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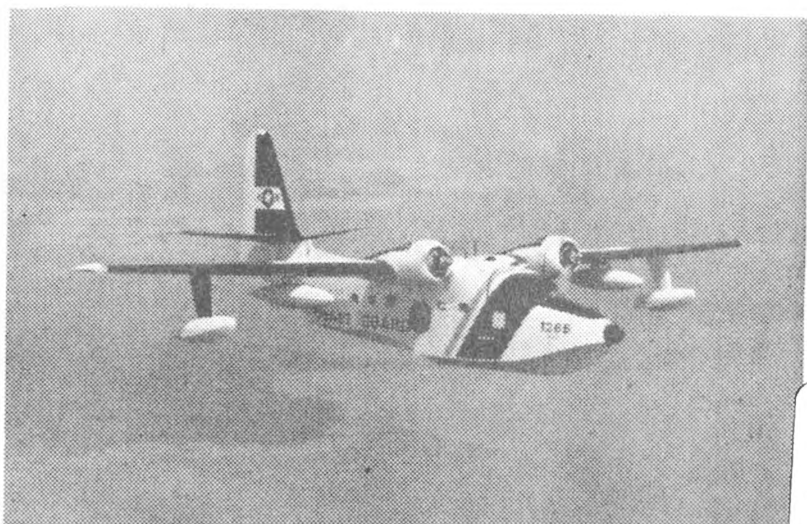
AERIAL OCEANOGRAPHIC OBSERVATIONS CAPE COD, MASSACHUSETTS TO MIAMI, FLORIDA

July 1969 - June 1970



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AERIAL OCEANOGRAPHIC OBSERVATIONS CAPE COD, MASSACHUSETTS TO MIAMI, FLORIDA

July 1969 - June 1970

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J. W. Deaver

United States Coast Guard
Oceanographic Unit
Washington, D.C.

June 1975

Table of Contents

List of Illustrations

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Aerial Oceanographic Observations, Cape Cod, Massachusetts to Miami, Florida

By

JOESPH W. DEAVER[1]

INTRODUCTION

Airborne radiation thermometer surveys of the United States Atlantic coastal waters are conducted monthly by personnel from the Coast Guard Oceanographic Unit. Coast Guard Air Stations located at Otis AFB, Cape Cod, Massachusetts, and Elizabeth City, North Carolina, furnish aircraft and flight crews to conduct these surveys. Two ART surveys, one north and one south of Cape Fear, North Carolina, are done within the same four day interval during the middle of each month (weather permitting).

The Grumman "Albatross" (HU-16E), a fixed wing search and rescue aircraft, is the primary platform for these monthly ART surveys. The same flight tracks are flown each month although sometimes the flight tracks are temporarily altered to avoid bad weather or active operational areas (air space in use by other agencies).

The product of these ART surveys is a "special" surface isotherm chart which is produced following the completion of each team's survey area. These special charts are mailed to selected users who have an immediate need for the data. "Regular" surface isotherm charts are refined composites of the "specials." These regular charts are mailed to users approximately three weeks following the completion of the monthly survey.

Coast Guard monthly ART surveys locate oceanographic features such as the Gulf Stream's western boundary, define the SST in 1°C isotherm contours, and report marine animal sightings from Cape Cod, Massachusetts to Miami, Florida.

Originally, systematic monthly surveys began in the fall of 1962 as a small feasibility study on the application of ART in support of a study to determine the effects of temperature and currents on the distribution of fishes over the Atlantic continental shelf of the United States. The study was a joint effort by the Bureau of Sport Fisheries (BSF), now a component of the National Marine Fisheries Services (NMFS), located at Sandy Hook Marine Laboratory, Highlands, New Jersey, and the U.S. Coast Guard which provided aircraft and flight crews. Initially monthly ART flights surveyed continental shelf waters between Montauk Point, Long Island and Cape May, New Jersey. A surface isotherm chart was prepared after each monthly survey and was distributed to interested parties. In July 1965, ART survey coverage was extended north to Cape Cod, Massachusetts and south to Cape Fear, North Carolina; and in July, 1966, south to Miami, Florida. By 1968, the ART survey had become a

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well established program. Sea surface temperature data were obtained monthly along more than 6,800 kilometers (3,670 nmi) of transects covering approximately 130,000 square kilometers (37,700 nmi^2) of Atlantic shelf and Slope Waters (fig. 1). The mailing list for the monthly surface isotherm charts had grown to 750, including government agencies, universities, private marine institutions, newspapers, journals, and commercial and sport fishermen.

Approximately 2,400 drift bottles and sea bed drifters were released each month for the Woods Hole Oceanographic Institution as part of their drifter program to study the circulation of the Atlantic shelf region.

Because of limited funds in FY69, the BSF felt that the ART survey could no longer operate within its research budget. The BSF and the Committee for the Scientific Exploration of the Atlantic Shelf (SEAS) considered the east coast ART survey too valuable to the oceanographic community to be discontinued. In July of 1969, the Coast Guard was asked to assume full responsibility for all aspects of the program. This report presents the scientific results of the ART program in its first year of operation by the Coast Guard Oceanographic Unit (CG OCEANOU).

INFRARED RADIOMETRY

Much work has been done in the field of airborne infrared radiometry. A good description of the past and present background in infrared radiometry is summarized in a report by J. L. Squire, Jr. (1971). Briefly, an infrared thermometer detects and measures the infrared radiation naturally emitted by objects. The intensity and spectral distribution of the energy emitted are functions of the radiometric temperature of the object and the nature of its surface (emissivity). Infrared energy (heat) emitted from the sea surface is transmitted through the atmosphere in the form of electromagnetic waves within the wavelength region between visible red light and microwaves (.7 to $10^3 \mu m$). The infrared energy emitted by distant objects can be reflected by conventional optical systems and directed toward an infrared detector which senses and measures the energy. Infrared radiation from the sea must pass through the atmosphere which contains gases and particulate matter that absorb and scatter the emitted radiation. To reduce these attenuating effects of the atmosphere, the detected radiation is usually limited by filters to the region between 8 to 14 μm. It is in this region or "window" that the atmospheric attenuation is at a minimum.

METHODS AND EQUIPMENT

Portable ART instrument packages were designed to cope with the logistic problems encountered by CG OCEANOU survey teams. Aluminum was used to construct the instrument package. The packages are extremely rugged, yet light in weight. A package includes four principal components: • Infrared thermometer with sensor head • Strip chart recorder • Regulated power inverter • Control panel (fig. 2).

The Barnes Engineering Company, Precision Radiation Thermometer (PRT-5) used to measure the sea surface temperature data presented in this report (A Barnes Engineering Company IT-3 was used on a few early surveys.) consists of a radiation sensing unit and an electronic processing unit. Naturally emitted radiation from the sea surface passes through an objective lens (10 mm, IRTRAN-2, F/2.8, [2° field of view] manufactured by Eastman Kodak Company) and a spectral filter which limits the radiation to the 9.5 to 11.5 μm atmospheric window, all located in a temperature controlled reference cavity. Through optical chopping the detector (a hyperimmersed thermistor bolometer) continuously compares emitted radiation levels from the sea surface with that emitted by the internal, controlled, reference environment. The detector now produces an electrical output signal proportional to their difference.

This output signal is preamplified in the optical unit and is transmitted via cable to the electronic processing unit where it is further amplified and then read by a panel meter or a recorder. Sensitivity of the PRT-5 is advertised by the manufacturer to be better than 0.1°C when sampling in the 500 millisecond mode at 25°C ambient temperature, and its accuracy is advertised to be ±.5°C. The sensing unit is mounted inside the aircraft, pointing through an open hatch at an angle near normal to the sea surface.

The infrared temperature is monitored on a dial meter calibrated in degrees Celsius. For permanent record, a solid-state Varian G1000 strip chart recorder manufactured by Varian Aerograph is used. The infrared (IR) signal is displayed at variable linear settings, e.g., the range is adjusted to match the expected SST range being surveyed. Standard strip chart paper having 100 equal divisions of 1.3 mm across its width is used. A range of 20°C full scale means that each division is 0.2°C (fig. 3).

The aircraft electrical output systems supply 28 Vdc. A Transpac Model IT2106RS transistorized d.c. to a.c. inverter manufactured by Electronic Research Associates is connected to the aircraft's 28 Vdc system to deliver 115 Vac, 60 Hz for the ART package operation. This inverter contains a unique magnetic regulator-filter assembly made of the ferroresonant type which suppresses aircraft electrical power fluctuations. This regulator prevents the 115 Vac output voltage frequency (60 Hz) from drifting. Such a drift can speed up or slow down the recorder's paper drive motor distorting its fixed inch/minute rate.

The ART package contains a control panel module from which the technician can remotely operate and monitor all of the electronic systems. An elapsed time clock is included on the control panel. This clock is manually synchronized with the aircraft's instrument clocks at the start of each survey to allow synchronization of the navigational notations between the navigator and the ART operator.

OPERATIONAL PROCEDURES

In-flight ART Calibration

The PRT-5 internal reference cavity temperature is remotely monitored by a dial meter on the PRT-5 console. Further quality control of ART data is accomplished through frequent in-flight calibration checks. The calibration procedure consists of aiming the sensor head alternately into a vacuum bottle filled with warm water and a second bottle filled with cold water and comparing the recorder readout with that of a calibrated mercury thermometer immersed in the bottle. If necessary, the recorder is adjusted to agree with the mercury thermometer.

Since the greatest percentage of infrared radiation energy detected by the IR thermometer is emitted only from the top 20 μm of the sea surface, ART measurements may not be directly comparable to "ground truth" surface temperatures obtained by mercurial bucket thermometer readings of water taken from the upper one to two feet, (Saunders, 1967). To minimize atmospheric attenuation, surveys are flown at altitudes of 150 meters or less.

Simultaneous measurements of SST by vessels and fixed offshore stations using a bucket thermometer and aircraft using a PRT-5 at an altitude of 150 meters, typically show a difference of ±0.5°C or less.

Navigation

Long Range Aid to Navigation (LORAN-A), on board radar, and dead reckoning are used for navigation on the HU16-E "Albatross" during ART surveys. Of these three methods, LORAN-A is the most accurate, allowing a position determination of ±1 nautical mile (±1.8 km) to be made. Standard survey tracks allow "landfall navigation" and "back course corrections" to be applied at approximately 1 hour intervals or less. Thus, navigation by LORAN-A, corrected by "post navigation," is the most reliable method.

Temperature Sampling

ART surveys are flown on transects normal to the coastline and expected thermal fronts. The north to south transect separations are approximately 55 km. After each monthly survey, the inflight calibration corrections are applied to the ART strip chart data at the CG OCEANOU. The data from the strip chart are plotted and contoured in whole degrees Celsius. Whole degree contours are drawn through the whole degree crossings on each transect. Contour philosophy allows subjective interpertation and is influenced by additional data from satellite and shipboard observations.

Marine Animal Observations

Although the principal objective of ART surveys is to gather monthly SST, surface marine animal sightings were observed and recorded. To do this, Coast Guard observers were trained by the National Marine Fisheries Service (NMFS) personnel from Sandy Hook Marine Laboratory, New Jersey. During the course of the survey, observations of marine life are noted on the strip chart. Each observation is carefully annotated at the appropriate points along the IR trace for later tabulation at CG OCEANOU. When practicable, photographs are taken of marine animals.

The most common marine animal observations are: flying fish, Ocean Sunfish, shark (other than Hammerhead sharks), Hammerhead shark, porpoise, whale, Manta ray, ray (other than Manta ray), and turtle.

Marine animal observations are limited by weather, sea state, and an organism's size and swimming characteristics.

RESULTS

Monthly Isotherm Charts

Sea surface temperature contoured charts for the Atlantic coastal waters from Cape Cod to Miami are presented in twelve monthly charts (figs. 4-15).

Sometimes a survey team had to return to an area missed earlier that month and in the interim the SST structure may have changed significantly preventing a logical contour plot. Dashed contours or blank (no data) areas on surface isotherm charts reflect these occasions.

A statistical approach was used to describe the seasonal SST variation over the continental shelf waters. A distance weighted mean temperature was obtained for each transect by the following formula:

$$\bar{T} = \frac{\sum_{i=1,n} \ell_i T_i}{\sum_{i\ 1,n} \ell_i}$$

Where: T = Distance weighted mean temperature

T_i = Value of an isotherm crossing transect

ℓ_i = Distance weighting factor equal to the distances between the isotherm crossing and the midpoints between it and adjacent isotherms or it and the end point of the transect as shown in figure 16.

n = Number of isotherms crossing the transects.

The statistical approach led to a time-series temperature profile on a time-space grid (fig. 17). Distance weighted averages taken from 20 monthly equally spaced transects normal to the coastline were point values of temperature used in constructing the profile. The profile is presented as a visual aid in examing the one year SST cycle between Cape Cod, Massachusetts and Miami, Florida. Fishery investigators may find this profile of interest in explaining possible variations of migratory commercial and sport fishes due to seasonal temperature changes.

Several thermal transistional zones are apparent (fig. 17). The first zone was between Cape Cod and Cape Hatteras. A second zone was between Cape Hatteras and Jacksonville. A third zone, not as well defined, was between Jacksonille and Miami, Florida.

A graph, (fig. 18), was constructed by plotting the positive and negative monthly temperature change at four selected sampling sections (20, 13, 9, 1) from figure 17. This figure shows the seasonal temperature rate of change trends for areas north and south of Cape Hatteras. The trends are predicatable, since these areas have separate water masses. An area which contained two or more water mass boundaries (Cape Cod, Cape Hatteras) has the greatest rate of temperature change (fig. 18).

This condition would indicate that marine animals in coastal regions bound by two or more water mass systems and of large ΔT's migrate farther than those in coastal regions bound by only one or two water mass systems but of a small ΔT. Hence, this would impact more on the fishing industry in the coastal areas north of Cape Hatteras than areas south of Cape Hatteras during July 1969 through June 1970, i.e., fish should migrate farther and the climate should be more variable.

Thermal Front (Cape Hatteras to Miami)

Aerial temperture observations have been used to track the Gulf Stream's thermal front since 1953 (von Arx et al., 1955). The Gulf Stream's thermal front when tracked by ART, can be masked by the overlapping or "shingling" of warm Gulf Stream water over the cooler Slope Water (Bratnick, 1970). Bratnick's study was conducted north of the area covered in this report; however, evidence of some surface shingling did occur on ART surveys east and north of Charleston, South Carolina but became less noticeable as the Gulf Stream approached Cape Hatteras. Other areas affected by "shingling" were the latitudes south of Palm Beach to Miami, Florida during summer months when solar radiation heated the surface film and masked the already small thermal gradient separating the Gulf Stream and warm coastal waters to the west. Wind mixing of the two water masses sometimes better defines the existing surface gradient; however, wind in excess of 25 knots generates sea spray, which becomes aerated, thus attenuating the ART measurements and masking the thermal front.

Without the aid of bathythermographs we can only assume that the strong thermal gradient indicated by the ART trace was the actual location of the Gulf Stream's thermal front. The actual point on the ART signature chosen as the thermal front crossing is defined as the first temperature value on the warm side of the signature slope and is indicated by the point [A], (fig. 19). Sometimes a visual indication accompanied the temperature change. These visual indications included lines of sargassum sea weed, water color changes, increased sea state on the warm side of a thermal front, and occasionally the formation of cumulus clouds on the warm side of the thermal crossing. The variations of the thermal front associated with the Gulf Stream divided into 3 month intervals from July 1969 to June 1970 between Miami, Florida and Cape Hatteras, North Carolina, (fig. 20), led to these conclusions.

- No apparent seasonal pattern existed between the thermal front positions and distance offshore.
- Yearly lateral (east to west) oscillations along the thermal front were limited in magnitude between Miami and Cape Canaveral, Florida (8 to 18 nmi.); increased from Cape Canaveral, Florida to a maximum variation off Cape Lookout, North Carolina (18 to 40 nmi.); decreased between Cape Lookout and Cape Hatteras (40 to 12 nmi.); and increased again north of Cape Hatteras.
- In general, the thermal front paralleled the 183 meter isobath.

- The thermal front was detectable in all seasons.

Marine Animal Observations

Yearly sightings of nine types of marine animals were chosen to be of most probable use to the oceanographic community. A graph was constructed which shows the annual temperature and latitude range of the nine animals as well as their weighted mean (fig. 21). The weighted mean temperature was computed using the following formula:

$$\overline{T} = \frac{\sum_{i=1}^{n} W_i T_i}{\sum_{i=1}^{n} w_i}$$

Where: T = SST of the sighting

W = Number of sightings at that SST

Likewise, the same formula was used for the weighted mean latitude:

Where: ℓ = Substituted for (T)

w = Number of sightings at that latitude

No attempt was made, nor should be, to attach any significance to the presence or absence of any marine animals. Although no observation of a specific animal was made during a particular flight, that does not necessarily indicate that the organism was absent from the sruvey area.

Marine animal observations are presented in this report as a by-product of ART surveys. This author feels that these sightings, limited as they are, will benefit those in the oceanographic community, both government and private, dedicated to the marine biological sciences.

ACKNOWLEDGEMENT

The author is indebted to the pilots and crews of the Coast Guard aircraft involved in the monthly ART surveys and especially to the Coast Guard Oceanographic Unit technicians who obtained these data.

REFERENCES

Bratnick M. (1970) Convolutions of the surface outcrop of the Northern Edge of the Gulf Stream. *U.S. Naval Oceanographic Office IR No. 70–11.*

Sauders, P. M. (1967) Aerial Measurement of Sea Surface Temperature in the Infrared, Journal of Geophsical Res., Vol. 72, No. 16: 4109–4117.

Squire, J. L., Jr. (1971) Measurement of Sea Surface Temperature on the Eastern Pacific Continental Shelf Using Airborne Infrared Radiometry, U.S. Coast Guard Oceanographic Report No. CG 373-47, 1–3.

von Arx, W. S., D. F. Bumpus, and W. S. Richardson (1955) On the Fine-Structure of the Gulf Stream Front, Deep-Sea Res., 3, 46–65.

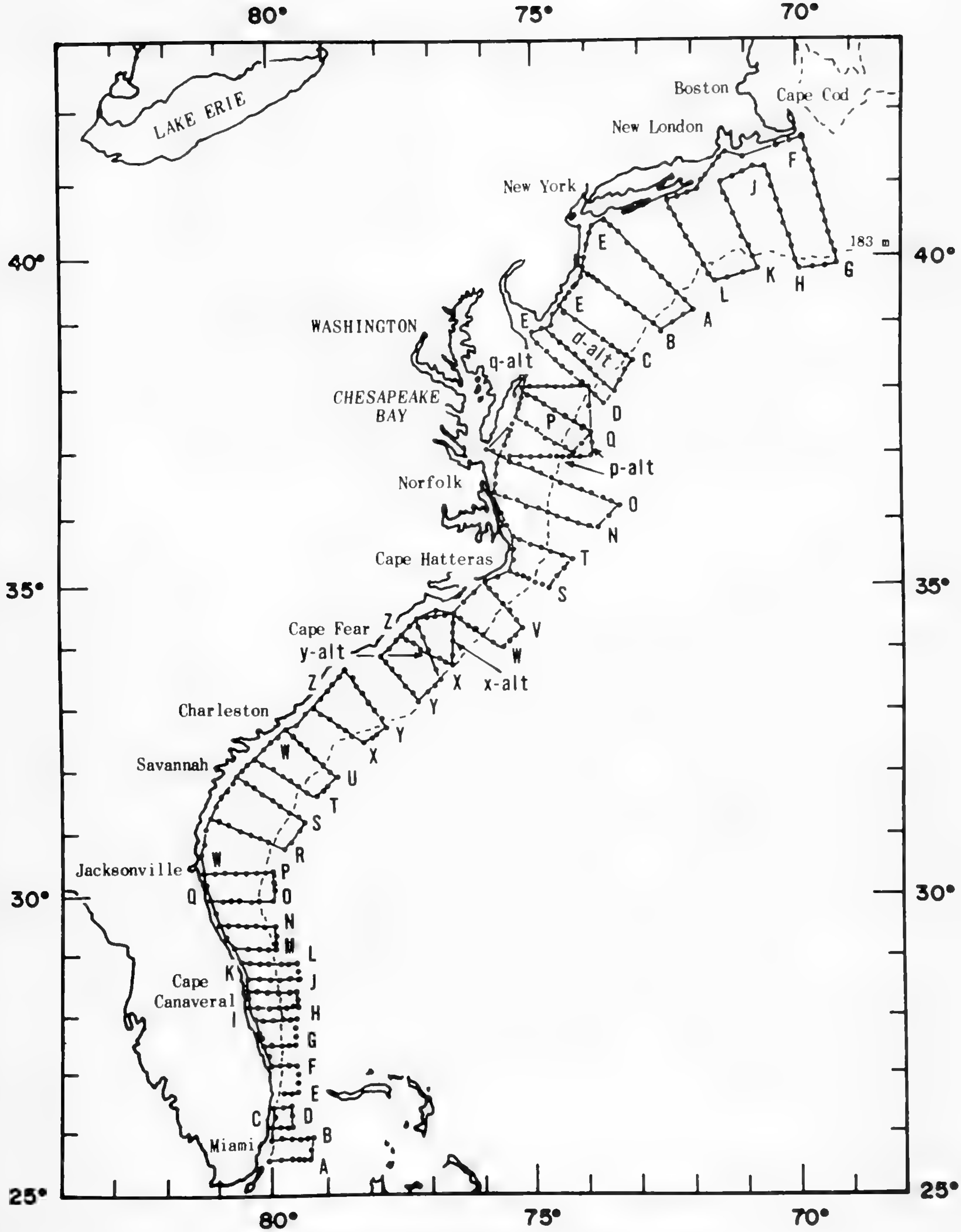
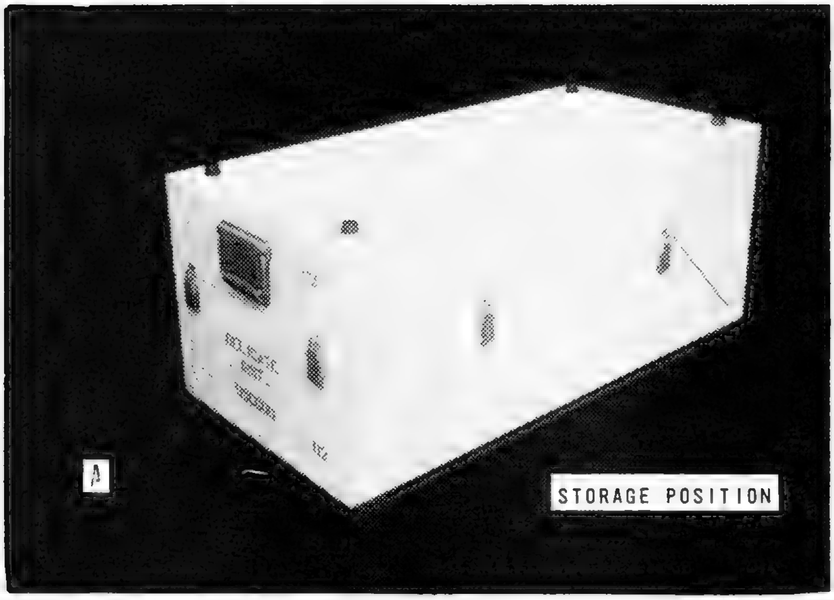


Figure 1.—Standard ART flight tracklines, July 1969 — June 1970.



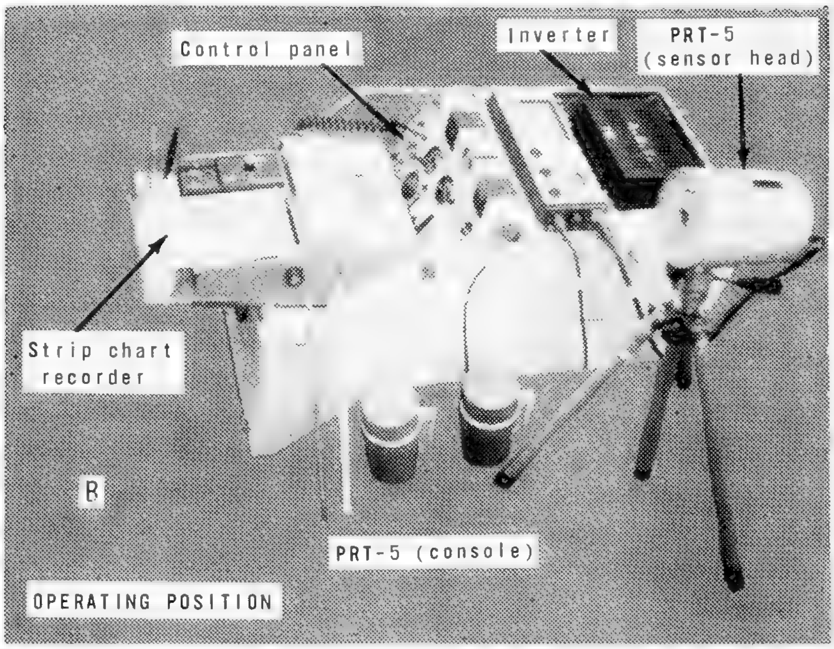


Figure 2.—Airborne radiation thermometer package viewed; (a) in storage position, (b) in operating position.

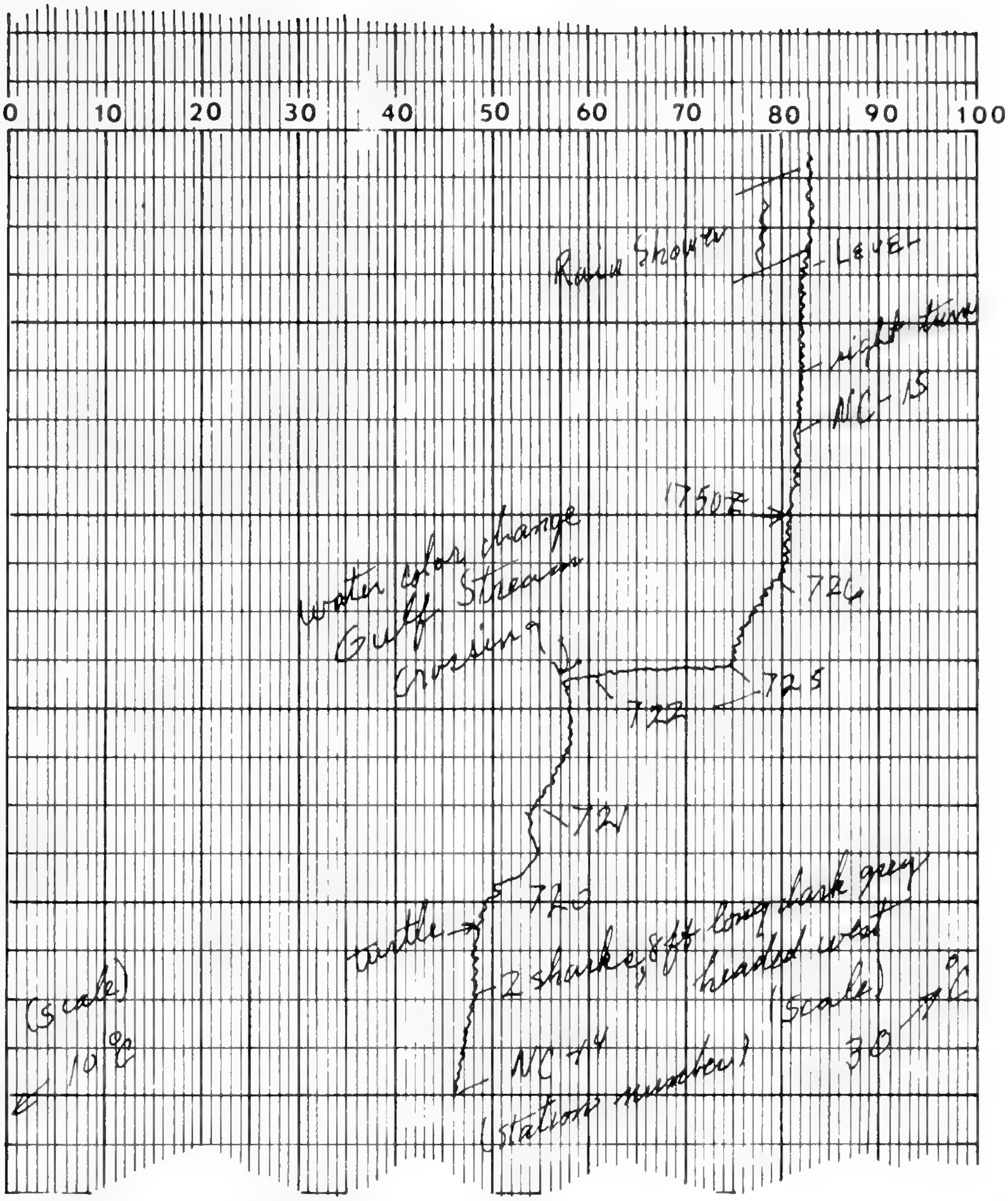


Figure 3.—Example of a typical ART strip chart trace. All events are noted on the trace as they occur.

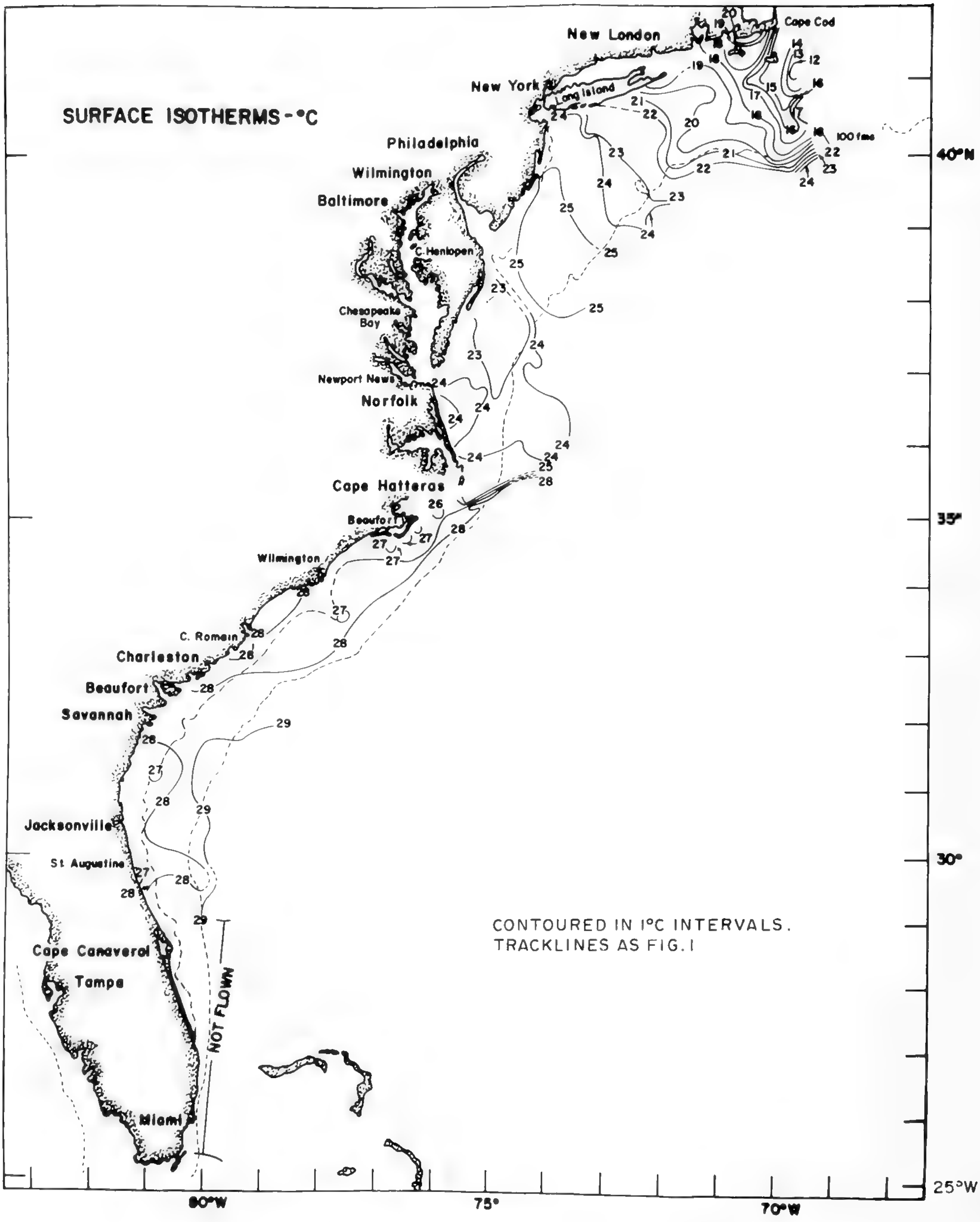


Figure 4.—**Monthly surface isotherm chart, July 14–18, 1969.**

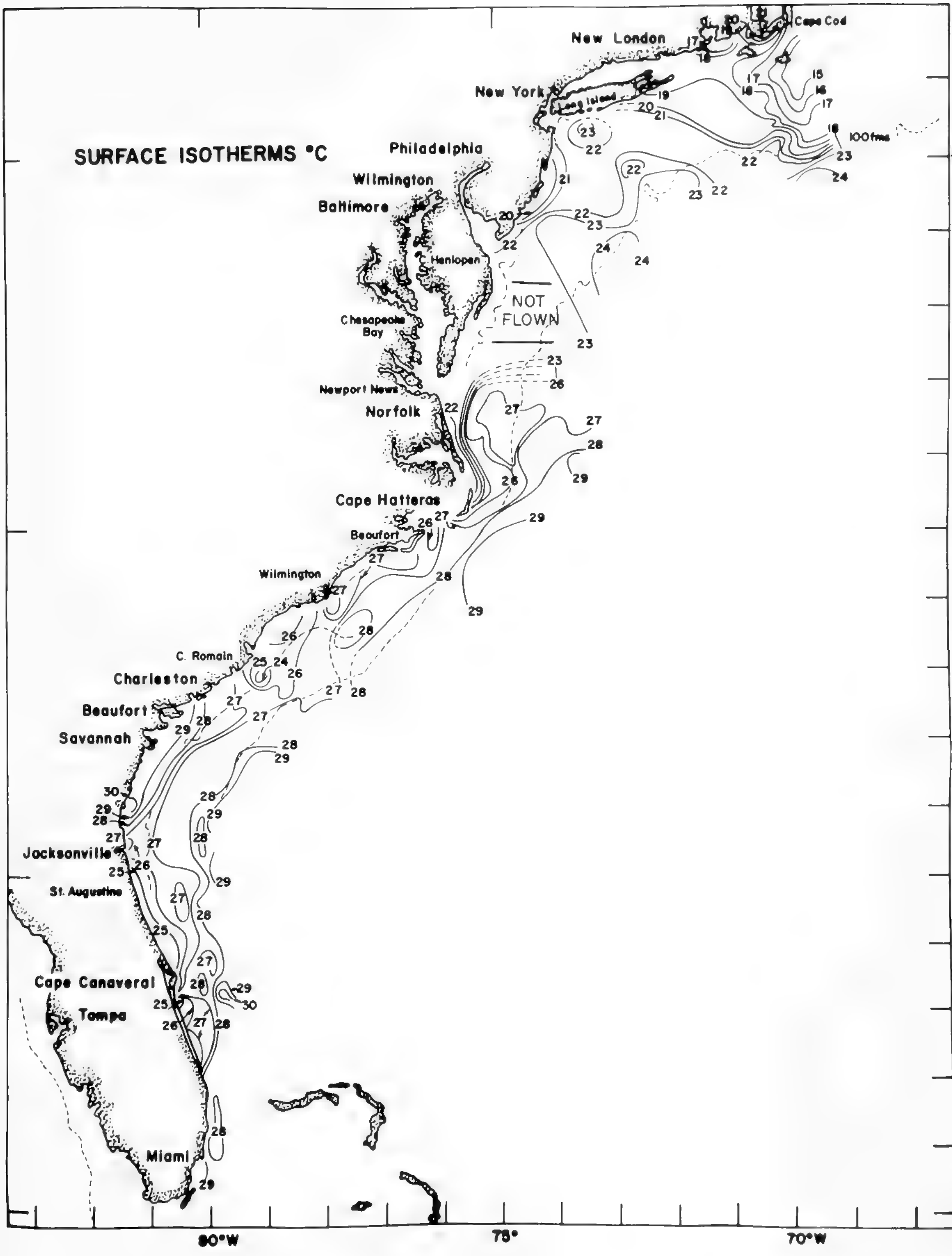


Figure 5.—Monthly surface isotherm chart, August 18–22, 1969.

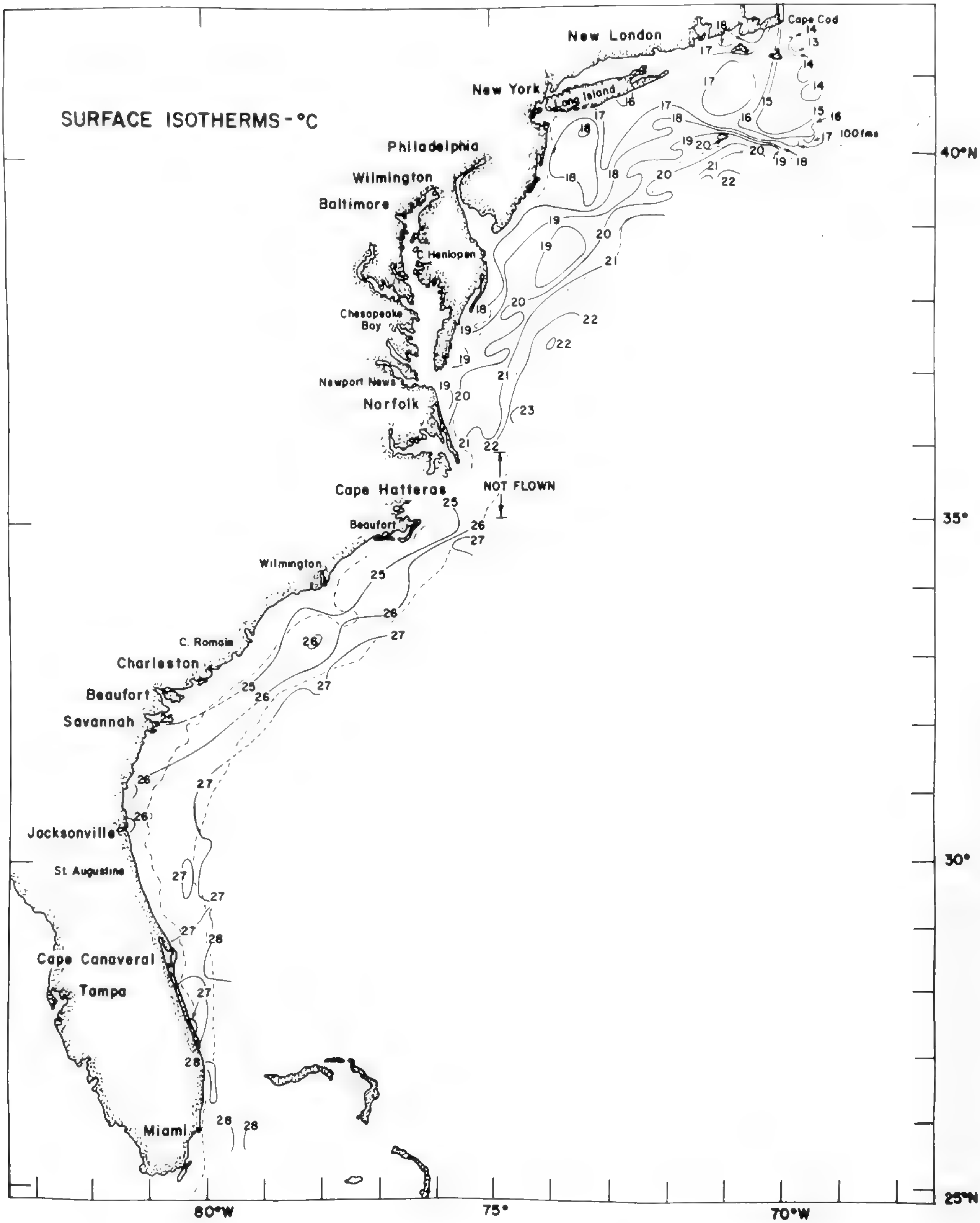


Figure 6.—Monthly surface isotherm chart, September 16, 19, 22, 23, 1969.

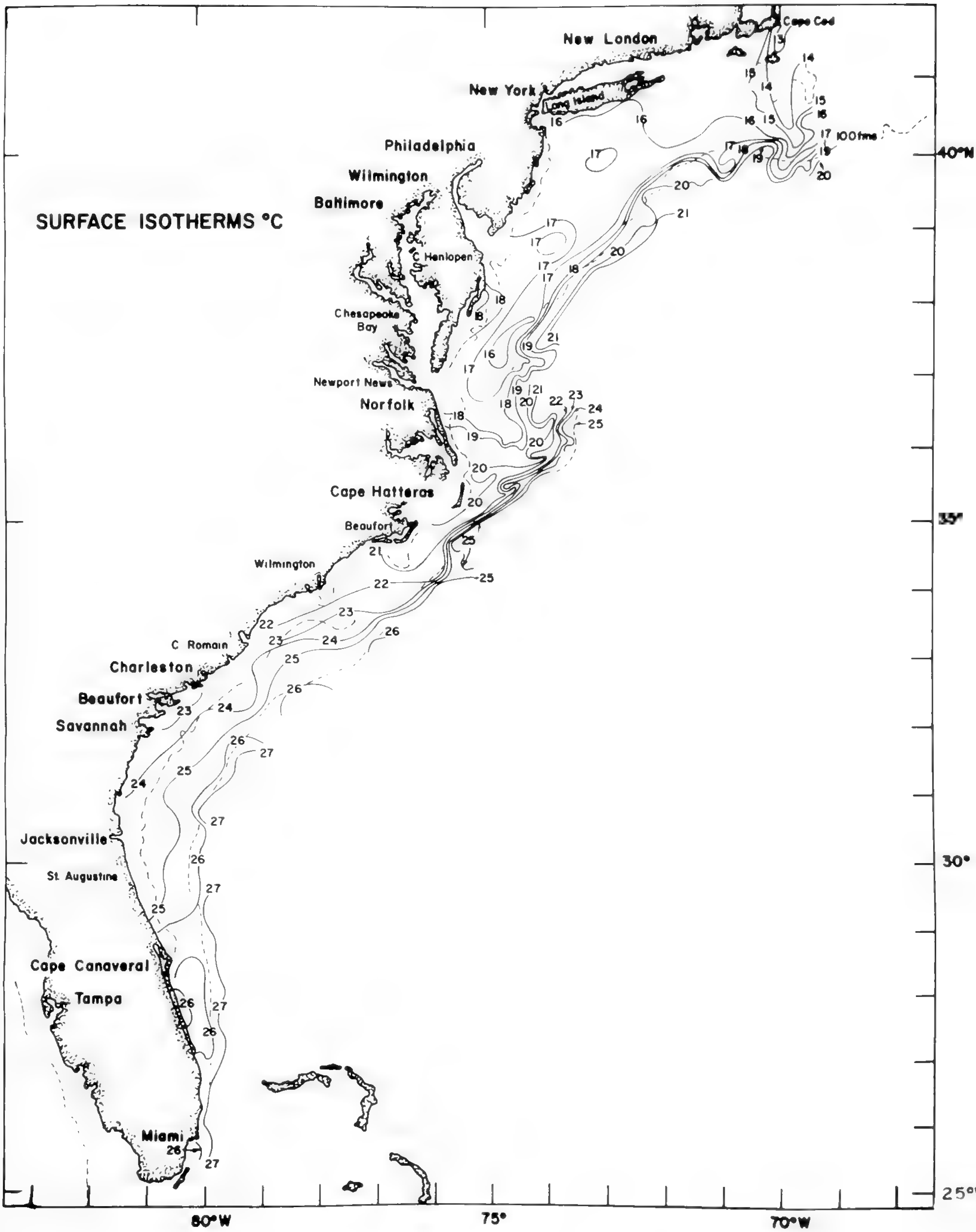


Figure 7.—Monthly surface isotherm chart, October 14–17, 20, 1969.

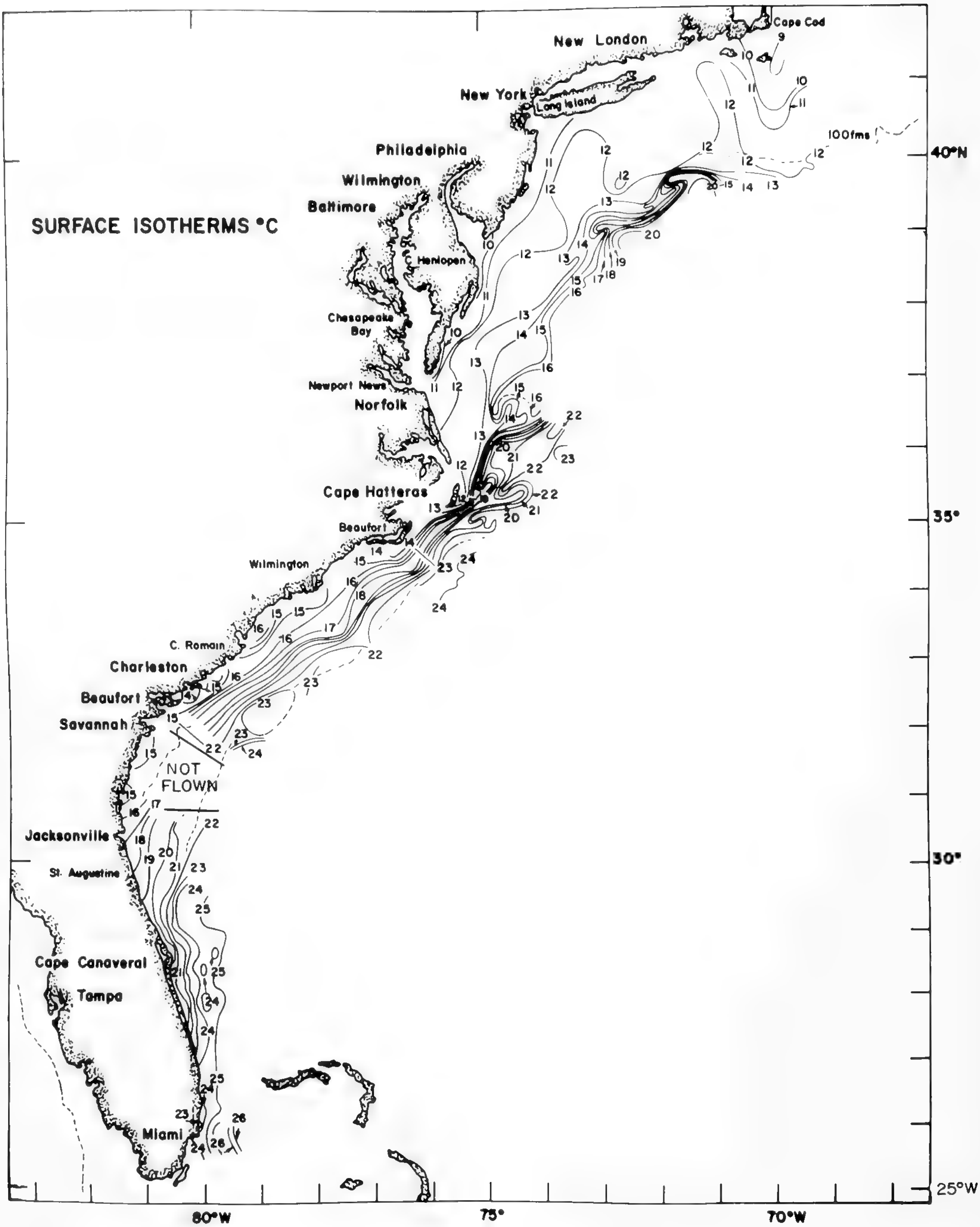


Figure 8.—Monthly surface isotherm chart, November 18, 19, 22, 24, 25, 1969.

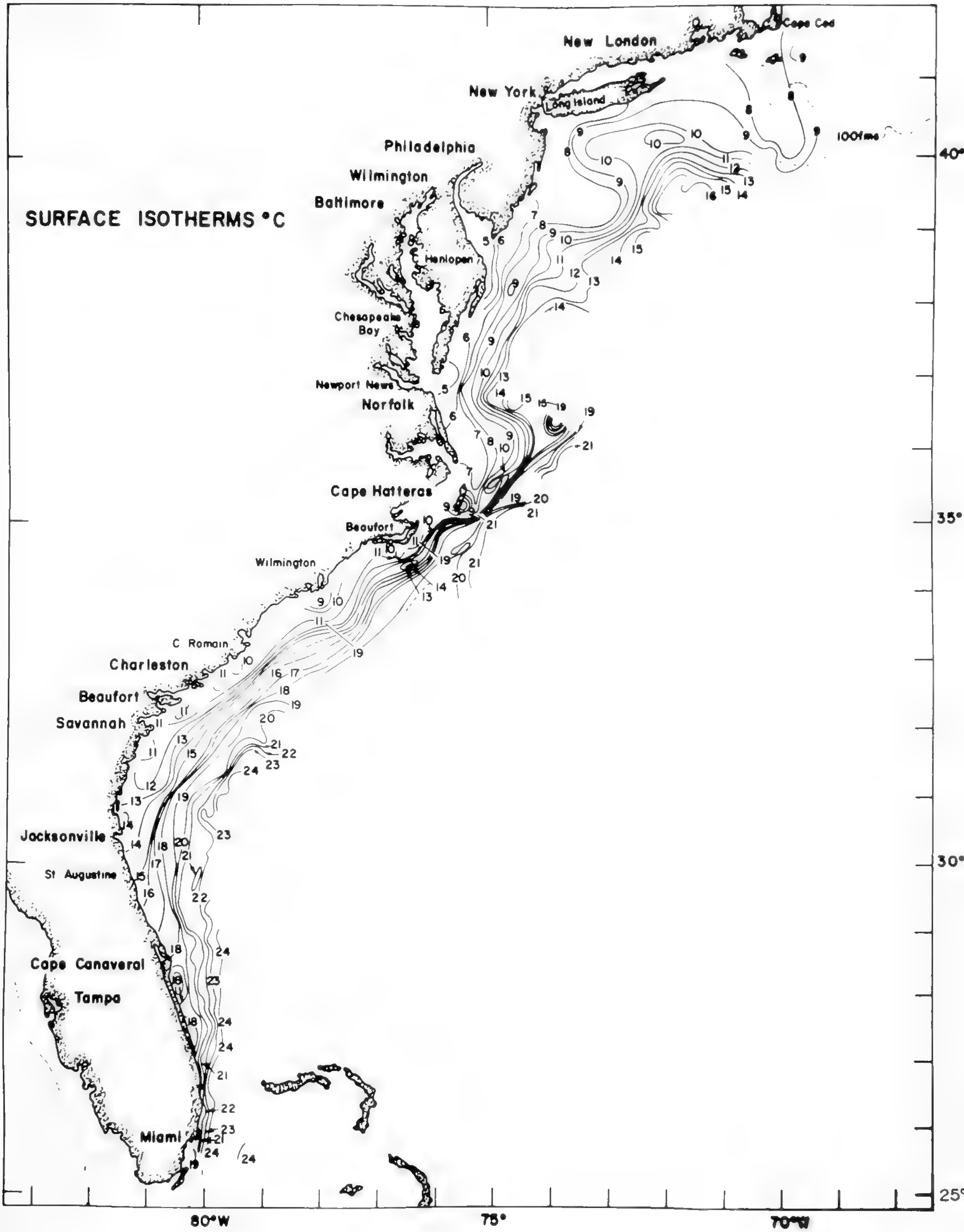


Figure 9.—Monthly surface isotherm chart, December 16–18, 29–31, 1969.

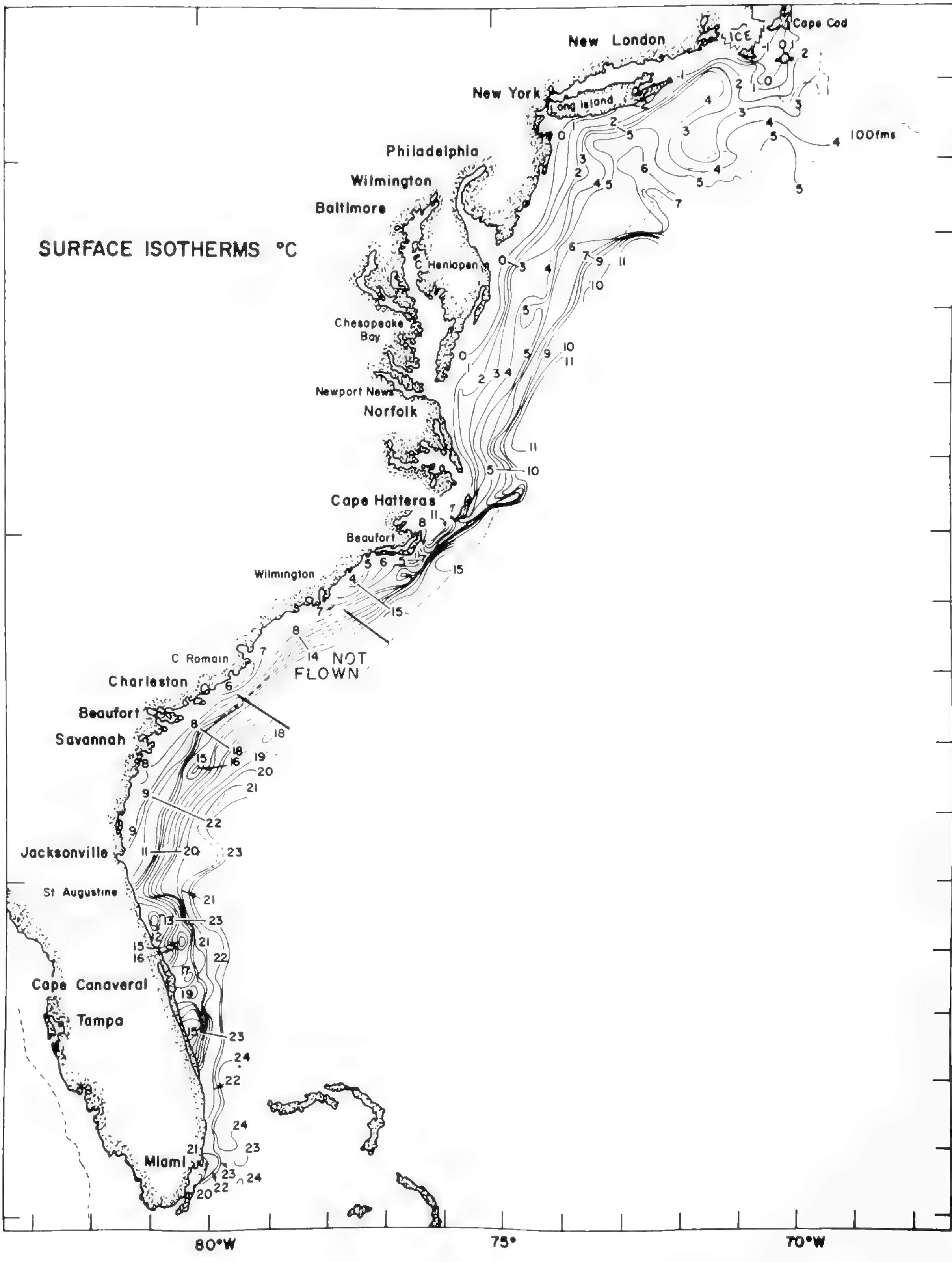


Figure 10.—Monthly surface isotherm chart, January 20–23, 26–28, 1970.

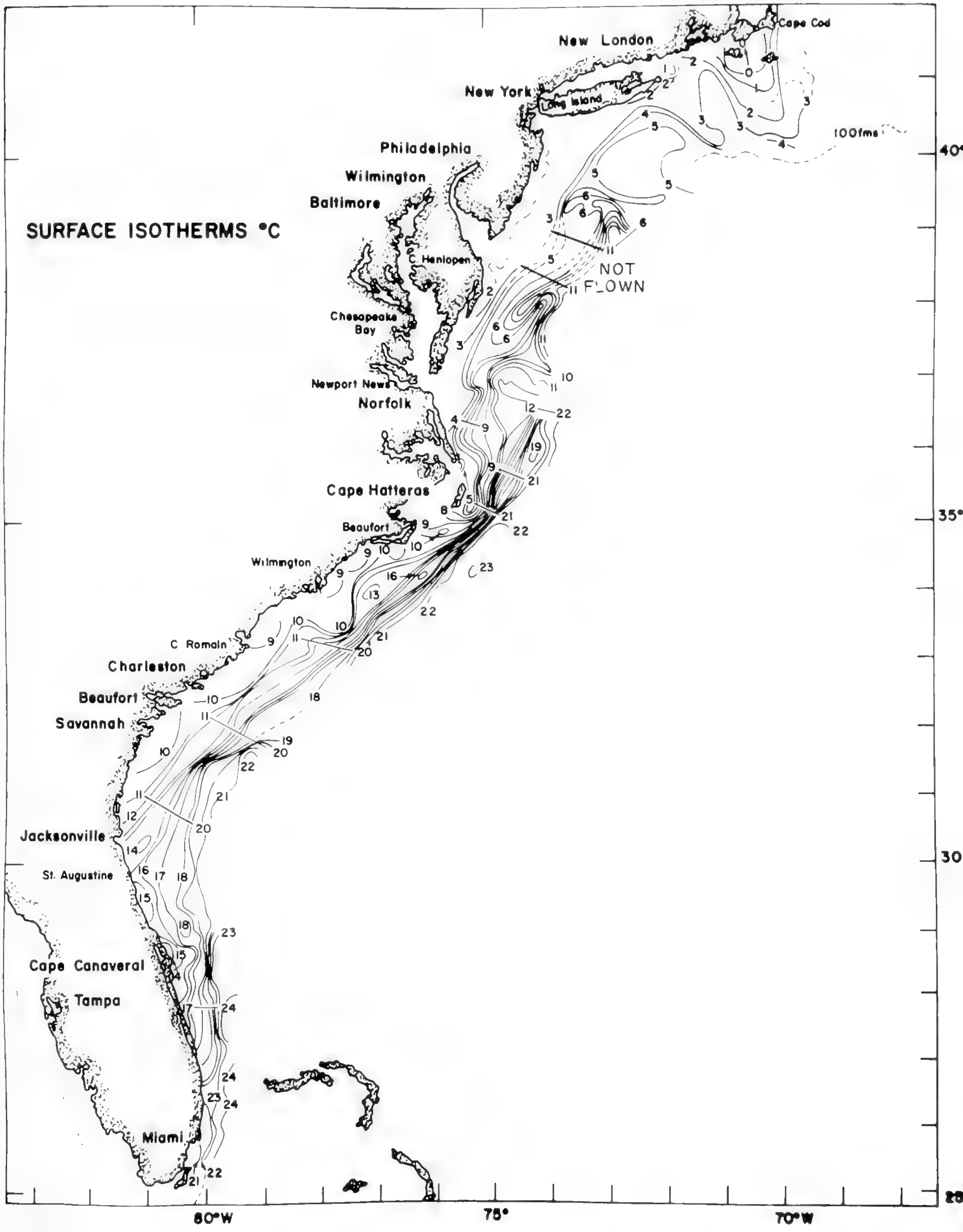


Figure 11.—Monthly surface isotherm chart, February 18–20, 25, 26, 1970.

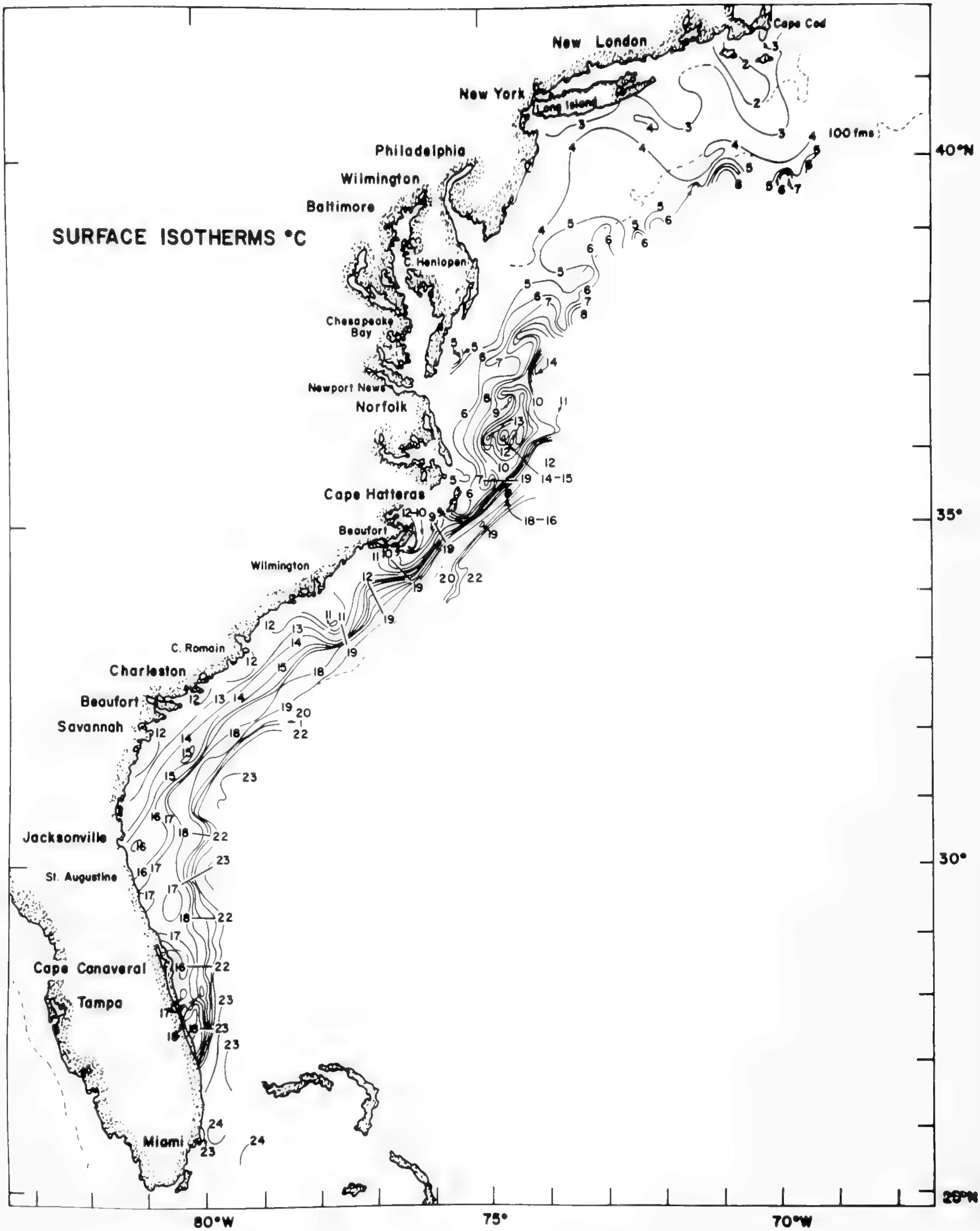


Figure 12.—Monthly surface isotherm chart, March 17, 18, 23, 24, 1970.

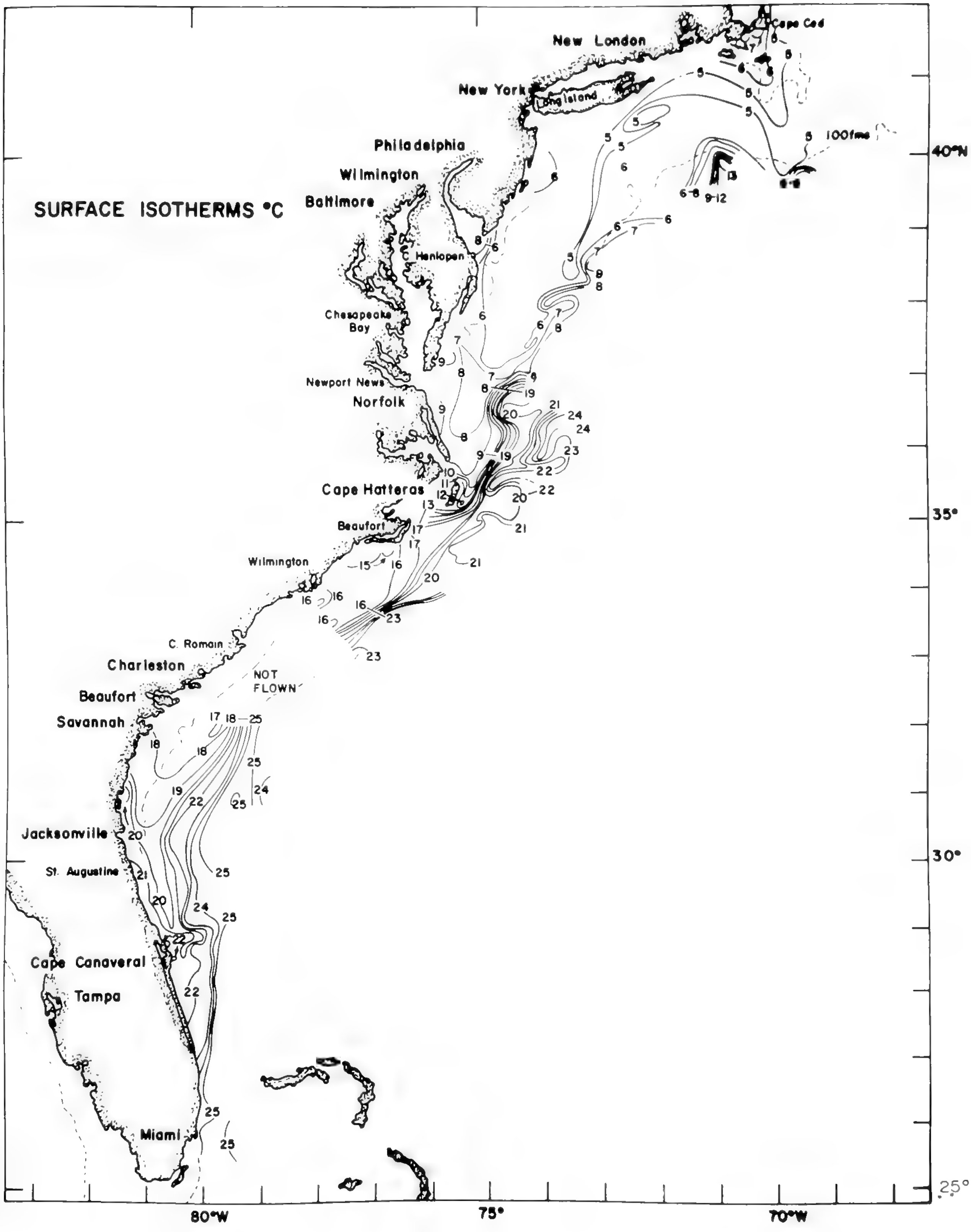


Figure 13.—Monthly surface isotherm chart, April 14–17, 22, 1970.

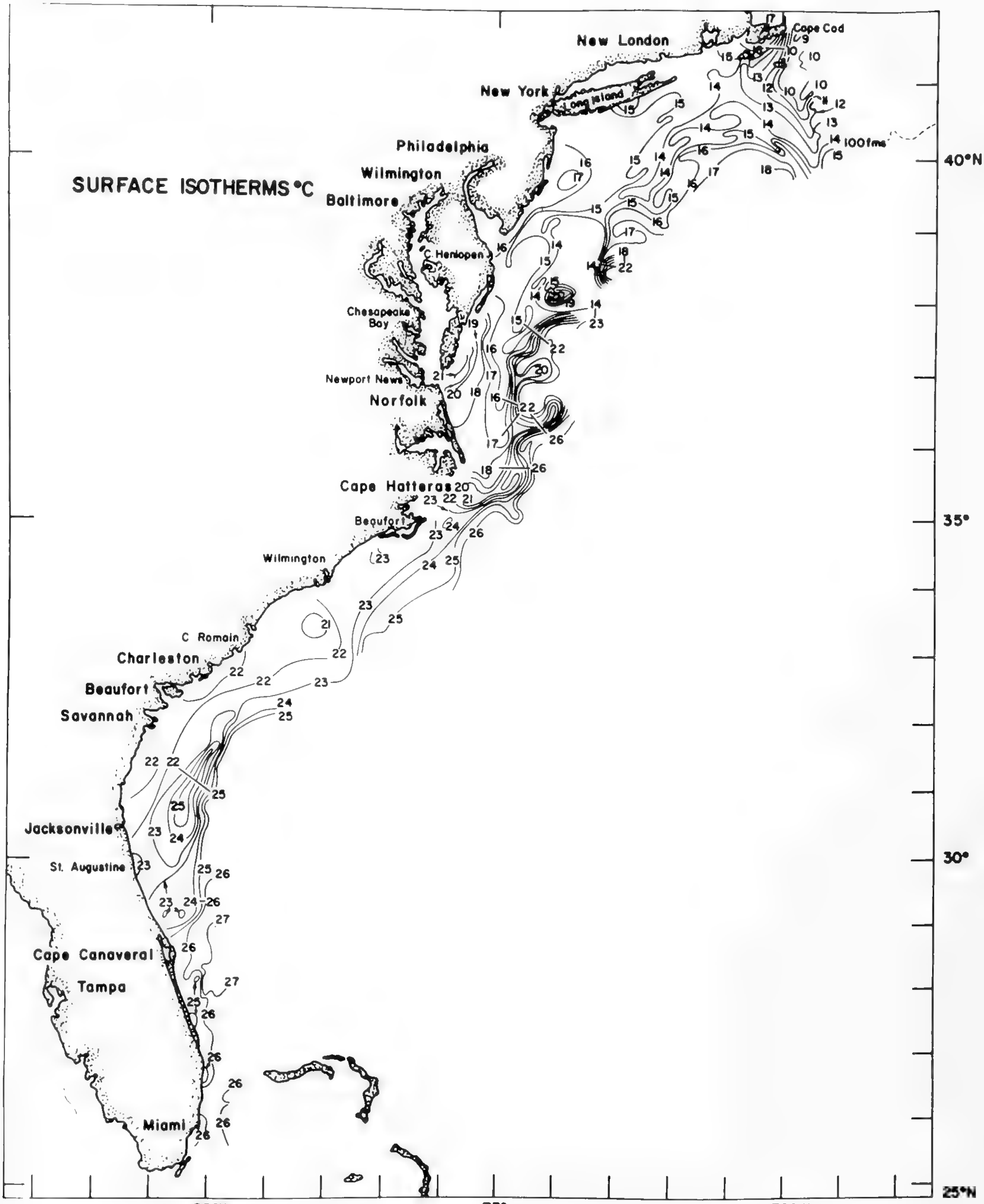


Figure 14.—Monthly surface isotherm chart, May 15, 18, 19, 27, 28 – June 2, 1970.

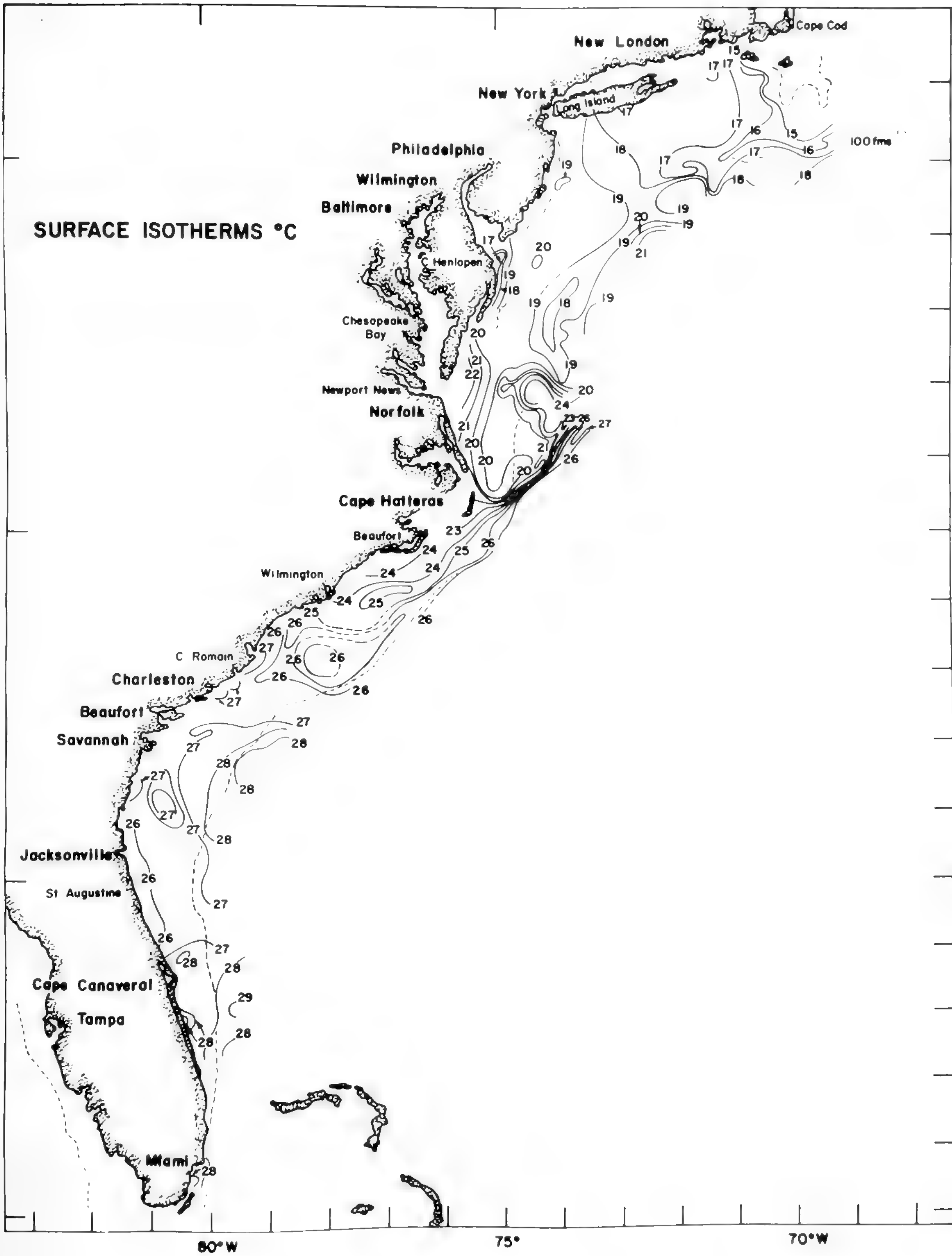


Figure 15.—Monthly surface isotherm chart, June 16, 17, 19, 22, 23, 1970.

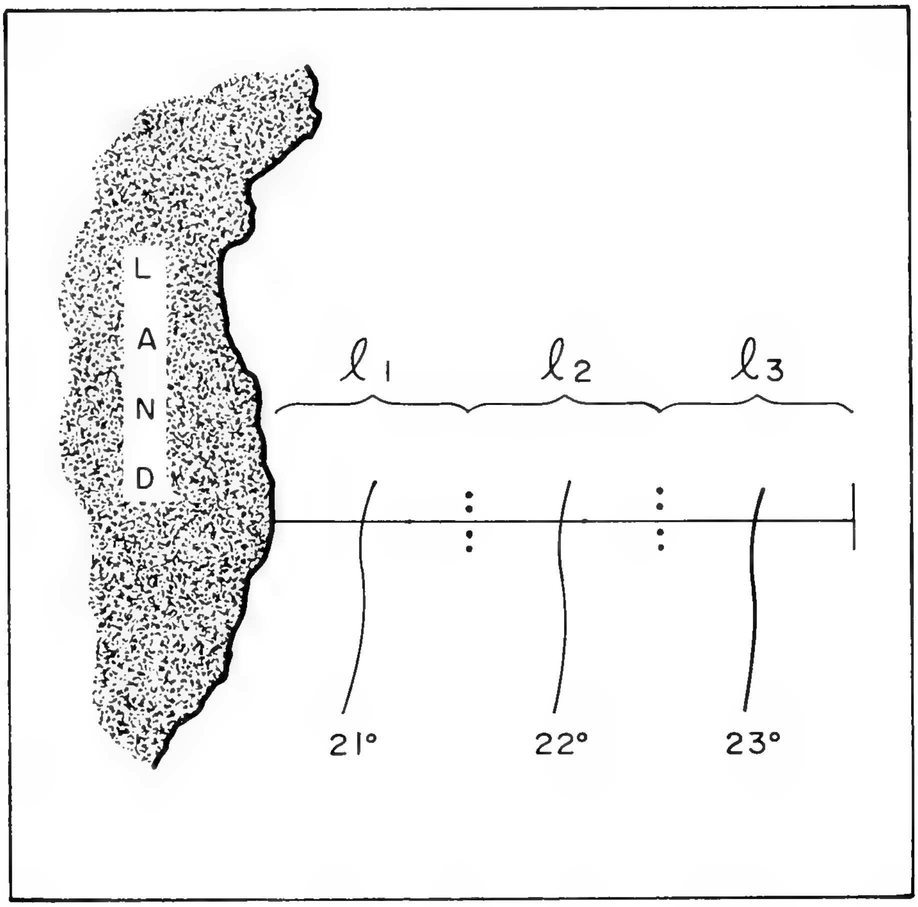


Figure 16.—Graphic portrayal of method used to select SST from a contoured isotherm chart for the time-series grid.

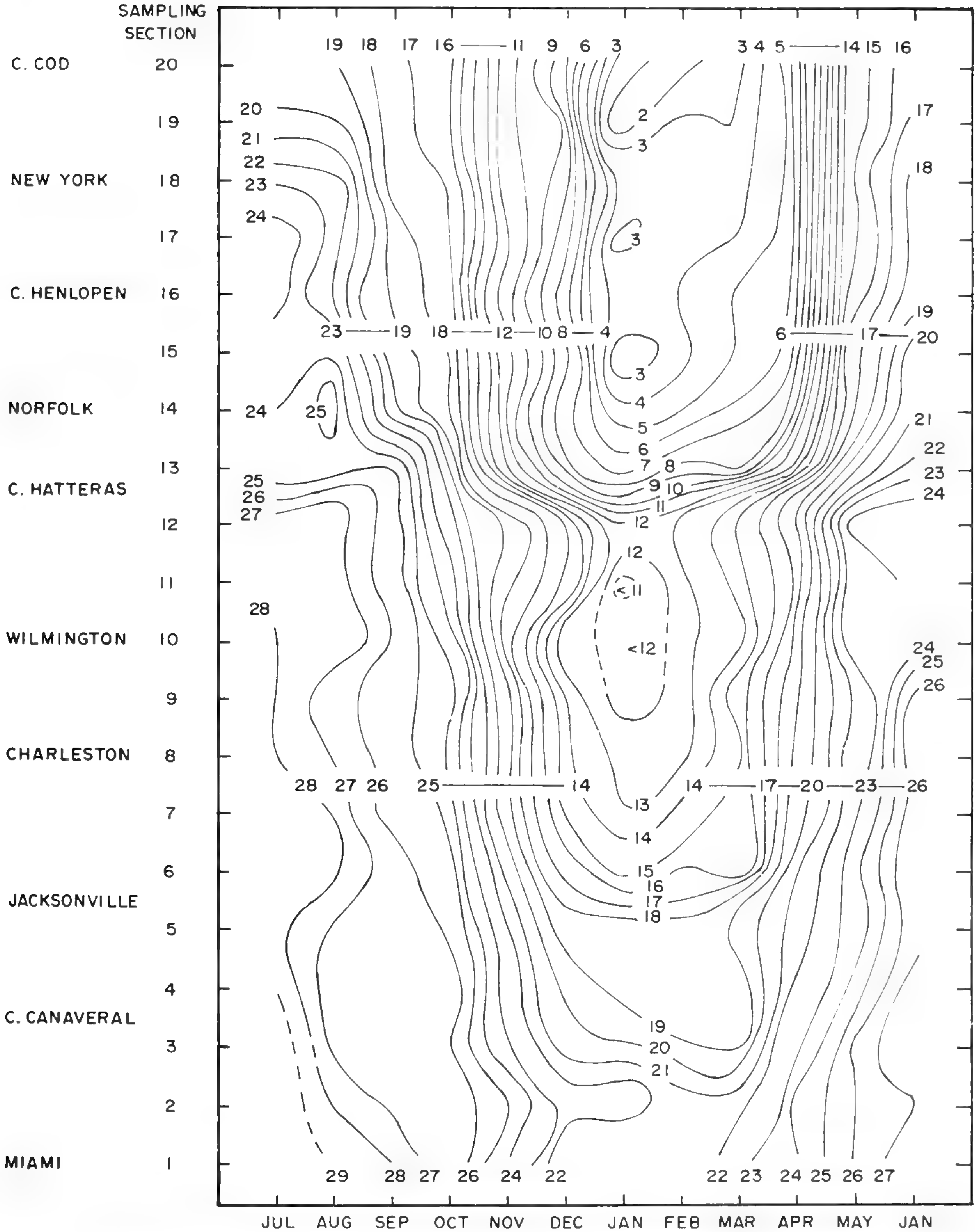


Figure 17.—**Profile of SST (distance-weighted transect means) in degrees Celsius of a space-time grid.**

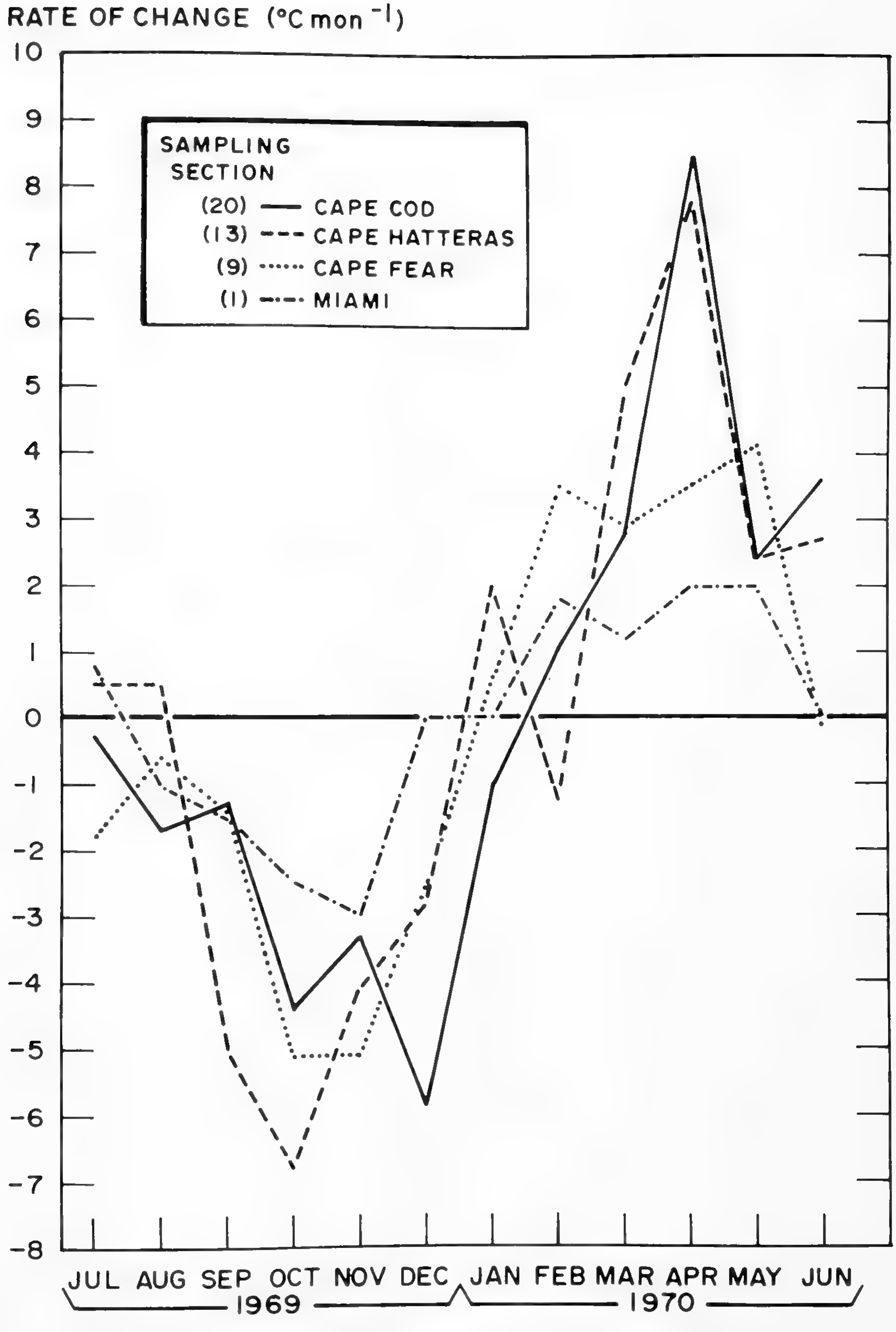


Figure 18.—Graph of rate of monthly SST changes between Cape Cod, Massachusetts and Miami, Florida; July 1969 – June 1970.

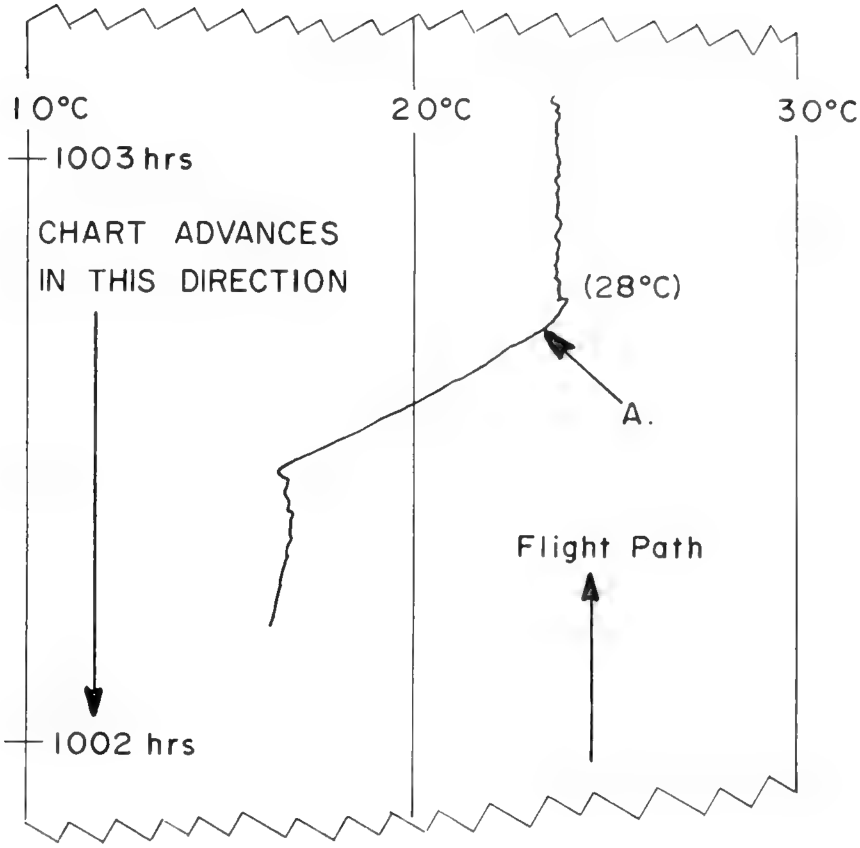


Figure 19.—Graphic example of the position on the ART strip chart record used to identify the Gulf Stream thermal front crossings.

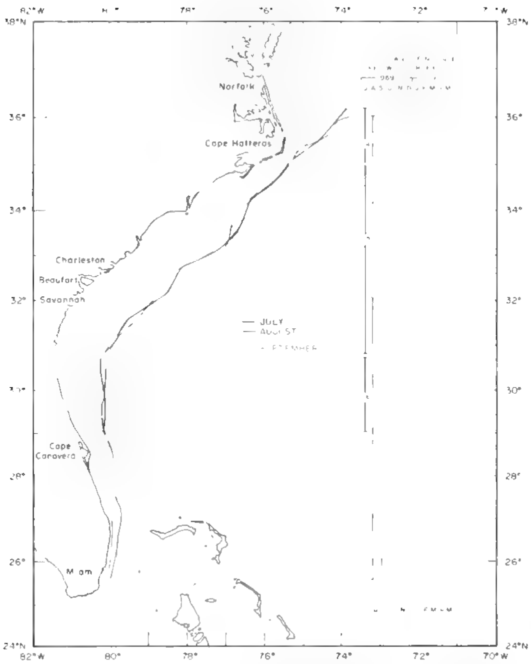


Figure 20.—**(a) Contoured monthly thermal front associated with the western wall of the Gulf Stream from Cape Hatteras, North Carolina to Miami, Florida for July 1969 – September 1969.**

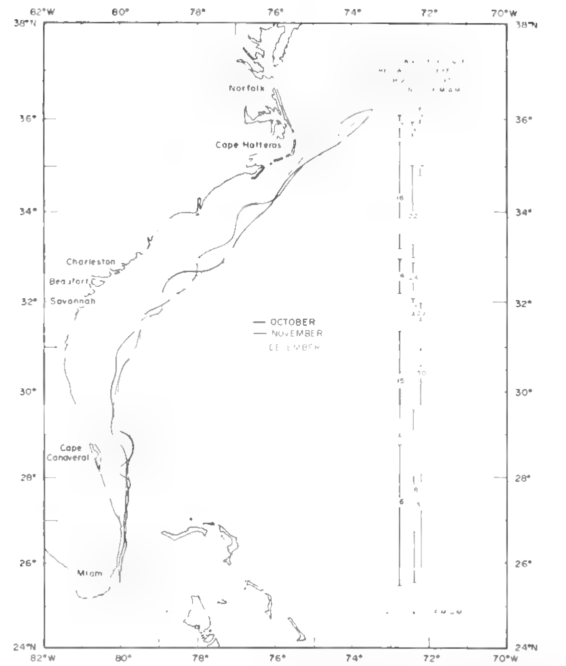


Figure 20.—**(b) Contoured monthly thermal front associated with the western wall of the Gulf Stream from Cape Hatteras, North Carolina to Miami, Florida for October 1969 – December 1969.**

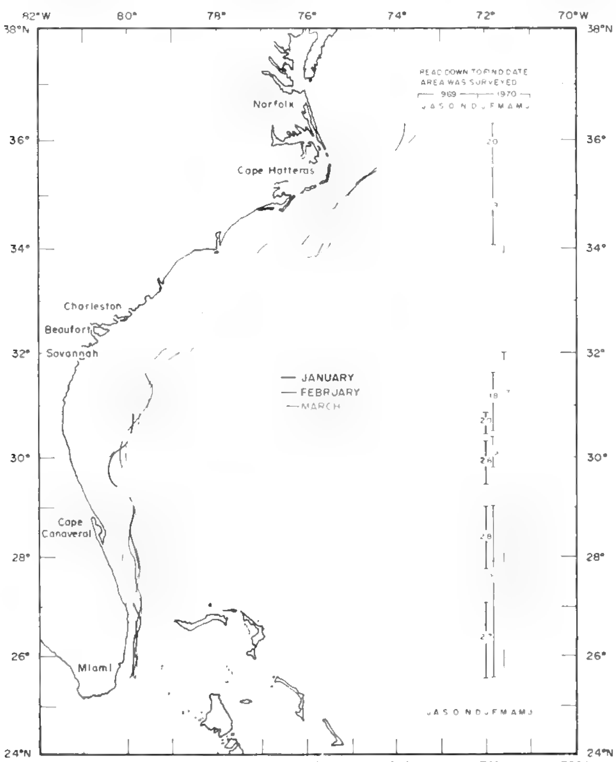


Figure 20.—**(c) Contoured monthly thermal front associated with the western wall of the Gulf Stream from Cape Hatteras, North Carolina to Miami, Florida for January 1970 – March 1970.**

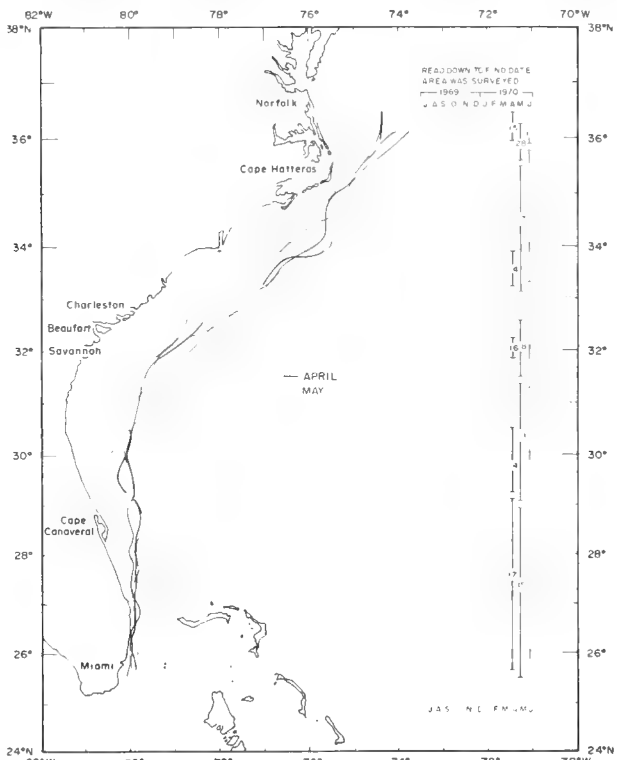


Figure 20.—**(d) Contoured monthly thermal front associated with the western wall of the gulf Stream from Cape Hatteras, North Carolina to Miami, Florida for April 1970 – June 1970.**

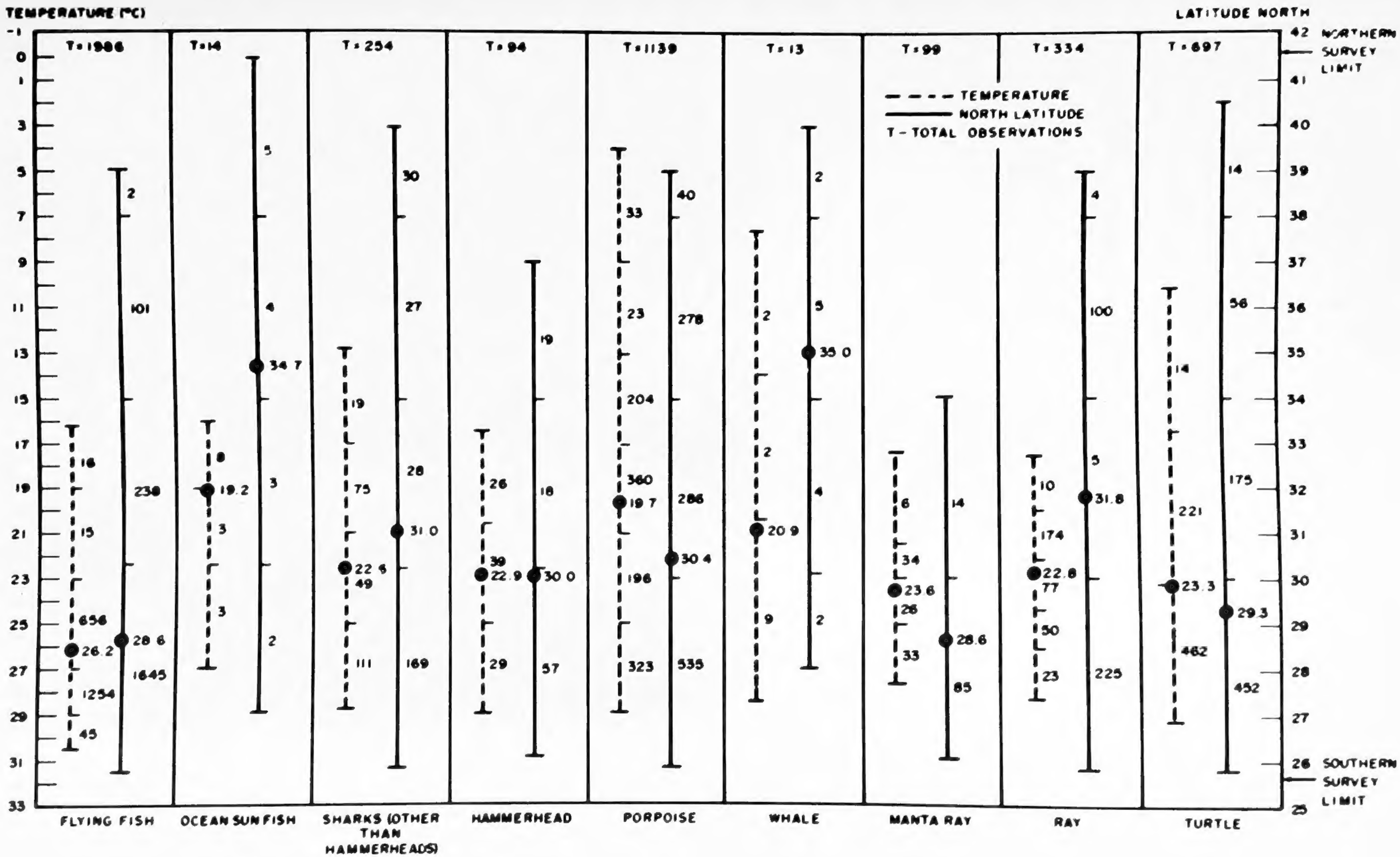


Figure 21.—Graph of the plotted annual range and weighted mean temperature and latitude distribution for marine animal observations July 1969 – June 1970.

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