-9 days later by peaks in the Beaufort Sea (1980: 15 May to 23-24 May; 1983:24 April to 3 May), suggesting a pulse-like character to the migration, but similar oscillations were not apparent from data in the other years. Tine oniy year that belukha sighting rate was correlated with bowhead whale sighting rate was 1982 (pearson r = 0.4985, $p < 0.01$), although there was a trend for correlation in 1981 (pearson r = 0.2335, $p < 0.1$). These data suggest that while belukhas and bowhead whales migrate during the same period, migration timing is not necessarily coordinated.

Daily sighting rates and swimming direction analyses collated by sea for the compiled 1980-84 data illustrate the range of temporal patterns of occurrence observed over the 5-year period (Fig. 4). In the northern Bering Sea, sighting rates were relatively high from mid- to late April, with the peak in mid-May a direct result of 1980 sightings. In the Chukchi and Beaufort seas, sighting rates were high from late April through mid-May, with the late May peak in the Beaufort Sea again due to 1980 sightings. Swimming direction was significantly clustered about northeasterly headings in the northern Bering and Chukchi Sea, with a significant easterly mean heading for whales in the Beaufort Sea (Fig. 4). Although statistically significant, the smaller 'r' and 'z' values for the northern Bering Sea data indicate that whales there were not as strongly directed in their movements as whales seen in the Chukchi and Beaufort seas.

Summer

There were 14 surveys (40.6 hours) flown in June 1980 in the Beaufort Sea and 13 surveys (54.0 hours) flown in June 1981 in the northern Bering and eastern Chukchi seas (Fig. 5). In 1980, there were 15 sightings of 191 belukhas along ca. 71030'N between 1480-1410 W longitude. Swimming direction was recorded for only two whales, both heading 82°T. In 1981, there were 19 sightings of 162 belukhas: 1 sighting of 14 whales north of Cape Lisburne on 10 June; 4 sightings of 99 whales in southern Kotzebue Sound on 15 June; 6 sightings of 37 whales in northern Kotzebue Sound on 16 June; and 8 sightings of 12 whales in Norton Sound on 22 June. Swimming direction was recorded for only four whales, with no heading predominant.

There were 138 flights totalling 517.4 survey hours conducted in July/August 1980-84 (Table 2; Fig. 6). Annual survey effort ranged from 48.2 hours in 1980 to 131.5 hours in 1982. Belukha numbers and sighting rate were highest in 1981 and 1983 and lowest in *1980.* Belukha summer distribution consisted of few and scattered sightings in southern Norton Sound (1981, 1983), and along the Chukchi coast (each summer except 1983), with most sightings in the Beaufort Sea (1982-83-84; Fig. 6).

Summer daily sighting rates in the Beaufort Sea peaked in mid- and late August (Fig. 7), but were an order of magnitude lower than spring rates (see Fig. 4). Although not statistically significant, swimming direction for belukhas seen in the Beaufort Sea was clustered about northwesterly headings. The mean heading for whales seen in July 1984

was 279 OT (z = 1.40, $0.2 < p < 0.5$; n = 8), while the mean heading for cumulative August 1982-84 data was 327oT (z = 1.55, $0.2 < p < 0.5$; n = 76). The lack of belukha sightings in the Beaufort Sea in 1980 and 1981 could have been related to the confinement of most surveys to waters overlying the continental shelf where depth is < 200 m. Average depth at belukha sightings collected while on random transect survey (i.e. 'random' sightings) indicates that whales were generally found in continental slope (i.e. water > 200 m depth), rather than continental shelf habitat (Table 3). Annual mean depth at sightings ranged from 1615 m to 1931 m, with large standard deviations describing the broad spread around the mean values. There was no significant difference in mean depth among years 1982-84 (ANOVA, F = 0.56, $p < 0.5$; a difference of 435 m in mean depth among years 1982-84 would have been detected 90% of the time at $\alpha = 0.05$ by this test).

DISCUSSION

Belukhas migrate northeastward through the northern Bering and eastern Chukchi seas in spring, then turn eastward and migrate along ca. 71 030'N latitude in the Alaskan Beaufort Sea. Fraker (1979) reported belukhas migrating between 710 and 75030'N in the western Canadian Beaufort Sea, which suggests that the extensive shorefast ice off the Alaska/Canada north coast keeps belukhas well offshore in spring. Comparisons of spring sighting rates between the northern Bering Sea and Beaufort Sea indicate that the spring belukha migration occurs in pulses, but the pulses seem less well-defined than for bowhead whales (Ljungblad et al., 1986). Of note, the major pulses of the bowhead migration were delayed by 20-30 days in 1980, seemingly by heavy ice at the Bering Strait

(Johnson, Braham, Krogman, Marquette, Sonntag and Rugh, 1981; Ljungblad et al., 1986); belukha sighting rates also peaked late in May 1980 in the Beaufort Sea. However, migration timing between bowheads and belukhas, as compared by daily sighting rates, was correlated in only one of five springs. Observed annual variation in belukha numbers and sighting rates could be a result of: a) differences in the survey timing relative to the timing of the belukha spring migration; b) the effect of environmental conditions on belukha distribution and movements; or c) the effect of environmental conditions on the ability of aerial observers to see belukhas; or some combination of all these factors.

Frost and Lowry (1990) provide a comprehensive review of belukha distribution, abundance and movements along the coast of western Alaska. Belukhas are occasionally seen in Norton Sound from November-March, with an increase in occurrence in April-May. This information, combined with data presented here (see Fig. 2), illustrates the dispersive nature of belukha distribution that occurs with the onset of ice break-up in spring, Belukha distribution in June seems largely confined to coastal waters of western Alaska (Frost and Lowry, 1990), although the sightings reported here for 1980 (see Fig. 5) indicate that some whales are yet migrating eastward. Conversely, few whales were seen along the western Alaska coast in July-August, with summer sightings largely confined to belukhas moving generally westward through continental slope waters in the Beaufort Sea. These data correspond with the report of Harrison and Hall (1978) of four belukha sightings during July/August 1975-77 in the western Beaufort Sea in water

1800 m deep. These whales seemingly represent the vanguard of the fall migration of belukhas from the Canadian Beaufort to the northeastern Chukchi Sea, as discussed in Clarke et al. (1992).

This summary of belukha distribution and movements in spring and summer expands upon earlier reviews of belukha occurrence in Alaskan waters (eg. Harrison and Hall, 1978; Braham, Krogman and Carroll, 1984). The presentation of whale numbers, sighting rates and swimming direction associated with distribution plots for belukhas seen offshore in spring and summer augments data on belukha seasonal occurrence along the Alaskan coast (e.g., Frost and Lowry, 1990), and may serve as baseline information during the planning of future research.

ACKNOWLEDGEMENTS

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Table 1. Summary of spring survey effort, belukha sightings and sighting rate 1980-84. SI/BE = number of sightings/number of belukha; BE/H = number of belukha/survey hour.

YEAR	SURVEY PERIOD	No. FLIGHTS	HOURS	SI/BE	BE/H
1980	20 April-31 May	24	68.4	272/3,471	50.7
1981	5 April-22 May	35	136.4	134/1 ,732	12.7
1982	23 April-25 May	23	82.0	78/1 ,650	20.1
1983	21 April-11 May	16	63.7	68/1 ,397	21.9
1984	24 April-10 May	13	53.2	75/1,562	29.4
Cumulative (1980-84)		111	403.7	627/9,81 2	24.3

Table 2. Summary of summer survey effort, belukha sightings and sighting rate, 1980-84. SI/BE = number of sightings/number of belukha; BE/H = number of belukha/survey hour.

YEAR	SURVEY PERIOD	No. FLIGHTS	HOURS	SI/BE	BE/H
1980	1 July-30 August	17	48.2	3/3	0.1
1981	2 July-30 August	27	103.1	21/175	1.7
1982	10 July-28 August	32	131.5	39/114	0.9
1983	20 July-31 August	31	116.2	48/188	1.6
1984	17 July-31 August	31	118.4	45/129	1.1
Cumulative (1980-84)		138	517.4	156/609	1.2

Table 3. Depth at random belukha sightings in the Beaufort Sea, summer 1982-84.

YEAR	n	RANGE	MEDIAN	MEAN	s.d.	95?40 c.].
1982	27	55-3255	2158	1742	1260.7	1243-2240
1983	29	53-3365	2385	1931	1175.9	7483-2378
1984	32	18-3109	2028	1615	1061.3	1233-1998

FIGURE CAPTIONS

1. Study area and aerial survey blocks.

2. Annual spring (April/May) survey effort and belukha distribution. Each symbol on the distribution maps represents a sighting of one or more whales, see Table 1: SI/BE.

3. Annual daily sighting rate (number belukha/survey hour) each spring, 1980-84. Be = northern Bering Sea survey; C = Chukchi Sea survey; B = Beaufort Sea survey; o = no survey; ● = survey, but no sightings.

4. Belukha daily sighting rate (number of belukha/survey hour) and swimming direction by sea for cumulative (1980-84) data. o = no survey; ● = survey, but no sightings.

5. Survey effort and belukha distribution in June: 1980 = 40.6 survey hours; 15 sightings for a total of 191 whales; 1981 = 54.0 survey hours; 19 sightings for a total of 162 whales.

6. Annual summer (July/August) survey effort and belukha distribution. Each symbol on the distribution maps represents a sighting of one or more whales, see Table 2: SI/BE.

7. Annual daily sighting rate (number belukha/survey hour) in the Beaufort Sea each summer, 1982-84. Be = northern Bering Sea survey; C = Chukchi Sea survey; o = no survey; ● = survey, but no sightings.

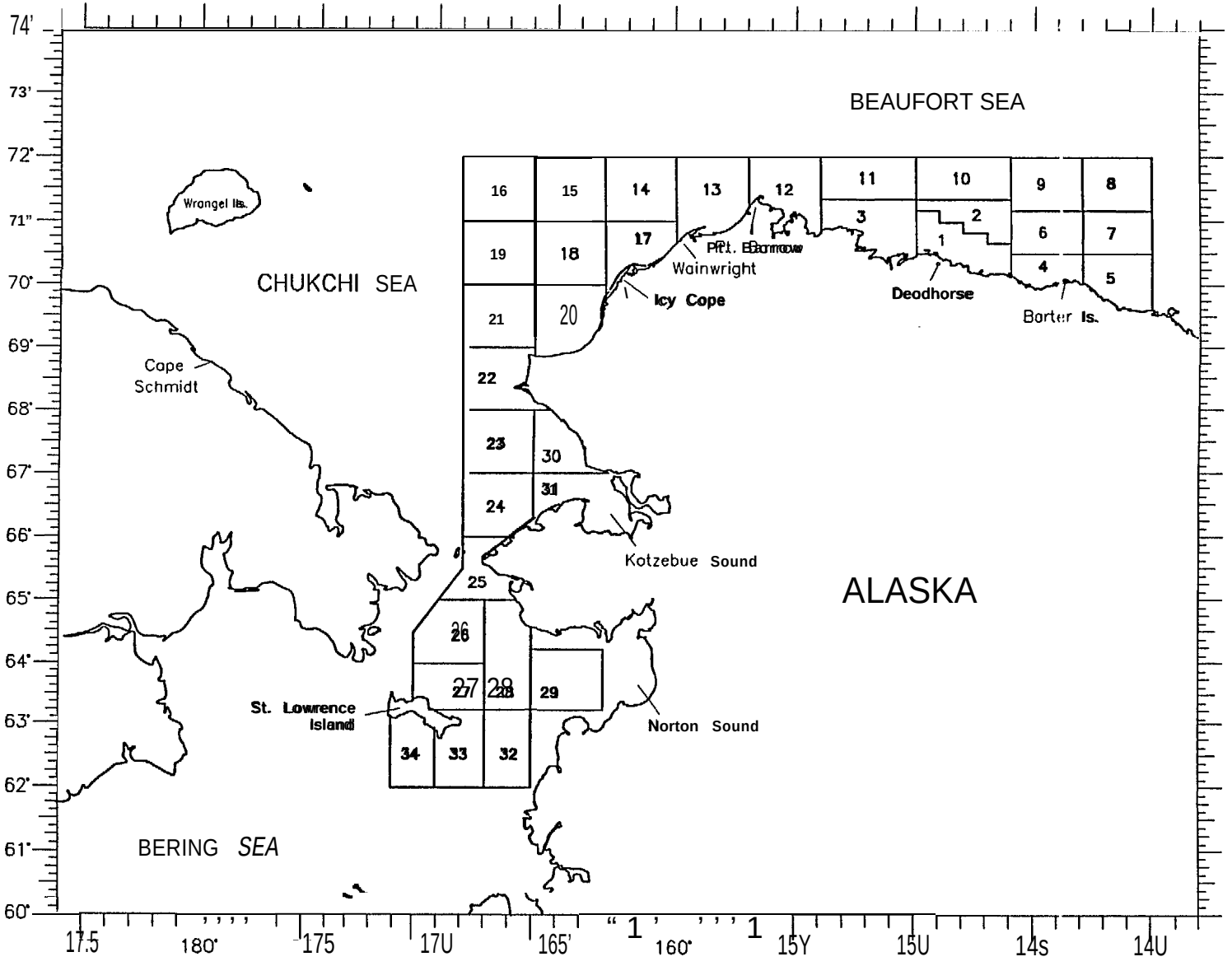

Figure 1

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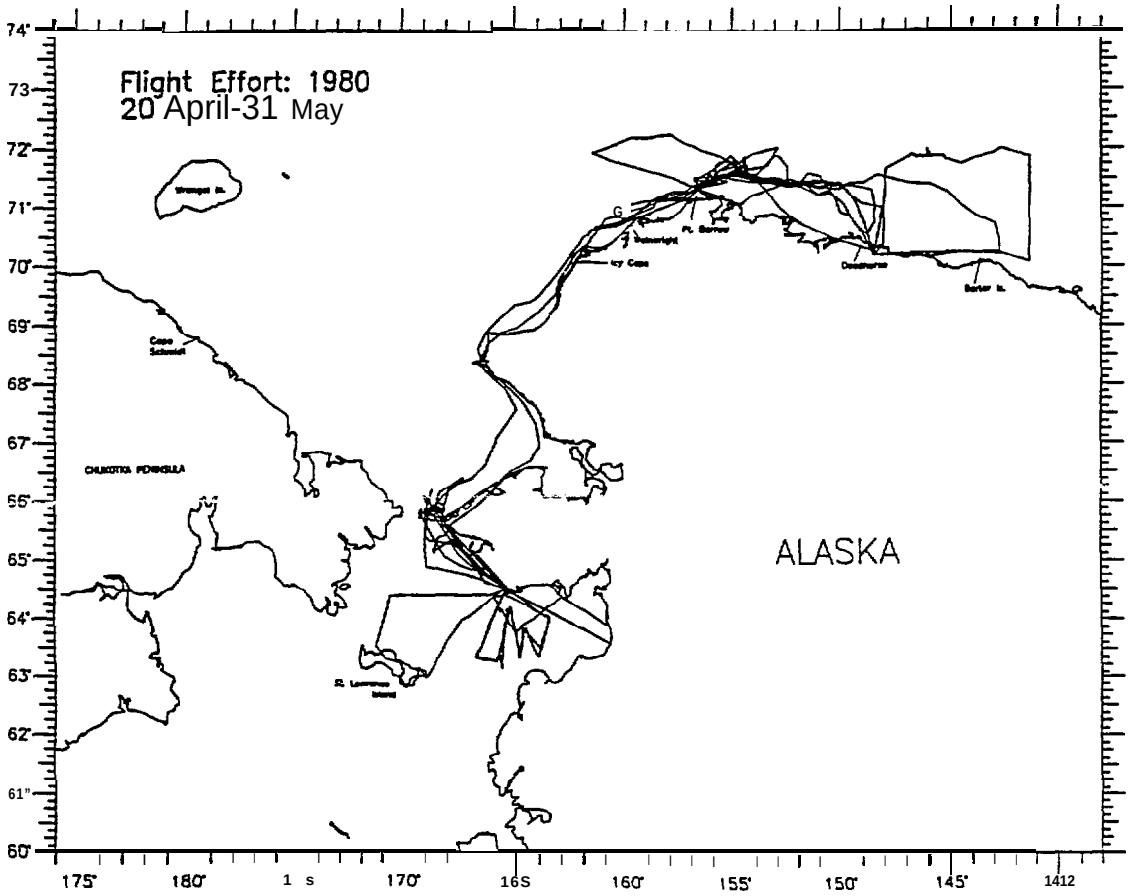

Flight Effort: 1980
20 April-31 May
ALASKA
CHUKOTKA PENINSULA

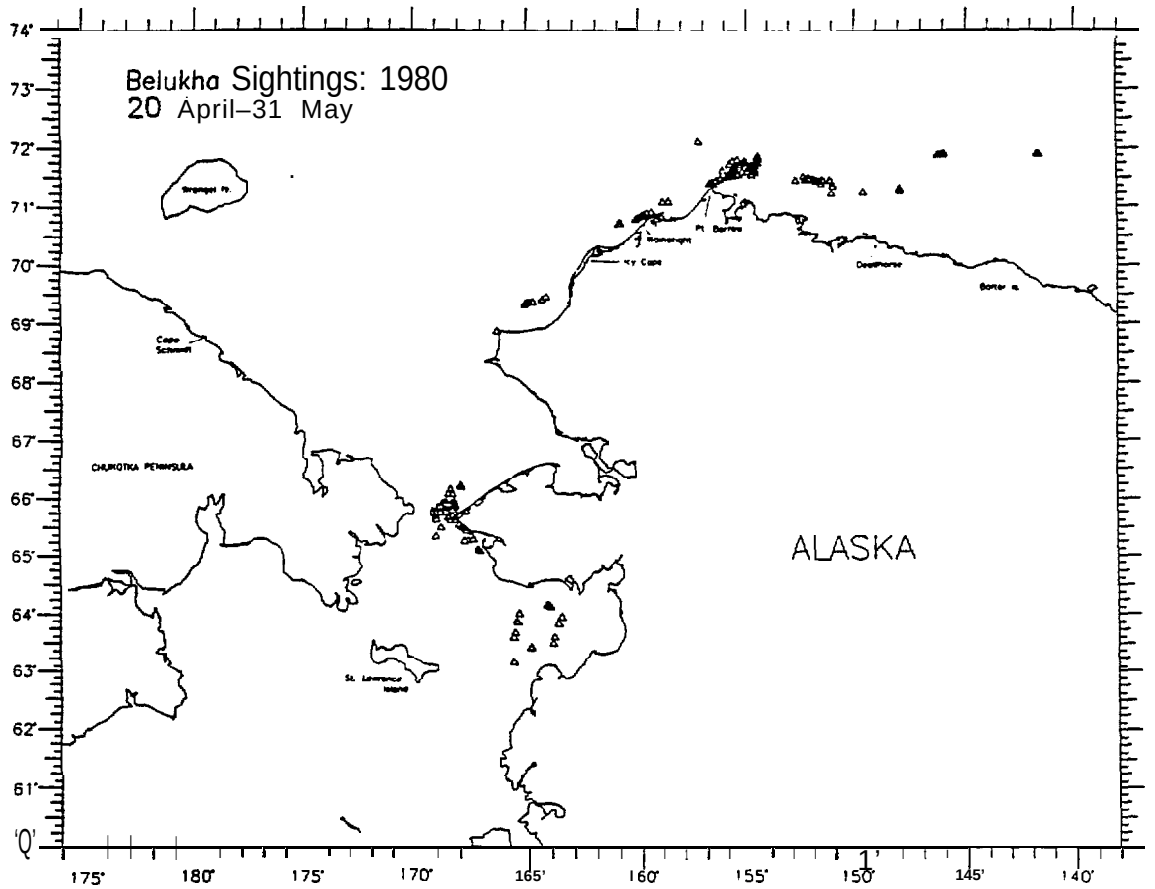
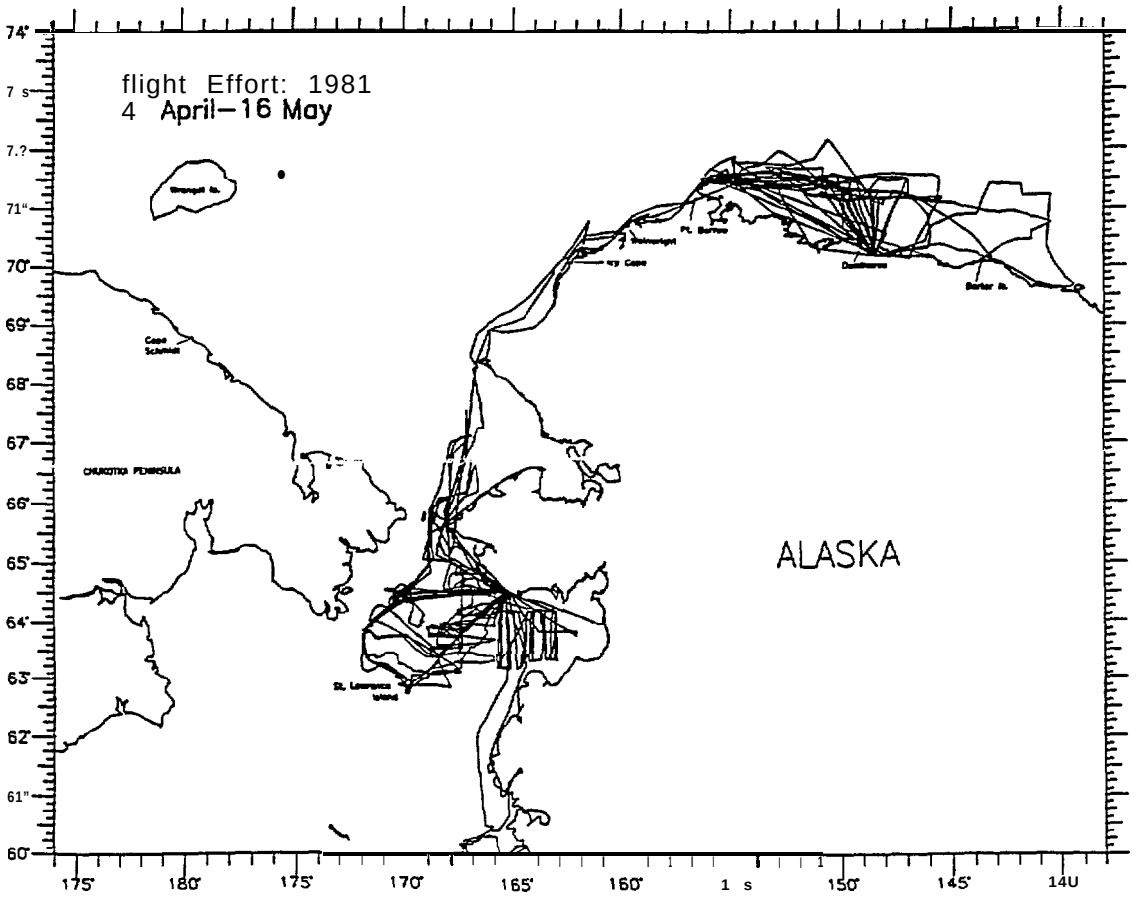

Belukha Sightings: 1980
20 April–31 May
ALASKA
CHUKOTKA PENINSULA

Figure 2.


flight Effort: 1981
4 April—16 May
ALASKA
CHUKOTKA PENINSULA
Cape Schmidt
Barrow Pt.
Pt. Barrow
Icy Cape
Oliktok Pt.
Barter Is.
St. Lawrence Island
74°
73°
72°
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69°
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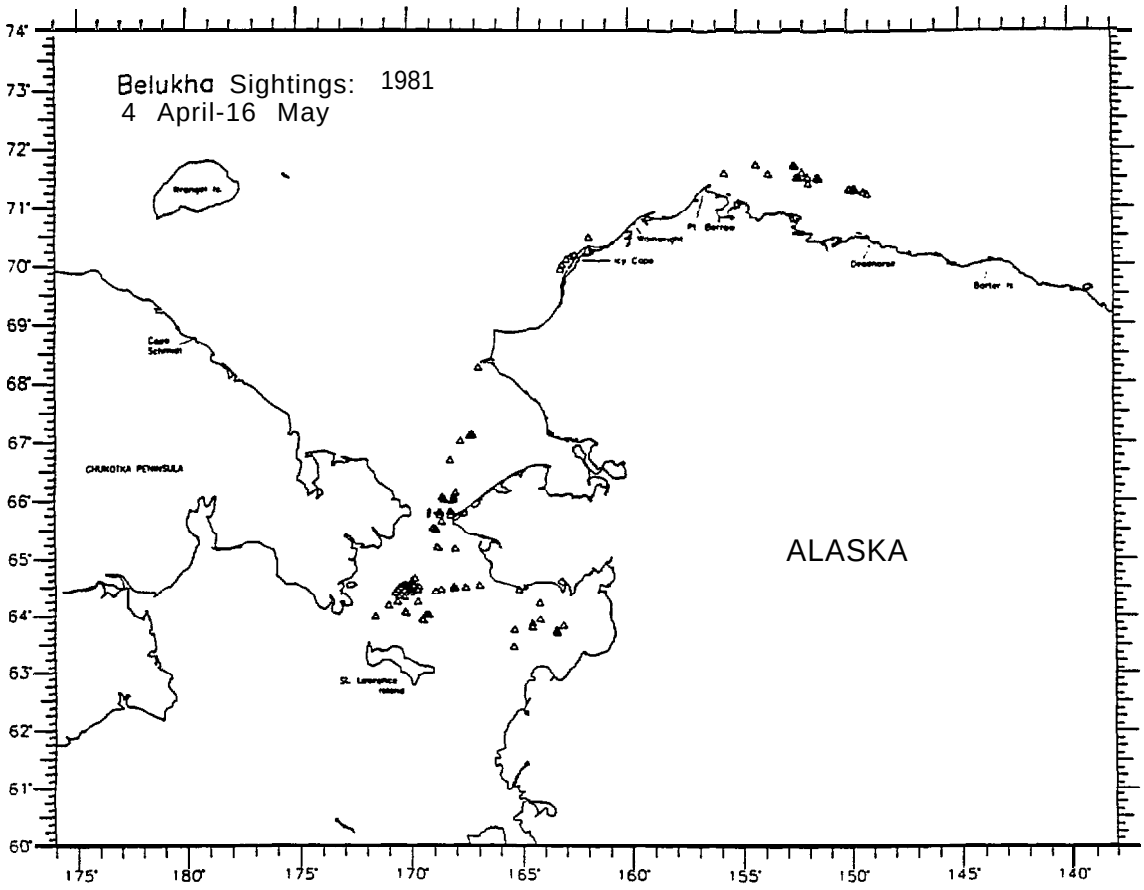
Belukha Sightings: 1981
4 April-16 May
ALASKA
CHUKOTKA PENINSULA
Cape Schmidt
Barrow Pt.
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Oliktok Pt.
Barter Is.
St. Lawrence Island
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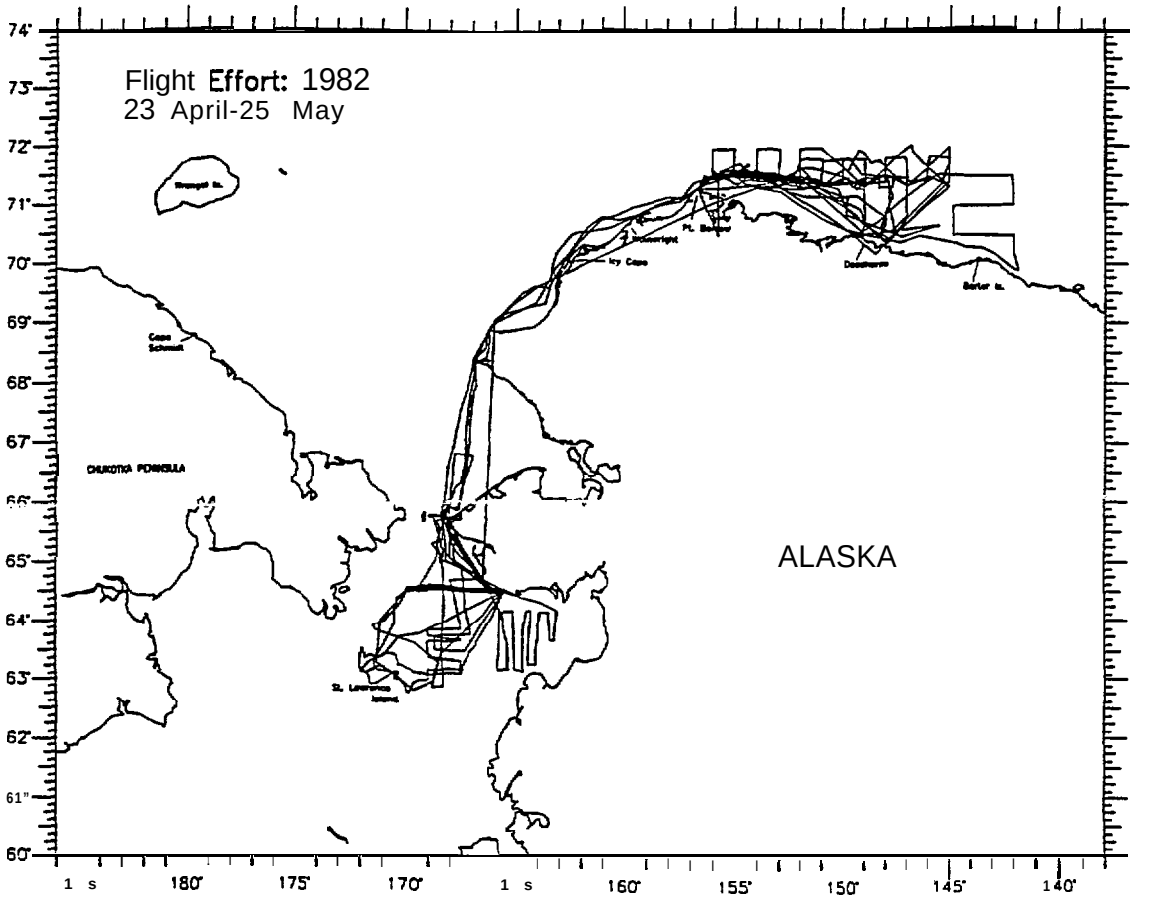
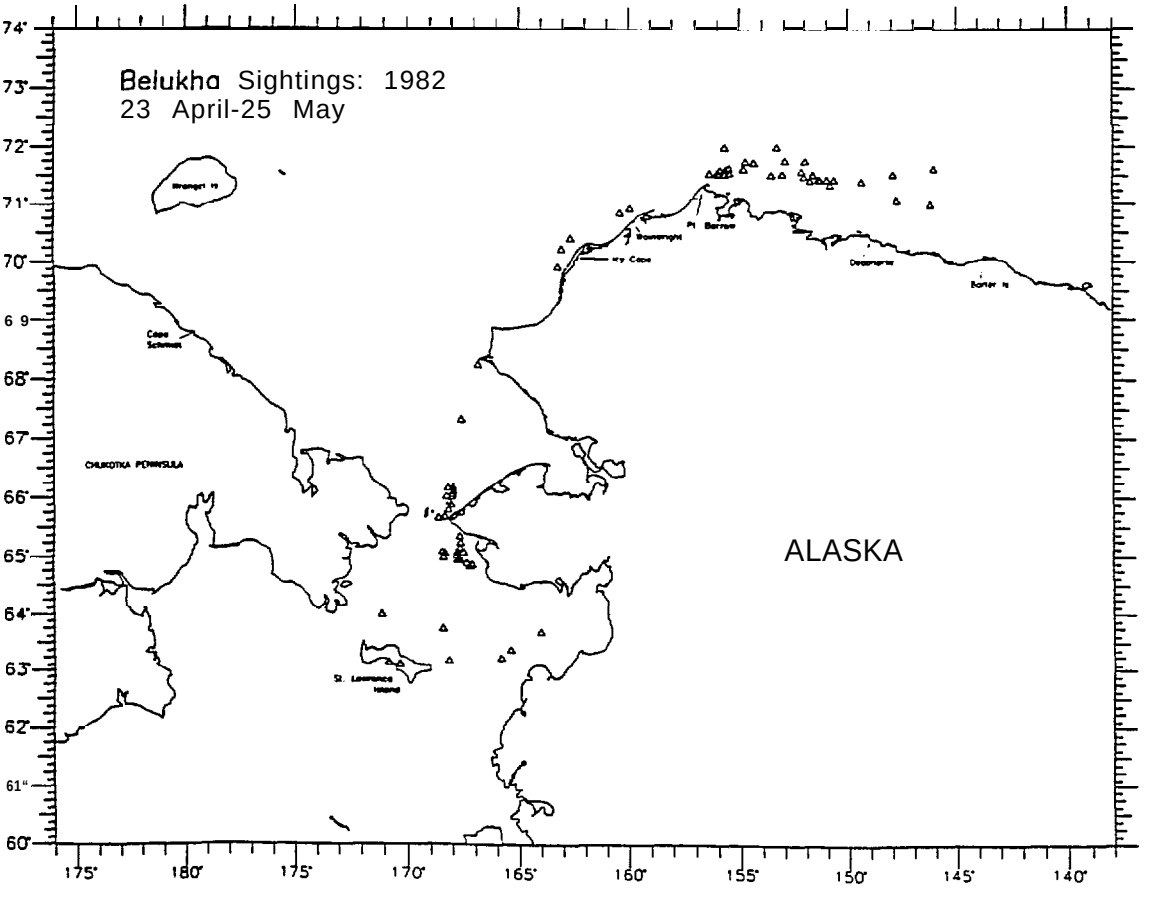
Figure 2.


Flight Effort: 1982
23 April-25 May
CHUKOTKA PENINSULA
ALASKA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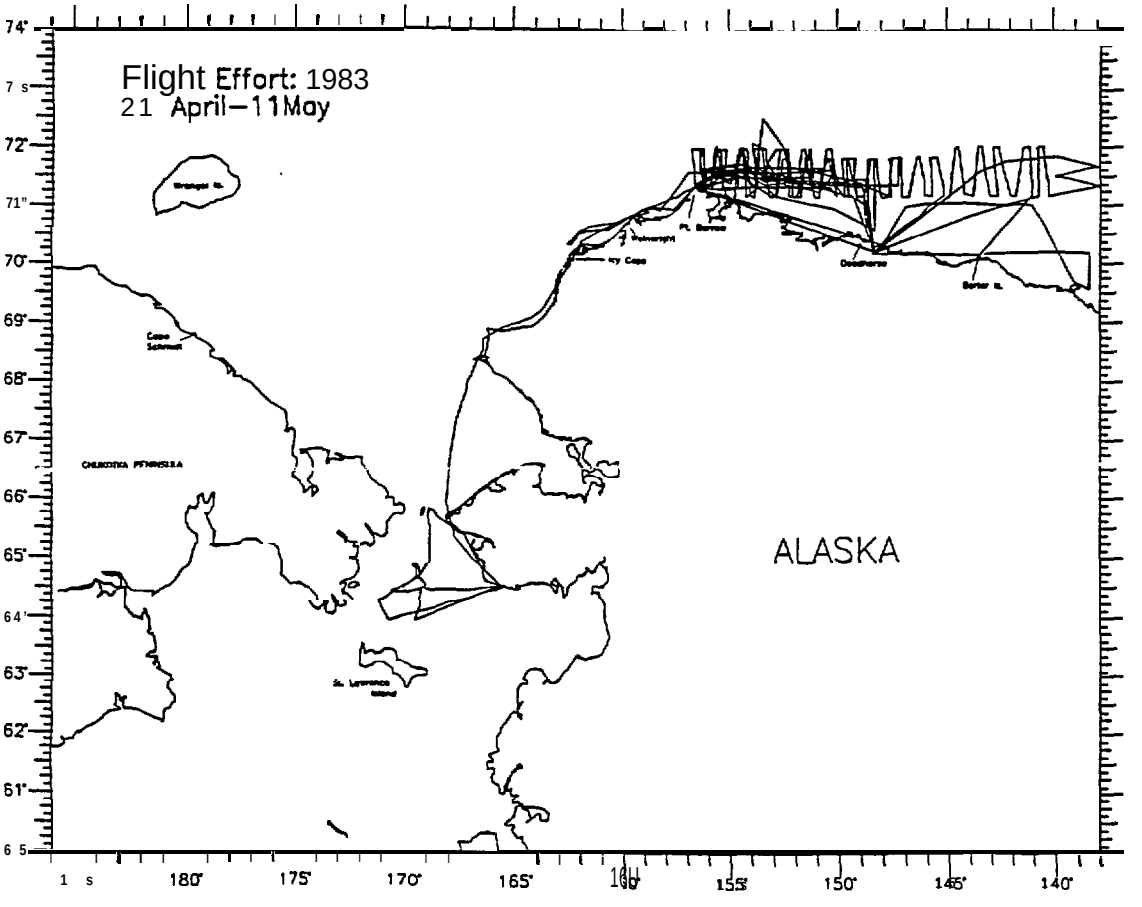
23 April-25 May
CHUKOTKA PENINSULA
ALASKA

Figure 2.


Flight Effort: 1983
21 April–11May
ALASKA
CHUKOTKA PENINSULA

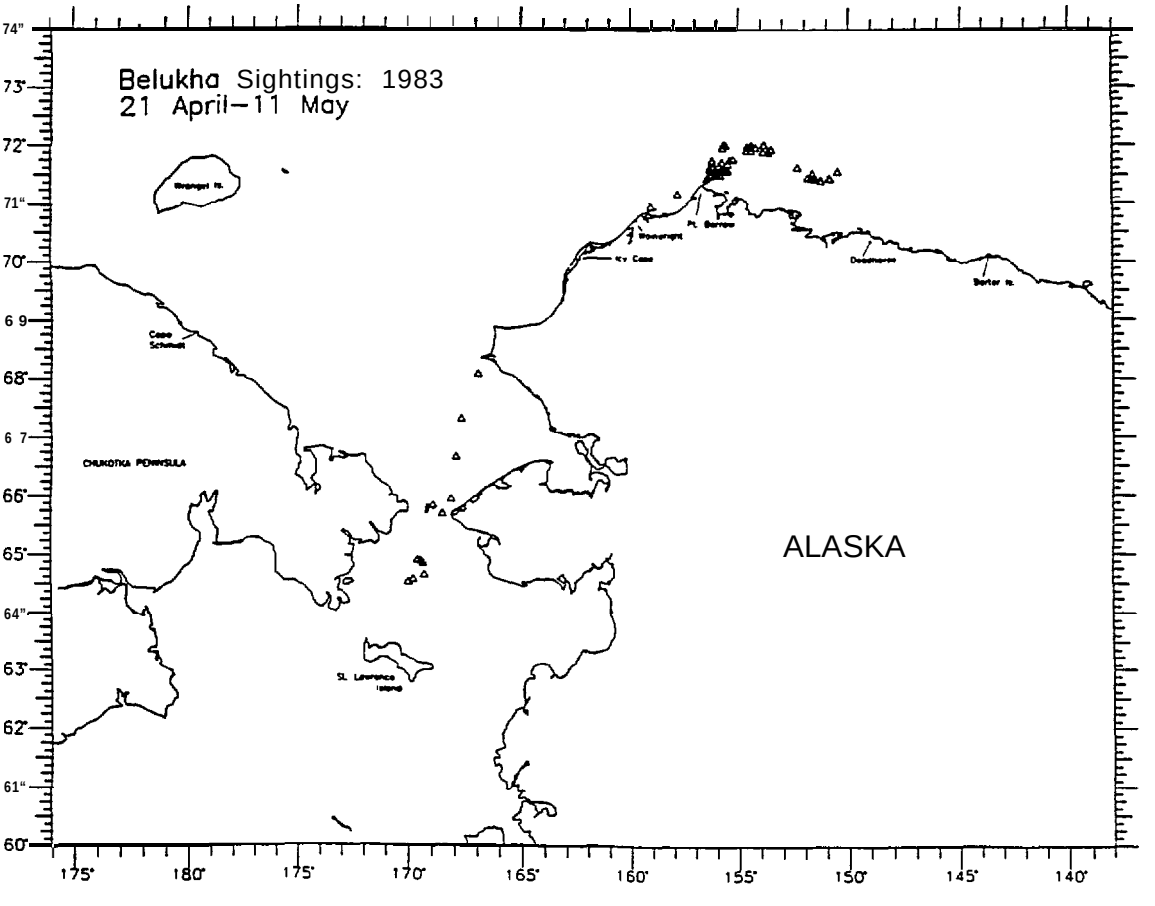
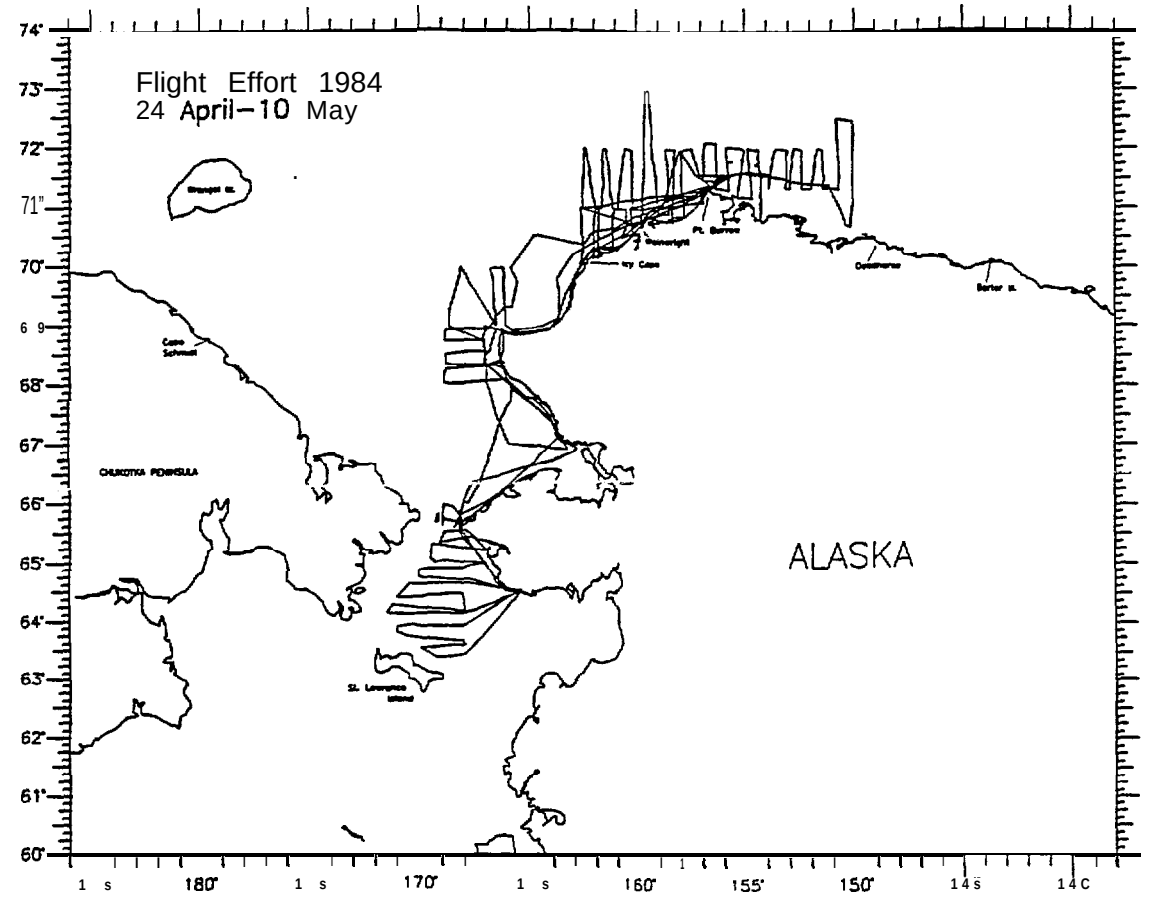

Belukha Sightings: 1983
21 April–11 May
ALASKA
CHUKOTKA PENINSULA

Figure 2.


Flight Effort 1984
24 April–10 May
ALASKA
CHUKOTKA PENINSULA
Cape Schmidt
St. Lawrence Island
Wrangel Is.
Pt. Barrow
Icy Cape
Demarcation
Barter Is.
74°
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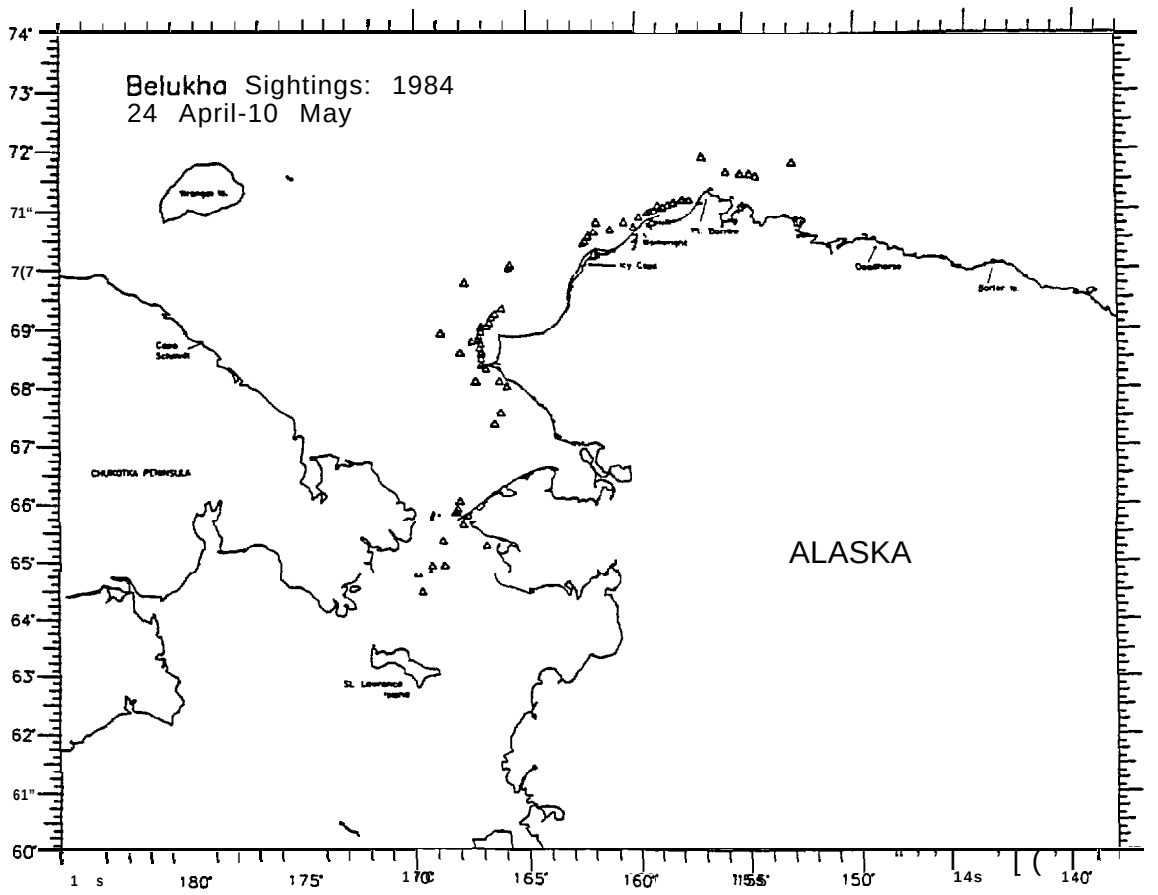
Belukha Sightings: 1984
24 April-10 May
ALASKA
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St. Lawrence Island
Wrangel Is.
Pt. Barrow
Icy Cape
Demarcation
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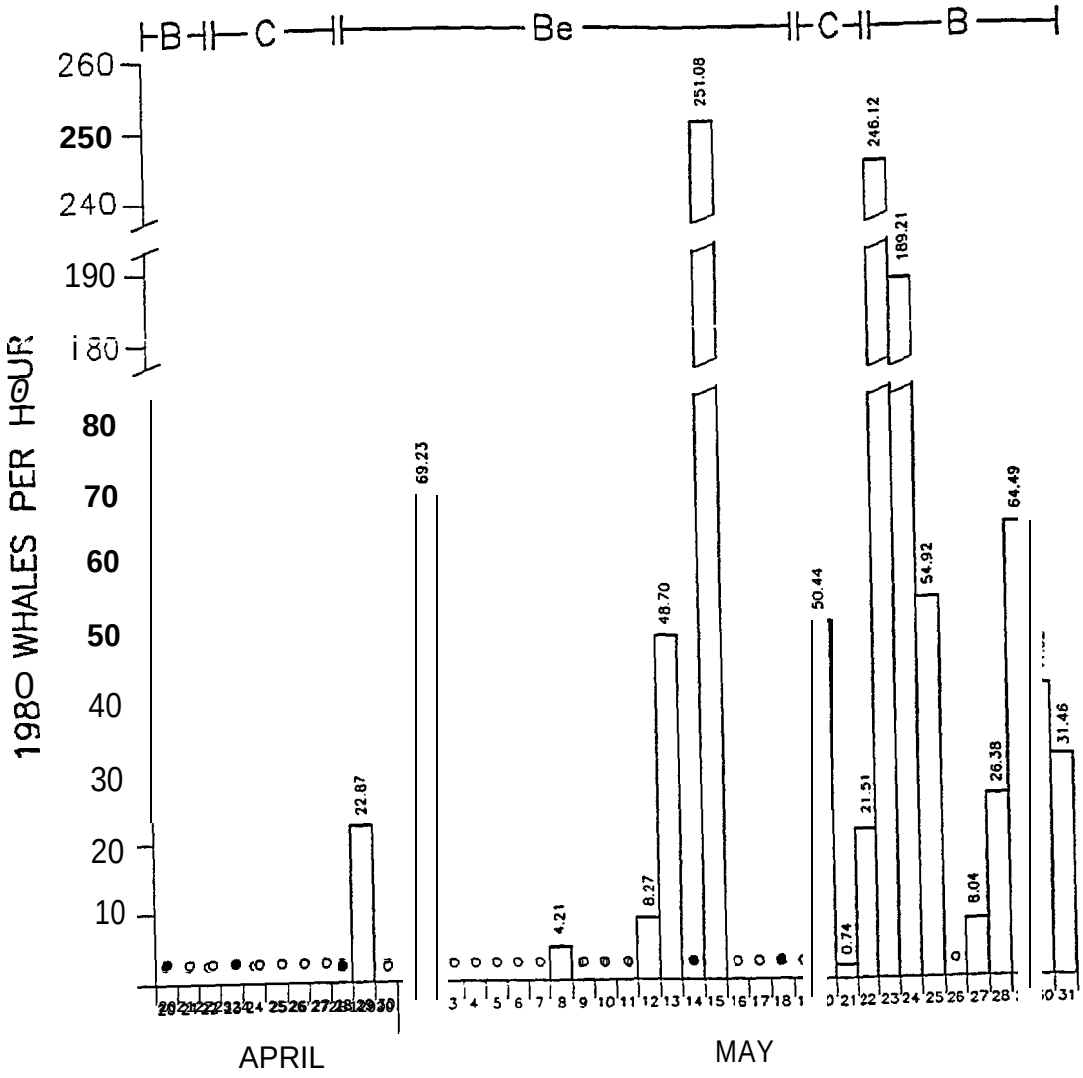
Figure 2.


B
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B
1980 WHALES PER HOUR
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250
240
190
180
80
70
60
50
40
30
20
10
22.87
69.23
4.21
8.27
48.70
251.08
50.44
0.74
21.51
246.12
189.21
54.92
8.04
26.38
64.49
31.46
APRIL
MAY

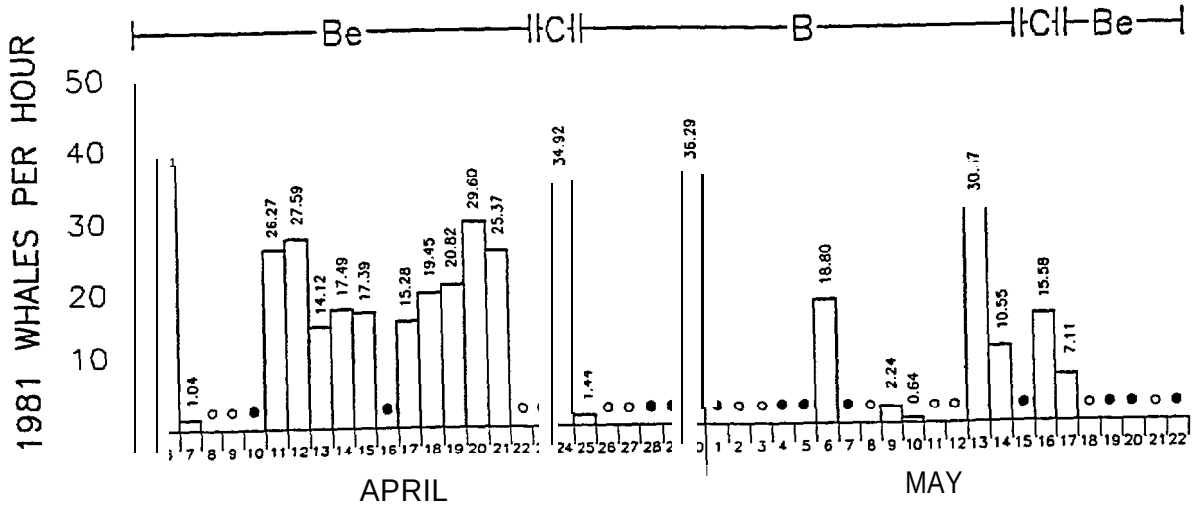

Be
C
B
C
Be
1981 WHALES PER HOUR
50
40
30
20
10
1.04
26.27
27.59
14.12
17.49
17.39
15.28
19.45
20.82
29.60
25.37
34.92
1.44
36.29
18.80
2.24
0.64
30.17
10.55
15.58
7.11
APRIL
MAY

Figure 3.

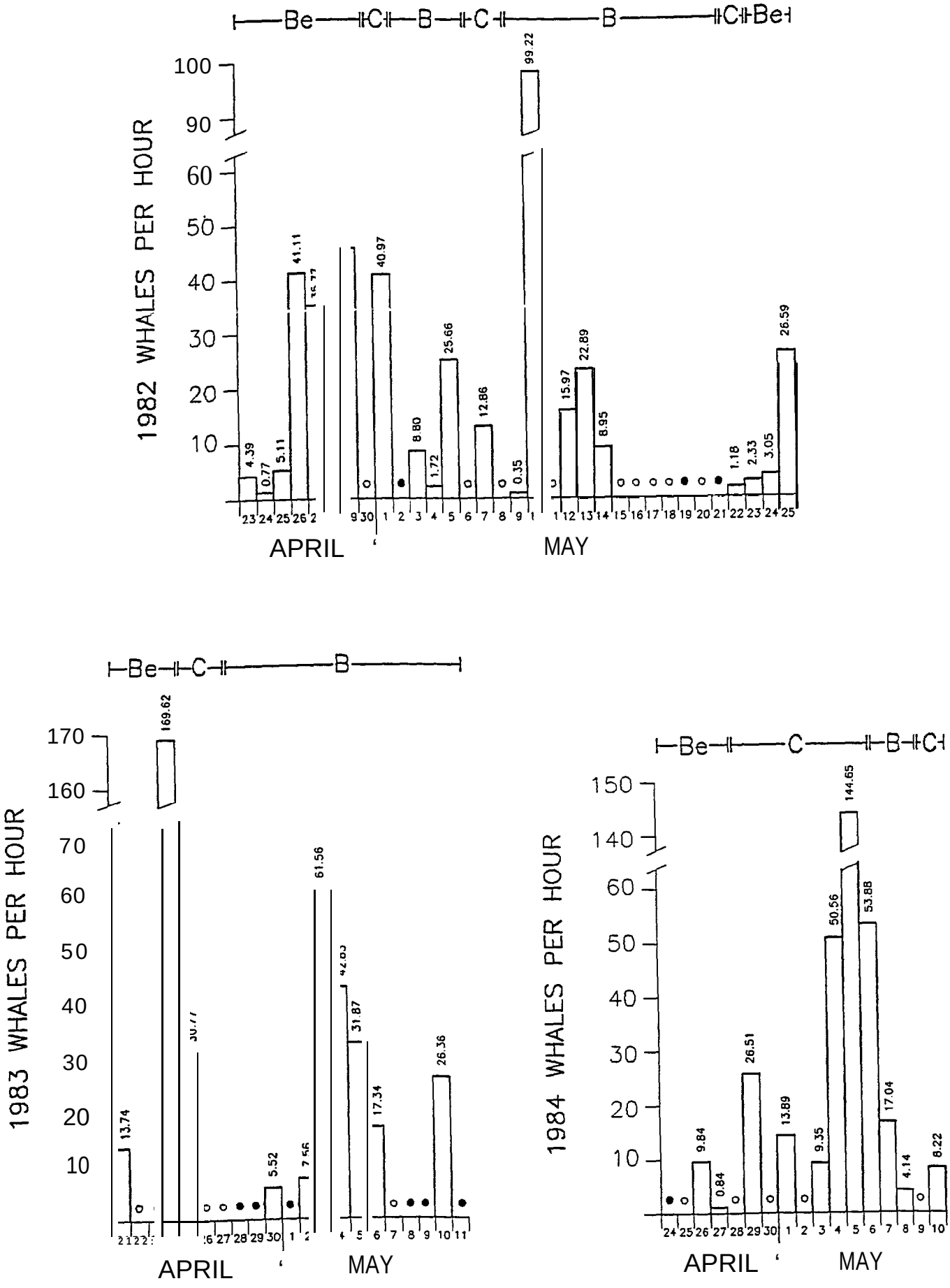

Be
C
B
C
B
C
Be
1982 WHALES PER HOUR
100
90
60
50
40
30
20
10
4.39
0.77
5.11
41.11
40.97
8.80
1.72
25.66
12.86
0.35
99.22
15.97
22.89
8.95
1.18
2.33
3.05
26.59
APRIL
MAY
1983 WHALES PER HOUR
170
160
70
60
50
40
30
20
10
169.62
13.74
5.52
61.56
31.87
17.34
26.36
APRIL
MAY
1984 WHALES PER HOUR
150
140
60
50
40
30
20
10
144.65
9.84
0.84
26.51
13.89
9.35
50.56
53.88
17.04
4.14
8.22
APRIL
MAY

Figure 3.

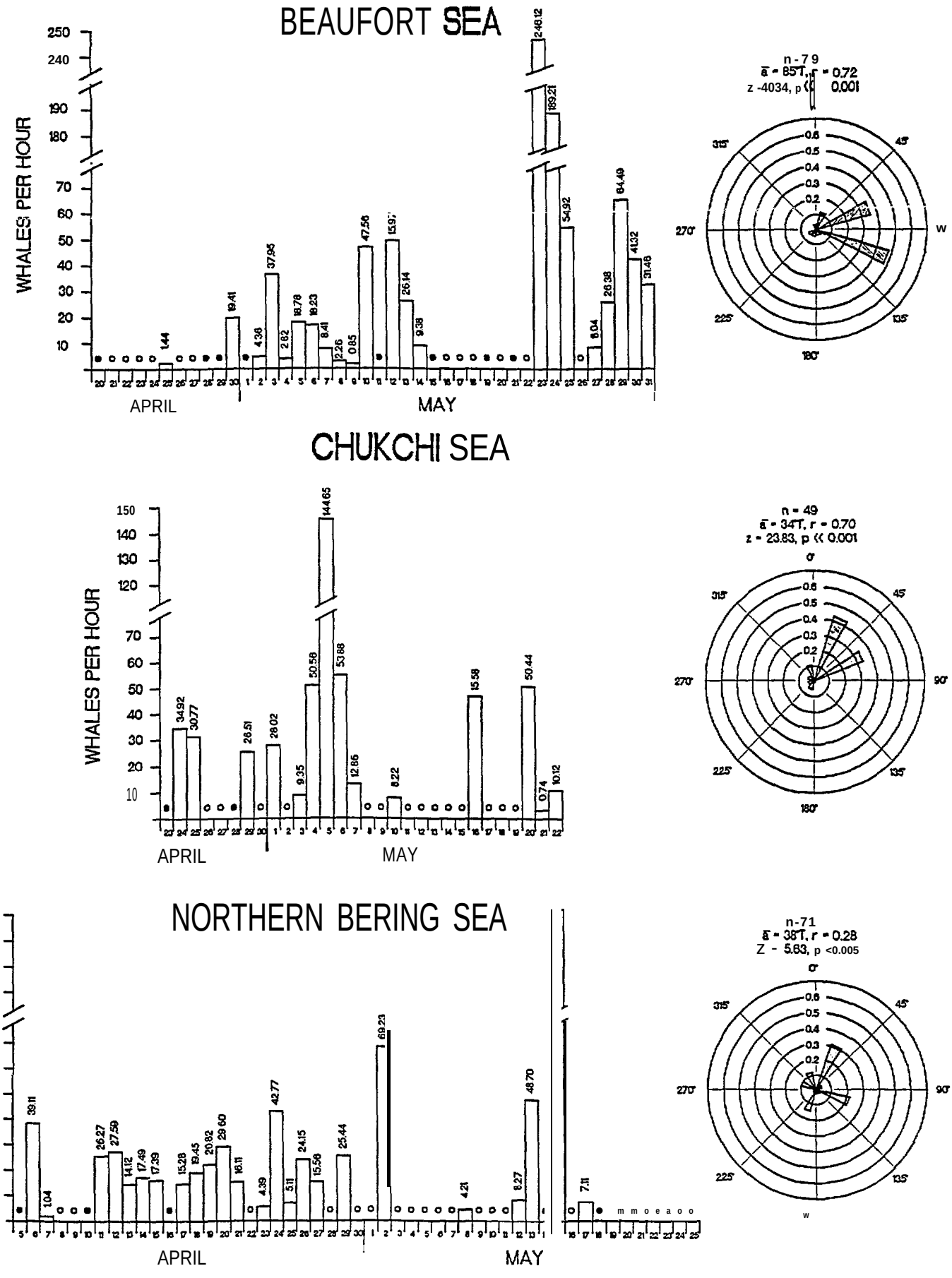
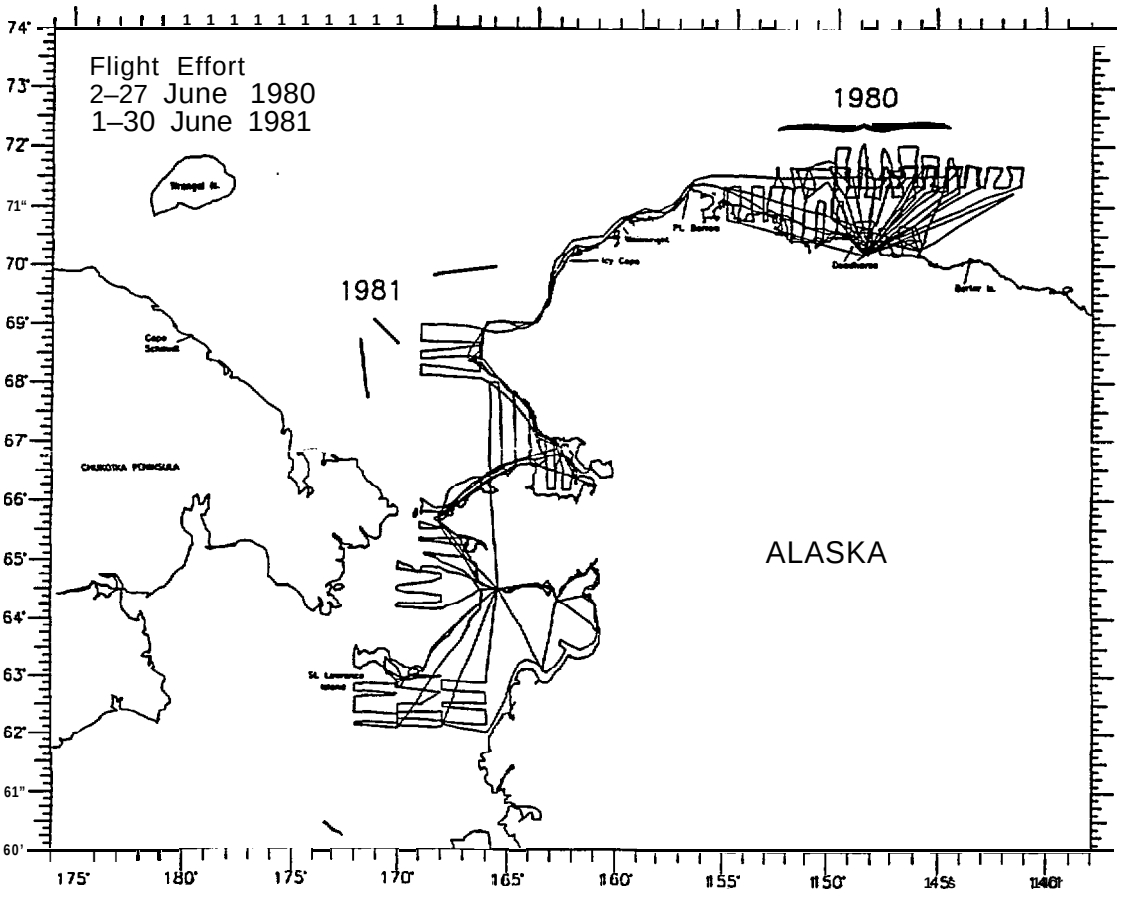

BEAUFORT SEA
WHALES PER HOUR
APRIL
MAY
n - 79
z -4034, p
0.001
CHUKCHI SEA
WHALES PER HOUR
APRIL
MAY
n = 49
z = 23.83, p << 0.001
NORTHERN BERING SEA
APRIL
MAY
n-71
Z - 5.83, p <0.005

Figure 4.


Flight Effort
2–27 June 1980
1–30 June 1981
1980
1981
ALASKA
CHUKOTKA PENINSULA
Cape Schmidt
Icy Cape
Barter Is.
St. Lawrence Island

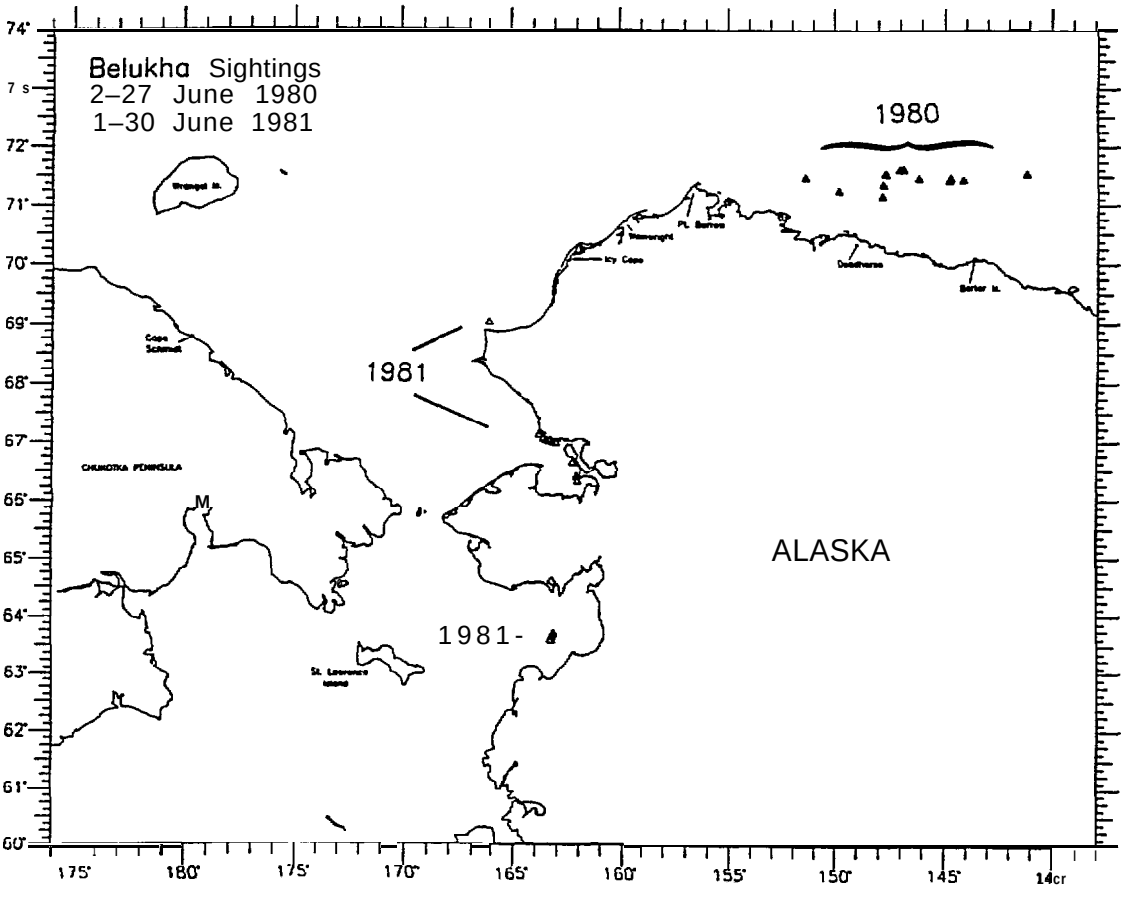
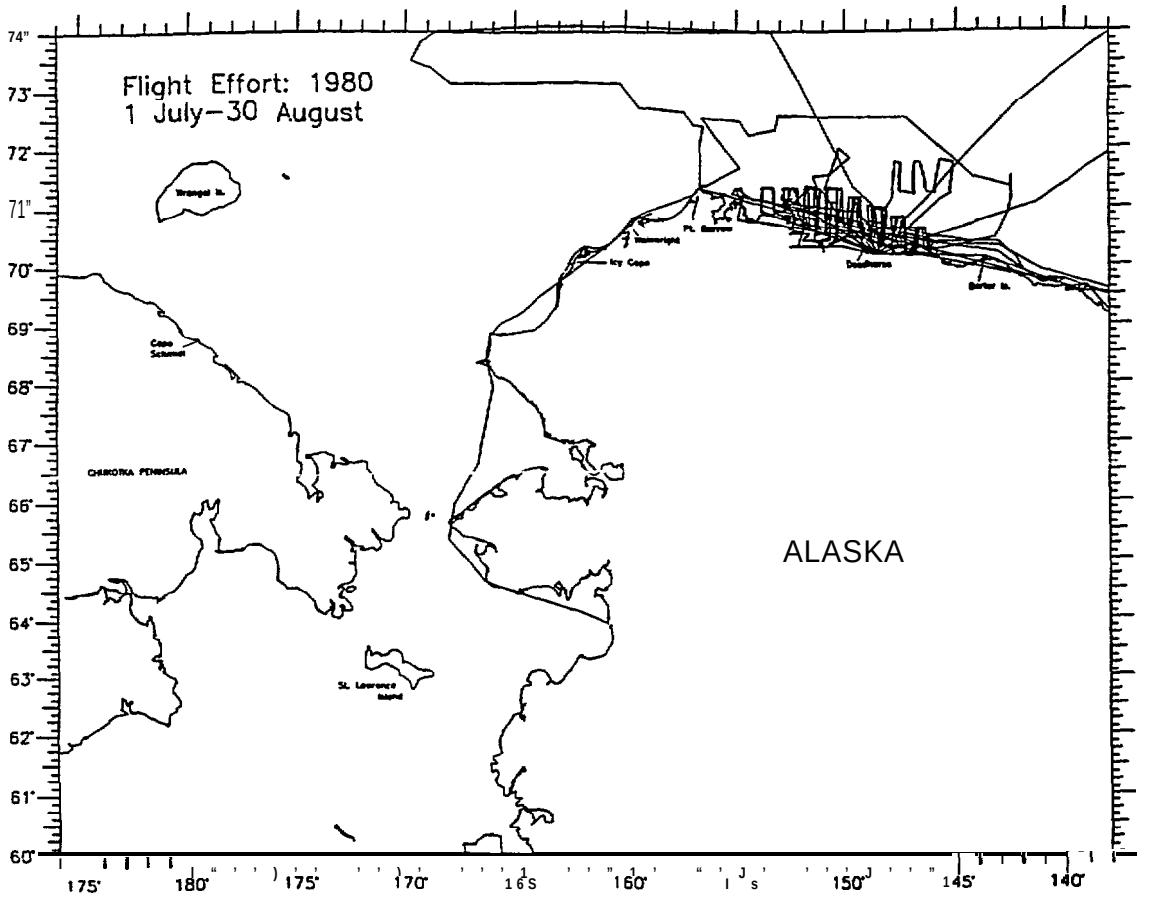

Belukha Sightings
2–27 June 1980
1–30 June 1981
1980
1981
1981-
ALASKA
CHUKOTKA PENINSULA
Cape Schmidt
Icy Cape
Barter Is.
St. Lawrence Island

Figure 5.


Flight Effort: 1980
1 July–30 August
ALASKA
CHUKOTKA PENINSULA
Cape Schmidt
Ivy Cape
Barter Is.
St. Lawrence Island
74°
73°
72°
71°
70°
69°
68°
67°
66°
65°
64°
63°
62°
61°
60°
175°
180°
175°
170°
165°
160°
150°
145°
140°

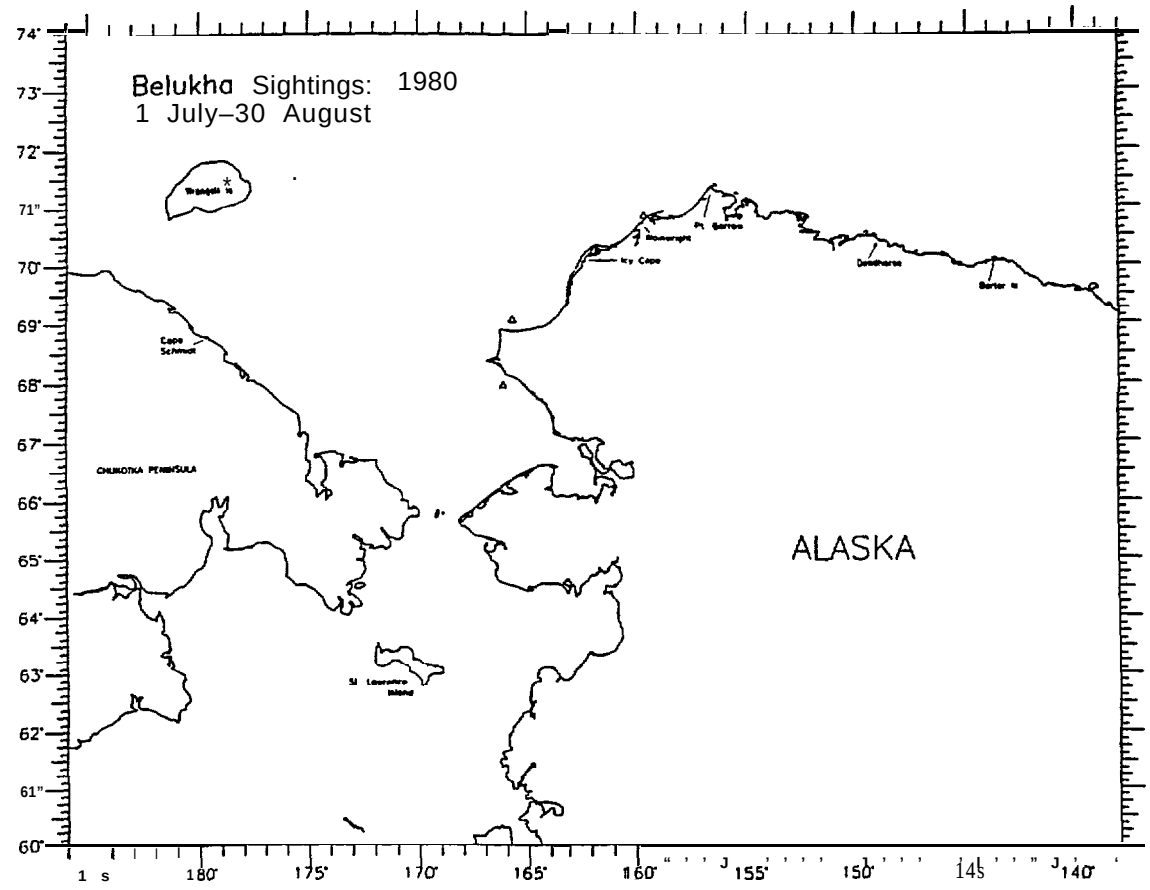
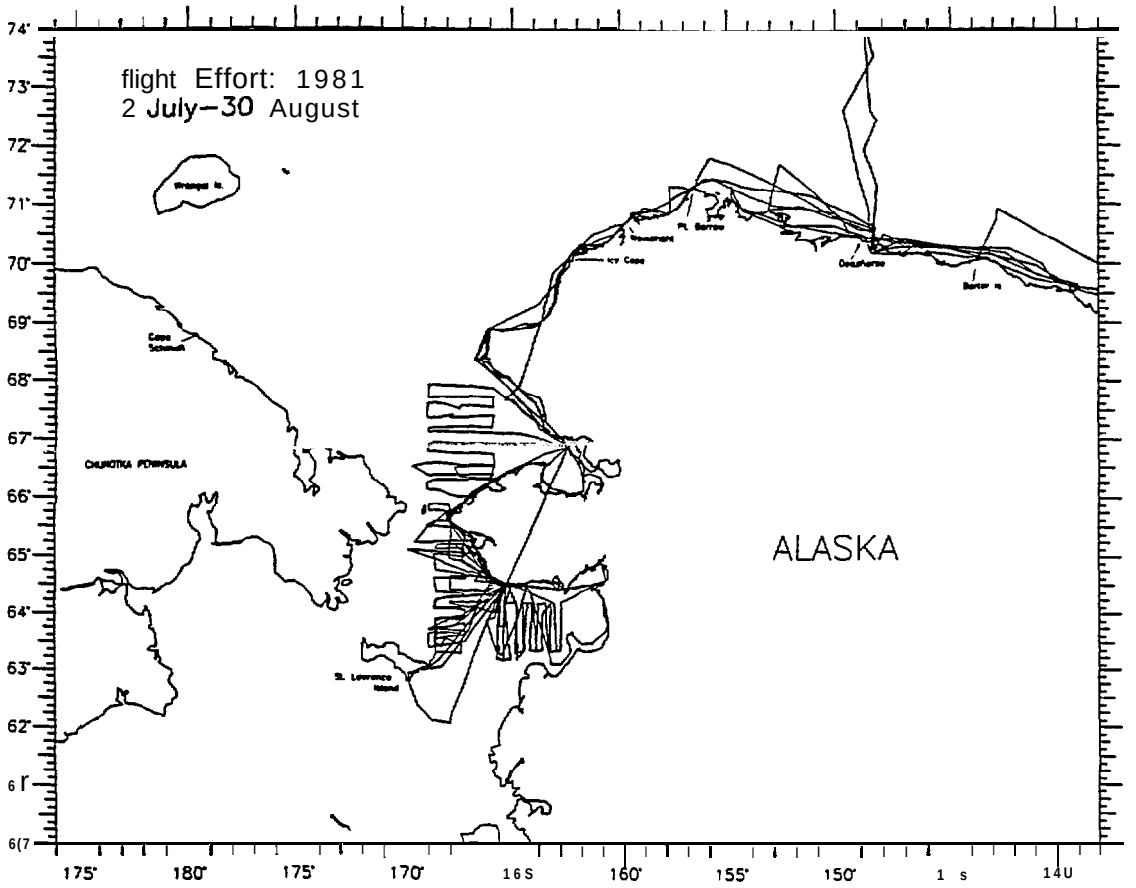

Belukha Sightings: 1980
1 July–30 August
ALASKA
CHUKOTKA PENINSULA
Cape Schmidt
Ivy Cape
Barter Is.
St. Lawrence Island
74°
73°
72°
71°
70°
69°
68°
67°
66°
65°
64°
63°
62°
61°
60°
180°
175°
170°
165°
160°
155°
150°
145°
140°

Figure 6.


flight Effort: 1981
2 July–30 August
ALASKA
CHUKOTKA PENINSULA
74°
73°
72°
71°
70°
69°
68°
67°
66°
65°
64°
63°
62°
175°
180°
175°
170°
160°
155°
150°
140°

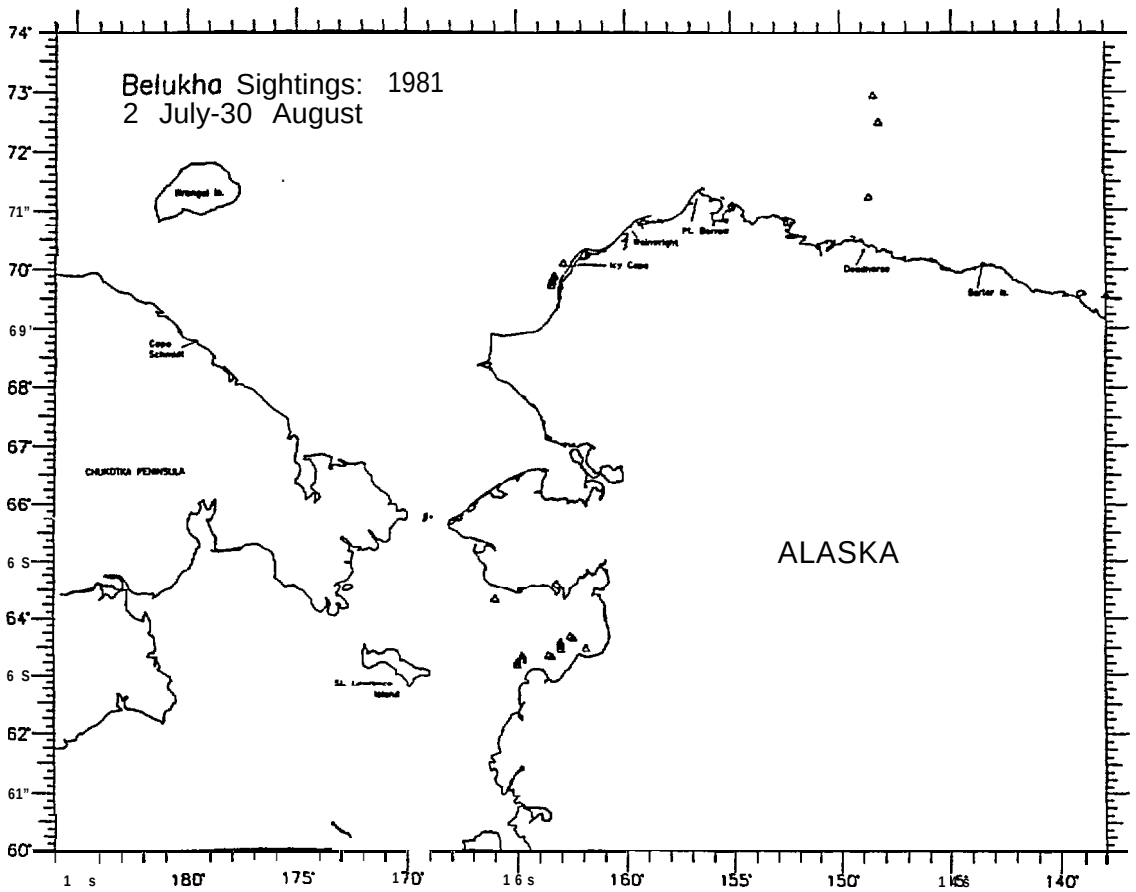
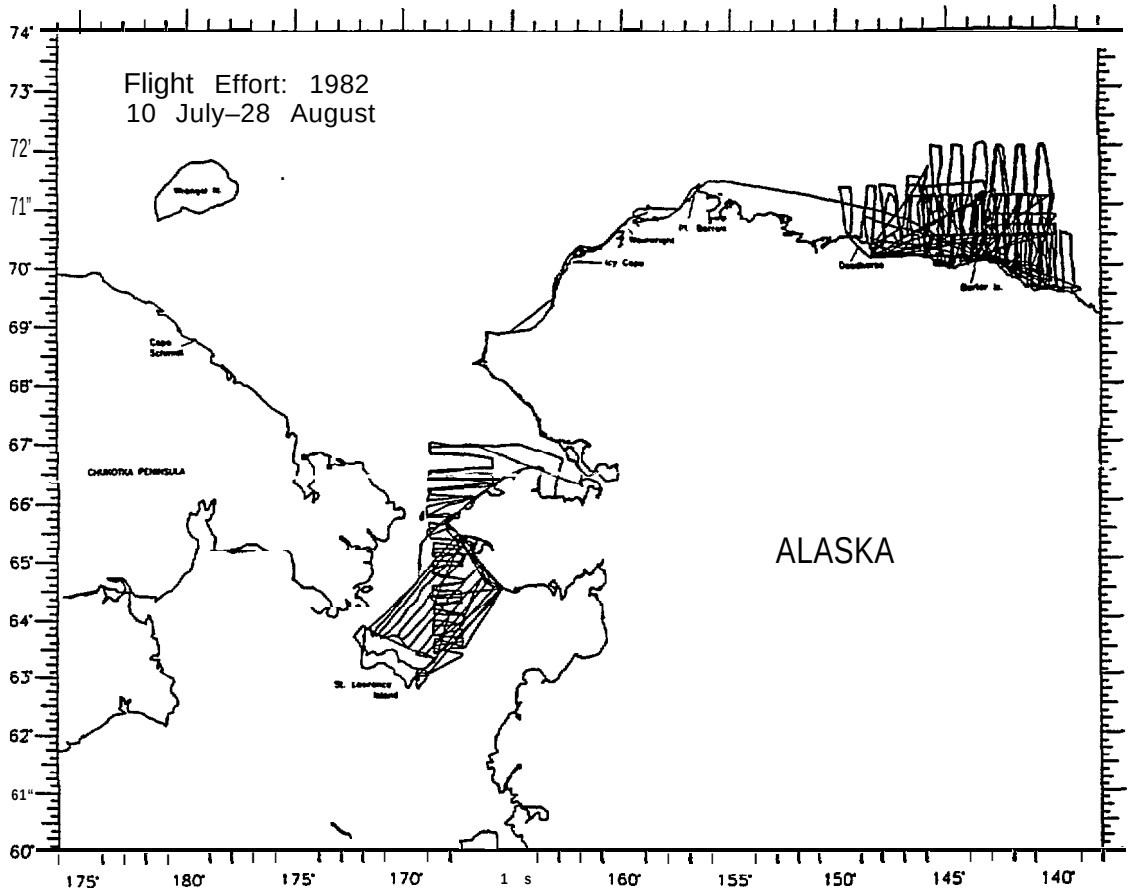

Belukha Sightings: 1981
2 July-30 August
ALASKA
CHUKOTKA PENINSULA
74°
73°
72°
71°
70°
69°
68°
67°
66°
64°
62°
61°
60°
180°
175°
170°
160°
155°
150°
140°

Figure 6.


Flight Effort: 1982
10 July–28 August
ALASKA
CHUKOTKA PENINSULA
Cape Schmidt
Icy Cape
Barrow
74°
73°
72°
71°
70°
69°
68°
67°
66°
65°
64°
63°
62°
61°
60°
175°
180°
175°
170°
160°
155°
150°
145°
140°

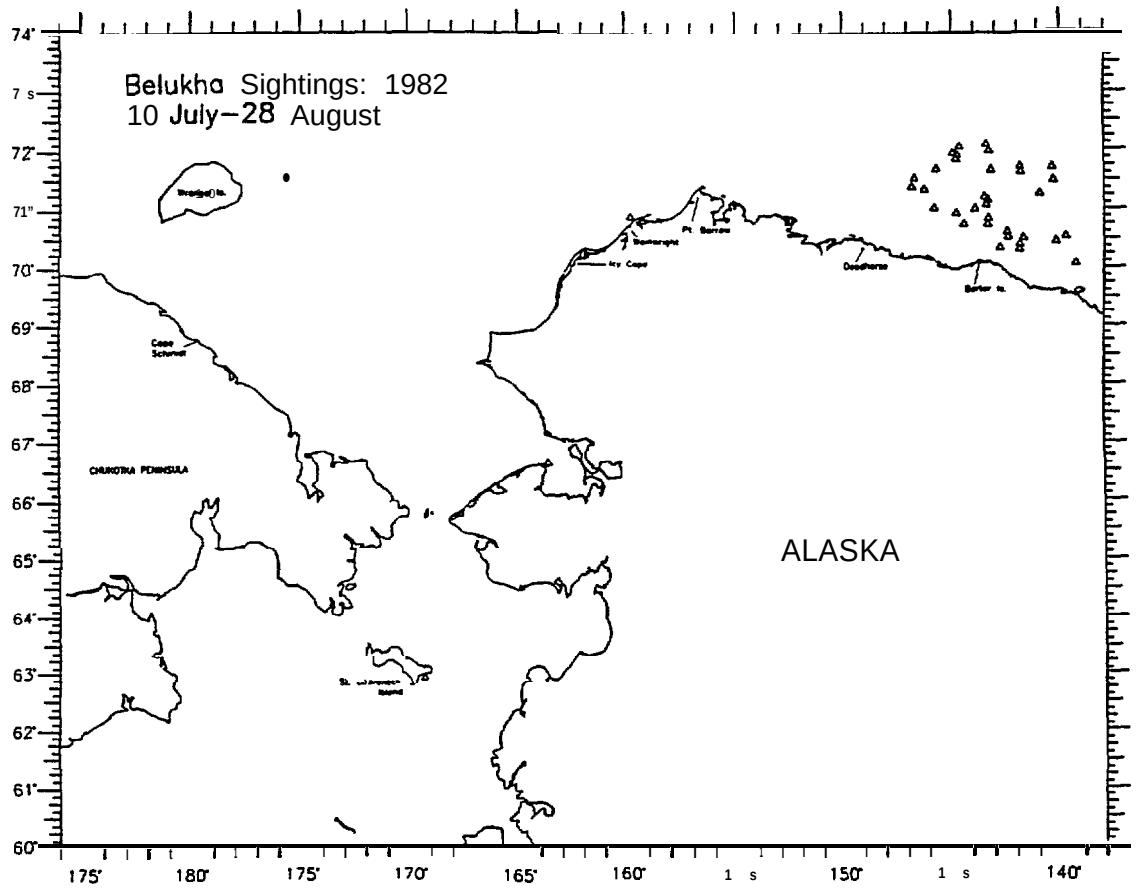
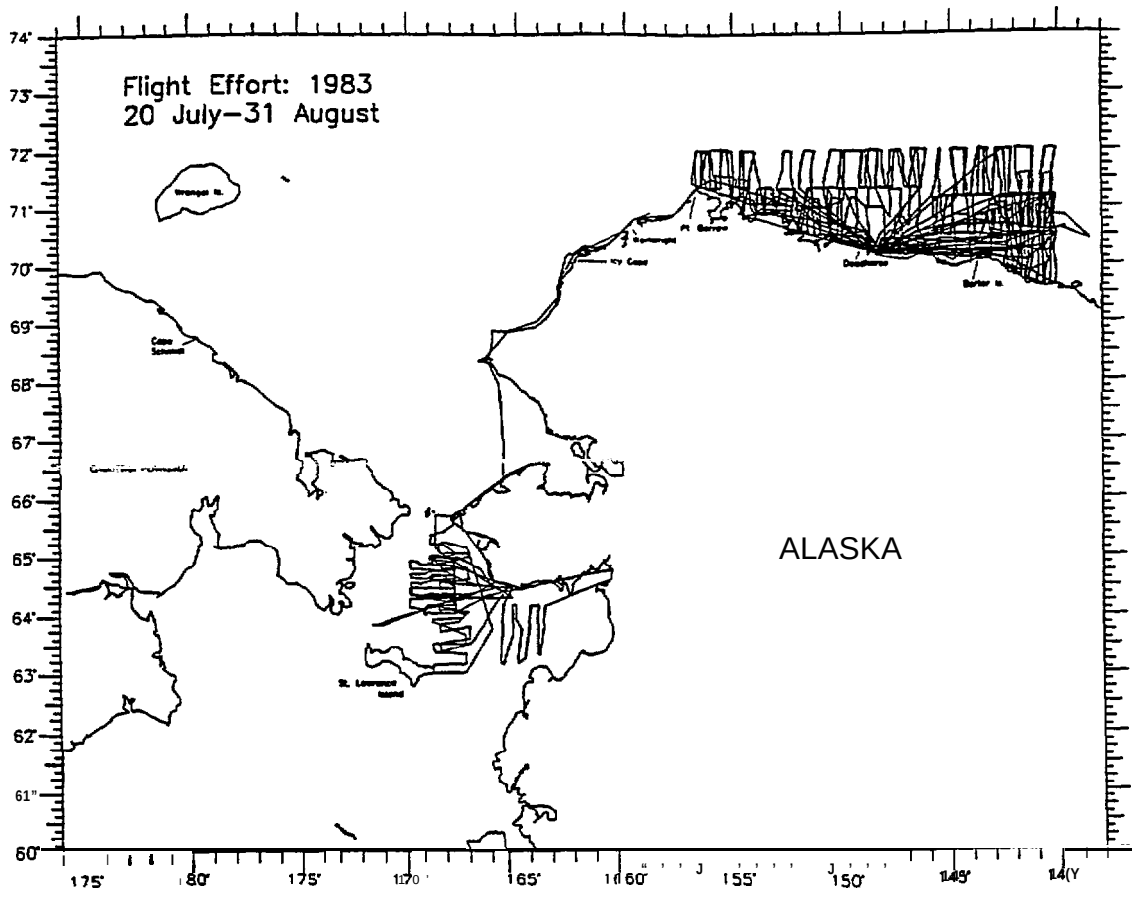

Belukha Sightings: 1982
10 July–28 August
ALASKA
CHUKOTKA PENINSULA
Cape Schmidt
Icy Cape
Barrow
74°
72°
71°
70°
69°
68°
67°
66°
65°
64°
63°
62°
61°
60°
175°
180°
175°
170°
165°
160°
150°
140°

Figure 6.


Flight Effort: 1983
20 July–31 August
ALASKA

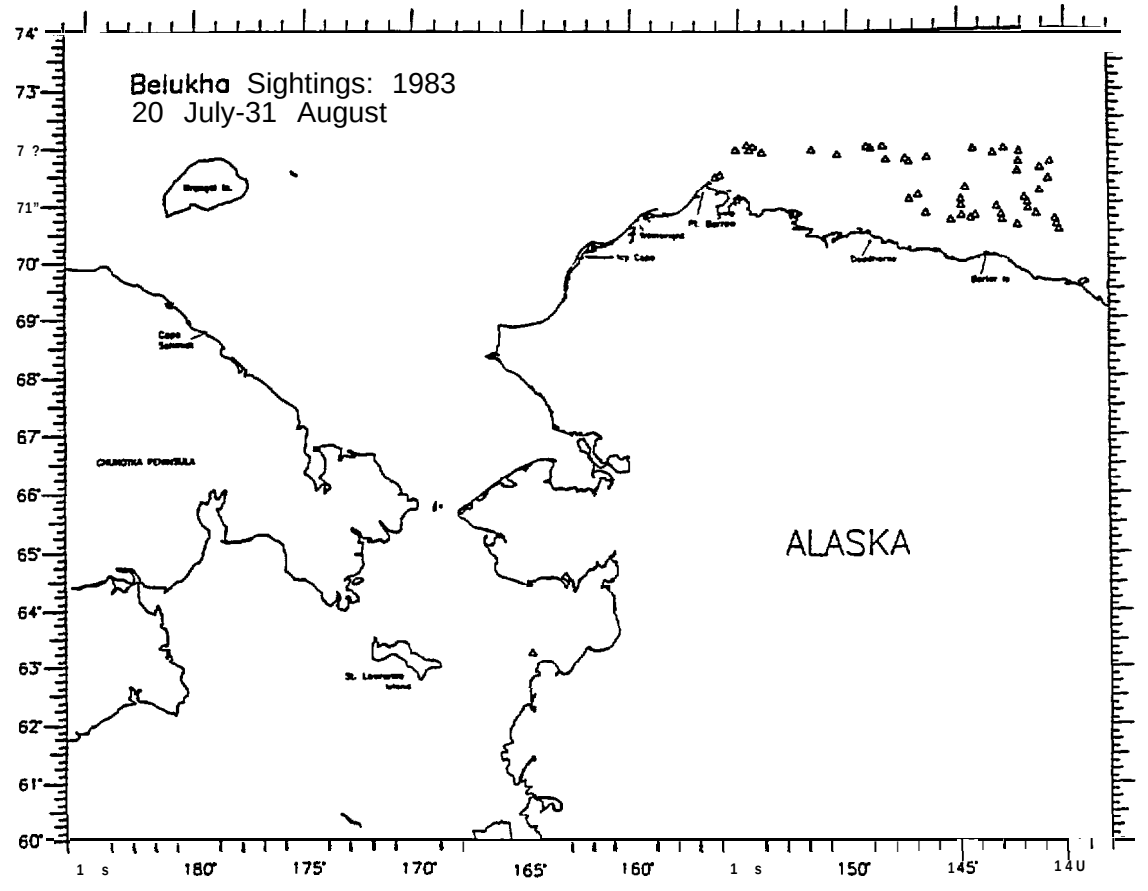
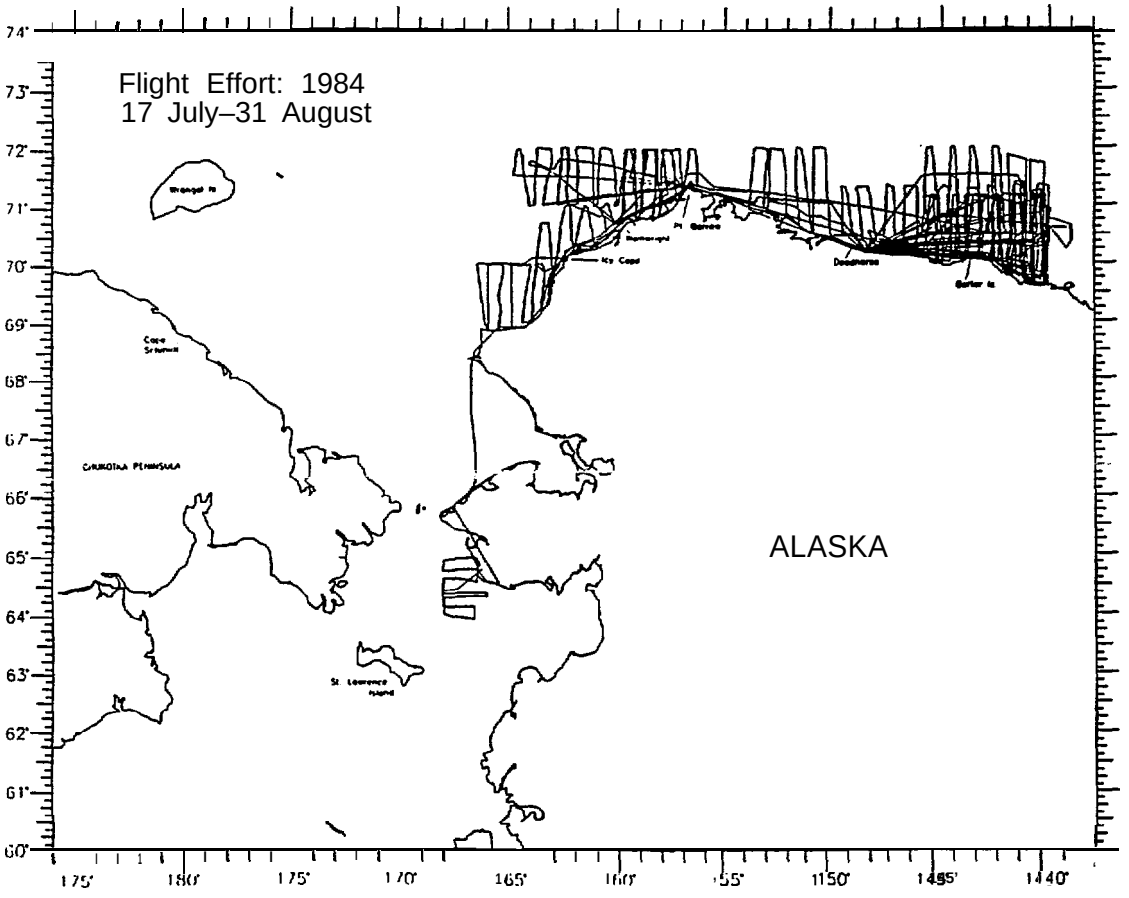

Belukha Sightings: 1983
20 July-31 August
ALASKA

Figure 6.


Flight Effort: 1984
17 July–31 August
ALASKA
CHUKOTKA PENINSULA
Cape Schmidt
St. Lawrence Island
Wrangel Is.
Pt. Barrow
Kivalina
Deadhorse
Barter Is.
74°
73°
72°
71°
70°
69°
68°
67°
66°
65°
64°
63°
62°
61°
60°
175°
180°
175°
170°
165°
160°
155°
150°
145°
140°

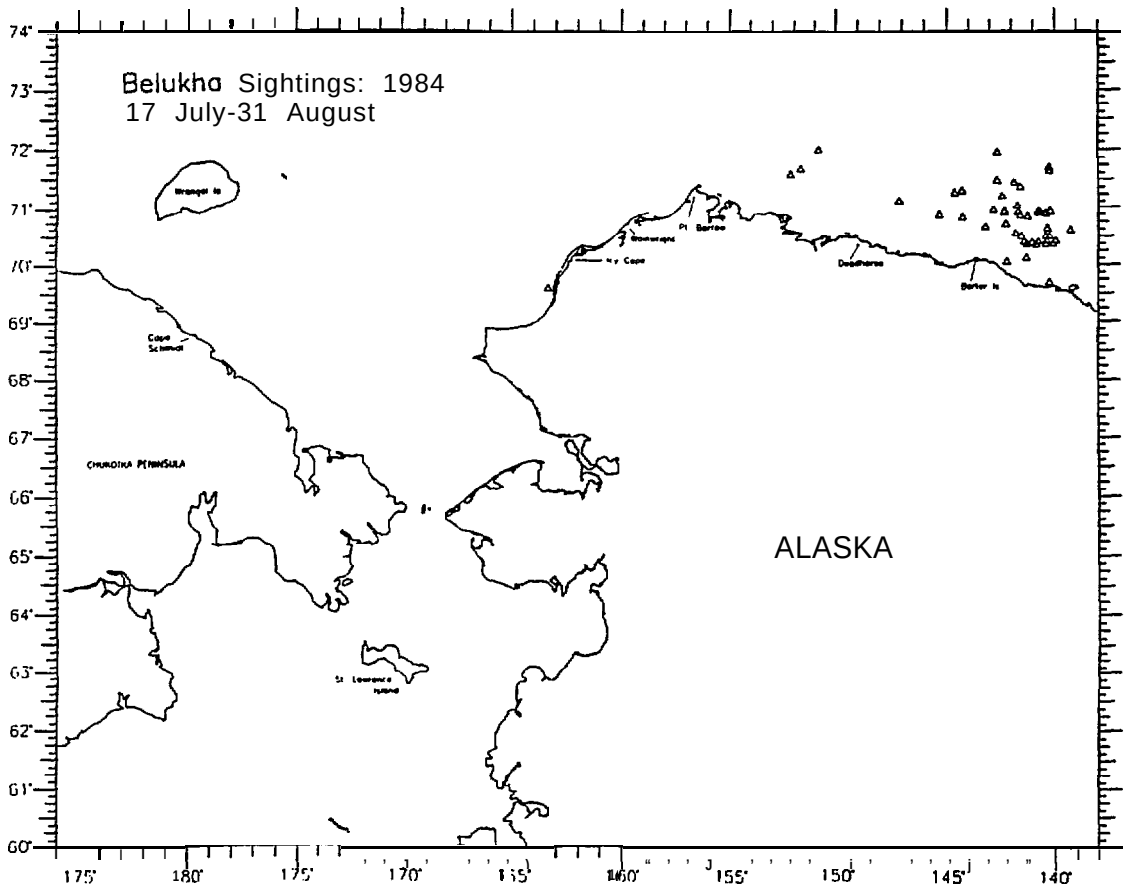

Belukha Sightings: 1984
17 July-31 August
ALASKA
CHUKOTKA PENINSULA
Cape Schmidt
St. Lawrence Island
Wrangel Is.
Pt. Barrow
Kivalina
Deadhorse
Barter Is.
74°
73°
72°
71°
70°
69°
68°
67°
66°
65°
64°
63°
62°
61°
60°
175°
180°
175°
170°
165°
160°
155°
150°
145°
140°

Figure 6.

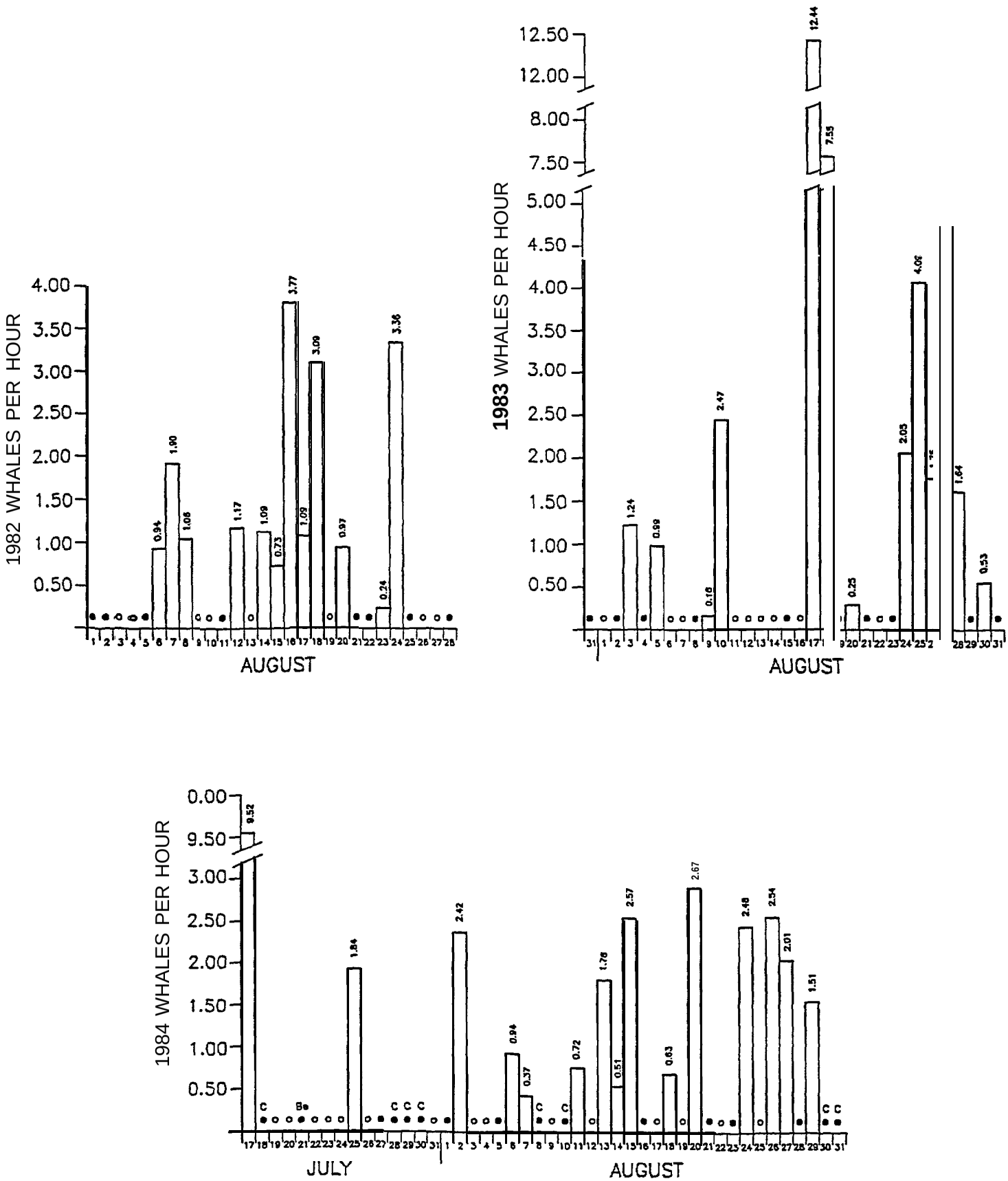

1982 WHALES PER HOUR
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.94
1.90
1.08
1.17
1.09
0.73
3.77
1.09
3.09
0.97
0.24
3.36
AUGUST
1983 WHALES PER HOUR
12.50
12.00
8.00
7.50
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
12.44
7.55
1.24
0.99
0.16
2.47
0.25
2.05
1.64
0.53
AUGUST
1984 WHALES PER HOUR
0.00
9.50
3.00
2.50
2.00
1.50
1.00
0.50
9.52
1.84
2.42
0.94
0.37
0.72
1.76
0.51
2.57
0.63
2.67
2.48
2.54
2.01
1.51
JULY
AUGUST

Figure 7.