NOAA TECHNICAL MEMORANDUM NWS AR-32

SEA ICE CONDITIONS IN COOK INLET, ALASKA DURING THE 1979-1980 WINTER

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UNITED STATES
DEPARTMENT OF COMMERCE
Malcolm Baldrige

NATIONAL OCEANIC AND
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National Weather
Service
Richard E. Hallgren, Director

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ABSTRACT

A warm fall and spring brought a late onset (December 12) and an early departure (March 26) of significant ice. This was the shortest ice season since records began in 1969. Ice coverage was extensive and reached its maximum by January 28 with nearly all Cook Inlet covered north of Anchor Point and Cape Douglas. Ice coverage changed little from late January through mid-March; however, periods of warming and cooling did cause changes in the ice concentrations and hardness. During an episode of strong north winds over the lower inlet on February 3, ice flowed past Cape Douglas into Shelikof Strait which included stamukhi more than a meter thick; this ice disintegrated by February 8. A period of rapid warming began on March 20 and the inlet was free of significant ice by March 26.

DATA SOURCES

Ice observations of Cook Inlet and for this report came mainly from the TIROS-N satellite imagery. TIROS-N is in a polar orbit approximately 840 km above the earth and furnishes two good observations (1 km resolution) of Cook Inlet each day; these observations may be in either the visual (0.55-0.68 μm) or in infrared (10.5-11.5 μm) spectrums. The infrared images can be enhanced to more easily define sea surface temperatures. Images in the visual spectrum are not very useful during the ice season due to the lack of daylight and interference due to cloud cover occurs frequently. Ice observations are also obtained from oil platforms, from the Union Chemical Dock at Nikiski, and from occasional ship and aircraft reports. Sea water temperatures are received from Phillips, Dolly Varden and Dillon platforms. At all three platforms, the sea water intake is located approximately 5 m below sea level and the temperature is measured as it enters a heat exchanger.

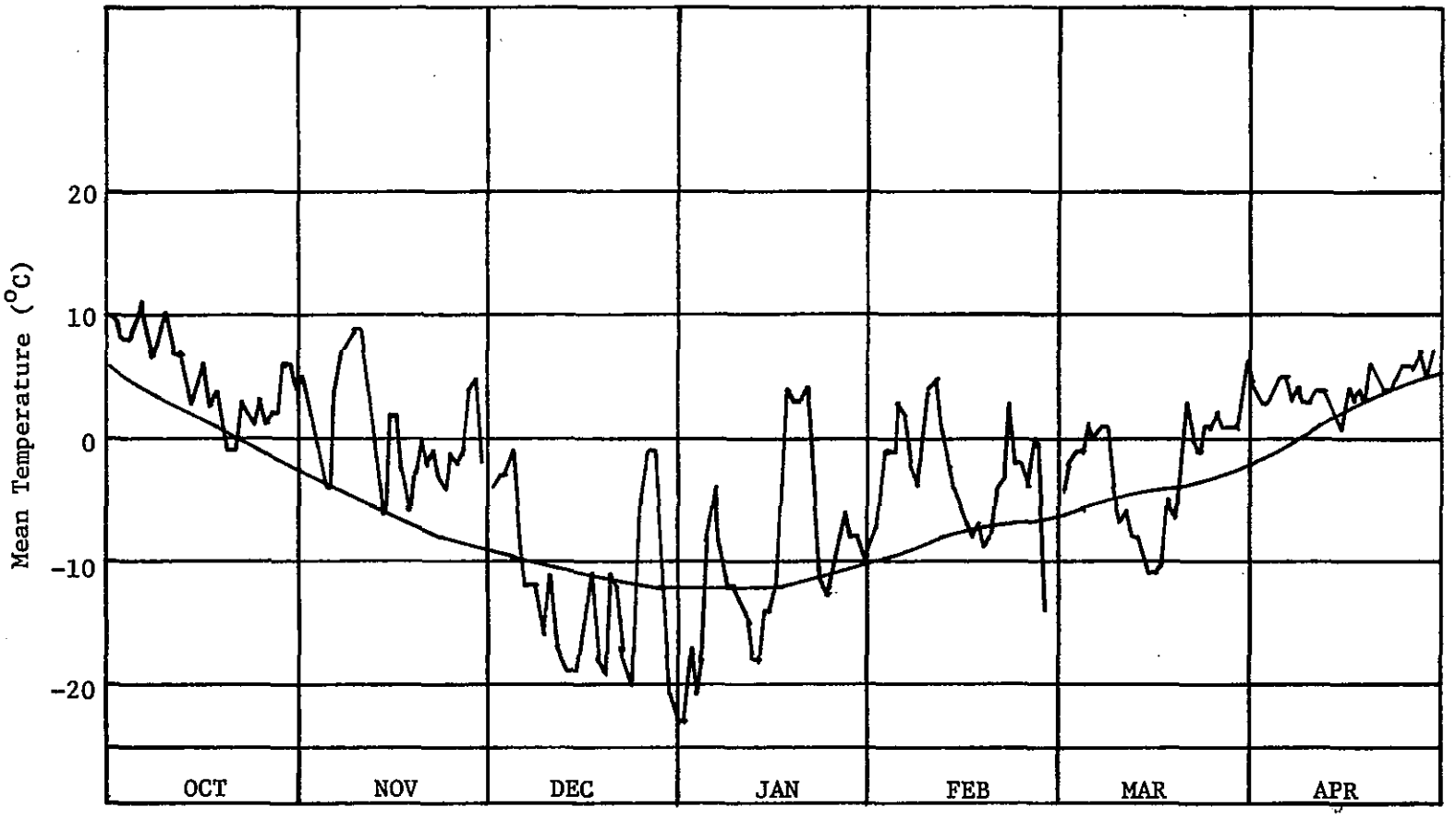

Figure 1. Mean Daily and Normal Temperatures at Anchorage, Alaska, Winter 1979-80

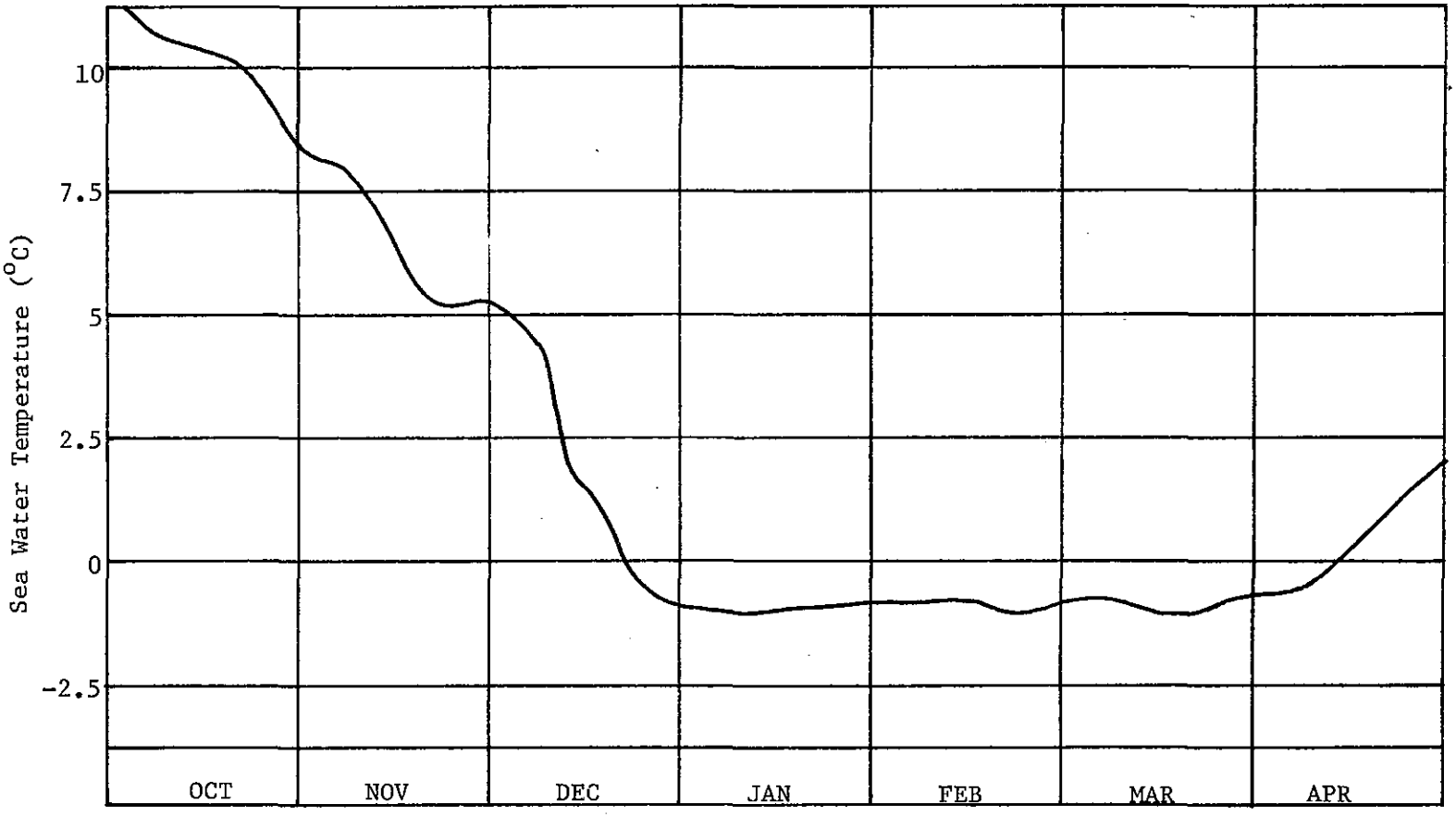

Figure 2. Sea Water Temperatures, Cook Inlet, Alaska, at Phillips Oil Platform 1979-80

ICE CONDITIONS

The fall of 1979 was relatively warm (figure 1) and wet. Because of the length and intensity of the rain and onshore flow along the North Gulf Coast, several periods of heat flux are evident at the Phillips Platform (see figure 2). The last warming period began November 23 and lasted until December 10 when a rapid drop in water temperature can be seen at the Phillips platform. A series of low pressure centers began moving across northern Alaska on December 1, and by December 9 the track had progressed southeastward into the Gulf of Alaska. Temperatures dropped below normal on December 5 and remained there, with two minor warming periods, through January 16.

The first ice formed on Cook Inlet on December 5, in the northern fresh water source areas, and rapidly expanded into the Anchorage port and the area around Fire Island. By December 12, the first concentration of ice significant to navigation was reported at the Phillips platform (figure 3). On December 15, an open to close pack of brash and pancake ice extended south to a line from just north of the East Forelands to Trading Bay, with very open ice (see Glossary) south to Kalgin Island. The heaviest concentration of ice was in mid-channel but the concentration shifted to the west side of the inlet on December 16 and remained there until December 18.

On December 24, north of the Forelands, there was an open to close pack of small floes to brash of young ice that increased to a close pack north of a line from the East Forelands to the North Forelands. South of the Forelands to Kalgin Island was an open pack of new ice of pancakes and brash. Strips and patches of new ice extended from the south end of Kalgin Island to Tuxedni Bay.

Ice growth came to a standstill December 25-29, then formed rapidly again through the first half of January. On January 1, fast ice began forming in the western bays from Tuxedni Bay to Cape Douglas. By January 15, the area north of the Forelands was covered with a very close pack of thin ice with up to medium floes; south of the Forelands to Ninilchik and Chinitna Bay was a close pack of young ice of brash to small floes. South of Chinitna Bay to Anchor Point and Cape Douglas was open pack, but shorefast ice extended from Chinitna Bay through Kamishak Bay to Cape Douglas.

Temperatures rose above freezing on January 17 and remained relatively high through January 22. There was some decrease in the concentration of ice and some softening during this period, but temperatures returned to normal January 23. By January 28, the southern edge of the ice lay from 16 km north of Anchor Point to 16 km west of Ninilchik to 30 km southeast of Chisik Island to 16 km south of Augustine Island to Cape Douglas.

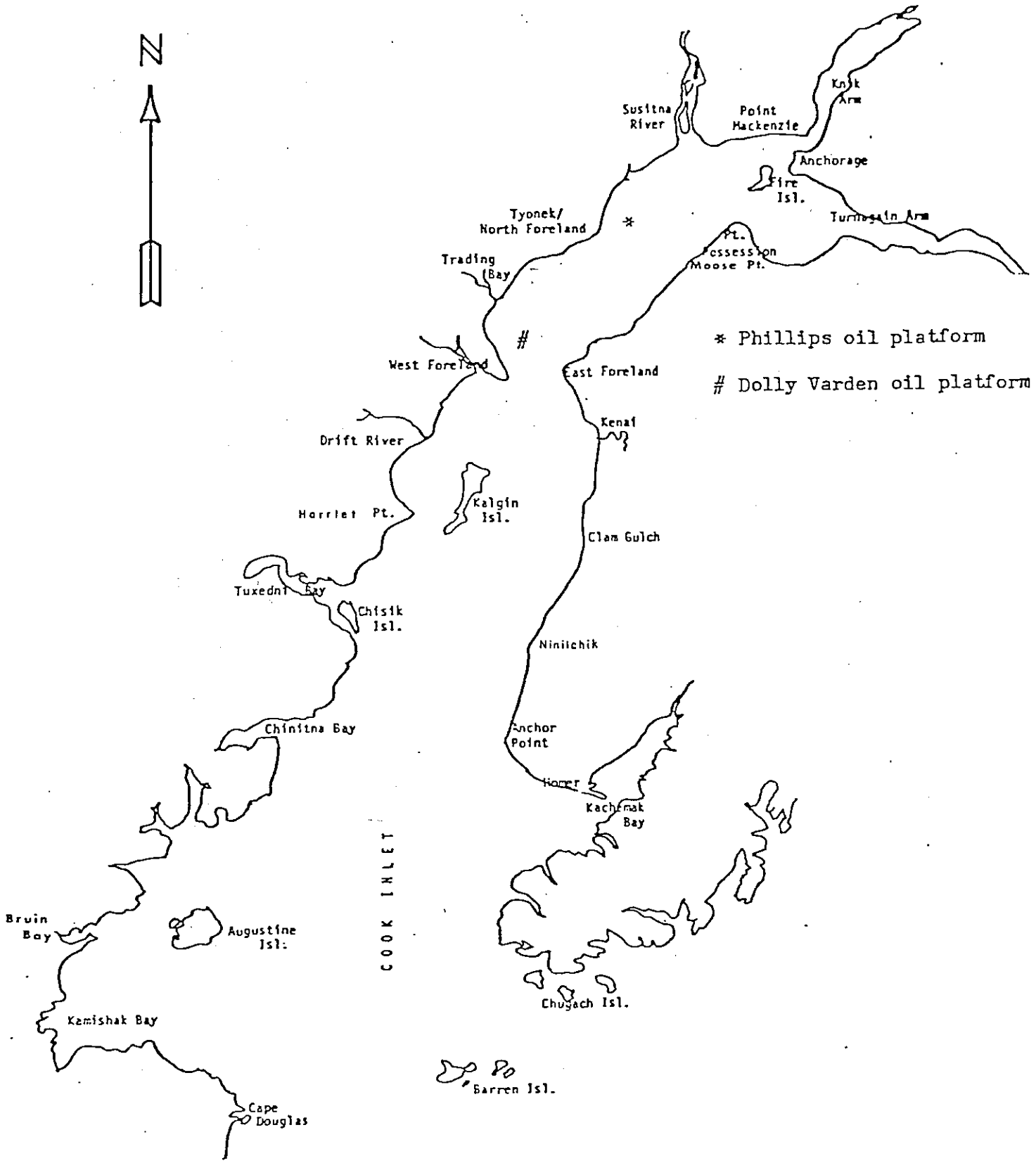

Figure 3. Map of Cook Inlet, Alaska.

A low pressure center moved into the northern Gulf of Alaska on January 27 and slowly deepened. Northeast winds opened the eastern quarter of the inlet to close to open pack of ice with some areas of very open pack. Strong northwest winds developed over the southern inlet on February 2 as the low pressure center moved east and, on February 3, ice flowed south of Cape Douglas into Shelikof Strait near Kiukpalik Island (38 km south of Cape Douglas) with an open to close pack of thin ice that included refloated beach ice in chunks more than a meter thick. This ice was reported in the area around Kiupalik Island until February 8.

During the remainder of February and in early March, temperatures varied with periods of rotting and diminishing ice and hardening and increasing ice. However, the area of coverage changed little. A sharp warming period began on March 20 as southerly flow was again established by a large low pressure center in the Bering Sea. Ice decreased and rotted rapidly and, on March 26, the inlet became free of significant ice.

SUMMARY

Ice formation on Cook Inlet during 1979-80 was late; the onset date of December 12 was the third latest (1976 and 1978 were later) since records began in 1969. There was a rapid accumulation of frost degree-days (FDD)[1] through the remainder of December and the first half of January (see figure 4). The remainder of the ice year was rather static with alternate periods of warming and cooling. Ice flowed into Shelikof Strait on February 3 and remained through the 8th. Stamukhi formed but were relatively small, being 1 to 2 m thick. Ice decreased rapidly after March 20 and the inlet was free of significant ice on March 26. Only two other years since records began had an earlier date of being ice-free: 1978 and 1970. The combination of the late onset and of becoming ice-free early made the 1979-80 ice season have fewer days of significant ice than any other year since records began in 1969 (see table 1). A maximum ice thickness of 60-120 cm was reported through January and February. This compares well with the calculated value of 76 cm obtained from an ice growth curve developed by Zubov (1938).

The total accumulated FDD's at the end of each month and for the season was below the average for the past 10 years (table 2). But the rate of accumulation between December 5 and January 22 was above normal and accounted for the areal extent and hardness of the ice during that period.

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[1] Frost degree-days are defined as the difference between $0^{\circ}C$ and the mean daily temperature. When the temperature is less than $0^{\circ}C$, 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.

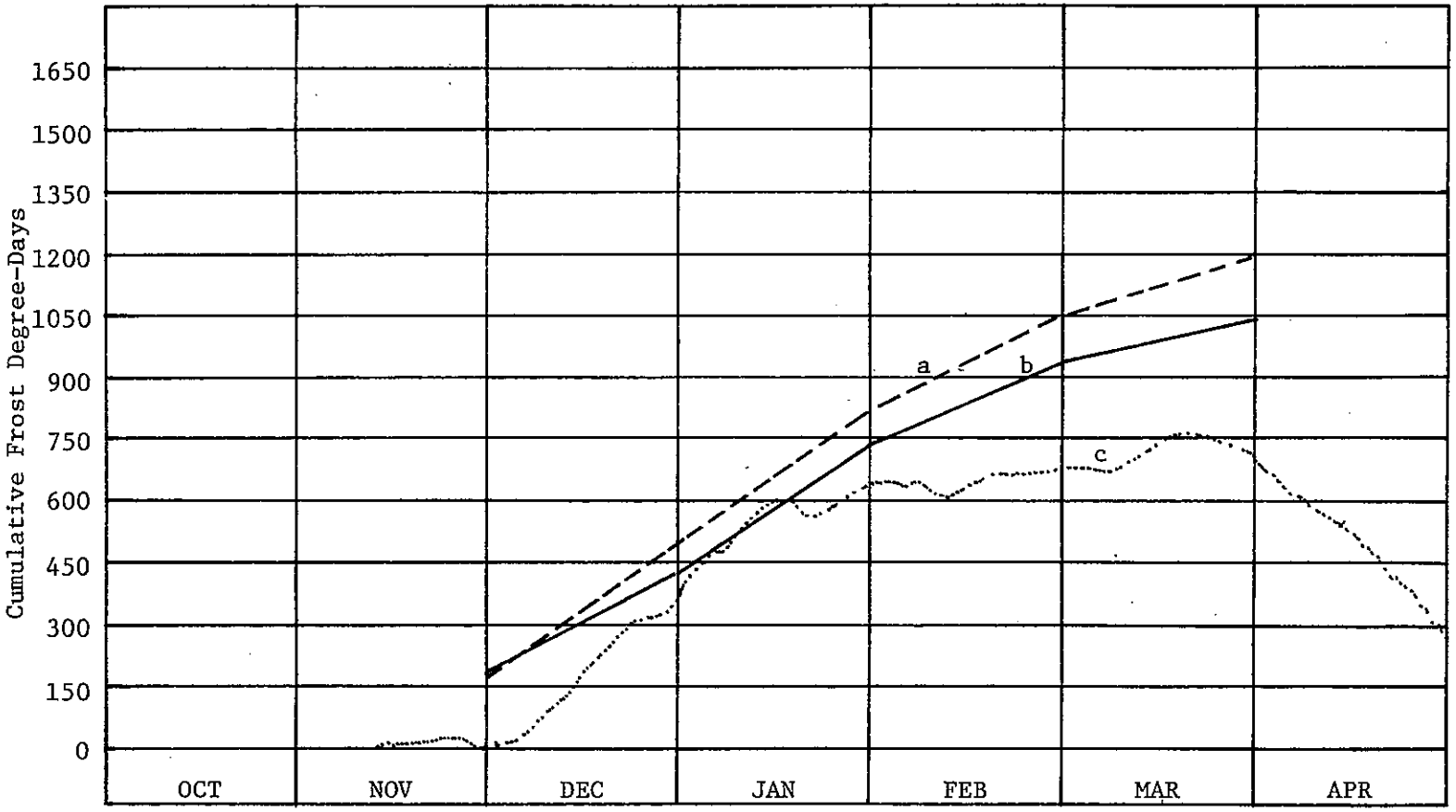

Figure 4. Daily Accumulation Frost Degree-Days (Base 0°C) at Anchorage, Alaska,
(a) 42-year Average, 1923-68 (1925-27 and 1928-29 missing),
(b) Average, 1969-79
(c) 1979-80

The average date for the onset of significant ice in Cook Inlet, using data from 1969 through 1980, is November 23 and the mean is November 20. The average and mean date the inlet is ice-free, again using data from 1969 through 1980, is April 9. Using a normal distribution, the probability of significant ice is 80% by December 9 and the date with an 80% probability of being ice-free is April 23.

ACKNOWLEDGEMENTS

My thanks to Richard L. Crisci for editing and Mary Jo Rugwell for typing this memorandum.

REFERENCE

Zubov, N.N., 1938: On the Maximum Thickness of Perennial Sea Ice. Meteorologiia i Gidroloiia 4, No. 4, 451 pp.

Table 1.--First significant ice and ice-free dates for Cook Inlet for the winters of 1969 through 1980.

	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
78-79	Dec 16	Mar 31
79-80	Dec 12	Mar 26
Average	Nov 23	Apr 9
Mean	Nov 20	Apr 9

Table 2.--Cumulative frost degree-days (based on $0^{o}C$) 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
1977-78	276	628	803	836	832
1978-79	6	227	387	716	650
Average	183	429	735	935	1038
1979-80	1	379	645	670	705

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

Other 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.