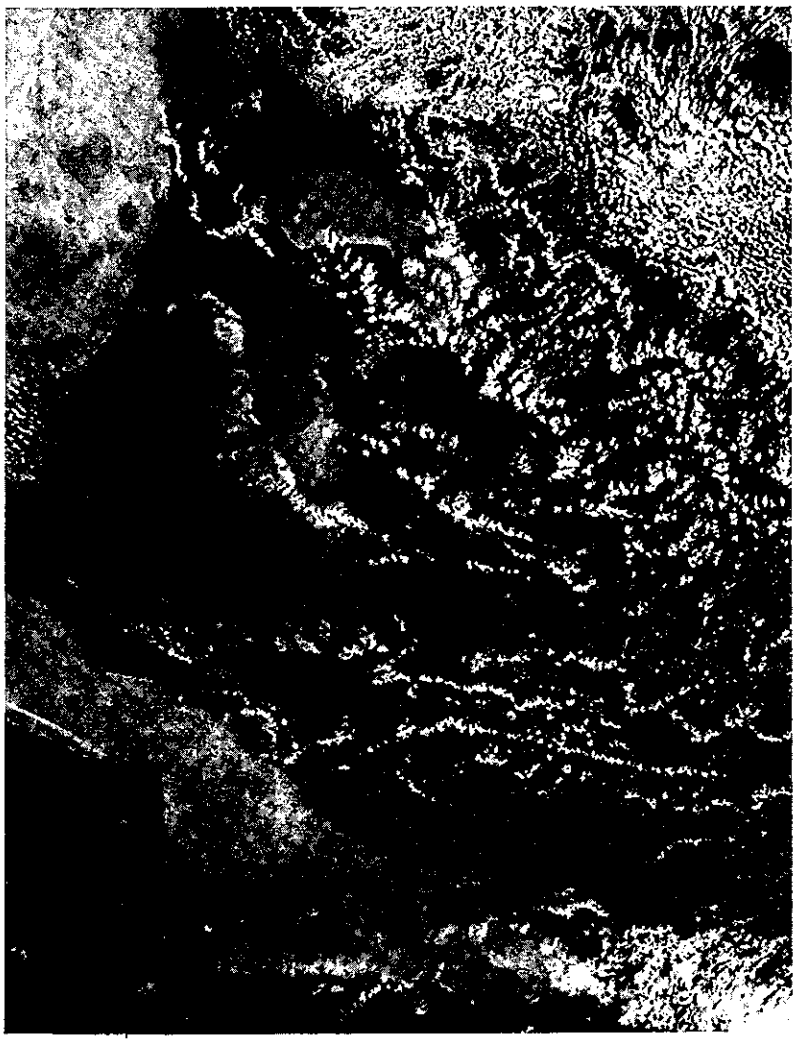
OCEANOGRAPHIC Monthly Summary

Volume VII Number 1 January 1987



The Bahama Banks, NOAA-10, AVHRR ch4, January 15, 1987. *(See page 3.)*

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National Weather Service
National Environmental Satellite, Data, and Information Service
National Ocean Service

Oceanographic Monthly Summary is published by the National Weather Service (NWS), the National Environmental Satellite, Data, and Information Service (NESDIS), and the National Ocean Service (NOS). *Oceanographic Monthly Summary* contains sea surface temperature (SST) analyses on both regional and ocean basin scales for the Atlantic, Pacific, and Indian Oceans. The ocean basin analyses are based on a "blend" of *in situ* and satellite data, in which *in situ* data are used to define "benchmark" temperature values in regions of frequent observations and satellite data are used to define the "shape" of the field between these points.[1]

An ocean basin SST anomaly is derived from the "blended" SST analysis[1] and the improved global SST.[2] The regional SST analyses are based upon a combination of *in situ* and satellite data measurements. The regional SST anomalies are calculated from the Robinson-Bauer Climatology.[3] Oceanographic Monthly Summary also contains Alaskan sea ice information and ocean feature information for contiguous U.S. ocean regions.

Oceanographic Monthly Summary welcomes articles containing information of interest to *Oceanographic Monthly Summary* readers, such as, news on operational oceanography, unusual ocean feature phenomena, etc. Contributions should be sent to the editor (address below). Accepted material will appear in the OceaNotes section of *Oceanographic Monthly Summary*. Contributions can be published as quickly as the next monthly issue.

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* Note:  Beginning with this issue, the familiar cover photo of the ocean wave is *
*        being replaced.  The new image may be a satellite photo or depict systems*
*        or activities related to the collection and analysis of oceanographic    *
*        data.                                                                     *
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[1]Reynolds, R.W. and W.H. Gemmill, 1984. A sea surface temperature analysis which blends *in situ* and satellite observations. *Proceedings of the Ninth Climate Diagnostics Workshop*, Corvallis, OR, Oct. 22-26, 1984, pp. 408-416.
[2]The climatology is derived from *in situ* data (1950-1979), satellite data (1982-1985) and an ice climatology.
[3]Robinson, M.K., 1976. Atlas of North Pacific Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOceano Ref. Pub. 2.*
Robinson, M.K., R.A. Bauer, and E.H. Schroeder, 1979. Atlas of North Atlantic-Indian Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOceano Ref. Pub. 18.*

Oceanographic Monthly Summary

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SATELLITE IMAGE OF THE MONTH*

Kim Buttleman
Interactive Processing Branch E/SP22
NESDIS, NOAA
Washington, DC 20233
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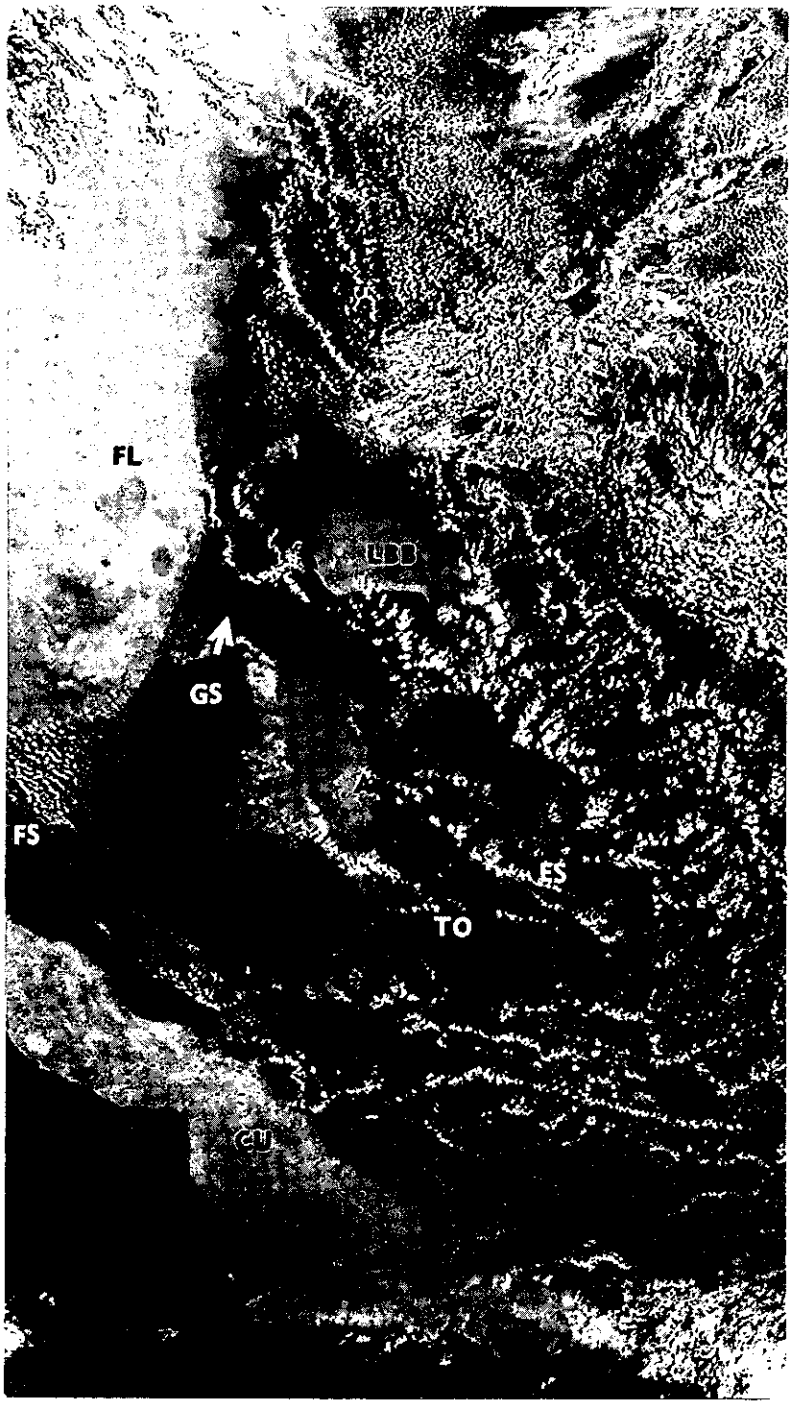
The Bahama Banks

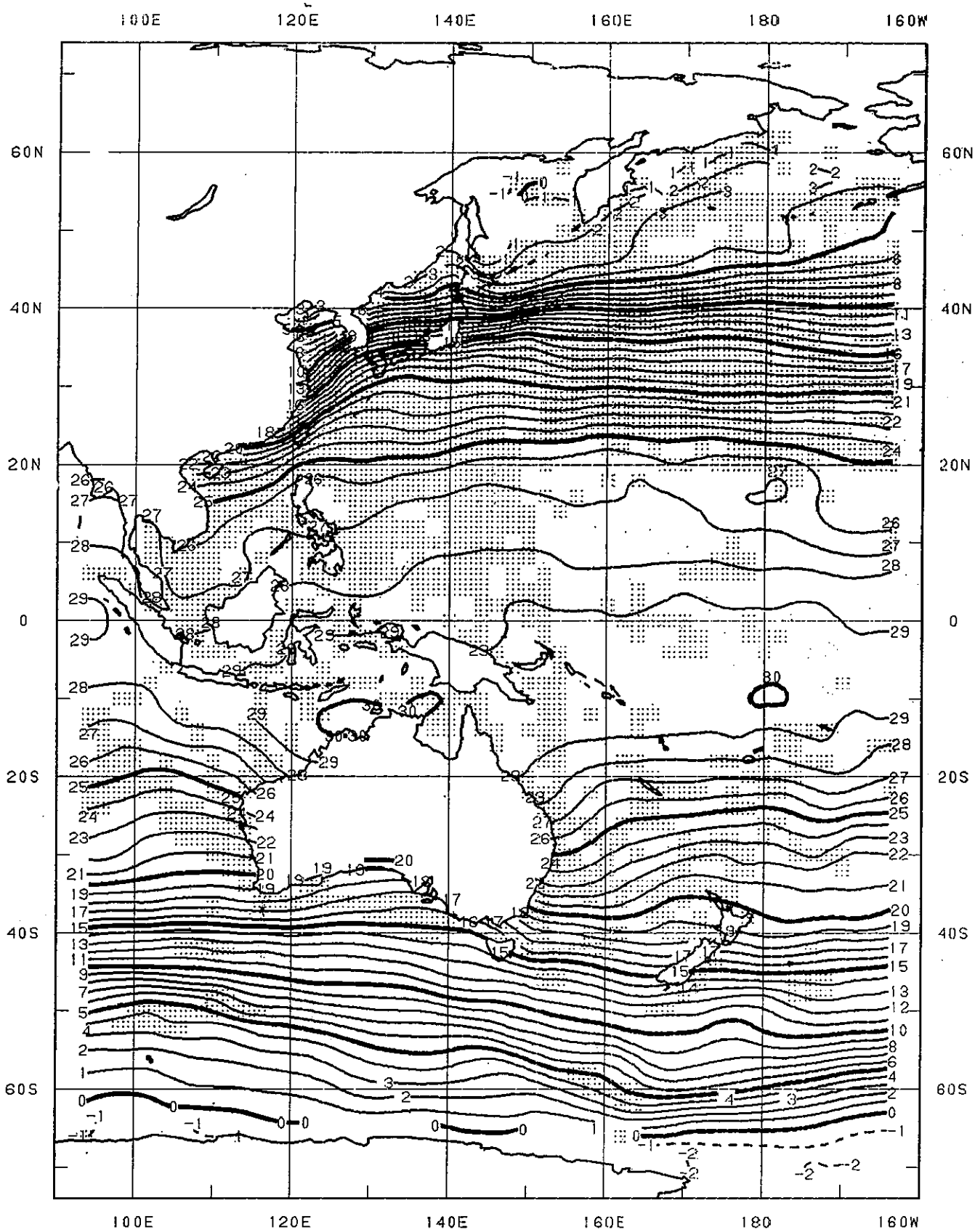
This image (NOAA-10, AVHRR ch 4) from January 15, 1987 (08:56 GMT) shows the Bahamas and adjacent areas of the Caribbean and North Atlantic. Included in the land areas are Florida (FL, with the lettering immediately north of Lake Okeechobee), as well as Cuba (CU) and Andros Island (A) in the Bahamas. Visible in the ocean areas are the Gulf Stream (GS) where it rounds the coast of Florida, having exited the Gulf of Mexico through the Florida Straits (FS). Very prominent are the Great Bahama Bank (GBB) and Litle Bahama Bank (LBB), which are generally less than 15 meters deep. With other banks, these outline much deeper Exuma Sound (ES) and the Tongue of the Ocean (TO), a 2000 meter deep canyon.

For some time prior to the acquisition of this image this area had been under the influence of abnormally cold weather, which cooled the surface waters. The water in the much deeper areas could be warmed by mixing from beneath by the relatively warm deep water, while the water over the banks could not. Thus the banks show up lighter (cooler) and the deeper areas are darker (warmer).

Also visible throughout Cuba are numerous hot spots, which show up as small black (hot) dots. Prior to harvesting, sugar cane fields are burned to reduce the excess vegetation and rid them of pests. Presumably the many hot spots there are such purposely set agricultural fires. However, south of Lake Okeechobee in Florida there is a much larger hot spot. This was a controlled brush fire which burned approximately 2500 acres.

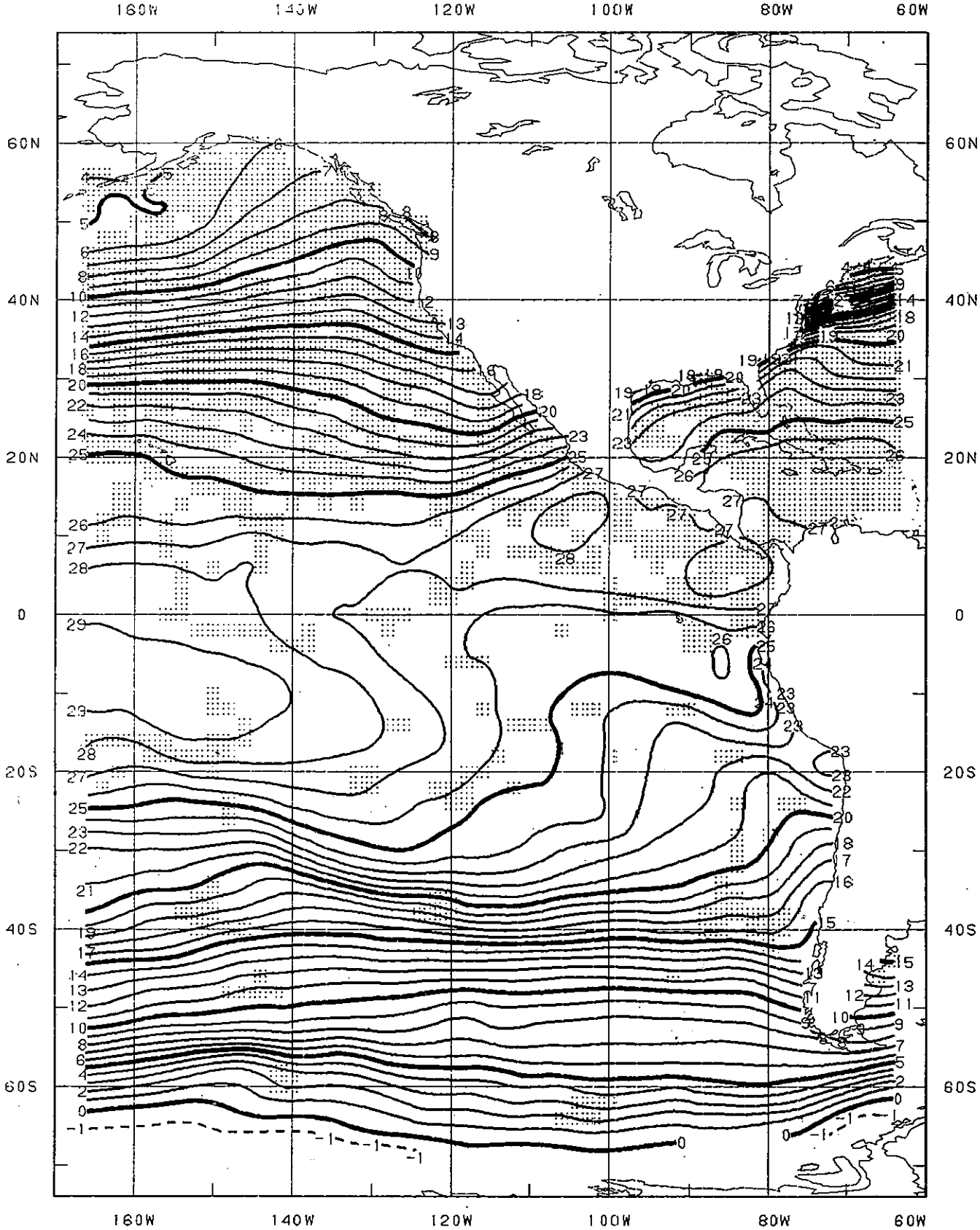


*In the December 1986 issue, the wave-like pattern evident in the water areas of the satellite photograph is an artifact of the printing process.



Western Pacific Ocean
SST--MONTHLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA
JANUARY 1987

Monthly mean sea surface temperature is the mean of *in situ* and satellite data within two-degree quadrangles. Contour line interval is 1.0°C. The stippling indicates where the analysis was fixed by the *in situ* data; contours are not shown in areas without data.



Eastern Pacific Ocean Ocean
SST--MONTHLY MEAN (°C)
SHIP, BUOY, AND SATELLITE
DATA
JANUARY 1987

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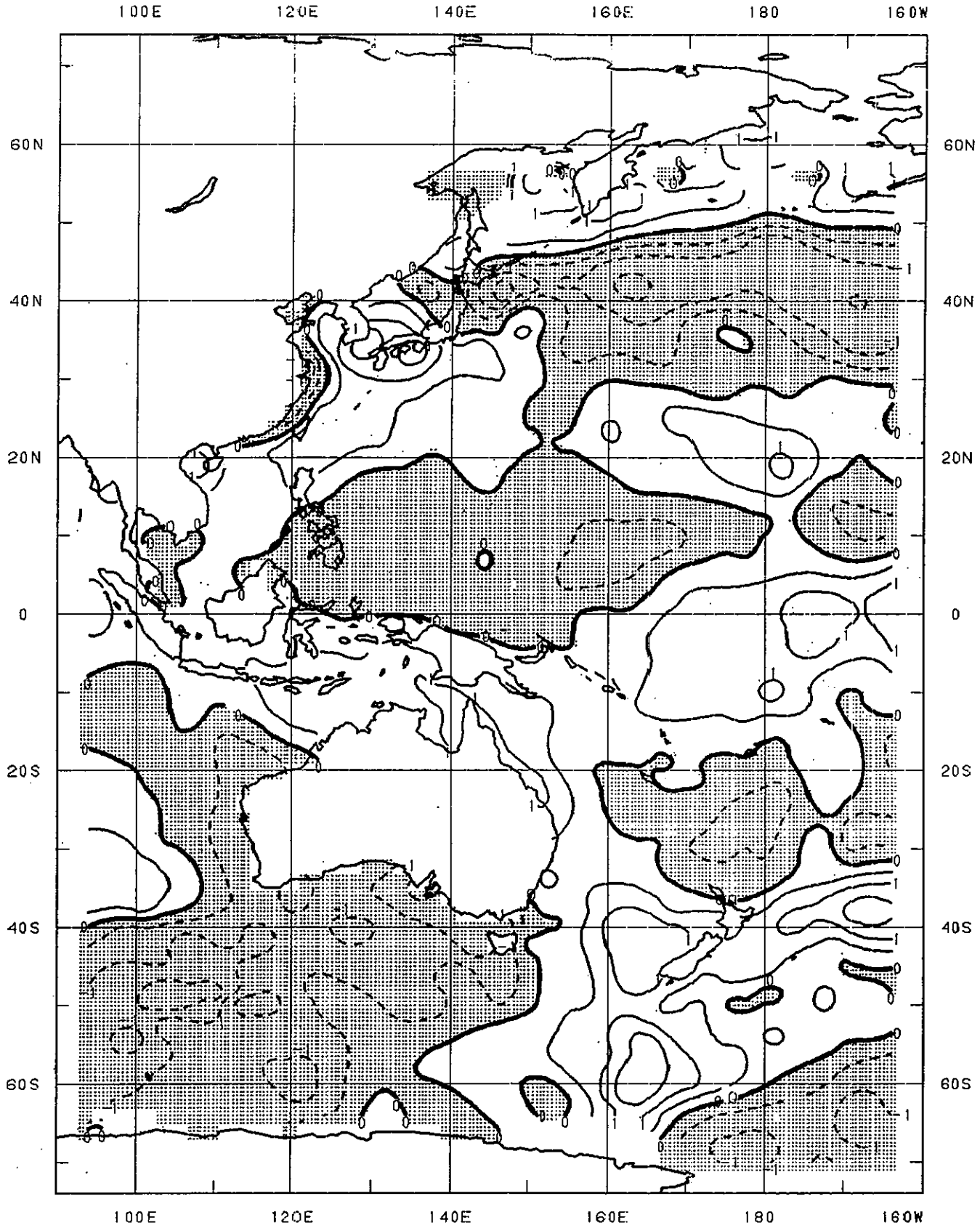

Western Pacific Ocean
SST--MONTHLY ANOMALY
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JANUARY 1987

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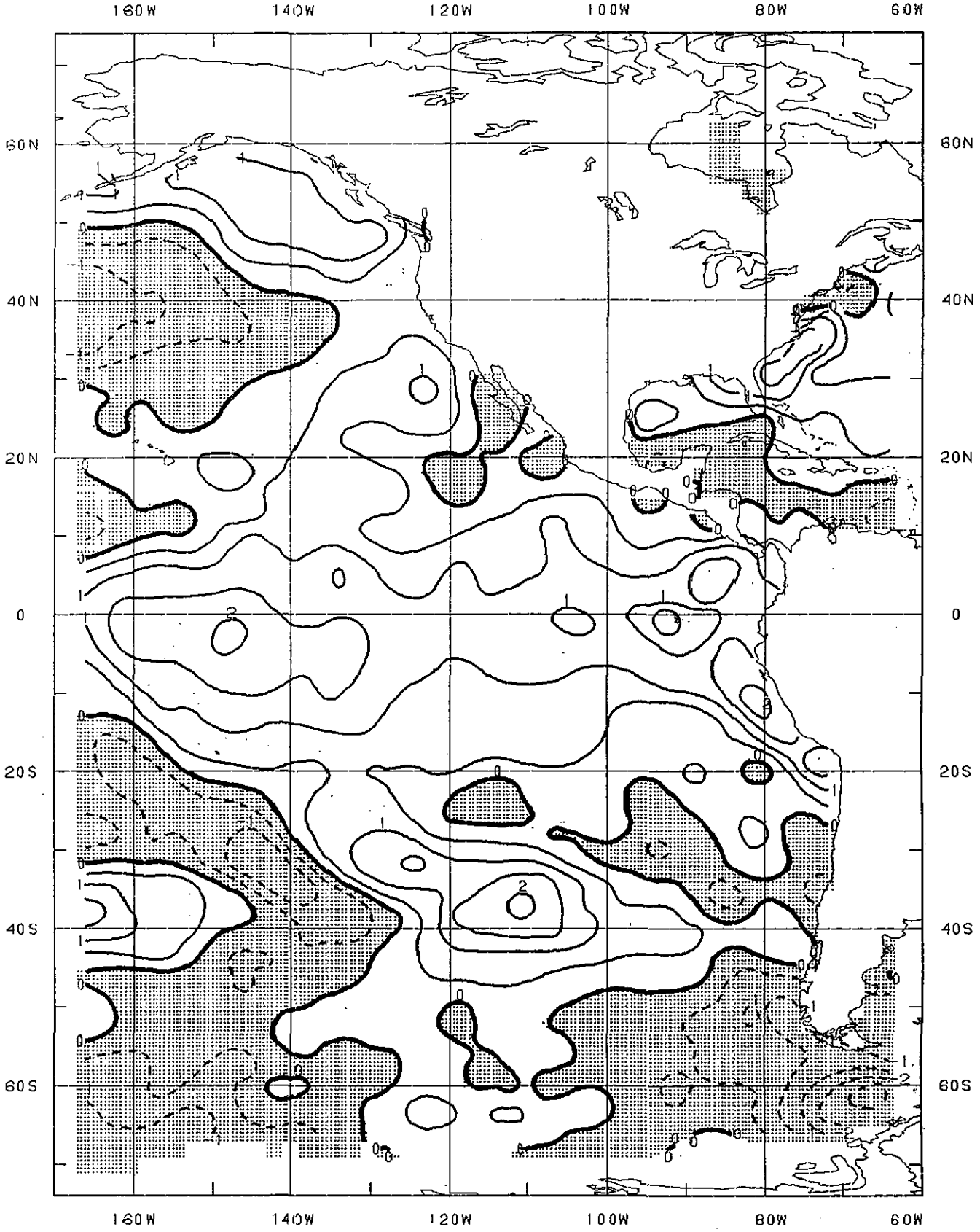

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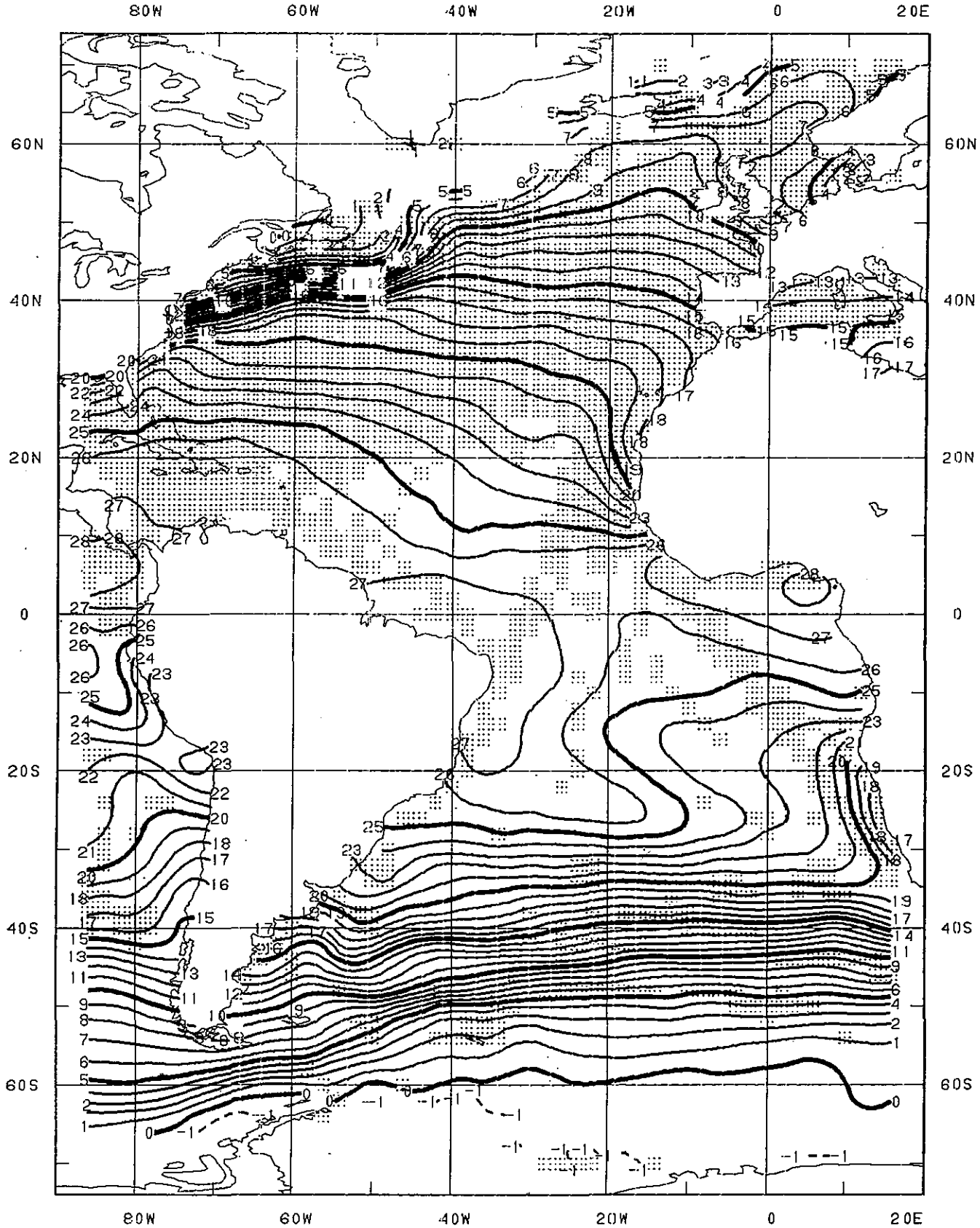

Atlantic Ocean
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SHIP, BUOY, AND SATELLITE DATA
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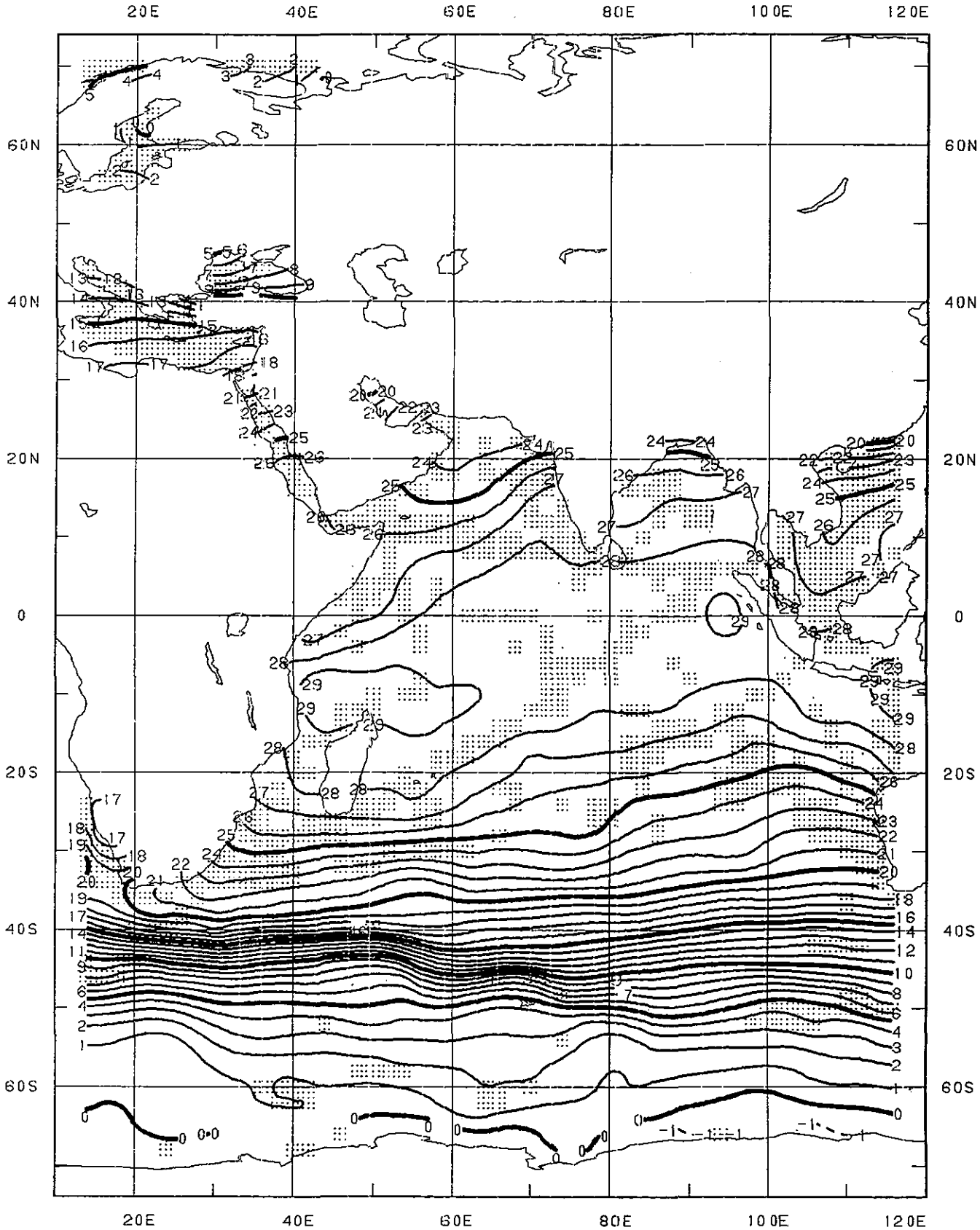

Indian Ocean
SST--MONTHLY MEAN (°C)
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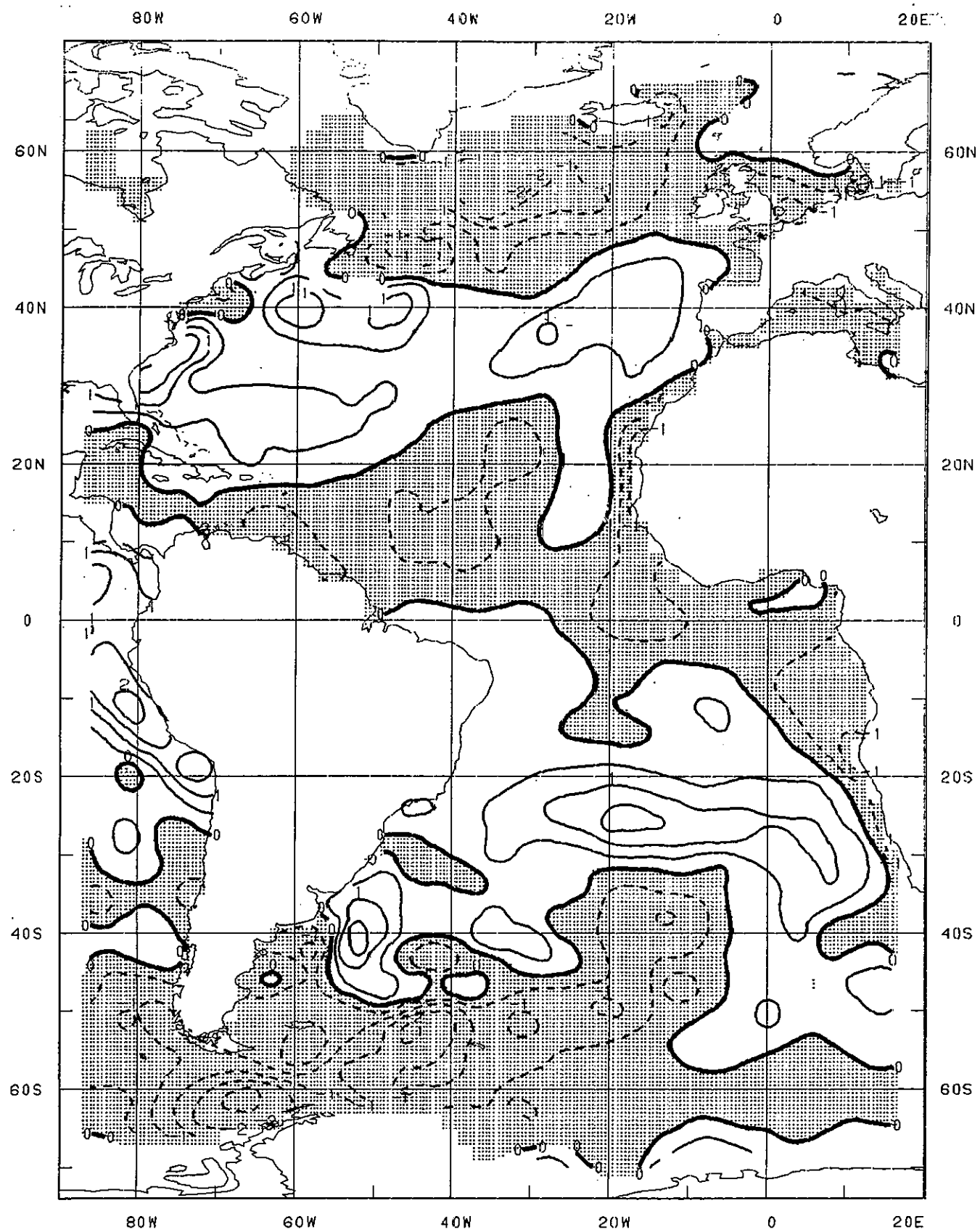

Atlantic Ocean
SST--MONTHLY ANOMALY (°C)
SHIP, BUOY, and SATELLITE DATA
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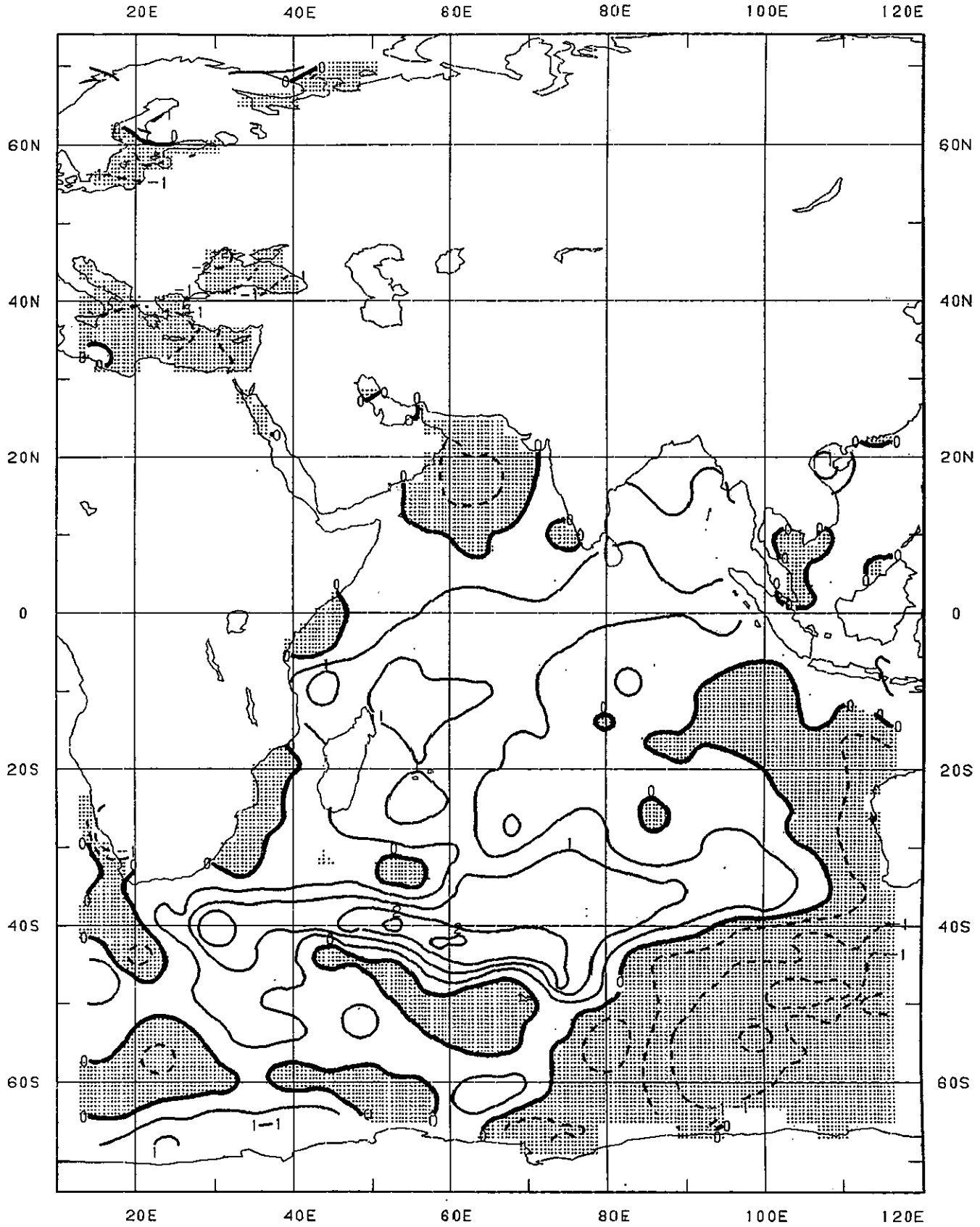

Indian Ocean
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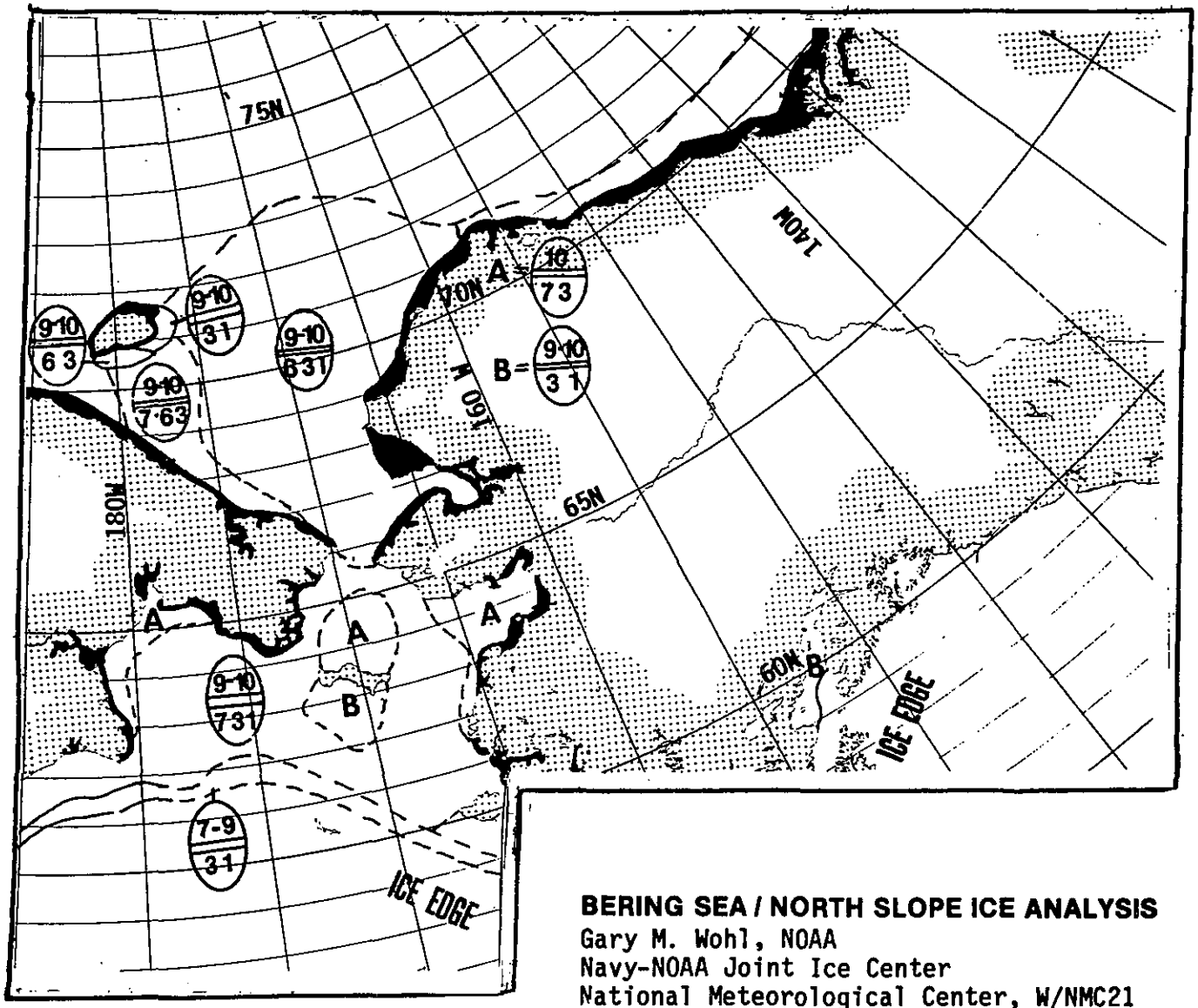
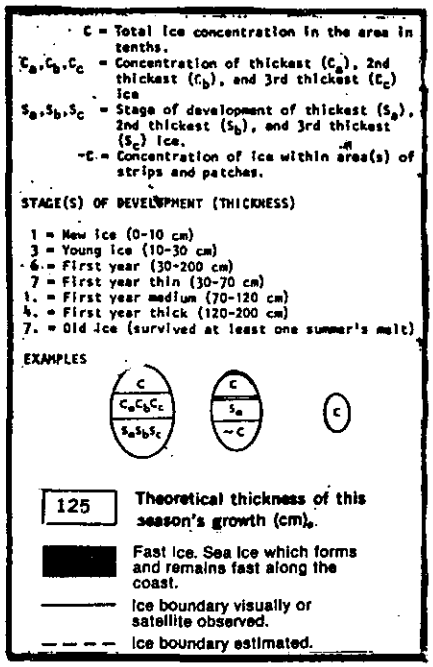


BERING SEA / NORTH SLOPE ICE ANALYSIS

Gary M. Wohl, NOAA
Navy-NOAA Joint Ice Center
National Meteorological Center, W/NMC21
(301) 763-5972



JANUARY 1987

Moderate temperatures and occasionally strong southerly winds through the Bering Sea during January held the sea ice edge north of St. Matthew Island and just south of Nunivak Island. At the end of January the ice edge was some 60 to 100 nautical miles north of its mean position. In Bristol Bay sea ice remained rather thin and was confined to the northern and extreme eastern sections. North of the edge, sea ice thickened and became more concentrated. Thinner ice was confined to the area immediately south of St. Lawrence Island, an area commonly covered by thin ice or open water due to northerly winds. In the Chukchi Sea, sea ice motion was observed along the Alaskan coastline apparently "feeding" ice toward the Bering Strait. Shorefast ice along the coasts of the Beaufort and Chukchi Seas continued to thicken and expand under cold winter temperatures.

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WEST COAST OCEAN FEATURES

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Satellite Field Service Station
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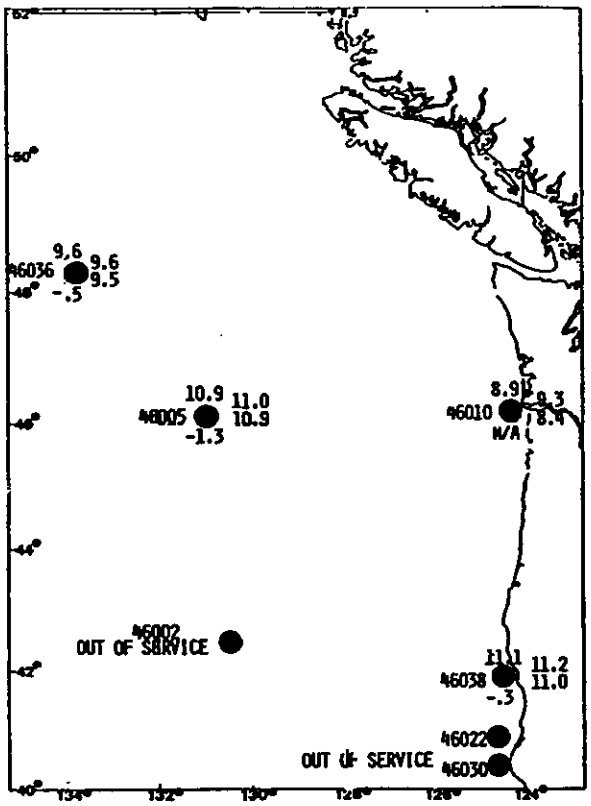
(415) 876-9122
FTS 470-9122

JANUARY 1987

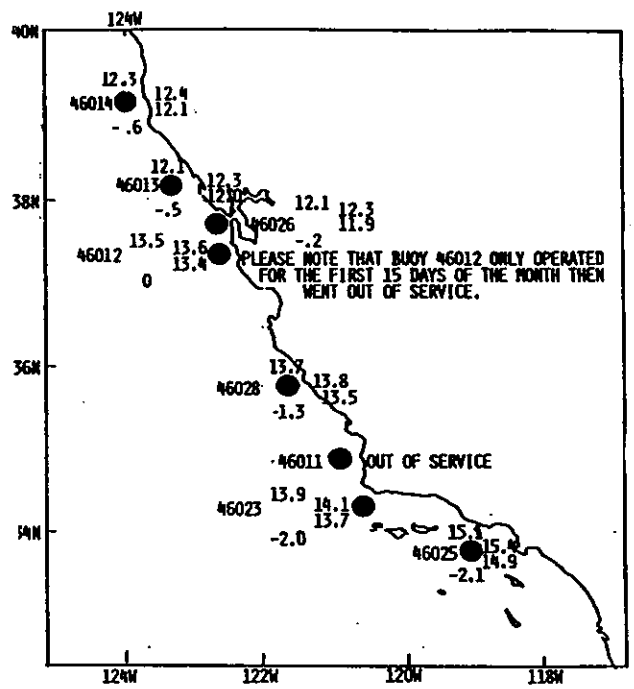
Sea surface temperatures in the North Panel continue to average above normal. The January climatological mean value over the analysis area is 9.3°C, but



the actual computed value was 10.2°C...nearly 1°C above normal. No area on the chart was cooler than climatology. Warm anomalies ranged from 0.2°C in the northwest corner of the North Panel to 1.4°C near 46°N 113°W. Generally speaking, nearshore waters were < 1°C above normal. When comparing January's statistics with December's, the entire analysis area cooled. Nearshore SST's cooled < 1°C while offshore waters averaged 1.5°C cooler than the previous month. Buoy statistics also show that ocean temperatures were warmer than normal and that there was overall cooling when compared to December.

SST's also averaged above normal in the South Panel. The climatological mean value is 15.1°C but the actual observed temperature was 15.6°C. Oddly enough, as contrasted to the North Panel, nearshore waters averaged 1.0° to 1.3°C above climatology while offshore waters were not as anomalous. There were two areas where SST's were below normal, and these were centered near 36.5°N 133°W and 31.5°N 122°W. Sea surface temperatures cooled between 0.5° and 1.7°C. The maximum cooling was observed in the northwest corner and southeast coastal sections of the South Panel. Like the North Panel buoy statistics, the South Panel SST's averaged above normal even though significant cooling occurred since December. The only exception was buoy 46012 which produced only a half month's data for computation.

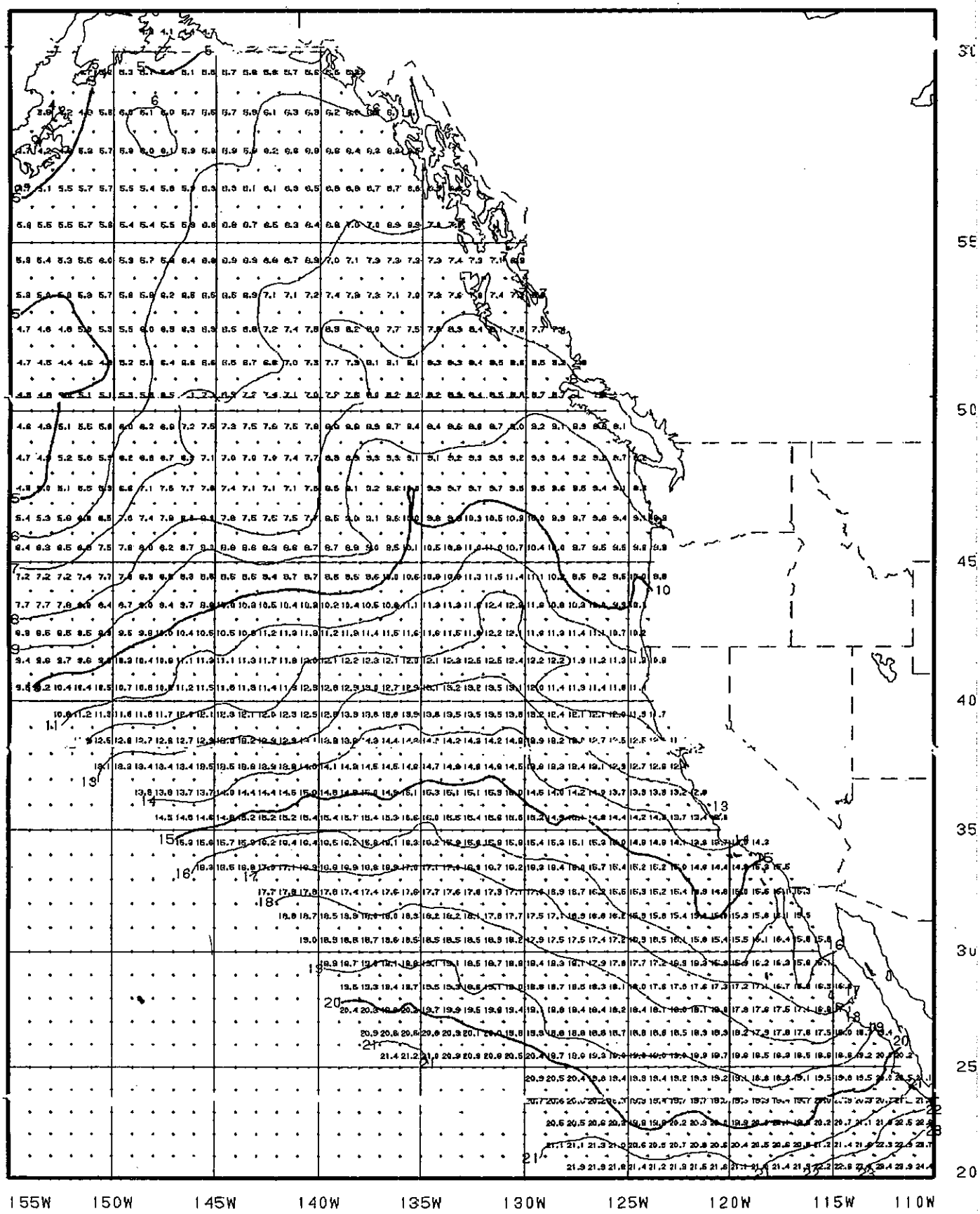
There were nine analyses generated for both Panels during the month.



KEY:

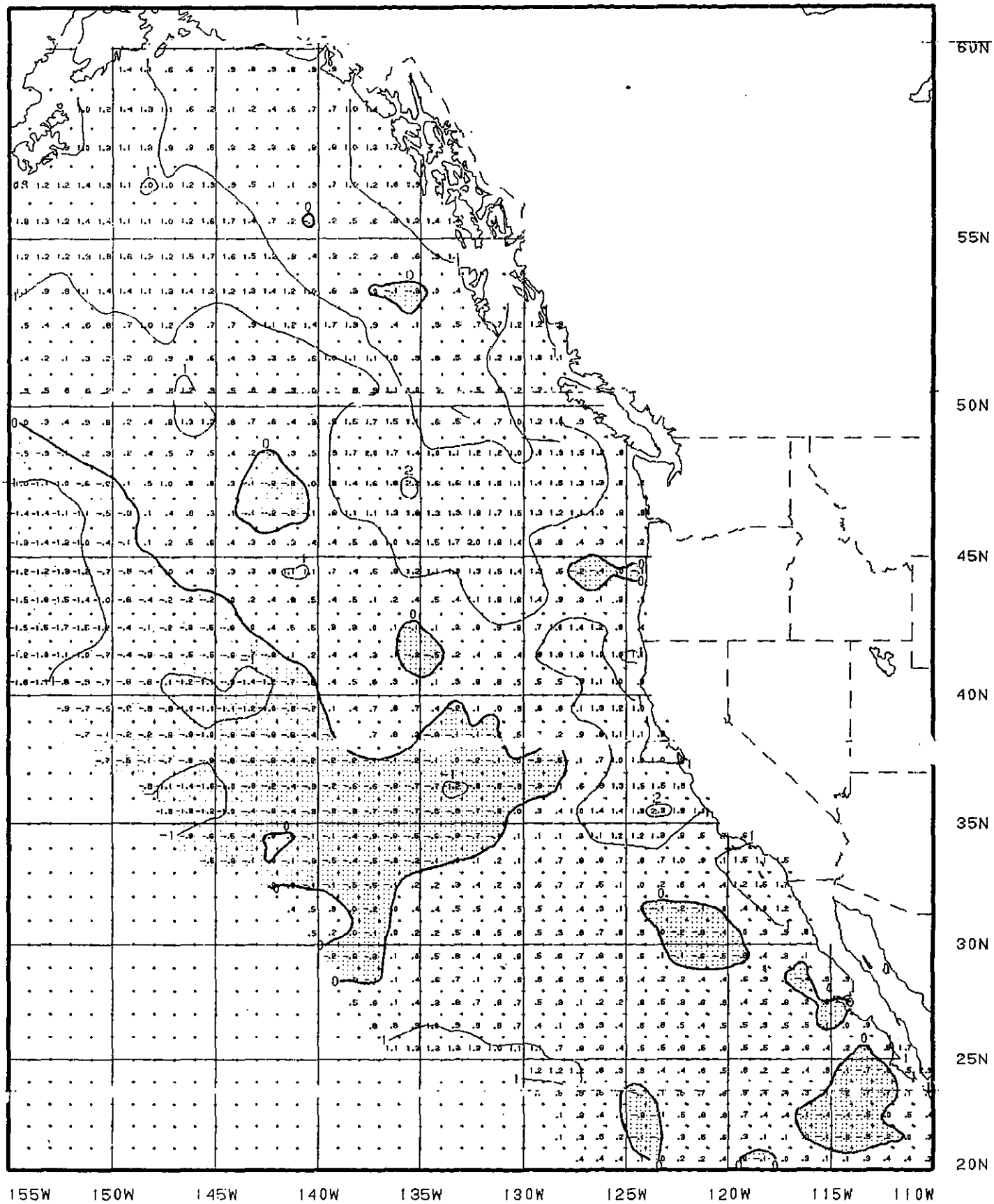
12.1 ← Monthly mean
LOCATION 13.5 ← Maximum daily mean
NAME 10.2 ← Minimum daily mean
-1.5 ← Change from previous month

● Denotes station position.



West Coast
SST--MONTHLY MEAN (°C)
January 1987

Monthly mean sea surface temperature is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0°C.



West Coast
SST--MONTHLY ANOMALY (C°)
January 1987

Monthly anomaly is the difference between the monthly mean sea surface temperature and the climatological monthly mean value -- shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0°C.

EAST COAST OCEAN FEATURES

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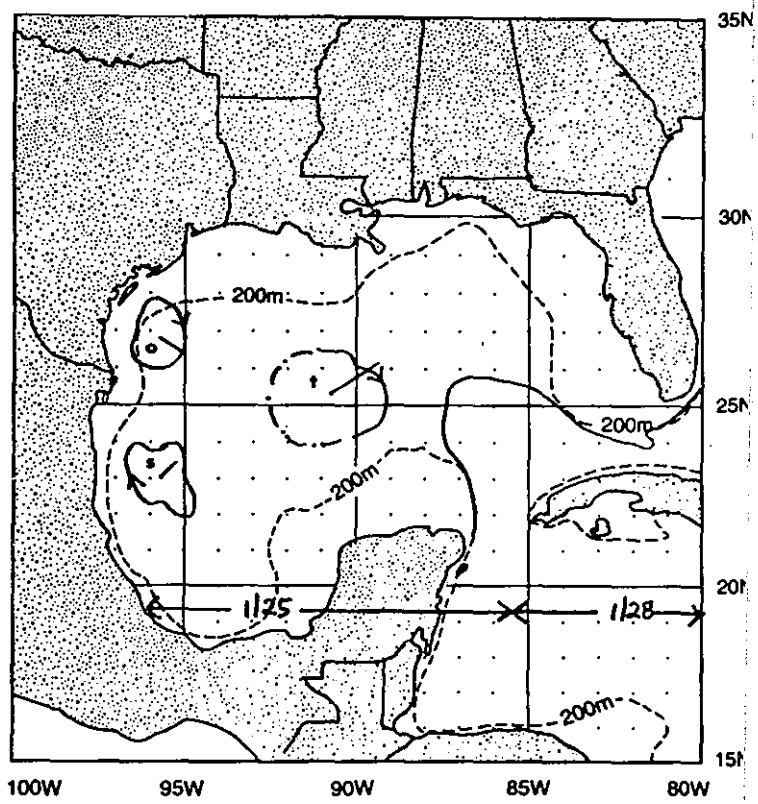
(301) 763-8239

JANUARY 1987

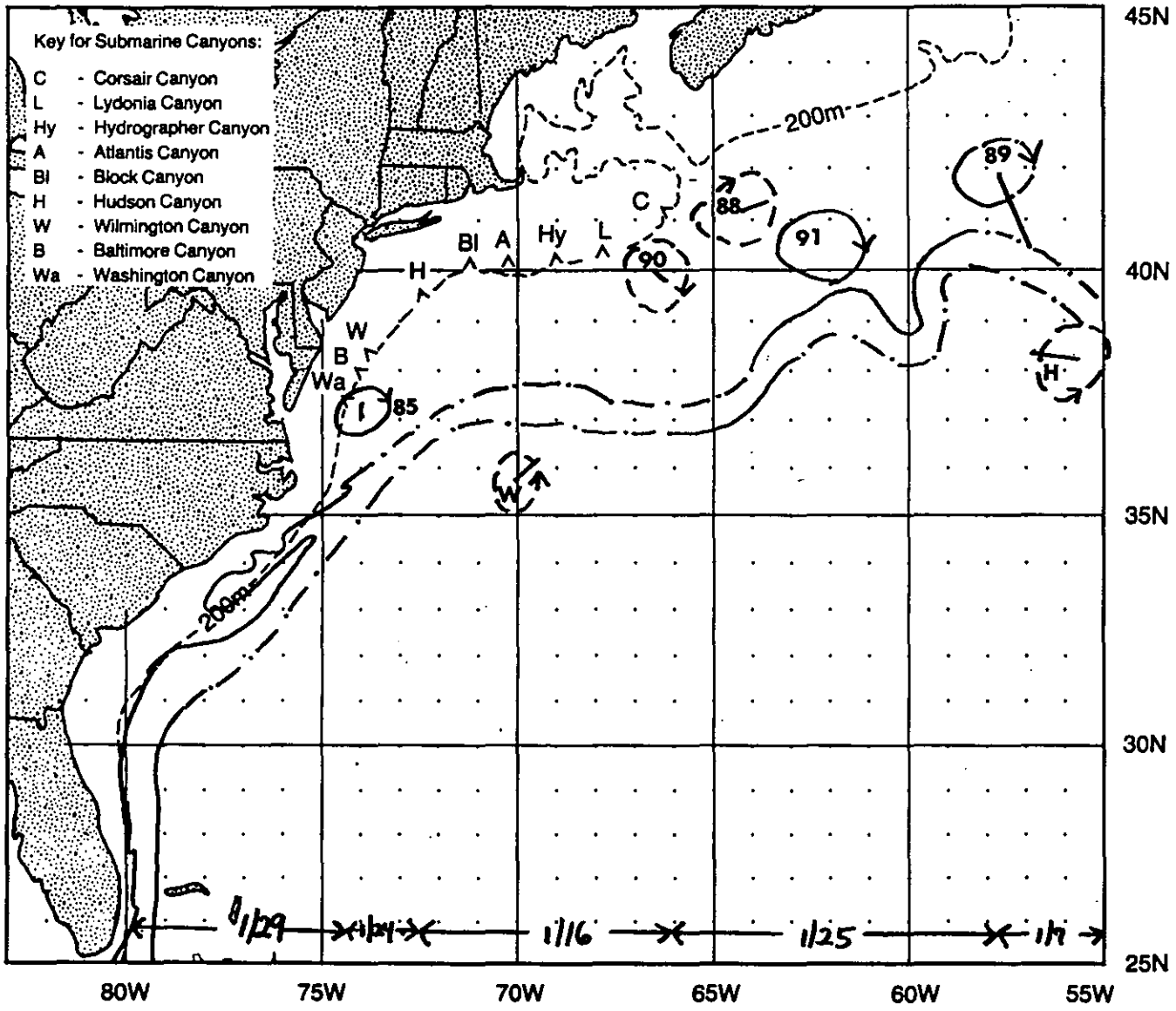
The end of this month's positions of the Gulf Stream System and its associated eddies are shown for the NW Atlantic and the Gulf of Mexico. The Gulf Stream and Loop Current boundaries are located by infrared satellite imagery or XBT (expendable bathythermograph) data. Anticyclonic eddies are labeled a-z in the Gulf of Mexico and 1-99 in the NW Atlantic. Cyclonic eddies are labeled A-Z. Arrows on eddies indicate direction of circulation. Warm-core or anticyclonic eddies rotate clockwise; cold-core or cyclonic eddies rotate counterclockwise. The line to the eddy center shows the net translation since last month or since last observed. Eddies or sections of the Gulf stream System which were not observed during the month are not shown on the analysis chart. The long arrows at the bottom of the chart indicate the data of data used.



GULF OF MEXICO

Data used in this analysis include:
- NOAA satellite infrared imagery, NESDIS
- Bathythermograph data, National Meteorological Center of National Weather Service
- Oceanographic Analysis, A daily detailed analysis issued by National Weather Service/NESDIS

The position of the Loop Current i the Gulf of Mexico moved northward b about 55 km compared to th end-of-December position. Anticyclonic eddy t translated 155 km SW. Eddie s and σ traveled 65 km SW and 65 k NW, respectively.

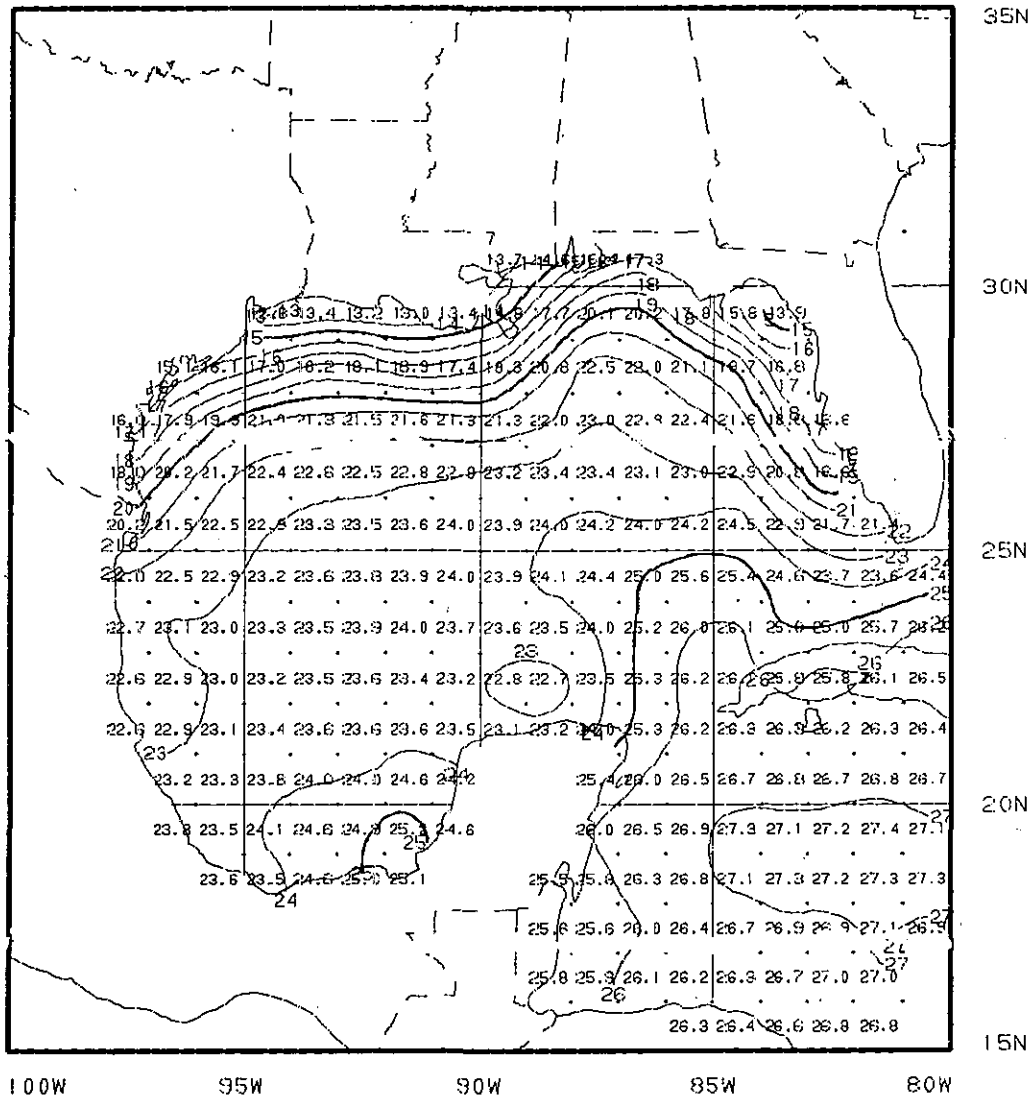


EAST COAST

One anticyclonic eddy seemingly dissipated and one formed during January. Eddy 87 was not observed due to extensive cloudiness and low thermal contrast. It is assumed to have dissipated near 38°30N 72°30W. Eddy 91 formed from a Gulf Stream meander near 41°N 62°W around January 21. Eddy 85 moved 25 km S. Eddy 90 translated 35 km NW when it was last observed on January 7. Eddy 88, last detected on January 16, traveled 55 km WSW. Eddy 89 moved 175 km NW.

Cyclonic eddy X apparently was absorbed by the Gulf Stream on January 15 near 38°N 60°W. Eddy W translated 55 km SW when it was last discerned on January 16. Eddy H last detected on January 7, moved 90 km E.

EAST COAST SST – MONTHLY MEAN



Gulf of Mexico
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January 1987

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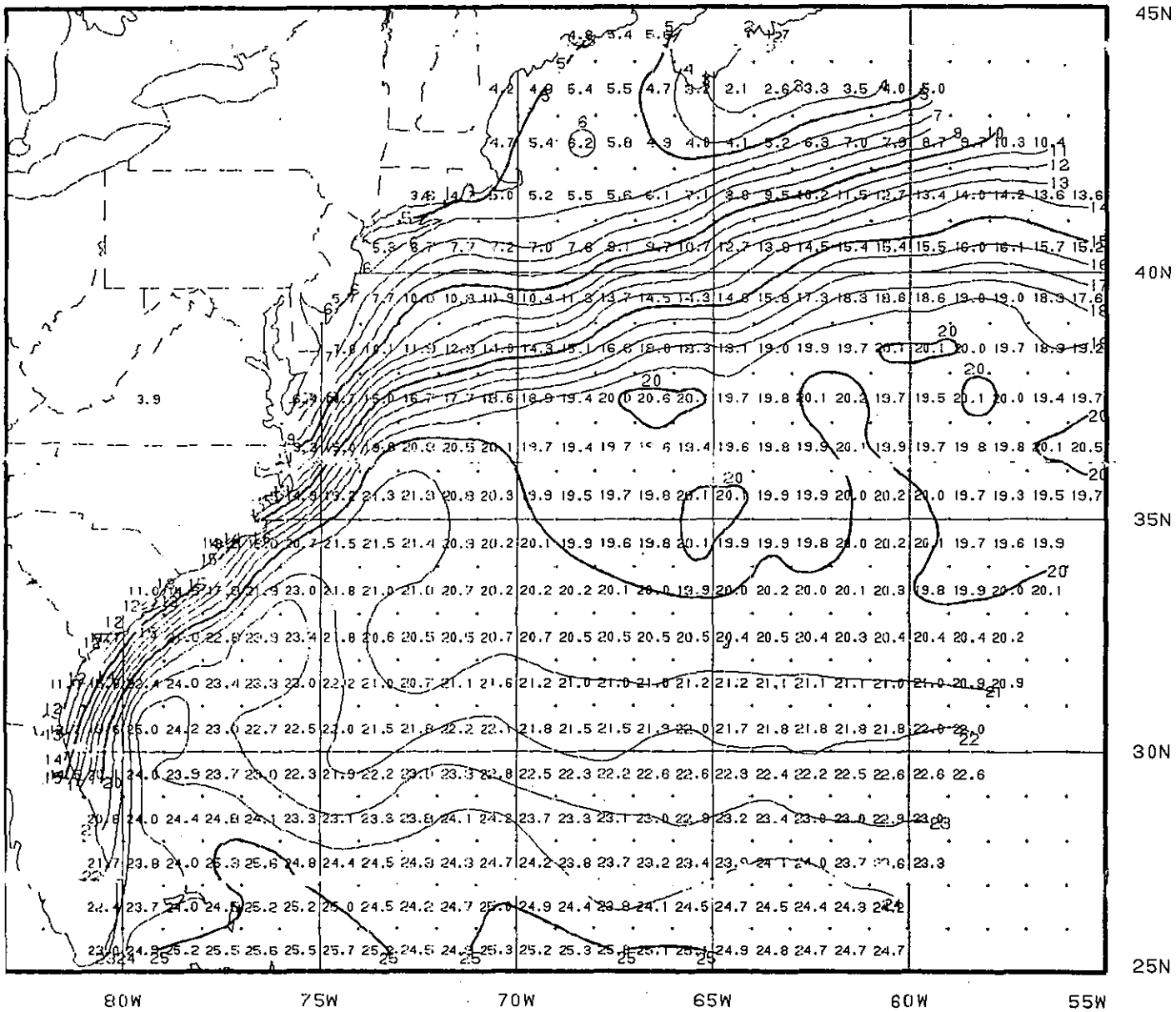

Northwest Atlantic Ocean
SST--MONTHLY MEAN (°C)
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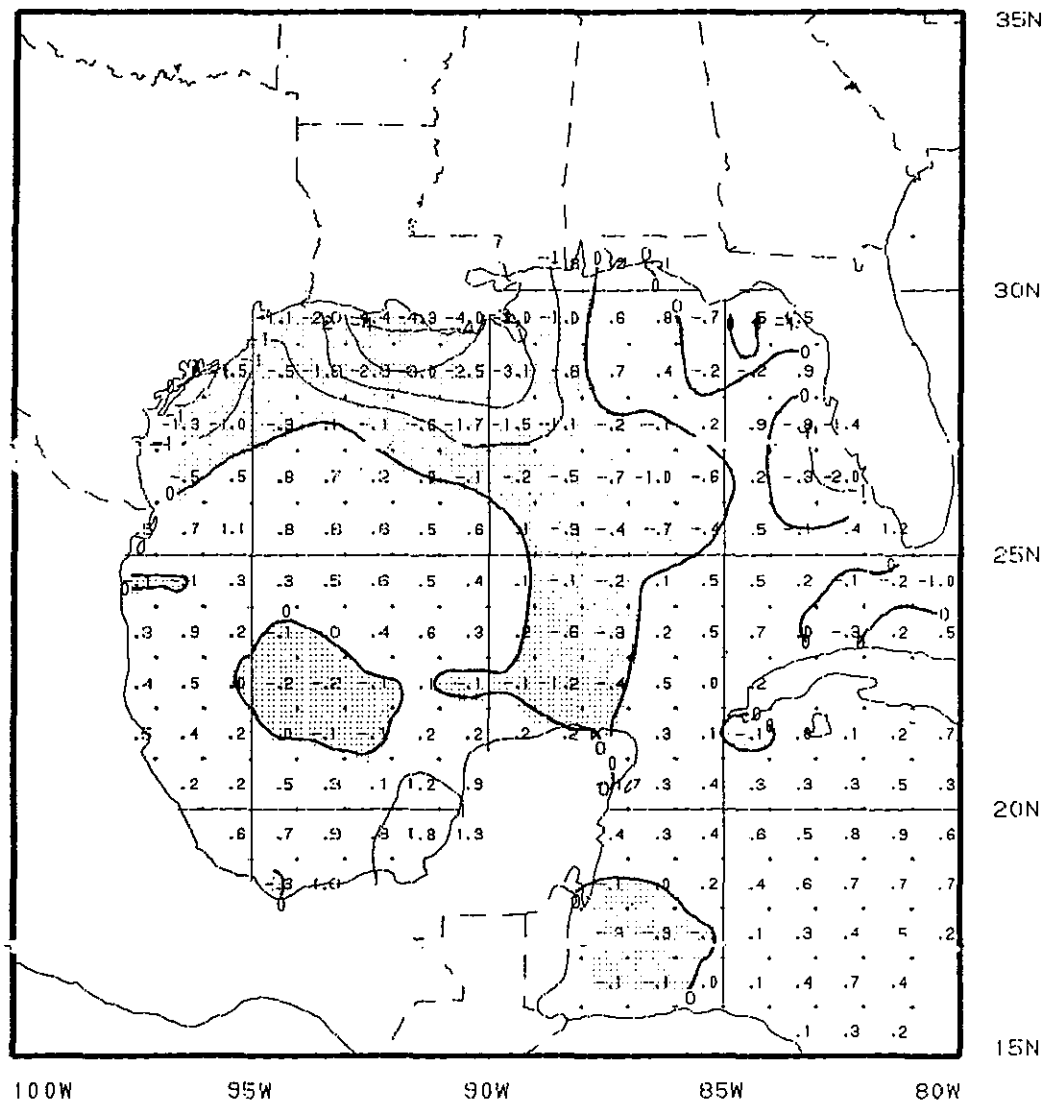
EAST COAST SST - ANOMALY



Gulf of Mexico
SST--MONTHLY ANOMALY (C°)
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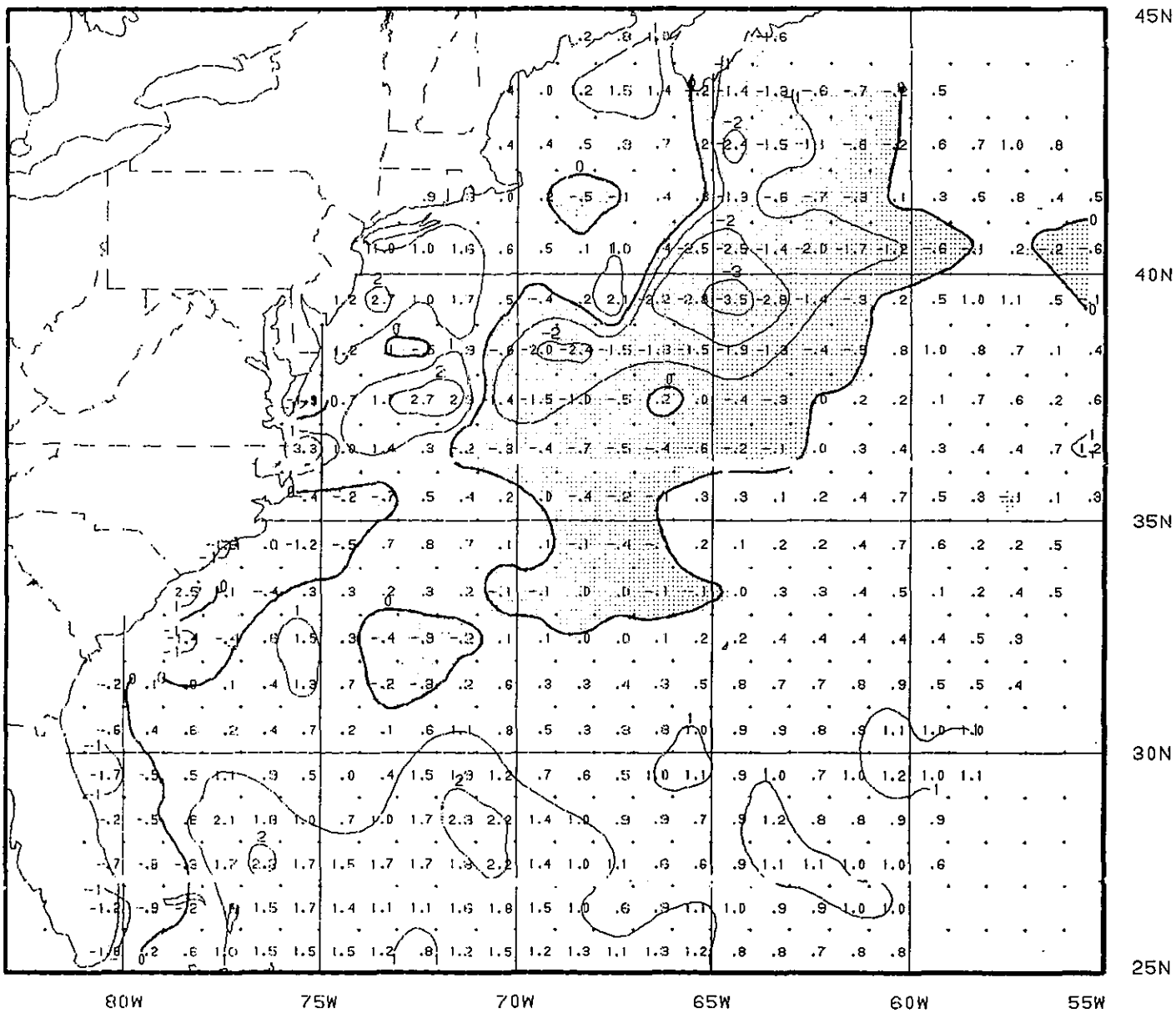

Northwest Atlantic Ocean
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The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through April 1, 1987.

NOAA LISD SEATTLE 30 MAR 1987

OCEANOGRAPHIC Monthly Summary

Volume VII Number 2 February 1987

The Maldive Archipelago. *(see page 3.)*

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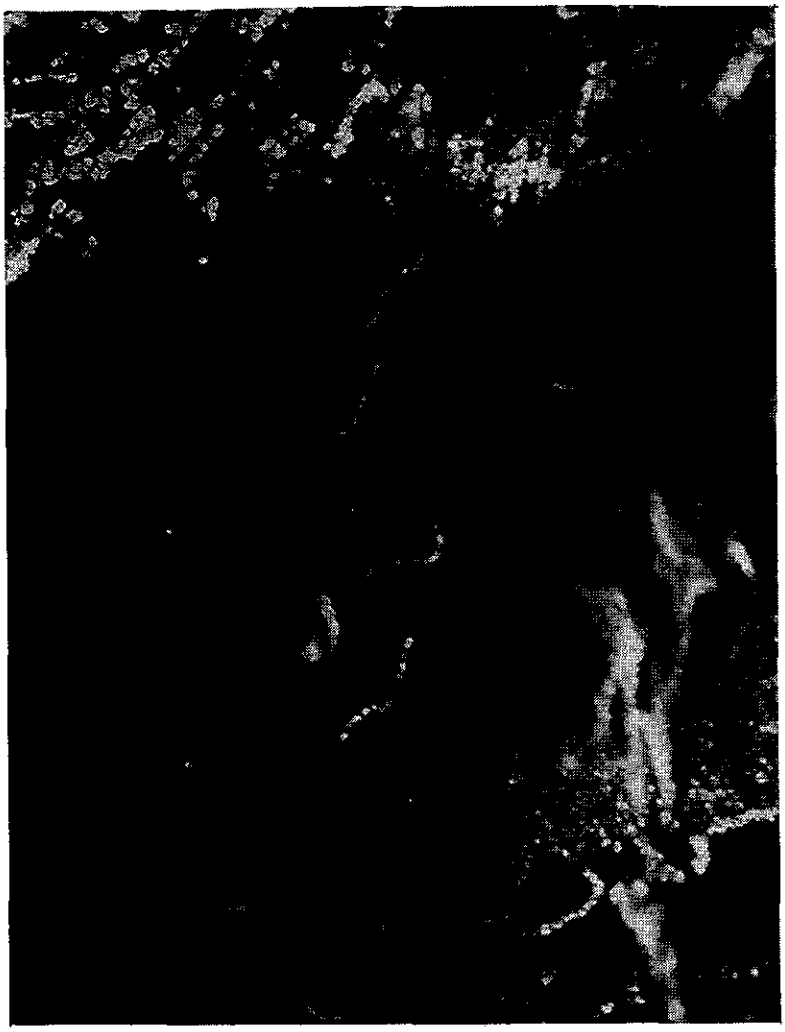

The Maldive Archipelago. *(see page 3.)*

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[1]Reynolds, R.W. and W.H. Gemmill, 1984. A sea surface temperature analysis which blends *in situ* and satellite observations. *Proceedings of the Ninth Climate Diagnostics Workshop*, Corvallis, OR, Oct. 22-26, 1984, pp. 408-416.
[2]The climatology is derived from *in situ* data (1950-1979), satellite data (1982-1985) and an ice climatology.
[3]Robinson, M.K., 1976. Atlas of North Pacific Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOceano Ref. Pub. 2.*
Robinson, M.K., R.A. Bauer, and E.H. Schroeder, 1979. Atlas of North Atlantic-Indian Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOceano Ref. Pub. 18.*

Oceanographic Monthly Summary

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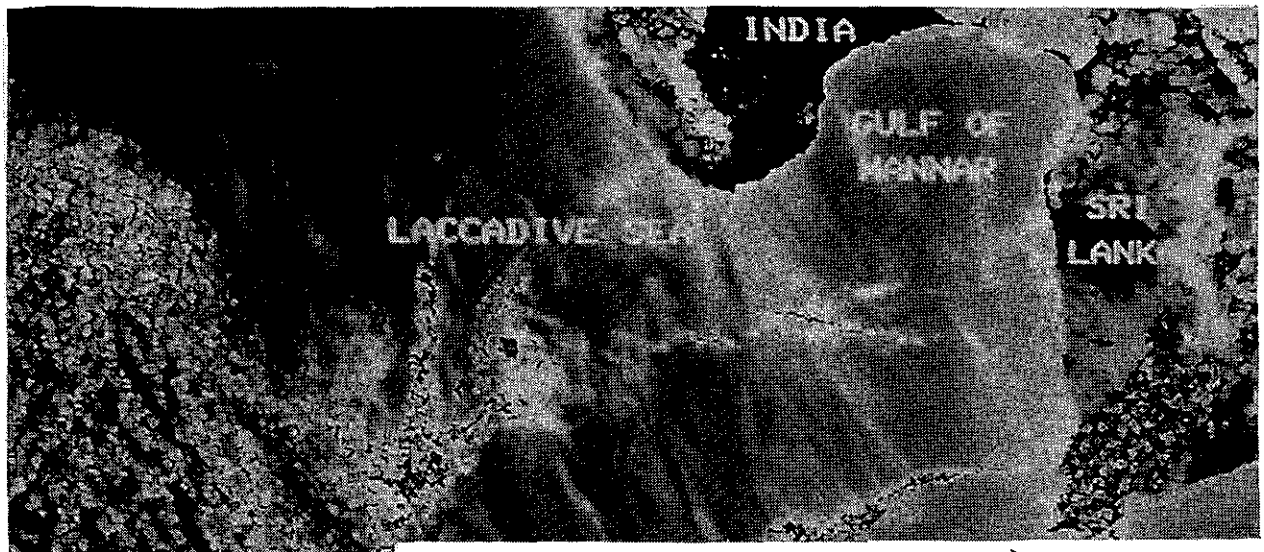

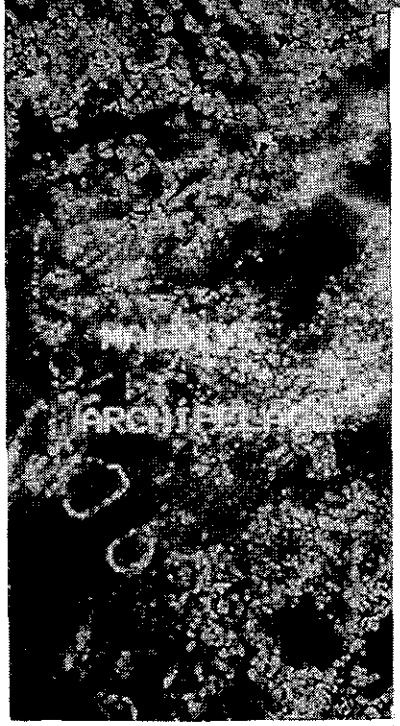

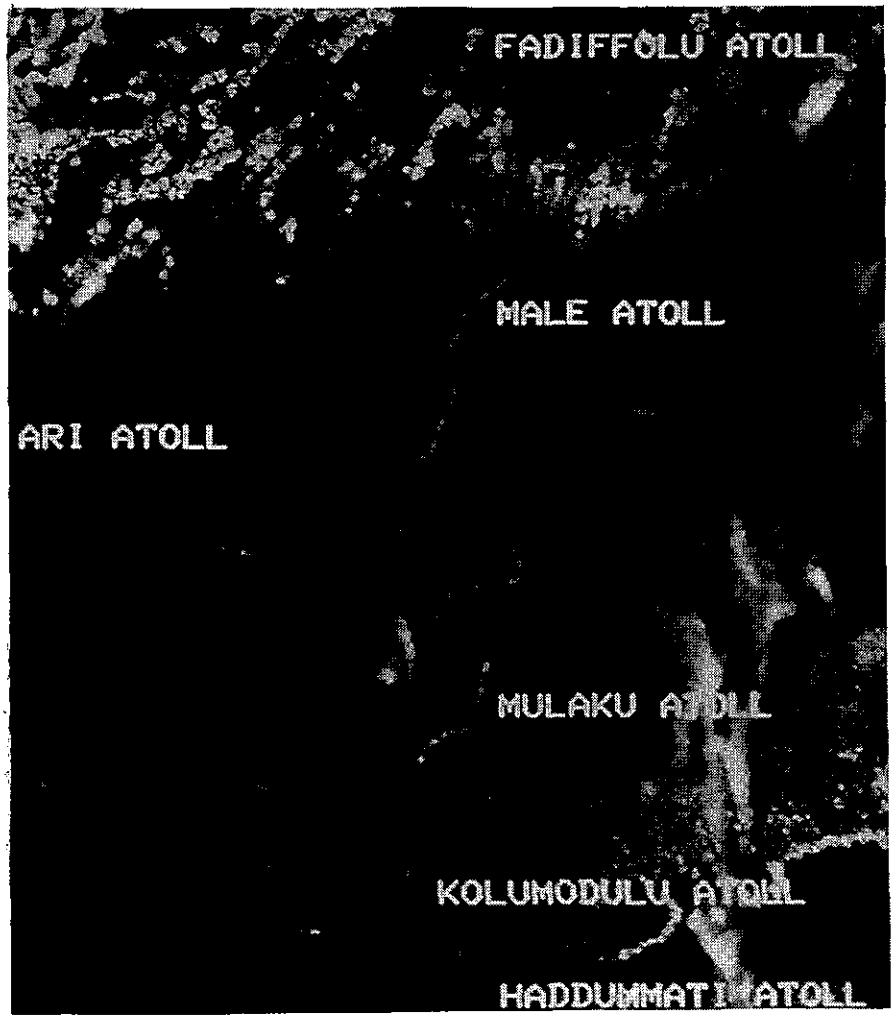

SATELLITE IMAGE OF THE MONTH
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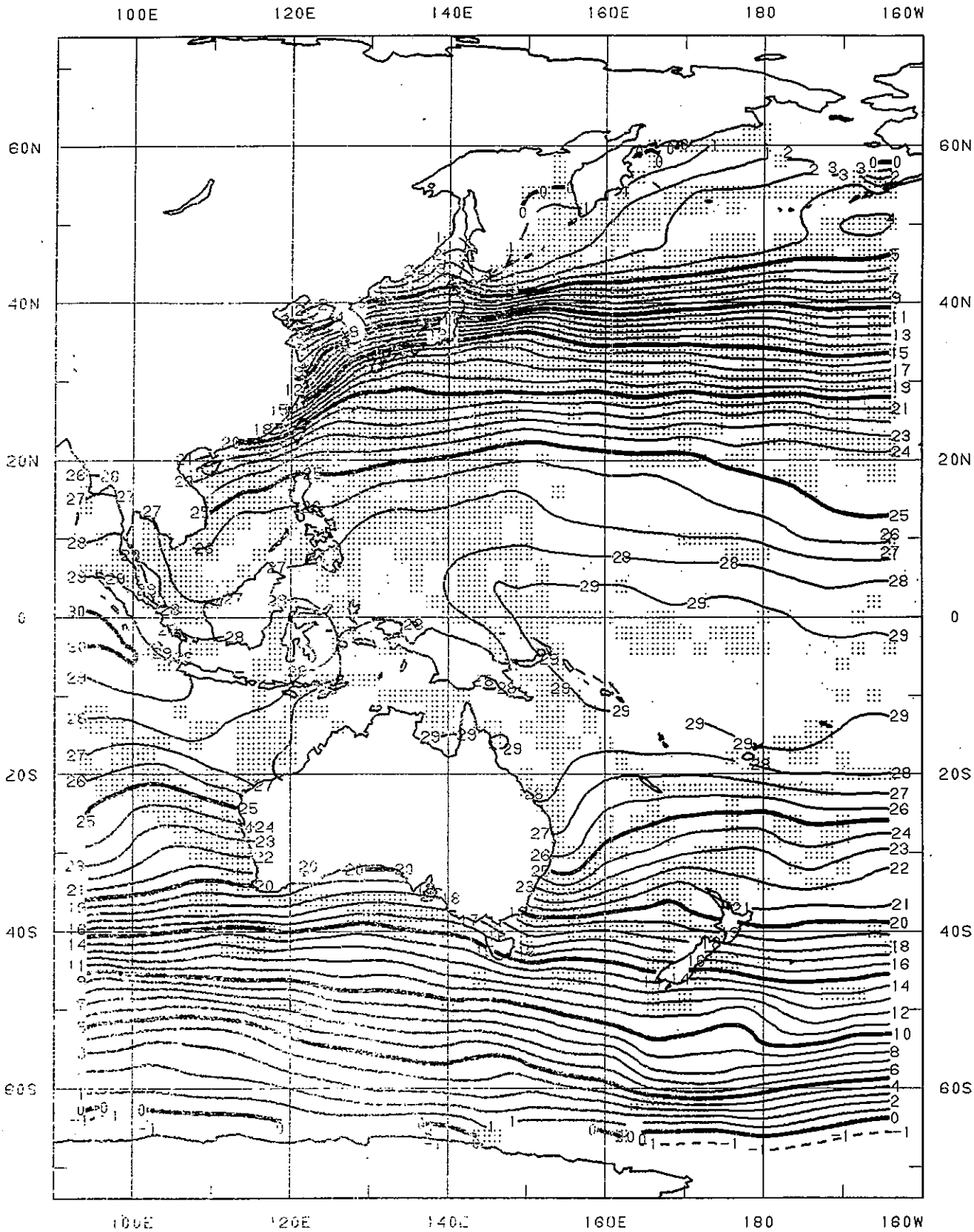
FEBRUARY 1987

The Maldive Archipelago

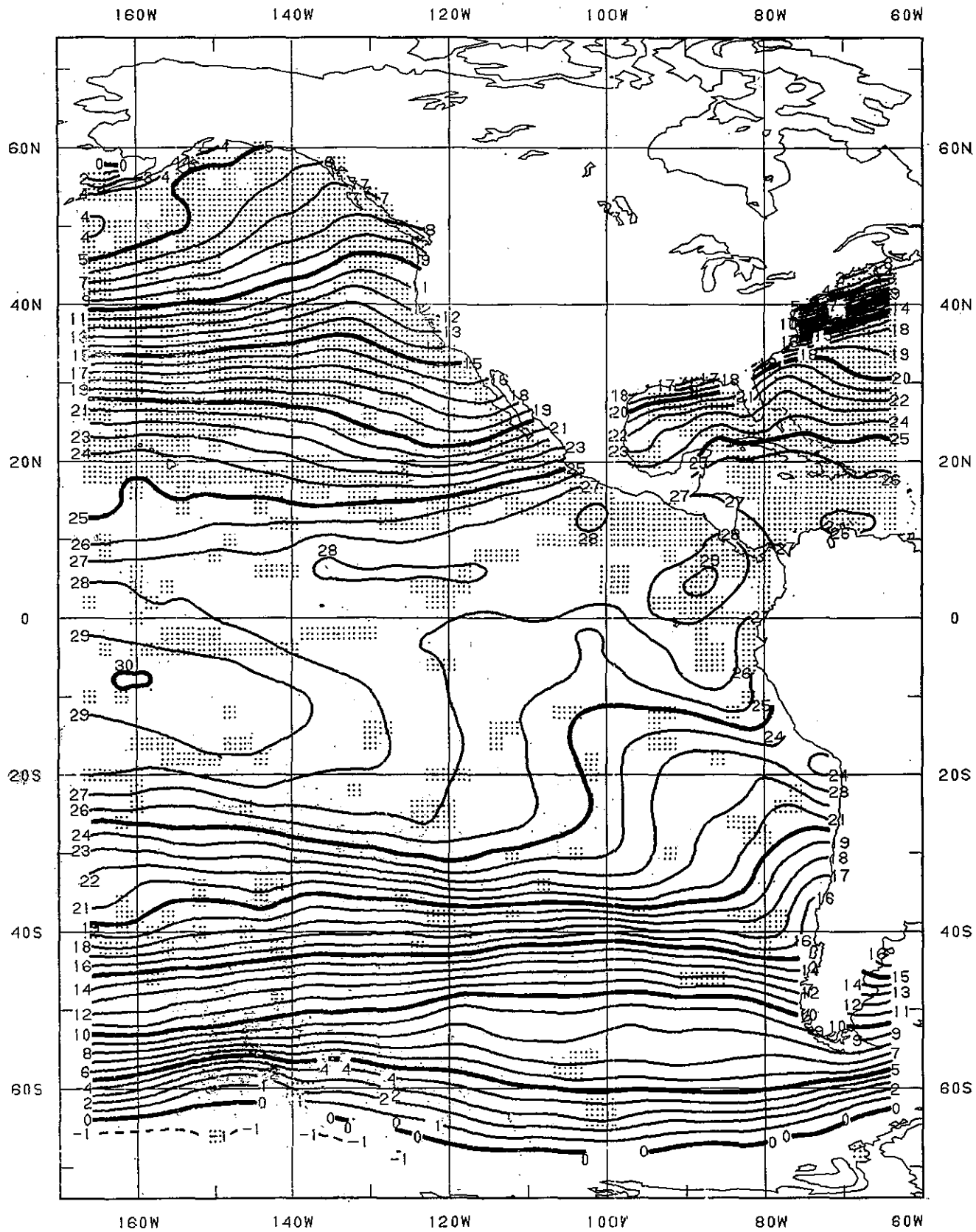
The images (NOAA-10, AVHRR enchanced channel 1) show the central Indian Ocean SSW of India. The upper image (March 1, 10:08 GMT, 2 km resolution) shows a large scale view of the area, from approximately the equator to 10 degrees N. At upper right are the southern tip of India and western Sri Lanka (formerly Ceylon, also formerly Serendib, whence the word serendipity), with the

(Text continued on page 13).



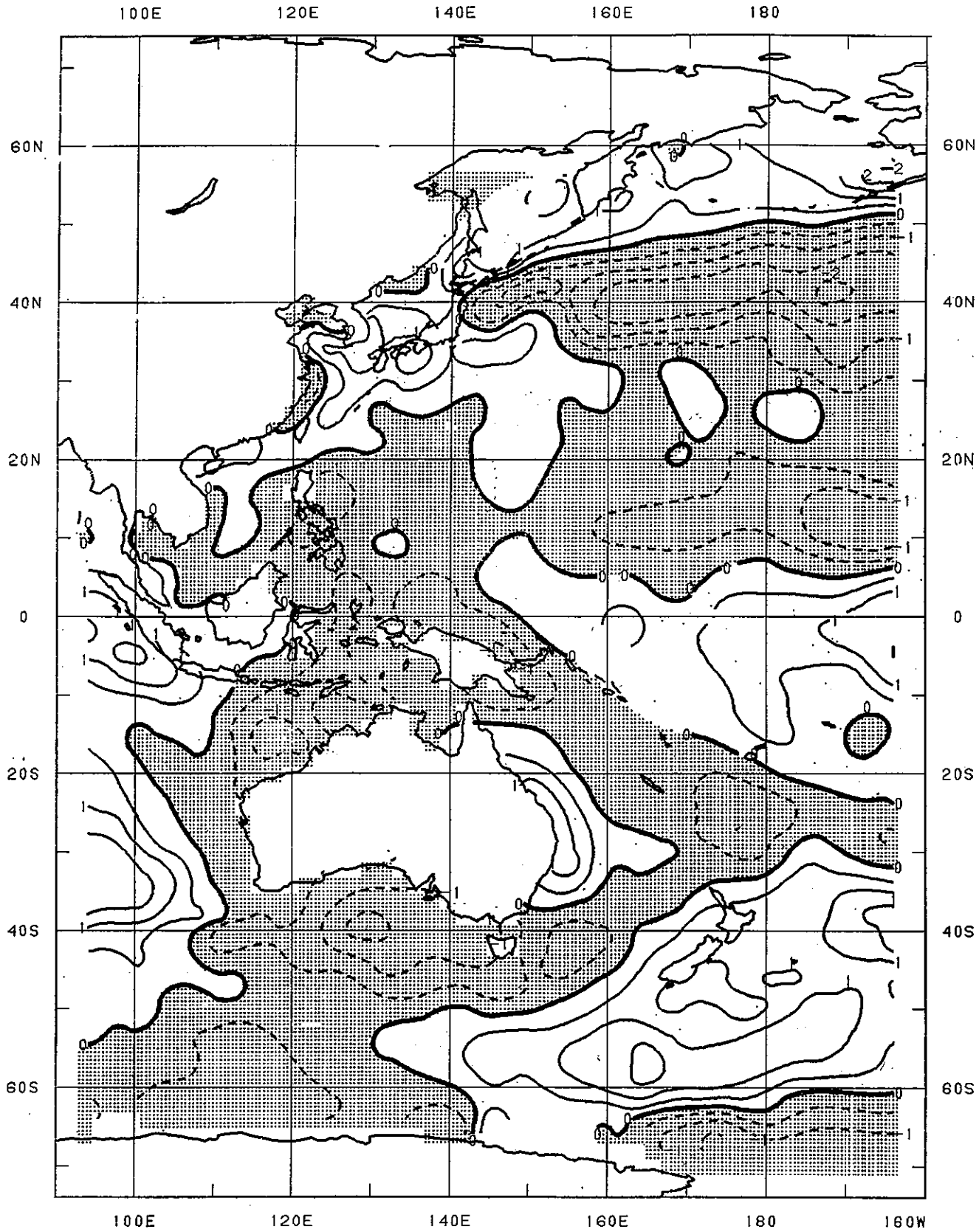
Western Pacific Ocean
SST--MONTHLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA
FEBRUARY 1987

Monthly mean sea surface temperature is the mean of *in situ* and satellite data within two-degree quadrangles. Contour line interval is 1.0°C. The stippling indicates where the analysis was fixed by the *in situ* data; contours are not shown in areas without data.



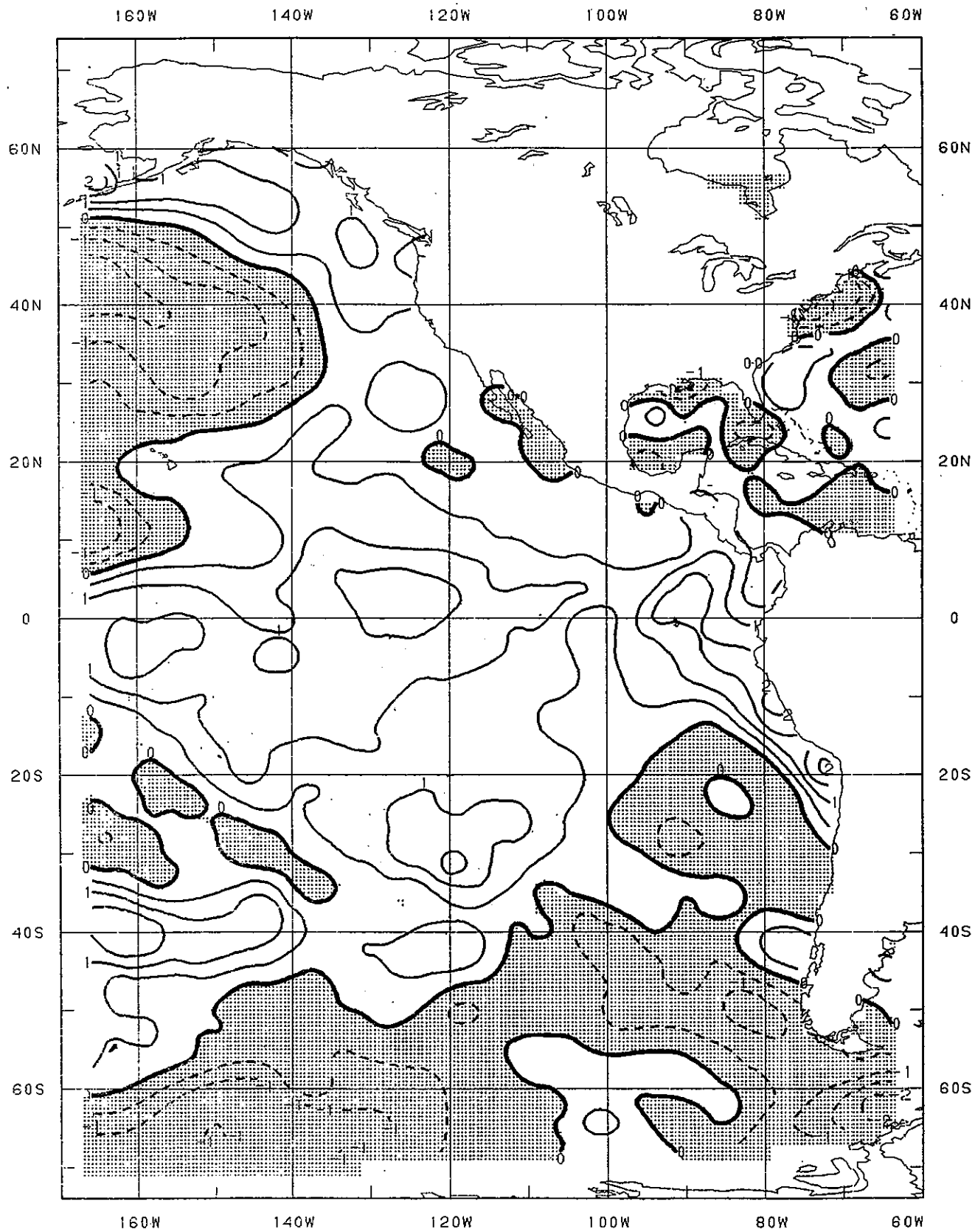
Eastern Pacific Ocean Ocean
SST--MONTHLY MEAN (°C)
SHIP, BUOY, AND SATELLITE
DATA
FEBRUARY 1987

Monthly mean sea surface temperature is the mean of *in situ* and satellite data within two-degree quadrangles. Contour line interval is 1.0°C. The stippling indicates where the analysis was fixed by the *in situ* data; contours are not shown in areas without data.



Western Pacific Ocean
SST--MONTHLY ANOMALY
SHIP, BUOY, AND SATELLITE DATA
FEBRUARY 1987

Monthly anomaly is the difference between the monthly mean sea surface temperature and the climatological monthly mean value. Contour line interval is 0.5°C. The stippling indicates where the monthly mean is colder than climatology; contours are not shown in areas without monthly or climatological data.



Eastern Pacific Ocean
SST--MONTHLY ANOMALY (°C)
SHIP, BUOY, AND SATELLITE DATA
FEBUARY 1987

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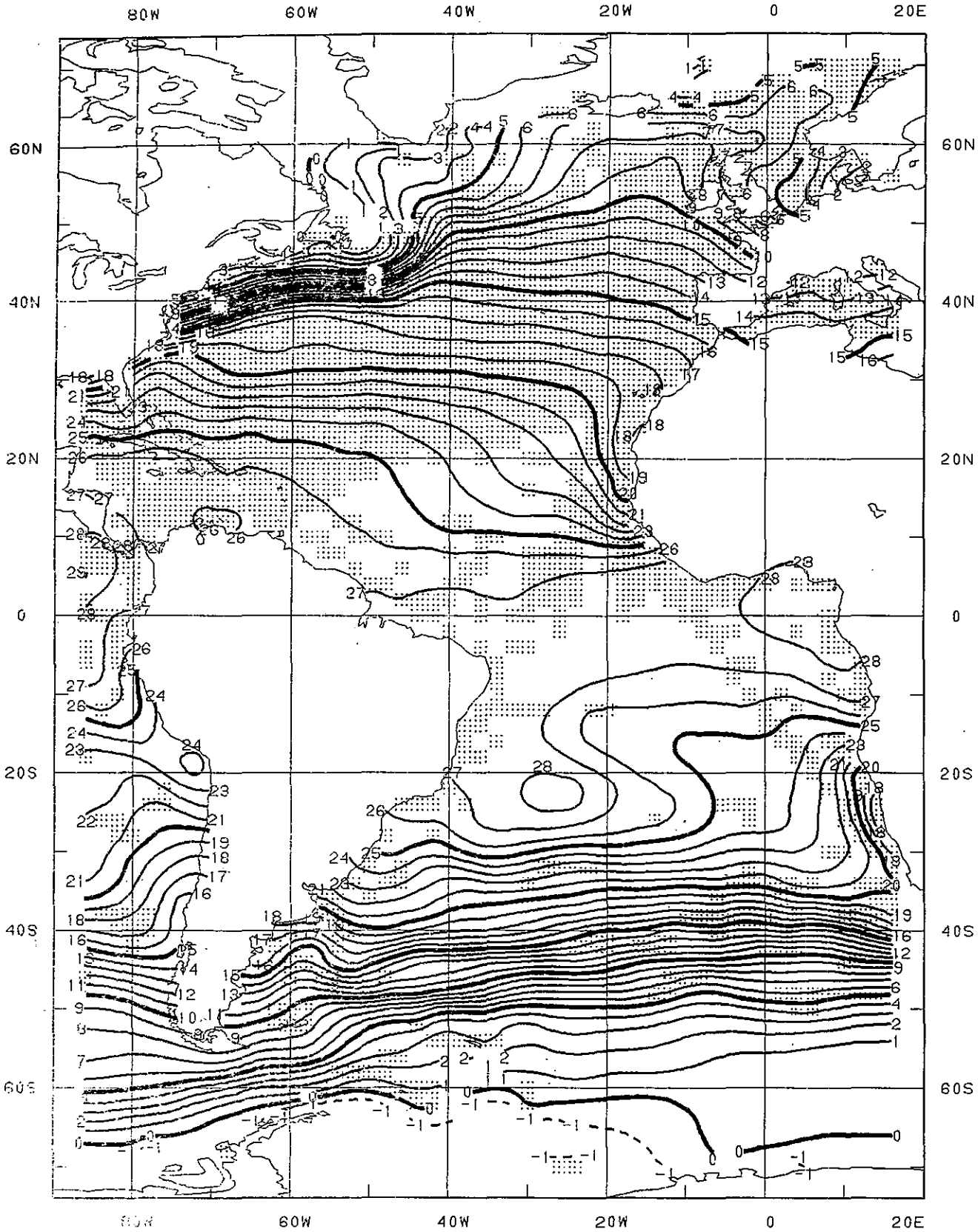
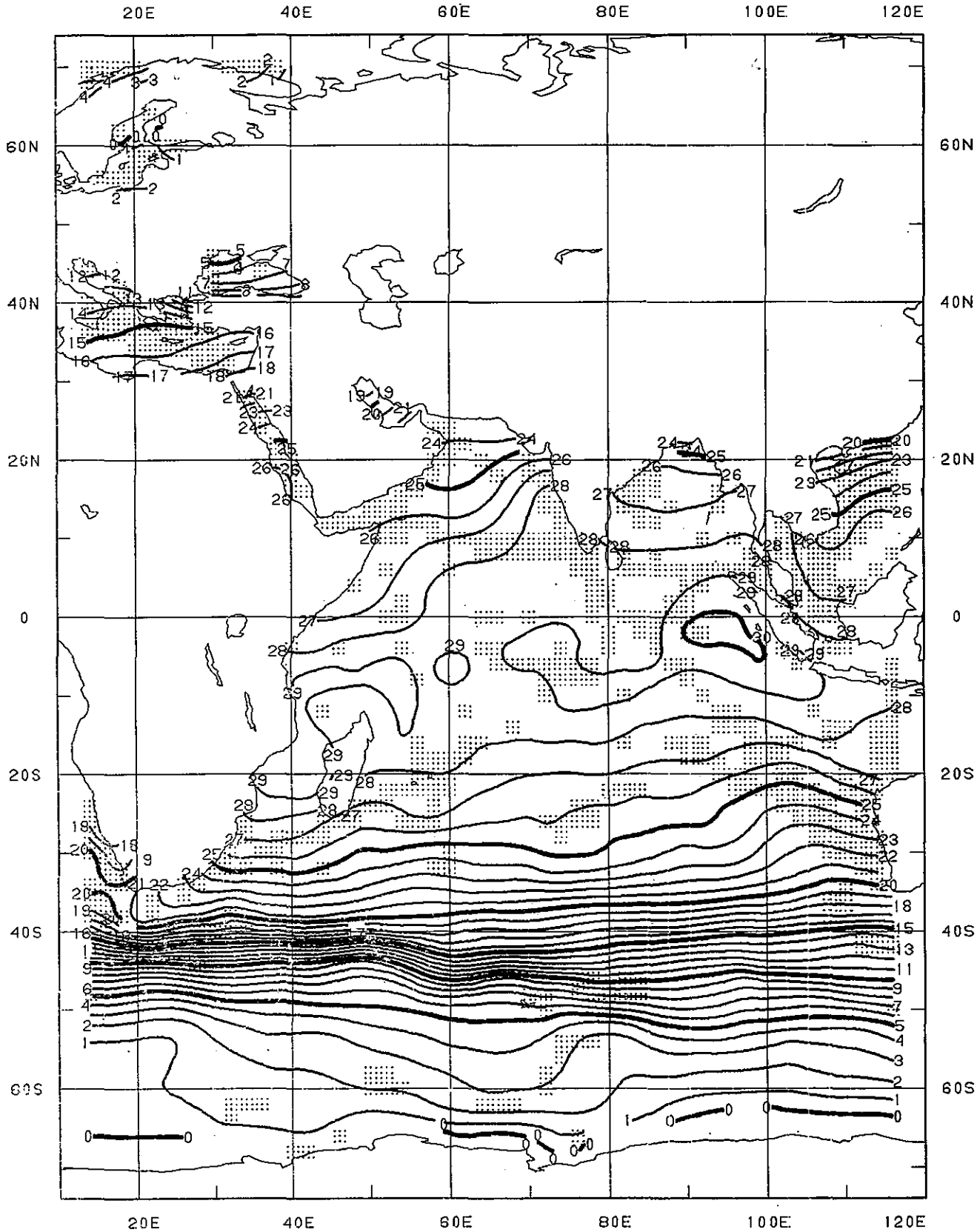


Atlantic Ocean
SST--MONTLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA
FEBRUARY 1987

Monthly mean sea surface temperature is the mean of *in situ* and satellite data within two-degree quadrangles. Contour line interval is 1.0°C. The stippling indicates where the analysis was fixed by the *in situ* data; contours are not shown in areas without data.



Indian Ocean
SST--MONTHLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA
FEBRUARY 1987

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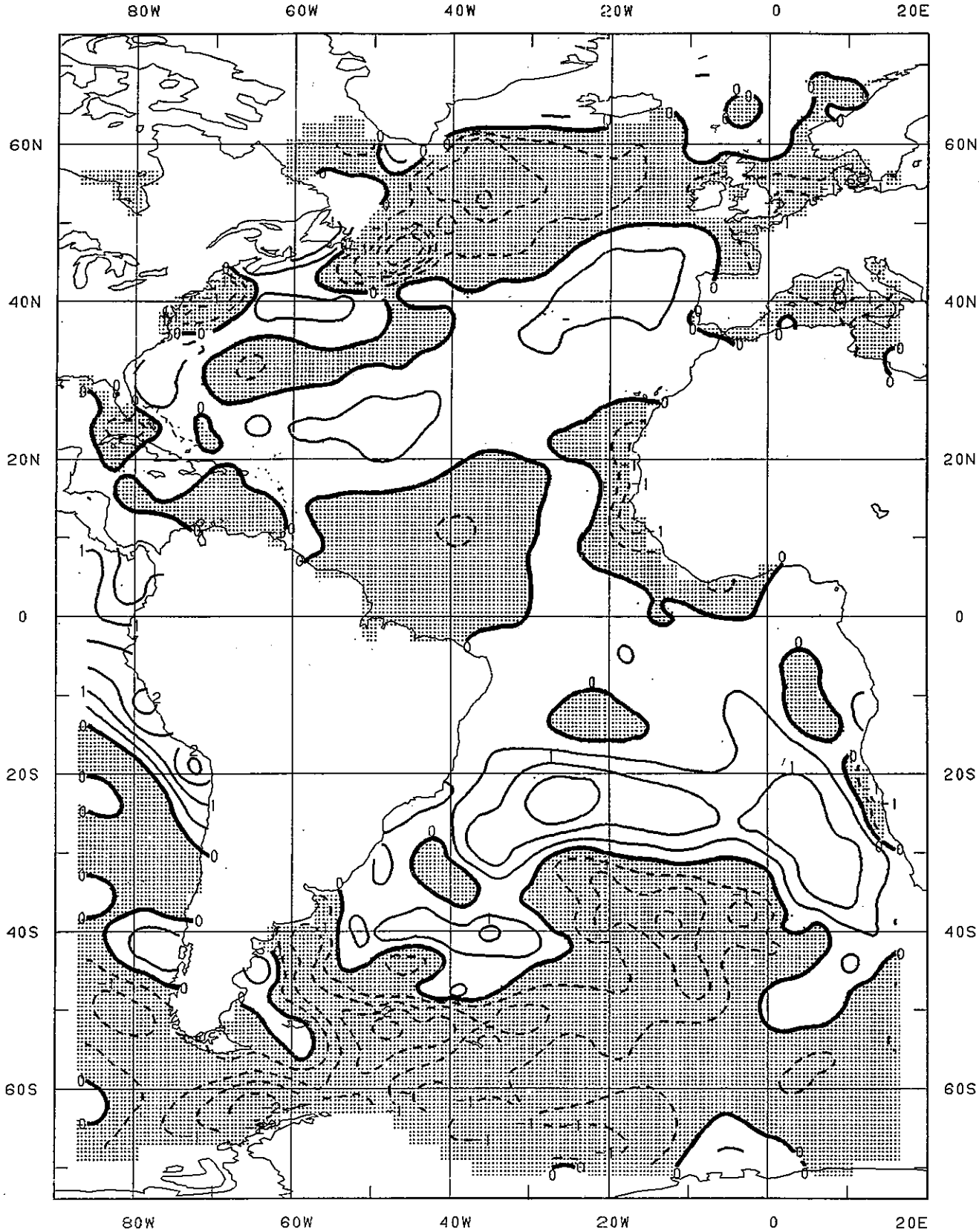
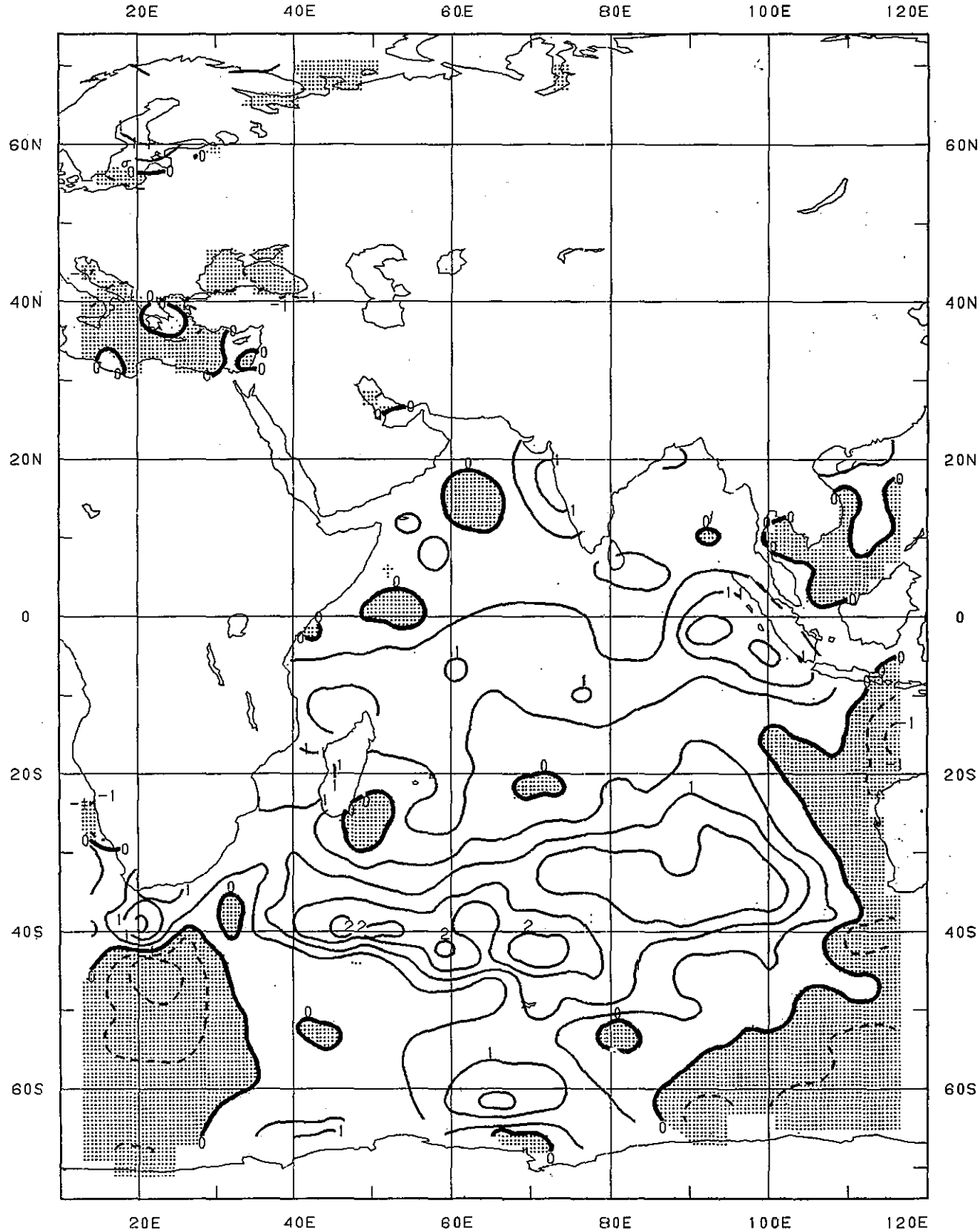


Atlantic Ocean
SST--MONTHLY ANOMALY (°C)
SHIP, BUOY, and SATELLITE DATA
FEBRUARY 1987

Monthly anomaly is the difference between the monthly mean sea surface temperature and the climatological monthly mean value. Contour line interval is 0.5°C. The stippling indicates where the monthly mean is colder than climatology; contours are not shown in areas without monthly or climatological data.



Indian Ocean
SST--MONTHLY ANOMALY (°C)
SHIP, BUOY, and SATELLITE DATA
FEBRUARY 1987

Monthly anomaly is the difference between the monthly mean sea surface temperature and the climatological monthly mean value. Contour line interval is 0.5°C. The stippling indicates where the monthly mean is colder than climatology; contours are not shown in areas without monthly or climatological data.

NOWCASTING CROSS-STREAM AVERAGED SURFACE SPEED IN THE FLORIDA CURRENT BETWEEN FLORIDA AND THE BAHAMAS

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Nowcasting, which is a statement of existing conditions from real-time data analysis, provides information that can be used to make decisions as they are needed. Fluctuations in the cross-stream averaged surface speed of the Florida Current are amenable to nowcasting because changes in surface speed cause measurable changes in sea level between Florida and the Bahamas; sea level can be measured in real-time from telemetering tide gauges. Figure 1 shows the location of two Coastal-Marine Automated Network (C-MAN) stations that relay sea level, sea surface and air temperature, atmospheric pressure, and wind velocity data via GOES to a NOAA computer where real-time nowcasting of surface speed is calculated.

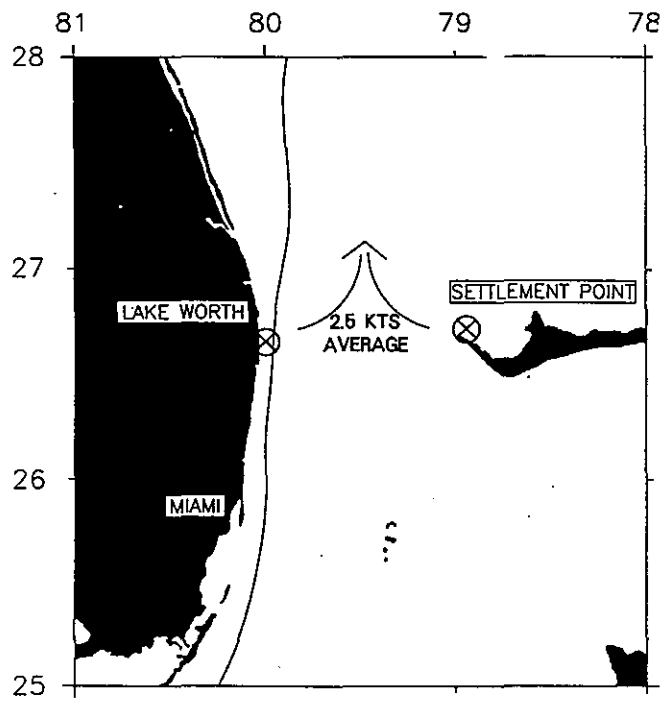

Figure 1: Location of the NOAA C-MAN stations that transmit sea level and weather from Lake Worth and Settlement Point. Map is based on the standard facsimile product showing the cross-stream averaged surface speed from C-MAN data, and the location of the west wall of the Gulf Stream from GOES infrared observations. The complete facsimile chart covering the eastern Gulf of Mexico to Cape Hatteras is available from the NOAA Miami SFSS via telephone (305-661-0738) using a Xerox Model 410 compatible telecopier, and an abbreviated voice version is on NOAA weather radio from Key West to Cape Hatteras at 162.40 MHz, 162.47 MHz, or 162.55 MHz.

The reason that sea level can be used to nowcast surface speed is that for currents, the primary balance of forces is between the Coriolis force and the horizontal pressure gradient. This balance is expressed in the geostrophic equation:

$$f\,vs = g\,dh/dx$$

where f is the Coriolis parameter, vs is the surface speed, g is the gravitational acceleration, dh is the sea level difference between tide gauges, and dx is the distance between them. Sea level at a tide station is affected by tides, weather, and steric changes, as well as surface currents, and the NOAA C-MAN installations provide measurements of the other variables for inclusion in the nowcast.

Sea level difference between the Lake Worth and Settlement Point C-MAN stations can only be determined in an empirical sense with these data. Similarly, weather effects on tide gauge measurements are determined empirically. The technique used to correlate the effects is multivariate linear regression. Data from direct observations of the Florida Current cross-stream averaged surface speed and local weather data are least squares fitted to a linear equation. Between 1982 and 1984 such a data set with 131 independent observations was acquired between Florida and the Bahamas, and the least squares best fit equation is:

$$Vs(cm/sec) = -1.00LWSL(cm) - 0.53BP(mb) + 3.58WT(^\circ C) - 0.13Nwind(m/s) + 0.11Ewind(m/s) + 1589.3$$

where Vs is the estimated cross-stream averaged surface speed, LWSL is Lake Worth Sea Level, BP is atmospheric Barometric Pressure, WT is Water Temperature, Nwind is the North Wind speed component, Ewind is the East Wind speed component, and 1589.3 is the least squares regression constant.

Regression coefficients for the weather terms in this multivariate equation are statistically significant using the F-test with $\alpha = 0.05$. However, a simpler estimation equation with slightly degraded accuracy can be computed from:

$$Vs(cm/sec) = -1.80LWSL(cm) + 1788.2$$

Standard error with this univariate equation is $\pm$ 12 cm/sec. Only Florida sea level is used because the 1982-1984 data were acquired before the Settlement Point Sea Level (SPSL) C-MAN station was established, but SPSL will be incorporated in future least squares analyses.

Figure 2 shows the correlation between observed cross-stream averaged surface speed between Florida and the Bahamas, and the speed estimated from the multivariate least squares equation which includes weather terms. The range of speeds is greater than 150 cm/sec and the standard error of estimation is $\pm$ 10 cm/sec. Diurnal and semidiurnal tides are removed from the C-MAN reports by averaging the previous 25 hours; thus nowcasts of surface speed are approximately 1/2 day late. Fourier transform techniques to nowcast without this time lag are being tested.

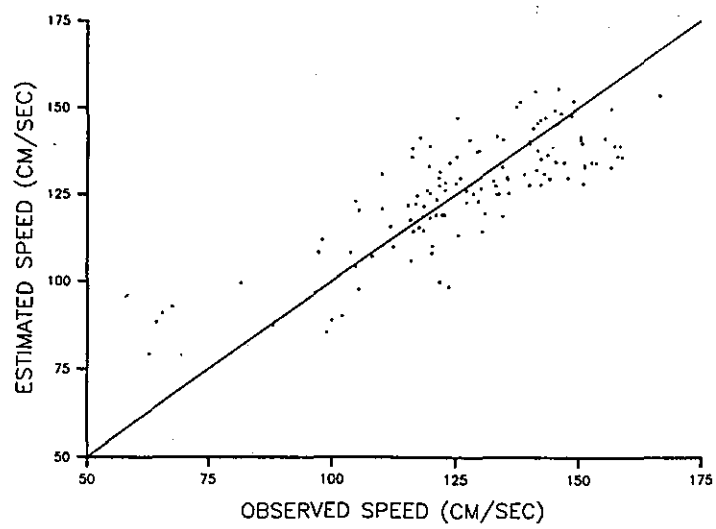

Figure 2: Correlation between the observed cross-stream averaged surface speed between Florida and the Bahamas from shipboard measurements, and the estimated speed from sea level and weather using the multivariate least squares equation. The linear correlation coefficient is 0.82.

Figure 3 shows the daily cross-stream averaged surface speed between Lake Worth and Settlement Point for 1986. Note the rapid changes in northward speed that occur on time scales less than fortnightly. This information is being broadcast on NOAA weather radio, and is entered on facsimile charts such as shown in Figure 1. The information is available to marine interests such as shipping, fishing, yachting, and to the Coast Guard, for their daily operations.

Acknowledgments: Programming to relay data sets between the GOES system and the NOAA computer was the work of S. Michael Minton and W. Douglas Wilson (AOML). Ray Canada (NWS) and William E. Woodward (NOS) established the LWSL and SPSL C-MAN stations and have supported their operation. John A. Sczymanski, Lake Worth City Engineer, and Douglas M. Martin (NOS) have been most helpful in the development of this product.

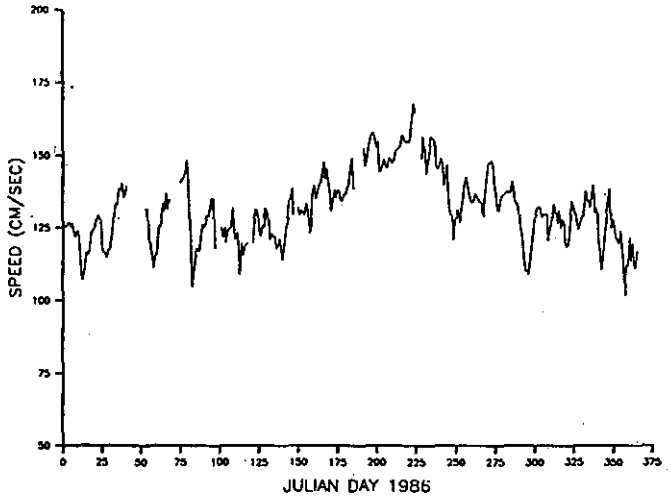

Figure 3: Time history of daily Florida Current cross-stream averaged surface speed for 1986 from the Lake Worth C-MAN station data. All variables used in the multivariate estimation equation are 40-hour low-pass filtered prior to computation of Vs. Small gaps in the record are caused by short-term transmission problems.

SATELLITE IMAGE OF THE MONTH
(Continued from page 3)

Gulf of Mannar between them. The Laccadive Sea is to the SW of India. Farther SW is the Maldive Archipelago, partially obscured by clouds. The lower image and cover (Feb. 28, 10:18 GMT, 1 km resolution) show a smaller scale view of the Maldive Islands, from approximately 1 degree N to 7 degrees N. Kolumodulu and Haddummati Atolls (labeled) are the most prominent in the large scale image, although portions of others may be discerned among the clouds.

The Maldives are part of the Chagos-Laccadive Ridge system. It is oriented in a N-S direction and stretches from the Chagos Islands at 5 to 7 degrees S to the Laccadive Islands at 10 to 12 degrees N. The ridge is aseismic, and is presumed to have been produced as the Indian crustal plate moved north over a large volcanic hotspot located on or near the Mid-Indian Ocean Ridge spreading center. Continuous extrusion of large quantitites of crustal material produced a ridge, instead of the more common chain of individual islands or seamounts, as found in the Hawaiian Island/Emperor Seamount chain and the island chains in the SW Pacific.

The atolls were formed as the sea floor crust subsided under the weight of the ridge. Initially a fringing coral reef is formed around the emergent island volcano. Upon extinction, the volcano begins to subside. The coral grows upward, and the fringing reef becomes an encirling barrier, enclosing a shallow lagoom with small islands connected by emergent or shallow reef. If continued subsidence is slow enough, coral growth can maintain the atoll. If subsidence rates exceed growth rates the atoll sinks and becomes a seamount.

Addendum: The January 1987 OMS Image of the Month was a Channel 3/4 split window image, produced by John Pritchard, NOAA/NESDIS.

BERING SEA / NORTH SLOPE ICE ANALYSIS

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FEBRUARY 1987

The general weather and sea ice pattern of the winter continued through February with mostly moderate temperatures and less than average sea ice extent in the southern Chukchi and Bering Seas. In the middle Bering Sea, sea ice approached the Pribilof Islands under the influence of cold Siberian air during the third and into the fourth week of the month. However, the ice advance halted some 60 nautical miles short of St. Paul due to a reversal of the wind direction. Sea ice decayed in Bristol Bay late in the month and the ice edge slowly retreated through the eastern and central Bering Sea due to warm winds from the Pacific Ocean. Meanwhile ice in the western Bering Sea continued to spread southward under the influence of cold temperatures and generally light northerly winds from the Siberian interior. Elsewhere, moderate temperatures in the southern Chukchi Sea of -0.3 F (5.8 F above normal for Kotzebue) have prevented all the ice in Kotzebue Sound from becoming shorefast; but, along the North Slope, temperatures of -40°F have contributed to near normal ice growth.

C = Total ice concentration in the area in tenths.

C_a, C_b, C_c = Concentration of thickest (C_a), 2nd thickest (C_b), and 3rd thickest (C_c) ice

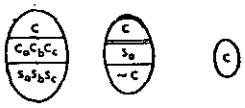
S_a, S_b, S_c = Stage of development of thickest (S_a), 2nd thickest (S_b), and 3rd thickest (S_c) ice.

-C = Concentration of ice within area(s) of strips and patches.

STAGE(S) OF DEVELOPMENT (THICKNESS)

1 = New ice (0-10 cm)
3 = Young ice (10-30 cm)
6 = First year (30-200 cm)
7 = First year thin (30-70 cm)
1. = First year medium (70-120 cm)
4. = First year thick (120-200 cm)
7. = Old ice (survived at least one summer's melt)

EXAMPLES

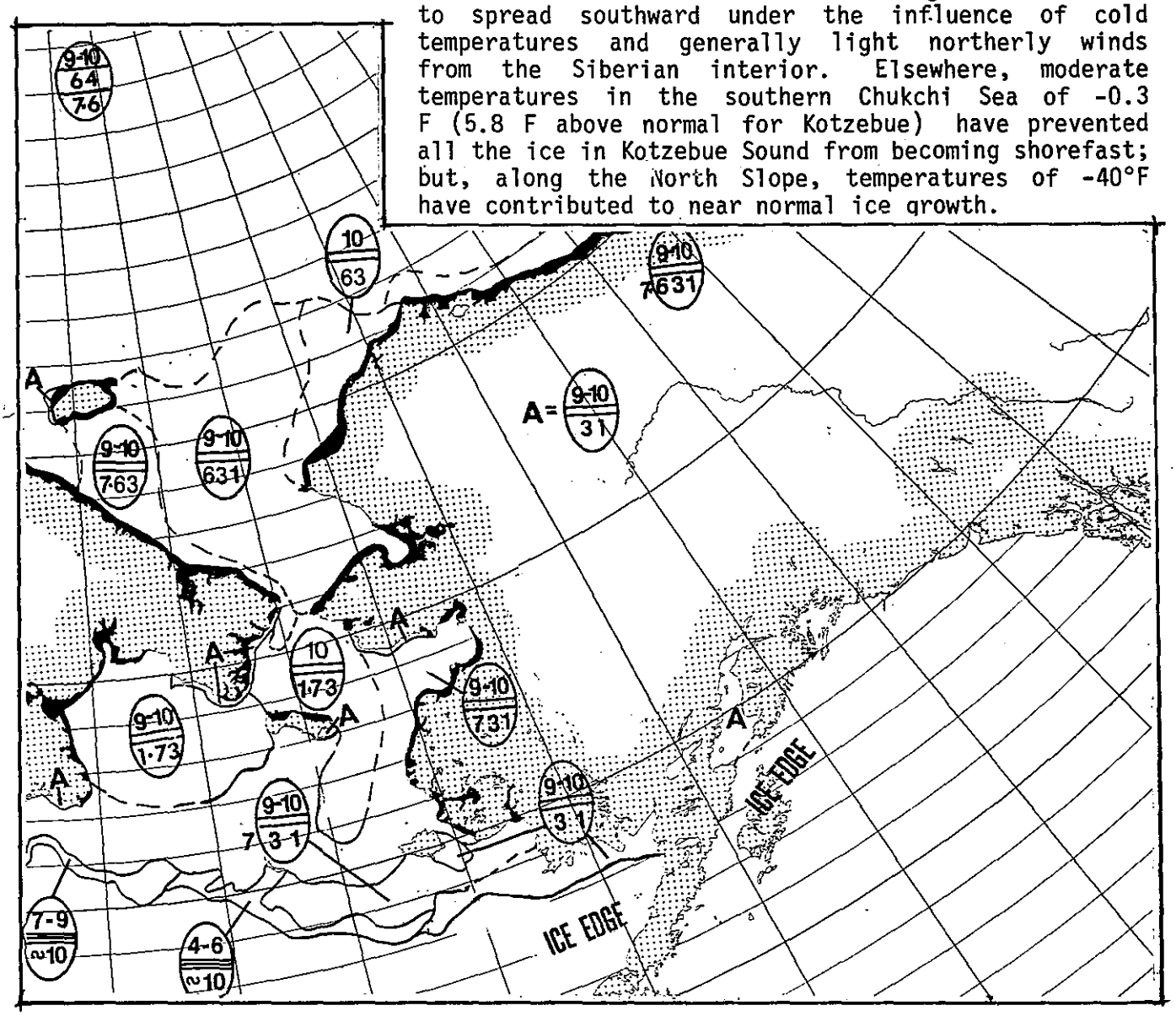


125 Theoretical thickness of this season's growth (cm).

Fast ice. Sea ice which forms and remains fast along the coast.

Ice boundary visually or satellite observed.

Ice boundary estimated.



WEST COAST OCEAN FEATURES

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Satellite Field Service Station
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Redwood City, CA 94063
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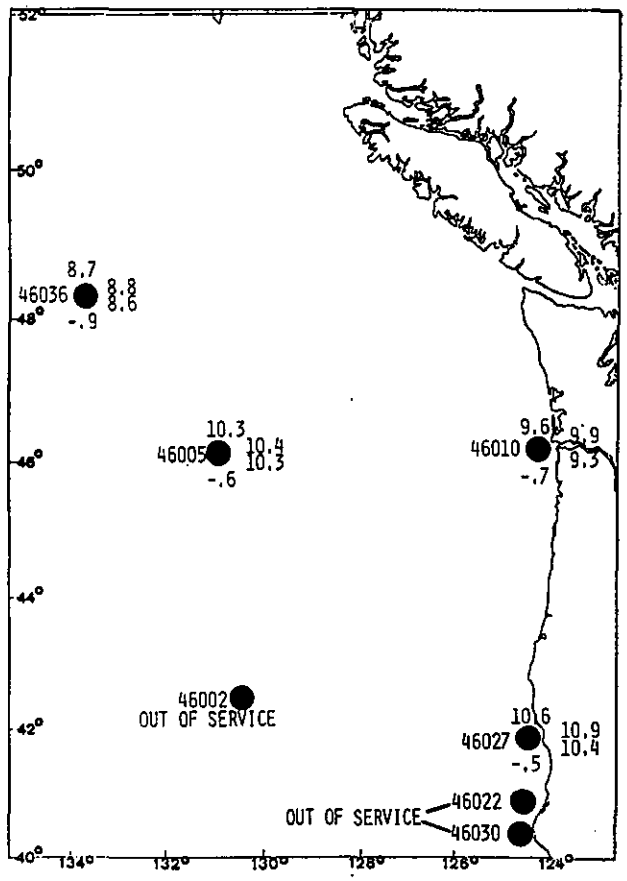
FEBRUARY 1987

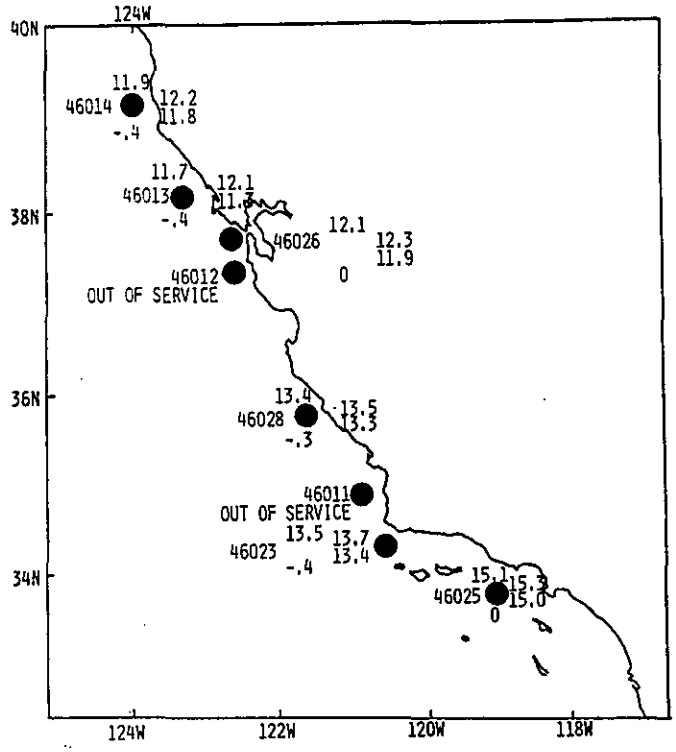
Sea surface temperatures along the West Coast continue to average above normal. In the North Panel, the computed mean temperature for the month was 9.4°C, or exactly 1° above the climatological



mean value. No area on the chart was cooler than climatology. The location of the least warm anomaly (+0.4°C) was near 51 N 134 W and the greatest (+1.7°C) was at 45 N 132 W. When comparing this month to last, sea surface temperatures cooled throughout the North Panel. The least amount of cooling was near 41N 128W, and the greatest cooling was observed at 45N 128W. The offshore areas tended to cool more than those alongshore.

In the South Panel, the computed mean SST for February was 15.0°C, or 0.5°C above climatology. Nearshore waters were above normal from 1.2°C to 1.4°C; offshore waters west of 131W were below normal. The location of the coolest anomaly (-1.1°C) was at 34N 135W. When comparing February's SST's to January's, the entire South Panel cooled. Nearshore surface water cooled less than in the offshore areas. The least cooling occurred just west of the San Francisco Bay area; the maximum cooling was centered near 36N 134W.

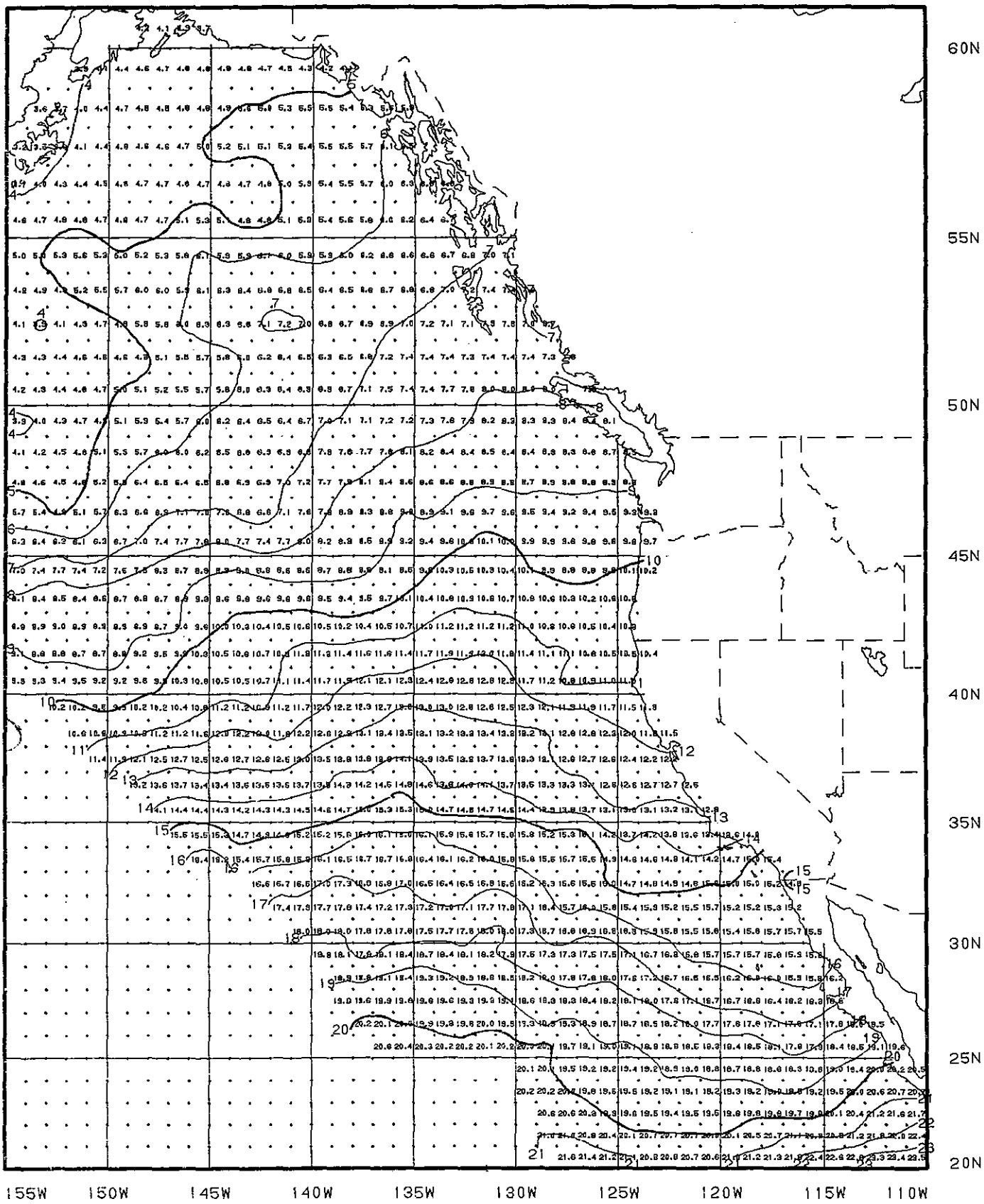
Daily buoy statistics revealed an interesting trend toward the end of the month. Beginning around February 22, buoy temperatures dropped markedly as a strong cold northerly flow developed on the surface. At buoy 46014, the SST's cooled almost 3.5°C over a 5 day period!



KEY:

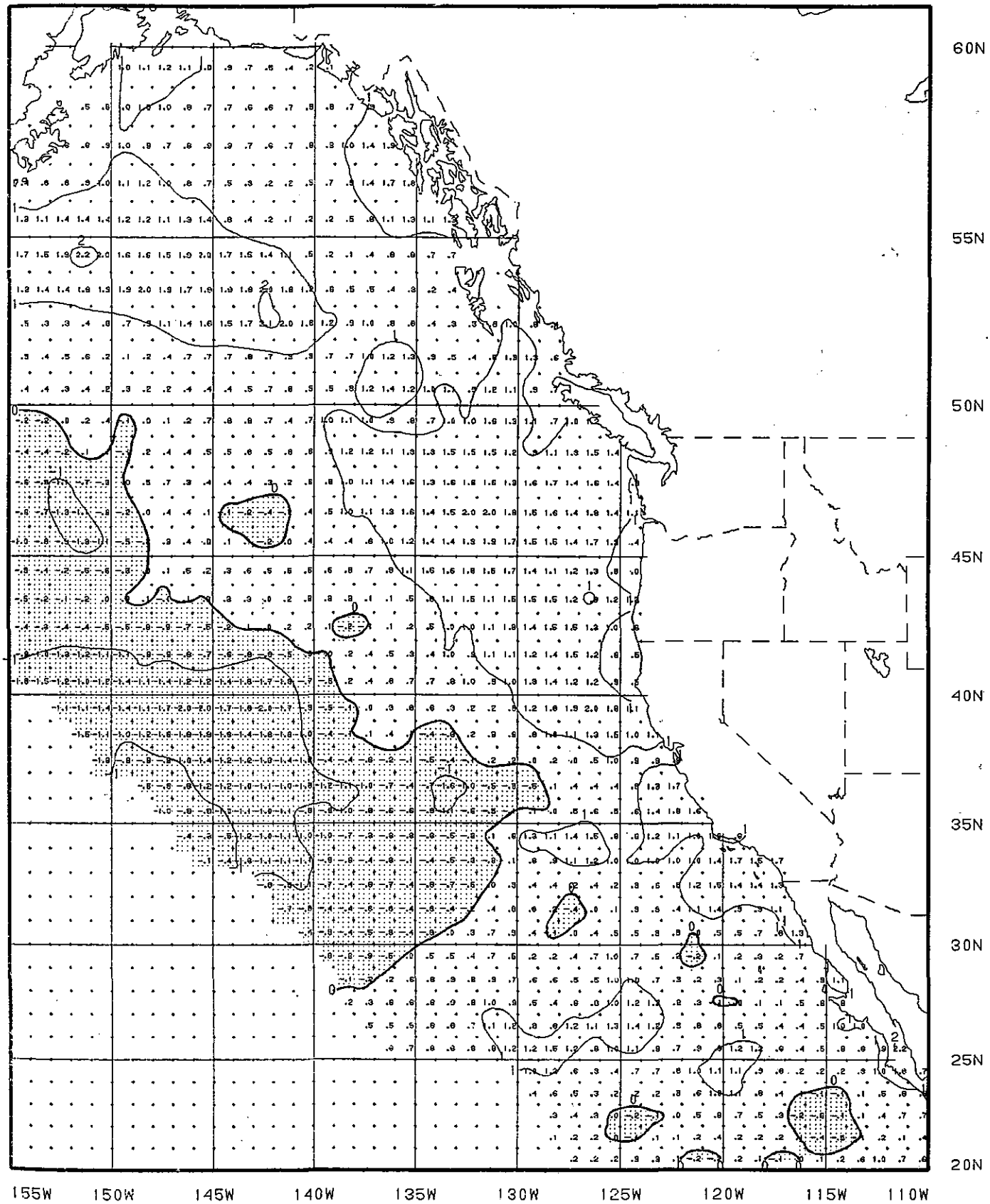
12.1 ← Monthly mean
LOCATION 13.5 ← Maximum daily mean
NAME 10.2 ← Minimum daily mean
-1.5 ← Change from previous month

● Denotes station position.



West Coast
SST--MONTHLY MEAN (°C)
FEBRUARY 1987

Monthly mean sea surface temperature is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0°C.



West Coast
SST--MONTHLY ANOMALY (°C)
FEBRUARY 1987

Monthly anomaly is the difference between the monthly mean sea surface temperature and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0°C.

EAST COAST OCEAN FEATURES

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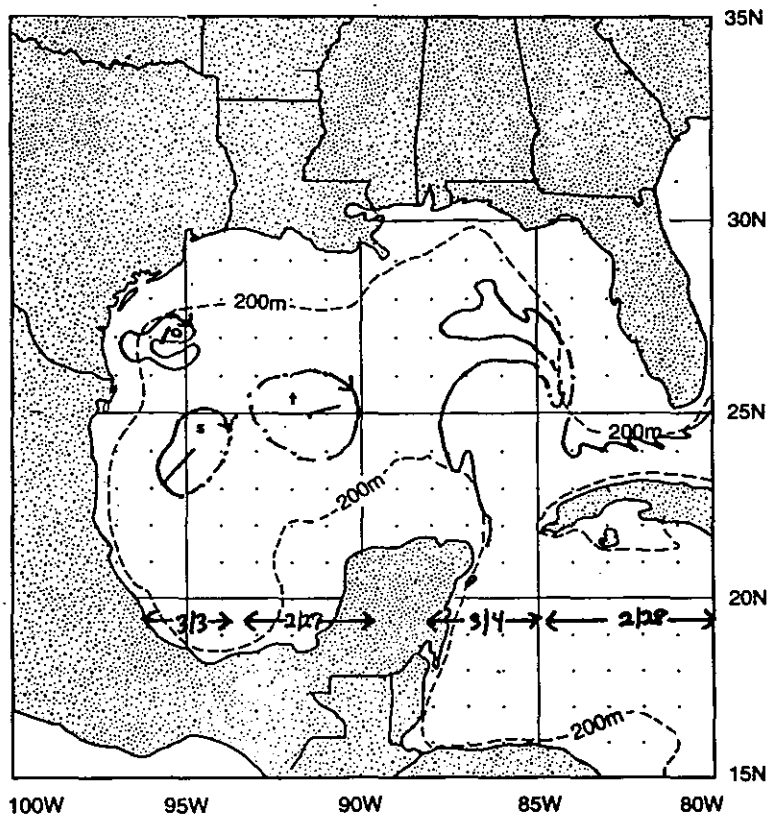
FEBRUARY 1987

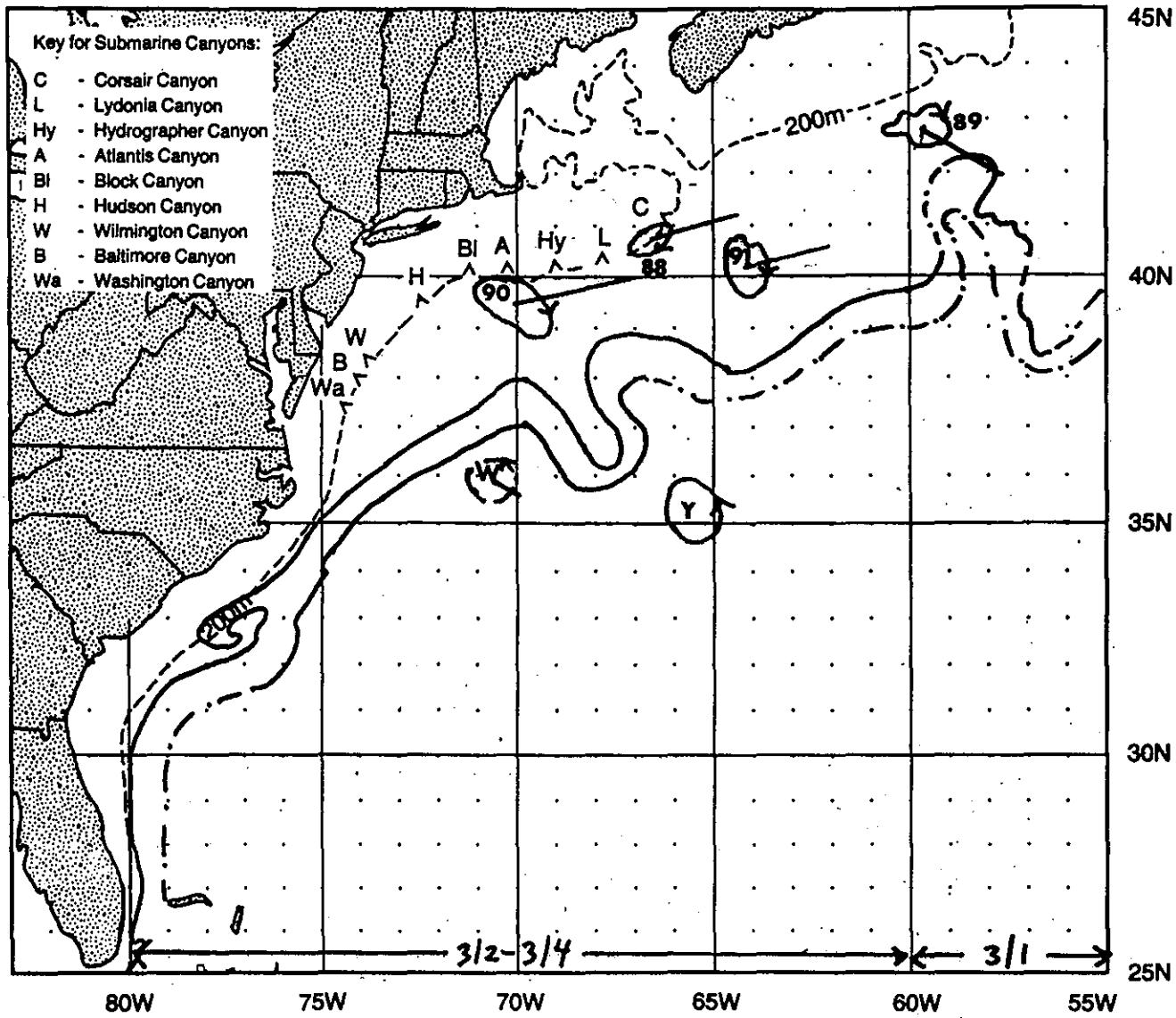
The end of this month's positions of the Gulf Stream System and its associated eddies are shown for the NW Atlantic and the Gulf of Mexico. The Gulf Stream and Loop Current boundaries are located by infrared satellite imagery or XBT (expendable bathythermograph) data. Anticyclonic eddies are labeled a-z in the Gulf of Mexico and 1-99 in the NW Atlantic. Cyclonic eddies are labeled A-Z. Arrows on eddies indicate direction of circulation. Warm-core or anticyclonic eddies rotate clockwise; cold-core or cyclonic eddies rotate counterclockwise. The line to the eddy center shows the net translation since last month or since last observed. The edge of continental shelf at 200 m is shown as a dashed line. Eddies or sections of the Gulf Stream System which were not observed during the month are not shown on the analysis chart or are indicated by "dot-dashed" lines. The long arrows at the bottom of the chart indicate the dates of data used.



Data used in this analysis include:
- NOAA satellite infrared imagery, NESDIS
- Bathythermograph data, National Meteorological Center of National Weather Service
- Oceanographic Analysis, A daily detailed analysis issued by National Weather Service/NESDIS

GULF OF MEXICO

The position of the Loop Current in the Gulf of Mexico moved northward by about 55 km compared to the end-of-January position. There is a long filament of warm water attached to the northeast section of the Loop Current from 27°N 87°W to 26°N 84°W. Anticyclonic eddy t apparently translated 85 km WSW. Its location is not clear. Eddy s traveled 140 km NE. Eddy o moved 35 km NE and appears to be dissipating.

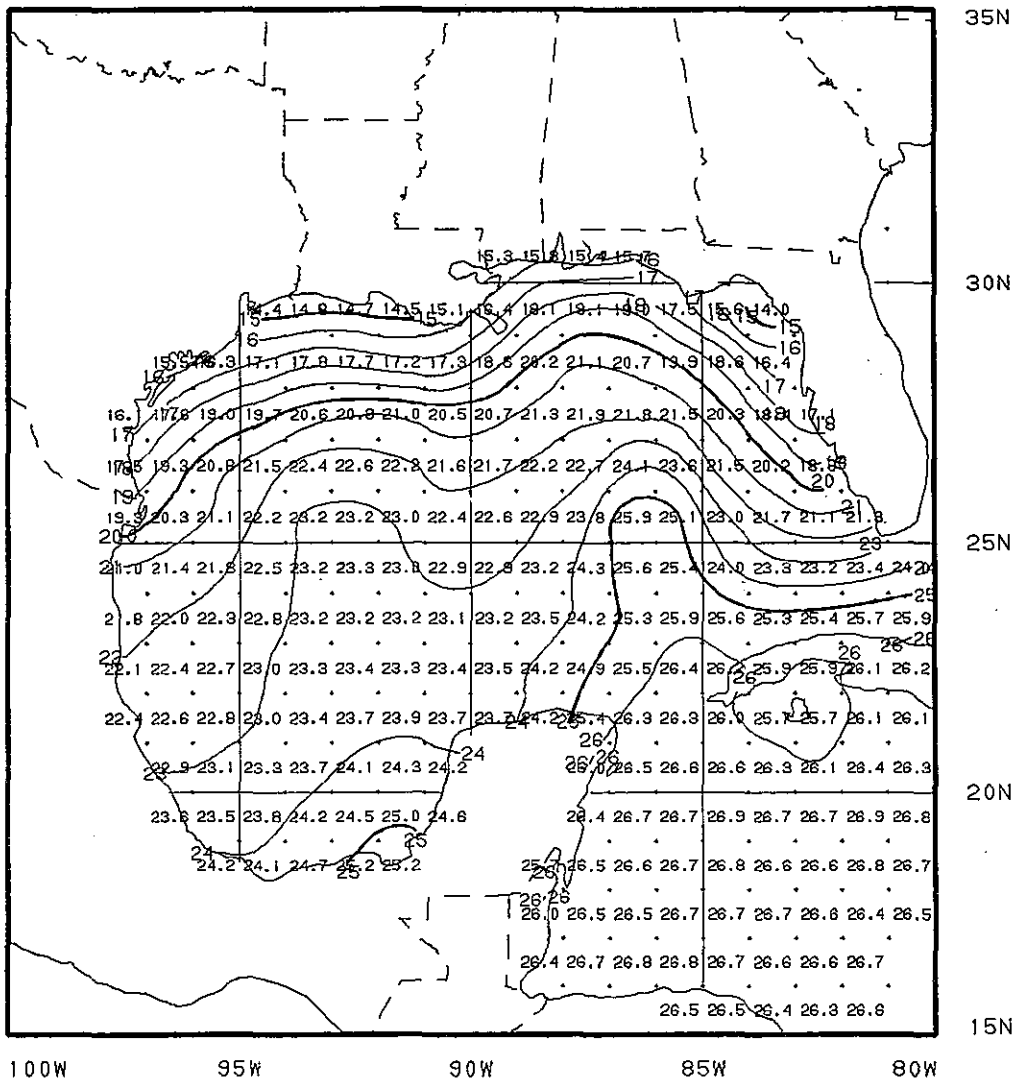


NORTHWEST ATLANTIC OCEAN

Anticyclonic eddy 85 was absorbed by the Gulf Stream near 37°N 74°W about February 4. Eddy 90 moved 285 km WSW while eddy 88 moved 185 km WSW. Eddy 91 translated 165 km WSW. Eddy 89 seemingly moved 195 km NW, but its position is not certain due to extensive cloudiness during February near 40-45°N 55-60°W.

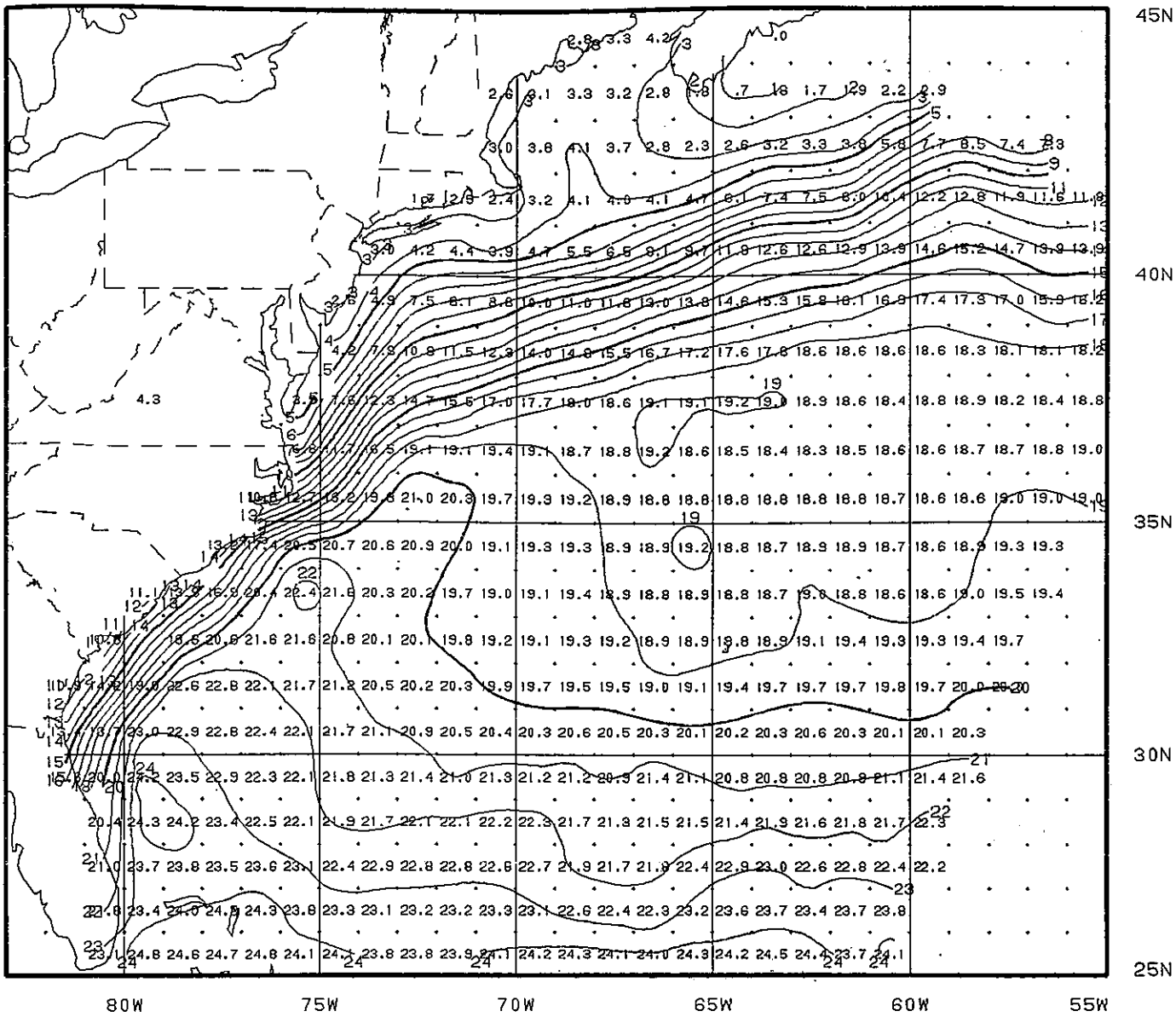
Cyclonic eddy (Y) was apparently newly observed near 35°30N 65°30W around February 4. Eddy U, last observed in December, was deleted from the chart after it was not observed for more than one month due to clouds. Eddy Y could actually be eddy U. However, it is named eddy Y since more than one month elapsed between observations of its position. Eddy W apparently traveled 55 km NW. Eddy H was not observed and therefore was deleted from the analysis chart.

EAST COAST SST – MONTHLY MEAN



Gulf of Mexico
SST--MONTHLY MEAN (°C)
FEBRUARY 1987

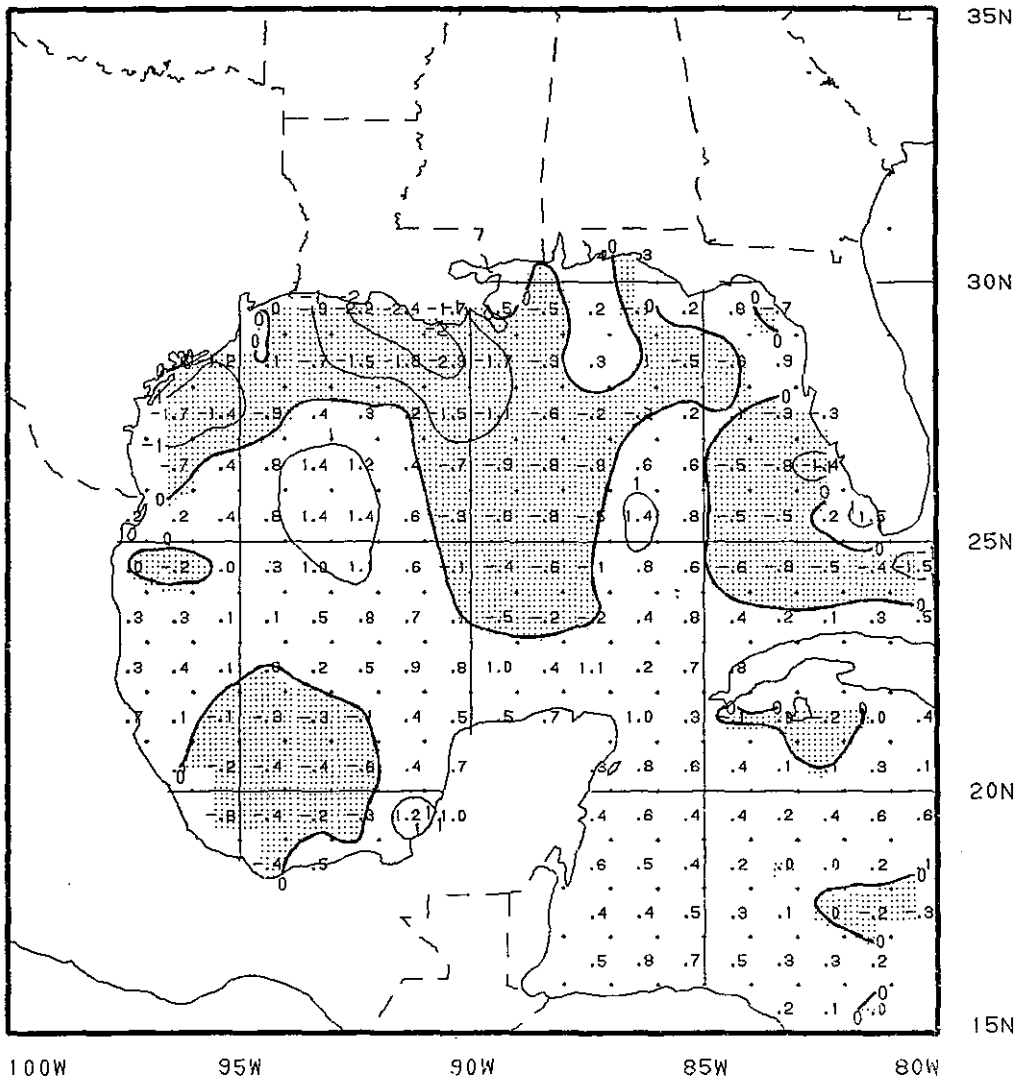
Monthly mean sea surface temperature is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0°C.



Northwest Atlantic Ocean
SST--MONTHLY MEAN (°C)
FEBRUARY 1987

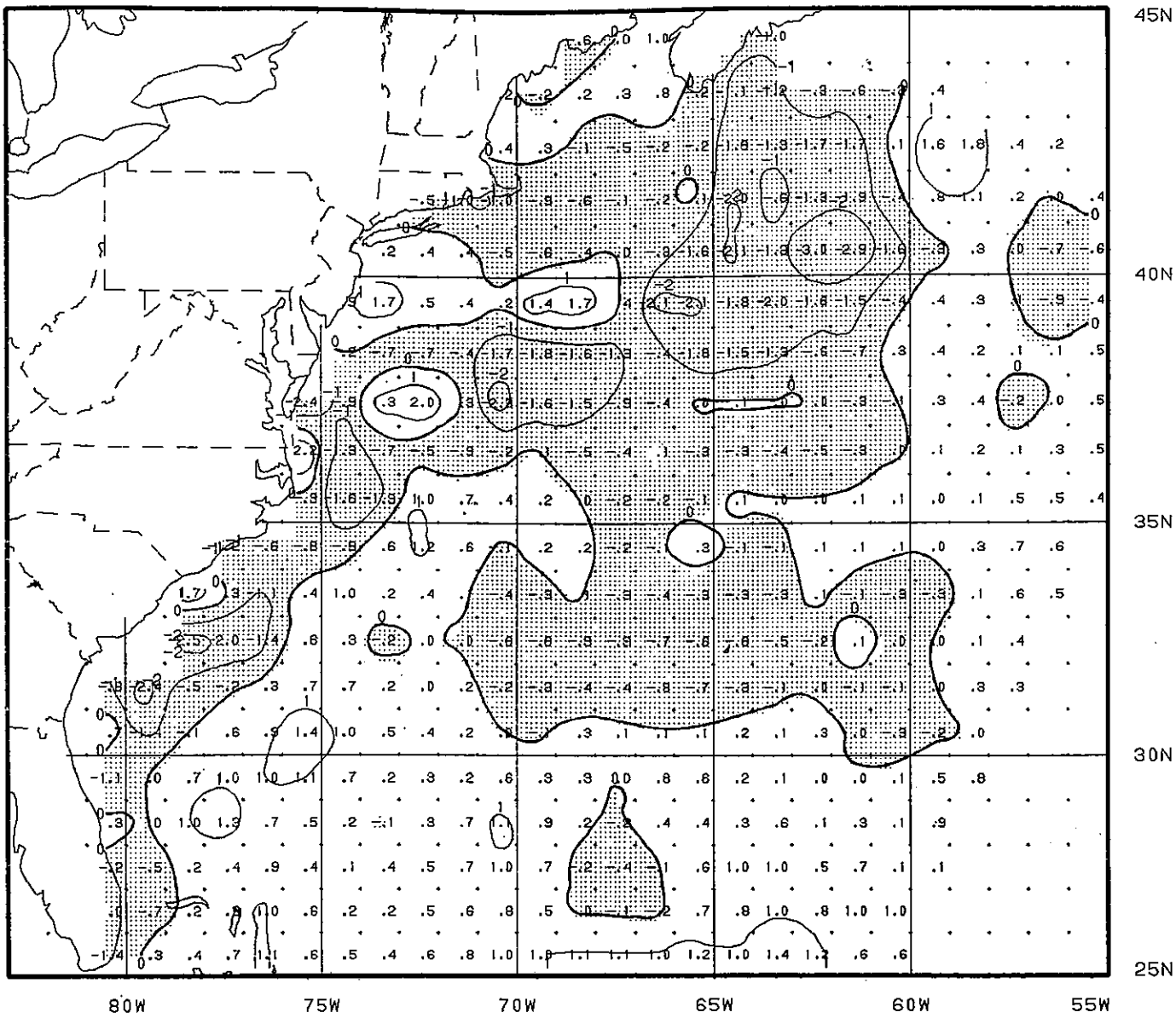
Monthly mean sea surface temperature is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0°C.

EAST COAST SST – ANOMALY



Gulf of Mexico
SST--MONTHLY ANOMALY (°C)
FEBRUARY 1987

Monthly anomaly is the difference between the monthly mean sea surface temperature and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0°C.



Northwest Atlantic Ocean
SST--MONTHLY ANOMALY (°C)
FEBRUARY 1987

Monthly anomaly is the difference between the monthly mean sea surface temperature and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0°C.

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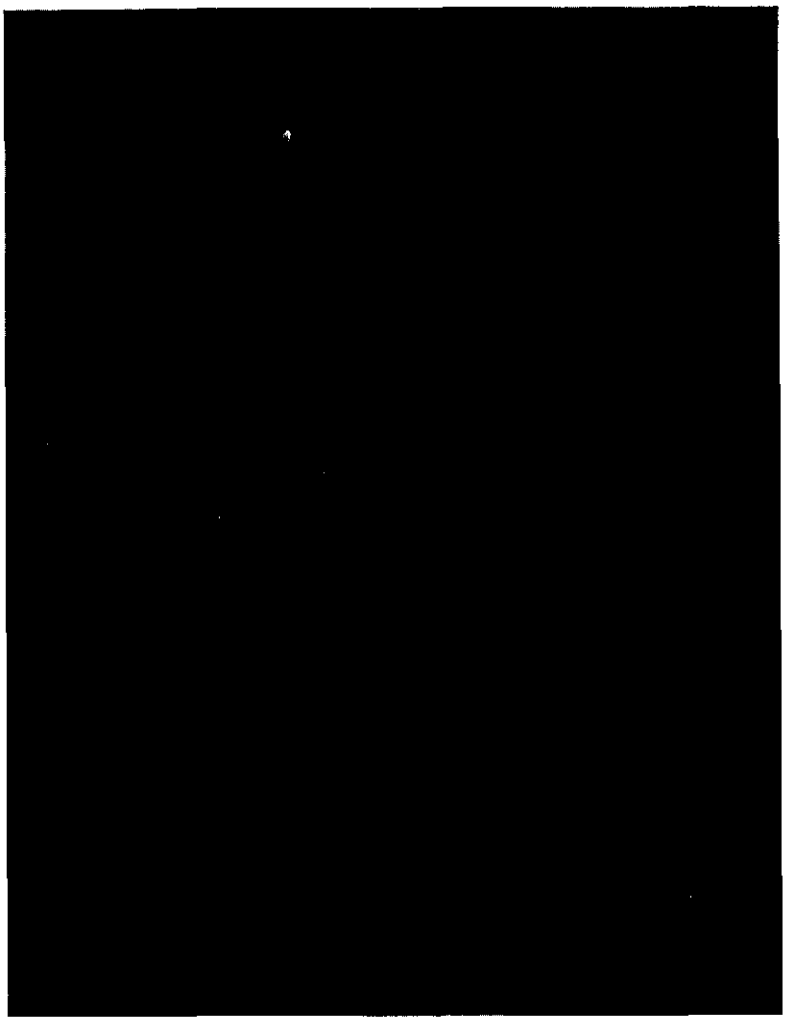
OCEANOGRAPHIC Monthly Summary

Volume VII Number 3 March 1987



Islands in the Sun (page 3)

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U.S. DEPARTMENT OF COMMERCE • National Oceanic and Atmospheric Administration
National Weather Service
National Environmental Satellite, Data, and Information Service
National Ocean Service

OCEANOGRAPHIC
Monthly Summary

Oceanographic Monthly Summary is published by the National Weather Service (NWS), the National Environmental Satellite, Data, and Information Service (NESDIS), and the National Ocean Service (NOS). *Oceanographic Monthly Summary* contains sea surface temperature (SST) analyses on both regional and ocean basin scales for the Atlantic, Pacific, and Indian Oceans. The ocean basin analyses are based on a "blend" of *in situ* and satellite data, in which *in situ* data are used to define "benchmark" temperature values in regions of frequent observations and satellite data are used to define the "shape" of the field between these points.[1]

An ocean basin SST anomaly is derived from the "blended" SST analysis[1] and the improved global SST.[2] The regional SST analyses are based upon a combination of *in situ* and satellite data measurements. The regional SST anomalies are calculated from the Robinson-Bauer Climatology.[3,4] *Oceanographic Monthly Summary* also contains Alaskan sea ice information and ocean feature information for contiguous U.S. ocean regions.

Oceanographic Monthly Summary welcomes articles containing information of interest to its readers, such as news on operational oceanography, unusual ocean feature phenomena, etc. Contributions should be sent to the editor (address below). Accepted material will appear in the OceaNotes section of *Oceanographic Monthly Summary*. Contributions can be published as quickly as the next monthly issue.

If you are interested in receiving *Oceanographic Monthly Summary* regularly, please refer to the back cover for subscription information.

[1]Reynolds, R.W. and W.H. Gemmill, 1984. A sea surface temperature analysis which blends *in situ* and satellite observations. *Proceedings of the Ninth Climate Diagnostics Workshop*, Corvallis, OR, Oct. 22-26, 1984, pp. 408-416.

[2]The climatology is derived from *in situ* data (1950-1979), satellite data (1982-1985) and an ice climatology.

[3]Robinson, M.K., 1976. Atlas of North Pacific Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOcean Ref. Pub. 2.*

[4]Robinson, M.K., R.A. Bauer, and E.H. Schroeder, 1979. Atlas of North Atlantic-Indian Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOceano Ref. Pub. 18.*

Oceanographic Monthly Summary

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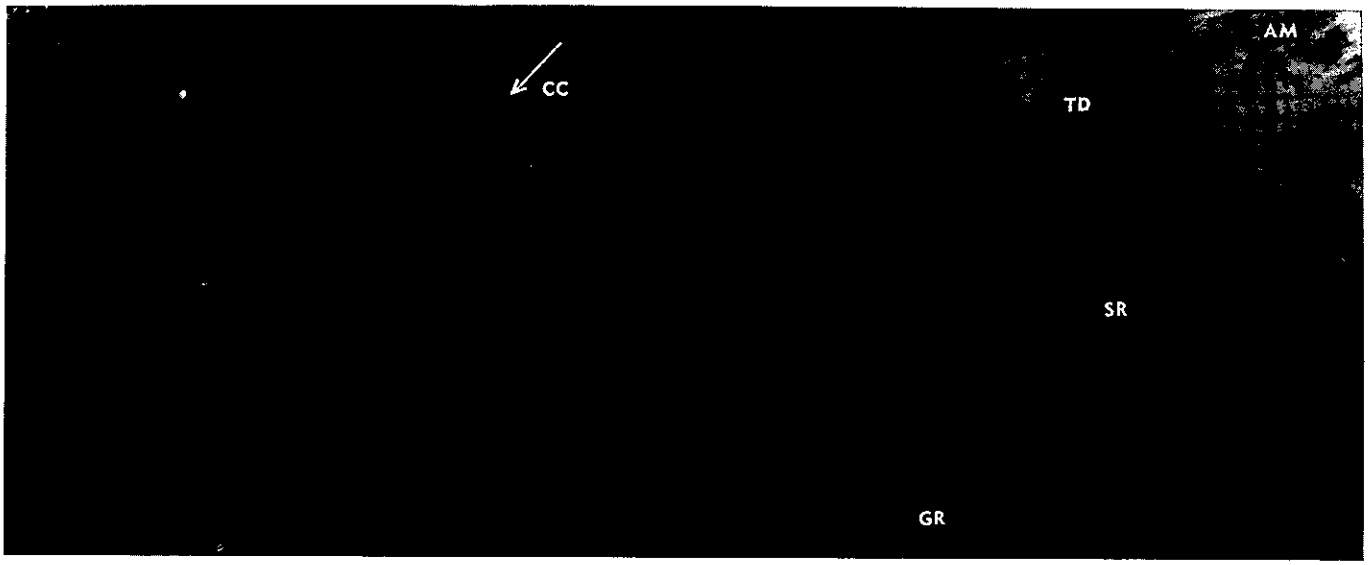
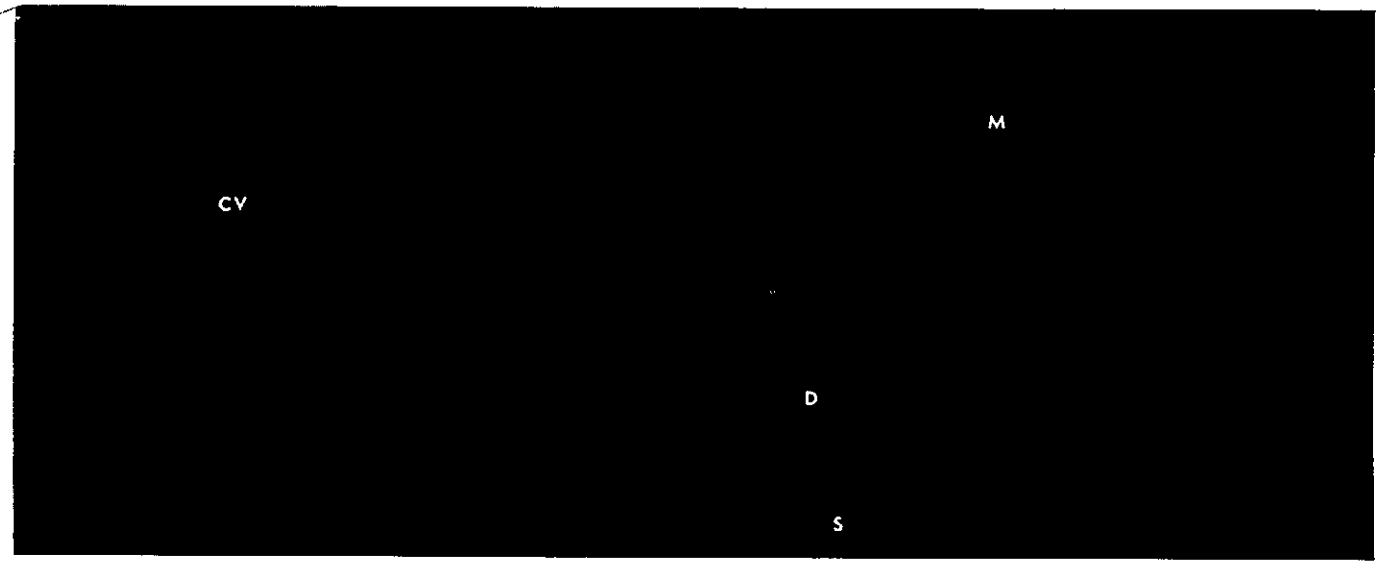




SATELLITE IMAGE OF THE MONTH

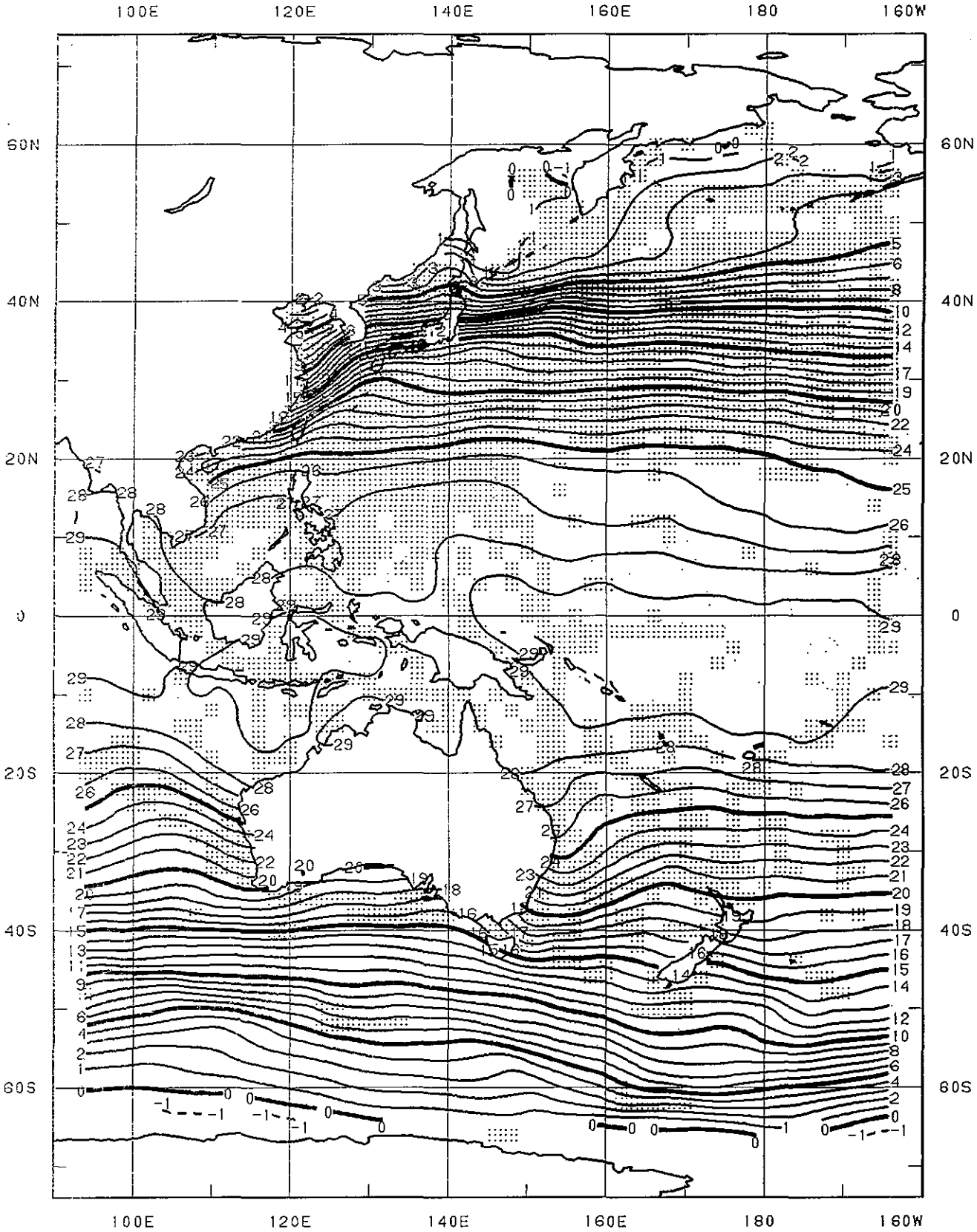
Kim Buttleman
Interactive Processing
Branch E/SP22
NESDIS, NOAA
Washington, DC 20233
(301) 763-8142

Islands in the Sun

The above images (NOAA-9 AVHRR: upper = channel 1, visible; lower = channel 4, infrared, enhancement table S) from March 24, 1987 (16:13 GMT) show the southeastern North Atlantic Ocean and the western coast of West Africa. Labeled geographical features are the Cape Verde Islands (CV), and the coasts of Mauritania (M) and Senegal (S). Visible in the land areas in the upper image is the Trarza Desert (TD), with substantial amounts of dust and sand from the Sahara arranged in long light - colored deposits, having been carried by aeolian transport from the Sahara through gaps in the Adrar Mountains (AM). Also visible are the location of the Senegal River (SR),, delineated by differences in vegetation, and the Gambia River (GR). Dakar (D), the capital of Senegal, is located at the tip of the peninsula. A number of physical phenomena are apparent in the two images, and a comparison between the two can reveal much information.

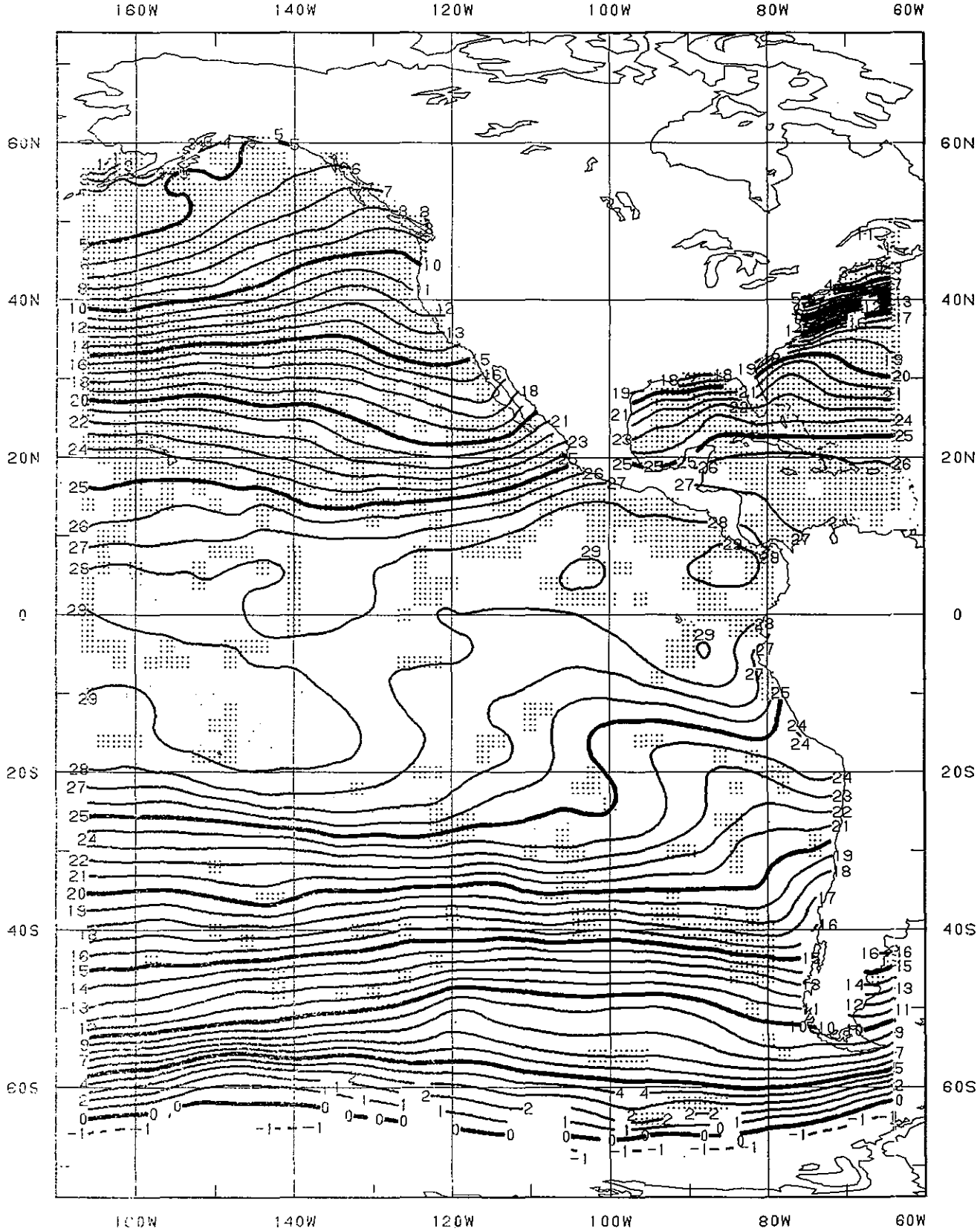
In the lower image substantial coastal upwelling is evident as the lighter (colder) areas adjacent to the coast. This is predominantly wind driven, as the wind off the Sahara pushes the warm surface waters away from the coast and it is replaced by colder water from below. This area supports a small indigenous littoral fishery, where the natives often capitalize on the phenomenon of porpoises "herding" schools of small fish into the shallows for easier feeding. The natives closely watch for this and net as many of the concentrated prey as possible during the brief feeding frenzies.

(text continued on page 13)



Western Pacific Ocean
SST--MONTHLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA
MARCH 1987

Monthly mean sea surface temperature is the mean of *in situ* and satellite data within two-degree quadrangles. Contour line interval is 1.0°C. The stippling indicates where the analysis was fixed by the *in situ* data; contours are not shown in areas without data.



Eastern Pacific Ocean
SST--MONTHLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA
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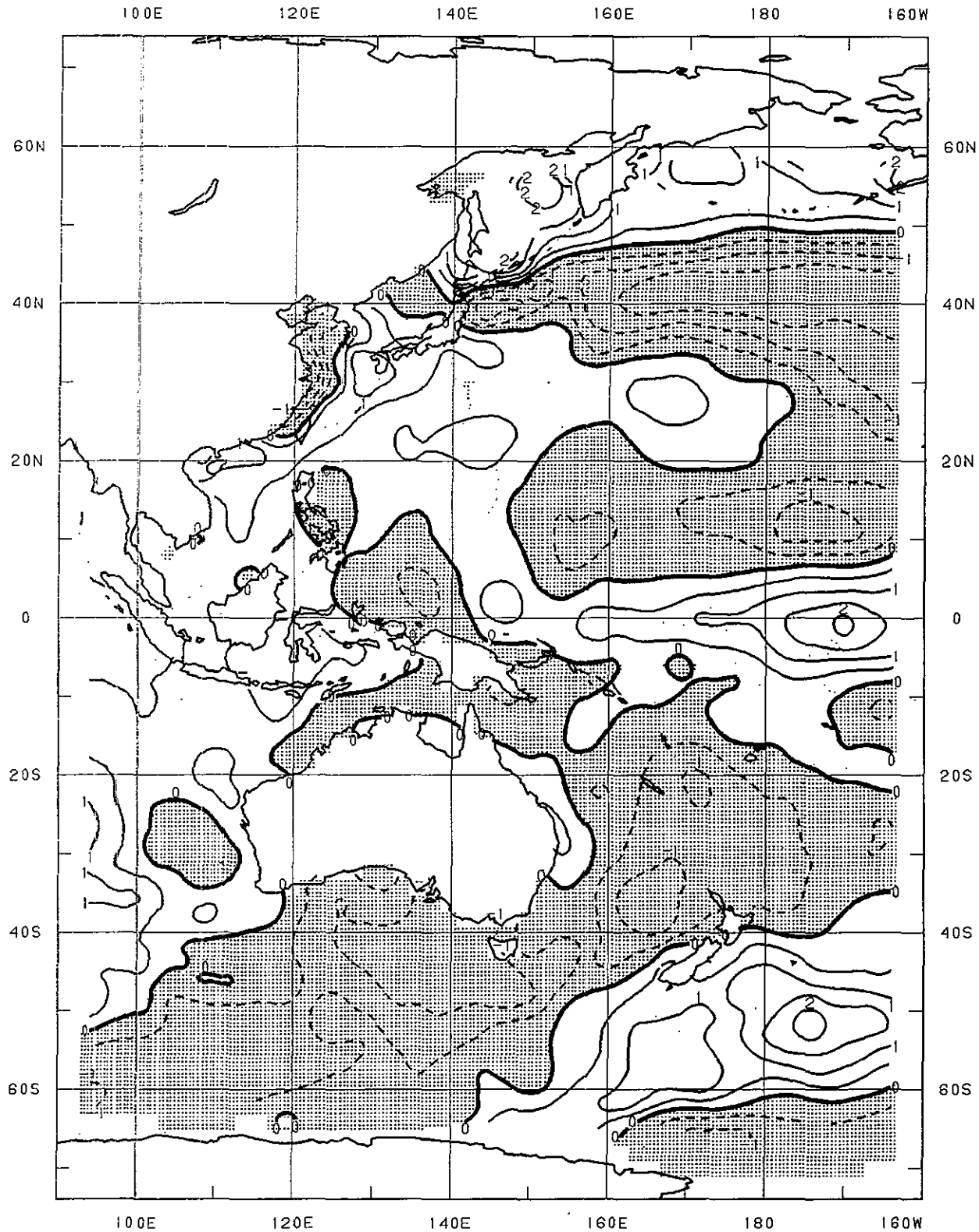
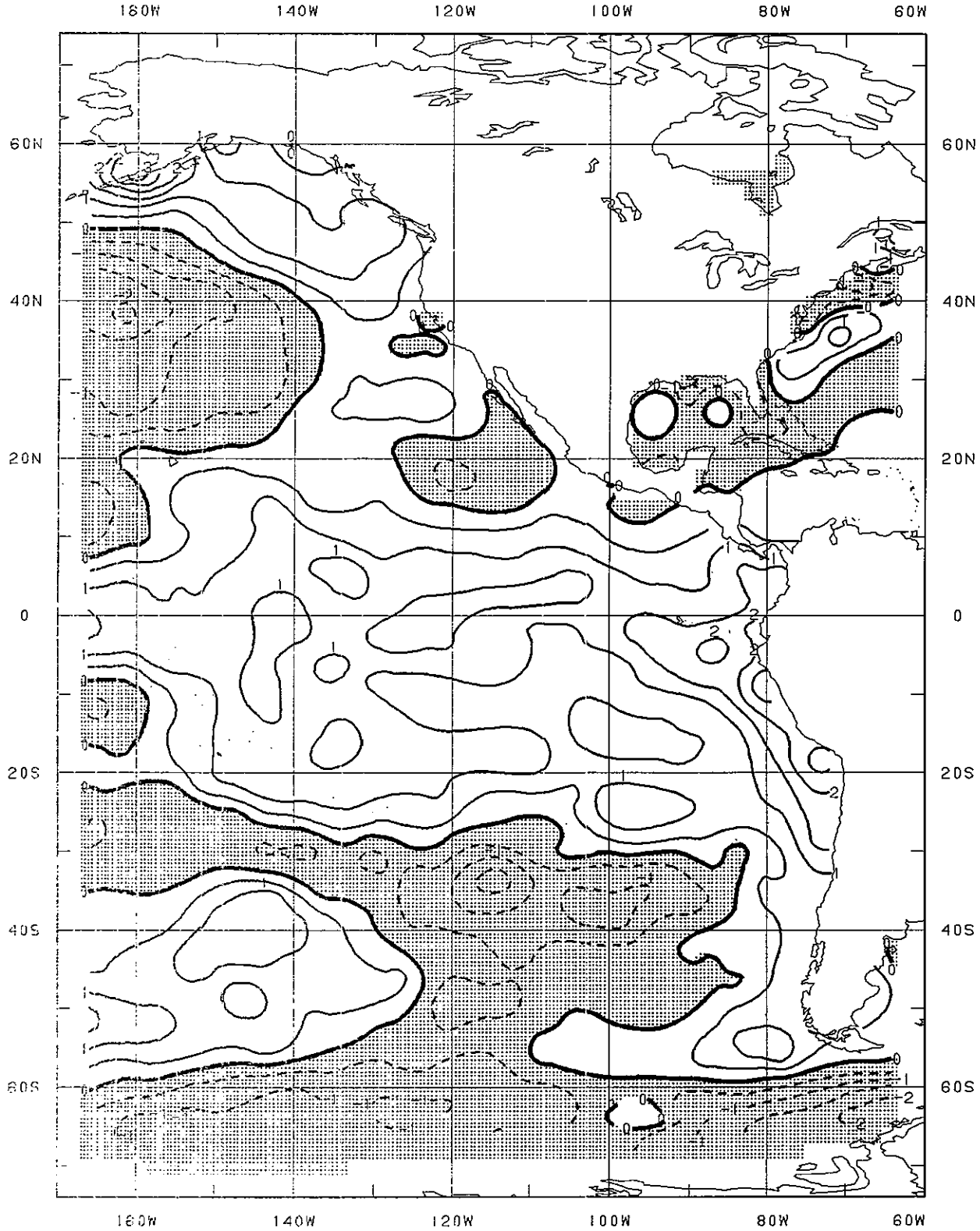


Western Pacific Ocean
SST--MONTHLY ANOMALY
SHIP, BUOY, AND SATELLITE DATA
MARCH 1987

Monthly anomaly is the difference between the monthly mean sea surface temperature and the climatological monthly mean value. Contour line interval is 0.5°C. The stippling indicates where the monthly mean is colder than climatology; contours are not shown in areas without monthly or climatological data.



Eastern Pacific Ocean
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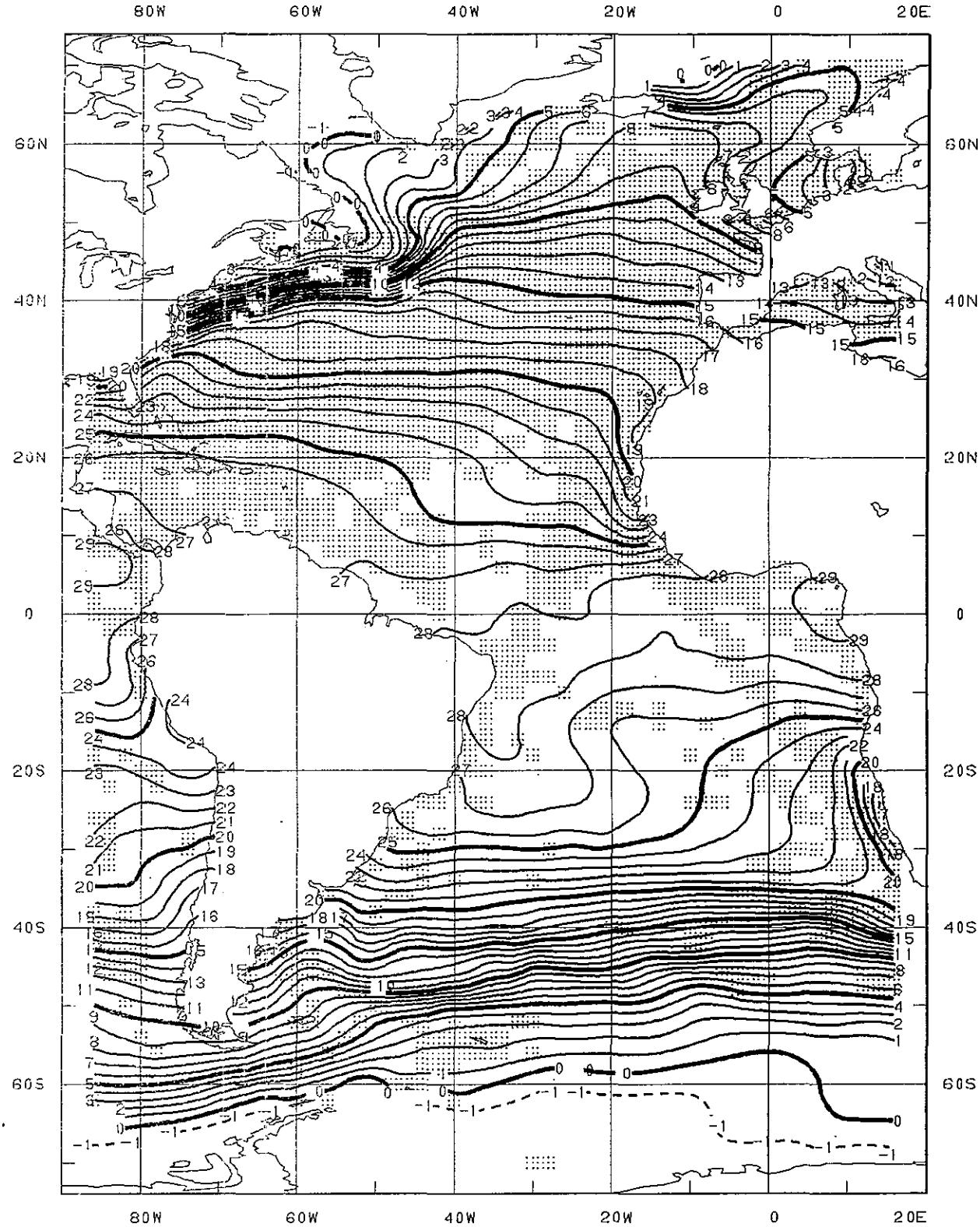

Atlantic Ocean
SST--MONTLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA
MARCH 1987

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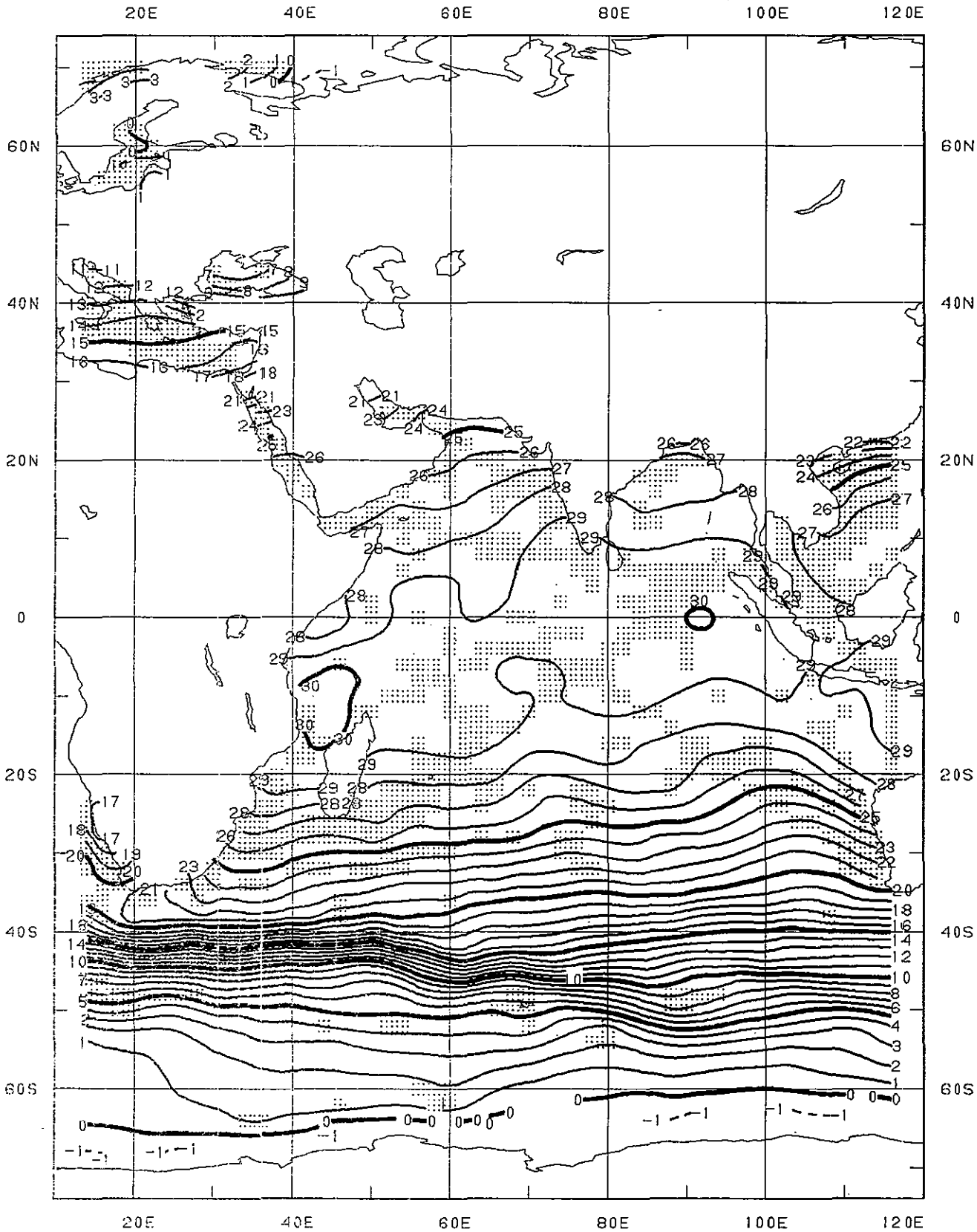

Indian Ocean
SST--MONTHLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA
MARCH 1987

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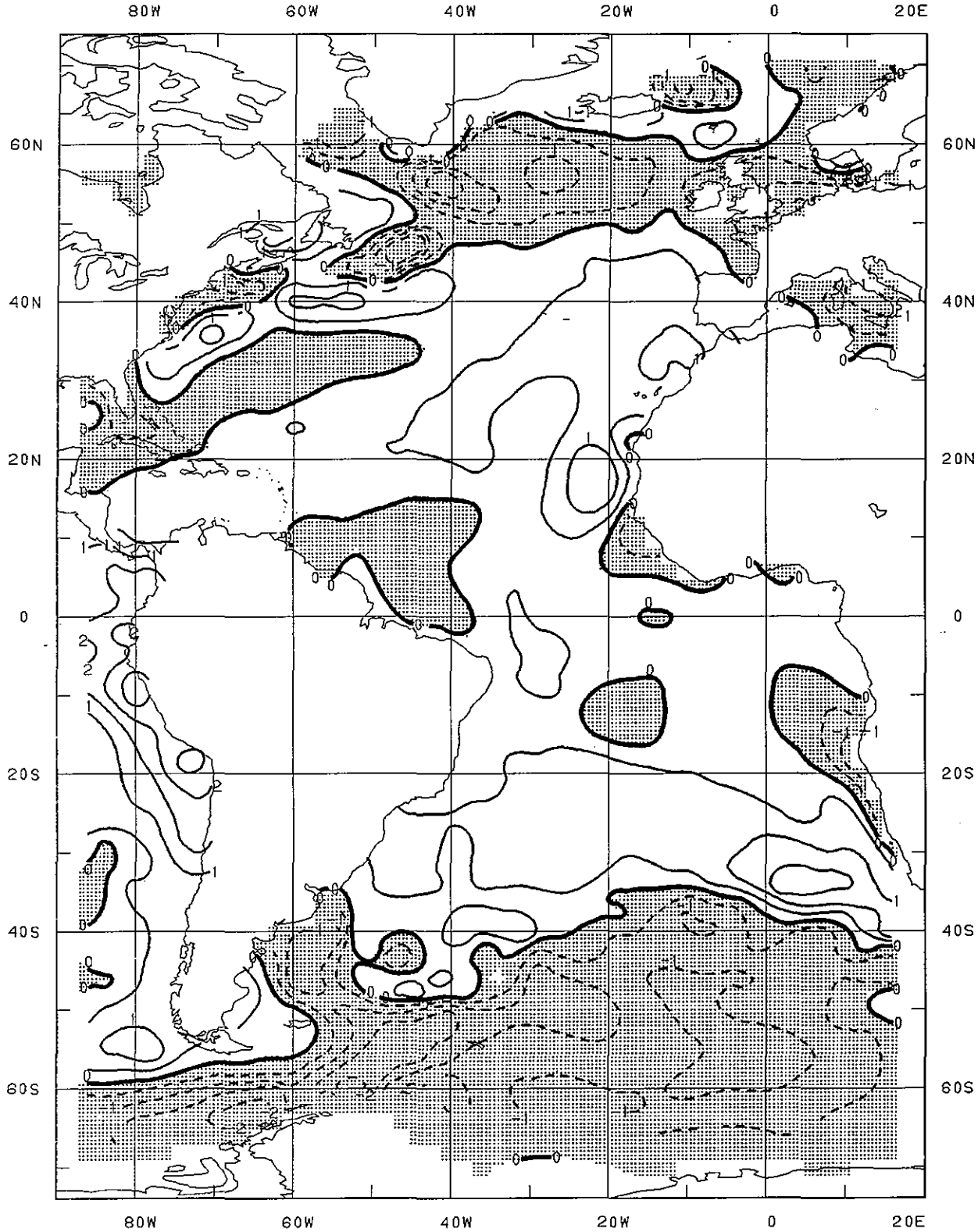

Atlantic Ocean
SST--MONTHLY ANOMALY (°C)
SHIP, BUOY, and SATELLITE DATA
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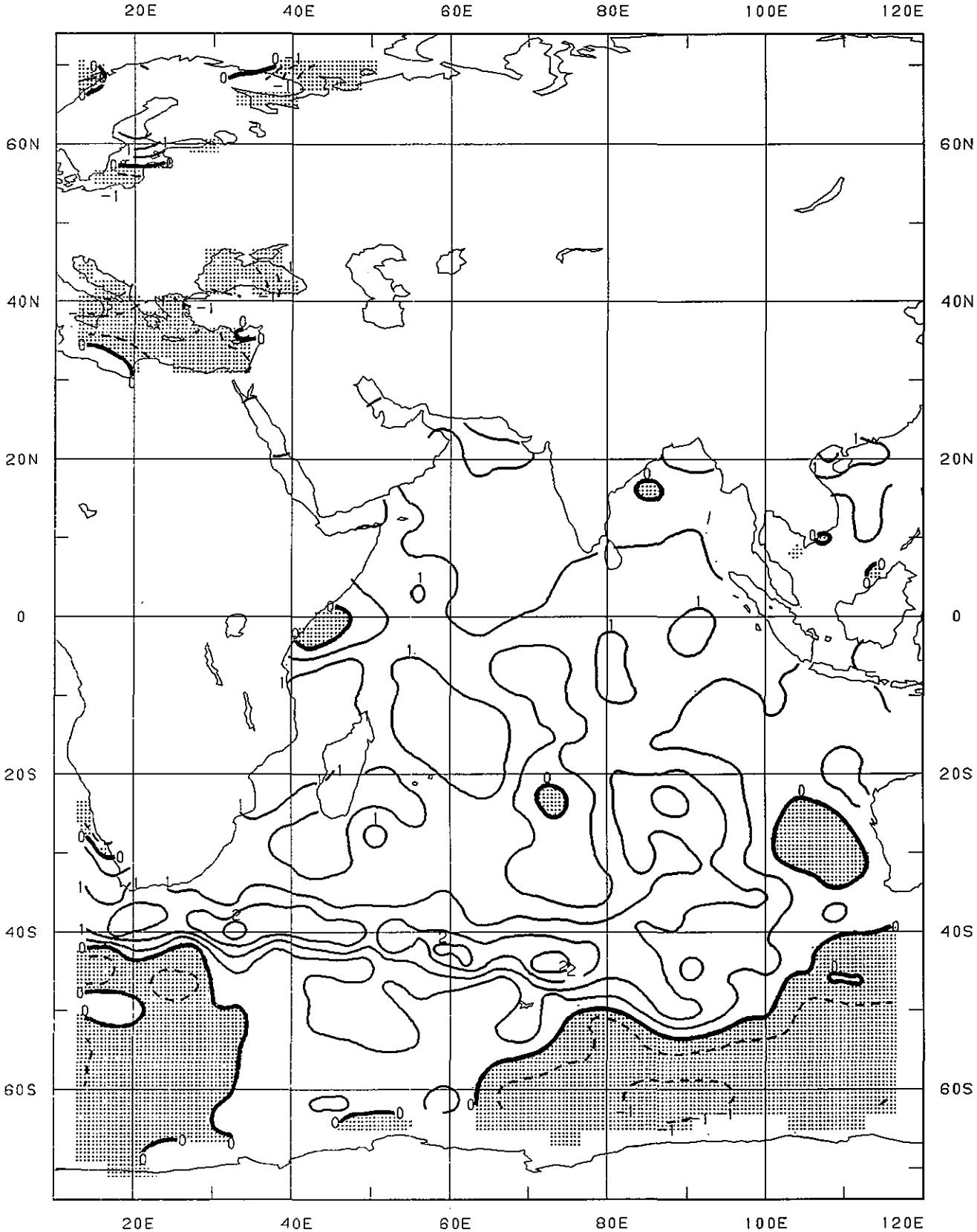

Indian Ocean
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MARCH 1987

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Dissemination and Utilization of Oceanographic Thermal Analyses on the Delmarva Peninsula (1984-1987)

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Sea Grant Marine Advisory Service
College of Marine Studies
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In May, 1984 the University of Delaware Sea Grant Marine Advisory Service began a Sea Surface Temperature and Oceanographic Analysis subscription service utilizing charts produced by Jenifer Clark, NWS. This service was begun to let the commercial and recreational fishing communities know that these charts were available. A legend containing °C to °F conversions, a canyon key, and a key to oceanographic abbreviations was produced and mailed to each subscriber.

During the first season, approximately 30 individuals utilized the service. Of these, 20 were offshore recreational fishermen and ten were commercial longliners. All fishermen realize that the offshore pelagic species follow thermal gradients while migrating north and south along the Atlantic coast. The charts allowed these individuals to have a good indication of what temperatures were occurring in what region. The first charts covered waters from Nova Scotia south to Cape Hatteras and out to 65 W. The fishermen found these charts to be valuable fishing tools but felt that the area covered was much too large. Consequently, a portion of the Oceanographic Analysis was enlarged to provide information mainly from 35° N to 40° N and 70° W to 75° W (See Figure). This change in chart format was very well received by the fishermen.

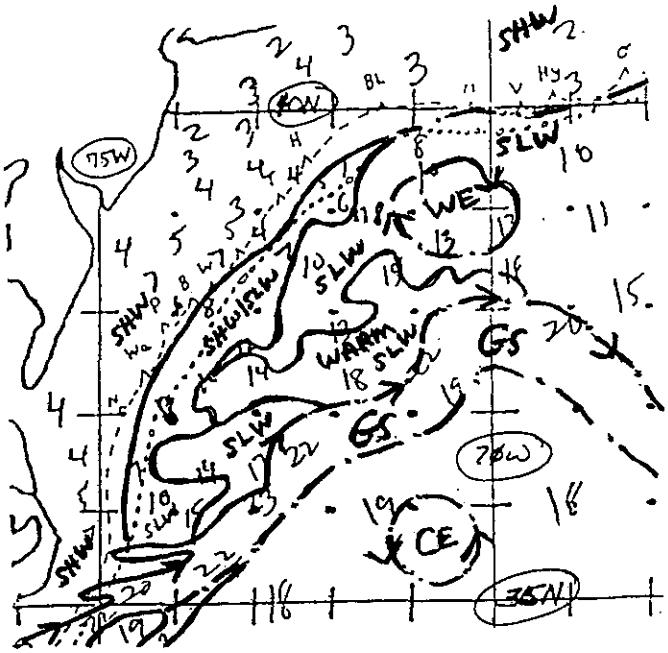


Figure 1. Enlarged portion of Oceanographic Analysis covering the Delmarva Peninsula.

In 1985 and 1986 the number of chart subscribers grew to 45 and 60, respectively. Through discussions with the new subscribers, it was determined that the reason they subscribed was that: 1) they had been told by associates that the charts were available and 2) they had seen samples of the new enlarged format.

When asked to describe the benefits of using the charts the results were summarized as follows:

"The charts allow me to find fish more quickly; that is, I don't have to run all over the ocean looking. Consequently, this saves me a lot of money in fuel and time. I also believe that using these charts has helped me increase my landings of many species especially swordfish, marlin, and tuna."

One warm eddy that was fished particularly hard in July and August, 1986, produced several record breaking catches, since these three fish averaged between 850 and 1100 pounds each. The states of Delaware, New Jersey, and New York all had their blue marlin records broken. These types of catches rapidly make chart users out of many fishermen.

The 1987 fishing season will see elimination of the chart subscription service by the University of Delaware Sea Grant Marine Advisory Service (MAS) for several reasons:

1. There are now two private firms (one is in Florida and the other is in New Jersey) that are providing thermal information for a fee. The firms are providing very detailed information to the fishermen.

2. The MAS has been approached by a local newspaper that would like to carry the Oceanographic Analysis as a feature each week.

Consequently, the MAS staff believes that it has fulfilled its goals of: 1) familiarizing the fishing community with the available thermal information and 2) demonstrating to a private local newspaper that this information is worthy of their dissemination network.

(article continued from page 3)

Islands in the Sun

In the upper image large amounts of atmospherically suspended Saharan dust are visible seaward from the Adrar Desert. It has the appearance of a diaphanous cloud, but since the dust is approximately the same temperature as the air, it is not apparent in the infrared image. Of perhaps more interest is the delineation of the wakes of the Cape Verde Islands in sunlight reflected from the ocean surface. The Canary Current (CC) sweeps southwest past the islands, leaving an area of calmer water in the downstream "shadows" of the islands. This area is more reflective than the rougher water on the upstream side and that flowing past the islands. By serendipitous coincidence of geometry of sun and spacecraft relative to the ocean surface, the island wakes are defined with great clarity, with little corresponding definition apparent in the infrared image. Downstream of Ilha de Santo Antao, the northernmost island, the first three cycles of a Van Karman vortex street can be seen (See OMS July, 1986). In the wake of the Brava, the southwesternmost island, a distinct v-shaped Kelvin wake can be seen, pointing upstream. It is dark in the visible image, indicating rougher water than the surrounding island wake, and it is lighter (colder) in the IR image, with a temperature difference of 2°C to 3°C. There is no known island at the apex of the vee. Its cause is unknown.

Under the right conditions sunglint can define thermal fronts as well as infrared imagery. Salinity fronts, which may have little or no thermal gradient, can often be easily seen, and sunken cold core eddies, with no surficial thermal signature, may still exhibit differences in surface roughness, thereby enabling continued tracking.

C = Total ice concentration in the area in tenths.

C_a, C_b, C_c = Concentration of thickest (C_a), 2nd thickest (C_b); and 3rd thickest (C_c) ice

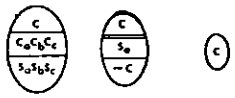
S_a, S_b, S_c = Stage of development of thickest (S_a), 2nd thickest (S_b), and 3rd thickest (S_c) ice.

~C = Concentration of ice within area(s) of strips and patches.

STAGE(S) OF DEVELOPMENT (THICKNESS)

1 = New ice (0-10 cm)
3 = Young ice (10-30 cm)
6 = First year (30-200 cm)
7 = First year thin (30-70 cm)
1. = First year medium (70-120 cm)
4. = First year thick (120-200 cm)
7. = Old ice (survived at least one summer's melt)

EXAMPLES



125 Theoretical thickness of this season's growth (cm).

Fast ice. Sea ice which forms and remains fast along the coast.

Ice boundary visually or satellite observed.

Ice boundary estimated.

BERING SEA / NORTH SLOPE ICE ANALYSIS

Gary M. Wohl, NOAA
Navy-NOAA Joint Ice Center
National Meteorological Center, W/NMC21
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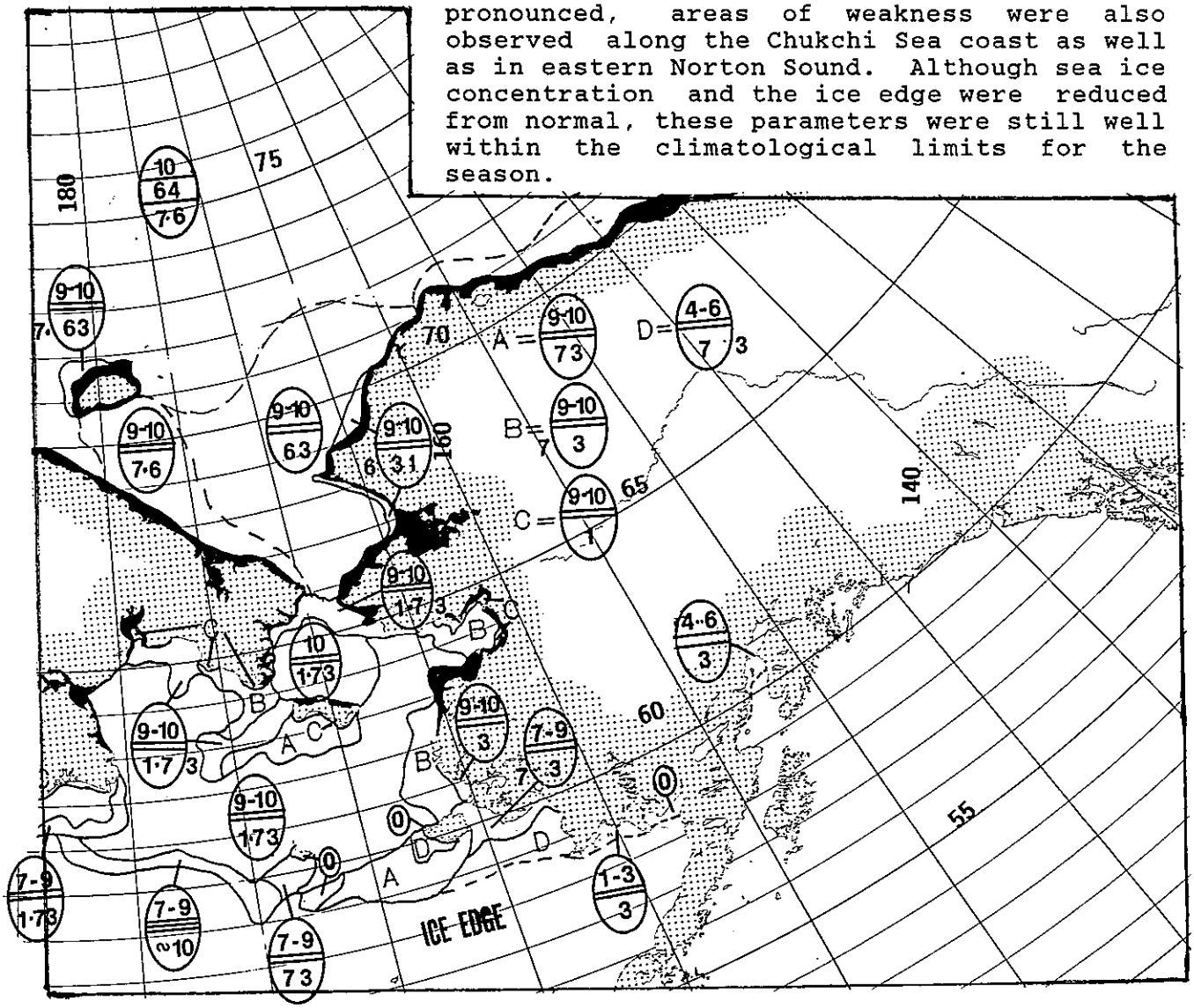
MARCH 1987

Nearly steady sea ice ablation characterized the month of March in the eastern Bering Sea. Air temperatures remained well above normal during the month (+10 °F at Nome), contributing to the early disintegration of sea ice. A substantial area of weakness developed off the Alaskan coast as warm air from the Pacific Ocean circled around a series of low pressure systems traversing the southern Bering Sea. The resulting warm, offshore winds caused ice in Bristol Bay to nearly disappear by the end of the month and an area of reduced ice concentration and thickness to develop from near Nunivak Island to Norton Sound. Similar, though less pronounced, areas of weakness were also observed along the Chukchi Sea coast as well as in eastern Norton Sound. Although sea ice concentration and the ice edge were reduced from normal, these parameters were still well within the climatological limits for the season.



WEST COAST OCEAN FEATURES

Ernest Daghir
NOAA/NWS
Satellite Field Service Station
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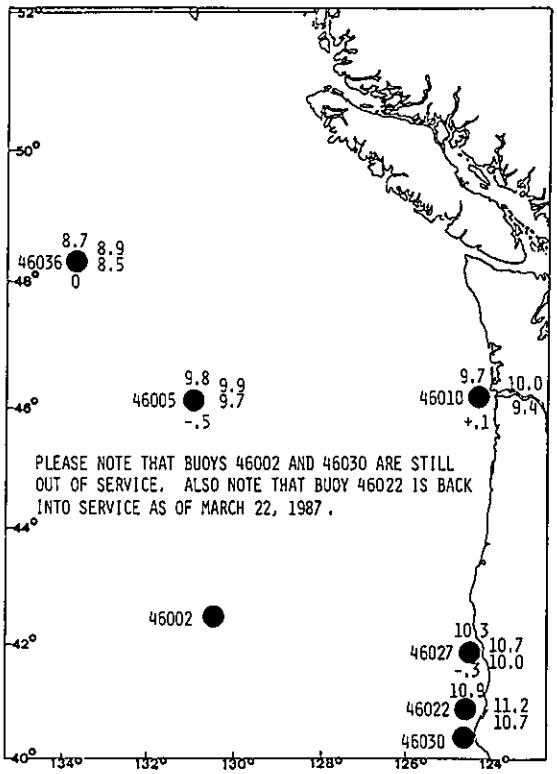
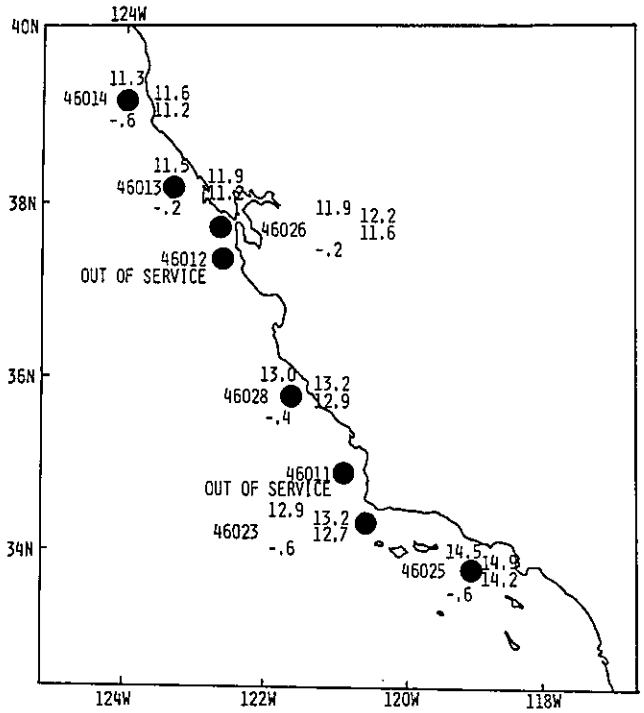
Redwood City, CA 94063
(415) 876-9122
FTS 470-9122
MARCH 1987

The above normal trend of sea surface temperatures along the West



Coast continues. The North Panel analysis area was a whole degree above climatology for the second month in a row at 9.3°C. No single location in the North Panel was cooler than climatology. The greatest anomaly of 1.7°C was centered near 45°N 132°W; the least was in the extreme northwest corner of the chart. When comparing this month to last, approximately one-third of the values on the chart remained the same or warmed slightly; this area is north of a line from near Newport, Oregon, on the coast, to around 49°N 135° W. The rest of the analysis area south of this line cooled between 0.1°C and 0.6°C since the end of February.

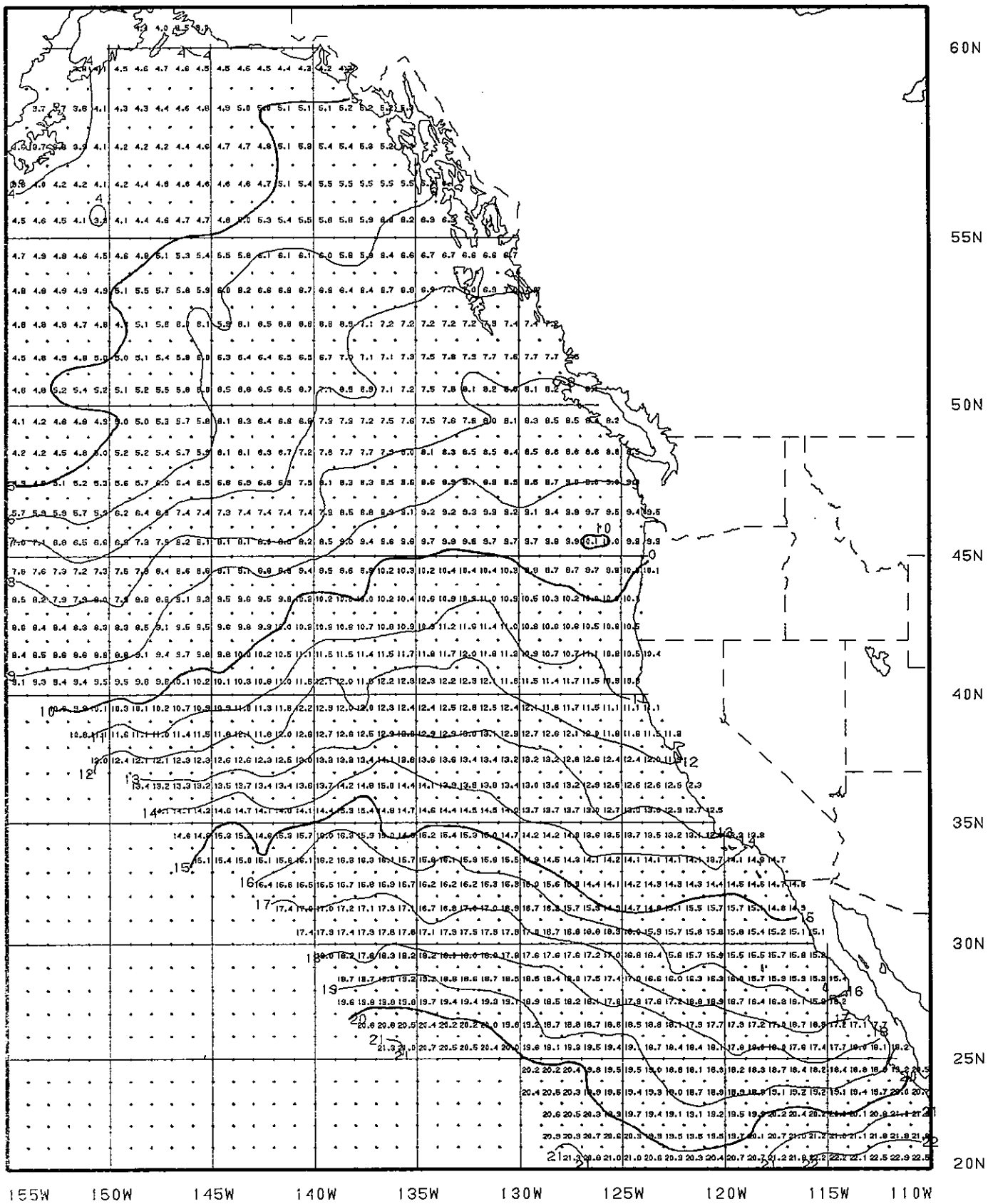
During March, the South Panel came within 0.2°C of climatology. The climatological normal is 14.4°C, but computed SST's averaged 14.6°C over the analysis area. Warm anomalies of 0.5°C to 1.0°C were observed nearshore and north of Baja California. West of 131°W, however, surface waters were below normal. In fact, at 34°N 135°W, a cool anomaly of 1.2°C appeared. March SST's in the South Panel cooled between 0.1°C and 0.8°C, when compared to the previous month. The three-hourly buoy observations used to compute the graphical depictions on this page showed remarkably similar trends when compared to the statistics generated from individual analyses as discussed above.



KEY:

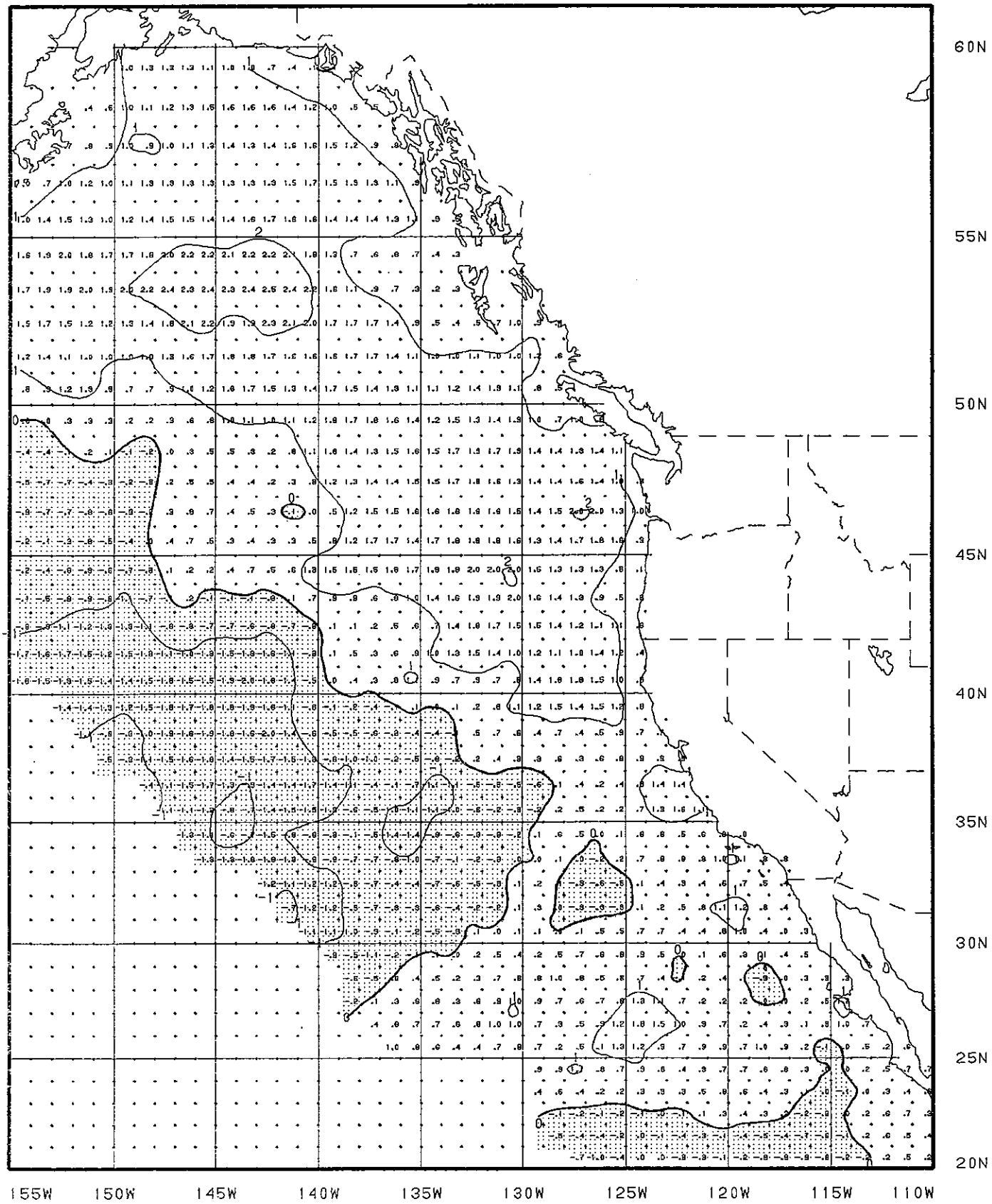
12.1 ← Monthly mean
LOCATION 13.5 ← Maximum daily mean
NAME 10.2 ← Minimum daily mean
-1.5 ← Change from previous month

● Denotes station position.



West Coast
SST--MONTHLY MEAN (°C)
MARCH 1987

Monthly mean sea surface temperature is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0°C.



West Coast
SST--MONTHLY ANOMALY (°C)
MARCH 1987

Monthly anomaly is the difference between the monthly mean sea surface temperature and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0°C.

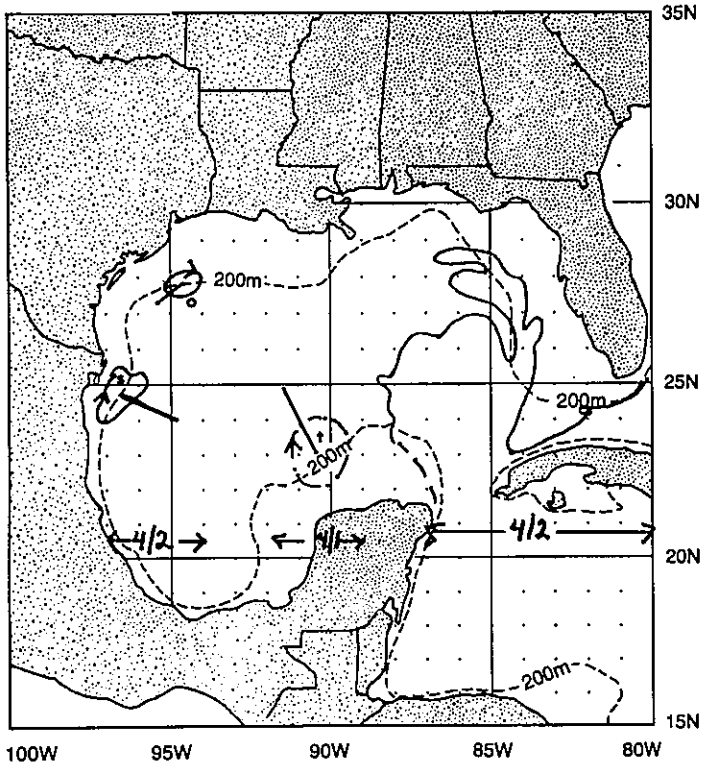
EAST COAST OCEAN FEATURES

Jenifer Clark
NOAA, NWS
Washington, DC 20233
(301) 763-8030

March 1987

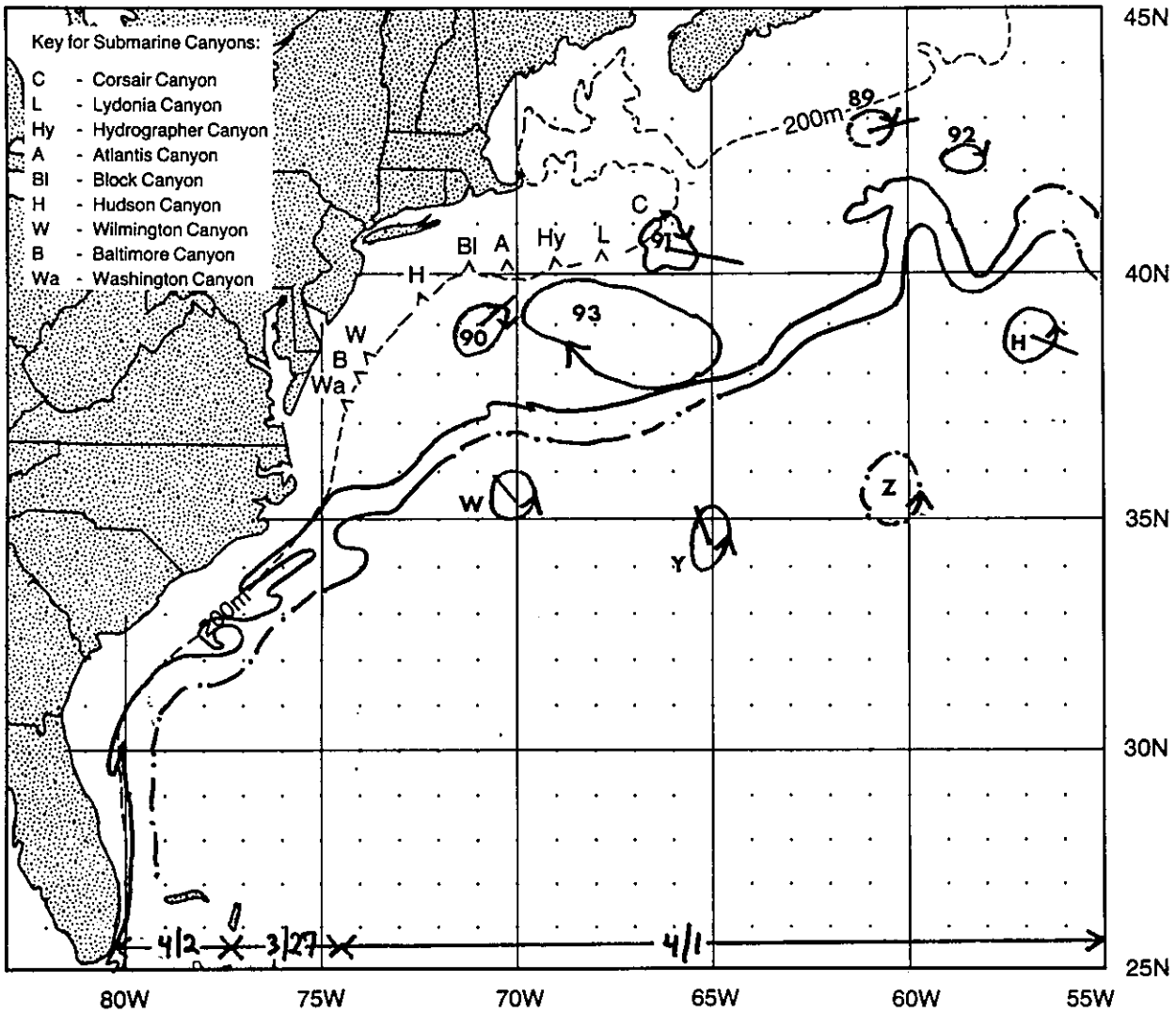
The end of this month's positions of the Gulf Stream System and its associated eddies are shown for the NW Atlantic and the Gulf of Mexico. The Gulf Stream and Loop Current boundaries are located by infrared satellite imagery or XBT (expendable bathythermograph) data. Anticyclonic eddies are labeled a-z in the Gulf of Mexico and 1-99 in the Northwest Atlantic. Cyclonic eddies are labeled A-Z. Arrows on eddies indicate direction of circulation. Warm-core or anticyclonic eddies rotate clockwise; cold-core or cyclonic eddies rotate counterclockwise. The line to the eddy center shows the net translation since last month or since last observed. The edge of continental shelf at 200 m is shown as a dashed line. Eddies or sections of the Gulf Stream System which were not observed during the month are not shown on the analysis chart or are indicated by "dot-dashed" lines. The long arrows at the bottom of the chart indicate the dates of data used.

Data used in this analysis include:
Infrared imagery from NOAA satellite - NESDIS
Bathythermograph data from National Meteorological Center of National Weather Service
Oceanographic Analysis -- A daily detailed analysis issued by National Weather Service



GULF OF MEXICO

The position of the Loop Current in the Gulf of Mexico moved northward again by 55 km during March as it did during February. The long filament of warm water attached to the northeast section of the Loop still persists; however, it seems to have moved northward while receding from the west. The present location of this warm filament is 28 N 86 W to 26 N 84 W. Anticyclonic eddy t apparently translated 250 km SE although its location is very unclear. Eddy s seemingly traveled 195 km NW. Although eddy o appeared to be dissipating last month, it had apparently moved 110 km NE.

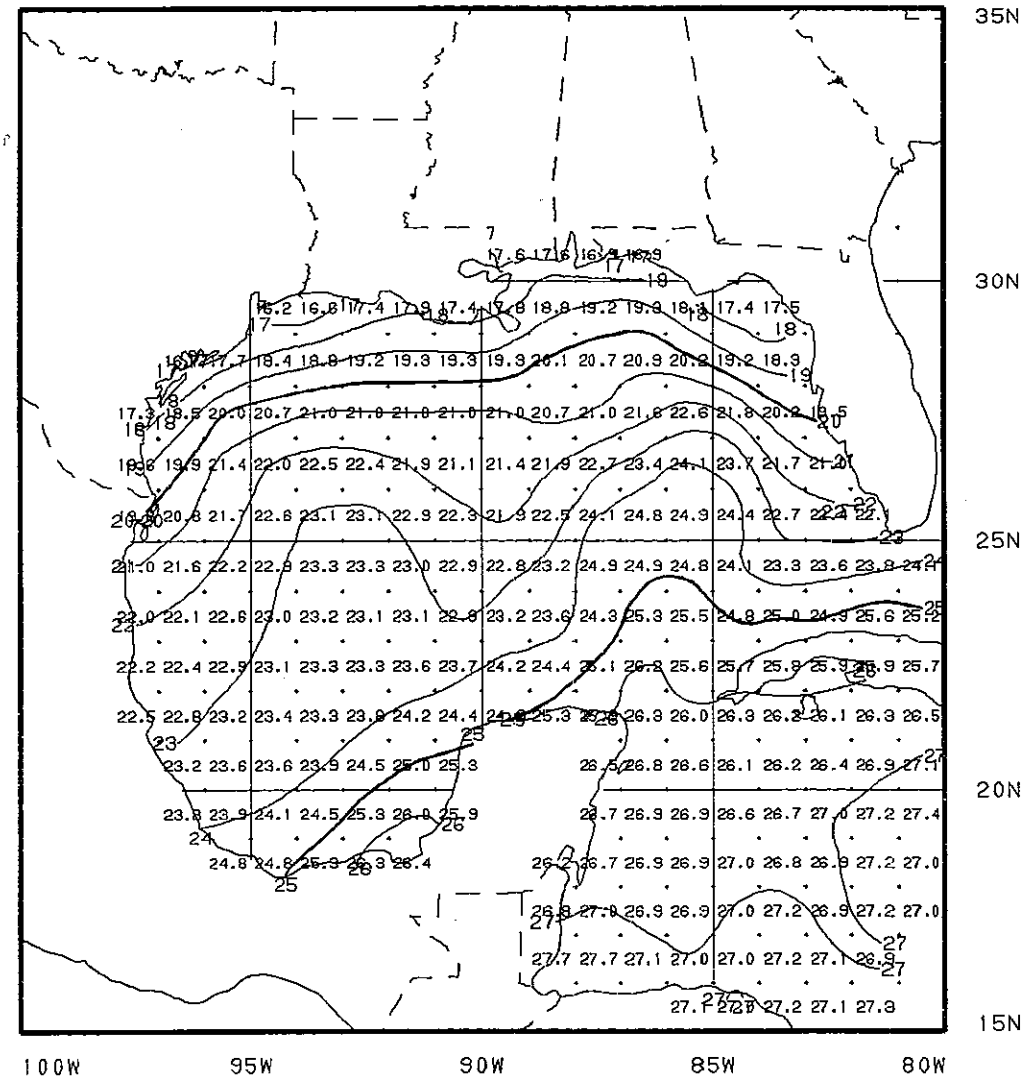


NORTHWEST ATLANTIC OCEAN

One anticyclonic eddy was absorbed during March. Eddy 88 was absorbed by a Gulf Stream meander near 40 N 68 W about March 27. Two anticyclonic eddies formed during March. Eddy 92 formed from a Gulf Stream meander near 42 N 59 W about March 18. Eddy 93 formed from a huge Gulf Stream meander near 40 N 68 W around March 30. It is centered near 38 30N 67 30W. The major and minor axes are 440 km and 195 km in length, respectively. Eddy 90 moved 100 km SW and eddy 91 moved 210 km NW. Eddy 89 seemingly translated 110 km WSW. Its location and existence are uncertain.

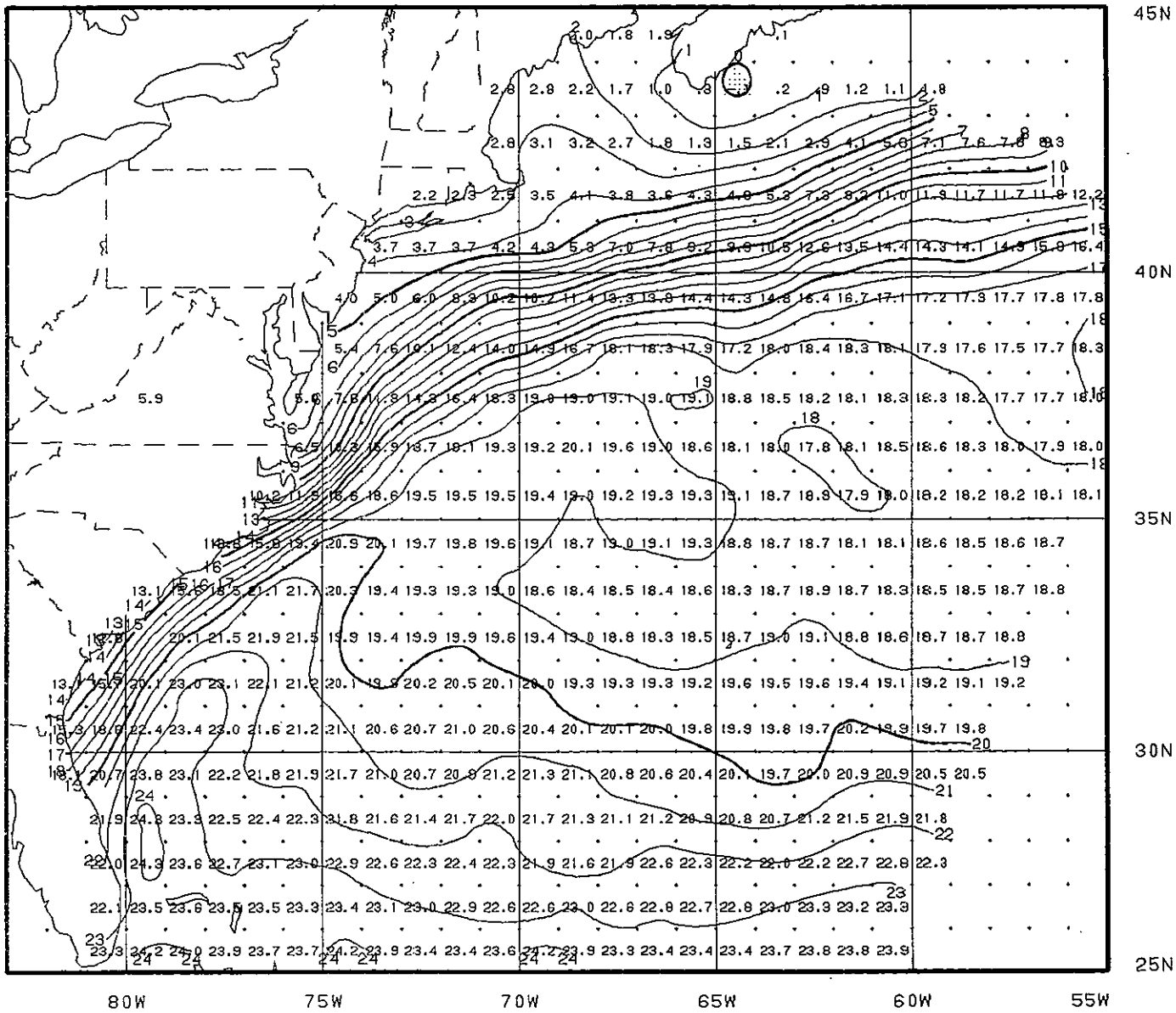
One cyclonic eddy was newly detected during March. Eddy Z, located by Harvard University/Navy XBT's, is apparently centered near 35 30N 60 30W. Eddy W moved 75 km SE while Eddy y traveled 85 km SE. Eddy H was deleted from last month's chart because it was not observed since January 7. Eddy H was detected again on April 1. It translated 90 km NW since January 7.

EAST COAST SST – MONTHLY MEAN



Gulf of Mexico
SST--MONTHLY MEAN (°C)
MARCH 1987

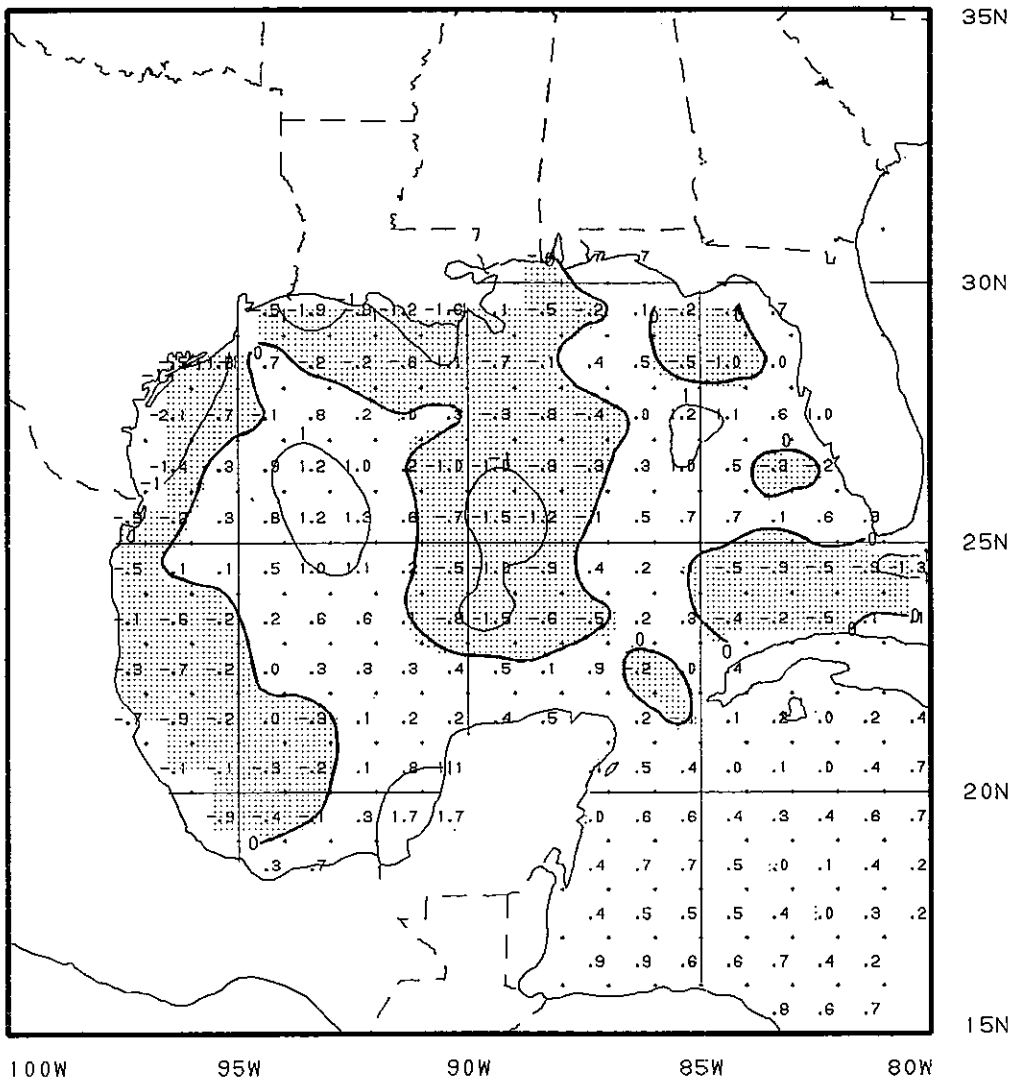
Monthly mean sea surface temperature is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0°C.



Northwest Atlantic Ocean
SST--MONTHLY MEAN (°C)
MARCH 1987

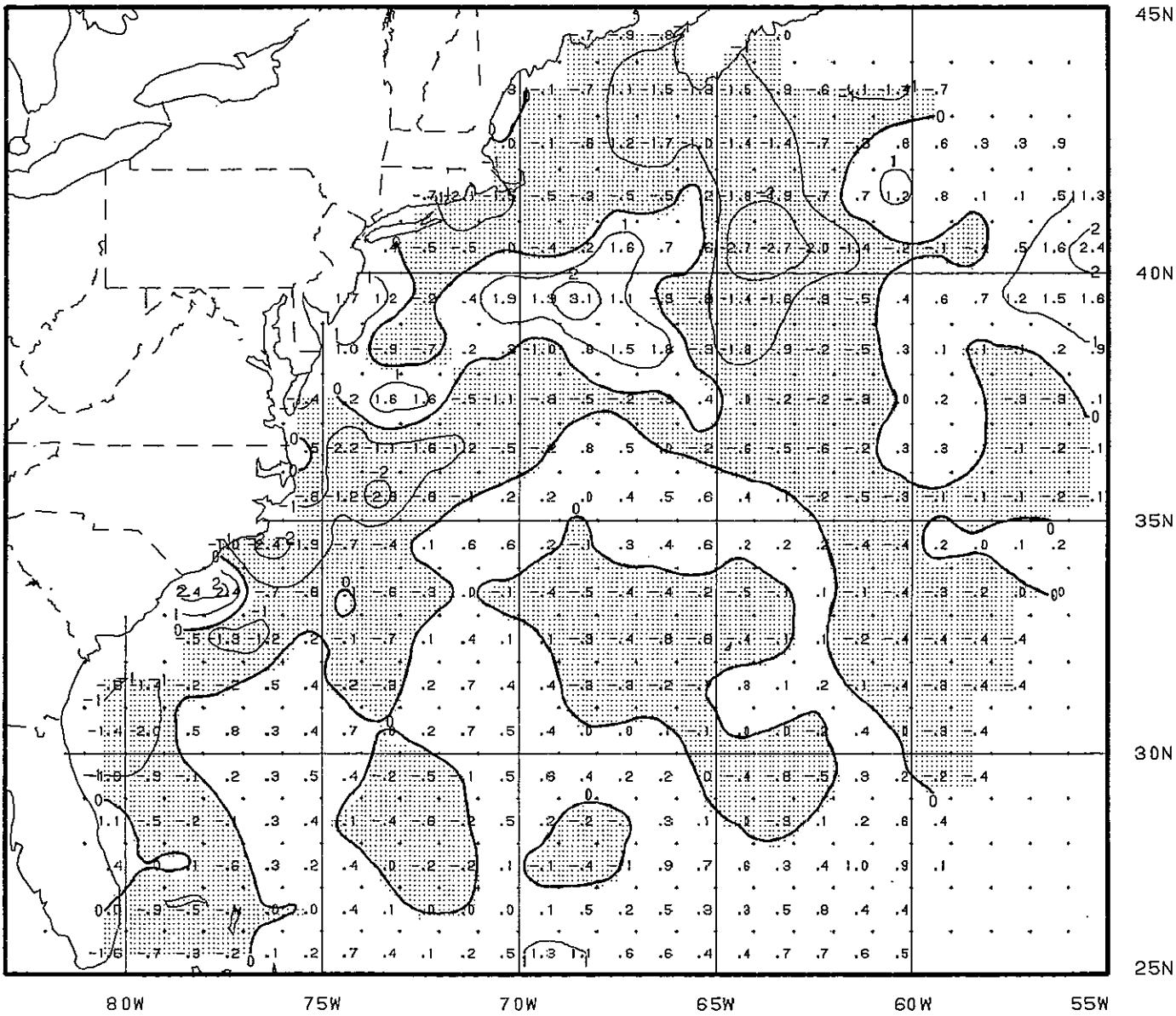
Monthly mean sea surface temperature is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0°C.

EAST COAST SST – ANOMALY



Gulf of Mexico
SST--MONTHLY ANOMALY (°C)
MARCH 1987

Monthly anomaly is the difference between the monthly mean sea surface temperature and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0°C.



Northwest Atlantic Ocean
SST--MONTHLY ANOMALY (°C)
MARCH 1987

Monthly anomaly is the difference between the monthly mean sea surface temperature and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0°C.

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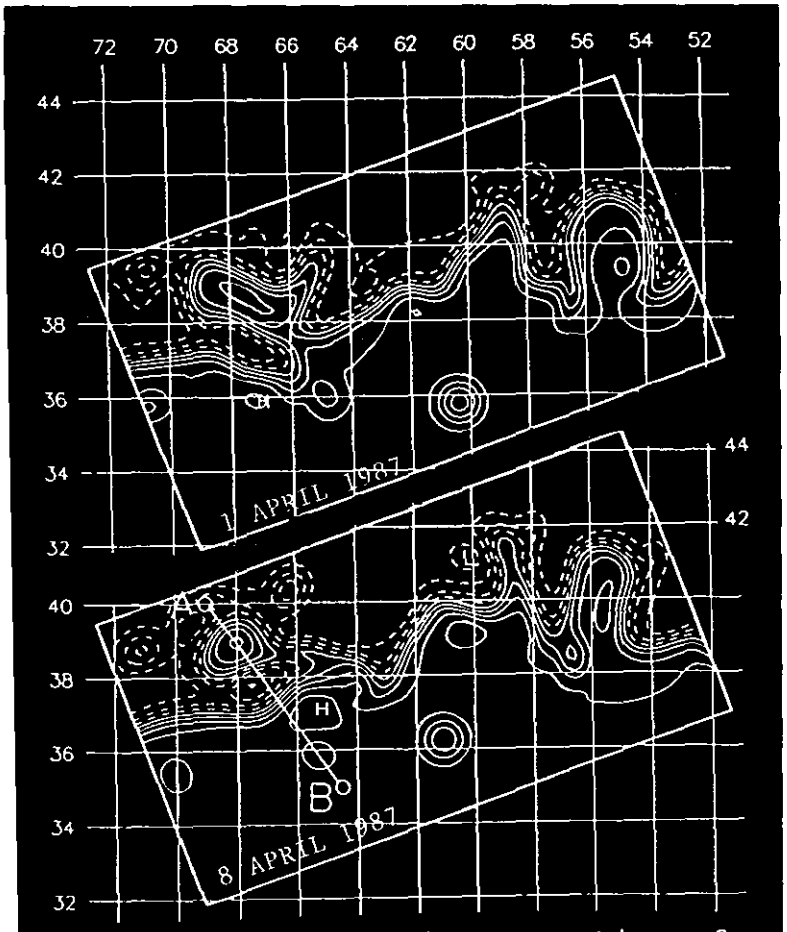
The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through April 1, 1987.

OCEANOGRAPHIC Monthly Summary

Volume VII Number 4 April 1987



Harvard Model Predicts Location of Gulf Stream Features (page 3).

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U.S. DEPARTMENT OF COMMERCE • National Oceanic and Atmospheric Administration
National Weather Service
National Environmental Satellite, Data, and Information Service
National Ocean Service

OCEANOGRAPHIC
Monthly Summary

Oceanographic Monthly Summary is published by the National Weather Service (NWS), the National Environmental Satellite, Data, and Information Service (NESDIS), and the National Ocean Service (NOS). *Oceanographic Monthly Summary* contains sea surface temperature (SST) analyses on both regional and ocean basin scales for the Atlantic, Pacific, and Indian Oceans. The ocean basin analyses are based on a "blend" of *in situ* and satellite data, in which *in situ* data are used to define "benchmark" temperature values in regions of frequent observations and satellite data are used to define the "shape" of the field between these points.[1]

An ocean basin SST anomaly is derived from the "blended" SST analysis[1] and the improved global SST.[2] The regional SST analyses are based upon a combination of *in situ* and satellite data measurements. The regional SST anomalies are calculated from the Robinson-Bauer Climatology.[3,4] *Oceanographic Monthly Summary* also contains Alaskan sea ice information and ocean feature information for contiguous U.S. ocean regions.

Oceanographic Monthly Summary welcomes articles containing information of interest to its readers, such as news on operational oceanography, unusual ocean feature phenomena, etc. Contributions should be sent to the editor (address below). Accepted material will appear in the OceaNotes section of *Oceanographic Monthly Summary*. Contributions can be published as quickly as the next monthly issue.

If you are interested in receiving *Oceanographic Monthly Summary* regularly, please refer to the back cover for subscription information.

[1]Reynolds, R.W. and W.H. Gemmill, 1984. A sea surface temperature analysis which blends *in situ* and satellite observations. *Proceedings of the Ninth Climate Diagnostics Workshop*, Corvallis, OR, Oct. 22-26, 1984, pp. 408-416.

[2]The climatology is derived from *in situ* data (1950-1979), satellite data (1982-1985) and an ice climatology.

[3]Robinson, M.K., 1976. Atlas of North Pacific Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOcean Ref. Pub. 2.*

[4]Robinson, M.K., R.A. Bauer, and E.H. Schroeder, 1979. Atlas of North Atlantic-Indian Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOceano Ref. Pub. 18.*

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OceaNotes

* *

*Note: Subject matter other than satellite images and their interpretation may be used to allow more flexibility in the selections of text and illustrations for feature articles. This issue presents the output of the Harvard Open Ocean Model as applied to 7-day forecasts of Gulf Stream features.

We hope readers will see this change as beneficial. Satellite images, however, will be featured often. Indeed, satellite IR images were used as input to the Harvard Model described in this Issue.

* *

GEOSAT Data Now Available from the NODC

Global ocean significant wave heights and other ocean data derived from altimetry measurements taken by the U.S. Navy Geodetic Satellite (GEOSAT) are now available from the National Oceanographic Data Center (NODC). The NODC has been designated as the archival and dissemination facility for Geophysical Data Records from the GEOSAT Exact Repeat Mission (ERM). During the ERM, which began on November 8, 1986, GEOSAT is collecting data along an orbital ground track with a 17-day repeat cycle. GEOSAT Sensor Data Records (SDRs) are converted to Geophysical Data Records (GDRs) by a group within the National Ocean Service (NOS) of the National Oceanic and Atmospheric Adminsitration (NOAA). This group transmits the GEOSAT GDRs to the NODC on 9-track, 6250 bpi magnetic tapes. Each tape contains 34 days of GEOSAT data, or two 17-day repeat cycles.

The NODC receives GEOSAT data approximately 30 to 60 days after observation. A new tape is received at the NODC about every five weeks. Copies of the GEOSAT GDR data tapes are provided to customers on either an annual subscription or individual order basis. Non-U.S. citizens must request these GEOSAT data through the science officer of their country's embassy in the United States.

Documentation provided with the data tapes includes a brief inventory giving the date and beginning and ending time and geographic position (latitude and lonitude) of each data file (day) on the tape, a plot of the GEOSAT ERM ground track for the data, and a copy of the GEOSAT Altimeter Geophysical Data Record (GDR) User Handbook produced by NOS.

To receive a copy of the GEOSAT Data Order Form or for further information about the availability of GEOSAT GDRs, please contact:

National Oceanographic Data Center
User Services Branch
NOAA/NESDIS E/OC21
Washington, DC 20235

Telephone: 202-673-5549 or
FTS 673-5549

Electronic Mail: OMNET/MAIL
mailbox "NODC.WDCA"

RECENT RESULTS FROM THE HARVARD GULF STREAM FORECASTING PROGRAM

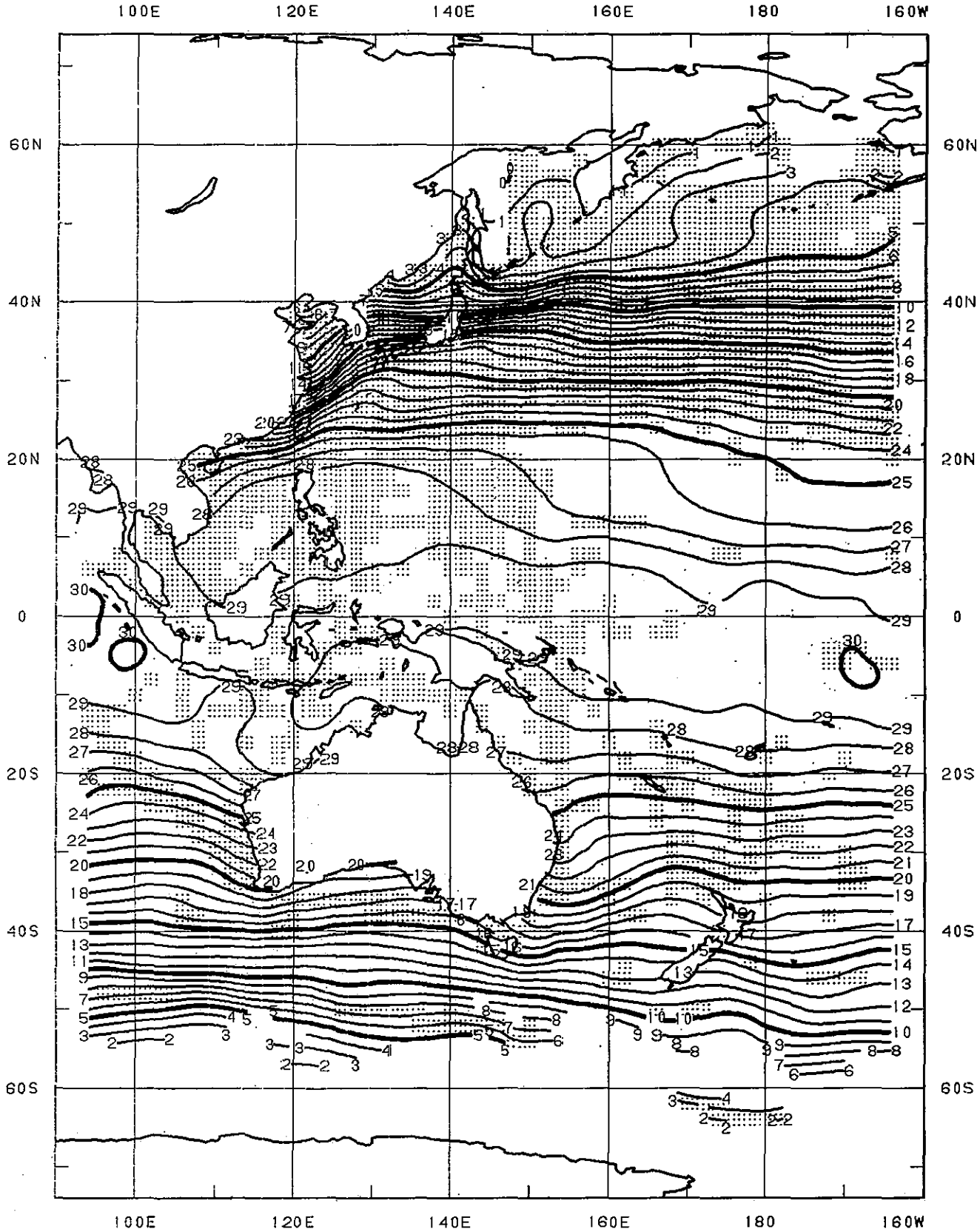
Scott Glenn
Allan Robinson
Michael Spall

Center for Earth and Planetary Physics
Harvard University
Cambridge, Mass.

The Harvard University Ocean Modeling and Forecasting Group has set up the Harvard Open Ocean Model, (Robinson and Walstad (1987)), in the Gulf Stream meander and ring formation region. Applications include: basic research on the dynamics and energetics of Gulf Stream meandering, ring interactions, and ring formations; and the development of a real time operational forecasting methodology to predict events on time scales of days to weeks. "Operational " forecasts that are still under development are currently performed at Harvard on a weekly basis for a region starting just east of Cape Hatteras to about 55W.

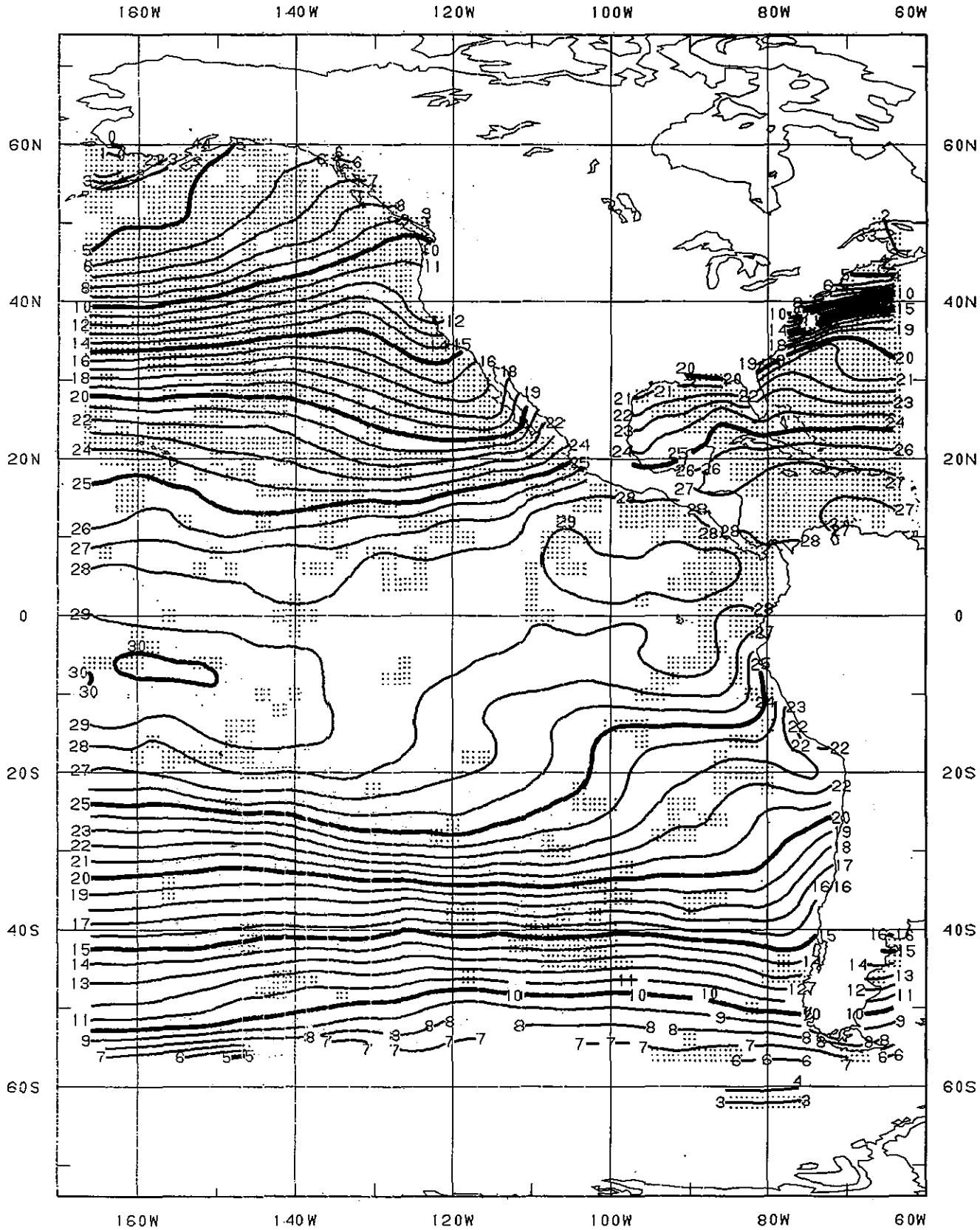
The current forecasting procedure consists of the following multistep process. First, the location of the Gulf Stream and rings is determined from i) satellite IR; ii) Harvard designed, U.S. Navy AXBT (air-deployable expendable bathythermograph) surveys; and iii) the Harvard model forecasts from the previous week. Next, given the new location of the Gulf Stream axis and rings, the 3-dimensional velocity fields used to initialize the model are generated with feature models (Robinson, Spall, and Pinardi, 1987). The feature models are expressions with adjustable parameters that describe the typical Gulf Stream and ring velocity distributions. Example parameters for the Gulf Stream feature model include stream

(text continued on page 12)



Western Pacific Ocean
SST--MONTHLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA
APRIL 1987

Monthly mean sea surface temperature is the mean of *in situ* and satellite data within two-degree quadrangles. Contour line interval is 1.0°C. The stippling indicates where the analysis was fixed by the *in situ* data; contours are not shown in areas without data.



Eastern Pacific Ocean
SST--MONTHLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA
APRIL 1987

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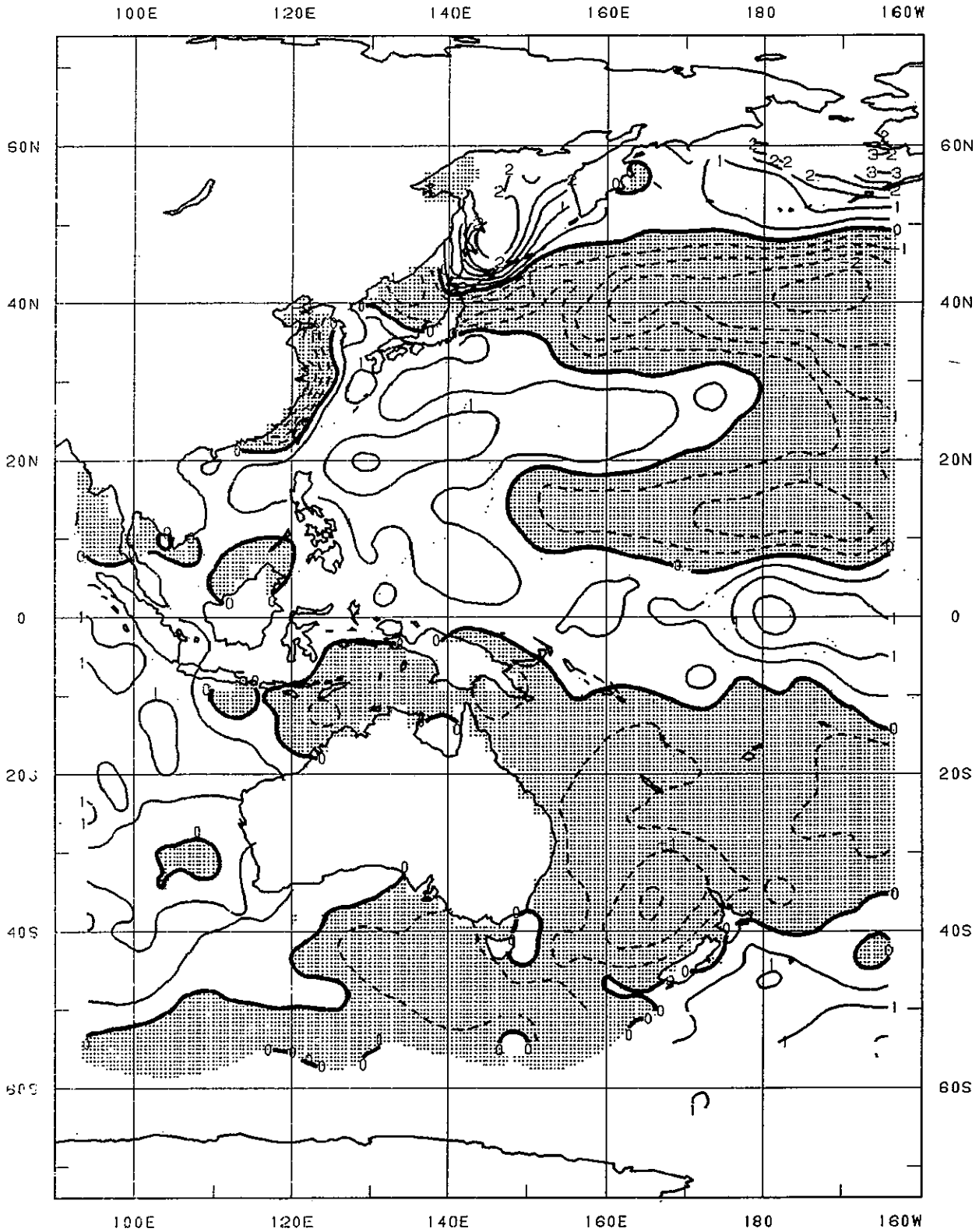
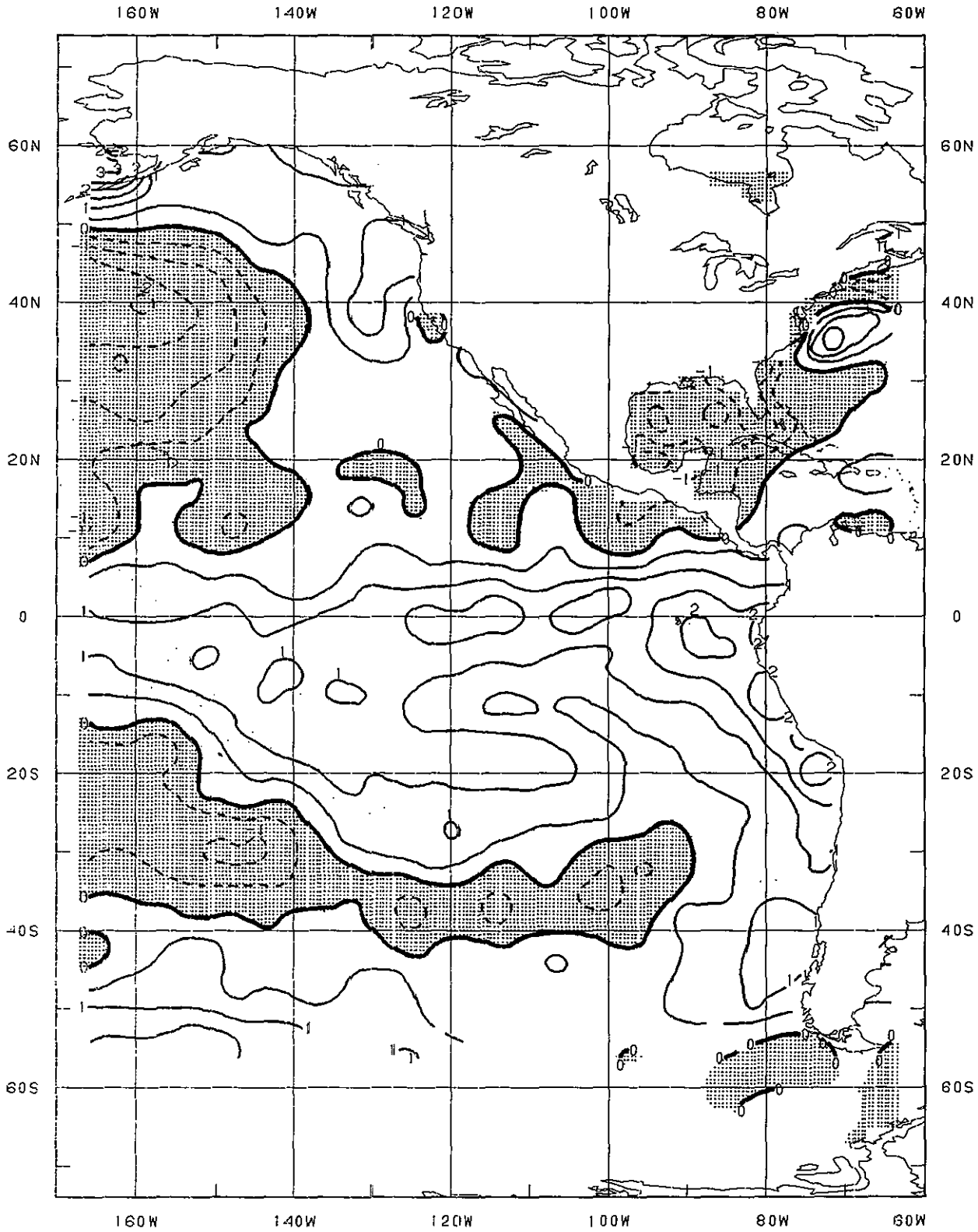


Western Pacific Ocean
SST--MONTHLY ANOMALY
SHIP, BUOY, AND SATELLITE DATA
APRIL 1987

Monthly anomaly is the difference between the monthly mean sea surface temperature and the climatological monthly mean value. Contour line interval is 0.5°C. The stippling indicates where the monthly mean is colder than climatology; contours are not shown in areas without monthly or climatological data.



Eastern Pacific Ocean
SST--MONTHLY ANOMALY (°C)
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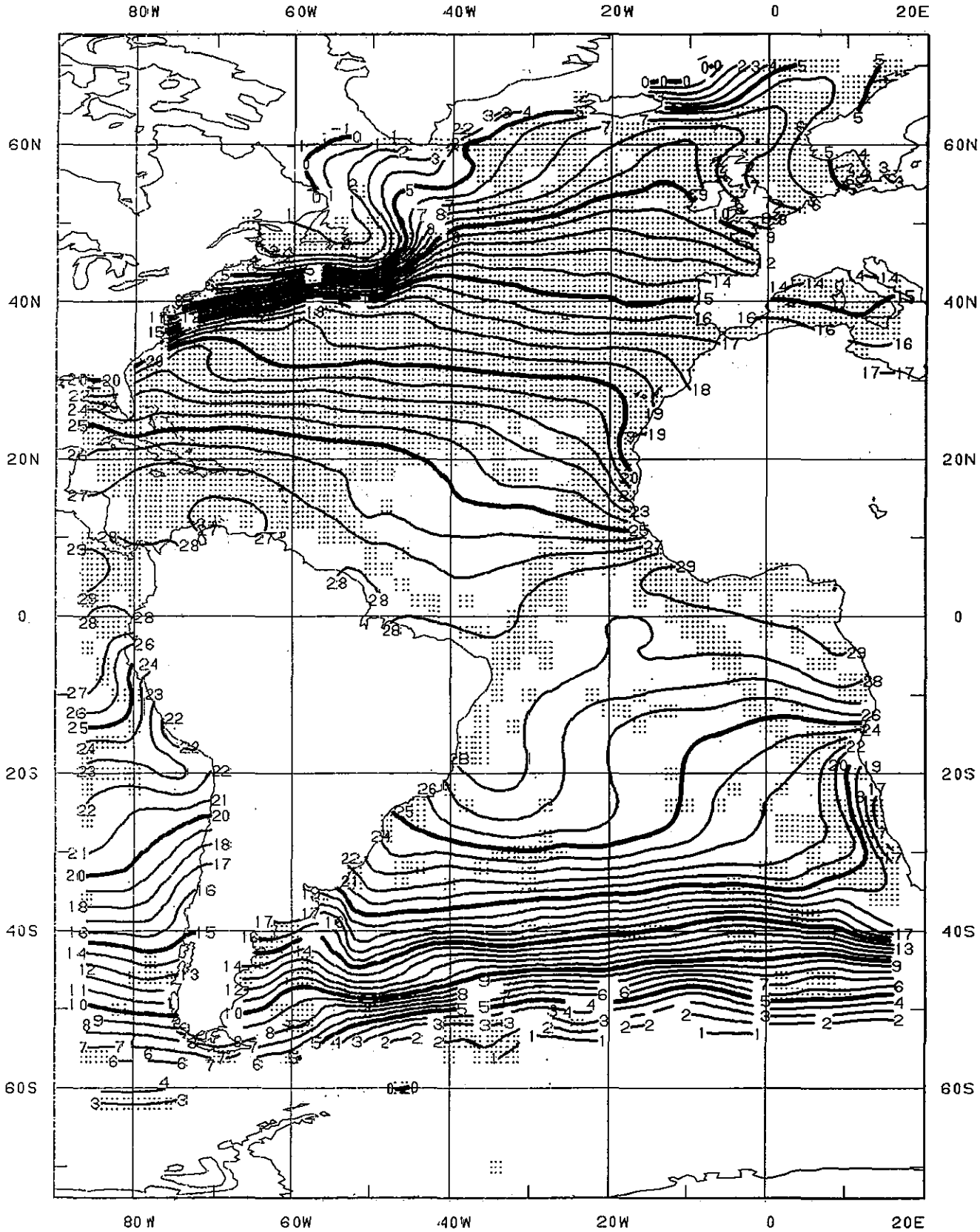
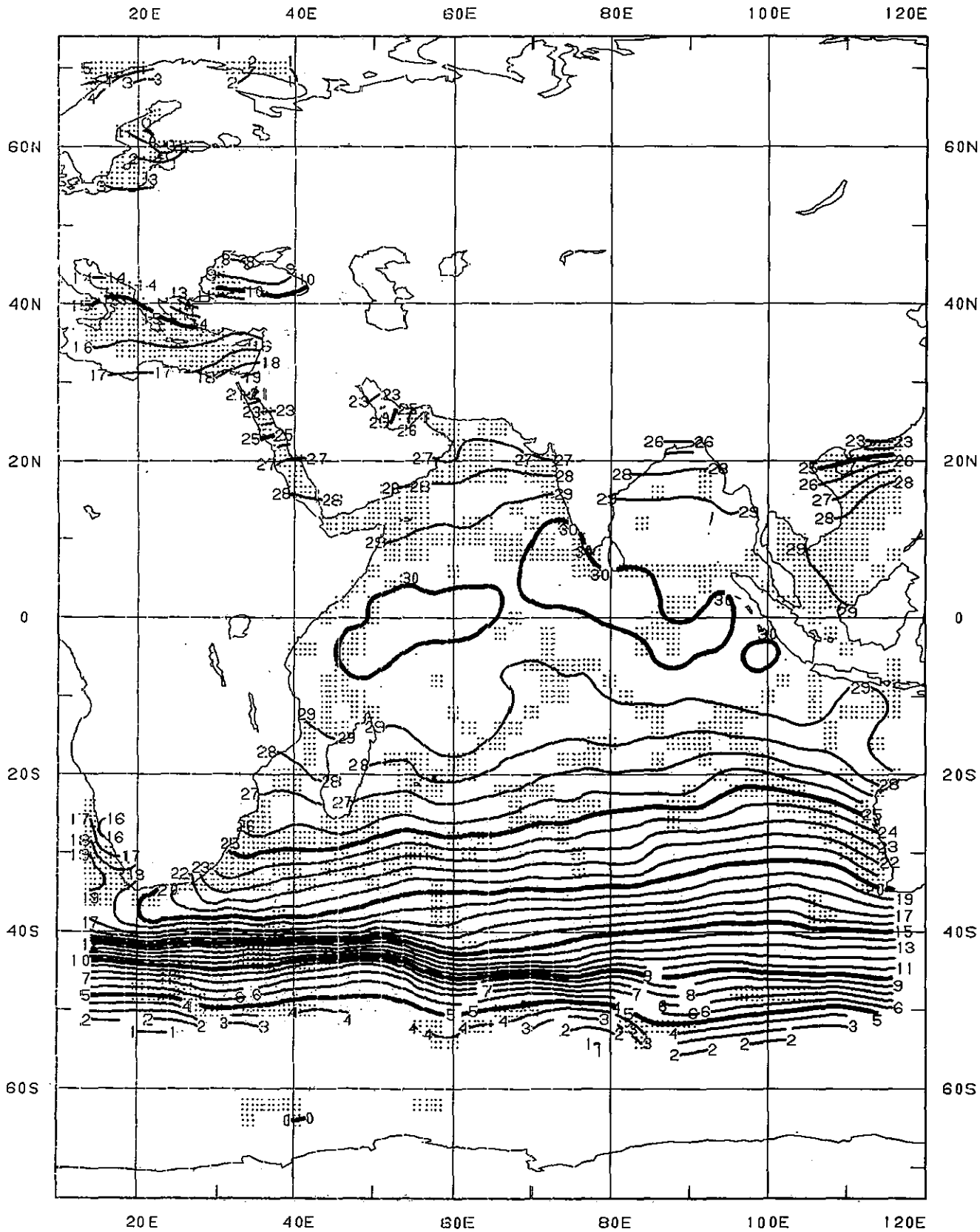


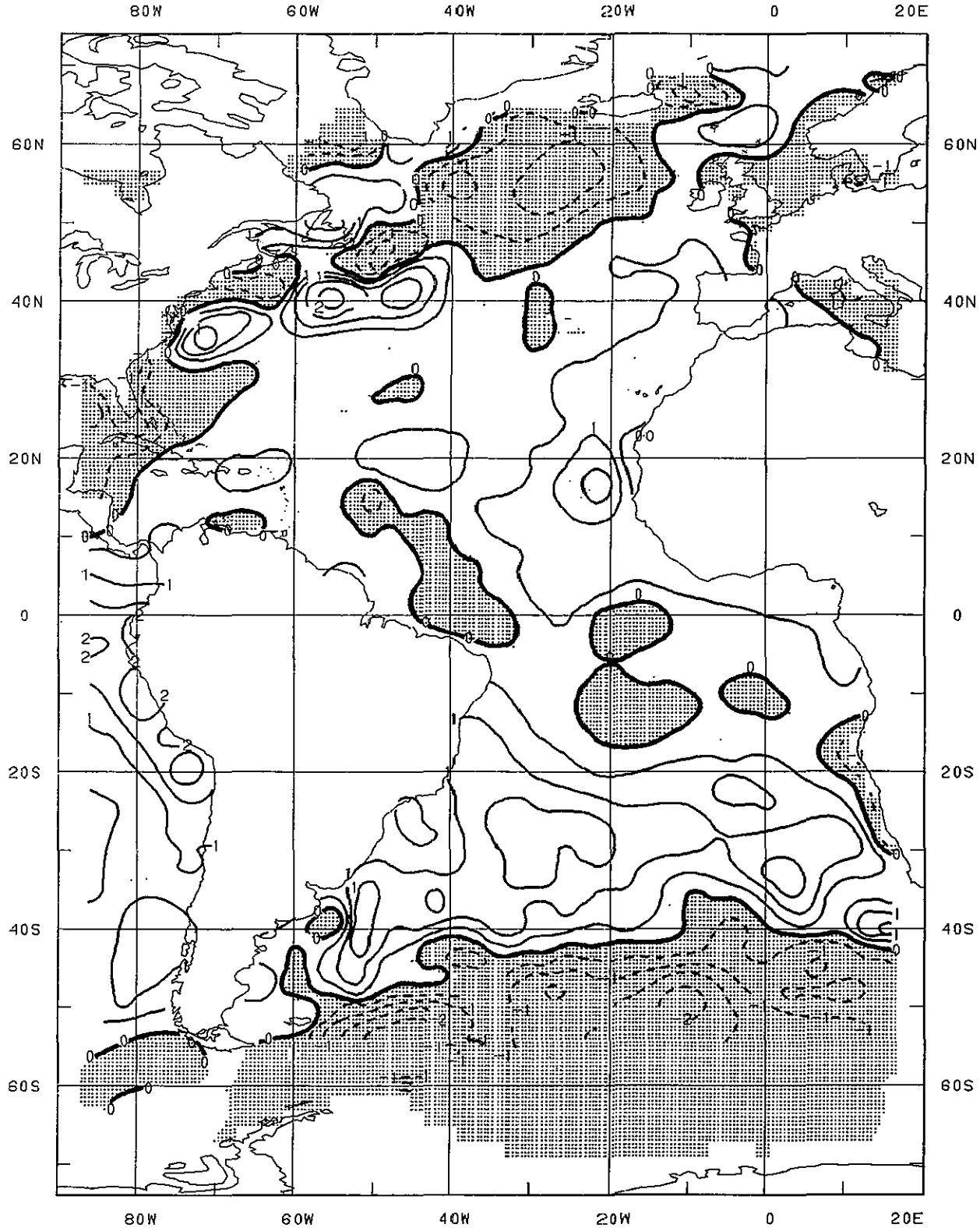
Atlantic Ocean
SST--MONTLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA
APRIL 1987

Monthly mean sea surface temperature is the mean of *in situ* and satellite data within two-degree quadrangles. Contour line interval is 1.0°C. The stippling indicates where the analysis was fixed by the *in situ* data; contours are not shown in areas without data.



Indian Ocean
SST--MONTHLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA
APRIL 1987

Monthly mean sea surface temperature is the mean of *in situ* and satellite data within two-degree quadrangles. Contour line interval is 1.0°C. The stippling indicates where the analysis was fixed by the *in situ* data; contours are not shown in areas without data.



Atlantic Ocean
SST--MONTHLY ANOMALY (°C)
SHIP, BUOY, and SATELLITE DATA

APRIL 1987

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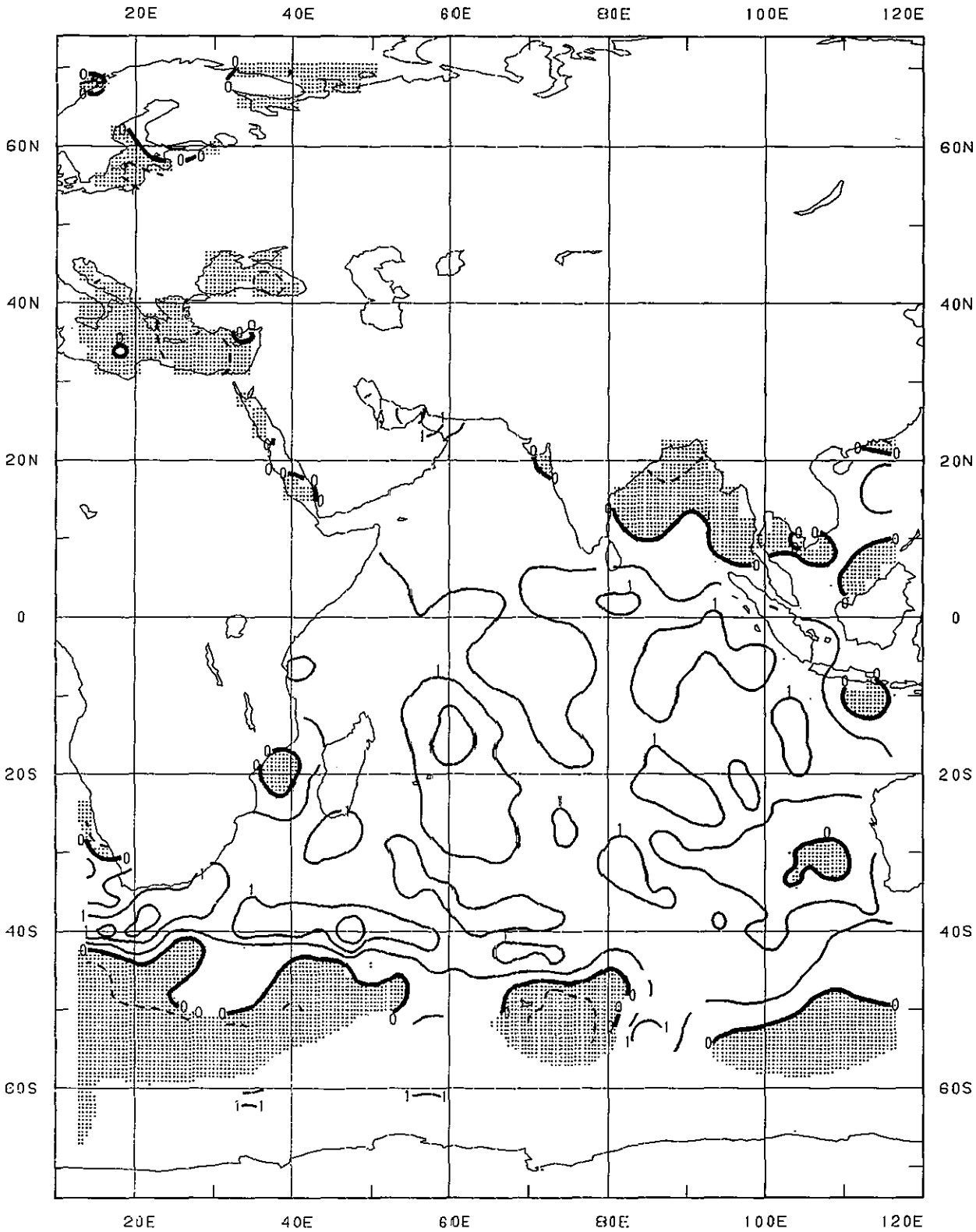

Indian Ocean
SST--MONTHLY ANOMALY (°C)
SHIP, BUOY, and SATELLITE DATA
APRIL 1987

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width, maximum velocity, and vertical current shear. Example parameters for the ring feature model include ring radius, depth, and maximum swirl velocity. Finally, the model is initialized with the full three dimensional fields and forecast ahead in time, usually one week, although longer forecasts have been done during times of poor satellite data.

To illustrate the forecast initialization and verification procedure, two recent research operational forecasts are presented. Figure 1 is taken from the March 25 - April 1 forecast, and Figure 2 is taken from the April 1 - April 8 forecast. This period was chosen because it covers a major evolutionary event , the birth of a giant warm core ring, and because clear skies prevailed so that good satellite imagery was available in the formation region. The sea surface temperature fronts actually observed in the satellite imagery were digitized for April 1 and April 8 from the NOAA/NWS Oceanographic Analysis charts and are replotted in the Harvard Gulf Stream forecast domain in Figures 3 and 4. The small circles in the eastern portion of Figure 3 are locations of AXBT drops.

In Figures 1 and 2, the top chart shows the feature model initialization, and the bottom chart shows the 7 day forecast. Contours of the streamfunction (pressure) at 100 meters depth were chosen to illustrate the flow in the model domain. The flow was actually calculated at six levels distributed throughout the water column but level 1 was chosen to compare with the SST data. In these maps, the flow is parallel to the streamfunction contours with the solid contours on the right. The circular features north and south of the Stream are the warm and cold core rings, respectively. Small scale features observed in the satellite images of sea surface temperature, such as shingles, are not included in the feature model initialization but may be generated by the model.

The March 25 initialization in Figure 1 was generated using the March 25 Oceanographic Analysis chart and the Harvard model forecast from the previous week. Due to cloud cover, many of the meanders and rings were identified based on forecast information alone. The most interesting feature to watch in this forecast is the evolution of the large meander system between 66W and 70W. The streamfunction contours at 100 meters indicate that a warm core ring may be in the process of breaking off. The forecast shows that a closed circulation has developed within the feature by April 1, but that the feature is still attached to the Gulf Stream. The Oceanographic Analysis chart depicting sea surface temperature for April 1, Figure 3, confirms that a body of Sargasso Sea water was surrounded by a warmer Gulf Stream water, and that the ring was still in the process of

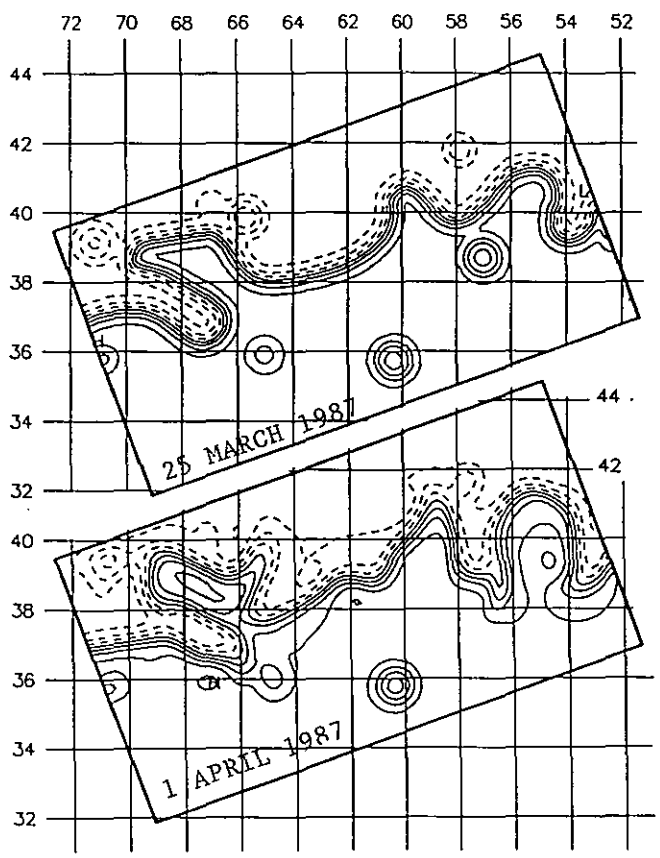

Figure 1: 100 m streamfunction research operational forecast, March 25 - April 1.

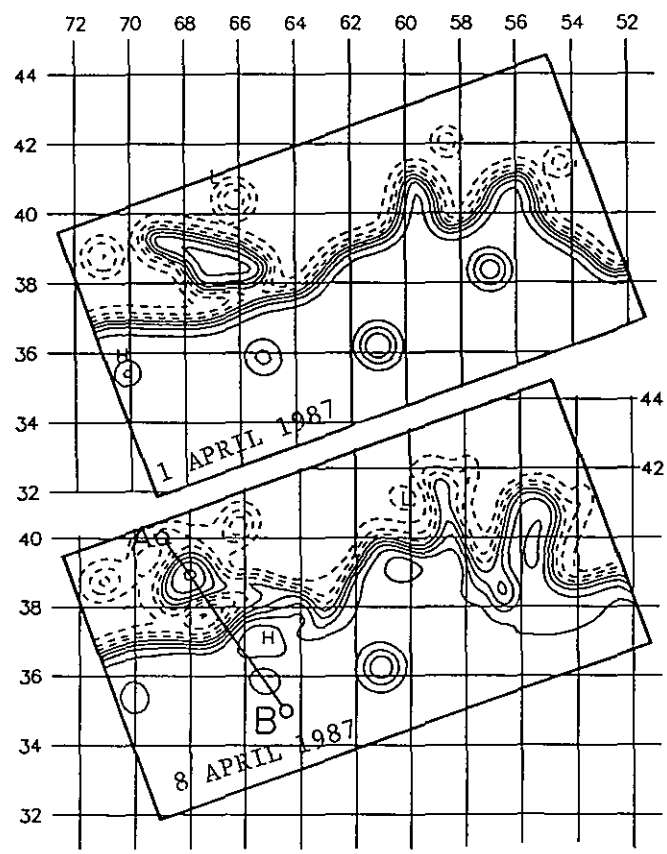

Figure 2: 100 m streamfunction research operational forecast, April 1 - 8.

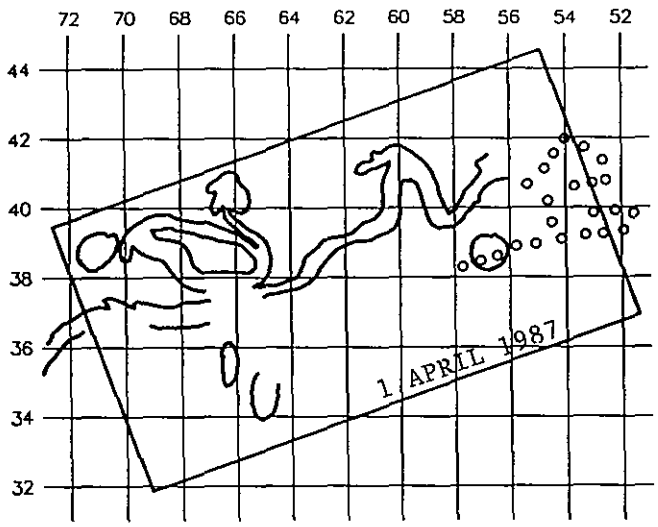

Figure 3: Thermal fronts from Oceanographic Analysis, April 1. Small circles indicate AXBT locations.

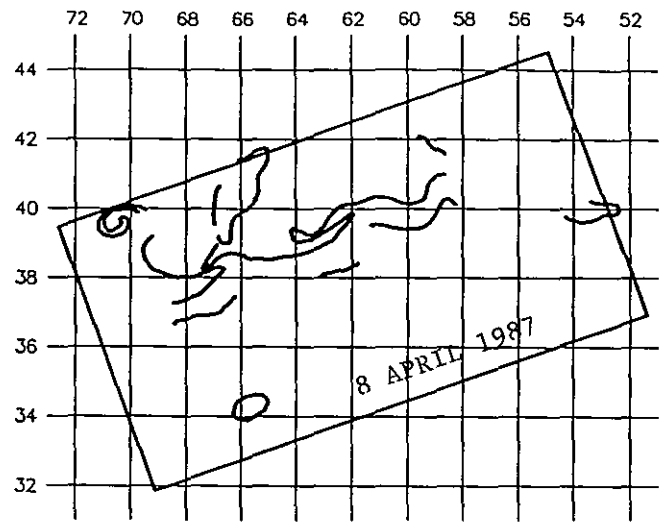

Figure 4: Thermal fronts from Oceanographic Analysis, April 8.

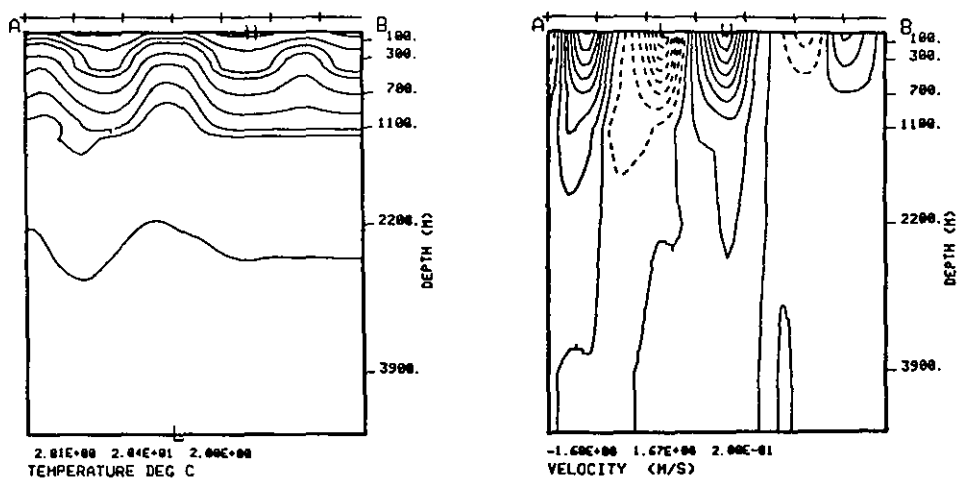

Figure 5: Vertical sections of temperature and velocity along line A-B from the model forecast on April 8. Tick marks are at 100 km intervals.

breaking off. This event is very unusual both because of the size of the ring and the location. Generally, rings are about half this size and form farther downstream.

The forecast domain initialization shown in Figure 2 for April 1 was based on the previous week's forecast modified slightly by the new satellite imagery and AXBT data. The AXBT survey was designed to map the clouded region east of 56W and locate the cold ring near 35N 57W. The large, newly forming, warm ring was initialized as still attached to the Gulf Stream, and the old warm ring was located at the position in the satellite imagery.

In the April 1-8 forecast the warm ring formation is completed. The newly formed large warm ring was reduced in size through a strong ring-stream interaction at 38.5N 66W and shingling near 40N 69W. This resulted in a ring more typical in size and shape for the region. The new ring shape and position, shingling, and stream interaction are all confirmed by the satellite imagery, Figure 4. Figure 5 is a vertical section through the model forecast on April 8 along line A-B. The tick marks along the top are spaced at 100 km intervals and the model levels are indicated along the depth axis. Clearly visible are the velocity and temperature signatures of the new warm ring, the Gulf Stream, and a cold ring. This demonstrates the realistic, three dimensional fields generated by the Harvard model and the Gulf Stream forecasting methodology.

This research is jointly supported by the Institute for Naval Oceanography and the Office of Naval Research.

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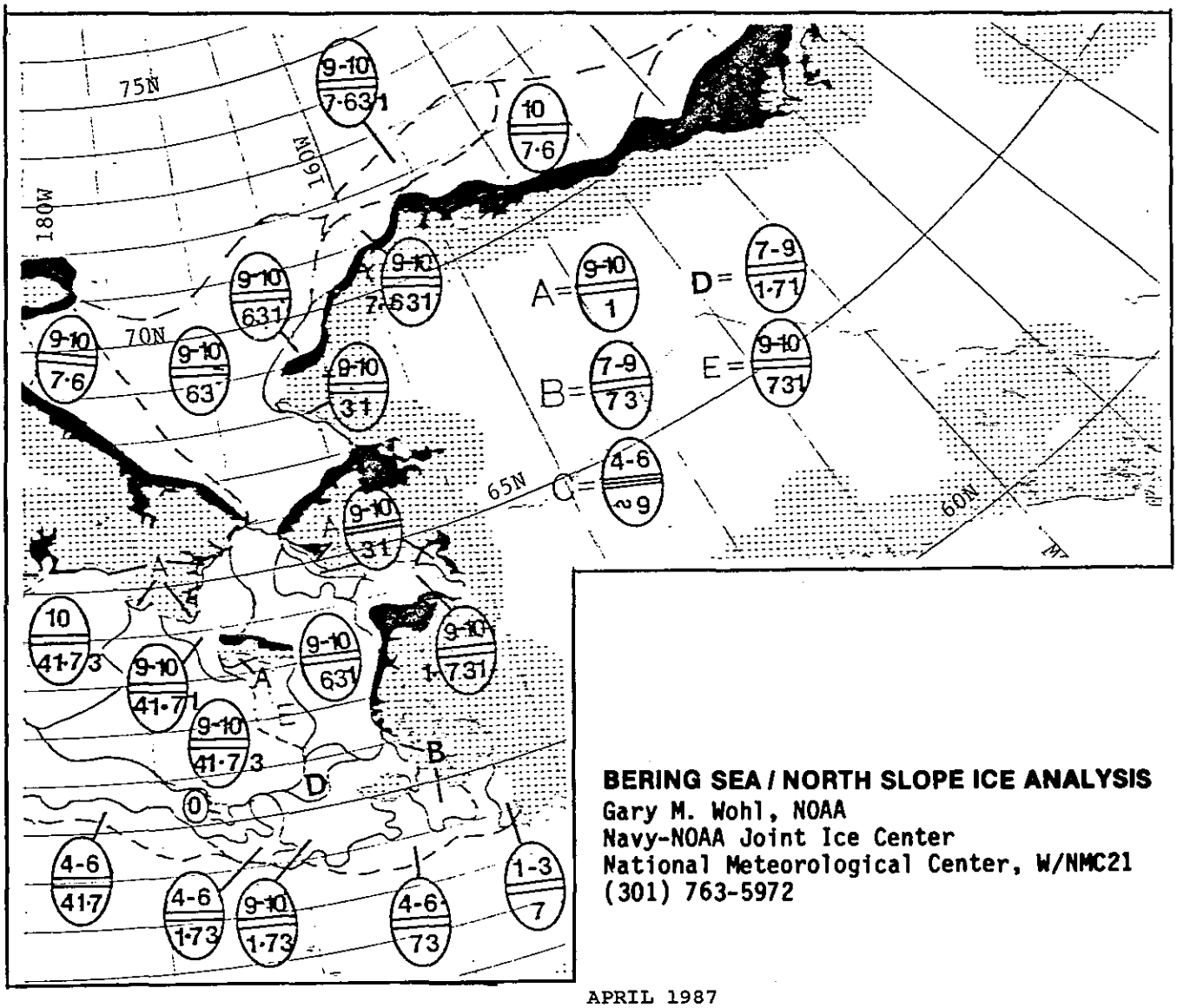
Robinson, A.R., M.A. Spall, and N. Pinardi, 1987. Gulf Stream Simulations and the Dynamics of Ring and Meander Processes. In Preparation.

Robinson, A.R., L.J. Walstad, 1987. The Harvard Open Ocean Model: Calibration and Application to Dynamical Process Forecasting and Data Assimilation Studies. J. App. Num. Math. In Press.



BERING SEA / NORTH SLOPE ICE ANALYSIS

Gary M. Wohl, NOAA
Navy-NOAA Joint Ice Center
National Meteorological Center, W/NMC21
(301) 763-5972

APRIL 1987

Sea ice conditions in the Bering Sea were variable during the month of April. Rising temperatures and ablation throughout the region characterized the first half of the month. A change in the weather pattern caused cold air from the Arctic to push south into the Bering Sea area during the middle of the month. Temperatures plummeted and new ice growth was observed across the Bering Sea. In addition, northerly winds caused the remaining ice to drift toward the south and the ice edge expanded into formerly ice free areas. Late in the month warmer air returned to the Bering Sea re-establishing the seasonal ice ablation pattern and the ice edge began to recess once again. To the north a significant area of weakness persisted from the Beaufort Sea north of Point Barrow into the Chukchi Sea. Temperatures there were near normal but the weather pattern included periods of strong winds. Otherwise ice conditions were near normal.

C = Total ice concentration in the area in tenths.
C_a, C_b, C_c = Concentration of thickest (C_a), 2nd thickest (C_b), and 3rd thickest (C_c) ice
S_a, S_b, S_c = Stage of development of thickest (S_a), 2nd thickest (S_b), and 3rd thickest (S_c) ice.
~C = Concentration of ice within area(s) of strips and patches.

STAGE(S) OF DEVELOPMENT (THICKNESS)

1 = New ice (0-10 cm)
3 = Young ice (10-30 cm)
6 = First year (30-200 cm)
7 = First year thin (30-70 cm)
1. = First year medium (70-120 cm)
4. = First year thick (120-200 cm)
7. = Old ice (survived at least one summer's melt)

EXAMPLES

125 Theoretical thickness of this season's growth (cm).

Fast ice. Sea ice which forms and remains fast along the coast.

Ice boundary visually or satellite observed.

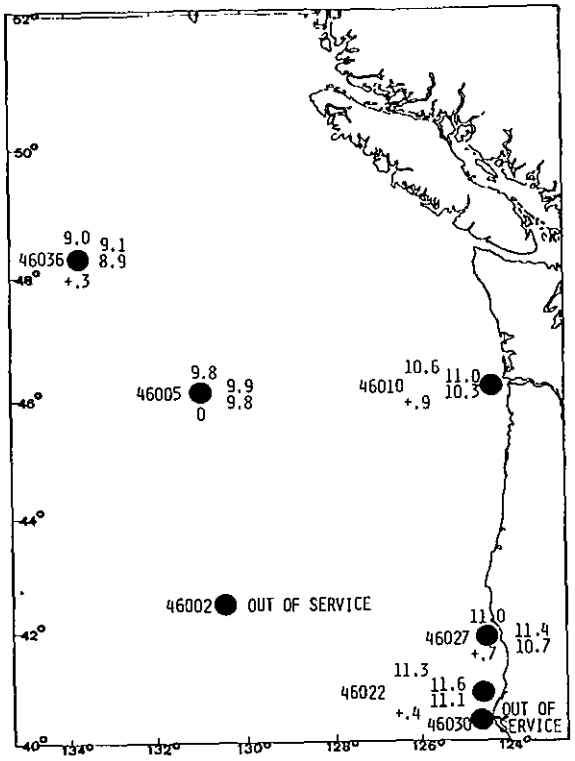
Ice boundary estimated.

WEST COAST OCEAN FEATURES

Ernest Daghir
NOAA/NWS
Satellite Field Service Station
660 Price Avenue
Redwood City, CA 94063
(415) 876-9122
FTS 470-9122

APRIL 1987

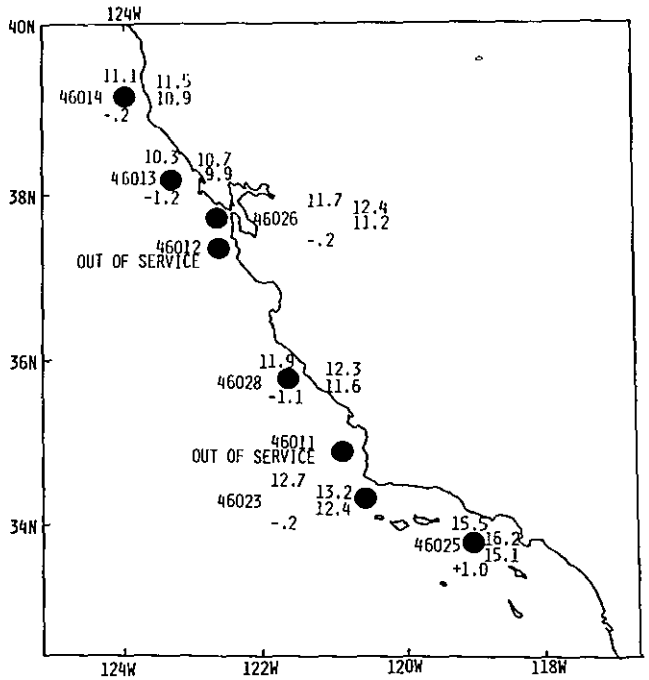
With spring here and a higher sun angle, sea surface temperatures generally are on the rise. However, in the south panel the fixed buoys close



to the coast cooled when compared to the previous month. Only buoy 46025 showed warming. The cooling was in response to some minor upwelling events caused by strong northwesterly winds.

In the South Panel area, the climatological mean temperature for April is 14.8C which coincided with the actual value computed from the 8 analyses generated. This is the first month in many where the climatological and computed temperatures were the same. SSTs west of 130W and east of 119W were slightly below normal; in between, however, waters were above normal. When compared to March, as mentioned above, all areas warmed except those adjacent to the coast.

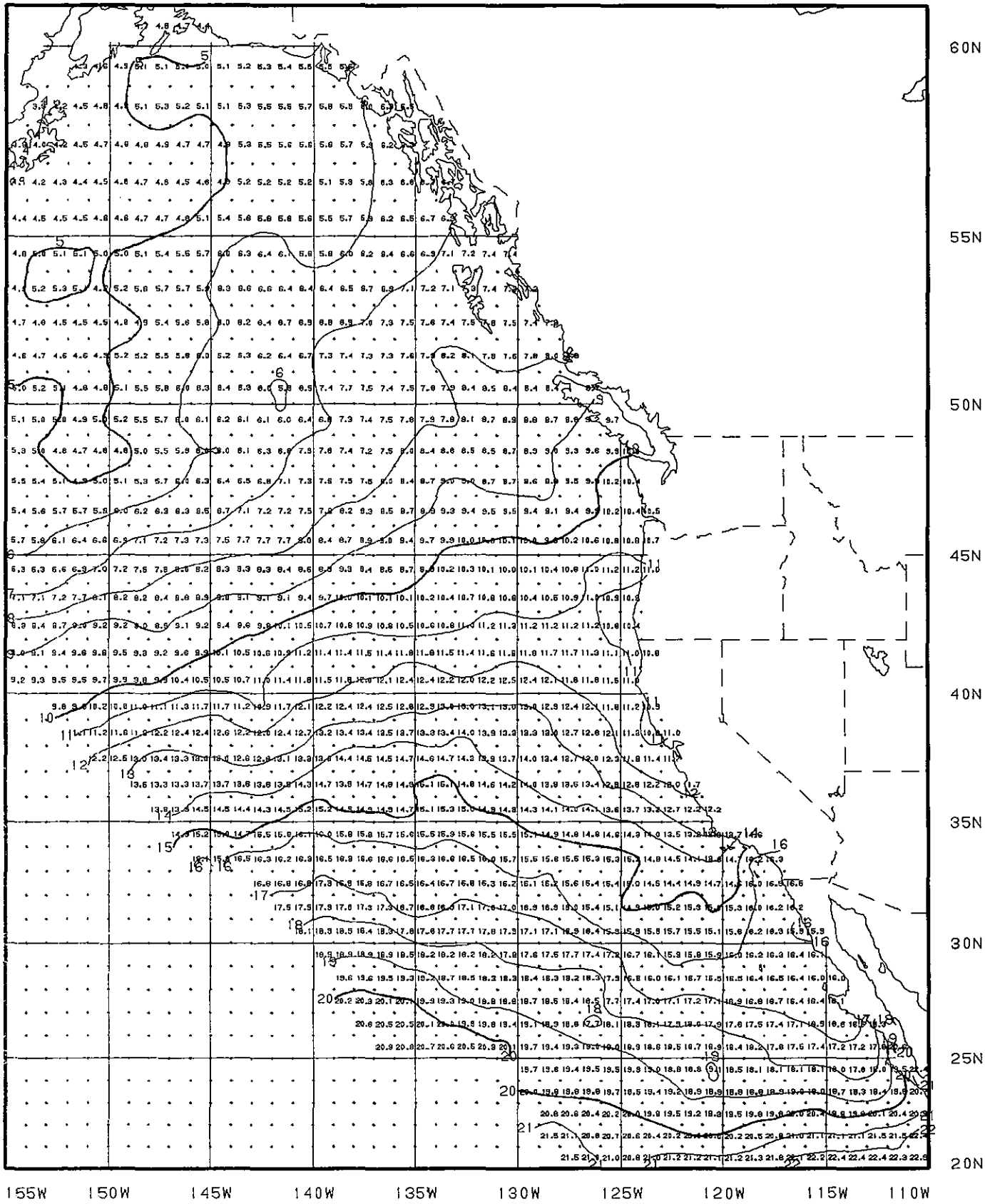
In the North Panel, ocean temperatures are above normal, especially nearshore. The climatological mean value for the area is 9.0C and the computed value was 9.6C. No area had SSTs below normal, and only one location (50N 135W) had normal SSTs. There was a warm anomaly of up to 1.5C near Cape Blanco (43N 126W). When comparing April's temperatures to the previous month, all areas warmed except for one; this was, oddly enough, in the center of the chart at 45N 130W. Again, around Cape Blanco, the SSTs warmed by 1.3C over the month.



KEY:

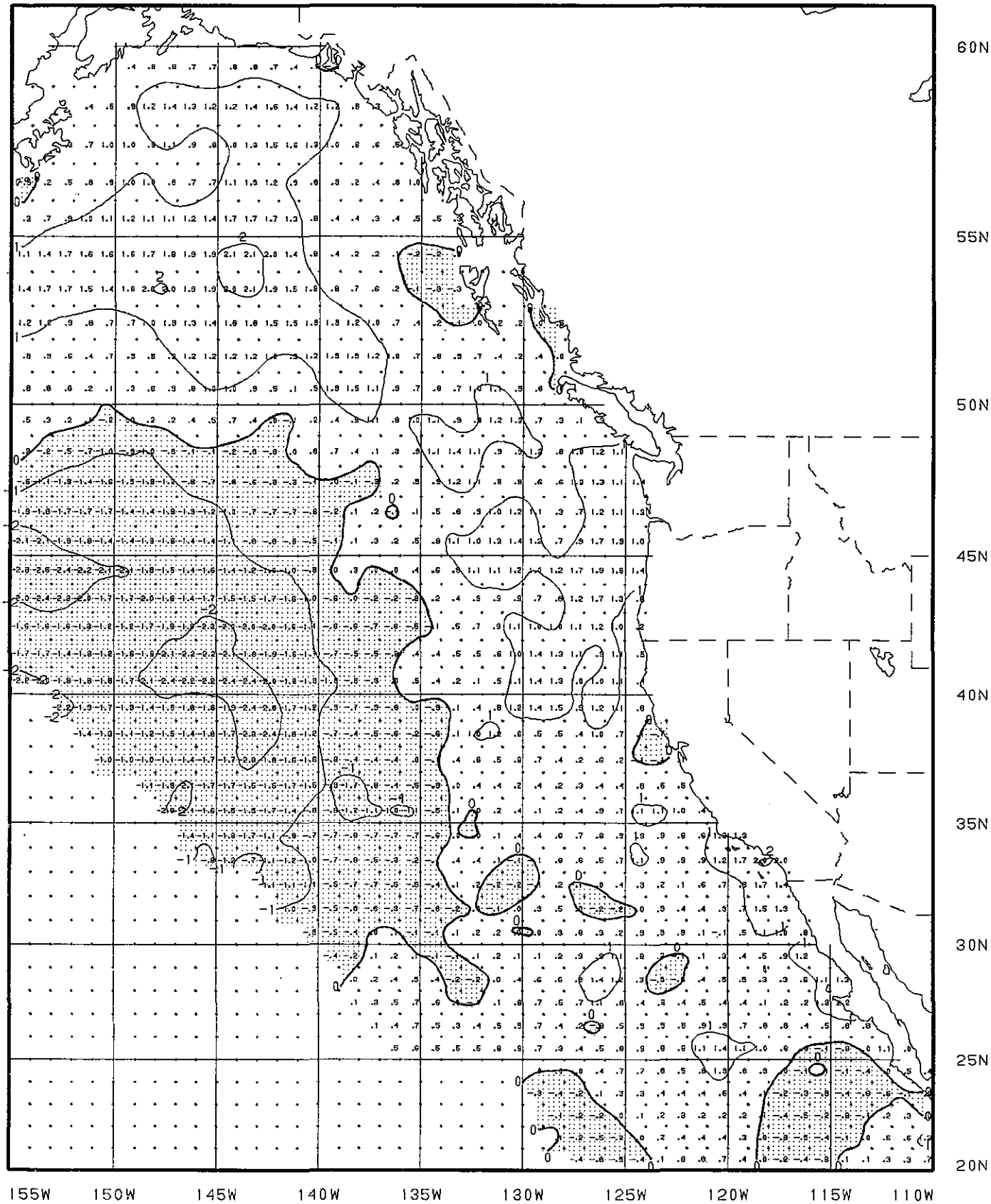
12.1 ← Monthly mean
LOCATION 13.5 ← Maximum daily mean
NAME 10.2 ← Minimum daily mean
-1.5 ← Change from previous month

● Denotes station position.



West Coast
SST--MONTHLY MEAN (°C)
APRIL 1987

Monthly mean sea surface temperature is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0°C.



West Coast
SST--MONTHLY ANOMALY (°C)
APRIL 1987

Monthly anomaly is the difference between the monthly mean sea surface temperature and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0°C.

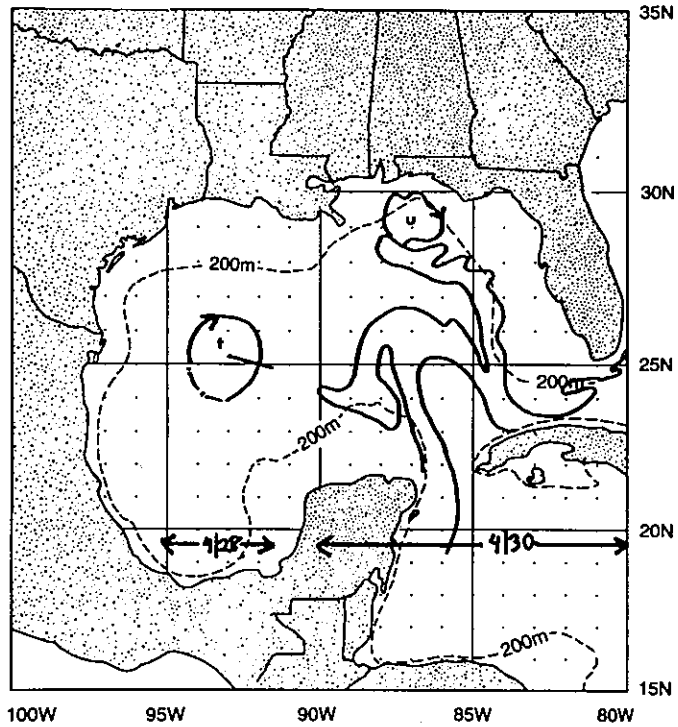
EAST COAST OCEAN FEATURES

Jenifer Clark
NOAA, NWS
Washington, DC 20233
(301) 763-8030

APRIL 1987

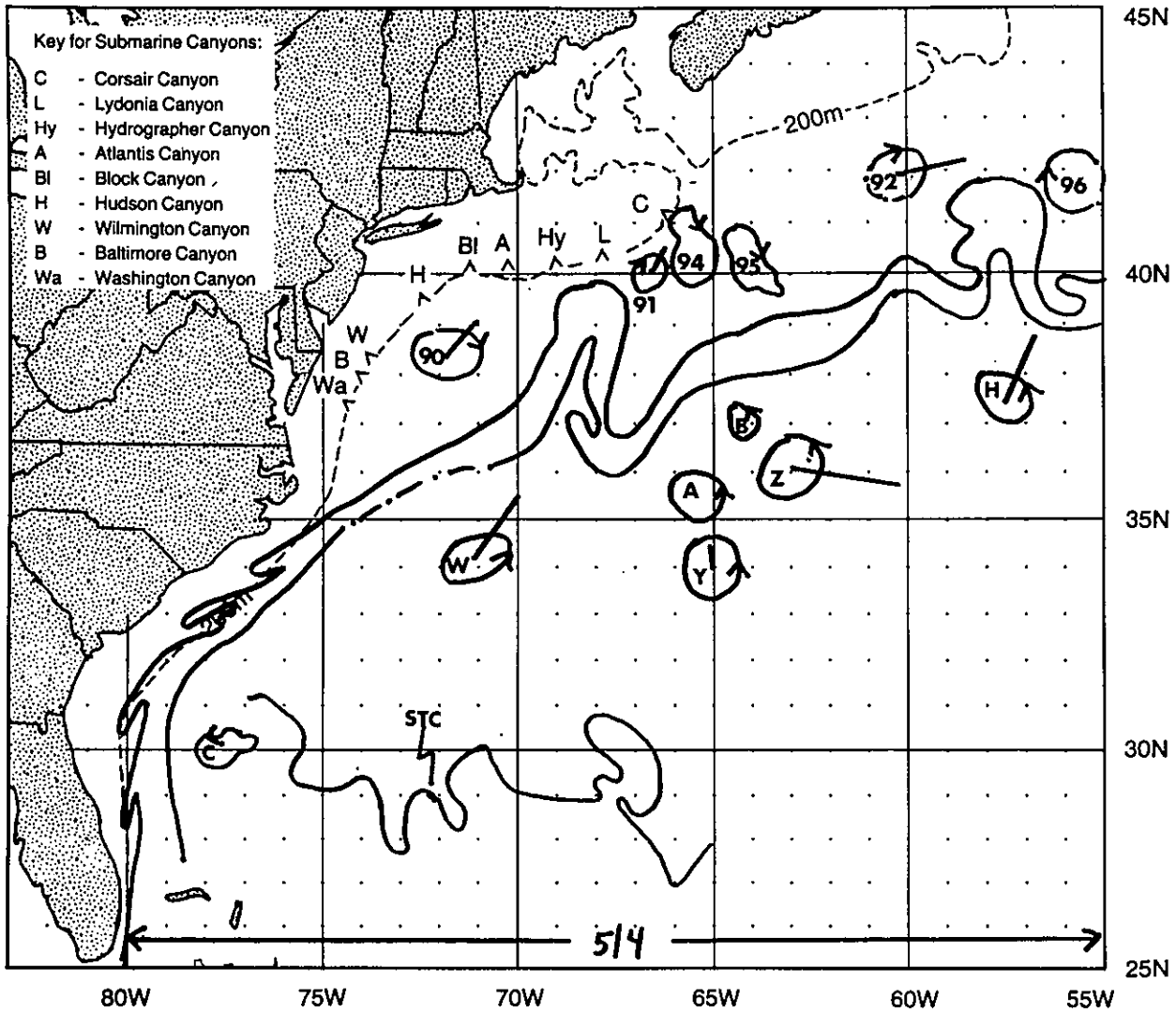
The end of this month's positions of the Gulf Stream System and its associated eddies are shown for the NW Atlantic and the Gulf of Mexico. The Gulf Stream and Loop Current boundaries are located by infrared satellite imagery or XBT (expendable bathythermograph) data. Anticyclonic eddies are labeled a-z in the Gulf of Mexico and 1-99 in the Northwest Atlantic. Cyclonic eddies are labeled A-Z. Arrows on eddies indicate direction of circulation. Warm-core or anticyclonic eddies rotate clockwise; cold-core or cyclonic eddies rotate counterclockwise. The line to the eddy center shows the net translation since last month or since last observed. The edge of continental shelf at 200 m is shown as a dashed line. Eddies or sections of the Gulf Stream System which were not observed during the month are not shown on the analysis chart or are indicated by "dot-dashed" lines. The long arrows at the bottom of the chart indicate the dates of data used.

Data used in this analysis include:
Infrared imagery from NOAA satellite - NESDIS
Bathythermograph data from National Meteorological Center of National Weather Service
Oceanographic Analysis -- A daily detailed analysis issued by National Weather Service



GULF OF MEXICO

The position of the Loop Current in the Gulf of Mexico moved northward 25 km during April. The long filament of warm water attached to the northeast section of the Loop pinched off anticyclonic eddy u near 29N 87W about April 21. Eddy u appears to be weak. Another warm filament is attached to the Loop from 26N 88W to 24N 89W. Eddy t apparently translated 150 km NW since its end of February location. (Its location was erroneously thought to be centered at 23N 90W east at the end of March). Eddy s and eddy o were not observed due to seasonal heating and clouds.

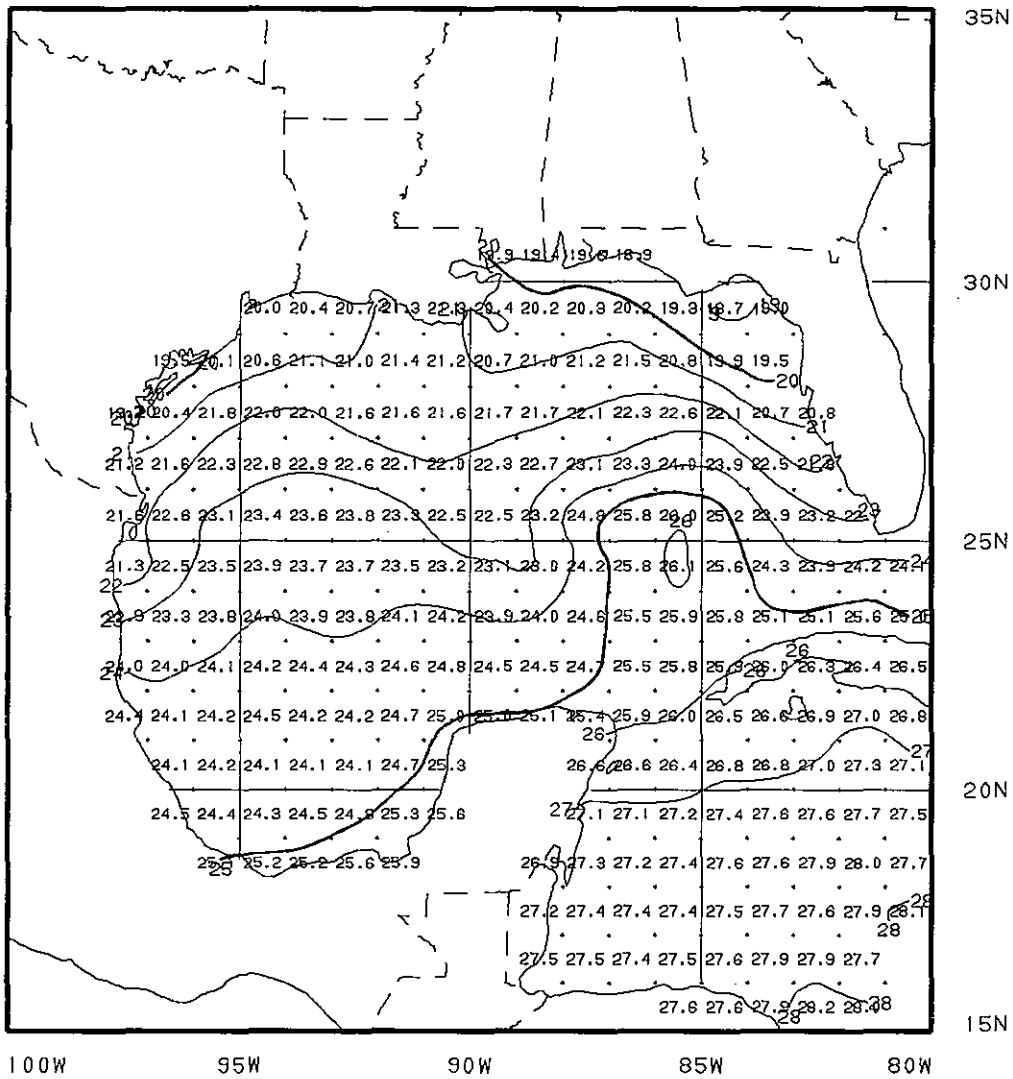


NORTHWEST ATLANTIC OCEAN

Two anticyclonic eddies were absorbed during April. Eddy 89 apparently dissipated about April 8 near 43N 61W. Eddy 93 translated 90 km and then interacted with a Gulf Stream meander near 40N 68W around May 4. It appears that the meander is absorbing eddy 93. This absorption was confirmed via radio patch to a fishing vessel searching for the eddy on May 5. Three anticyclonic eddies formed during April. Eddy 94 formed when eddy 91 seemingly split into two eddies on April 13 near 40N 66W. Eddies 95 and 96 apparently formed from Gulf Stream aneurisms around April 8 and April 15, respectively. Eddy 90 traveled 90 km SW while eddy 91 traveled 55 km SW. Eddy 92 moved 140 km WSW.

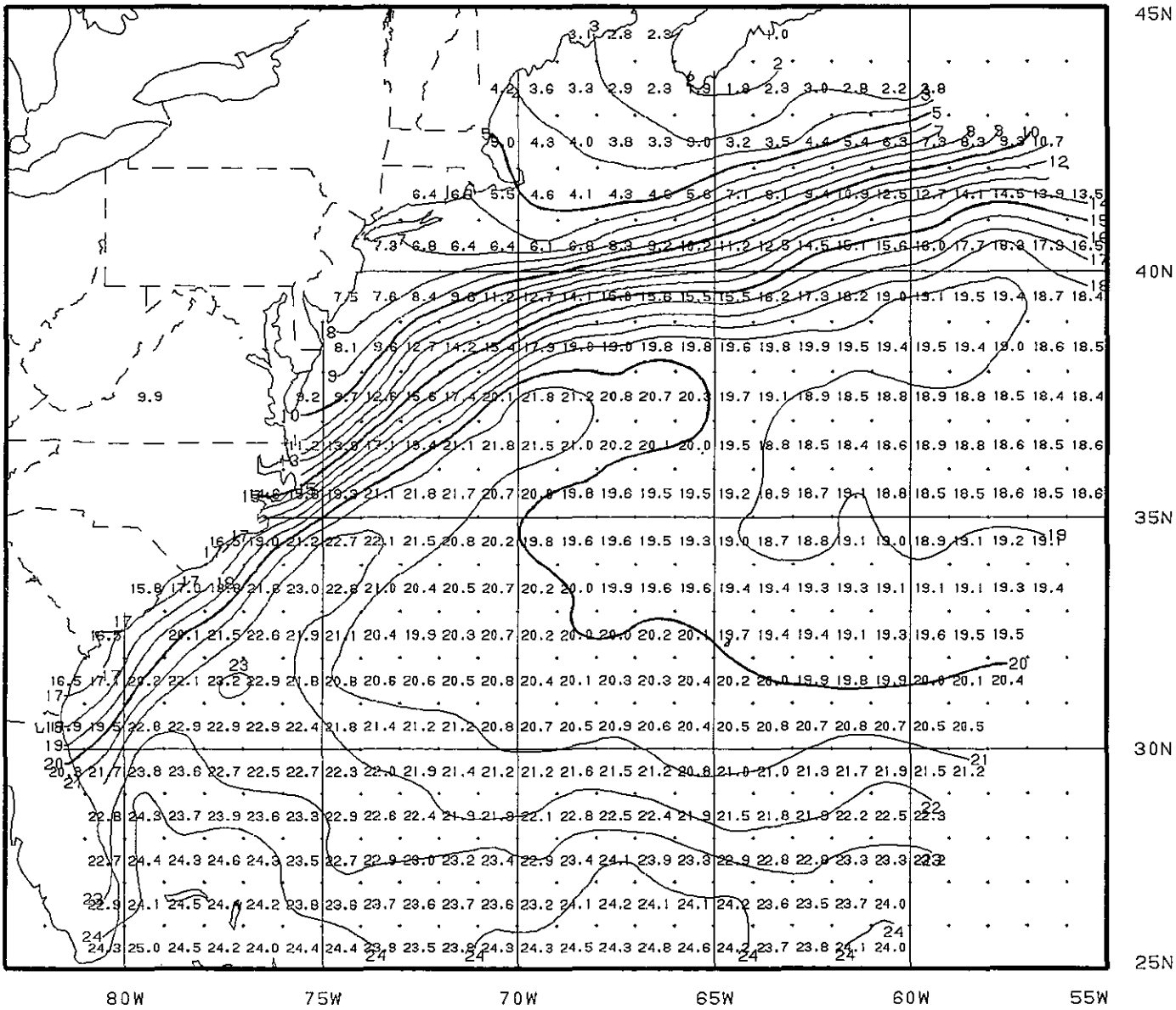
Three cyclonic eddies were newly observed during April although their origins are not known. Eddy A was observed near 35N 65W around April 13. Eddy B was detected about April 13 near 36N 64W. Eddy C was discerned near 30N 78W about April 7. Eddy W translated 155 km SW. Eddy Y moved 55 km S. Eddy Z seemingly traveled 240 km WNW. Eddy H translated 165 km SW. The Subtropical Convergence Front (STC) was observed on May 5 from 31N 76W to 28N 65W.

EAST COAST SST – MONTHLY MEAN



Gulf of Mexico
SST--MONTHLY MEAN (°C)
APRIL 1987

Monthly mean sea surface temperature is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0°C.



Northwest Atlantic Ocean
SST--MONTHLY MEAN (°C)
APRIL 1987

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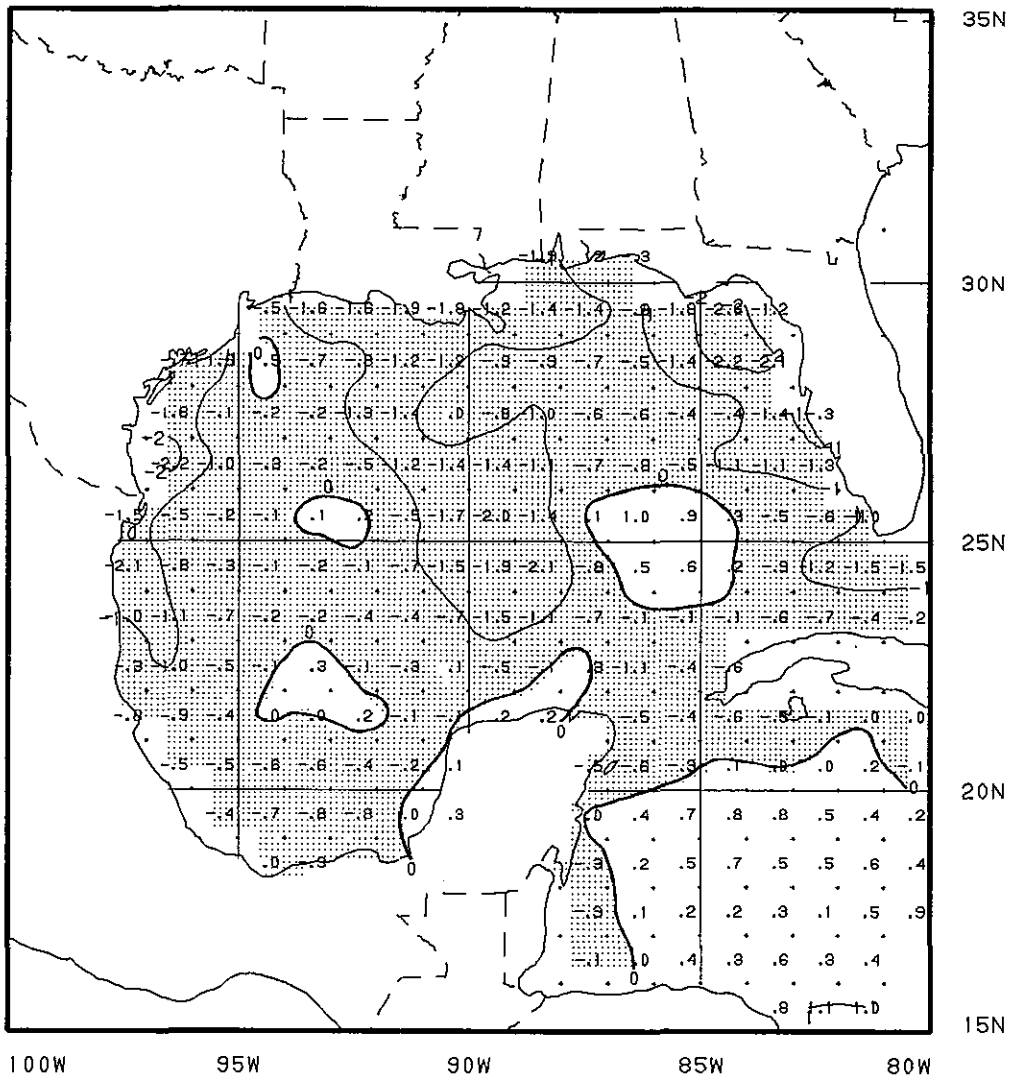
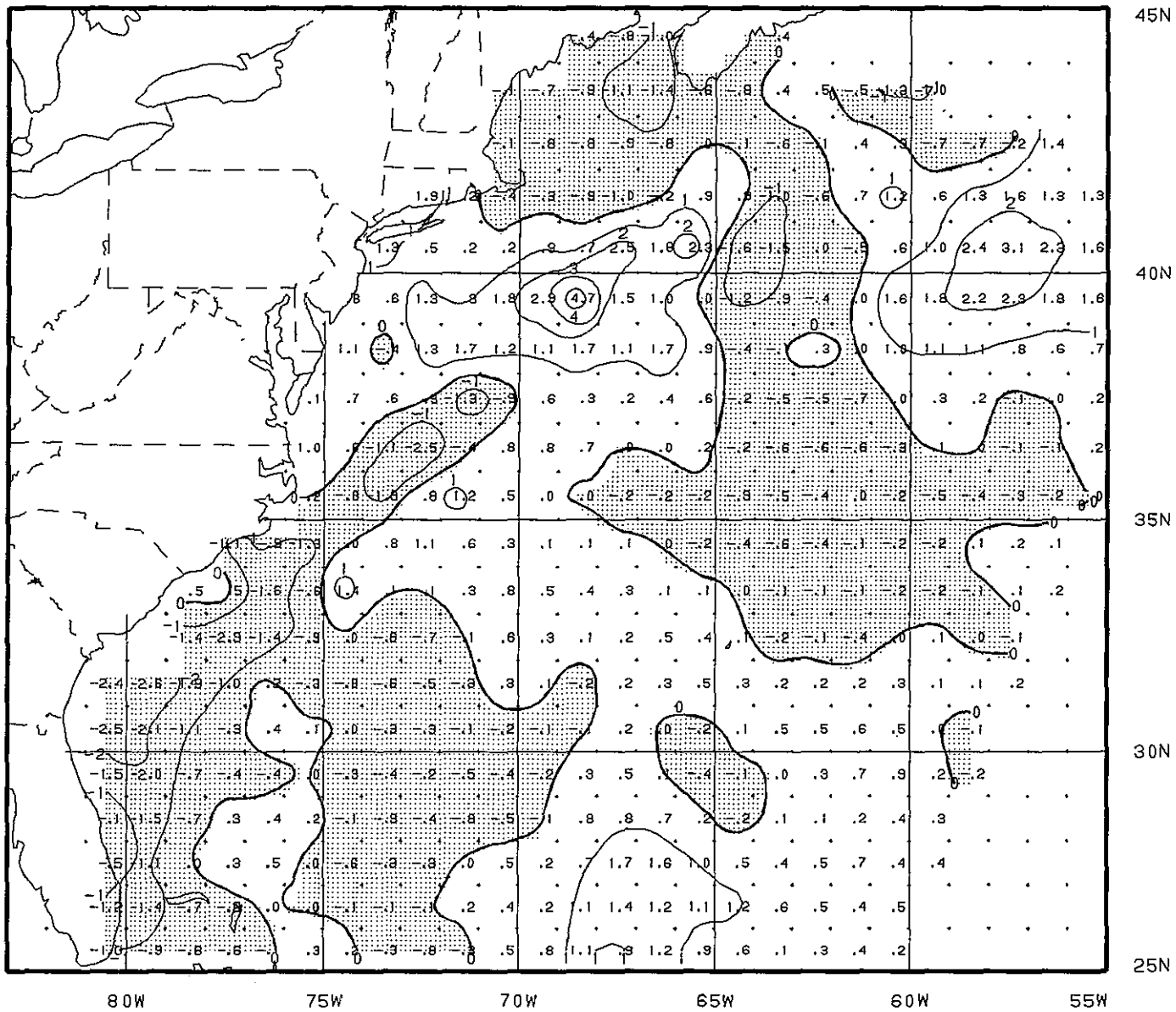
EAST COAST SST – ANOMALY



Gulf of Mexico
SST--MONTHLY ANOMALY (°C)
APRIL 1987

Monthly anomaly is the difference between the monthly mean sea surface temperature and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0°C.



Northwest Atlantic Ocean
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The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through April 1, 1987.

OCEANOGRAPHIC Monthly Summary

Volume VII Number 5 May 1987

The Humboldt Current (page 3)

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U.S. DEPARTMENT OF COMMERCE • National Oceanic and Atmospheric Administration
National Weather Service
National Environmental Satellite, Data, and Information Service
National Ocean Service

OCEANOGRAPHIC
Monthly Summary

Oceanographic Monthly Summary is published by the National Weather Service (NWS), the National Environmental Satellite, Data, and Information Service (NESDIS), and the National Ocean Service (NOS). *Oceanographic Monthly Summary* contains sea surface temperature (SST) analyses on both regional and ocean basin scales for the Atlantic, Pacific, and Indian Oceans. The ocean basin analyses are based on a "blend" of *in situ* and satellite data, in which *in situ* data are used to define "benchmark" temperature values in regions of frequent observations and satellite data are used to define the "shape" of the field between these points.[1]

An ocean basin SST anomaly is derived from the "blended" SST analysis[1] and the improved global SST.[2] The regional SST analyses are based upon a combination of *in situ* and satellite data measurements. The regional SST anomalies are calculated from the Robinson-Bauer Climatology.[3,4] *Oceanographic Monthly Summary* also contains Alaskan sea ice information and ocean feature information for contiguous U.S. ocean regions.

Oceanographic Monthly Summary welcomes articles containing information of interest to its readers, such as news on operational oceanography, unusual ocean feature phenomena, etc. Contributions should be sent to the editor (address below). Accepted material will appear in the OceaNotes section of *Oceanographic Monthly Summary*. Contributions can be published as quickly as the next monthly issue.

If you are interested in receiving *Oceanographic Monthly Summary* regularly, please refer to the back cover for subscription information.

[1]Reynolds, R.W. and W.H. Gemmill, 1984. A sea surface temperature analysis which blends *in situ* and satellite observations. *Proceedings of the Ninth Climate Diagnostics Workshop*, Corvallis, OR, Oct. 22-26, 1984, pp. 408-416.

[2]The climatology is derived from *in situ* data (1950-1979), satellite data (1982-1985) and an ice climatology.

[3]Robinson, M.K., 1976. Atlas of North Pacific Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOcean Ref. Pub. 2.*

[4]Robinson, M.K., R.A. Bauer, and E.H. Schroeder, 1979. Atlas of North Atlantic-Indian Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOceano Ref. Pub. 18.*

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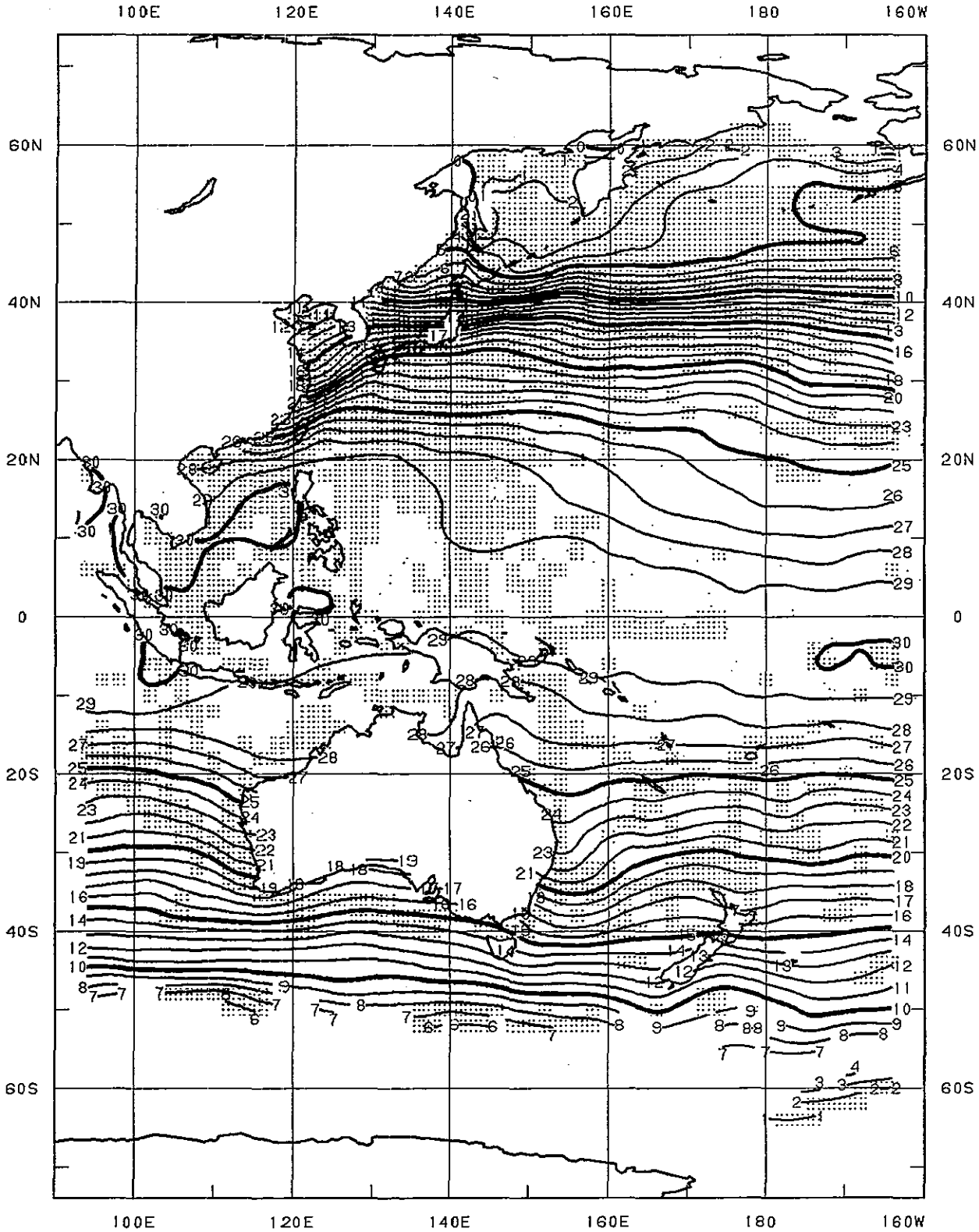
May 1987

The Humboldt Current

The cover and the above images (both NOAA-9 AVHRR channel 4, infrared, enhancement table S) show the Chilean coast of South America and the eastern South Pacific Ocean. The cover image (May 7, 1987 at 19:57 GMT) extends from approximately 17S to approximately 26S. The most prominent feature is the Peninsula Mejillones. The city of Antofagasta is located on the bay on its southern side. The above image (May 4, 1987 at 20:26 GMT) extends from approximately 18S to 34S. Labeled cities or towns, from north to south, are Arica (Ar); Antofagasta (A), with the Peninsula obscured by clouds; Coquimbo (C); and Valparaiso (V). The Cordillera Occidental of the Andes runs along the right side of the images (lighter areas, including snow cover and clouds). The darker (warmer) area between the mountains and the coast is the Atacama Desert (AD).

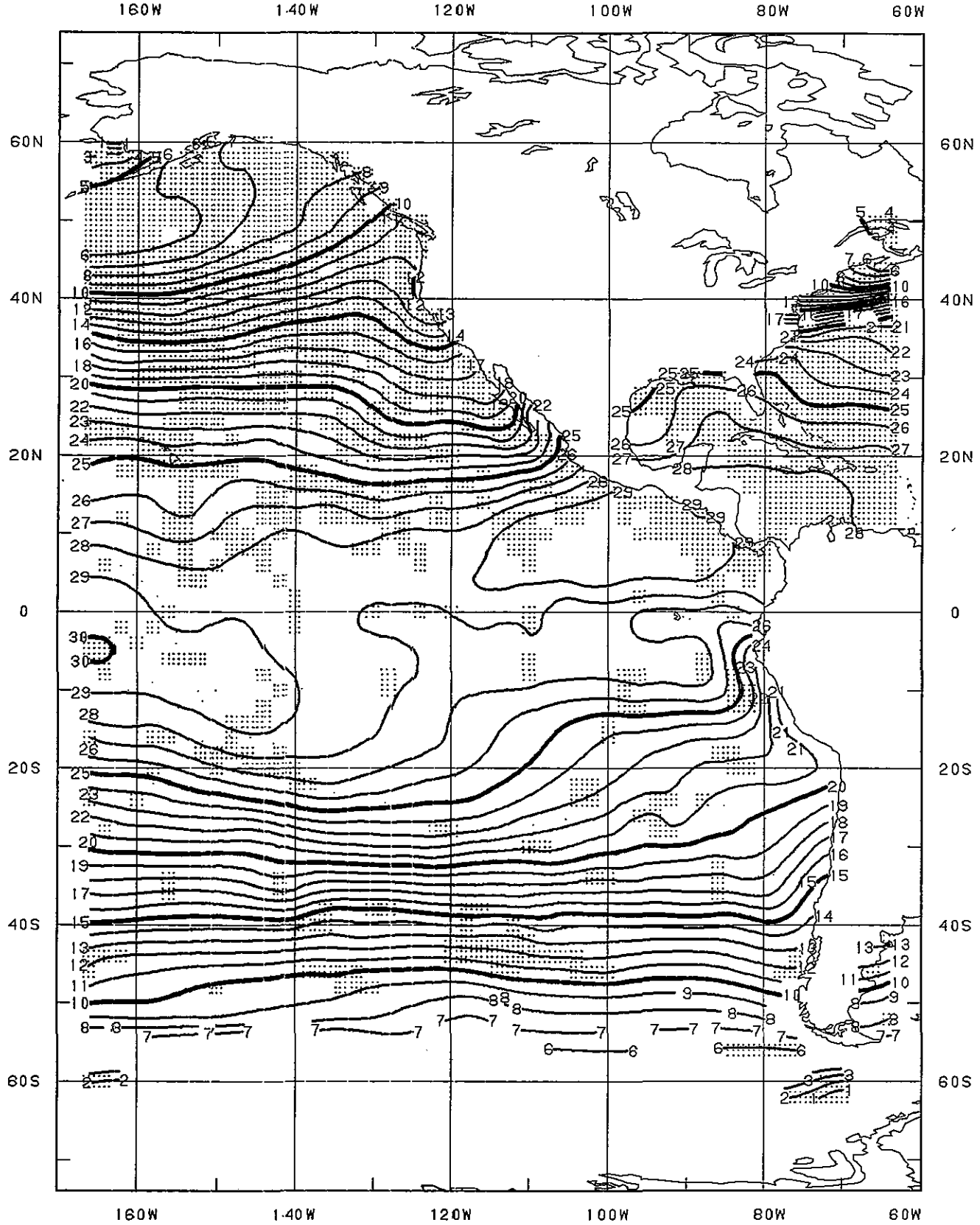
The Humboldt Current runs northward along the coast, and is the southern hemisphere equivalent of the California Current. Winds off the continent cause upwelling immediately adjacent to the coast. This is apparent as the lighter toned areas from

(text continued on page 23)



Western Pacific Ocean
SST--MONTHLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA
MAY 1987

Monthly mean sea surface temperature is the mean of *in situ* and satellite data within two-degree quadrangles. Contour line interval is 1.0°C. The stippling indicates where the analysis was fixed by the *in situ* data; contours are not shown in areas without data.



Eastern Pacific Ocean
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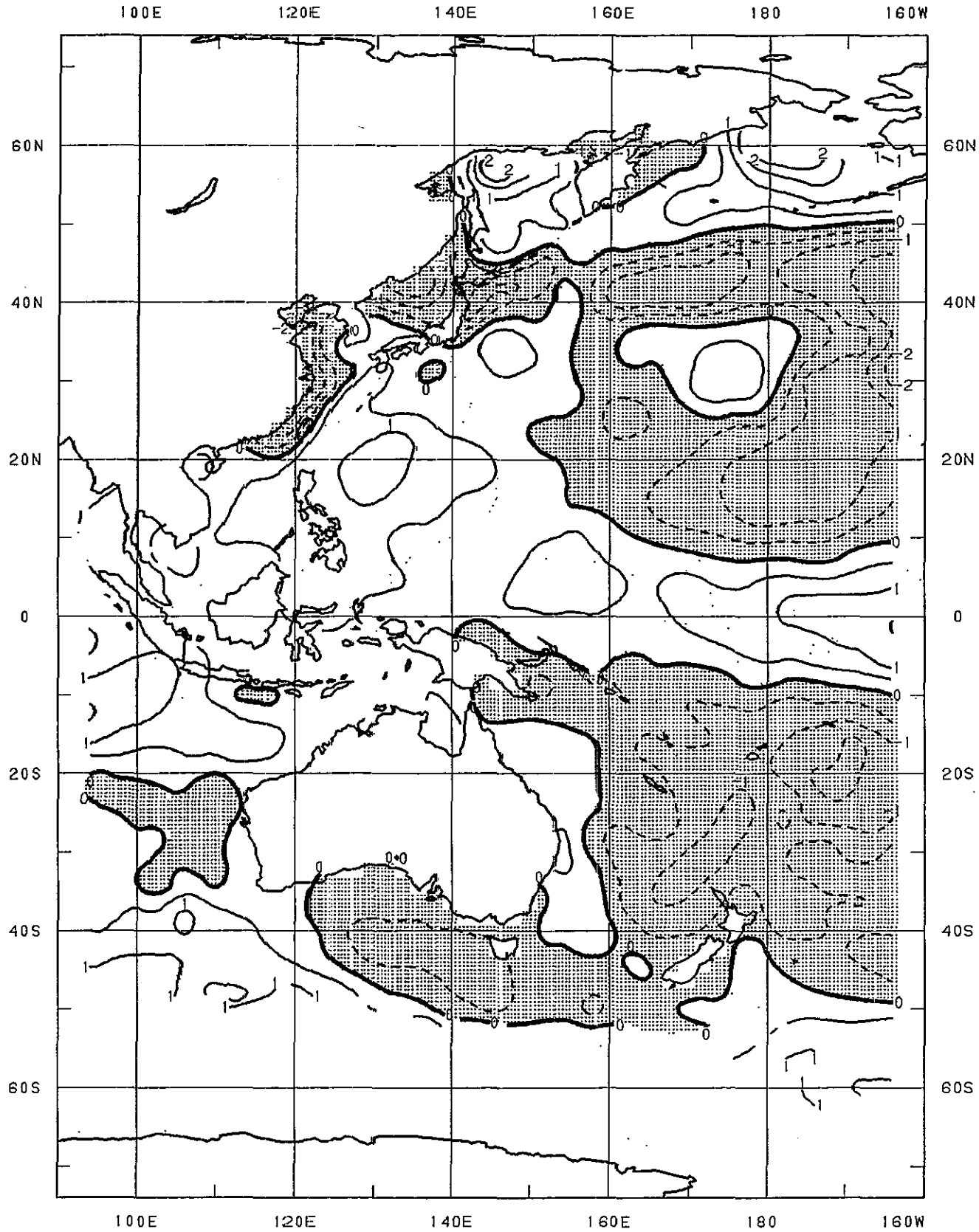

Western Pacific Ocean
SST--MONTHLY ANOMALY
SHIP, BUOY, AND SATELLITE DATA
MAY 1987

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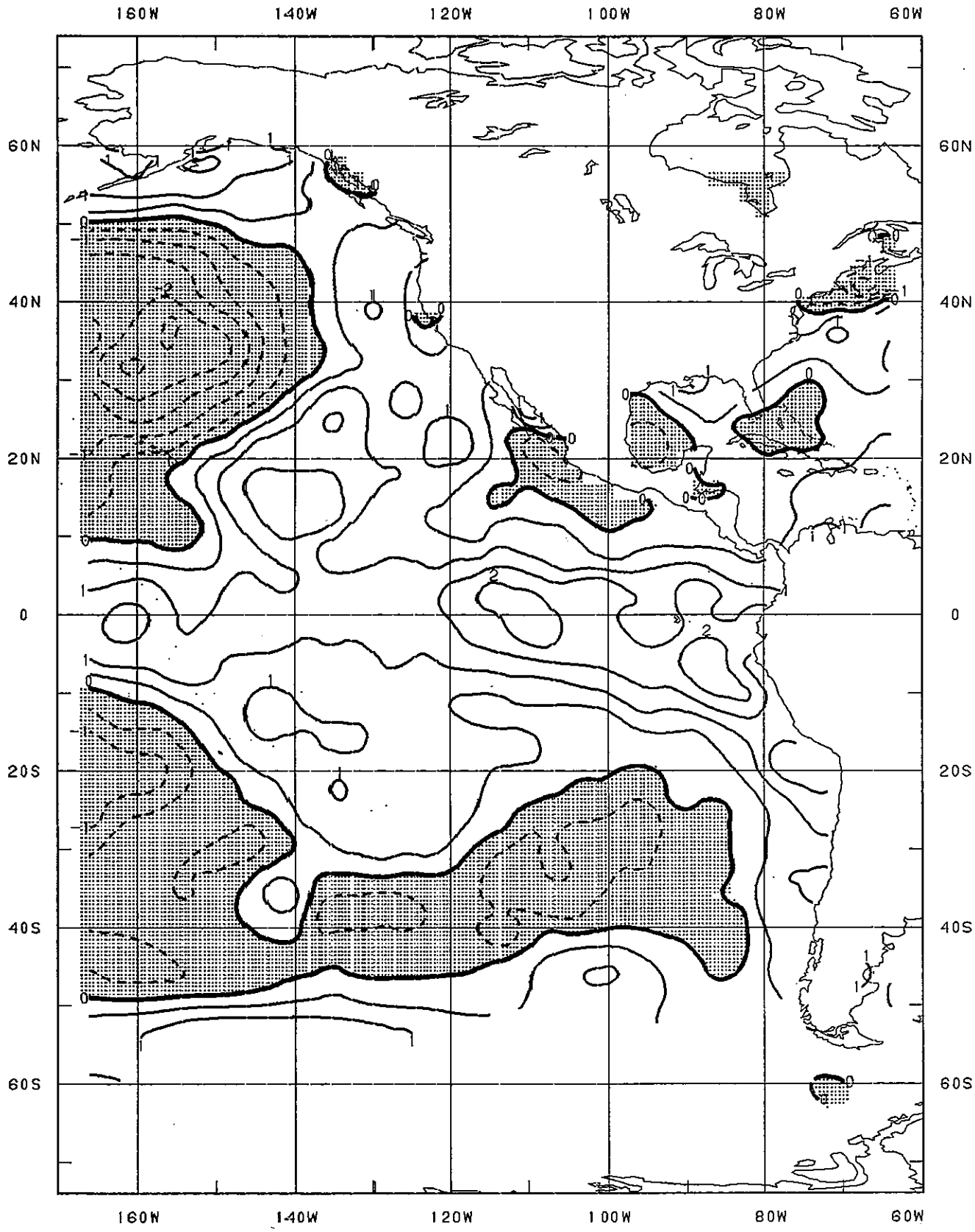

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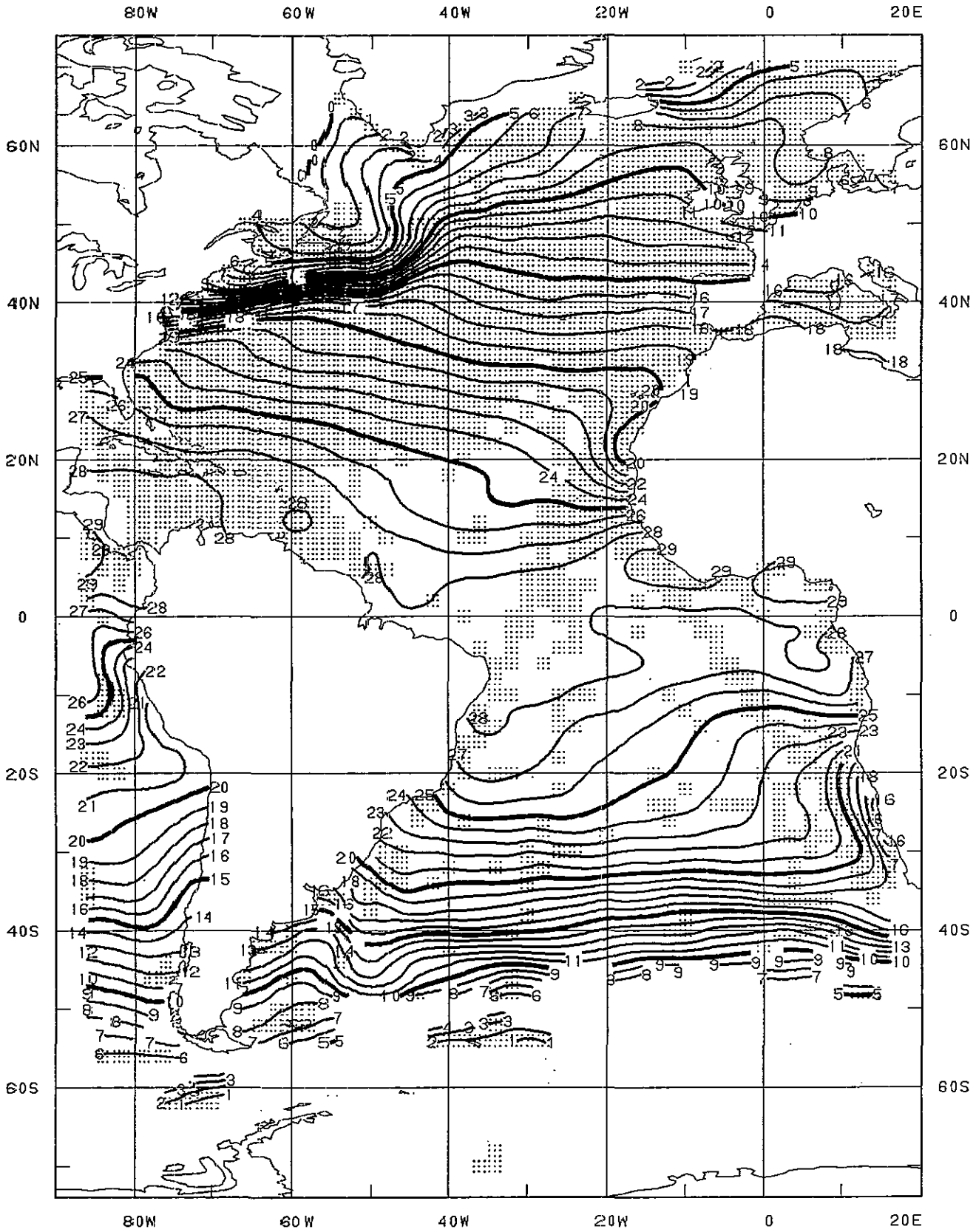

Atlantic Ocean
SST--MONTLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA

MAY 1987

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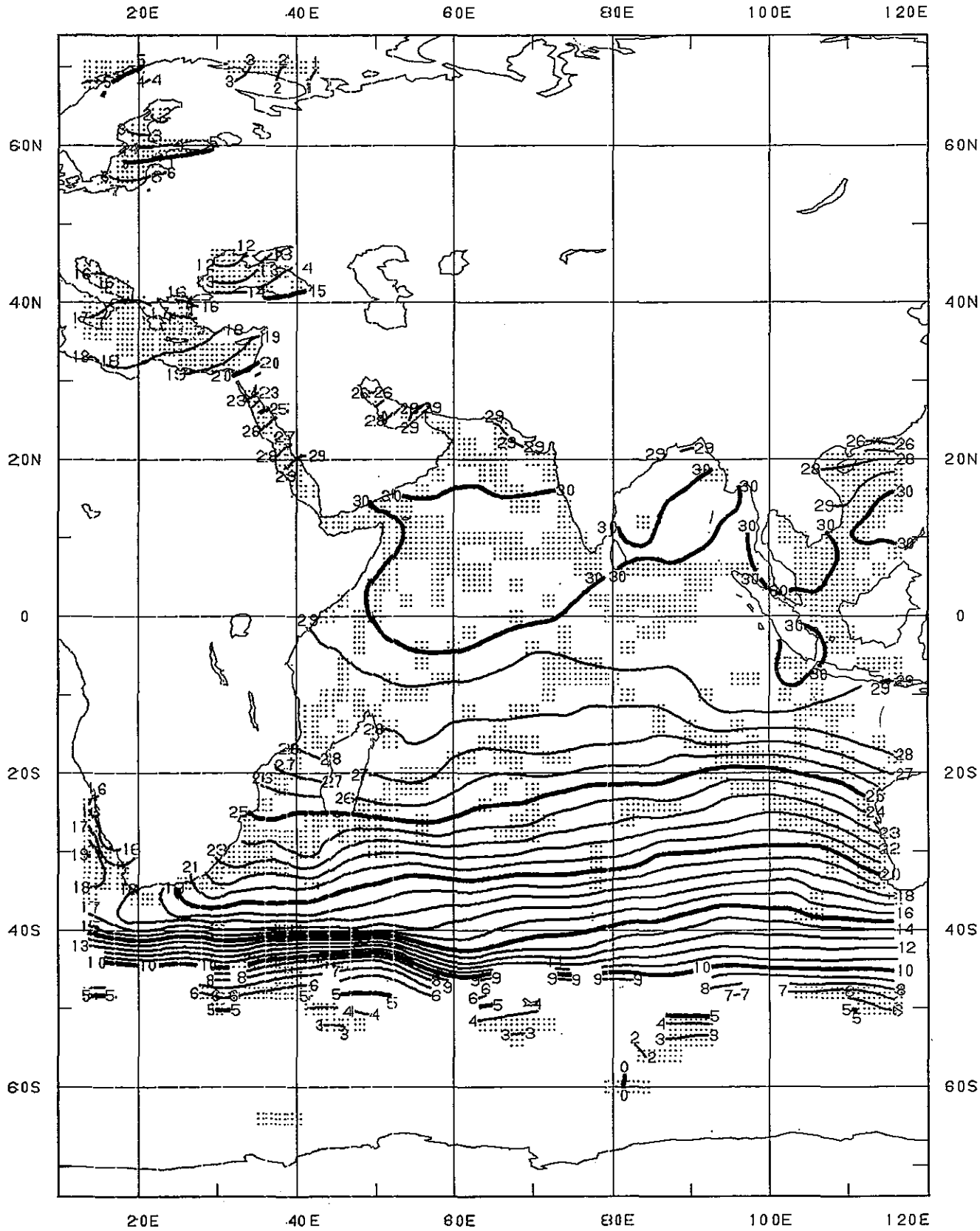

Indian Ocean
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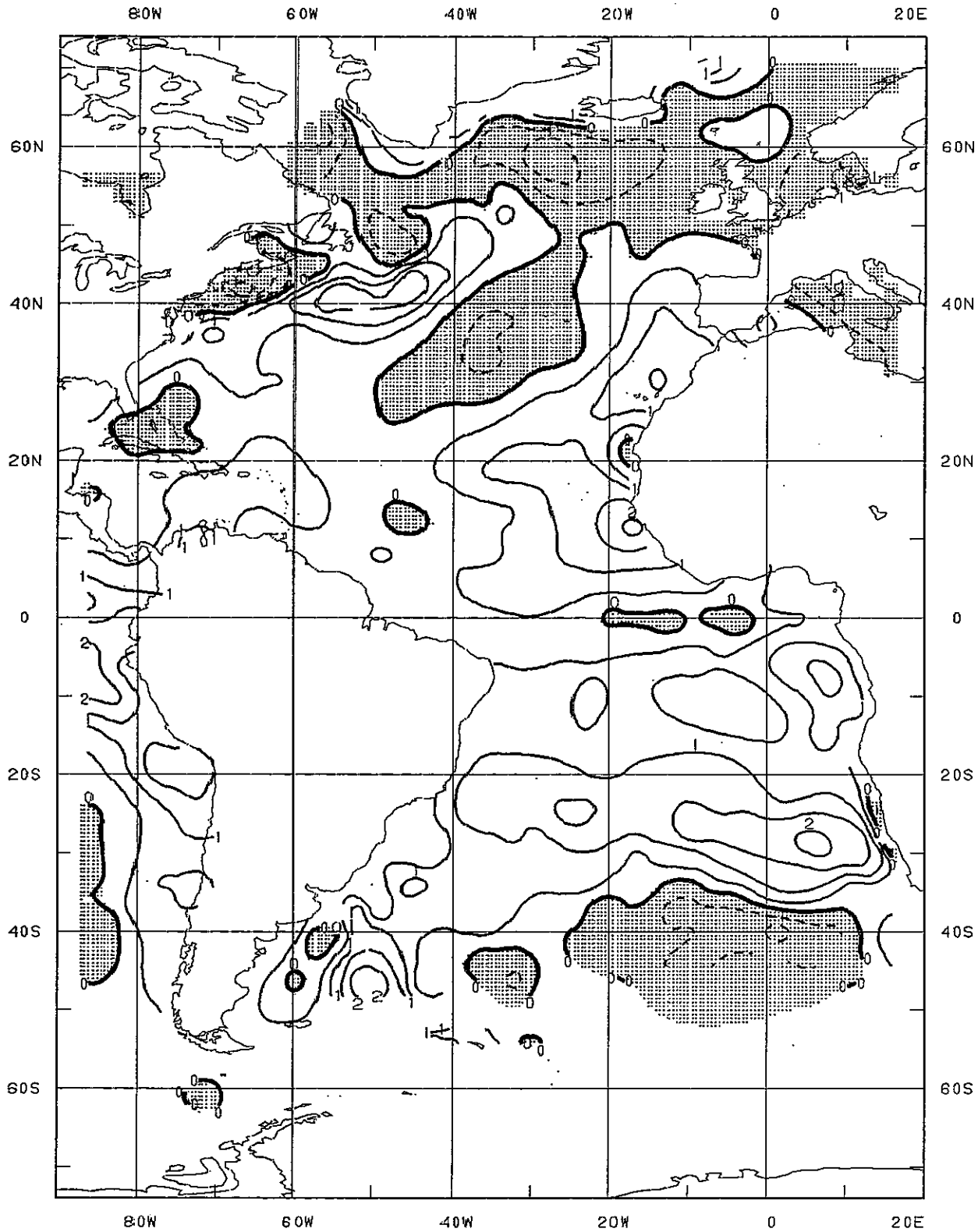

Atlantic Ocean
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SHIP, BUOY, and SATELLITE DATA

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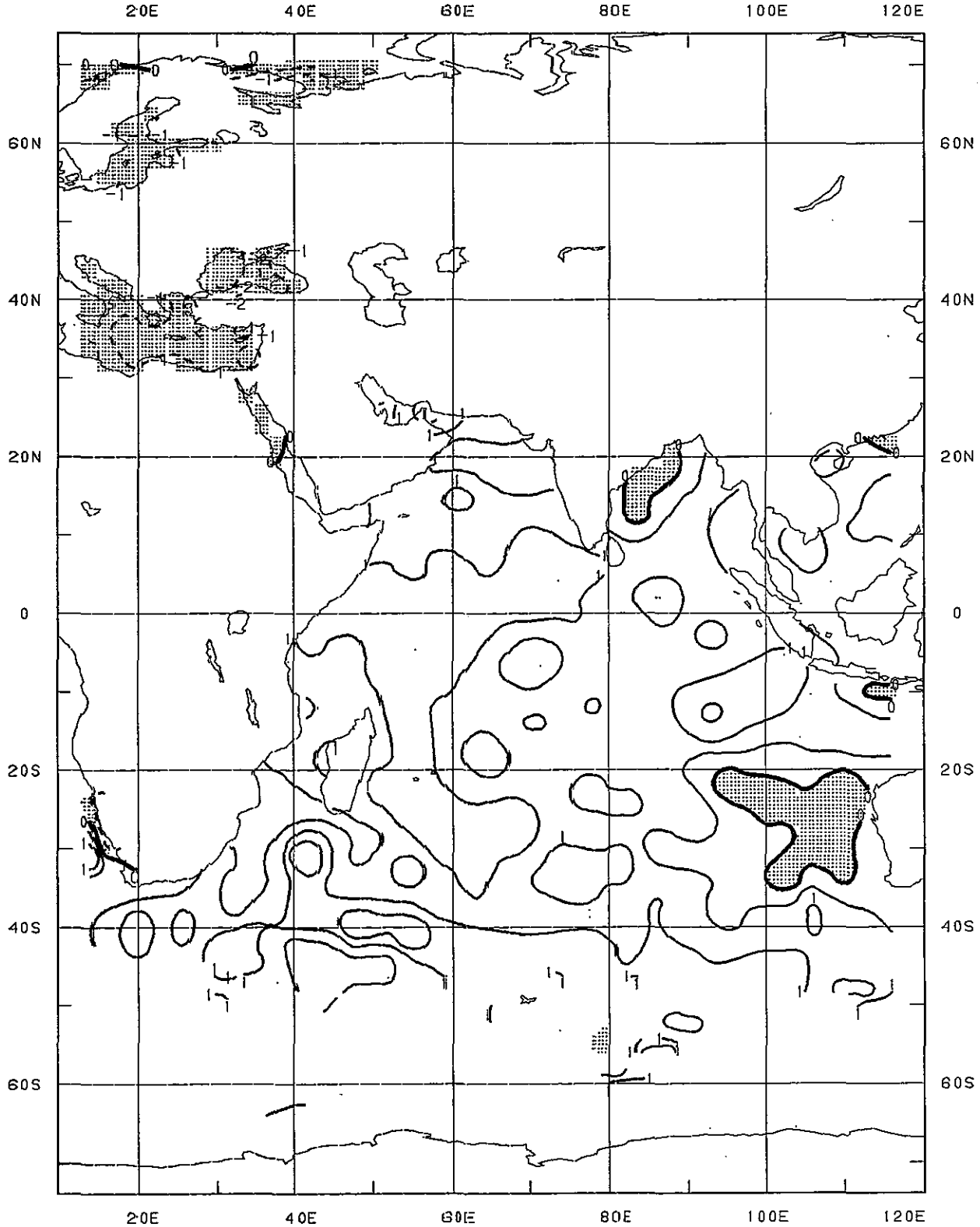

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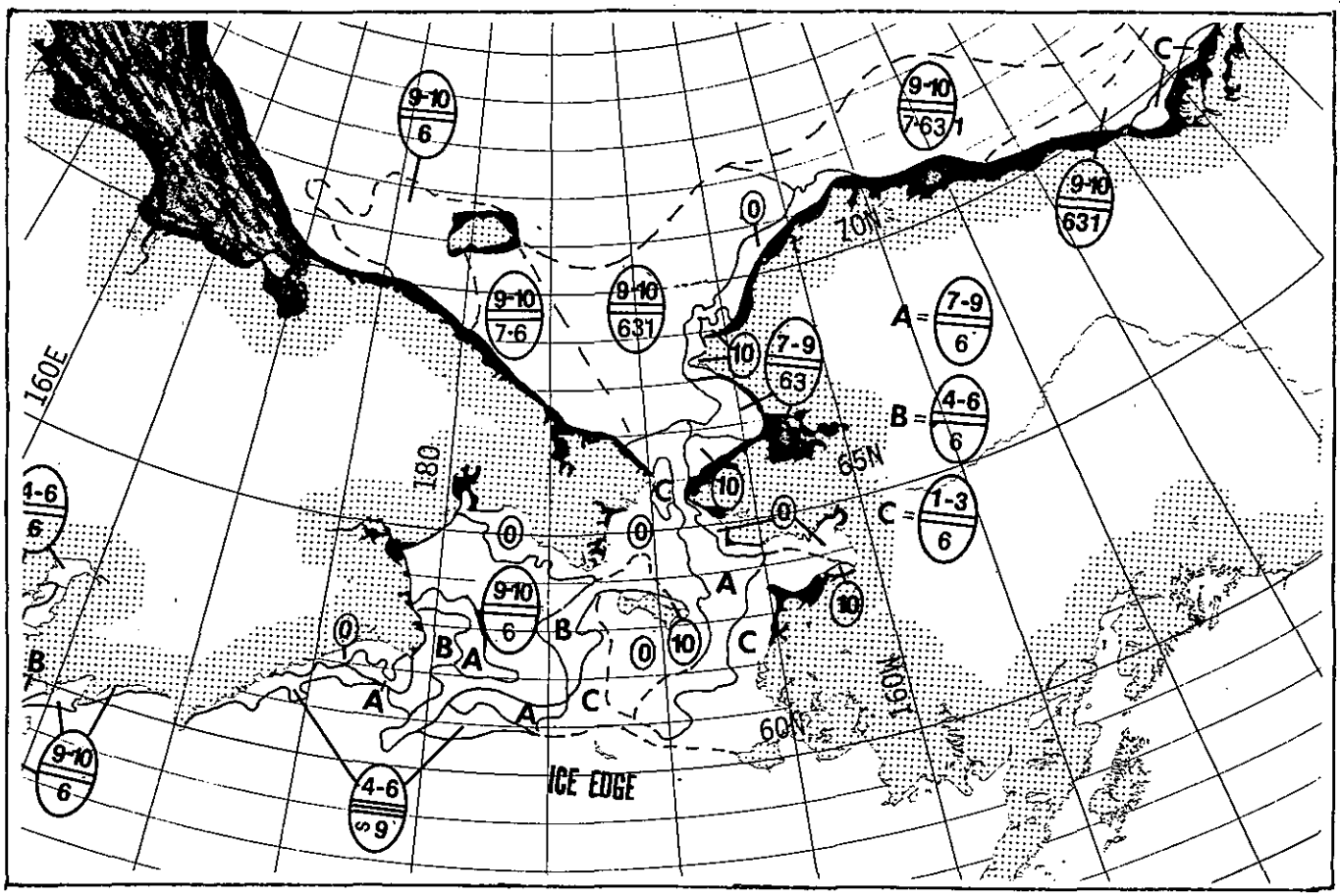

BERING SEA / NORTH SLOPE ICE ANALYSIS

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MAY 1987

Slow but steady ablation characterized ice conditions during the month of May across the Bering, Chukchi, and southern Beaufort Seas. In the Bering Sea somewhat warmer than normal temperatures supported sea ice ablation, eliminating much of the ice that grew during April. Substantial inner pack ice ablation belied the southerly position of the ice edge. Considerable fast ice persisted in southern Norton Sound and between Sledge Island and Nome. This fast ice delayed shipping to Nome until well into June. In the Chukchi Sea persistent offshore winds opened a navigable flaw lead from Point Hope to Point Barrow. Ice concentrations seaward of Kotzebue Sound decreased, especially in the vicinity of the Bering Strait, but fast ice persisted within the Sound itself. In the southern Beaufort Sea, ice ablation and substantial motion were observed seaward of the fast ice and the major rivers were observed to begin flooding onto the ice late in the month.

C = Total ice concentration in the area in tenths.
C_a, C_b, C_c = Concentration of thickest (C_a), 2nd thickest (C_b), and 3rd thickest (C_c) ice
S_a, S_b, S_c = Stage of development of thickest (S_a), 2nd thickest (S_b), and 3rd thickest (S_c) ice.
-C = Concentration of ice within area(s) of strips and patches.

STAGE(S) OF DEVELOPMENT (THICKNESS)

1 = New ice (0-10 cm)
3 = Young ice (10-30 cm)
6 = First year (30-200 cm)
7 = First year thin (30-70 cm)
1. = First year medium (70-120 cm)
4. = First year thick (120-200 cm)
7. = Old ice (survived at least one summer's melt)

EXAMPLES

125 — Theoretical thickness of this season's growth (cm).
Fast ice. Sea ice which forms and remains fast along the coast.
Ice boundary visually or satellite observed.
Ice boundary estimated.

WEST COAST OCEAN FEATURES

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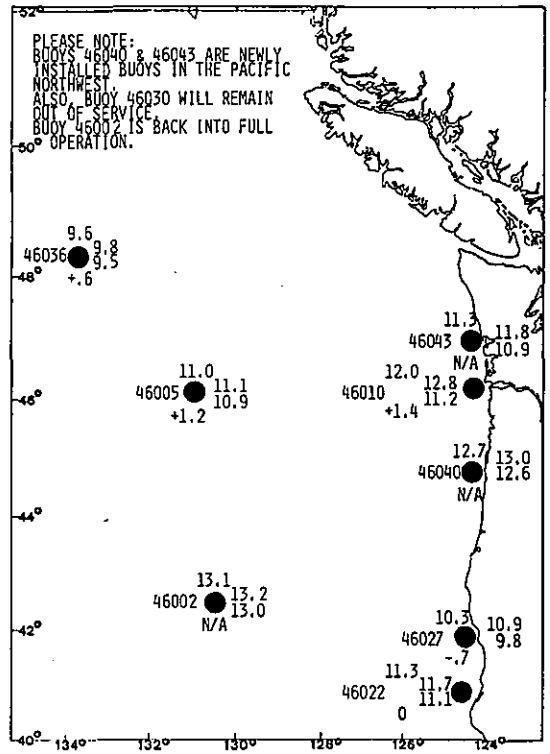
MAY 1987

Sea surface temperatures in both the North and South Panels were warmer than climatology. The North Panel climatological mean is 10.4C, but the actual mean was 10.8C in May. The South Panel climatological mean is 15.2C, but the actual mean was 15.9C.

In general, the nearshore waters in the North Panel were above normal, while offshore waters were below normal. The warm anomaly along the coast was greatest (>1.0C) from the Columbia River to Cape Mendocino. The waters west of 132W averaged from 0.1 to 0.4C below normal. When comparing SST's to the previous month, all areas warmed by at least 0.6C. The most warming, of 1.5C or greater, occurred from Vancouver Island and the Straits of Juan de Fuca southward to a point near 42N 131W. Buoy statistics in the North Panel revealed similar warming when compared to April, except for the two buoys south of Cape Blanco where cooler temperatures were maintained by upwelling episodes. In fact, on May 19th and 20th, one SST observation at buoy 46027 dropped to 6.6C!

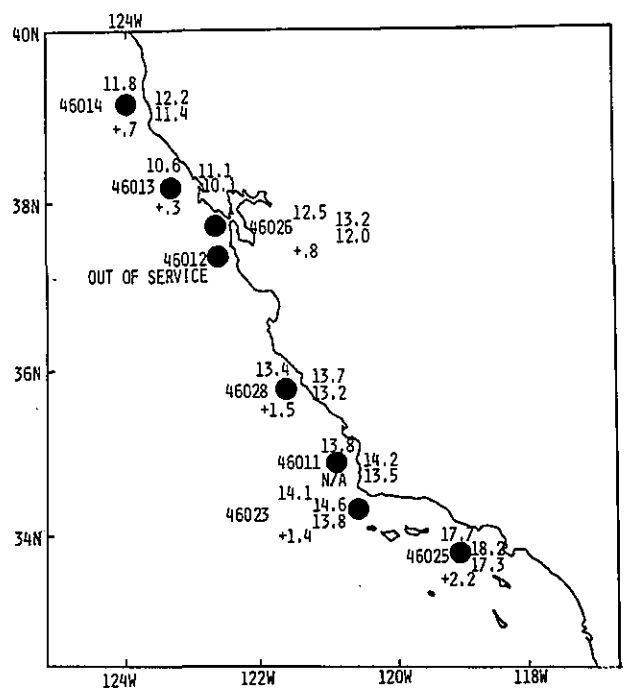
In the South Panel, the northwest edge of the analysis area averaged below normal, but all other locations were warmer. In particular, the Los Angeles Bight and Northern Baja peninsula had a warm anomaly of over 2.0C. In between the two aforementioned locations, SST's were from 0.1 to 1.1C above climatology. When comparing May to April, the entire area warmed from 0.4 to 1.8C. The least warming was in the southwest corner of the chart, and the maximum was near 36N 132W. During May, a huge plume of warm water was advected toward the north from a large surface low pressure system. The result was a significant rise in temperatures lasting over 10 days. Buoy statistics showed a rise in SST's from the previous month, too. The smallest rise occurred at buoy 46013 because of ongoing upwelling activity for a good portion of the month.

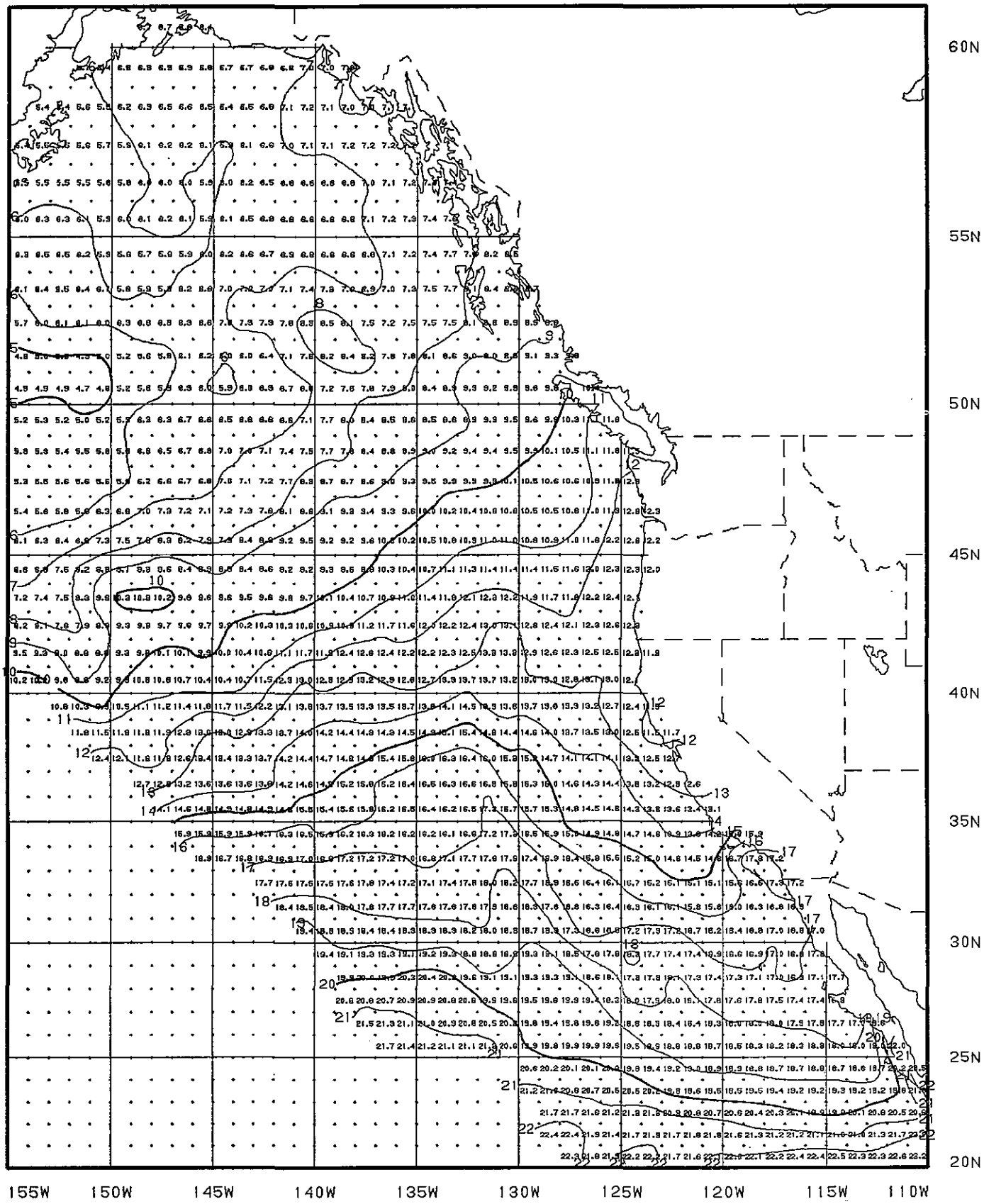


KEY:

12.1 ← Monthly mean
LOCATION NAME 13.5 ← Maximum daily mean
10.2 ← Minimum daily mean
-1.5 ← Change from previous month

● Denotes station position.





West Coast
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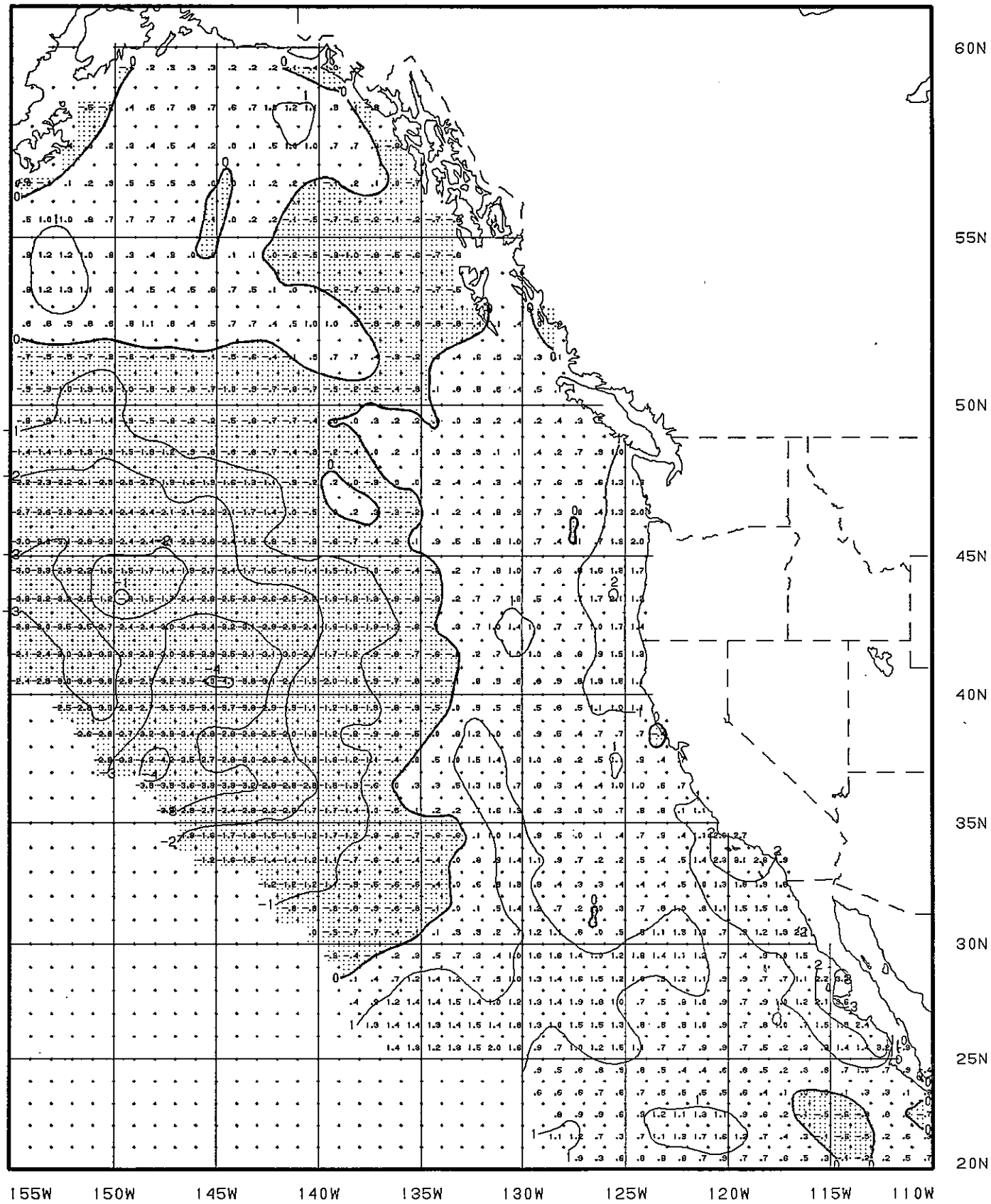

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EAST COAST OCEAN FEATURES

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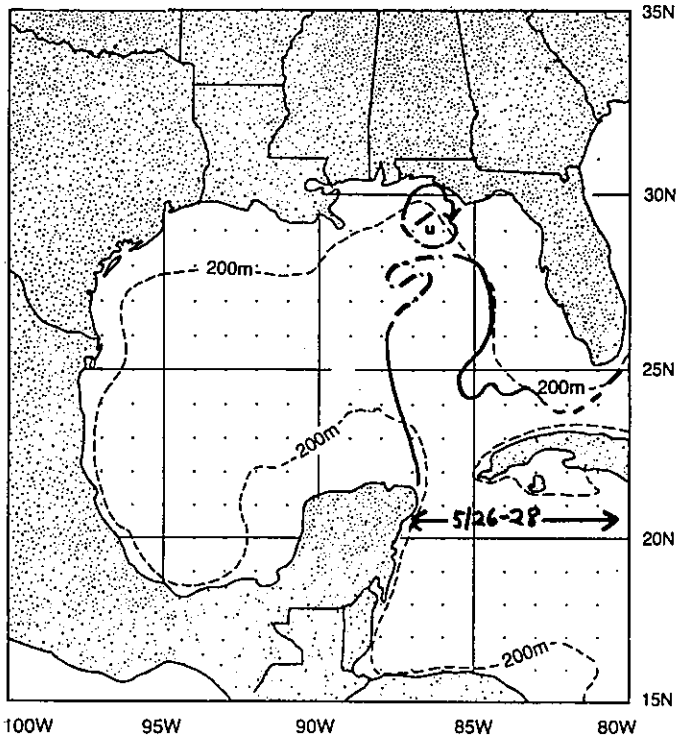
(301) 763-8030

MAY 1987

The end of this month's positions of the Gulf Stream System and its associated eddies are shown for the NW Atlantic and the Gulf of Mexico. The Gulf Stream and Loop Current boundaries are located by infrared satellite imagery or XBT (expendable bathythermograph) data. Anticyclonic eddies are labeled a-z in the Gulf of Mexico and 1-99 in the Northwest Atlantic. Cyclonic eddies are labeled A-Z. Arrows on eddies indicate direction of circulation. Warm-core or anticyclonic eddies rotate clockwise; cold-core or cyclonic eddies rotate counterclockwise. The line to the eddy center shows the net translation since last month or since last observed. The edge of continental shelf at 200 m is shown as a dashed line. Eddies or sections of the Gulf Stream System which were not observed during the month are not shown on the analysis chart or are indicated by "dot-dashed" lines. The long arrows at the bottom of the chart indicate the dates of data used.

Data used in this analysis include:
Infrared imagery from NOAA satellite - NESDIS
Bathythermograph data from National Meteorological Center of National Weather Service
Oceanographic Analysis -- A daily detailed analysis issued by National Weather Service

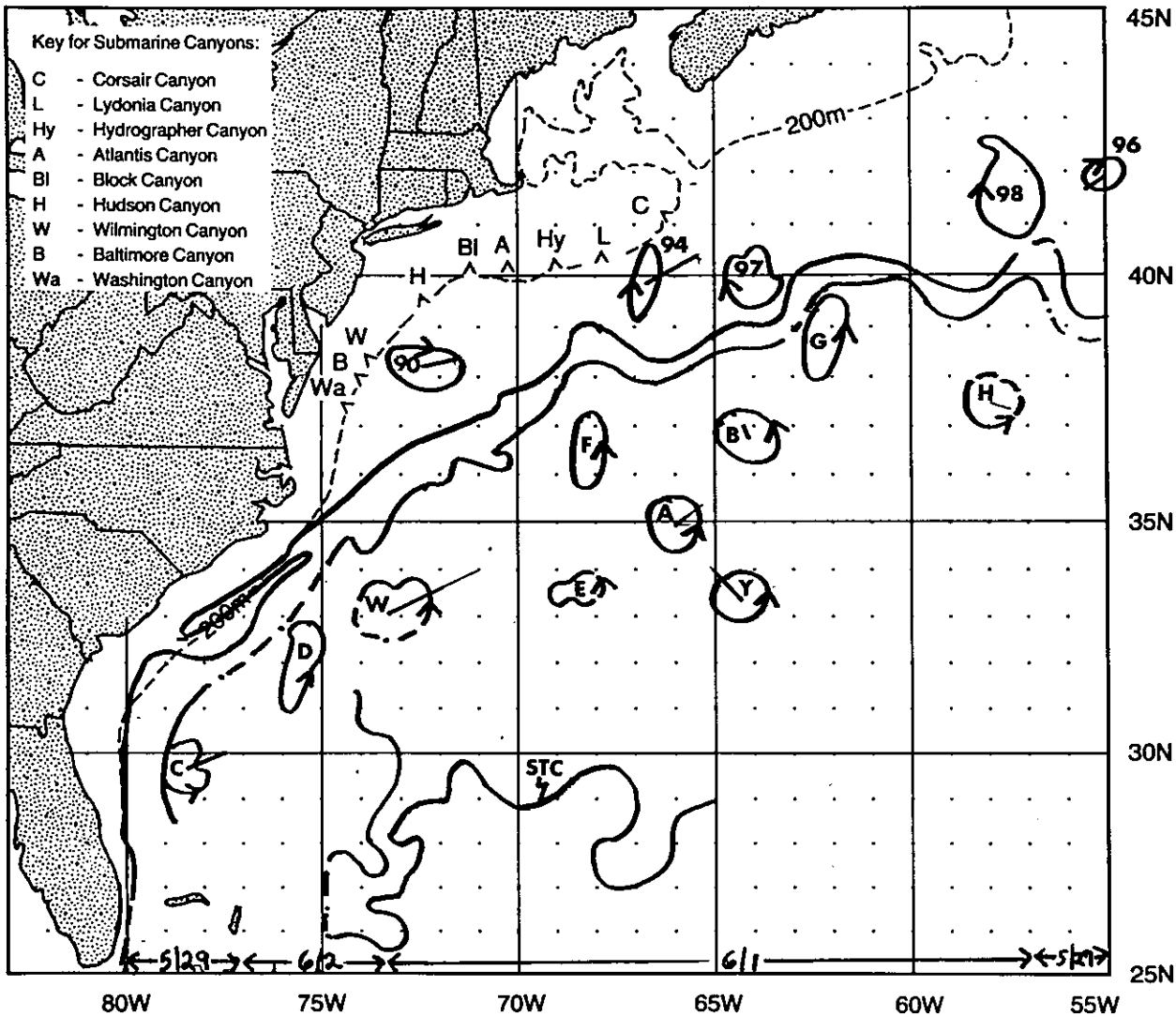


GULF OF MEXICO

The position of the Loop Current in the Gulf of Mexico advanced northward 195 km during May. Anticyclonic eddy u appears to still be very weak. Its position is difficult to discern due to near isothermal conditions. Eddy u apparently translated 55 km NE during May. Eddy t was not observed owing to seasonal heating and clouds.

NORTHWEST ATLANTIC OCEAN

The formation and absorption of both anticyclonic and cyclonic eddies was unusually dynamic during May. Three anticyclonic eddies dissipated or were absorbed by the Gulf Stream. Eddy 91 was absorbed by a Gulf Stream meander near 40N 67W about May 11. Eddy 95 weakened and seemingly dissipated on May 13 near 41N 64W. Eddy 92 also weakened and apparently dissipated around May 29 near 42N 62W. Two anticyclonic eddies formed. Eddy 97 was generated in a very unique way. Two aneurisms from adjacent meanders at 39N 65W and 40N 63W interacted and birthed an eddy on June 1 near 40N 64W. Eddy 98 formed from a meander near 42N 58W about May 11.



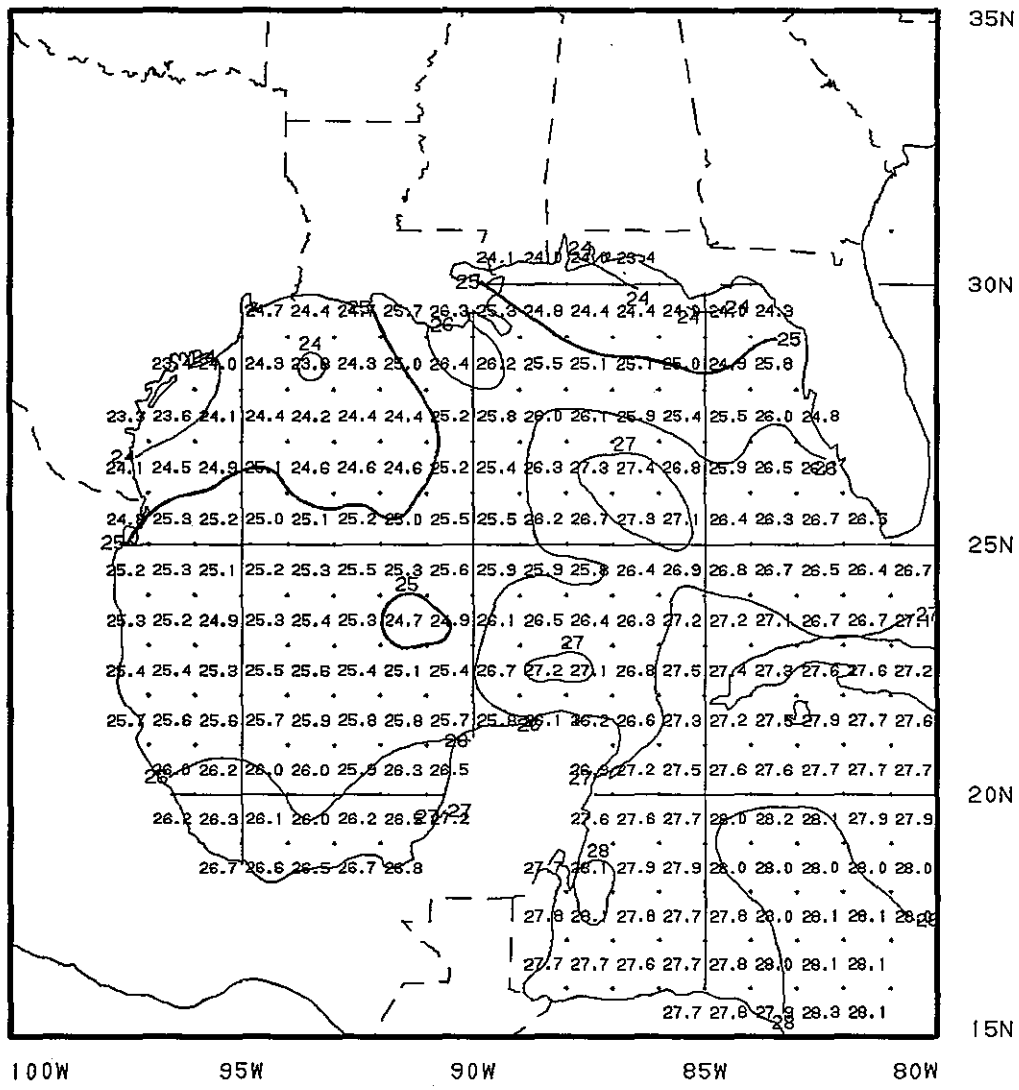
Eddy 90 traveled 55 km WSW and appears to be weak. Eddy 90 also appears to have very little thermal structure. In fact, the adjacent Continental Slope Water at the surface seems to be warmer than warm eddy 90. Eddy 94 moved 110 km SW while eddy 96 translated 55 km NE.

One cyclonic eddy, eddy Z, was absorbed by a Gulf Stream meander on May 27 near 37N 63W. Four cyclonic eddies were newly detected this month. Of these cyclonic eddies, eddy G was observed forming from a Gulf Stream meander near 38N 63W on June 1. Cyclonic eddy G formed at the same time that anticyclonic eddy 97 formed. The presence of eddy D was suspected last month and confirmed this month at 32N 76W; its origin is unknown. Eddies E and F were newly observed during May. Eddy E was first discerned at 34N 69W on May 11. Its origin is also not known. Eddy F, like eddy G, was observed to form when a Gulf Stream meander pinched off near 37N 68W around May 11. Since then it has translated 75 km W.

Eddy C moved 110 Km WSW and eddy W traveled 220 km SW. Eddy A translated 90 km SW while eddy Y translated 100 km SE. Eddy B moved 25 km SSE. Eddy H traveled 35 km WNW.

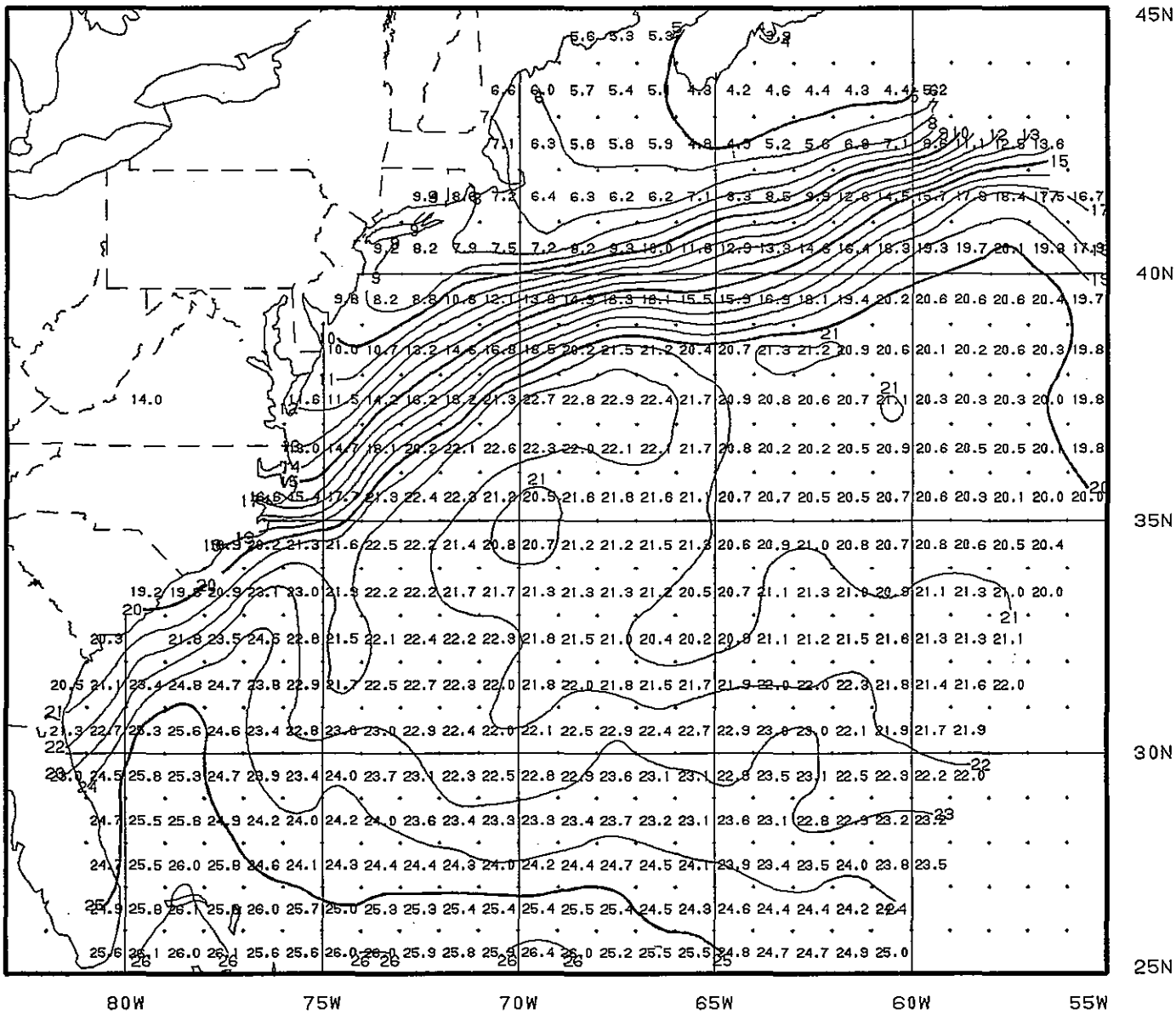
The Subtropical Convergence Front (STC) was observed on May 21. It extended from about 31N 74W down to 26N 73W and back up to 29N 65W.

EAST COAST SST – MONTHLY MEAN



Gulf of Mexico
SST--MONTHLY MEAN (°C)
MAY 1987

Monthly mean sea surface temperature is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0°C.



Northwest Atlantic Ocean
SST--MONTHLY MEAN (°C)
MAY 1987

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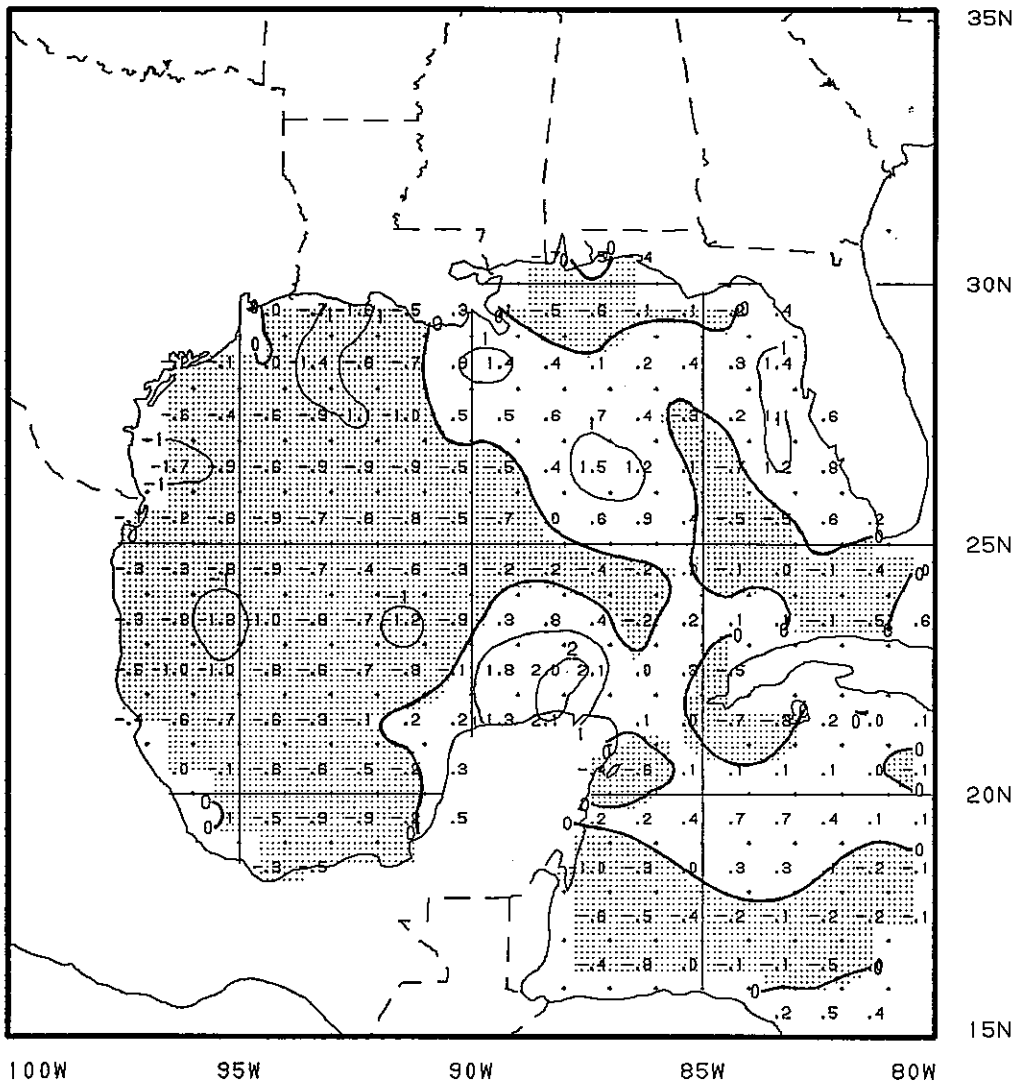
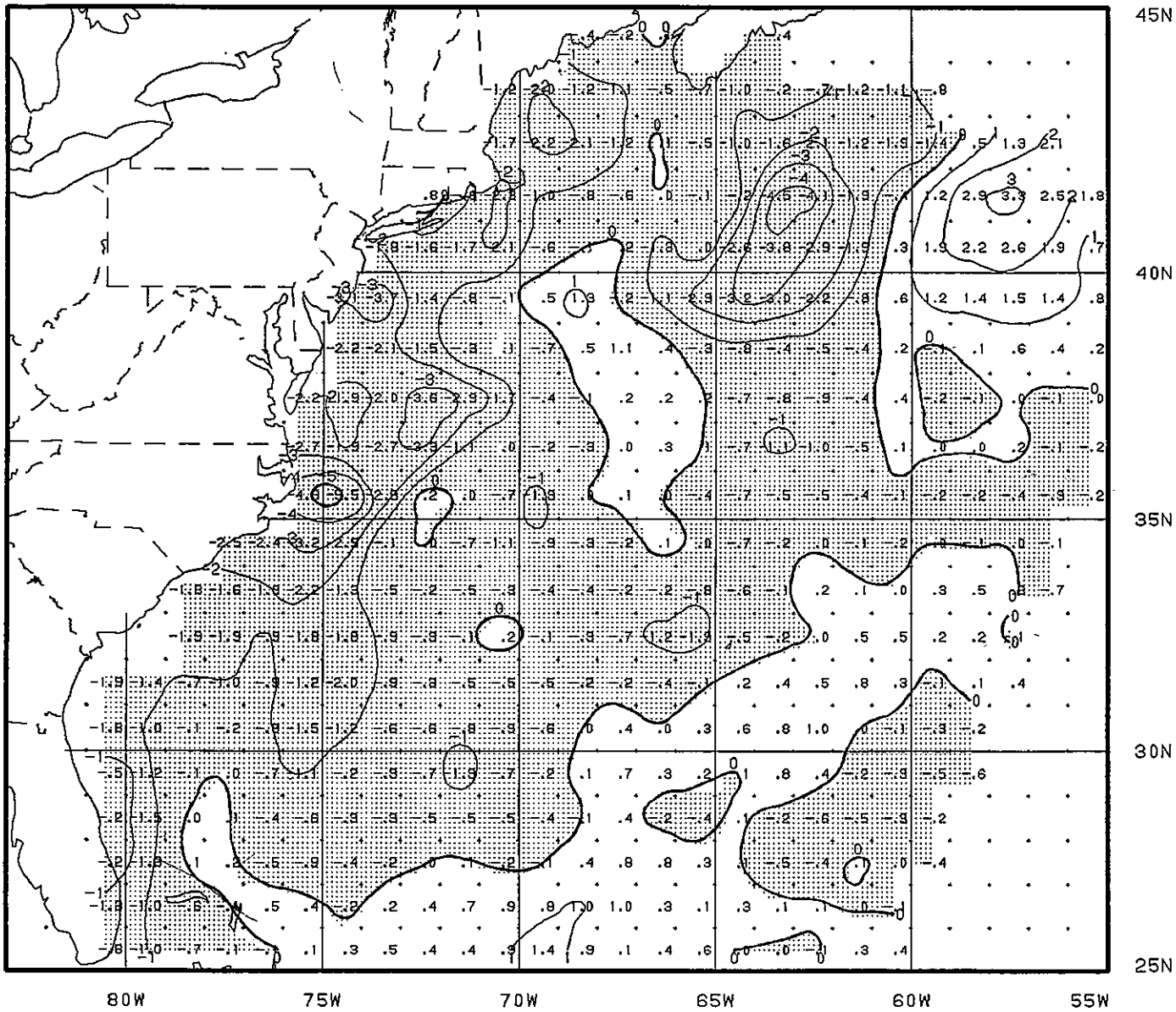
EAST COAST SST – ANOMALY



Gulf of Mexico
SST--MONTHLY ANOMALY (°C)
MAY 1987

Monthly anomaly is the difference between the monthly mean sea surface temperature and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0°C.



Northwest Atlantic Ocean
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MAY 1987

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OceaNotes

(continued from page 3)

Valparaiso to north of Coquimbo in the above image. In the cover image, the three tooth-shaped areas and the two filaments of cold water appear to be the result of larger ephemeral upwelling events. The cold filaments of upwelled water may extend up to two hundred kilometers offshore, and may be due to effects of topography on the winds. It also appears that the upwelled water is undergoing southward shear as it moves off the coast.

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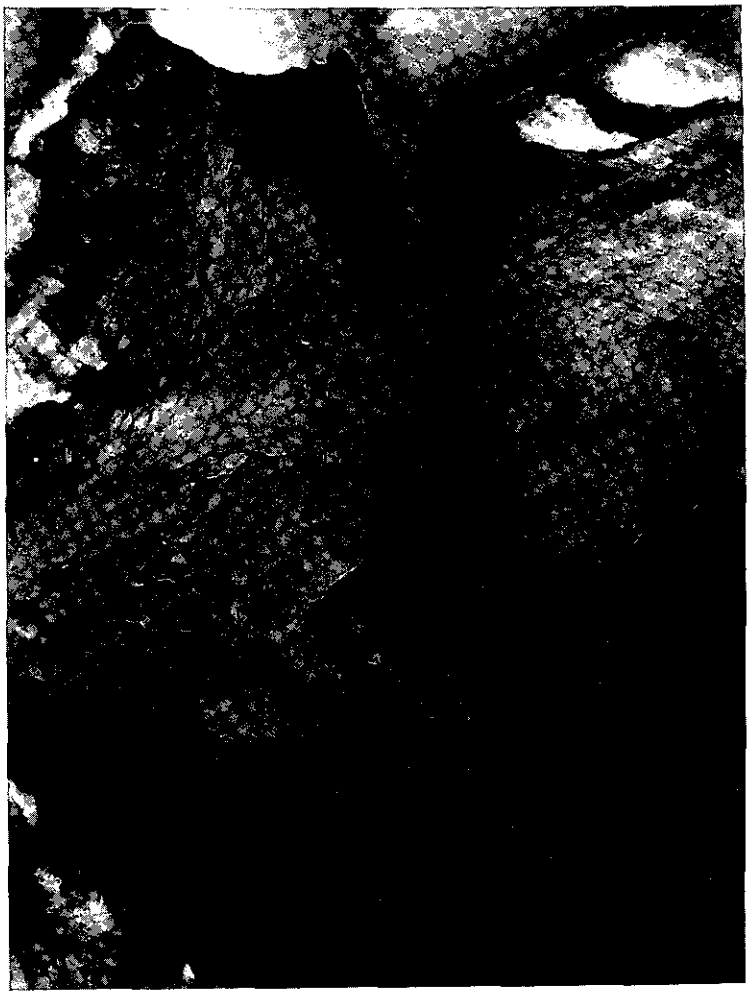
The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through April 1, 1988.

7 AUG 1987
NOAA LISD SEATTLE

OCEANOGRAPHIC Monthly Summary

Volume VII Number 46 June 1987



The Amery Ice Shelf (page 3)

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U.S. DEPARTMENT OF COMMERCE • National Oceanic and Atmospheric Administration
National Weather Service
National Environmental Satellite, Data, and Information Service
National Ocean Service

OCEANOGRAPHIC
Monthly Summary

Oceanographic Monthly Summary is published by the National Weather Service (NWS), the National Environmental Satellite, Data, and Information Service (NESDIS), and the National Ocean Service (NOS). *Oceanographic Monthly Summary* contains sea surface temperature (SST) analyses on both regional and ocean basin scales for the Atlantic, Pacific, and Indian Oceans. The ocean basin analyses are based on a "blend" of *in situ* and satellite data, in which *in situ* data are used to define "benchmark" temperature values in regions of frequent observations and satellite data are used to define the "shape" of the field between these points.[1]

An ocean basin SST anomaly is derived from the "blended" SST analysis[1] and the improved global SST.[2] The regional SST analyses are based upon a combination of *in situ* and satellite data measurements. The regional SST anomalies are calculated from the Robinson-Bauer Climatology.[3,4] *Oceanographic Monthly Summary* also contains Alaskan sea ice information and ocean feature information for contiguous U.S. ocean regions.

Oceanographic Monthly Summary welcomes articles containing information of interest to its readers, such as news on operational oceanography, unusual ocean feature phenomena, etc. Contributions should be sent to the editor (address below). Accepted material will appear in the OceaNotes section of *Oceanographic Monthly Summary*. Contributions can be published as quickly as the next monthly issue.

If you are interested in receiving *Oceanographic Monthly Summary* regularly, please refer to the back cover for subscription information.

[1]Reynolds, R.W. and W.H. Gemmill, 1984. A sea surface temperature analysis which blends *in situ* and satellite observations. *Proceedings of the Ninth Climate Diagnostics Workshop*, Corvallis, OR, Oct. 22-26, 1984, pp. 408-416.

[2]The climatology is derived from *in situ* data (1950-1979), satellite data (1982-1985) and an ice climatology.

[3]Robinson, M.K., 1976. Atlas of North Pacific Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOcean Ref. Pub. 2.*

[4]Robinson, M.K., R.A. Bauer, and E.H. Schroeder, 1979. Atlas of North Atlantic-Indian Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOceano Ref. Pub. 18.*

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OceaNotes

THE AMERY ICE SHELF

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Interactive Processing Branch
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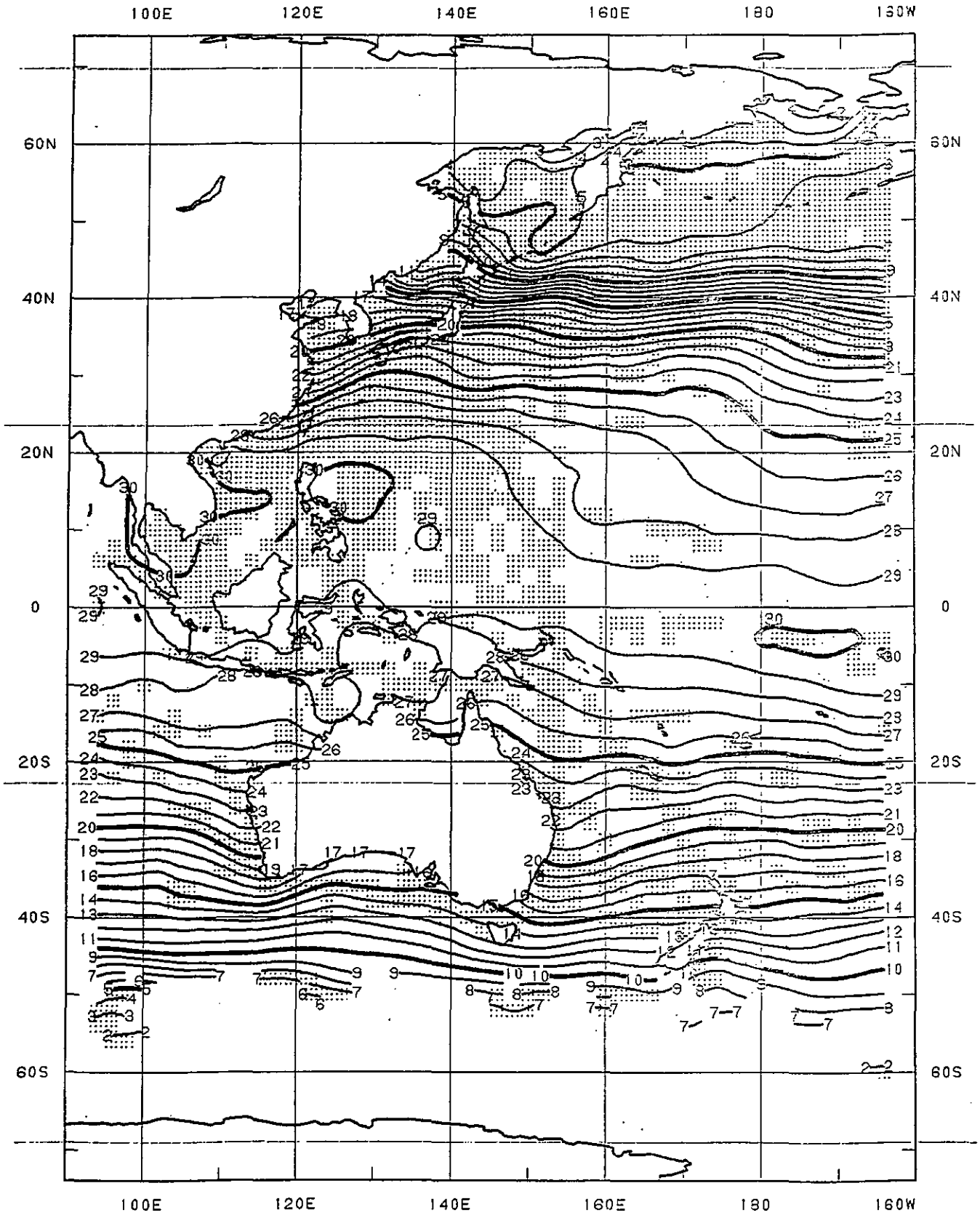
(301) 763-8142

The NOAA-10 infrared satellite image of the Amery Ice Shelf, West Ice Shelf and Antarctic ice edge was taken June 2, 1987 at 0117 GMT. Amery Ice Shelf (A) is centered at approximately 72E 68S, and the West Ice Shelf (W) is centered at approximately 85E 66S. Except for two areas of thinner ice off the West Ice Shelf (TI), 90 to 100 percent of the area is covered by a combination of first year ice 120-200 cm thick and ice that has survived the melt of previous summers (old ice). Part of the ice edge (dashed line) is obscured by cloud lines streaming off the pack ice. The ice configuration shown in this image is fairly stable and normal for the Southern Hemisphere winter season. Maximum ice extent normally occurs in September. Also typical for the area is the accumulation of fast ice along the coast. Fast ice (F) forms either by freezing of pack ice or by freezing from sea water and, by definition, remains along the coast. In this

(Text continued on page 13)



Western Pacific Ocean
SST--MONTHLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA

JUNE 1987

Monthly mean sea surface temperature is the mean of *in situ* and satellite data within two-degree quadrangles. Contour line interval is 1.0°C. The stippling indicates where the analysis was fixed by the *in situ* data; contours are not shown in areas without data.

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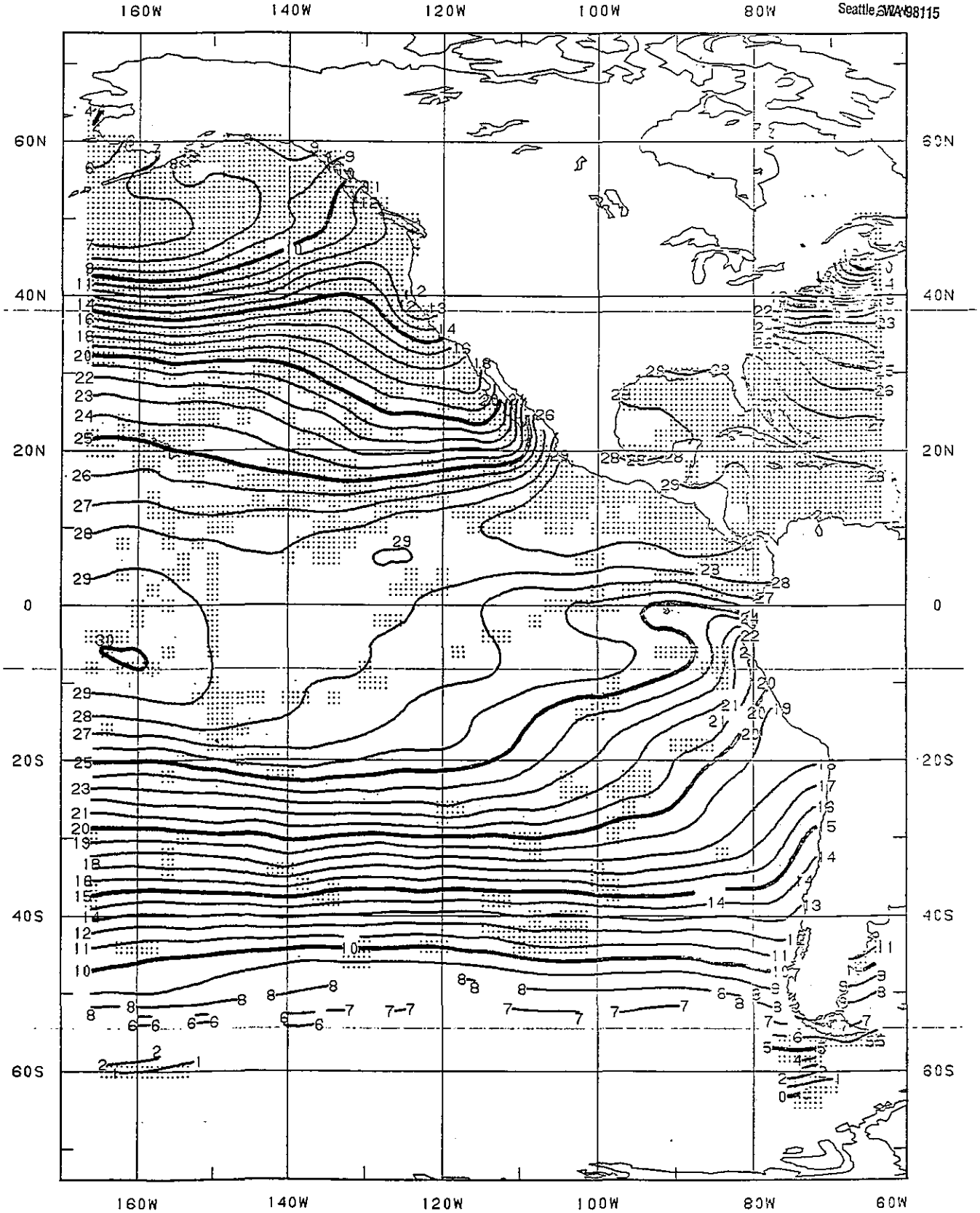

Eastern Pacific Ocean
SST--MONTHLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA
JUNE 1987

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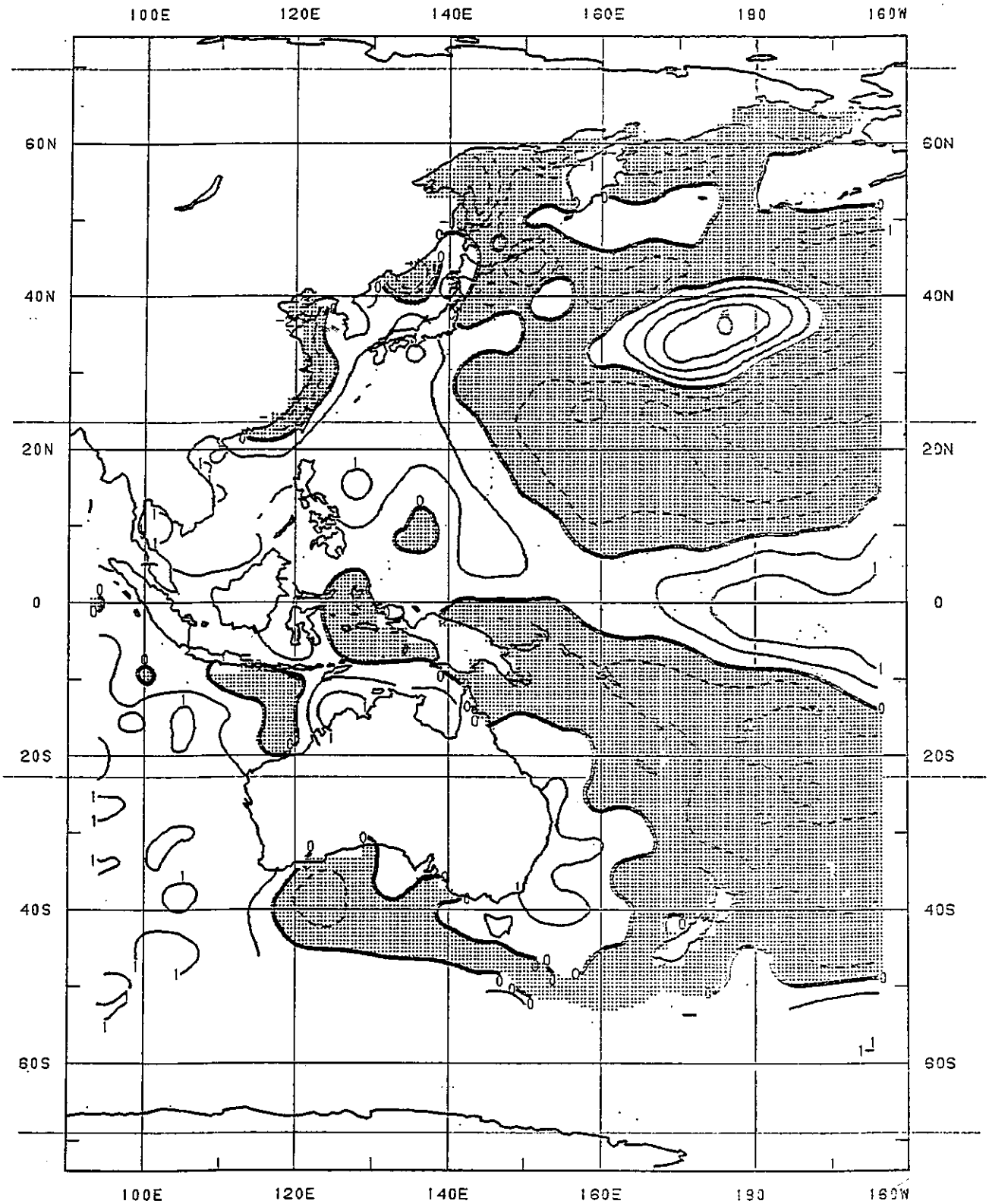

Western Pacific Ocean
SST--MONTHLY ANOMALY (°C)
SHIP, BUOY, and SATELLITE DATA
JUNE 1987

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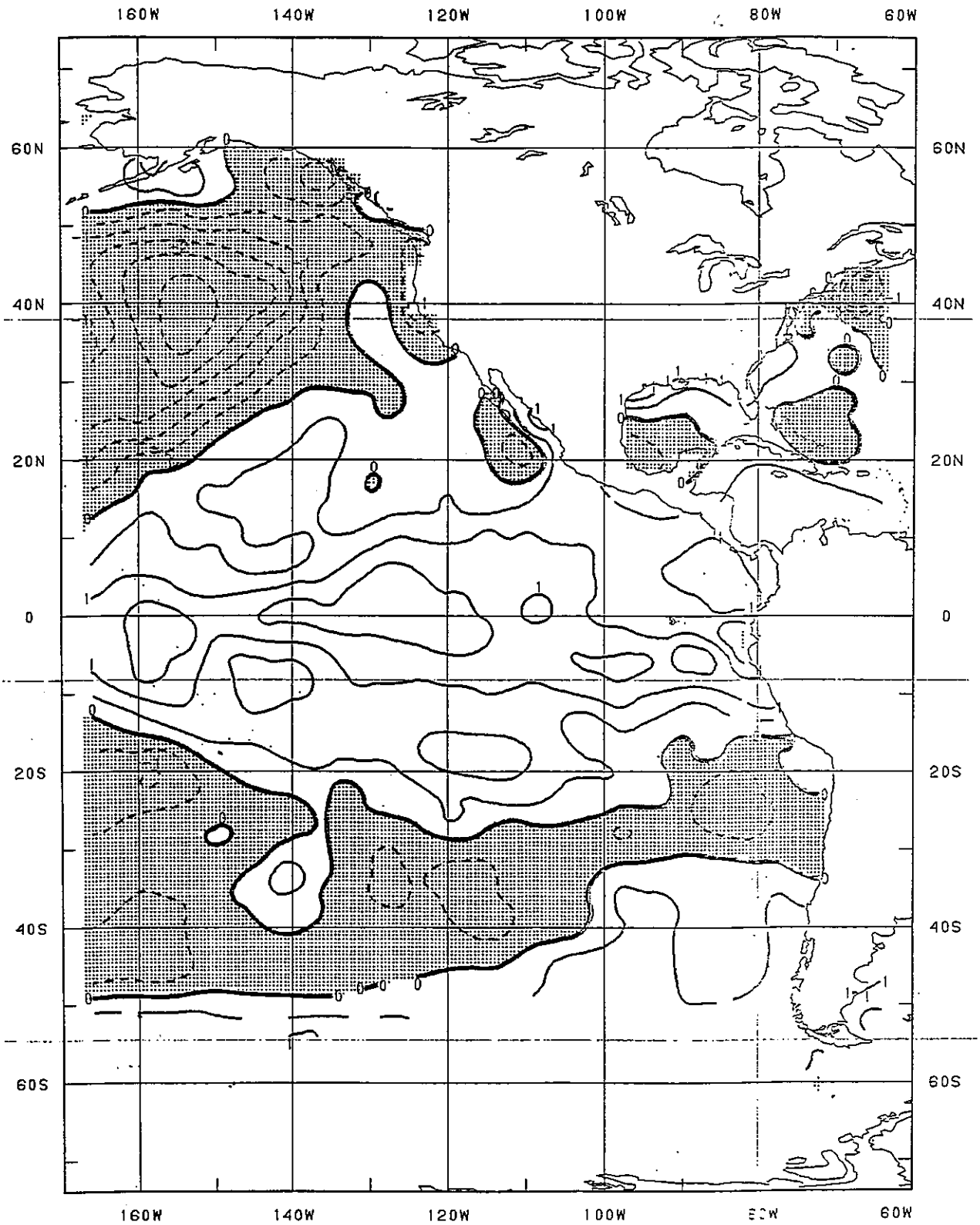

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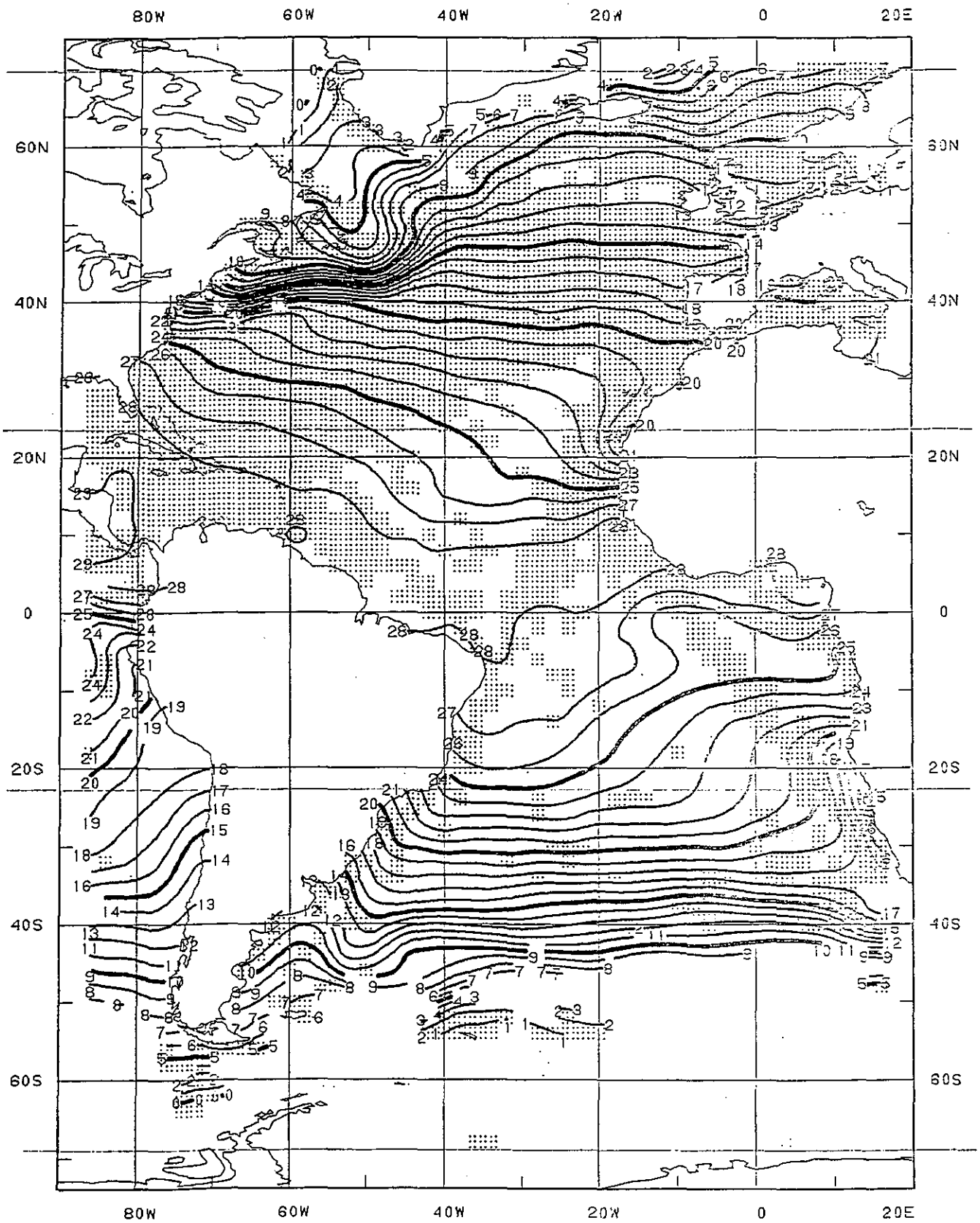

Atlantic Ocean
SST--MONTHLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA

JUNE 1987

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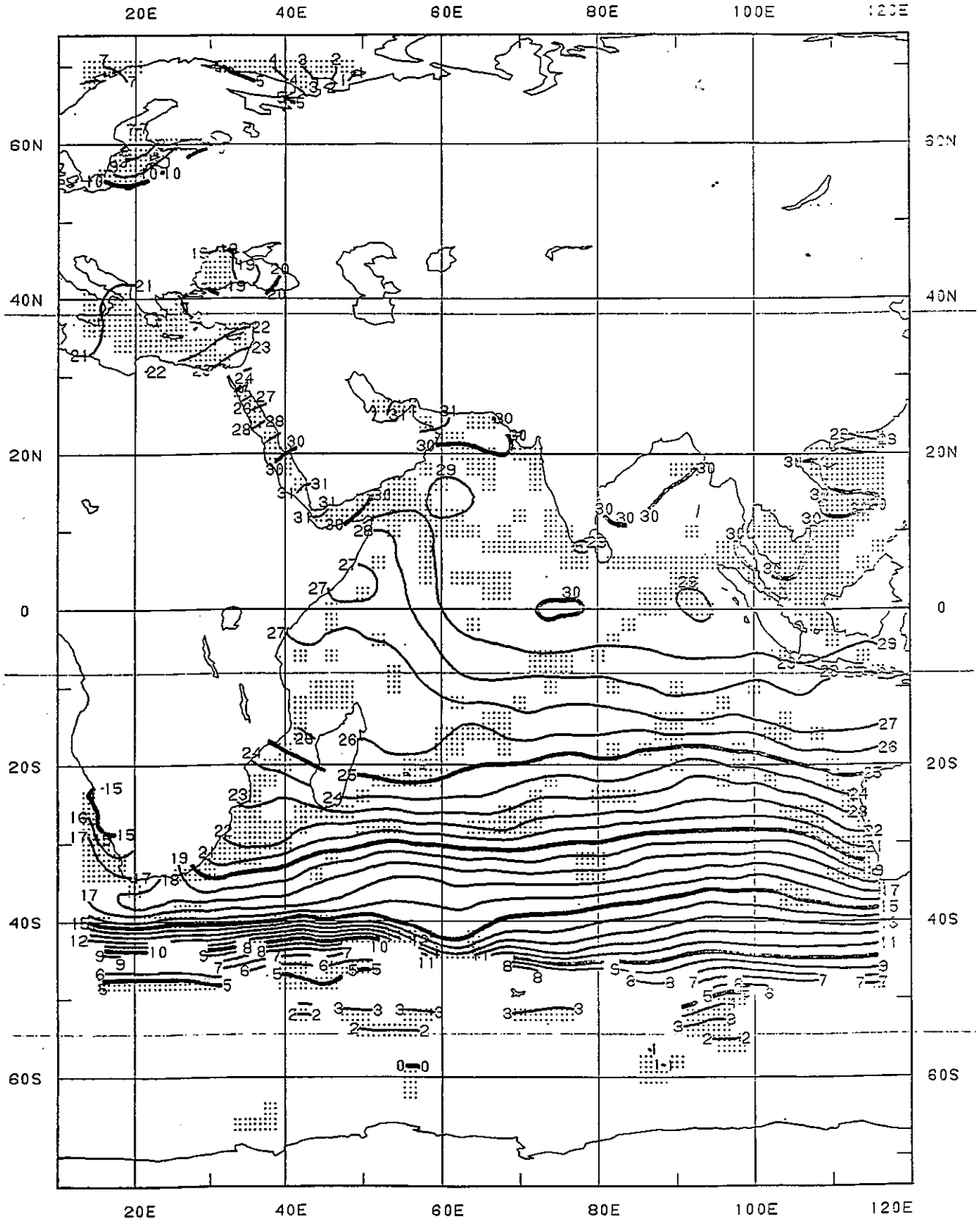

Indian Ocean
SST--MONTHLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA
JUNE 1987

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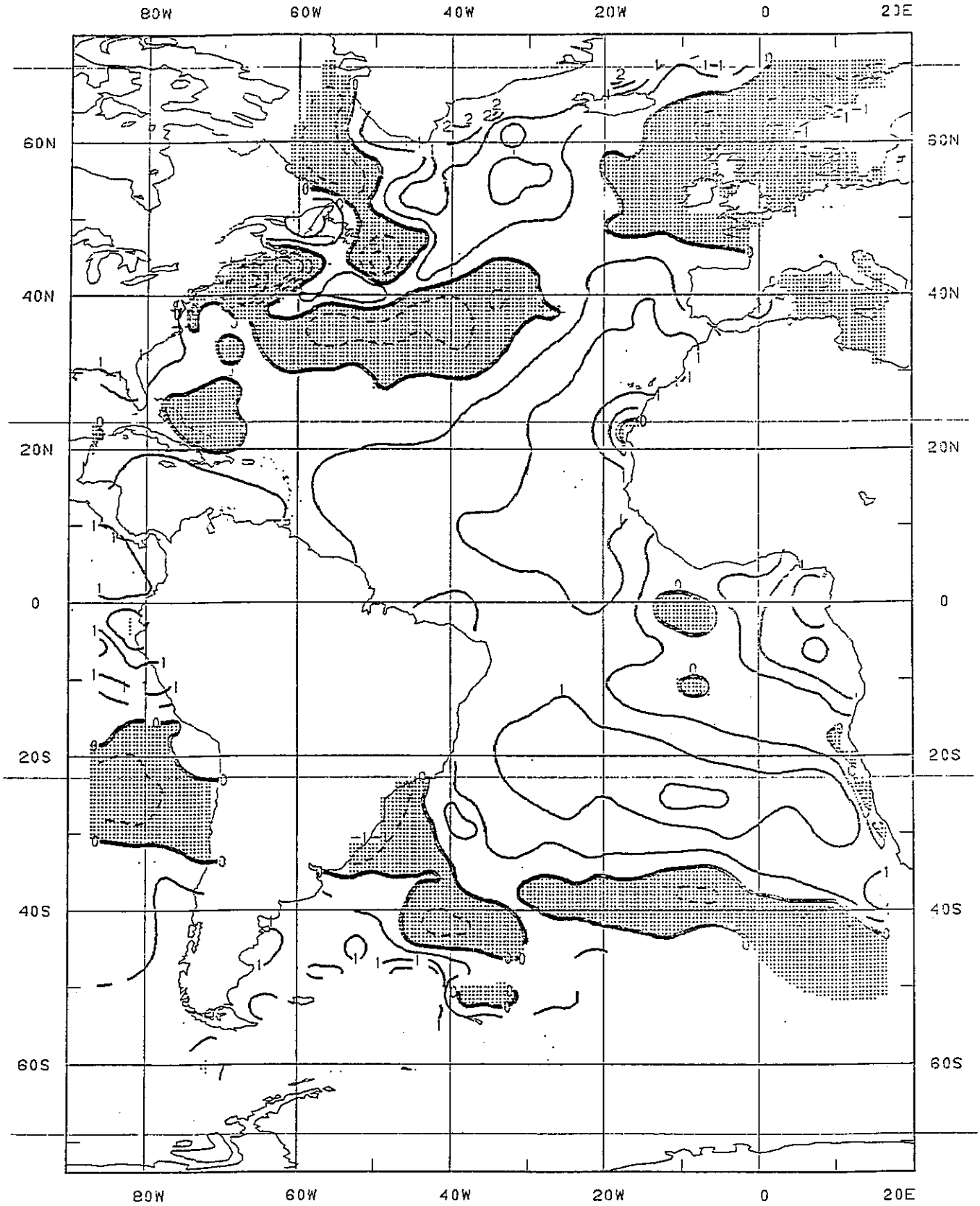

Atlantic Ocean
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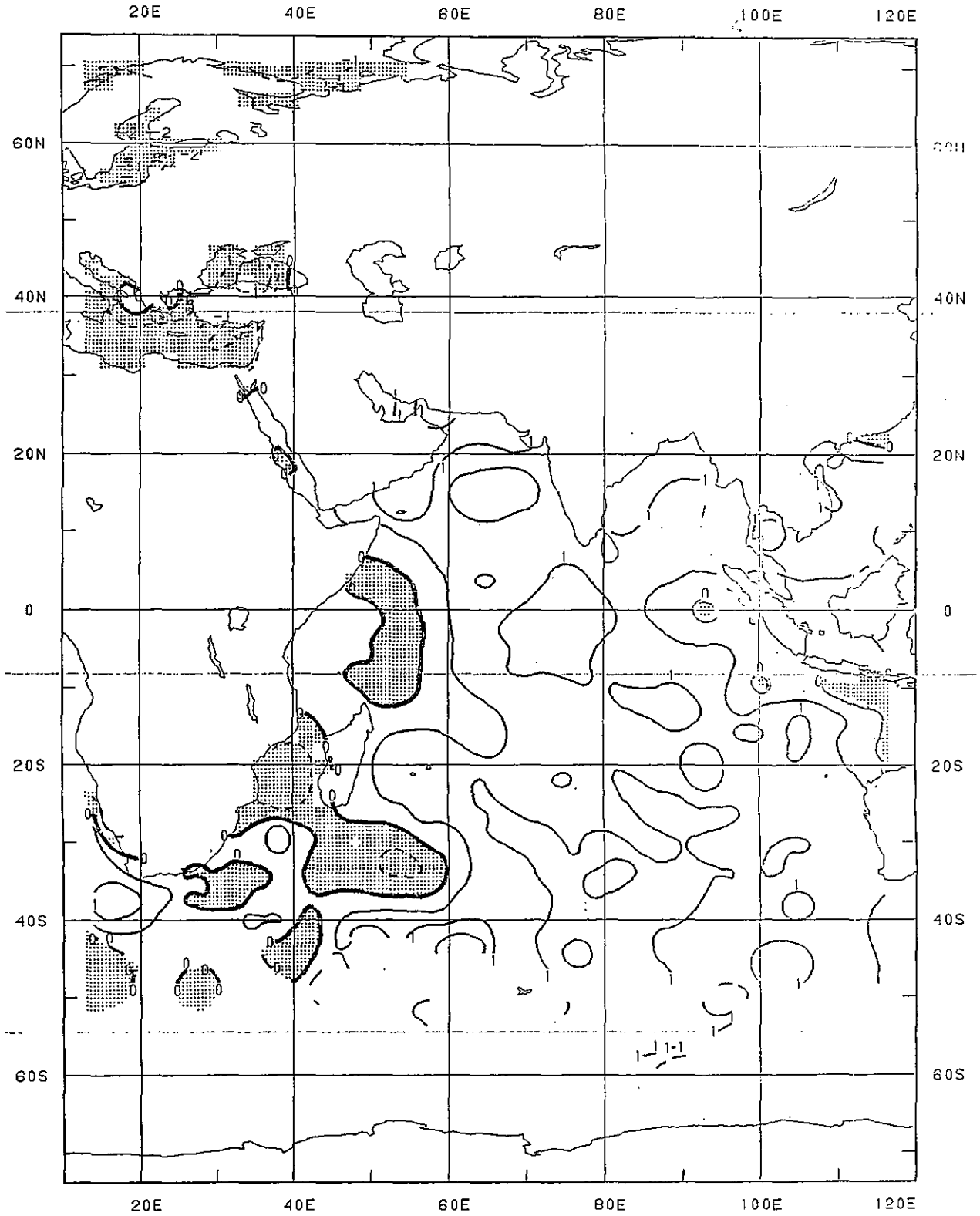

Indian Ocean
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SHIP, BUOY, and SATELLITE DATA
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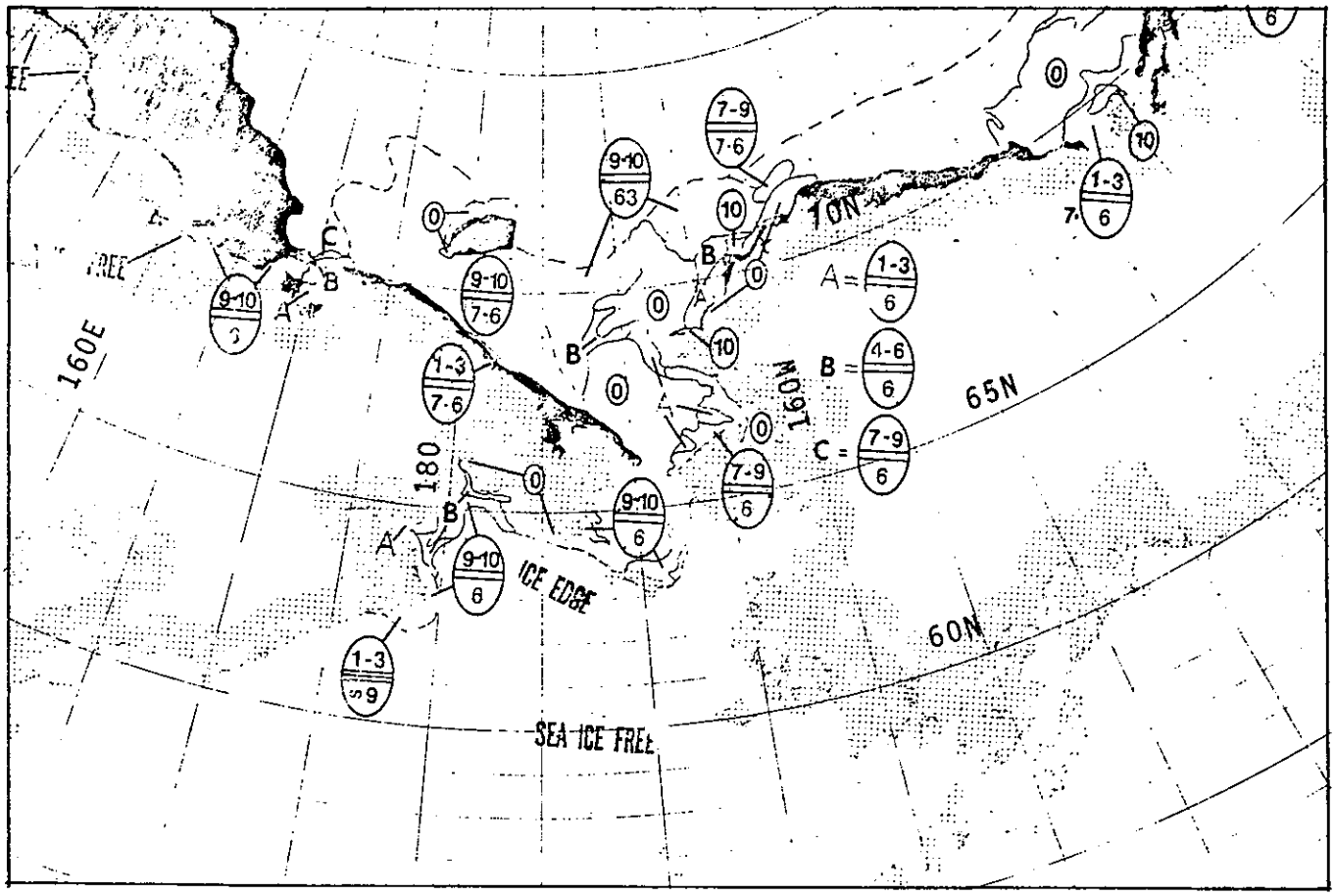
OceaNotes

(continued from page 3)

image, it obscures much of the coast of Antarctica east of the Amery Shelf. The darker area adjacent to a piece of fast ice (F1) indicates an area of thinner ice (new ice). This area, along with several others indicated by arrows, is caused by katabatic winds blowing offshore. Persistent katabatic winds are responsible for an unusual "summer" melt pattern, where ice is melted alongshore as well as along the ice edge. During the Southern Hemisphere summer months, two scientific stations manned by Australia, Davis at 78E 68S and Mawson at 63E 68S, are resupplied. Also to begin in early 1988 is a scientific expedition in Prydz Bay (P) to study paleoclimate, water circulation, water mass formation tectonic evolution and ice volume. Scientists from Texas A&M University are in charge of the study.

MCSSTs --- Surface Layer Diurnal Heating

Users of sea surface temperature products derived solely or predominantly from satellite-based multi-channel sea surface temperatures (MCSSTs) should be aware of a sometimes pronounced daytime elevation of the MCSST values relative to SSTs which are obtained from buoys, XBTs, or ship intakes at depths of a meter or more. Satellite or other infrared-based radiation detectors sense only the temperature of the ocean "skin" which, under normal mixing conditions generally differs from that at depth by a couple of tenths of a degree. With near-calm winds and quiet seas, however, the upper few tens of centimeters of the sea are directly heated by the sun, particularly in the subtropics and tropics, to temperatures as much as 2C-to-4C or more than those at a depth of only one meter. Although the MCSSTs are "tuned" shortly after launch by means of a global set of match-ups with drifting buoy SSTs, this results in only an overall average normalization to buoy depth, and it will not adjust for such anomalous diurnal heating effects.



BERING SEA / NORTH SLOPE ICE ANALYSIS

Gary M. Wohl, NOAA
Navy-NOAA Joint Ice Center
National Meteorological Center, W/NMC21
(301) 763-5972

JUNE 1987

Milder than normal weather conditions led to accelerated sea ice ablation in the Alaskan region during June. Ice remaining in the Bering Sea rapidly disappeared as temperatures and daylight hours increased. By the third week nearly all the ice had gone from U.S. waters except in the immediate vicinity of St. Lawrence Island. To the north, in Chukchi Sea, sea ice also ablated rapidly, the southern portion of the Sea opening up for shipping about one week earlier than normal. The flaw lead observed in May in the vicinity of Icy Cape and Wainwright opened wider and only remnants of shorefast ice prevented access to the coast. Along the Beaufort Sea coast, warm temperatures melted the snow on the surface of the fast ice causing it to darken in appearance on satellite images. Continuous easterly winds kept the ice pack in motion and large openings appeared in the eastern Beaufort Sea. In all, the breakup pattern appeared to be about one week ahead of schedule.

C = Total ice concentration in the area in tenths.

C_a, C_b, C_c = Concentration of thickest (C_a), 2nd thickest (C_b), and 3rd thickest (C_c) ice

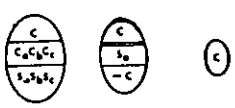
S_a, S_b, S_c = Stage of development of thickest (S_a), 2nd thickest (S_b), and 3rd thickest (S_c) ice.

-C = Concentration of ice within area(s) of strips and patches.

STAGE(S) OF DEVELOPMENT (THICKNESS)

1 = New Ice (0-10 cm)
3 = Young Ice (10-30 cm)
6 = First year (30-200 cm)
7 = First year thin (30-70 cm)
4 = First year medium (70-120 cm)
5 = First year thick (120-200 cm)
7 = Old ice (survived at least one summer's melt)

EXAMPLES



125 — Theoretical thickness of this season's growth (cm).

Fast ice. Sea ice which forms and remains fast along the coast.

Ice boundary visually or satellite observed.

Ice boundary estimated.

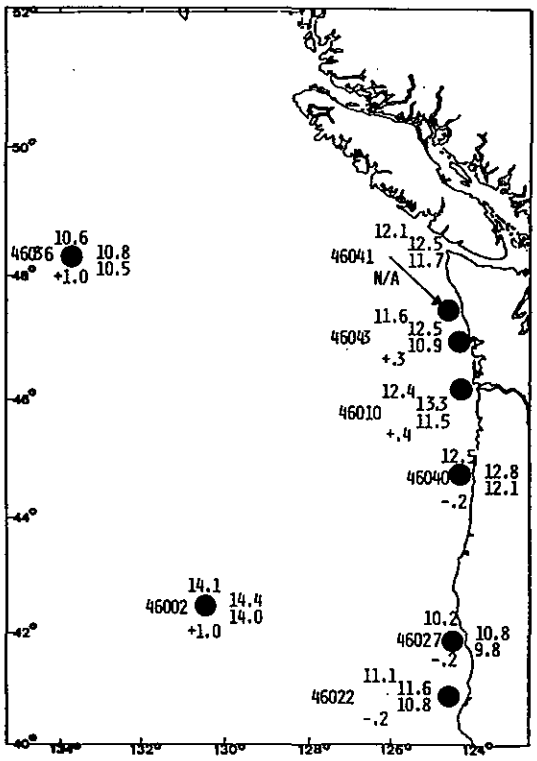
WEST COAST OCEAN FEATURES

Ernest Daghir
NOAA/NWS
Satellite Field Service Station
660 Price Avenue
Redwood City, CA 94063
(415) 876-9122
FTS 470-9122

JUNE 1987

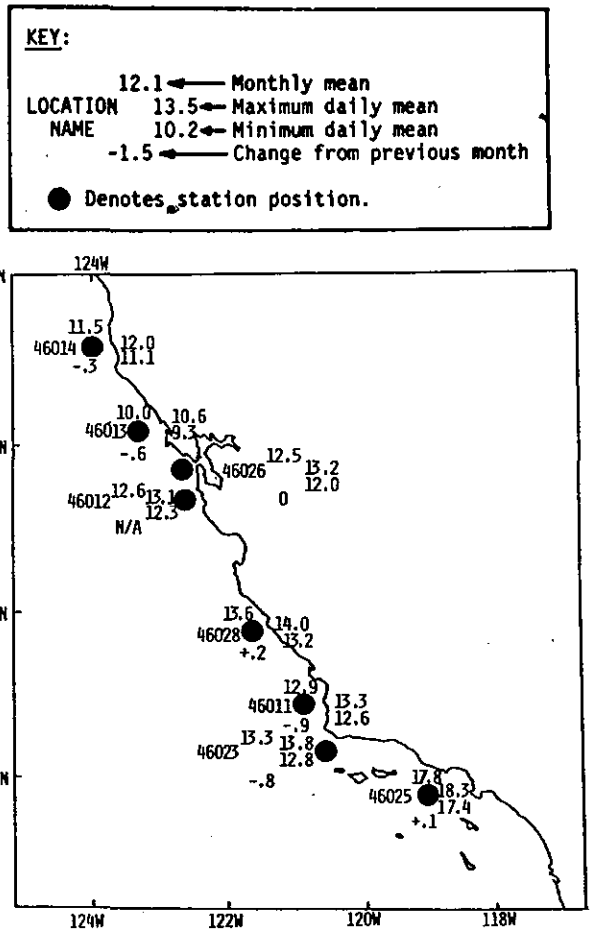
Sea surface temperatures along the U.S. West Coast were near normal during June. In fact, the North Panel averaged 12.5C, exactly the climatological mean value for the area. The South Panel averaged only 0.2C warmer than the normal mean of 16.2C.

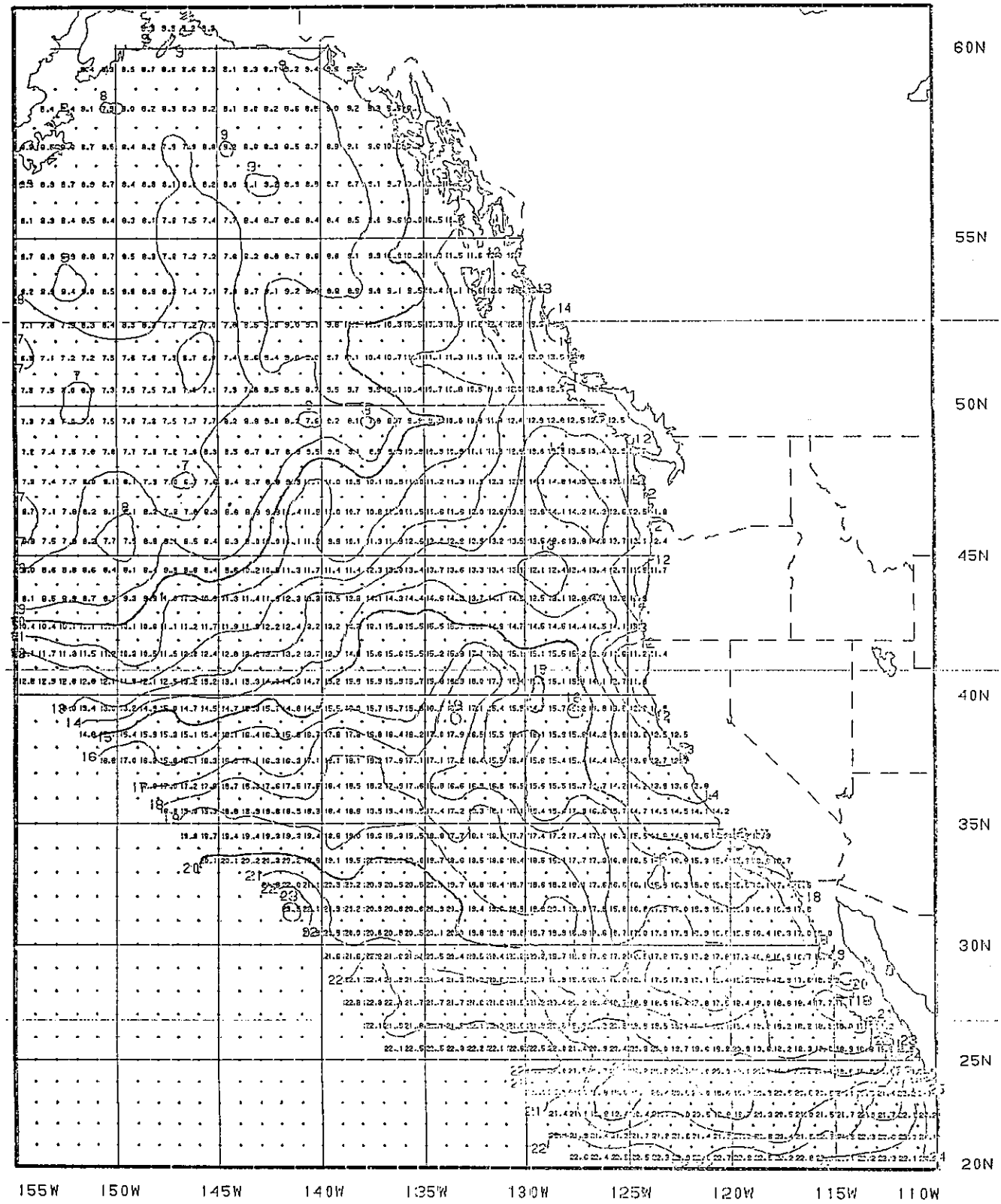
In the North Panel, the area south of 48N and east 130W was



above normal. The warmest anomaly of 0.7C was centered near Cape Blanco. The remainder of the analysis area was 0.1C to 0.4C below normal. Warming was the predominant feature with temperatures rising from 1.3C to 2.0C in all locations. Buoys closest to the coast had variations of warming and cooling. Both offshore buoys, however, showed more significant warming.

Ocean water temperatures in the South Panel appeared to be above normal in the southeastern half of the chart and below normal in the northwestern half. The greatest anomaly observed was in Los Angeles Bight and along the northern Baja Peninsula where temperatures were 1.3C to 1.6C above normal. The greatest cool anomalies were in the northwest corner of the chart near 36N 127W. The entire South Panel warmed since May, ranging from 0.1C along the coast south of Pt. Conception to 1.6C in the southwest corner of the analysis area. Most of the coastal buoys showed some cooling in June, most likely in response to upwelling episodes during the month.





West Coast
SST--MONTHLY MEAN (°C)
JUNE 1987

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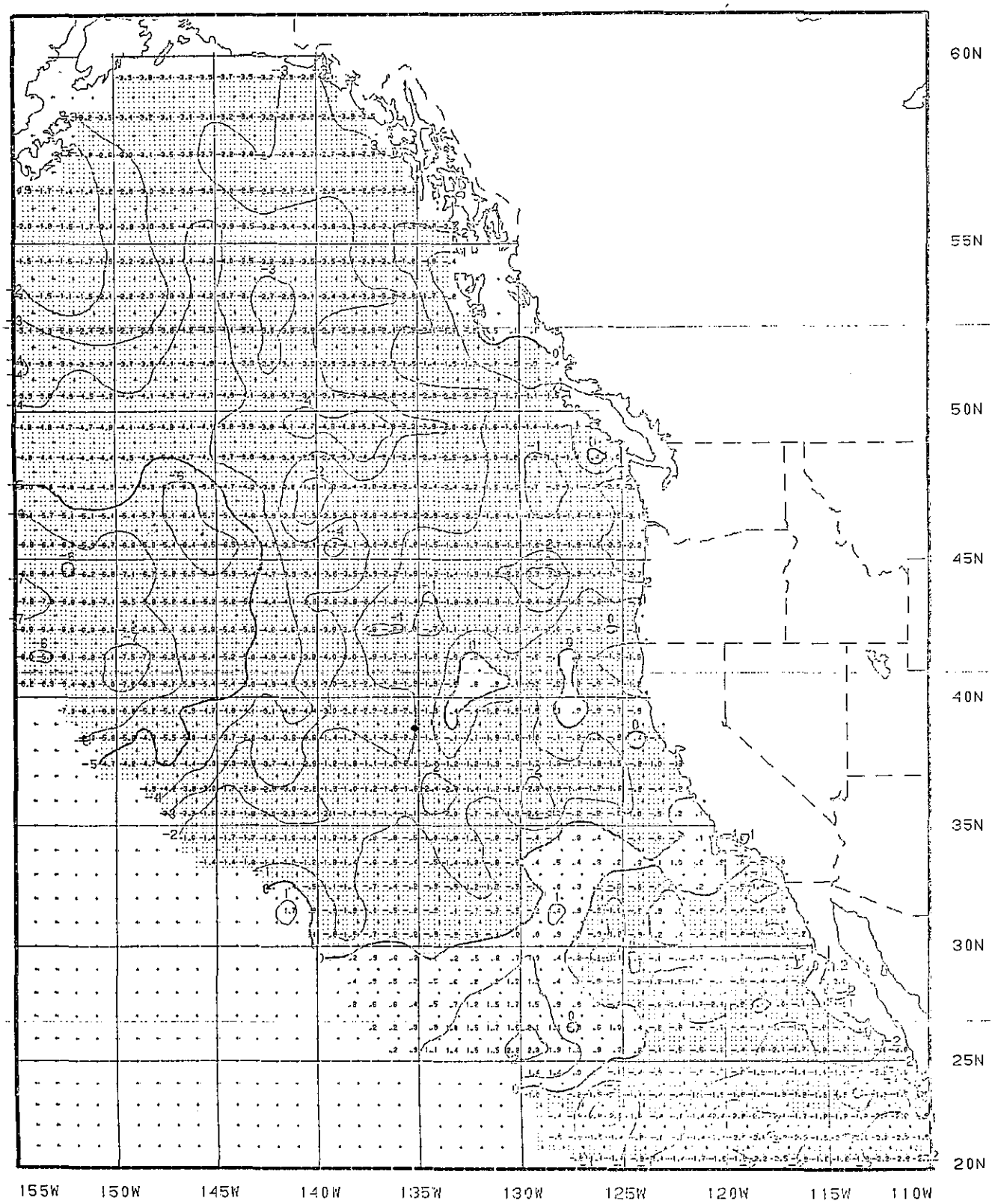

West Coast
SST--MONTHLY ANOMALY (°C)
JUNE 1987

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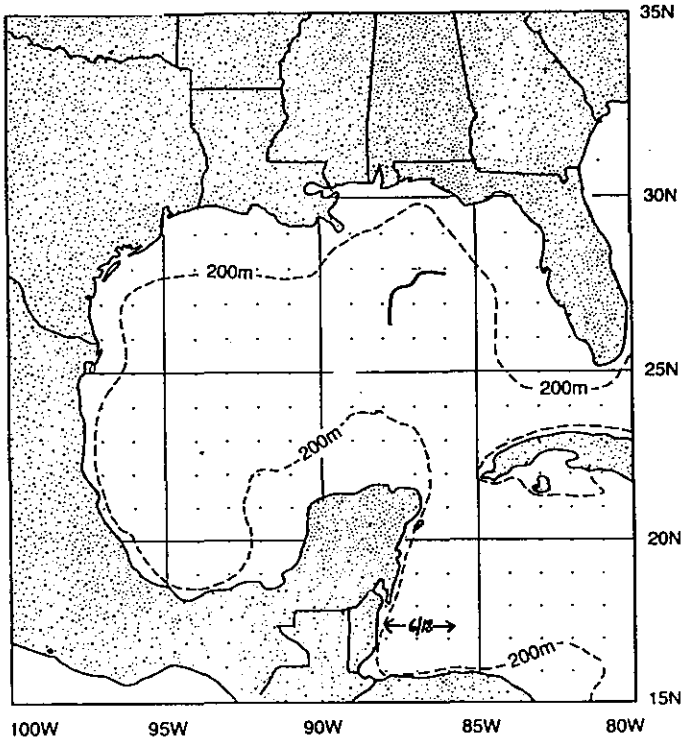
EAST COAST OCEAN FEATURES

Jenifer Clark
NOAA, NWS
Washington, DC 20233
(301) 763-8030

JUNE 1987

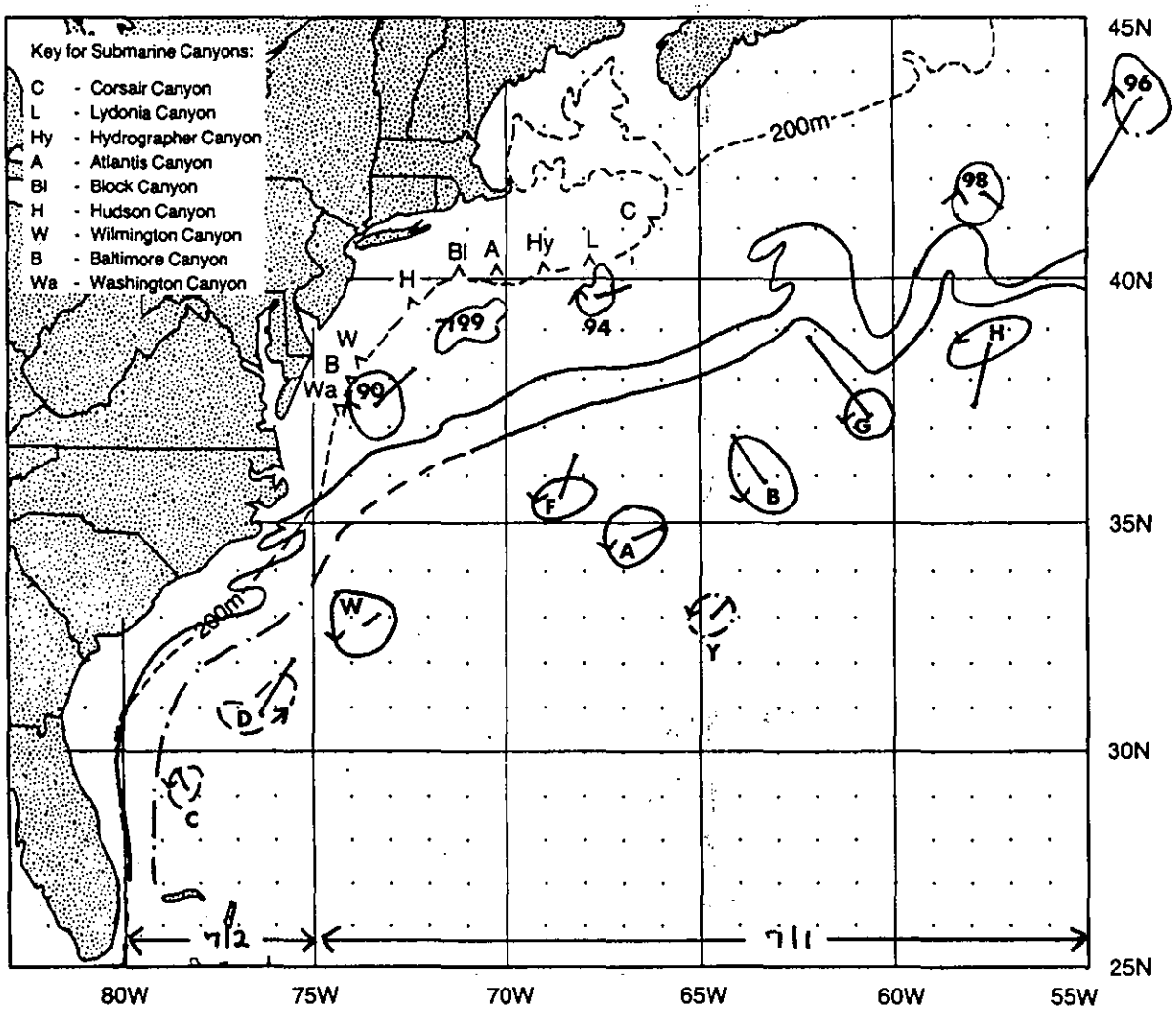
The end of this month's positions of the Gulf Stream System and its associated eddies are shown for the NW Atlantic and the Gulf of Mexico. The Gulf Stream and Loop Current boundaries are located by infrared satellite imagery or XBT (expendable bathythermograph) data. Anticyclonic eddies are labeled a-z in the Gulf of Mexico and 1-99 in the Northwest Atlantic. Cyclonic eddies are labeled A-Z. Arrows on eddies indicate direction of circulation. Warm-core or anticyclonic eddies rotate clockwise; cold-core or cyclonic eddies rotate counterclockwise. The line to the eddy center shows the net translation since last month or since last observed. The edge of continental shelf at 200 m is shown as a dashed line. Eddies or sections of the Gulf Stream System which were not observed during the month are not shown on the analysis chart or are indicated by "dot-dashed" lines. The long arrows at the bottom of the chart indicate the dates of data used.

Data used in this analysis include:
Infrared imagery from NOAA satellite - NESDIS
Bathythermograph data from National Meteorological Center of National Weather Service
Oceanographic Analysis -- A daily detailed analysis issued by National Weather Service



GULF OF MEXICO

Due to near isothermal conditions and cloudiness, the Loop Current was mostly unobserved during June. The only exception was a section of the Loop Current about 260 km long located near 27N 88W to 28N 86W observed on June 18. Anticyclonic eddy u was not discerned during June.



NORTHWEST ATLANTIC OCEAN

One anticyclonic eddy formed and one was absorbed during June. Eddy 99 apparently formed from a meander near 39N 68W and from eddy 94 around May 27. It appears to have translated rapidly westward by 275 km. Eddy 97 was absorbed by a Gulf Stream meander near 40N 63W around June 15.

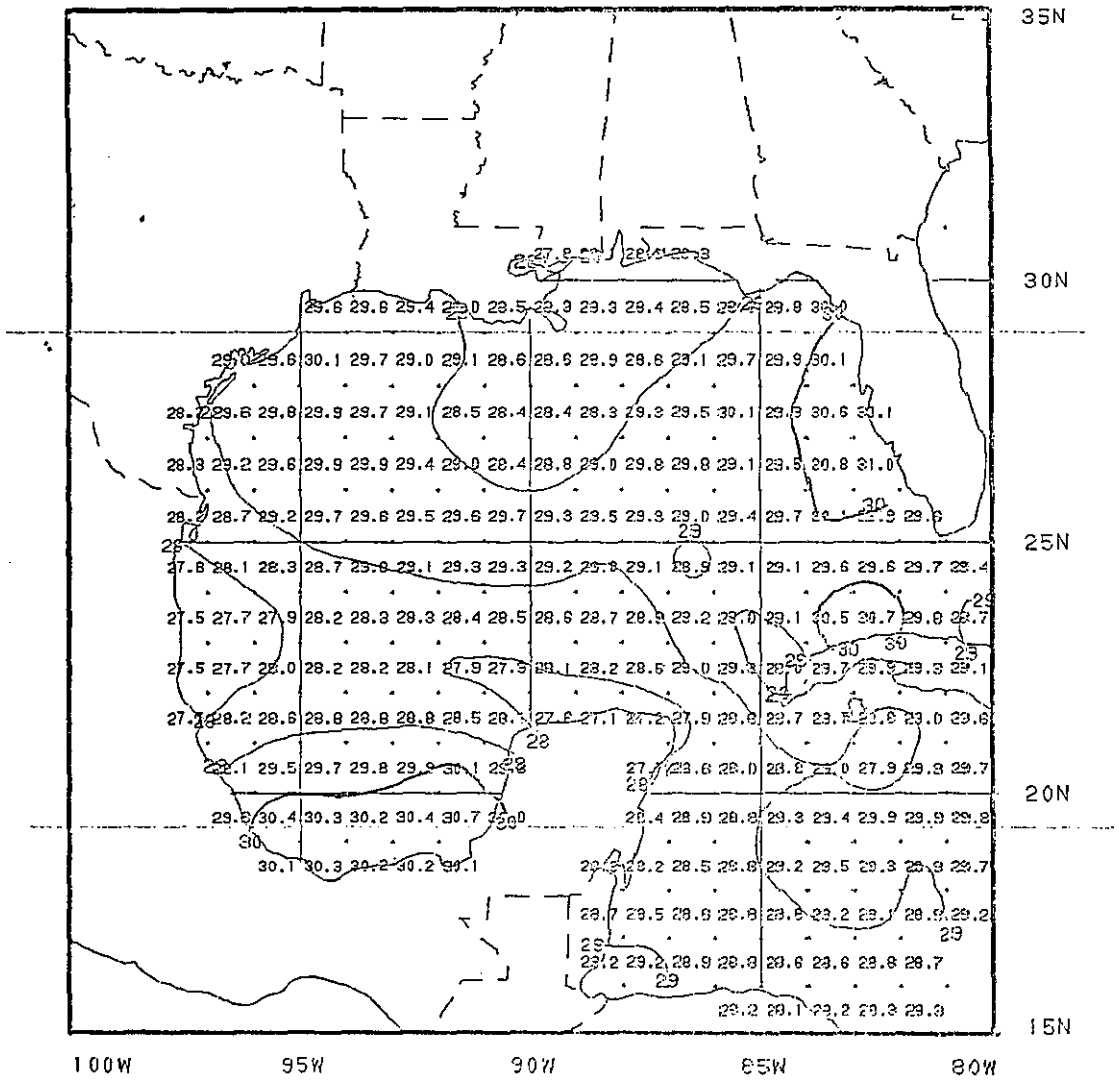
Eddy 90 translated 110 km SW. Eddy 94 moved 75 km WSW. Eddy 98 traveled 55 km NW while eddy 96 traveled 195 km NE.

One cyclonic eddy dissipated and another cyclonic eddy was absorbed during June. Eddy E, previously located near 33N 69W, seemingly dissipated according to Harvard/Navy XBT data. Eddy H was absorbed by a Gulf Stream meander near 38N 58W on June 22, but it reformed near 39N 58W from the same meander on July 1.

Eddy C, last observed on June 11, moved 45 km SE. Eddy D, last observed on June 18, translated 140 km SW. Eddy w traveled 35 km WSW, and eddy F moved 90 km SSW. Eddies A and Y translated 65 km WSW and 55 km SW, respectively. Eddy B traveled 120 km SE and eddy G moved 210 km SE.

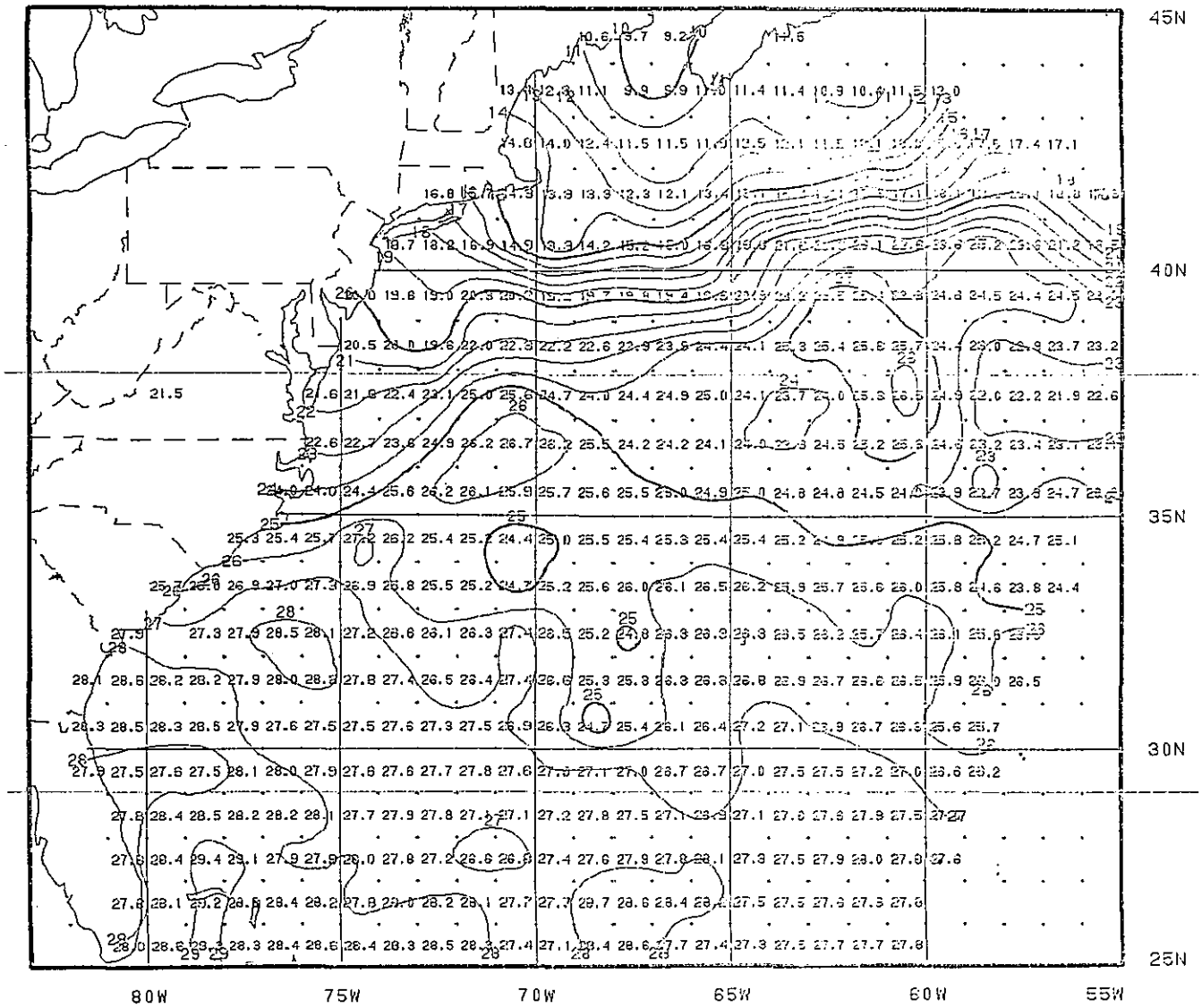
The Subtropical Convergence Front was not observed.

EAST COAST SST – MONTHLY MEAN



Gulf of Mexico
SST--MONTHLY MEAN (°C)
JUNE 1987

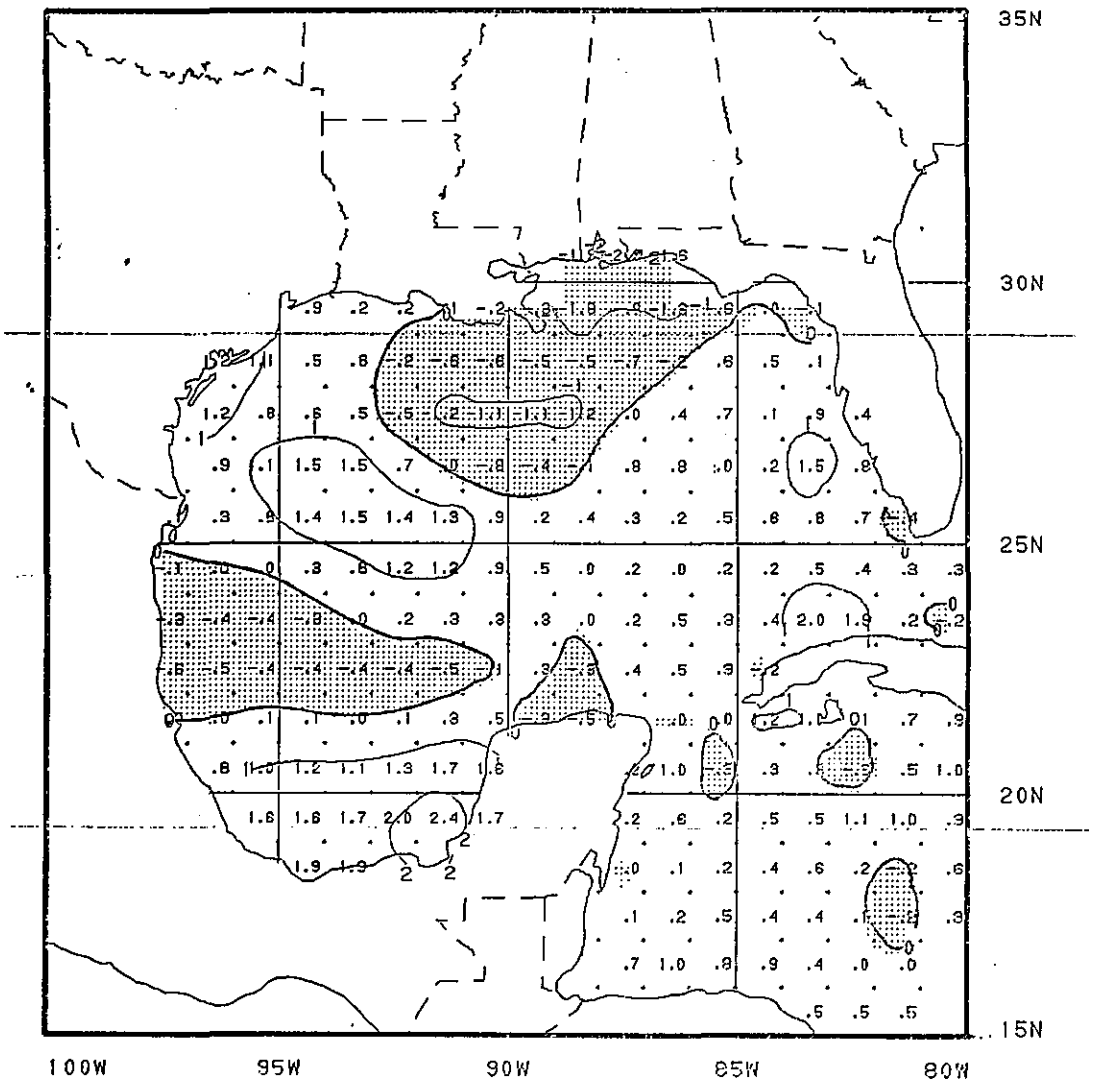
Monthly mean sea surface temperature is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0°C.



Northwest Atlantic Ocean
SST--MONTHLY MEAN (°C)
JUNE 1987

Monthly mean sea surface temperature is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0°C.

EAST COAST SST – ANOMALY



Gulf of Mexico
SST--MONTHLY ANOMALY (°C)
JUNE 1987

Monthly anomaly is the difference between the monthly mean sea surface temperature and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0°C.

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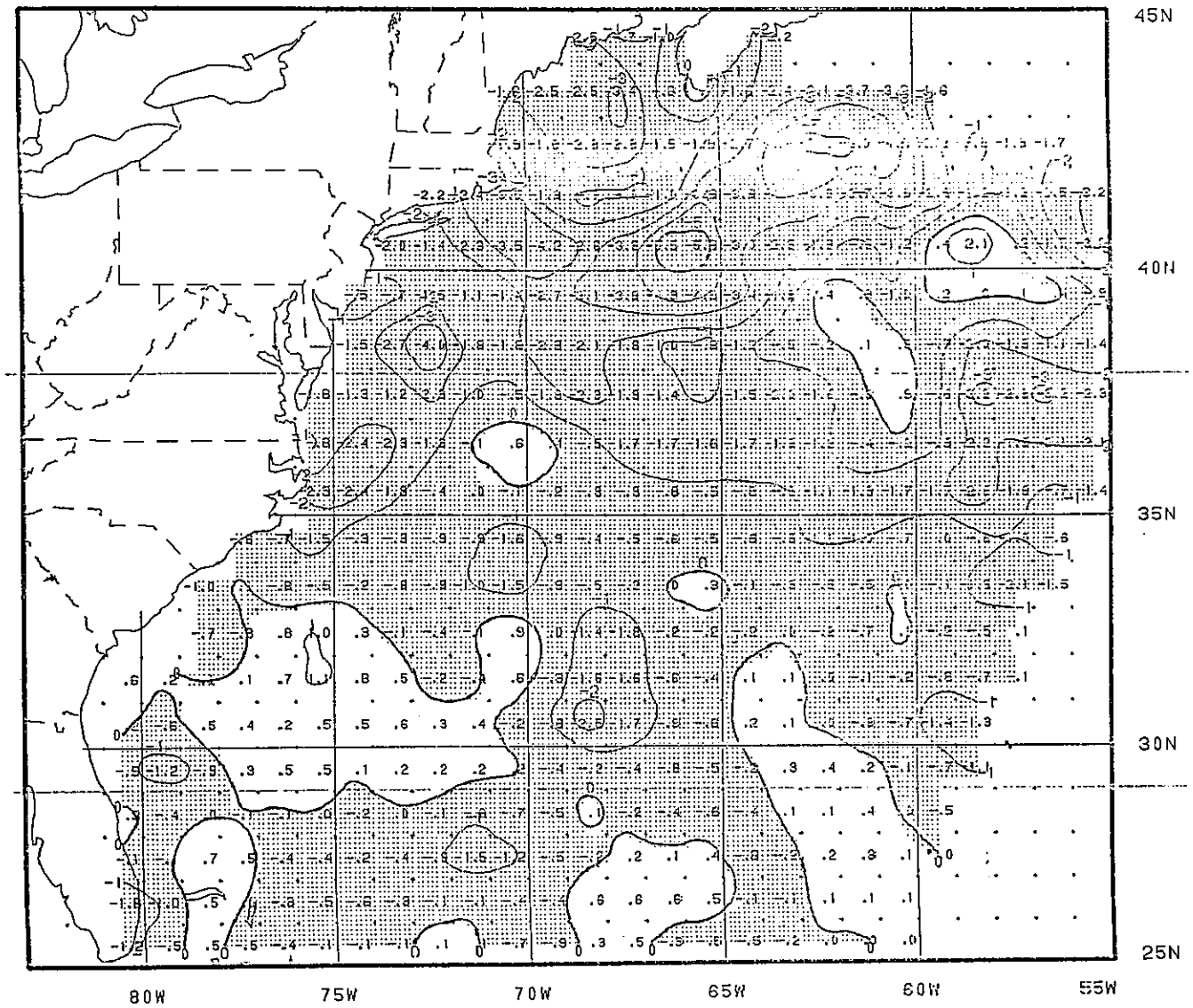


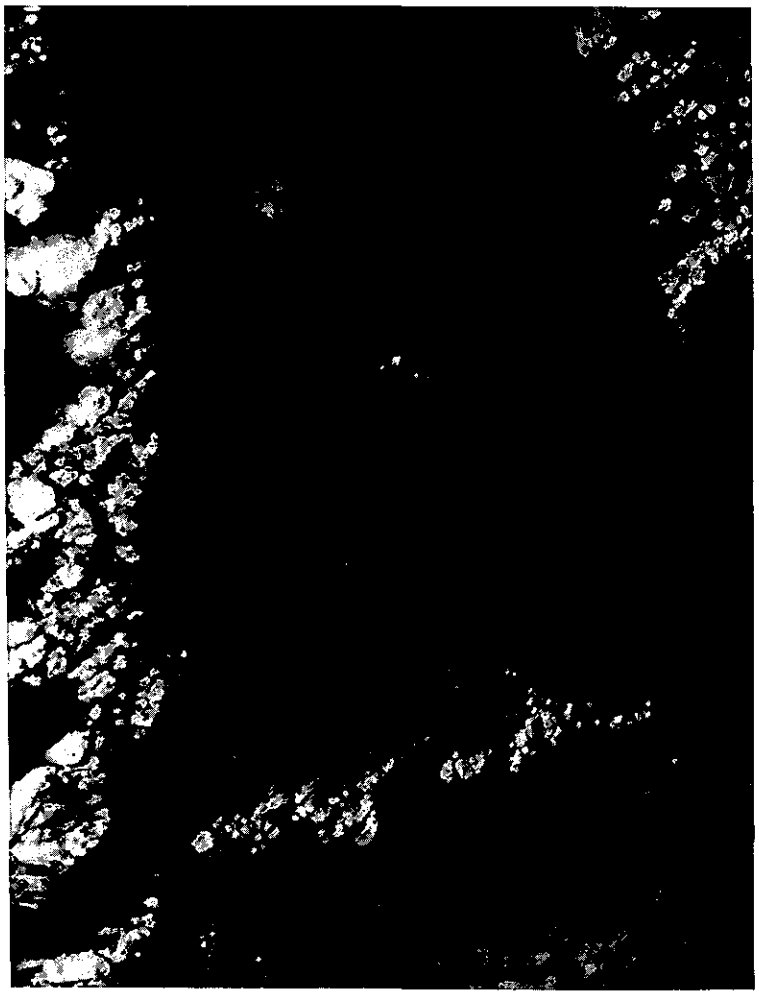
Northwest Atlantic Ocean
SST--MONTHLY ANOMALY (°C)
JUNE 1987

Monthly anomaly is the difference between the monthly mean sea surface temperature and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0°C.

16 SEP 1987
NOAA LISD SEATTLE

OCEANOGRAPHIC Monthly Summary

Volume VII Number 7 July 1987



The Afar Triangle(page 3)

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U.S. DEPARTMENT OF COMMERCE • National Oceanic and Atmospheric Administration
National Weather Service
National Environmental Satellite, Data, and Information Service
National Ocean Service

OCEANOGRAPHIC
Monthly Summary

Oceanographic Monthly Summary is published by the National Weather Service (NWS), the National Environmental Satellite, Data, and Information Service (NESDIS), and the National Ocean Service (NOS). *Oceanographic Monthly Summary* contains sea surface temperature (SST) analyses on both regional and ocean basin scales for the Atlantic, Pacific, and Indian Oceans. The ocean basin analyses are based on a "blend" of *in situ* and satellite data, in which *in situ* data are used to define "benchmark" temperature values in regions of frequent observations and satellite data are used to define the "shape" of the field between these points.[1]

An ocean basin SST anomaly is derived from the "blended" SST analysis[1] and the improved global SST.[2] The regional SST analyses are based upon a combination of *in situ* and satellite data measurements. The regional SST anomalies are calculated from the Robinson-Bauer Climatology.[3,4] *Oceanographic Monthly Summary* also contains Alaskan sea ice information and ocean feature information for contiguous U.S. ocean regions.

Oceanographic Monthly Summary welcomes articles containing information of interest to its readers, such as news on operational oceanography, unusual ocean feature phenomena, etc. Contributions should be sent to the editor (address below). Accepted material will appear in the OceaNotes section of *Oceanographic Monthly Summary*. Contributions can be published as quickly as the next monthly issue.

If you are interested in receiving *Oceanographic Monthly Summary* regularly, please refer to the back cover for subscription information.

[1]Reynolds, R.W. and W.H. Gemmill, 1984. A sea surface temperature analysis which blends *in situ* and satellite observations. *Proceedings of the Ninth Climate Diagnostics Workshop*, Corvallis, OR, Oct. 22-26, 1984, pp. 408-416.

[2]The climatology is derived from *in situ* data (1950-1979), satellite data (1982-1985) and an ice climatology.

[3]Robinson, M.K., 1976. Atlas of North Pacific Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOcean Ref. Pub. 2.*

[4]Robinson, M.K., R.A. Bauer, and E.H. Schroeder, 1979. Atlas of North Atlantic-Indian Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOceano Ref. Pub. 18.*

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CORRECTION: The front cover of last month's issue displays the wrong issue number and should be corrected manually as illustrated below .

Volume VII Number ~~4~~ 6 June 1987

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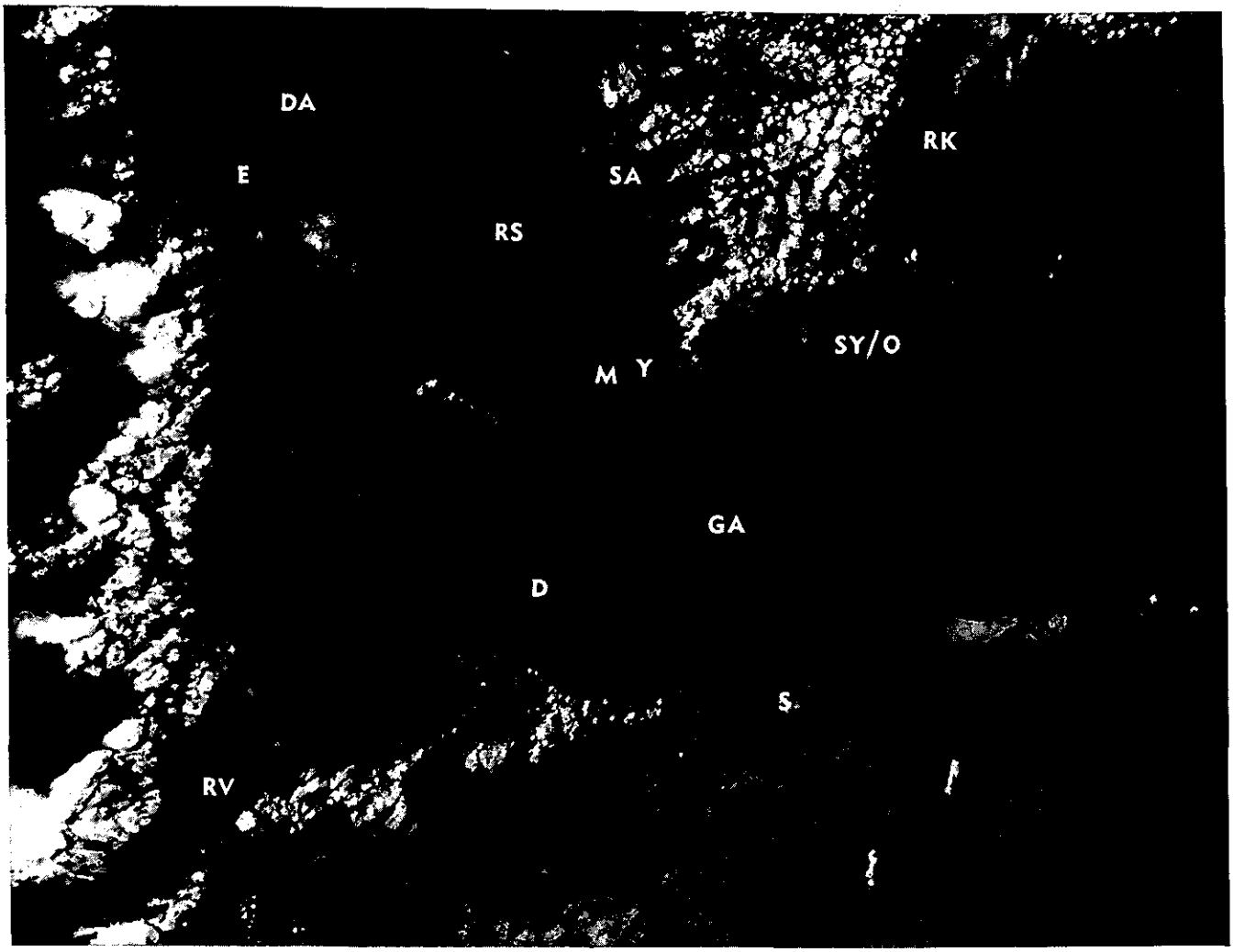


OceaNotes

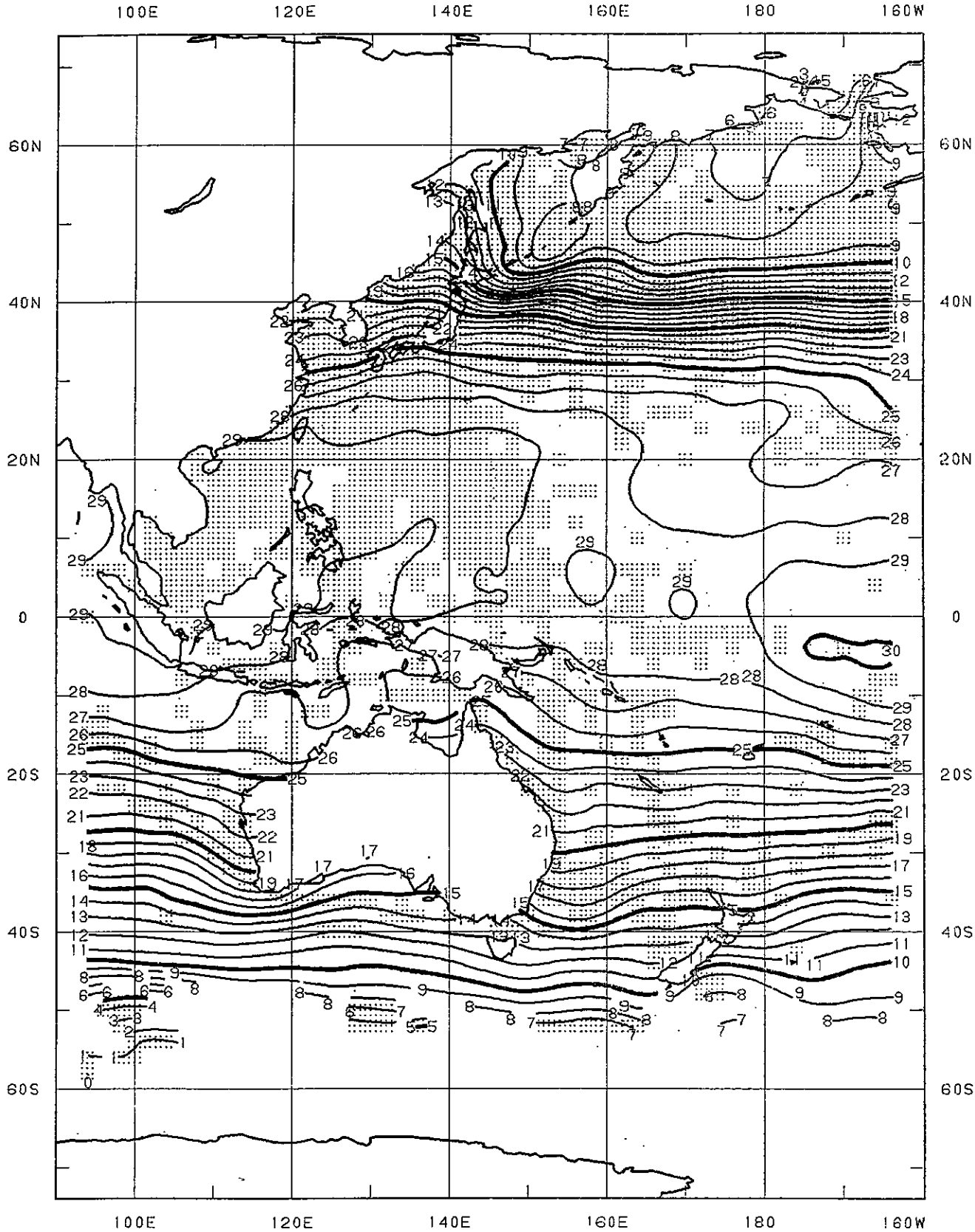
PLATE TECTONICS AND A NASCENT OCEAN

Kim Buttleman
Interactive Processing Branch
NESDIS, NOAA E/SP22
Washington, DC 20233
(301) 763-8142

The above image (NOAA-9 AVHRR, ch 1, visible) from July 17, 1987 (12:15 GMT) shows the southern end of the Red Sea (RS) and the western end of the Gulf of Aden (GA), connected by the straits of Bab al Mandab (the Gate of Tears). The Red Sea has been so named from antiquity because of the often extensive blooms of the cyanobacteria Trichodesmium erythmaeum, which turn the normally intense blue waters a dull red during senescence. It is bordered by the Eritrean coast of Ethiopia (E) on the west and by the Asir coast of Saudi Arabia (SA) and Yemen (Y) on the east. The Gulf is bordered by Somalia (S) on the south, South Yemen and Oman (SY/O) on the north, and Djibouti (D) on the west. Other labeled geographical features are the Dahlak Archipelago (DA), known for its ancient pearl and nacre fishery; the port of Mukha, or Mocha (M), in Yemen, the main source of coffee for Europe from the late Middle Ages until the 18th century; and the southern edge of the Rub' al Khali (RK), or the Empty Quarter of the Arabian Peninsula. At lower left is the northern end of the Great Rift Valley of Africa (RV).

The geological history of the area is very interesting, and contributes to the similarly interesting oceanography of the Red Sea. It is considered to be a relatively new sea, whose development closely resembles that of the young Atlantic Ocean. It was formed in two stages, with its initial opening and growth coming between 50M and 20M years ago, when the Arabian plate began rifting from the African plate. A decrease in rifting ensued, during which the basin, like the Mediterranean, was cut off from the ocean and dried up at least several times, as evidenced by evaporite layers several hundred meters thick. A second stage of renewed rifting began between 3M and 4M years ago, during which time spreading has proceeded at approximately 1.5 cm/yr. In this second stage the Afar Triangle was formed. It lies at the southern end of the Red Sea, and in this image is demarcated by the southern Ethiopian, Djibouti, and northern Somali coasts (line E-S), and by the V formed by the Ethiopian and the Somali Escarpments (lines E-RV and RV-S, respectively). (The locations of both escarpments are highlighted by cloud cover.) The Afar Triangle lies at the triple junction where the Great Rift Valley of Africa meets the rifts of the Red Sea and the Gulf of Aden. It consists of exposed oceanic crust which has been lifted by upwelling mantle material, and has elevations from 155m below sea level to 2000m above. Elevations along the bordering escarpments reach 4200m. The area has also had intermittent connection with the Red Sea and Gulf of Aden, with evaporite deposits up to 1000m thick. The entire region exhibits

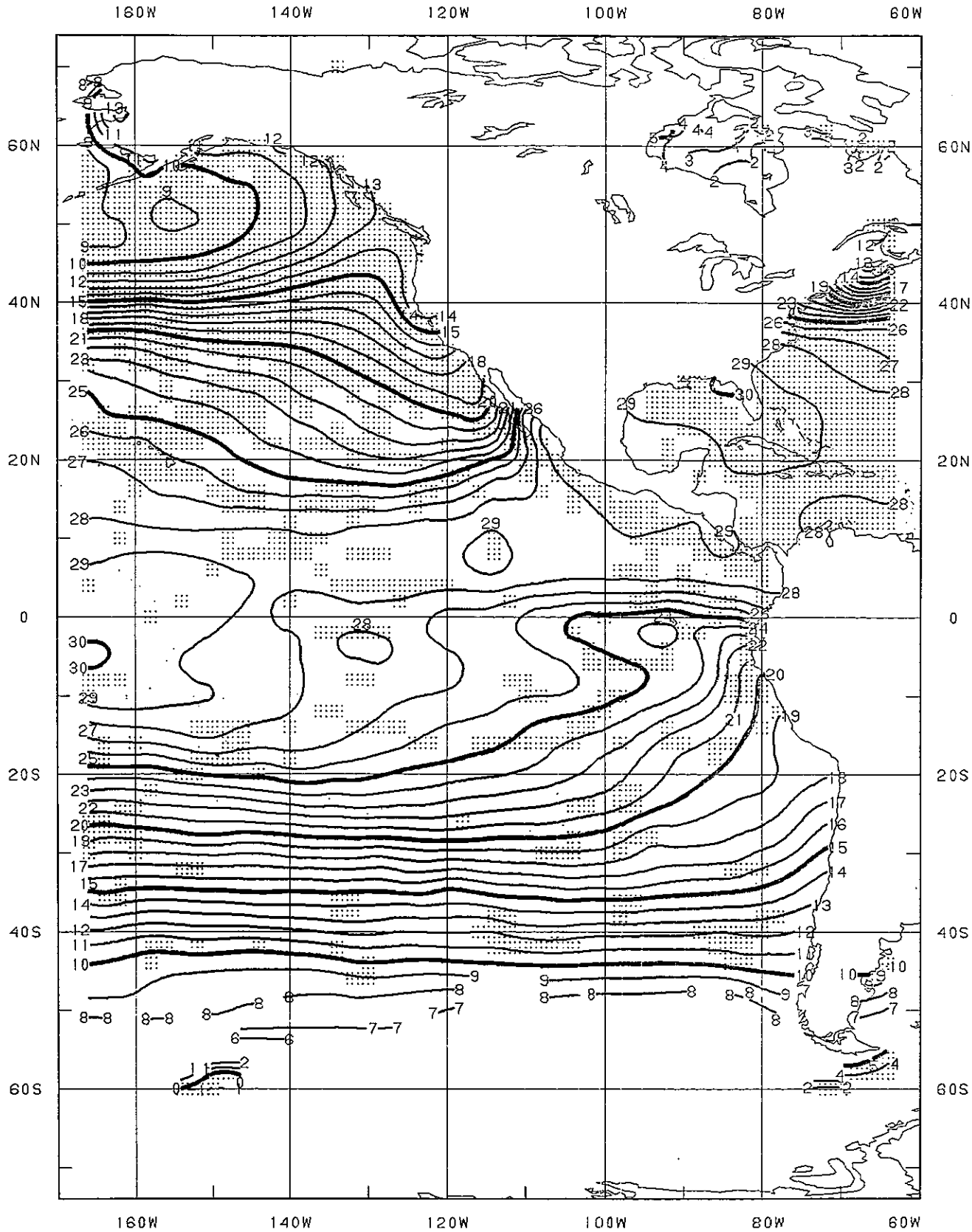
(Text continued on page 12)



Western Pacific Ocean
SST--MONTHLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA

JULY 1987

Monthly mean sea surface temperature is the mean of *in situ* and satellite data within two-degree quadrangles. Contour line interval is 1.0°C. The stippling indicates where the analysis was fixed by the *in situ* data; contours are not shown in areas without data.



Eastern Pacific Ocean
SST--MONTHLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA

JULY 1987

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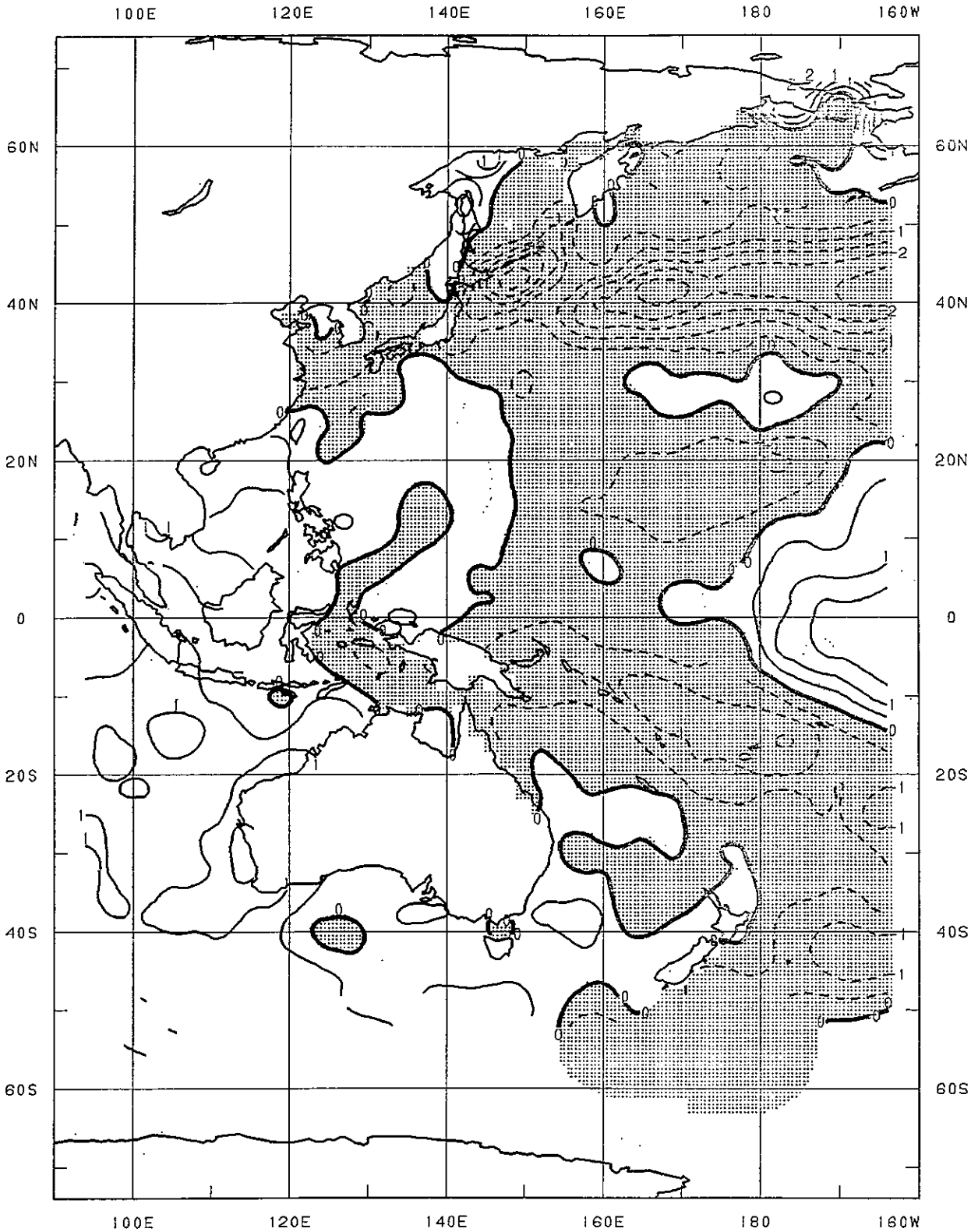
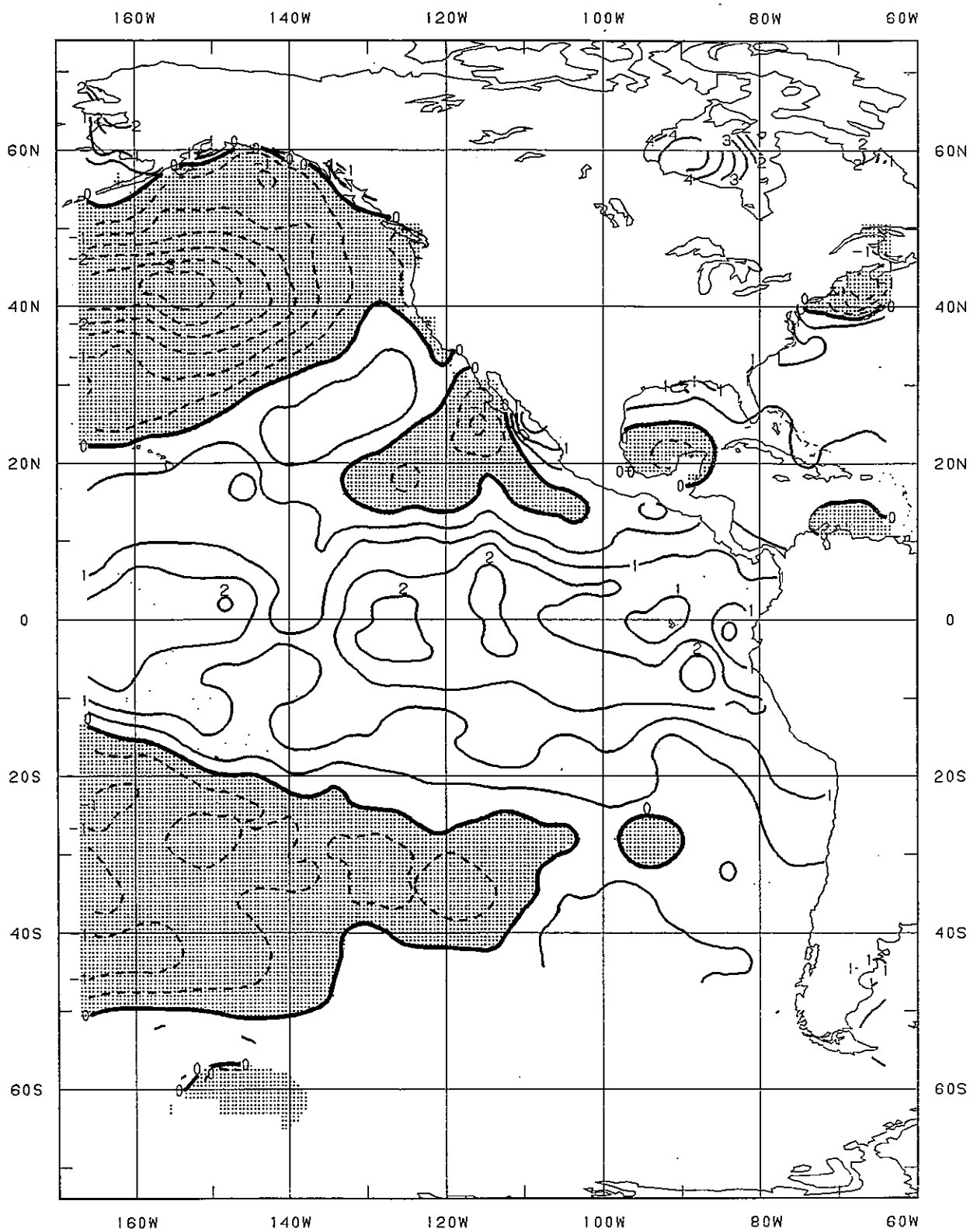


Western Pacific Ocean
SST--MONTHLY ANOMALY (°C)
SHIP, BUOY, and SATELLITE DATA

JULY 1987

Monthly anomaly is the difference between the monthly mean sea surface temperature and the climatological monthly mean value. Contour line interval is 0.5°C. The stippling indicates where the monthly mean is colder than climatology; contours are not shown in areas without monthly or climatological data.



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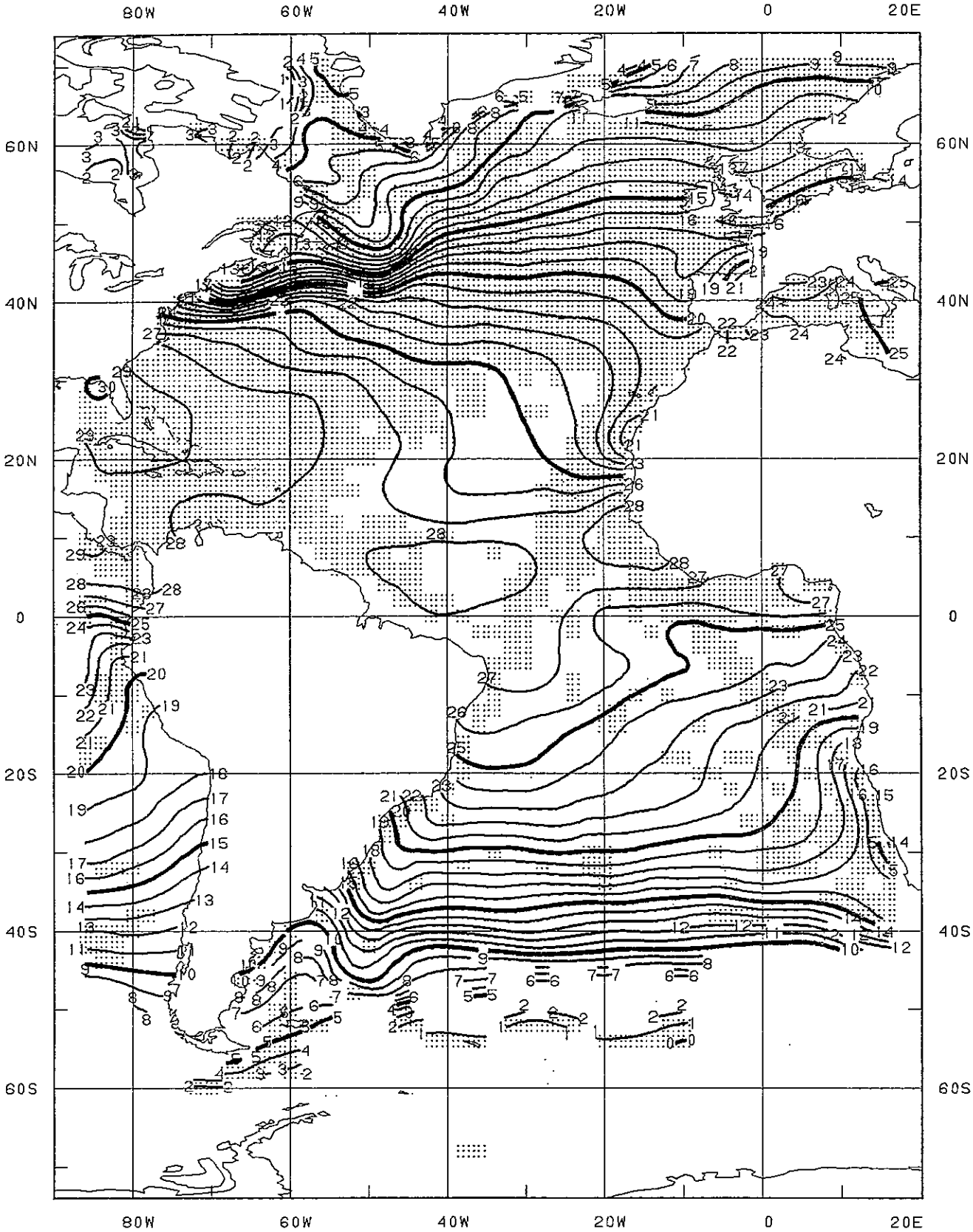

Atlantic Ocean
SST--MONTHLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA

JULY 1987

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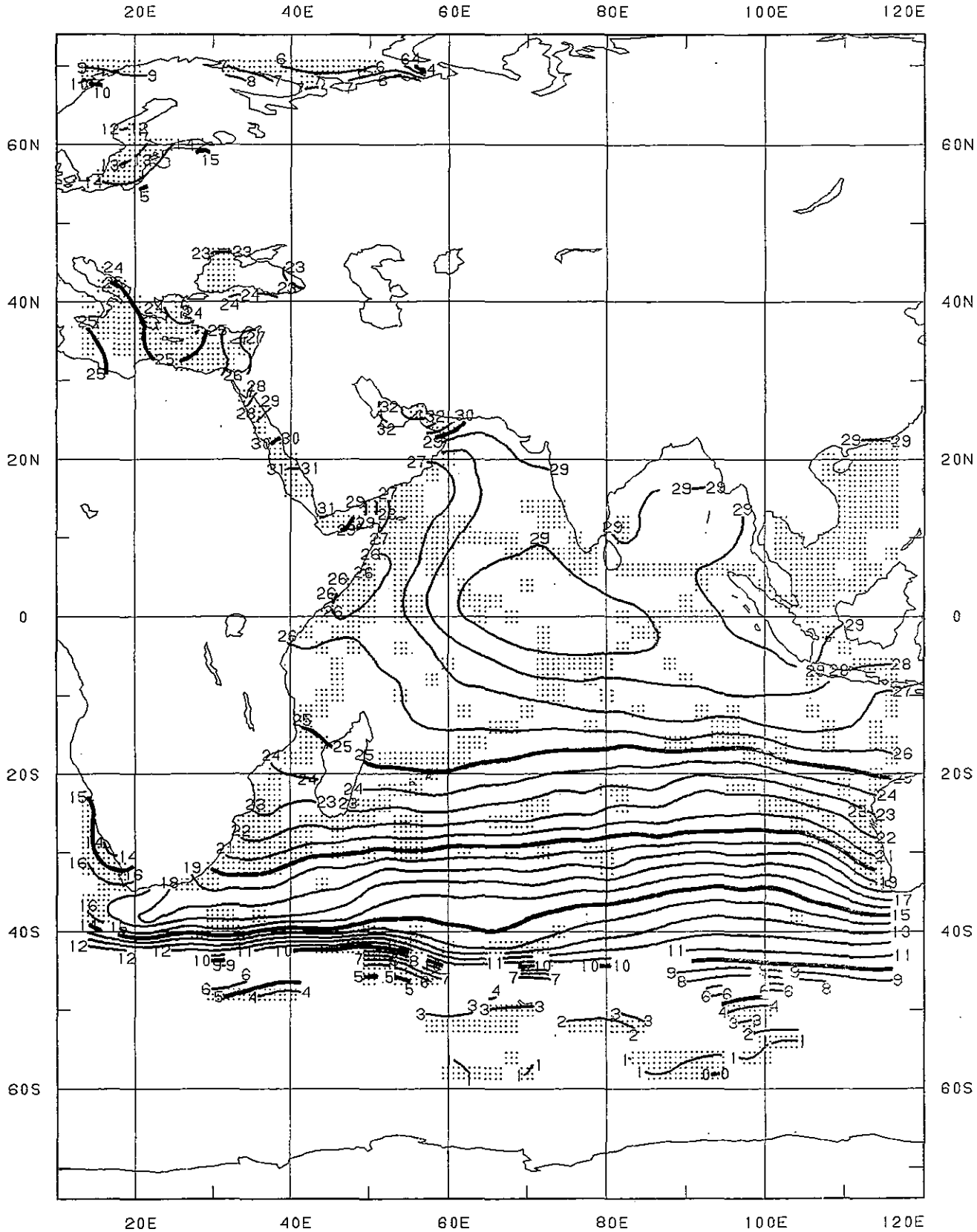

Indian Ocean
SST--MONTHLY MEAN (°C)
SHIP, BUOY, AND SATELLITE DATA
JULY 1987

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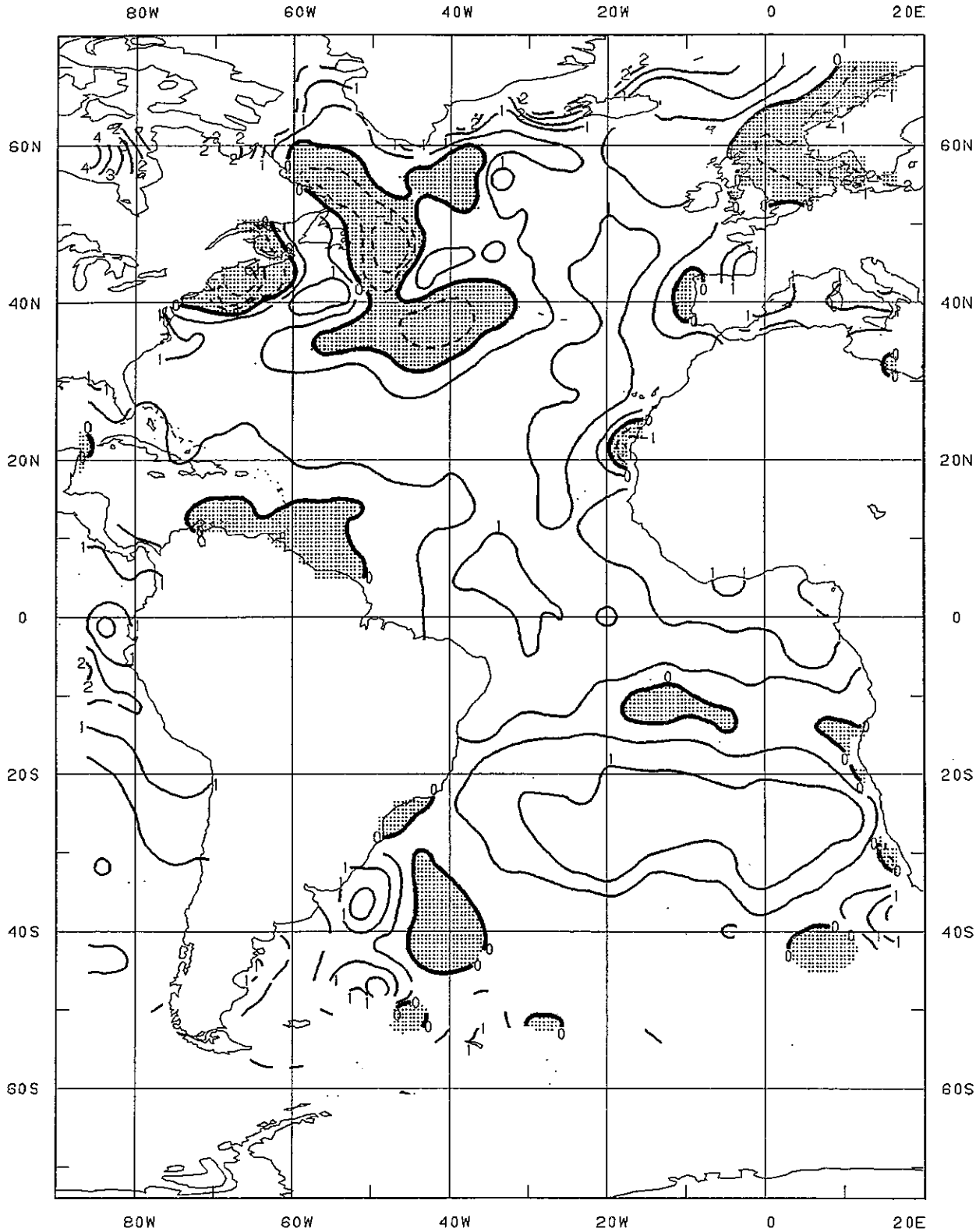

Atlantic Ocean
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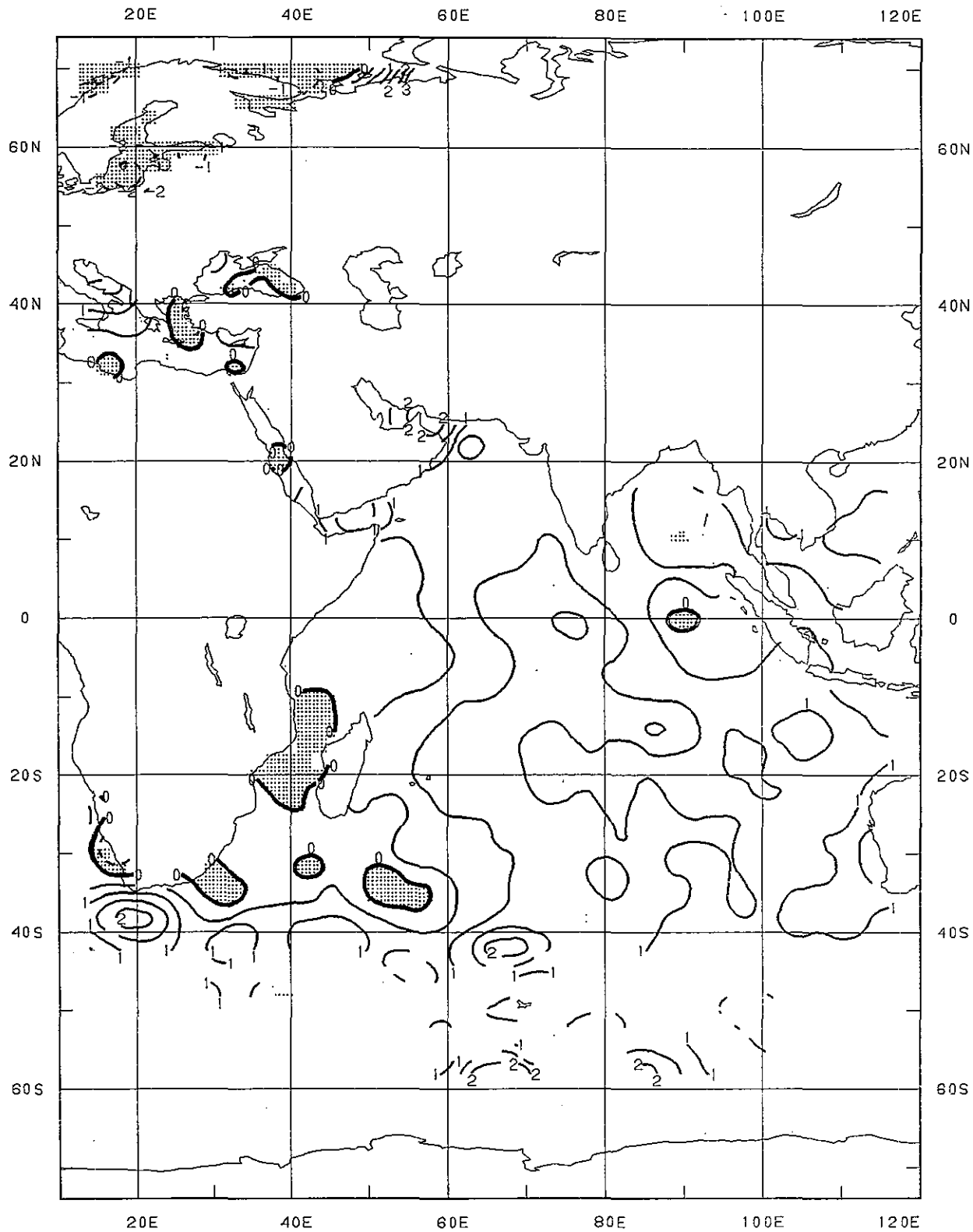

Indian Ocean
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substantial tectonic and volcanic activity, and the Triangle is marked with numerous lava lakes, fumaroles, and active and inactive volcanoes, including many which formed while the area was still submerged.

The Red Sea has no riverine inputs and has little rainfall, and evaporative losses exceed 80 inches per year. This results in very high salinities at the northern end and a substantial inflow from the Gulf of Aden to replace the losses. The more saline water sinks and accumulates below 200m, and is nearly isothermal and isohaline at 22 deg. C and 41 ppt. A density driven outflow of this water spills over the sill at Bab al Mandab and can be traced far into the Indian Ocean. Additionally, in the deepest portions of the trough, below approximately 2000m, there are pools of hot brine of up to 60 deg. C and over 260 ppt salinity. These have very high metals content, and appear to originate from leaching of evaporite and sedimentary deposits by recirculating tectonically heated water. This process may be the mechanism by which ore bodies are formed.

LARGE GULF STREAM MEANDER AFFECTS FISHING OPERATIONS NEAR HYDROGRAPHER CANYON IN EARLY 1987

By Kenneth W. Barton, LTJG, NOAA

Marine Climatology Investigation
Northeast Fisheries Center
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Narragansett, RI

Since 1974, scientists of the Northeast Fisheries Center (NEFC) of the National Marine Fisheries Service/NOAA and the University of Rhode Island's Oceanographic Remote Sensing Laboratory have been using satellite infrared data and analyses to monitor and track warm-core rings and their development from Gulf Stream meanders off the northeast coast of the United States. Interest in the NEFC has been focused on the impact of the rings on fisheries and fish distribution and abundance, particularly as the rings approach and interact with the waters of the continental shelf and upper slope.

Early in 1987, a large Gulf Stream meander developed in the ocean off the mid-Atlantic Bight and, some two months later, brought anomalous conditions to the waters near the shelf break in the vicinity of Hydrographer Canyon, south of Cape Cod. On February 2, satellite infrared data from the NOAA polar-orbiting satellites indicated that a meander had formed in the Gulf Stream with the resorbtion of the remnants of a warm-core ring near 73W. As the meander formed, it developed excursions in the course of the Gulf Stream that extended both northward and southward of the general path of the Stream. Subsequently, the meander slowly propagated downstream (eastward) until late February, when it came in contact with another warm-core ring near 70W.

In early March, satellite imagery showed the meander interacting strongly with a large cold eddy to its south. This process seemed to halt the eastward propagation of the meander while enhancing its northward expansion. Clouds obscured the sea surface during the middle of March and it wasn't until March 26 that the north wall of the Gulf Stream could be seen. At that time, the Gulf Stream was located as close as about 15km (8 nautical miles) from the continental shelf break southeast of Cape Cod. A composited image (see photo) from March 28 and 29 shows that the Gulf Stream meander had moved northward and was oriented in a northwest/southeast direction and was still attached to the main body of the Gulf Stream.

Lobster and red crab fishermen working in the area of Hydrographer Canyon, southeast of Cape Cod, experienced apparent Gulf Stream conditions during this time. Eastward currents of 3-4 knots prevented the fishermen from setting their gear. Surface temperature gradients of more than 13C were in evidence along the shelf/slope front with temperatures of 8-9C to the north and 20-21C to the south of the front.

Subsequent satellite imagery showed the meander in the process of pinching off from the Gulf Stream and forming a warm-core ring centered at 38.7N 67.0W. In the process, the meander resorbed a small weak eddy to the northeast (86H) and caused strong, warm water entrainment around two other warm core rings (86I and 87A). Ring 87A eventually split into two rings in mid April, due partly to this strong interaction. Meanders of this size are not uncommon in the area between 65W and 70W, and large temperature fronts often exist along the continental shelf. What is different about this situation is that the Gulf Stream meandered much farther to the north than normal in an area where no warm-core ring already existed and it strongly impacted fishing operations along a large section of the continental shelf break.

Image analysis was performed at the University of Rhode Island's Oceanographic Remote Sensing Laboratory with software developed by O. Brown, R. Evans, J. Brown, and A. Li at the University of Miami.

EDITOR'S NOTE: The Harvard Open Ocean Model, featured in the April 1987 issue of The Oceanographic Monthly Summary, describes the birth and development of the same warm core ring. We are fortunate to have published both mutually supporting accounts.

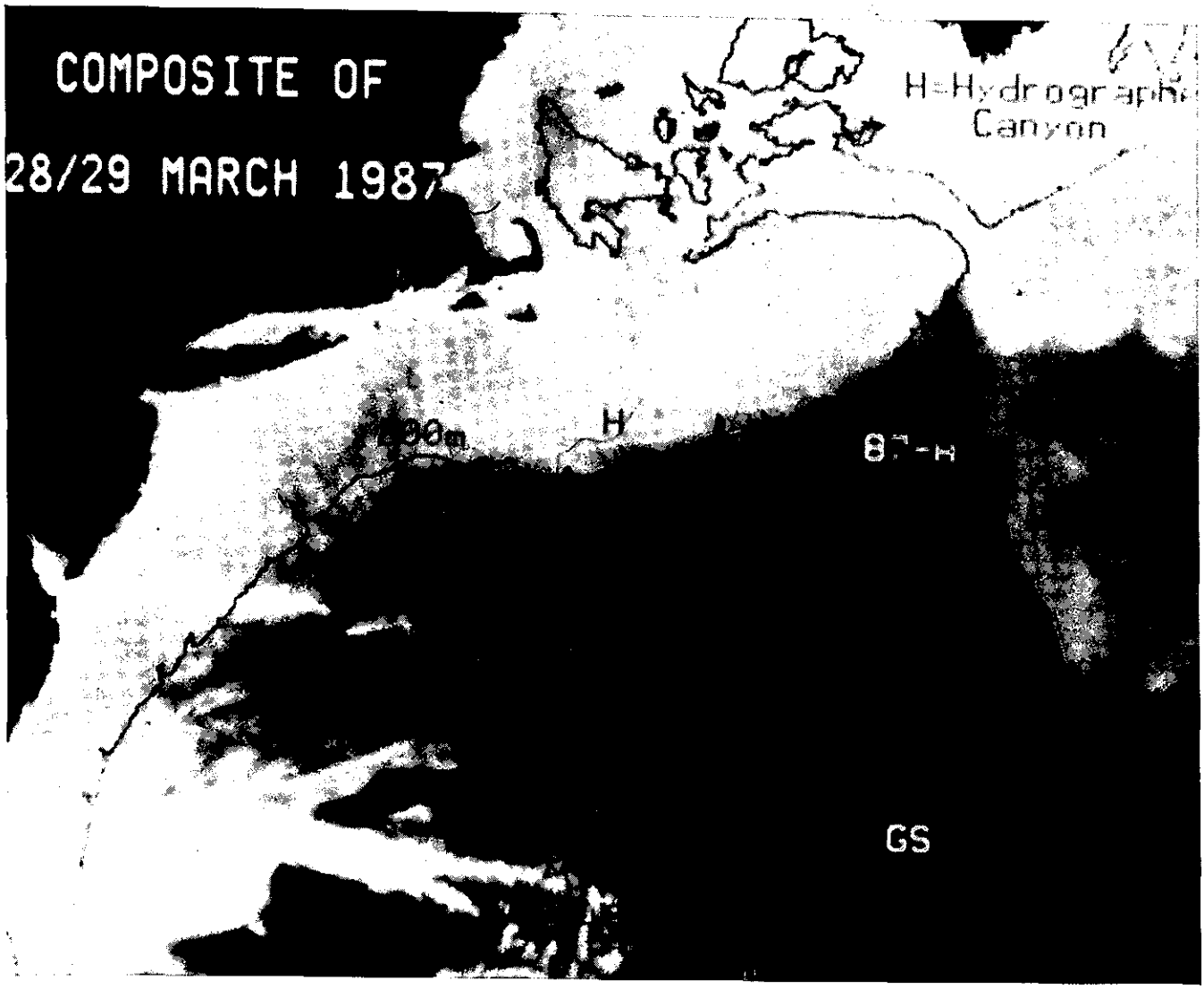
FGGE* OPERATIONAL YEAR (FOY) GLOBAL OCEAN CLIMATE DATA BASE

The National Oceanographic Data Center (NODC) has announced the availability of the Global Ocean Climate Data Base, a collection of oceanographic data submitted to NODC by 17 different countries. Although the formal FGGE operational year was from 1 December 1978 to 30 November 1979, the data set covers the extended FOY period from 1 September 1978 to 29 February 1980.

FGGE = First GARP Global Experiment, also known as the Global Weather Experiment. GARP = Global Atmospheric Research Program.

The data base includes four types of data: (1) oceanographic hydrocast (bottle) data, (2) conductivity/salinity-temperature-depth (C/STD) data, (3) expendable bathythermograph (XBT) data, and (4) Eulerian current (current meter) data. The data are recorded on magnetic tape in two different formats: (1) the Intergovernmental Oceanographic Commission General Exchange Format 3 (GF3) and (2) NODC archive formats (different format for each of the four types of data). In GF3 the data base comprises eight magnetic tapes; in the NODC formats the data base comprises four tapes.

Magnetic tape copies of the FOY Global Ocean Climate Data Base are available from the NODC in



either GF3 format or in NODC archive formats. Magnetic tape characteristics are: (1) GF3 format -- 9 track, 1600 bpi, ANSI/ASCII, non-labeled, variable record length, maximum block size = 4,160 (oceanographic station and i/STD data), 2,6000 (XBT data), and any multiple of 60 (current meter data).

Costs of the data tapes are as follows:

--GF3 Format $800
Complete set (Eight 1600 bpi tapes)

--NODC Archive Formats $460
Complete set (Four 6250 bpi tapes)

Complete ordering information is available from:

National Oceanographic Data Center
User Services Branch
NOAA/NESDIS E/OC21
Washington, DC 20235

Telephone: 202-673-5549 or FTS 673-5549
Electronic Mail: OMNET/MAIL mailbox "NODC.WDCA"

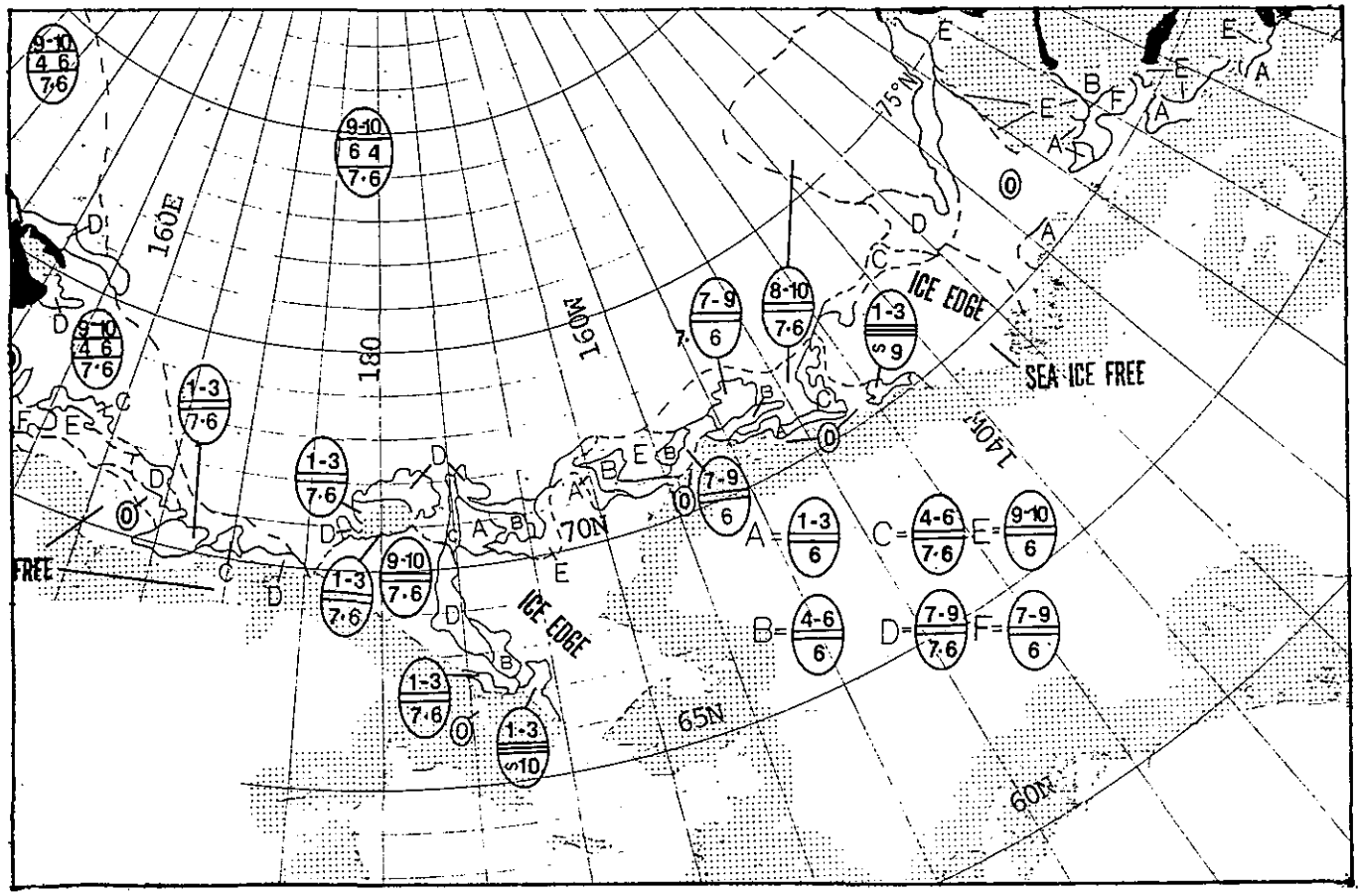
Foreign customers may prefer to order these sets from:

World Data Center A, Oceanography
NOAA/NESDIS E/OC22
Washington, DC 20235
USA

FOY Global Ocean Climate Data Tapes

Data Type	Data Quantity	Number of Tapes: GF3 Format (1600 bpi)	Number of Tapes: NODC Format (6250 bpi)*
Oceanographic Station (hydrocast)	10,413 stations (128 cruises)	2	1
CTD/STD	4,030 stations (62 cruises)	1	1
XBT	28,733 stations (571 cruises)	3	1
Current Meter	294 months (27 meters)	2	1
	TOTAL	8	4

*Data tapes in NODC archive formats are also available by special request in 1600 bpi density. Please contact NODC for details.

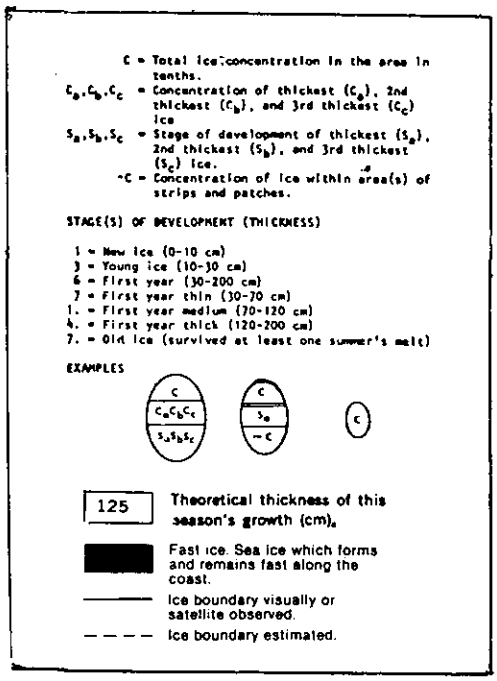


BERING SEA / NORTH SLOPE ICE ANALYSIS

Gary M. Wohl, NOAA
Navy-NOAA Joint Ice Center
National Meteorological Center, W/NMC21
(301) 763-5972

JULY 1987

A ridge of high pressure through Alaska on the surface and in the upper atmosphere supported a rapid decay of the ice in the Chukchi and Beaufort Seas. The pattern established in June of breakup being accelerated by about one week continued into July, and by month's end breakup appeared to be about ten days advanced. In the northern Chukchi Sea a classic pattern of breakup was established with ice massifs separated by open water areas. This pattern is evidently caused by the bottom topography which steers warmer waters from the Bering Sea into several canyons. Very favorable sea ice conditions for shipping to North Slope locations had been established by the fourth week of July. Except for the area immediately surrounding Point Barrow a navigable open water passage to Prudhoe Bay was observed on satellite imagery by the end of July.



WEST COAST OCEAN FEATURES

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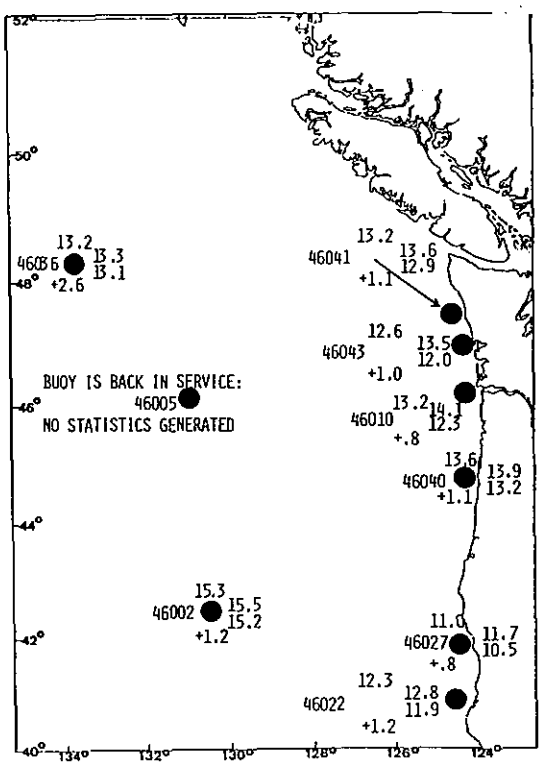
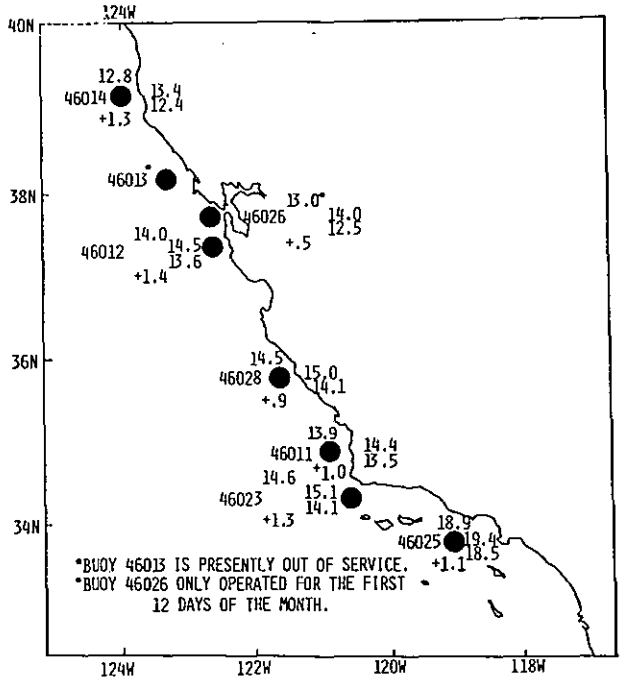
(415) 876-9122
FTS 470-9122

JULY 1987

Sea surface temperatures in the North Panel during July averaged 0.2C below the climatological mean value of 14.8C for the area. Generally speaking, temperatures were cooler than normal from Vancouver Island and Washington state toward the southwest edge of the analysis area. The coolest anomaly of 1.0C was observed near 43N 127W. When comparing July's SST's to the previous month, the entire chart experienced warming from 1.6C to 3.0C. The area of maximum warming was in the NW corner of the North Panel. Nearshore upwelling activity was ongoing for practically the entire month between 40 and 45N. The buoy statistics herein also substantiate the warming that was observed since June.

In the South Panel, SST's fared differently. The computed monthly mean temperatures averaged 0.4C warmer than the normal value of





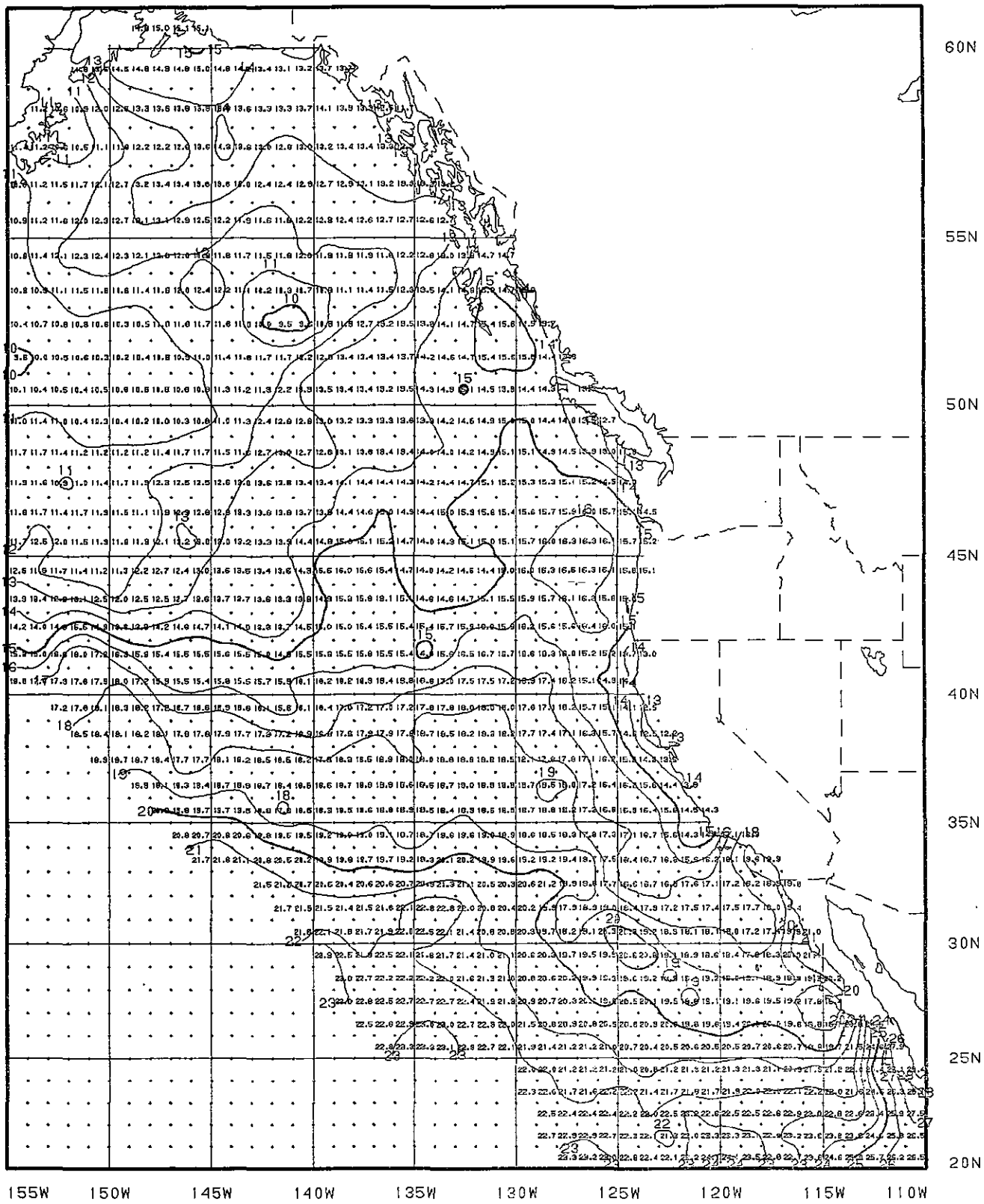
17.4C. Again, there was a "mixed bag" of some areas above and some below normal. To simplify the overall picture, waters east of 130W were warmer than normal and those west of 130W, cooler. The greatest warm anomaly of 1.5C was analyzed at 29N 125W. Nearshore waters were from 0.2C to 0.8C warmer than climatology. The maximum cool anomaly of 1.5C was in the extreme NW corner of the chart. Looking at how the temperatures changed since June, the same trend was observed in the South Panel with overall warming in every location. The greatest warming of from 1.5 to 2.1C occurred between

KEY:

12.1 ← Monthly mean
LOCATION 13.5 ← Maximum daily mean
NAME 10.2 ← Minimum daily mean
-1.5 ← Change from previous month

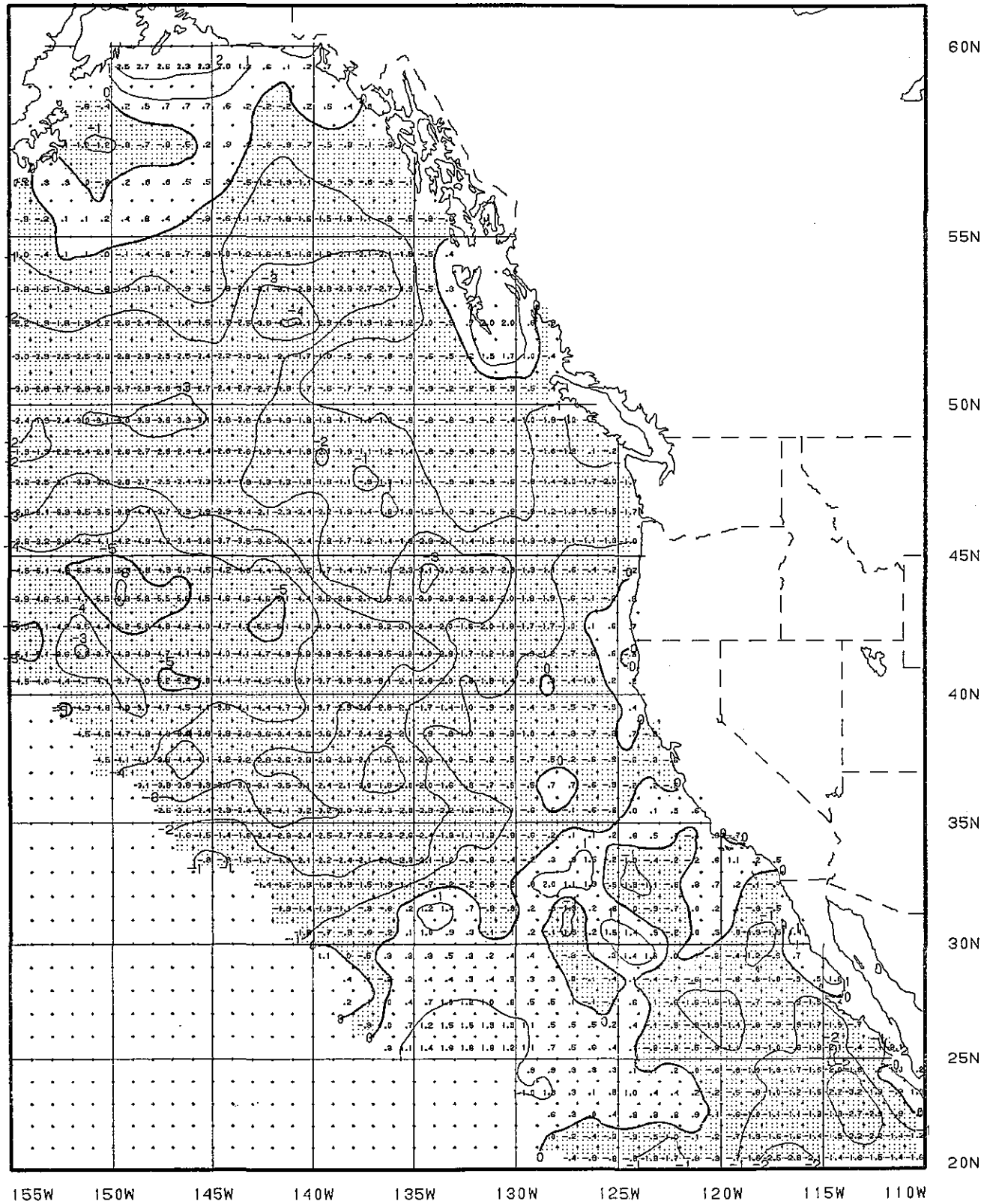
● Denotes station position.

124 and 132W. The least warming of 0.5C or less was in 2 locations: the Los Angeles Bight and in the southwest corner of the chart. Buoy statistics revealed similar information as in the North Panel...warming at all fixed buoy locations. Upwelling was an ongoing process along the California coast from San Francisco Bay northward during the month of July.



West Coast
SST--MONTHLY MEAN (°C)
JULY 1987

Monthly mean sea surface temperature is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0°C.



West Coast
SST--MONTHLY ANOMALY (°C)
JULY 1987

Monthly anomaly is the difference between the monthly mean sea surface temperature and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0°C.

EAST COAST OCEAN FEATURES

Jenifer Clark
NOAA, NWS
Washington, DC 20233
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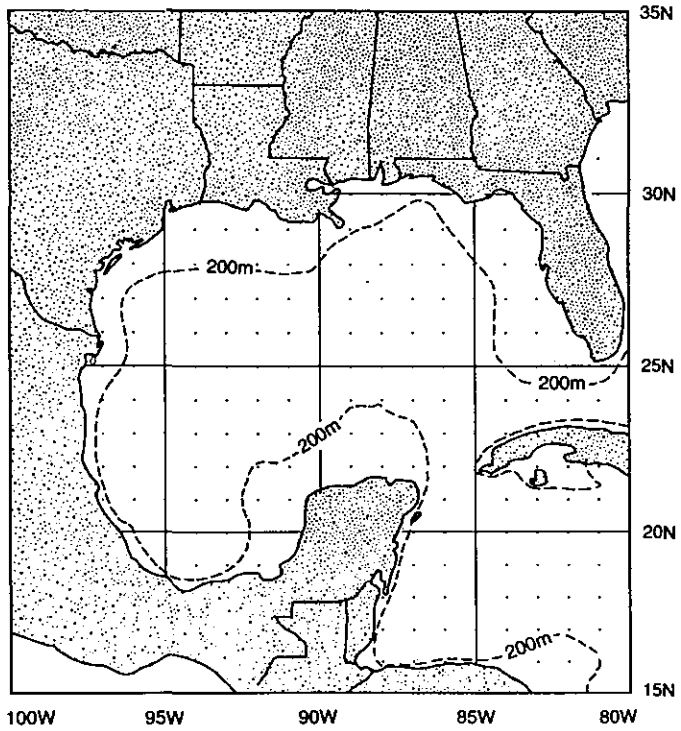
Data used in this analysis include:
Infrared imagery from NOAA satellite - NESDIS
Bathythermograph data from National Meteorological Center of National Weather Service
Oceanographic Analysis -- A daily detailed analysis issued by National Weather Service

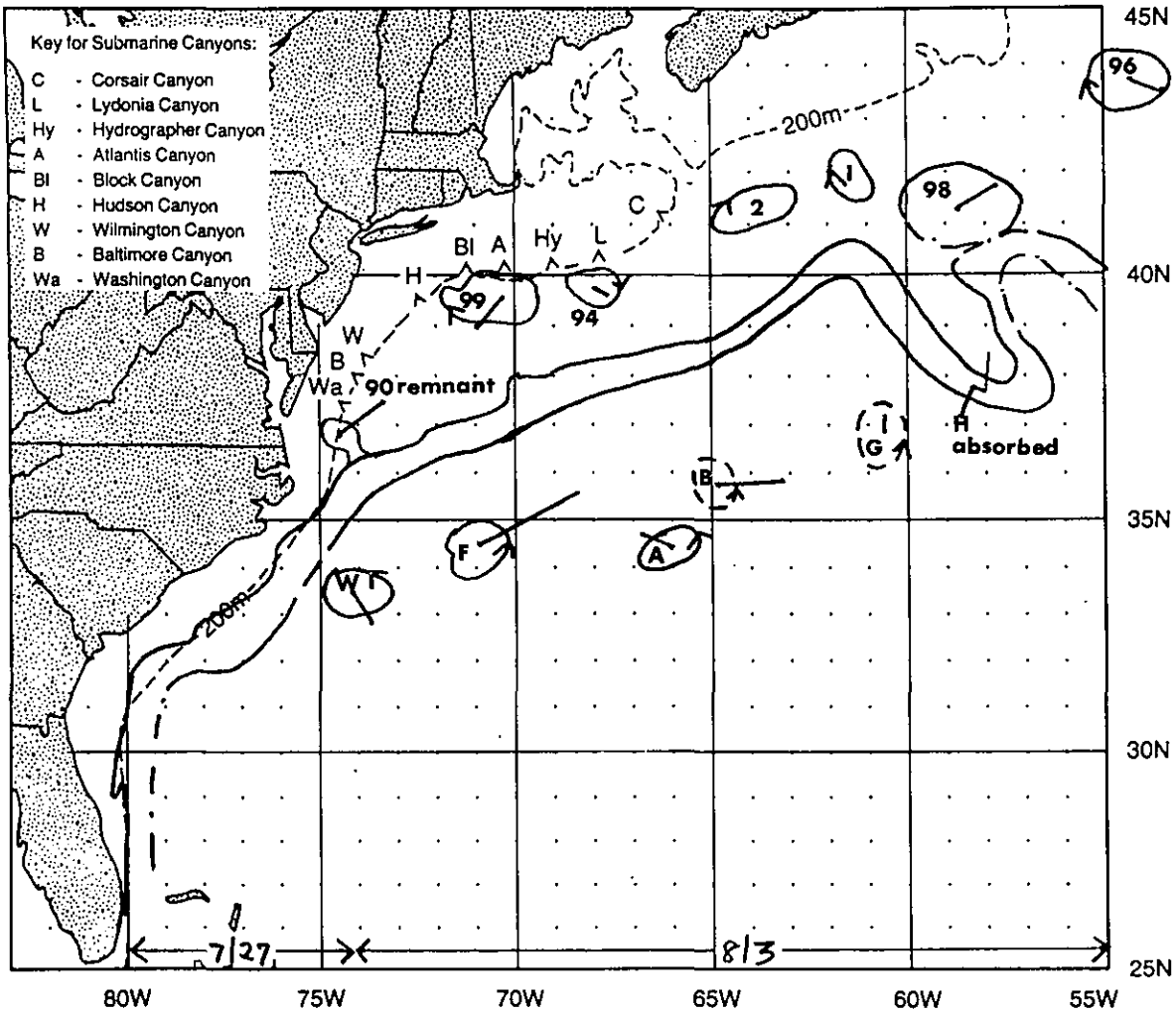
JULY 1987

The end of this month's positions of the Gulf Stream System and its associated eddies are shown for the NW Atlantic and the Gulf of Mexico. The Gulf Stream and Loop Current boundaries are located by infrared satellite imagery or XBT (expendable bathythermograph) data. Anticyclonic eddies are labeled a-z in the Gulf of Mexico and 1-99 in the Northwest Atlantic. Cyclonic eddies are labeled A-Z. Arrows on eddies indicate direction of circulation. Warm-core or anticyclonic eddies rotate clockwise; cold-core or cyclonic eddies rotate counterclockwise. The line to the eddy center shows the net translation since last month or since last observed. The edge of continental shelf at 200 m is shown as a dashed line. Eddies or sections of the Gulf Stream System which were not observed during the month are not shown on the analysis chart or are indicated by "dot-dashed" lines. The long arrows at the bottom of the chart indicate the dates of data used.



GULF OF MEXICO

Due to isothermal conditions and cloudiness, the Loop Current in the Gulf of Mexico was not observed.



NORTHWEST ATLANTIC OCEAN

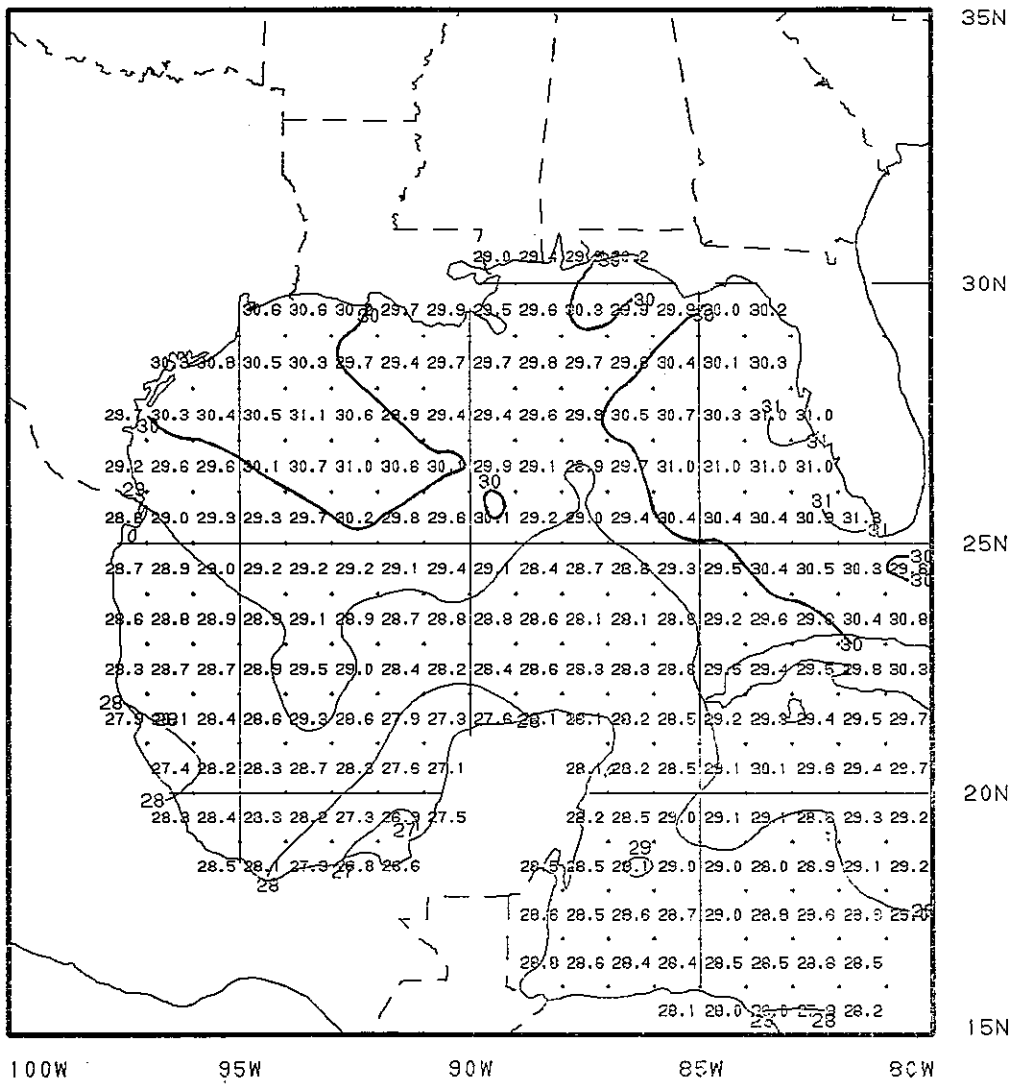
Two anticyclonic eddies apparently formed during July. Eddy 1 possiby formed from a Gulf Stream aneurism near 41N 61W about July 1. The origin of eddy 2 (centered near 41N 64W) is not clearly known due to clouds. Eddy 2 may have formed from a Gulf Stream meander near 41 63W around July 8. One anticyclonic eddy was absorbed by the Gulf Stream. Eddy 90 translated 110 km SW and appears to be absorbed by the Gulf Stream near 37N 74W.

Eddy 99 translated 75 km NE while eddy 94 translated 45 km NW. Eddy 98 moved 75 km SW. Eddy 96 traveled 65 km NW.

One cyclonic eddy was absorbed twice during July. Eddy H was absorbed by the Gulf Stream on July 8 near 38N 58W. On July 13 eddy H formed again. On August 3 eddy H was again resorbed by the Gulf Stream.

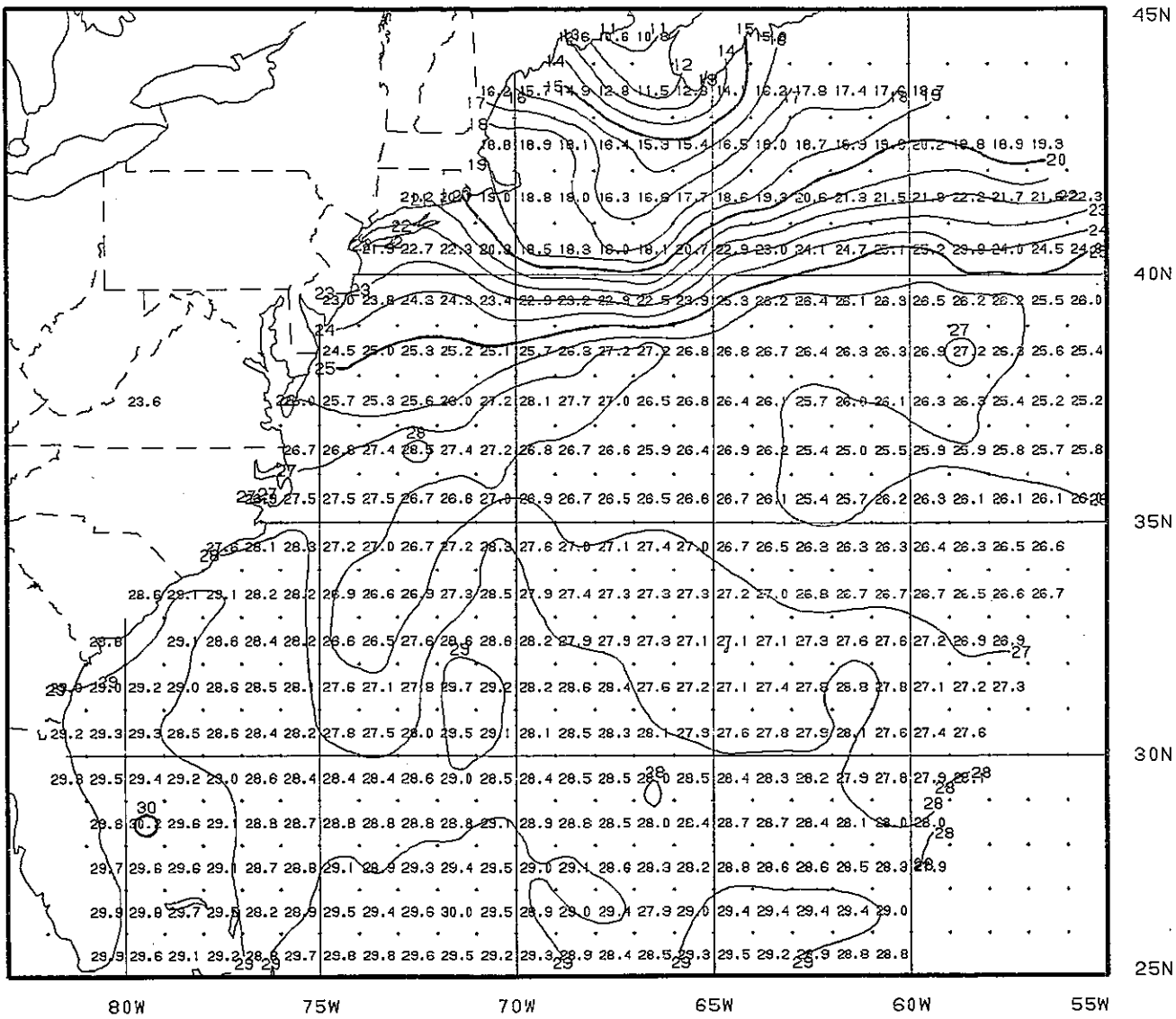
Eddy W translated 85 km NW. Eddy F moved 240 km SW. Eddies A and B traveled 65 km SE and 130 km W, respectively. Eddy G moved 35 km S. Eddies C, D, and Y were not observed and were therefore eliminated from the chart.

EAST COAST SST – MONTHLY MEAN



Gulf of Mexico
SST--MONTHLY MEAN (°C)
JULY 1987

Monthly mean sea surface temperature is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0°C.



Northwest Atlantic Ocean
SST--MONTHLY MEAN (°C)
JULY 1987

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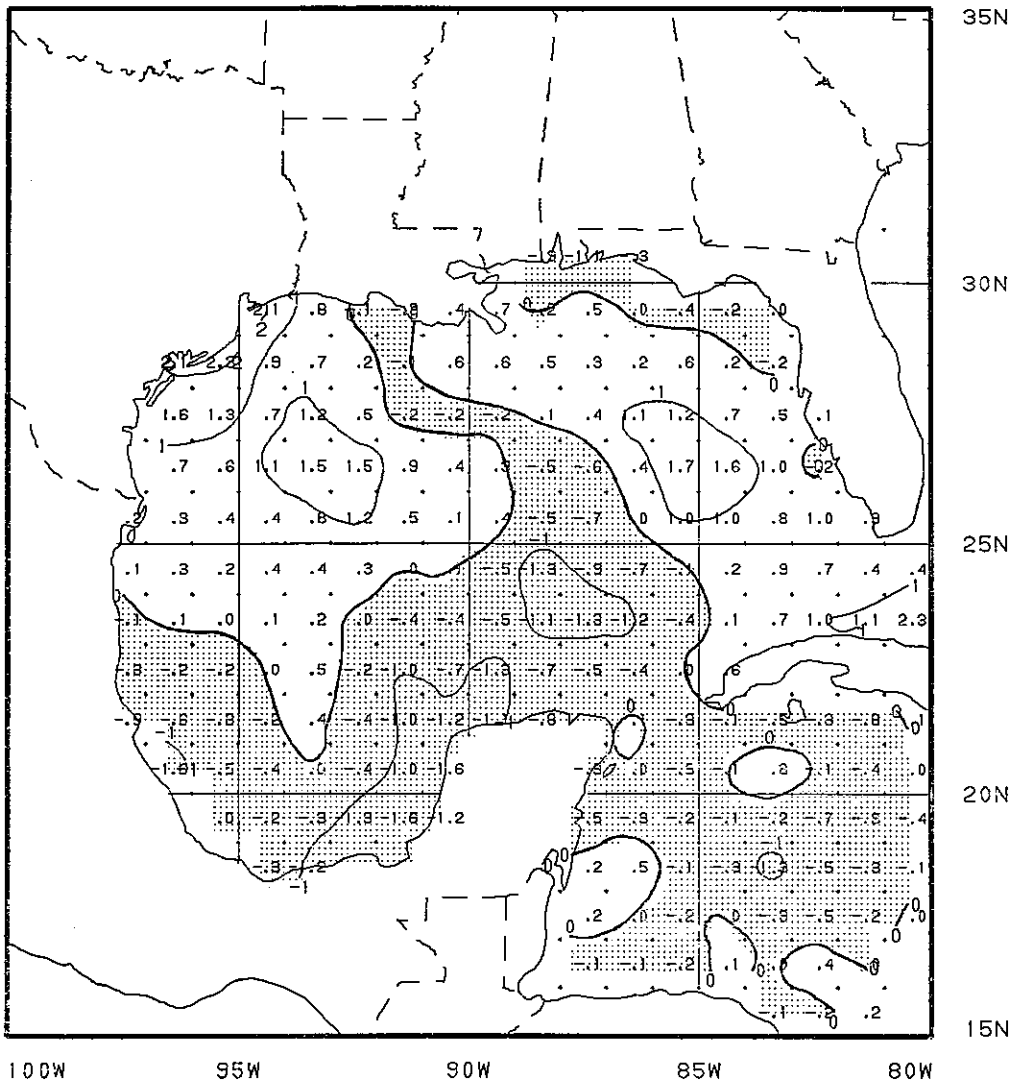
EAST COAST SST – ANOMALY



Gulf of Mexico
SST--MONTHLY ANOMALY (°C)
JULY 1987

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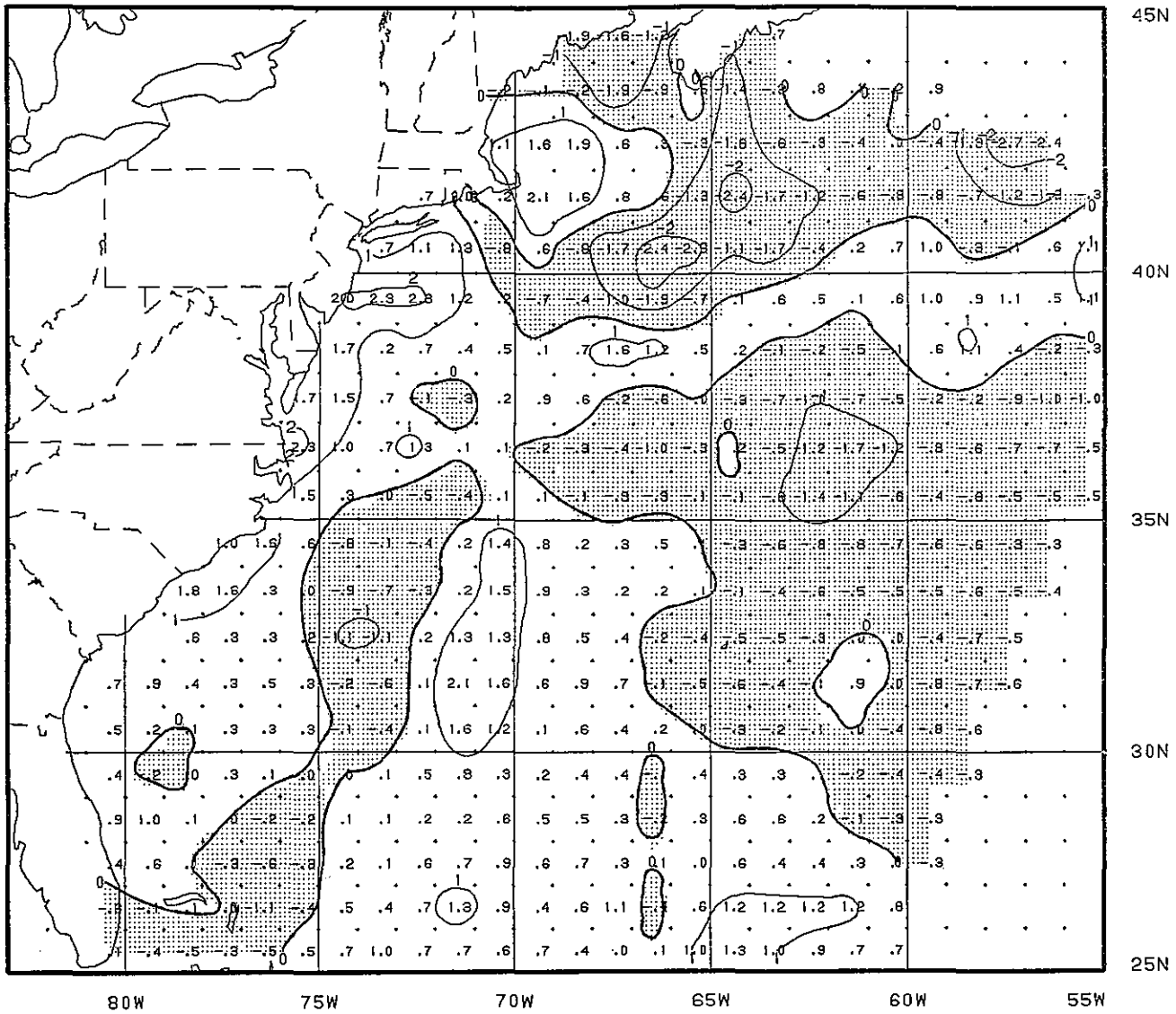

Northwest Atlantic Ocean
SST--MONTHLY ANOMALY (°C)
JULY 1987

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OCEANOGRAPHIC Monthly Summary

/olume VII Number 8 August 1987

Chukchi Sea Meltback (page 3)

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National Environmental Satellite, Data, and Information Service
National Ocean Service

OCEANOGRAPHIC
Monthly Summary

Oceanographic Monthly Summary is published by the National Weather Service (NWS), the National Environmental Satellite, Data, and Information Service (NESDIS), and the National Ocean Service (NOS). *Oceanographic Monthly Summary* contains sea surface temperature (SST) analyses on both regional and ocean basin scales for the Atlantic, Pacific, and Indian Oceans. The ocean basin analyses are based on a "blend" of *in situ* and satellite data, in which *in situ* data are used to define "benchmark" temperature values in regions of frequent observations and satellite data are used to define the "shape" of the field between these points.[1]

An ocean basin SST anomaly is derived from the "blended" SST analysis[1] and the improved global SST.[2] The regional SST analyses are based upon a combination of *in situ* and satellite data measurements. The regional SST anomalies are calculated from the Robinson-Bauer Climatology.[3,4] *Oceanographic Monthly Summary* also contains Alaskan sea ice information and ocean feature information for contiguous U.S. ocean regions.

Oceanographic Monthly Summary welcomes articles containing information of interest to its readers, such as news on operational oceanography, unusual ocean feature phenomena, etc. Contributions should be sent to the editor (address below). Accepted material will appear in the OceaNotes section of *Oceanographic Monthly Summary*. Contributions can be published as quickly as the next monthly issue.

If you are interested in receiving *Oceanographic Monthly Summary* regularly, please refer to the back cover for subscription information.

[1]Reynolds, R.W. and W.H. Gemmill, 1984. A sea surface temperature analysis which blends *in situ* and satellite observations. *Proceedings of the Ninth Climate Diagnostics Workshop*, Corvallis, OR, Oct. 22-26, 1984, pp. 408-416.

[2]The climatology is derived from *in situ* data (1950-1979), satellite data (1982-1985) and an ice climatology.

[3]Robinson, M.K., 1976. Atlas of North Pacific Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOcean Ref. Pub. 2.*

[4]Robinson, M.K., R.A. Bauer, and E.H. Schroeder, 1979. Atlas of North Atlantic-Indian Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOceano Ref. Pub. 18.*

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OceaNotes

CHUKCHI SEA MELTBACK PATTERN

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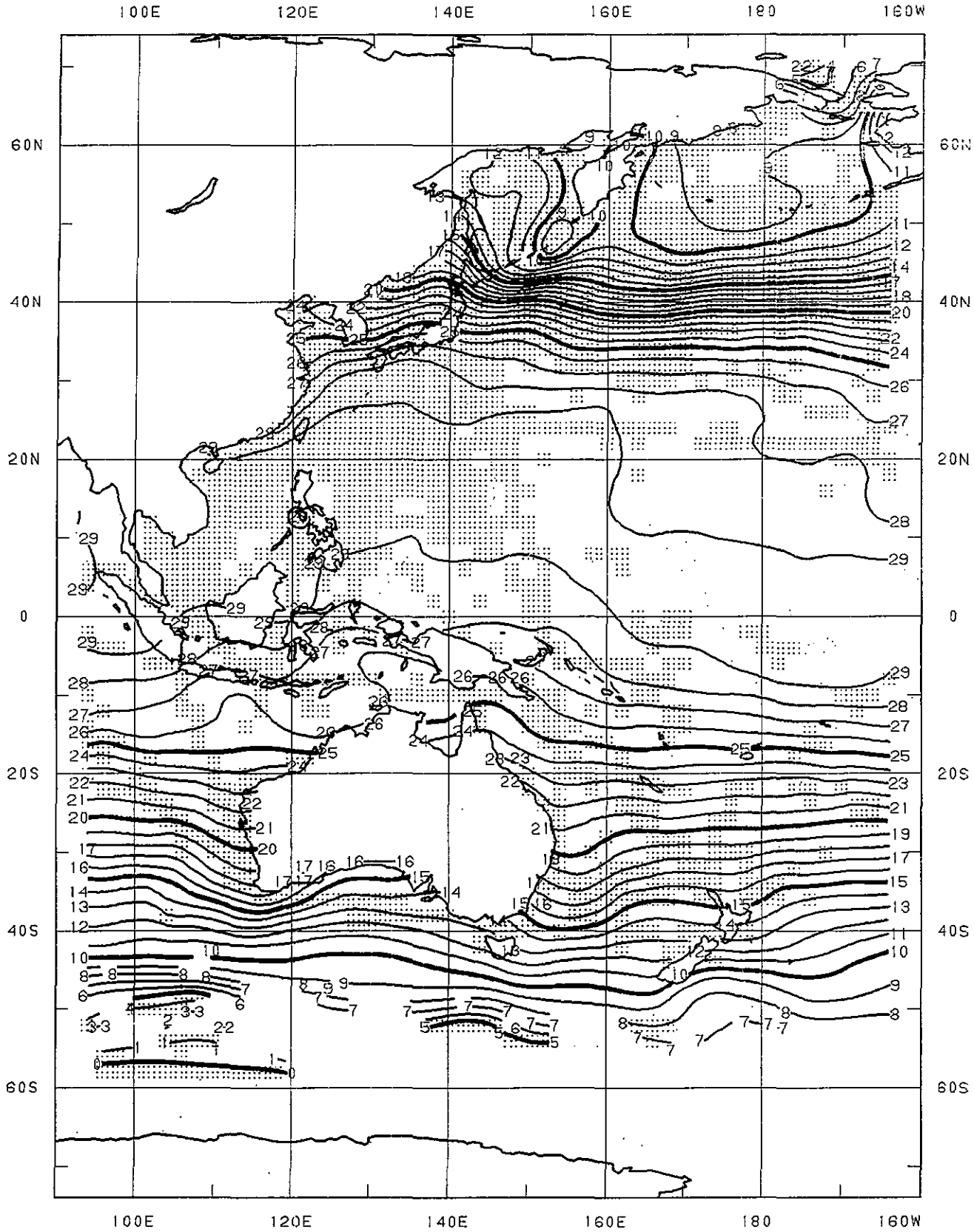
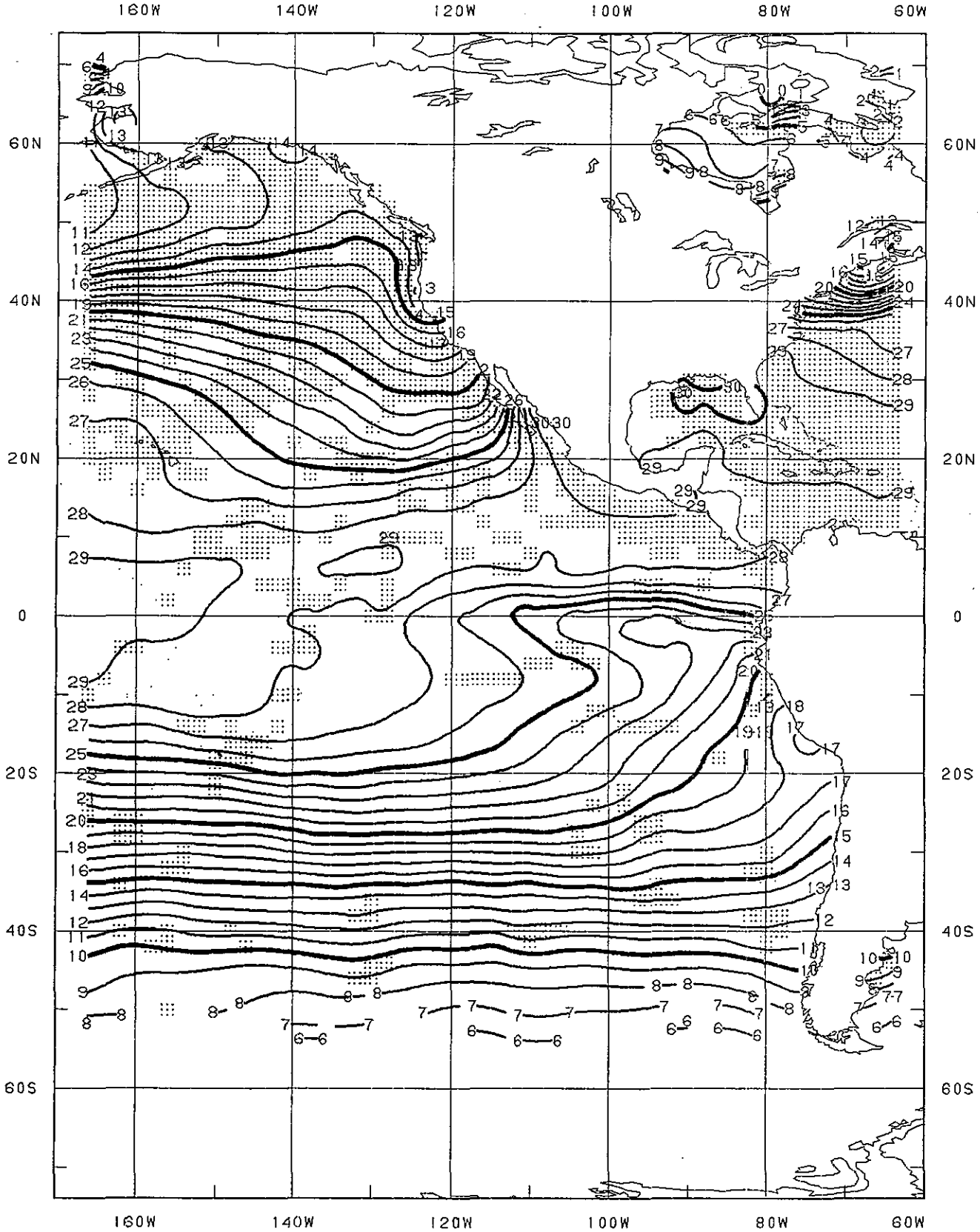
This NOAA-9 AVHRR visible image of the Chukchi Sea was taken July 7, 1987 at 12:45 GMT. The Chukchi Sea (CS) lies immediately north of the Bering Strait (BS). It is bounded on the west by Wrangel Island (WI), on the north by the edge of the Continental Shelf, and on the east by Point Barrow (PB).

This image represents the typical meltback pattern of the Chukchi Sea. It is the result of a temperature and salinity front formed as the result of ice melt by warm surface water from the south. The front is controlled by steering of the currents by bottom bathymetry. In the summer this is one of the strongest fronts to be found in any ocean. The sharply defined boundaries mark the warm southern and cold northern waters. The Chukchi Sea is a shallow sea with a mean depth of 40-50 meters. The flows indicated by the melted out bays are closely correlated with troughs in the bathymetry.

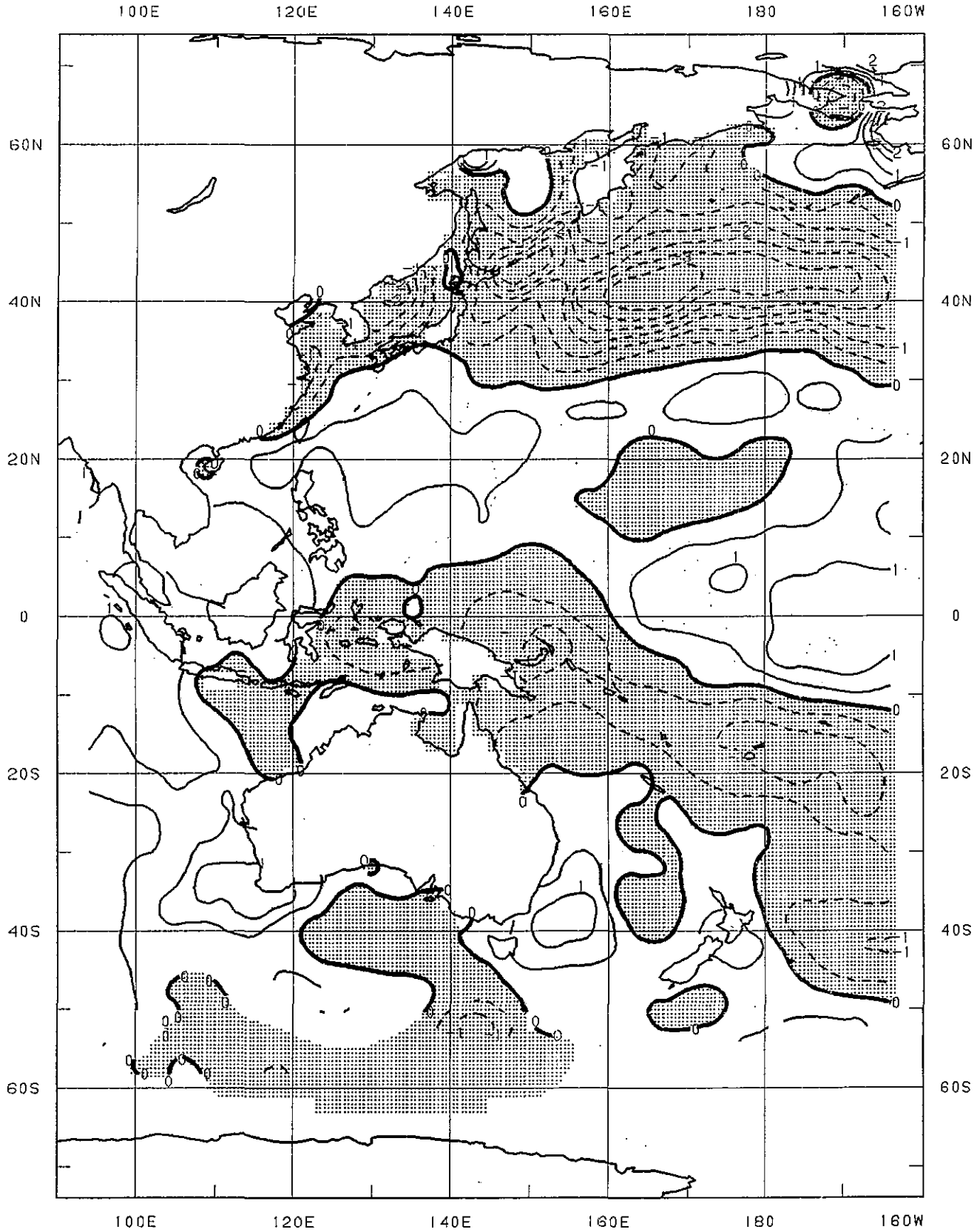
(text continued on page 13)



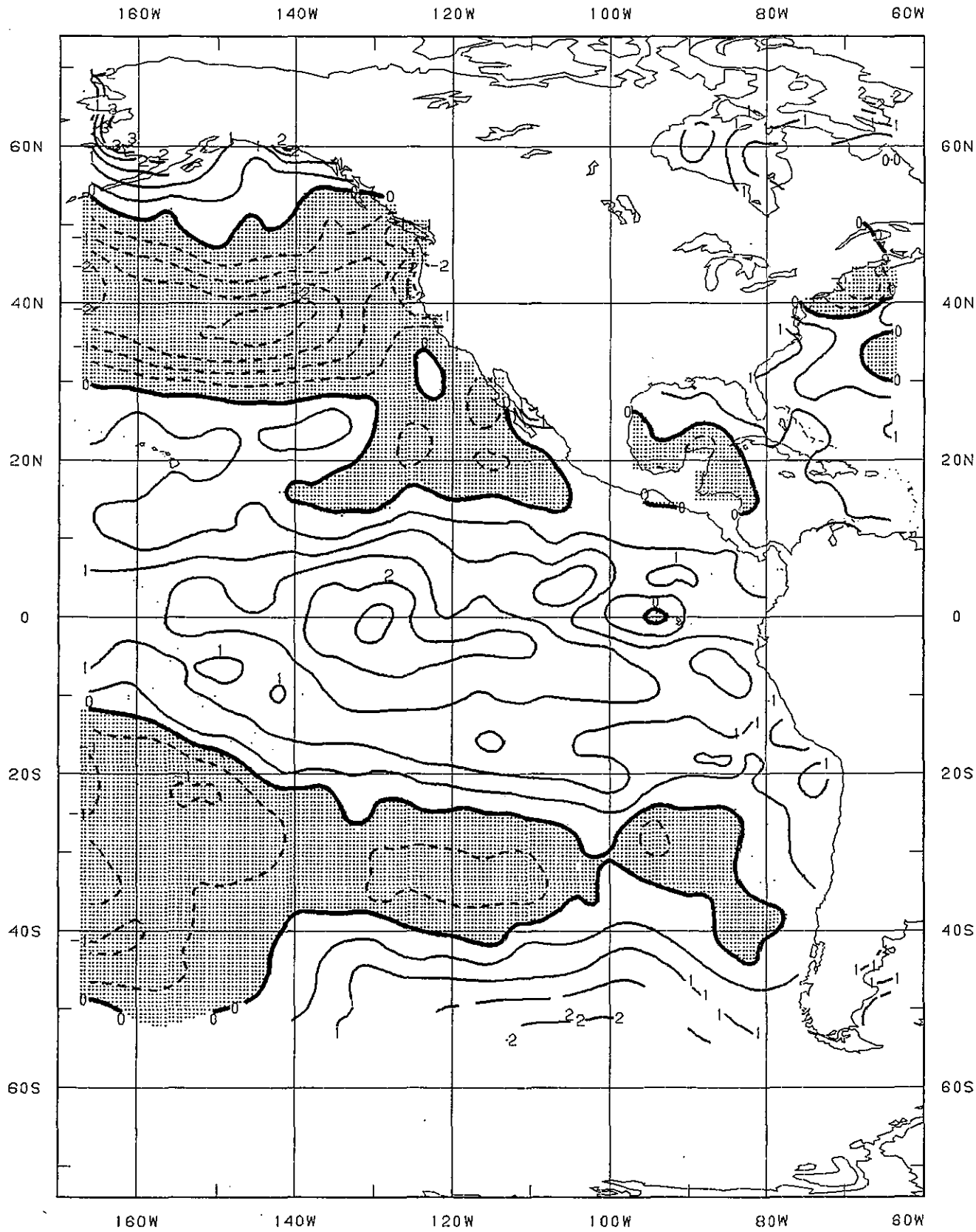
AUGUST 1987 WESTERN PACIFIC OCEAN SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of **in situ** (ship, buoy) and satellite data within two-degree quadrangles. Contour line interval is 1.0 C. The stippling indicates where the analysis was fixed by the **in situ** data; contours are not shown in areas without data.



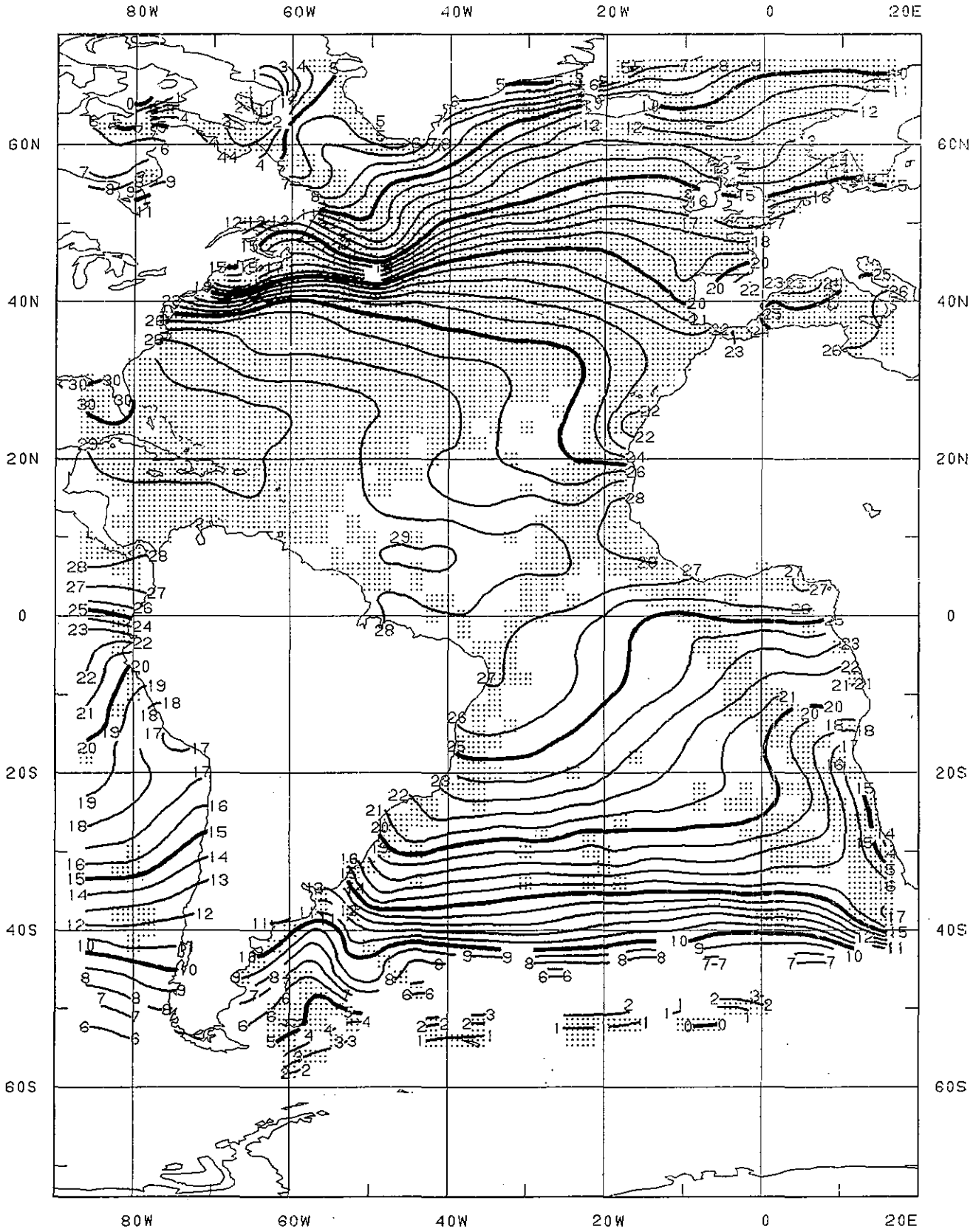
AUGUST 1987 EASTERN PACIFIC OCEAN SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of **in situ** (ship, buoy) and satellite data within two-degree quadrangles. Contour line interval is 1.0 C. The stippling indicates where the analysis was fixed by the **in situ** data; contours are not shown in areas without data.



AUGUST 1987 WESTERN PACIFIC OCEAN SST--MONTHLY ANOMALY (C)--Monthly anomaly is the difference between the monthly mean SST and the climatological monthly mean value. Contour line interval is 0.5 C. The stippling indicates where the monthly mean is colder than climatology; contours are not shown in areas without monthly or climatological data.



AUGUST 1987 EASTERN PACIFIC OCEAN SST--MONTHLY ANOMALY (C)--Monthyly anomaly is the difference between the monthly mean SST and the climatological monthly mean value. Contour line interval is 0.5 C. The stippling indicates where the monthly mean is colder than climatology; contours are not shown in areas without monthly or climatological data.



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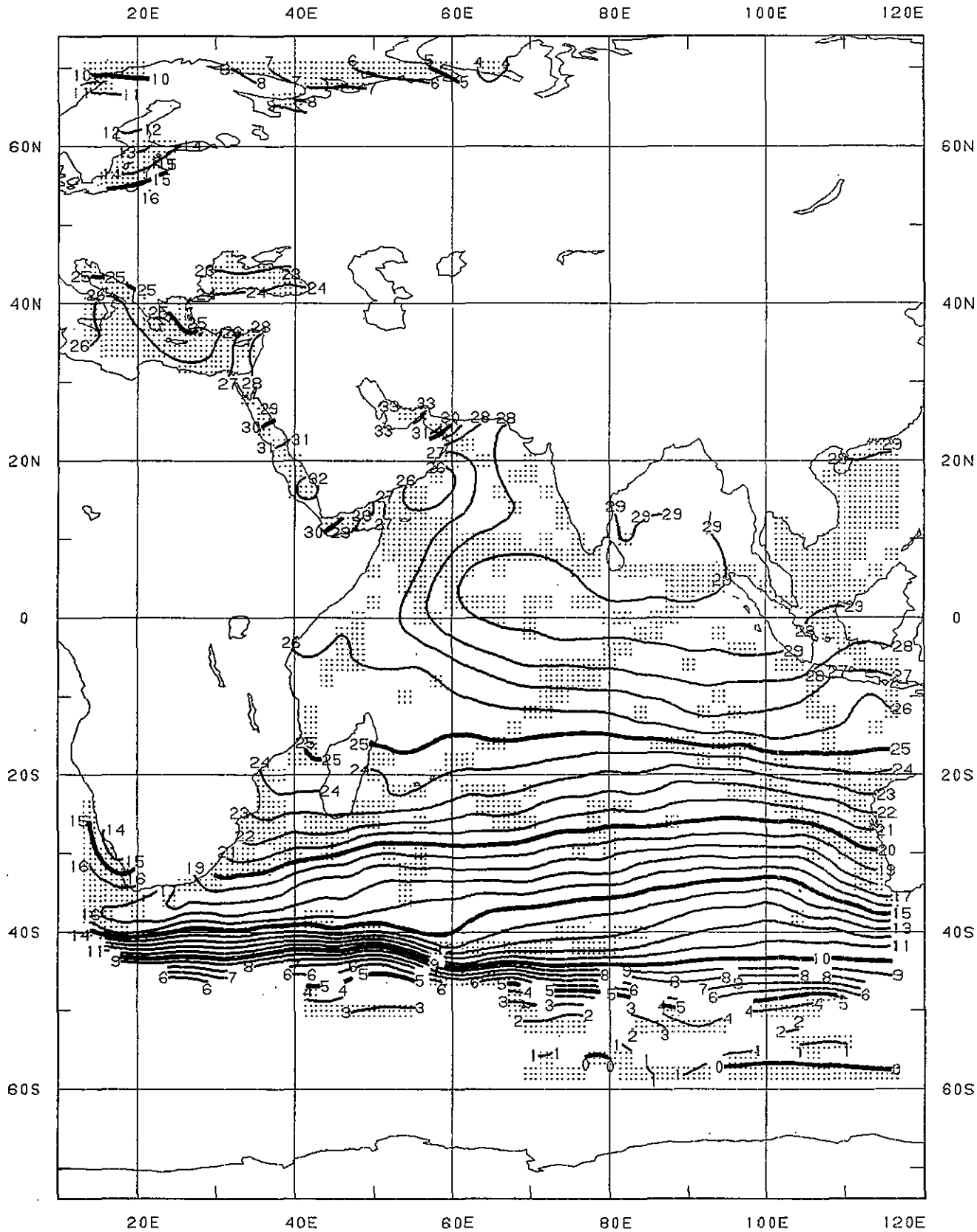
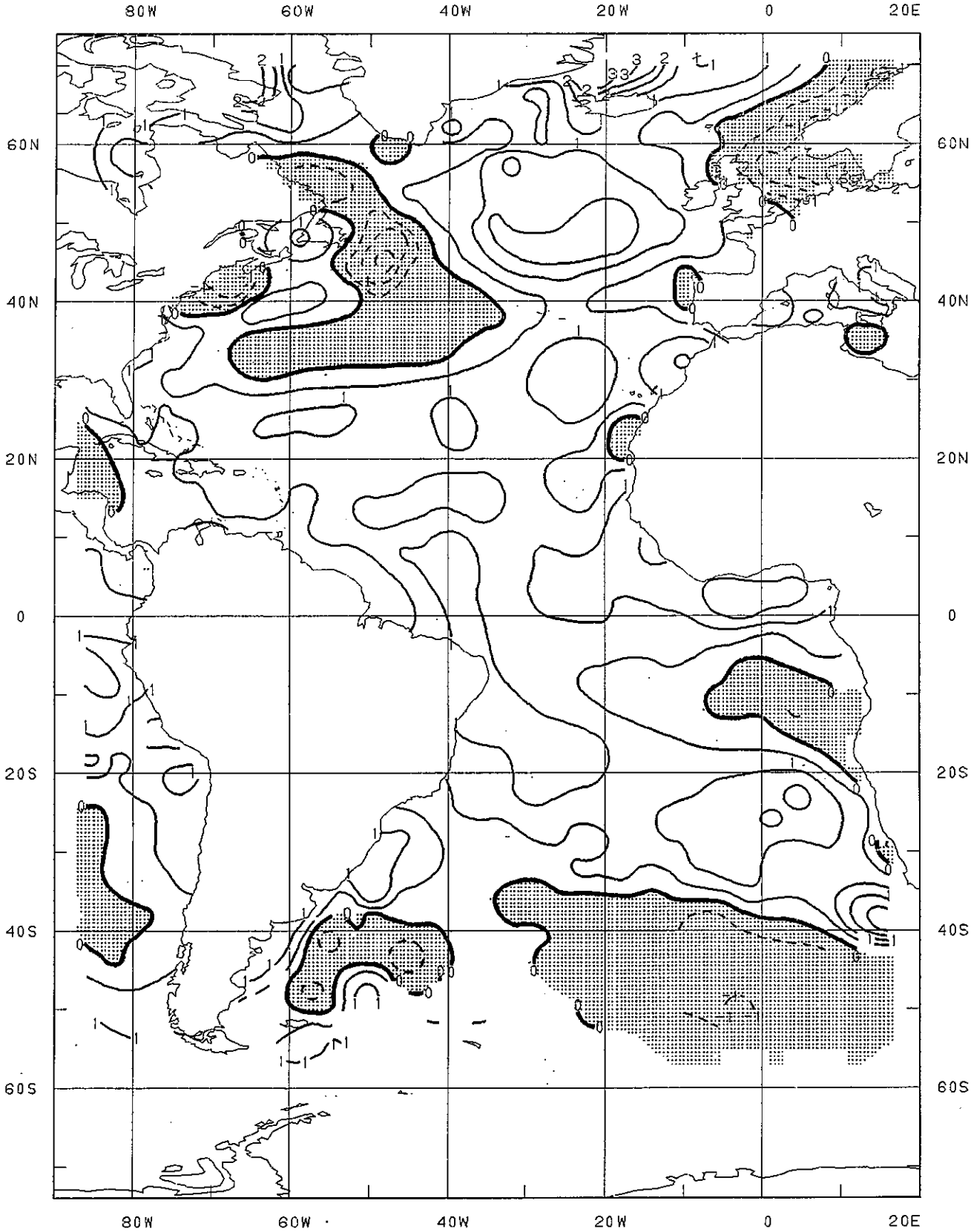


AUGUST 1987 INDIAN OCEAN SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of **in situ** (ship, buoy) and satellite data within two-degree quadrangles. Contour line interval is 1.0 C. The stippling indicates where the analysis was fixed by the **in situ** data; contours are not shown in areas without data.



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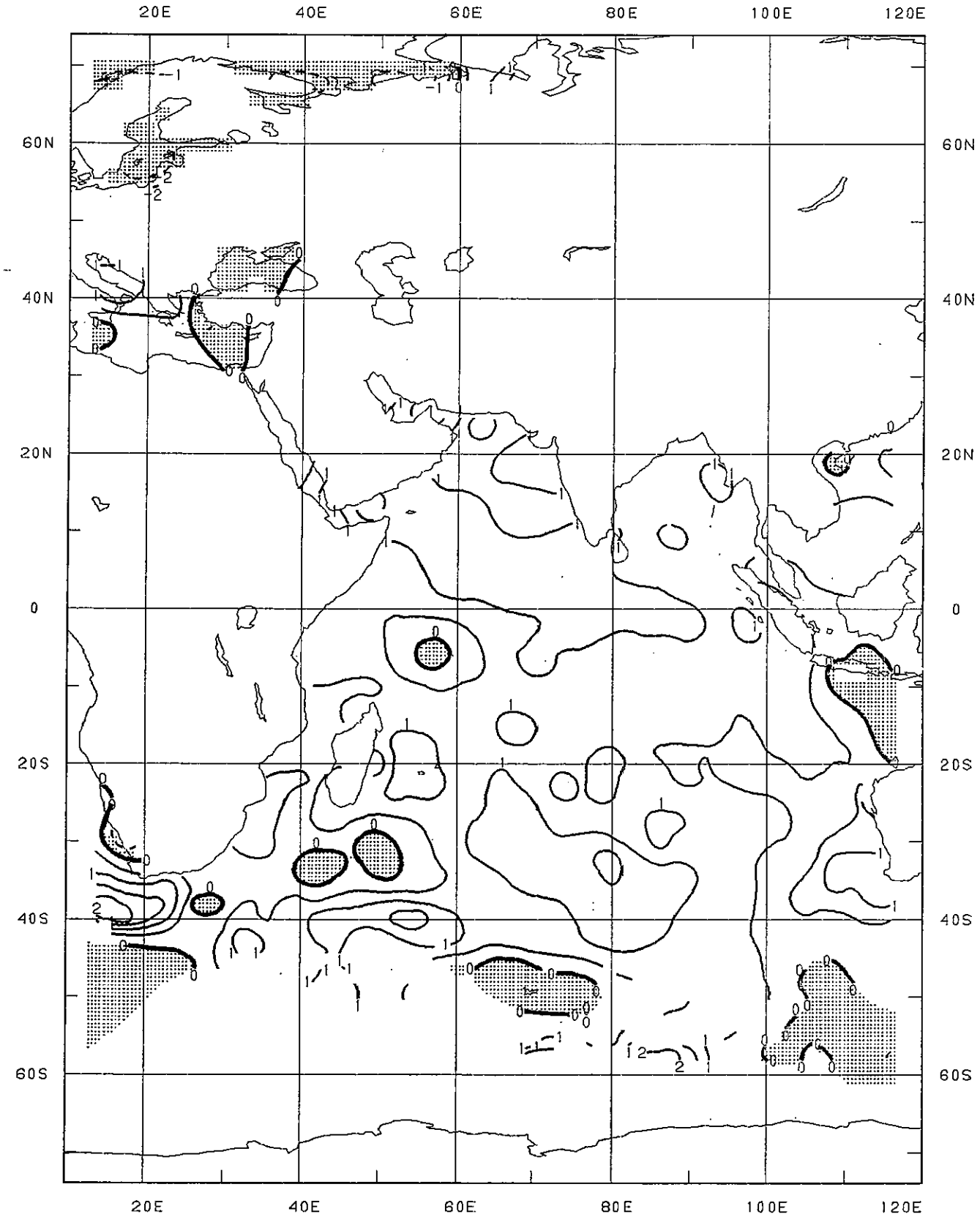

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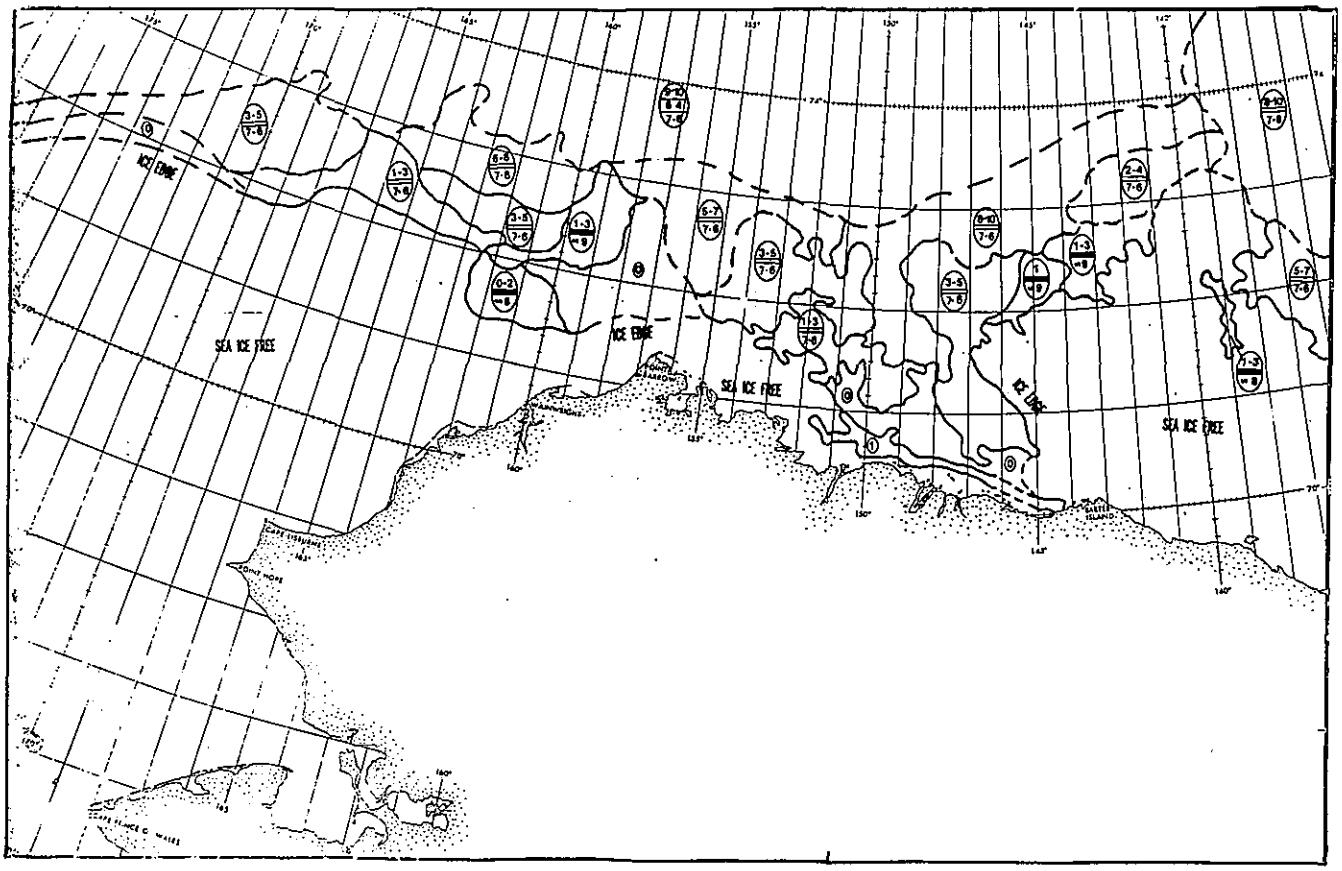
OceaNotes

(Continued from page 3)

The area between the heavy dashed line and the consolidated pack ice is known as the Marginal Ice Zone (MIZ). It is the boundary between ice covered and open ocean where ice and relatively warm water interact. The MIZ is marked by a band of loose ice floes. Winds blowing off the ice and currents emerging from under it tend to loosen the floes and form a broad zone. Winds off the sea and currents flowing toward the ice compact the margin. The margin is indented by bays of various sizes, some of them similar from year to year and caused by characteristic water circulation. The ice is melted partly by insolation but mainly by a current of warm salty water that flows northward through the Bering Strait.

The ice reaches its maximum retreat at 72°-75°N in mid-September. The Barrow Canyon parallels the coast of Alaska and heads far back on the shelf. Herald Canyon, just east of Herald Island (71°20N 176°W), has a shallow trough. These areas have flow paths that are moving northward, helping to form the meltback pattern. The Alaskan coastal current, a northeasterly current, flows along the coast from Cape Lisburne (CL) to Point Barrow and then eastward into the Beaufort Sea. This warm stream probably is the principal cause of the melting of the shore lead along the northwestern Alaskan Coast.

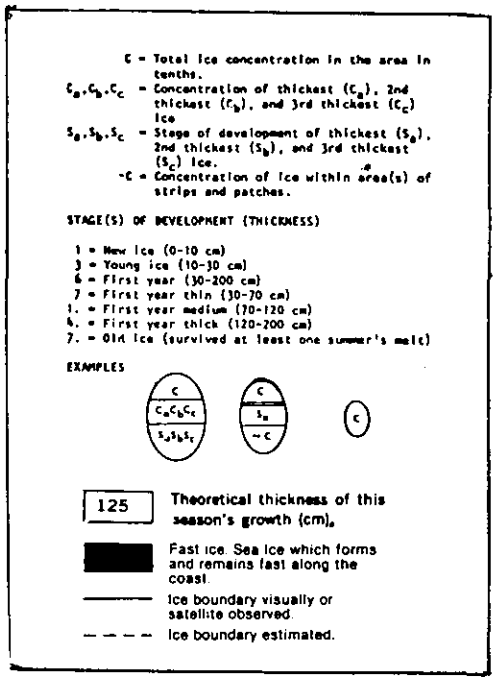


BERING SEA / NORTH SLOPE ICE ANALYSIS

Gary M. Wohl, NOAA
Navy-NOAA Joint Ice Center
National Meteorological Center, W/NMC21
(301) 763-5972

AUGUST 1987

August was a month of change across the Beaufort Sea. Sea ice decay continued during the first half of the month much as it had during July. High pressure to the north maintained a flow of warm easterly winds across the southern Beaufort Sea. A large area of ice-free ocean developed in the eastern Beaufort Sea in response to these winds and the shipping lane was easily traversed to Prudhoe Bay and other points along the North Slope. Toward the middle of the month the atmospheric pattern changed. A weak low pressure center to the north and a high pressure area to the southwest produced northwesterly winds and colder temperatures over the Beaufort Sea. Inner pack ice concentrations became more stable and decay proceeded more slowly along the ice margin. By the end of the month, sea ice had become more of a concern for shipping although the lane remained navigable. Increasing storminess forebodes difficult September for late season operators on the Beaufort Sea.



WEST COAST OCEAN FEATURES

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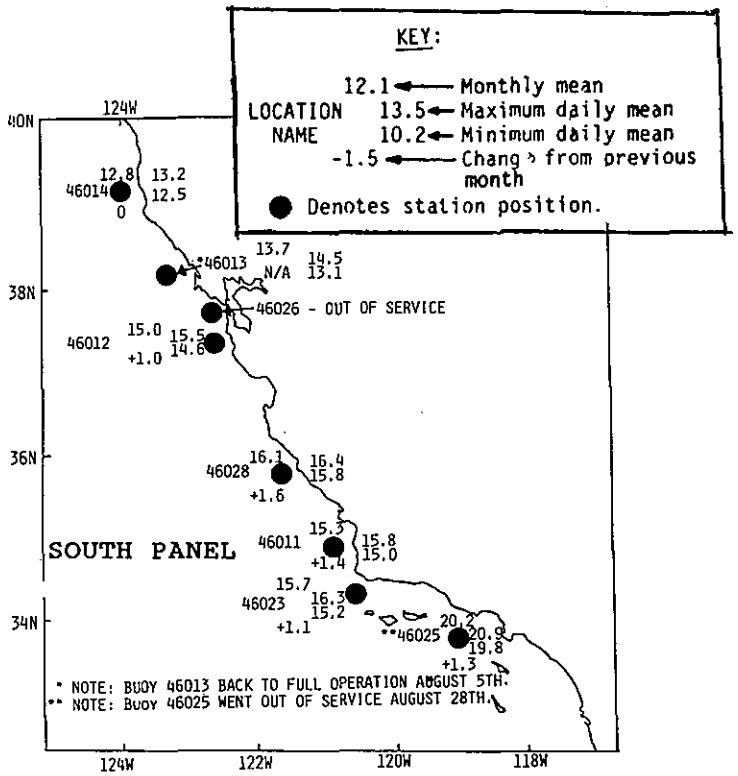
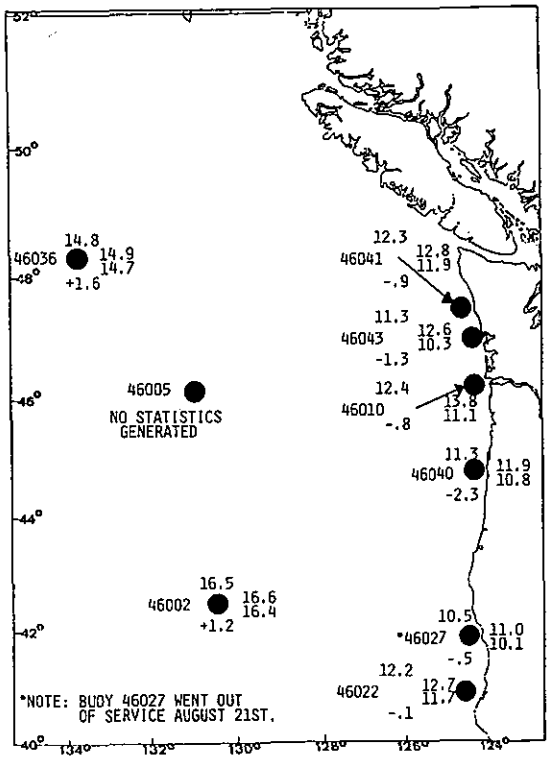
FTS 470-9122

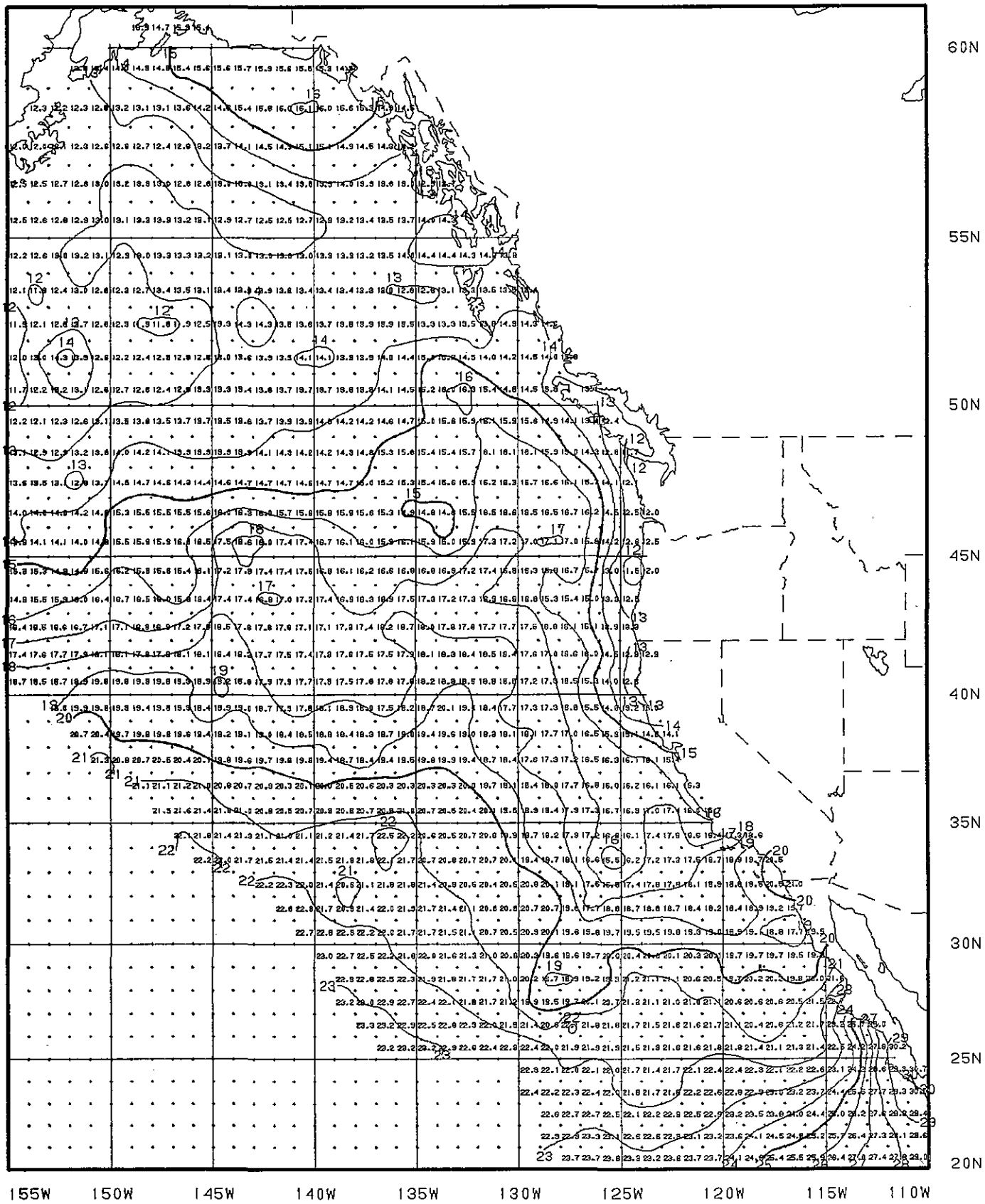
AUGUST 1987

Sea surface temperatures in the North Panel were cooler than normal during the month. The normal climatological mean temperature for the area is 16.4°C, but the actual observed value was 15.5°C. The only location near normal was in the northern portion of the chart west of Vancouver Island. The greatest cool anomaly of 1.8°C was along the Washington coast west of Gray's Harbor. When compared with last month, all offshore locations warmed; however, nearshore waters cooled. This can be seen on the adjacent chart. The cooling was the result of persistent upwelling activity that brought very cold water to the surface. In fact, on August 21 and 22 buoys 46040 and 46043 reported temperatures of 8.6°C during an intense upwelling episode. The area west of 130°W warmed between 1.0°C and 1.5°C since the end of July.



The climatological mean temperature of the South Panel is 18.6°C, and that figure is precisely the observed actual value for this month. Interestingly, when a line is drawn from Monterey Bay to the southwest corner of the chart, all temperatures to the right of the line are above normal and those to the left are below normal. The greatest cool anomaly observed was 2.3°C in the northwest corner of the analysis area; the warmest anomaly of 1.8°C occurred just west of buoys 46011 and 46028. Compared to the previous month, the entire chart warmed between 0.4°C and 1.7°C, except for one small area near buoy 46014; again, this was the result of upwelling activity. Nearshore waters of central and southern California, particularly from the Los Angeles Bight to Baja peninsula, showed the greatest increase in temperatures. Upwelling in the South Panel was pretty much confined to the north coast and, even here, was not as intense as observed in the North Panel.





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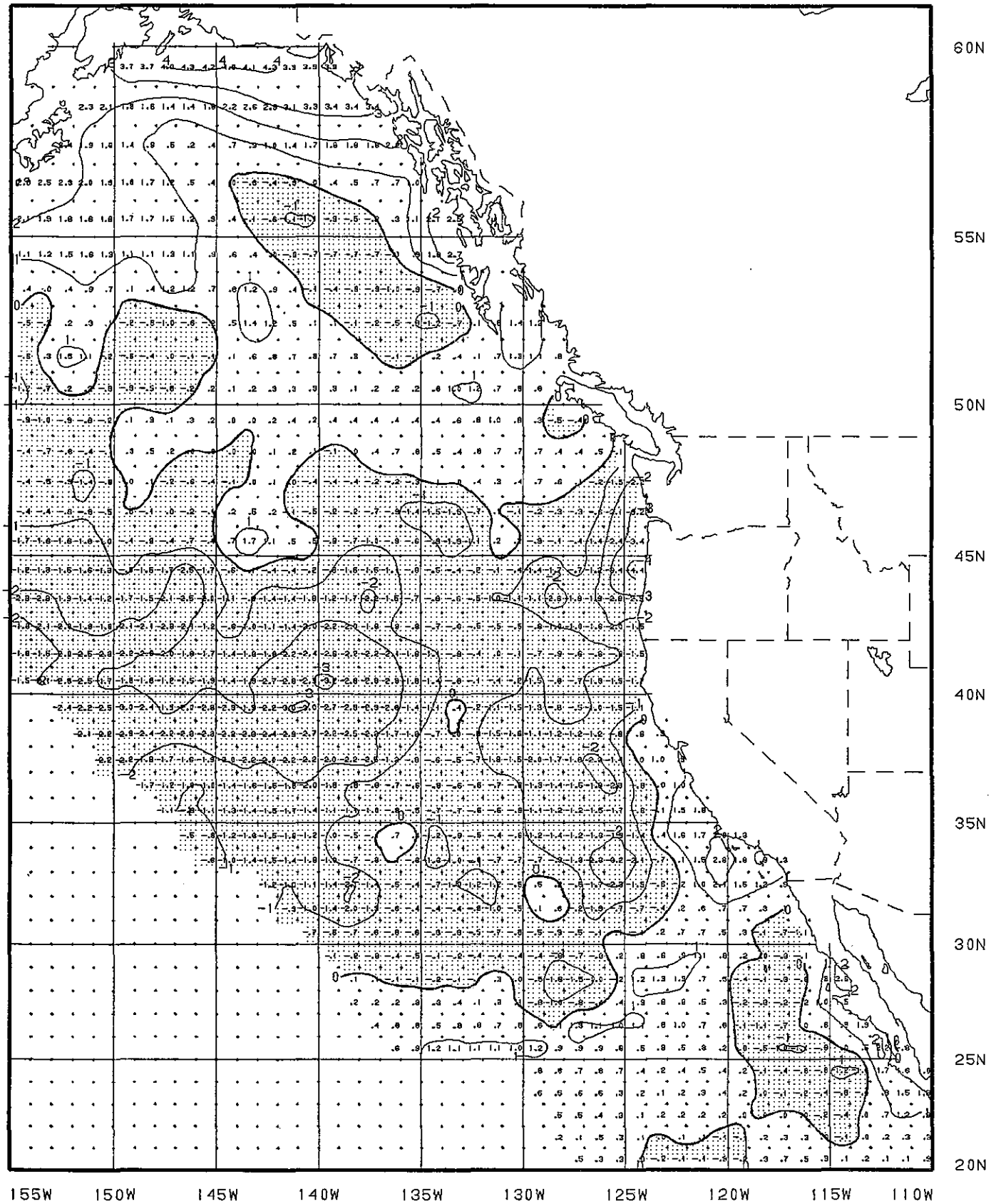

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EAST COAST OCEAN FEATURES

Jenifer Clark
NOAA, NWS
Washington, DC 20233
(301) 763-8030

Data used in this analysis include:
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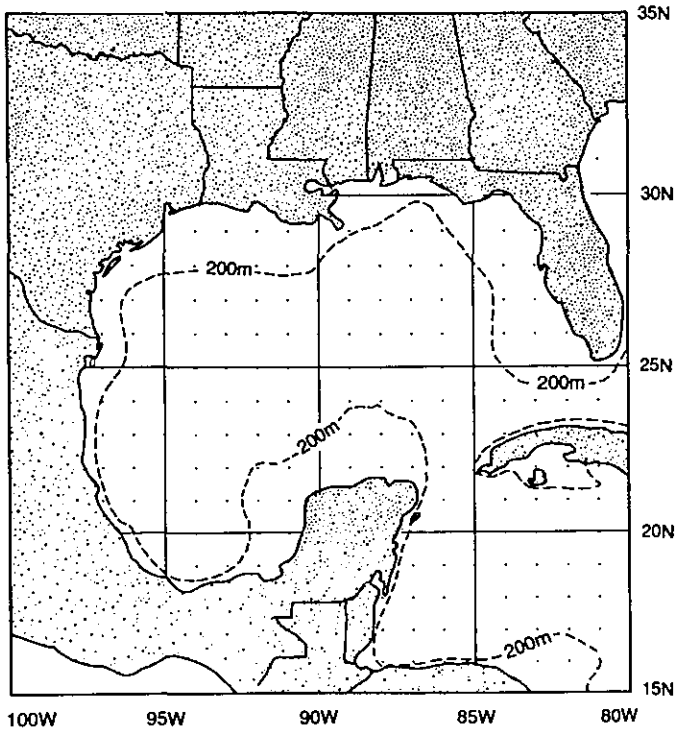
Bathythermograph data from National Meteorological Center of National Weather Service
Oceanographic Analysis -- A daily detailed analysis issued by National Weather Service

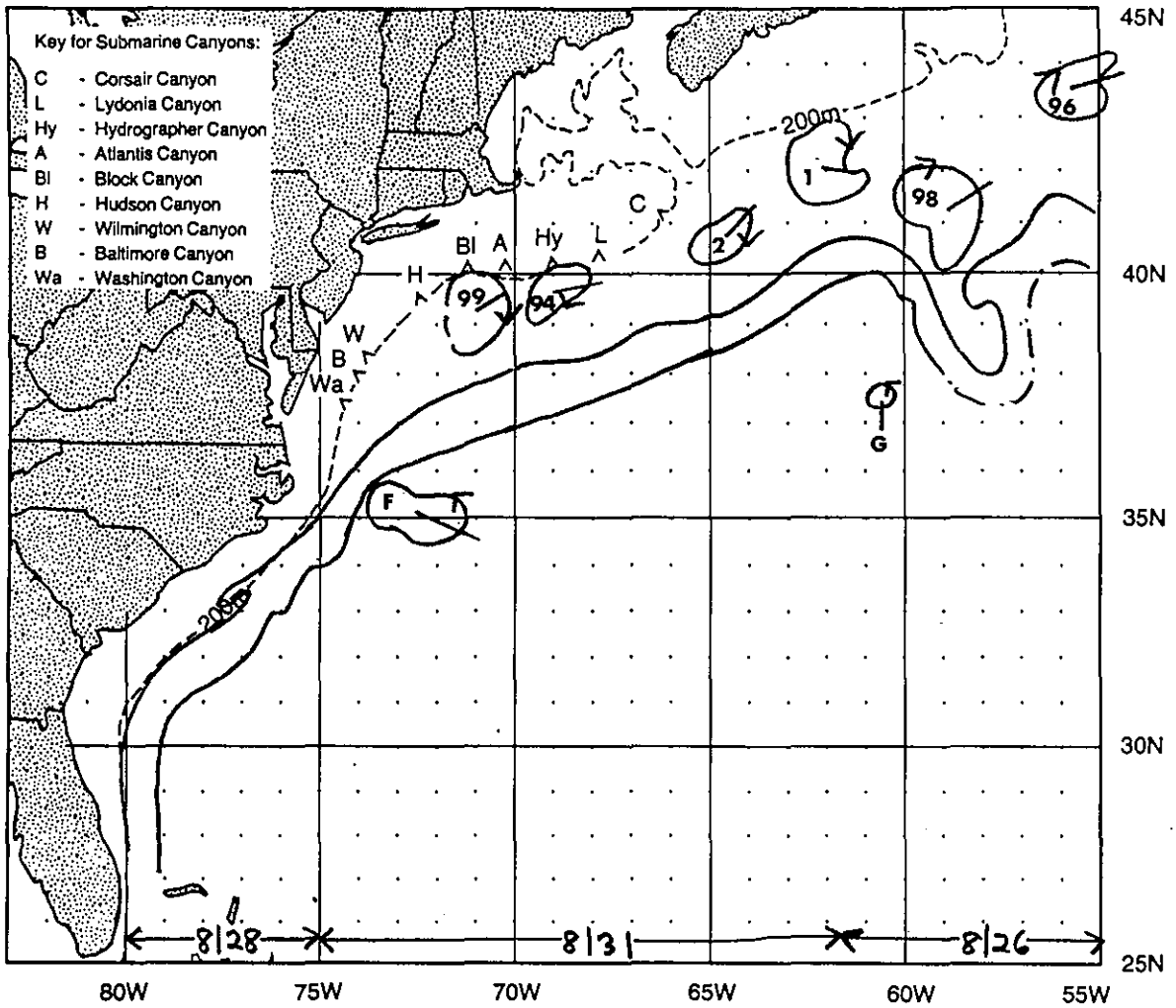
August 1987

The end of this month's positions of the Gulf Stream System and its associated eddies are shown for the NW Atlantic and the Gulf of Mexico. The Gulf Stream and Loop Current boundaries are located by infrared satellite imagery or XBT (expendable bathythermograph) data. Anticyclonic eddies are labeled a-z in the Gulf of Mexico and 1-99 in the Northwest Atlantic. Cyclonic eddies are labeled A-Z. Arrows on eddies indicate direction of circulation. Warm-core or anticyclonic eddies rotate clockwise; cold-core or cyclonic eddies rotate counterclockwise. The line to the eddy center shows the net translation since last month or since last observed. The edge of continental shelf at 200 m is shown as a dashed line. Eddies or sections of the Gulf Stream System which were not observed during the month are not shown on the analysis chart or are indicated by "dot-dashed" lines. The long arrows at the bottom of the chart indicate the dates of data used.



GULF OF MEXICO

Due to near isothermal sea surface conditions, the Loop Current in the Gulf of Mexico was not observed during August.



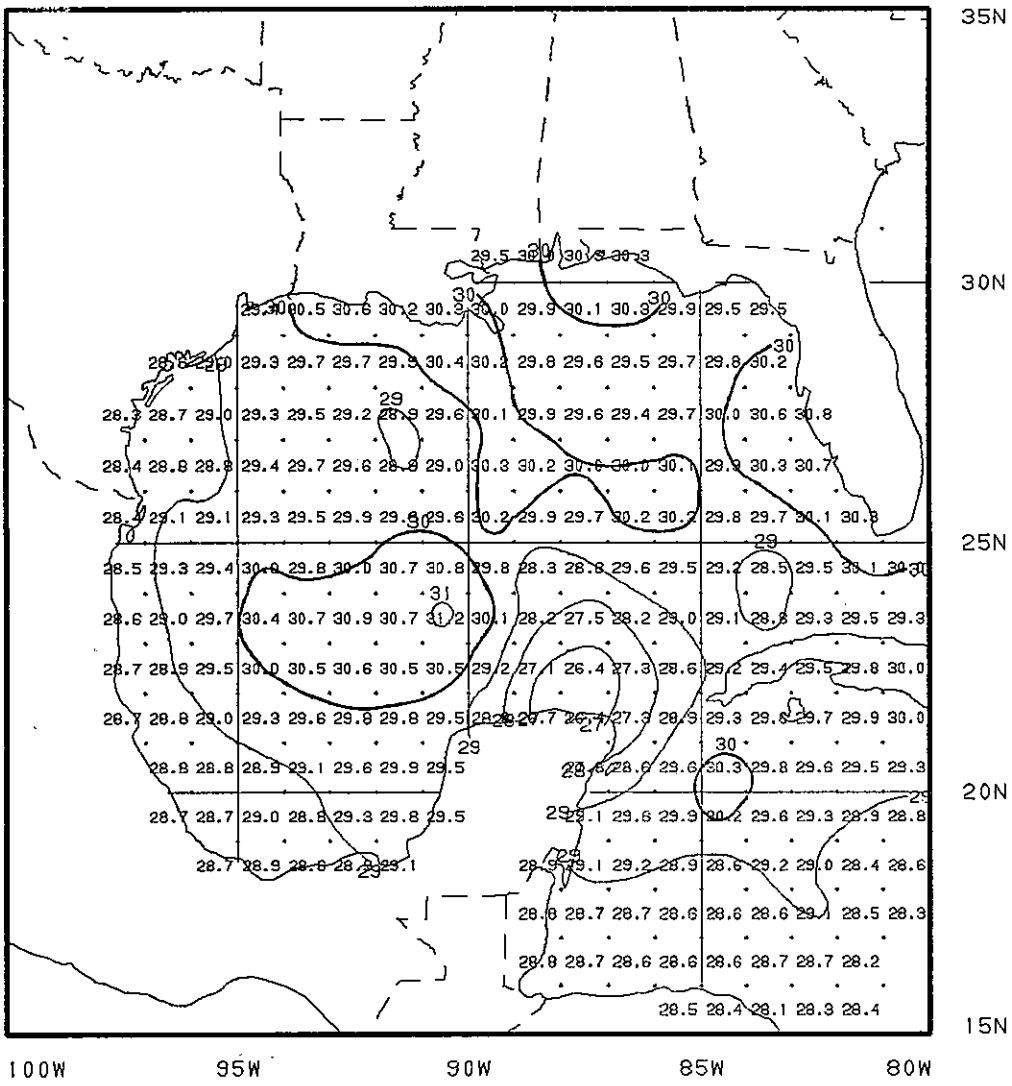
NORTHWEST ATLANTIC OCEAN

The Gulf Stream appeared to be unusually stable. No anticyclonic or cyclonic eddies formed or were absorbed by the Gulf Stream during August according to satellite thermal infrared imagery.

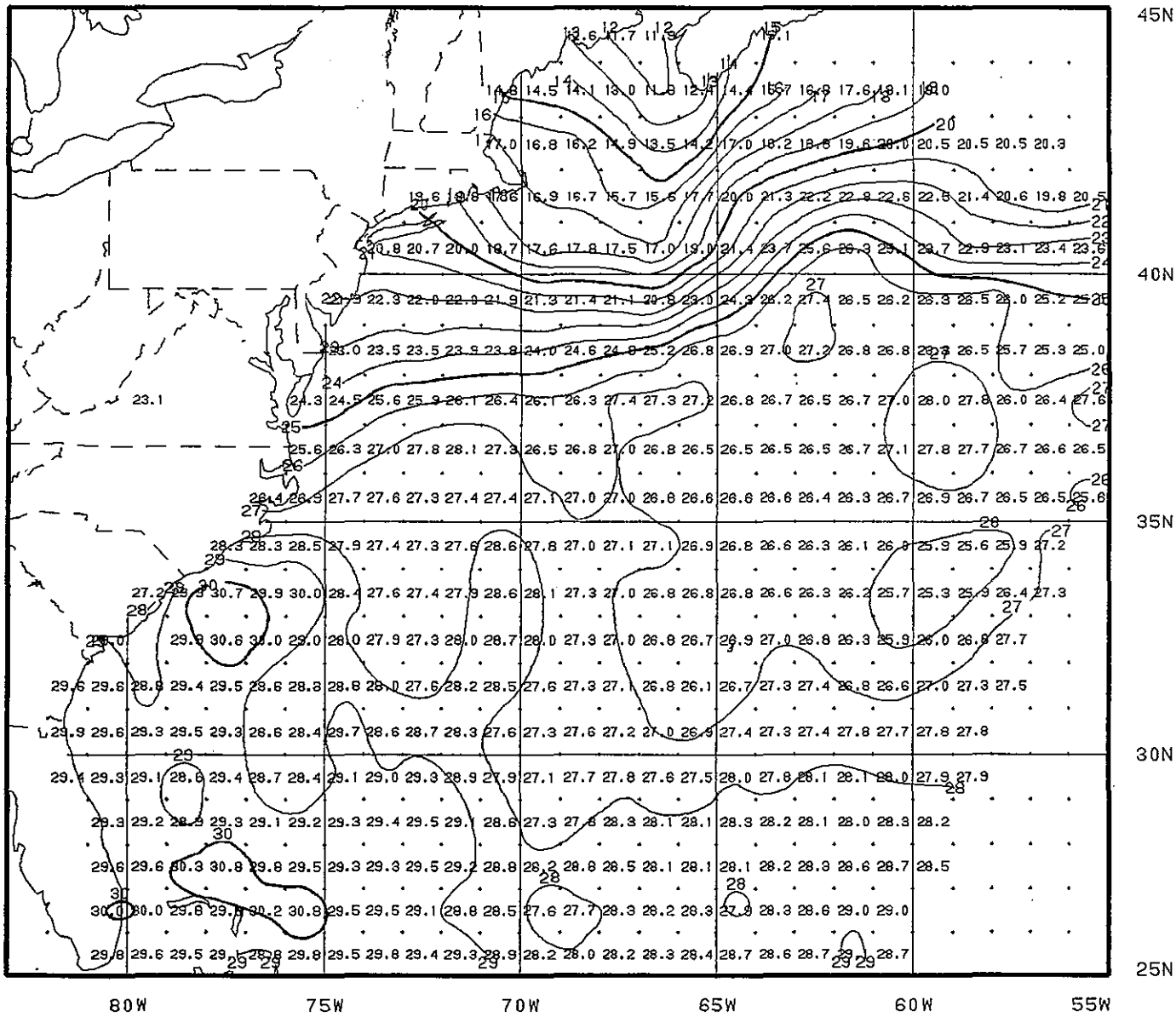
Anticyclonic eddy 99 translated 75 km SW and eddy 94 translated 100 km WSW. Eddy 2 moved 85 km SW, while eddy 1 moved 55 km WNW. Eddy 98 traveled 110 km SW. Eddy 96 translated 100 km WSW.

Cyclonic eddies W, A, and B were not observed during August and were deleted from the analysis. Eddy F traveled 150 km NW. Eddy G translated 75 km N.

EAST COAST SST – MONTHLY MEAN

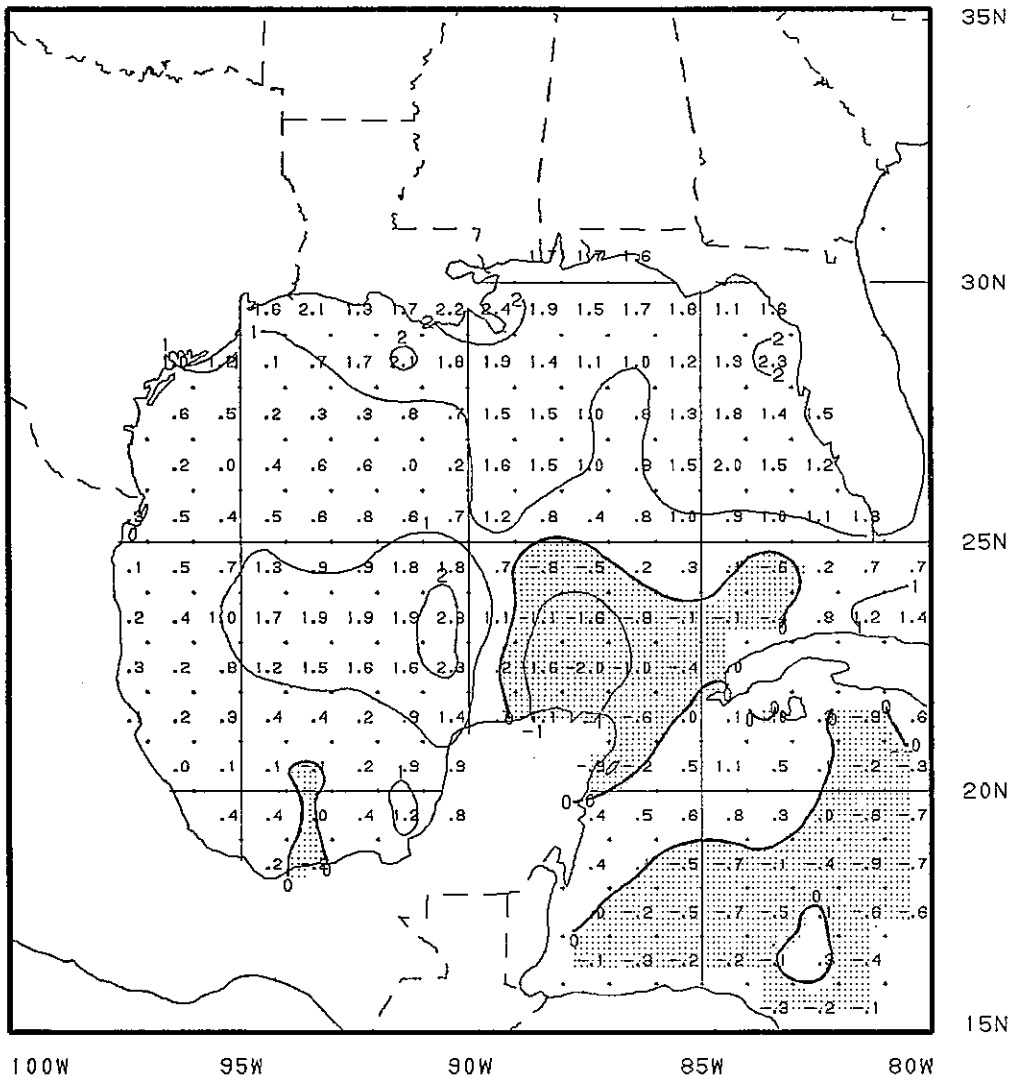


AUGUST 1987 GULF OF MEXICO SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0C.

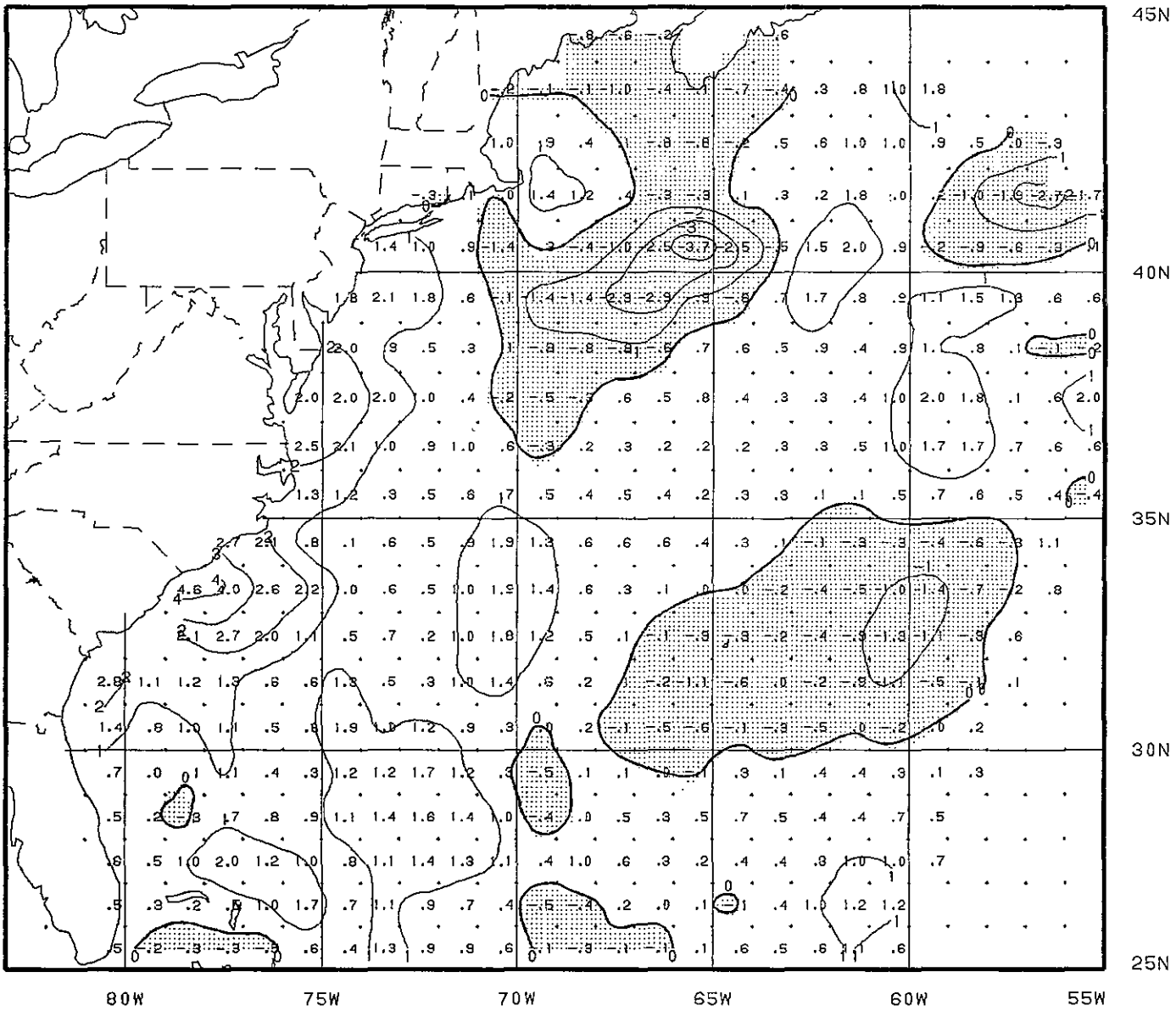


AUGUST 1987 U.S. EAST COAST SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0C.

EAST COAST SST – ANOMALY



AUGUST 1987 GULF OF MEXICO SST--MONTHLY ANOMALY (C)--Monthly anomaly is the difference between the monthly mean SST and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0C.



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The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through April 1, 1988.

9 NOV 1987

OCEANOGRAPHIC Monthly Summary

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Volume VII Number 9

NOAA LISD SEATTLE

September 1987

Adventures of Big Bergs (Page 3)

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U.S. DEPARTMENT OF COMMERCE • National Oceanic and Atmospheric Administration
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National Ocean Service

OCEANOGRAPHIC
Monthly Summary

Oceanographic Monthly Summary is published by the National Weather Service (NWS), the National Environmental Satellite, Data, and Information Service (NESDIS), and the National Ocean Service (NOS). *Oceanographic Monthly Summary* contains sea surface temperature (SST) analyses on both regional and ocean basin scales for the Atlantic, Pacific, and Indian Oceans. The ocean basin analyses are based on a "blend" of *in situ* and satellite data, in which *in situ* data are used to define "benchmark" temperature values in regions of frequent observations and satellite data are used to define the "shape" of the field between these points.[1]

An ocean basin SST anomaly is derived from the "blended" SST analysis[1] and the improved global SST.[2] The regional SST analyses are based upon a combination of *in situ* and satellite data measurements. The regional SST anomalies are calculated from the Robinson-Bauer Climatology.[3,4] *Oceanographic Monthly Summary* also contains Alaskan sea ice information and ocean feature information for contiguous U.S. ocean regions.

Oceanographic Monthly Summary welcomes articles containing information of interest to its readers, such as news on operational oceanography, unusual ocean feature phenomena, etc. Contributions should be sent to the editor (address below). Accepted material will appear in the OceaNotes section of *Oceanographic Monthly Summary*. Contributions can be published as quickly as the next monthly issue.

If you are interested in receiving *Oceanographic Monthly Summary* regularly, please refer to the back cover for subscription information.

[1]Reynolds, R.W. and W.H. Gemmill, 1984. A sea surface temperature analysis which blends *in situ* and satellite observations. *Proceedings of the Ninth Climate Diagnostics Workshop*, Corvallis, OR, Oct. 22-26, 1984, pp. 408-416.

[2]The climatology is derived from *in situ* data (1950-1979), satellite data (1982-1985) and an ice climatology.

[3]Robinson, M.K., 1976. Atlas of North Pacific Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOcean Ref. Pub. 2.*

[4]Robinson, M.K., R.A. Bauer, and E.H. Schroeder, 1979. Atlas of North Atlantic-Indian Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOceano Ref. Pub. 18.*

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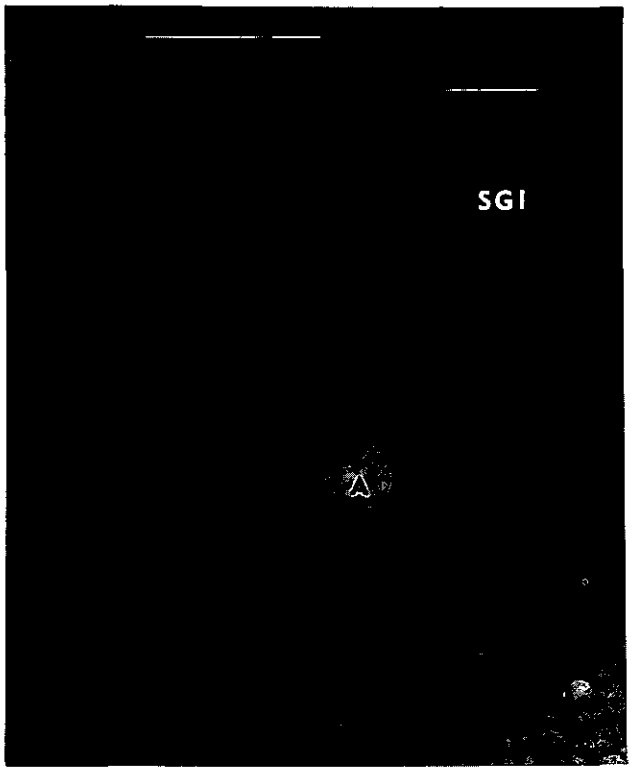


OceaNotes

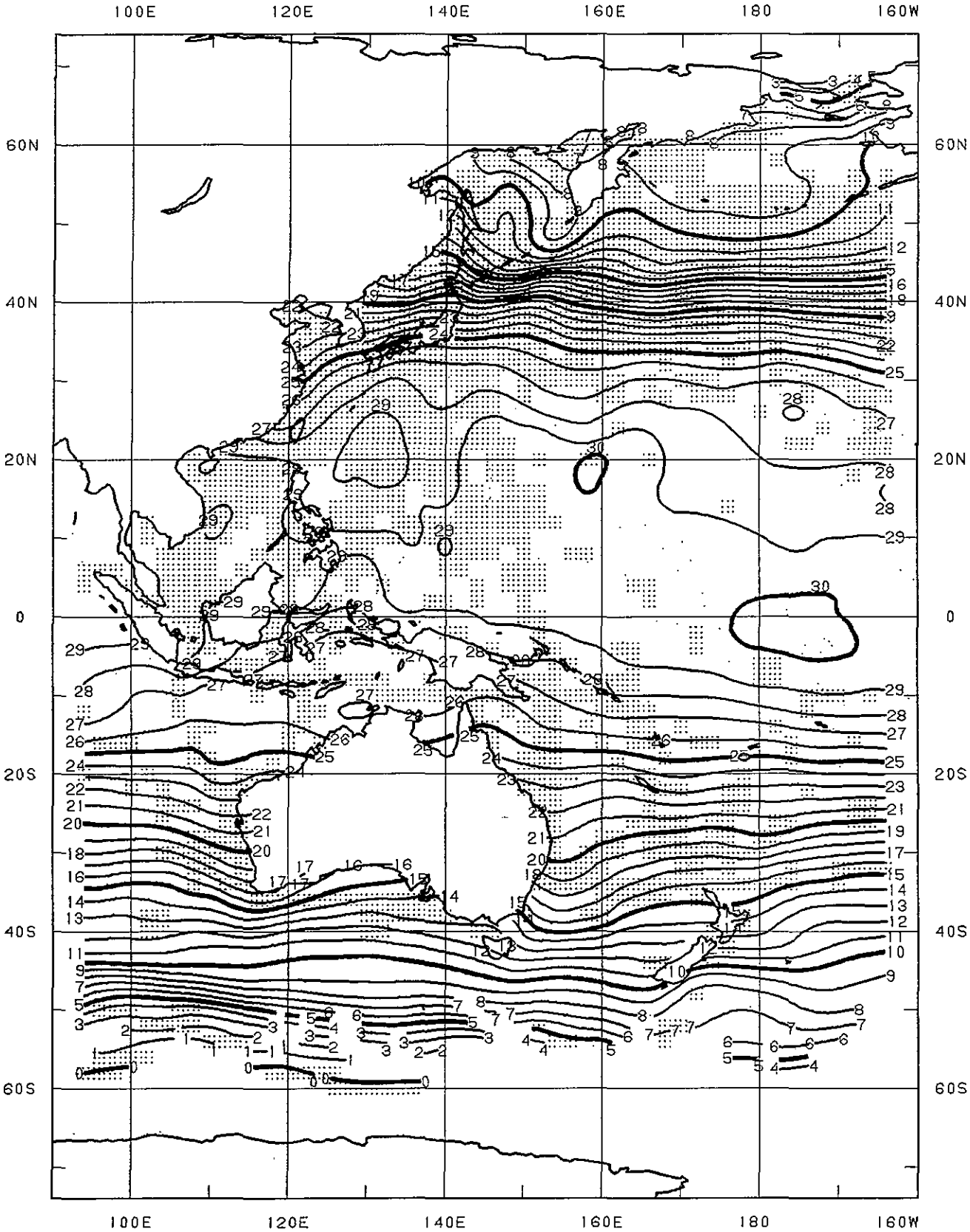
THE FURTHER ADVENTURES OF BIG BERGS

Kim Buttleman
Interactive Processing Branch
NESDIS, NOAA
E/SP22
Washington, DC 20233
(301) 763-8142

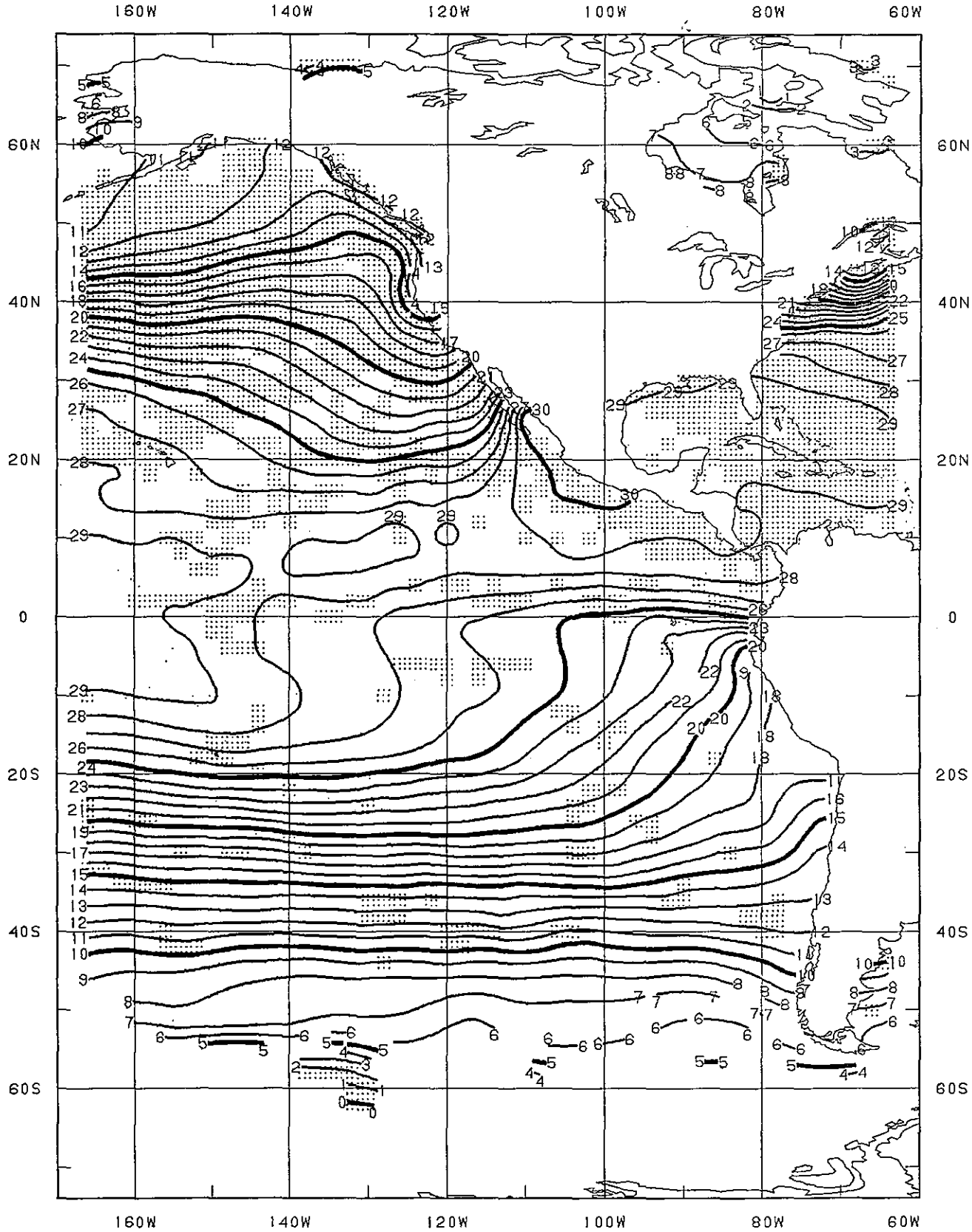
The two images above and the one the cover (all NOAA-9, AVHRR Channel 4) show the recent positions of the two icebergs discussed in the Satellite Image of the Month article in the November 1986 Oceanographic Monthly Summary. Some time in early 1986 a large tongue of ice, approximately 80 x 110 km (indicated on maps dating from 1947) separated from the Larsen Ice Shelf. Over the austral winter the tongue had broken into two large pieces as well as numerous smaller pieces. By November 1986 the two large pieces had moved about 600 km from their origin and were then both located off the tip of the Antarctic Peninsula.

Since then, the two bergs have moved about 1500 km northwest from their November position and are now in the vicinity of South Georgia Island. The left image above (July 30, 1987; 08:43 GMT) shows the island (SGI) and berg B, the smaller of the two, at about 80x40 km. It is approximately 250 km south southeast of the island and is at the edge of the flow ice. The right image above (August 28, 1987; 09:53 GMT) shows the island and berg A, the larger at about 80x55 km. At that time it was located approximately 300 km southwest of the island. The cover image (September 9, 1987; 09:14 GMT) shows both bergs flanking South Georgia Island. Berg A has moved about 100 km closer to the island and has rotated about 80 degrees clockwise. The pack ice, which has been blown to the northwest, shows a distinct wind wake downstream from the berg. Berg B is about 100 km northeast of the island. It has moved about 300 km to the northwest and has also rotated about 90 degrees clockwise. The shapes and sizes of both bergs are essentially unchanged from that of November 1986.

(OceaNotes Continued on page 12)



SEPTEMBER 1987 WESTERN PACIFIC OCEAN SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of **in situ** (ship, buoy) and satellite data within two-degree quadrangles. Contour line interval is 1.0 C. The stippling indicates where the analysis was fixed by the **in situ** data; contours are not shown in areas without data.



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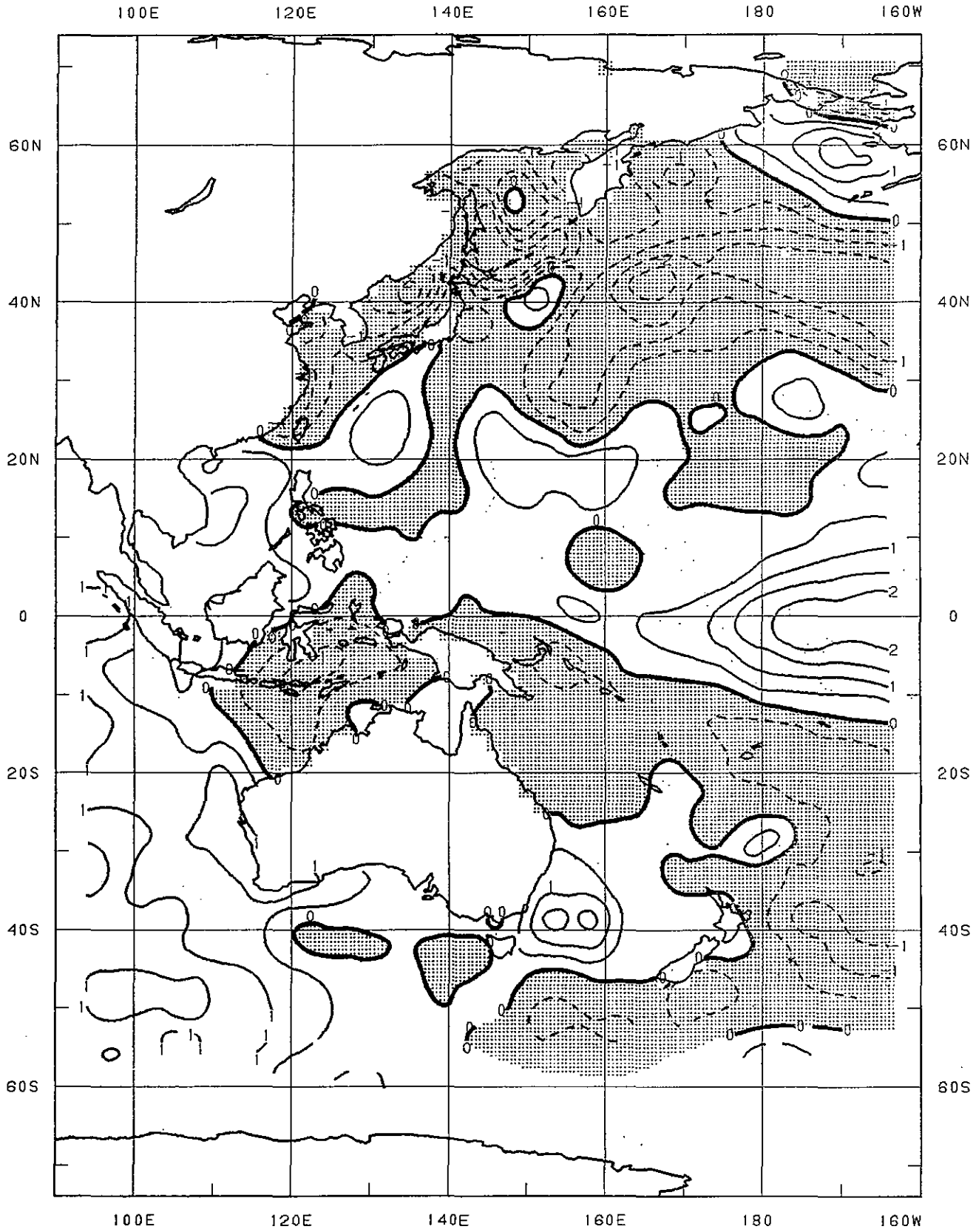

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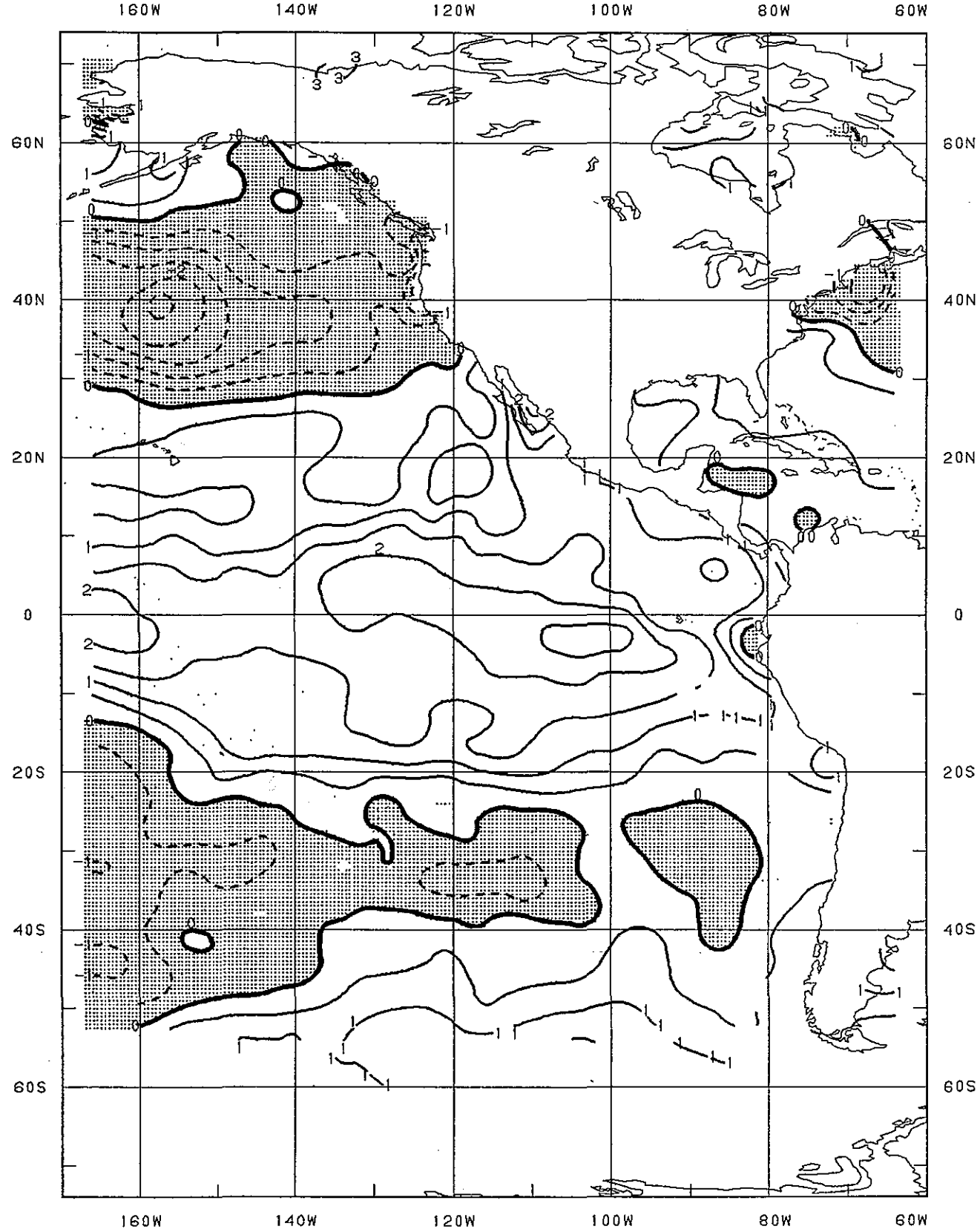

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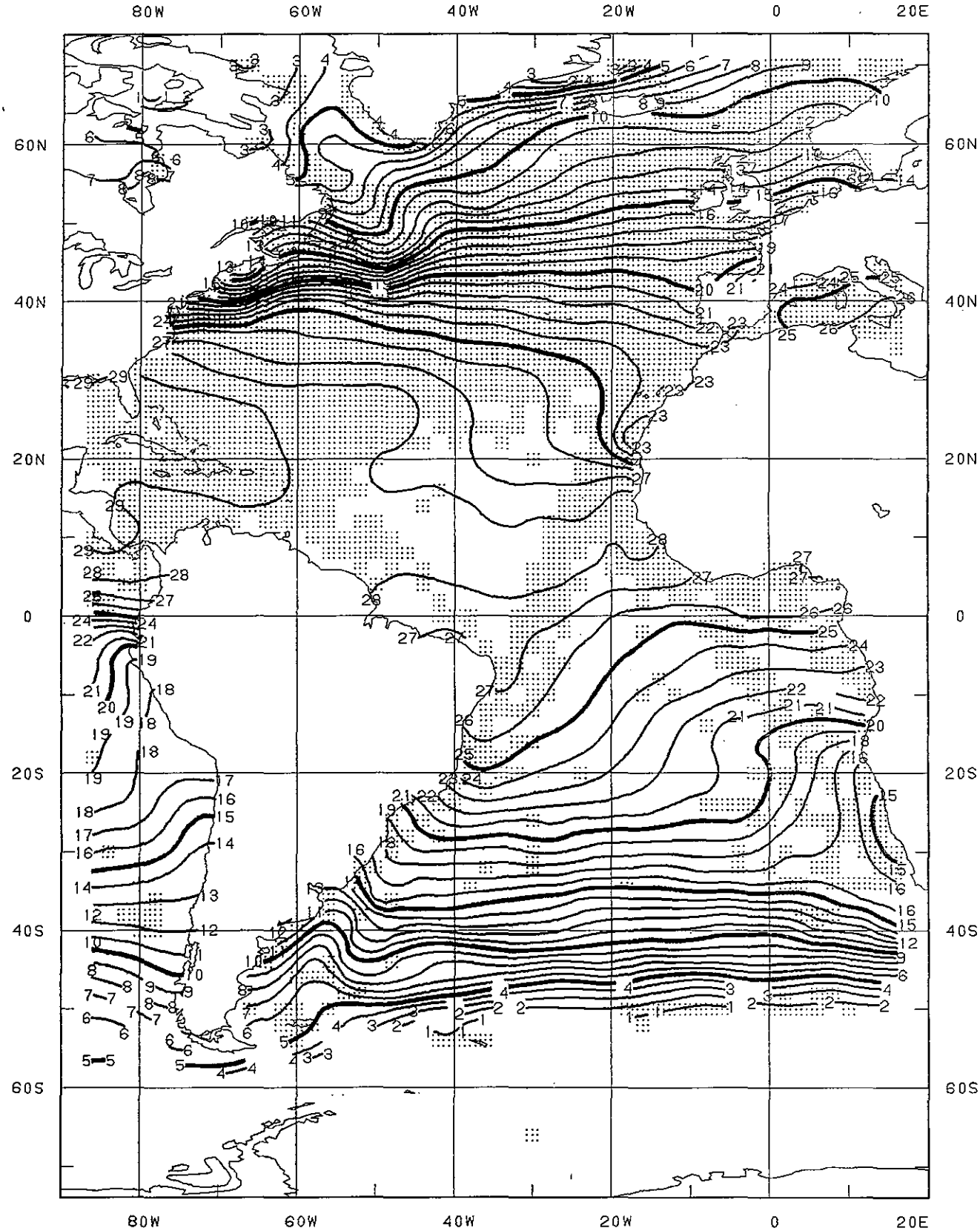

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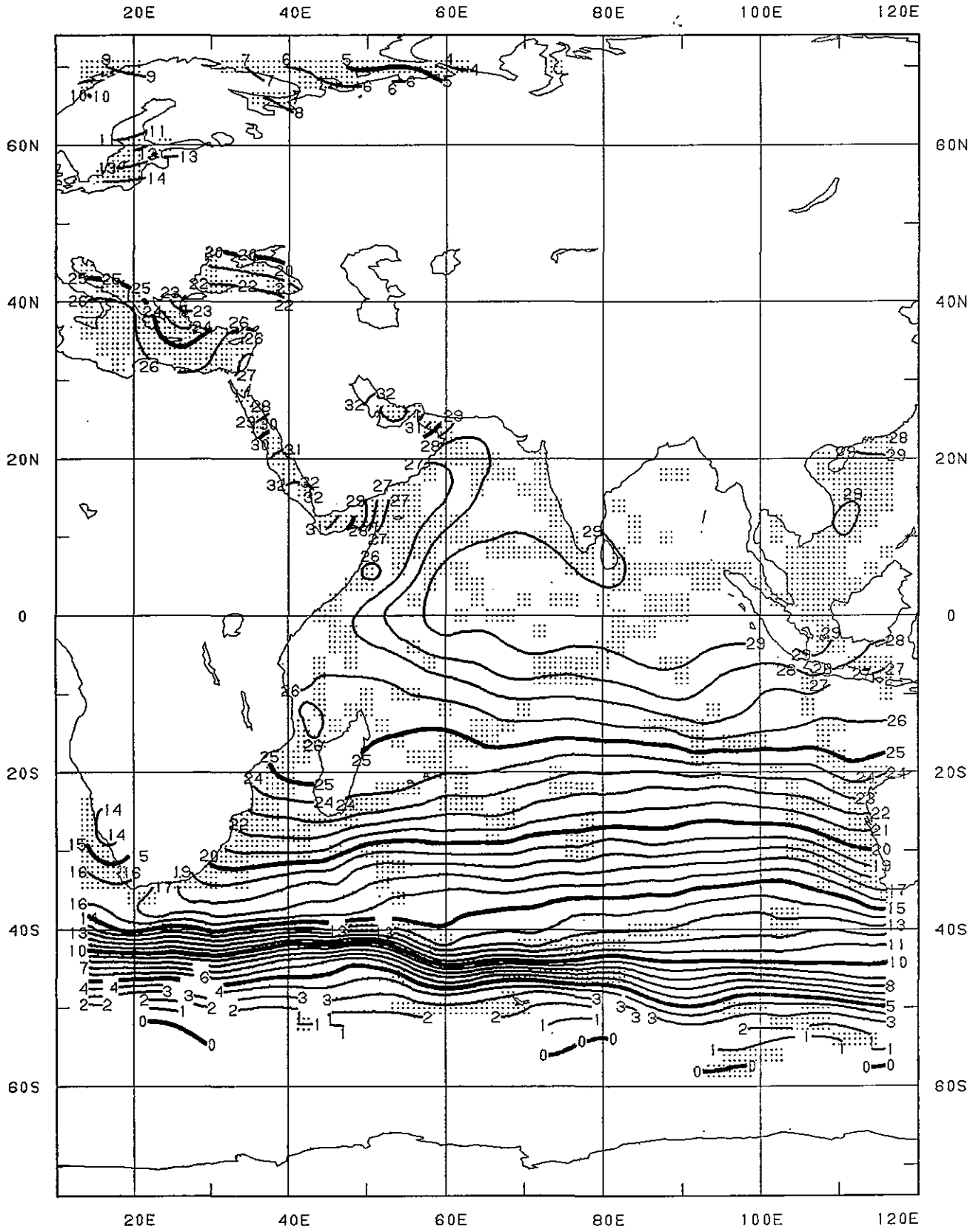
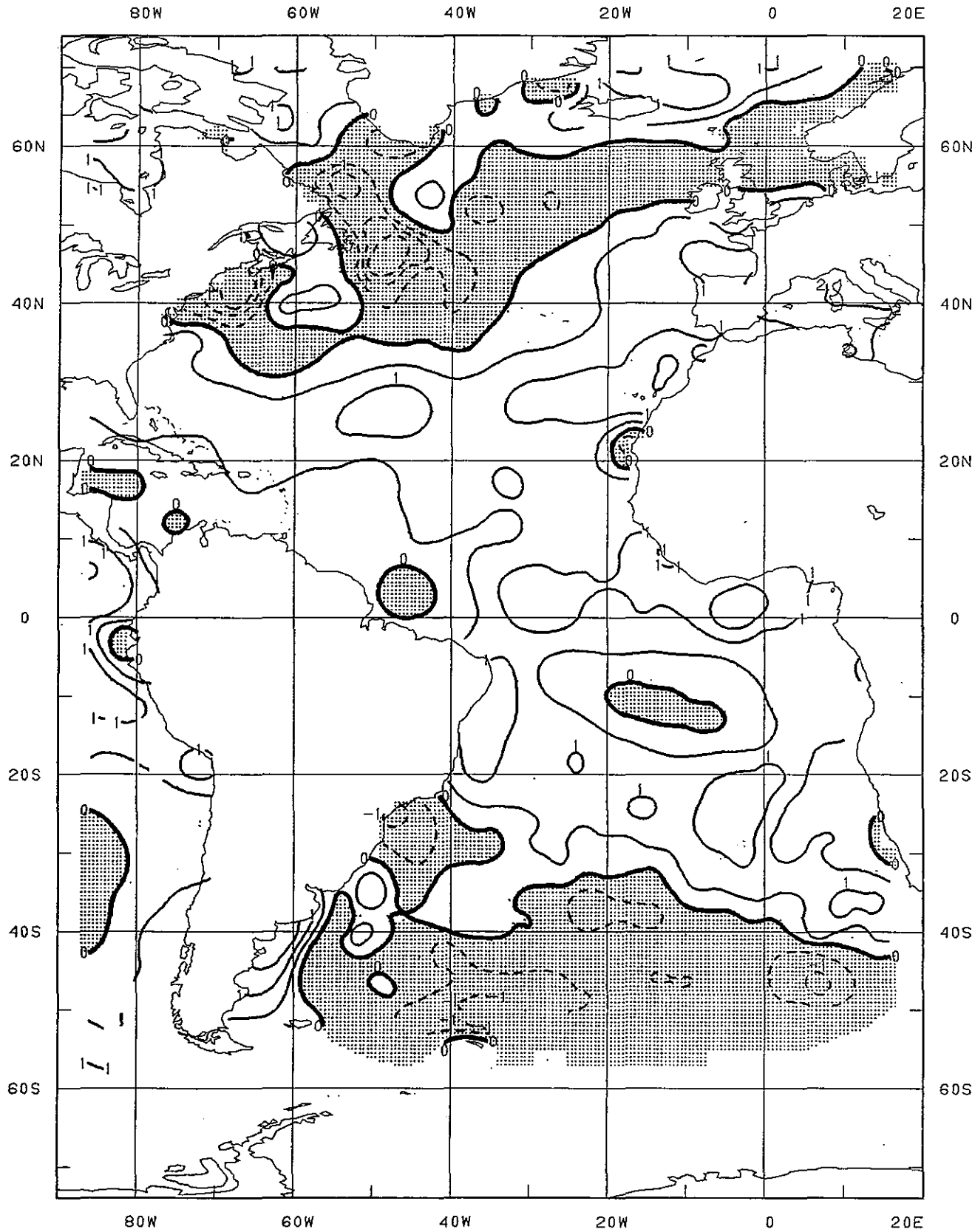


SEPTEMBER 1987 INDIAN OCEAN SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of **in situ** (ship, buoy) and satellite data within two-degree quadrangles. Contour line interval is 1.0 C. The stippling indicates where the analysis was fixed by the **in situ** data; contours are not shown in areas without data.



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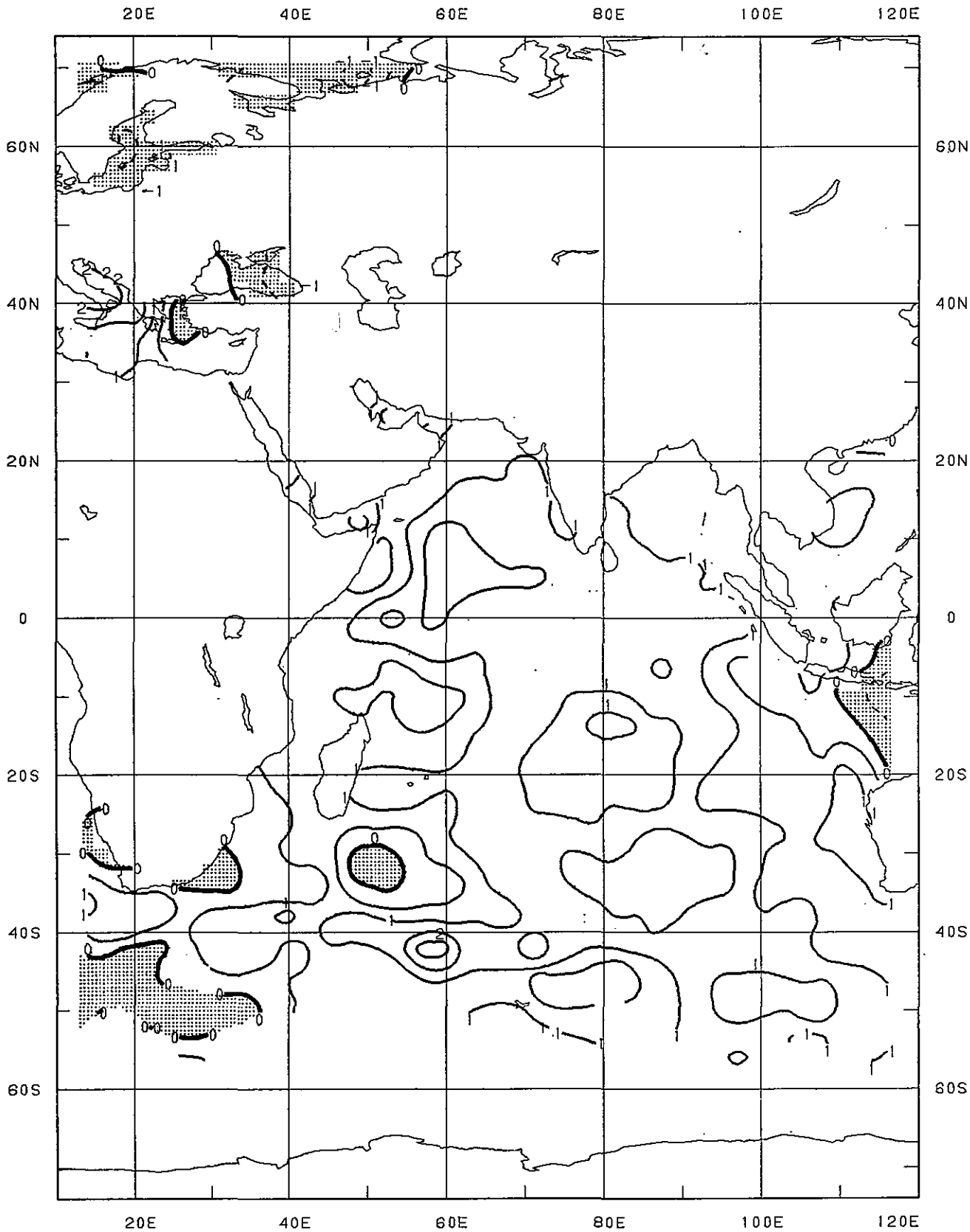

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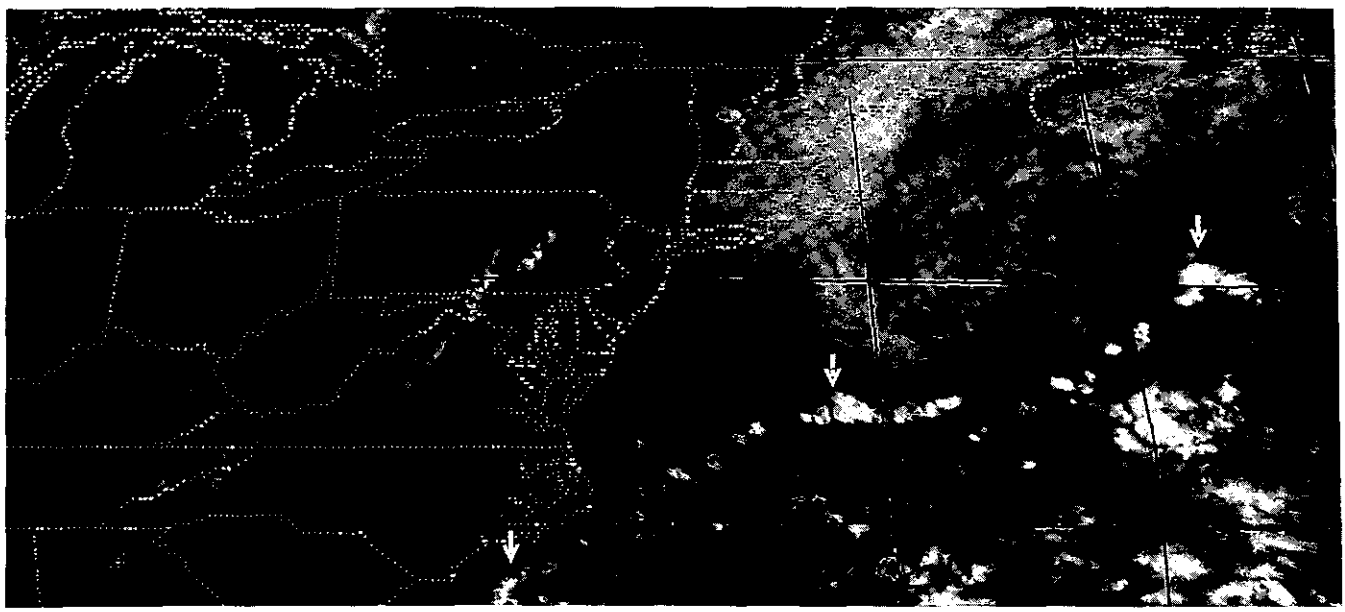


Figure 1

OceaNotes (continued)

AIR-SEA INTERACTION OVER GULF STREAM

Stephen F. Hogan

NWS, NOAA
Room 302, World Weather Bldg.
Camp Springs, MD 20746
(301) 763-8088

The marine environment is very complex involving many interactions. Many of these interactions occur on the mesoscale. The sparse density of conventional observations makes it difficult to observe many of these features. However, the advent of remote sensing platforms such as satellites makes this task more manageable.

The air-sea boundary is common ground for both meteorologists and oceanographers. By working together, these scientists are learning more about the coupling of the oceanic and atmospheric circulation systems and the exchange of energy between the two.

The following satellite picture clearly indicates the nature of the mesoscale. A narrow band of convective clouds extends over the ocean (figure 1). These clouds form a near perfect fit with the position of the north wall of the Gulf Stream. The north wall is highlighted on the Oceanographic Analysis (figure 2) by a bold line. This pattern clearly displays the coupling phenomenon.

The atmospheric circulation during this time was weak, being dominated by high pressure(figure 3). Within this pattern, the energy flux of the Gulf Stream plays a dominant role. The resultant temperature gradient across the Gulf Stream caused destabilization of the lower layers of the atmosphere. This pattern persisted over several days. The local instability ultimately led to a line of convergence in the low level wind field.

It is such mesoscale features that tend to enhance and localize regions of instability. By monitoring these features, local changes in atmospheric patterns can be anticipated based on sound physical reasoning.

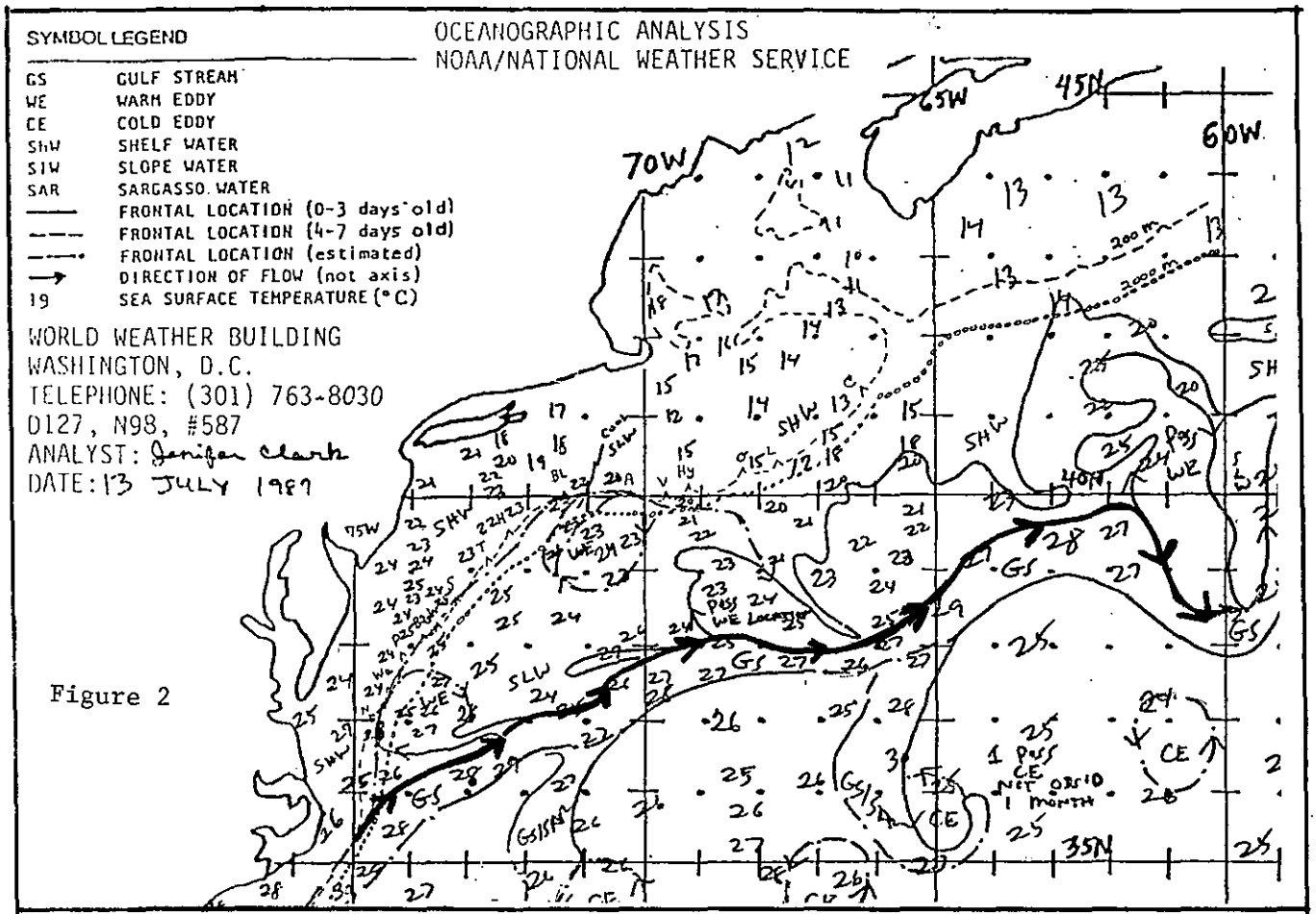


Figure 2

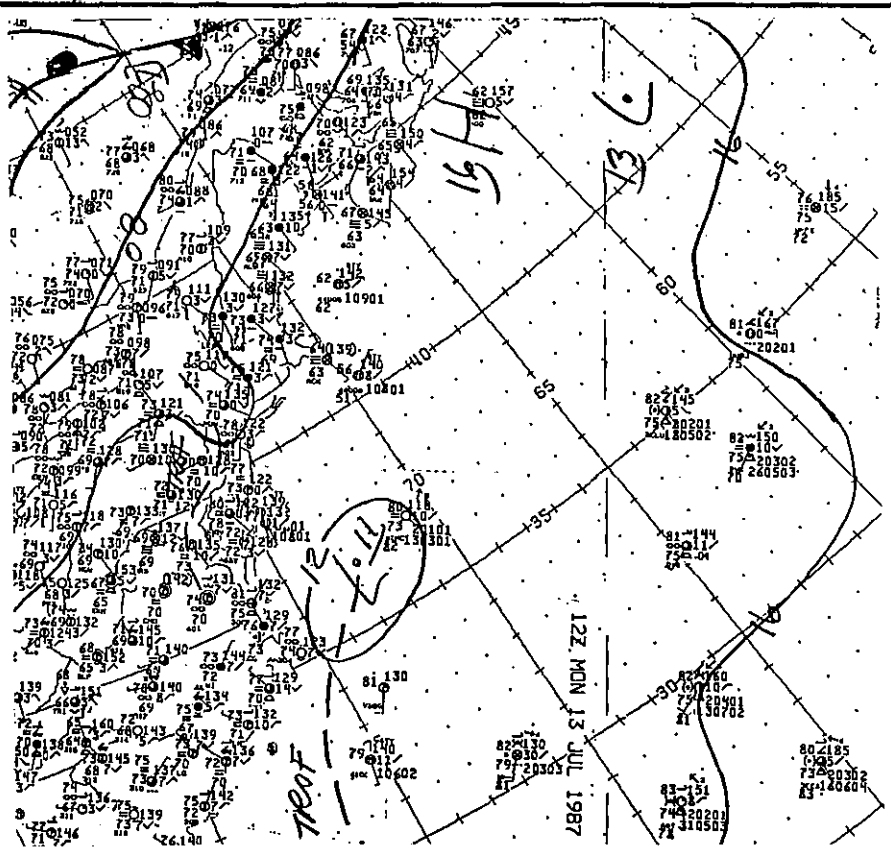
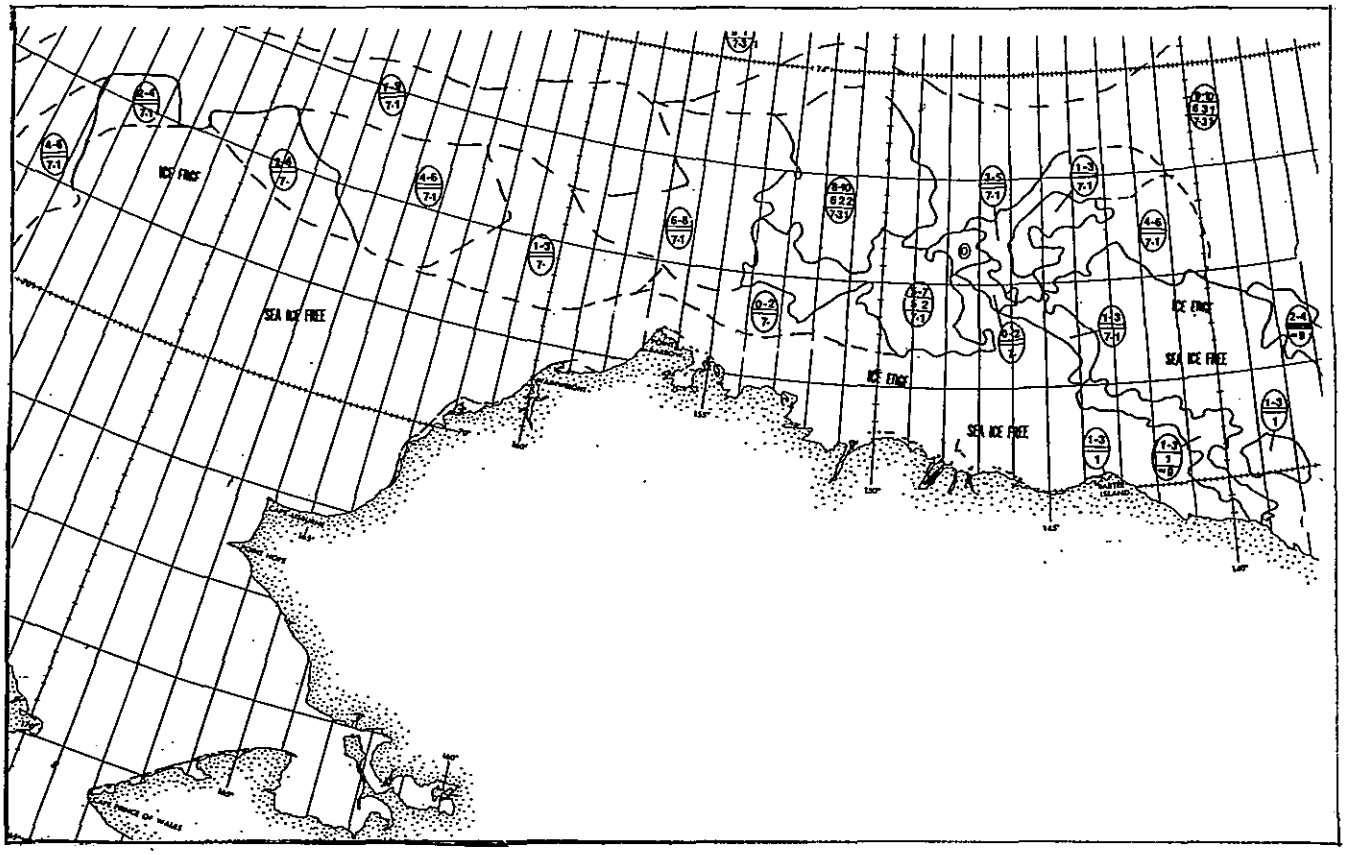


Figure 3



BERING SEA / NORTH SLOPE ICE ANALYSIS

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Navy-NOAA Joint Ice Center
National Meteorological Center, W/NMC21
(301) 763-5972

SEPTEMBER 1987

North Slope operators experienced moderate ice conditions during September thanks to an Arctic low pressure center located in the northern Chukchi Sea rather than in the Beaufort Sea. That atmospheric anomaly caused some northwesterly winds and below normal temperatures at Barrow and other locations along the Alaskan coast. The northwesterlies caused some sea ice to move into the open waters of the southern Beaufort Sea. However, the winds and low temperatures were not persistent enough to cause major changes in the shipping route which remained mainly open water (less than one tenth sea ice) with a few areas of slightly higher ice concentration. Had storms been more persistent in the Beaufort Sea, the shipping route would likely have been closed at Point Barrow where the polar pack was located just 30 to 40 nmi to the north by month's end.

C = Total ice concentration in the area in tenths.

C_a, C_b, C_c = Concentration of thickest (C_a), 2nd thickest (C_b), and 3rd thickest (C_c) ice

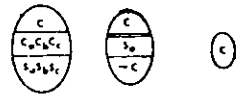
S_a, S_b, S_c = Stage of development of thickest (S_a), 2nd thickest (S_b), and 3rd thickest (S_c) ice.

-C = Concentration of ice within area(s) of strips and patches.

STAGE(S) OF DEVELOPMENT (THICKNESS)

1 = New ice (0-10 cm)
3 = Young ice (10-30 cm)
6 = First year (30-200 cm)
7 = First year thin (30-70 cm)
1. = First year medium (70-120 cm)
4. = First year thick (120-200 cm)
7. = Old ice (survived at least one summer's melt)

EXAMPLES



125 Theoretical thickness of this season's growth (cm).

Fast ice. Sea ice which forms and remains fast along the coast

Ice boundary visually or satellite observed

Ice boundary estimated.

WEST COAST OCEAN FEATURES

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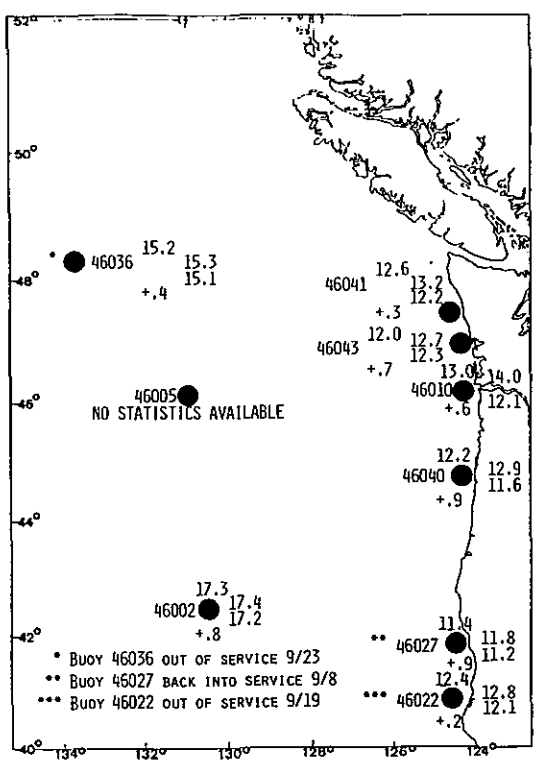
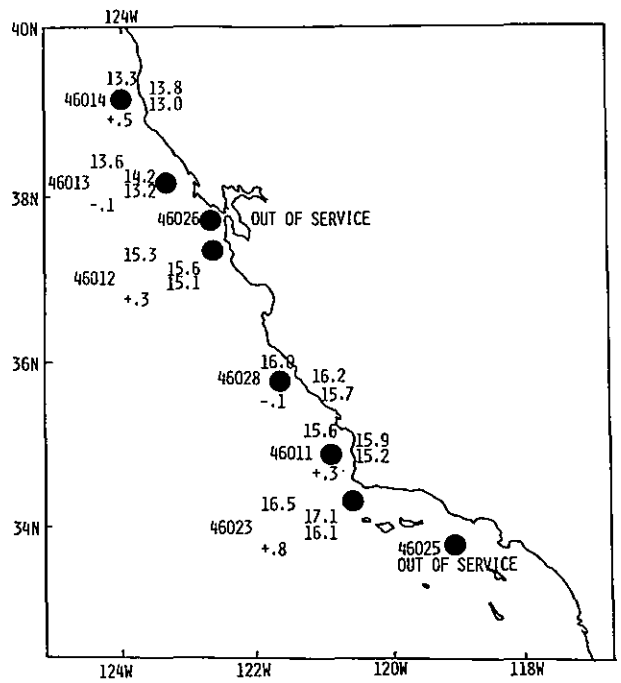
FTS 470-9122

SEPTEMBER 1987

The overall sea surface temperature pattern in the North and South Panels during September was very similar to that of August. For instance, in the North Panel, temperatures remained below normal both near and offshore; in the South Panel, nearshore waters were above normal and offshore waters below. In fact, the unusual thing about the South Panel is that even though there were positive and negative anomalies up to 1.5C, the observed mean temperature for the analysis equaled that of climatology or 19.1C. The center of the cooler than normal water was at 37.5N 129W; the warmer than normal area extended from near Pt. Piedras Blancas to Pt. Baja. Comparing this month's South Panel temperatures to last month's, the entire chart warmed except for one small area along the central California coast. The warmest anomaly of 1.5C was in the extreme northwest corner of the chart.



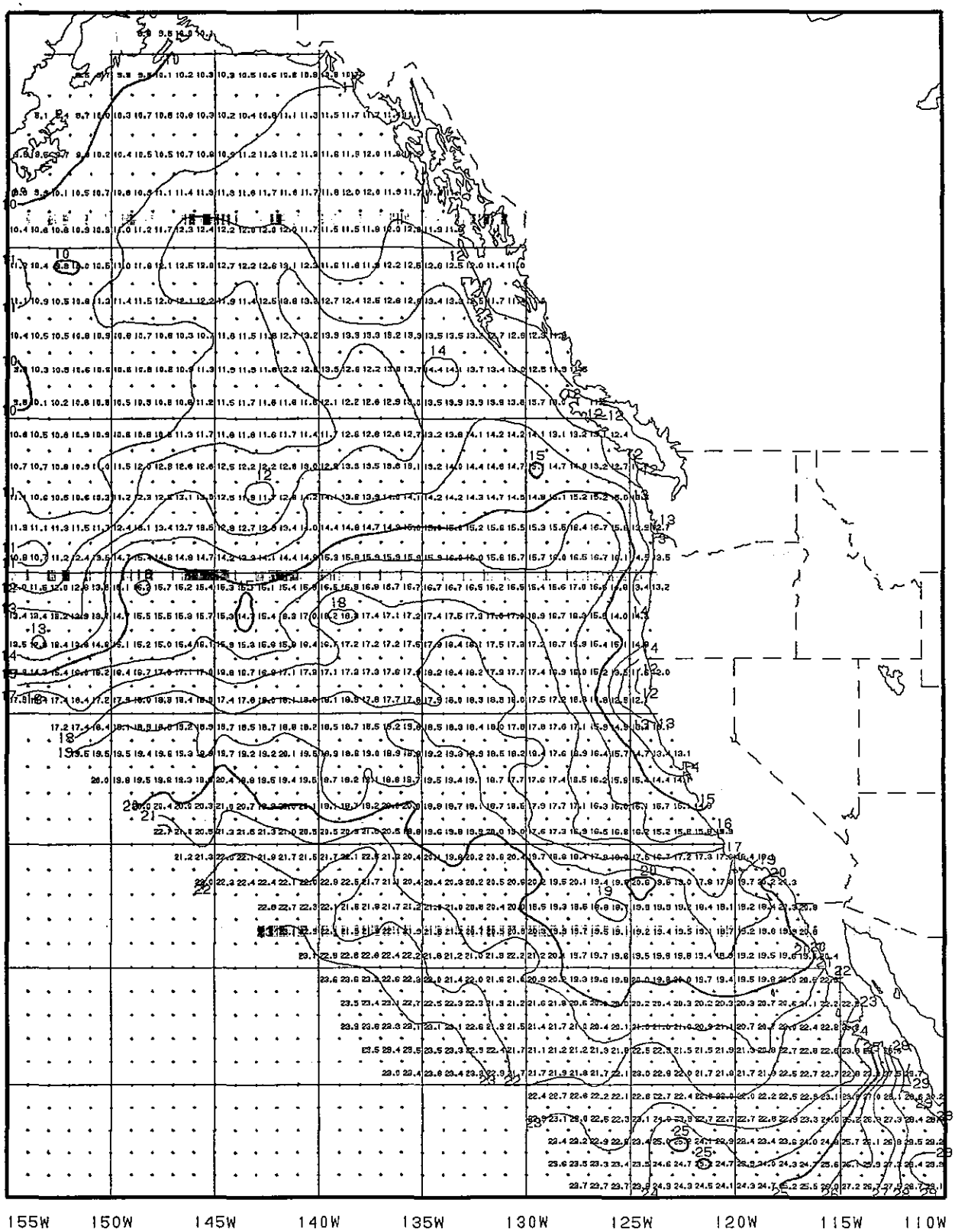
As mentioned previously, the North Panel's observed monthly mean temperature was cooler than climatology. The normal monthly mean for the area is 16.5C, but the computed value was 0.6 lower. The coolest anomalies were both centered at 43N but one was at 126W and the other at 134W. The only area that cooled when compared to August was north and west of Vancouver Island. The remainder of the North Panel warmed by as much as 1.1C with the area of maximum warming located in the southwest corner of the chart. The greatest observed decrease in temperature over the month was a value of 0.7C south of Cape St. James, Canada.



KEY:

12.1 ← Monthly mean
LOCATION 13.5 ← Maximum daily mean
NAME 10.2 ← Minimum daily mean
-1.5 ← Change from previous month

● Denotes station position.



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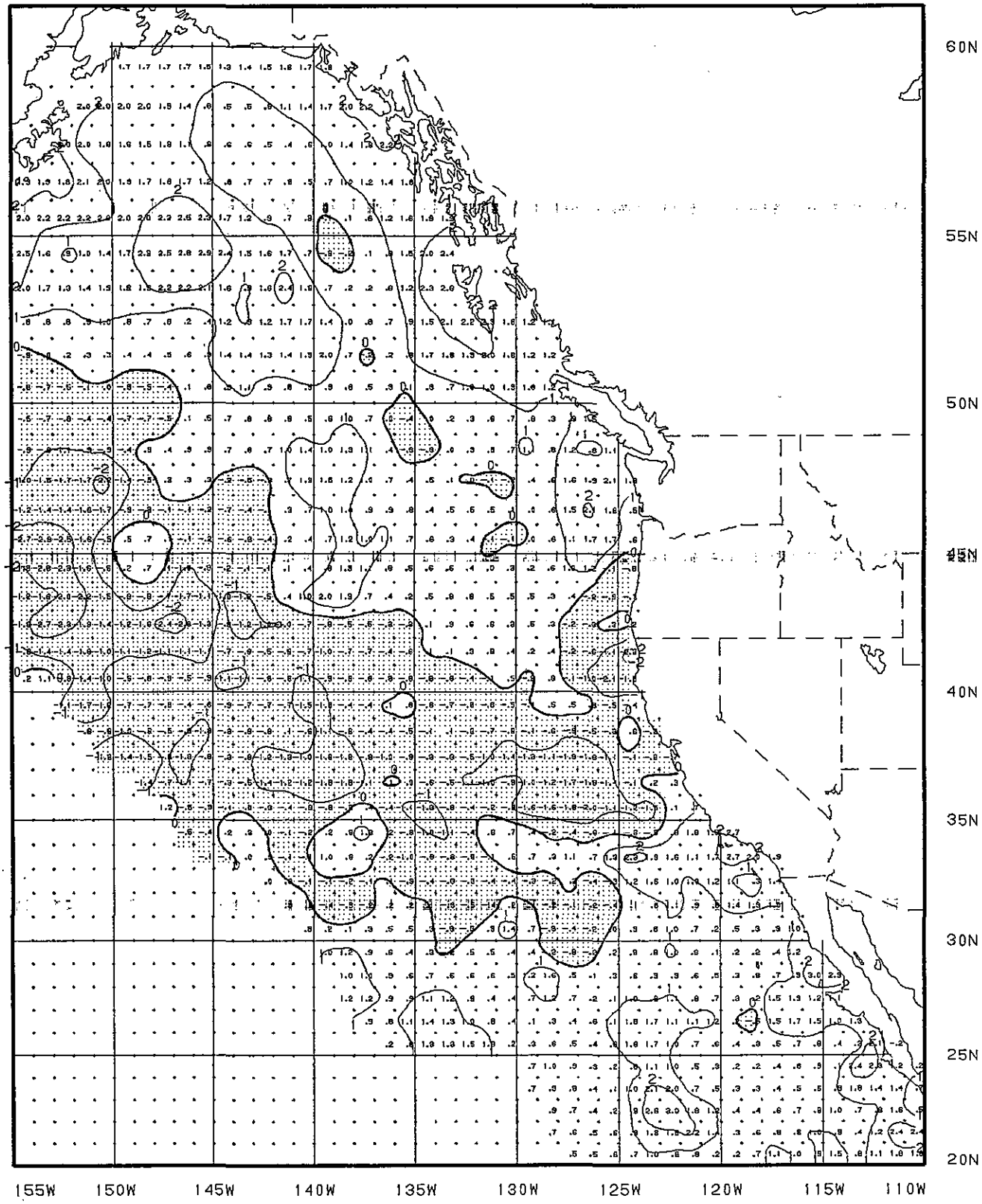

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EAST COAST OCEAN FEATURES

Jenifer Clark
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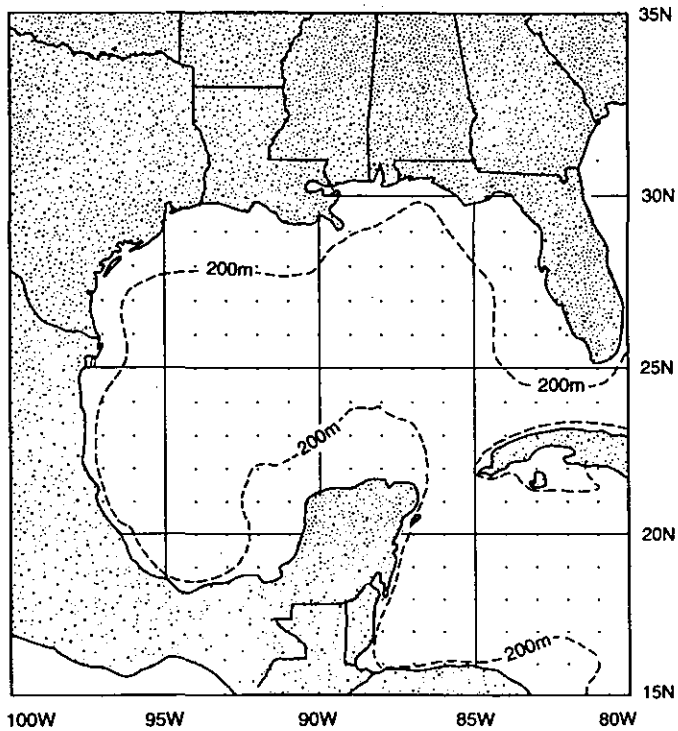
(301) 763-8030

SEPTEMBER 1987

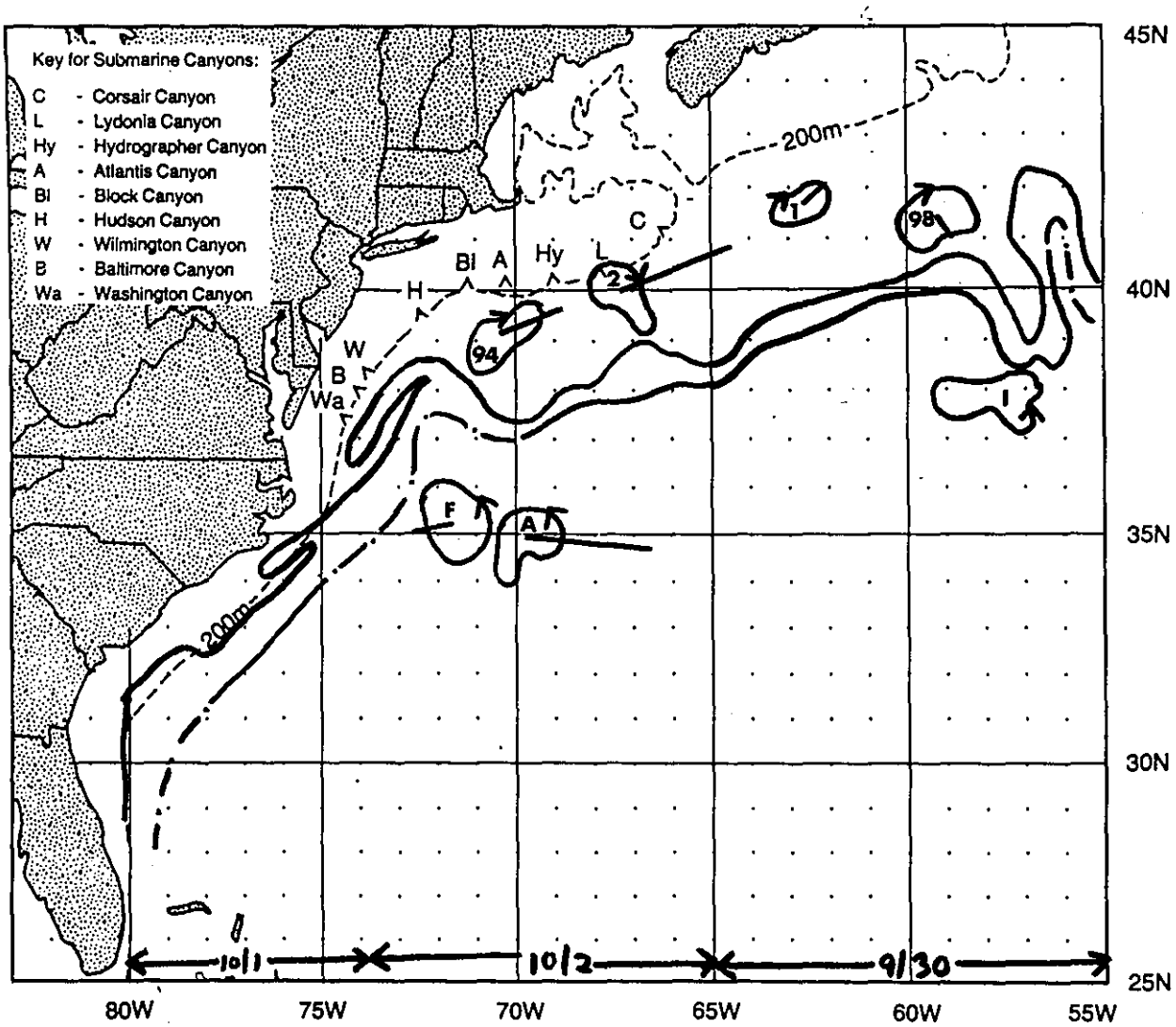
The end of this month's positions of the Gulf Stream System and its associated eddies are shown for the NW Atlantic and the Gulf of Mexico. The Gulf Stream and Loop Current boundaries are located by infrared satellite imagery or XBT (expendable bathythermograph) data. Anticyclonic eddies are labeled a-z in the Gulf of Mexico and 1-99 in the Northwest Atlantic. Cyclonic eddies are labeled A-Z. Arrows on eddies indicate direction of circulation. Warm-core or anticyclonic eddies rotate clockwise; cold-core or cyclonic eddies rotate counterclockwise. The line to the eddy center shows the net translation since last month or since last observed. The edge of continental shelf at 200 m is shown as a dashed line. Eddies or sections of the Gulf Stream System which were not observed during the month are not shown on the analysis chart or are indicated by "dot-dashed" lines. The long arrows at the bottom of the chart indicate the dates of data used.

Data used in this analysis include:
Infrared imagery from NOAA satellite - NESDIS
Bathythermograph data from National Meteorological Center of National Weather Service
Oceanographic Analysis -- A daily detailed analysis issued by National Weather Service



GULF OF MEXICO

Due to continued near isothermal conditions in the central Gulf of Mexico, the Loop Current was not observed.



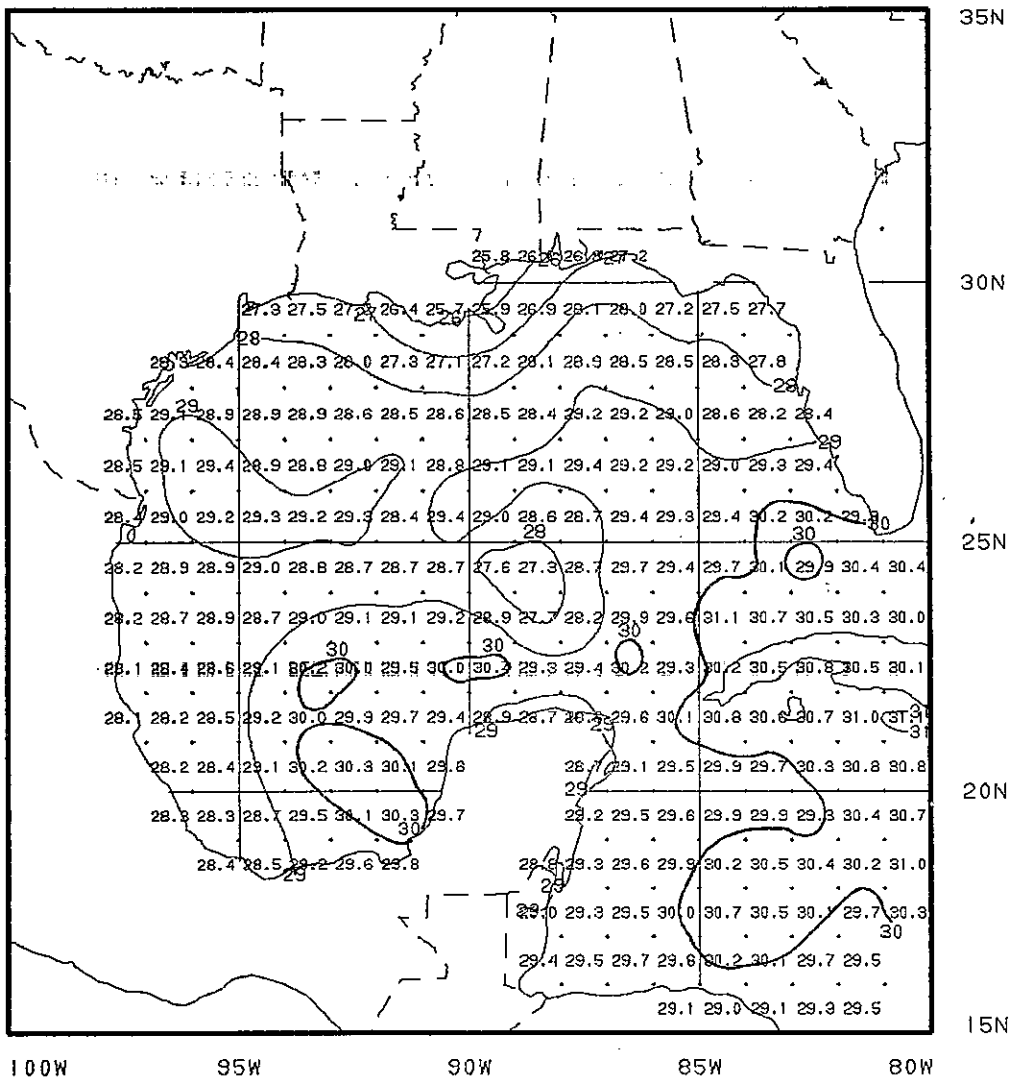
NORTHWEST ATLANTIC OCEAN

One anticyclonic eddy was absorbed during September. Eddy 99 translated 140 km SW and then was absorbed by the Gulf Stream near 38N 72W around October 2. Eddy 96 was not observed and may have dissipated. It was, therefore, deleted from the analysis chart.

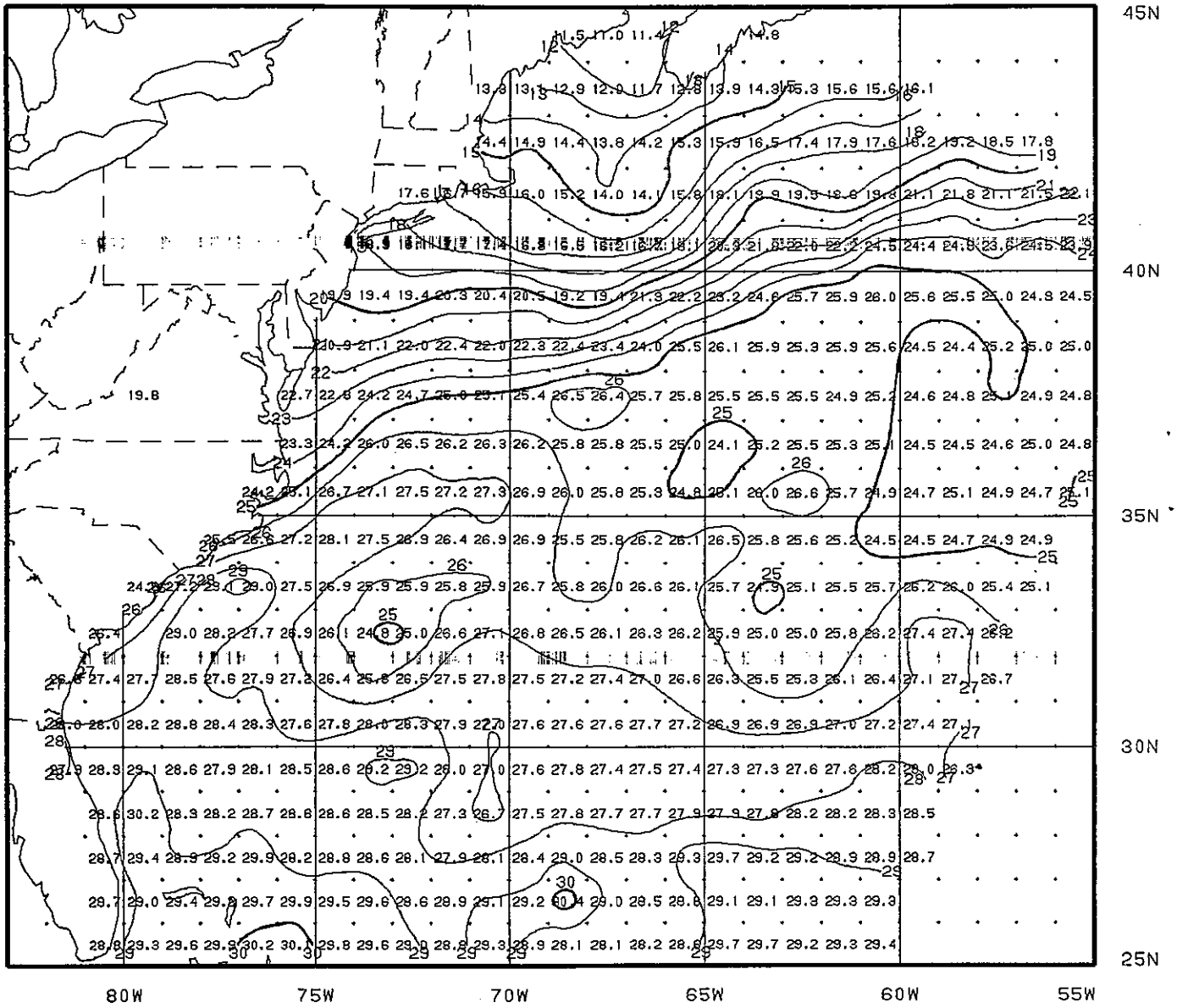
Eddy 94 moved 140 km SW while eddy 2 translated 240 km SW. Eddies 1 and 98 traveled 55 km SW and 55 km NW, respectively.

One cyclonic eddy formed from a Gulf Stream meander. Eddy I formed near 38N 59W around September 23. Eddy F translated 85 km ENE. Eddy A was not observed during August and was deleted from the analysis chart last month. However, eddy A was again detected near 35N 70W. It had again detected near 35N 70W. It had moved 275 km WNW since it was last observed at the end of July. Since eddy G was not observed during September, it was dropped from the chart.

EAST COAST SST – MONTHLY MEAN

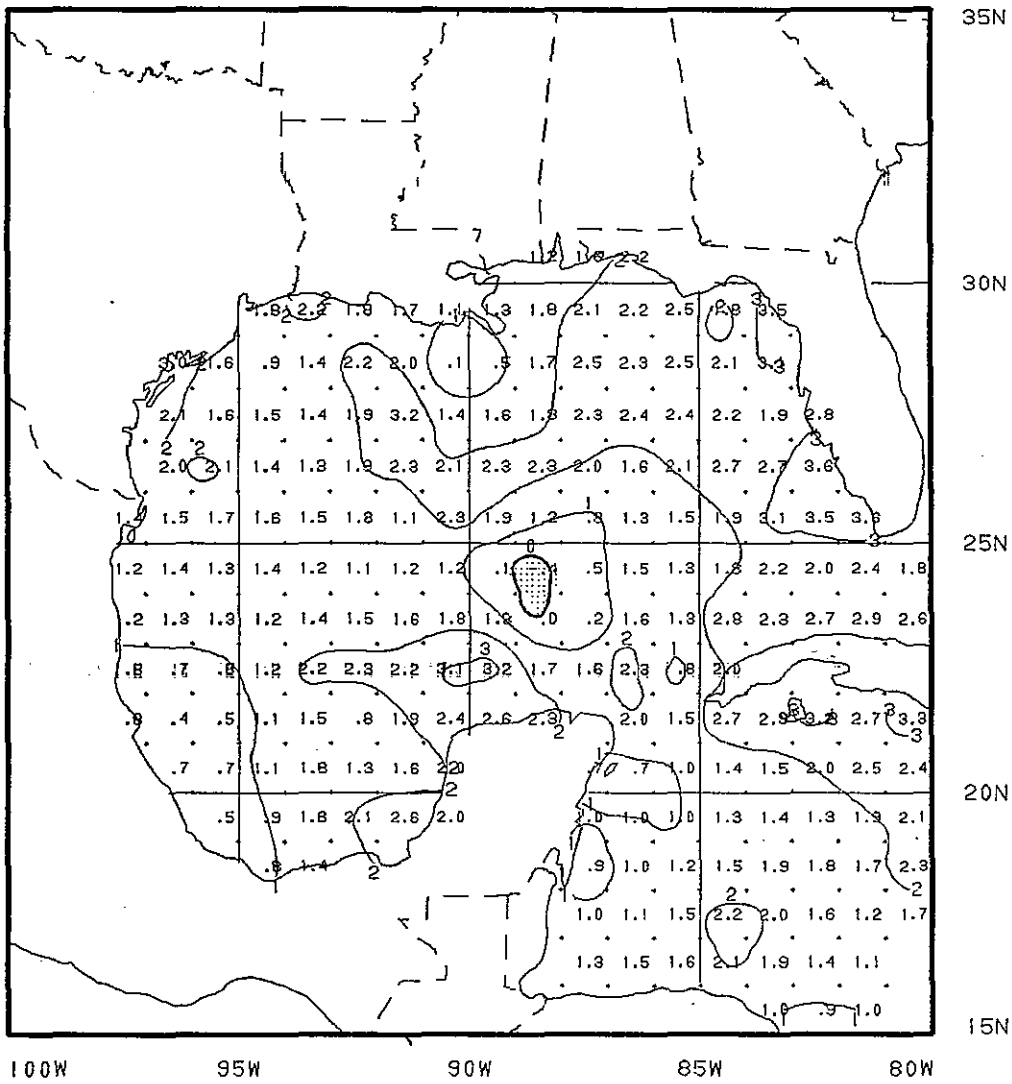


SEPTEMBER 1987 GULF OF MEXICO SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0C.

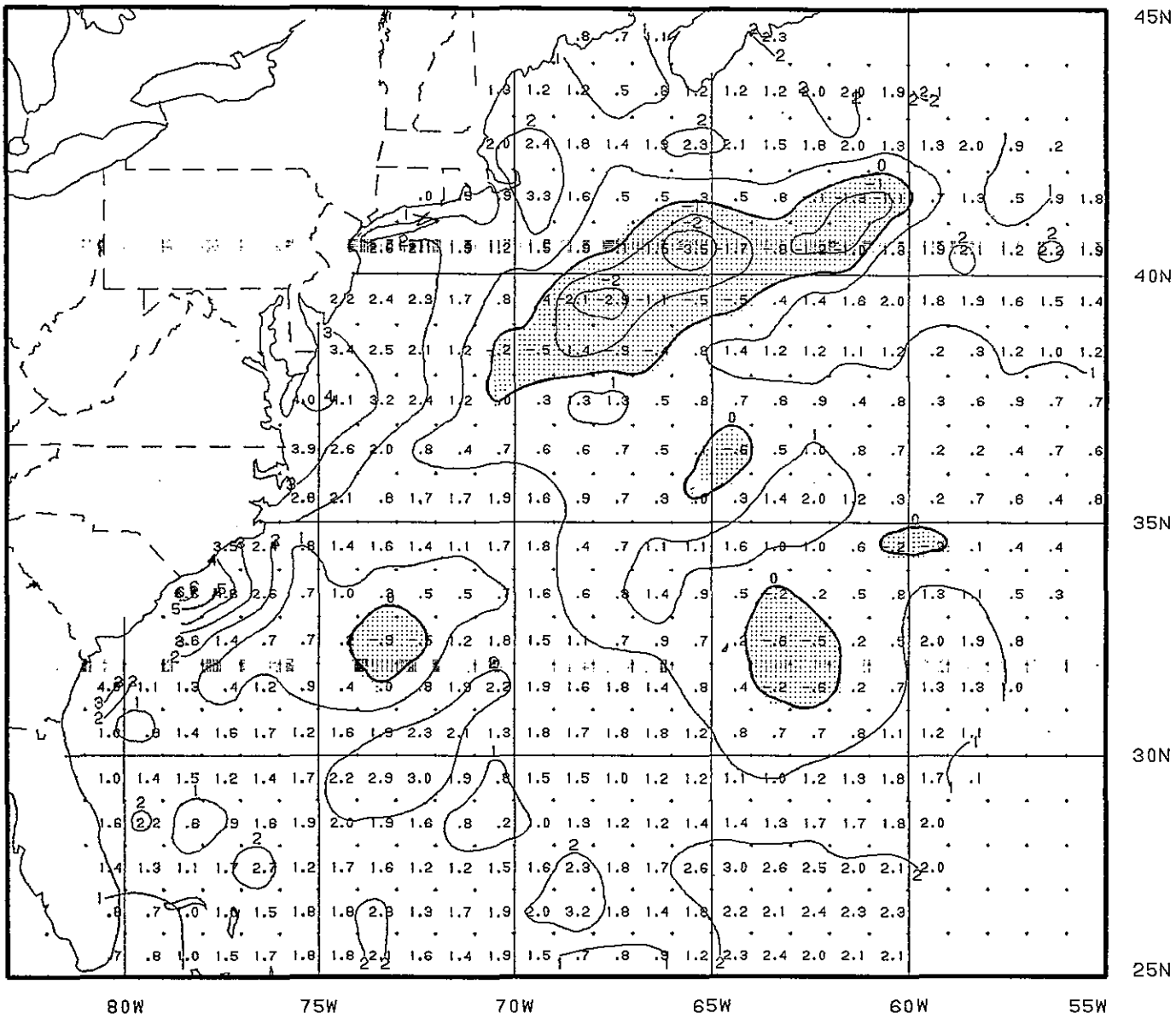


SEPTEMBER 1987 U.S. EAST COAST SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0C.

EAST COAST SST – ANOMALY



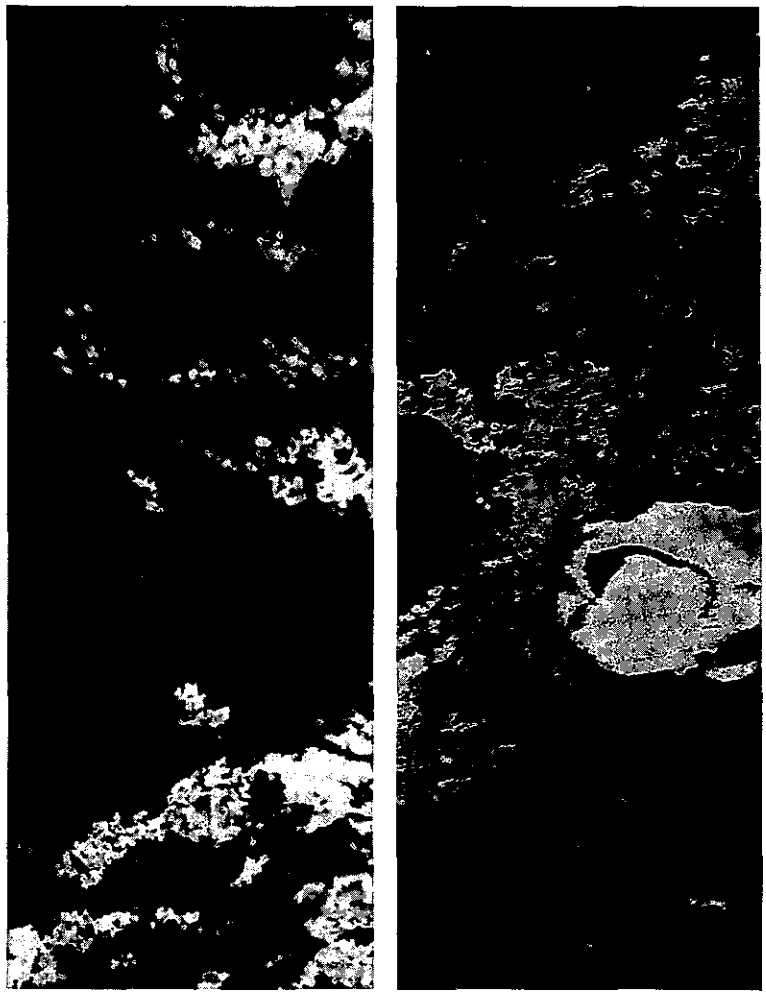
SEPTEMBER 1987 GULF OF MEXICO SST--MONTHLY ANOMALY (C)--Monthly anomaly is the difference between the monthly mean SST and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0C.



SEPTEMBER 1987 U.S. EAST COAST SST--MONTHLY ANOMALY (C)--Monthly anomaly is the difference between the monthly mean SST and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0C.

OCEANOGRAPHIC Monthly Summary

Volume VII Number 10 October 1987



The Pillars of Hercules(page 3)

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U.S. DEPARTMENT OF COMMERCE • National Oceanic and Atmospheric Administration
National Weather Service
National Environmental Satellite, Data, and Information Service
National Ocean Service

OCEANOGRAPHIC
Monthly Summary

Oceanographic Monthly Summary is published by the National Weather Service (NWS), the National Environmental Satellite, Data, and Information Service (NESDIS), and the National Ocean Service (NOS). *Oceanographic Monthly Summary* contains sea surface temperature (SST) analyses on both regional and ocean basin scales for the Atlantic, Pacific, and Indian Oceans. The ocean basin analyses are based on a "blend" of *in situ* and satellite data, in which *in situ* data are used to define "benchmark" temperature values in regions of frequent observations and satellite data are used to define the "shape" of the field between these points.[1]

An ocean basin SST anomaly is derived from the "blended" SST analysis[1] and the improved global SST.[2] The regional SST analyses are based upon a combination of *in situ* and satellite data measurements. The regional SST anomalies are calculated from the Robinson-Bauer Climatology.[3,4] *Oceanographic Monthly Summary* also contains Alaskan sea ice information and ocean feature information for contiguous U.S. ocean regions.

Oceanographic Monthly Summary welcomes articles containing information of interest to its readers, such as news on operational oceanography, unusual ocean feature phenomena, etc. Contributions should be sent to the editor (address below). Accepted material will appear in the OceaNotes section of *Oceanographic Monthly Summary*. Contributions can be published as quickly as the next monthly issue.

If you are interested in receiving *Oceanographic Monthly Summary* regularly, please refer to the back cover for subscription information.

[1]Reynolds, R.W. and W.H. Gemmill, 1984. A sea surface temperature analysis which blends *in situ* and satellite observations. *Proceedings of the Ninth Climate Diagnostics Workshop*, Corvallis, OR, Oct. 22-26, 1984, pp. 408-416.

[2]The climatology is derived from *in situ* data (1950-1979), satellite data (1982-1985) and an ice climatology.

[3]Robinson, M.K., 1976. Atlas of North Pacific Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOcean Ref. Pub. 2.*

[4]Robinson, M.K., R.A. Bauer, and E.H. Schroeder, 1979. Atlas of North Atlantic-Indian Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOceano Ref. Pub. 18.*

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OceaNotes

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The Pillars of Hercules

Featured on this month's cover are two different images from polar-orbiting satellites taken over the Straits of Gibraltar, Alboran Sea and the Western Mediterranean. The image on the left is an atmospheric moisture-corrected sea surface temperature NOAA-9 pass from September 25, 1985. The panel on the right is a thermal infrared image from the DMSP satellite from September 1, 1987. The higher contrast of the DMSP is due the fewer grey shades available with 8-bit digital data as compared with the NOAA imagery of 11-bits and higher number of possible grey shades to delimit subtile features. The basic geographical features of the coastlines of Spain and Algeria and the inrush of the cooler (darker shade) Atlantic Ocean water through the Straits of Gibraltar (with its characteristic coriolis curvature) are readily apparent in both satellite's images.

Known as the Pillars of Hercules to the ancient Phoenicians, the perils of passing through the Straits of Gibraltar in open galleys are well documented in the chronicles of Phyra (400-500 BC) and the Athenian sailors of 500-600 BC. The constant surface current rushing in through the narrow Straits (approximately 10 km wide) is caused by the physical characteristics of the Mediterranean Basin. It is an enclosed sea 4000 km long which is dominated by warm climate. The common clear skies and warm water produces much surface evaporation and thus produces an increased salinity and lowered sea level within the Mediterranean. The waters of the Atlantic Ocean, being higher in sea level, flow into the Western Mediterranean but must pass over a relatively shallow sill at the Straits of Gibraltar.

The stream of cooler Atlantic Ocean water rushing through the shallow, narrow Straits into the saltier Mediterranean is at sufficient velocity to retain its integrity and temperature identity well over 50 km past the Straits. The coriolis rotation of this separately identifiable water mass is clearly visible in both images. The entrainment of some of the warmer Mediterranean water and some of the North African upwelled (very light color) coastal water is more evident in the NOAA image but the extent of the Atlantic inrush current in more apparent in the DMSP image.

LONG-TERM VARIABILITY IN SEA SURFACE TEMPERATURE AT ONE LOCATION ALONG THE CENTRAL CALIFORNIA COAST

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Sea-surface temperatures (SSTs) have been acquired since March 1, 1971 at Granite Canyon, a shore location 11 km north of Pt. Sur and about 25 km south of Monterey along the central California coast (figure 1). This location has a good exposure to the deep ocean with the continental shelf extending only 6 km offshore. The observations are taken daily with a calibrated immersion thermometer at approximately 0800 local time by the Marine Culture Laboratory of the California Fish and Game Commission.

(text continued on page 13)

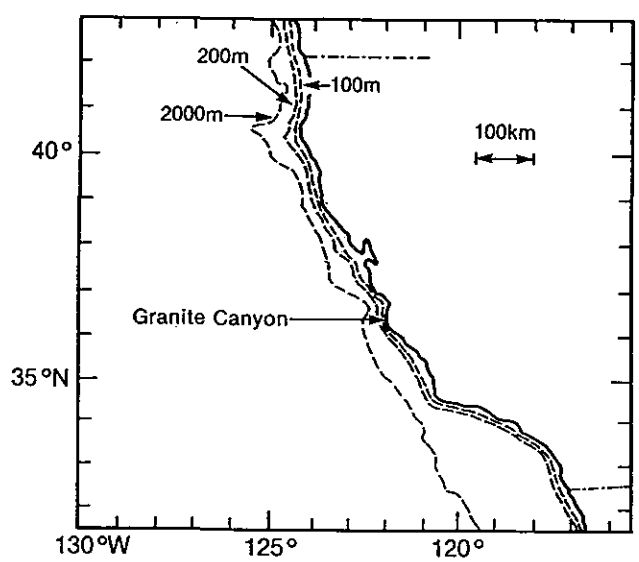
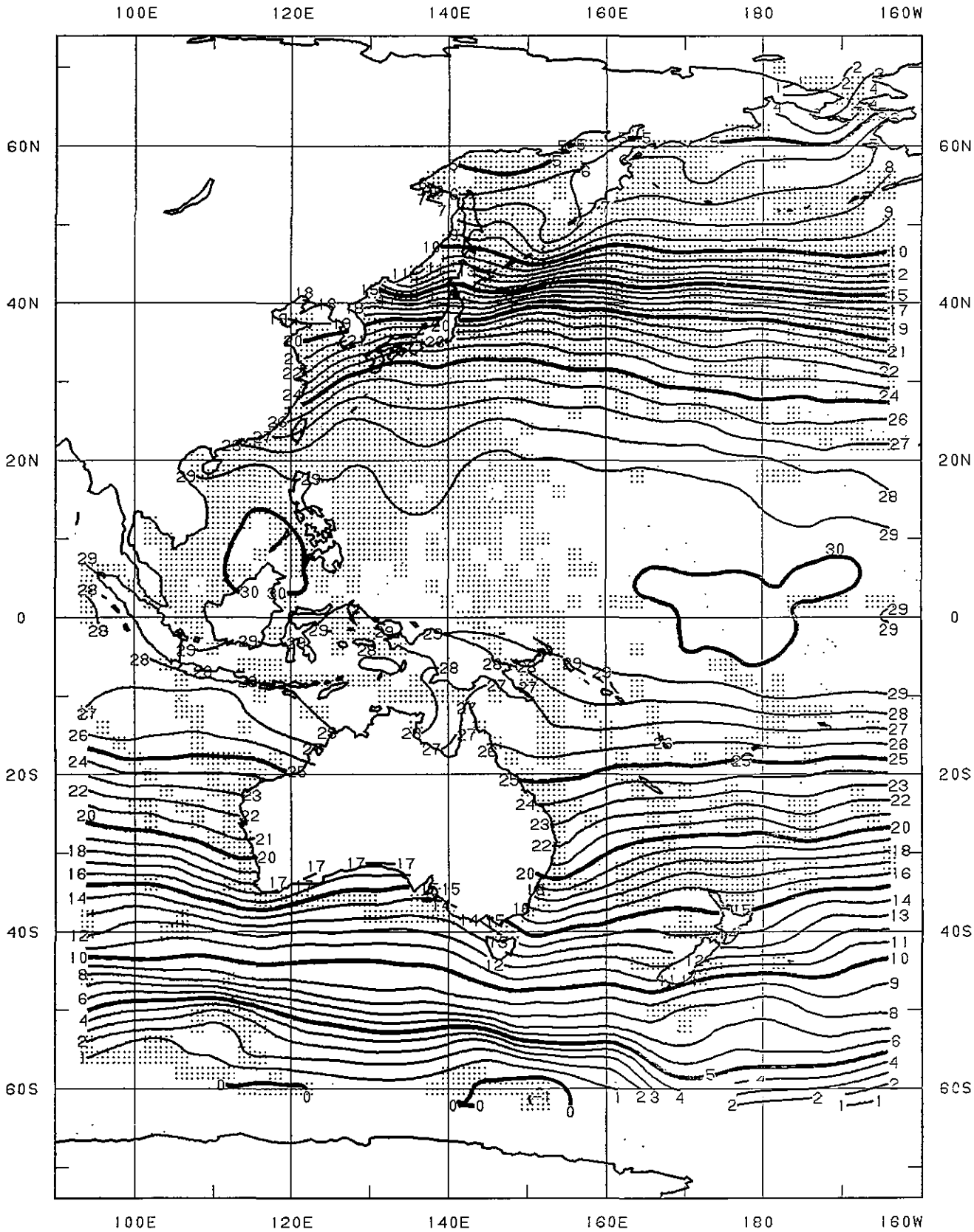
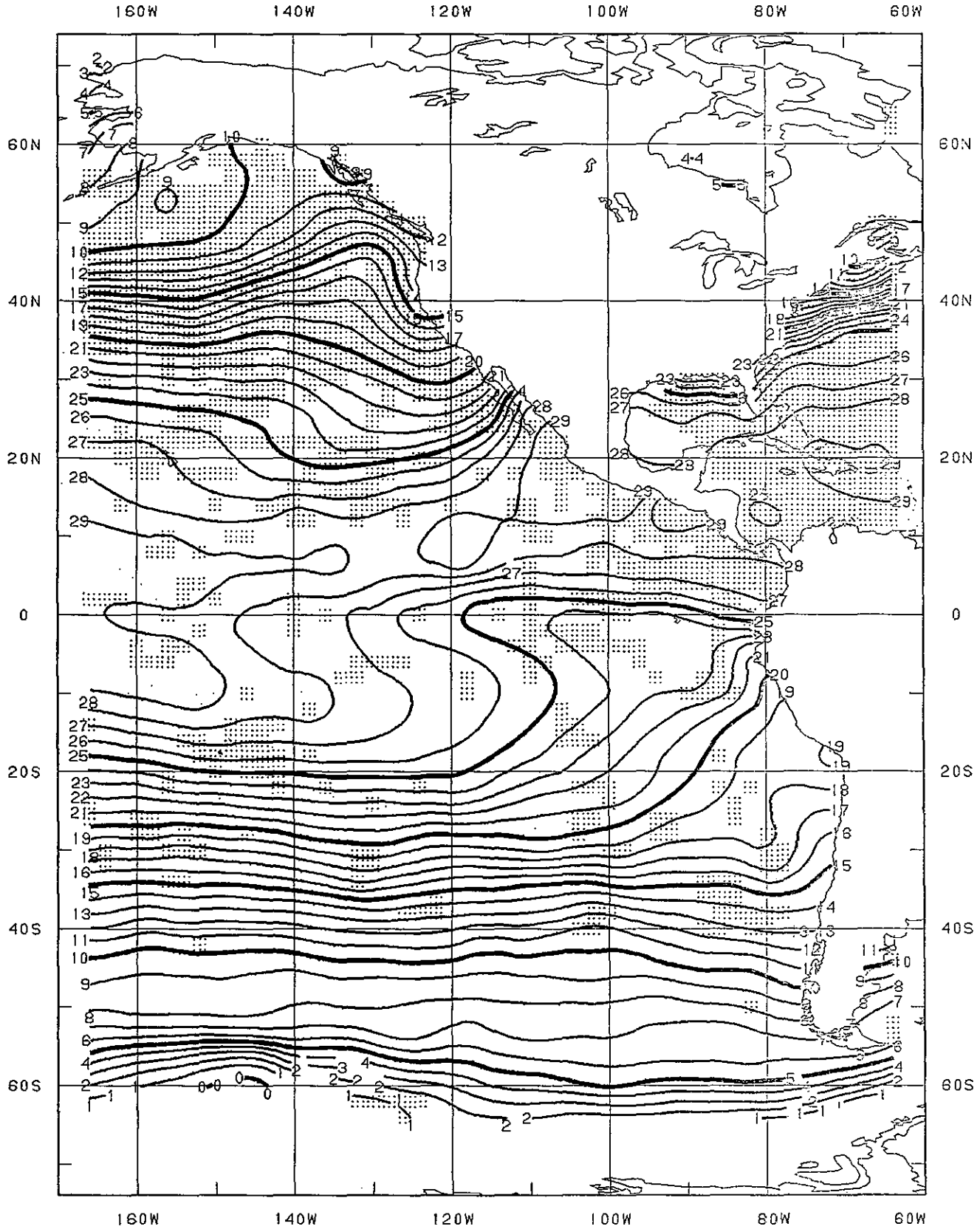


Fig. 1. Location of sea surface temperature acquisition site along the central California coast.



OCTOBER 1987 WESTERN PACIFIC OCEAN SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of **in situ** (ship, buoy) and satellite data within two-degree quadrangles. Contour line interval is 1.0 C. The stippling indicates where the analysis was fixed by the **in situ** data; contours are not shown in areas without data.



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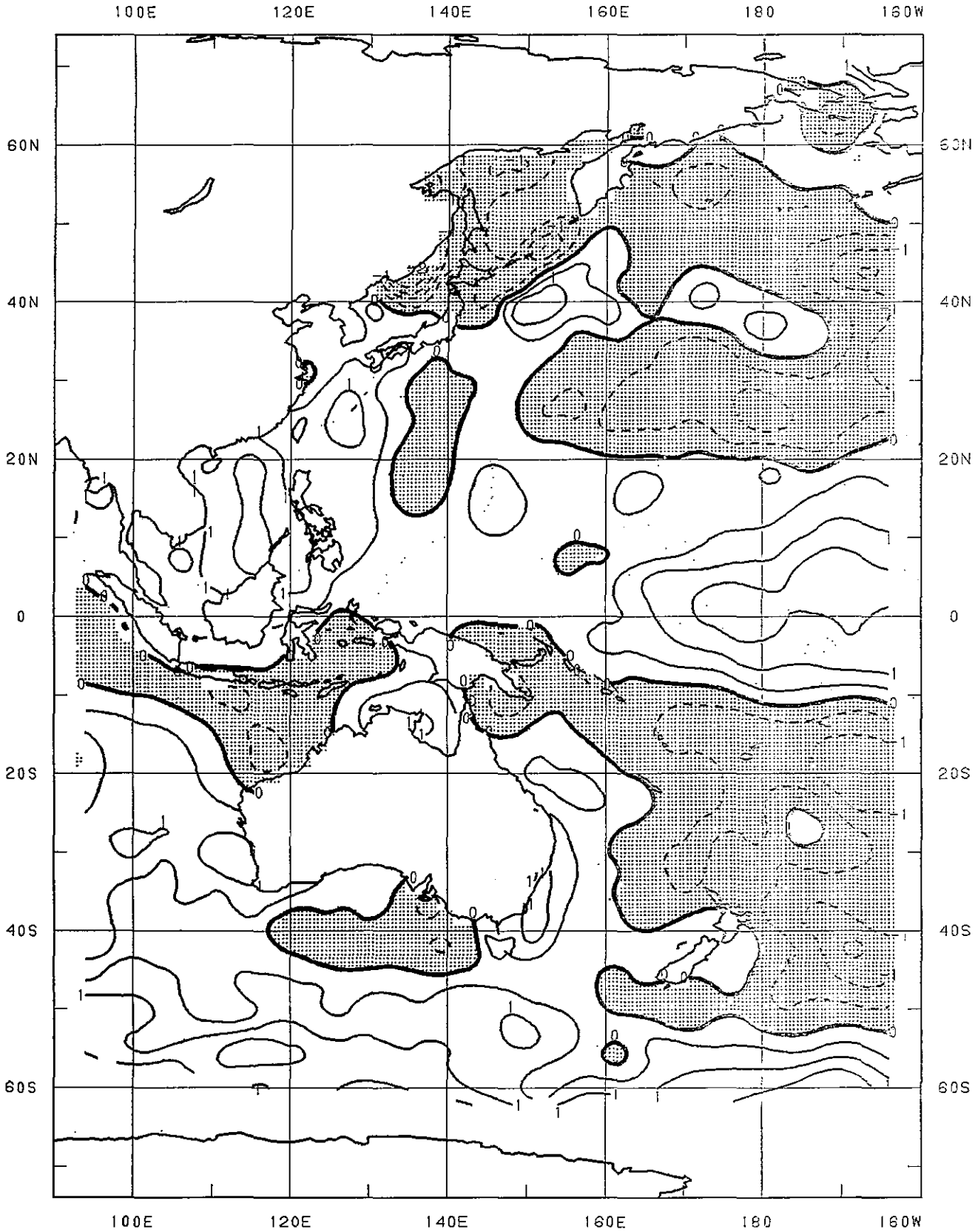

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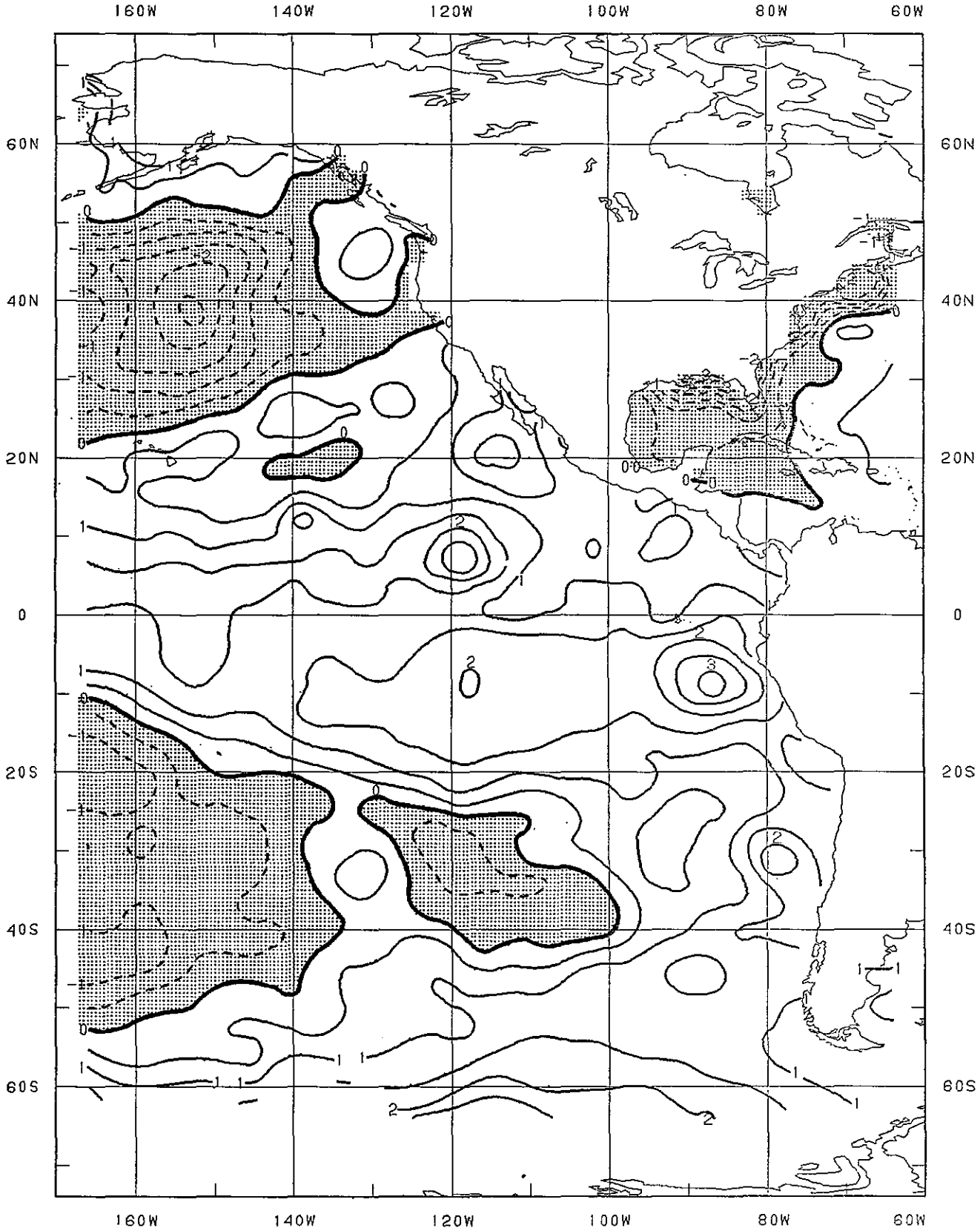

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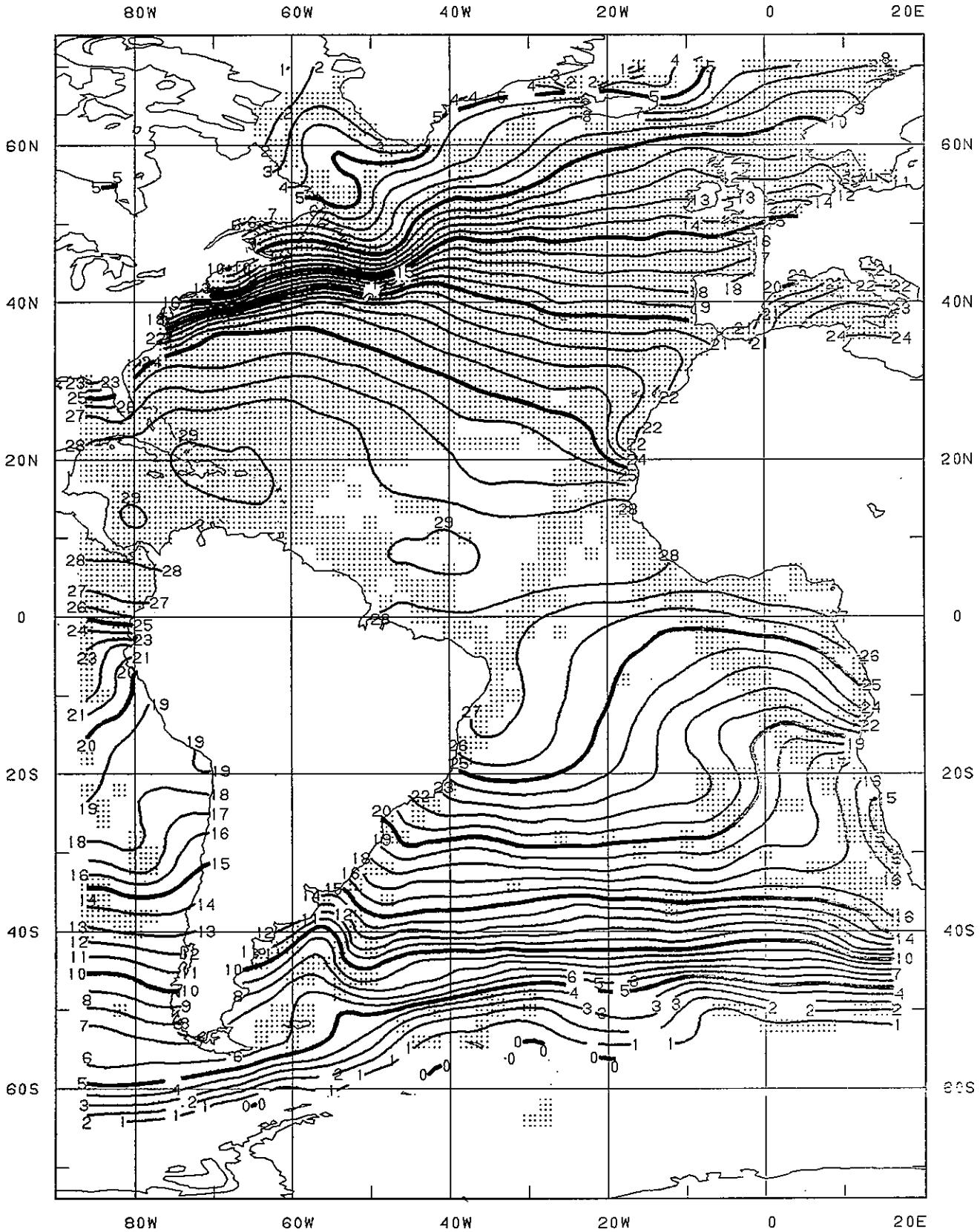
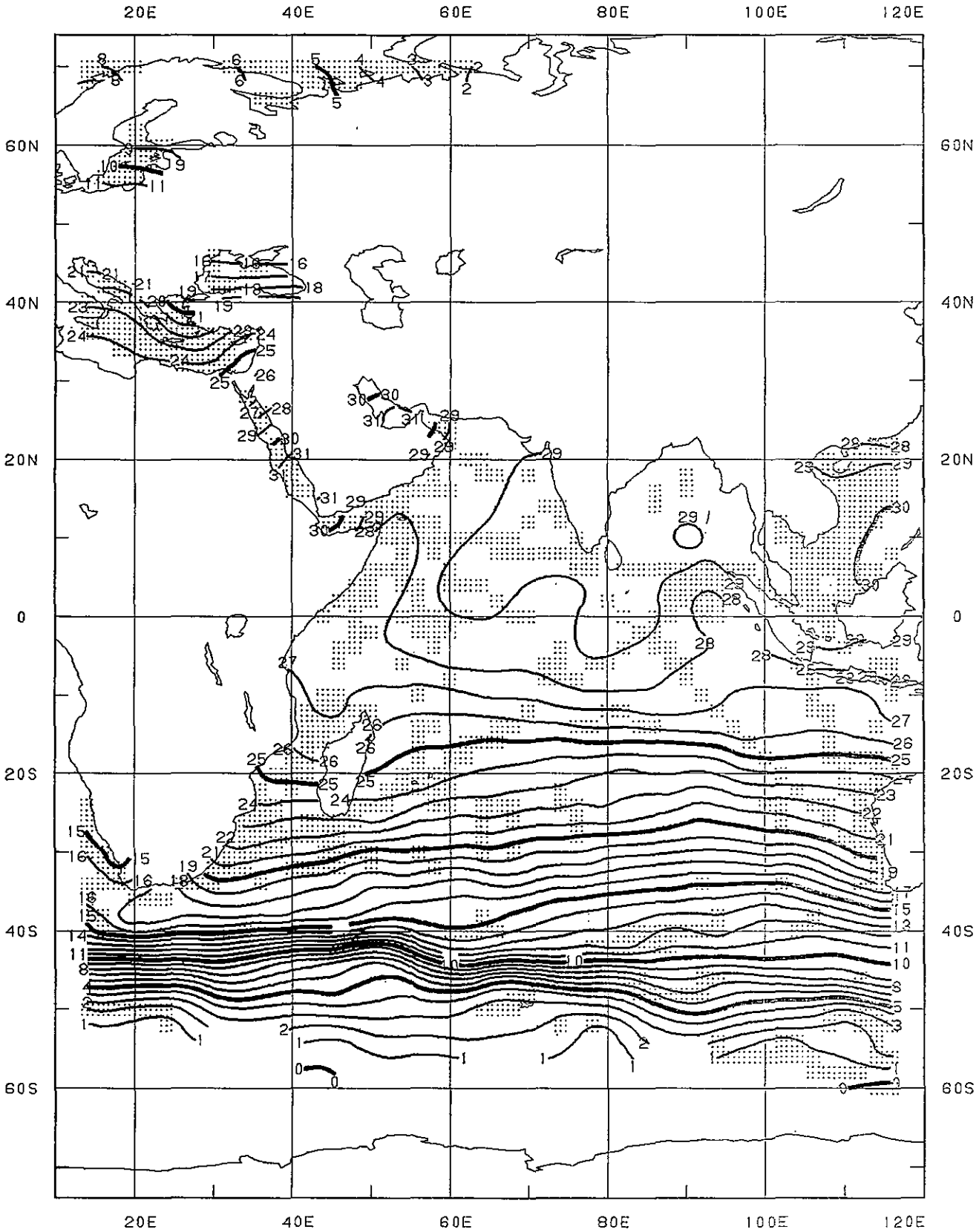
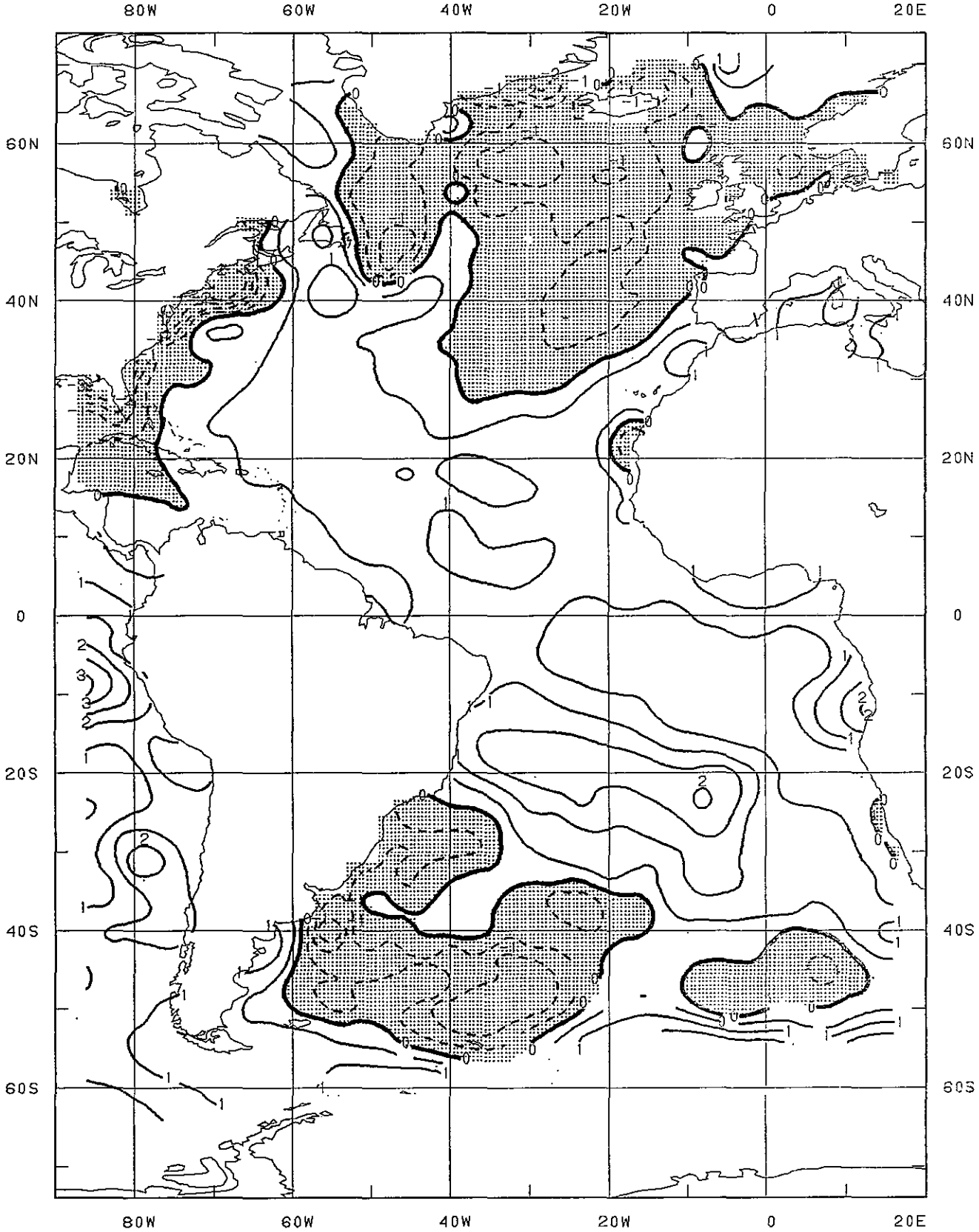


OCTOBER 1987 ATLANTIC OCEAN SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of **in situ** (ship, buoy) and satellite data within two-degree quadrangles. Contour line interval is 1.0 C. The stippling indicates where the analysis was fixed by the **in situ** data; contours are not shown in areas without data.



OCTOBER 1987 INDIAN OCEAN SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of **in situ** (ship, buoy) and satellite data within two-degree quadrangles. Contour line interval is 1.0 C. The stippling indicates where the analysis was fixed by the **in situ** data; contours are not shown in areas without data.



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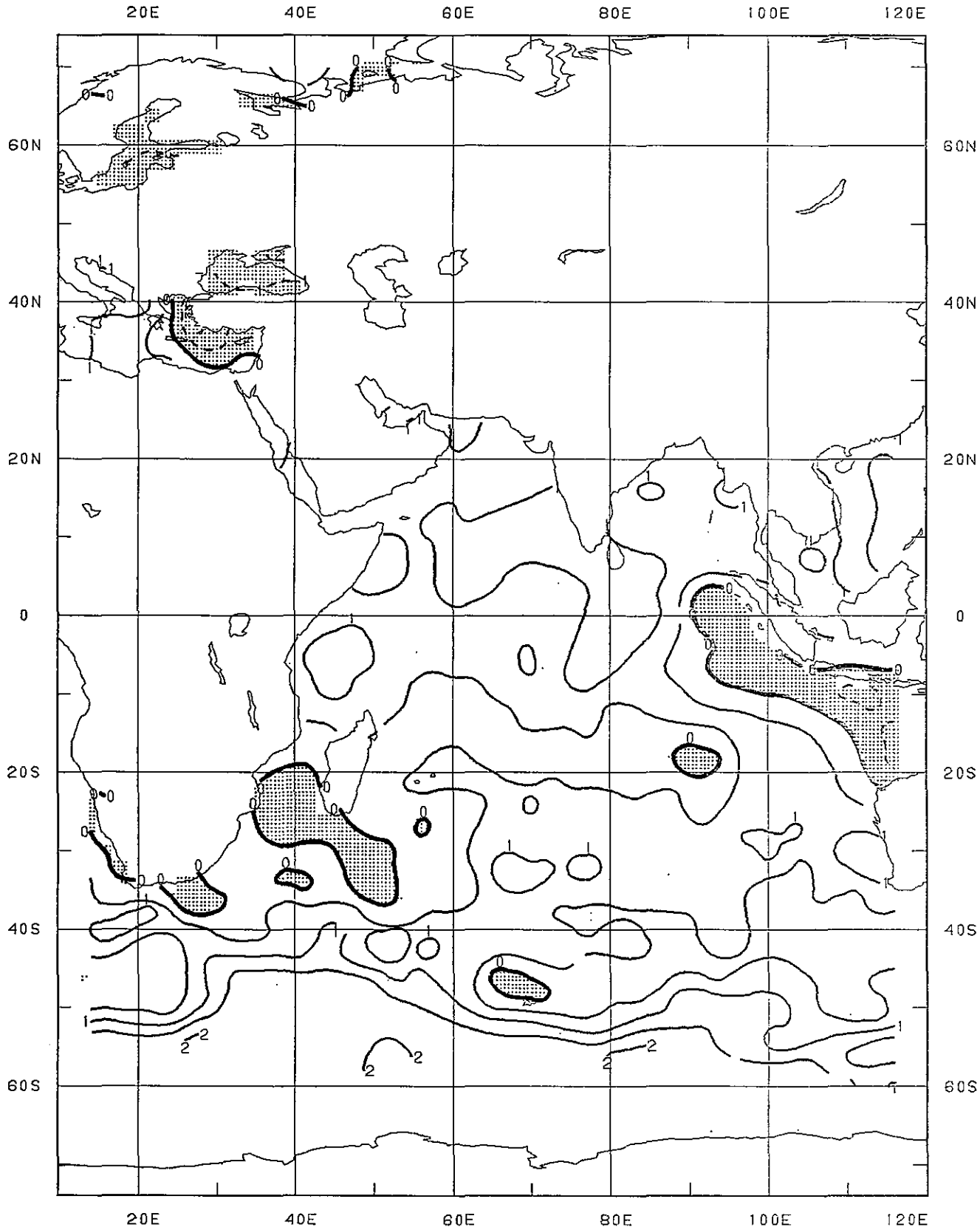

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(continued from page 3)

Figure 2 shows the time-series of daily SST at Granite Canyon from March 1, 1971 to March 1, 1986. Long-term variability on interannual time scales is clearly evident. Specifically, each El Nino episode occurring over the period of record is indicated by a vertical arrow (the 1972-73, 1976-77, 1979-80, and the 1982-83 episodes). By equatorial standards, the 1972-73 episode was classified as strong, whereas the 1976-77 El Nino was classified as an episode of moderate intensity. The 1982-83 El Nino episode was the most intense episode within the past 25 years. Even the relatively weak El Nino episode of 1979-80 can be easily identified in the raw data. Closer inspection of these data indicate that El Nino influence at mid-latitudes along the central California coast is most pronounced during fall and winter and that this is most likely associated with intensified poleward flow in the Davidson coastal current.

Abrupt decreases in temperature can also be seen in 1973, 1977, 1980 and 1981 and correspond to spring transitions to coastal upwelling. The spring transition is a major event along the coasts of California and Oregon that signals the seasonal change from non-upwelling to upwelling conditions. This transition is not always distinct, but in those years that it can be uniquely identified, it is apparently most intense following El Nino episodes.

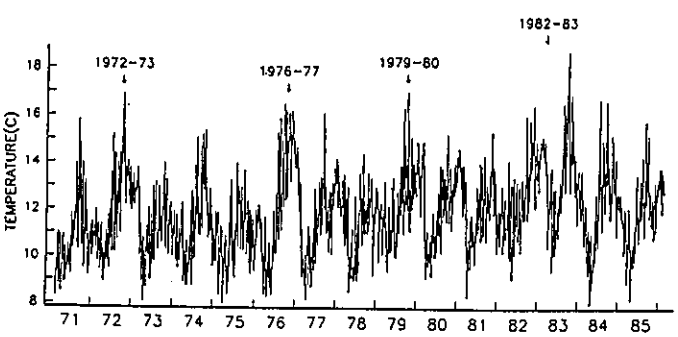


Fig. 2. Daily sea surface temperatures at Granite Canyon from 1 March 1971 to March 1986.

Of particular interest is the 1982-83 El Nino because of its intensity and duration. Figure 3 shows a comparison of SSTs at Granite Canyon starting on January 1, 1982 and ending on January 1, 1984. The solid curve (smoothed slightly) represents a 12-year annual mean which has been repeated to span the two-year period. The dashed curve represents the raw data during the same period.

Periods of major warming associated with this episode occur, during January, February, and March and during September, October and November of 1983. During September and October, temperatures were almost 5 C above average. Above average temperatures persisted for approximately 20 months starting in April of 1982. By comparison, the significantly higher temperatures associated with the 1972-73 and 1976-77 El Ninos lasted for approximately 12 months. Although not shown, temperatures were also above normal during most of 1984.

Sea-surface temperature appears to be a sensitive indicator of El Nino influence along the central California coast. During the past 16 years, four El Nino episodes of varying intensity were revealed in the time-series of SST at Granite Canyon. Due to their frequency of occurrence, intensity and duration, these episodes must be considered to be a major source of interannual variability along the central California coast.

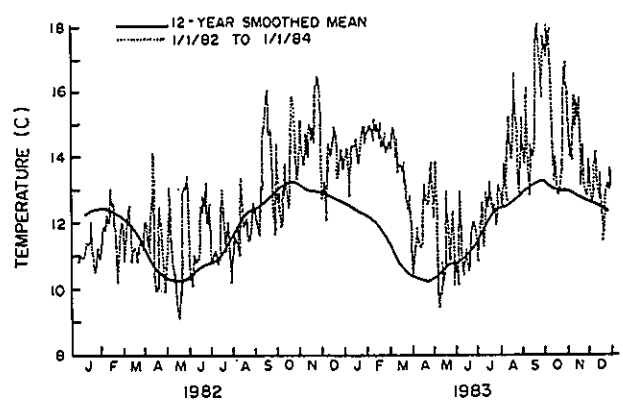
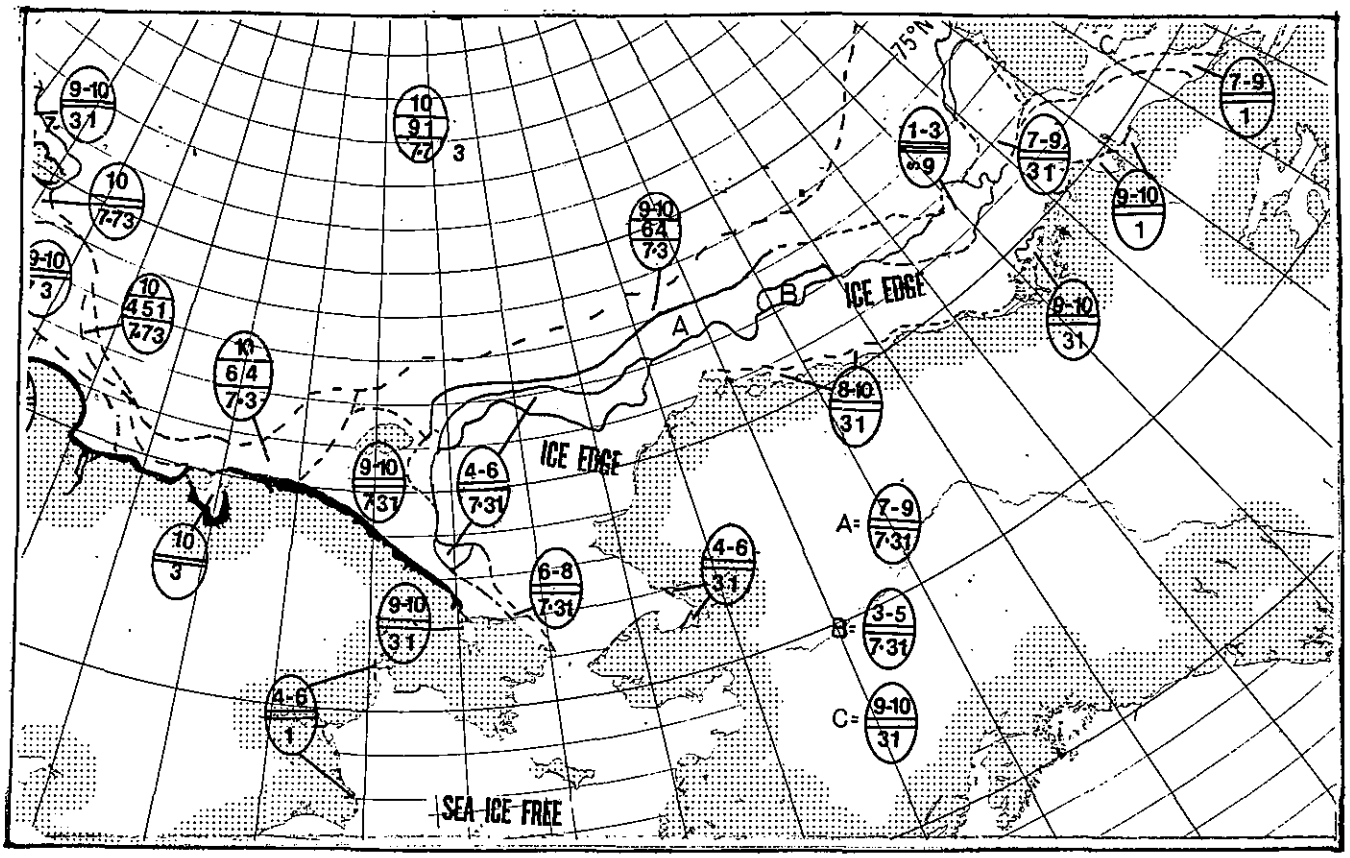


Fig. 3. SSTs at Granite Canyon from 1 January 1982 to 1 January 1984. The solid curve is the smoothed mean annual cycle at Granite Canyon calculated from 12 years of data (1 March 1971 to 1 March 1983). The dashed curve is the raw data at Point Sur.



BERING SEA / NORTH SLOPE ICE ANALYSIS

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OCTOBER 1987

Generally mild conditions persisted through nearly all of October along Alaska's North Slope region. Strong storms in the Bering Sea area and high pressure to the east maintained a flow of warm air over the interior of Alaska and into the southern Beaufort and Chukchi Seas. The multiyear ice comprising the permanent polar ice pack was maintained offshore at the same time that the development of new ice in protected bays and inlets was inhibited. By the last week of the month only a narrow strip of new and young ice could be found along the Beaufort Sea coastline. As the month ended the atmospheric conditions responsible for the mild pattern weakened allowing more seasonably cold air to enter the Chukchi and Beaufort Seas. Ice growth is anticipated to be rapid during November as temperatures fall and daylight hours are drastically reduced.

C = Total ice concentration in the area in tenths.

C_a, C_b, C_c = Concentration of thickest (C_a), 2nd thickest (C_b), and 3rd thickest (C_c) ice

S_a, S_b, S_c = Stage of development of thickest (S_a), 2nd thickest (S_b), and 3rd thickest (S_c) ice.

$^{\bullet}C$ = Concentration of ice within area(s) of strips and patches.

STAGE(S) OF DEVELOPMENT (THICKNESS)

1 = New ice (0-10 cm)
3 = Young ice (10-30 cm)
6 = First year (30-200 cm)
7 = First year thin (30-70 cm)
1. = First year medium (70-120 cm)
4. = First year thick (120-200 cm)
7. = Old ice (survived at least one summer's melt)

EXAMPLES

125 Theoretical thickness of this season's growth (cm).

Fast ice. Sea ice which forms and remains fast along the coast.

Ice boundary visually or satellite observed.

Ice boundary estimated.

WEST COAST OCEAN FEATURES

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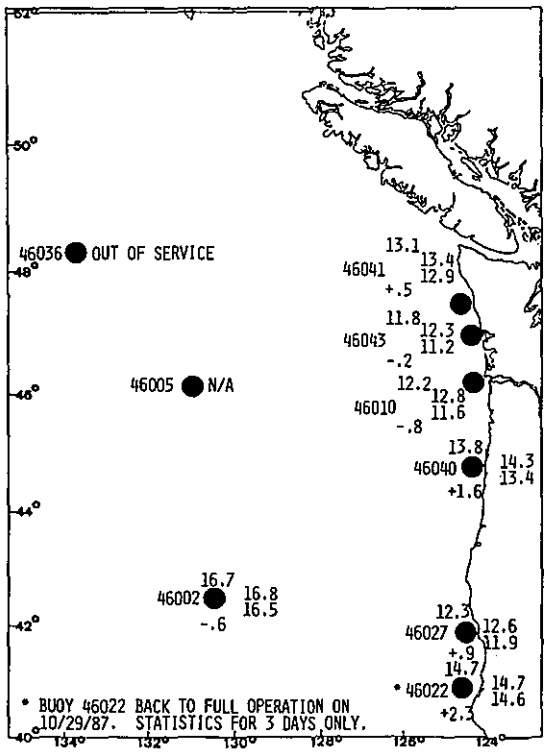
OCTOBER 1987

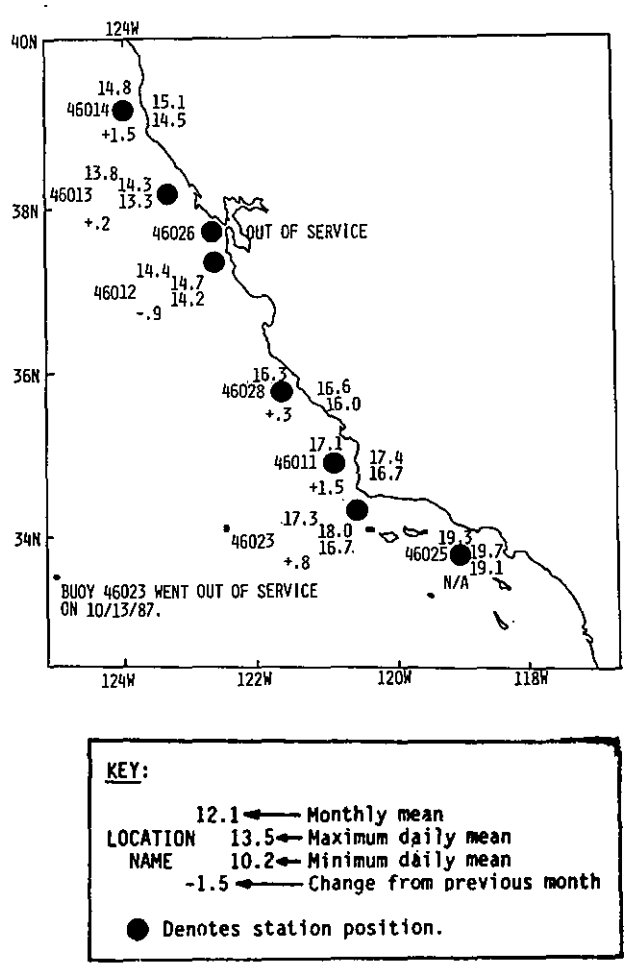
During October, sea surface temperatures in both the North and South Panels averaged above normal. The observed mean temperature of the North Panel was 15.6 C, or 0.6 warmer than climatology; in the South Panel, 19.2 C was the observed mean, compared to the climatological mean for the area of 18.8 C. Therefore, the entire West Coast averaged about a half degree warmer than normal.

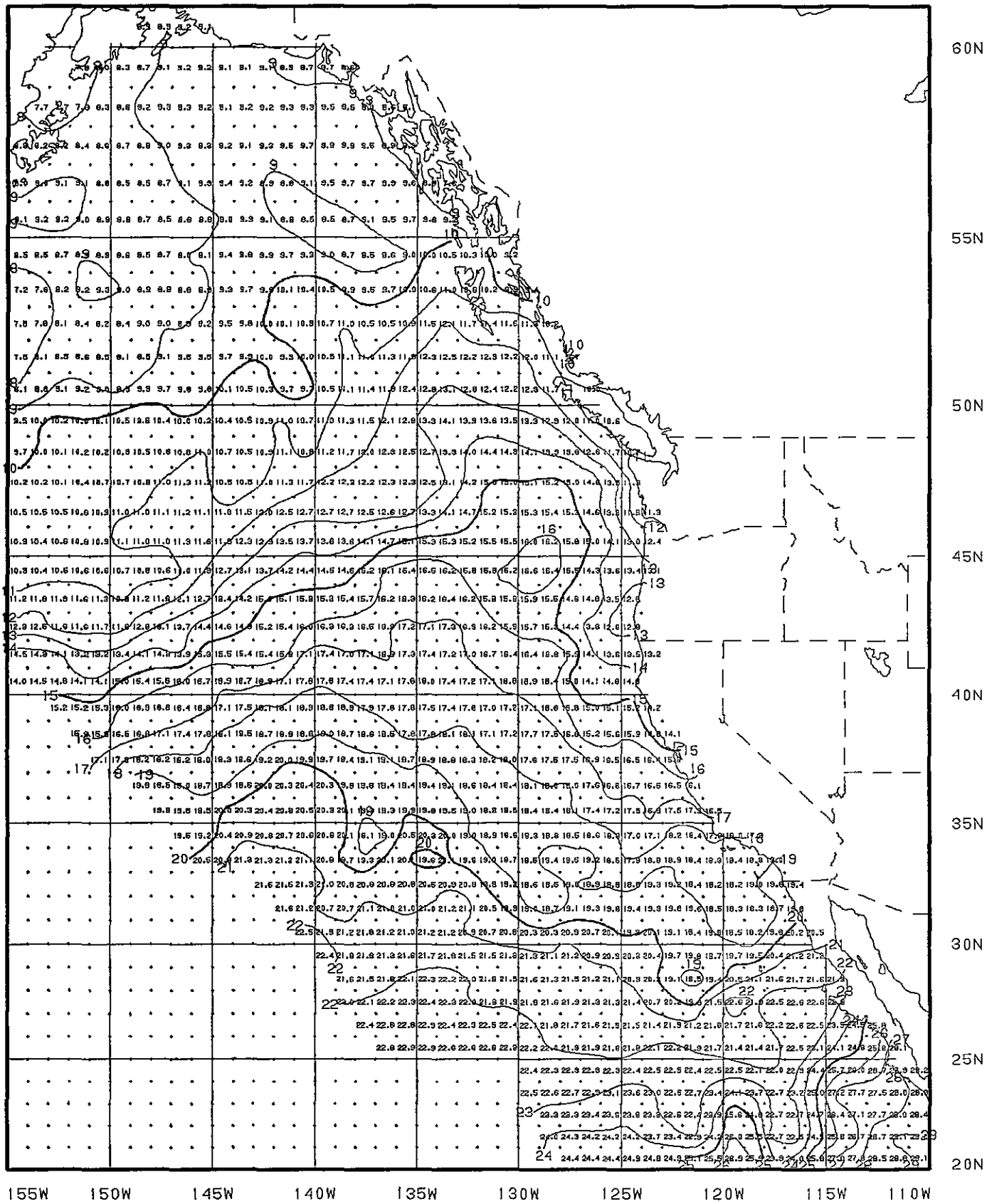
In the North Panel, locations to the north of the 43rd parallel were warmer than climatology and had positive anomalies over 1.5 C, particularly around Vancouver Island and to the west of Washington State. South of 43N, temperatures were from 0.2 to 0.4C below normal. Comparing this month's SSts to those of last month, there was a general decline in temperature between 0.2 and 0.9C. A small elongated area along the 132nd meridian showed a slight increase in values.



South Panel SSts continued to show the trend that offshore waters are below normal and nearshore waters are above. The area north of 32N and west of 126W was cooler than climatology; all other locations were warmer. A negative anomaly of 1.1C was the highest observed and this was centered at 37N 128 W. Along the coast, positive anomalies ranged between 0.6C on the northern California coast to 2.0C along the Baja peninsula. Comparing October SSTs to those of September, there was both warming and cooling observed. The greatest warming (+0.7C) was near 35N 122W, and the maximum cooling (-.4C) occurred at 34N 130W.

The above information is based on the nine analyses produced in each panel during the month. The graphical information depicted here is generated solely from the 3 hourly SST observations stored in the NMC data base from each fixed buoy in the analysis area.





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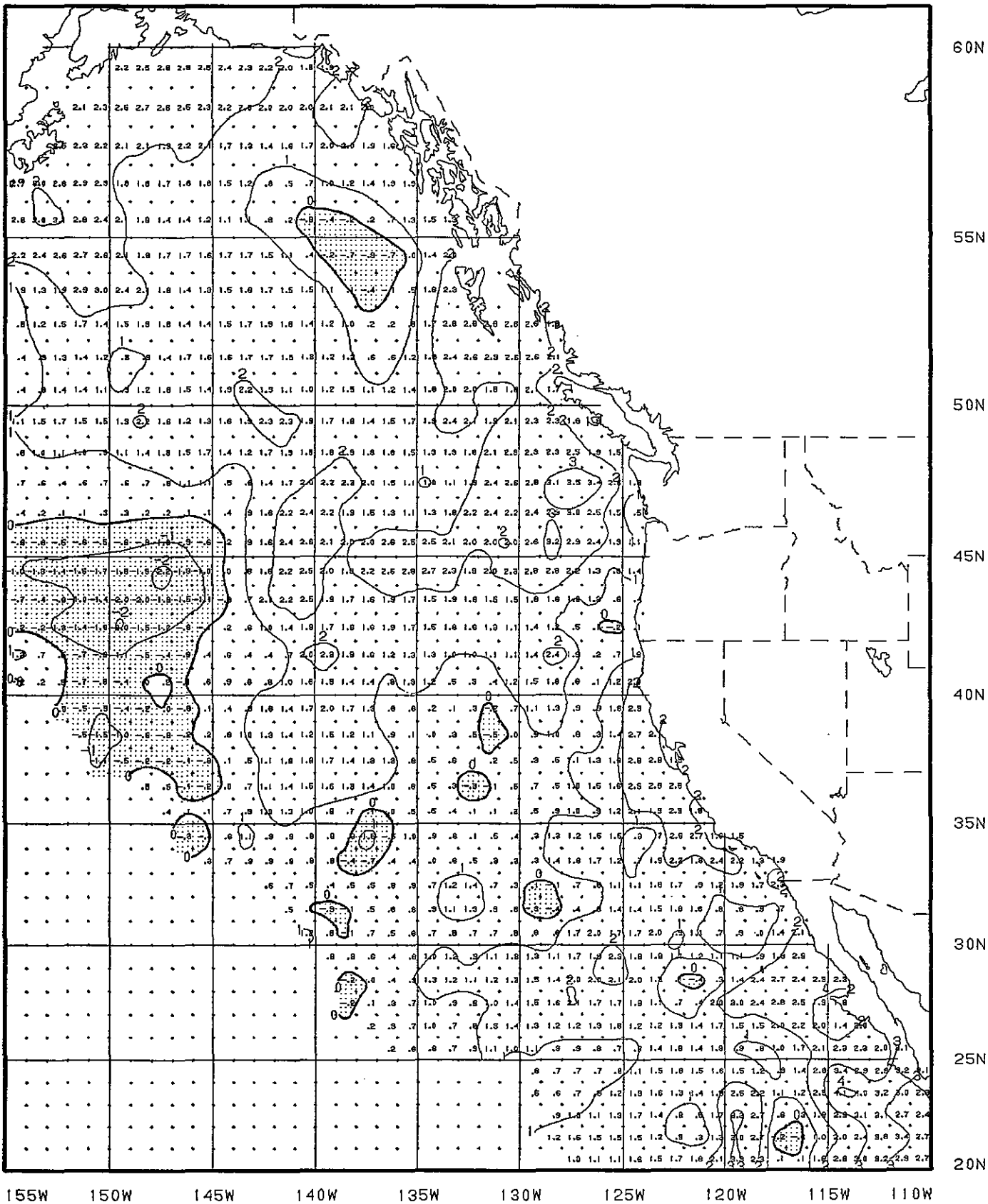

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EAST COAST OCEAN FEATURES

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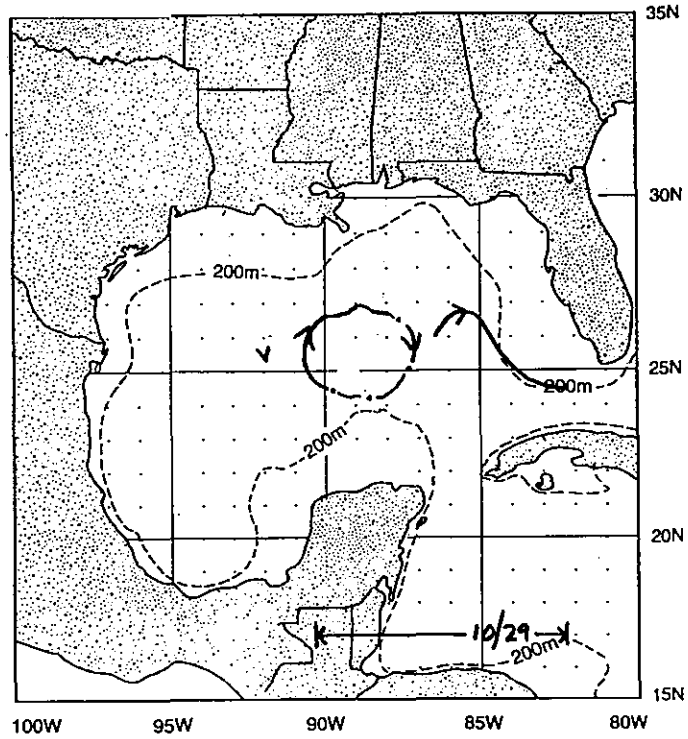
Washington, DC 20233
(202) 899-3296

Data used in this analysis include:
Infrared imagery from NOAA satellite - NESDIS
Bathythermograph data from National Meteorological Center of National Weather Service
Oceanographic Analysis -- A daily detailed analysis issued by National Weather Service

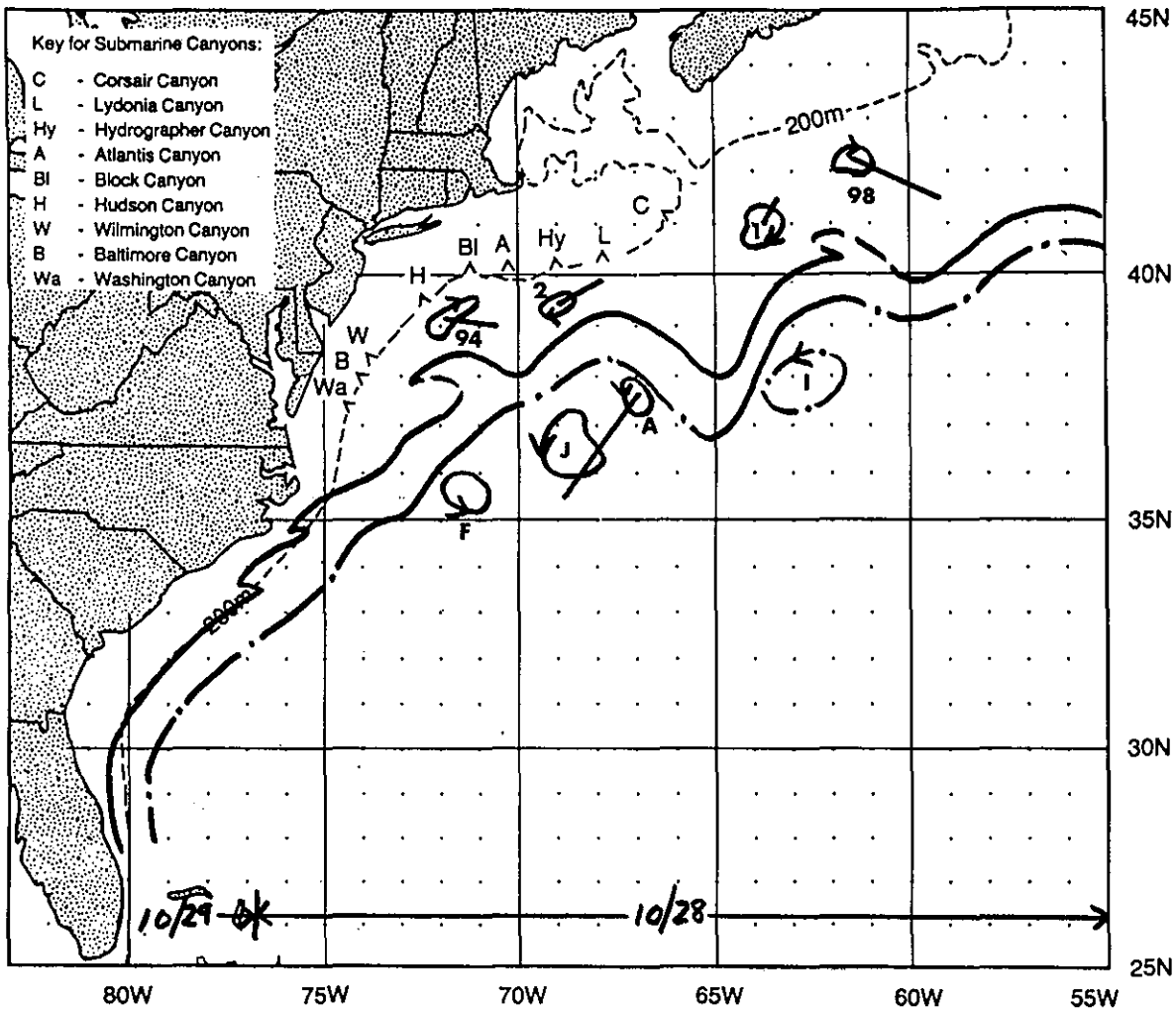
OCTOBER 1987

The end of this month's positions of the Gulf Stream System and its associated eddies are shown for the NW Atlantic and the Gulf of Mexico. The Gulf Stream and Loop Current boundaries are located by infrared satellite imagery or XBT (expendable bathythermograph) data. Anticyclonic eddies are labeled a-z in the Gulf of Mexico and 1-99 in the Northwest Atlantic. Cyclonic eddies are labeled A-Z. Arrows on eddies indicate direction of circulation. Warm-core or anticyclonic eddies rotate clockwise; cold-core or cyclonic eddies rotate counterclockwise. The line to the eddy center shows the net translation since last month or since last observed. The edge of continental shelf at 200 m is shown as a dashed line. Eddies or sections of the Gulf Stream System which were not observed during the month are not shown on the analysis chart or are indicated by "dot-dashed" lines. The long arrows at the bottom of the chart indicate the dates of data used.



GULF OF MEXICO

Near isothermal conditions continued into the early part of the month, but indications of the Loop Current and a possible anticyclonic eddy began to appear late in October. Eddy v apparently spun off the Loop Current, while an area of warm water appeared over the northeastern part of the Gulf.



NORTHWEST ATLANTIC OCEAN

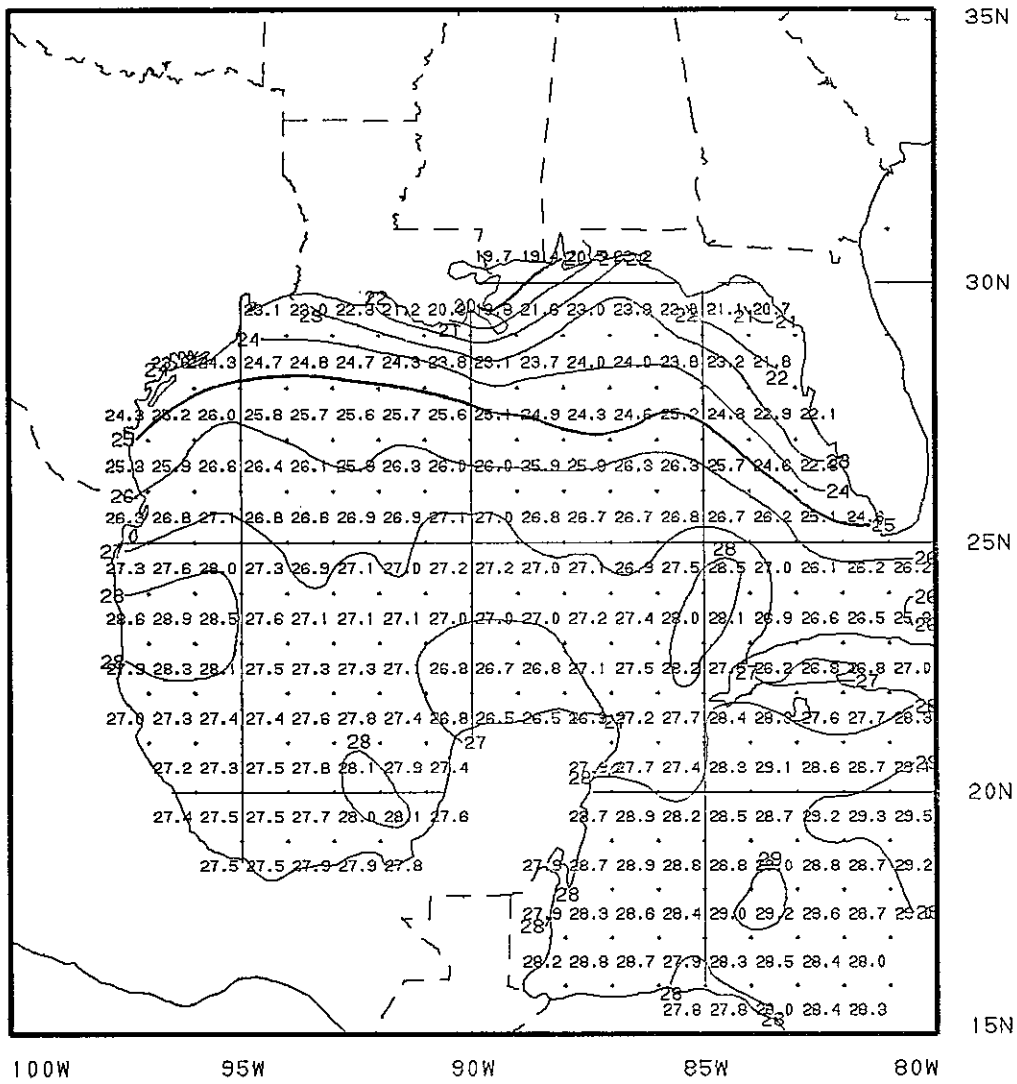
The Gulf Stream was quite active between 68W and 70W during October, as a sharp meander absorbed one eddy and spun off a new one. Anticyclonic eddy 94 moved 95 km west before being absorbed into the Gulf Stream by the last week in the month.

Anticyclonic eddy 98 moved west northwest 175 km. Eddy 1 drifted 55 km south southwest and eddy 2 translated 95 km toward the southwest.

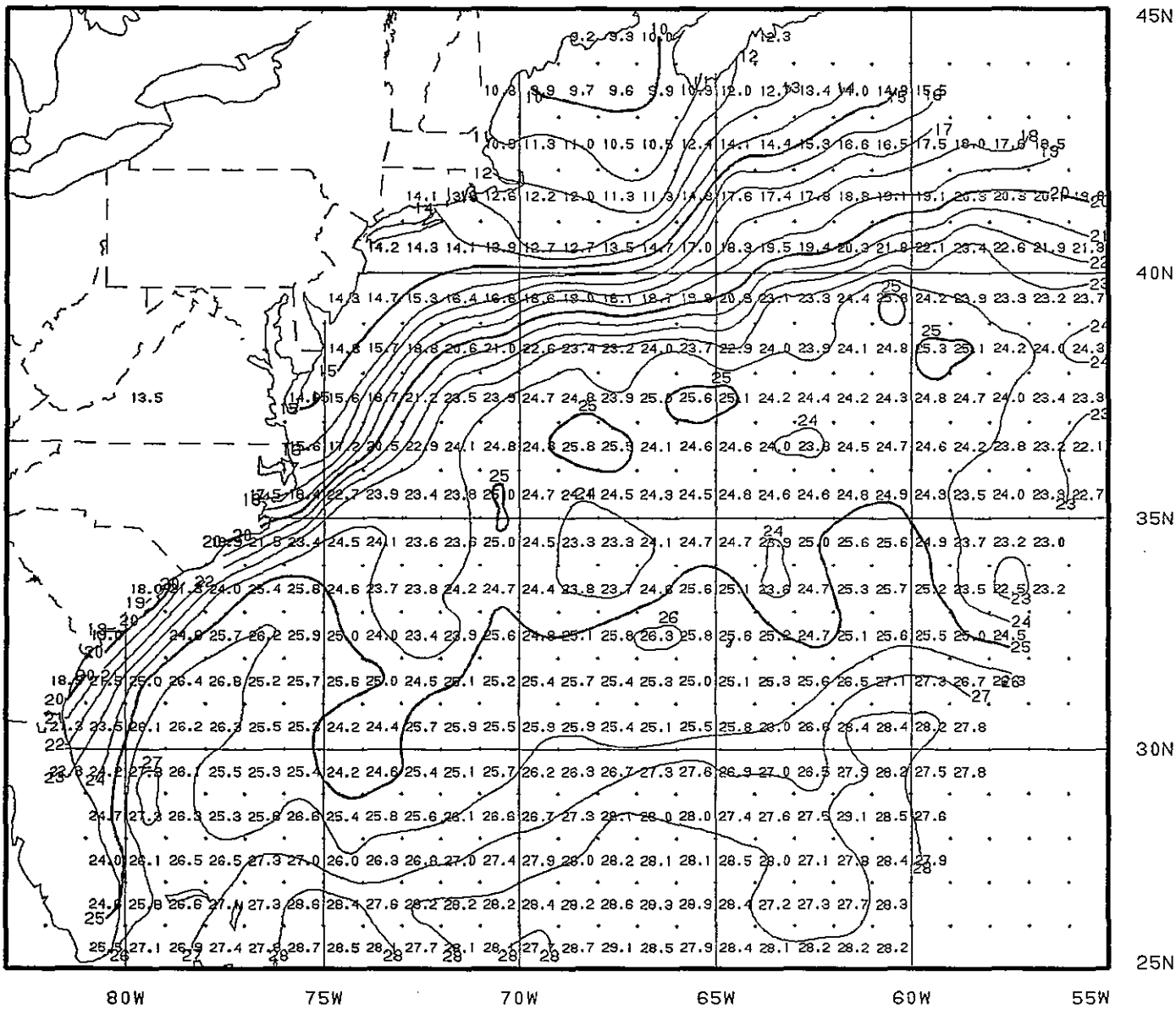
The Gulf Stream meander forced cyclonic eddy A to move northeastward 240 km. Meanwhile, eddy J formed near the sharply curved Gulf Stream by the last week in October. Eddy F remained about stationary. Eddy I was not observed during the month.

Late in the month, the Gulf Stream began to develop a new meander near 65W.

EAST COAST SST – MONTHLY MEAN

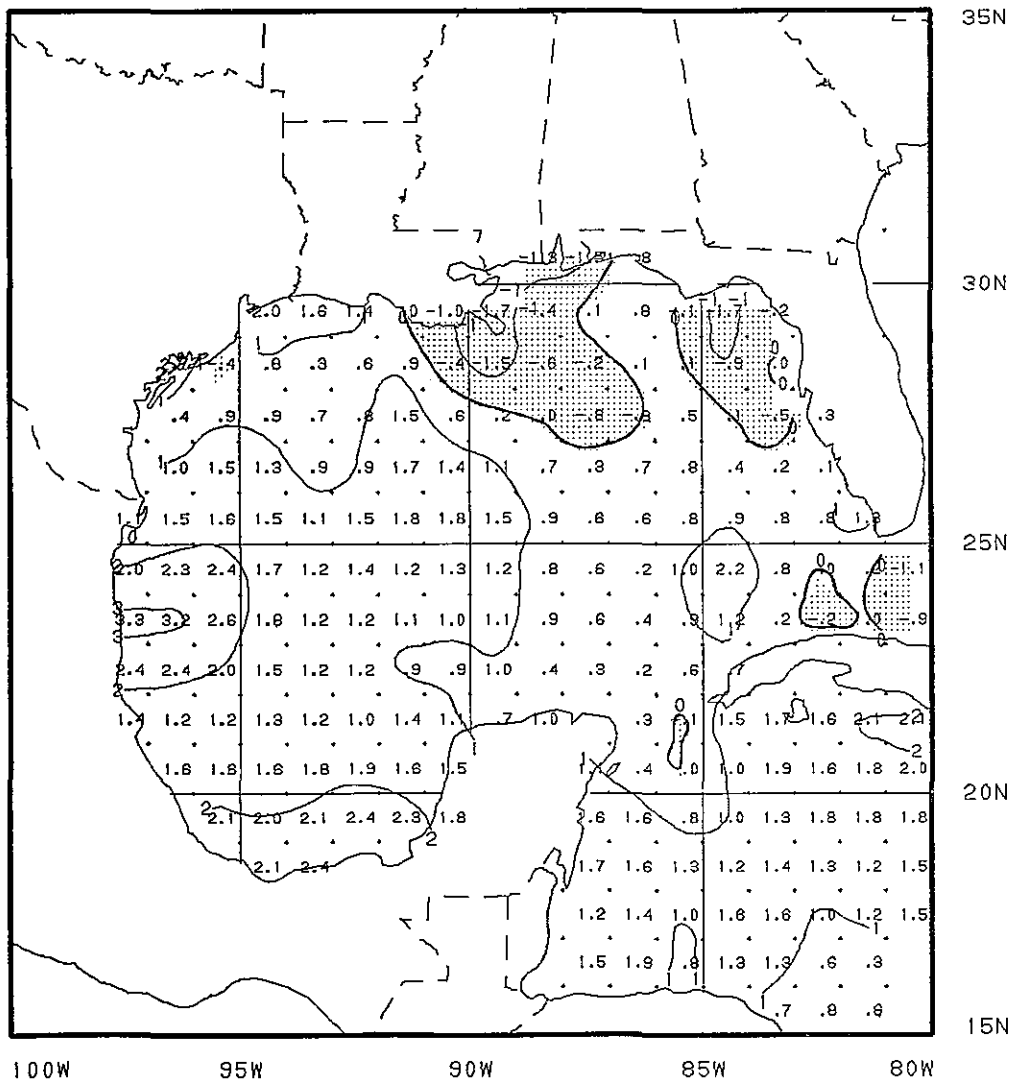


OCTOBER 1987 GULF OF MEXICO SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0C.

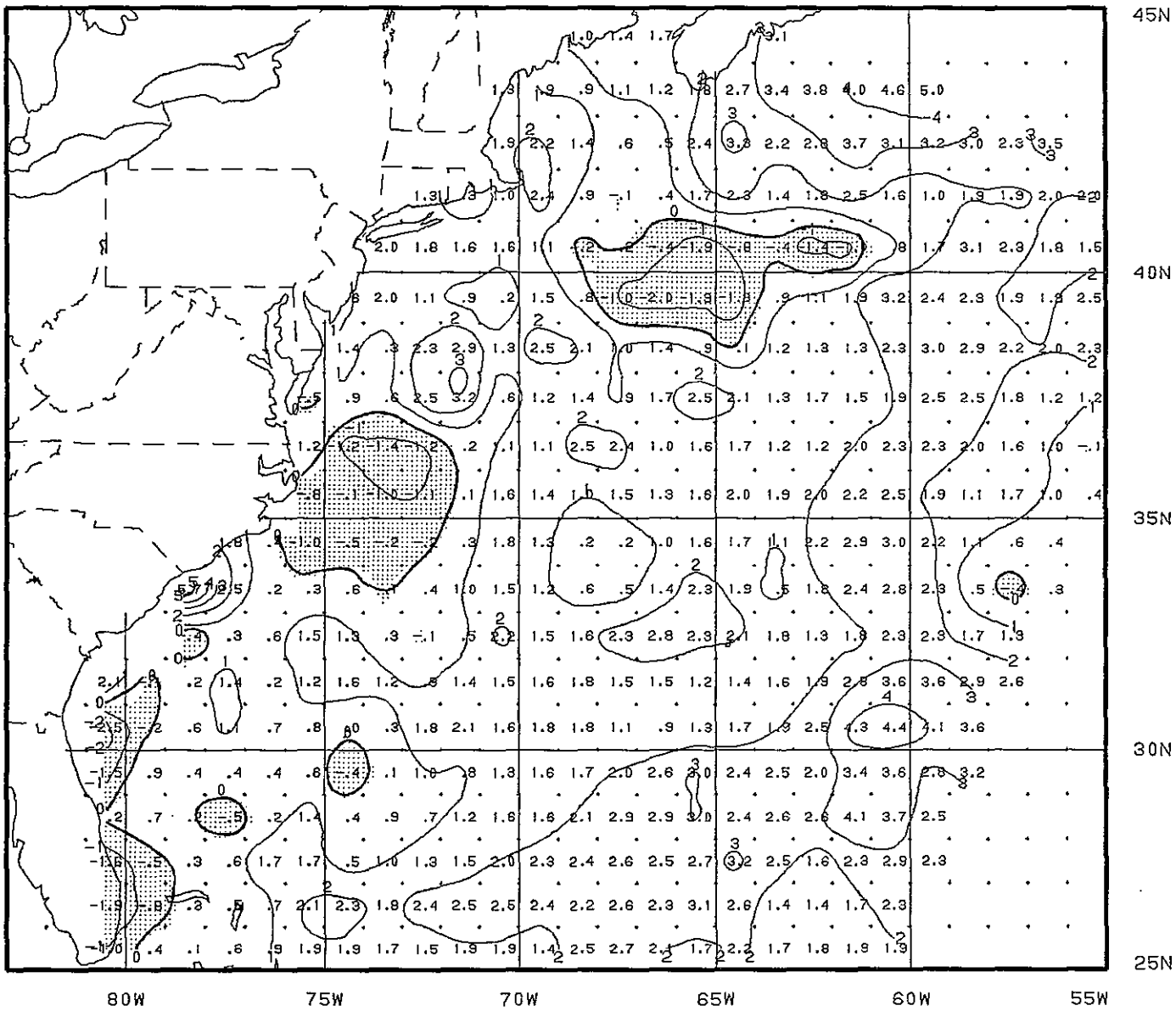


OCTOBER 1987 U.S. EAST COAST SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0C.

EAST COAST SST – ANOMALY



OCTOBER 1987 GULF OF MEXICO SST--MONTHLY ANOMALY (C)--Monthly anomaly is the difference between the monthly mean SST and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0C.



OCTOBER 1987 U.S. EAST COAST SST--MONTHLY ANOMALY (C)--Monthly anomaly is the difference between the monthly mean SST and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0C.

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The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through April 1, 1988.

OCEANOGRAPHIC Monthly Summary

Volume VII Number 11 November 1987

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U.S. DEPARTMENT OF COMMERCE • National Oceanic and Atmospheric Administration
National Weather Service
National Environmental Satellite, Data, and Information Service
National Ocean Service

OCEANOGRAPHIC
Monthly Summary

Oceanographic Monthly Summary is published by the National Weather Service (NWS), the National Environmental Satellite, Data, and Information Service (NESDIS), and the National Ocean Service (NOS). *Oceanographic Monthly Summary* contains sea surface temperature (SST) analyses on both regional and ocean basin scales for the Atlantic, Pacific, and Indian Oceans. The ocean basin analyses are based on a "blend" of *in situ* and satellite data, in which *in situ* data are used to define "benchmark" temperature values in regions of frequent observations and satellite data are used to define the "shape" of the field between these points.[1]

An ocean basin SST anomaly is derived from the "blended" SST analysis[1] and the improved global SST.[2] The regional SST analyses are based upon a combination of *in situ* and satellite data measurements. The regional SST anomalies are calculated from the Robinson-Bauer Climatology.[3,4] *Oceanographic Monthly Summary* also contains Alaskan sea ice information and ocean feature information for contiguous U.S. ocean regions.

Oceanographic Monthly Summary welcomes articles containing information of interest to its readers, such as news on operational oceanography, unusual ocean feature phenomena, etc. Contributions should be sent to the editor (address below). Accepted material will appear in the OceaNotes section of *Oceanographic Monthly Summary*. Contributions can be published as quickly as the next monthly issue.

If you are interested in receiving *Oceanographic Monthly Summary* regularly, please refer to the back cover for subscription information.

[1]Reynolds, R.W. and W.H. Gemmill, 1984. A sea surface temperature analysis which blends *in situ* and satellite observations. *Proceedings of the Ninth Climate Diagnostics Workshop*, Corvallis, OR, Oct. 22-26, 1984, pp. 408-416.

[2]The climatology is derived from *in situ* data (1950-1979), satellite data (1982-1985) and an ice climatology.

[3]Robinson, M.K., 1976. Atlas of North Pacific Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOcean Ref. Pub. 2.*

[4]Robinson, M.K., R.A. Bauer, and E.H. Schroeder, 1979. Atlas of North Atlantic-Indian Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOceano Ref. Pub. 18.*

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OceaNotes

THE NEW ROSS SEA ICEBERG

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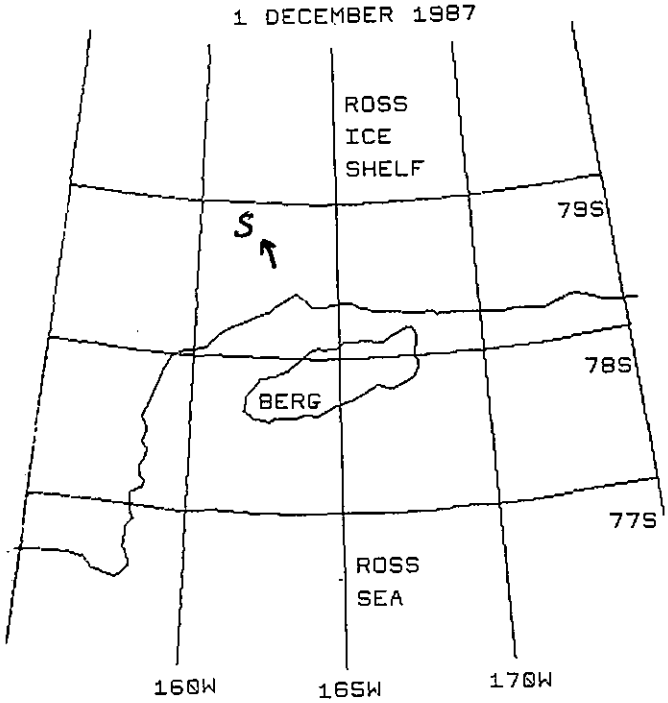
As shown in the NOAA-10 visible satellite image from October 27, 1987 (cover), a large tabular iceberg has broken off the Ross Ice Shelf into the Ross Sea. This makes the third major ice calving event off Antarctic glaciers during 1986-1987 and the first significant calving in the eastern section of the Ross Shelf. As of the first of December, the berg was located at 77.6 S, 165 W, with dimensions of approximately 25 miles in width and 99 miles in length, and a thickness of 900 feet. Of that thickness, about 125 feet is above the water line.

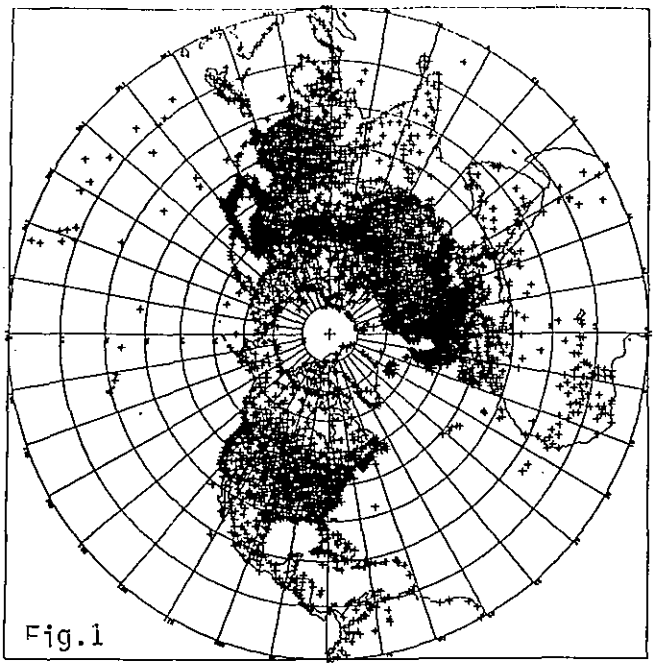
The NOAA/Navy Joint Ice Center (JIC), Suitland, Maryland, has been tracking the calving process since it's probable inception in January, 1987. Then, a large fissure (crack) was detected along the Ross Shelf on satellite data. A counterclock-wise rotation and a slight westward drift has been detected in subsequent images, as shown in the analysis (above right) of a NOAA-10 visible satellite image from December 1, 1987. JIC predicts the berg will drift slowly toward the west in the Ross Sea gyre and eventually find its way into the Antarctic Circumpolar Current. Due to its long and narrow size (twice the length of Rhode Island), the berg may begin to break up into smaller bergs (bergy bits) and growlers, or become grounded on submarine ridges in the Ross Sea during the remaining austral summer season. In these instances the berg will become trapped in seasonal ice growth during next year's austral winter.



SYNOPTIC SURFACE MARINE DATA MONITORING

Vera M. Gerald
NOAA/NWS
Ocean Products Center
Camp Spring, MD

The oceans cover approximately seventy percent of the earth surface and have a significant influence on global weather and climate. However, the oceanic domain is less densely sampled for surface meteorological parameters as compared to land. For example, figures 1 and 2 show northern hemisphere synoptic surface data distribution at 00Z over land and sea, respectively. It is clear that the



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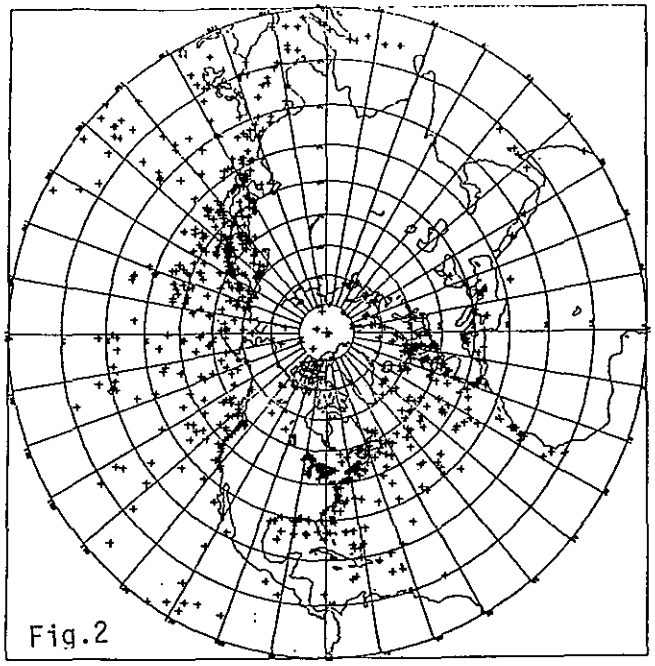

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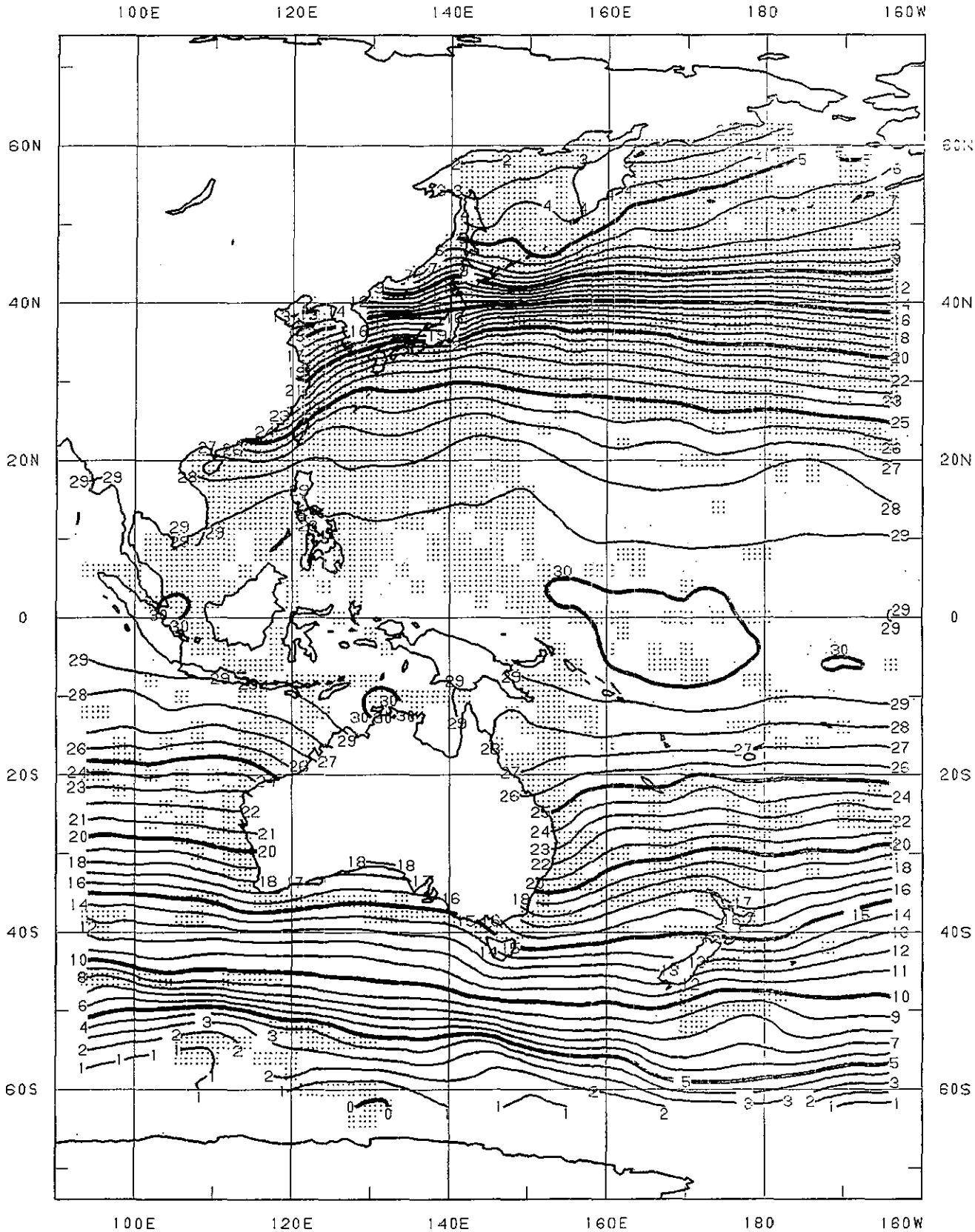
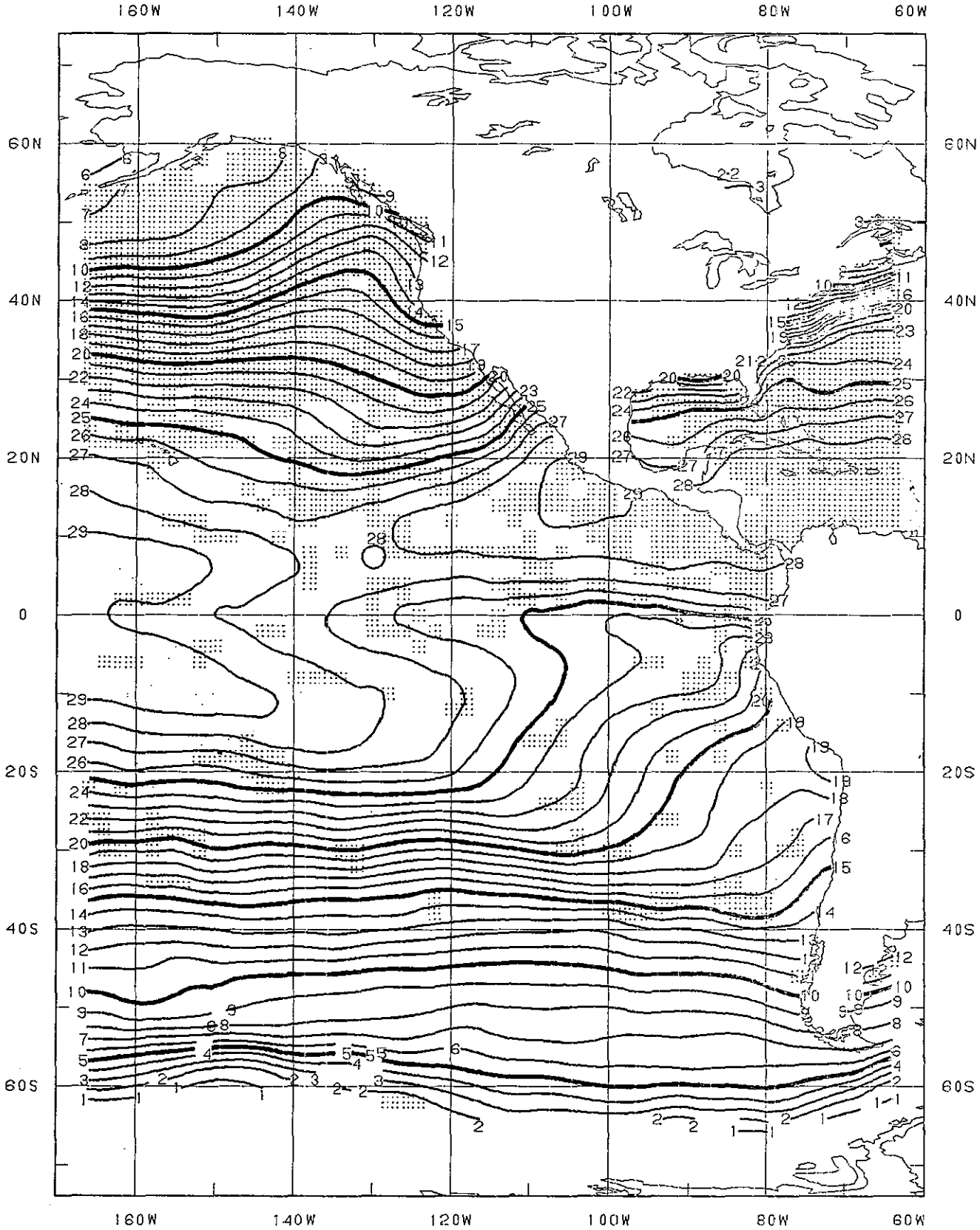
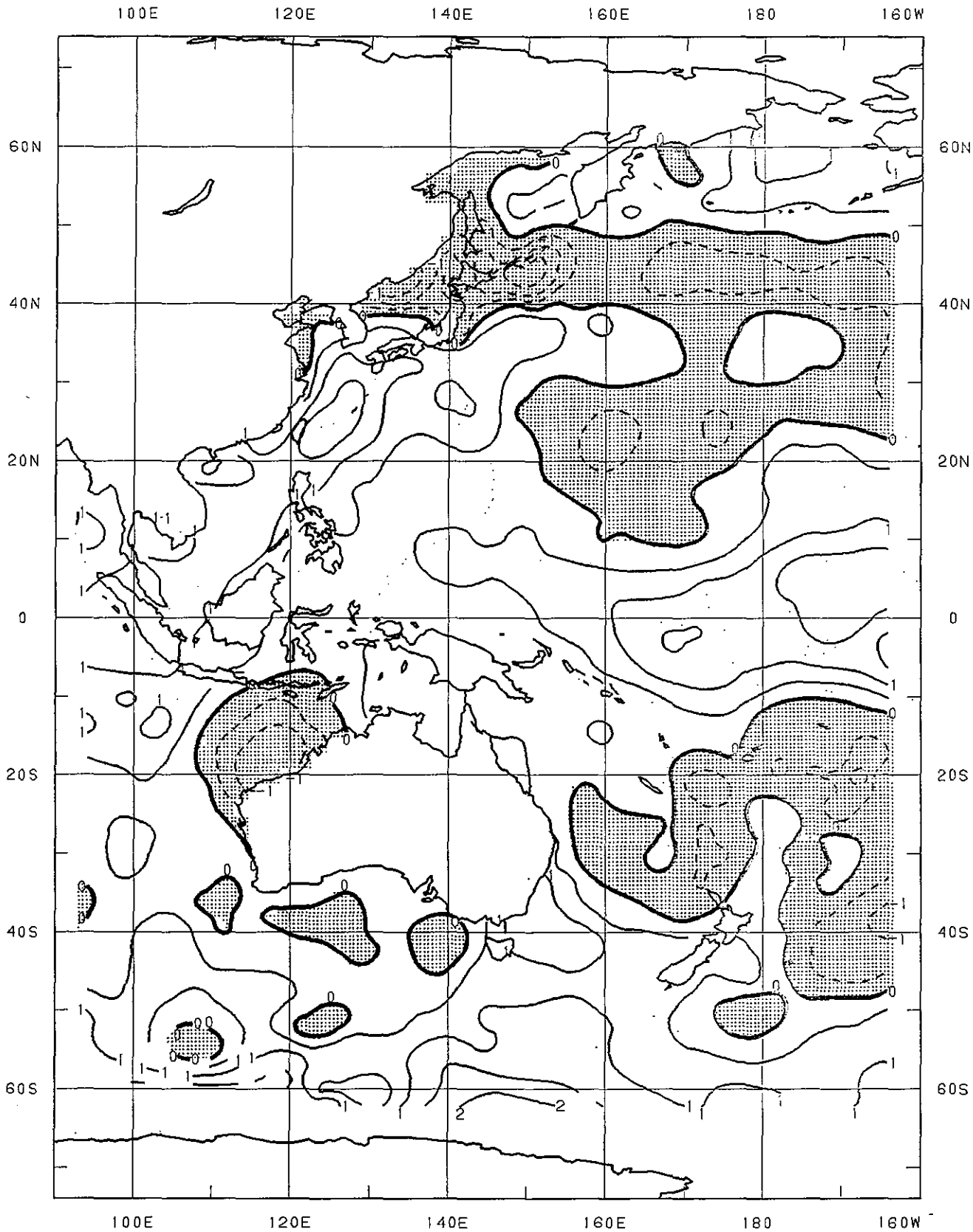
(text continued on page 12)



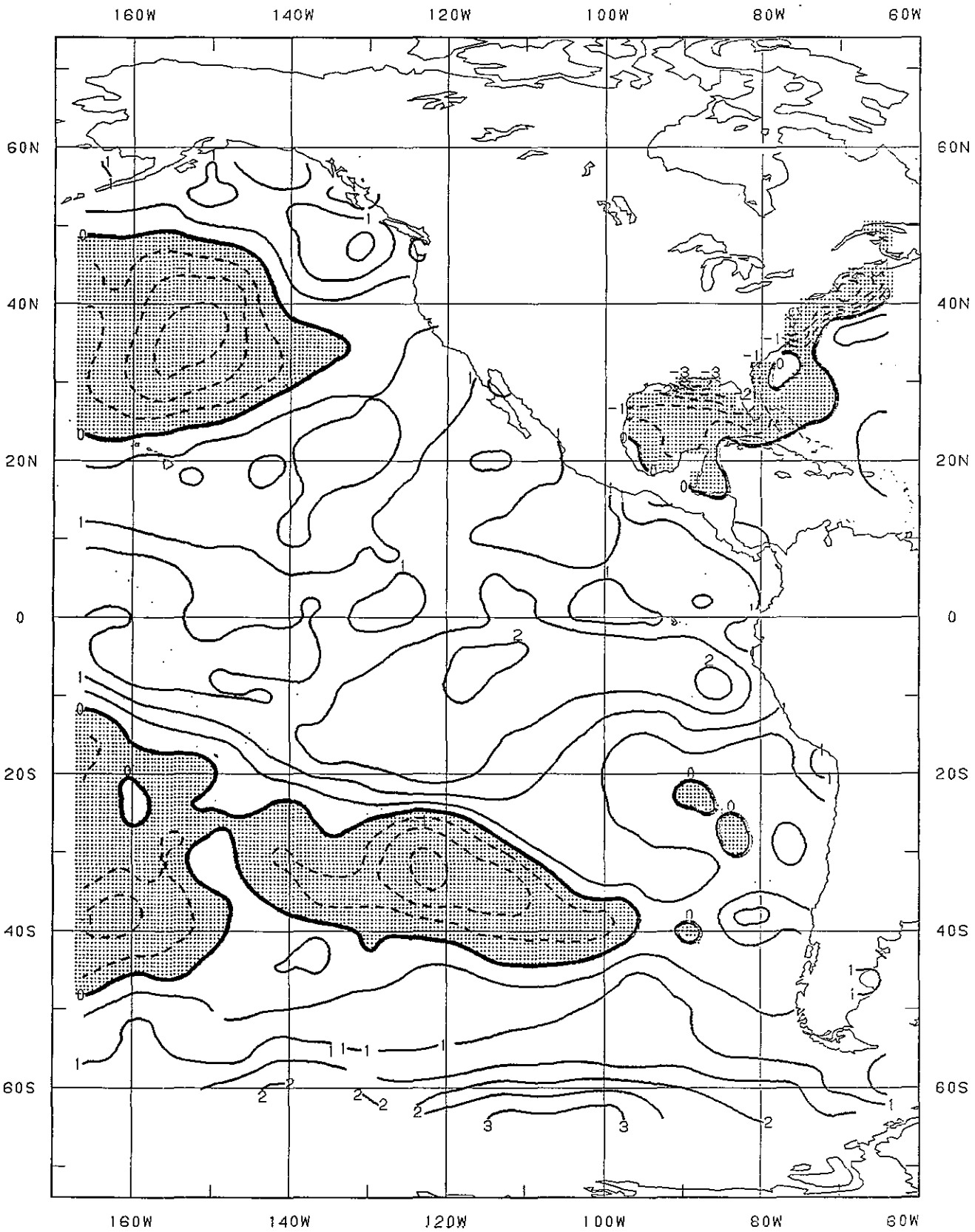
NOVEMBER 1987 WESTERN PACIFIC OCEAN SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of **in situ** (ship, buoy) and satellite data within two-degree quadrangles. Contour line interval is 1.0 C. The stippling indicates where the analysis was fixed by the **in situ** data; contours are not shown in areas without data.



NOVEMBER 1987 EASTERN PACIFIC OCEAN SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of **in situ** (ship, buoy) and satellite data within two-degree quadrangles. Contour line interval is 1.0 C. The stippling indicates where the analysis was fixed by the **in situ** data; contours are not shown in areas without data.



NOVEMBER 1987 WESTERN PACIFIC OCEAN SST--MONTHLY ANOMALY (C)--Monthly anomaly is the difference between the monthly mean SST and the climatological monthly mean value. Contour line interval is 0.5 C. The stippling indicates where the monthly mean is colder than climatology; contours are not shown in areas without monthly or climatological data.



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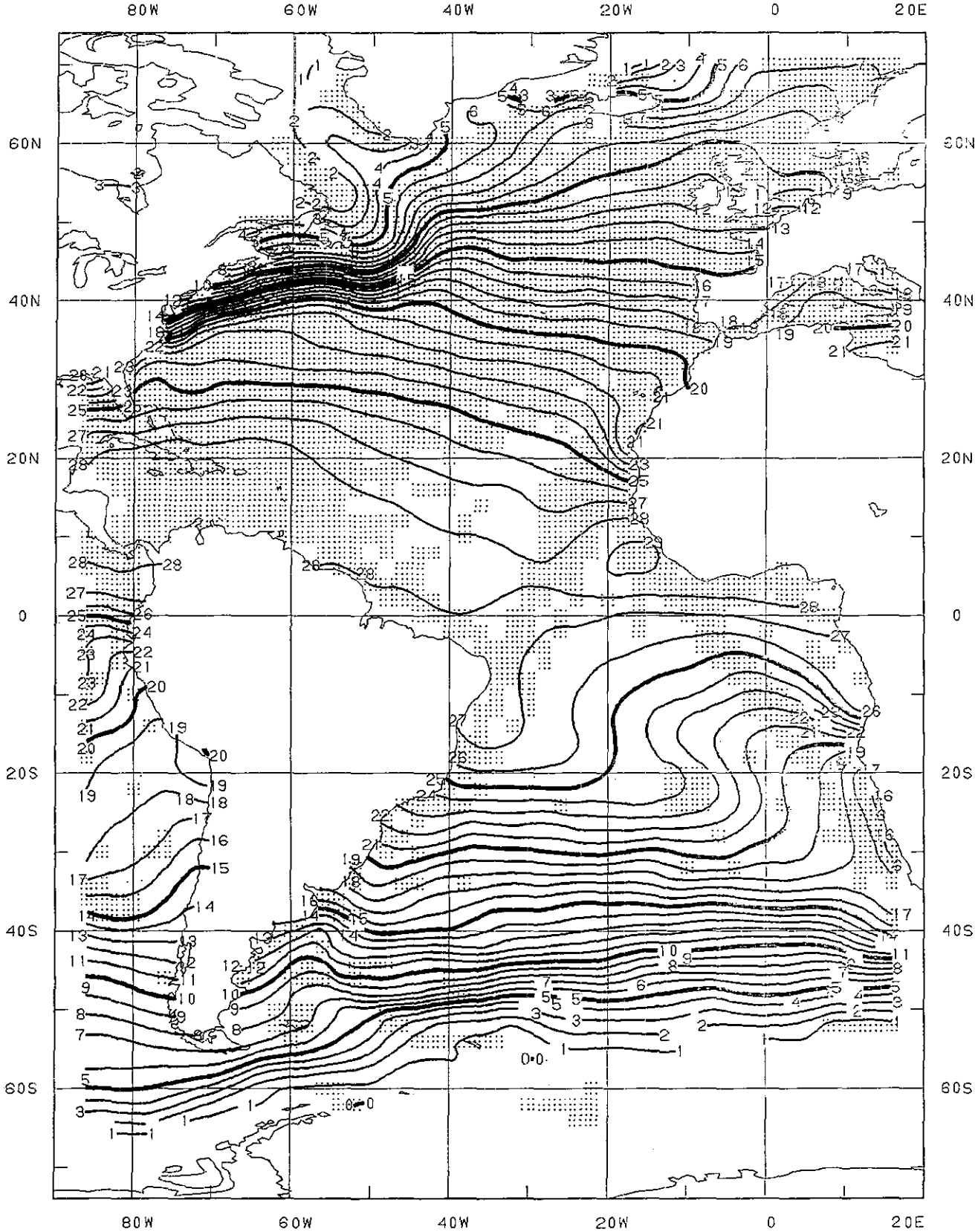

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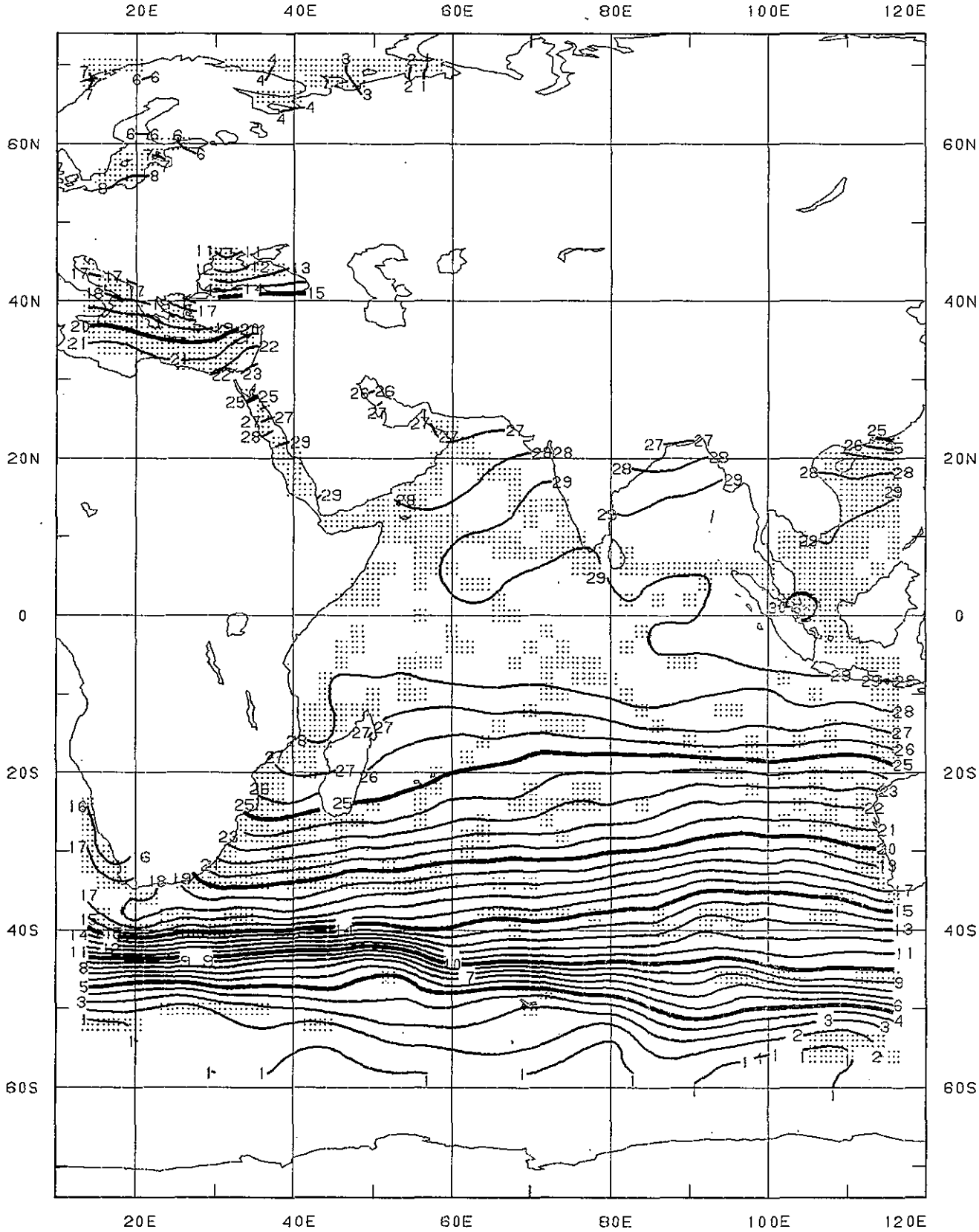
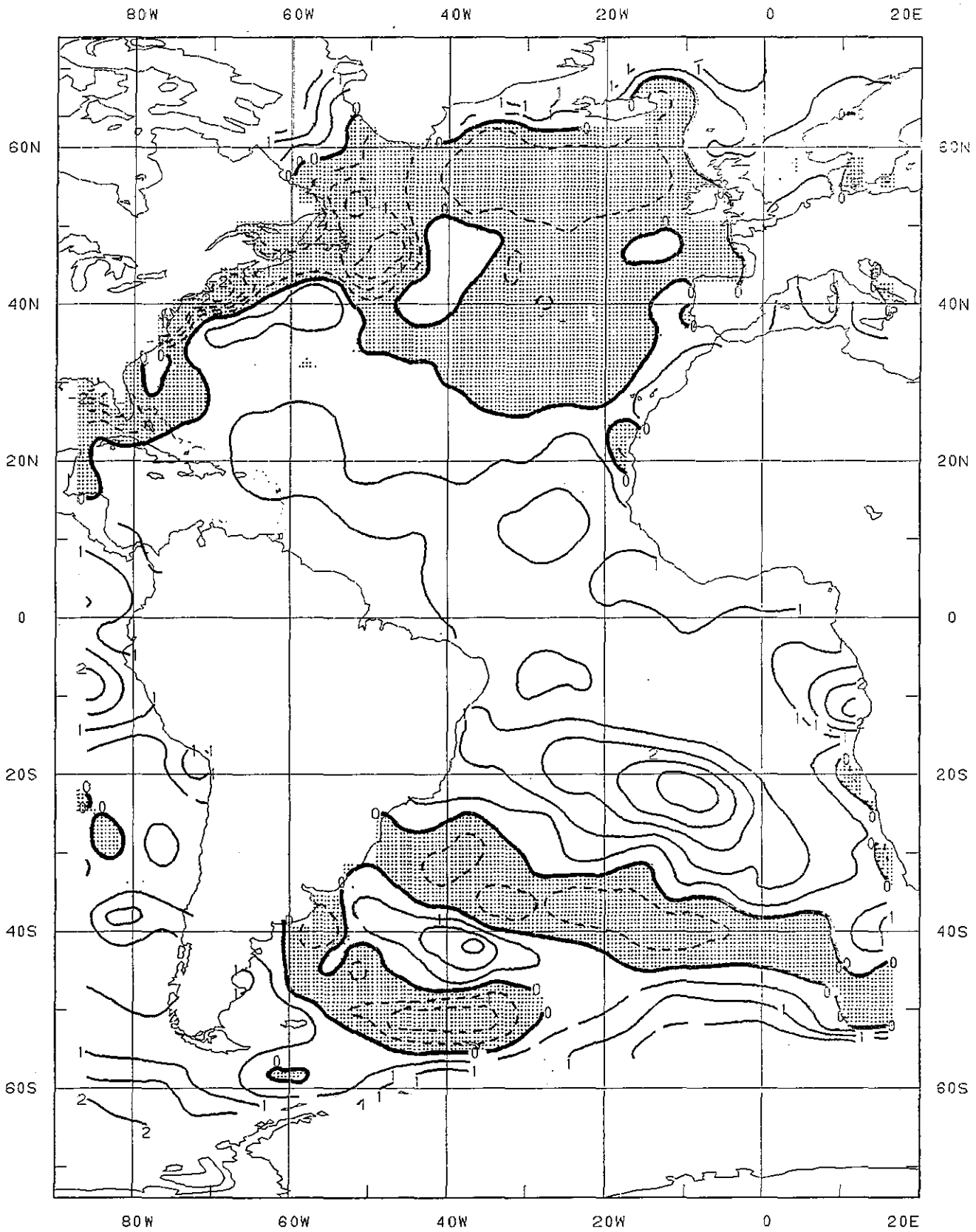


NOVEMBER 1987 INDIAN OCEAN SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of **in situ** (ship, buoy) and satellite data within two-degree quadrangles. Contour line interval is 1.0 C. The stippling indicates where the analysis was fixed by the **in situ** data; contours are not shown in areas without data.



NOVEMBER 1987 ATLANTIC OCEAN SST--MONTHLY ANOMALY (C)--Monthly anomaly is the difference between the monthly mean SST and the climatological monthly mean value. Contour line interval is 0.5 C. The stippling indicates where the monthly mean is colder than climatology; contours are not shown in areas without monthly or climatological data.

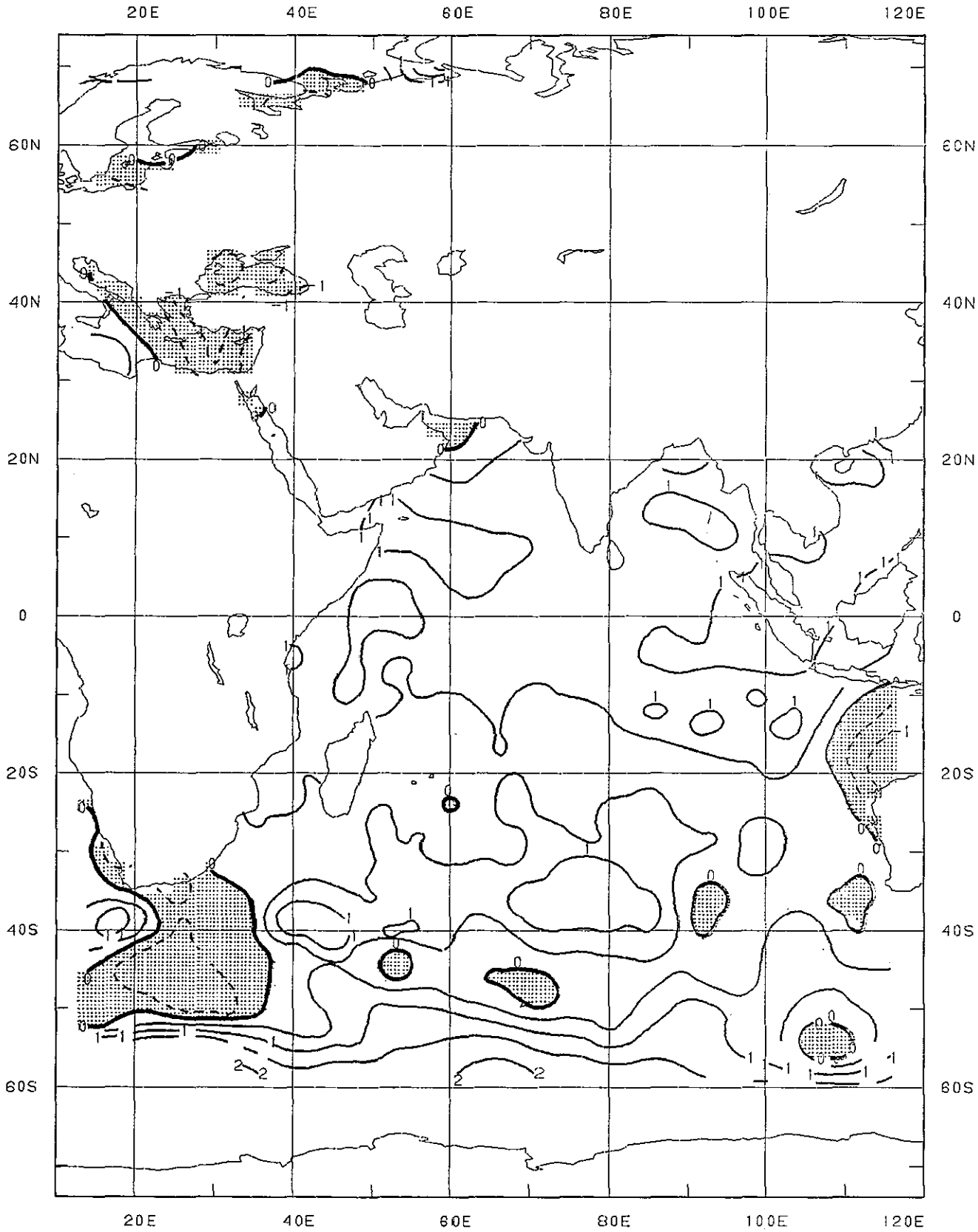


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Table 1 MONTHLY TABULATIONS OF SURFACE MARINE REPORTS RECEIVED AT NMC FOR 1986

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL FOR YEAR'86	(%) TOT
UNISHP	100014	93791	102068	99356	108143	103153	107018	108423	105664	107075	107761	98752	1241218	56.2 %
UNKSHP	4310	4322	4552	4184	4729	4533	4632	4141	4349	4181	4122	3433	51468	2.3 %
FBUOYS	11343	10885	11344	11444	11328	12712	14164	13660	13372	13564	12645	11779	148240	6.7 %
DBUOYS	48125	39984	50905	57275	55198	48350	45460	52350	49417	55445	58828	57546	618783	28.0 %
MARS	8862	7822	8895	8868	9221	8832	9304	9344	8860	9106	9205	9513	107832	4.9 %
OWS	632	586	634	635	882	1496	1526	1383	1362	1469	1465	1583	13653	0.6 %
LAND	4635	3365	2266	1508	1574	1519	1465	2159	2189	2454	3001	2217	28352	1.3 %
TOTAL	177921	160655	180664	183270	191075	180595	183569	191460	185213	193294	197027	184823	2209566	100.0 %

marine data base is sparse and that maximum use should be made of these data in studies of atmospheric and oceanographic processes.

The National Meteorological Center (NMC) receives real-time synoptic marine data from various platforms. All data that are available by the time of the scheduled model run are used with first-guess fields to produce initial analyses for use within the suite of operational numerical prediction models of NMC.

In view of the necessity for a real-time synoptic marine data base, it is important to ensure that all data arrive in time to be used within NMC's analyses and quality controlled in real time to maximize their impact on forecasts. Therefore, systems collecting surface marine reports are actively monitored to ensure maximum availability of data.

Synoptic marine data are stored on a 10-day rotating file consisting of all observations reported by voluntary ships, naval and research vessels, drifting and fixed buoys, ocean weather stations and marine reporting stations. These reports are transmitted to NMC by coastal radio stations, the Global Telecommunication System (GTS) and the GOES data collection network. Table 1 summarizes the monthly tabulation of surface marine data received at NMC for the year 1986. The platform types are ships with unique call signs (UNISHP), ships without call signs (UNKSHP), fixed buoys (FBUOYS), drifting buoys (DBUOYS), marine reporting stations (MARS), ocean weather stations (OWS), and all reports with position errors (LAND).

During 1986, NMC received 2,209,566 synoptic marine observations. The last column of Table 1 shows the percentage of this total for each platform type. Ships remain the dominant data source (56.2%). Fixed buoys represent less than 7 percent of the total. The second largest contribution to the surface marine data base comes from drifting buoys (22.0%). Position errors (1.3%) refer to all synoptic surface marine observations on land.

A monthly parameter list for September 1987 (Table 2) contains the frequency of air temperature, sea surface temperature, wind speed and direction, dew point depression, present and past weather, sea level and station pressure, pressure quality marks, cloud coverage, swell direction, swell height, swell period, wave direction and height, and the number of position errors for each platform type.

The timely dissemination of surface marine data is vital to improving and updating NMC's analyses and forecasts. Time-delay refers to the interval between the time an observation is taken and the time it is received at NMC. For example, table 3 shows time-delay distributions for ships with unique call signs, fixed buoys, drifting buoys and marine reporting stations for September, 1987.

Surface marine reports transmitted directly through the GOES network to NMC are delivered in a timely fashion. As can be seen in Table 3, time-delay tabulations for FBUOYS and MARS show that 93 to 96 percent of the data arrive within one hour or less. However, most ship reports are transmitted during the radio officer's watch by radio message to a coastal receiving station. Because of economic constraints, shippers have been forced to reduce the number of radio officers. Unfortunaetly the result has been a continued reduction in the timely transmission of ship reports (Richardson, Gerald, 1987). Presently, less than 50 percent of ship data are received within one hour.

Table 2

PARAMETERS QUANTITY SUMMARIES FOR 1987 09 01 002 10 1987 09 30 .12

	UNIQUE SHIPS	UNKNOWN SHIPS	OWS FIXED	MARS FIXED	FIXED BUOYS	DRIFT BUOYS	TOTAL NO. PARAMETER
STATION ELEVAT	106080	5243	1072	8887	12861	24852	158995
SEA LEVEL PRESS	99610	4971	1070	8540	12829	20635	147655
STATION PRESS	1864	18	0	0	0	0	1882
WIND DIRECTION	102193	4984	1060	8879	12099	2303	131518
WIND SPEED	102193	4984	1060	8879	12099	3046	132261
AIR TEMPERATURE	102958	5089	1072	8879	12467	16612	147077
DEW POINT DEPRES	54152	4103	1067	0	1299	122	60743
PRESENT WEATHER	44294	3207	629	0	4	78	48212
PAST WEATHER	43846	3184	629	0	5	78	47742
CLOUD COVER	106080	5243	1072	0	1440	594	114429
LOW CLOUD COVER	76354	4103	1039	0	12	116	81624
HGHT ABV GRND CL	106080	5243	1072	0	1440	594	114429
QUALITY MARKERS	106080	5243	1072	8887	12861	24852	158995
PERIOD WAVES	71734	3920	813	0	11373	107	87947
HEIGHT WAVES	79810	4067	936	0	11374	108	96255
PERIOD SWELL	41927	2484	511	0	12	94	45028
HEIGHT SWELL	43525	2507	658	0	12	94	46796
DIR SWELL MOVNT	45331	2677	655	0	12	94	48769
SEA SURFACE TMP	82800	4416	1062	3101	12517	18876	122772
NO. RPTS. ON LAND	800	59	1	0	1	752	1613
TOTAL AVAILABLE	106080	5243	1072	8887	12861	24852	158995
NO CAT 51 DATA	0	0	0	0	0	0	0
NO CAT 52 DATA	9455	394	7	0	0	5973	15829

Table 3

TIME DELAY DISTRIBUTION FOR SURFACE MARINE OBSERVATIONS RECEIVED BETWEEN 1987 09 01 00Z TO 1987 09 30 232

TIME-DELAY DISTRIBUTION FOR UNISHP

HOURS (< OR =) :	1	2	3	4	5	6	7	8	9	10	UP-TO-DATA CUT-OFF
TOTAL BY BIN	46031	31861	8701	4736	2933	1652	3492	4796	1432	302	140
CUMULATIVE TOTAL	46031	77892	86593	91329	94262	95914	99406	104202	105634	105936	106076
CUMULATIVE PCT	43.39	73.43	81.63	86.10	88.86	90.42	93.71	98.23	99.58	99.87	100.00

TIME-DELAY DISTRIBUTION FOR MARS(C)

HOURS (< OR =) :	1	2	3	4	5	6	7	8	9	10	UP-TO-DATA CUT-OFF
TOTAL BY BIN	8582	156	45	49	16	39	0	0	0	0	0
CUMULATIVE TOTAL	8582	8738	8783	8832	8848	8887	8887	8887	8887	8887	8887
CUMULATIVE PCT	96.57	98.32	98.83	99.38	99.56	100.00	100.00	100.00	100.00	100.00	100.00

TIME-DELAY DISTRIBUTION FOR FBUOYS

HOURS (< OR =) :	1	2	3	4	5	6	7	8	9	10	UP-TO-DATA CUT-OFF
TOTAL BY BIN	11998	251	61	63	5	51	0	2	0	0	430
CUMULATIVE TOTAL	11998	12249	12310	12373	12378	12429	12429	12431	12431	12431	12861
CUMULATIVE PCT	93.29	95.24	95.72	96.21	96.24	96.64	96.64	96.66	96.66	96.66	100.00

TIME-DELAY DISTRIBUTION FOR DBUOYS

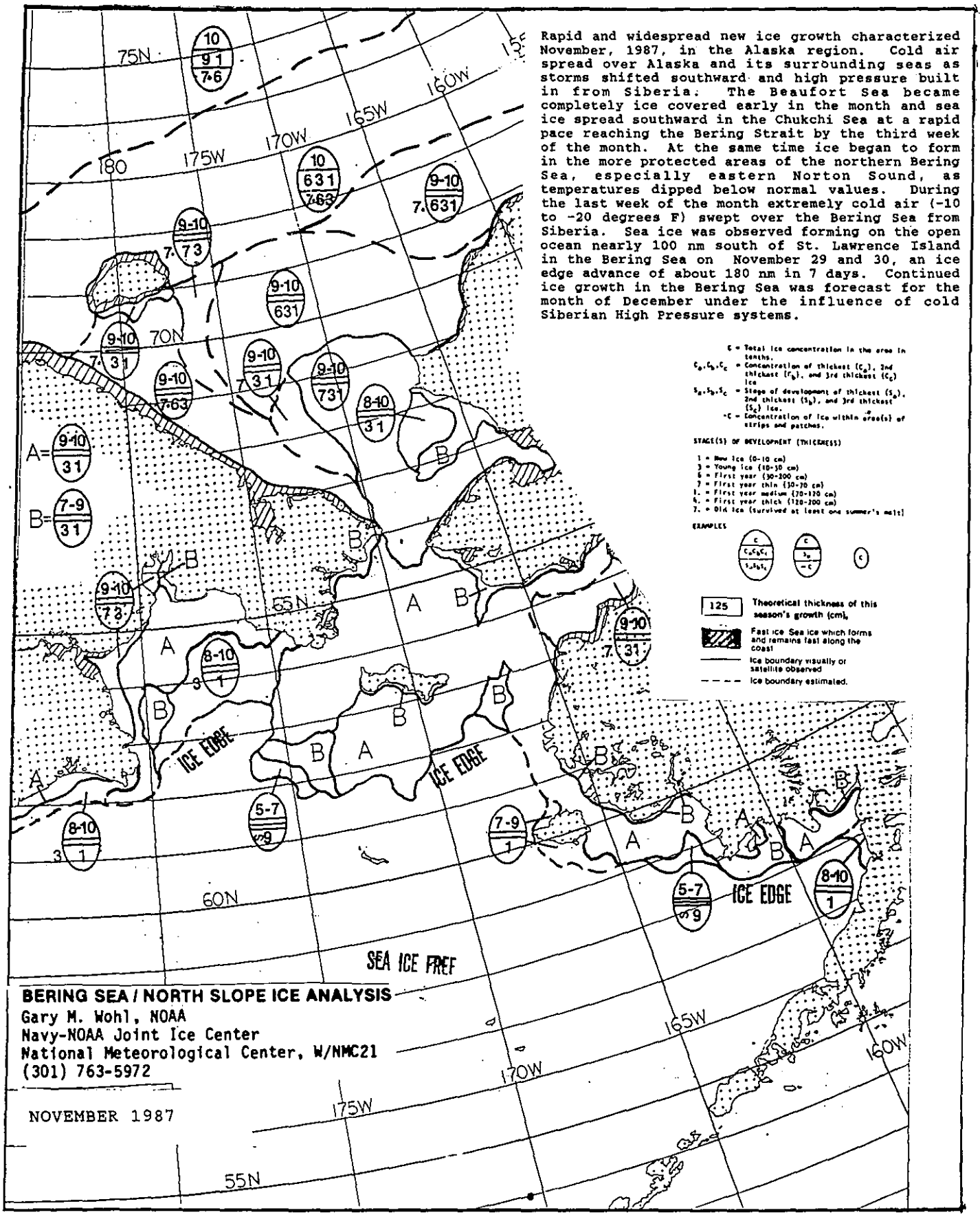
HOURS (< OR =) :	1	2	3	4	5	6	7	8	9	10	UP-TO-DATA CUT-OFF
TOTAL BY BIN	6644	10469	4418	1601	744	527	242	100	99	8	0
CUMULATIVE TOTAL	6644	17113	21531	23132	23876	24403	24645	24745	24844	24852	24852
CUMULATIVE PCT	26.73	68.86	86.64	93.08	96.07	98.19	99.17	99.57	99.97	100.00	100.00

The amount of drifting buoy data arriving within one hour are low, less than 27 percent, due to the data processing system i.e., DBUOYS reports are collected by polar orbiting satellites and transmitted via Service Argos to the Argos data processing center in Toulouse, France; then the data must be decoded from engineering to metric units, compiled into the standard World Meteorological Organization (WMO) format, and finally entered onto the GTS network.

Quarterly ship track summaries of all VOS observations are tabulated and distributed to the Marine Observing Program of the Observing System Branch. Each reporting VOS receives a mercator map depicting it's track north of the equator during the past three months and the total number of reports received at NMC.

As a result of the monitoring effort described herein, it is clear that while the amount of surface marine data available at NMC has increased tremendously, the receipt of ship and drifting buoy data remain low and needs improvement. In an attempt to increase the number of surface ship observations received at NMC, monthly and quarterly surface marine tabulations are delivered to the Marine Observing Program of the Observing System Branch and the National Ocean Service for distribution to voluntary ship operators. Future plans to improve the availability of drifting buoy data at NMC involves the establishment of a direct data link to the Service Argos data center in Landover, MD. This will make drifting buoy data available 2 hours earlier.

Rapid and widespread new ice growth characterized November, 1987, in the Alaska region. Cold air spread over Alaska and its surrounding seas as storms shifted southward and high pressure built in from Siberia. The Beaufort Sea became completely ice covered early in the month and sea ice spread southward in the Chukchi Sea at a rapid pace reaching the Bering Strait by the third week of the month. At the same time ice began to form in the more protected areas of the northern Bering Sea, especially eastern Norton Sound, as temperatures dipped below normal values. During the last week of the month extremely cold air (-10 to -20 degrees F) swept over the Bering Sea from Siberia. Sea ice was observed forming on the open ocean nearly 100 nm south of St. Lawrence Island in the Bering Sea on November 29 and 30, an ice edge advance of about 180 nm in 7 days. Continued ice growth in the Bering Sea was forecast for the month of December under the influence of cold Siberian High Pressure systems.



BERING SEA / NORTH SLOPE ICE ANALYSIS

Gary M. Wohl, NOAA
Navy-NOAA Joint Ice Center
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NOVEMBER 1987

WEST COAST OCEAN FEATURES

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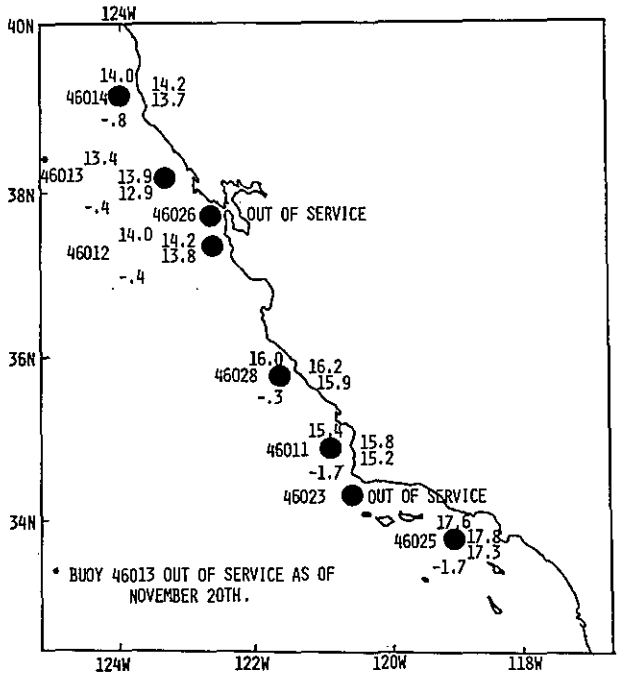
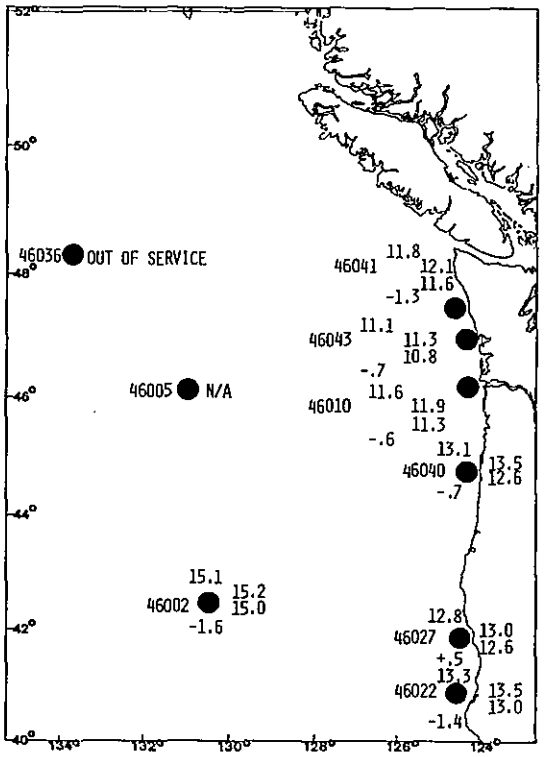
NOVEMBER 1987

Sea surface temperatures in the North and South Panels remain above normal; the North Panel averaged 1.2°C warmer than climatology and the South Panel averaged .6°C above climatology. The climatological mean temperature for each area is 12.9°C and 17.7°C, respectively. This above normal trend has been observed for the past couple of months.

The greatest observed positive anomalies in the North Panel were in the northern half of the chart. In fact, in and around Vancouver Island, temperatures were greater than 2.0°C above normal. No location in the North Panel was cooler than climatology. The southern half of the chart had anomalies on the order of .3° to .9° above climatology. When comparing this month's SST's to last month's, the entire North Panel cooled from between 1.0° to 1.9°C, with the majority of cooling in the central portion of the analysis. Buoy statistics showed similar trends when compared to October's values, except for buoy #46027.



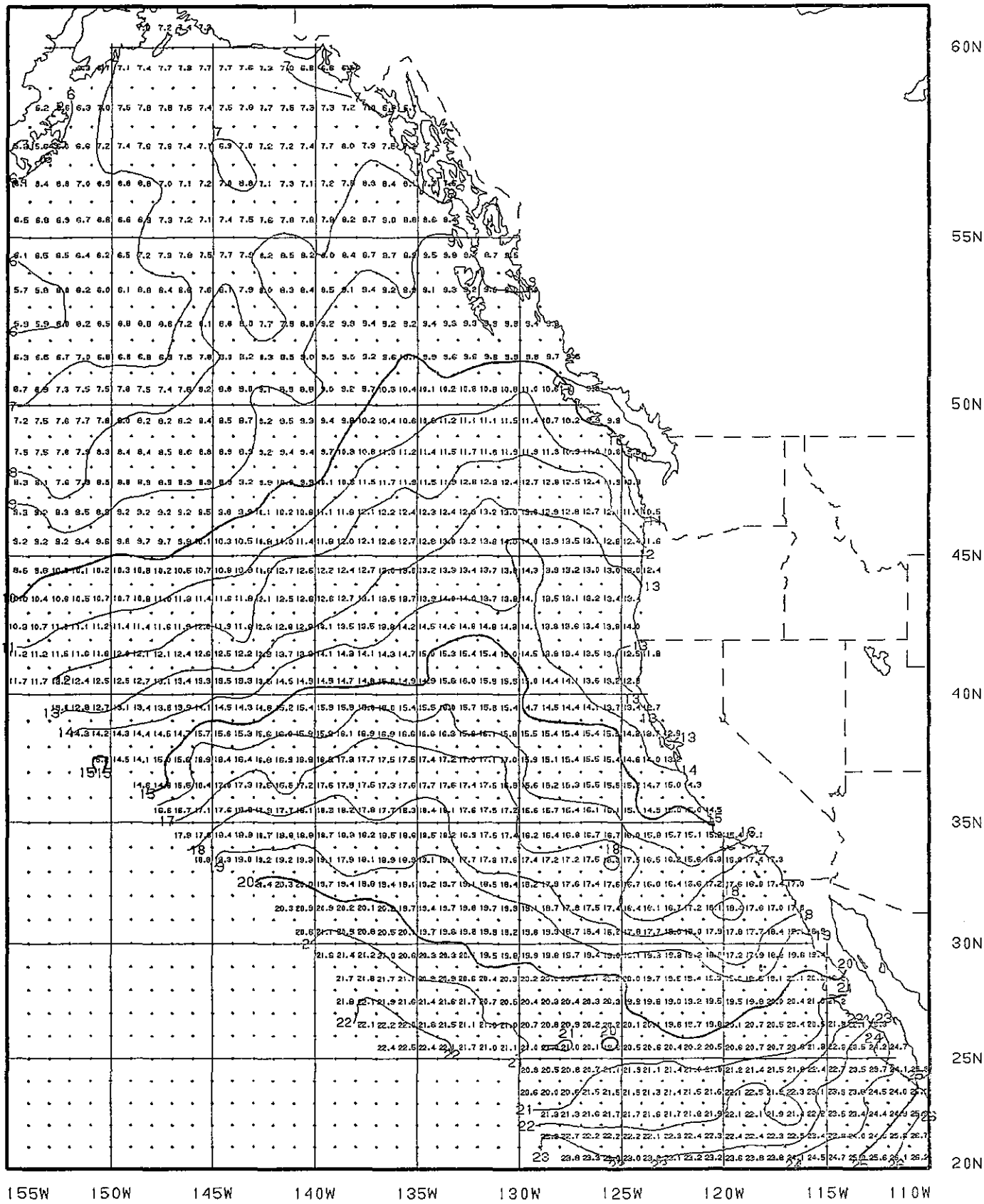


South Panel SST's had the greatest positive anomalies along the coast with values of 1.1°C near San Francisco Bay to 2.0°C along the Baja peninsula. Offshore waters were generally less than 0.5° warmer than normal with an area near 36.5N 132.5W, being .7°C cooler than climatology. This was the only location in the South Panel below normal. When comparing November's SST's to October's, the entire South Panel cooled with values ranging from .5°C in a number of locations to 1.4°C in the northwest corner of the chart. Buoy statistics also showed that temperatures cooled during the month along the entire California coastline. There were 8 analyses prepared for each Panel during November.

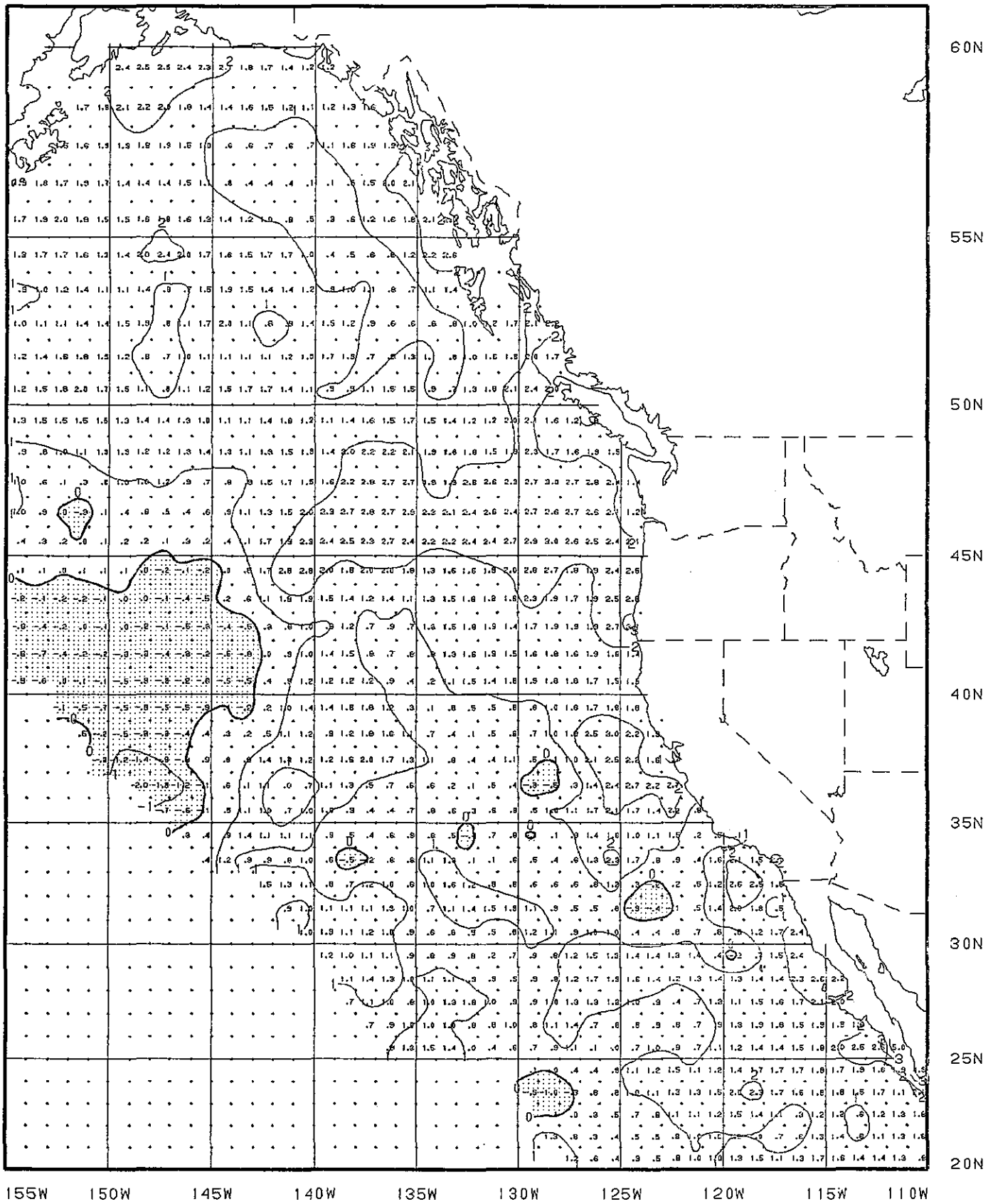
KEY:

12.1 ← Monthly mean
LOCATION 13.5 ← Maximum daily mean
NAME 10.2 ← Minimum daily mean
-1.5 ← Change from previous month

● Denotes station position.



NOVEMBER 1987 U.S. WEST COAST SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0C.



NOVEMBER 1987 U.S. WEST COAST SST--MONTHLY ANOMALY (C)--Monthly anomaly is the difference between the monthly mean SST and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0C.

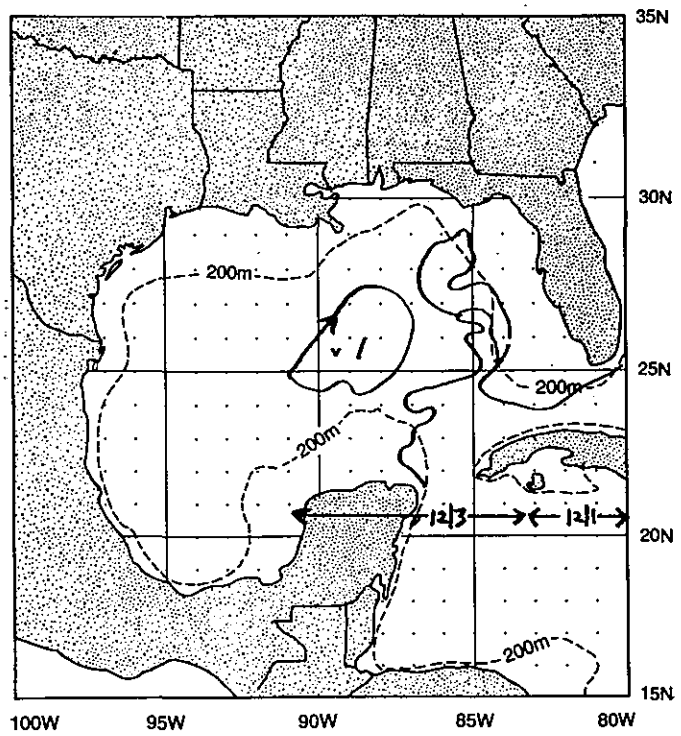
EAST COAST OCEAN FEATURES

Jenifer Clark
NOAA/NOS
Washington, DC 20233
(301) 763-8030

Data used in this analysis include:
Infrared imagery from NOAA satellite - NESDIS
Bathythermograph data from National Meteorological Center of National Weather Service
Oceanographic Analysis -- A daily detailed analysis issued by National Weather Service

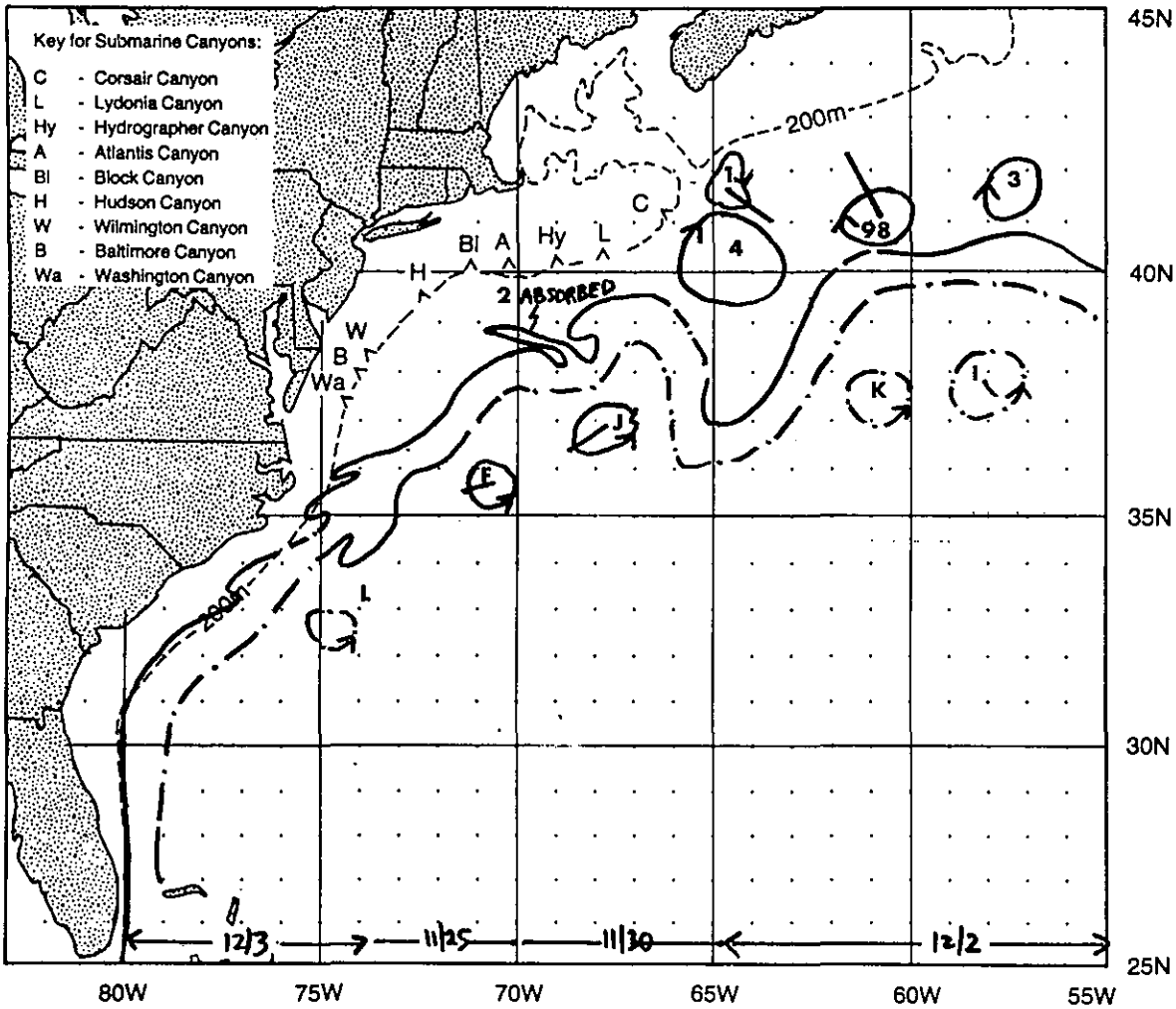
NOVEMBER 1987

The end of this month's positions of the Gulf Stream System and its associated eddies are shown for the NW Atlantic and the Gulf of Mexico. The Gulf Stream and Loop Current boundaries are located by infrared satellite imagery or XBT (expendable bathythermograph) data. Anticyclonic eddies are labeled a-z in the Gulf of Mexico and 1-99 in the Northwest Atlantic. Cyclonic eddies are labeled A-Z. Arrows on eddies indicate direction of circulation. Warm-core or anticyclonic eddies rotate clockwise; cold-core or cyclonic eddies rotate counterclockwise. The line to the eddy center shows the net translation since last month or since last observed. The edge of continental shelf at 200 m is shown as a dashed line. Eddies or sections of the Gulf Stream System which were not observed during the month are not shown on the analysis chart or are indicated by "dot-dashed" lines. The long arrows at the bottom of the chart indicate the dates of data used.



GULF OF MEXICO

The Loop Current in the Gulf of Mexico was discernible during November due to the return of sea surface temperature gradients. Anticyclonic eddy v drifted 65 Km NNE since October. The area of warm water over the northeast part of the Gulf persisted and is eddy like in appearance.



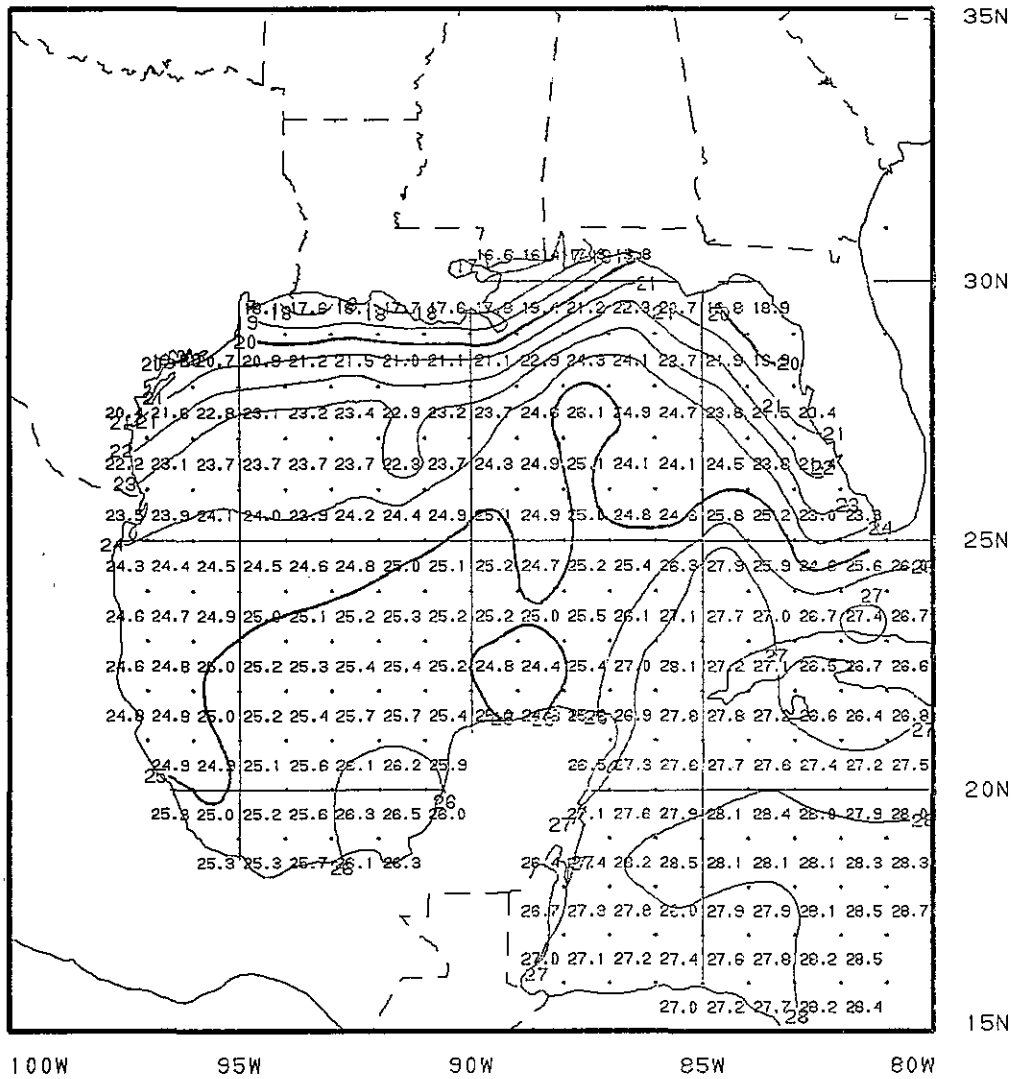
NORTHWEST ATLANTIC OCEAN

Two anticyclonic eddies formed from Gulf Stream meanders and one anticyclonic eddy was absorbed during November. Eddy 3 formed from a meander near 41N 57W around November 23. Eddy 4 pinched off from a Gulf Stream meander near 40N 65W about November 25. Eddy 2 was absorbed by a meander near 38°30N 69°30W around November 23. Eddy I translated 110 Km NW while eddy 98 traveled 165 Km SE.

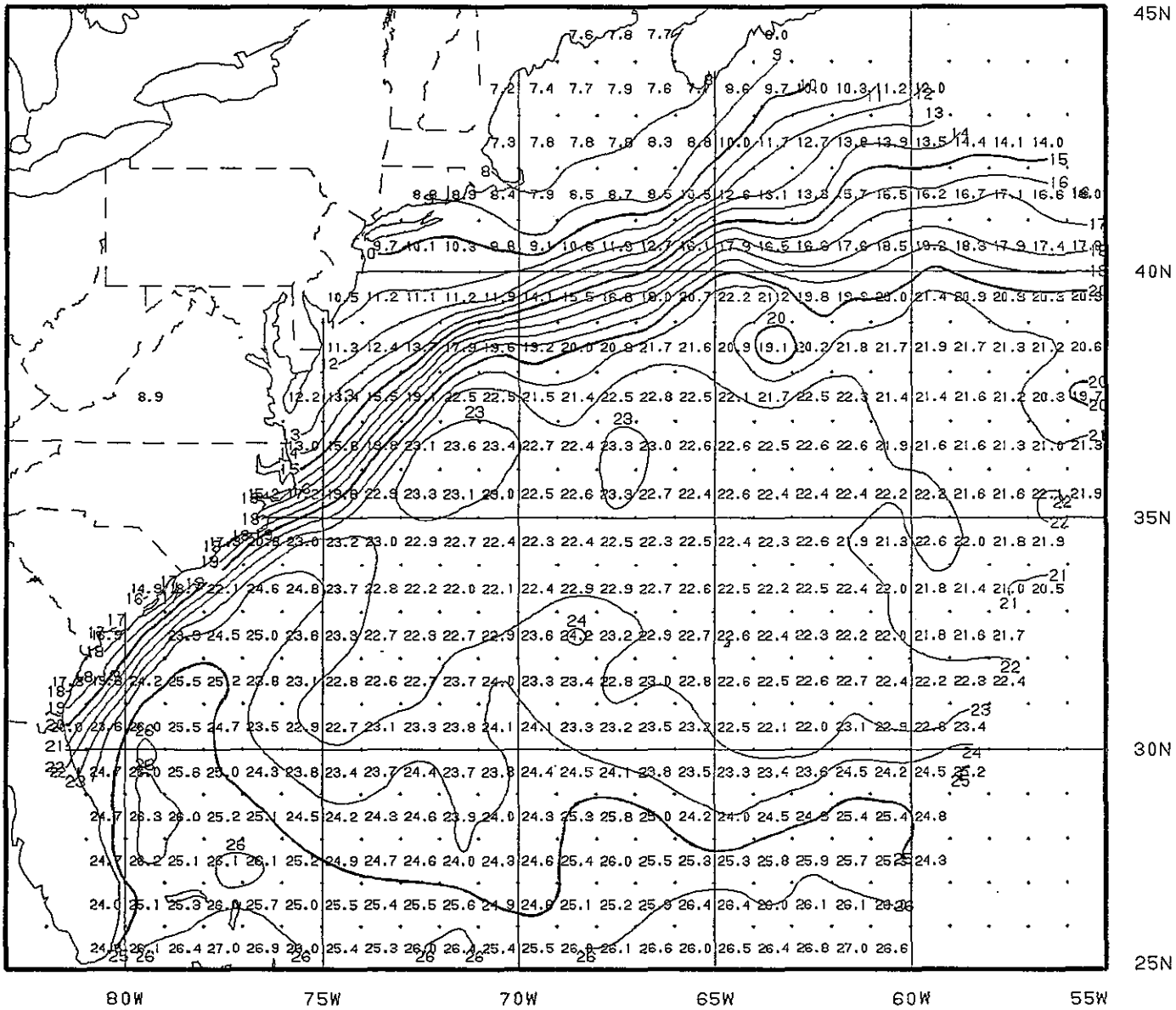
Two cyclonic eddies were newly observed during November. Eddy K was detected in late October by XBTs from Harvard/Navy. Eddy K is apparently centered near 37°30N 60°30W. Eddy L was newly observed on November 9 from infrared satellite imagery near 33°N 75°W. The origins of eddies K and L are not known. One cyclonic eddy was seemingly absorbed in late November. Eddy A was advected rapidly eastward near 38N 67W in October and was probably absorbed by the Gulf Stream near 38N 66W during November.

Eddy F moved 75 Km ENE. Eddy J translated 90 Km NE. Eddy I drifted 35 Km NW since it was previously observed in September.

EAST COAST SST – MONTHLY MEAN



NOVEMBER 1987 GULF OF MEXICO SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0C.



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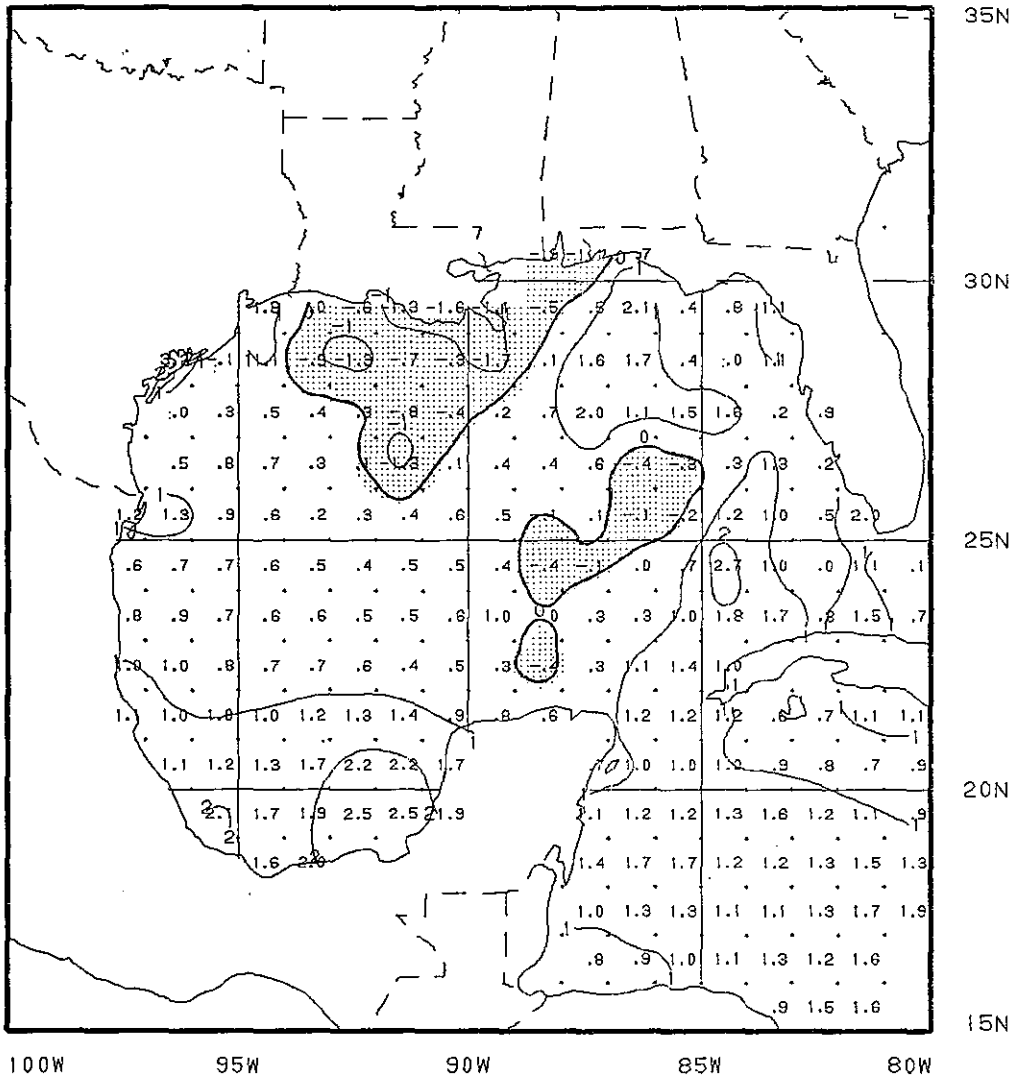
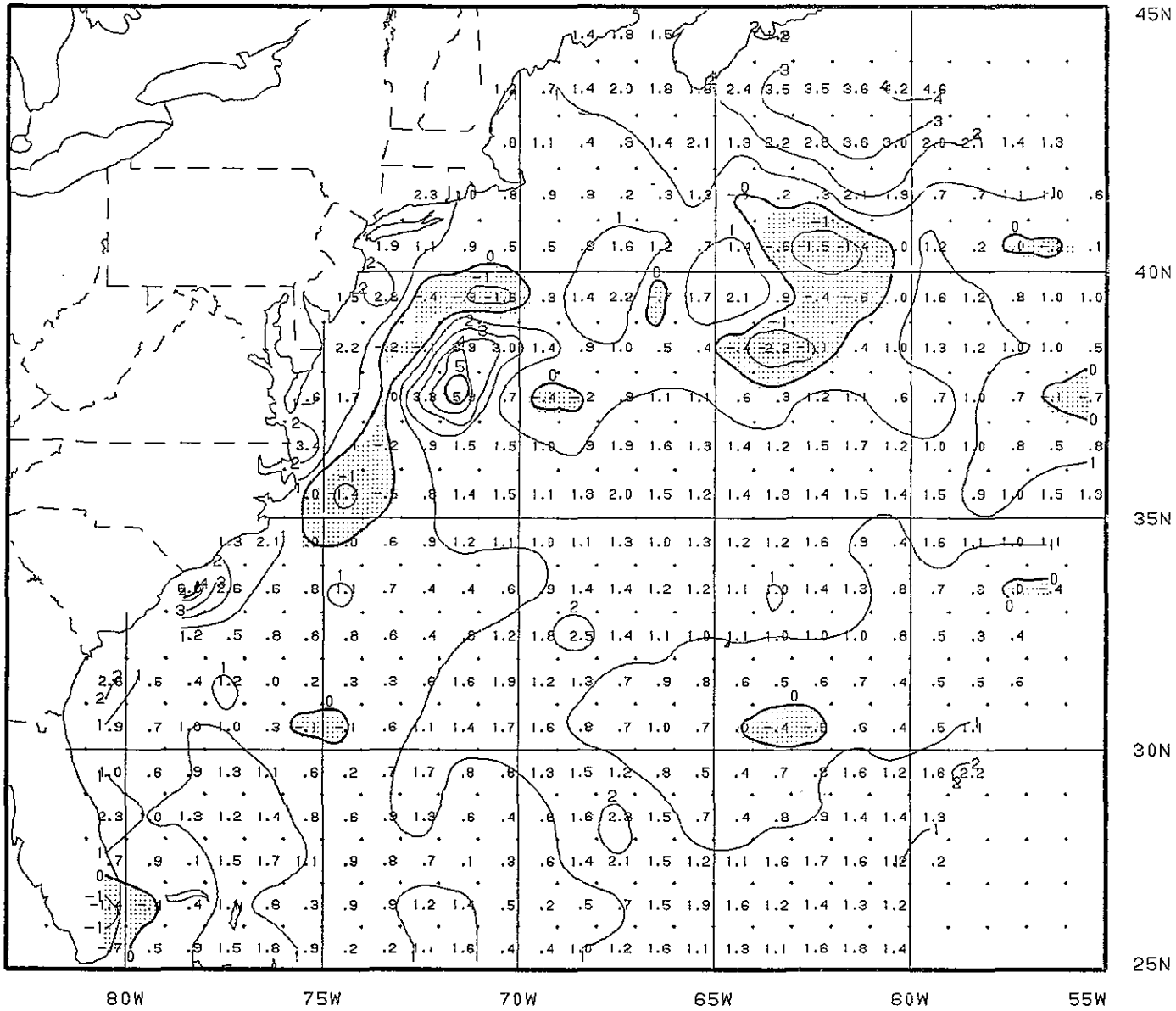
EAST COAST SST - ANOMALY



NOVEMBER 1987 GULF OF MEXICO SST--MONTHLY ANOMALY (C)--Monthly anomaly is the difference between the monthly mean SST and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0C.



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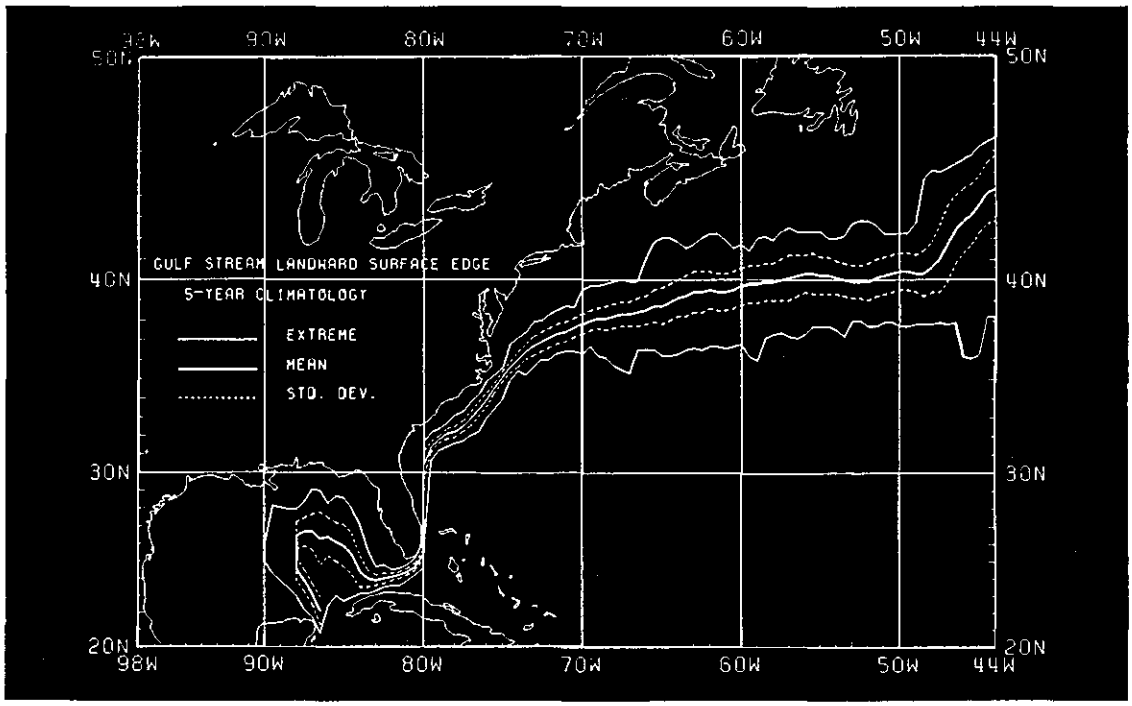
The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through April 1, 1988.

OCEANOGRAPHIC Monthly Summary

Volume VII Number 12 December 1987



Five-year climatological GSLSE Curves (page 3)

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OCEANOGRAPHIC
Monthly Summary

Oceanographic Monthly Summary is published by the National Weather Service (NWS), the National Environmental Satellite, Data, and Information Service (NESDIS), and the National Ocean Service (NOS). *Oceanographic Monthly Summary* contains sea surface temperature (SST) analyses on both regional and ocean basin scales for the Atlantic, Pacific, and Indian Oceans. The ocean basin analyses are based on a "blend" of *in situ* and satellite data, in which *in situ* data are used to define "benchmark" temperature values in regions of frequent observations and satellite data are used to define the "shape" of the field between these points.[1]

An ocean basin SST anomaly is derived from the "blended" SST analysis[1] and the improved global SST.[2] The regional SST analyses are based upon a combination of *in situ* and satellite data measurements. The regional SST anomalies are calculated from the Robinson-Bauer Climatology.[3,4] *Oceanographic Monthly Summary* also contains Alaskan sea ice information and ocean feature information for contiguous U.S. ocean regions.

Oceanographic Monthly Summary welcomes articles containing information of interest to its readers, such as news on operational oceanography, unusual ocean feature phenomena, etc. Contributions should be sent to the editor (address below). Accepted material will appear in the OceaNotes section of *Oceanographic Monthly Summary*. Contributions can be published as quickly as the next monthly issue.

If you are interested in receiving *Oceanographic Monthly Summary* regularly, please refer to the back cover for subscription information.

[1]Reynolds, R.W. and W.H. Gemmill, 1984. A sea surface temperature analysis which blends *in situ* and satellite observations. *Proceedings of the Ninth Climate Diagnostics Workshop*, Corvallis, OR, Oct. 22-26, 1984, pp. 408-416.

[2]The climatology is derived from *in situ* data (1950-1979), satellite data (1982-1985) and an ice climatology.

[3]Robinson, M.K., 1976. Atlas of North Pacific Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOcean Ref. Pub. 2.*

[4]Robinson, M.K., R.A. Bauer, and E.H. Schroeder, 1979. Atlas of North Atlantic-Indian Ocean Monthly Mean Temperatures and Mean Salinities of the Surface Layer; *NavOceano Ref. Pub. 18.*

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OceaNotes

FIVE-YEAR CLIMATOLOGICAL SURVEY OF THE GULF STREAM SYSTEM AND ITS ASSOCIATED RINGS

Stephen J. Auer[1]

National Environmental Satellite, Data, and Information Service, Suitland, MD

[This OceaNote highlights the methodology and results of the study published in a recent journal article by Auer who recently served as OMS editor -- J. Geophys. Res. 92 (11,709-11,726) 1987. We have selected the following illustrations and tables from the journal article to supplement our summary, retaining the same figure and table numbers: figures 1, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, and table 4].

The 5-year weekly data set used in this study contains an Eulerian representation of the weekly GSLSE[2] positions and a Lagrangian description of the center positions and average diameters of the warm-core rings (WCRs) and the cold-core rings (CCRs). The data set was manually compiled from 1300 Oceanographic Analysis Charts produced by the National Weather Service and the National Environmental Satellite, Data, and Information Service. The charts contain positions of ocean thermal fronts which are manually analyzed from polar-orbiting satellite infrared imagery along with available expendable bathythermograph reports, data buoys, and ship SST observations.

The GSLSE latitudinal position to the nearest 0.1° was determined at each 0.5° longitudinal transect from 91.0°W to 44.0°W. The weekly WCR and CCR observations were compiled with a ring name, a center position, and an average diameter. Ring formation and absorption events were also noted. When possible, the ring names are the same names as found in the Oceanographic Monthly Summary (published by NOAA since 1981) or its predecessor, the Gulf Stream (published by National Weather Service through 1980). In some instances the ring names or movements reported in the above-mentioned publications were corrected during the extensive review of all the charts. These ring corrections are an acceptable result of the advantage of more accurately determining the ring events after the complete history of observed ring movements is known, a luxury not available to the real time schedule of the monthly publications.

Figure 1 shows all the observed weekly GSLSE positions during the 260-week (5-year) data period; it illustrates the northward (and slightly westward) intrusive nature of the Loop Current, the expanding range of the GSLSE down-stream from Cape Hatteras, and the increased meandering downstream from Cape Hatteras.

Figure 3 presents the 5-year climatological GSLSE curves. None of these curves is representative of any particular week's synoptic GSLSE position

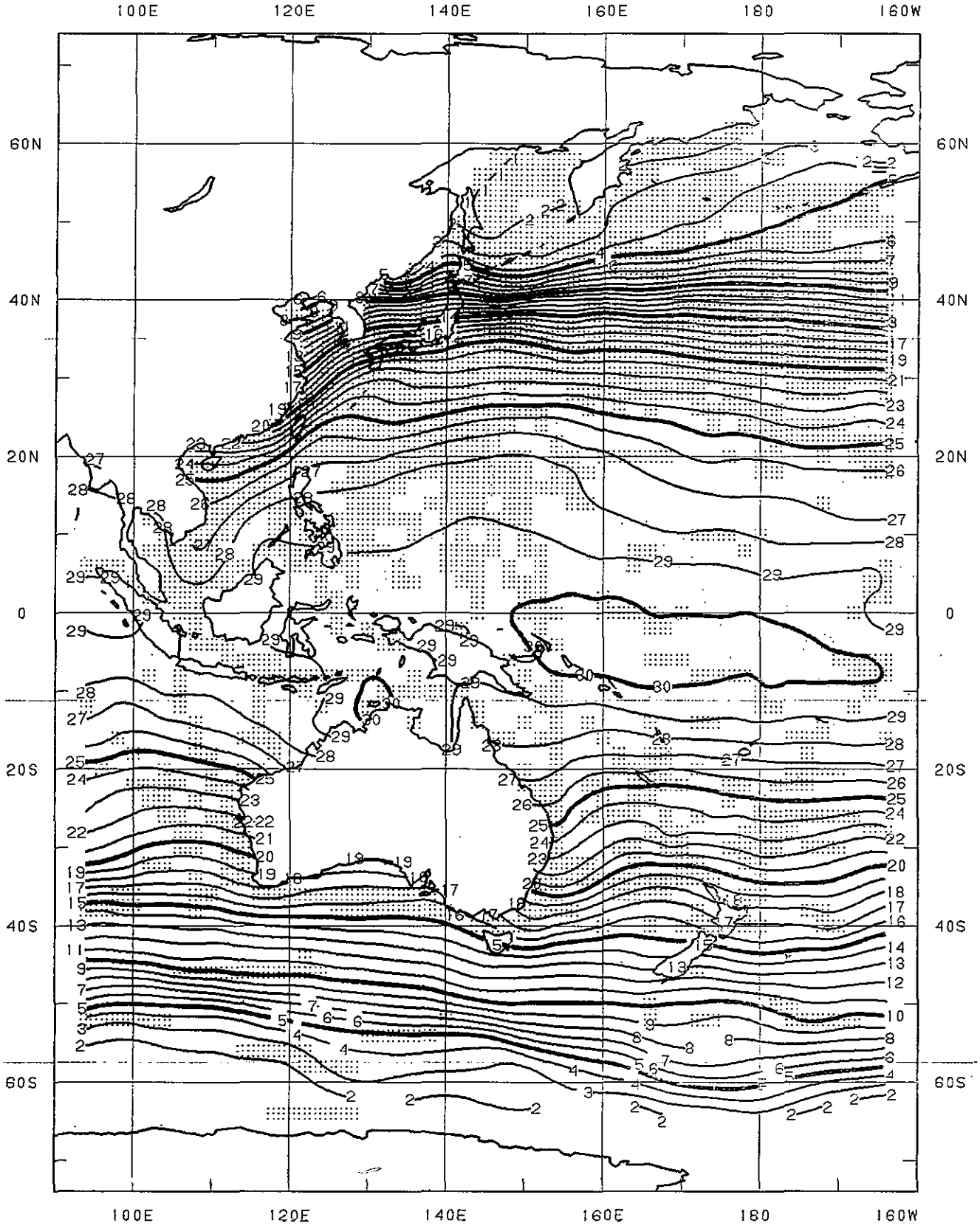
The extreme GSLSE curves connect the most northern (and southern) observed positions between the transects. The extreme curves reveal the expansive intrusion range of the Loop Current to the North and west. The range narrows in the Florida Straits, then slightly widens along the Carolinas (75°-80°W) where small-amplitude wave-like meanders often propagate downstream with a prominent weekly time scale. Past Cape Hatteras, large-amplitude meanders are observed to grow, translate, and occasionally pinch off or reform.

---

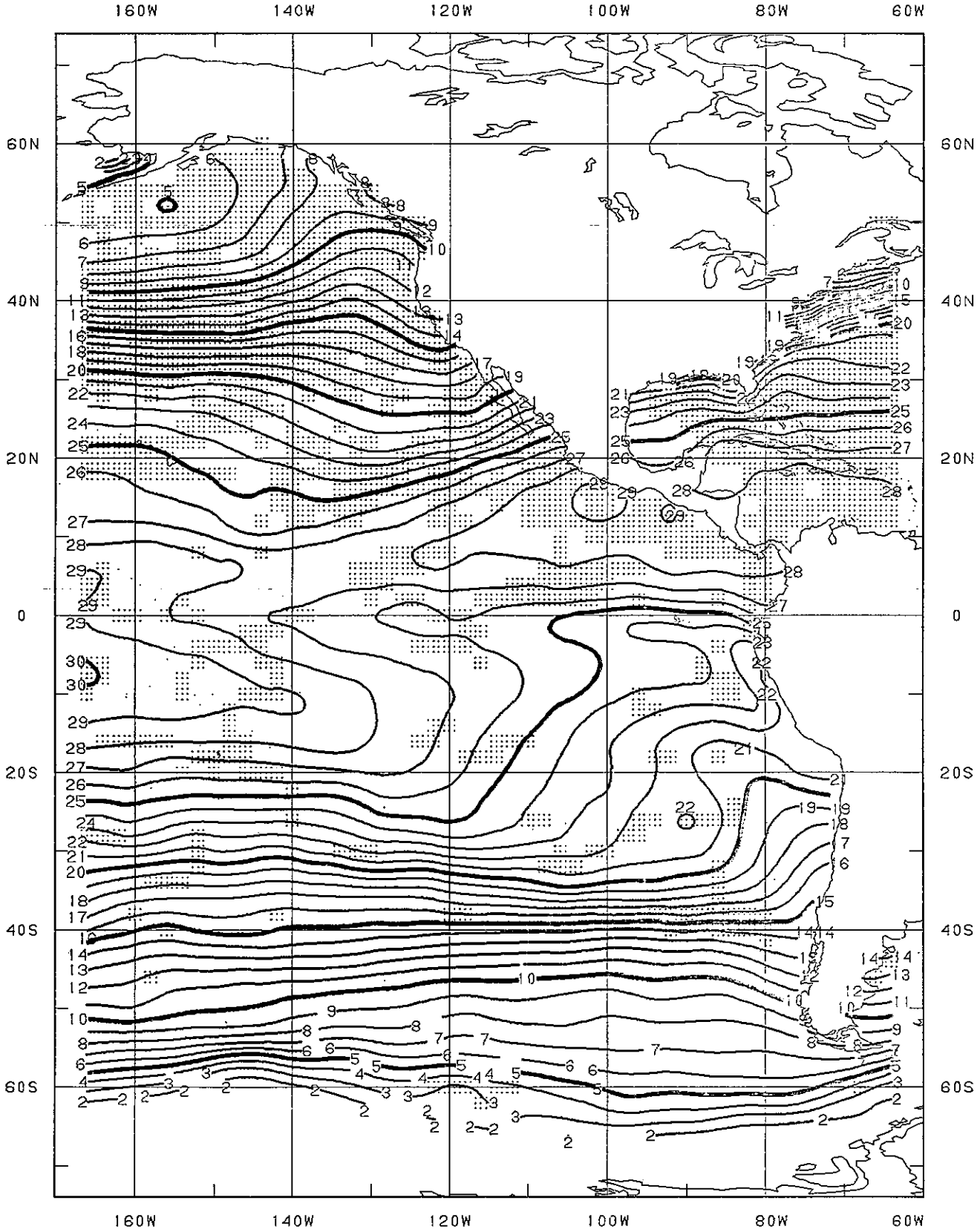
1. Formerly with Ocean Products Center, National Meteorological Center, Camp Springs, MD.

2. The term Gulf Stream Landward Surface Edge (GSLSE) is utilized in this paper to denote the current's edge nearest to the North American continental landmass. This same edge in the northwest Atlantic Ocean is synonymously referred to as the "north wall" or "cold wall" of the Gulf Stream due to the large temperature gradient inherent across it.

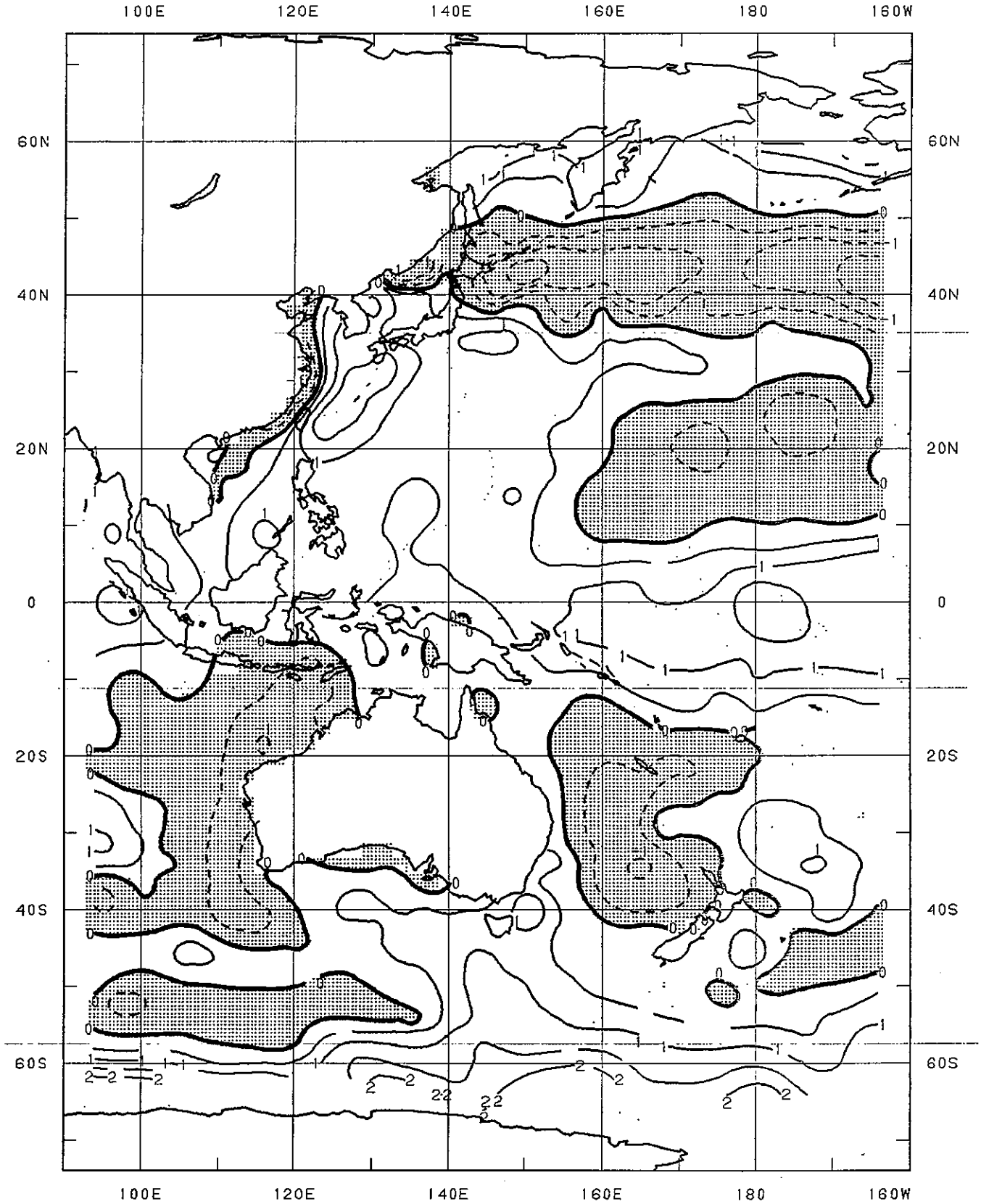
(continued on page 12)



DECEMBER 1987 WESTERN PACIFIC OCEAN SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of **in situ** (ship, buoy) and satellite data within two-degree quadrangles. Contour line interval is 1.0 C. The stippling indicates where the analysis was fixed by the **in situ** data; contours are not shown in areas without data.



DECEMBER 1987 EASTERN PACIFIC OCEAN SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of **in situ** (ship, buoy) and satellite data within two-degree quadrangles. Contour line interval is 1.0 C. The stippling indicates where the analysis was fixed by the **in situ** data; contours are not shown in areas without data.



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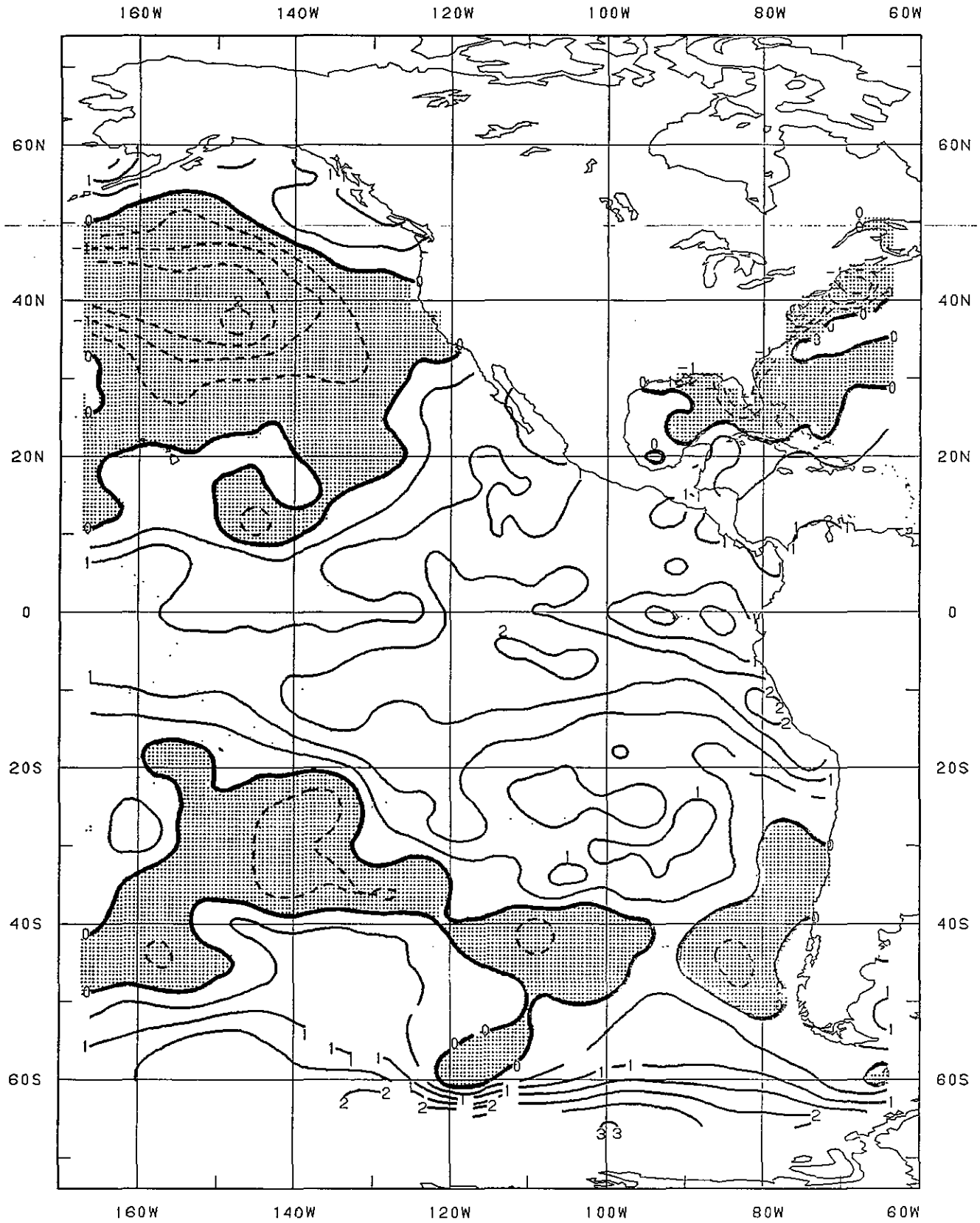

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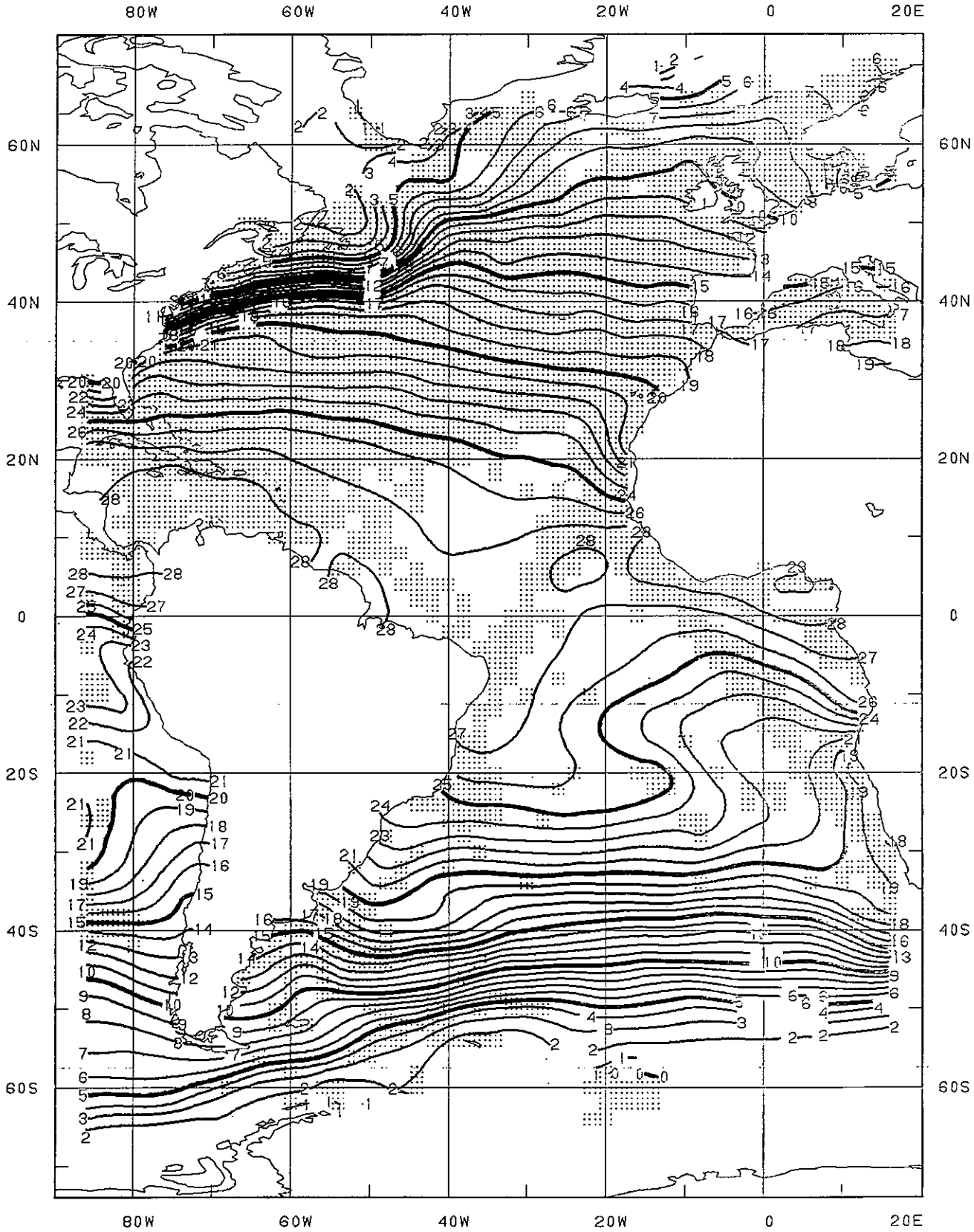

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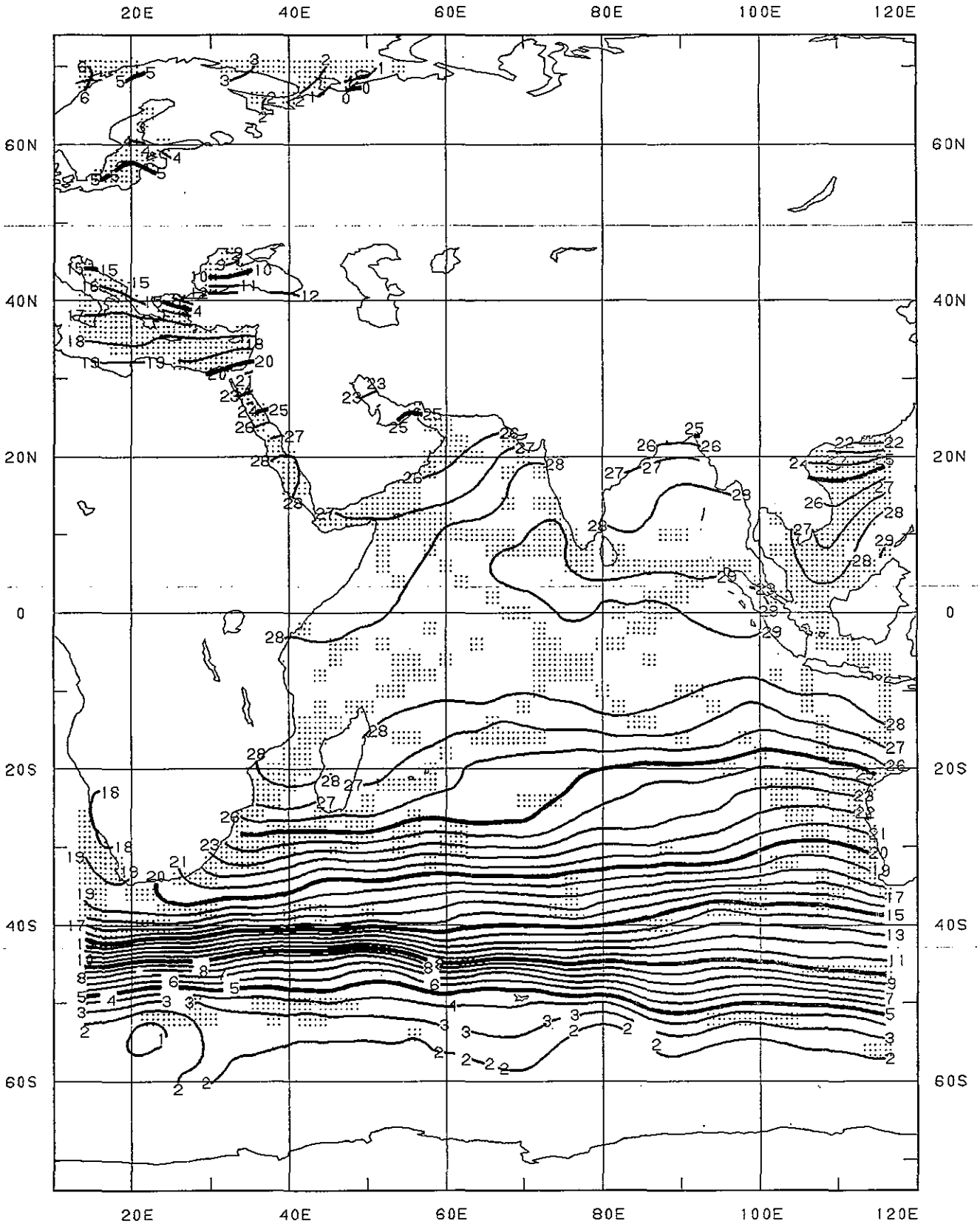
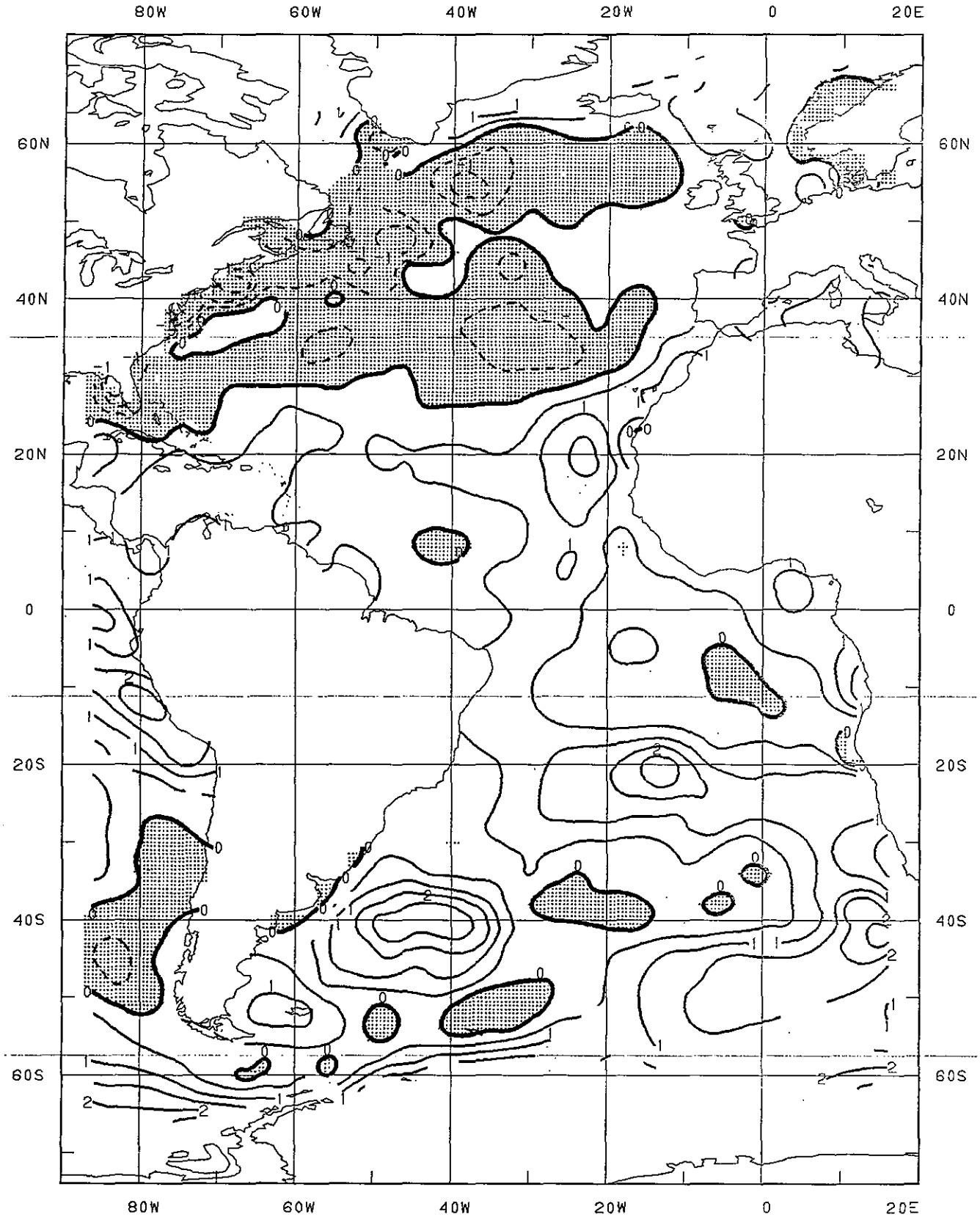


DECEMBER 1987 INDIAN OCEAN SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of **in situ** (ship, buoy) and satellite data within two-degree quadrangles. Contour line interval is 1.0 C. The stippling indicates where the analysis was fixed by the **in situ** data; contours are not shown in areas without data.



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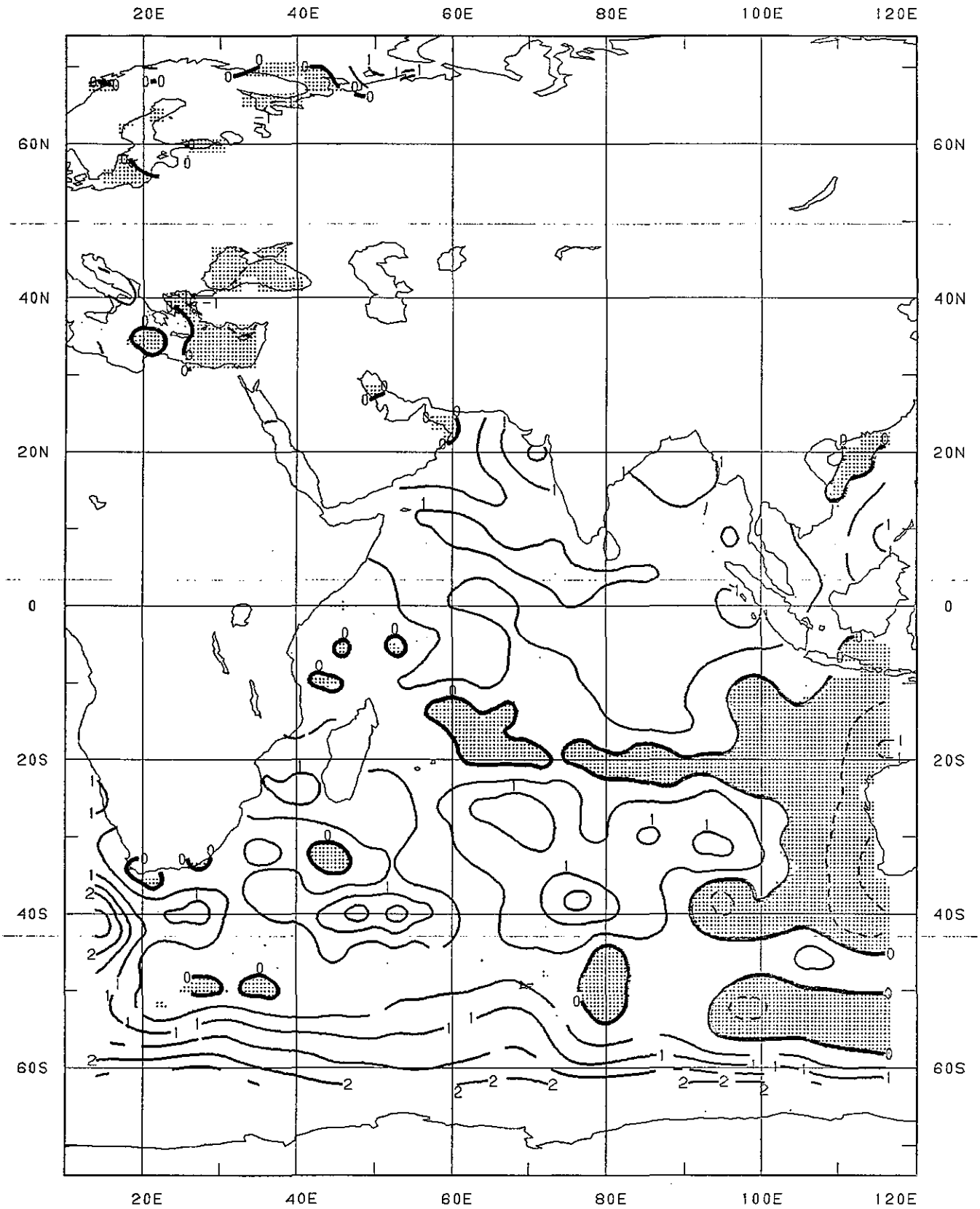

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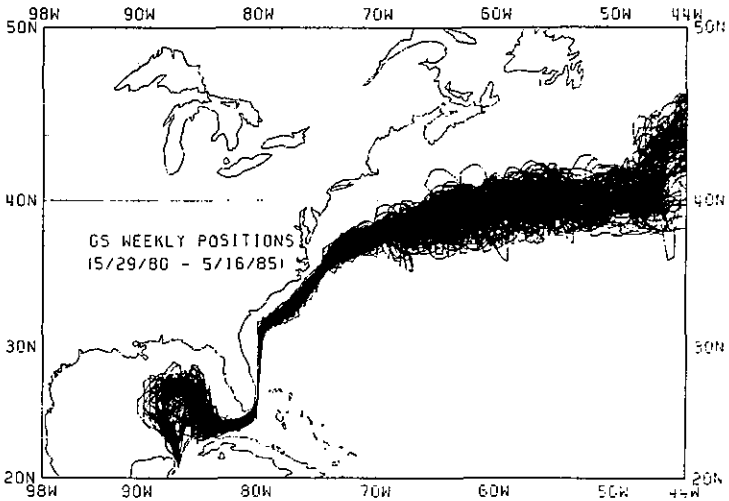

Fig. 1. The observed weekly Gulf Stream System Landward Surface Edge positions for 260 weeks (5-year data period).

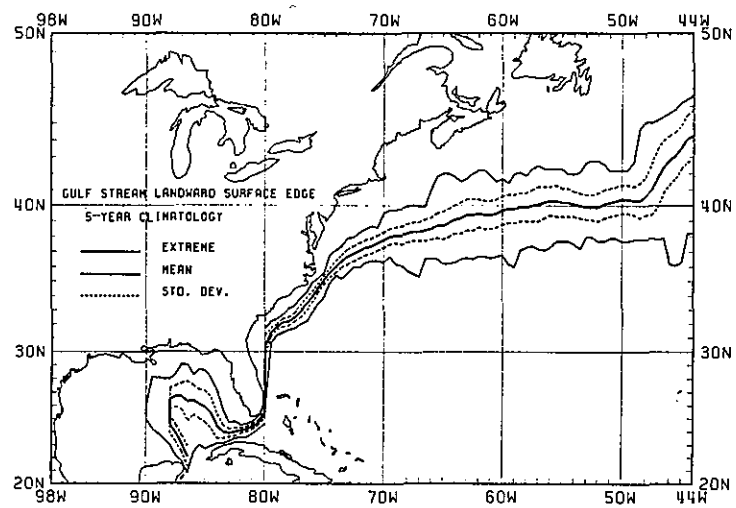

Fig. 3. The 5-year climatological curves of the Gulf Stream System Landward Surface Edge defined for each 0.5° of longitude. The bold solid line delineates the mean position. The dashed lines delineate a one standard deviation envelope about the mean. The light solid lines delineate the 5-year observed extreme excursions.

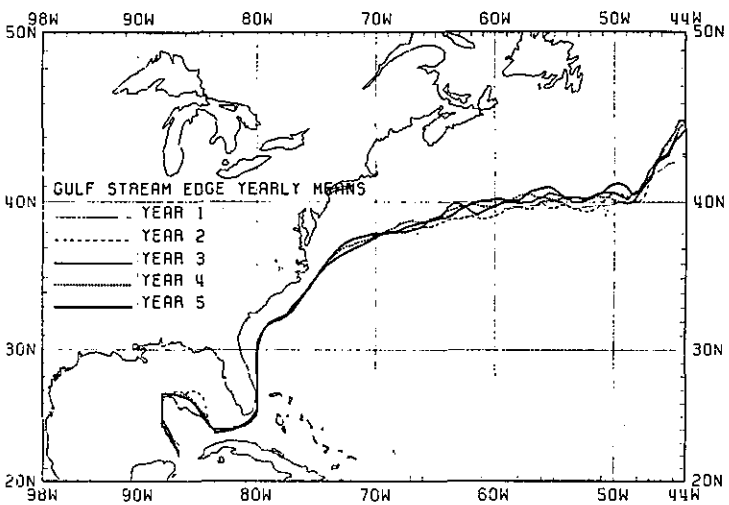

Fig. 4. Comparison of the Gulf Stream Landward Surface Edge yearly mean curves. The year dates are given in Table 1. Interannual variability is seen in the Loop Current's northward penetration at 86.5°W and in the Gulf Stream north of Cape Hatteras.

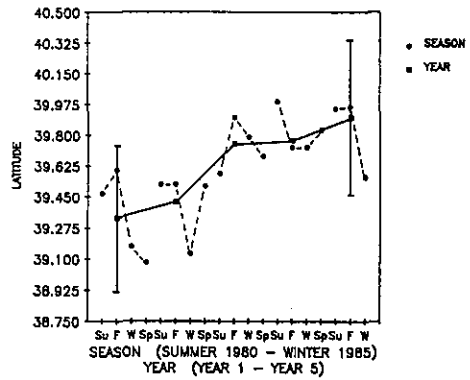

Fig. 5. The 5 yearly and 19 seasonal mean Gulf Stream Landward Surface Edge positions over the longitude band 74°–44°W. Confidence limits (95%) are drawn for years 1 and 5. An incremental northward shift is seen over years 1–5. Year 1 is found to be significantly south of year 5. An F test of these two samples indicates that the interannual variability is equal to the annual variability.

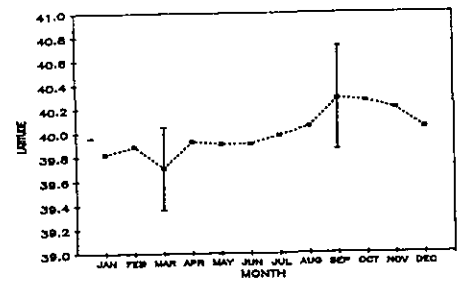

Fig. 7. The 12 monthly Gulf Stream Landward Surface Edge means for the longitude band 70°–44°W. Confidence limits (95%) are drawn for March and September. A one-tail student t test indicates that the March mean is significantly south of the September mean.

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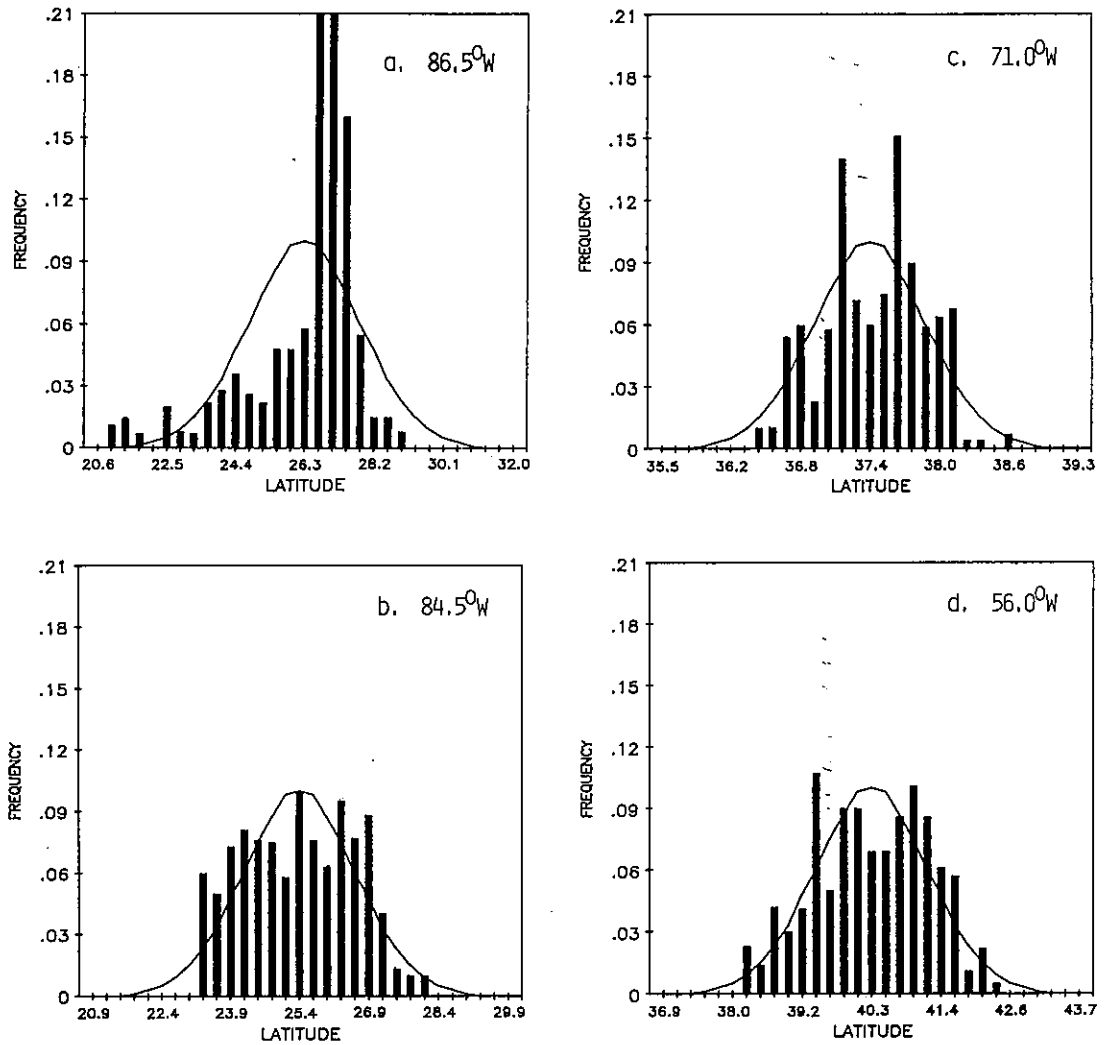

Fig. 8. Probability distribution of Gulf Stream Landward Surface Edge observations for 5 years at four selected longitudinal transects (Figure 8*a*, 86.5°W; Figure 8*b*, 84.5°W; Figure 8*c*, 71.0°W; and Figure 8*d*, 56.0°W). A standard normal curve is provided as a reference. The Gulf Stream Landward Surface Edges have a quasi-normal distributions according to goodness of fit tests, except at 86.5°W (Figure 8*a*). The long negative tail at 86.5°W implies that the Loop Current's northward penetration rate is rapid following an eddy shedding event.

Figure 4 gives the five yearly mean GSLSE curves. Interannual variability is evident in the Loop Current's northward penetration, especially at 86.5°W, where years 2, 4, and 5 have a more northern position than years 1 and 3. This caused by the Loop Current warm-core ring shedding variability. The interannual variability is also evident in the stream east of Cape Hatteras.

Figure 5 gives the five yearly and 19 seasonal mean GSLSE latitude values for the longitudinal band 74°-44°W. Confidence limits are drawn for the means of years 1 and 5. A northward trend is seen in years 1 through 5.

An annual cycle is found (Figure 7) for the GSLSE in the longitudinal band 70°-44°W, where the March mean is significantly south of the September mean (65km shift). Similar tests of an annual cycle in six smaller longitudinal bands over the region east of Cape Hatteras found no significant annual shift for bands 74°-70°W and 64.5°-60°W but found significant annual shifts for bands 69.5°-65°W (45 km) 59.5°-55°W (55 km), 54.5°-50°W (55 km), and 49.5°-44°W (175 km). The magnitude of the annual shift in the Grand Banks area is slightly inflated by the nonorthogonal transects; it may also have some error associated with cloud persistence which may bias wintertime observations to more southern crossings.

Figures 8a-8d show the 5-year GSLSE frequency distributions observed at selected longitudinal transects. The frequency distribution for 86.5°W (Figure 8a), a good longitude for monitoring the northward penetration of the Loop Current into the Gulf of Mexico, has a deltalike distribution with a long negative tail. This distribution implies that the Loop Current growth following an eddy shedding event from a minimum position (within the negative tail of the distribution) toward its mean position is relatively rapid compared to the subsequent growth prior to the eventual shedding of a Loop Current warm-core ring. Figures 8b-8d are typical of the remaining GSLSE transects in having quasi-normal distributions which pass goodness of fit tests (95% confidence level).

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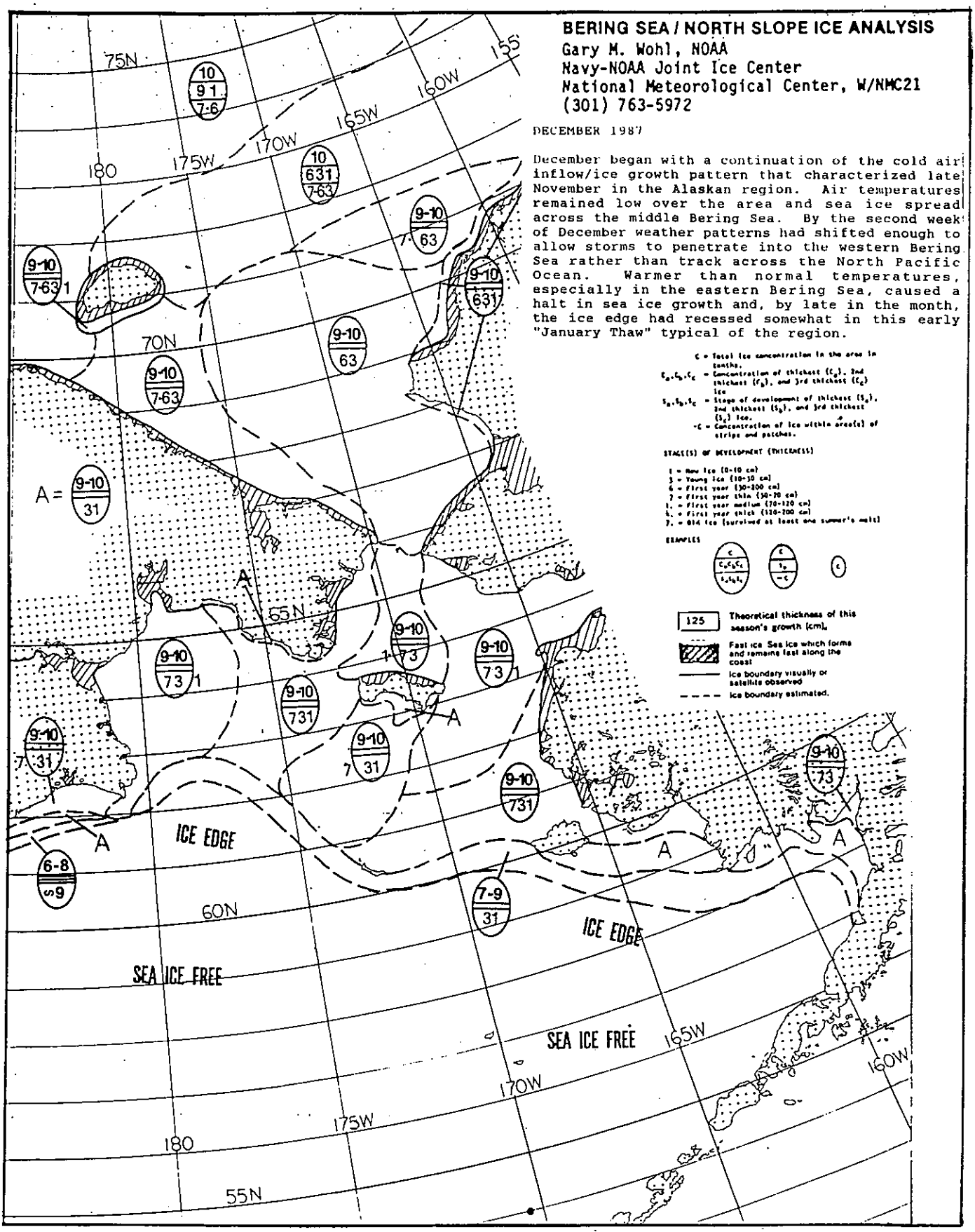

BERING SEA / NORTH SLOPE ICE ANALYSIS

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DECEMBER 1987

December began with a continuation of the cold air inflow/ice growth pattern that characterized late November in the Alaskan region. Air temperatures remained low over the area and sea ice spread across the middle Bering Sea. By the second week of December weather patterns had shifted enough to allow storms to penetrate into the western Bering Sea rather than track across the North Pacific Ocean. Warmer than normal temperatures, especially in the eastern Bering Sea, caused a halt in sea ice growth and, by late in the month, the ice edge had recessed somewhat in this early "January Thaw" typical of the region.

C = Total ice concentration in the area in tenths.

C_a, C_b, C_c = Concentration of thickest (C_a), 2nd thickest (C_b), and 3rd thickest (C_c) ice

S_a, S_b, S_c = Stage of development of thickest (S_a), 2nd thickest (S_b), and 3rd thickest (S_c) ice.

-C = Concentration of ice within area(s) of strips and patches.

STAGE(S) OF DEVELOPMENT (THICKNESS)

1 = New ice (0-10 cm)
3 = Young ice (10-30 cm)
4 = First year (30-200 cm)
7 = First year thin (30-70 cm)
1. = First year medium (70-120 cm)
4. = First year thick (120-200 cm)
7. = Old ice (survived at least one summer's melt)

EXAMPLES

125 Theoretical thickness of this season's growth (cm).

Fast ice. Sea ice which forms and remains fast along the coast

Ice boundary visually or satellite observed

Ice boundary estimated.

WEST COAST OCEAN FEATURES

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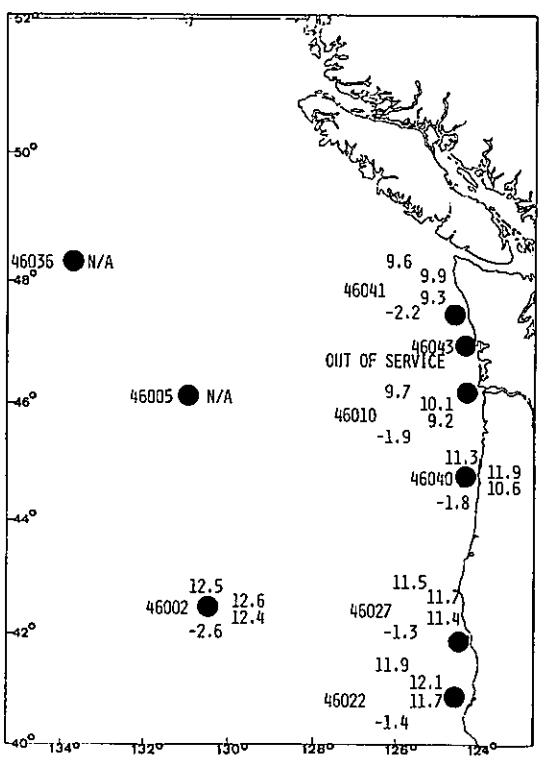
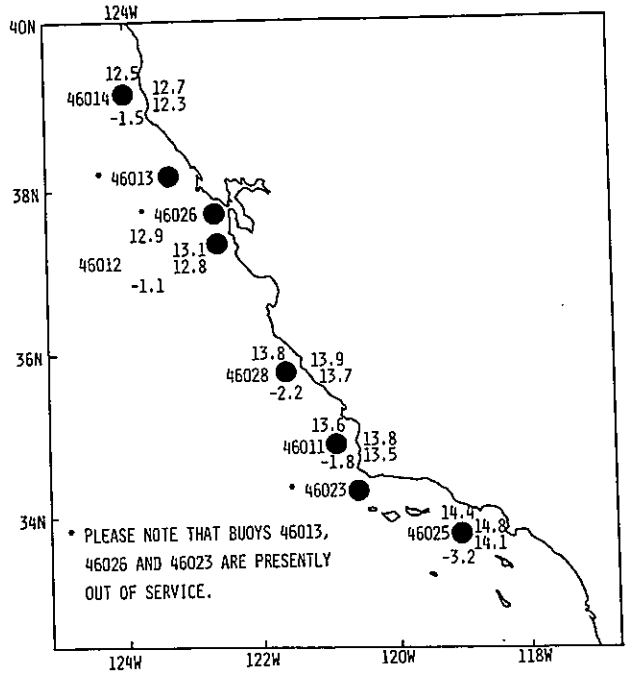
DECEMBER 1987

Sea surface temperatures in the North and South Panels continue to average above normal when compared to NOAA's SST climatology. The averaged observed value in the northern analysis area was 11.8°C, or 0.9°C warmer than normal; in the south, the actual SST was 16.7°C and, climatologically, it should have been 16.3°C. This anomalously warm trend has continued for some time now.

In the North Panel, the greatest positive anomalies were observed near shore with decreasing values toward the offshore. In fact, only one location near 43°N 134°W, averaged a mere .1°C below climatology. The highest value of +1.9°C was analyzed west of Washington near 47°N 126°W. All other locations on the chart had above normal temperatures somewhere between the two forementioned values. When comparing the trend in SST's to last month, there was overall cooling throughout the North Panel. Oddly enough, the greatest cooling occurred offshore and the least cooling occurred toward the nearshore. The area of maximum cooling (-2.9°C) was analyzed





near 46°N 133°W. The smallest decrease in temperatures (-1.2°C) was centered near Cape Blanco, Oregon (43°N 126°W).

When comparing South Panel SST's to climatology, results were similar to those in the North Panel. Nearshore waters had the greatest positive anomalies with decreasing values farther offshore. The greatest observed positive anomalies (+1.4°C) were found from Monterey Bay to the northern limit of the chart. Observed temperatures west of 131°W were actually below normal with the greatest value of -1.0°C near 37°N 133°W. At the location 31°N 123°W, the observed mean temperature was the same as climatology.

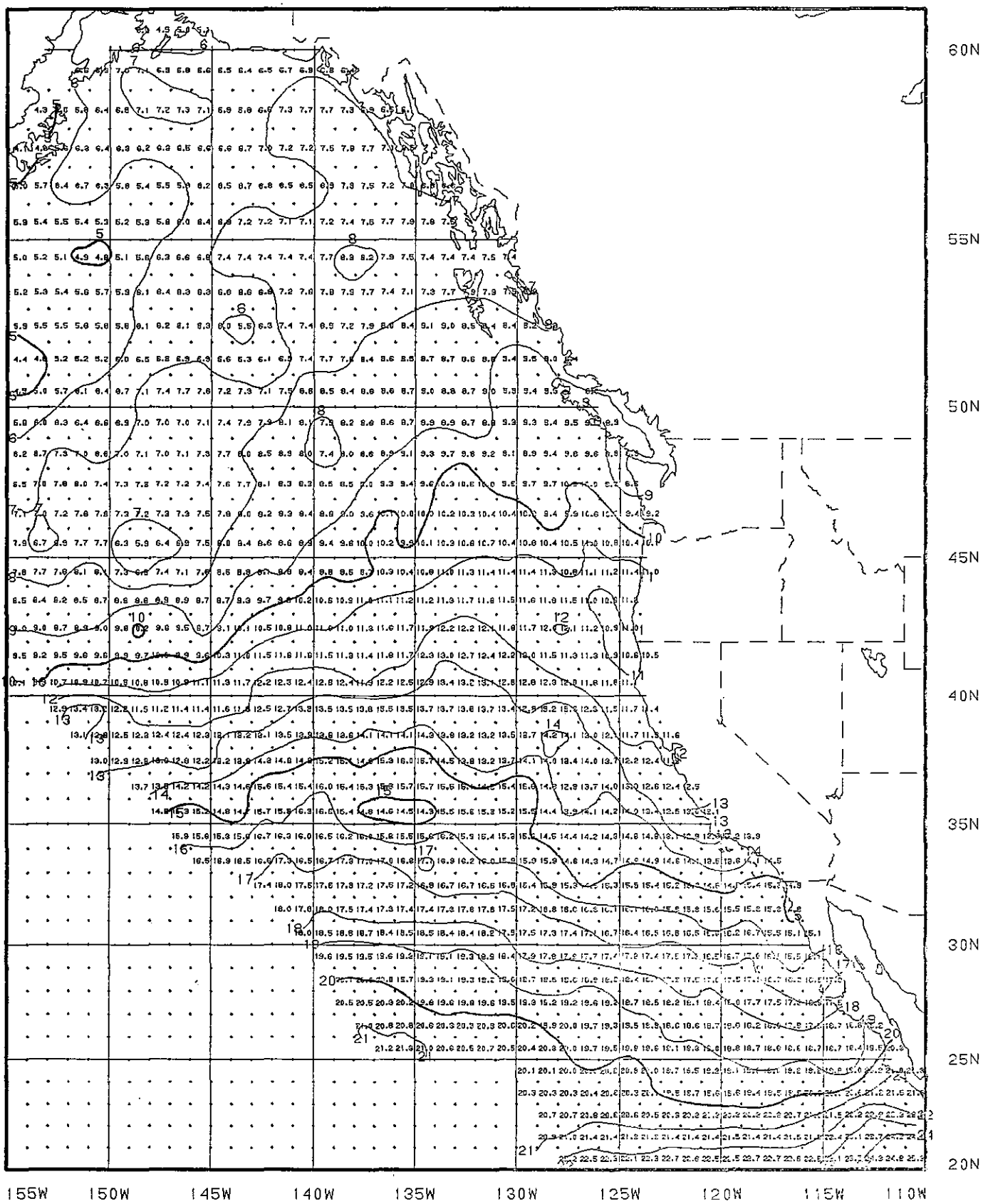
From November through December, the entire South Panel cooled. Observed values ranged from a decrease of 1.0°C near San Francisco Bay to -2.4°C in the northwest corner of the chart. A 2.3°C decrease was observed in the Los Angeles Bight.

Buoy statistics in both panels agreed quite well with the statistics generated from the eight analyses produced during the month.

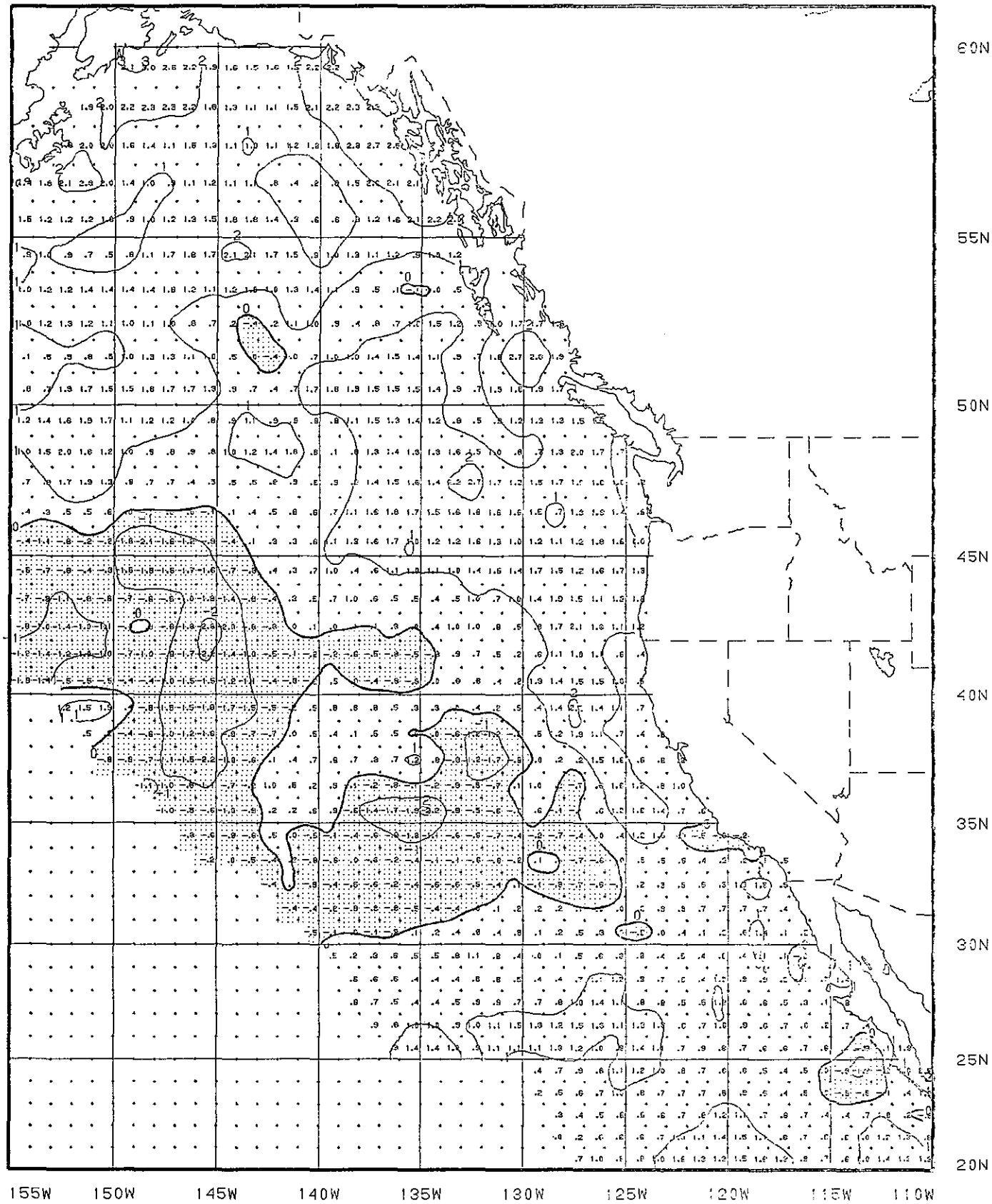
KEY:

	12.1 ←	Monthly mean
LOCATION	13.5 ←	Maximum daily mean
NAME	10.2 ←	Minimum daily mean
	-1.5 ←	Change from previous month

● Denotes station position.



DECEMBER 1987 U.S. WEST COAST SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0C.



DECEMBER 1987 U.S. WEST COAST SST--MONTHLY ANOMALY (C)--Monthly anomaly is the difference between the monthly mean SST and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0C.

EAST COAST OCEAN FEATURES

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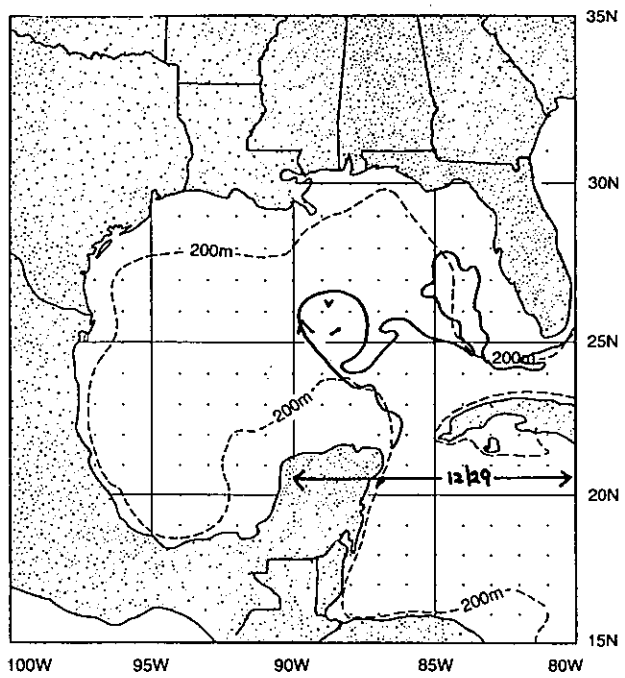
DECEMBER 1987

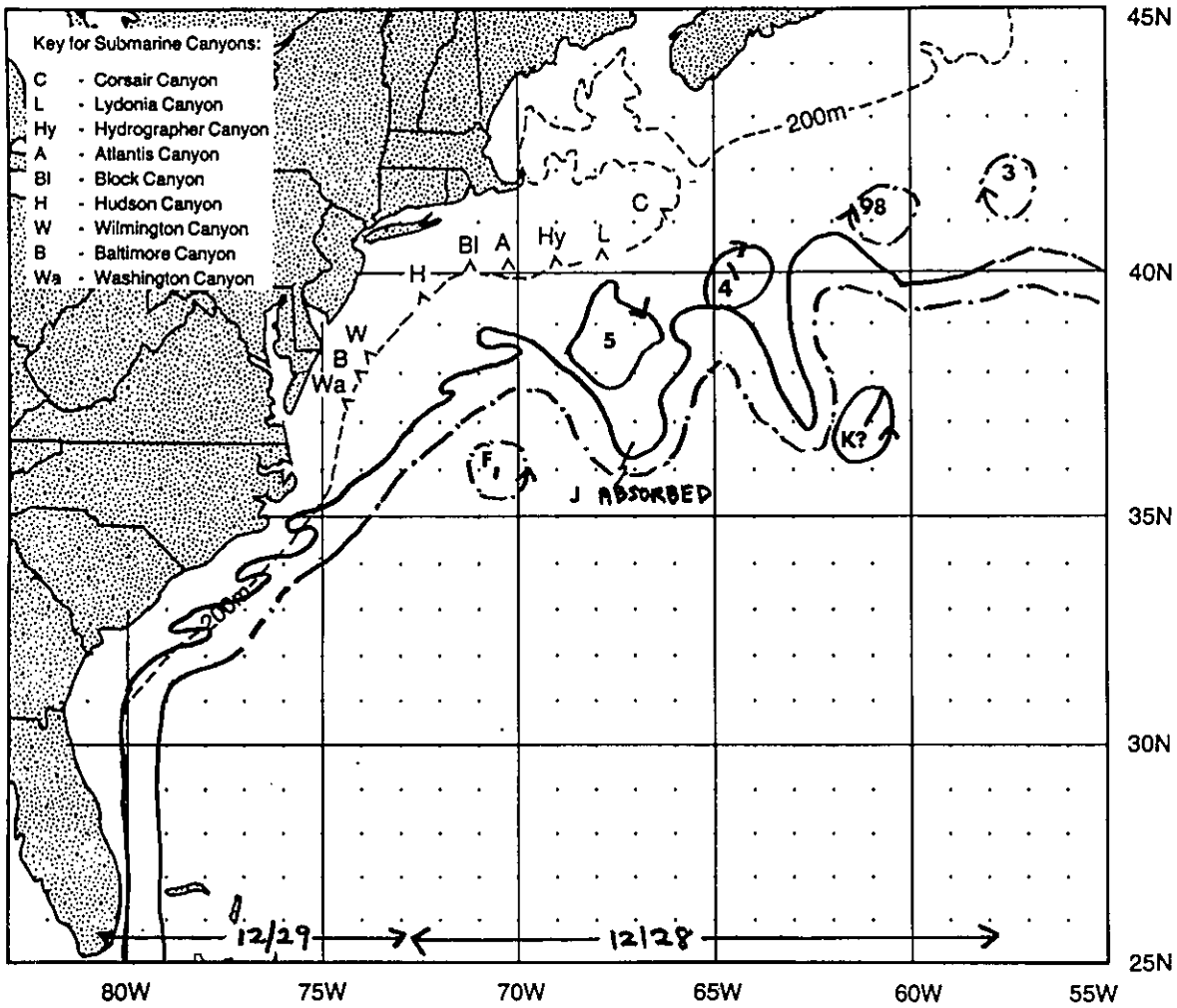
The end of this month's positions of the Gulf Stream System and its associated eddies are shown for the NW Atlantic and the Gulf of Mexico. The Gulf Stream and Loop Current boundaries are located by infrared satellite imagery or XBT (expendable bathythermograph) data. Anticyclonic eddies are labeled a-z in the Gulf of Mexico and 1-99 in the Northwest Atlantic. Cyclonic eddies are labeled A-Z. Arrows on eddies indicate direction of circulation. Warm-core or anticyclonic eddies rotate clockwise; cold-core or cyclonic eddies rotate counterclockwise. The line to the eddy center shows the net translation since last month or since last observed. The edge of continental shelf at 200 m is shown as a dashed line. Eddies or sections of the Gulf Stream System which were not observed during the month are not shown on the analysis chart or are indicated by "dot-dashed" lines. The long arrows at the bottom of the chart indicate the dates of data used.

Data used in this analysis include:
Infrared imagery from NOAA satellite - NESDIS
Bathythermograph data from National Meteorological Center of National Weather Service
Oceanographic Analysis -- A daily detailed analysis issued by National Weather Service



GULF OF MEXICO

The Loop Current intruded about 65 km to the northwest in the Gulf of Mexico during December. Anticyclonic eddy v drifted 25 km NE. The warm filament previously located near 29°N, 86°W has retracted about 110 km. Its northern extent is located near 28°N 85°W.



NORTHWEST ATLANTIC OCEAN

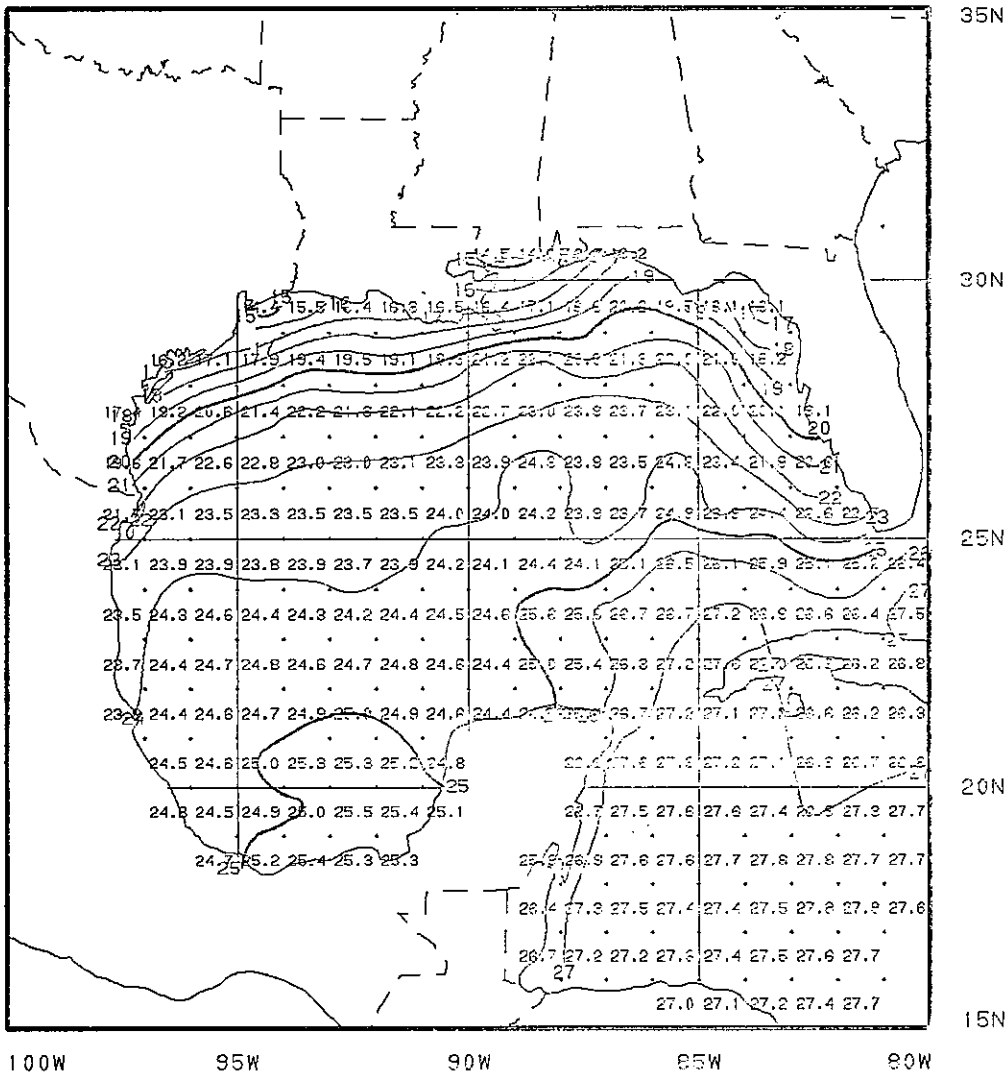
One anticyclonic eddy formed from a Gulf Stream meander during December and one was apparently absorbed by another anticyclonic eddy. Eddy 5 formed about December 23 near 39°N 68°W. On December 17, the Harvard University Open Ocean Model had predicted its formation to occur around December 22. Polar orbiting satellite imagery partially confirmed the existence of eddy 5 on December 23.. Clouds contaminated the imagery and only parts of the eddy were detected, Eddy 1 was seemingly absorbed by eddy 4 near 41°N 65°W around December 11.

Eddy 4 translated 35 km SE during December. Eddies 98 and 3 were not observed during December due to extensive and prolonged cloudiness. Since it is likely that these eddies still exist, they were not deleted from the analysis.

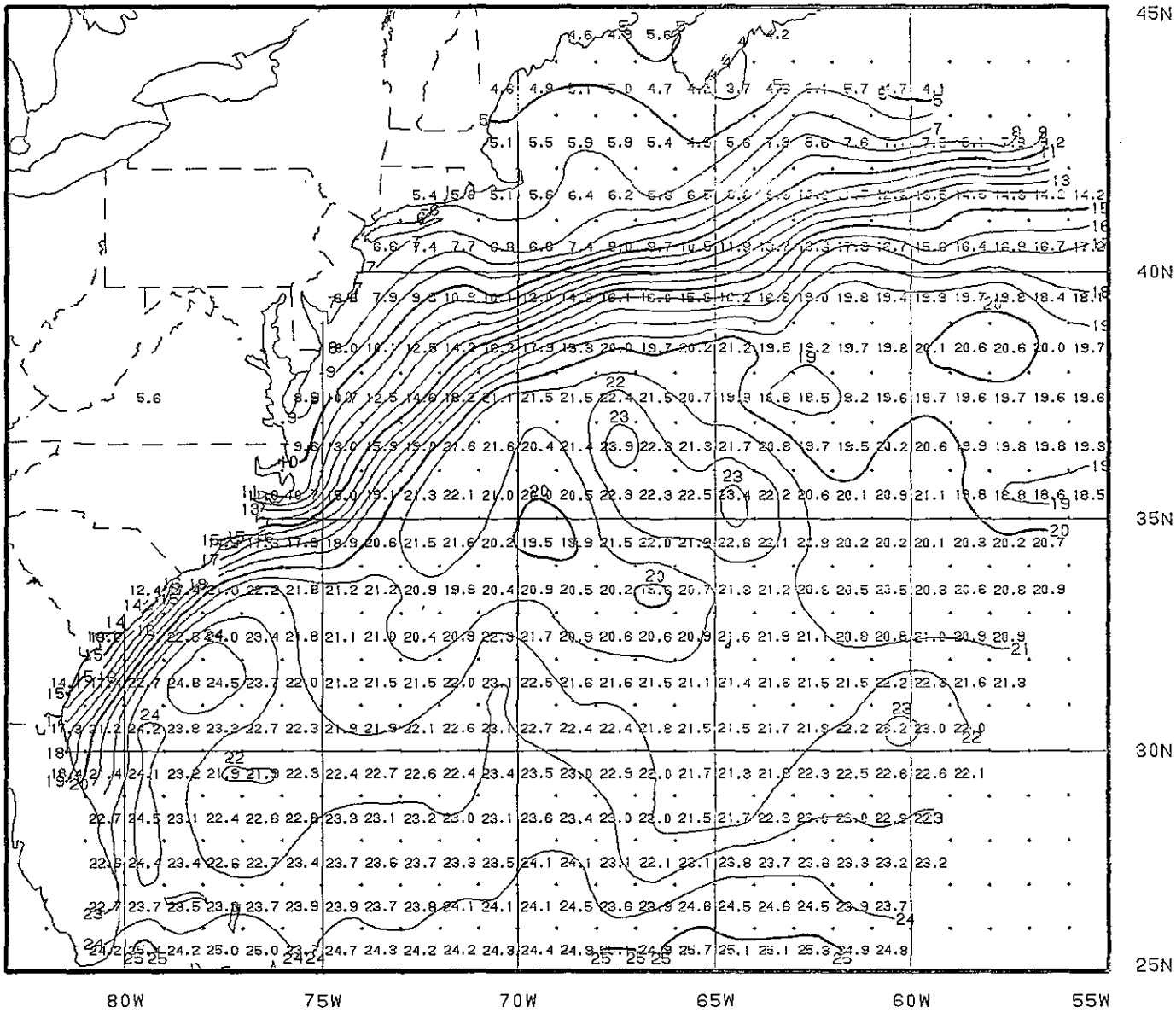
One cyclonic eddy was absorbed by a Gulf Stream meander in December. On December 9, eddy J was absorbed by a meander near 36°N 67°W. Eddy I was previously located at 38°N 58°W. Harvard/Navy XBTs could not confirm its existence on December 9, so it has been deleted from the analysis. Eddy L was not observed since November 9 so it, too, was dropped from the analysis.

Eddy F traveled 25 Km NNE when it was last observed on December 11. The status of eddy K is uncertain due to extensive cloud cover during the entire month. An eddy was partially observed through clouds near 37°N 61°W on January 4, 1988. Sea Surface temperatures substantiated the temperature gradient across the eddy. Assuming this is eddy K, it has moved 75 km SSW. However, it could be a new cold eddy formed from a Gulf Stream meander.

EAST COAST SST – MONTHLY MEAN

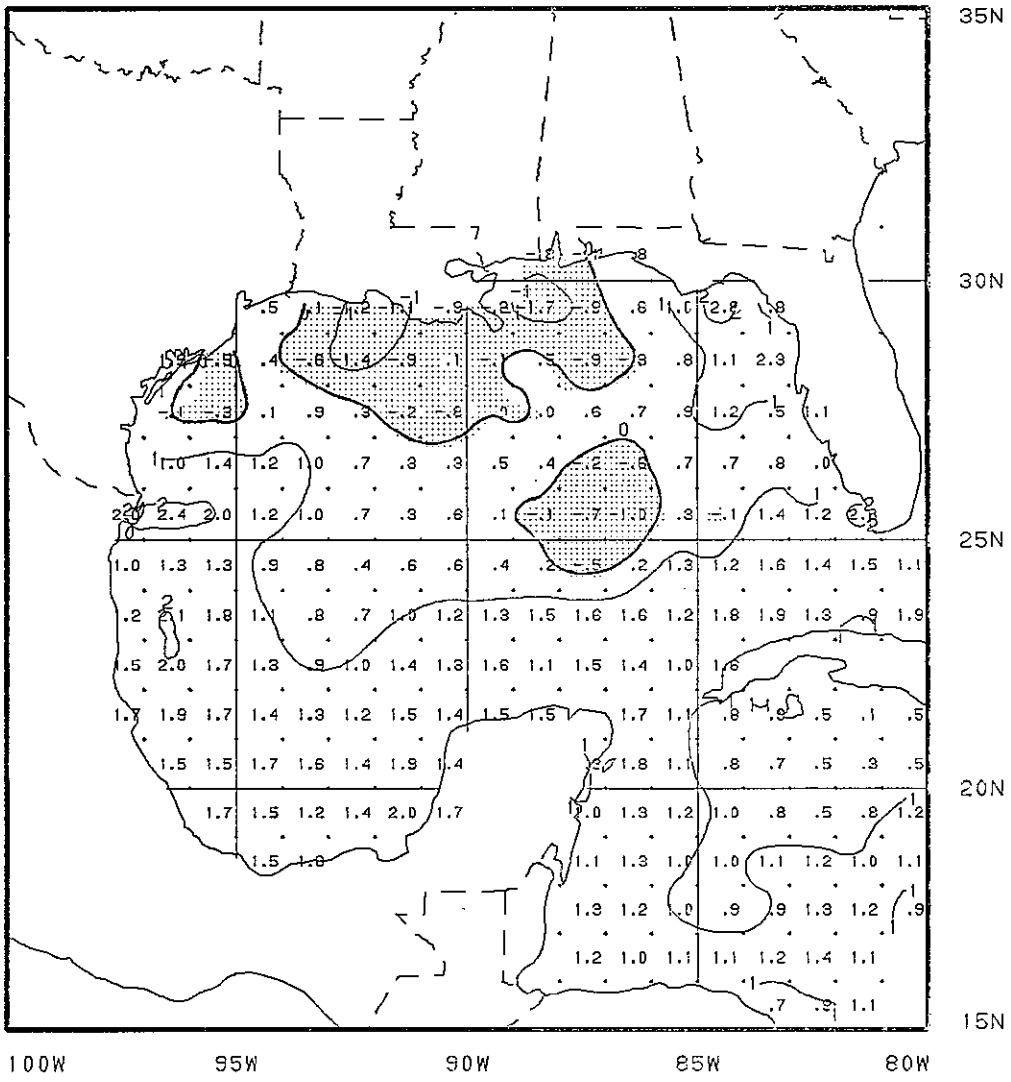


DECEMBER 1987 GULF OF MEXICO SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0C.

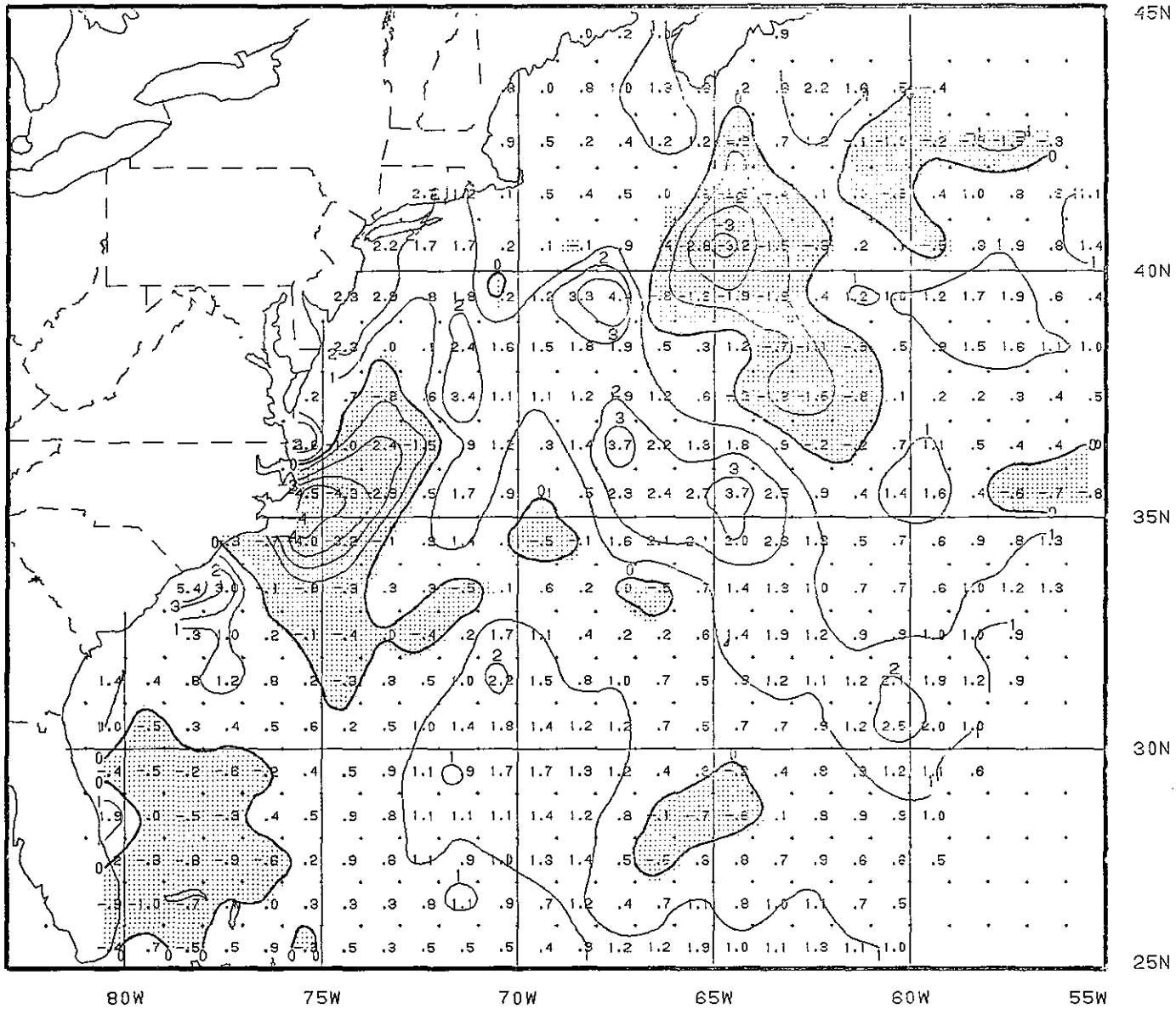


DECEMBER 1987 U.S. EAST COAST SST--MONTHLY MEAN (C)--Monthly mean SST is the mean of twice-weekly analyses using ship, buoy, and satellite observations. Contour line interval is 1.0C.

EAST COAST SST – ANOMALY



DECEMBER 1987 GULF OF MEXICO SST--MONTHLY ANOMALY (C)--Monthly anomaly is the difference between the monthly mean SST and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0C.



DECEMBER 1987 U.S. EAST COAST SST--MONTHLY ANOMALY (C)--Monthly anomaly is the difference between the monthly mean SST and the climatological monthly mean value--shading shows where the monthly mean is colder than climatology. Contour line interval is 1.0C.

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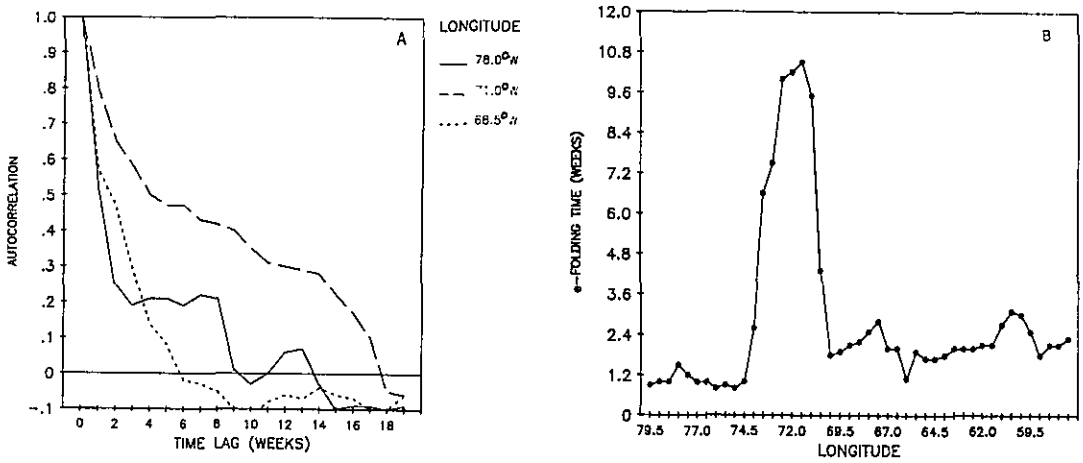

Fig. 9. Normalized Gulf Stream Landward Surface Edge autocorrelation at three selected longitudinal transects (Figure 9*a*) the estimated *e*-folding times for all longitudinal transects between 79.5° and 57.5°W (Figure 9*b*). Three *e*-folding regimes are found for the Gulf Stream along the Carolinas, just offshore of Cape Hatteras, and farther offshore of Cape Hatteras.

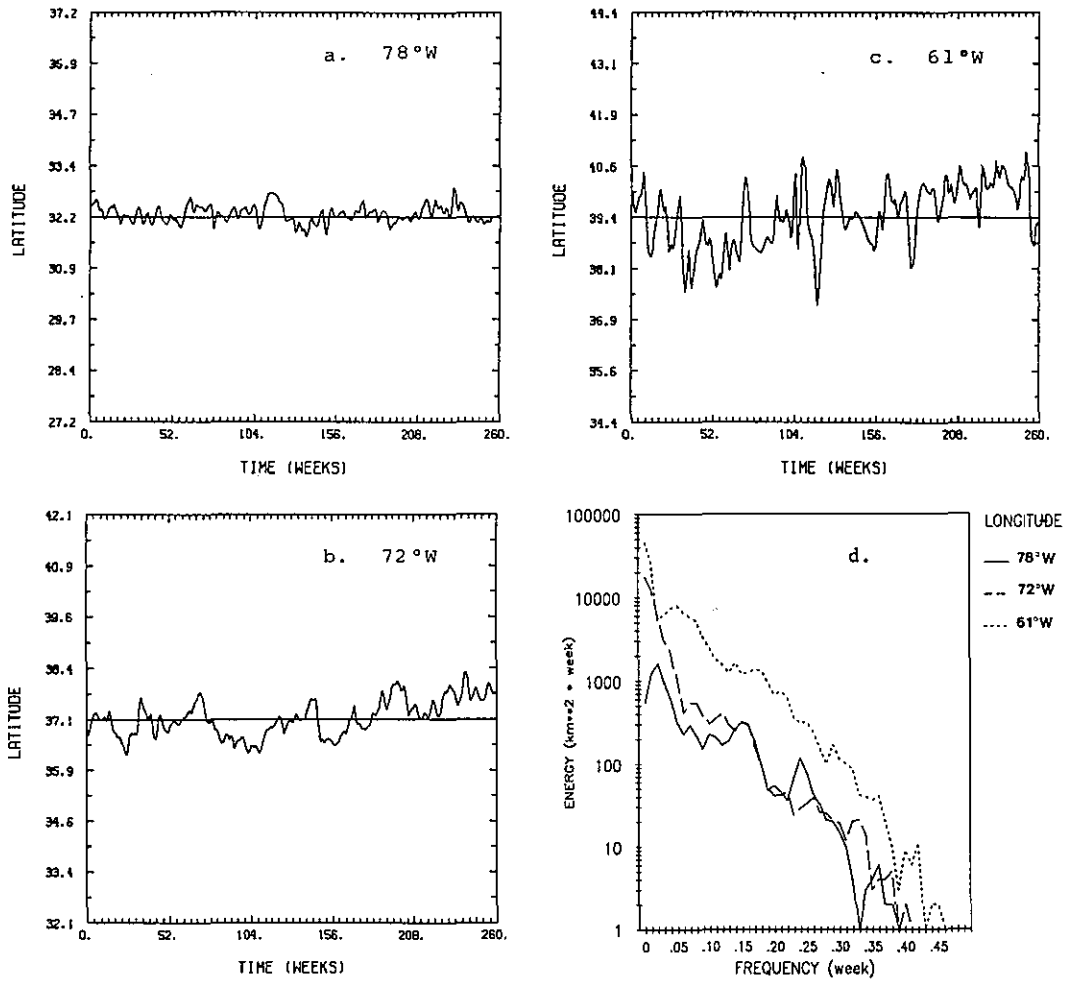

Fig. 10. Smoothed 5-year time series (Figures 10*a*, 10*b*, and 10*c*) and power spectra (Figure 10*d*) of the Gulf Stream Landward Surface Edge at three longitudinal transects. The time series at 78°W is relatively uneventful compared to the others which have large variability associated with meander growth and ring formation/absorption episodes. The power spectra are red with dominant periods of about 1 year. The total spectra energy increases downstream.

Autocorrelations from the 5-year time series of the GSLSE position for the 45 longitudinal transects between 79.5° and 57.5°W show three separate, distinct e-folding time regimes occurring downstream from 80°W. Representative autocorrelation plots from the three regimes are illustrated in Figure 9a. The e-folding times are estimated from the plotted autocorrelation curves. Figure 9b, a plot of the estimated e-folding times, manifests the three regimes which are separated by distinct boundaries near 74°W and 70°W with smooth transitions.

Smoothed time series (Figures 10a-10c) and power spectra plots (Figure 10d) are given for longitudinal transects 78°W, 72°W, and 61°W. The time series plots show the mean GSLSE latitude as the zero reference line. The time series at 78°W is relatively uneventful. The time series at 72°W and 61°W have large variability associated with meander growth and translation and ring absorption episodes. The time series at 61° W also contains sudden meander detachment (GS WCR formation) episodes. In addition, these two time series and most time series east of 74°W show a long-period trend toward a more northern position. The power spectra have good agreement with other published values.

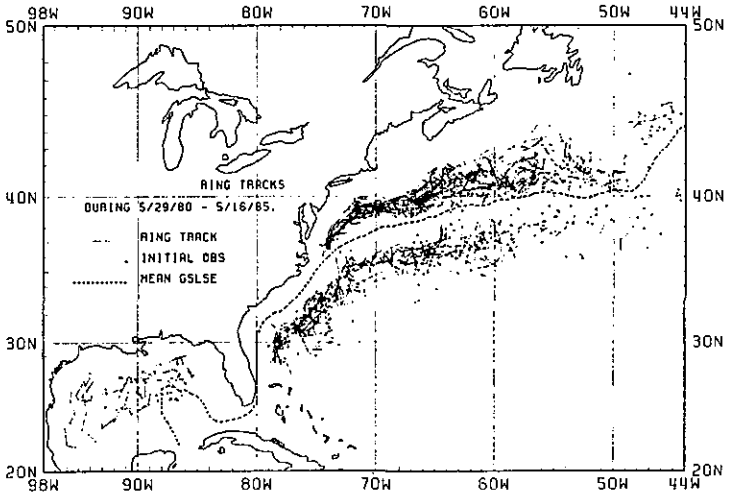

Fig. 11. Observed warm-core and cold-core ring tracks for 5 years. The dashed line is the 5-year mean Gulf Stream Landward Surface Edge.

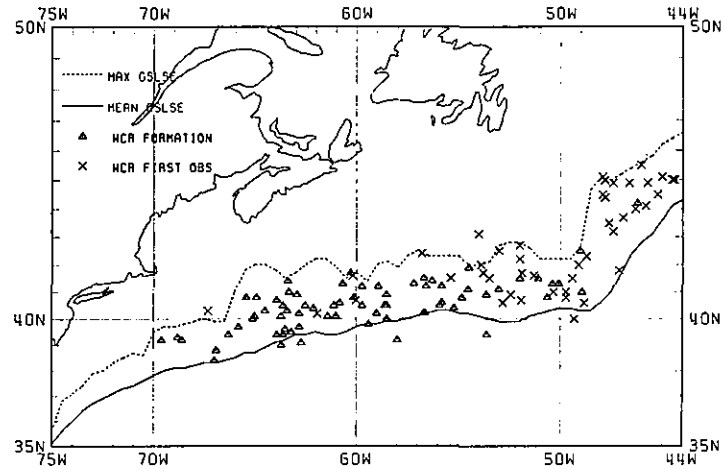

Fig. 12. Formation or first observation locations of 115 Gulf Stream warm-core rings. Triangles demark observed formations while crosses demark first sightings. The solid line is the mean, and the dashed line is the extreme Gulf Stream Landward Surface Edge. The spatial distribution appears uniform from 65° to 45 W.

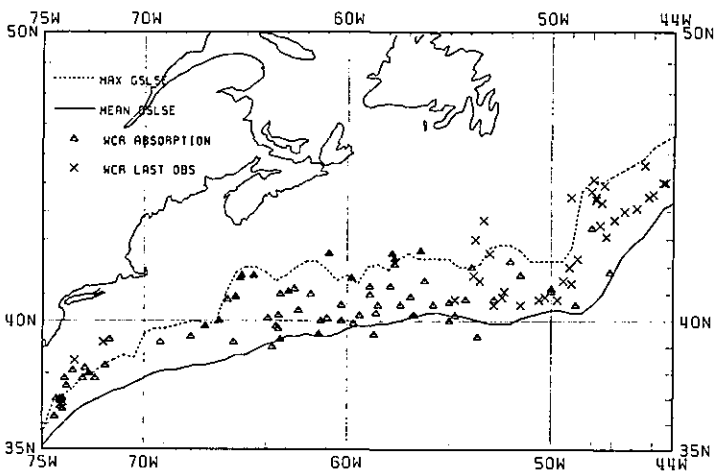

Fig. 13. Observed center positions of last observation or prior to absorption for 115 Gulf Stream warm-core rings. Open triangles demark observed absorptions and crosses demark last sightings. The solid triangles indicate a ring absorption by another warm-core ring. The solid and dashed lines are the 5-year mean and extreme Gulf Stream Landward Surface Edge positions. A warm-core ring absorption frequency minimum exists between 71° and 67°W.

TABLE 4. The 5-Year Gross Statistics for 115 Gulf Stream Warm-Core Rings (GS WCR), 13 Loop Current Warm-Core Rings (LC WCR), and 175 Cold-Core Rings (CCR)

	Number	Mean	S.D.	Minimum	Maximum
		Scalar Speed, km/d			
GS WCR	905	6.8	4.9	0	37
LC WCR	108	6.2	4.5	0	28
CCR	539	7.2	4.8	0	28
		U Velocity Component, km/d			
GS WCR	905	−2.3	6.1	−37	26
LC WCR	108	−2.3	5.7	−26	14
CCR	539	−0.6	6.3	−21	23
		V Velocity Component, km/d			
GS WCR	905	−0.5	5.2	−27	24
LC WCR	108	−0.7	4.6	−17	11
CCR	539	−0.7	5.9	−14	27
		Surface Diameter, km			
GS WCR	1015	129	42.7	46	370
LC WCR	107	222	69.1	102	389
CCR	707	105	28.0	35	230
		(Observed Initial) Surface Diameter Ratio			
GS WCR	838	0.85	0.30	0.20	1.80
		Surface Diameter Decay Rate			
GS WCR	832	−0.026 per week			
LC WCR	86	−0.024 per week			

Figure 11 is a spaghetti plot of all the WCR (warm-core ring) and CCR (cold-core ring) tracks observed during the 5-year study period. A total of 136 different WCRs and 175 CCRs are observed during the period. The WCRs can be separated into 21 LC WCRs (Loop Current WCRs) and 115 GS WCRs (Gulf Stream WCRs). The LC WCRs generally translate west-southwestward into the western basin of the Gulf of Mexico. The GS WCRs tend to translate west or southwestward between the mean GSLSE and the continental shelf. The CCRs translate west to southwest in the Sargasso Sea south of the Stream. An open swath of space separates the GS WCRs from the CCRs. The 5-year mean GSLSE position is located along the northern edge of this open swath being located closer to the GS WCR tracks. The GS WCRs translate closer to the mean GSLSE as a result of the confining effect of the continental shelf. Only four of 67 GS WCRs are observed to have formed south of the mean GSLSE, while none of the CCRs are observed to have formed north of the mean GSLSE.

Table 4 gives the gross statistics for the 115 GS WCRs observed between 75°W and 44°W over the 5-year study period. The (scalar) speed and the u and v velocity components are determined from the weekly (or longer) observed ring center position movements. The age, (observed/initial) diameter ratio (weekly observed diameter relative to the initial ring diameter at formation), and surface diameter decay rate are determined from the life histories of 71 GS WCRs whose formations were observed.

Figures 12 and 13 show the GS WCR formation or first observation and absorption or last observation locations of 115 GS WCRs (some of the events occurred outside the 5-year period). The spatial distribution of the GS WCR formation or first observation locations is fairly uniform from 65°W to 45°W with fewer between 70°W and 65°W and none west of 70°W. The spatial frequency of the GS WCR absorption or last observation locations appears uniform over the entire slope water region except for a minimum between 71°W and 67°W.

In the Gulf of Mexico, 13 warm-core features can be identified by a known or probable Loop Current shedding event during the 5-year period. The nearly complete lack of summertime satellite observations in the Gulf of Mexico hinders the tracking of LC WCRs into the western basin of the Gulf of Mexico (and ultimately to their dissipation).

Cold-core rings (CCRs) are more difficult to delineate in satellite imagery by surface thermal signal than the warm-core rings since the CCR surface gradient boundary tends to be weaker and the denser cold water core tends to sink with time, wiping out the SST anomaly. CCRs are best discerned during springtime when the SST gradients are greater (345 of 707 CCR observations detected in spring) and when interacting with the Gulf Stream which produces a hooklike entrainment pattern of warmer water around the CCR. The CCR identification problems prevent the making of good estimates of both the number of CCRs and the average CCR life span from the satellite-derived data samples. Cold-core ring life histories are tentative, and therefore only general statistics are determined which give a mean cool-core surface diameter of 105 km and a mean velocity of 1 km/d southwestward.

This report is rigorous in seeking to define a climatology which encompasses the Loop Current, the Gulf Stream, and their associated ring events and movements over a relatively long, continuous 5-year period using the same data base.