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NASA

Technical Memorandum 85020

MIZEX-WEST NASA CV-990 Flight Report

D. J. Cavalieri and P. Gloersen

APRIL 1983

National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

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MIZEX-WEST

NASA CV-990

FLIGHT REPORT

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ABSTRACT

NASA's Convair 990 airborne laboratory made a series of flights over the Bering Sea during February 1983 as part of the Bering Sea marginal ice zone winter experiment (MIZEX-WEST). The experiment was an intensive field study of the oceanography, meteorology, and sea ice properties of the marginal ice zone utilizing surface vessels, aircraft, and satellite. NASA's aircraft flights were coordinated with the NOAA research ship DISCOVERER, the USCG icebreaker WESTWIND, the NOAA P-3 research aircraft, and the Nimbus-7 spacecraft. The purpose of these flights was first to assess the potential of using an extended range of wavelengths for improving passive microwave sea ice observations from spacecraft and second to provide an overview of the MIZ for large-scale processes studies. For these purposes, the aircraft was equipped with both imaging and fixed-beam, dual-polarized passive microwave radiometers ranging from 1.5 millimeter to 3 centimeter wavelengths. Visual, photographic, and thermal (10.7 micron) infrared surface observations were also made from the aircraft to complement the microwave measurements. Following a brief discussion of the flight operations and in-flight observations, a summary of each flight is presented including flight objective and instrument status. Preliminary mosaic images obtained with the ESMR imager, Nimbus-7 orbits over the Bering Sea, ice observations obtained by an ice observer on board, and composite maps of the general ice conditions for the month of February are also presented.

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I Background

During February 1983, NASA participated in the Bering Sea marginal ice zone (MIZ) winter experiment (MIZEX-WEST) field study. MIZEX-WEST is a coordinated program of study involving oceanographers, meteorologists, and remote sensing scientists utilizing ships, aircraft, and satellite to investigate the regional air-sea-ice interactions. The overall goal of this experiment is to understand how the oceanic, atmospheric, and internal ice forces drive the ice movement and control the position of the ice edge. Ultimately, the results of this study are expected to impove short-range forecasts of the Bering MIZ. NASA's participation in MIZEX-WEST consisted of a series of seven Convair-990 airborne laboratory flights over the marginal ice zone in the eastern Bering Sea from February 10 through February 22, 1983. The purpose of these flights was first to assess the potential of using an extended range of wavelengths for improving passive microwave sea ice observations from space platforms and second to provide an overview of the MIZ characteristics for large-scale ice processes studies. For these purposes, the aircraft was equipped with both imaging and fixed-beam, dual-polarized passive microwave radiometers ranging from 1.5 millimeter to 3 centimeter wavelengths. Visual, photographic, and thermal (10.7 micron) infrared surface observations were also made from the aircraft to complement the microwave measurements. The CV-990 also carried a version of the radar altimeter planned for the European Space Agency satellite ERS-1. A summary of the aircraft instrumentation is given in Table I. The CV-990 flights were coordinated with the observational oceanographic and meteorological programs of the NOAA P-3 research aircraft, the USCG icebreaker WESTWIND, and the NOAA research ship DISCOVERER. In addition, ice properties relevant to the microwave remote sensing program were measured from the ships as well

as from the ice surface itself whenever feasible. The combined oceanographic, meteorological, and sea ice data sets will be utilized to provide a cohesive description of the air-sea-ice interactions in the Bering MIZ.

II Flight Operations

A flight summary for each of the CV-990 flights associated with the MIZEX--WEST mission is presented in Appendix A along with a map of the flight tracks for each of the seven Bering Sea overflights. Each summary includes the objective of the individual flight, the latitude, longitude, time in GMT, and altitude for each of the data runs.

Part of the overall aircraft operations plan called for coordination between the CV-990 flights and overpasses by the Nimbus-7 Scanning Multichannel Microwave Radiometer (SMMR). The coordinated aircraft and satellite observations will be used to validate and improve current sea ice algorithms. On days when a CV-990 flight coincided with a SMMR off-day, the operations supervisor at the Goddard Space Flight Center Nimbus Ground Station was notified the day before the scheduled flight and the SMMR was turned on in time for the Bering MIZEX overpass. Portions of the Nimbus daytime orbit crossing of the Bering Sea for each day the CV-990 was flown are shown in Appendix B.

III In-Flight Observations

One objective of the CV-990 flights was to provide an overview of the experimental area including real-time imagery to assist surface vessels locate the ice edge and ice-edge features such as ice bands. For this purpose, the aircraft Electrically Scanning Microwave Radiometer (A/C-ESMR) was used to generate microwave images of the marginal ice zone. These images were then

displayed on monitors on board the aircraft, hard copies were made, and mosaics were produced while in flight. Analysis of the ESMR imagery provided the required information which was radioed to the vessels below. The real-time imagery also proved valuable in providing information for detailed planning of subsequent flights. Based on both an analysis of the A/C ESMR imagery and visual observations, a decision was made to devote the last three flights to the St. Matthew Island vicinity. This area was observed to exhibit rapid changes in the distribution of sea ice and to serve as an excellent site for conducting thin-ice studies. An earlier plan to extensively overfly Norton Sound, where available infrared and visible satellite imagery indicated a large area of thin (black) sea ice, was changed after in-flight analysis of the real-time data acquired in the initial pass over Norton Sound indicated that no such ice was present. Mosaics generated on five of the seven flights and earth registered with an interim latitude/longitude grid are shown in Appendix C. The coordinates were obtained from the inertial navigation system and correlated with the A/C ESMR through the common GMT code present on both data sets.

On each flight, AG2 Kurt Ritchey of the Naval Polar Oceanography Center provided visual ice observations. Estimates of total ice cover, ice types, amount of snow cover, amount of ice cover with ridging and rafting, and amount of open water were some of the ice characteristics mapped along each flight track. The ice charts for each of the seven flights are presented in Appendix D. Mr. Bruce Webster of the Ocean Services Unit, National Weather Service, Anchorage, Alaska and Dr. Lyn McNutt of F. G. Bercha and Associates Limited provided additional ice observations and interpretations. Composite ice analyses based on (1) visual observations from the NASA CV-990 and NOAA P-3 aircraft, (2) derived ice concentrations from Nimbus-7 SMMR data obtained through

Dr. Rene Ramseier of the Canadian Atmospheric Environment Service and Mr. Frank Thirkettle of Ph.D. Associates Inc., and (3) U.S. Navy ice analyses were prepared by Mr. Bruce Webster and appear in Appendix E.

IV Acknowledgements

The MIZEX-WEST portion of the NASA CV-990 airborne laboratory 1983 winter program was supported by NASA's Oceanic Processes Branch. The successful completion of the aircraft operations phase of this mission is due largely to George Alger, mission manager, and Earl Petersen, assistant mission manager, through their excellent coordination and skillful integration of aircraft and data system requirements with scientific objectives. We thank also the CV-990 crew and in particular Bob Innis and Glen Stinnett, NASA CV-990 pilots, and Gene Moniz, navigator, for their support and full cooperation in the planning and execution of each of the flights. Finally, the authors gratefully acknowledge the invaluable information for our flight planning activities each day provided by Bruce Webster of the Ocean Services Unit, National Weather Service, Anchorage, Alaska.

TABLE I

CV-990 INSTRUMENTATION

PASSIVE MICROWAVE

Freq (GHz)	View Angle	Polarization	Resolution/ Altitude	Comments
19.35	50°L-50°R	H	1/20	AC/ESMR: Imager for large-scale synoptic maps of ice-edge position; ice-band size and spacing; thin ice and open water resolution
19.35	50°L-50°R	H	1/40	RMR: High resolution imager
10.7 18.0 21.0 37.0	45°R 45°R 45°R 45°R	H,V H,V H,V H,V	1/7 1/7 1/7 1/7	AMMR: Multispectral signatures of various ice types
21.0 37.0	uplooker uplooker	N/A N/A	N/A N/A	Uplookers: Views atmosphere above aircraft
94.0 183.0	45°L-45°R	Mixed	1/30	AMMS: High frequency signatures of various ice types; evaluation for polar ice studies

RAL RADAR ALTIMETER

13.7 GHz radar altimeter operates in two modes:
(1) altimeter mode used for ice surface roughness studies
(2) scatterometer mode used for obtaining directional ocean swell spectra

INFRARED RADIOMETER

10.7 micron nadir viewing infrared radiometer (PRT-5) used for obtaining ice surface temperatures and for discriminating between thin ice and open water during clear atmospheric conditions.

CARTOGRAPHIC CAMERAS

(1) KS-87B 5-inch format nadir viewing
(2) KS-87B 5-inch format 45°R view angle

APPENDIX A

Flight Summary

Flight No. 1 Date Feb. 1, 1983

Objectives: Instrument and data system checkout

Instrument Status: All instruments operational except KS87B nadir camera

Flight Track Data Runs	Lat (N)	Lon (W)	Time (GMT)	Alt (Ft)	Base
Takeoff	37 25.0	122 01.4	18 29 08	-----	Moffett Field, CA
Start Run 1	38 35.2	123 01.4	18 46 28	5000	
End Run 1	38 57.4	123 13.2	18 51 20	5000	
Start Run 2	41 20.7	124 36.4	19 16 10	5000	
End Run 2	41 39.7	124 50.7	19 21 09	5000	
Start Run 3	41 45.7	124 52.6	19 22 39	5100	
End Run 3	41 44.6	124 50.4	19 23 08	5000	
Start Run 4	41 32.5	124 48.0	19 26 03	2000	
End Run 4	40 37.6	124 37.0	19 40 28	2000	
Start Run 5	37 50.3	119 11.6	20 26 43	32900	
End Run 5	37 44.4	118 50.2	20 29 01	32900	
Start Run 6	37 40.0	119 04.0	20 33 18	32900	
End Run 6	37 59.1	119 24.7	20 36 48	33000	
Start Run 7	39 45.2	125 14.9	21 20 50	06000	
End Run 7	39 54.4	125 42.9	21 26 49	06000	
Start Run 8	40 21.2	126 31.3	21 36 29	07000	
End Run 8	40 35.4	126 23.6	22 02 29	35000	
Start Run 9	40 31.9	126 10.3	22 09 15	34900	
End Run 9	40 13.0	125 40.5	22 14 17	34900	
Start Run 10	39 25.8	124 28.8	22 25 43	01000	
End Run 10	39 09.0	124 03.6	22 30 41	01000	
Start Run 11	37 53.0	122 45.5	22 49 29	00700	
End Run 11	37 33.3	122 34.3	22 54 39	00700	
Touchdown	37 25.0	122 01.4	23 04 50	-----	Moffett Field, CA

Flight No. 2 Date Feb. 7, 1983

Objectives: Transit flight to Elmendorf AFB, Anchorage, Alaska; overfly ocean buoys

Instrument Status: All instruments operational; RMR off at 21:22

Flight Track Data Runs	Lat (N)	Lon (W)	Time (GMT)	Alt (Ft)	Base
Takeoff	37 05.0	122 02.9	20 05 12	-----	Moffett Field, CA
Touchdown	61 14.9	149 49.0	00 28 10	-----	Elmendorf AFB, AK

Flight No. 3 Date Feb. 10, 1983

Objectives: Obtain overview of Bering MIZ experimental area and overfly buoy array.

Instrument Status: All instruments operational

Flight Track Data Runs	Lat (N)	Lon (W)	Time (GMT)	Alt (Ft)	Base
Takeoff	61 15.0	149 46.1	22 07 54	-----	Elmendorf AFB, AK
Start Run 1	58 46.6	172 27.8	23 53 41	30900	
End Run 1	61 15.5	168 47.2	00 16 55	31000	
Start Run 2	61 18.5	169 04.6	00 23 21	31000	
End Run 2	58 50.3	172 45.7	00 49 45	31000	
Start Run 3	58 56.0	172 59.4	00 54 24	30900	
End Run 3	61 21.1	169 25.0	01 17 07	31000	
Start Run 4	61 24.3	169 43.5	01 22 33	30900	
End Run 4	59 08.9	173 04.7	01 46 23	31000	
Touchdown	61 12.4	149 46.6	03 34 20	-----	Elmendorf AFB, AK

Flight No. 4 Date Feb. 12, 1983

Objectives: Determine amount of open water within the MIZ and ice compactness

Instrument Status: All instruments operational; RMR down at 20:24

Flight Track Data Runs	Lat (N)	Lon (W)	Time (GMT)	Alt (Ft)	Base
Takeoff	61 15.0	149 46.1	20 03 32	-----	Elmendorf AFB, AK
Start Run 1	58 30.1	173 03.9	21 48 59	30900	
End Run 1	61 04.8	170 00.6	22 12 17	31000	
Start Run 2	61 10.1	170 19.8	22 16 13	30900	
End Run 2	59 39.7	173 30.2	22 40 29	31000	
Start Run 3	58 45.8	173 43.0	22 42 57	30900	
End Run 3	61 15.1	170 30.6	23 06 05	31000	
Start Run 4	61 19.3	170 50.6	23 09 29	30900	
End Run 4	58 50.2	174 00.0	23 33 33	31000	
Touchdown	61 13.2	149 45.7	01 25 20	-----	Elmendorf AFB, AK

Flight No. 5 Date Feb. 13, 1983

Objectives: Overfly Norton Sound on ferry legs and fly low level runs over areas of thin ice.

Instrument Status: All instruments operational except RMR

Flight Track Data Runs	Lat (N)	Lon (W)	Time (GMT)	Alt (Ft)	Base
Takeoff	61 15.0	149 46.1	20 34 26	-----	Elmendorf AFB, AK
Start Run 1	64 25.4	161 28.6	21 33 59	31000	
End Run 1	62 31.5	170 47.0	22 10 41	31000	
Start Run 2	62 23.2	170 59.5	22 12 03	31000	
End Run 2	59 40.1	172 44.4	22 35 41	31000	
Start Run 3	59 47.0	172 59.6	22 39 53	30900	
End Run 3	61 44.9	171 40.9	22 55 07	31000	
Start Run 4	60 00.6	172 42.9	23 27 05	3500	
End Run 4	62 22.0	170 48.5	00 03 01	3500	
Touchdown	61 13.2	149 45.7	00 33 00	-----	Elmendorf AFB, AK

Flight No. 6 Date Feb. 15, 1983

Objectives: Return to Moffett Field, CA for aircraft repairs; data runs for RAL radar altimeter.

Instrument Status: All instruments operational; RMR removed at Moffett Field

Flight Track Data Runs	Lat (N)	Lon (W)	Time (GMT)	Alt (Ft)	Base
Takeoff	61 15.0	149 46.1	09 26 00	-----	Elmendorf AFB, AK
Start Run 1	42 51.8	126 14.4	23 00 33	2380	
End Run 1	42 40.5	126 04.2	23 02 59	2370	
Start Run 2	42 27.0	125 51.4	23 05 43	2000	
End Run 2	40 50.9	124 26.0	23 26 41	2020	
Touchdown	37 23.1	122 04.3	00 09 40	-----	Moffett Field, CA

Flight No. 7 Date Feb. 17, 1983

Objectives: Return to Elmendorf AFB, AK for continuation of MIZEX-WEST; Data runs for RAL radar altimeter.

Instrument Status: All instruments operational except KS87B nadir camera

Flight Track Data Runs	Lat (N)	Lon (W)	Time (GMT)	Alt (Ft)	Base
Takeoff	37 25.0	122 02.9	20 06 09	-----	Moffett Field, CA
Start Run 1	57 17.7	143 42.3	23 32 46	2000	
End Run 1	59 25.5	146 22.4	23 54 46	2000	
Touchdown	61 14.2	149 47.5	00 26 01	-----	Elmendorf AFB, AK

Flight No. 8 Date Feb. 17, 1983

Objectives: Overfly the St. Lawrence Island polynya to obtain thin ice signatures; survey ice types from St. Lawrence to ice edge.

Instrument Status: All instruments operational except AMMS

Flight Track Data Runs	Lat (N)	Lon (W)	Time (GMT)	Alt (Ft)	Base
Takeoff	61 15.2	149 46.6	21 51 12	-----	Elmendorf AFB, AK
Start Run 1	62 47.9	165 02.8	22 58 00	30900	
End Run 1	64 06.0	171 16.2	23 24 18	31000	
Start Run 2	63 59.5	171 31.6	23 25 38	30900	
End Run 2	58 55.0	173 15.4	00 03 00	30900	
Start Run 3	59 02.0	173 31.5	00 06 10	30900	
End Run 3	63 50.0	171 53.9	00 47 37	30800	
Start Run 4	63 08.2	169 54.4	01 09 15	31000	
End Run 4	63 05.5	172 04.1	01 22 01	32000	
Start Run 5	63 08.2	172 00.2	01 29 43	31000	
End Run 5	63 21.4	170 25.9	01 43 01	31000	
Touchdown	61 14.2	149 47.5	03 10 30	-----	Elmendorf AFB, AK

Flight No. 9 Date Feb. 19, 1983

Objectives: Overfly array and ships for coordinated observations of experimental area; 24K ft run for RAL altimeter.

Instrument Status: All instruments operational except AMMS and 37 GHz uplooker

Flight Track Data Runs	Lat (N)	Lon (W)	Time (GMT)	Alt (Ft)	Base
Takeoff	61 15.2	149 46.6	20 06 54	-----	Elmendorf AFB, AK
Start Run 1	61 32.2	166 02.0	21 14 13	30900	
End Run 1	61 30.2	172 11.0	21 36 53	30900	
Start Run 2	61 20.7	172 48.0	21 39 29	30900	
End Run 2	60 03.9	176 48.0	21 57 15	31000	
Start Run 3	59 58.5	176 32.2	22 03 13	31000	
End Run 3	61 04.3	173 10.4	22 19 57	31000	
Start Run 4	60 57.2	172 57.5	22 25 15	30900	
End Run 4	59 52.4	176 17.2	22 39 57	31000	
Start Run 5	59 40.9	176 20.2	22 44 59	31000	
End Run 5	60 51.6	172 42.5	23 03 05	31000	
Start Run 6	60 44.4	172 29.8	23 07 49	30900	
End Run 6	59 40.5	175 49.9	23 22 35	31000	
Start Run 7	59 33.9	175 36.6	23 27 59	31000	
End Run 7	60 38.0	172 14.5	23 44 49	31000	
Start Run 8	60 29.8	174 42.2	00 05 09	23900	
End Run 8	60 31.3	173 56.3	00 08 27	24000	
Touchdown	61 14.2	149 47.5	01 52 40	-----	Elmendorf AFB, AK

Flight No. 10 Date Feb. 21, 1983

Objectives: Overfly array and ships for coordinated observations; low level runs over St. Matthew Island polynya for thin ice signatures

Instrument Status: All instruments operational; AMMS failed at 21:52, back on line 22:00; KS87B side viewing camera failure at 23:50

Flight Track Data Runs	Lat (N)	Lon (W)	Time (GMT)	Alt (Ft)	Base
Takeoff	61 15.2	149 46.6	20 51 19	-----	Elmendorf AFB, AK
Start Run 1	61 01.9	160 01.3	21 37 33	31000	
End Run 1	61 01.9	165 01.2	21 56 45	31000	
Start Run Mos1	60 41.6	171 16.5	22 21 07	31000	
End Run Mos1	59 28.6	175 20.0	22 39 21	31000	
Start Run 2	59 34.5	175 29.5	22 41 41	31200	
End Run 2	60 38.0	172 16.6	22 57 37	30900	
Start Run 3	60 44.6	172 30.6	23 01 49	30900	
End Run 3	59 40.3	175 50.0	23 16 47	31000	
Start Run 4	59 46.8	176 01.6	23 20 47	30900	
End Run 4	60 51.0	172 44.3	23 36 55	30800	
Start Run 5	59 58.8	172 33.0	23 55 05	3500	
End Run 5	60 29.2	173 40.0	00 06 31	3500	
Start Run 6	60 41.7	173 34.5	00 15 15	3500	
End Run 6	60 07.1	172 14.5	00 27 11	3500	
Start Run 7	59 40.1	167 59.1	00 47 19	2890	
End Run 7	59 39.8	161 29.6	01 13 39	2890	
Touchdown	61 14.2	149 47.5	02 05 40	-----	Elmendorf AFB, AK

Flight No. 11 Date Feb. 22, 1983

Objectives: Fly mosaic pattern over Bering MIZ experimental area and coordinate observations with surface vessels; 500 ft run for RAL radar altimeter.

Instrument Status: All instruments operational; power failure at 22:05, back on line at 22:20

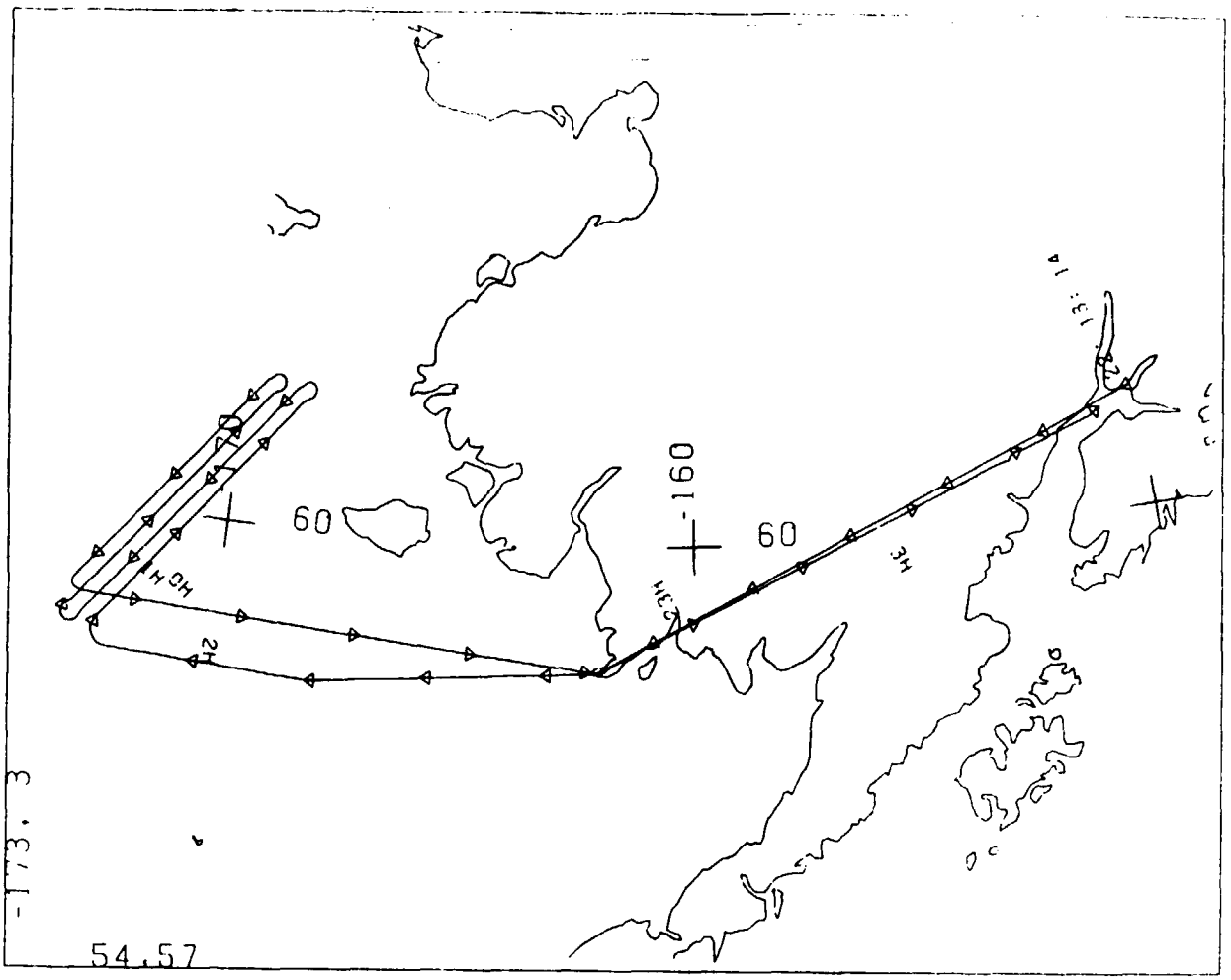
Flight Track Data Runs	Lat (N)	Lon (W)	Time (GMT)	Alt (Ft)	Base
Takeoff	61 15.2	149 46.6	19 49 53	-----	Elmendorf AFB, AK
Start Run 1	61 46.5	166 06.2	20 57 19	30800	
End Run 1	59 47.5	176 33.0	21 42 53	31000	
Start Run 2	59 44.9	176 07.3	21 46 11	31000	
End Run 2	60 50.2	172 46.3	22 01 21	31000	
Start Run 3	-- ----	--- ----	-- -- --	-----	(power failure)
End Run 3	59 28.0	176 26.1	22 25 27	31000	
Start Run 4	59 25.9	176 00.0	22 28 45	31000	
End Run 4	60 28.9	172 44.6	22 43 45	31000	
Start Run 5	60 16.2	172 51.4	22 47 49	31000	
End Run 5	59 21.9	175 39.0	23 01 07	31000	
Start Run 6	58 39.7	173 30.2	23 14 53	15000	
End Run 6	58 10.0	170 45.1	23 33 35	15000	
Start Run 7	58 19.0	171 33.4	23 46 27	551	
End Run 7	58 12.7	170 57.5	23 51 37	485	
Touchdown	61 14.2	149 47.5	01 34 40	-----	Elmendorf AFB, AK

Flight No. 12 Date Feb. 23, 1983

Objectives: Return to Moffett Field, CA; overfly NOAA buoys; 15K ft run for RAL

Instrument Status: All instruments operational

Flight Track Data Runs	Lat (N)	Lon (W)	Time (GMT)	Alt (Ft)	Base
Takeoff	61 15.2	149 46.6	21 56 38	-----	Elmendorf AFB, AK
Start Run 1	44 58.7	130 46.8	00 46 54	14900	
End Run 1	42 11.1	129 08.6	01 18 04	15300	
Touchdown	37 25.0	122 02.9	02 33 00	-----	Moffett Field, CA



1993 WINTER PROGRAM FLIGHT #3 ANCHORAGE LOCAL FEB. 10 1993
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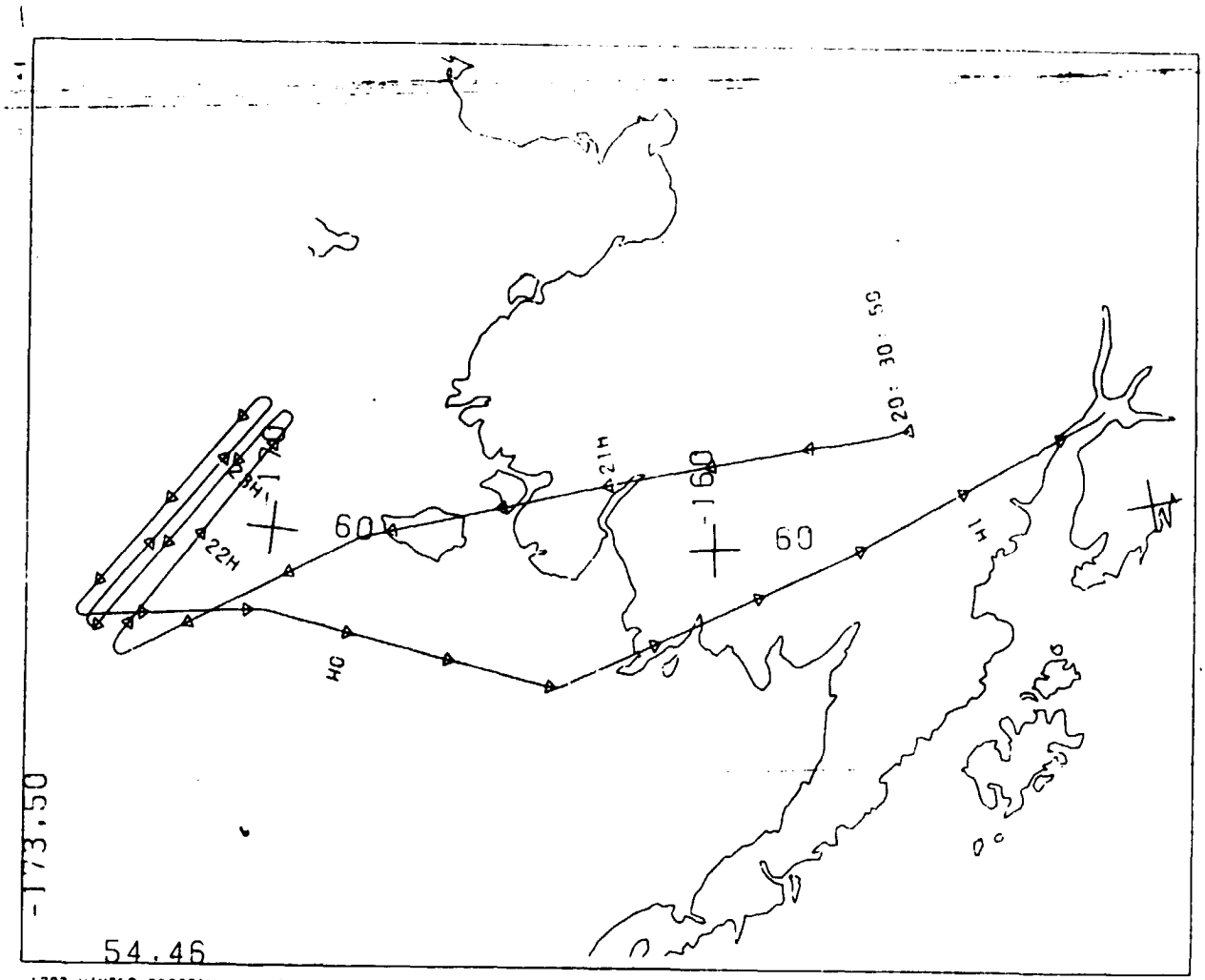

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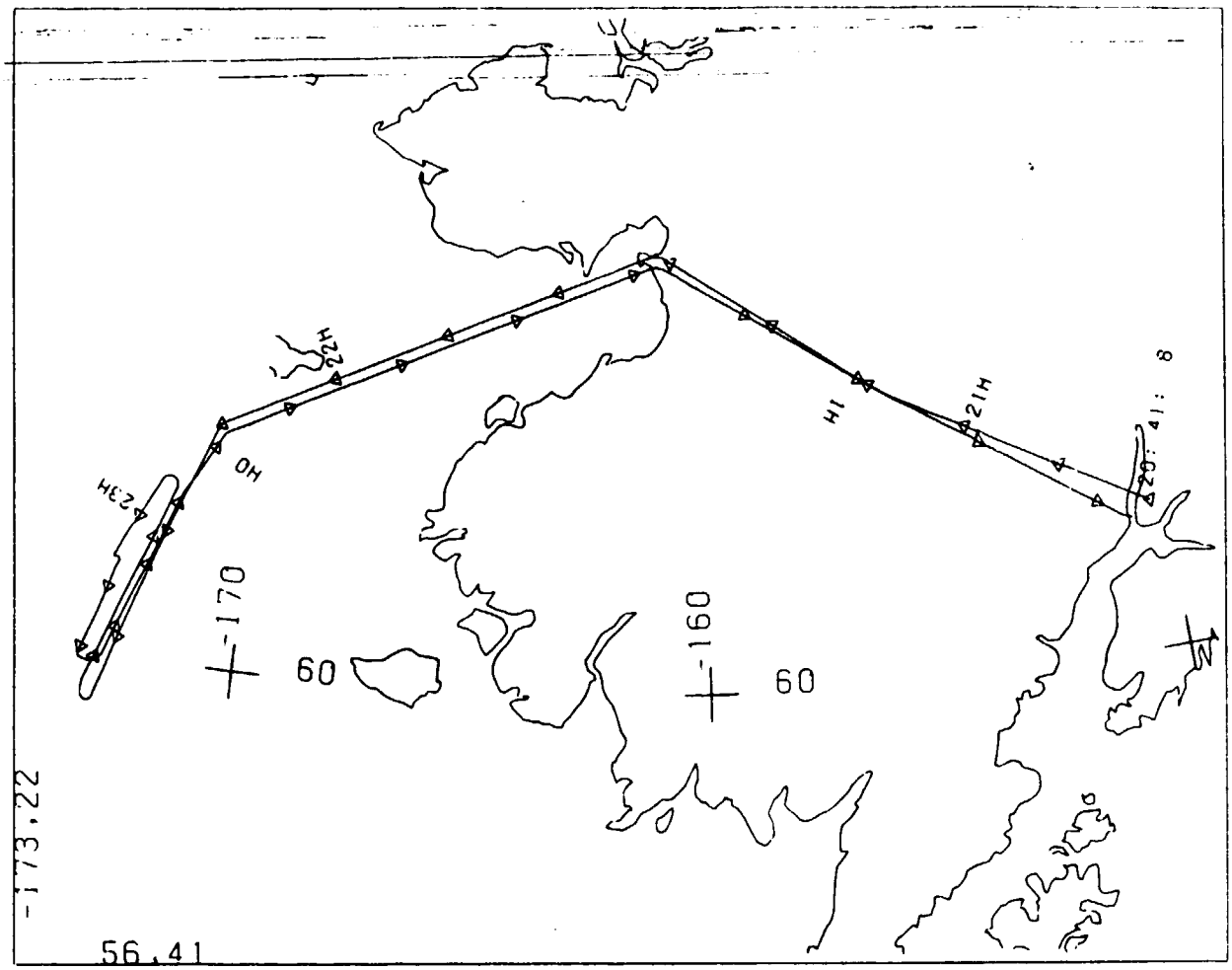

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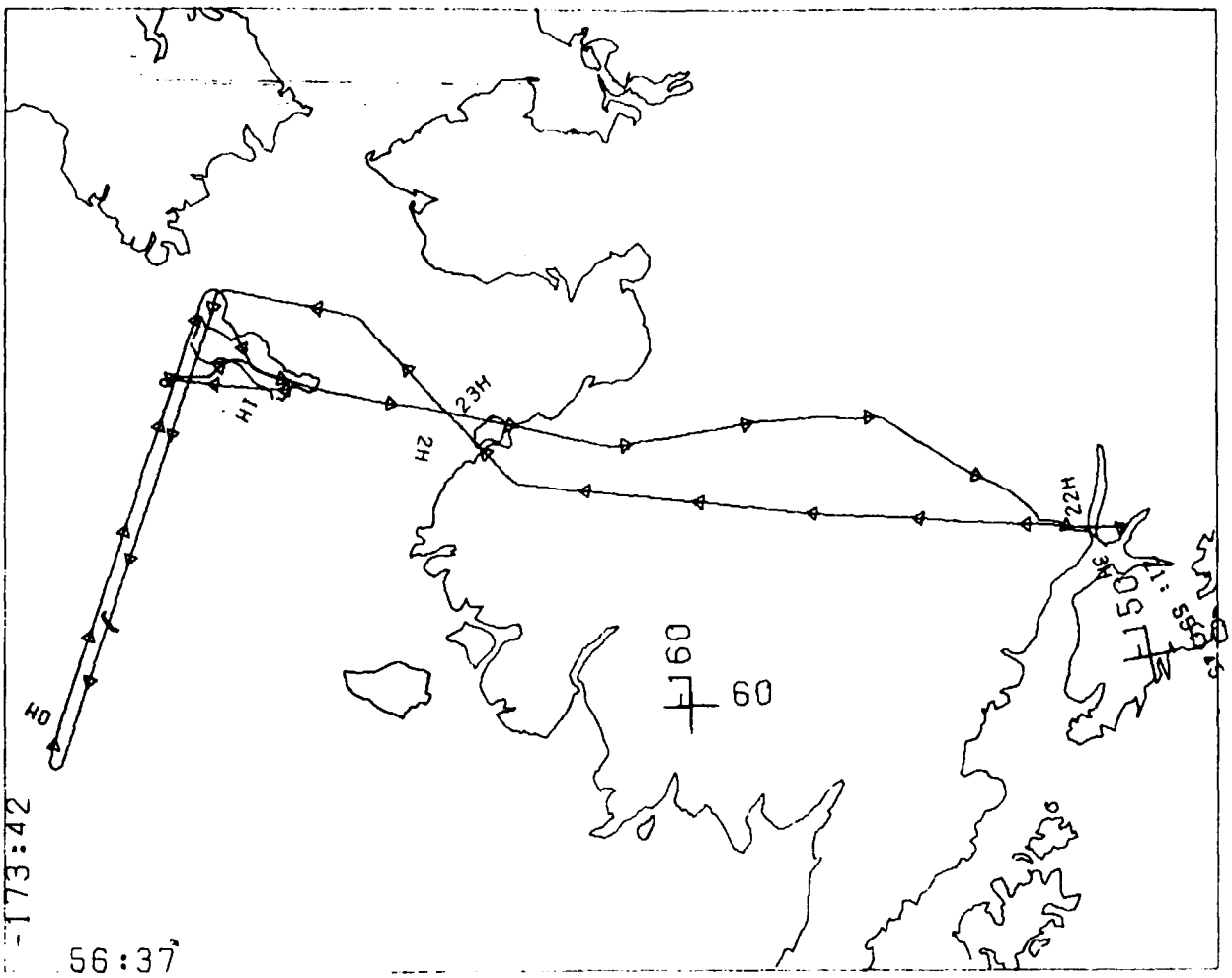

WINTER PROGRAM FLT #8 ANCHORAGE LOCAL FEB. 18. 1983
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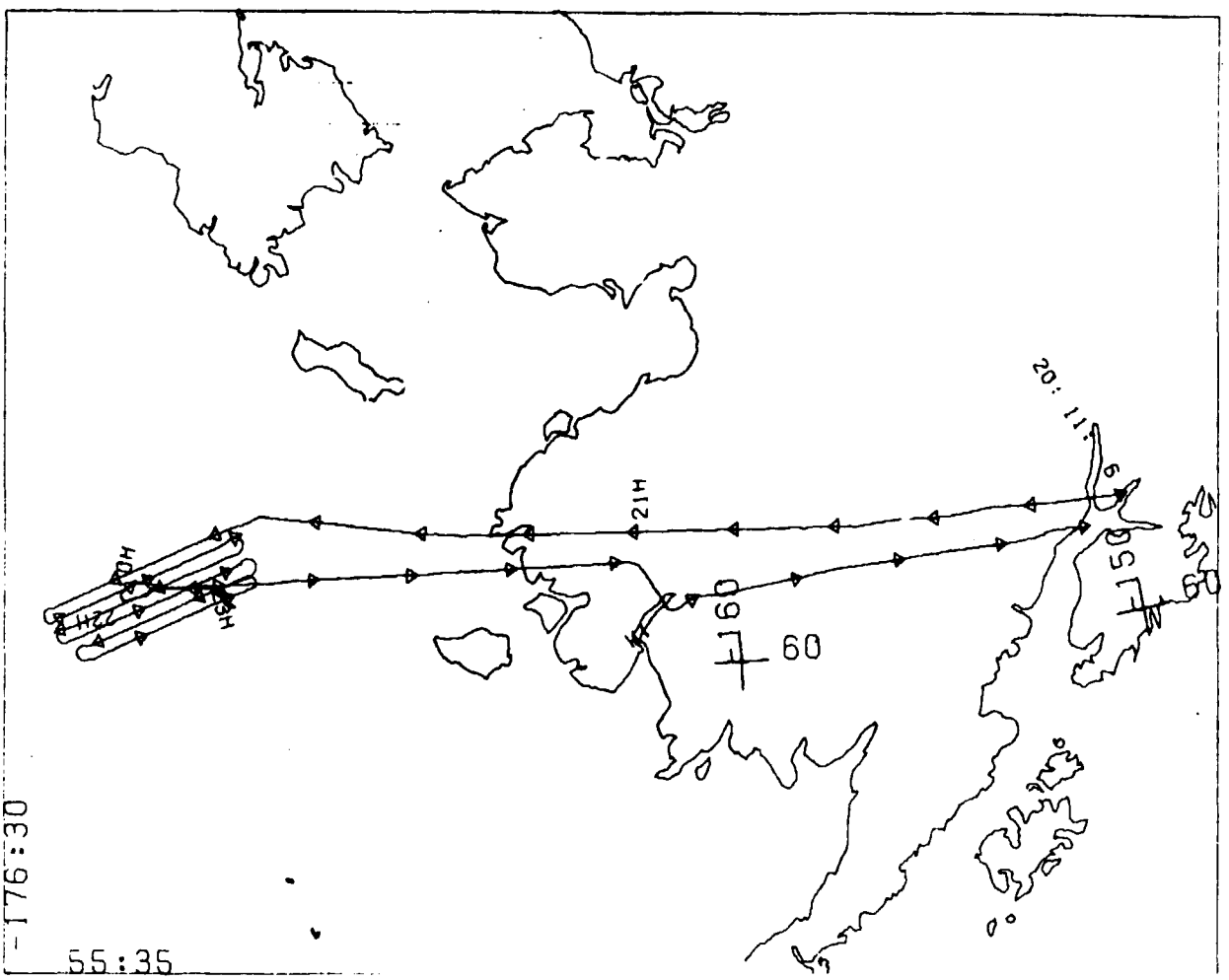
SCALE = 1:5.24E+06 TIME TICS EVERY 10.00 MINUTES



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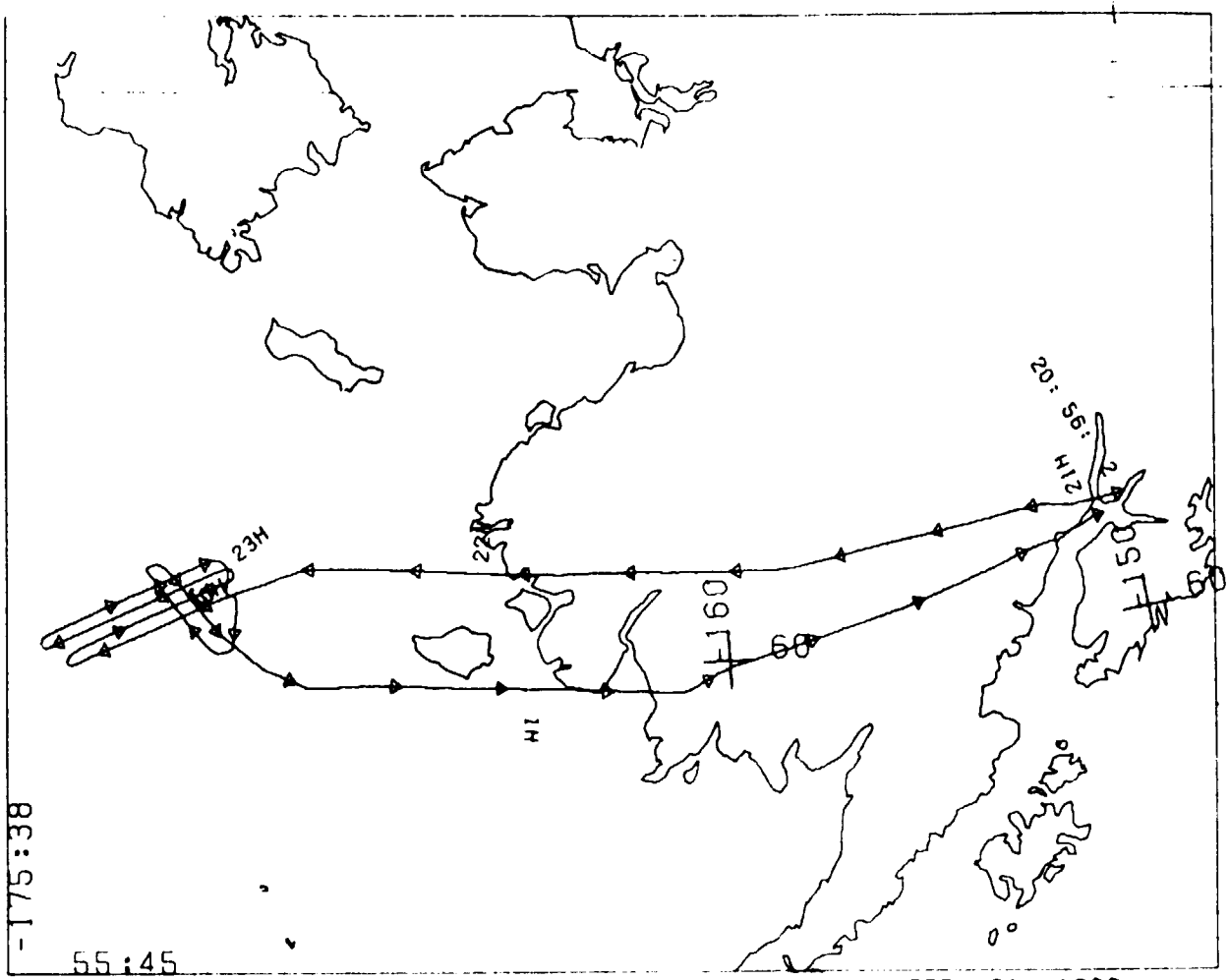

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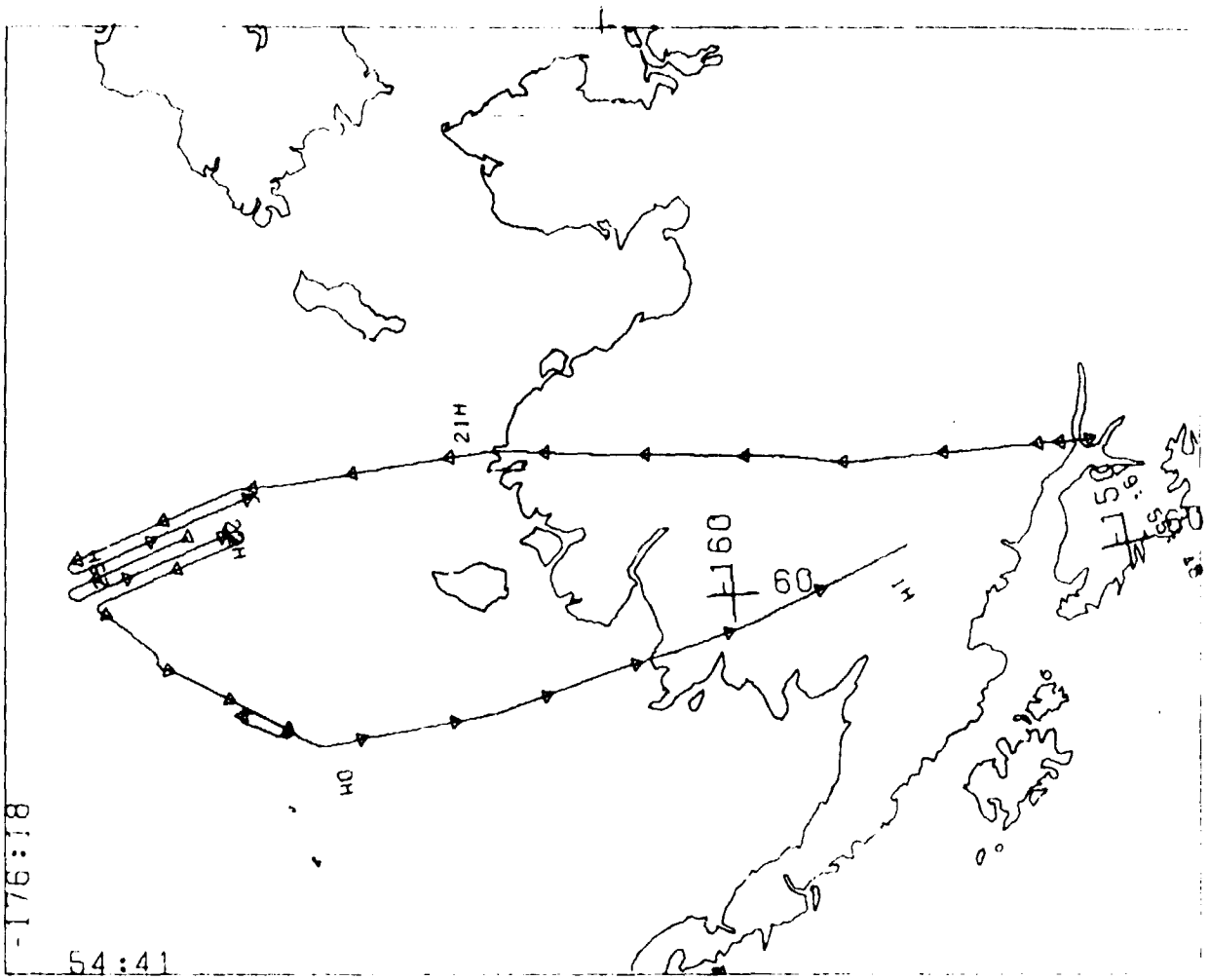


WINTER PROGRAM FLT #11 ANCHORAGE LOCAL FEB. 22, 1983
OVERLAY FOR ALA ROTATED BY 0.0 -1: 0: 0 TO 1: 3:46 UT.
SCALE = 1:5.99E+06 TIME TICS EVERY 10.00 MINUTES

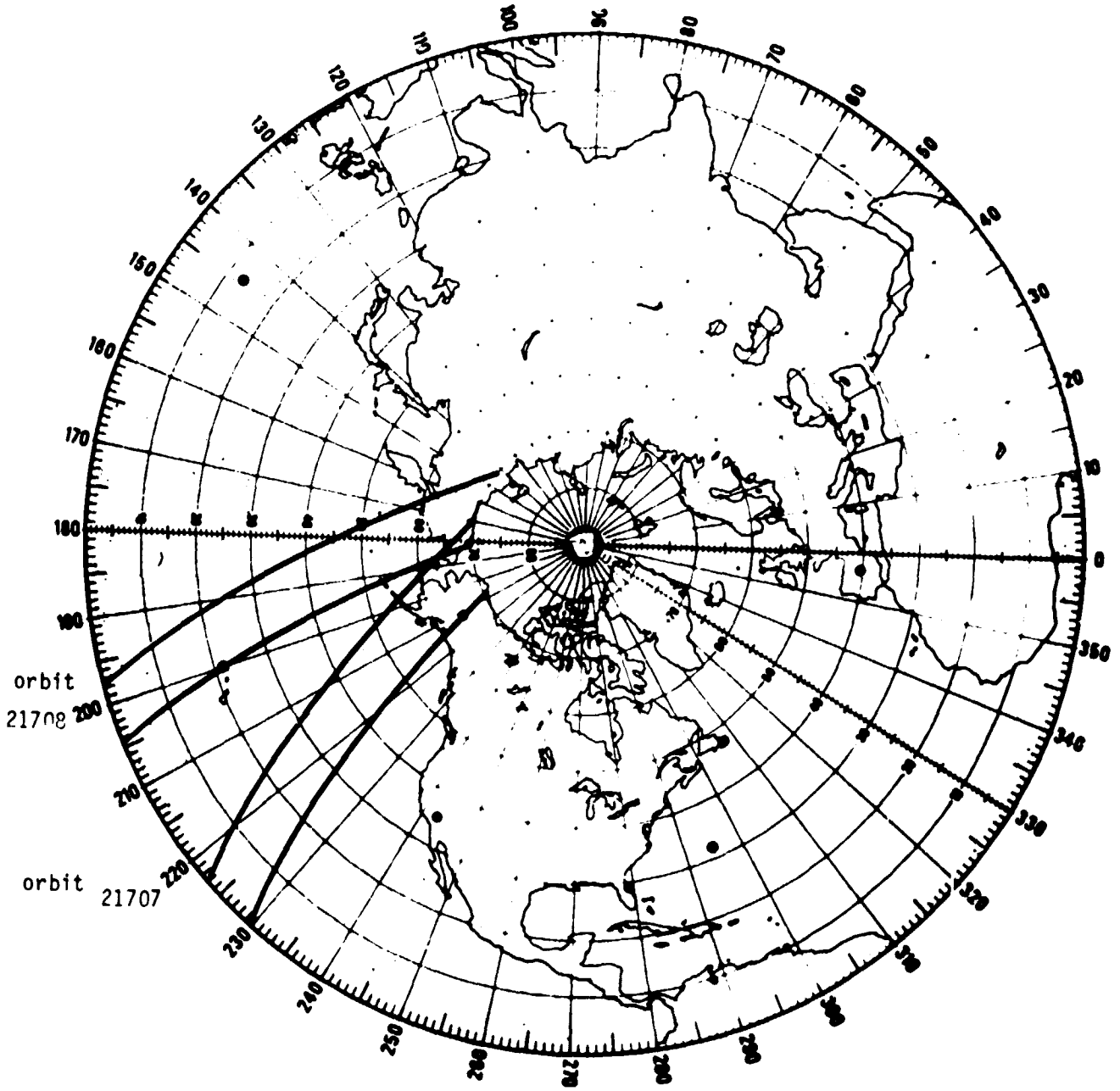
APPENDIX B

Nimbus-7 Orbits

NIMBUS-7 SMMR

ORBITAL SWATH LOCATER

February 10, 1983

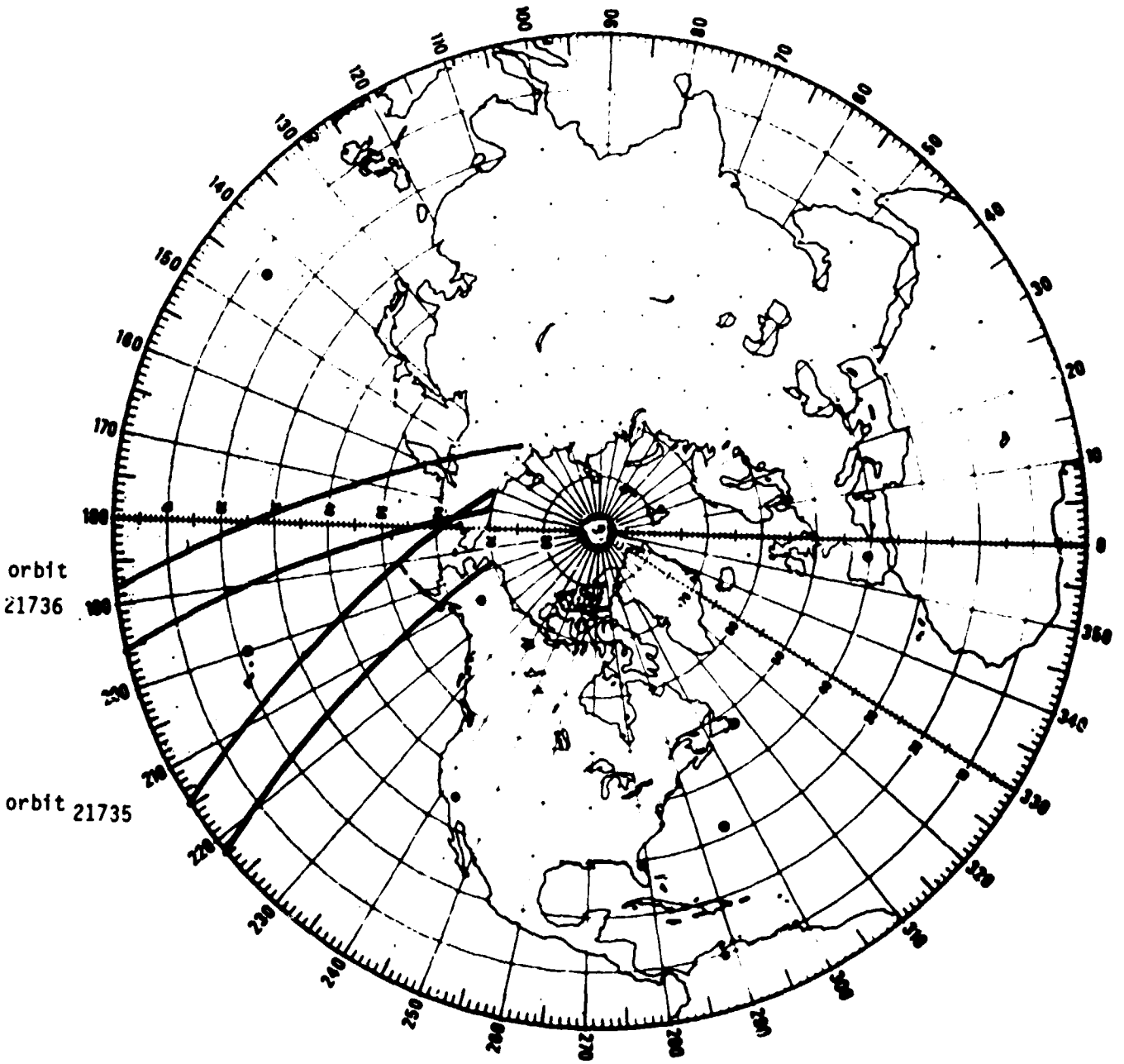


ORIGINAL PAGE IS
OF POOR QUALITY

NIMBUS-7 SMMR

ORBITAL SWATH LOCATER

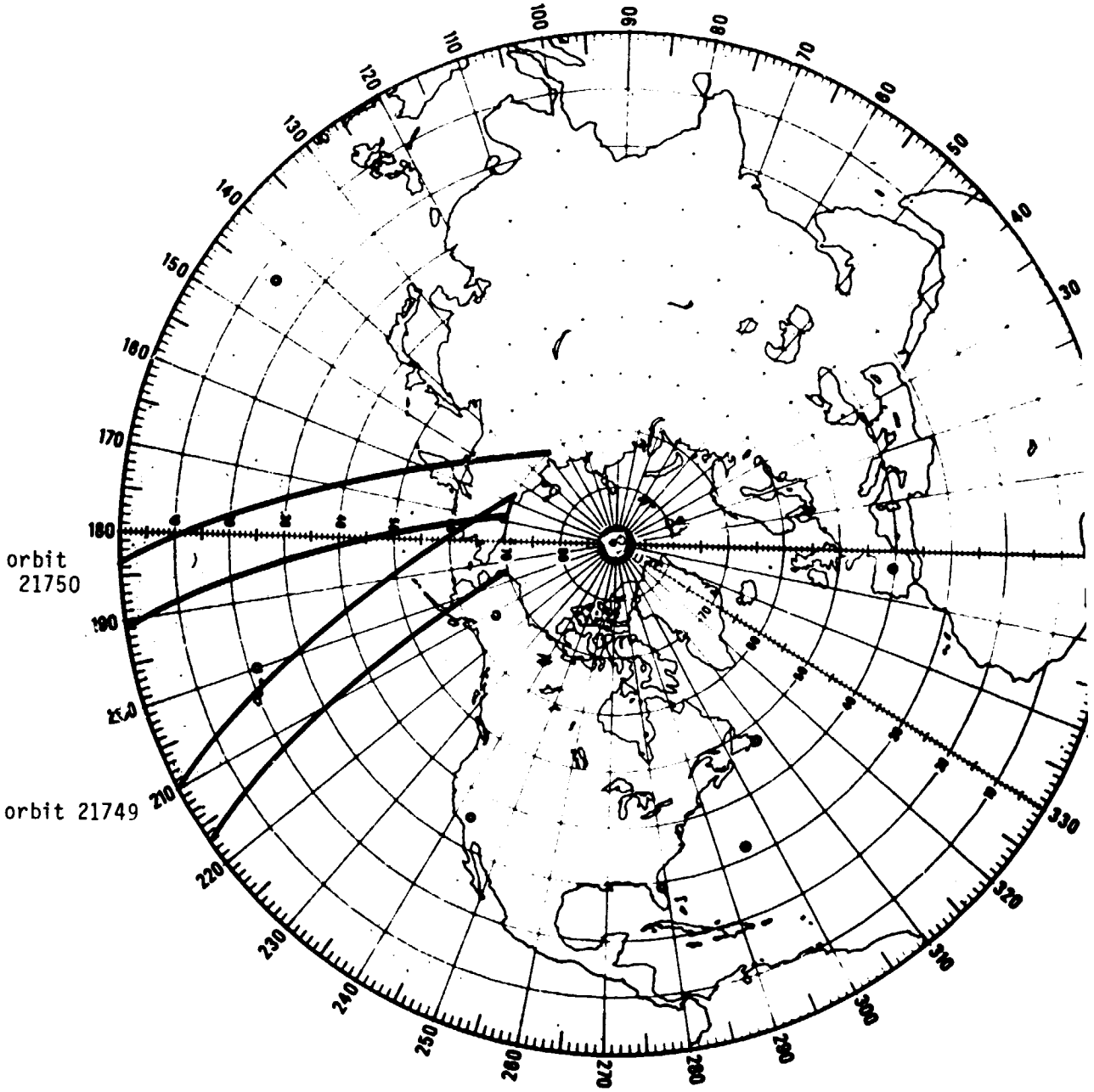
February 12, 1983



NIMBUS-7 SMMR

ORBITAL SWATH LOCATER

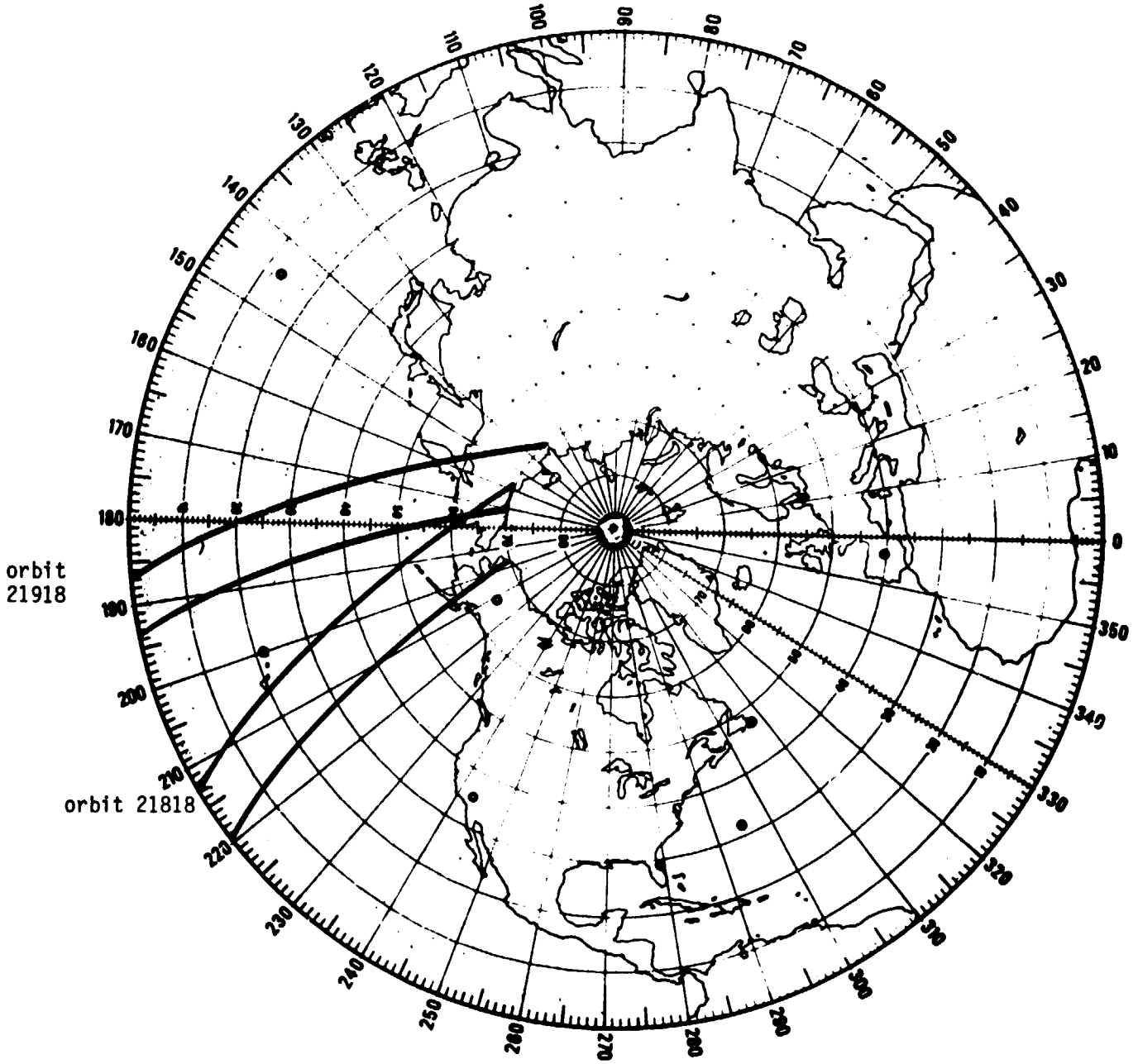
February 13, 1983



NIMBUS-7 SMMR

ORBITAL SWATH LOCATER

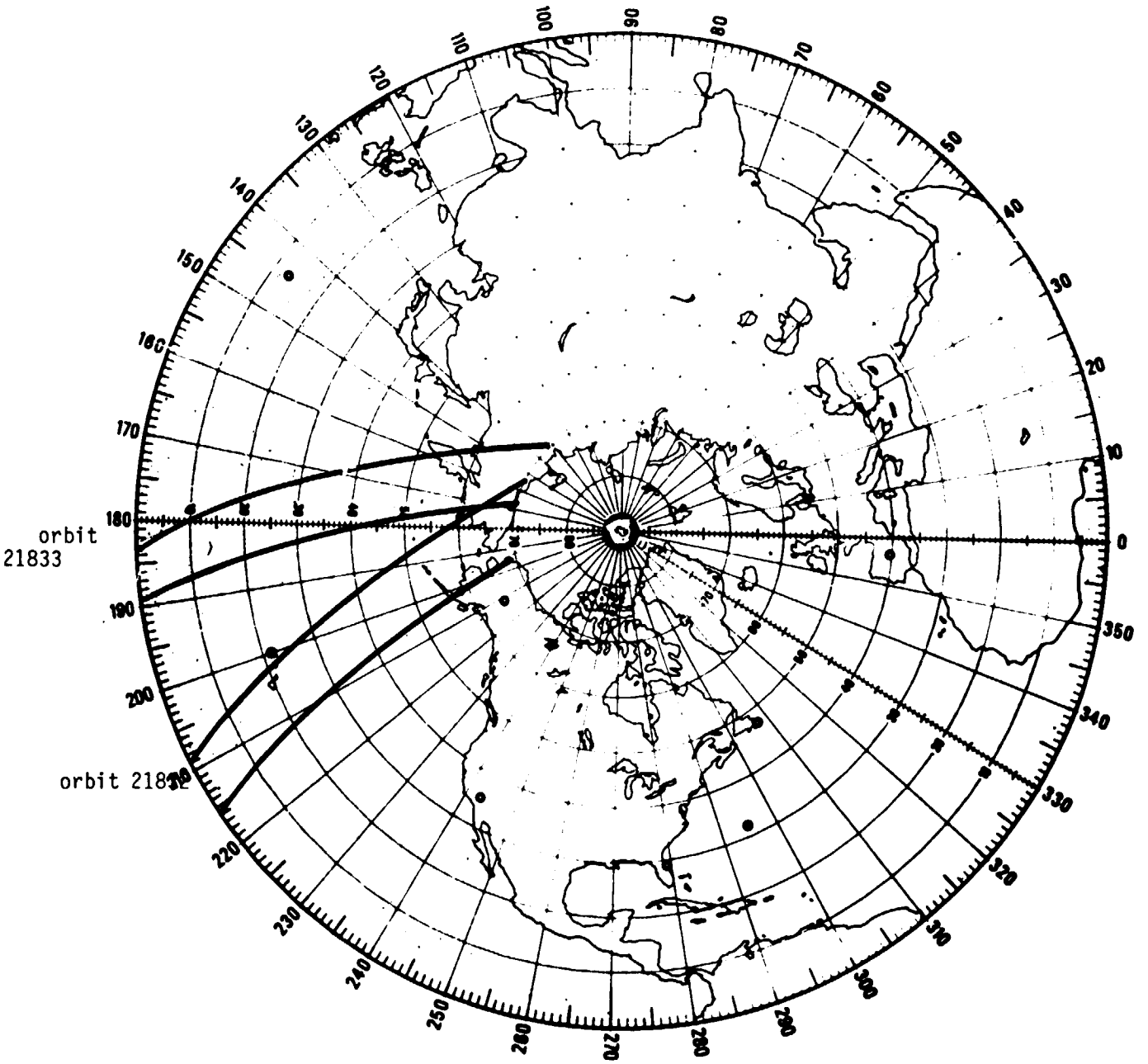
February 18, 1983



NIMBUS-7 SMMR

ORBITAL SWATH LOCATER

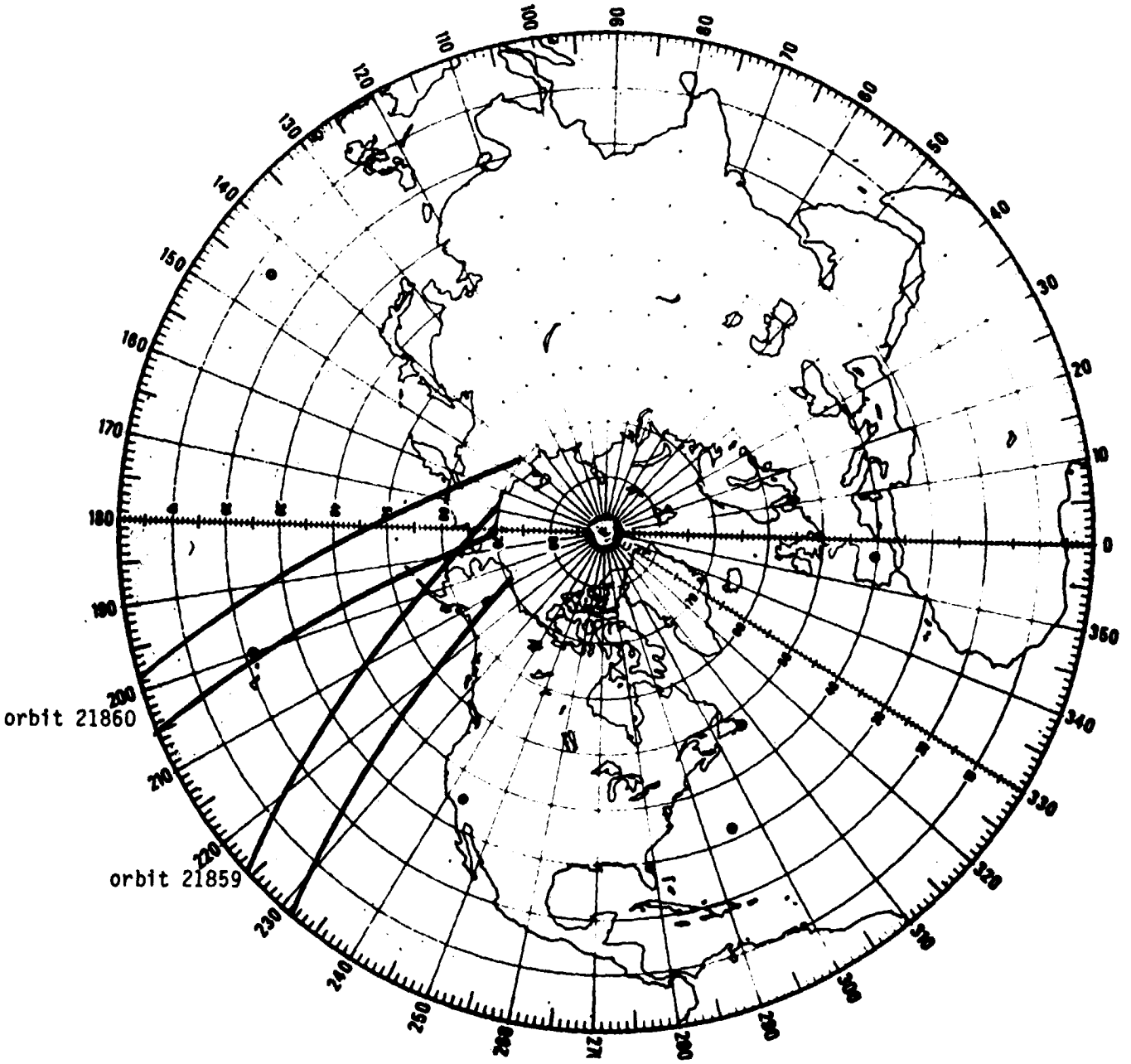
February 19, 1983



NIMBUS-7 SMMR

ORBITAL SWATH LOCATER

February 21, 1983

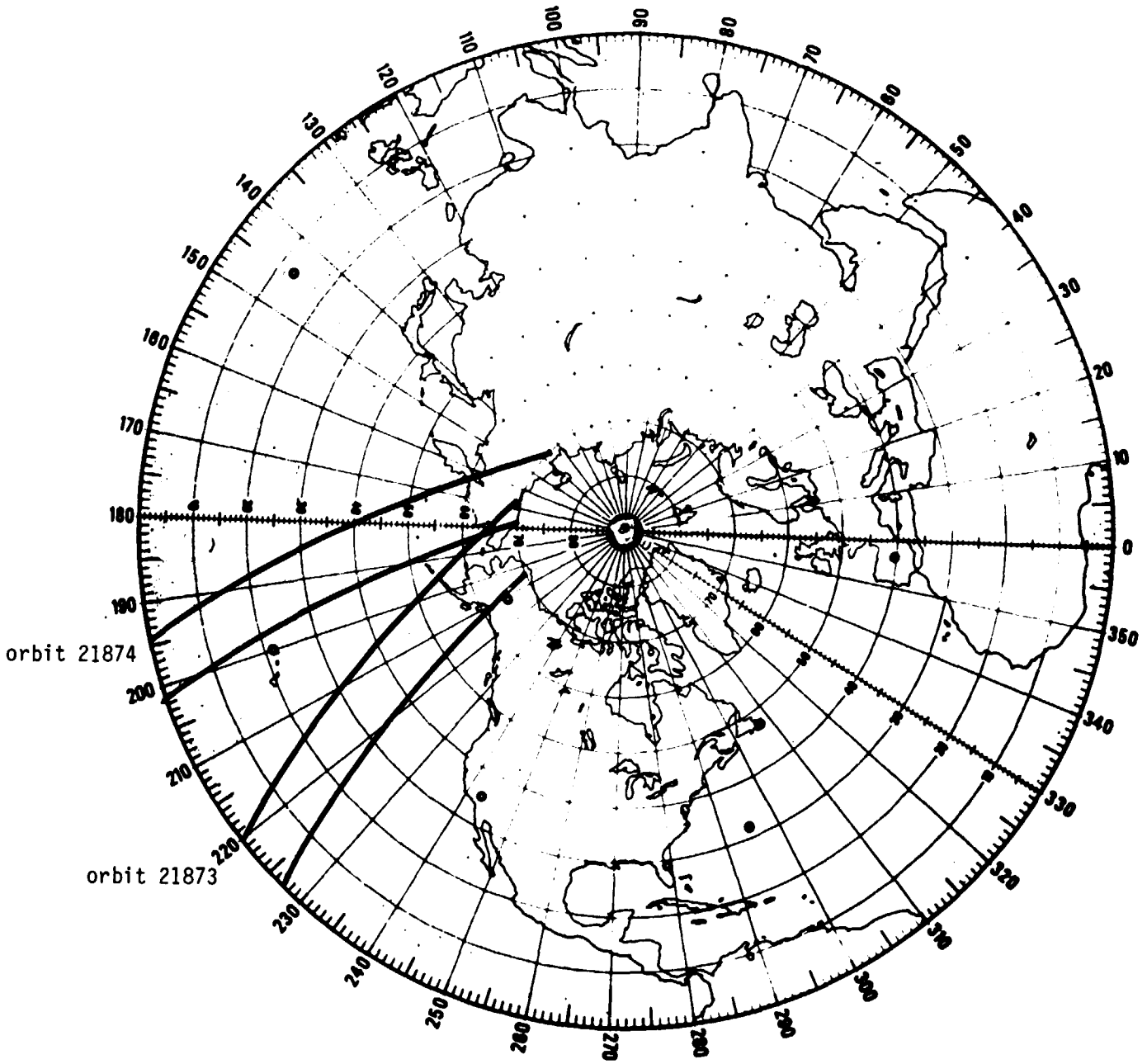


C...
OF ...

NIMBUS-7 SMMR

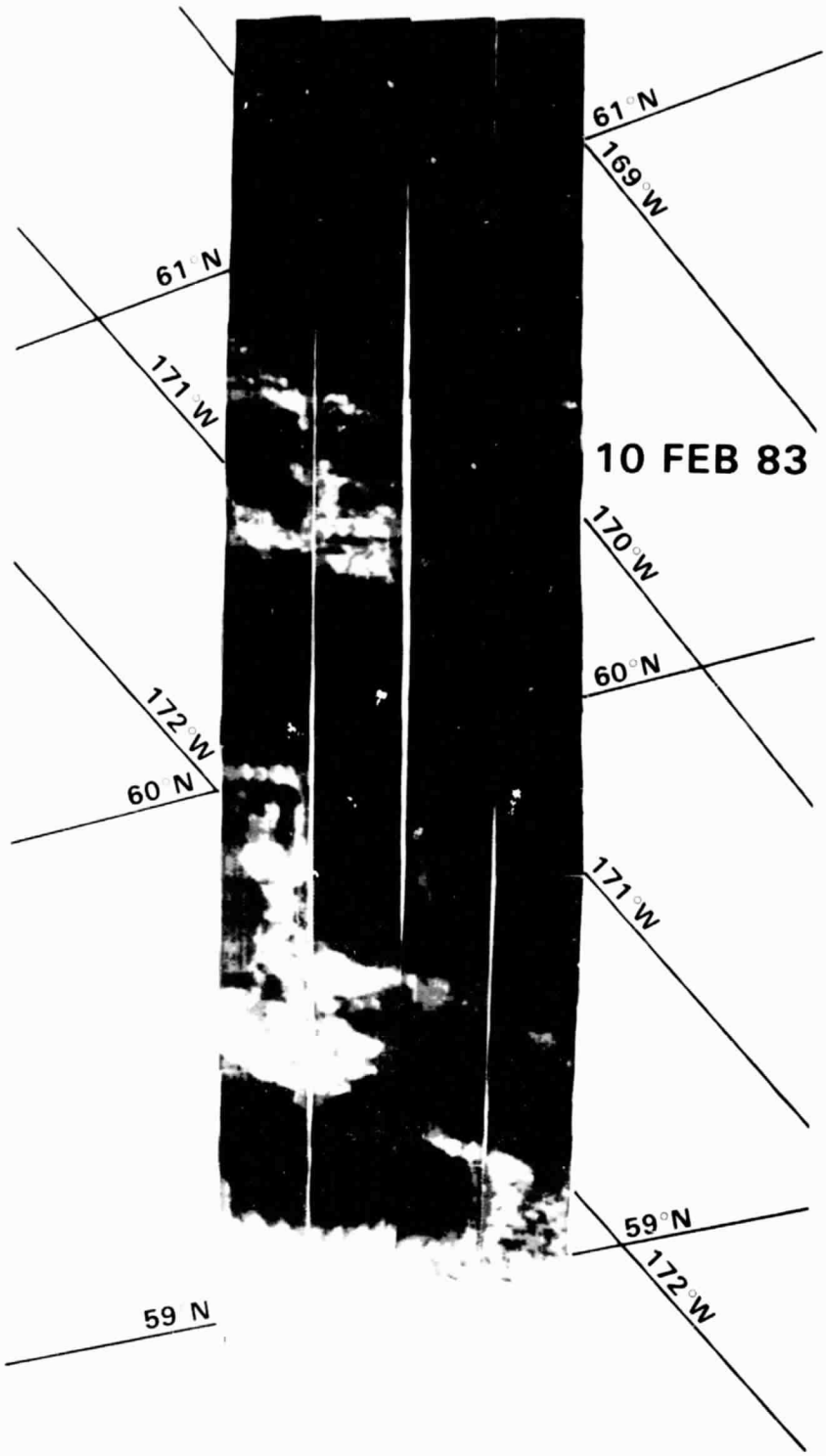
ORBITAL SWATH LOCATER

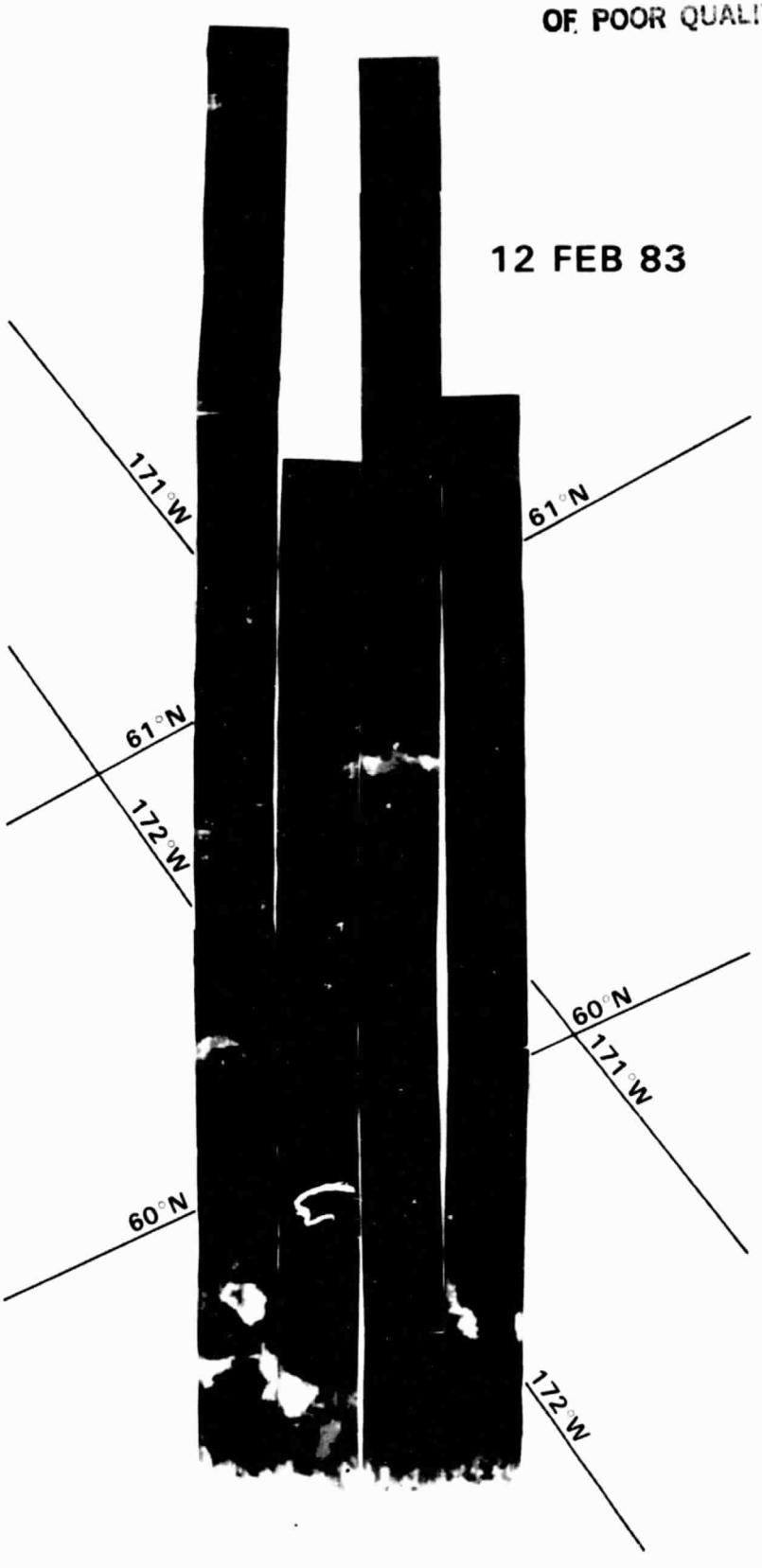
February 22, 1983

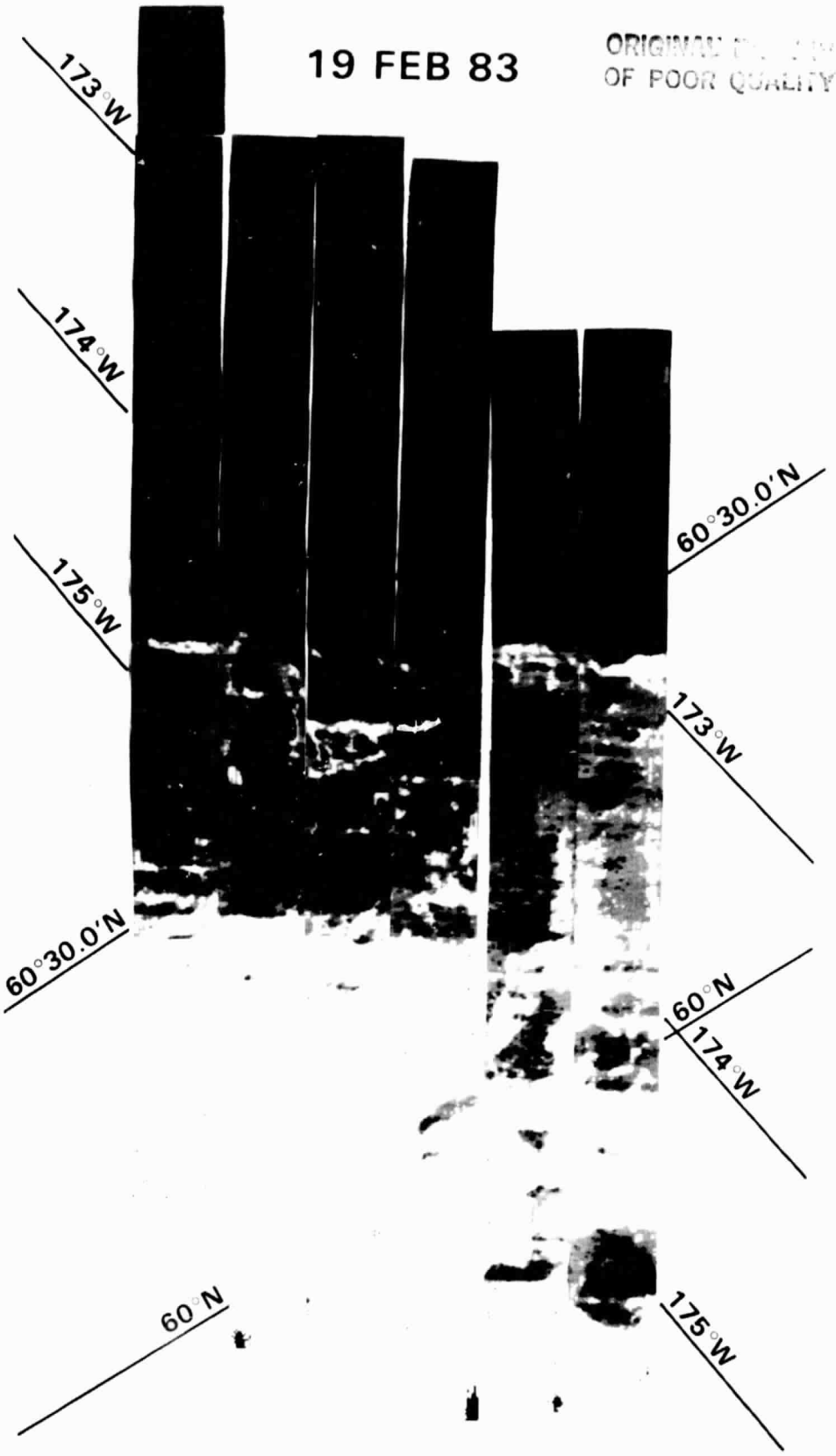


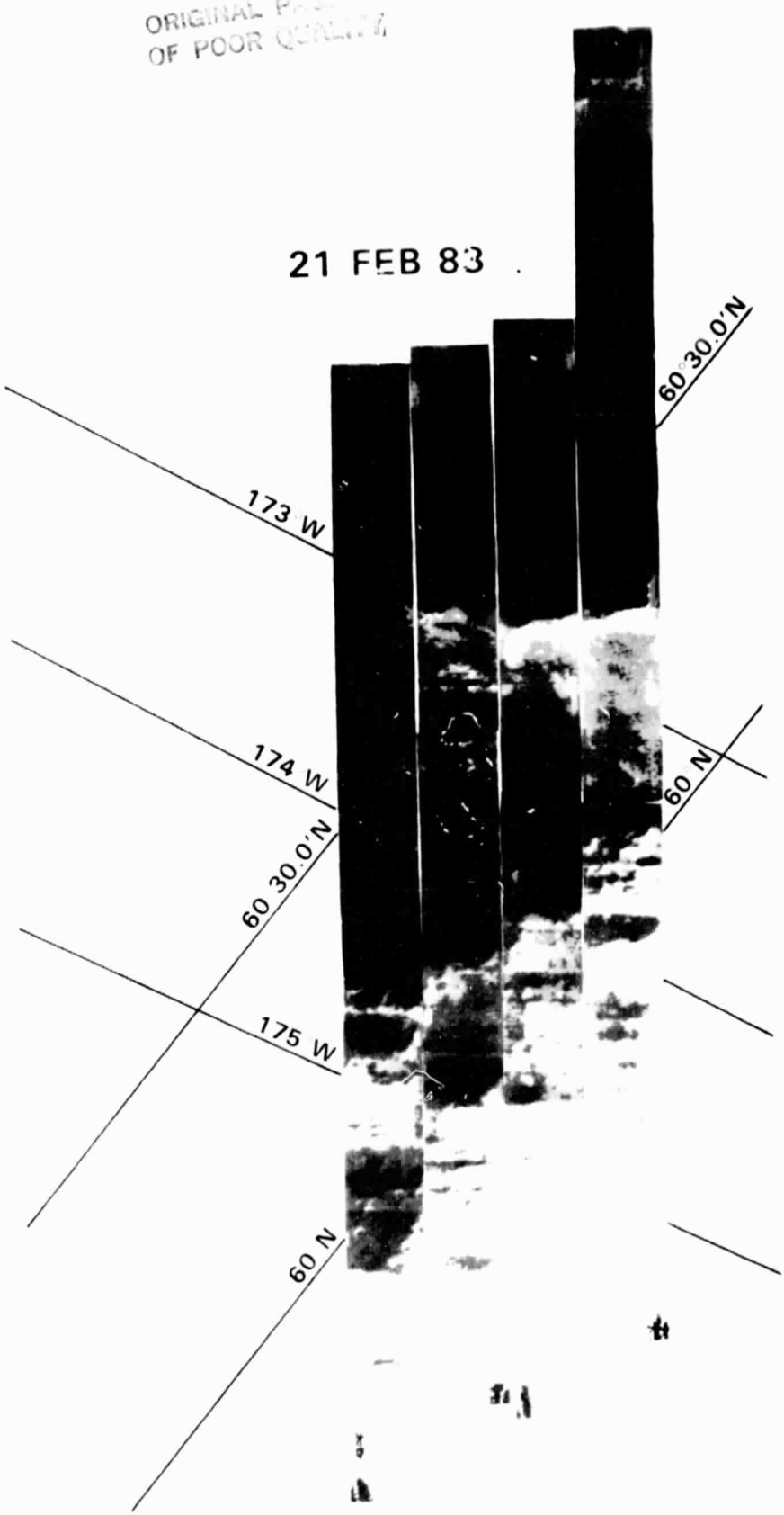
APPENDIX C

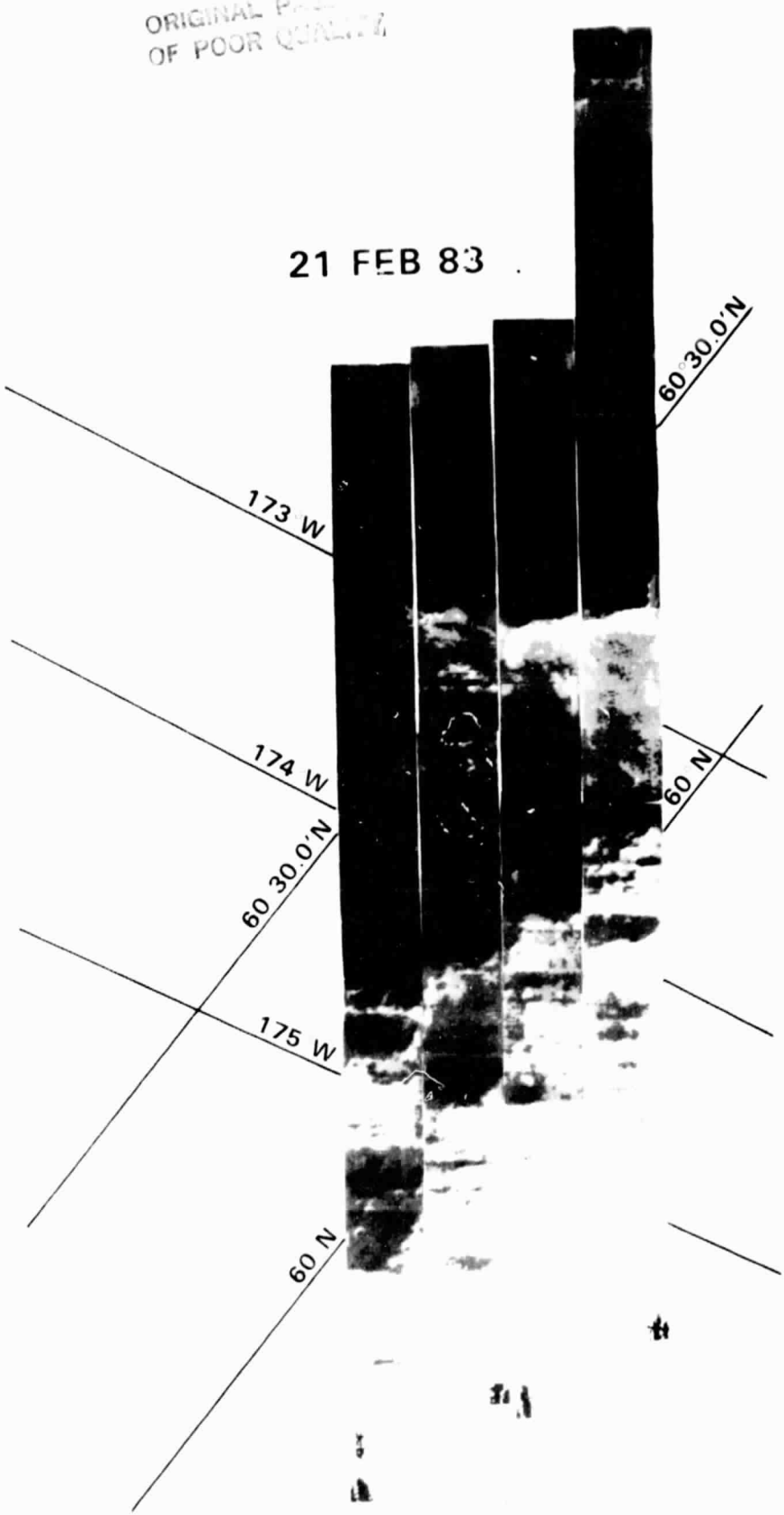
A/C ESMR Mosaics

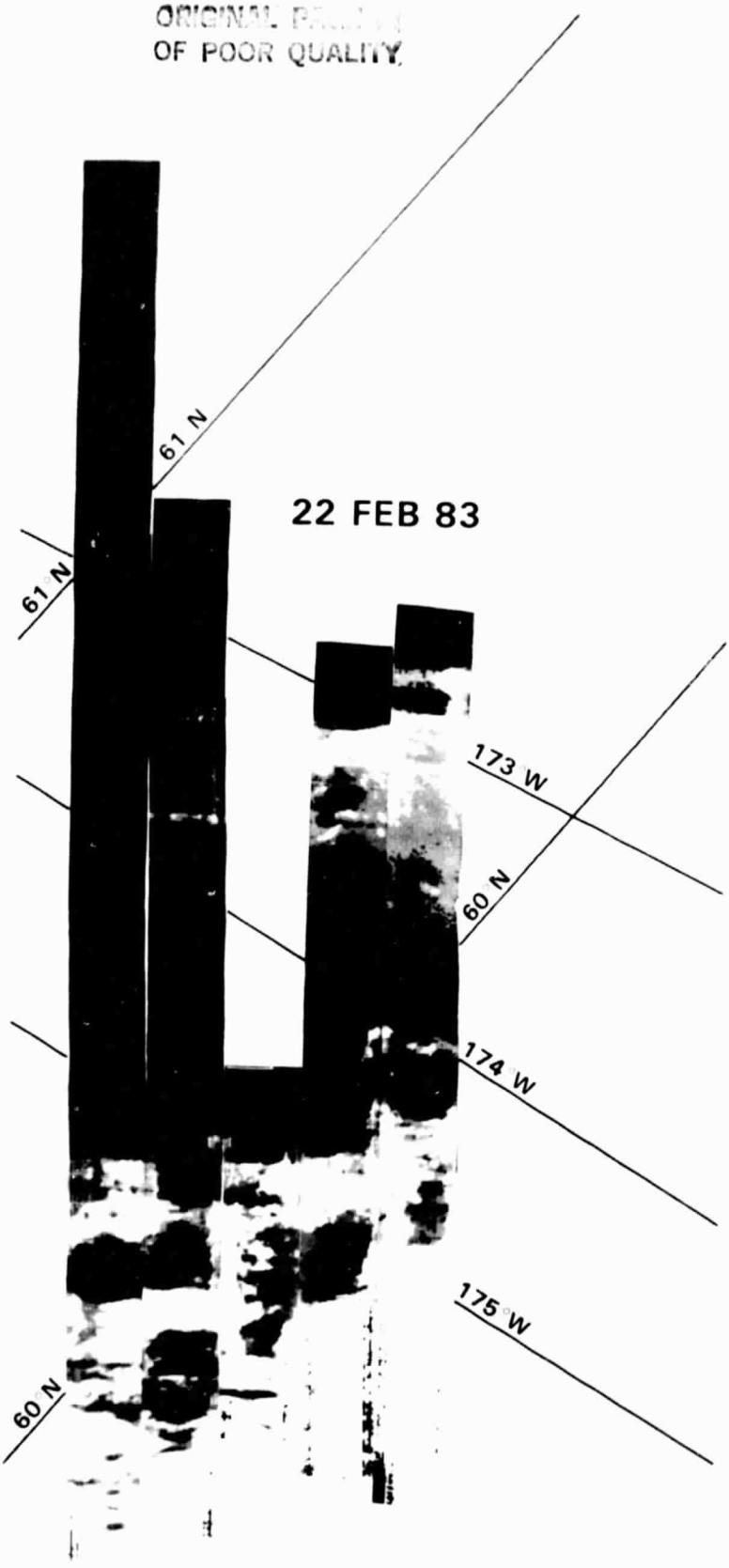





19 FEB 83
ORIGINAL PAGE IS
OF POOR QUALITY
173°W
174°W
175°W
60°30.0'N
60°N

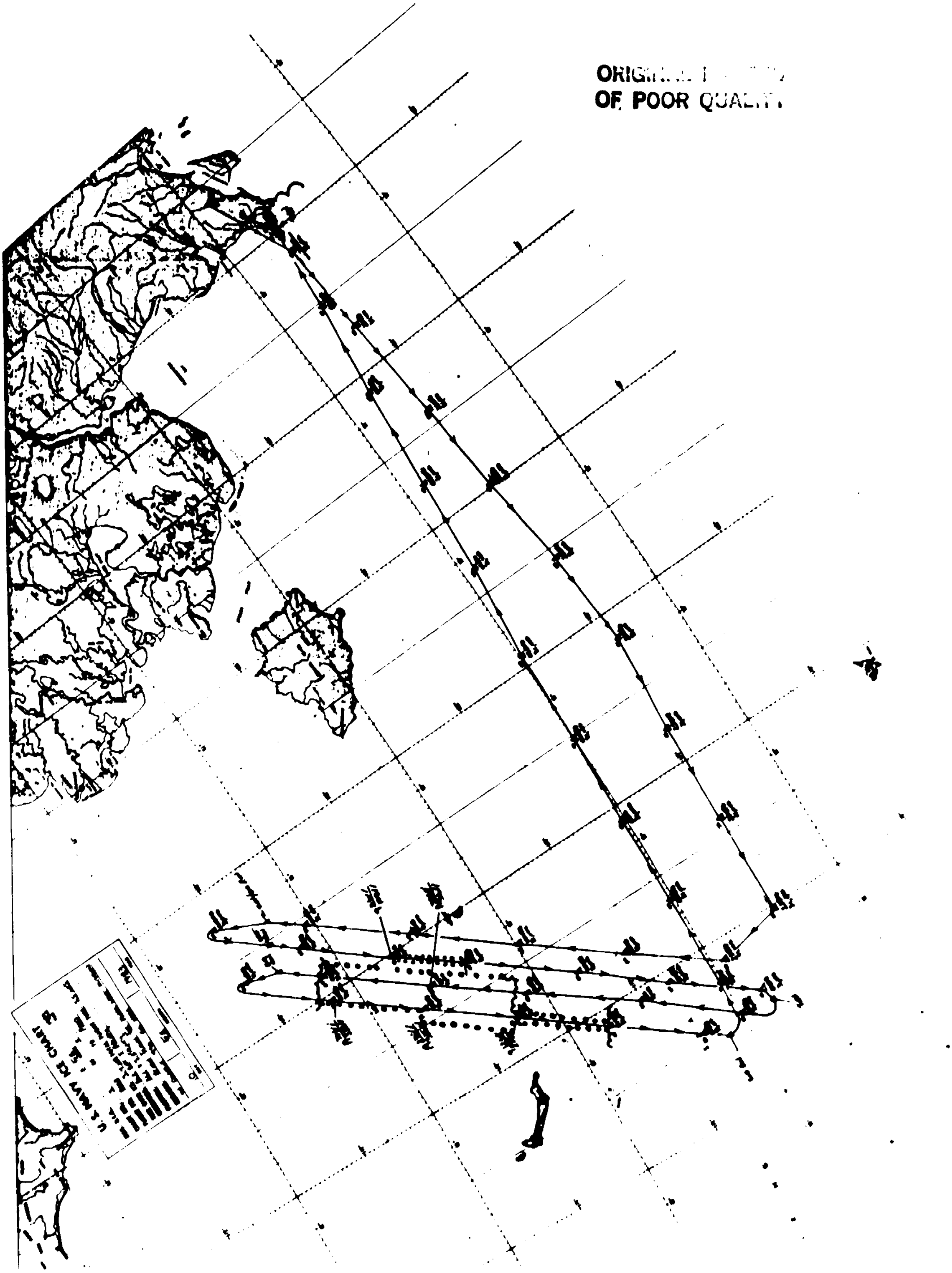


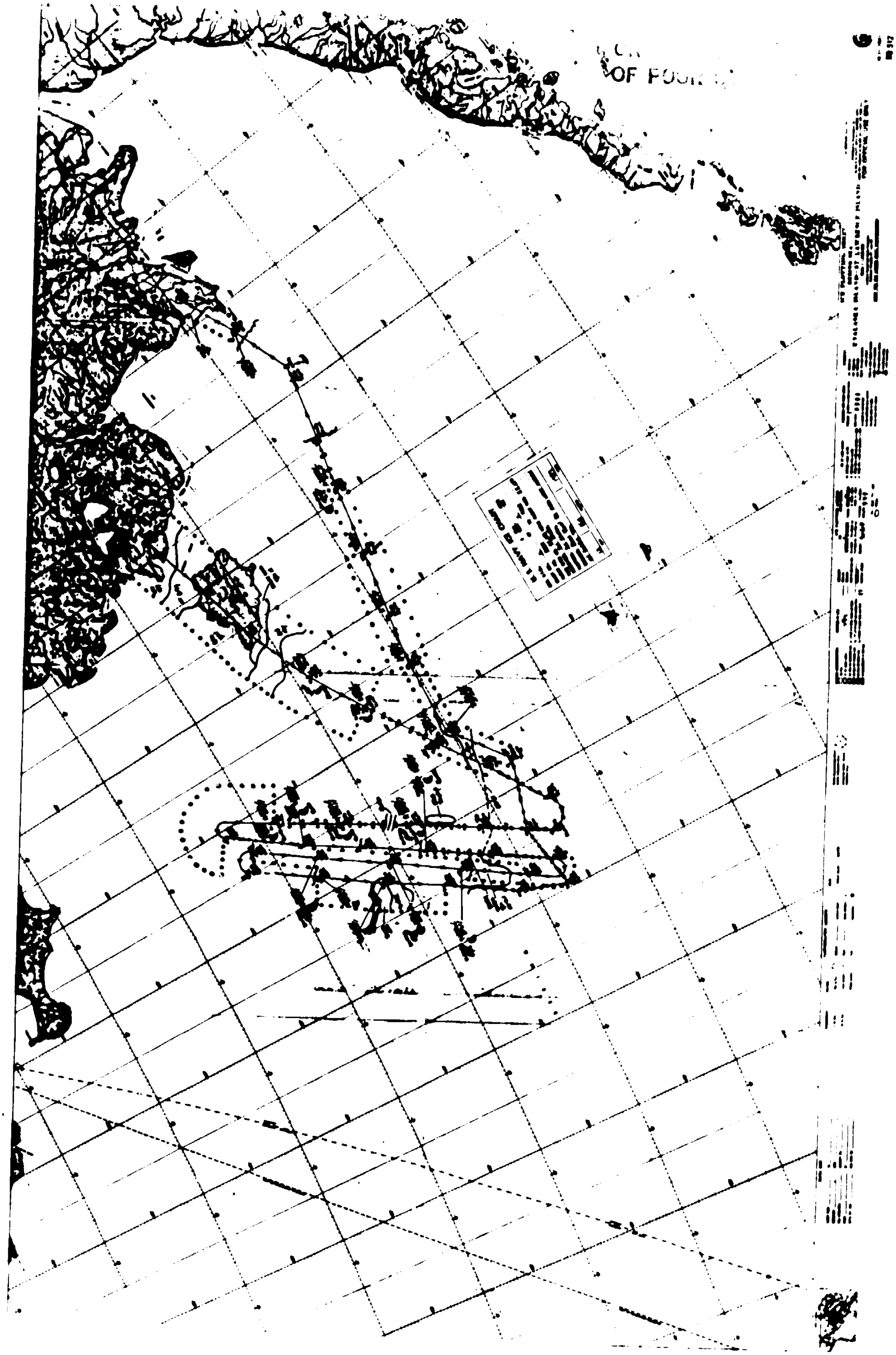


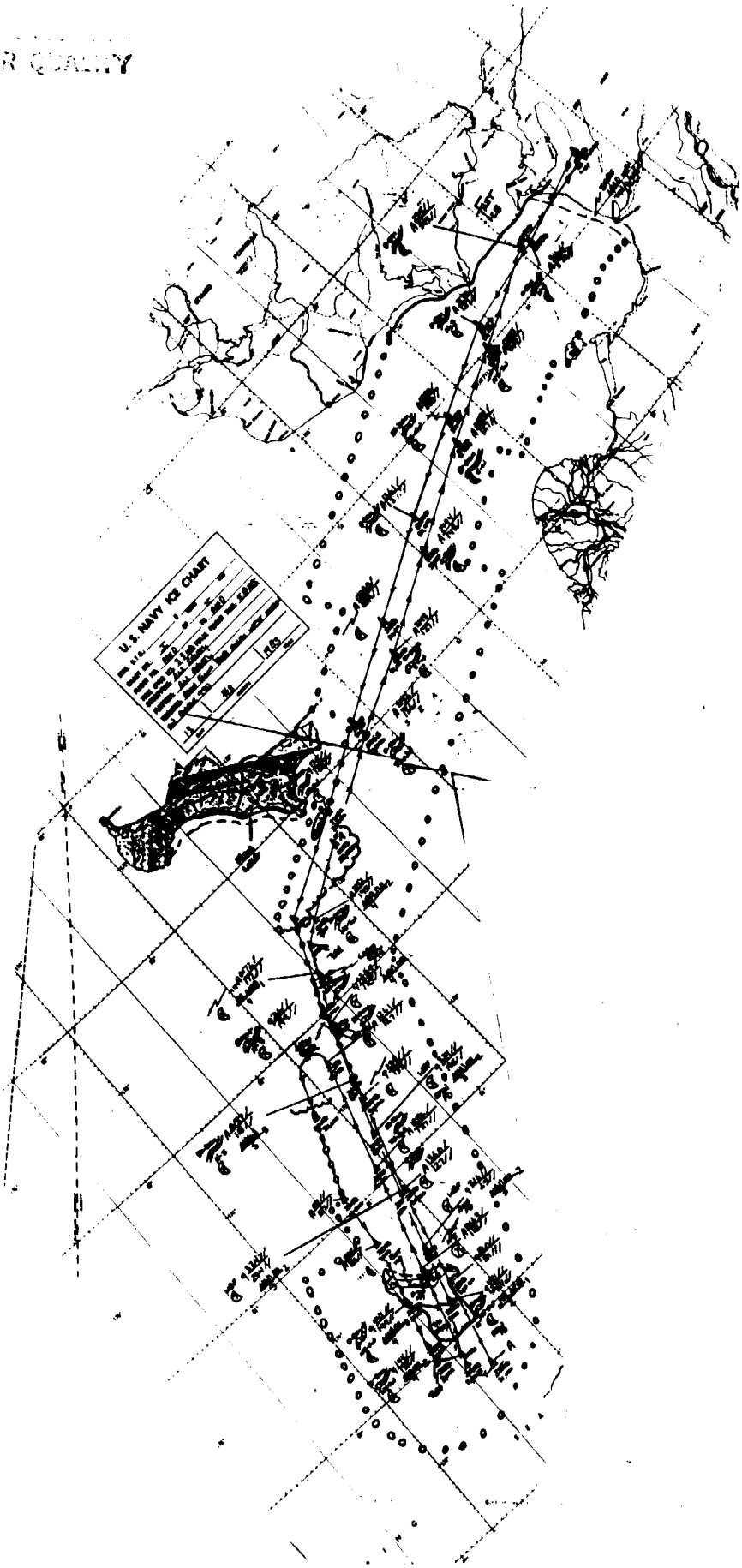


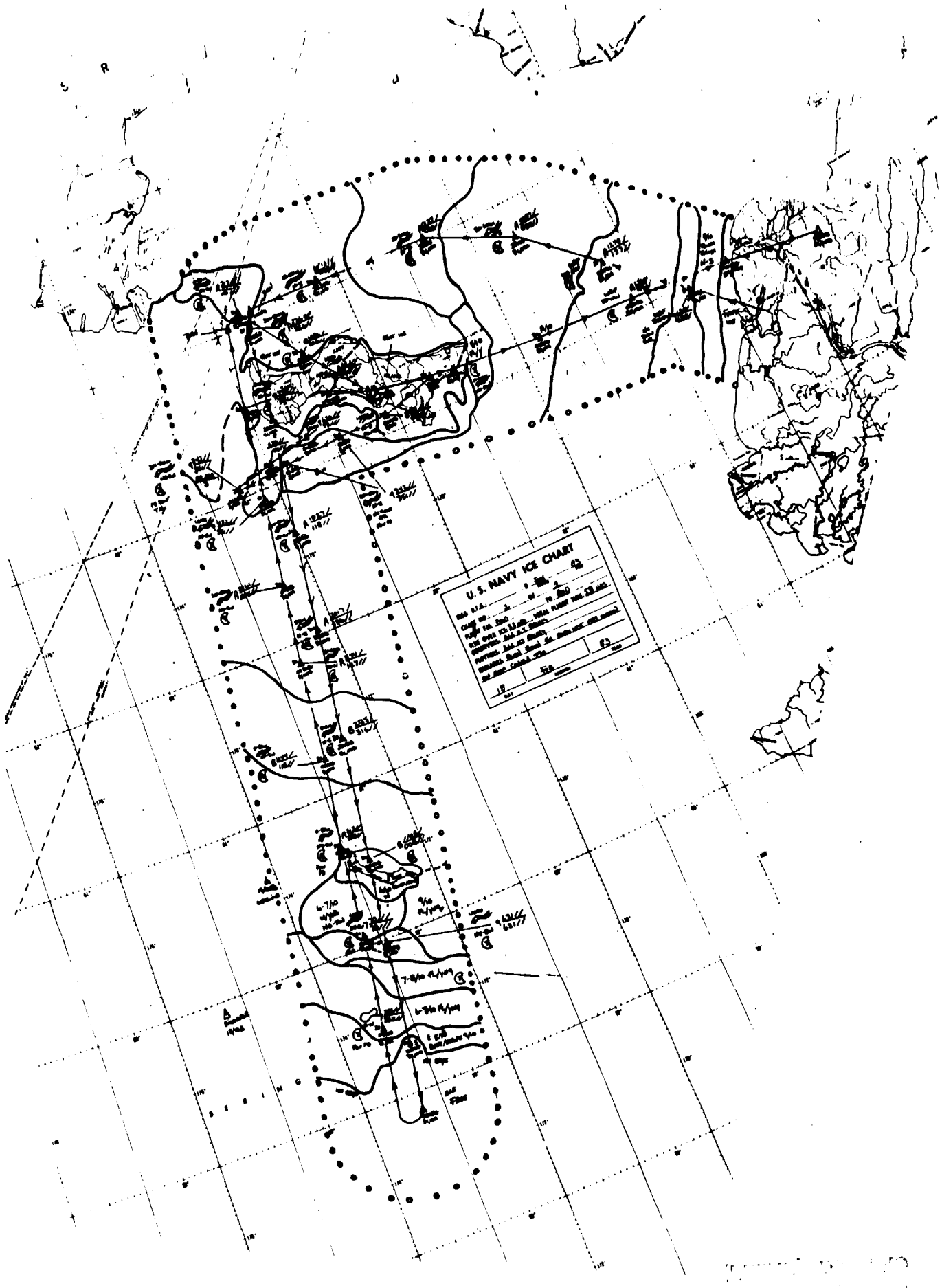
APPENDIX D

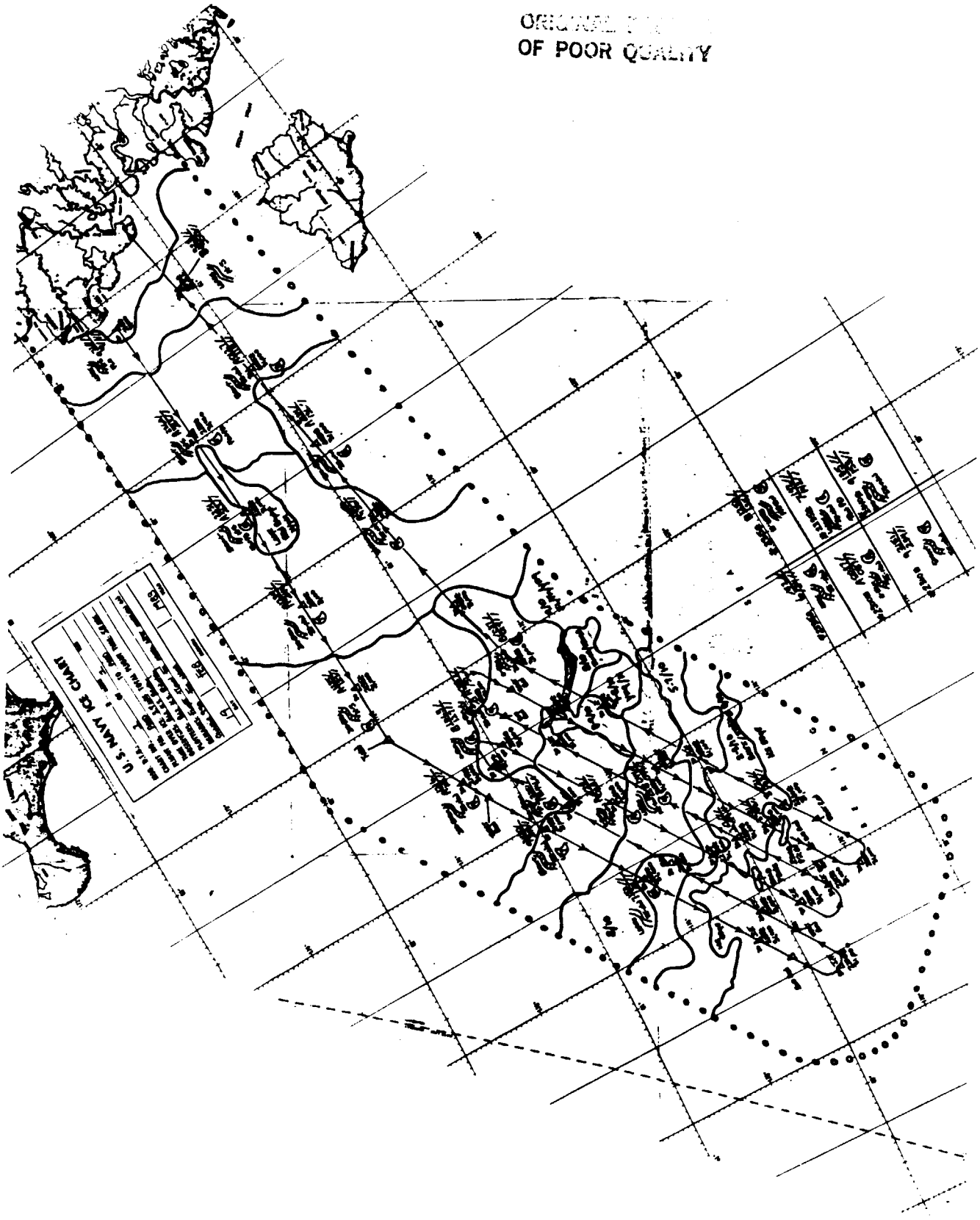
Ice Charts

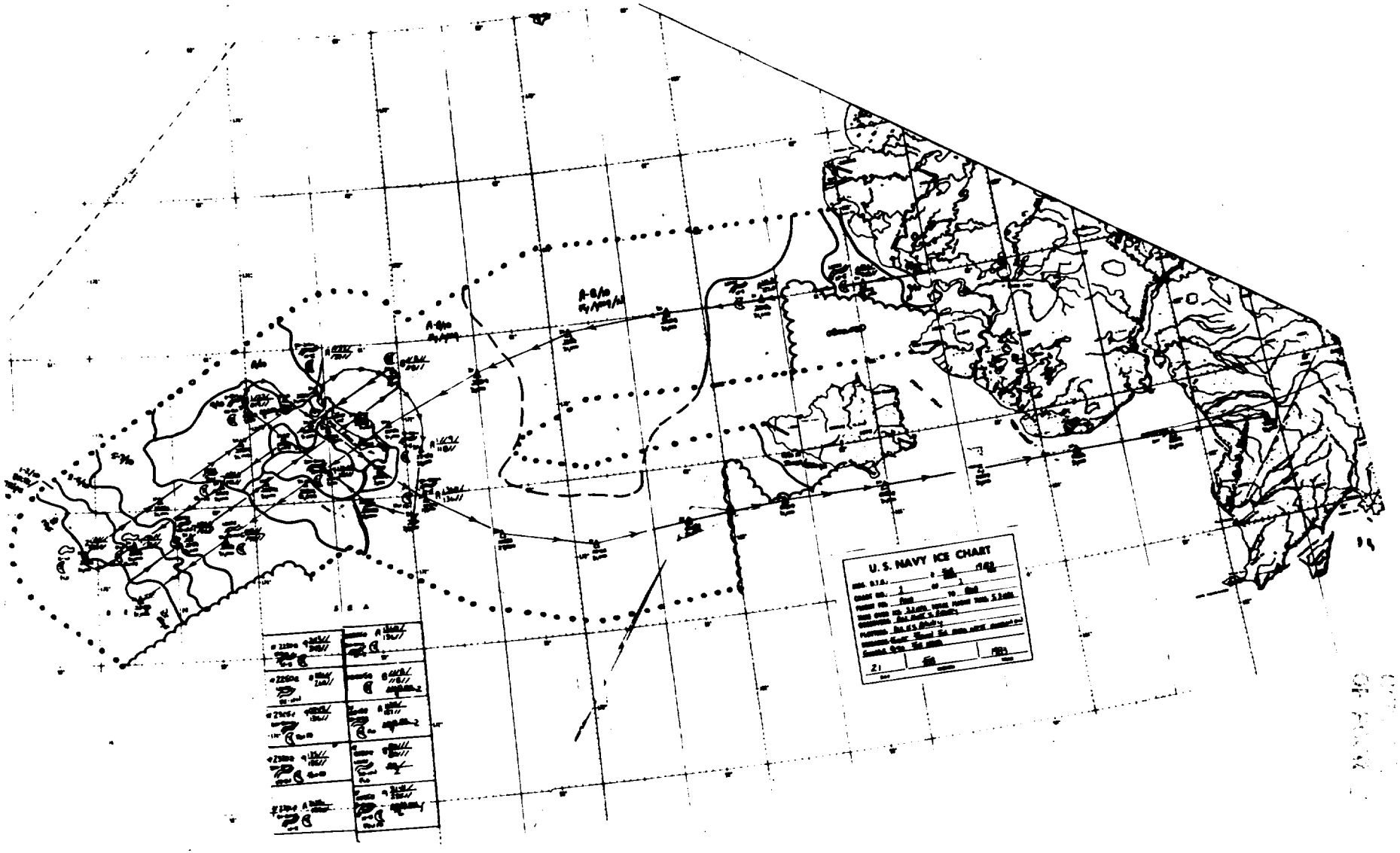


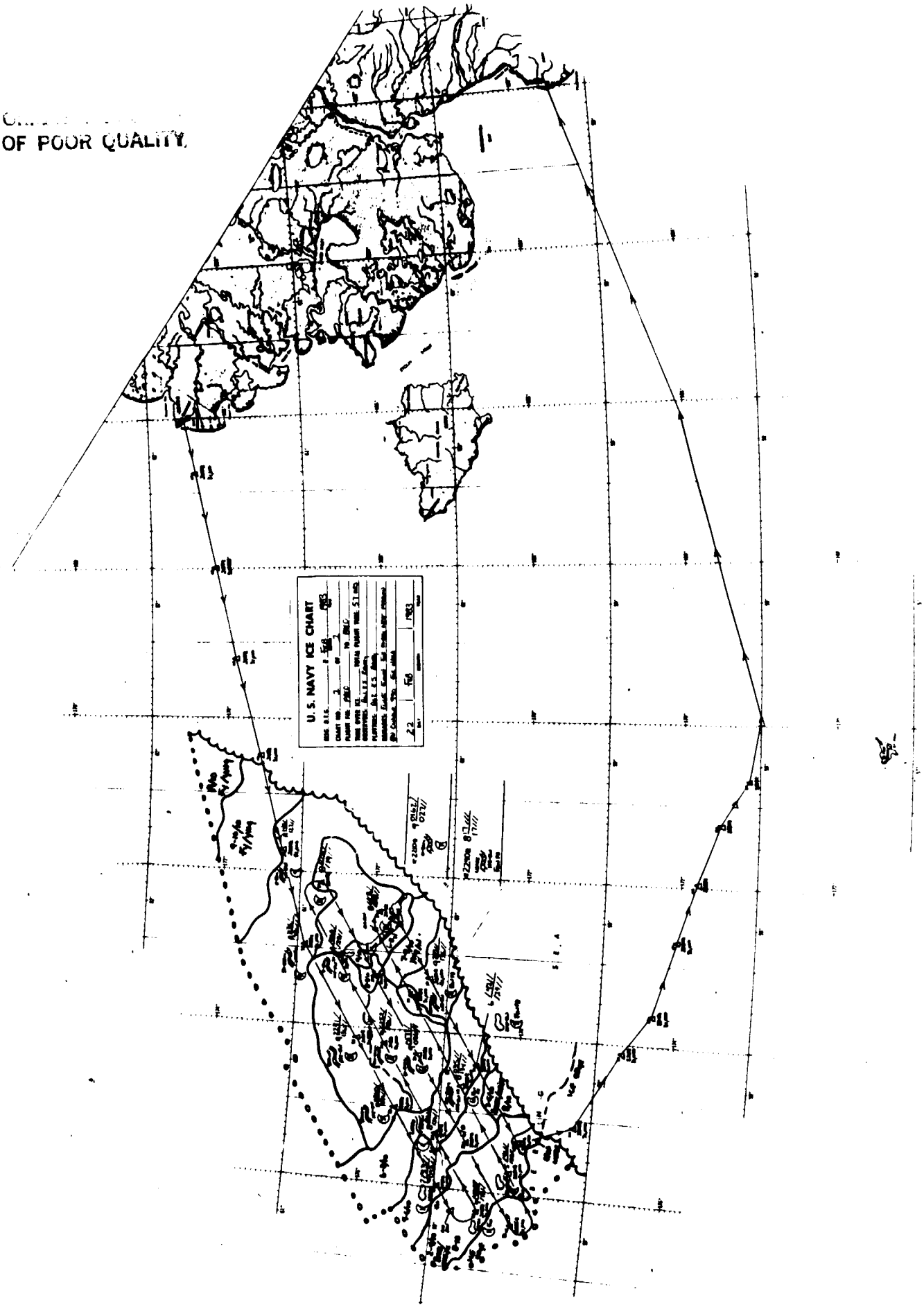





U.S. NAVY ICE CHART

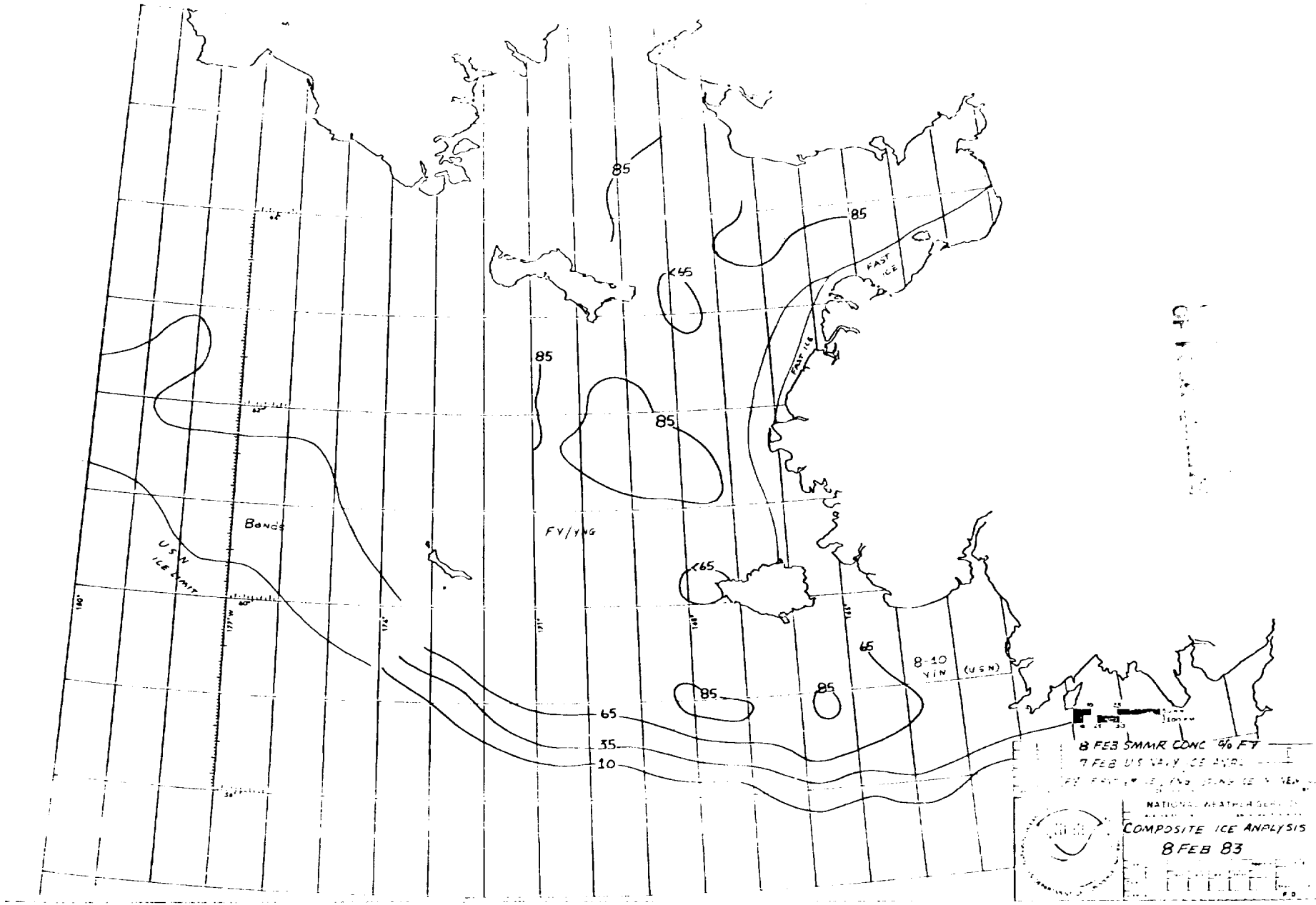


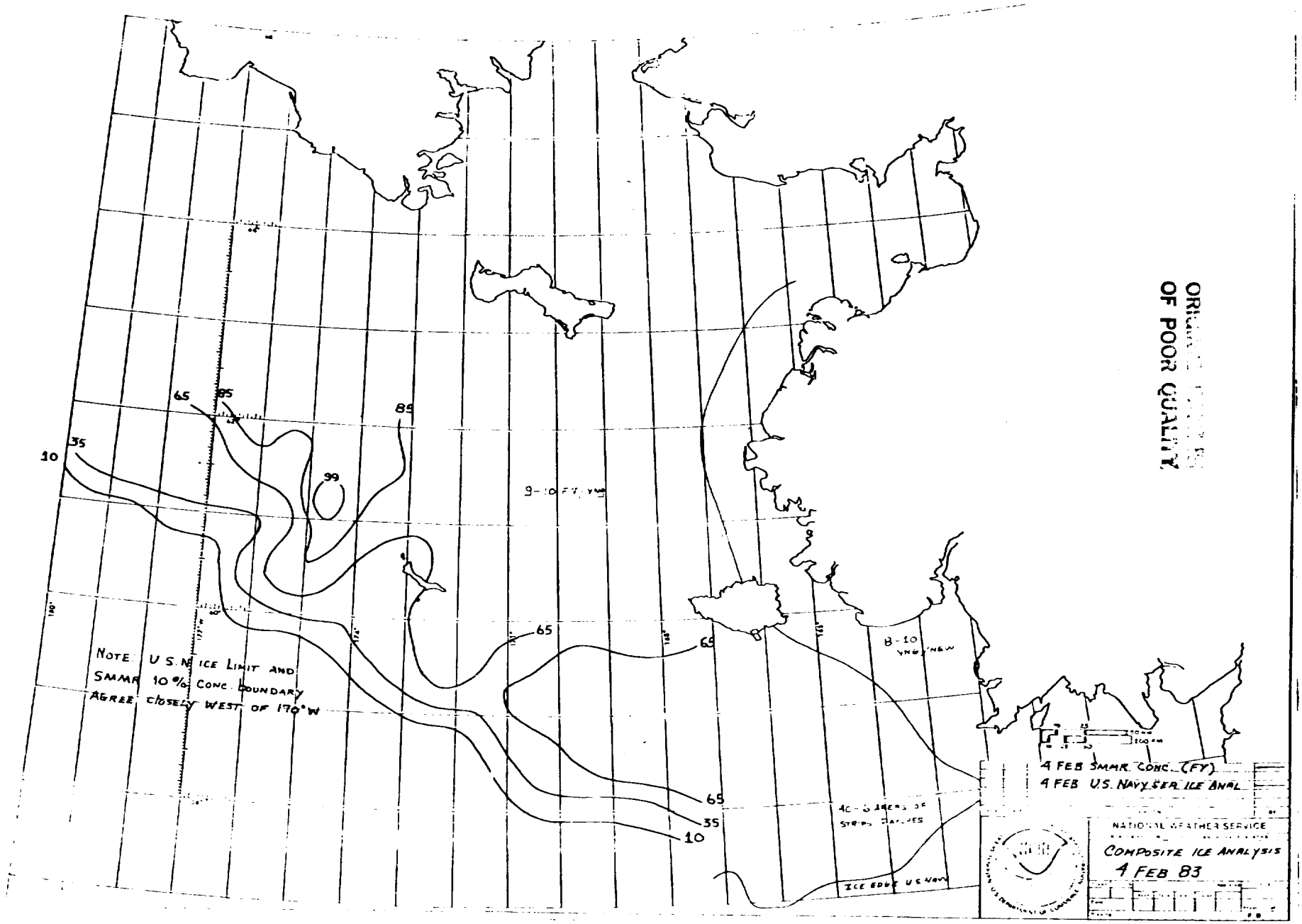

U.S. NAVY ICE CHART

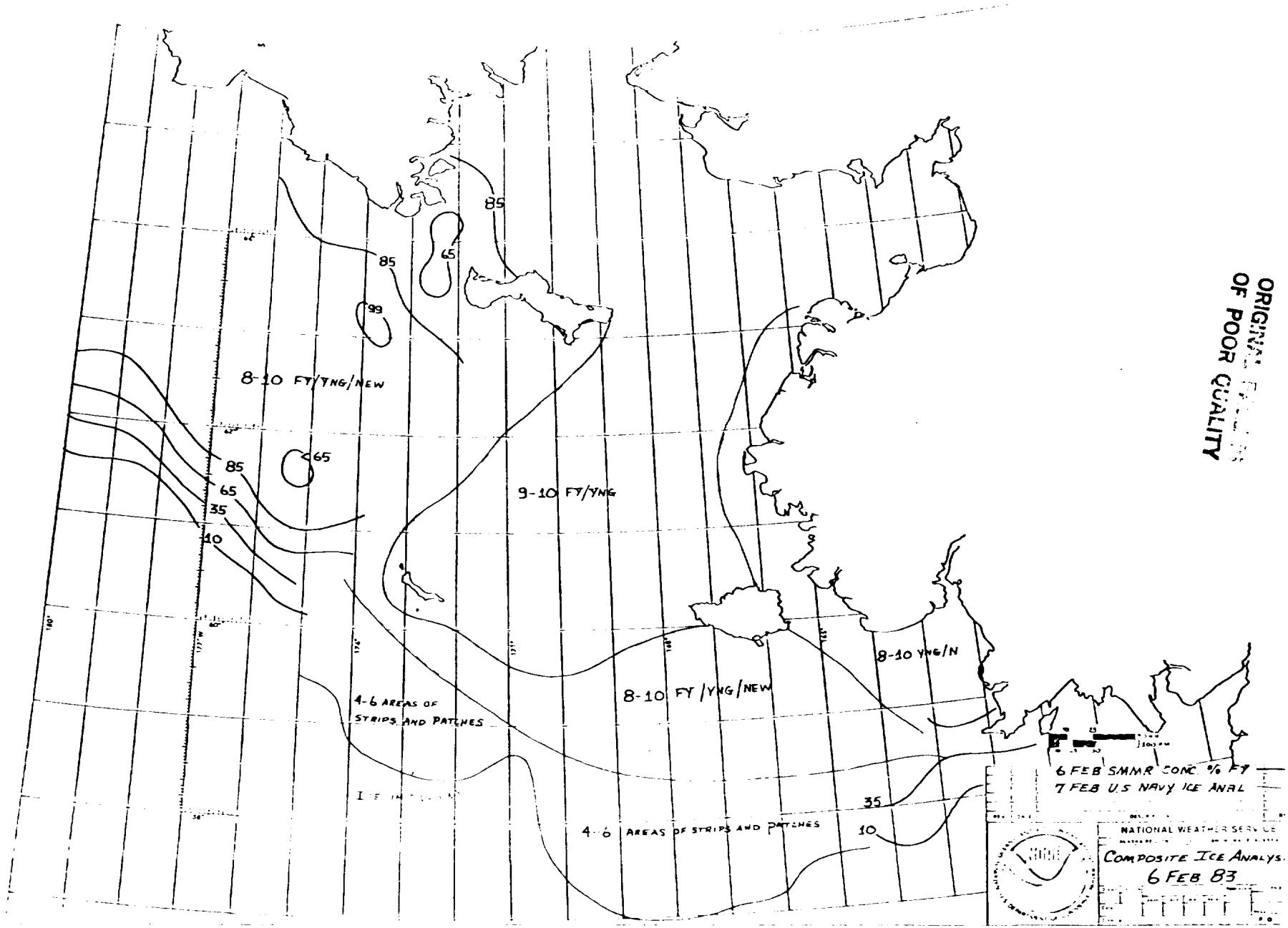


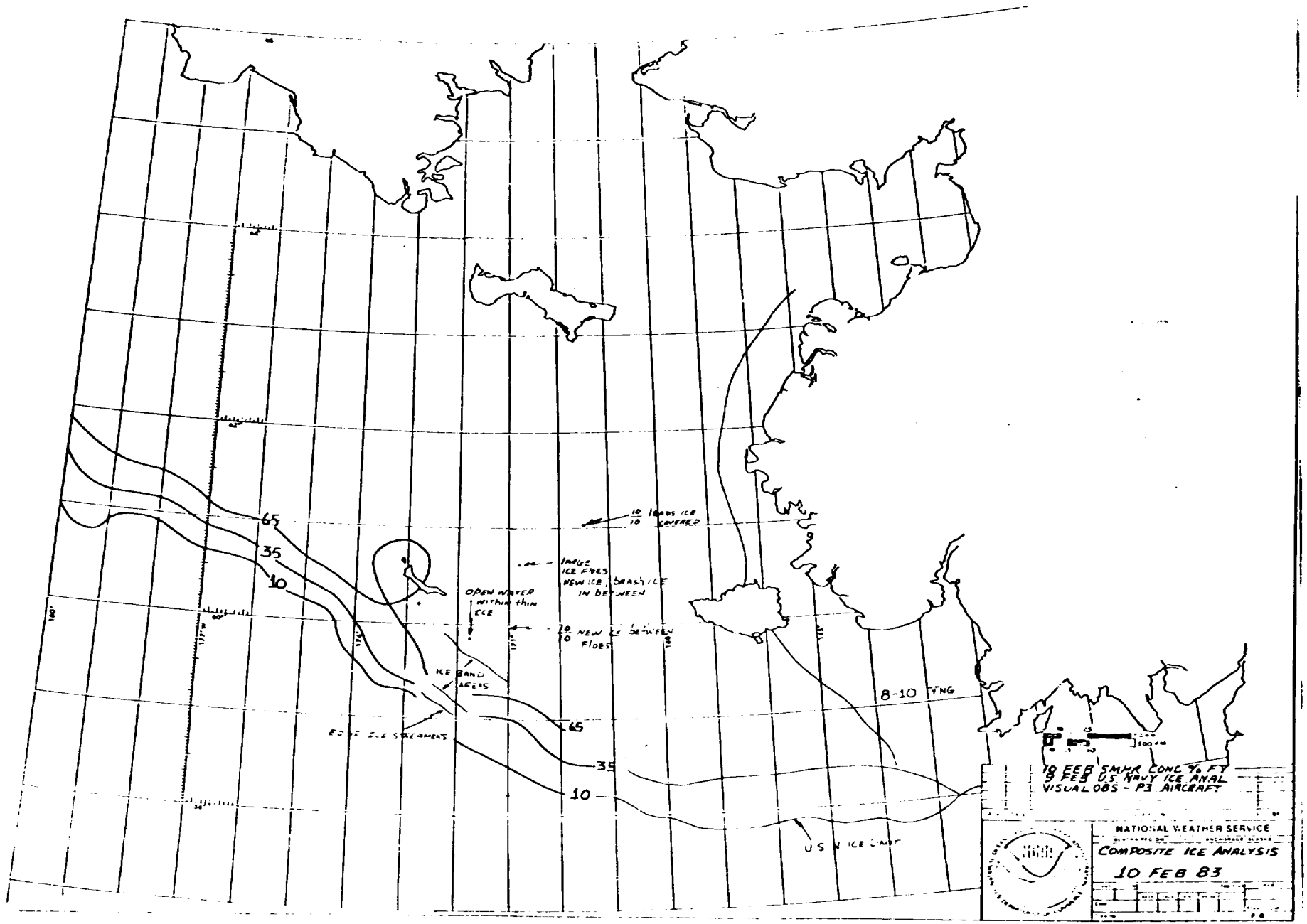
APPENDIX E

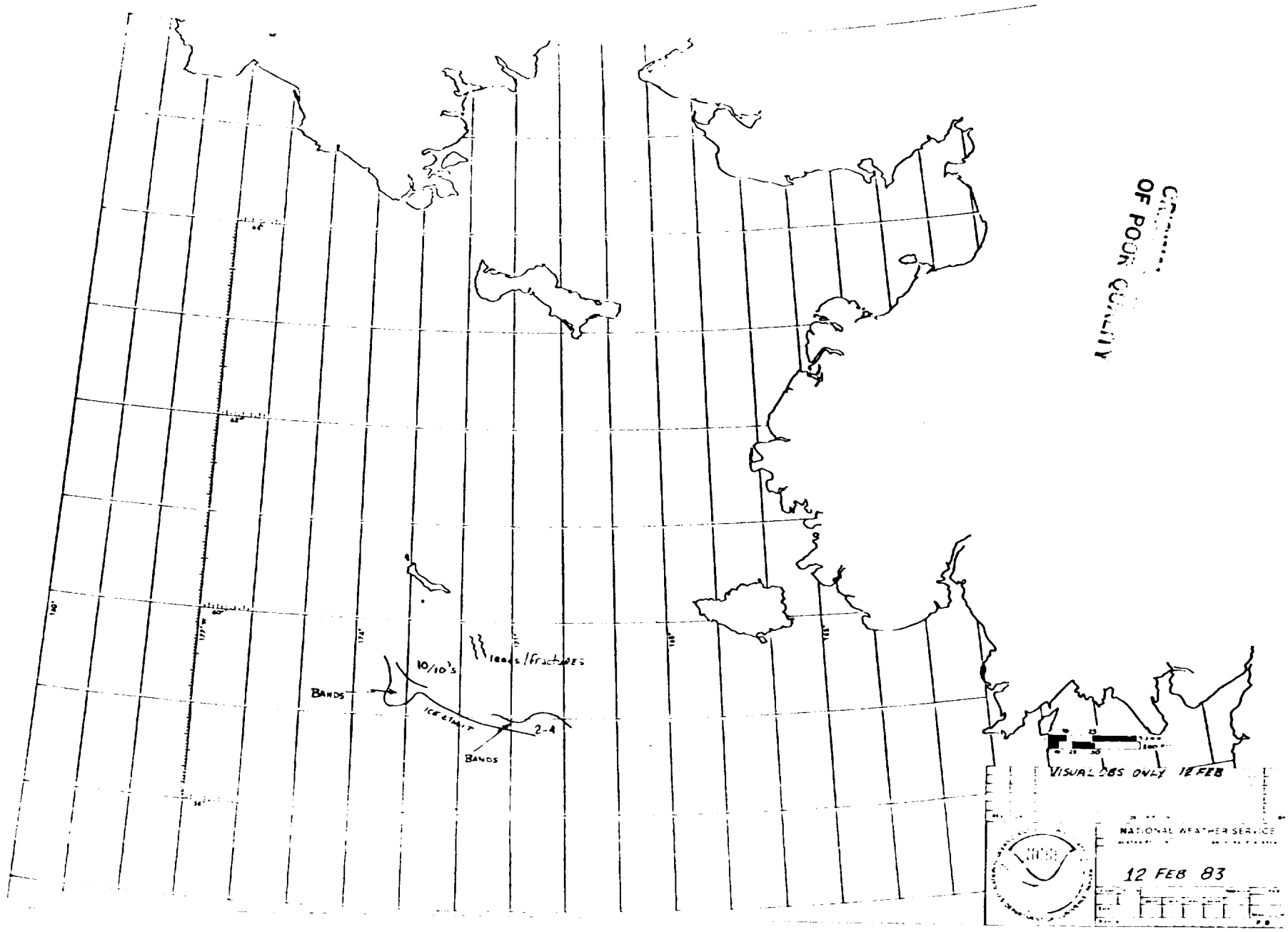
Composite Ice Maps

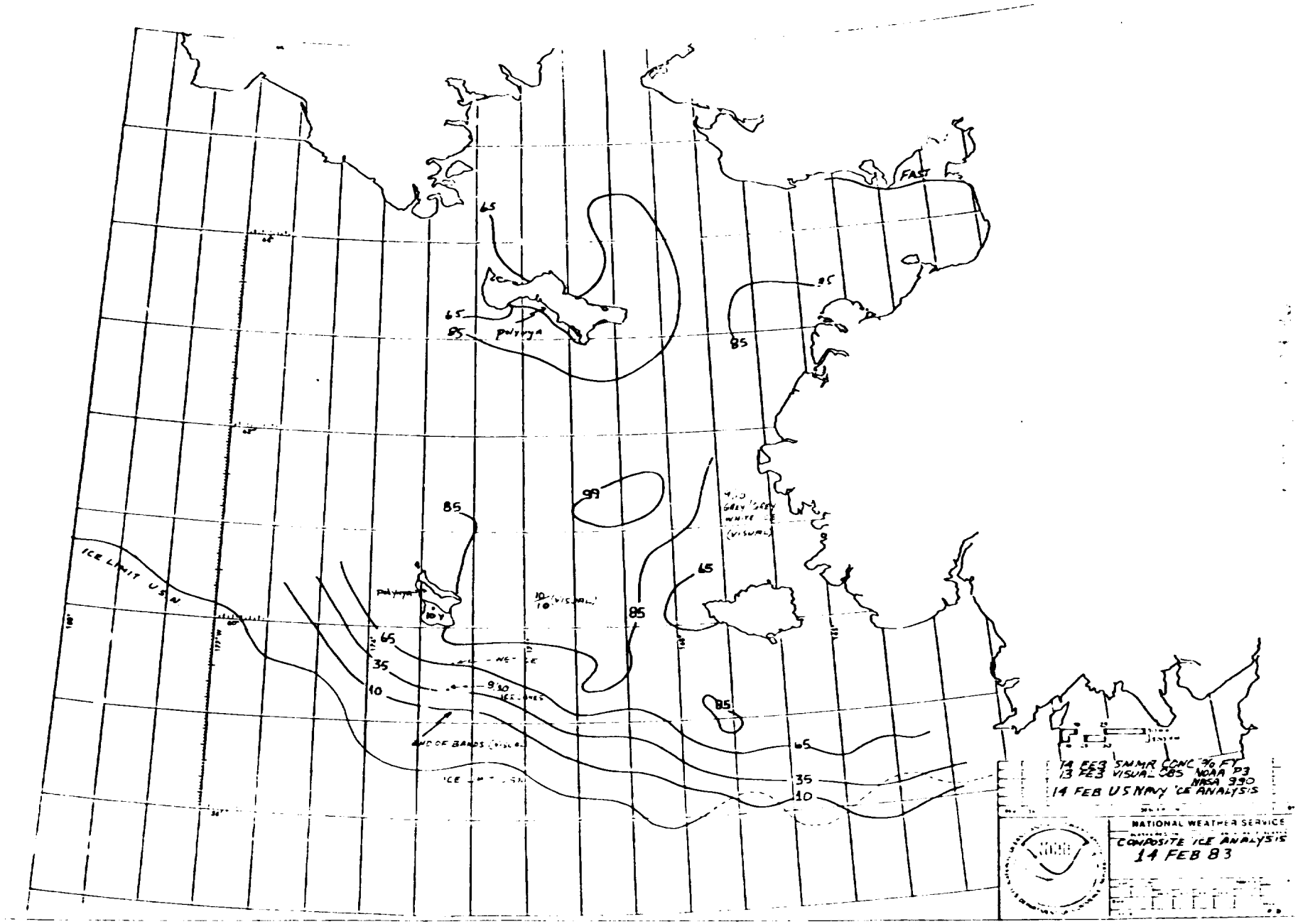

85
85
85
85
65
65
65
65
35
10
FAST ICE
FAST ICE
Bands
FY/YNG
USN ICE LIMIT
8-10 YIN (USN)
8 FEB SMMR CONC % FT
7 FEB USN/NOAA ICE ANAL
COMPOSITE ICE ANALYSIS
8 FEB 83

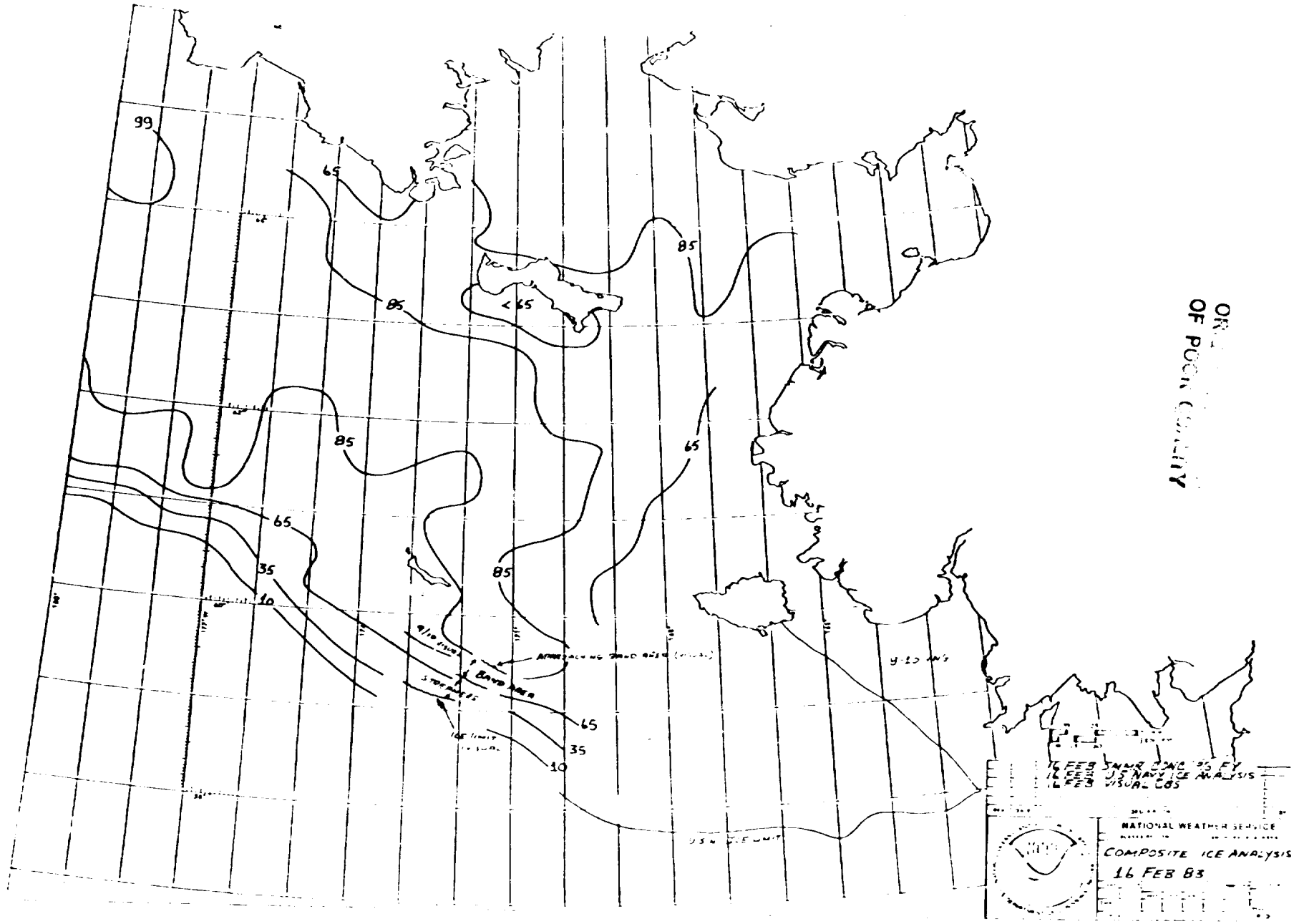


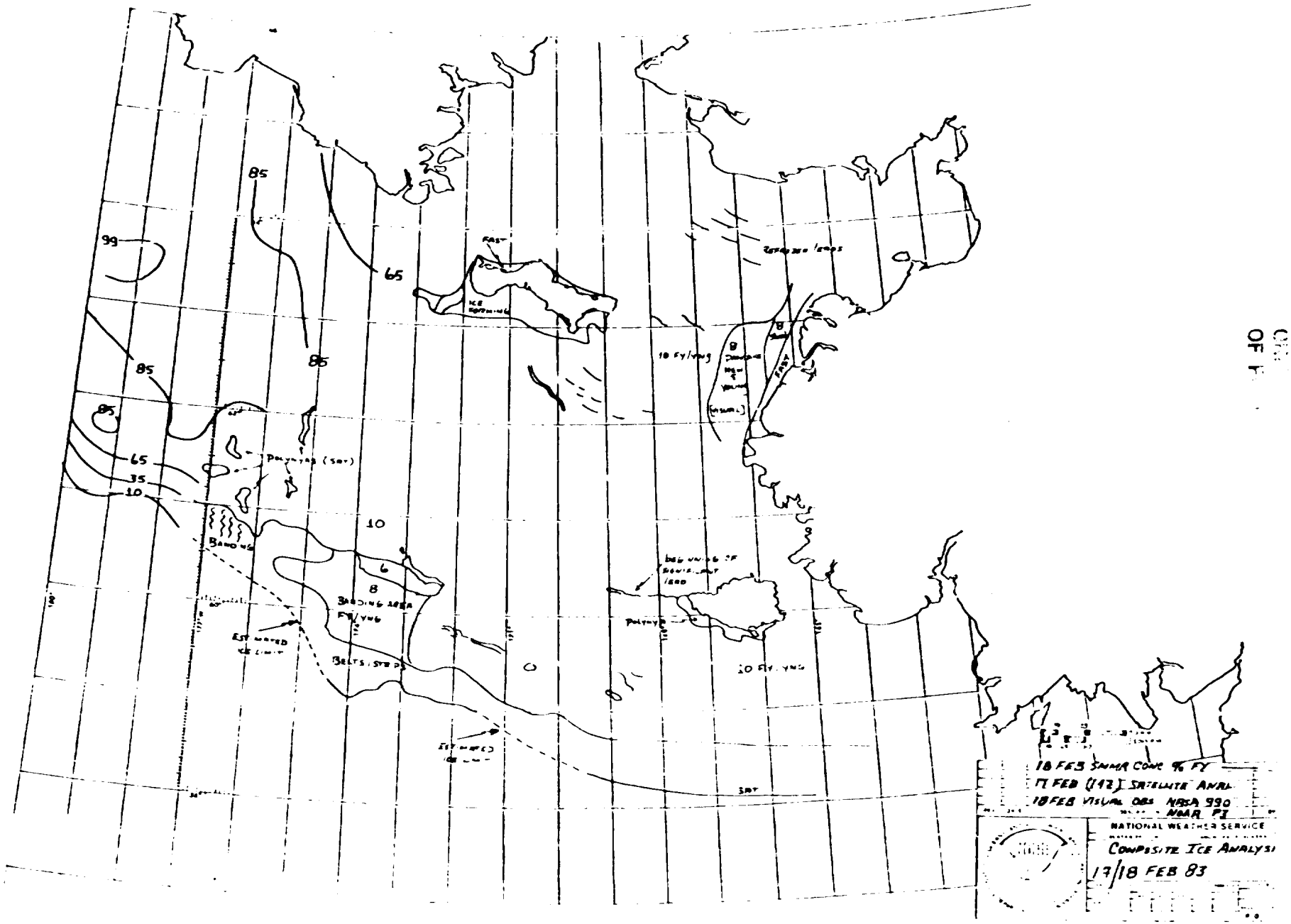


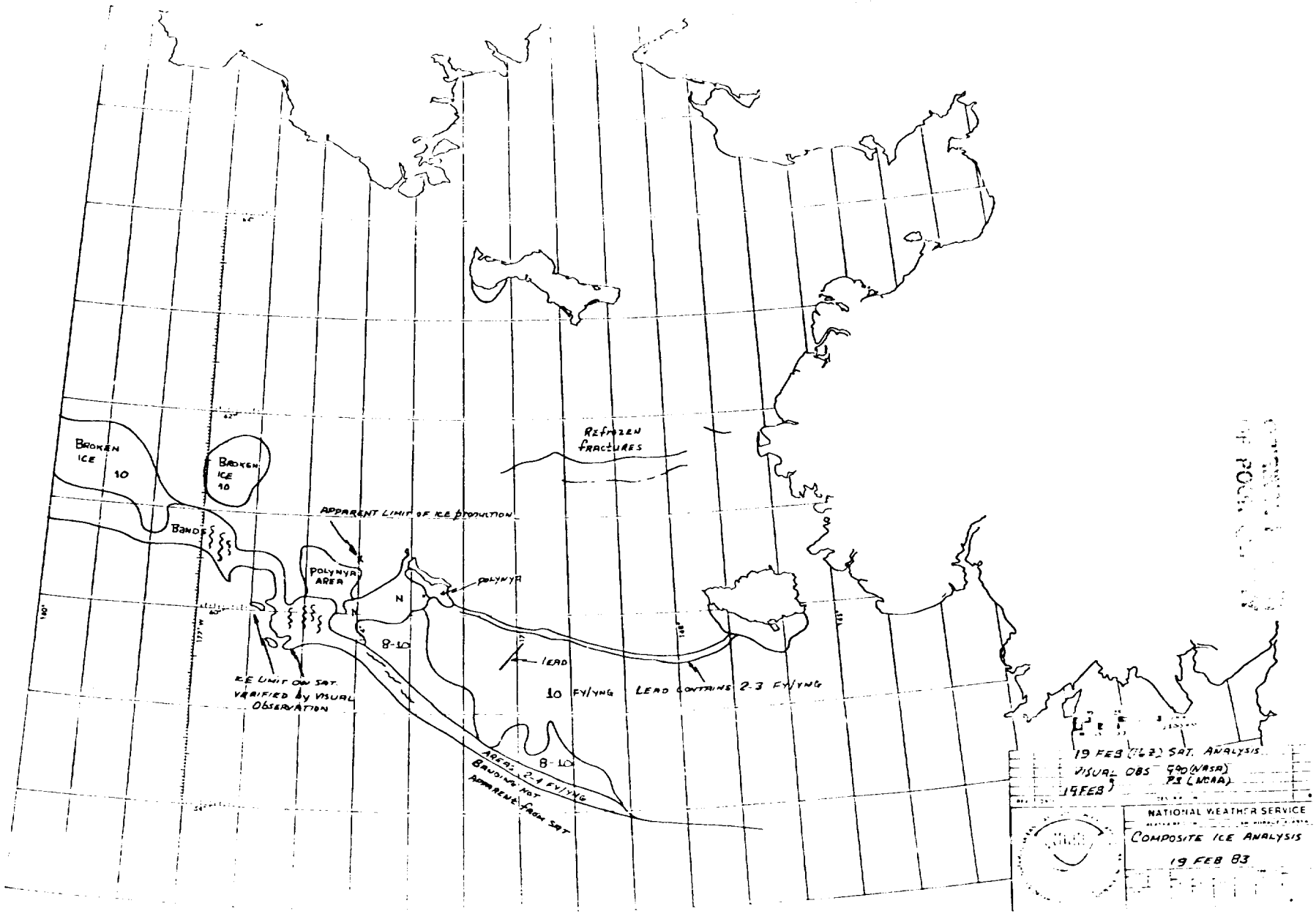

65
35
10
10 Tenths ice covered
Indiv. ice floes, new ice, brash ice in between
Open water within thin ice
70 new ice between floes
Ice band areas
Edge ice streamers
8-10 tenths
65
35
10
U.S. ice limit
10 FEB SMMR CONC % FT
9 FEB U.S. NAVY ICE ANAL
VISUAL OBS - P3 AIRCRAFT
NATIONAL WEATHER SERVICE
COMPOSITE ICE ANALYSIS
10 FEB 83

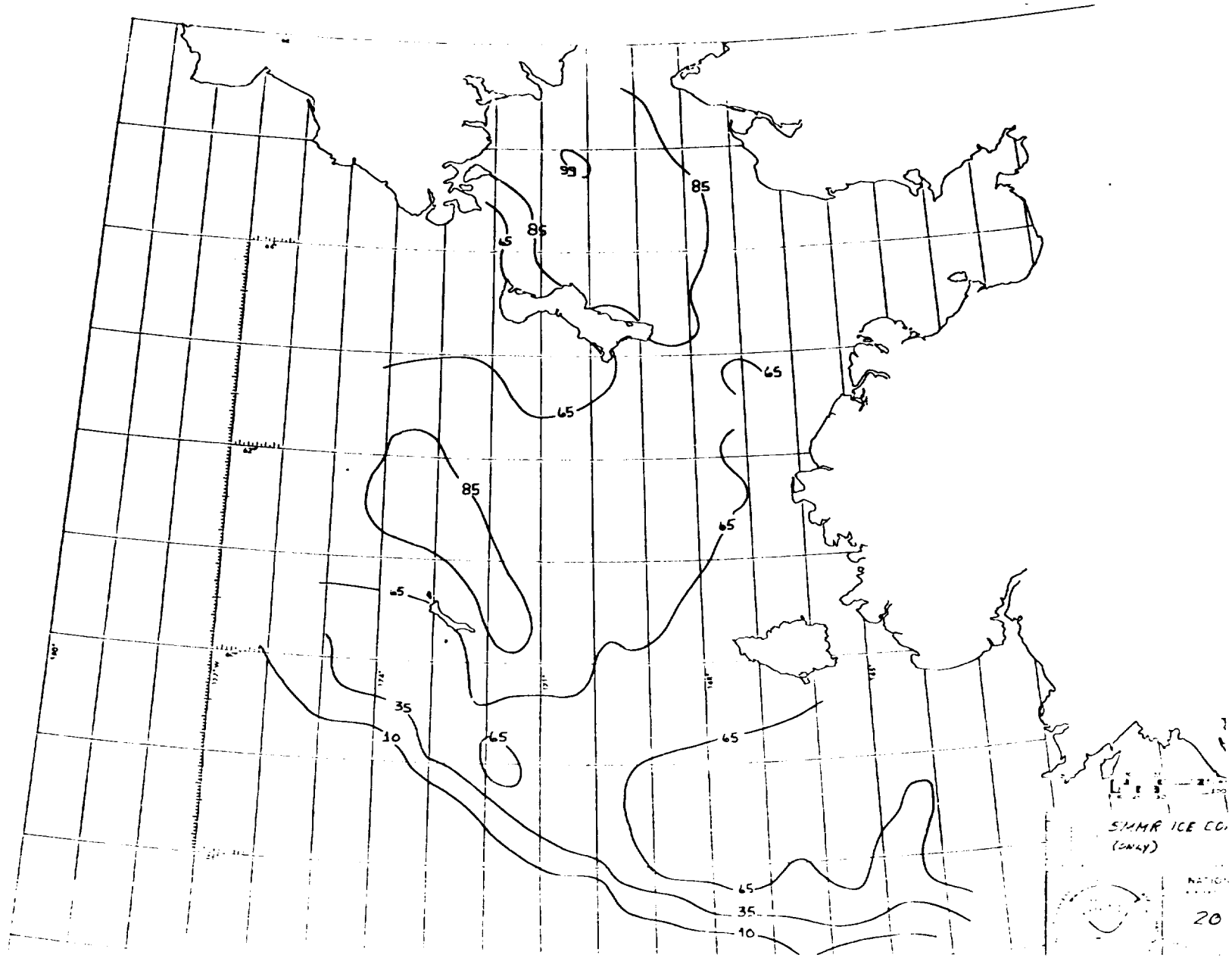

OF POOR QUALITY
10/10's
Leads/Fractures
BANDS
ICE EDGE
2-4
BANDS
VISUALOBS ONLY 12 FEB
NATIONAL WEATHER SERVICE
12 FEB 83

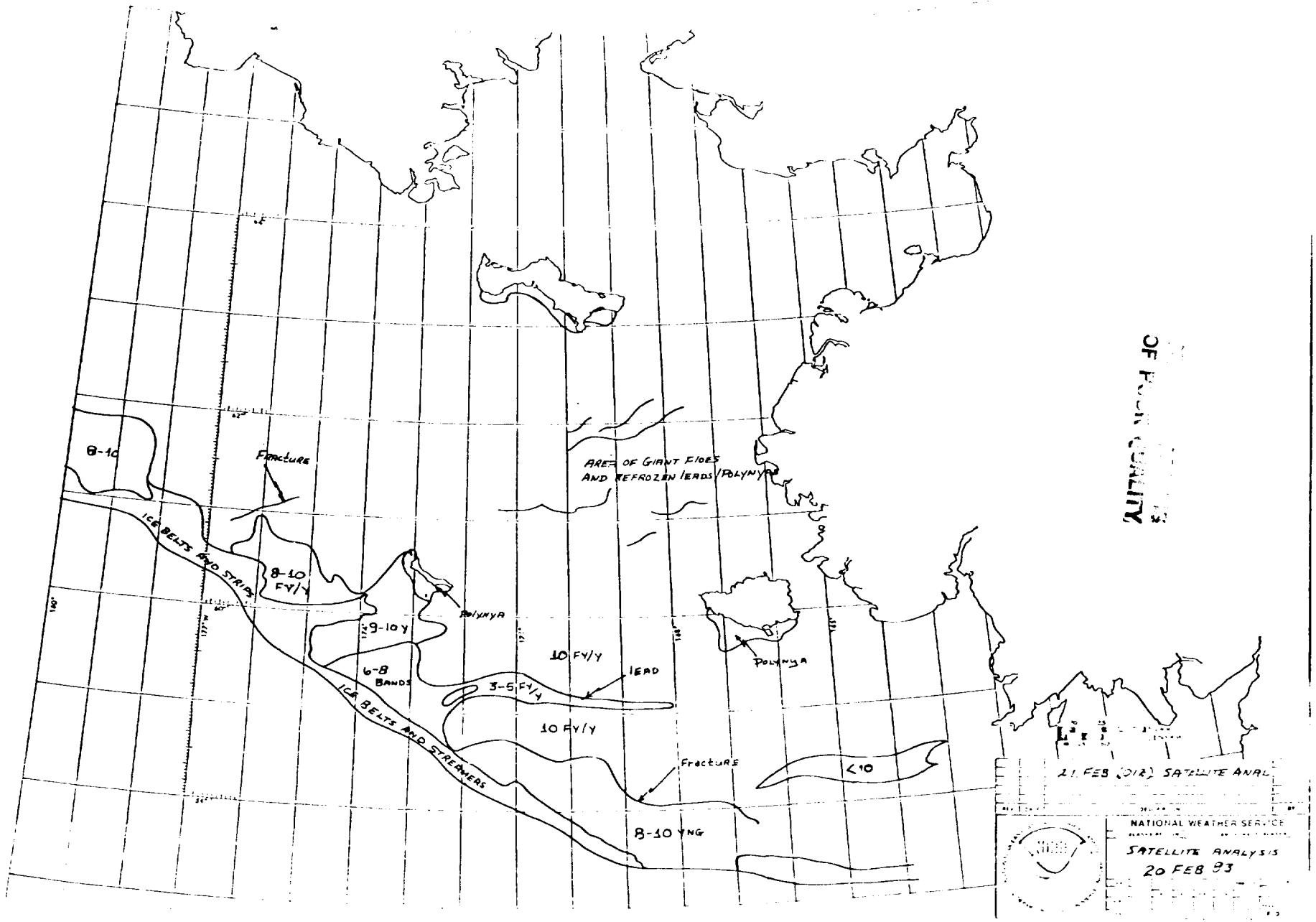

FAST
65
85
polynya
99
ICE LIMIT USN
10/10 (VIS SMLI)
35
10
14 FEB SNMR CONC % FY
13 FEB VISUAL OBS NOAA P3
NASA 990
14 FEB USNAVY ICE ANALYSIS
NATIONAL WEATHER SERVICE
COMPOSITE ICE ANALYSIS
14 FEB 83

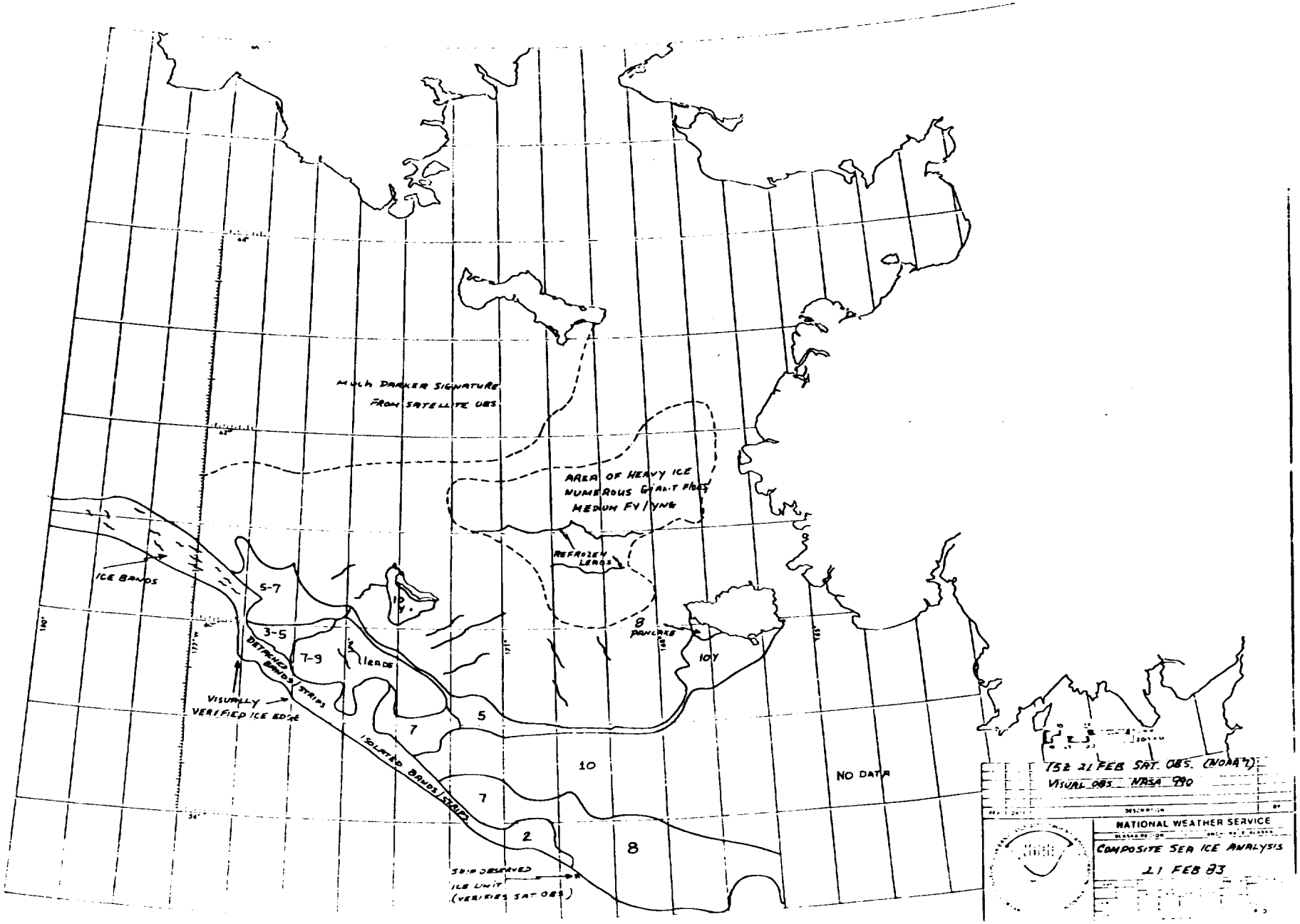

99
65
85
<65
85
65
35
10
85
65
65
35
10
NATIONAL WEATHER SERVICE
COMPOSITE ICE ANALYSIS
16 FEB 83

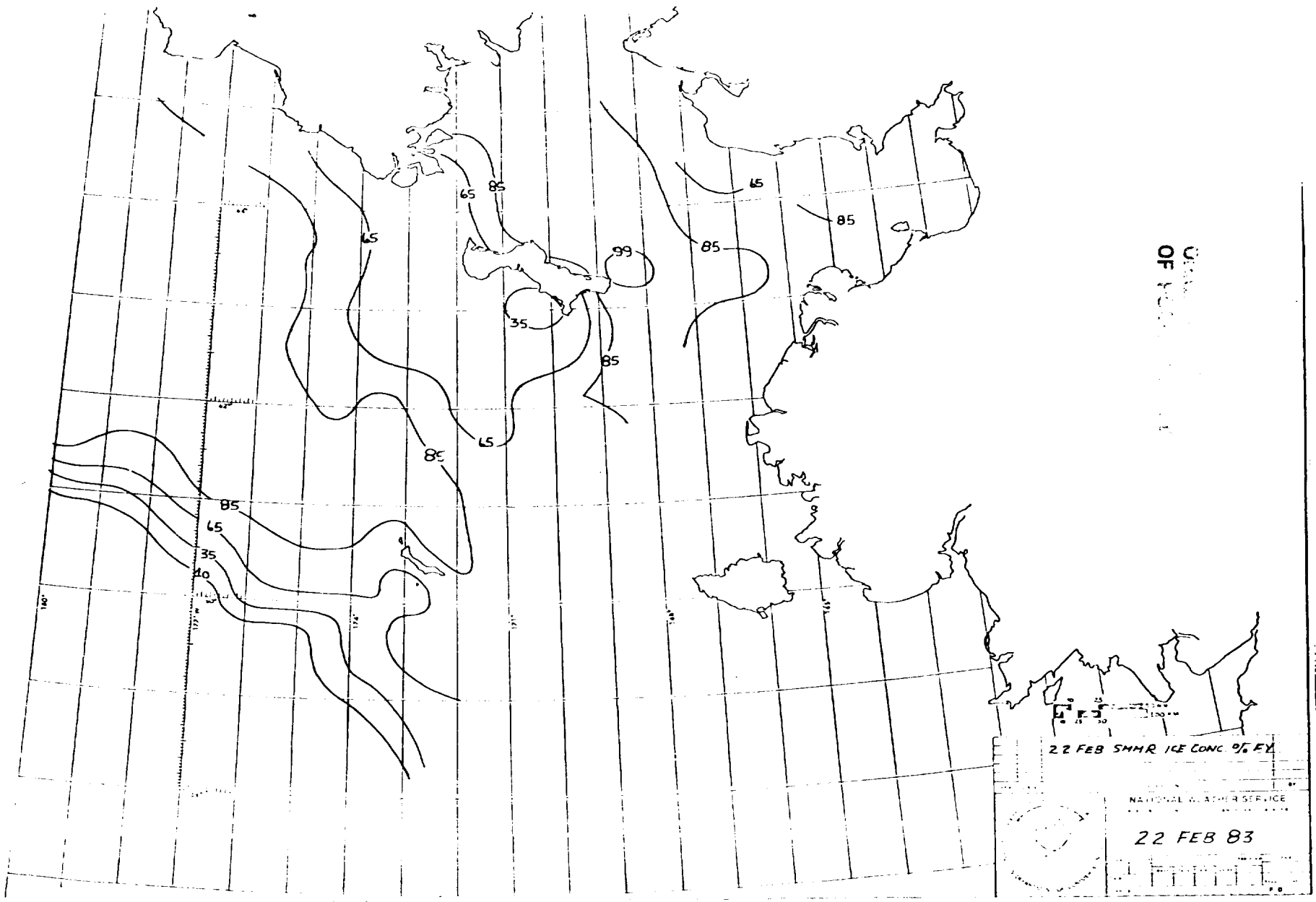

85
99
65
85
85
86
65
35
10
10
6
8
10
0
10 FY/yng
10 FY/yng
18 FEB SMMR CONC % FY
17 FEB (1982) SATELLITE ANAL
18 FEB VISUAL OBS NOAA 990 NOAA PI
NATIONAL WEATHER SERVICE
COMPOSITE ICE ANALYSIS
17/18 FEB 83

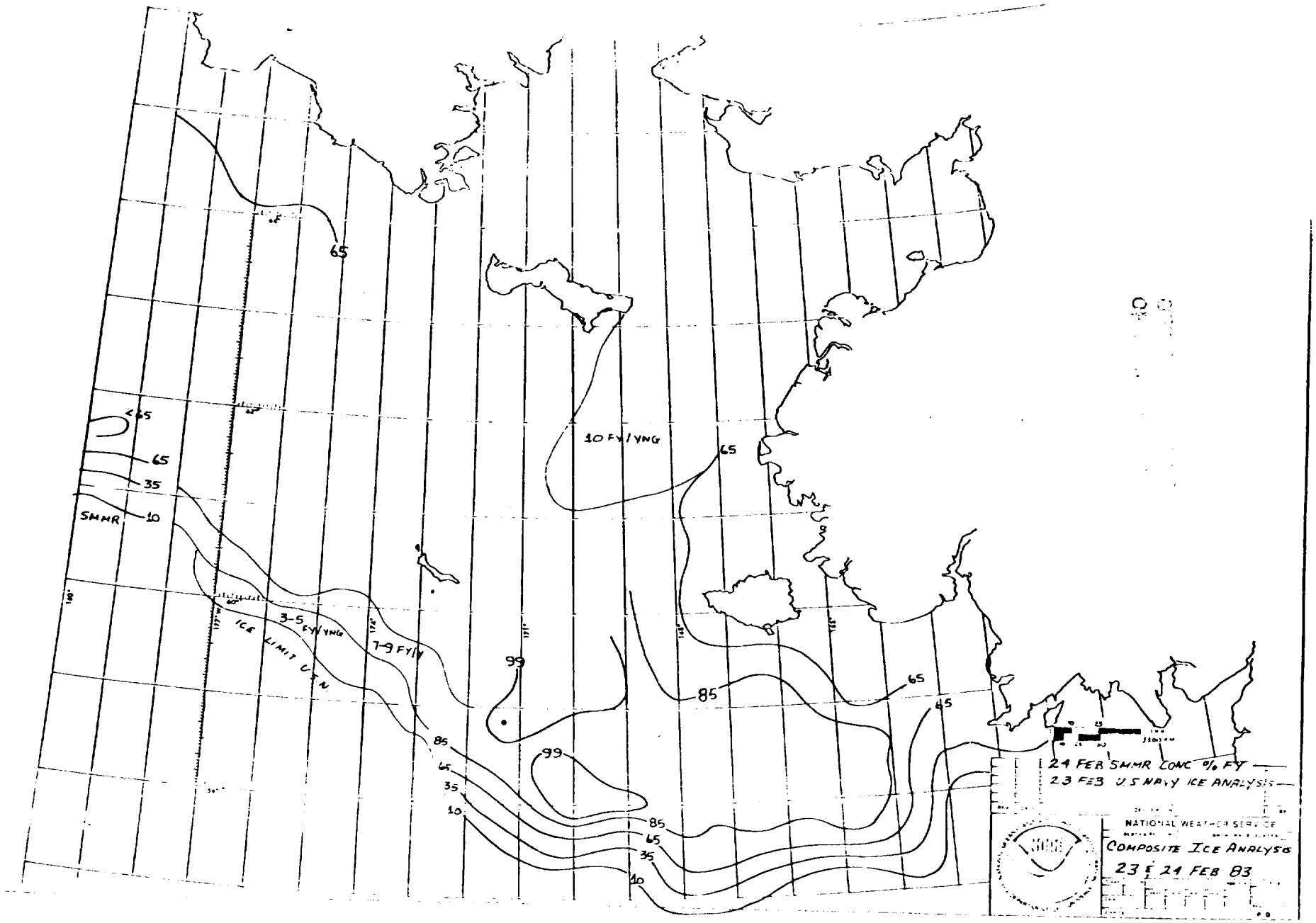

BROKEN ICE 10
BROKEN ICE 10
BANDS
APPARENT LIMIT OF ICE FORMATION
POLYNYA AREA
POLYNYA
N
N
8-10
ICE UNIT ON SAT. VERIFIED BY VISUAL OBSERVATION
LEAD
10 FY/YNG
LEAD CONTAINS 2-3 FY/YNG
REFROZEN FRACTURES
AREA: 2-4 FY/YNG
BANDING NOT APPARENT FROM SAT
8-10
19 FEB (1642) SAT. ANALYSIS
VISUAL OBS 500 (NASA)
PS (NOAA)
19FEB
NATIONAL WEATHER SERVICE
COMPOSITE ICE ANALYSIS
19 FEB 83


99
85
85
65
65
65
85
65
65
35
10
65
65
65
35
10
SUMMR ICE CO
(ONLY)
20


8-10
FRACTURE
AREA OF GIANT FLOES
AND REFROZEN LEADS/POLYNYA
ICE BELTS AND STRIPS
8-10 FY/Y
9-10 Y
POLYNYA
10 FY/Y
LEAD
6-8 BANDS
3-5 FY/Y
ICE BELTS AND STREAMERS
10 FY/Y
FRACTURE
<10
8-10 YNG
POLYNYA
21 FEB (DIR) SATELLITE ANAL
NATIONAL WEATHER SERVICE
SATELLITE ANALYSIS
20 FEB 93


MUCH DARKER SIGNATURE FROM SATELLITE OBS
AREA OF HEAVY ICE NUMEROUS GIANT FLOES MEDIUM FY/MYI
REFROZEN LEADS
ICE BANDS
5-7
3-5
7-9
LEADS
8 PANCAKE
10Y
DETACHED BANDS STRIPS
VISUALLY VERIFIED ICE EDGE
ISOLATED BANDS/STRIPS
7
5
10
7
2
8
NO DATA
SHIP OBSERVED ICE UNIT (VERIFIES SAT OBS)
152 21 FEB SAT. OBS. (NOAA 7)
VISUAL OBS NASA 990
NATIONAL WEATHER SERVICE
COMPOSITE SEA ICE ANALYSIS
21 FEB 83


65
85
65
99
85
85
35
85
65
85
85
65
35
10
22 FEB SMMR ICE CONC % FY
NATIONAL WEATHER SERVICE
22 FEB 83


65
65
35
SMMR 10
10 FY/YNG
65
99
85
65
65
99
85
65
35
10
85
65
35
10
3-5 FY/YNG
7-9 FY/Y
ICE LIMIT U.S.N.
24 FEB SMMR CONC % FY
23 FEB U.S.NAVY ICE ANALYSIS
NATIONAL WEATHER SERVICE
COMPOSITE ICE ANALYSIS
23 & 24 FEB 83