



TECHNICAL REPORT

FROST DEGREE DAY, RELATED ICE THICKNESS
CURVES, AND HARBOR FREEZEUP AND BREAKUP
DATES FOR SELECTED ARCTIC STATIONS

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and

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Oceanographic Prediction Division

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U. S. NAVAL OCEANOGRAPHIC OFFICE

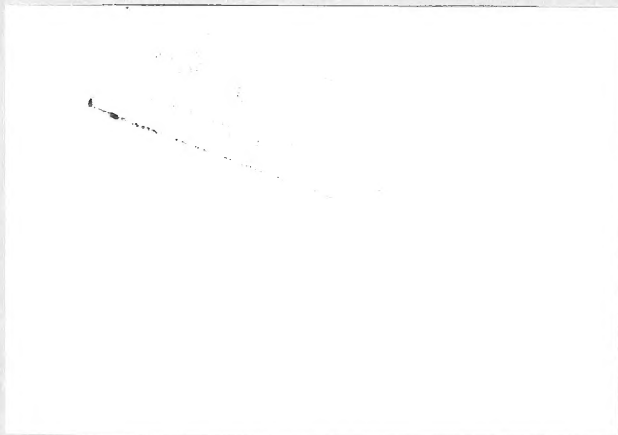
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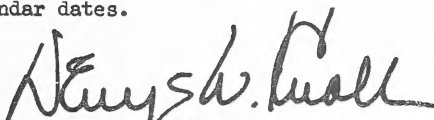
Frost degree day data and sea ice information for selected stations throughout the Arctic are described. Related frost degree day and ice growth curves are graphically illustrated. Harbor breakup and freezeup dates are furnished for selected stations.



FOREWORD

Successful arctic operations require considerable preparation and planning. To aid such planning, the Oceanographic Office has been engaged in developing various techniques for forecasting formation, growth, movement, and disintegration of sea ice, especially in harbor areas, since each arctic and subarctic harbor constitutes a special environmental problem.

This report is based on available sea ice information and frost degree data for 58 arctic stations. Freezeup and breakup dates for 39 stations are included. The earliest, latest, and average dates of freezeup or breakup are given in calendar dates.



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15. Wales	32-33	44. Mould Bay	90-91
16. Nome	34-35	45. Resolute	92-93
17. Gambell	36-37	46. Dundas Harbor	94-95
18. Nunivak	38-39	47. Arctic Bay	96-97
19. Bethel	40-41	48. Pond Inlet	98-99
20. Naknek	42-43	49. Herschel Island	100-101
21. St. Paul Island	44-45	50. Aklavik	102-103
22. Alert	46-47	51. Coppermine	104-105
23. Thule	48-49	52. Cambridge Bay	106-107
24. Clyde River	50-51	53. Lake Harbour	108-109
25. Padloping	52-53	54. Nottingham Island	110-111
26. Frobisher	54-55	55. Coral Harbor	112-113
27. Resolution Island	56-57	56. Chesterfield	114-115
28. Hopedale	58-59	57. Churchill	116-117
29. Goose Bay	60-61	58. Port Harrison	118-119
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I. INTRODUCTION

This report presents available frost degree day data and sea ice information for selected arctic harbors. Emphasis is placed on three general categories of data: (1) cumulative frost degree days, (2) ice growth and disintegration, and (3) harbor breakup and freezeup dates.

II. METHOD OF COMPILATION

A. Frost Degree Days

Frost degree day curves were drawn for the 58 arctic and subarctic stations identified in figure 1 and listed in table 1. A frost degree day is defined as a daily mean temperature 1°F below an arbitrary base of 32°F . The frost degree day curves were based on mean monthly, mean daily maximum, and mean daily minimum temperatures. These three parameters were used to construct corresponding frost degree day curves, which give a normal frost degree day accumulation, and an envelope showing maximum and minimum frost degree day values for each station. These curves, together with a mean temperature curve, are shown in figures 3A through 60A.

b. Ice Growth

Associated with the frost degree day curves are corresponding ice growth and disintegration curves (figures 3B through 60B). Two types of ice growth curves are depicted in this report: (1) a theoretical curve based on cumulative frost degree days, and (2) an empirical curve based on observed ice thickness data. At the stations where ice thickness data were available for at least 3 years, empirical curves were constructed for normal ice growth, as well as for the maximum and minimum growth. For stations which lacked ice thickness data, a theoretical curve was constructed from a variation of the Zubov ice growth curve given by the following:

$$1.43I^2 + 28.6I - \sum \text{FDD} = 0$$

where I is ice thickness, and FDD is the summation of the cumulative frost degree days in degrees Fahrenheit. An average date for theoretical complete disintegration of the ice was also computed. The period between maximum ice growth and complete disintegration of the ice for each station was based upon available ice information. Initial ice growth and rate of disintegration for the empirical and several theoretical ice growth curves were estimated and are indicated by broken lines in the figures. The sparsity of freezeup and breakup data at the individual stations made this estimation necessary.

III. HARBOR BREAKUP AND FREEZEUP DATES

Harbor freezeup data were compiled for the 39 arctic and subarctic stations listed in table 2. Breakup data were sufficient for only 30 stations. The data for each particular station were divided into three main categories based on calendar dates. These categories consisted of earliest, latest, and average dates of breakup or freezeup. Freezeup is defined as the date of initial ice formation. Breakup is the date when

ice concentration decreases to one tenth or less in a given harbor. It is to be emphasized that breakup dates apply only to the harbor at the specified stations. Quite often, the harbor will become essentially ice free, but the approaches to the station may still be congested with heavier ice concentrations.

IV. SUMMARY

This report shows the relationship between ice growth and air temperature. An average date based upon available ice information was computed for disintegration of ice at various stations. The relationship between the number of warming degree days and melting of specific maximum ice growths is not discussed in this report. It should be stressed that other parameters, such as ocean currents, winds, and tidal action, also affect ice growth and dissipation at some locations. Further study of these parameters is currently being conducted.

Table 1

Location Identifier for Frost Degree Day and Ice Growth Curves

1. *Barter Island	21. Thule	41. Isachsen
2. Pt. Barrow	22. Clyde River	42. Mould Bay
3. Wainwright	23. Padloping Island	43. Resolute
4. Pt. Lay	24. Frobisher Bay	44. Dundas Harbor
5. Pt. Hope	25. Resolution Island	45. Arctic Bay
6. Kotzebue	26. Hopedale	46. Pond Inlet
7. Wrangel Island	27. Goose Bay	47. Herschel Island
8. Mys Schmidta	28. Cartwright	48. Aklavik
9. Mys Vankarem	29. Belle Isle	49. Coppermine
10. Mys Dezhneva	30. Upernavik	50. Cambridge Bay
11. Uelen	31. Umanak	51. Lake Harbour
12. Mys Chaplina	32. Godhavn	52. Nottingham Island
13. Wales	33. Jakobshavn	53. Coral Harbor
14. Nome	34. Sondrestrom	54. Chesterfield
15. Gambell	35. Godthaab	55. Churchill
16. Nunivak	36. Ivigtut	56. Port Harrison
17. Bethel	37. Nanortalik	57. Cape Hopes Advance
18. Naknek	38. Angmagssalik	58. Fort Chimo
19. St. Paul Island	39. Nord	
20. Alert	40. Eureka	

* Numbers agree with those shown in figure 1.

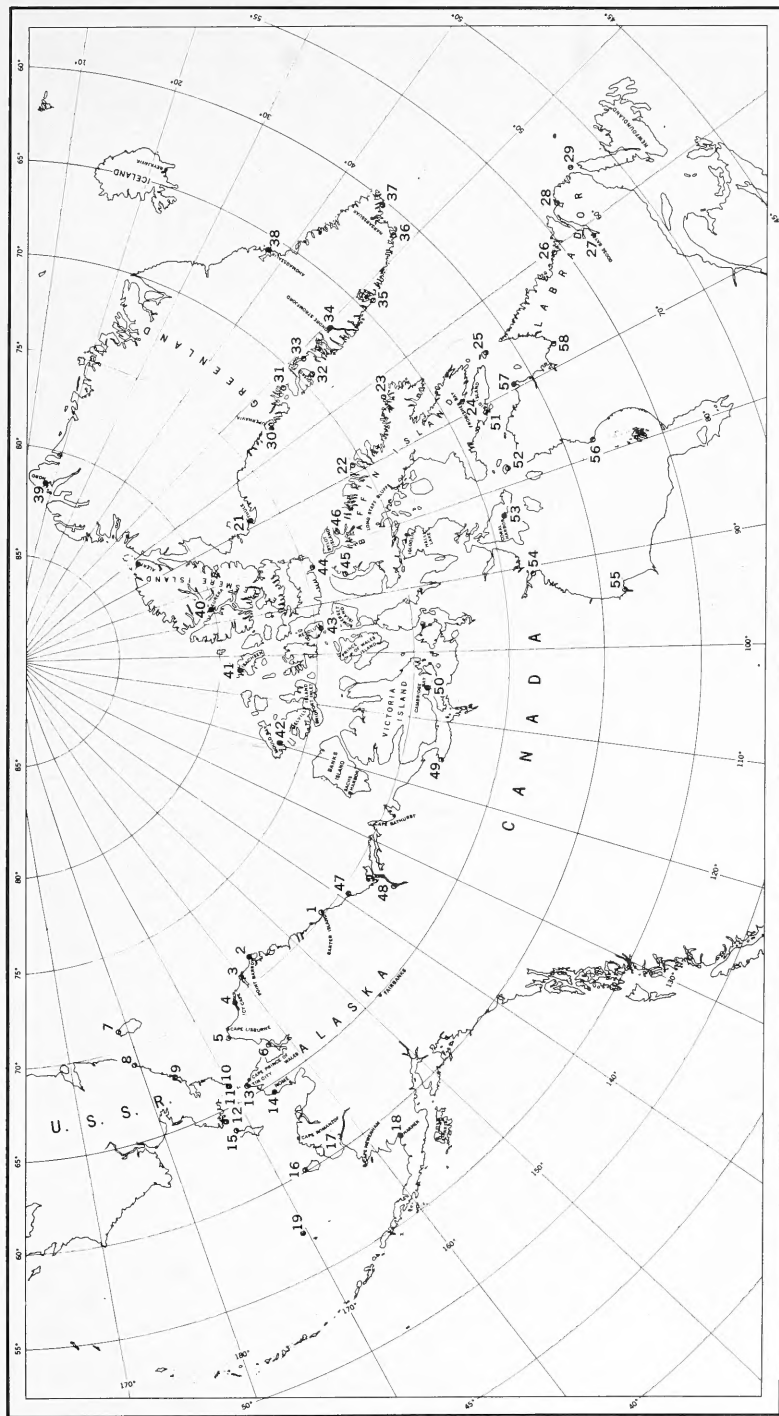


FIGURE 1 LOCATION MAP FOR FROST DEGREE DAY AND ICE GROWTH AND DISINTEGRATION CURVES

Table 2

Location Identifier for Harbor Breakup and Freezeup Dates

Site	Freezeup				Breakup			
	Earliest	Latest	Avg	Yrs Data	Earliest	Latest	Avg	Yrs Data
1. *Barter Island	9/24	9/24		1	7/15	8/31	8/13	3
2. Pt. Barrow	8/30	12/19	9/17	25	6/15	8/24	7/24	25
3. Wainwright	9/16	10/25	10/5	8	6/7	7/26	7/5	7
4. Pt. Lay	10/15	11/27		4	5/20	7/10	6/15	3
5. Pt. Hope	10/6	12/19	11/11	8	5/30	7/8	6/20	8
6. Kotzebue	10/2	11/5	10/23	14	5/17	6/8	5/31	14
7. Wrangel Island	10/18	12/4		3	7/30	8/16		4
8. Wales	10/8	1/8	12/3	16	5/15	6/30	6/8	16
9. Nome	10/13	12/13	11/12	50	4/28	6/28	5/29	50
10. Gambell	10/15	12/14	11/21	10	5/1	7/1	5/26	10
11. Nunivak	11/20	12/13	12/1	2	5/11	5/30	5/20	2
12. Bethel	10/8	11/24	10/29	27	4/24	5/28	5/15	27
13. Naknek	10/17	12/15	11/17	7	3/19	4/25		7
14. Alert	8/27	9/17	9/3	4	7/31	8/5	8/2	2
15. Thule	9/19	11/1	10/9	15	7/8	8/16	7/22	11
16. Clyde River	10/1	11/11	10/19	9	8/16	9/28	9/3	6
17. Padloping Island	10/3	11/24	10/26	10	7/31	9/8	8/24	6
18. Cape Dyer	10/3	11/7	10/19	7	7/28	9/1	8/20	6
19. Frobisher Bay	10/9	11/14	10/24	11	7/28	8/28	8/16	6
20. Resolution Island	10/9	11/18	11/6	10	6/30	8/25	7/23	6
21. Hopedale	11/12	12/14	11/23	8	6/15	7/25	7/11	6
22. Goose Bay	10/20	11/24	11/14	19	5/25	7/15	6/25	11
23. Cartwright	11/12	12/16	12/1	9	5/25	6/30	6/17	6
24. St. Anthony	11/30	12/5	12/3	3	5/3	7/13	6/8	6
25. Sondrestrom	10/8	11/7	11/1	15	5/22	6/12	6/7	11
26. Kulusuk	9/30	11/26	11/4	12	7/15	9/10	8/12	10
27. Eureka	9/6	9/21	9/13	6	7/15	8/20	7/28	5
28. Isachsen	8/24	9/6	8/31	5	8/1	8/16	8/10	3
29. Mould Bay	9/1	9/15	9/6	4	8/20	8/26	8/23	2
30. Resolute	9/12	9/26	9/19	9	7/20	8/13	7/29	4
31. Arctic Bay	10/7	10/19	10/13	3				
32. Sachs Harbor	9/28	10/31	10/15	7				
33. Aklavik	10/9	10/27	10/16	3				
34. Coppermine	10/16	11/4	10/26	5				
35. Cambridge Bay	9/25	10/16	10/7	5				
36. Coral Harbor	10/21	11/26	11/7	5				
37. Chesterfield	10/30	11/15	11/7	4				
38. Churchill	10/17	11/19	11/7	3				
39. Port Harrison	11/5	11/13	11/9	3				

* Numbers agree with those shown in figure 2.

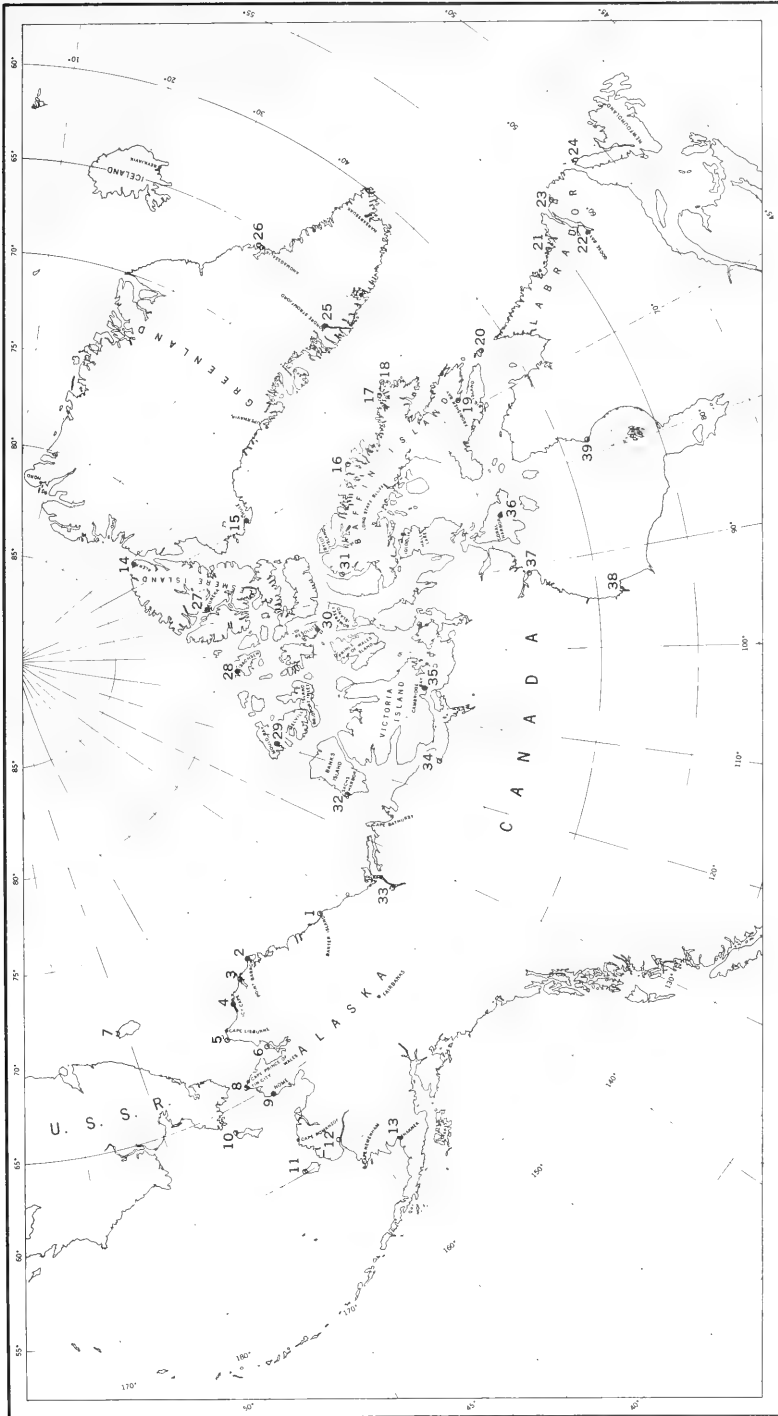


FIGURE 2 LOCATION MAP FOR HARBOR BREAKUP AND FREEZEUP DATES



BIBLIOGRAPHY

- Canada, Department of Transport, Meteorological Branch. Ice Thickness Data for Selected Canadian Stations Freezeup 1961--Breakup 1962, by M. N. Monsinger and T. B. Kilpatrick.
- . Ice Thickness Data for Selected Canadian Station Freezeup 1958--Breakup 1961.
- U.S. Arctic Weather Central, 11th Weather Squadron. River and Harbor Ice Freezeup and Breakup, Project 50-12-11, by Donald O. Roelle. January 1951.
- U.S. Army Headquarters Quartermaster Research and Engineering Command, Environmental Protection Research Division. Temperatures of Northern North America, Research Study Report RER-9, by Donald W. Hogue. Natick, Mass., June 1956 (revised October 1957).
- U.S. Department of Commerce, Coast and Geodetic Survey. United States Coast Pilot 9. Alaska, Cape Spencer to Arctic Ocean. Sixth Edition (1954).
- U.S. Navy Hydrographic Office. Report of the Ice Observing and Forecasting Program 1955. Technical Report No. 50, Washington, D.C. 1956.
- . Report of the Ice Observing and Forecasting Program 1956. Technical Report No. 51, Washington, D.C. 1957.
- . Report of the Ice Observing and Forecasting Program 1957. Technical Report No. 52, Washington, D.C. 1958.
- . Report of the Ice Observing and Forecasting Program 1958. Technical Report No. 66, Washington, D.C. 1959.
- . Report of the Ice Observing and Forecasting Program 1959. Technical Report No. 69, Washington, D.C. August 1961.
- Zubov, N. N. On the Maximum Thickness of Sea Ice of Many Year's Growth. *Meteorologiya i Gidrologiya* 4, 1938, pp 123-131.

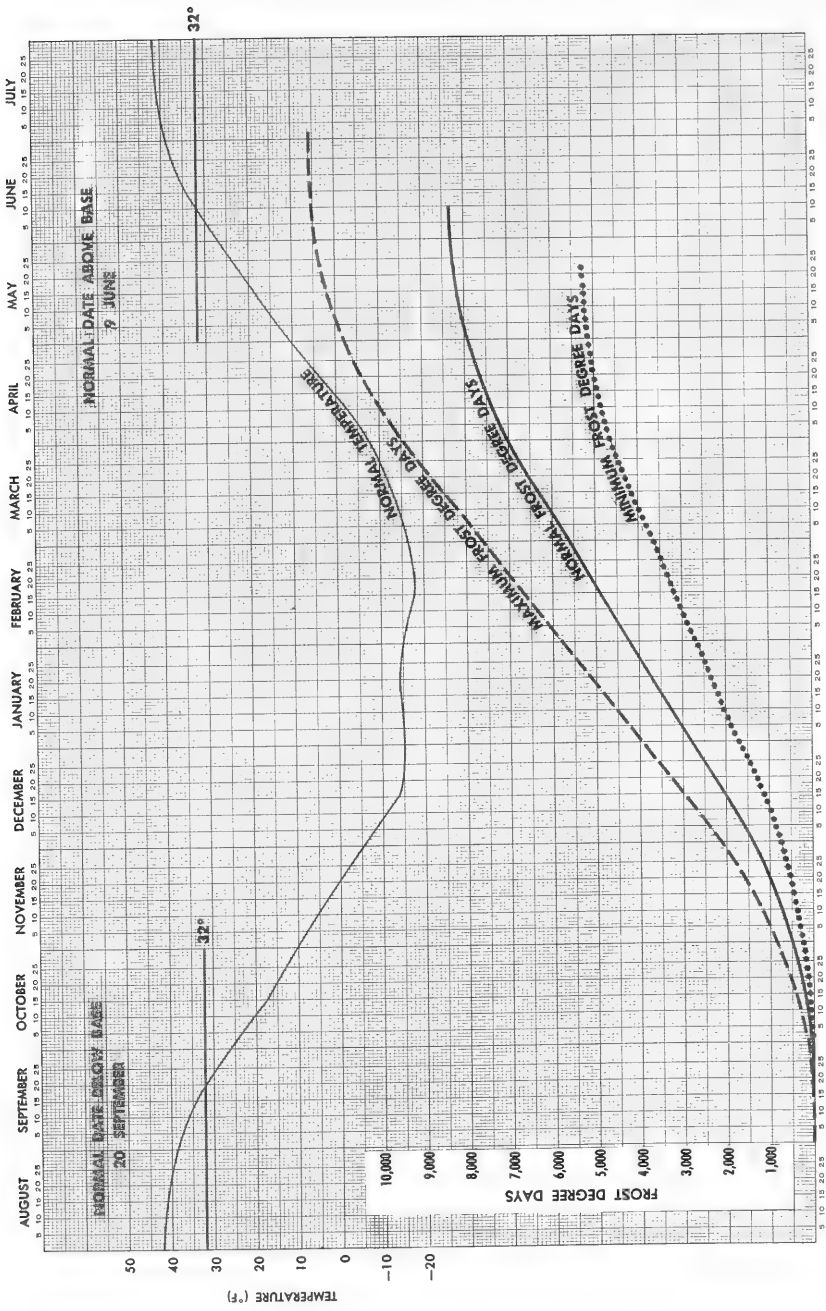


FIGURE 3A BARTER ISLAND (9 YEARS RECORD)

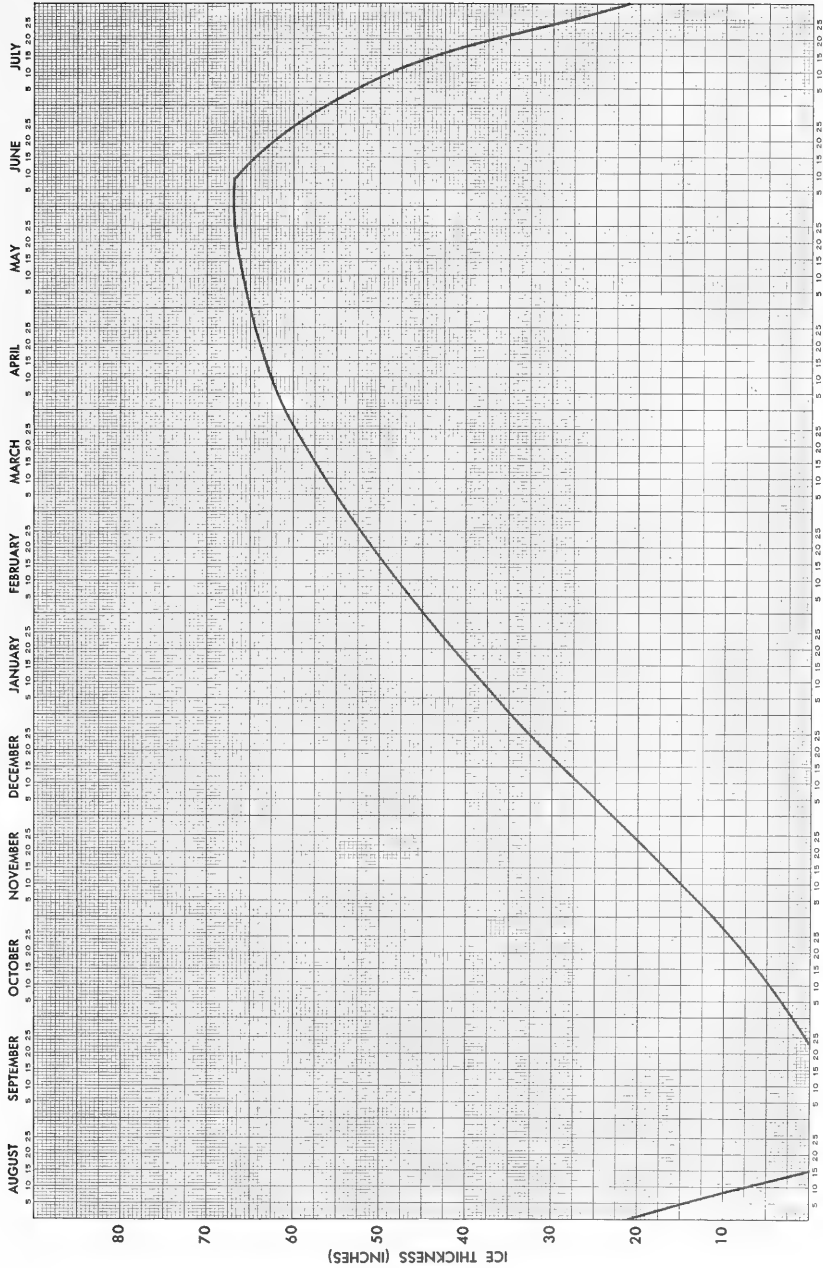


FIGURE 3B BARTER ISLAND THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE



FIGURE 4A POINT BARROW (30 YEARS RECORD)

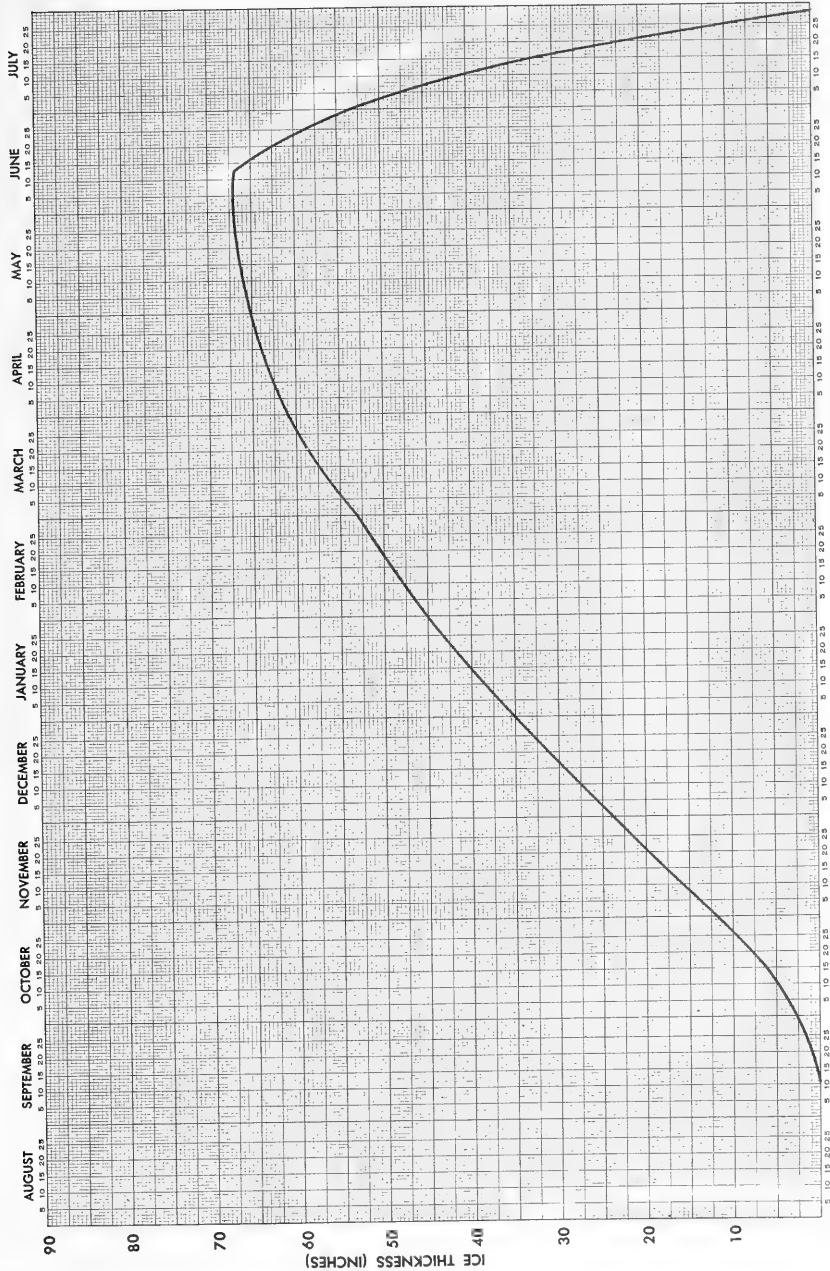


FIGURE 4B POINT BARROW THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

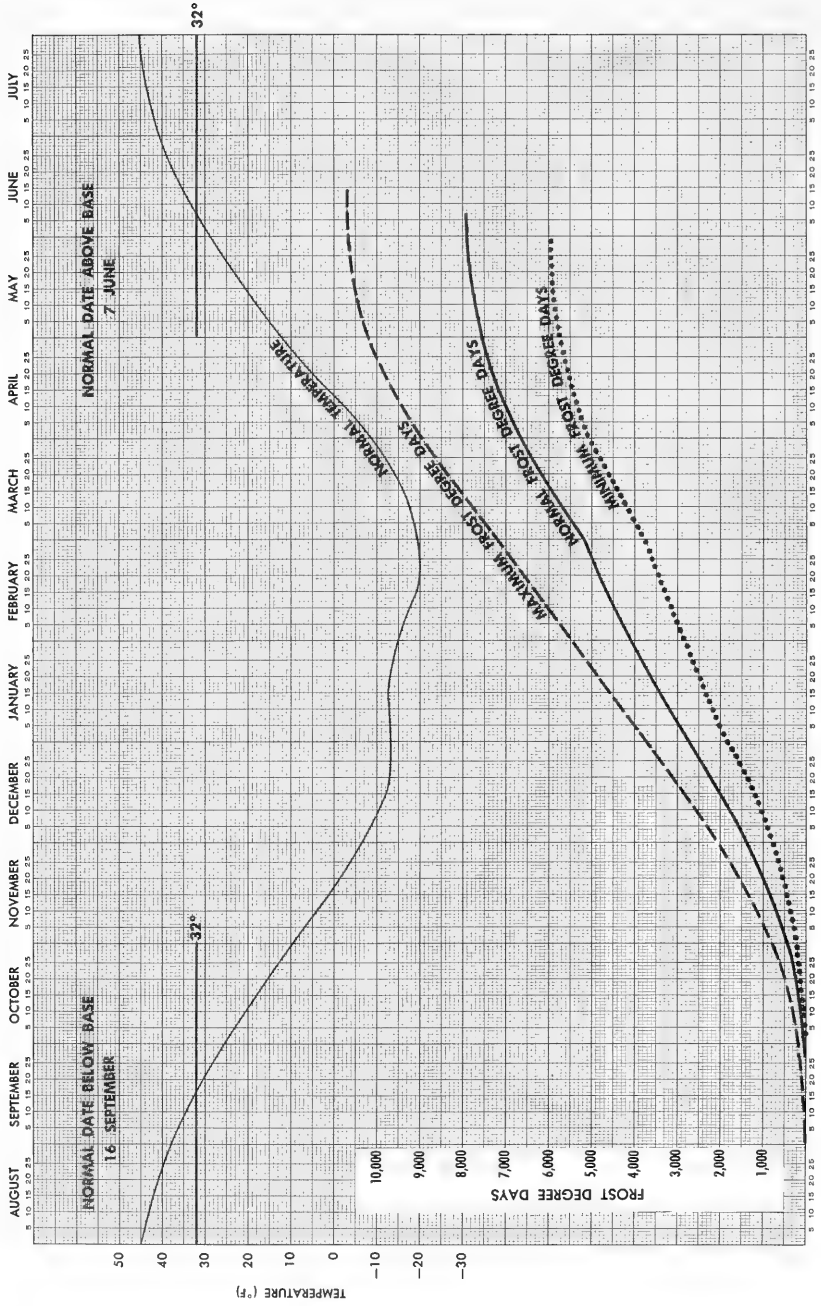


FIGURE 5A WAINWRIGHT (10 YEARS RECORD)

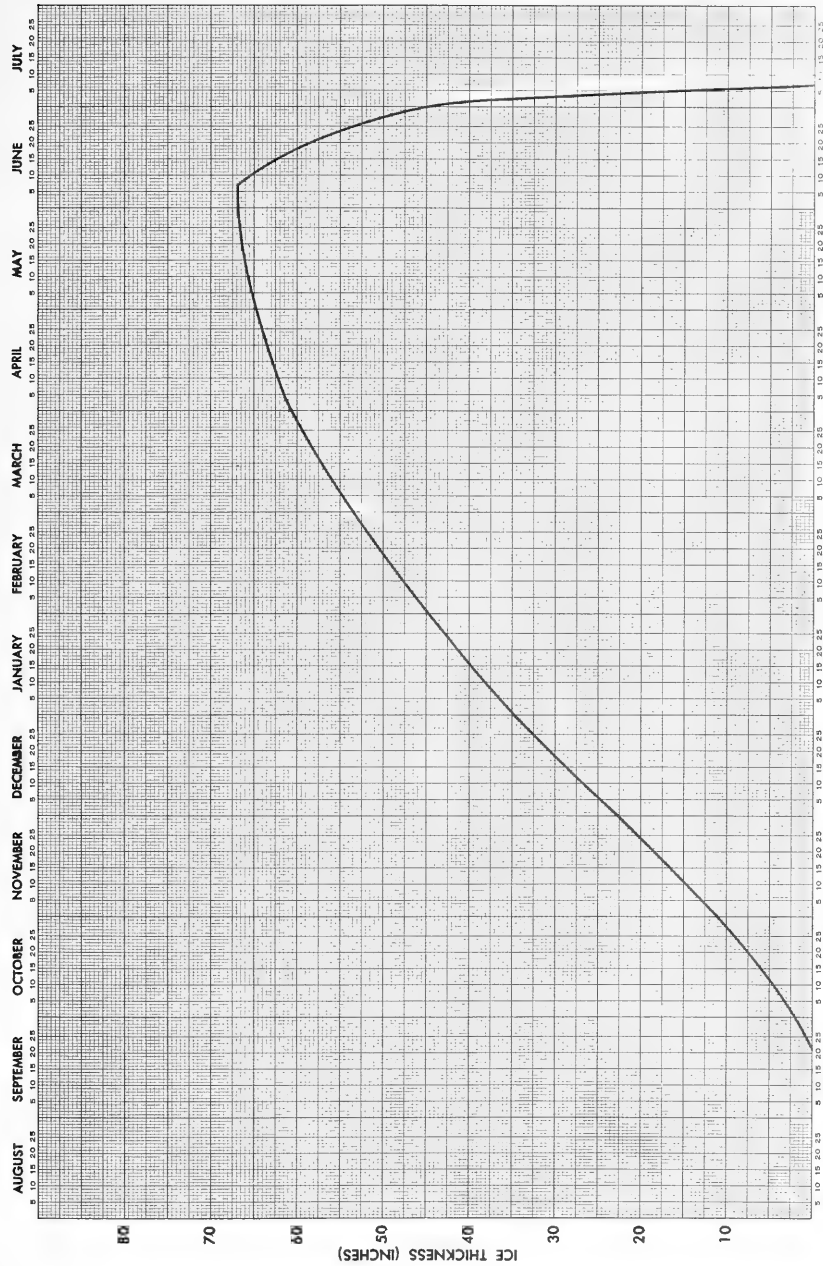


FIGURE 5B WAINWRIGHT THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

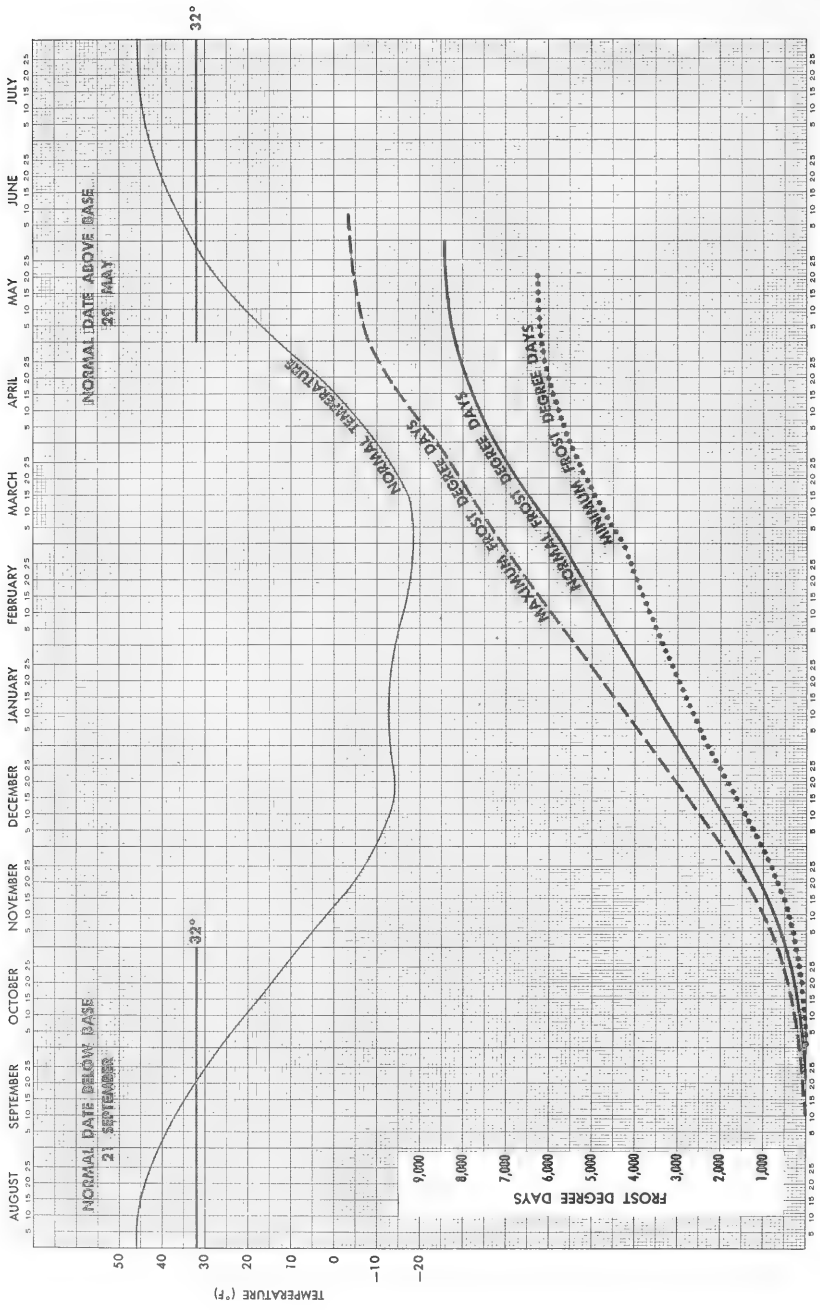


FIGURE 6A POINT LAY (8 YEARS RECORD)

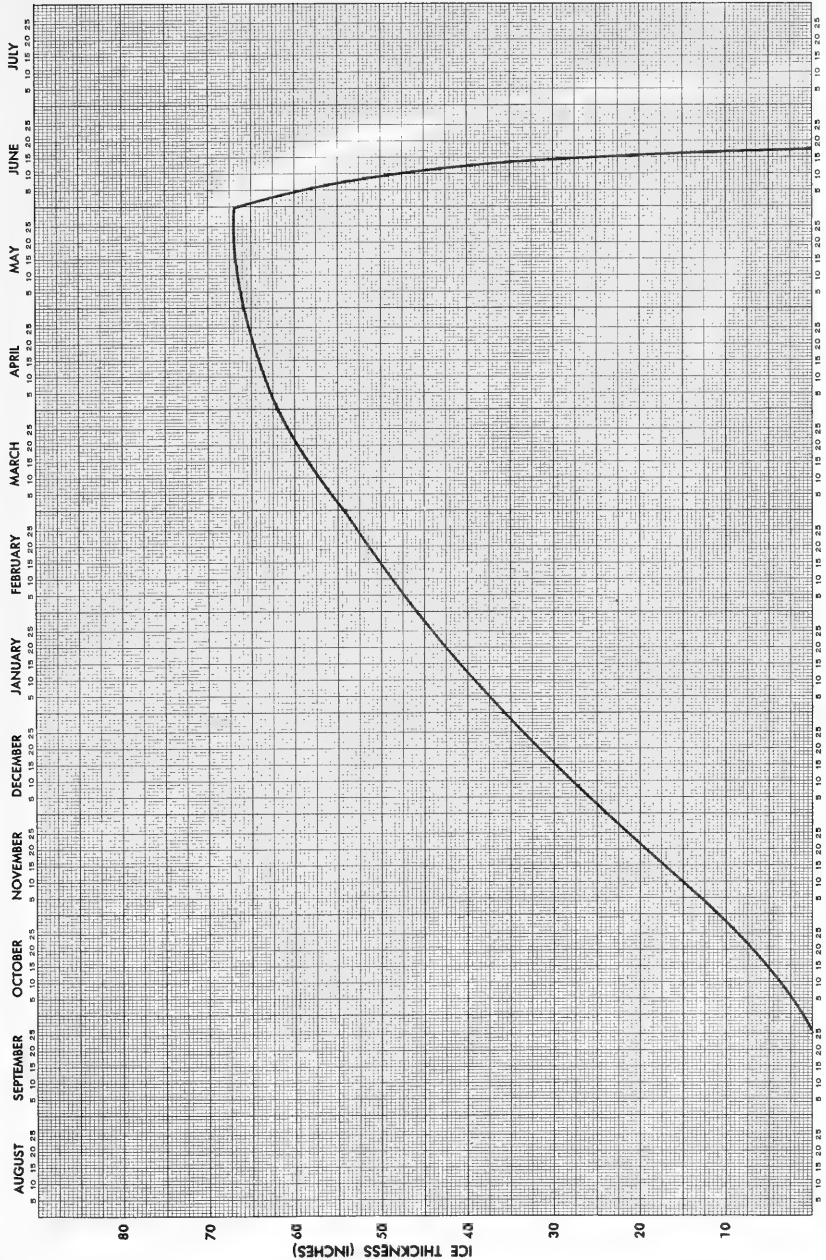


FIGURE 68 POINT LAY THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

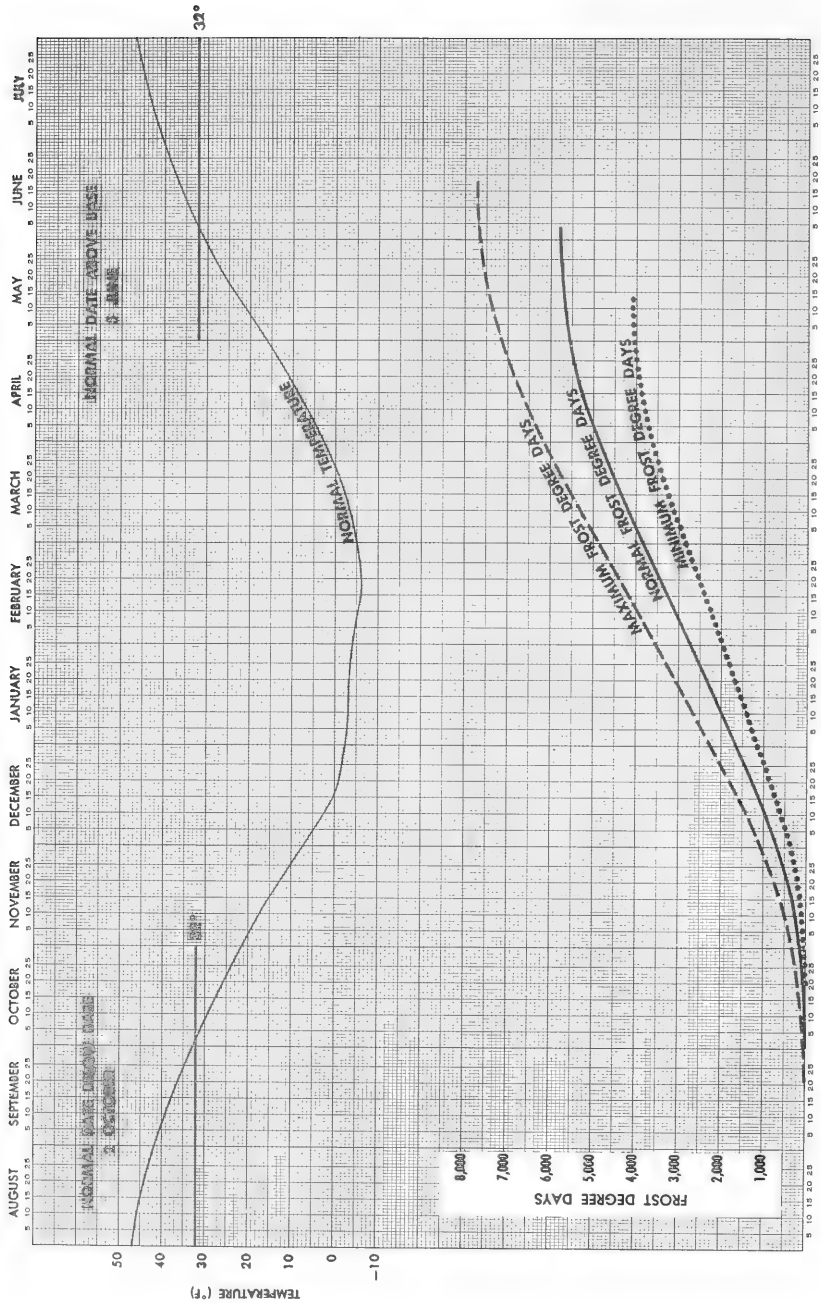


FIGURE 7A POINT HOPE (8 YEARS RECORD)

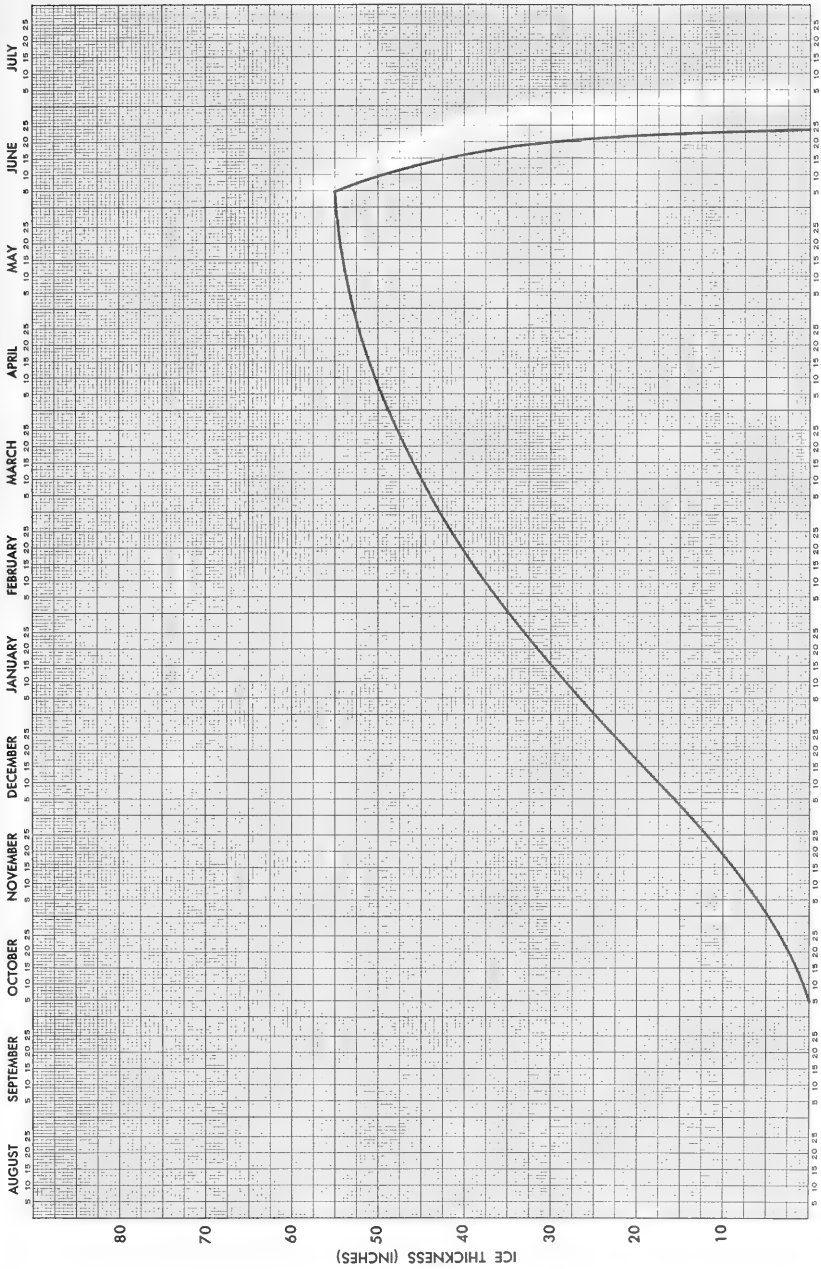


FIGURE 7B POINT HOPE THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE



FIGURE 8A KOTZEBUE (30 YEARS RECORD)

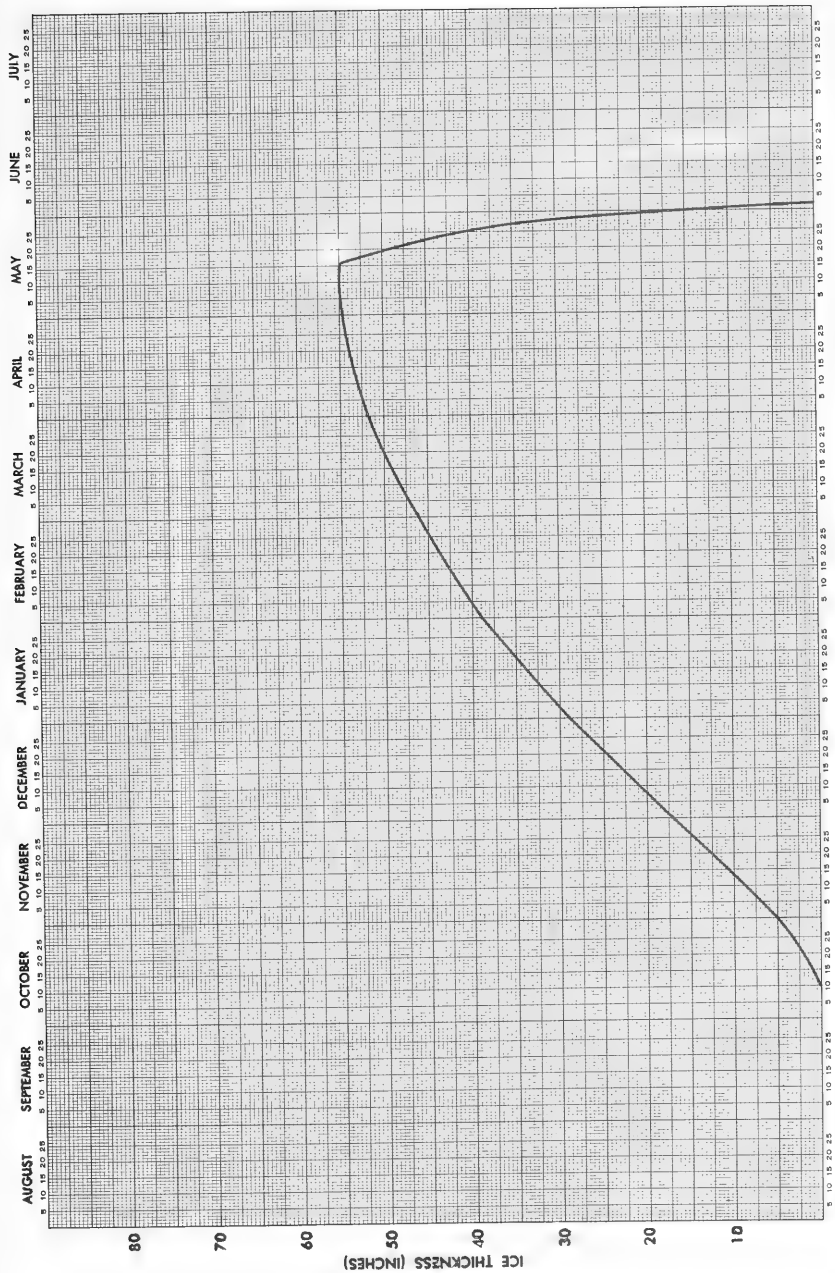


FIGURE 88 KOTZEBUE THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

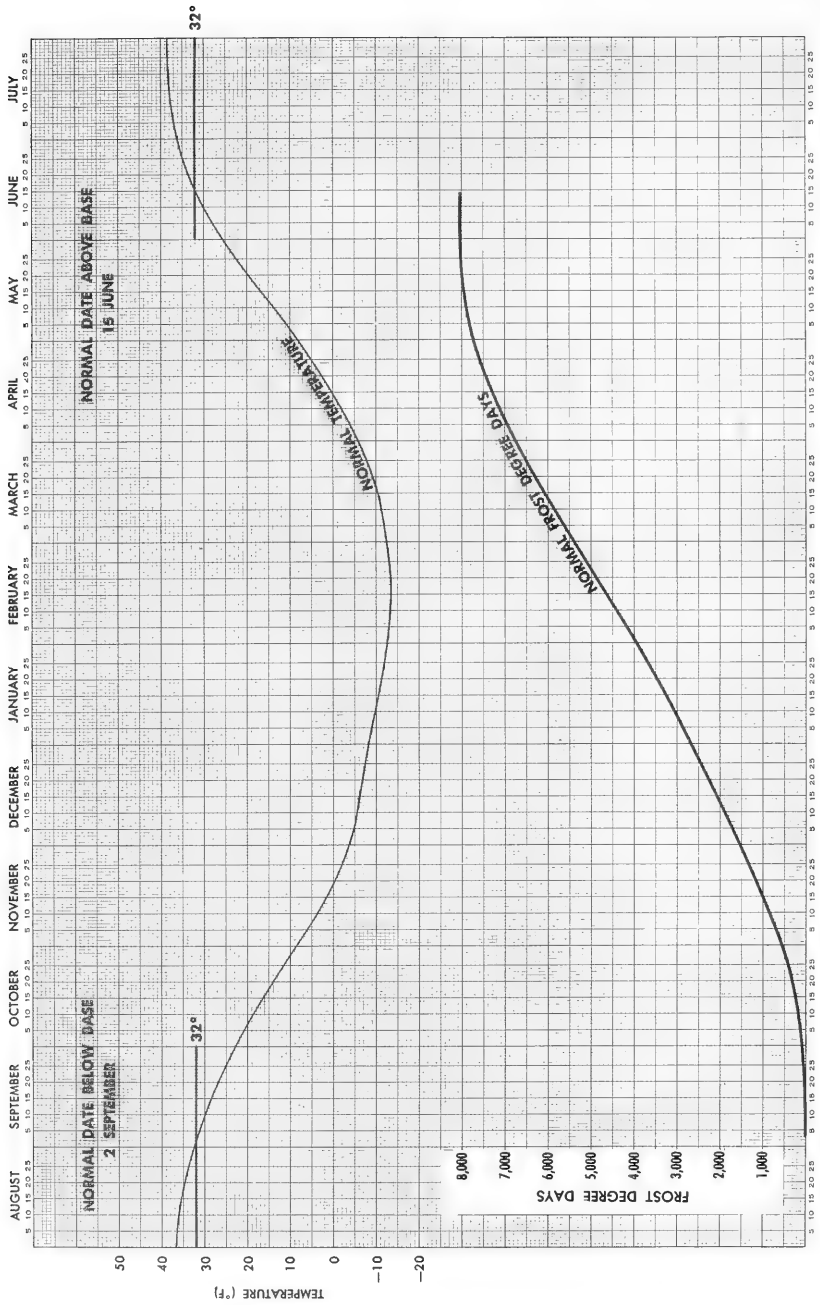


FIGURE 9A WRANGEL ISLAND (9 YEARS RECORD)

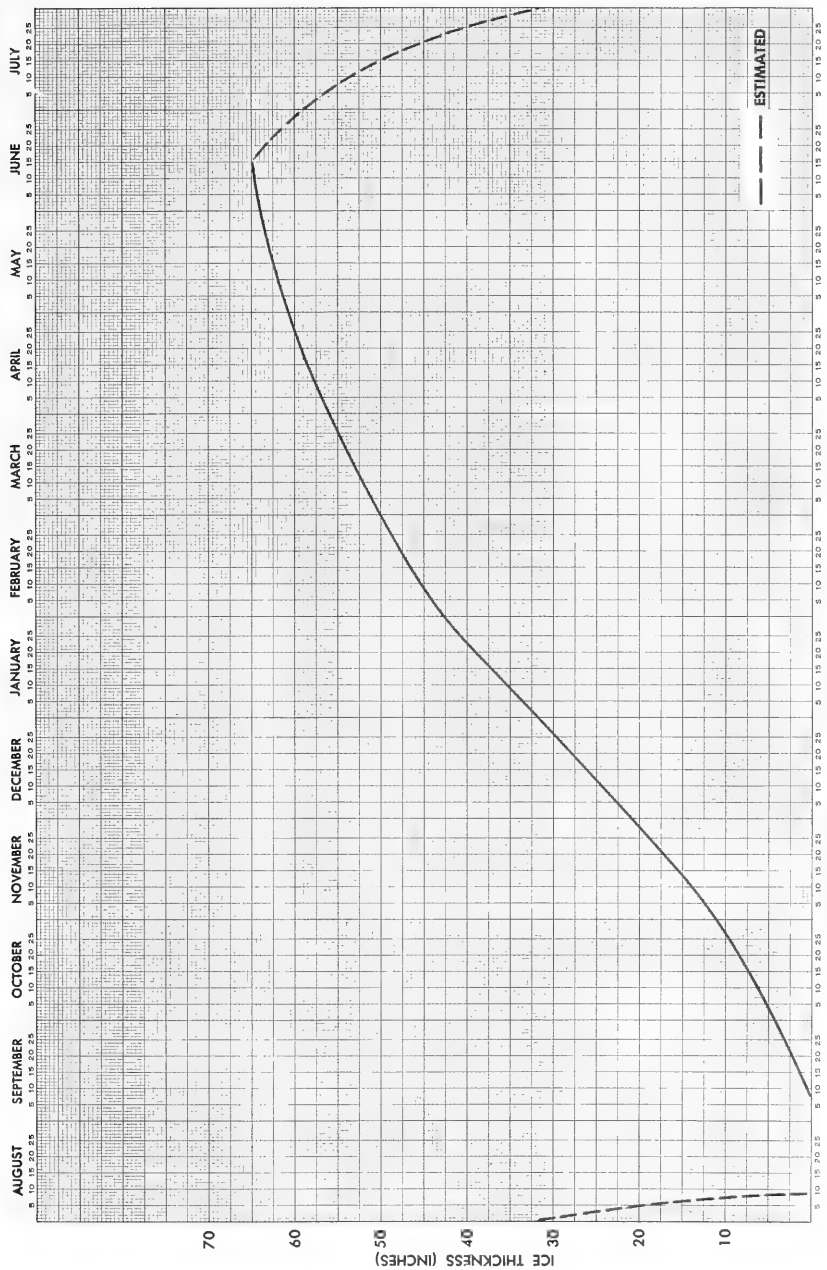


FIGURE 98 WRANGLER ISLAND THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

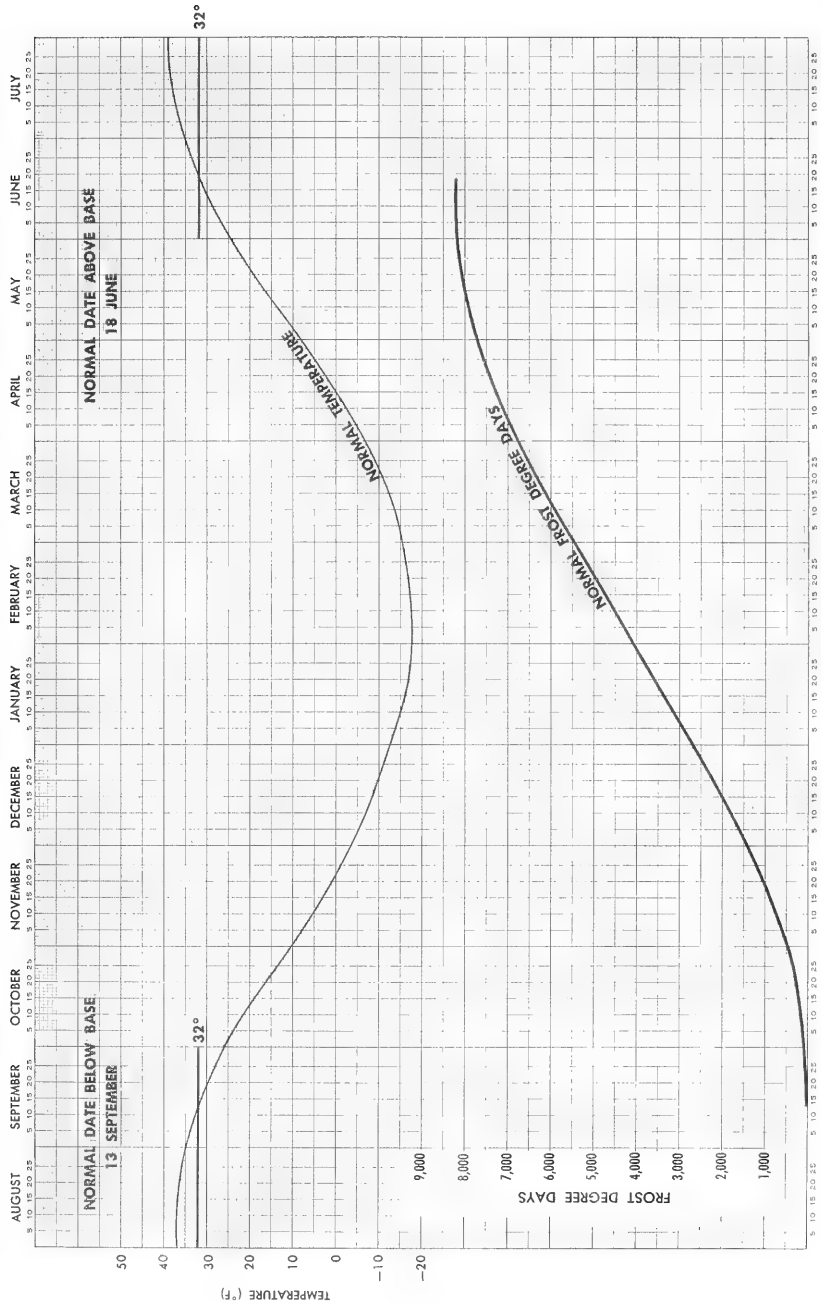


FIGURE 10A MYS SCHMIDTA (9 YEARS RECORD)

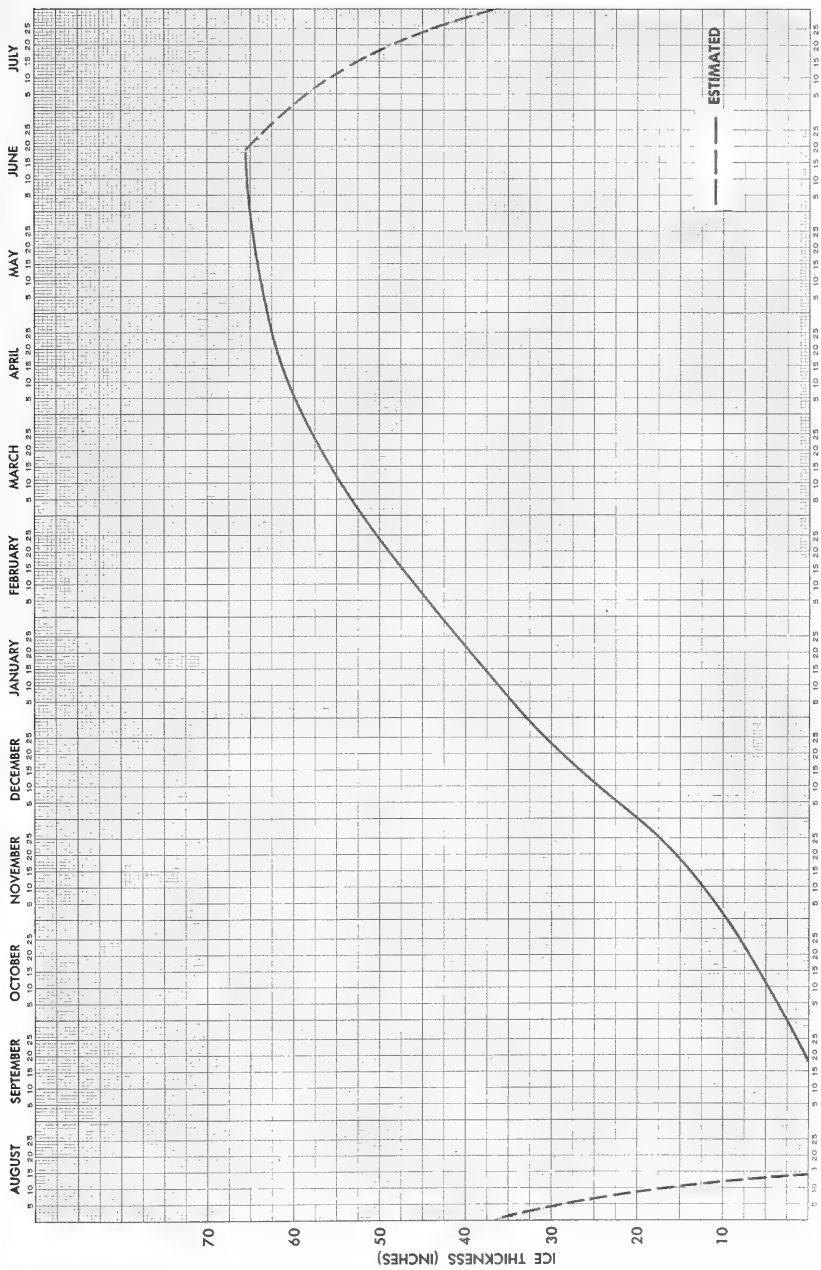


FIGURE 10B MYS SCHMIDTA THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

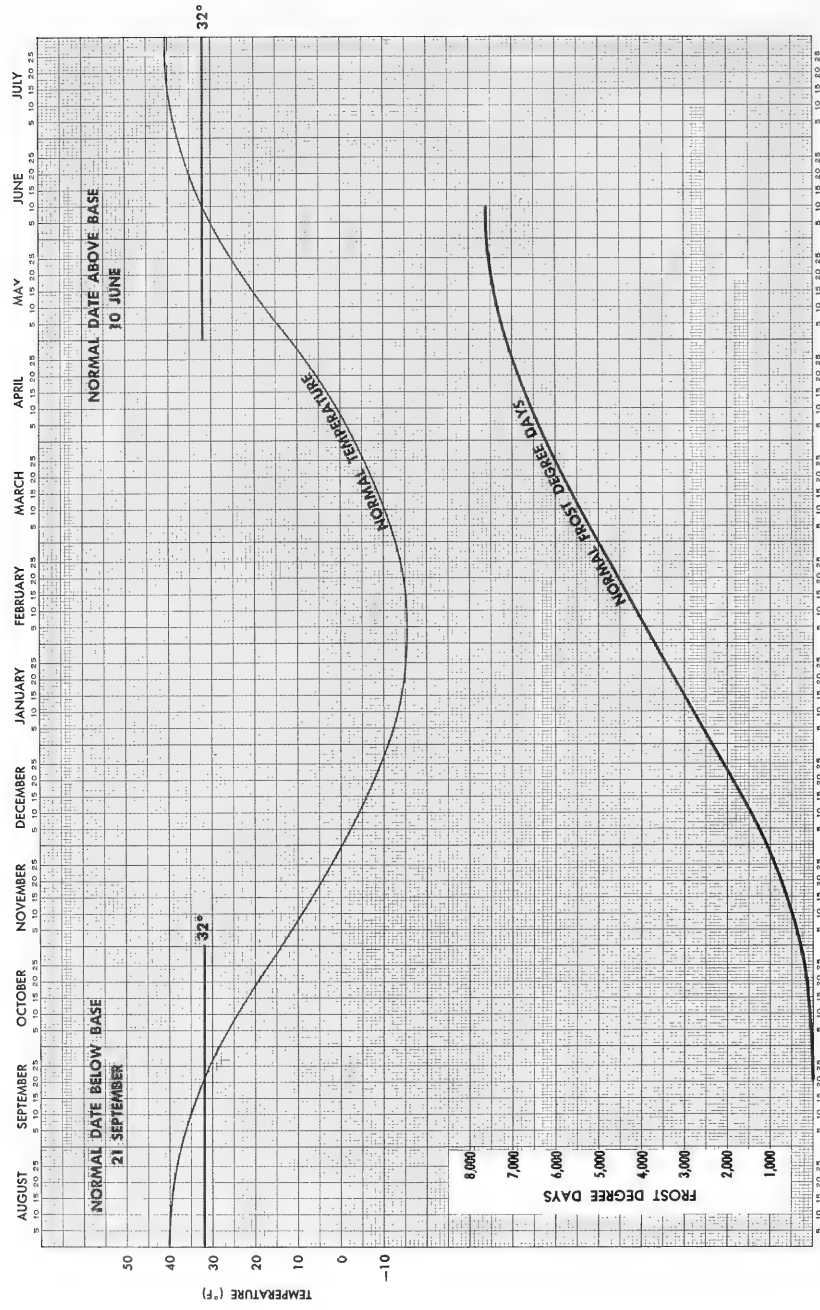


FIGURE 11A MYS VAN KAREM (9 YEARS RECORD)

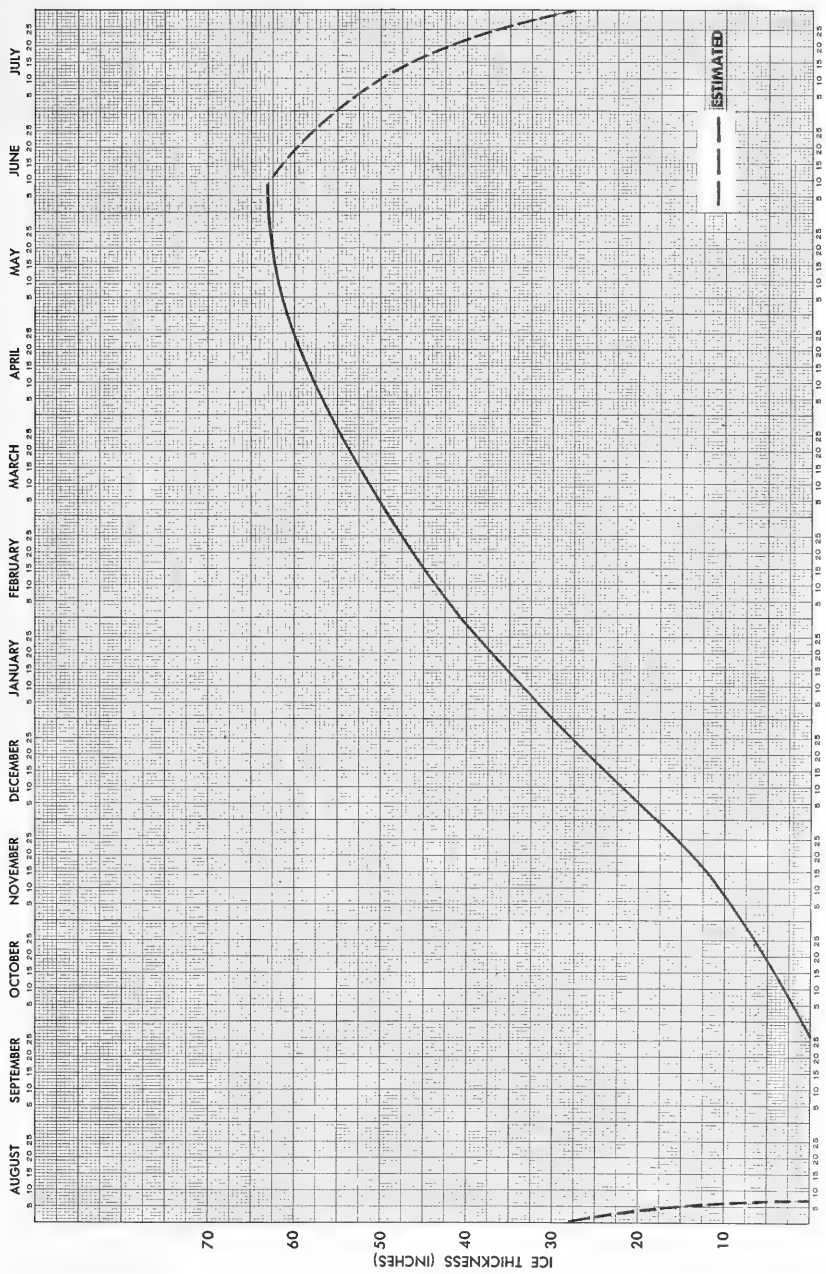


FIGURE 11B MYS VAN KAREM THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

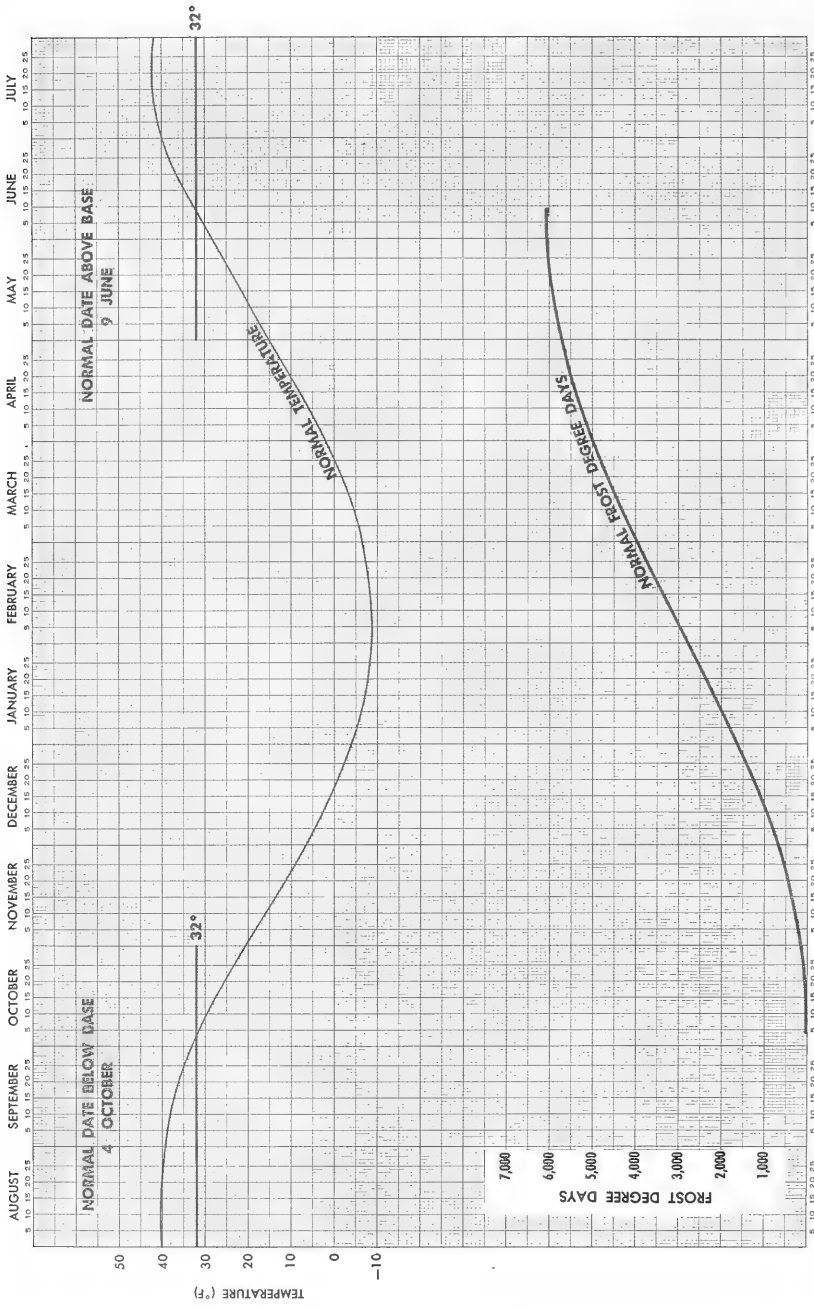


FIGURE 12A MYS DEZHNEVA (9 YEARS RECORD)

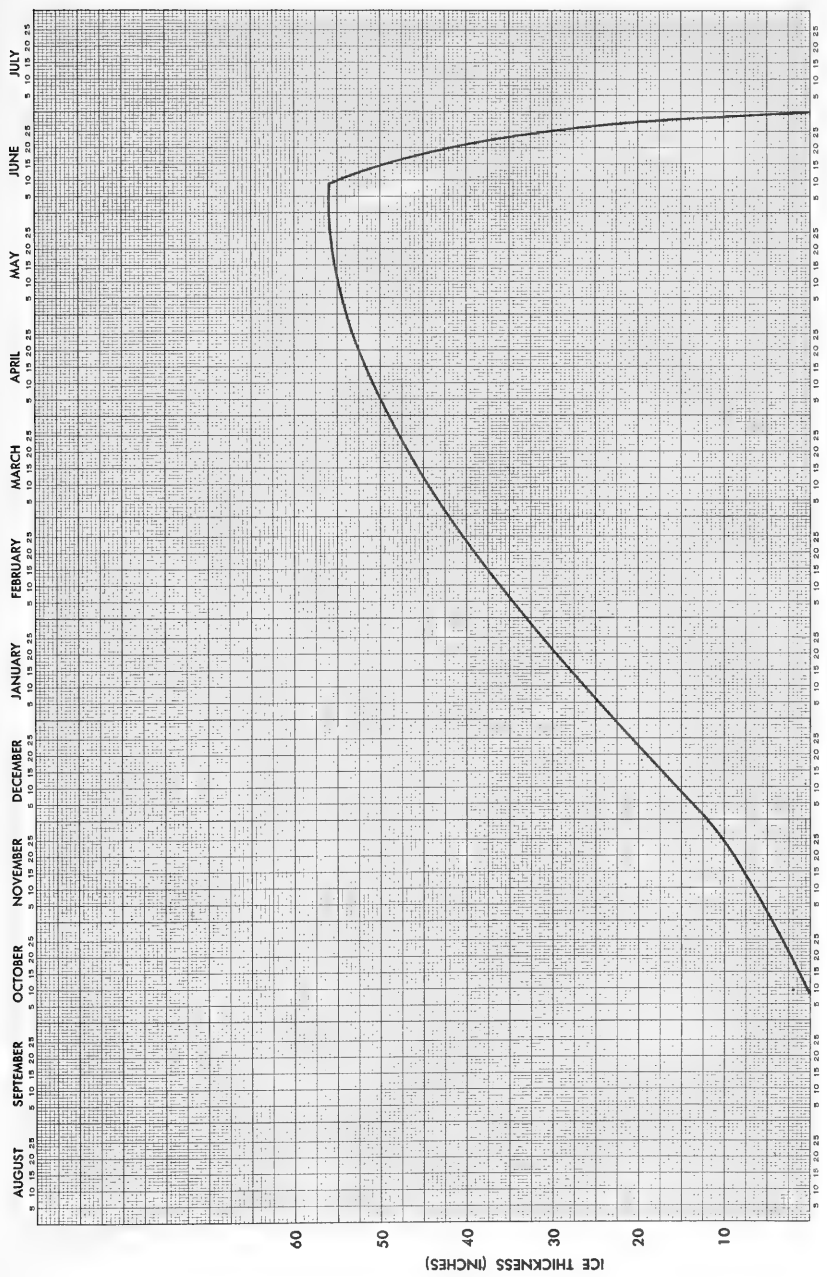


FIGURE 12B MYS DEZHNEVA THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

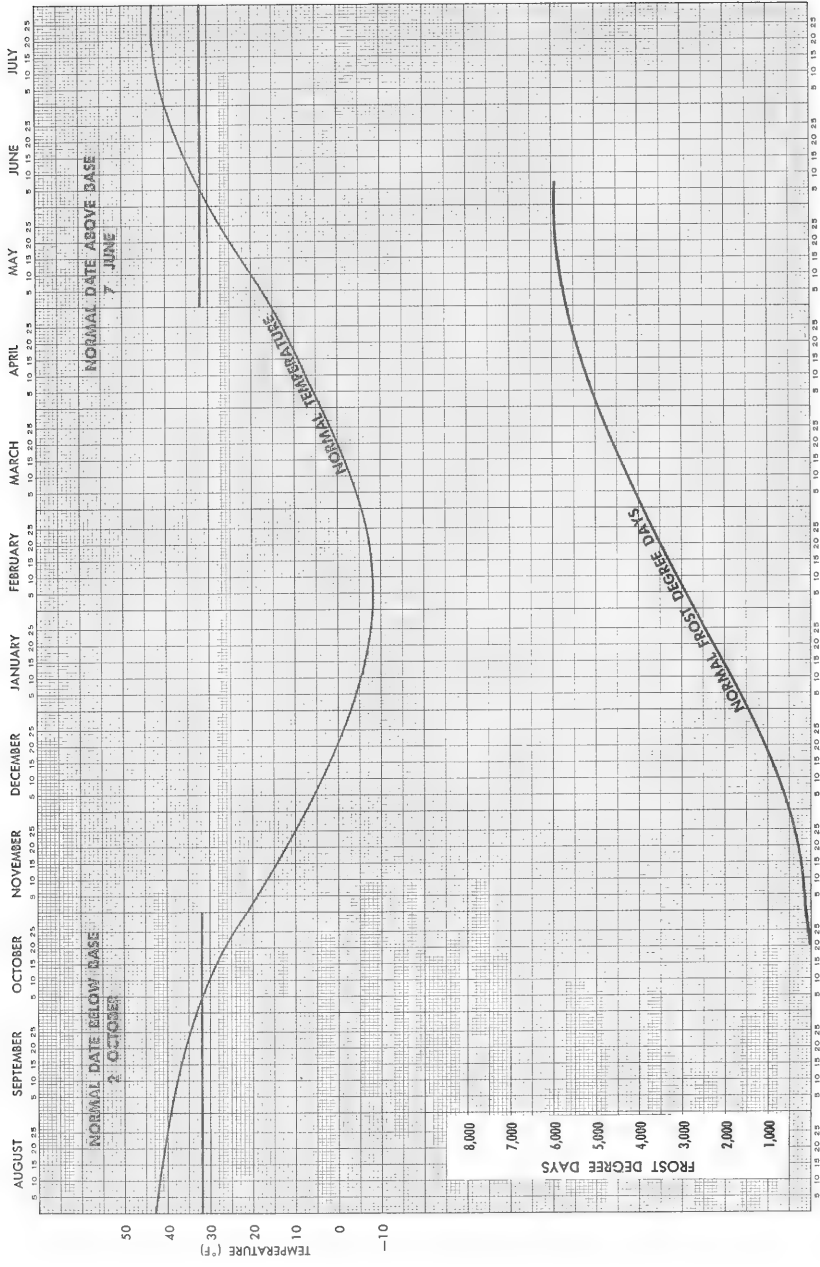


FIGURE 13A UELLEN (9 YEARS RECORD)

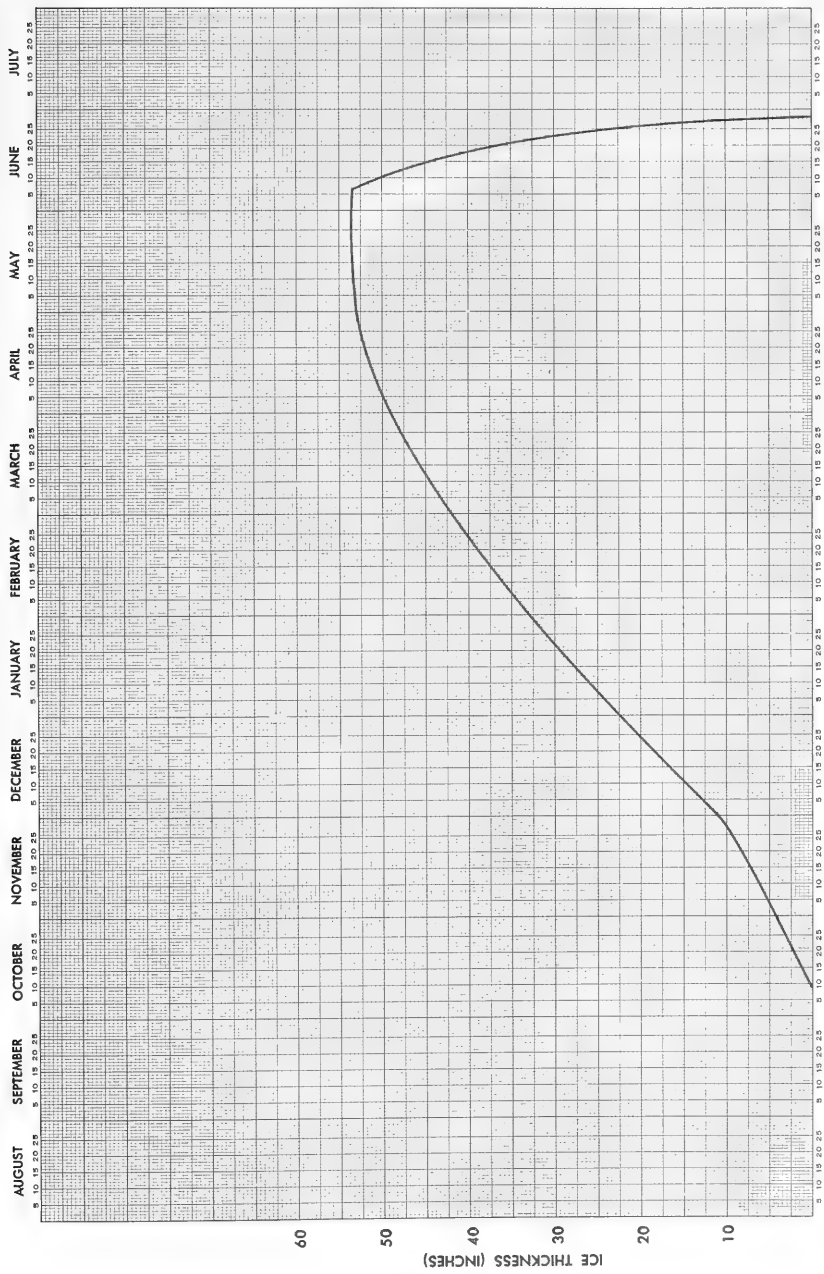


FIGURE 13B UELN THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

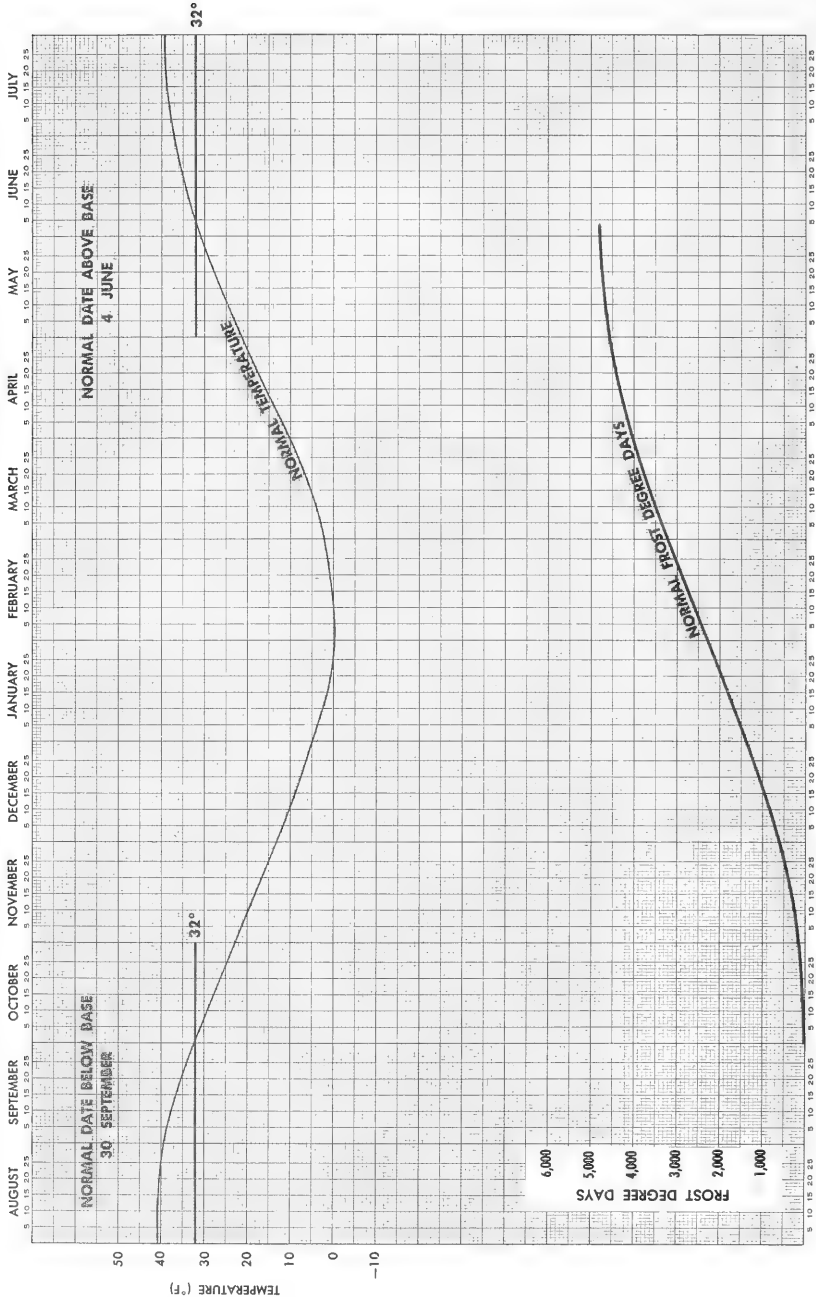


FIGURE 14A MYS CHAPLINA (9 YEARS RECORD)

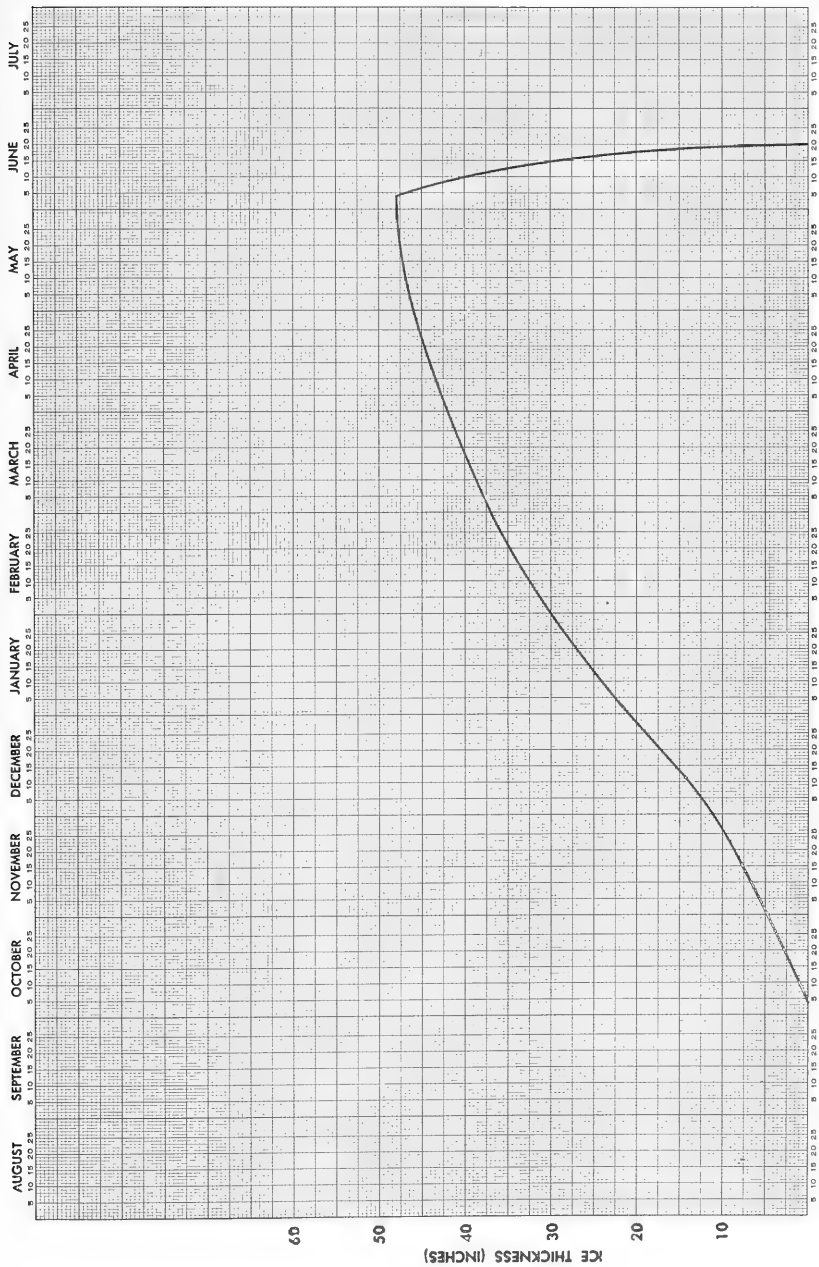


FIGURE 14B MYS CHAPLINA THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

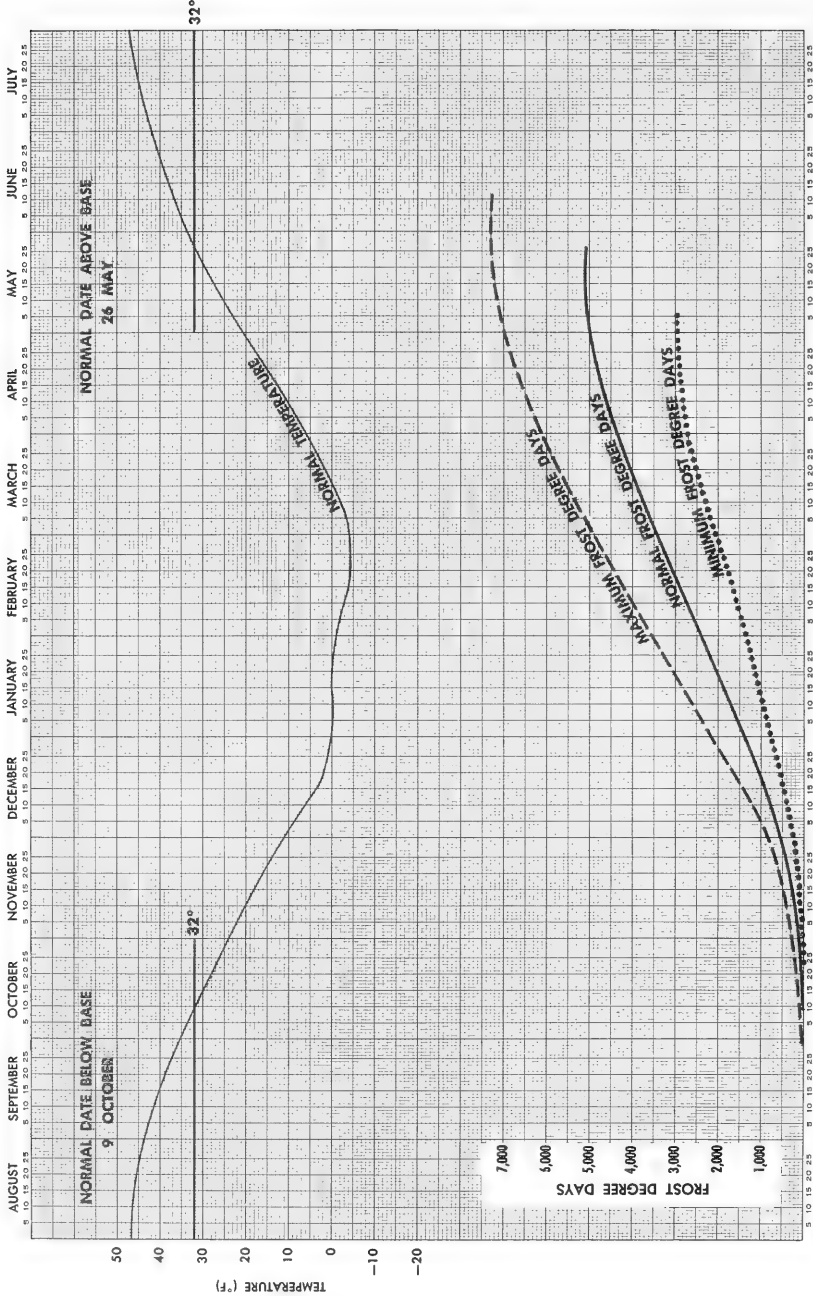


FIGURE 15A WALES (12 YEARS RECORD)

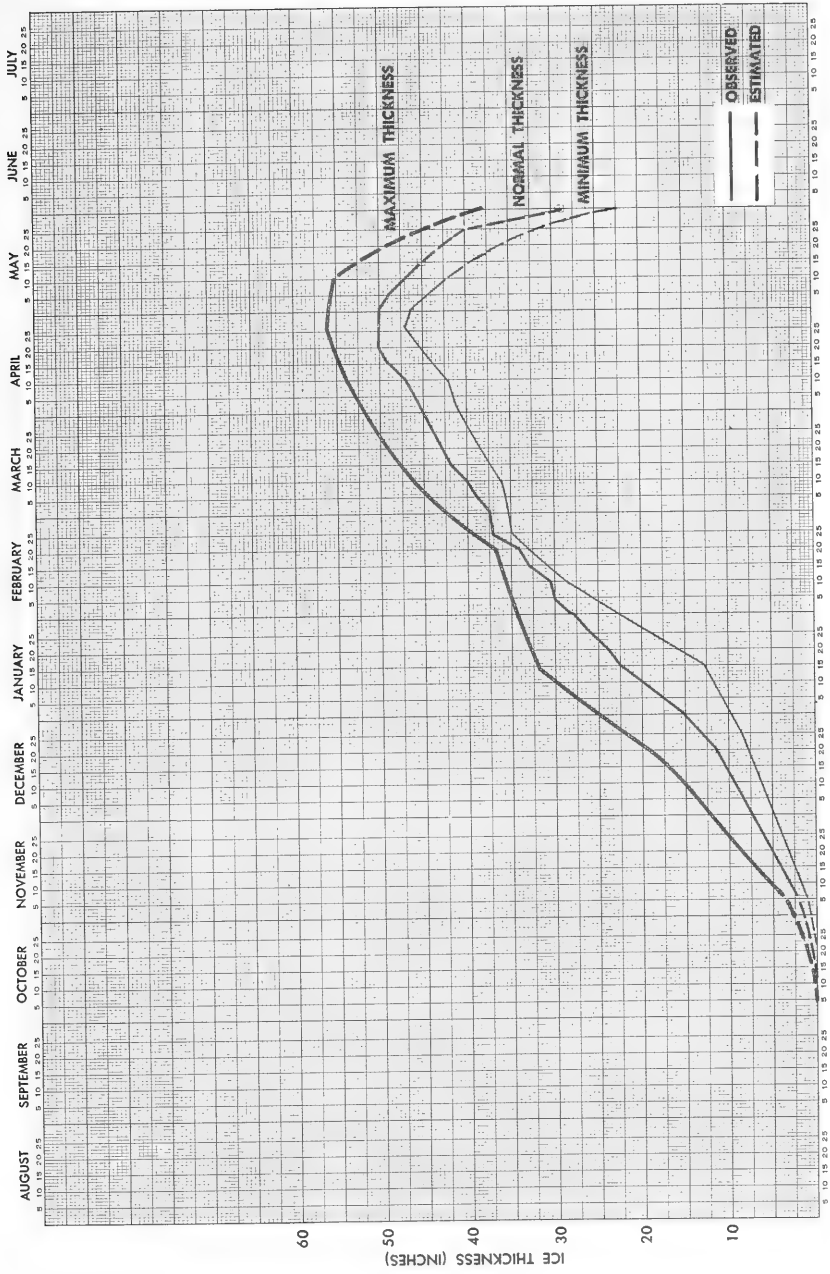


FIGURE 15B WALES EMPIRICAL ICE GROWTH AND DISINTEGRATION CURVE (3 YEARS RECORD)

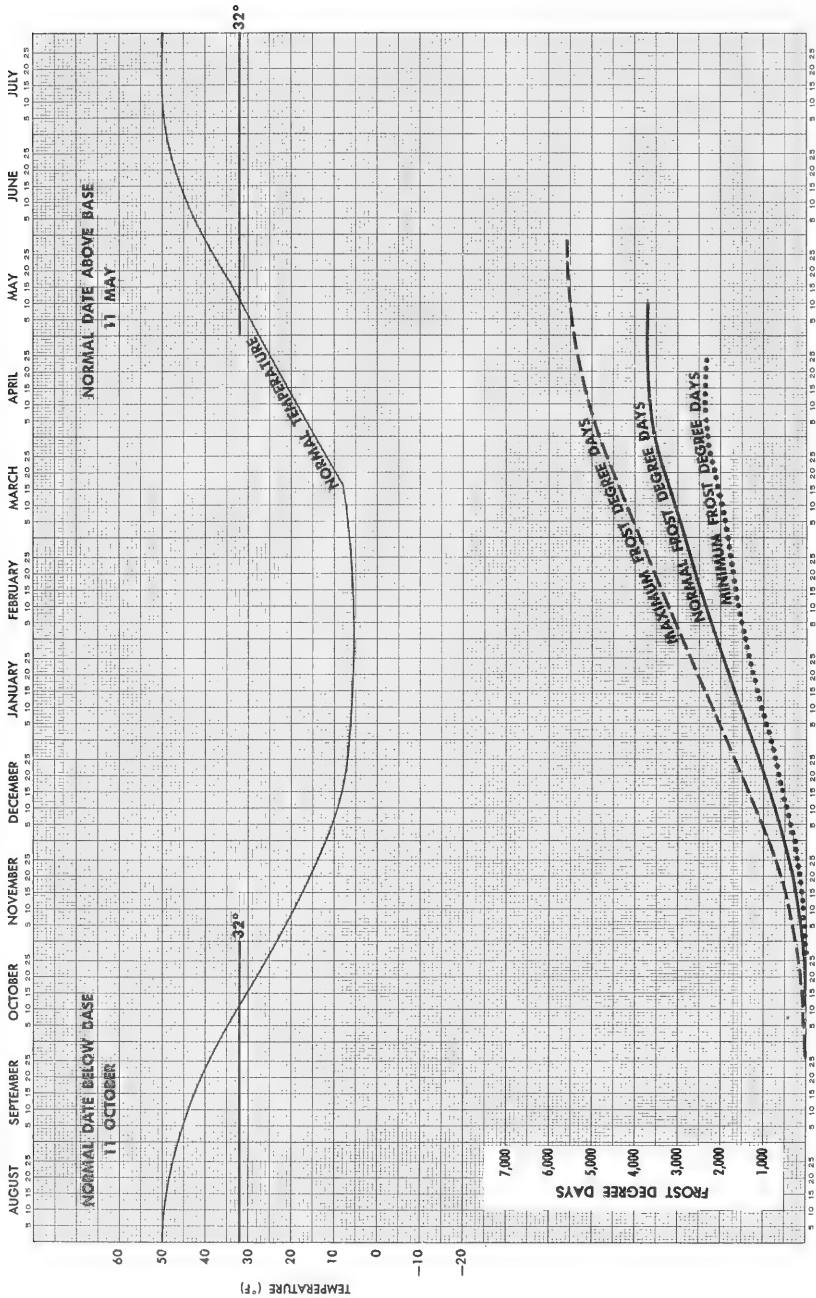


FIGURE 16A NOME (30 YEARS RECORD)

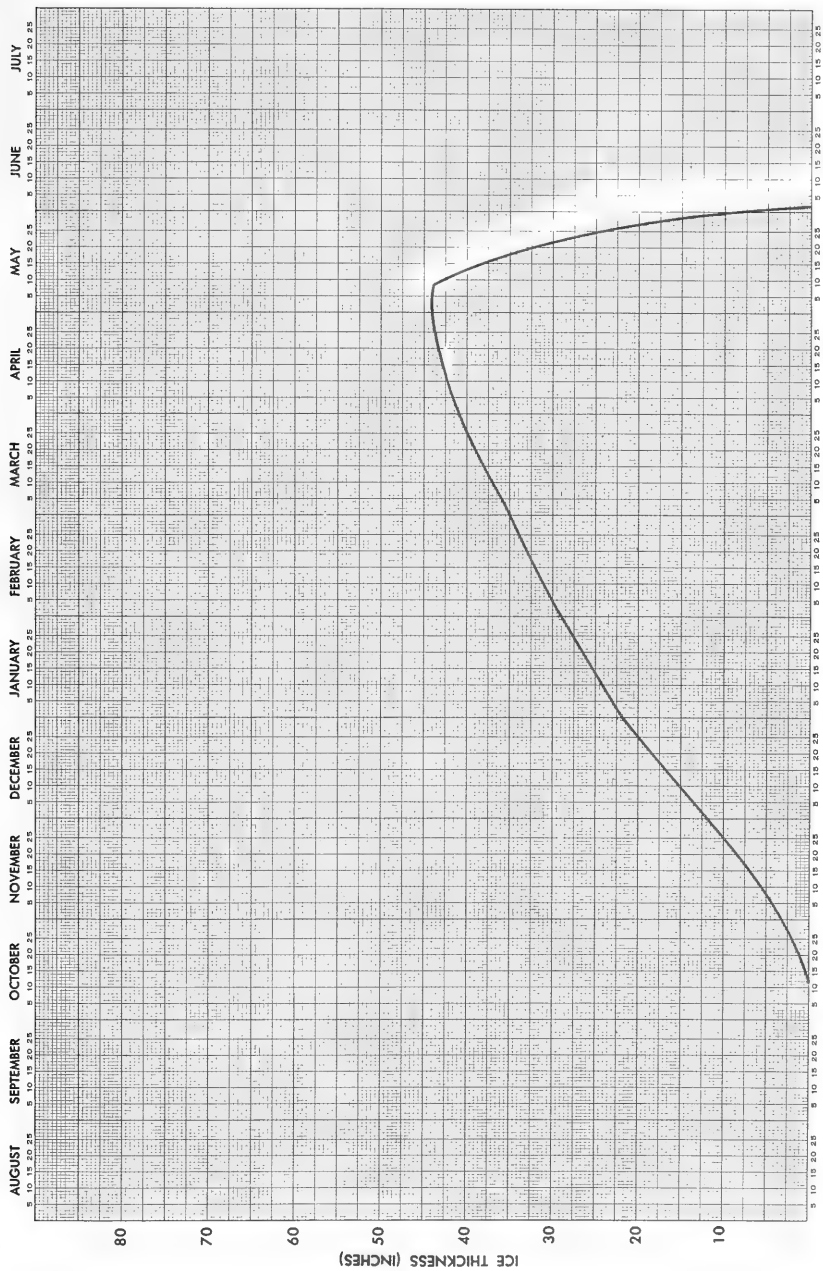


FIGURE 1.68 NOME THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

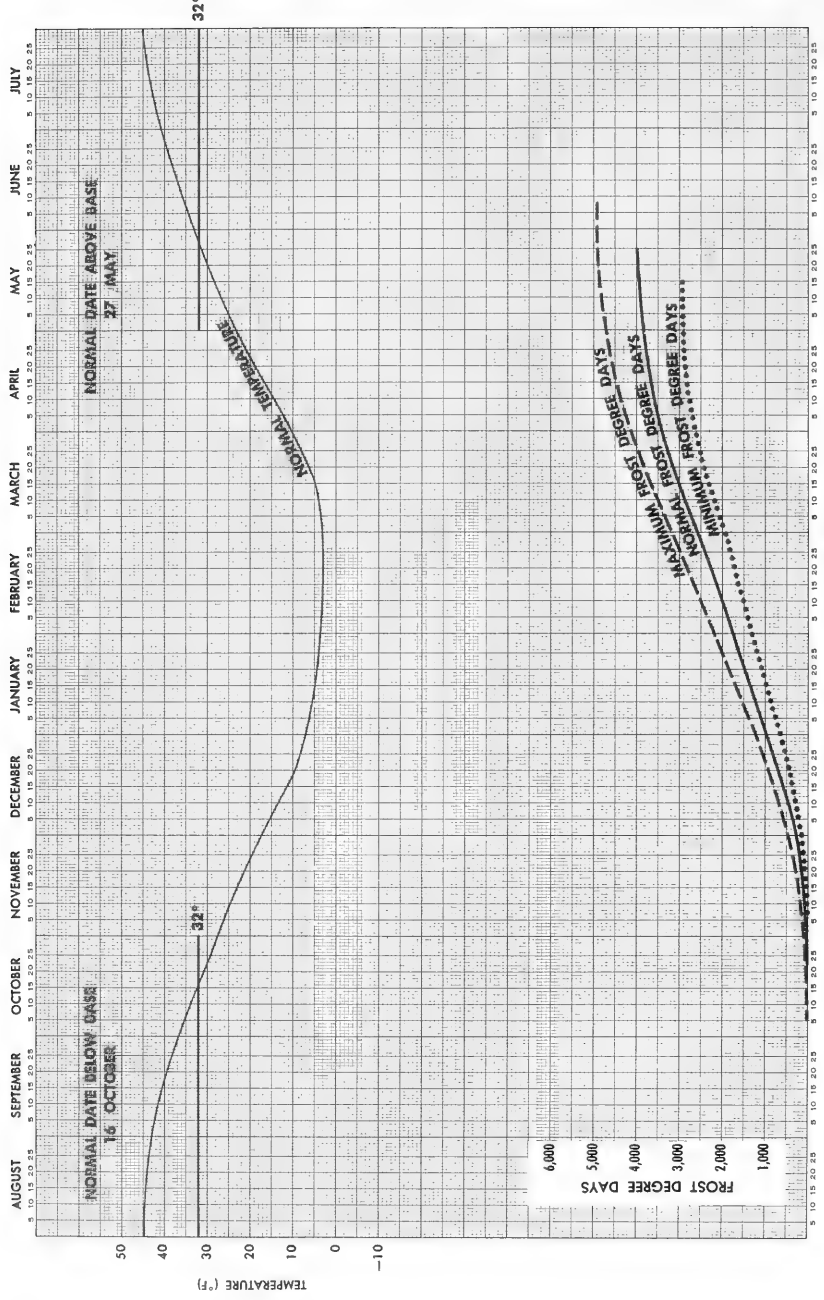


FIGURE 17A GAMBELL (10 YEARS RECORD)

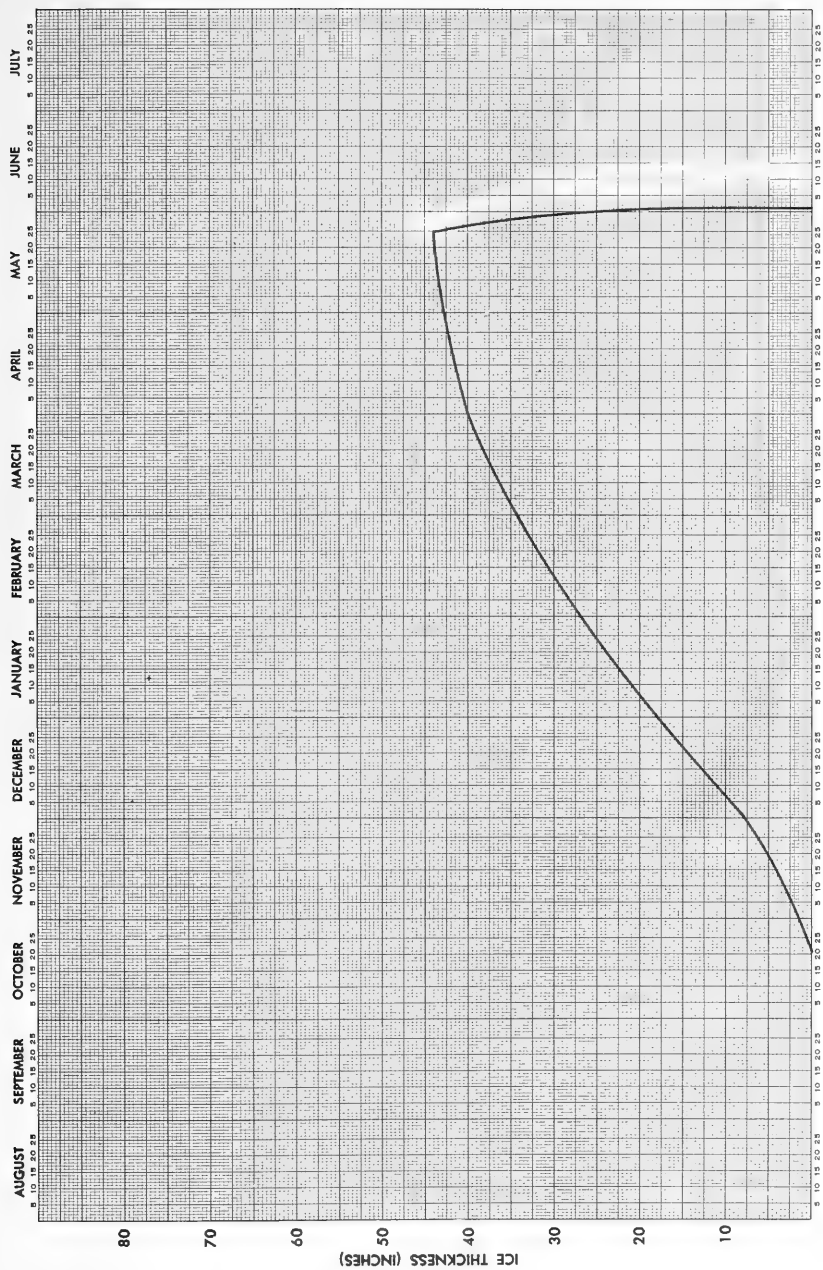


FIGURE 17B GAMBELL THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

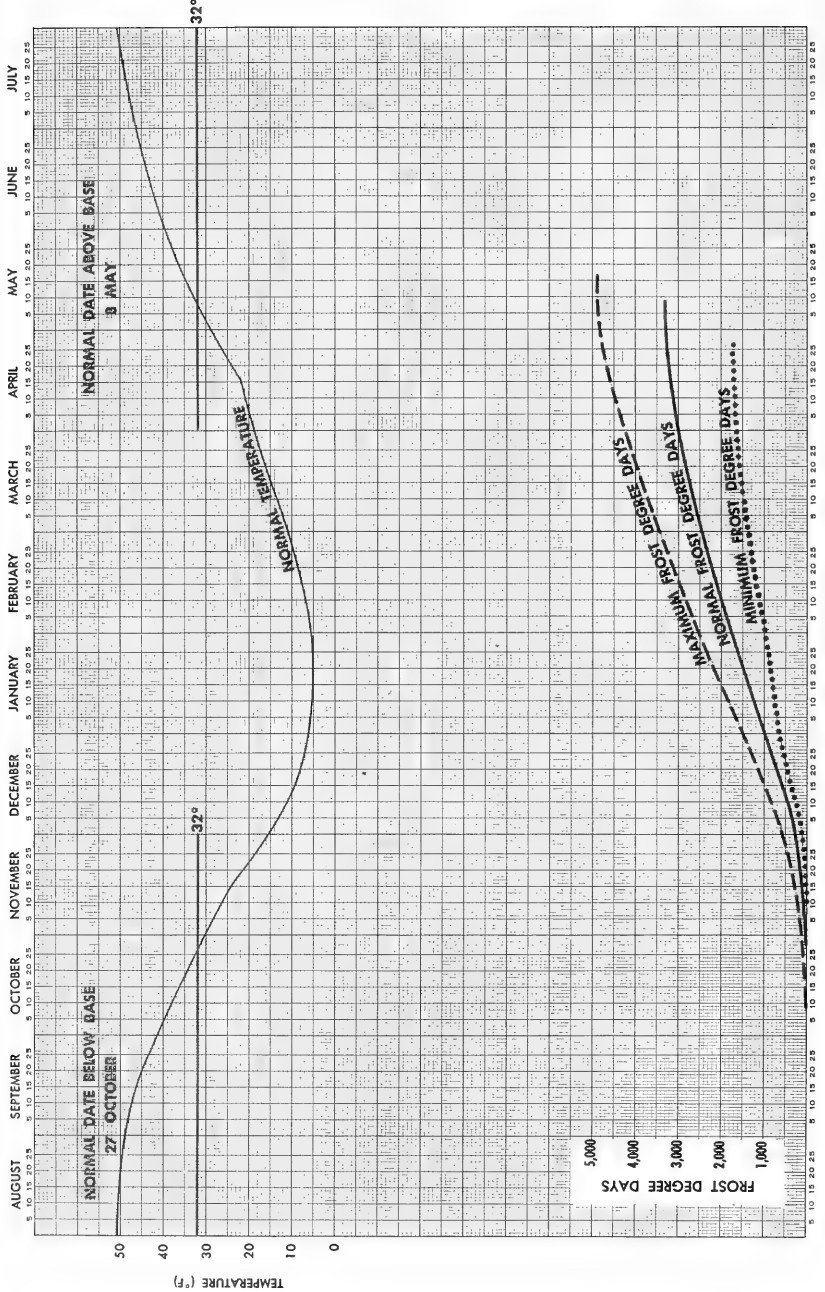


FIGURE 18A NUNIVAK (9 YEARS RECORD)

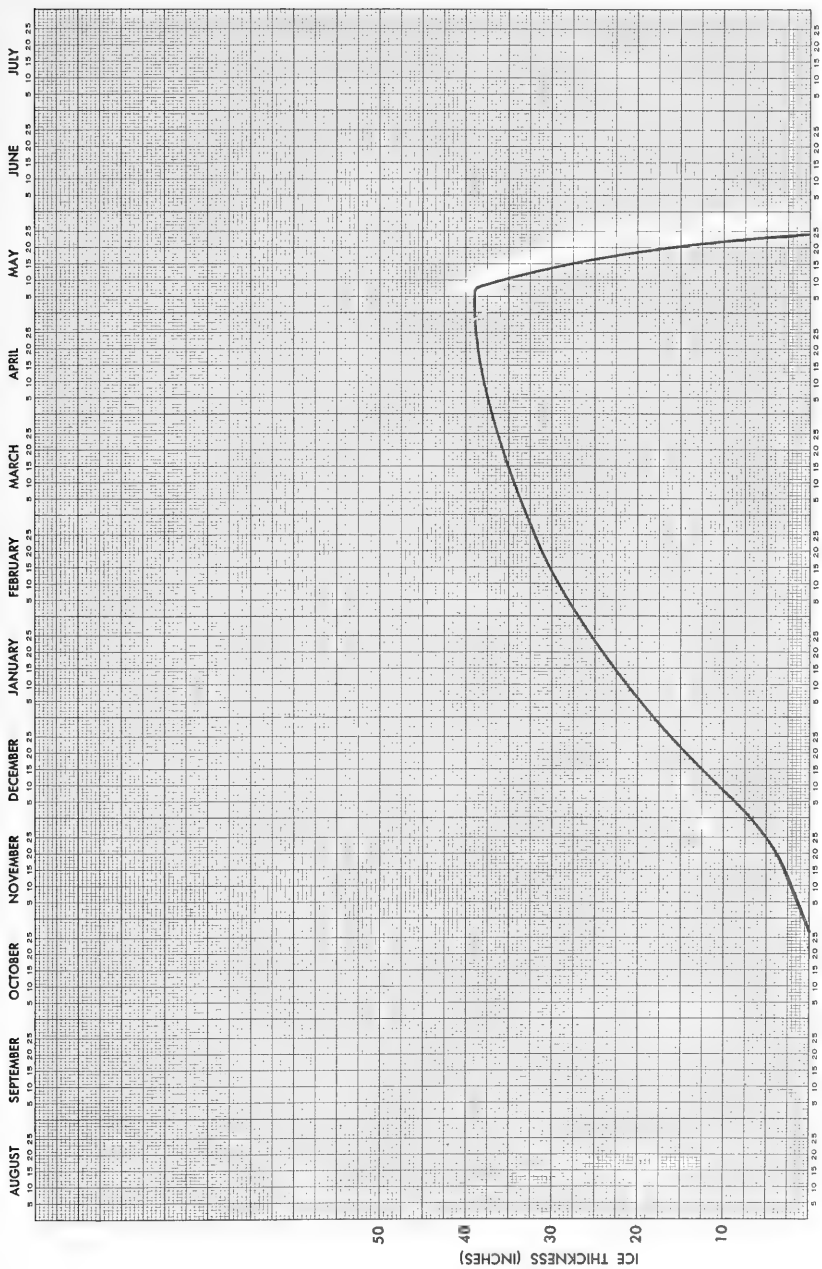


FIGURE 18B NUNIVAK THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

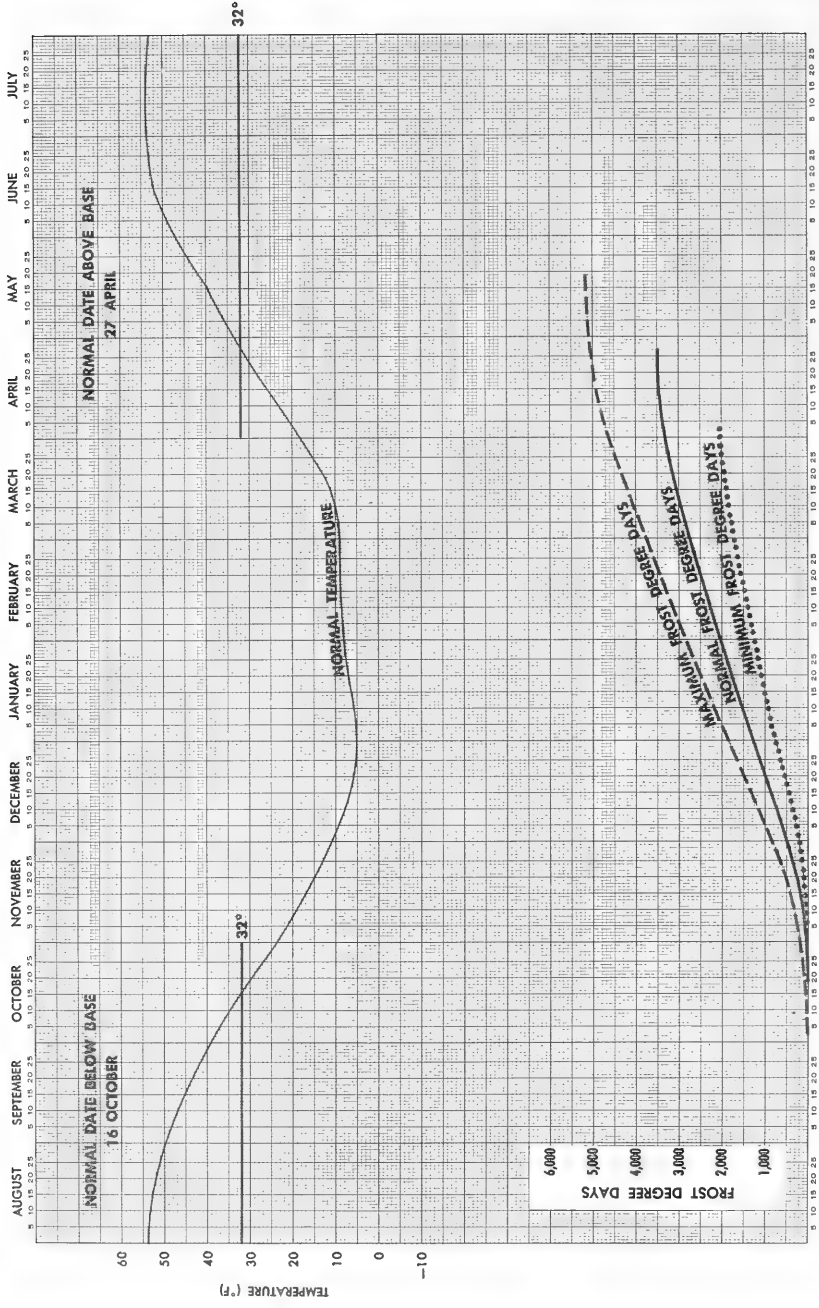


FIGURE 19A BETHEL (30 YEARS RECORD)

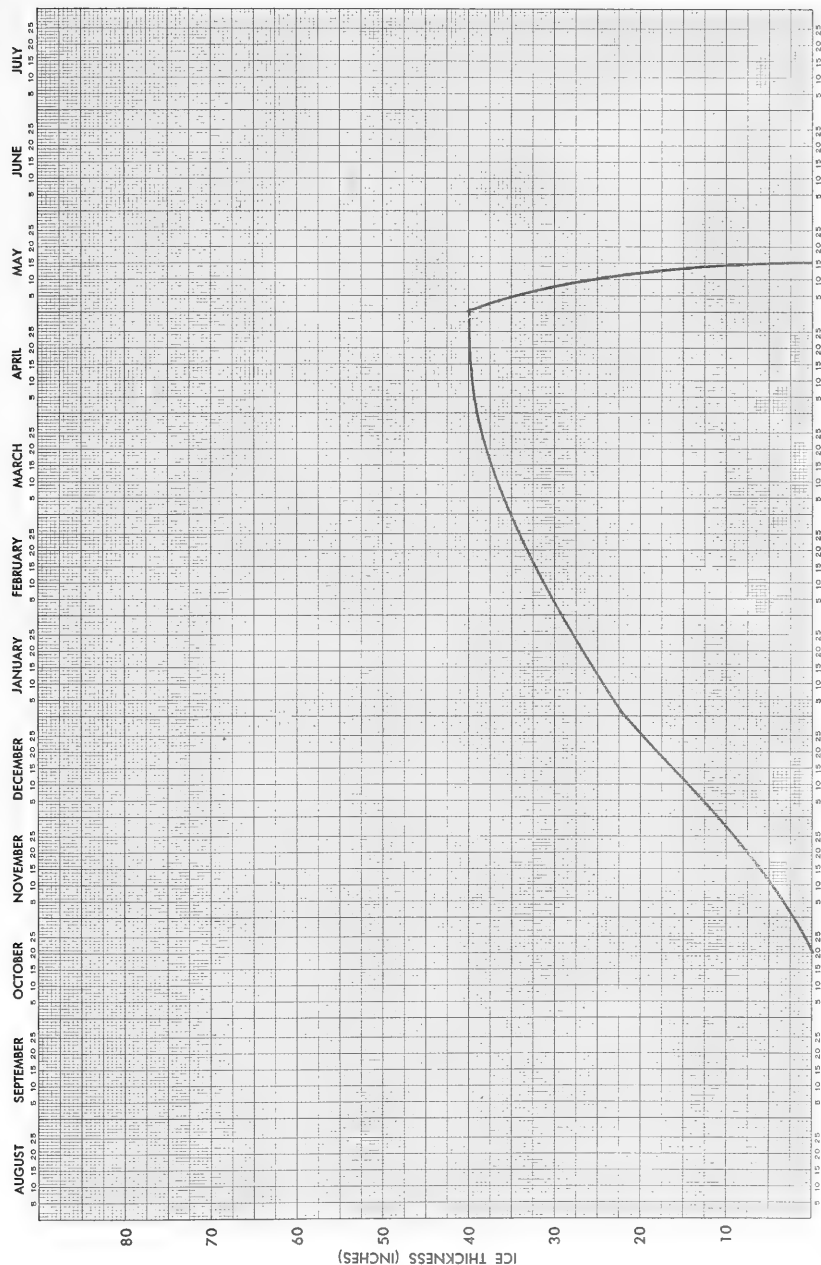


FIGURE 198 BETHEL THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

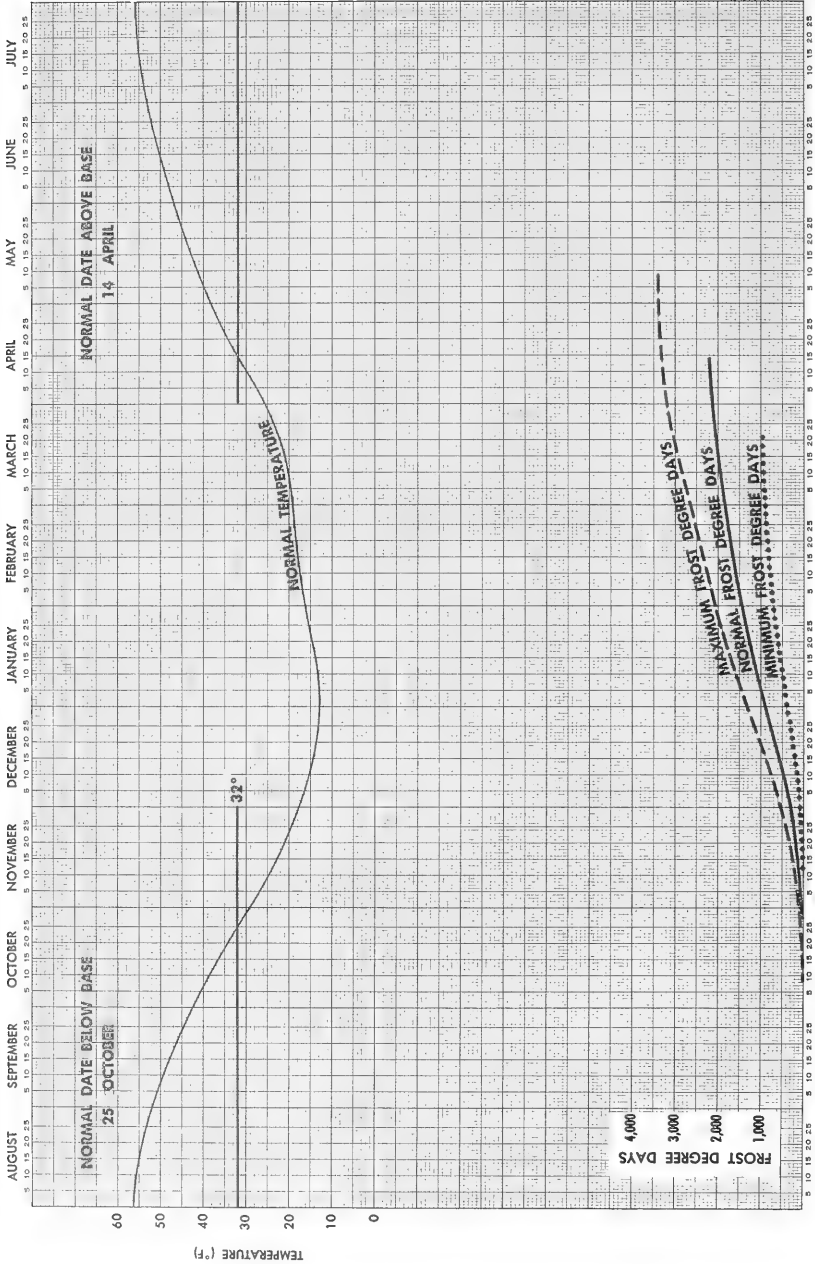


FIGURE 20A NAKNEK (30 YEARS RECORD)

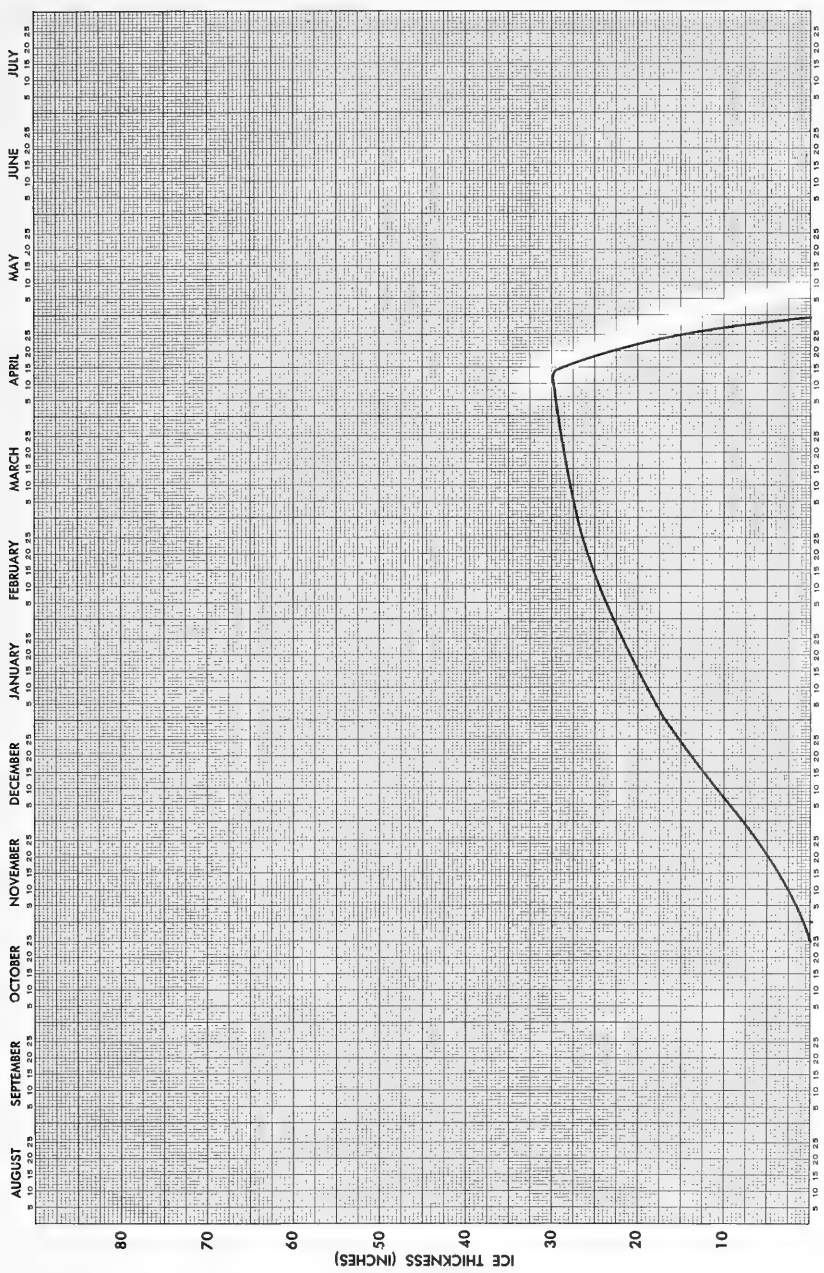


FIGURE 208 NAKNEK THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

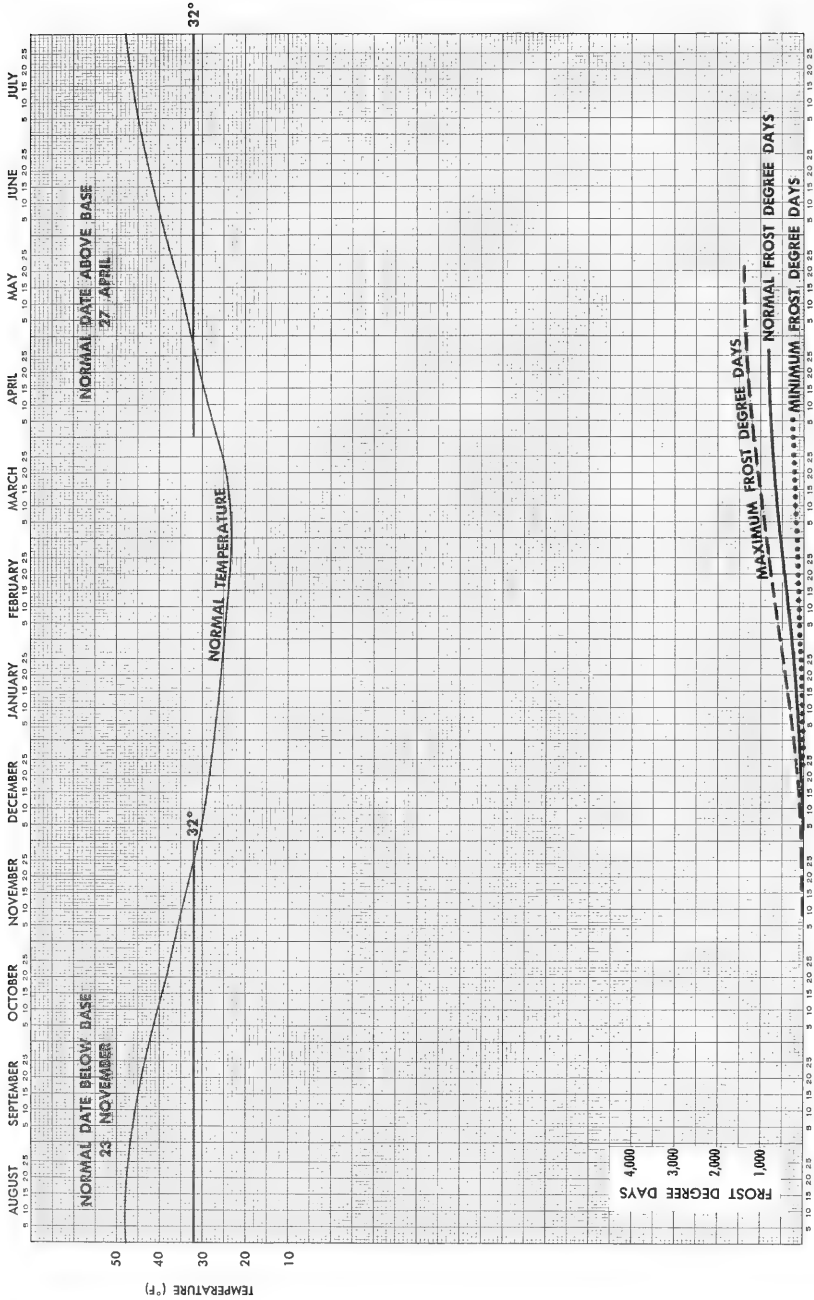


FIGURE 21A ST PAUL ISLAND (30 YEARS RECORD)

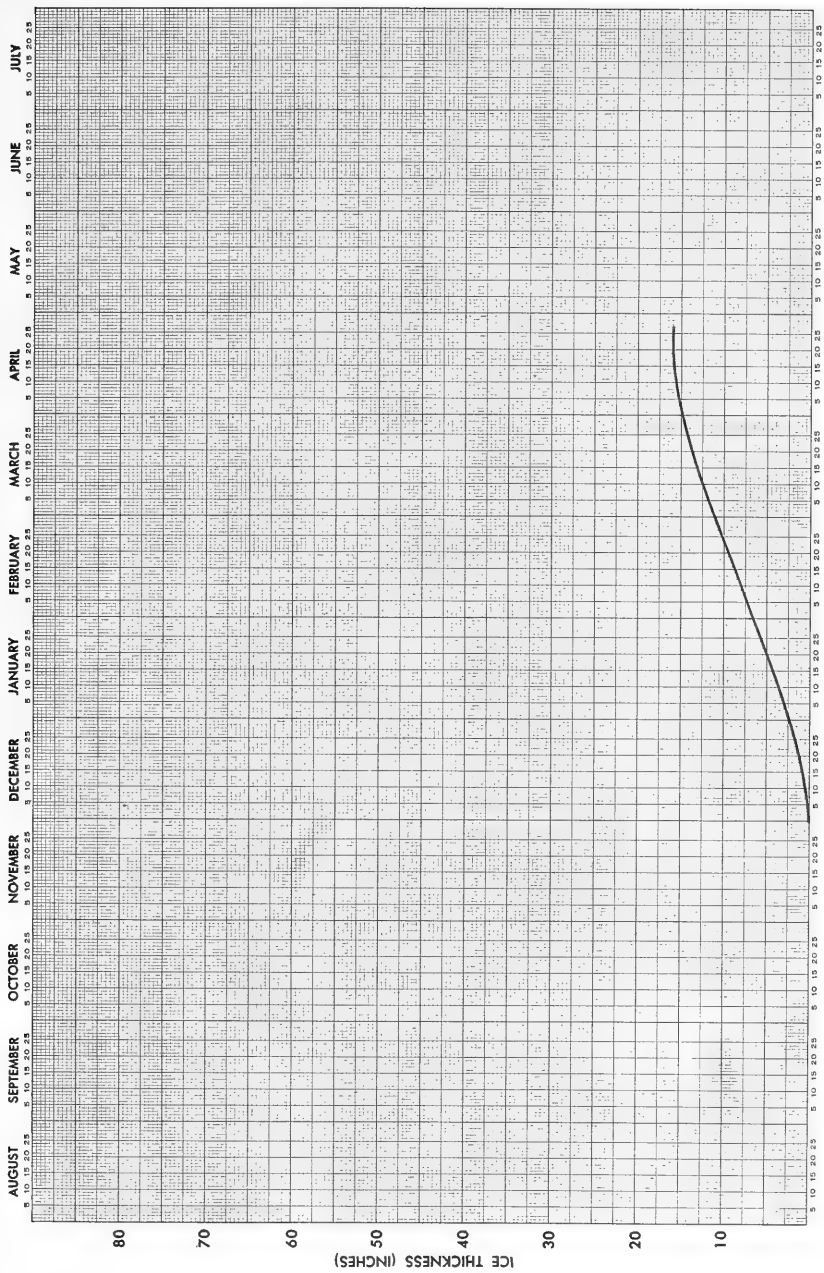


FIGURE 21B ST PAUL ISLAND ICE GROWTH CURVE

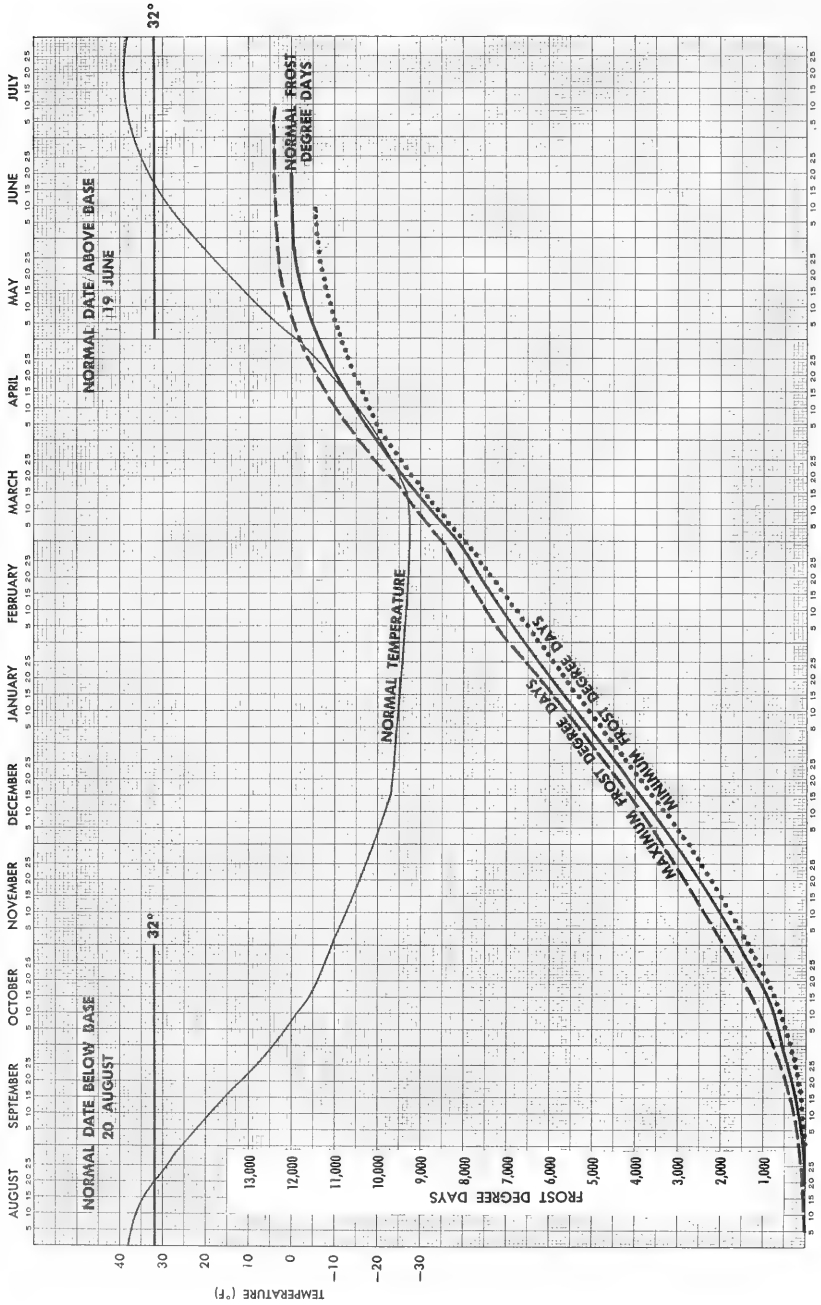


FIGURE 22A ALERT (11 YEARS RECORD)

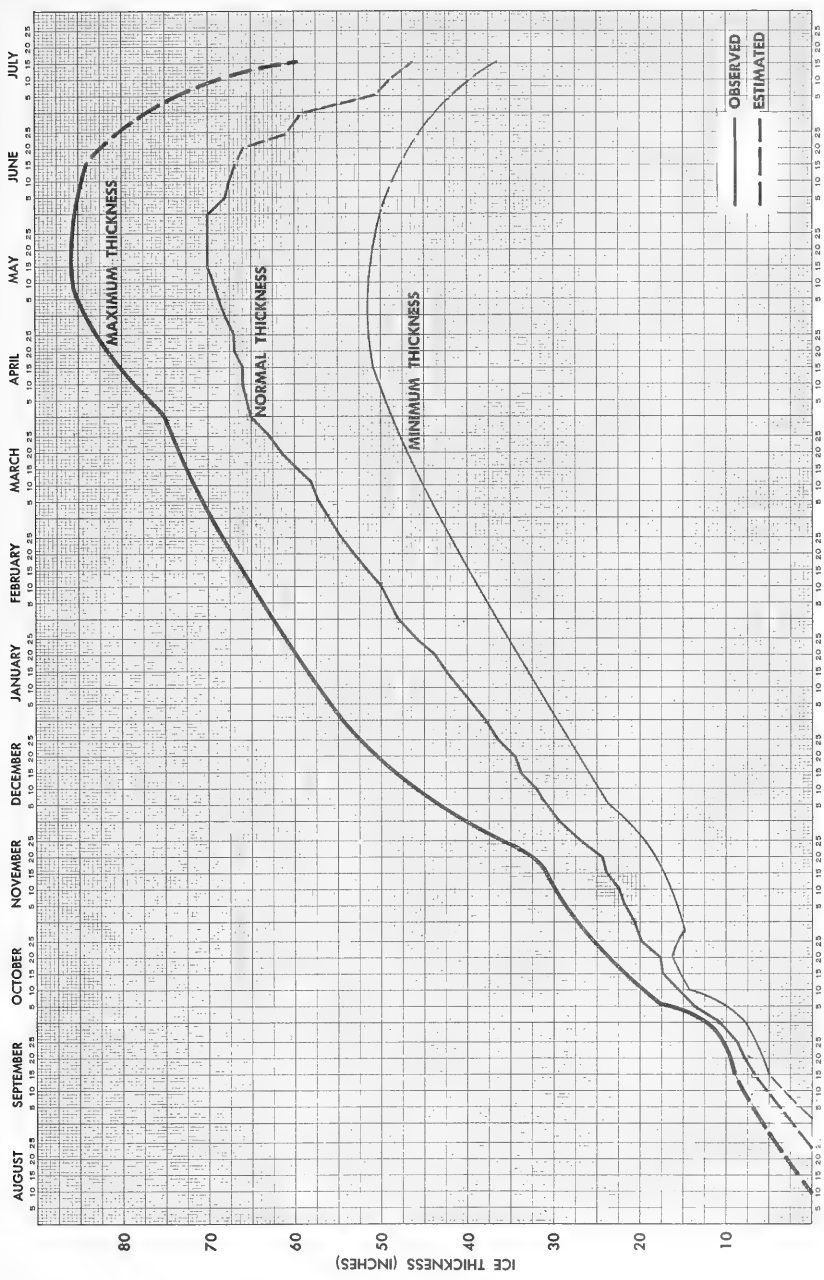


FIGURE 22B ALERT EMPIRICAL ICE GROWTH AND DISINTEGRATION CURVE (10 YEARS RECORD)

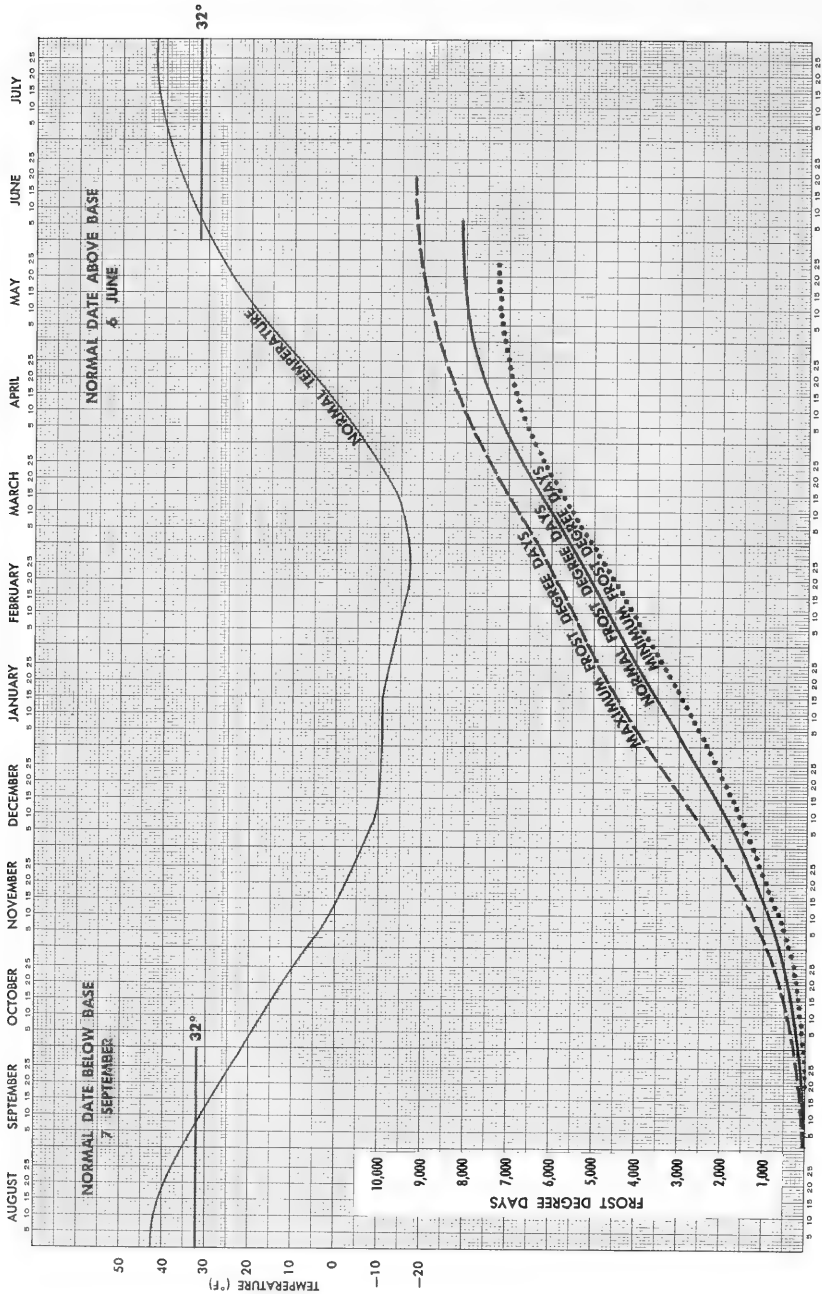


FIGURE 23A THULE (6 YEARS RECORD)

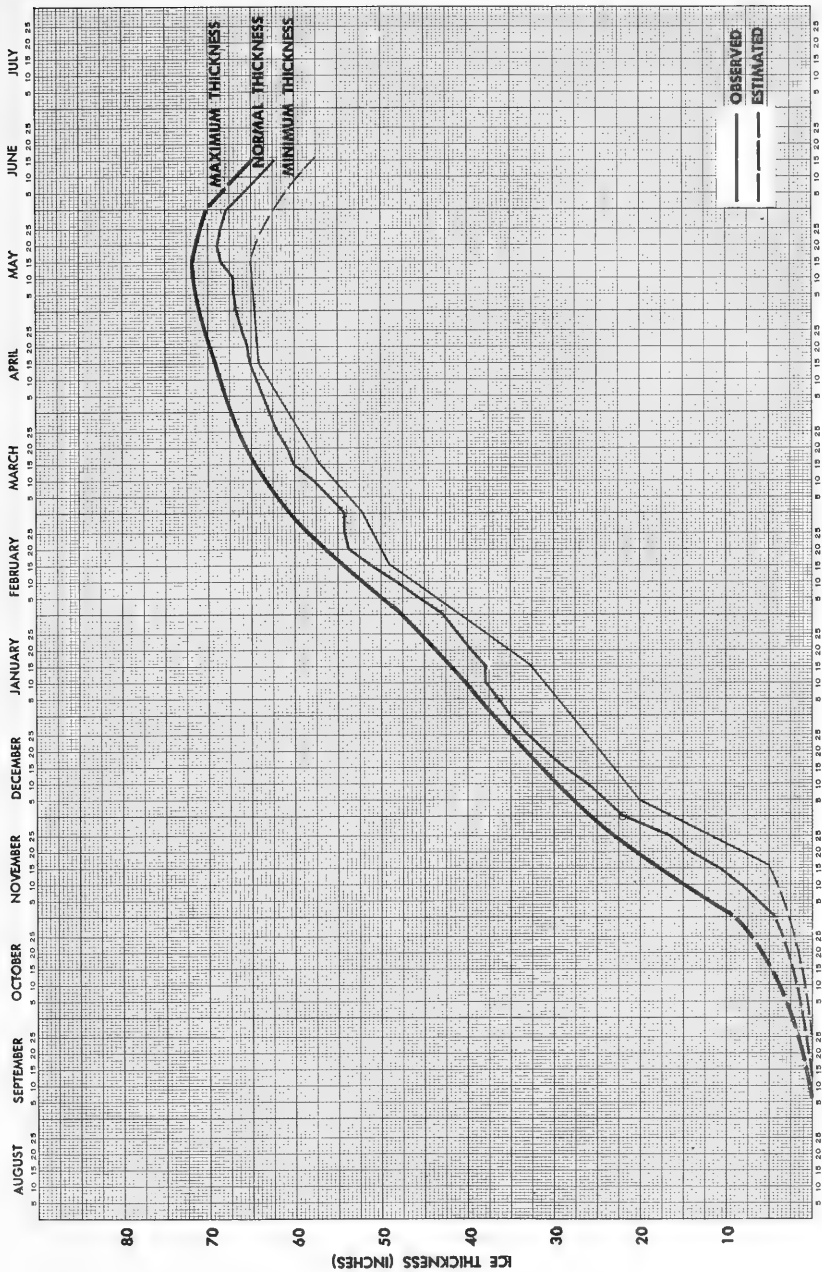


FIGURE 23B THULE EMPIRICAL ICE GROWTH AND DISINTEGRATION CURVE (5 YEARS RECORD)

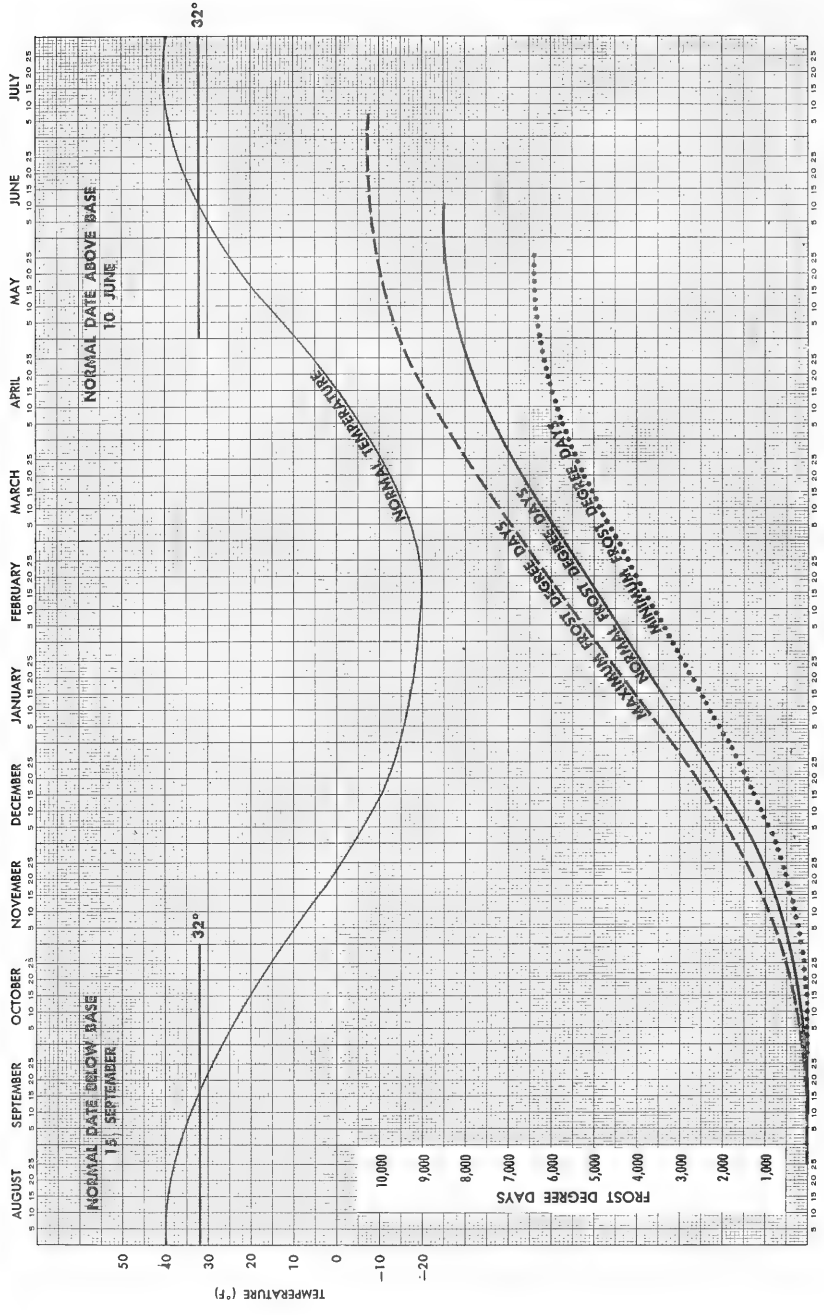


FIGURE 2.4A CLYDE RIVER (11 YEARS RECORD)

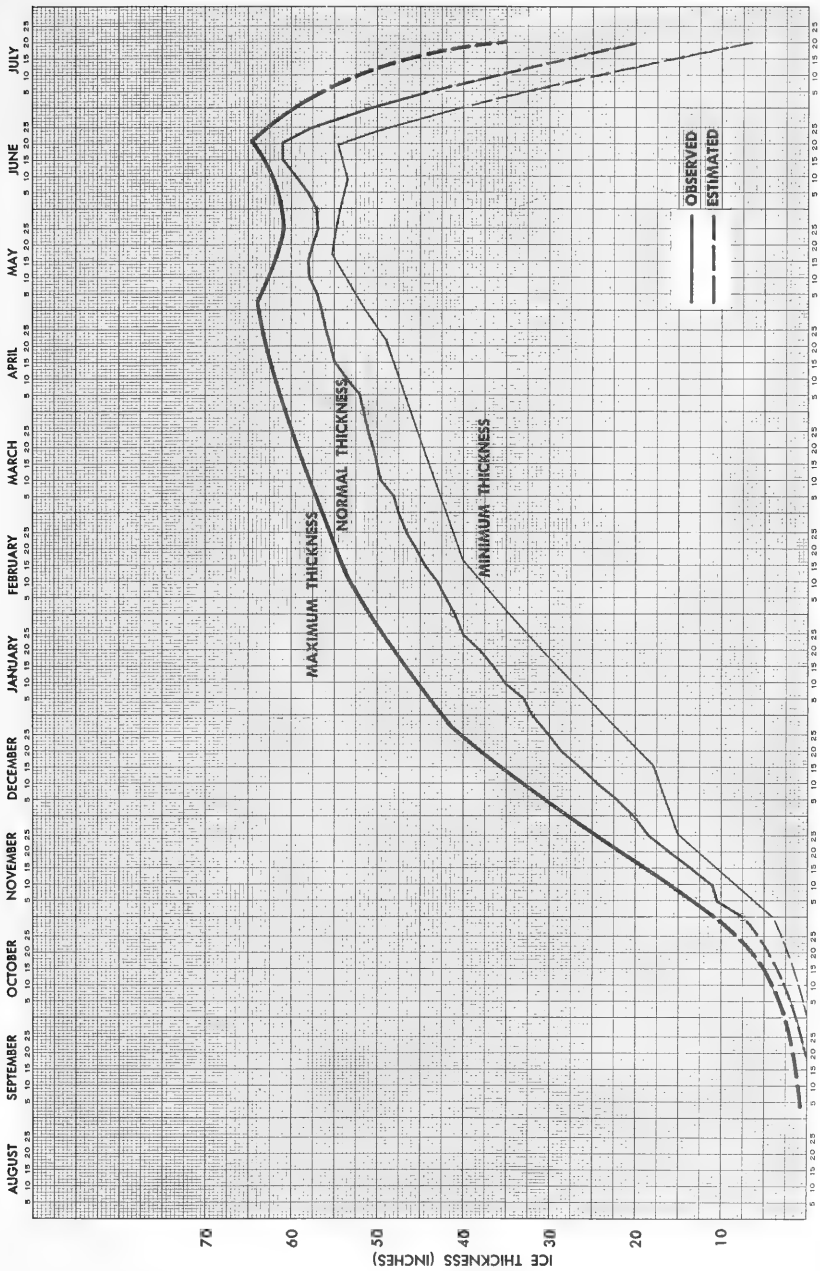


FIGURE 24B CLYDE RIVER EMPIRICAL ICE GROWTH AND DISINTEGRATION CURVE (3 YEARS RECORD)

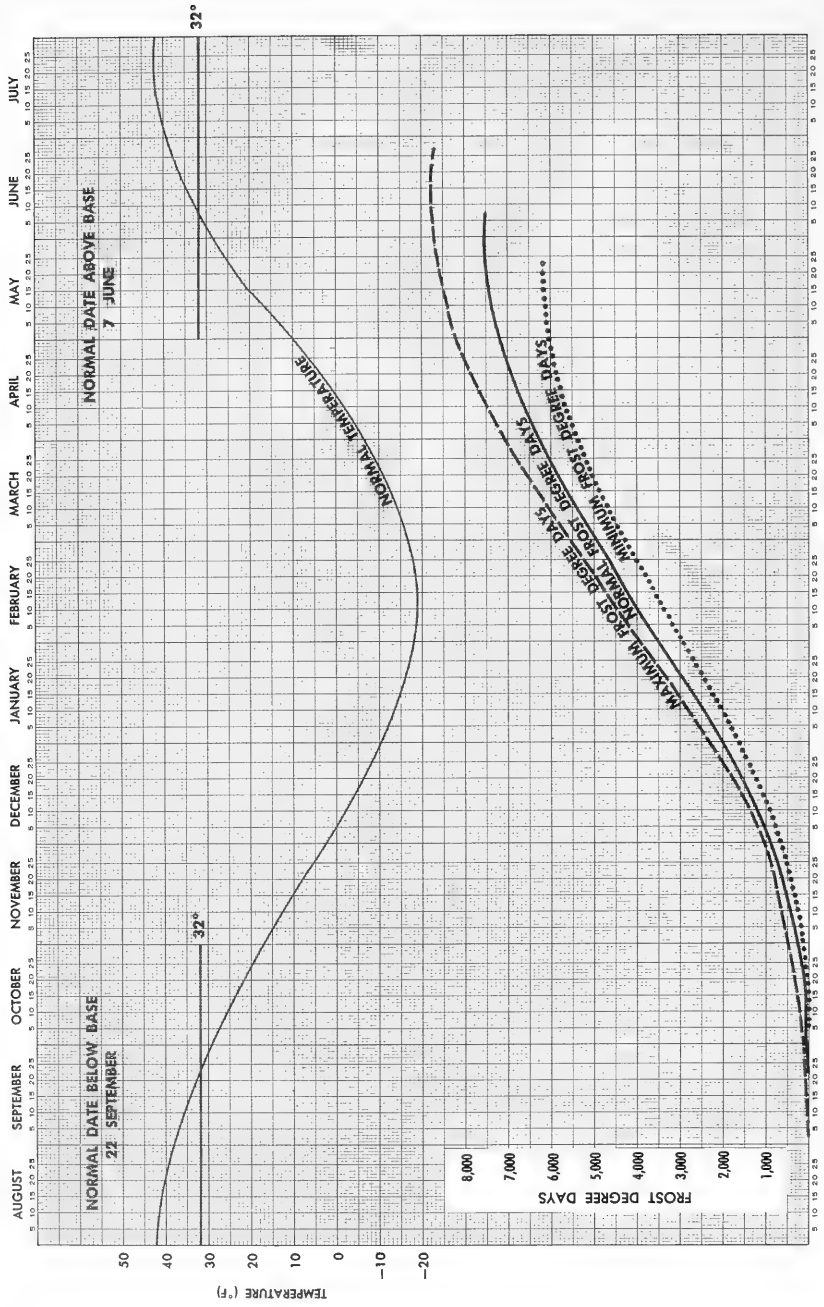


FIGURE 25A PADLOPING ISLAND (10 YEARS RECORD)

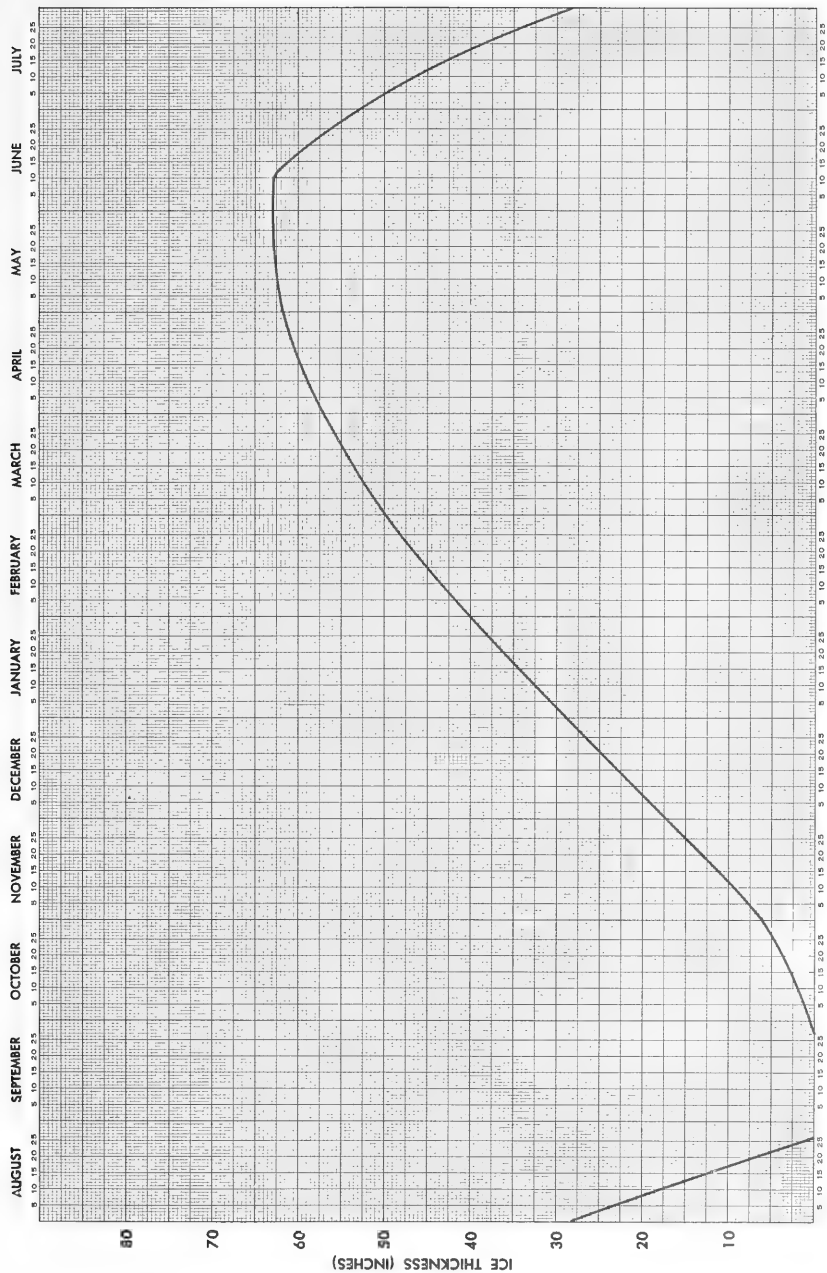


FIGURE 25B PADIOLPING ISLAND THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

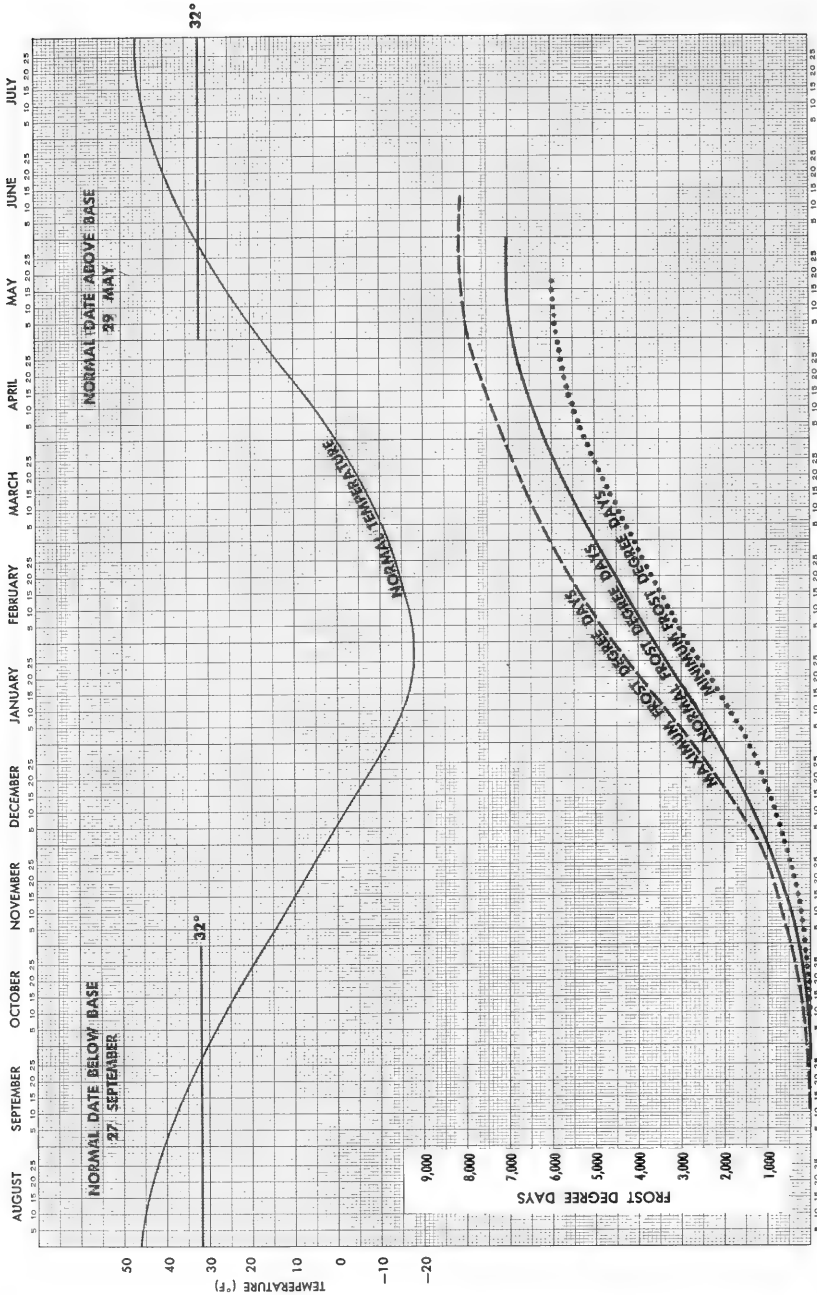


FIGURE 26A FROBISHER BAY (10 YEARS RECORD)

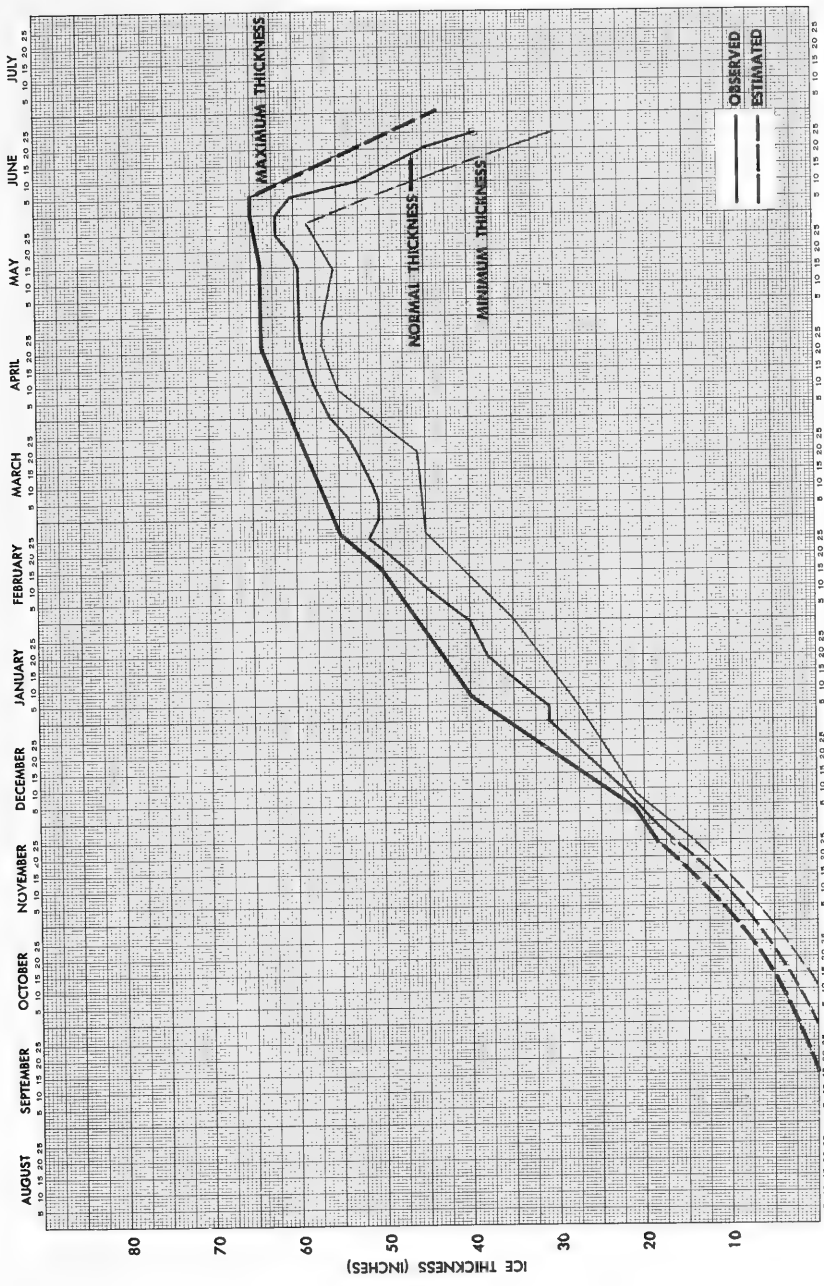


FIGURE 268 FROBISHER BAY EMPIRICAL ICE GROWTH AND DISINTEGRATION CURVE (4 YEARS RECORD)

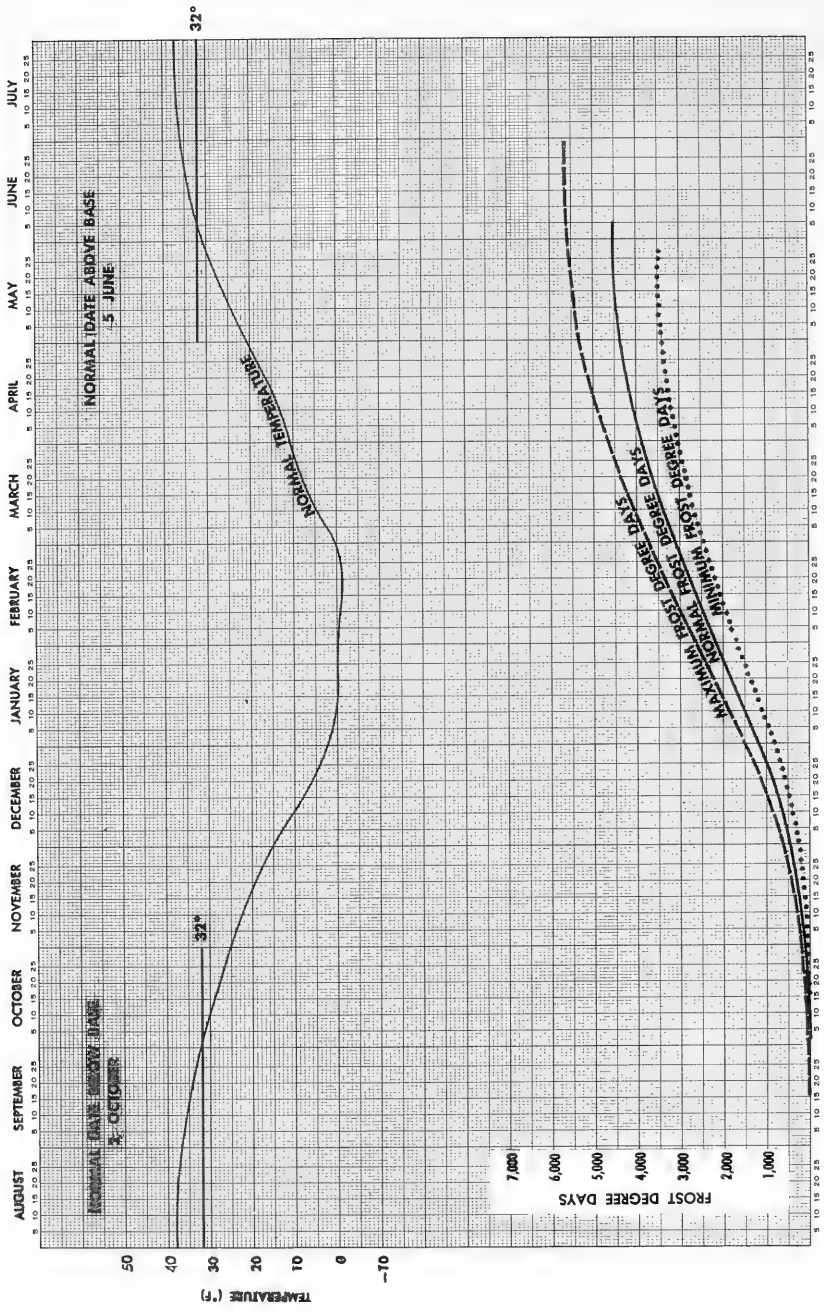


FIGURE 27A RESOLUTION ISLAND (20 YEARS RECORD)

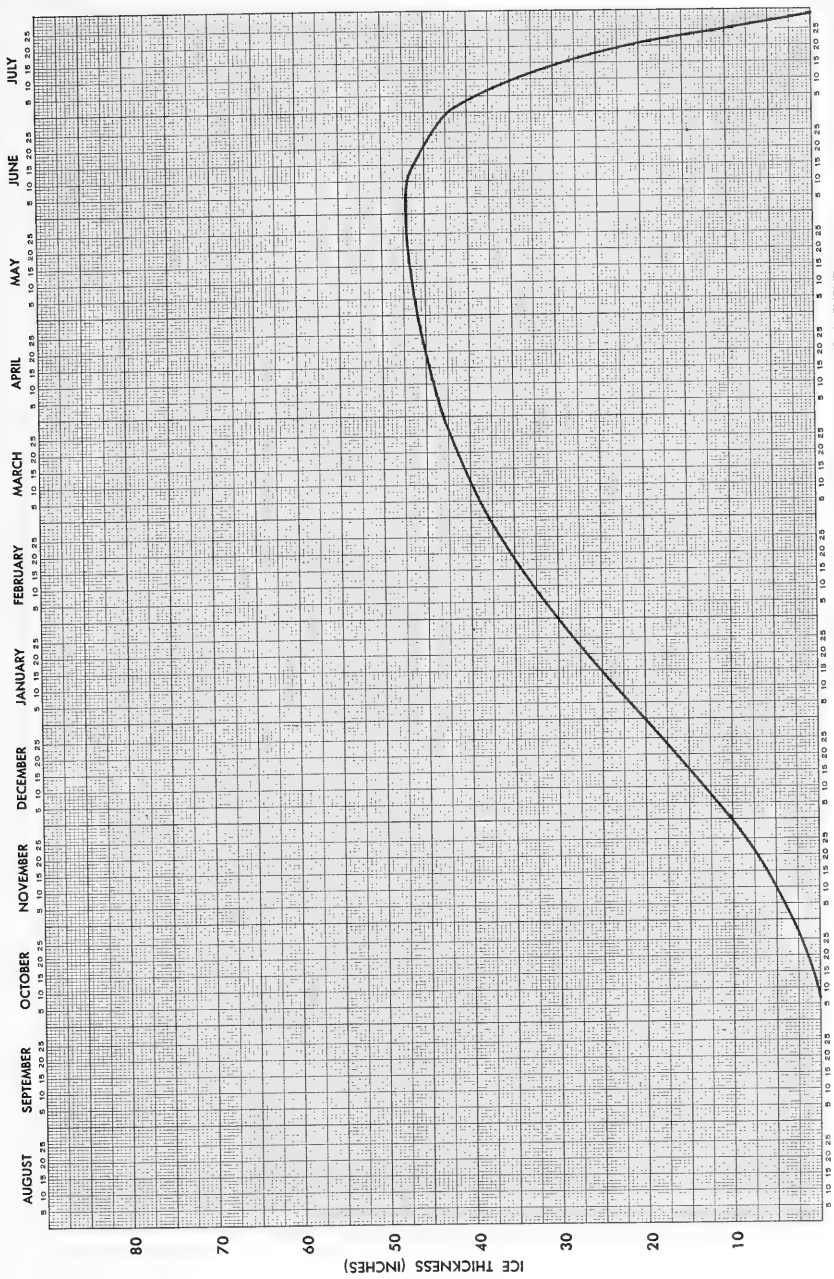


FIGURE 278 RESOLUTION ISLAND THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

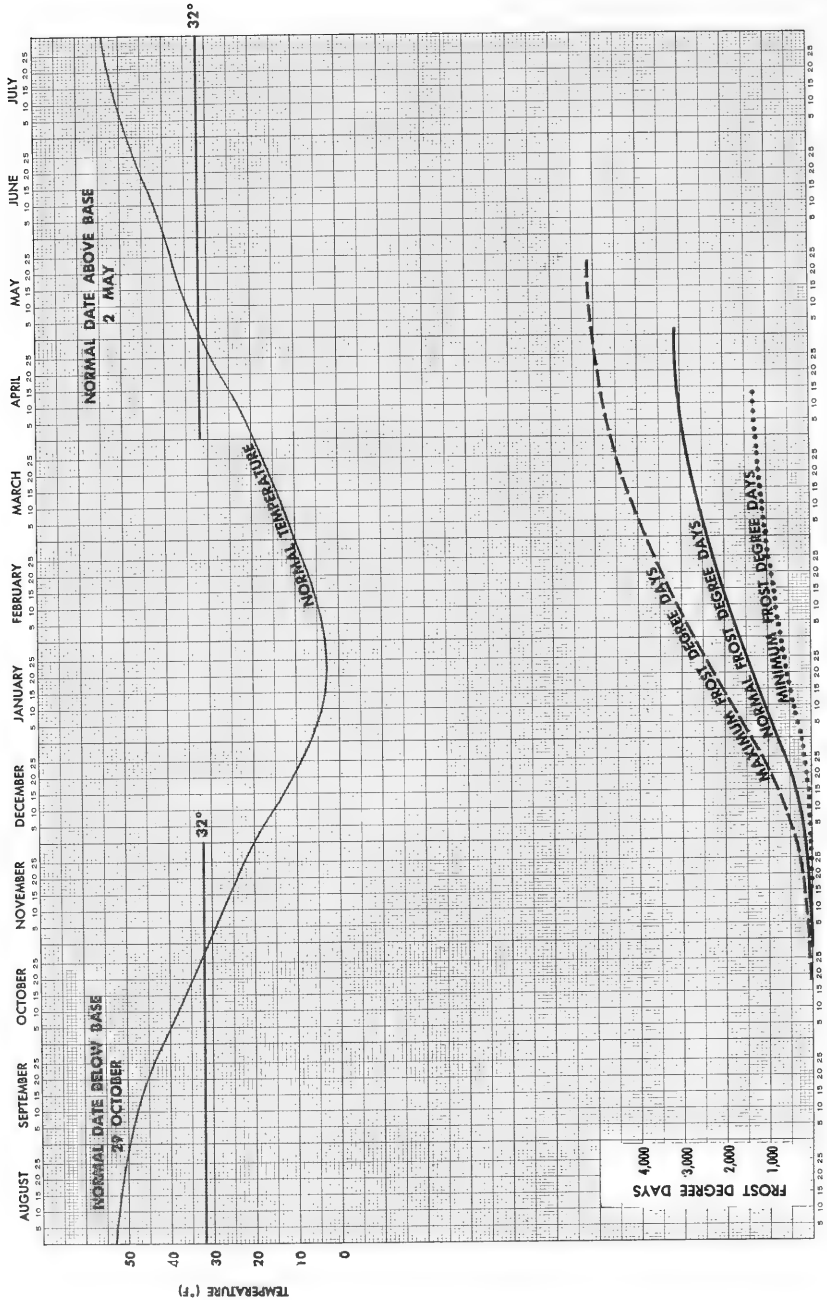


FIGURE 28A HOPEDALE (12 YEARS RECORD)

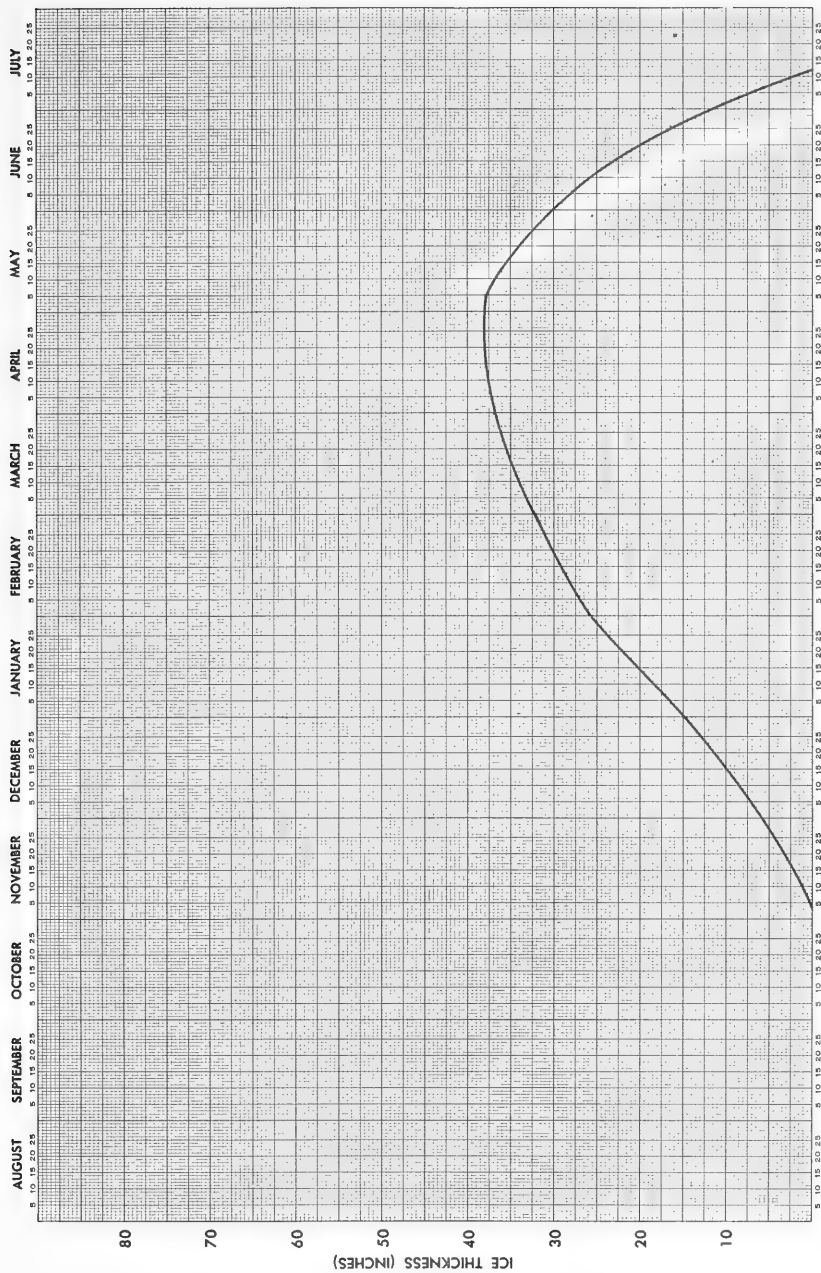


FIGURE 288 HOPEDALE THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

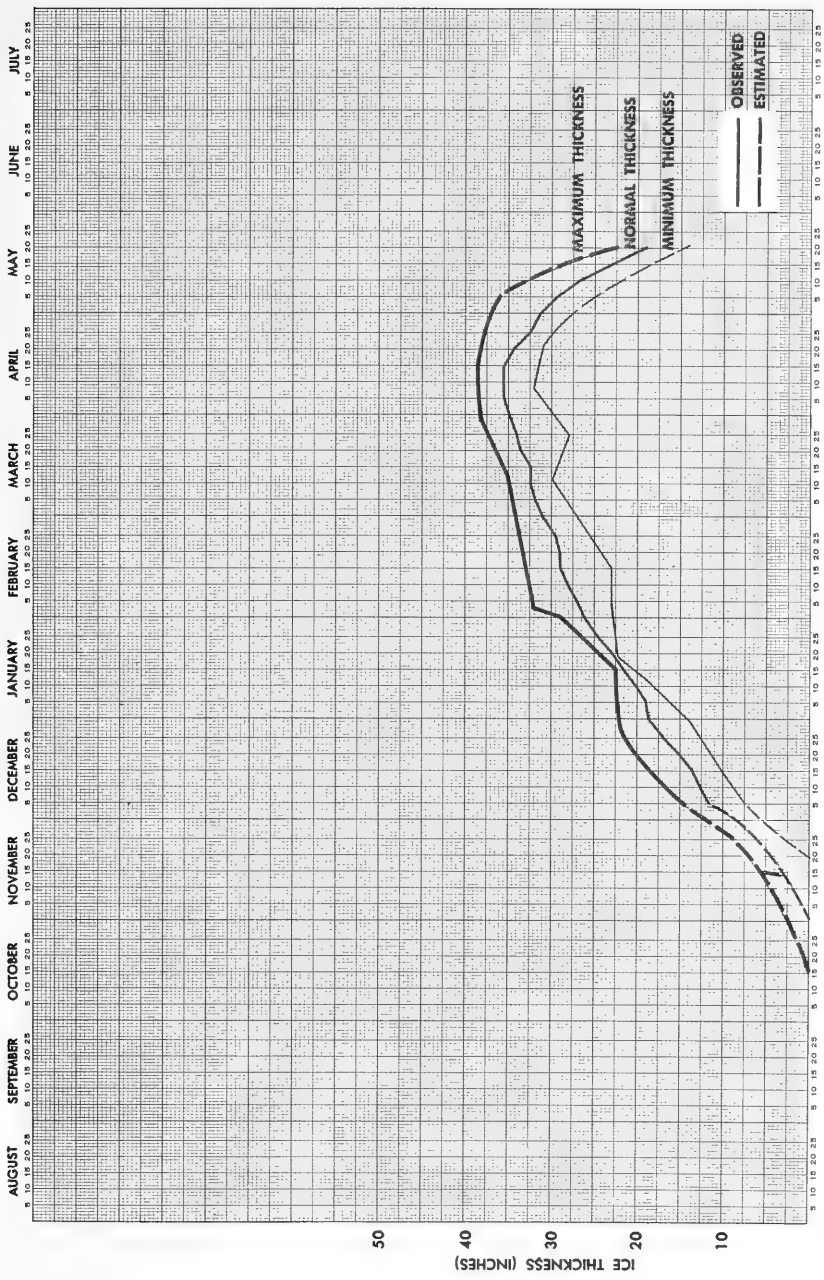


FIGURE 298 GOOSE BAY EMPIRICAL ICE GROWTH AND DISINTEGRATION CURVE (6 YEARS RECORD)



FIGURE 30A CARTWRIGHT (16 YEARS RECORD)

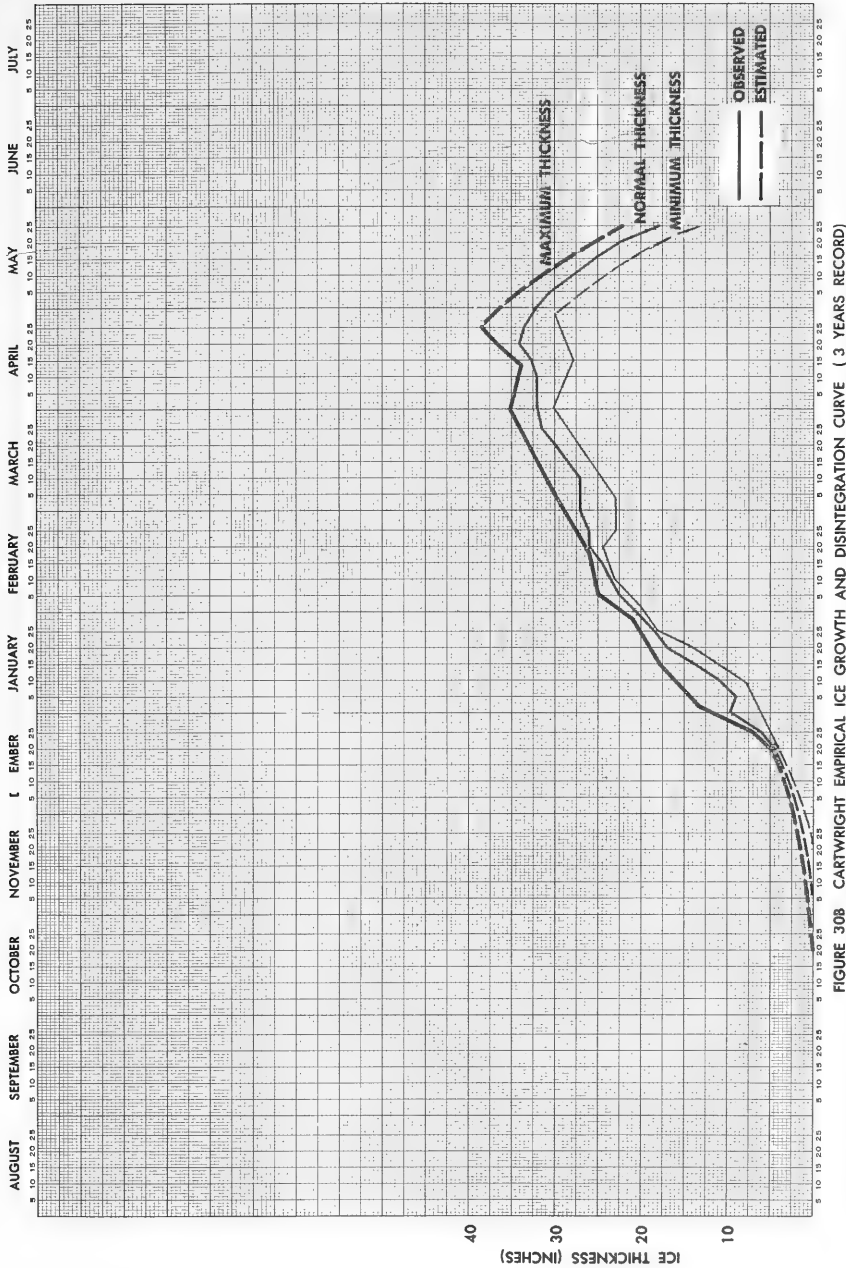


FIGURE 308 CARTWRIGHT EMPIRICAL ICE GROWTH AND DISINTEGRATION CURVE (3 YEARS RECORD)

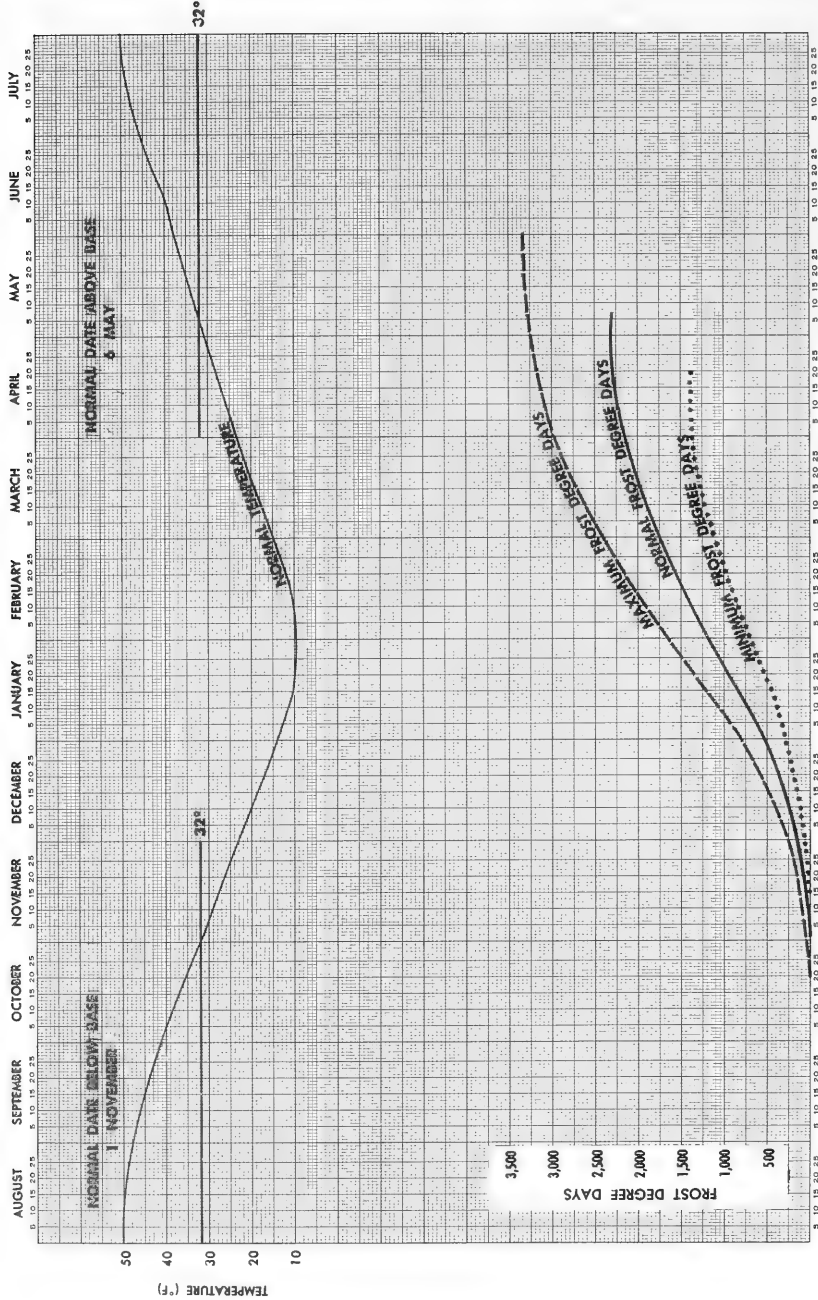


FIGURE 31A BELLE ISLE (27 YEARS RECORD)

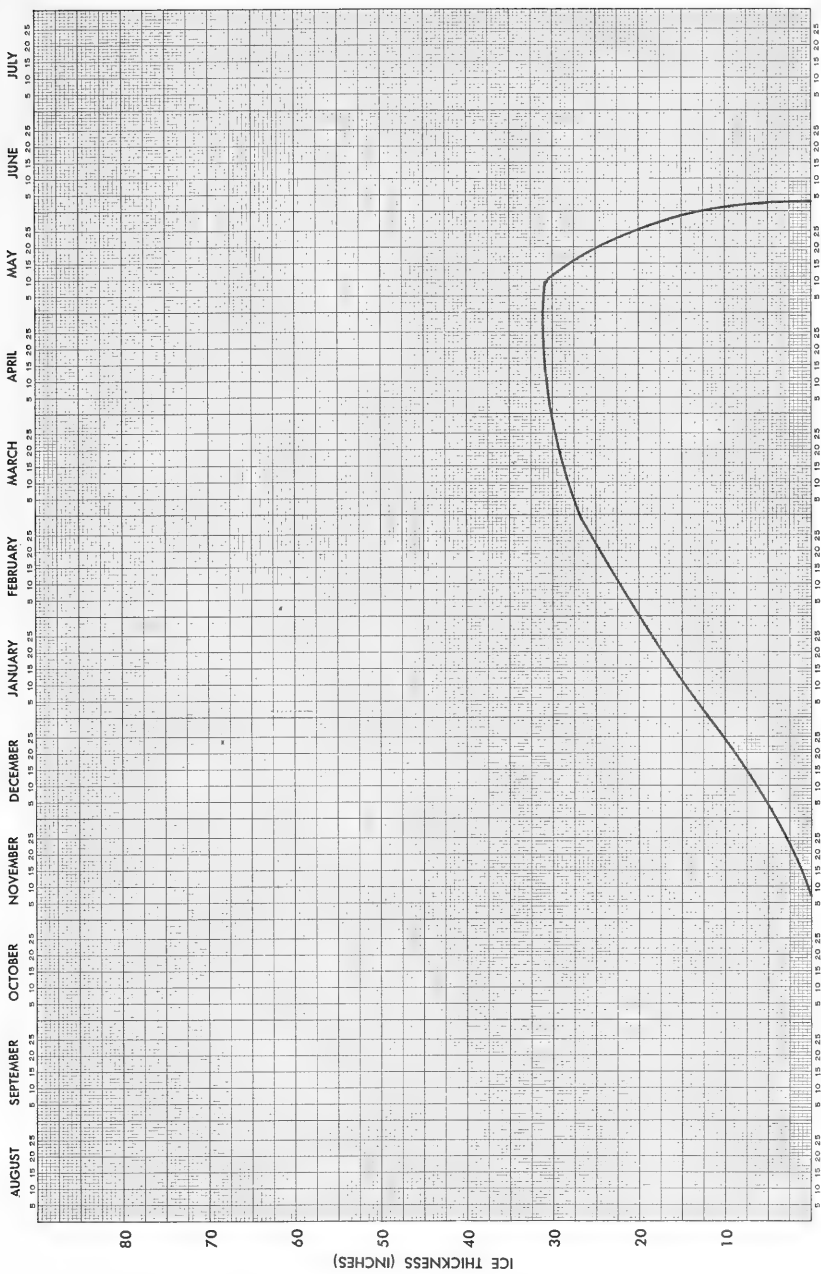


FIGURE 31B BELLE ISLE THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

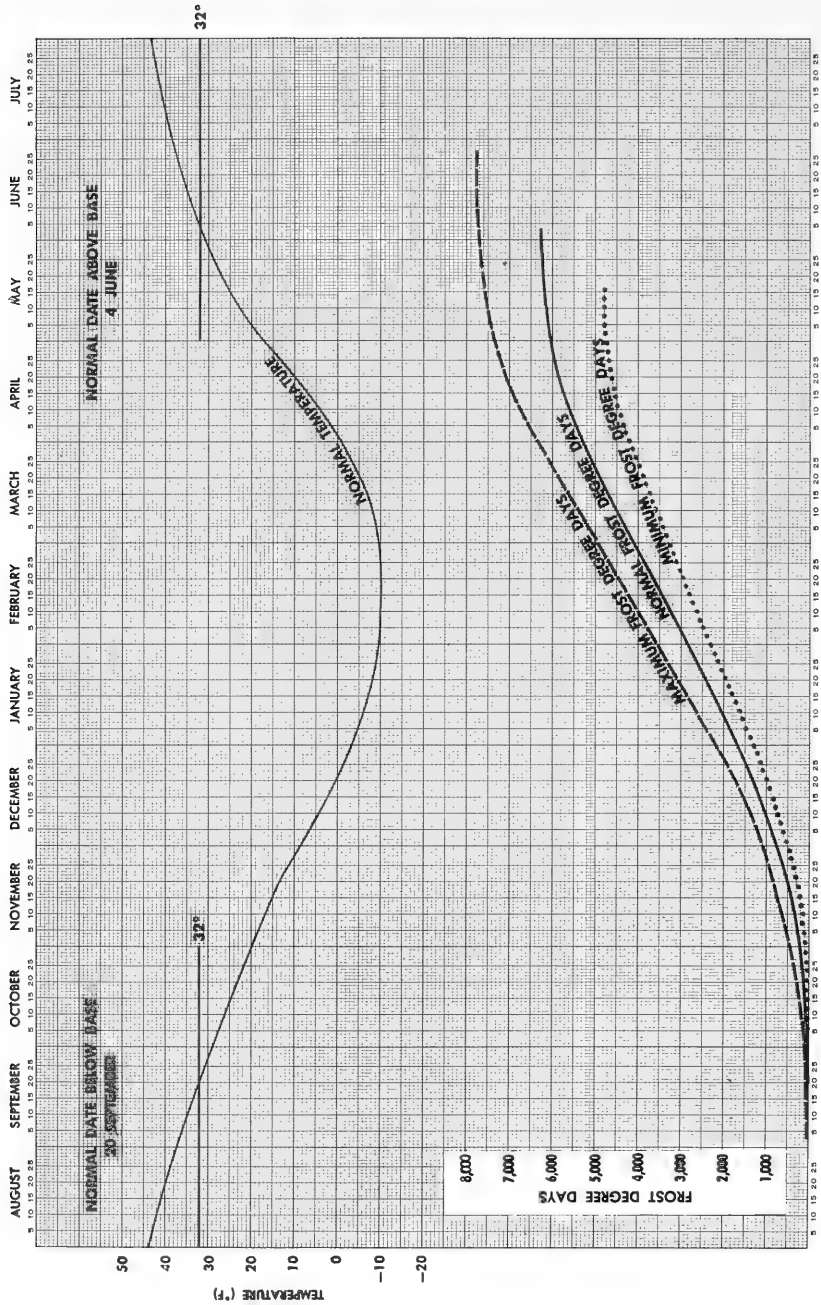


FIGURE 32A UPERNAVIK (50 YEARS RECORD)

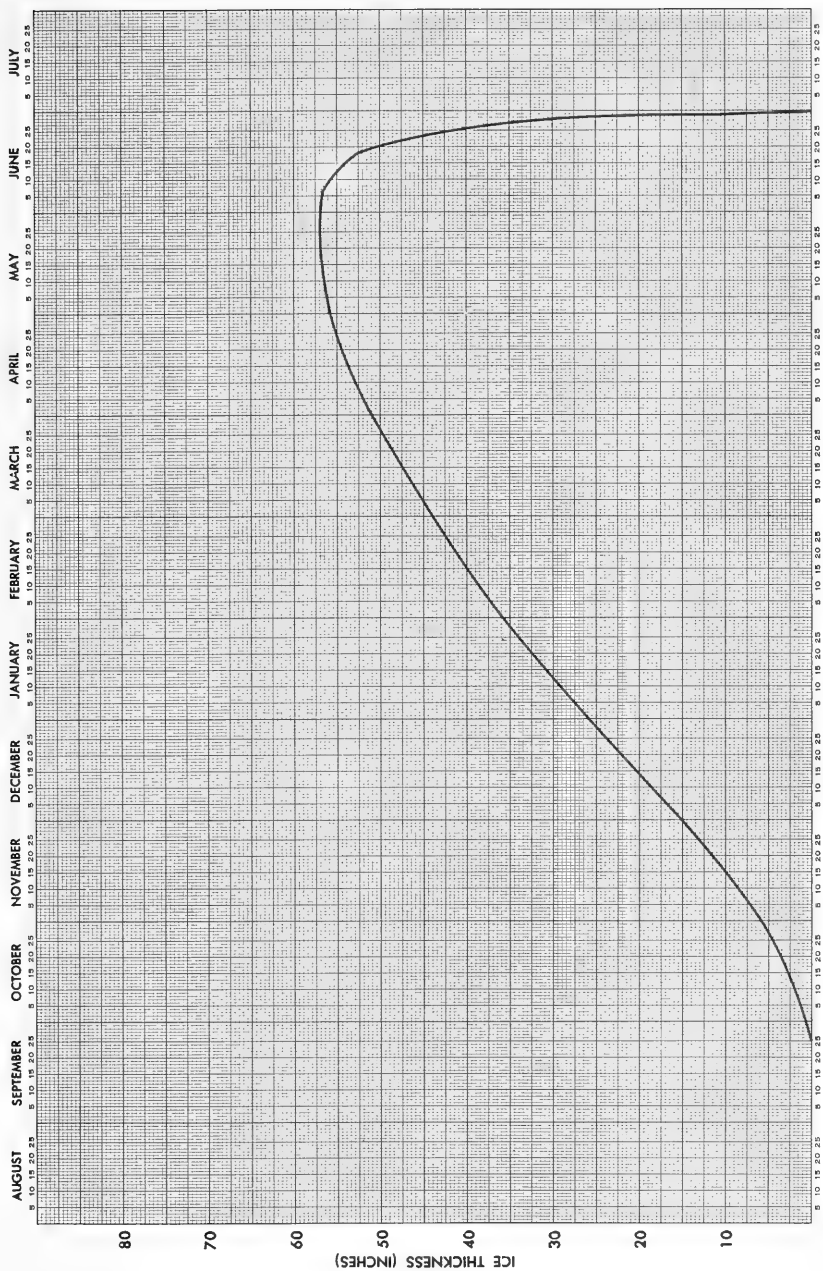


FIGURE 32B UPERNAVIK THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

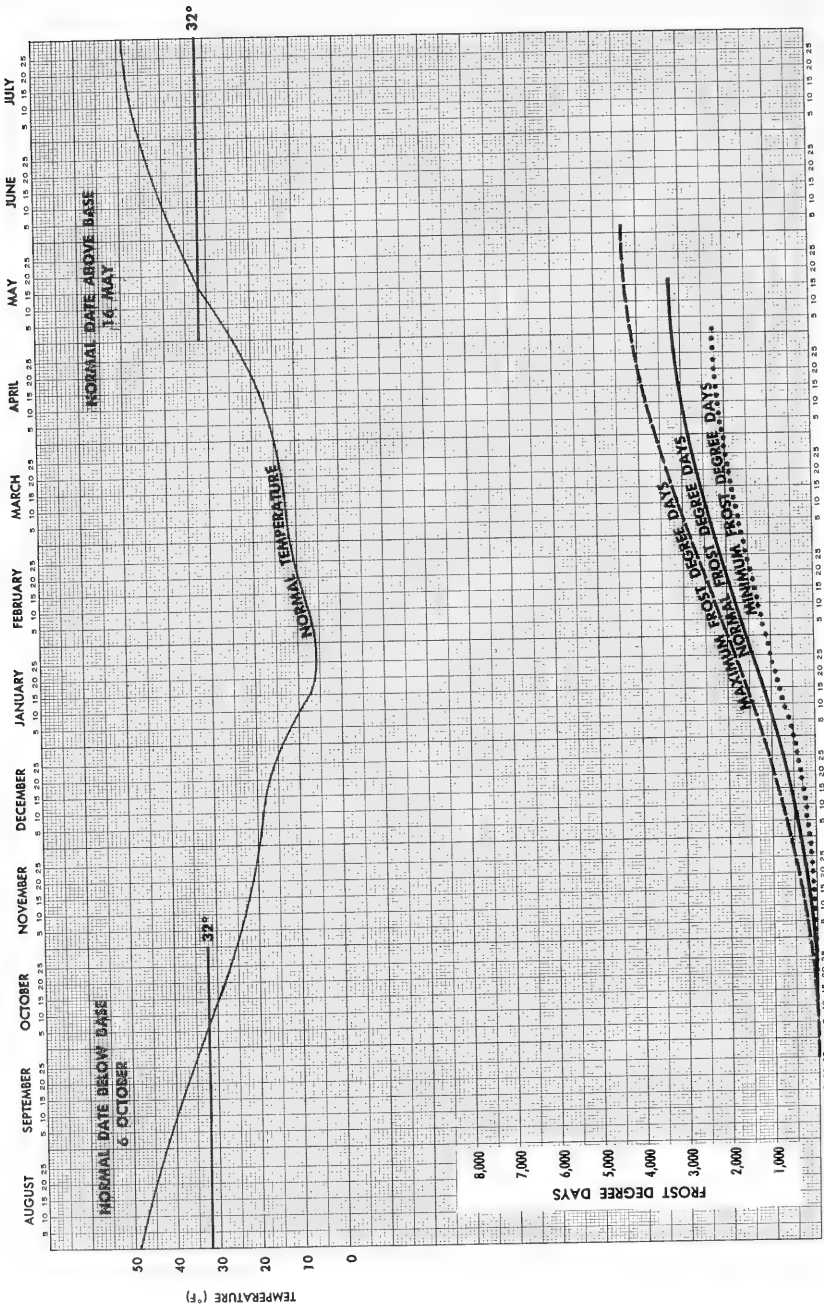


FIGURE 33A UMANAK (5 YEARS RECORD)

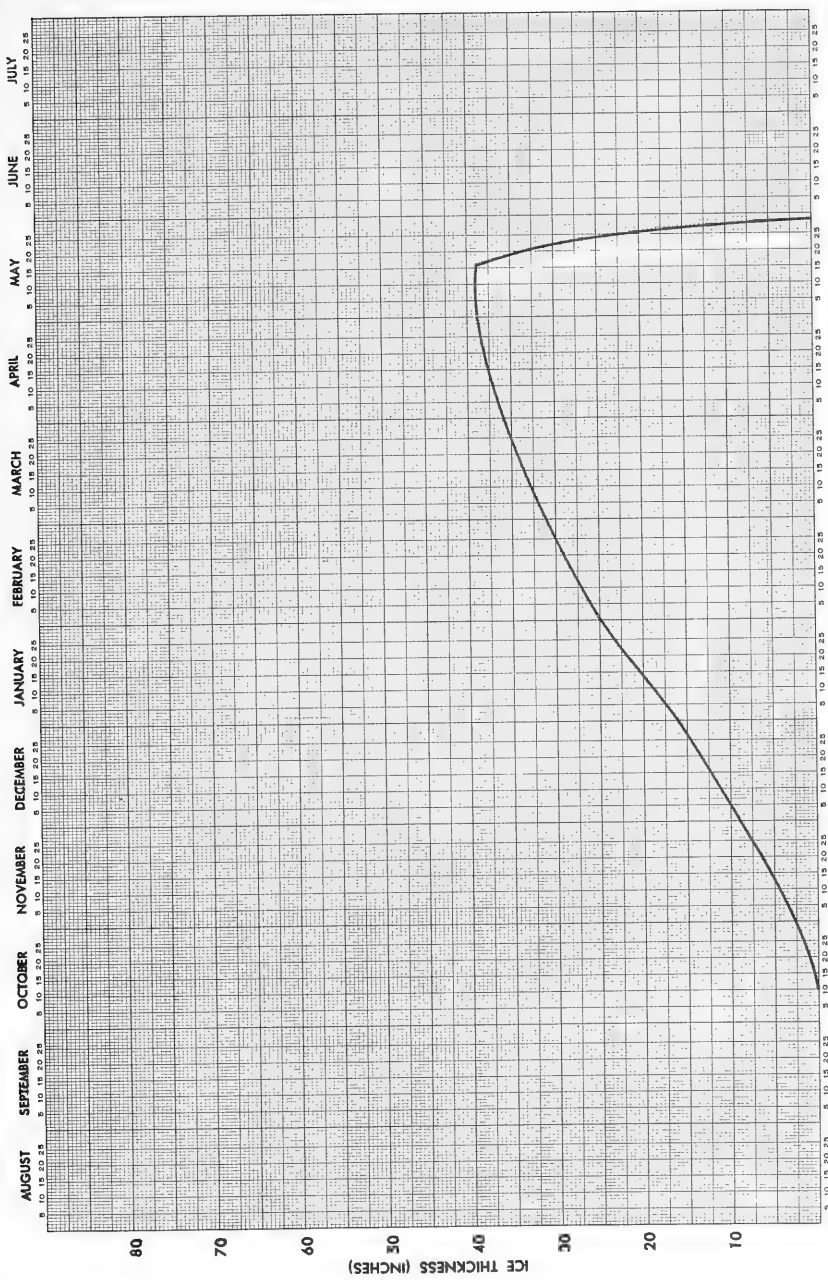


FIGURE 338 UMANAK THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

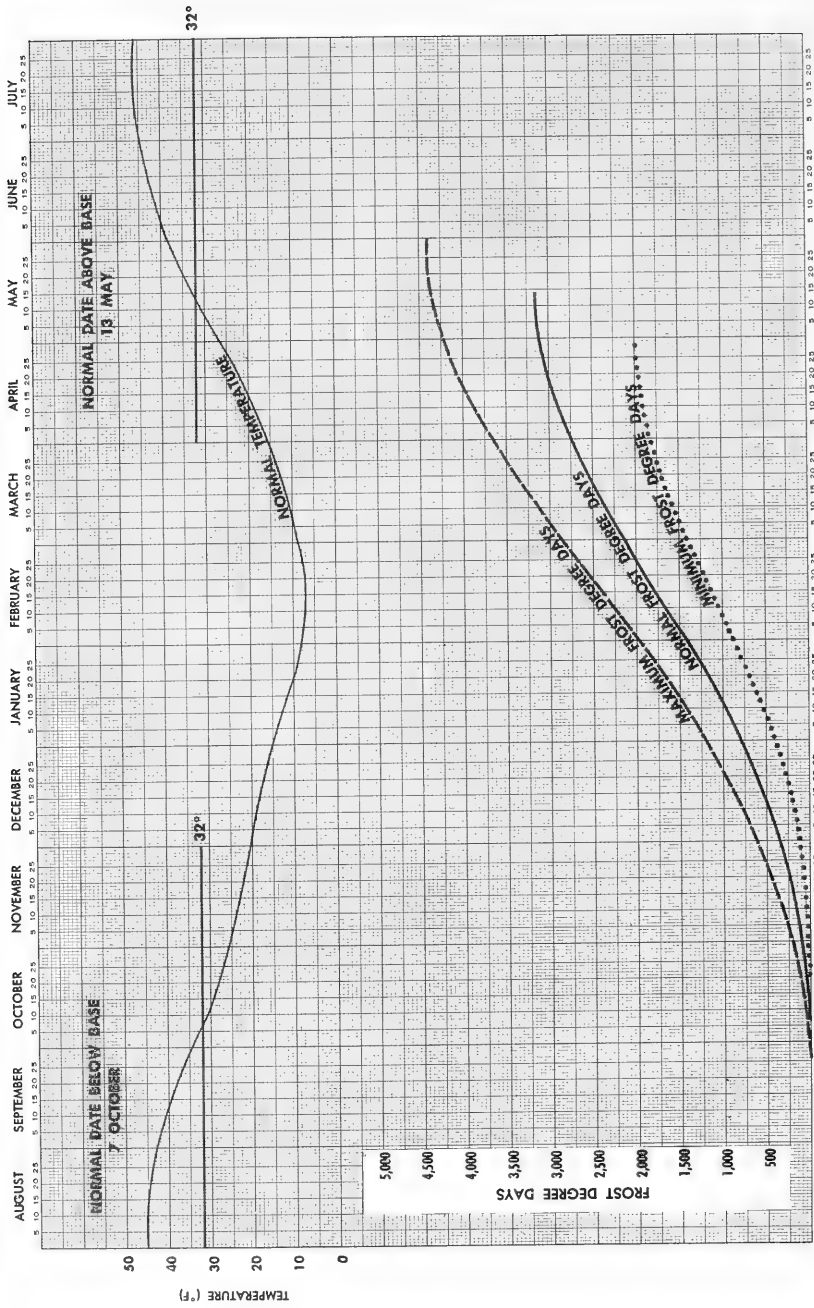


FIGURE 34A GODHAVN (12 YEARS RECORD)

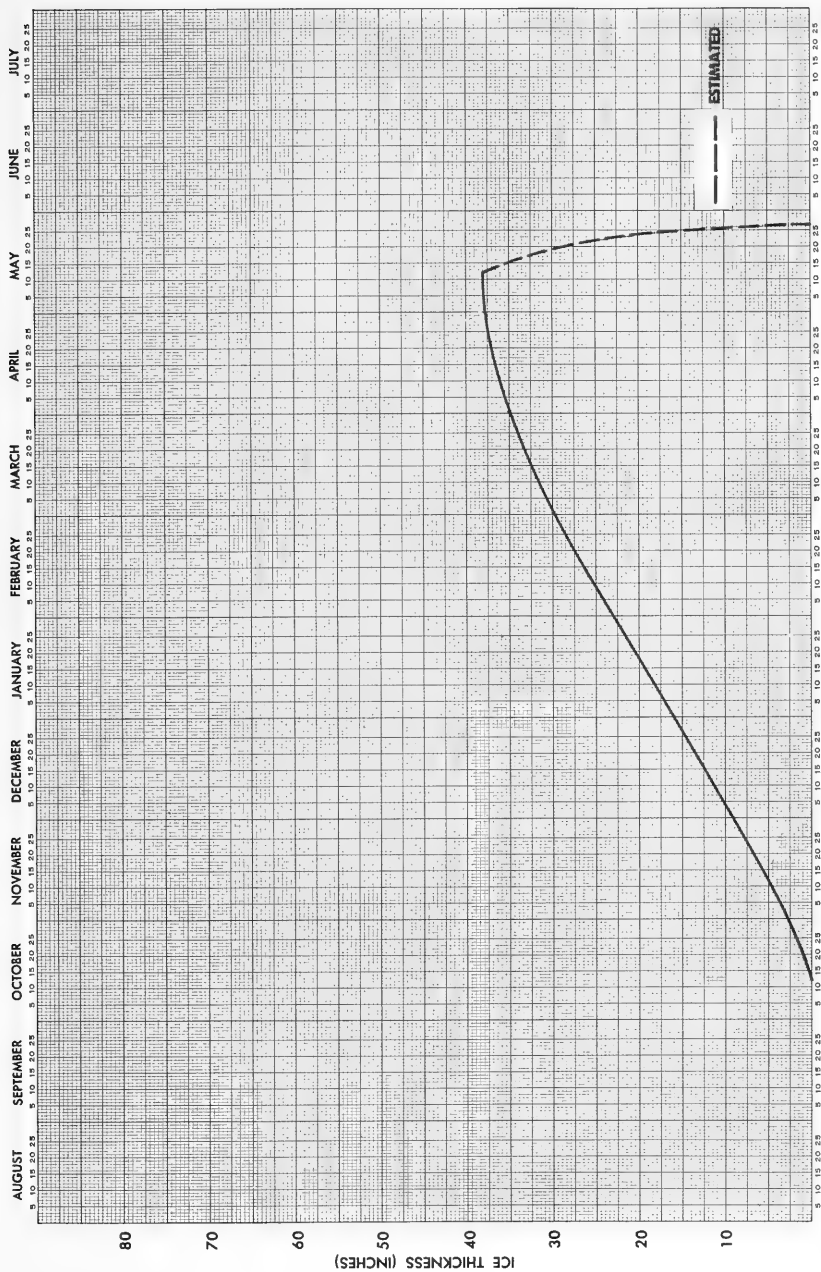


FIGURE 34B GODHAVN THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

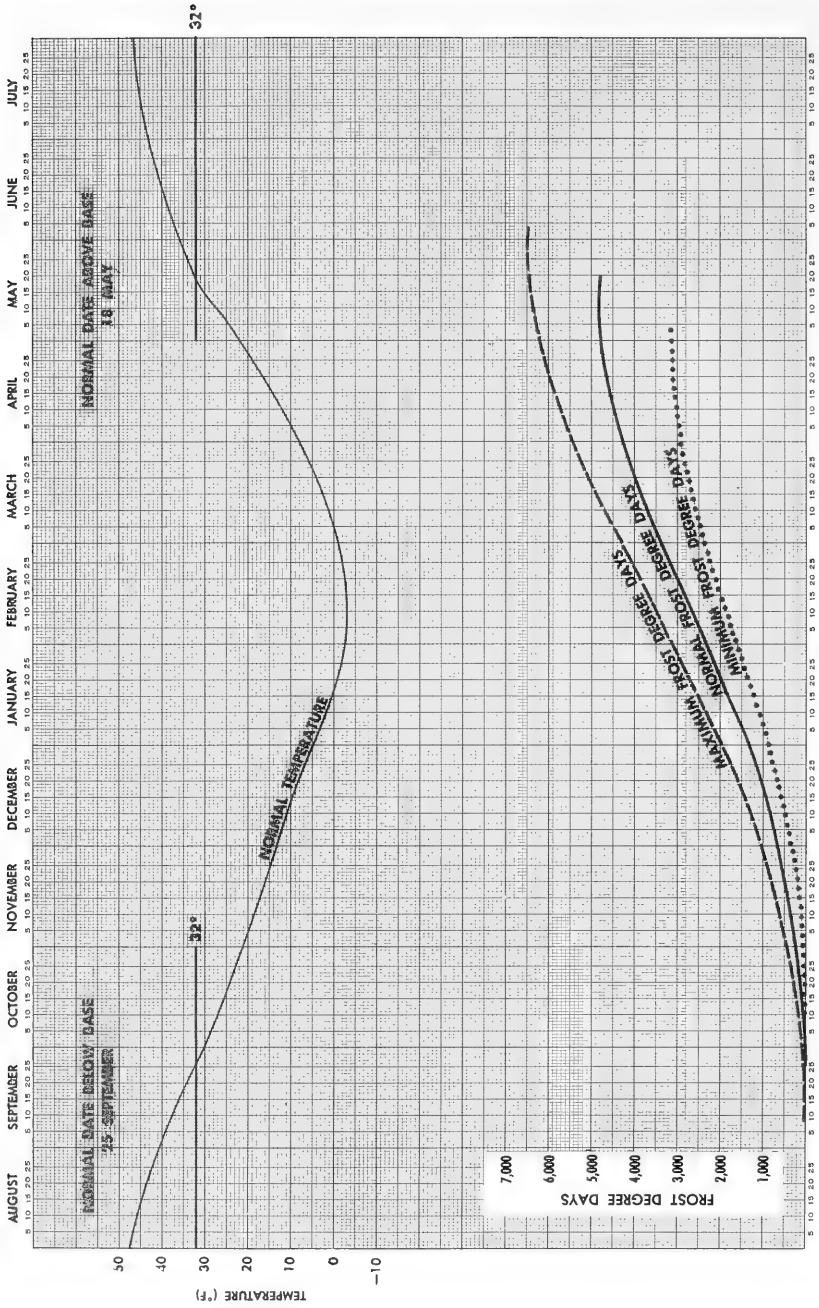


FIGURE 35A JAKOBSHAVN (50 YEARS RECORD)

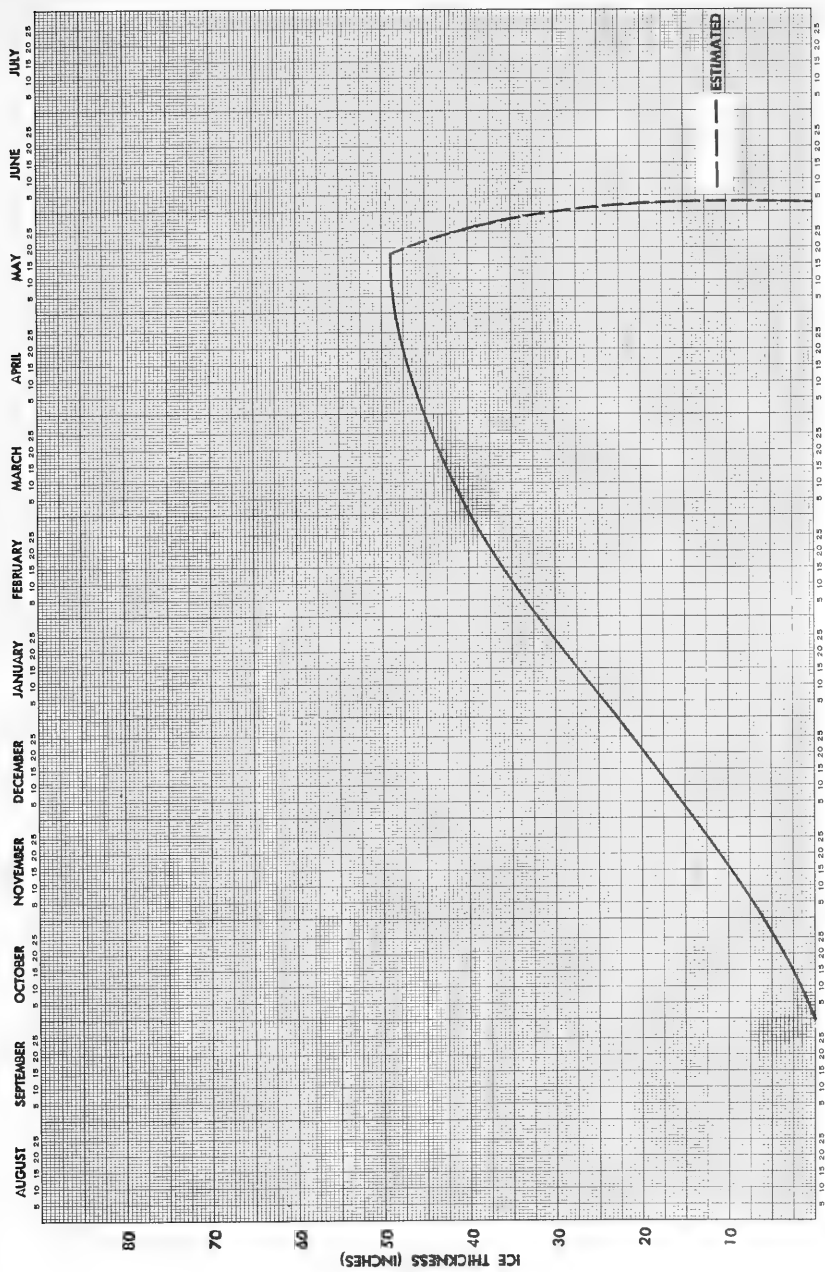


FIGURE 35B JAKOBSHAVN THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

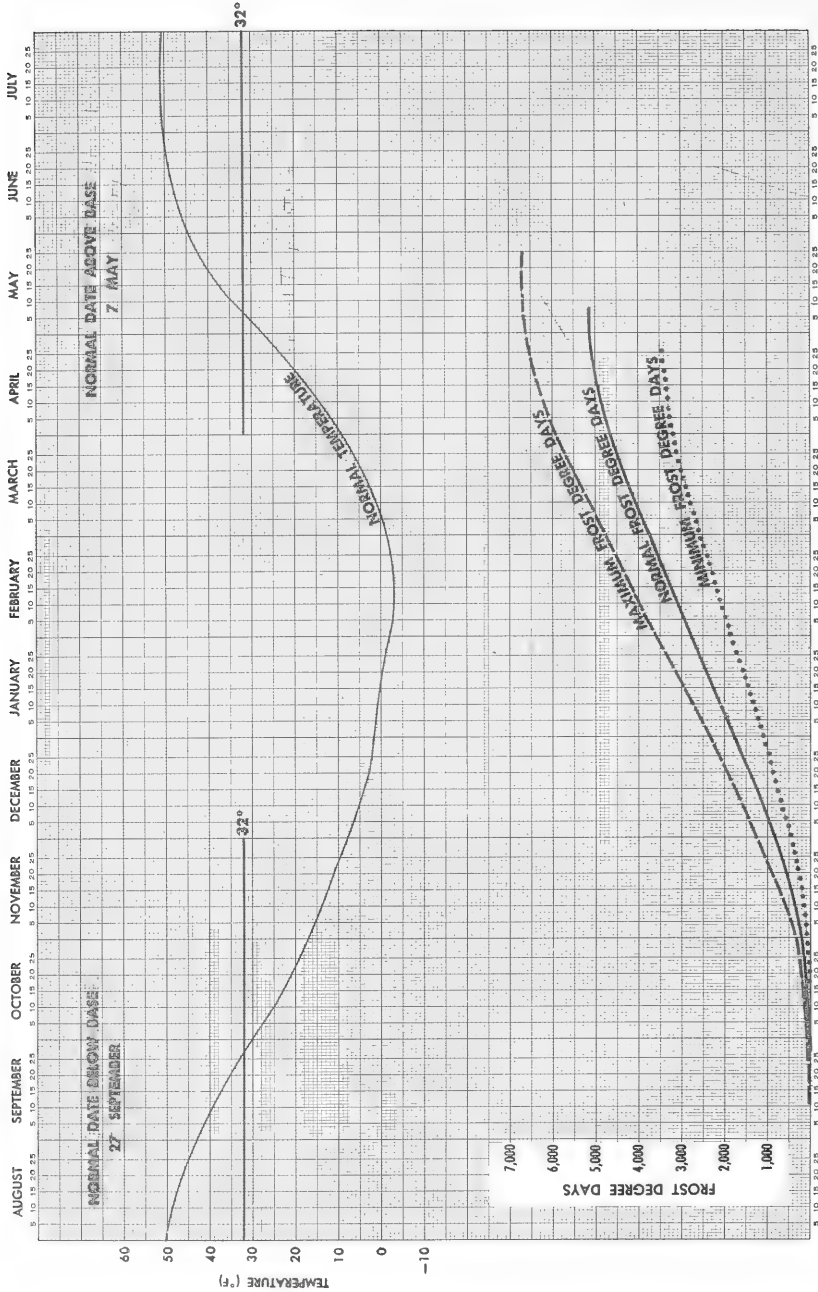


FIGURE 36A SONDRSTROM (12 YEARS RECORD)

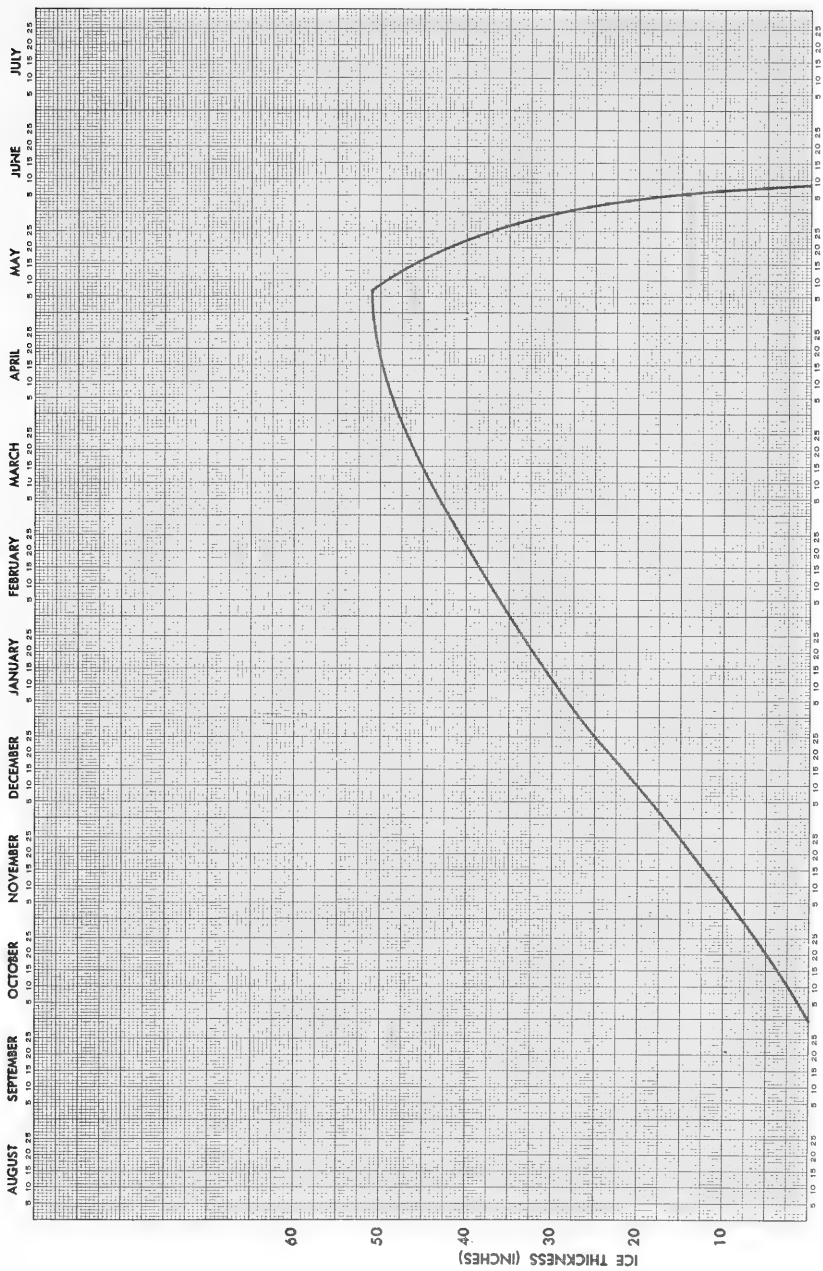


FIGURE 3-68 SONDRSTROM THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

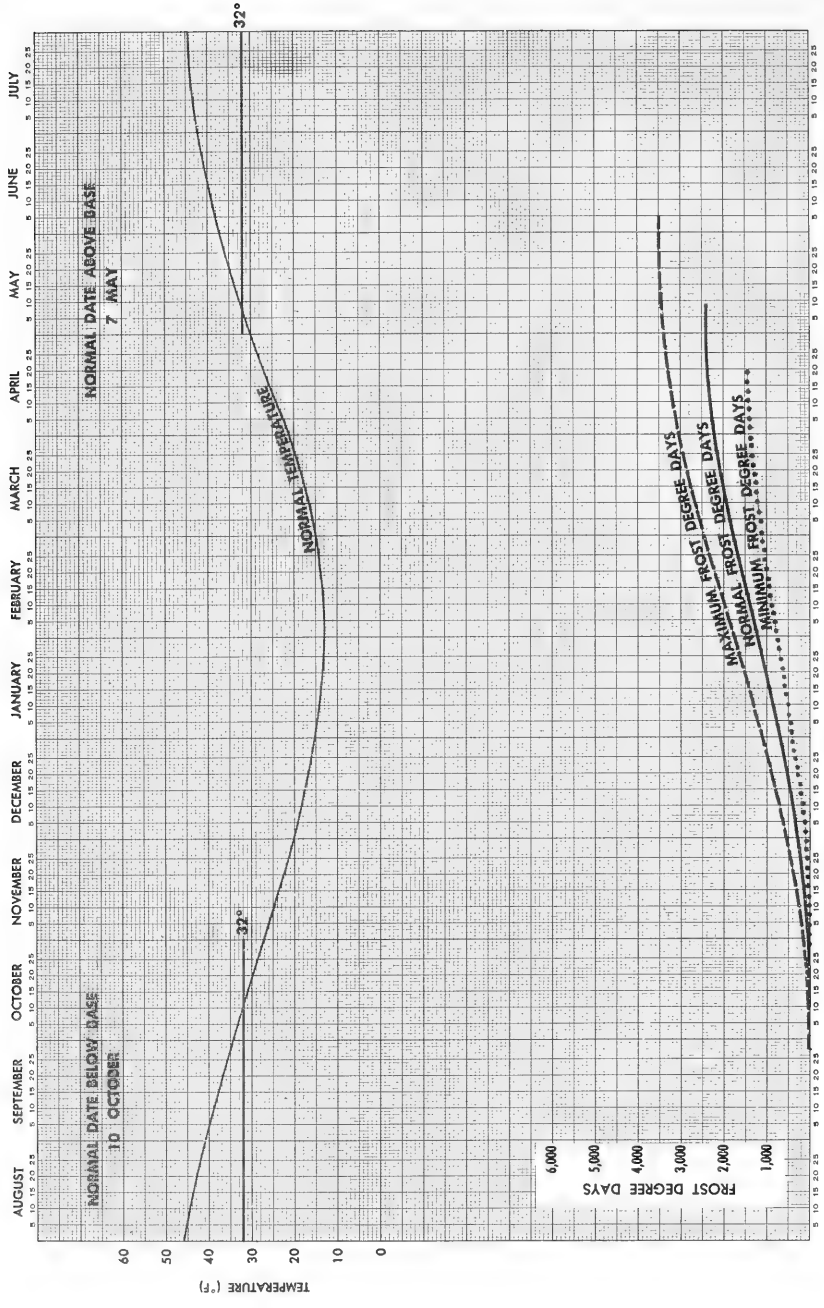


FIGURE 37A GODTHAAB (50 YEARS RECORD)

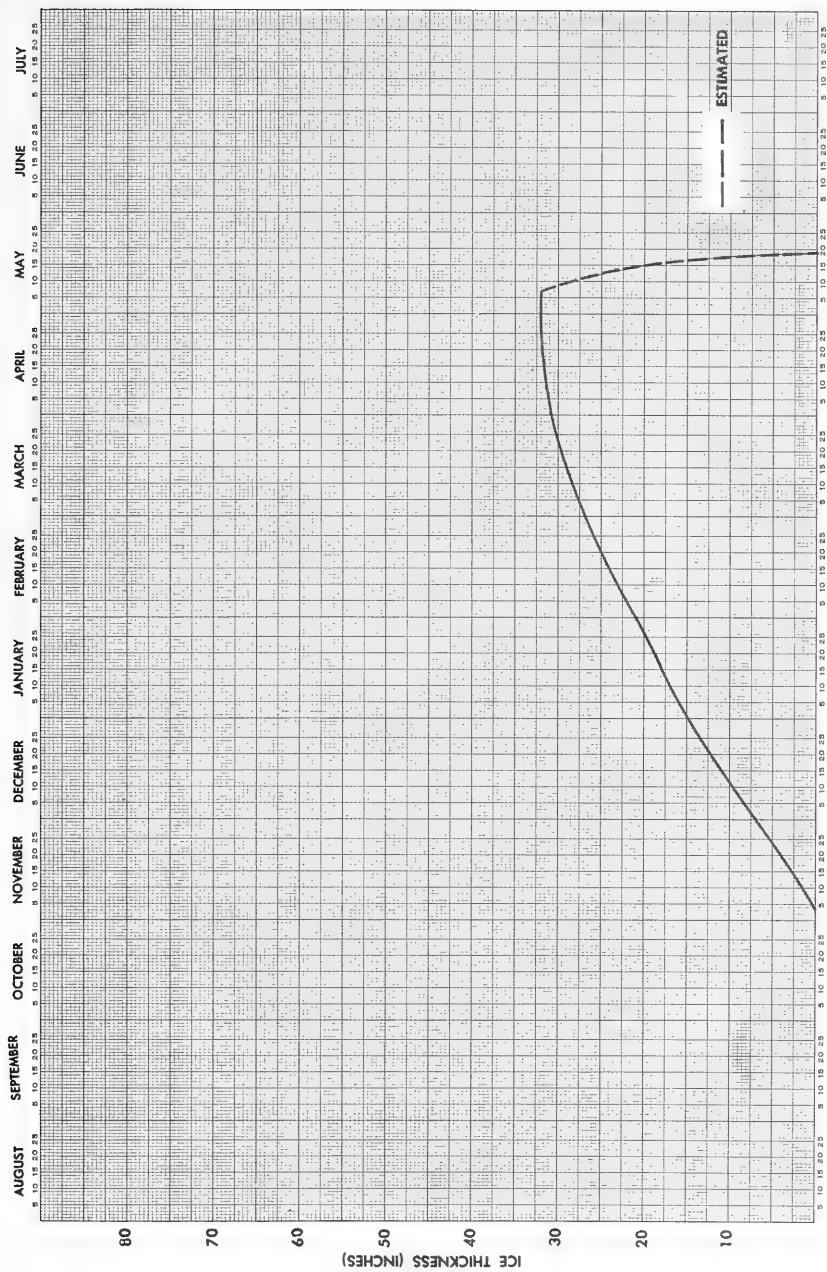


FIGURE 37B GODTHAAB THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

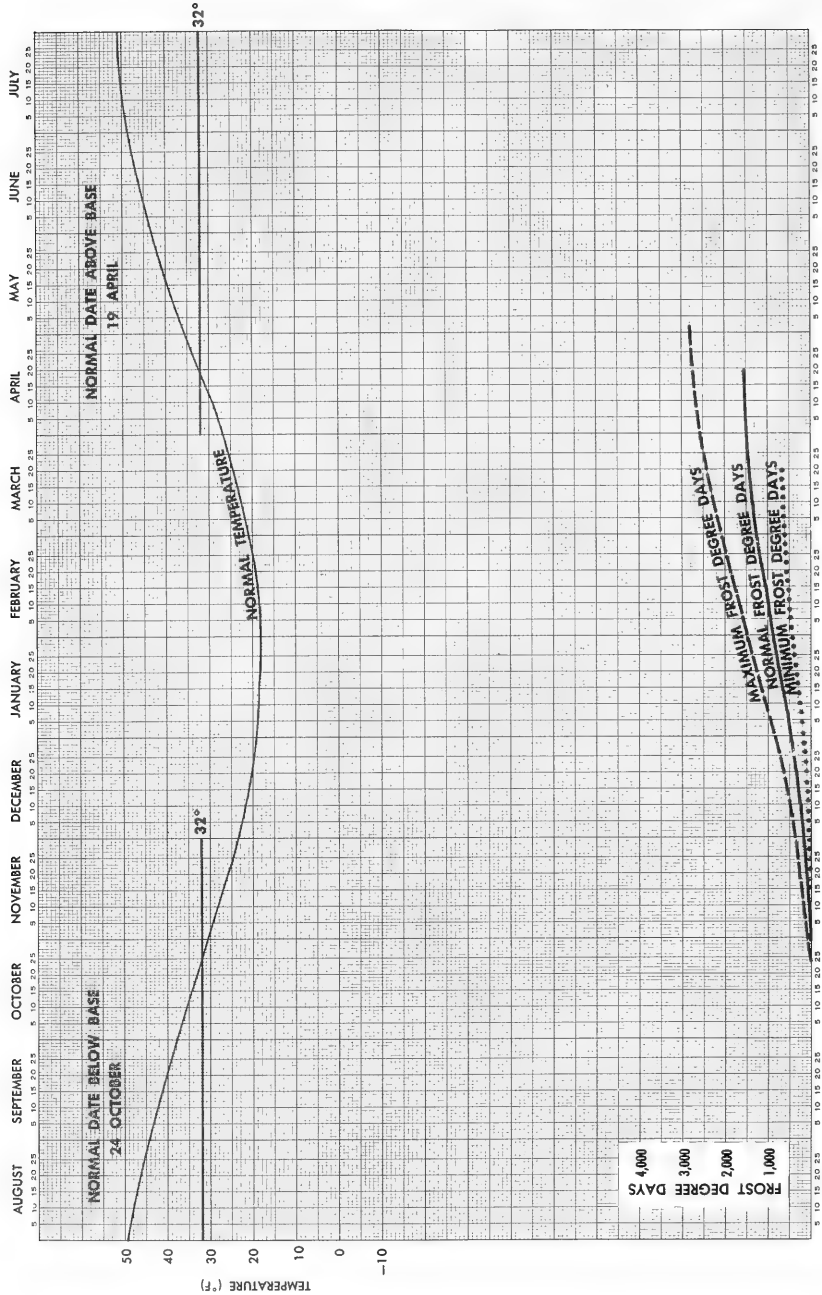


FIGURE 38A IVIGTUT (48 YEARS RECORD)

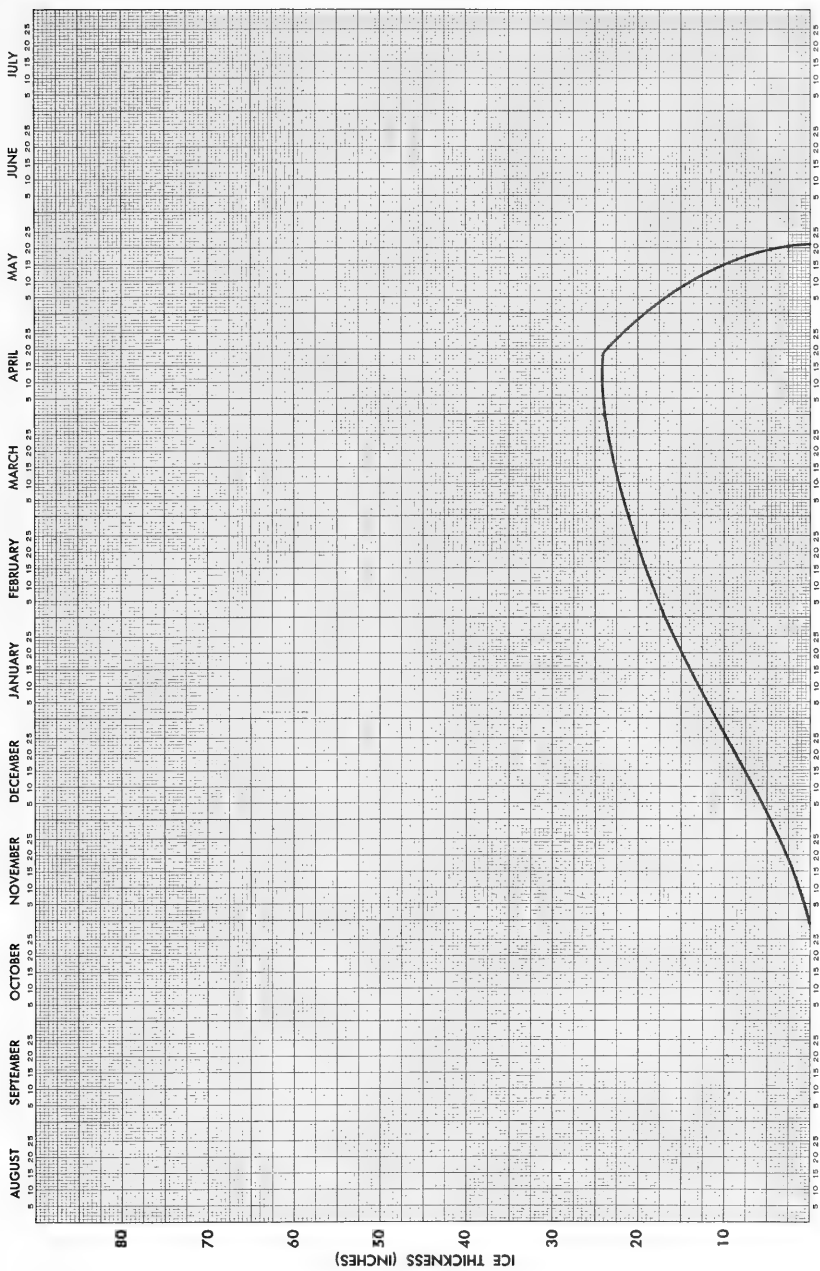


FIGURE 38B IVGTUT THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

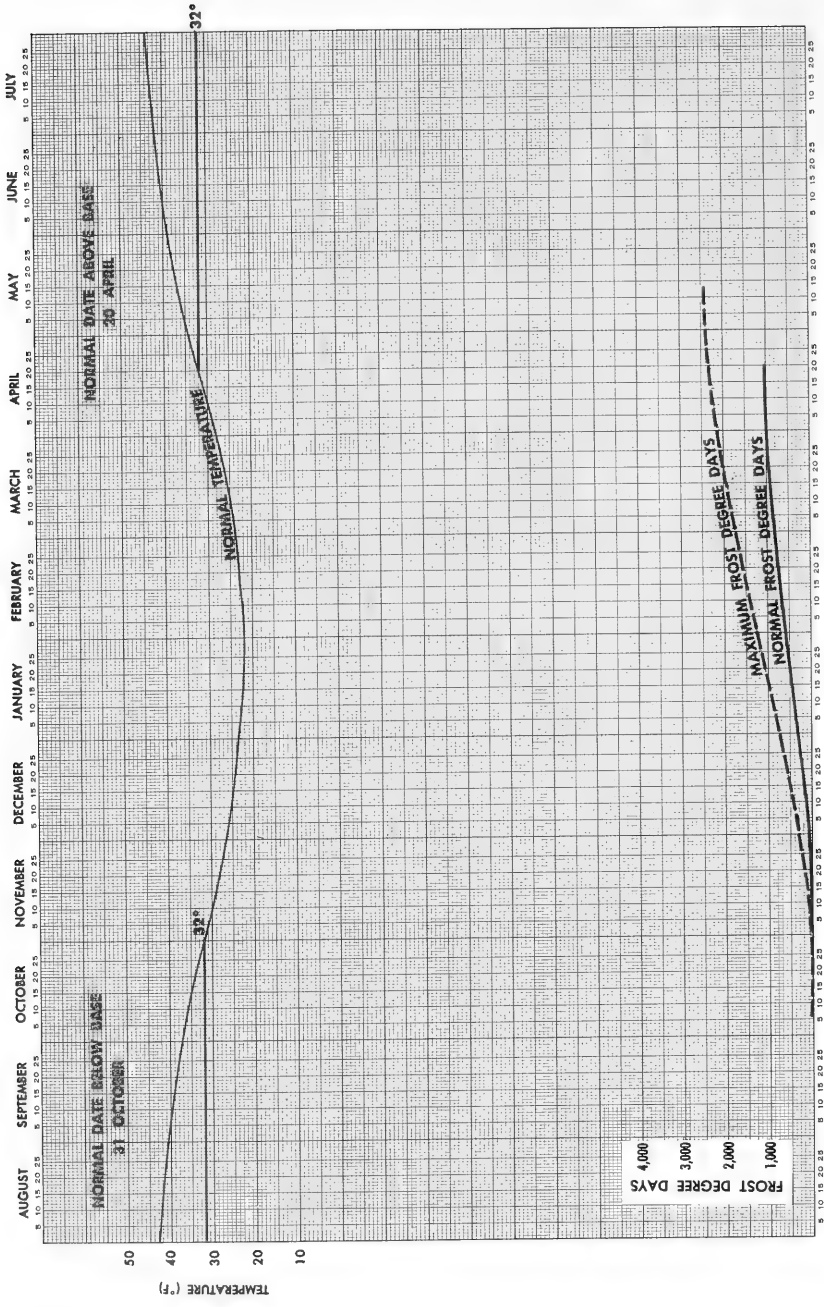


FIGURE 39A NANORTALIK (45 YEARS RECORD)

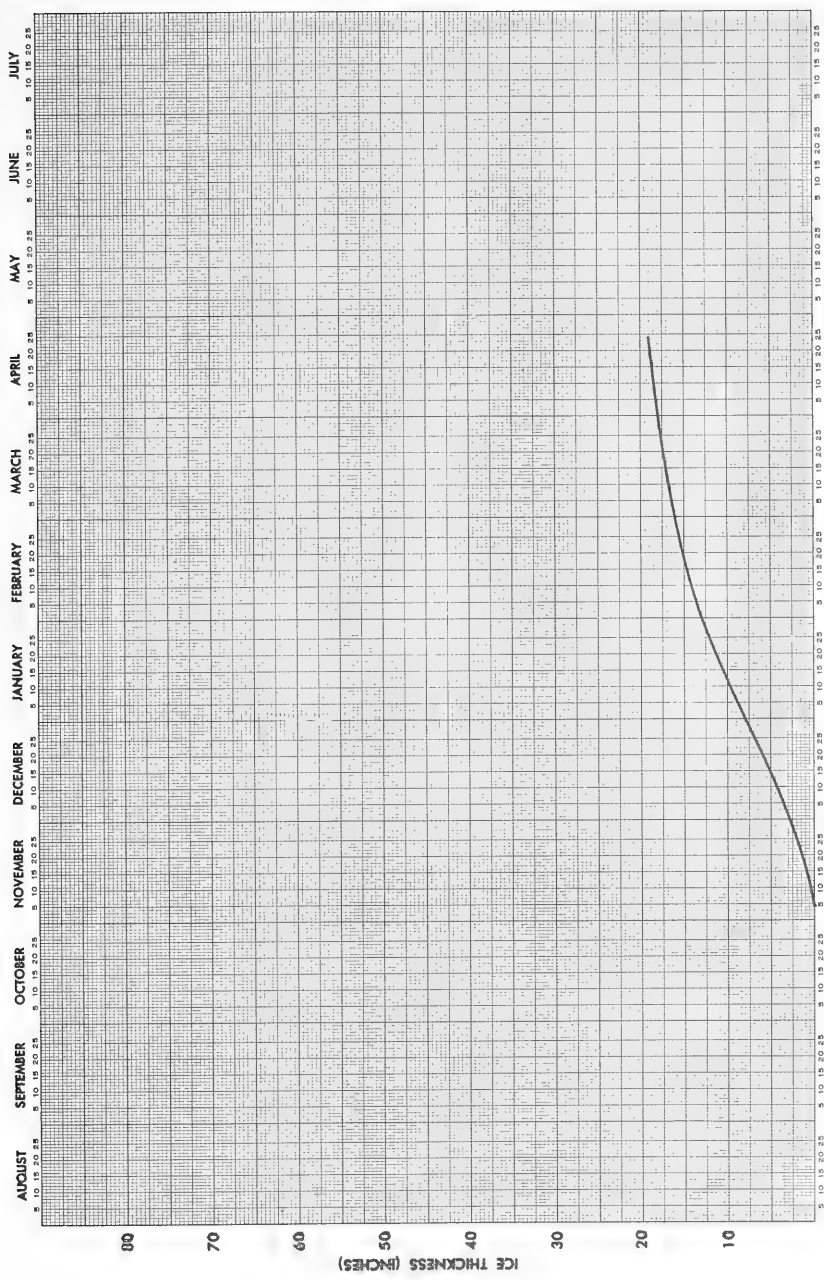


FIGURE 398 NANORTALIK THEORETICAL ICE GROWTH CURVE

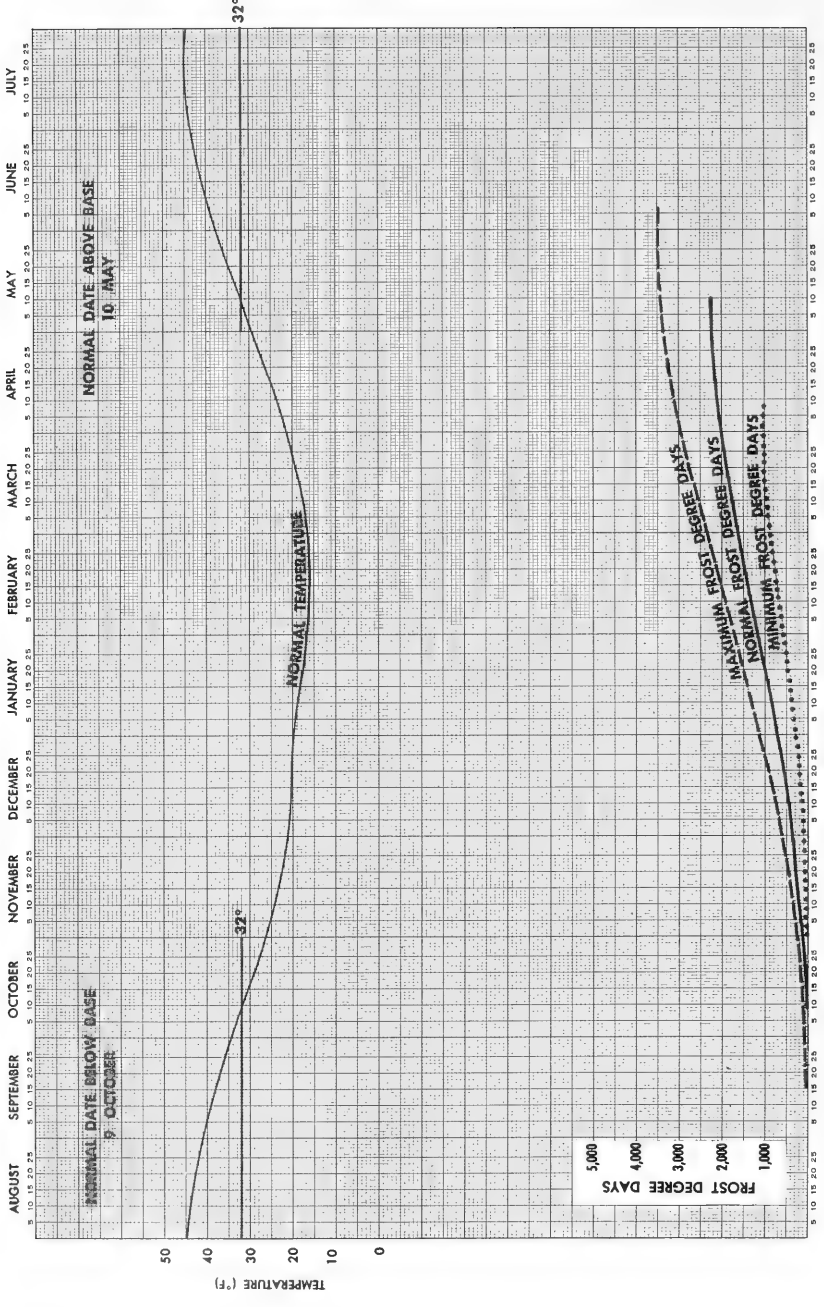


FIGURE 40A ANGMAGSSALIK (32 YEARS RECORD)

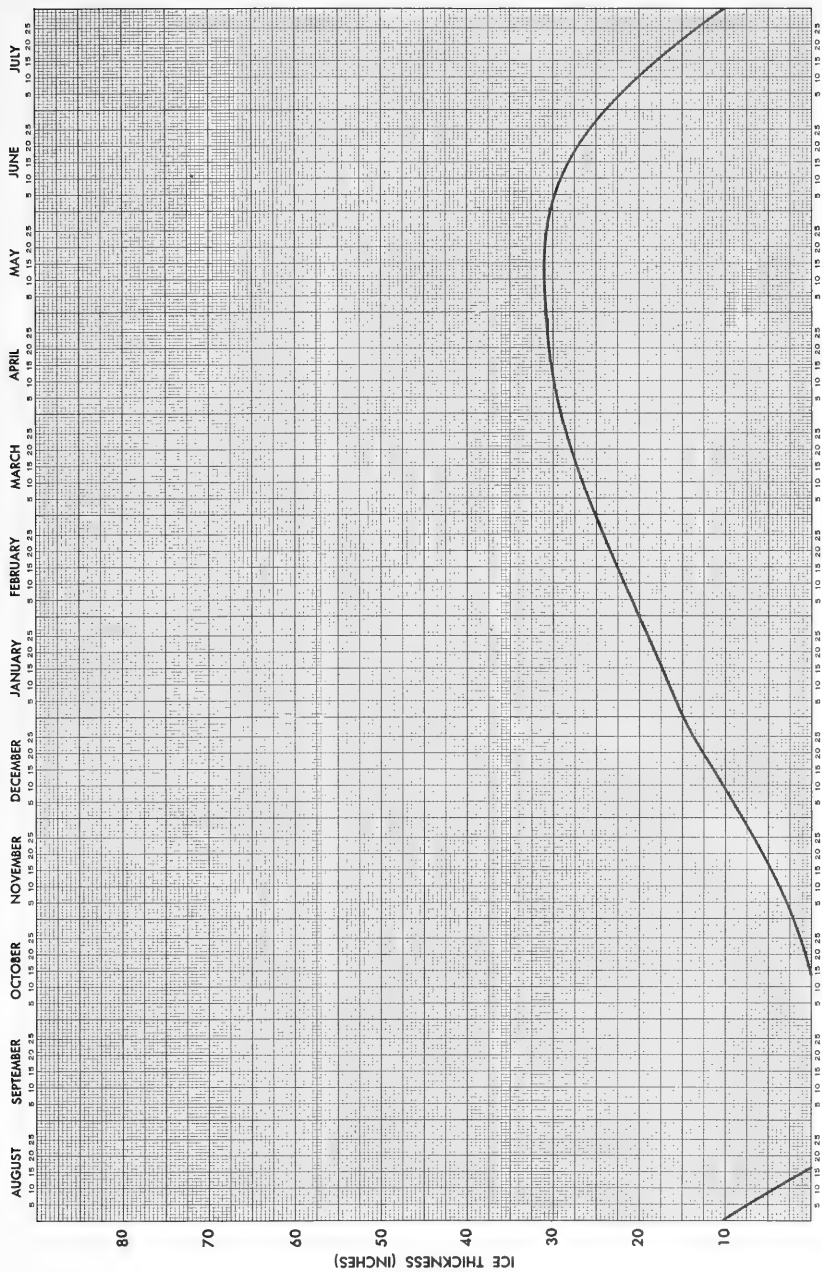


FIGURE 40B ANGMAGSSALIK THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

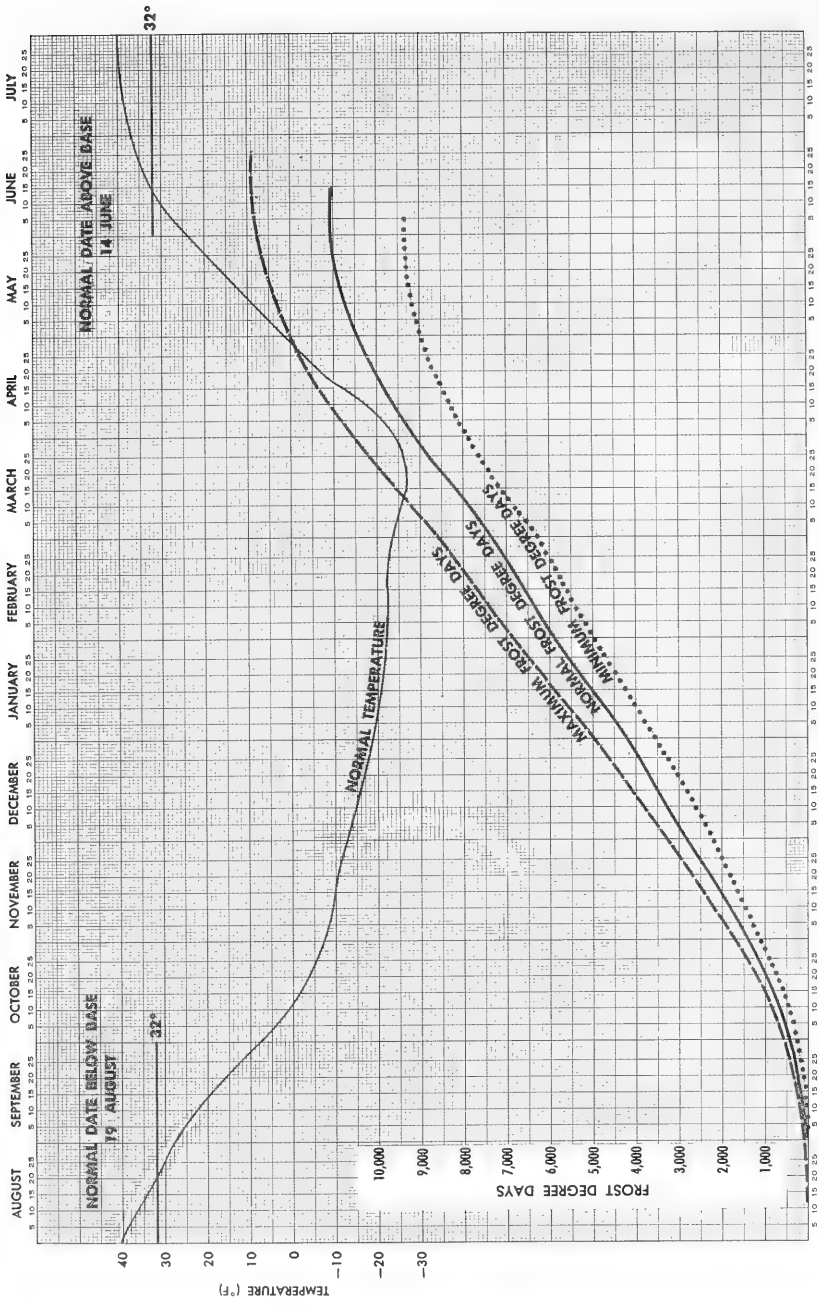


FIGURE 41A NORD (4 YEARS RECORD)

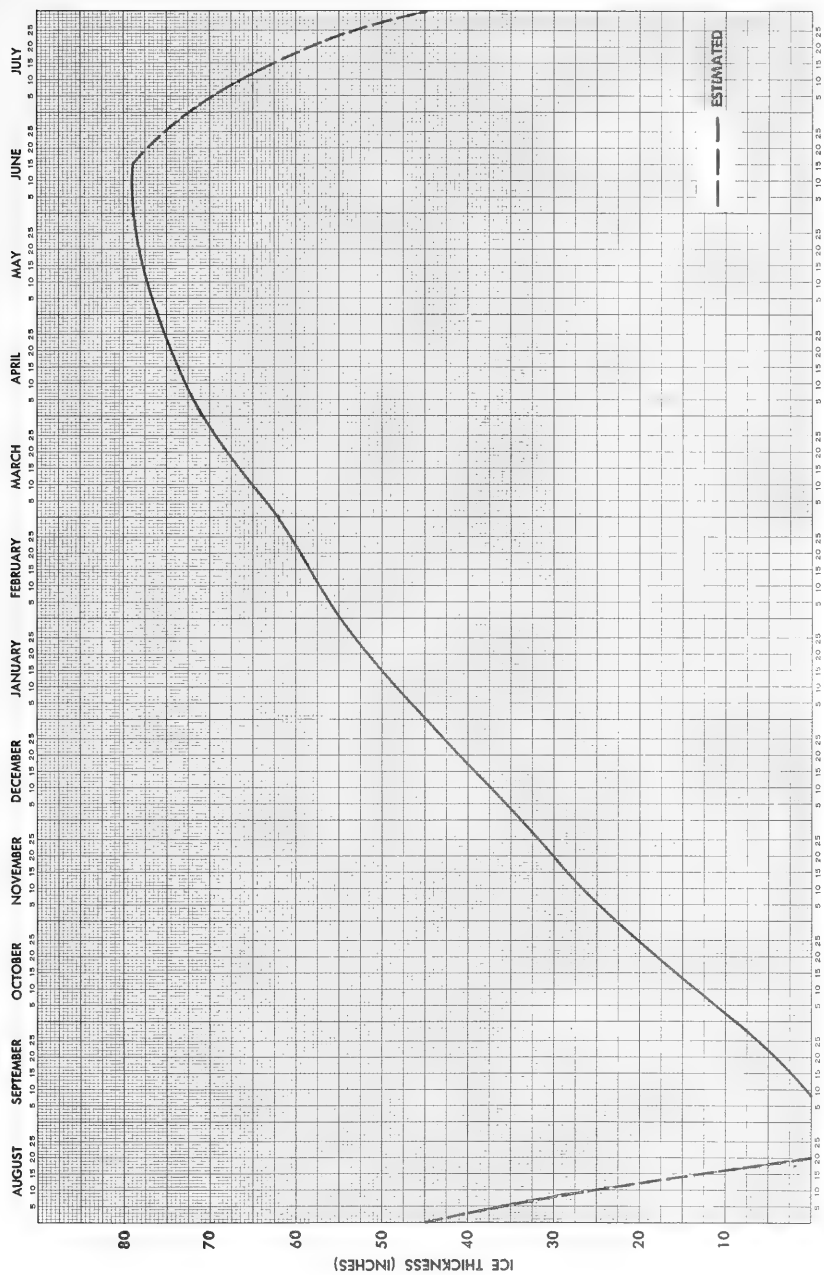


FIGURE 41B NORD THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

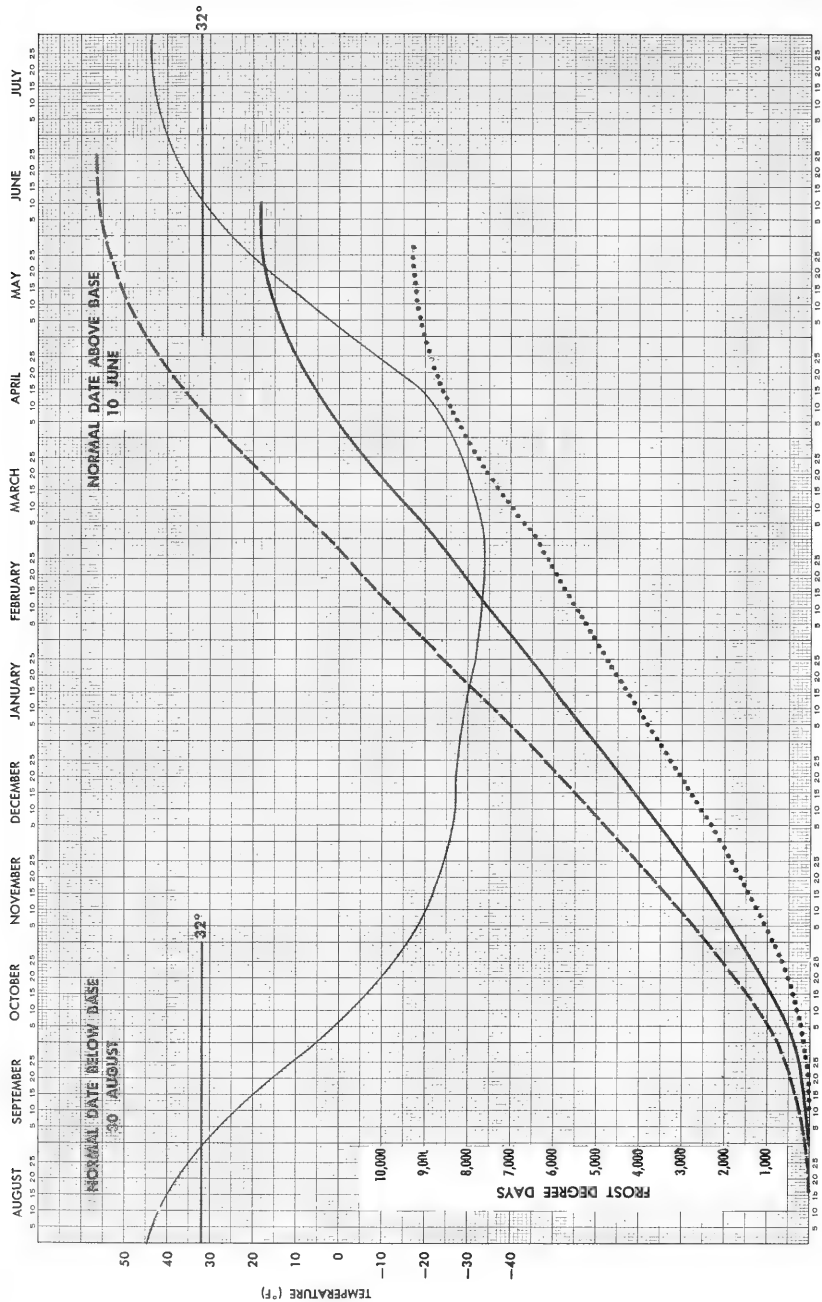


FIGURE 42A EUREKA (13 YEARS RECORD)

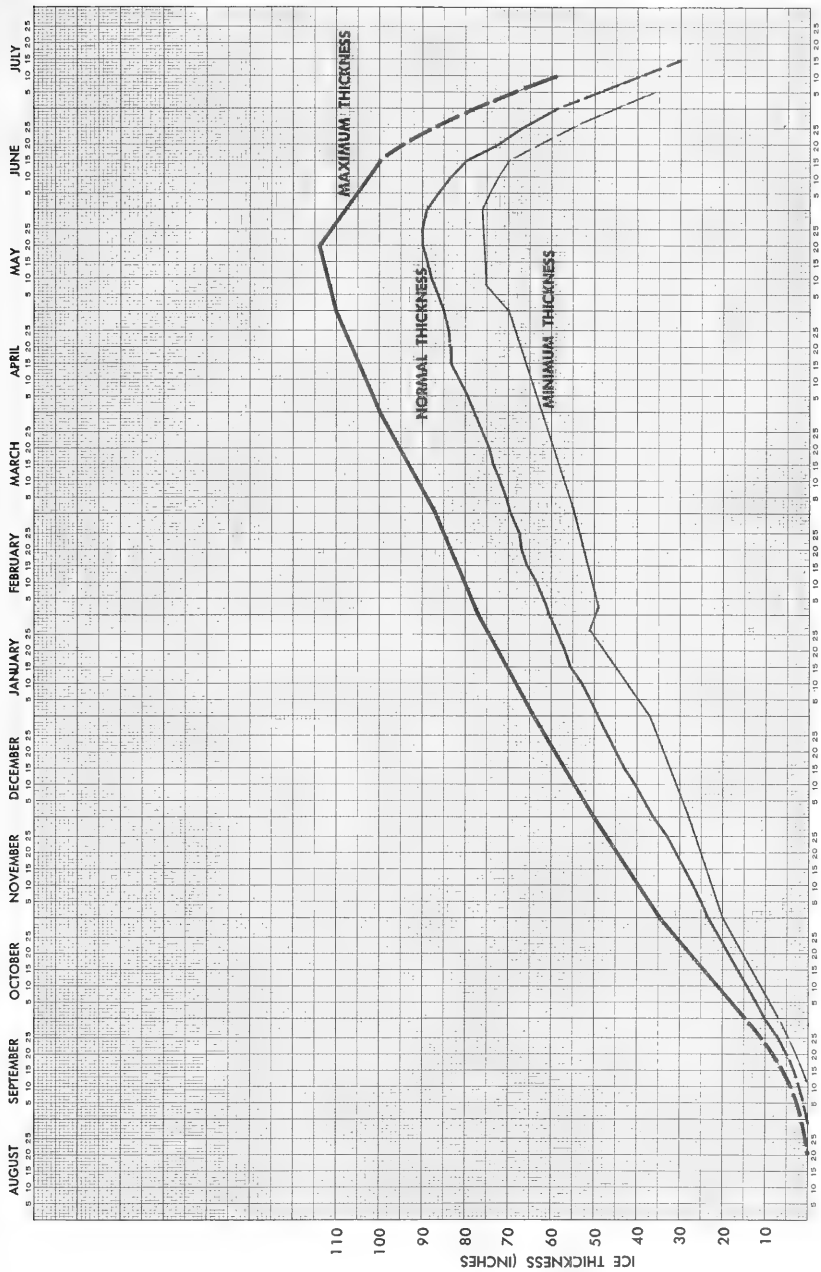


FIGURE 42B EUREKA EMPIRICAL ICE GROWTH AND DISINTEGRATION CURVE (7 YEARS RECORD)

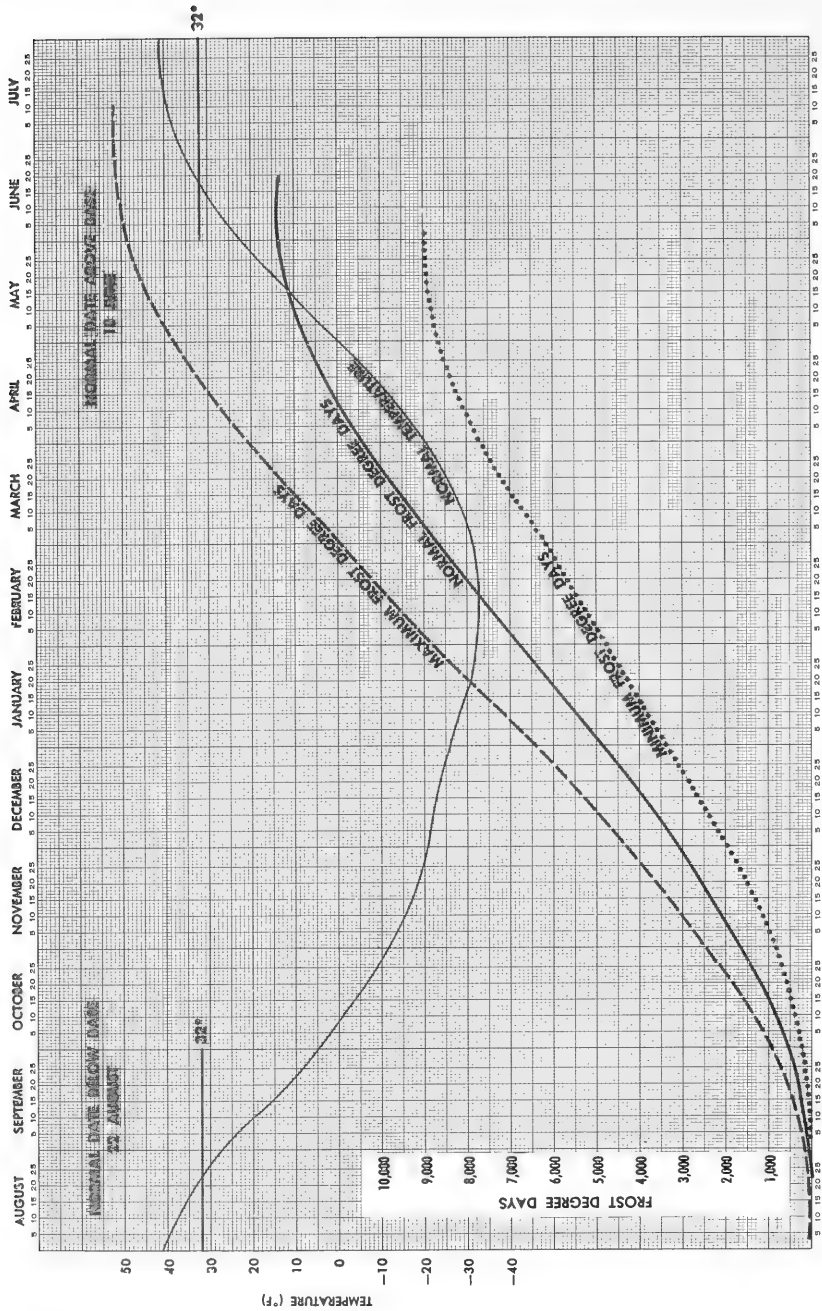


FIGURE 43A ISACHSEN (12 YEARS RECORD)

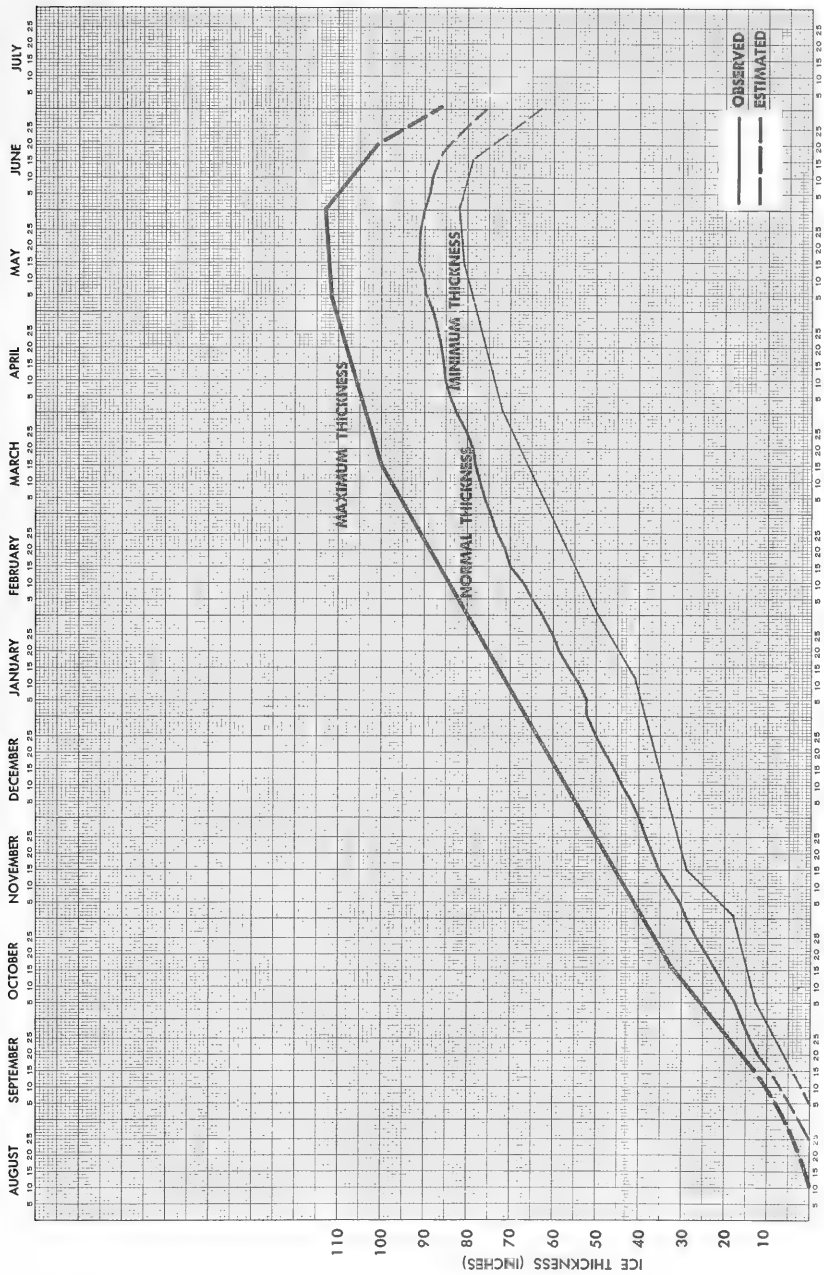


FIGURE 438 ISACHSEN EMPIRICAL ICE GROWTH AND DISINTEGRATION CURVE (14 YEARS RECORD)

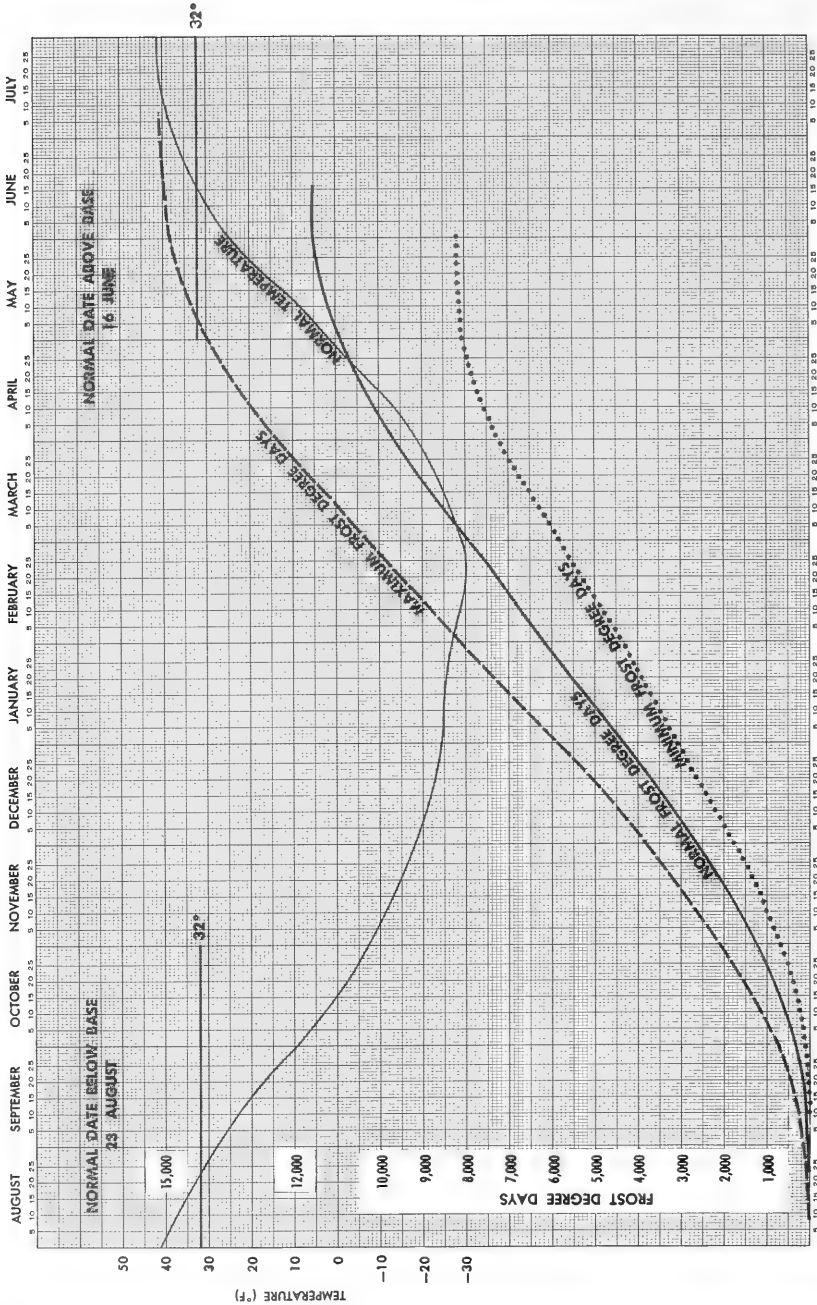


FIGURE 44A MOULD BAY (12 YEARS RECORD)

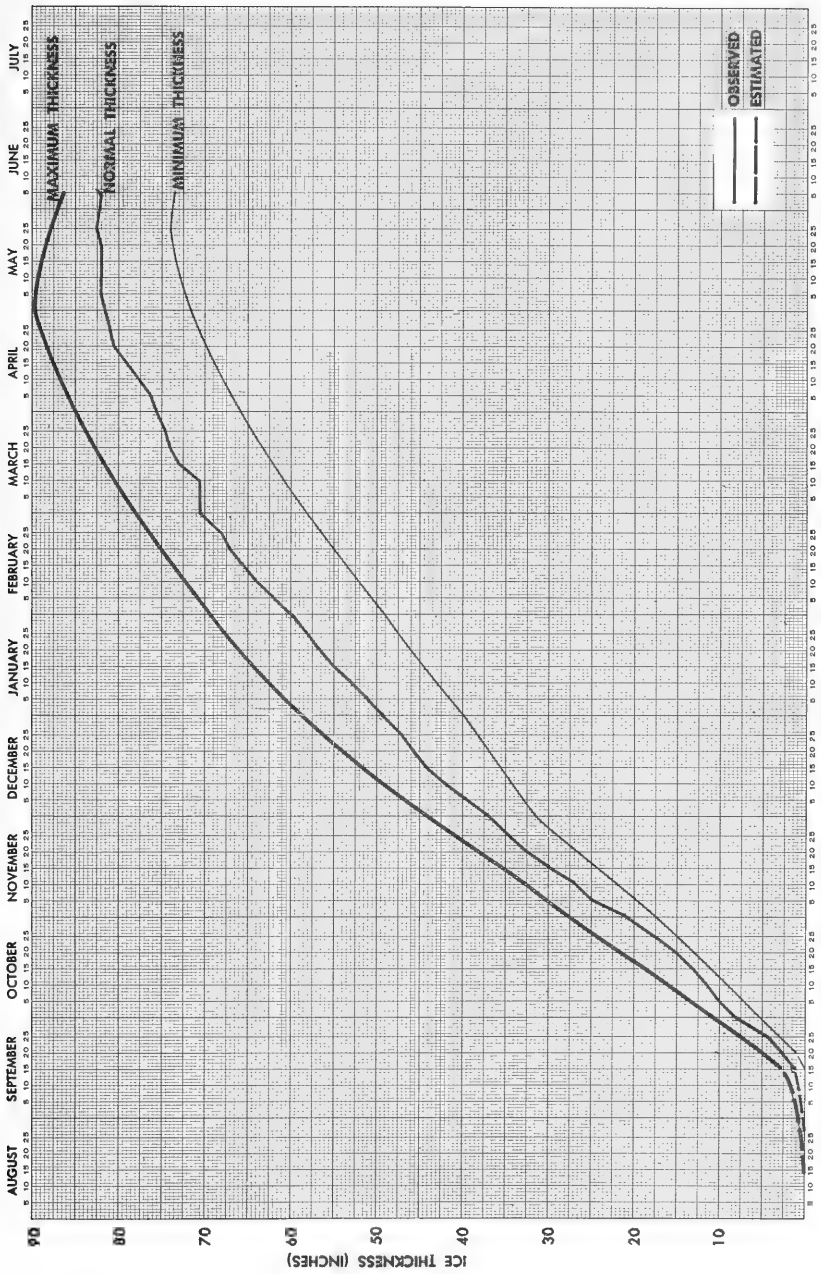


FIGURE 448 MOULD BAY EMPIRICAL ICE GROWTH AND DISINTEGRATION CURVE (10 YEARS RECORD)

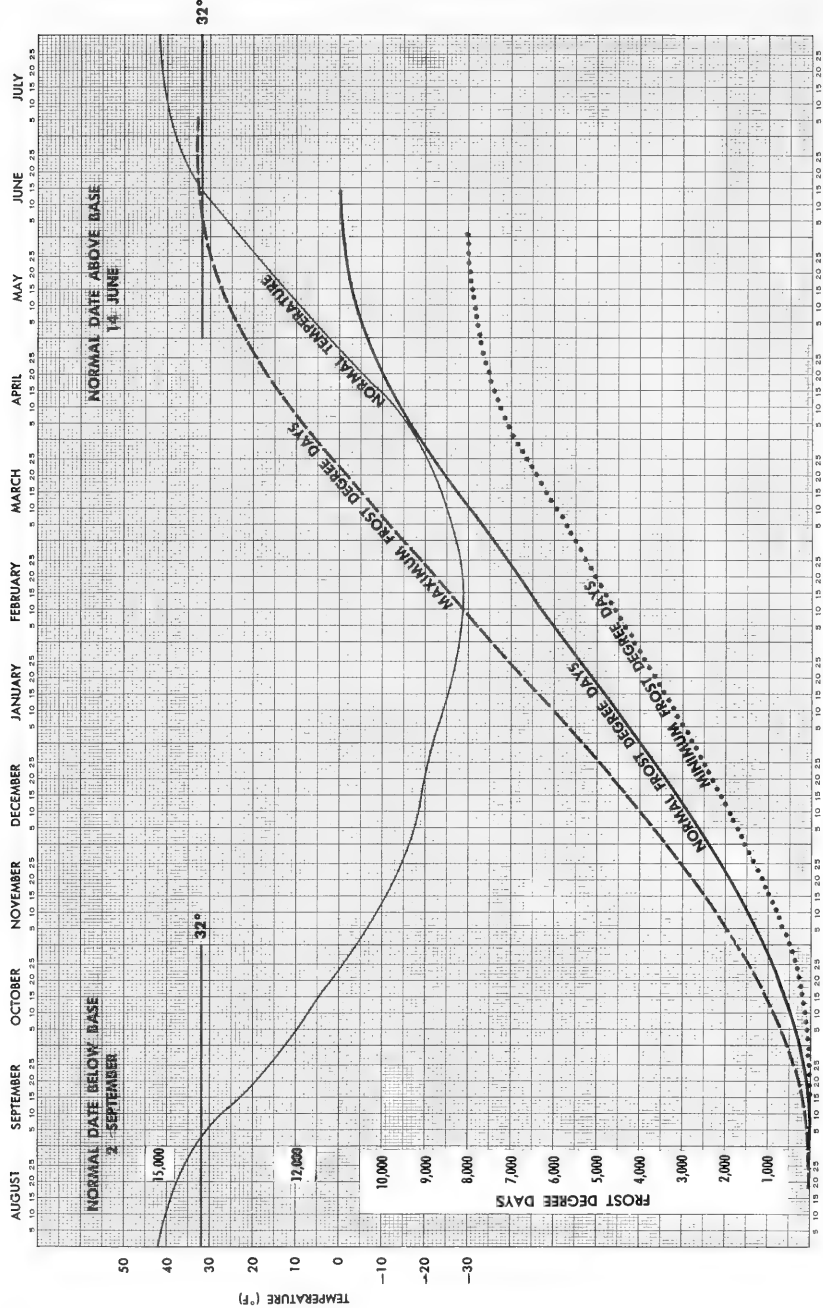


FIGURE 45A RESOLUTE BAY (13 YEARS RECORD)

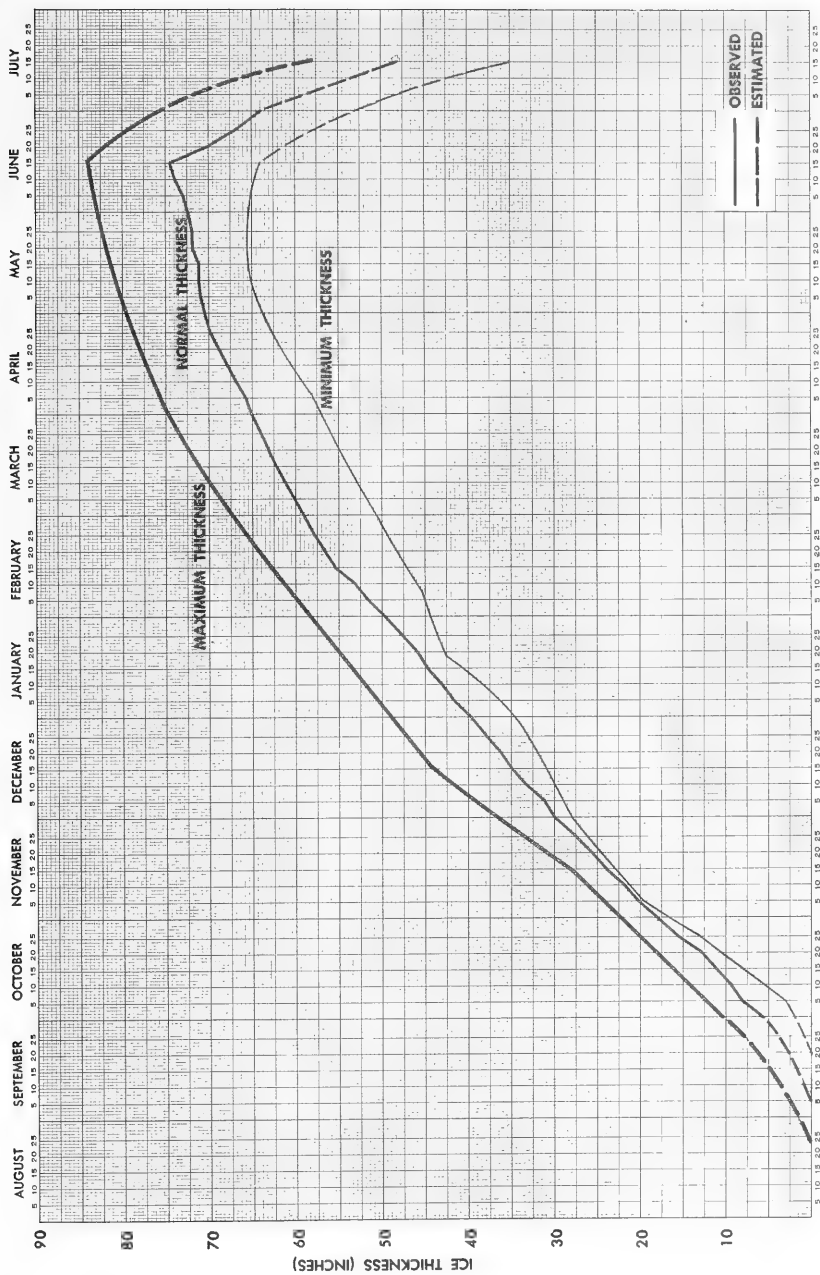


FIGURE 45B RESOLUTE BAY EMPIRICAL ICE GROWTH AND DISINTEGRATION CURVE (1.5 YEARS RECORD)

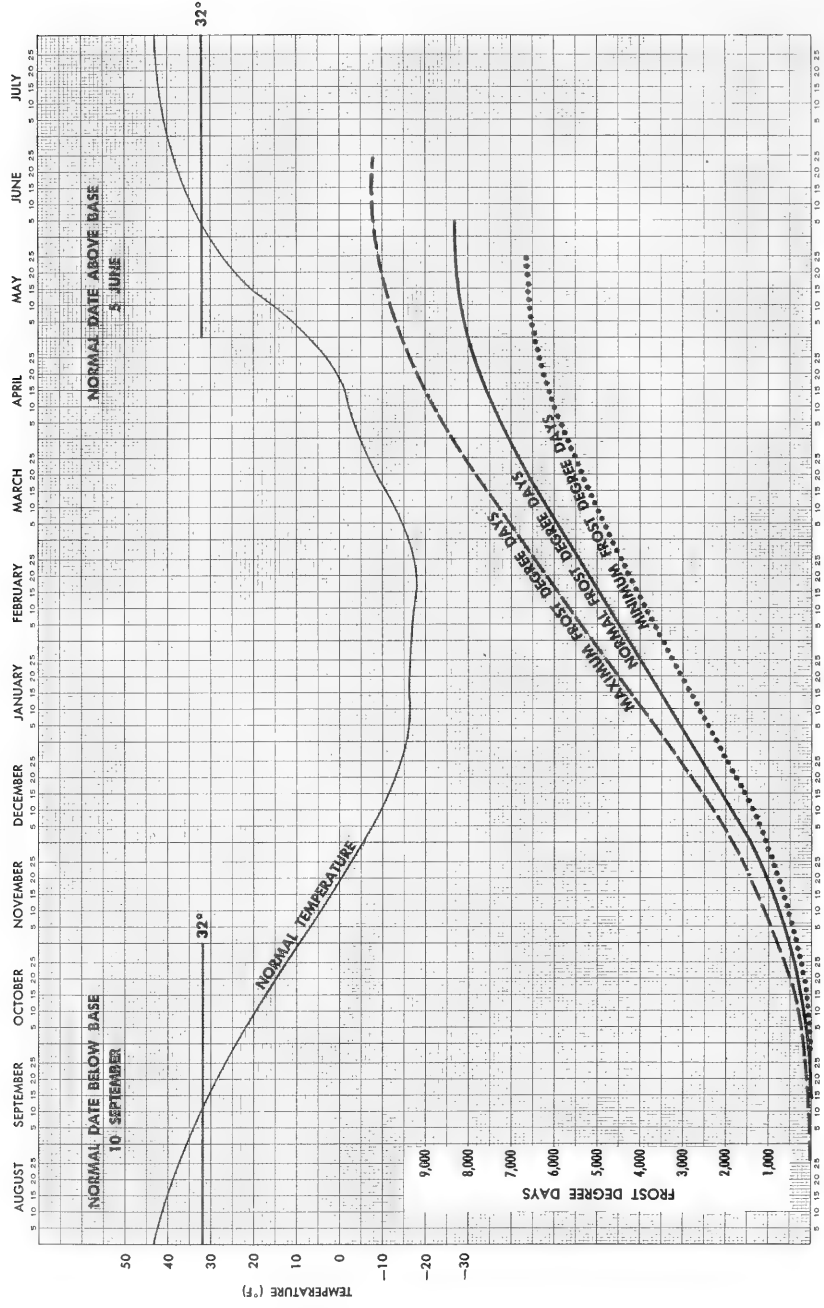


FIGURE 46A DUNDAS HARBOR (7 YEARS RECORD)

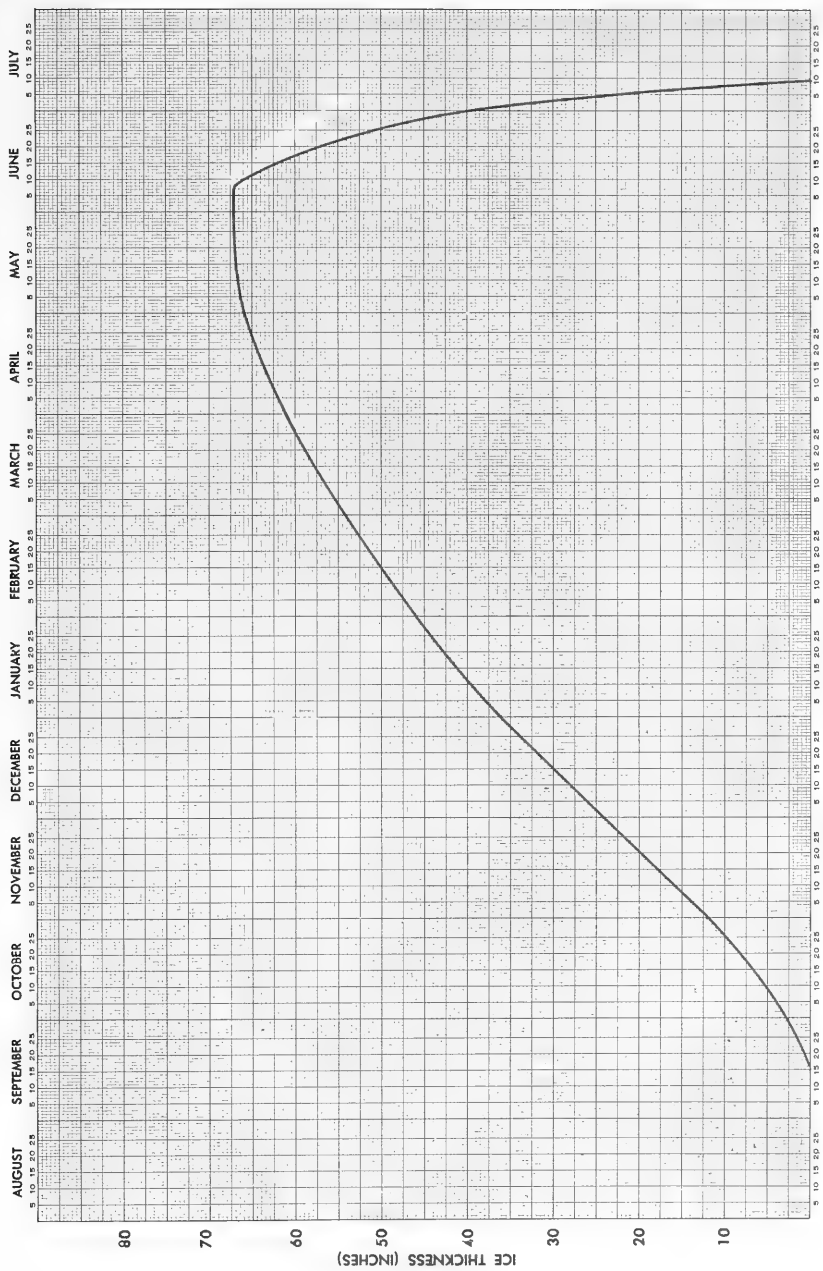


FIGURE 468 DUNDAS HARBOR THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

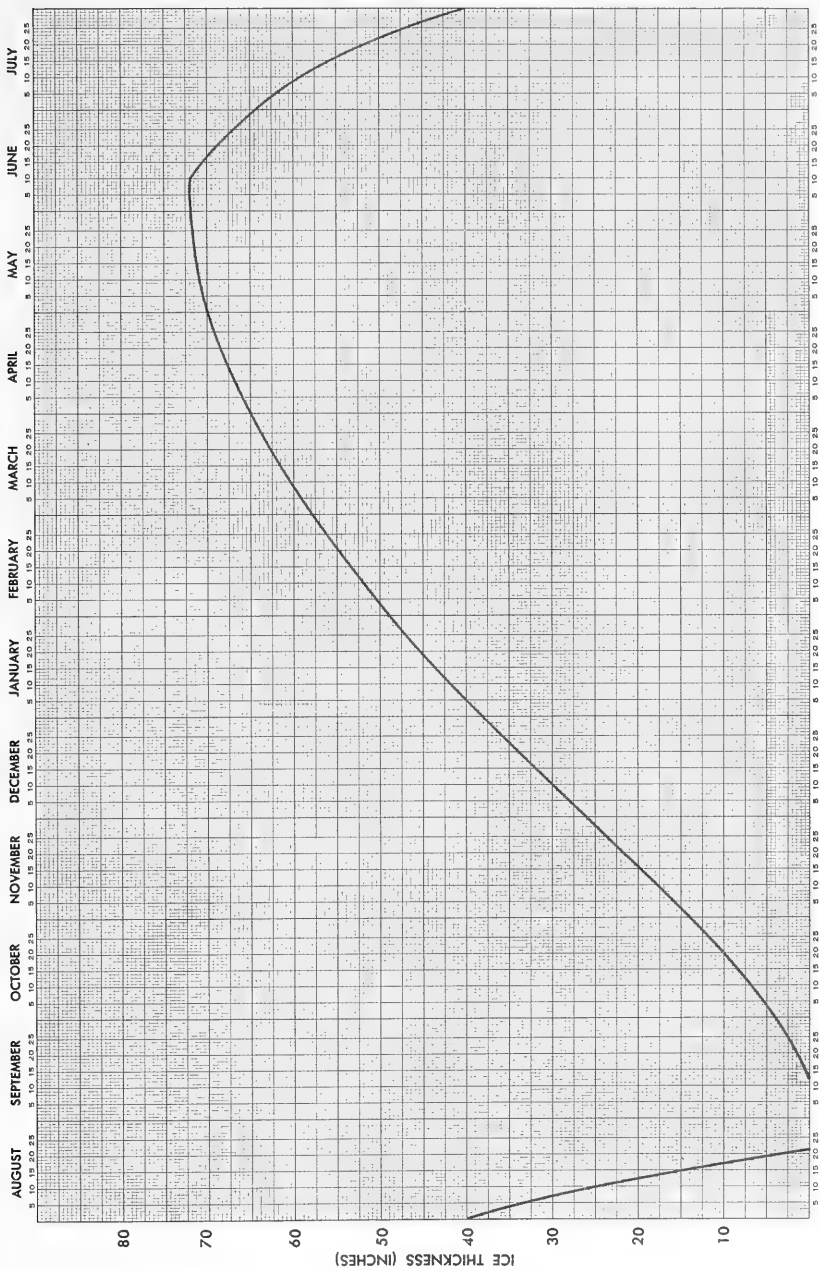


FIGURE 47B ARCTIC BAY THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

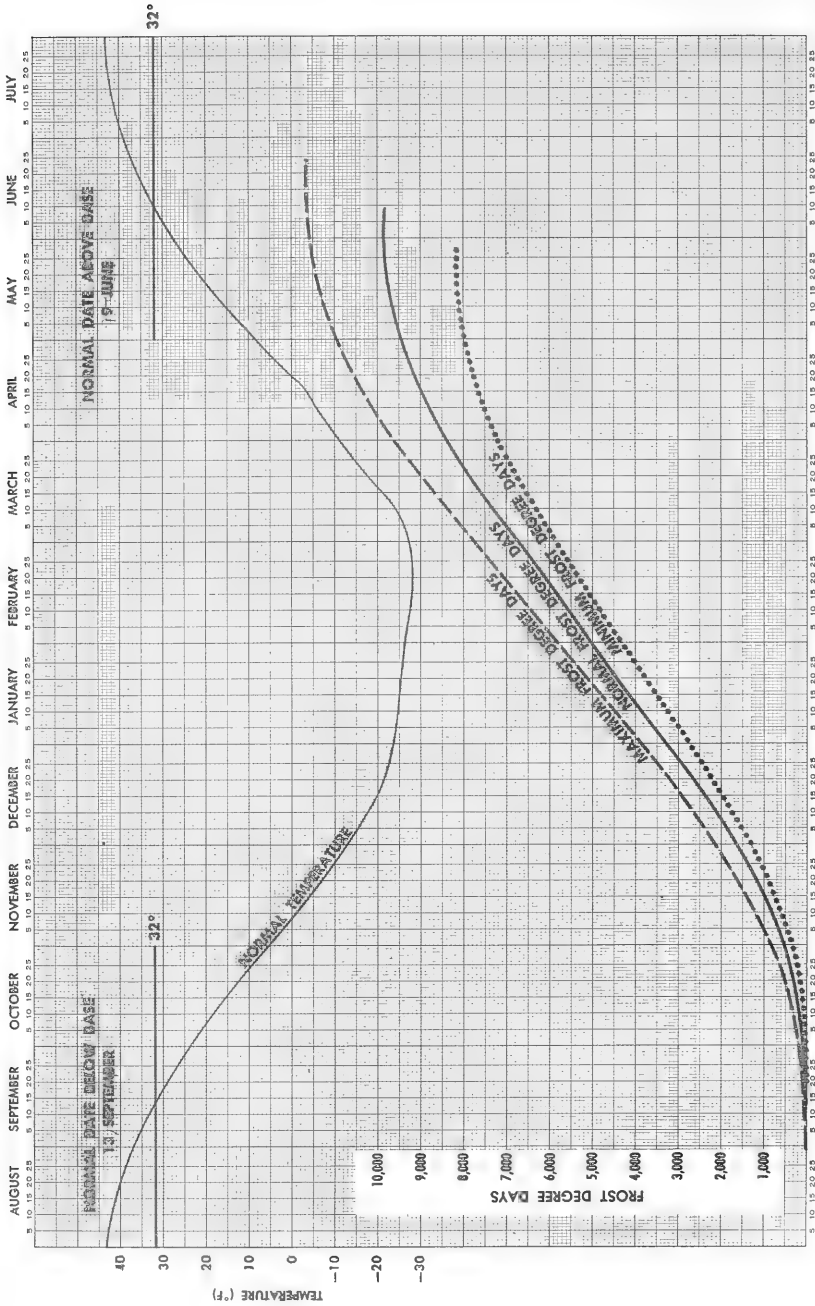


FIGURE 48A POND INLET (24 YEARS RECORD)

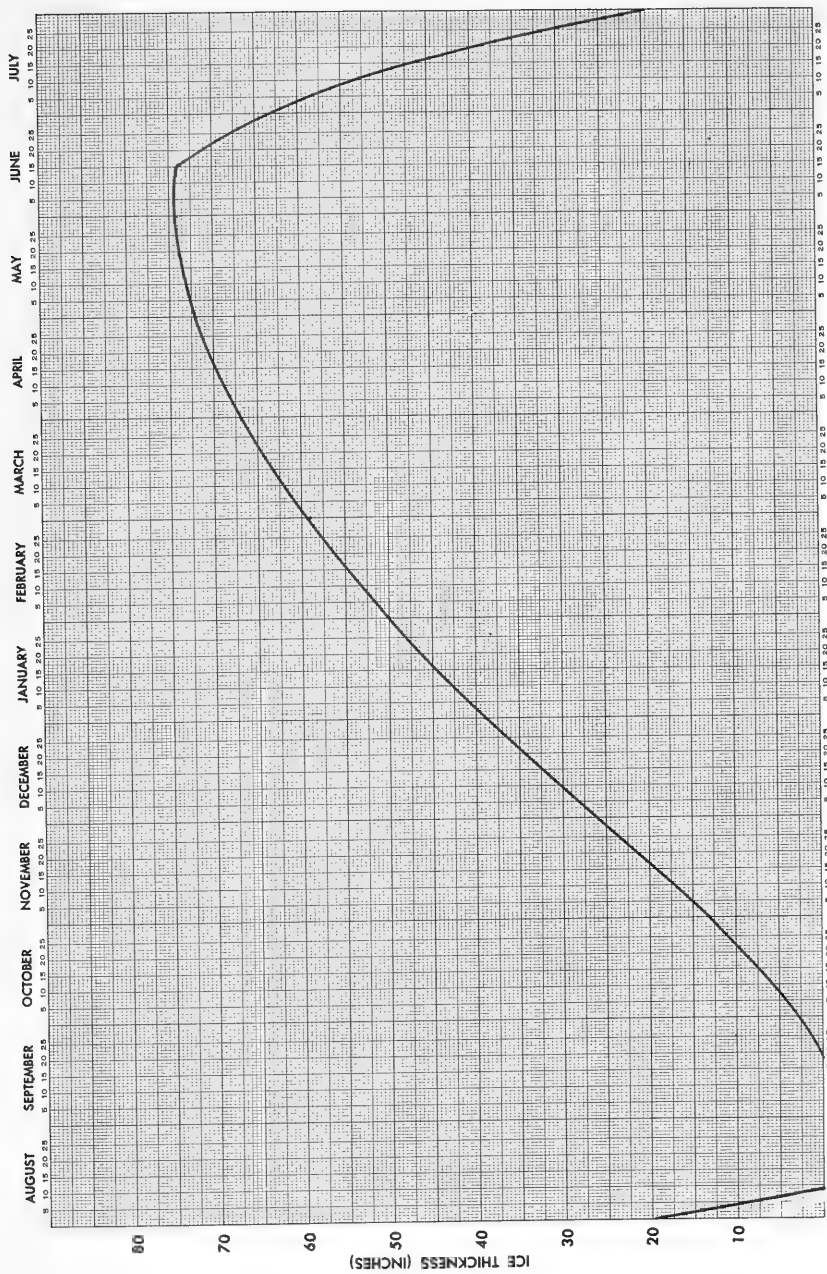


FIGURE 488 POND INLET THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE



FIGURE 49A HERSCHEL ISLAND (7 YEARS RECORD)

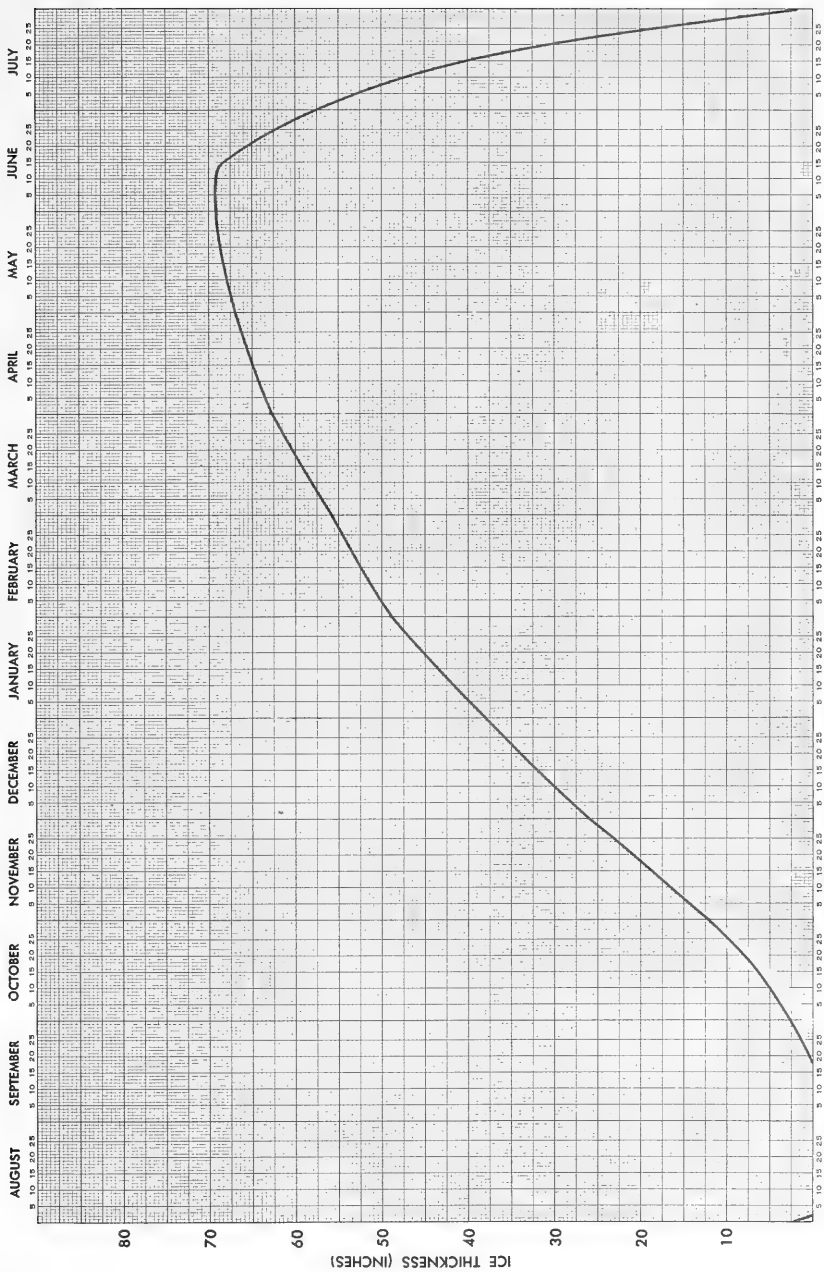


FIGURE 49B HERSCHEL ISLAND THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

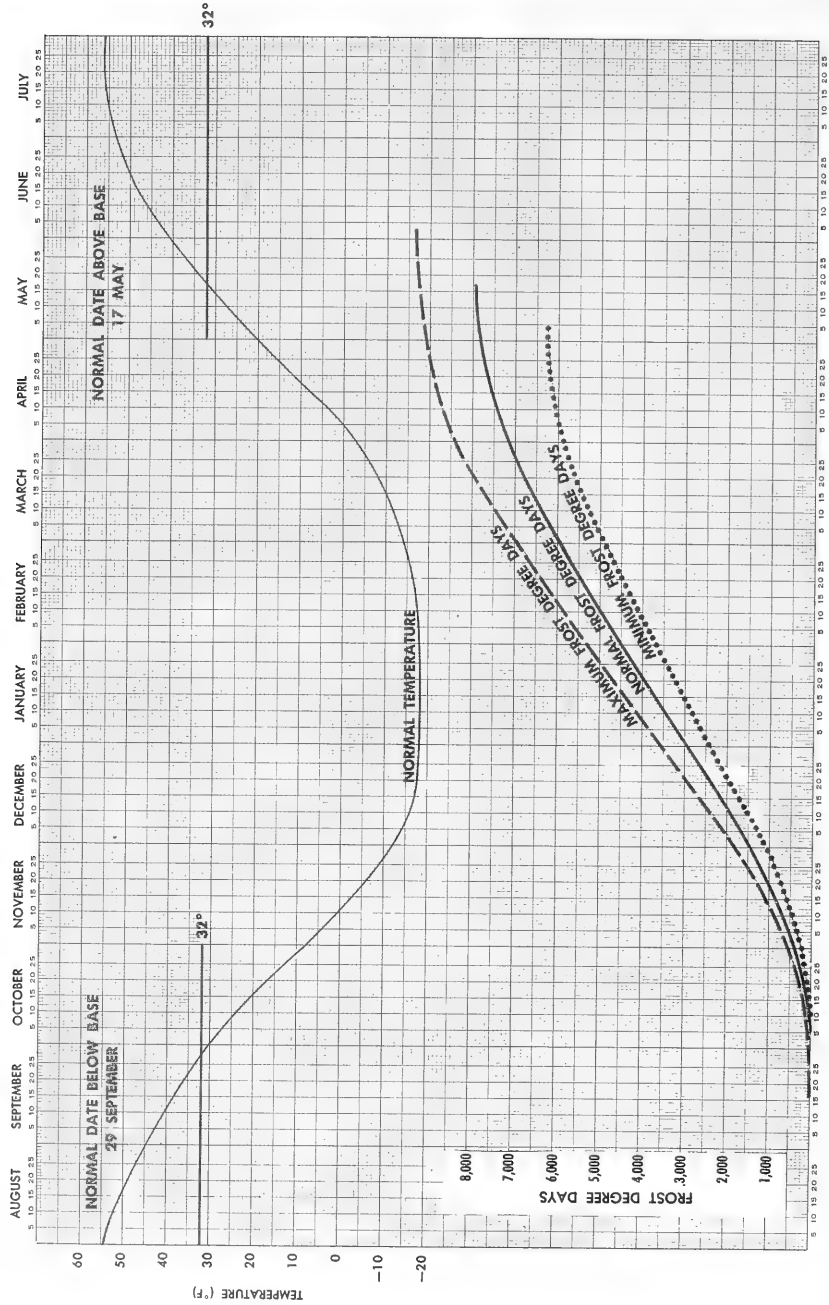


FIGURE 50A AKLAVIK (25 YEARS RECORD)

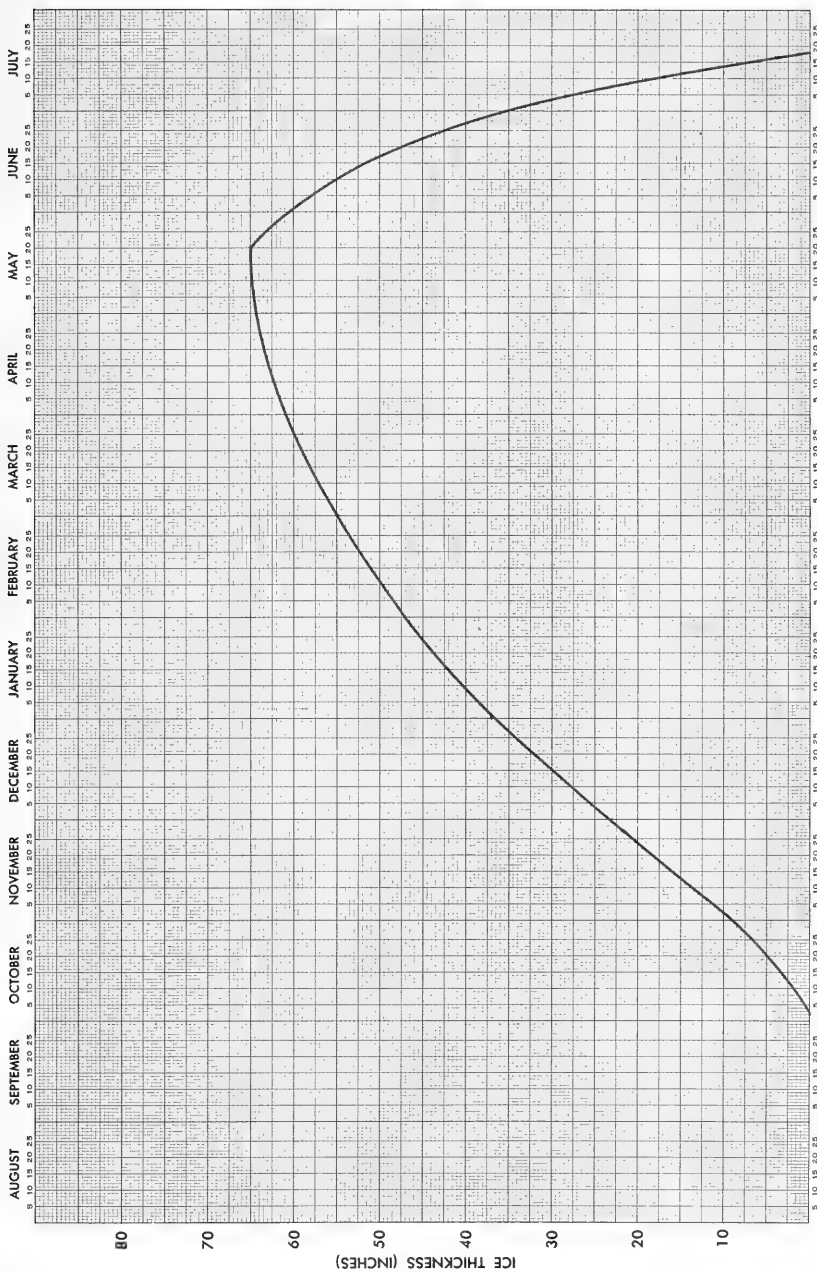


FIGURE 508 AKLAVIK THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

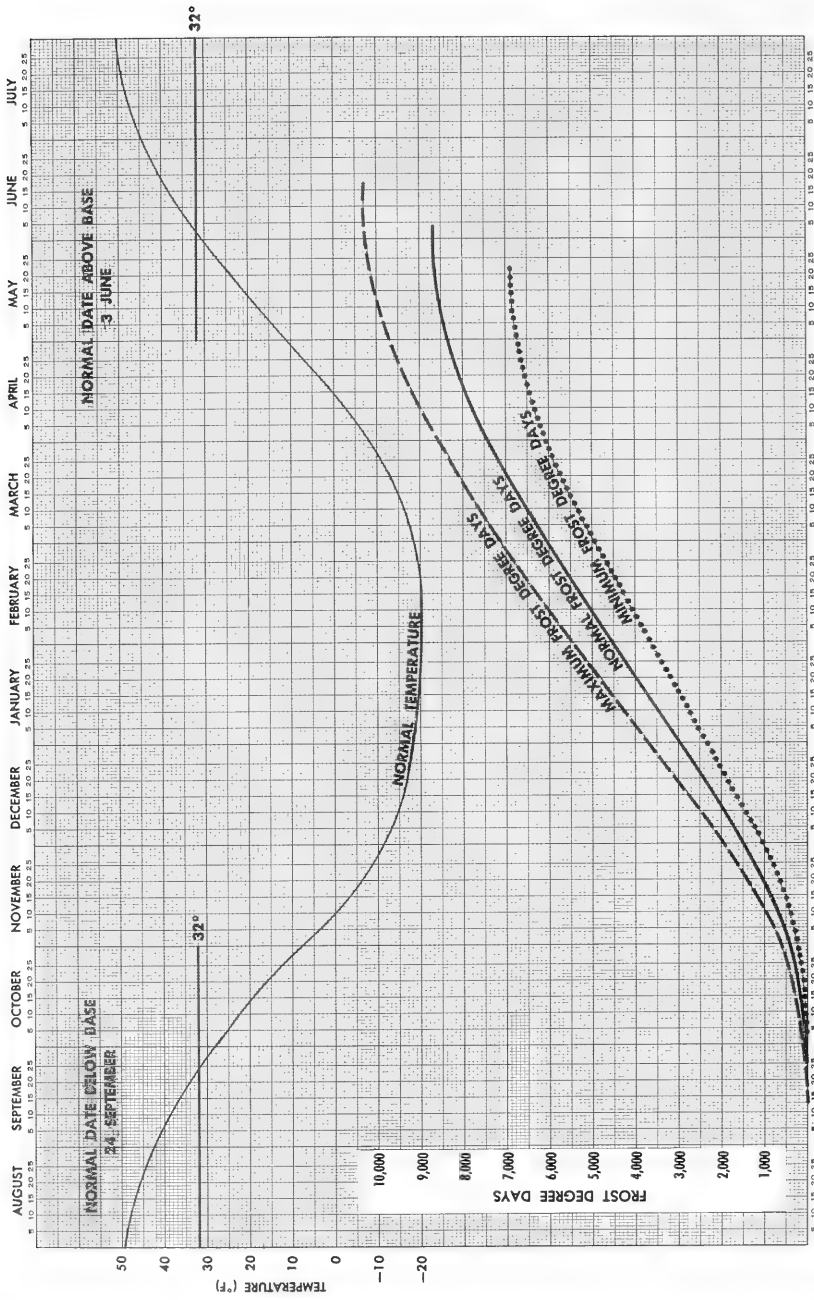


FIGURE 51A COPPERMINE (30 YEARS RECORD)

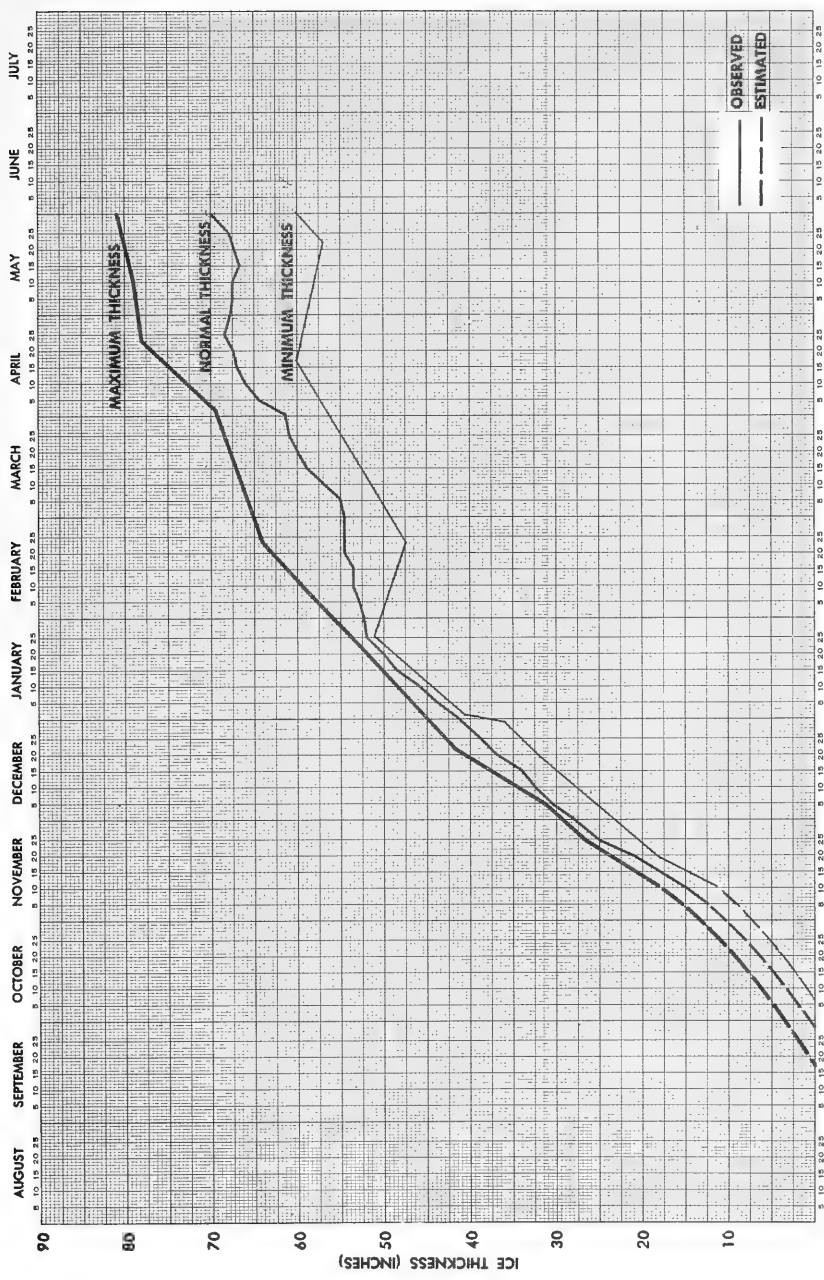


FIGURE 51B COPPERMINE EMPIRICAL ICE GROWTH CURVE (4 YEARS RECORD)

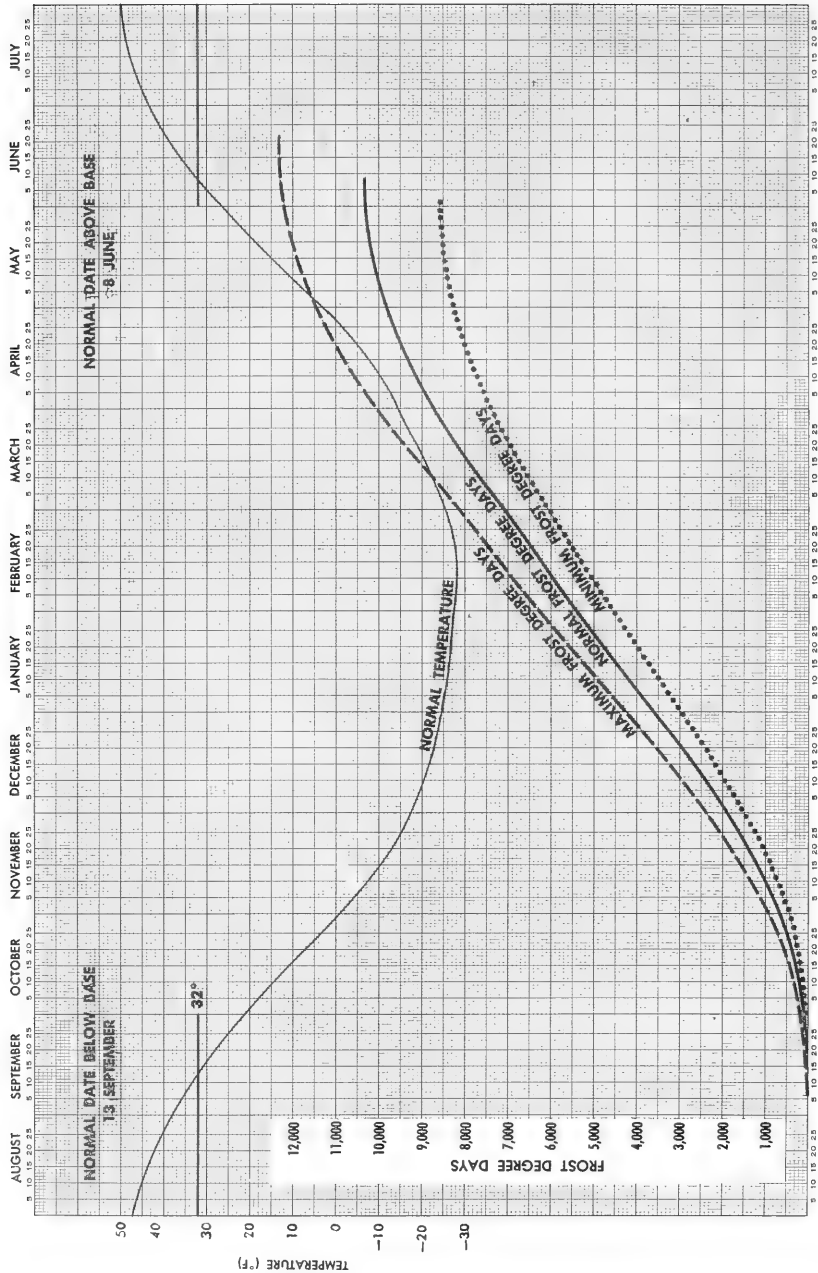


FIGURE 52A CAMBRIDGE BAY (14 YEARS RECORD)

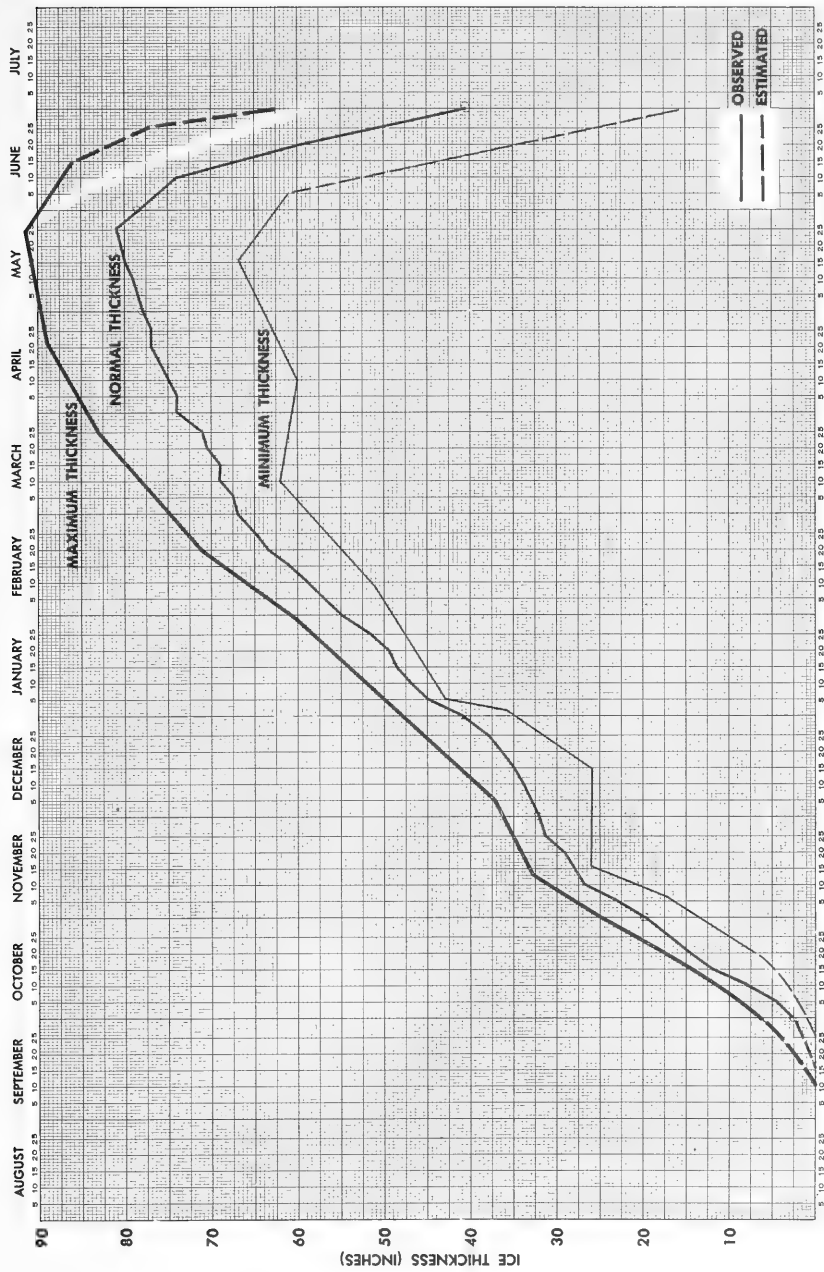


FIGURE 528 CAMBRIDGE BAY EMPIRICAL ICE GROWTH AND DISINTEGRATION CURVE (3 YEARS RECORD)

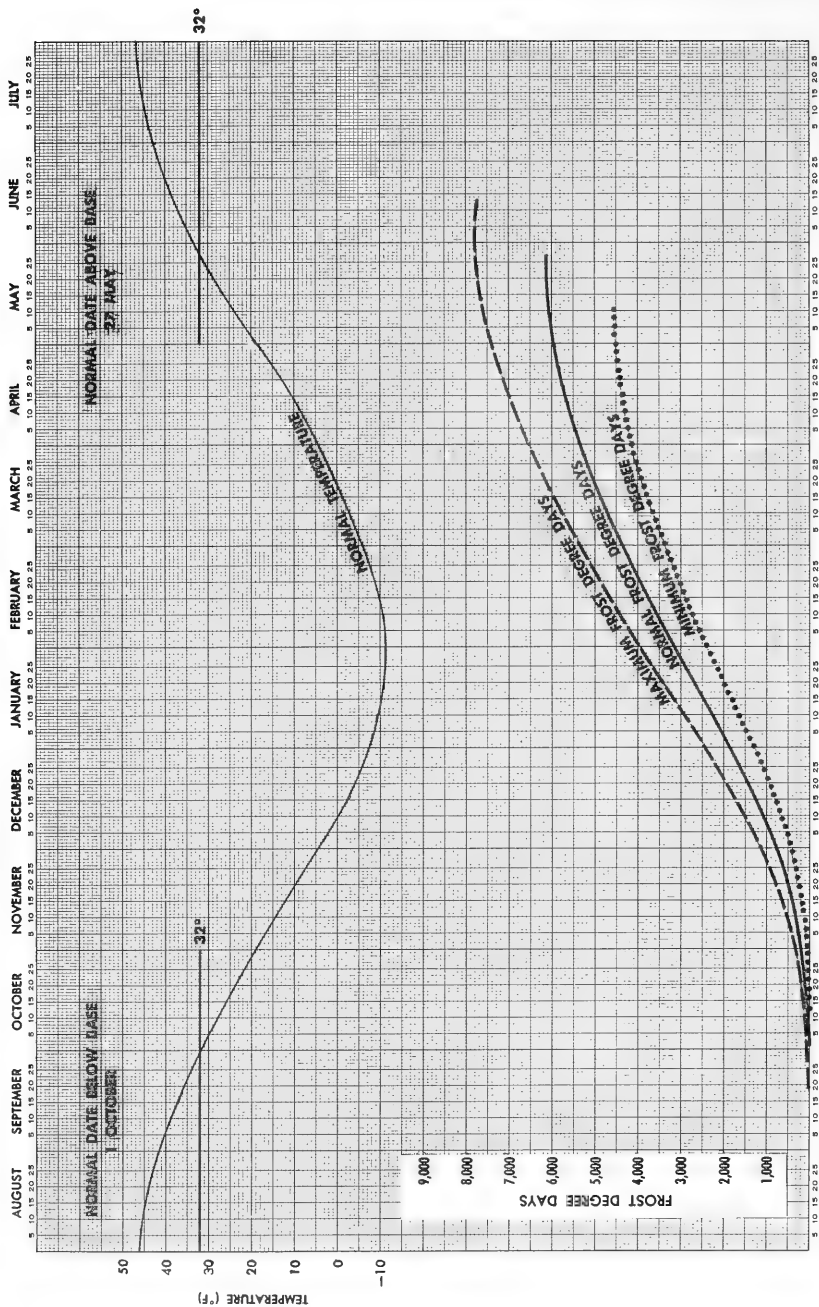


FIGURE 53A LAKE HARBOUR (19 YEARS RECORD)

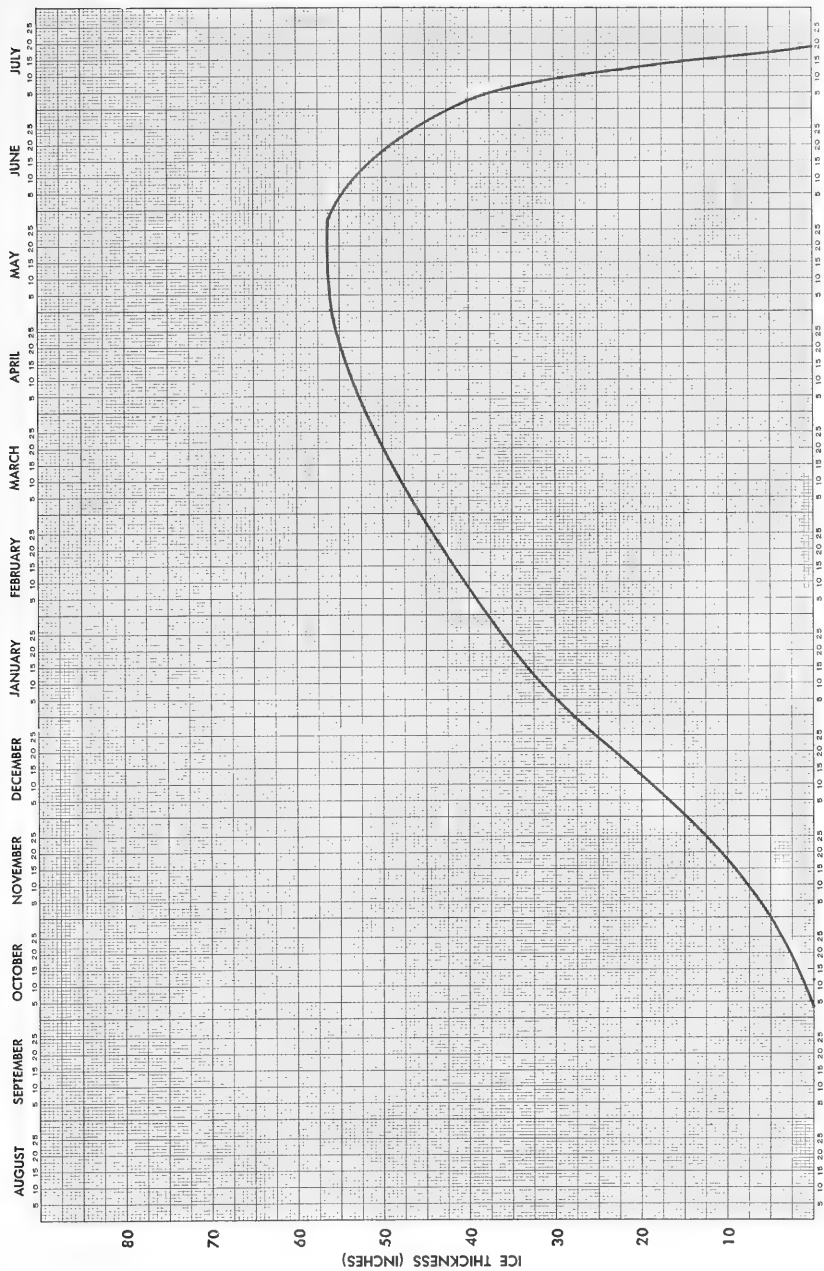


FIGURE 538 LAKE HARBOUR THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE



FIGURE 54A NOTTINGHAM ISLAND (22 YEARS RECORD)

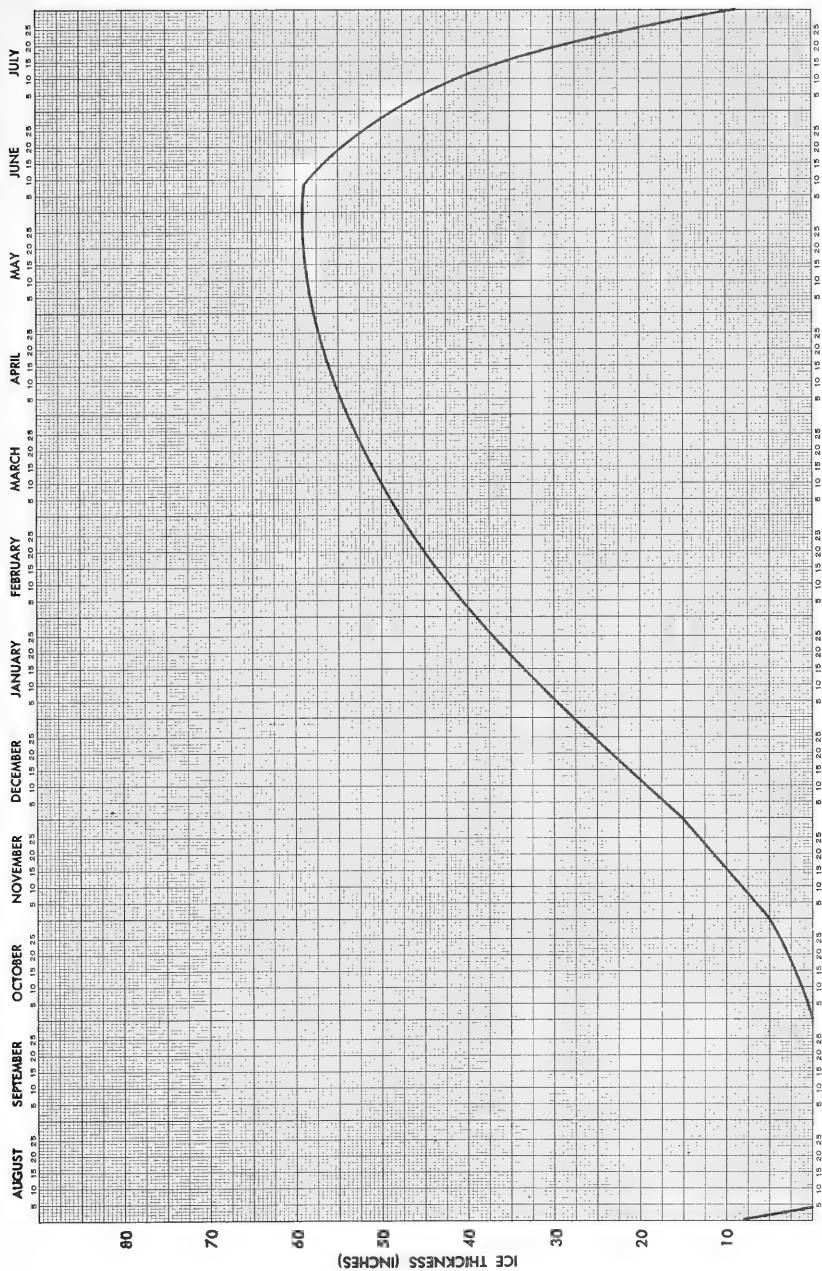


FIGURE 54B NOTTINGHAM ISLAND THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

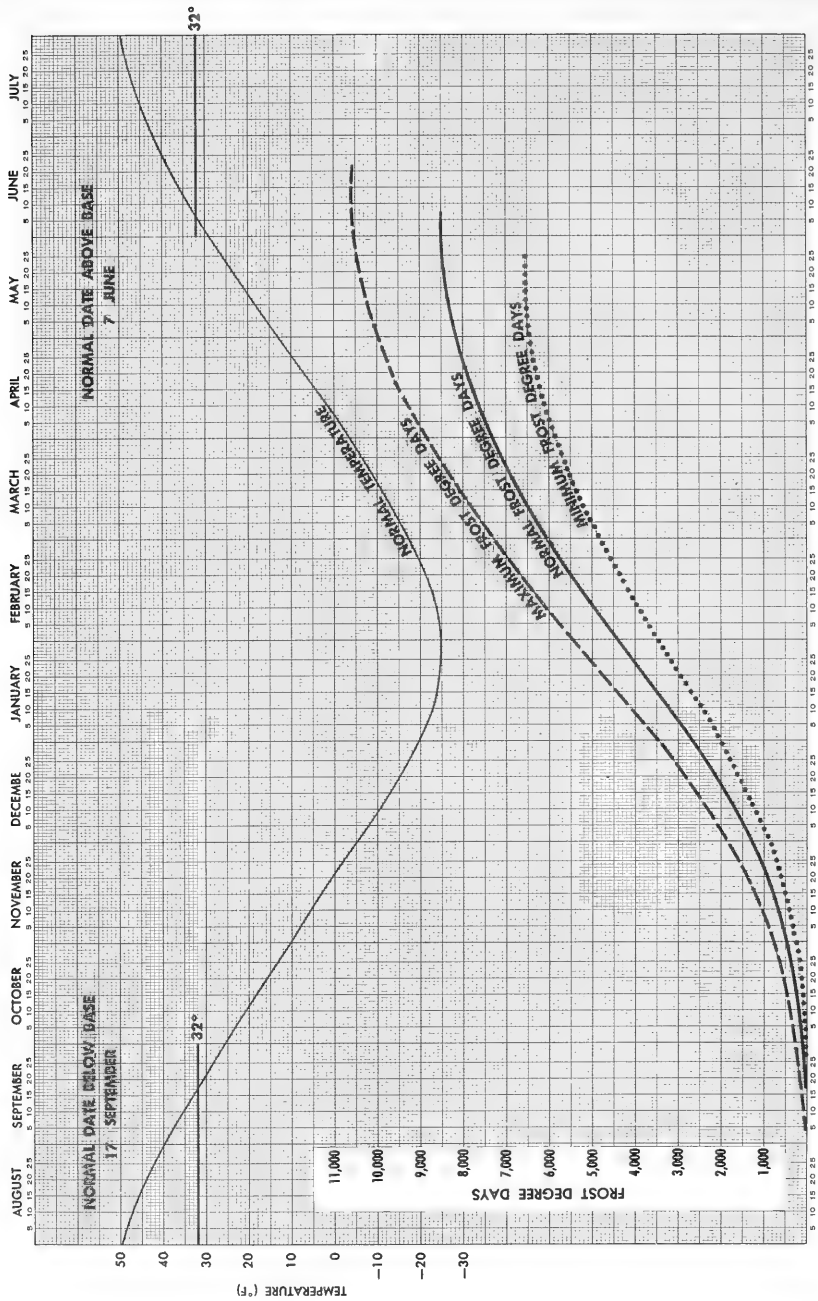


FIGURE 55A CORAL HARBOR (11 YEARS RECORD)

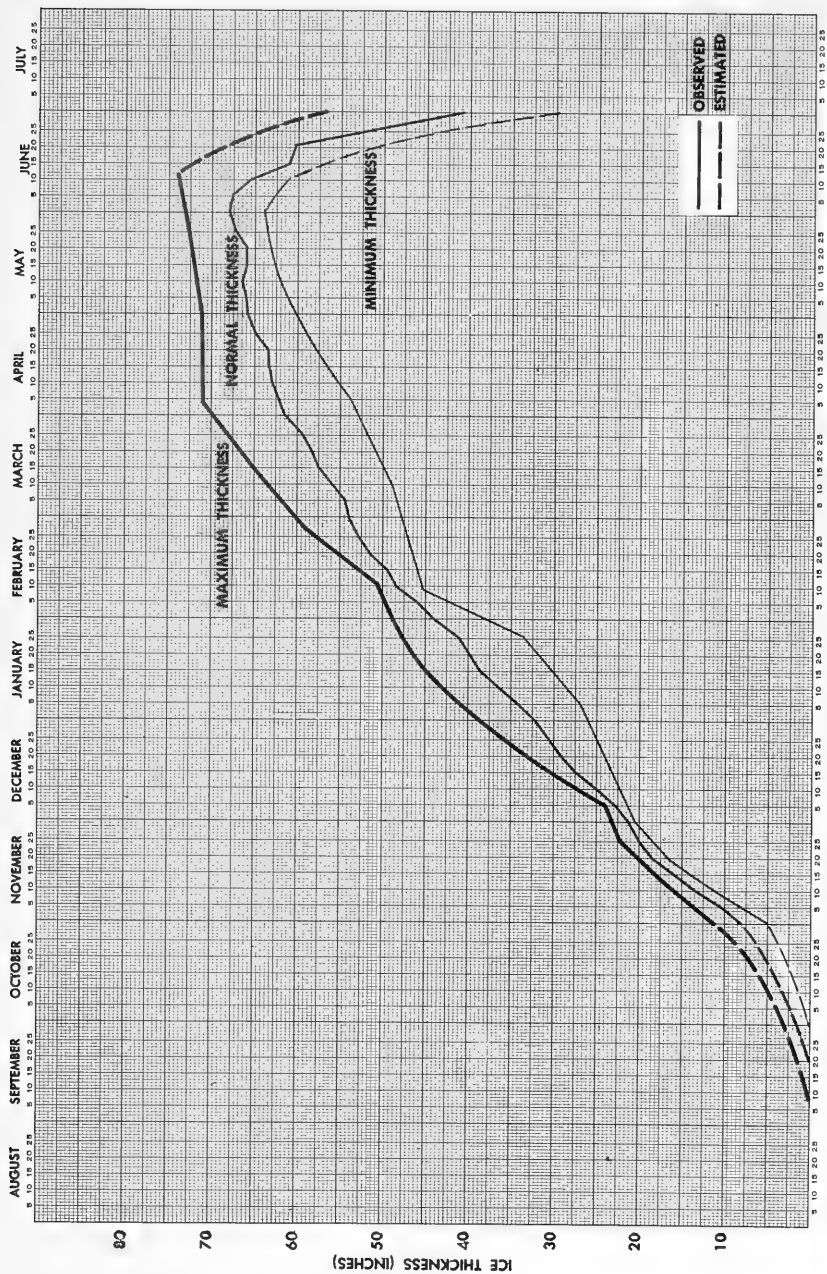


FIGURE 55B CORAL HARBOR EMPIRICAL ICE GROWTH AND DISINTEGRATION CURVE

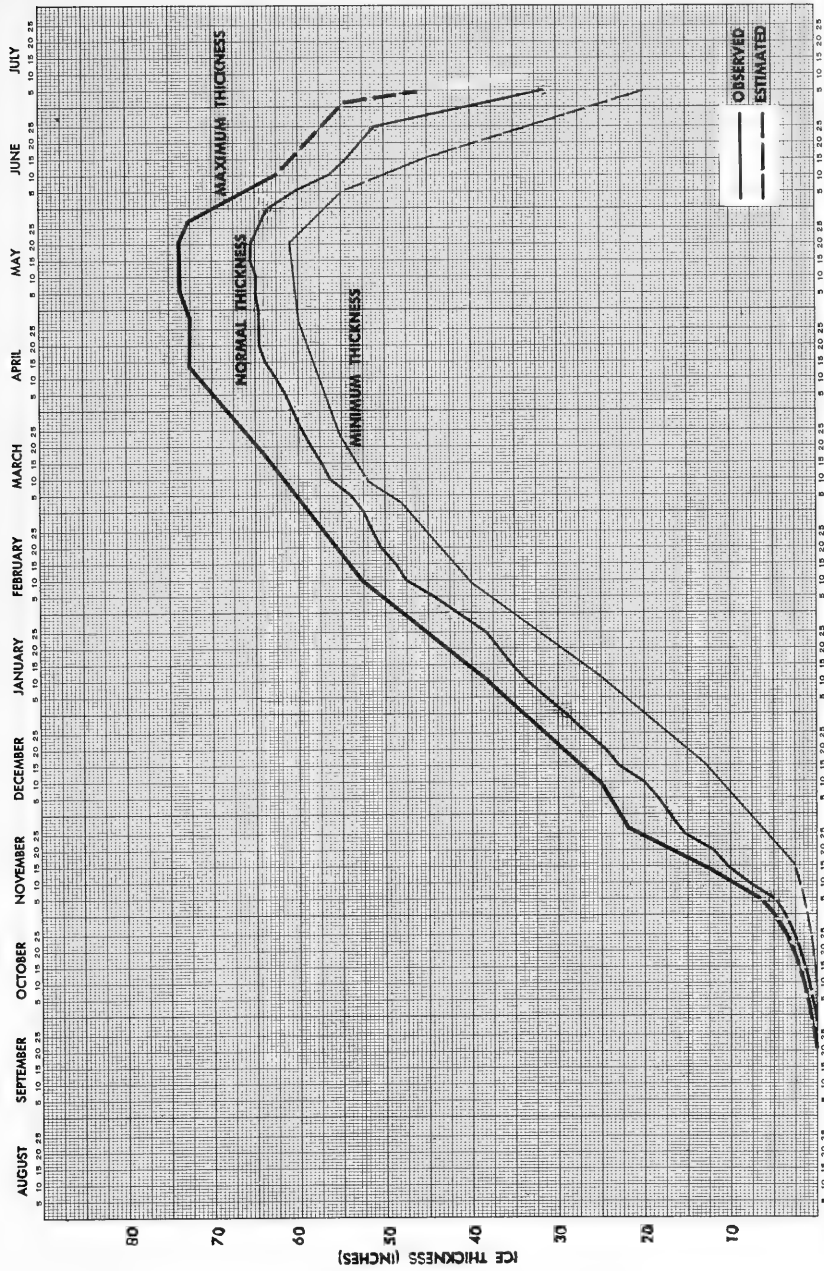


FIGURE 568 CHESTERFIELD EMPIRICAL ICE GROWTH AND DISINTEGRATION CURVE (3 YEARS RECORD)

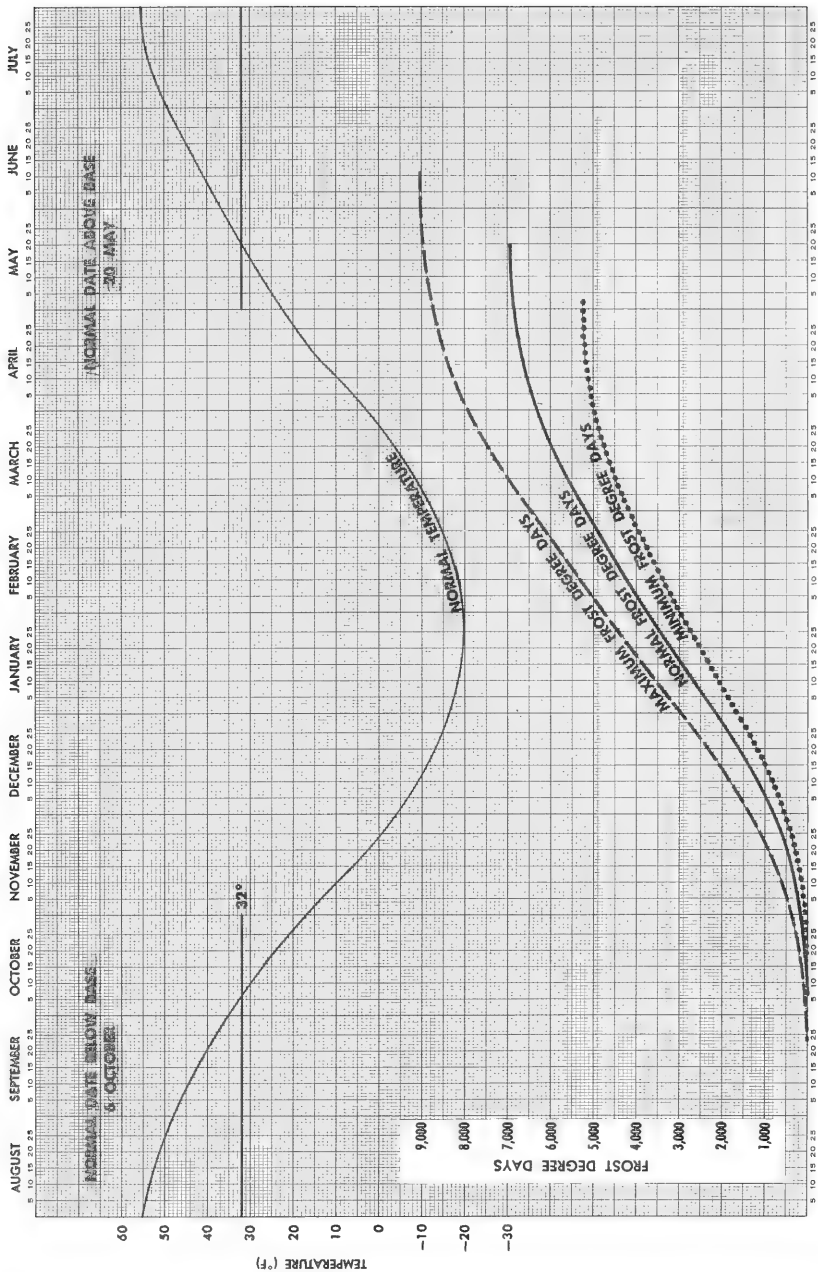


FIGURE 57A CHURCHILL (61 YEARS RECORD)

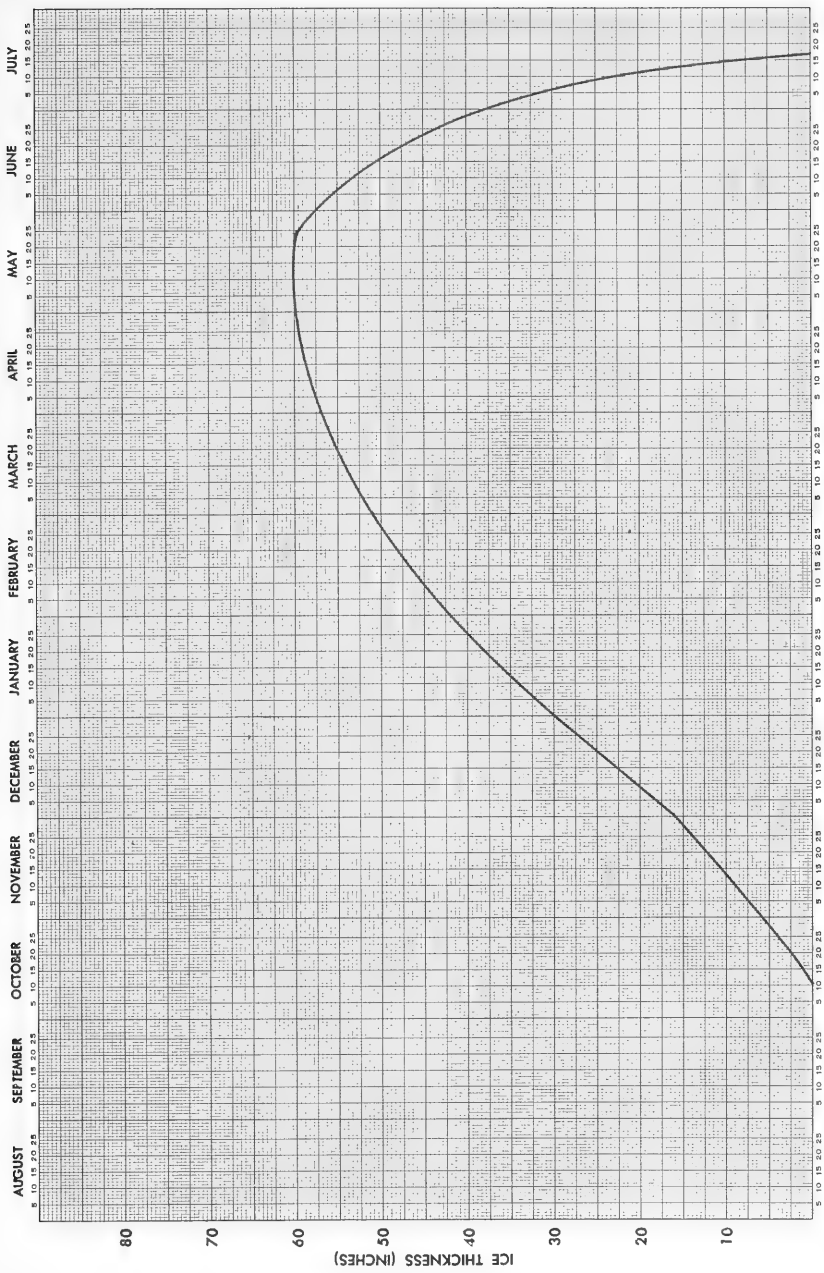


FIGURE 57B CHURCHILL THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

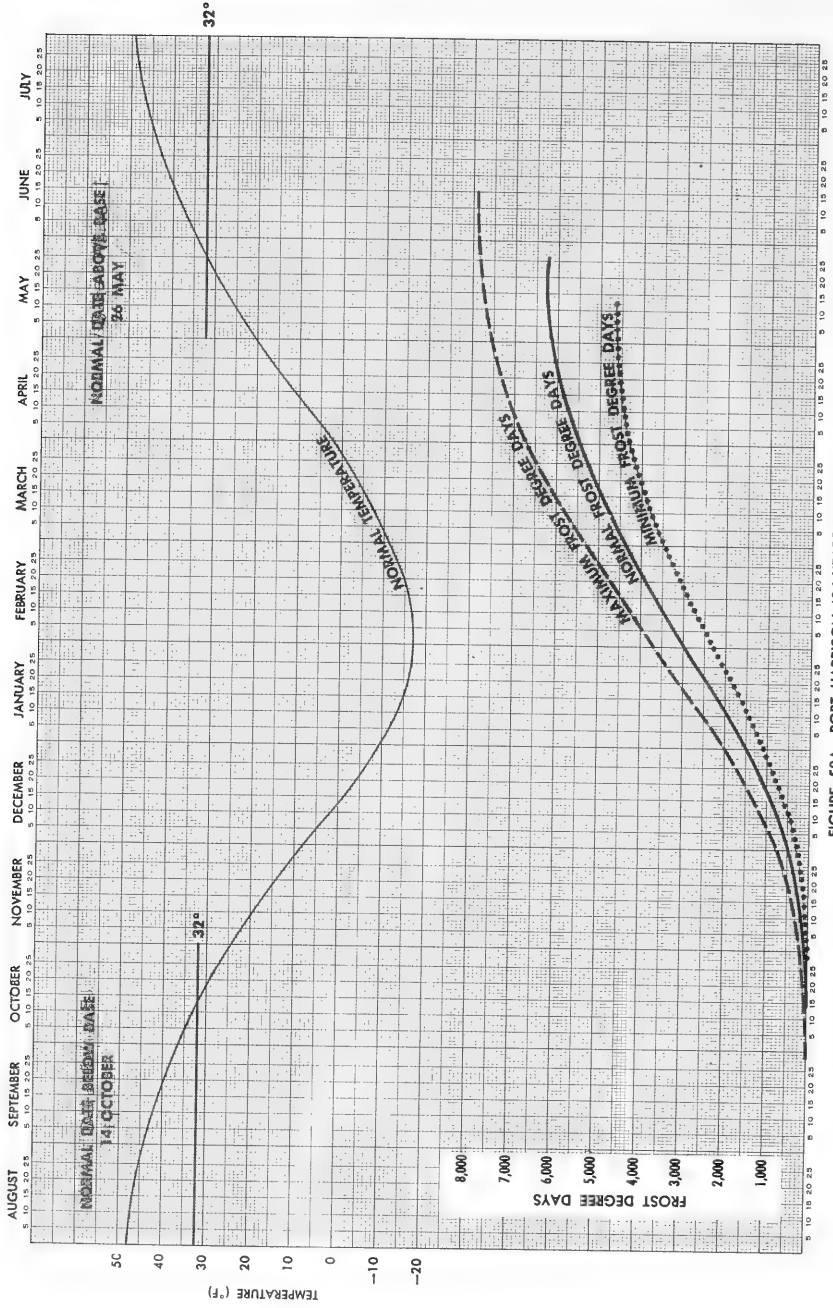


FIGURE 58A PORT HARRISON (26 YEARS RECORD)

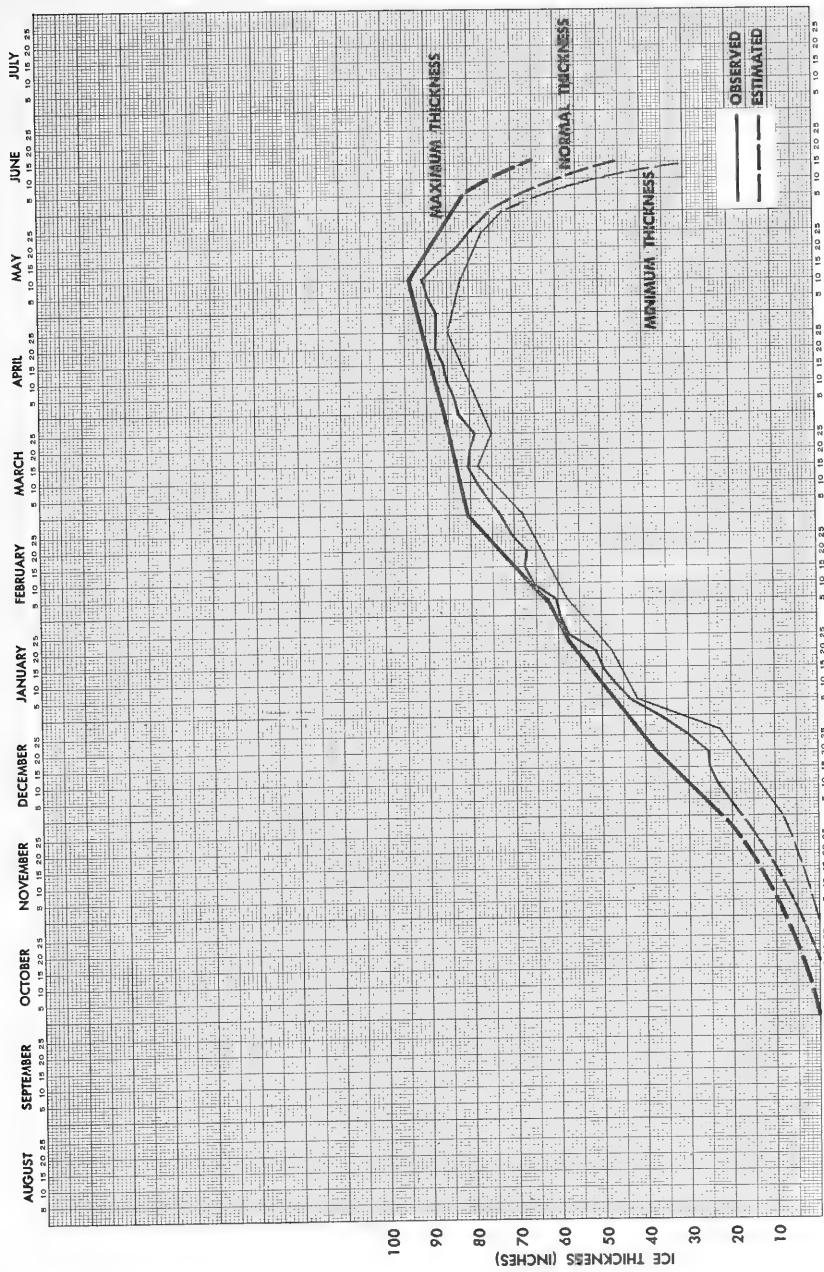


FIGURE 58B PORT HARRISON EMPIRICAL ICE GROWTH AND DISINTEGRATION CURVE (4 YEARS RECORD)

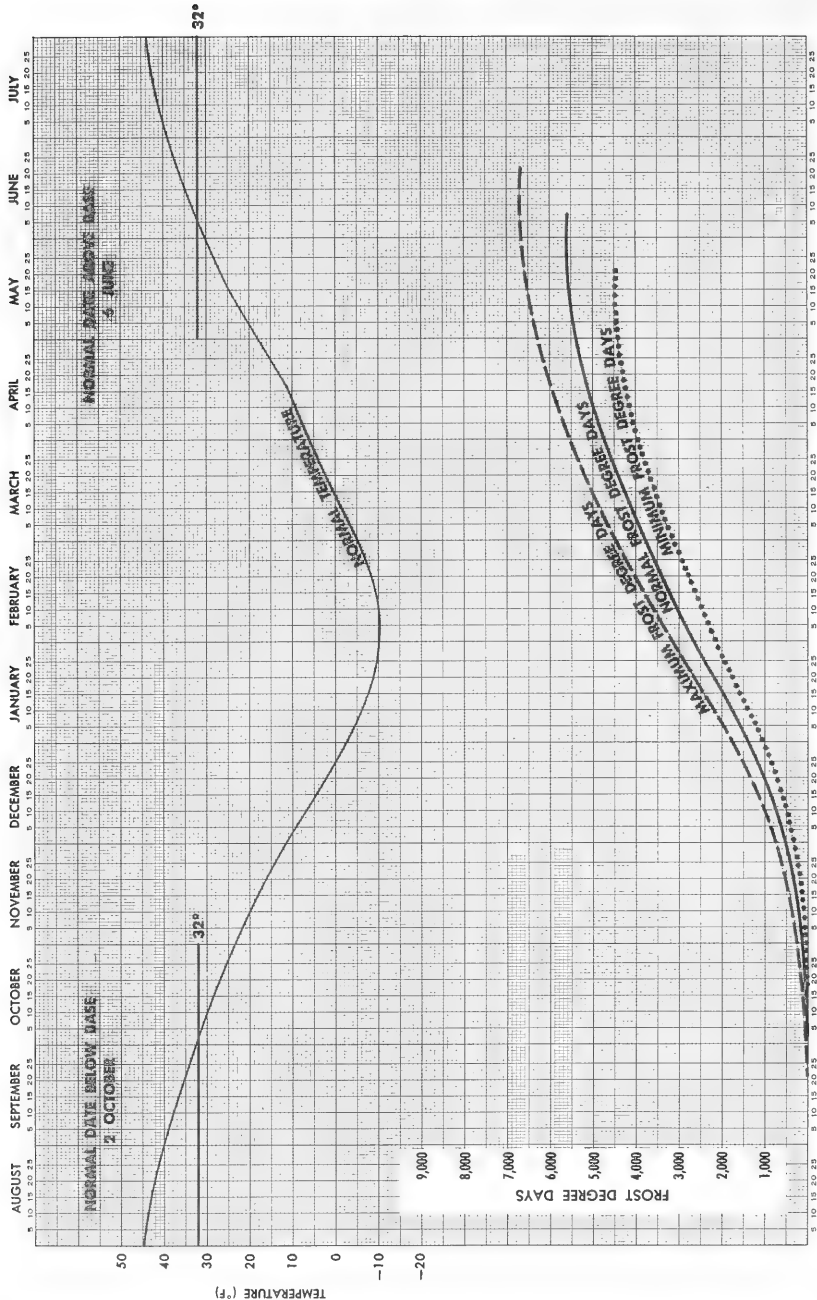


FIGURE 59A CAPE HOPES ADVANCE (12 YEARS RECORD)

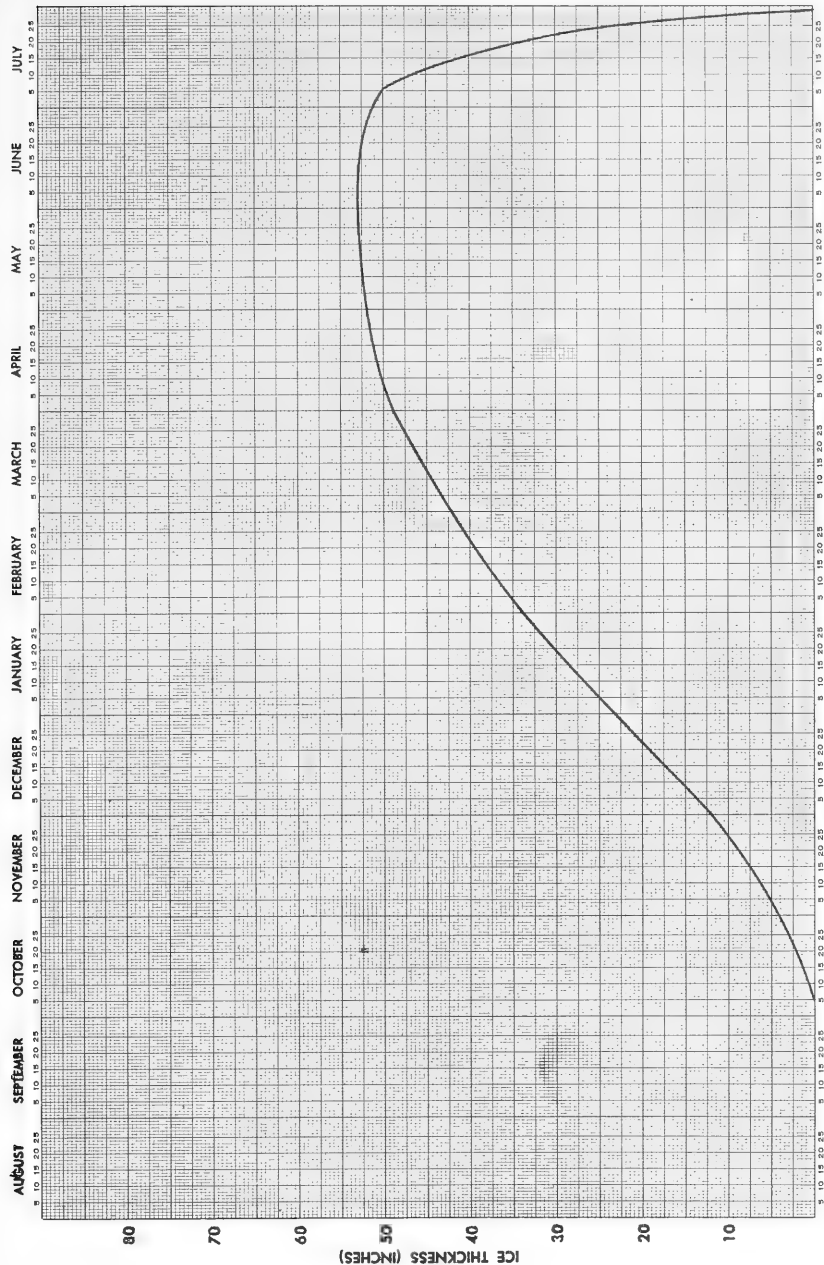


FIGURE 59B CAPE HOPES ADVANCE THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

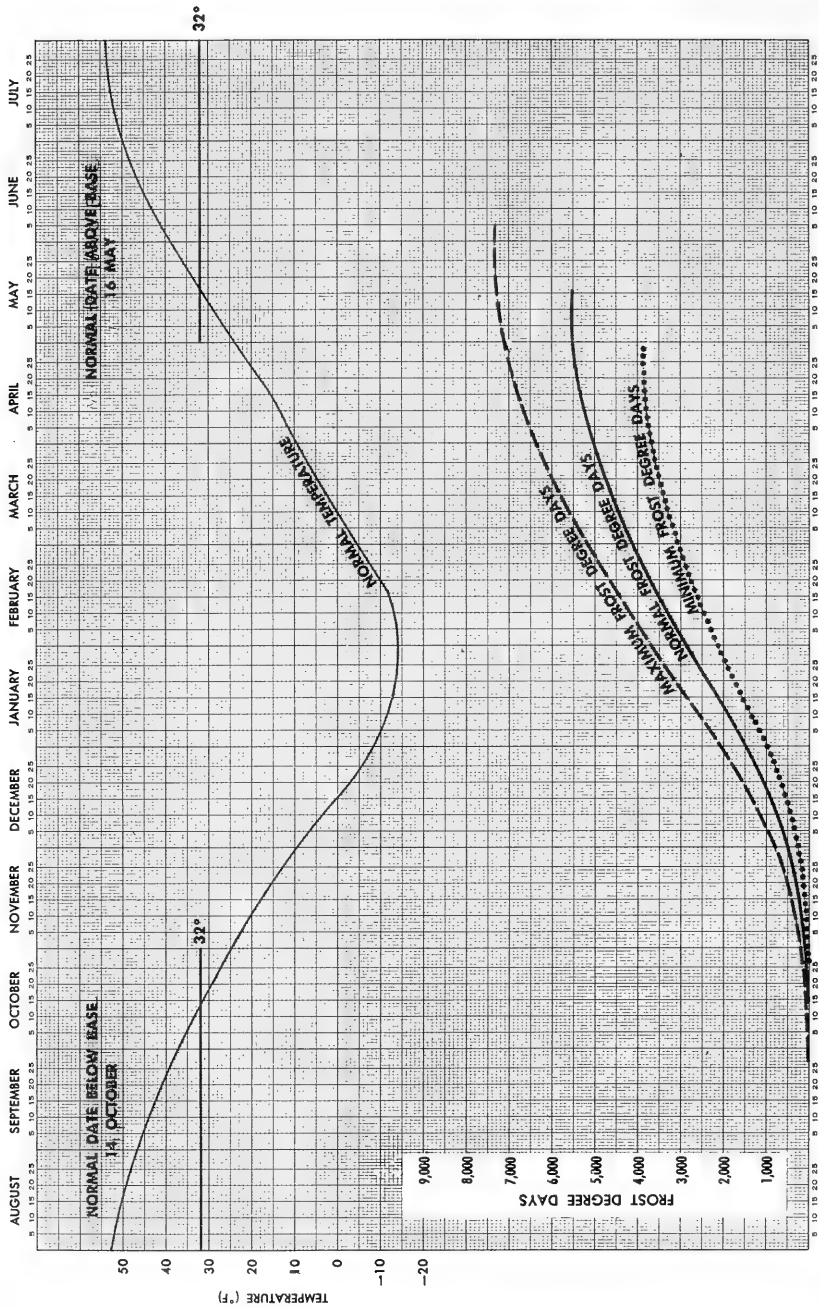


FIGURE 60A FORT CHIMO (10 YEARS RECORD)

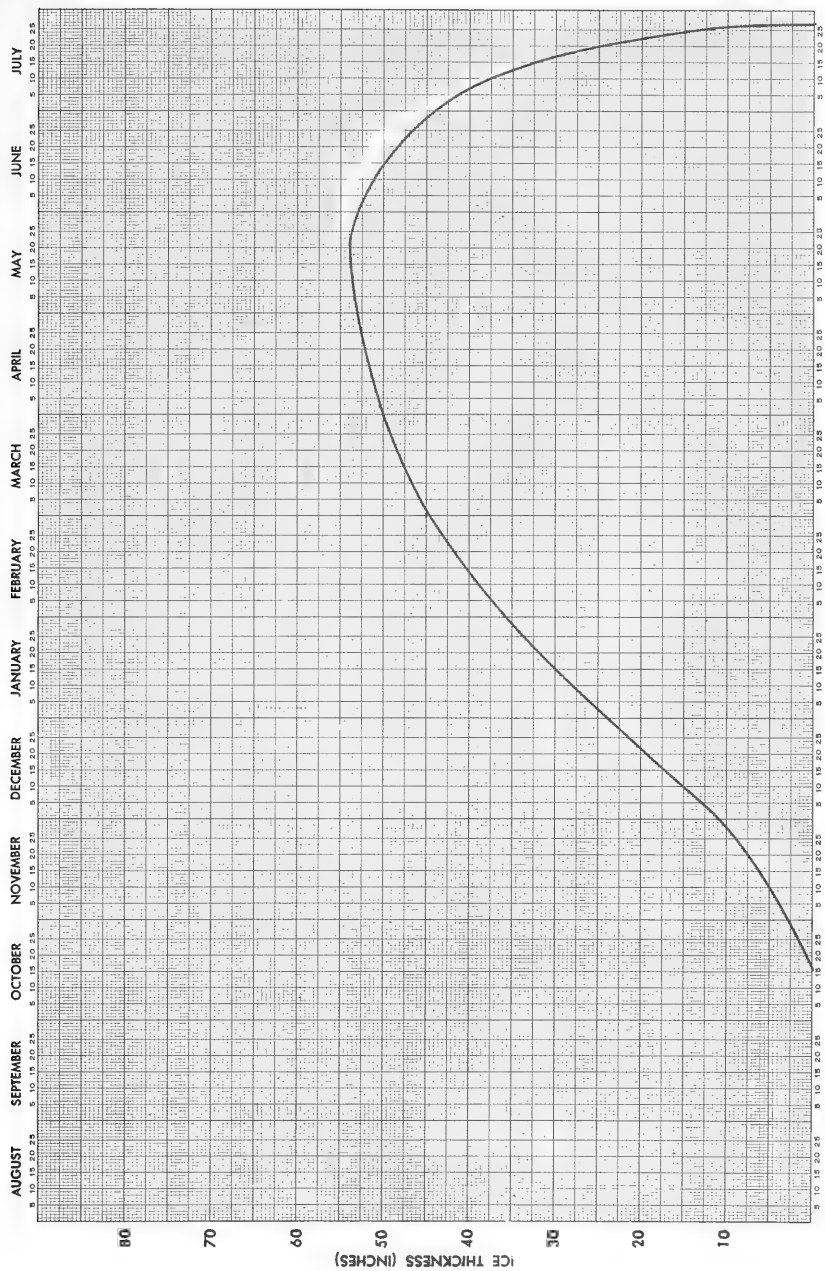


FIGURE 608 FORT CHIMO THEORETICAL ICE GROWTH AND DISINTEGRATION CURVE

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14.	KEY WORDS	LINK A		LINK B		LINK C	
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FRONT DEGREE DAY, RELATED FOR THICKNESS
CONTOUR, AND HARBOR FRESHUP AND BREAKUP
DAYS FOR SELECTED ARCTIC STATIONS, by
Franklin E. Kulkarni and Gabriel J. Toloczky,
July 1969, 123 P., including 131 Figures
and 7 tables. (TM-60)

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This report presents a compilation of available front degree day data and sea ice information for selected Arctic stations. Related front degree day and ice growth curves are depicted in graphic form. Harbor freshup and breakup dates which include monthly, latent, and average values of breakup are given for selected stations.

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2. Freshup dates
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4. Front degree day relationship to sea ice conditions
5. Title: Front degree day, related for thickness curves, and harbor freshup and breakup dates for selected Arctic stations
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