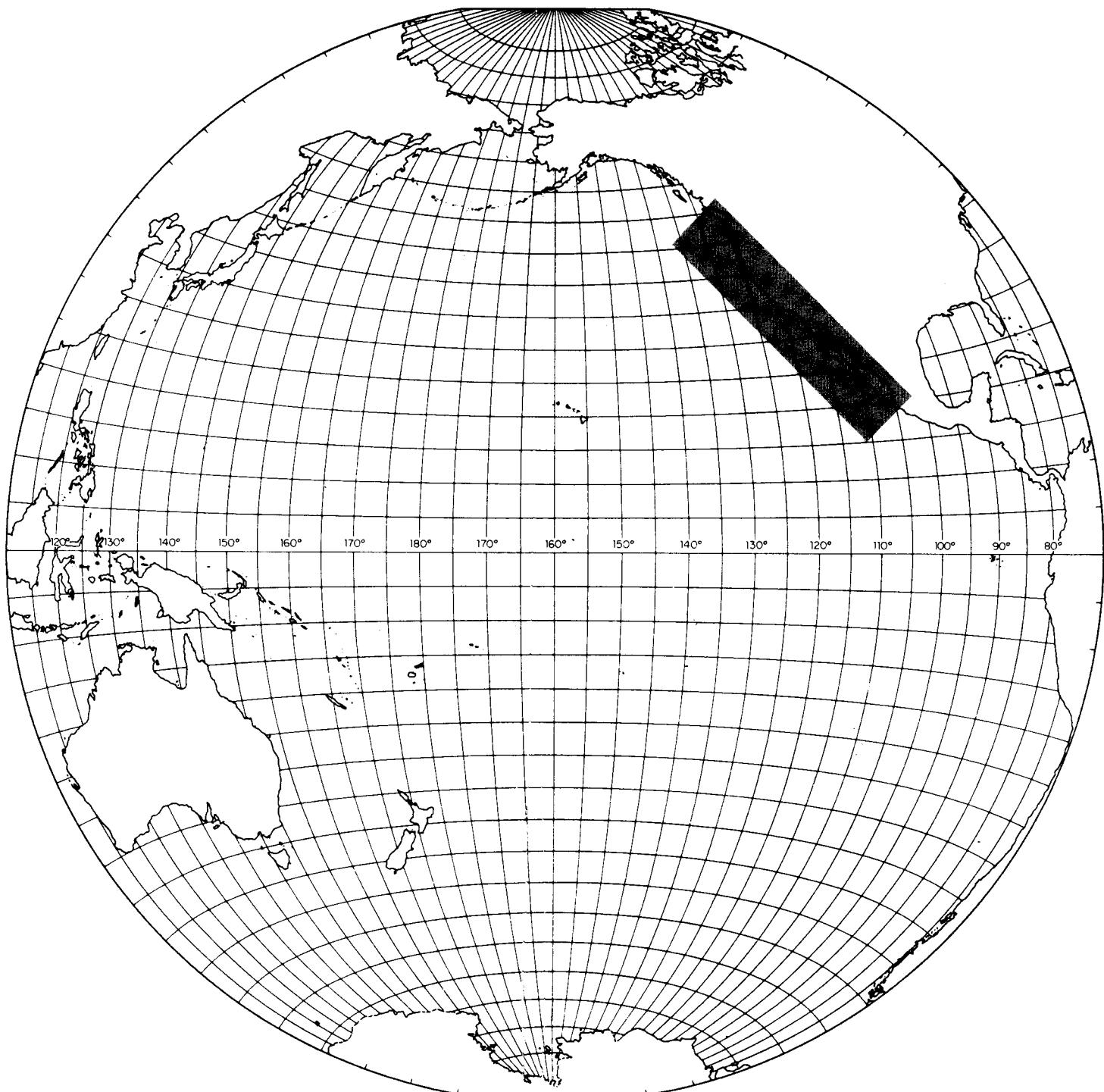


STATE OF CALIFORNIA
MARINE RESEARCH COMMITTEE



**CALIFORNIA COOPERATIVE OCEANIC
FISHERIES INVESTIGATIONS**

ATLAS No. 15

CALIFORNIA
COOPERATIVE
OCEANIC
FISHERIES
INVESTIGATIONS

Atlas No. 15

STATE OF CALIFORNIA
MARINE RESEARCH COMMITTEE

Cooperating Agencies:
CALIFORNIA ACADEMY OF SCIENCES
CALIFORNIA DEPARTMENT OF FISH AND GAME
STANFORD UNIVERSITY, HOPKINS MARINE STATION
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, NATIONAL MARINE FISHERIES SERVICE
UNIVERSITY OF CALIFORNIA, SCRIPPS INSTITUTION OF OCEANOGRAPHY

June, 1971

THE CALCOFI ATLAS SERIES

This is the fifteenth in a series of atlases containing data on the hydrography and plankton from the region of the California Current. The field work was carried out by the California Cooperative Oceanic Fisheries Investigations,¹ a program sponsored by the State of California under the direction of the State's Marine Research Committee. The cooperating agencies in the program are:

California Academy of Sciences
California Department of Fish and Game
Stanford University, Hopkins Marine Station
National Oceanic and Atmospheric Administration, National Marine Fisheries Service²
University of California, Scripps Institution of Oceanography

CalCOFI atlases³ are issued as individual units as they become available. They provide processed physical, chemical and biological measurements of the California Current region. Each number may contain one or more contributions. A general description of the CalCOFI program with its objectives appears in the preface of Atlas No. 2.

This atlas was prepared by the Data Collection and Processing Group of the Marine Life Research Program, Scripps Institution of Oceanography.

CalCOFI Atlas Editorial Staff:

Abraham Fleminger and Hans T. Klein, Editors
John G. Wyllie, Cartographer

CalCOFI atlases in this series, through June 1971, are:

- No. 1. Anonymous, 1963. CalCOFI atlas of 10-meter temperatures and salinities 1949 through 1959.
- No. 2. Fleminger, A., 1964. Distributional atlas of calanoid copepods in the California Current region, Part I.
- No. 3. Alvariño, A., 1965. Distributional atlas of Chaetognatha in the California Current region.
- No. 4. Wyllie, J. G., 1966. Geostrophic flow of the California Current at the surface and at 200 meters.
- No. 5. Brinton, E., 1957. Distributional atlas of Euphausiacea (Crustacea) in the California Current region, Part I.
- No. 6. McGowan, J. A., 1967. Distributional atlas of pelagic molluscs in the California Current region.
- No. 7. Fleminger, A., 1967. Distributional atlas of calanoid copepods in the California Current region, Part II.
- No. 8. Berner, L., 1967. Distributional atlas of Thaliacea in the California Current region.
- No. 9. Kramer, D., and E. H. Ahlstrom, 1968. Distributional atlas of fish larvae in the California Current region: Northern Anchovy, *Engraulis mordax* Girard, 1951 through 1965.
- No. 10. Isaacs, J. D., A. Fleminger and J. K. Miller, 1969. Distributional atlas of zooplankton biomass in the California Current region: Spring and Fall 1955-1959.
- No. 11. Ahlstrom, E. H., 1969. Distributional atlas of fish larvae in the California Current region: jack mackerel, *Trachurus symmetricus*, and Pacific hake, *Merluccius productus*, 1951 through 1966.
- No. 12. Kramer, D., 1970. Distributional atlas of fish eggs and larvae in the California Current region: Pacific sardine, *Sardinops caerulea* (Girard), 1951 through 1966.
- No. 13. Smith, P. E., 1971. Distributional atlas of zooplankton volume in the California Current region, 1951 through 1966.
- No. 14. Isaacs, J. D., A. Fleminger and J. K. Miller, 1969. Distributional atlas of zooplankton biomass in the California Current region: Winter 1955-1959.
- No. 15. Wyllie, J. G., and R. J. Lynn, 1971. Distribution of temperature and salinity at 10 meters, 1960-1969 and mean temperature, salinity and oxygen at 150 meters, 1950-1968 in the California Current.

¹Usually abbreviated CalCOFI, sometimes CALCOFI or CCOFI.

²Formerly called U. S. Fish and Wildlife Service, Bureau of Commercial Fisheries.

³For citation this issue in the series should be referred to as CalCOFI Atlas No. 15.

**DISTRIBUTION OF TEMPERATURE AND SALINITY AT 10 METERS, 1960-1969,
AND MEAN TEMPERATURE, SALINITY AND OXYGEN AT 150 METERS, 1950-1968,
IN THE CALIFORNIA CURRENT**

John G. Wyllie and Ronald J. Lynn

CALCOFI ATLAS NO. 15

Data Collection and Processing Group
Marine Life Research Program
Scripps Institution of Oceanography
La Jolla, California

June, 1971

DISTRIBUTION OF TEMPERATURE AND SALINITY AT 10 METERS, 1960-1969, AND MEAN TEMPERATURE, SALINITY AND OXYGEN AT 150 METERS, 1950-1968, IN THE CALIFORNIA CURRENT

John G. Wyllie and Ronald J. Lynn

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10-METER TEMPERATURE AND SALINITY

Charts of the temperature and salinity distribution at 10-meters depth for individual CalCOFI cruises are presented for the years 1960 through 1969. These charts continue the 11-year (1949 to 1959) series presented in CalCOFI Atlas No. 1 (Anon., 1963). The presentation used in Atlas No. 1 has been retained. The distributions by month are graphically summarized on Charts 2 and 3.

The 10-meter depth level has been used

throughout the CalCOFI program as representative of the surface layer. It was chosen in preference to the sea surface in order to avoid shallow transient conditions.

10-meter Temperature Time Series

The temperature and temperature anomaly time series for selected stations given in Atlas No. 1 are continued in this atlas through 1969 for the same stations. No new monthly mean temperatures have been computed; the monthly means based on the data for 1950 through 1959 have been retained as the reference for computations of anomalies. Selection of the stations used in the time series was based upon the number and the time distribution of the measurements available for a given station. Sampling was approximately monthly during 1960, 1966 and 1969; observed values within these years are connected by a solid line. The years 1961 through 1965 were sampled quarterly; these observed values are connected by a heavy dashed line. The years 1967 and 1968 were infrequently sampled; these observed values are connected by light dashed lines. Positive anomalies from the 1950 to 1959 mean are shown as grey bars and negative anomalies as black bars.

150-METER MONTHLY MEANS

A series of monthly mean distribution charts of temperature, salinity and oxygen at a depth of 150 meters is presented on Charts 132 to 167. The 150-meter level was chosen because it is the standard oceanographic level nearest the maximum depth (140 meters) fished by the standard CalCOFI zooplankton net. The distribution of properties at 150 meters of depth is, therefore, very nearly that which is encountered at the maximum depth of the zooplankton net tow routinely taken at CalCOFI stations.

All available CalCOFI data for the 150-

meter level in the years 1950 through 1968 were used in the preparation of the charts. The data were obtained from the National Oceanographic Data Center, Oceanic Observations of the Pacific (1950-1959) and the Physical and Chemical Data Report series for the years 1960 to 1968, the last two sources being issued by the University of California, Scripps Institution of Oceanography. The 150-meter means also include measurements obtained from acceptable hydrographic bottle casts which malfunctioned and casts requiring extrapolations to the 150-meter level that are not included in the National Oceanographic Data Center files.

Method of Analysis

The monthly mean values were computed by the method of harmonic analysis as given by Lynn (1967). Briefly, the method groups all data from the time series of each station into one 365-day period; i.e., only the month and the day of sampling are considered. A curve formed by the annual and semi-annual harmonics is then fitted to the observations by the method of least squares regression. Monthly means are obtained by selecting mid-month values from the resulting curve; these values were plotted and contoured.

This method of analysis is preferred over computation of arithmetic monthly means be-

cause it interpolates in time and thus provides a good estimate for months that were infrequently sampled.

The 19-year Mean and the Standard Error of Estimate

The statistical analysis also furnished an overall mean for the years 1950 through 1968; the contoured distribution of these 19-year means are given in three charts, one each for temperature, salinity and oxygen. The residuals between the fitted curve and the individual datum values are used to compute the standard error of estimate about the curve; the contoured distributions of standard error of estimate, one each for temperature, salinity and oxygen, are presented. Observed temperature records and the fitted curves for two sample stations, 60.60 and 110.80, are plotted in Figure 1. The dashed lines are drawn at plus and minus one standard error of estimate. The regression curve for Station 60.60 provides a reasonable fit to the data. For Station 110.80 the dispersion about the mean is very large and there is no discernible seasonal variation; the resulting curve varies little from the overall mean. In general, only near-shore stations reveal significant seasonal variation. The 150-meter level intersects the thermocline in most offshore stations and this produces the large dispersion seen, for ex-

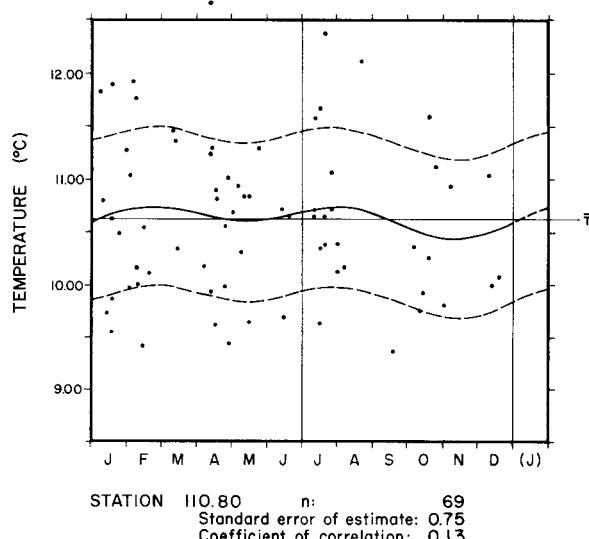
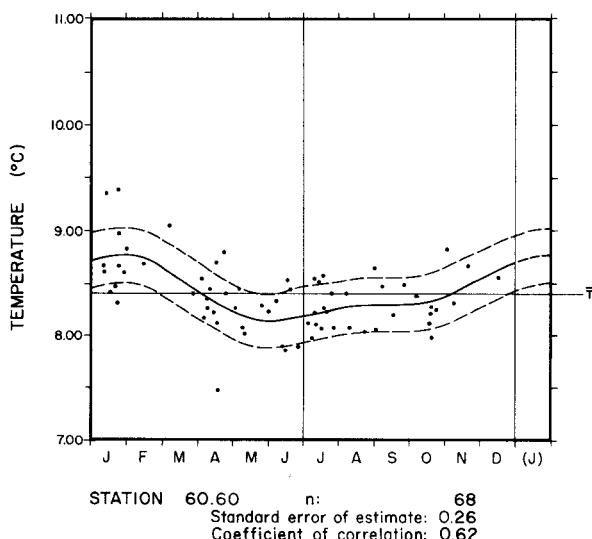


Figure 1. Station regression curves and observations. Horizontal lines are 19-year means. Dashed lines are drawn at plus and minus 1 standard error of estimate.

ample, at Station 110.80. The intersection of the main portion of the thermocline with the 150-meter level is seen as a large lateral gradient in the 150-meter temperature charts.

Arithmetic monthly means were calculated for stations lacking adequate data for harmonic analysis. The contours about these points are dashed.

CONDITIONS BETWEEN THE SEA SURFACE AND 150 METERS

The charts described above characterize conditions in the California Current region at the uppermost and lowermost portions of the standard CalCOFI zooplankton tow. Standard tows have been made systematically by participating agencies of the CalCOFI program beginning in 1949 and continuing to the present (Smith, 1971). Since 1950 they have been routinely collected at every occupied hydrographic station by oblique hauls between the surface and 140 meters of depth. A large number of the CalCOFI atlases has been concerned with studies based on this extensive time series of zooplankton samples.

When considering distributional features of the zooplankton in the context of the hydrographic climate it is useful to have estimates of surface layer thickness at sampling localities and a summary of prevalent conditions between

the surface layer and the bottom of the tow. The charts and figures discussed below characterize these two features.

Mean Surface-layer Depth

The mean surface-layer depth is presented in a set of monthly charts (Charts 177 to 188). Surface-layer depth is defined here as the depth at which the temperature differs from that at the sea surface by more than 2°F (1.1°C). Thus, the temperature found at 10 meters is representative throughout the layer whose mean thickness is given by these charts. The data were derived primarily from bathythermograph traces.¹

Vertical Distribution of Temperature, Salinity and Oxygen

Figures 2, 3 and 4 present the vertical distributions of temperature, salinity and oxygen in the upper 300 meters for CalCOFI Lines 60, 90, 110, and 130. The means for these sections were calculated from a representative portion of the available data and are included in order to show the general conditions in the region. These sections indicate, for example, features through which the zooplankton nets are towed: the thermocline, the salinity minimum and the large gradients of oxygen concentration.

¹The concept of, and data for, the surface-layer depth were provided by M. K. Robinson, Head BT Analysis and Processing Section, Scripps Institution of Oceanography.

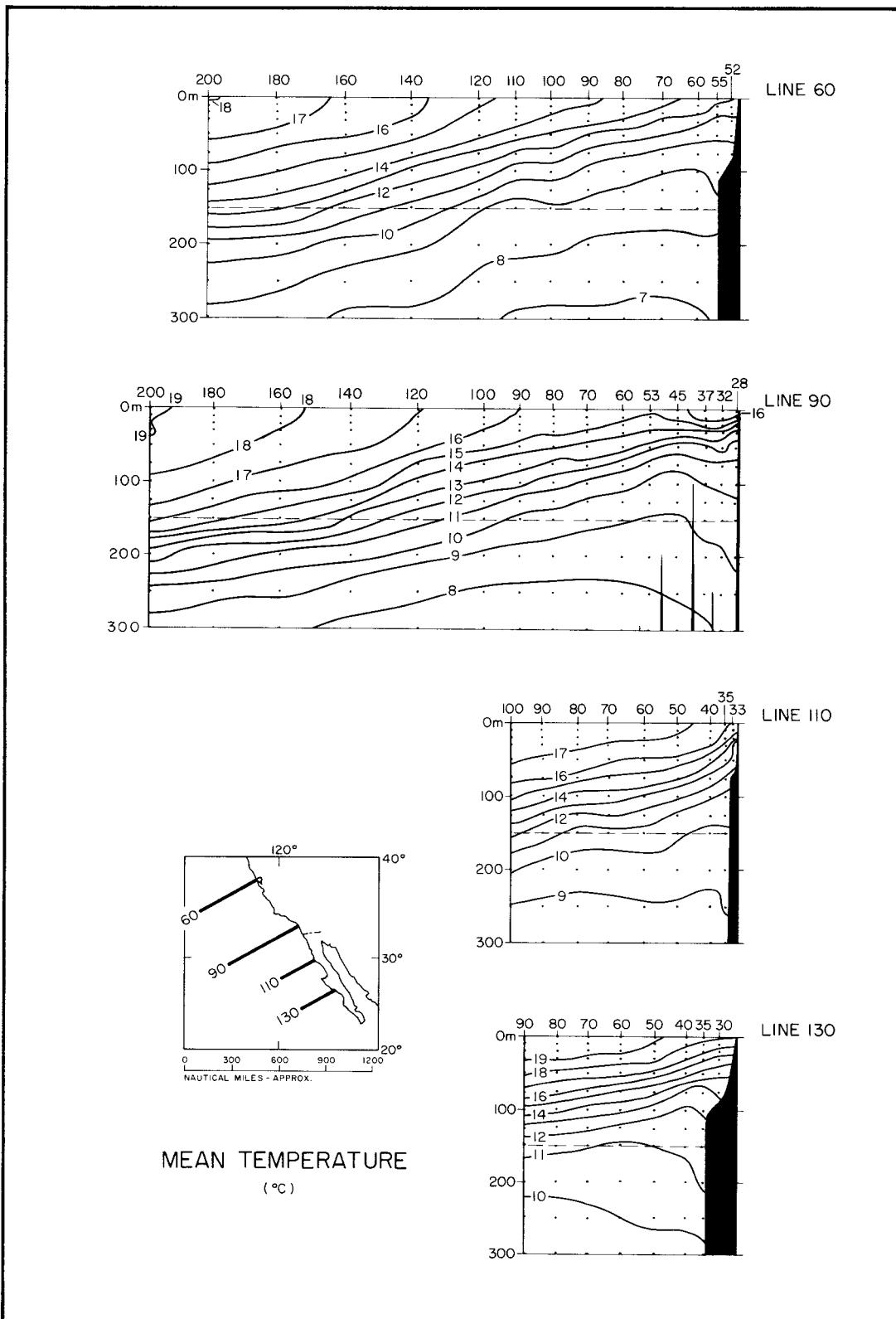


Figure 2. Representative vertical sections of temperature for Lines 60, 90, 110 and 130.

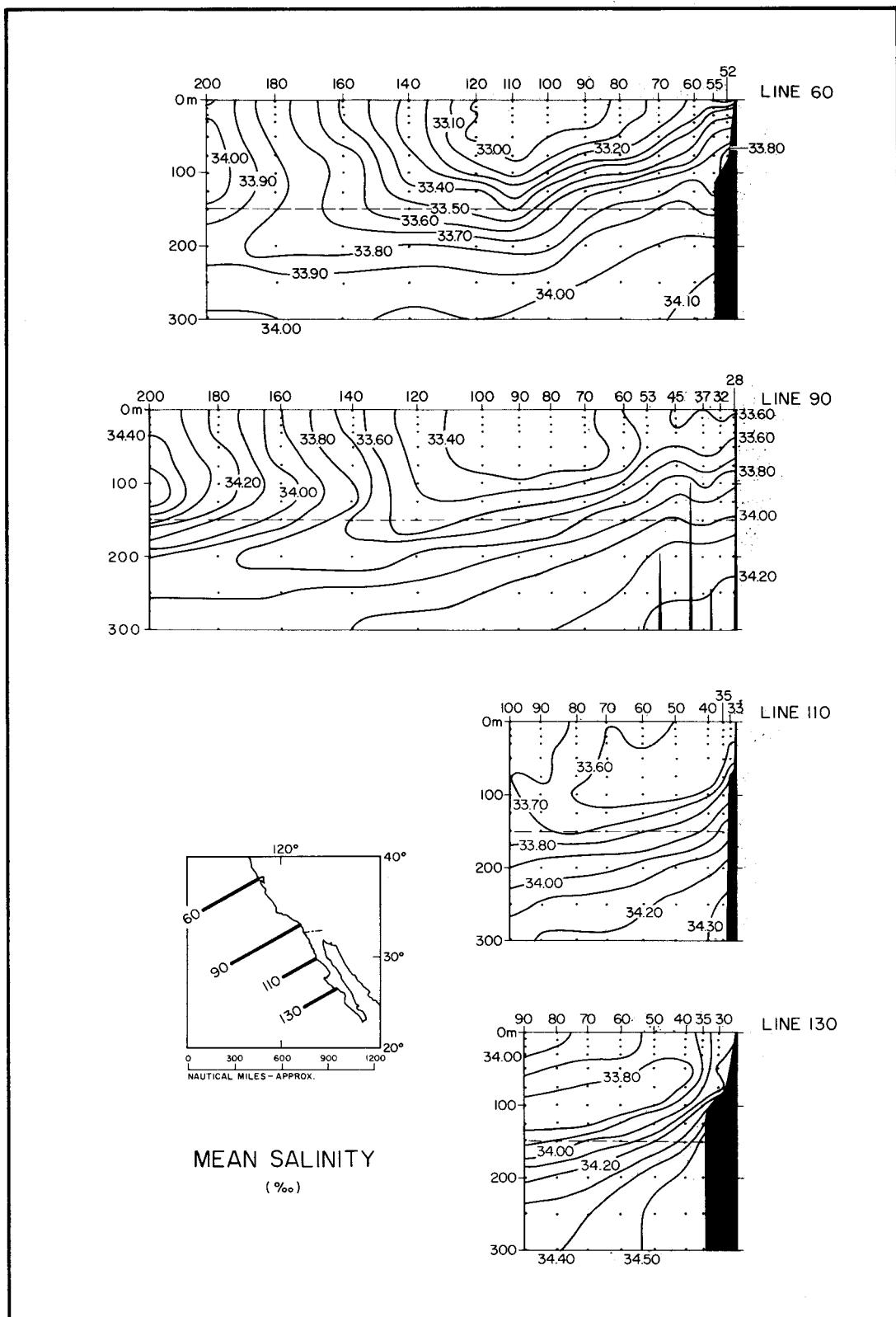


Figure 3. Representative vertical sections of salinity for Lines 60, 90, 110 and 130.

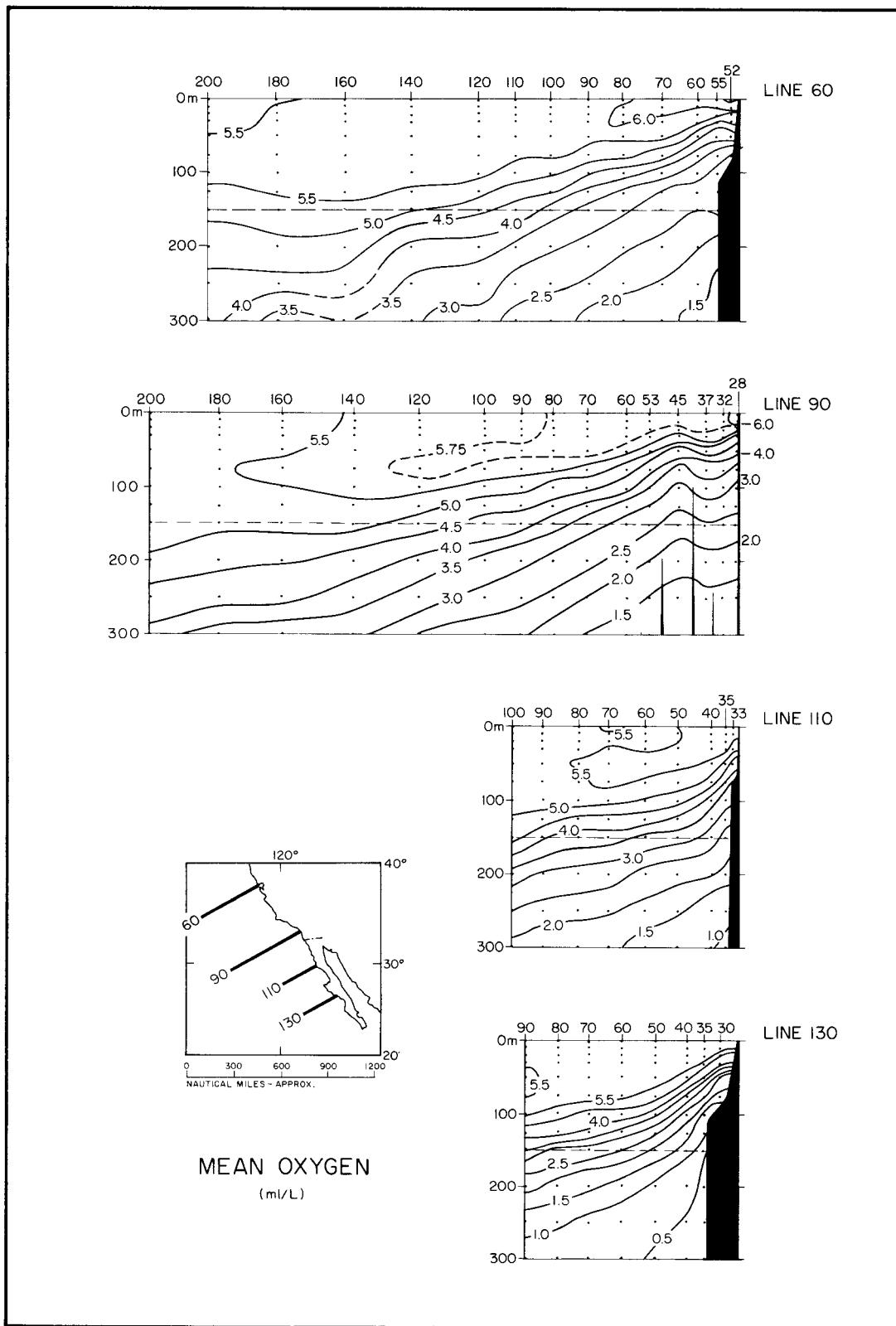
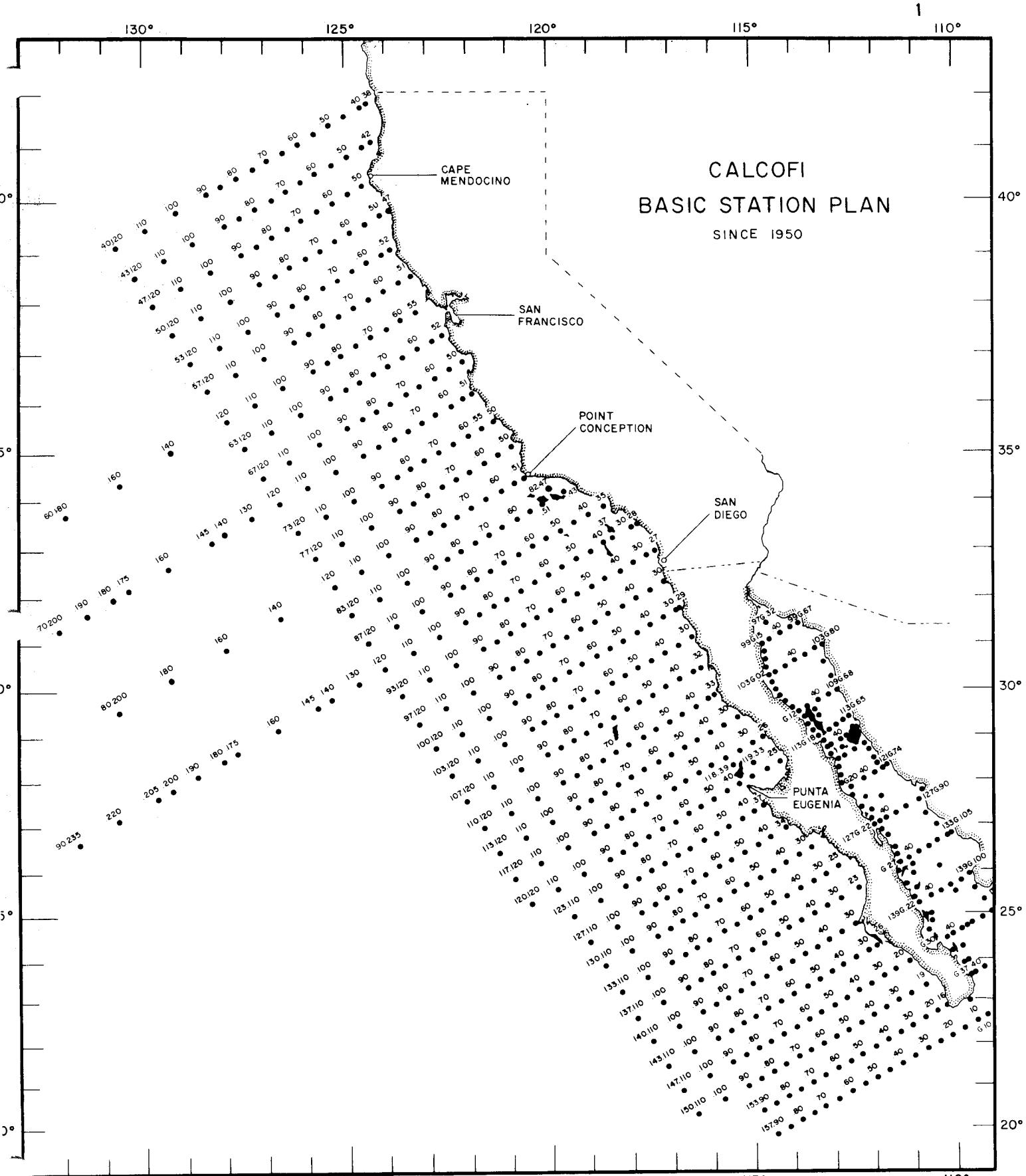


Figure 4. Representative vertical sections of oxygen for Lines 60, 90, 110 and 130.

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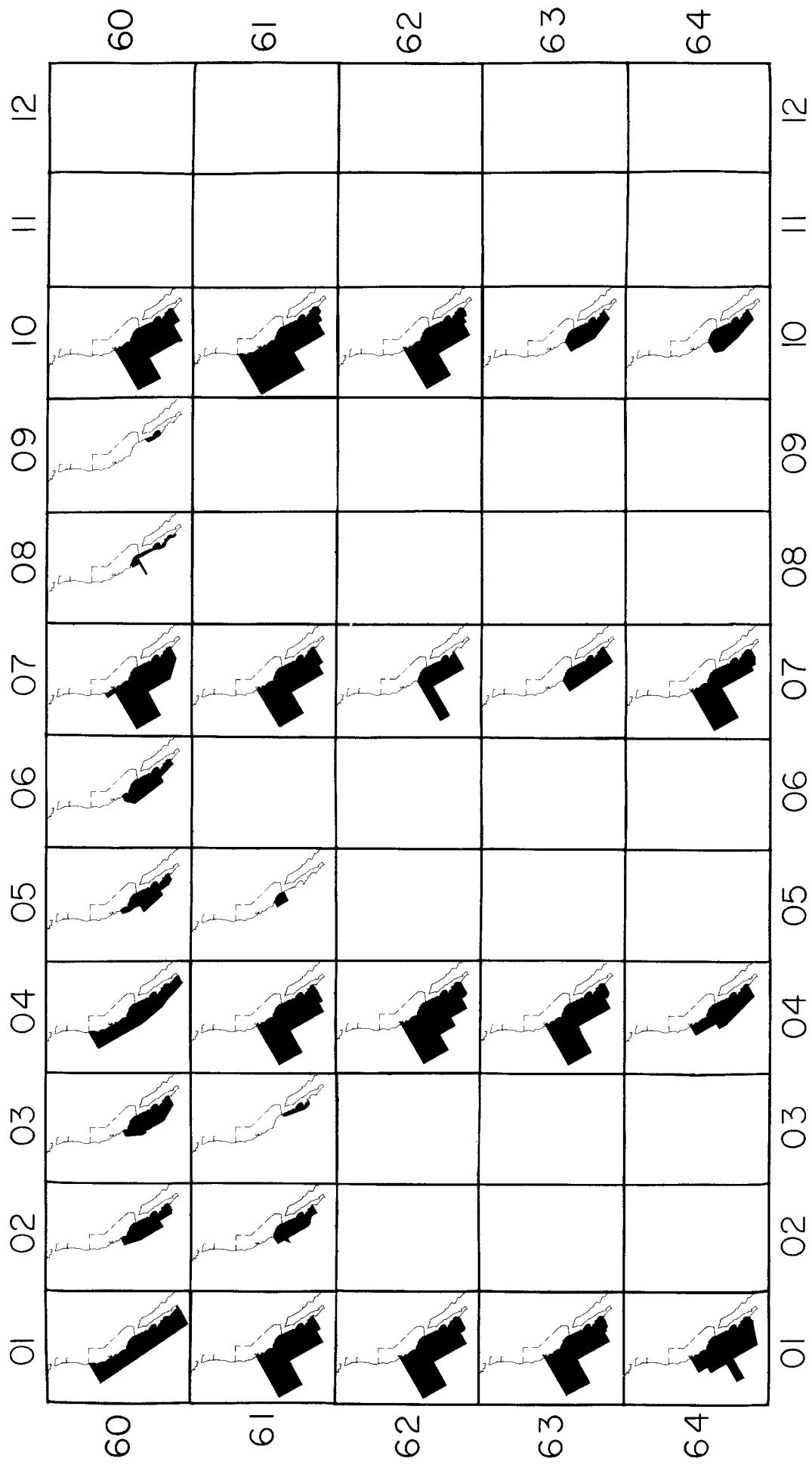
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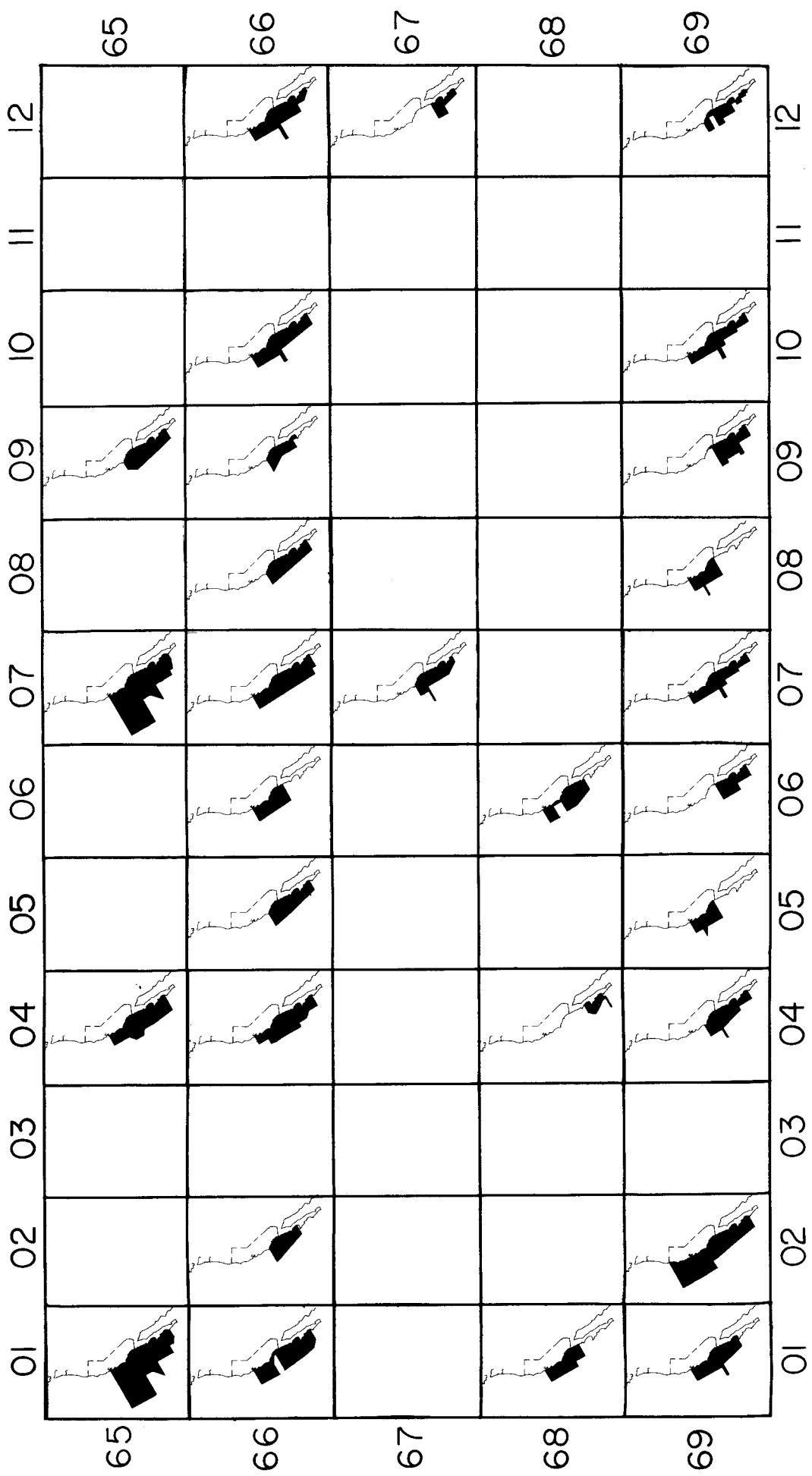
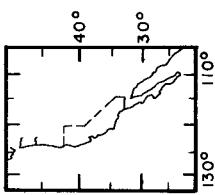
CALCOFI

BASIC STATION PLAN
SINCE 1950

CALCOFI AREA INDEX — 1960 through 1969



MONTHLY 10-METER TEMPERATURE AND SALINITY COVERAGE



10-Meter Temperature Charts

10-Meter Temperature Time Series

10-Meter Salinity Charts

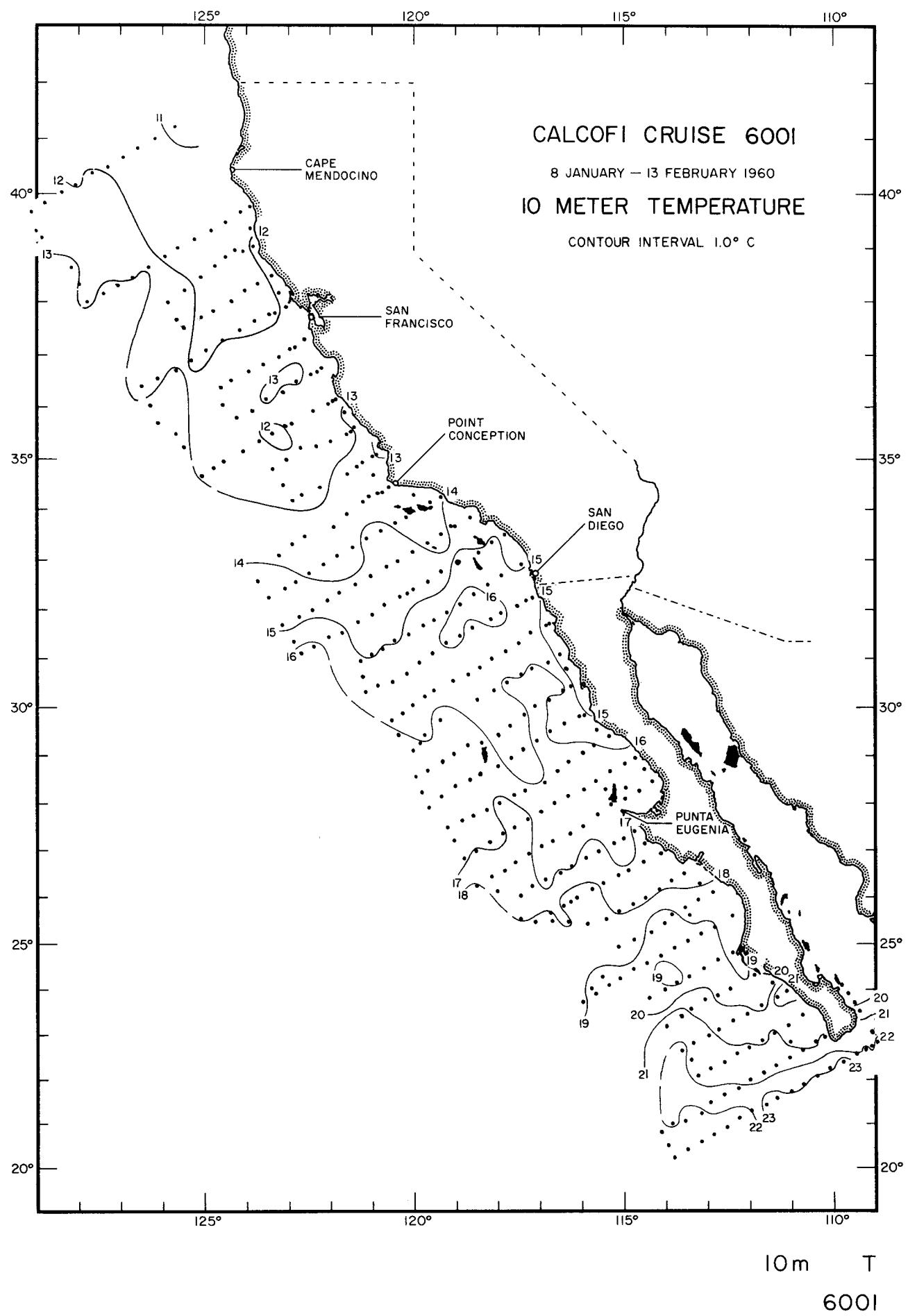
150-Meter Monthly Temperature Regression Mean Charts

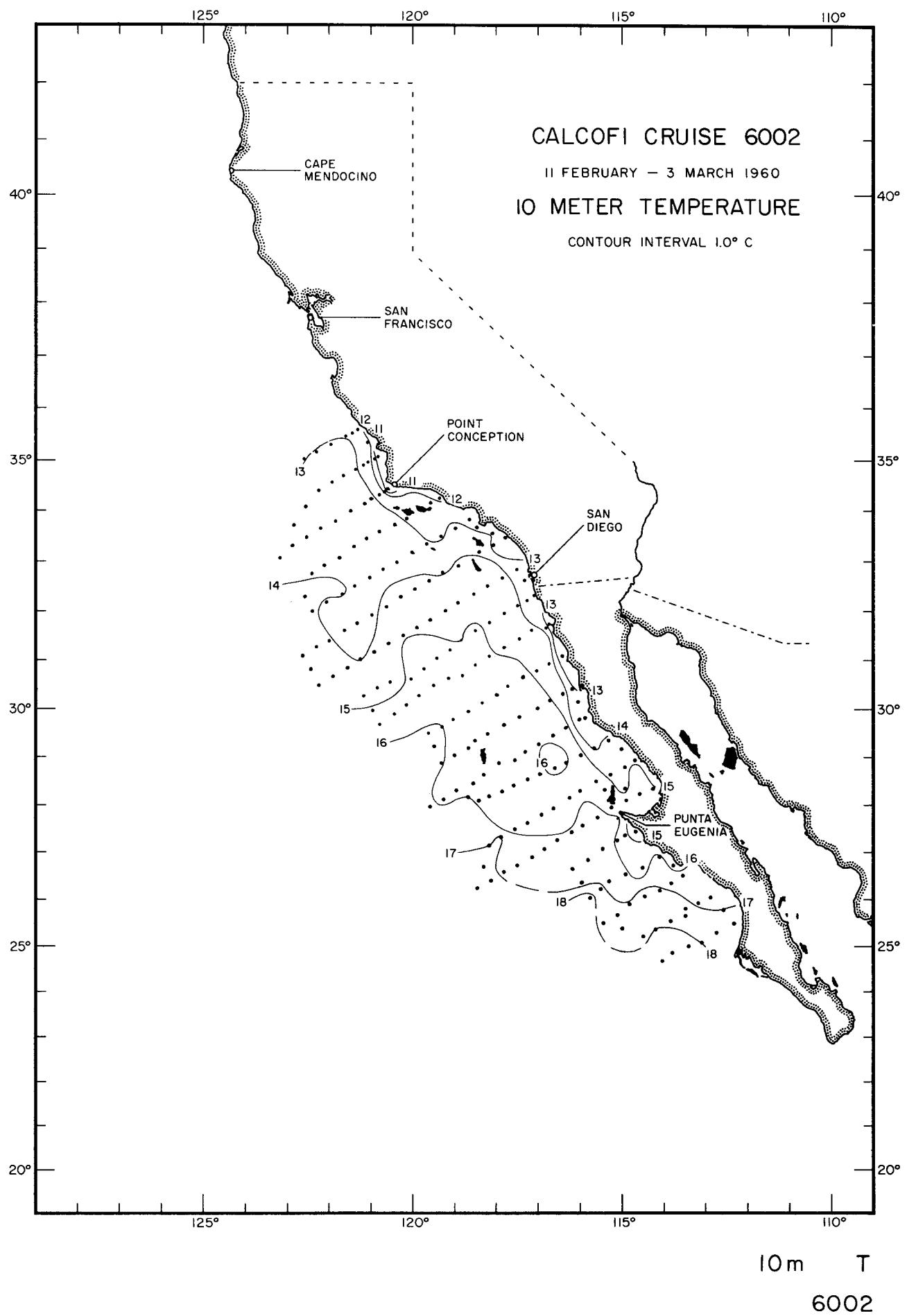
150-Meter Monthly Salinity Regression Mean Charts

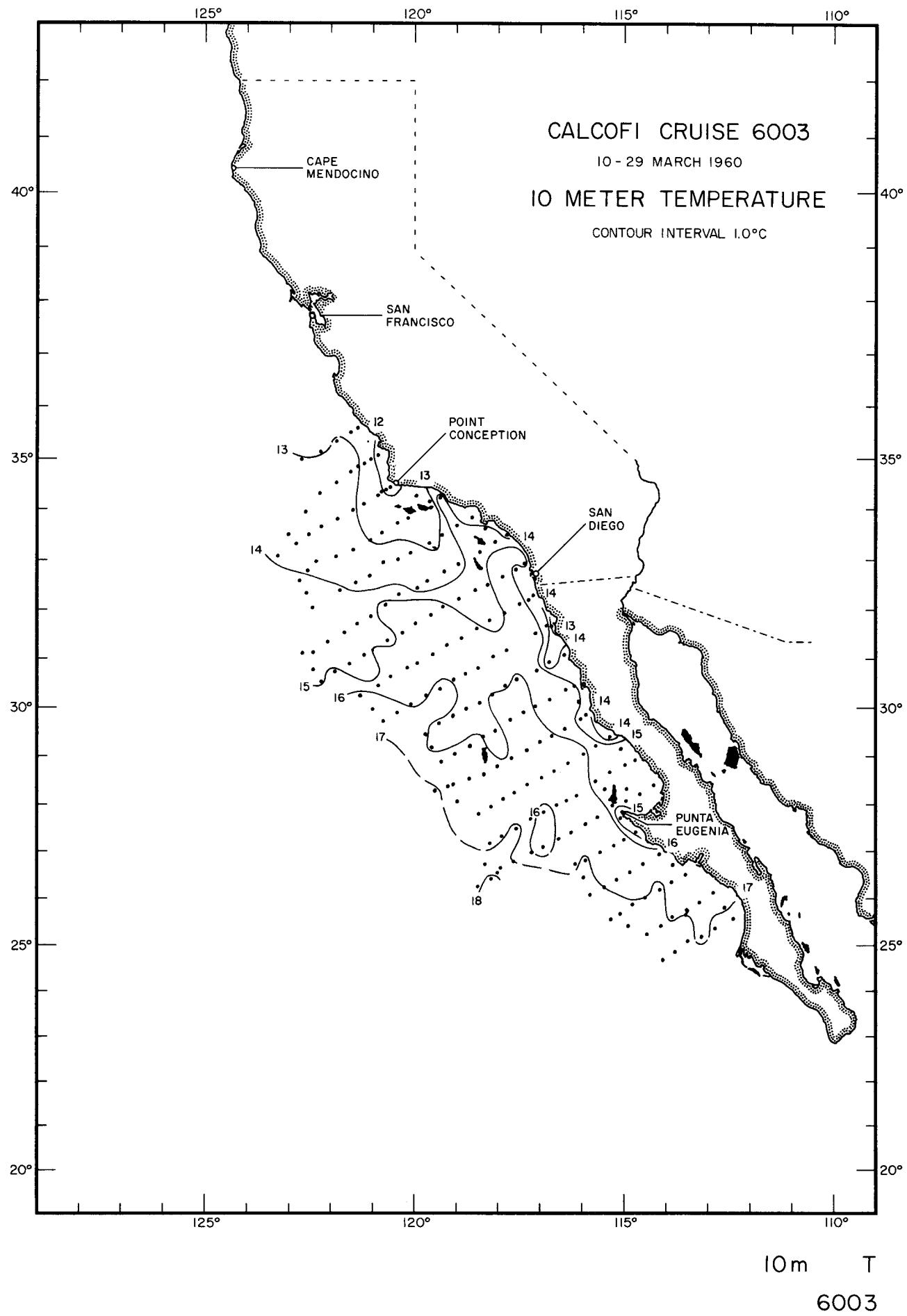
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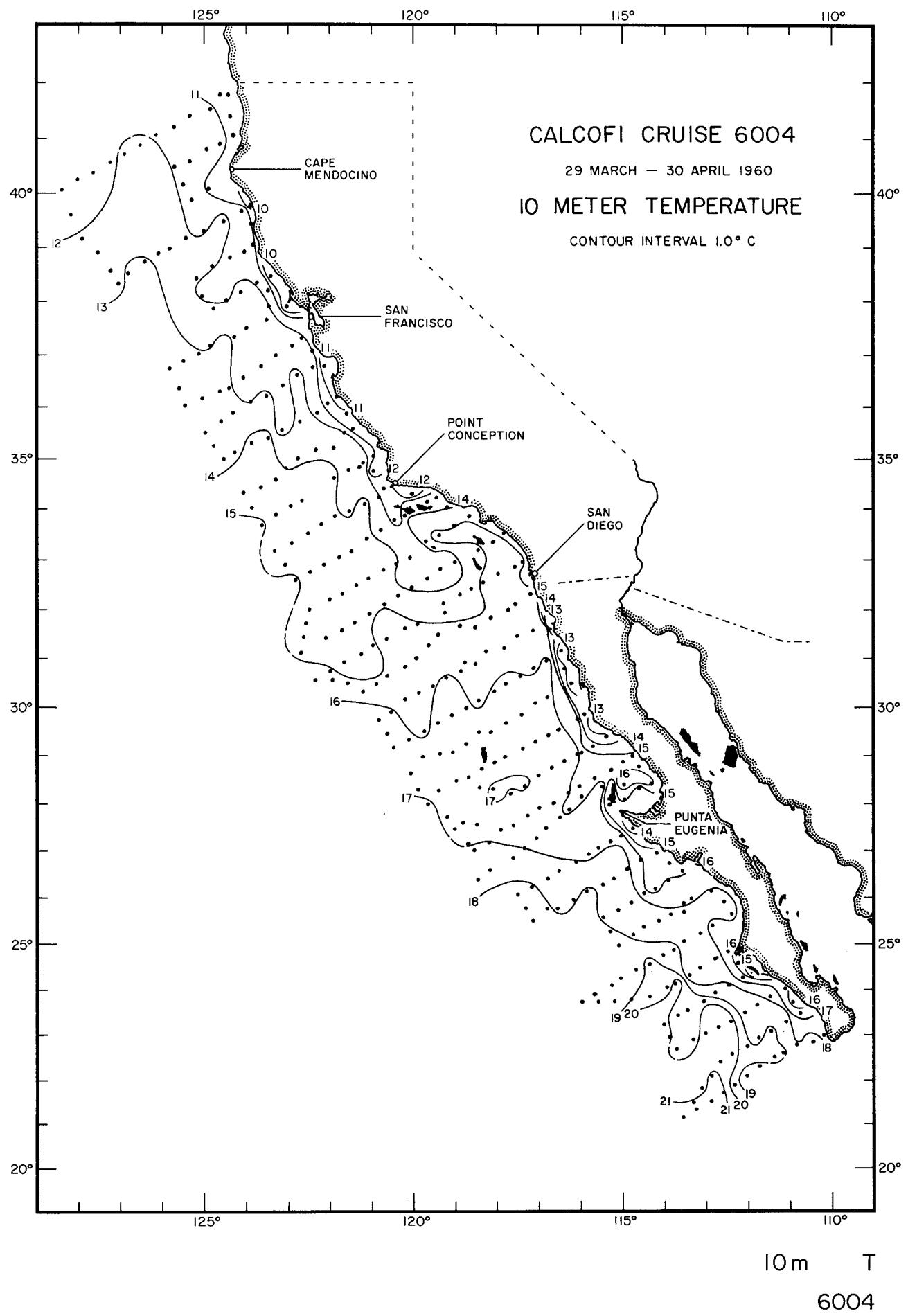
150-Meter: 19-year Regression Mean Charts
150-Meter: Standard Error of Estimate Charts
150-Meter: Total Number of Observations Charts

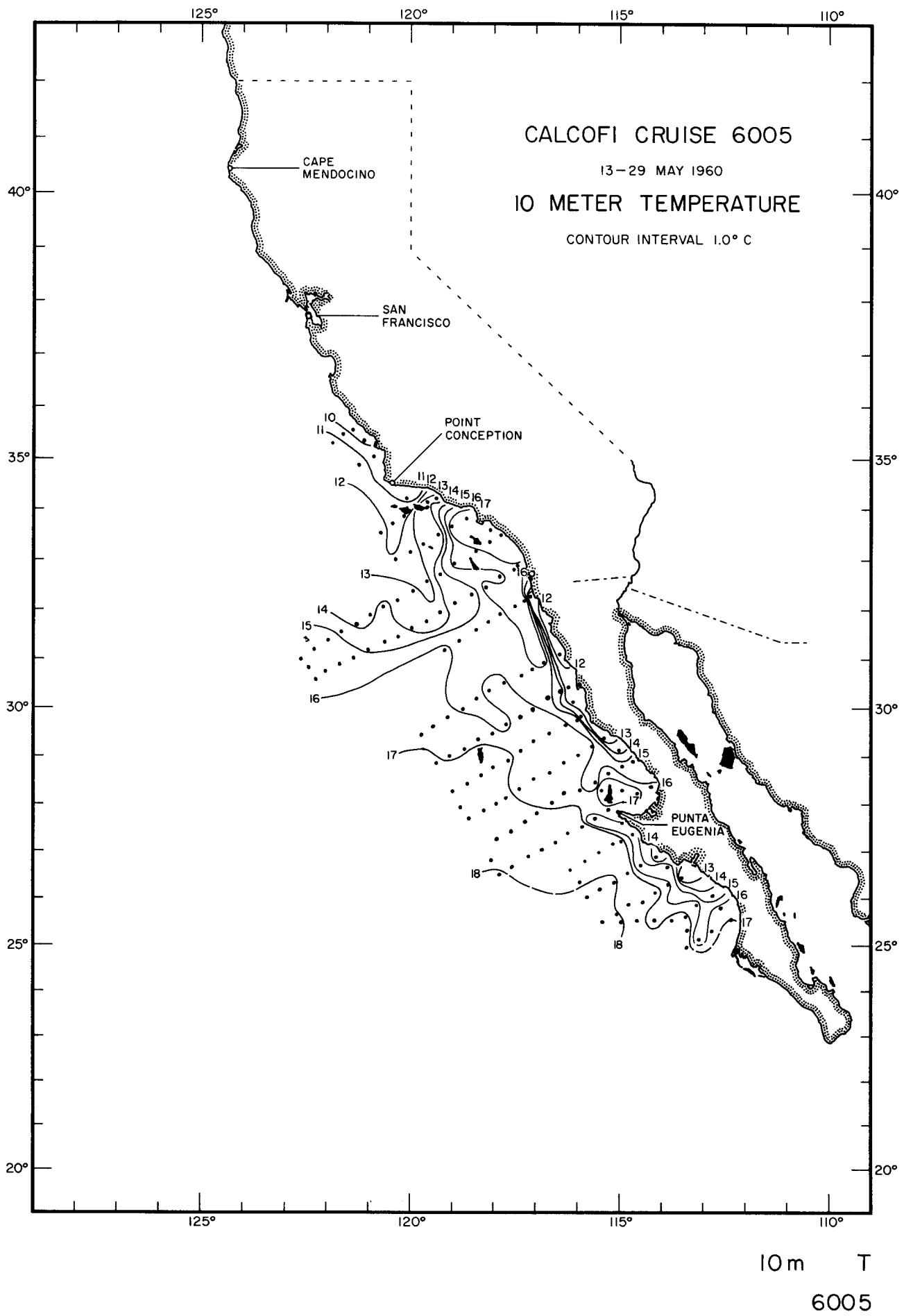
Mean Surface-Layer Depth Charts

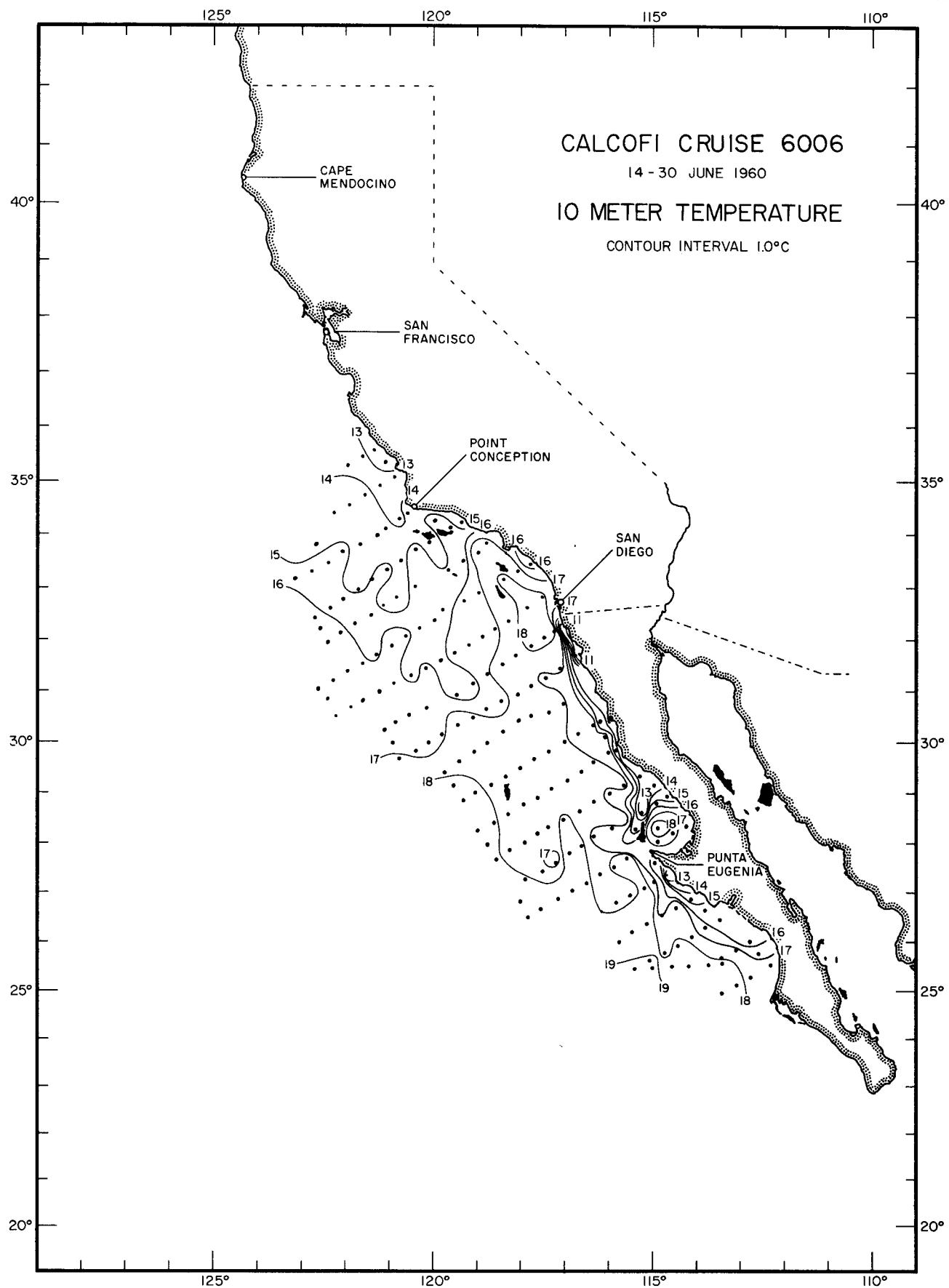




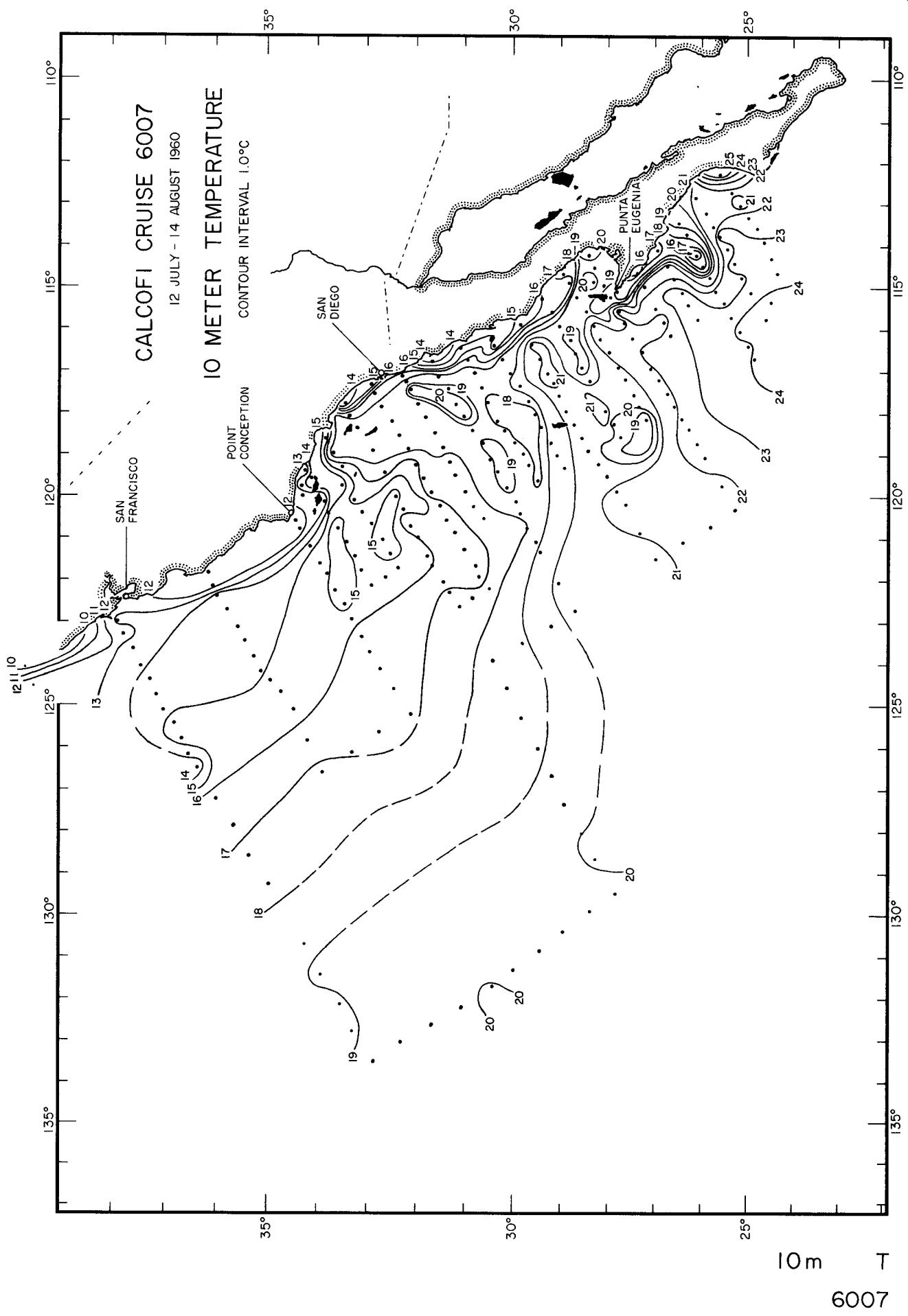


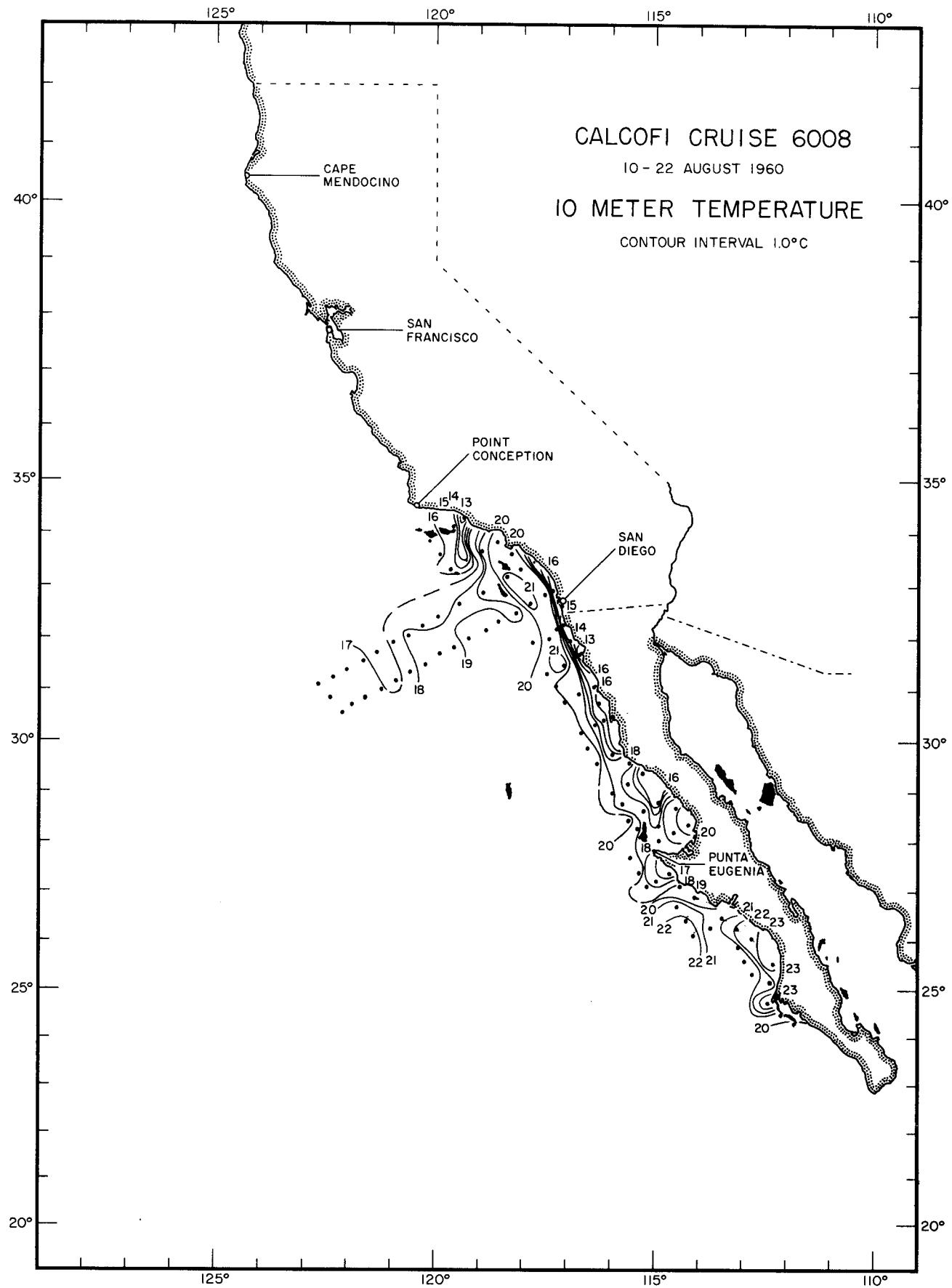


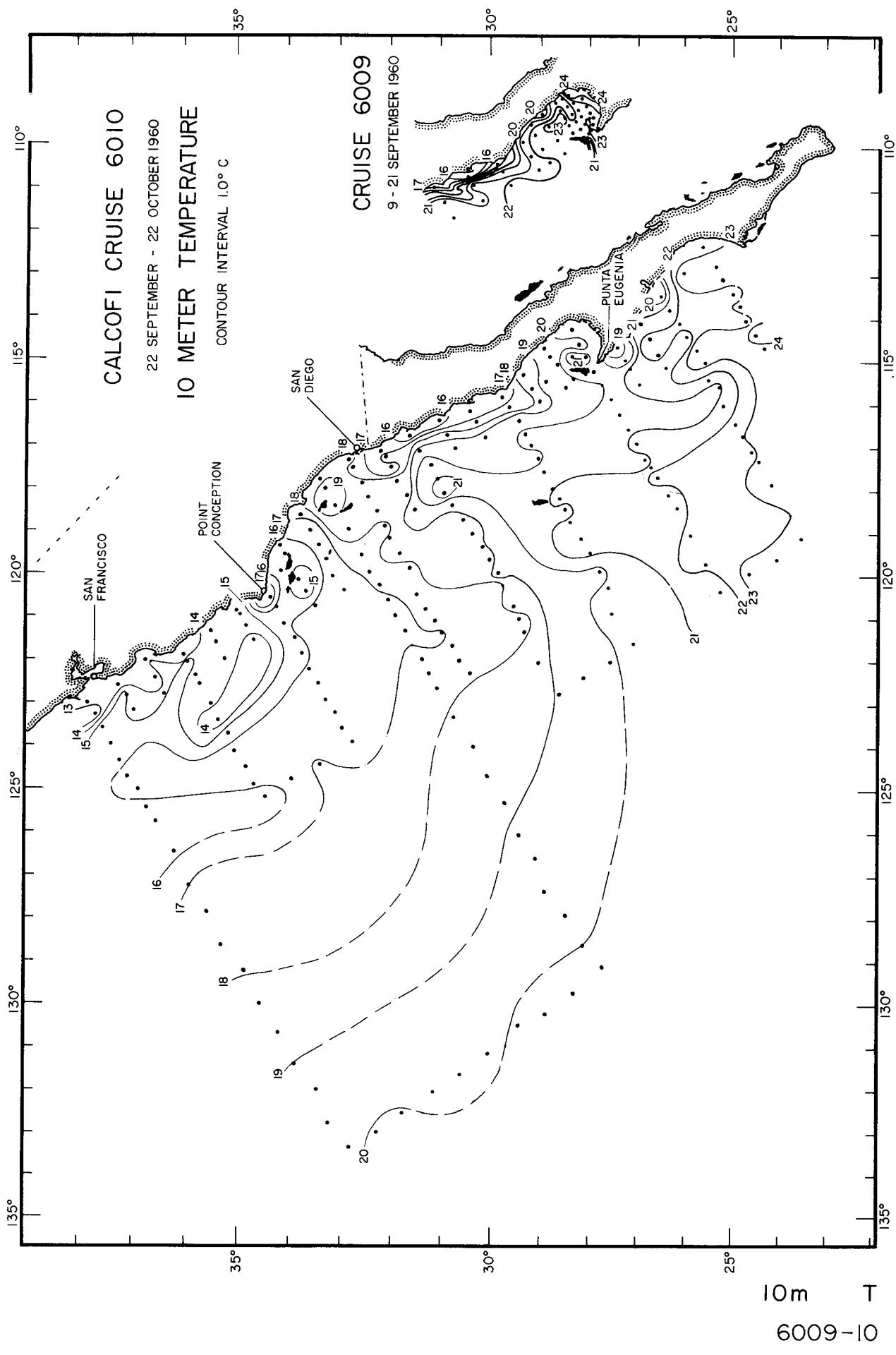


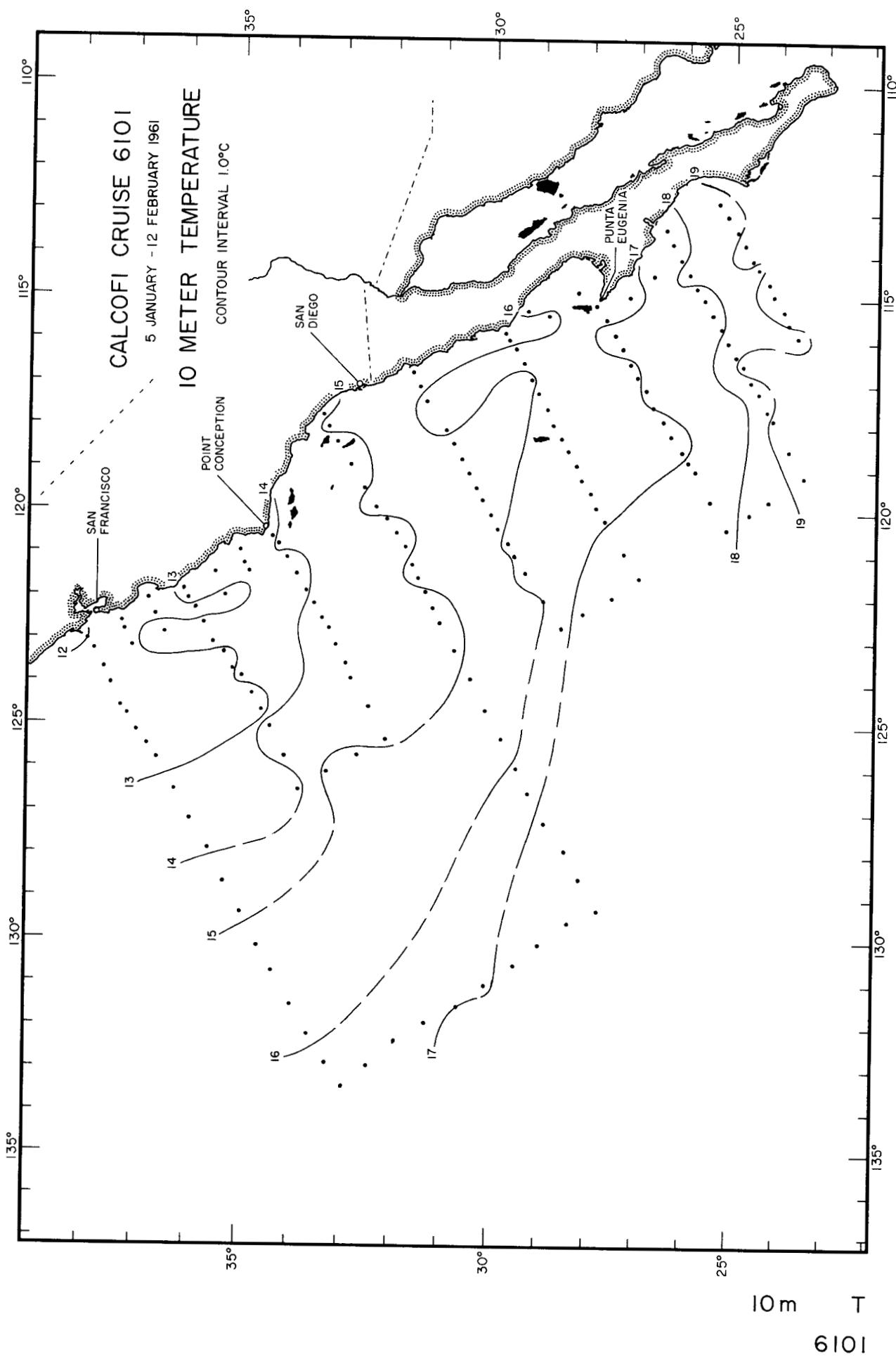


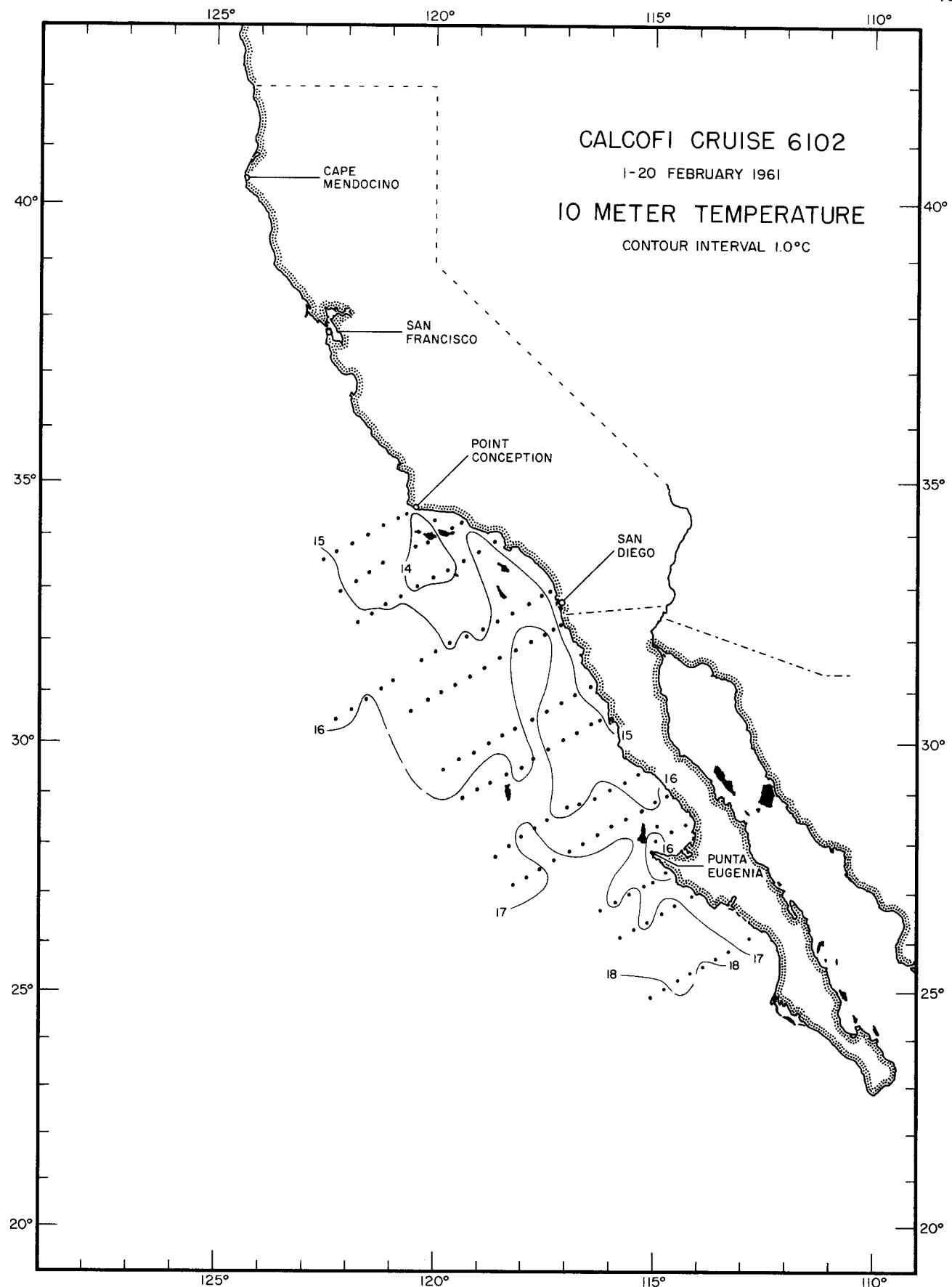
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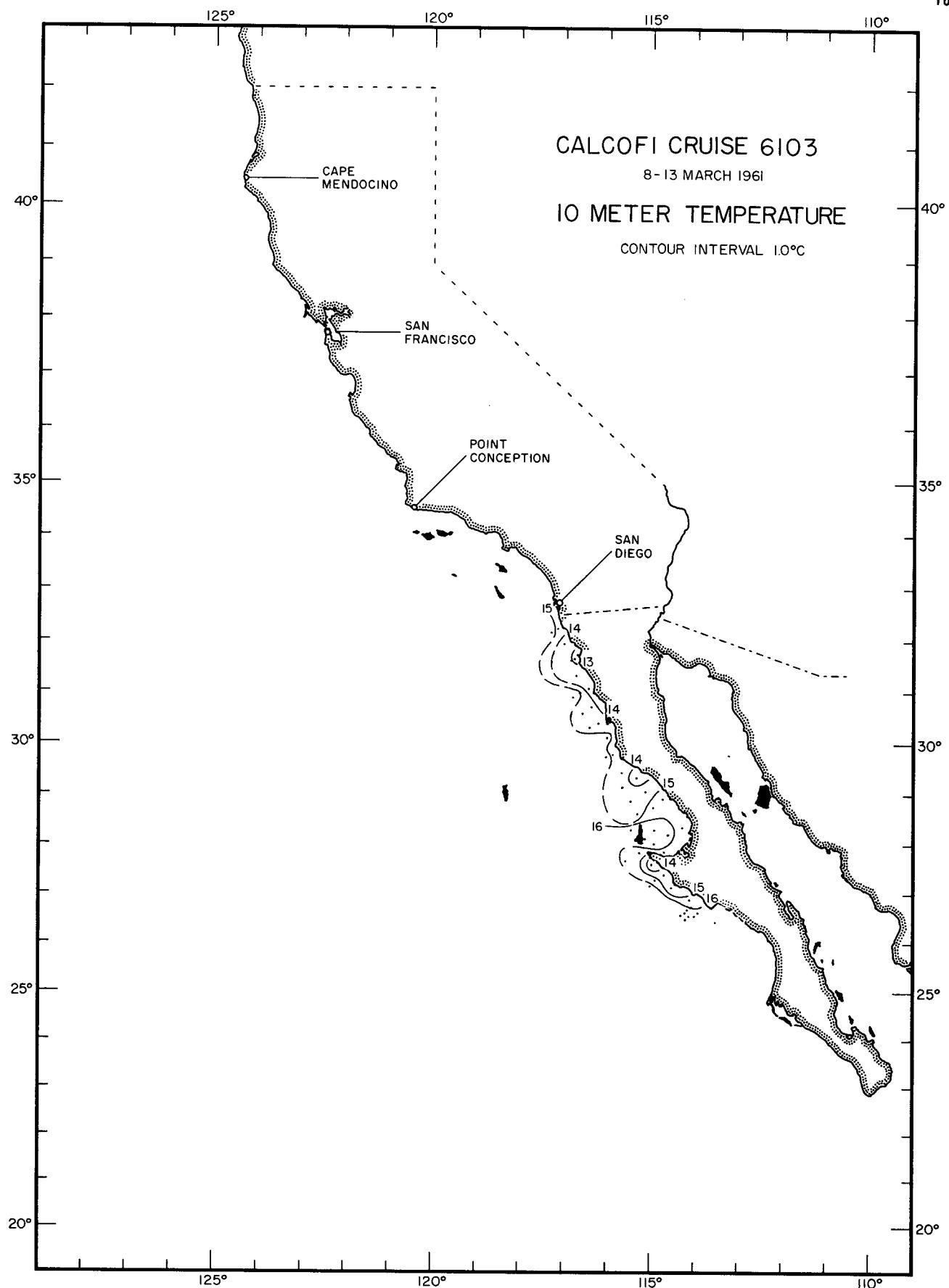






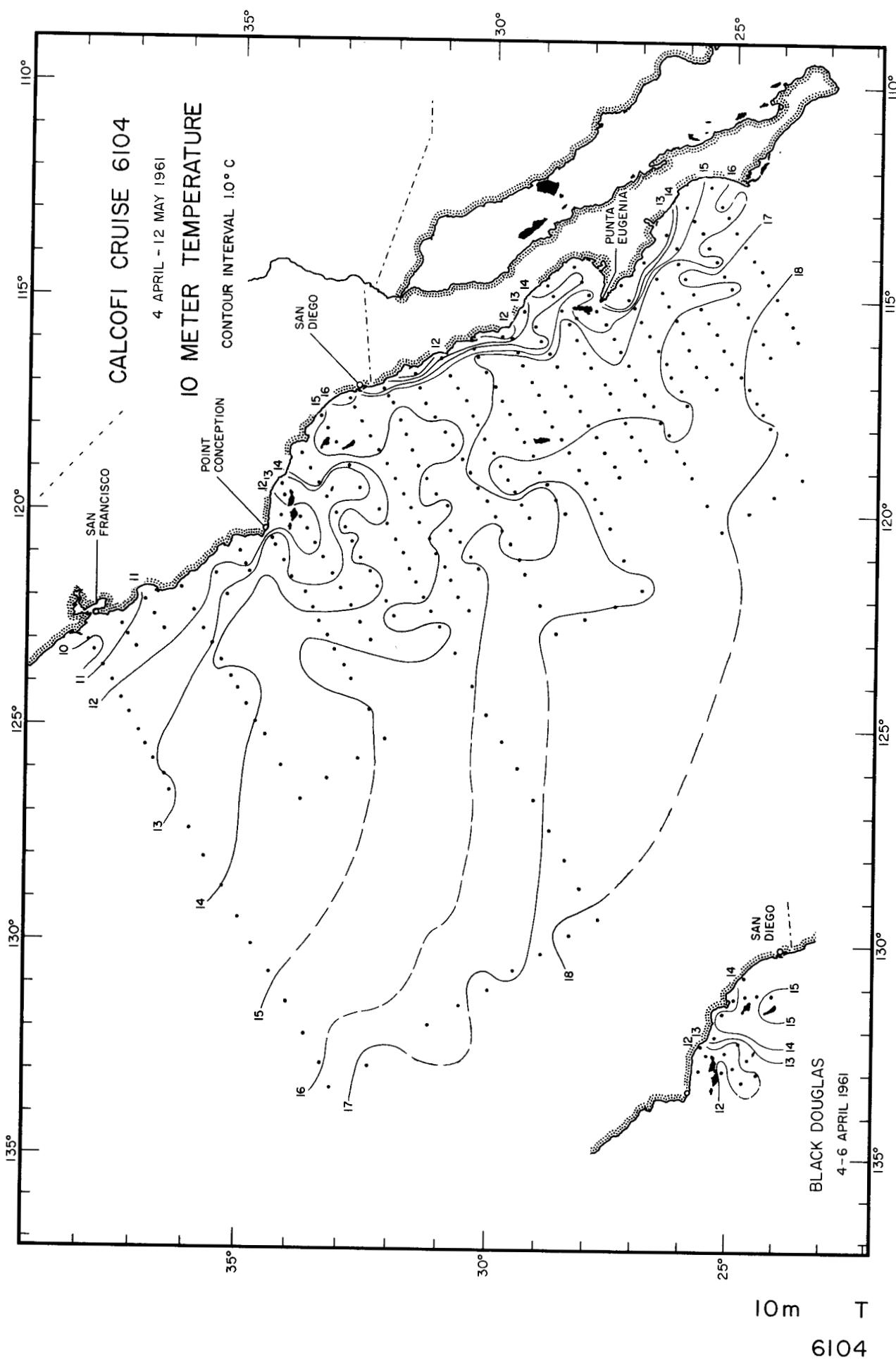


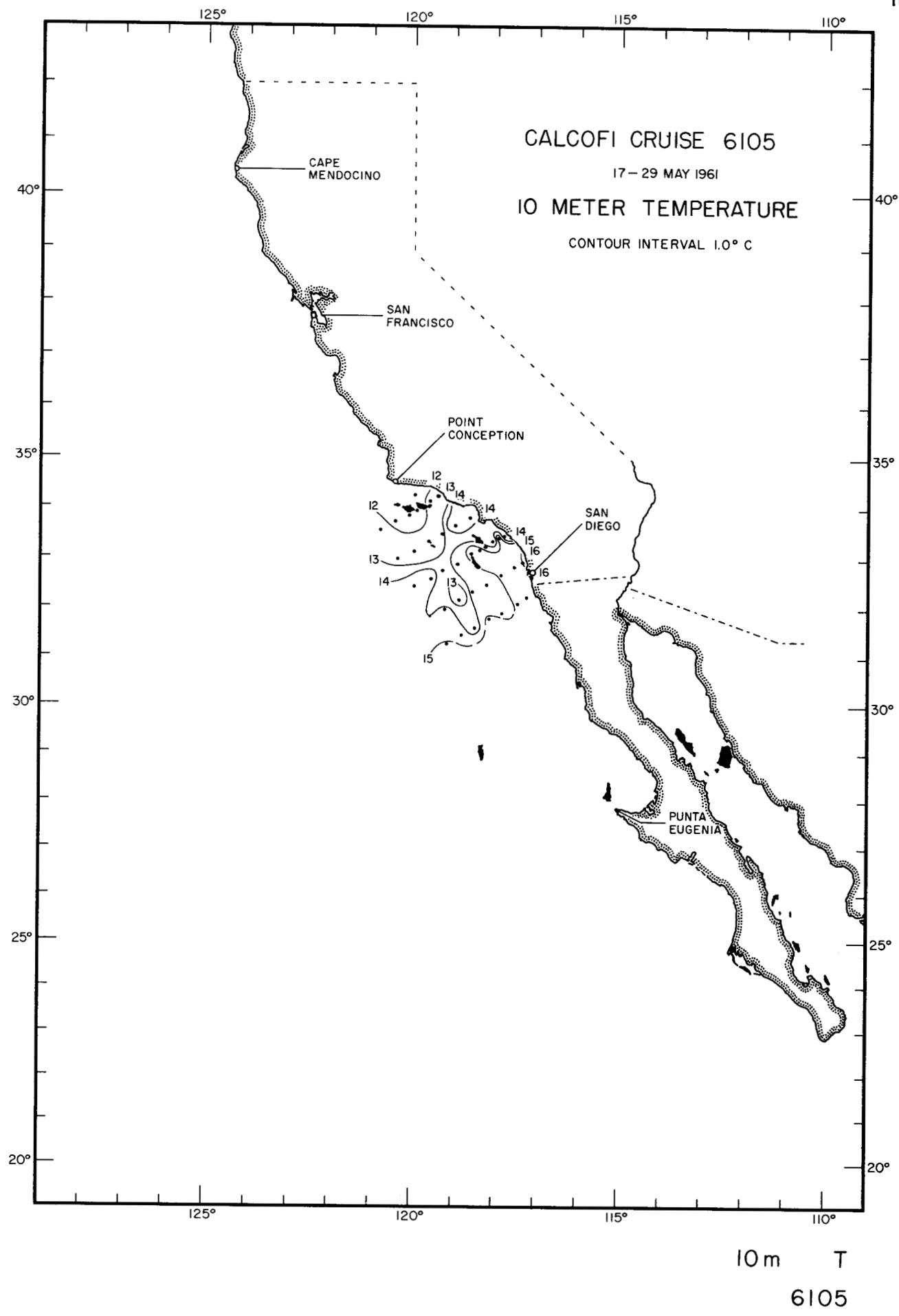
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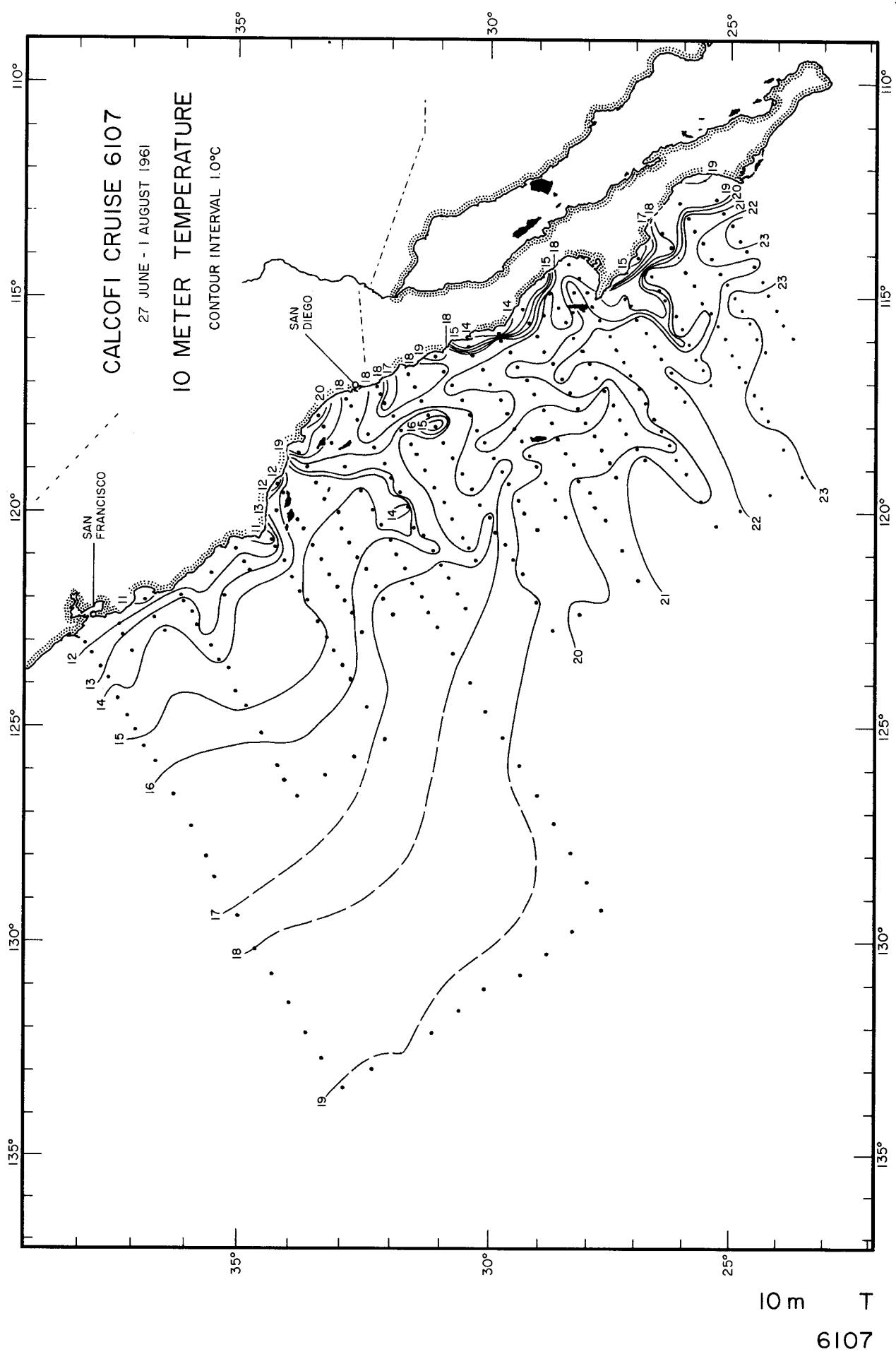


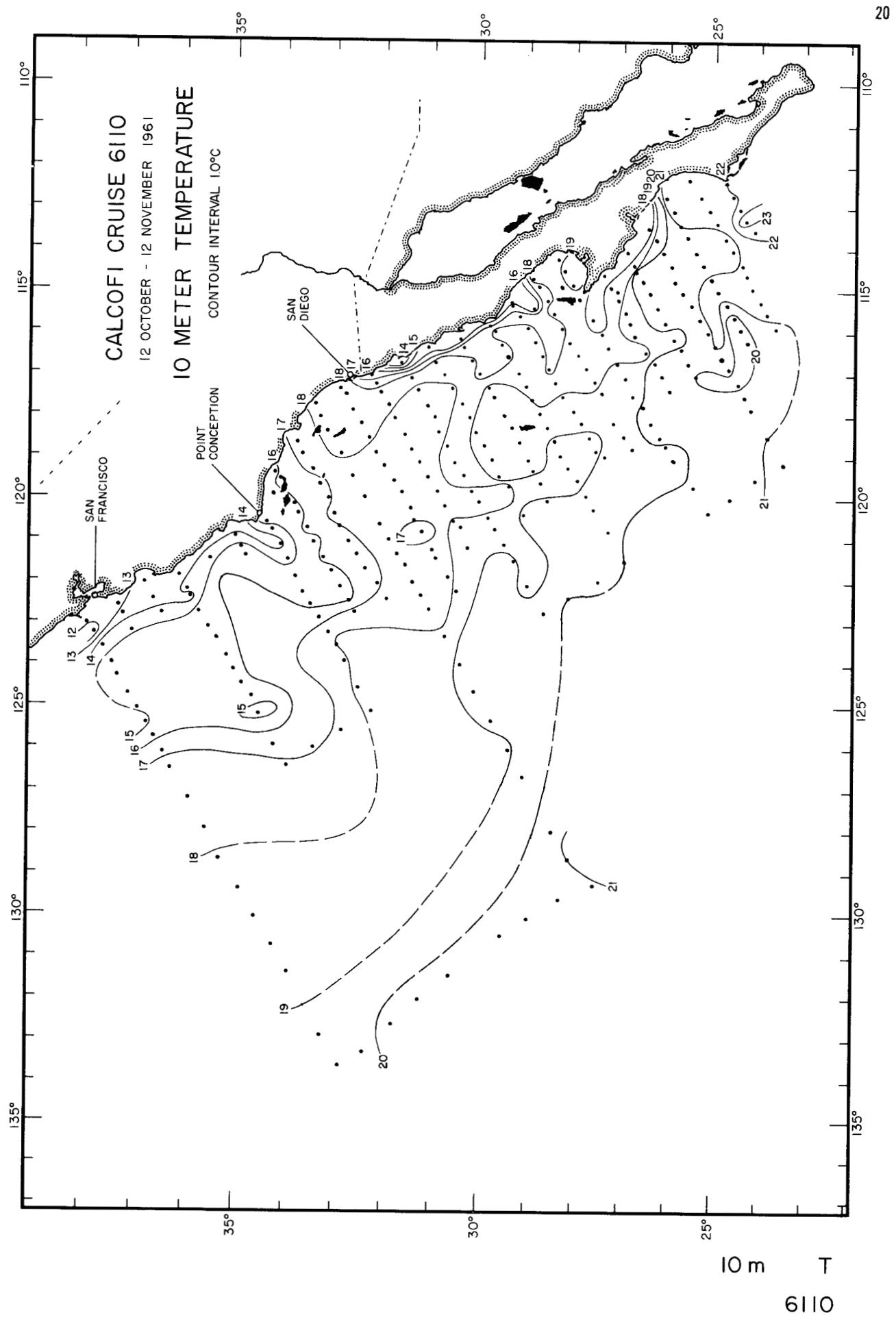
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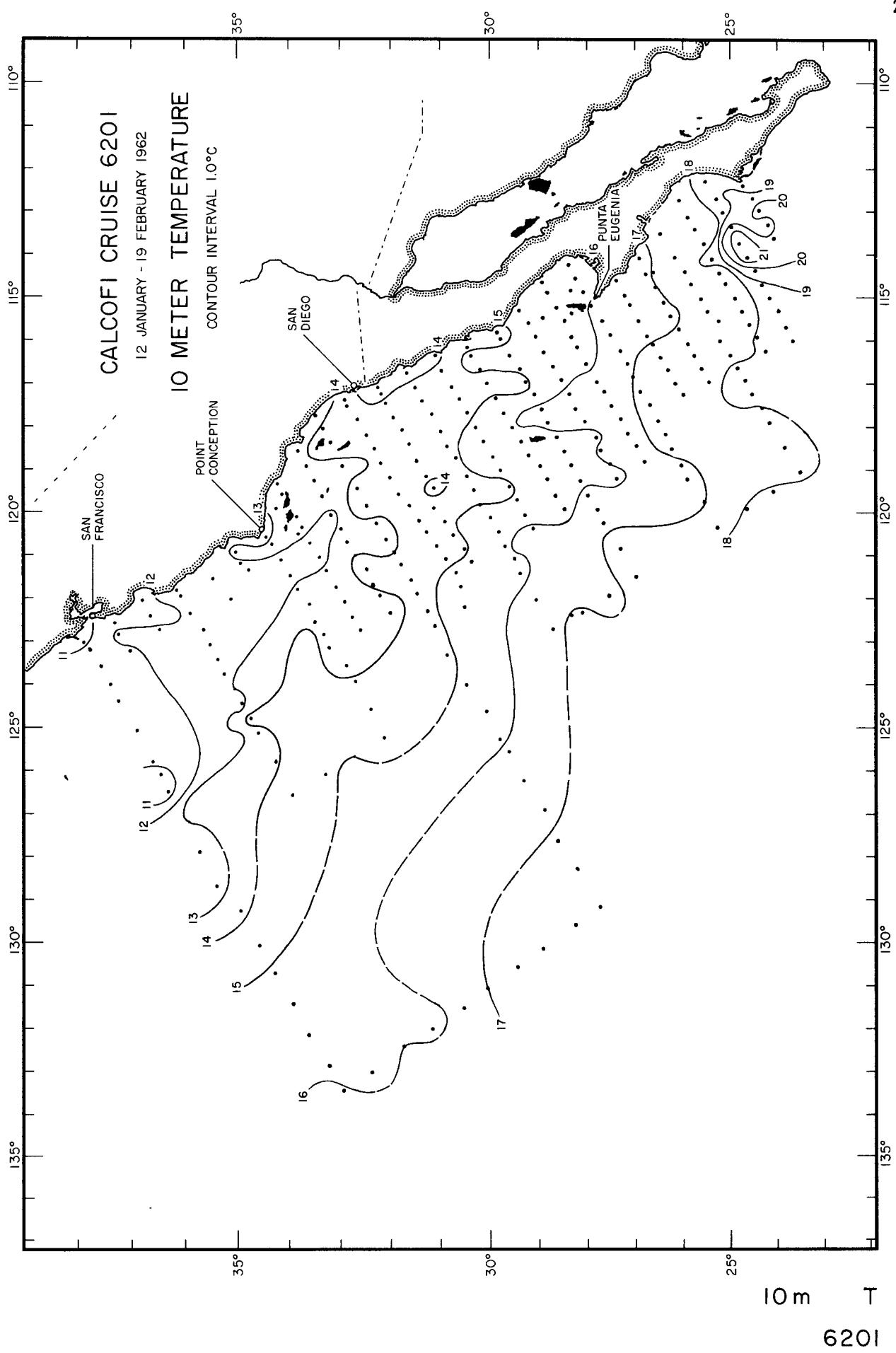
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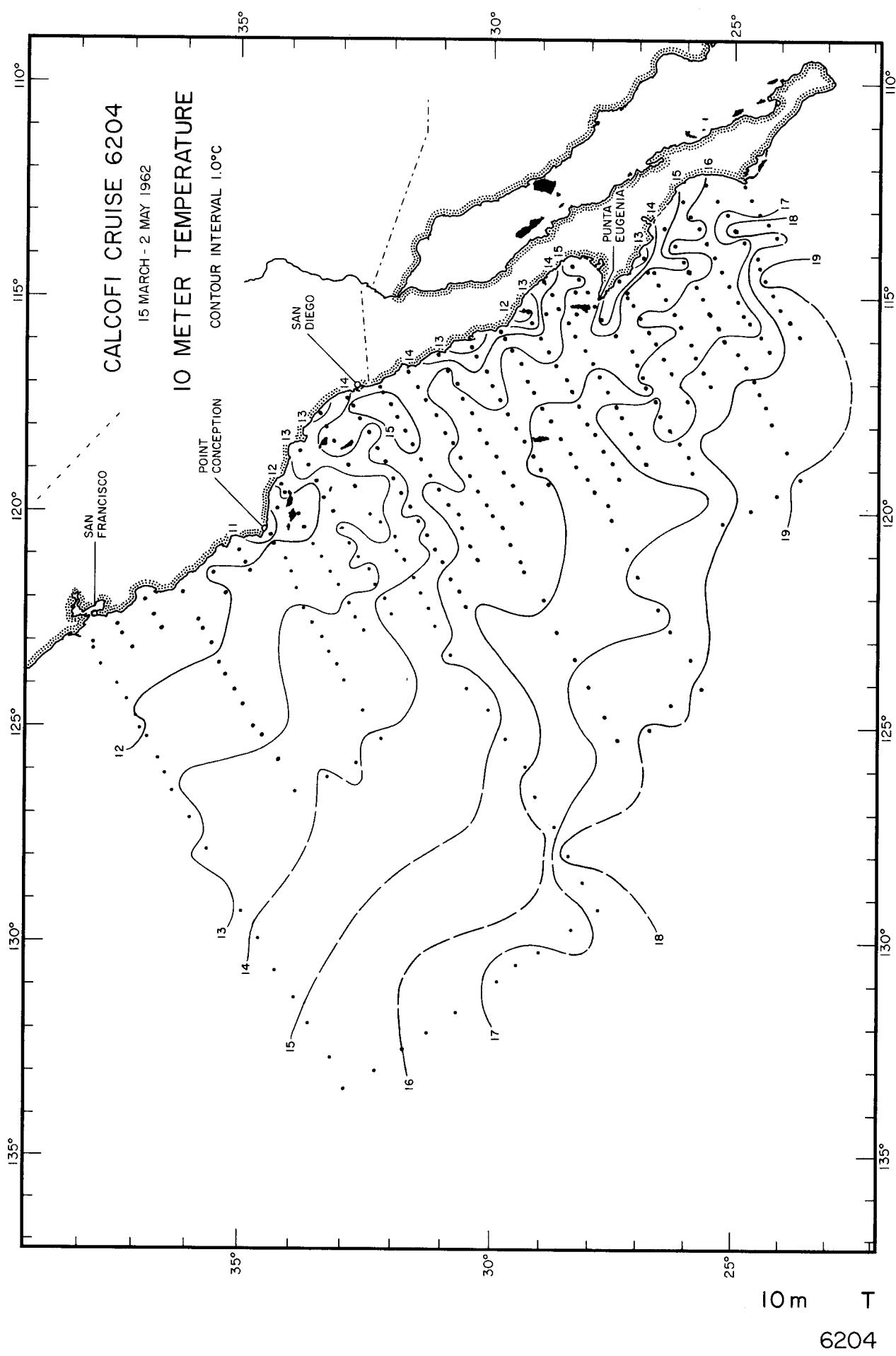


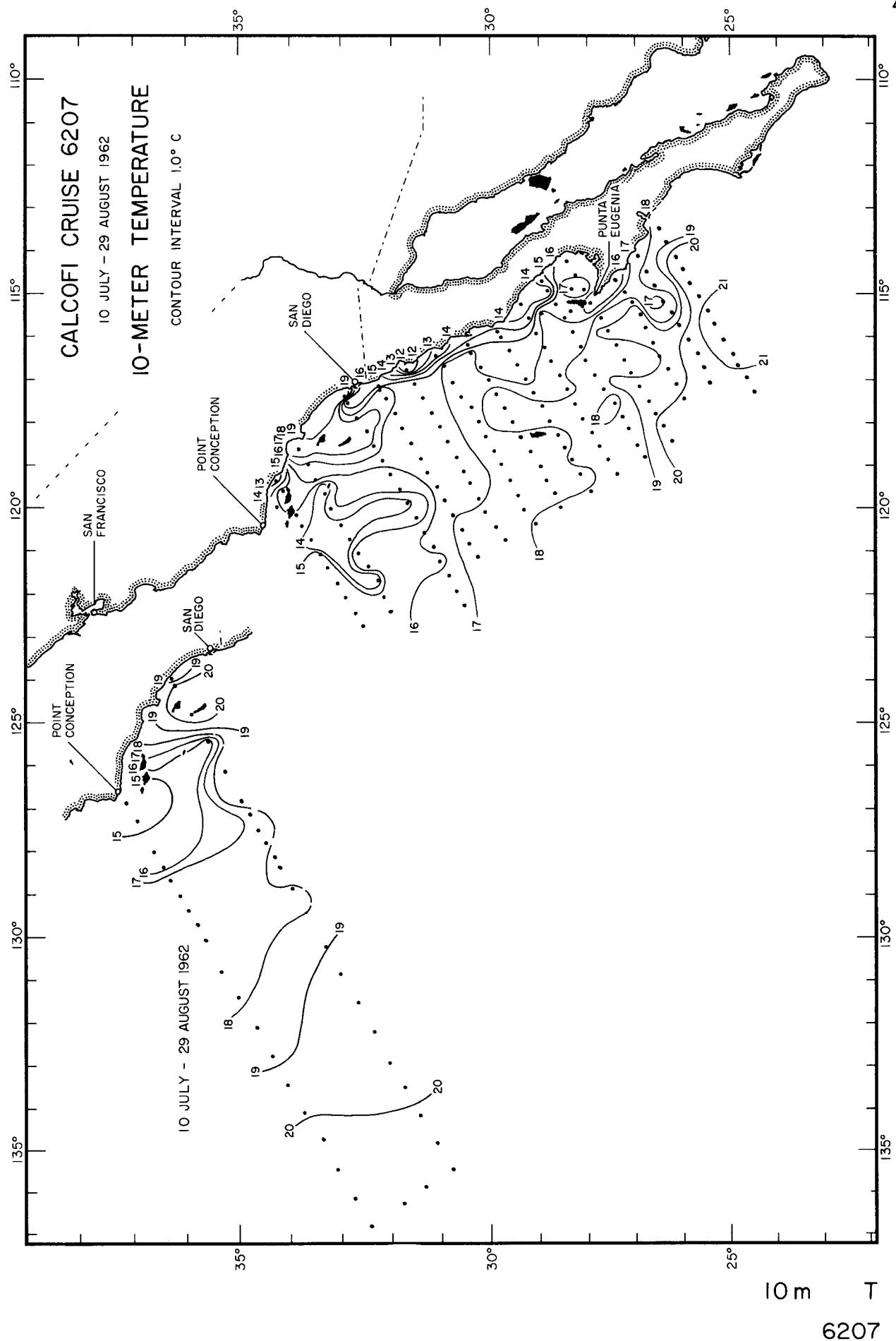


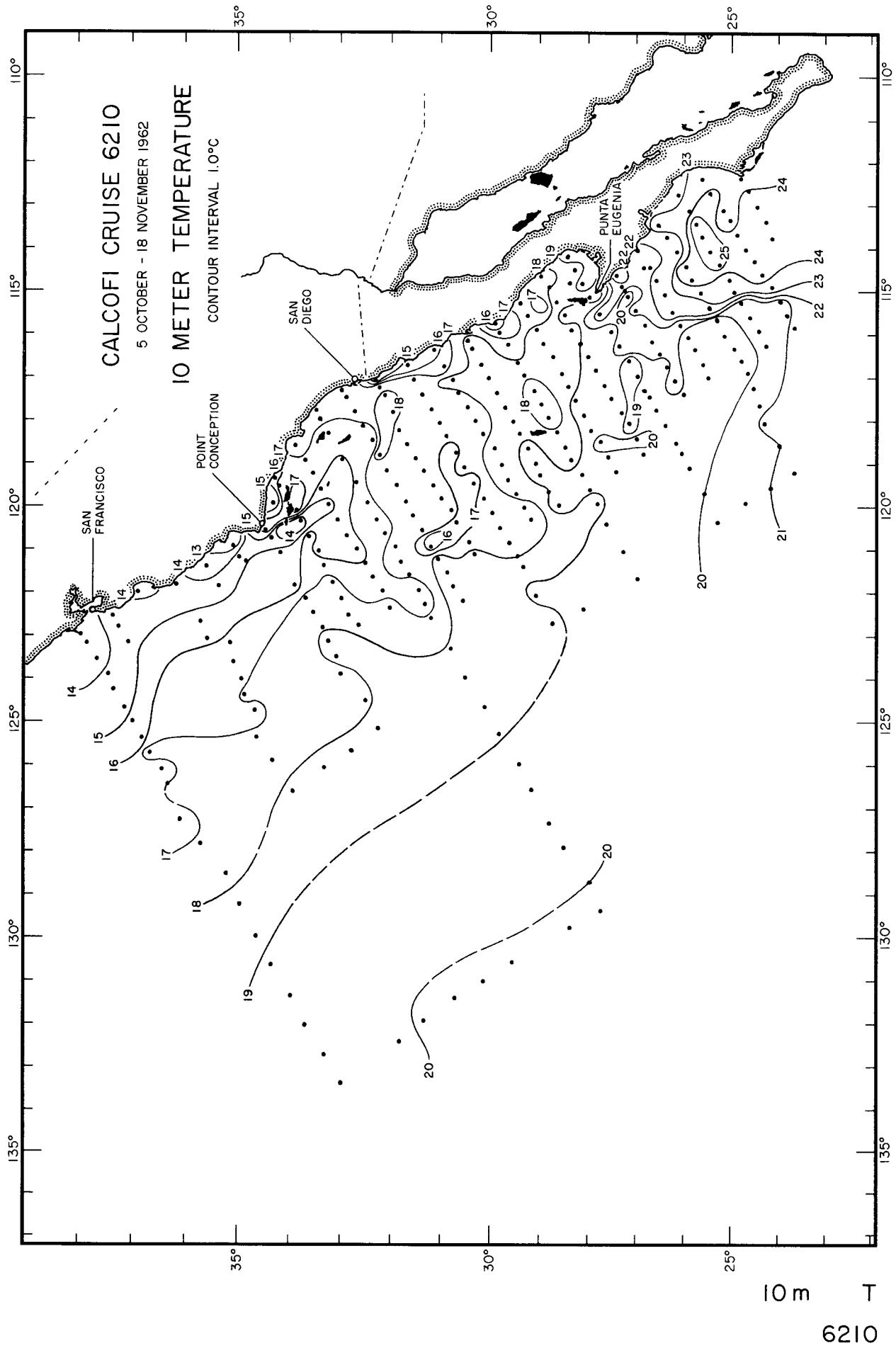


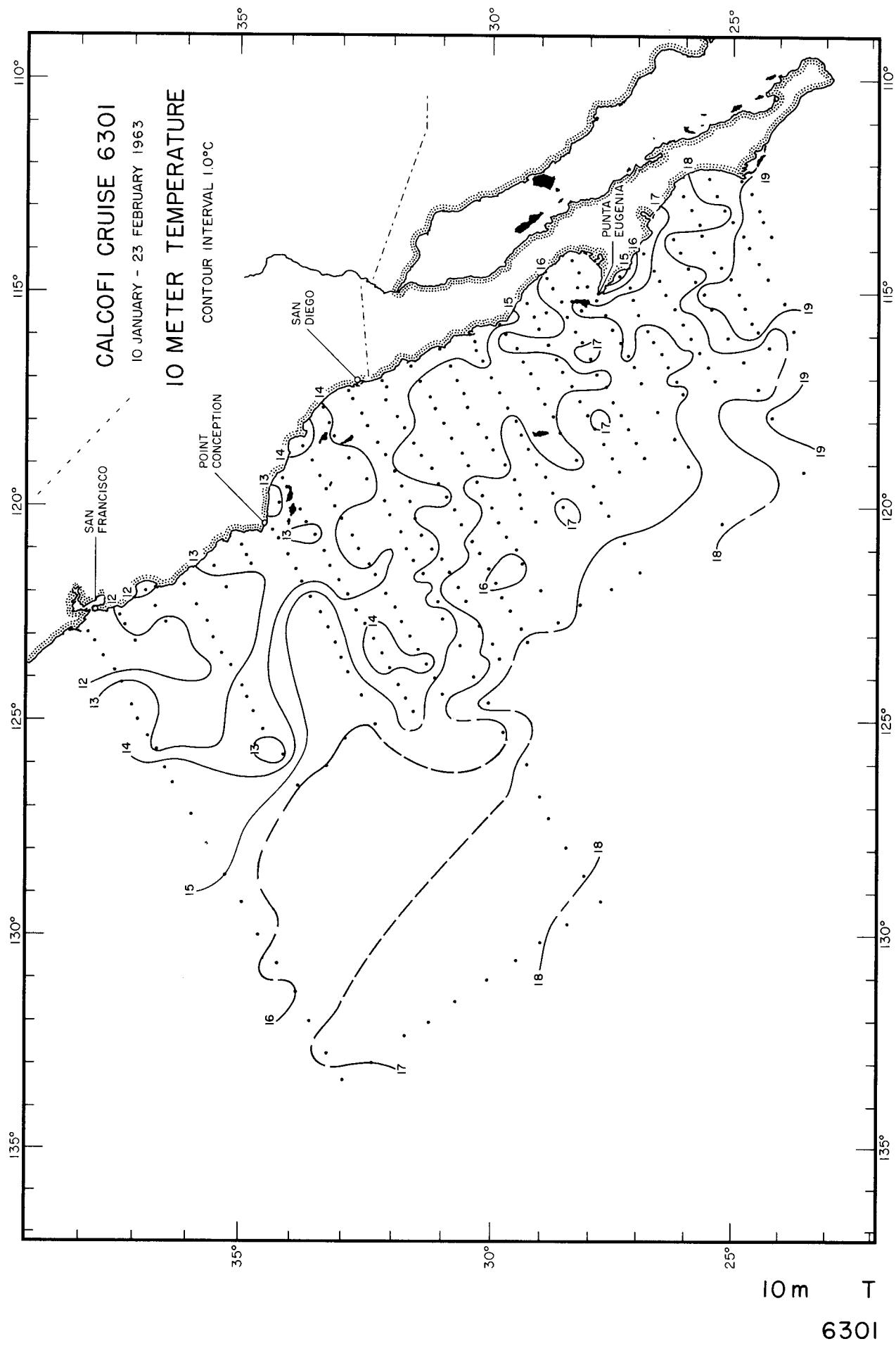


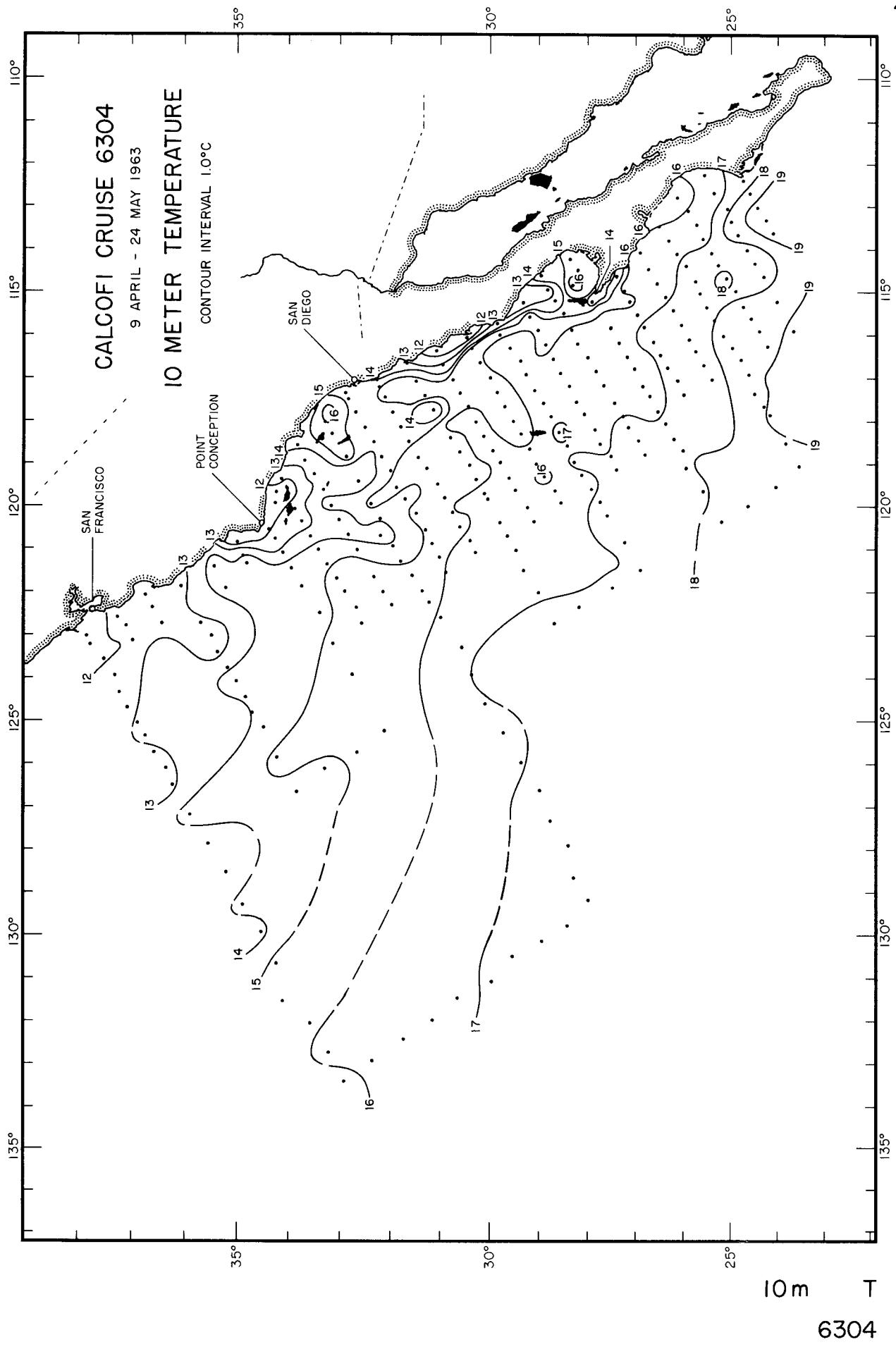


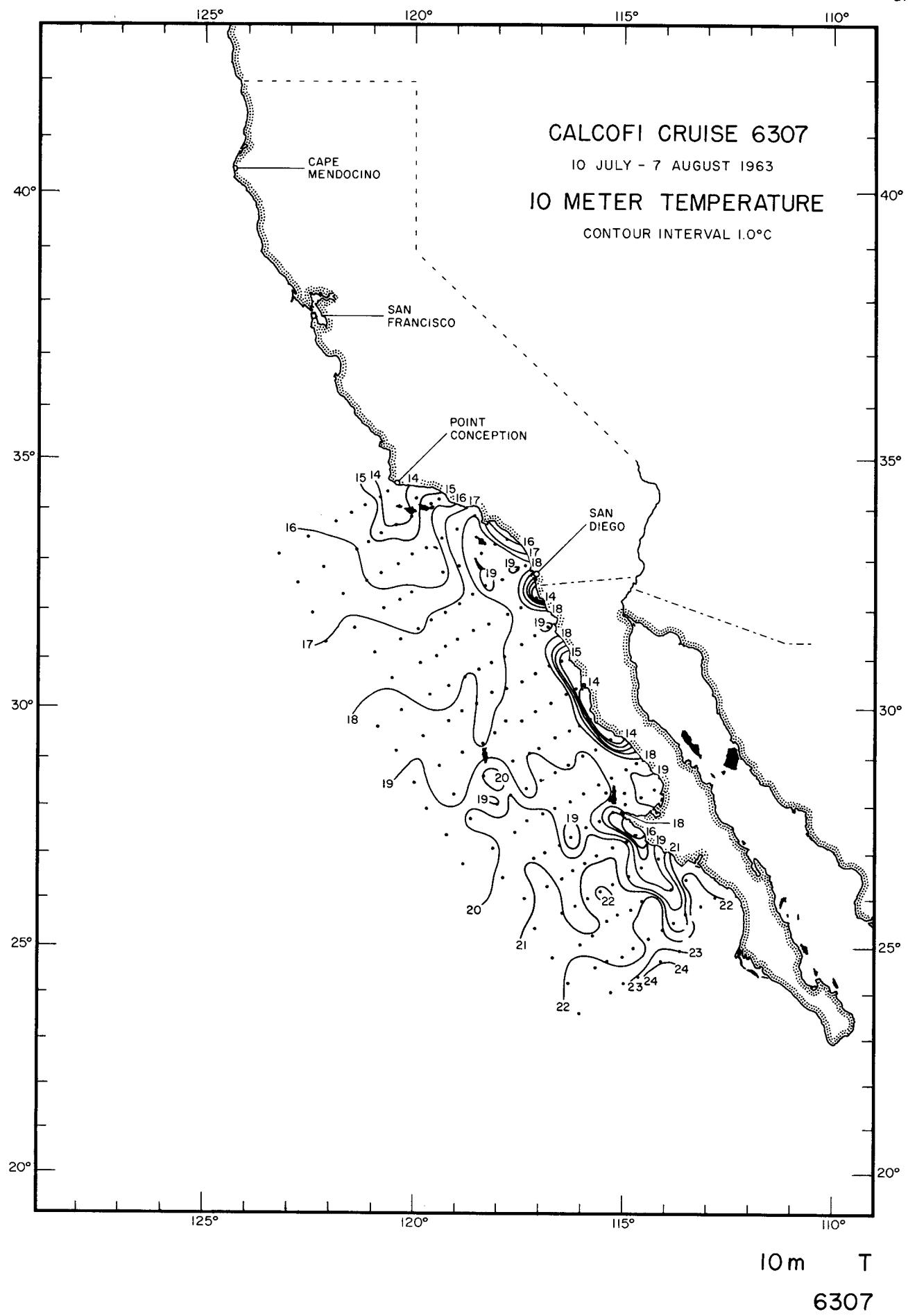


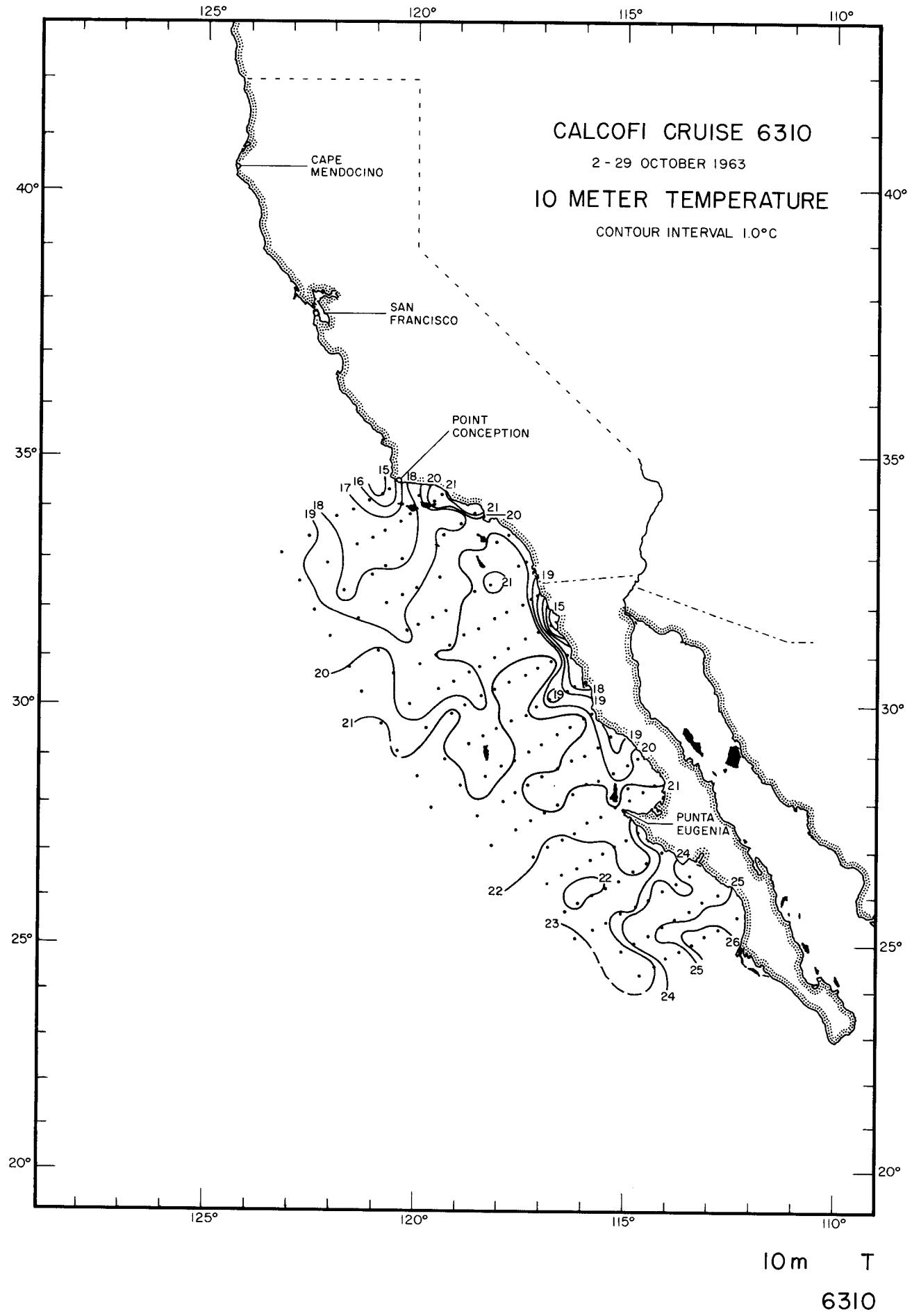


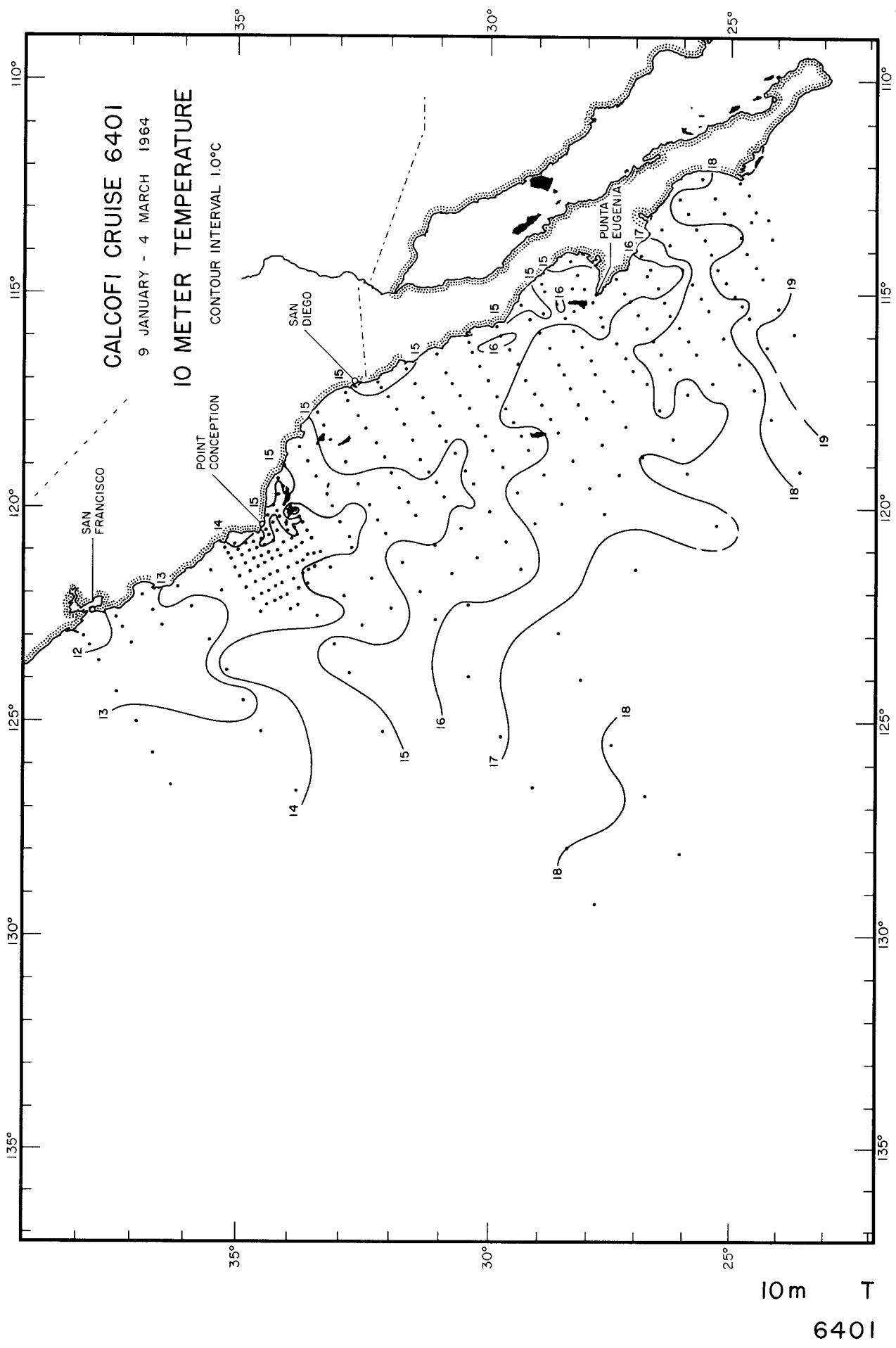


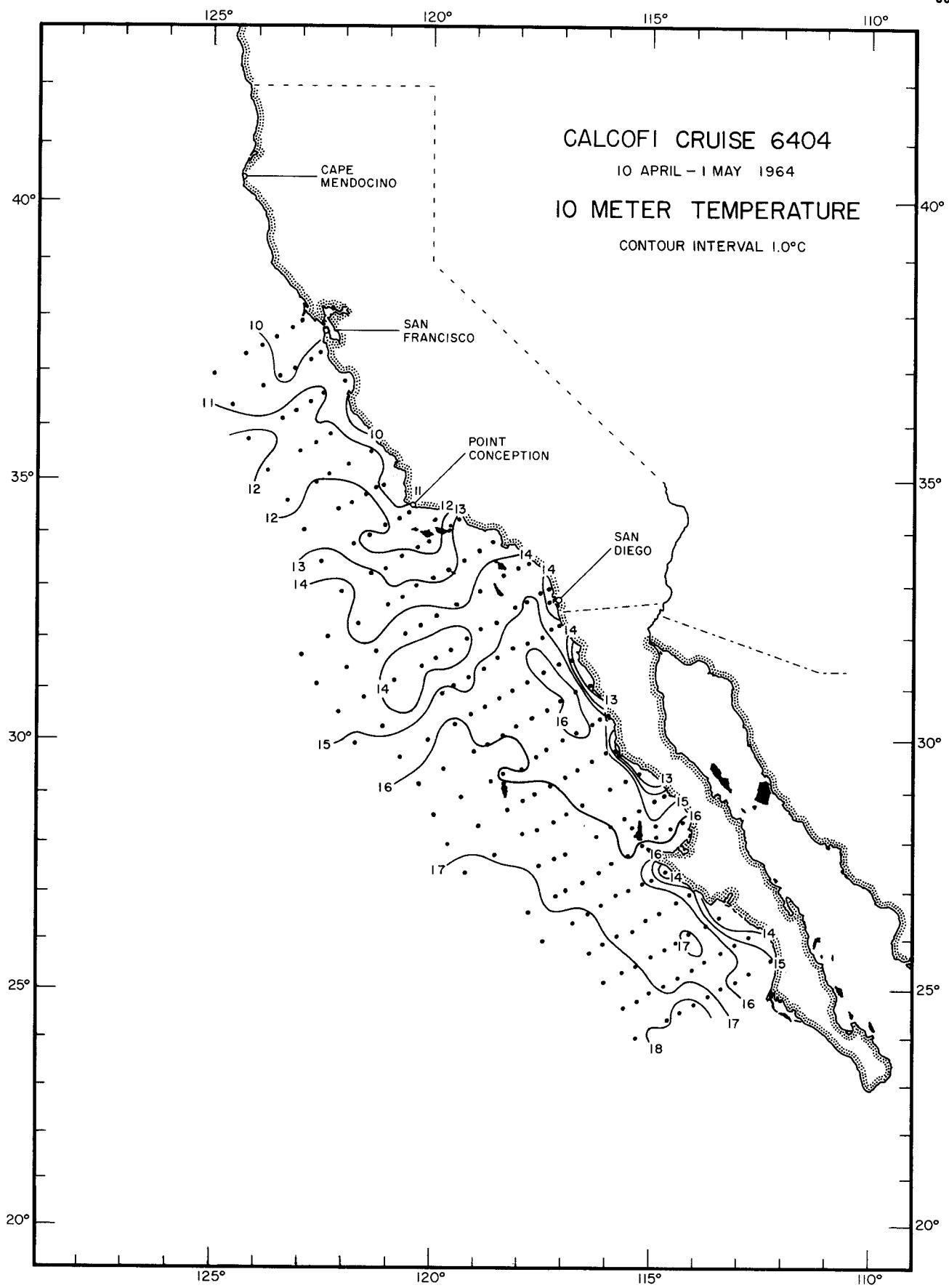




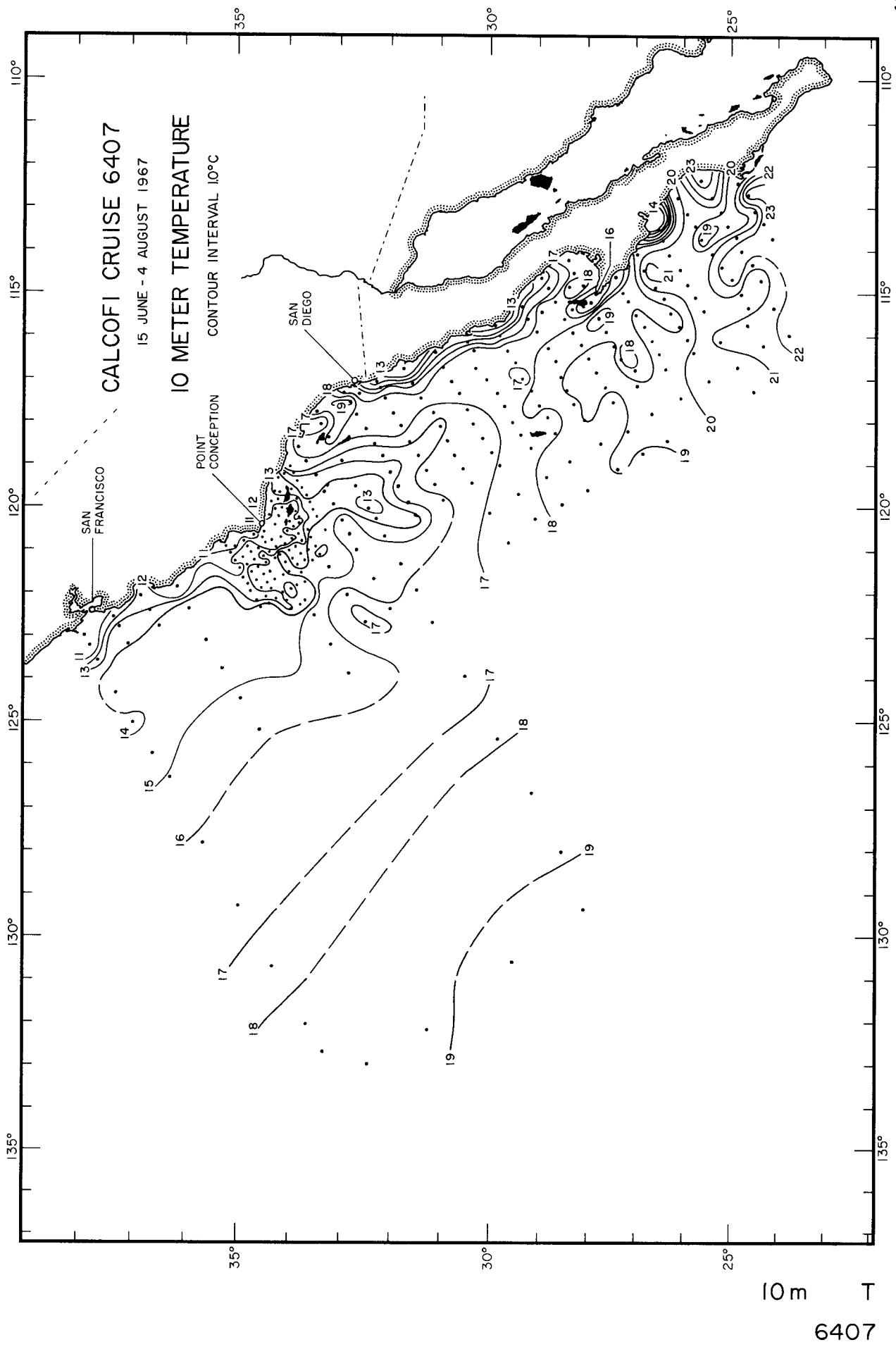


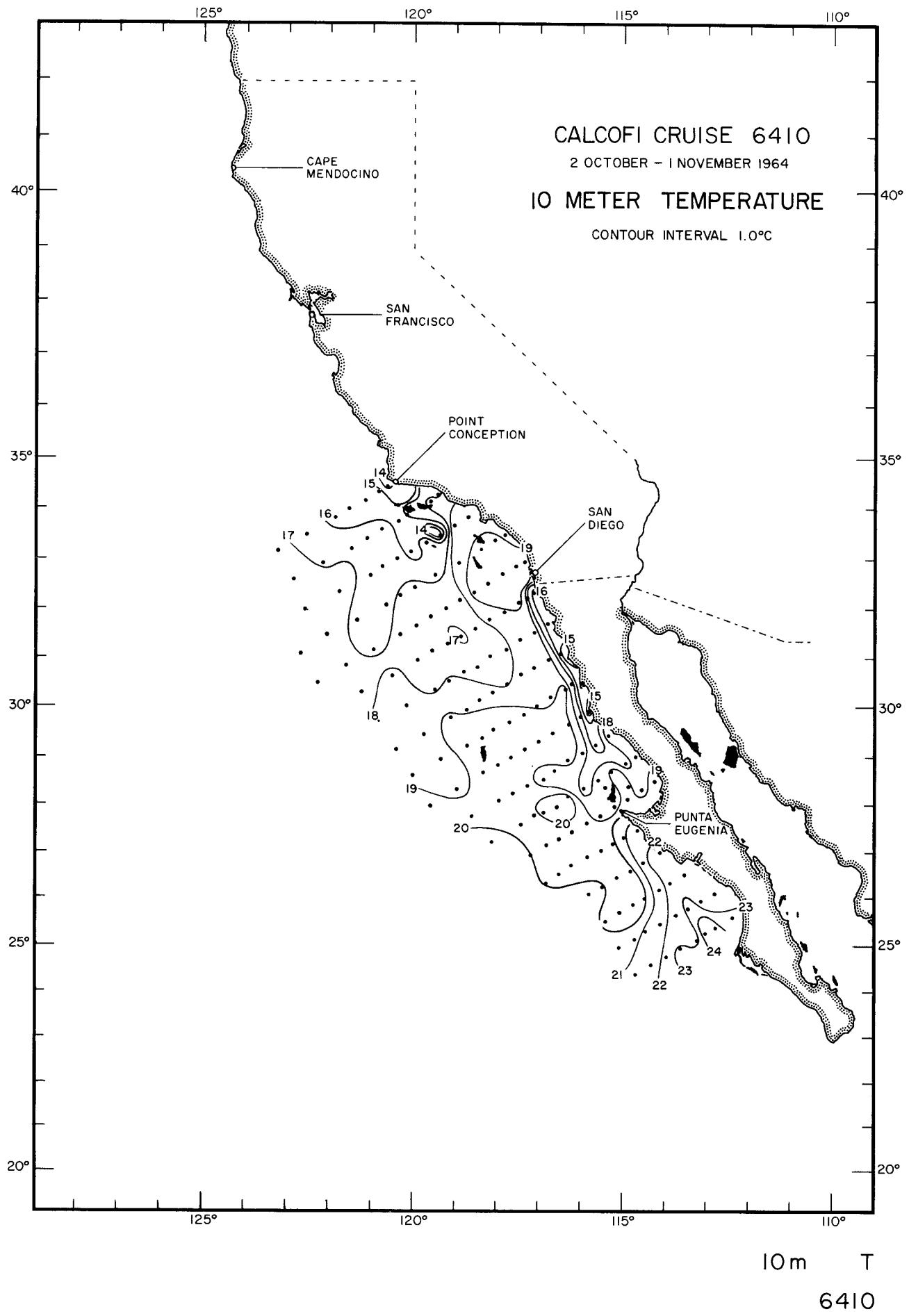


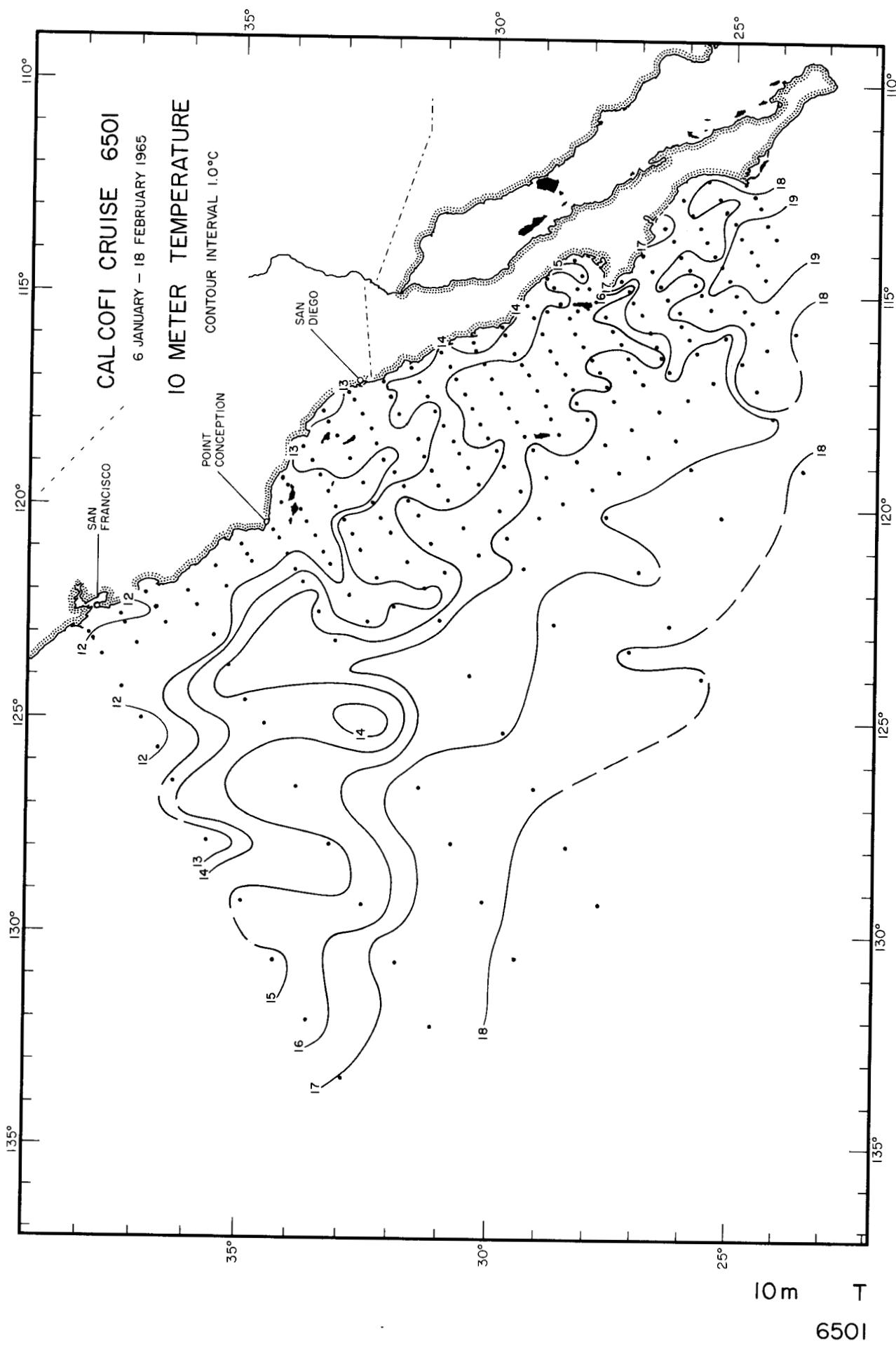


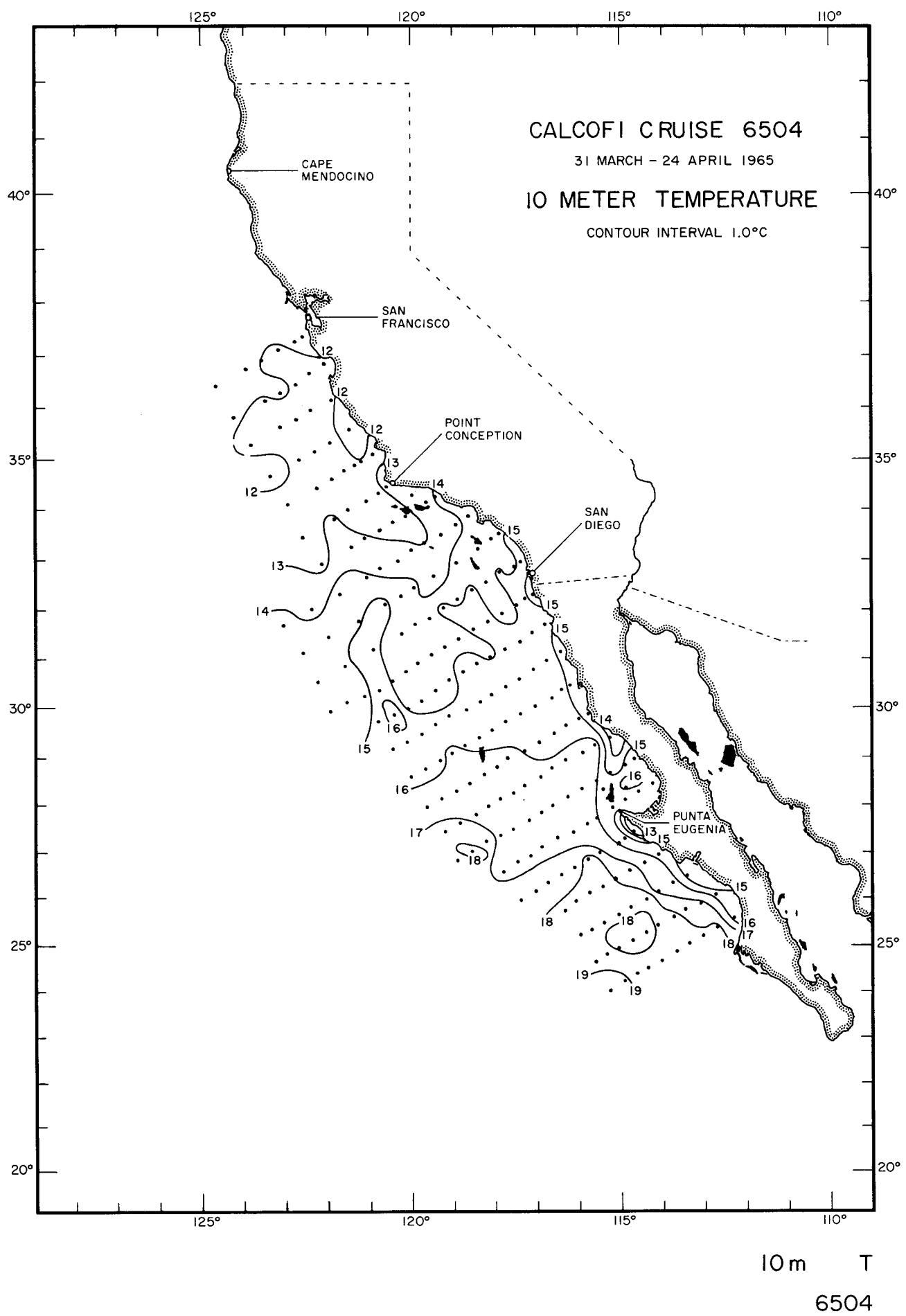


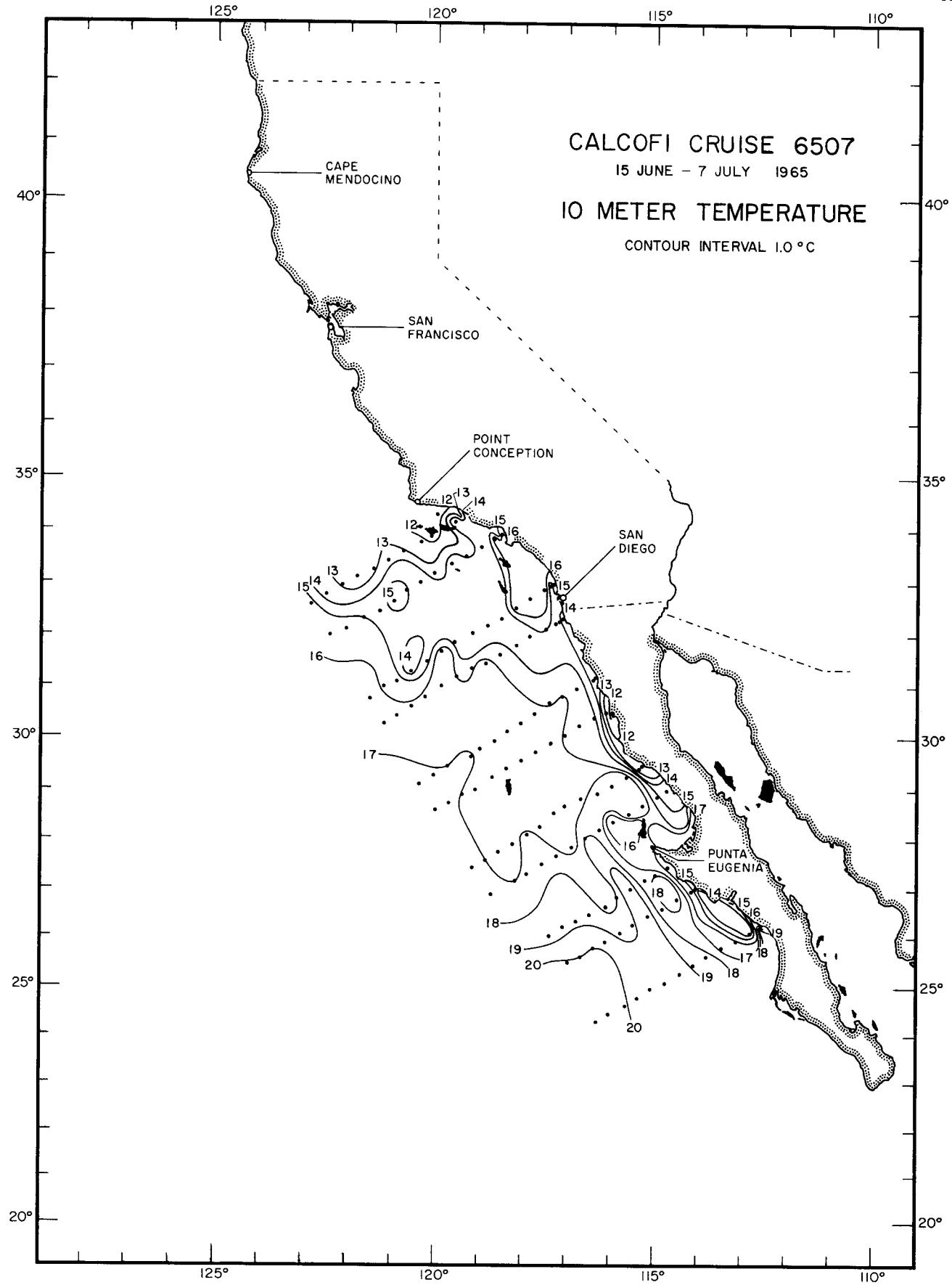
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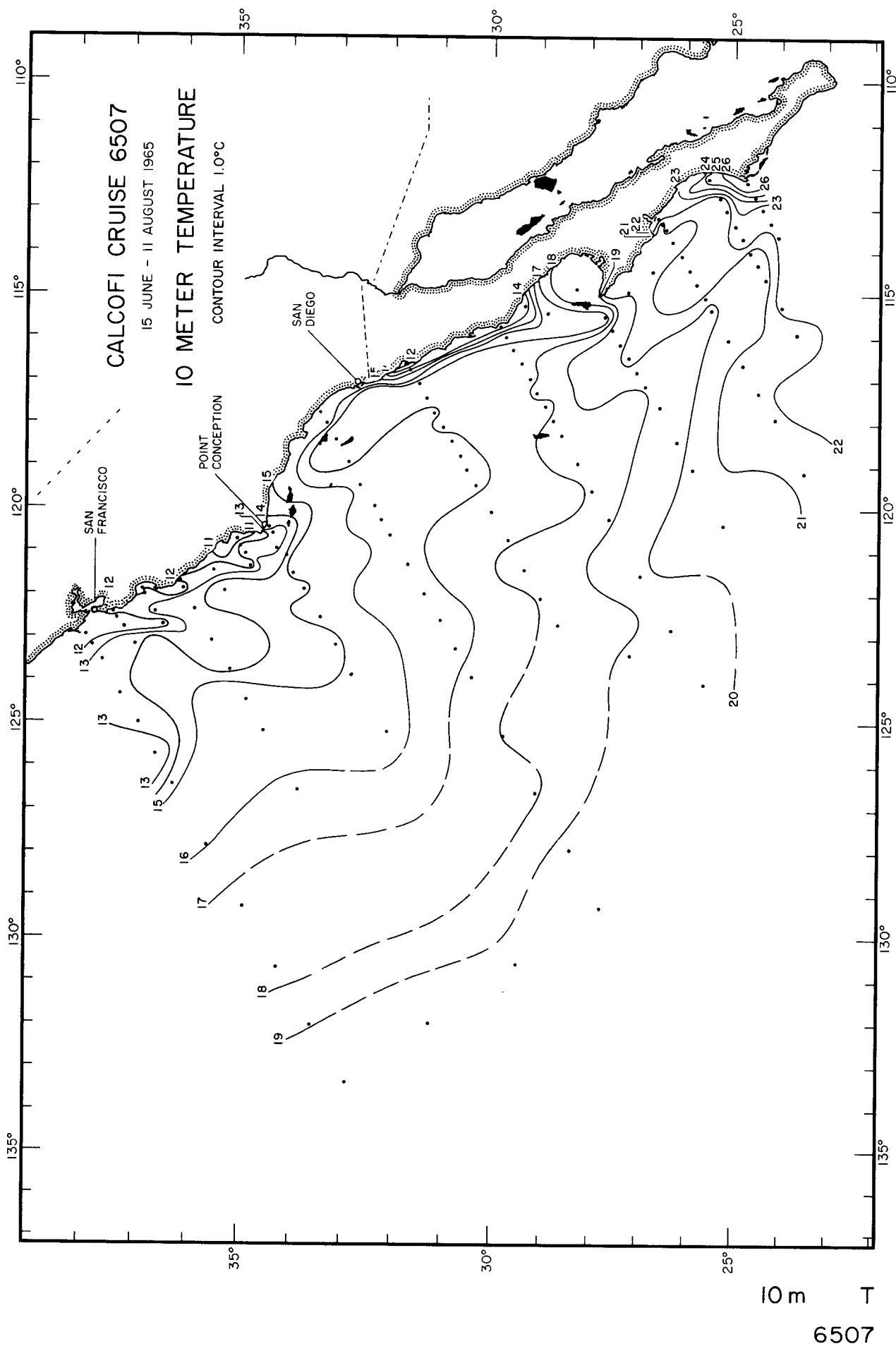


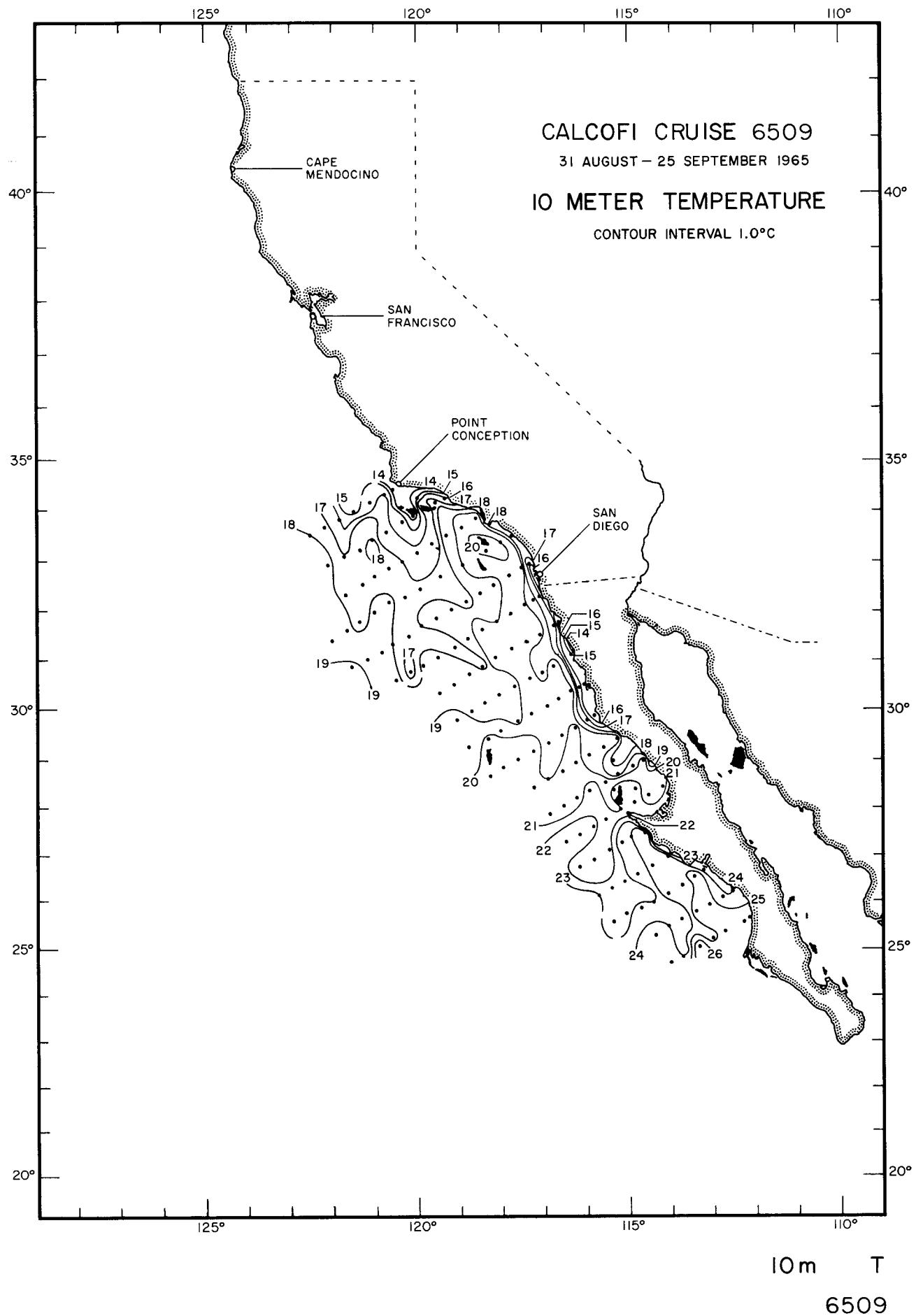


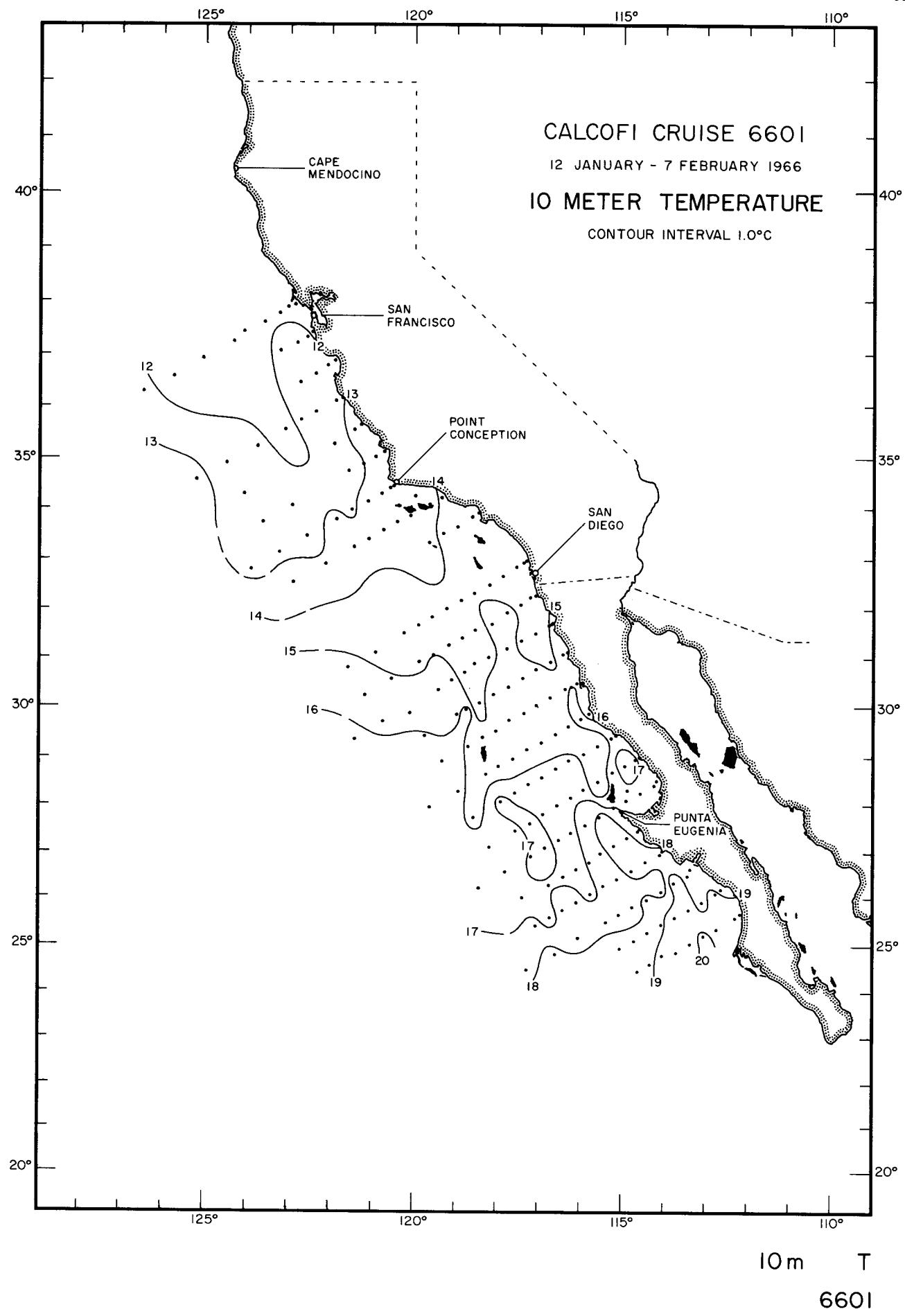


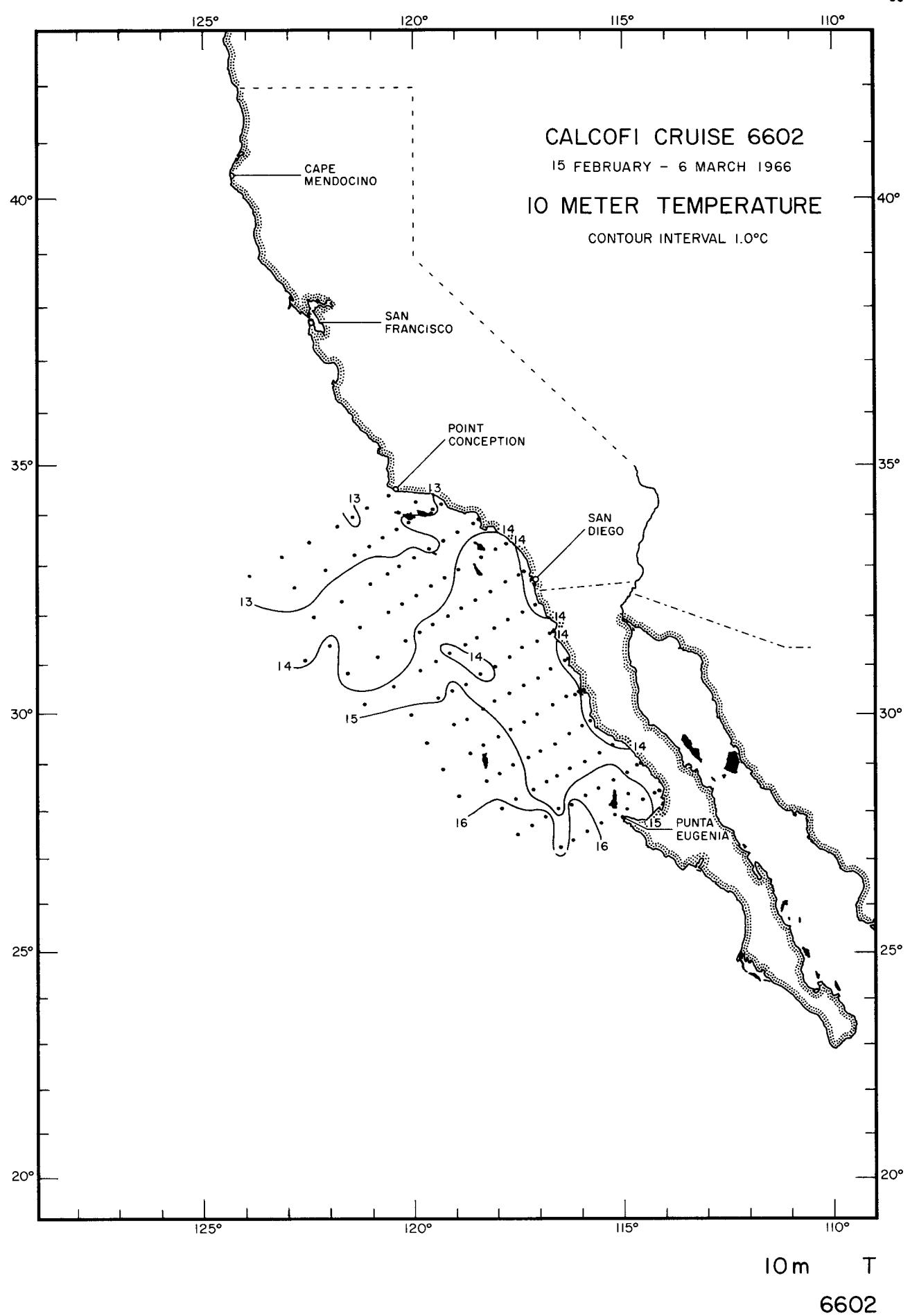


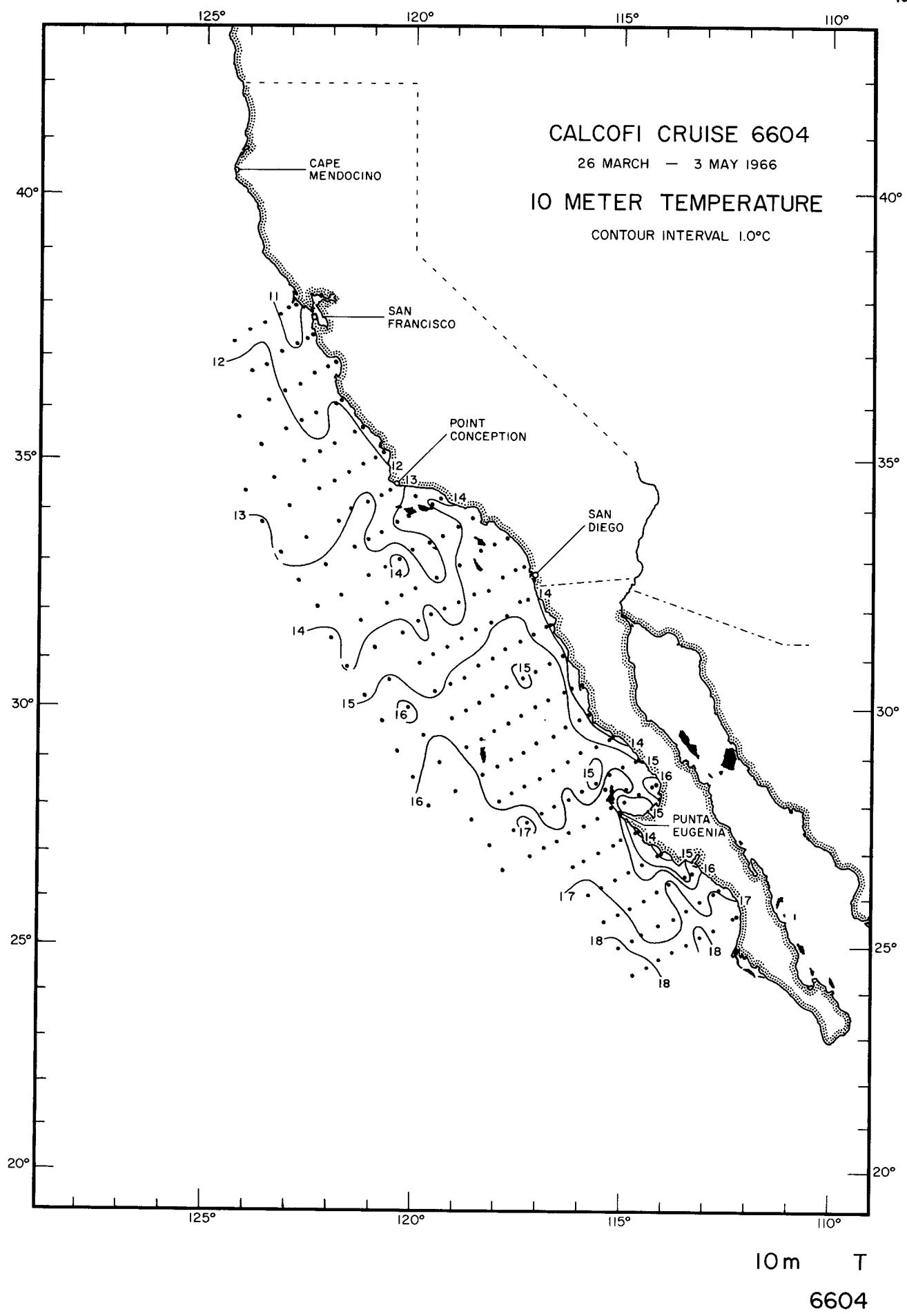
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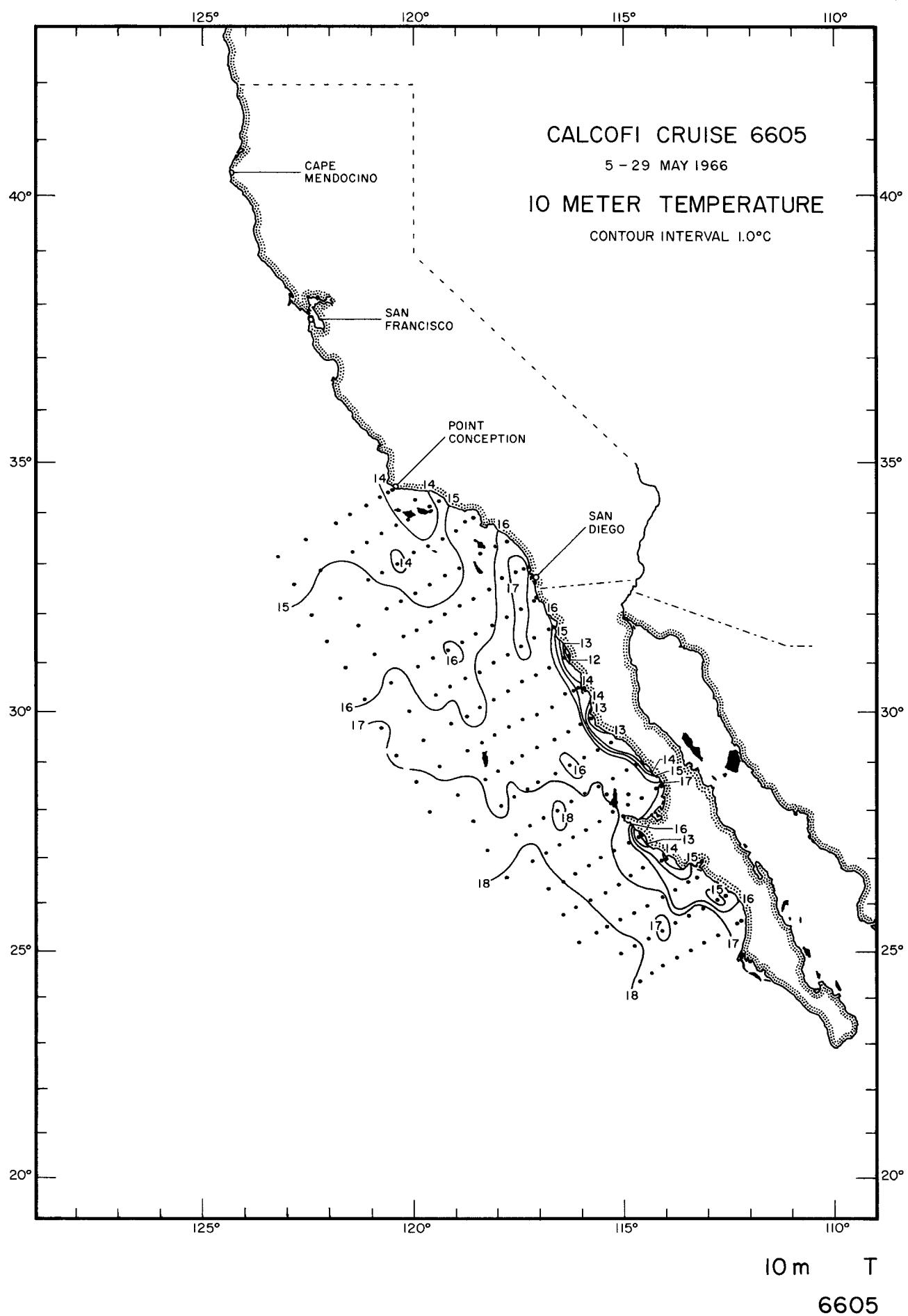


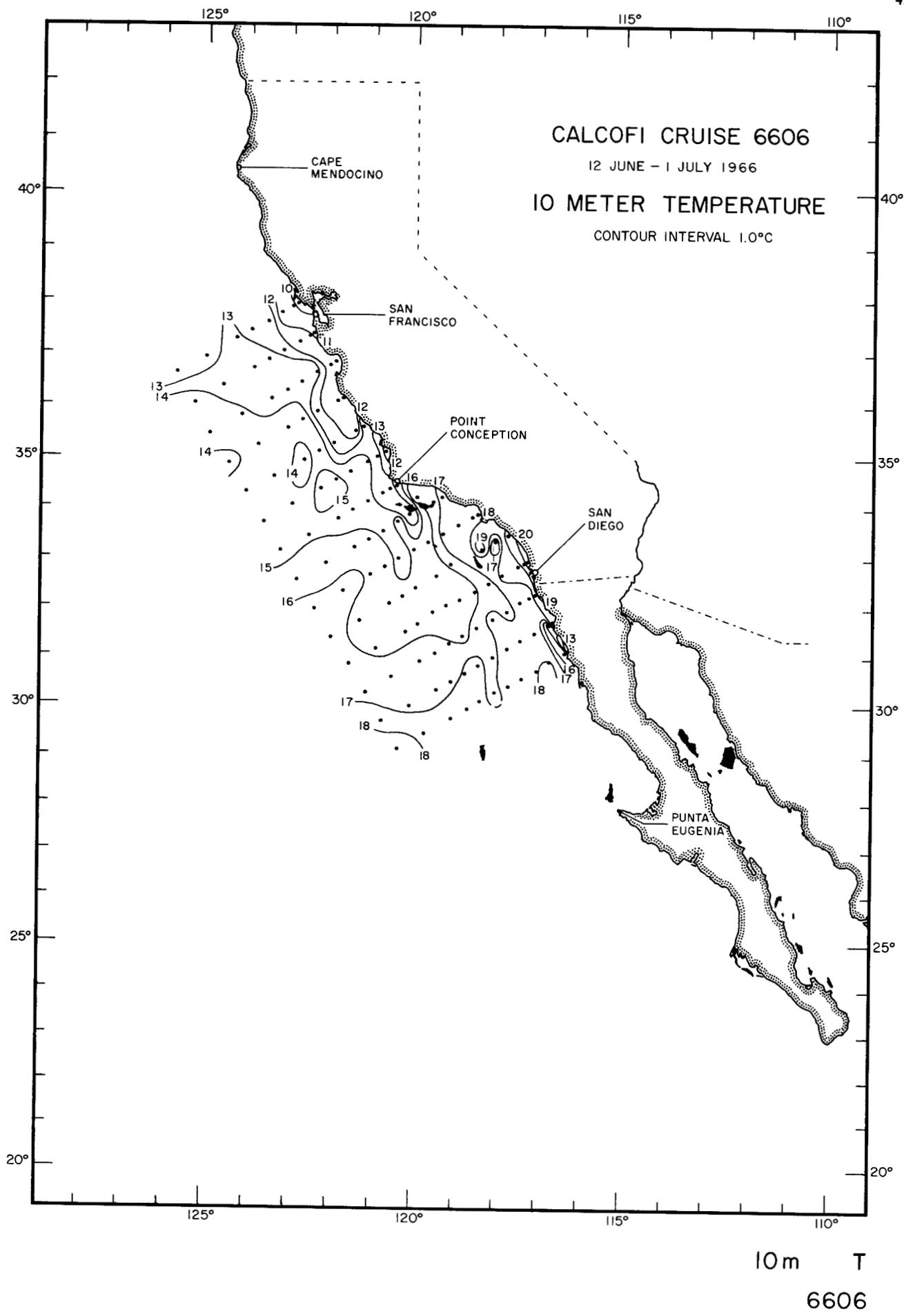


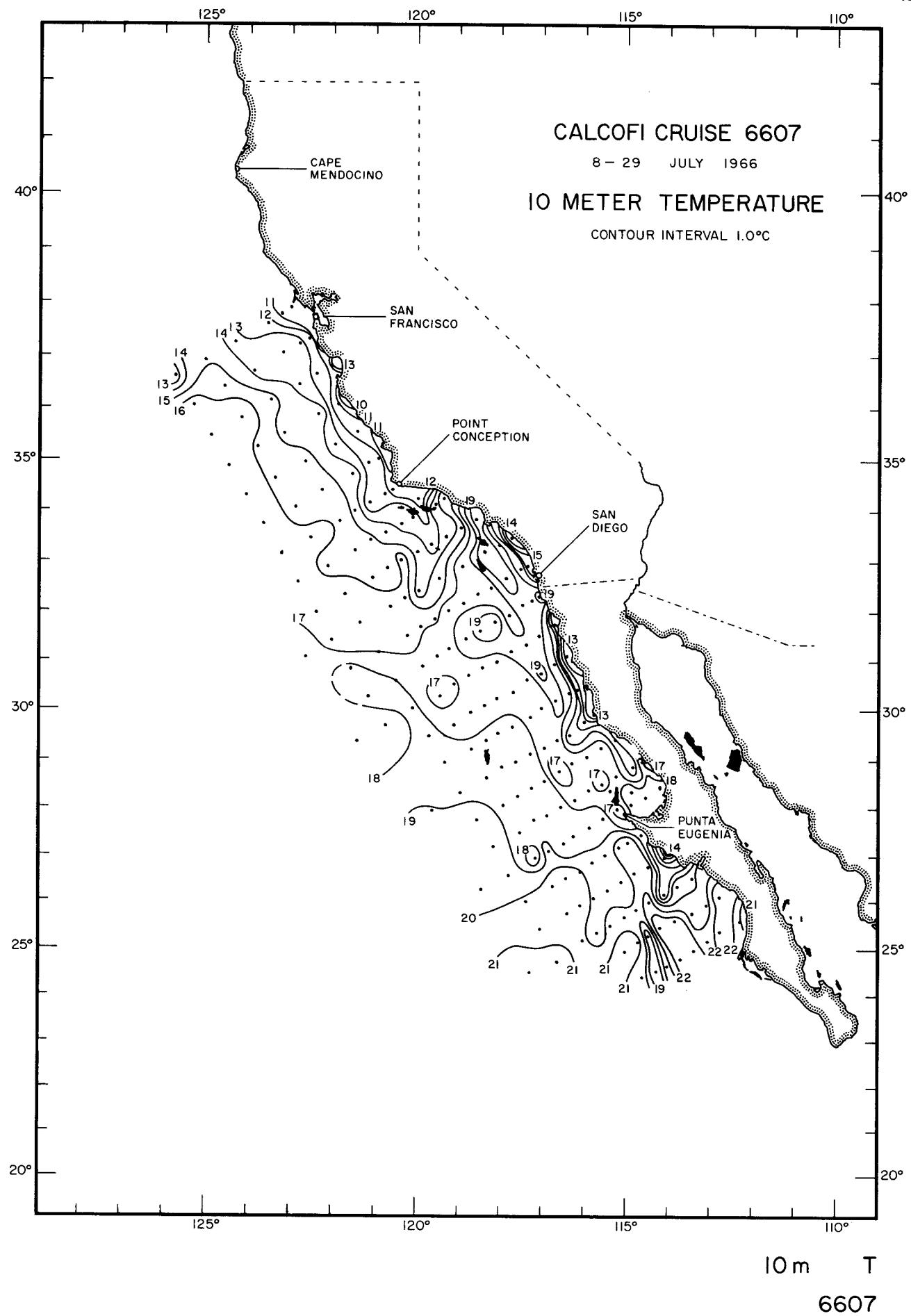


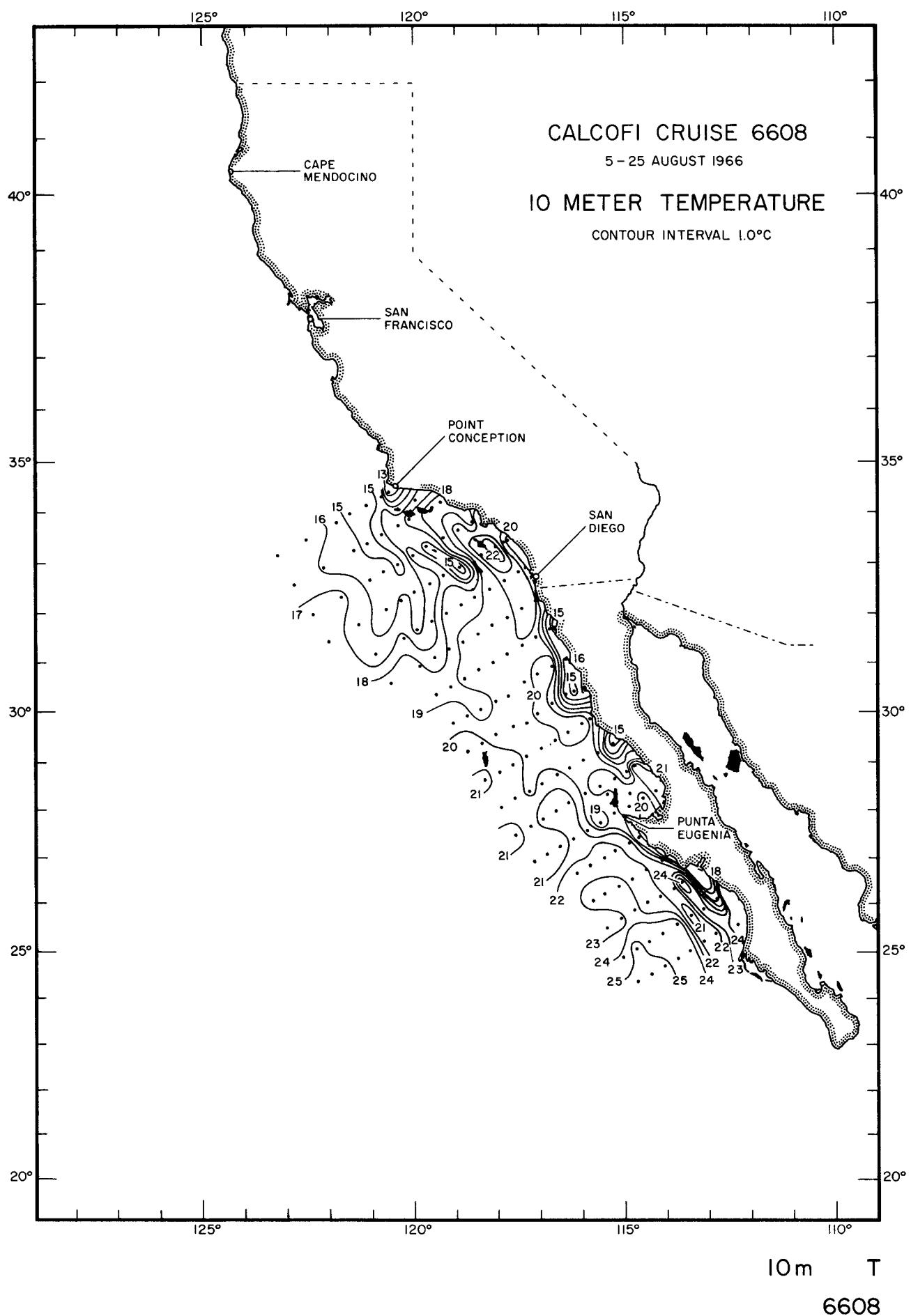


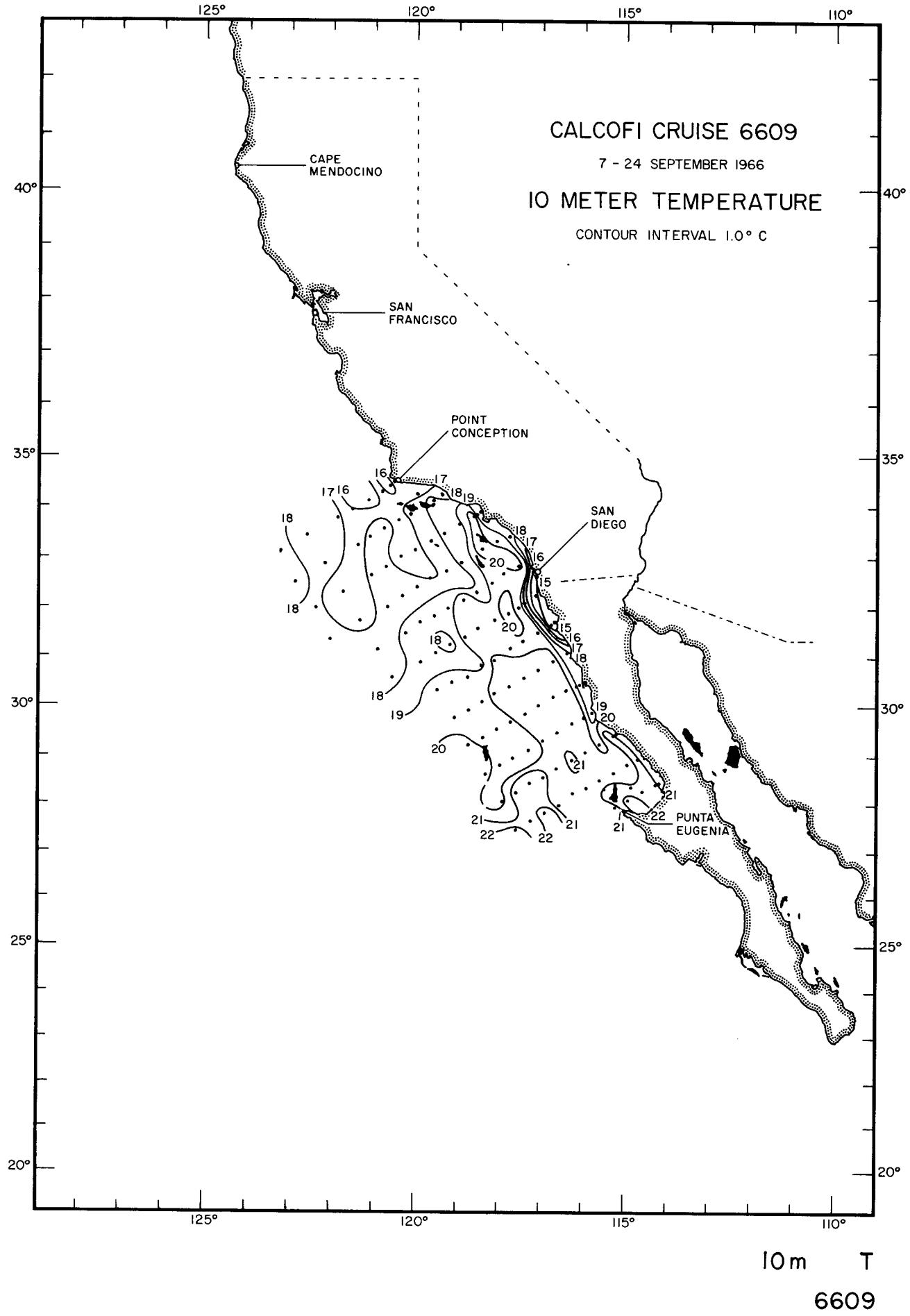


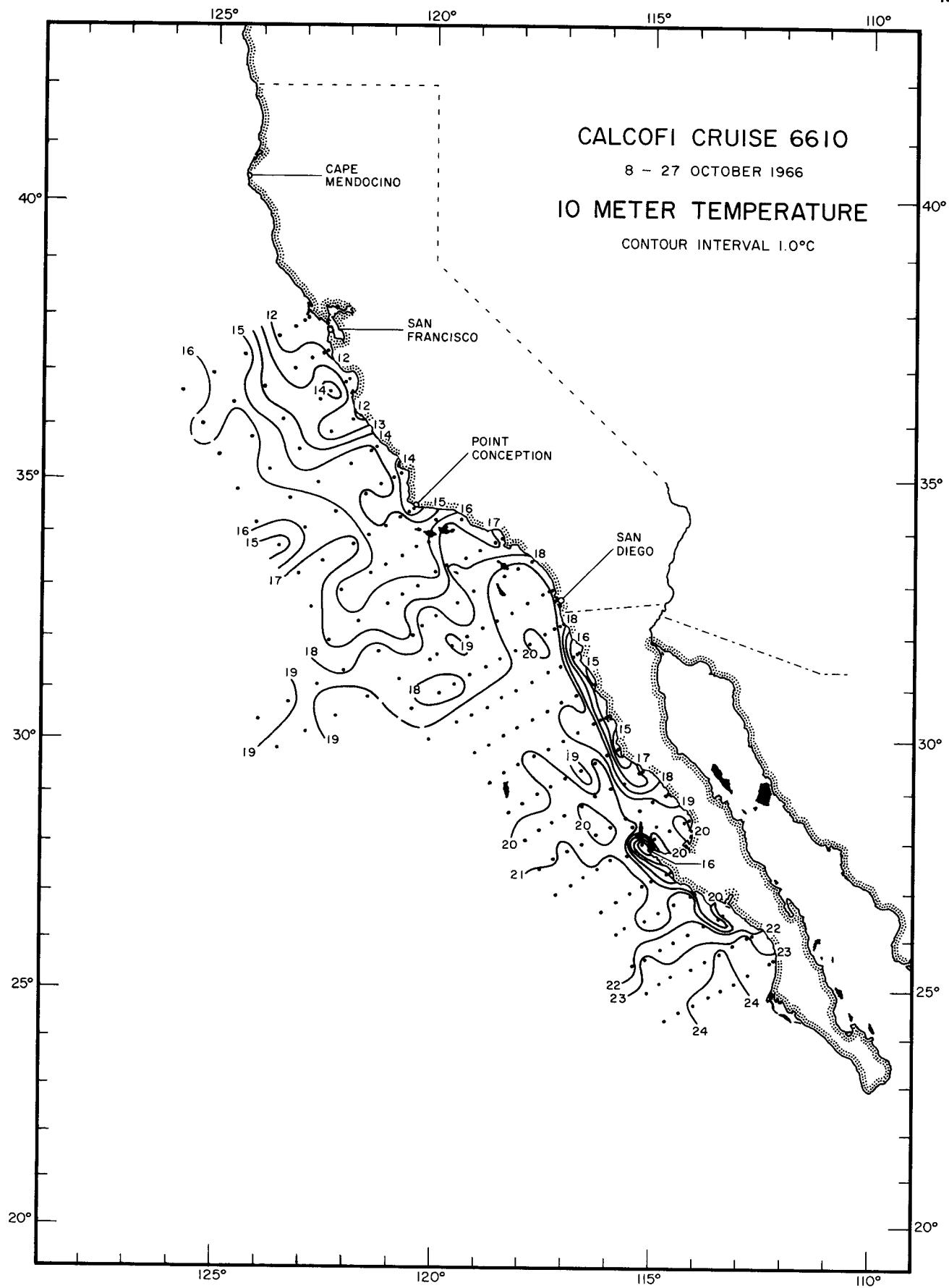






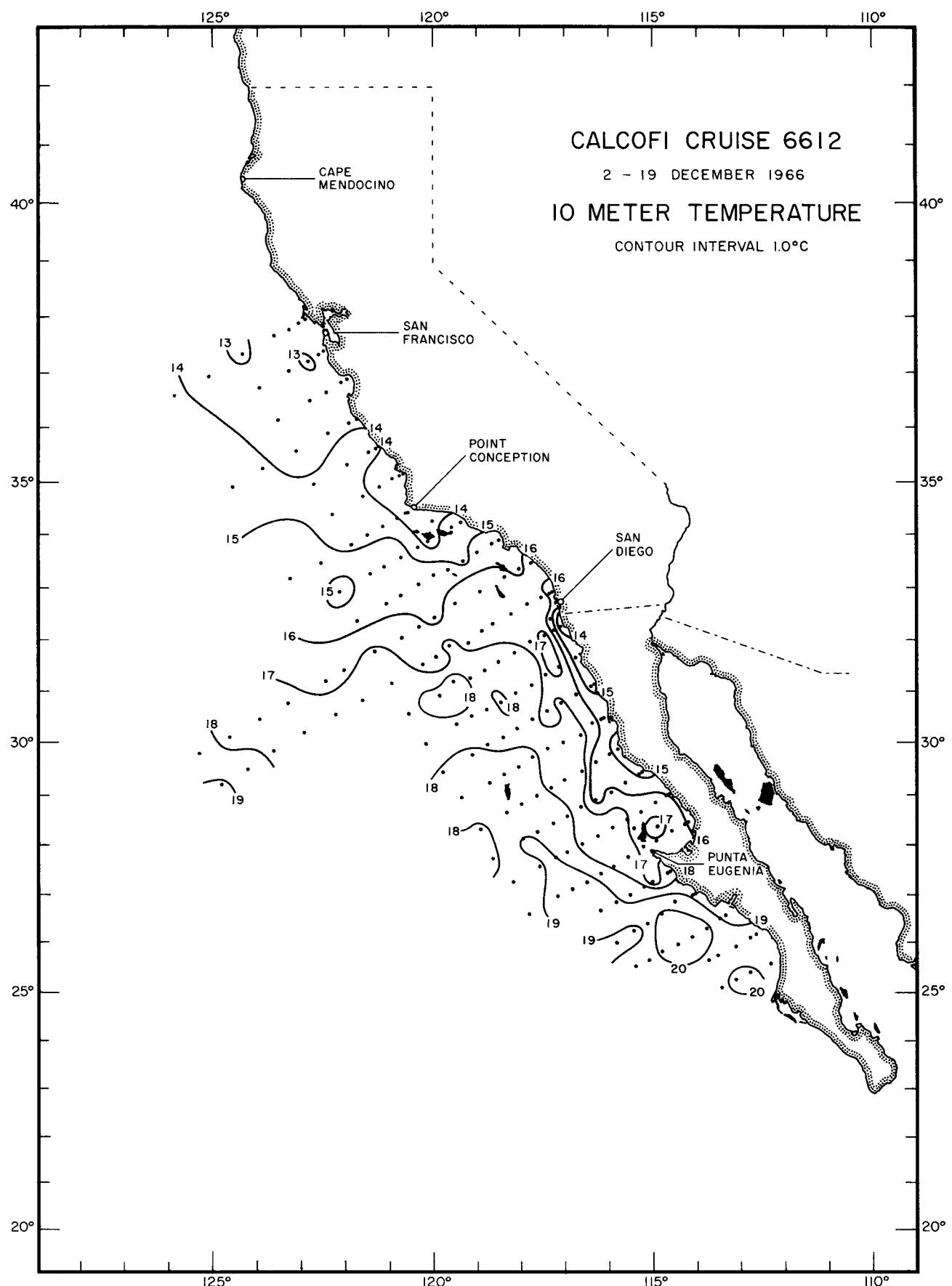






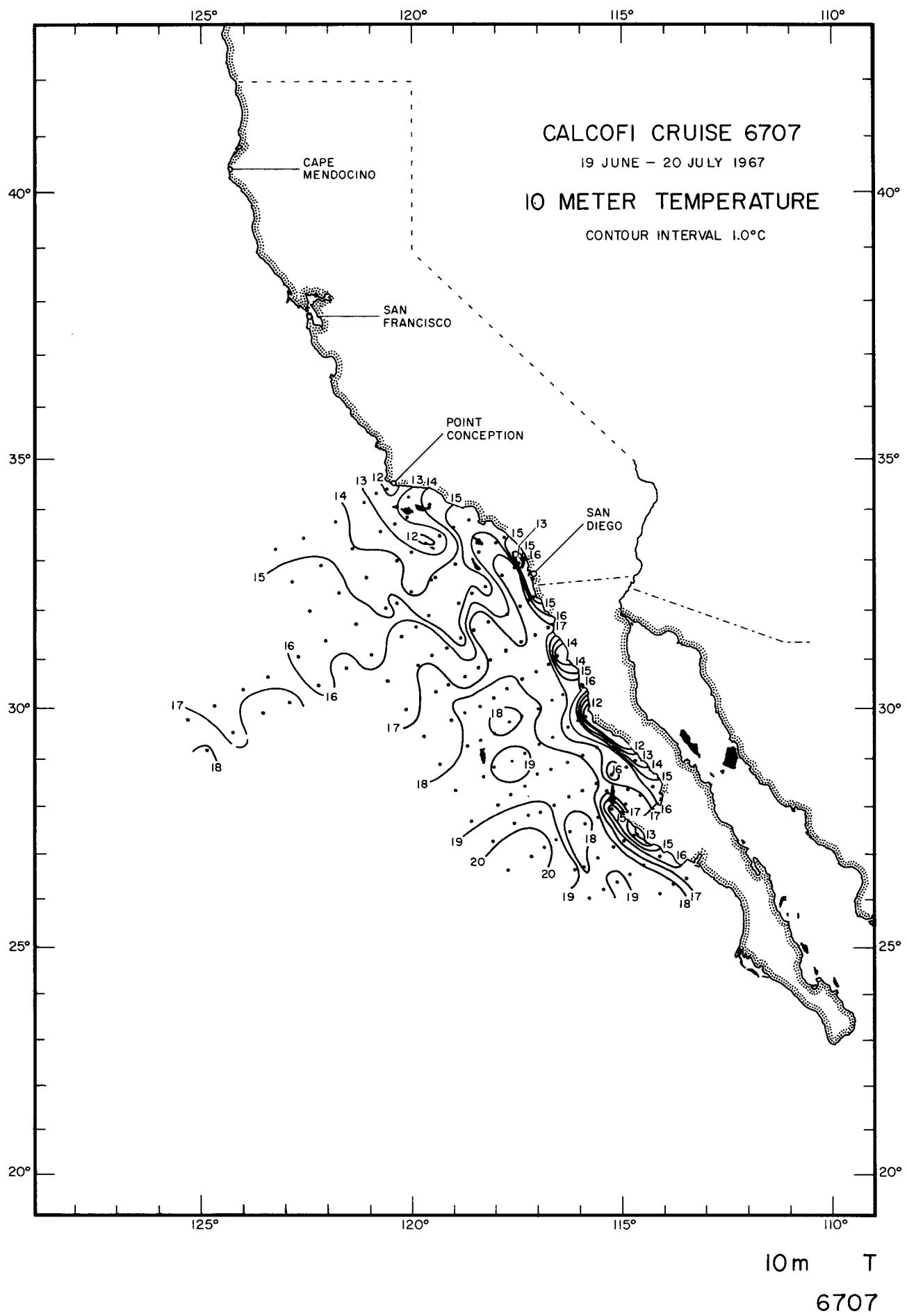
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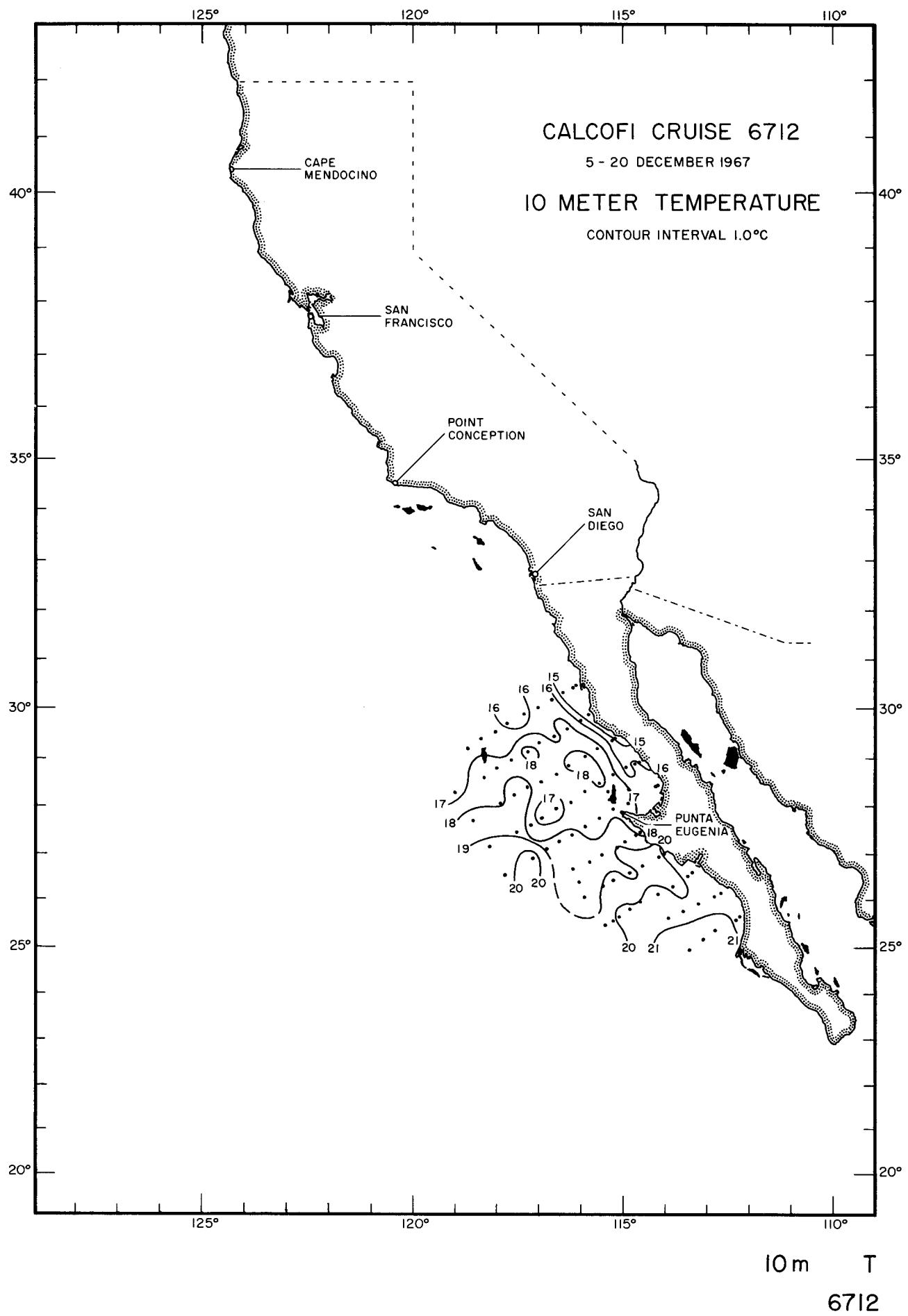
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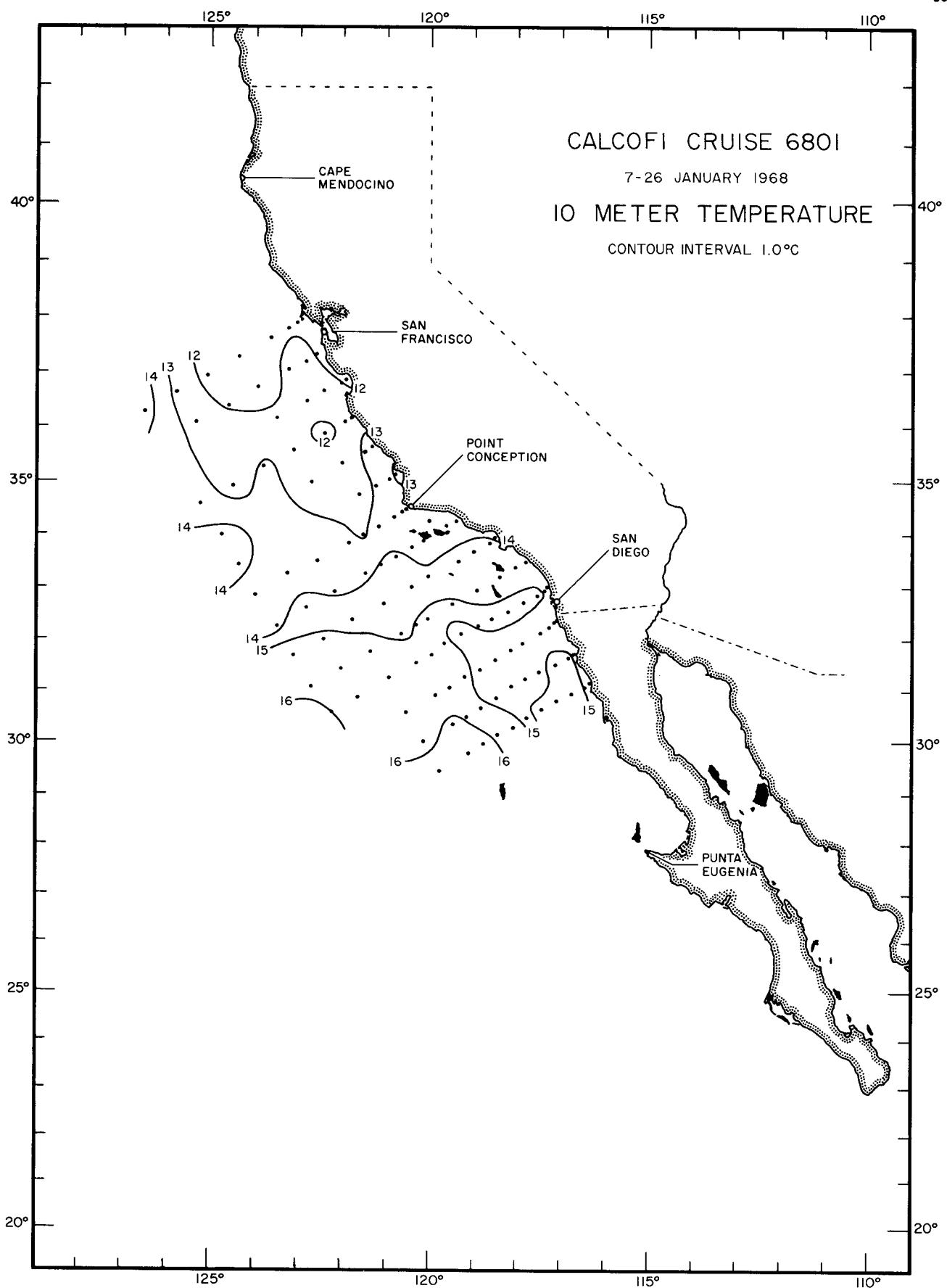


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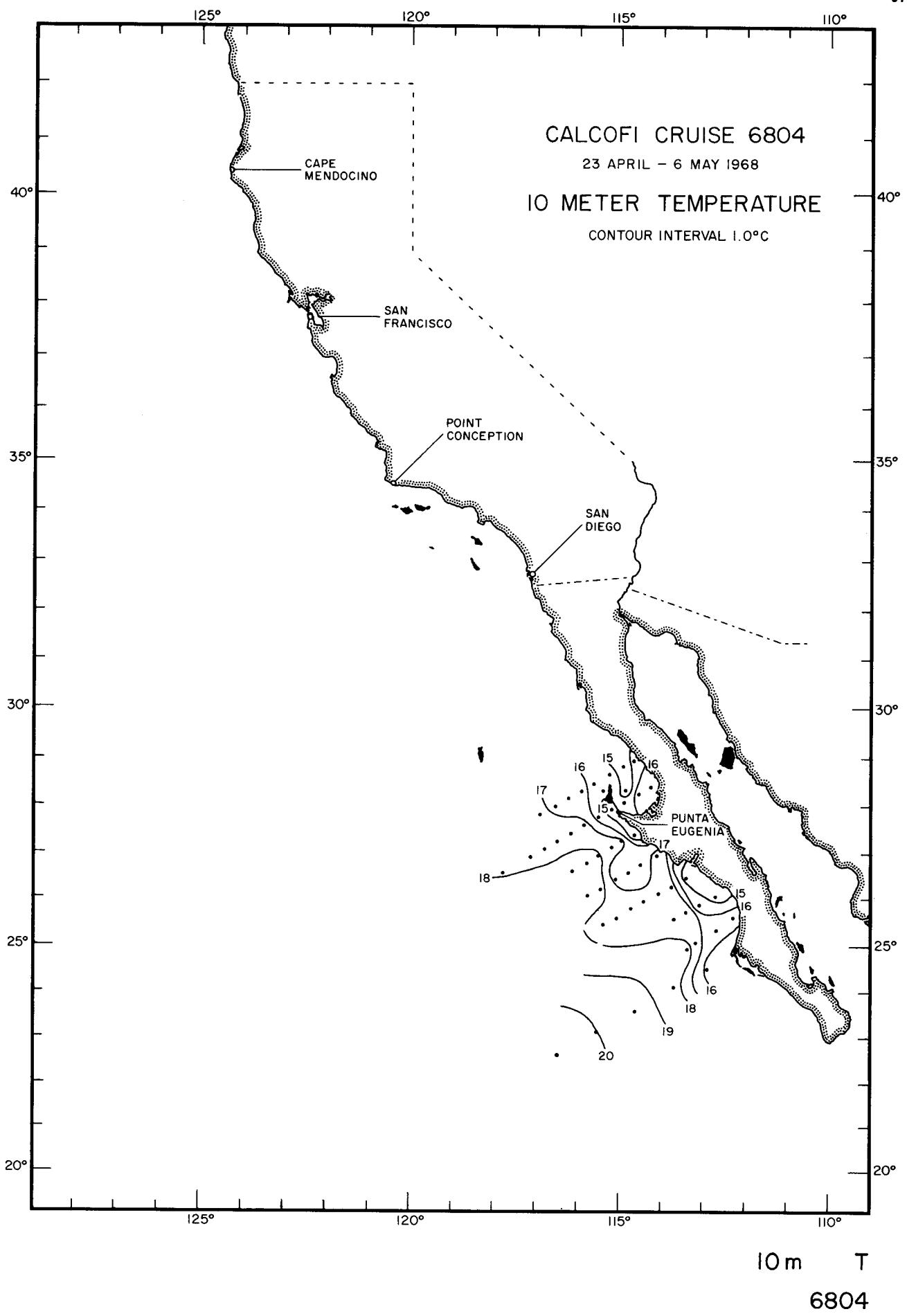
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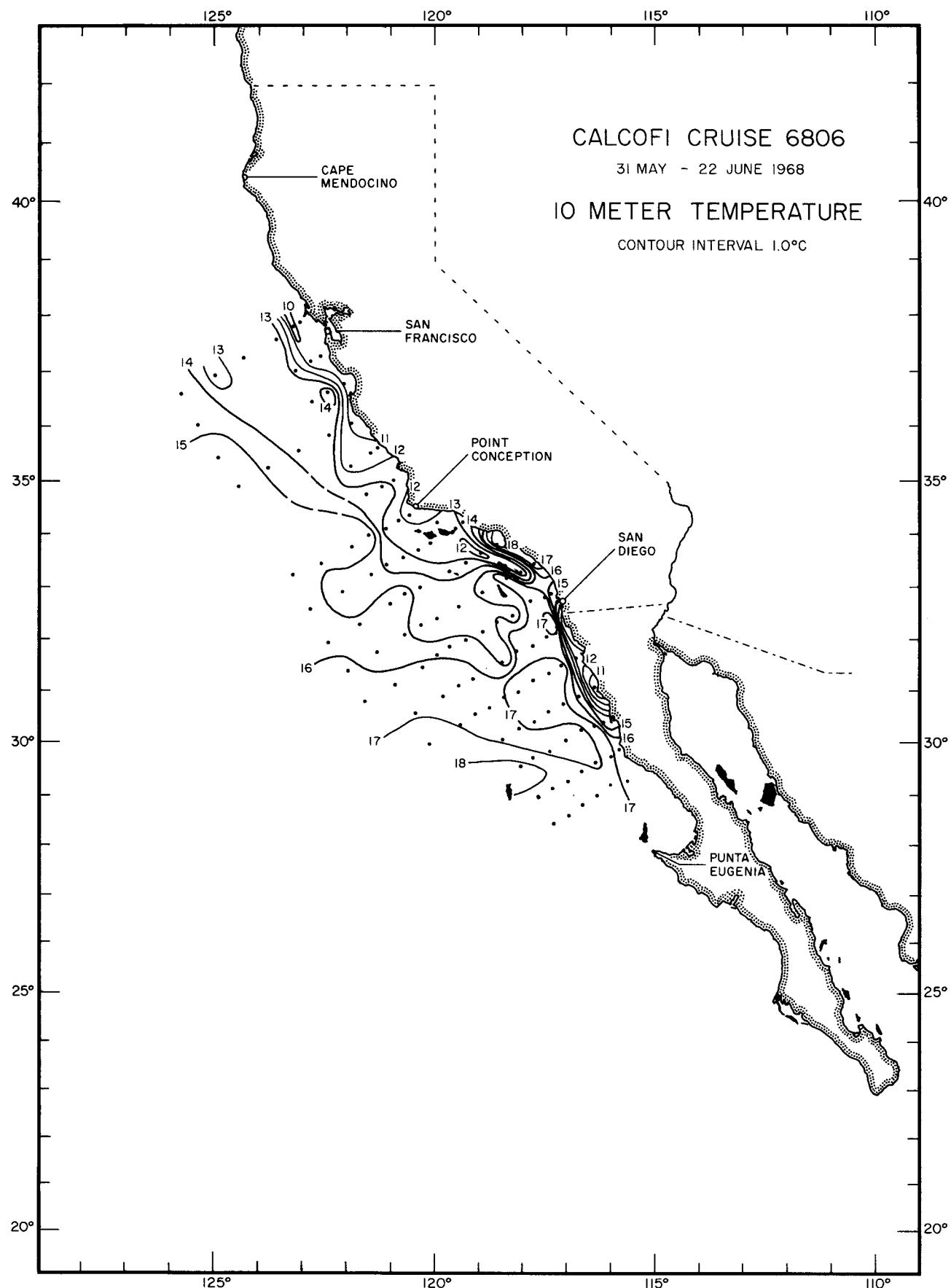


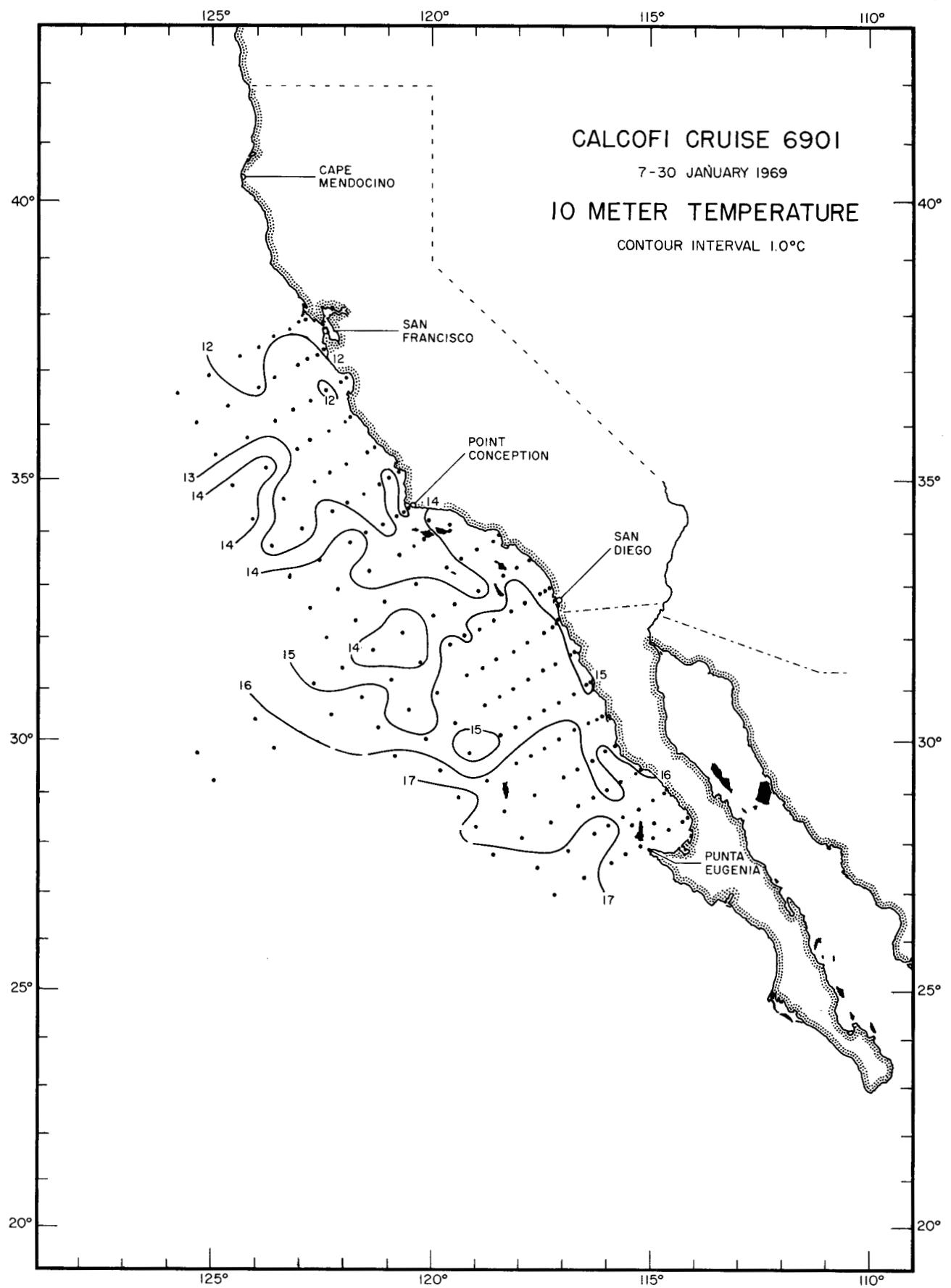




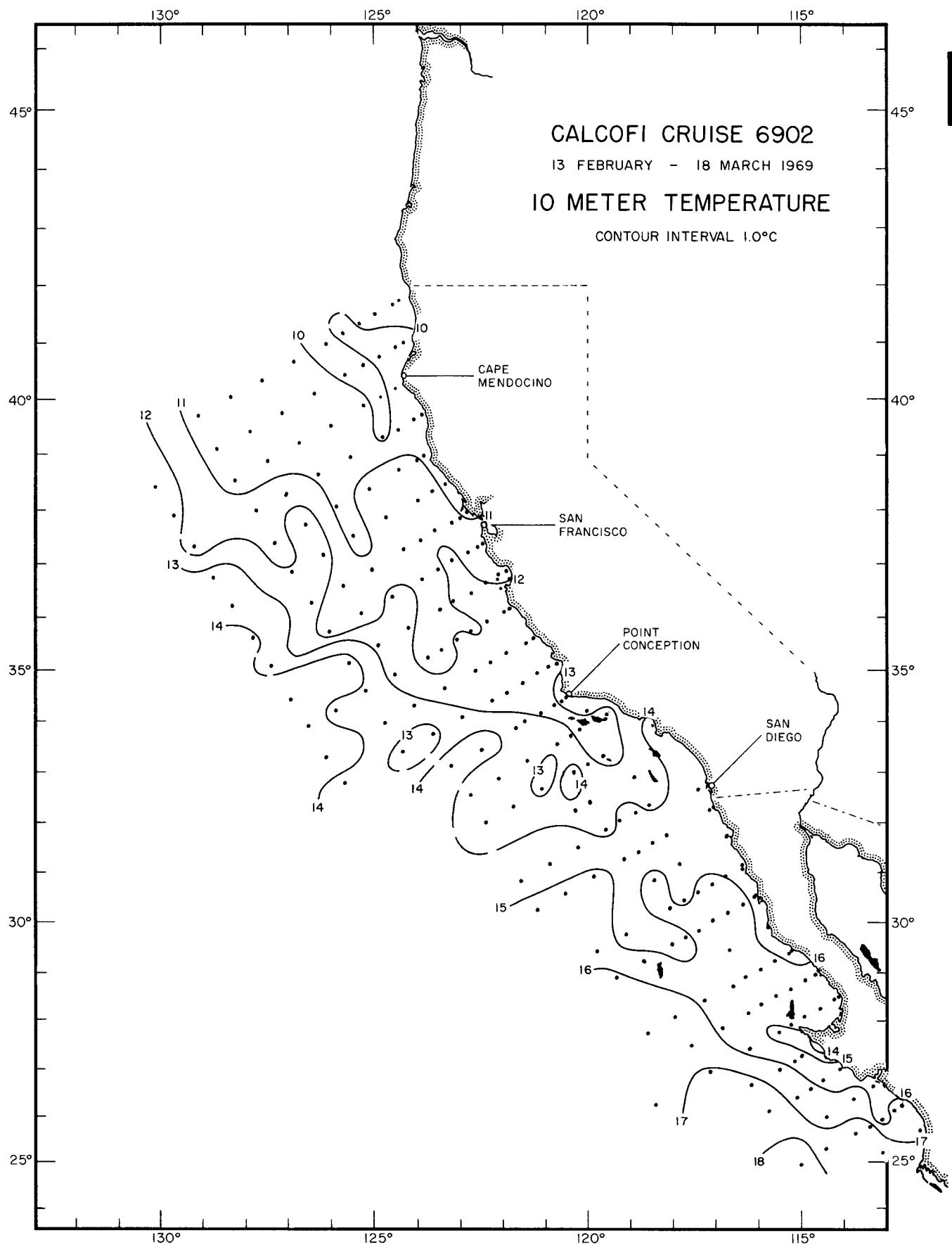
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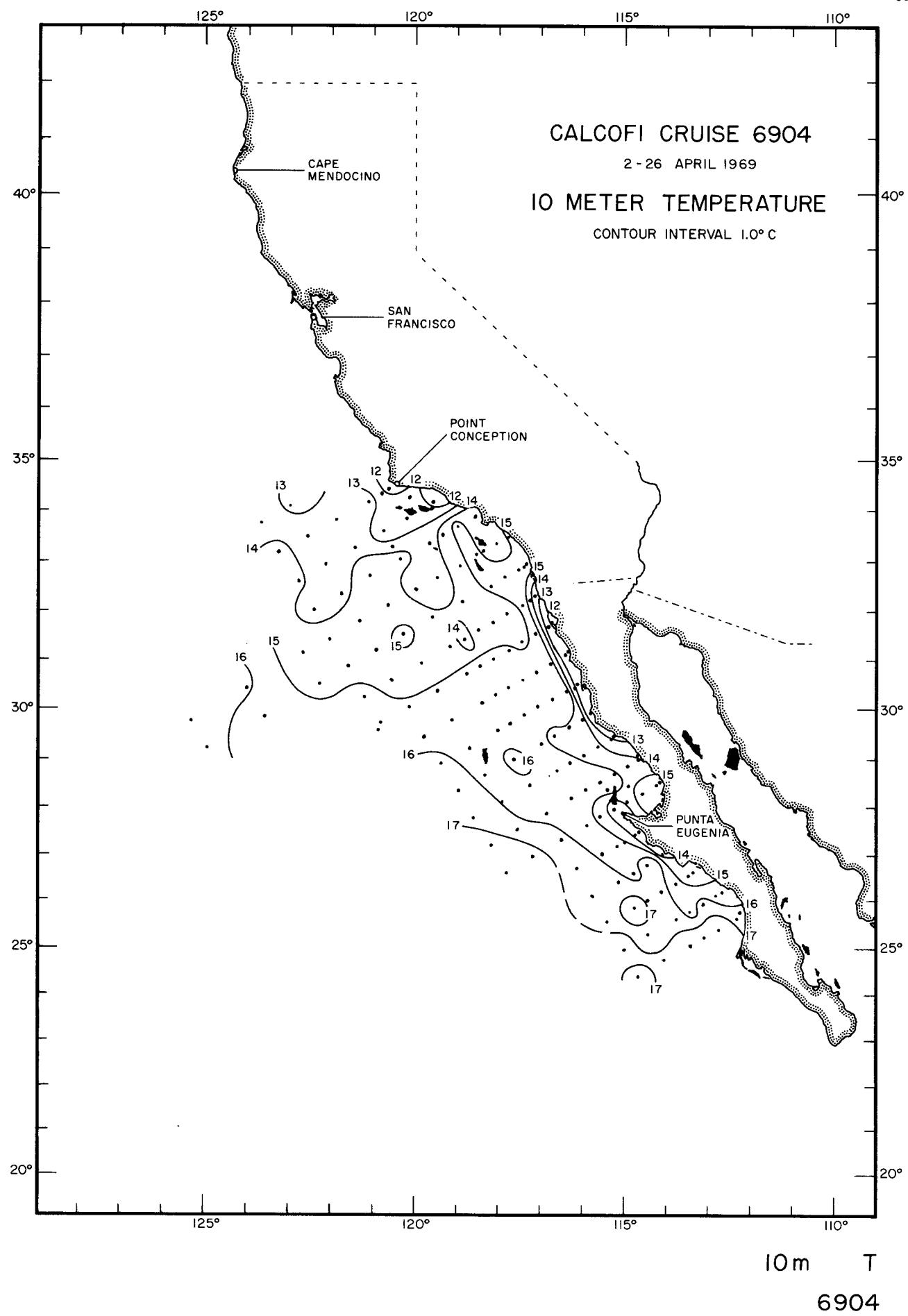


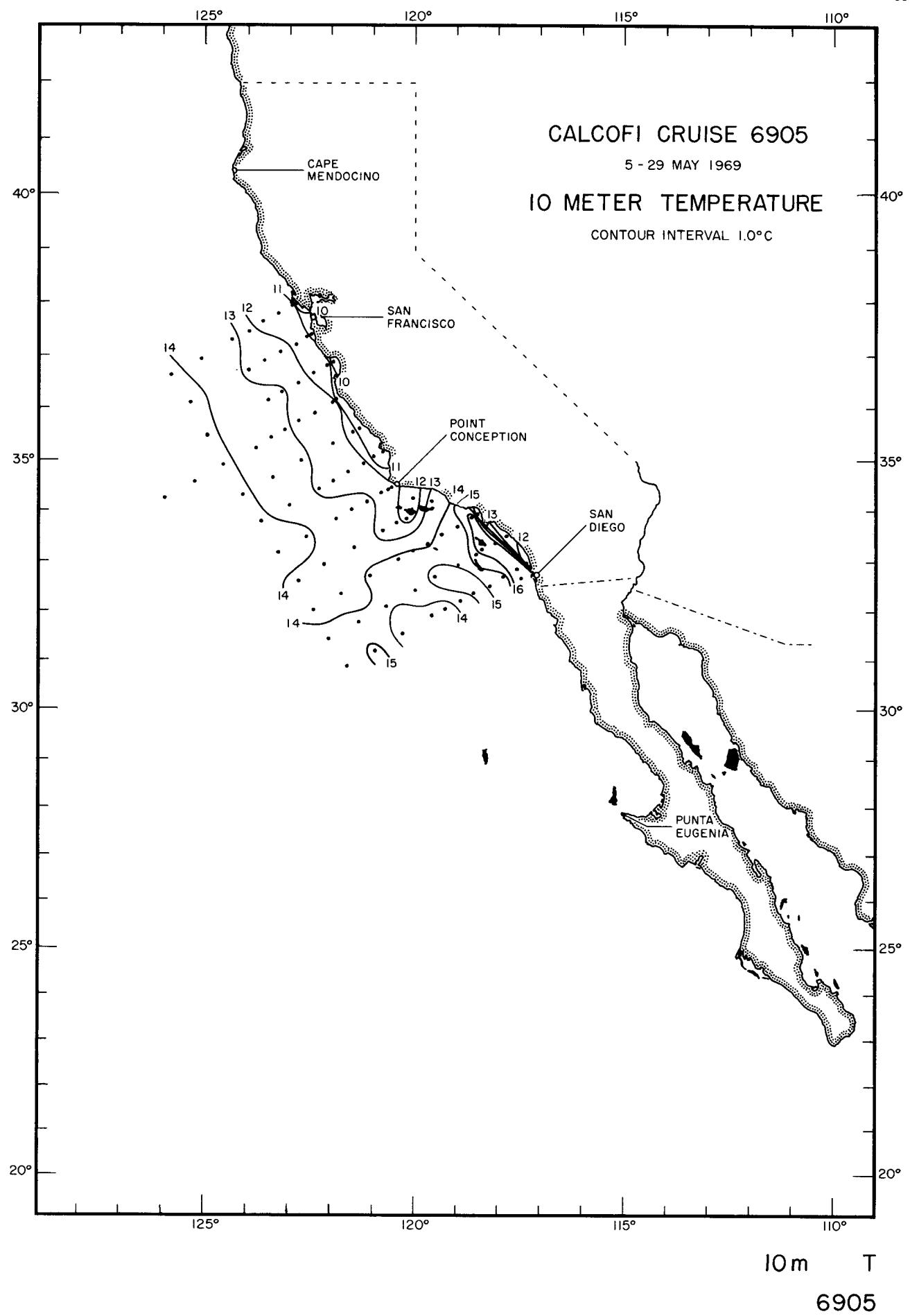


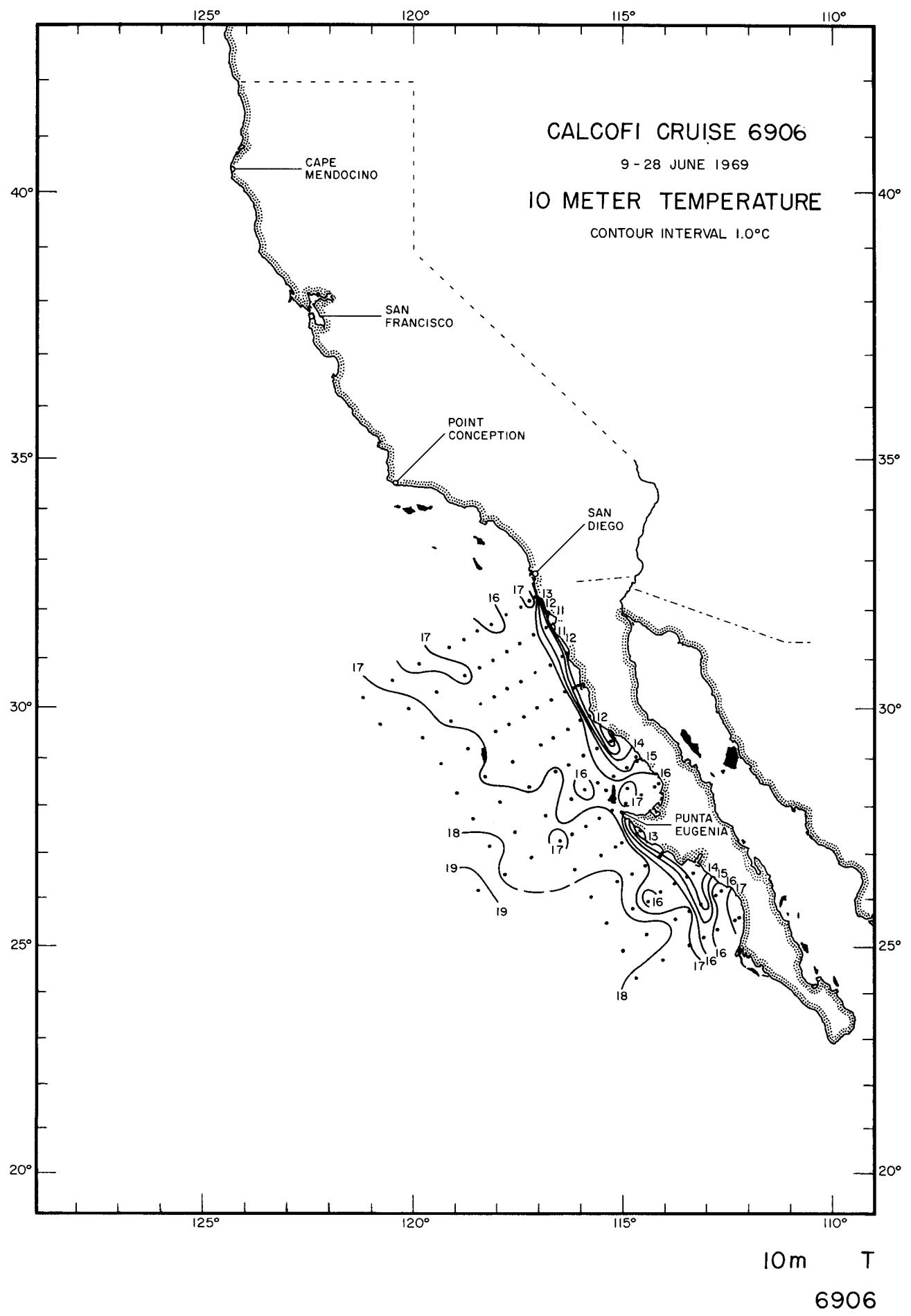
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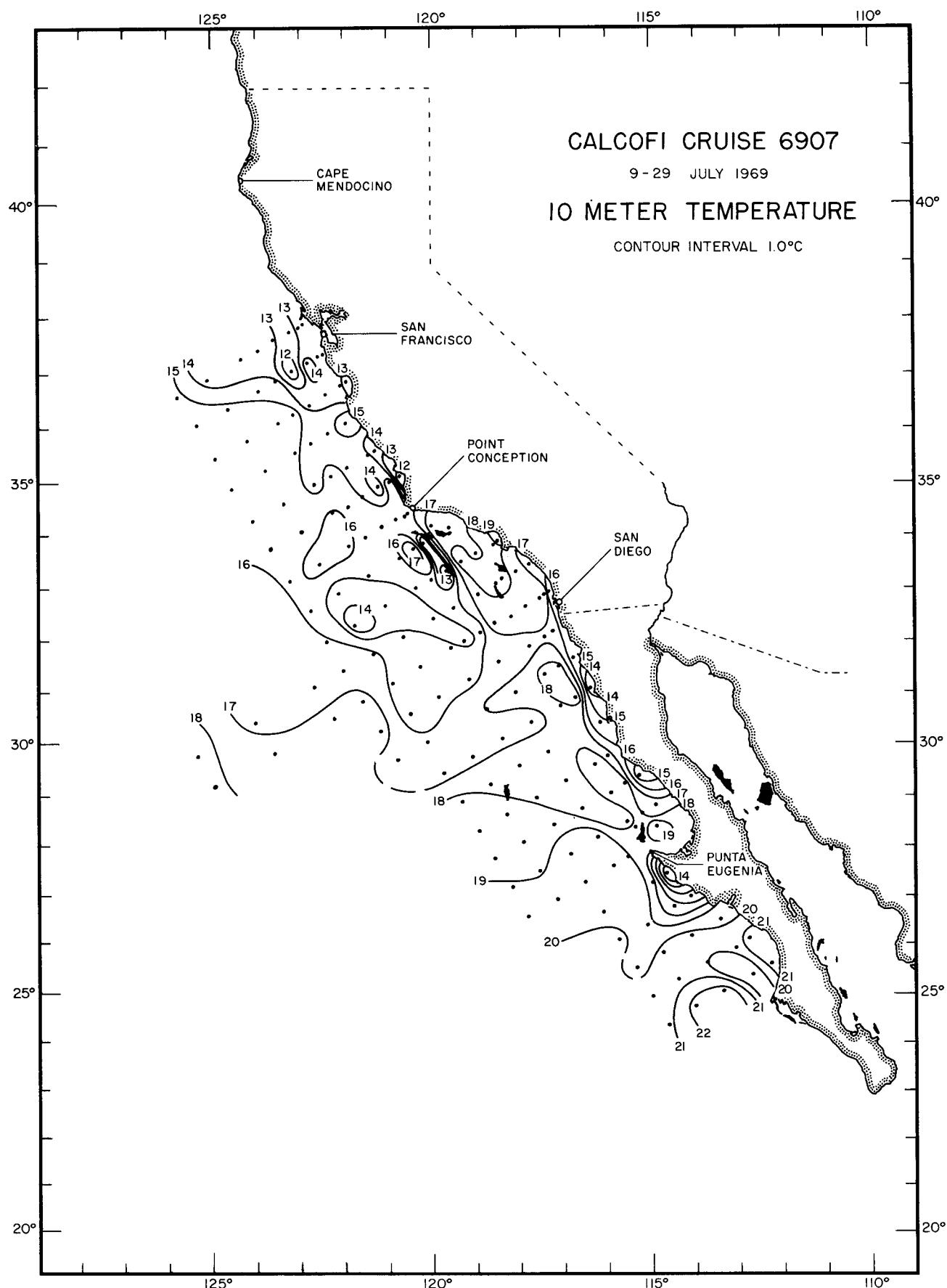


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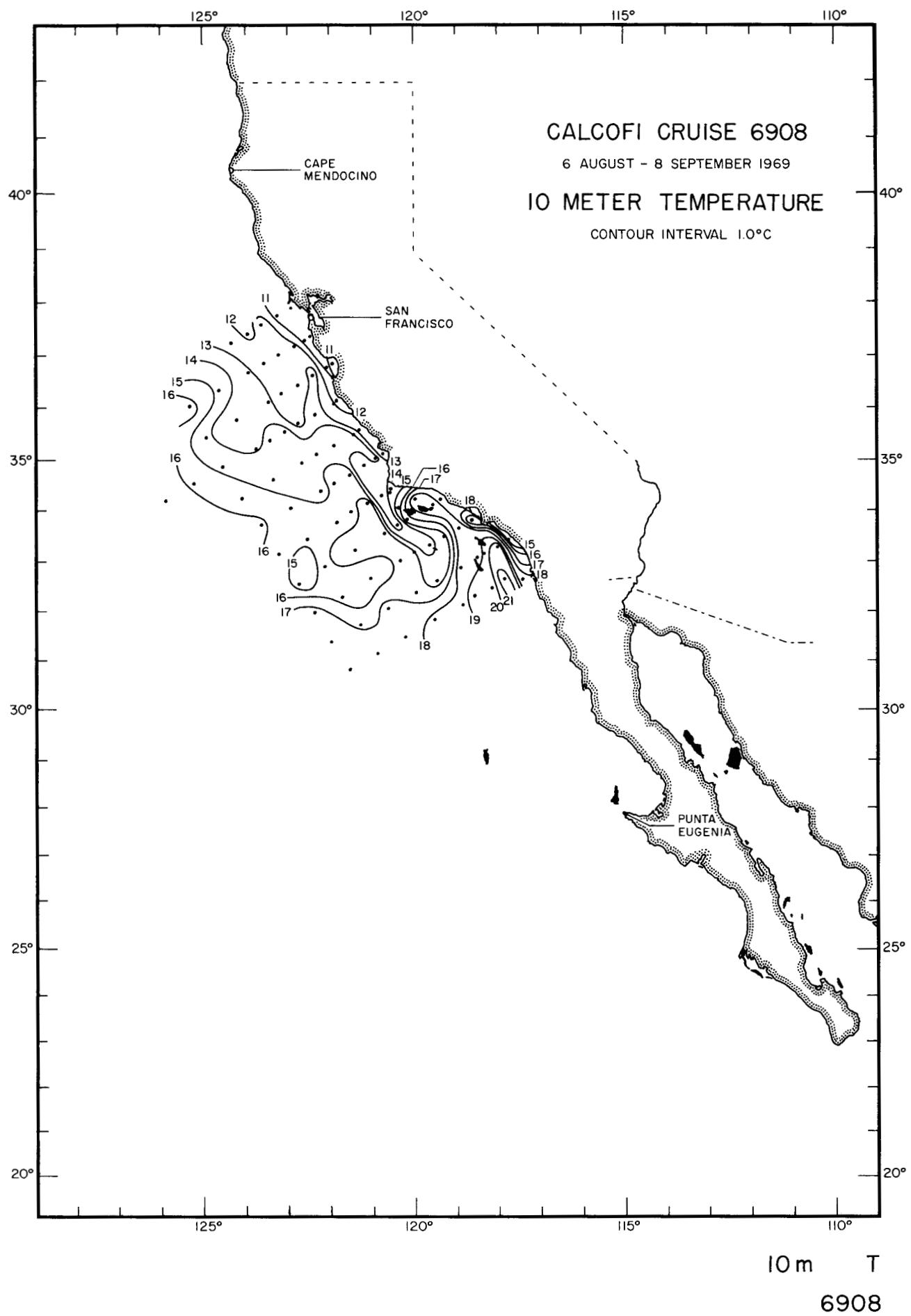


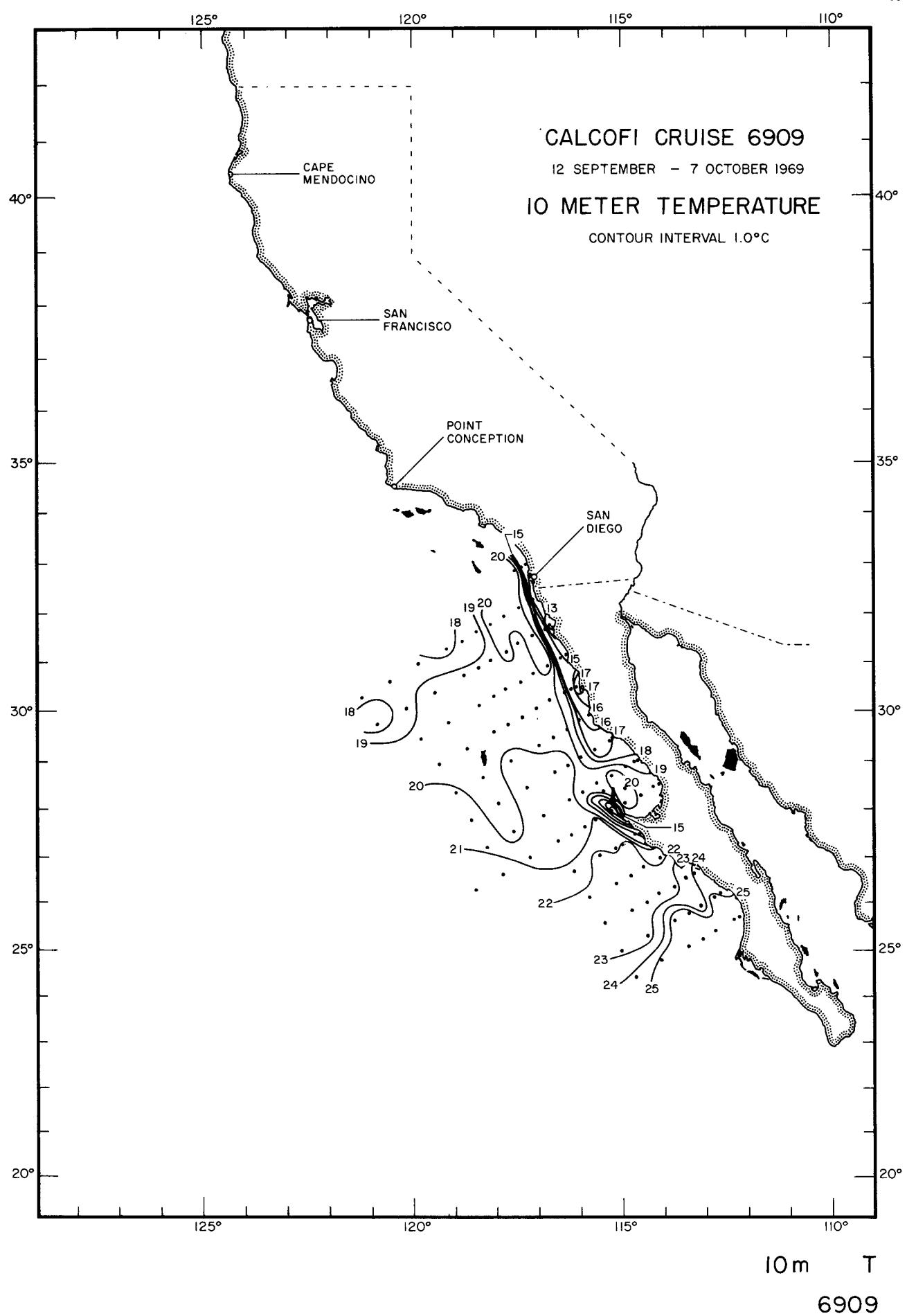


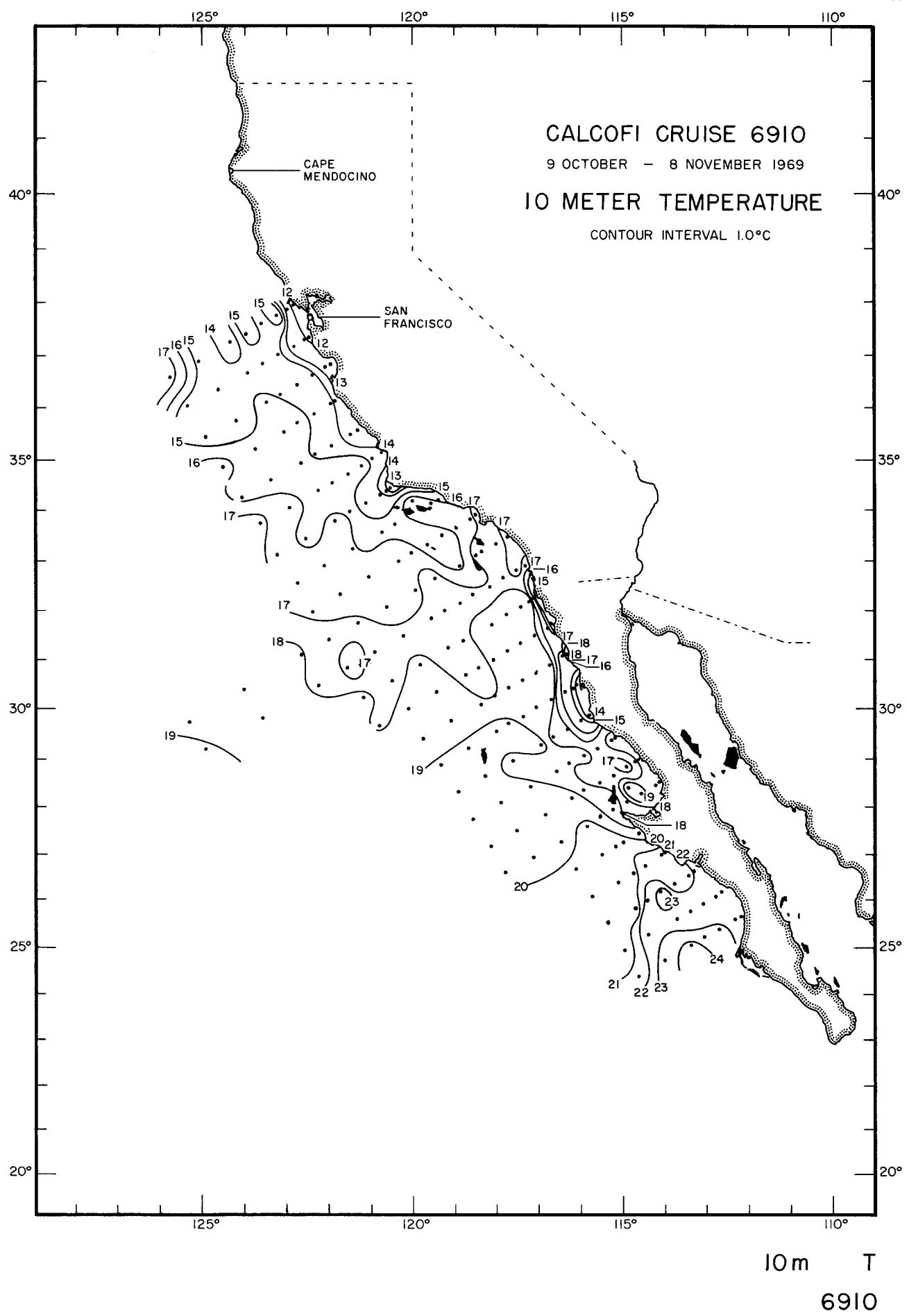


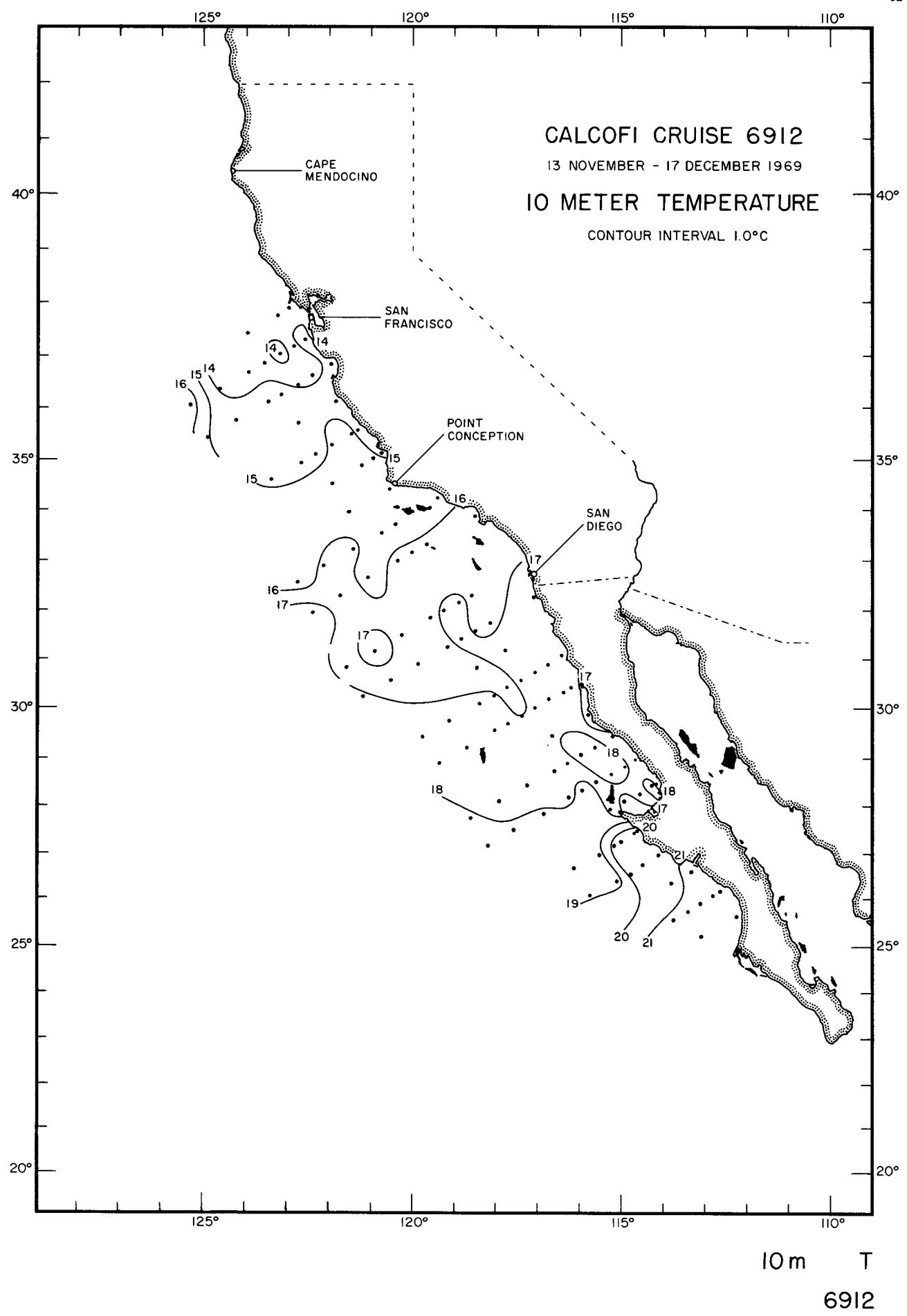


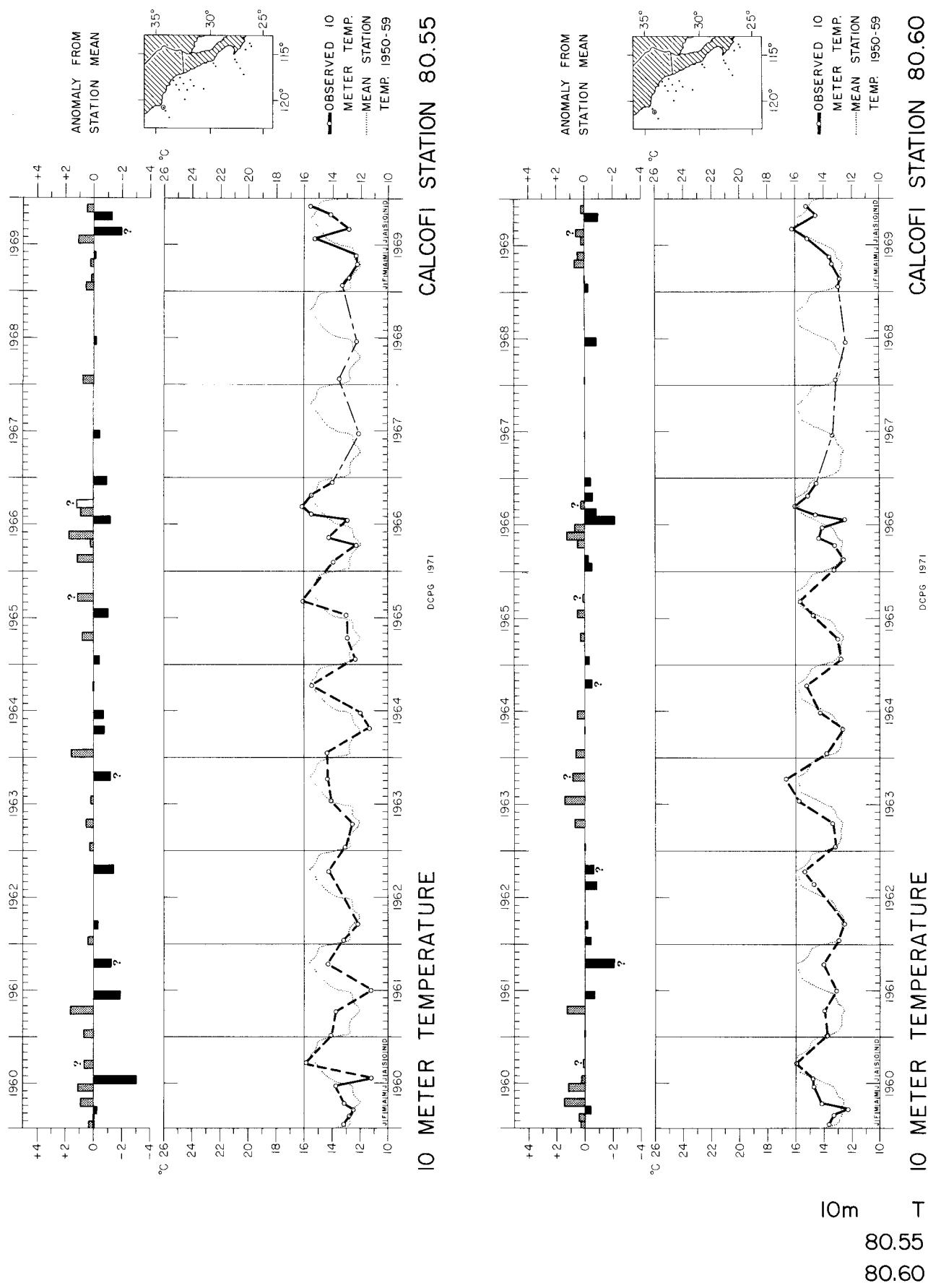
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6907









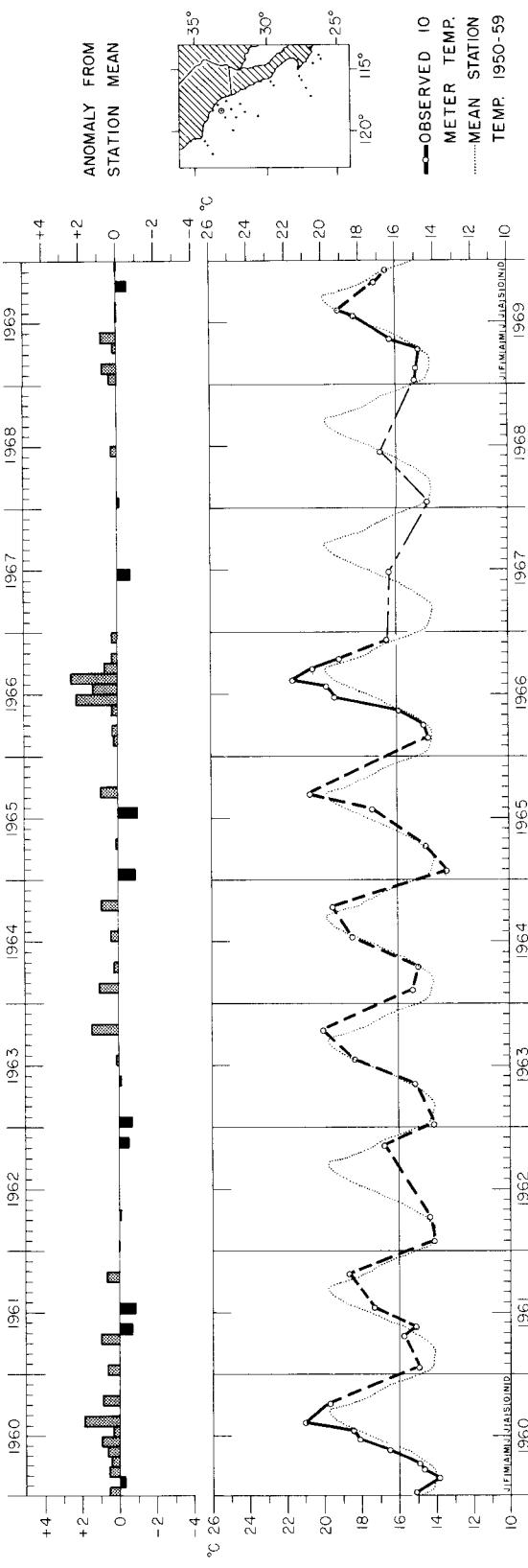


CALCOFI STATION 90.37



80.70
90.37

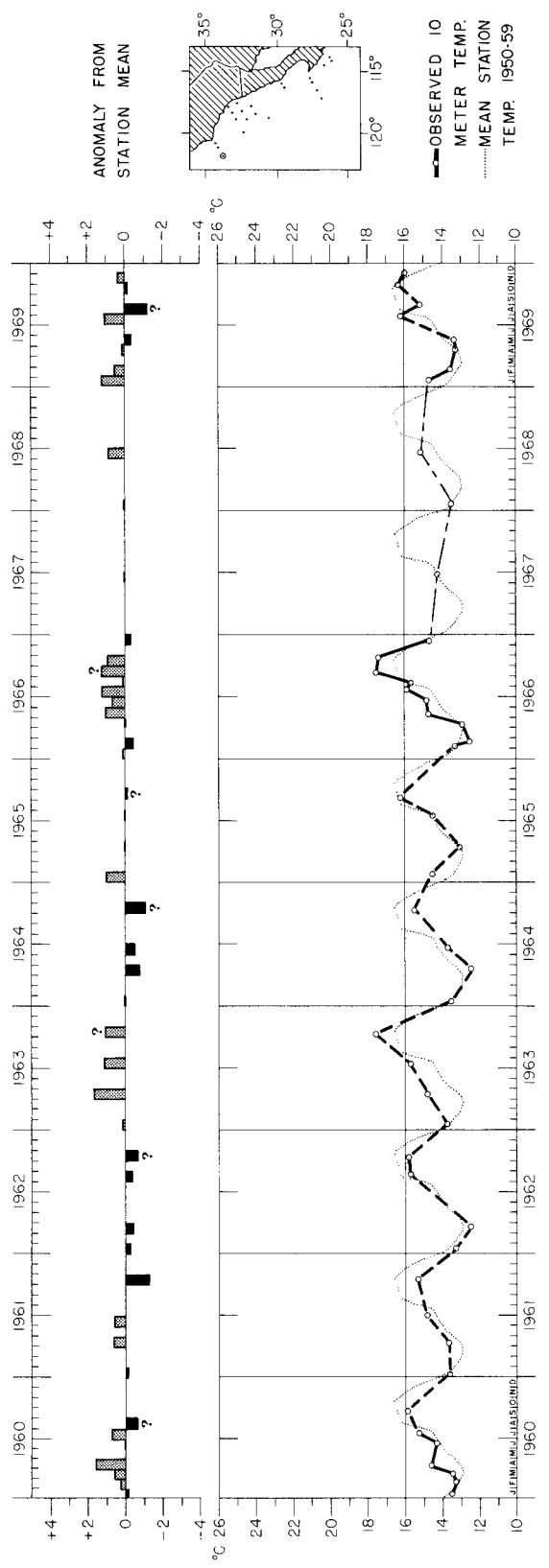
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80.70

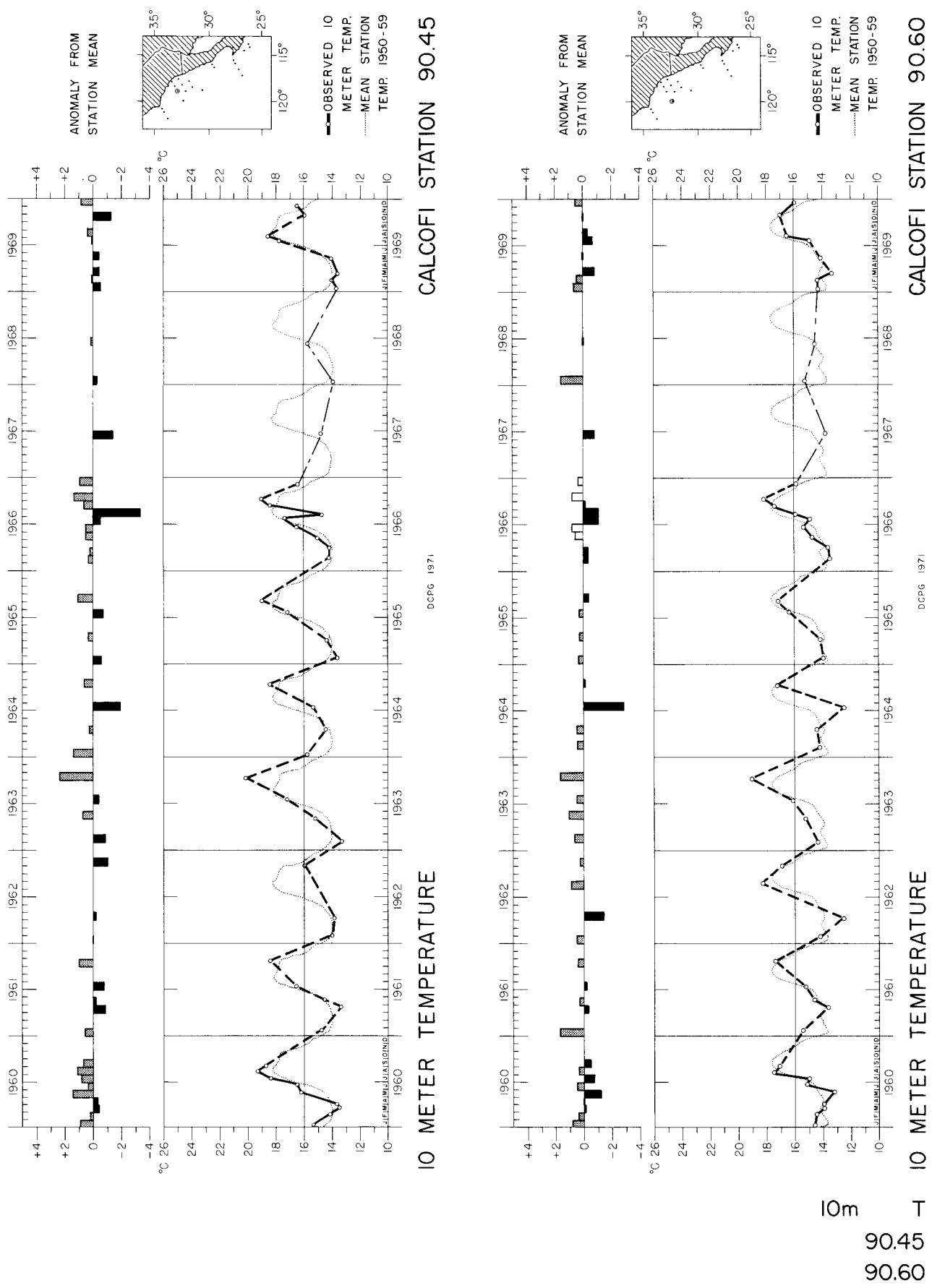
DCPG | 97|

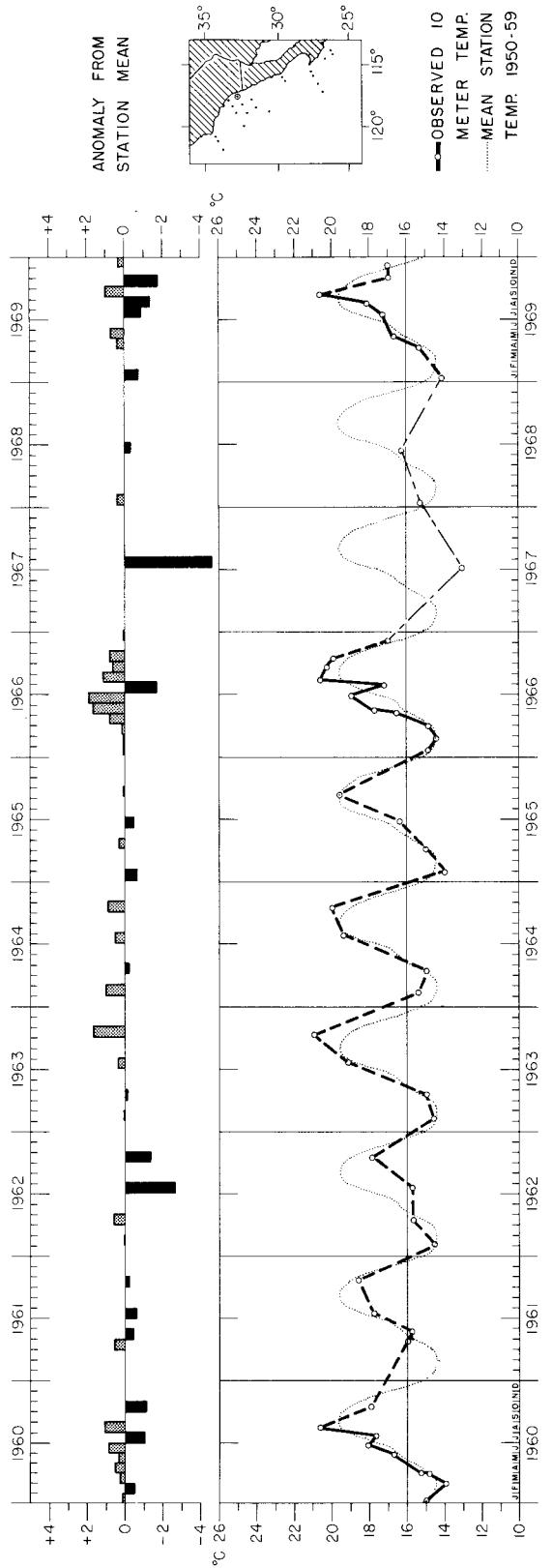
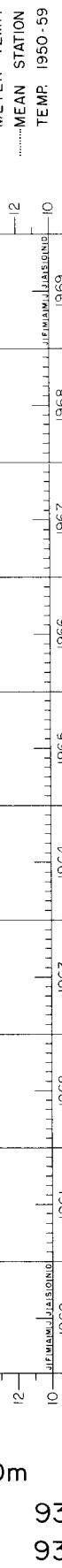
10 METER TEMPERATURE



10 METER TEMPERATURE

10 METER TEMPERATURE

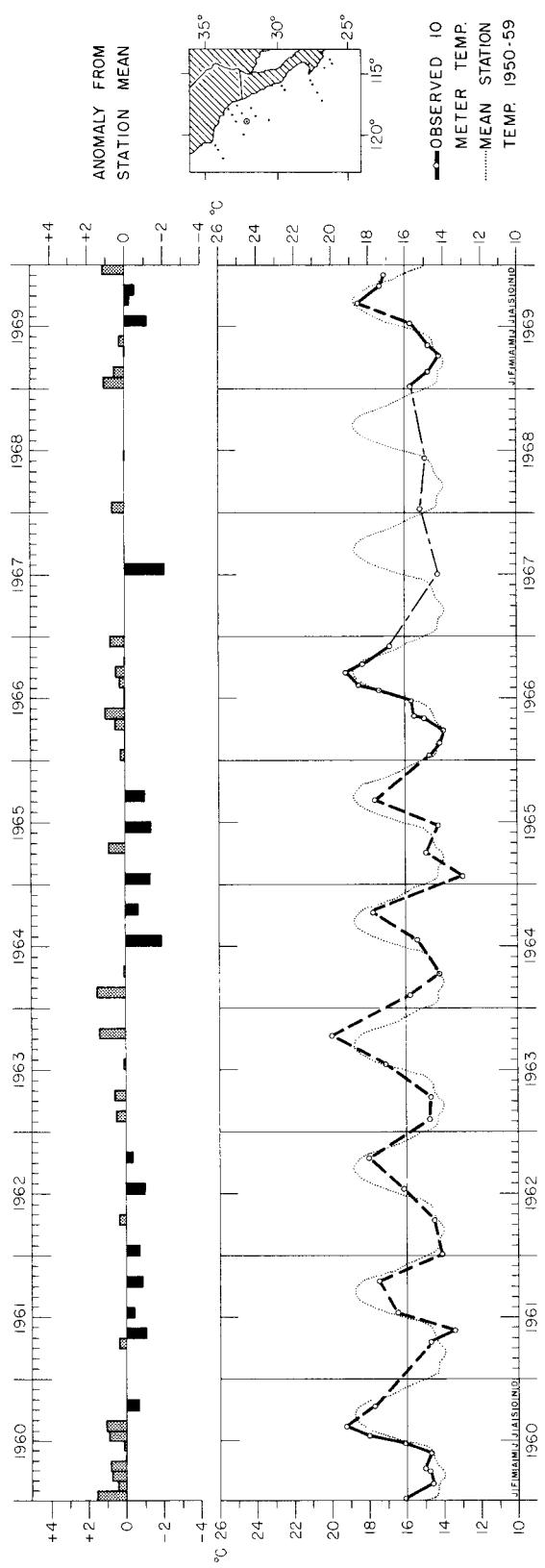




CALCOFI STATION 93.50

DCP6 1971

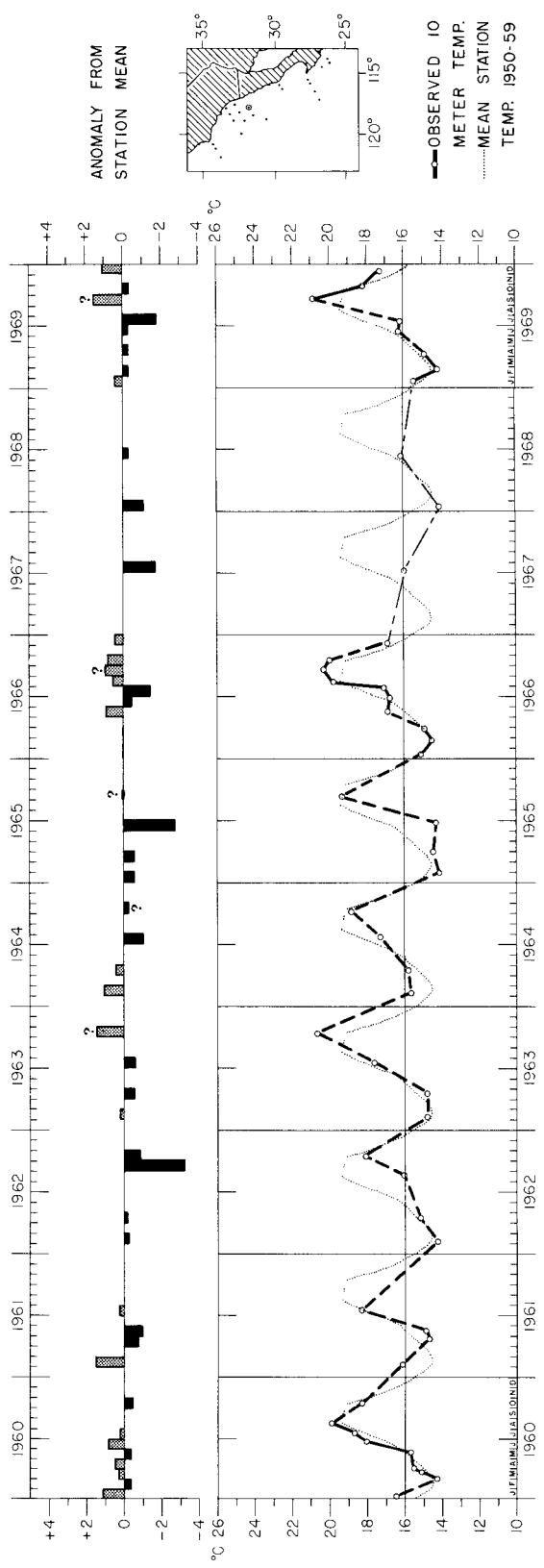
10 METER TEMPERATURE



10m

93.50
97.40

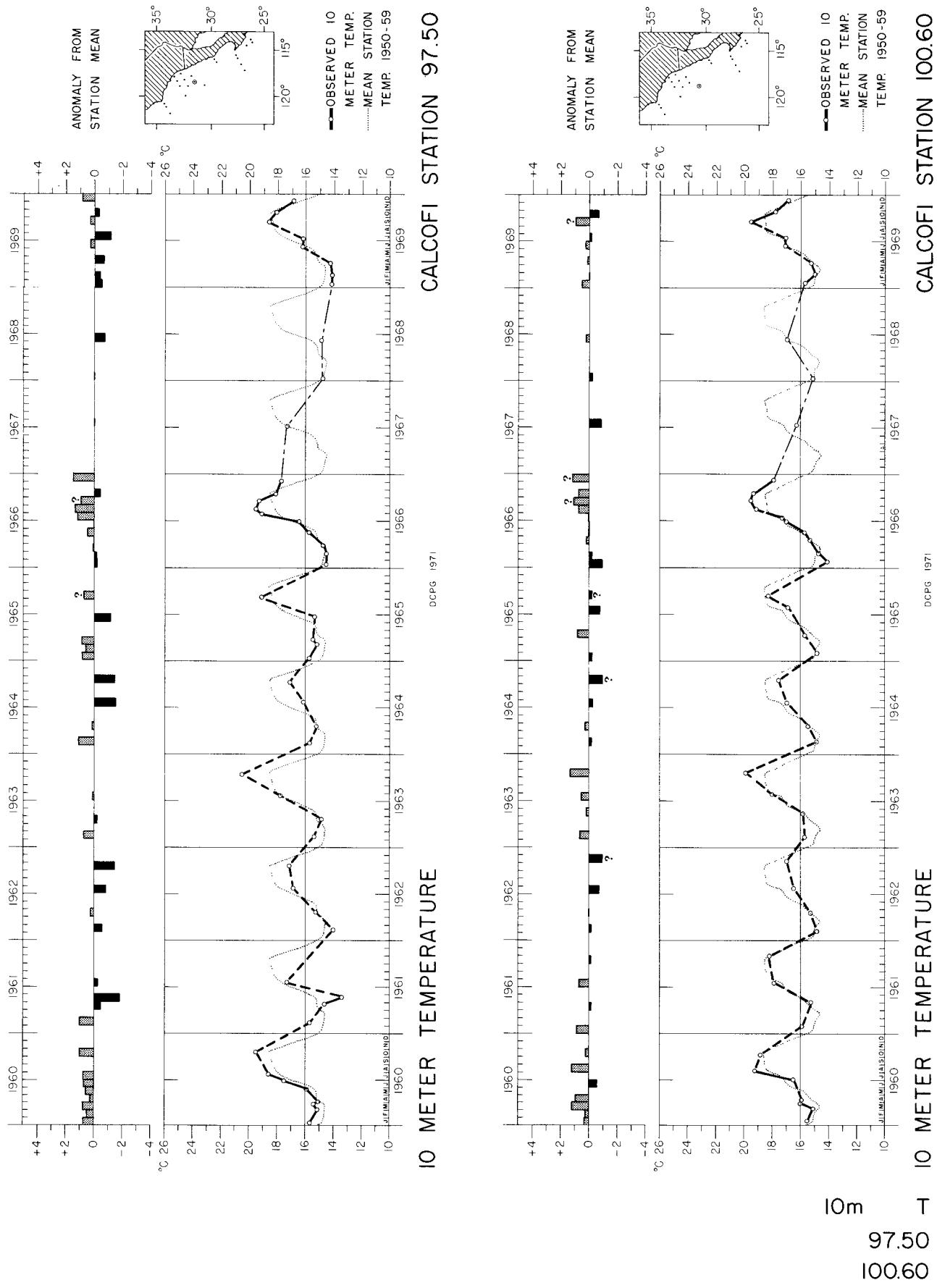
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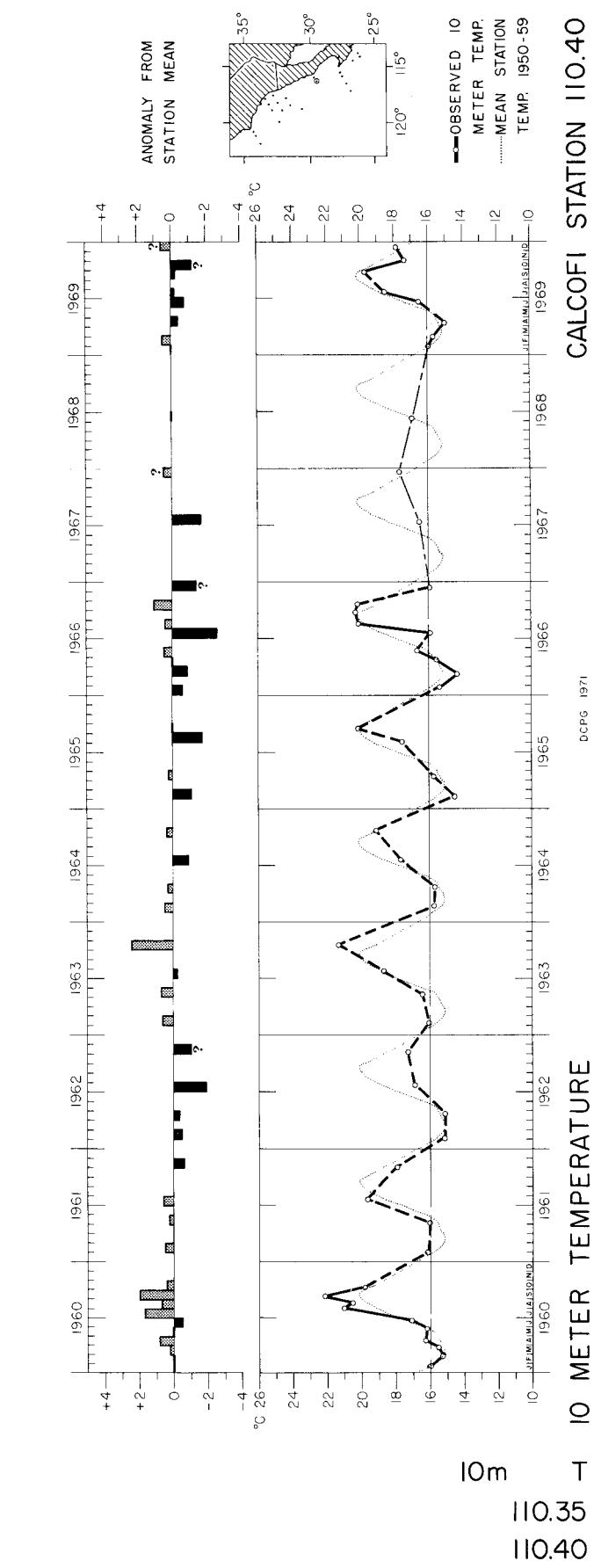
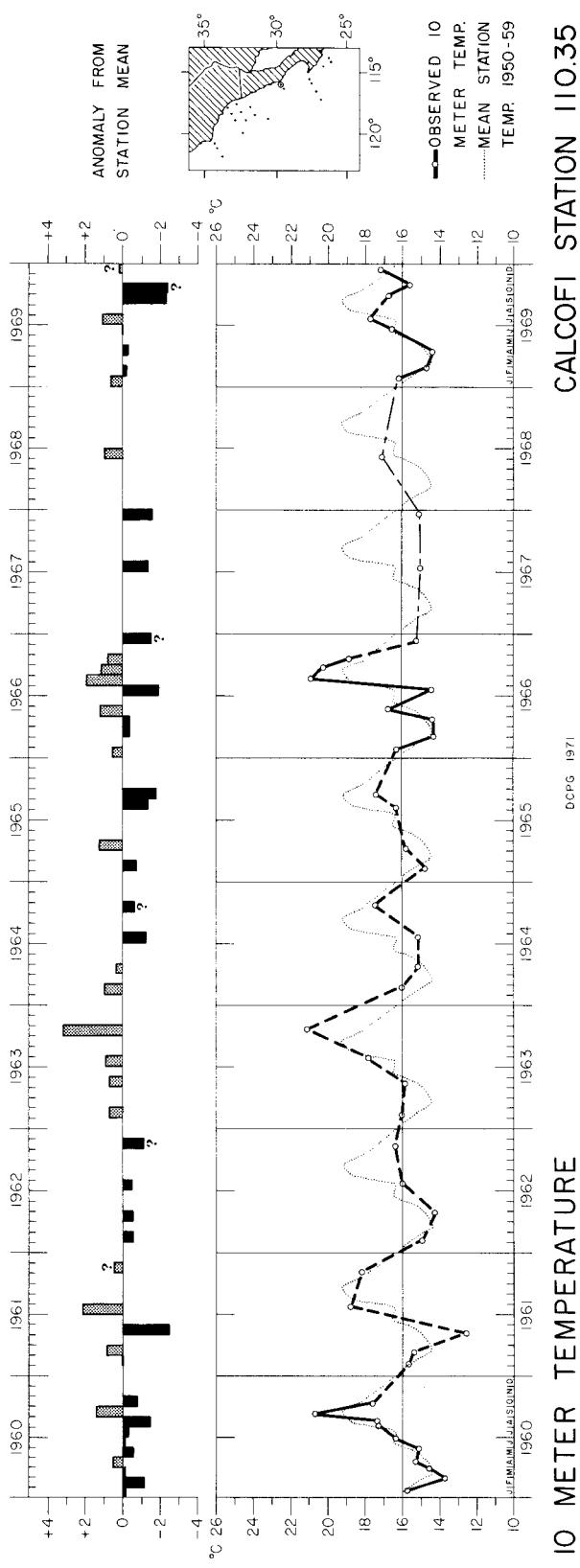
93.50
97.40

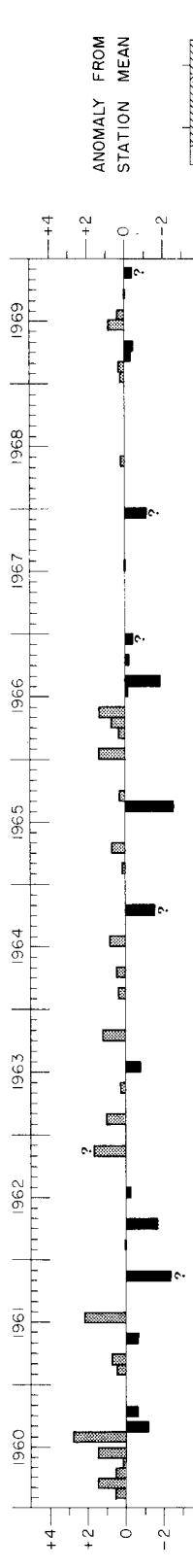
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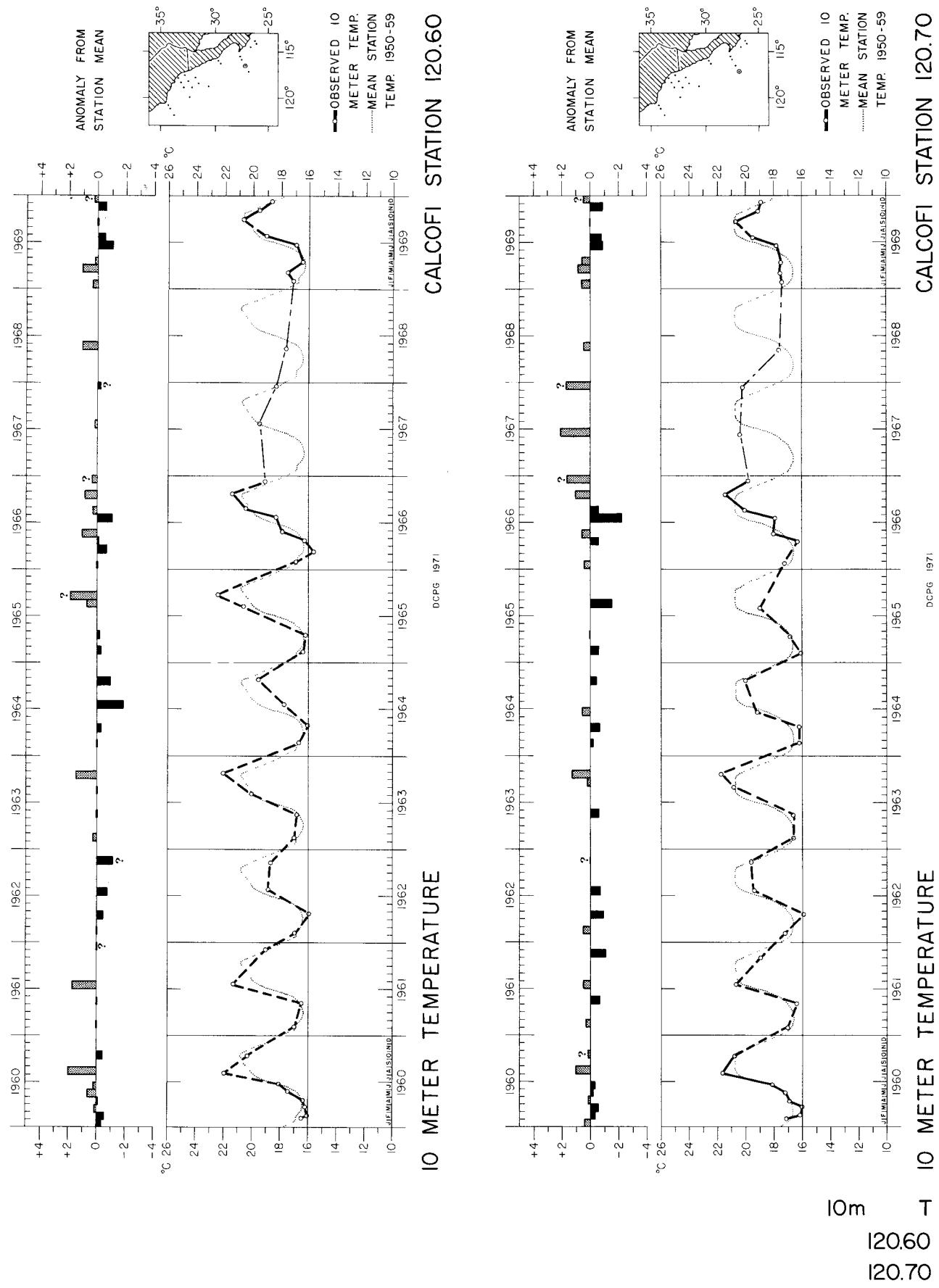
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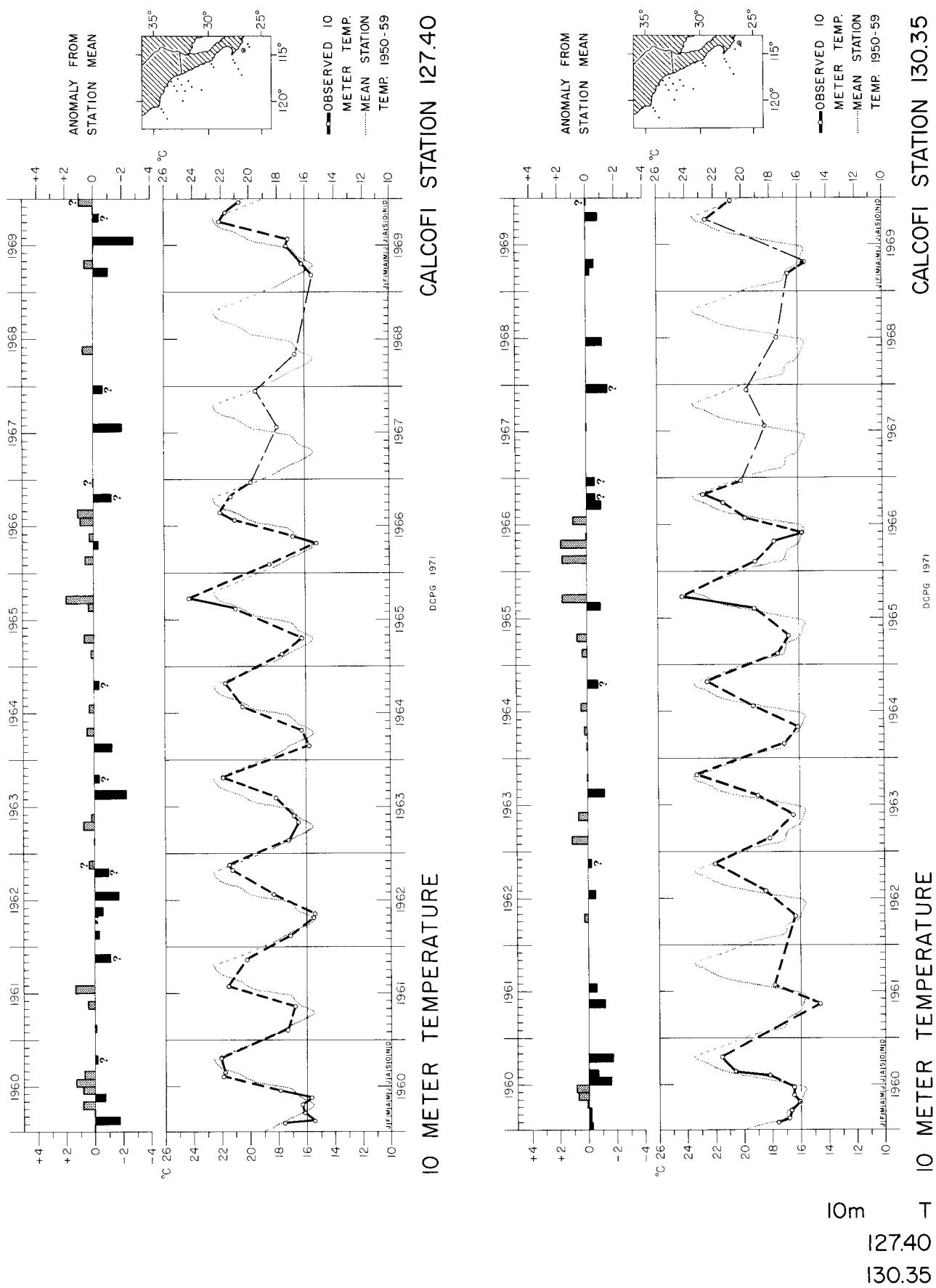
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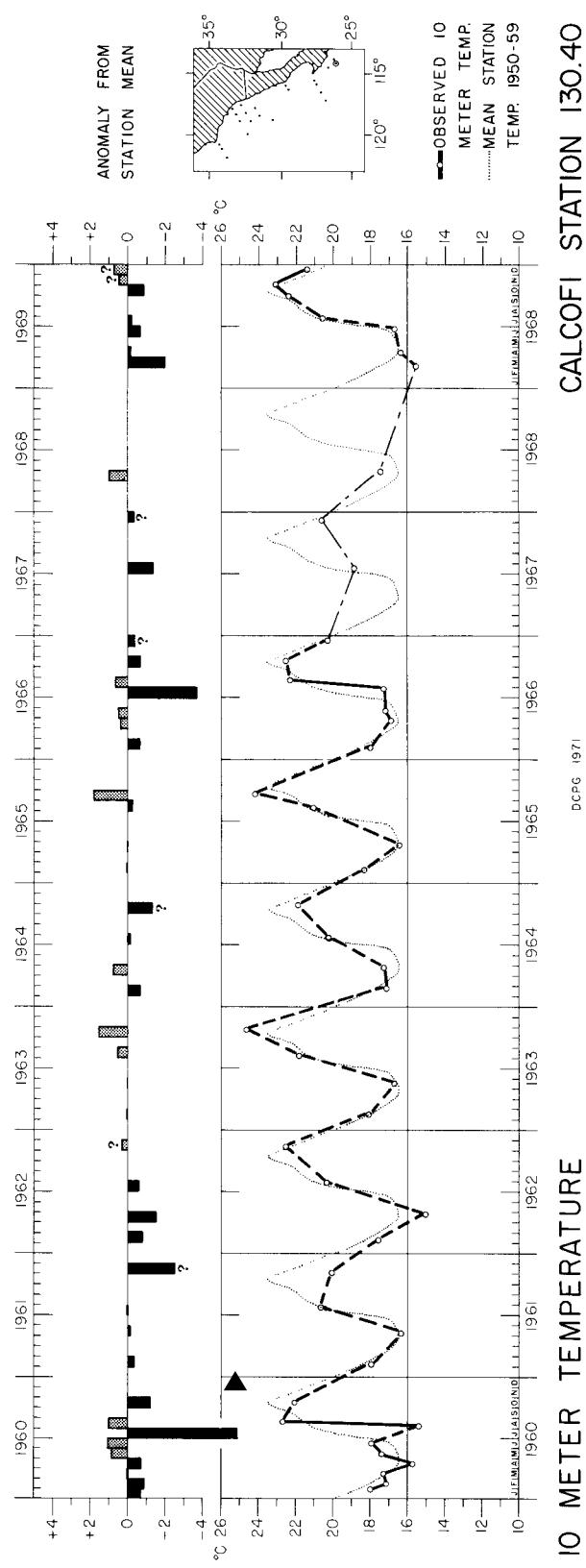


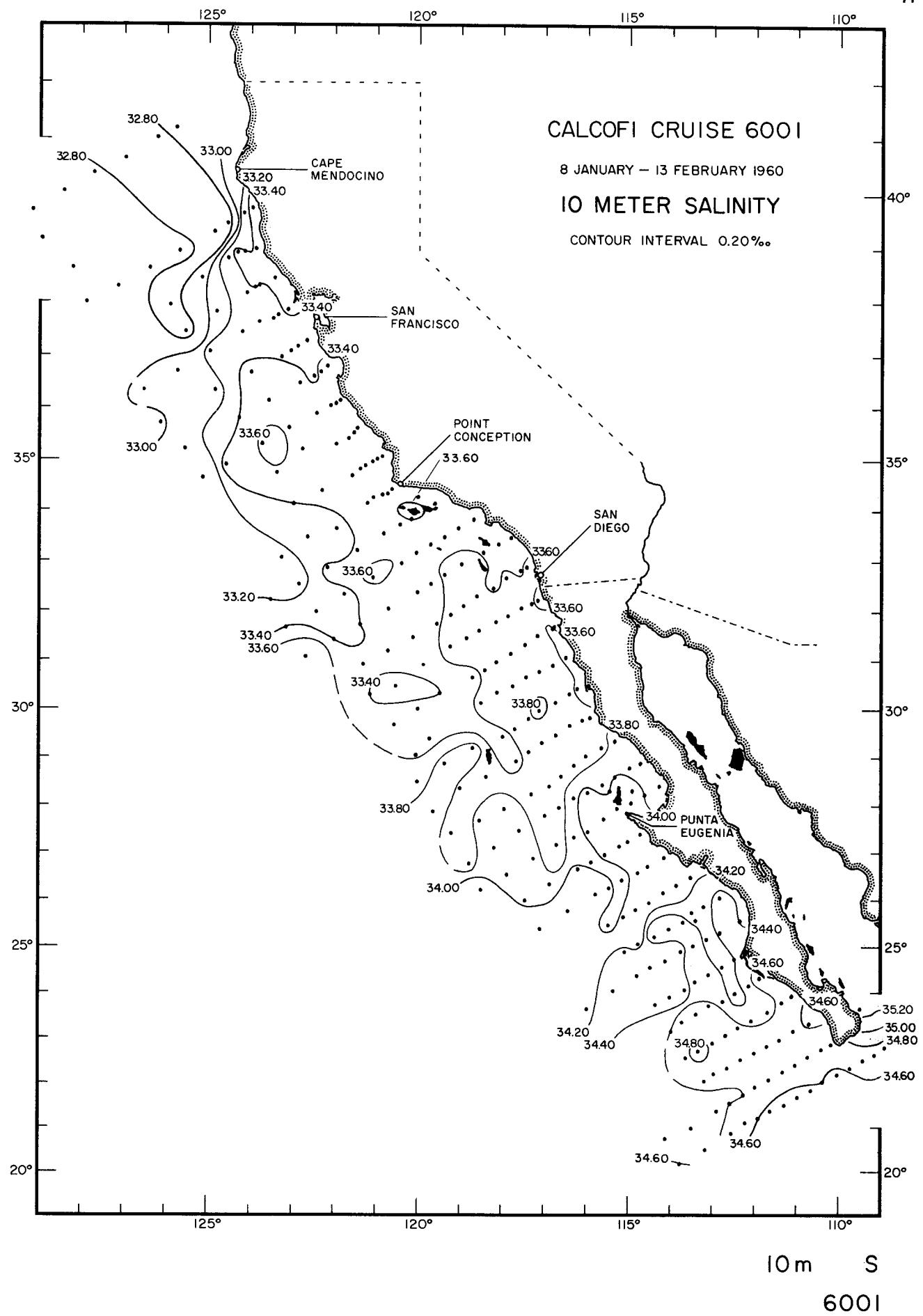


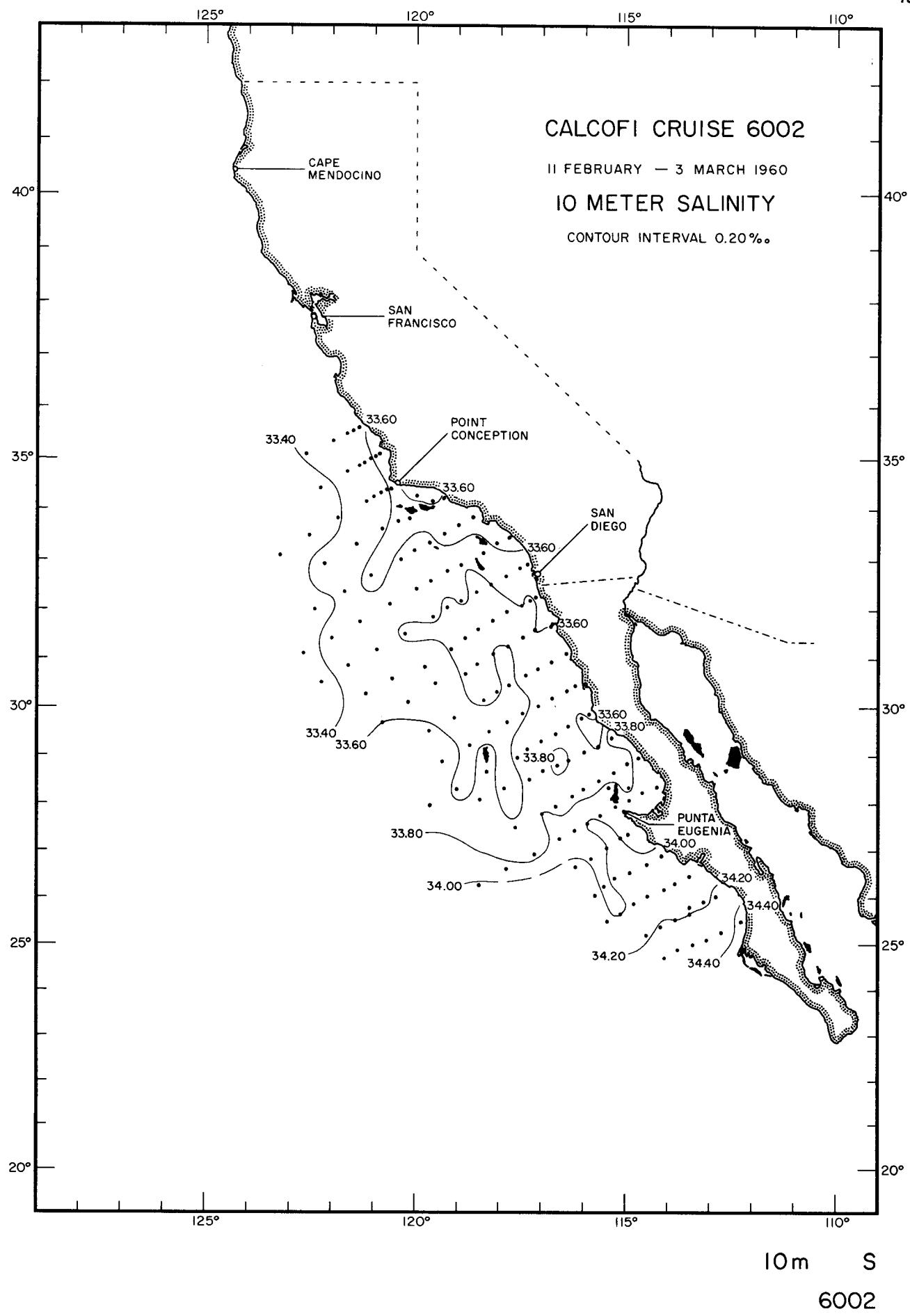


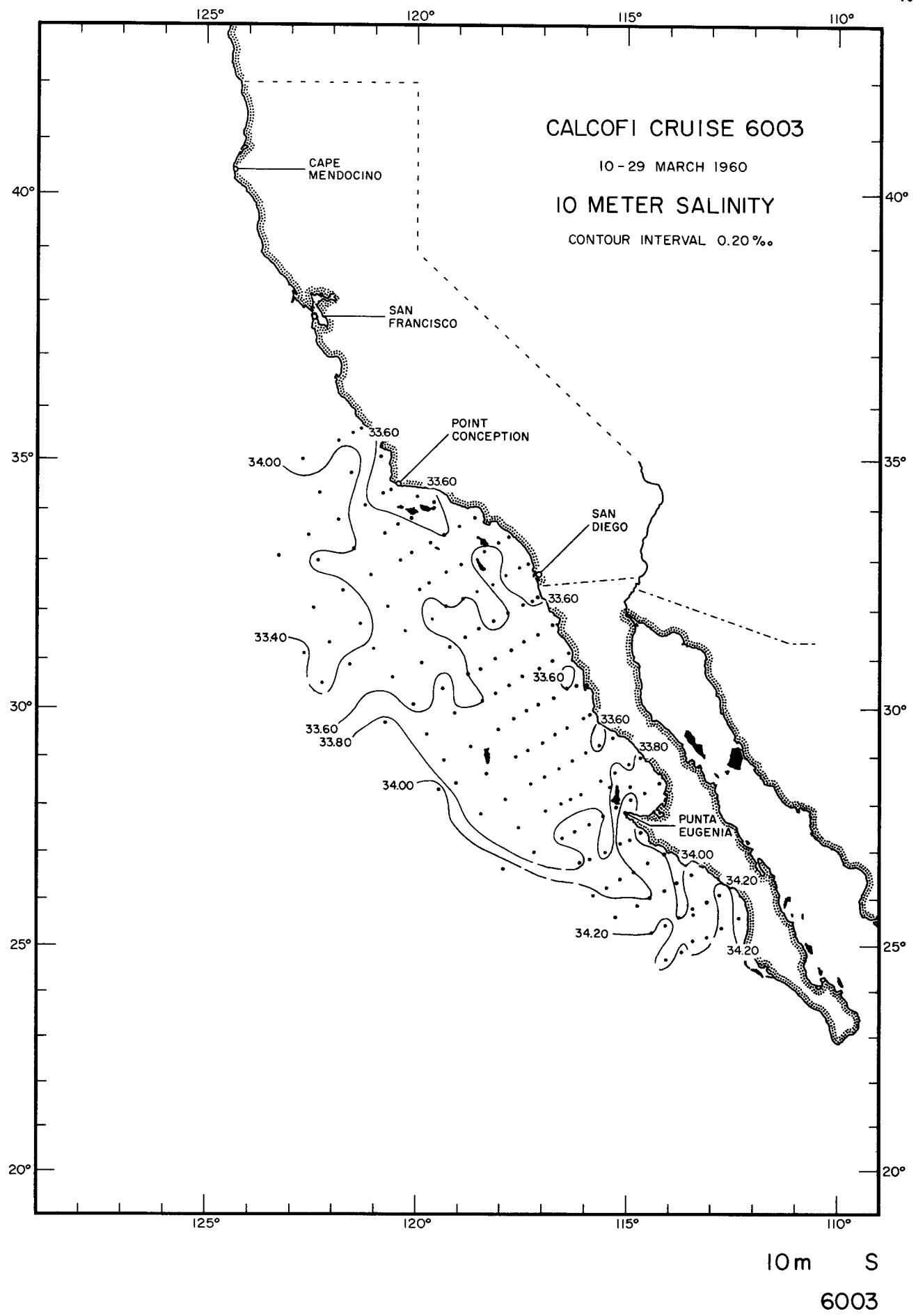


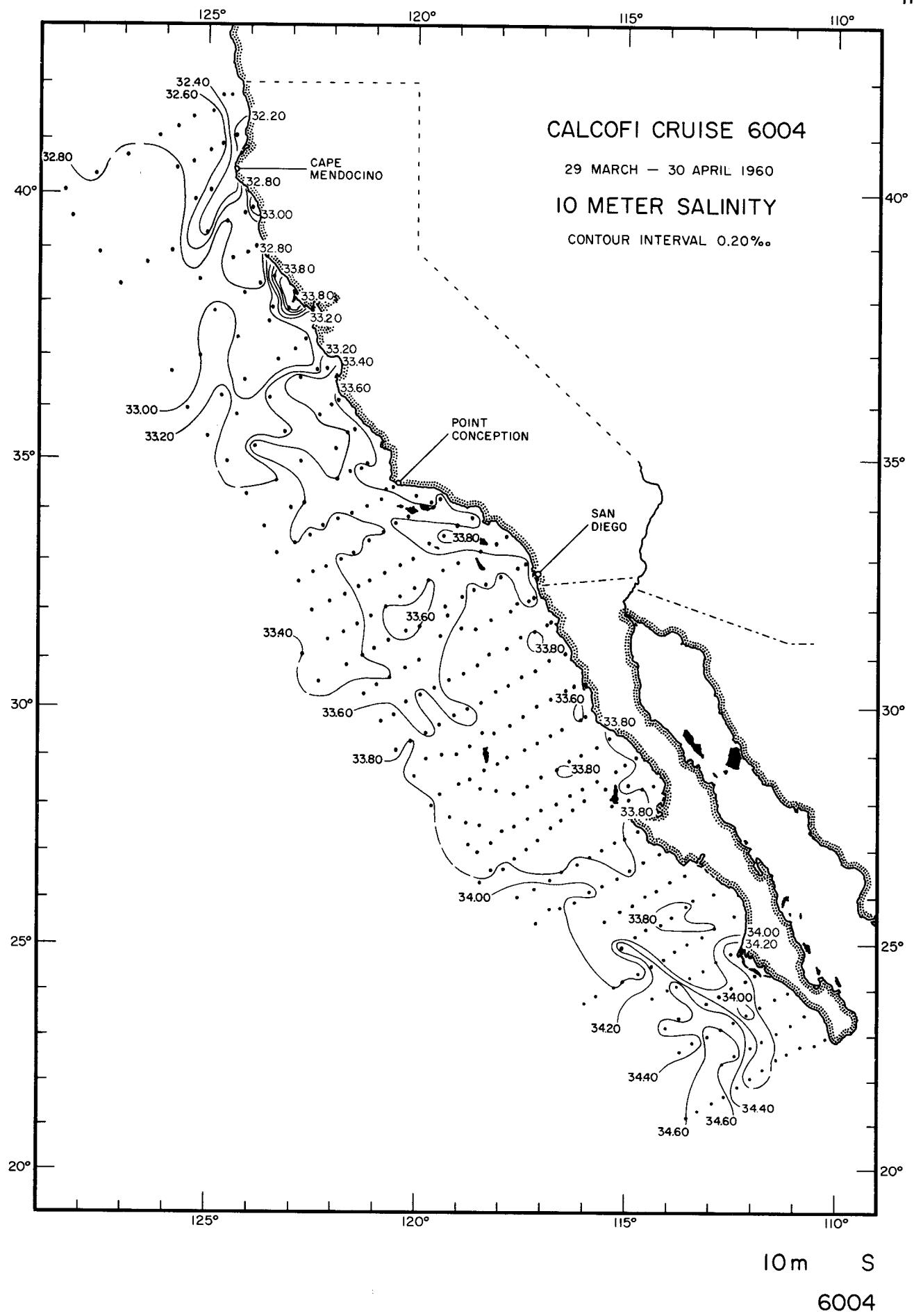


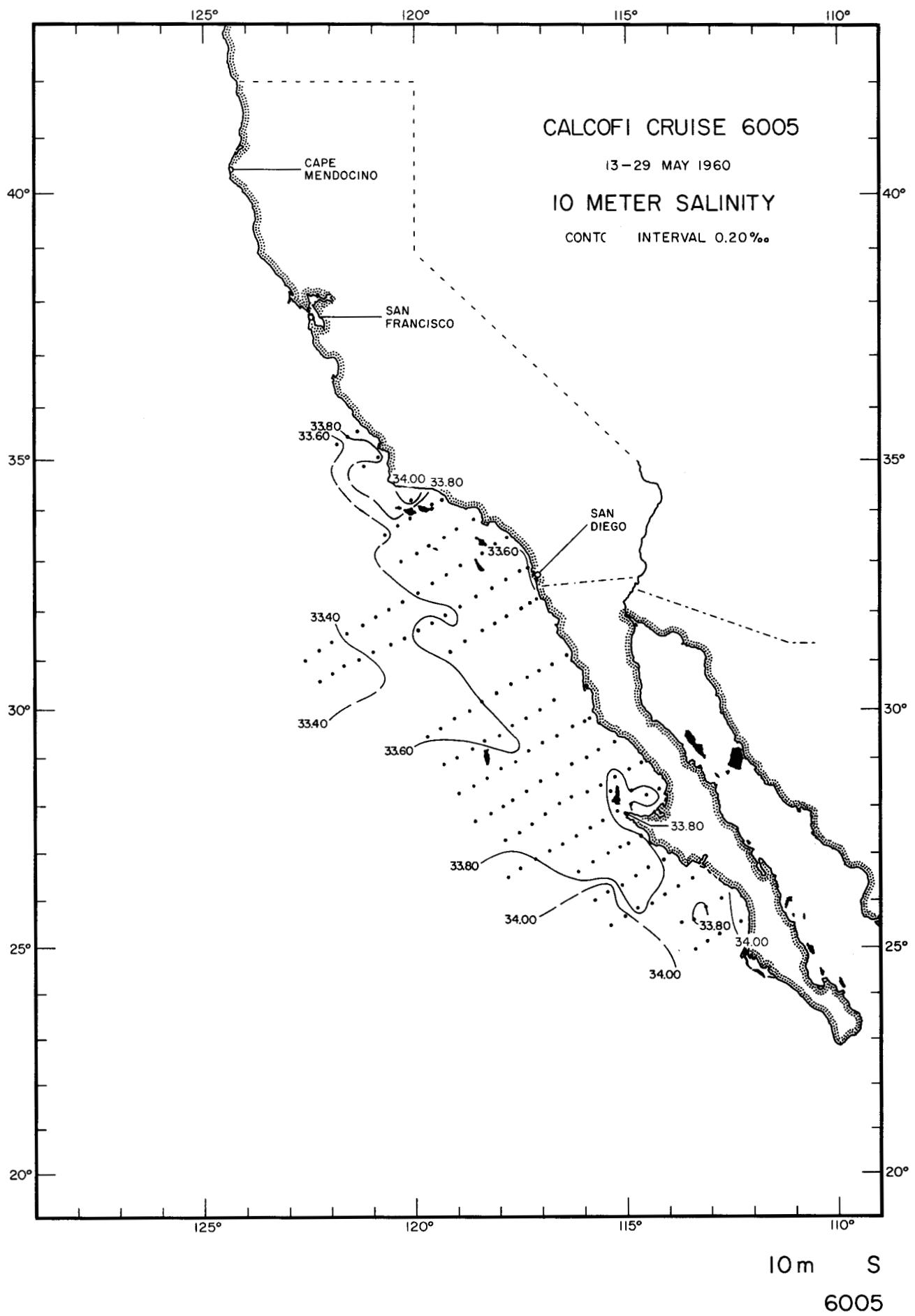


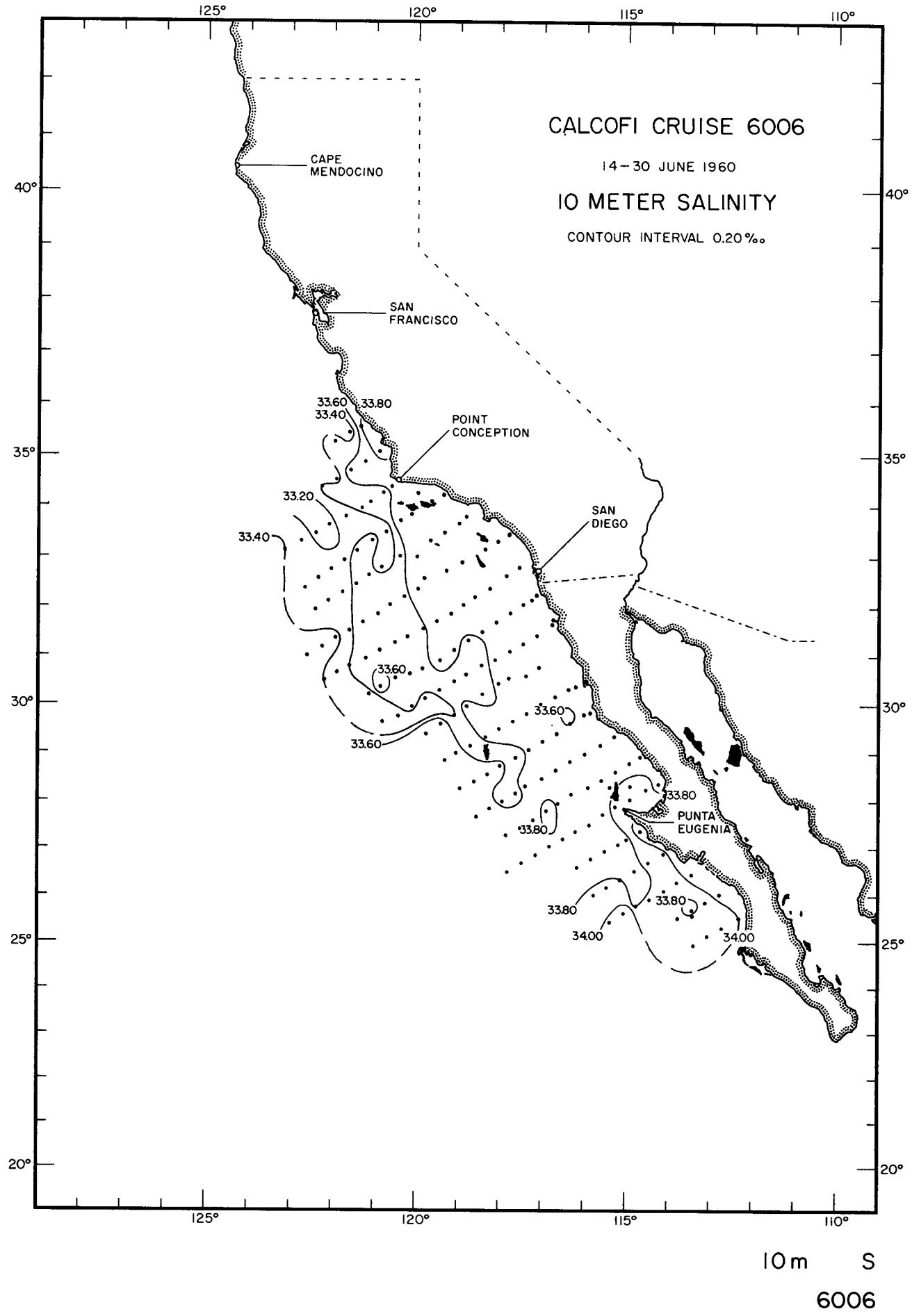


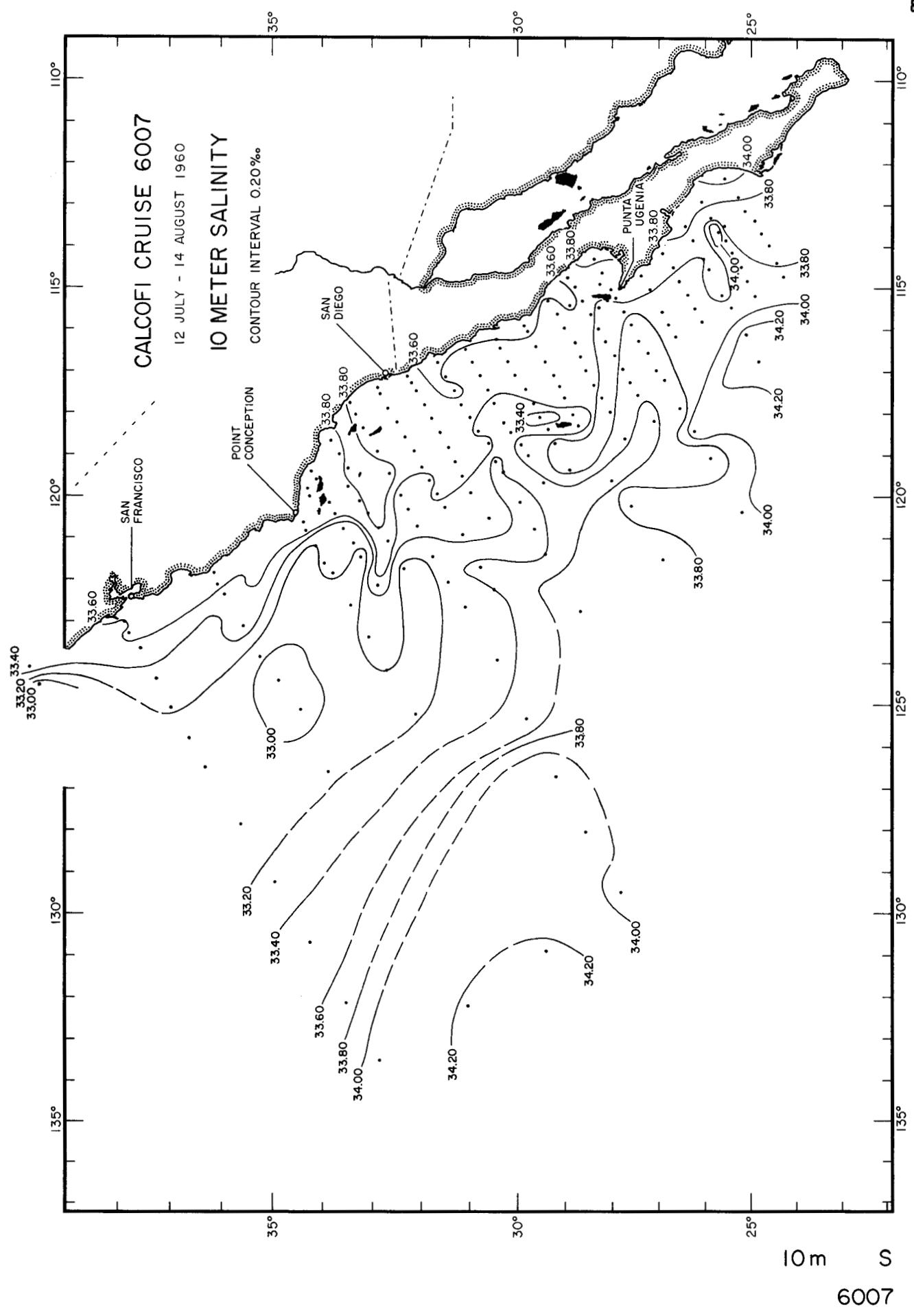


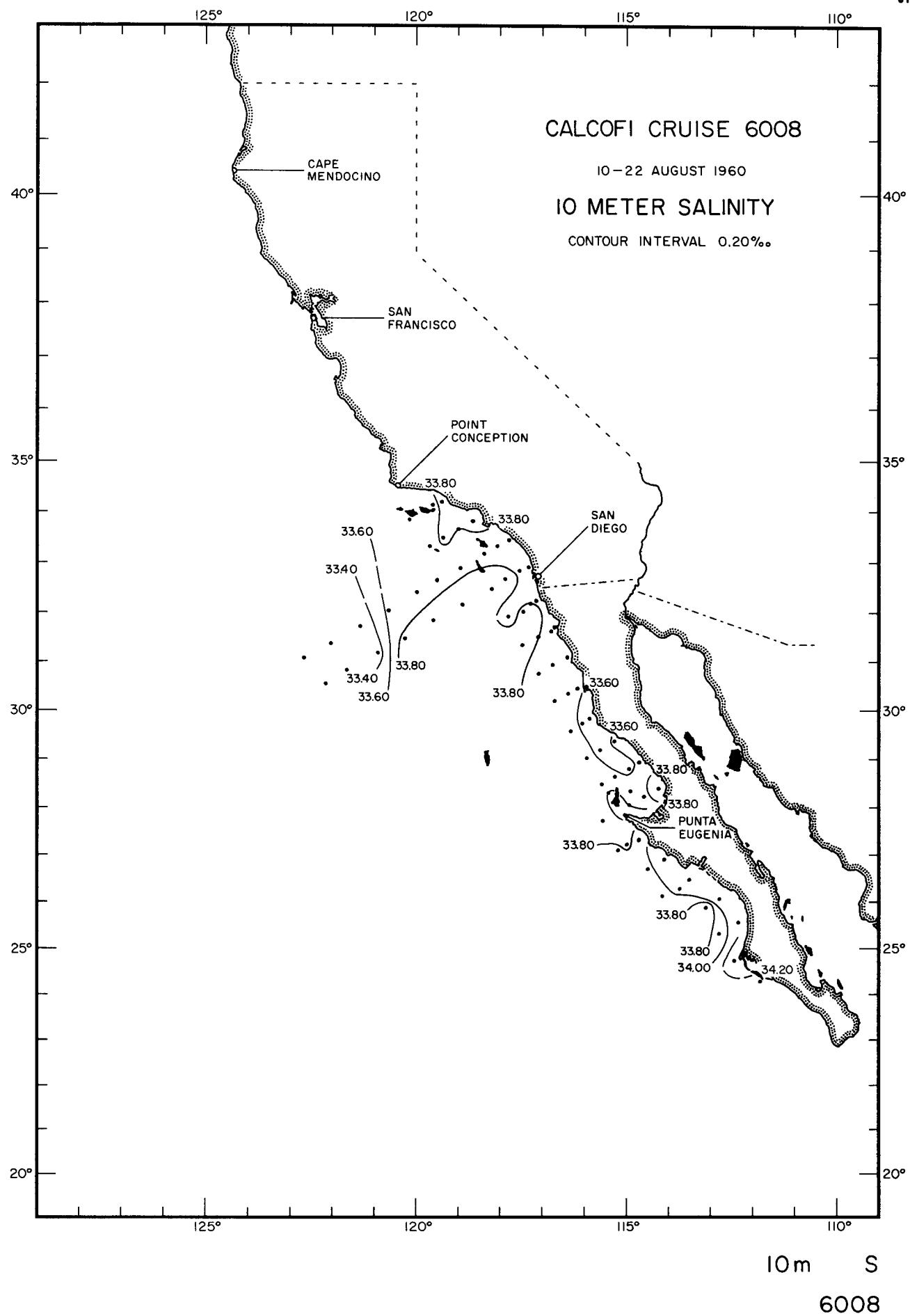


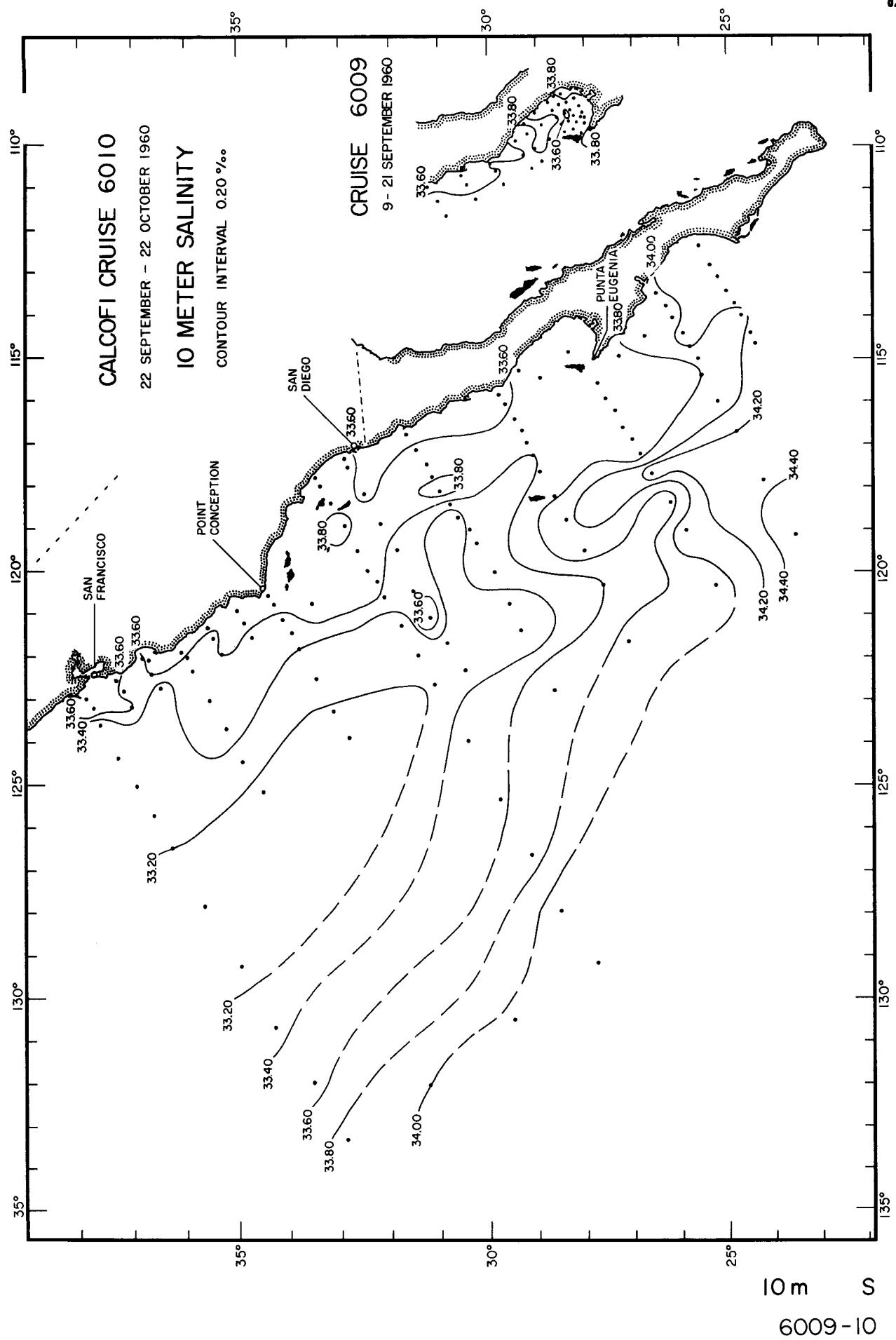


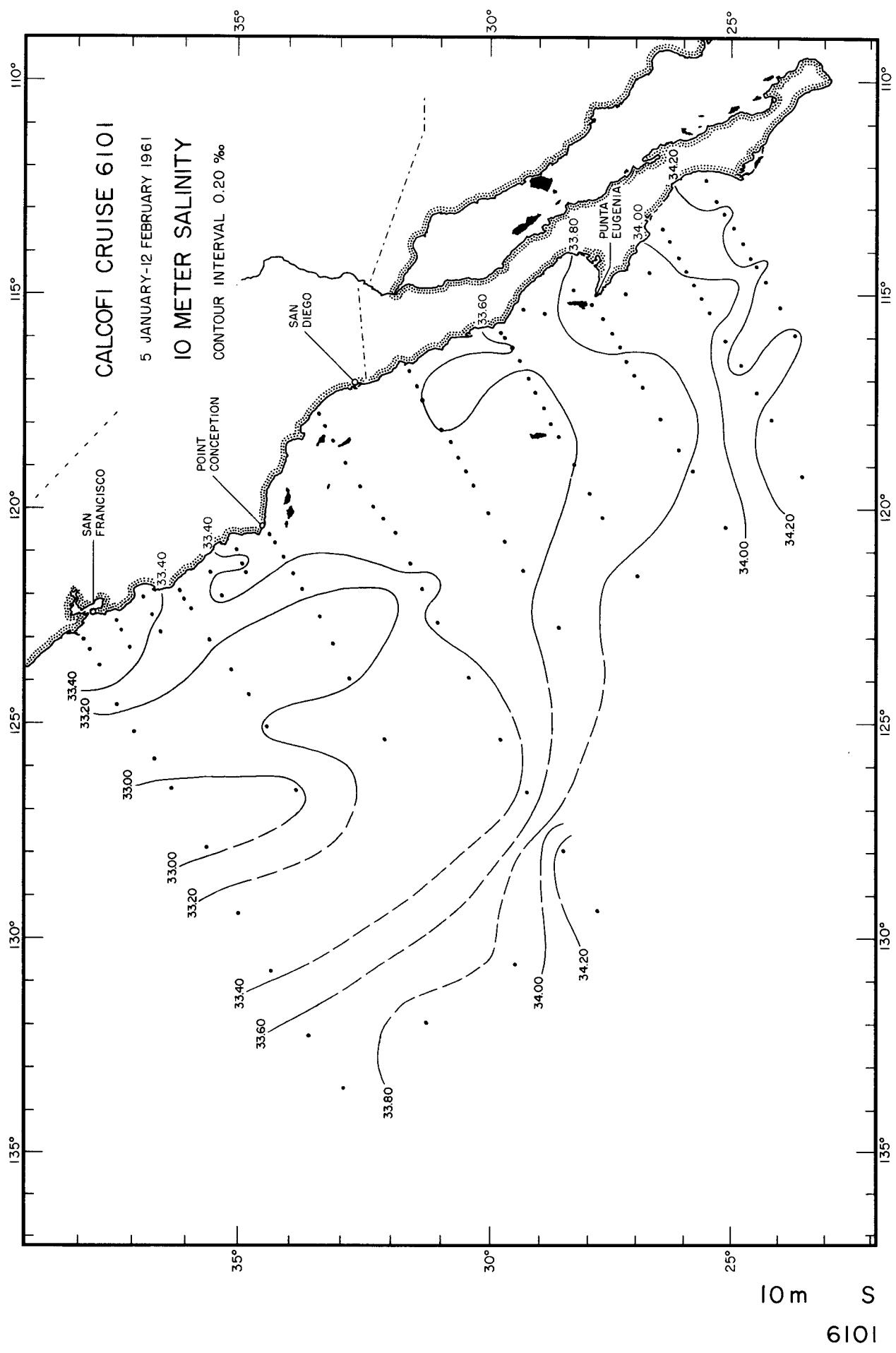


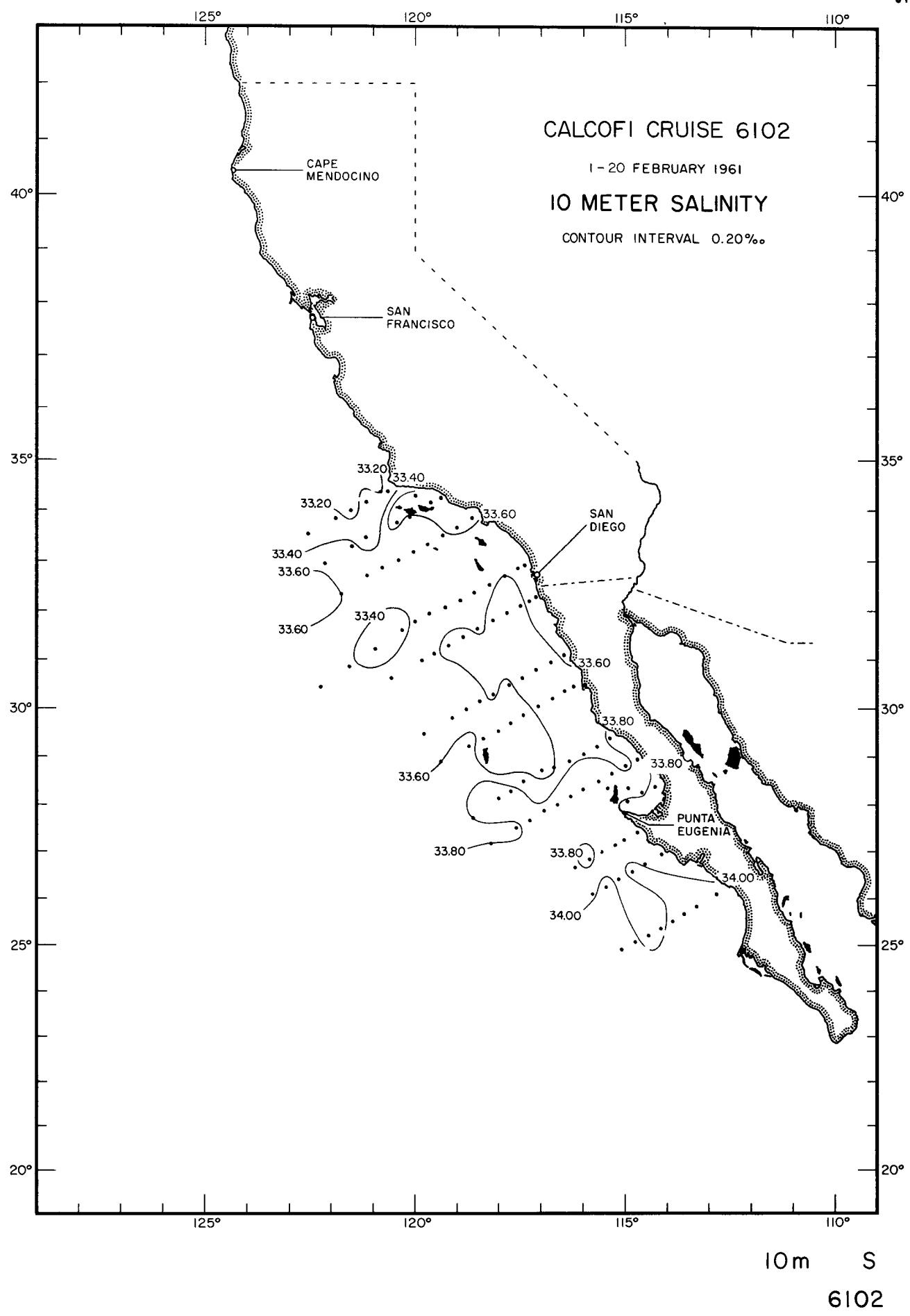


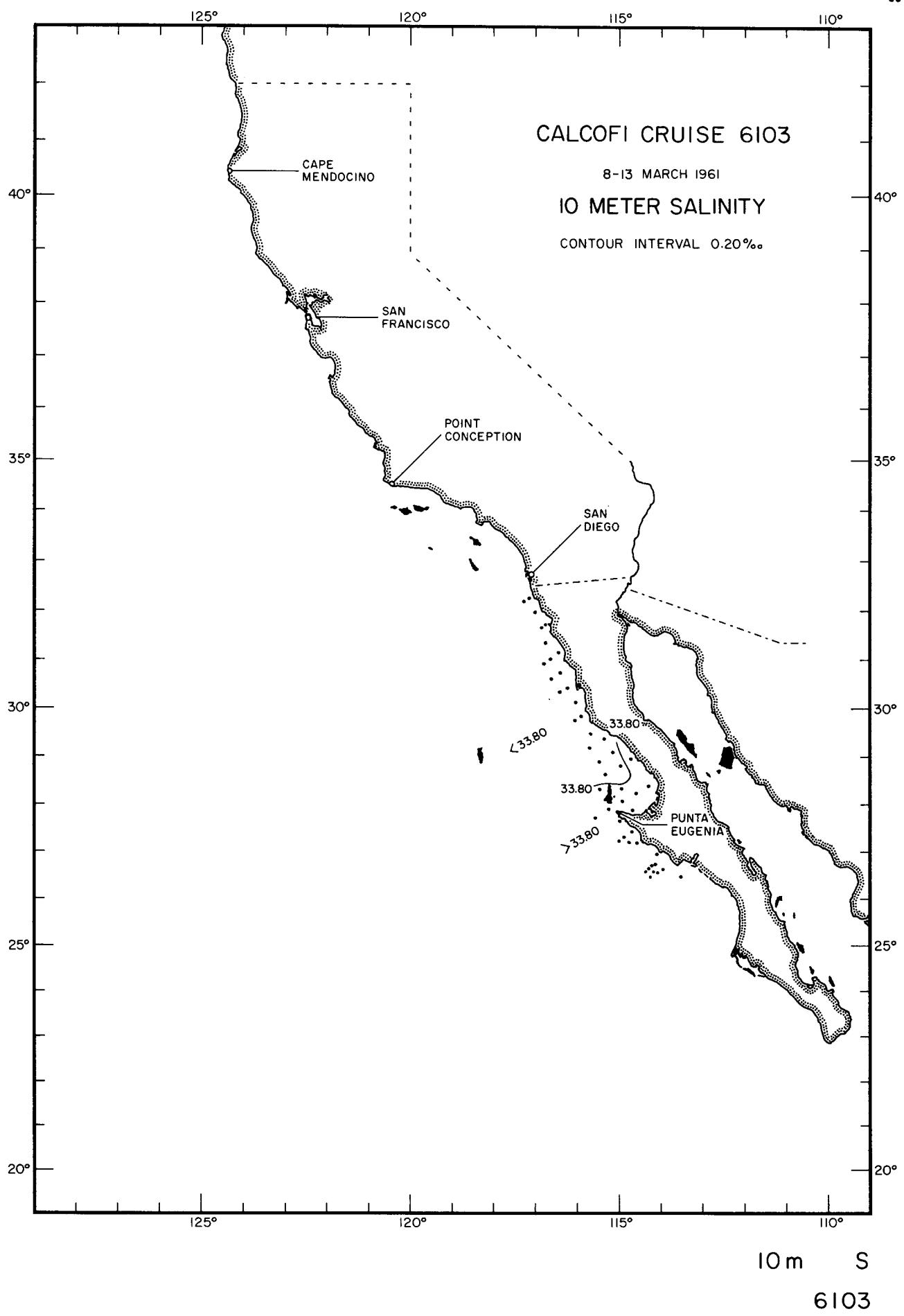


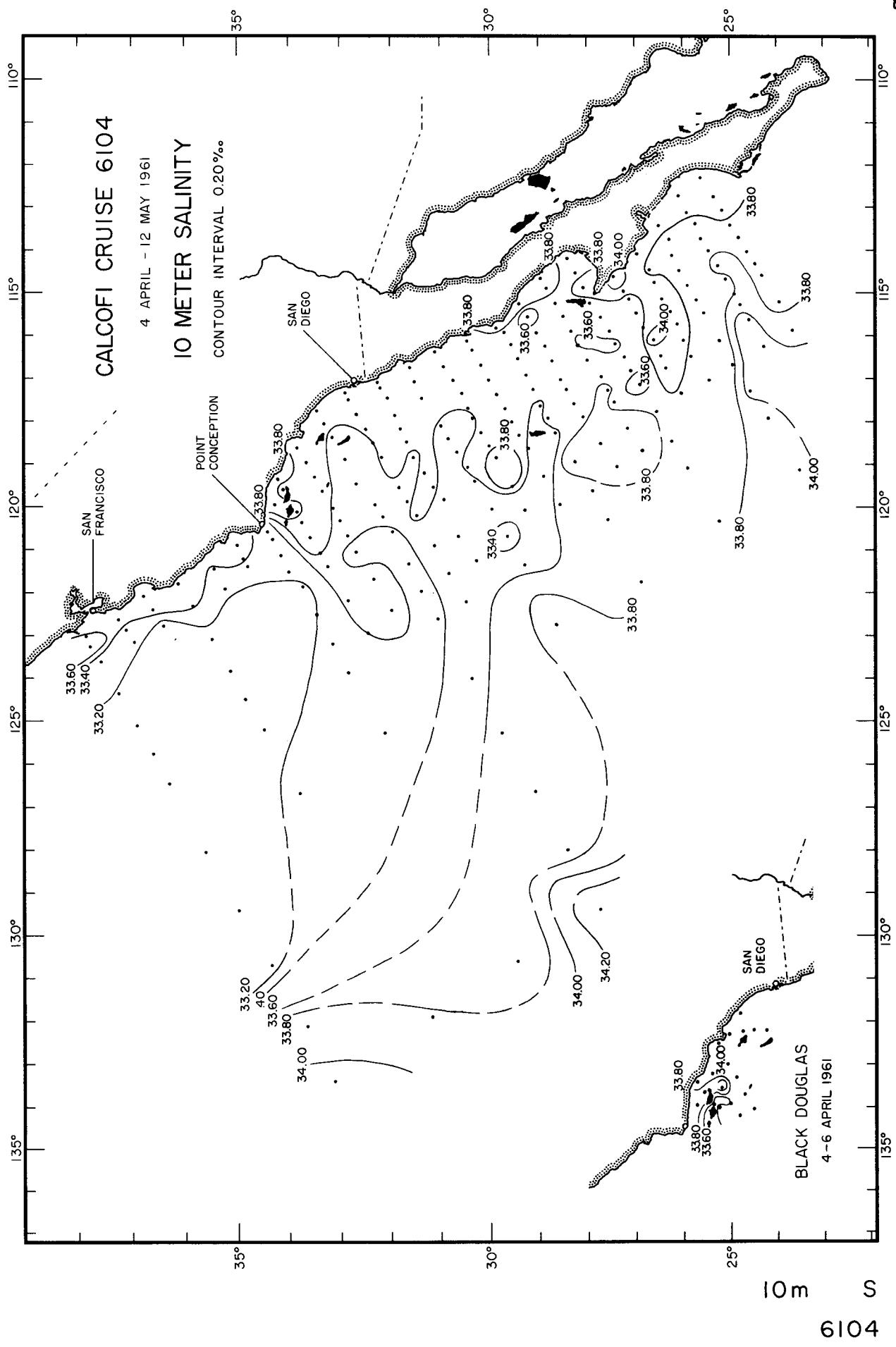


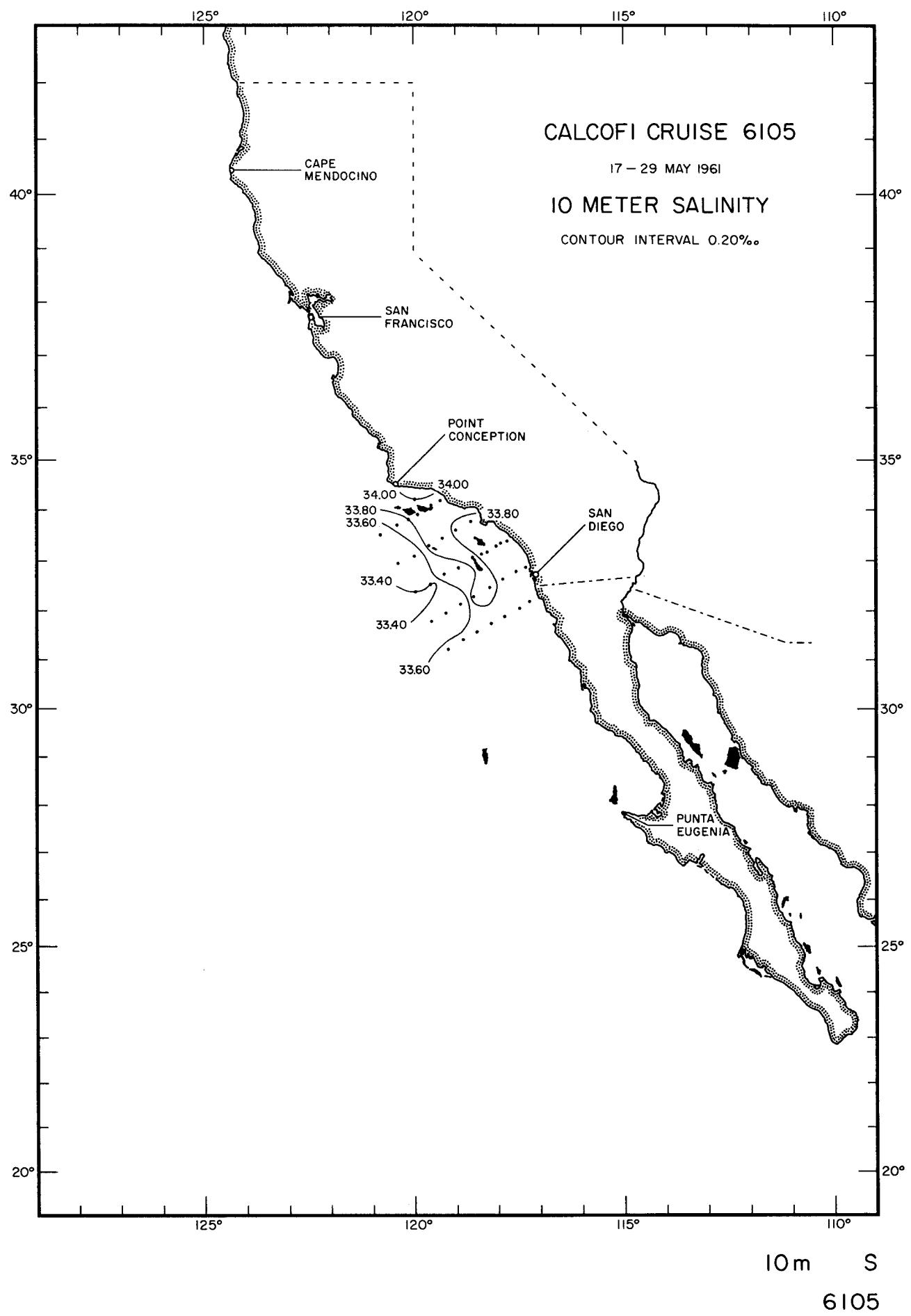


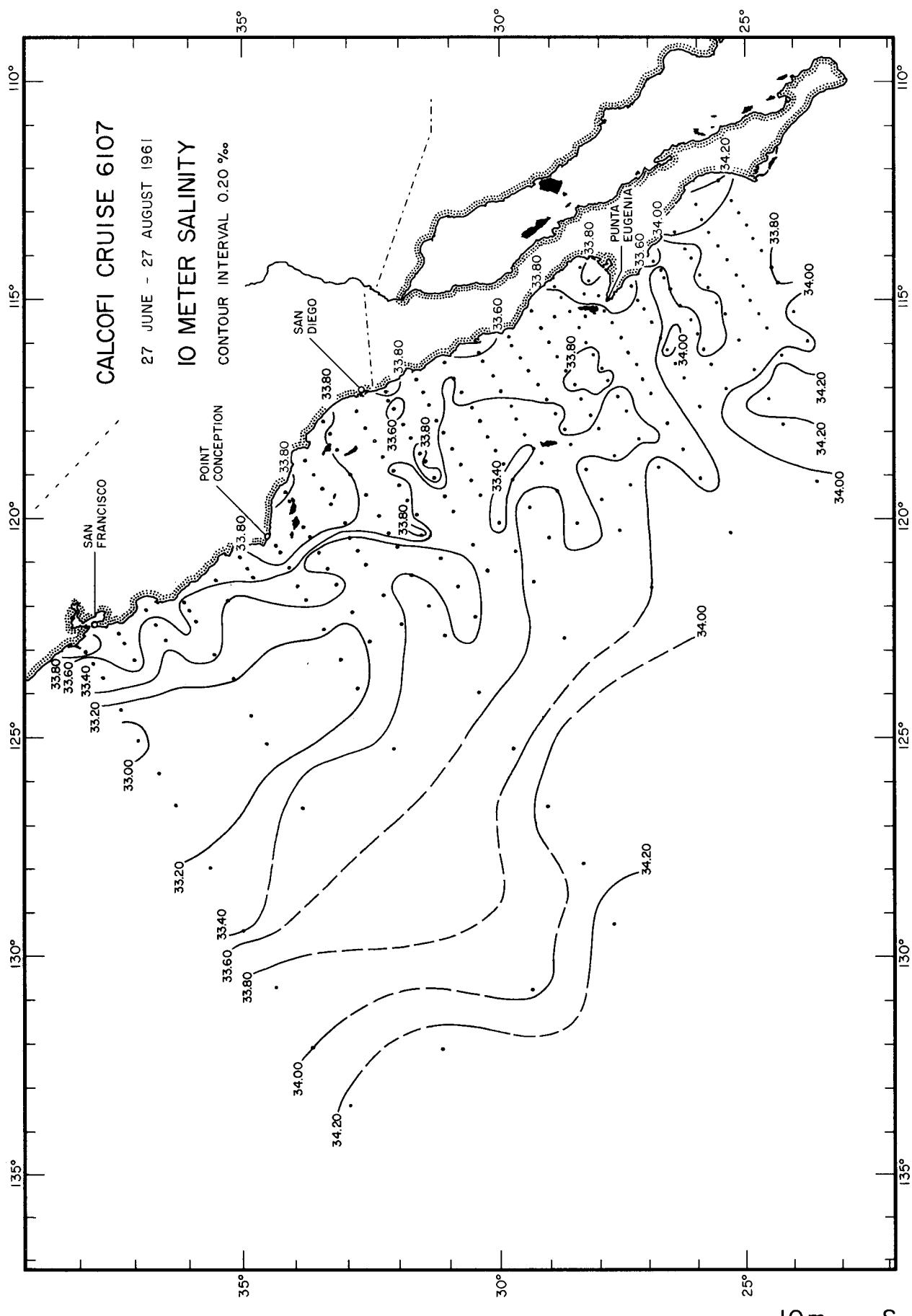




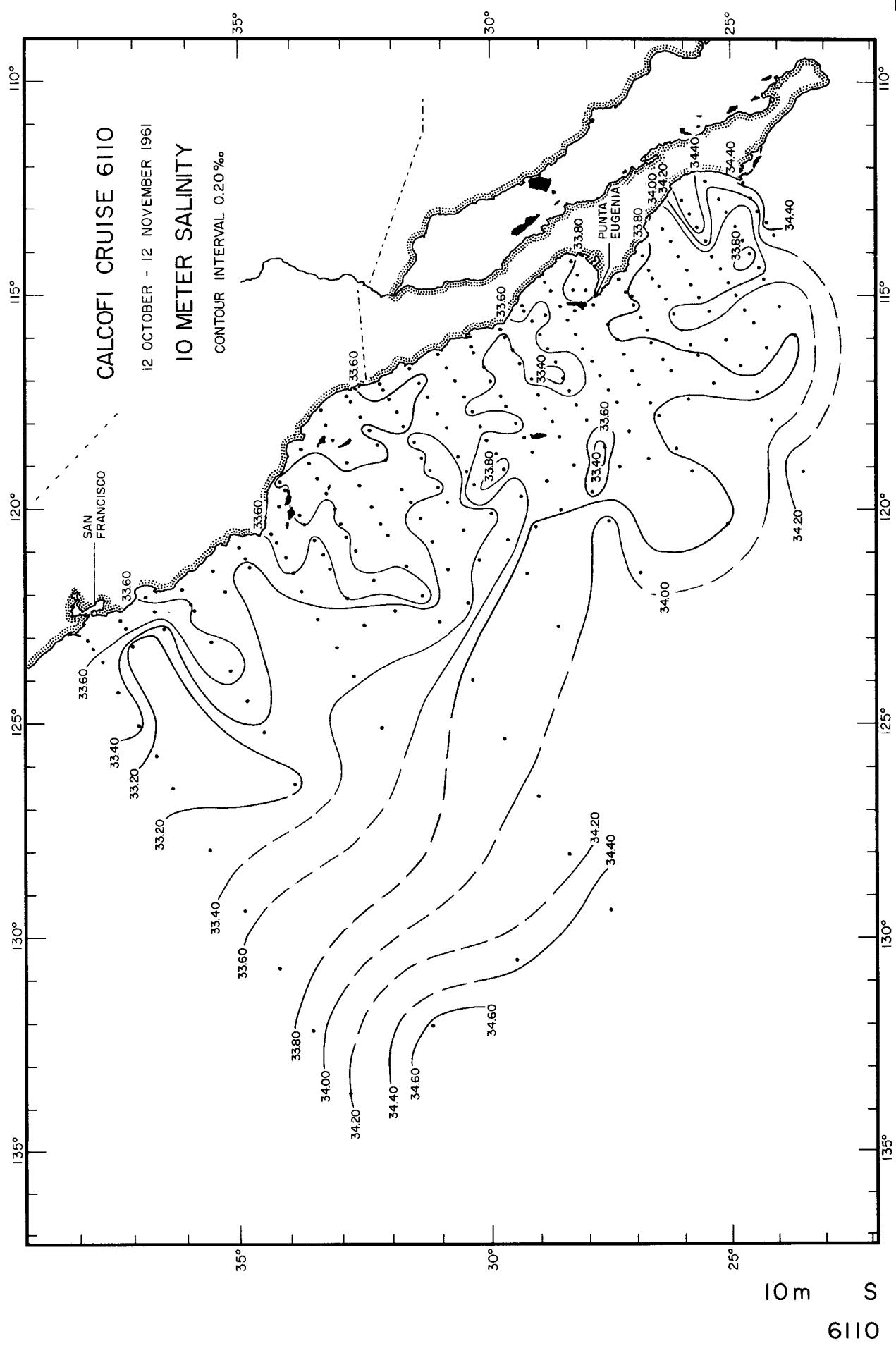


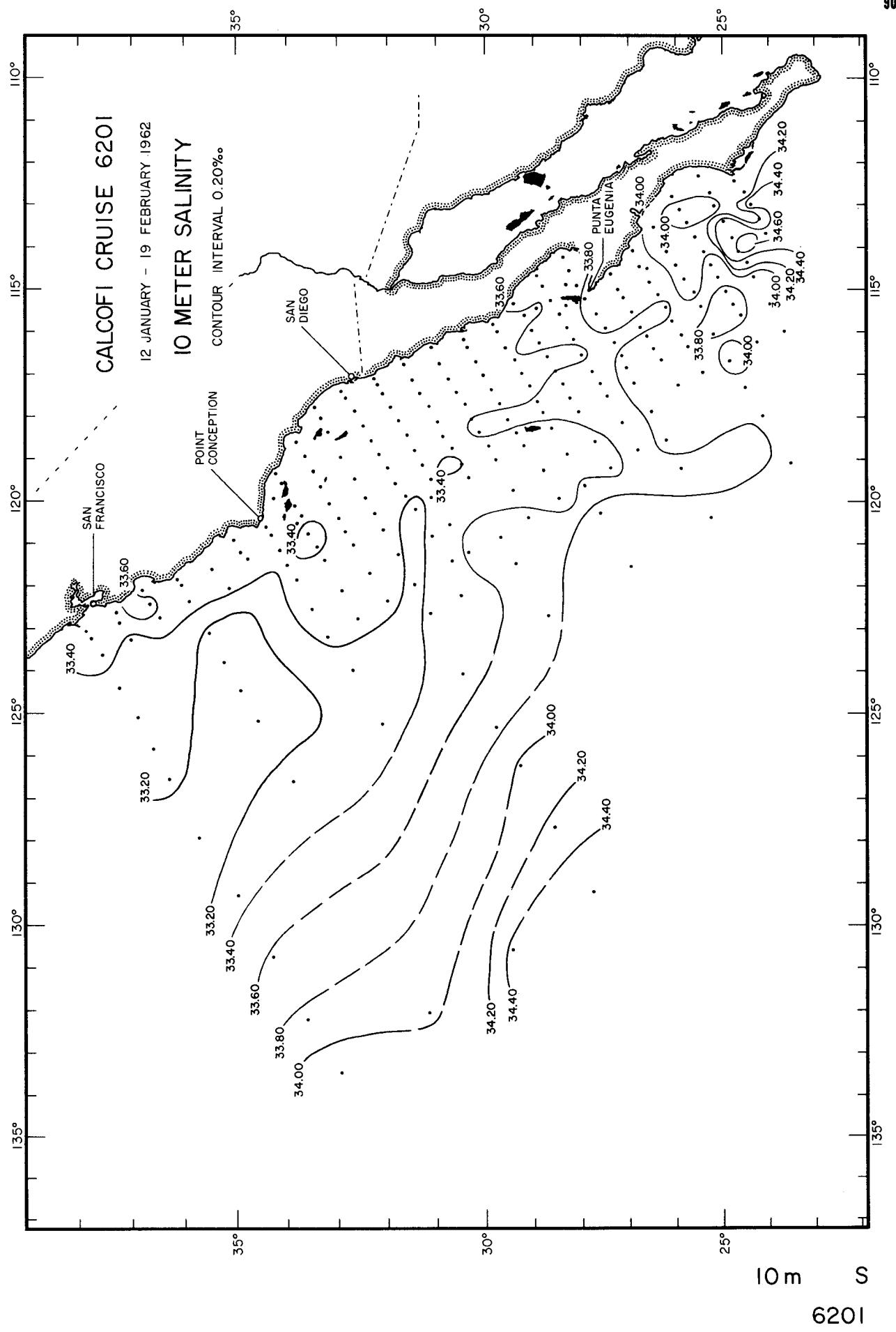




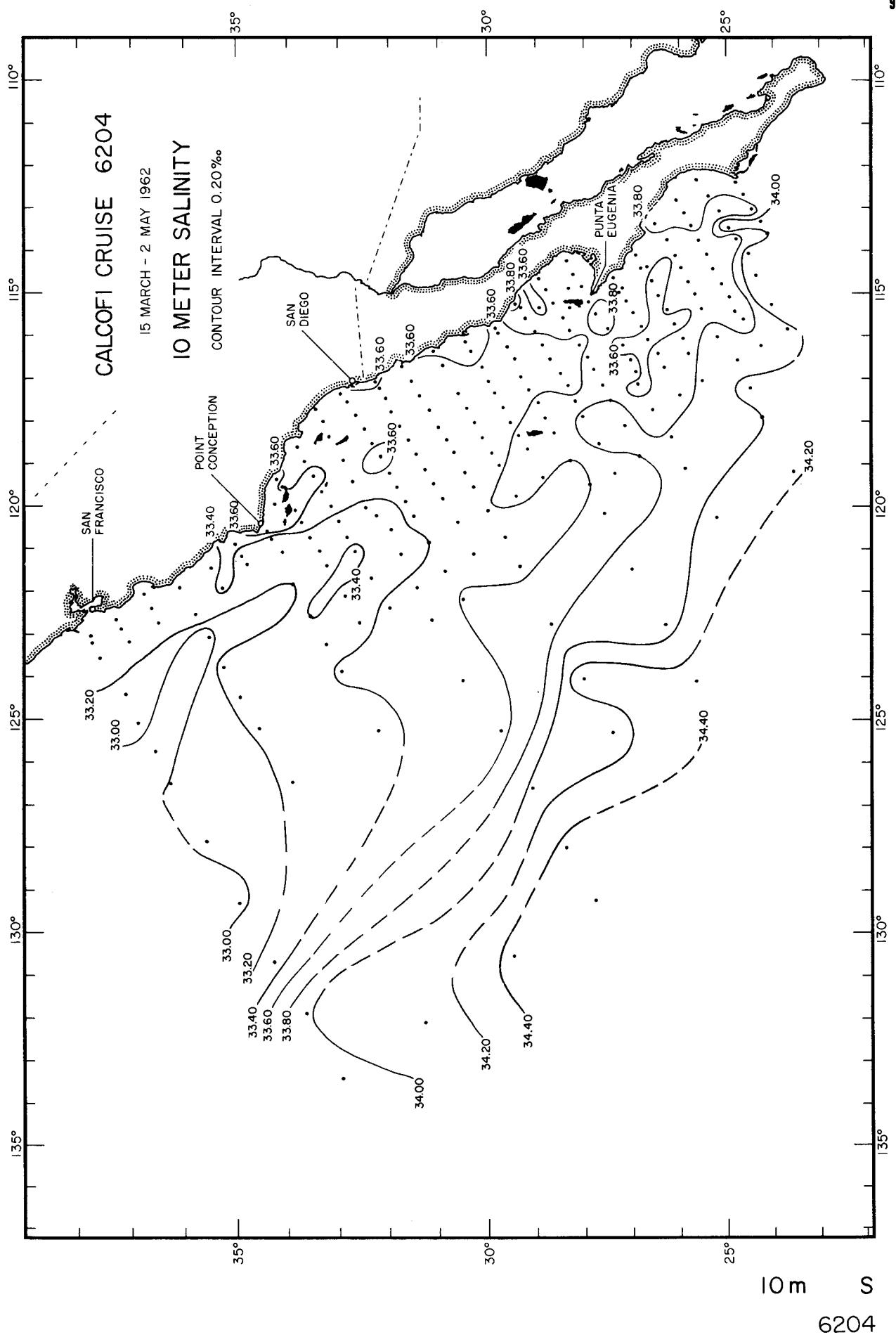


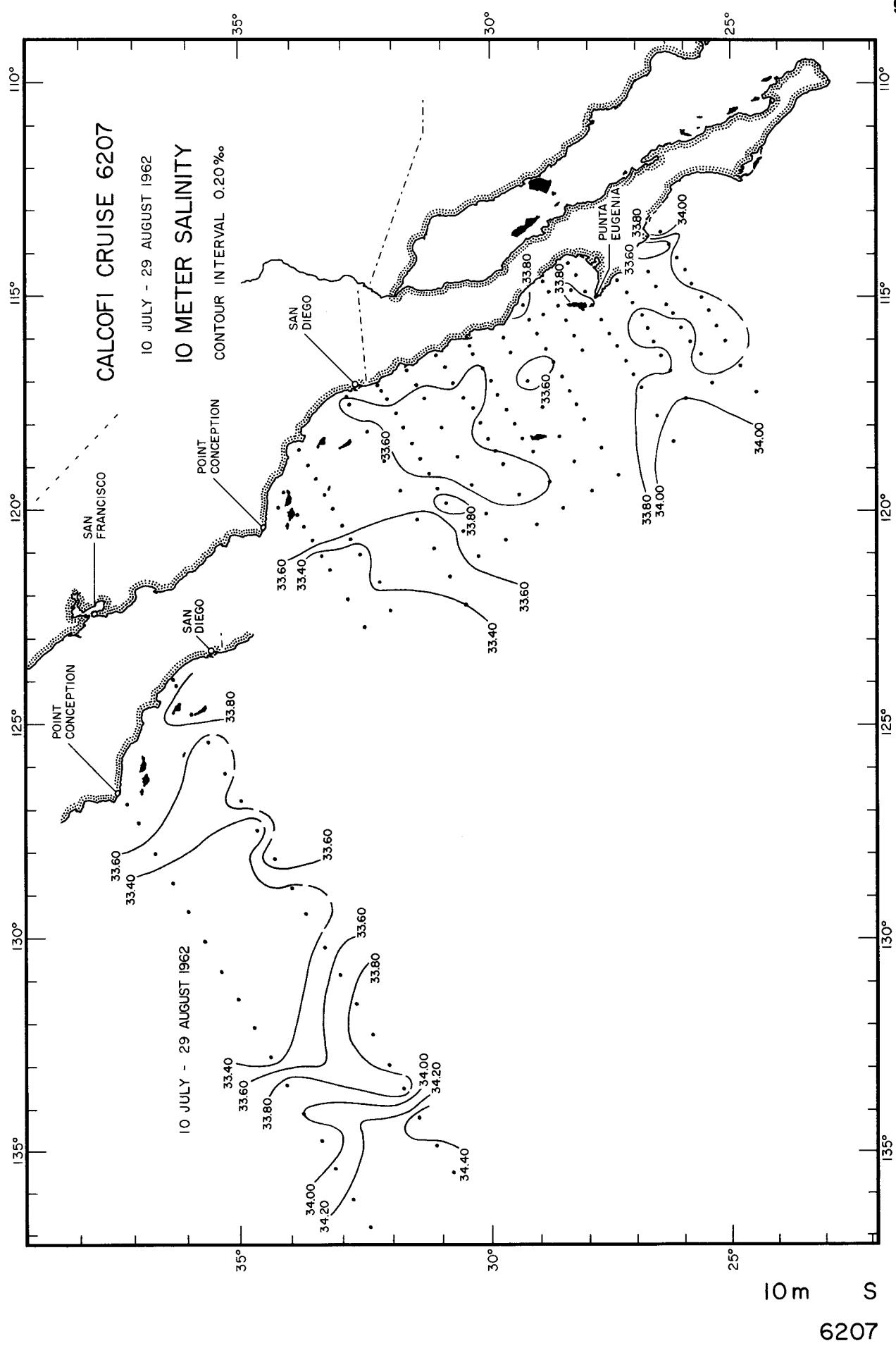
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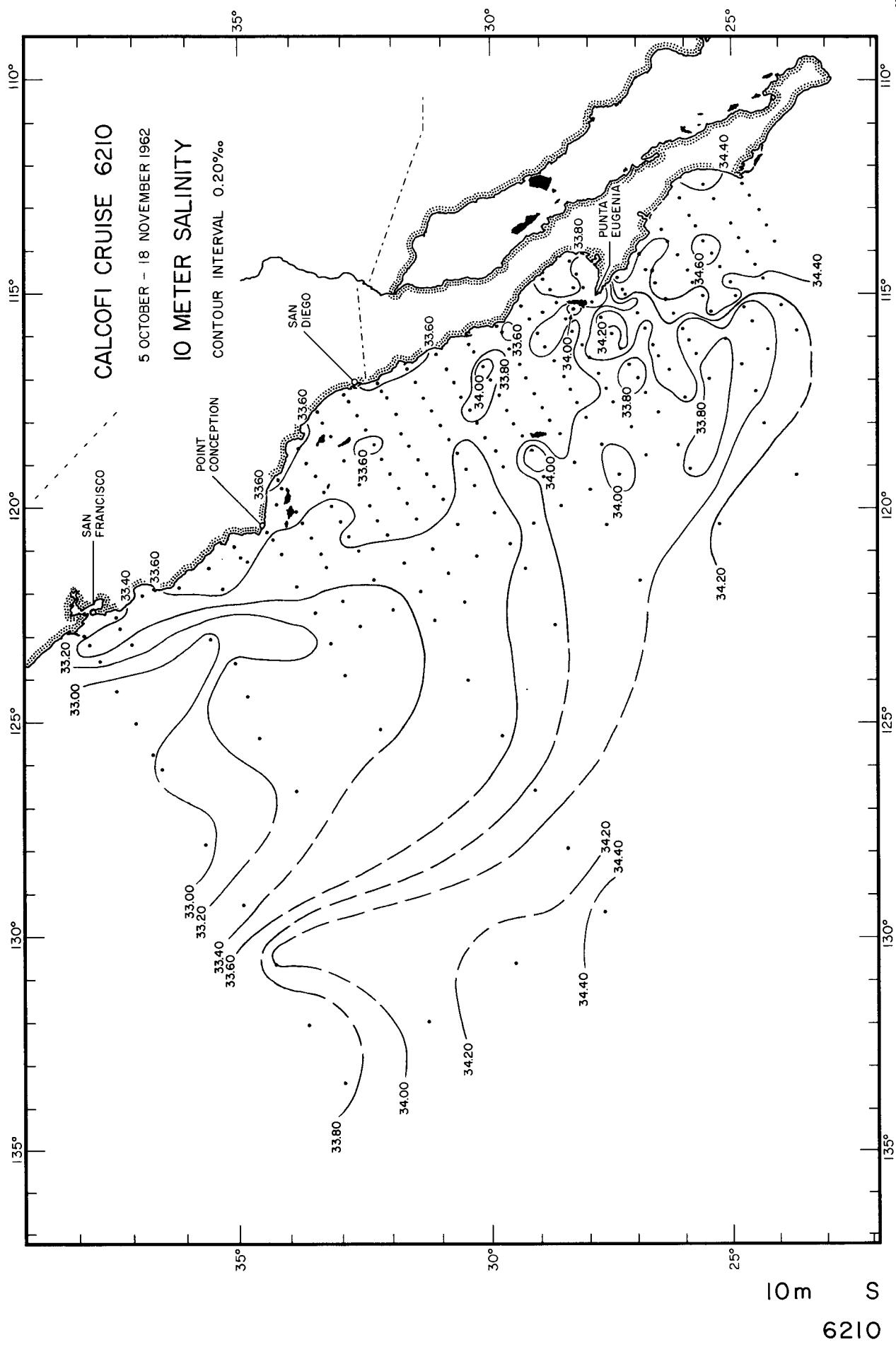


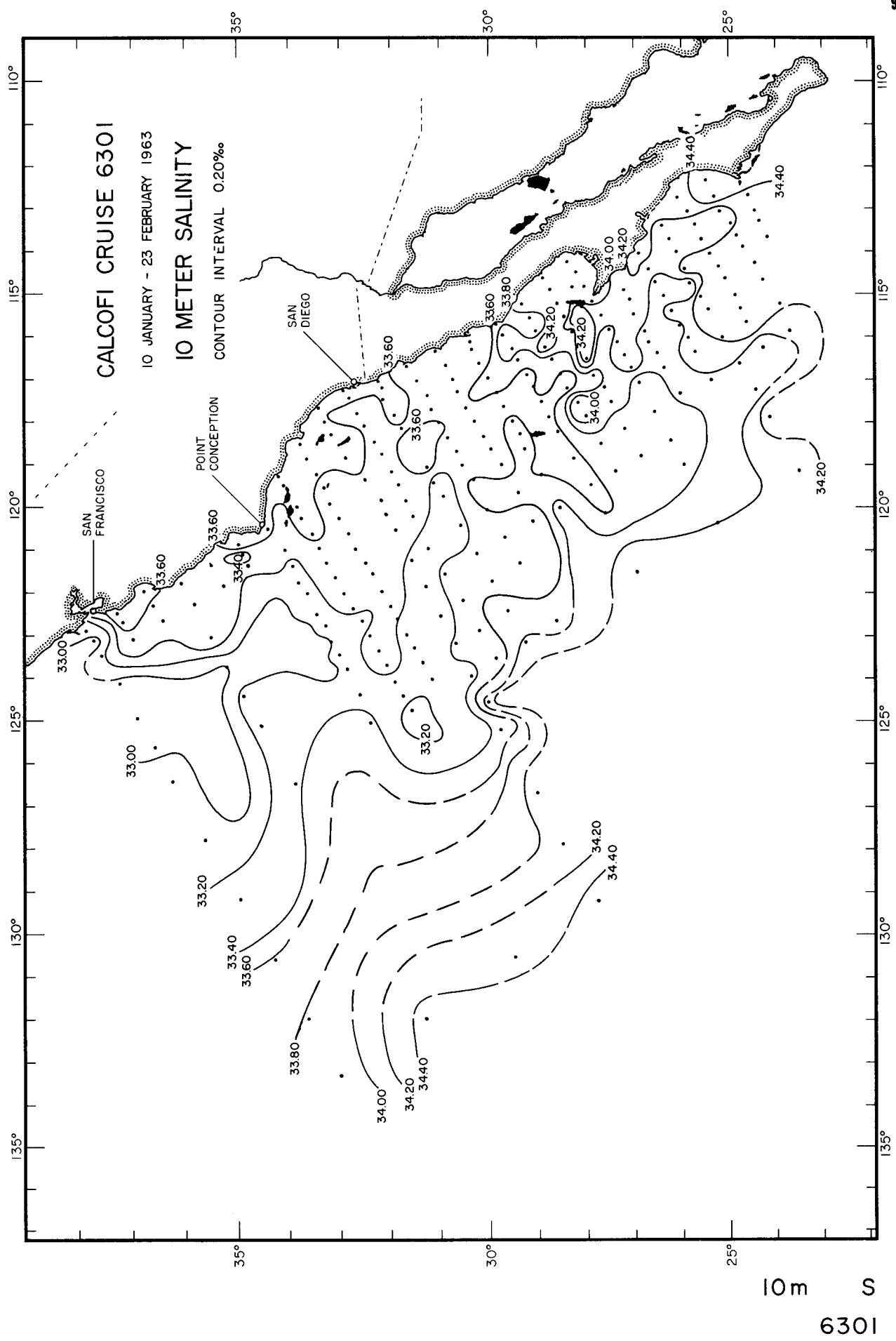


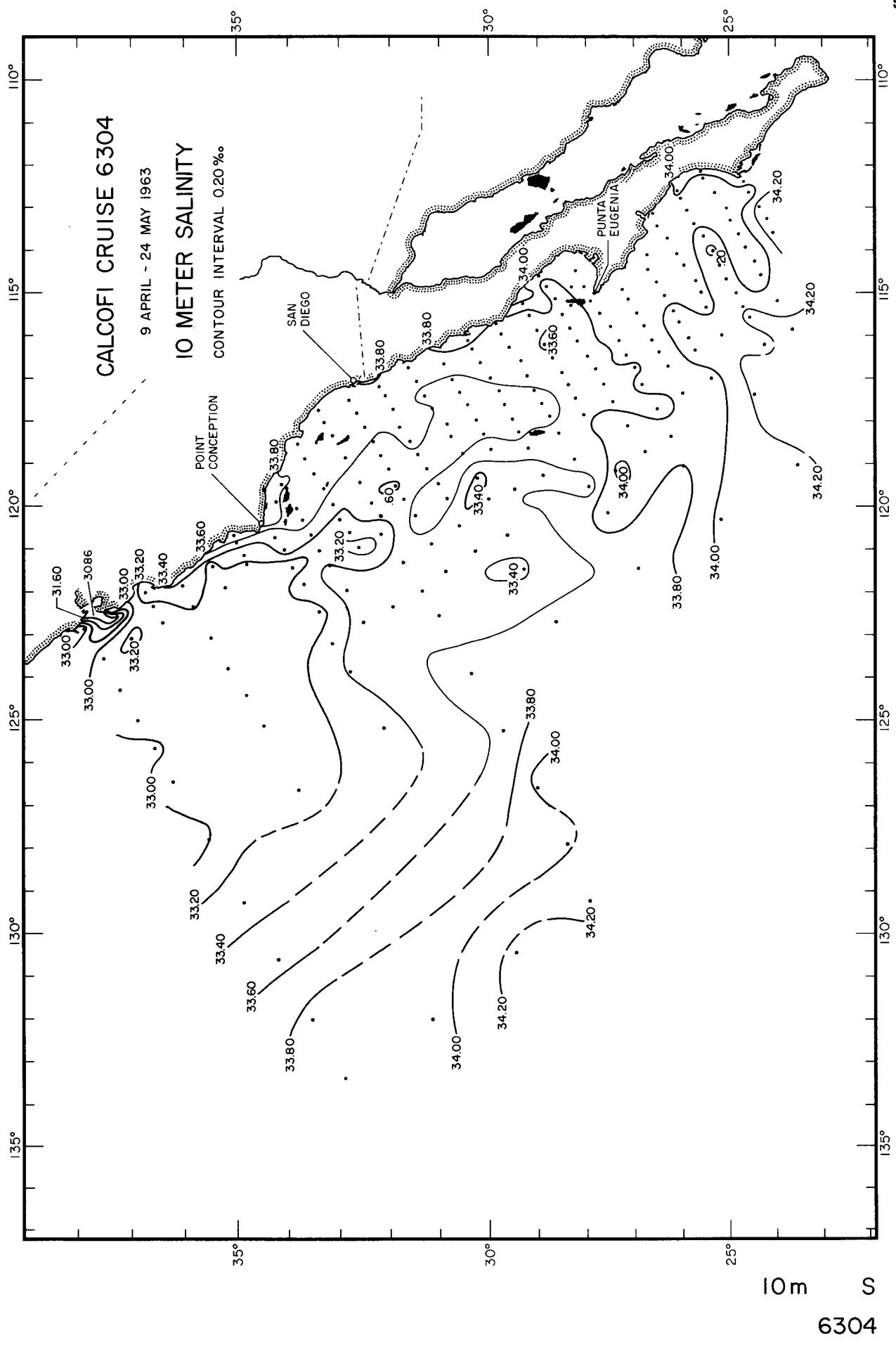
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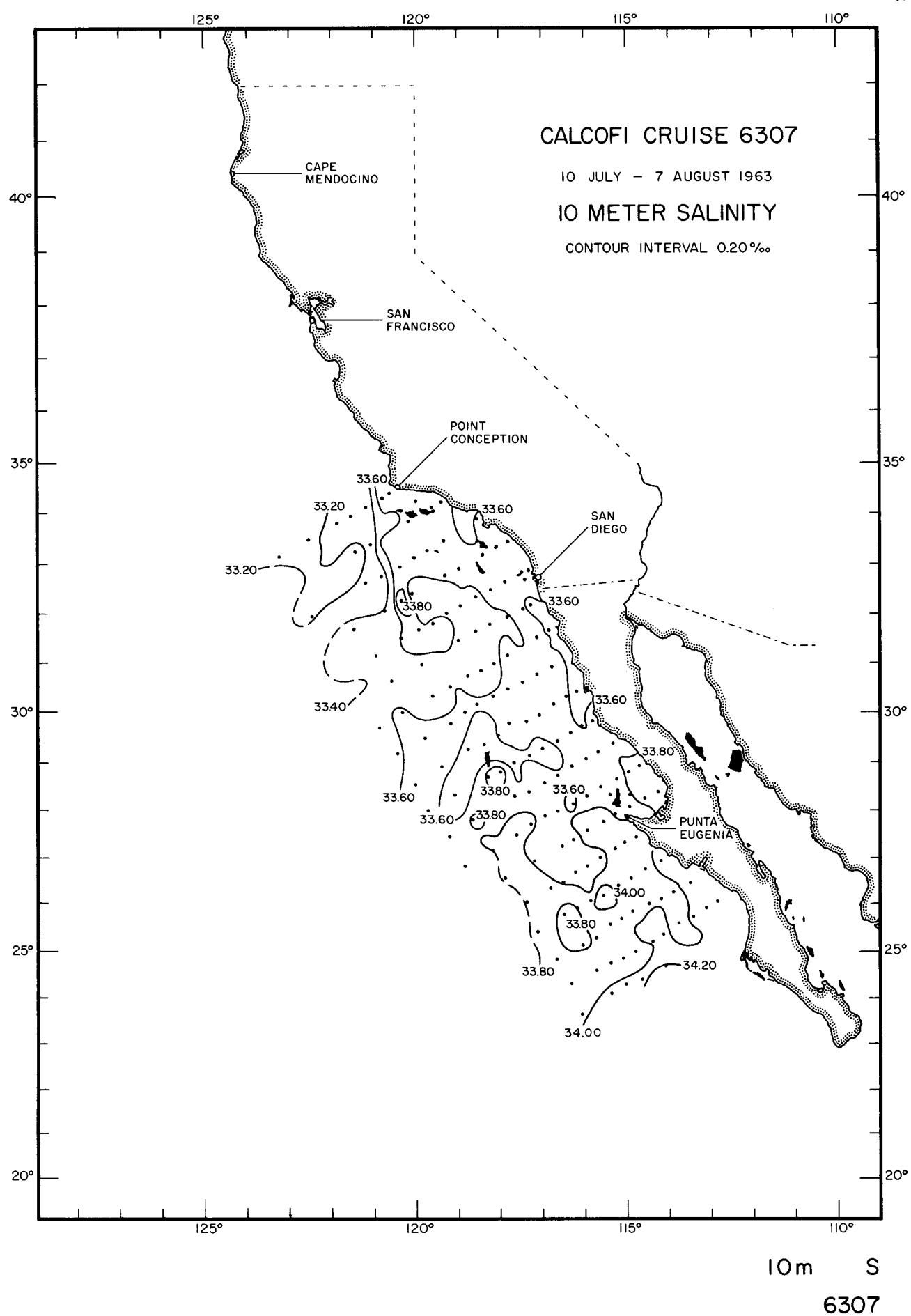


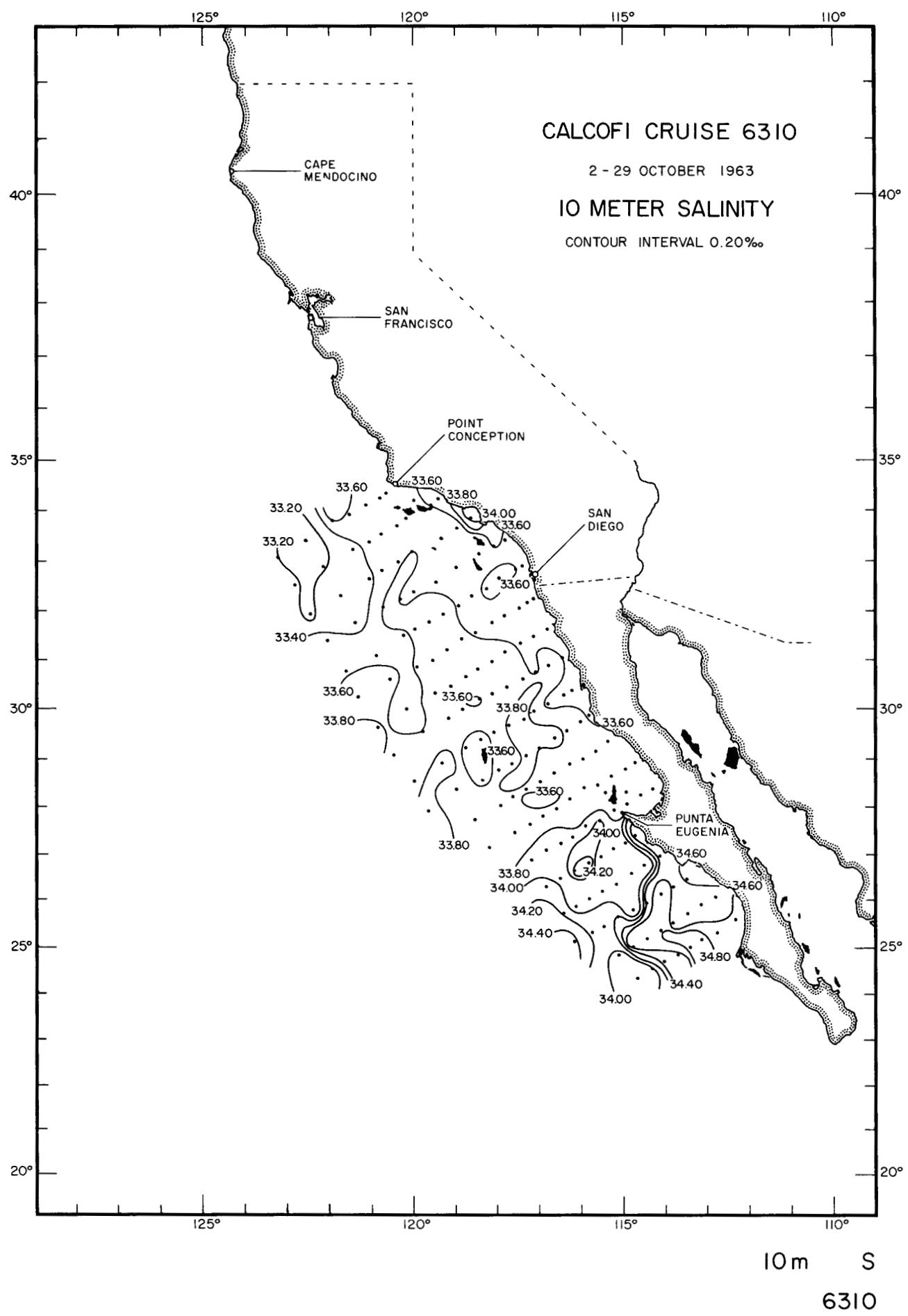


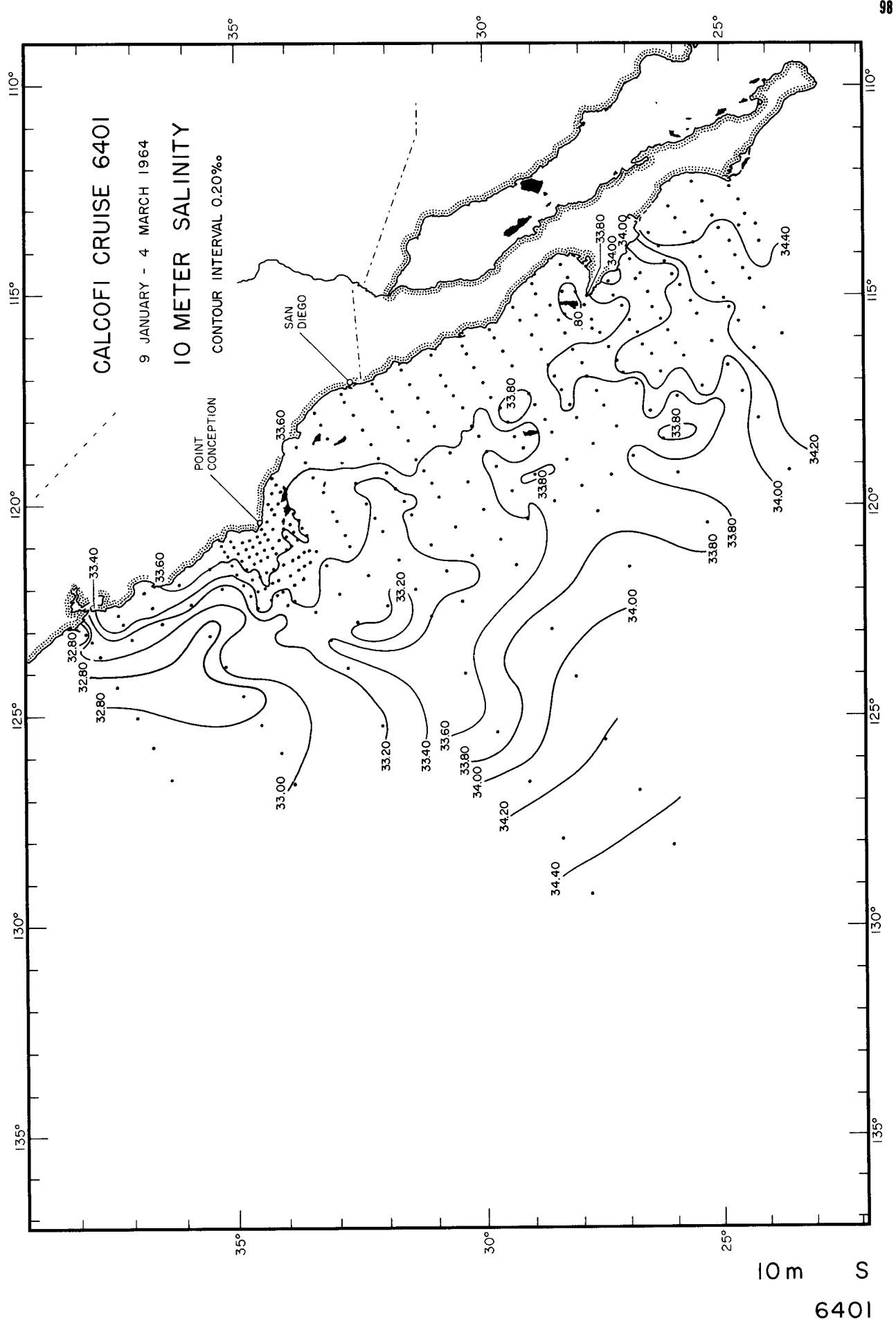


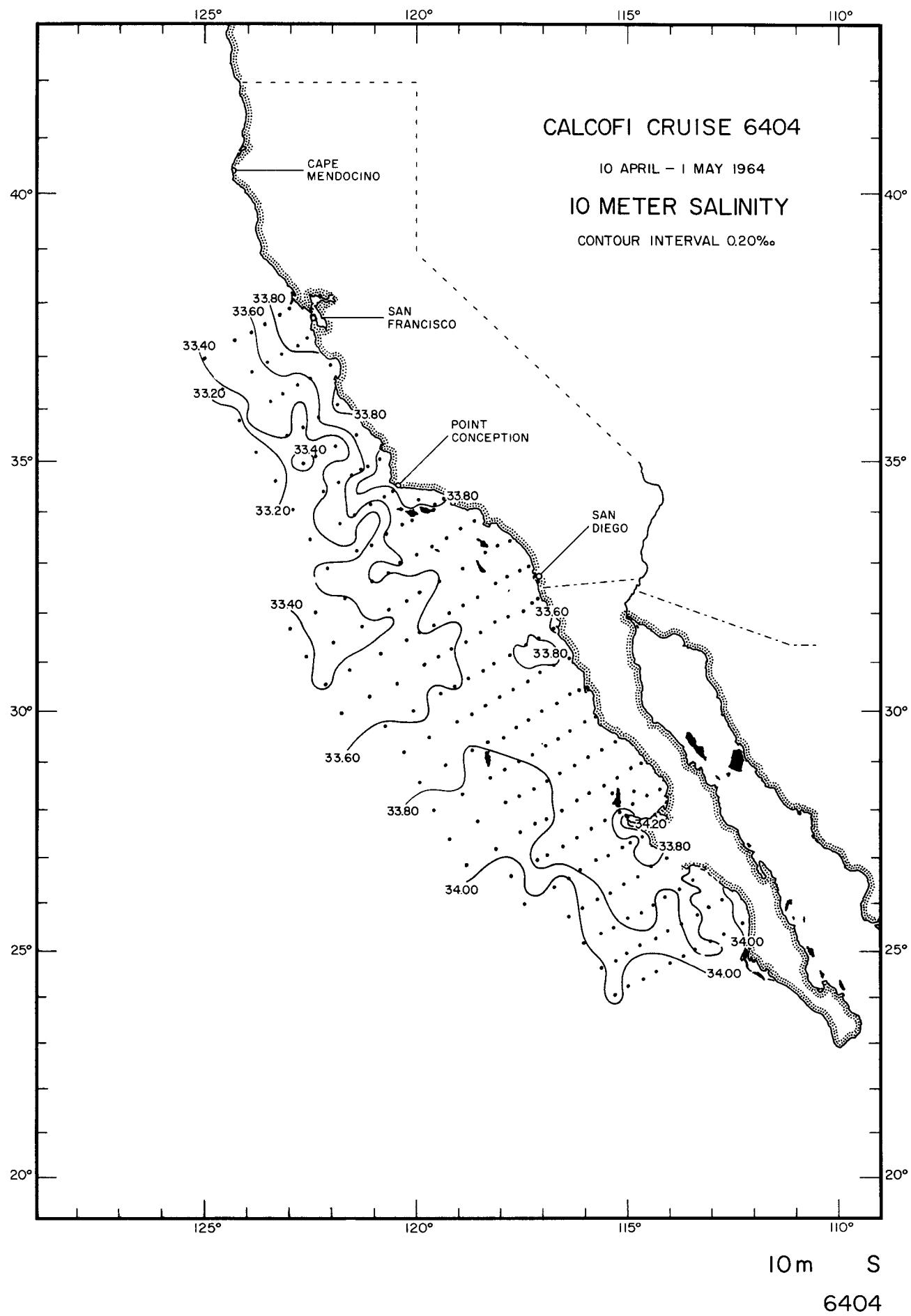


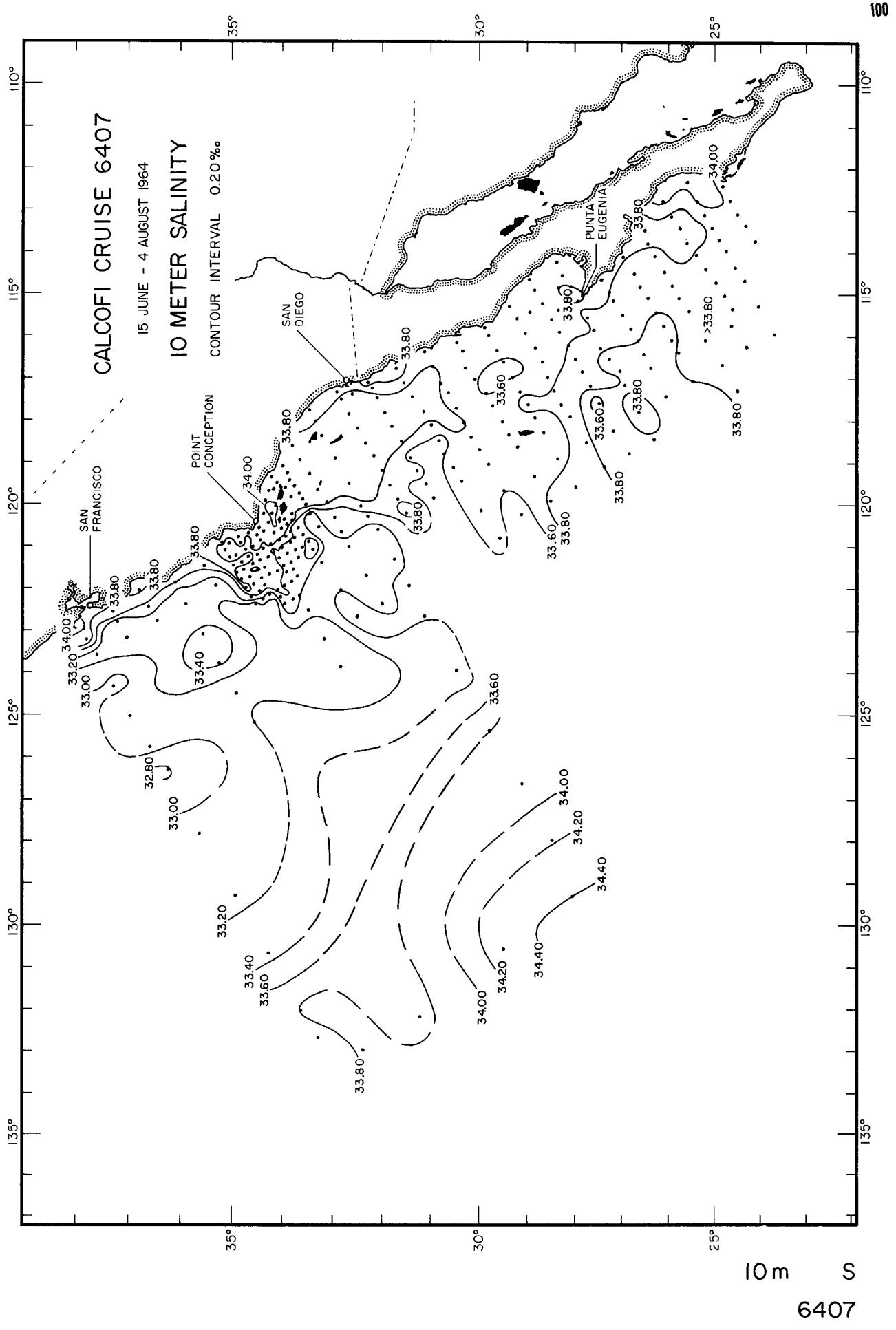


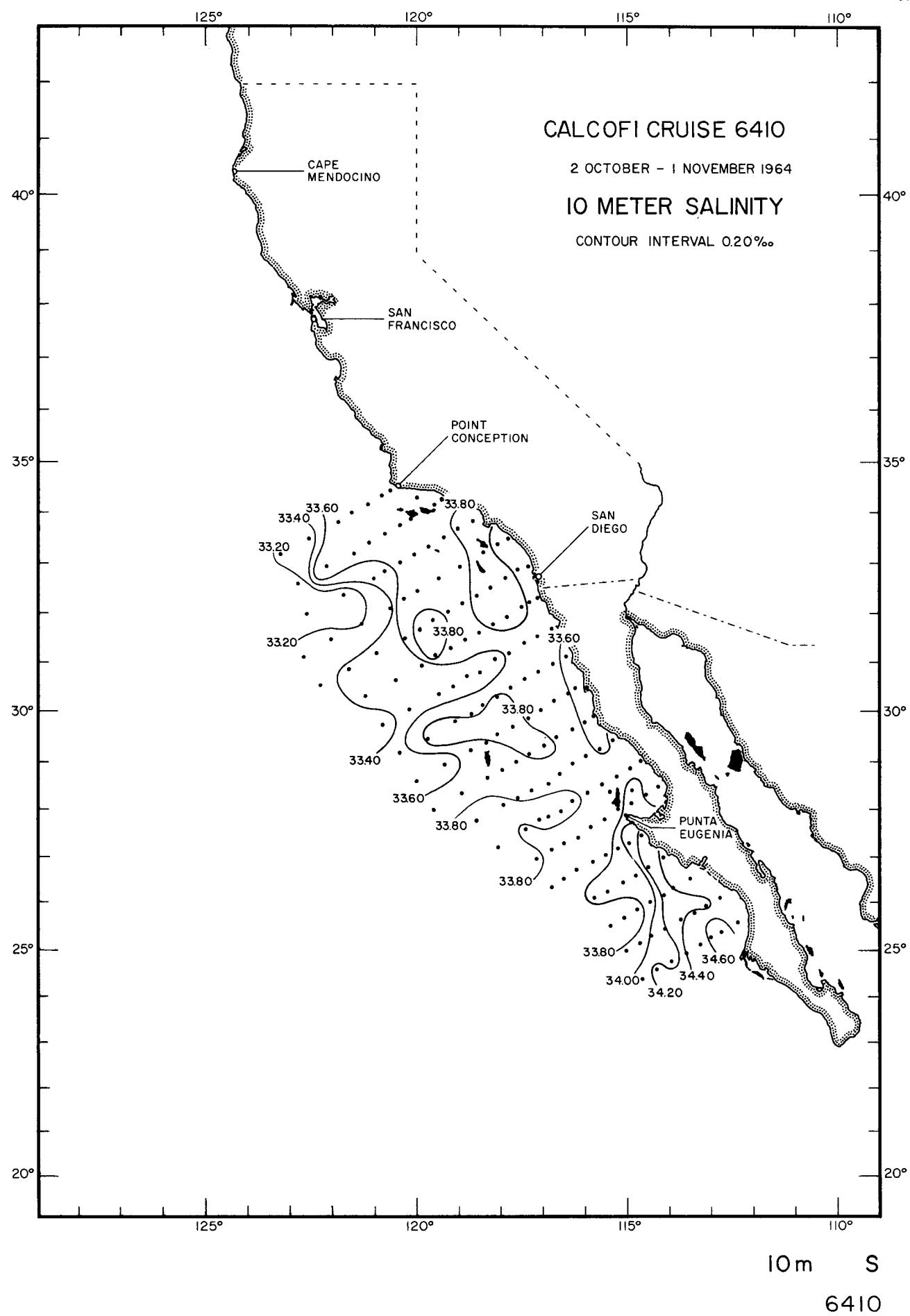


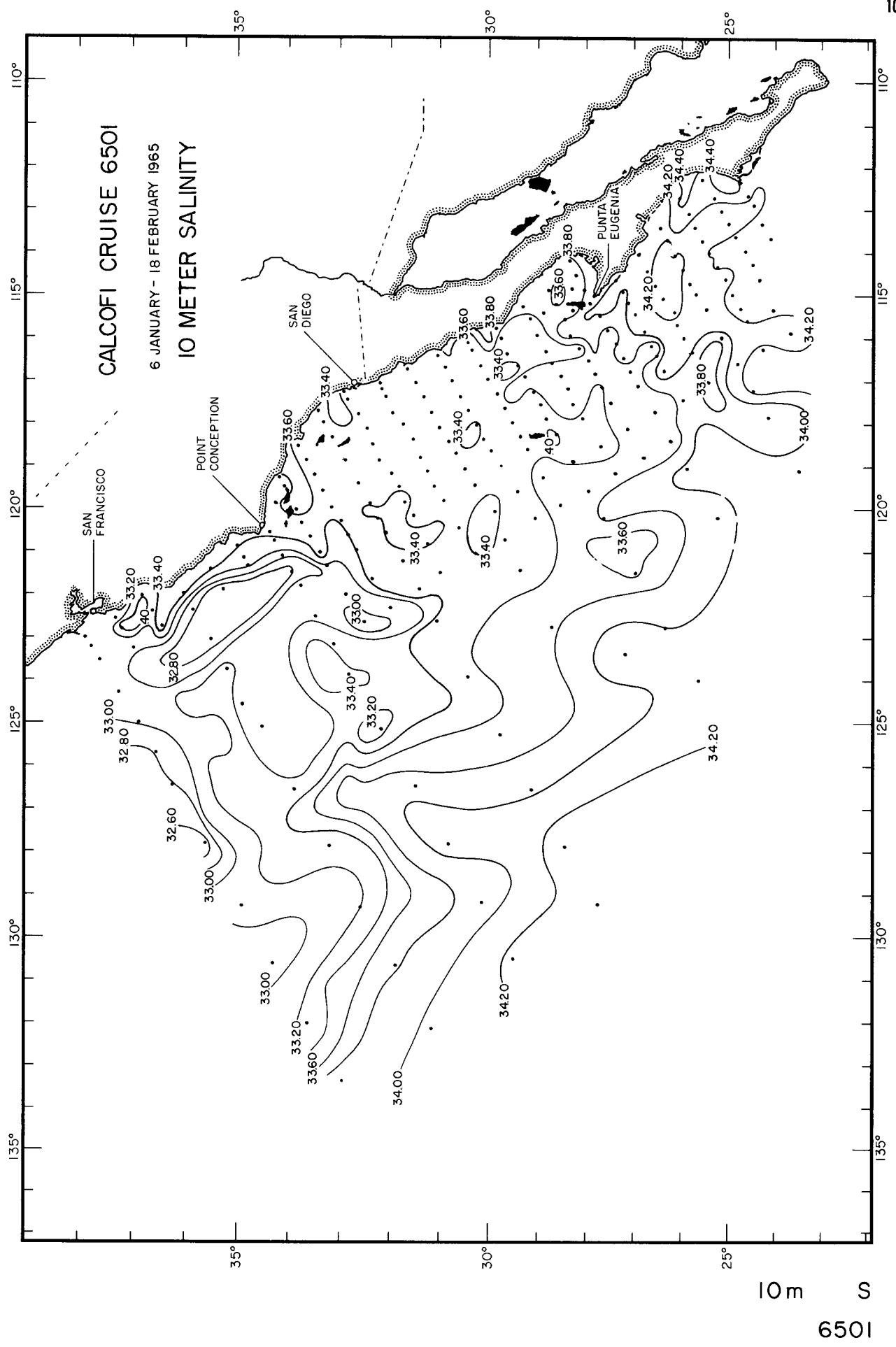


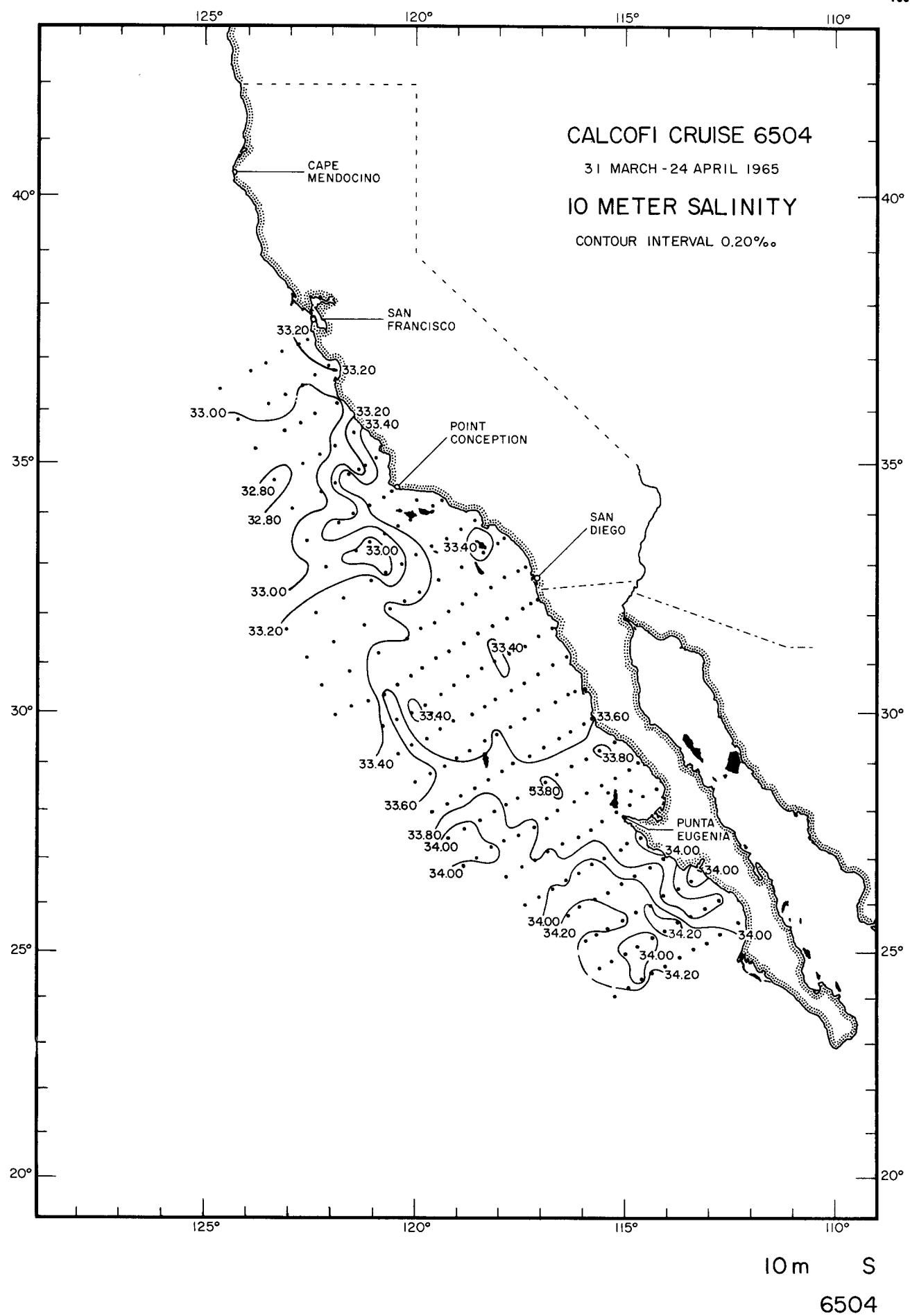


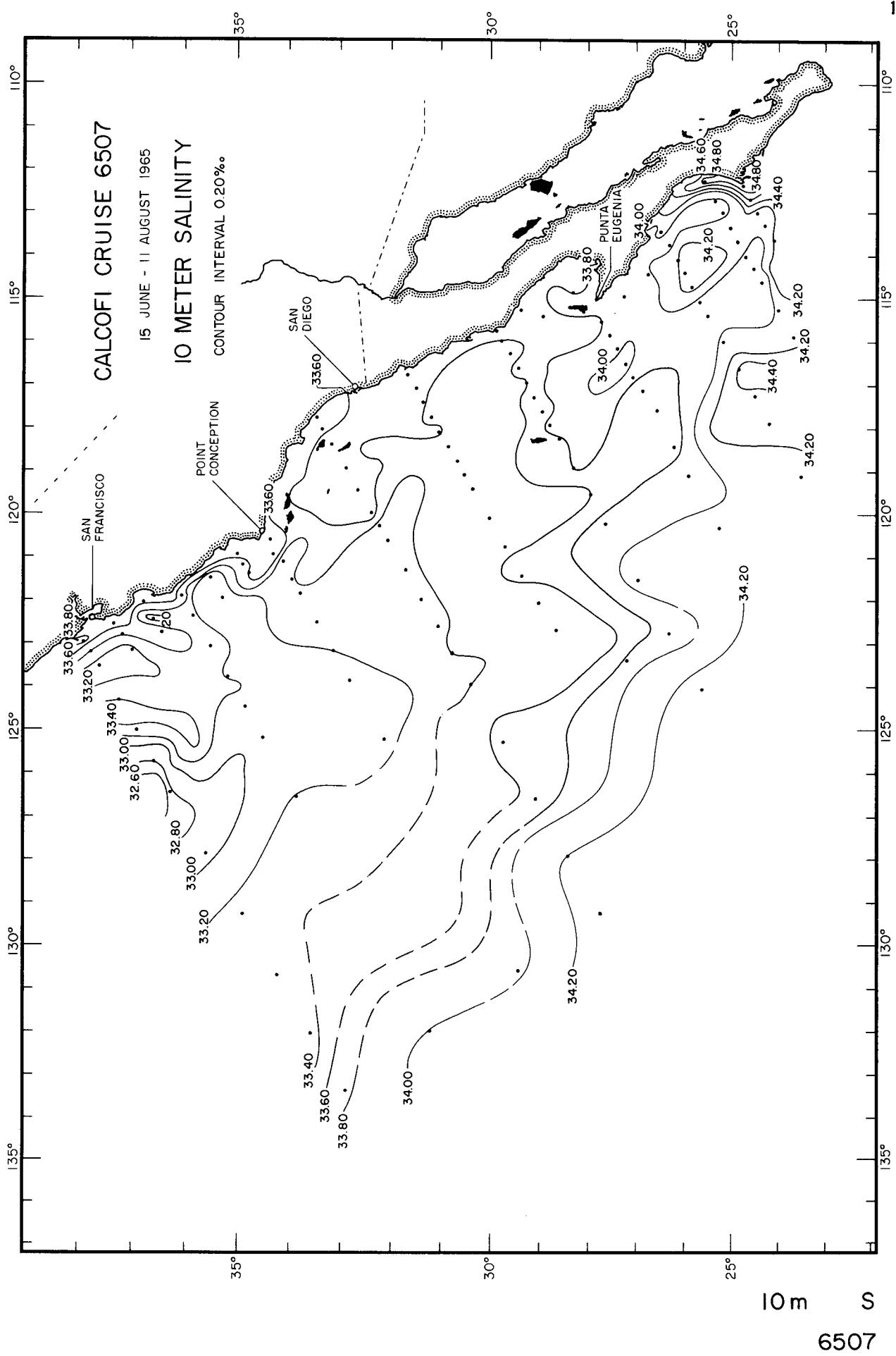


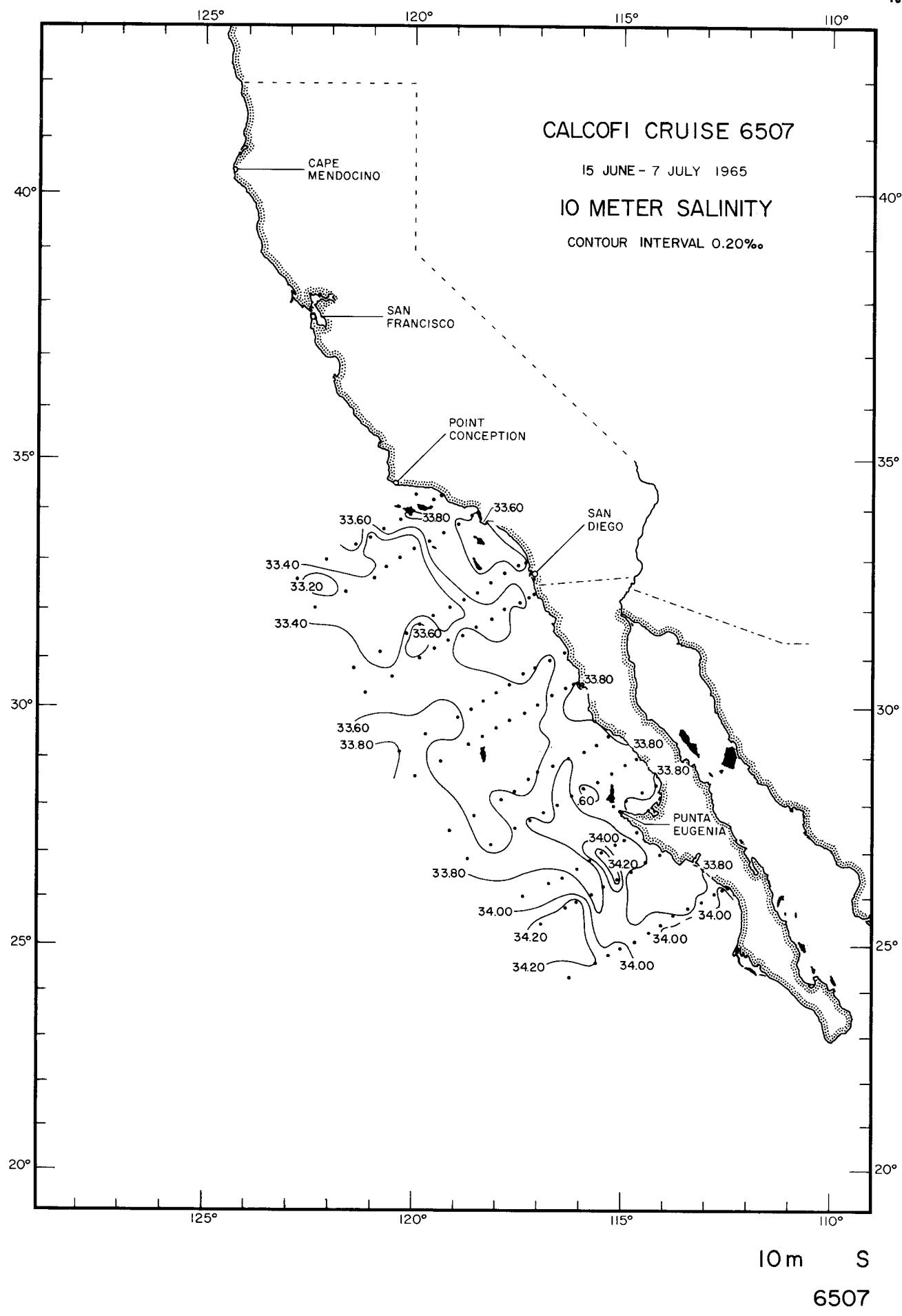


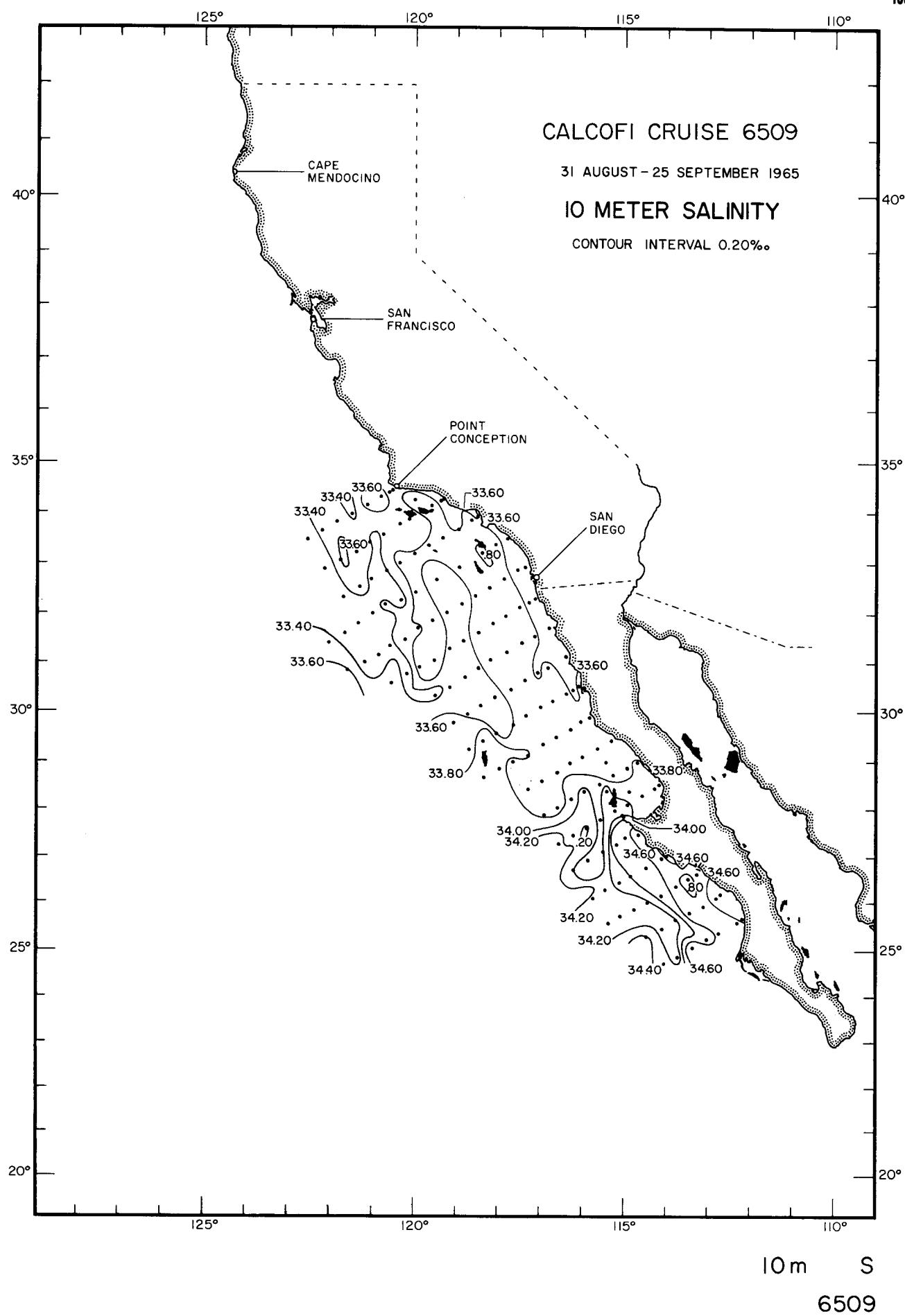


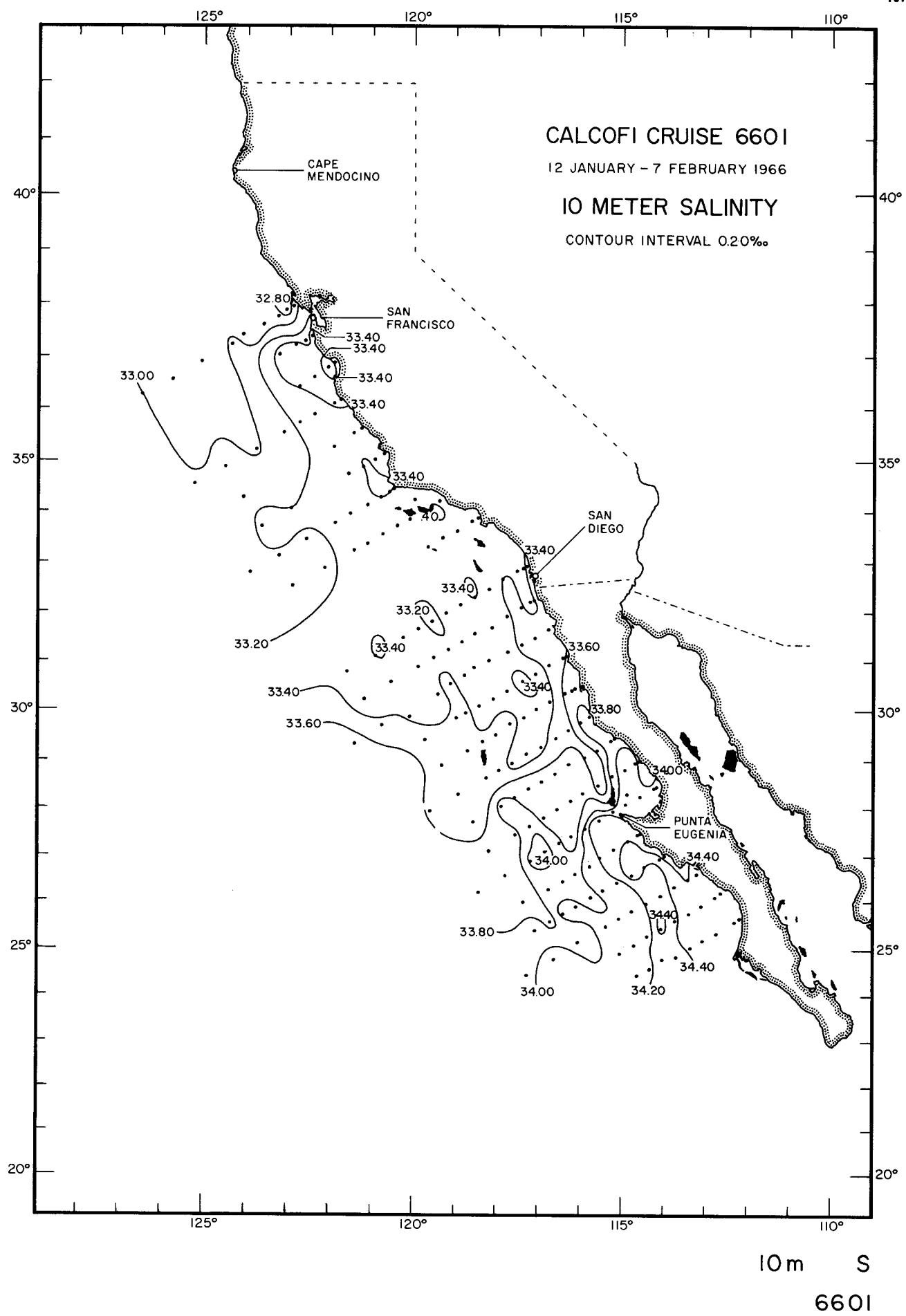


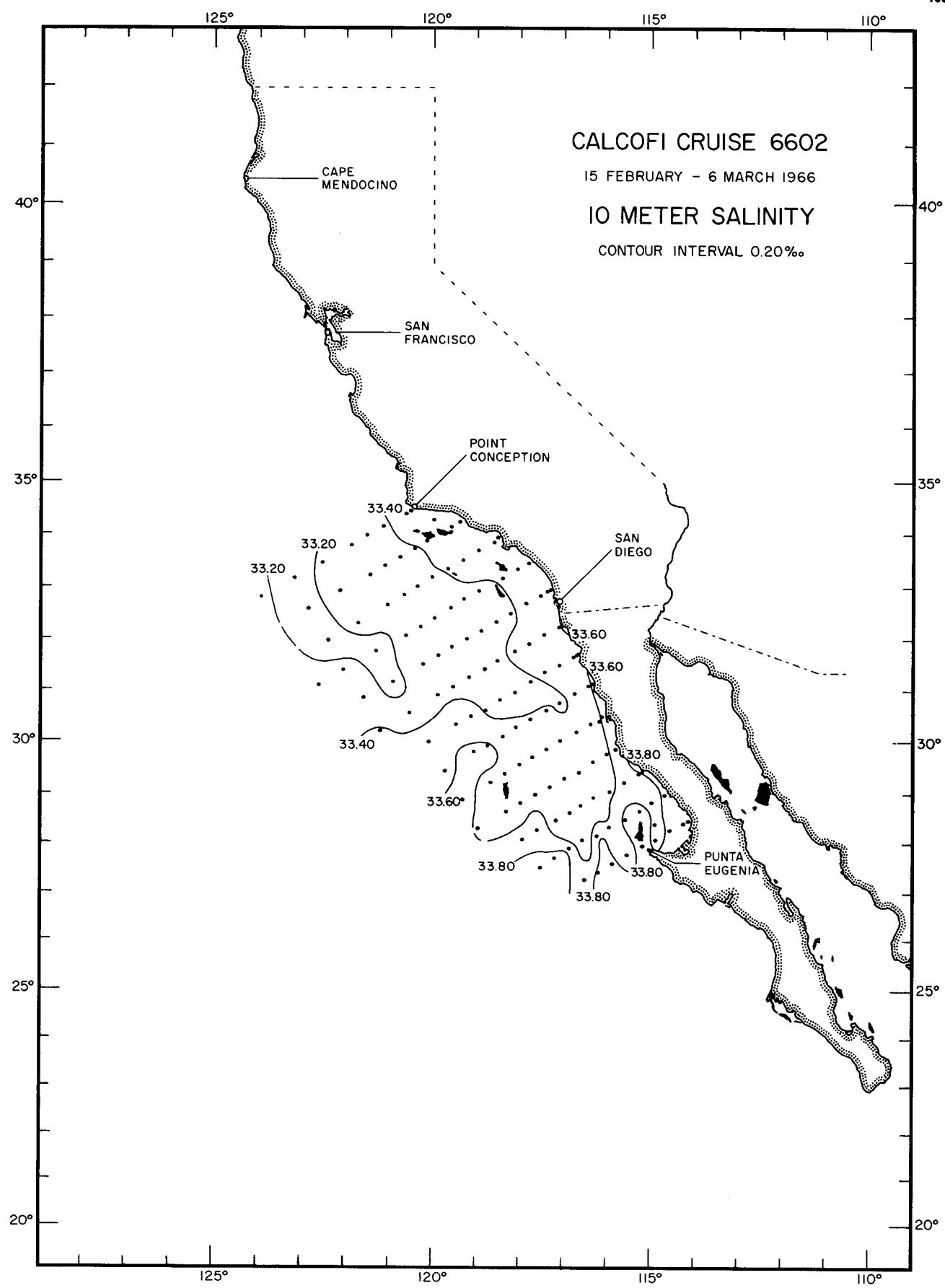




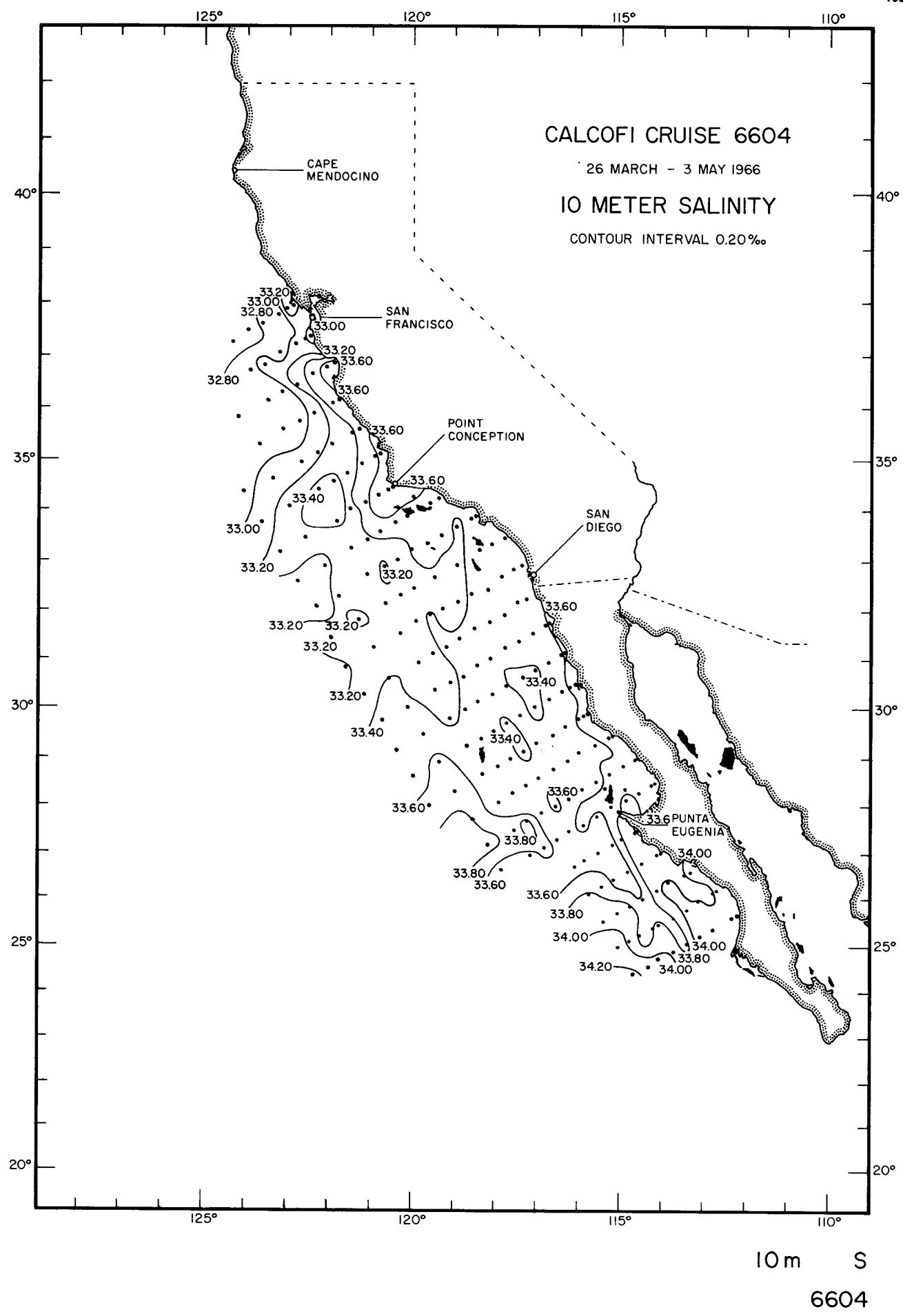


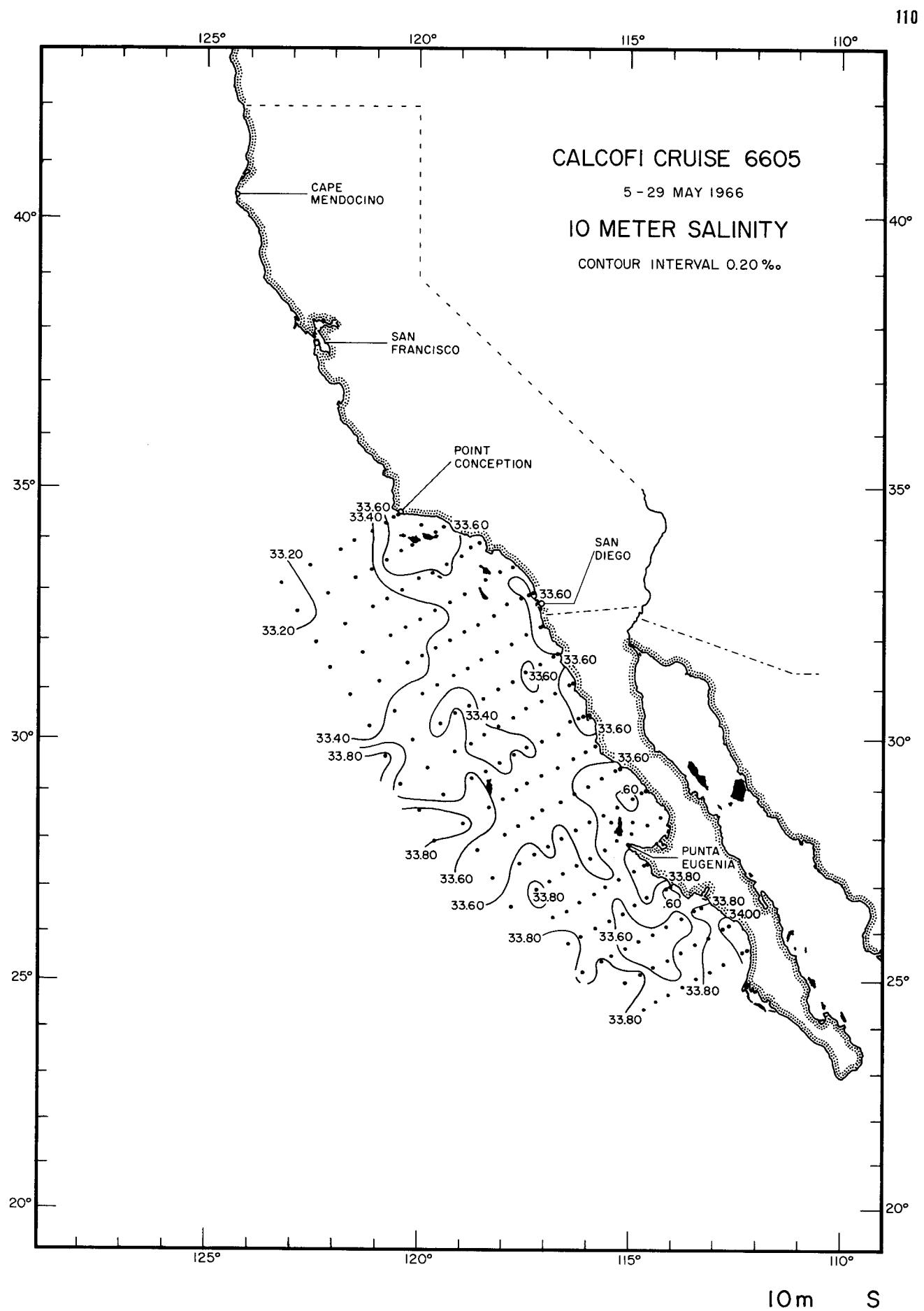


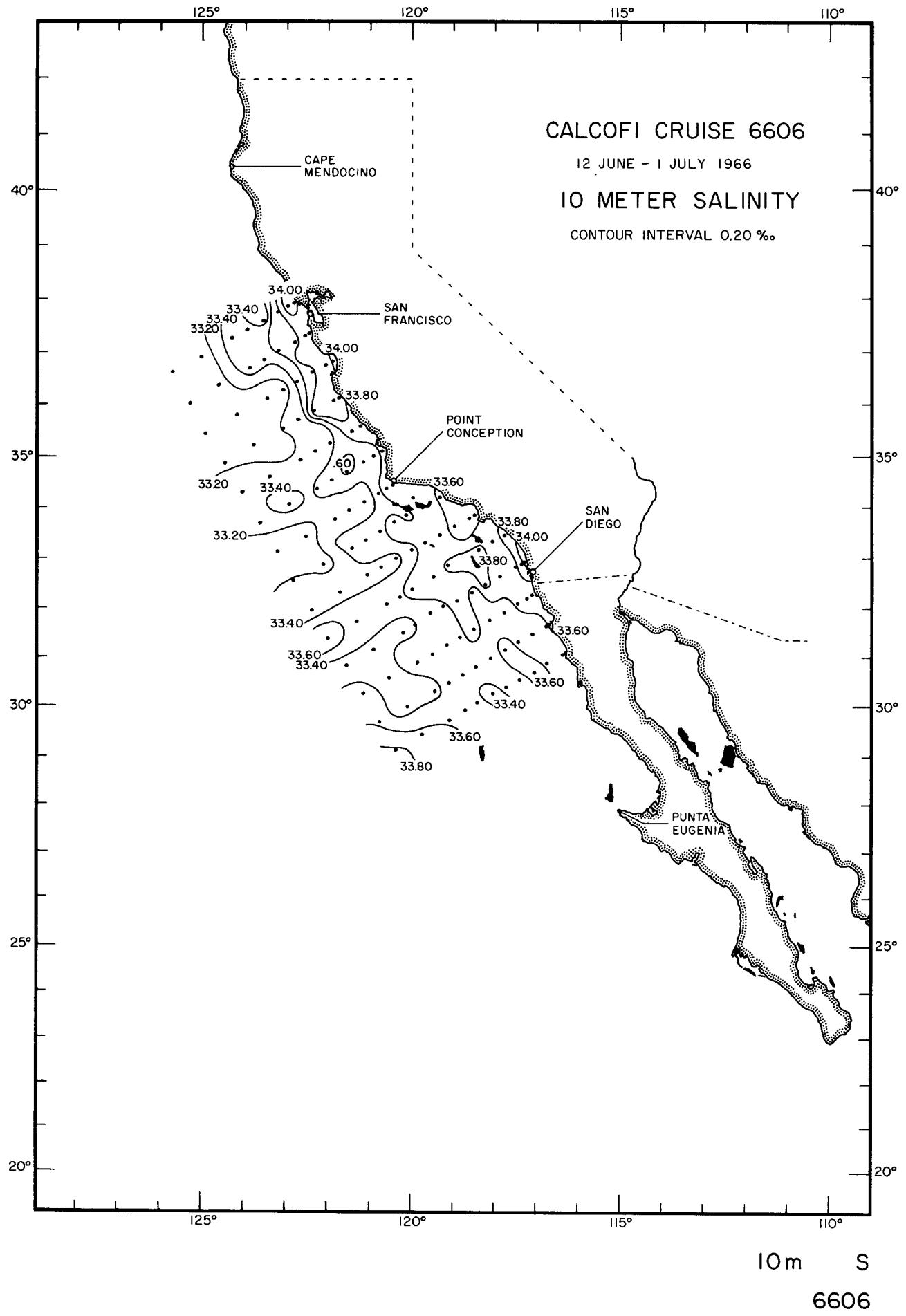


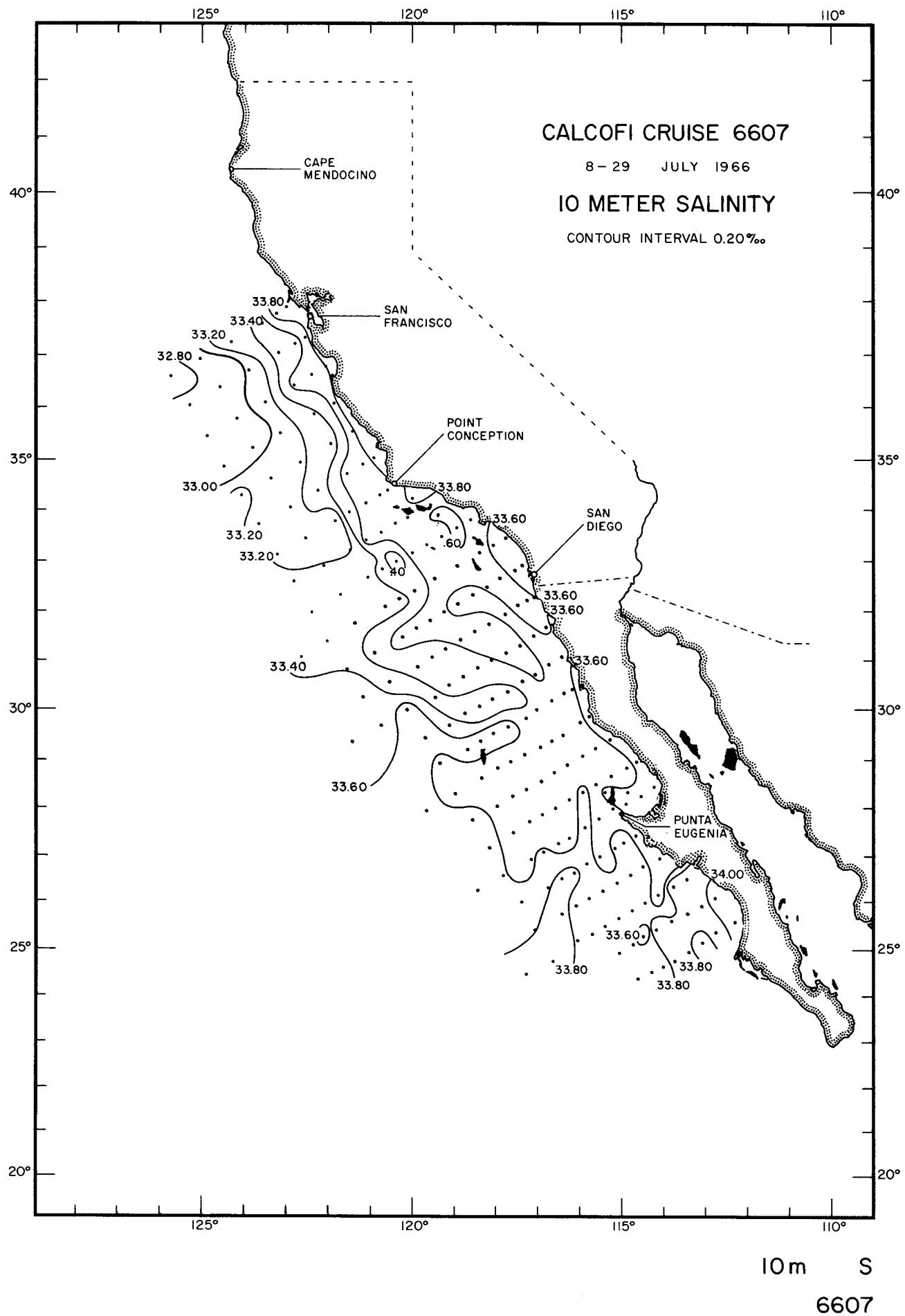


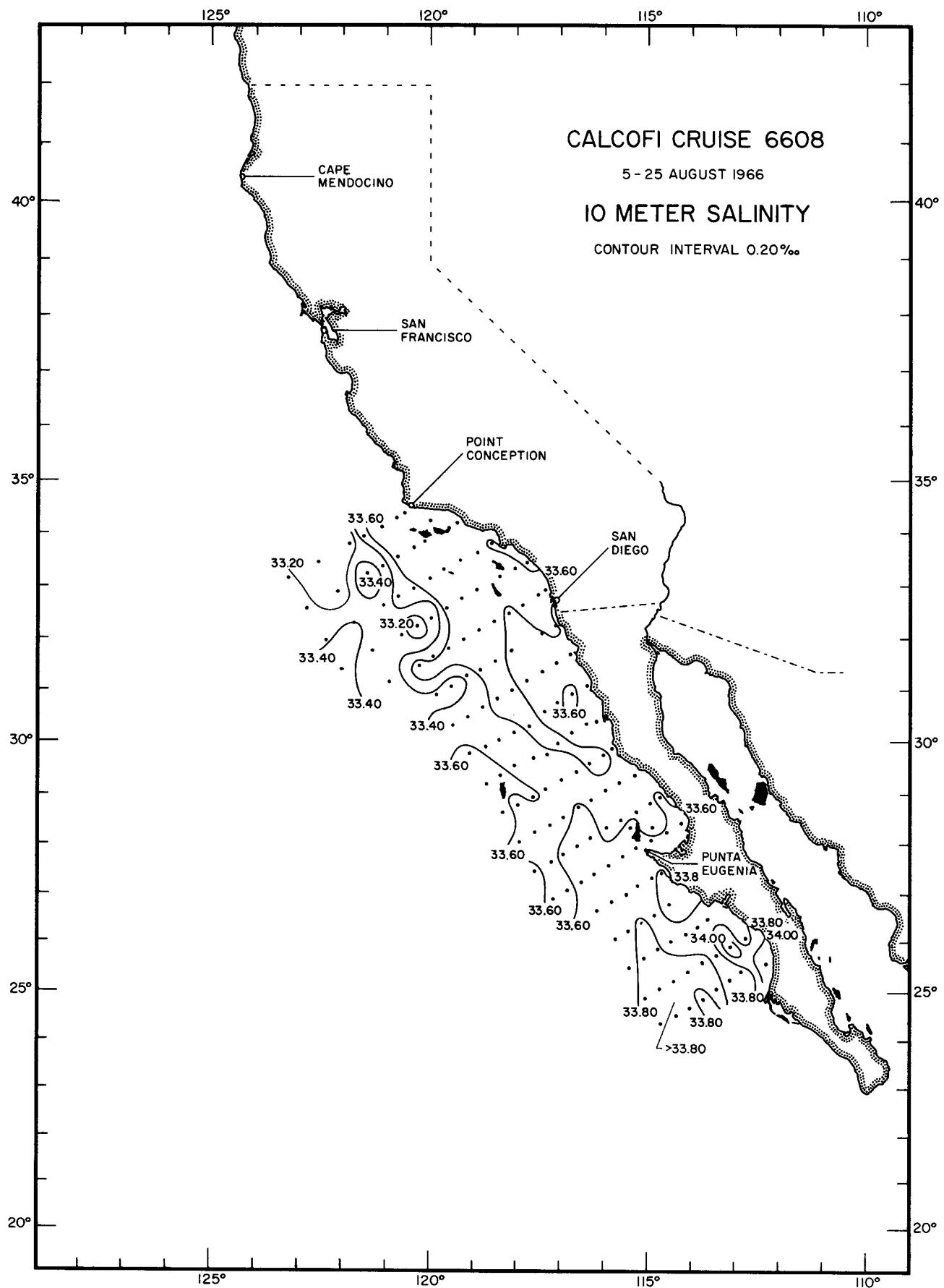
10m S
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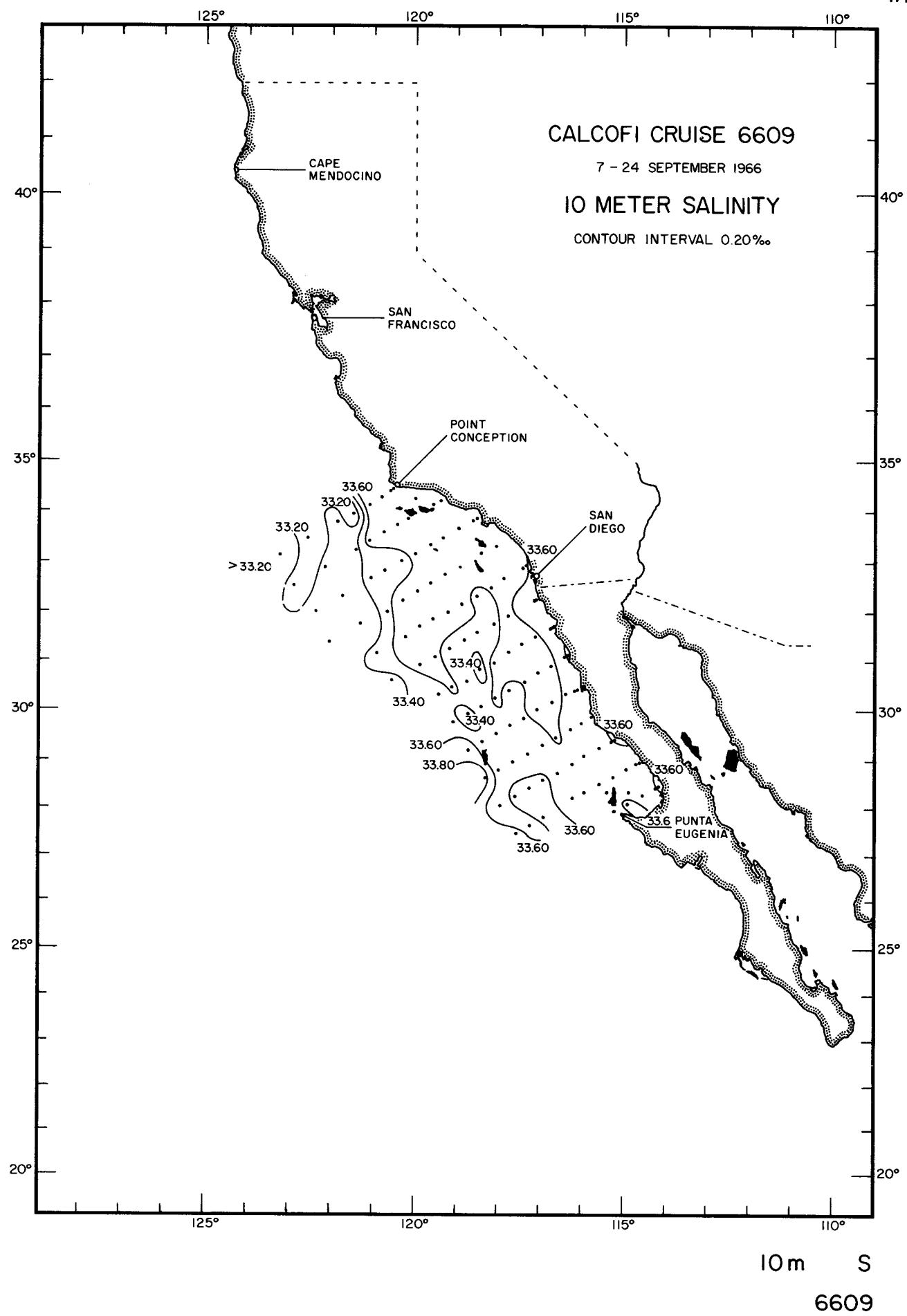


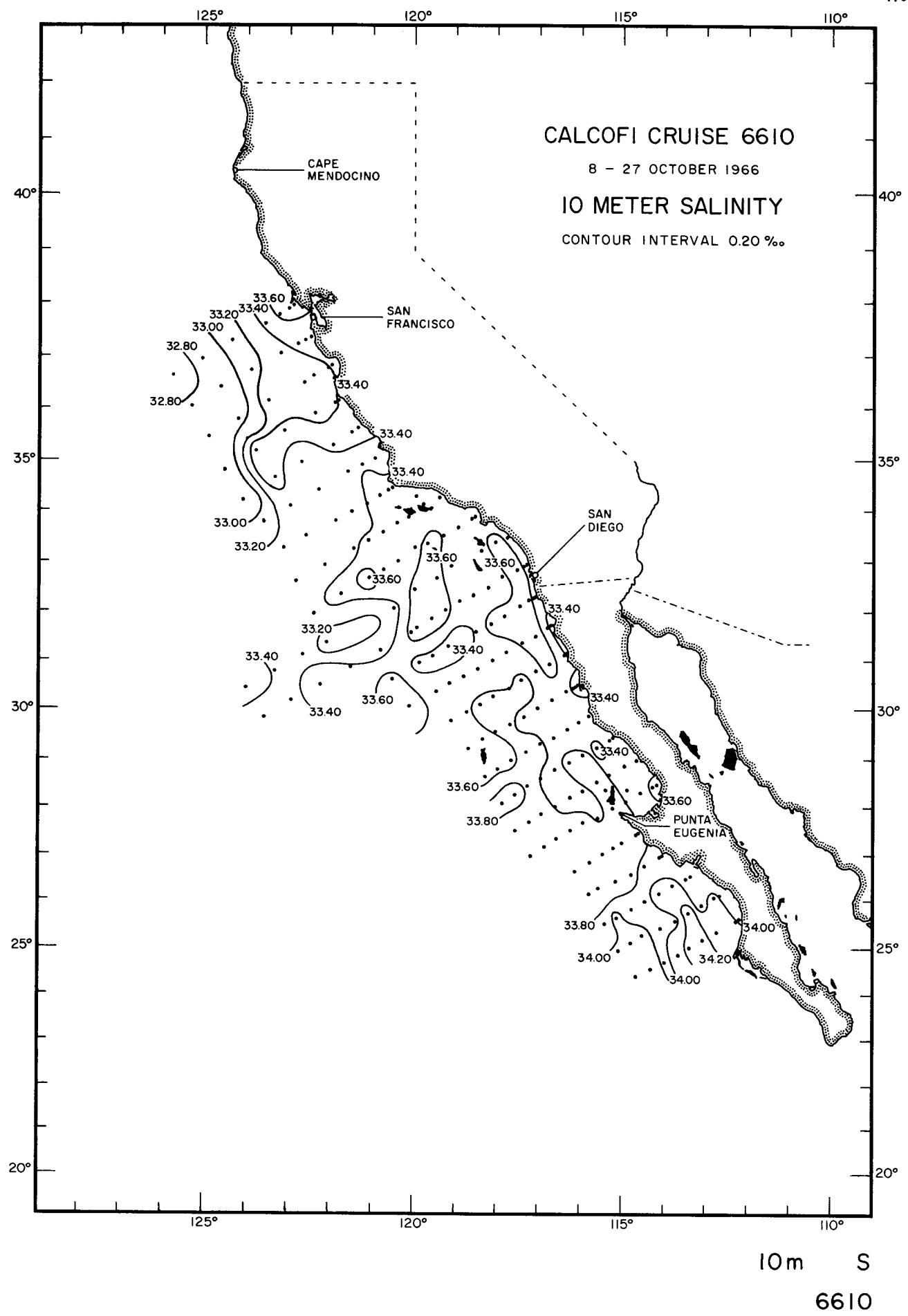


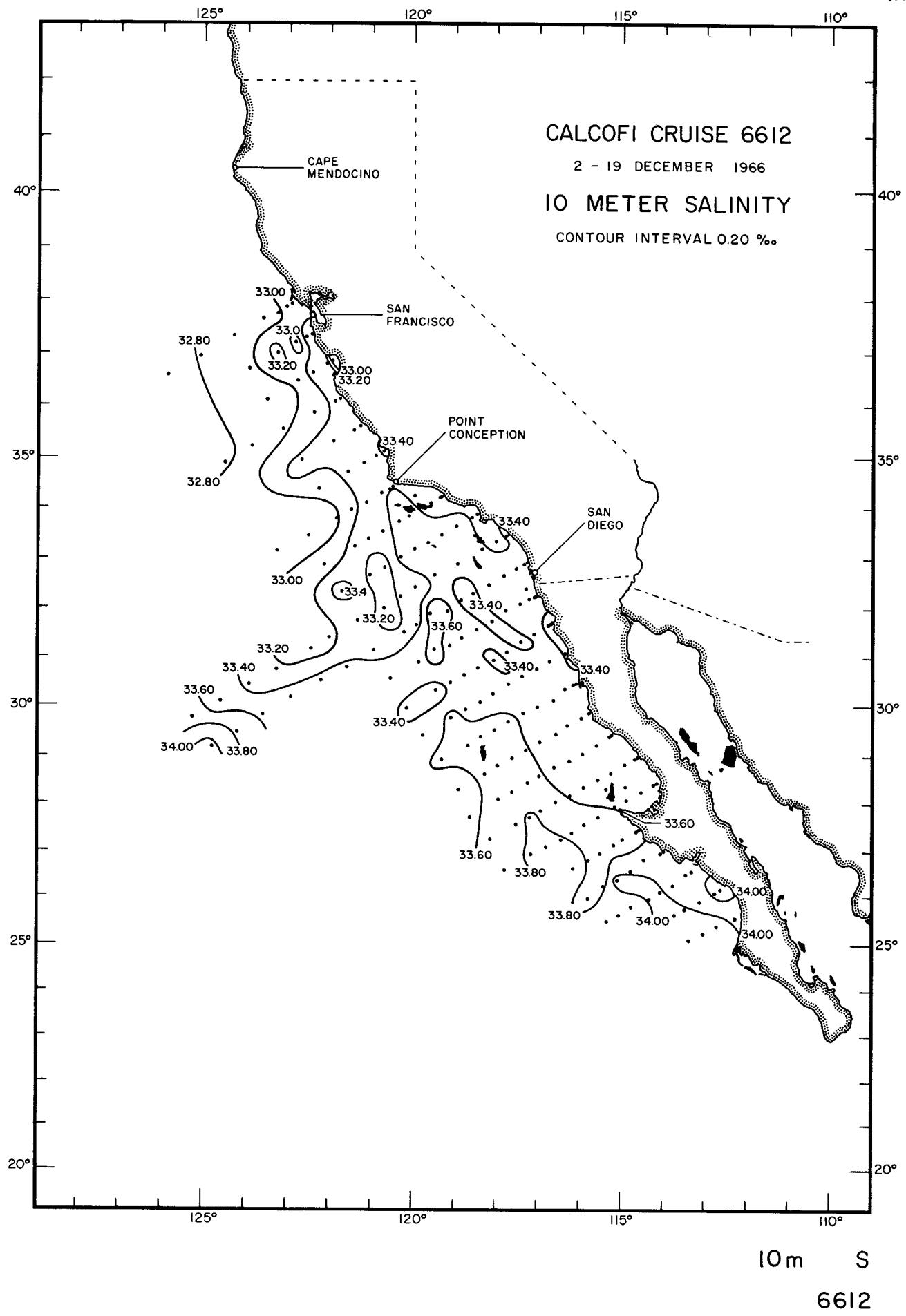


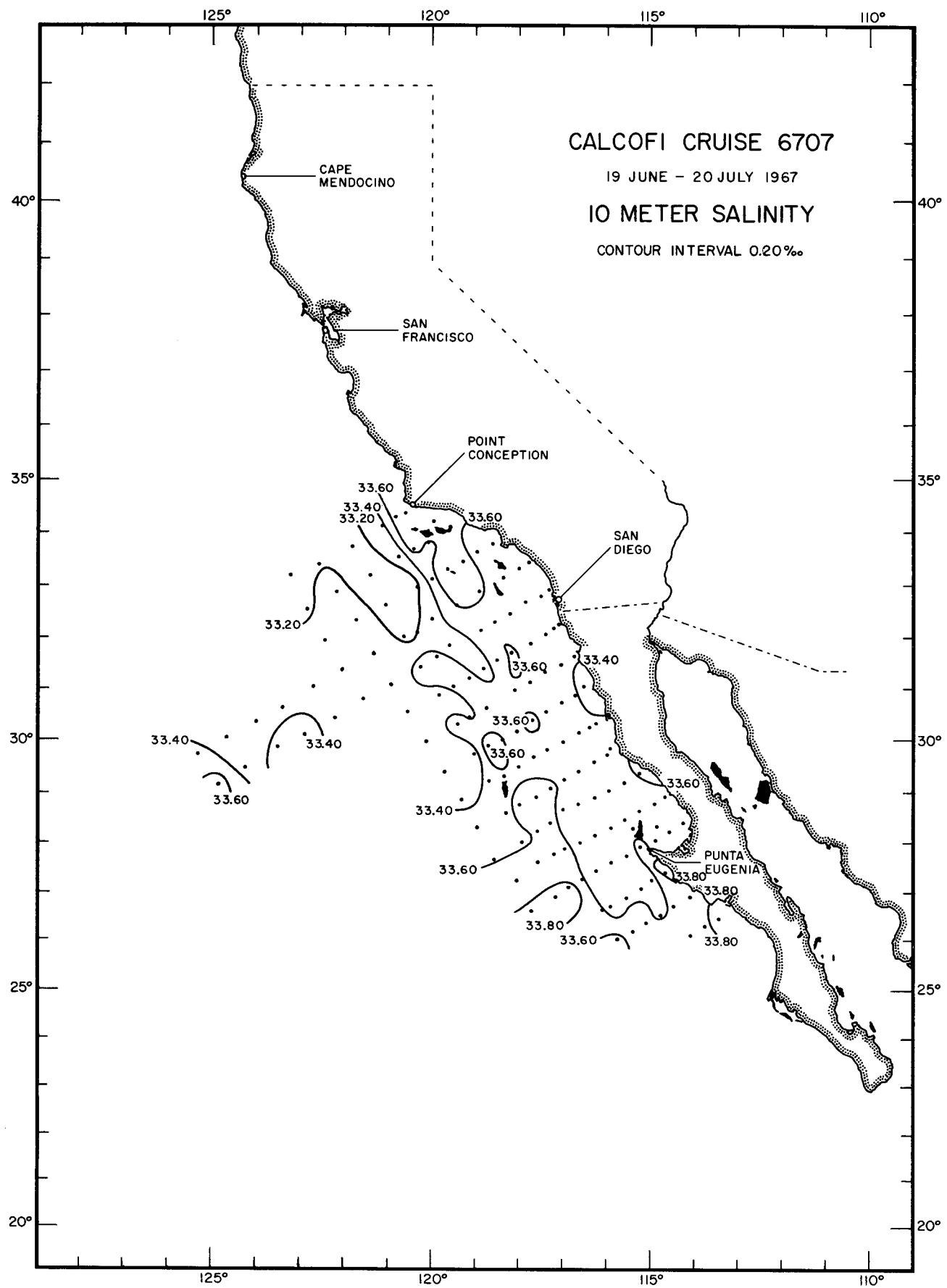


10m S
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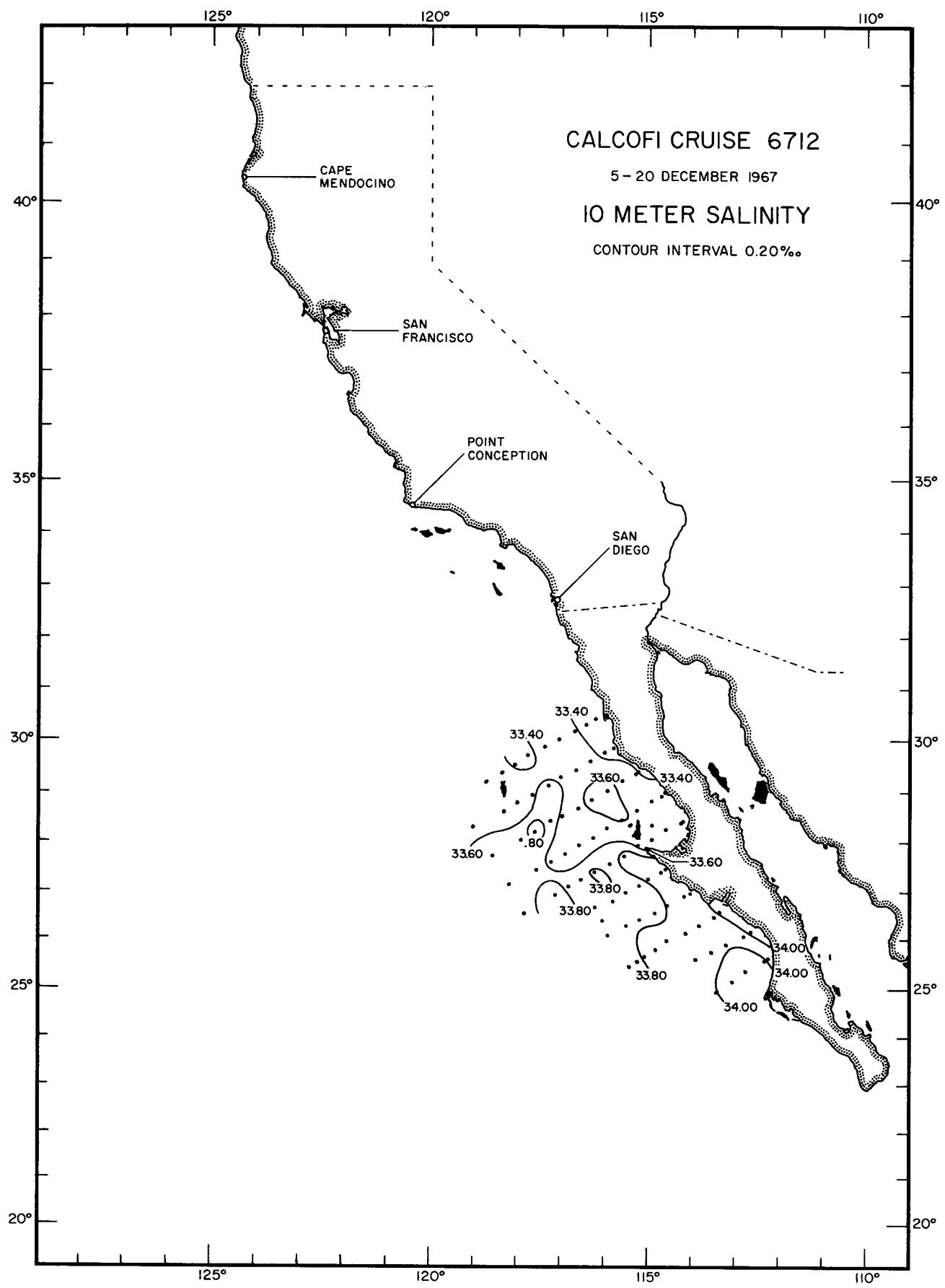




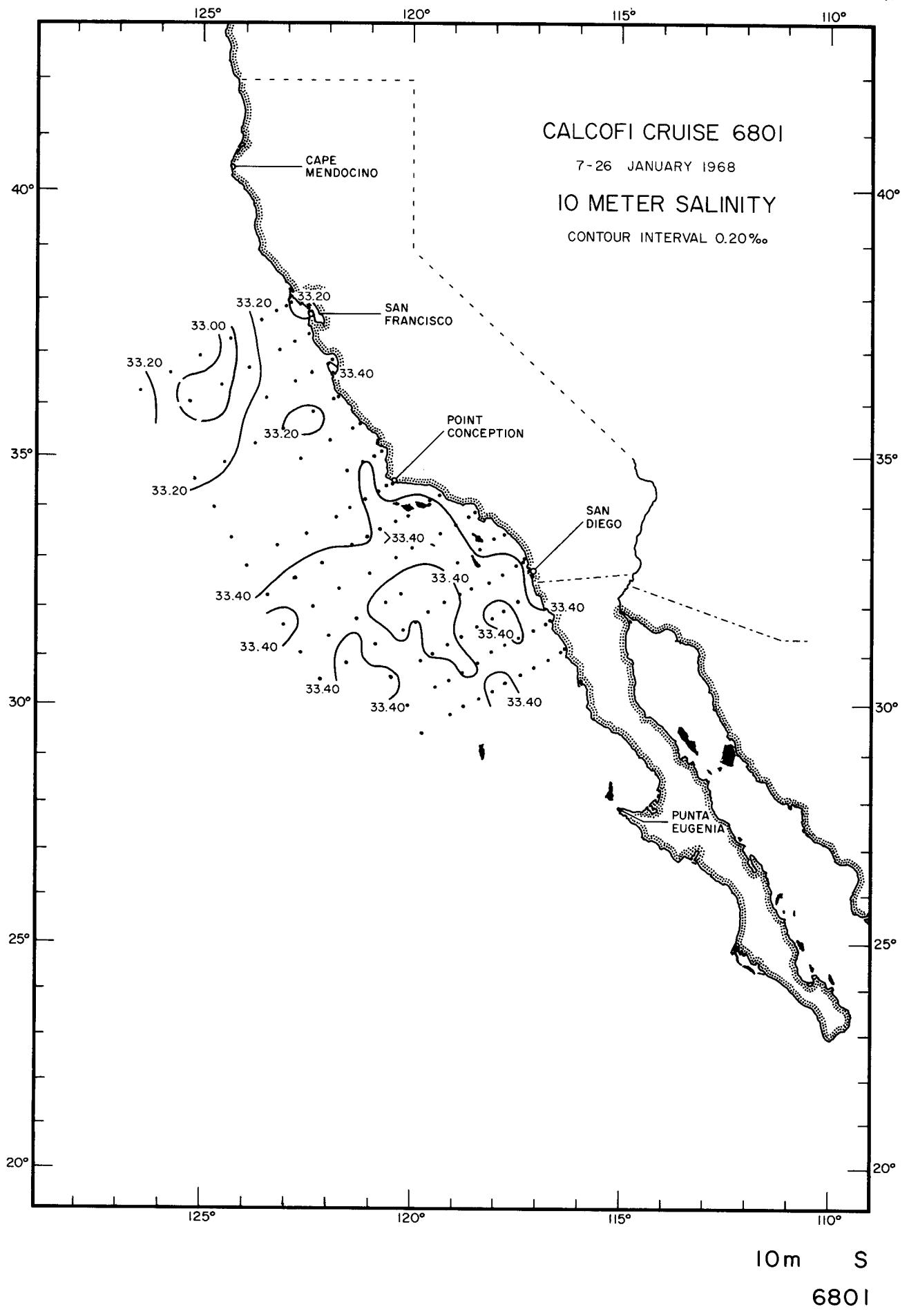


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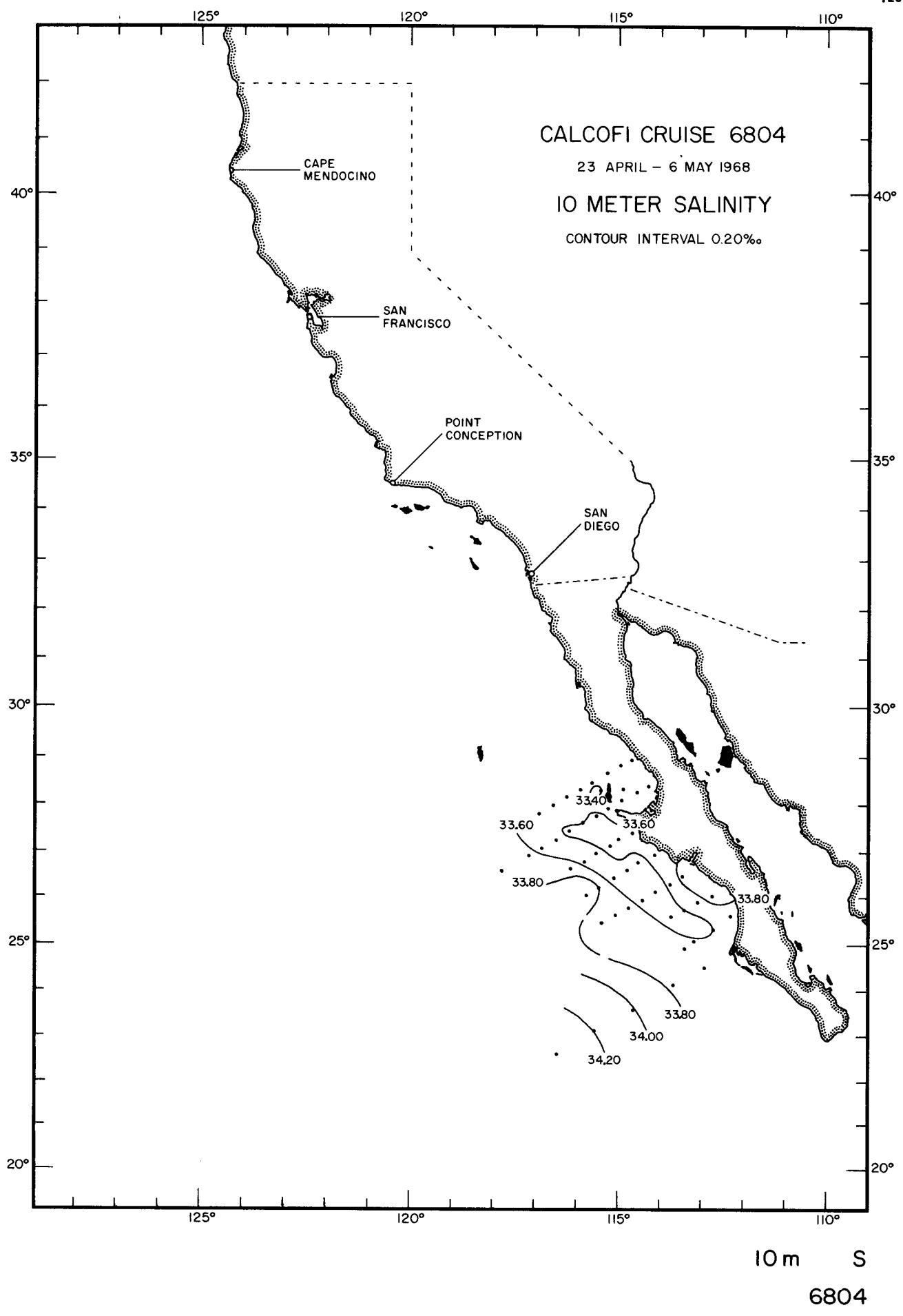
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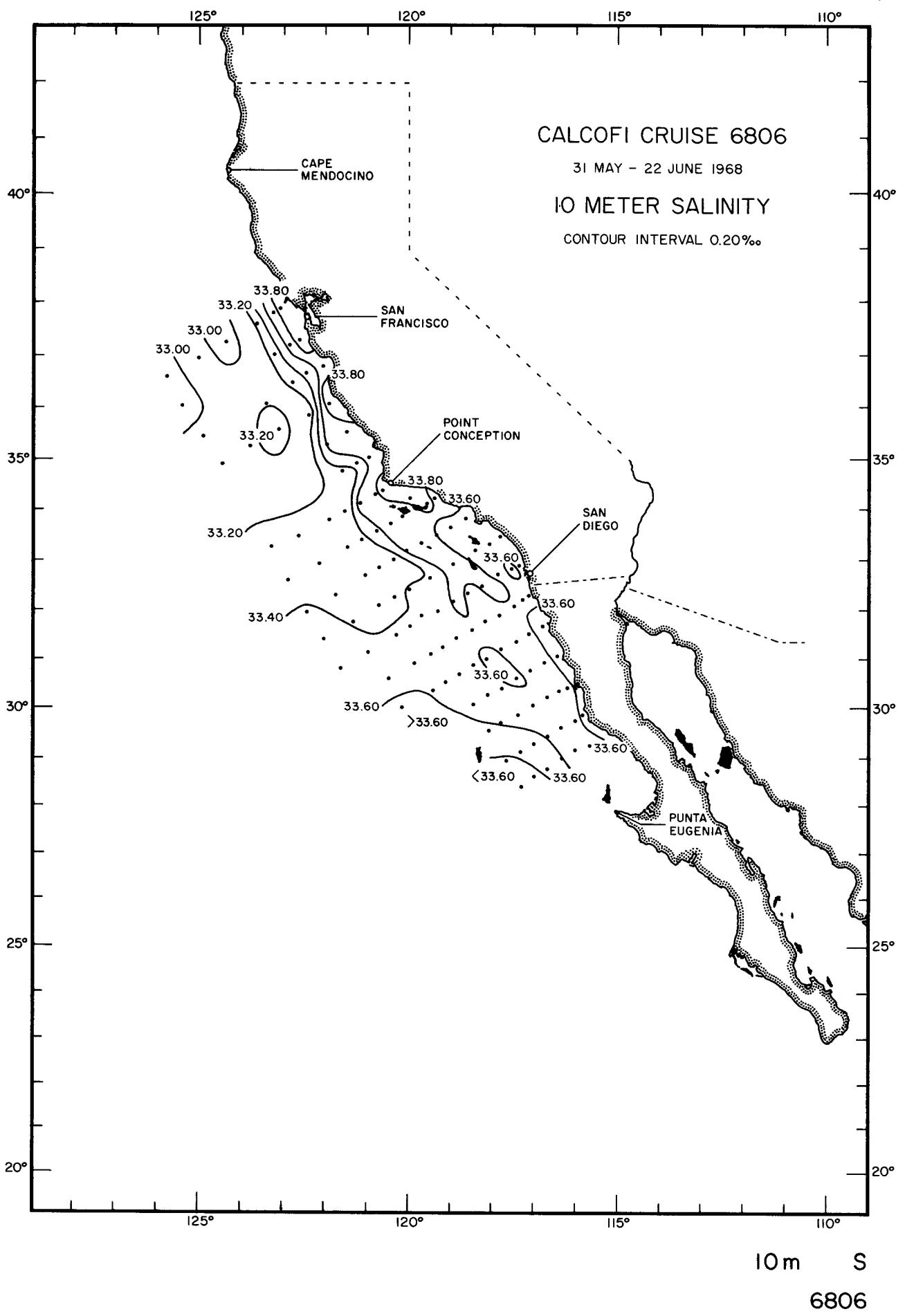


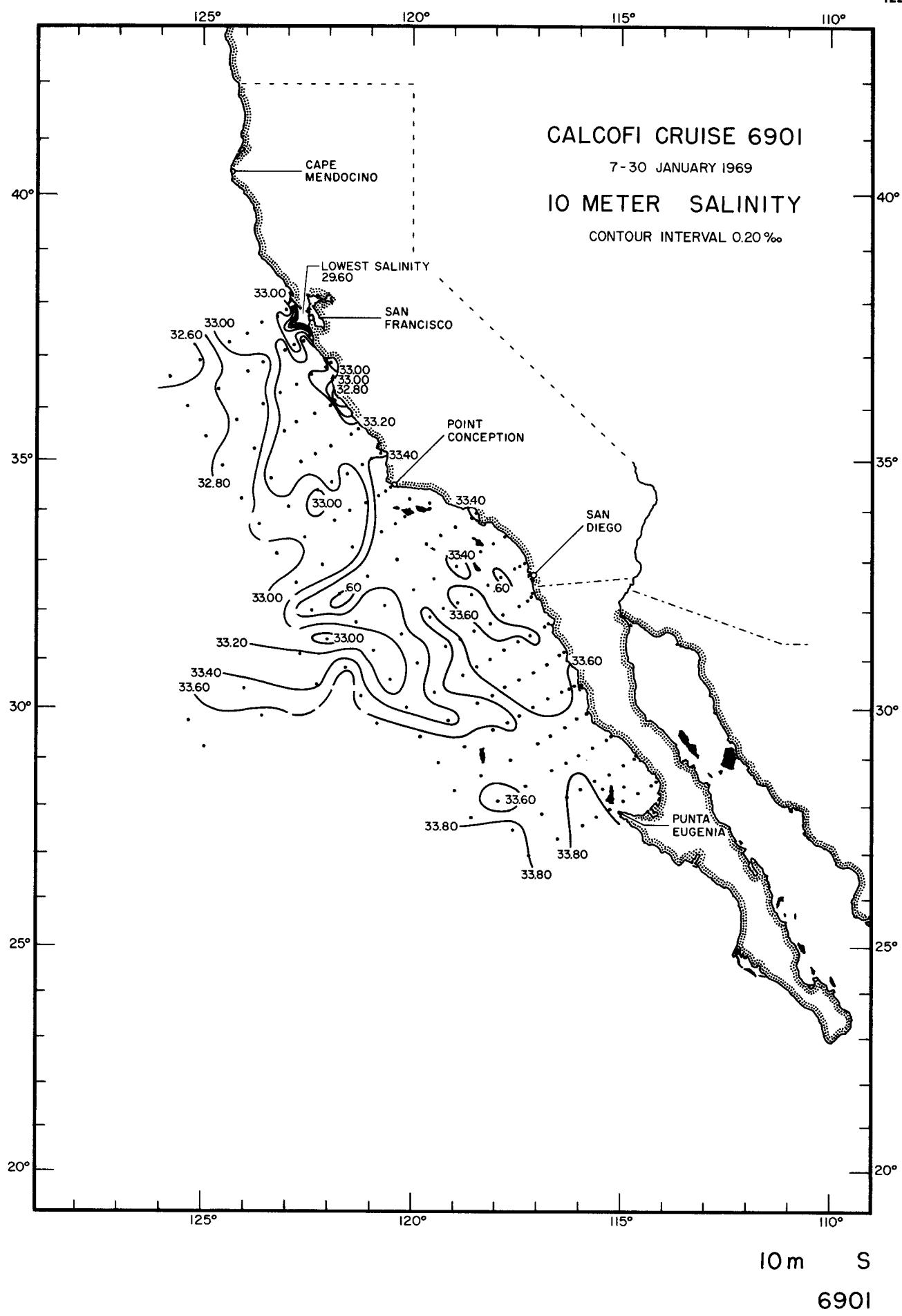
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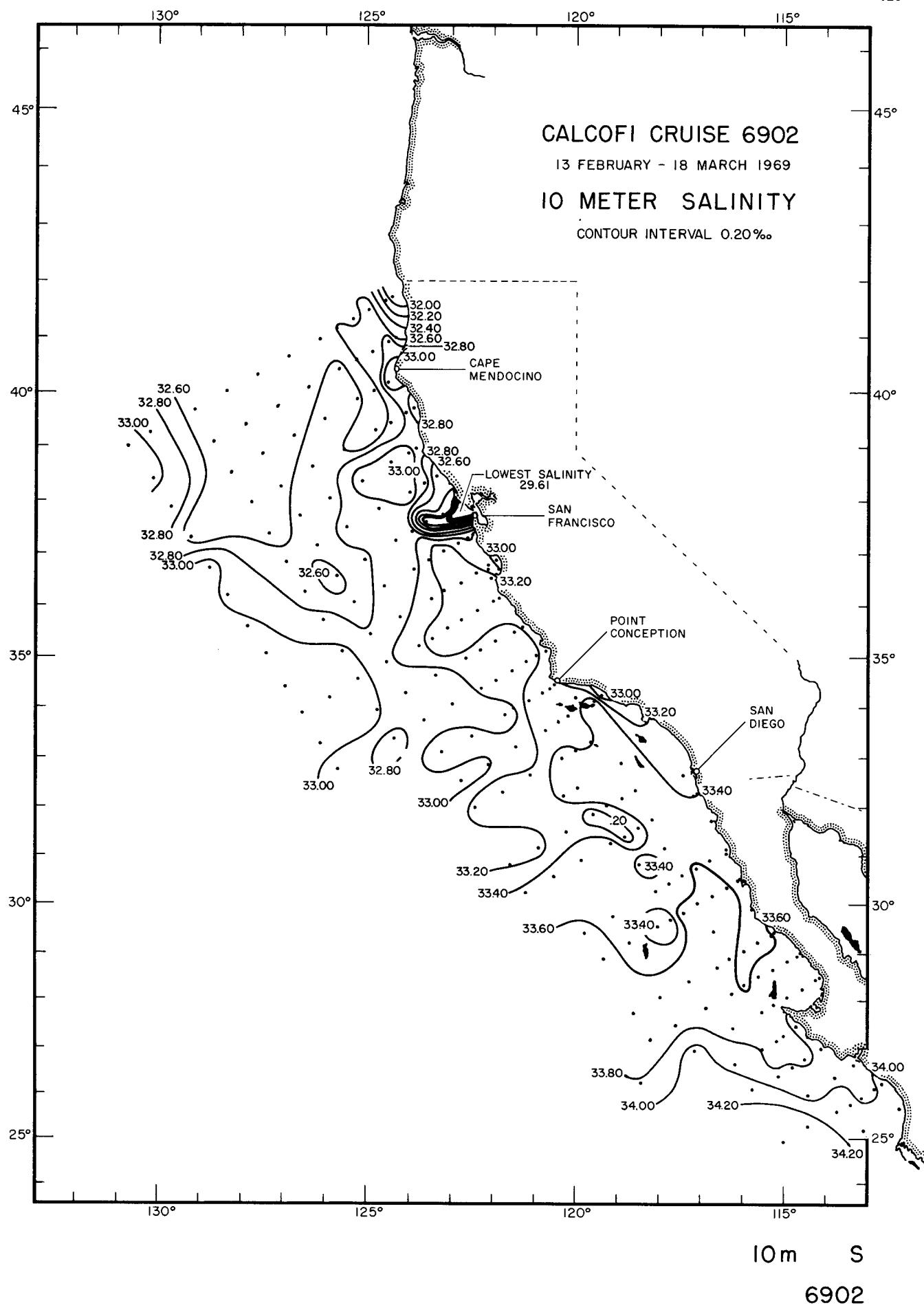


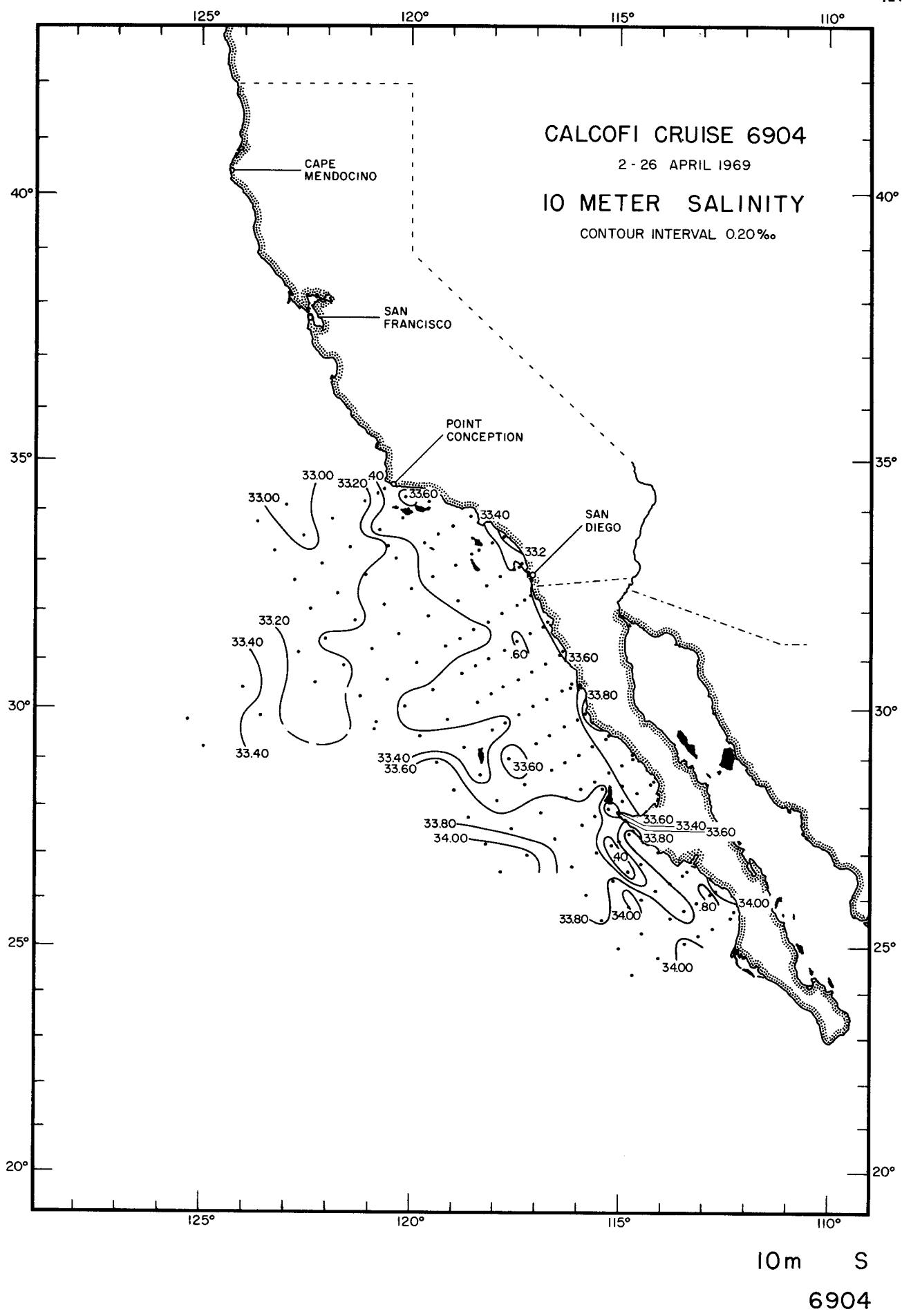
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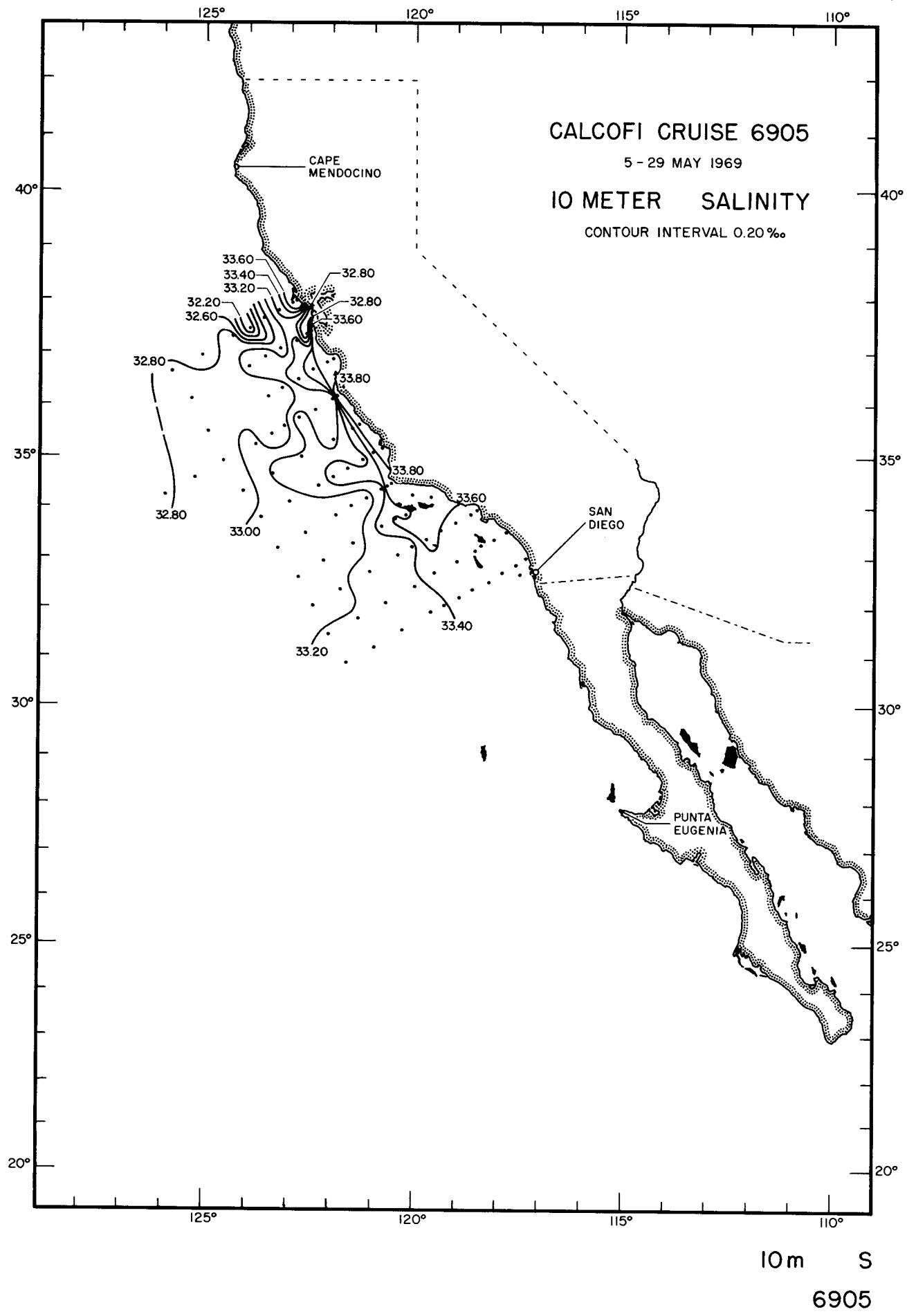


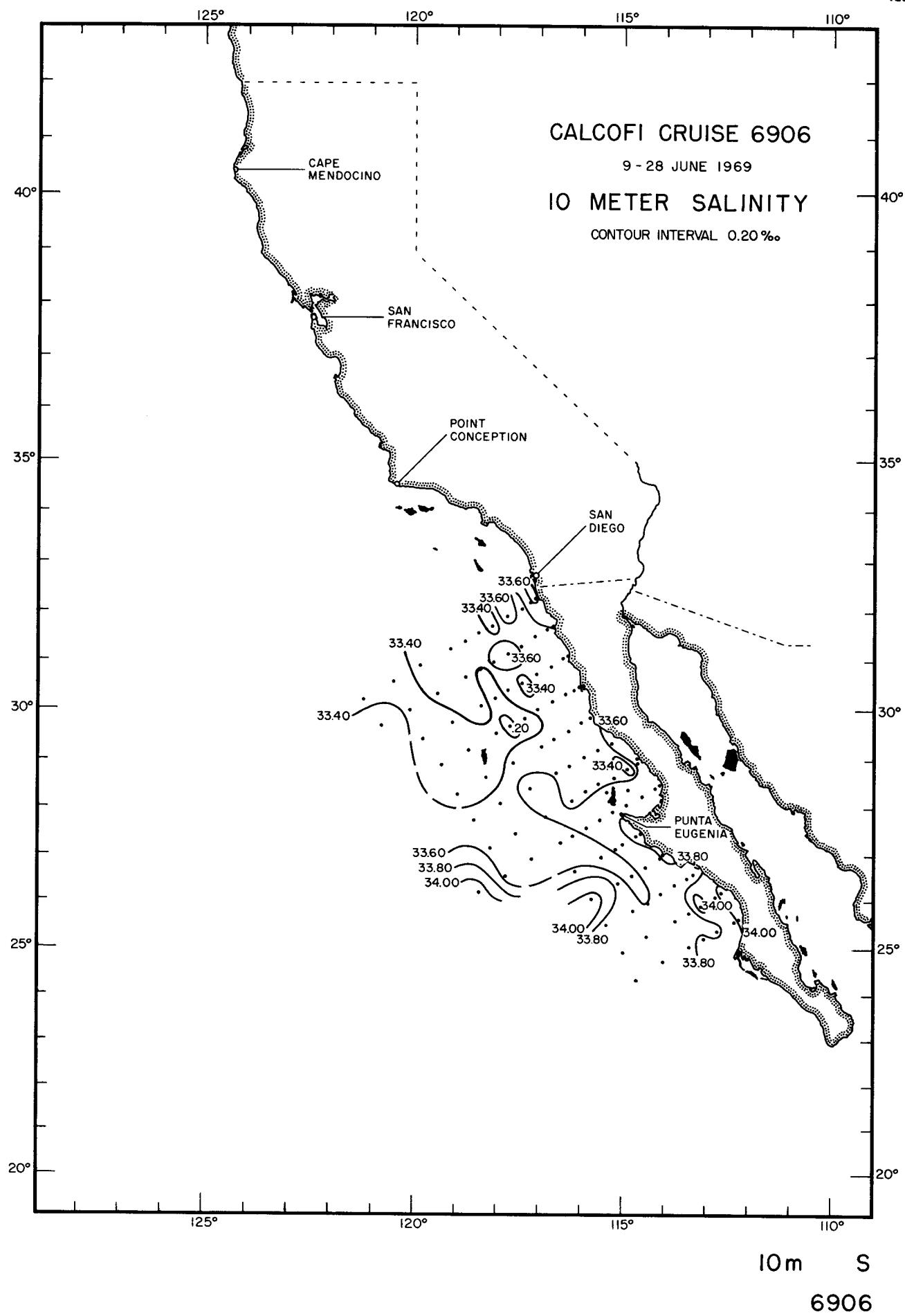


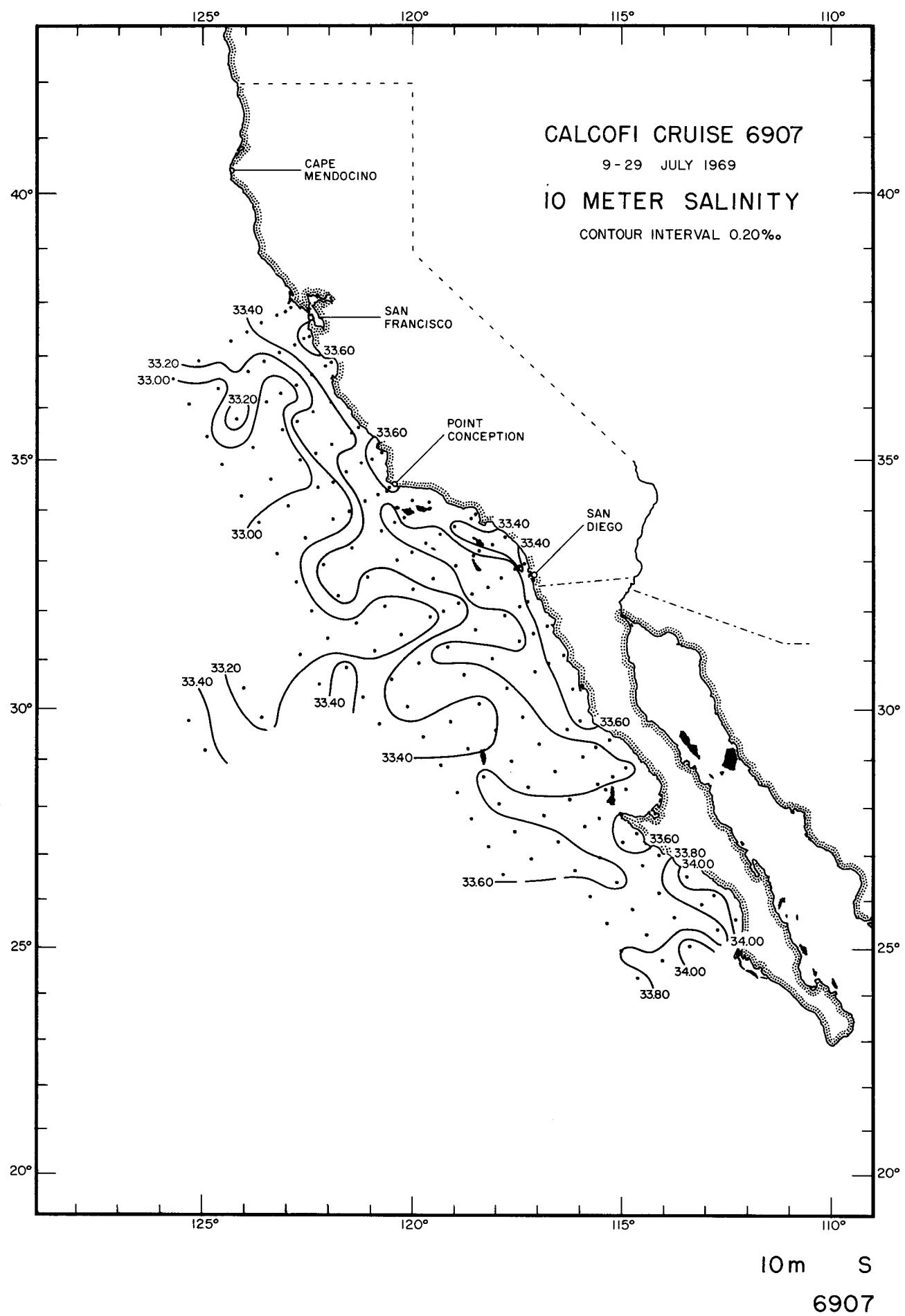


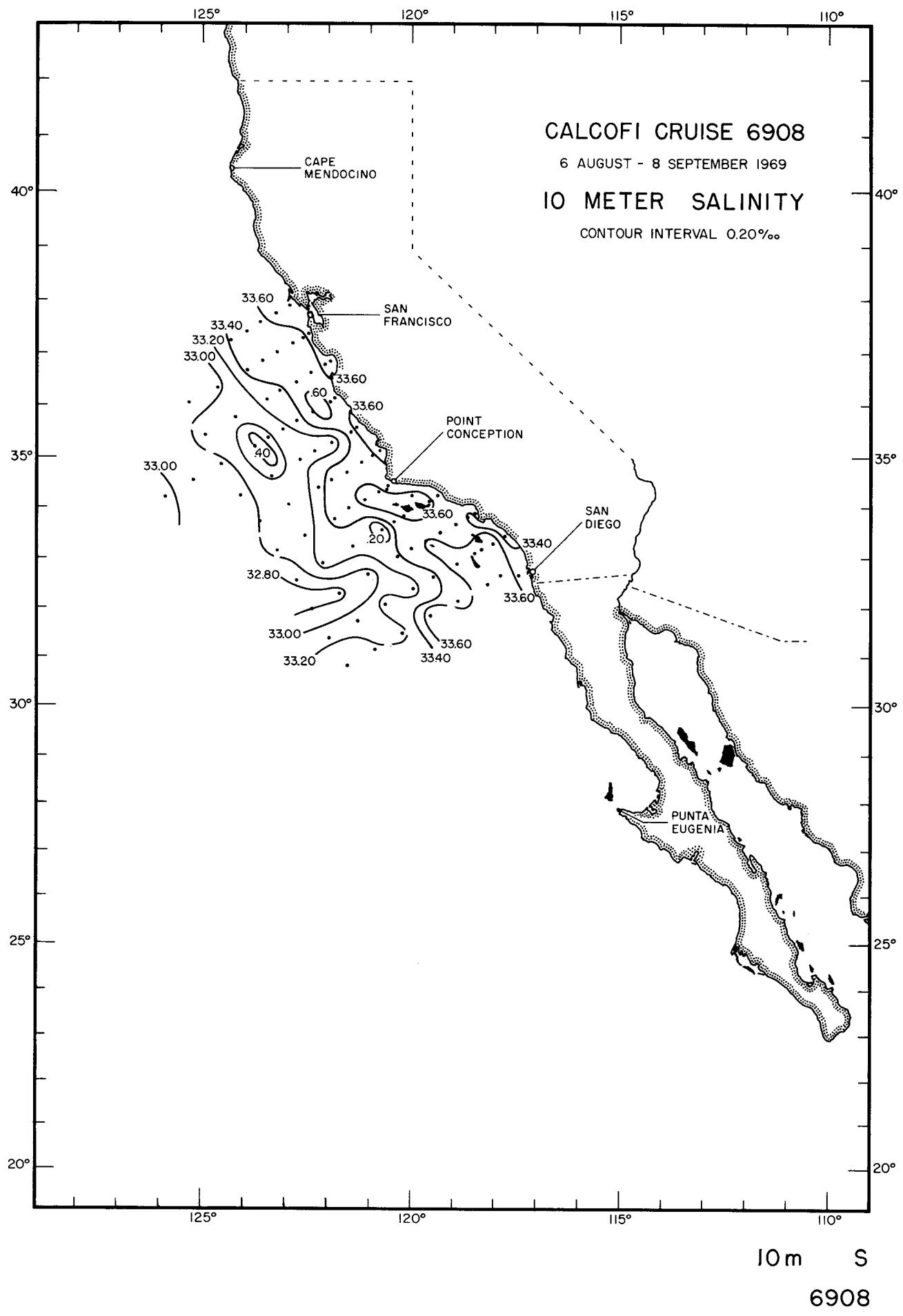


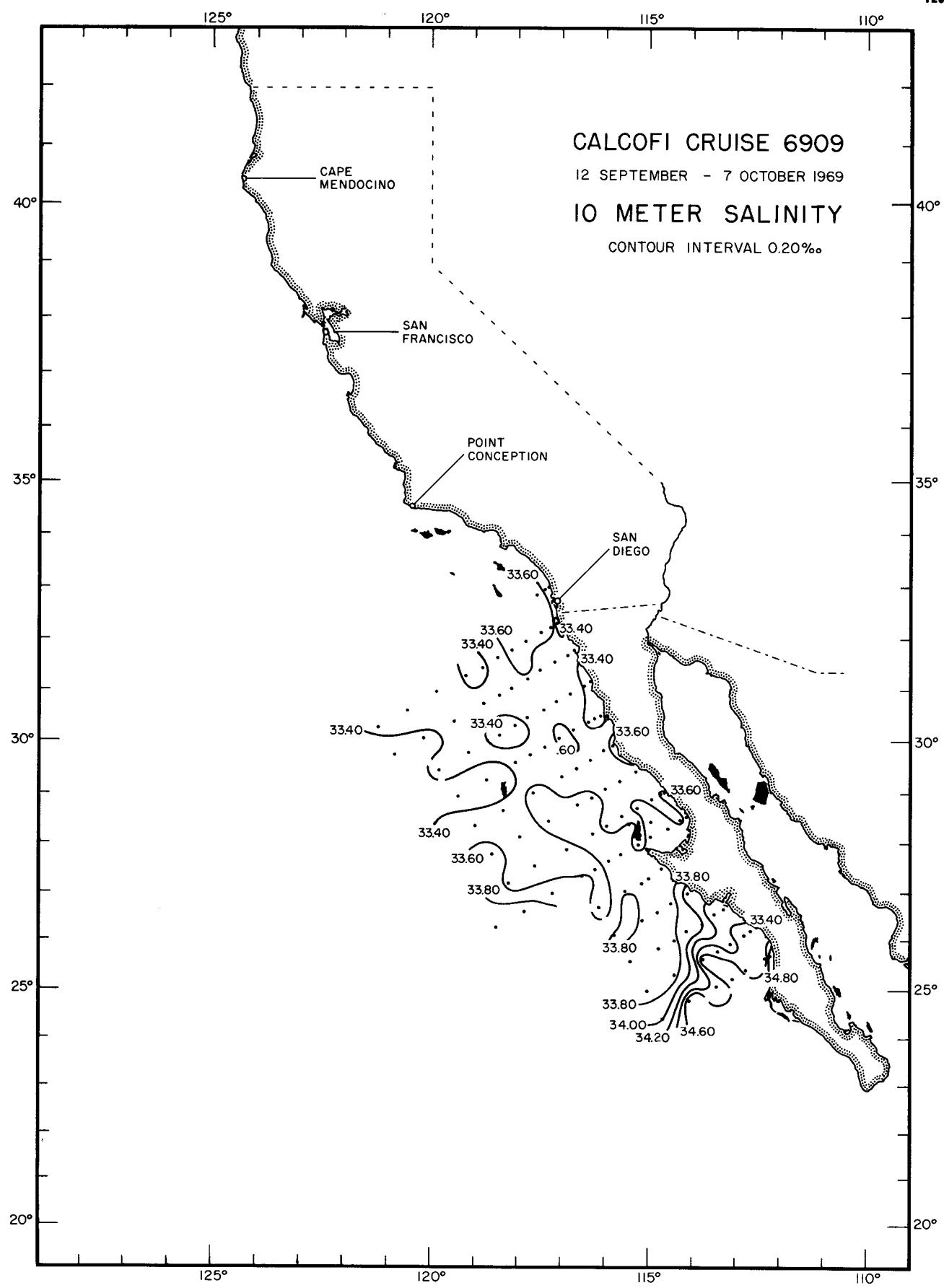






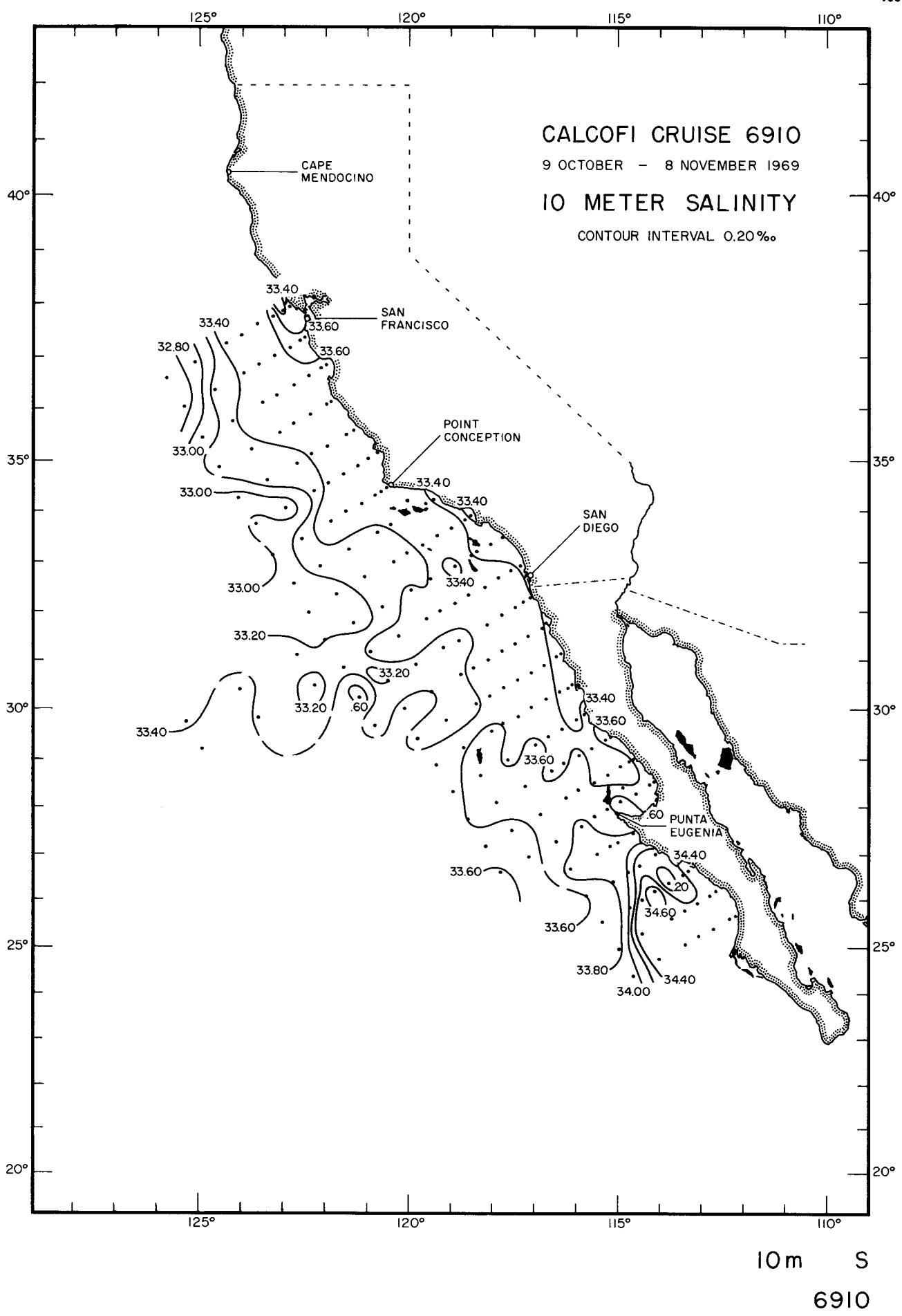


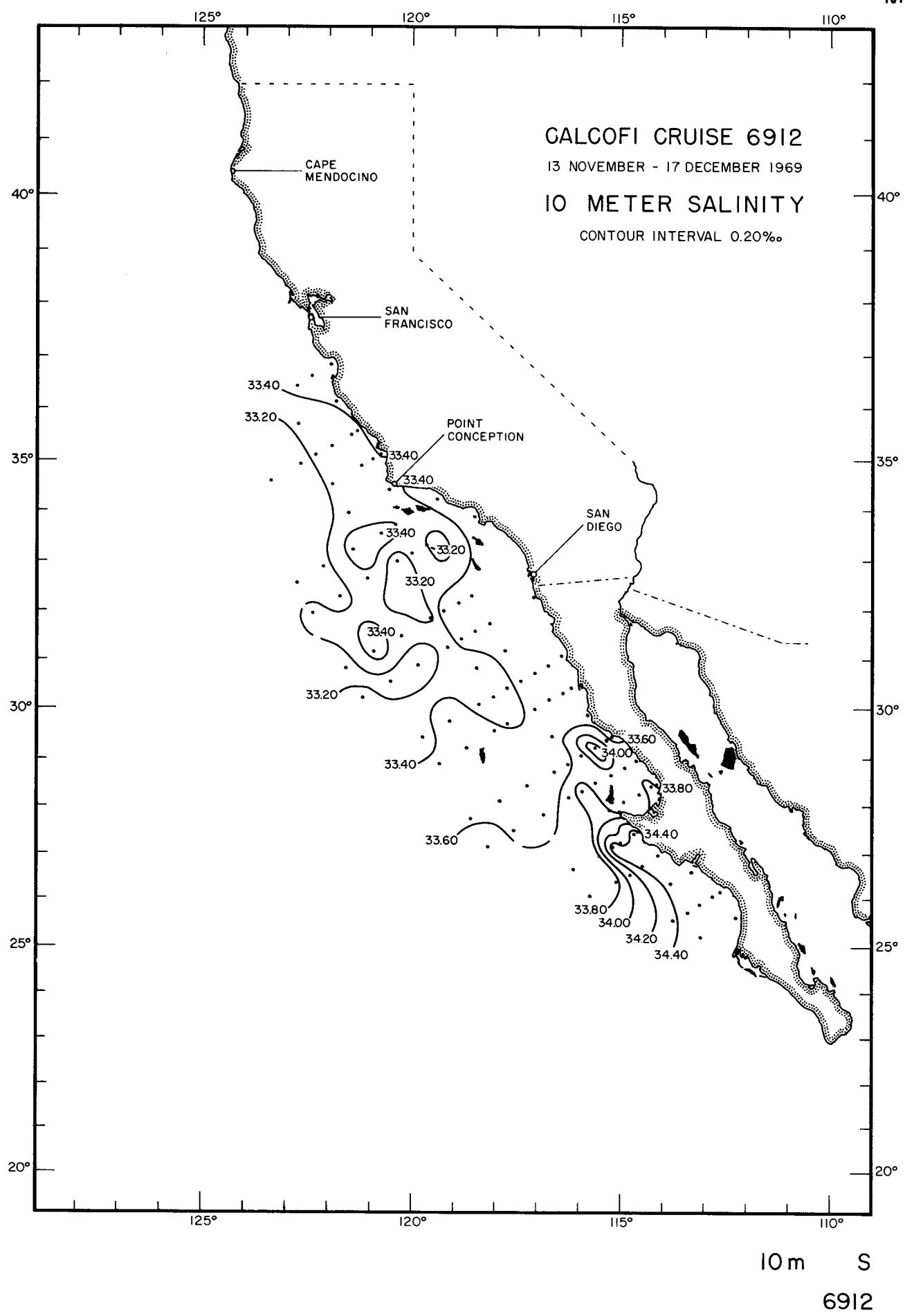


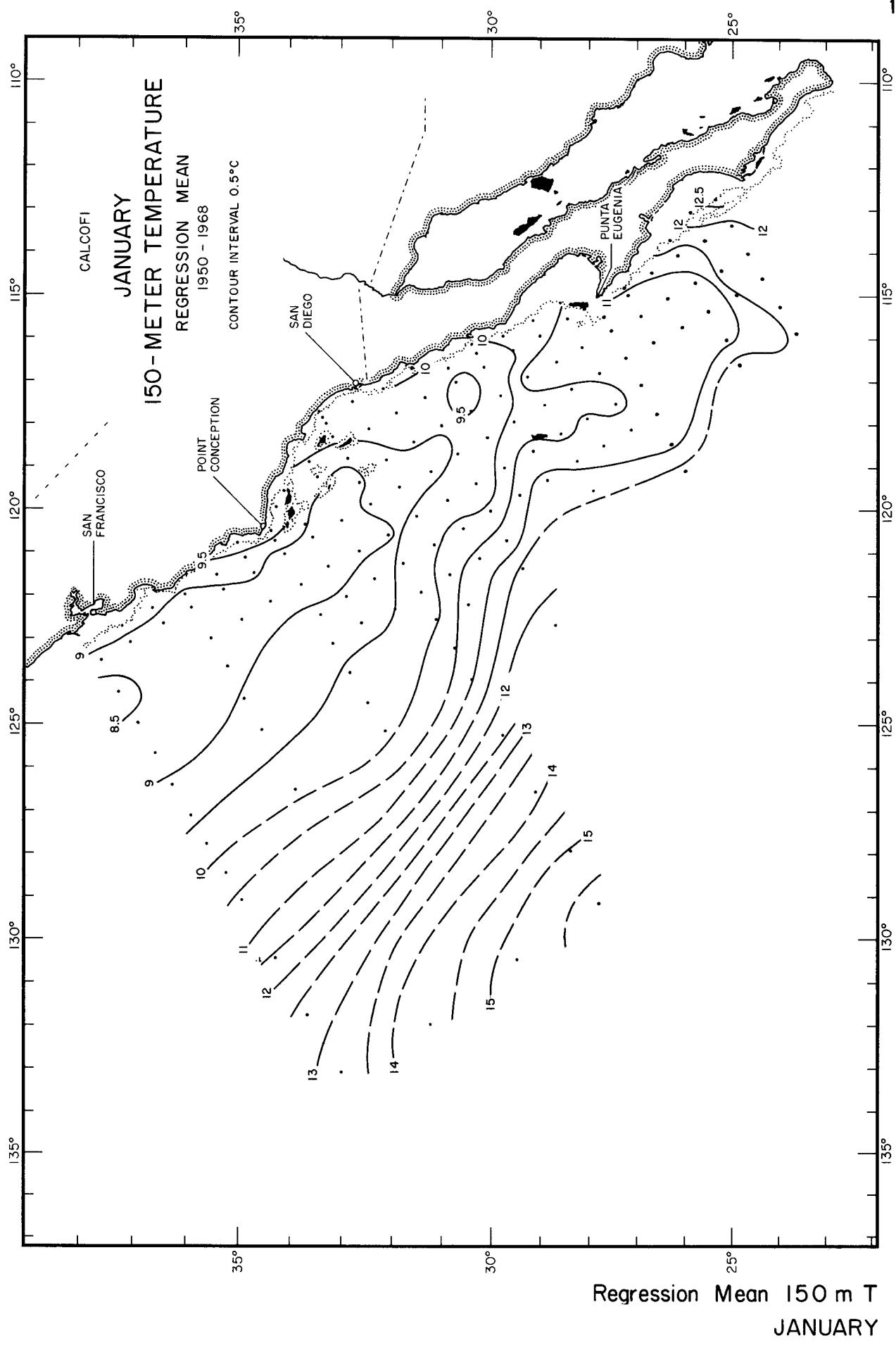


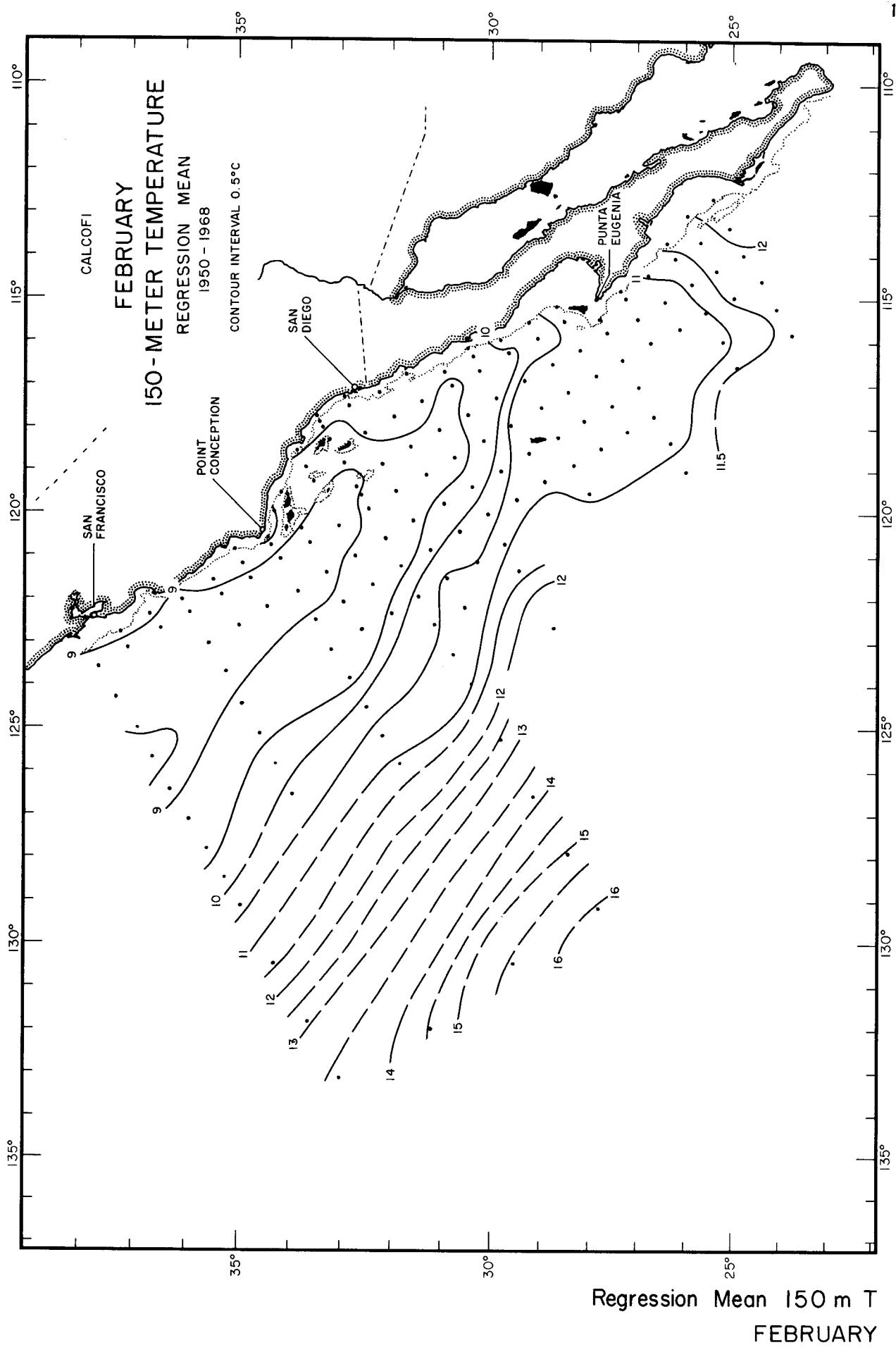
10m S

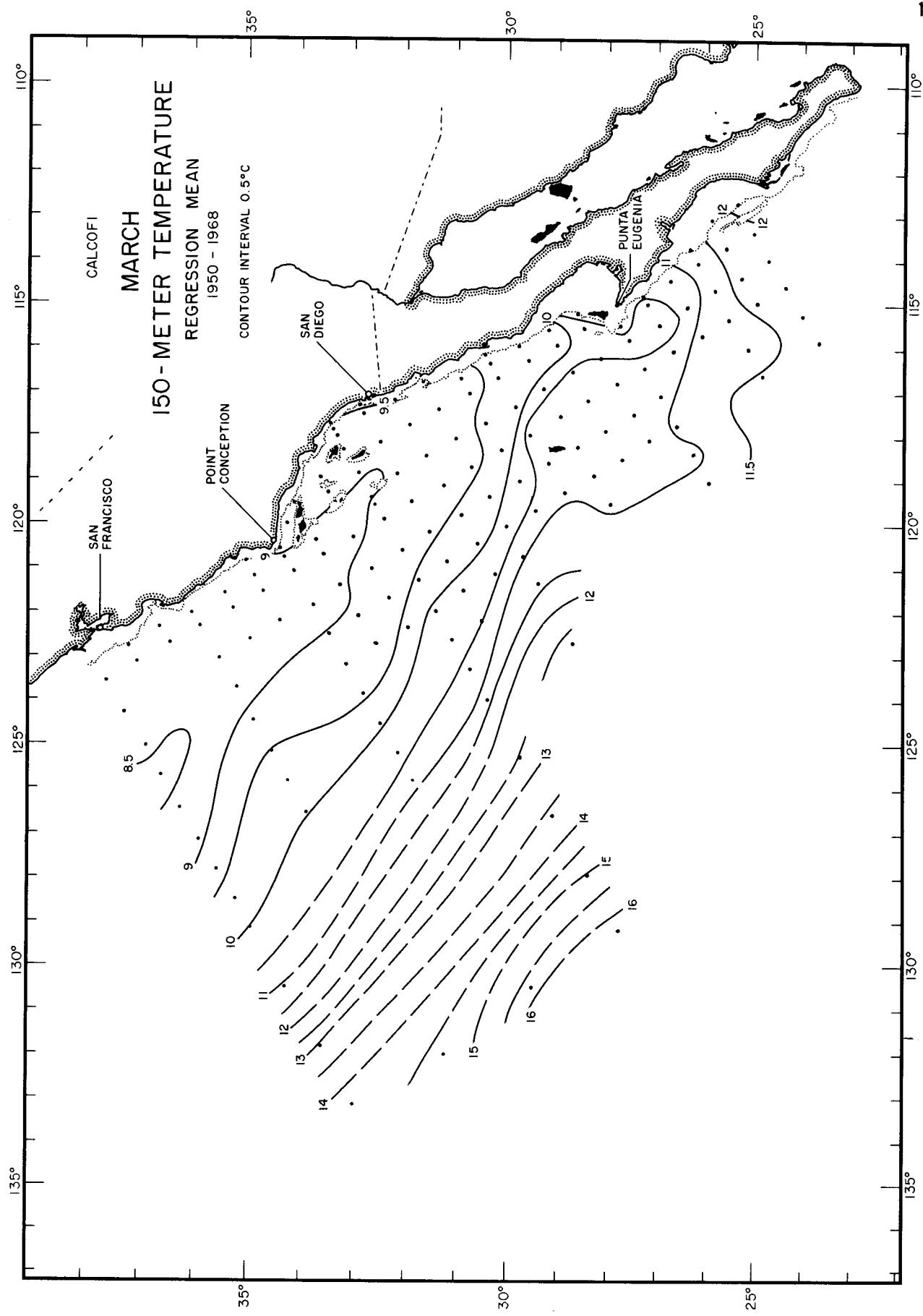
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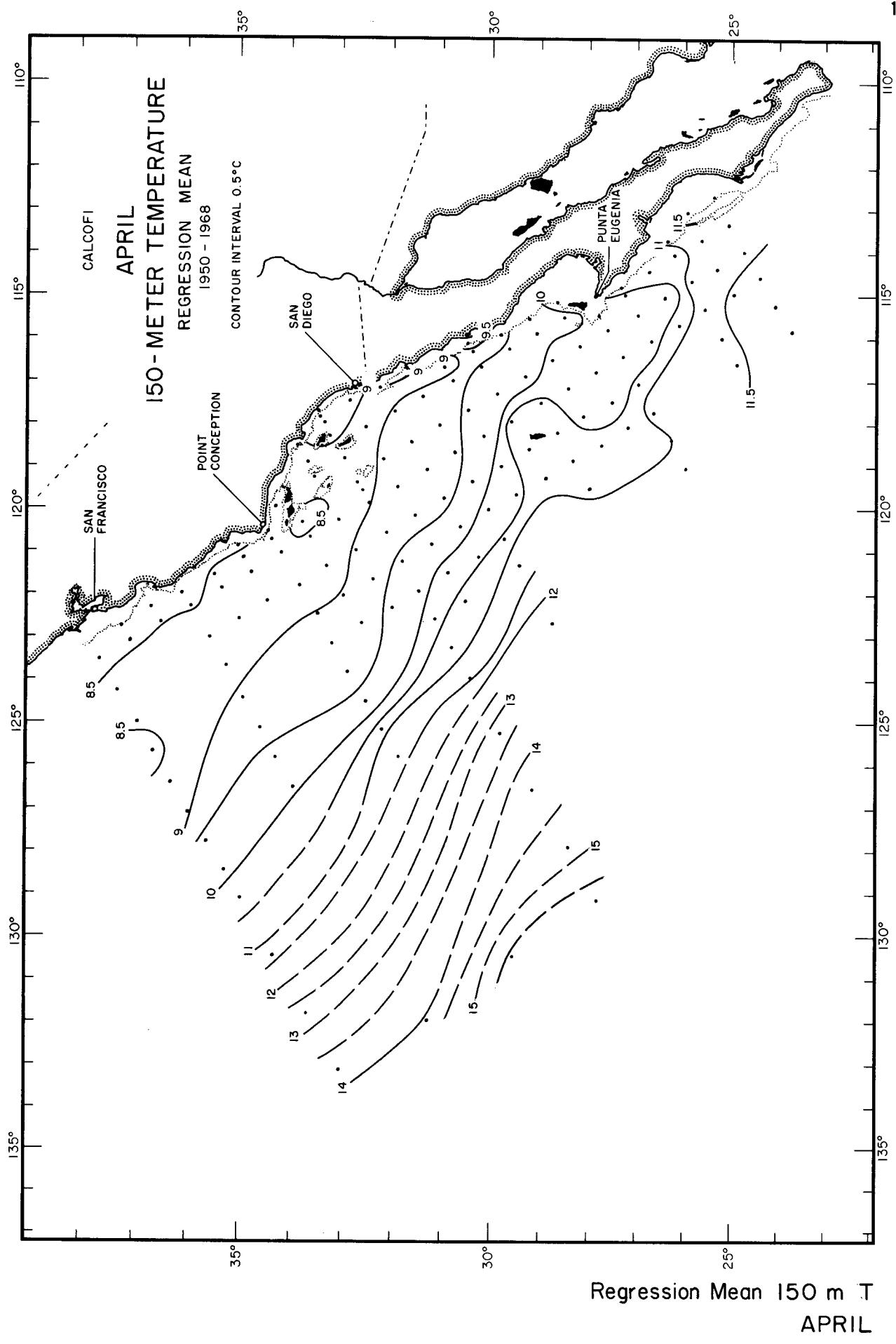


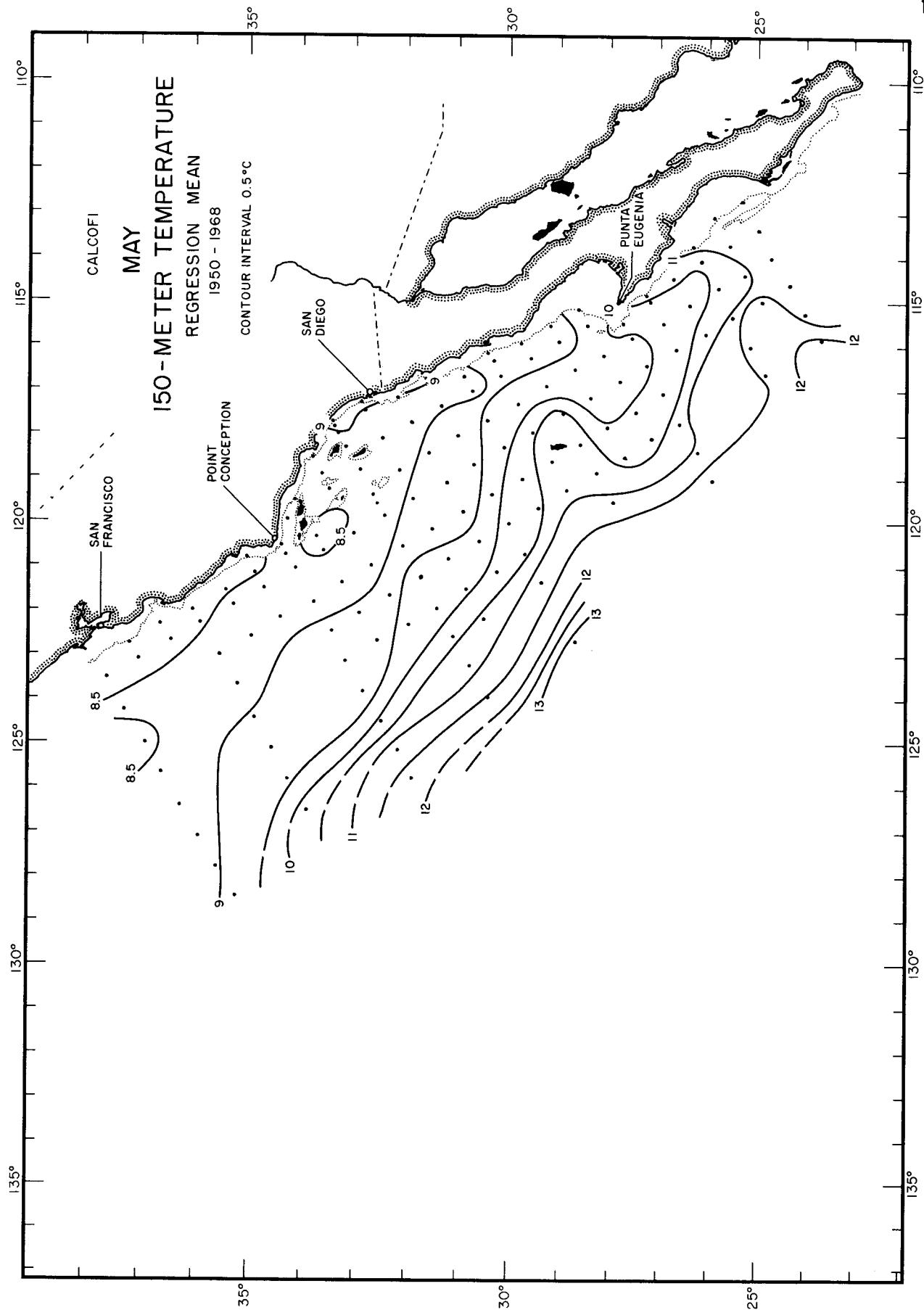




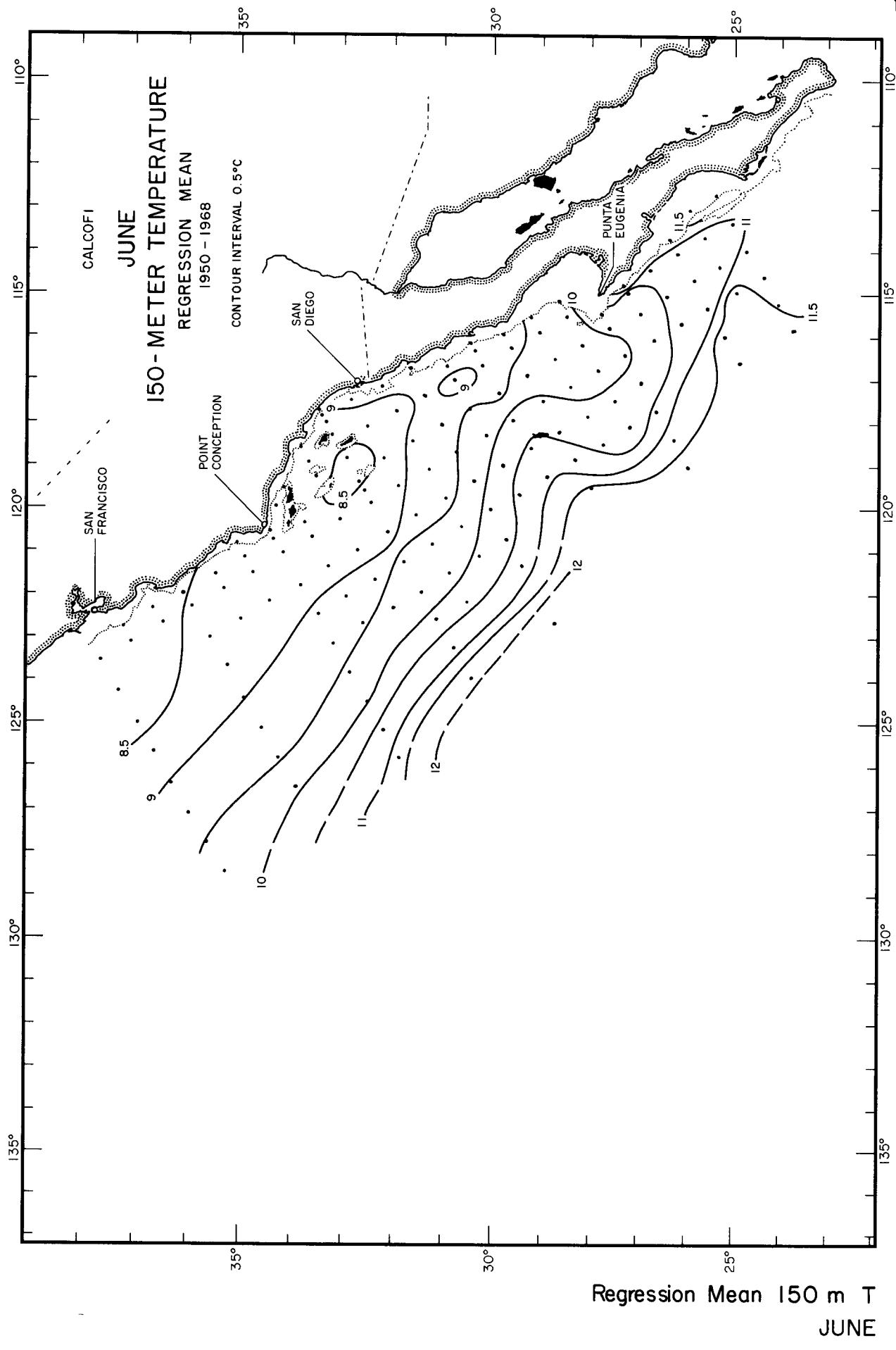


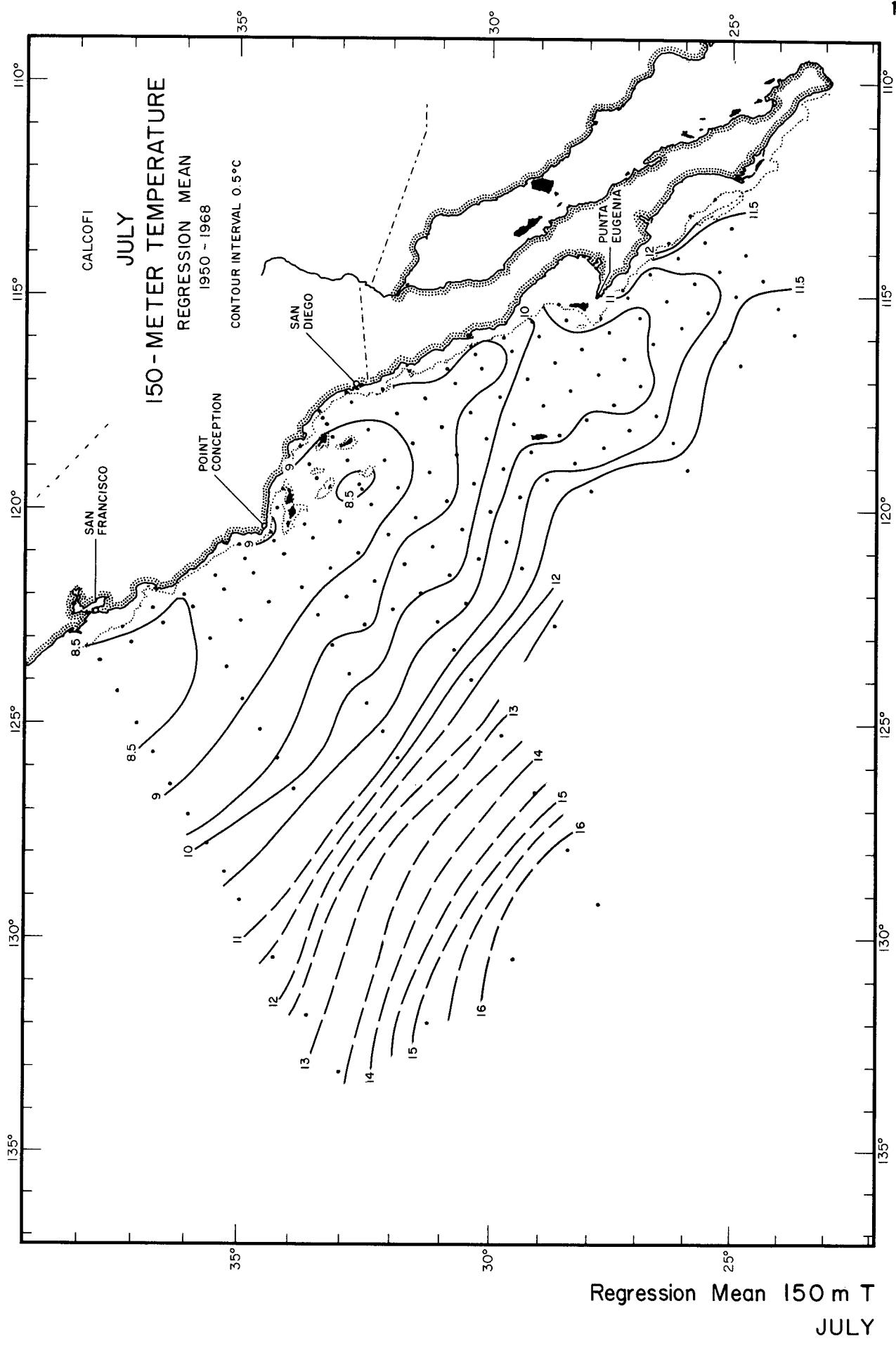


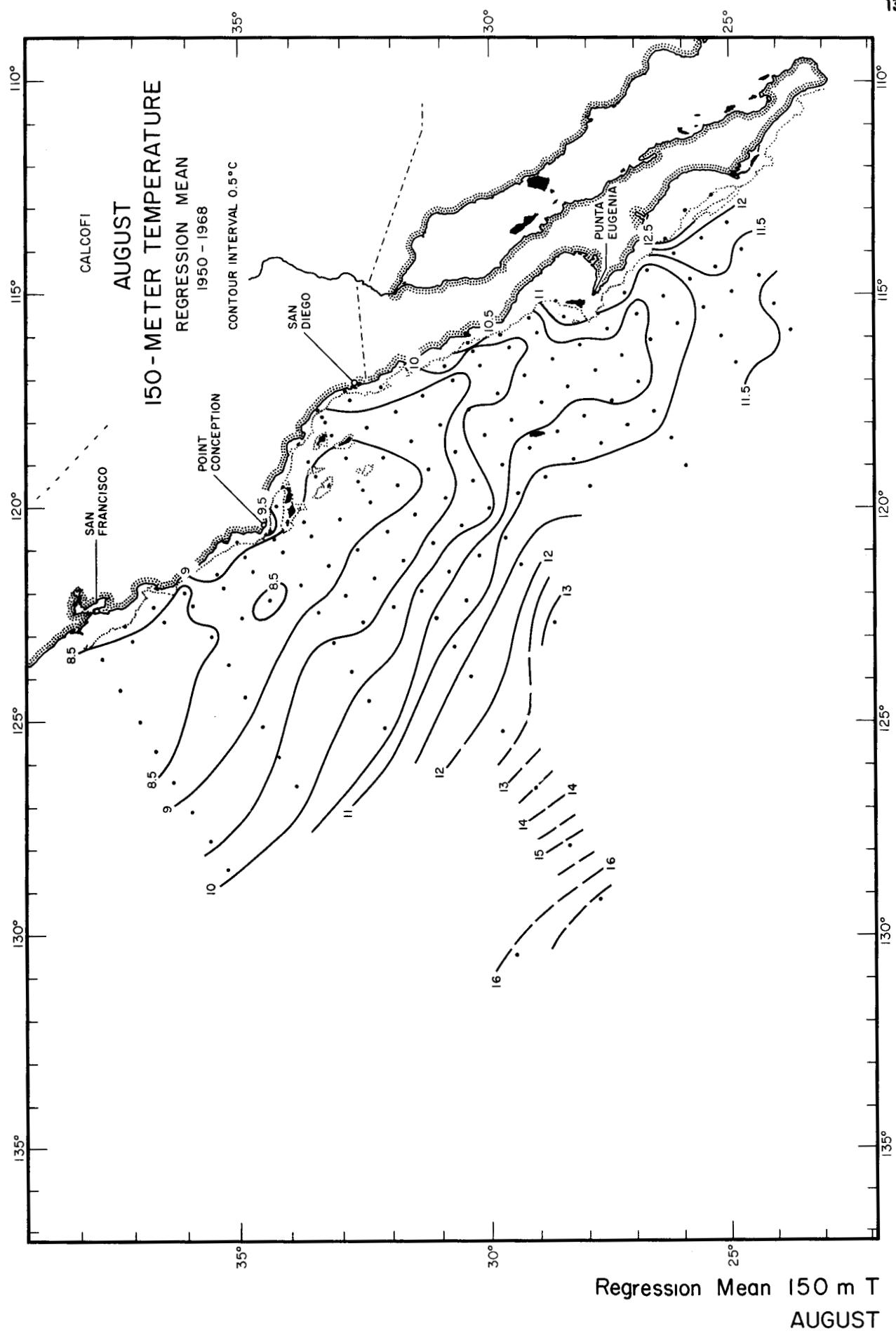


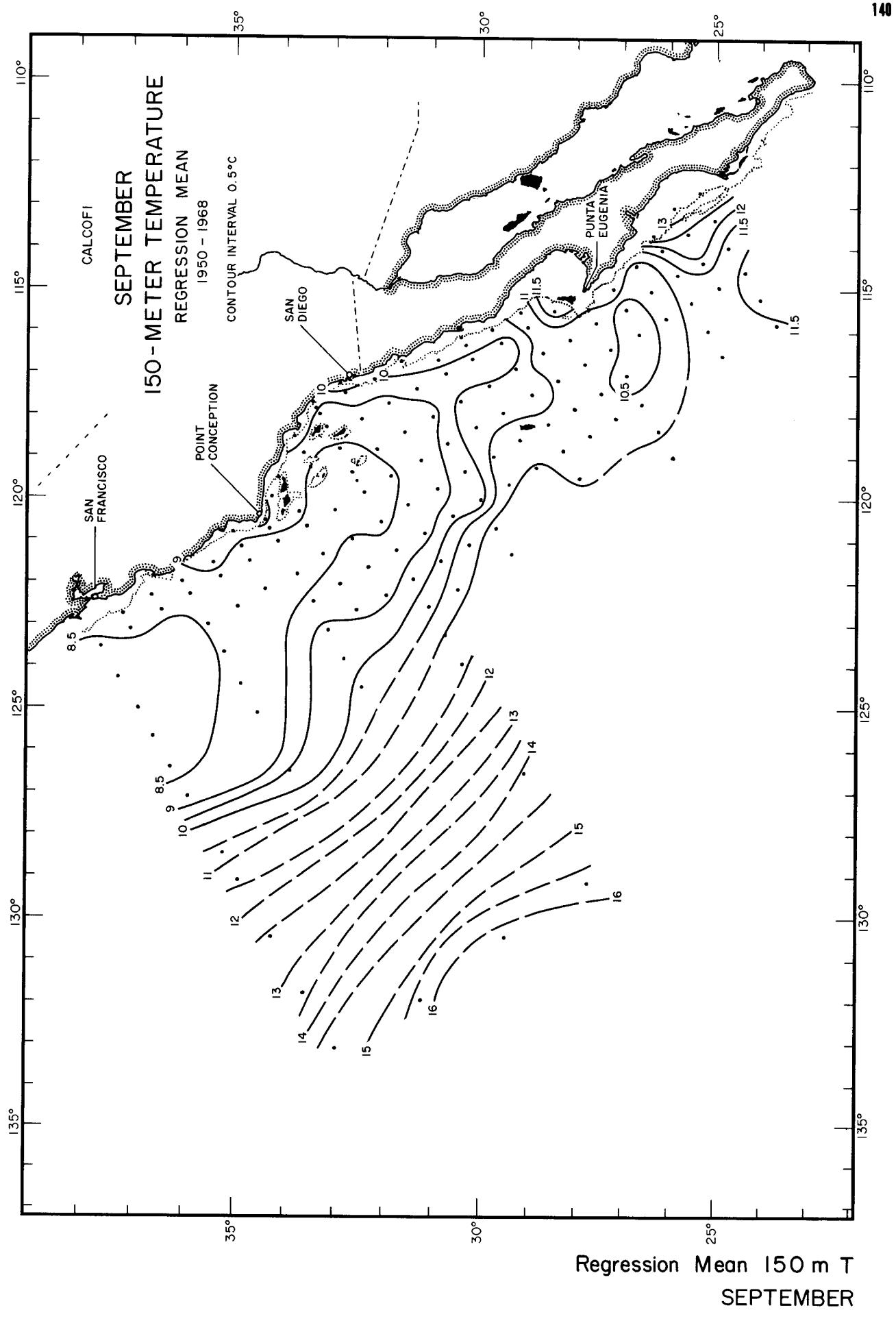


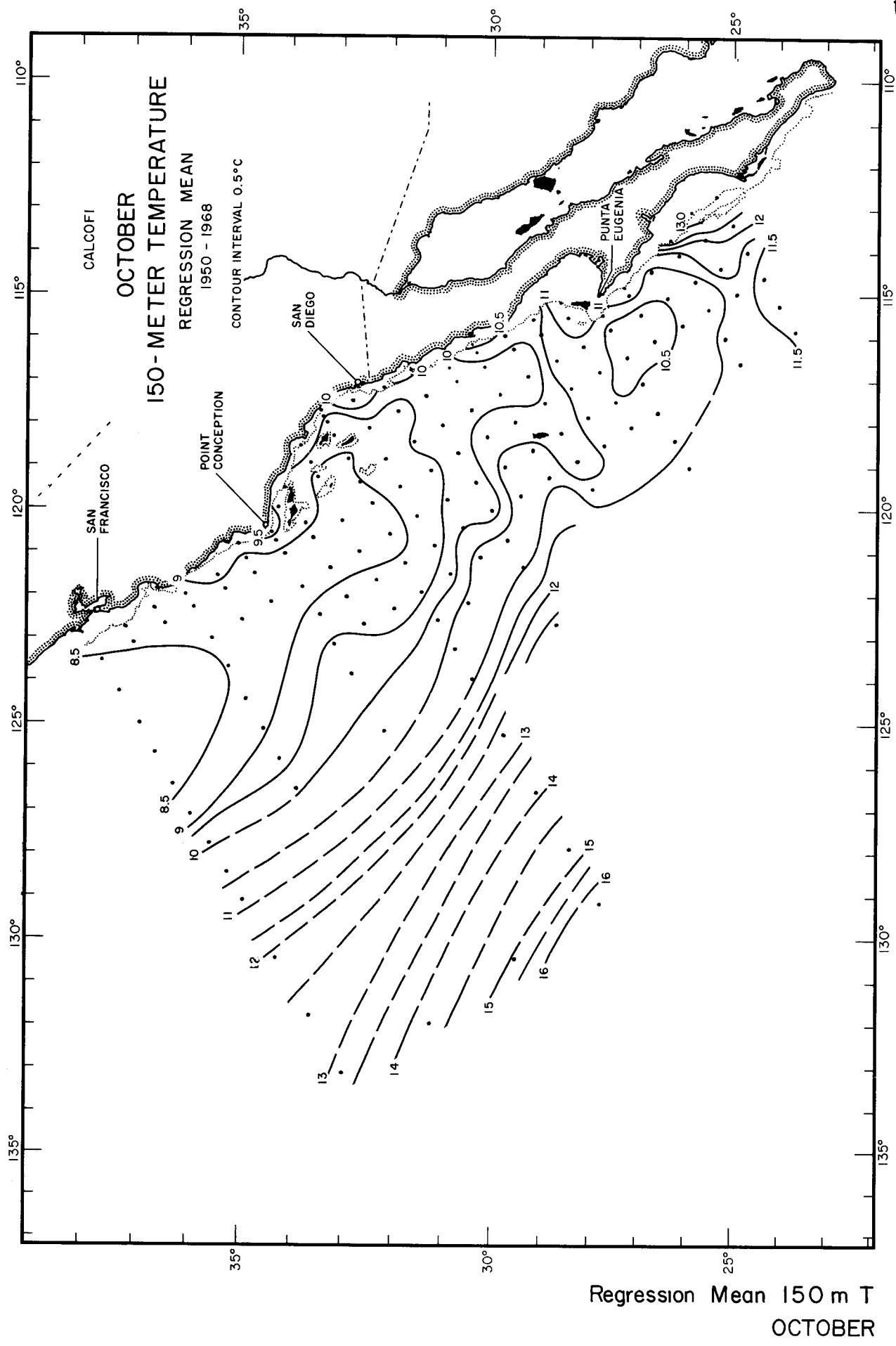
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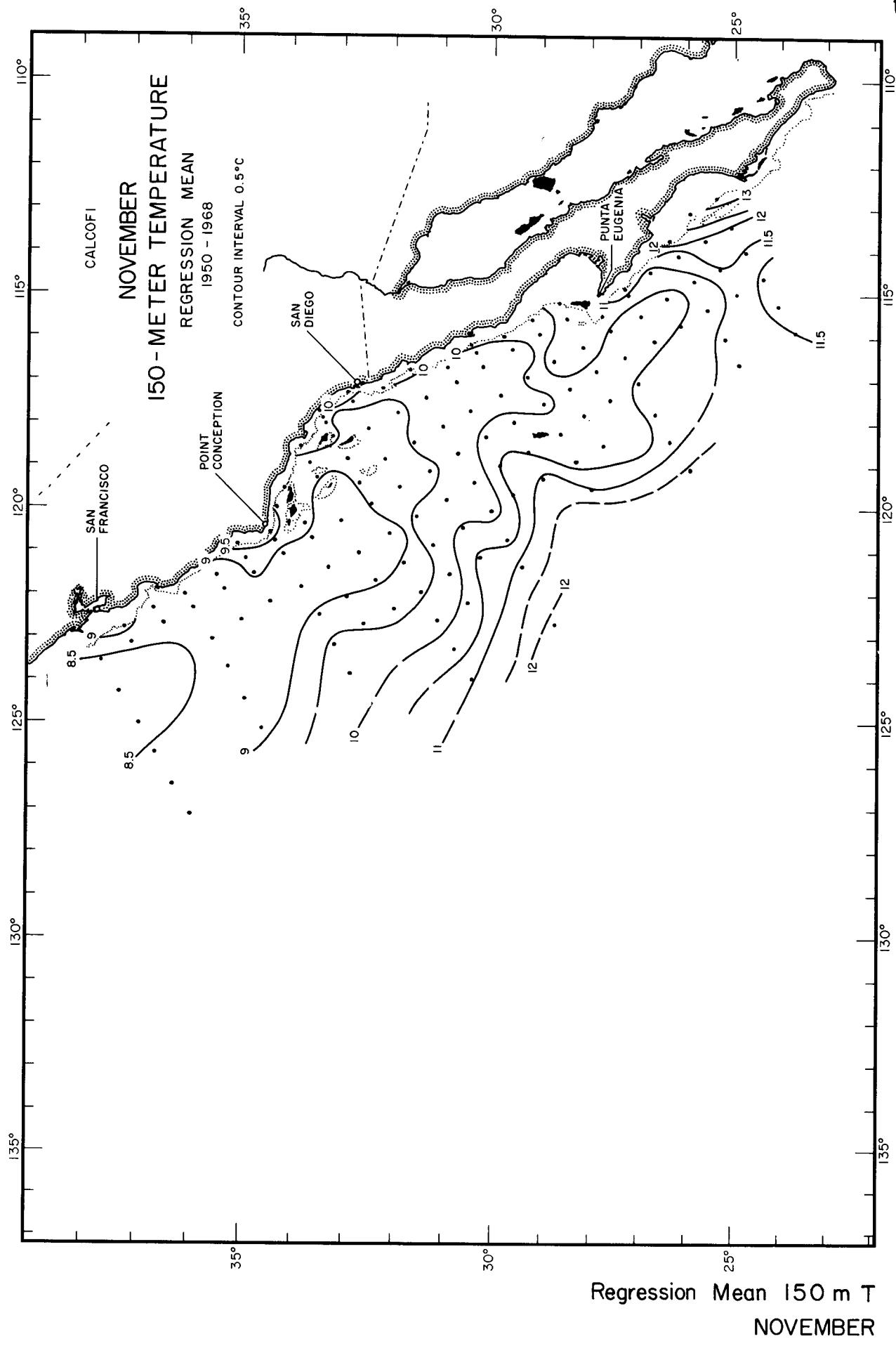


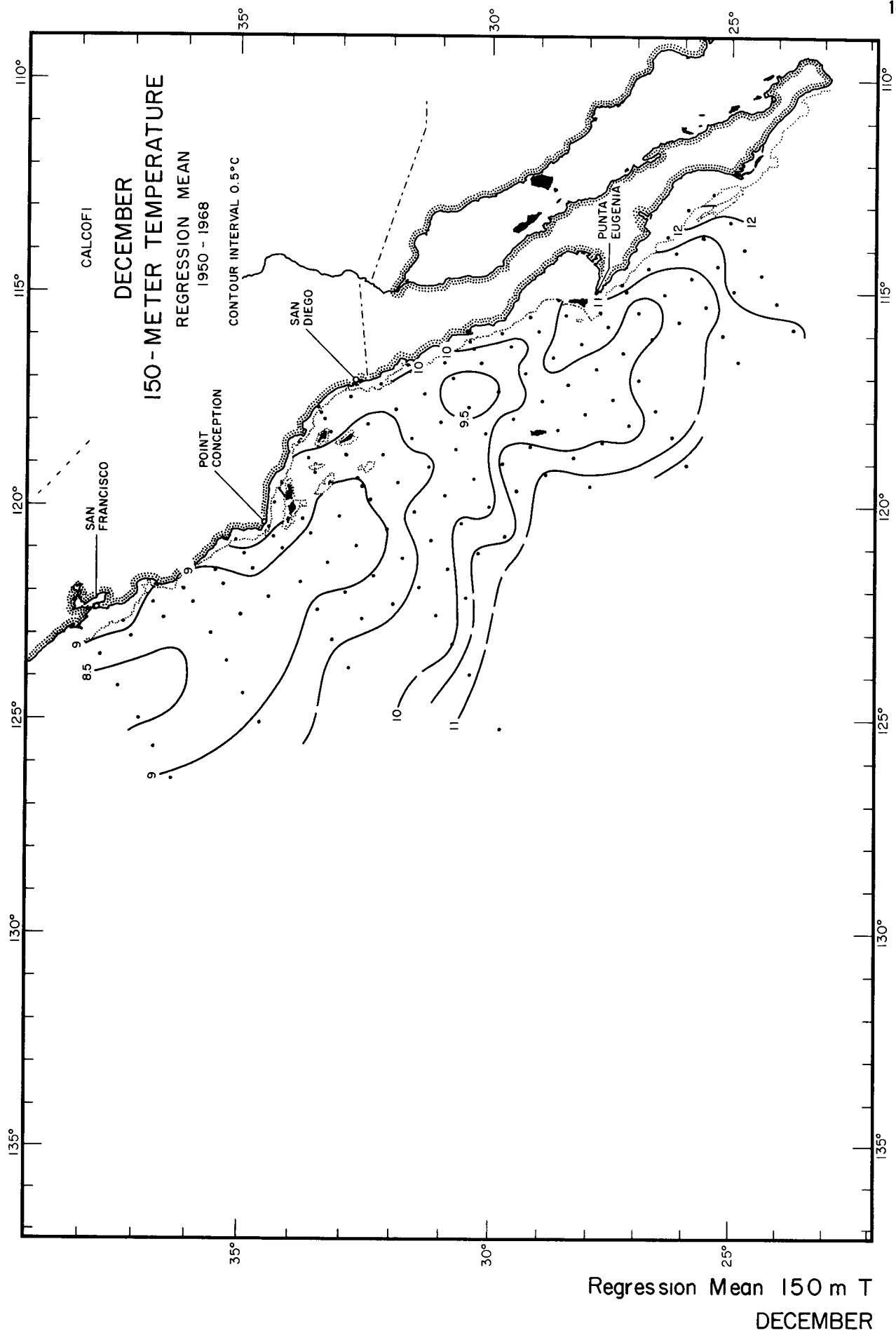


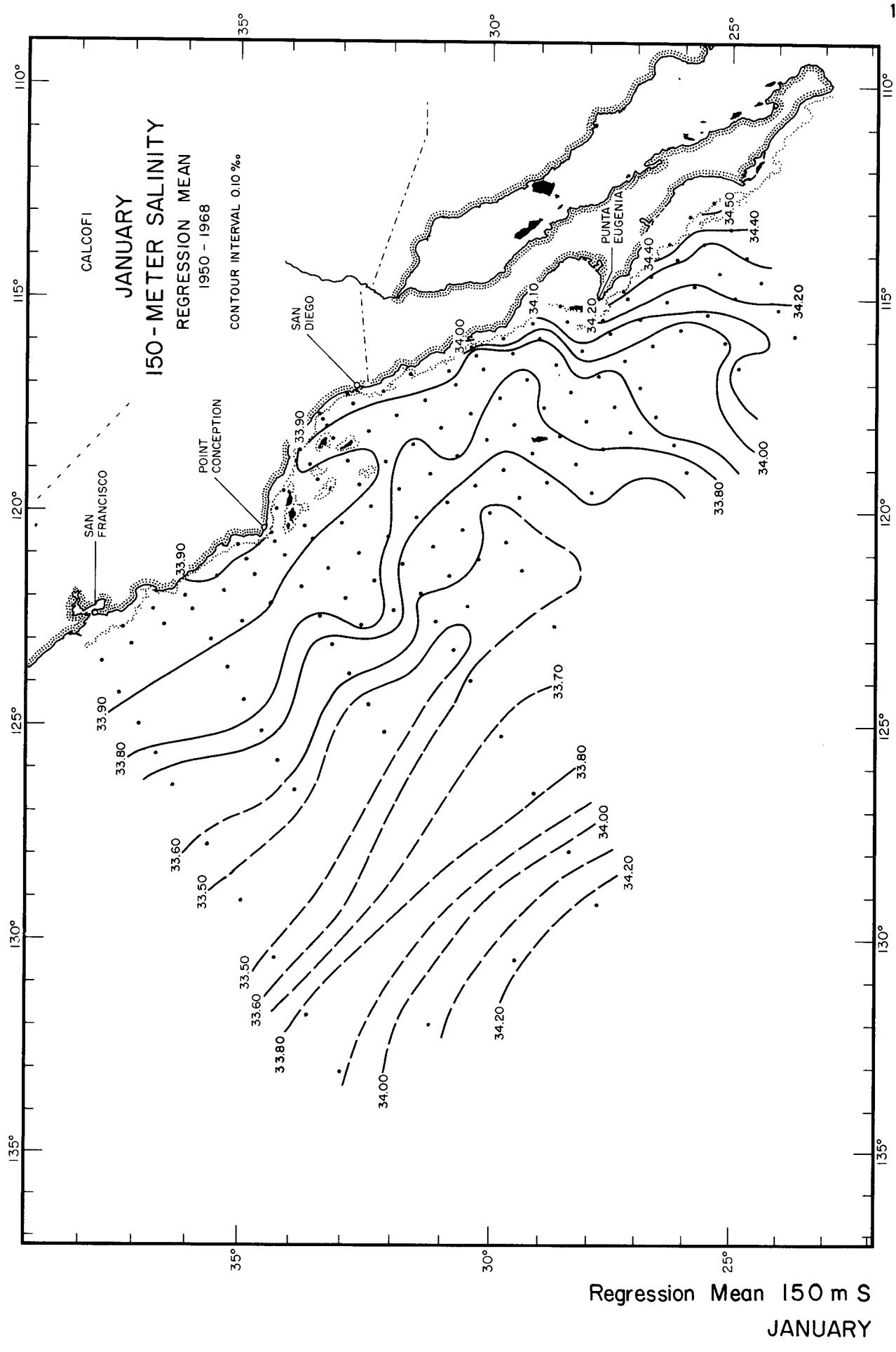


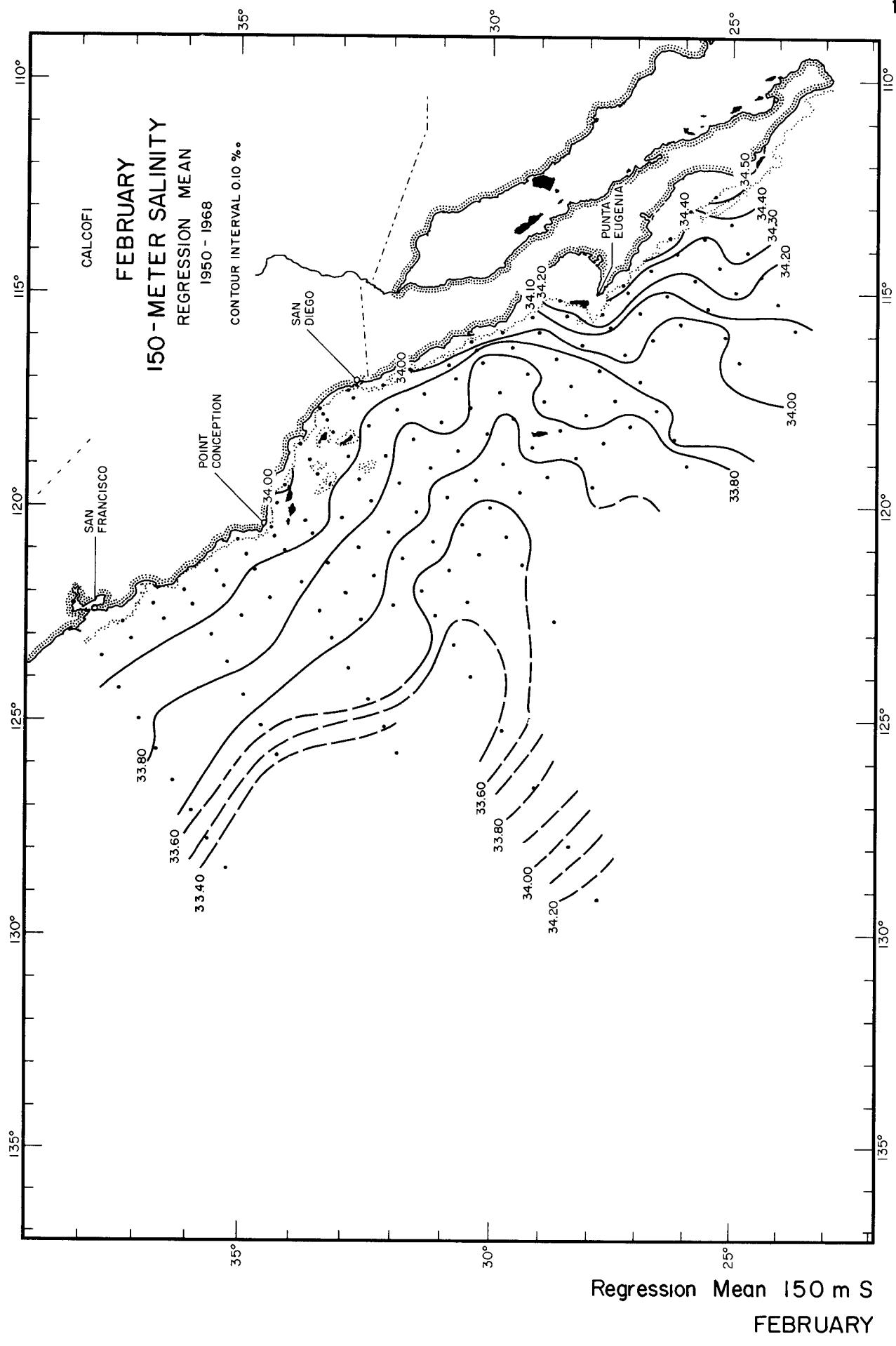


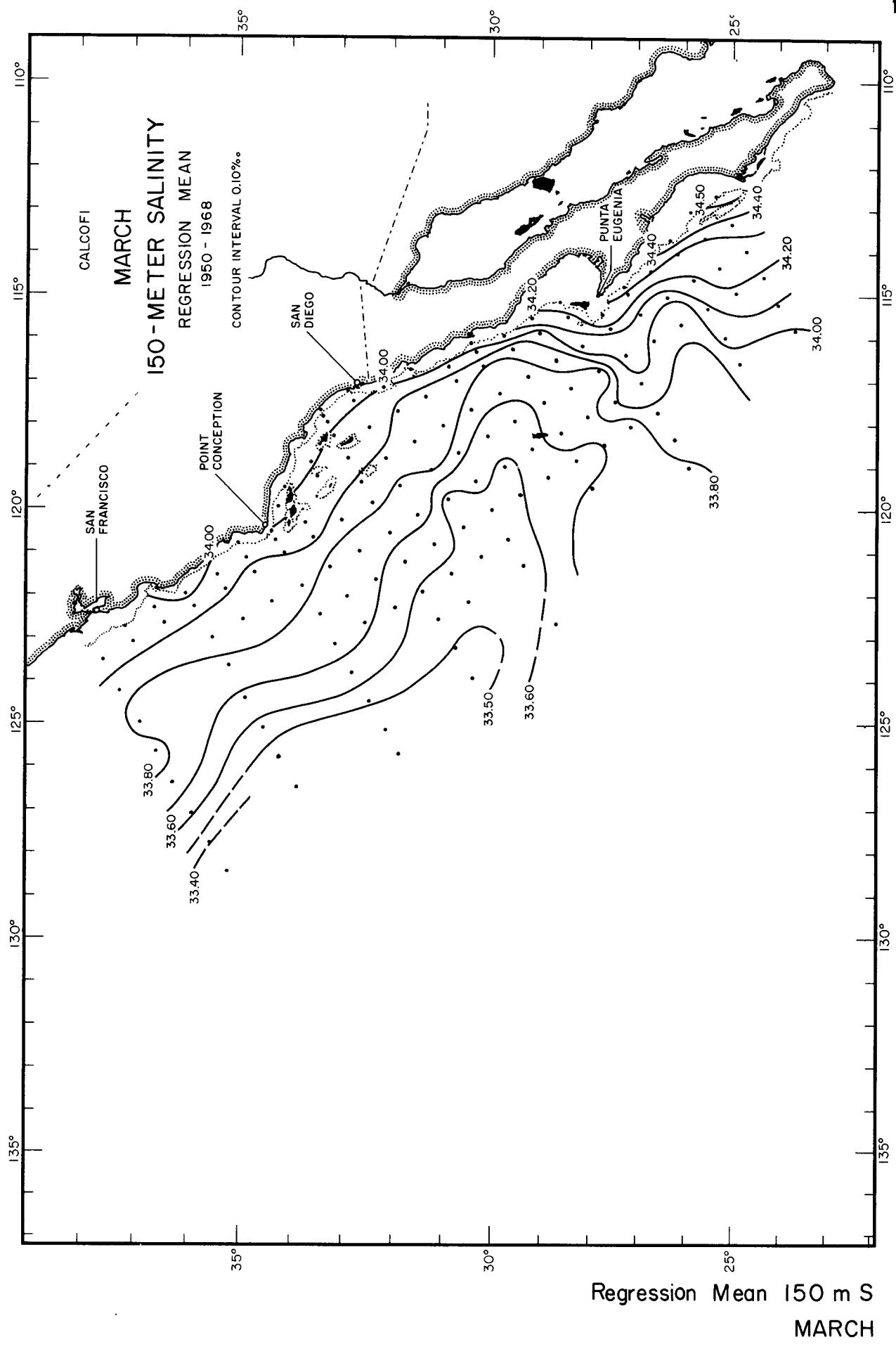


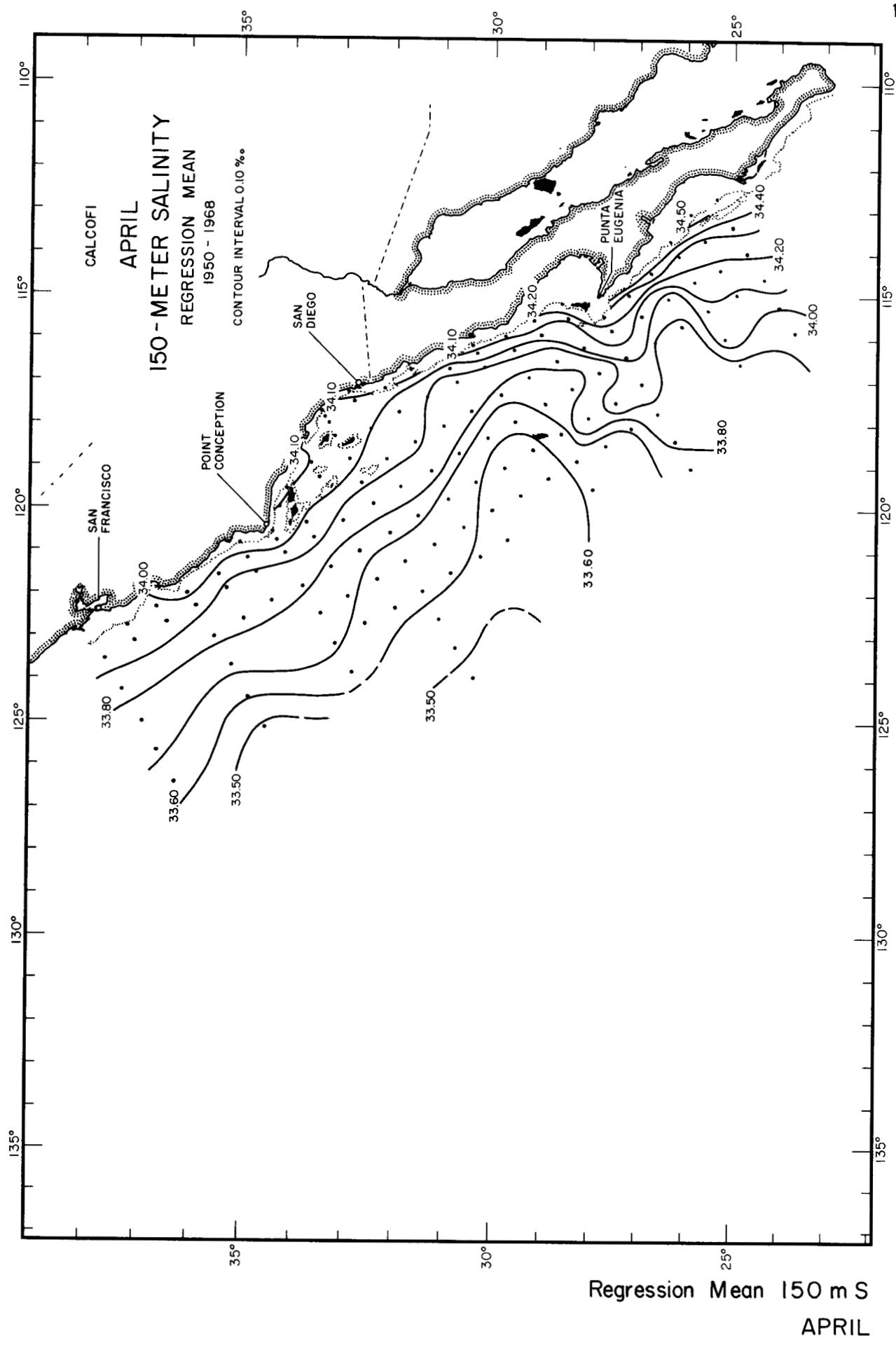


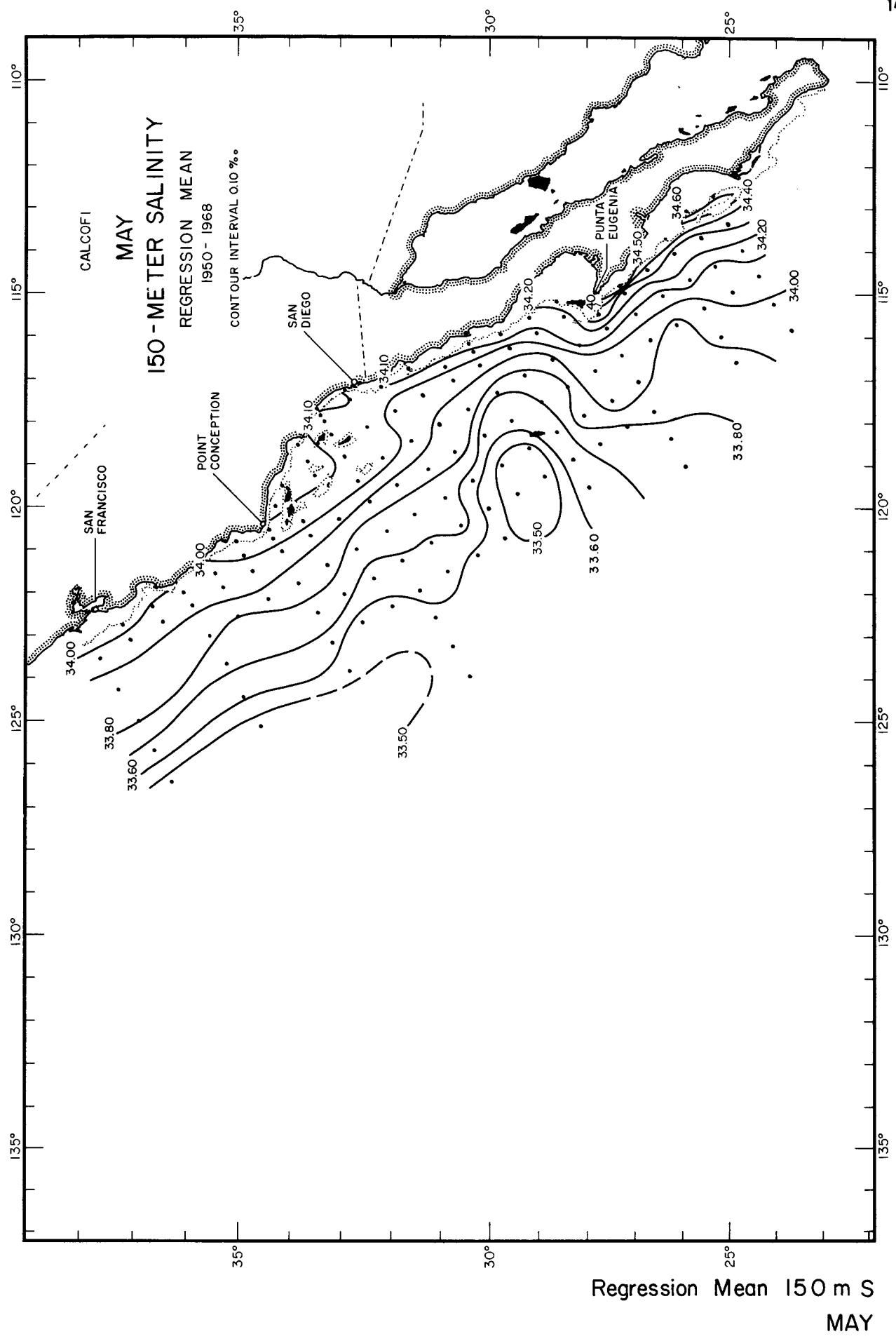


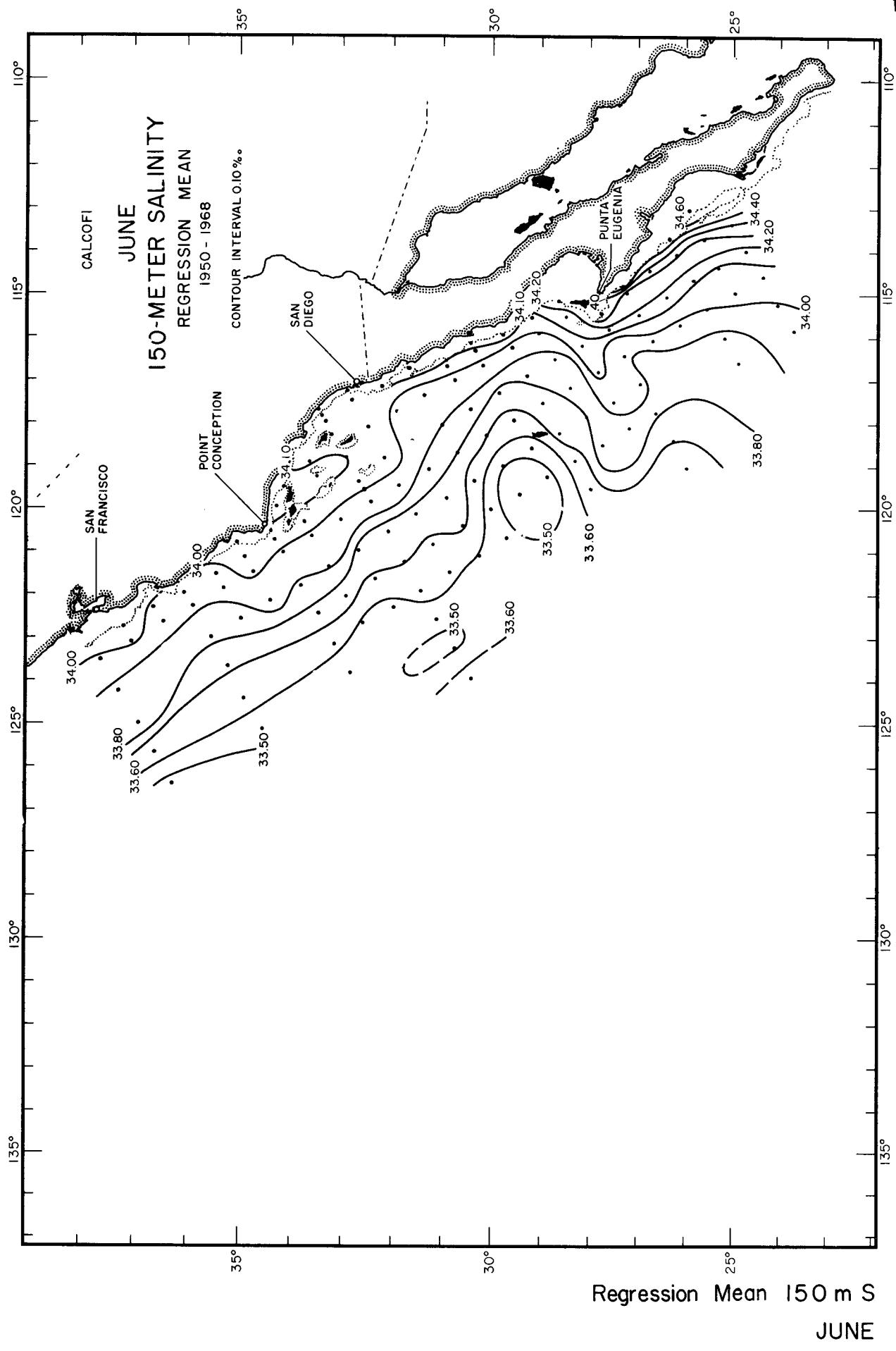


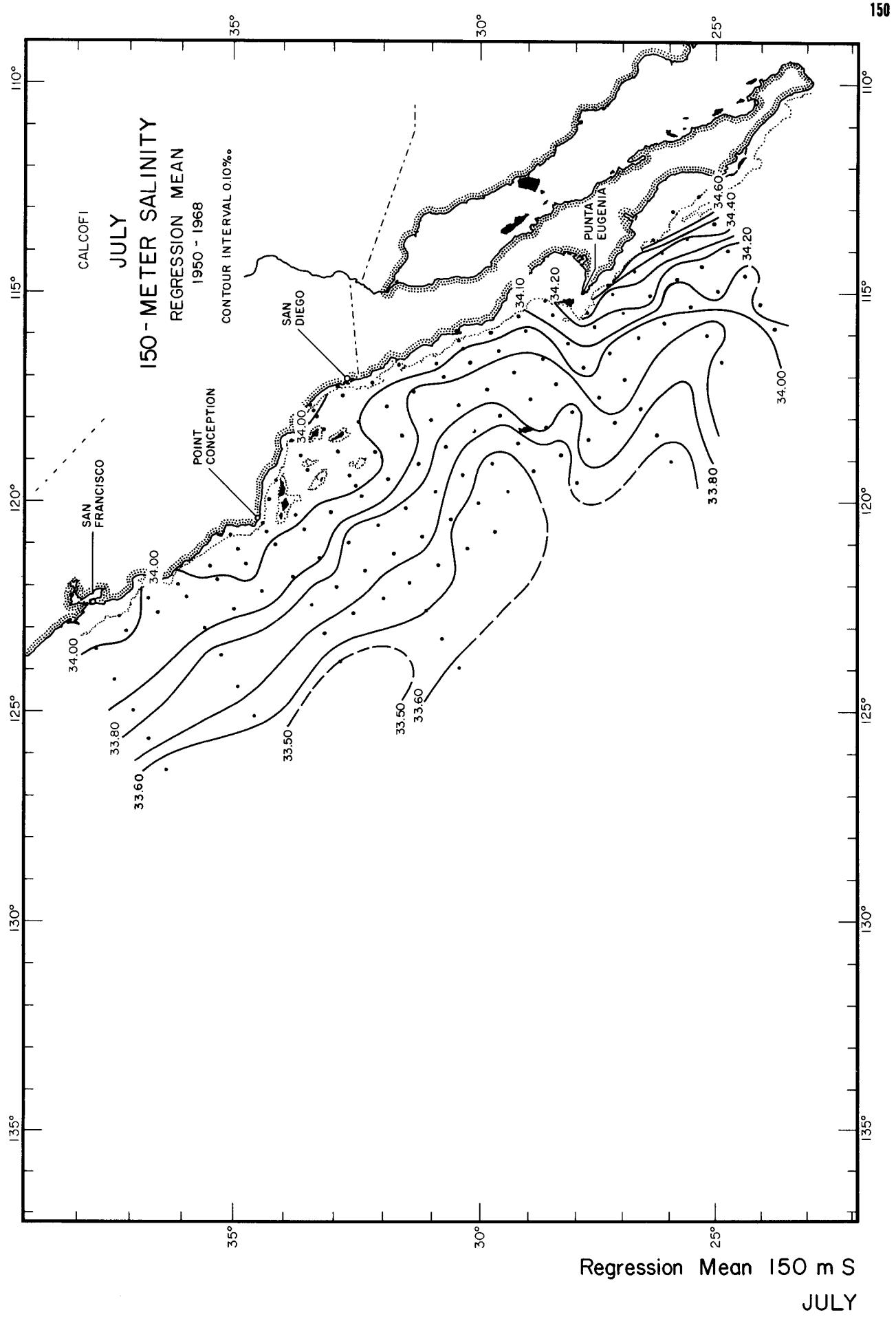


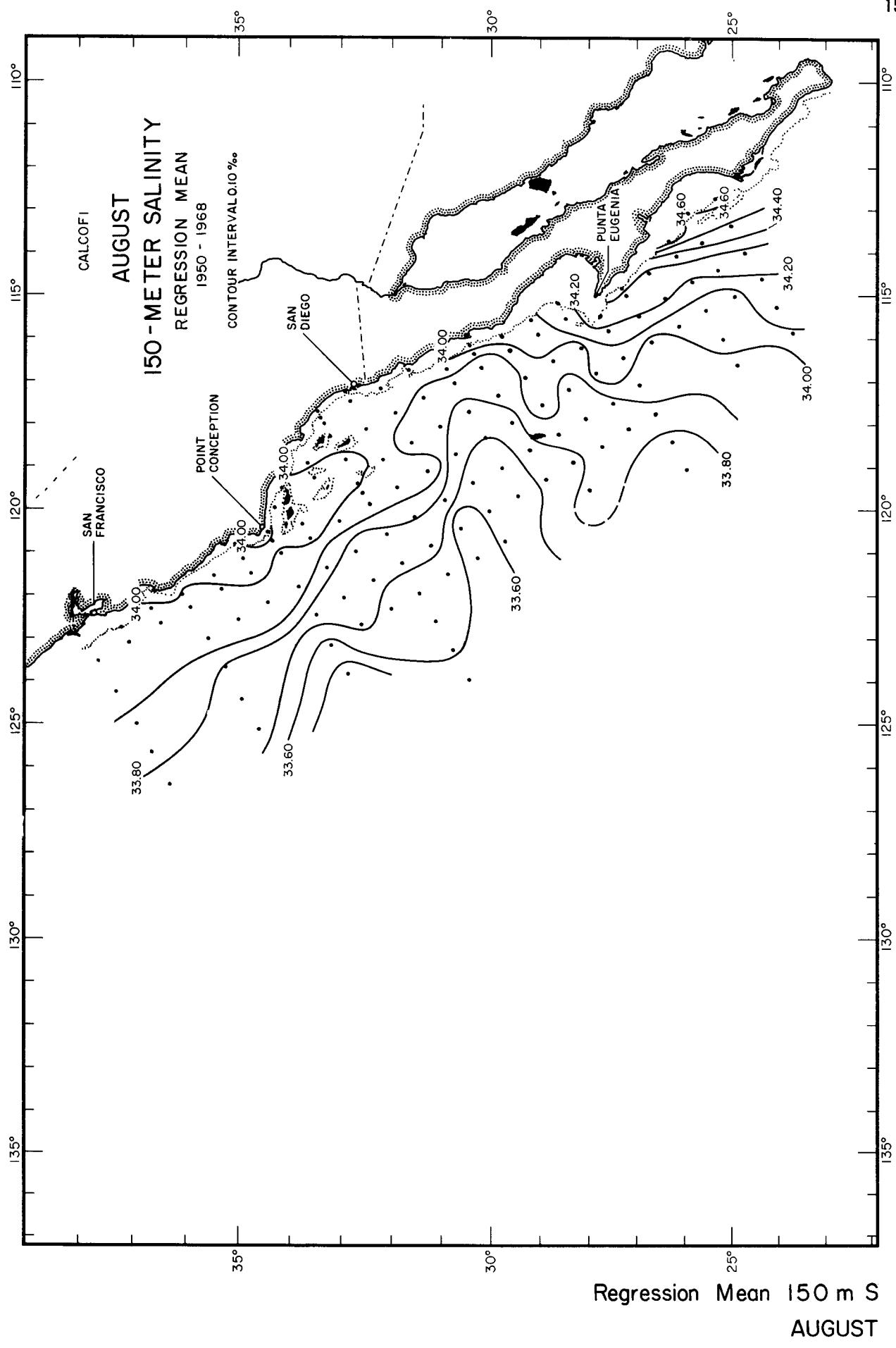


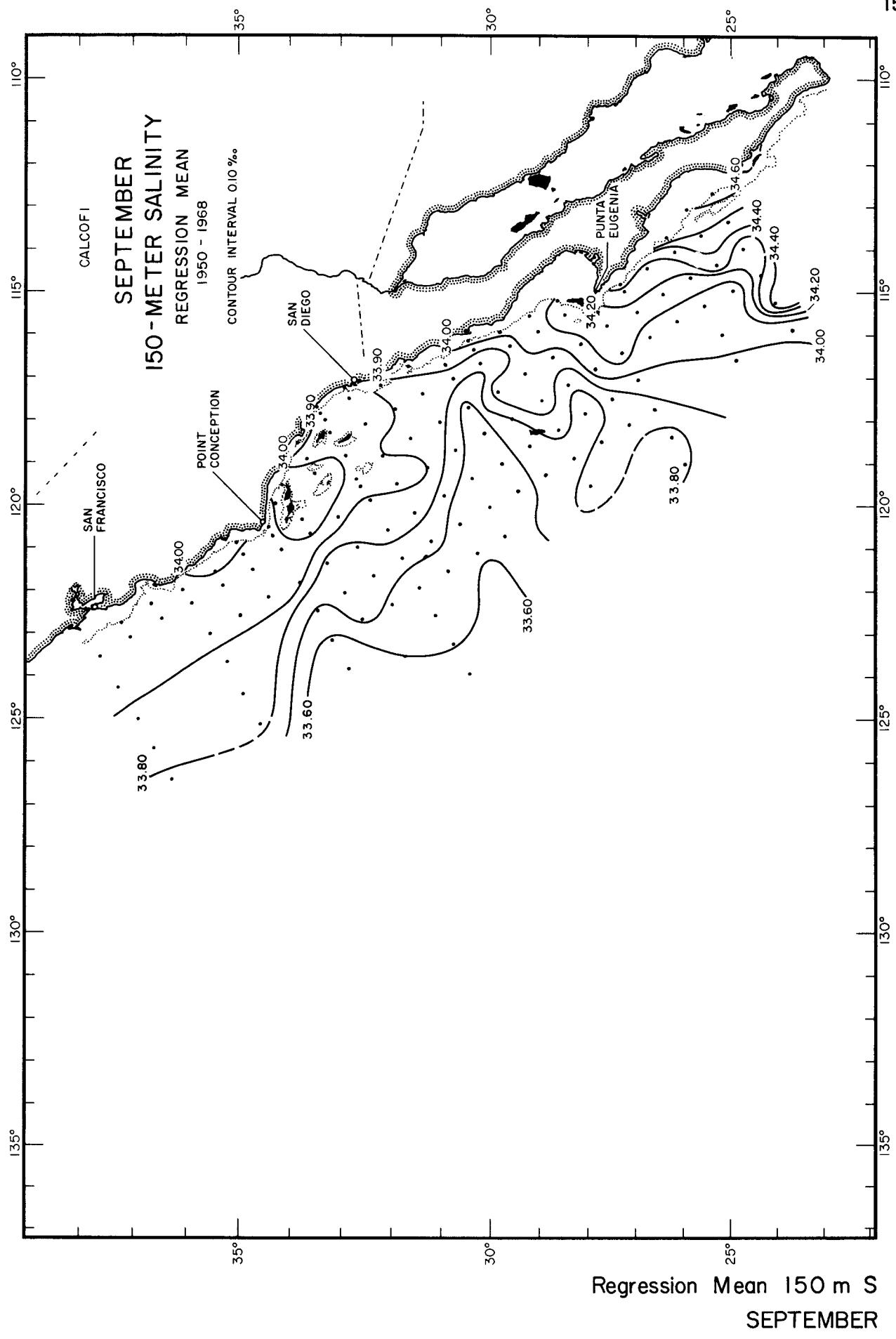


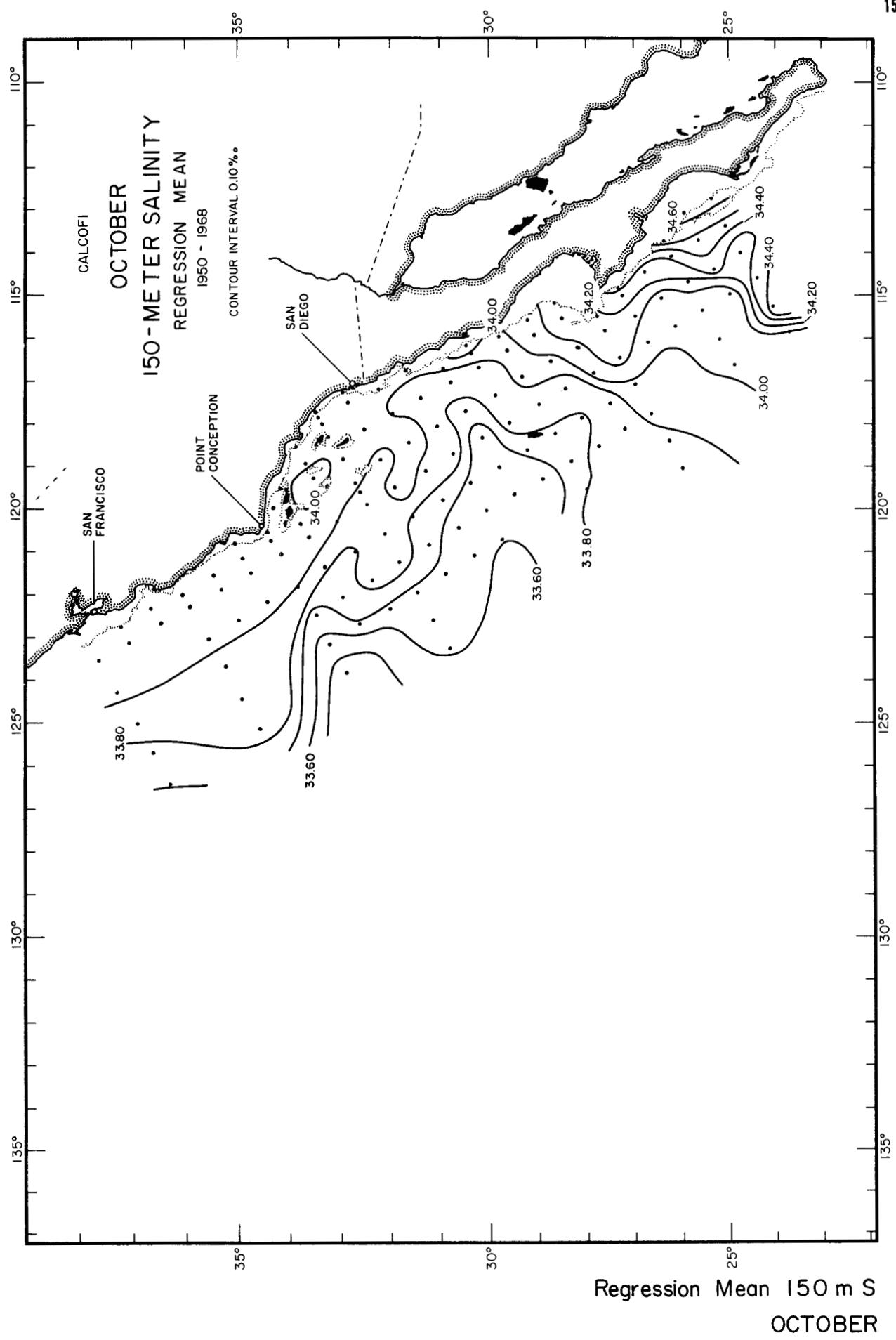


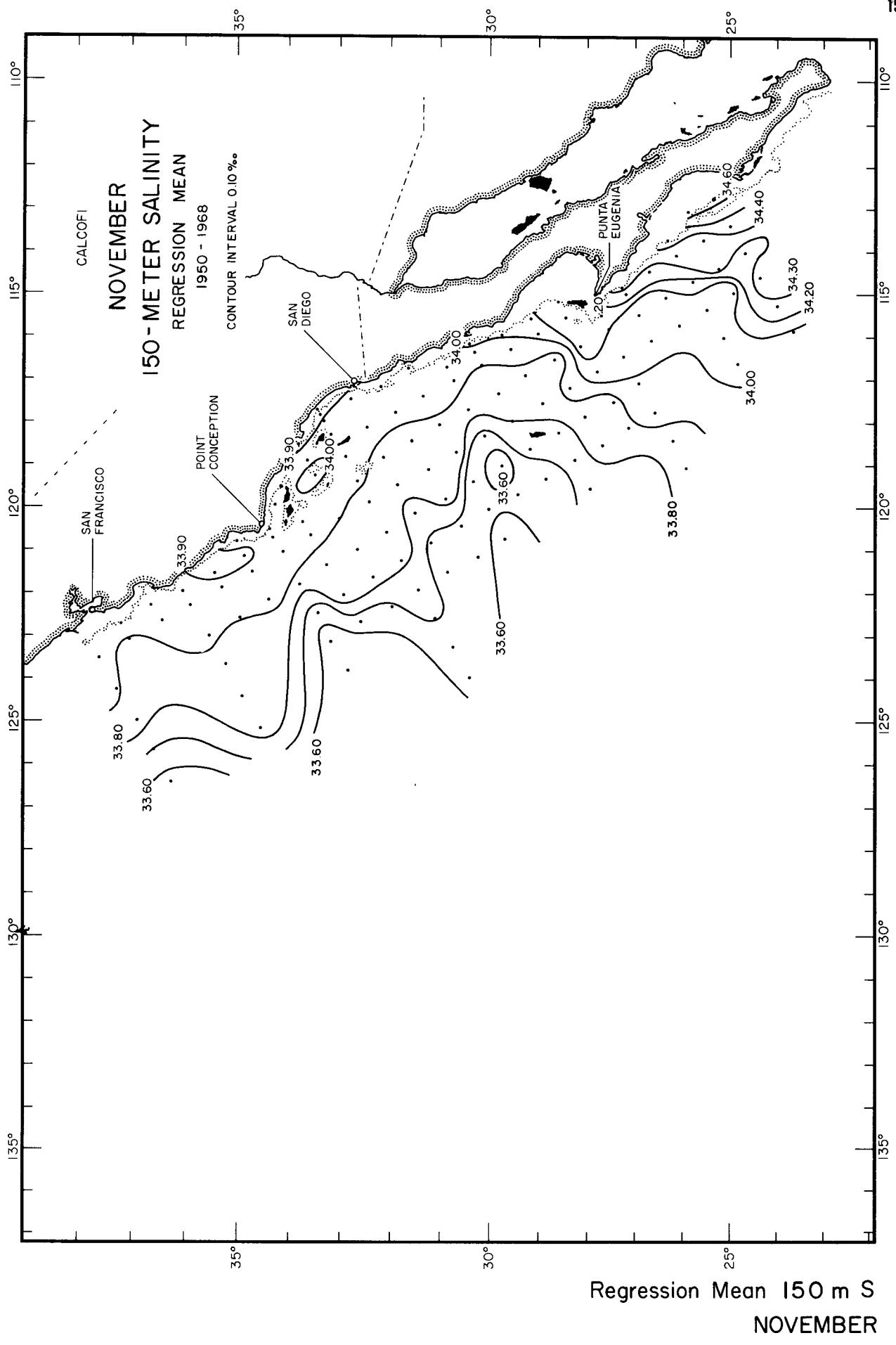


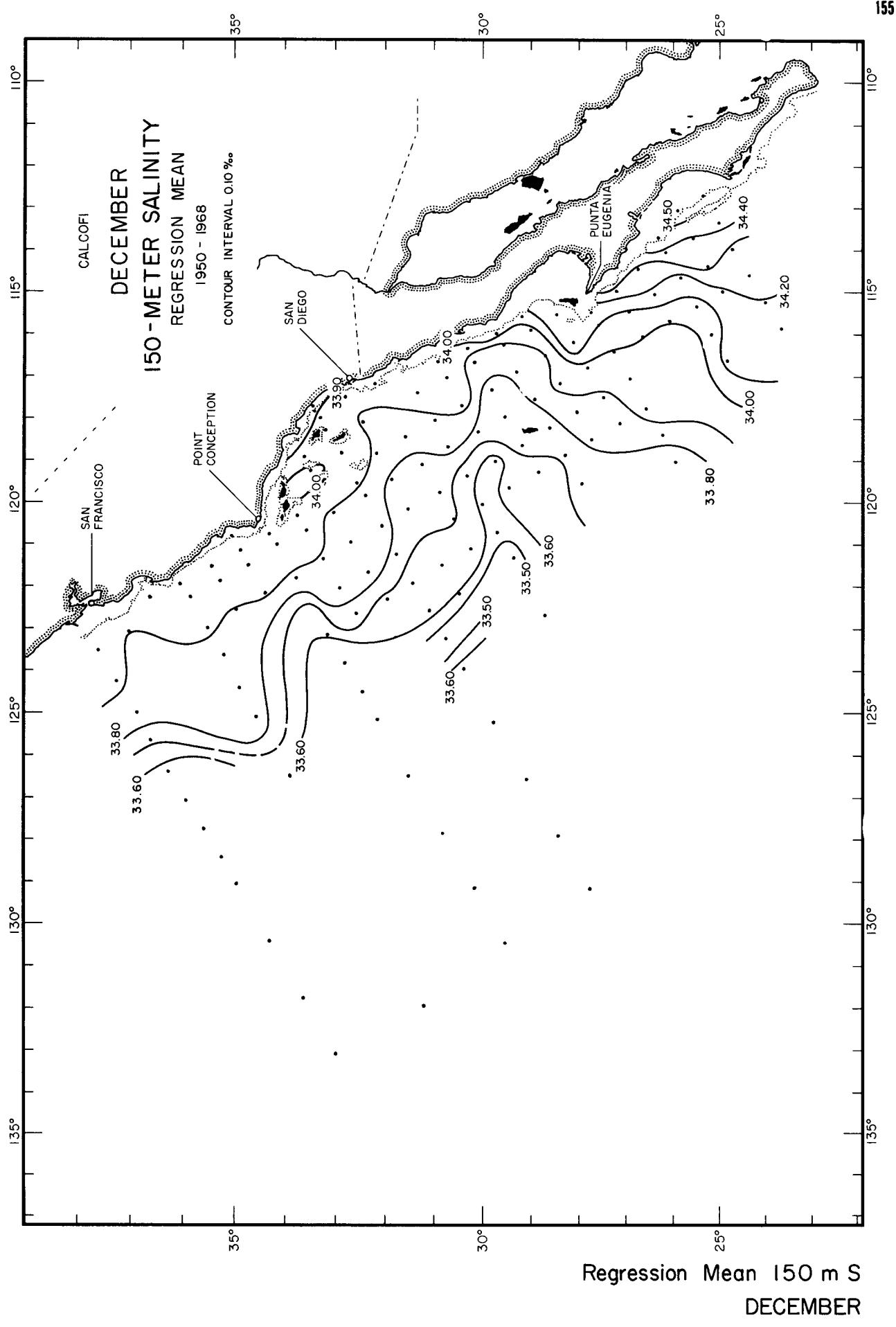


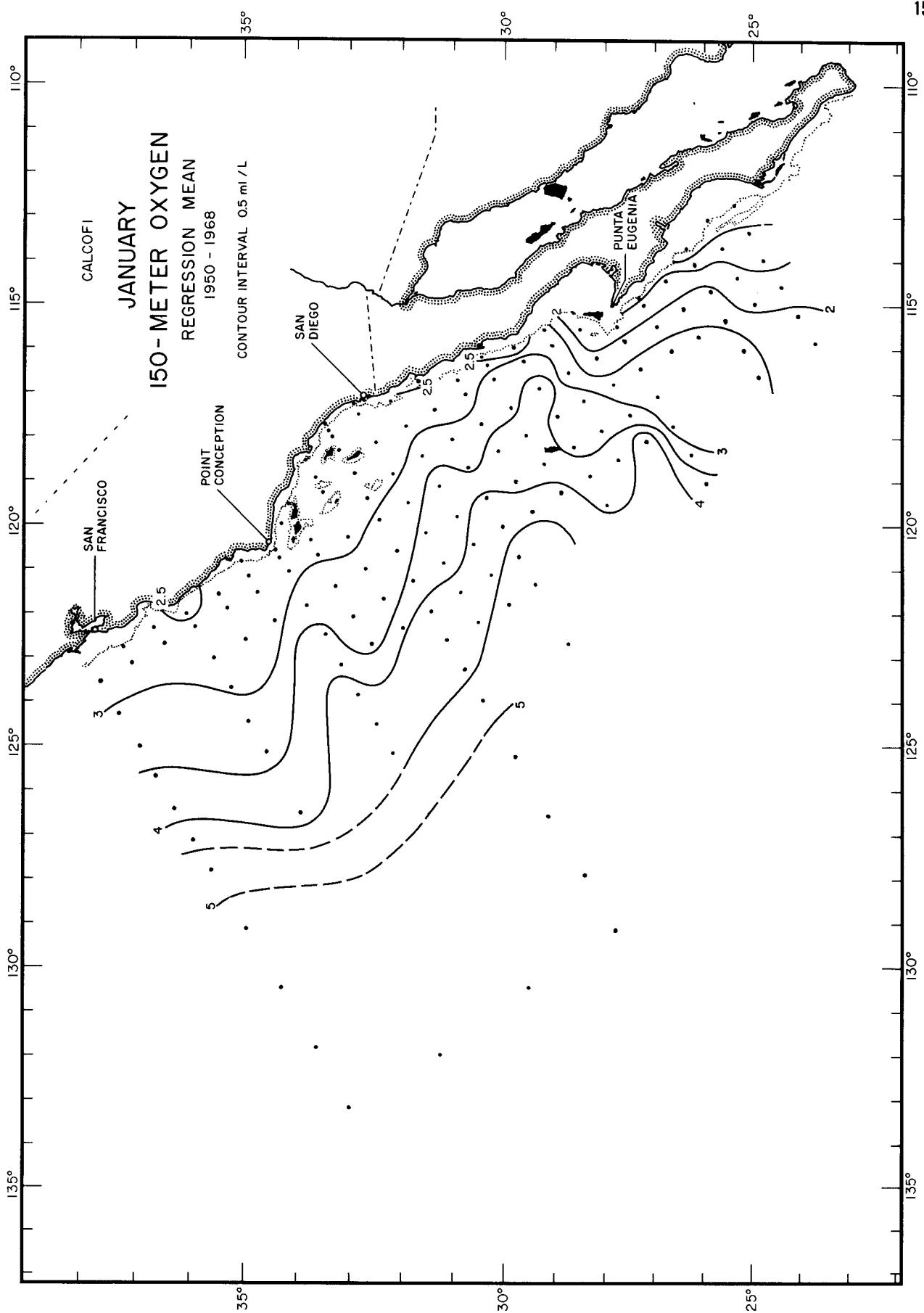


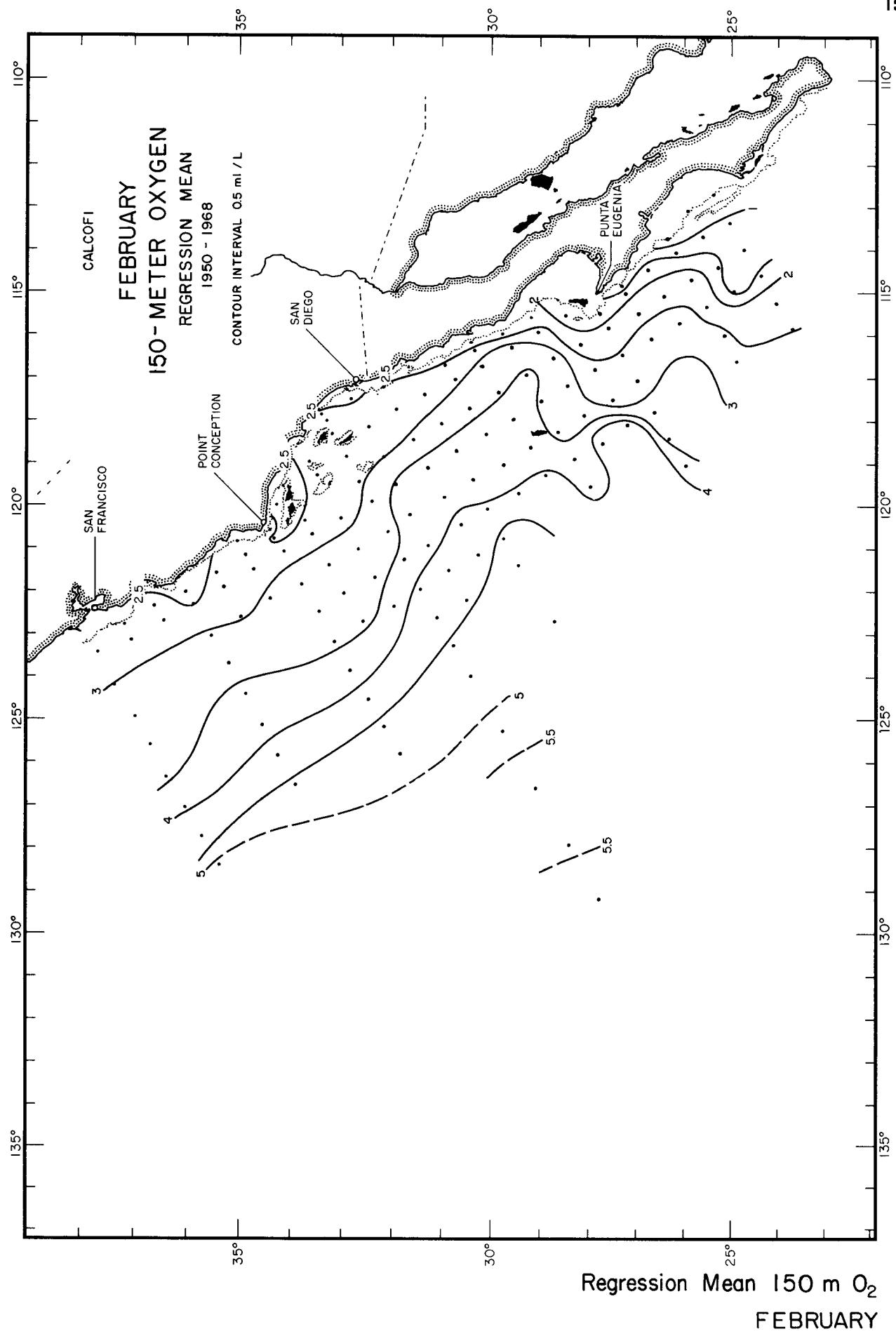


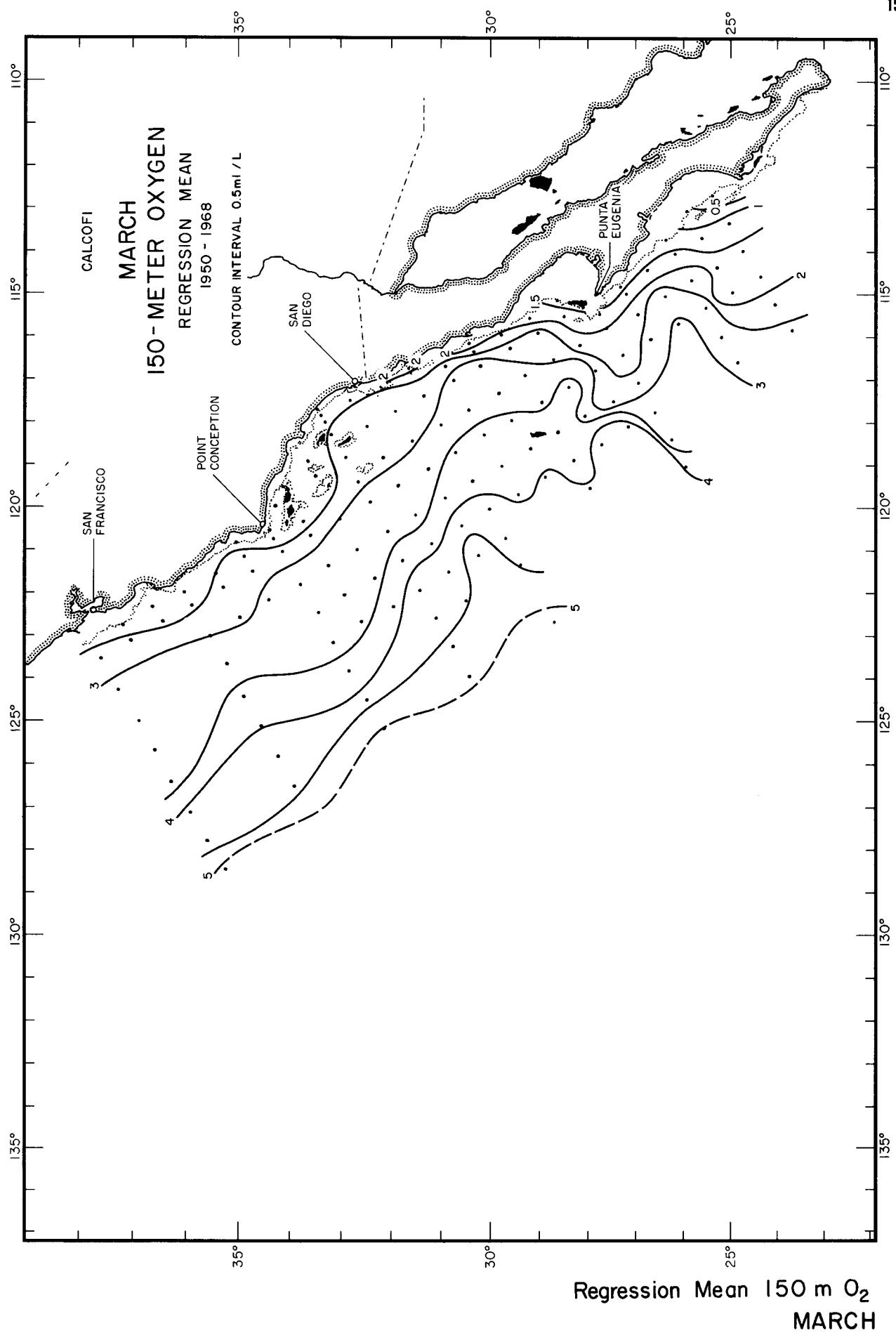


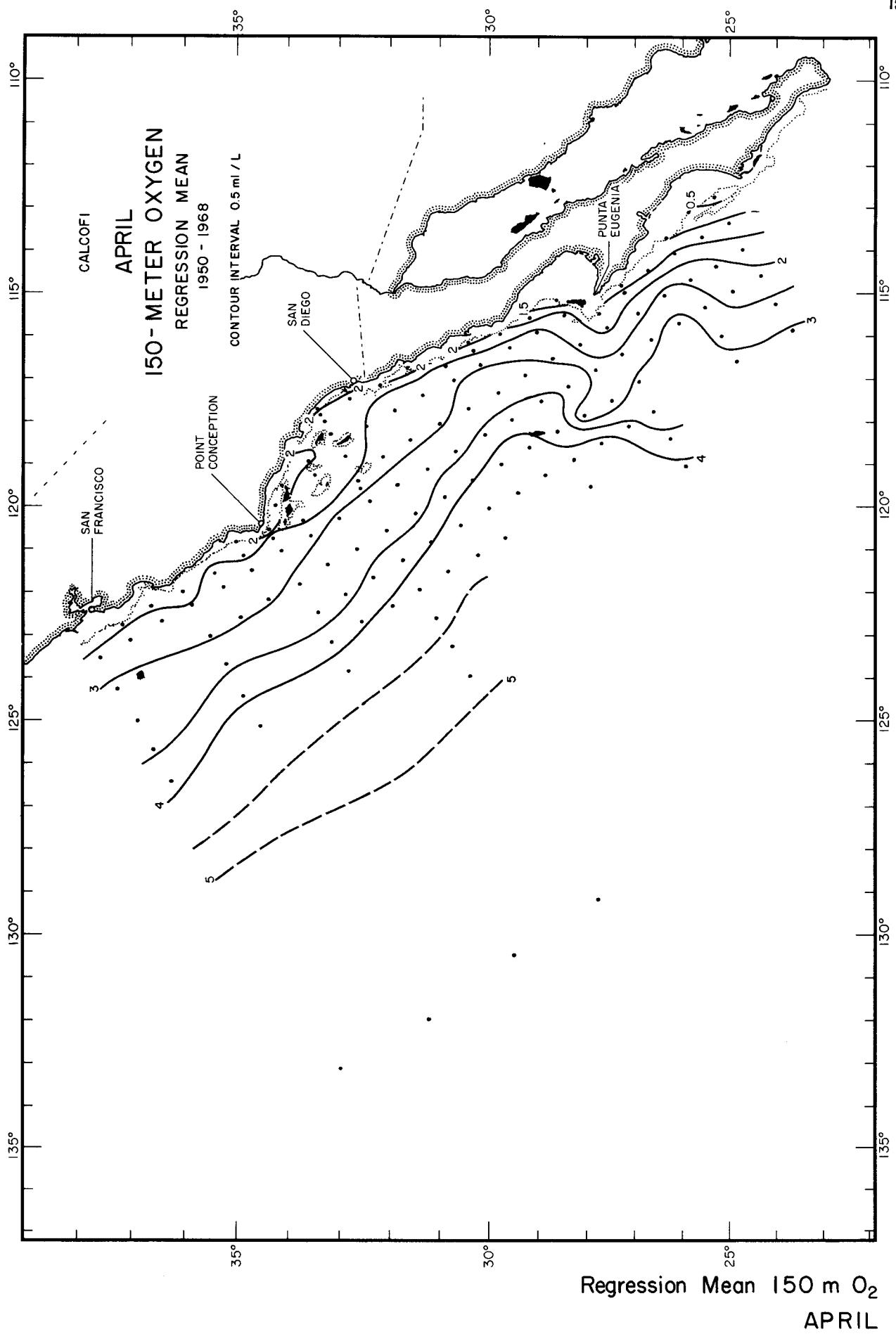


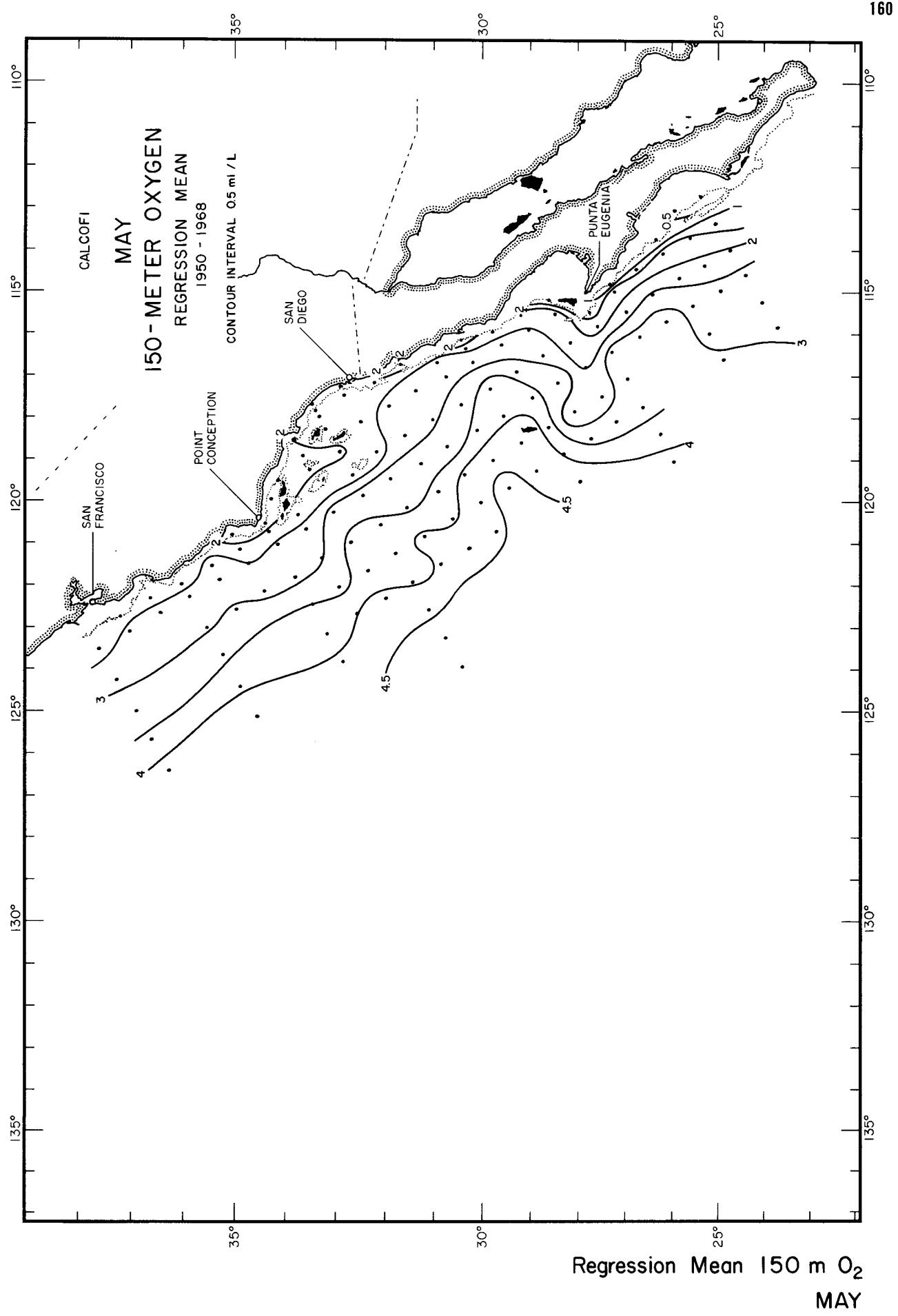


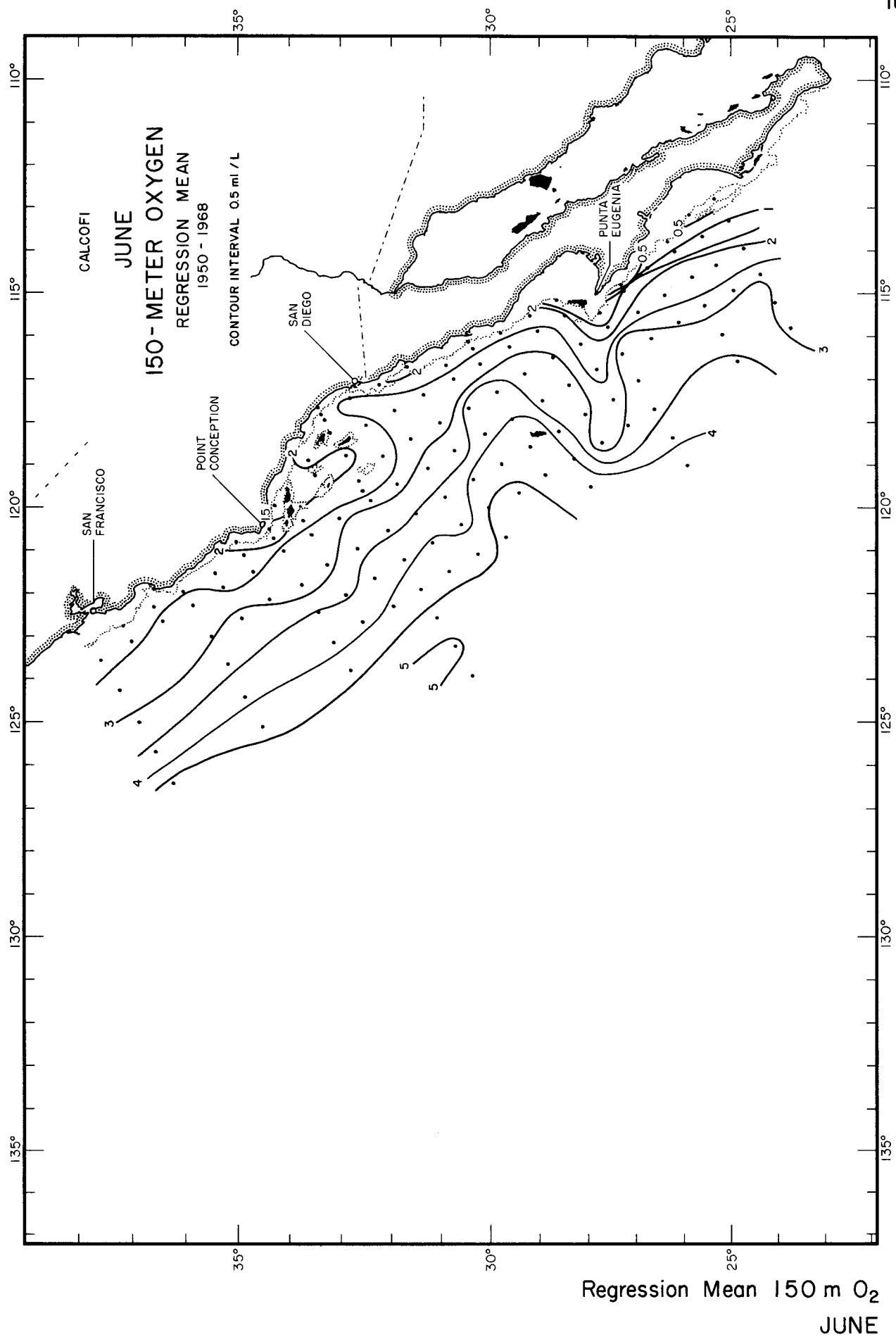


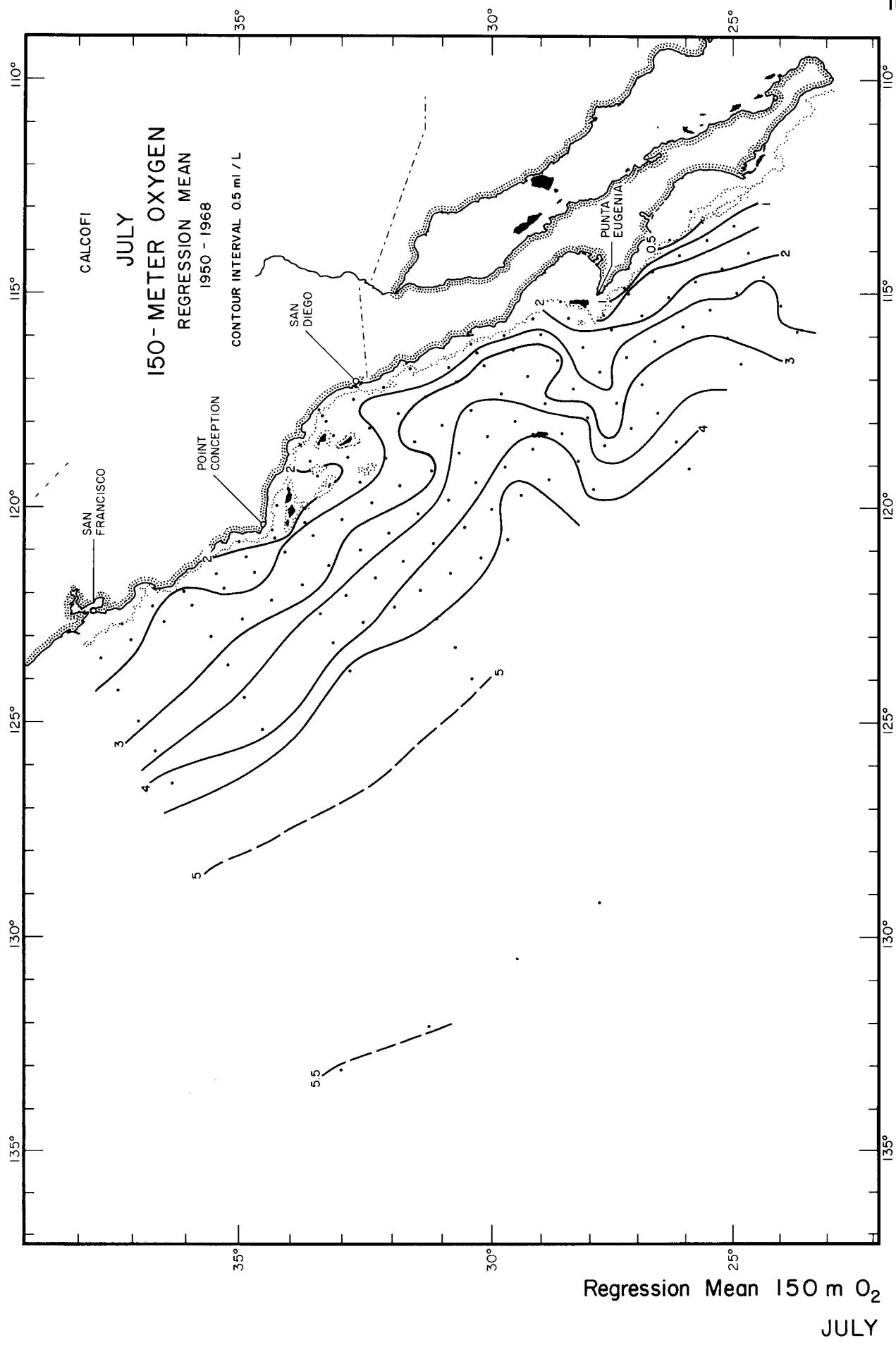


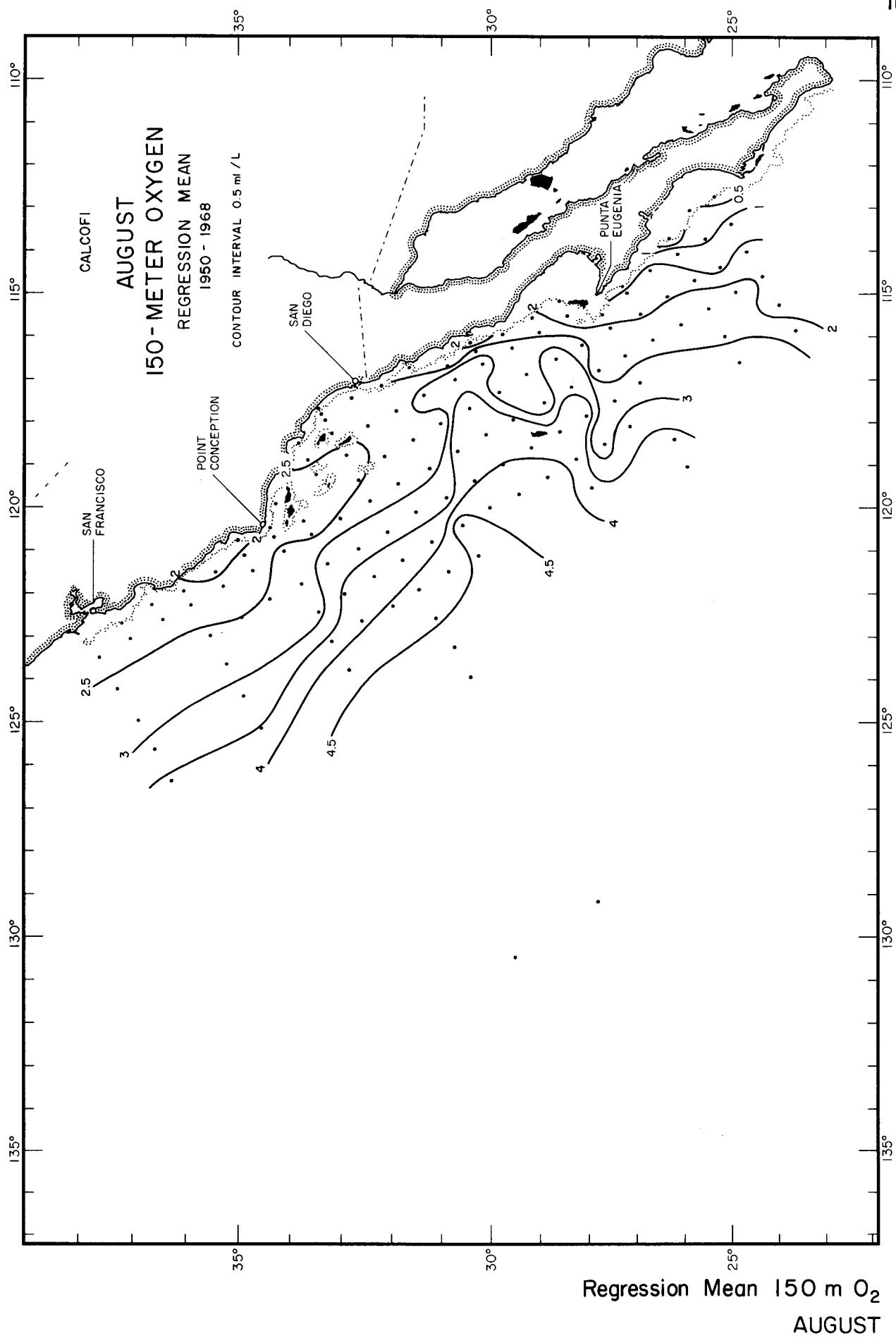


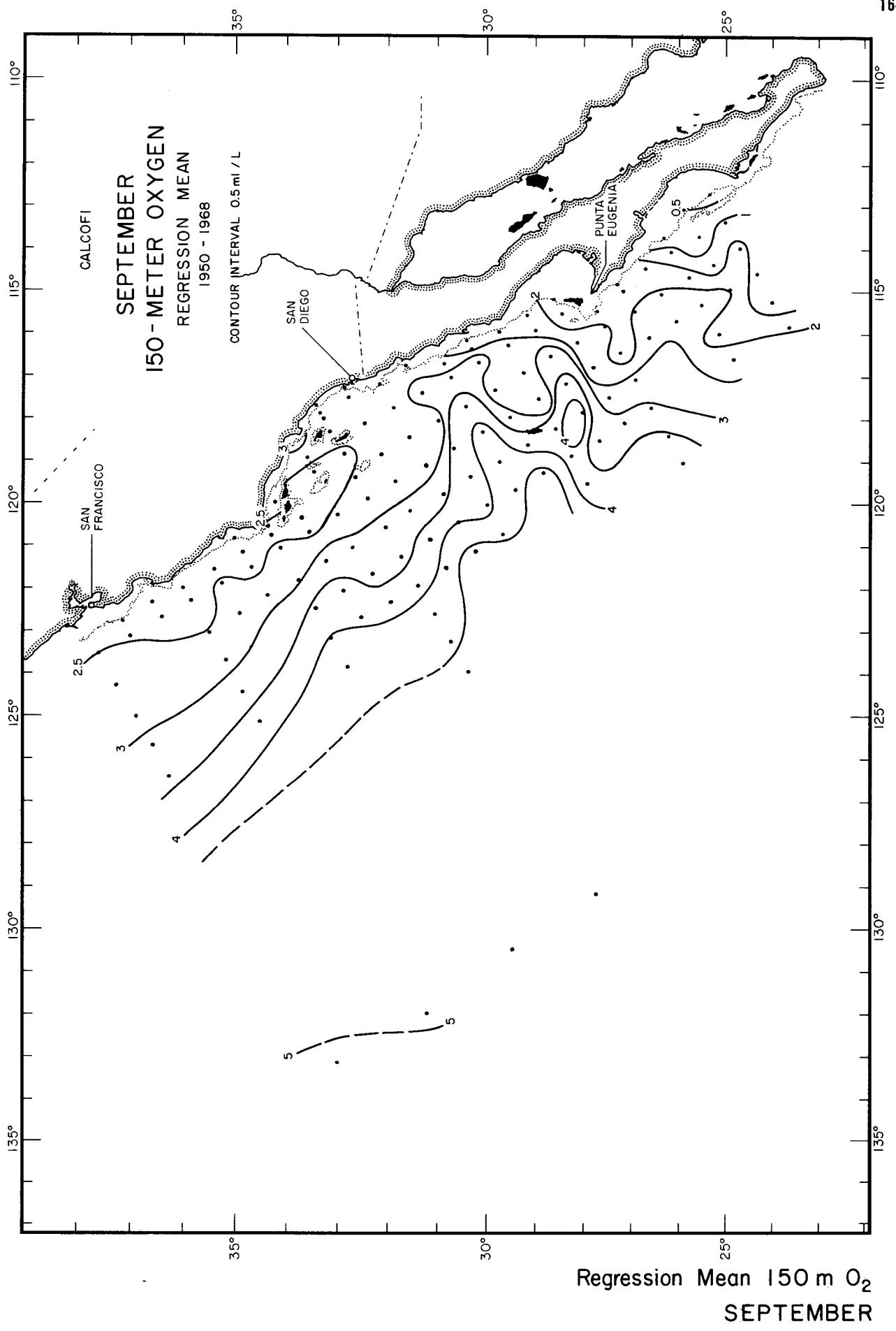


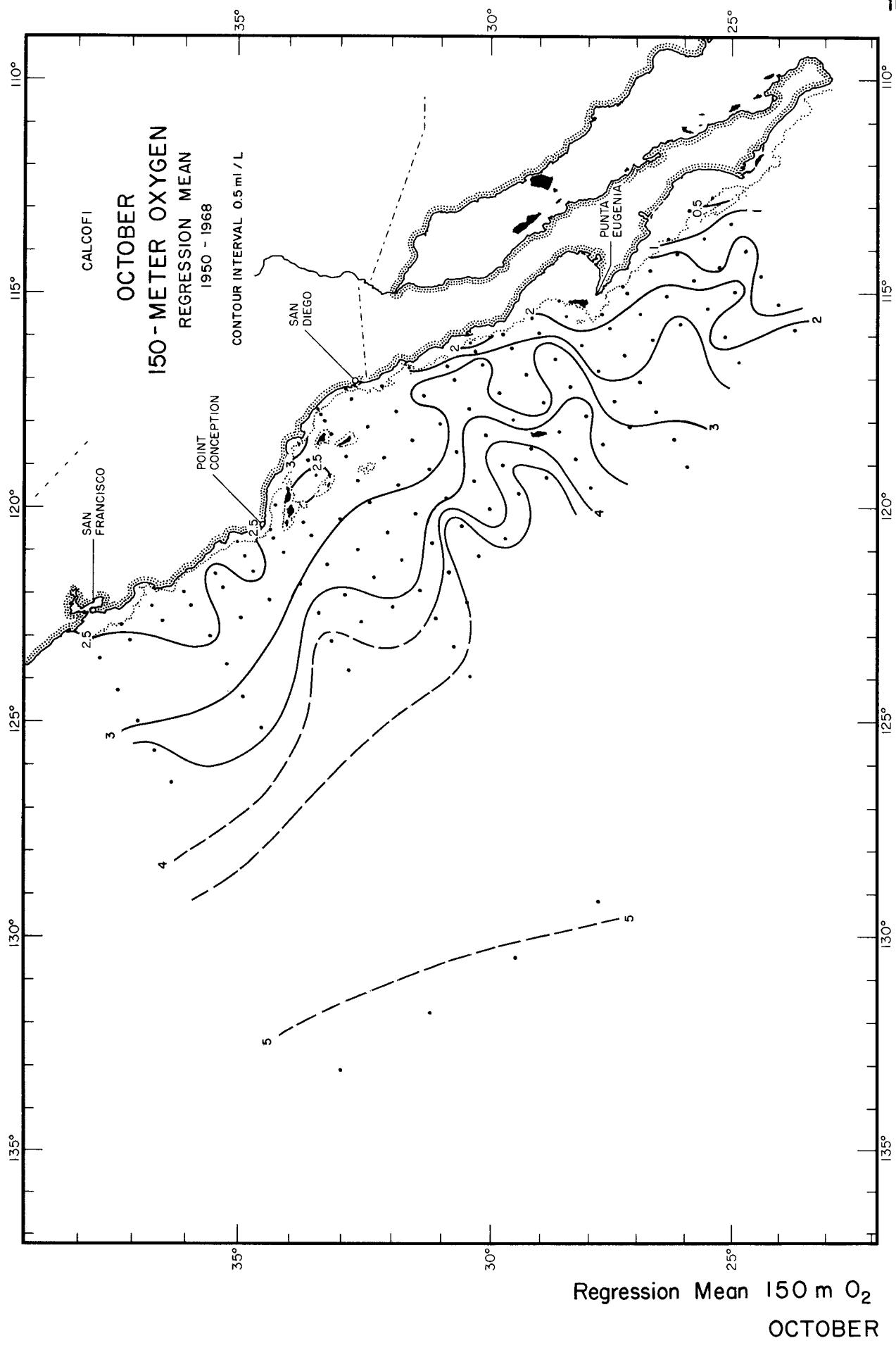


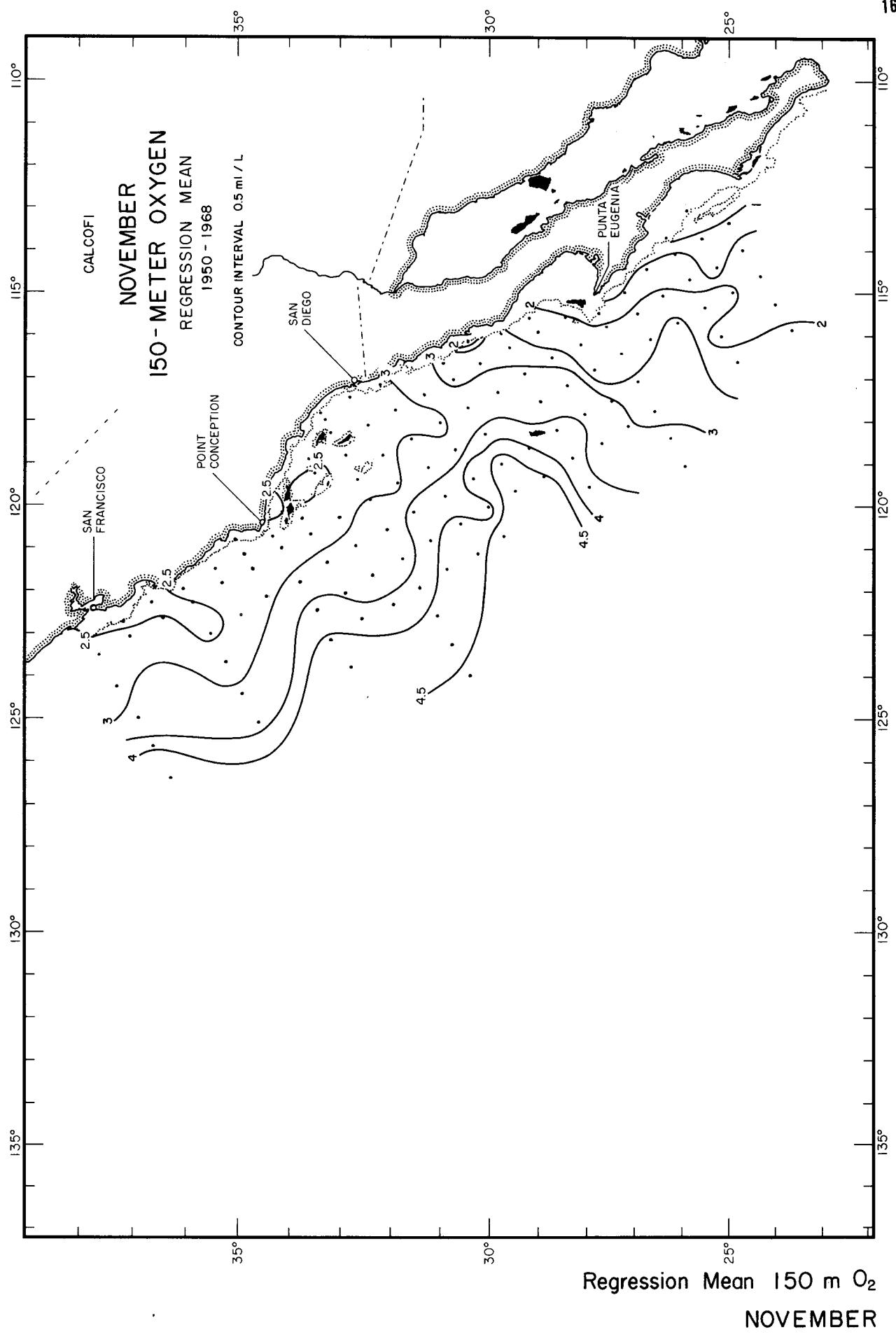


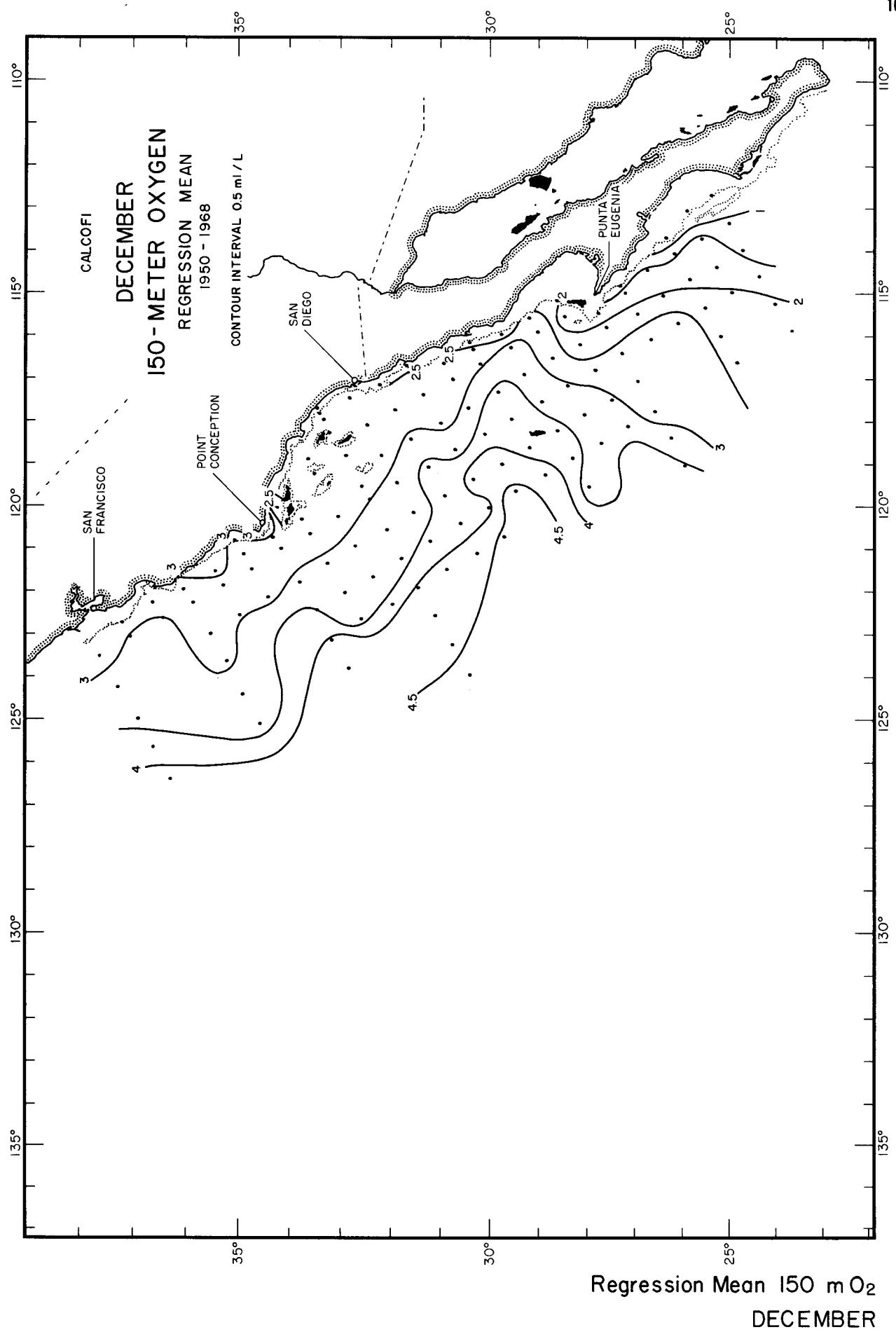


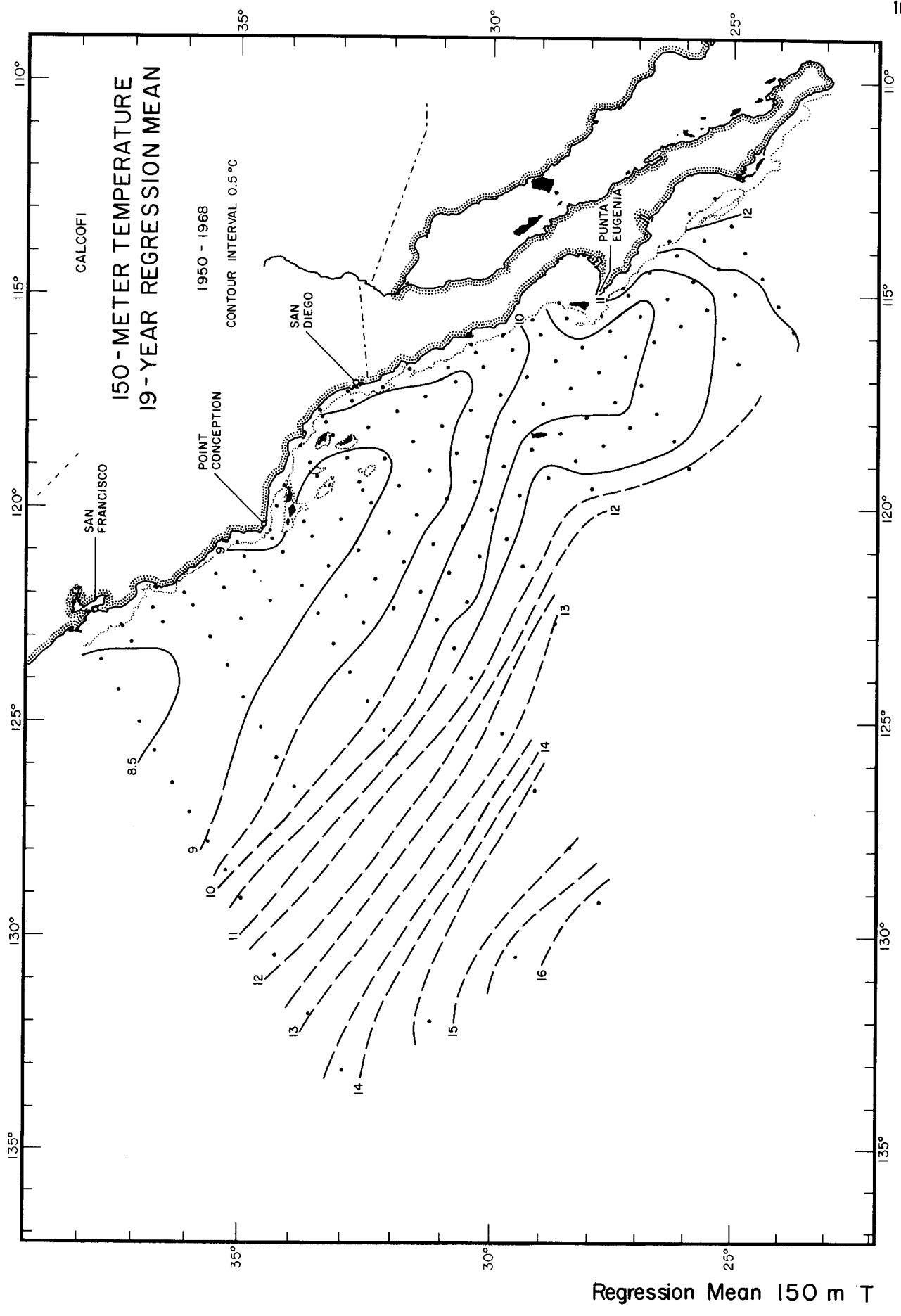


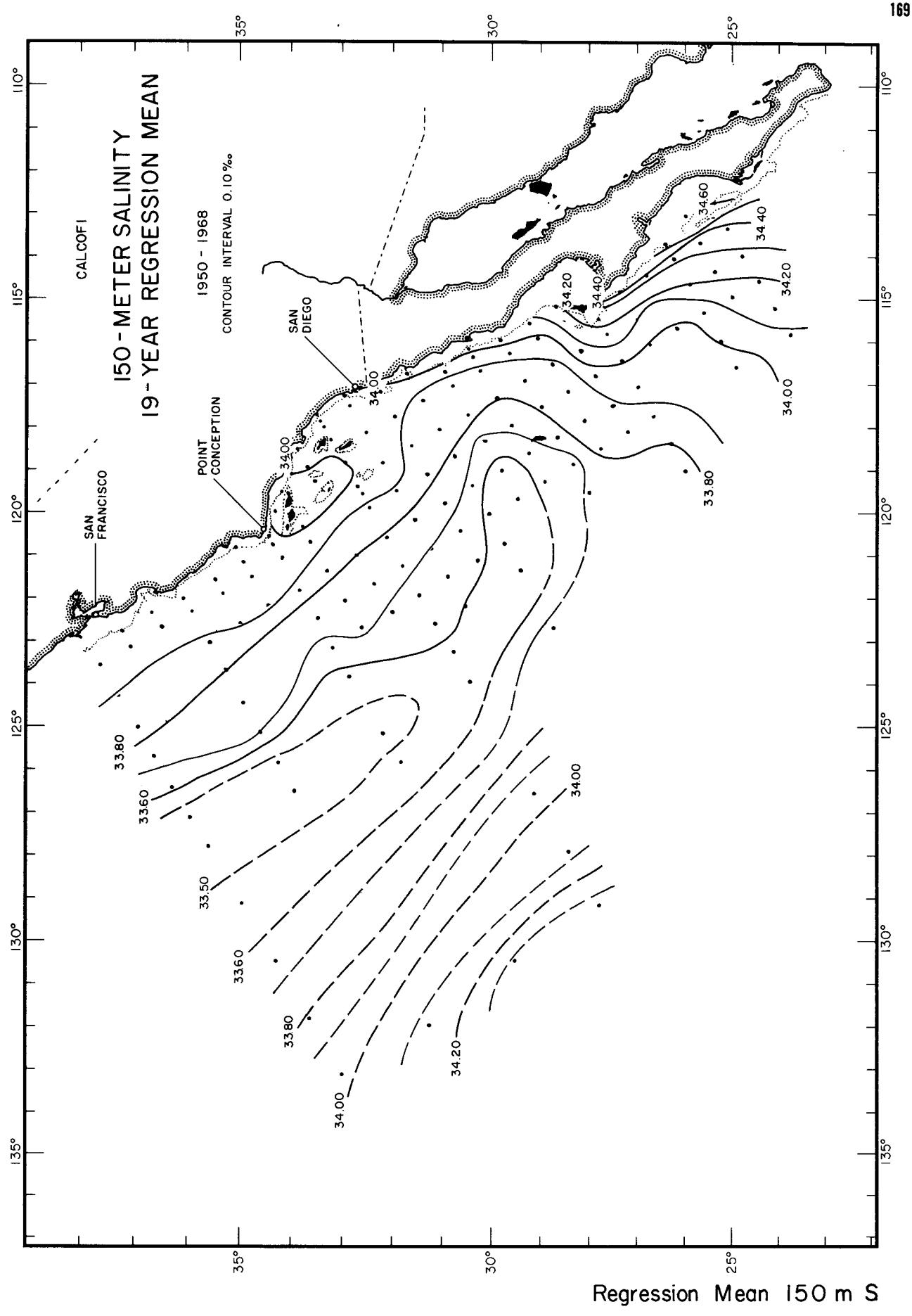


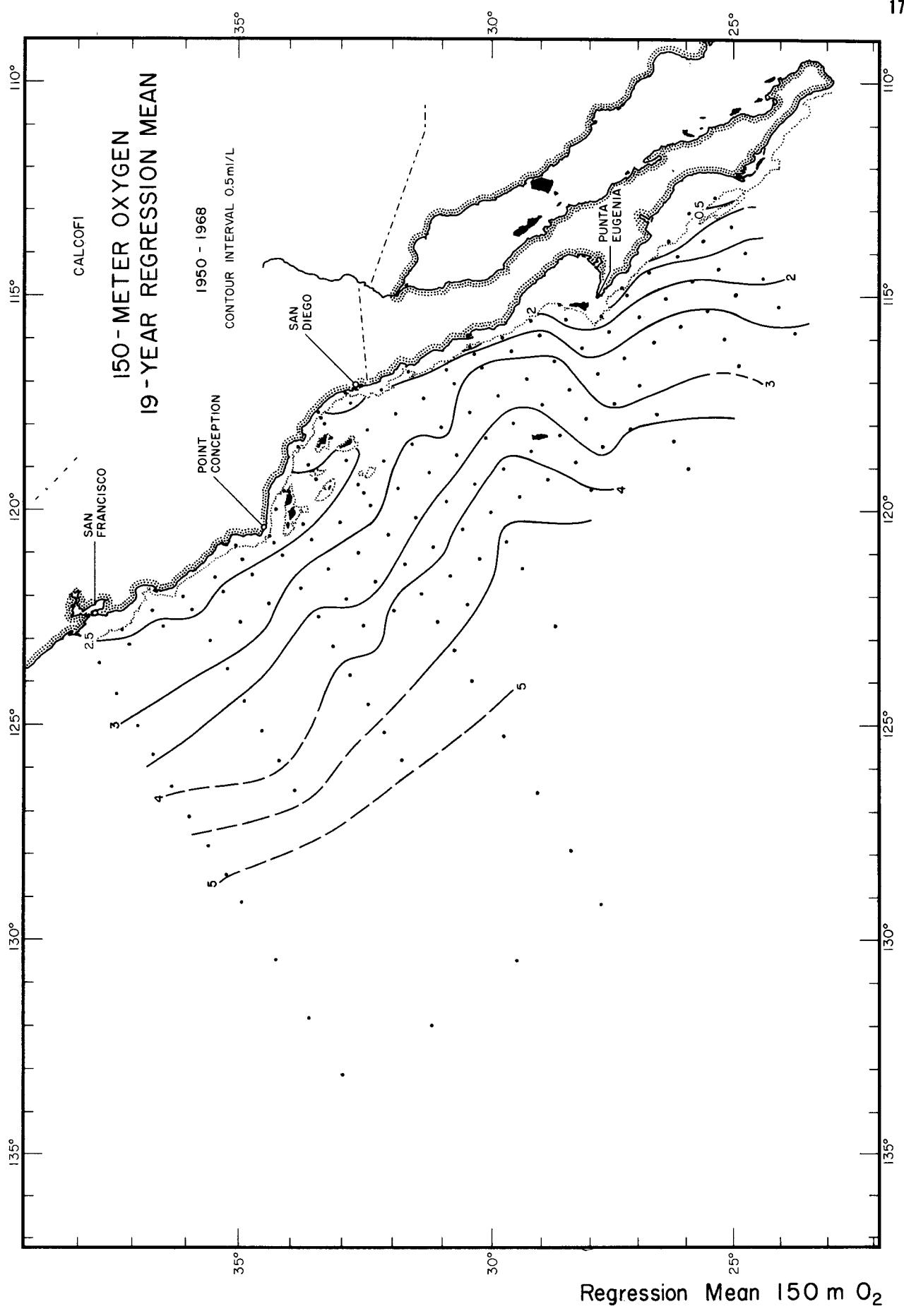


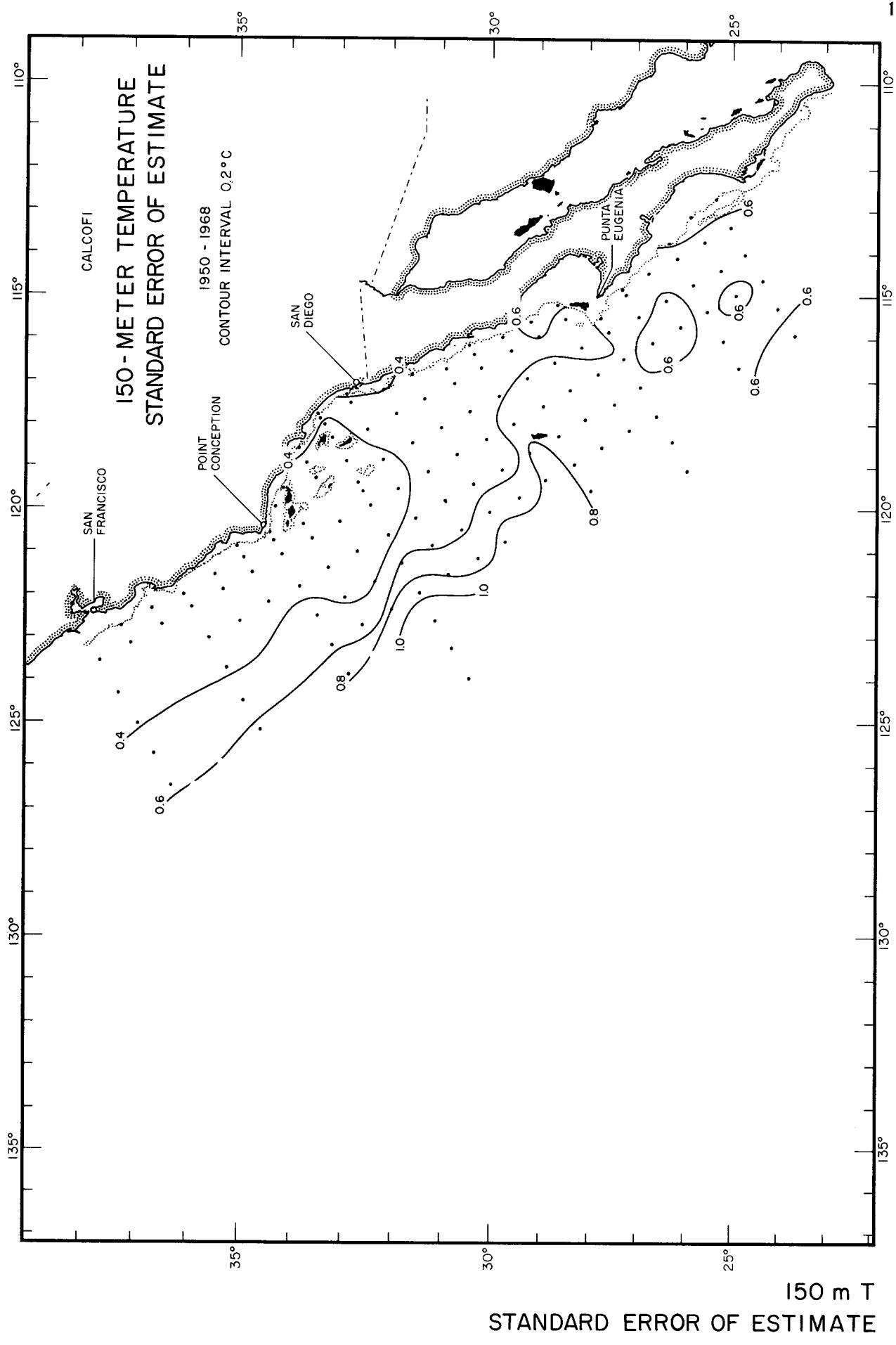


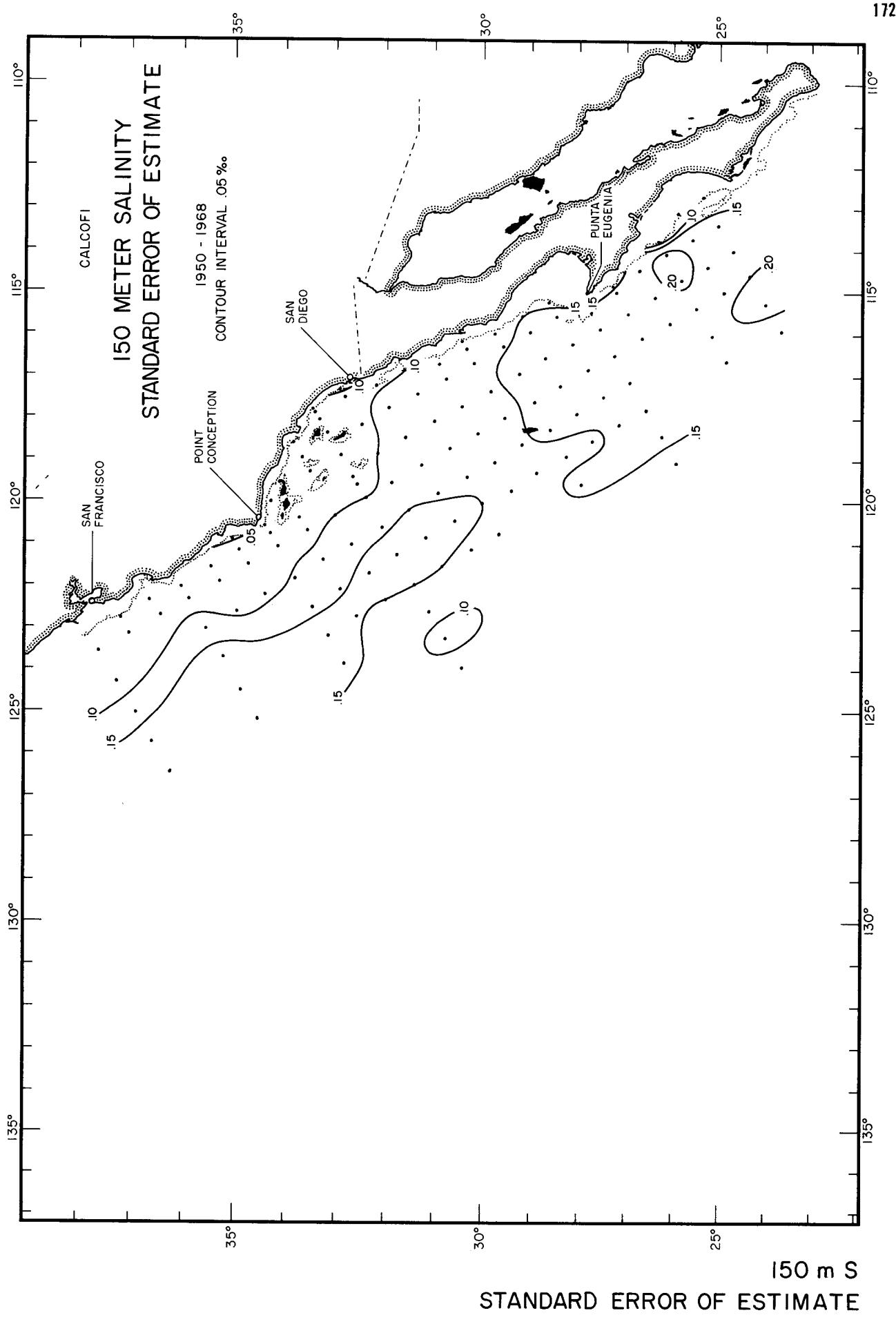




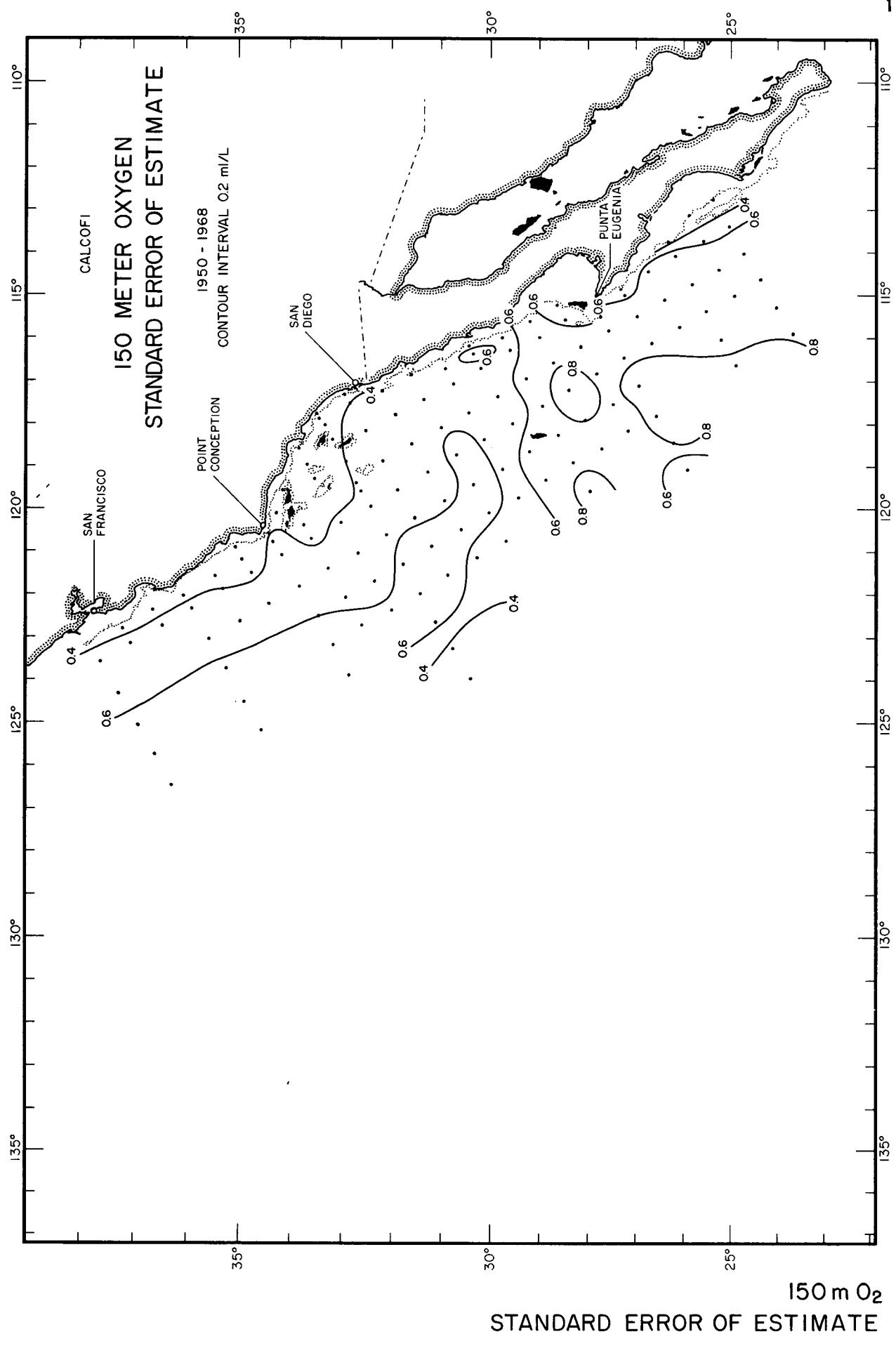


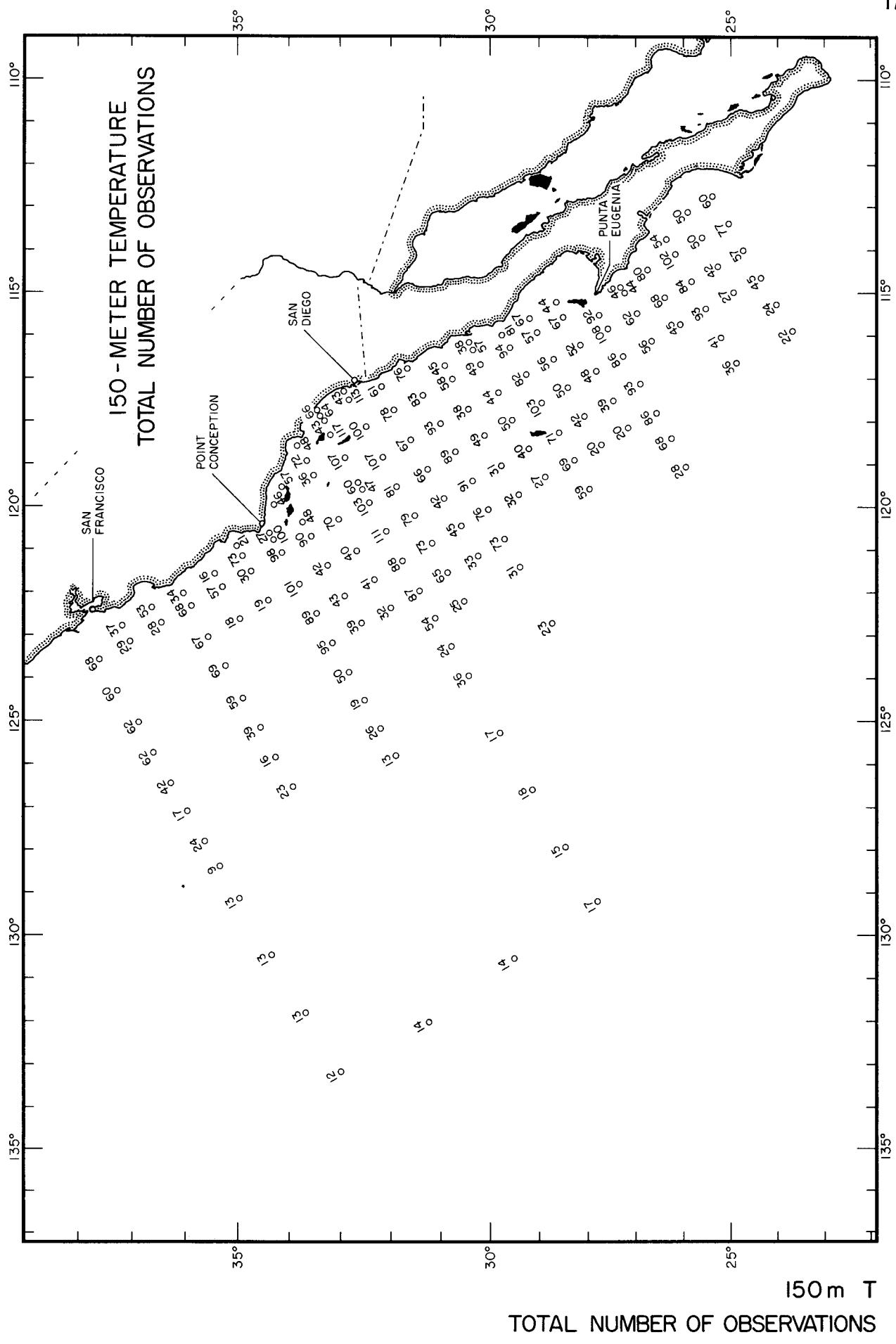


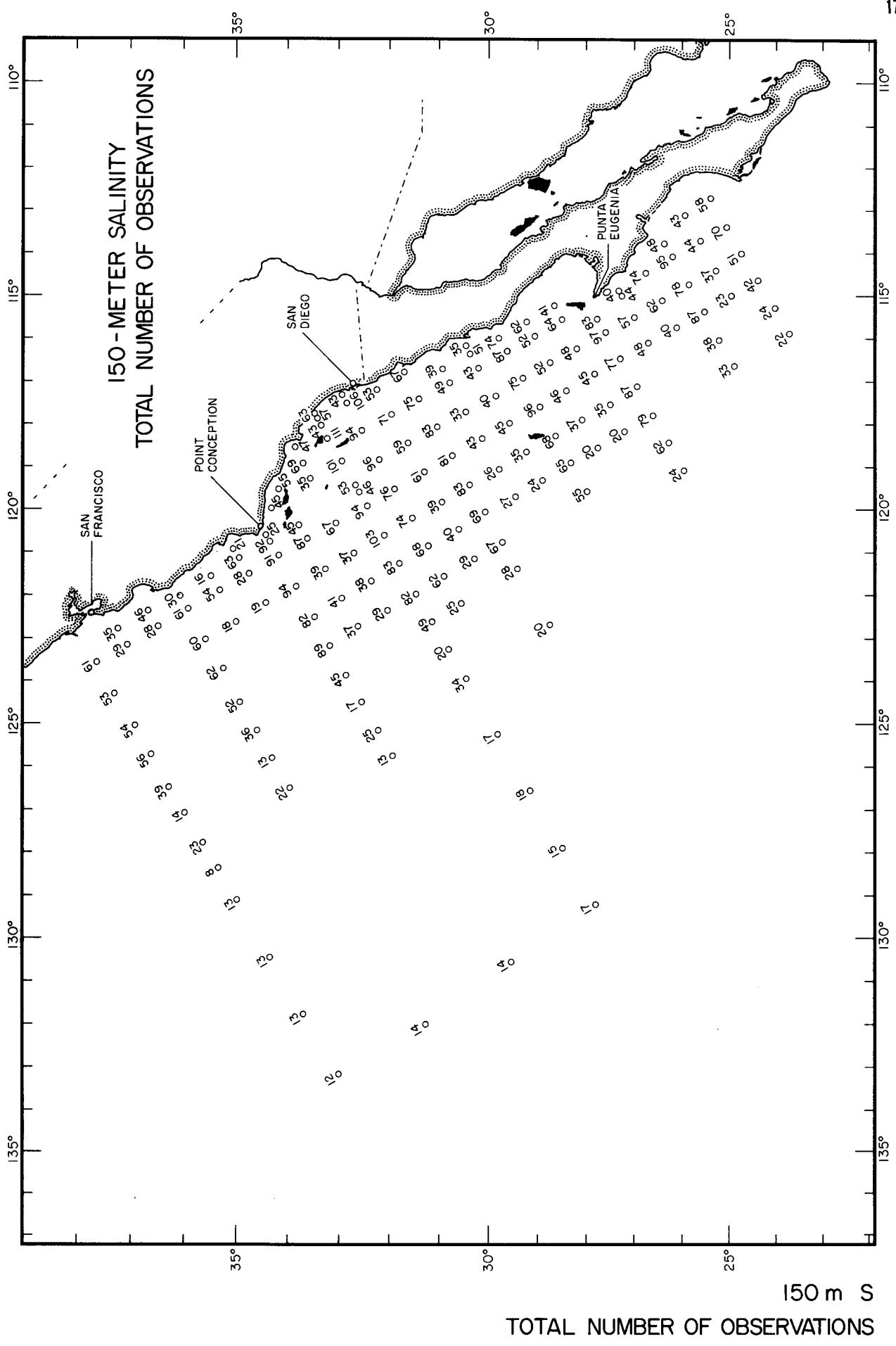


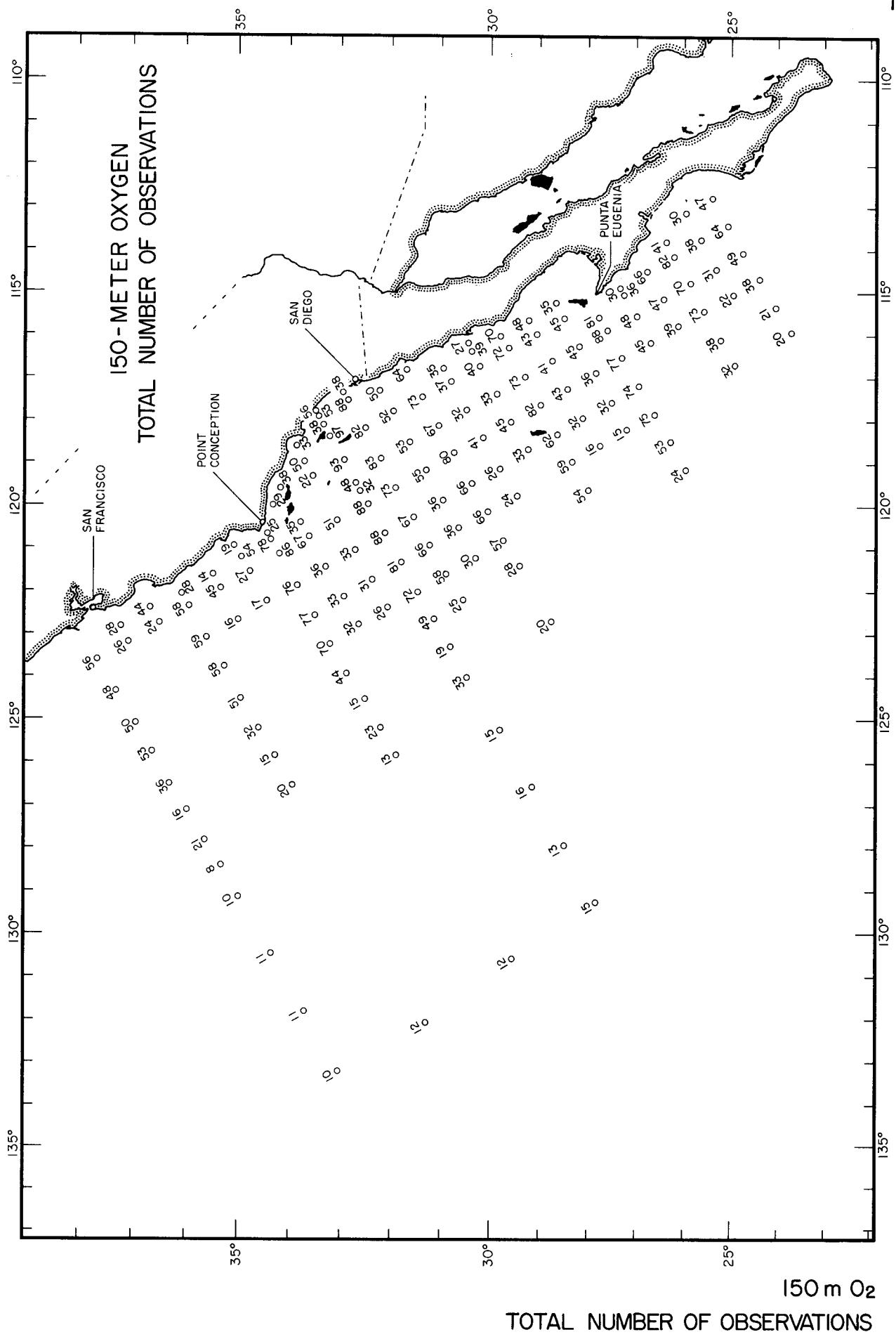


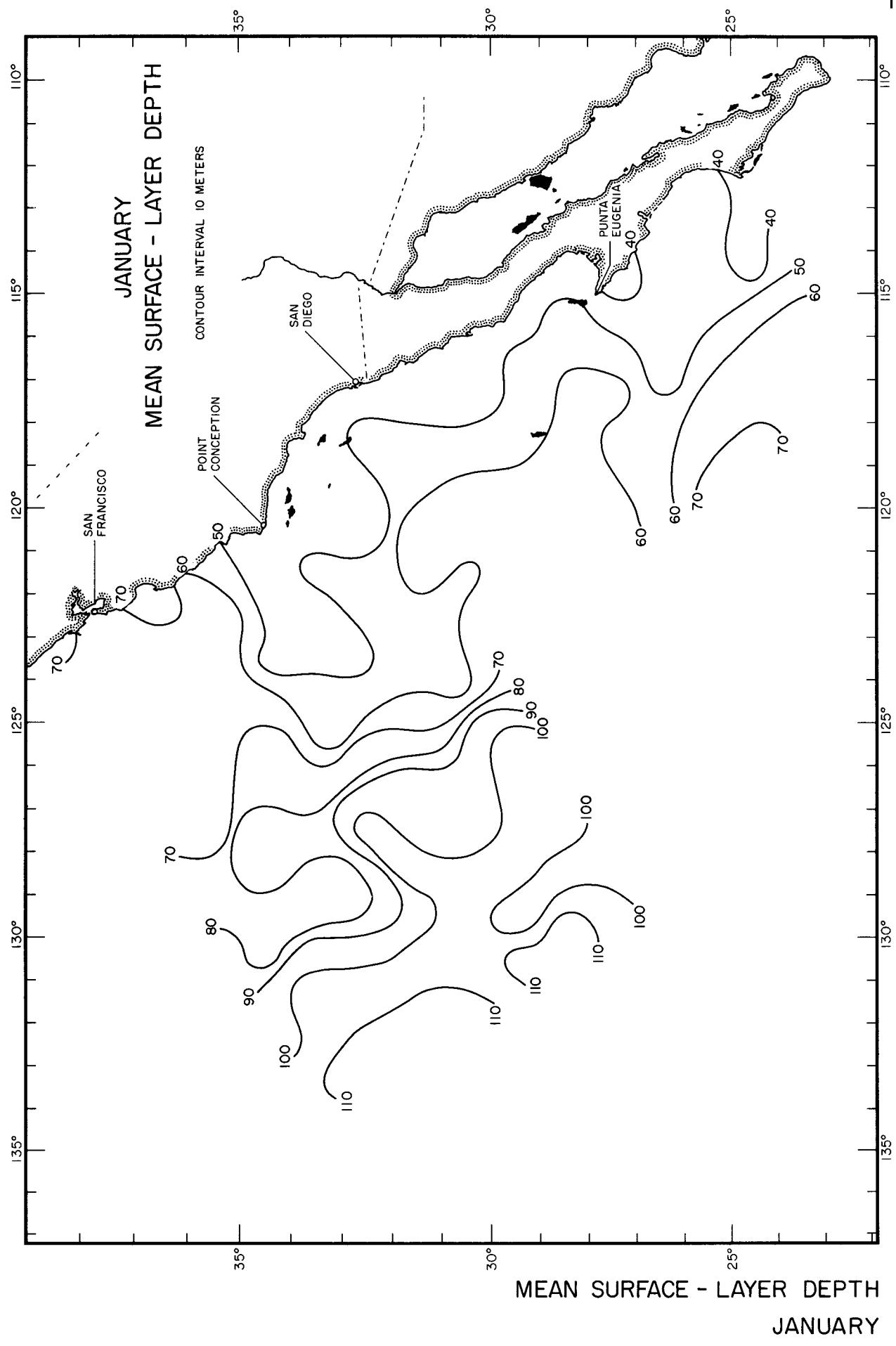
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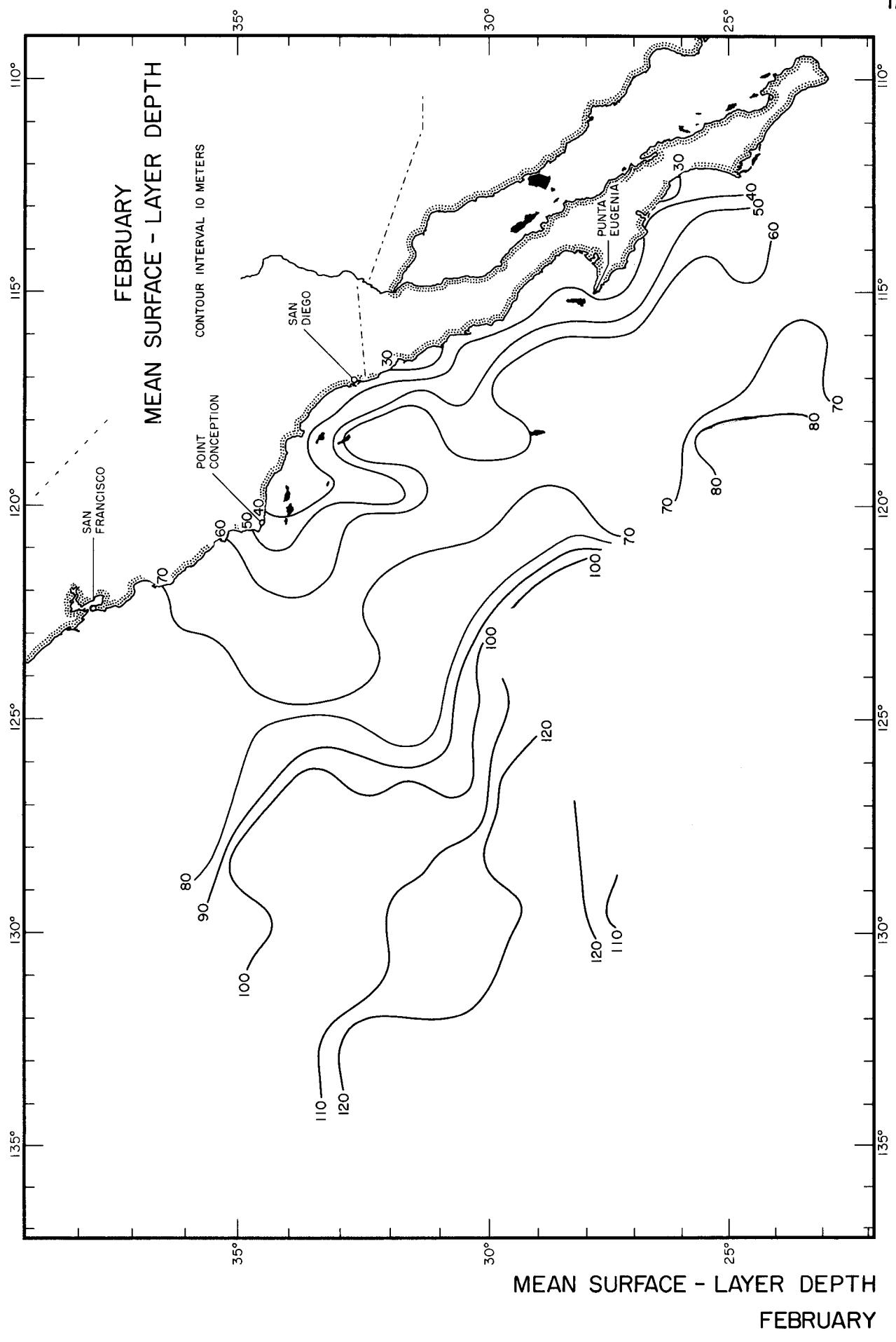


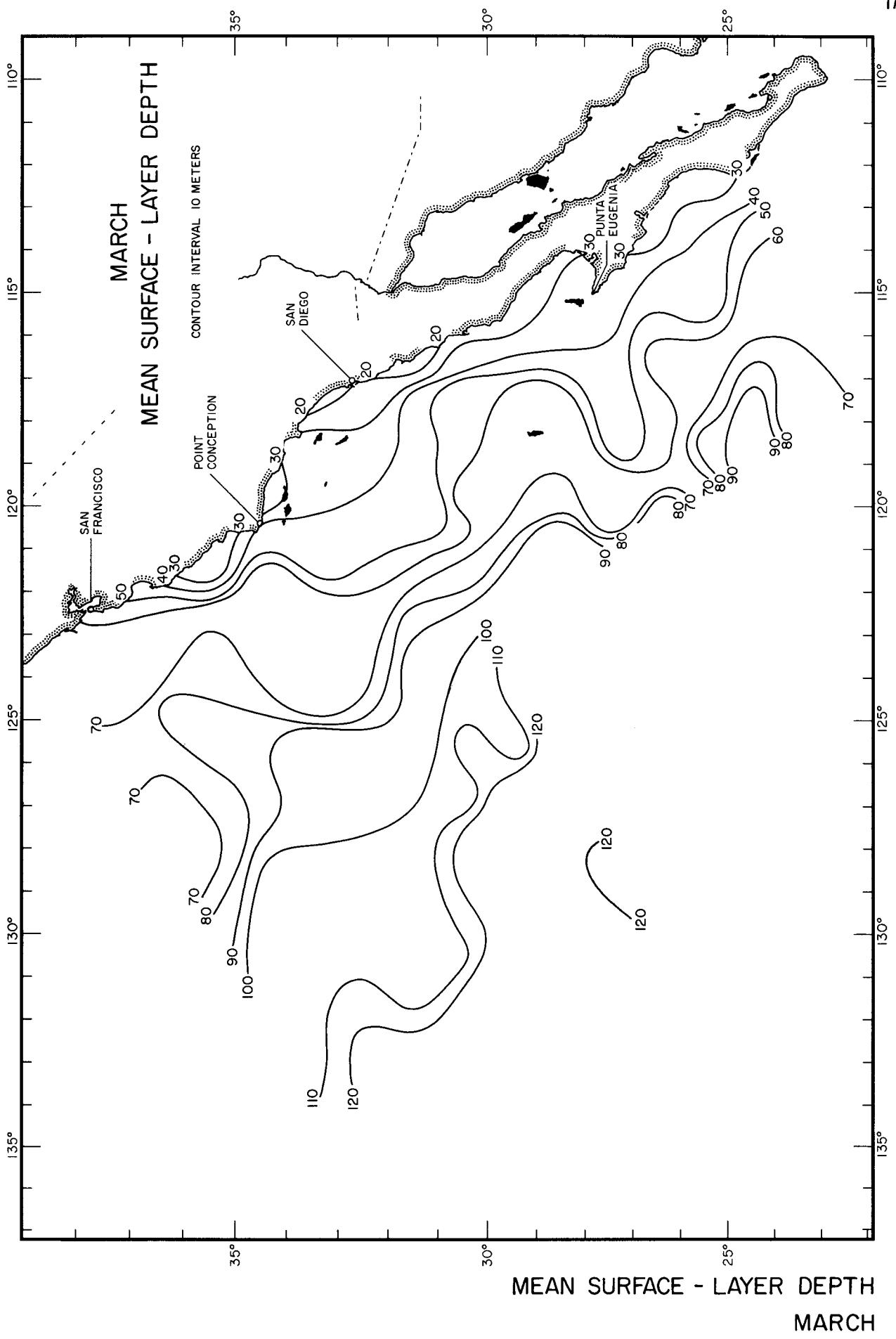


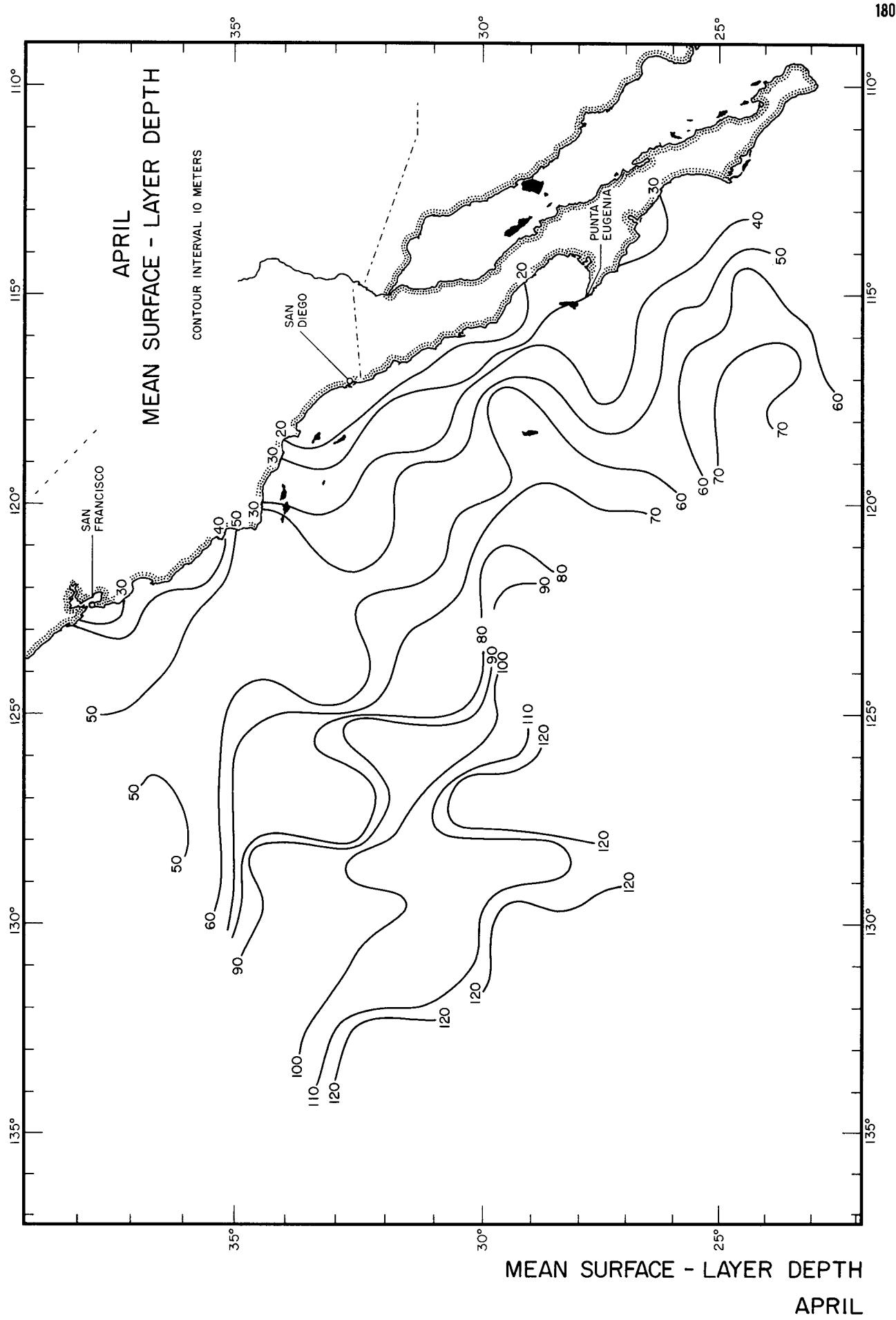


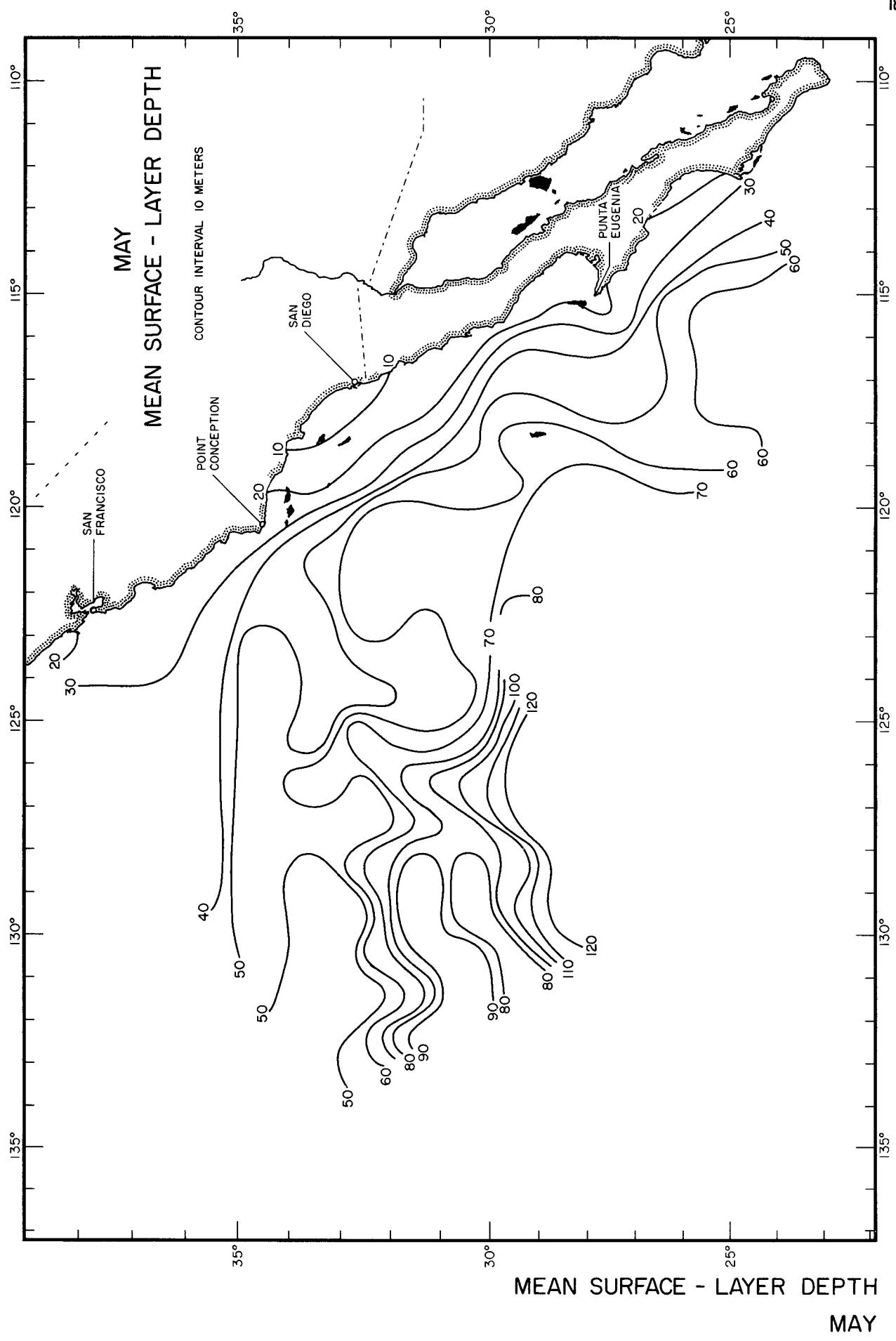


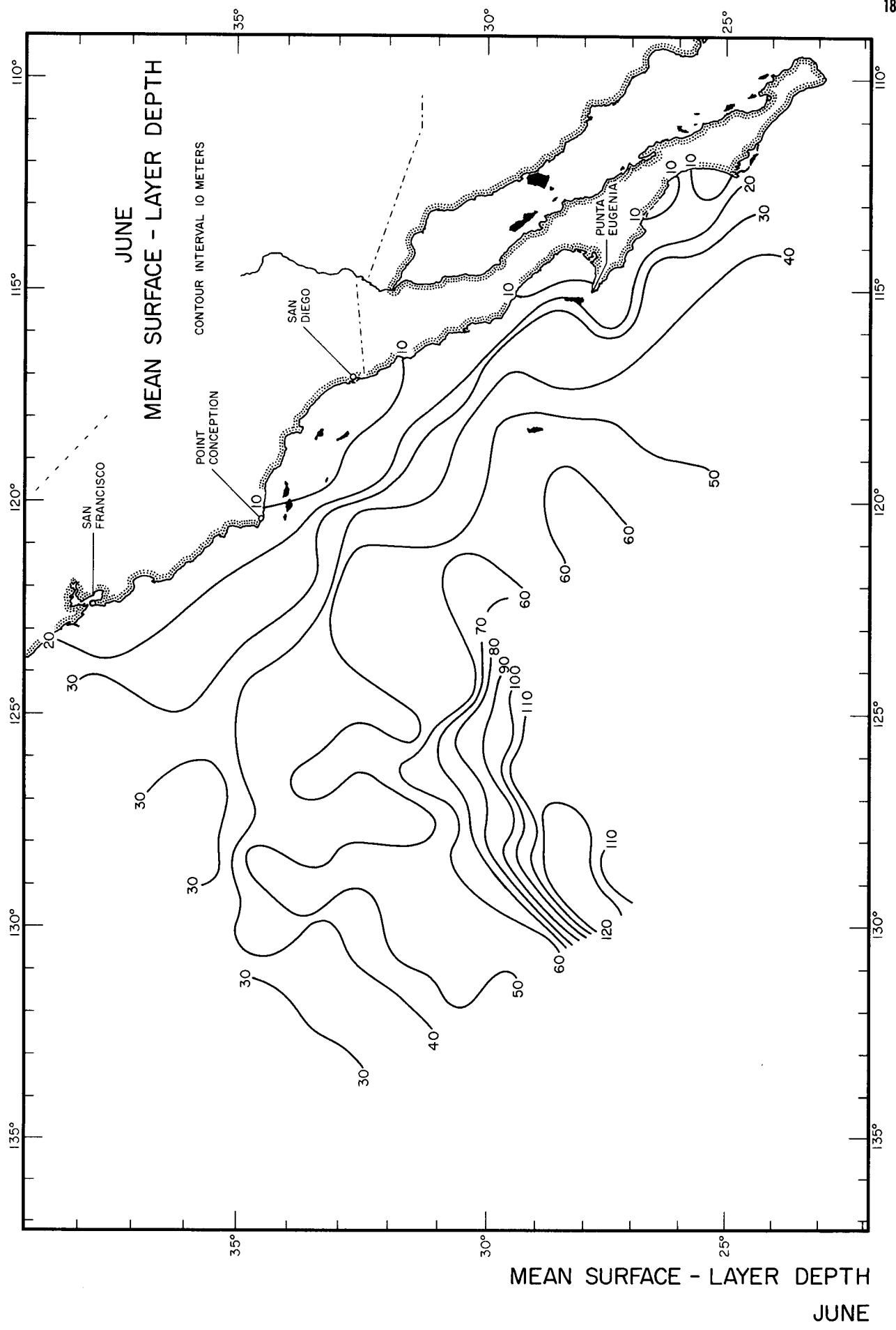


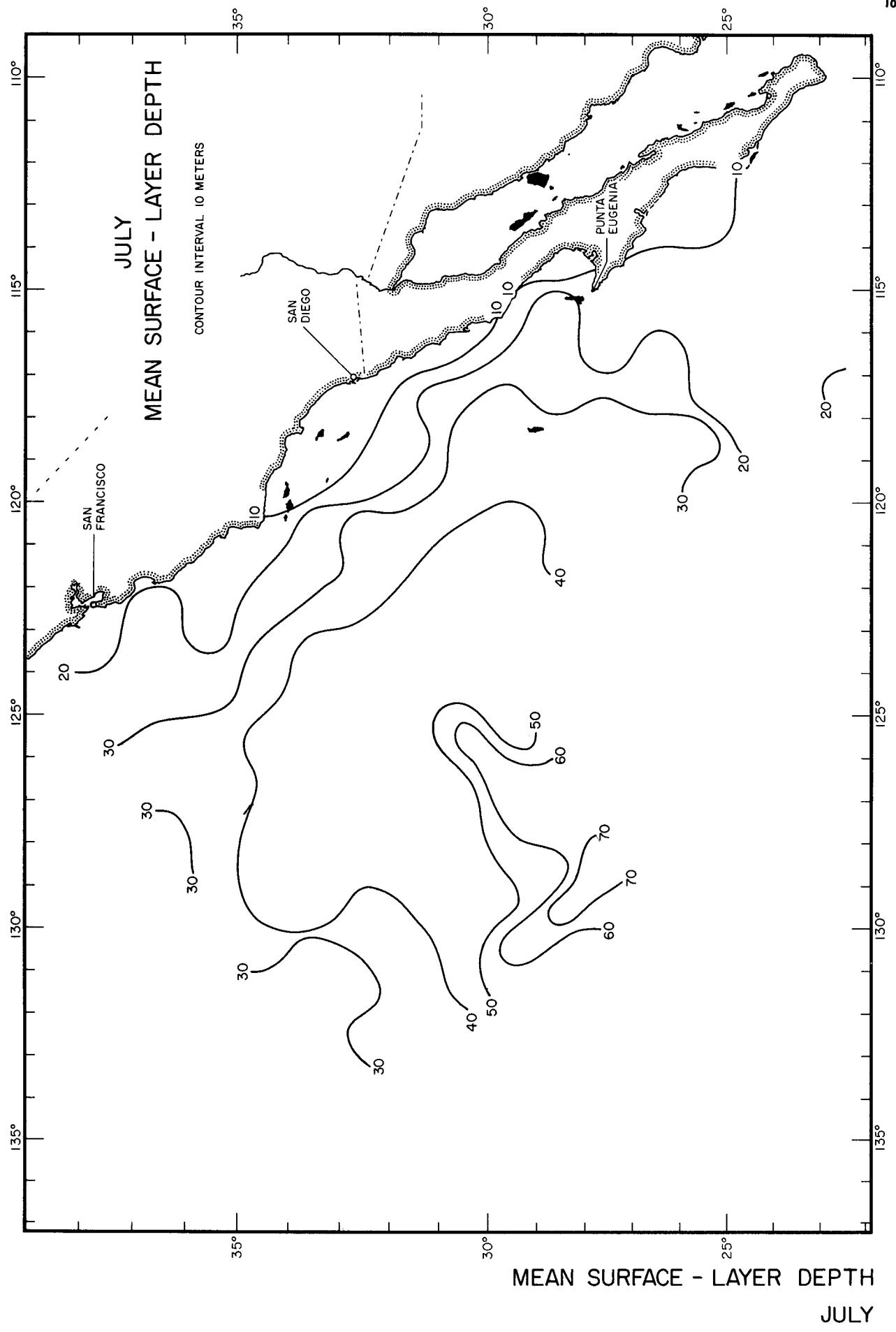


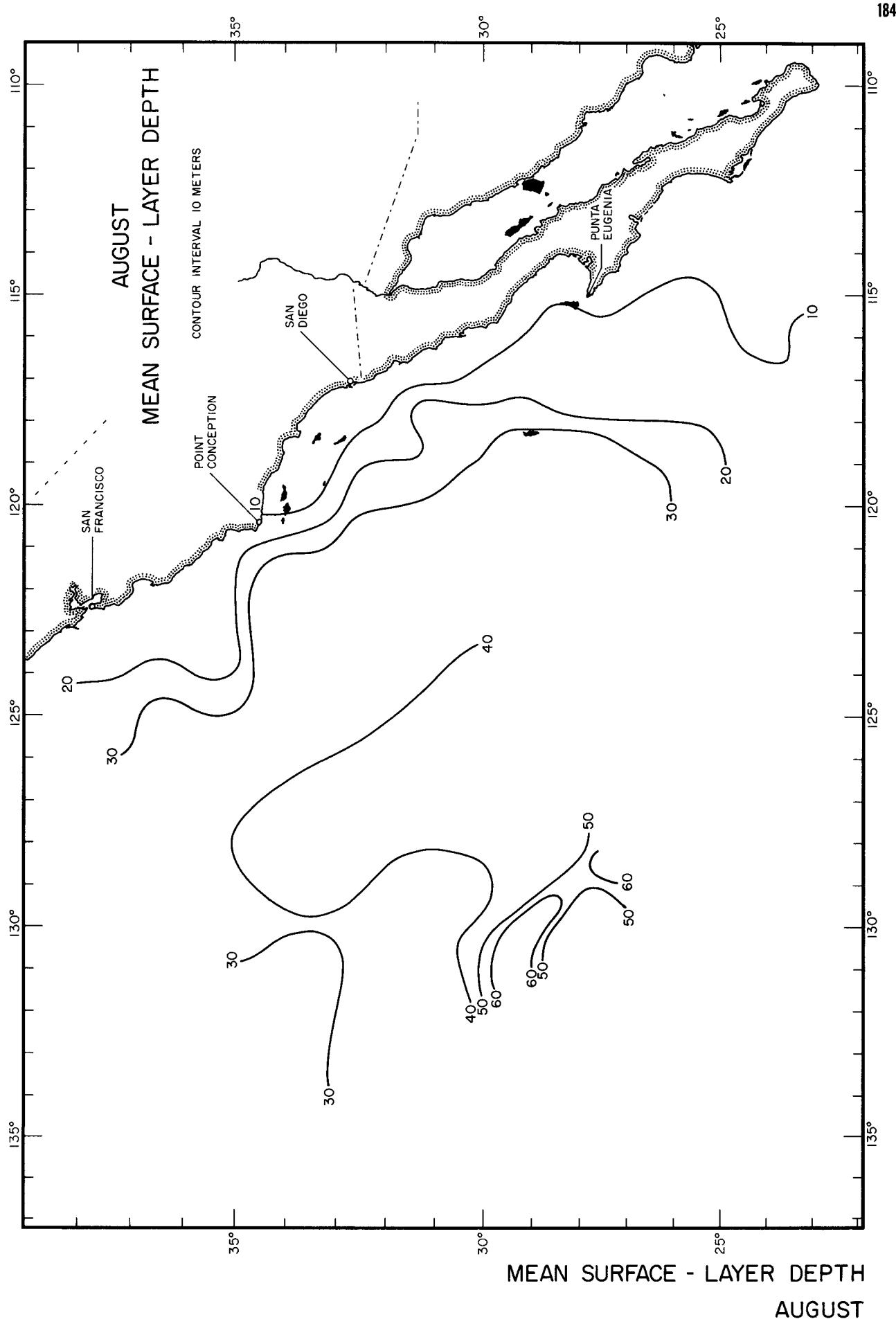


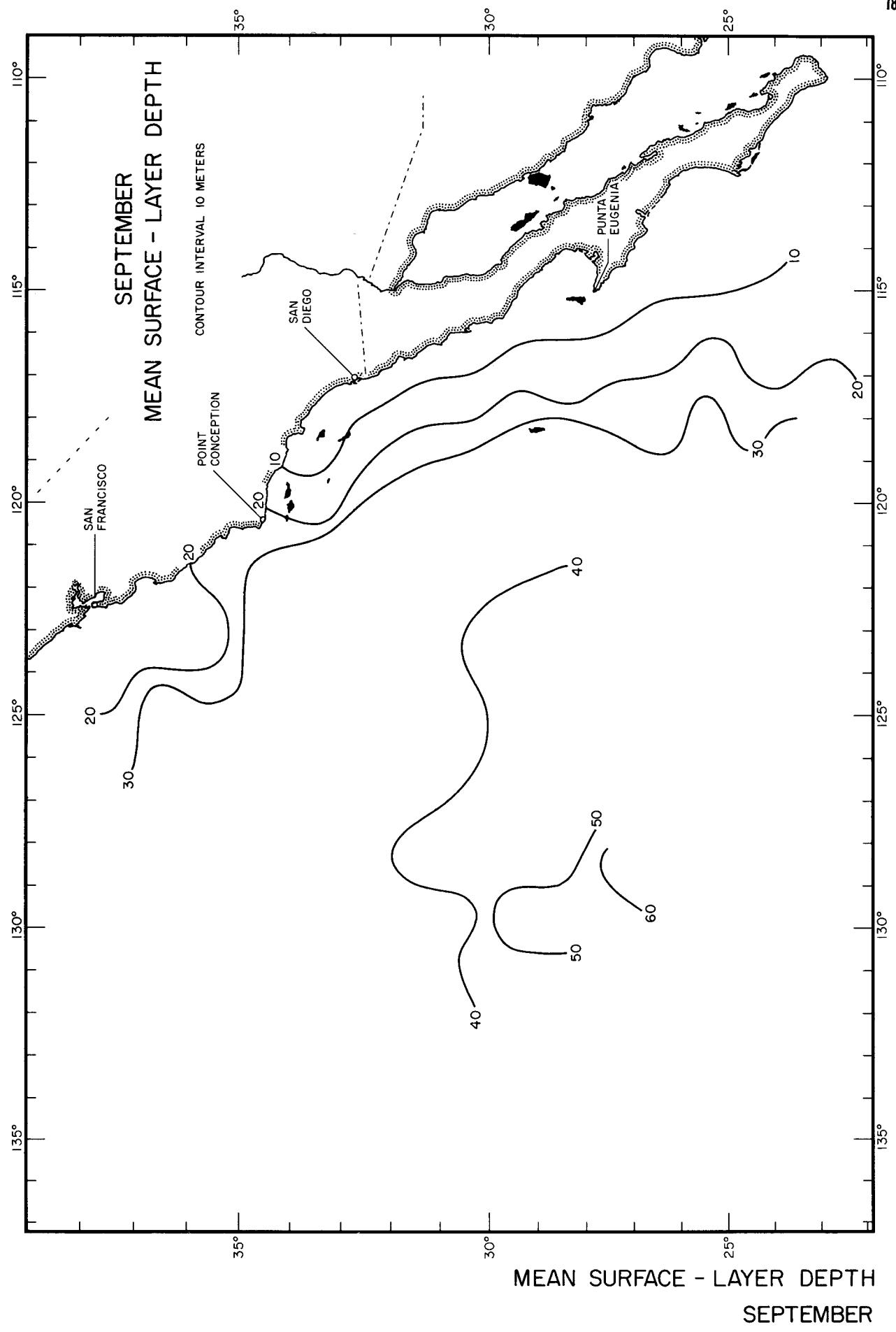


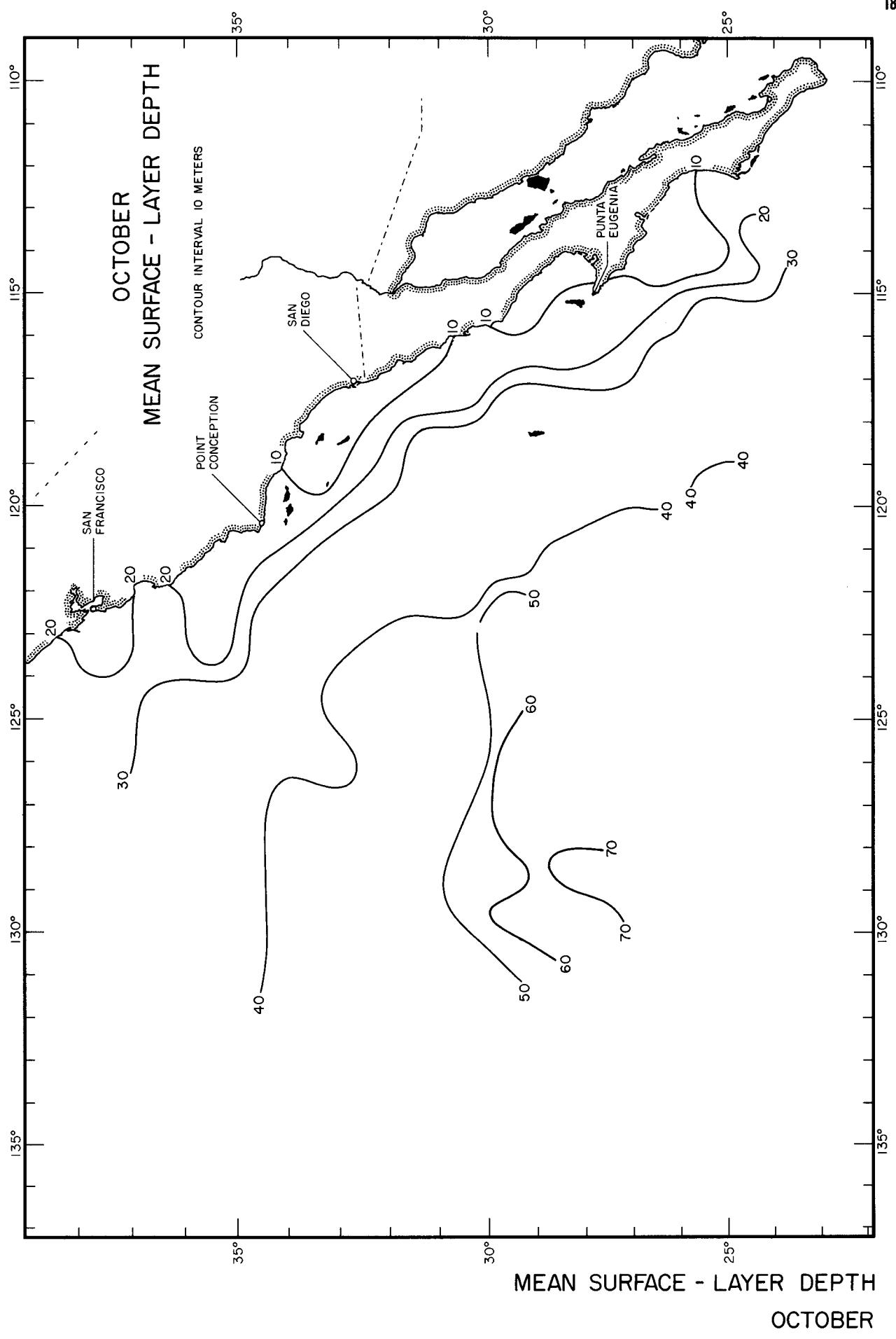


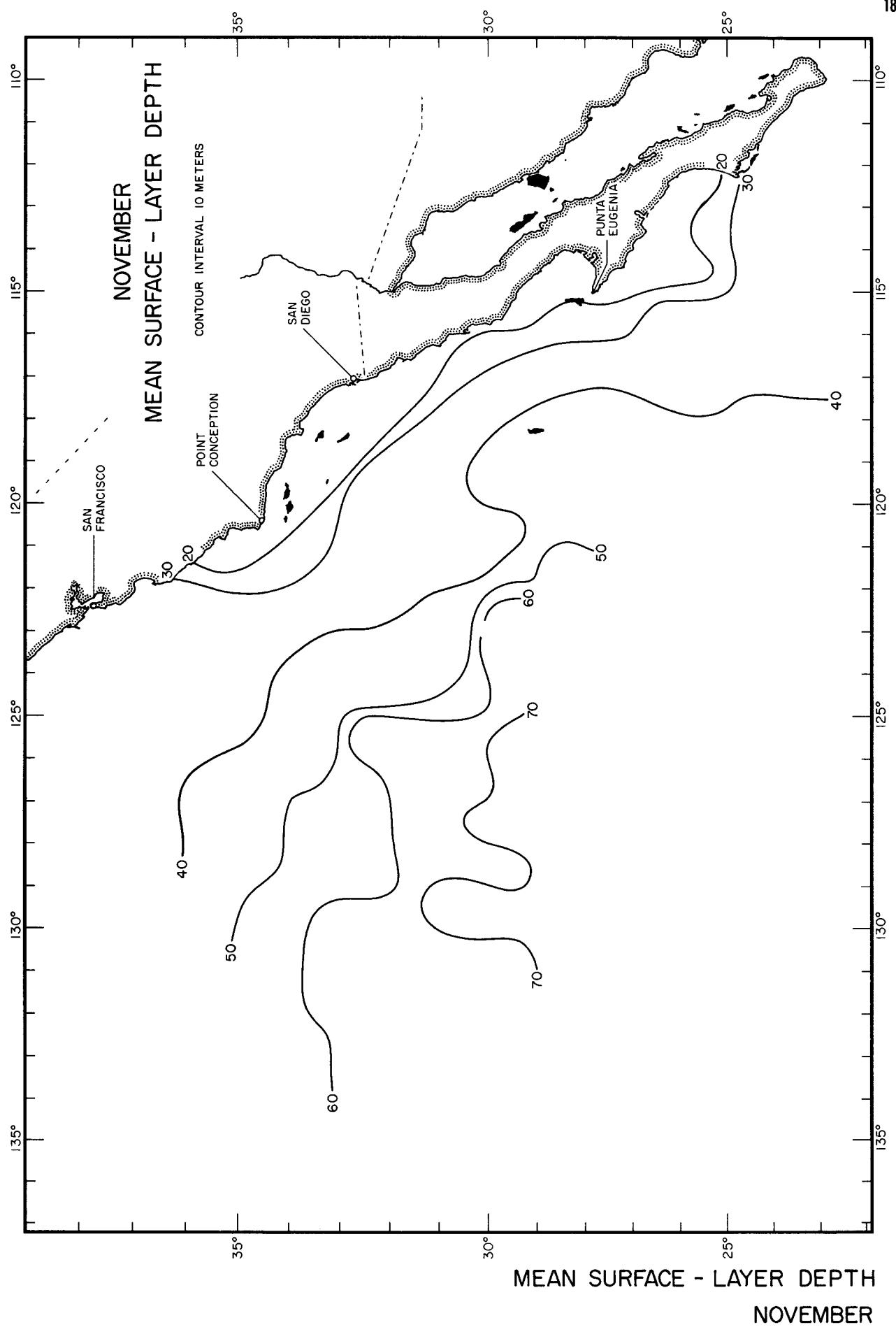


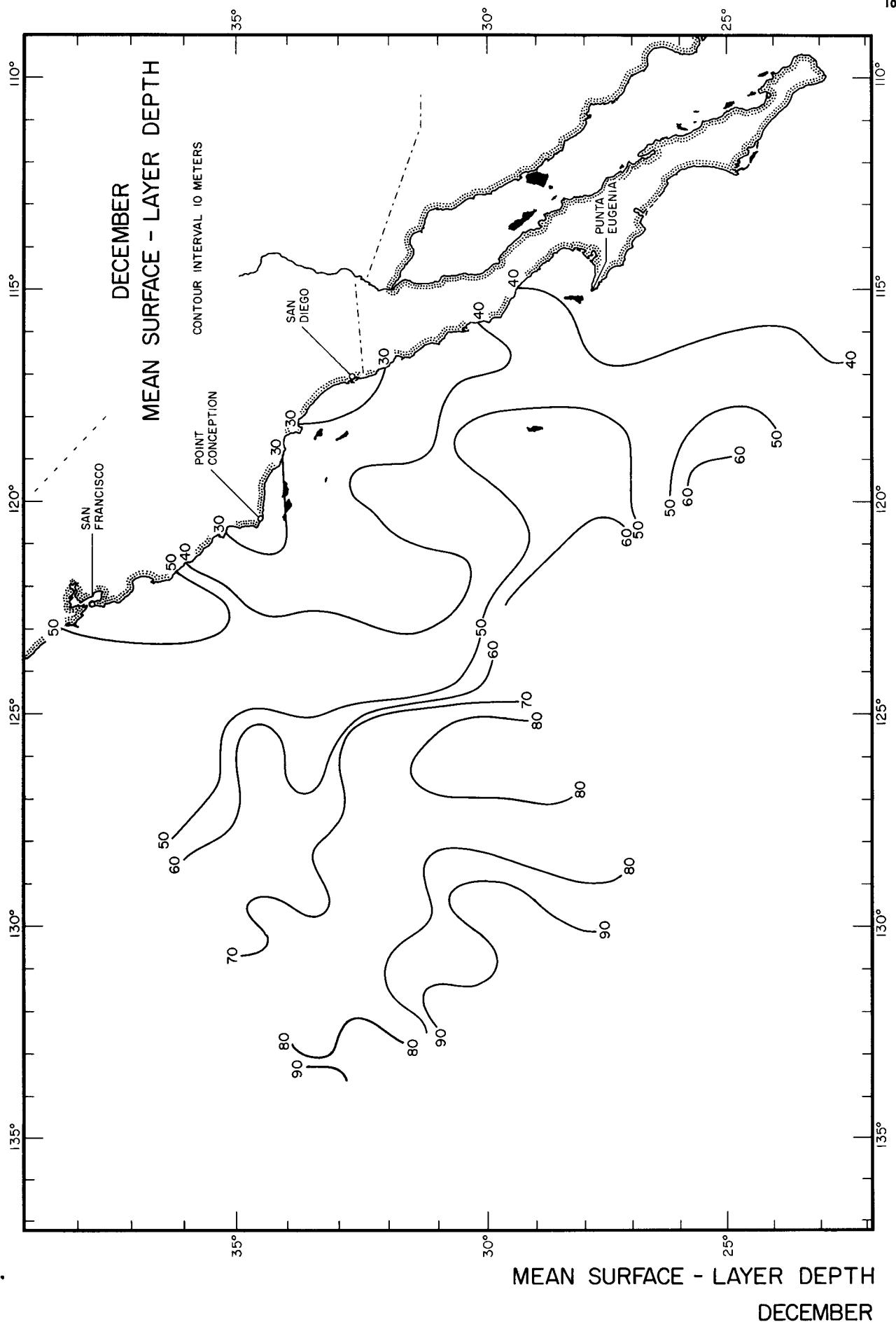


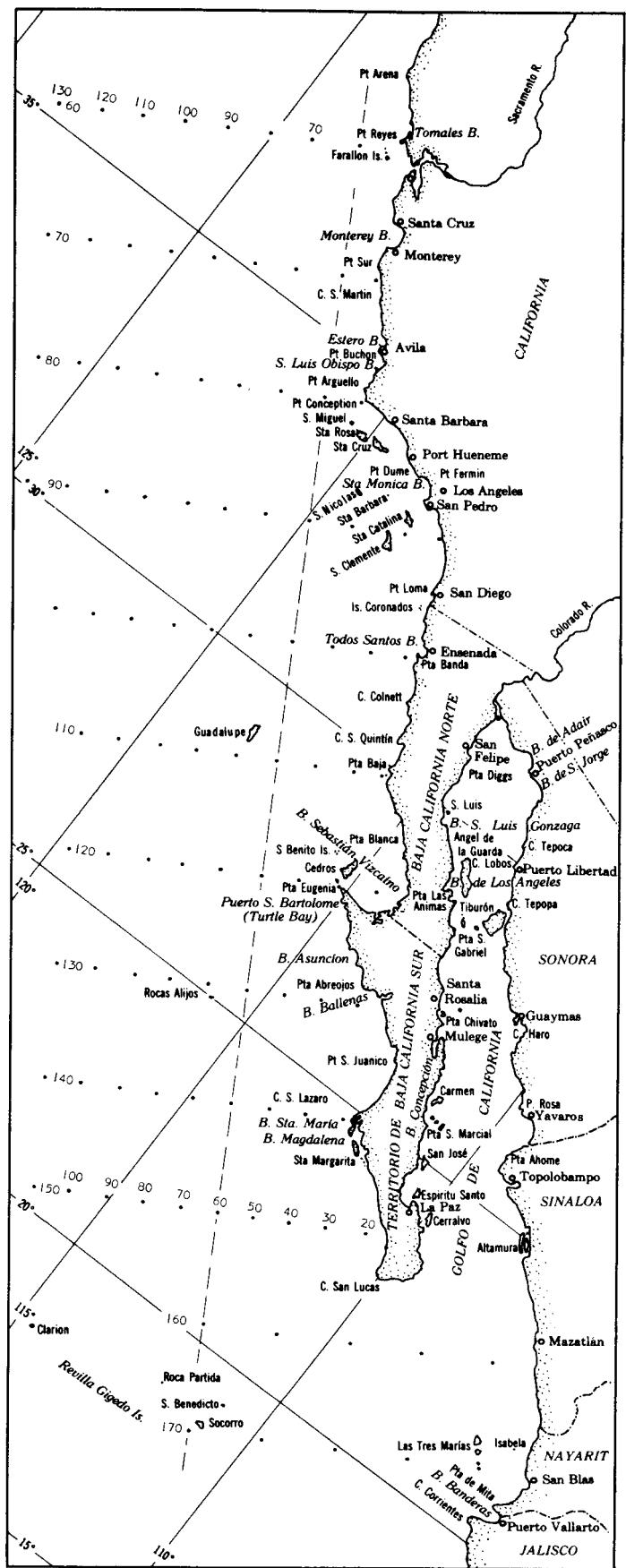
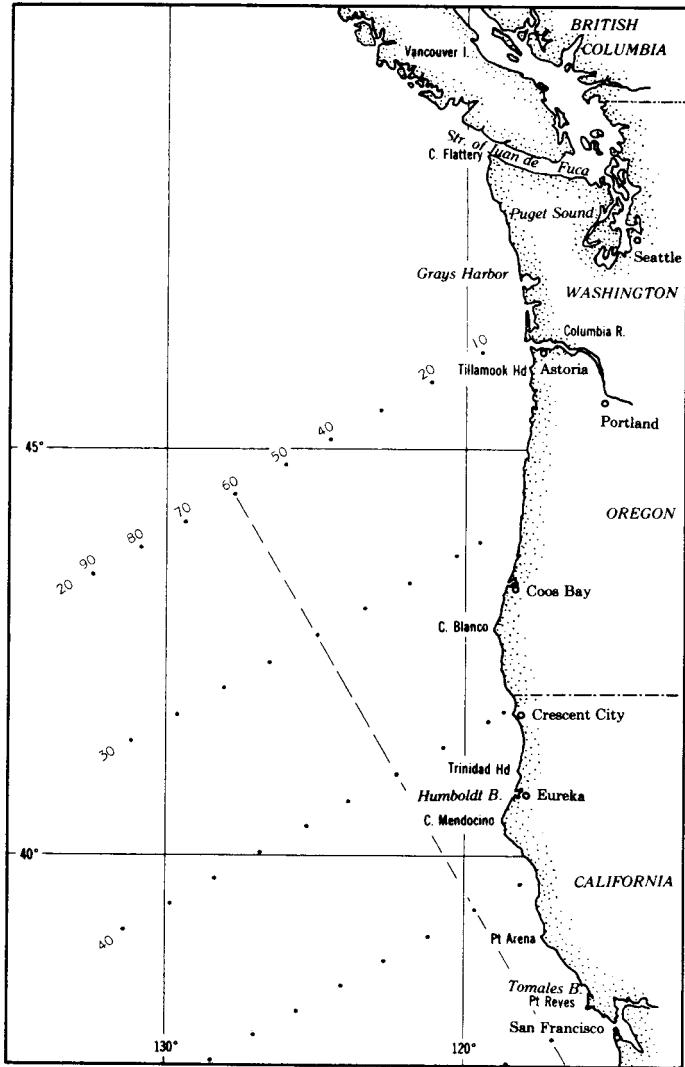












These maps are designed to show essential details of the area most intensively studied by the California Cooperative Oceanic Fisheries Investigations. This is approximately the same area as is shown in color on the front cover. Geographical place names are those most commonly used in the various publications emerging from the research. The cardinal station lines extending southwestward from the coast are shown. They are 120 miles apart. Additional lines are utilized as needed and can be as closely spaced as 12 miles apart and still have individual numbers. The stations along the lines are numbered with respect to the station 60 line, the numbers increasing to the west and decreasing to the east. Most of them are 40 miles apart, and are numbered in groups of 10. This permits adding stations as close as 4 miles apart as needed. An example of the usual identification is 120.65. This station is on line 120, 20 nautical miles southwest of station 60.

The projection of the front cover is Lambert's Azimuthal Equal Area Projection. The detail maps are a Mercator projection.

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