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SEA ICE CONDITIONS IN COOK INLET, ALASKA DURING THE 1977-78 WINTER

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ABSTRACT. The winter of 1977-78 marked a return of more typical sea ice conditions in Cook Inlet, Alaska, after the very light ice conditions of 1976-77. Very close pack ice in the inlet was reported as far south as the Forelands by December 4. By January 5, close pack ice had reached a line from Ninilchik to Chinitna Bay and into Kamishak Bay. On March 5, a giant ice floe measuring over 30 km long moved south of Cape Douglas into Shelikof Strait. During the next week, strips and patches of ice were reported as far south as Halo Bay on the west side of Shelikof Strait. The inlet ice grew to a maximum thickness of 56 cm, although stamukhi up to 2 m thick were reported toward the end of March.

Temperatures were below normal during the first half of the winter and frost degree-days accumulated steadily to 723 by the second week of January. During the second half of winter, temperatures were well above normal: by March 31, the frost degree-day total was only 832, making it the fourth warmest winter on record.

The date the inlet became free of significant ice was March 18. Ice conditions as of April 1 were limited to a few strips of very open brash east of Point Possession and that vanished by April 14.

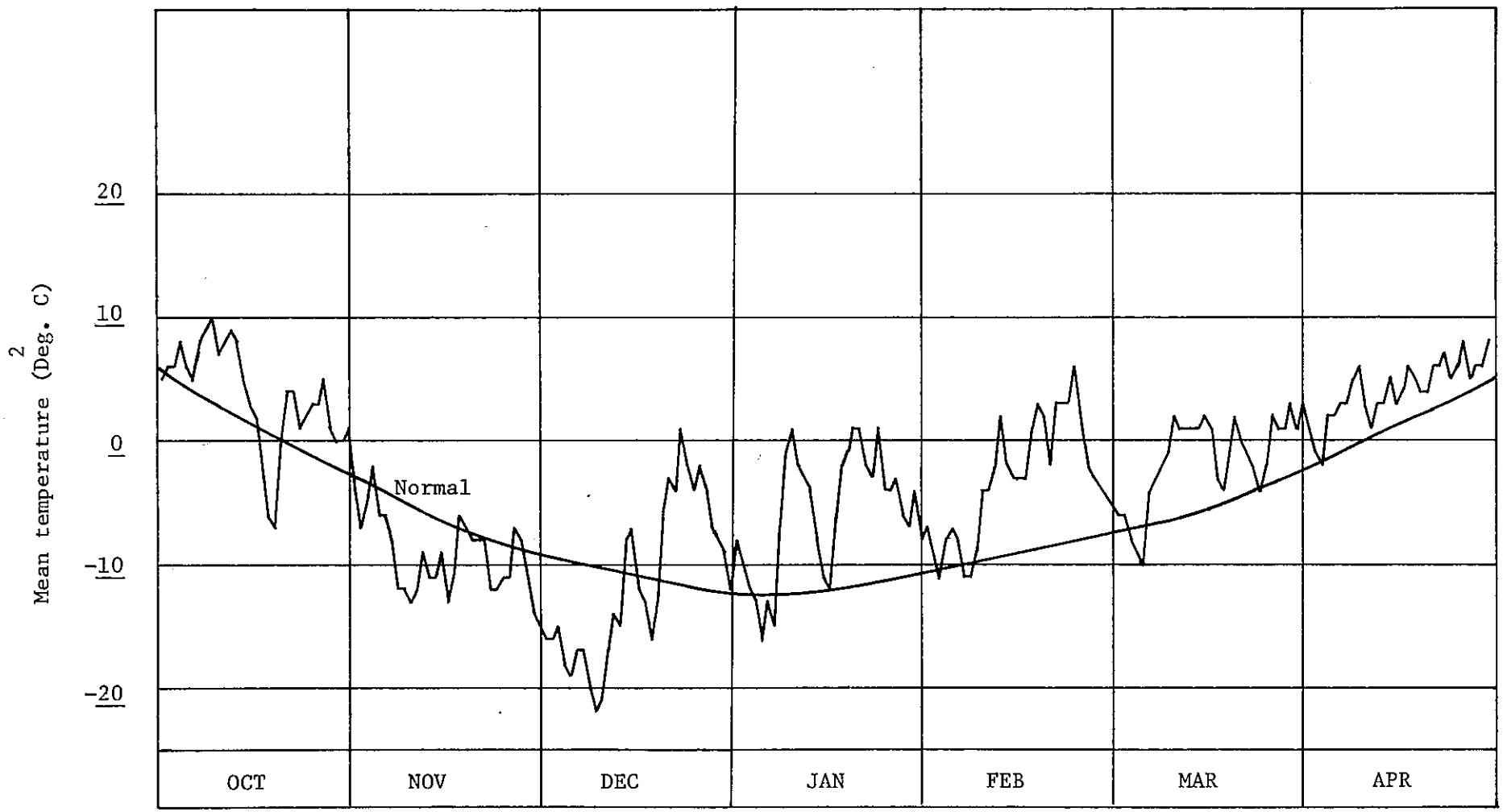

Figure 1. Mean daily temperatures at Anchorage, Alaska, winter 1977-78

DESCRIPTION OF ICE CONDITIONS

A mean temperature of 4.4°C made 1978 the warmest year on record in Anchorage, Alaska. 1977 was a close second with a mean of 3.9°C. Figure 1 compares Anchorage's mean daily temperatures of the winter of 1977-78 with the daily normals computed for the years 1934 through 1970. The months of October, January, February, March, and April were above normal; however, November was 3.2°C below normal and December was 0.9°C below.

Alaska's overall weather pattern for the winter of 1977-78 was one of frequent change. The average track of low pressure systems was into southcentral Alaska and the northern Gulf of Alaska for most of the winter; this pattern sustained the warmer than normal temperatures. The typical large cold highs of interior Alaska had few chances to develop and even less opportunity to become well established.

The first significant ice of the season in Cook Inlet (see figure 2) occurred on November 20; close pack new ice had covered both Turnagain Arm and Knik Arm by November 16. By the end of the month, open pack young ice stretched as far south as the Forelands. The storm track shifted to the south of Alaska towards the end of the month and a cold high pressure system was able to develop over the interior. This, coupled with a low pressure trough in the northern Gulf of Alaska, sent cold air flowing southward over Cook Inlet; the pattern persisted through the middle of December.

Open pack young ice extended to Kalgin Island by the first week of December. Ice forming in Kamishak Bay was being broken off and pushed down the west side of Shelikof Strait by northerly winds and strong water currents. By mid-December open pack new ice and brash extended as far south as a line from Ninilchik to Cape Douglas with some ice still being pushed along the west side of Shelikof Strait.

After mid-December, an alternating pattern of fair and foul weather was established over southern Alaska and the amount of ice in the southern end of the inlet decreased. Very close pack small and medium floes of thin ice were located north of the Forelands by the end of the month. Open to close pack small floes of young ice and brash covered the area between the Forelands and Tuxedni Bay.

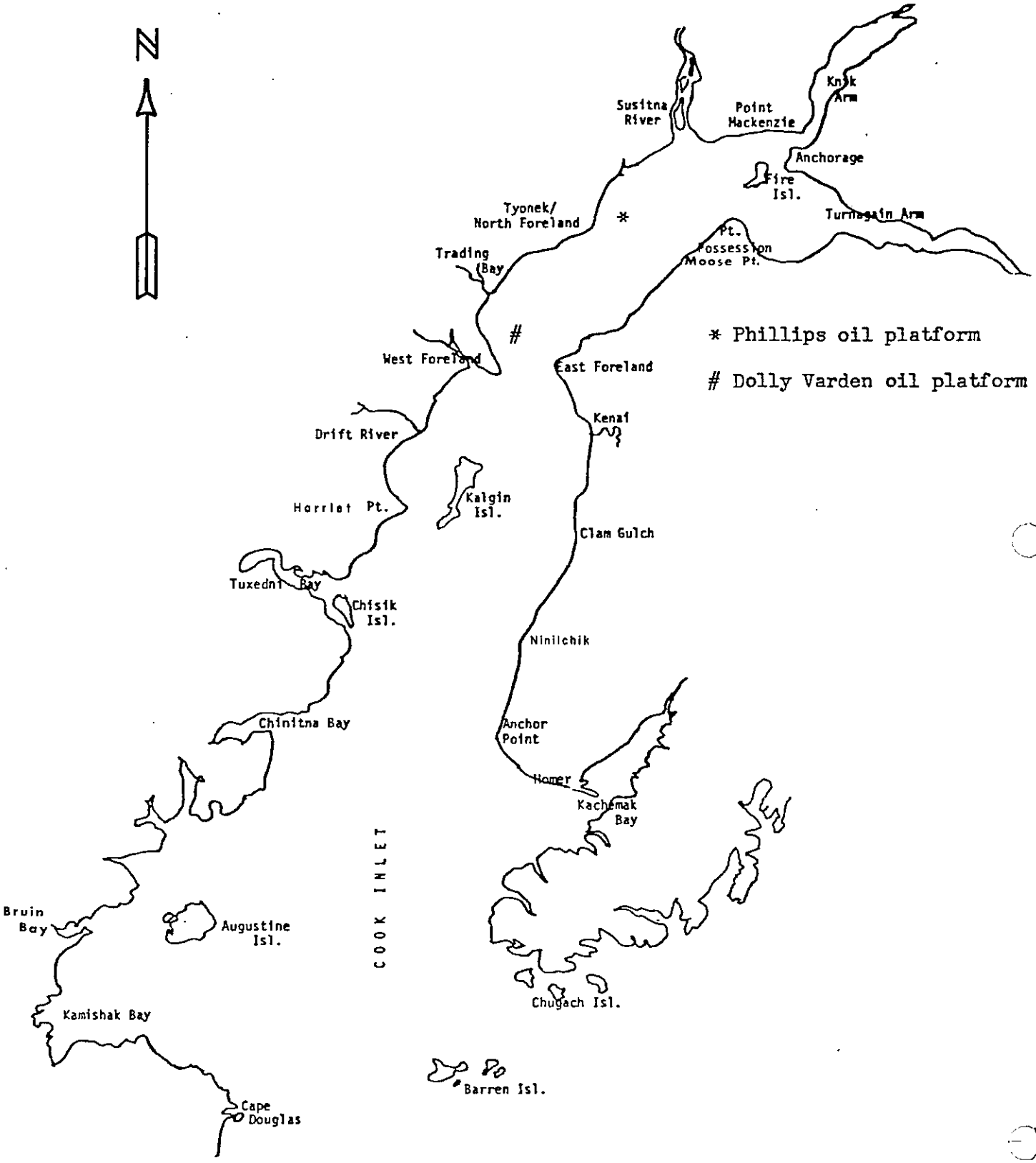

Figure 2. Map of Cook Inlet, Alaska

This alternating weather pattern continued through most of January. Ice continued to accumulate in the inlet and, by the second week of January, maximum ice growth was achieved. Frost degree-days[1] accumulated steadily through the period and reached a total of 723. Using data substantiated by Zubov (1938), the maximum ice thickness was estimated to be 56 cm.

Early in January, ice had again developed in Kamishak Bay. By the end of the month, the inlet contained ice north of a line from Ninilchik to Kamishak Bay. North of Clam Gulch and Tuxedni Bay the ice consisted of close to very close pack young and thin ice of small and medium floes along with brash; the remainder of the area had open to close pack new ice of cakes and brash. Towards the end of January, a high pressure system grew along the Alaska-Yukon border which caused the storm track to shift southward.

The ice from Chinitna Bay to Kamishak Bay, which had disintegrated by February 1, began reforming on February 5 but was gone again by the 18th. The rest of the inlet had opened up considerably by the end of February. North of the Forelands, patches and strips of young and thin ice of cakes and brash and considerable slush were reported. There was very open pack new and young ice of cakes and brash on the west side of the inlet from the Forelands to Harriet Point; the remainder of the inlet was essentially ice free. Tidal action and the fact that the storm track had again shifted into southern Alaska by mid-month were the main reasons for the light ice conditions. At the end of the month, however, another high pressure area developed in the Yukon Territory and the inlet ice began to increase.

The beginning of March found open to close pack new ice stretching north of a line from Ninilchik to Tuxedni Bay; new ice was forming in Kamishak Bay. On March 2, a cold front entered northwestern Alaska. It moved southeastward over Cook Inlet and caused a low pressure center to form in the mouth of the inlet by the morning of March 5. This low pressure system caused a giant floe of ice, over 30 km in length, to break out of Kamishak Bay and move into the north end of Shelikof Strait that day. Strips and patches of young ice of cakes and brash were reported as far south as Halo Bay on the west side of Shelikof Strait until March 11.

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[1]Frost degree-days are defined as the difference between 0°C and the mean daily temperature. When the temperature is less than 0°C, the correlation is one to one and positive. When the temperature is above freezing, the correlation is 3.33 to one and negative because the rate of decay of sea ice is approximately 3 1/3 times the rate of growth.

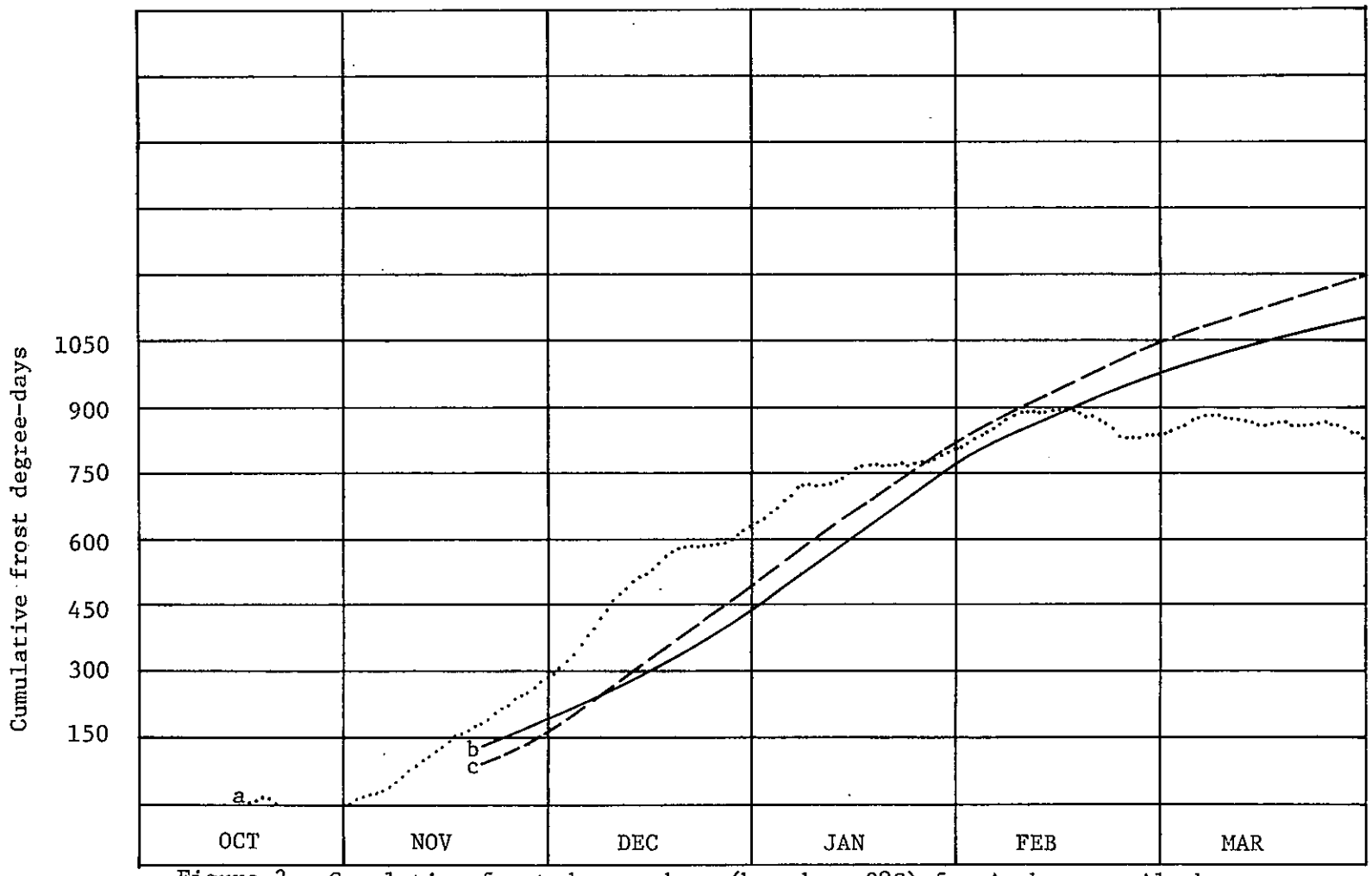

Figure 3. Cumulative frost degree-days (based on 0°C) for Anchorage, Alaska
a) 1977-78
b) 8-year average 1969-77
c) 42-year average 1923-68 (1925-27 and 1928-29 are missing)

Cook Inlet ice was rather extensive on March 5: it was reported over most of the area north of a line from Anchor Point to Cape Douglas. Several days after the giant ice floe was released into the northern end of Shelikof Strait, the inlet ice began to diminish. By March 13, only strips and patches of very open young ice of cakes and brash were reported north of the Forelands and on the west side of the inlet from Chinitna to the Forelands; 2 m thick stamukhi which formed during the winter were set afloat by the tides. The inlet became free of significant ice on March 18. A storm track, which brought low pressure systems from the Aleutians into the northern Gulf of Alaska and into Bristol Bay, established itself by March 7 and continued through the end of the month.

The remaining ice in the northern end of the inlet disintegrated rapidly during April. April 13 was the last day any ice was reported in the inlet.

The winter of 1977-78 started off near normal as compared with other winters. Figure 3 is a graph comparing cumulative frost degree-days for the winter of 1977-78 to an 8-year average from 1969 to 1977 and also to a 42-year average from 1923 to 1968. From both figures 1 and 3 it can easily be seen that the winter of 1977-78 was unseasonably warm from mid-February onward.

Table 1 shows end-of-the-month totals of frost degree-days for the winters of 1969 through 1978. The previous winter, 1976-77, was by far the warmest on record. It was a very light ice season in Cook Inlet and may have made the 1977-78 season seem worse than it was but, in fact, the 1977-78 winter was the fourth warmest on record. Although the end of March total of 832 frost degree-days was almost seven times as great as the warmest winter on record, it was less than half that of the coldest winter, 1955-56.

Dates of the first significant ice and ice-free days in Cook Inlet were first established during the winter of 1969-70; table 2 lists the dates for nine winters. Statistics, using these dates, indicate the average date of first significant ice is November 17 and the average date the inlet becomes free of significant ice is April 12. There is an 80% chance the first significant ice will occur as late as November 29, and a 20% chance it will occur as early as November 9. There is an 80% chance that the day the inlet becomes free of significant ice will occur as late as April 27, and a 20% chance it will be as early as March 28.

Ice observations are obtained from the Phillips and Dolly Varden oil platforms (see figure 2), satellite pictures (see figures 4-7), and occasional aircraft reports. The satellite pictures are received on a real-time basis at the Weather Service Forecast Office in Anchorage and are the mainstay of the ice observation program but can be used only on cloud-free days.

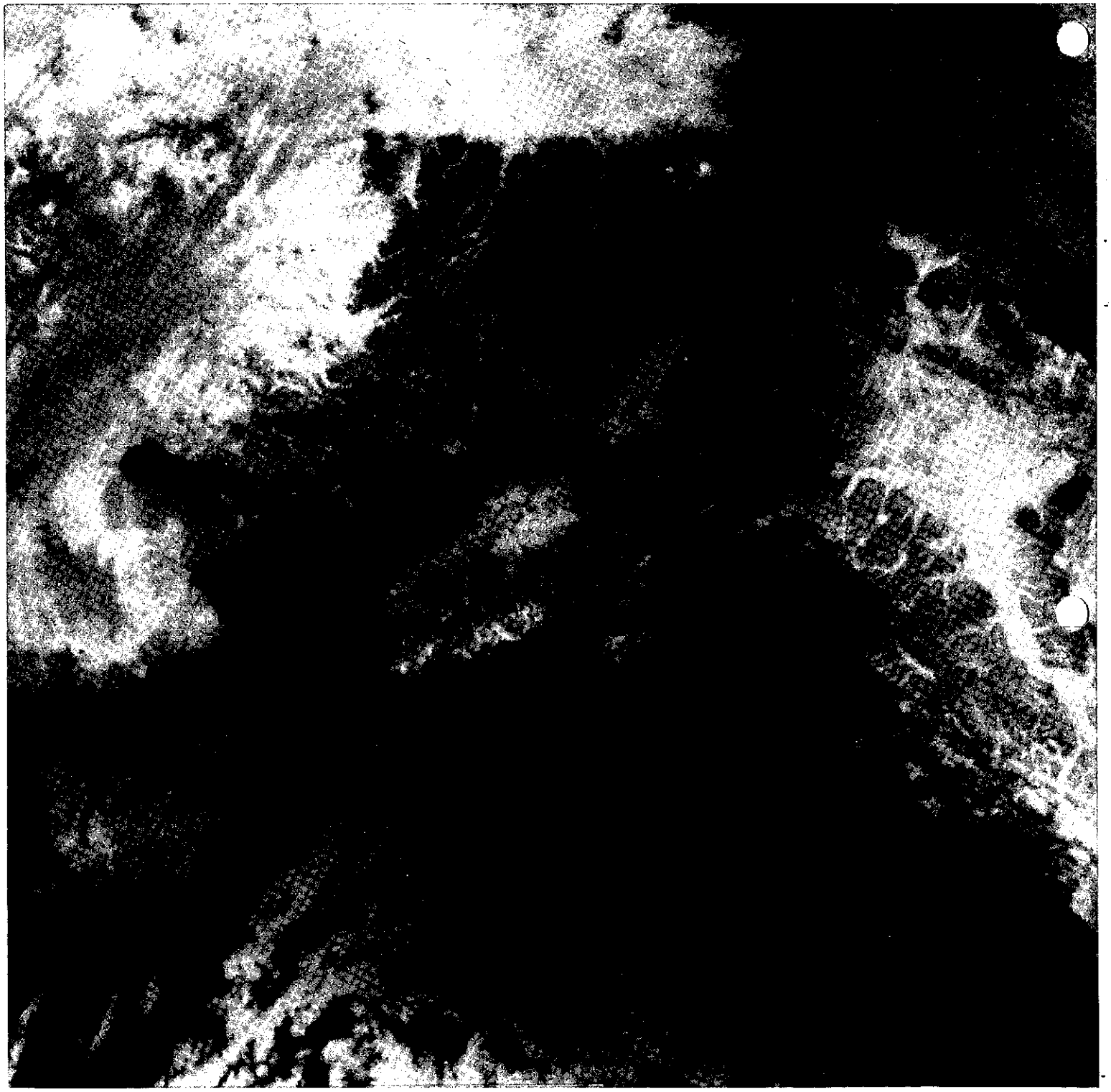

Figure 4. Cook Inlet... the infrared satellite photograph taken by the NOAA5 satellite at 0449Z December 6, 1977

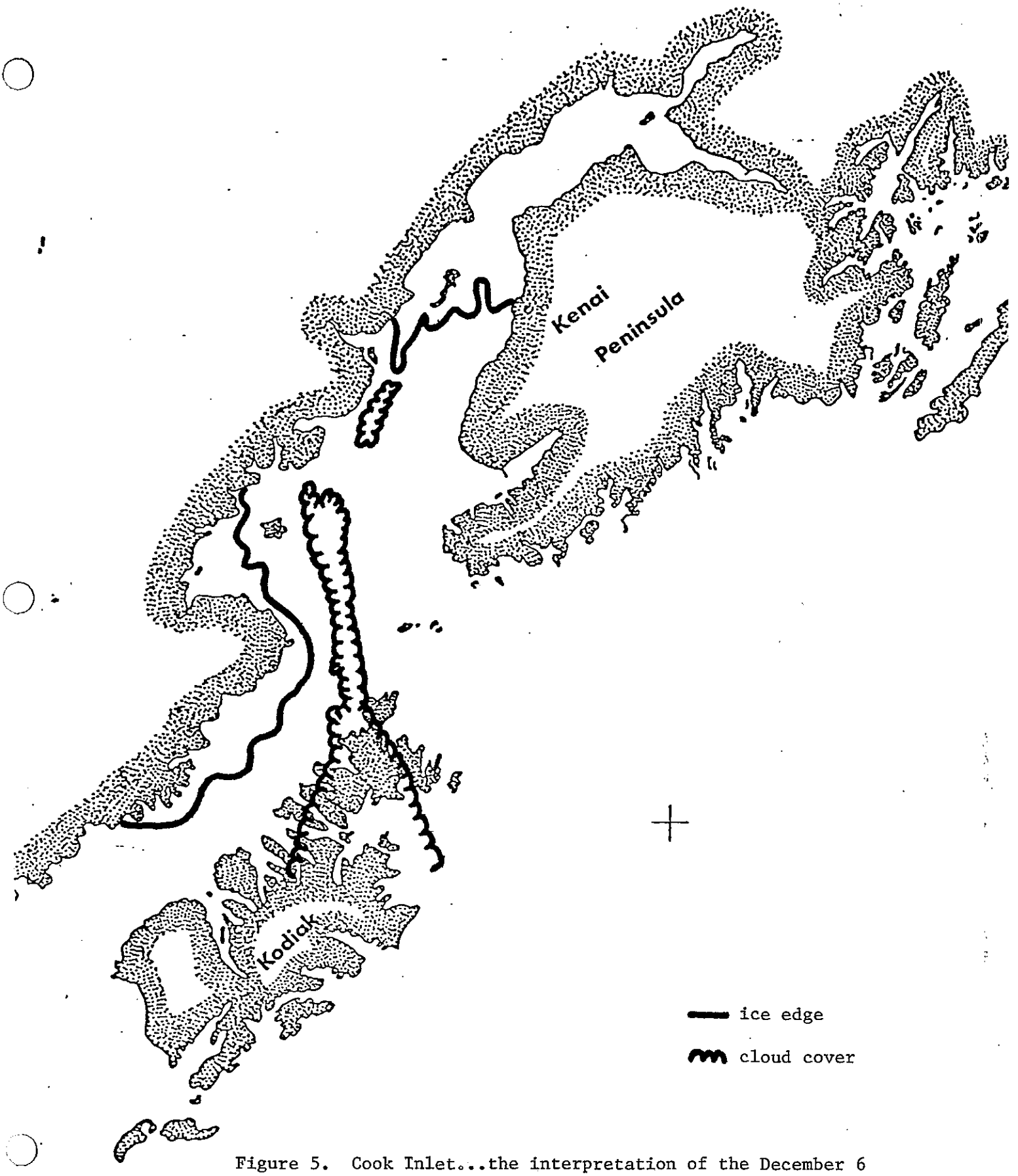

Figure 5. Cook Inlet...the interpretation of the December 6 satellite photograph

154°

150°

Figure 6. Cook Inlet...the infrared satellite photograph taken by the NOAA5 satellite at 0459Z December 19, 1977

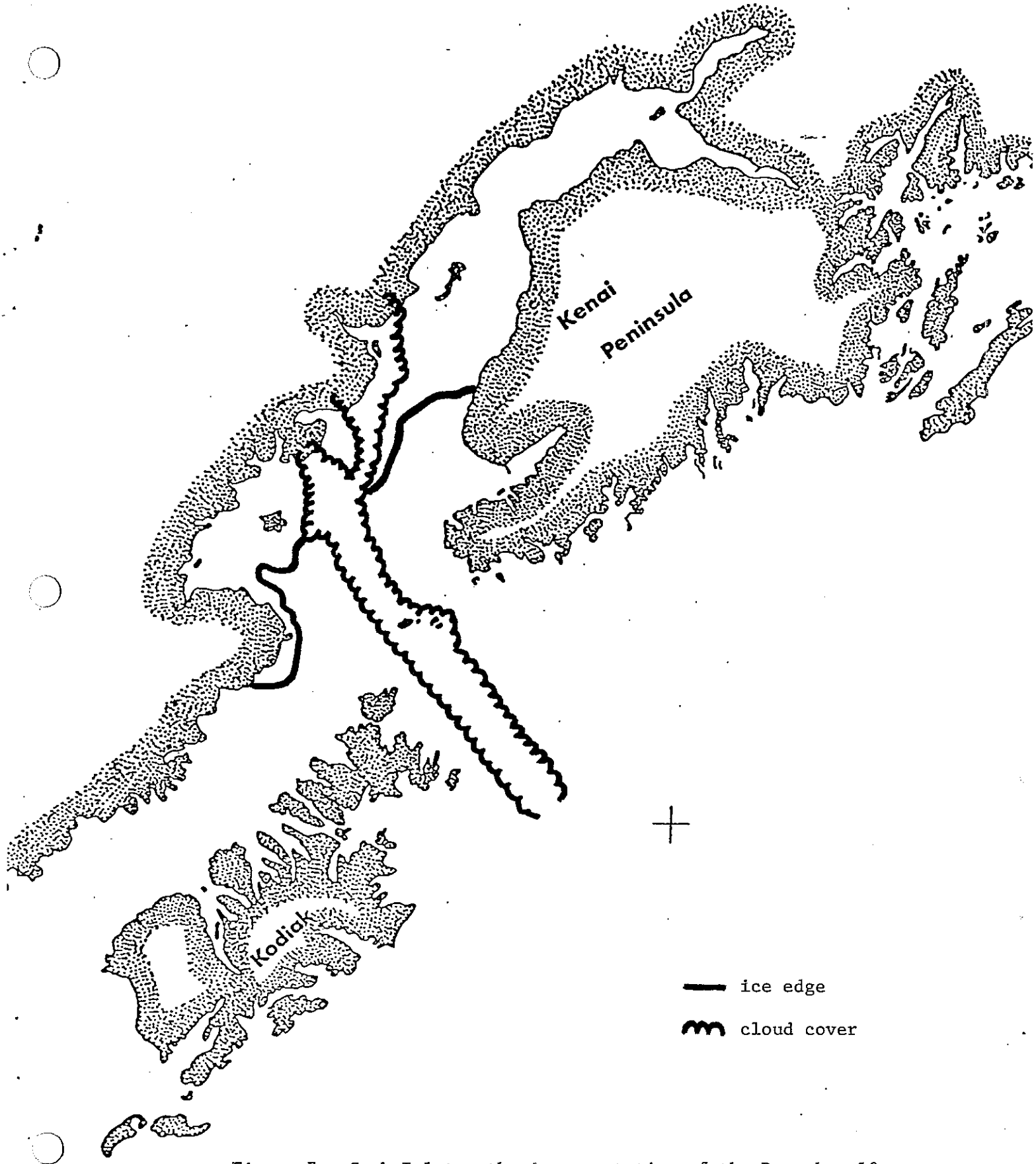

Figure 7. Cook Inlet...the interpretation of the December 19 satellite photograph

154°

150°

Table 1.--Cumulative frost degree-days (based on 0°C) at Anchorage, Alaska, since ice records began in 1969.

Winter of	Period ending 11/30	12/31	1/31	2/28*	3/31
1969-70	147	205	599	643	581
1970-71	201	497	1008	1196	1500
1971-72	227	498	938	1236	1514
1972-73	181	528	1014	1306	1450
1973-74	300	512	931	1229	1297
1974-75	151	358	682	957	1111
1975-76	339	686	929	1217	1321
1976-77	0	149	56	12	123**
Average	193	429	770	975	1104
1977-78	276	628	803	836	832
1955-56	378	786	1244	1596	1807***
42 Year average 1923-68 (data missing for 1925-27 and 1928-29)	174	491	822	1043	1192

*In leap years 2/29
** Warmest on record
*** Coldest on record

Table 2.--First significant ice and ice-free dates for Cook Inlet for the winters of 1969 through 1978.

	First ice	Ice free
69-70	Nov 18	Mar 23
70-71	Oct 17	May 7
71-72	Nov 23	May 15*
72-73	Nov 13	Apr 10
73-74	Nov 18	Apr 6
74-75	Nov 24	Apr 9
75-76	Nov 12	Apr 10
76-77	Dec 17*	Apr 9
77-78	Nov 20	Mar 18
Median	Nov 18	Apr 9
Average	Nov 17	Apr 12

*Latest occurrences

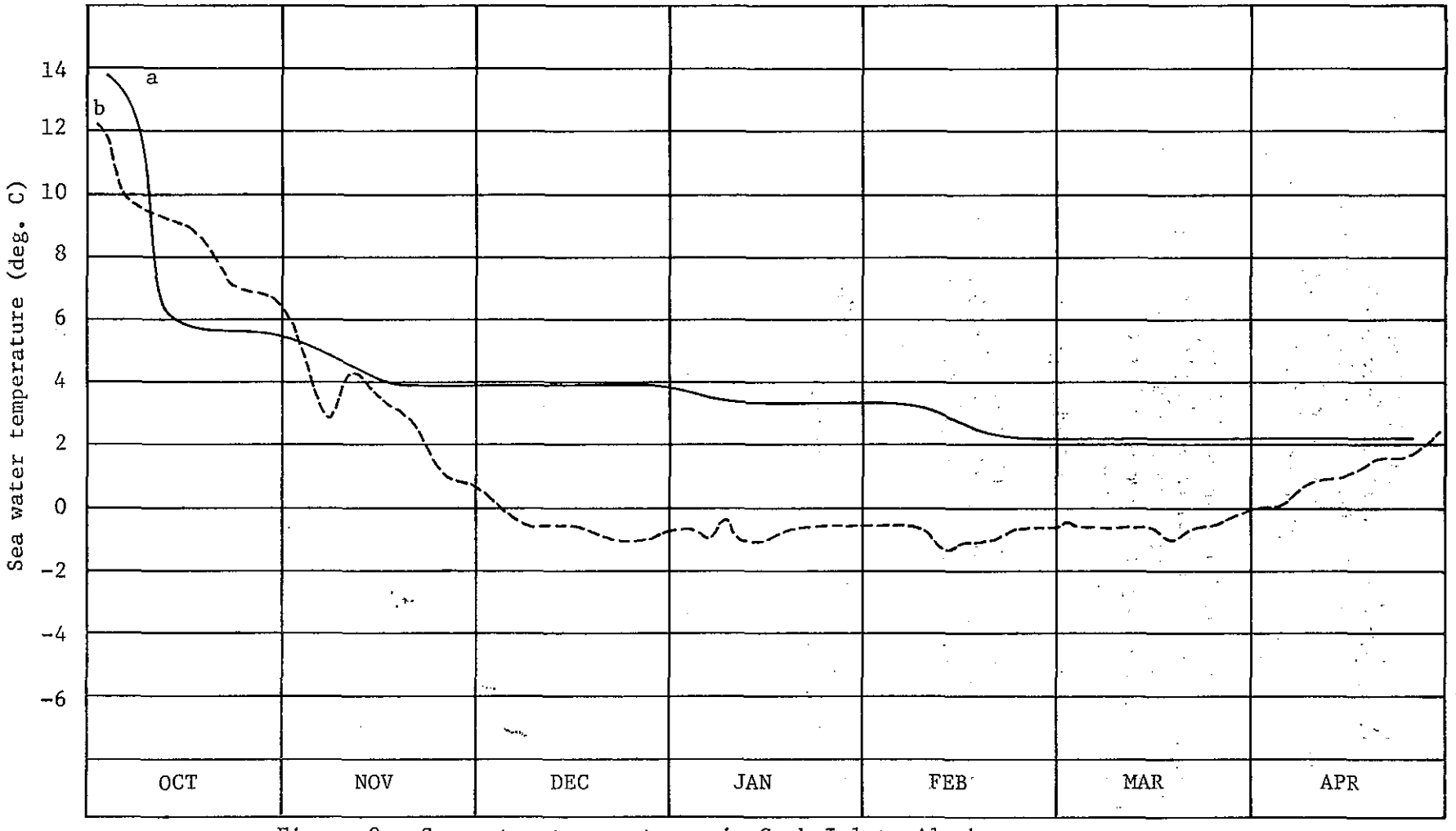

Figure 8. Sea water temperatures in Cook Inlet, Alaska
a) Dolly Varden Oil Platform, 1977-78
b) Phillips Oil Platform, 1977-78

The oil platforms provided weather and ice observations on a fairly regular basis; figure 8 compares their sea water temperatures for the winter of 1977-78. Sea water of normal salinity freezes at -1.9°C. Cook Inlet sea water is 'contaminated' by many freshwater sources; experience has shown that sea water in upper Cook Inlet freezes at -1.1°C.

Overall, the inlet ice conditions in the 1977-78 season were relatively mild. The rapid changes in average air temperatures did not allow the ice to get significantly hard and, since normal tidal action breaks up the ice, the inlet was passable for the majority of the ice season.

ACKNOWLEDGEMENTS

My thanks to my colleagues, Francis W. Poole and Gary L. Hufford, for technical assistance, to Richard L. Crisci for general assistance and to Doris Brown for typing the final copy.

REFERENCE

Zubov, N. N., 1938: on the Maximum Thickness and Perennial Sea Ice, Meteorologiia I Gidsoloiia 4, No 4: 123-131.

APPENDIX. ICE GLOSSARY

Term	Usual age	Usual thickness
New ice	Hours to days	Less than 10 cm
Young ice	Days to weeks	10-30 cm
Thin (first year) ice	Weeks to months	30-60 cm
Medium (first year) ice	Months	60-120 cm
Thick (first year) ice	Months	Greater than 120 cm
Multi-year ice	More than one year	3 m or more

Categorical term	Coverage (in tenths)
Ice free	0
Very open pack ice	1-3
Open pack ice	4-6
Close pack ice	7-9
Very close pack ice	10

Term	Size (diameter)
Brash (disintegration of other ice)	Less than 1.5 m
Cakes	1.5-20 m
Small floe	20-90 m
Medium floe	90-450 m
Big floe	450 m - 1.5 km
Vase floe	1.5-10 km
Giant floe	Greater than 10 km

Others terms used

Fast ice: attached to the shore, beached, stranded in shoal water, or attached to the bottom of shoal areas.

Slush: an accumulation of ice crystals which may or may not be slightly frozen together; sometimes found as a viscous, floating mass in water after heavy snowfall.

Stamukha: (plural: stamukhi)... results when a piece of beach ice has been deposited on the mud flats by the tides and is frozen to the underlying mud. Ice floes floating toward the beach are caught on top of the piece of ice and, as the tide recedes, the overhanging edges break off leaving a stack of layered ice with nearly straight sides. This process may be repeated many times, limited only by the height of the tides and strength with which the original beach ice was frozen to the mud.

Significant ice: in Cook Inlet, ice is considered significant when the concentration of ice at the Phillips oil platform is 10% or more.