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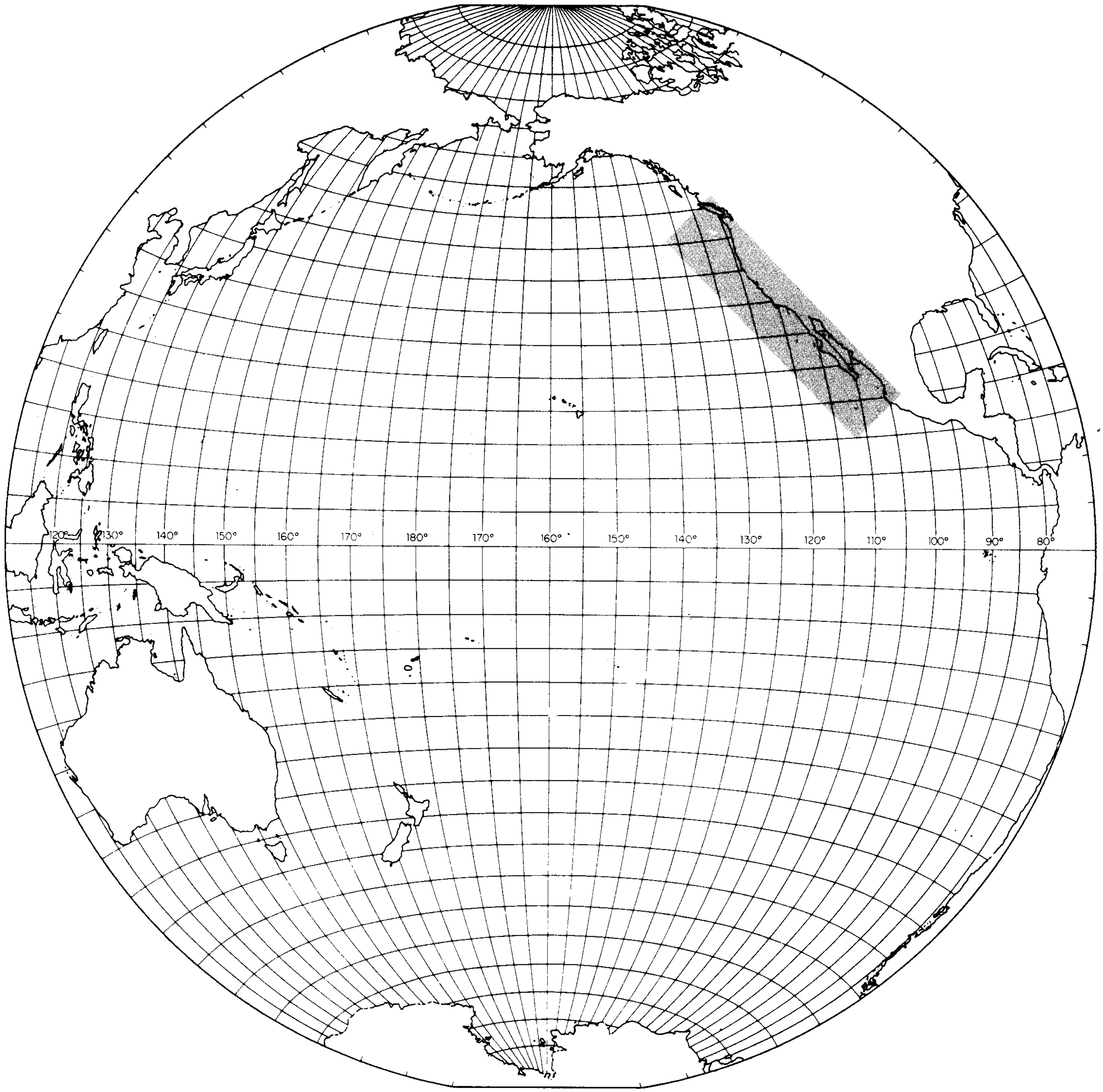
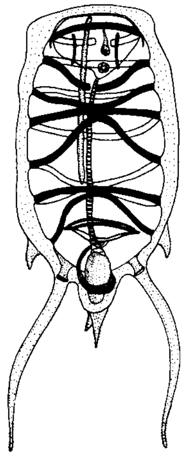
MARINE RESEARCH COMMITTEE



CALIFORNIA COOPERATIVE OCEANIC FISHERIES INVESTIGATIONS

ATLAS No. 10



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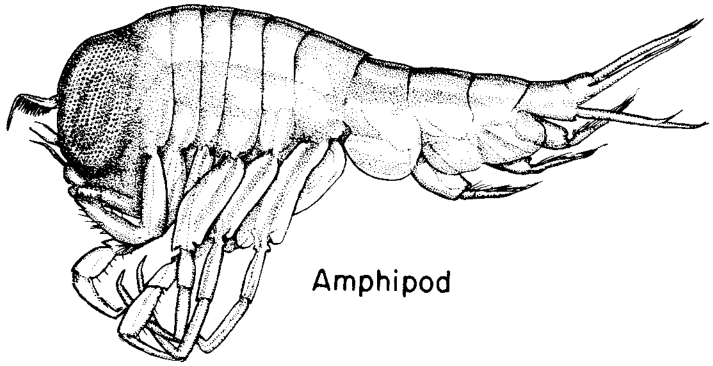
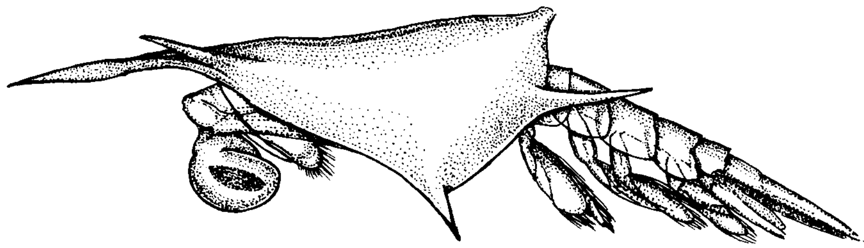


Amphipod



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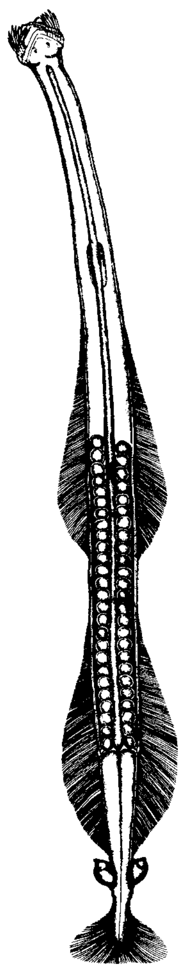
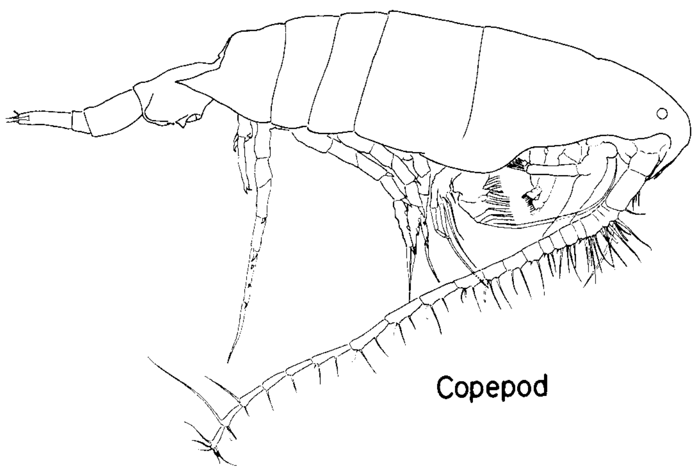
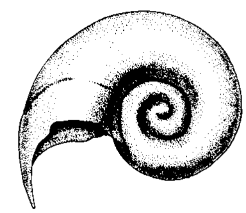


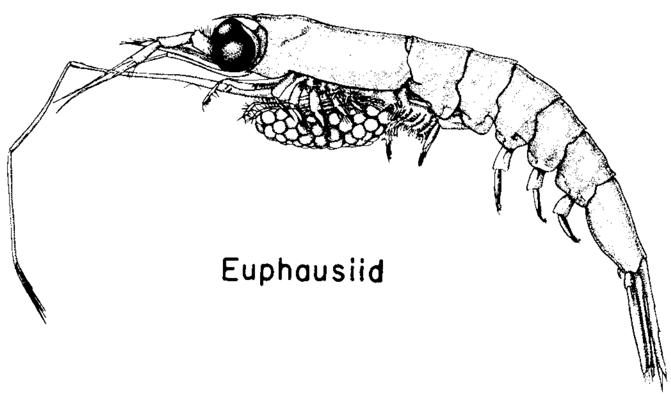
Chaetognath



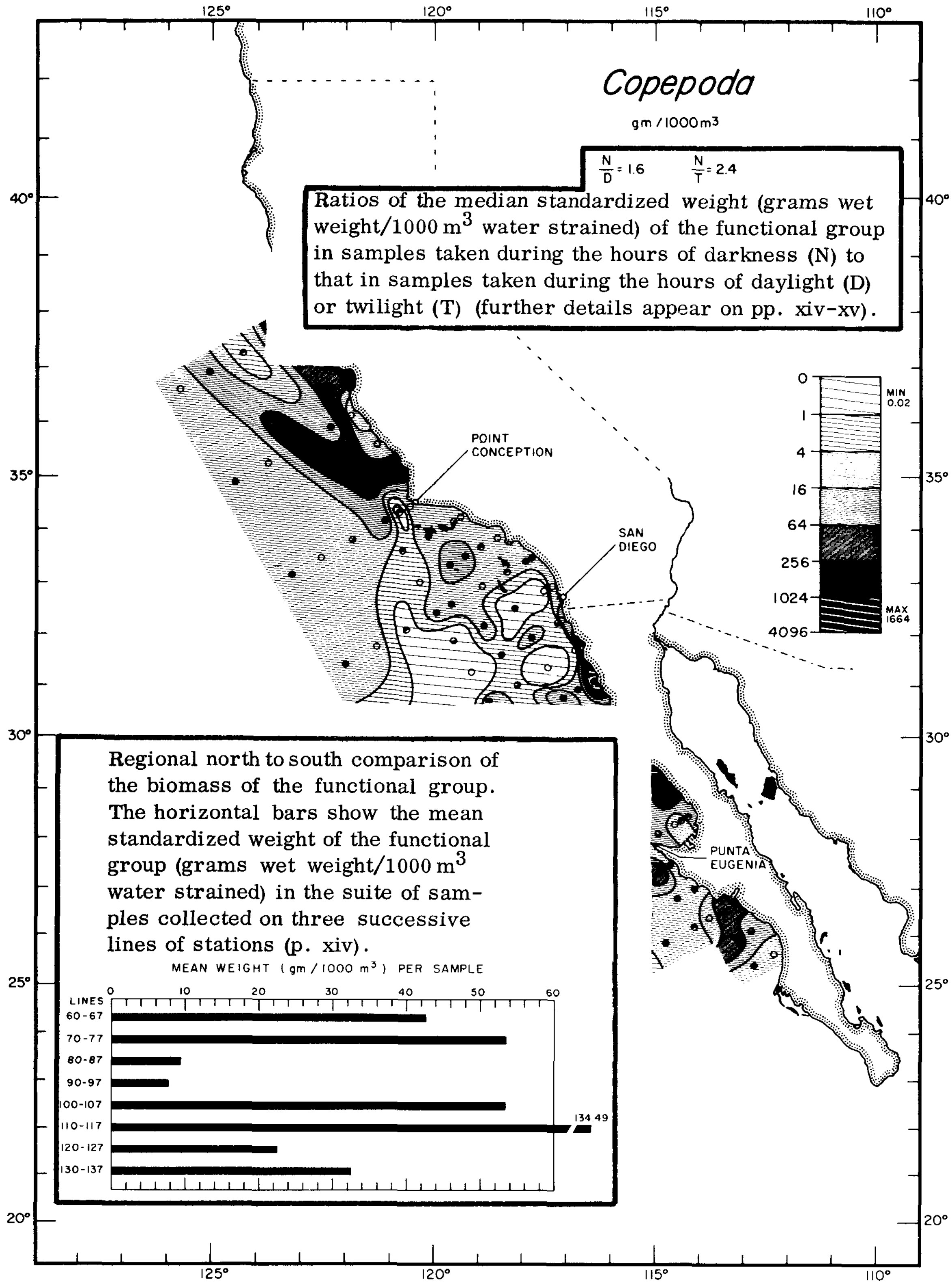
Copepod



Pteropod



Euphausiid



Biomass

Copepoda

0	39	%	100
0	4799	gm/1000m³	12344

Graphic comparison of the sum of the standardized weights (grams wet weight/1000 m^3 water strained) of the named functional group and that of All Taxa Combined obtained from all stations of the numbered cruise. The values below are the summed total of standardized weights, the biomass of the functional group appearing on the left, that of All Taxa Combined appearing on the right. The percentage above shows the sum of the biomass of the functional group as a ratio of that of All Taxa Combined (p. xiv).

CALIFORNIA COOPERATIVE OCEANIC FISHERIES INVESTIGATIONS

Atlas No. 10

STATE OF CALIFORNIA
MARINE RESEARCH COMMITTEE

Cooperating Agencies:
CALIFORNIA ACADEMY OF SCIENCES
CALIFORNIA DEPARTMENT OF FISH AND GAME
STANFORD UNIVERSITY, HOPKINS MARINE STATION
U. S. FISH AND WILDLIFE SERVICE, BUREAU OF COMMERCIAL FISHERIES
UNIVERSITY OF CALIFORNIA, SCRIPPS INSTITUTION OF OCEANOGRAPHY

June, 1969

THE CALCOFI ATLAS SERIES

This is the tenth 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
U. S. Fish and Wildlife Service, Bureau of Commercial Fisheries
University of California, Scripps Institution of Oceanography

CalCOFI atlases[2] 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

Atlases in this series, through June 1969, are:

CalCOFI Atlas No. 1
Anonymous — CalCOFI atlas of 10-meter temperatures and salinities 1949 through 1959.

CalCOFI Atlas No. 2
Fleminger, A. — Distributional atlas of calanoid copepods in the California Current region, Part I.

CalCOFI Atlas No. 3
Alvariño, A. — Distributional atlas of Chaetognatha in the California Current region.

CalCOFI Atlas No. 4
Wyllie, J. G. — Geostrophic flow of the California Current at the surface and at 200 meters.

CalCOFI Atlas No. 5
Brinton, E. — Distributional atlas of Euphausiacea (Crustacea) in the California Current region, Part I.

CalCOFI Atlas No. 6
McGowan, J. A. — Distributional atlas of pelagic molluscs in the California Current region.

CalCOFI Atlas No. 7
Fleminger, A. — Distributional atlas of calanoid copepods in the California Current region, Part II.

CalCOFI Atlas No. 8
Berner, L. — Distributional atlas of Thaliacea in the California Current region.

CalCOFI Atlas No. 9
Kramer, D., and E. H. Ahlstrom. — Distributional atlas of fish larvae in the California Current region: Northern Anchovy, *Engraulis mordax* Girard, 1951 through 1965.

CalCOFI Atlas No. 10
Isaacs, J. D., A. Fleminger and J. K. Miller. — Distributional atlas of zooplankton biomass in the California Current region: Spring and Fall 1955 - 1959.

[1] Usually abbreviated CalCOFI, sometimes CALCOFI or CCOFI.
[2] For citation this issue in the series should be referred to as CalCOFI Atlas No. 10.

DISTRIBUTIONAL ATLAS OF ZOOPLANKTON BIOMASS IN THE CALIFORNIA CURRENT REGION: SPRING AND FALL 1955 - 1959

J. D. Isaacs, A. Fleminger and J. K. Miller

CALCOFI ATLAS NO. 10

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

June 1969

DISTRIBUTIONAL ATLAS OF ZOOPLANKTON BIOMASS IN THE

CALIFORNIA CURRENT REGION: SPRING AND FALL 1955 - 1959

J. D. Isaacs, A. Fleminger and J. K. Miller[1/]

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[1/]Scripps Institution of Oceanography, University of California, San Diego, La Jolla, California.

Introduction

Beginning in 1949, the California Cooperative Oceanic Fisheries Investigations (CalCOFI) program has systematically monitored a variety of oceanographic features across the California Current region. Standardized measurements and collections of physical, chemical and biological components are taken from a network of stations. The stations are usually spaced at 40-mile intervals between 25°N and 38°N and extend seaward to several hundred miles off the Pacific coast of North America (Chart 1). The California Current region, distinguished by upwelling and relatively high productivity, comprises the eastern boundary current of the north Pacific Ocean.

The CalCOFI Zooplankton Collection with more than 30,000 standard samples has already served a large number of specialized studies concerned with distribution and abundance of organisms among the epipelagic fauna of the region. For example, data in CalCOFI Atlases 2, 3 and 5 through 9 confirm the eastern features of the biogeographical patterns proposed for the mixed layers of the north Pacific Ocean (recently reviewed by Beklemishev, 1967). The CalCOFI data illustrate the relatively stable relationships among these features as well as their seasonal latitudinal displacement. In addition to seasonal variation, striking distributional changes have also occurred between periods of several years duration (Ahlstrom, 1960; Balech, 1960; Berner, 1960; ______ and Reid, 1961; Brinton, 1960; Radovich, 1960). These fluctuations will be better understood in the course of relating hydrographic, meteorological and biological measurements regularly made during the CalCOFI study.

Displacement volumes of the CalCOFI plankton collections are routinely measured by a standard procedure. Such data for the cruises between 1949 and 1960 have been published in the Special Scientific Report series of the Bureau of Commercial Fisheries, U. S. Fish and Wildlife Service (Nos. 73, 100, 125, 132, 161, 177, 188, 232, 326, 374, 414, 581). Displacement volumes afford a rapid estimate of the standing crop of plankton at minimal cost. However, without qualification as to contents, their contribution to an understanding of the region's ecosystem is limited.

Quantitative estimates of phylogenetically different groups may provide an estimate of nutritive quality of the standing crop as well as an index of trophodynamic complexity in the region. Biomass estimates made species by species, however, are a practical impossibility for large collections. A simpler procedure would be to group together species of higher taxonomic categories since it is probable that the components of such categories occupy similar or overlapping trophic levels. Species within a category would tend to be like each other in morphology, nutrient storage and size, and therefore similar in terms of nutrient quality relative to other categories. For example, chaetognaths are primarily metazoan carnivores, salps are fine-screen filterfeeders and epiplanktonic copepods range from coarser screen filterfeeders to obligate secondary consumers. These three taxonomically high-ranking groups not only occupy somewhat different positions in the trophic spectrum but are quite different from one another with respect to body proportions, size range of adults, proportion of water in body weight and presumably mechanisms of defense against predation. In general, therefore, taxonomic categories may also be viewed ecologically and nutritionally as "functional groups."

The number of functional groups to be employed in analyzing the distribution of biomass in a set of samples must of necessity be determined by the optimum desired resolution versus the limitations of the laboratory. In the present study, zooplankton biomass is being measured in terms of 17 functional groups (Table 1). The wet weight of each functional group corrected for interstitial water is estimated in every sample. All of the standard zooplankton collections from 20 CalCOFI cruises, namely, mid-spring, mid-summer, mid-fall and mid-winter cruises from the years 1955 through 1959, are analyzed in this manner. This atlas presents contoured biomass distributions of the 17 functional groups found in the mid-spring and mid-fall sets of samples.

Materials and Methods

Selection of the years 1955 through 1959 for analysis of biomass distribution was dictated by interest in the occurrence and nature of patterns of seasonal and annual variability among the functional groups of zooplankton. During this time, yearly mean temperatures above the thermocline shifted upward from the relatively cold years of 1955 and 1956 to the relatively warm years of 1958 and 1959. These changes in the California Current region are well documented (Anon., 1963), and broader ramifications as experienced in other areas within the north Pacific were discussed in a CalCOFI-sponsored symposium entitled "The Changing Pacific Ocean in 1957 and 1958," (Sette and Isaacs, Eds., 1960).

In the present atlas, spring is represented by the April cruises and fall by the October cruises of 1955 through 1959 (Table 2). Similar analyses of the summer and winter seasons, now in preparation, are scheduled to appear in a future CalCOFI atlas. The net and the procedures employed in obtaining CalCOFI plankton samples have already been described at length several times (e.g., Ahlstrom, 1948, 1952, 1954; Fleminger, 1964). Suffice it to say that the net is 1 meter in diameter at the mouth and about 5 meters long, the conical straining section having a mesh size of approximately 0.5 mm. The net, towed obliquely from a ship underway at about 2 knots, makes a traverse from the surface to 140 meters and return, requiring about 14.5 minutes and usually straining 400 to 600 cubic meters of sea water.

Analysis of samples for this atlas has been carried out by the Biomass Laboratory, a team established for this purpose within the Marine Life Research Group at Scripps Institution of Oceanography. This laboratory is regularly staffed by a small number of technically trained personnel and also employs temporary and part-time employees recruited from among the student body of the University of California at San Diego. Newcomers undergo a training phase followed by a prolonged apprenticeship. During this trial period their work is closely scrutinized and must satisfactorily meet a number of quality control tests before their analyses of samples are included among the laboratory's data output. Plankton specialists at Scripps Institution participated with the laboratory supervisor, Mr. Julian K. Miller, in training the initial cadre of the Biomass Laboratory and subsequent recruits have been trained and tested by the Laboratory's senior personnel. The usual quality

TABLE 1. Number of epiplanktonic species in CalCOFI region.

Functional Group[1]	Approximate number of species found in regions between the surface and 140 meters depth; source of estimate.
Amphipoda	≧41 (Bowman, 1953)
Chaetognatha	24 (Alvariño, 1965)
Cladocera	5 (Baker, 1938; Strickland, et. al., 1968)
Copepoda	≧235 (Esterly, 1905; Olson, 1949; Fleminger, 1967)
Crustacean larvae	No estimate available
Ctenophora	≧4 (Torrey, 1904)
Decapoda	No estimate available
Euphausiacea	28 (Brinton, 1967a)
Heteropoda	13 (McGowan, 1967)
Larvacea	26 (Tokioka, 1960)
Medusae	24 (Alvariño, in press)
Mysidacea	≧14 (Banner, 1948; Tattersall, 1951; W. D. Clarke, pers. comm., 1969)
Ostracoda	≧16 (Juday, 1906; C. Miller, pers. comm., 1969)
Pteropoda	29 (McGowan, 1967)
Radiolaria, Tripylea[2]	≧20 (Kling, 1966; P. B. Helms and E. D. Milow, pers. comm., 1969)[2]
Thaliacea	≧23 (Berner, 1967)
Siphonophora	44 (Alvariño, in press)
All Taxa Combined	≧546

[1] Fish eggs, fish larvae and squid are regularly removed from CalCOFI plankton samples by the La Jolla Laboratory, Bureau of Commercial Fisheries, U.S. Fish and Wildlife Service and are being reported elsewhere. Within the functional group "Decapoda" we have included for convenience galatheid crabs, holoplanktonic Natantia, planktonic juveniles of other Natantia and planktonic juveniles of stomatopods (Hoplocarida). Our functional group "Crustacean larvae" is comprised of the pelagic larvae of Brachyura and Anomura without the galatheids. Other identifiable larvae, crustacean or otherwise, are included within their respective functional groups. In general the forms included herein are those large enough to be retained regularly by 0.5 mm mesh.

[2] Radiolarian counts usually do not include the acantharians, often poorly preserved, and the much smaller-sized polycystins; adding the latter two groups brings the number of radiolarian species in the California Current region to about 200 (R. Casey, pers. comm., 1969).

control test consists of re-submitting selected samples already analyzed but disguised by substituting a false label for the original one. Re-analysis is performed by either the same worker or some other member of the laboratory. Selection of the operator, the sample and the frequency of the test is random unless deviations from the standards are excessive. Variation of less than ±5% is regarded as an acceptable performance. The reliability of data produced in this laboratory has been tested independently by Professor E. W. Fager of Scripps Institution, who has kindly provided a summary of results in Appendix I. [3]

TABLE 2. CalCOFI zooplankton samples selected for analysis of spring and fall conditions. The first two digits of the cruise number represent the year, the last two, the month of a cruise.

Cruise	Number of samples
Spring	
5504	125
5604	178
5704	208
5804	271
5904	251
	1033
Fall	
5510	108
5610	42
5710	142
5810	250
5910	222
	764

Sample Analyses: Procedures

The operator analyzing the sample seeks to obtain a representative wet weight, less interstitial water, standardized to grams per 1000 m^3 of sea water, for each functional group present in the sample. These weights comprise an estimate of standing crop occurring between the surface and about 140 m depth. Weight has been determined indirectly by means of a standardized length, as described below.

[3] We thank Prof. Fager for devising and analyzing this test and Mr. G. T. Hemingway for requesting the test and for supervising the gathering of the data.

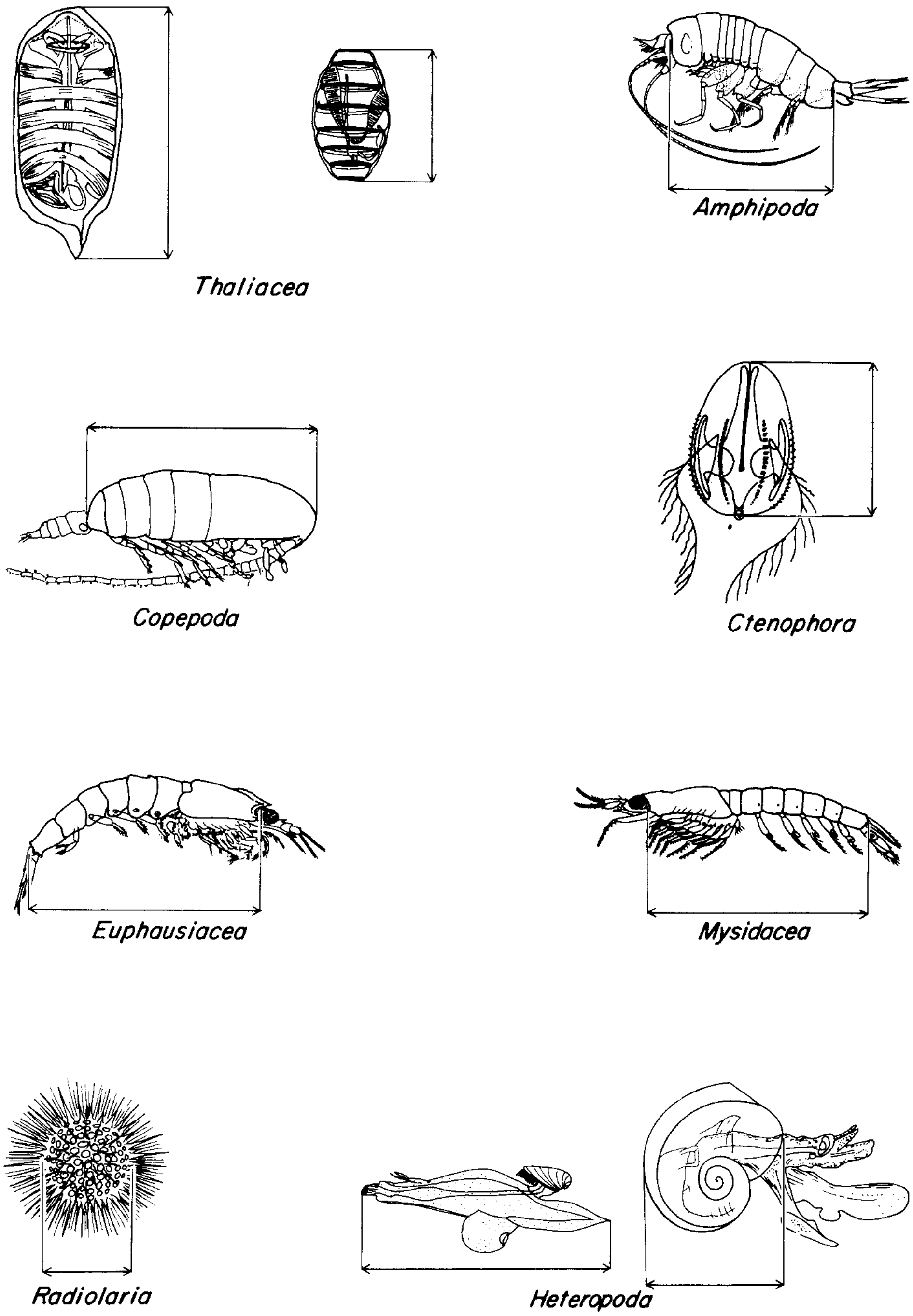

Figure 1. Standard lengths used in this study. The measurements delimited by arrows are taken with the aid of an ocular micrometer at 7X magnification.

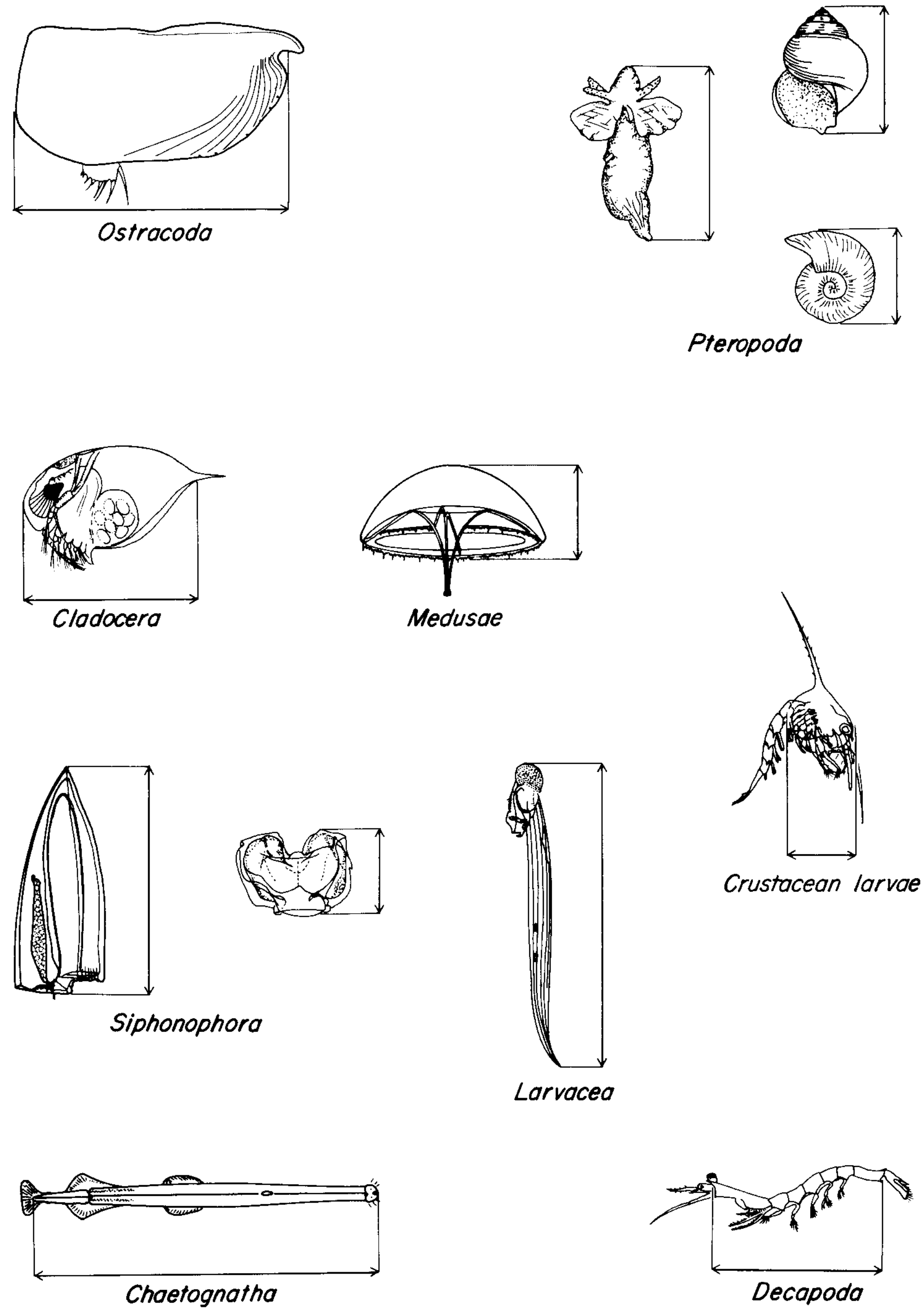

Figure 1, cont. Tables showing the relationship of standard length to weight among zooplankton from the California Current region appear in Appendix 2.

In practice, analysis begins with displacement volumes following the method of Ahlstrom and Thrailkill (1963) taken before and after removal of "large jellies" (thaliaceans, cnidarians, heteropods). Large jellies are also sorted into their respective functional groups and weight is estimated directly with the aid of an analytical balance. The biomass of the other functional groups is determined from an aliquot ranging in size from 1/2 to 1/32, depending upon the volume of the sample after removal of the large jellies. As a rule the size of the aliquot examined is at least 1 cc in displacement volume. Its adequacy is judged by comparison with the displacement volume of the total sample as described below. The aliquot is obtained with the aid of a Folsom splitter (McEwen, Johnson and Folsom, 1954).

The aliquot is poured into a square transparent dish of plexiglass 20 by 20 cm whose chamber is partitioned into seven equal subchambers by six equidistant parallel ridges. The contents are examined with the aid of a stereomicroscope at 7X magnification. One of the oculars is fitted with a ruled ocular disc bearing 100 equally spaced divisions (1 division = 0.167 mm at 7X magnification) that is used to estimate the length of each specimen. Standard length measurements for conversion to weight (conversion tables are presented in Appendix II) are made to the nearest division. The specimens are tallied in size classes which vary somewhat depending on the overall size range of the functional group. The points of reference for taking a standard length in each functional group are shown in Figure 1. Where practical, bent specimens are straightened and, based on experience, allowances are made for slight to moderate distortions. Grossly distorted specimens are removed and weighed on a balance. To eliminate the effect of interstitial water the standard weight is corrected by reducing it to two thirds of the gross weight (Ahlstrom and Thrailkill, 1963). This correction for interstitial water has been incorporated in the length-weight conversion tables of Appendix II. Weights are also taken directly of functional groups dominated by a single growth stage or a species that is morphometrically atypical with respect to its functional group. The conversion tables are based upon typical samples in which each functional group consists of a heterogeneous mixture of species and growth stages.

The estimated weights of all functional groups within a sample are summed, and to be acceptable, must be within 10% of the normalized weight based upon displacement volume of the total sample. Use of the displacement volume to estimate weight is predicated upon the relationship of volume and weight in stabilized preserved samples, as determined by Ahlstrom and Thrailkill (1963).

Presentation of Data

In general, practices established in earlier atlases of this series have been followed. The results of each cruise is shown separately by functional group and plotted on standard charts. We have departed from previous contouring practices by using contour intervals based upon a power of 4. The change from our usual power of 10 was dictated by (1) the range of biomass values extending below as well as above unity, (2) the desirability of having the value, one gram (i.e., one part organism in 10^9 parts sea water) coincide with a contour line, (3) the need for a system of interpolable logarithmic contours and (4) the range (0.5 to 2 times) of the 95% confidence limits of any single estimate with respect to variability from laboratory procedures employed in sample analysis (see Appendix I).

The biomass estimates are expressed in terms of grams wet weight per 1000 m^3 of sea water strained (corrected for interstitial water) per functional group. Contour intervals are factors of 4 and contour lines coincide with a sequence of values as follows: 0.016, 0.062, 0.25, 1, 4, 16 and 64. The contour intervals increase exponentially and the contours are defined by the equation:

$$C_n = KB^{an}$$

where

C_n	is the value of a contour for a value of the exponent n,
B	is the base,
K	is a constant,
a	is constant, and
n	is a variable with integer values.

As employed here, K = 1, B = 4, a = 1, and n = -3, -2, -1, 0, 1, 2, 3, etc. The system permits indefinite extension above and below unity. Interpolation or extrapolation into a finer or coarser series of logarithmic intervals can be readily accommodated.

No more than seven contour intervals are shown per chart and seven grades of shading are applied in the same sequence of increasing abundance. The sequence of seven values within the exponential series used on a specific chart is the one that best fits the range of abundance estimates shown by a functional group in a specific cruise. The highest and the lowest estimates of biomass (greater than zero) are shown in Arabic numerals to the right alongside the index of contour interval shadings in the chart legend. The charts have been arranged by functional groups which follow an alphabetical sequence, the sum total of the functional groups appearing first under the heading "All Taxa Combined." Within each category the charts are arranged by season, each seasonal set of five cruises following in chronological order.

In addition to the contoured estimates of biomass overlying the station plan, each chart presents two graphic summaries pertaining to the abundance of the functional group. Latitudinal distribution of biomass is estimated in terms of the mean weight per station in each set of three successive lines of stations. This is shown as a histogram to the left of the distribution. The proportion of the functional group to the category All Taxa Combined, i.e., the total zooplankton biomass per cruise less fish eggs, fish larvae and squid is shown in actual values and in percentage in a bar diagram located in the lower left margin of the chart.

Zooplankton Abundance and Diurnal Vertical Migration

CalCOFI monitoring cruises usually survey large areas exceeding 200,000 square miles and occupy 200 or more stations during a 30 to 40-day period. The severe time limitations imposed upon the sampling program do not permit the sampling of zooplankton with regard to time of day, intensity and quality of light striking the sea surface or water transparency. It is well known that samples of zooplankton from the mixed layer vary appreciably in both quality and quantity when collected under similar conditions but at different times within a 24-hour cycle (King and Demond, 1953; King and Hida, 1954, 1957a, b). Not only is this phenomenon known to prevail in the California Current region (e.g., Kramer, 1963), but Brinton (1962, 1967) has shown that species of euphausiids may vary in abundance by an order of magnitude or more in replicate samples differing primarily in the hour of collection.

Seasonal influences on biotic and abiotic factors, extent of cloud cover, moon phase, water transparency, etc., may influence in part the abundance and quality of day and night samples of zooplankton. At present, however, the level of understanding of horizontal and vertical distribution in local waters is inadequate to standardize abundance and quality of samples taken at different times within a 24-hour cycle.

Some of the functional groups considered here failed to show consistent day-night differences. Moreover, among the highly diverse groups such as copepods some taxa do not ordinarily migrate below the sampling level (e.g., Clausocalanus, most candaciids, pontellids), others may virtually disappear from the uppermost 140 meters in daylight (e.g., Pleuromamma, Undeuchaeta) while still others may be predominantly epipelagic in one portion of the region and mesopelagic when present elsewhere (e.g., Calanus, Eucalanus, Rhincalanus).

We have provided three visual aids to assist in recognizing possible artifacts in a distribution introduced by time of sampling. Each station symbol shows whether the sample was obtained during the hours of daylight, twilight (sunrise or sunset) or night. Twilight is used here to denote a period of time extending one-and-one-half hours before and one-and-one-half hours after local sunrise or local sunset. The terms day and night are restricted to the hours between the two twilight periods.

Ratios of the median values of night (N), twilight (T) and day (D) catches are shown in the chart legend as N/D and N/T. When these ratios are close to unity it is assumed that the contour intervals absorb much if not all of the variability due to time of sampling. The relationship between these ratios and the distribution of day, twilight and night values for a few typical examples is shown in Figure 2.

The less abundant functional groups were frequently absent from one-half or more of the total number of observations per cruise. In these instances, N/D and N/T ratios were estimated graphically. Abundance was ranked by cruise and rank was plotted against abundance. To normalize differences in the number of observations between time periods under comparison, the linear distance between units along the scale of ranks for the set of fewer observations was adjusted to match the distance required for the ranks of the set with the higher number of observations. If the two resulting curves are roughly parallel the N/D and N/T ratios are determined by the distance between the two lines along the ordinate scale (Fig. 2). If the curves were strongly oblique or crossing, the differences were assumed to be due to factors other than time of day and N/D or N/T ratios were not estimated.

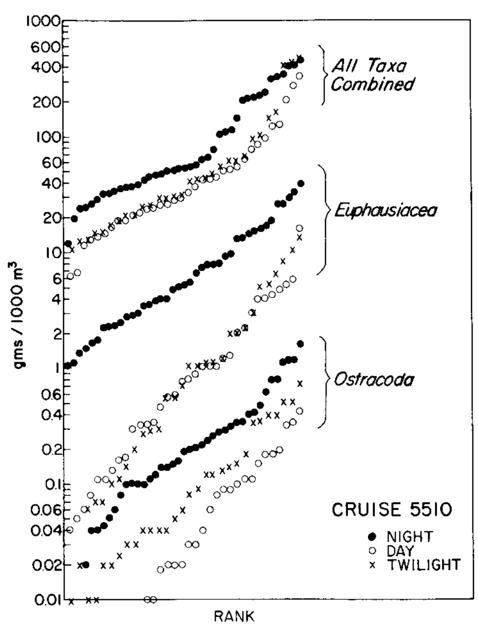

Figure 2. Scatter diagram of three representative examples showing the distribution of biomass ranked in order of increasingly higher values. Each set of data consists of all measurements of a functional group derived from a single cruise. Day, twilight and night samples are differentiated and the scale of ranked position (abscissa) is adjusted so that the number of samples per time period extends over the same length irrespective of the number of observations. Further comments in the text.

Contoured distributions may be noticeably influenced by the time of sampling when the ratio of the median exceeds 2. Accordingly, to compensate for artifacts when N/D or N/T equalled or exceeded 2, an additional chart was prepared in which day and twilight catches were multiplied by N/D and N/T, respectively, so as to more closely approximate an equivalent night-time distribution. Each of the adjusted charts is preceded by a contoured presentation of the unfactored data.

Variability due to the hour of collection appears to have a consistent and noticeable effect on the charted distributions in only certain of the functional groups, namely euphausiids, amphipods and perhaps copepods. Adjustment of the estimated abundances in these cases, however, has resulted in only moderately improved coherence within the distributions. Due to the general agreement among the large number of samples in our data and evidence based on repeated sampling of euphausiids (Brinton, 1962; Figs. 16-23), we believe the charts reflect real geographical variations in relative abundance, irrespective of accumulated errors from escapement, avoidance, patchiness and vertical migration.

Questions arose over the use of medians derived from unpaired sets of observations to determine the ratios, N/D and N/T. Paired observations may be simulated by pairing samples from adjacent stations along the cruise track which were occupied successively in different time phases (day, twilight or night). Pairing increases the likelihood that differences in the catch reflect variability due primarily to time of collection; i.e., the sets of observations were made on ecologically and biogeographically similar assemblages of organisms. Comparisons between the ratios of such simulated pairs with unpaired data were carried out for various representative functional groups (Table 3).

TABLE 3. N/D ratios for paired and unpaired observations.

	Unpaired observations		Paired observations
	$\frac{\text{mean N}}{\text{mean D}}$	$\frac{\text{median N}}{\text{median D}}$	Median $\frac{N}{D}$
Cruise 5510			
All Taxa Combined	1.5	1.9	1.9
Euphausiacea	4.0	6.5	6.8
Copepoda	1.5	2.0	2.0
Pteropoda	1.9	3.8	2.4
Ostracoda	3.5	6.7	8.0
Cruise 5910			
All Taxa Combined	1.0	1.4	1.5

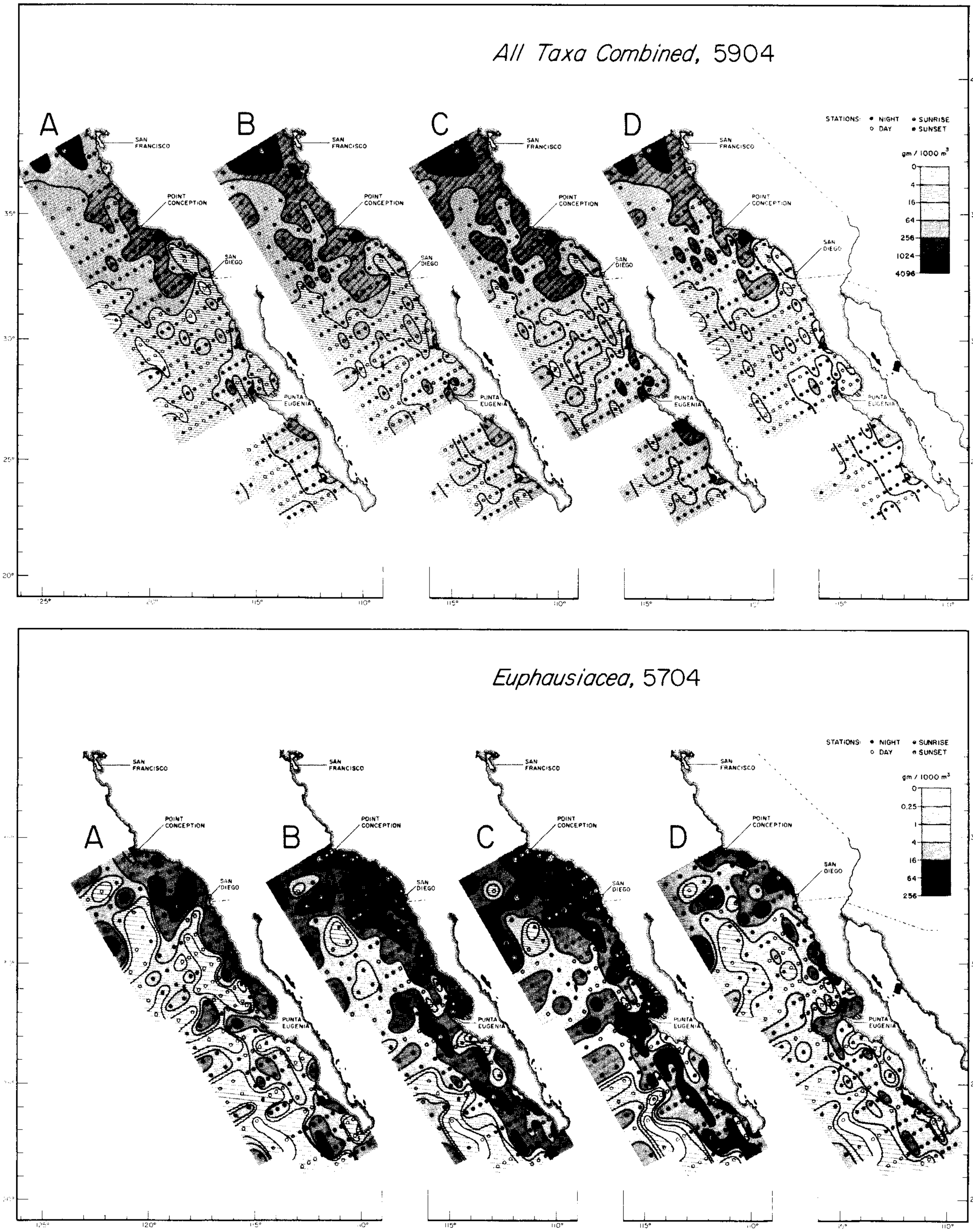

Figure 3. Comparison of two methods to compensate for the effect of diurnal vertical migration on plankton abundance. Categories "All Taxa Combined" and "Euphausiacea" were selected as examples to show moderate and pronounced differences in abundance, respectively, among samples taken at different times of the 24-hour cycle. In B, C and D the abundance of samples taken in hours other than the desired sampling time has been adjusted by the appropriate factor. The distribution of the biomass estimates is contoured in the usual manner.

(A) unadjusted values; (B) day and twilight values adjusted by the ratio of the medians method to approximate median night values; (C) values adjusted by the sine curve method (King and Hida, 1954) to approximate abundance at 0000 hours; (D) as in C, above, but adjusted to approximate abundance at 0600 and 1800 hours when sine is zero as originally employed by King and Hida (1954). Additional explanation and comments in text.

The ratios of paired observations were found to scatter broadly. No more than about one third were within ±0.5 of either the ratio of the medians or the general trend observable in graphed data similar to Figure 2. On the other hand, the median ratio of the paired sets (Table 3) is remarkably similar to the ratio of the medians of unpaired observations as well as to the trend of the differences between the day and night curves in Figure 2. We conclude that simulating paired observations does not noticeably improve upon the use of the ratio of the medians, N/D and N/T, in compensating for day, twilight and night effects on standing-crop estimates from standard CalCOFI tows.

Our method for adjusting catch size relative to time of sampling was chosen over the sine curve method employed on mid-Pacific plankton by King and Hida (1954, 1957a, b) for several reasons. Chief among them are: (1) our practice of estimating biomass separately for each functional group; (2) our region of study which spans a biogeographical gradient from the boreal to the tropical and an ecological gradient from coastal-neritic water to central waters overlying the ocean basin; (3) the full range of variability shown by our samples with respect to their individual extent of faunal homogeneity. We are reluctant to assume that different combinations of faunally heterogeneous species comprising a functional group will tend to behave diurnally in a similar manner. In fact, N/D and N/T may show considerable variability within functional groups (Fig. 2) and the ratio of the medians differs appreciably between groups. It might also be noted that compared to the sine curve method, calculation and employment of the ratio of the medians was carried out more easily.

Using the data for All Taxa Combined from Cruise 5904 and for euphausiids from Cruise 5704, both selected solely for the sake of convenience, direct comparisons of contour patterns were made between values adjusted for differences in the time of catch by means of the King and Hida sine curve factor and the ratio of the medians factor. With N/D being 2.04 for All Taxa Combined and 24.5 for the euphausiid data, the two examples approximate the breadth of the range in the ratio of the medians encountered during the study. We found no noticeable differences in either the general pattern or in coherence of the contours between the sets of data adjusted by the two different procedures (Fig. 3).

It should be noted that in contrast to the adjustments by King and Hida, we have normalized data to represent median night values, typically the period of time yielding the highest standing crop for most of the functional groups. Computer programs for adjusting catch size by the sine curve method or by the ratio of the medians method are on file at Scripps Institution of Oceanography. A copy may be obtained by writing Prof. E. W. Fager.

LIST OF CHARTS

	Spring					Fall				
Cruise Number	5504	5604	5704	5804	5904	5510	5610	5710	5810	5910
All Taxa Combined	2	3	4	5	6	8	9	11	12	14
All Taxa Combined, adjusted					7		10		13	
Amphipoda	15	17	19	21	23	25	27	29	31	33
Amphipoda, adjusted	16	18	20	22	24	26	28	30	32	34
Chaetognatha	35	36	37	38	39	40	41	42	43	44
Cladocera	45	46	47	48	49	50	51	52	53	54
Copepoda	55	56	57	58	60	62	63	65	66	68
Copepoda, adjusted				59	61		64		67	
Crustacean larvae	69	70	72	74	75	76	77	79	81	82
Crustacean larvae, adjusted		71	73				78	80		83
Ctenophora	84	85	86	87	88	89	90	91	92	93
Decapoda	94	96	98	100	102	104	106	108	110	112
Decapoda, adjusted	95	97	99	101	103	105	107	109	111	113
Euphausiacea	114	116	118	120	122	124	126	128	130	132
Euphausiacea, adjusted	115	117	119	121	123	125	127	129	131	133
Heteropoda	134	136	137	138	139	140	142	143	144	145
Heteropoda, adjusted	135					141				146
Larvacea	147	148	149	150	151	152	154	155	156	157
Larvacea, adjusted						153				
Medusae	158	159	161	162	163	164	165	166	167	169
Medusae, adjusted		160							168	
Mysidacea	170	171	172	173	174	175	176	177	178	179
Ostracoda	180	182	184	186	188	190	192	194	196	198
Ostracoda, adjusted	181	183	185	187	189	191	193	195	197	199
Pteropoda	200	202	204	206	208	209	211	212	213	214
Pteropoda, adjusted	201	203	205	207		210				215
Radiolaria	216	217	218	219	220	221	222	224	225	226
Radiolaria, adjusted							223			
Siphonophora	227	229	230	231	232	233	234	235	236	238
Siphonophora, adjusted	228								237	
Thaliacea	239	240	241	242	243	245	247	249	250	252
Thaliacea, adjusted					244	246	248		251	

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APPENDIX I[1/]

Reliability of Laboratory Measurements

There are a number of possible sources of error in making the counts involved in this program: incorrect splitting of samples to obtain the aliquots, operator bias, differences in efficiency of counting different classes of organisms and differences in efficiency associated with differences in relative numbers.

The first two have been examined by having replicate counts done on the same sample. In five cases the same operator made the counts but was unaware the same sample was being recounted; in 17 cases, different operators counted the same sample and the second person did not know the sample had already been counted. The median number of categories counted in each sample was 12 (range: 9-16). The signed-ranks test was applied to the paired counts on each of the samples. All five of the cases involving two counts by the same person and 15 of the 17 involving two operators were non-significant at the 20% level. This probably represents random error because it is just over the expected number at this level, namely 1.1.

Six operators were involved in the preceding test. Examination of the paired counts in the 17 cases where two persons did the counts revealed only one operator whose counts were consistently below or above those of all others who counted the same sample. This operator, D, recorded counts that were on the average somewhat below those of her partners in 7 of 8 cases ($p = .10$). In no case was the operator sufficiently far below the partner to make the difference significant by the signed-ranks test. From these tests one can conclude that bias in sample splitting or in counting by the operators is no greater than would be expected as a result of random errors.

In order to determine whether the type of organism counted or its relative abundance had an effect on the counts, samples representing high, medium and low abundances of 10 classes of organisms were selected. Three replicate counts were done on each sample in such a manner that the operators did not know whether a sample had been counted before or not. In addition to the counts, weights were determined in the standard fashion. An analysis of variance was run on both sets of data. The average counts for the different classes of organisms ranged from 25 to 5532; the corresponding weights ranged from .029 to 1.924 grams. The average

[1/] Prepared by E. W. Fager, Scripps Institution of Oceanography.

counts for the three abundance classes of samples were 2623, 1026 and 47; the corresponding weights were 1.035, .864 and .047 grams. As was expected, mean squares for both of these factors and for their interaction were highly significant.

Only one of the total of six mean squares for replicates, type of organism, replicate interaction and abundance-replicate interaction was significant and this was at the 20% level. From these tests it may be concluded that neither the type of organism nor the relative abundance of the organisms have any significant effect on either the counts or the weights. The error mean square can, therefore, be used to set confidence limits for the observations. In order to make these most useful, the analyses were rerun with the data transformed to logarithms, 95% confidence limits were calculated and then transformed to antilogarithms. The results indicate that conservative 95% confidence limits for both counts and weights are given by 0.45 and 2.20 times the observed value. These account only for the variability introduced in the laboratory handling of the samples and do not include any that may have been introduced by the sampling procedures in the field.

APPENDIX II[1]

Relationship of Length to Weight, California Current Region

Ocular[2] Micrometer Units	No./gm
Amphipods	
10	1023
20	376
30	159
40	101
50	64
60	48
70	29
80	26
90	14
100	10
110	7
Chaetognaths	
20	6994
30	3808
40	2168
50	1522
60	762
70	614
80	425
90	330
100	253
110	200
120	142
130	110
140	75
150	61
160	44
170	40
180	34
190	31
200	27
210	23
220	18
230	16
240	14
250	13
260	11
270	9
280	6
290	5
Cladocerans	
3	11731
6	3921
Copepods	
5	5814
10	1873
15	698
20	254
25	123
30	70
35	50
40	31
Crustacean larvae	
(a) Anomuran Zoea	
3	752
5	254
10	162
15	146
20	128
25	111
30	100
(b) Brachyuran Zoea	
4	3403
7	2762
10	949
13	500
15	200
25	65
(c) Megalopa	
15	500
20	235
30	105
40	68
50	39
60	23
Ctenophores	
Usually weighed	
"Decapods"	
(a) Galatheids	
30	286
40	125
50	36
60	28
70	18
80	15
90	10
(b) Hoplocarids	
8	1368
20	775
30	253
40	217
50	157
60	83

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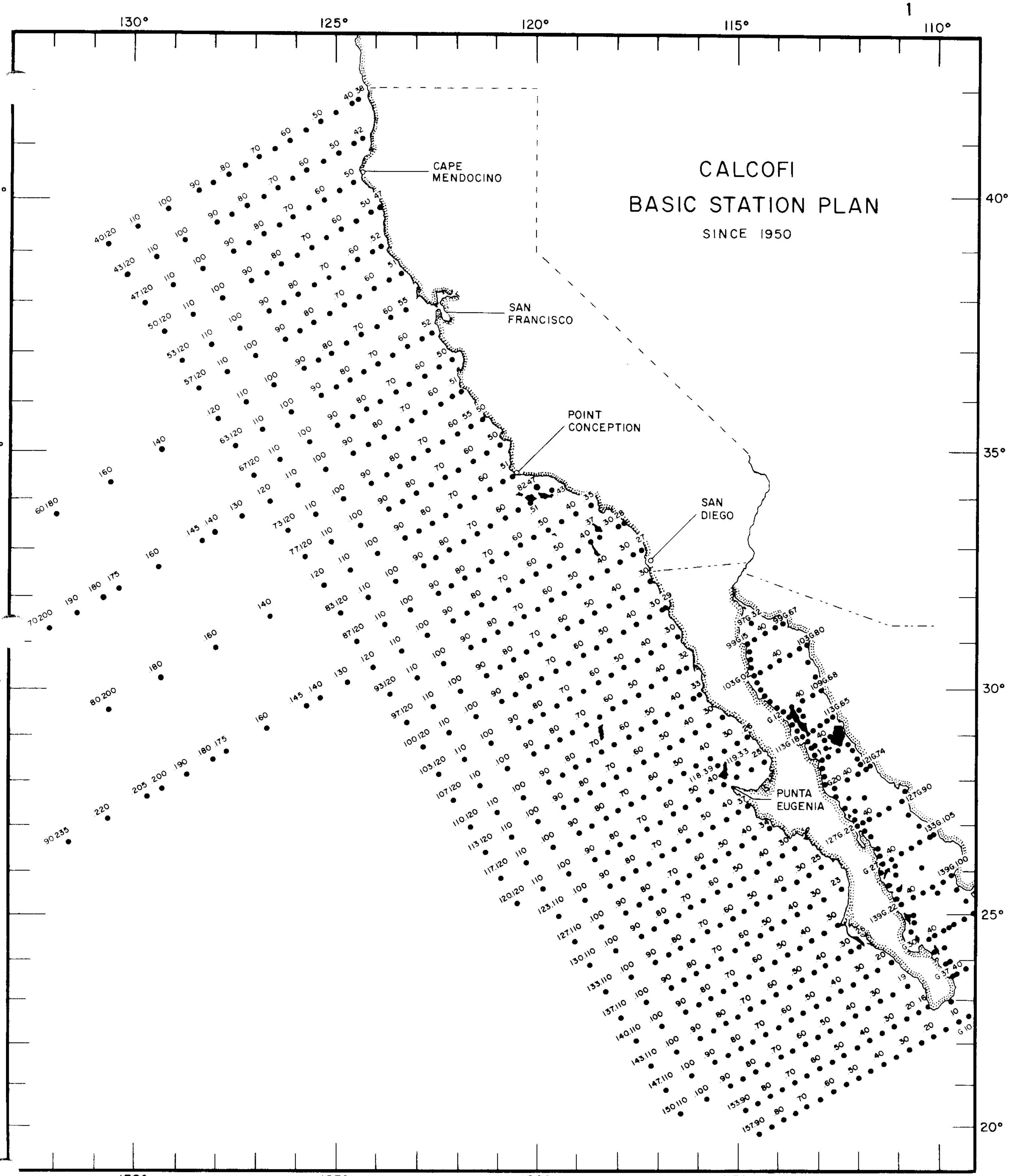
[1] This table was prepared by J. K. Miller and is based upon 1-gram samples of each size category of a functional group sorted from a variety of plankton collections characterized by pronounced diversity in species and in developmental stages.
[2] One Ocular Micrometer Unit = 0.167 mm at 7X magnification.

Ocular Micrometer Units	No./gm
70	71
80	50
90	40
(c) Natantians	
5	7143
15	1744
25	765
35	539
45	379
55	147
65	54
75	42
85	29
95	20
105	18
115	15
125	13
135	11
145	8
155	7
165	6
175	5
185	4
195	3
205	2
215	1.5
250	1
Euphausiids	
5	11111
10	6243
15	4200
20	1426
25	930
30	778
35	451
40	308
50	175
55	125
60	99
65	89
70	60
80	45
90	31

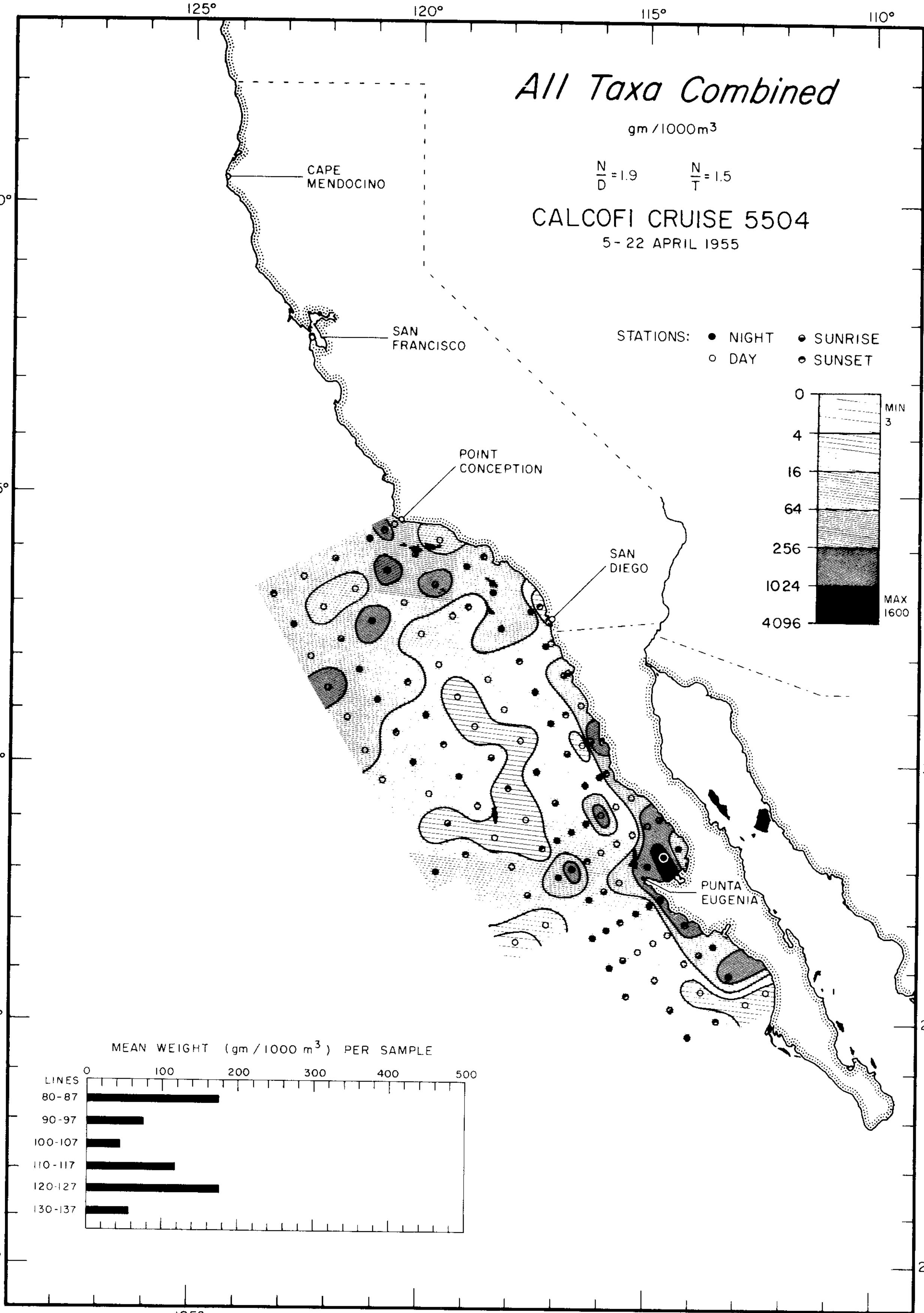
Ocular Micrometer Units	No./gm
100	21
110	17
120	13
130	10
140	8
150	7
160	6
170	5
210	4
240	3
270	2
300	1
330	1
360	1
390	1
Heteropods	
5	7000
10	2147
15	941
20	525
30	375
40	222
50	185
60	158
70	105
80	83
90	61
100	48
Larger forms usually weighed	
Larvaceans	
10 - 15	13200
15 - 20	7173
20 - 25	5200
25 - 30	3848
30 - 35	2564
35 - 40	2197
40 - 50	1923
50 - 60	405
60 - 70	267
Medusae	
Usually weighed	

Ocular Micrometer Units	No./gm
Mysids	
15	5400
25	3420
35	2500
45	1075
55	625
65	300
75	154
85	133
95	48
110	15
Ostracods	
5	3465
10	1496
15	501
20	341
25	96
30	87
Pteropods	
5	3520
10	1444
15	910
20	327
25	185
30	140
35	122
40	100
45	62
50	42
55	33
Radiolarians	
4	5106
5	3998
6	2431
Thaliaceans	
Usually weighed	
Siphonophores	
Usually weighed	



CALCOFI

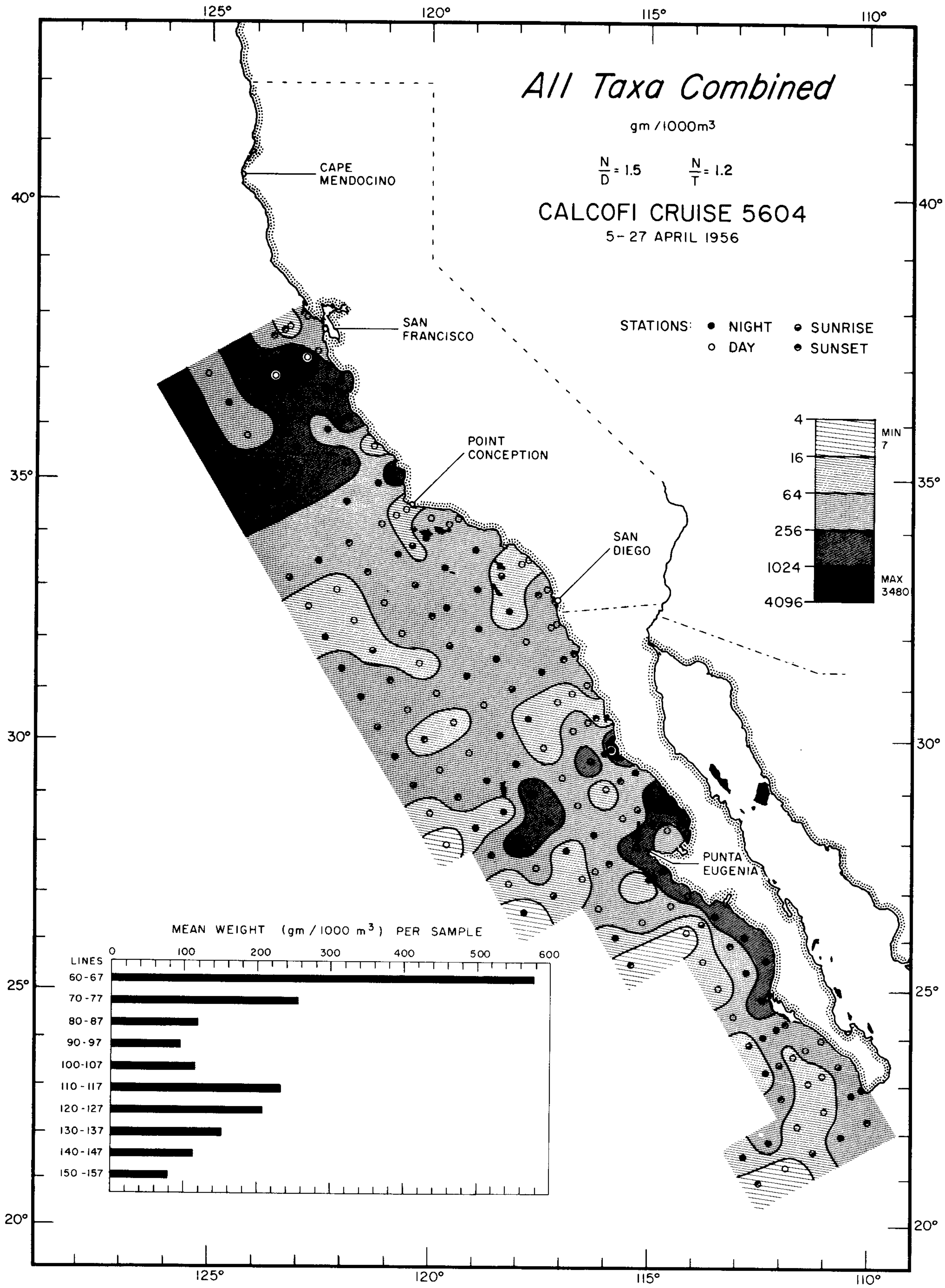
BASIC STATION PLAN
SINCE 1950



Biomass

All Taxa Combined

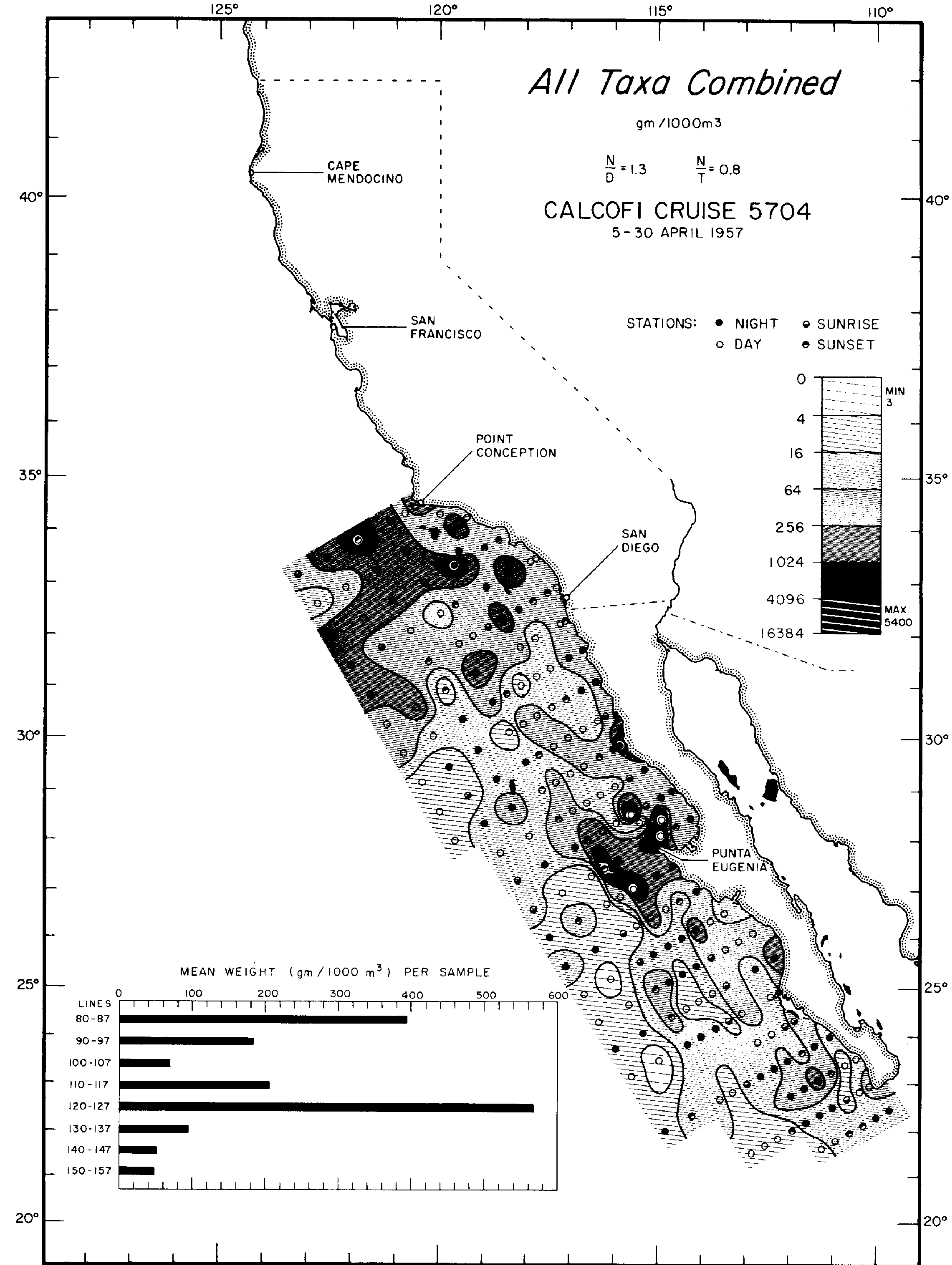
5504



Biomass

All Taxa Combined

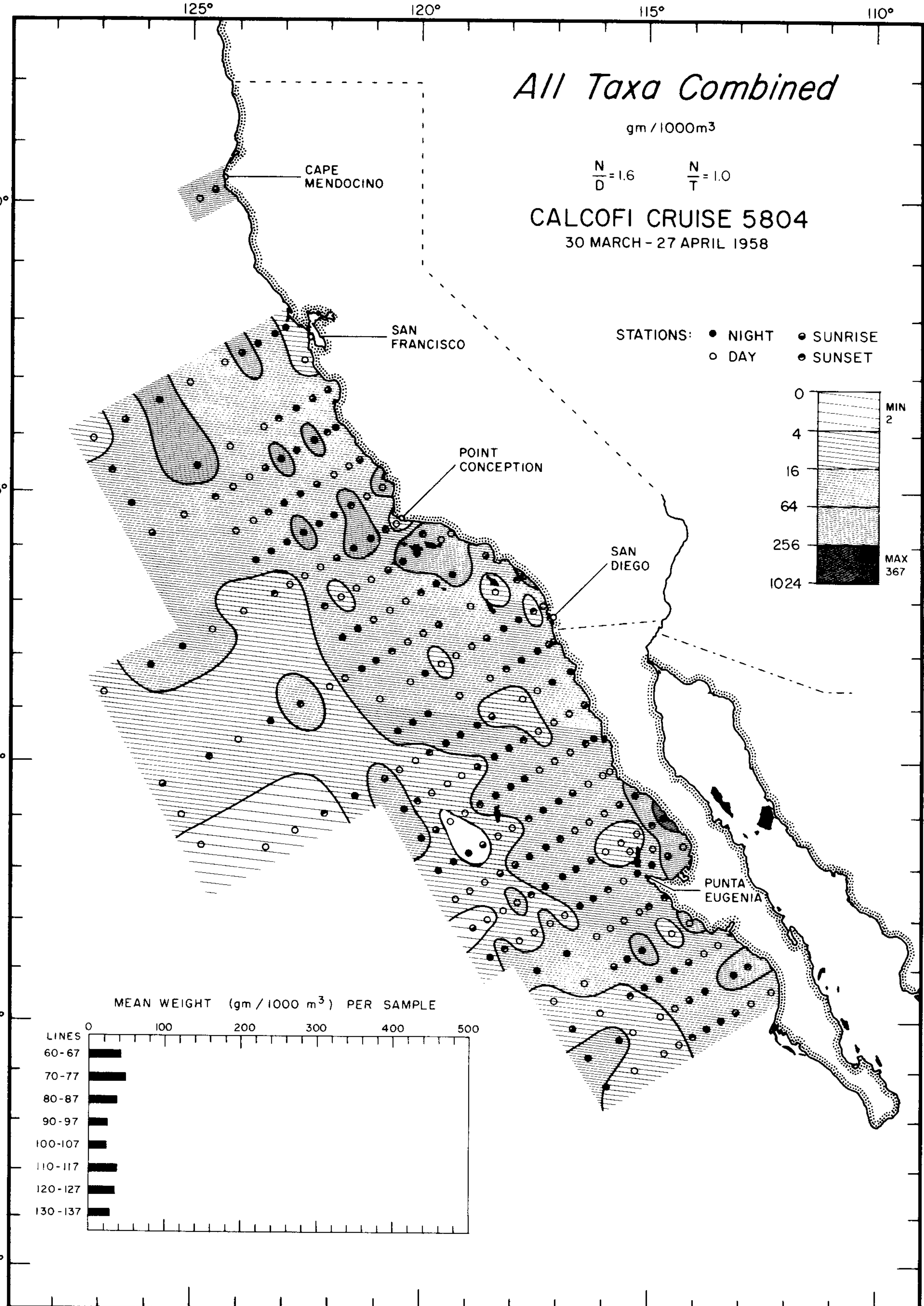
5604



Biomass

All Taxa Combined

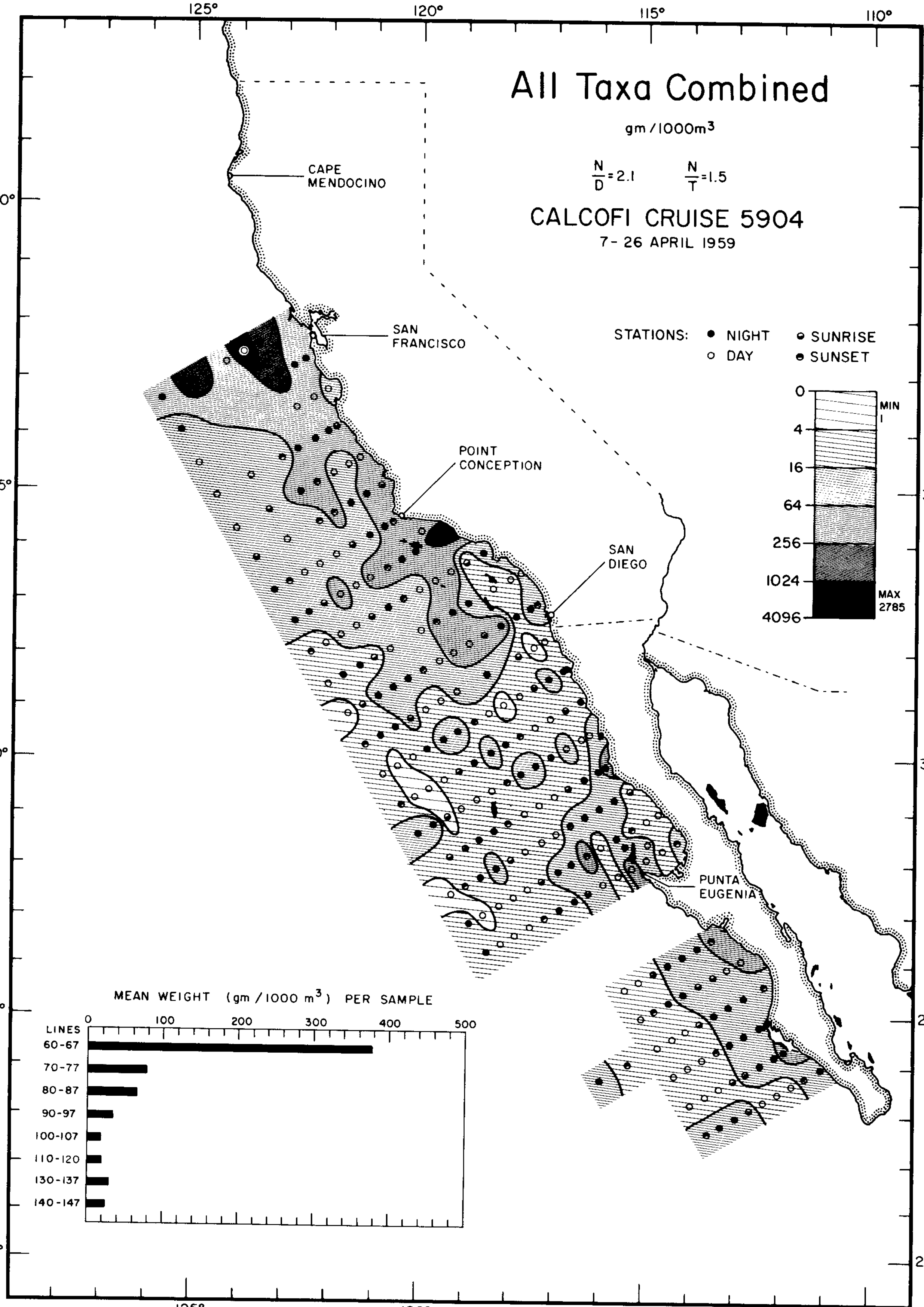
5704



Biomass

All Taxa Combined

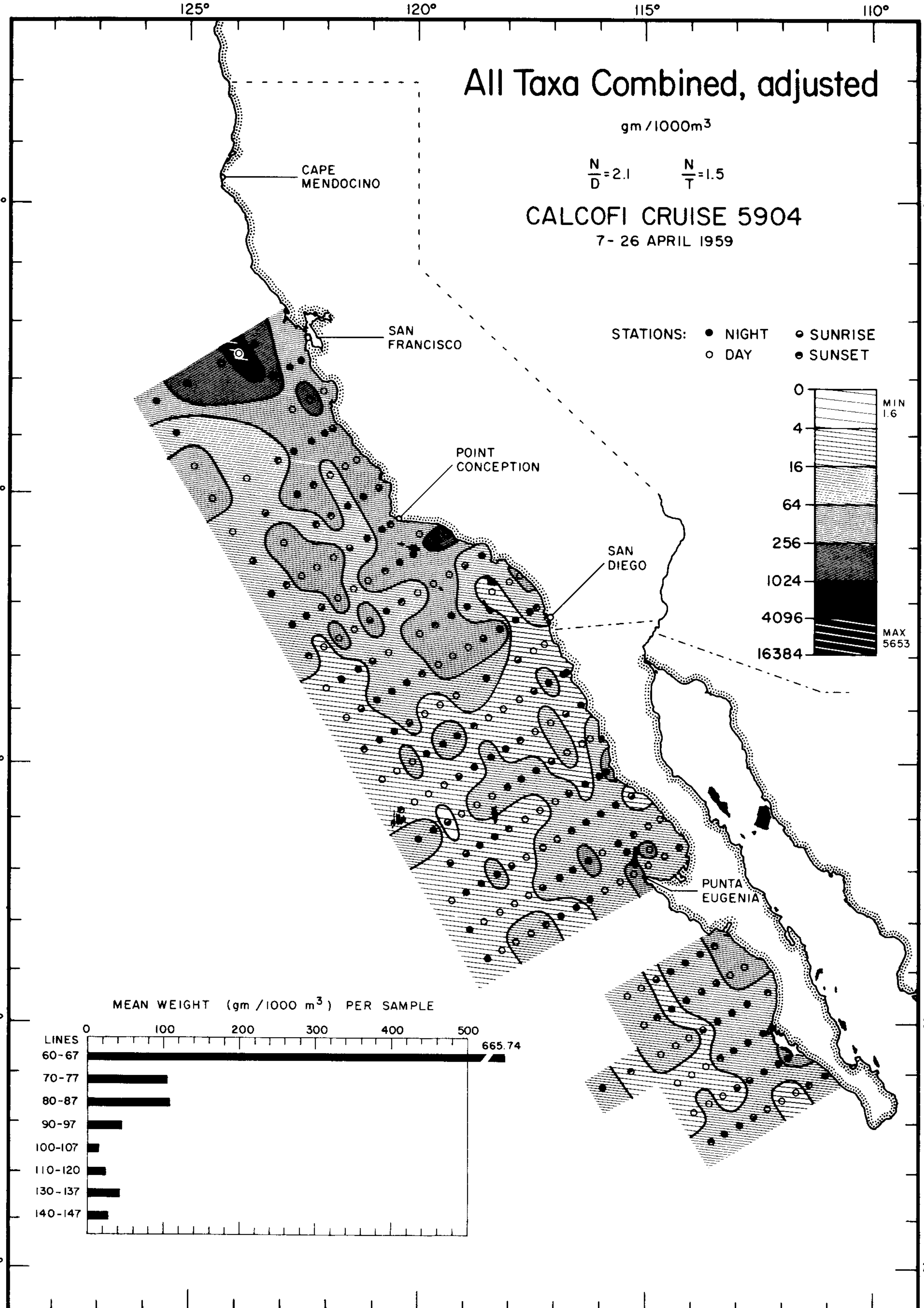
5804



Biomass

All Taxa Combined

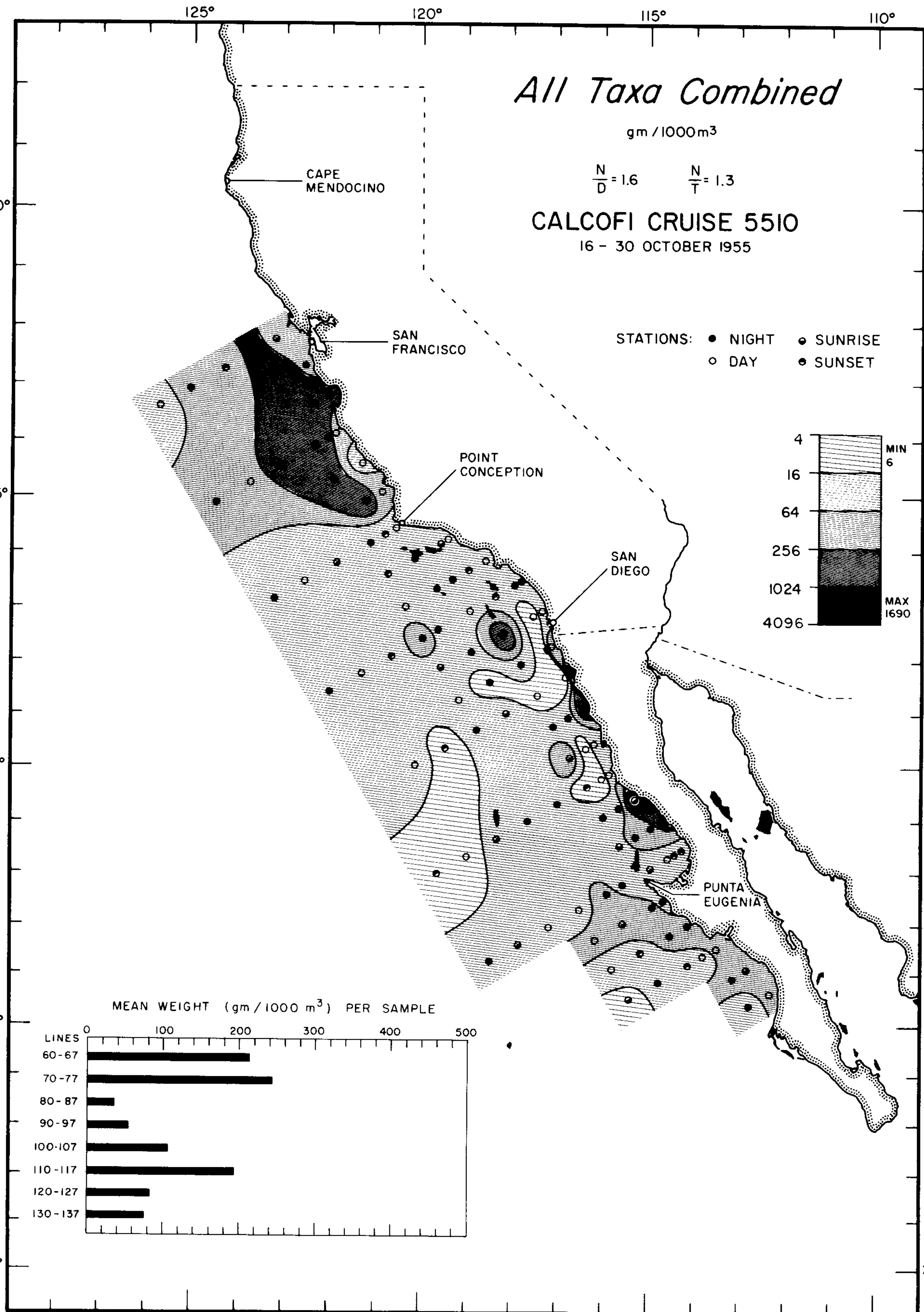
5904



Biomass

All Taxa Combined, adjusted

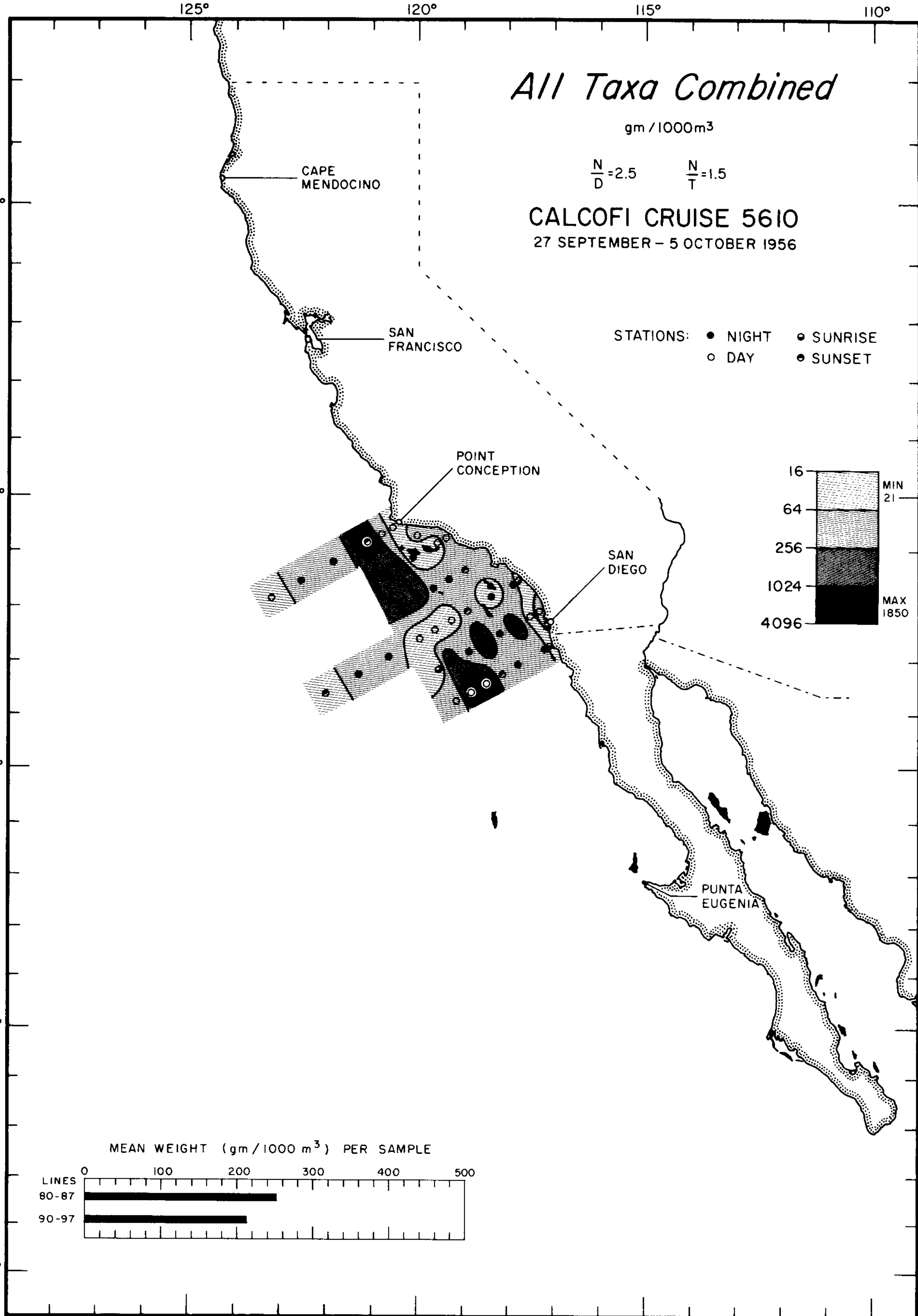
5904



Biomass

All Taxa Combined

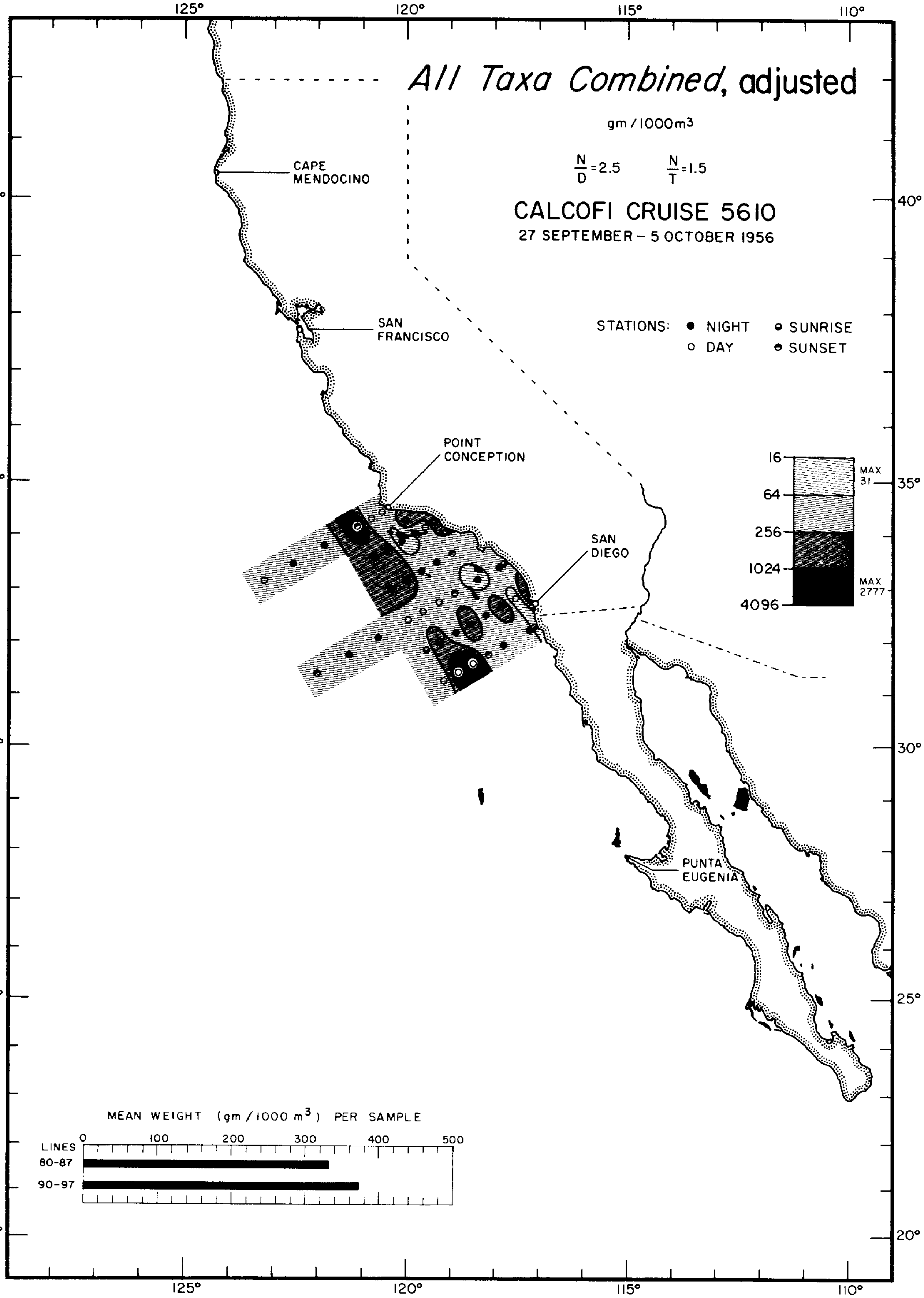
5510



Biomass

All Taxa Combined

5610



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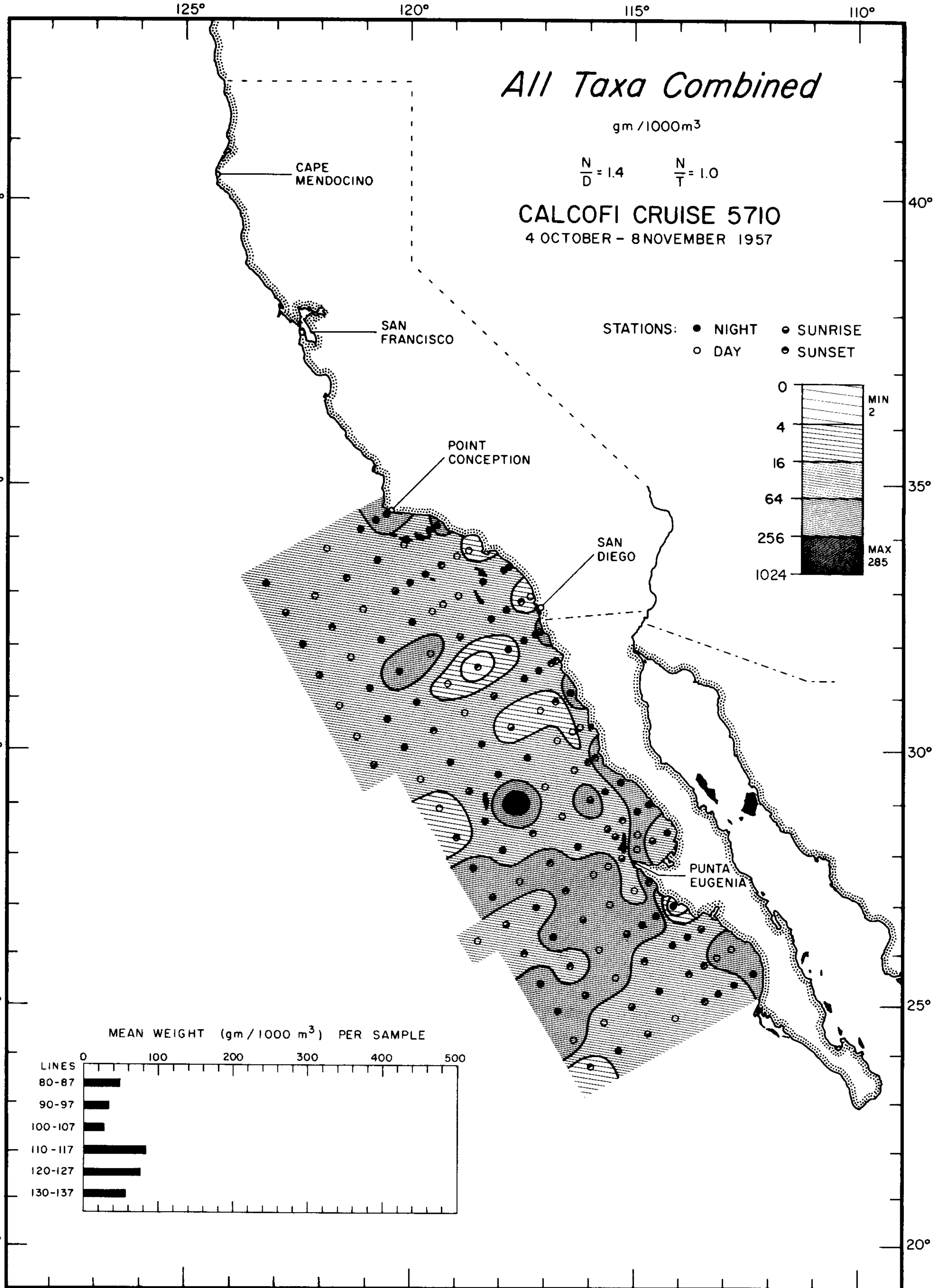
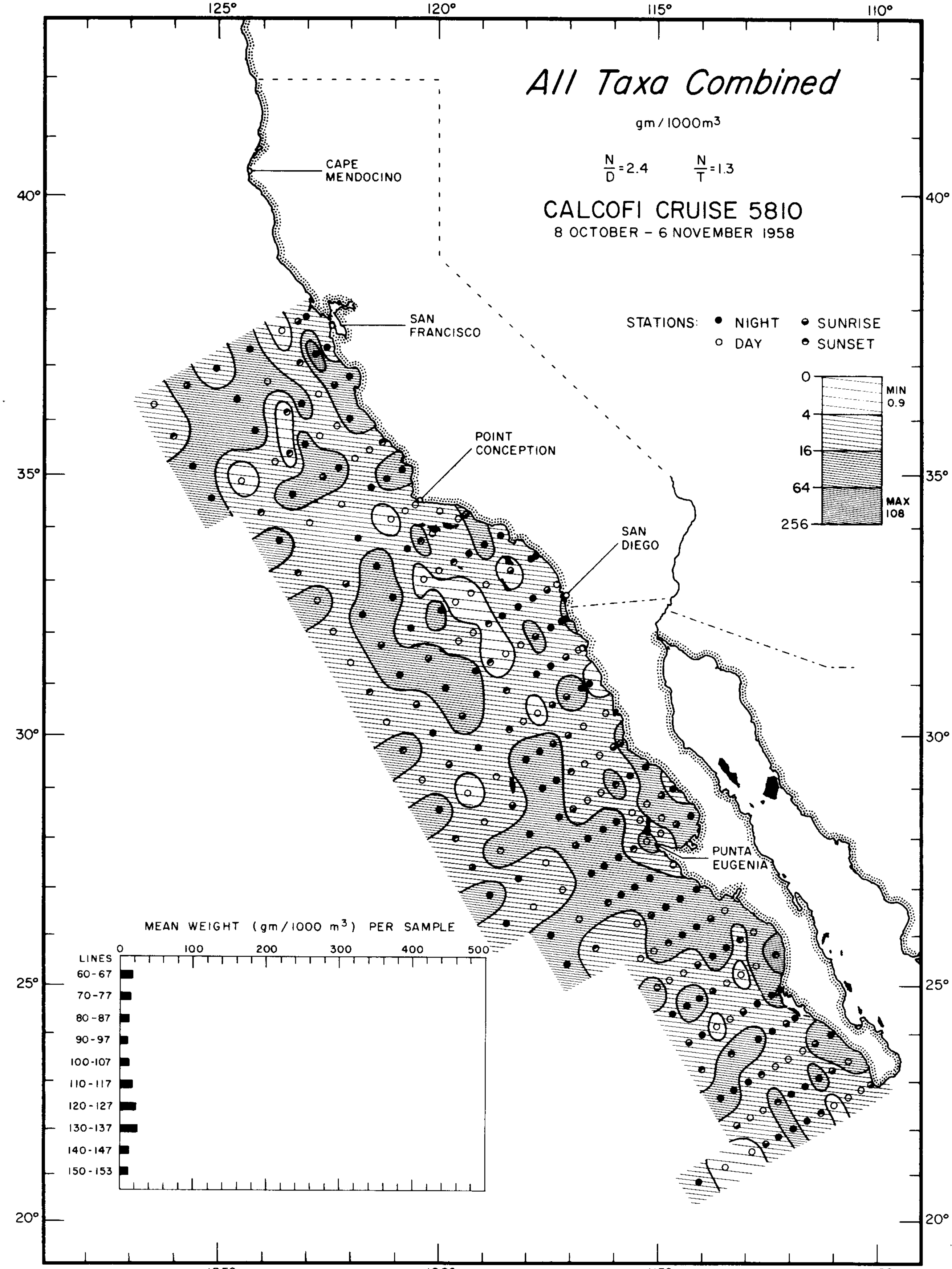
All Taxa Combined, adjusted

5610



Biomass
All Taxa Combined
5710



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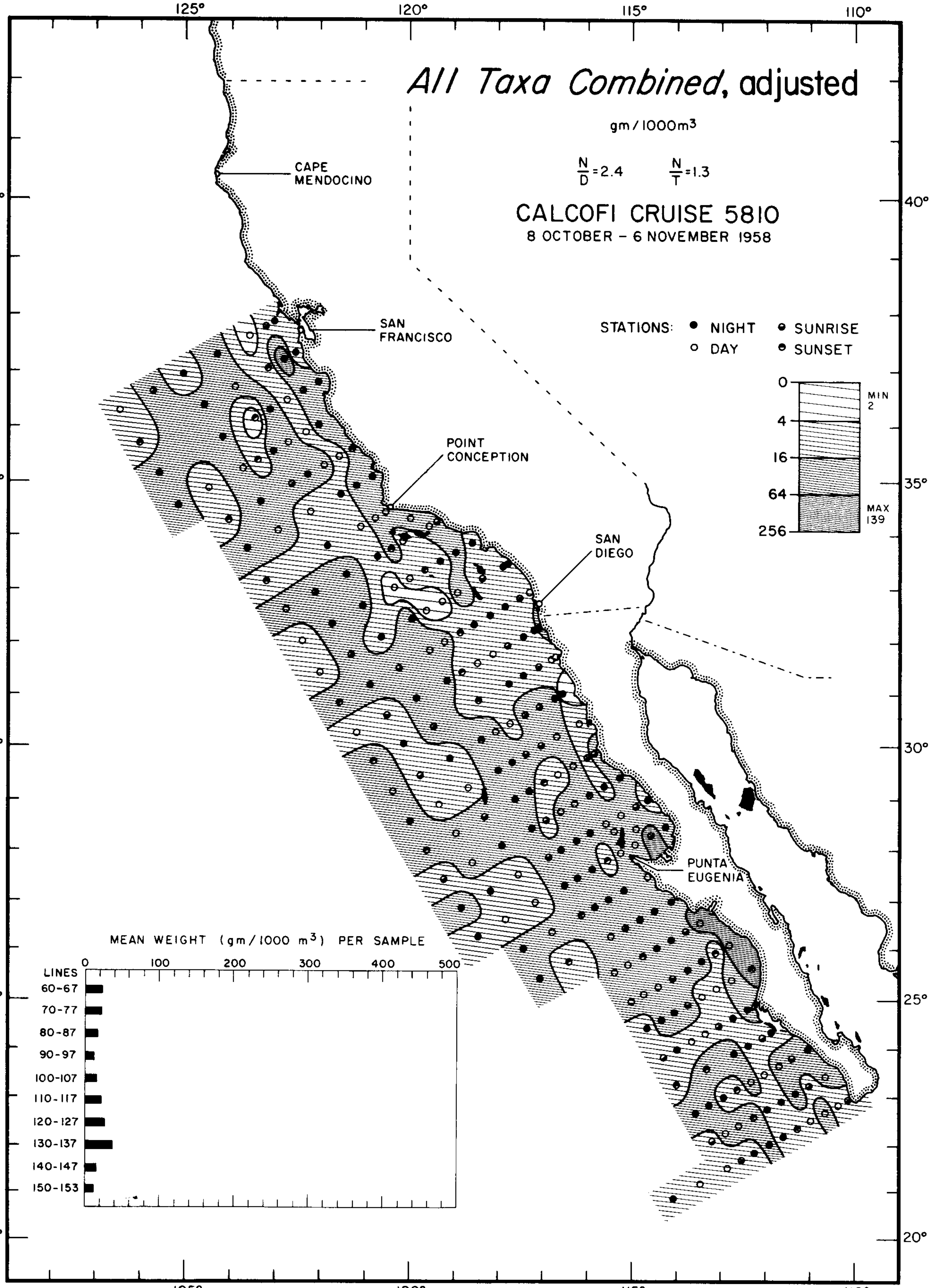
All Taxa Combined

5810



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All Taxa Combined, adjusted

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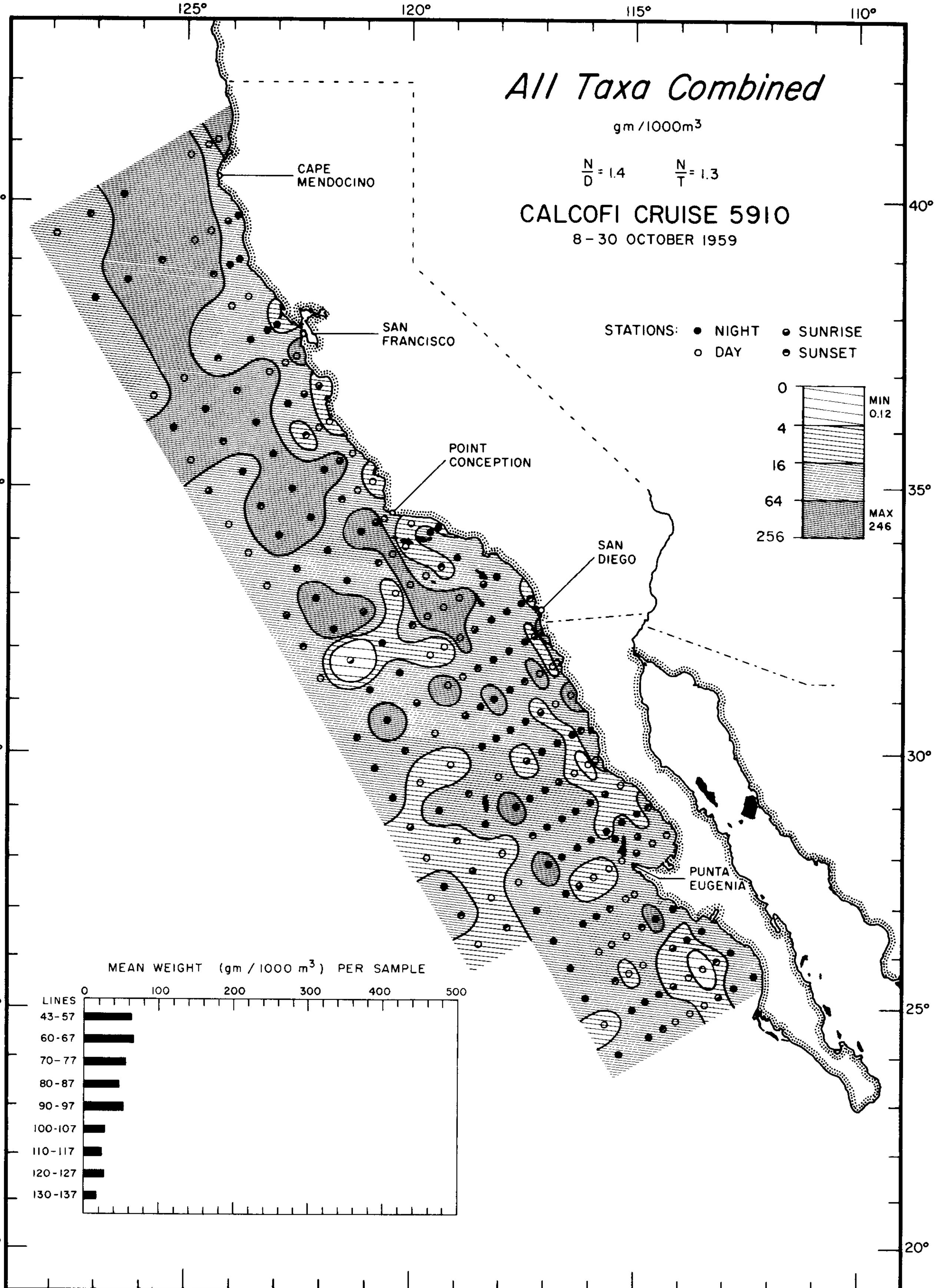
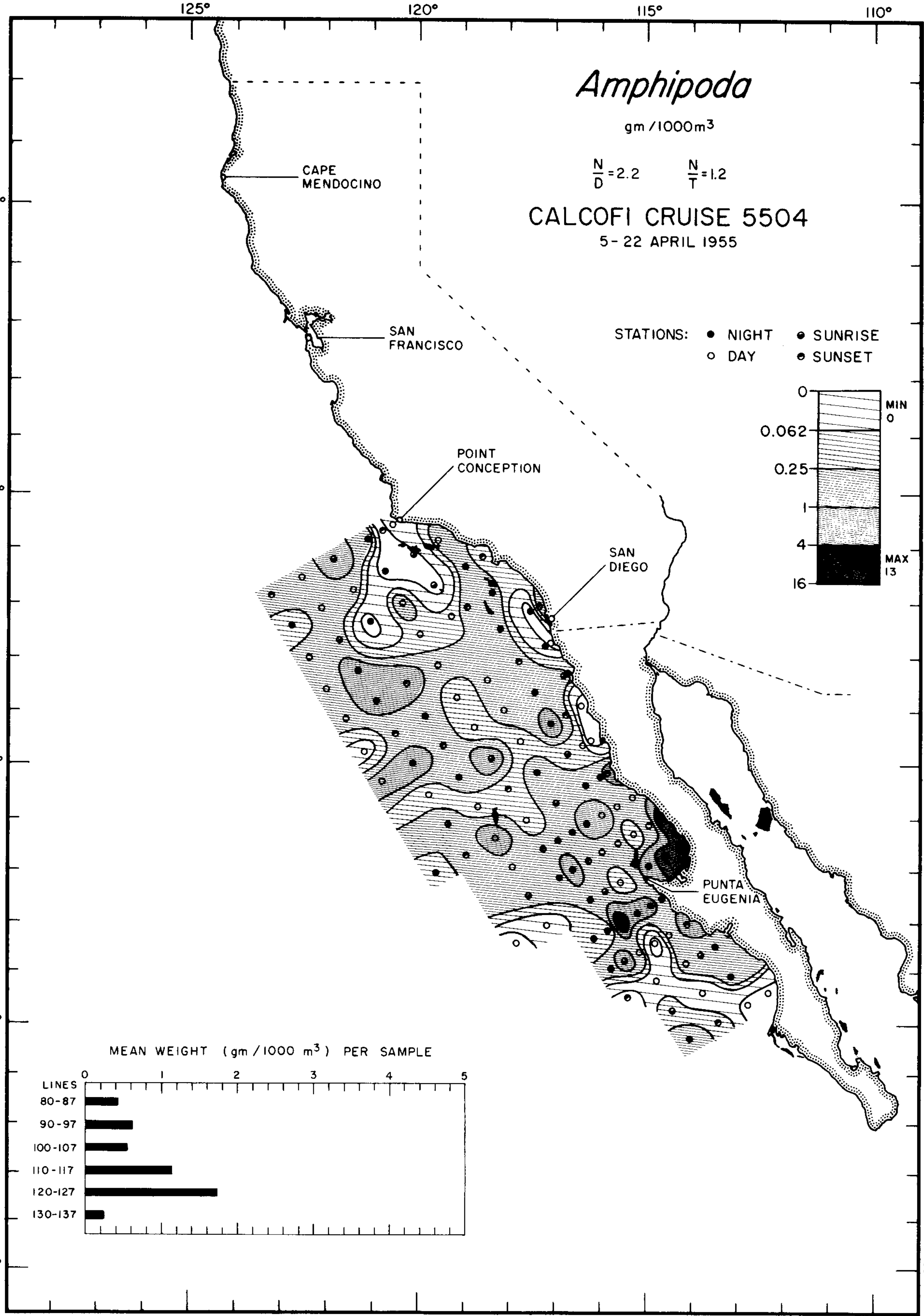


Biomass

All Taxa Combined

5910



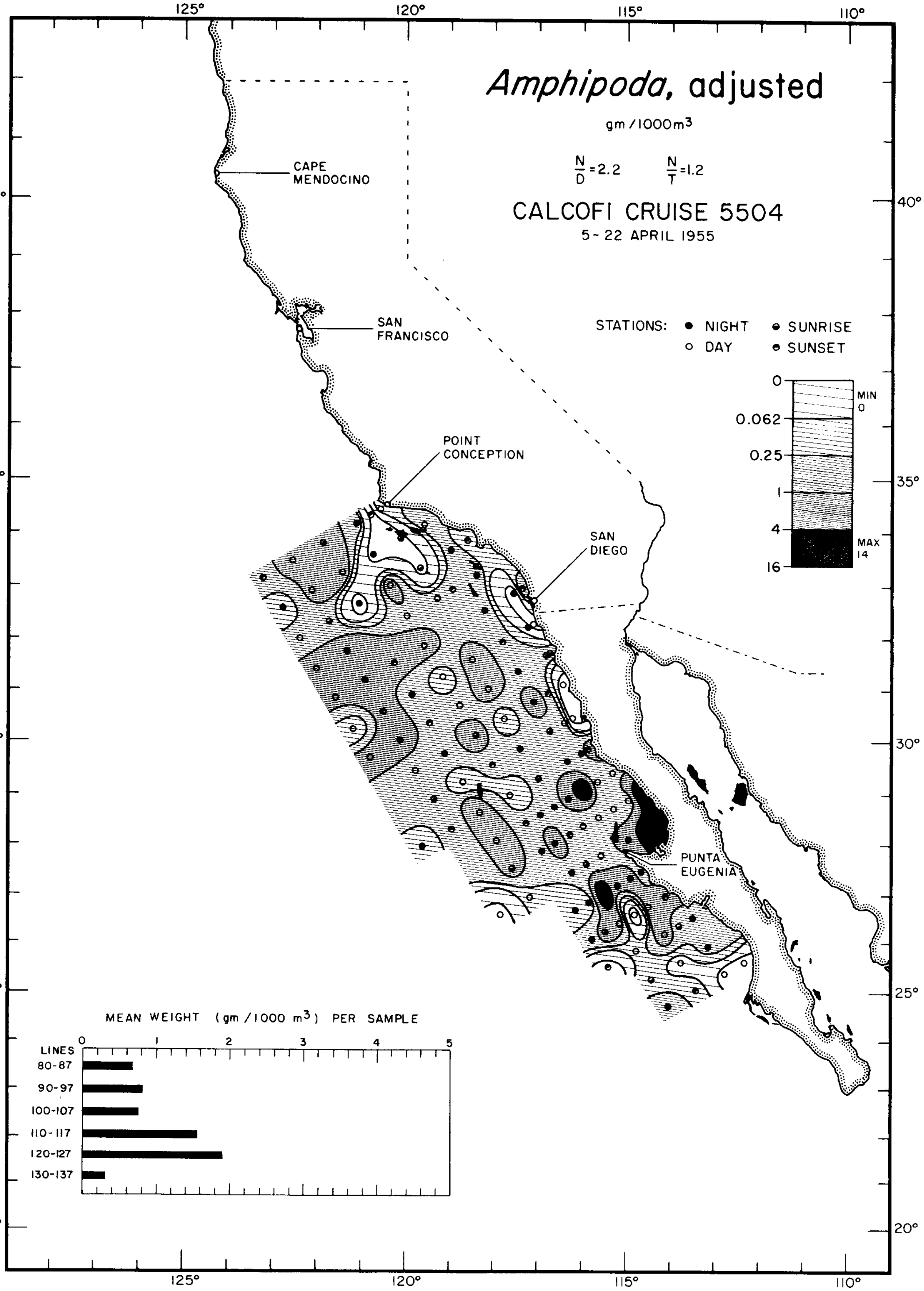
0.7 % 100

98 gm/1000m3 12801

Biomass

Amphipoda

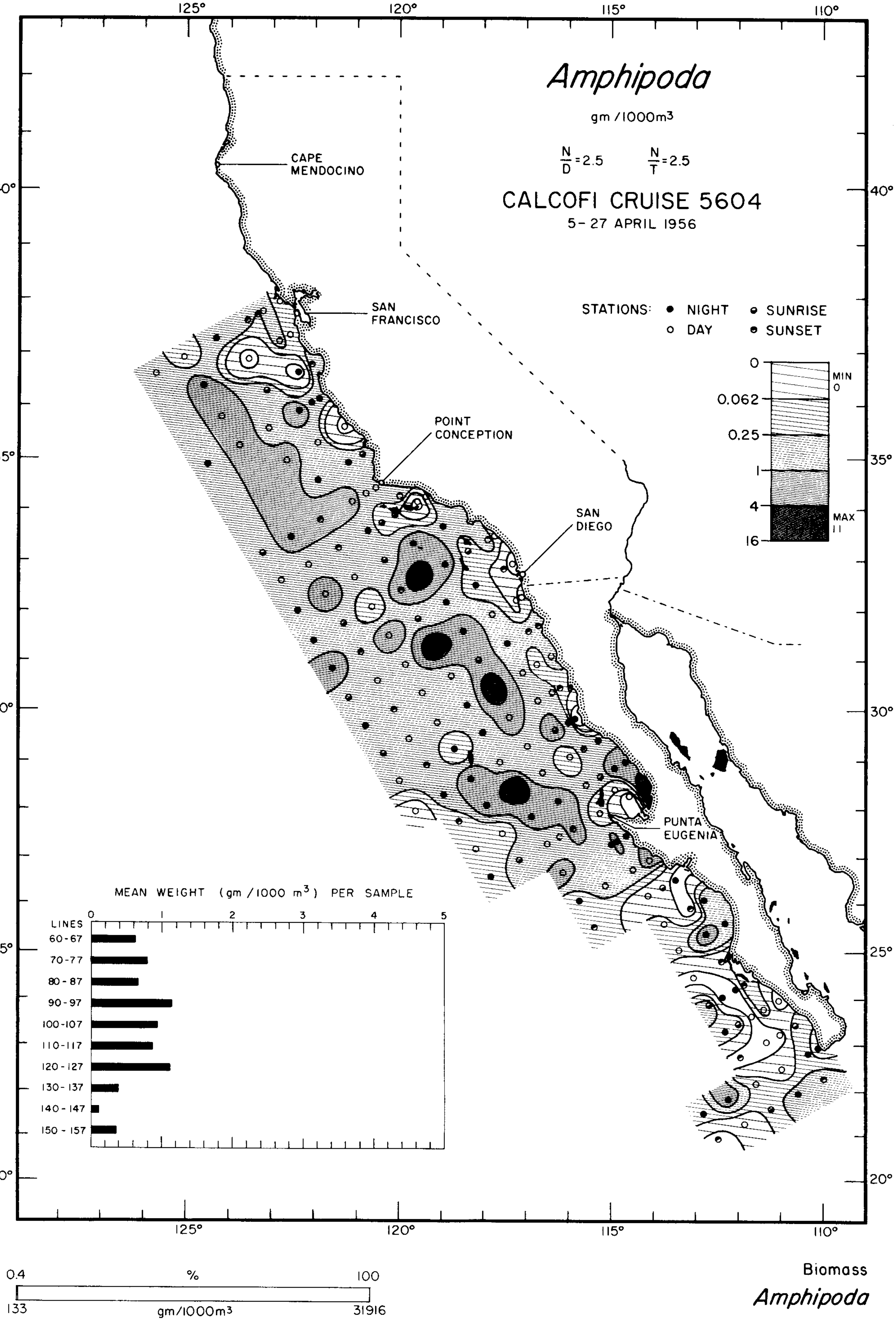
5504



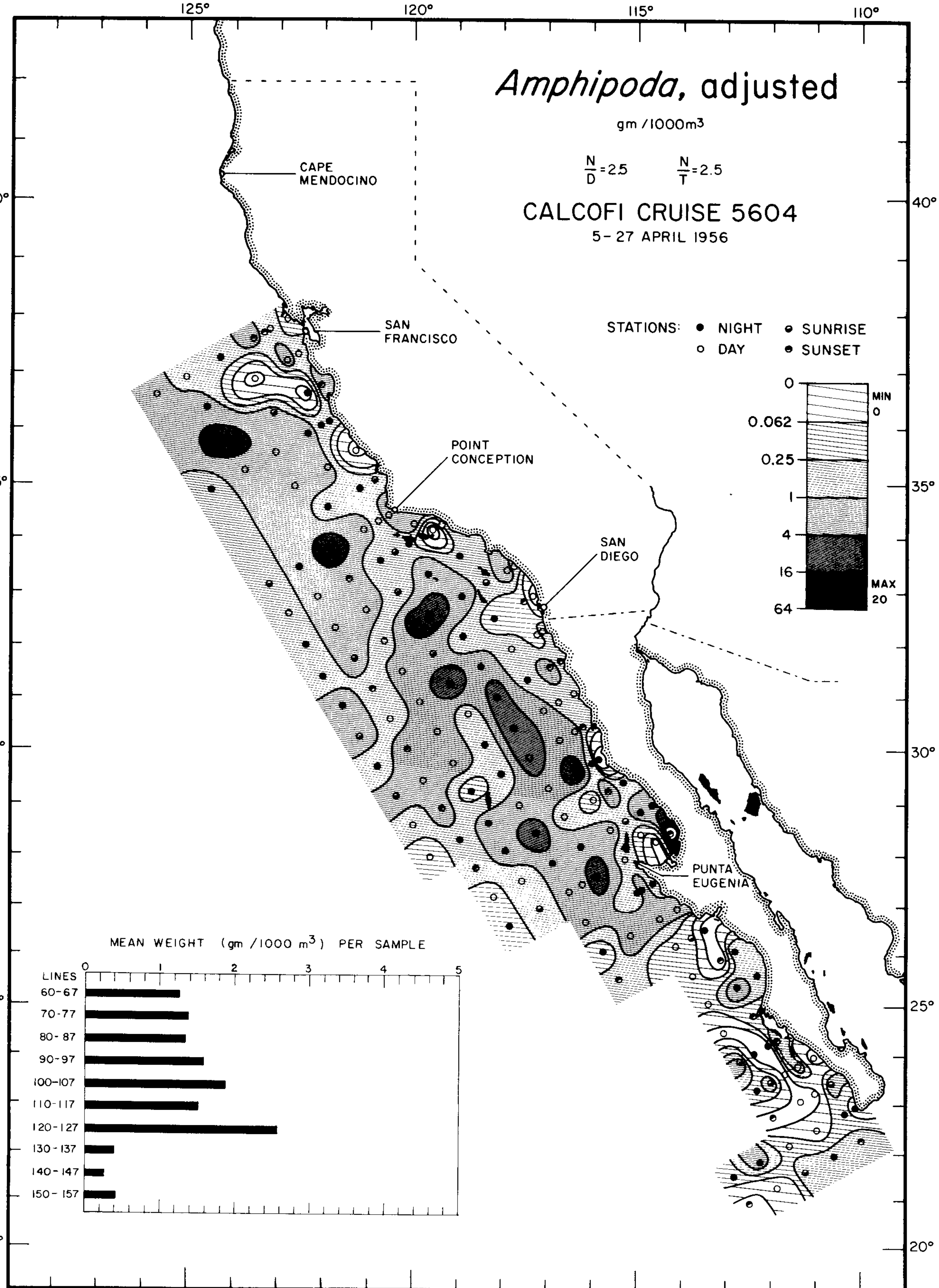
Biomass

Amphipoda, adjusted

5504



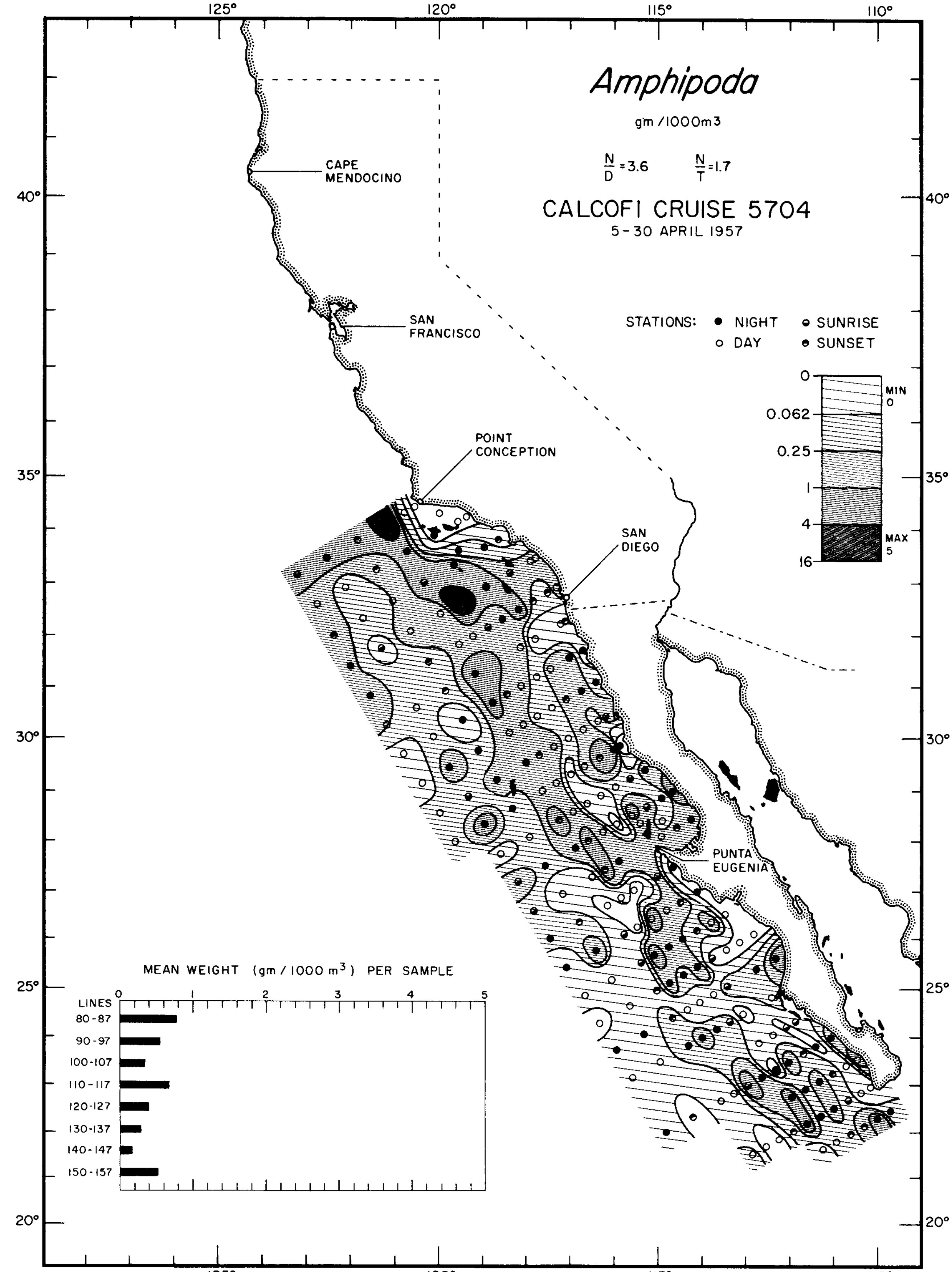
Biomass
Amphipoda
5604

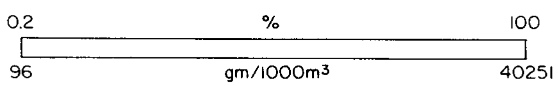


Biomass

Amphipoda, adjusted

5604

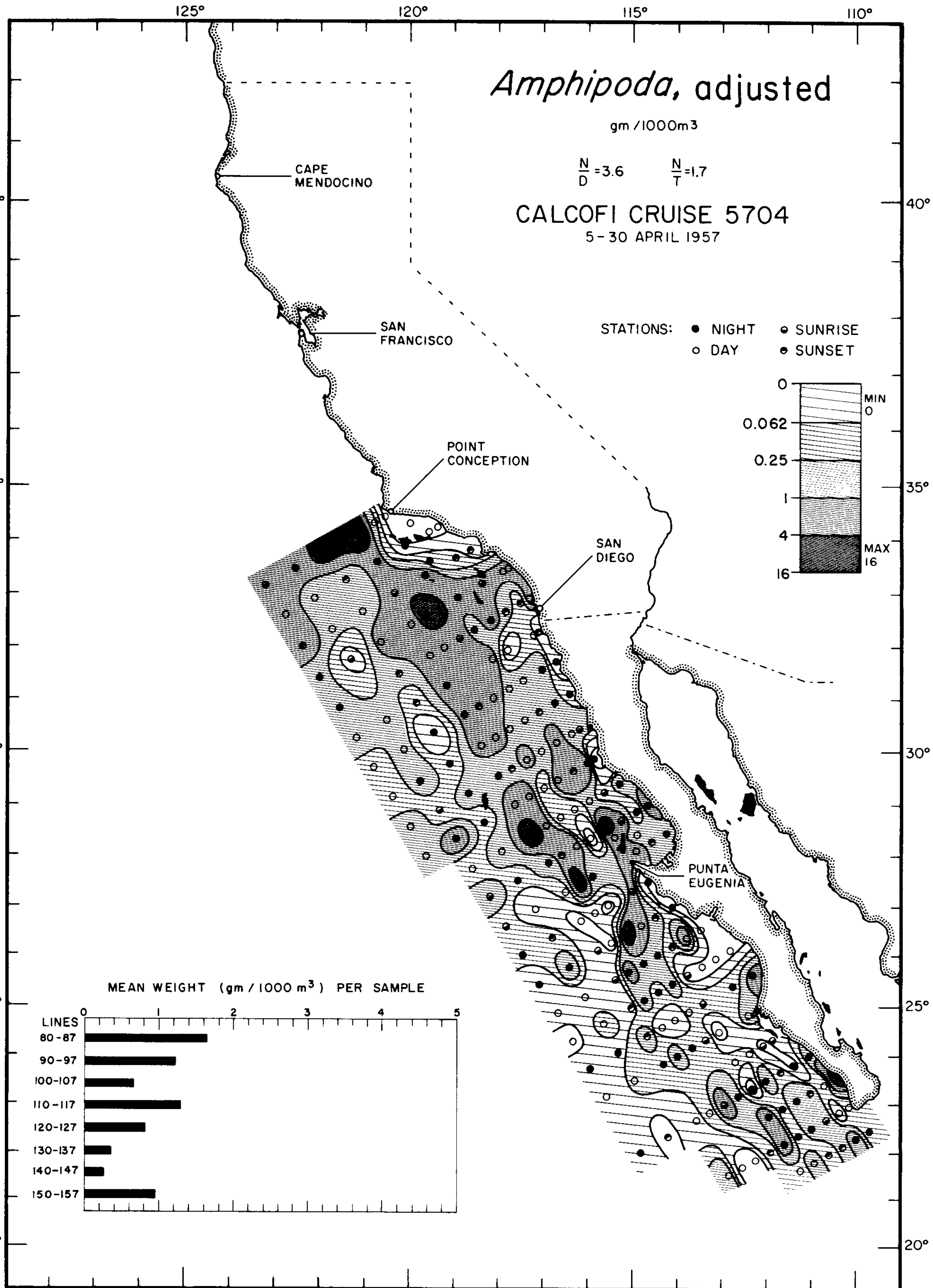




Biomass

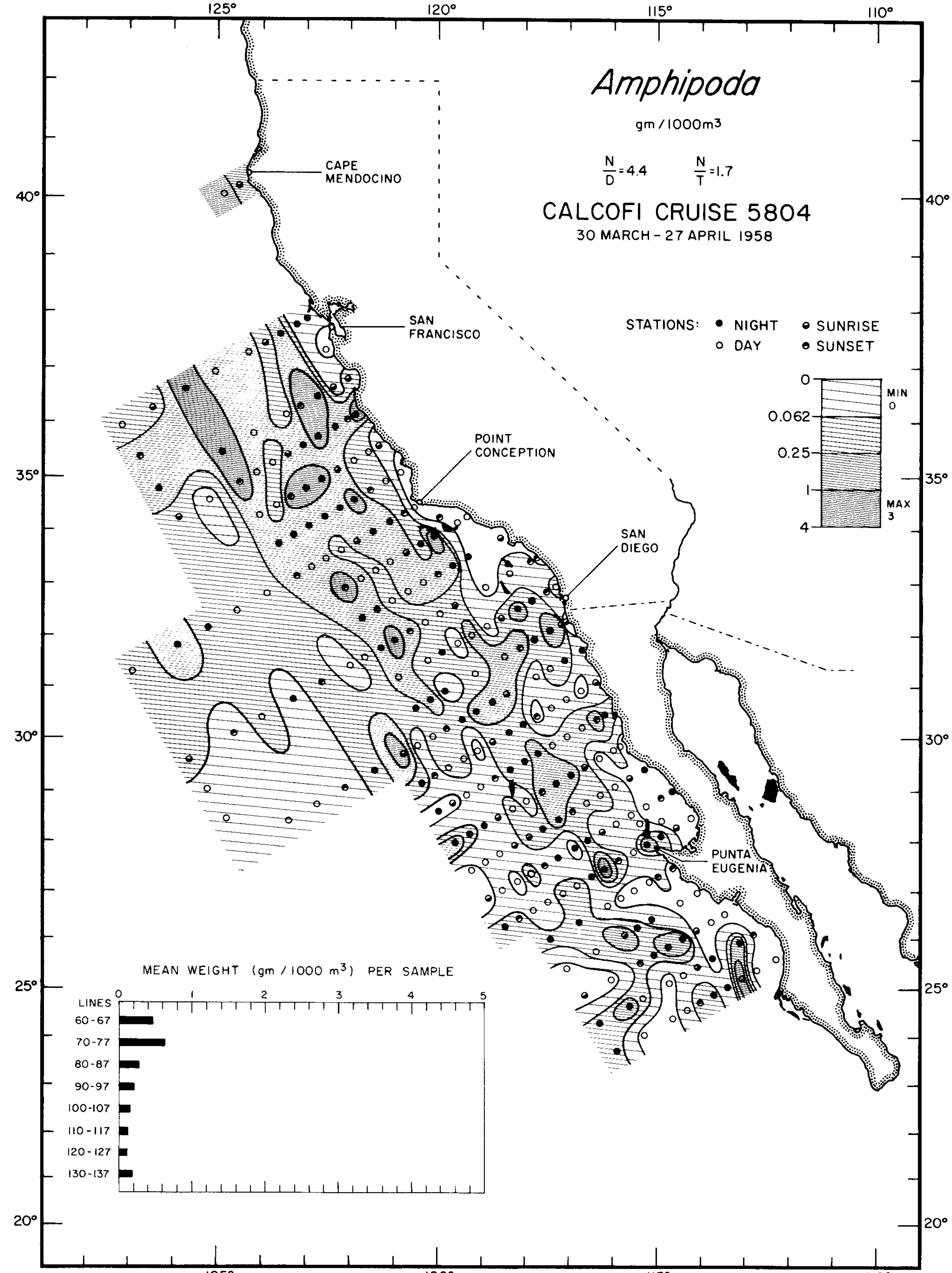
Amphipoda

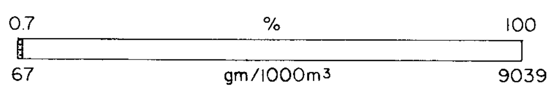
5704



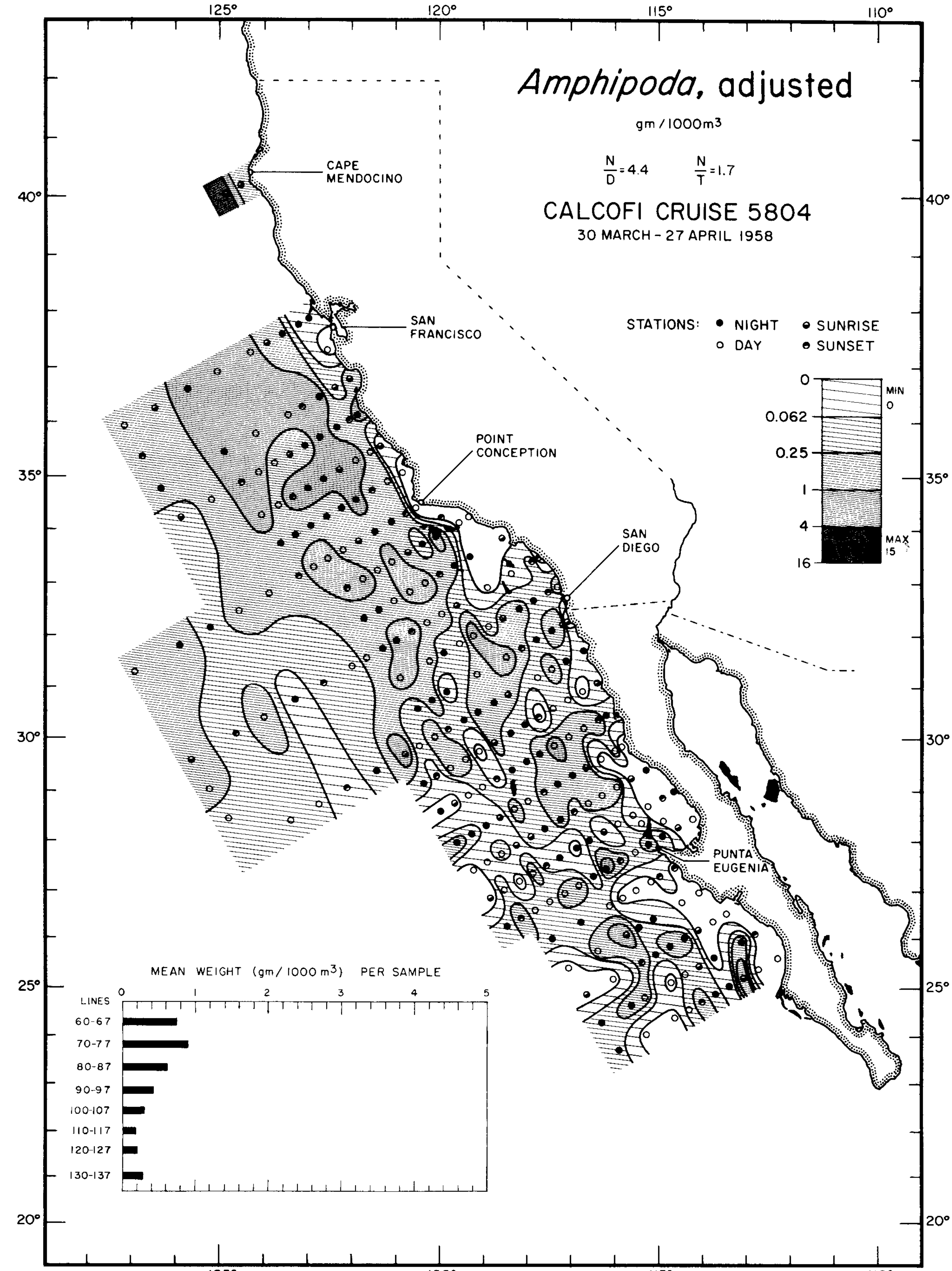
Biomass

Amphipoda, adjusted
5704





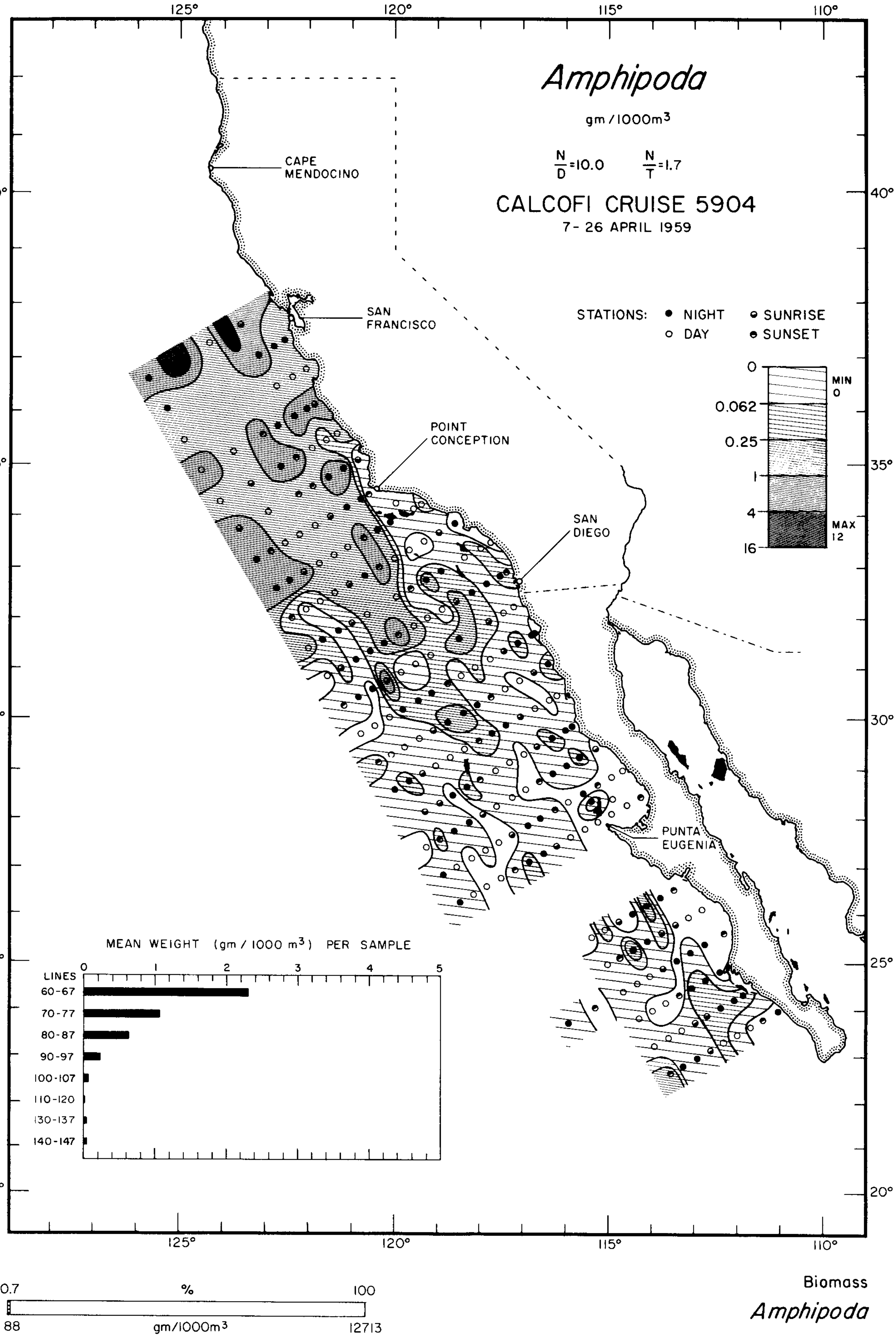
Biomass
Amphipoda
5804



Biomass

Amphipoda, adjusted

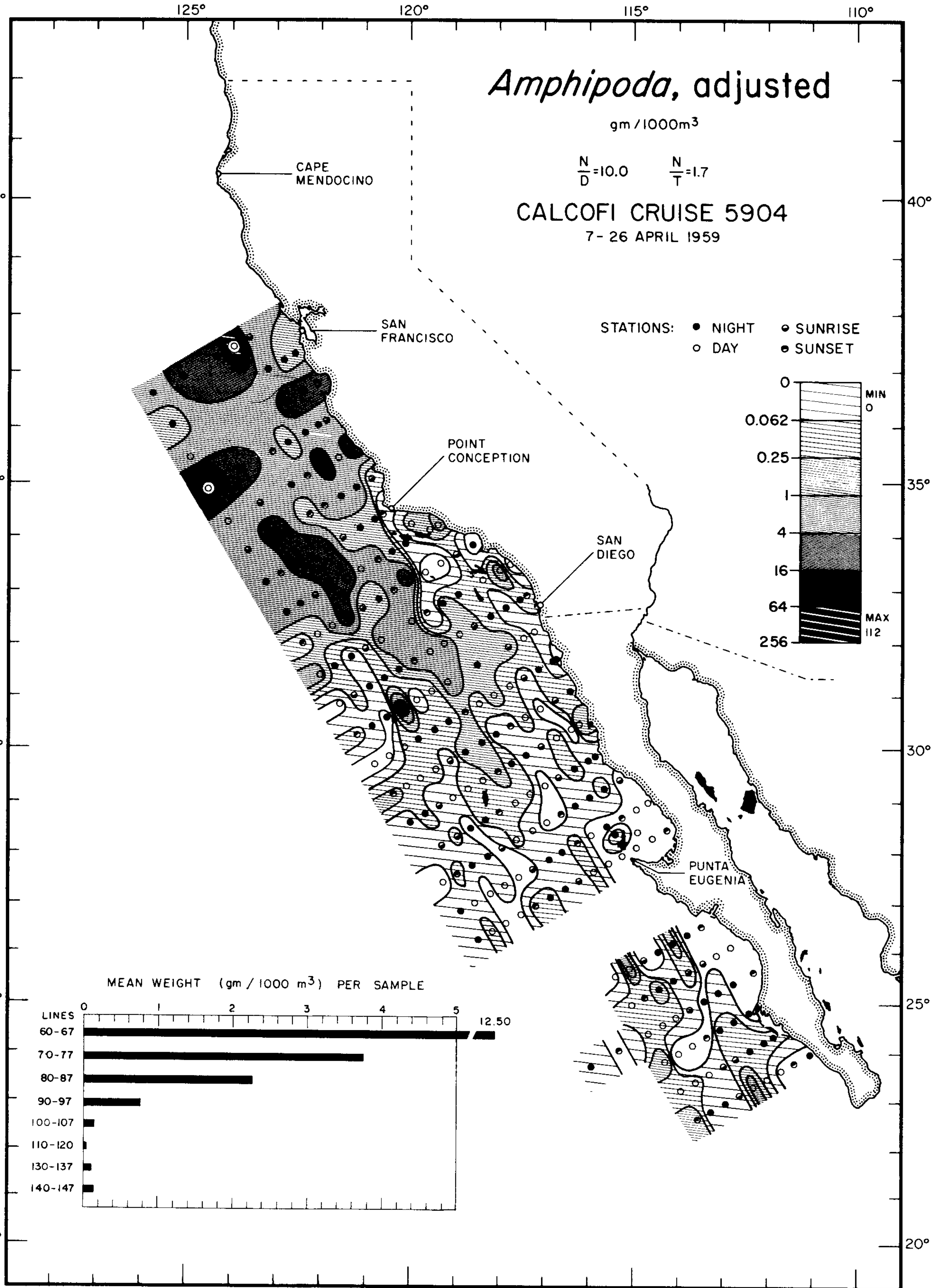
5804



Biomass

Amphipoda

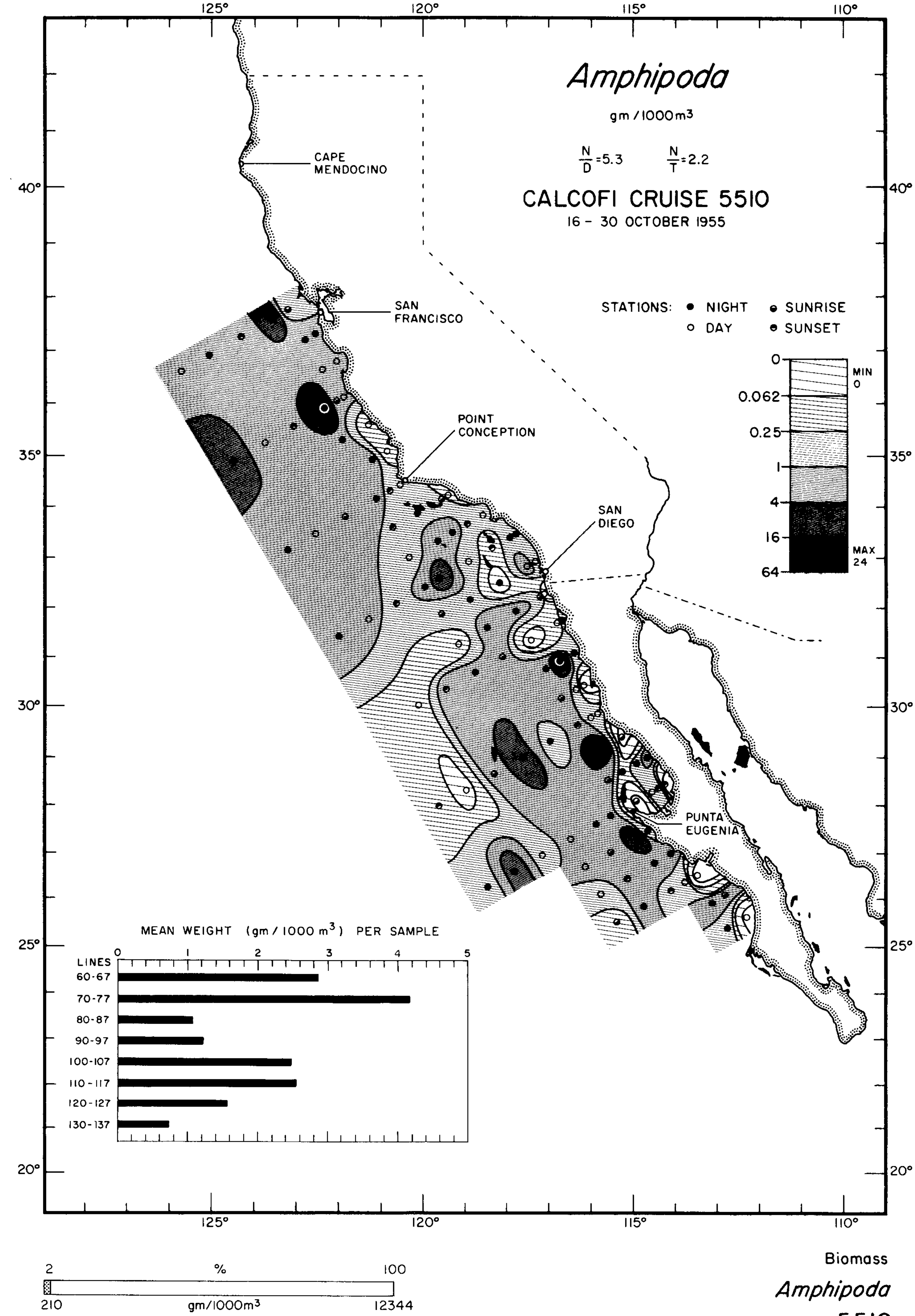
5904



Biomass

Amphipoda, adjusted

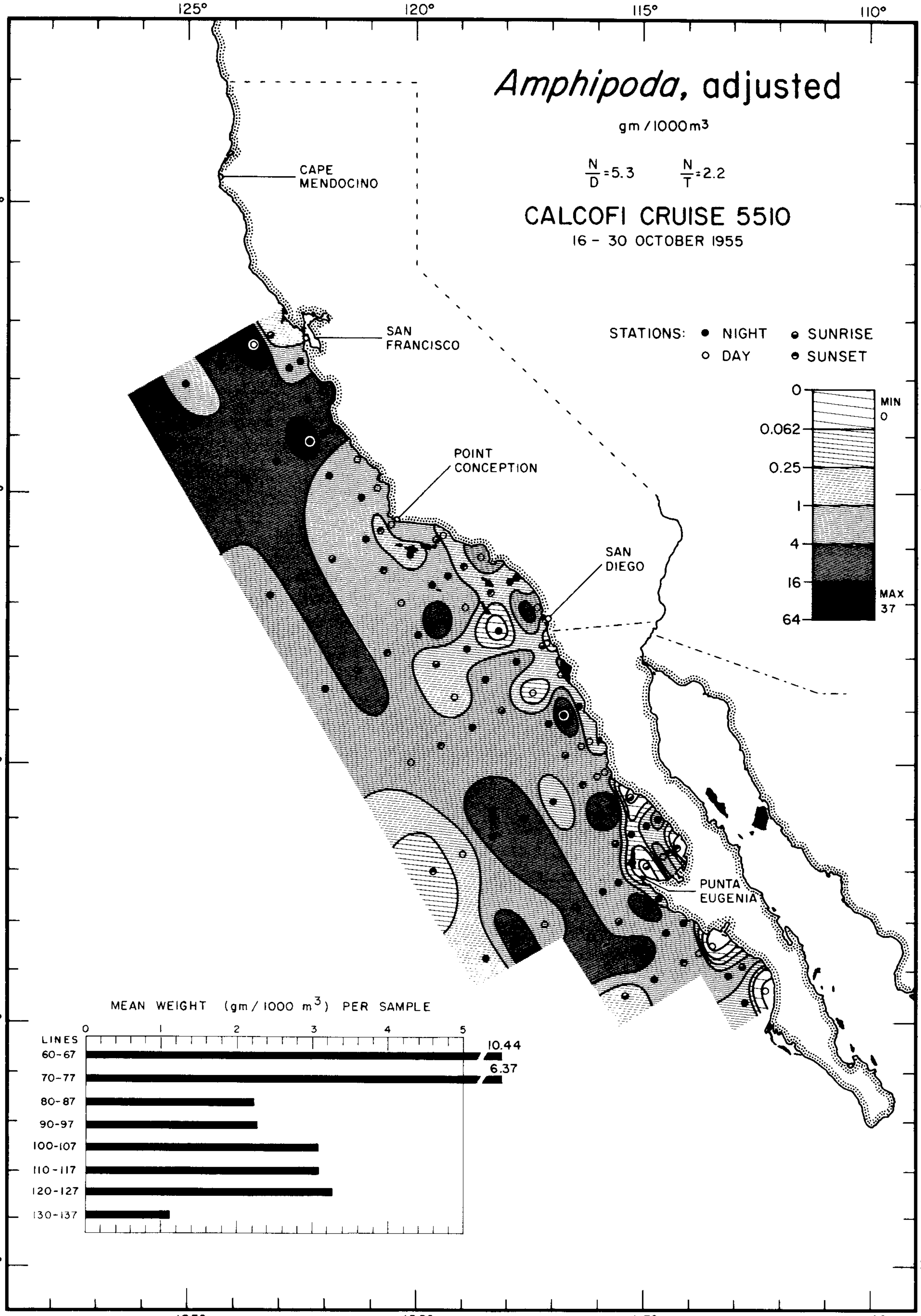
5904



Biomass

Amphipoda

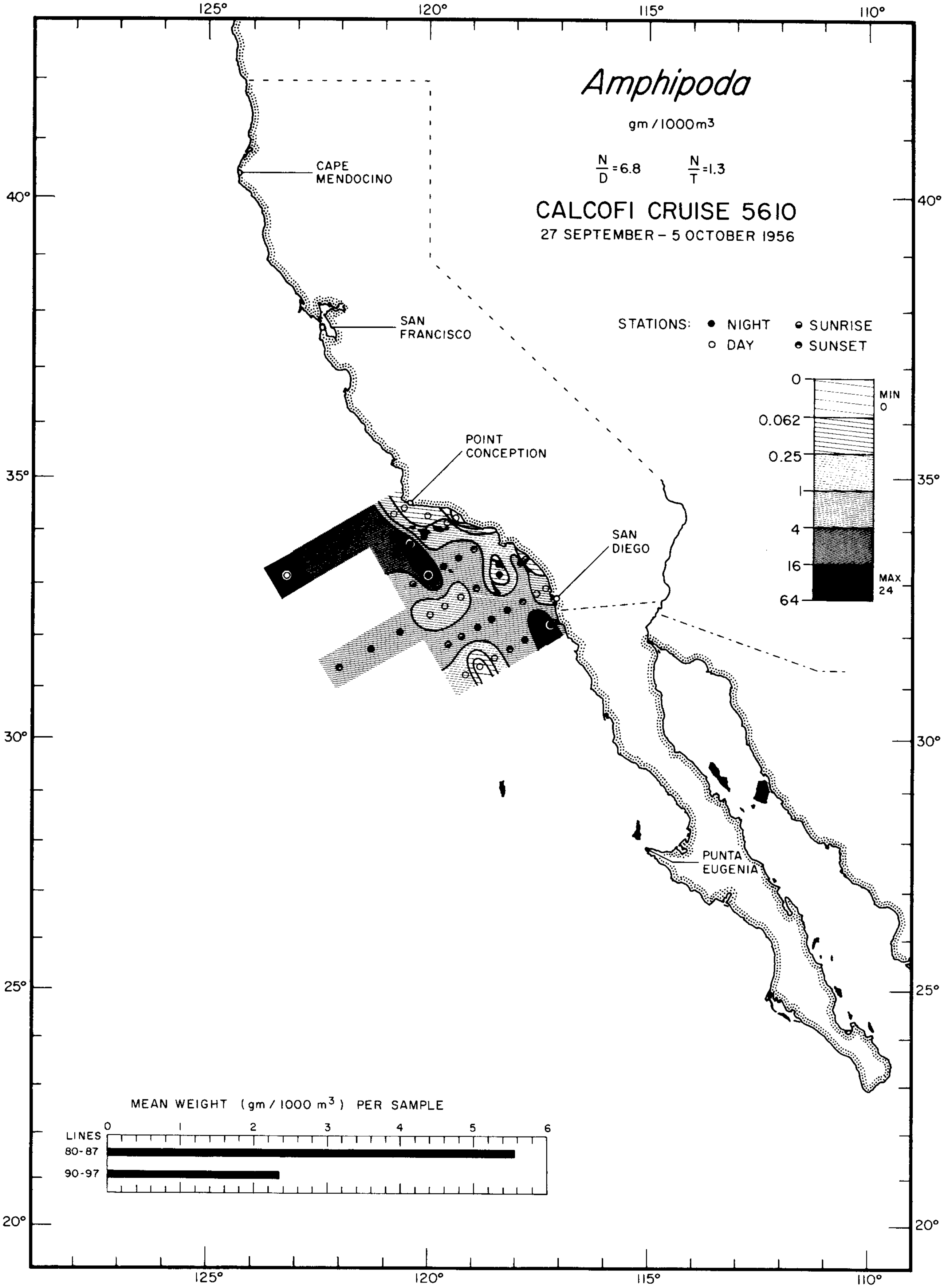
5510

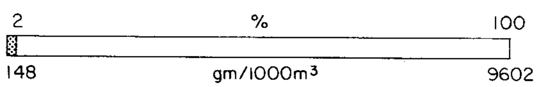


Biomass

Amphipoda, adjusted

5510

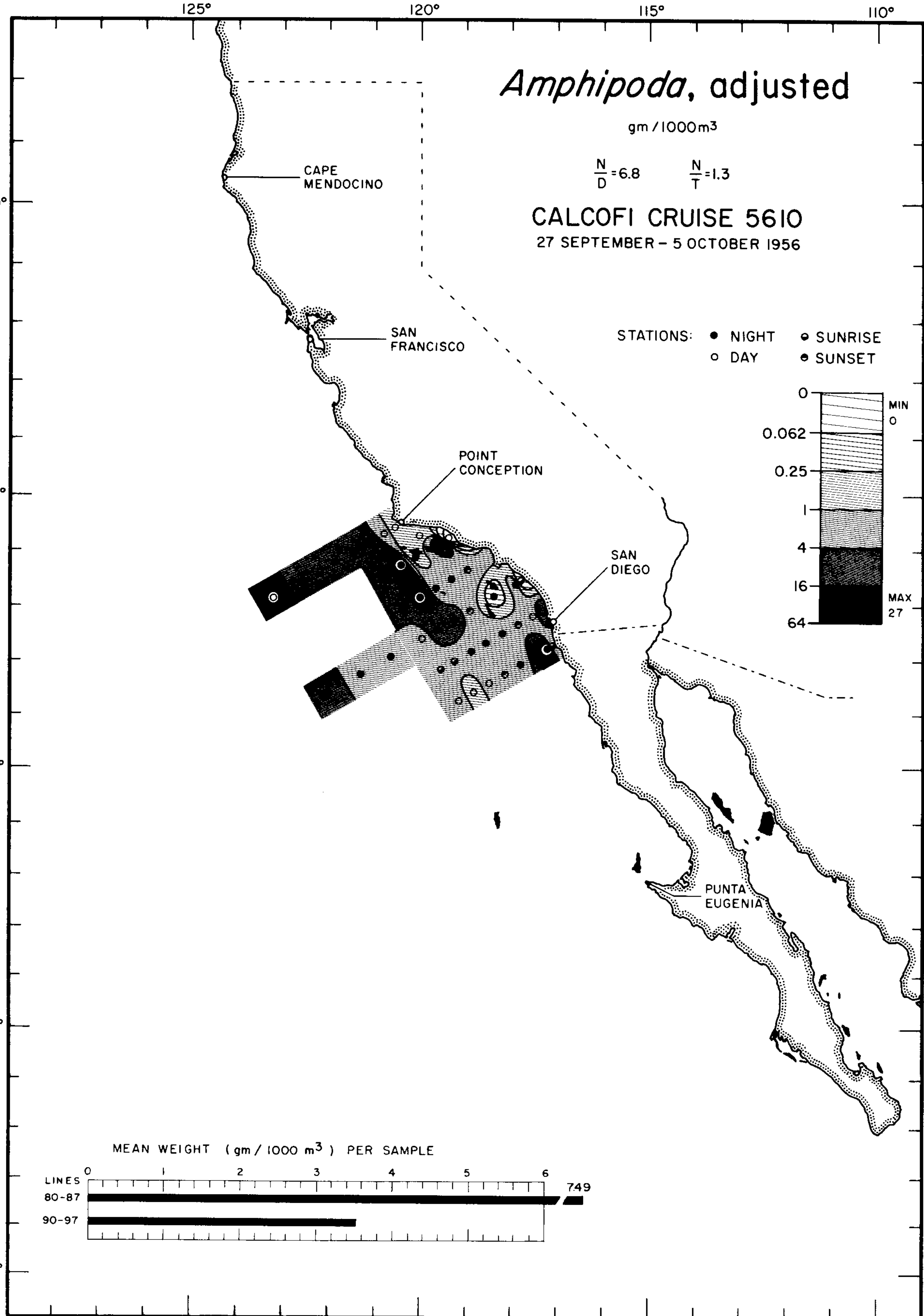




Biomass

Amphipoda

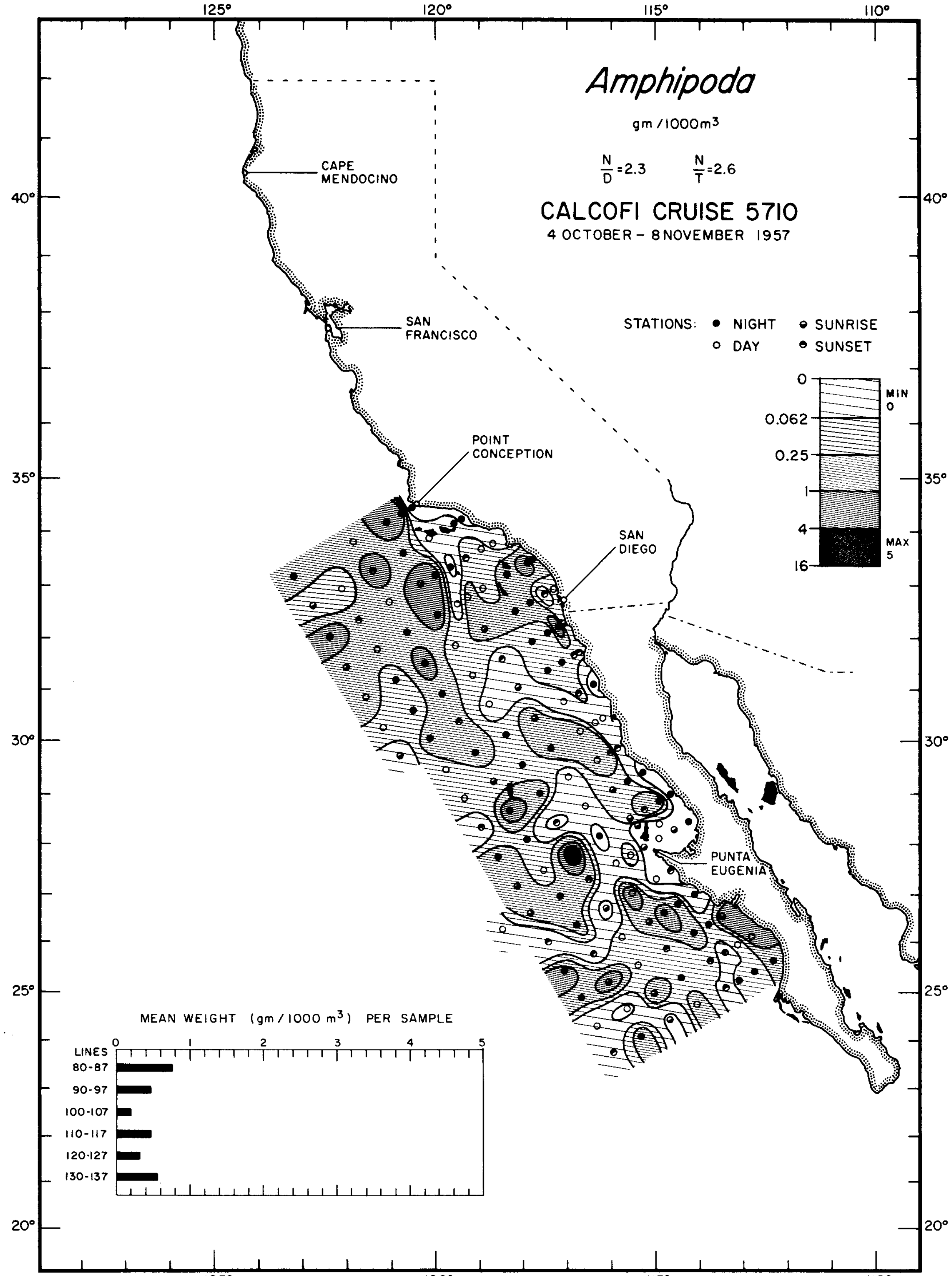
5610

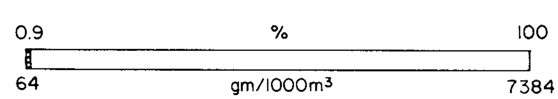


Biomass

Amphipoda, adjusted

5610

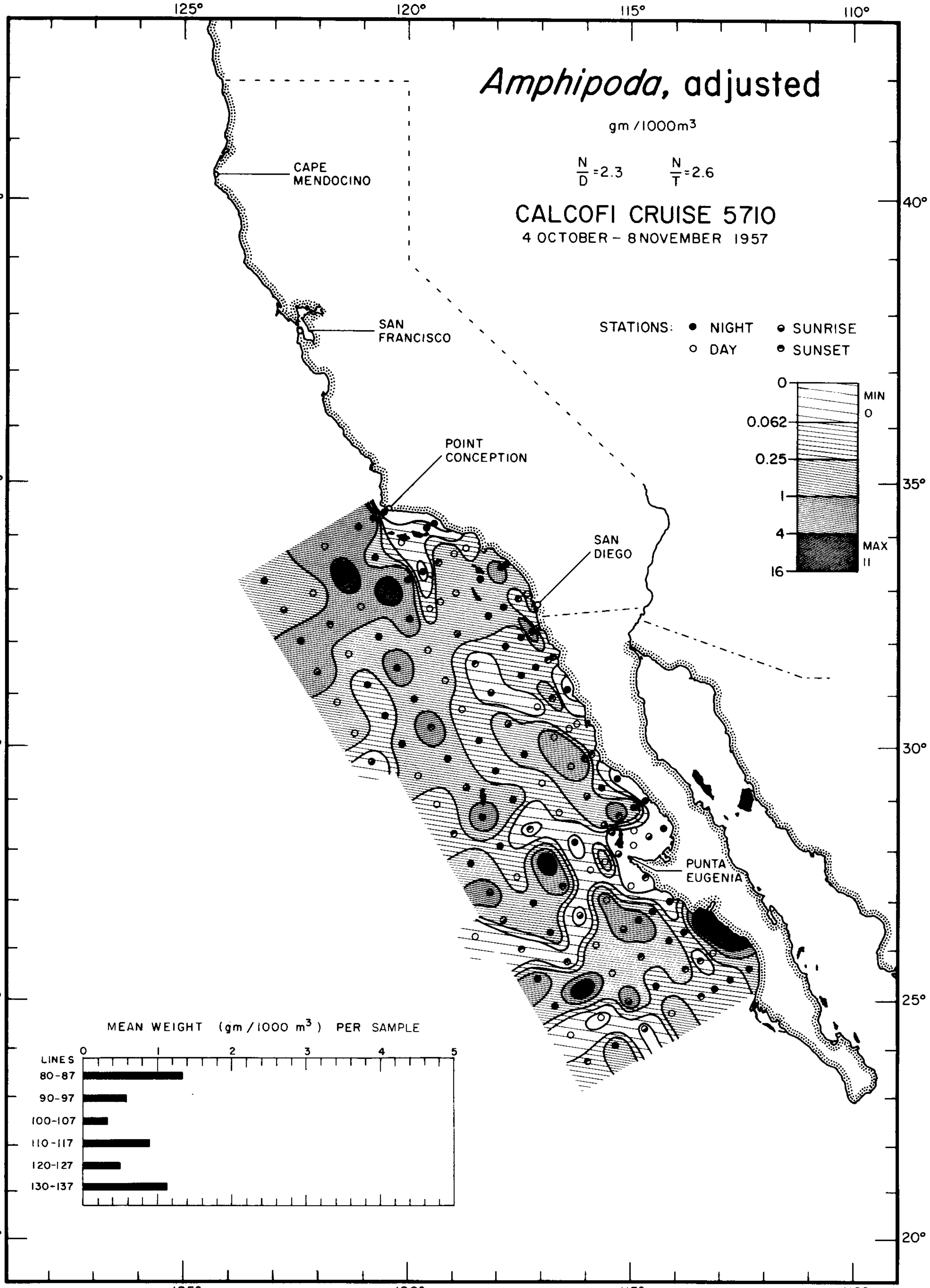




Biomass

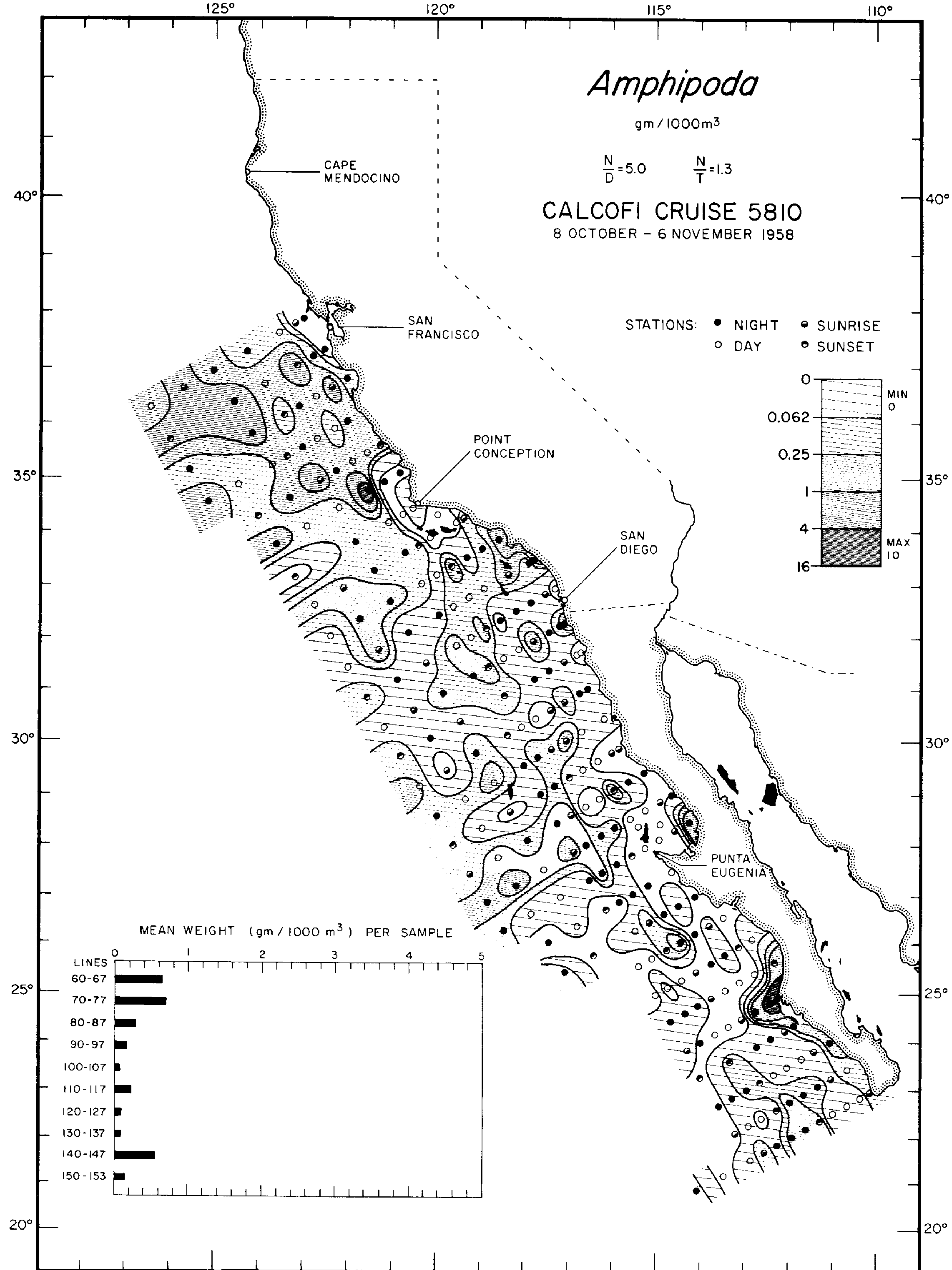
Amphipoda

5710



Biomass

Amphipoda, adjusted
5710



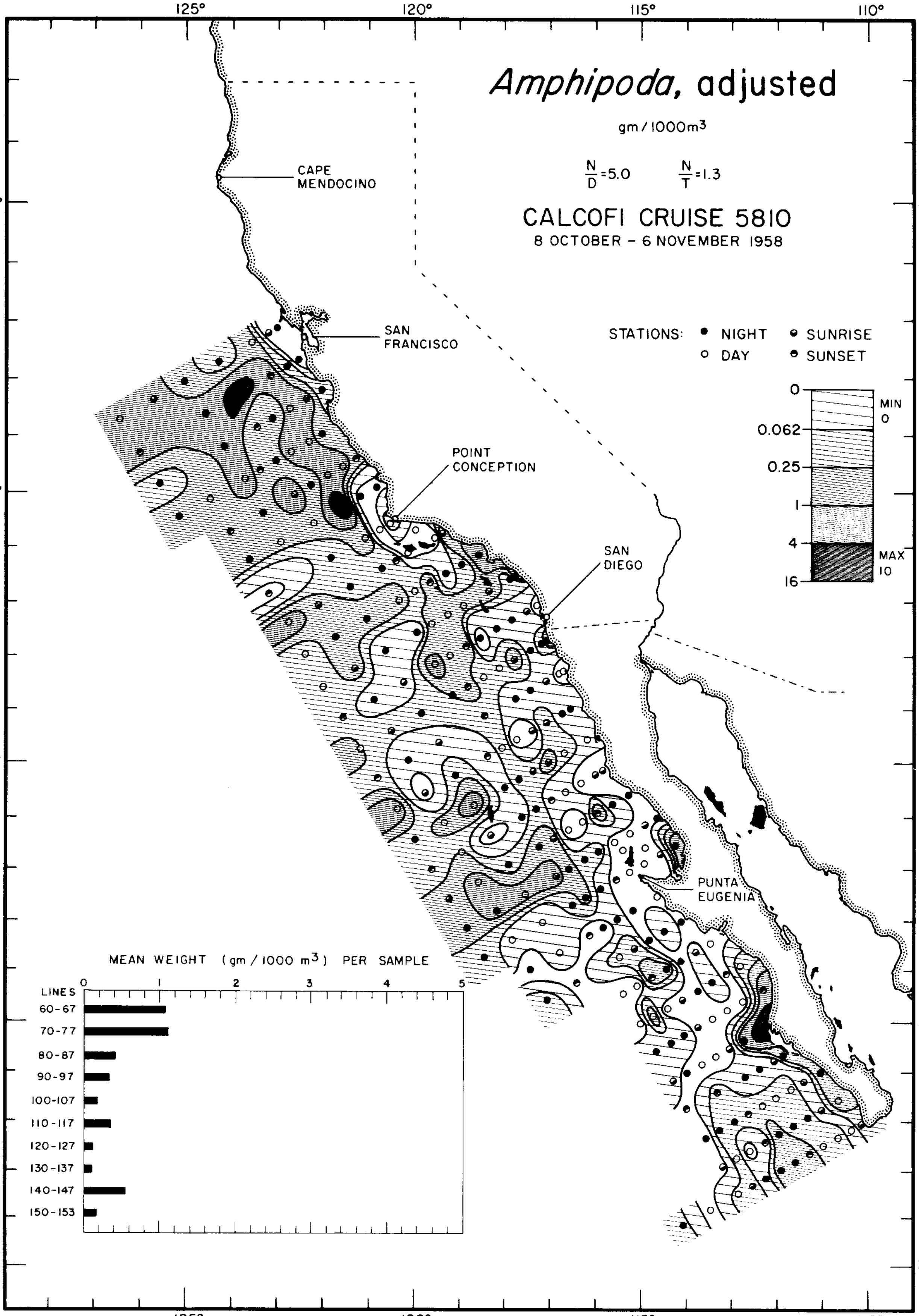
2 % 100

69 gm/1000 m³ 3935

Biomass

Amphipoda

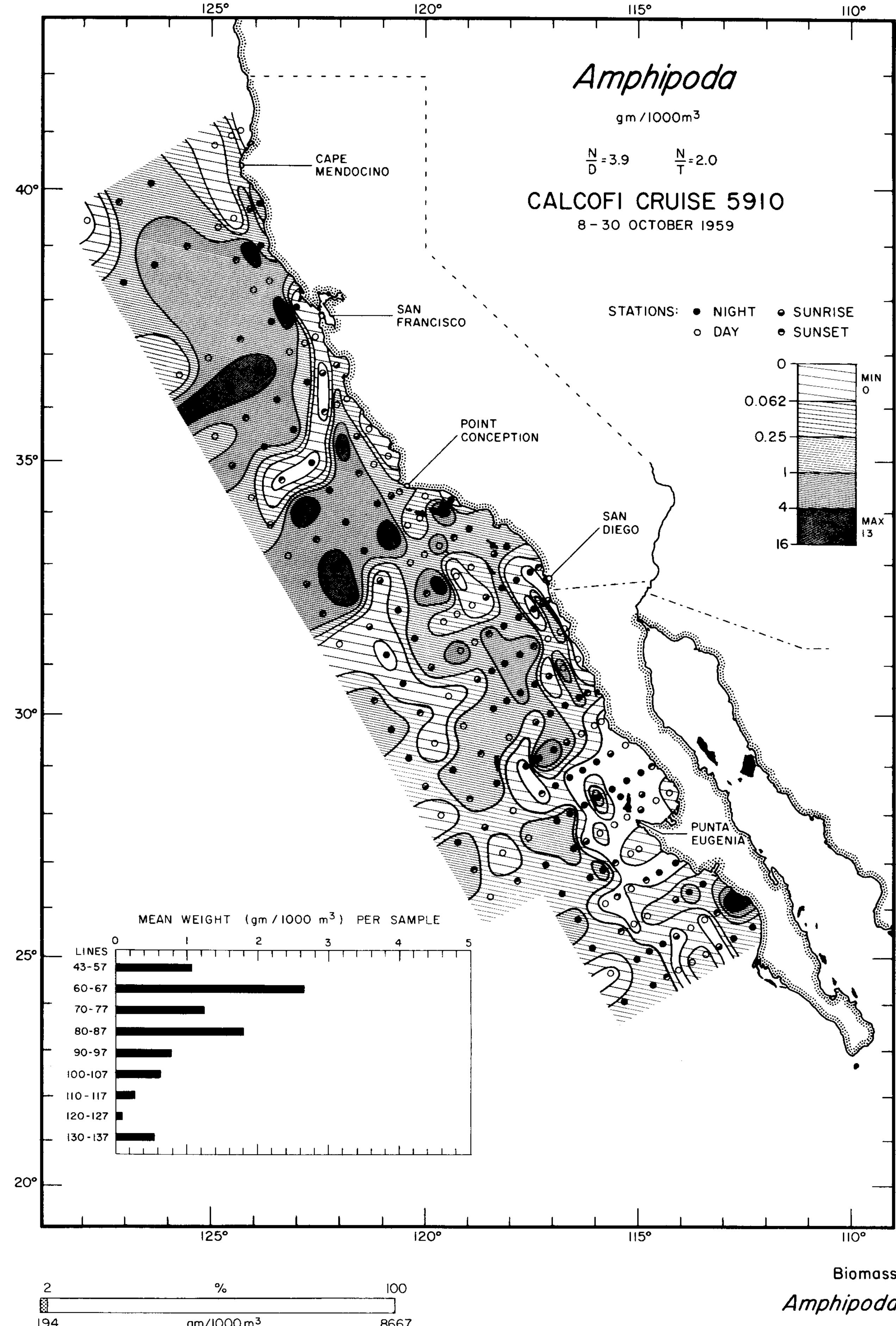
5810



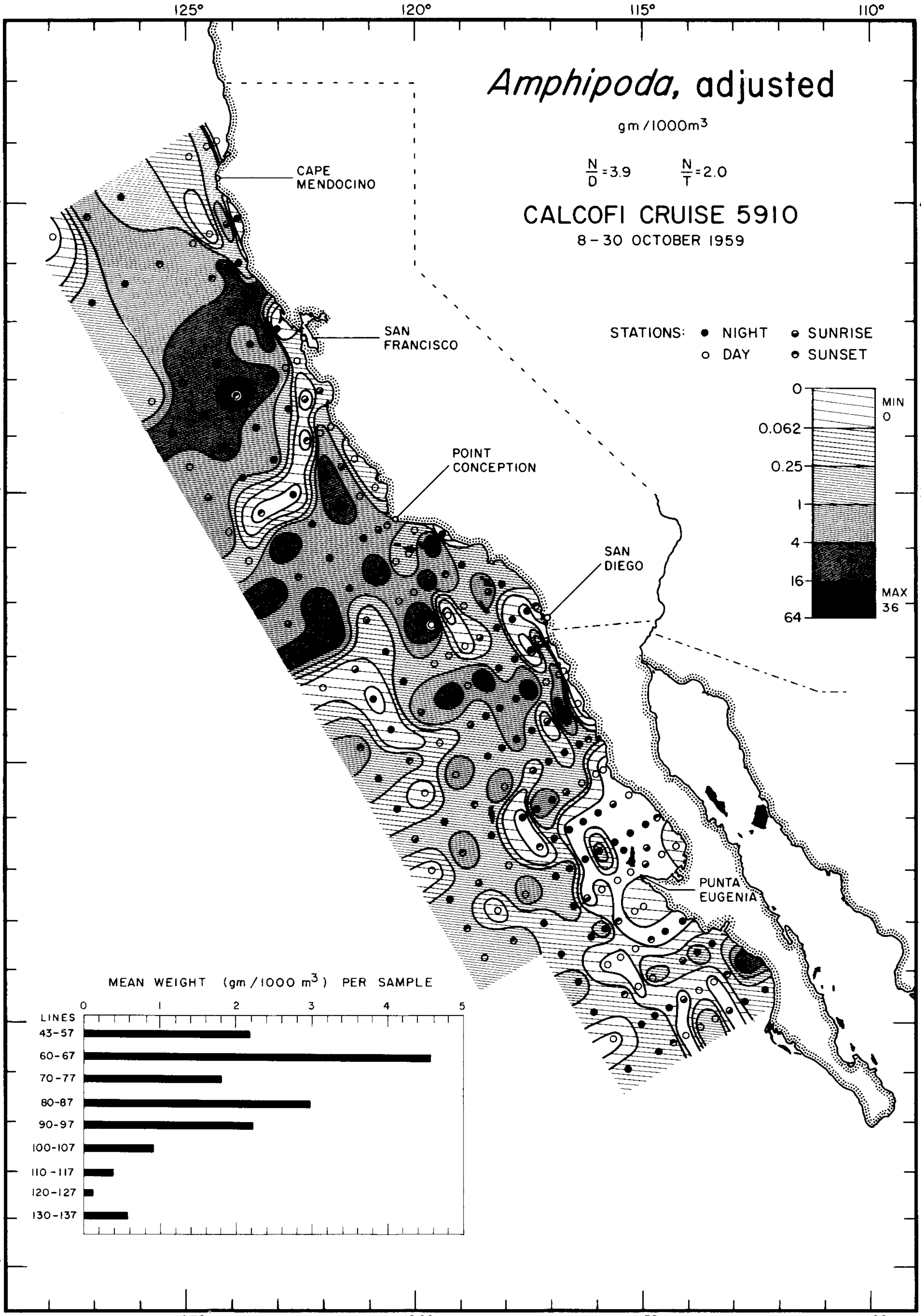
Biomass

Amphipoda, adjusted

5810



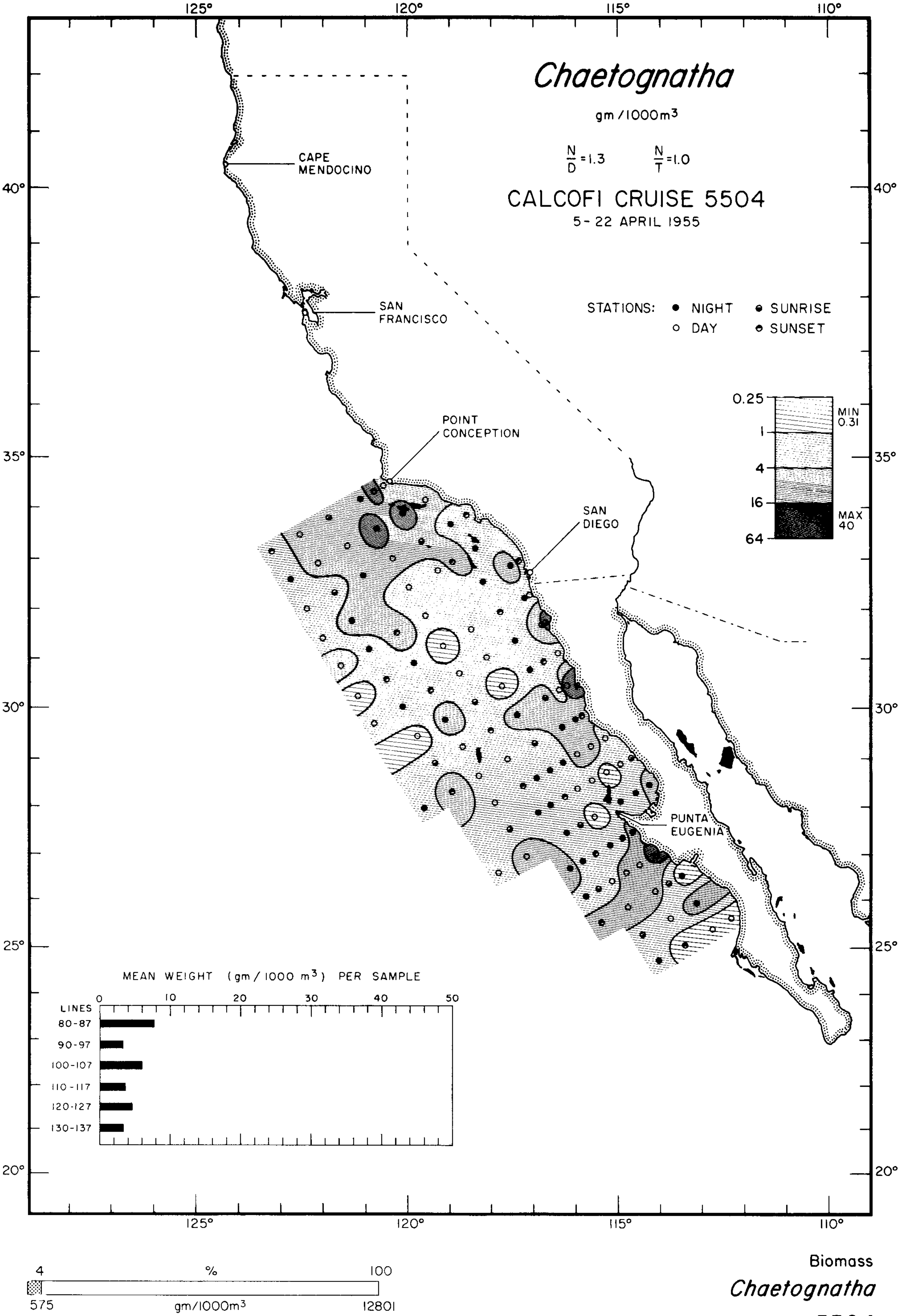
Biomass
Amphipoda
5910



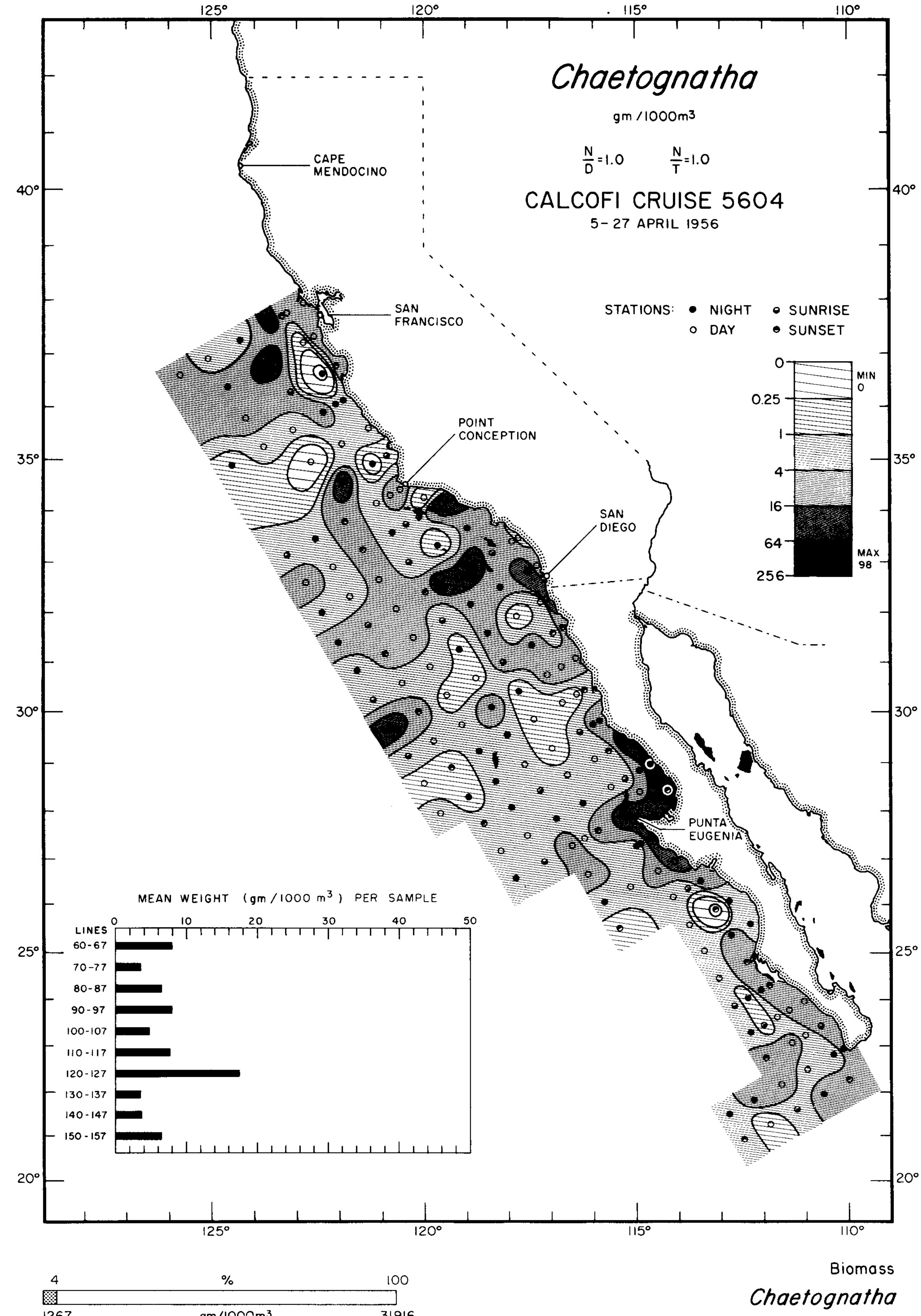
Biomass

Amphipoda, adjusted

5910



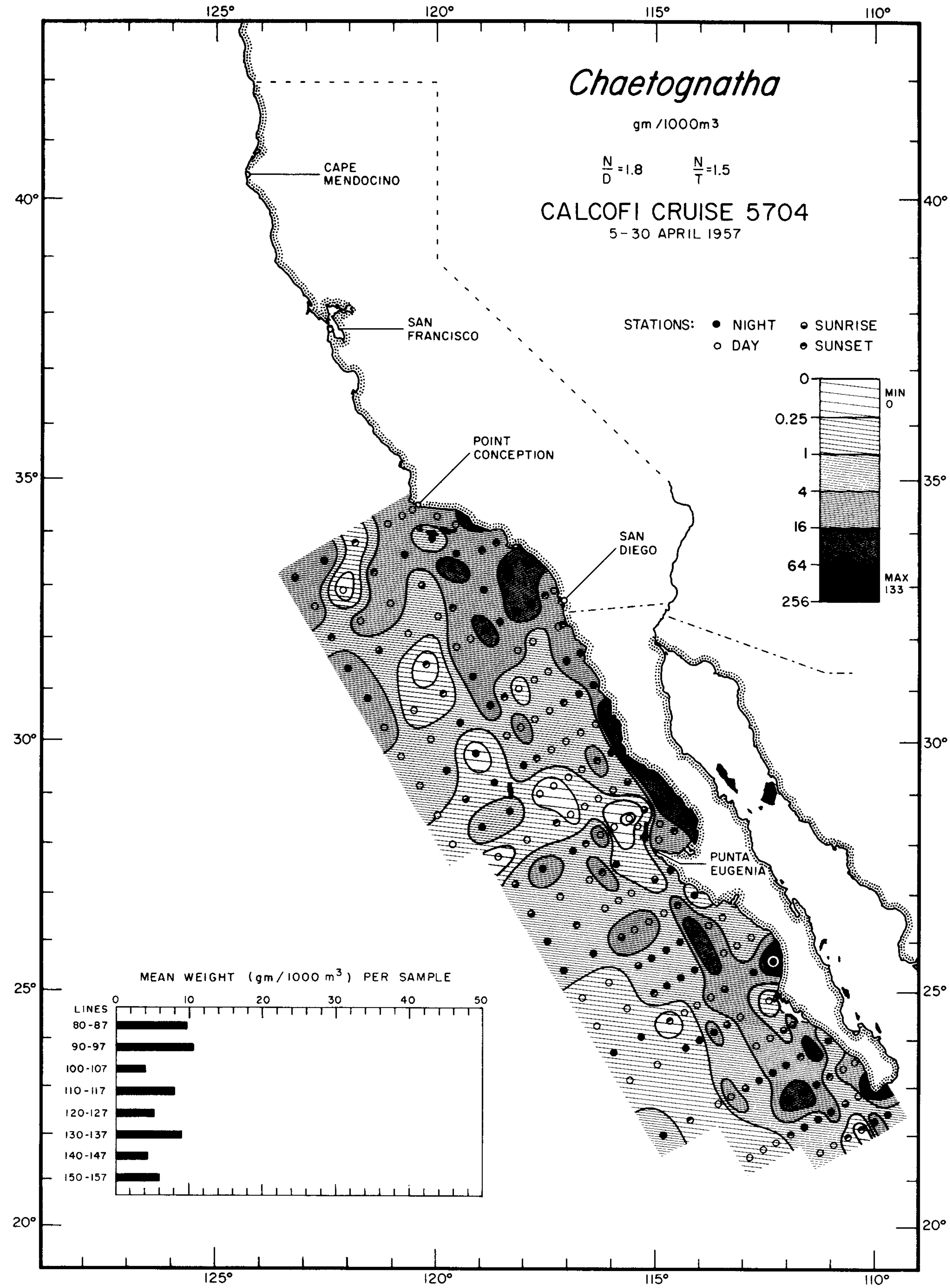
Biomass
Chaetognatha
5504

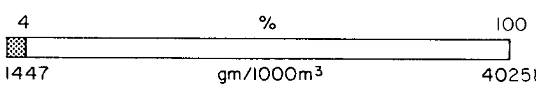


Biomass

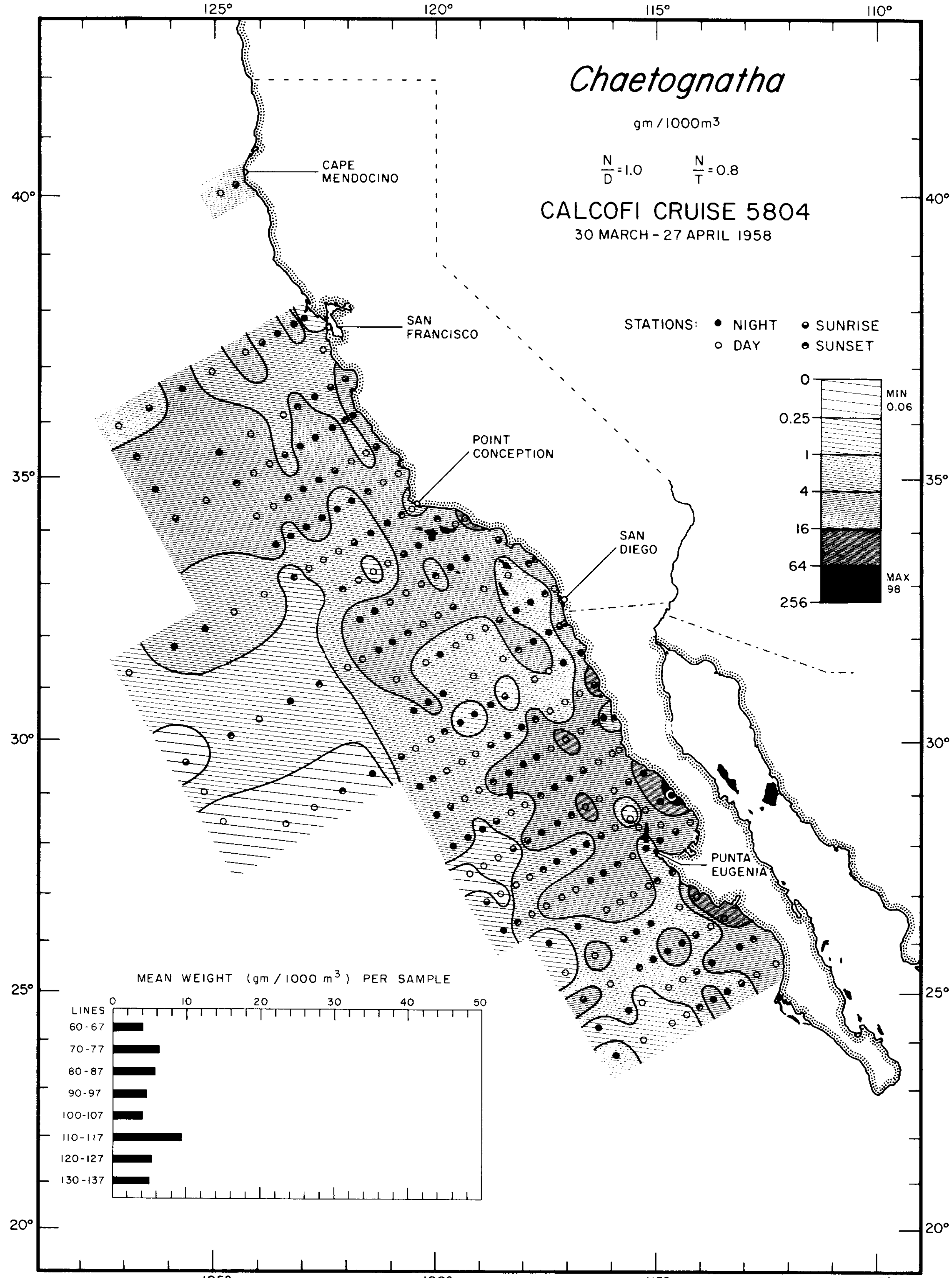
Chaetognatha

5604





Biomass
Chaetognatha
5704



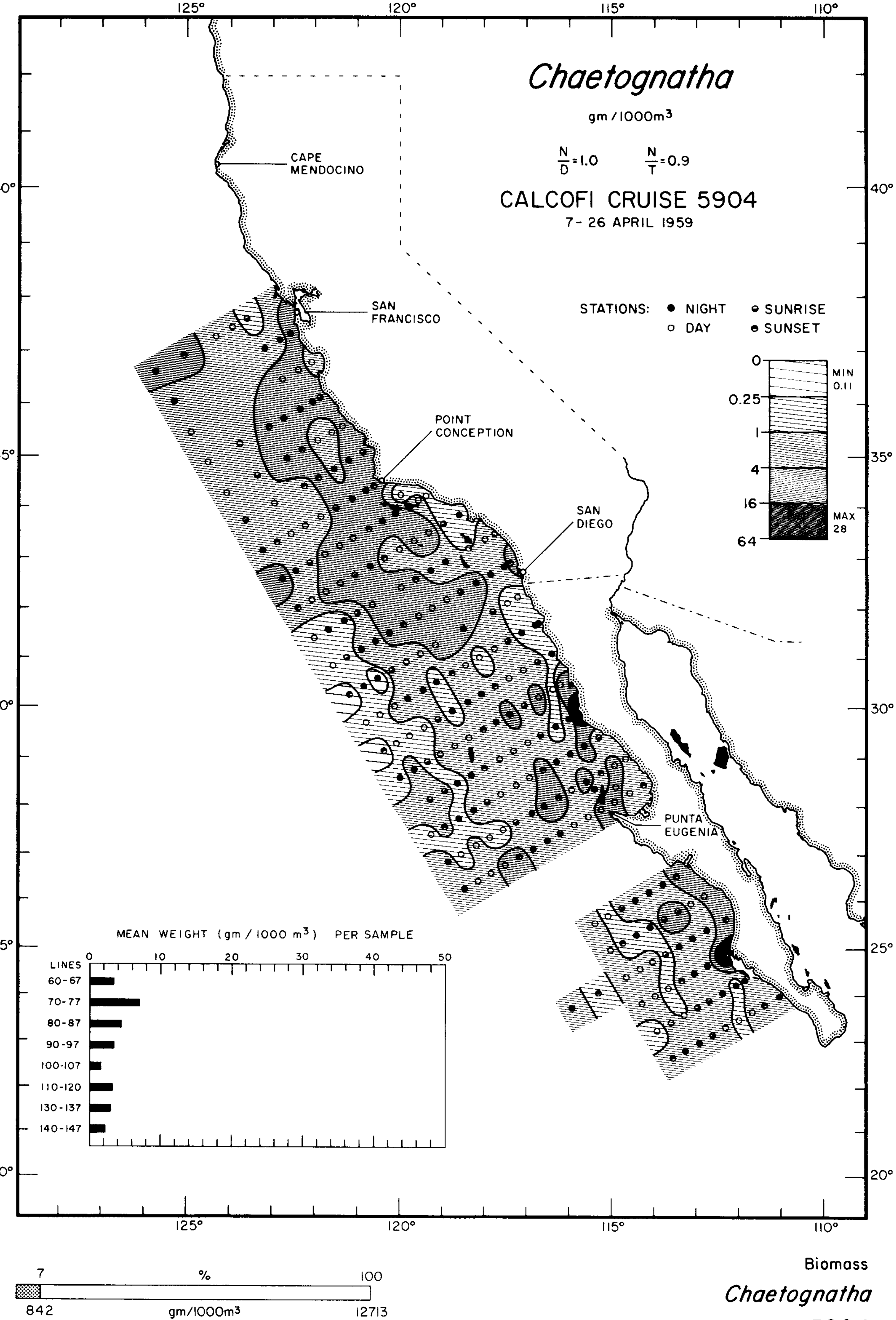
0 17 % 100

0 1510 gm/1000m3 9039

Biomass

Chaetognatha

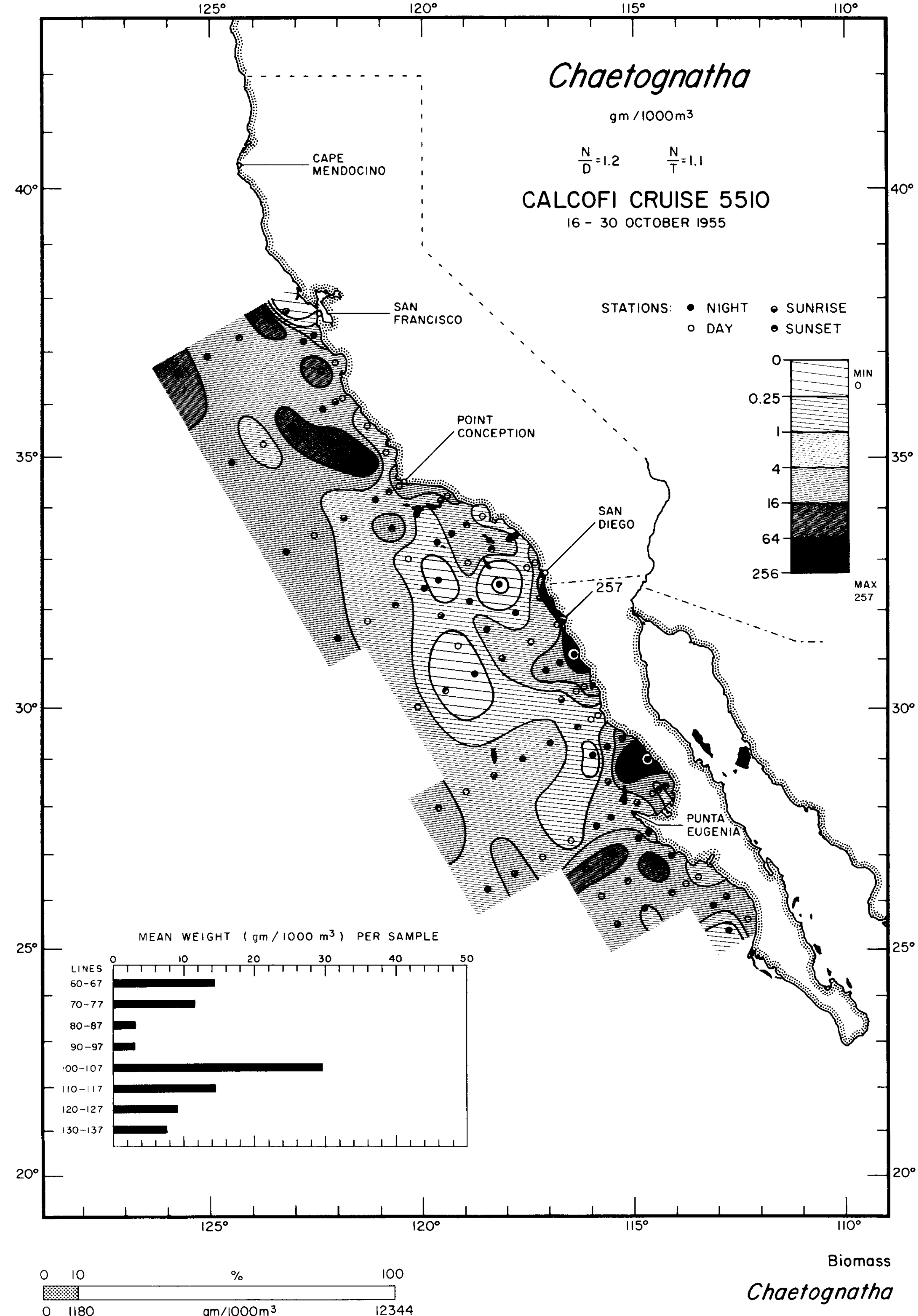
5804



Biomass

Chaetognatha

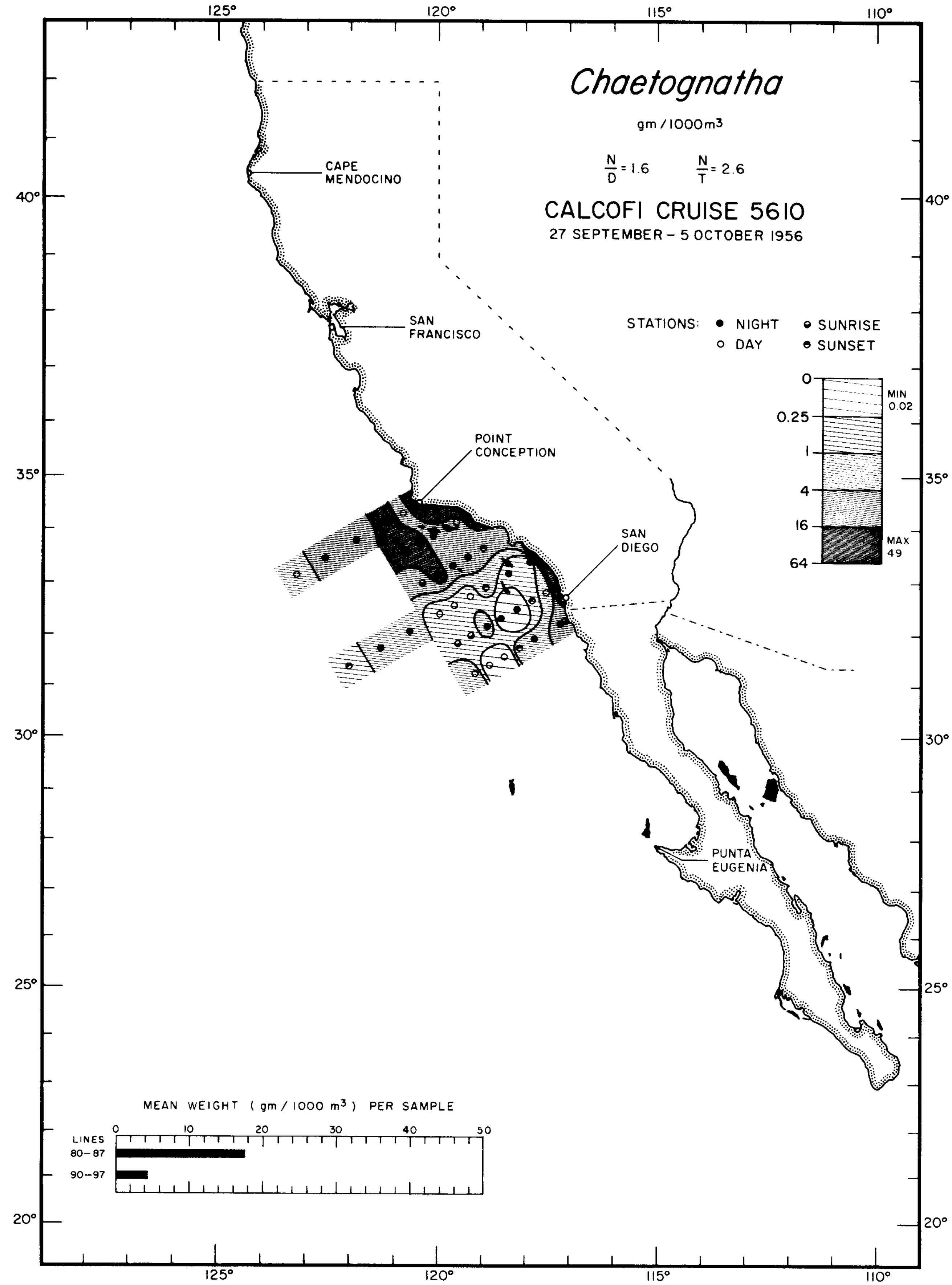
5904

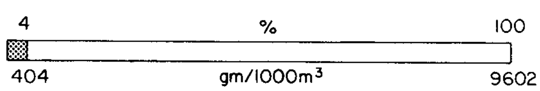


Biomass

Chaetognatha

5510

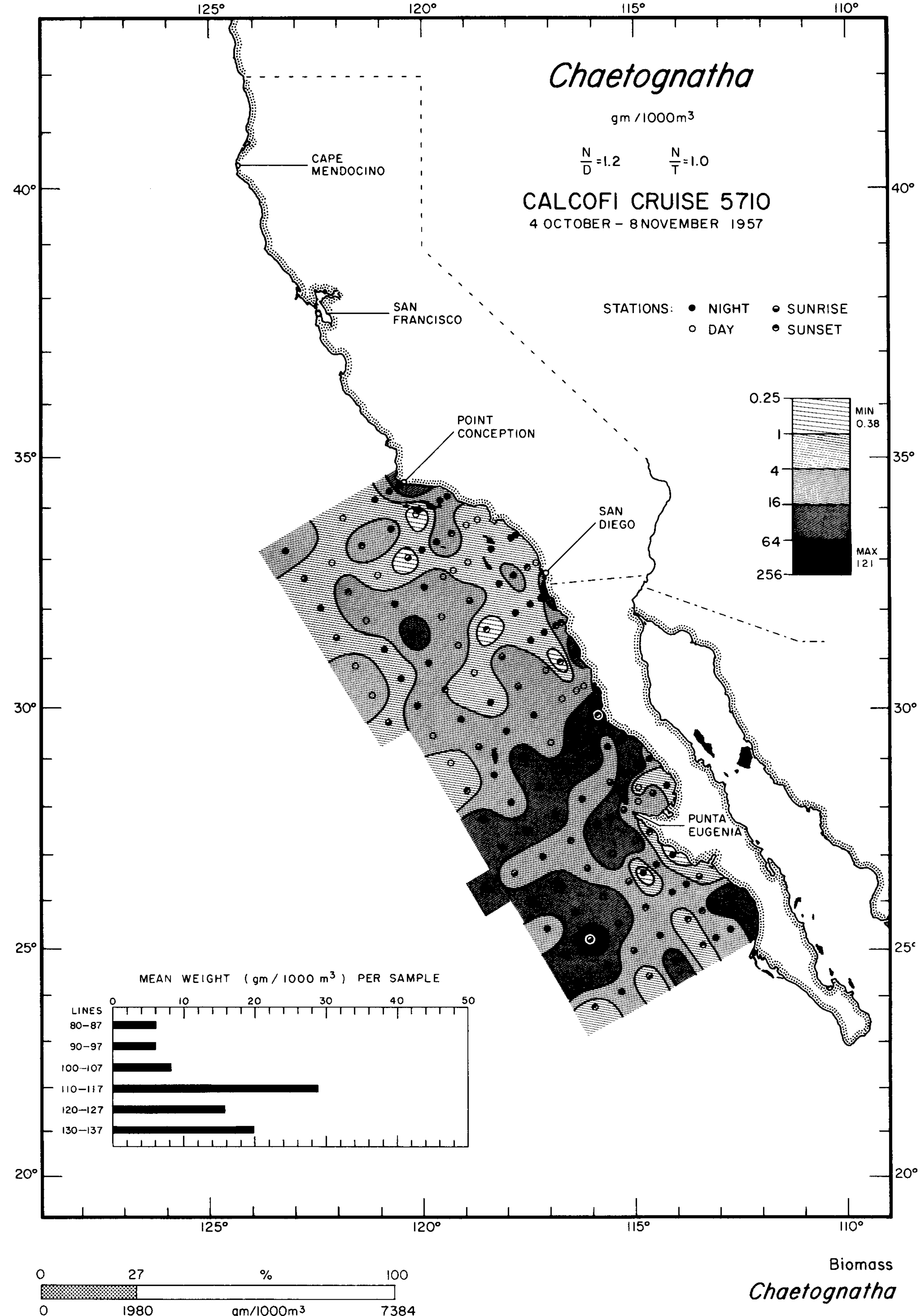




Biomass

Chaetognatha

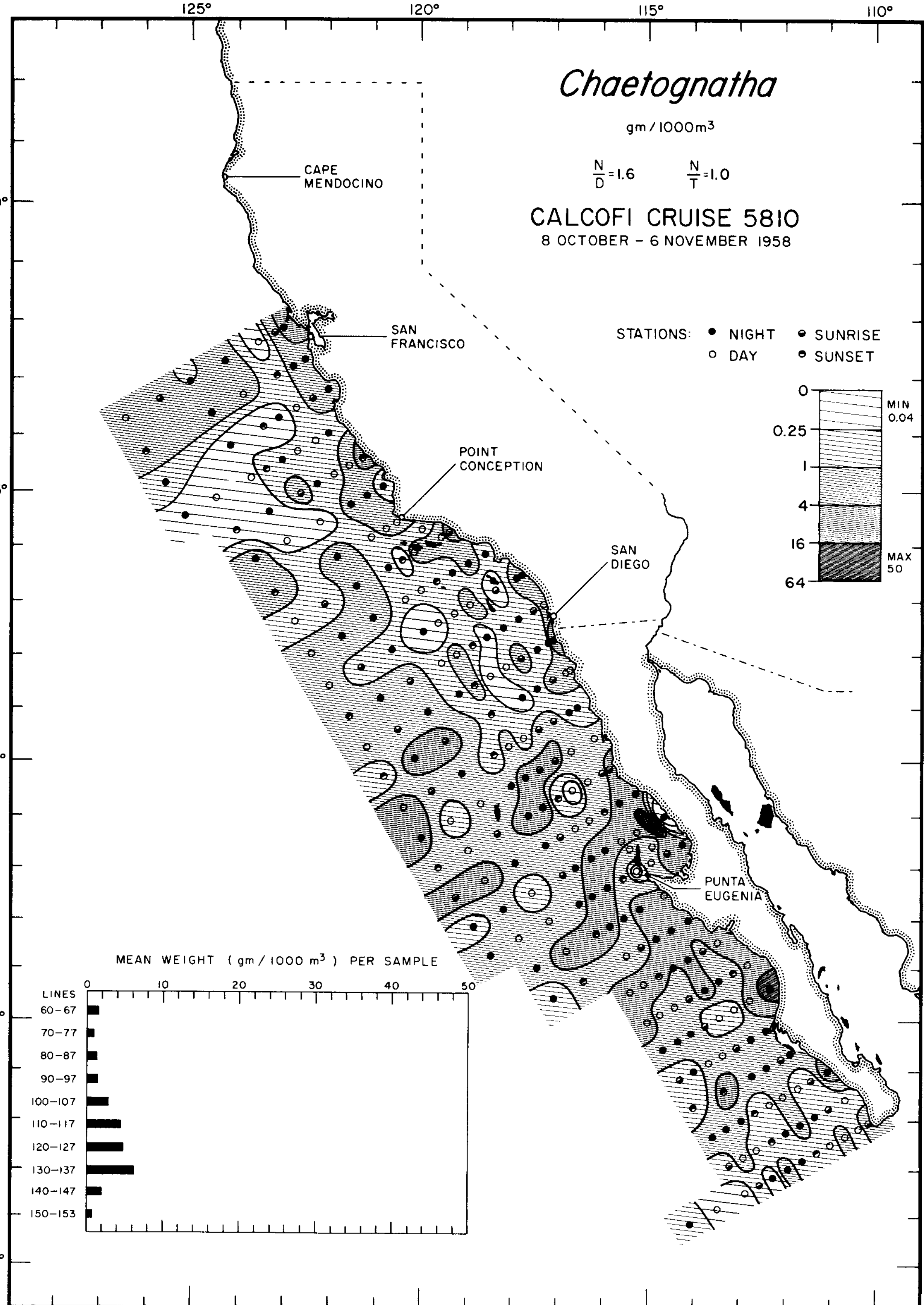
5610

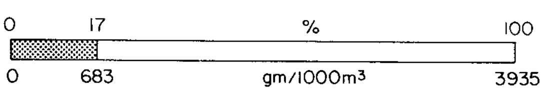


Biomass

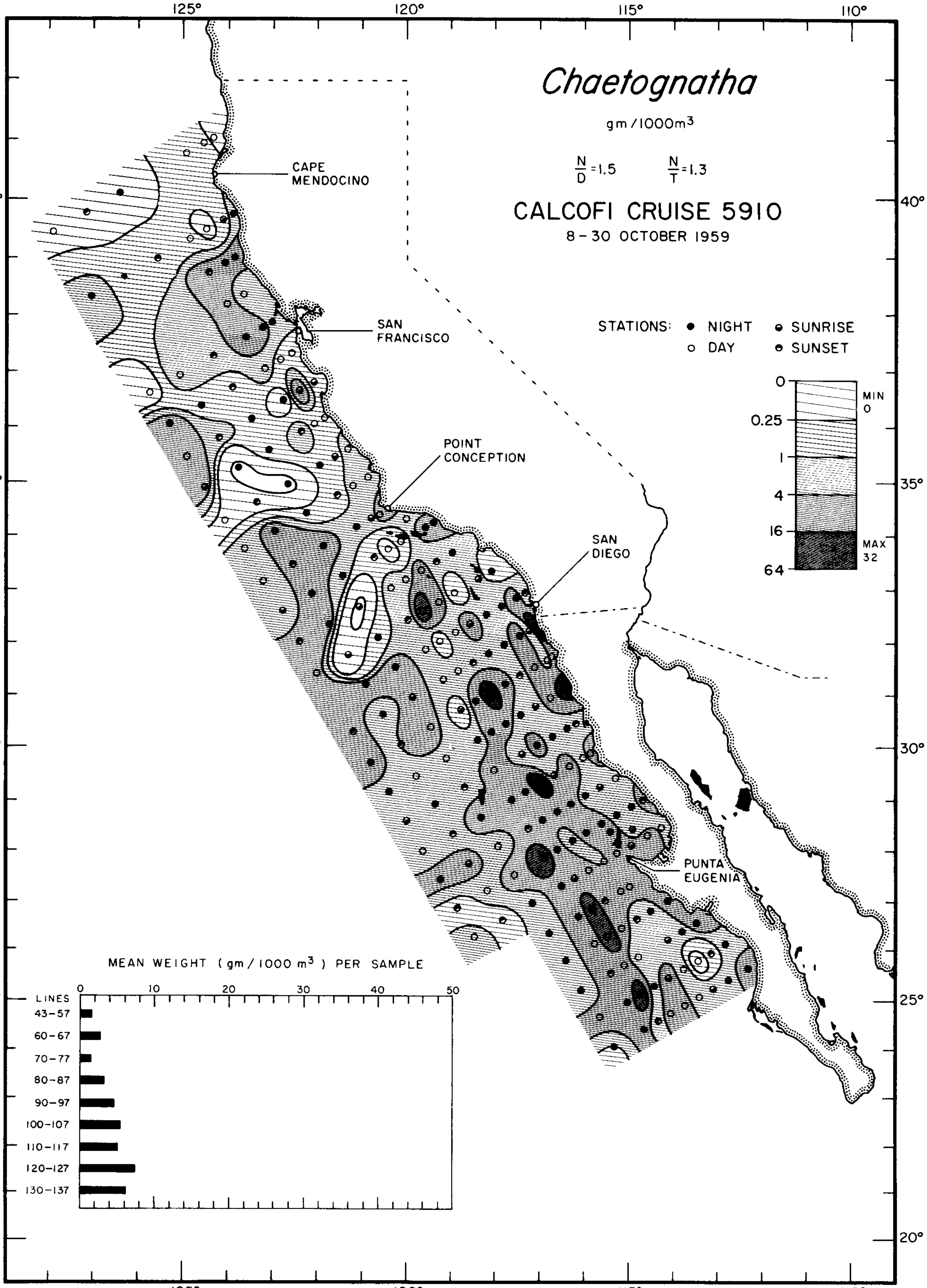
Chaetognatha

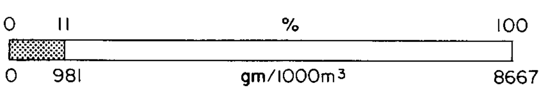
5710



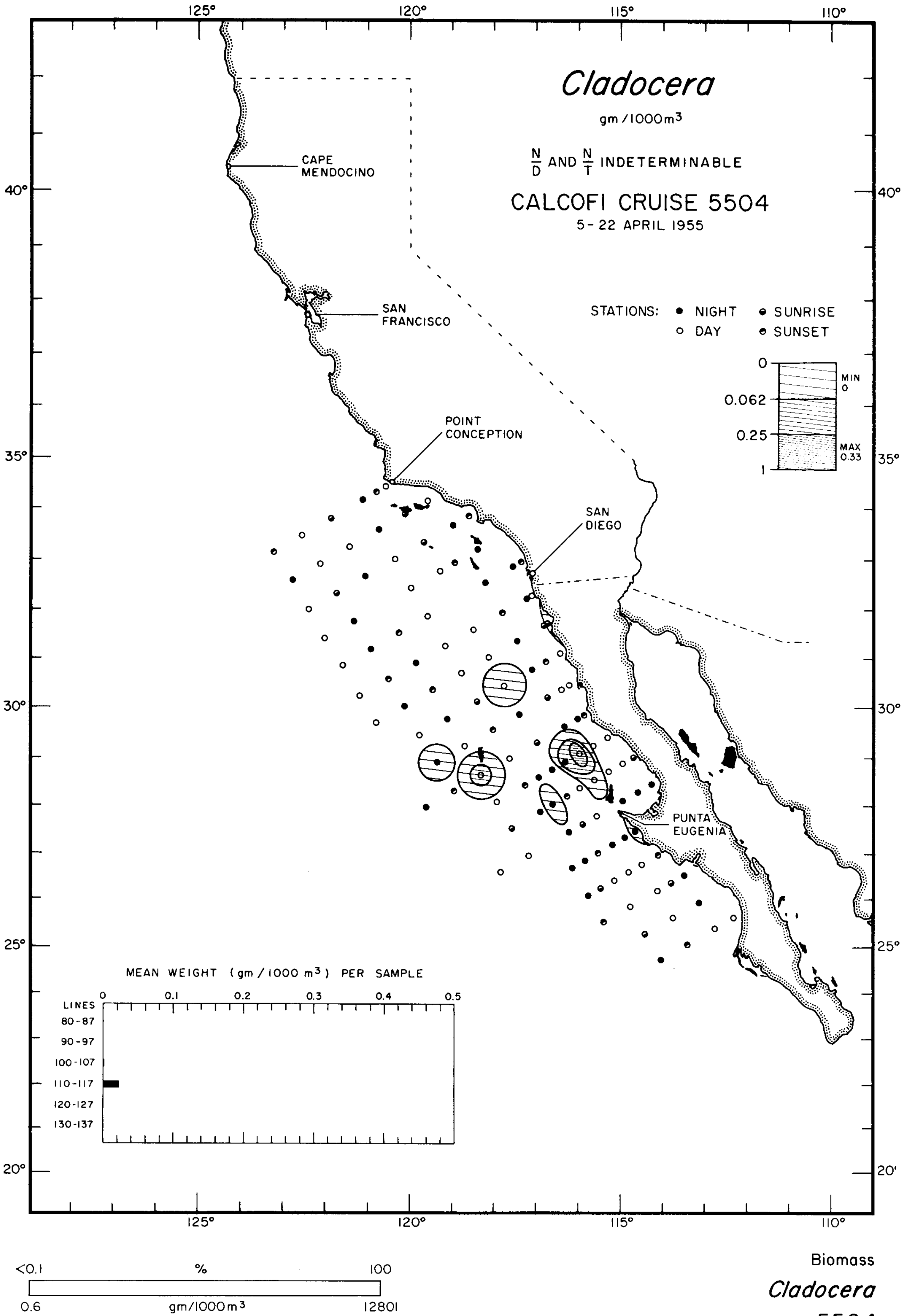


Biomass
Chaetognatha
5810





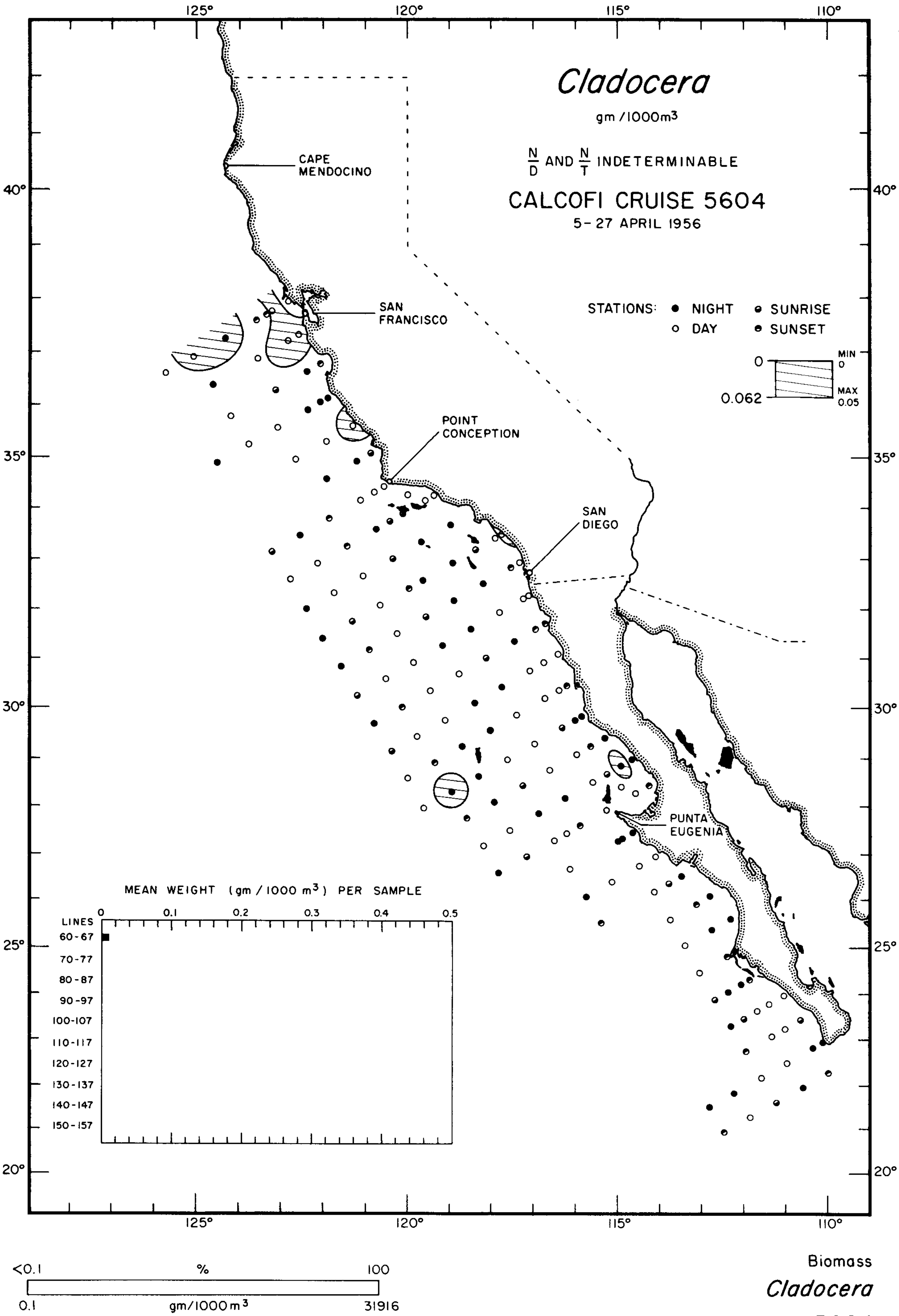
Biomass
Chaetognatha
5910



Biomass

Cladocera

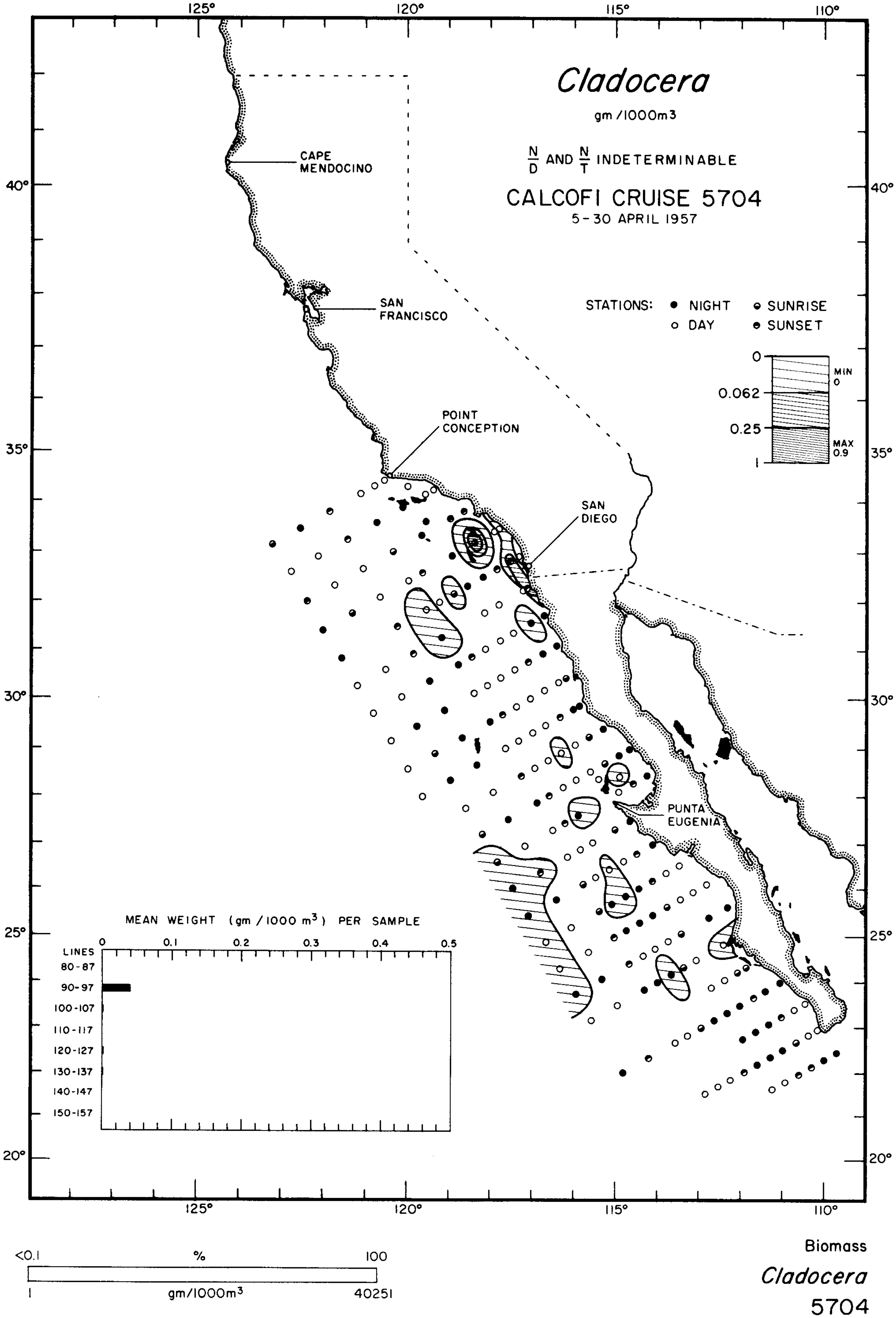
5504



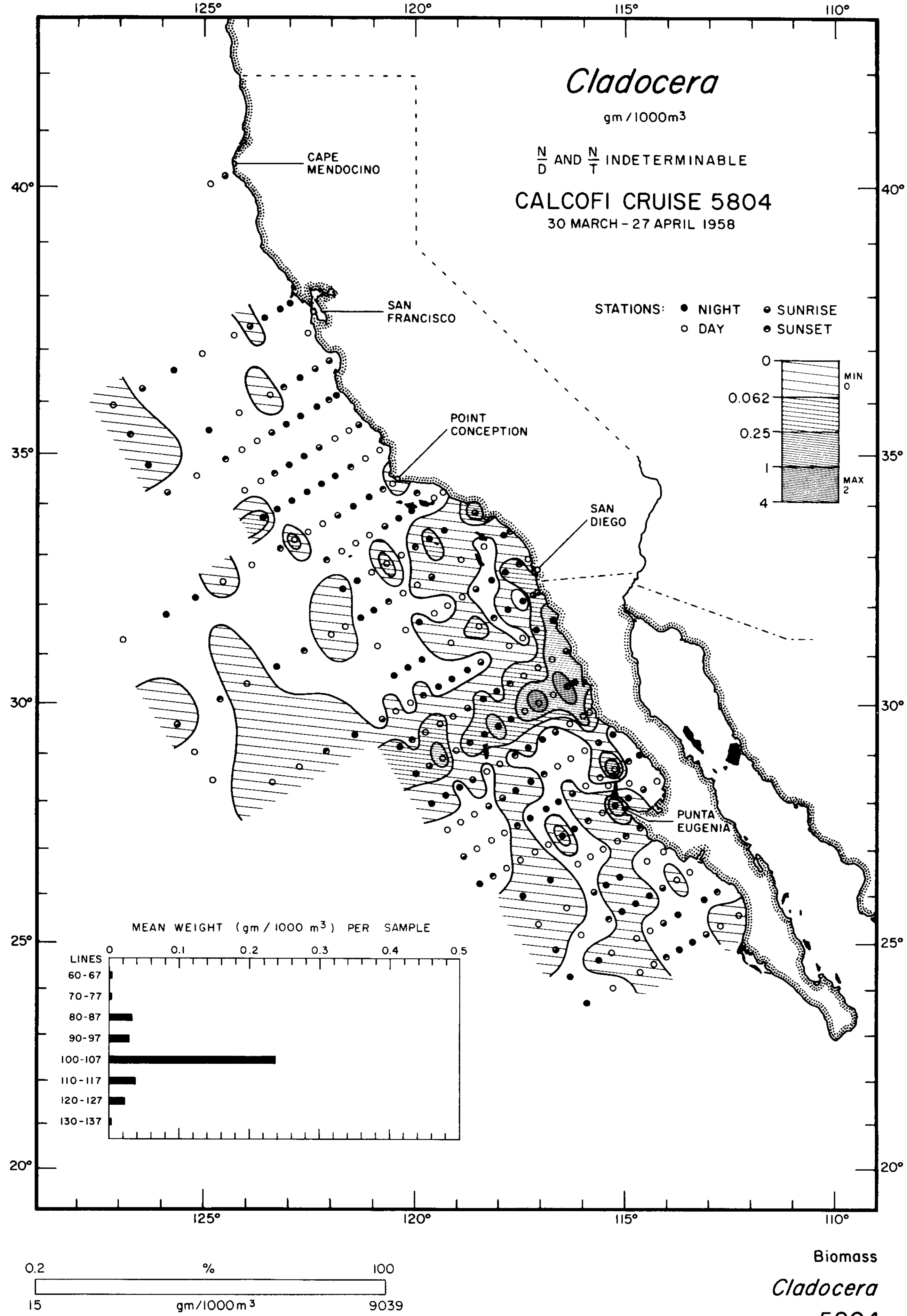
Biomass

Cladocera

5604



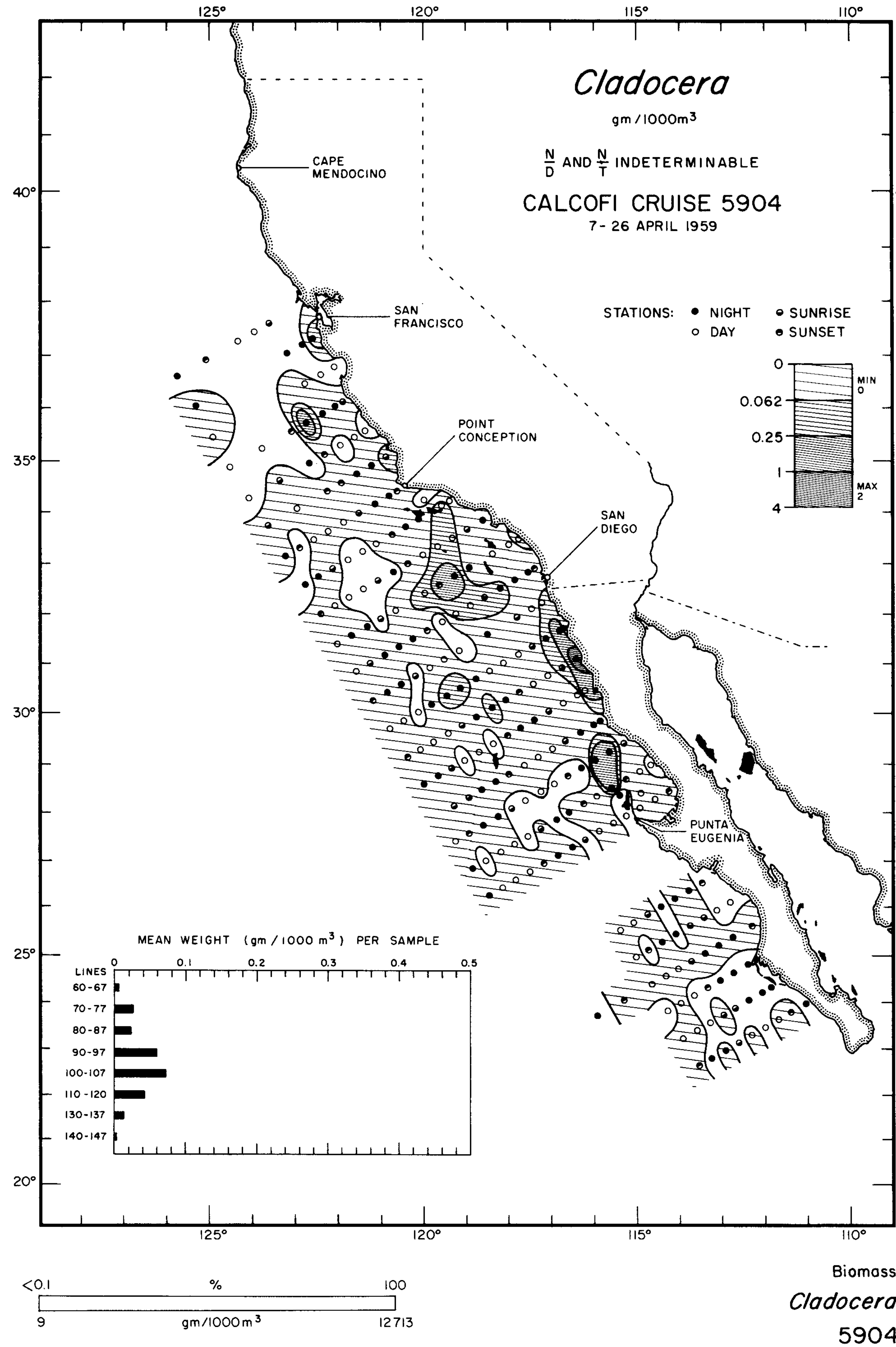
Biomass
Cladocera
5704



Biomass

Cladocera

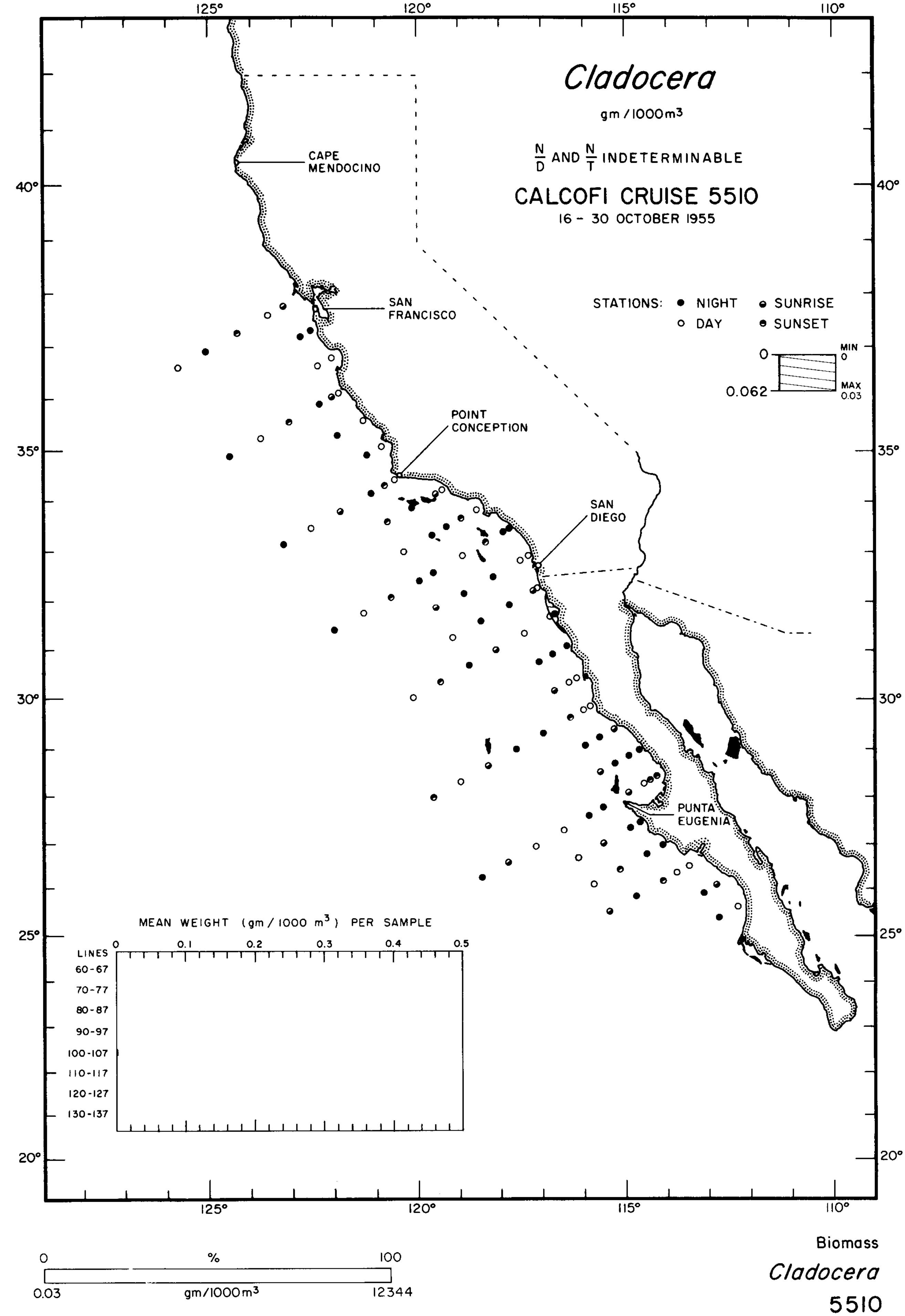
5804



Biomass

Cladocera

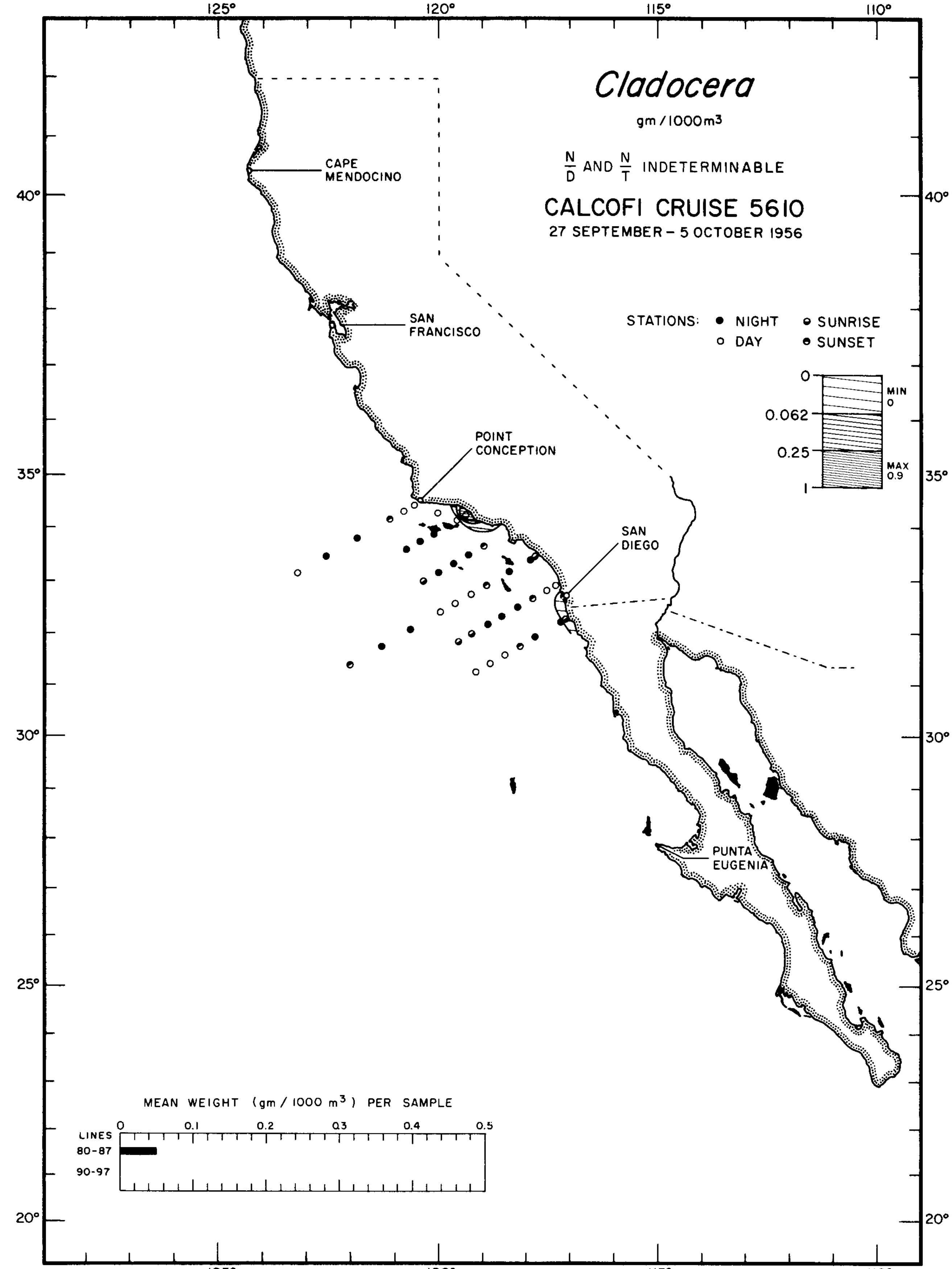
5904



Biomass

Cladocera

5510



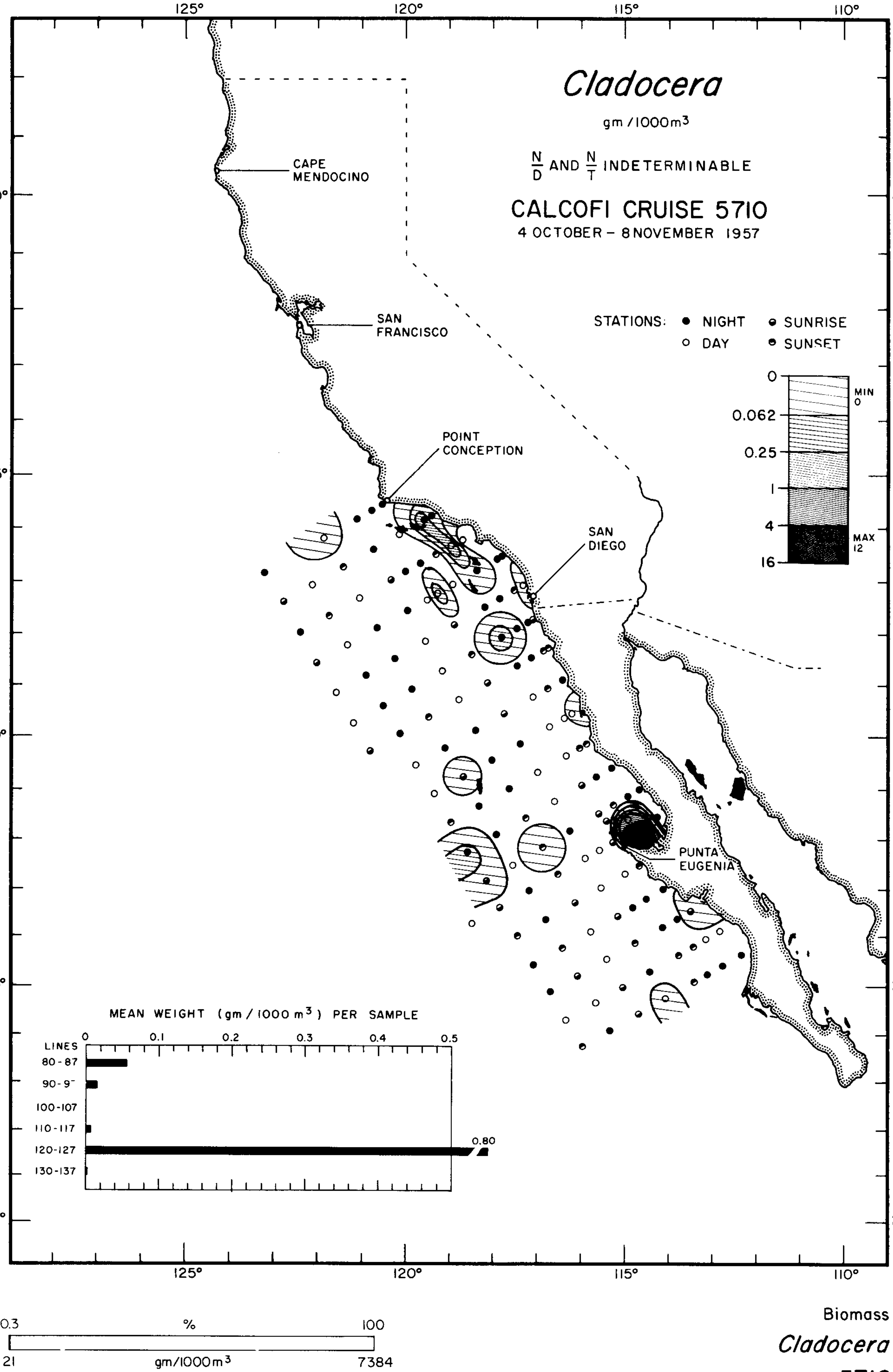
<0.1 % 100

0.9 gm/1000m3 9602

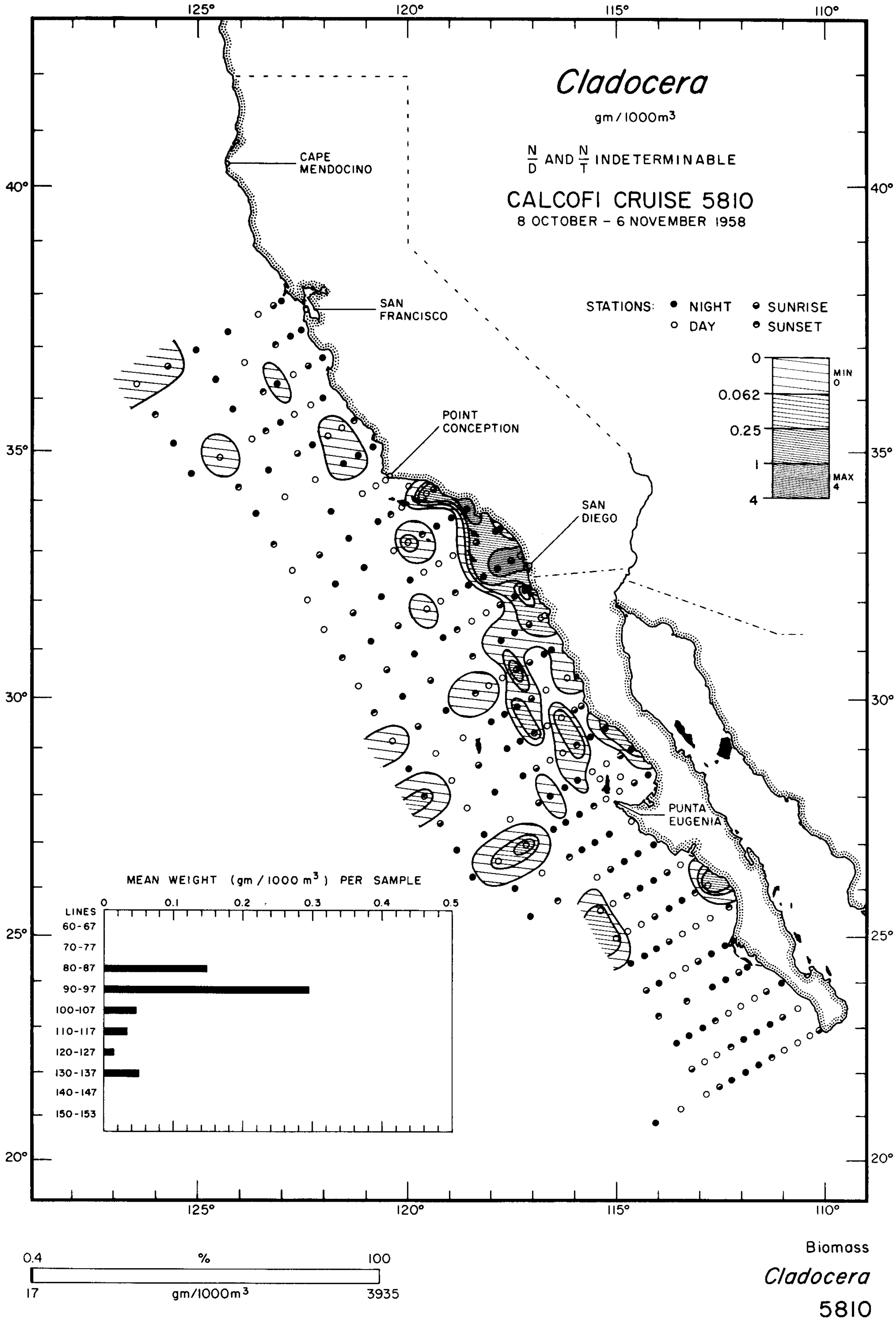
Biomass

Cladocera

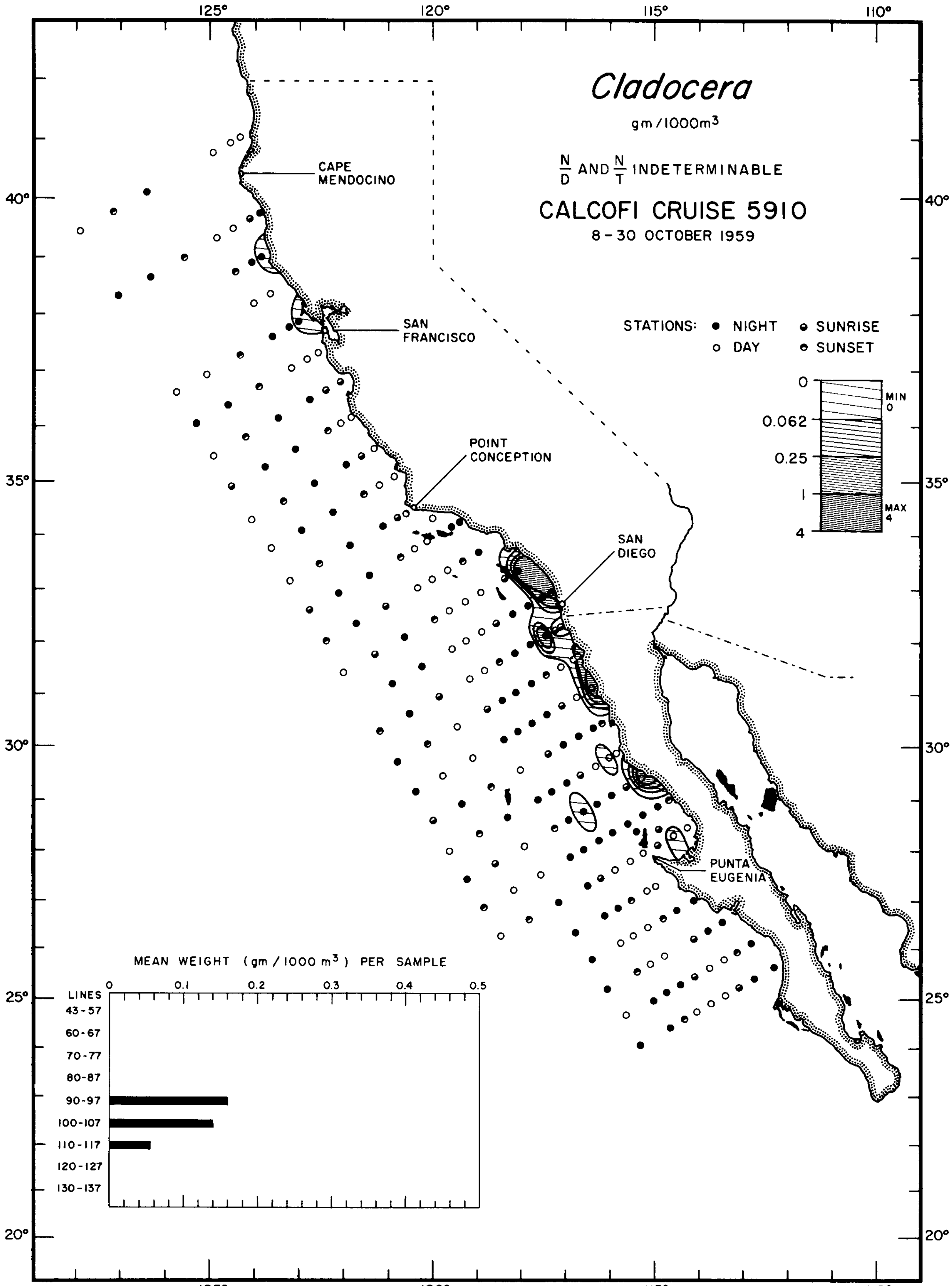
5610

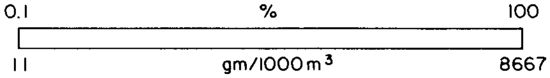


Biomass
Cladocera
5710

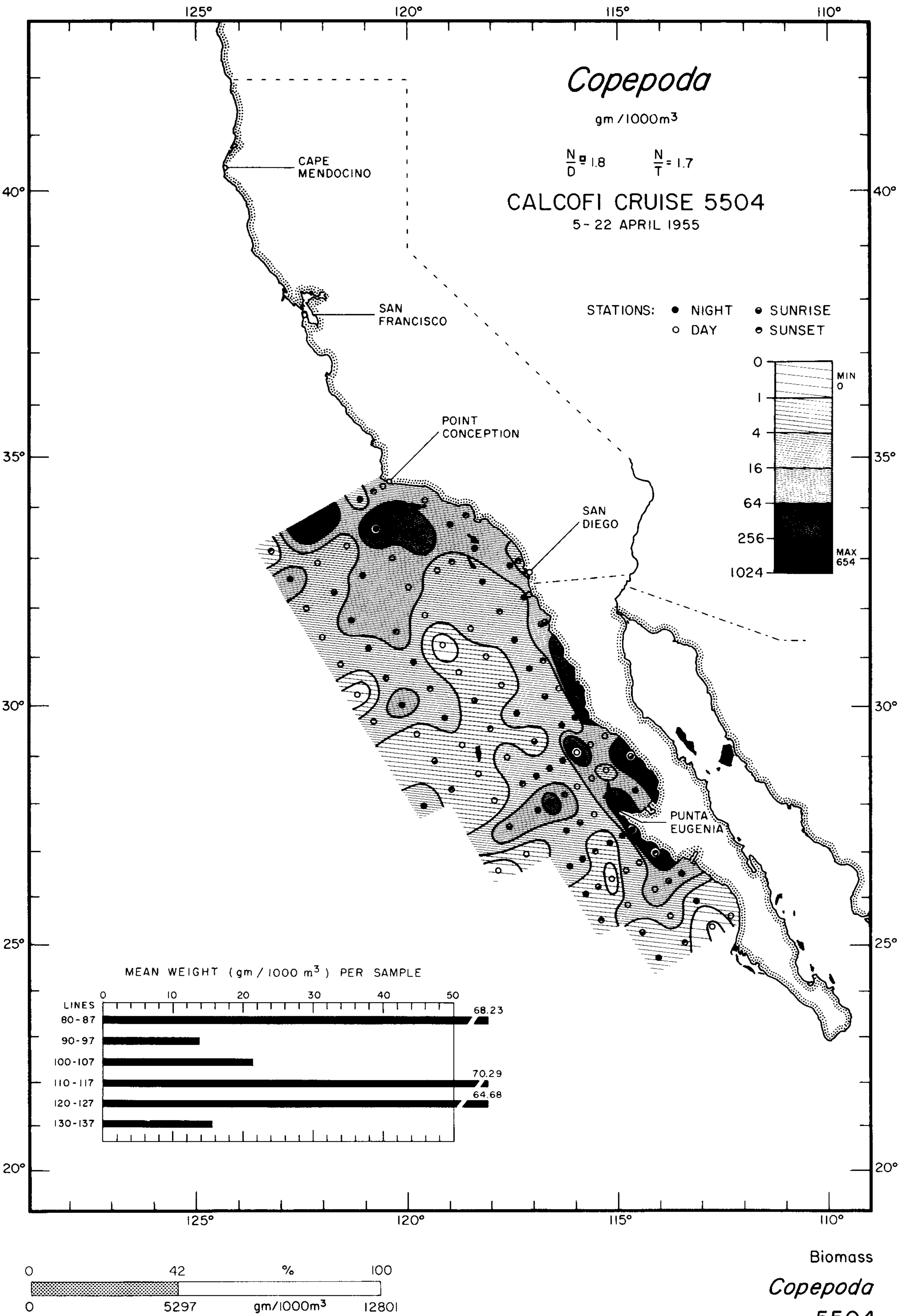


Biomass
Cladocera
5810





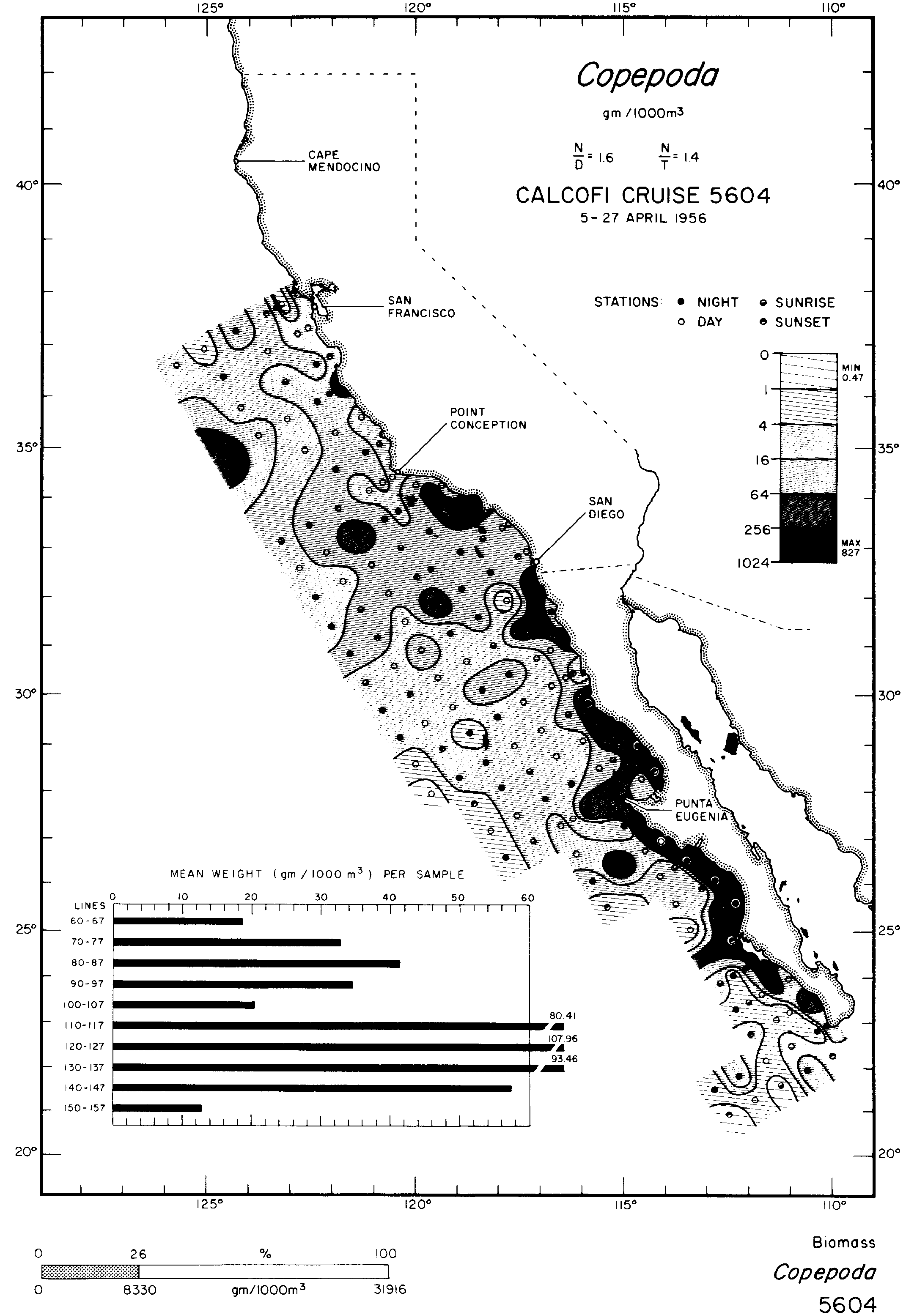
Biomass
Cladocera
5910



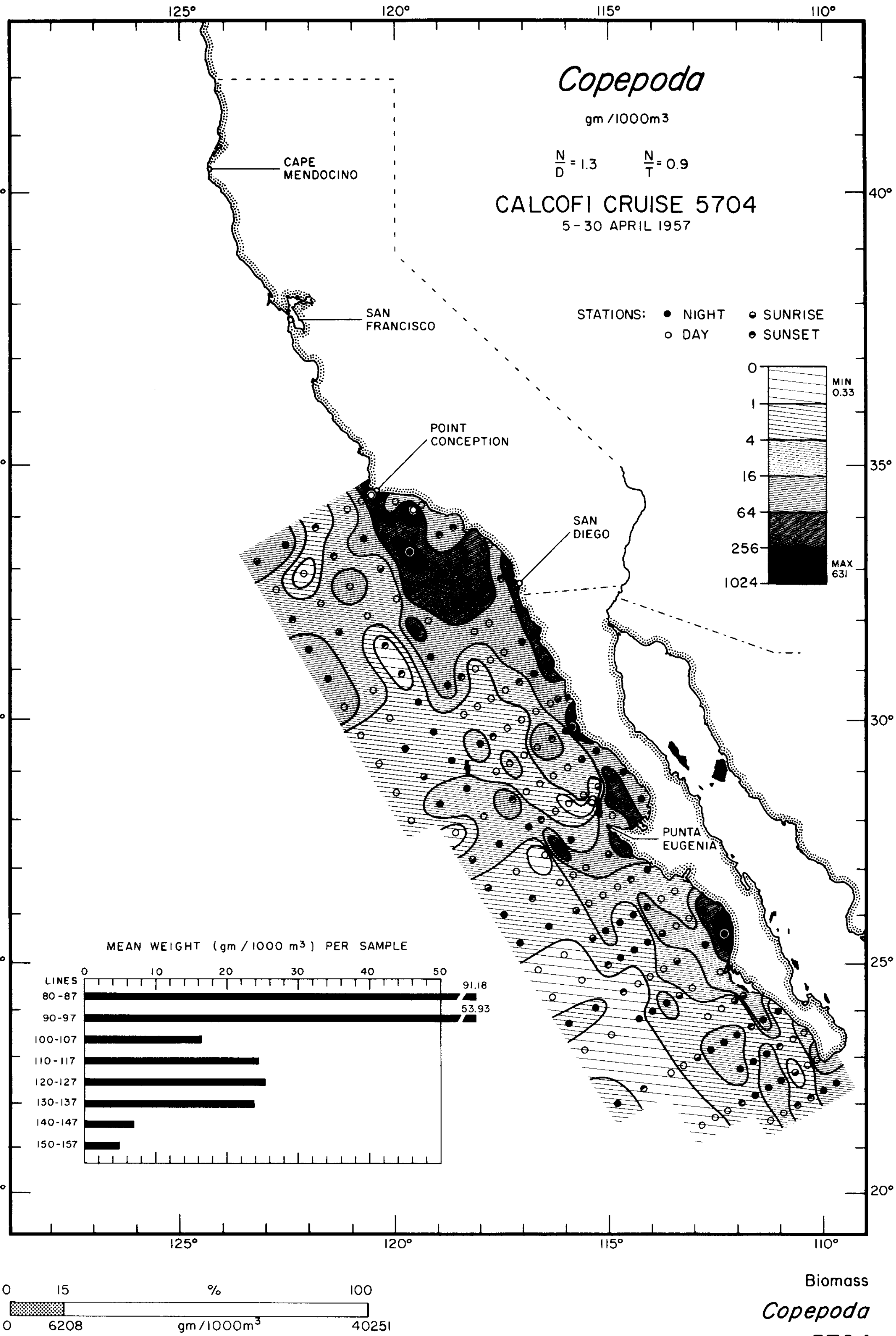
Biomass

Copepoda

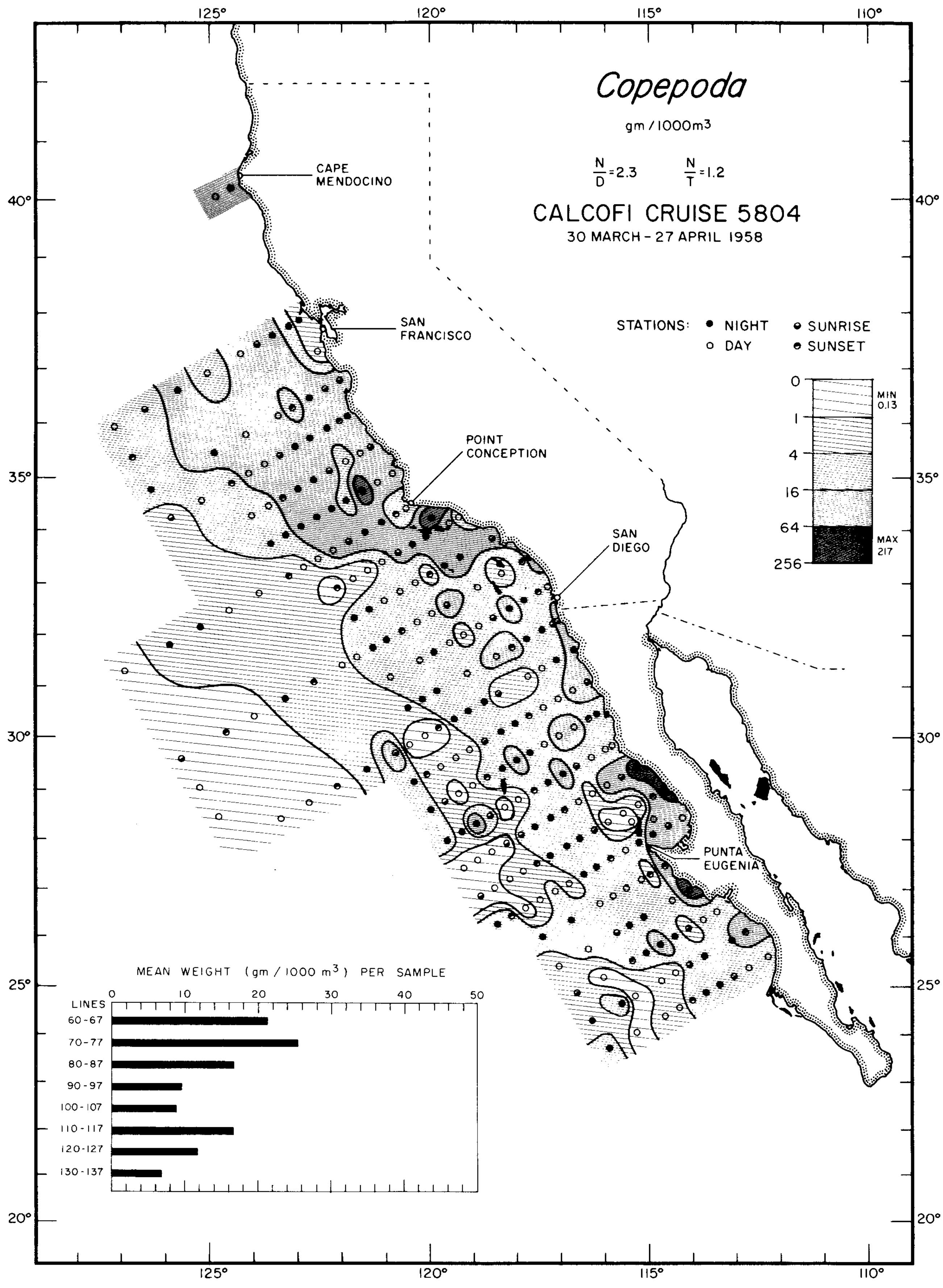
5504

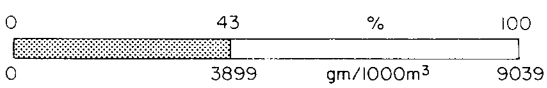


Biomass
Copepoda
5604



Biomass
Copepoda
5704

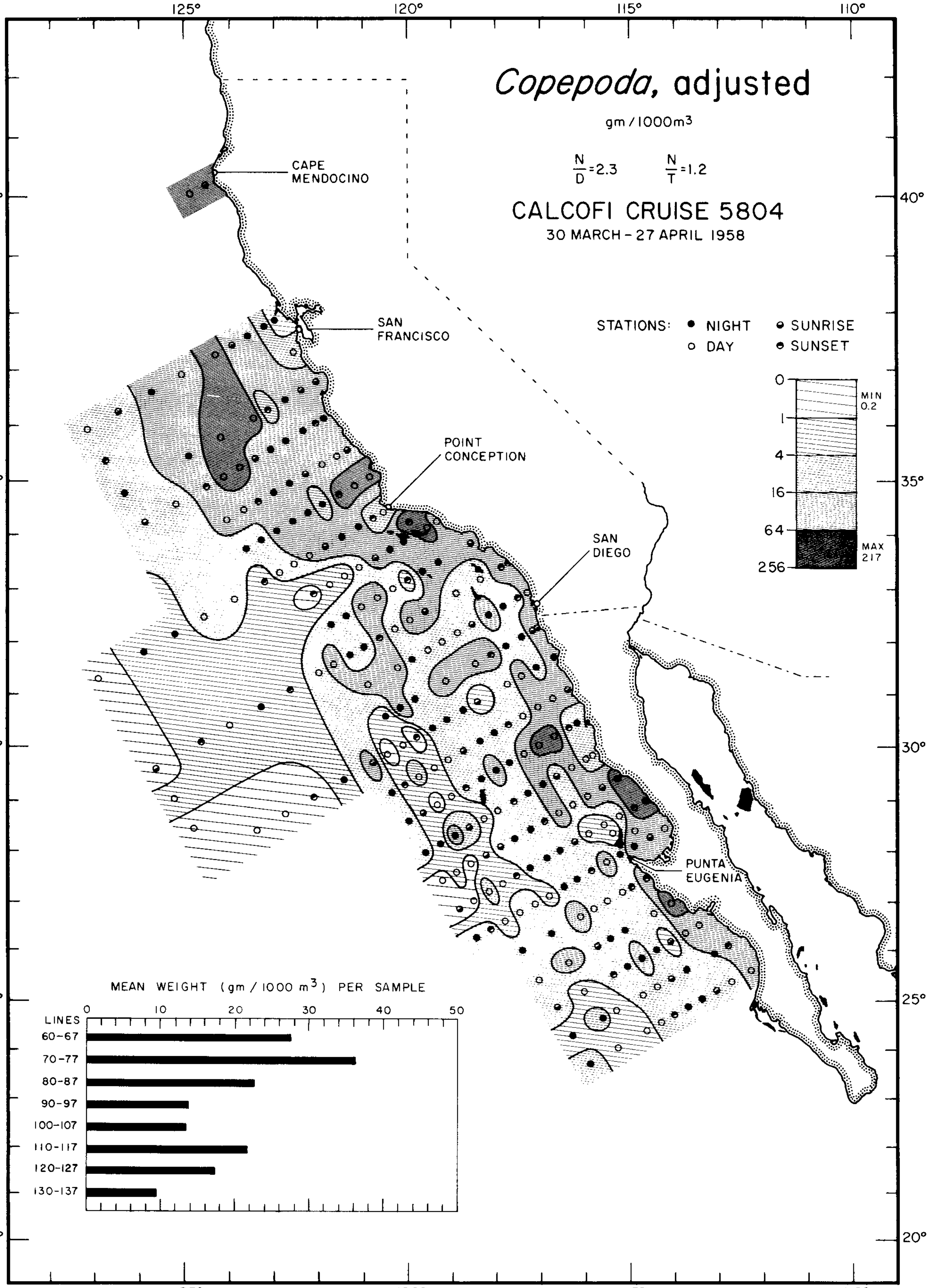




Biomass

Copepoda

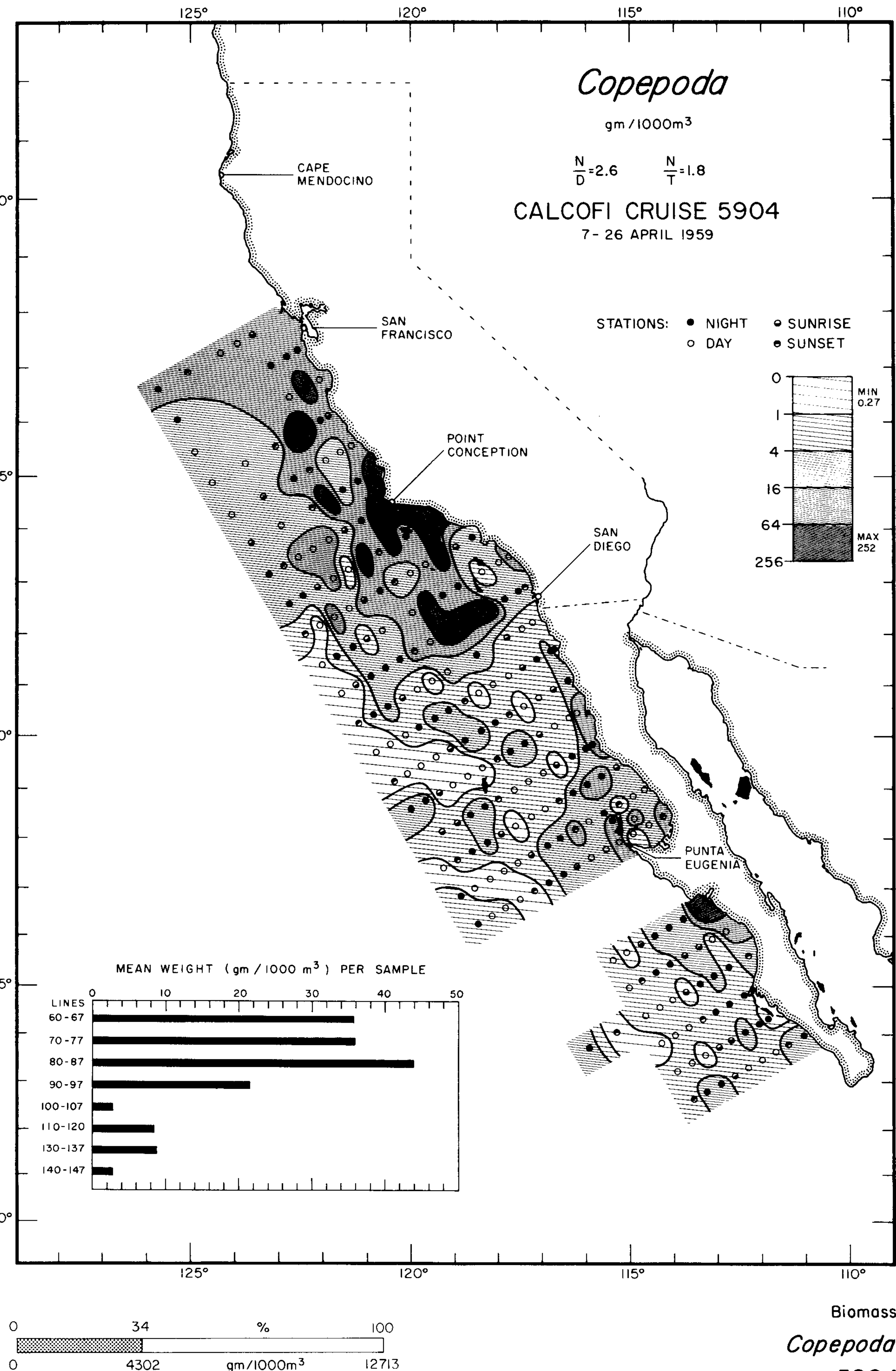
5804



Biomass

Copepoda, adjusted

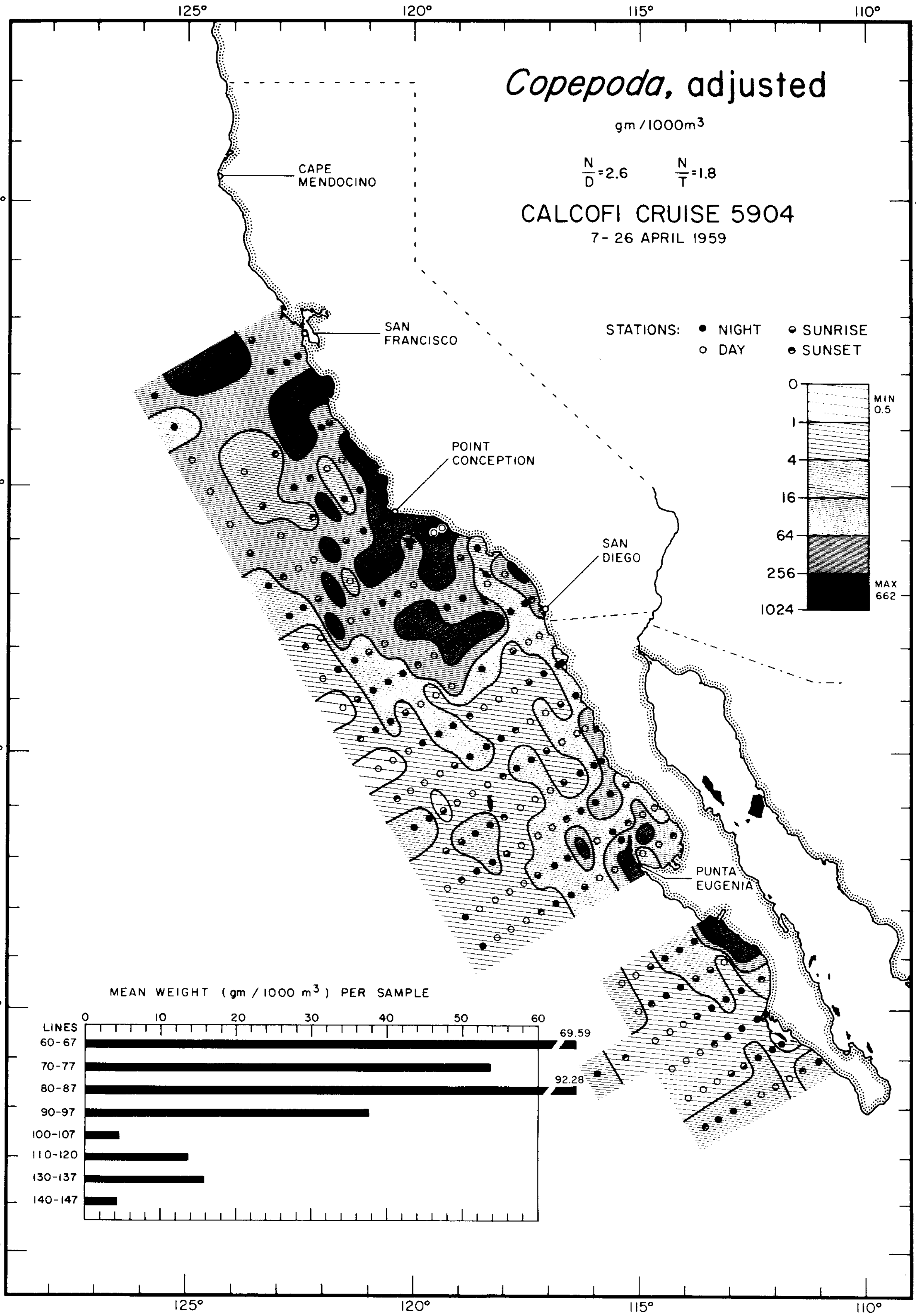
5804



Biomass

Copepoda

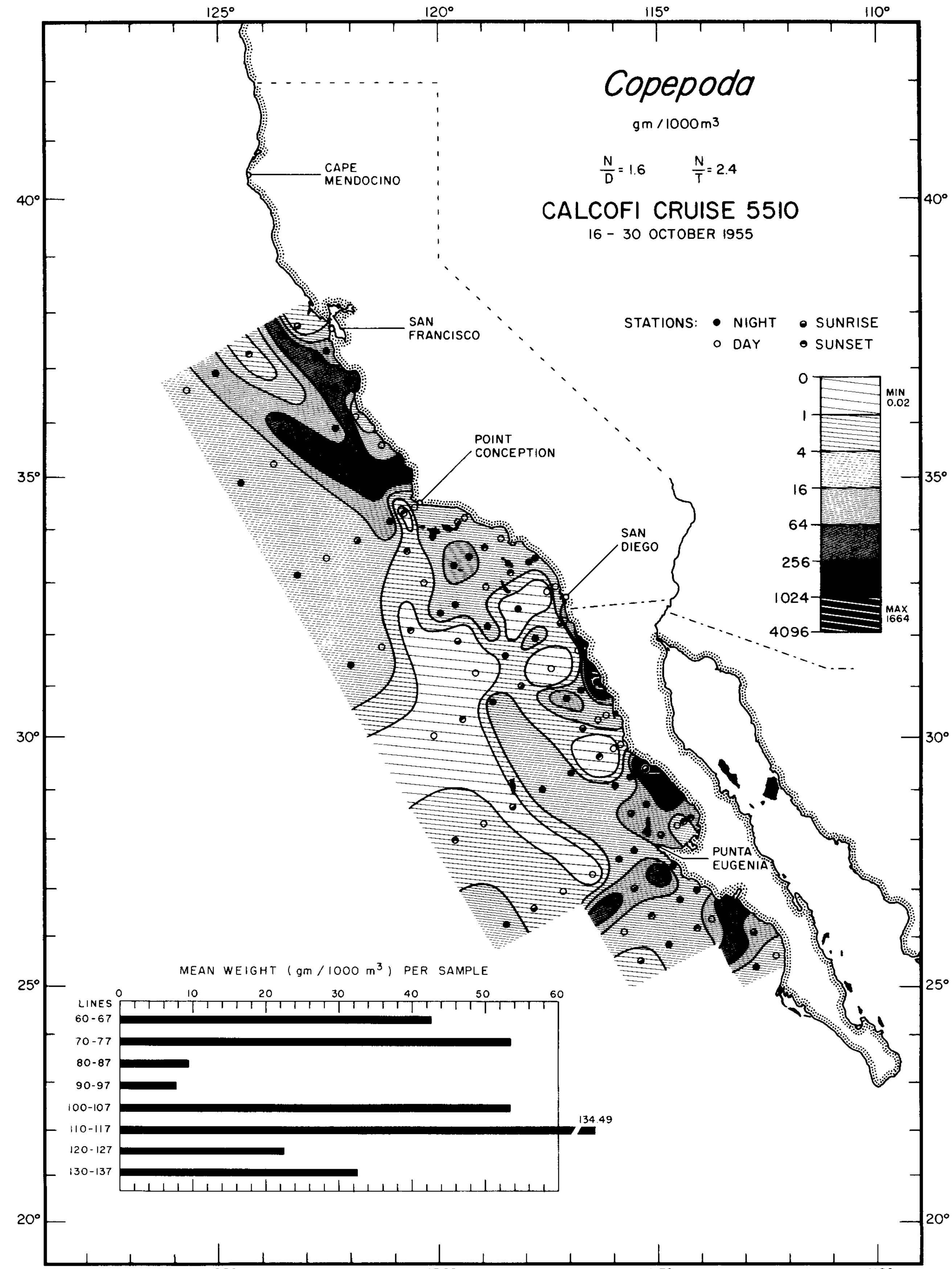
5904



Biomass

Copepoda, adjusted

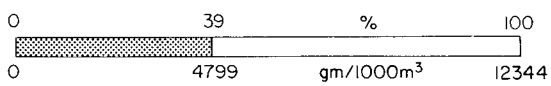
5904

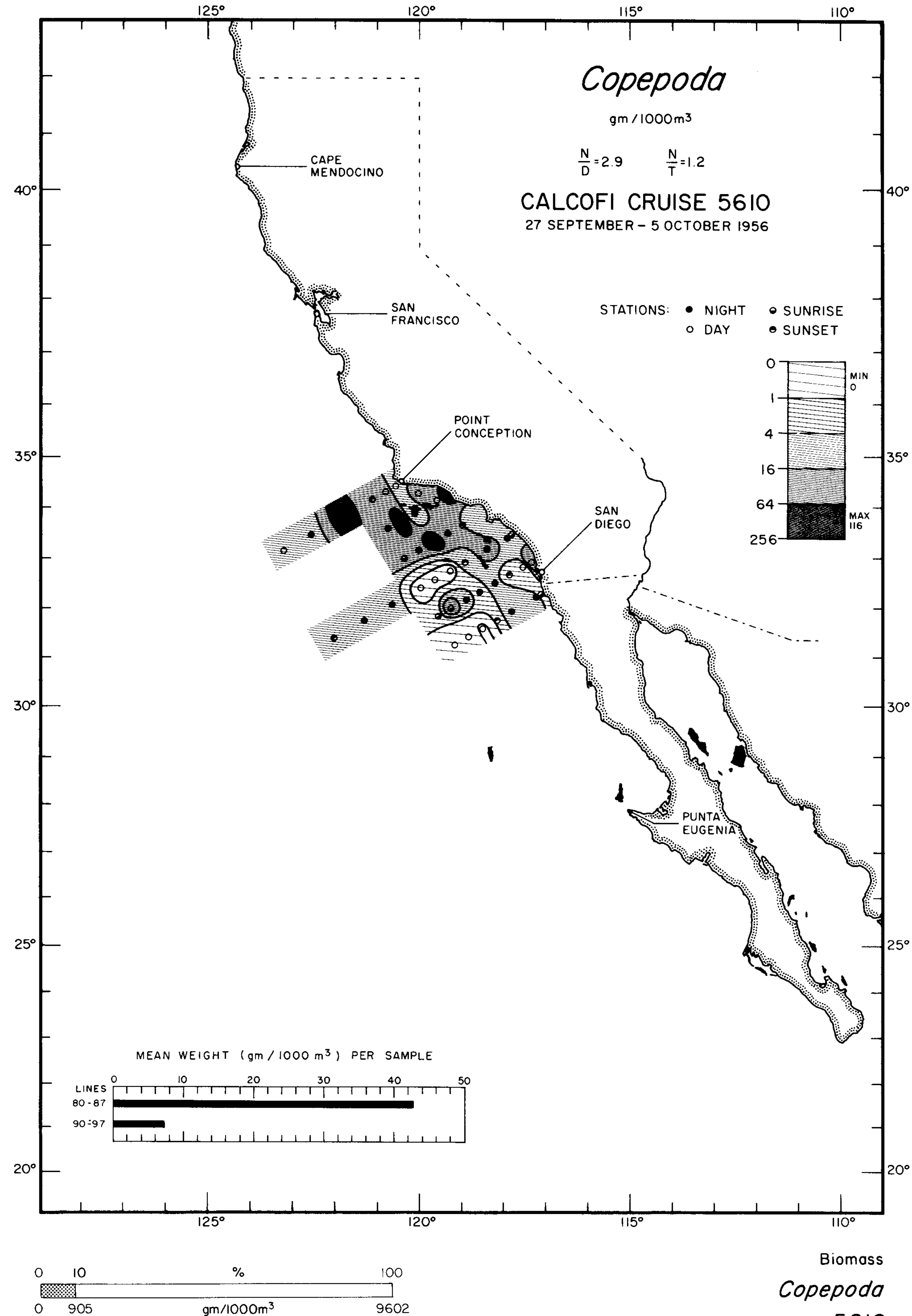


Biomass

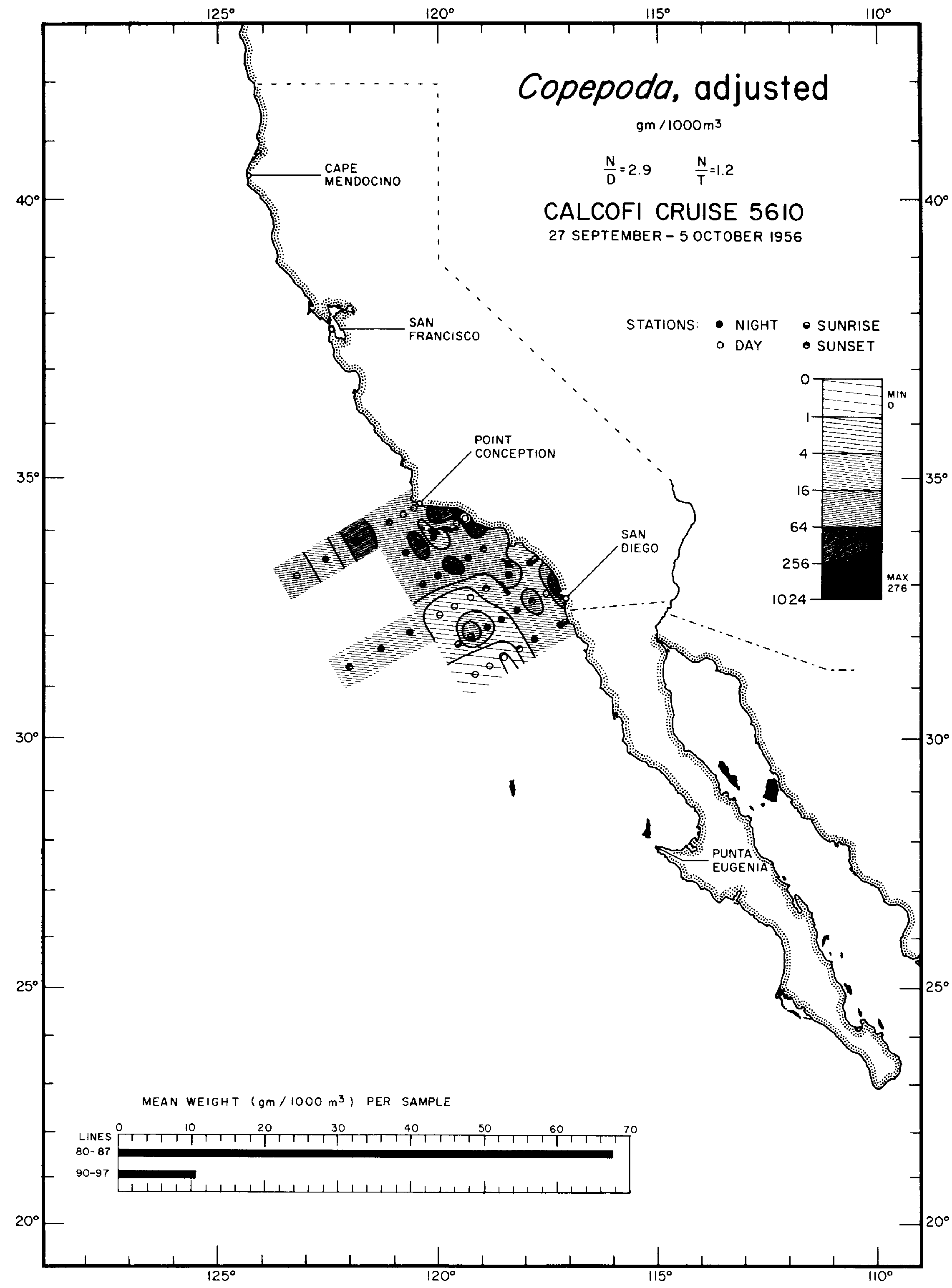
Copepoda

5510





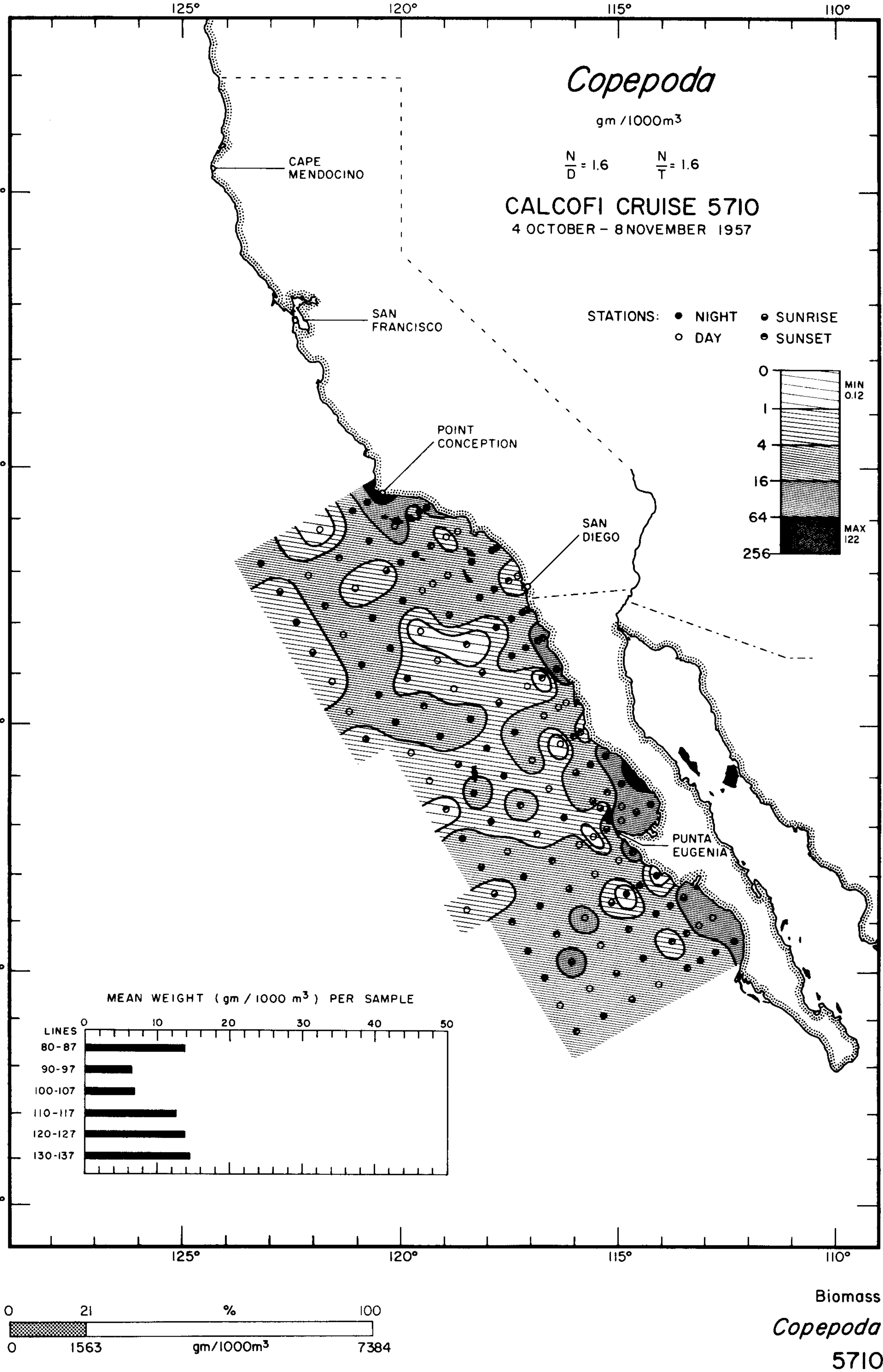
Biomass
Copepoda
5610



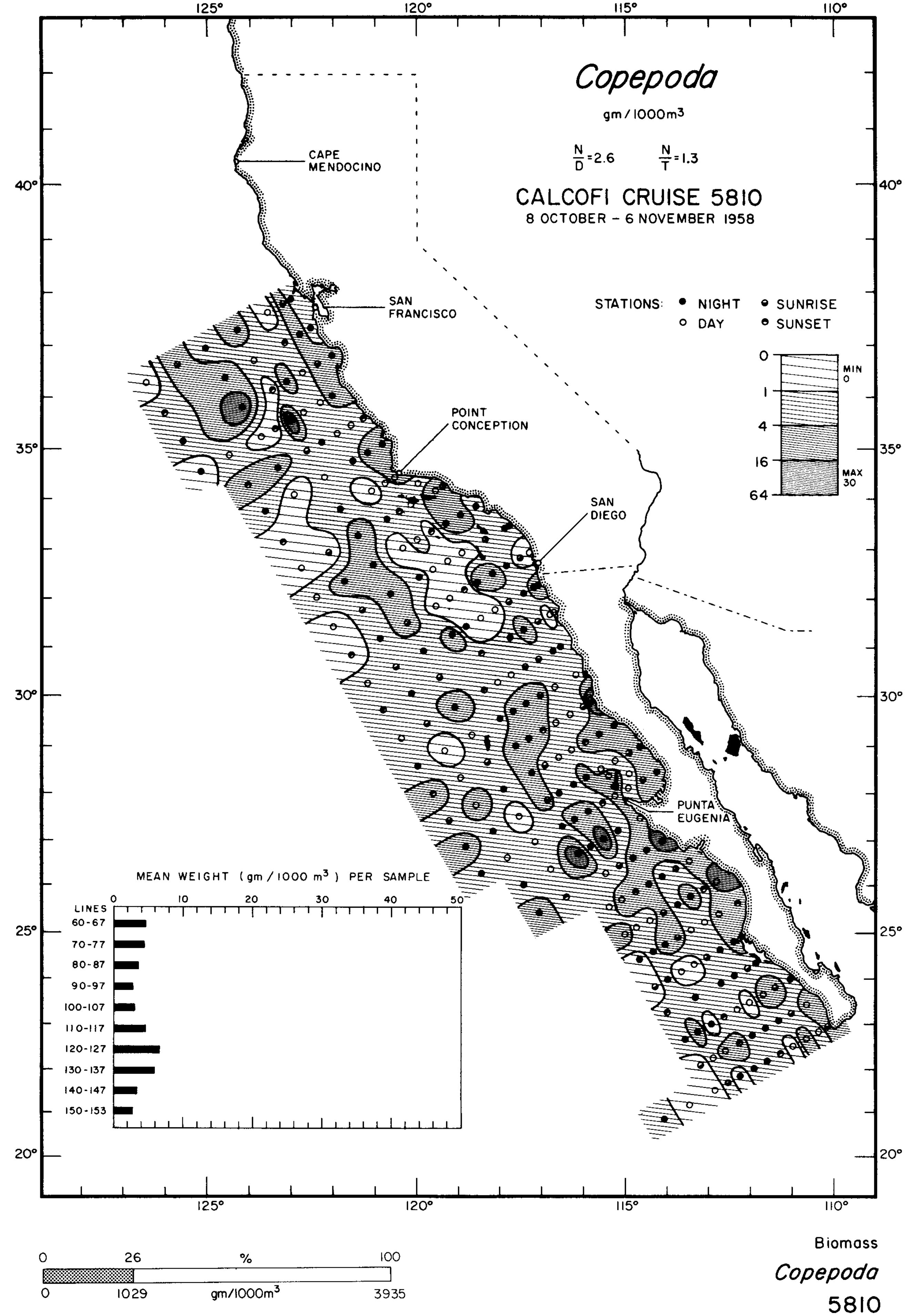
Biomass

Copepoda, adjusted

5610



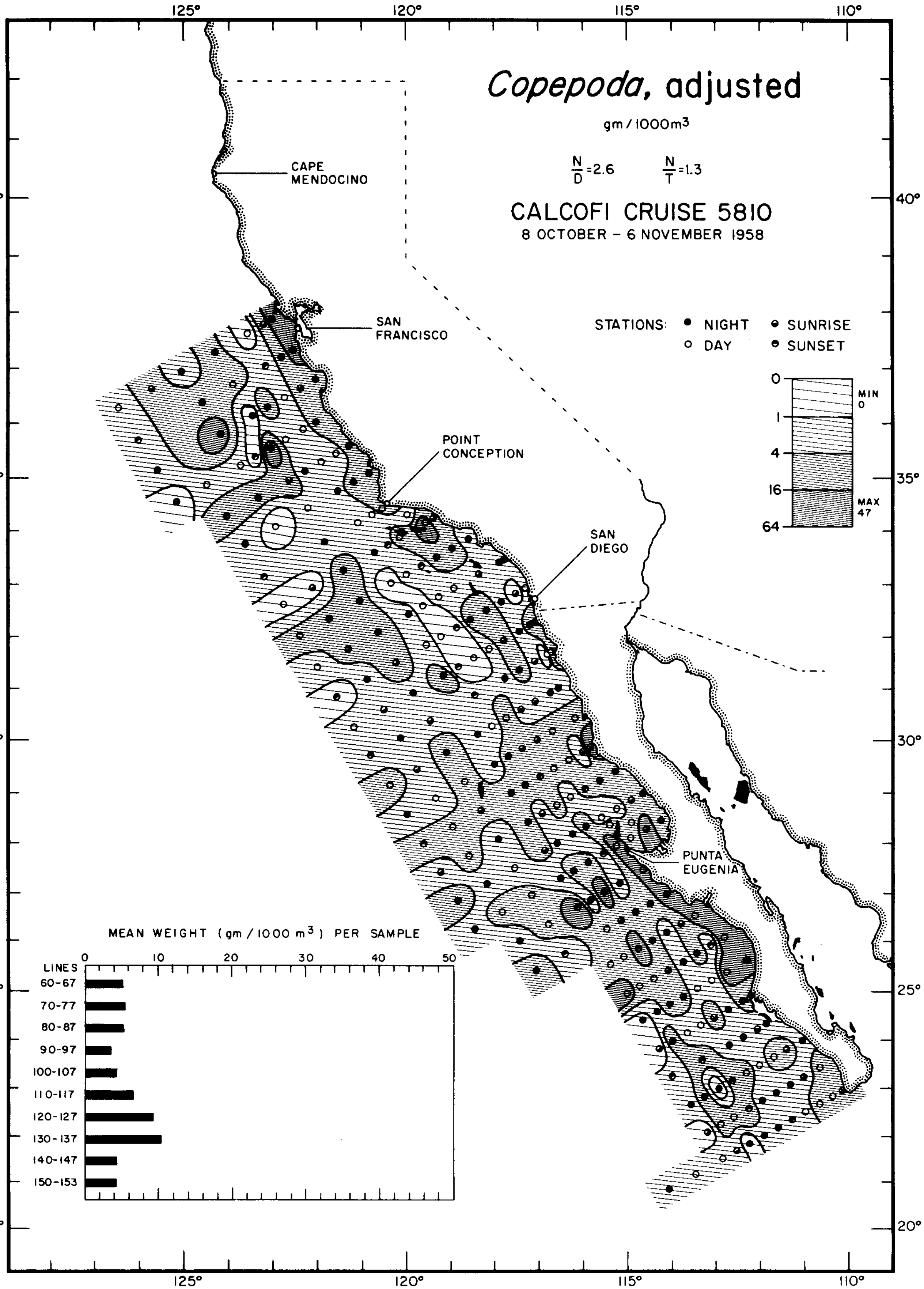
Biomass
Copepoda
5710



Biomass

Copepoda

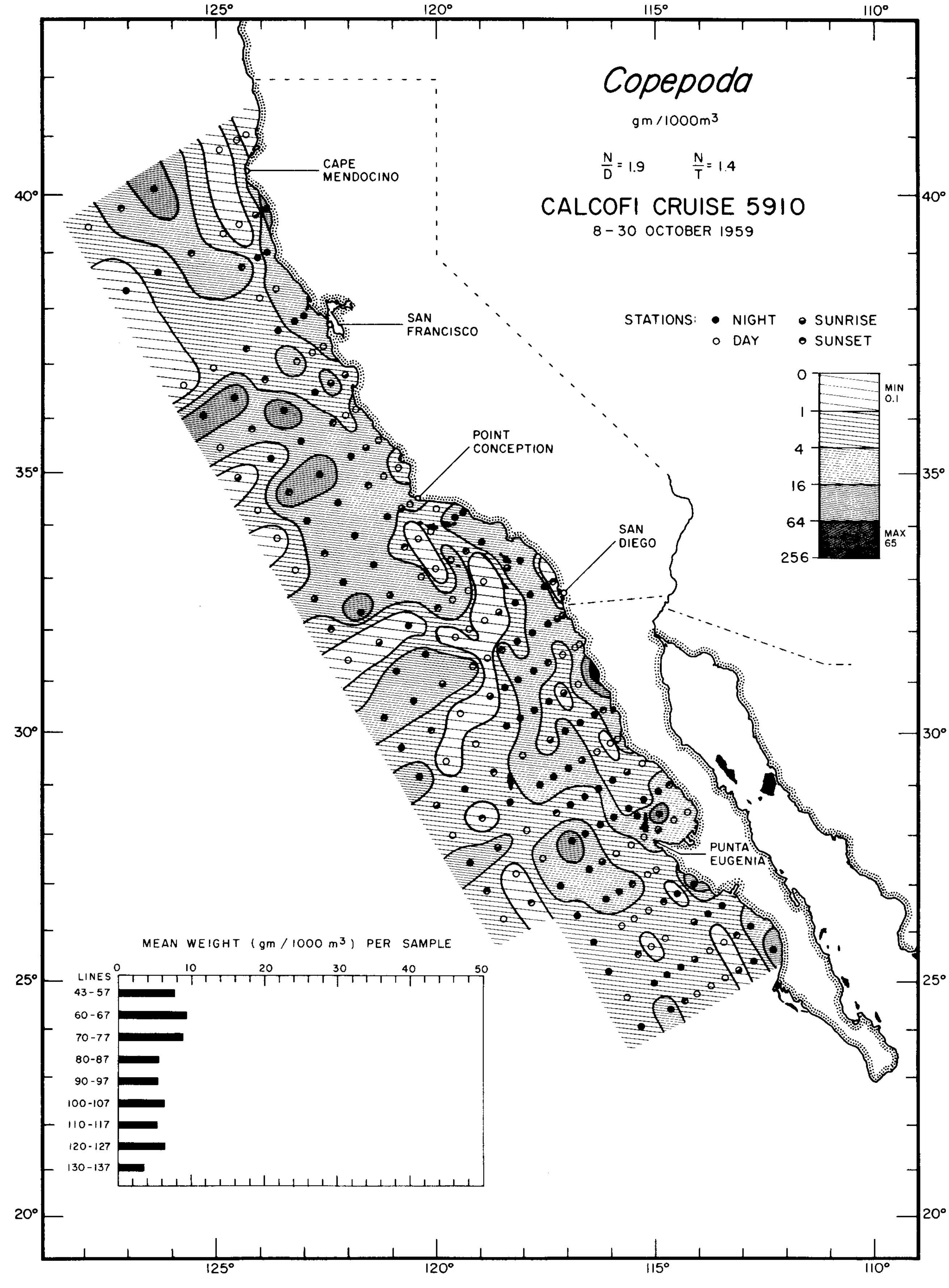
5810

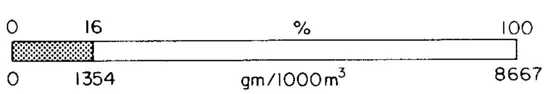


Biomass

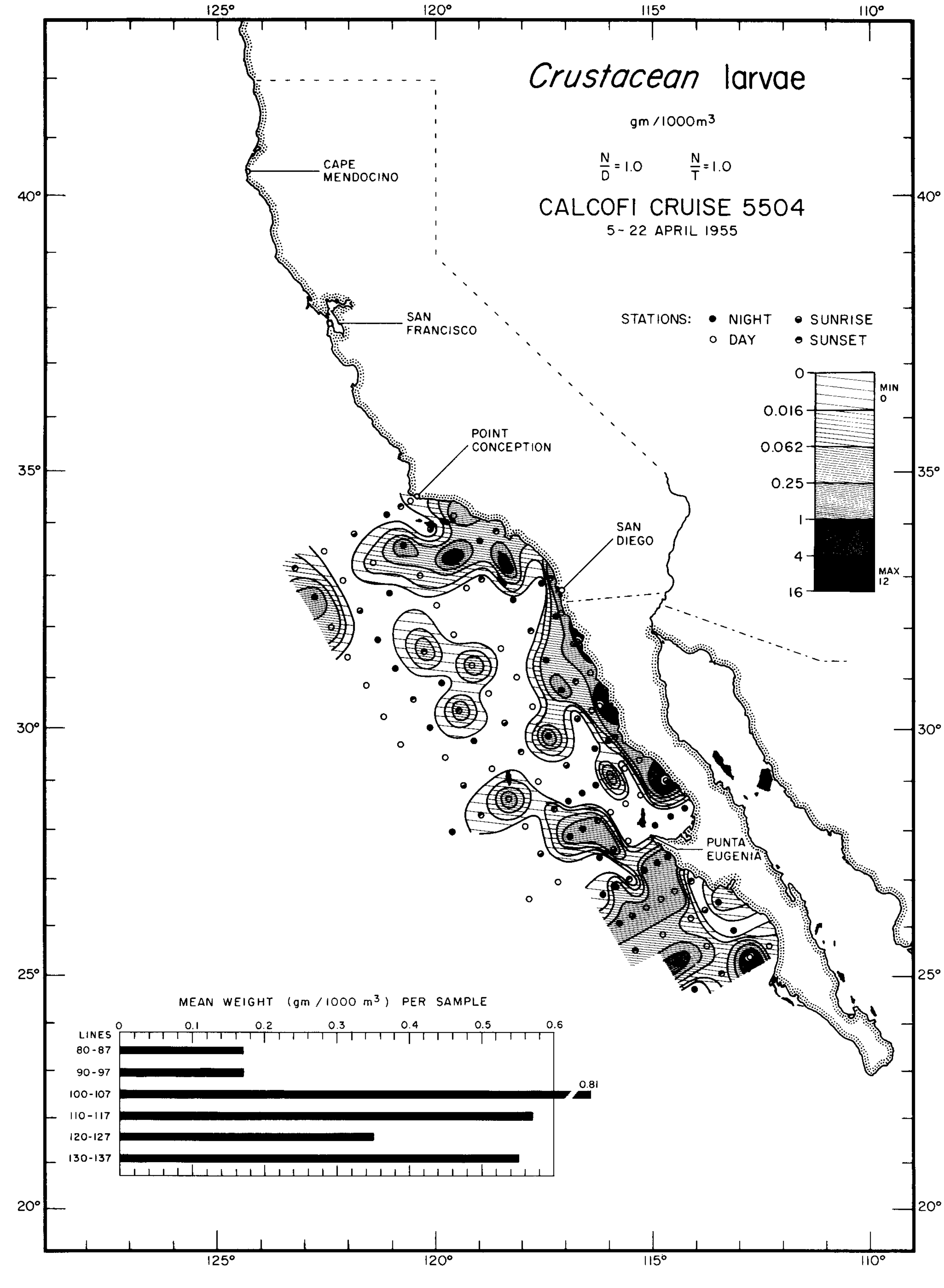
Copepoda, adjusted

5810





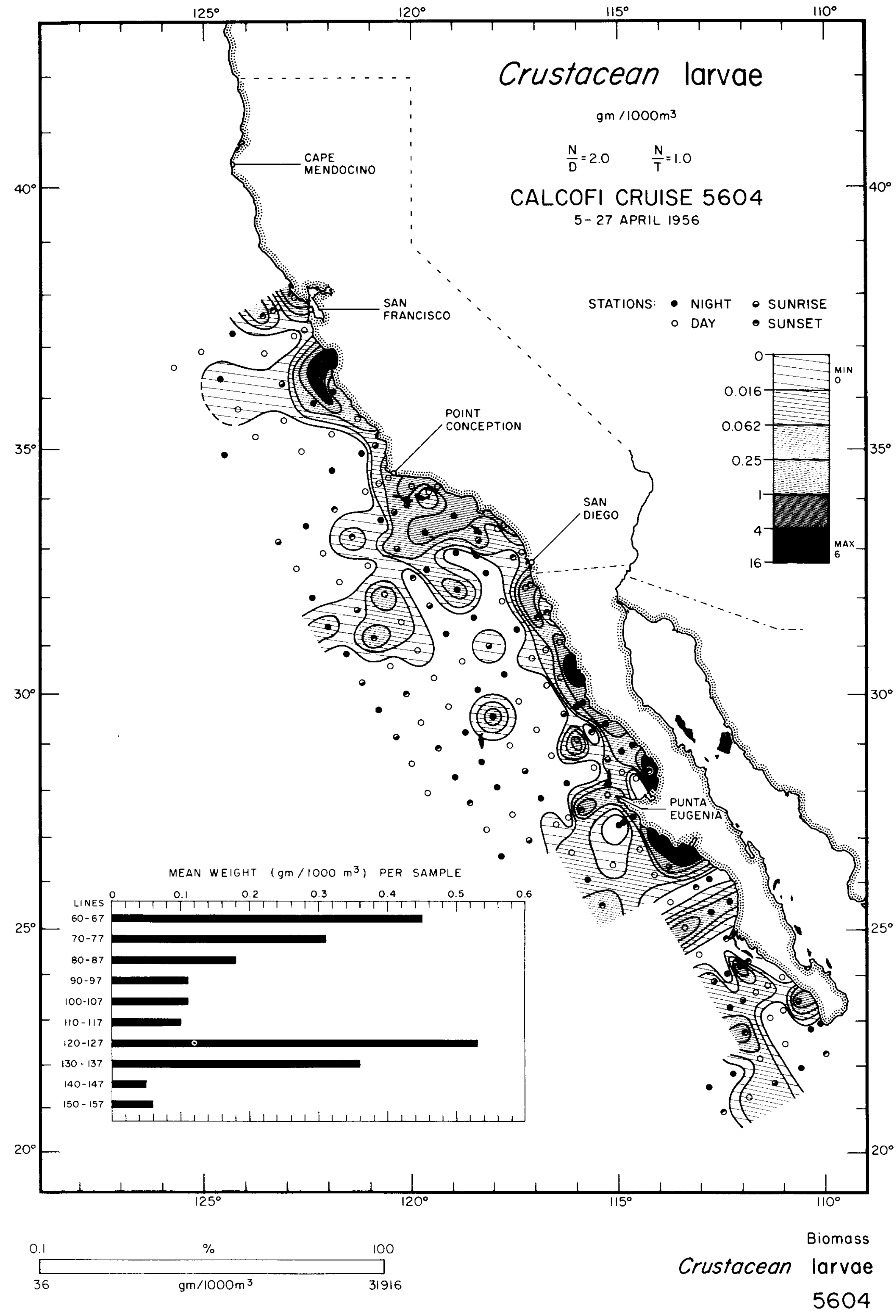
Biomass
Copepoda
5910



Biomass

Crustacean larvae

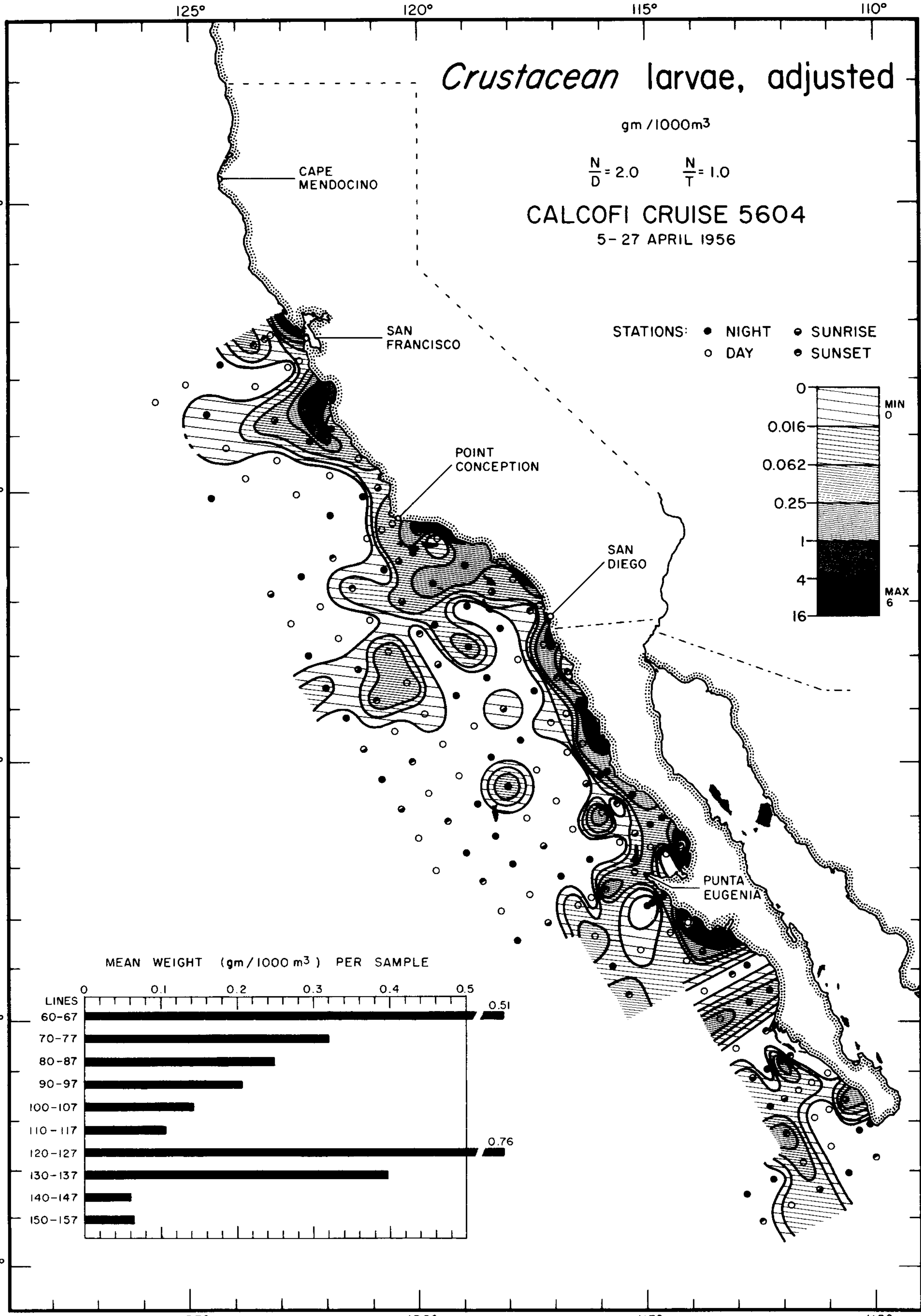
5504



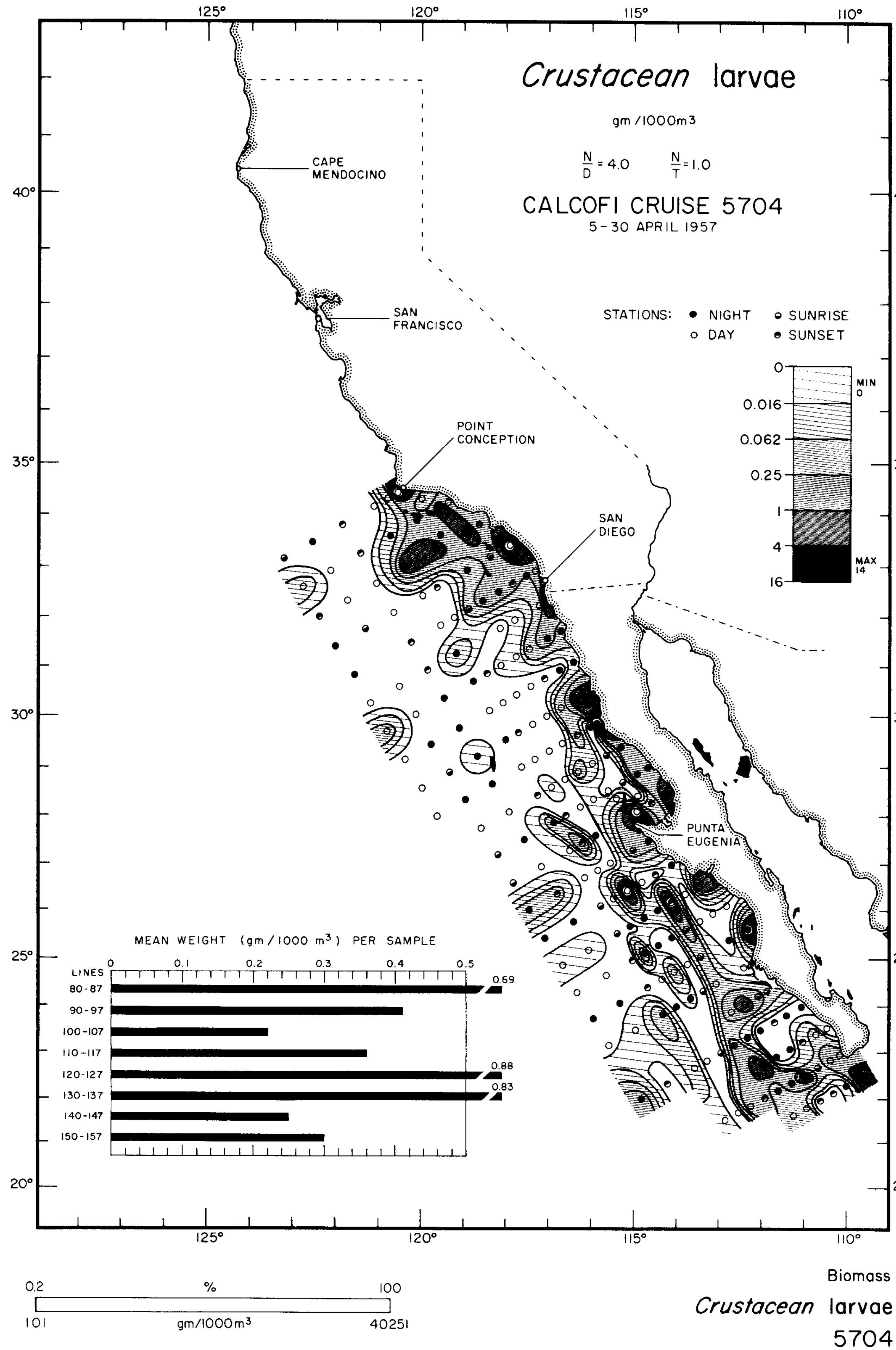
Biomass

Crustacean larvae

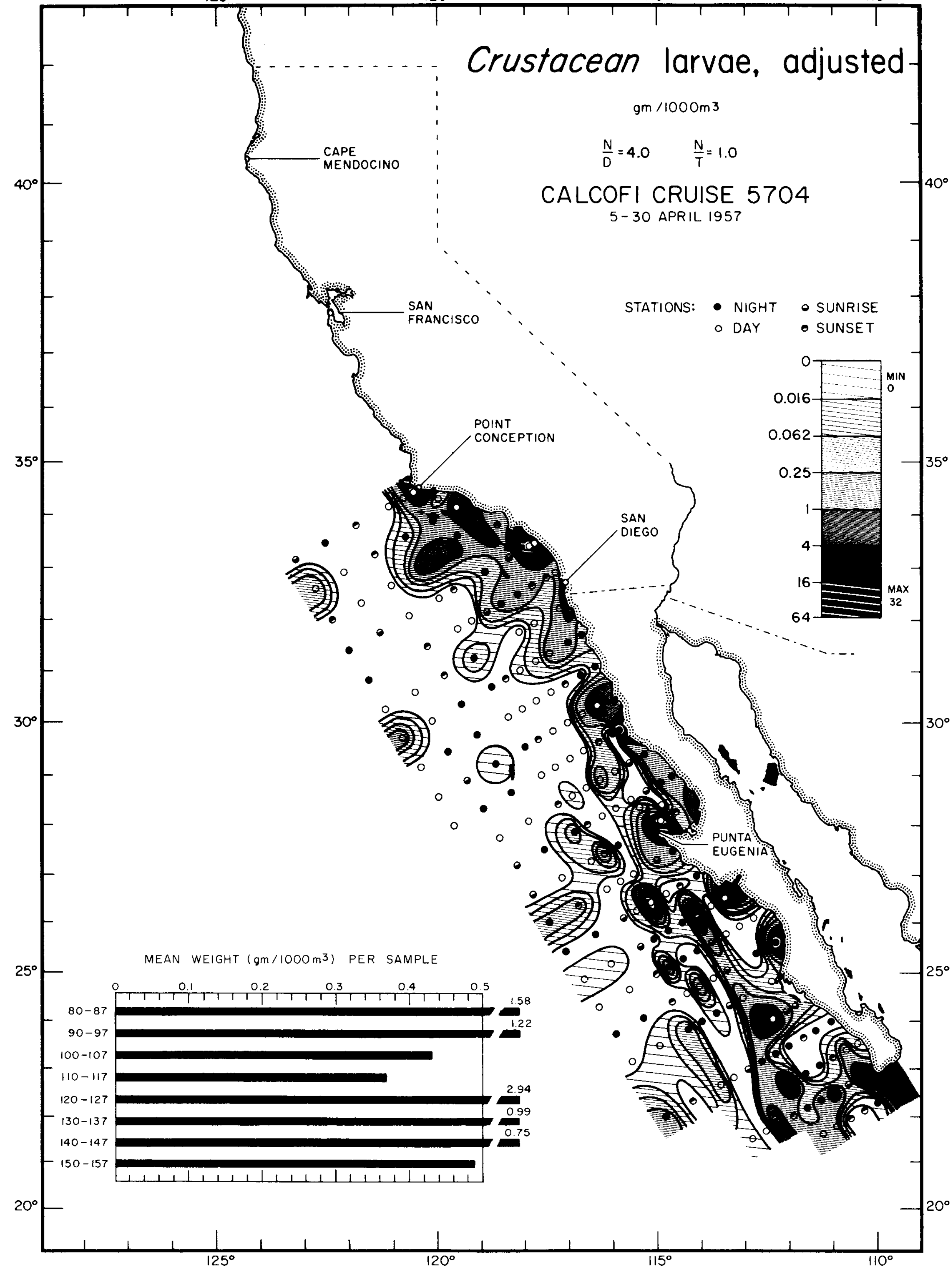
5604



Biomass
Crustacean larvae, adjusted
5604



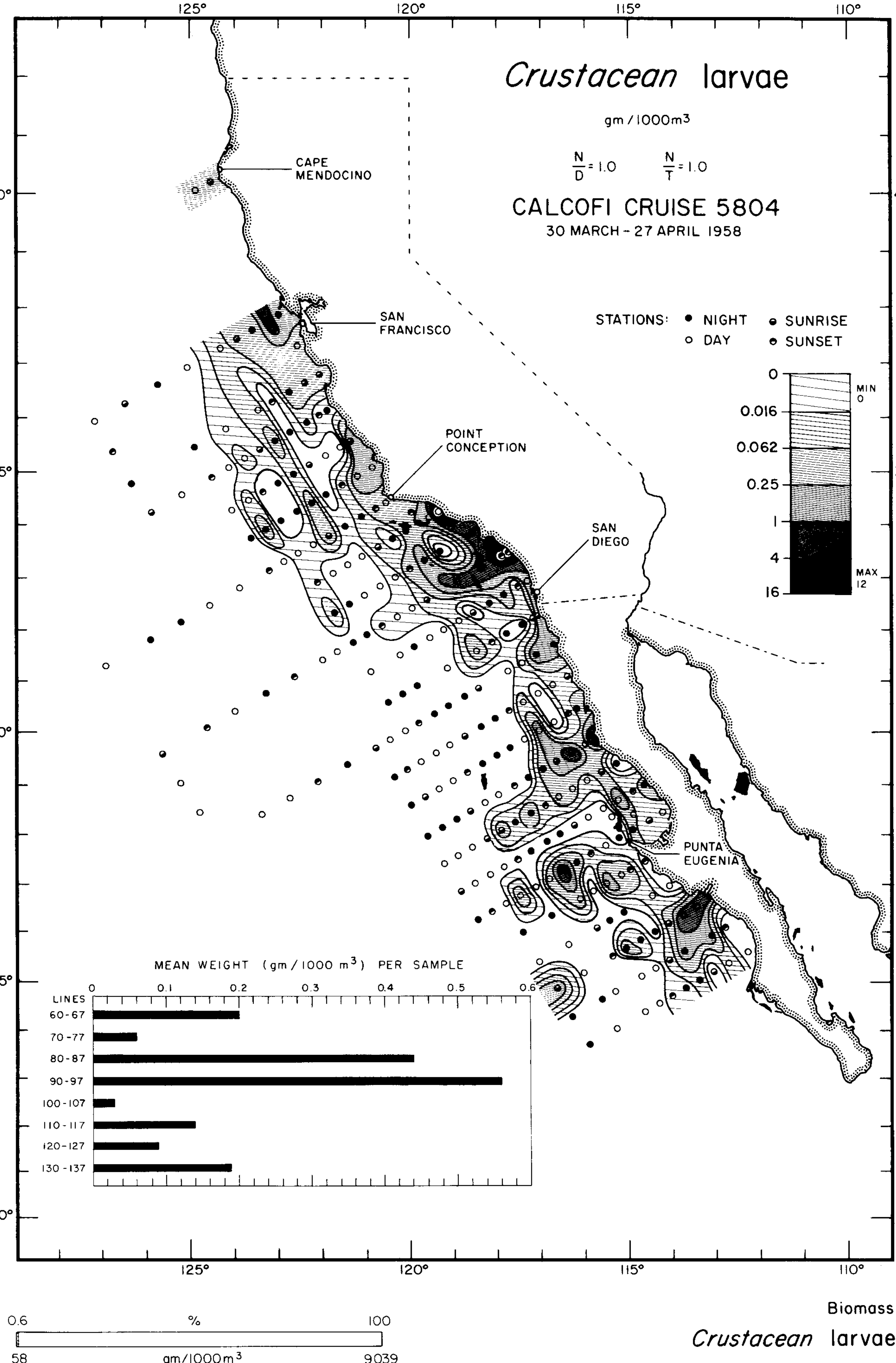
Biomass
Crustacean larvae
5704



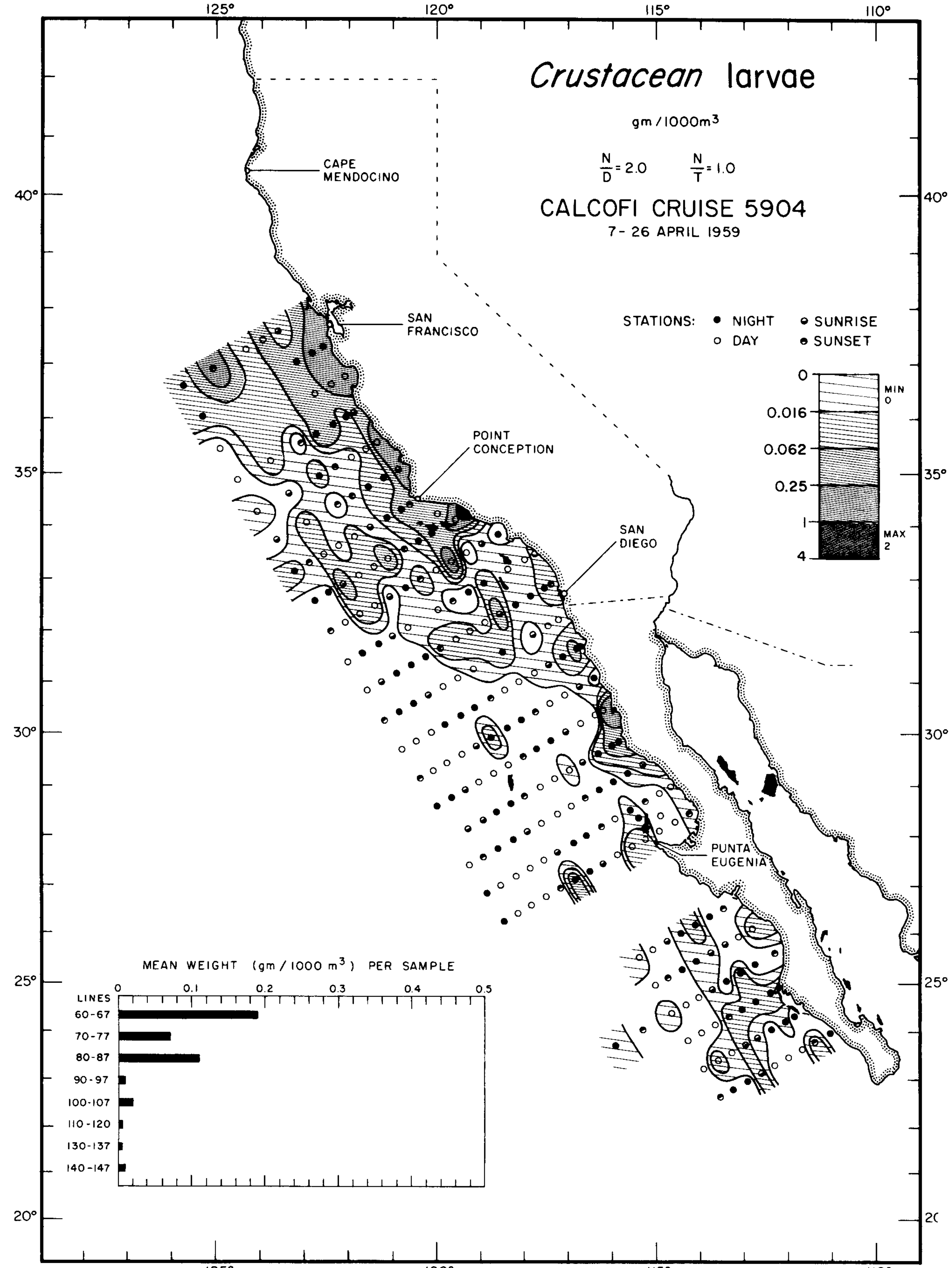
Biomass

Crustacean larvae, adjusted

5704



Biomass
Crustacean larvae
5804



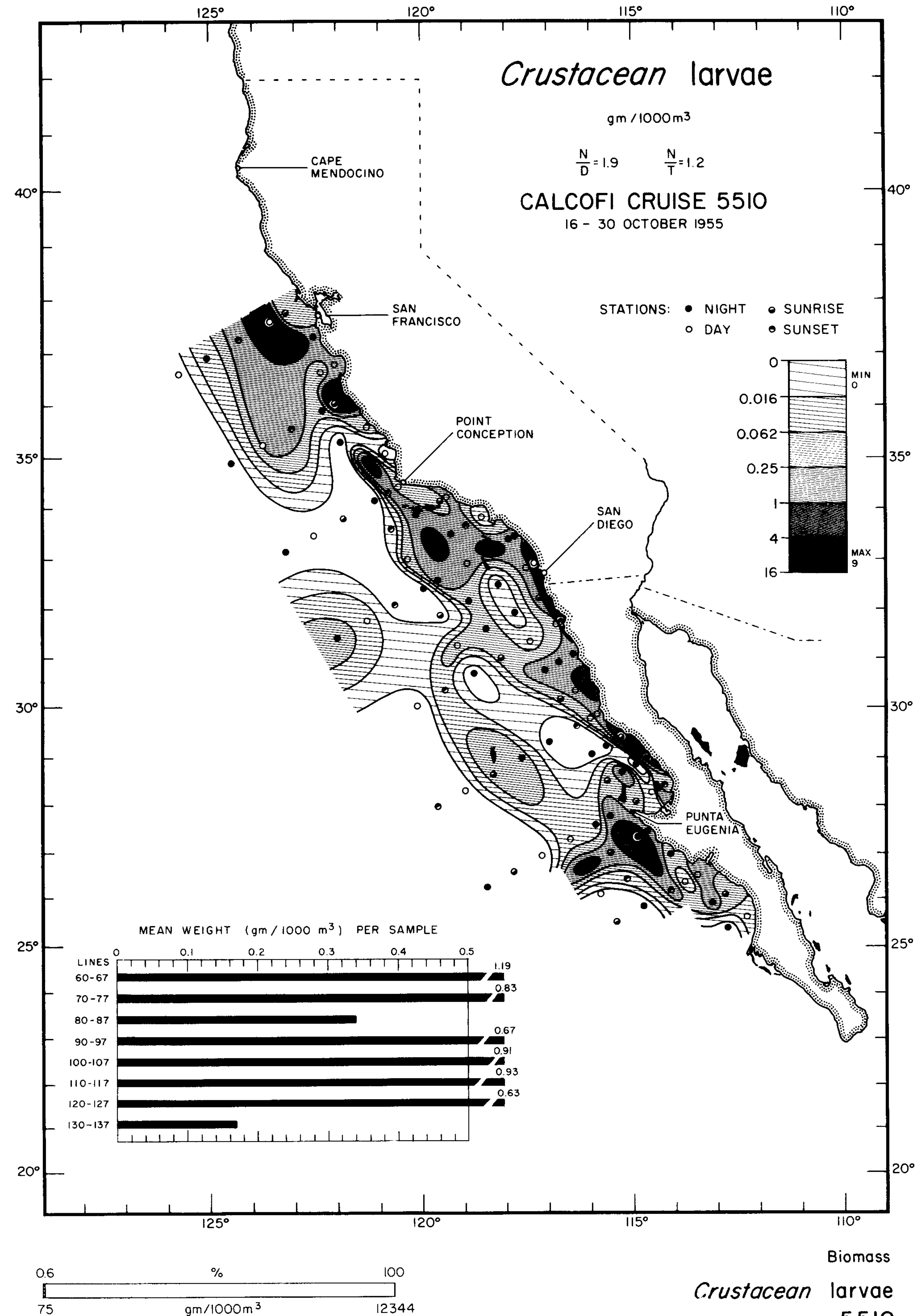
<0.1 % 100

10 gm/1000m³ 12713

Biomass

Crustacean larvae

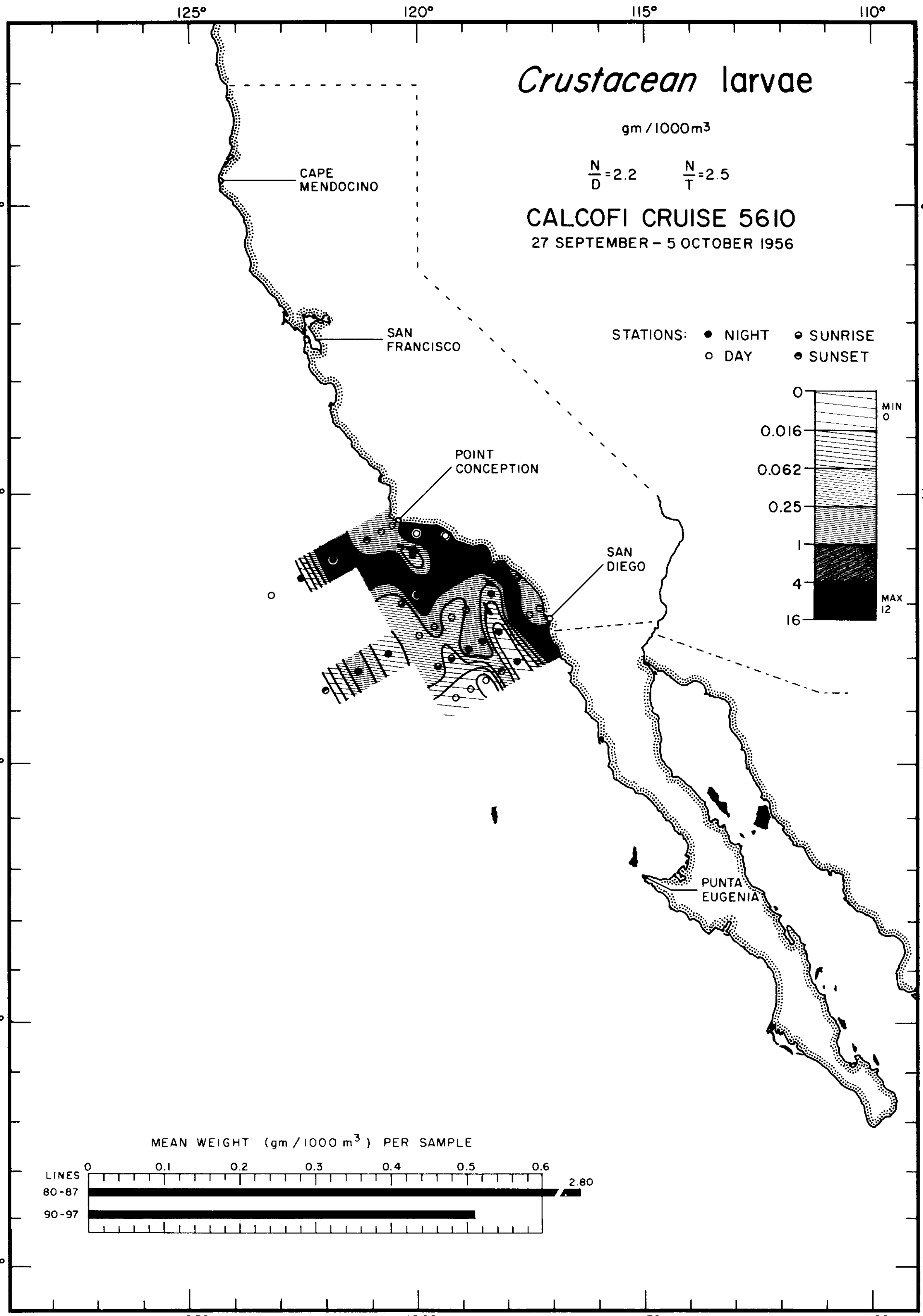
5904

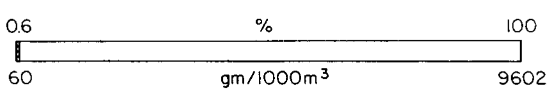


Biomass

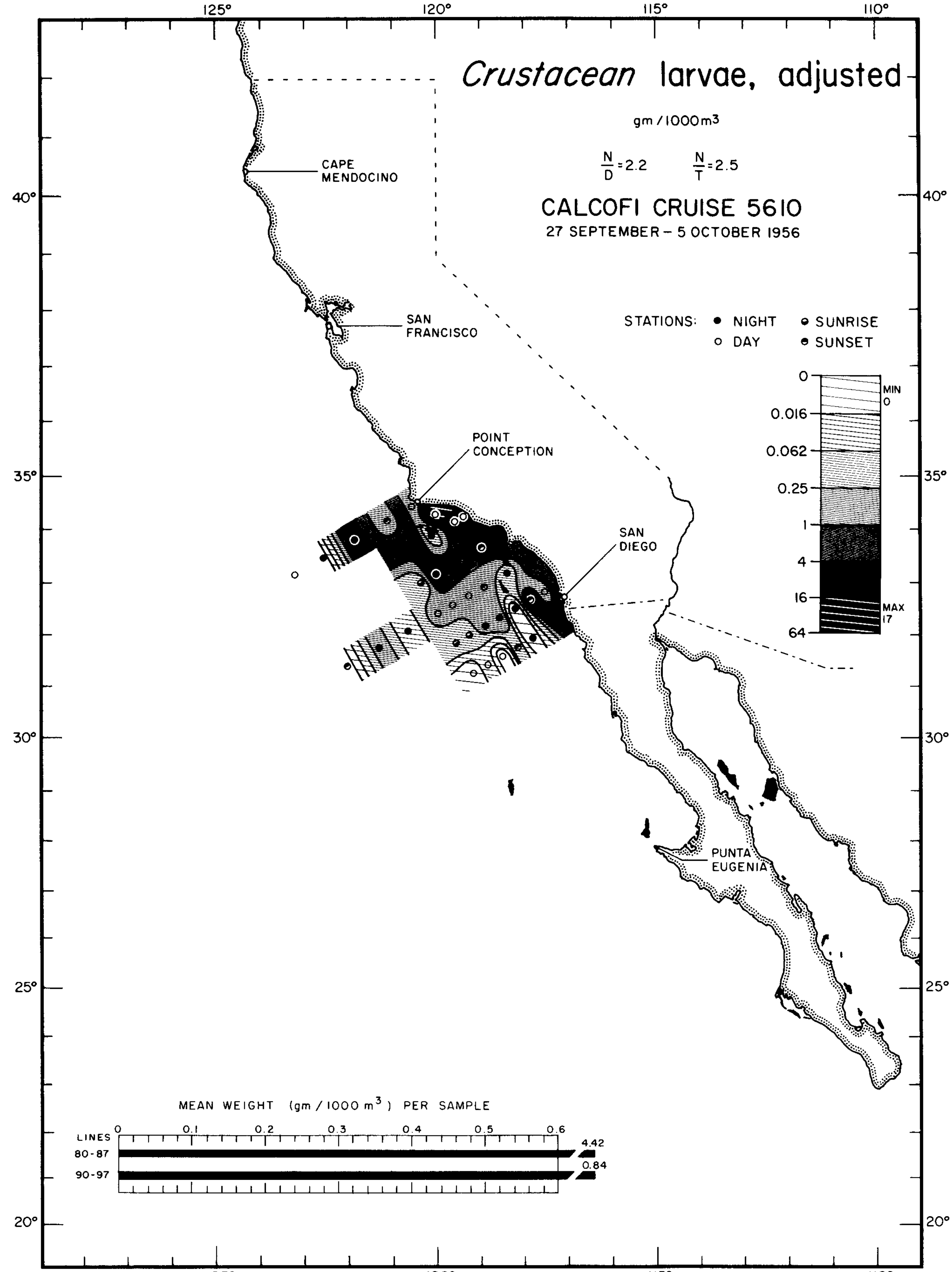
Crustacean larvae

5510





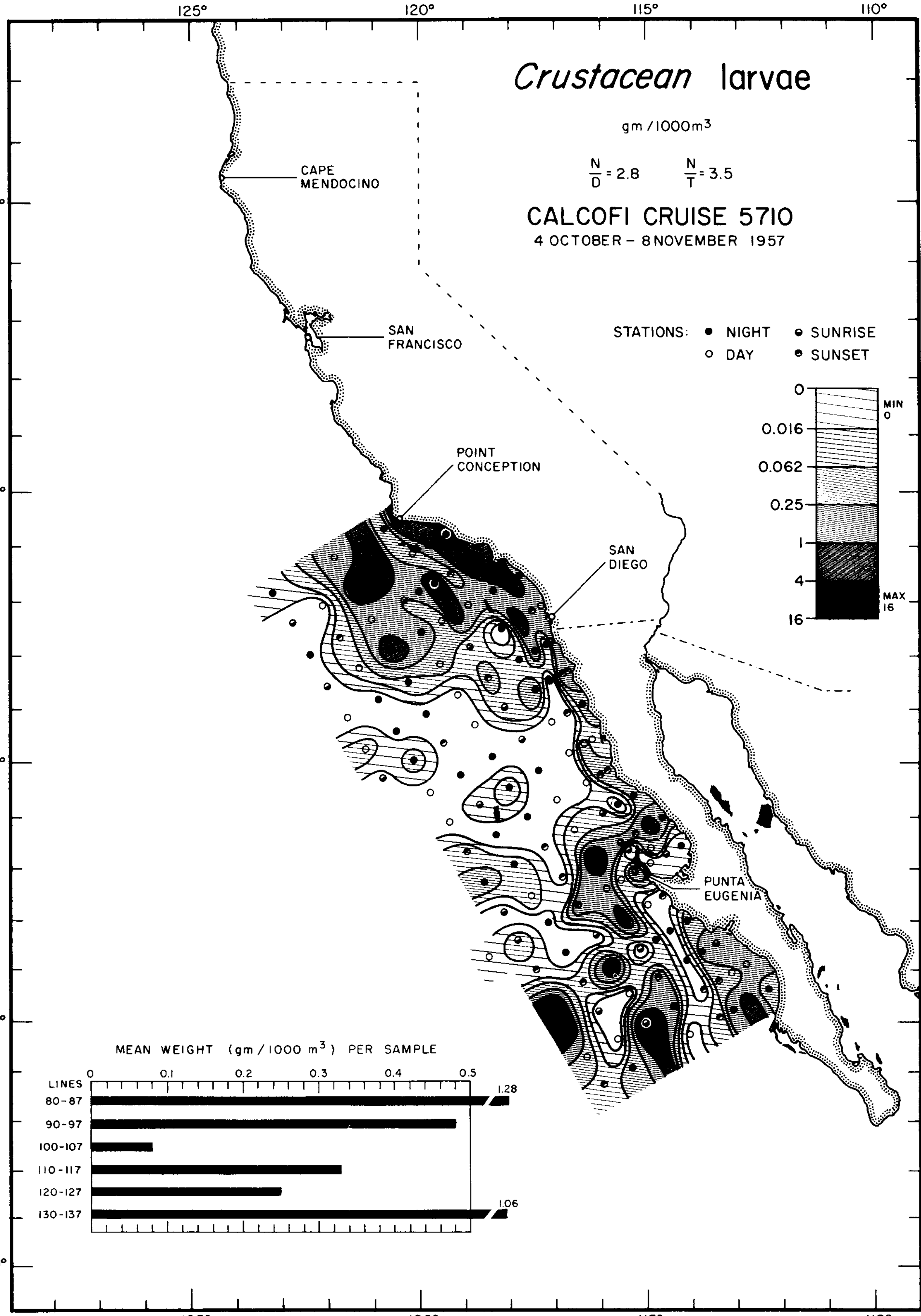
Biomass
Crustacean larvae
5610

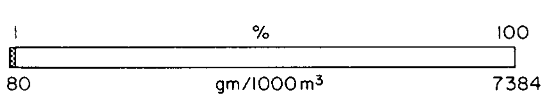


Biomass

Crustacean larvae, adjusted

5610

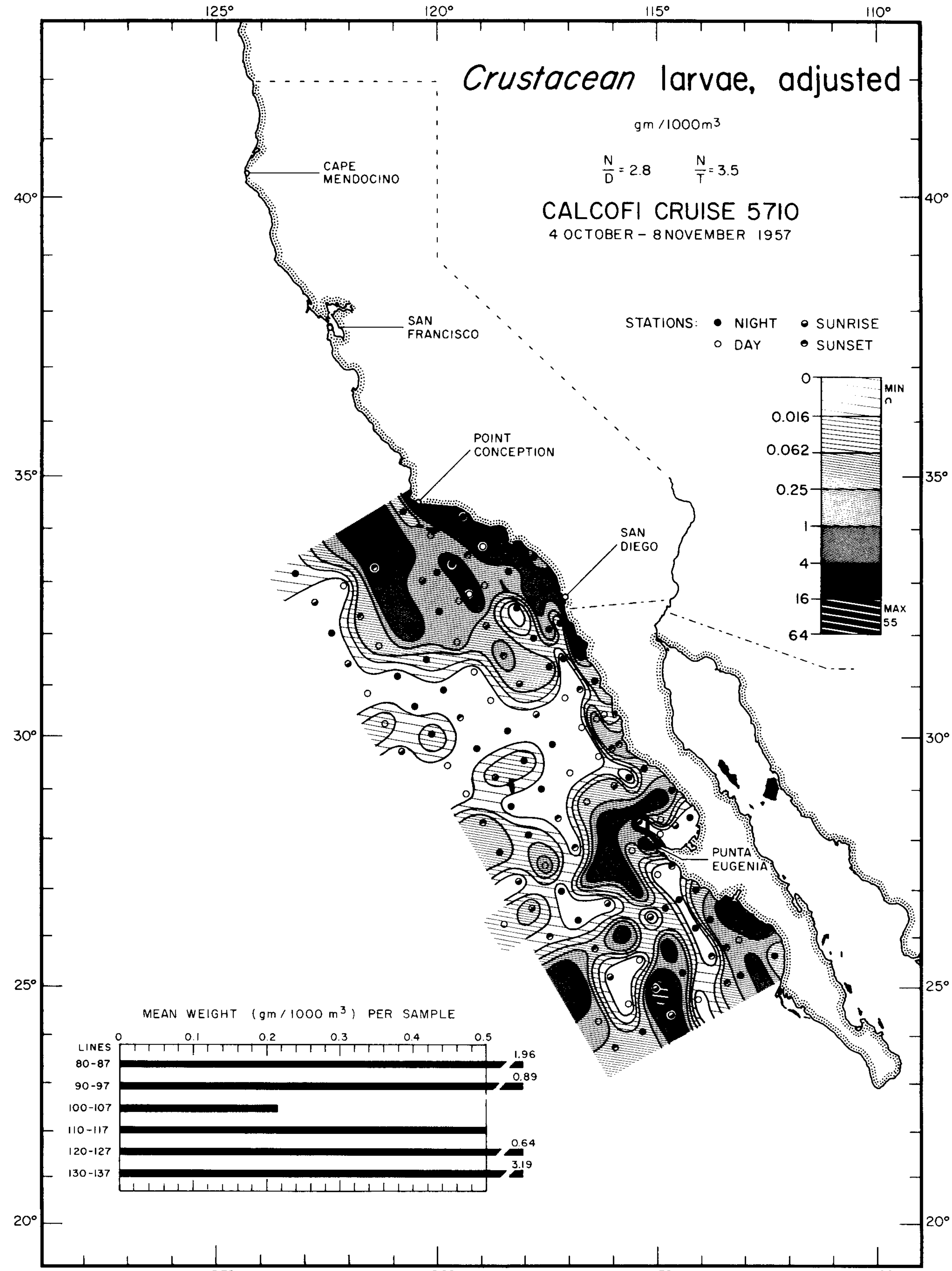




Biomass

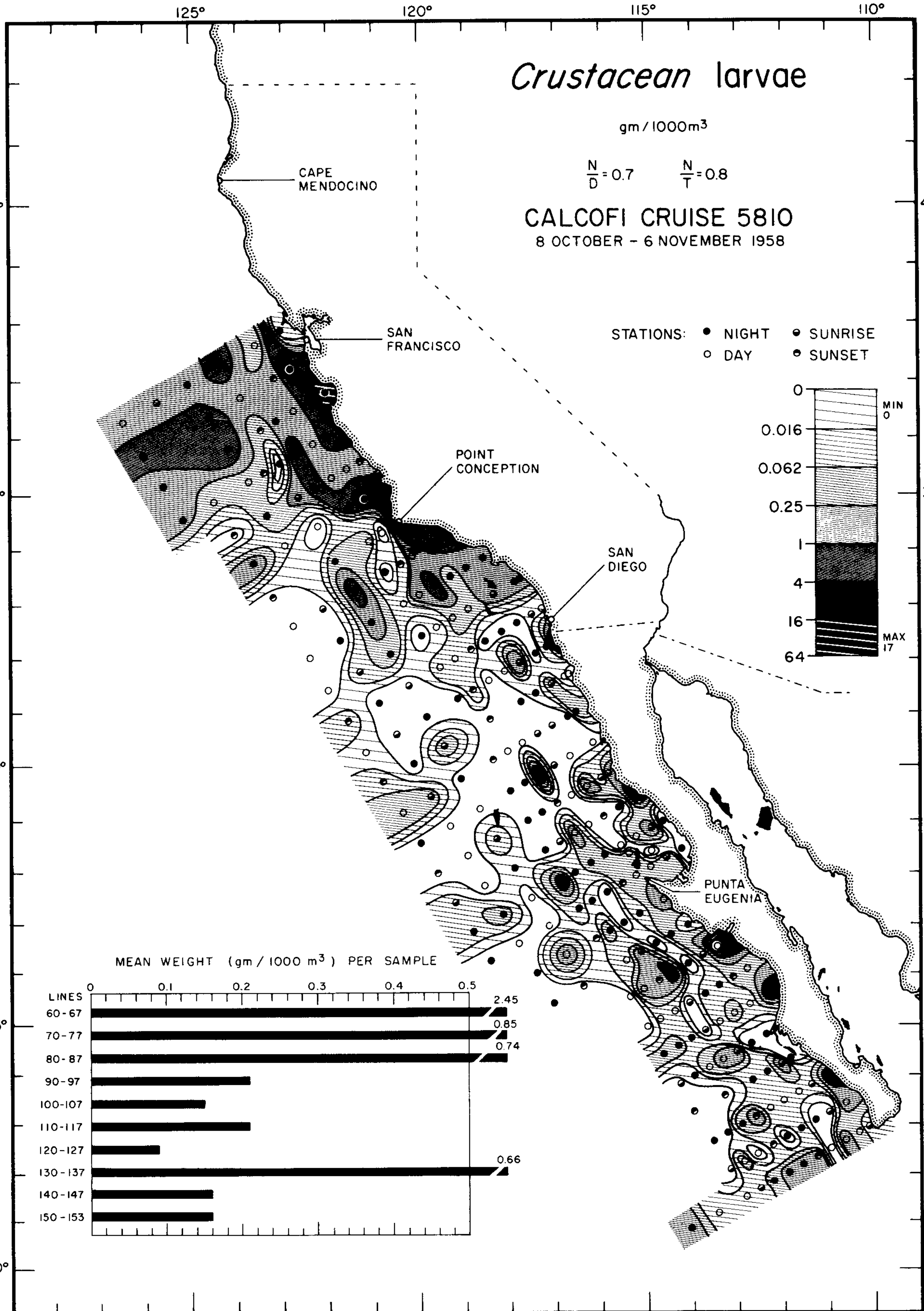
Crustacean larvae

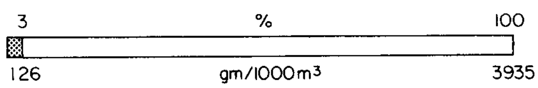
5710



Biomass

Crustacean larvae, adjusted
5710

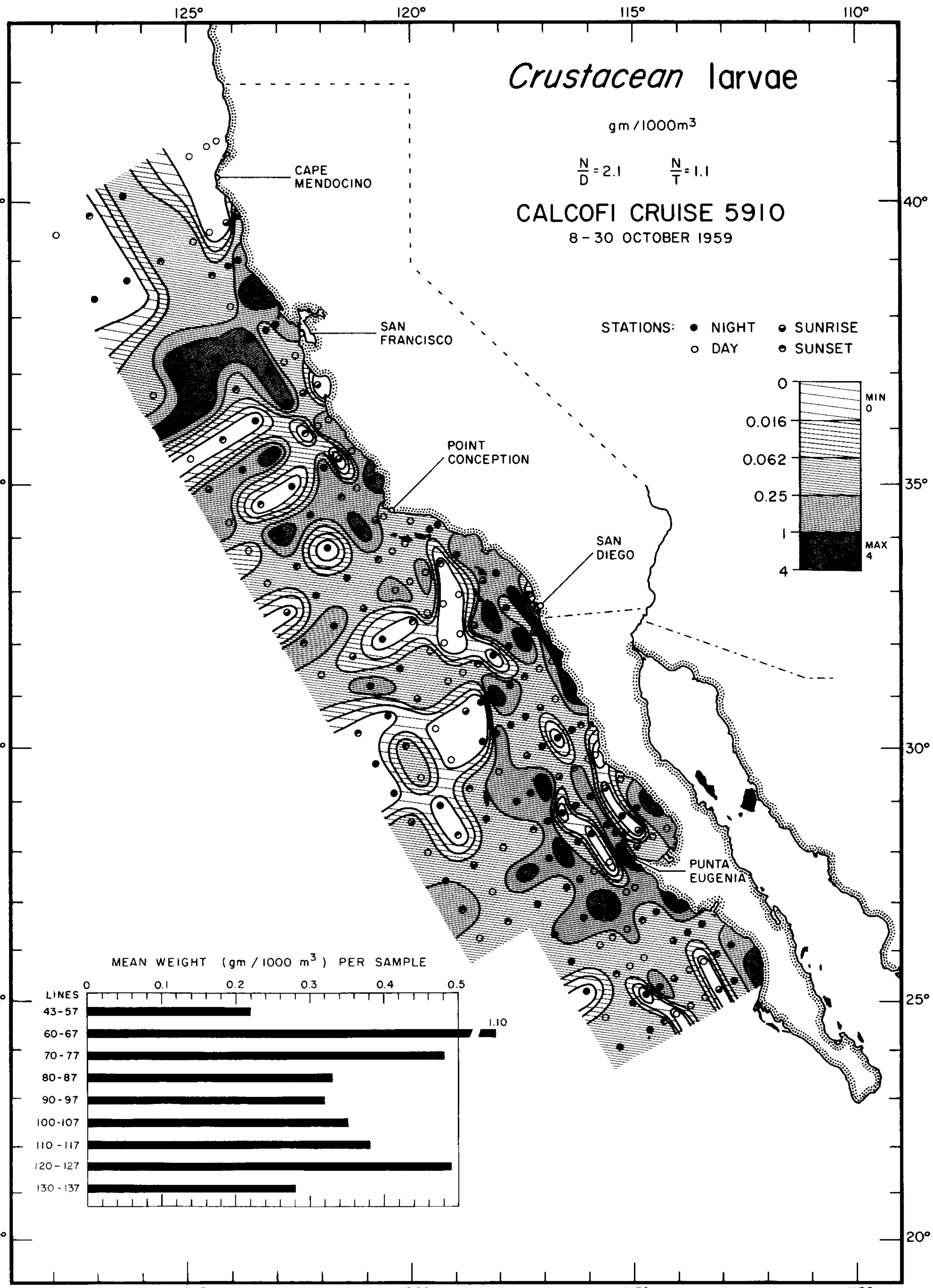


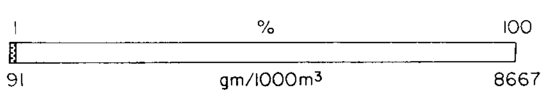


Biomass

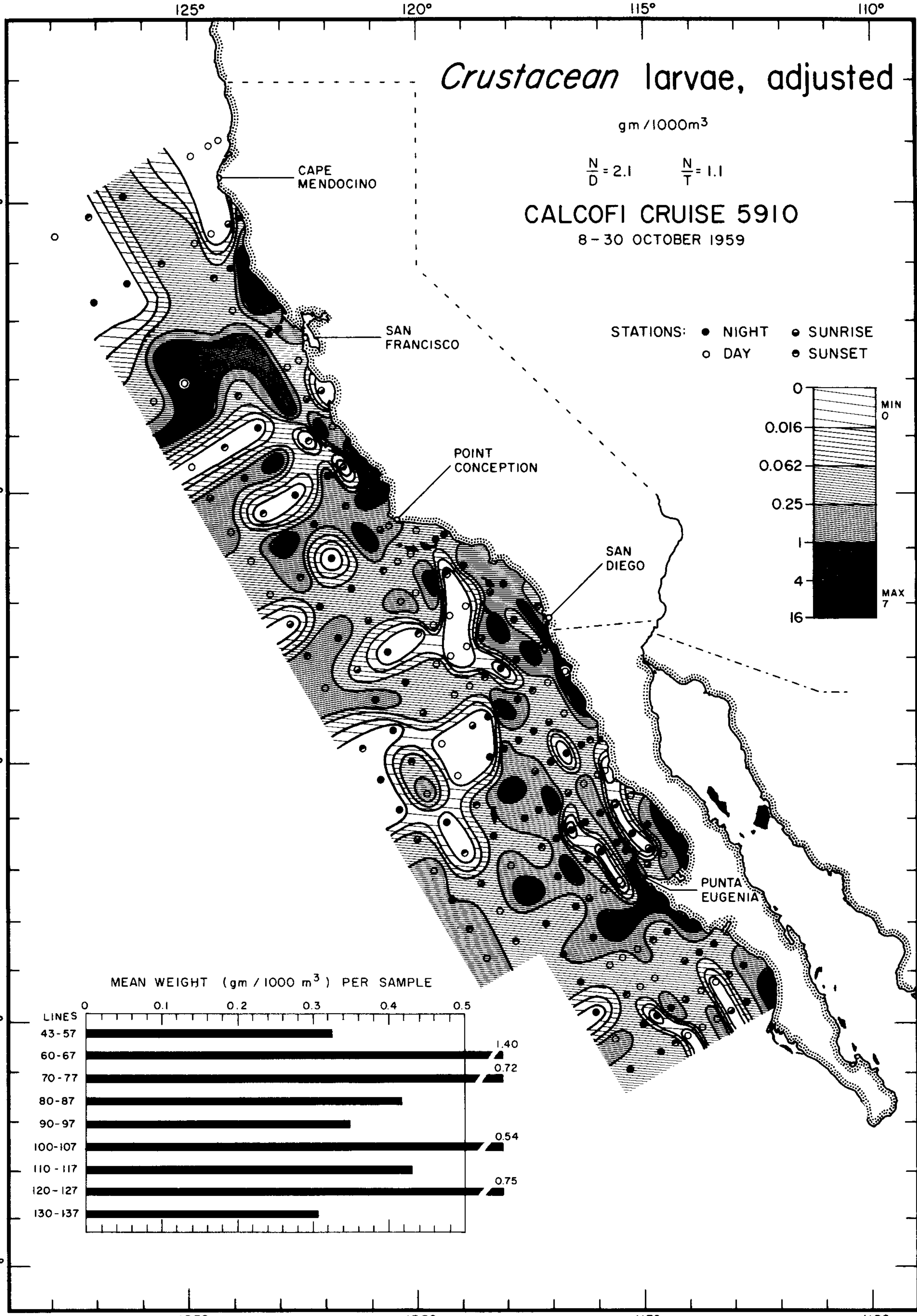
Crustacean larvae

5810





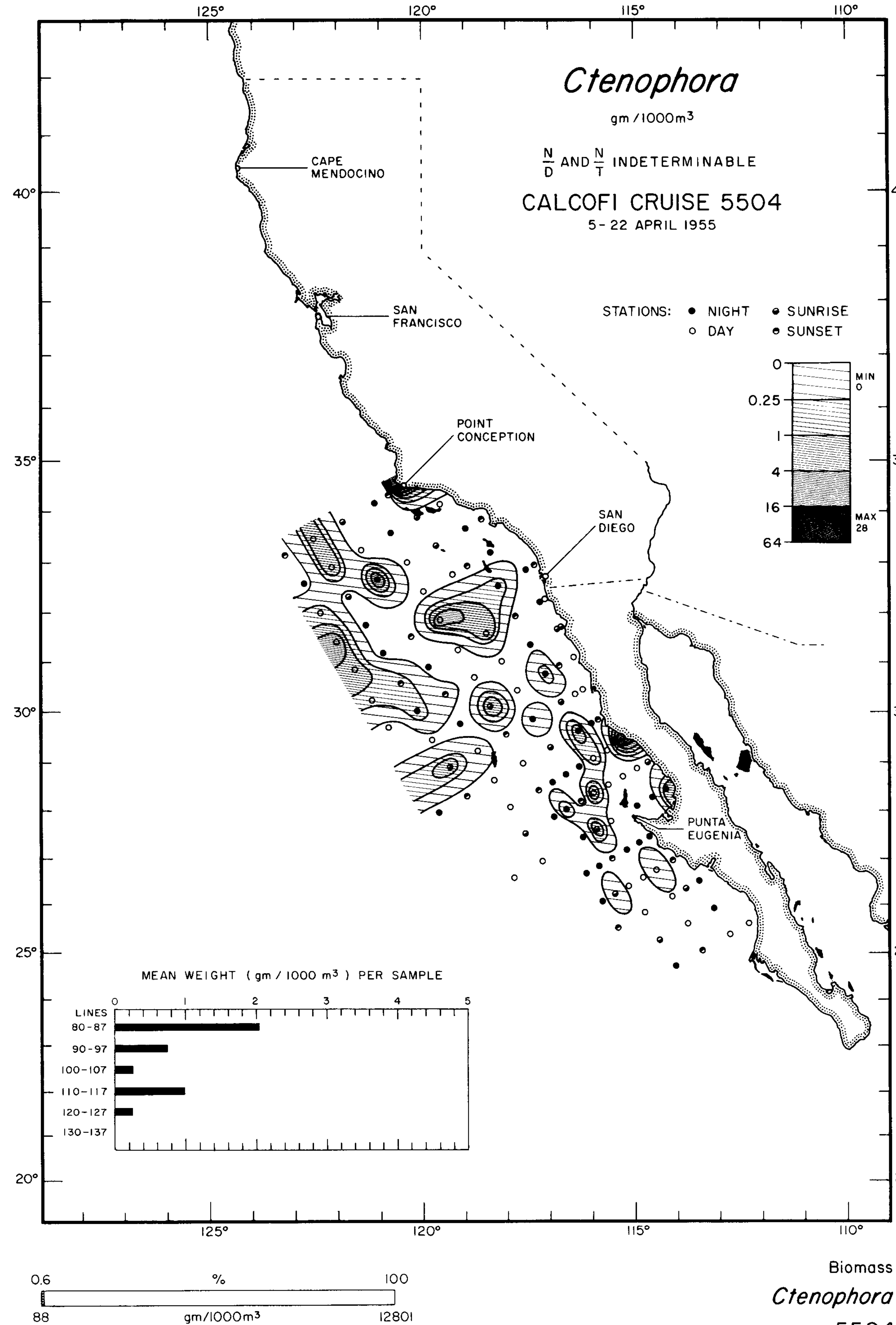
Biomass
Crustacean larvae
5910



Biomass

Crustacean larvae, adjusted

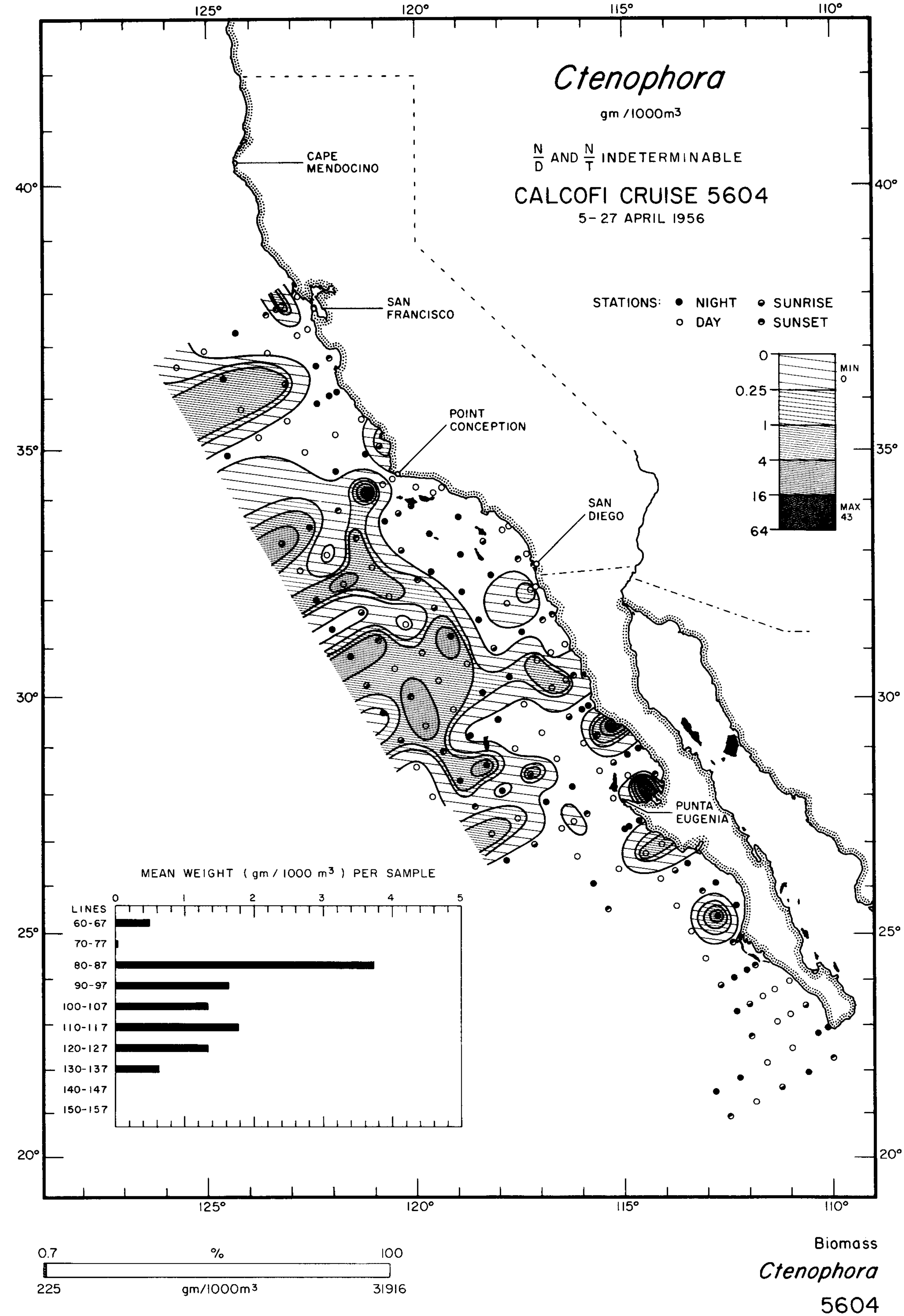
5910



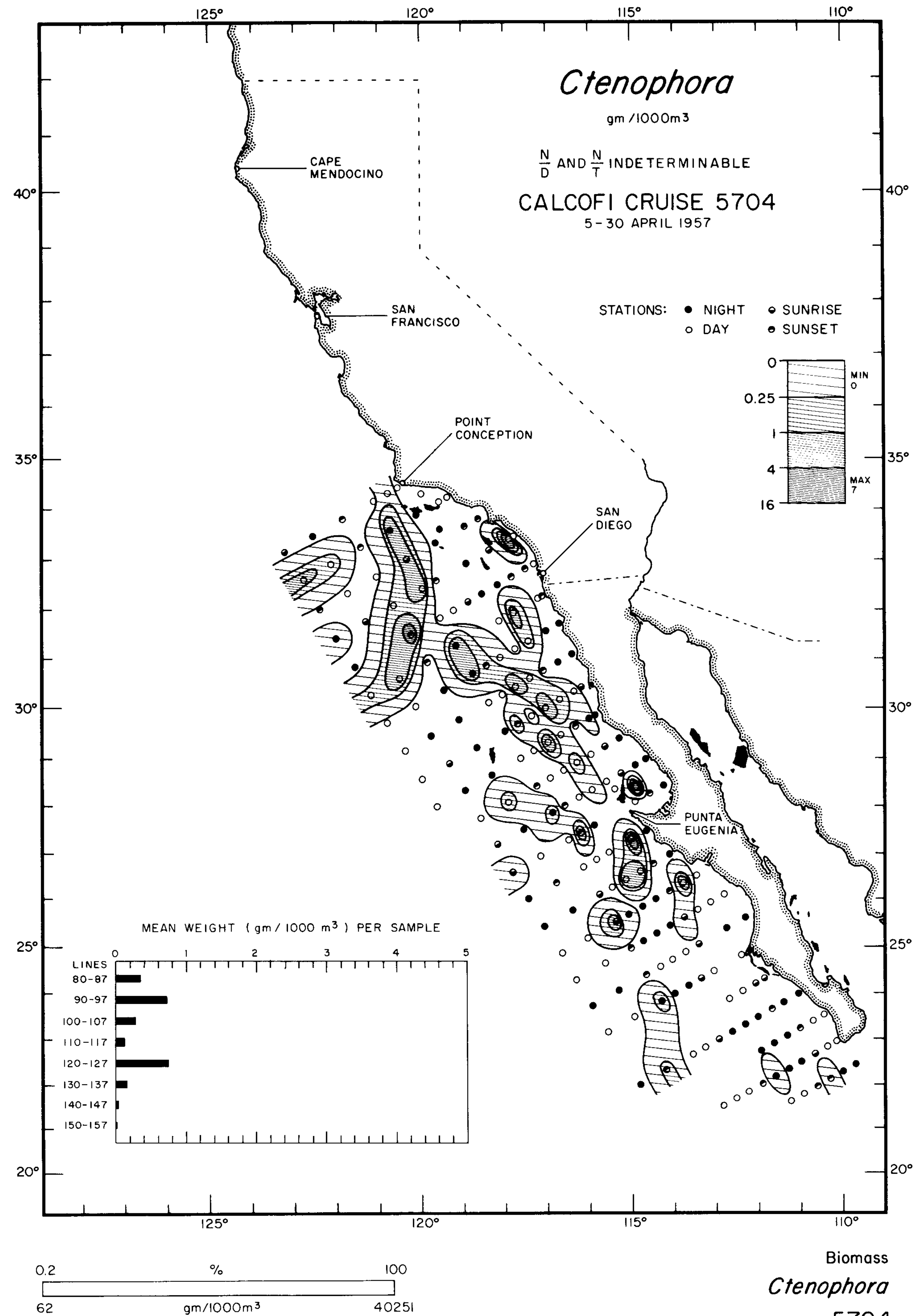
Biomass

Ctenophora

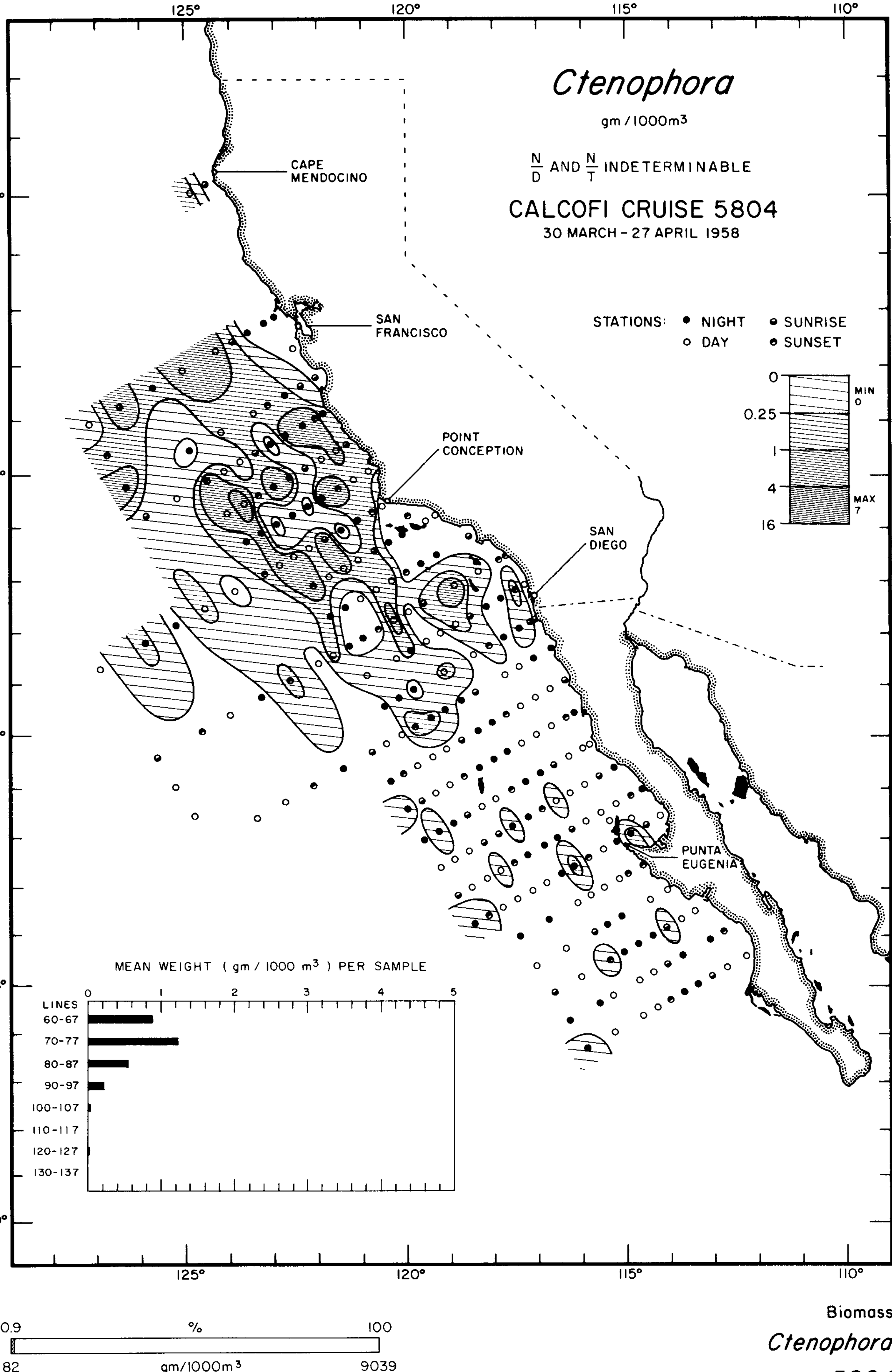
5504



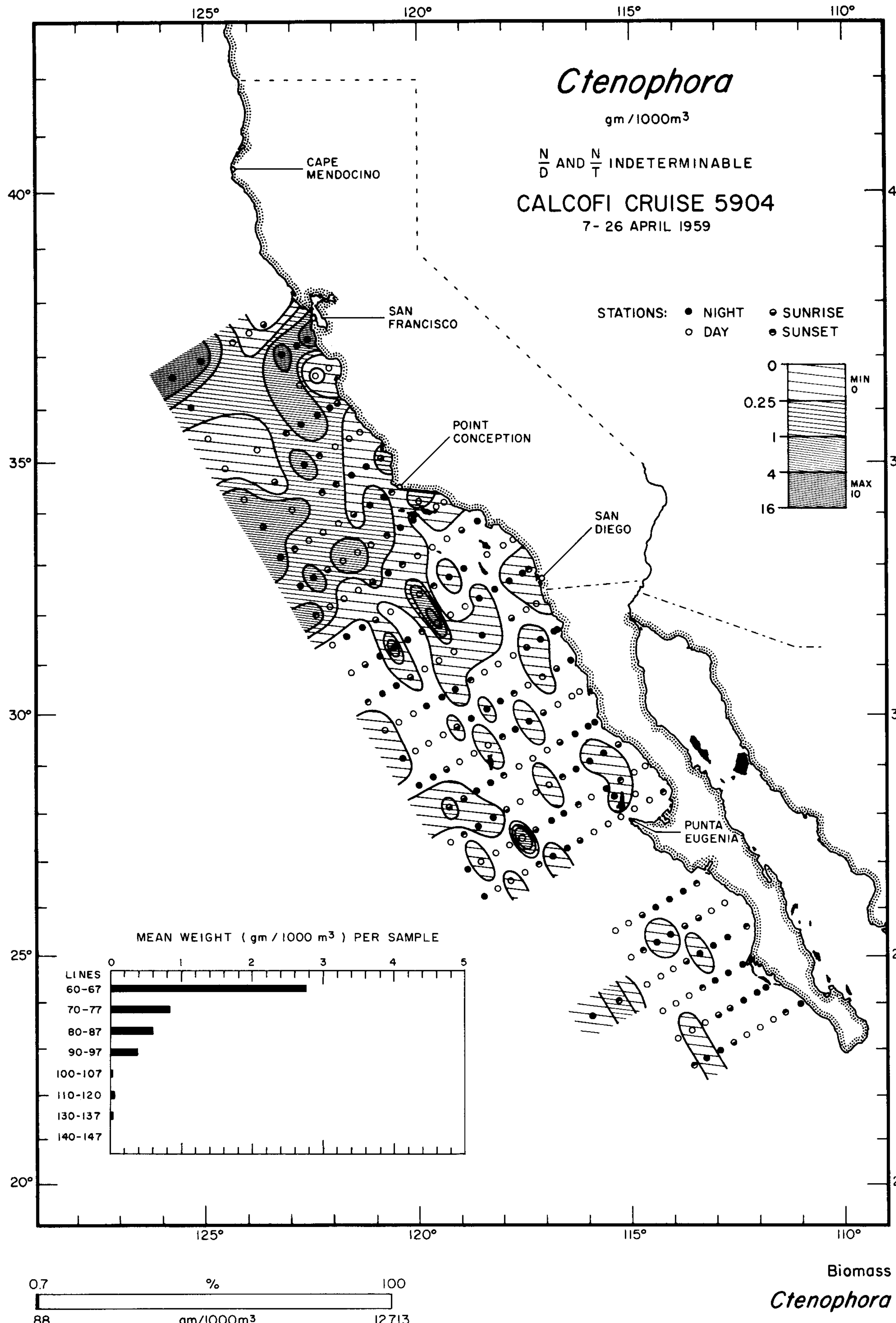
Biomass
Ctenophora
5604



Biomass
Ctenophora
5704



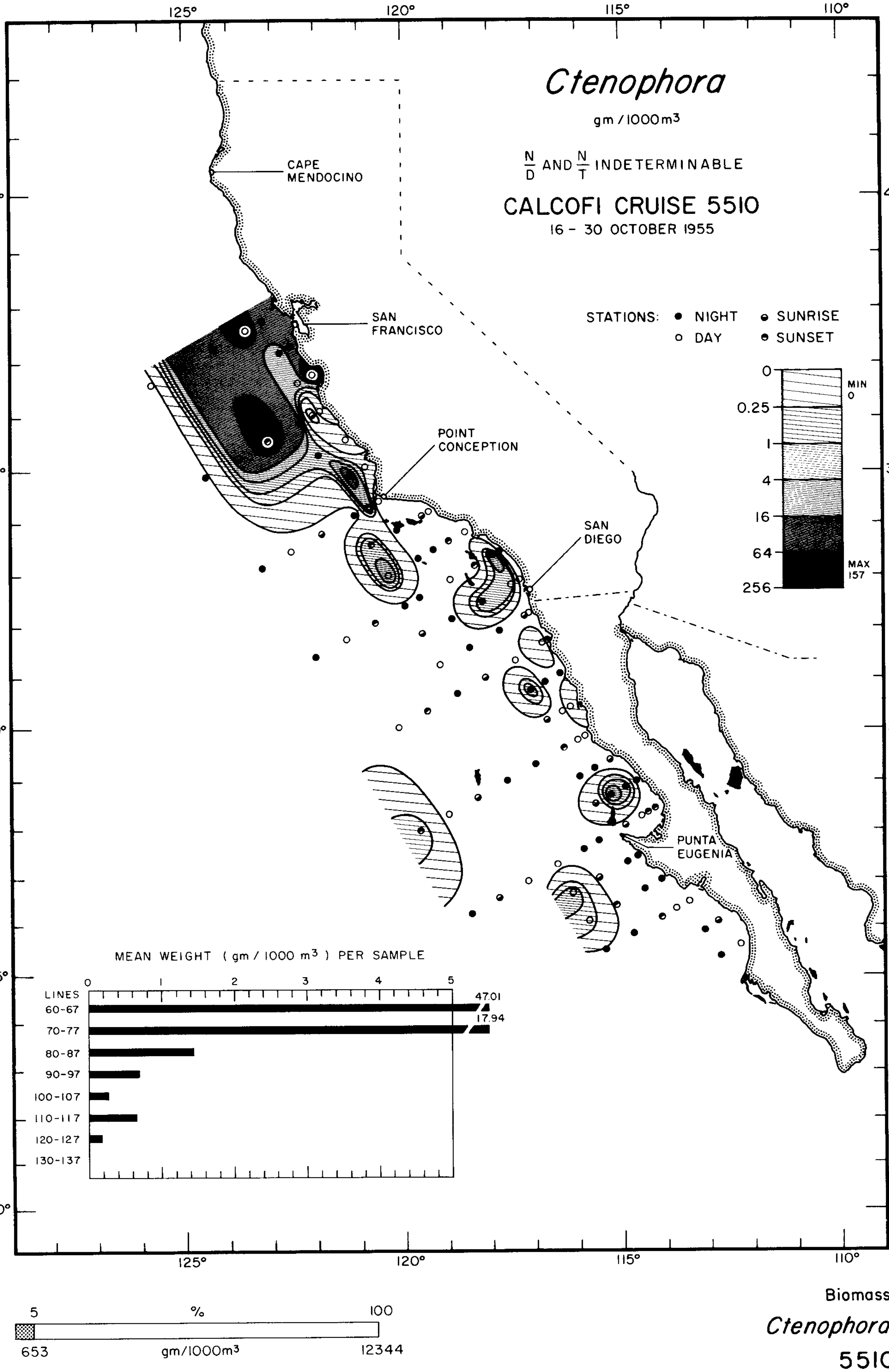
Biomass
Ctenophora
5804



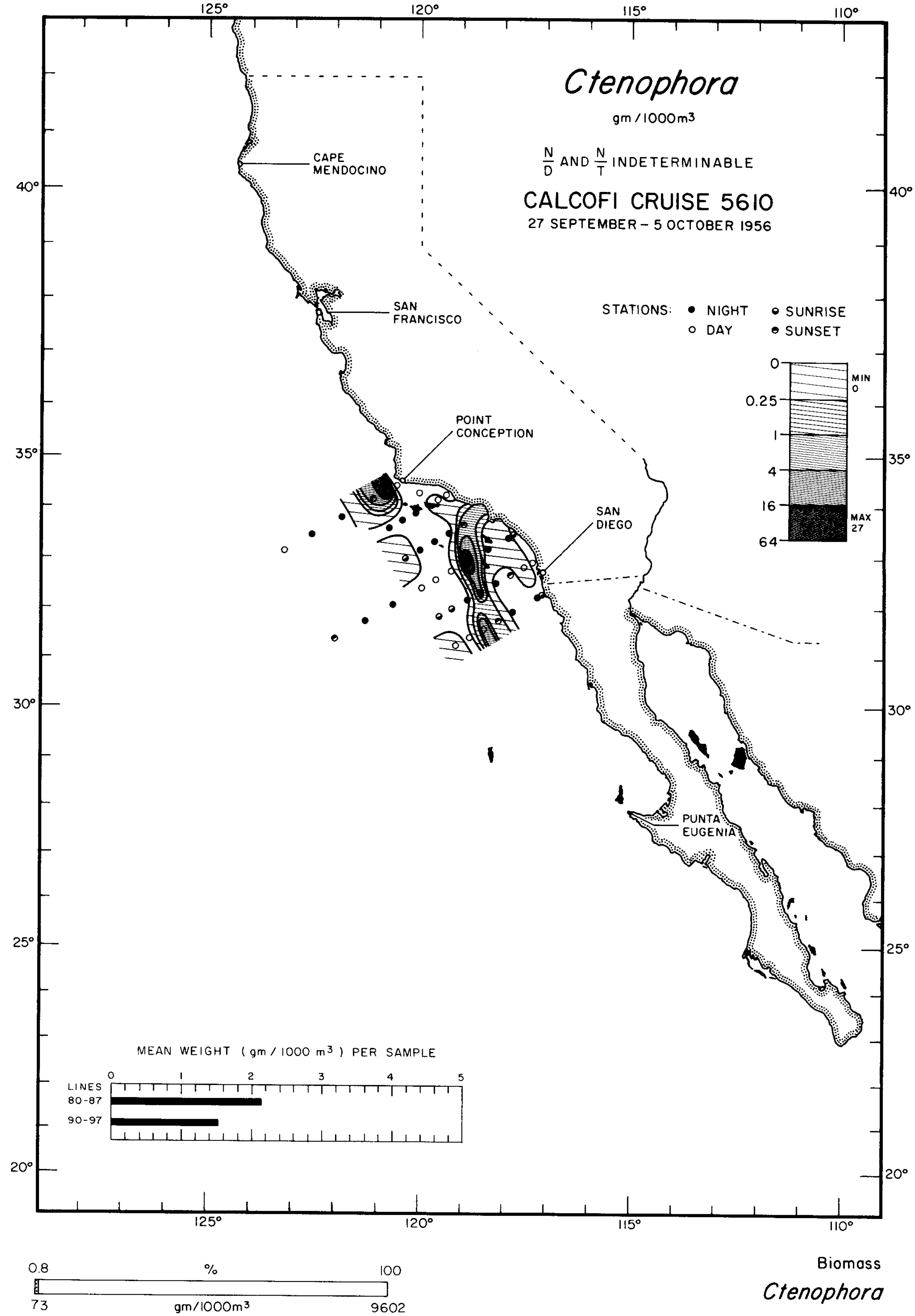
Biomass

Ctenophora

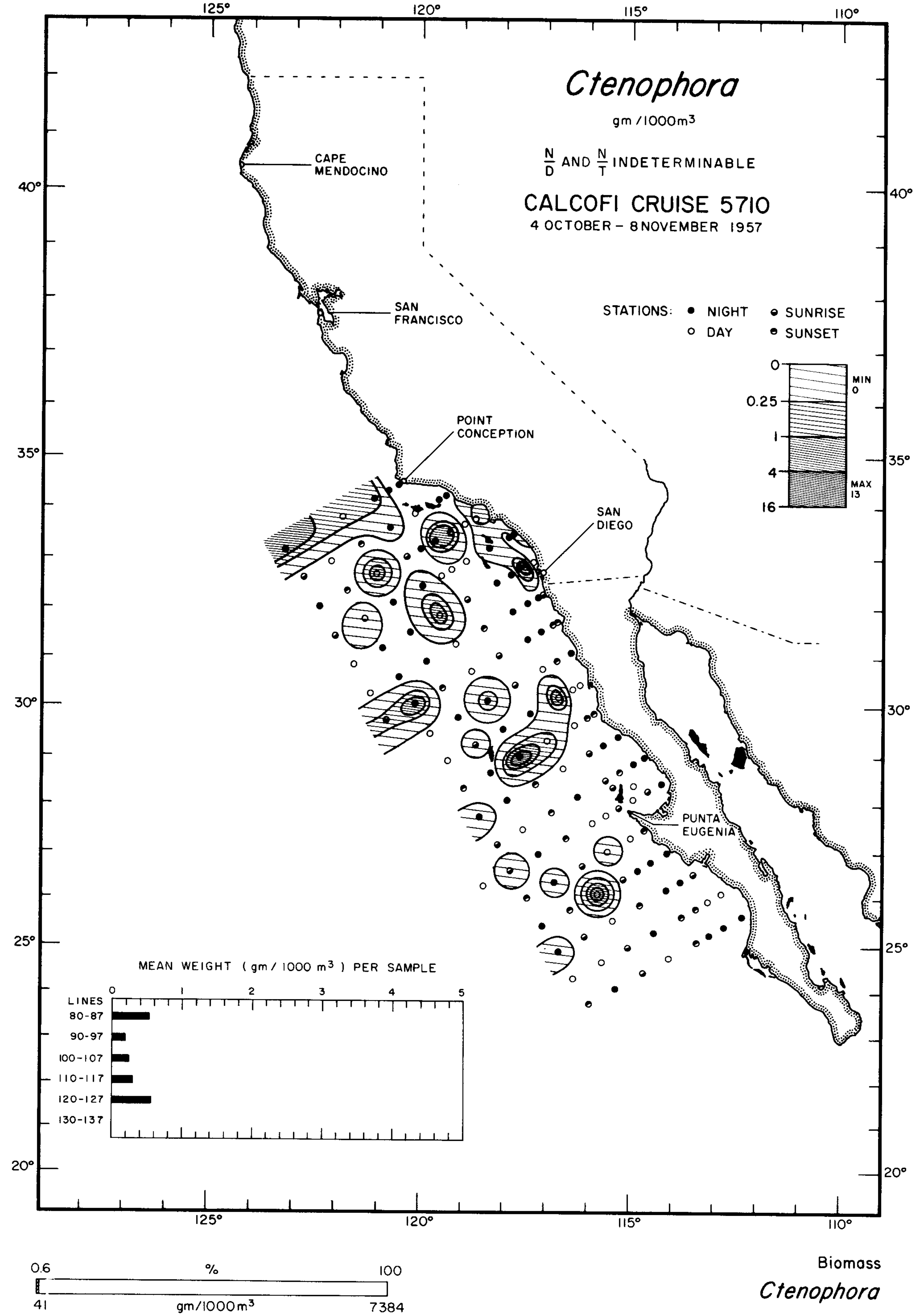
5904



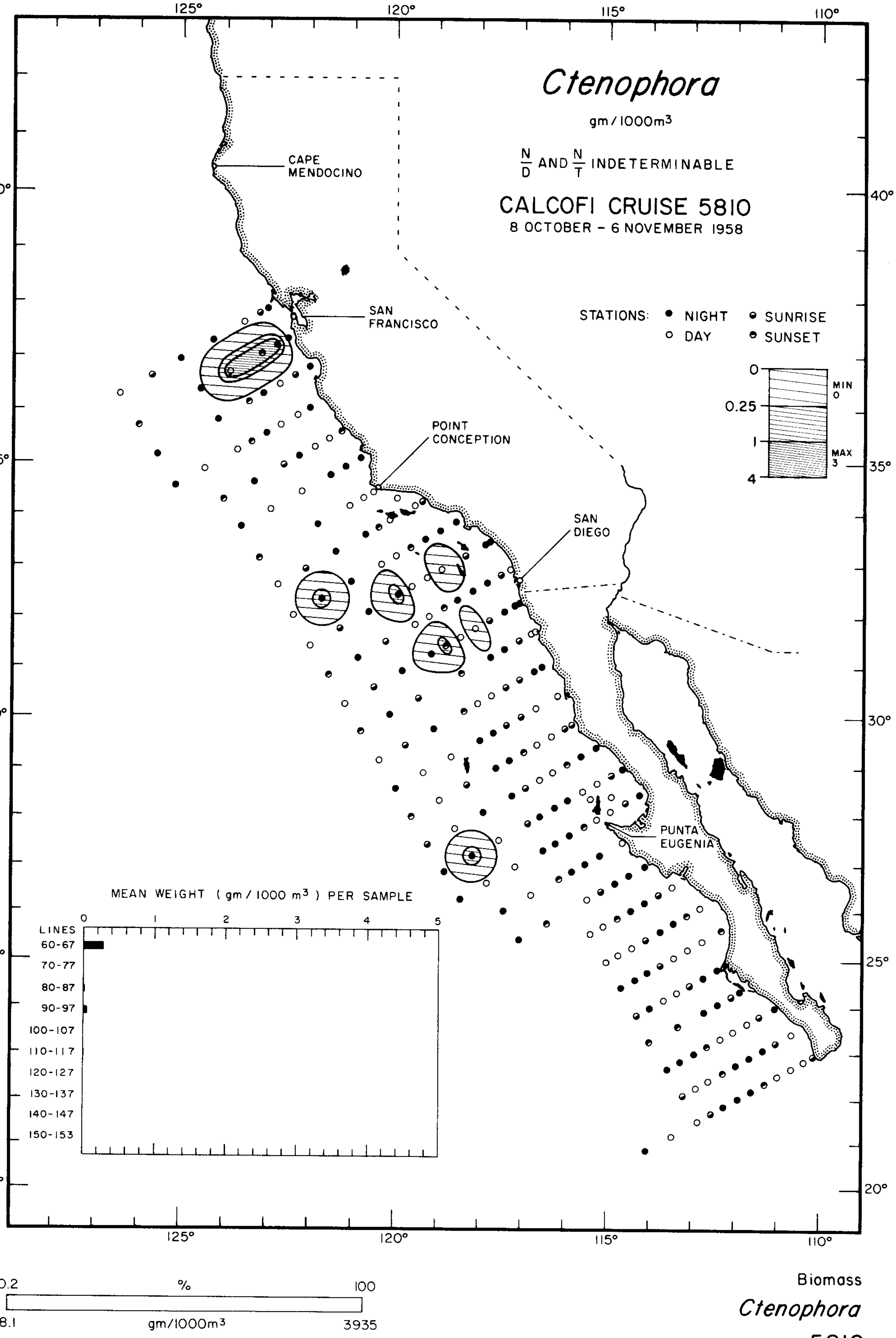
Biomass
Ctenophora
5510



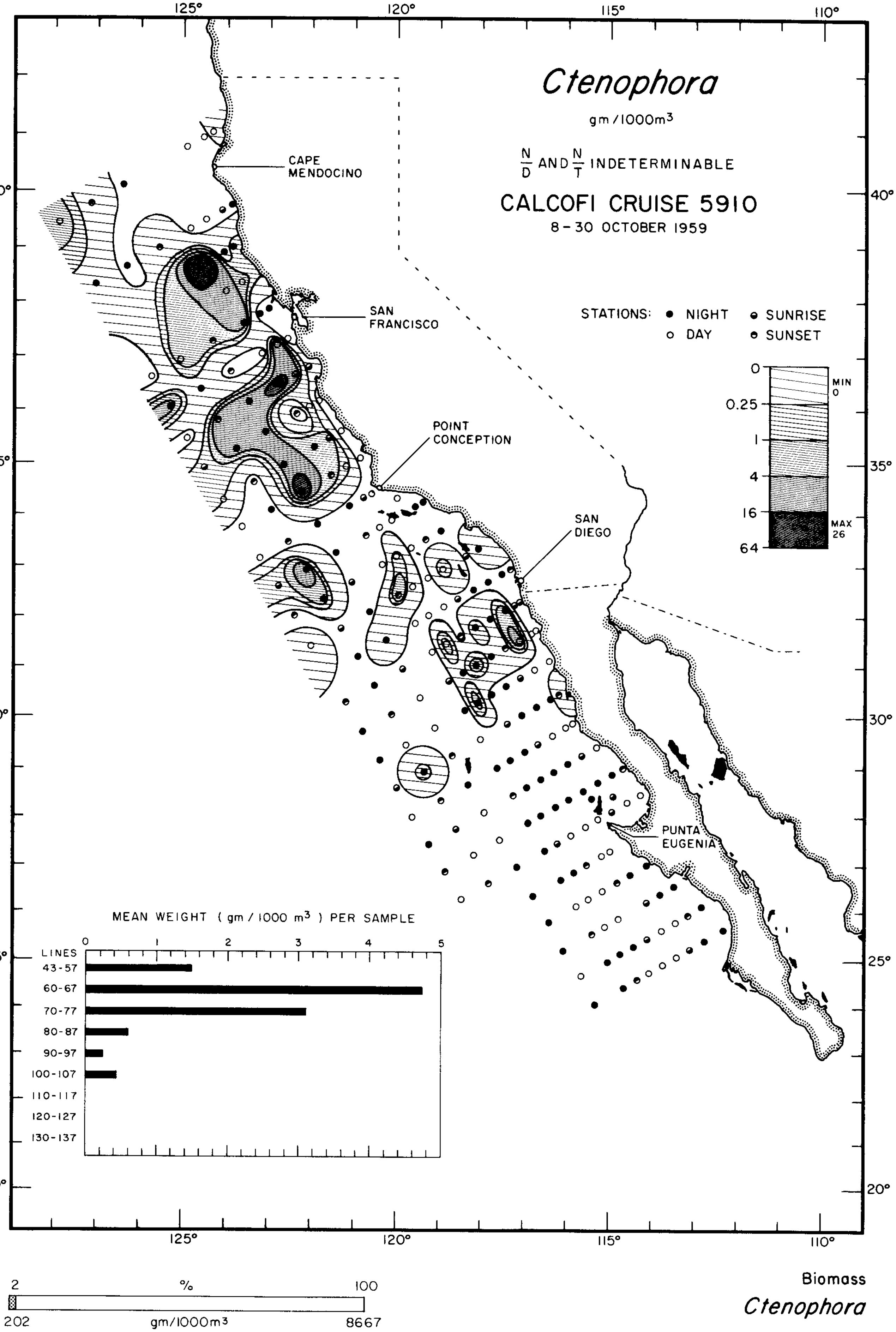
Biomass
Ctenophora
5610



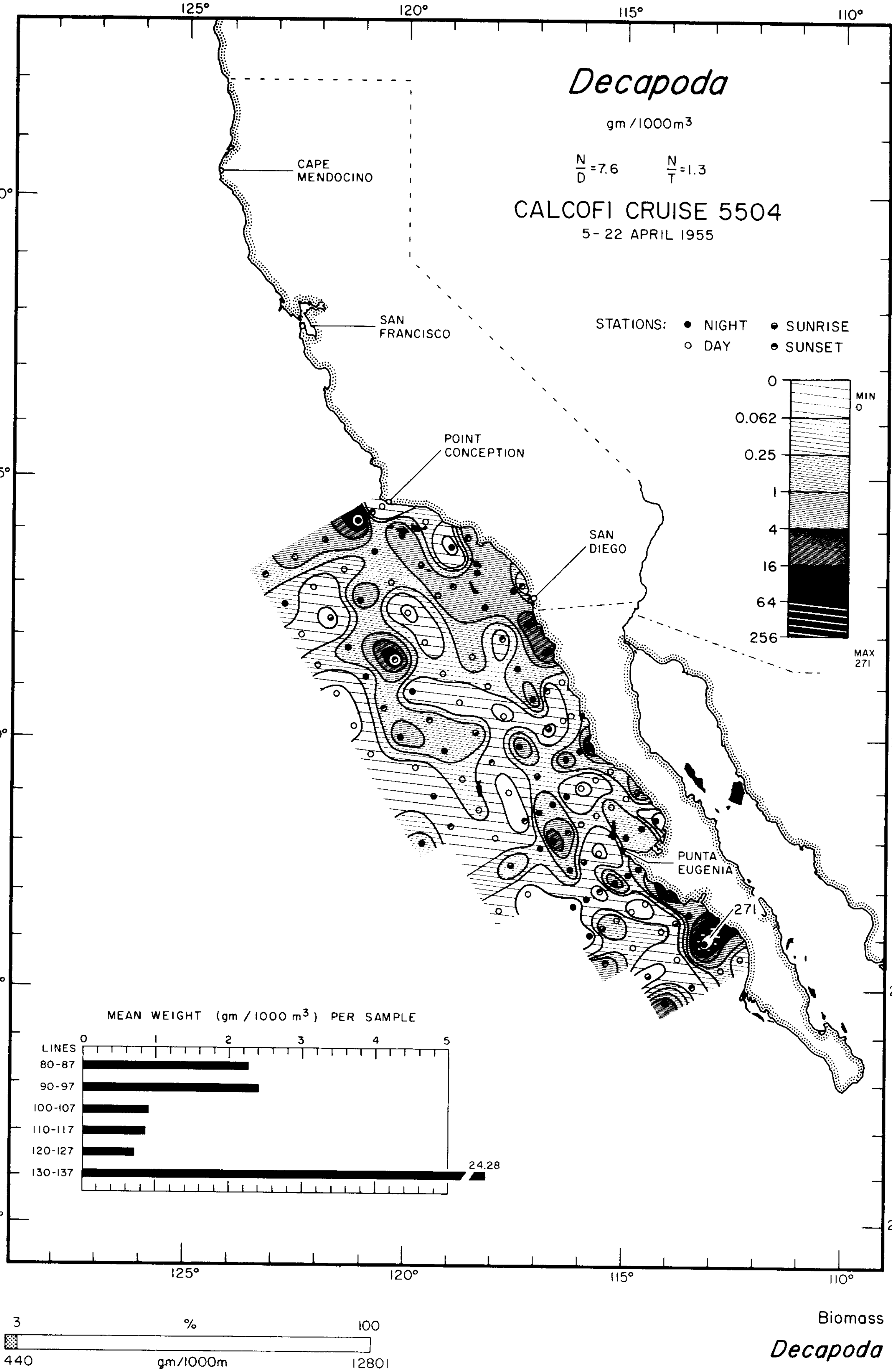
Biomass
Ctenophora
5710



Biomass
Ctenophora
5810



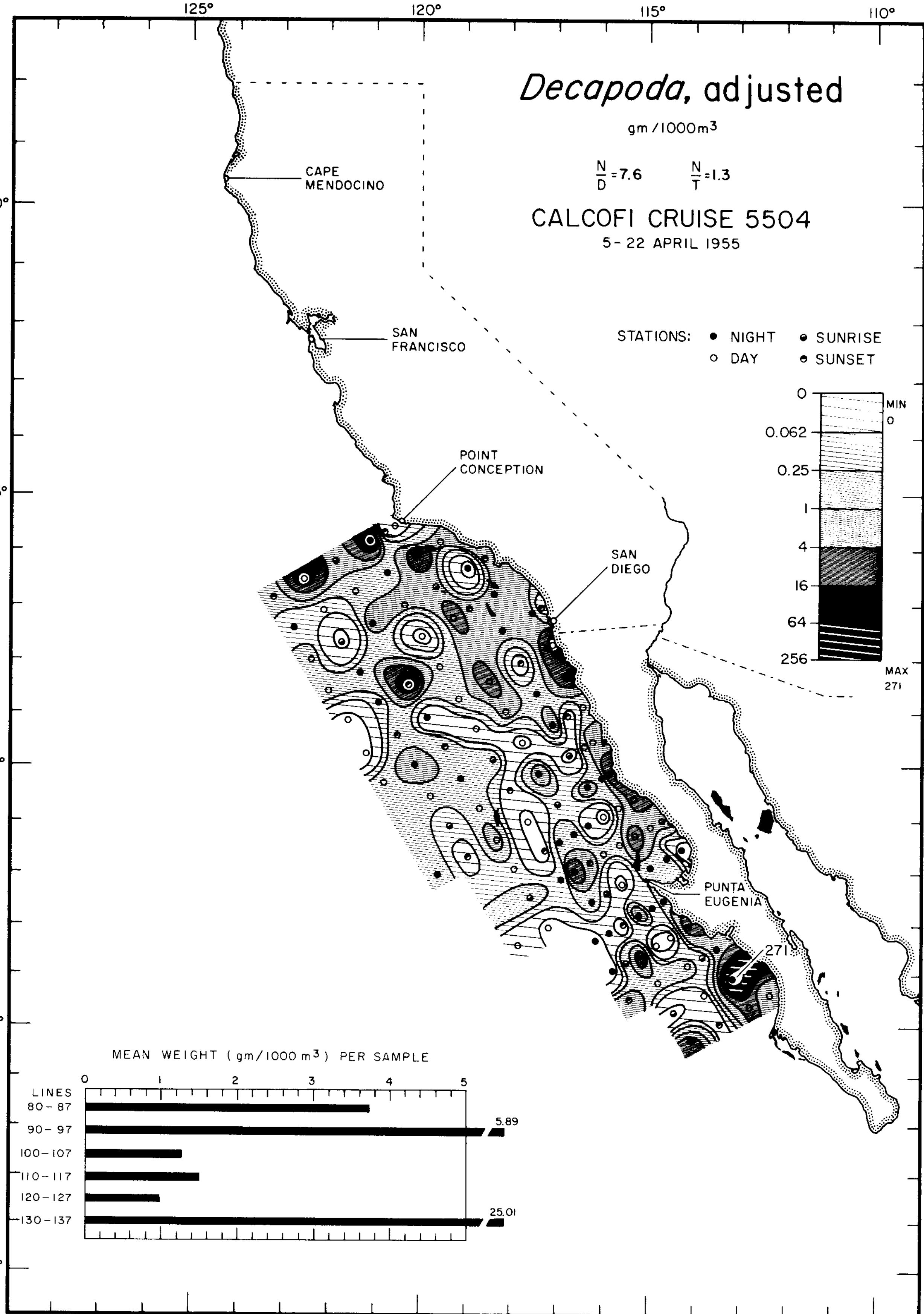
Biomass
Ctenophora
5910



Biomass

Decapoda

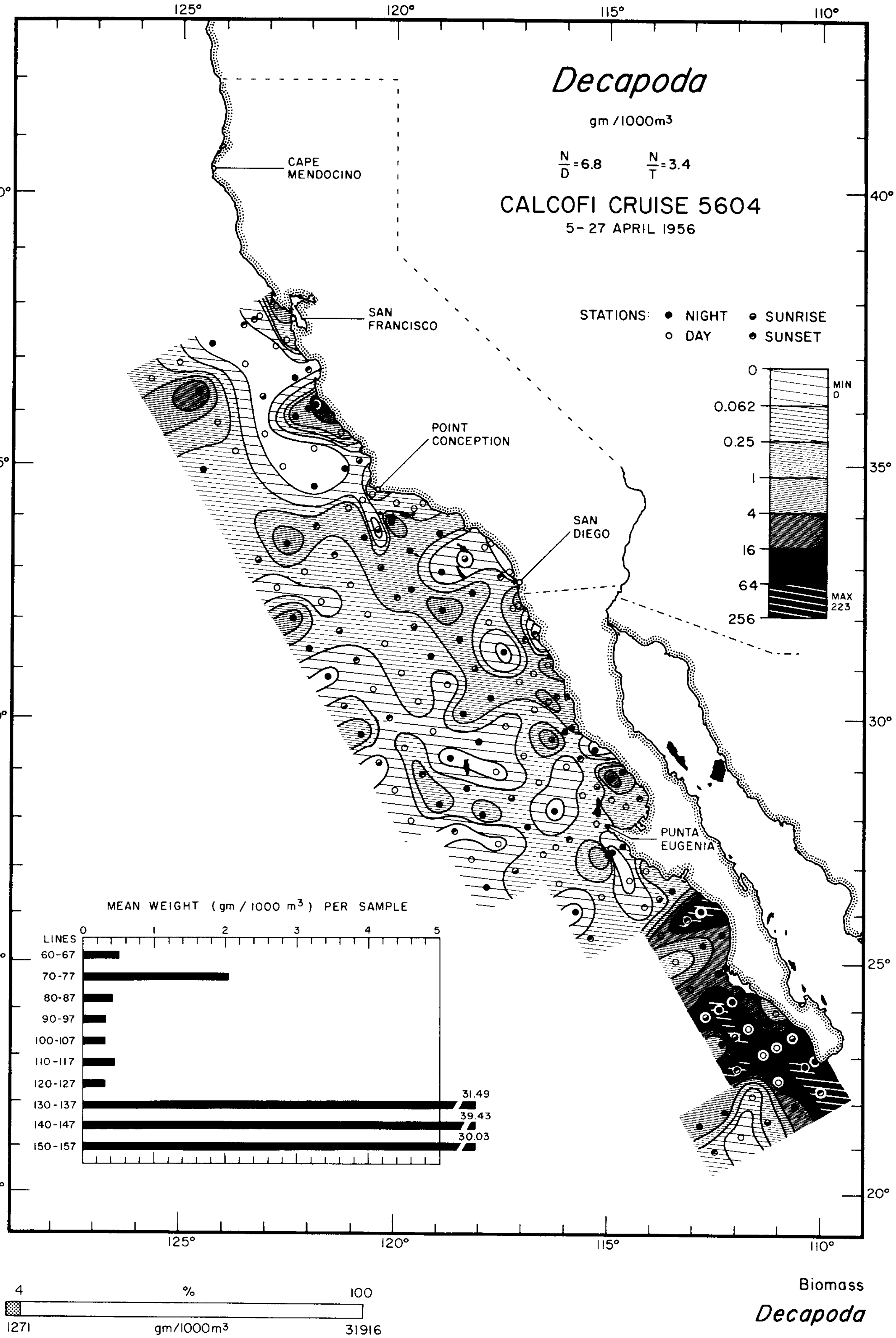
5504



Biomass

Decapoda, adjusted

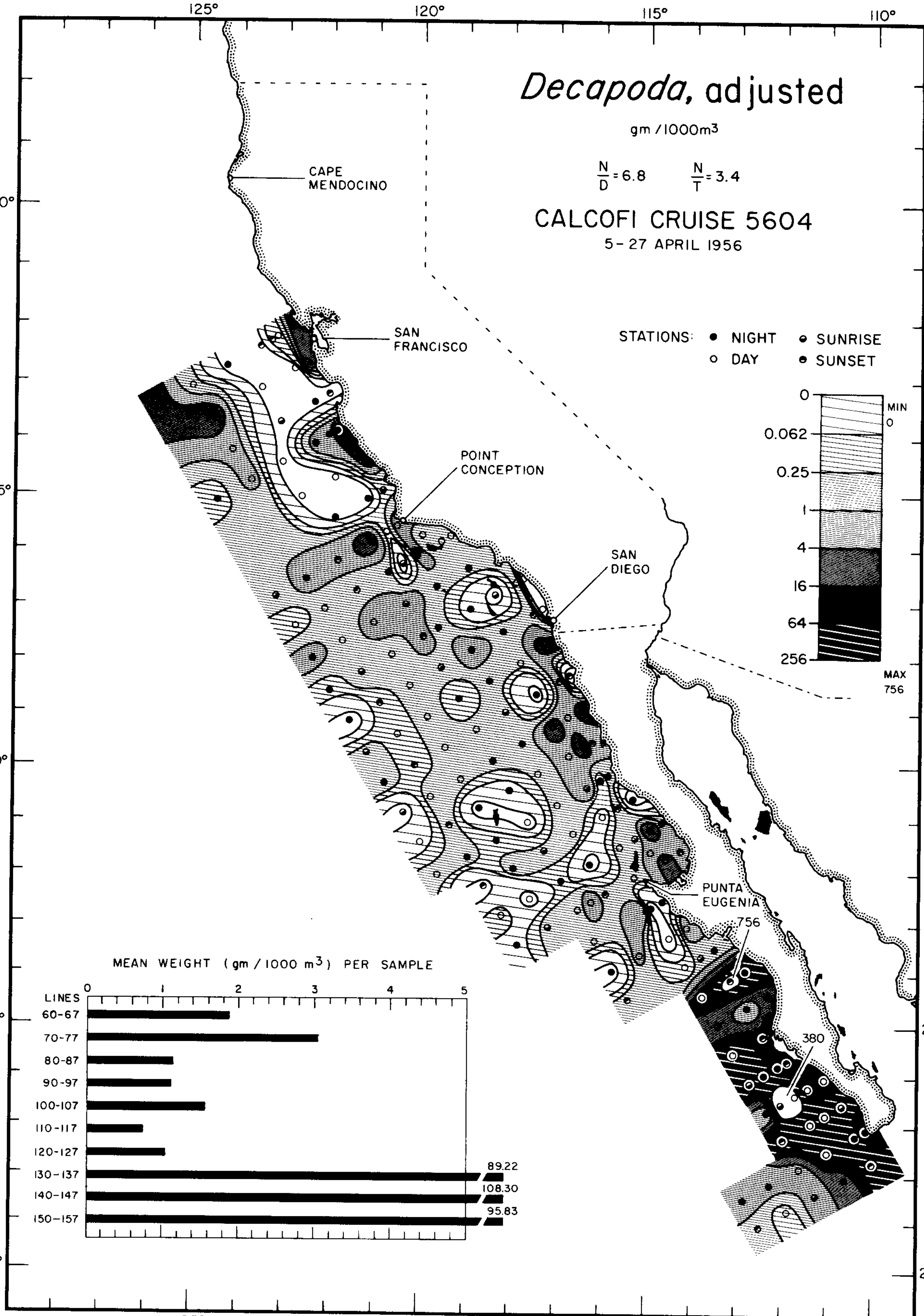
5504



Biomass

Decapoda

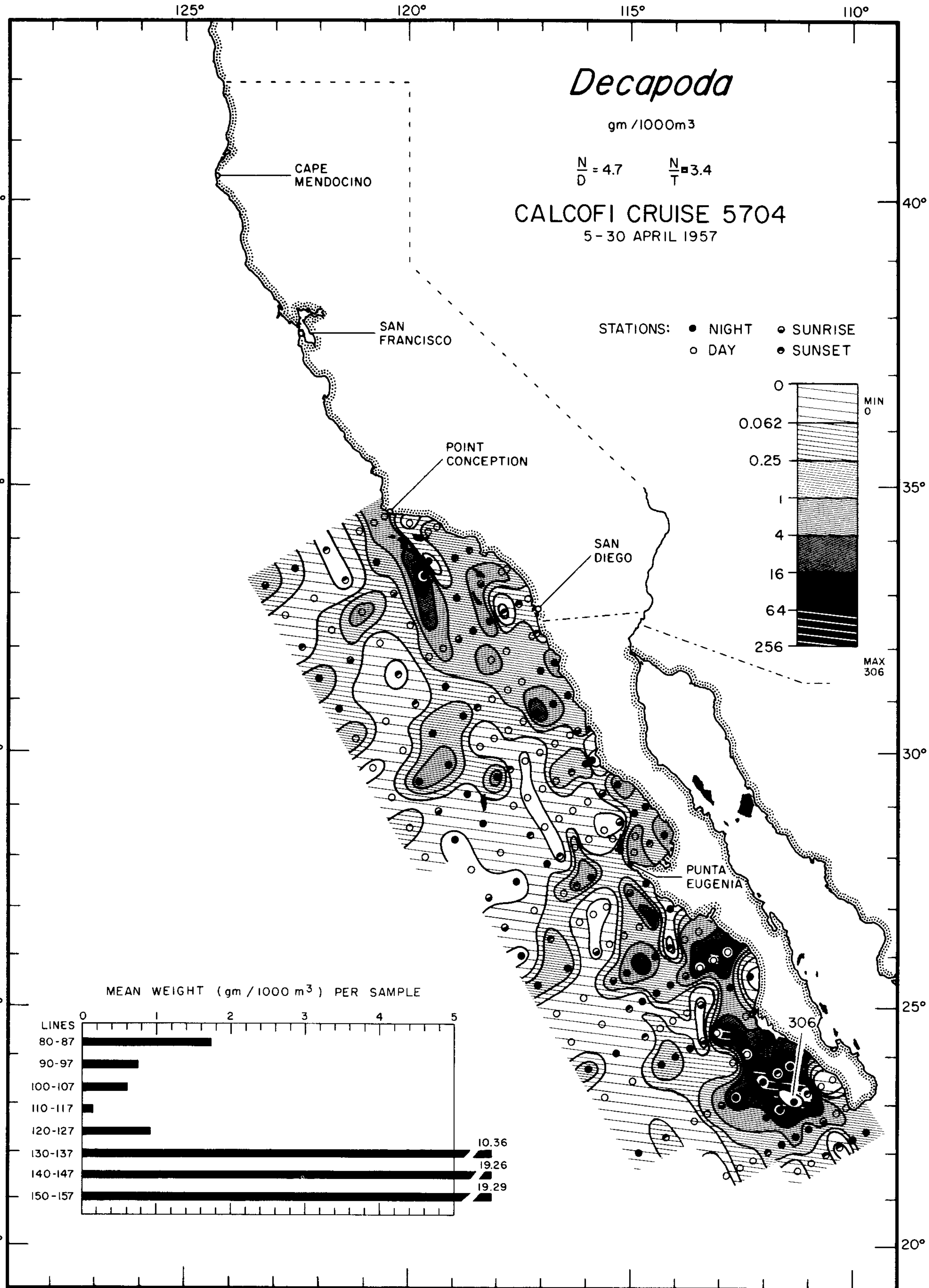
5604



Biomass

Decapoda, adjusted

5604



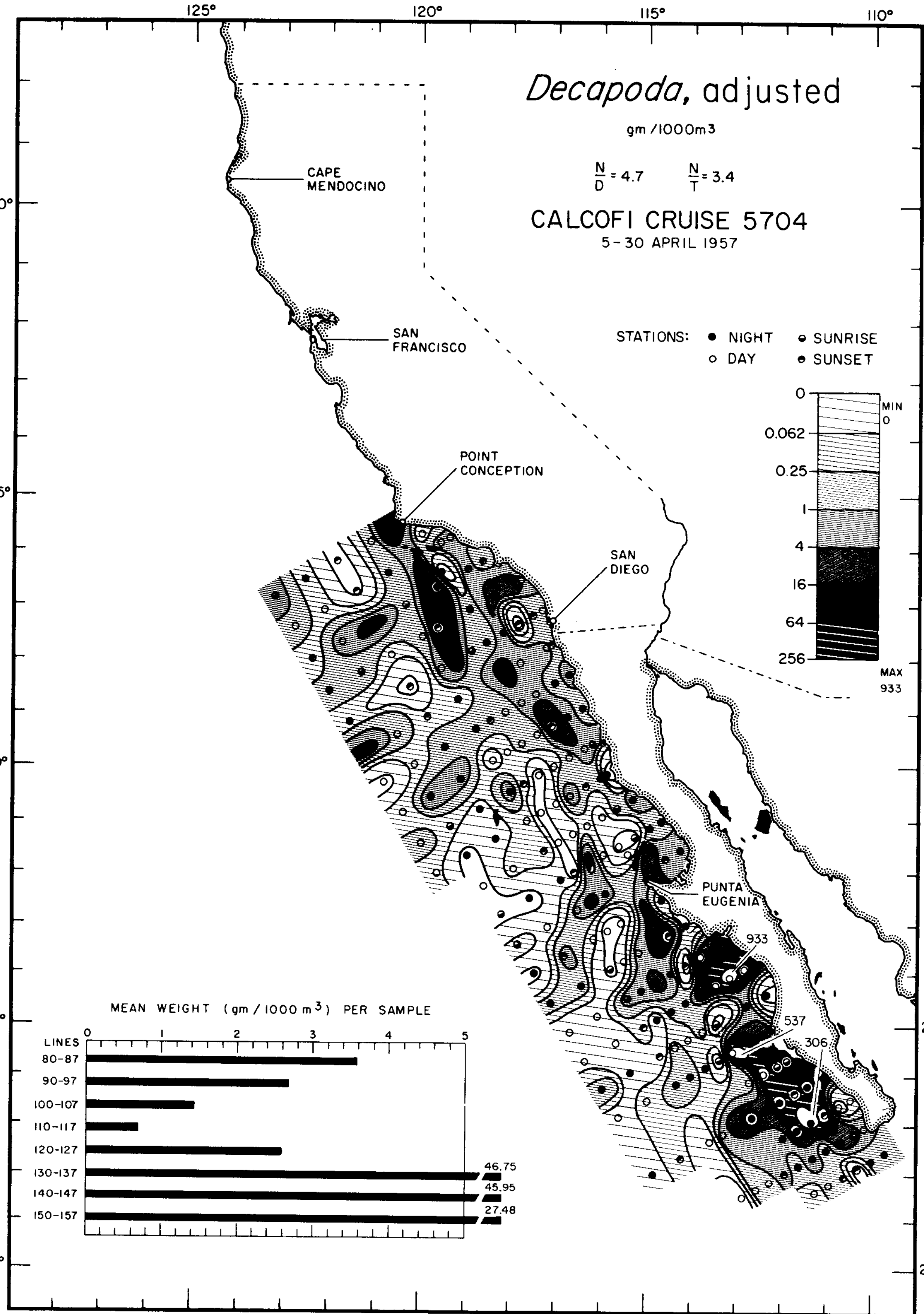
3 % 100

1261 gm/1000m³ 40251

Biomass

Decapoda

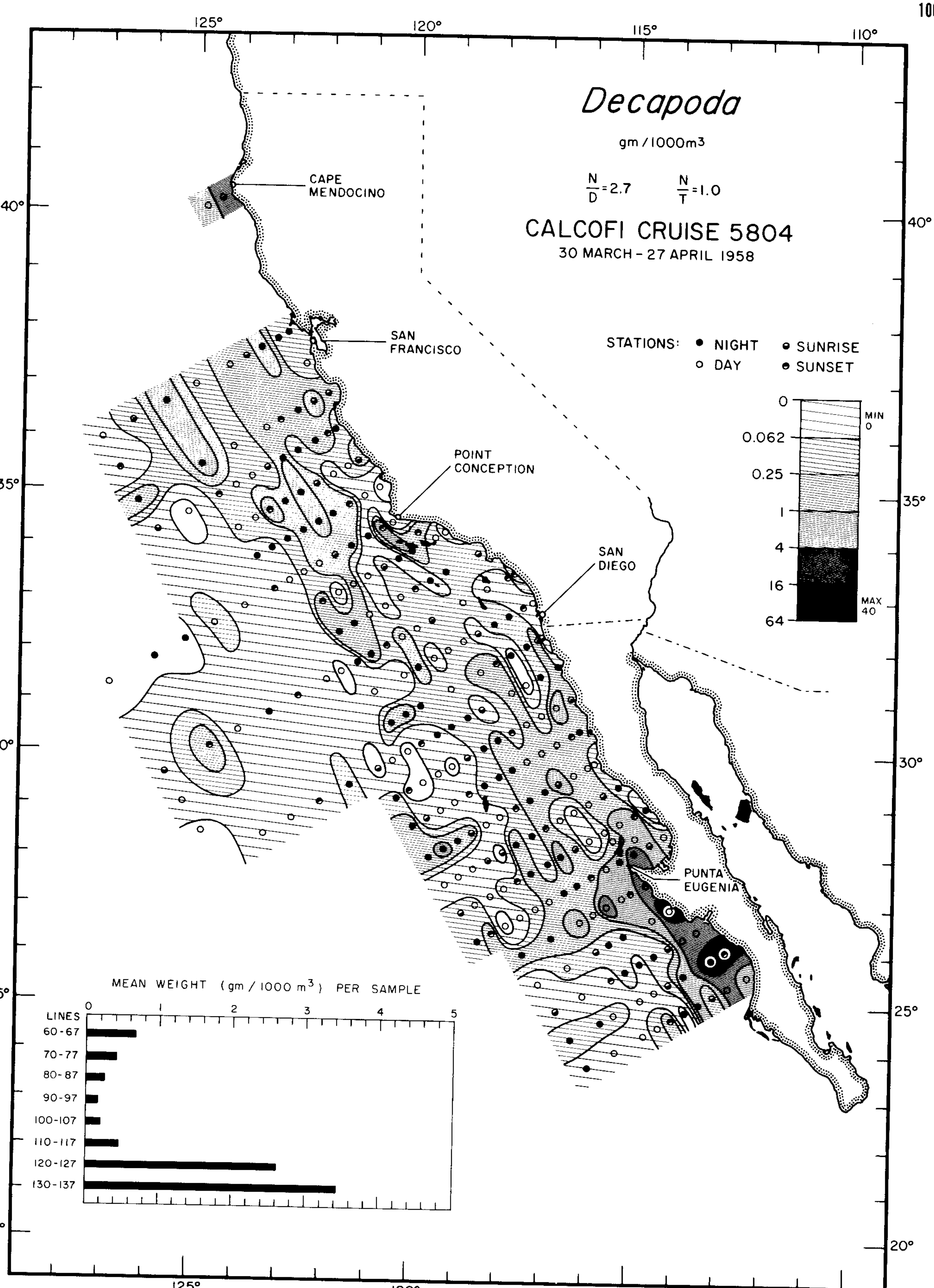
5704

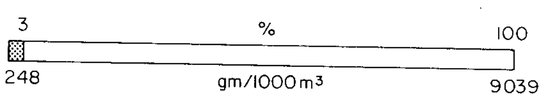


Biomass

Decapoda, adjusted

5704

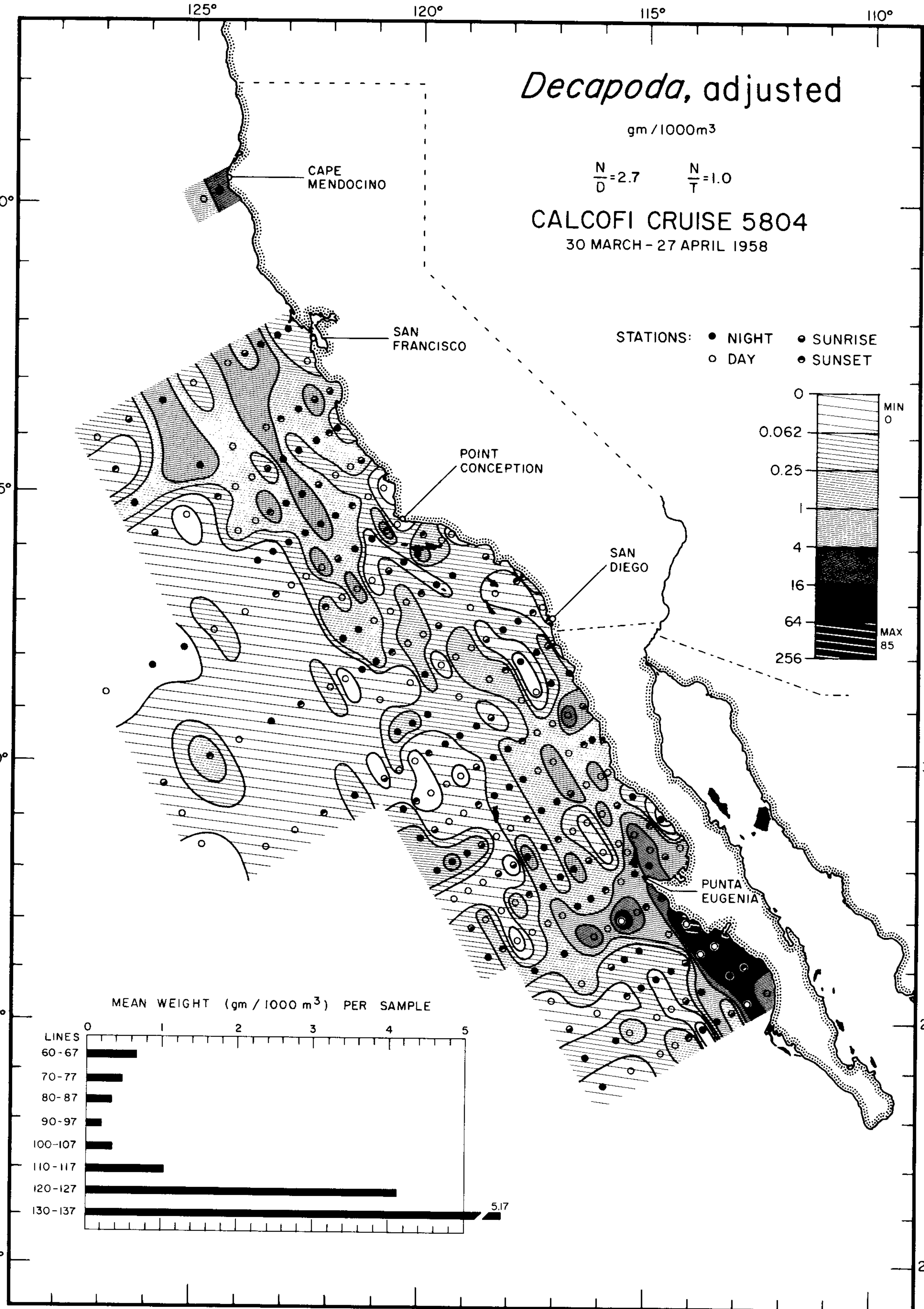




Biomass

Decapoda

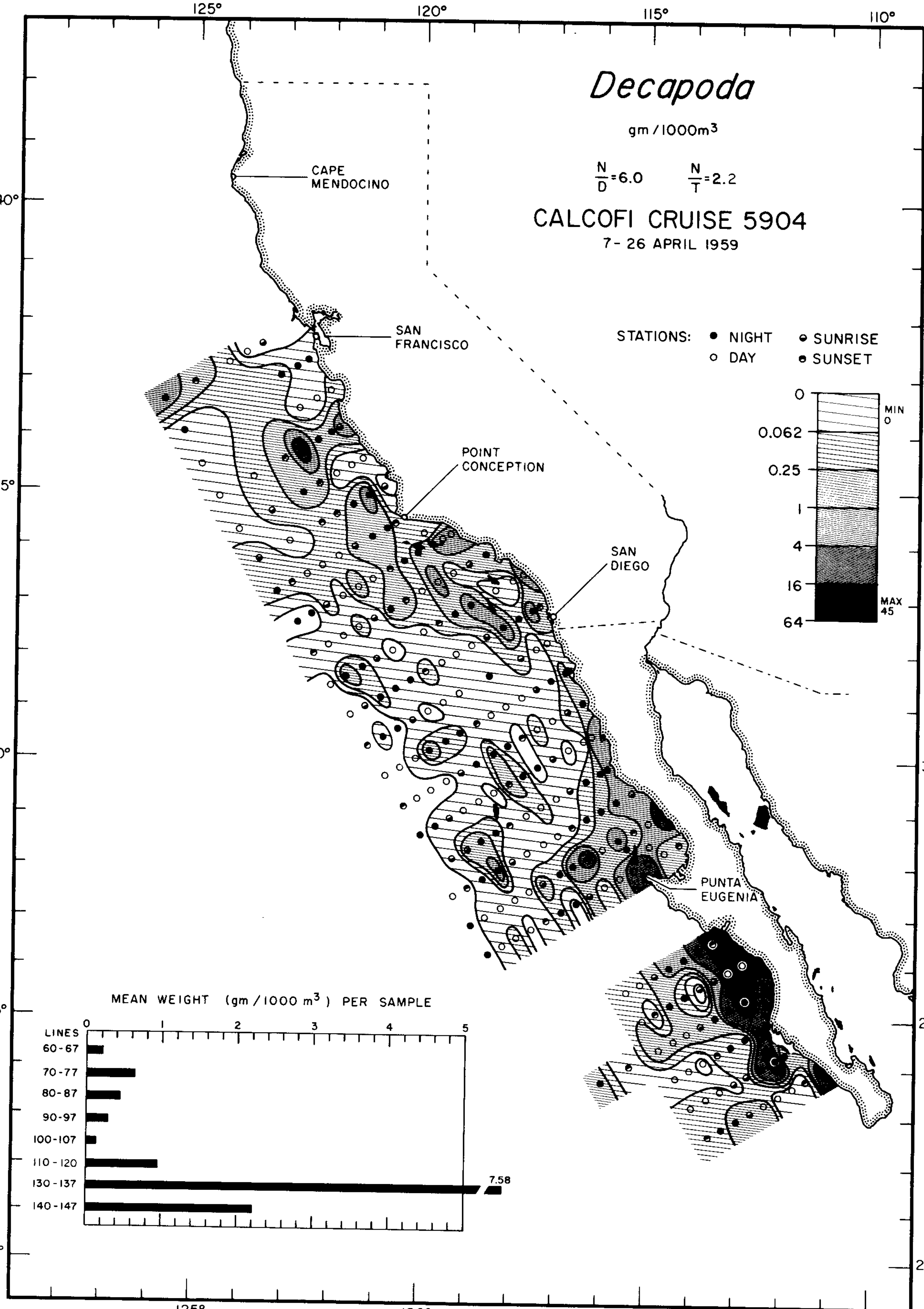
5804



Biomass

Decapoda, adjusted

5804



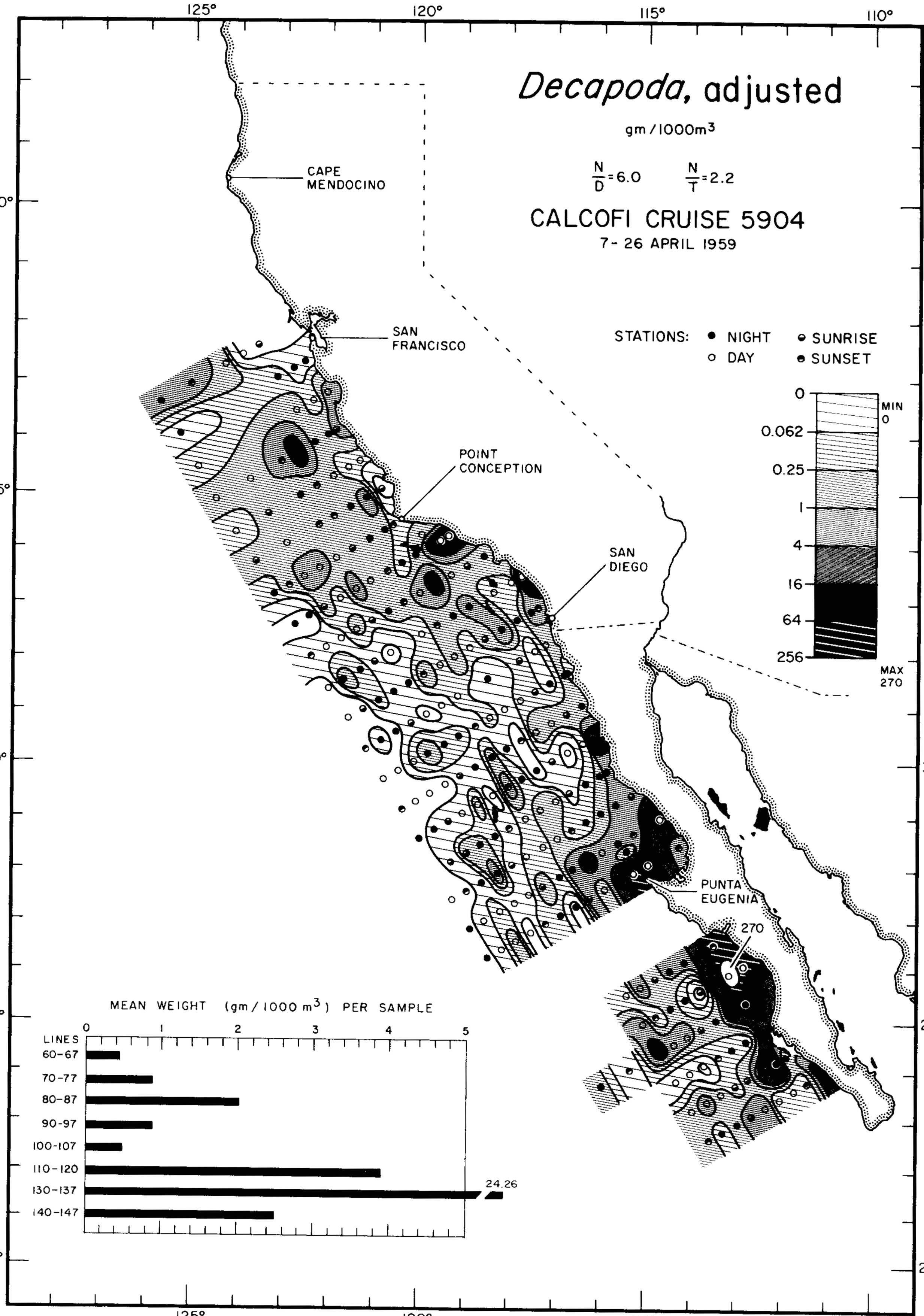
3 % 100

341 gm/1000m³ 12713

Biomass

Decapoda

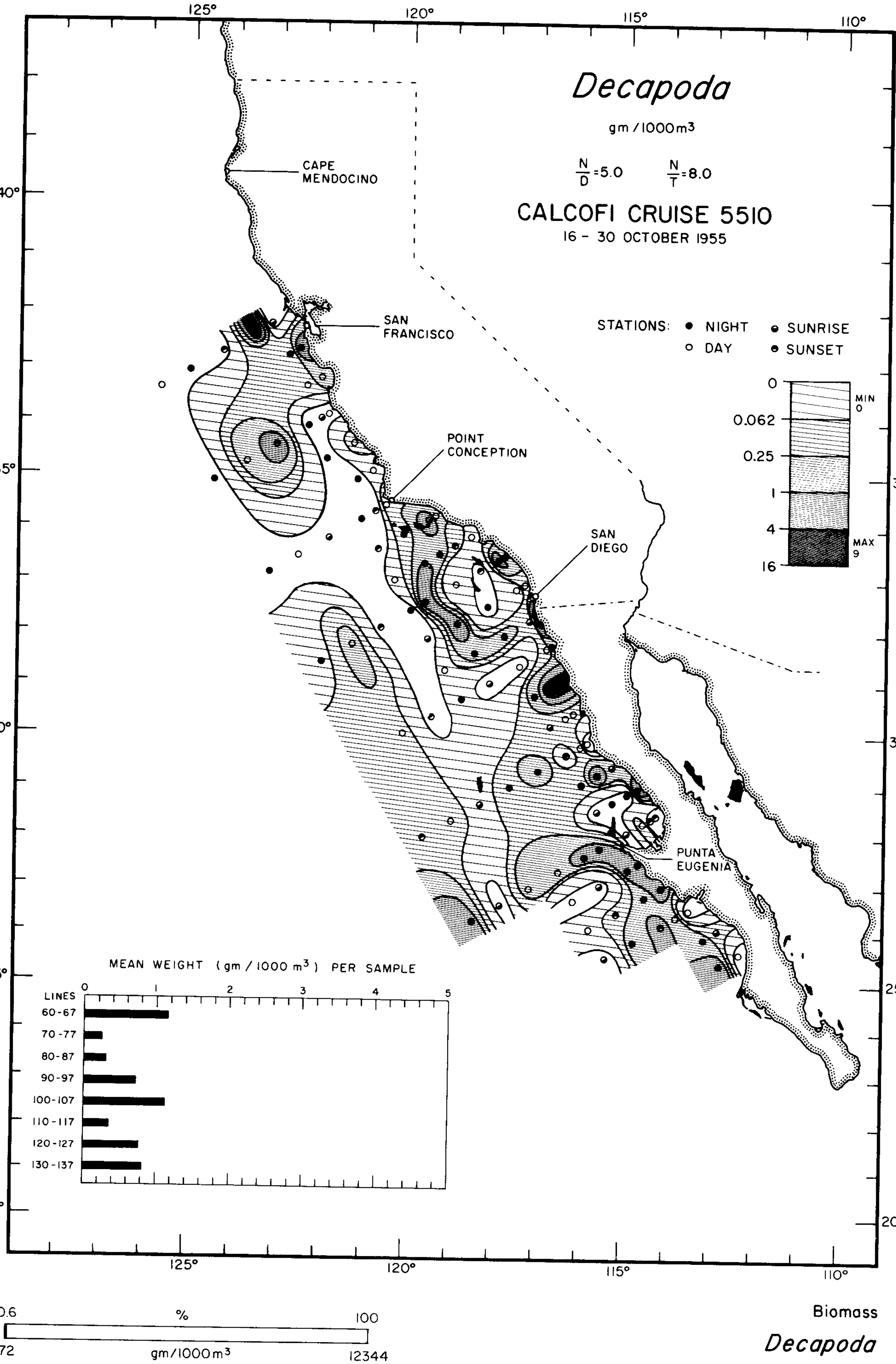
5904



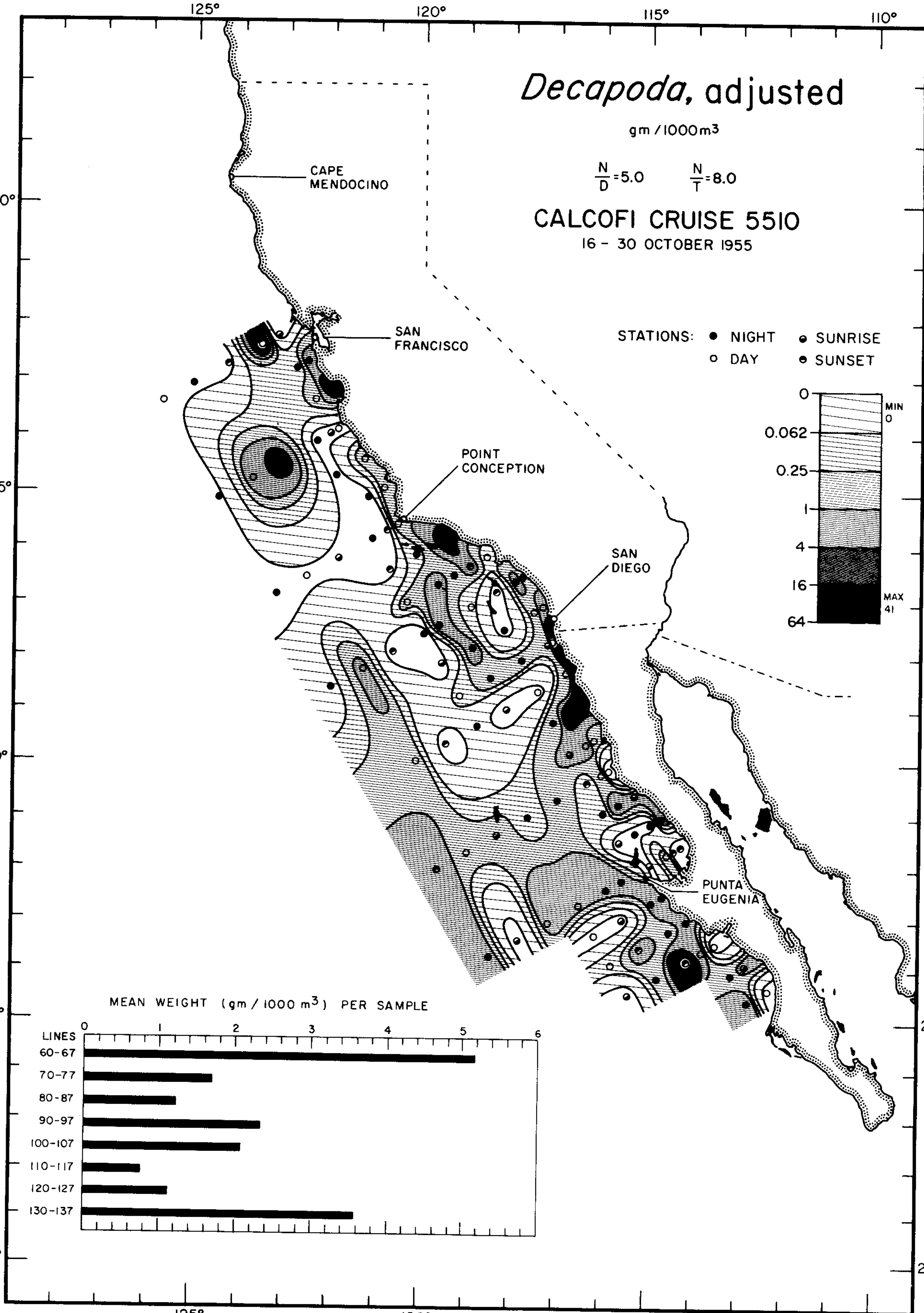
Biomass

Decapoda, adjusted

5904



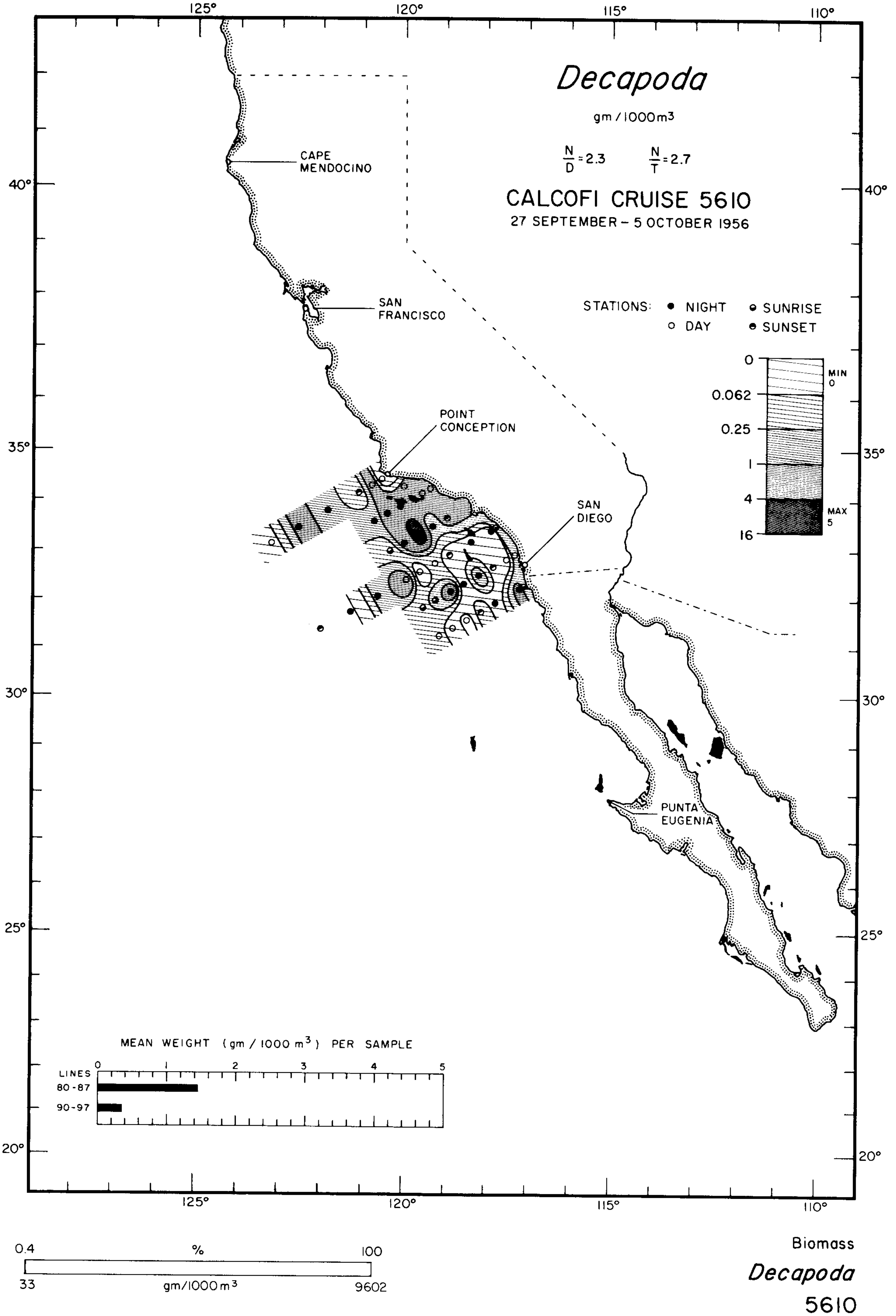
Biomass
Decapoda
5510



Biomass

Decapoda, adjusted

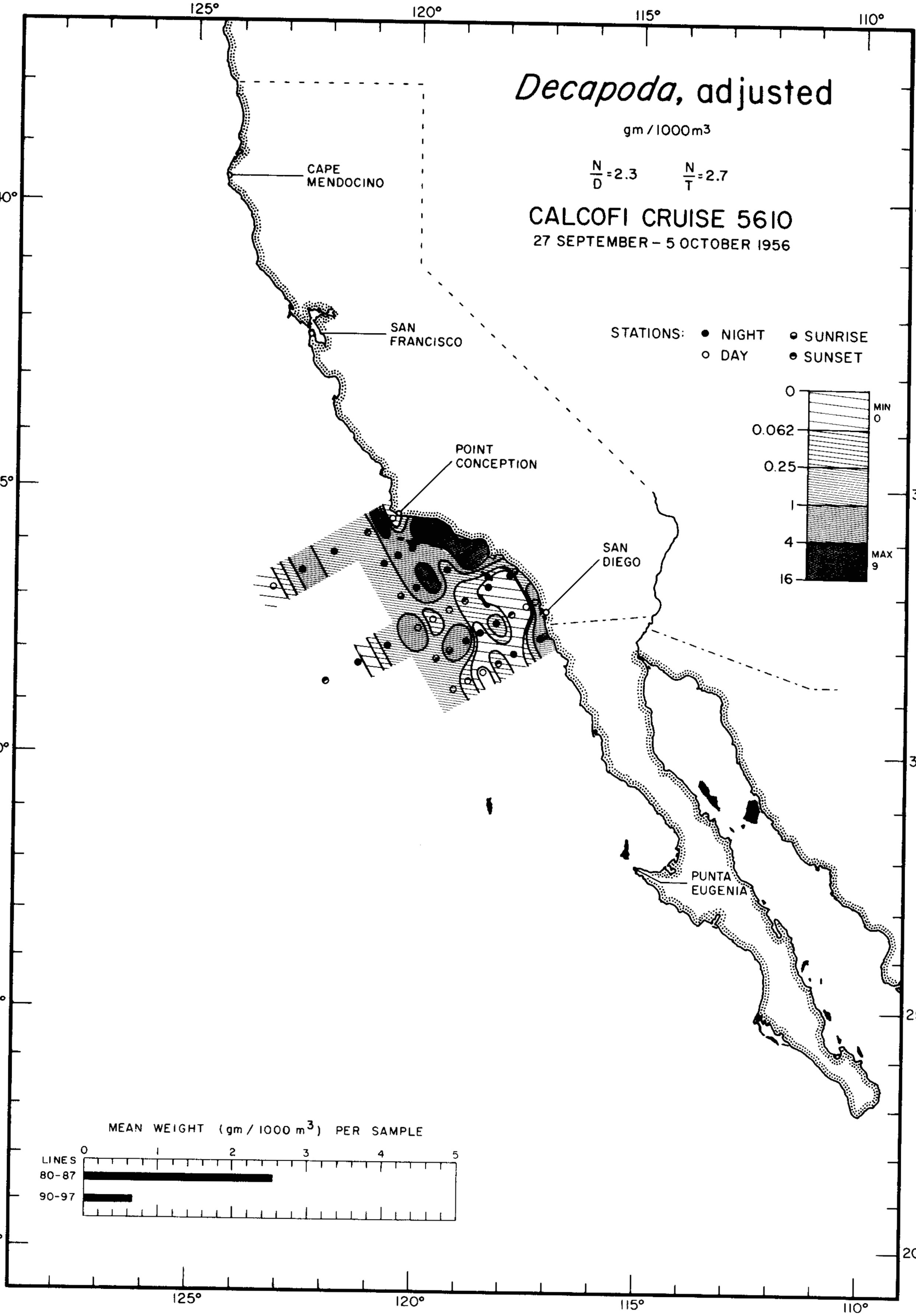
5510



Biomass

Decapoda

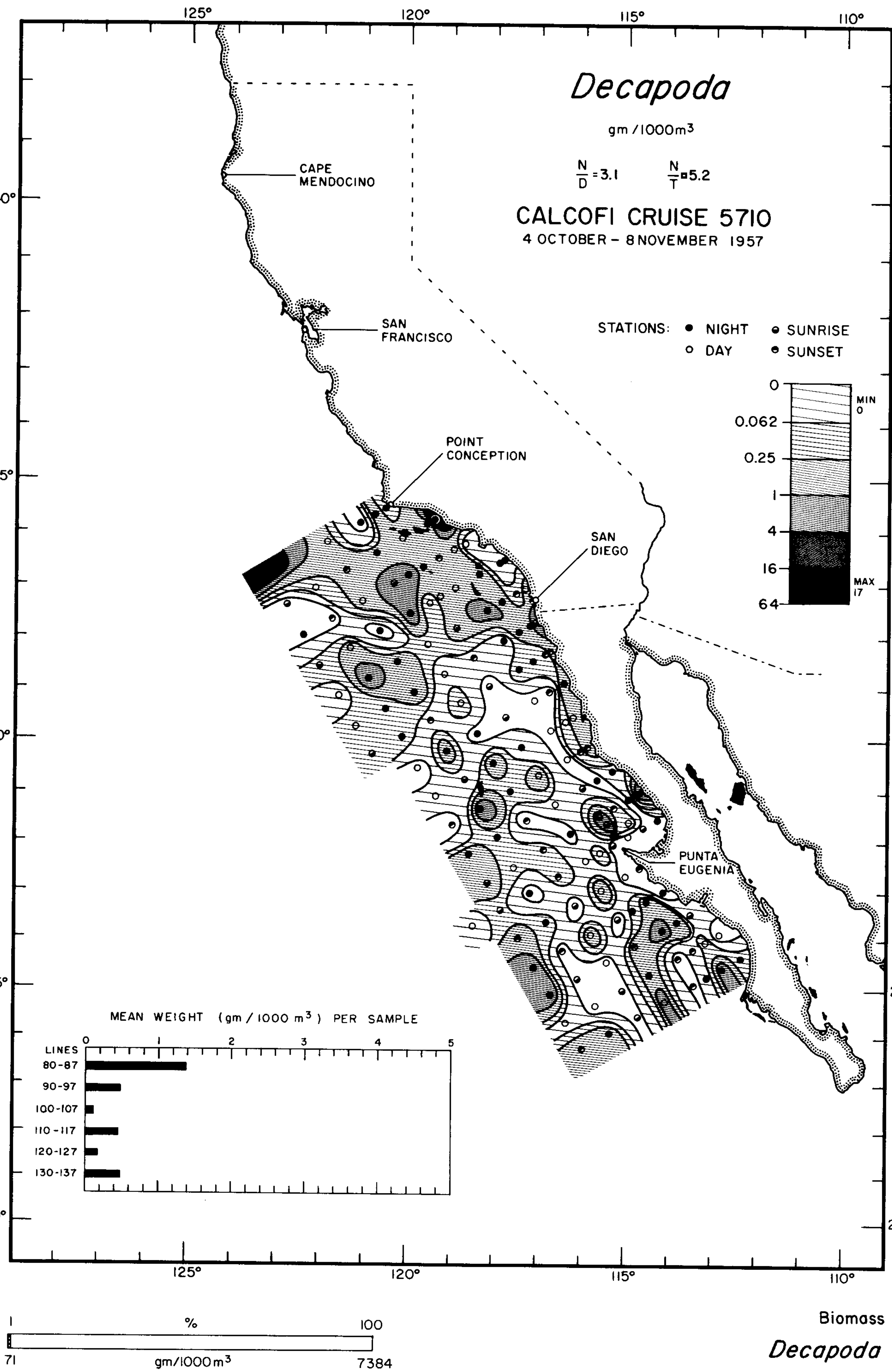
5610



Biomass

Decapoda, adjusted

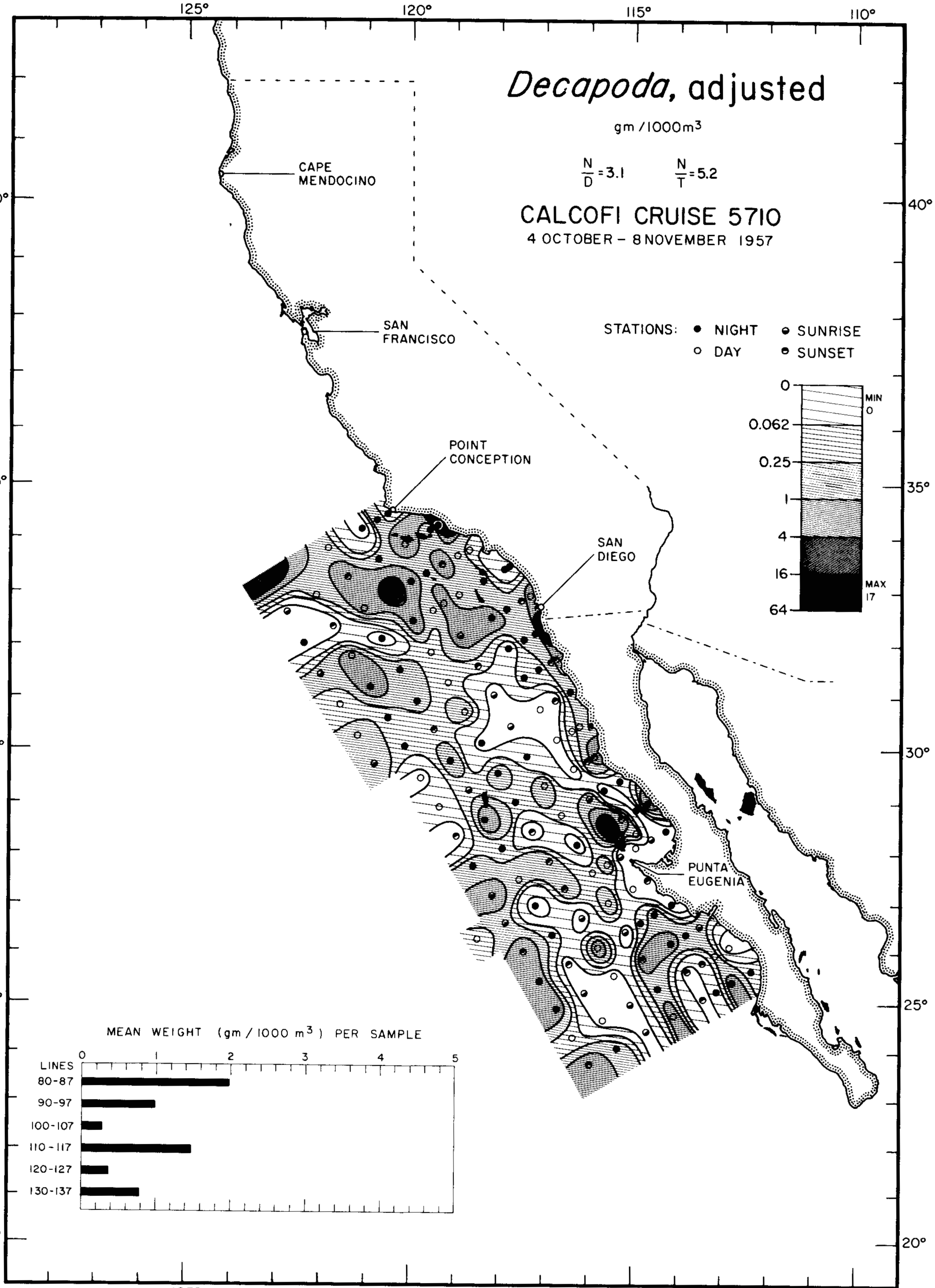
5610



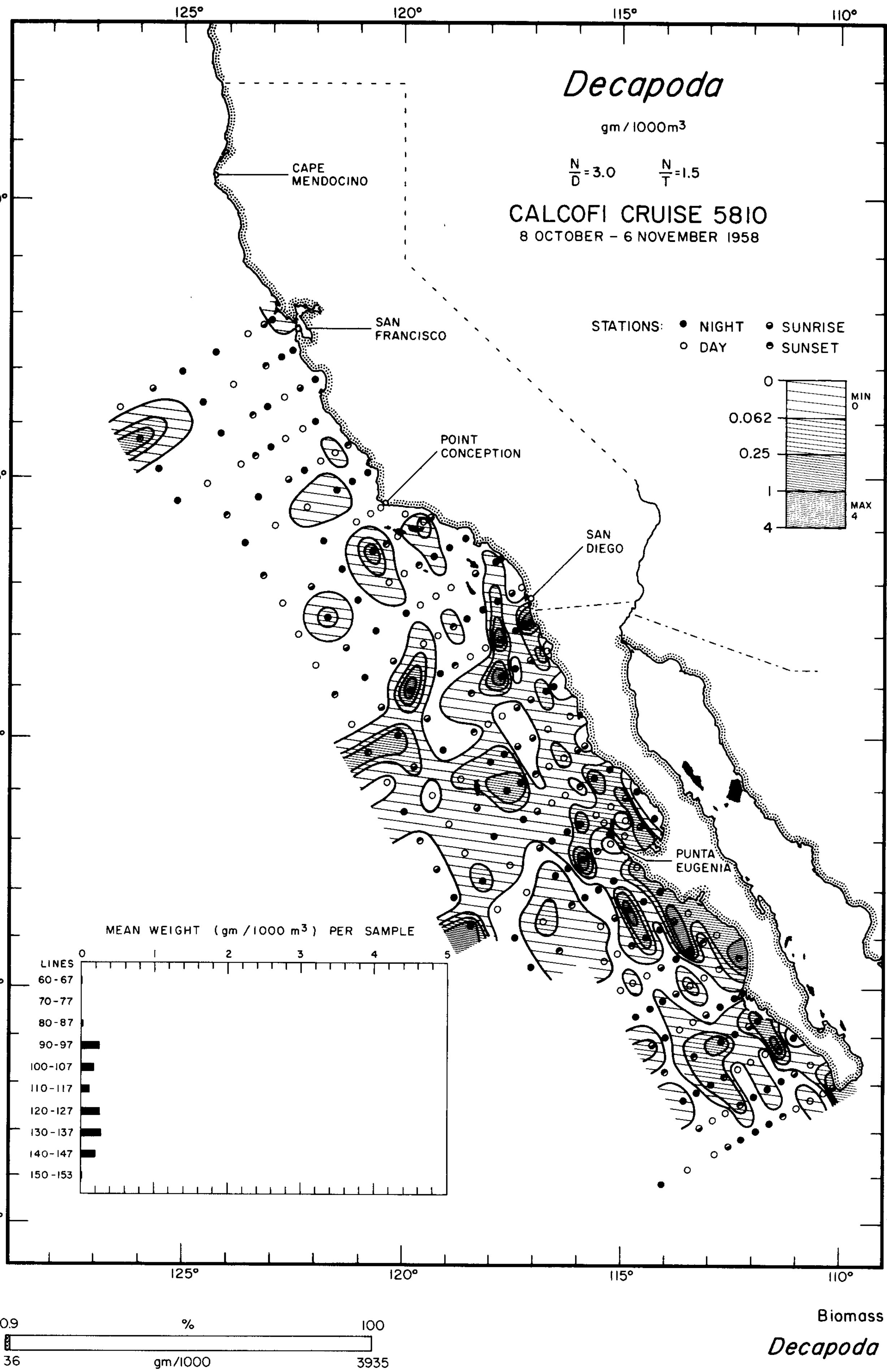
Biomass

Decapoda

5710



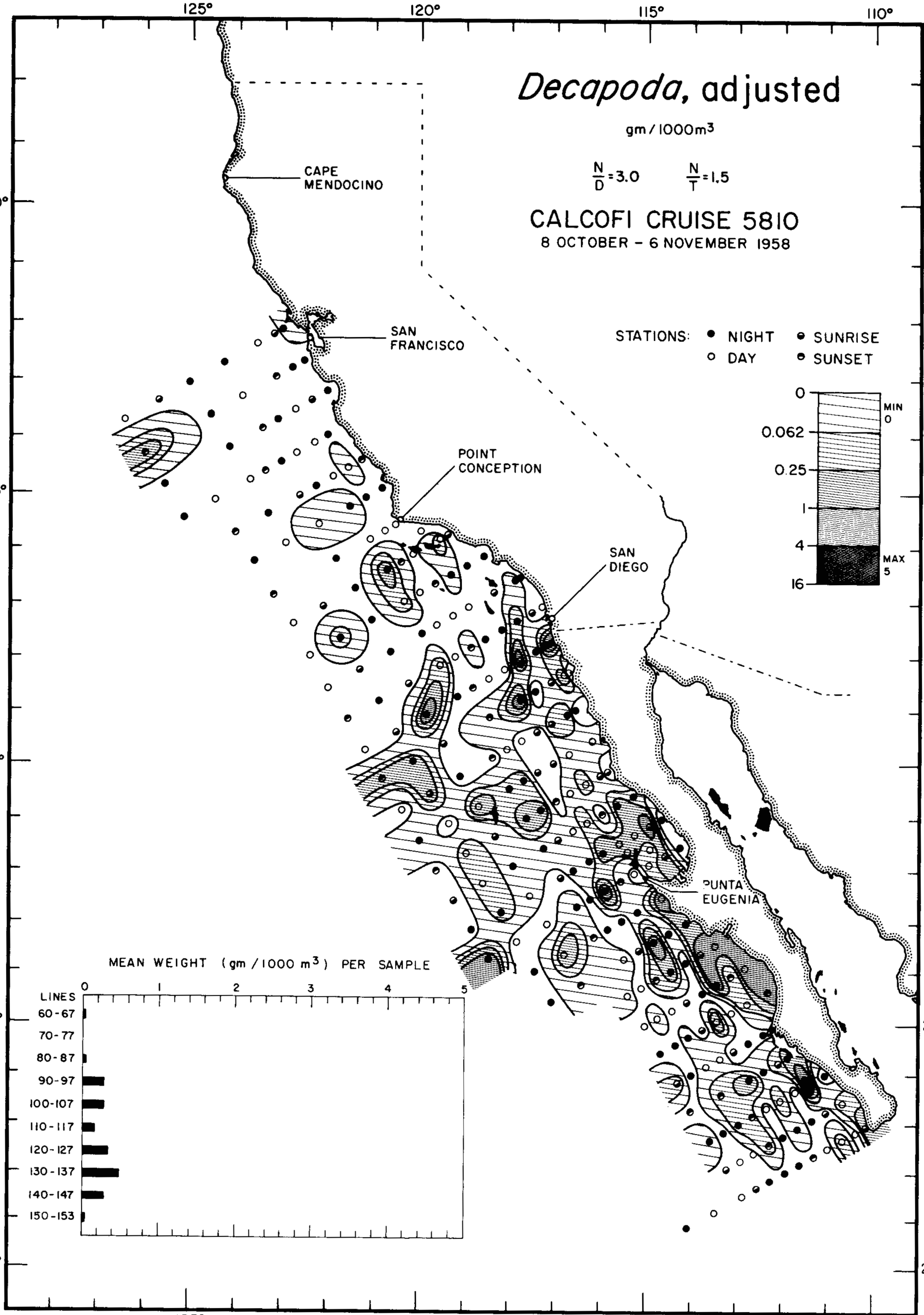
Biomass
Decapoda, adjusted
5710



Biomass

Decapoda

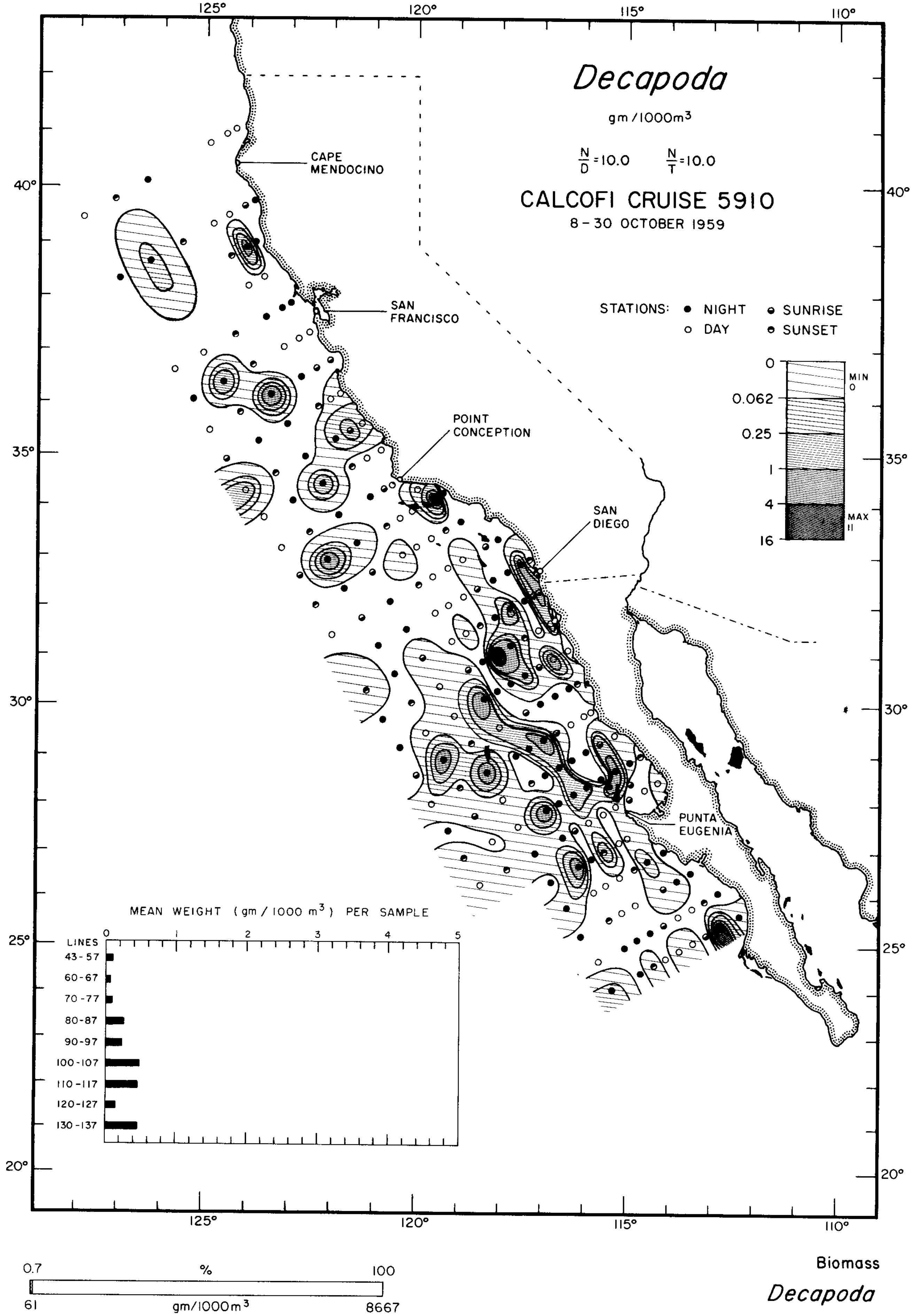
5810



Biomass

Decapoda, adjusted

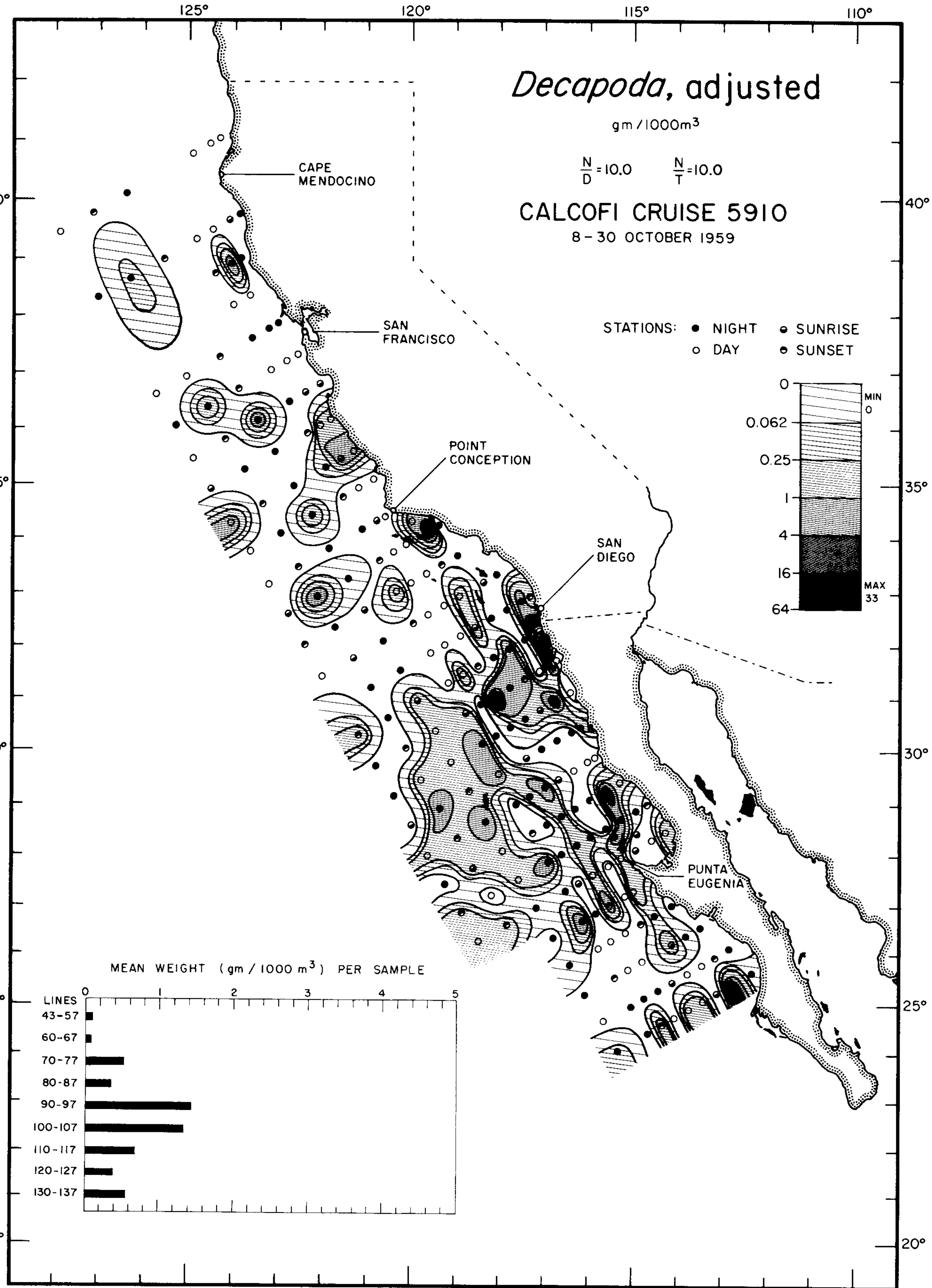
5810



Biomass

Decapoda

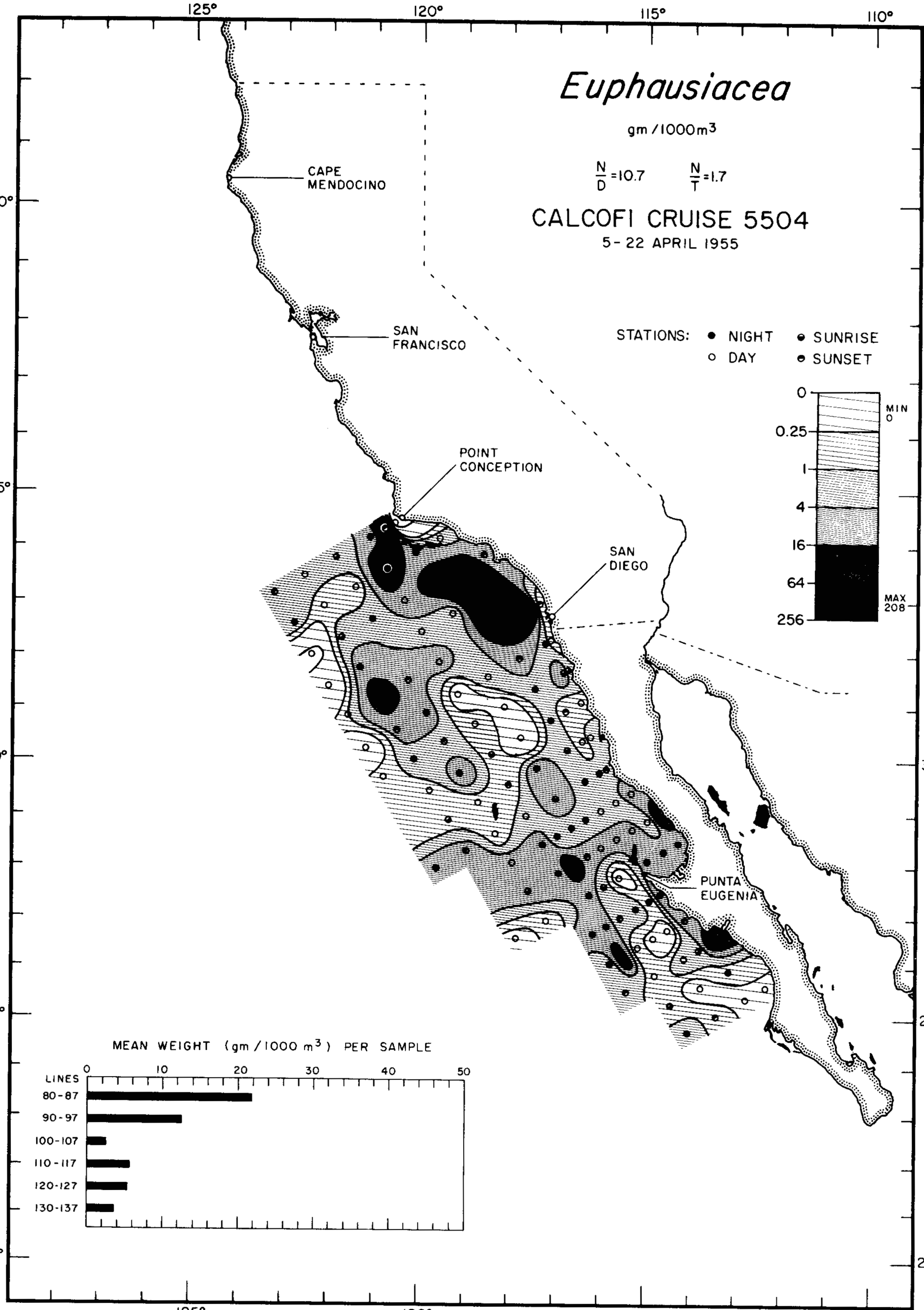
5910

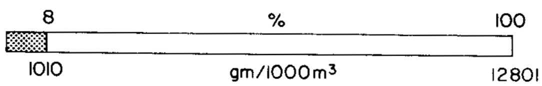


Biomass

Decapoda, adjusted

5910

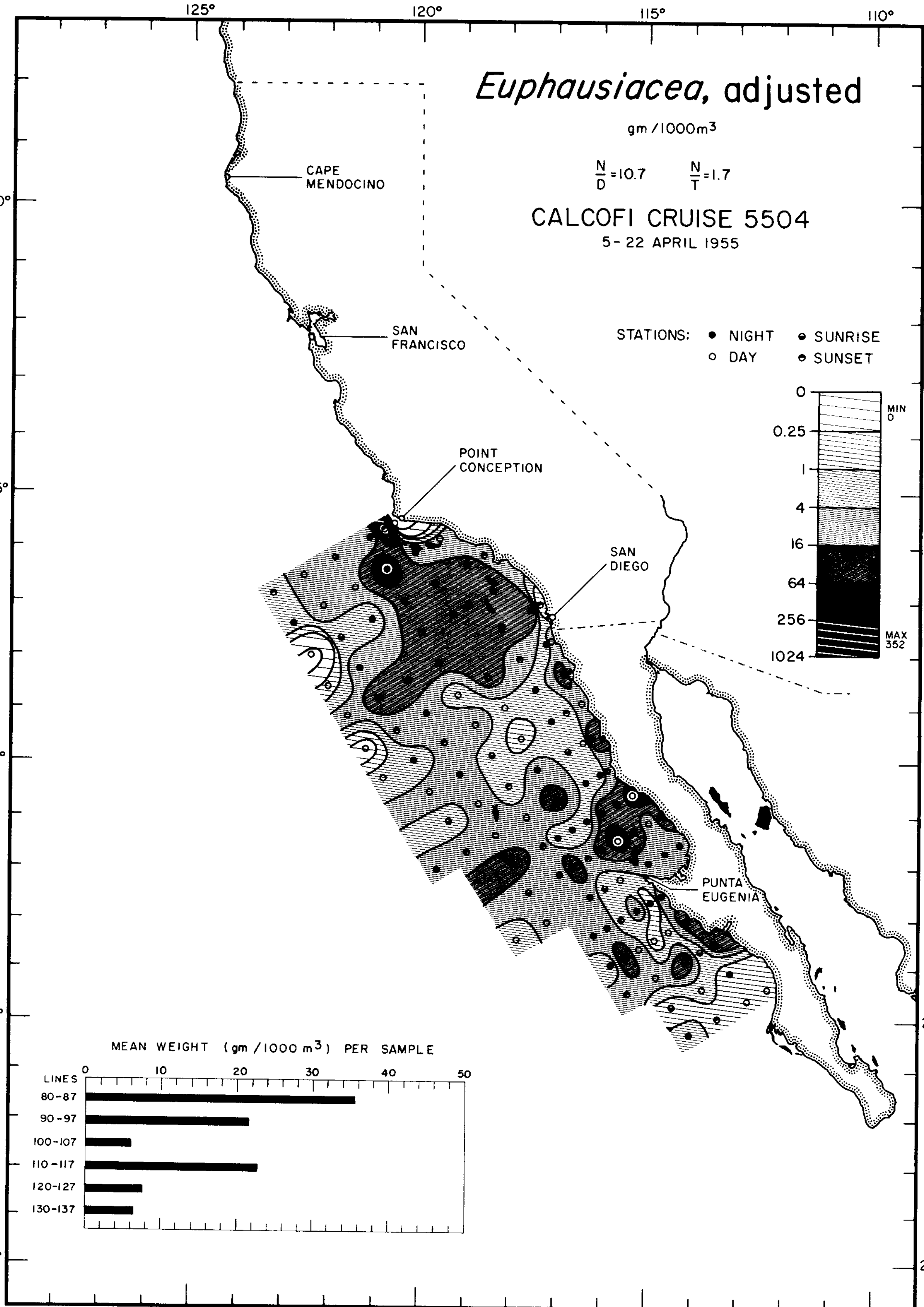




Biomass

Euphausiacea

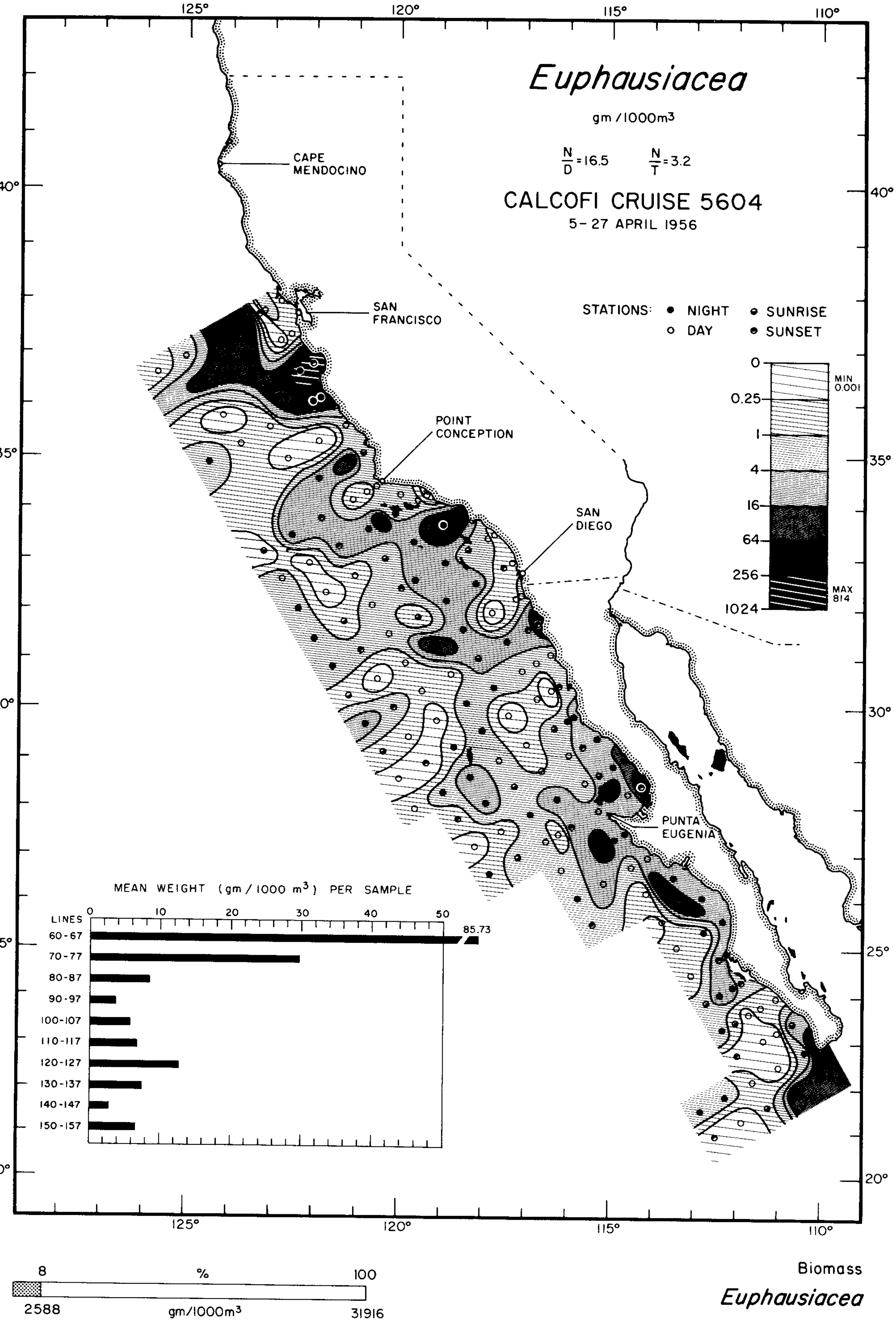
5504



Biomass

Euphausiacea, adjusted

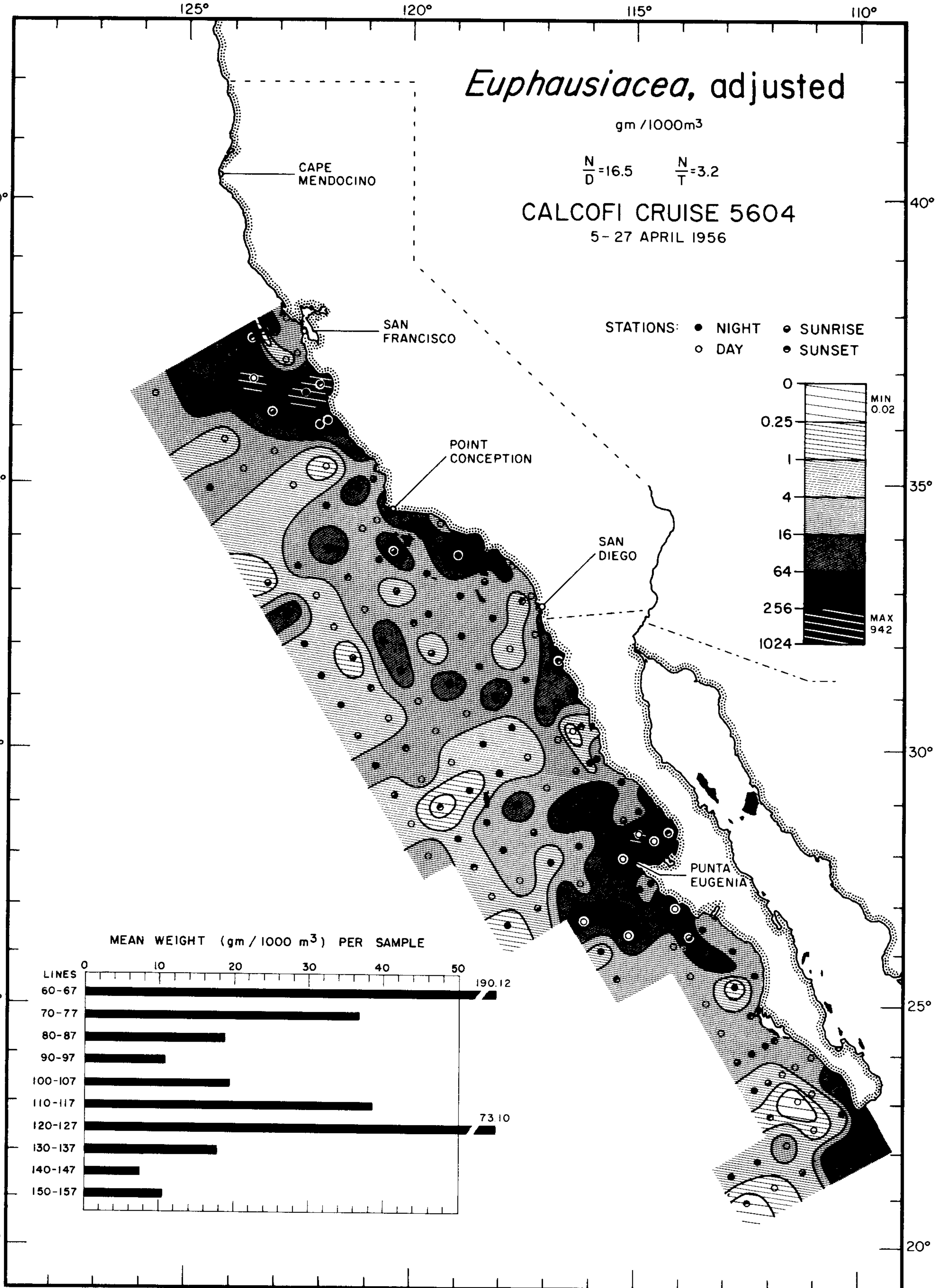
5504



Biomass

Euphausiacea

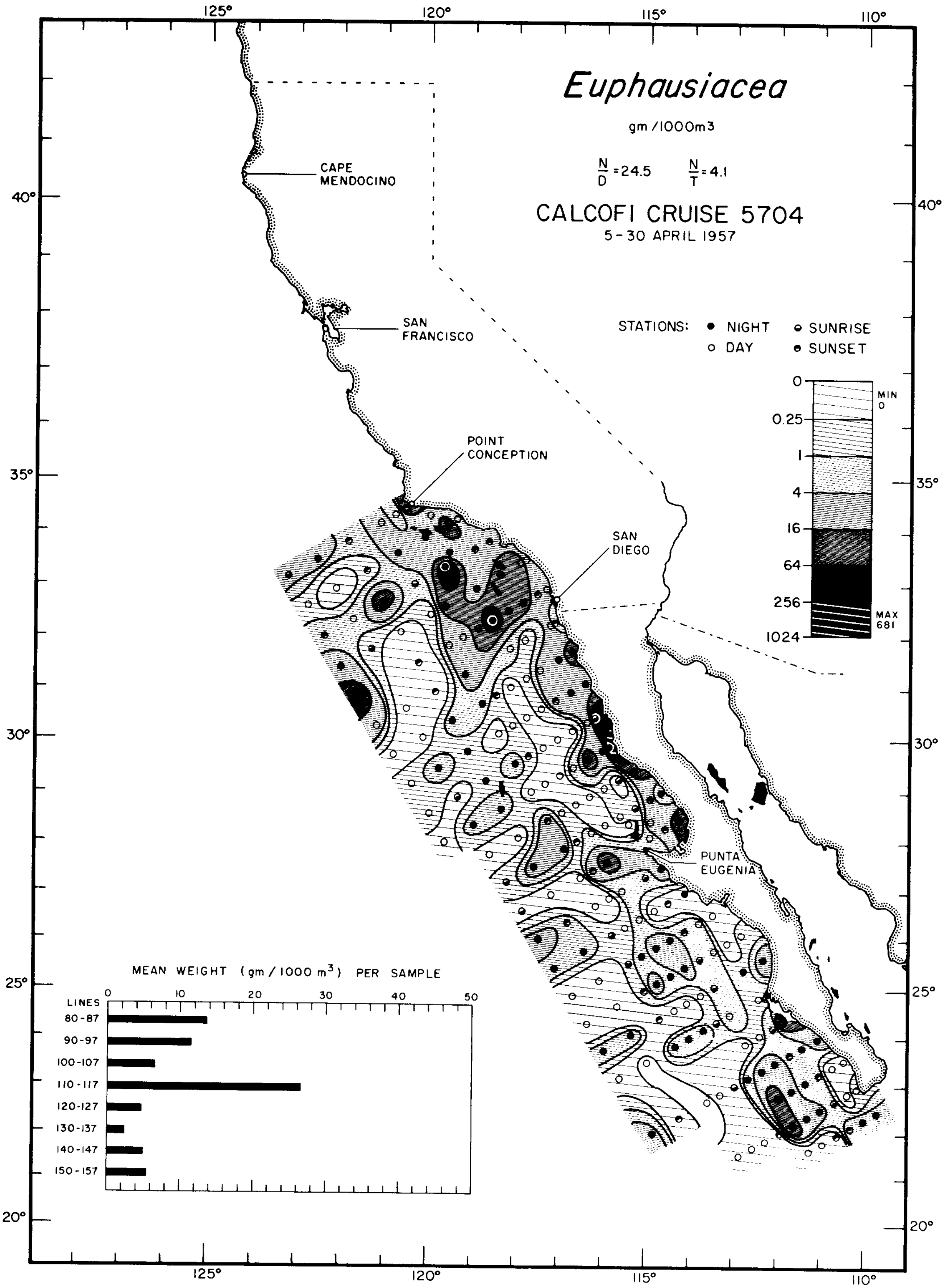
5604

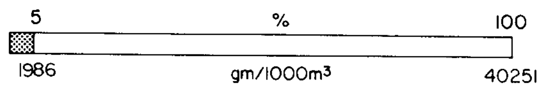


Biomass

Euphausiacea, adjusted

5604

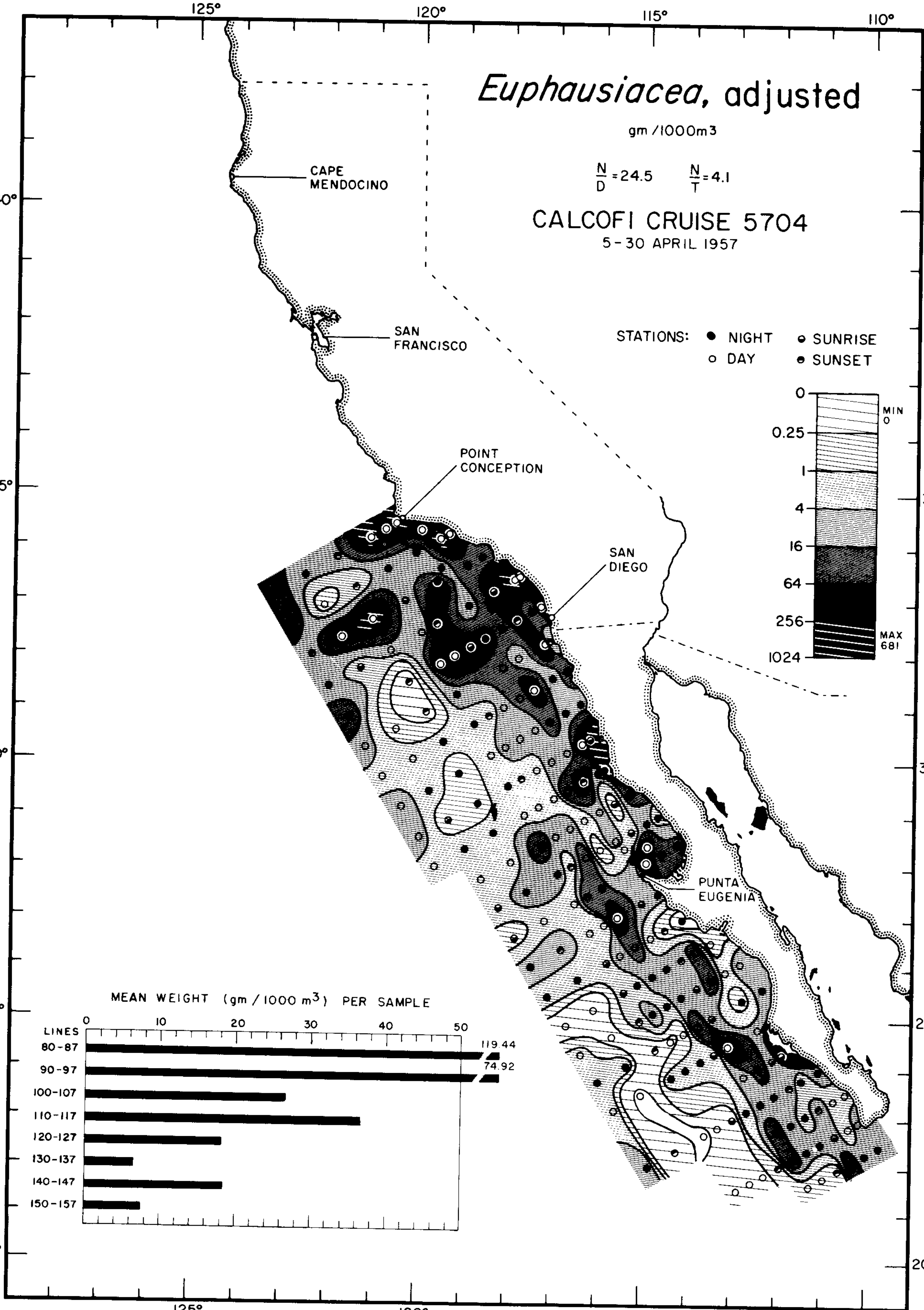




Biomass

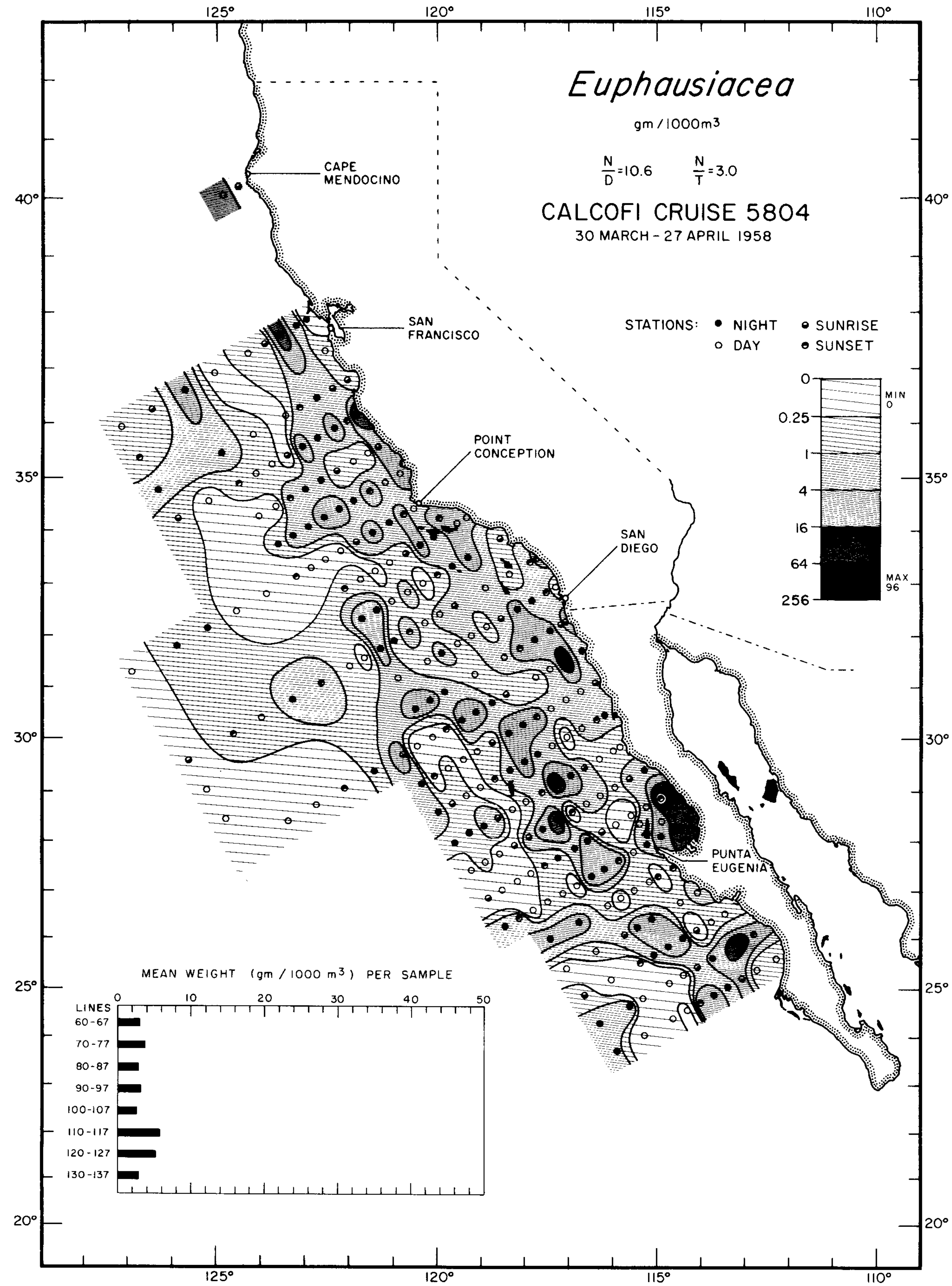
Euphausiacea

5704



Biomass

Euphausiacea, adjusted
5704



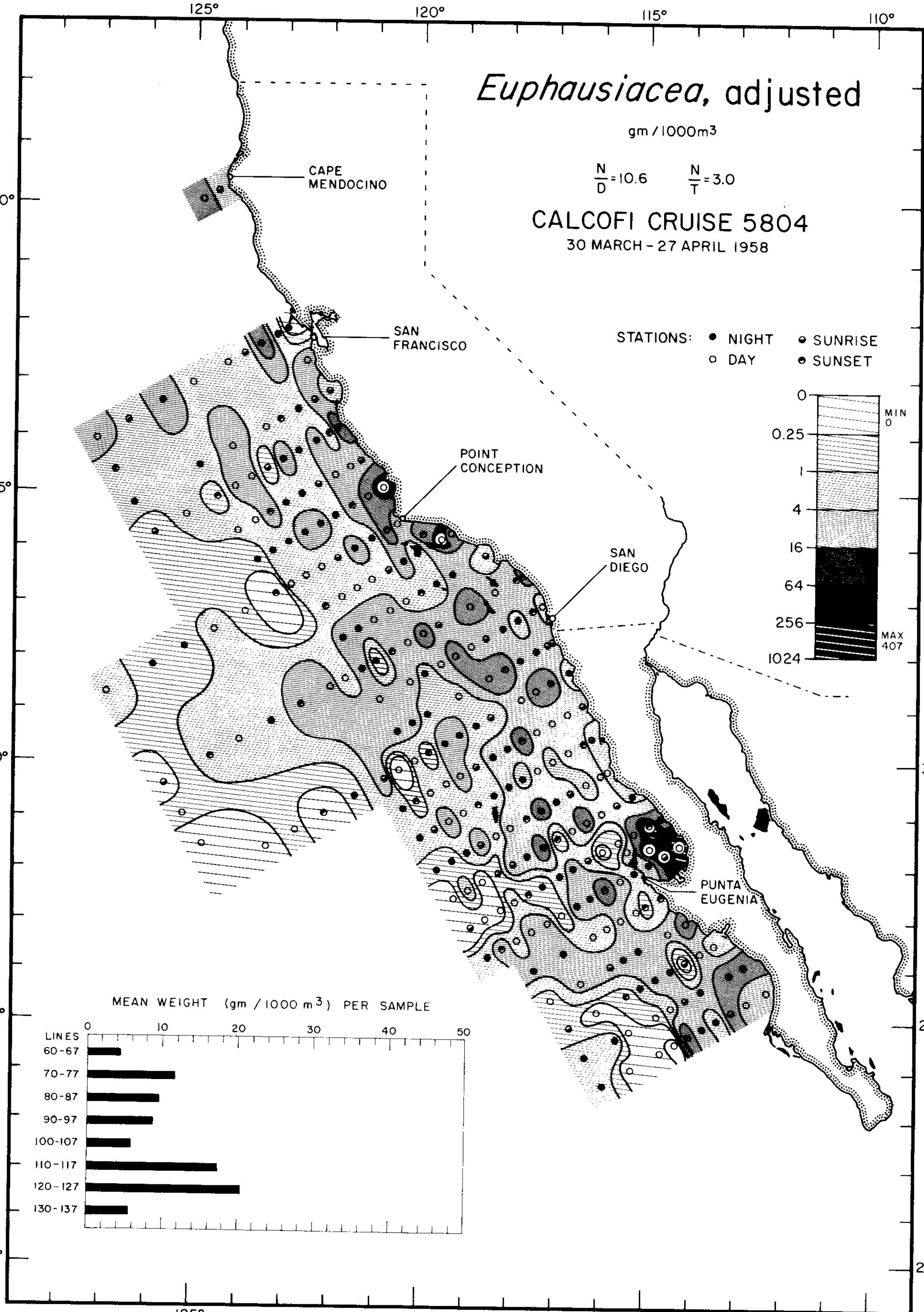
0 11 % 100

0 958 gm/1000m3 9039

Biomass

Euphausiacea

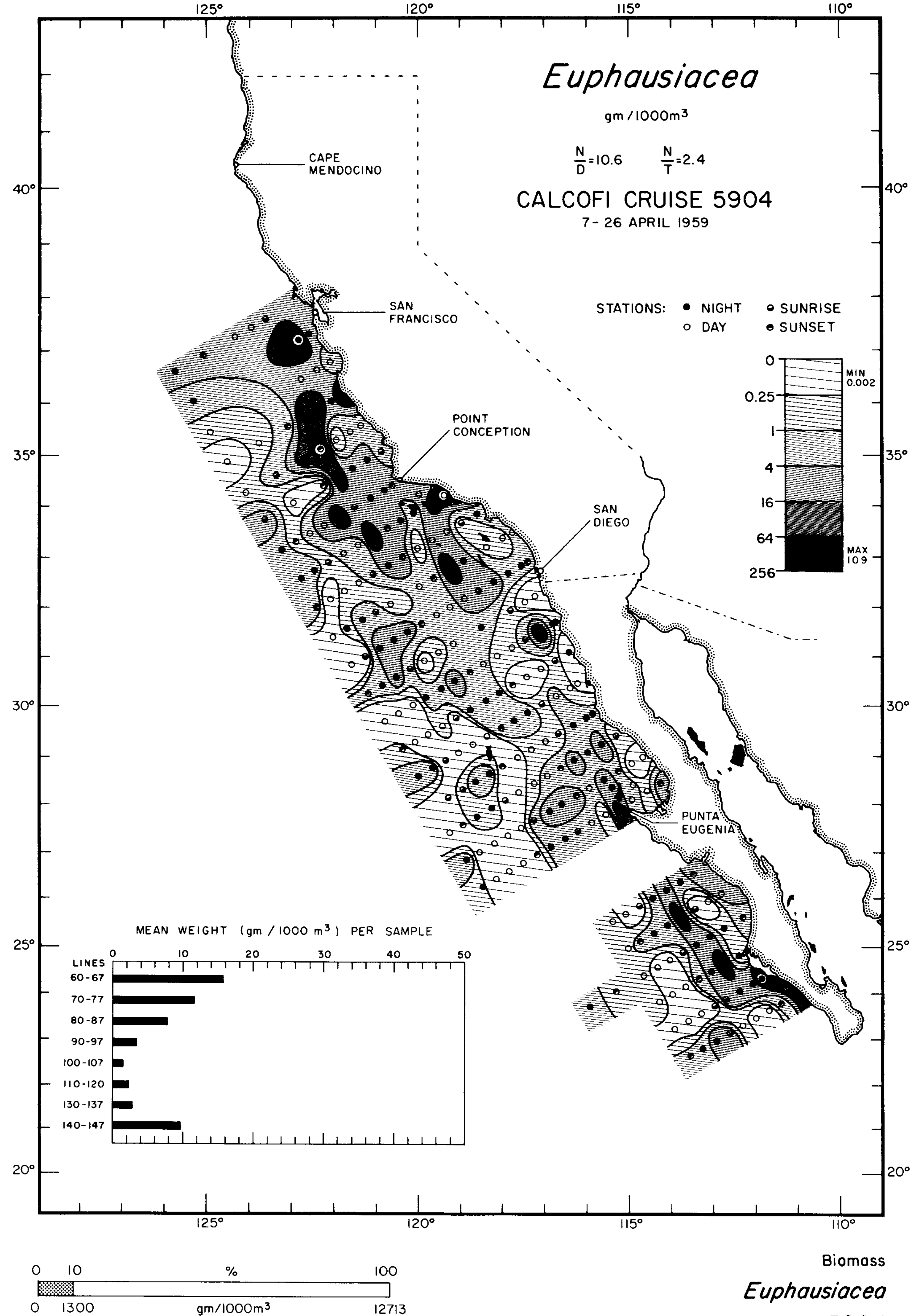
5804



Biomass

Euphausiacea, adjusted

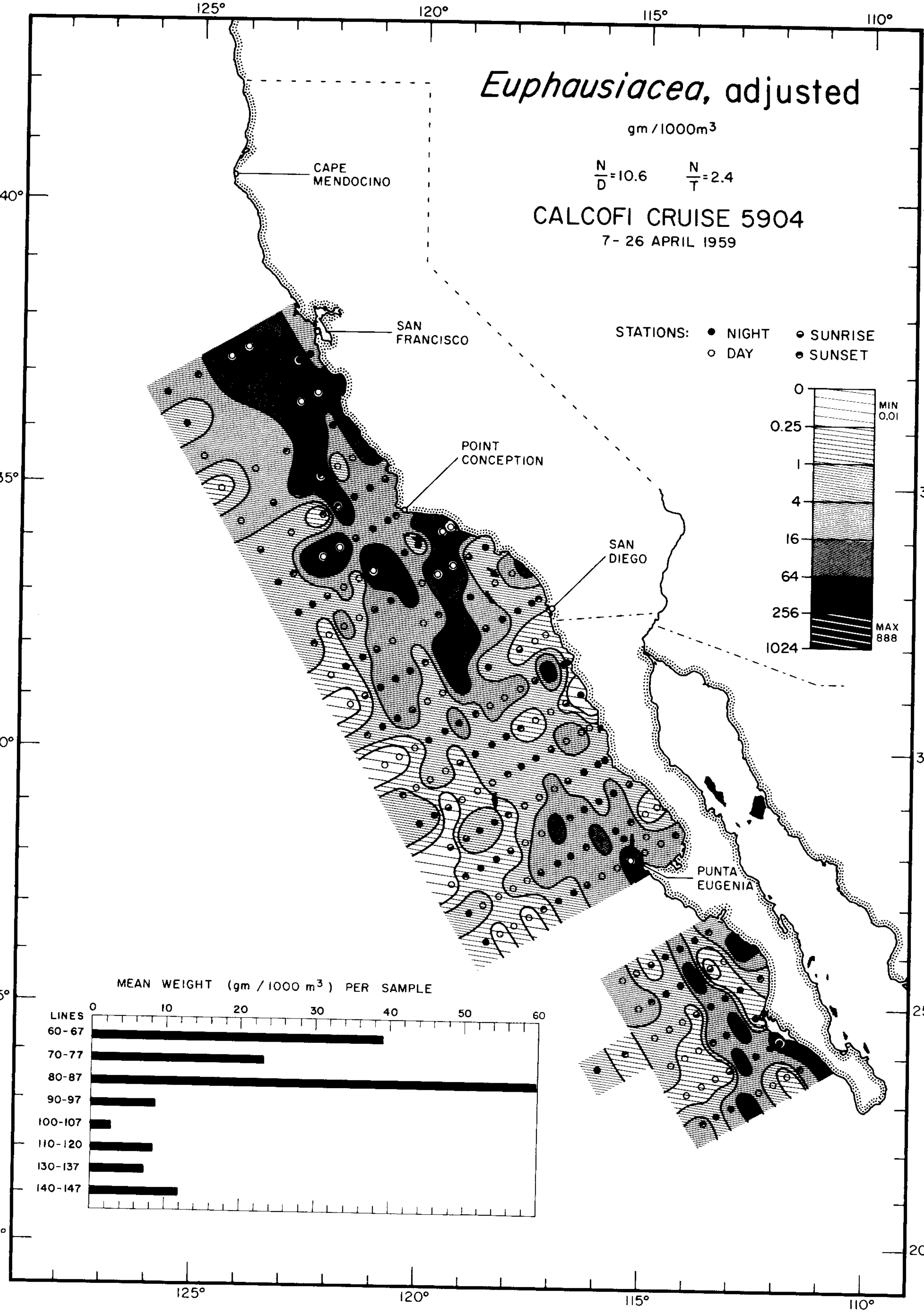
5804



Biomass

Euphausiacea

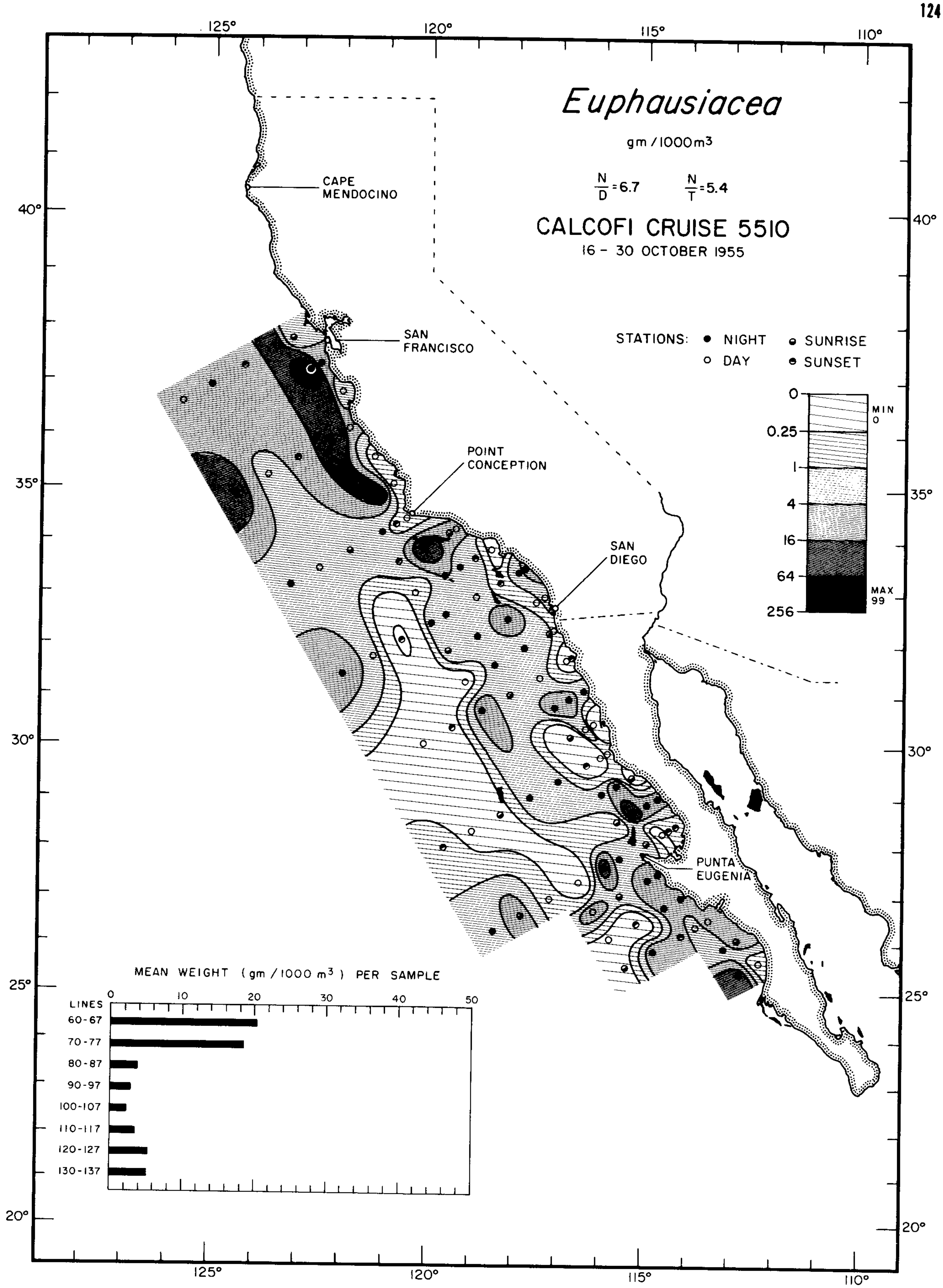
5904



Biomass

Euphausiacea, adjusted

5904



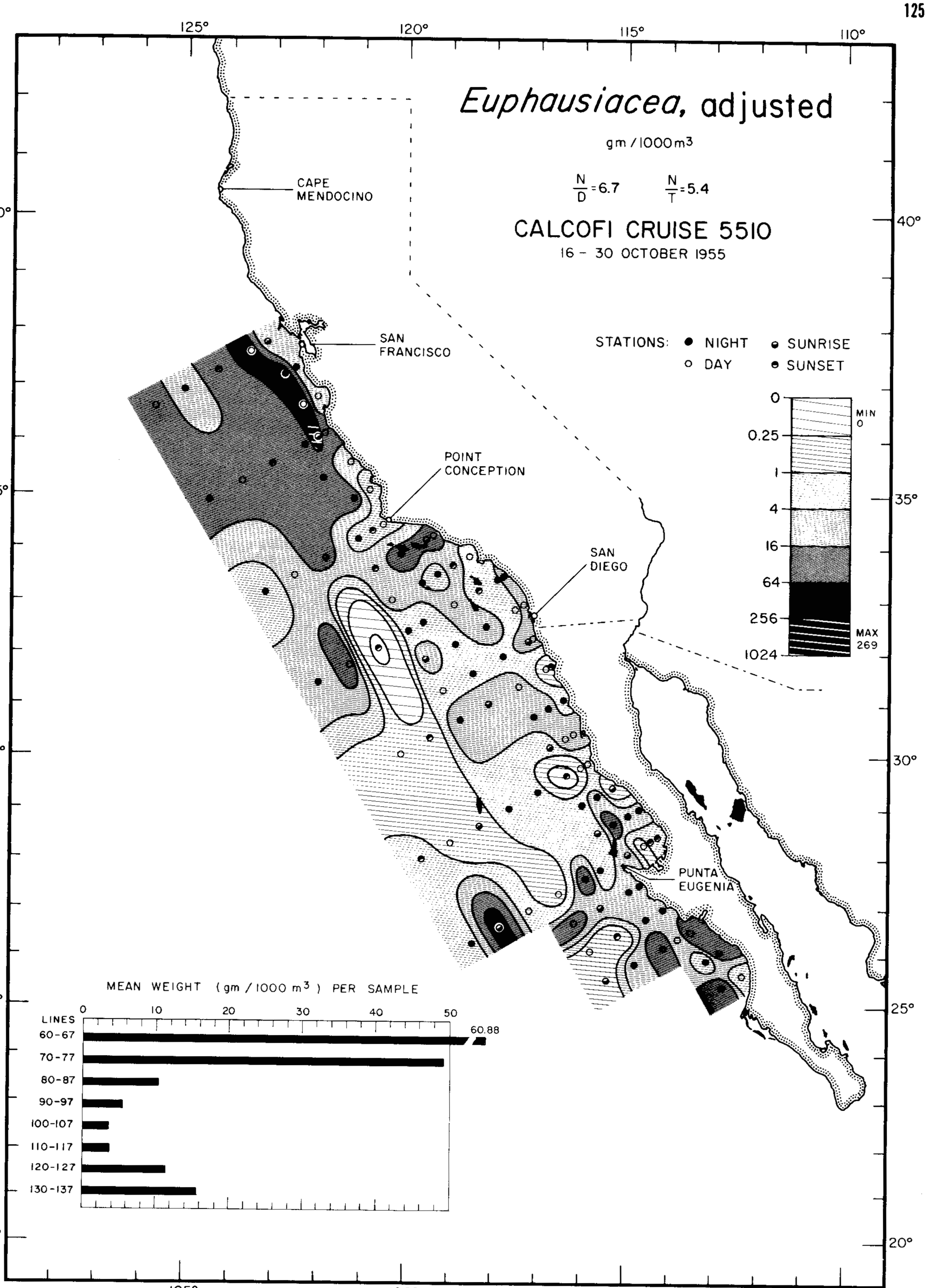
6 % 100

698 gm/1000 m3 12344

Biomass

Euphausiacea

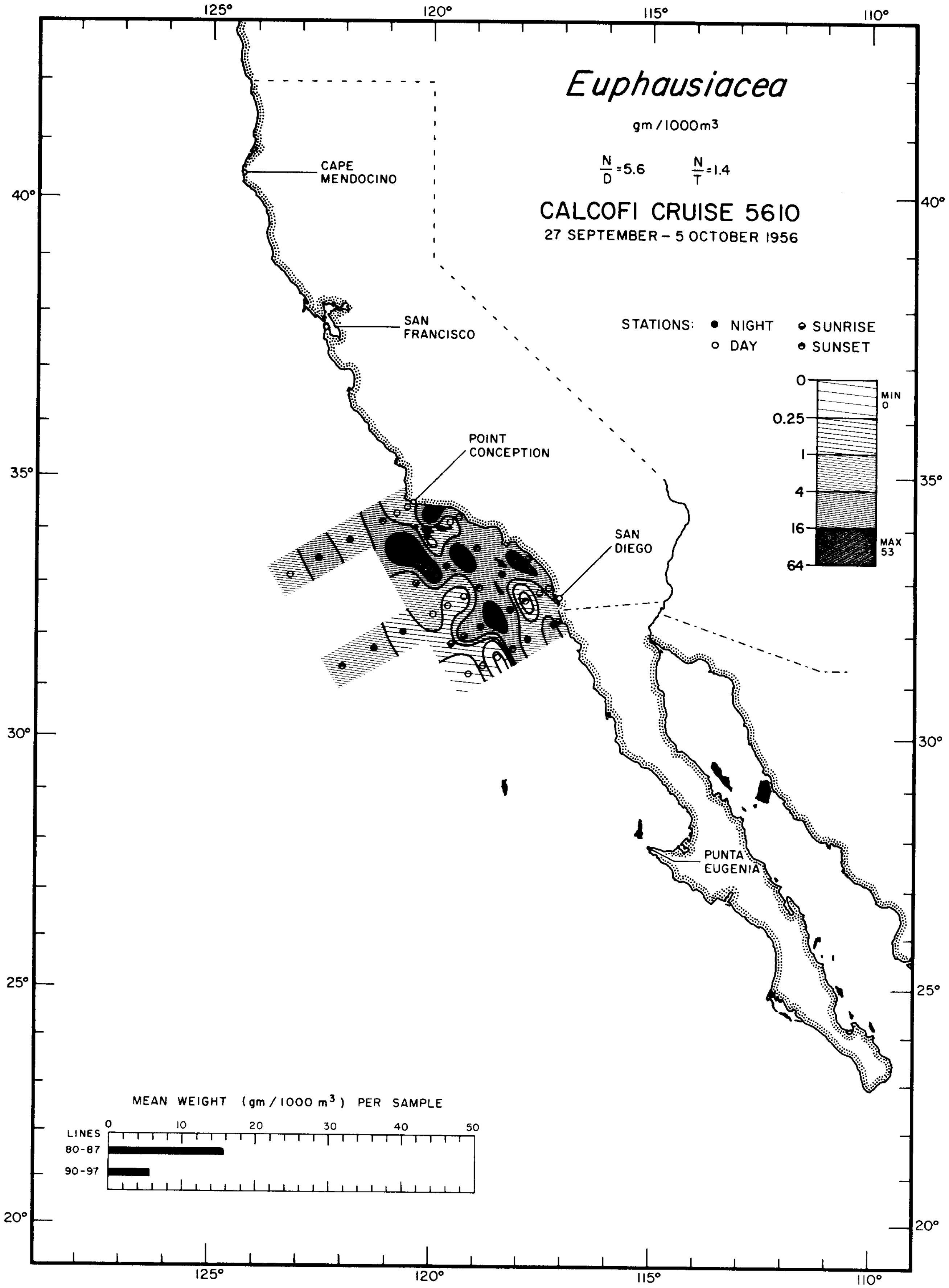
5510

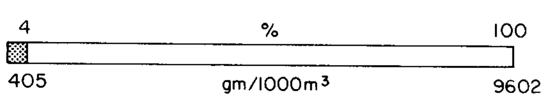


Biomass

Euphausiacea, adjusted

5510

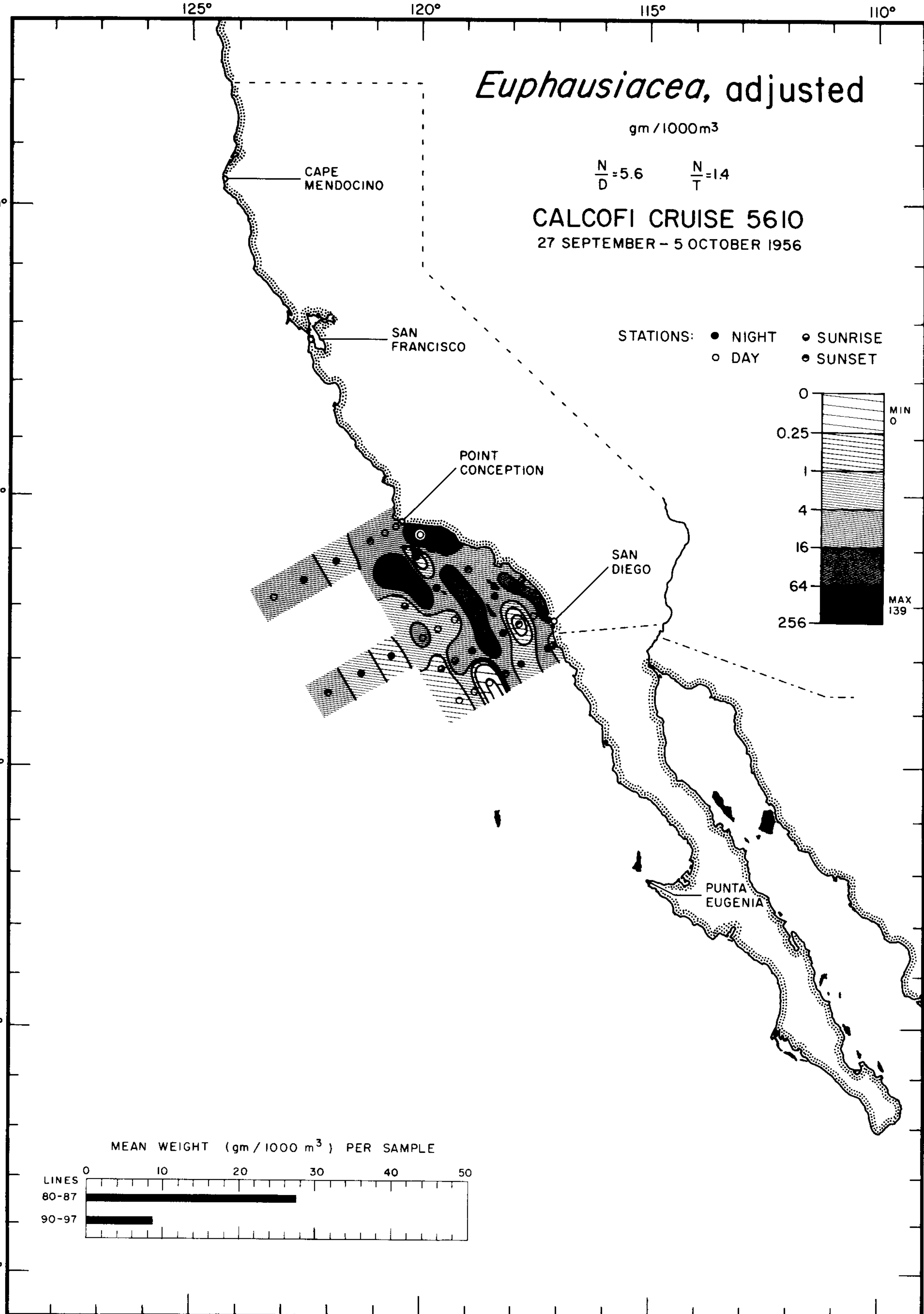




Biomass

Euphausiacea

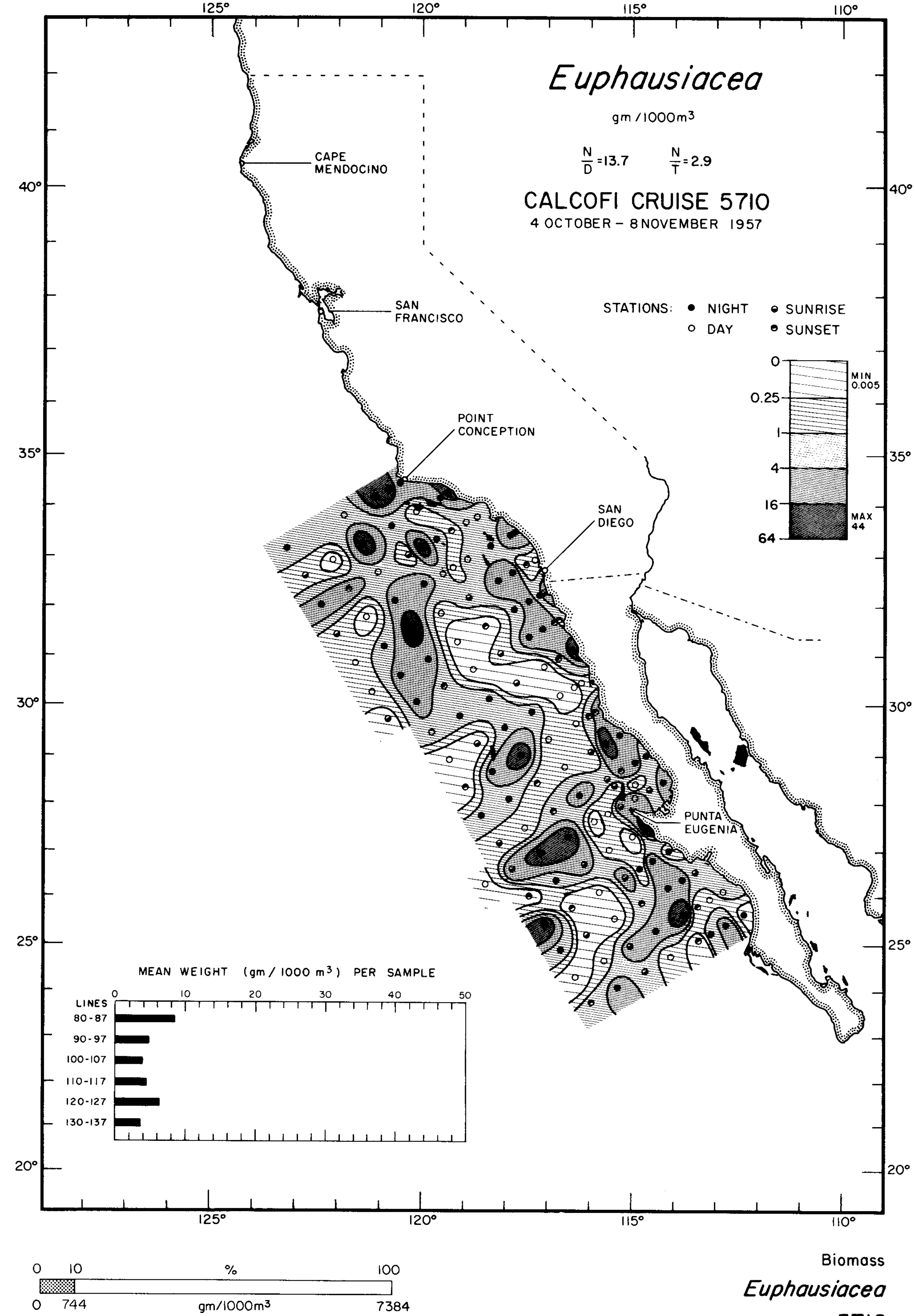
5610



Biomass

Euphausiacea, adjusted

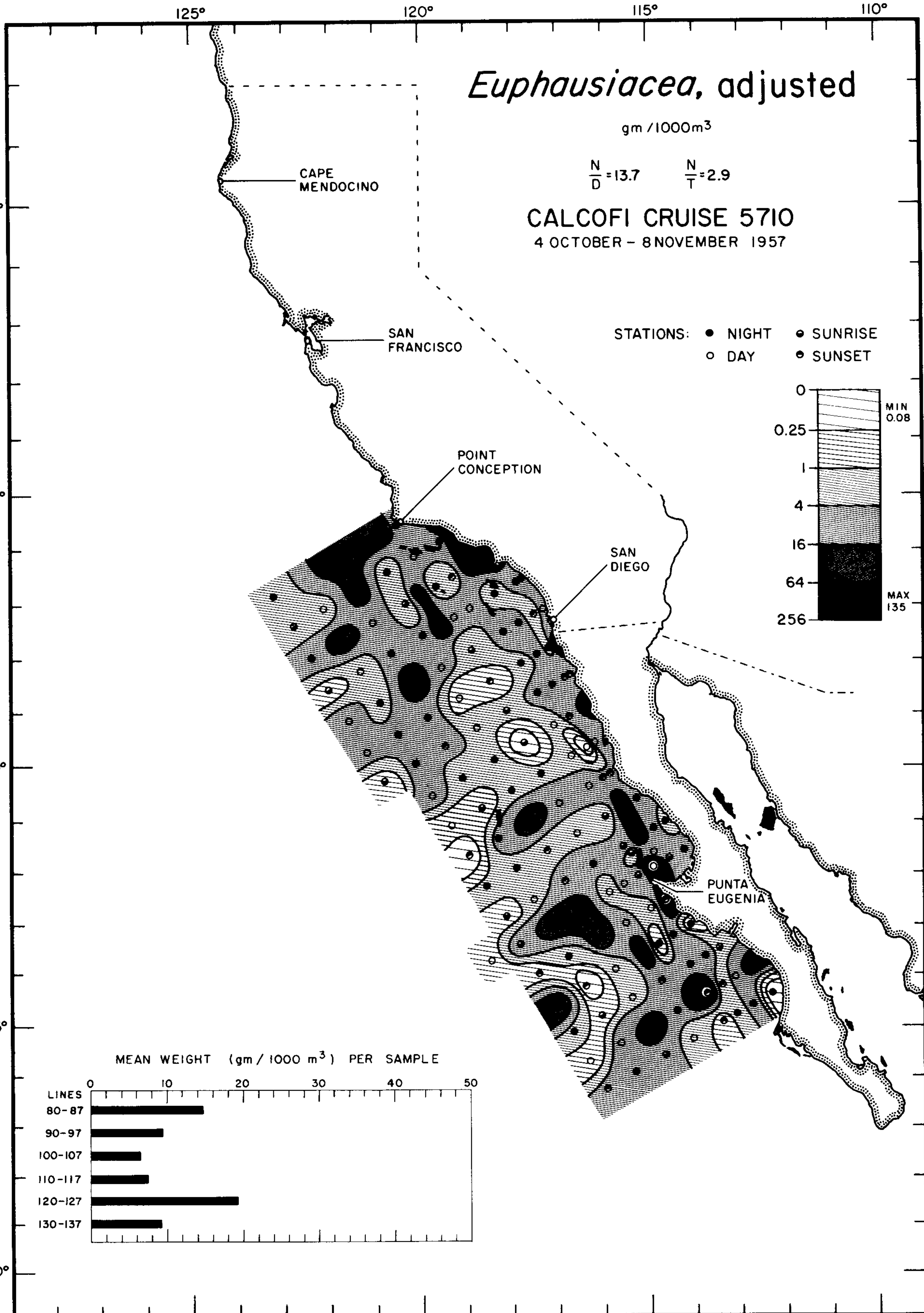
5610



Biomass

Euphausiacea

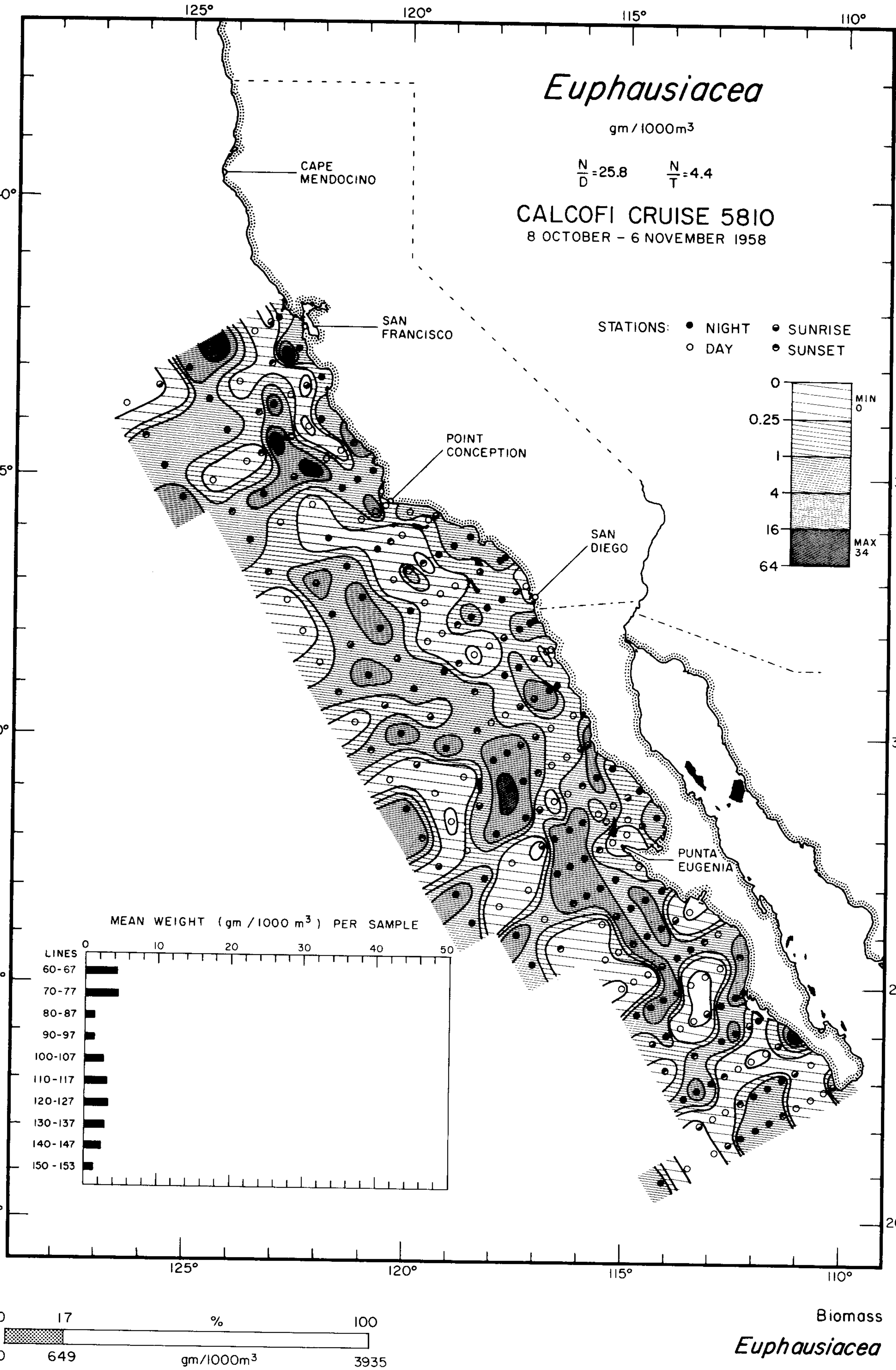
5710



Biomass

Euphausiacea, adjusted

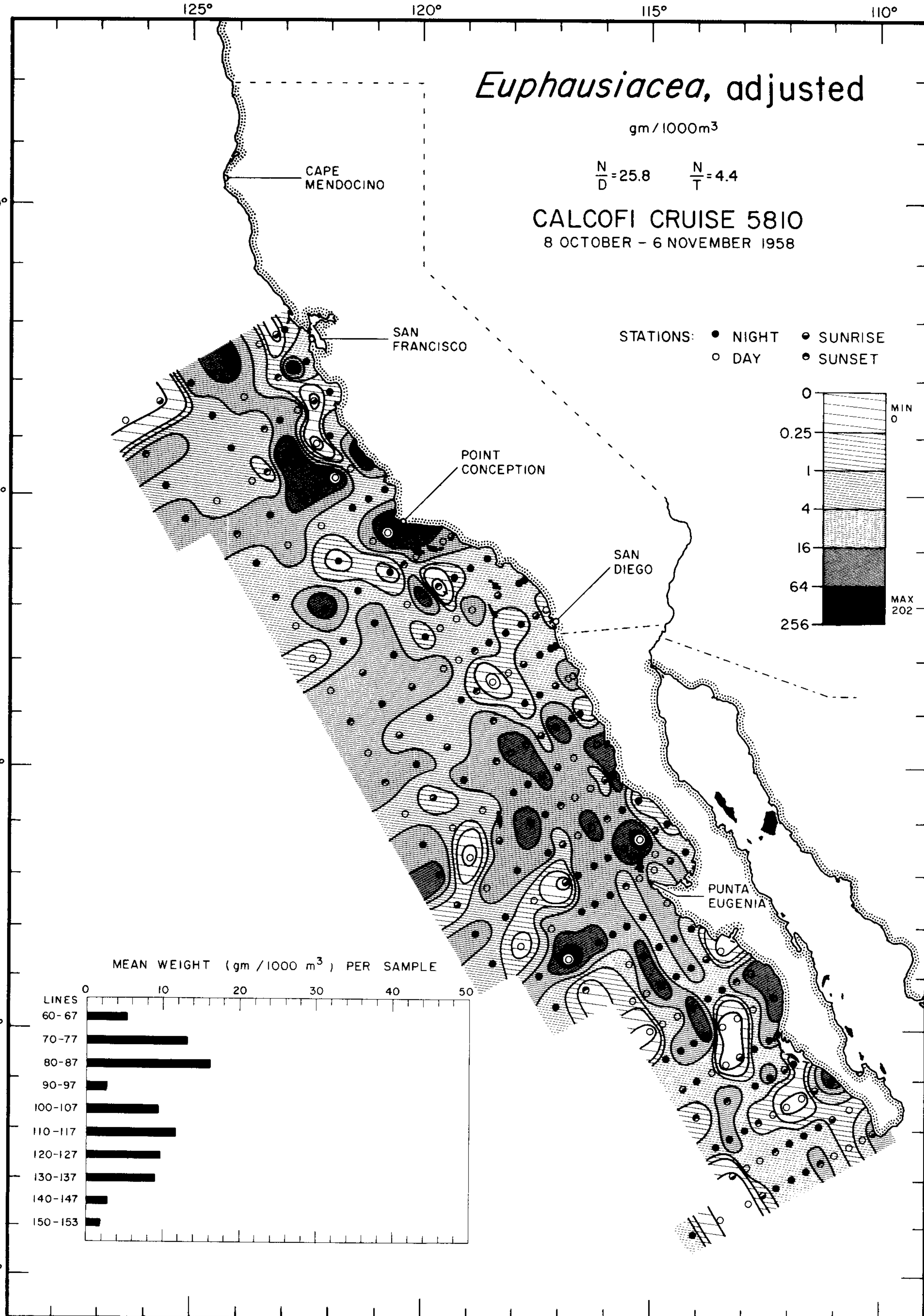
5710



Biomass

Euphausiacea

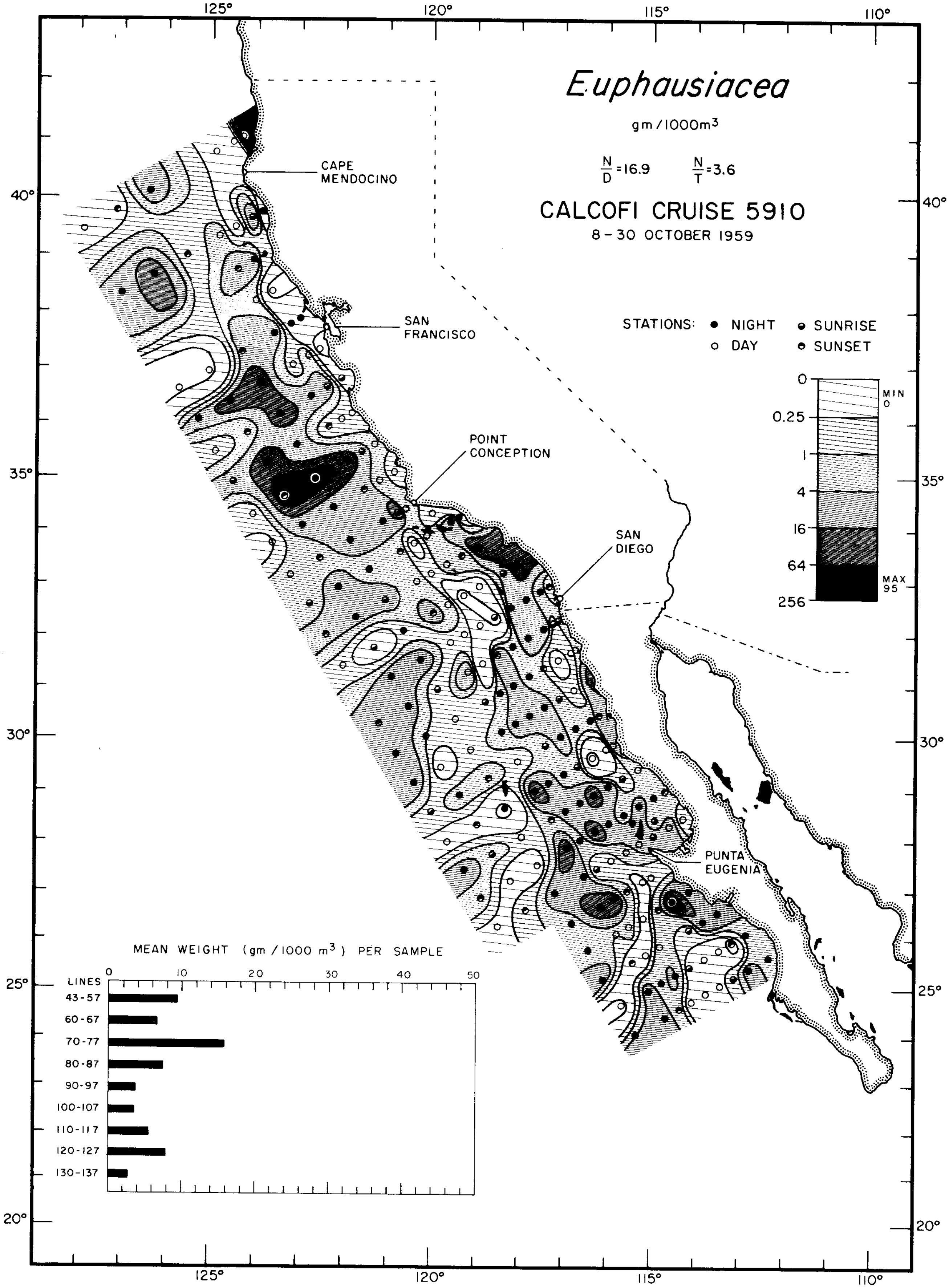
5810

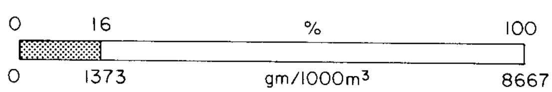


Biomass

Euphausiacea, adjusted

5810

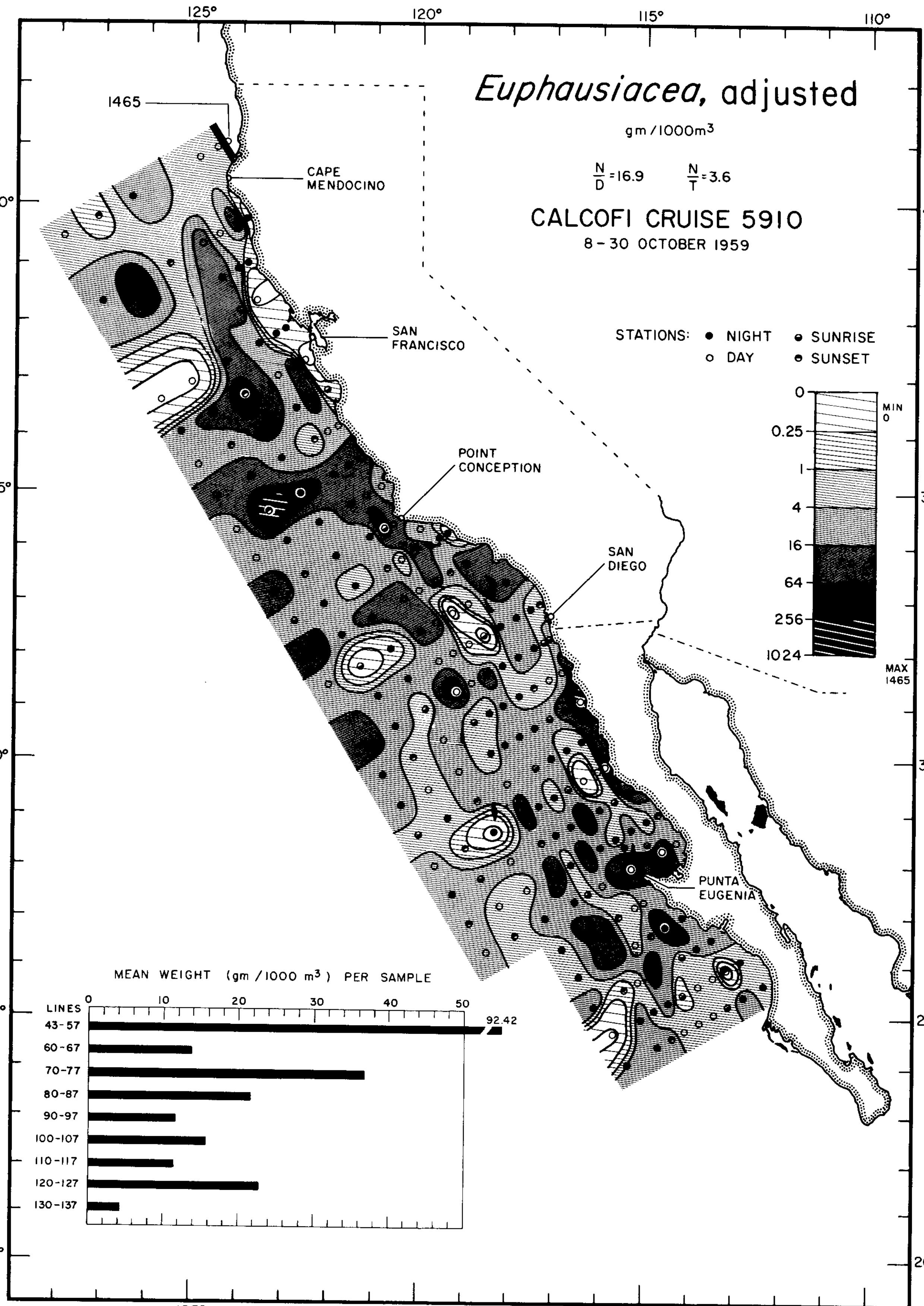




Biomass

Euphausiacea

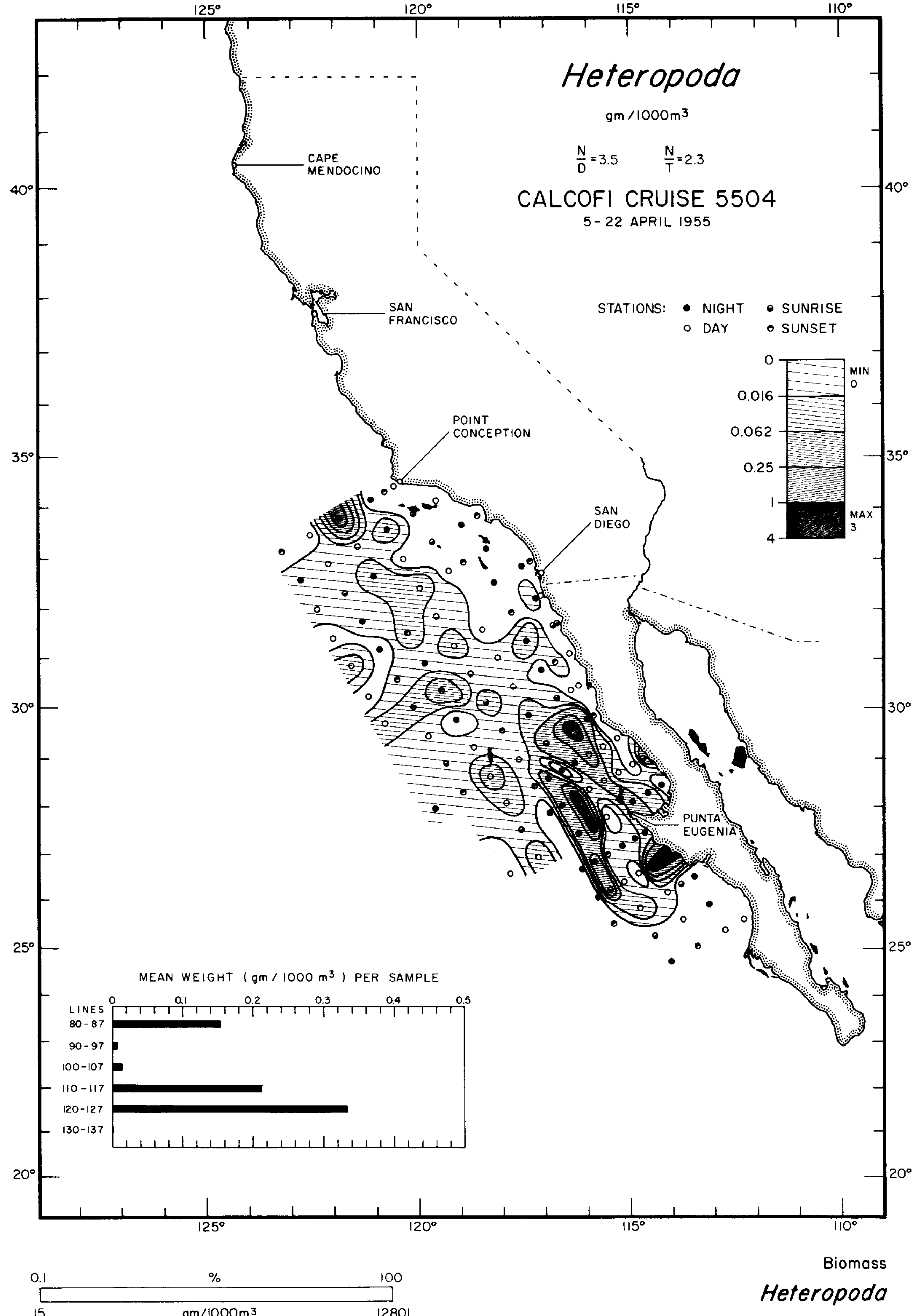
5910



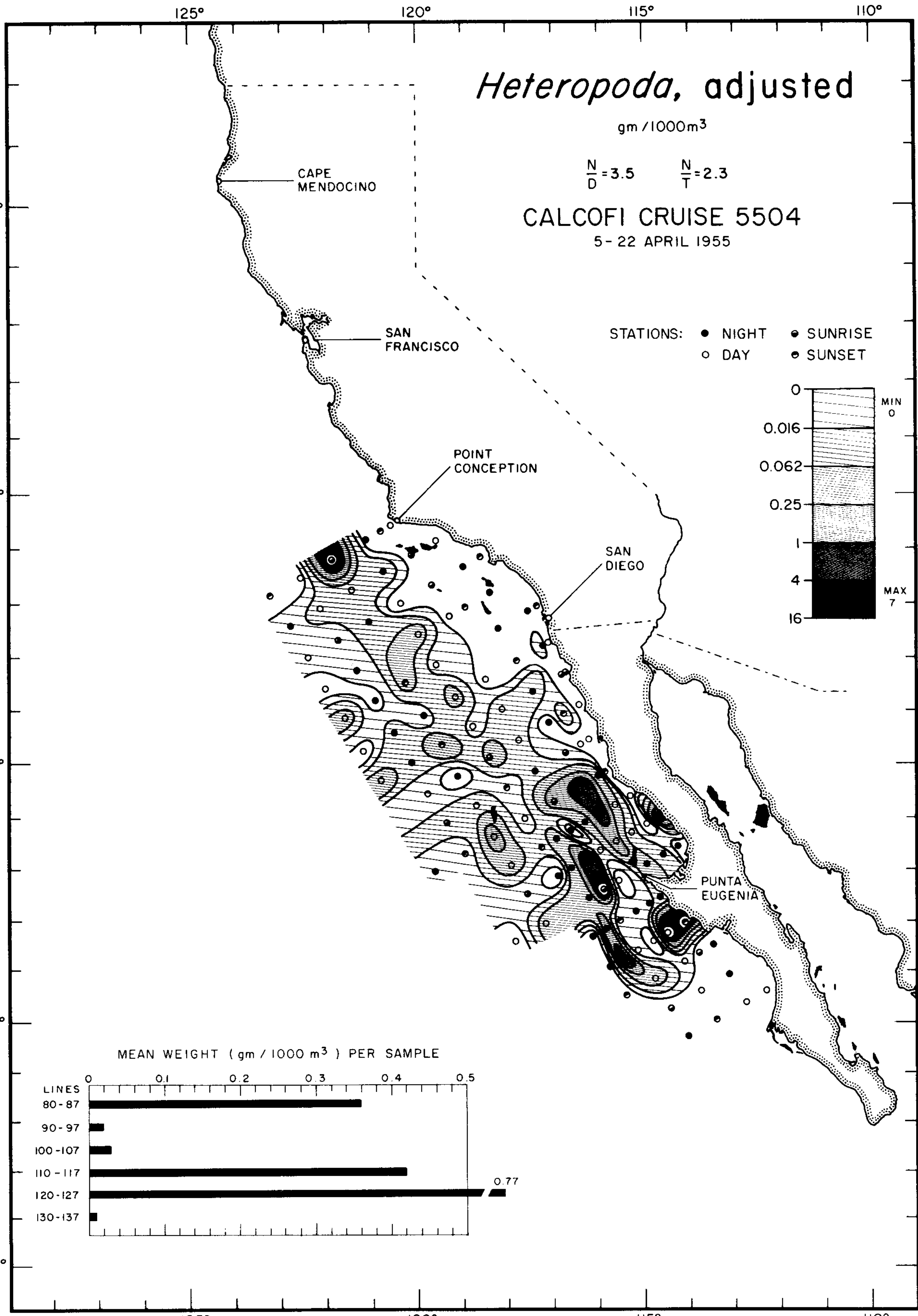
Biomass

Euphausiacea, adjusted

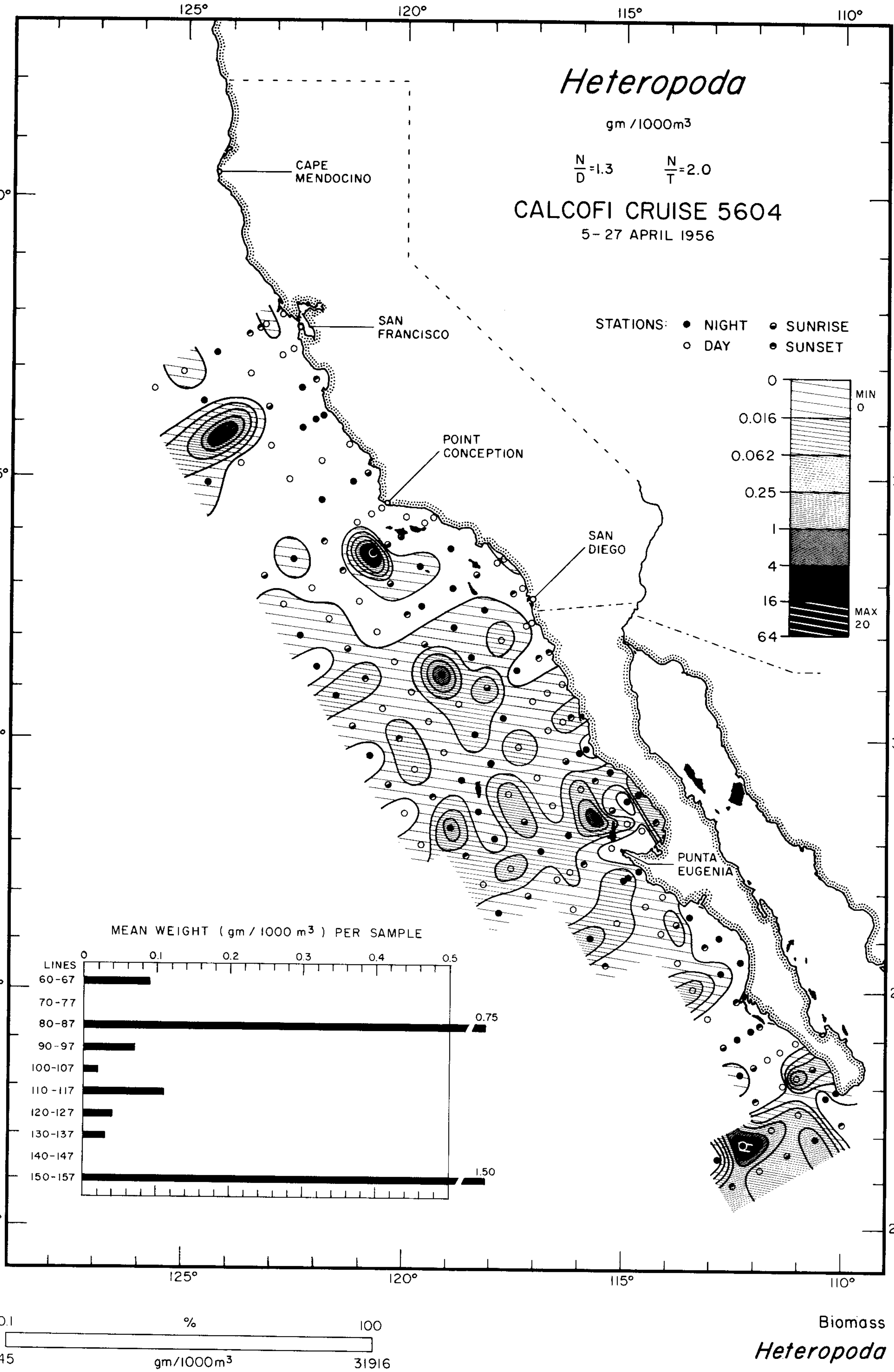
5910



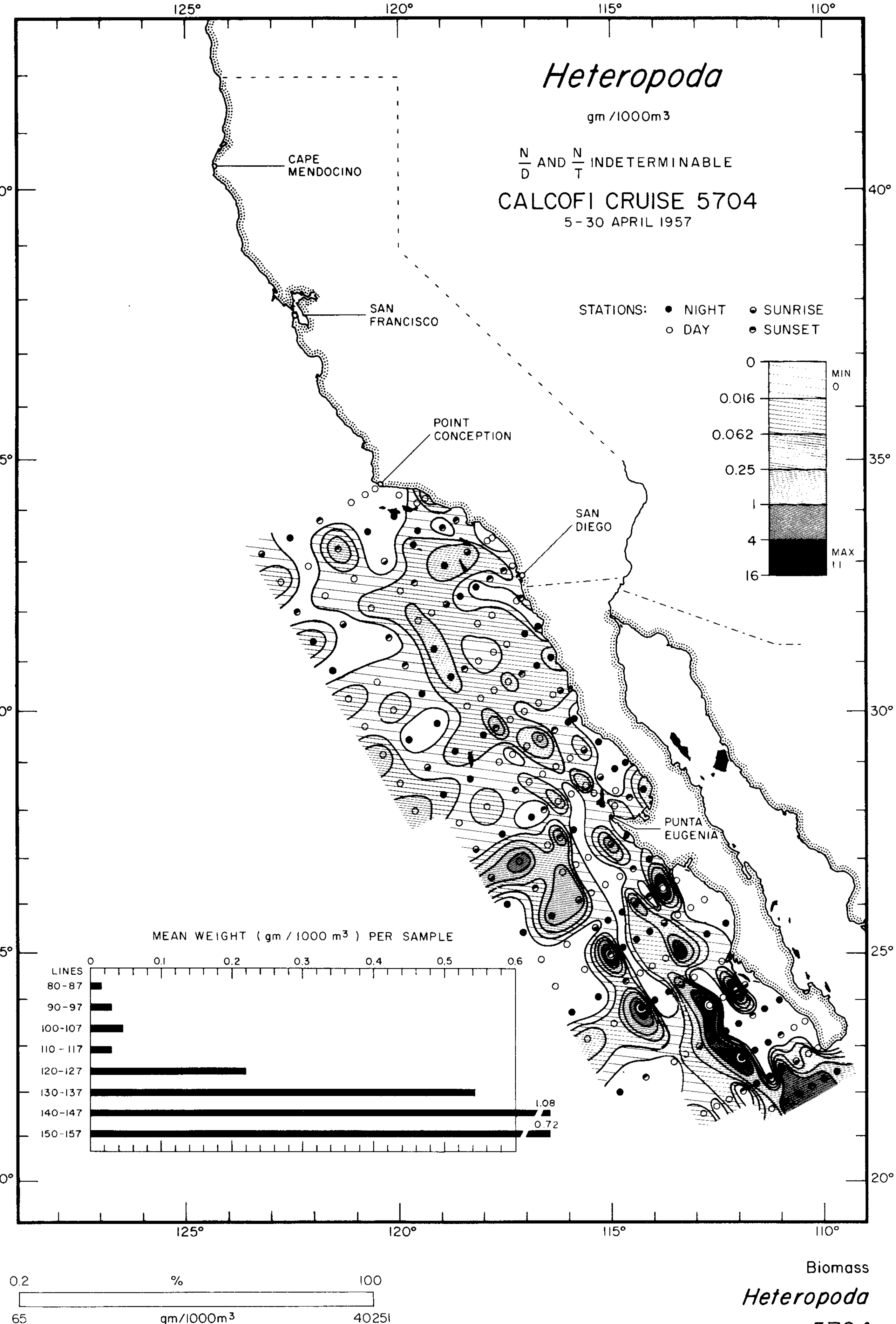
Biomass
Heteropoda
5504



Biomass
Heteropoda, adjusted
5504



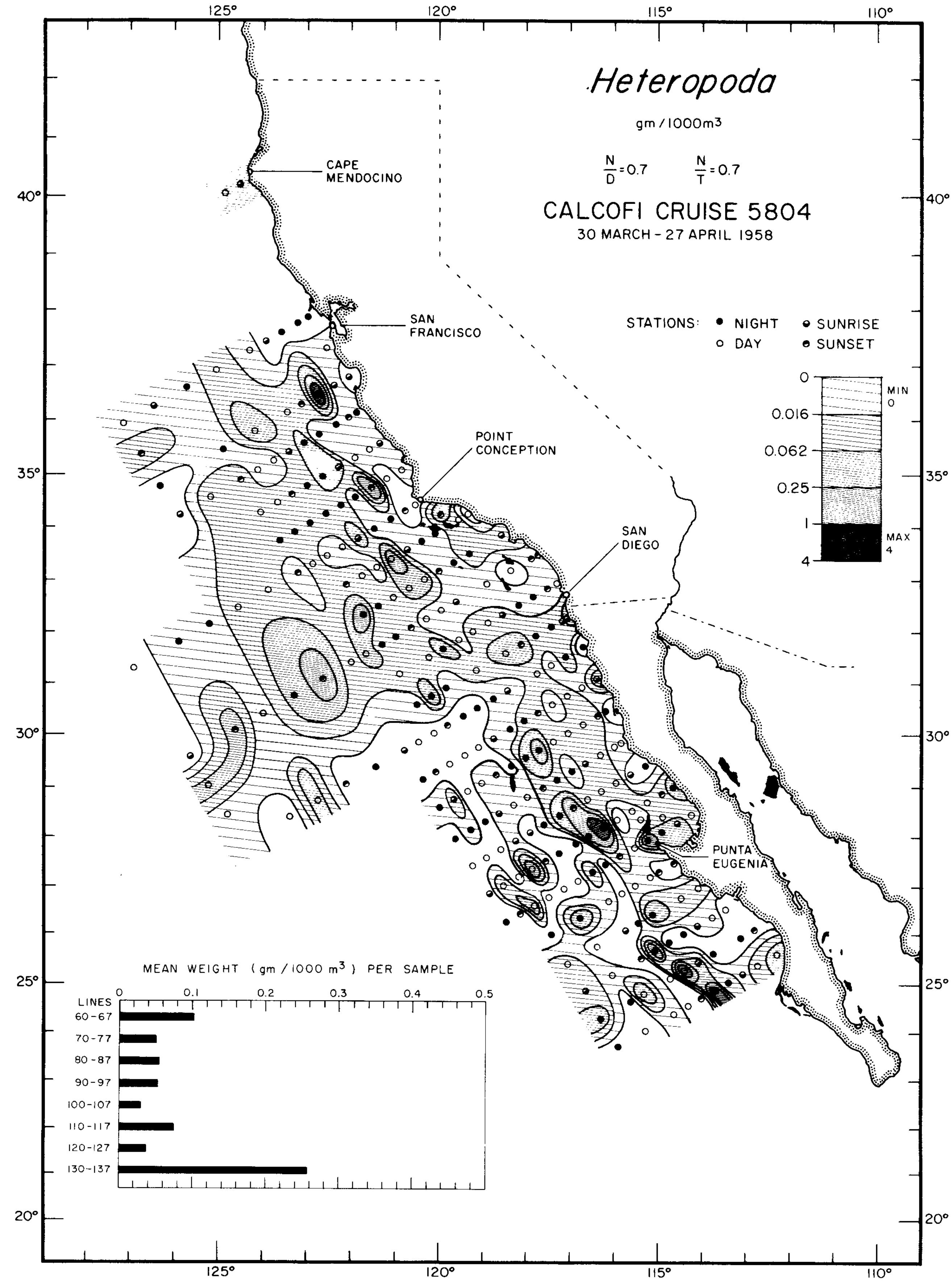
Biomass
Heteropoda
5604



Biomass

Heteropoda

5704



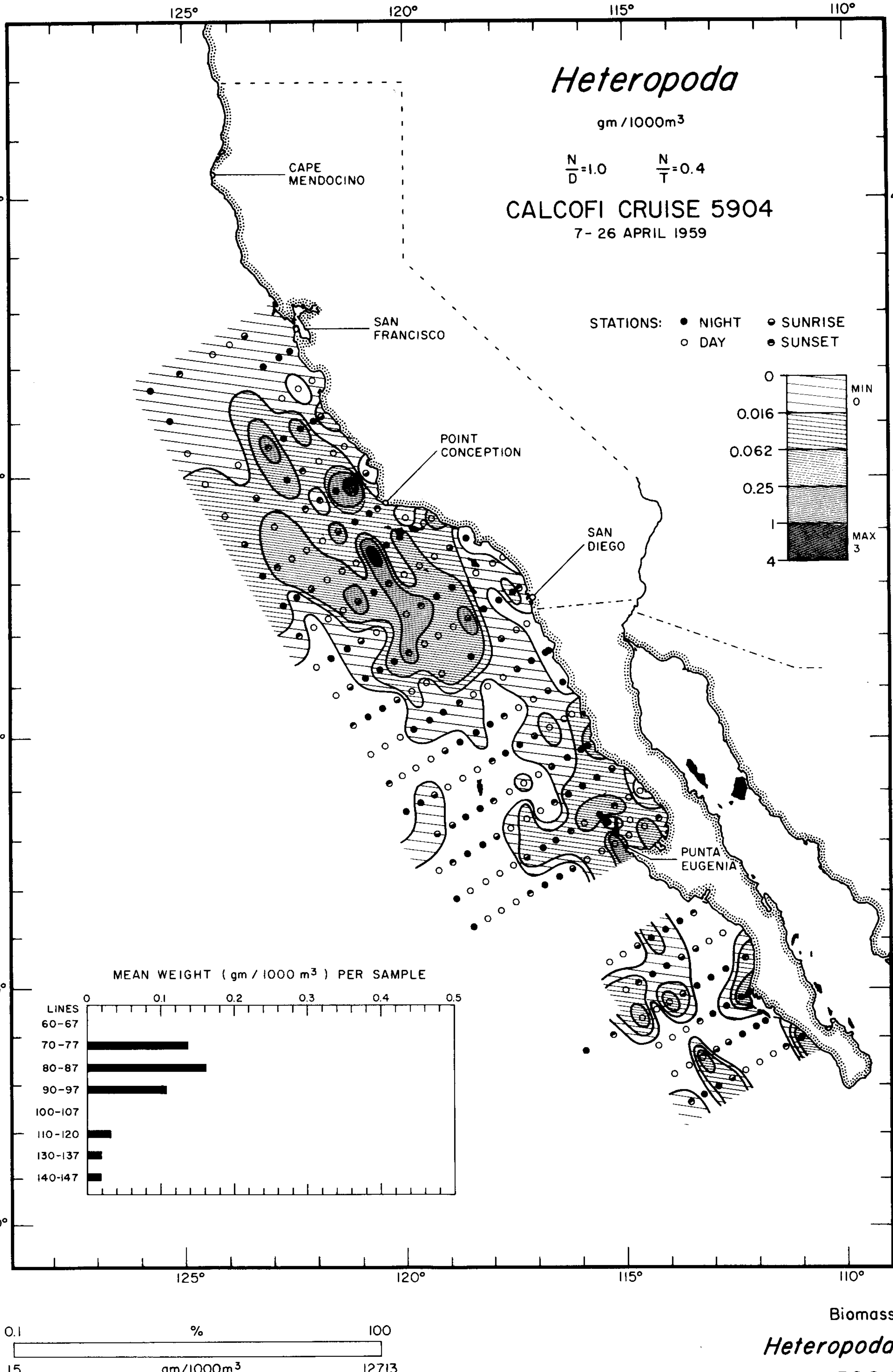
0.2 % 100

20 gm/1000m3 9039

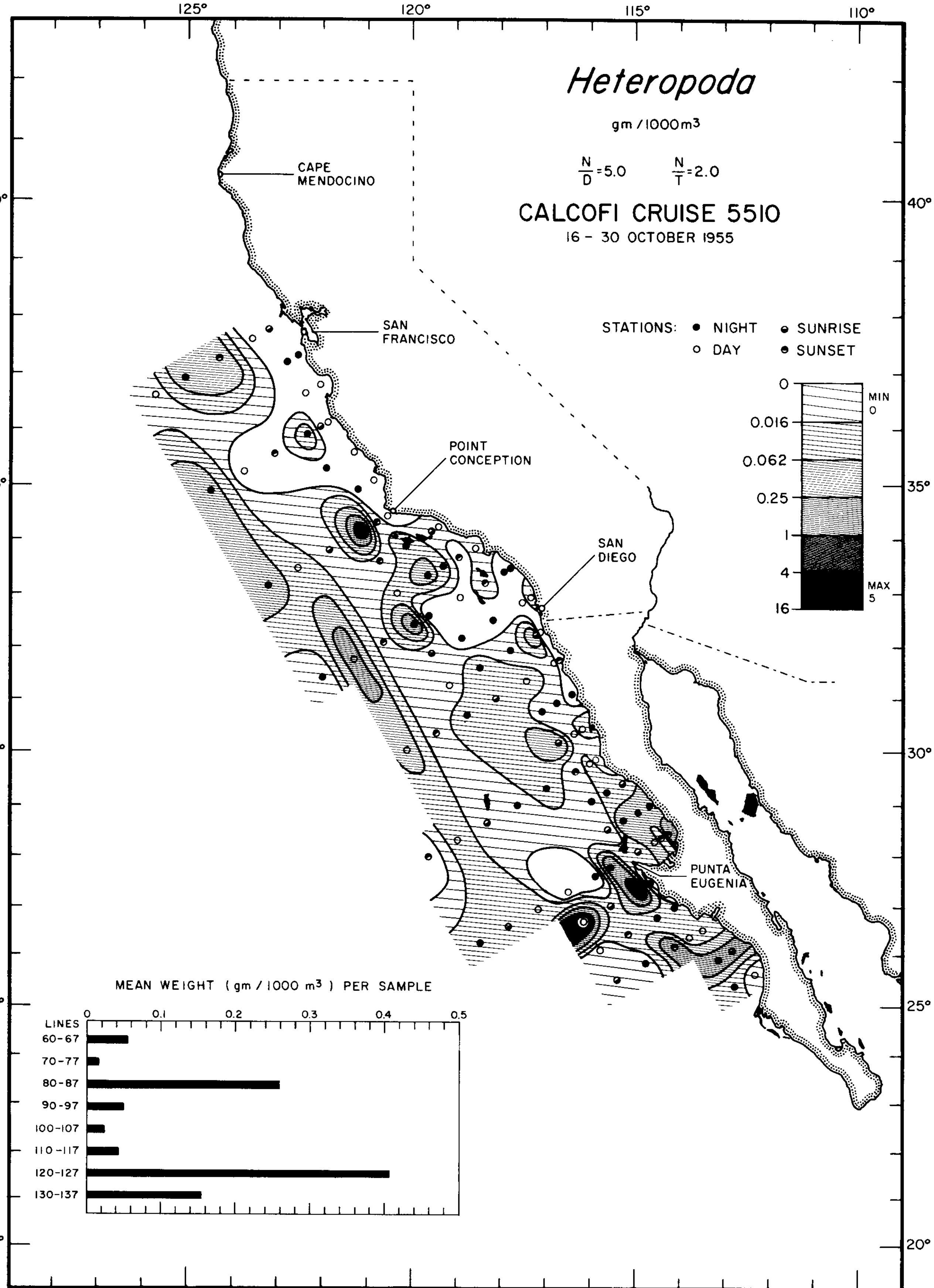
Biomass

Heteropoda

5804



Biomass
Heteropoda
5904



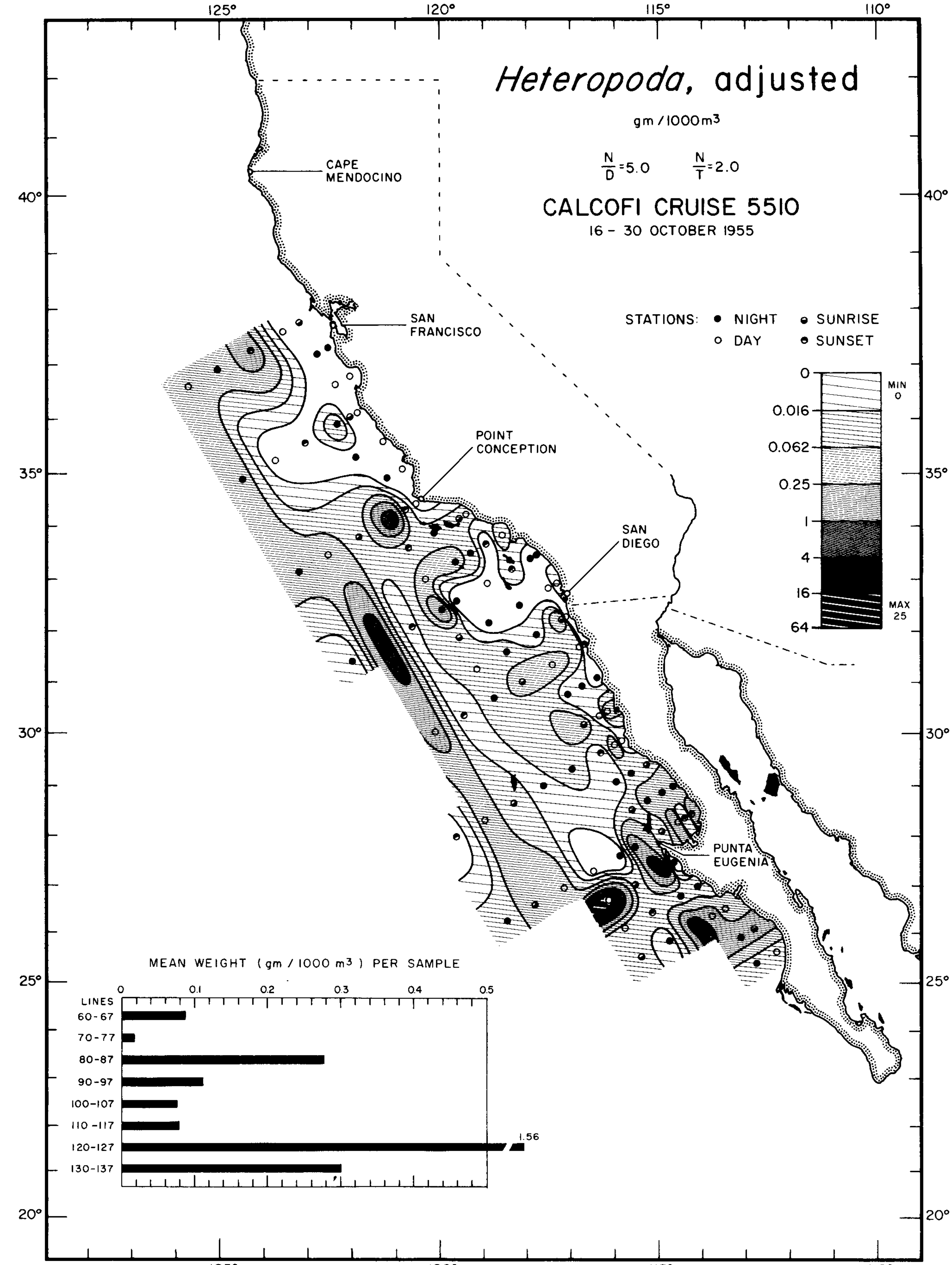
0.1 % 100

15 gm/1000m³ 12344

Biomass

Heteropoda

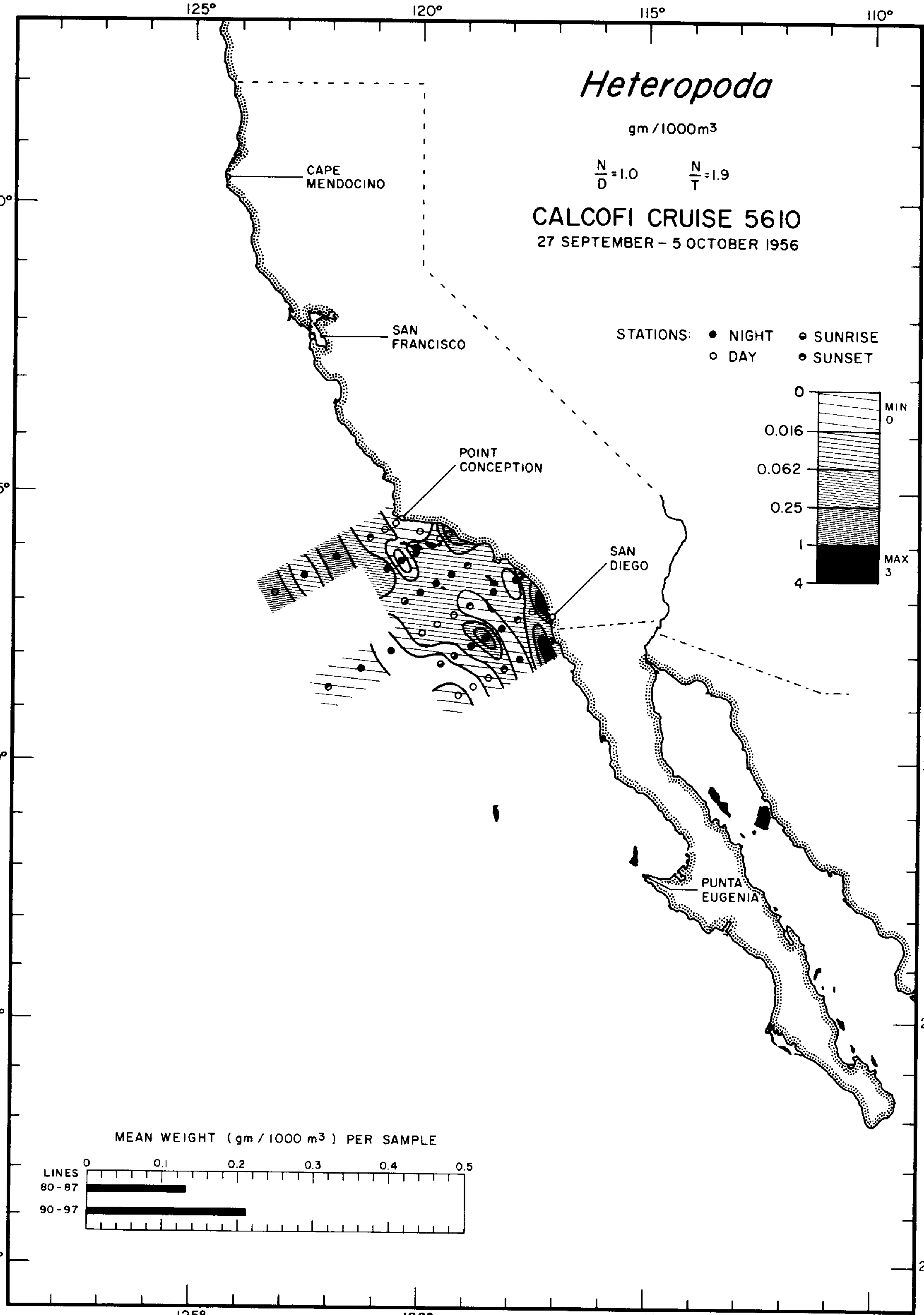
5510



Biomass

Heteropoda, adjusted

5510



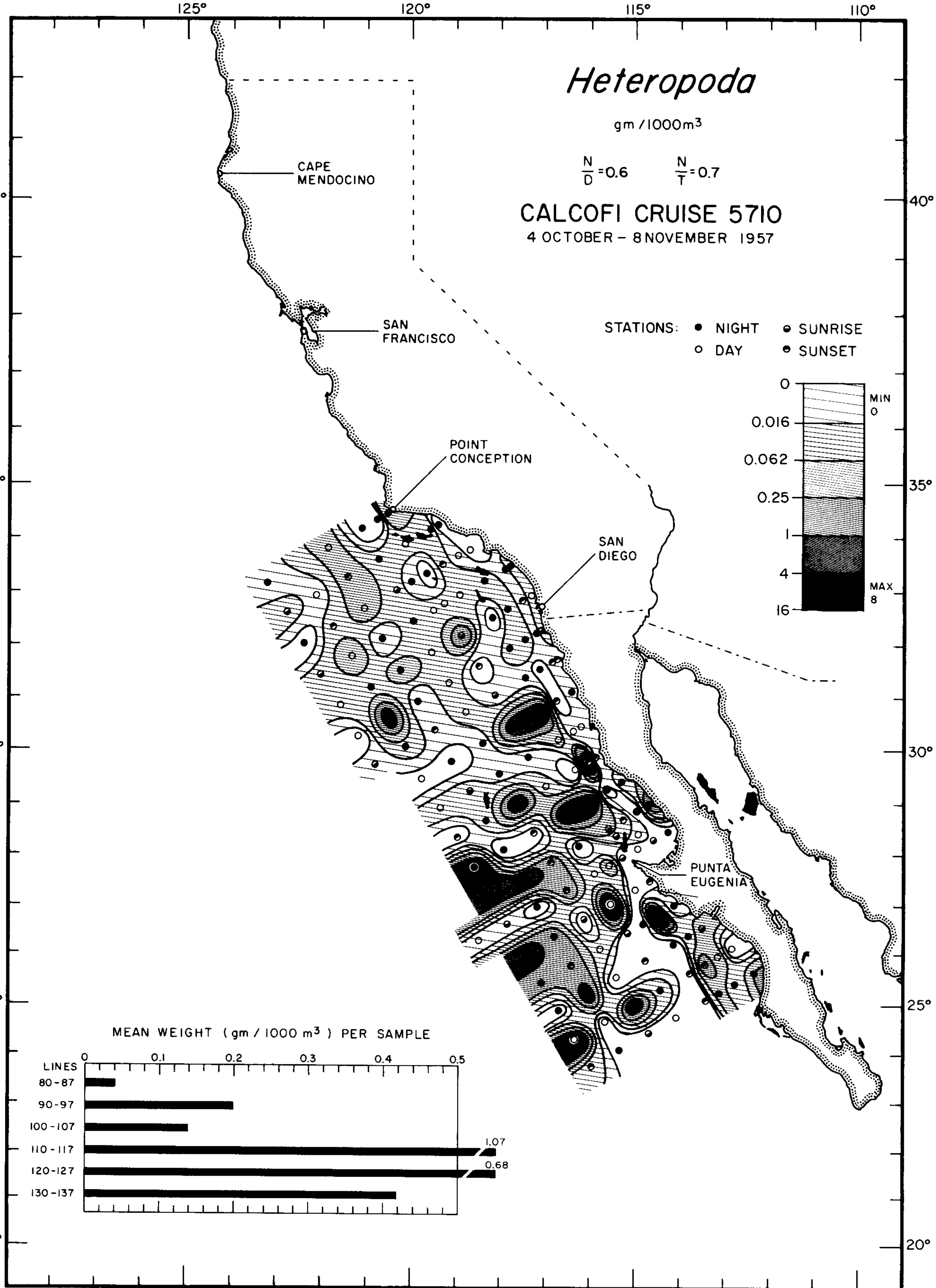
<0.1 % 100

7 gm/1000m³ 9602

Biomass

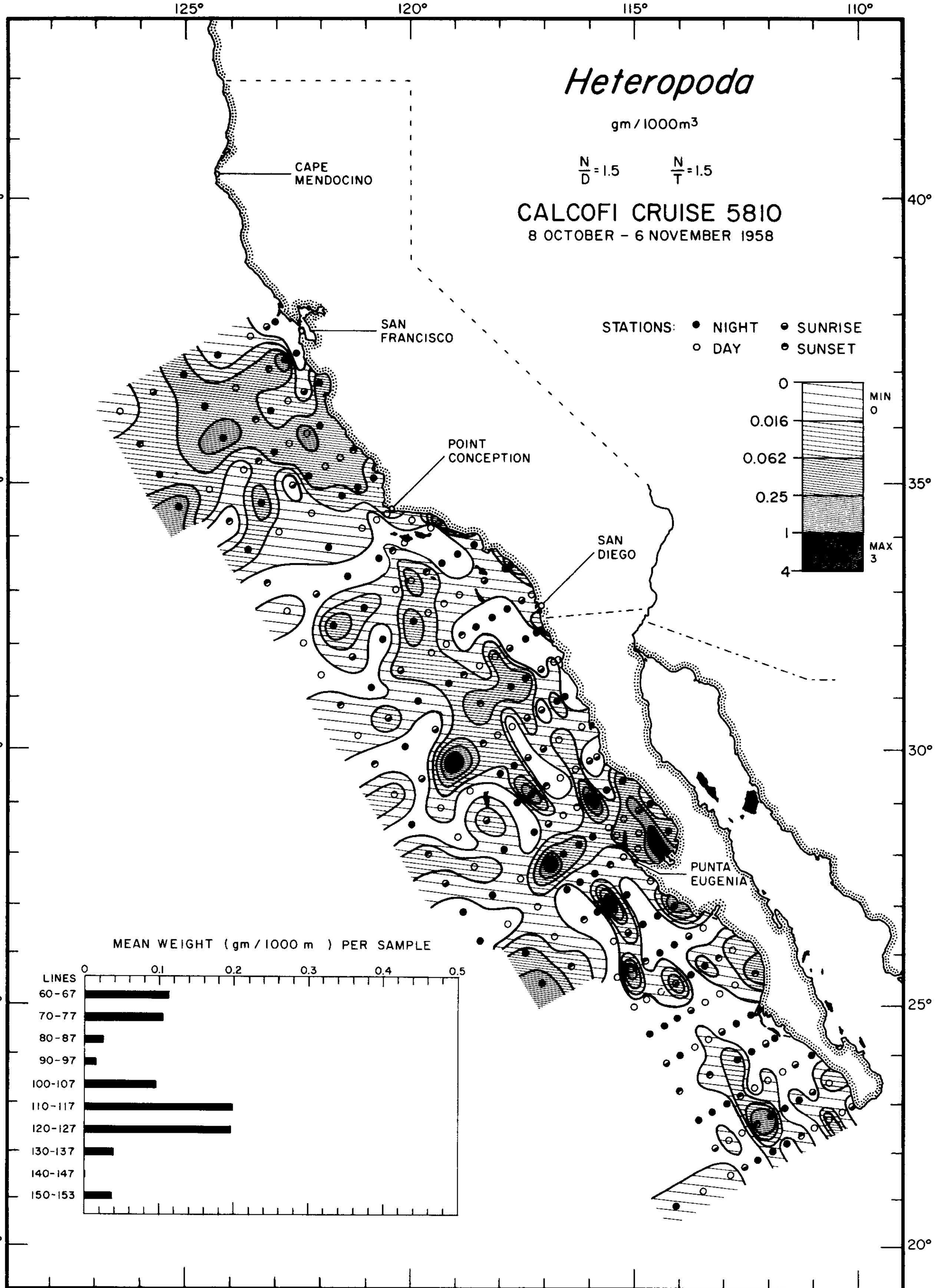
Heteropoda

5610



0.8	%	100
60	gm/1000m3	7384

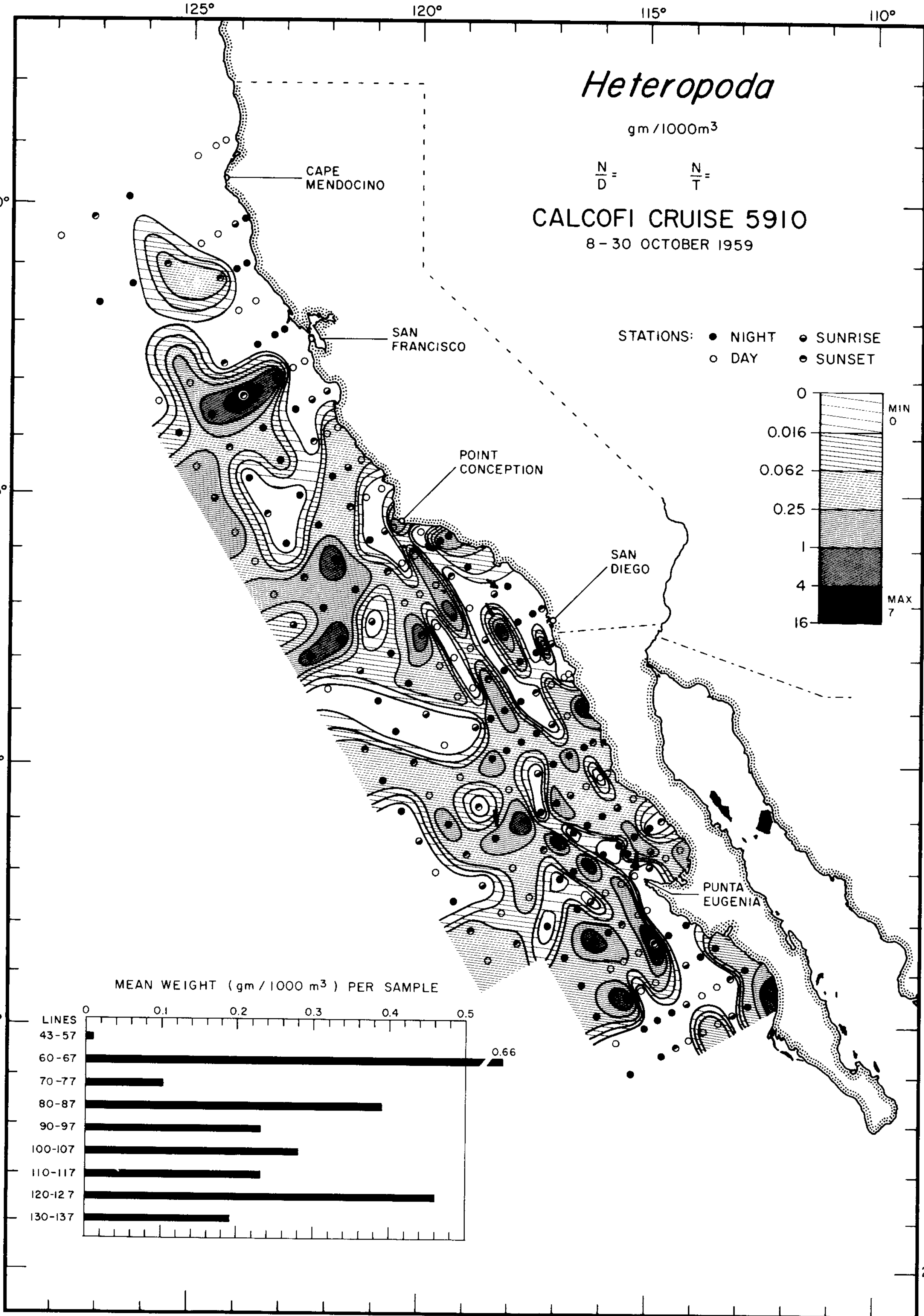
Biomass
Heteropoda
5710

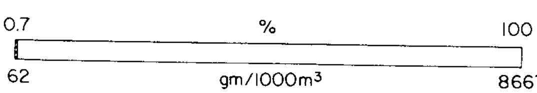


Biomass

Heteropoda

5810

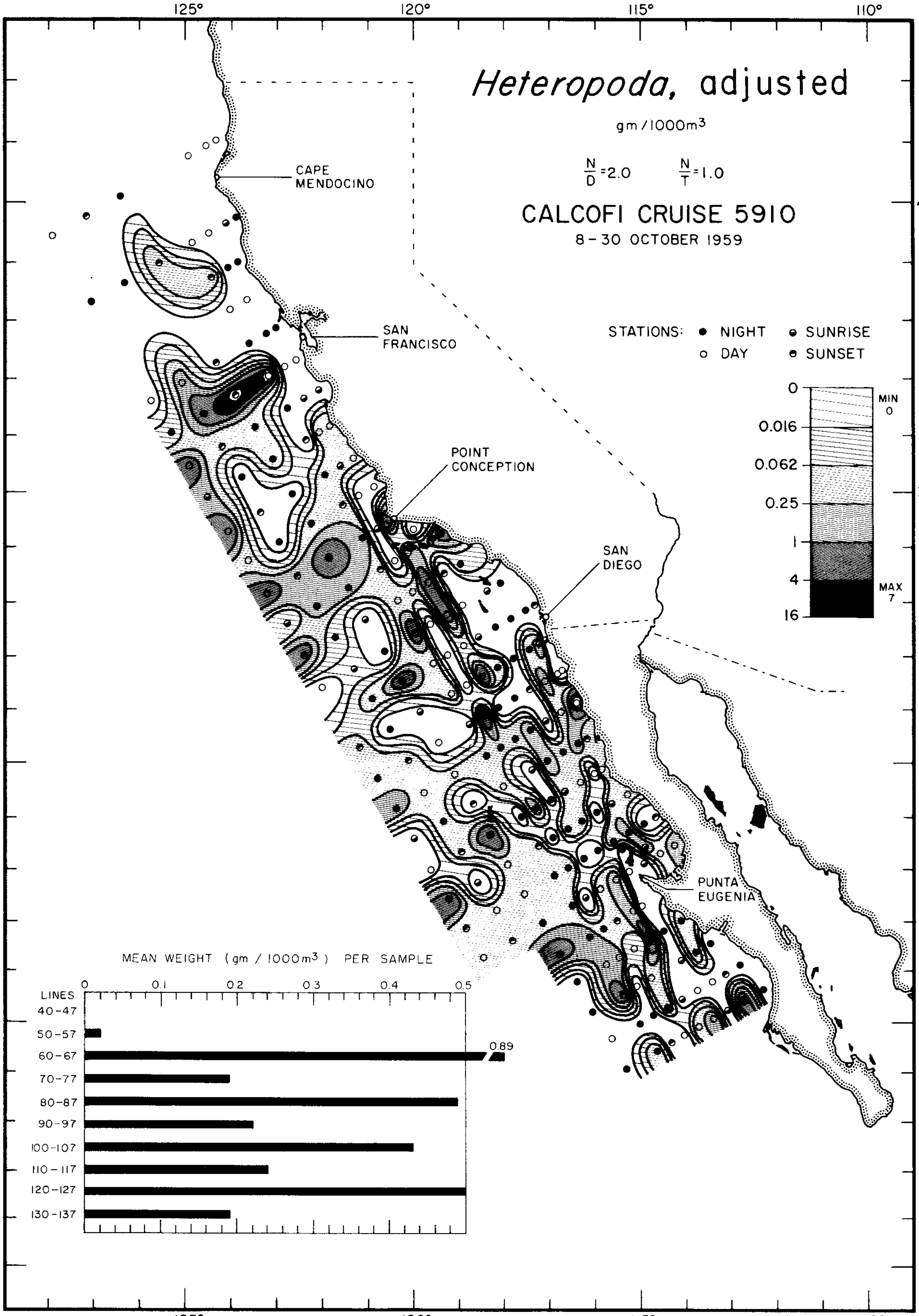




Biomass

Heteropoda

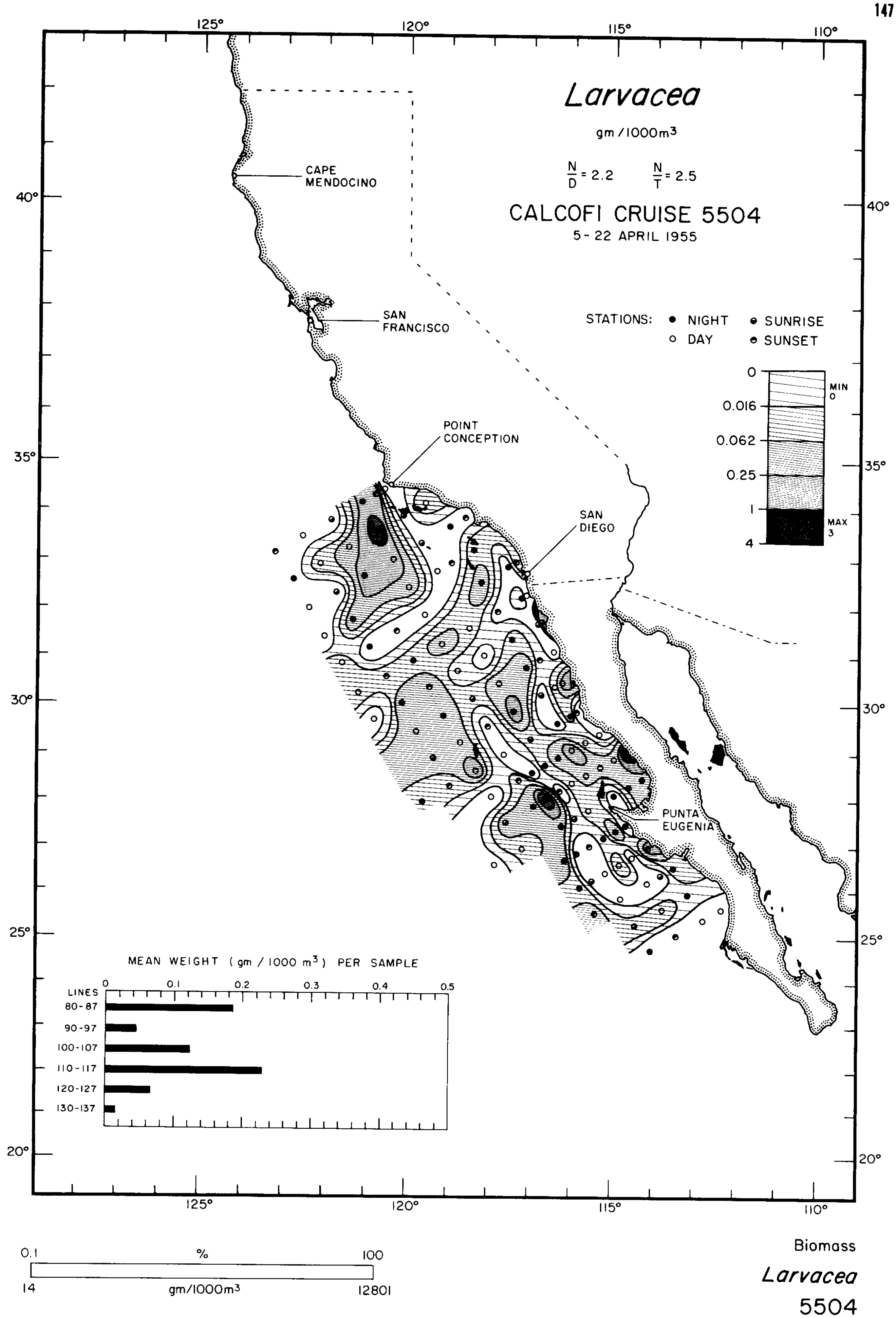
5910



Biomass

Heteropoda, adjusted

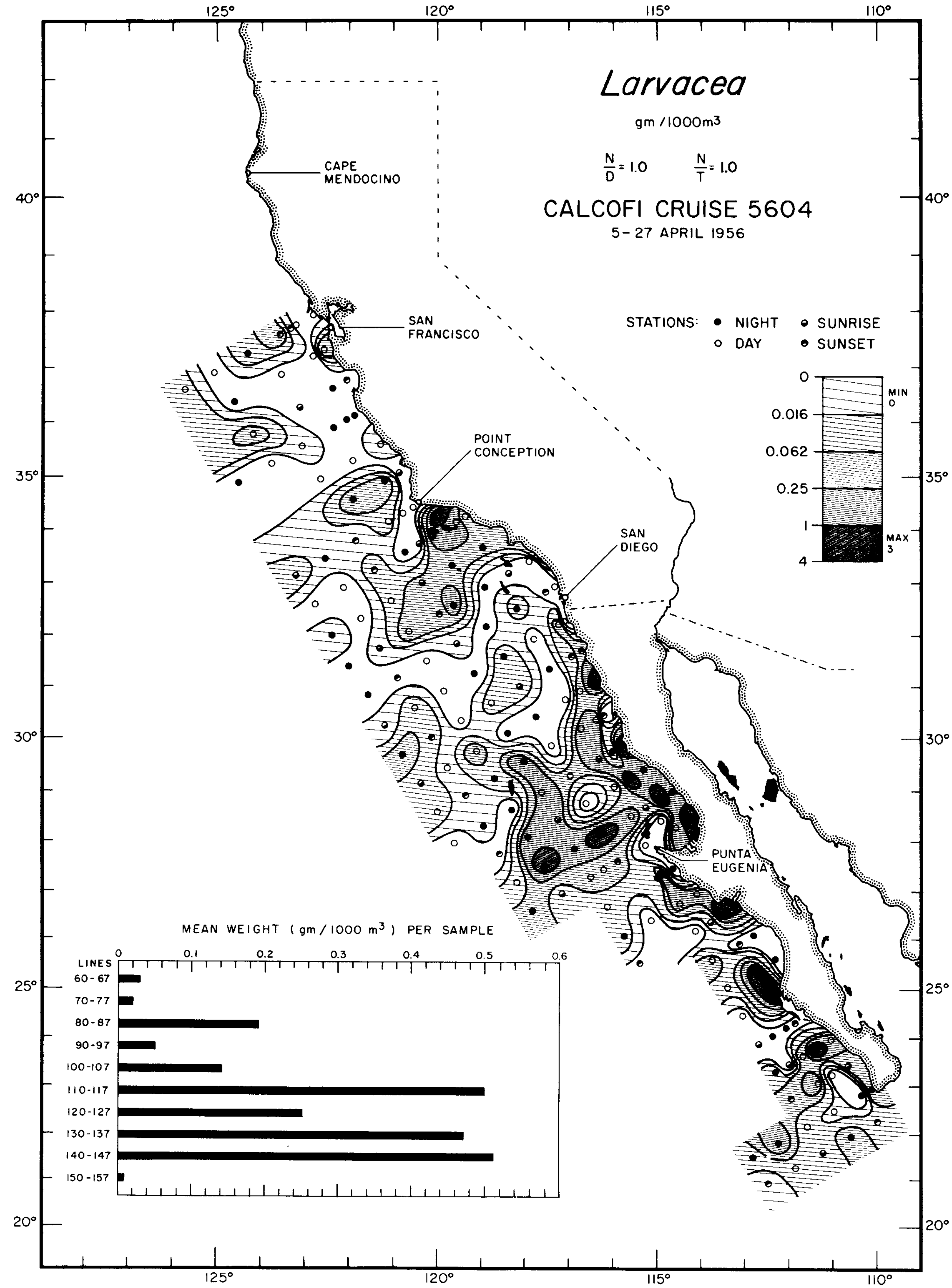
5910



Biomass

Larvacea

5504



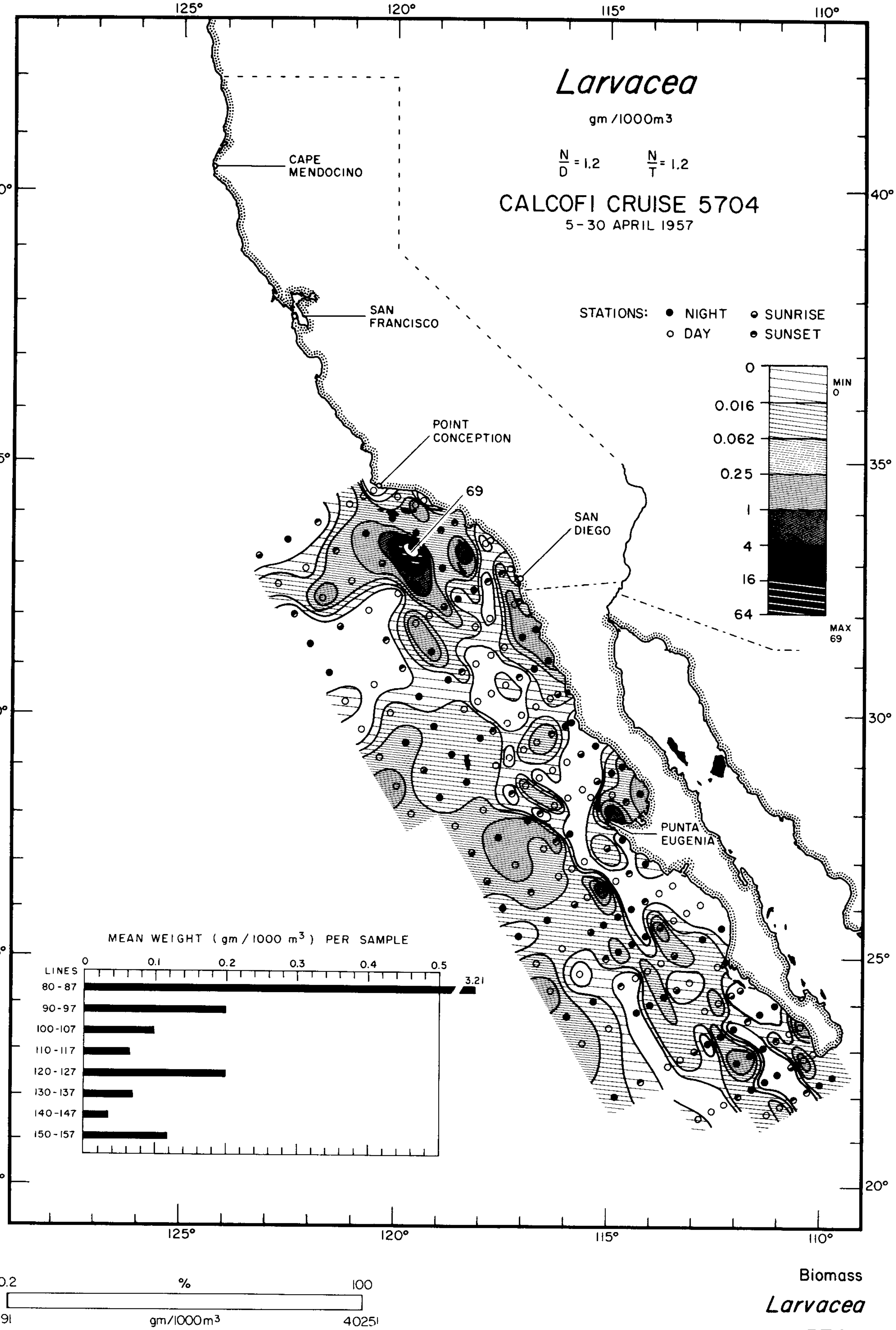
0.1 % 100

37 gm/1000m3 31916

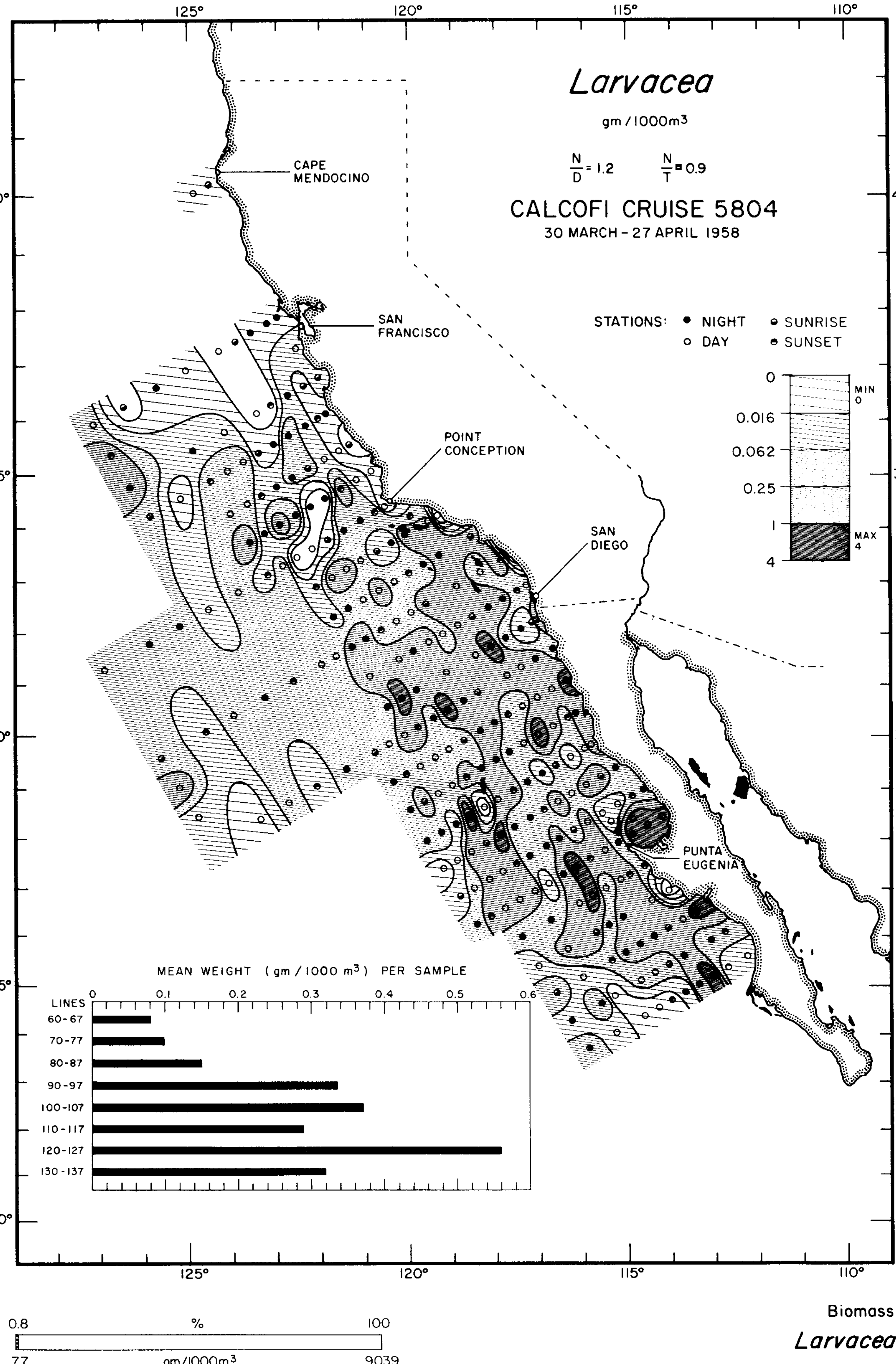
Biomass

Larvacea

5604



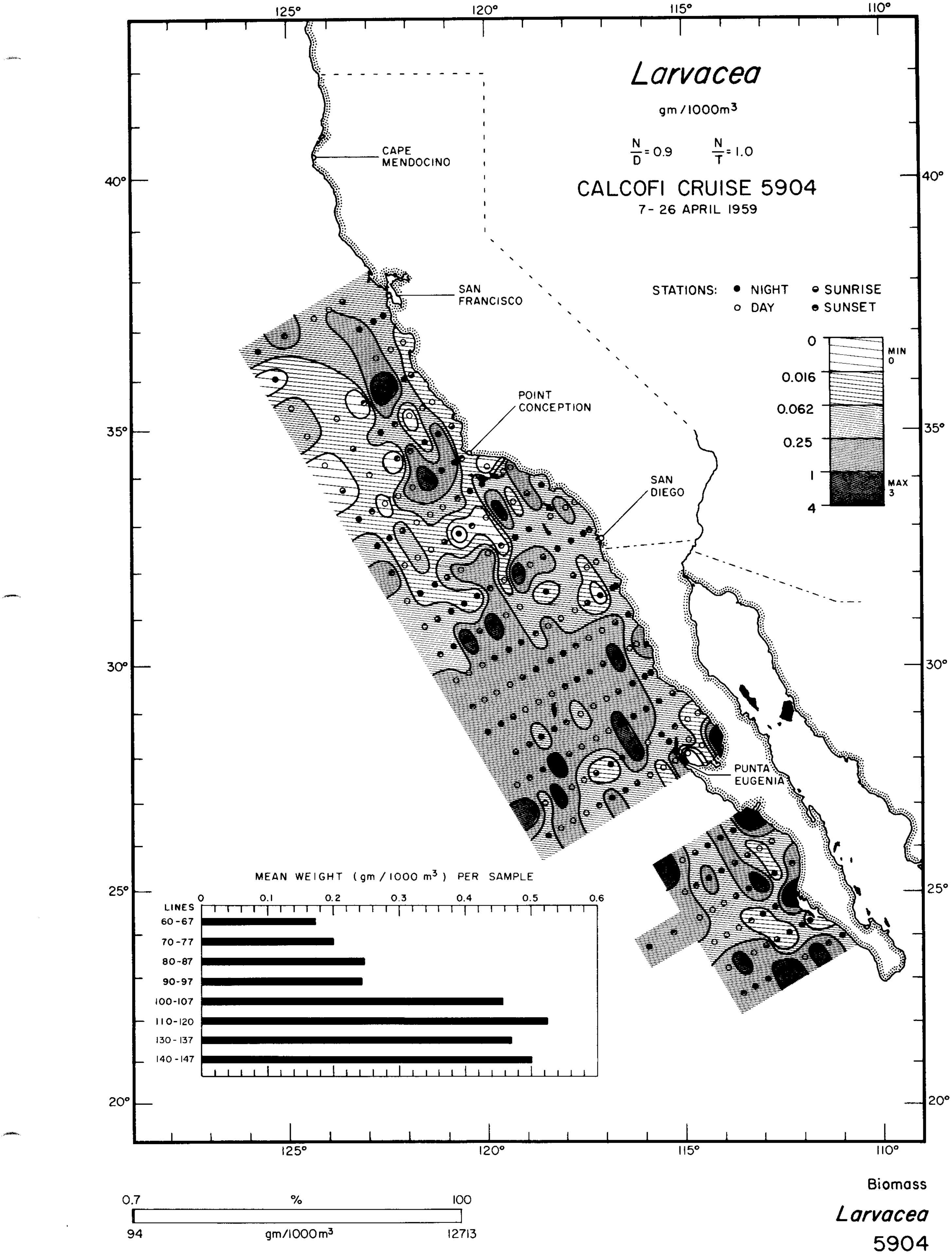
Biomass
Larvacea
5704

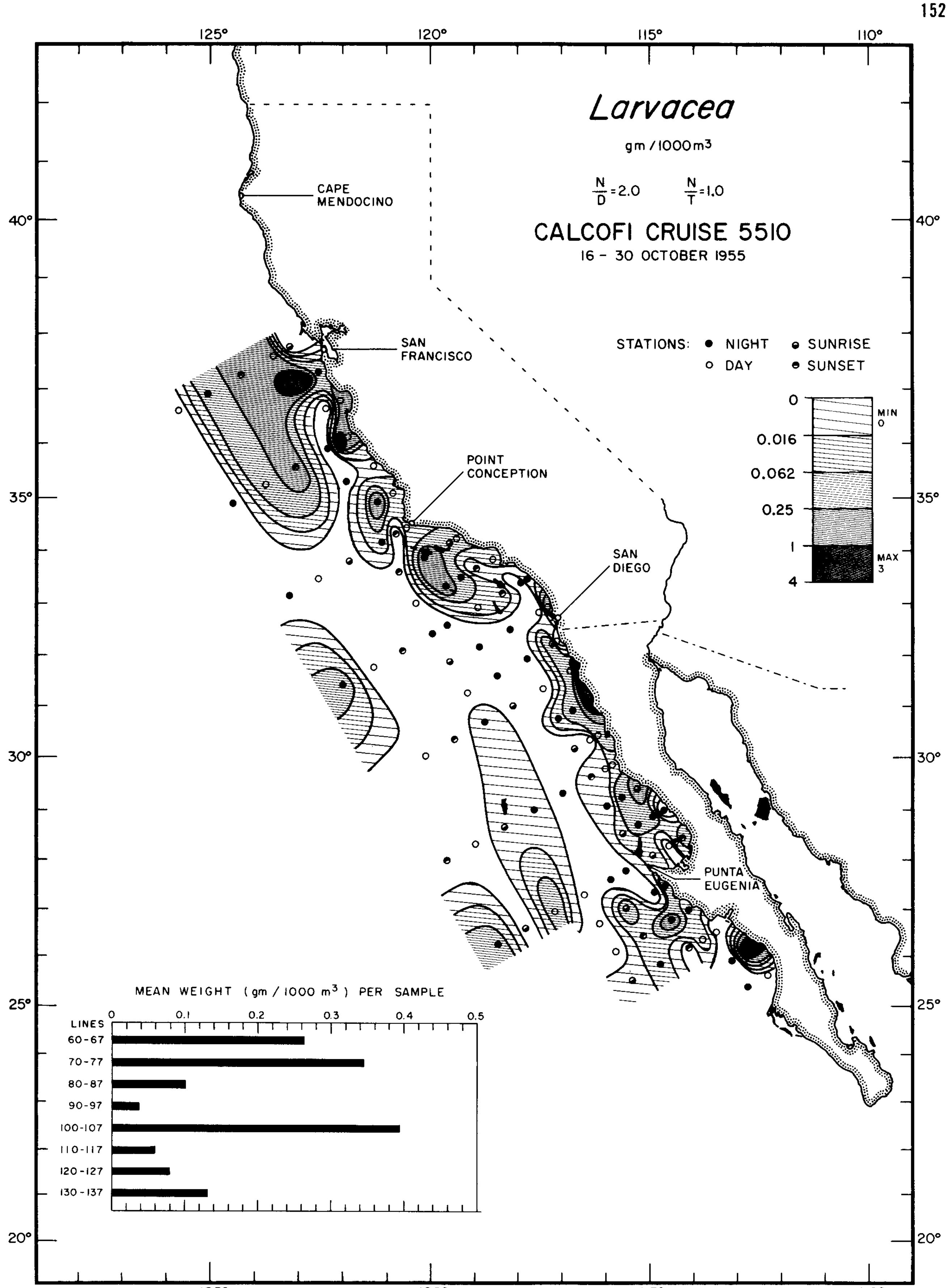


Biomass

Larvacea

5804


Larvacea
gm/1000m³
N/D = 0.9
N/T = 1.0
CALCOFI CRUISE 5904
7-26 APRIL 1959
STATIONS: ● NIGHT ○ DAY SUNRISE SUNSET
0
0.016
0.062
0.25
1
4
MIN 0
MAX 3
CAPE MENDOCINO
SAN FRANCISCO
POINT CONCEPTION
SAN DIEGO
PUNTA EUGENIA
125°
120°
115°
110°
40°
35°
30°
25°
20°
MEAN WEIGHT (gm / 1000 m³) PER SAMPLE
LINES
0
0.1
0.2
0.3
0.4
0.5
0.6
60-67
70-77
80-87
90-97
100-107
110-120
130-137
140-147
0.7
%
100
94
gm/1000m³
12713
Biomass
Larvacea
5904



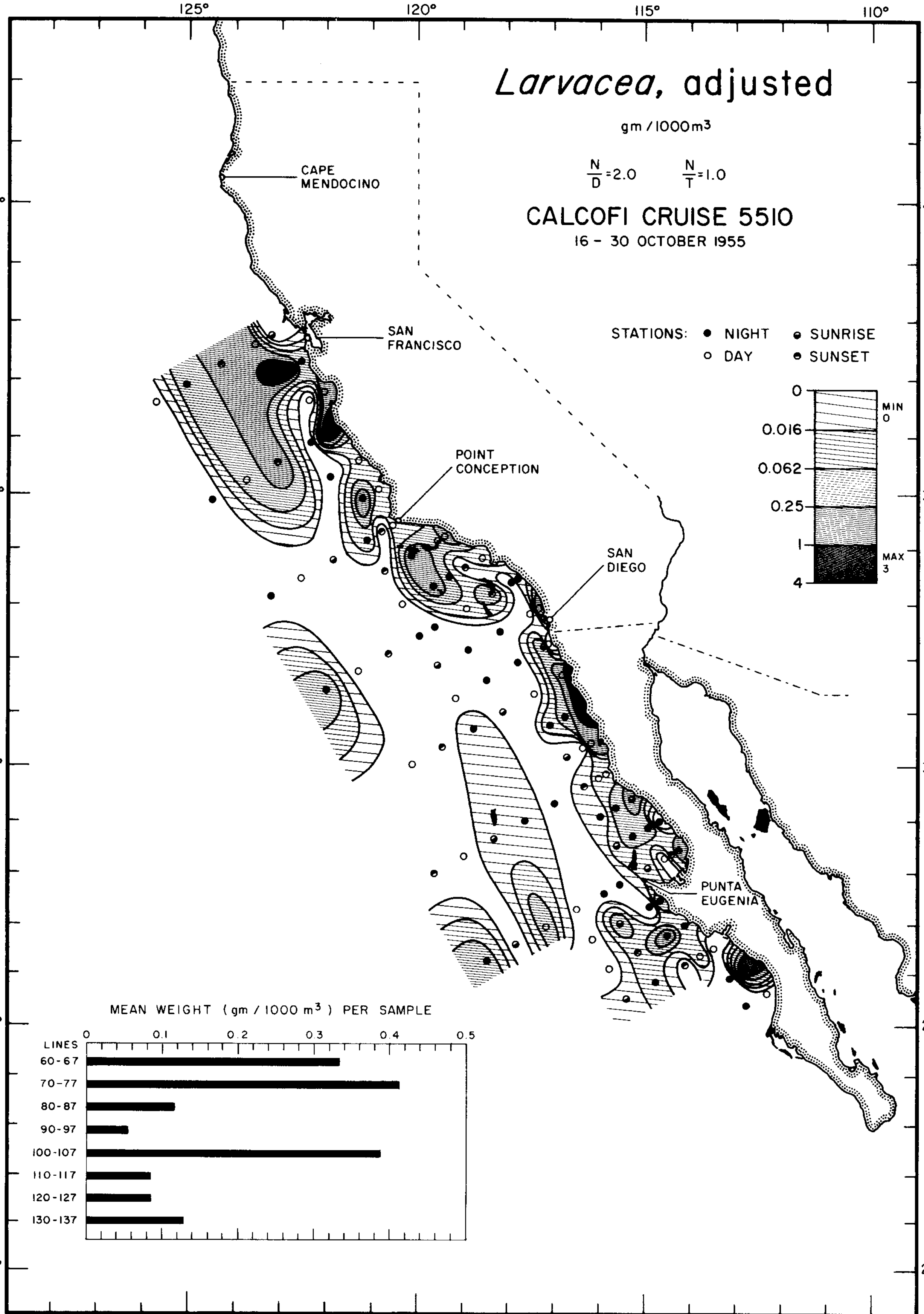
0.1 % 100

17 gm/1000m3 12344

Biomass

Larvacea

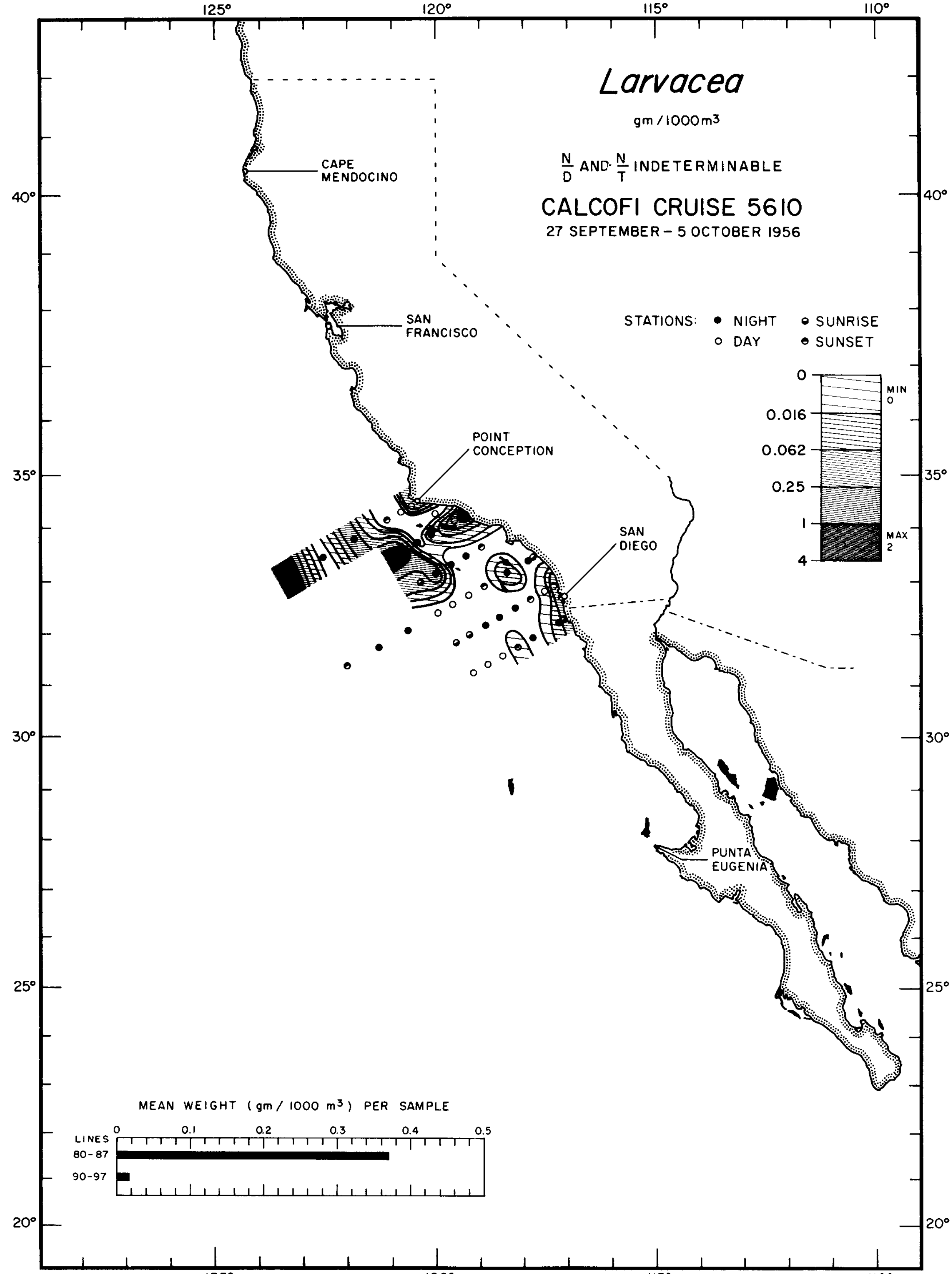
5510

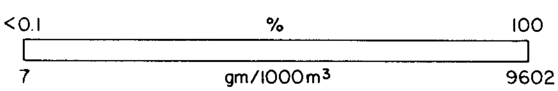


Biomass

Larvacea, adjusted

5510

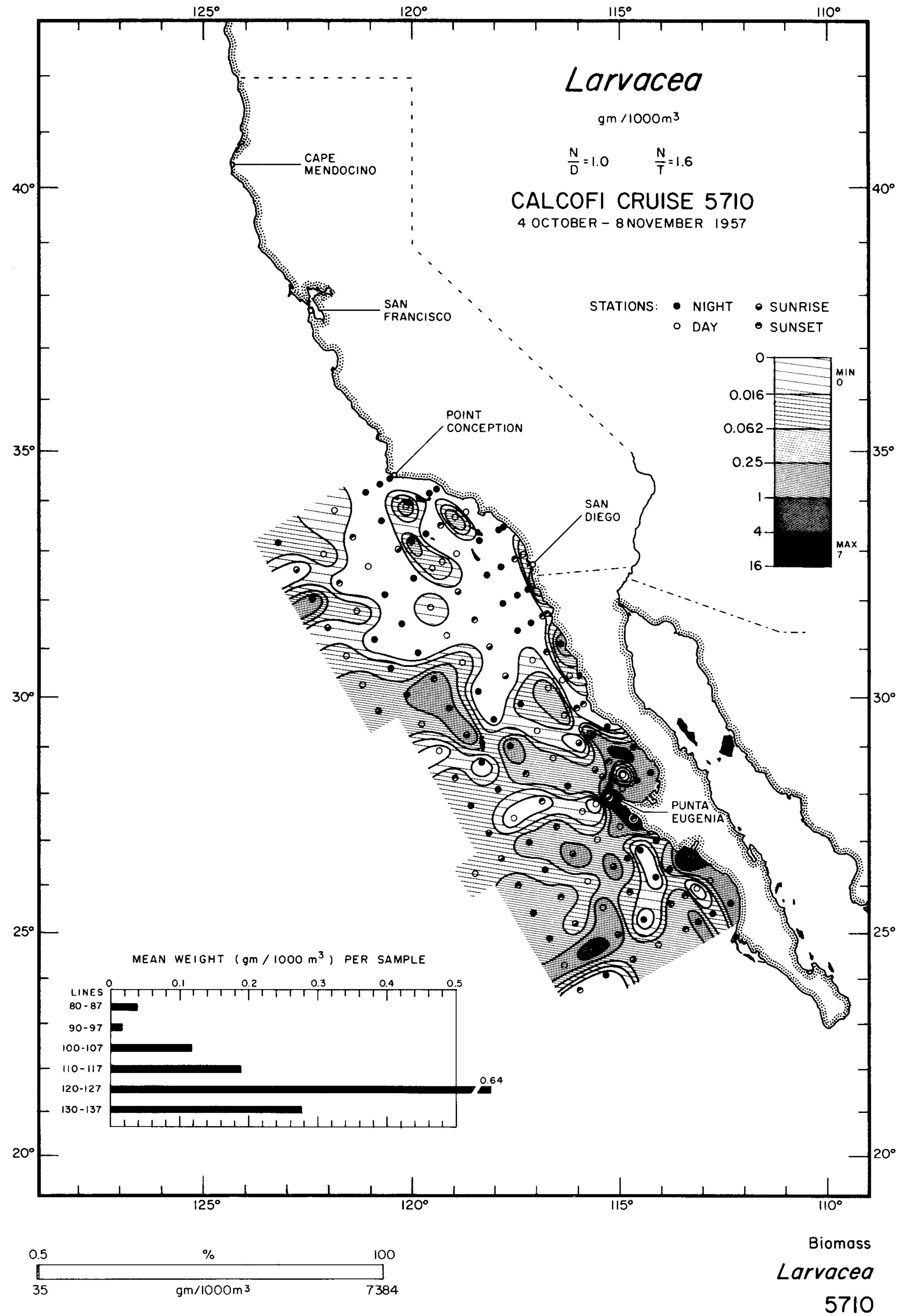




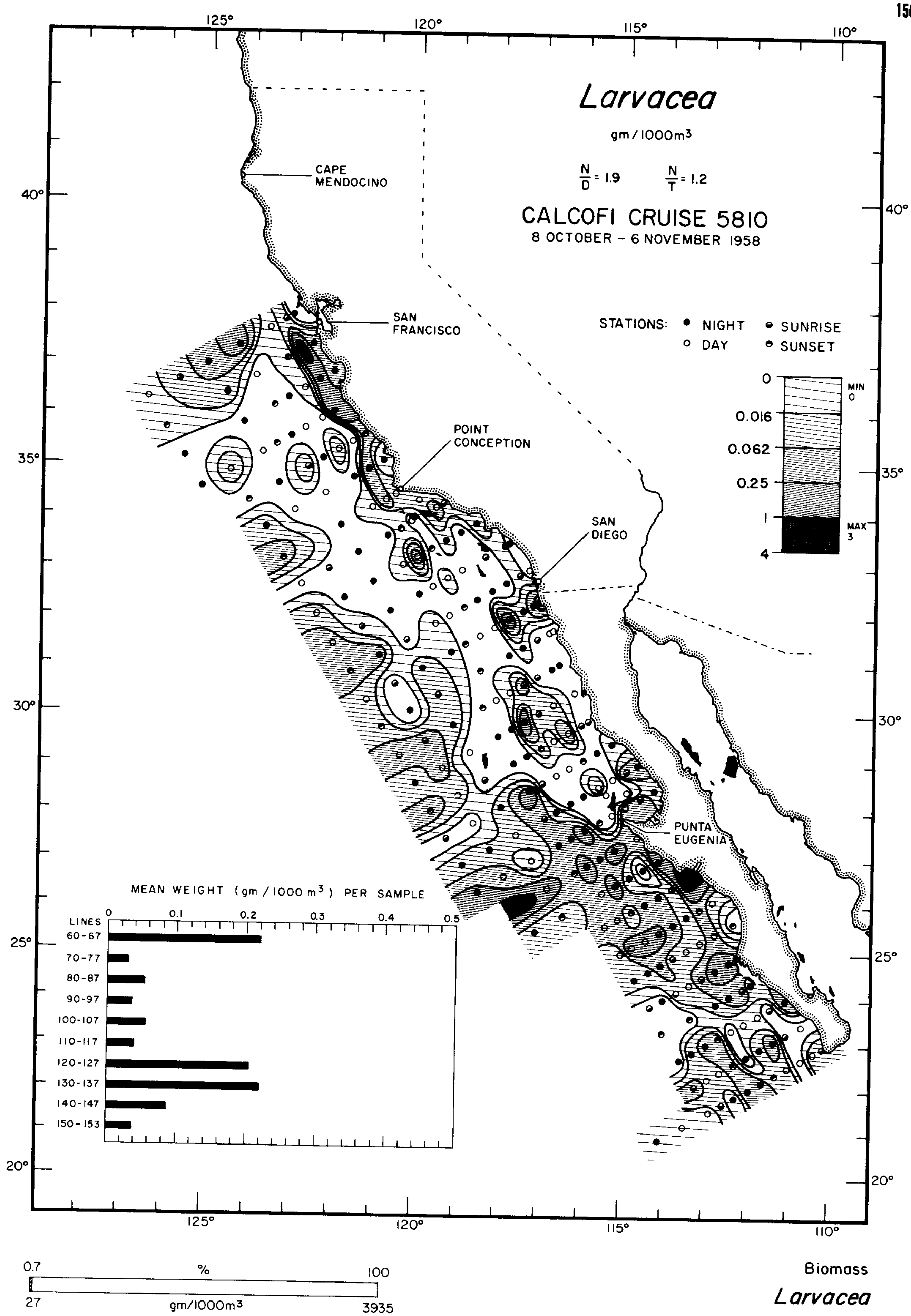
Biomass

Larvacea

5610



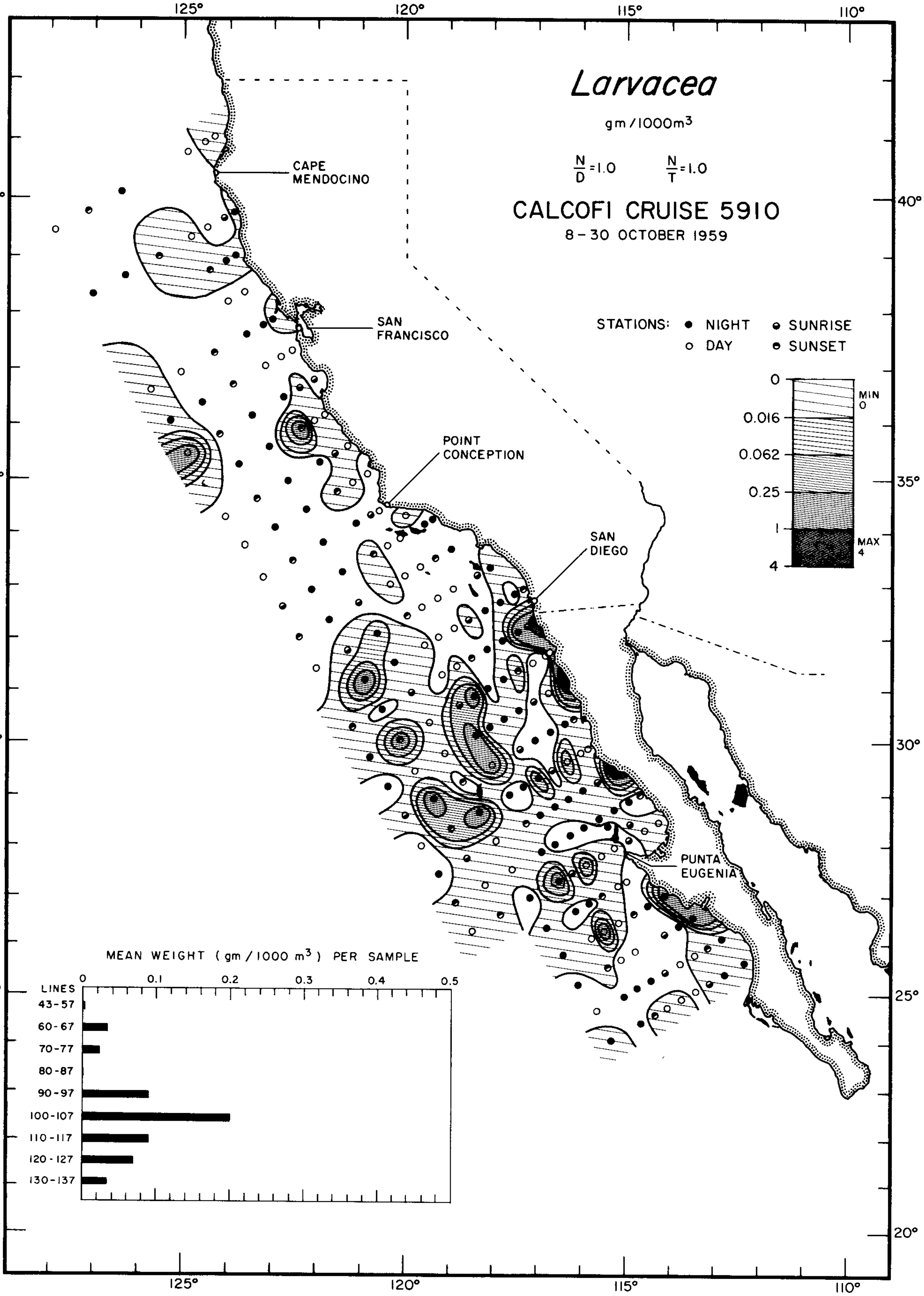
Biomass
Larvacea
5710



Biomass

Larvacea

5810



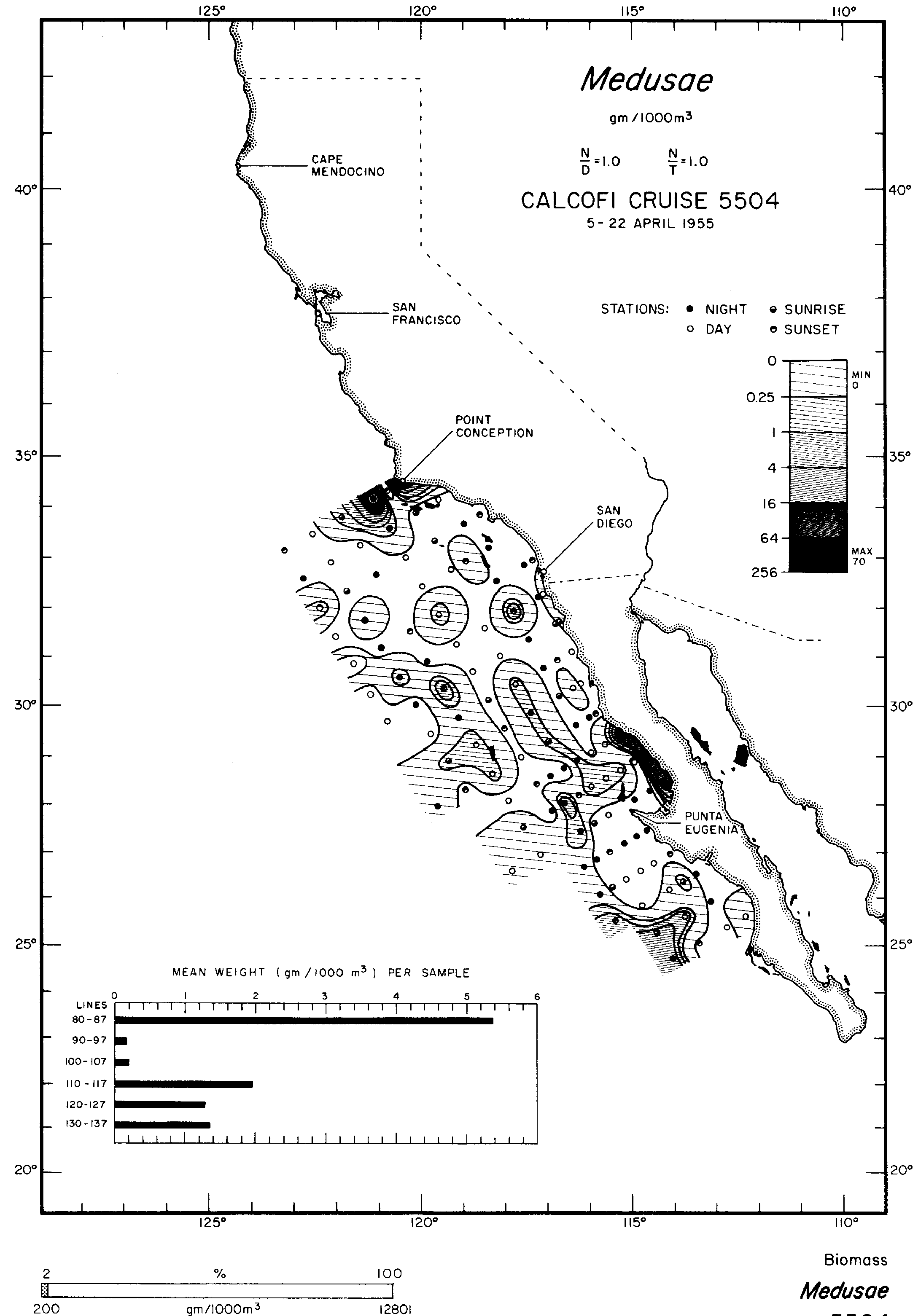
0.2 % 100

15 gm/1000 m³ 8667

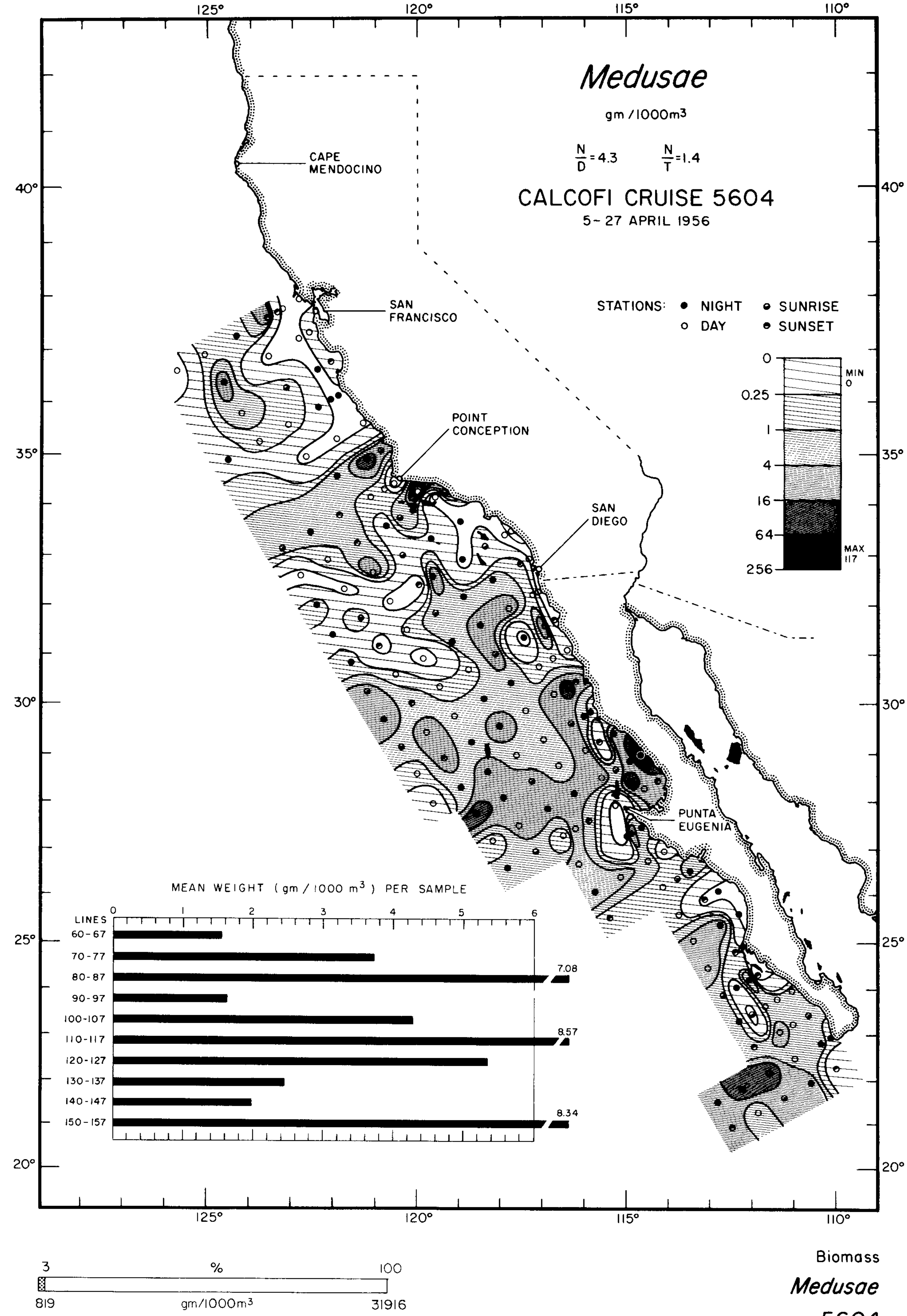
Biomass

Larvacea

5910



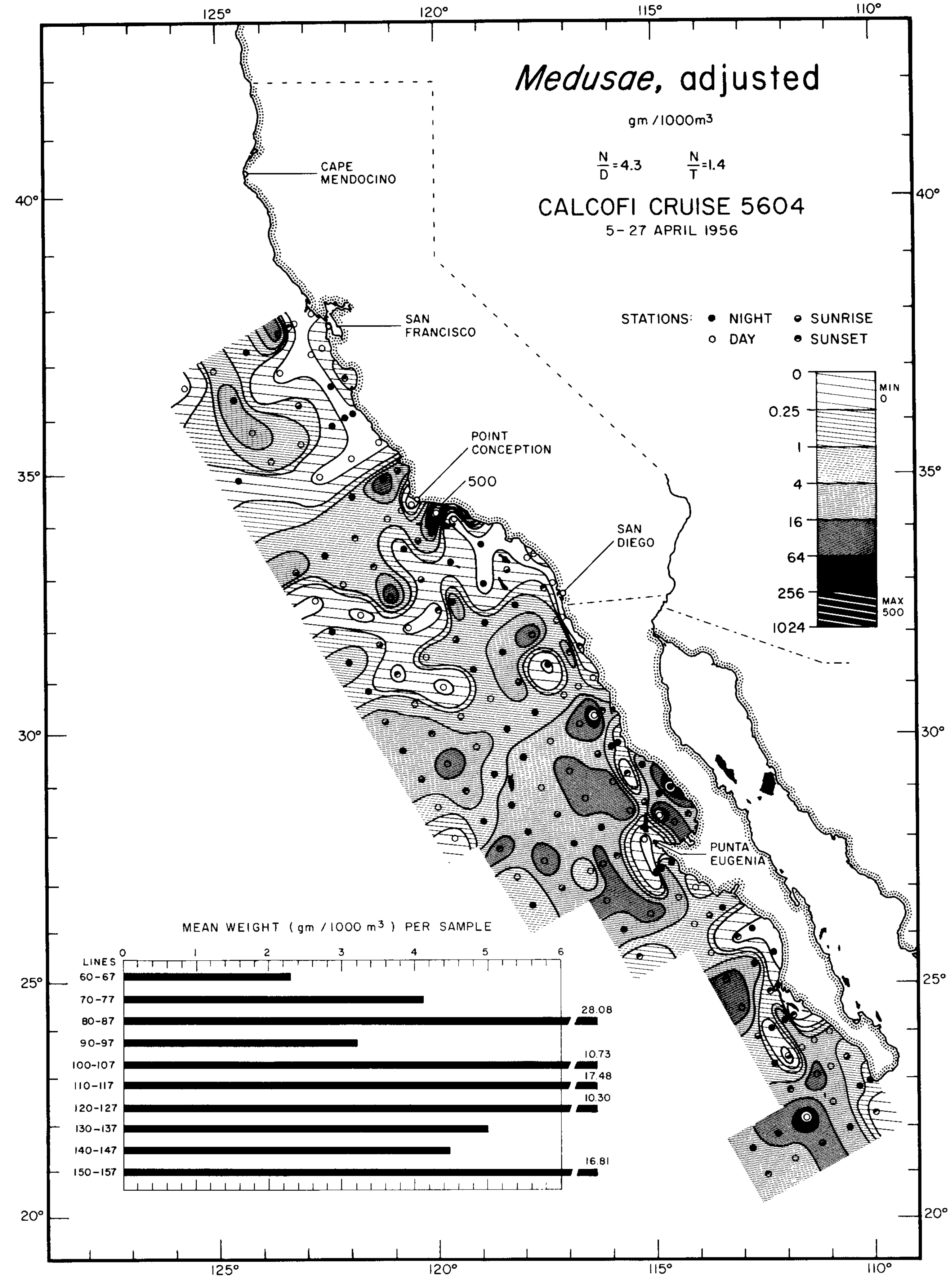
Biomass
Medusae
5504



Biomass

Medusae

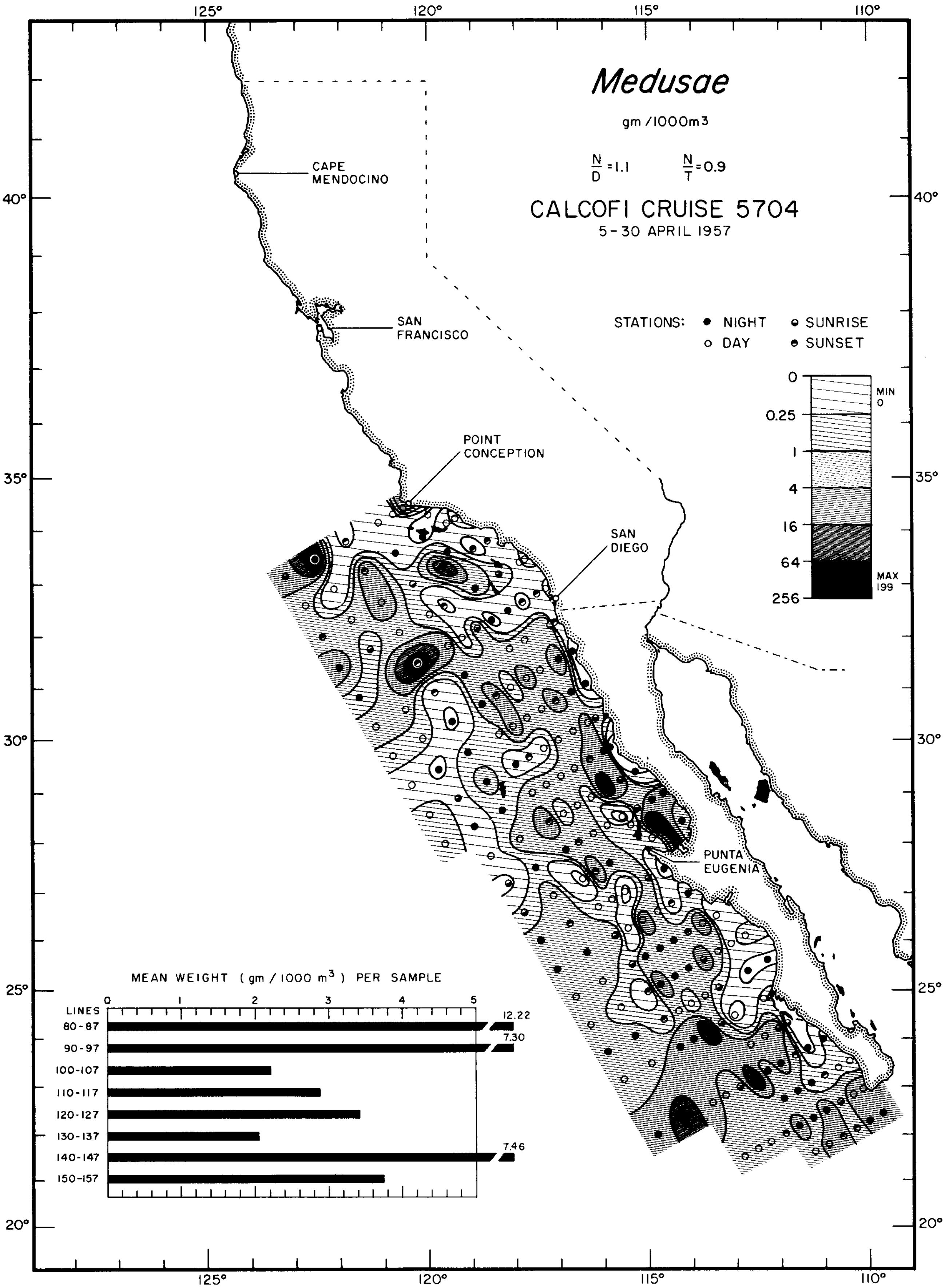
5604

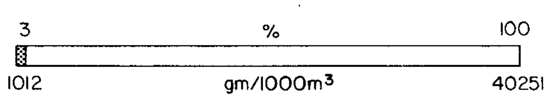


Biomass

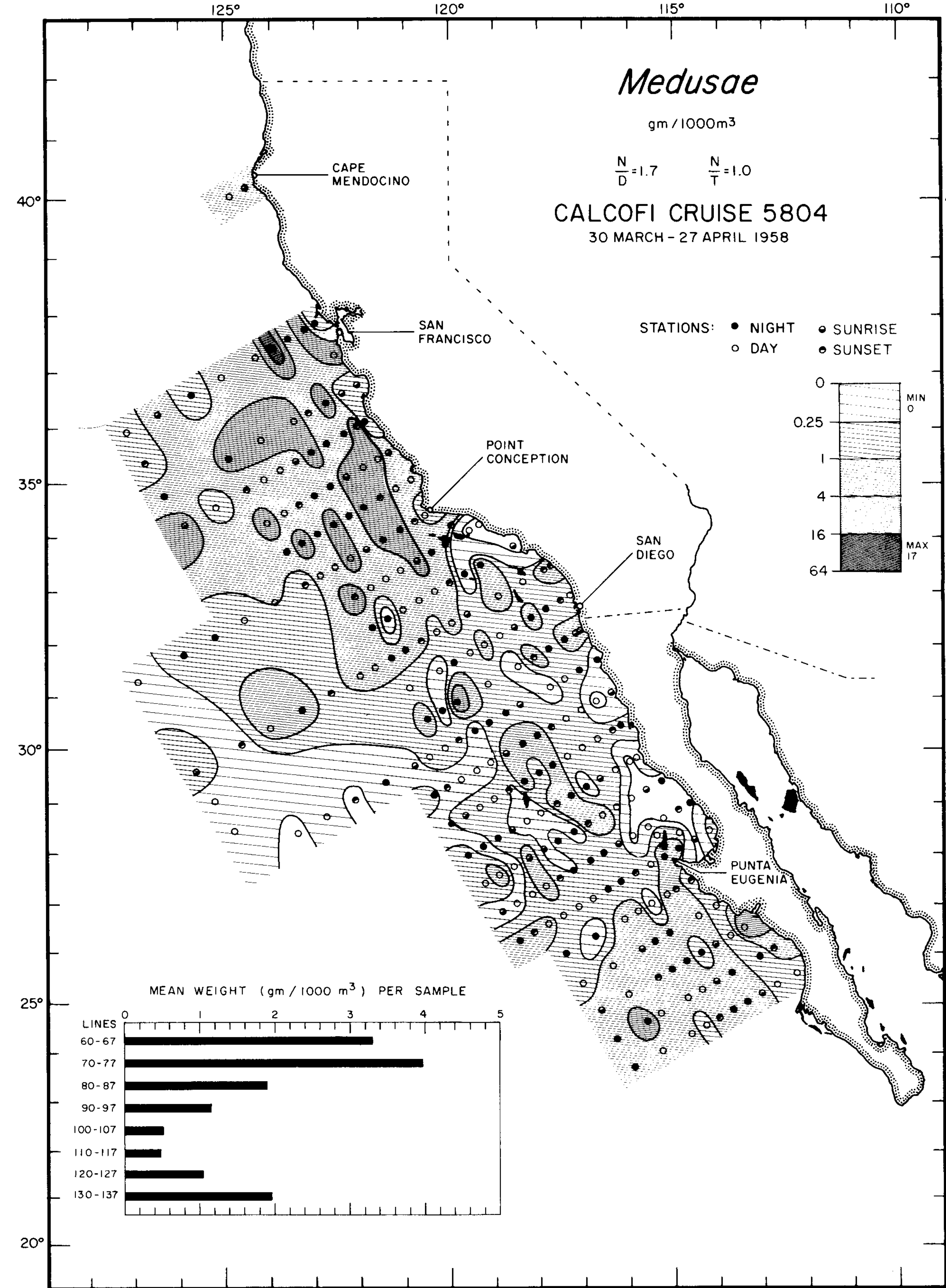
Medusae, adjusted

5604





Biomass
Medusae
5704



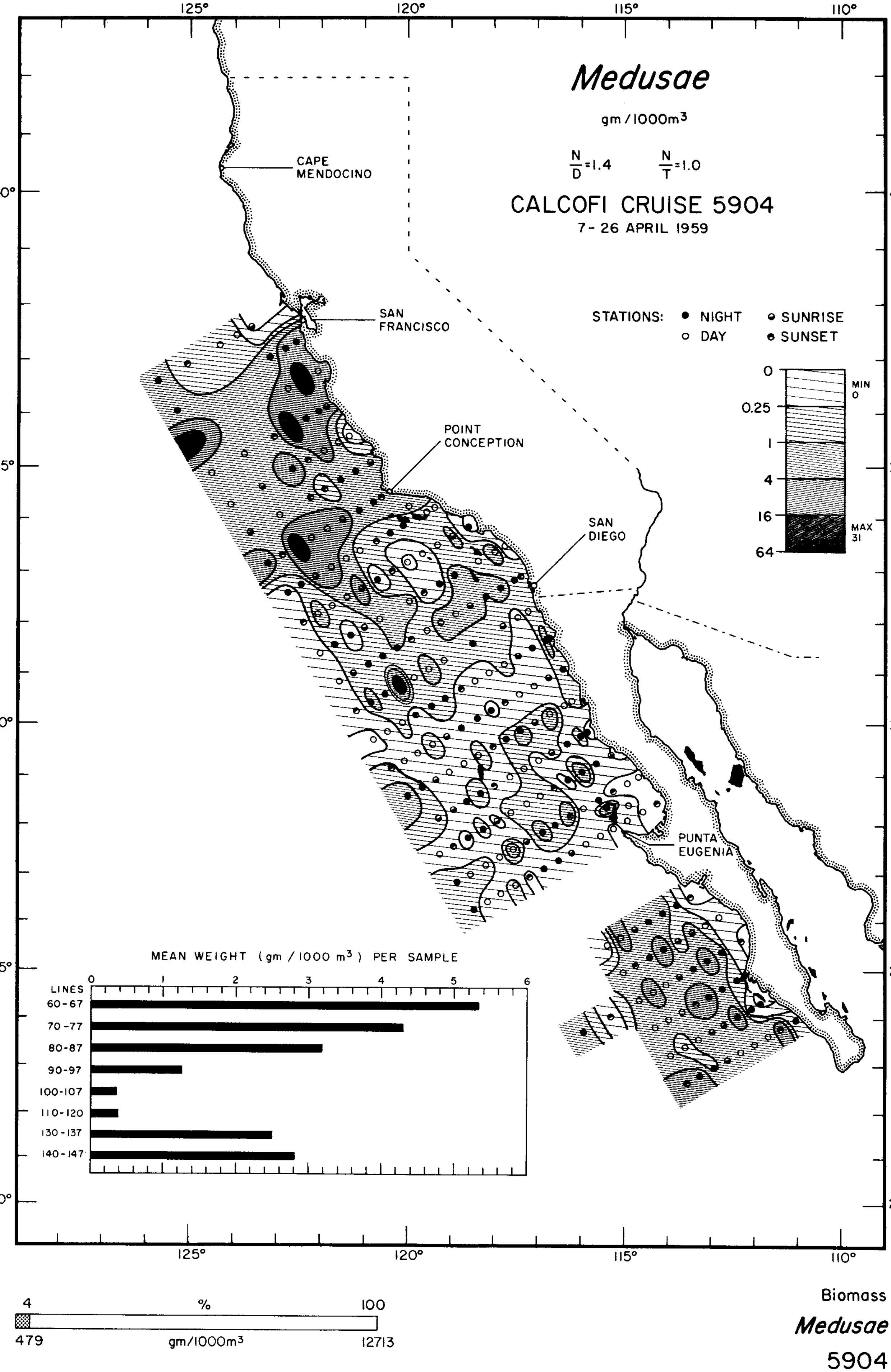
5 % 100

418 gm/1000m3 9039

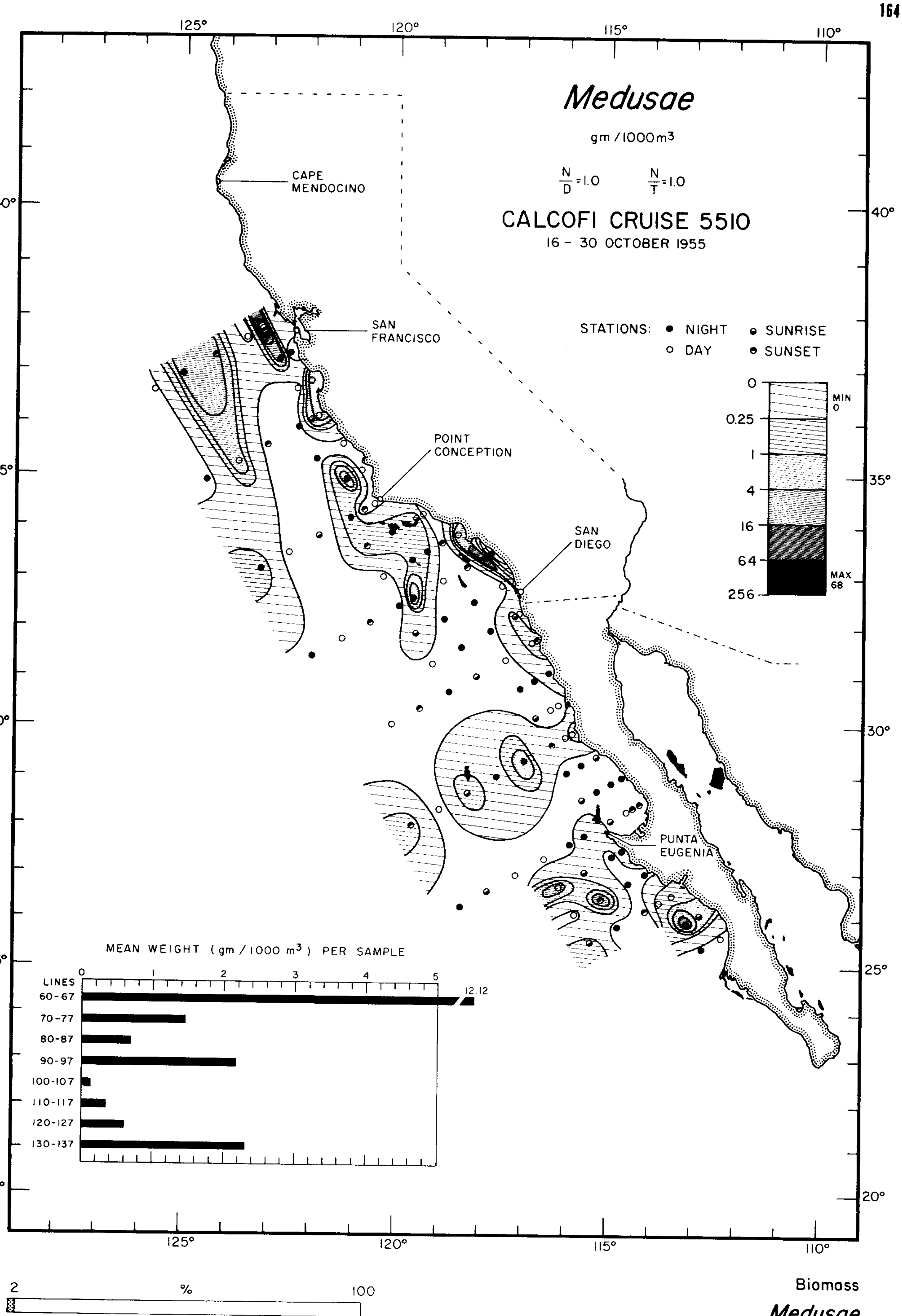
Biomass

Medusae

5804



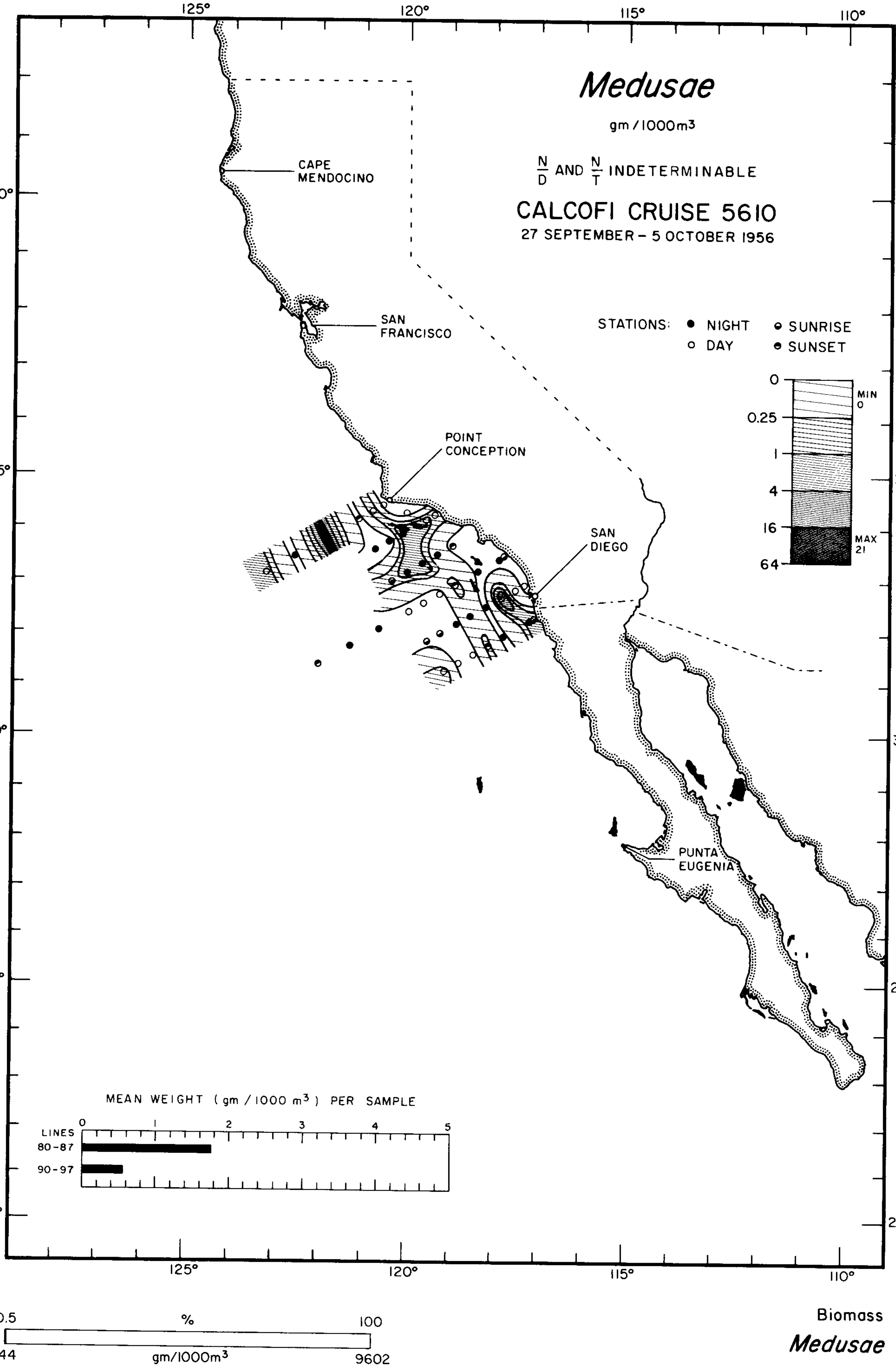
Biomass
Medusae
5904



Biomass

Medusae

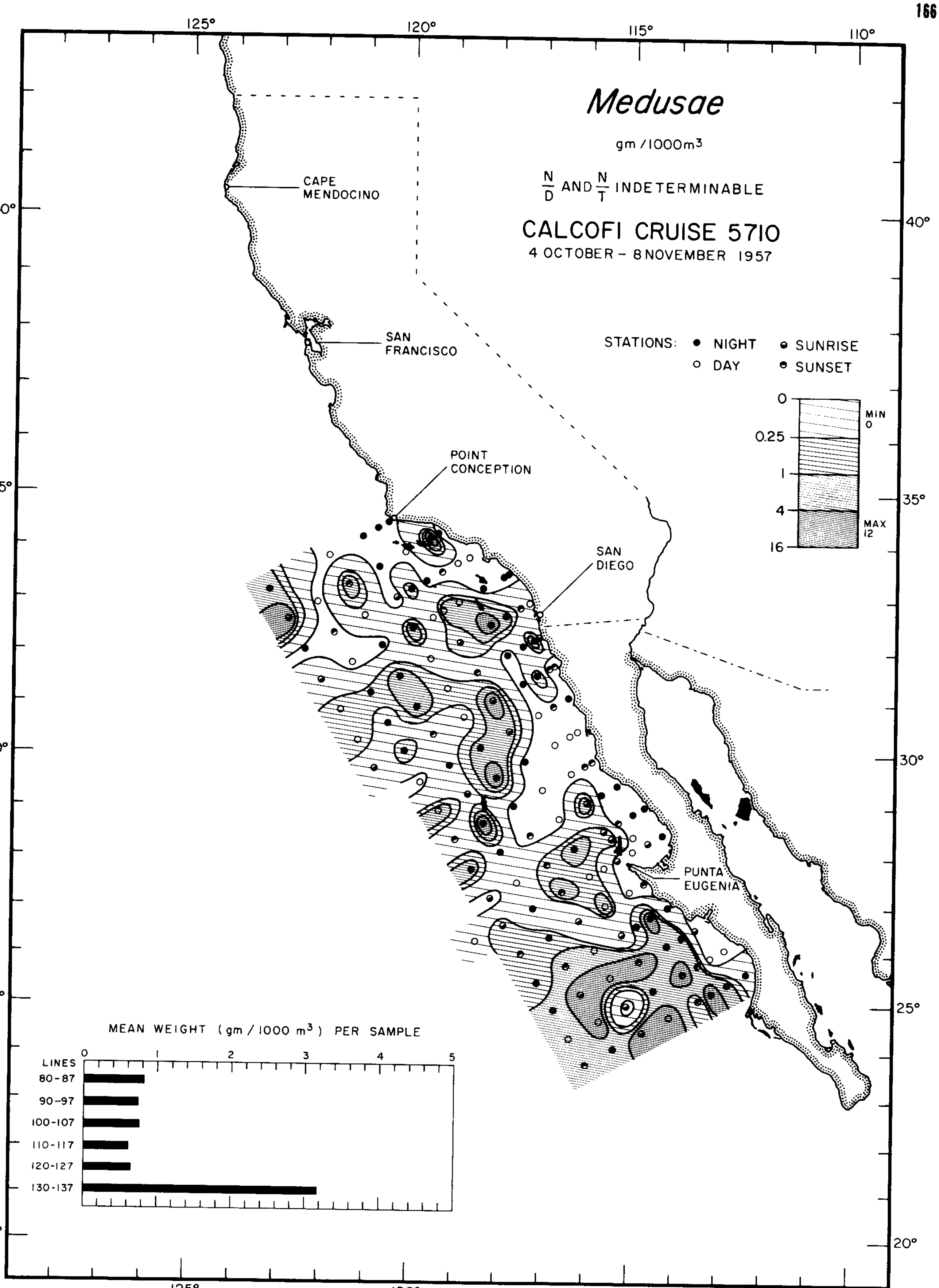
5510



Biomass

Medusae

5610



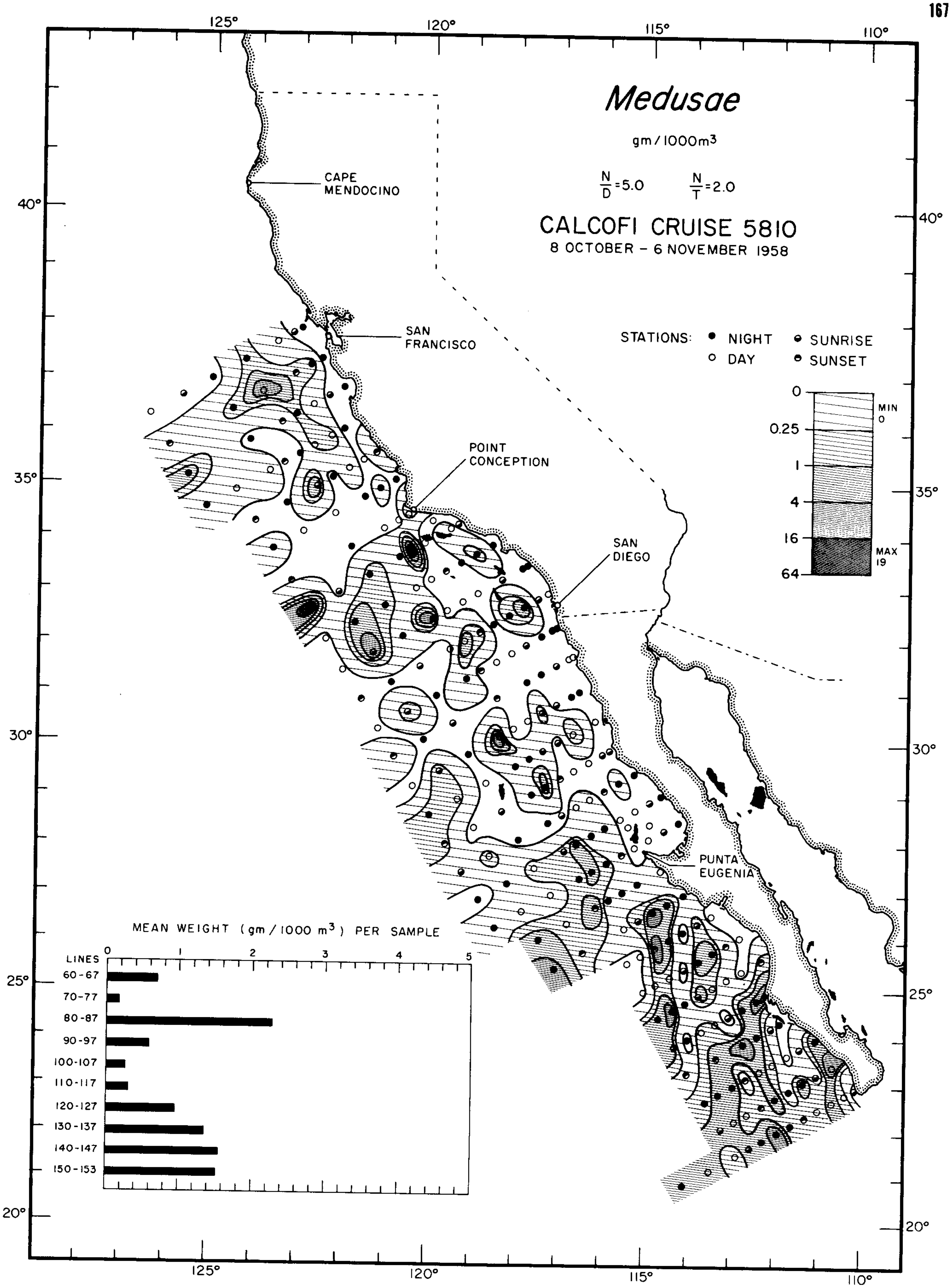
2 % 100

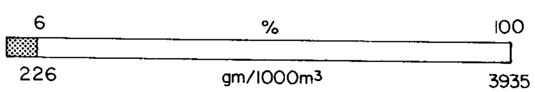
156 gm/1000m3 7384

Biomass

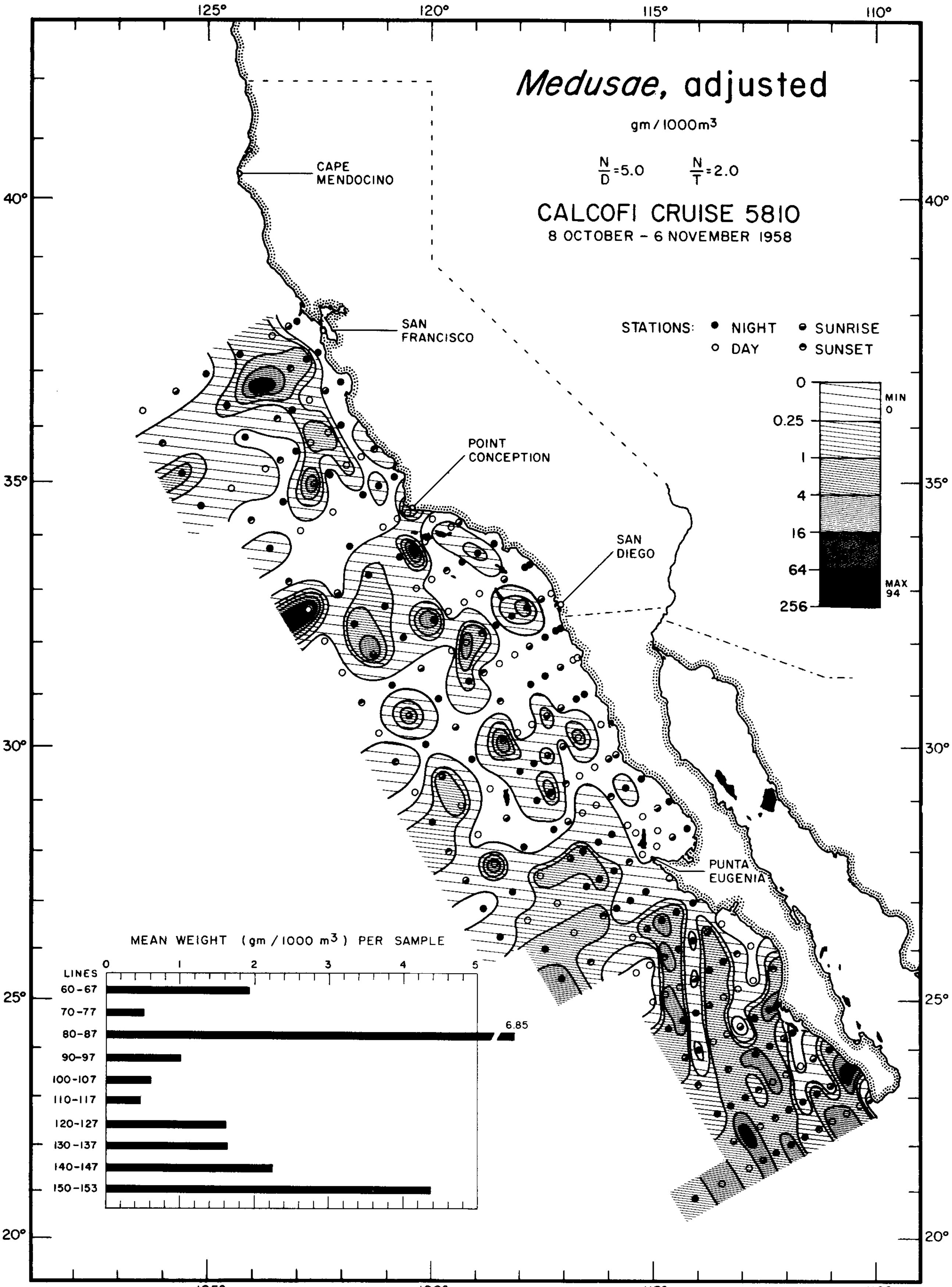
Medusae

5710





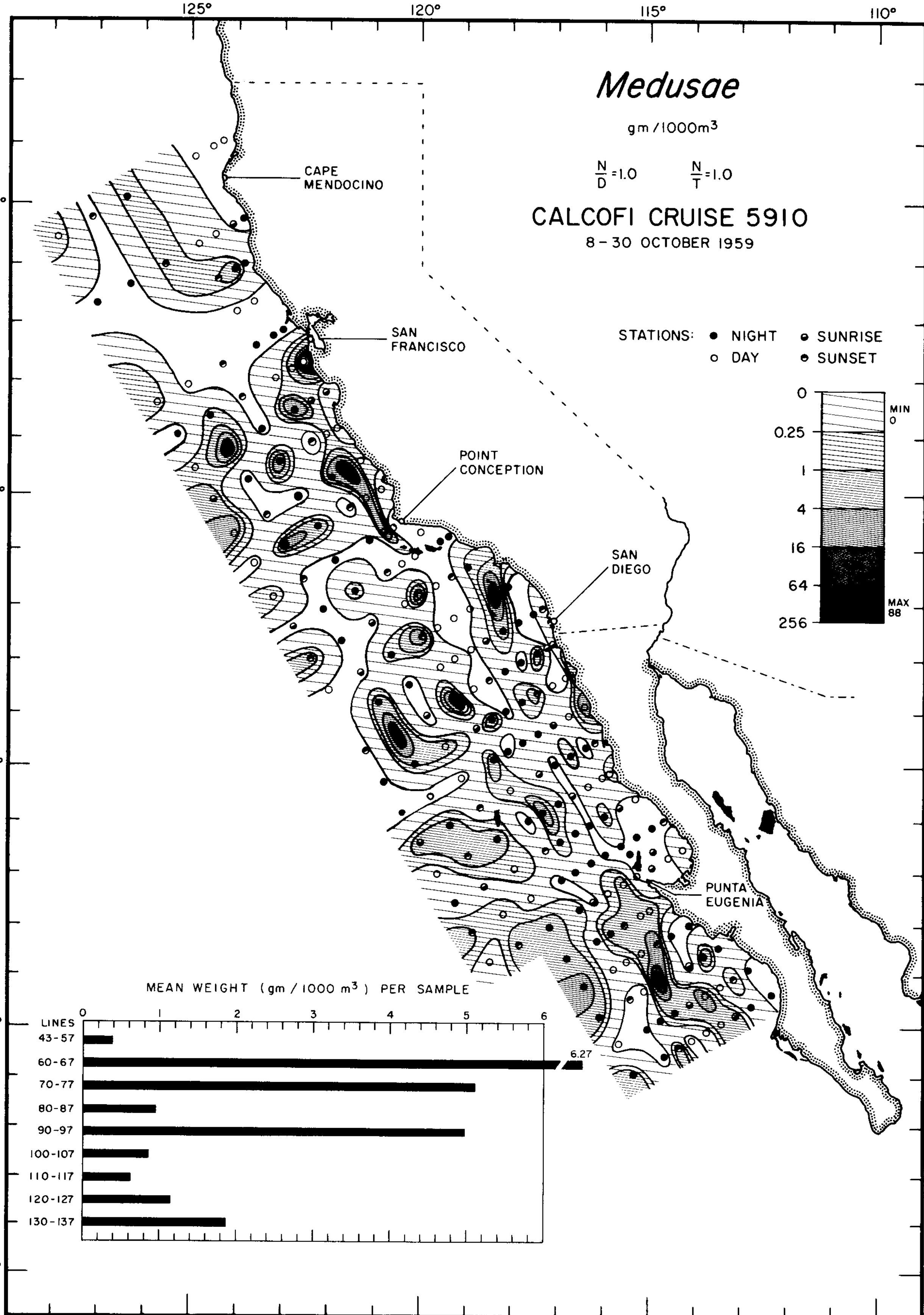
Biomass
Medusae
5810



Biomass

Medusae, adjusted

5810



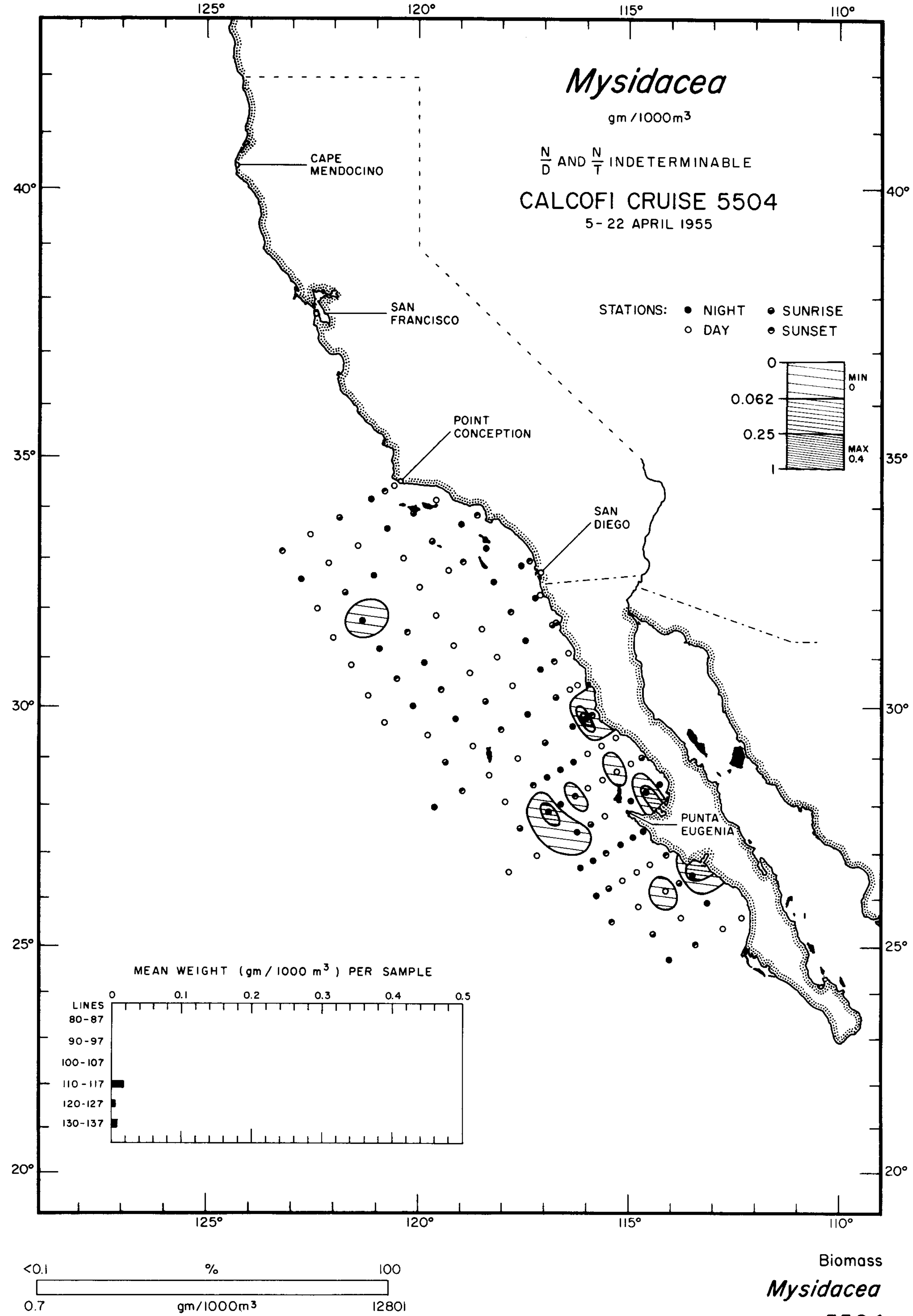
6 % 100

501 gm/1000m³ 8667

Biomass

Medusae

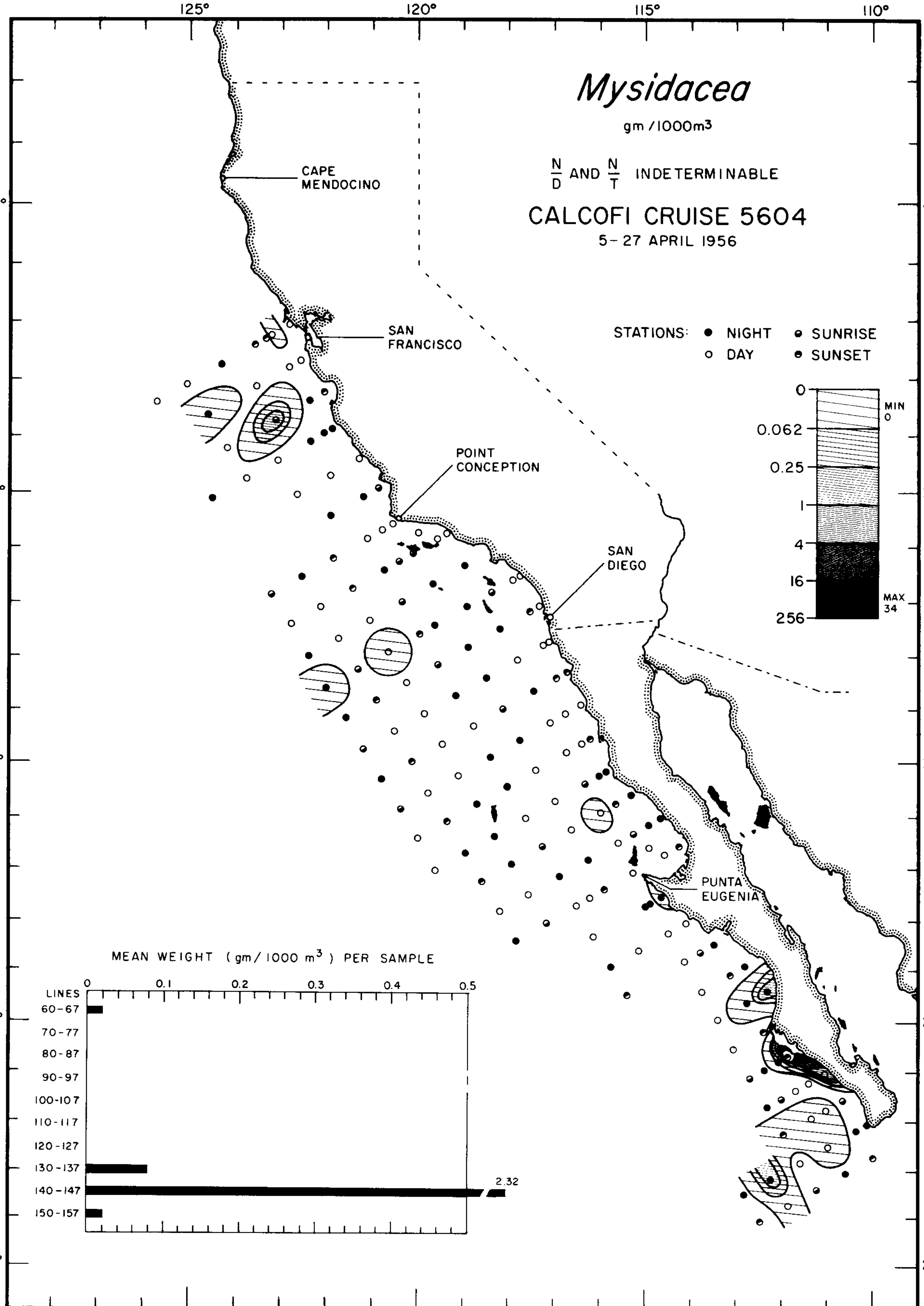
5910



Biomass

Mysidacea

5504



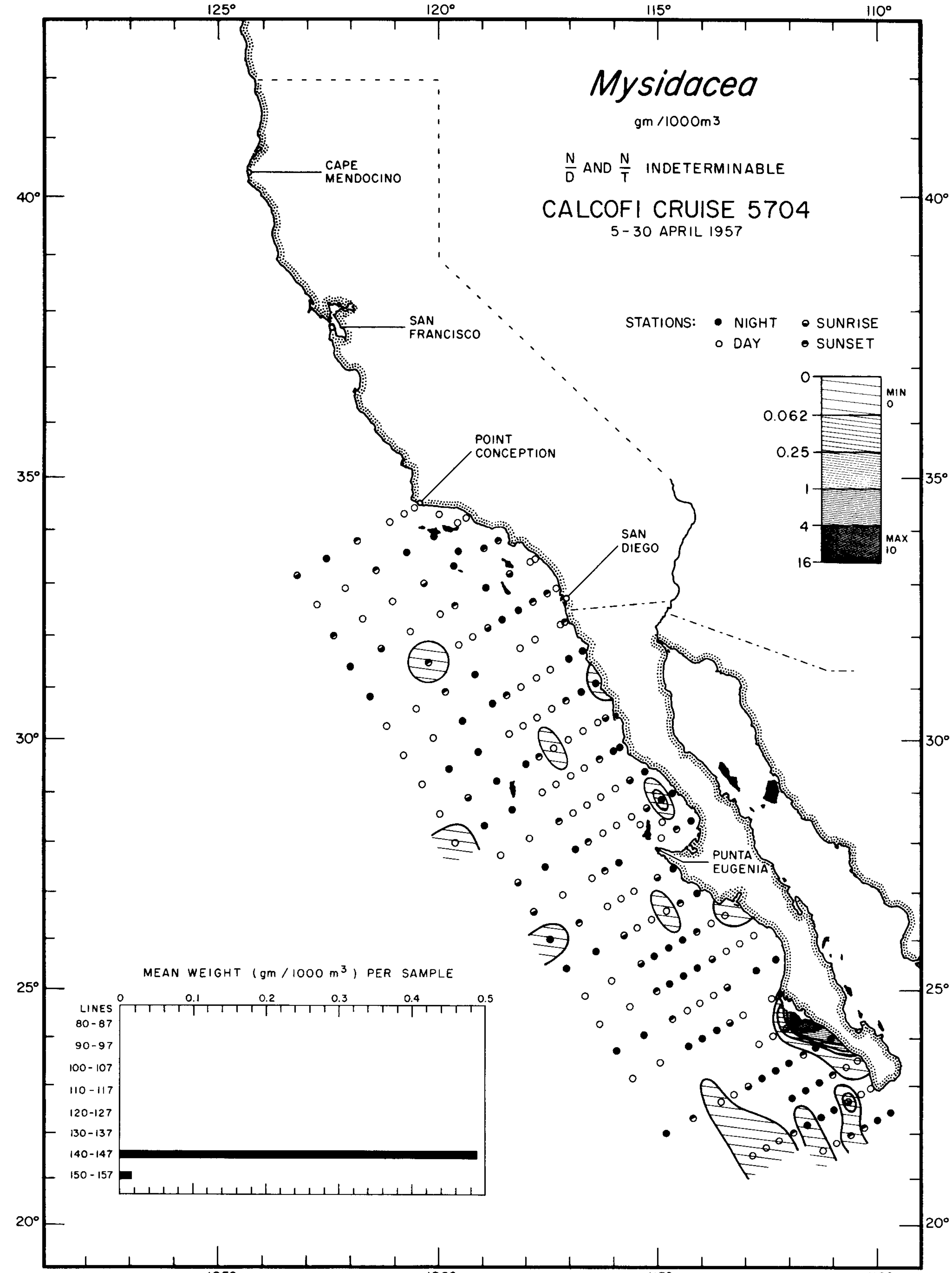
0.1 % 100

37 gm/1000m3 31916

Biomass

Mysidacea

5604



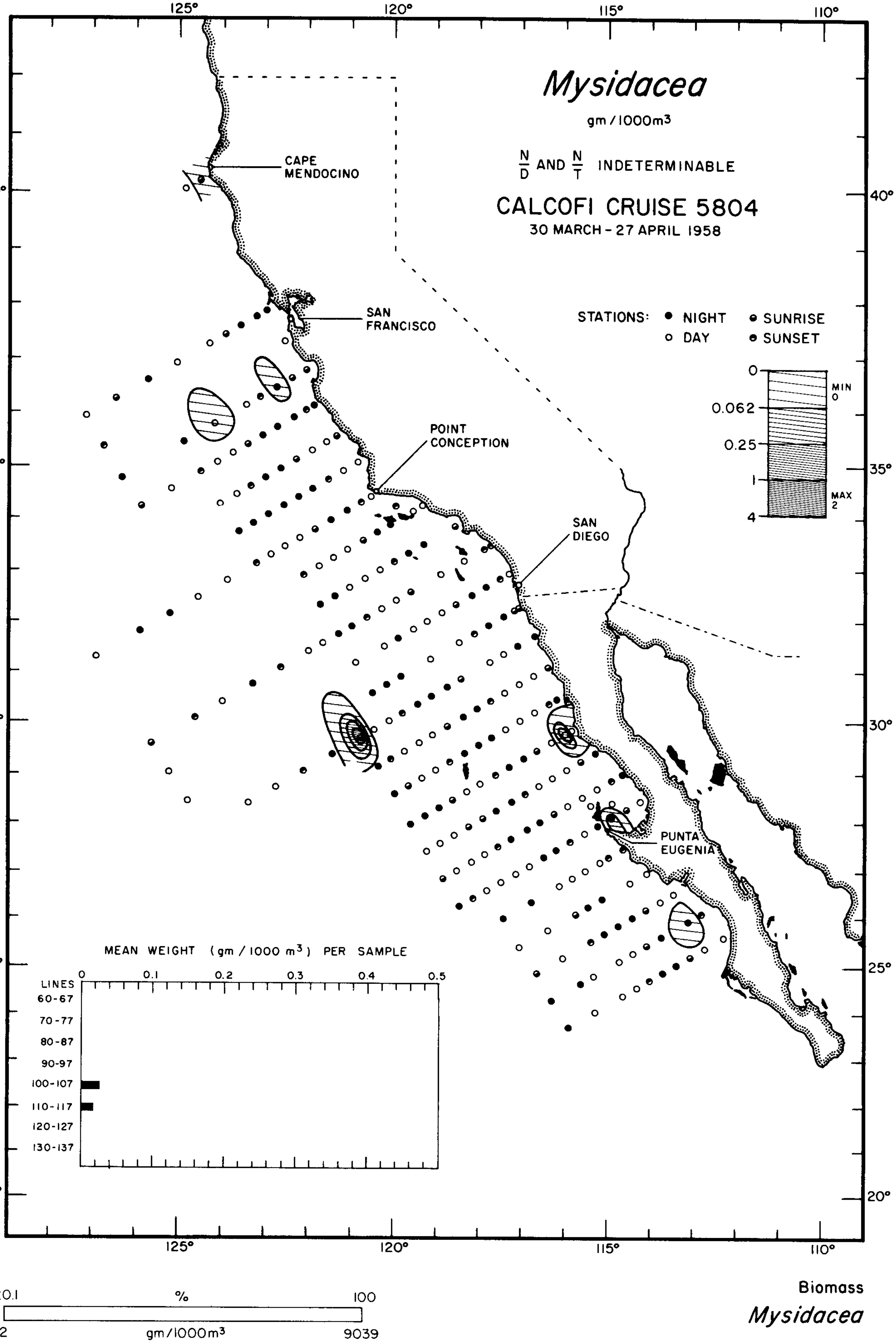
<0.1 % 100

12 gm/1000m³ 40251

Biomass

Mysidacea

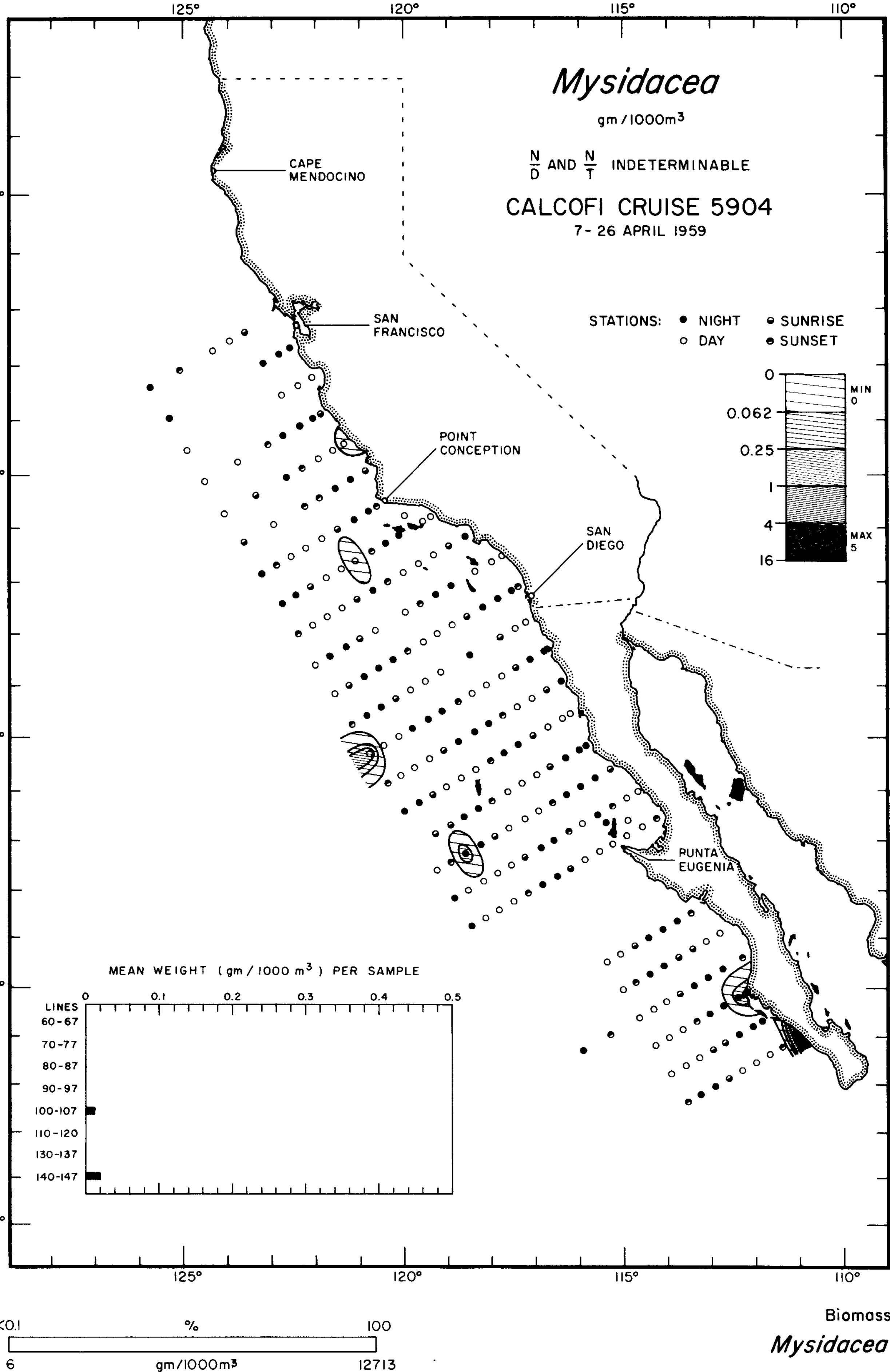
5704



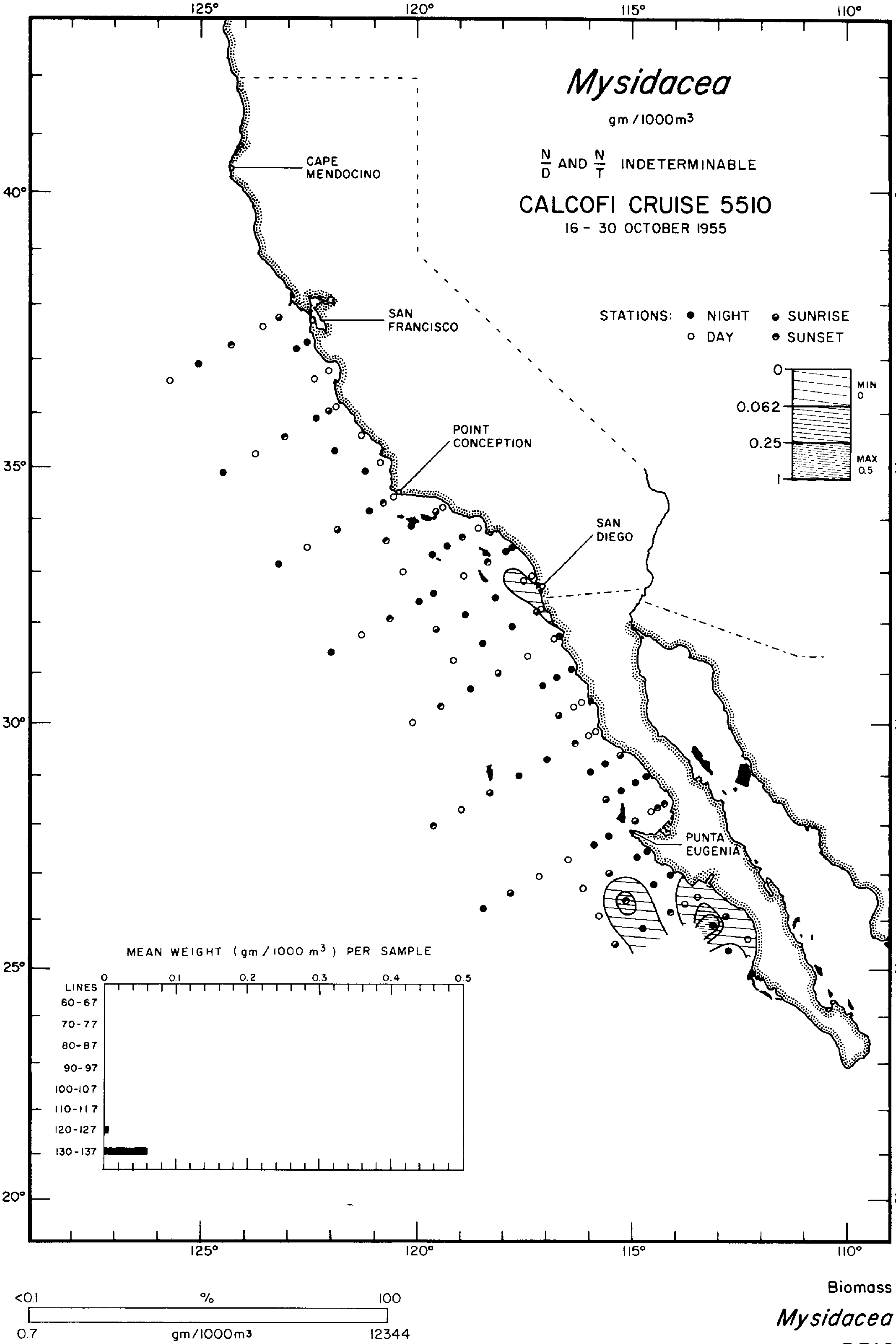
Biomass

Mysidacea

5804



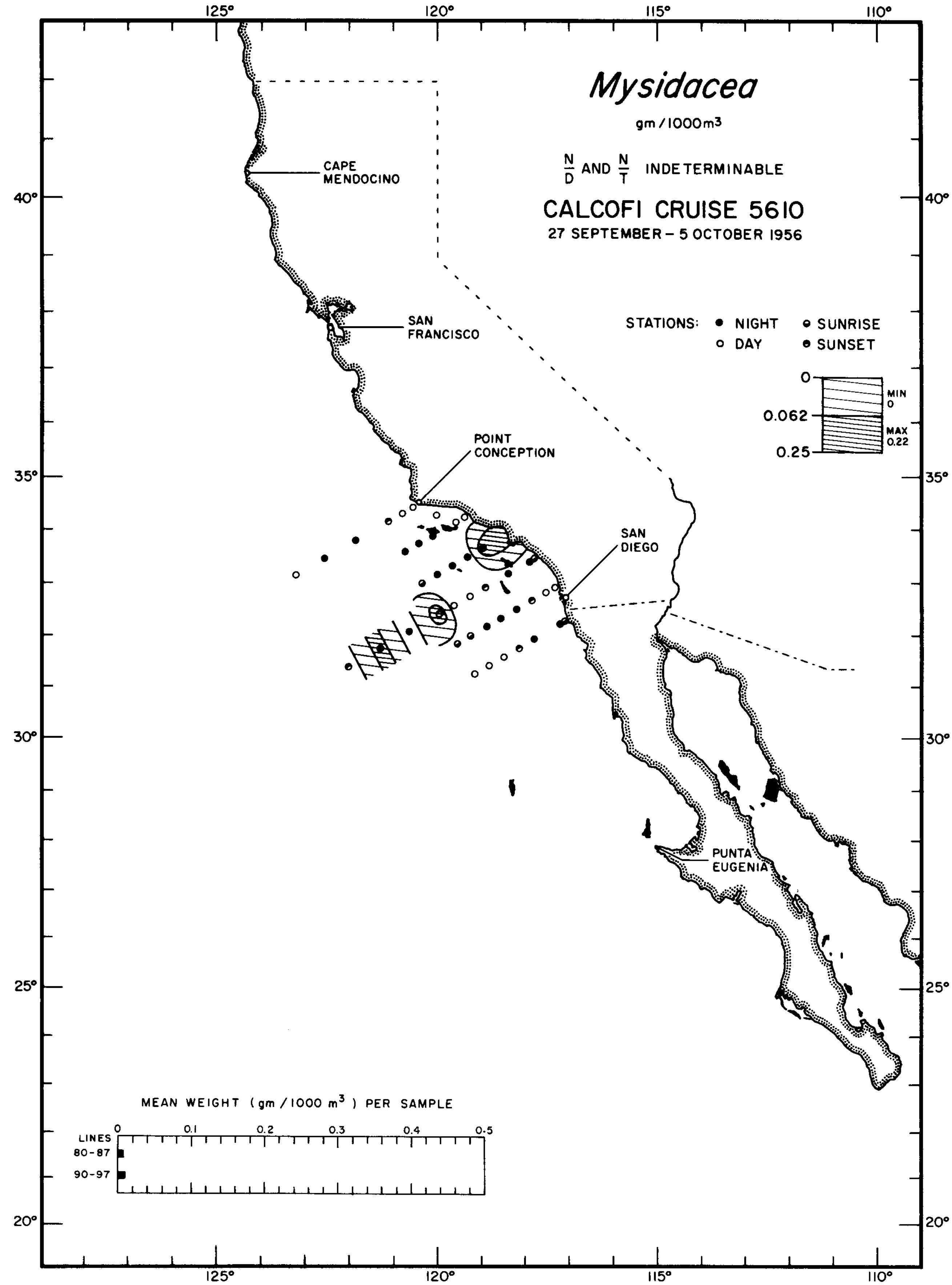
Biomass
Mysidacea
5904



Biomass

Mysidacea

5510



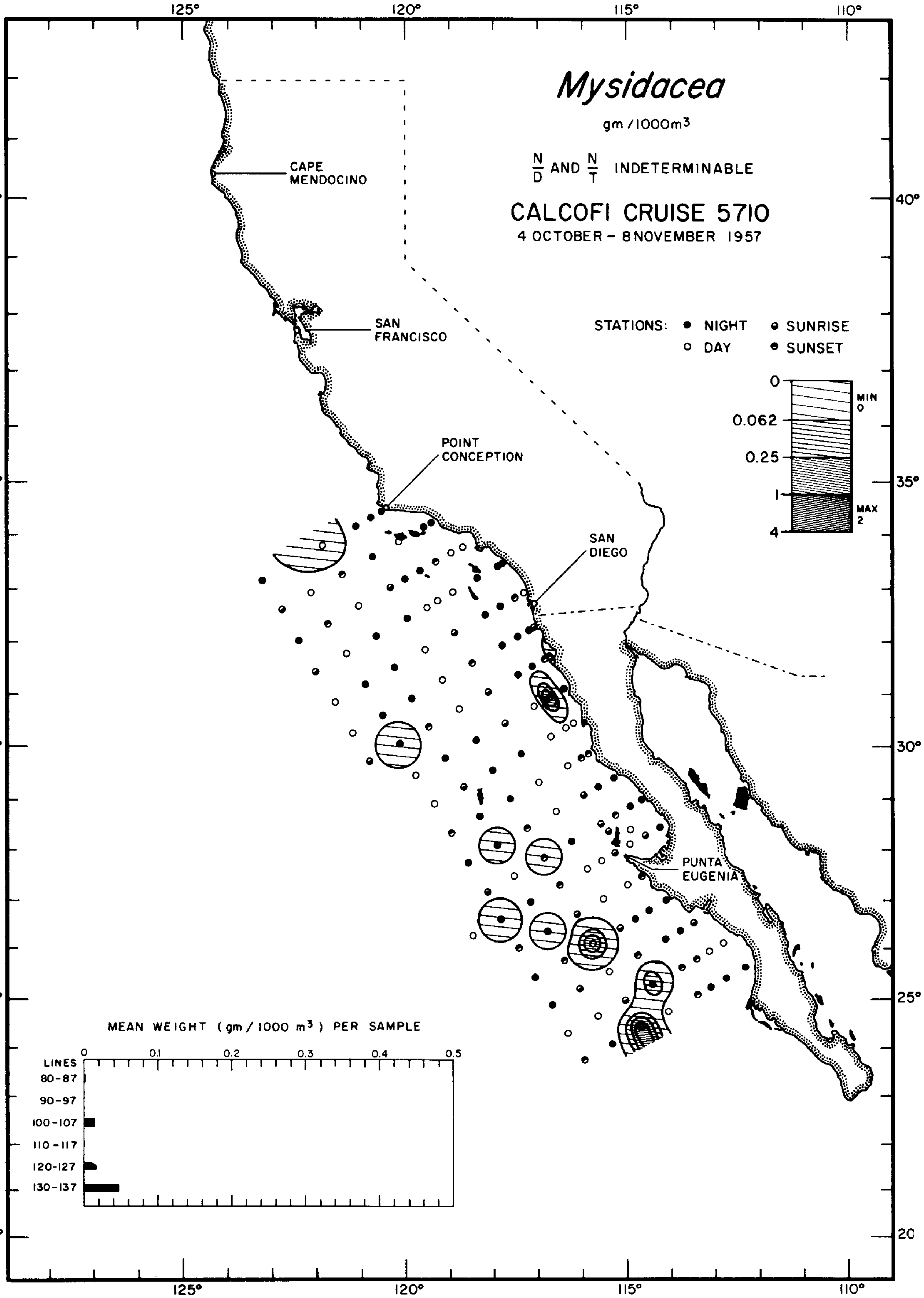
<0.1 % 100

0.5 gm/1000m³ 9602

Biomass

Mysidacea

5610



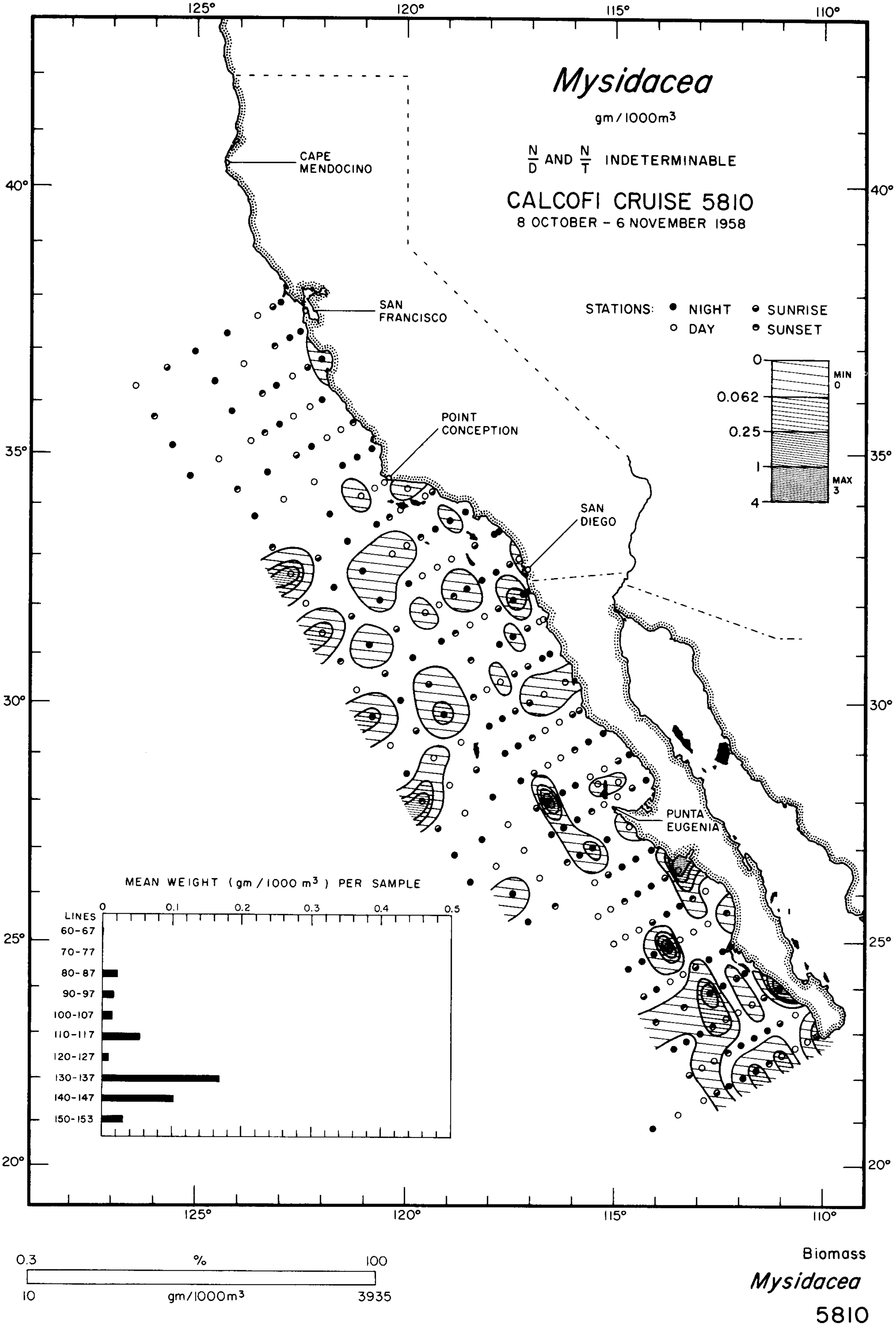
<0.1 % 100

1.9 gm/1000³ 7384

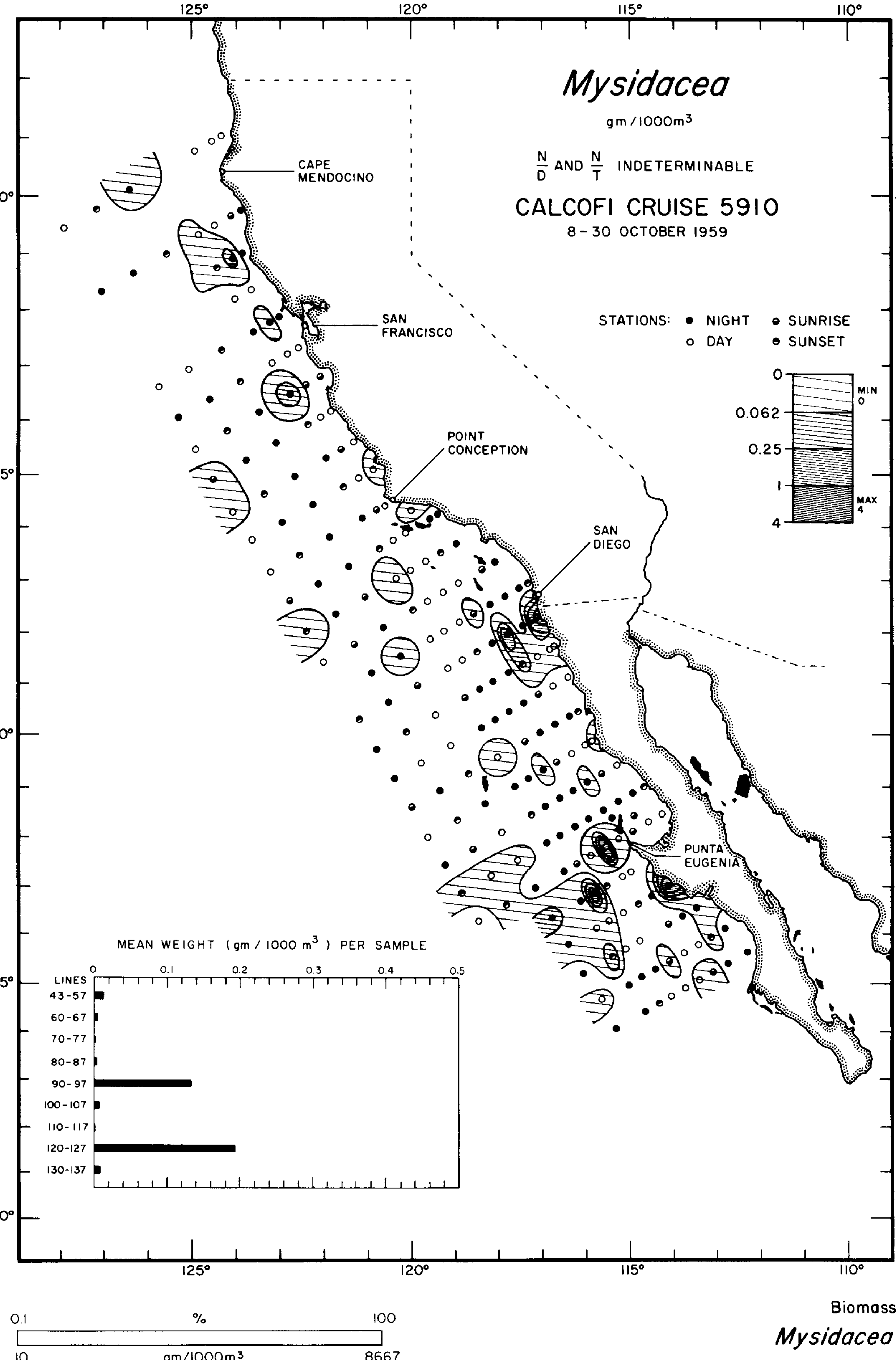
Biomass

Mysidacea

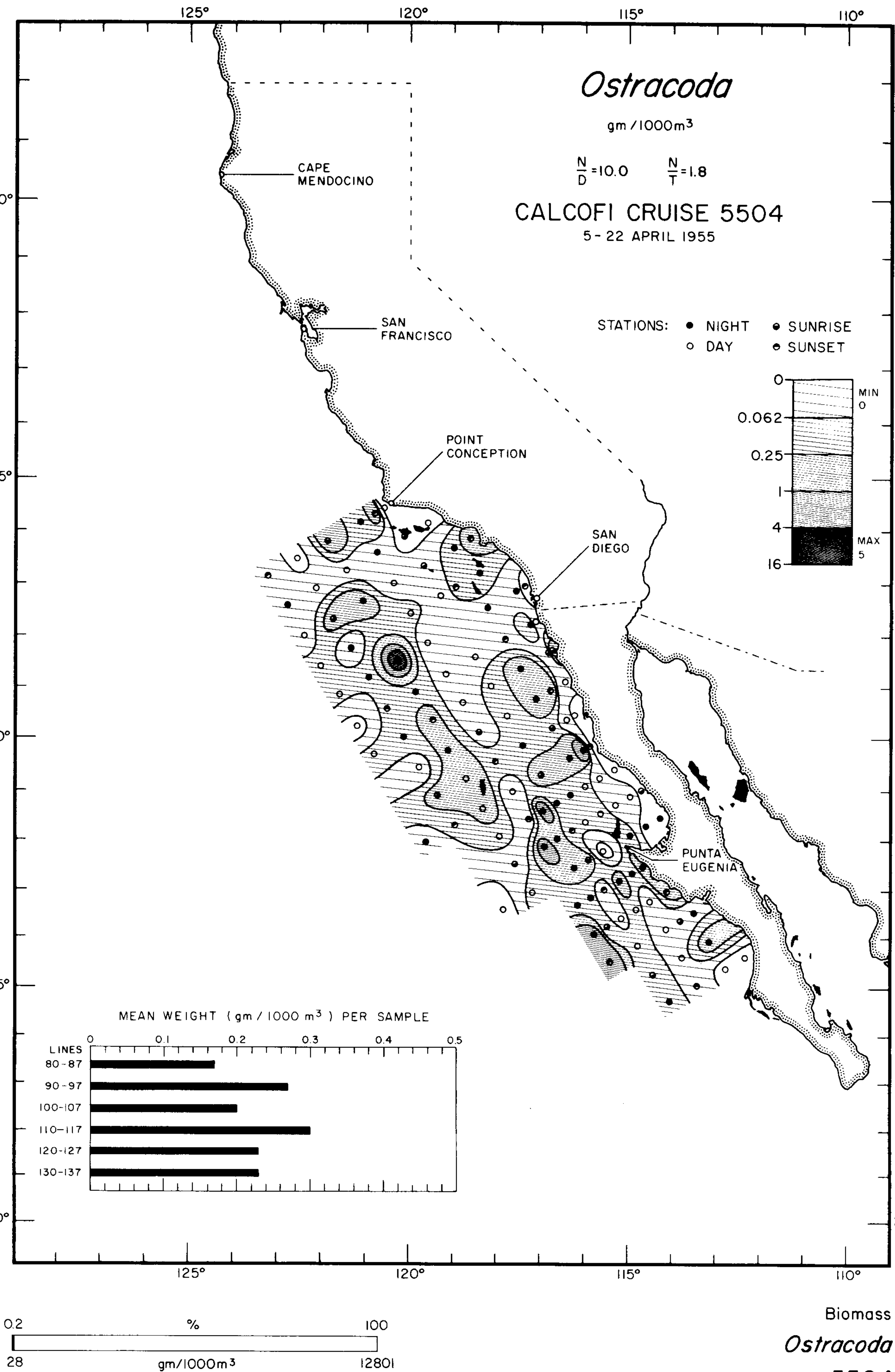
5710



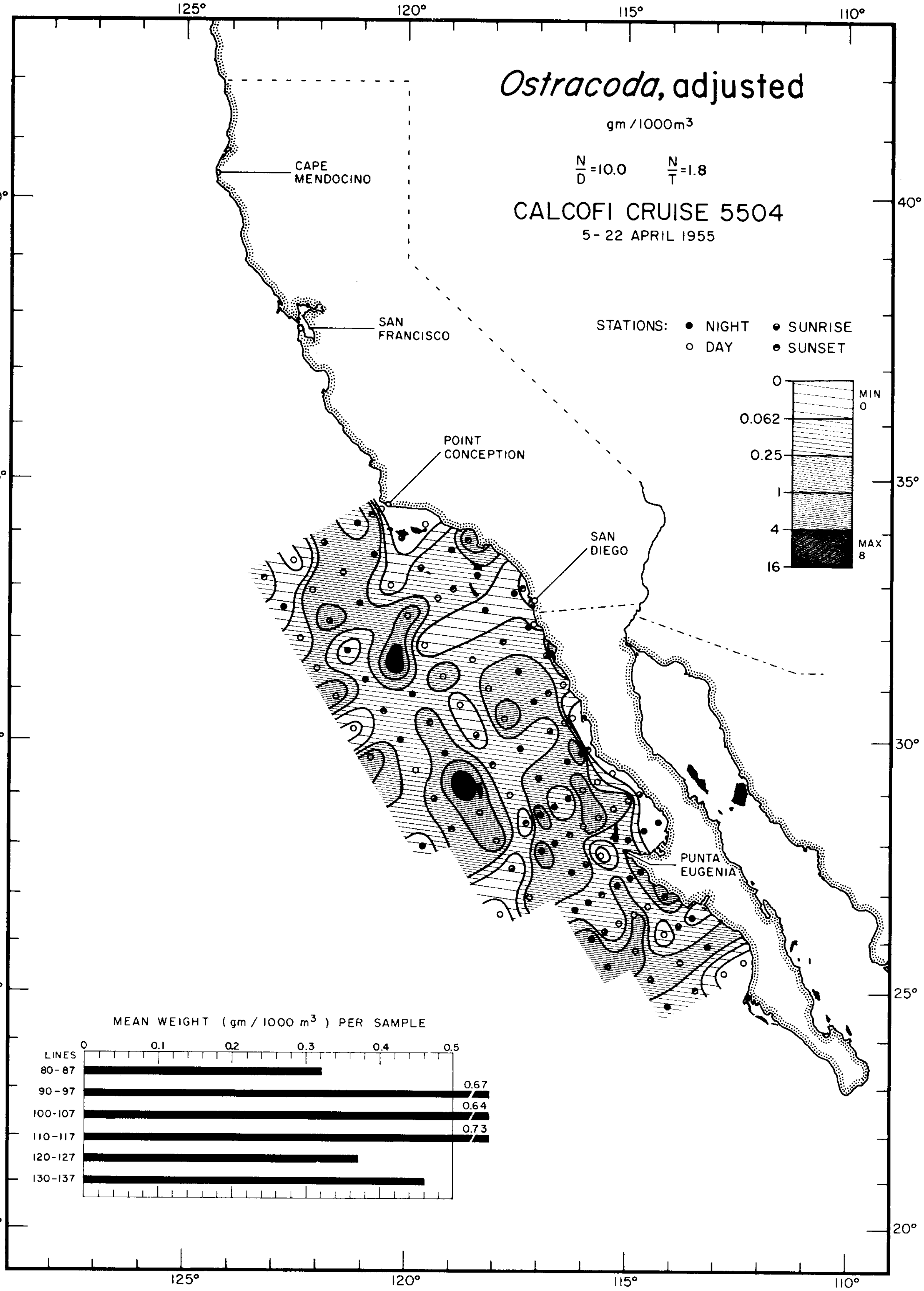
Biomass
Mysidacea
5810



Biomass
Mysidacea
5910



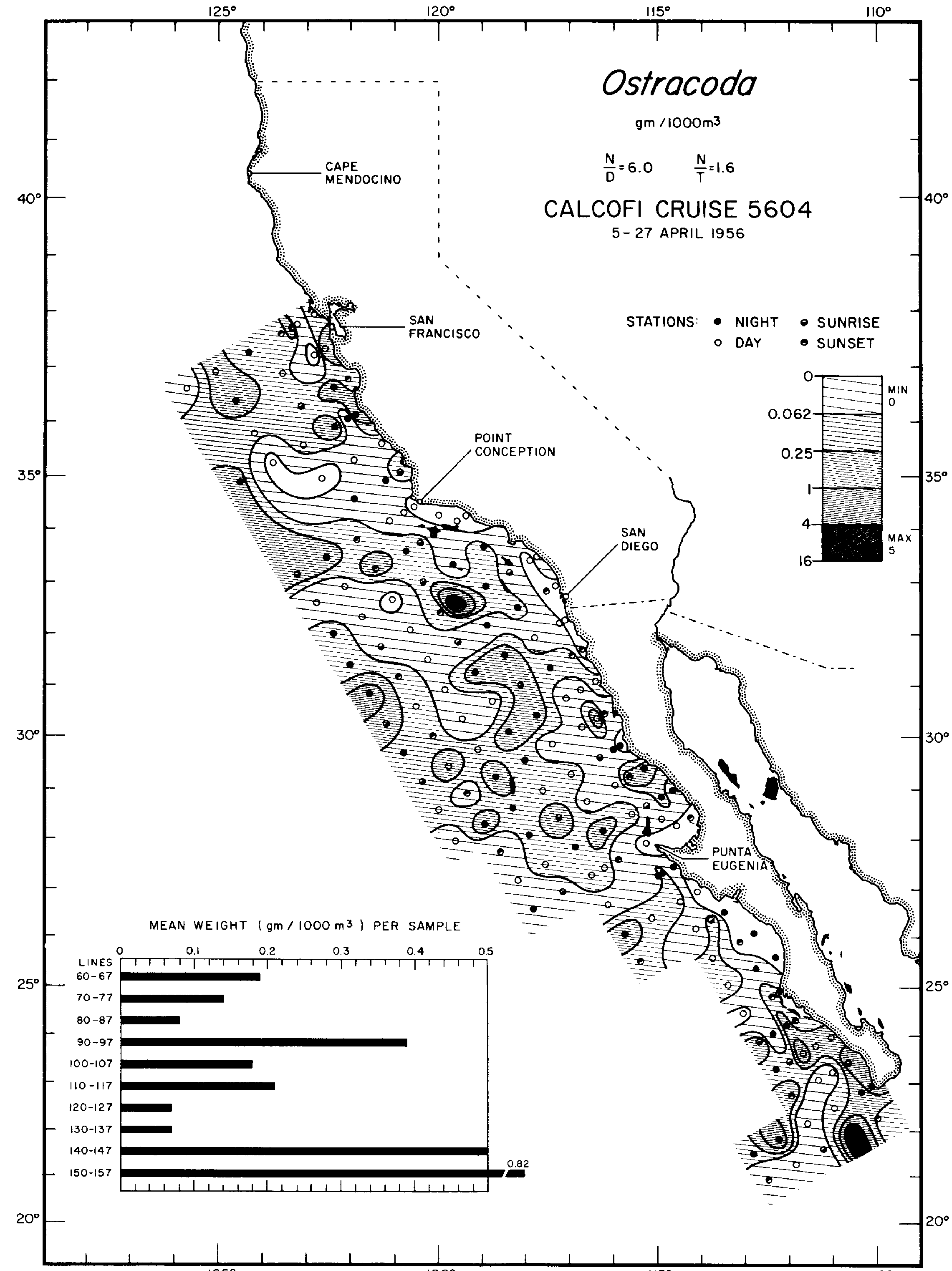
Biomass
Ostracoda
5504



Biomass

Ostracoda, adjusted

5504



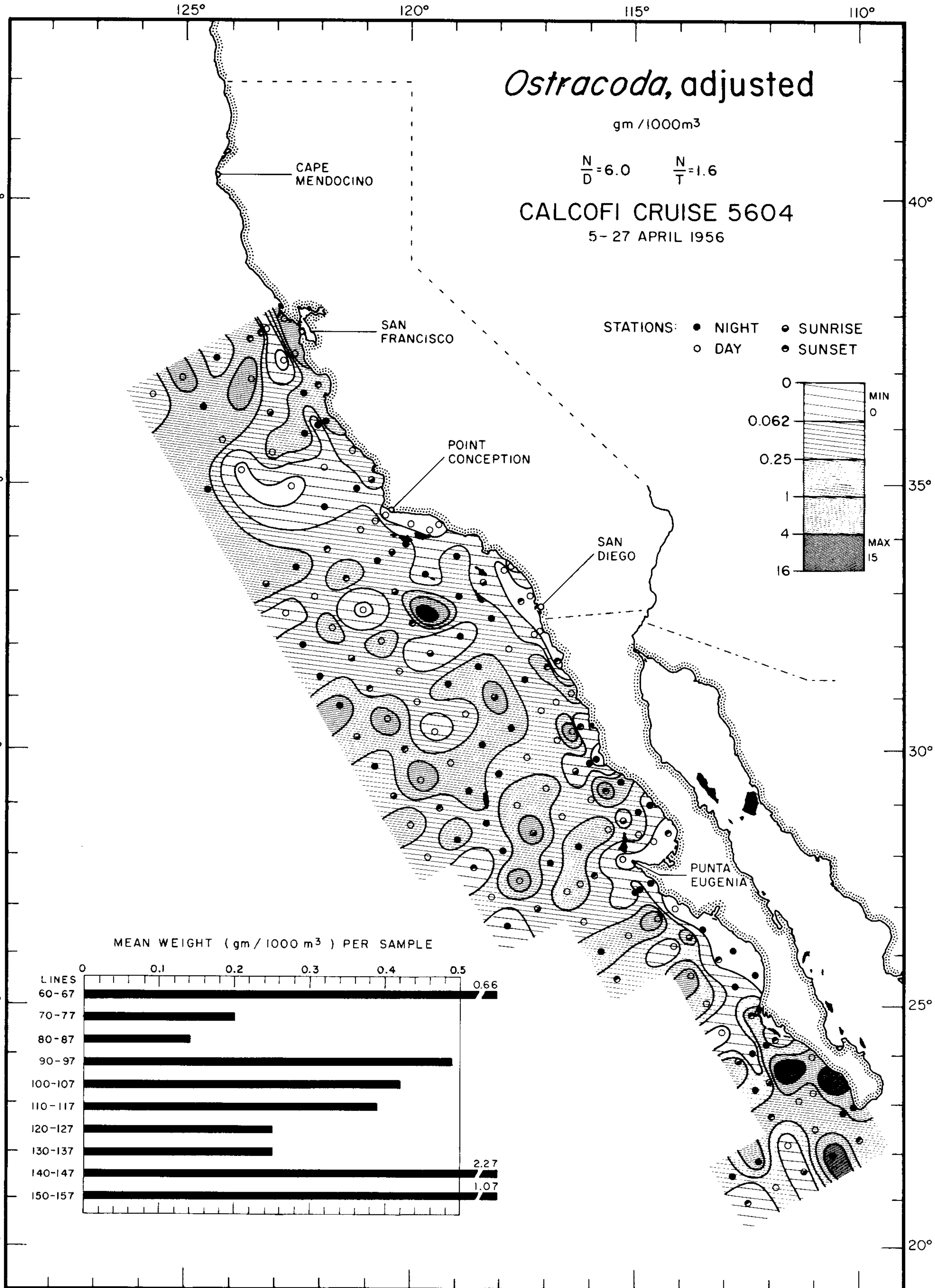
0.1 % 100

45 gm/1000m3 31916

Biomass

Ostracoda

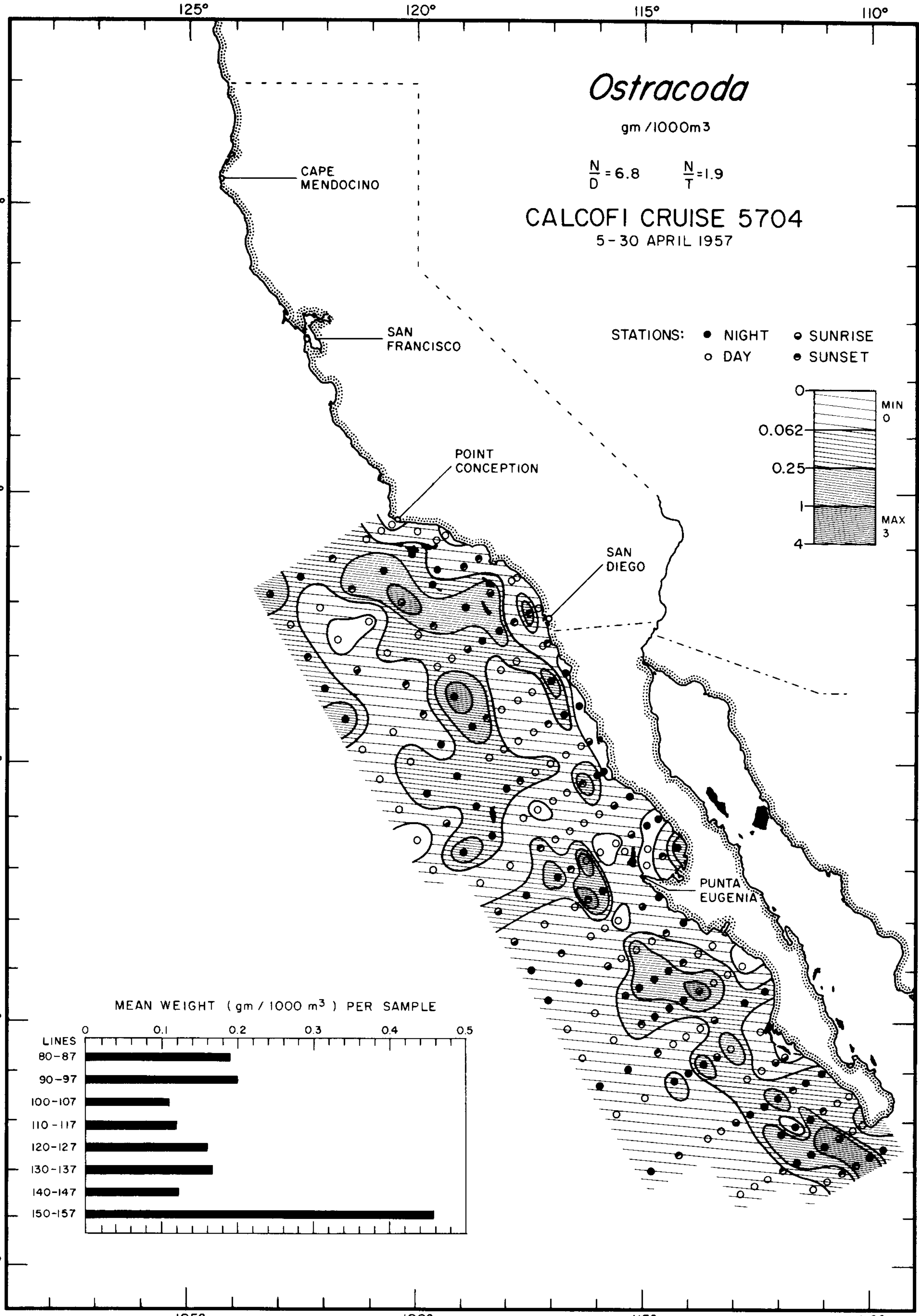
5604



Biomass

Ostracoda, adjusted

5604



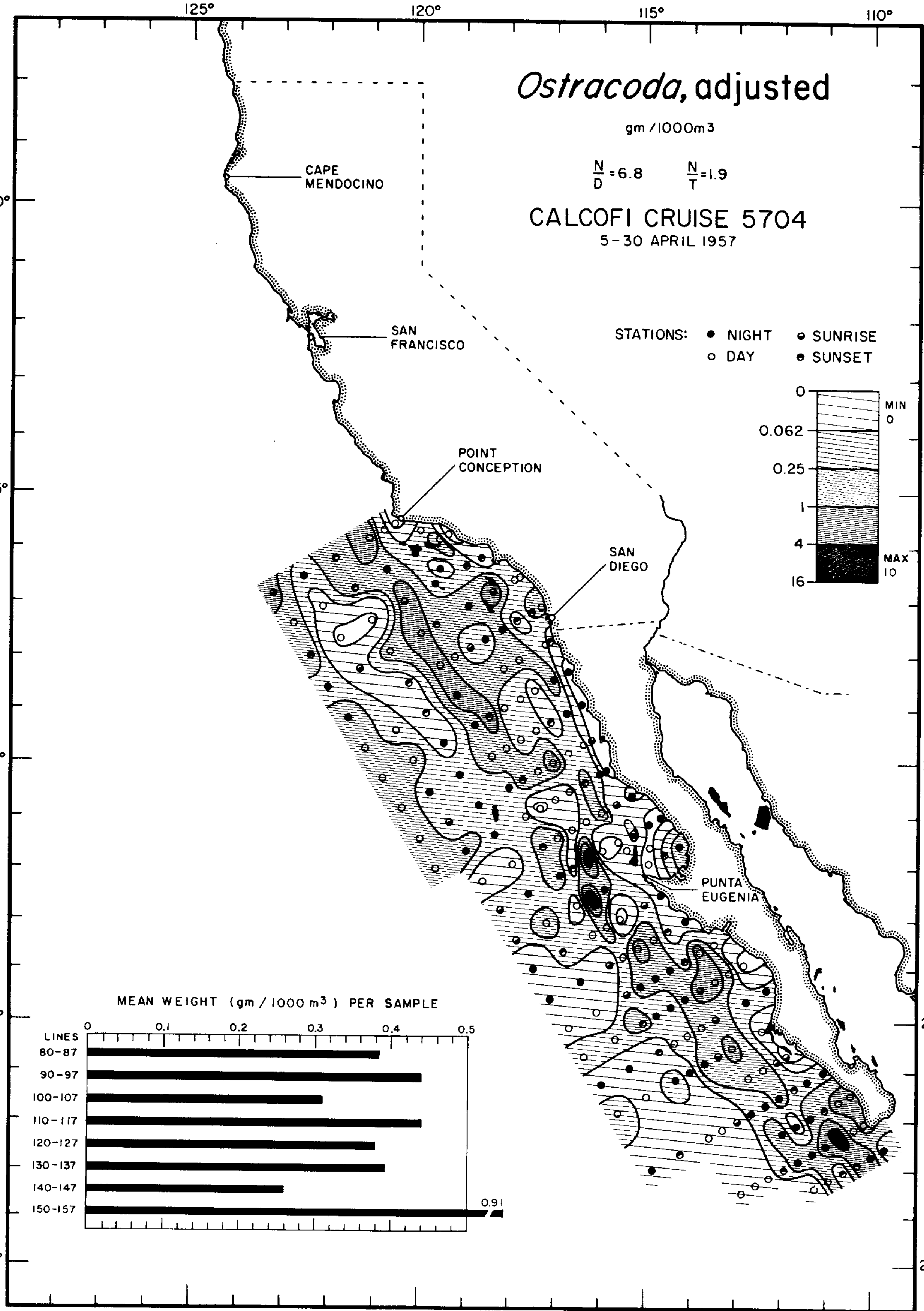
<0.1 % 100

38 gm/1000m³ 40251

Biomass

Ostracoda

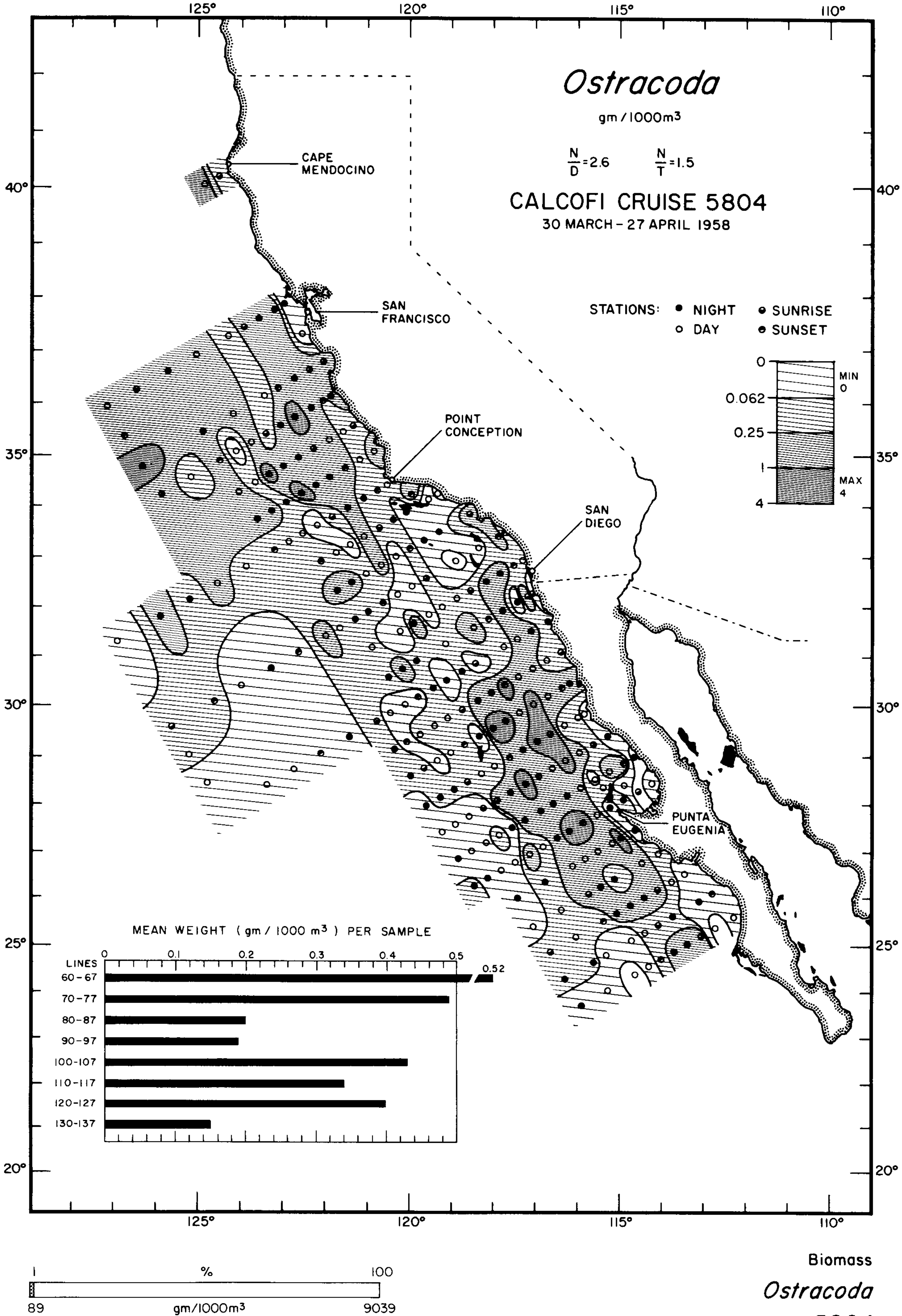
5704



Biomass

Ostracoda, adjusted

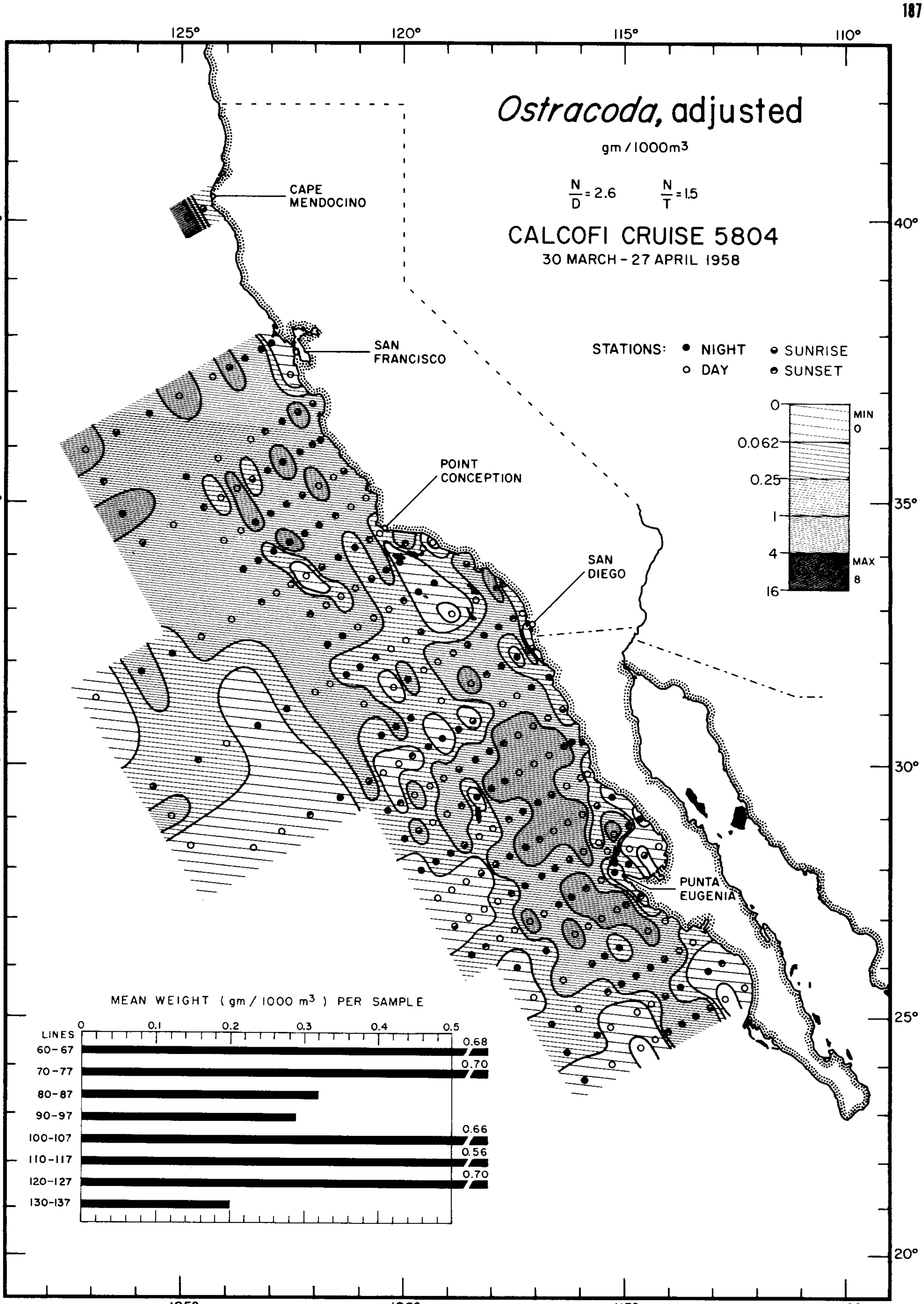
5704



Biomass

Ostracoda

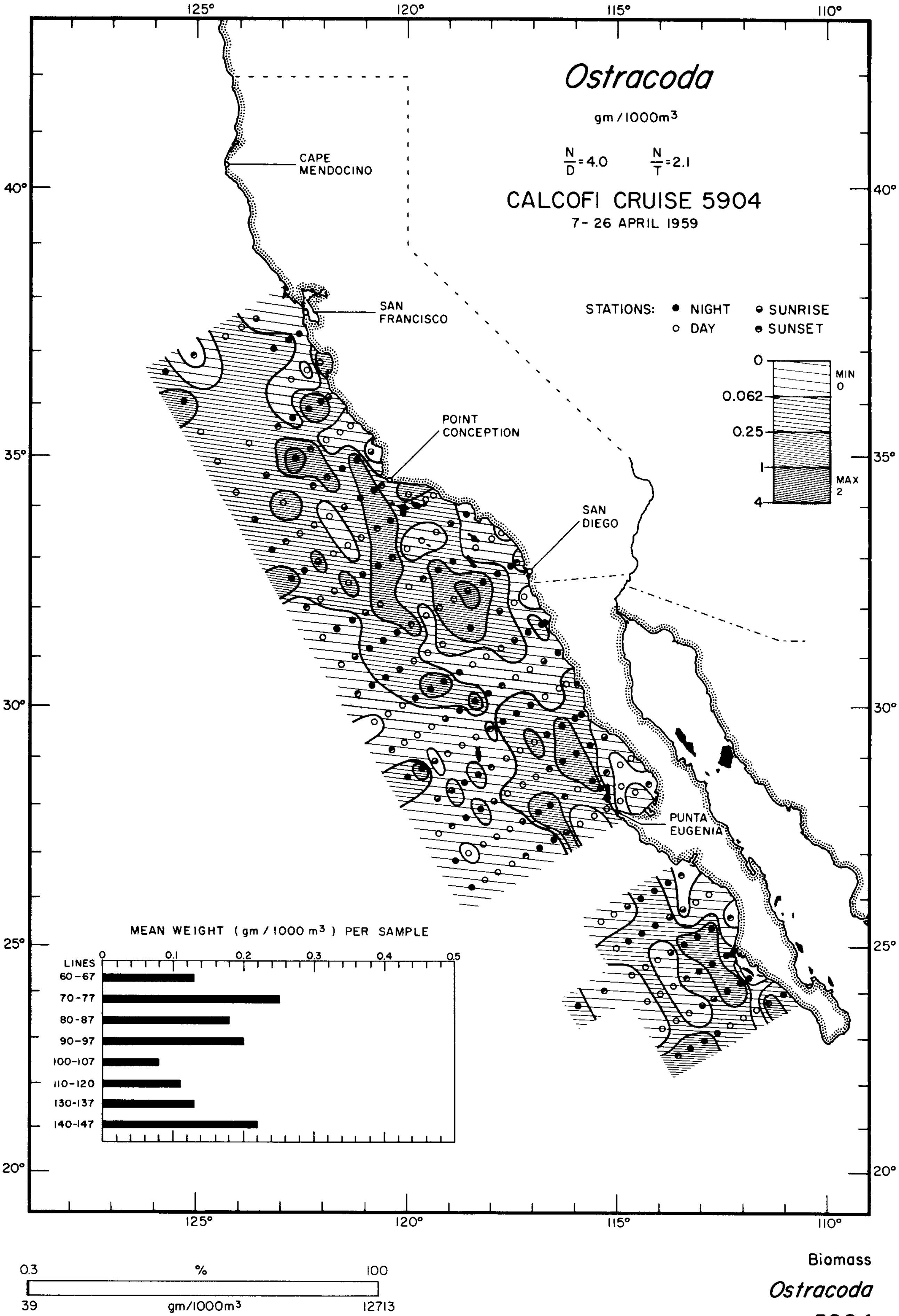
5804



Biomass

Ostracoda, adjusted

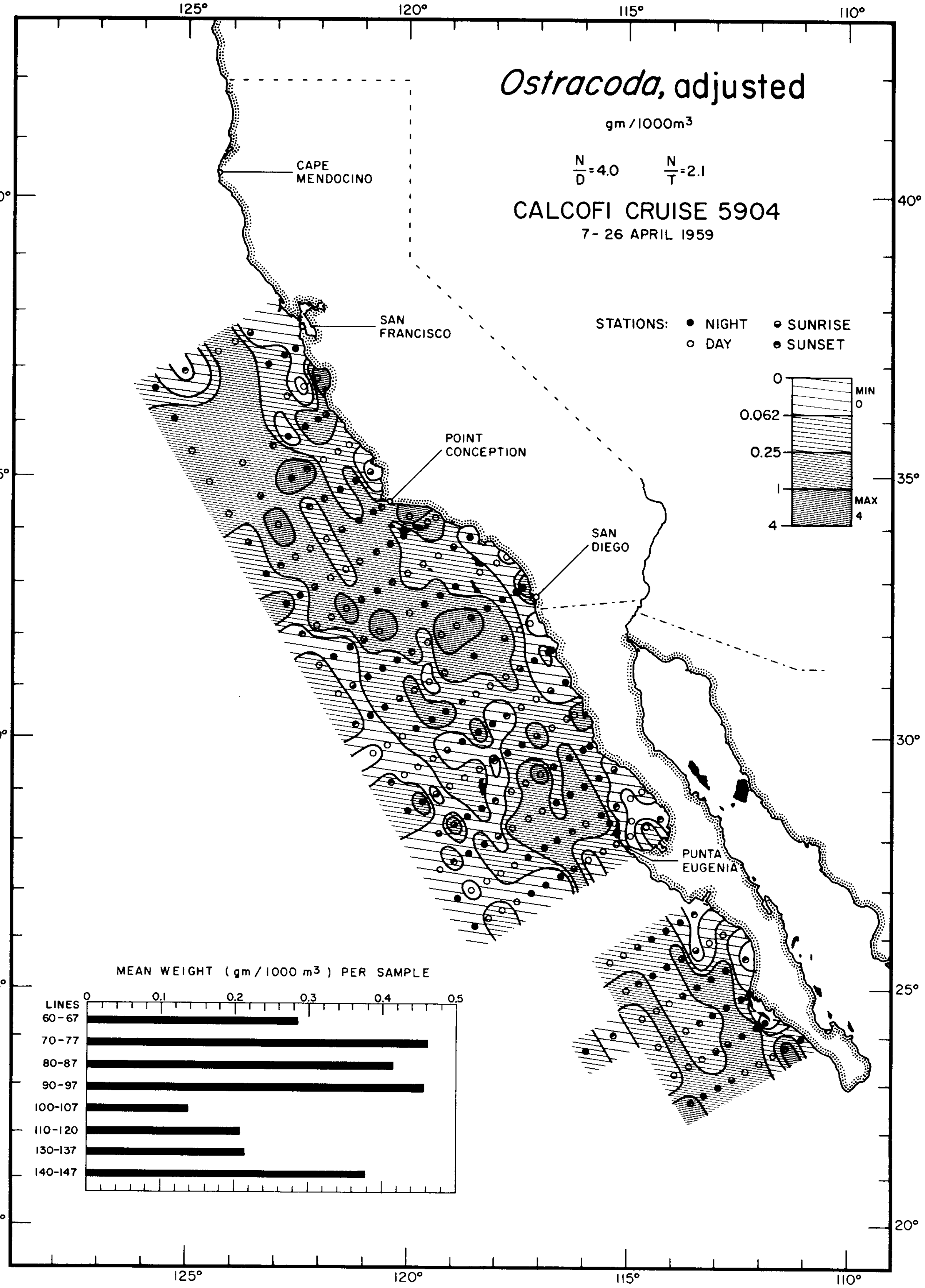
5804



Biomass

Ostracoda

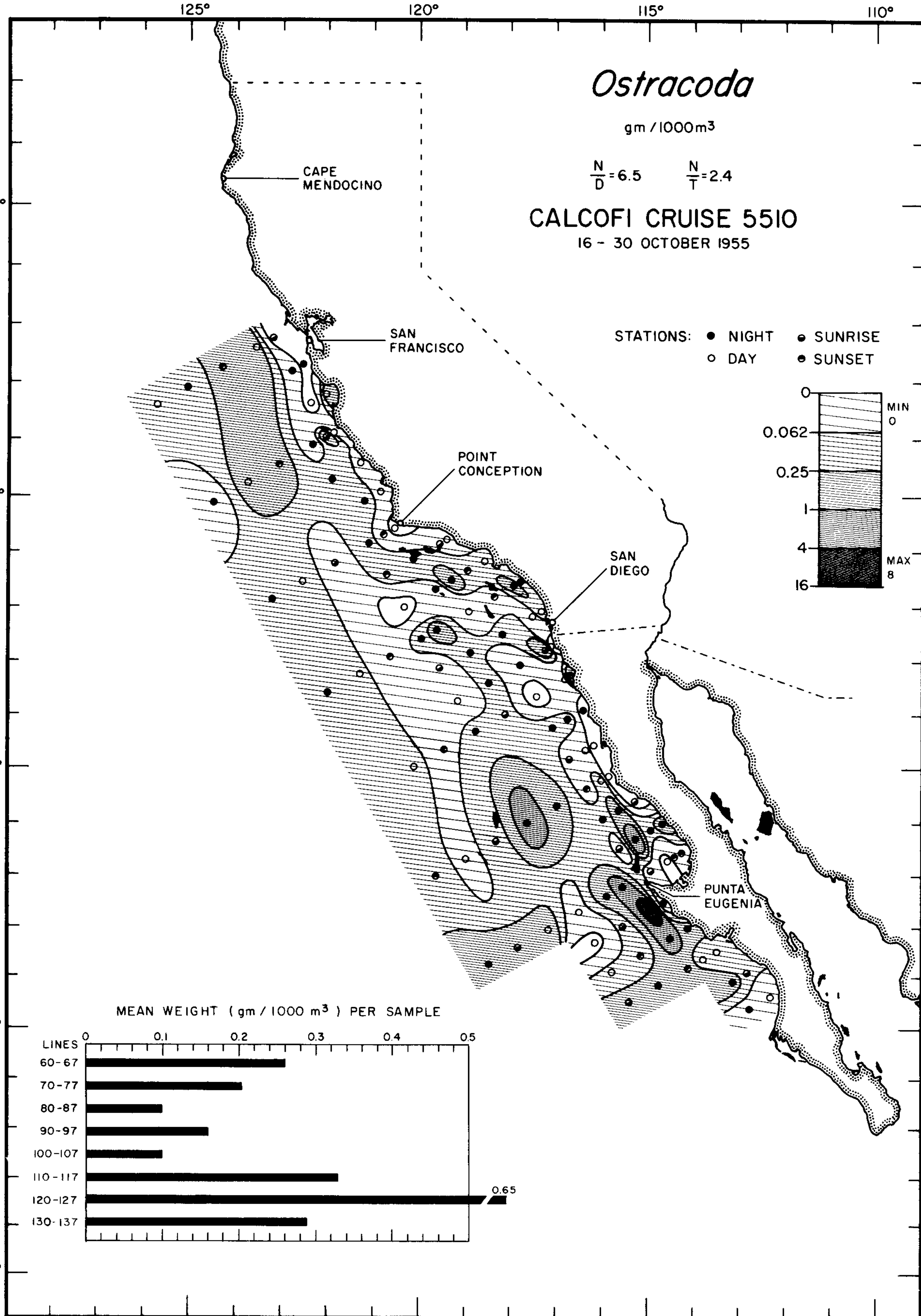
5904



Biomass

Ostracoda, adjusted

5904



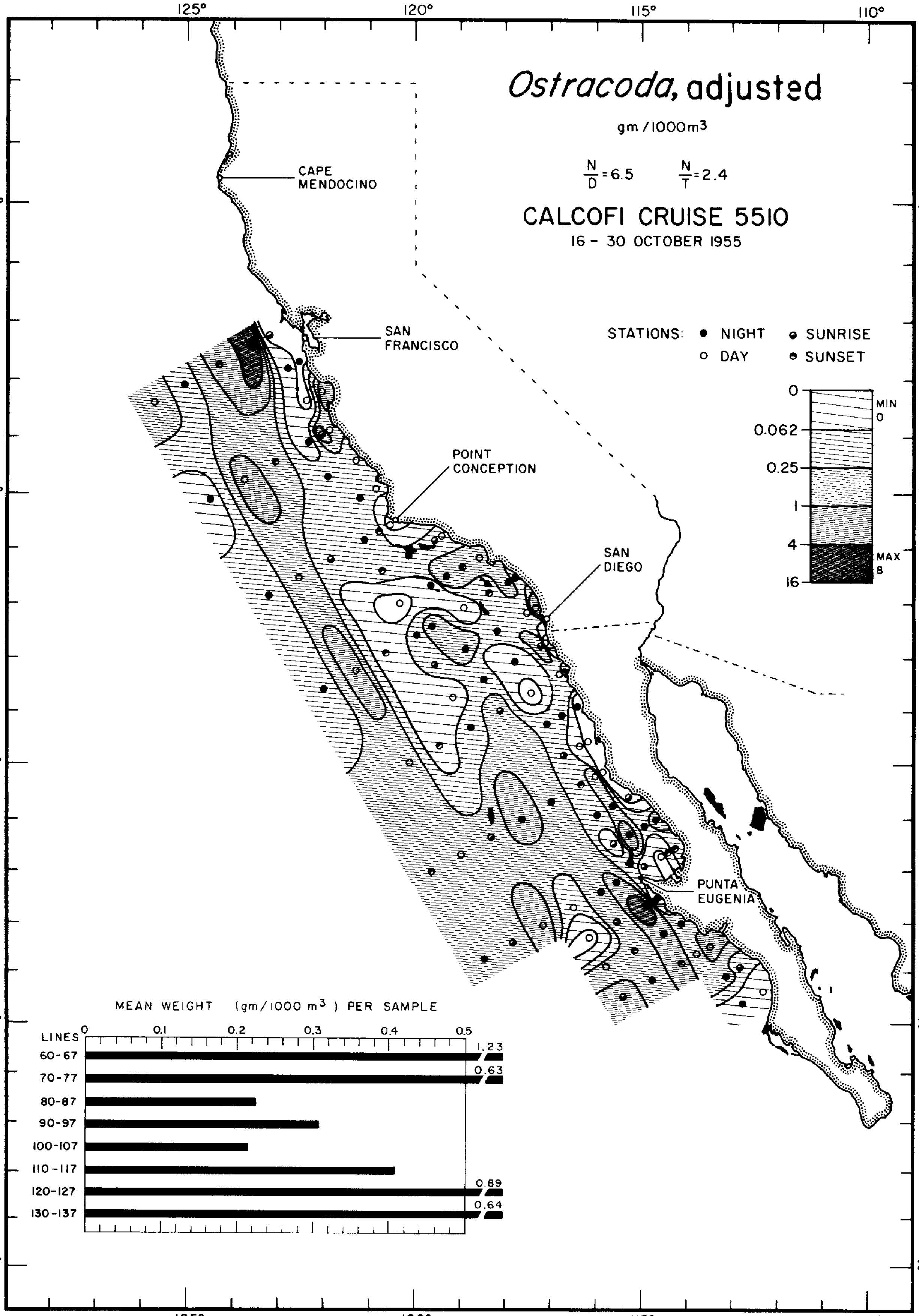
0.2 % 100

29 gm/1000m3 12344

Biomass

Ostracoda

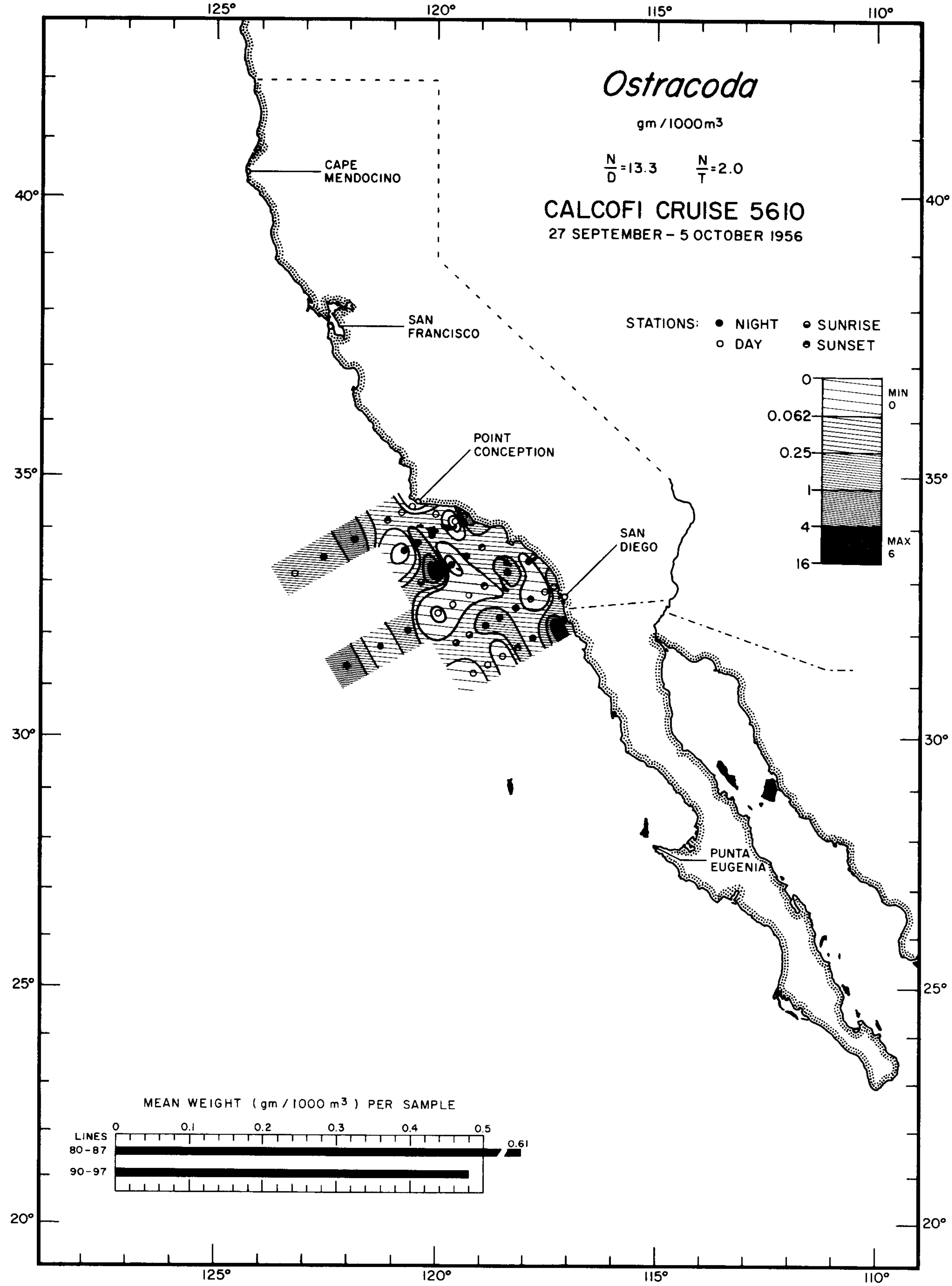
5510

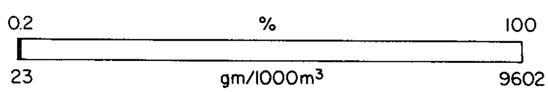


Biomass

Ostracoda, adjusted

5510

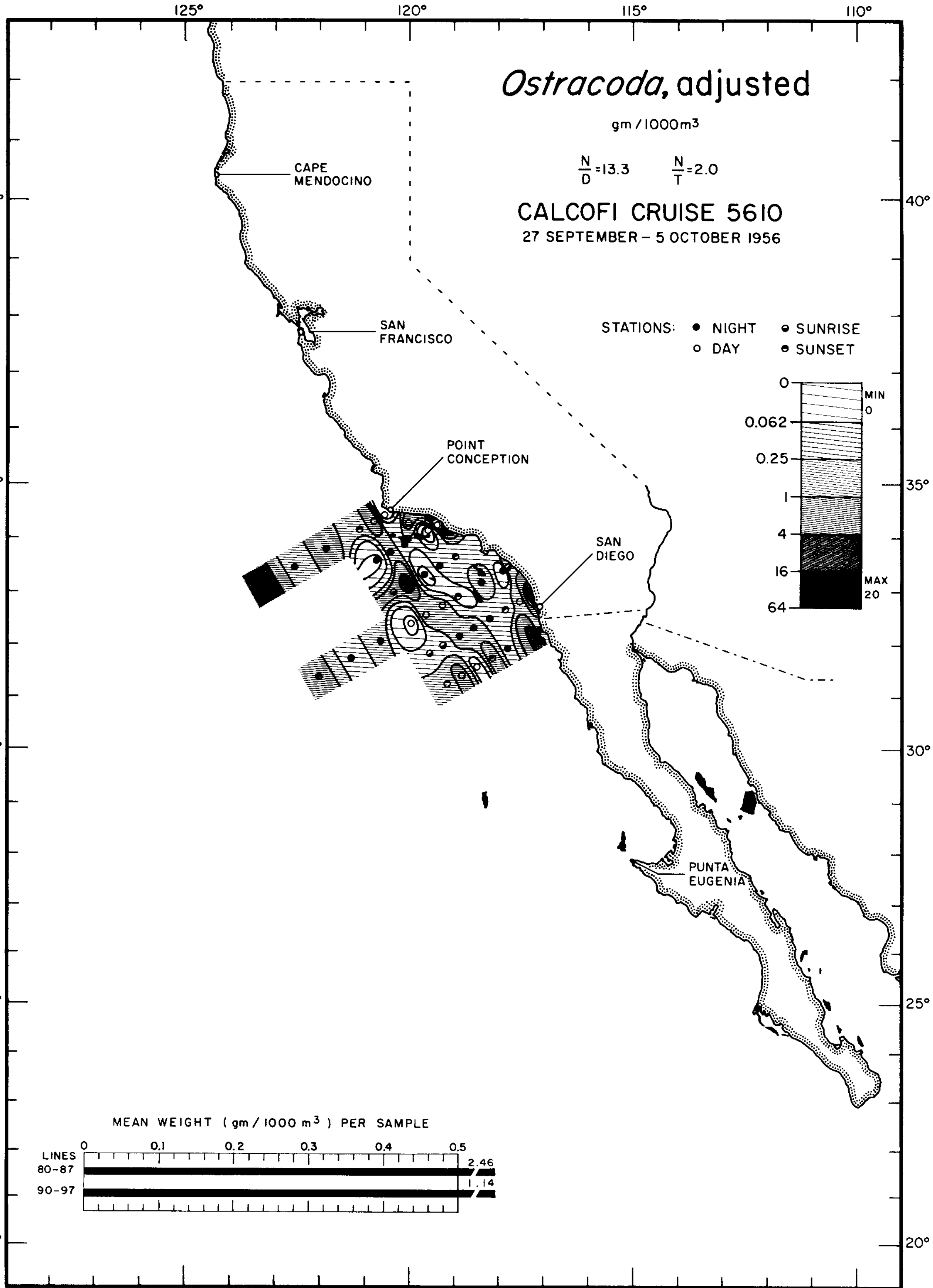




Biomass

Ostracoda

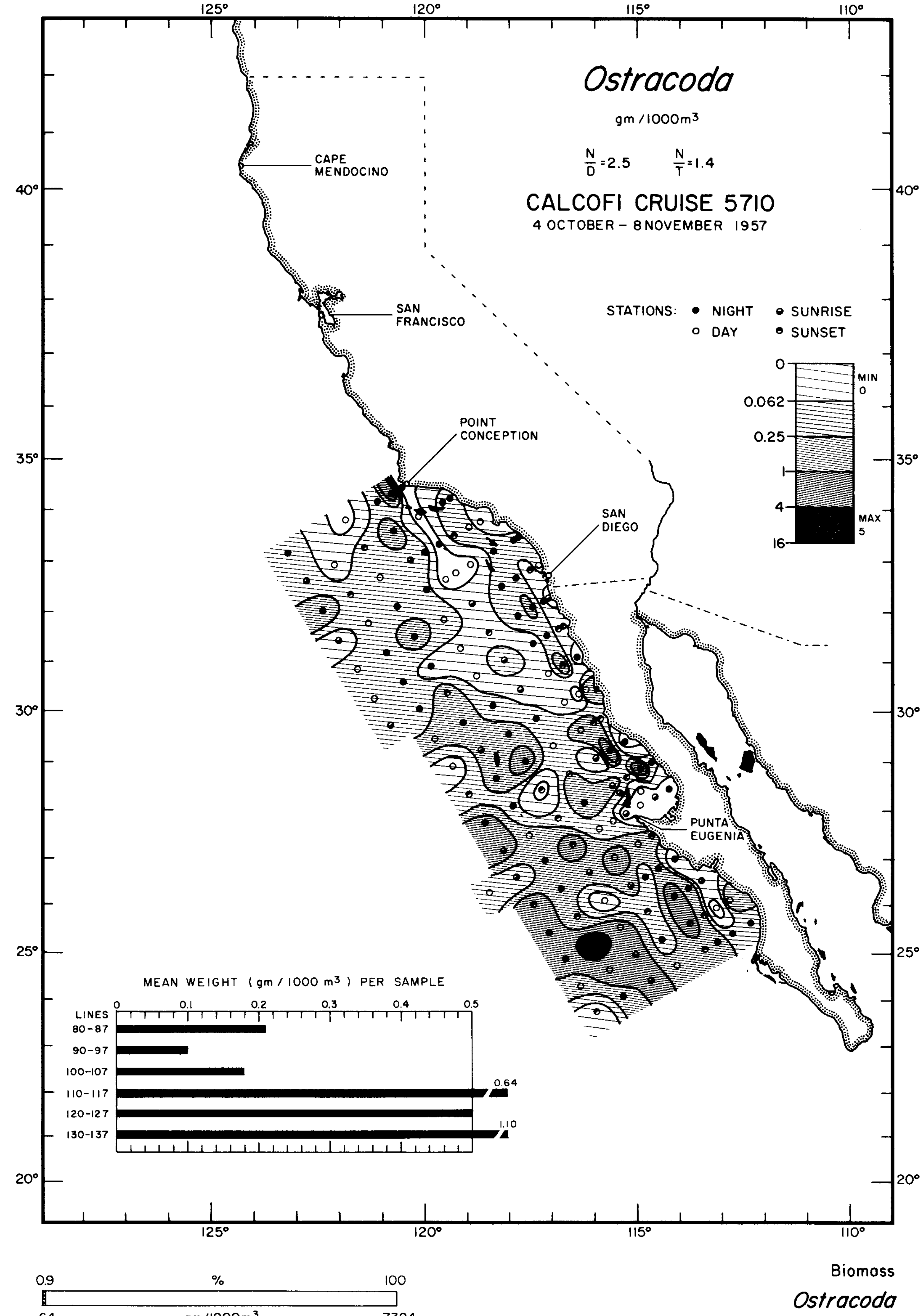
5610



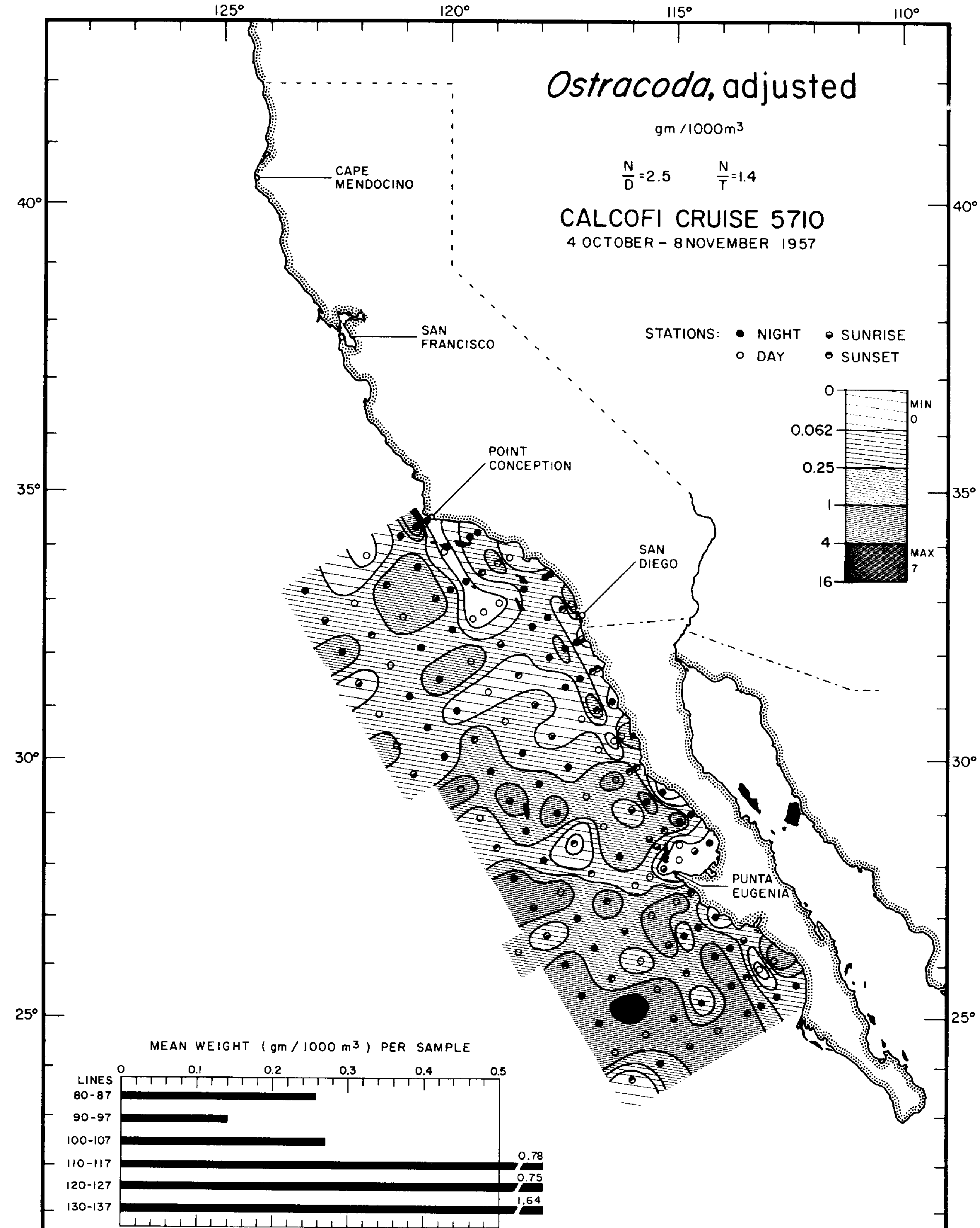
Biomass

Ostracoda, adjusted

5610



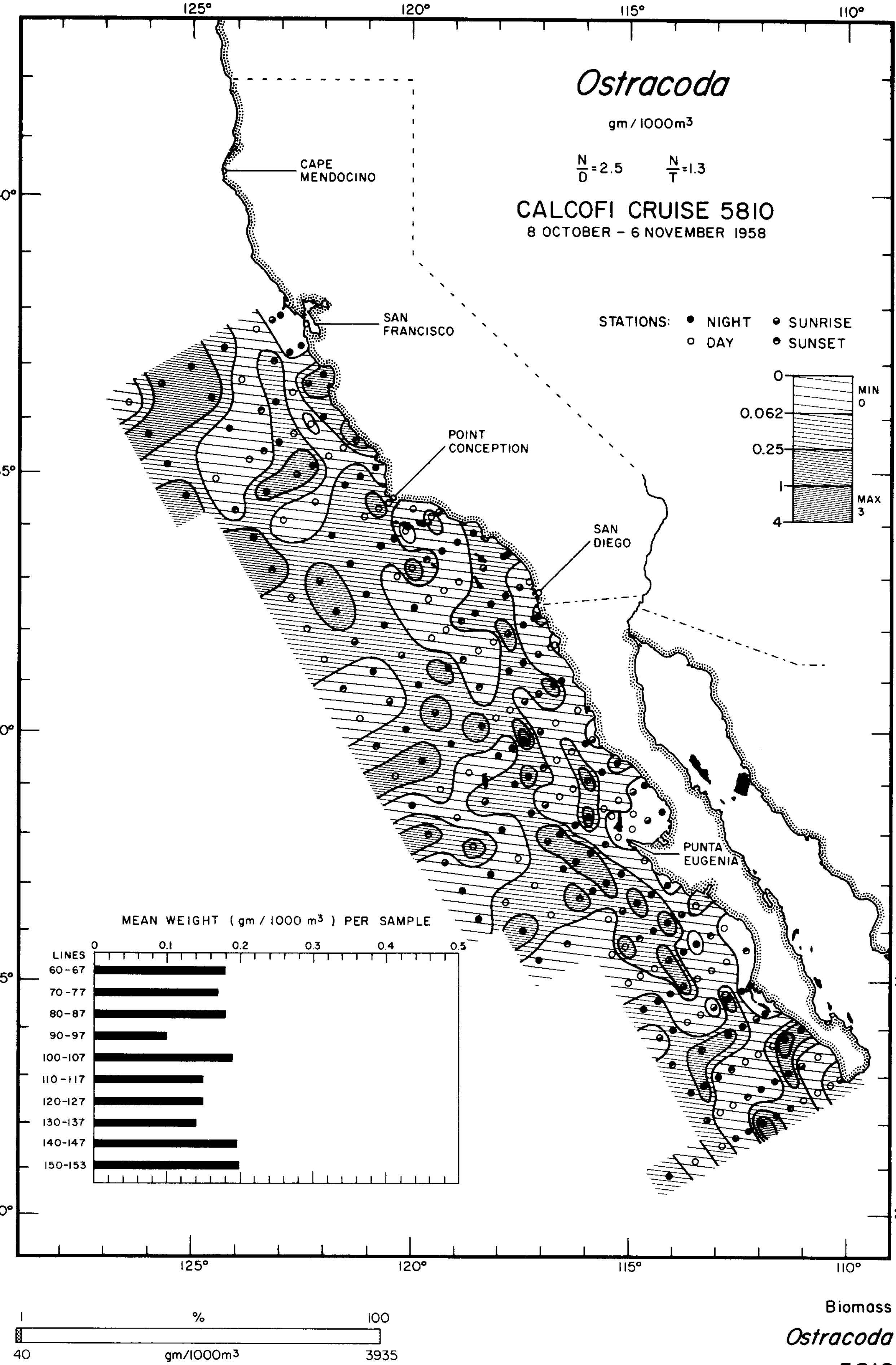
Biomass
Ostracoda
5710



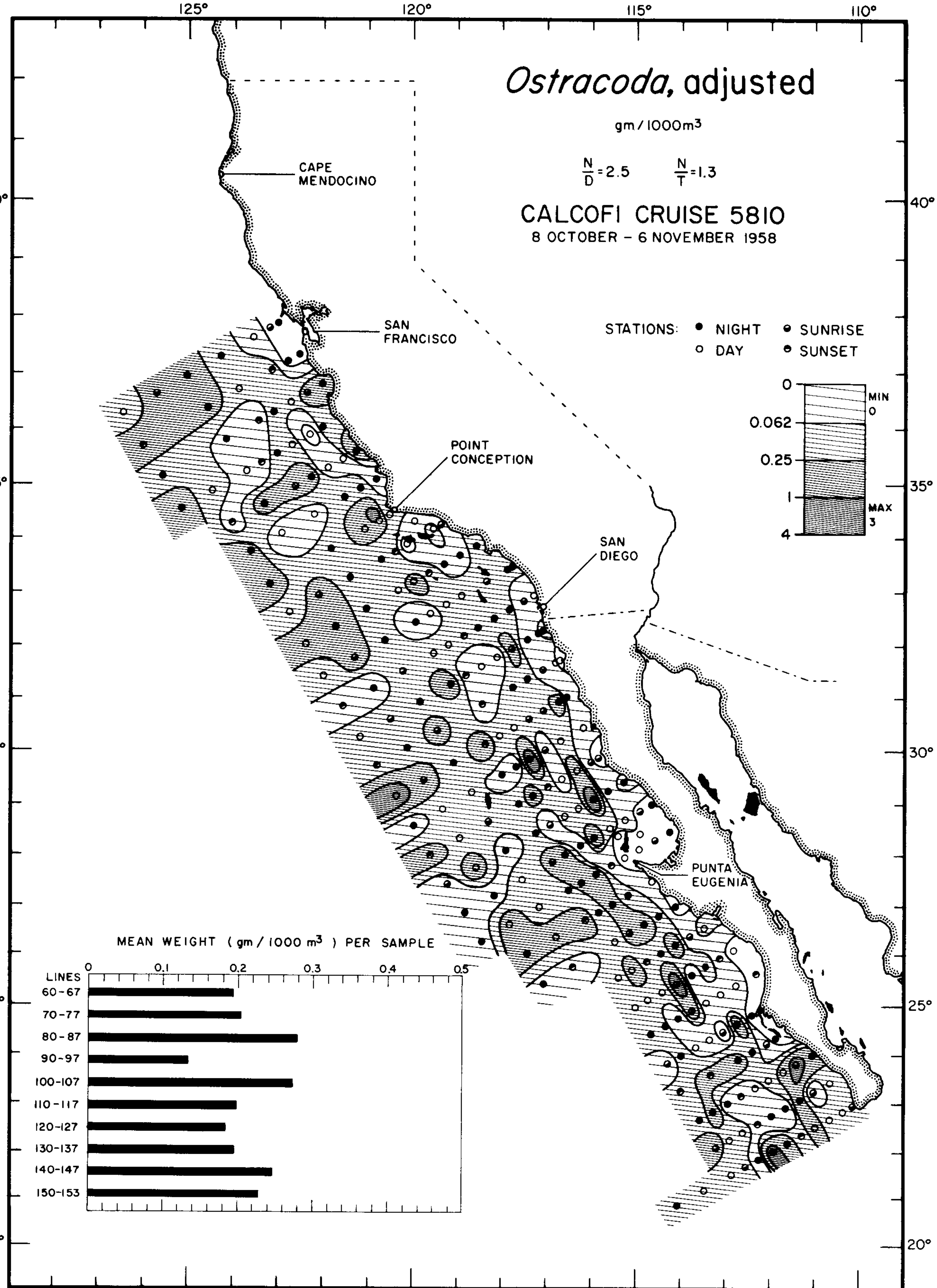
Biomass

Ostracoda, adjusted

5710



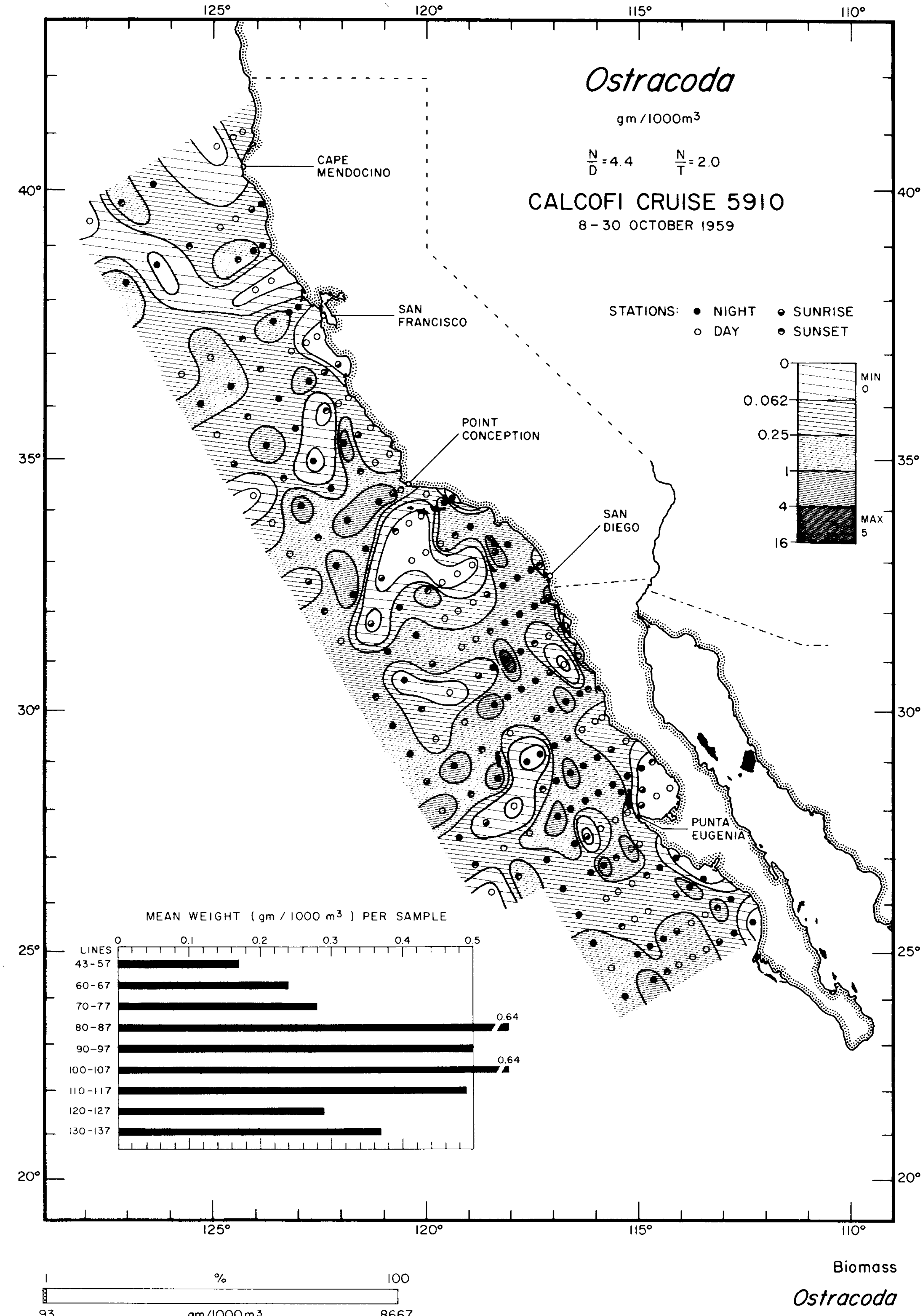
Biomass
Ostracoda
5810



Biomass

Ostracoda, adjusted

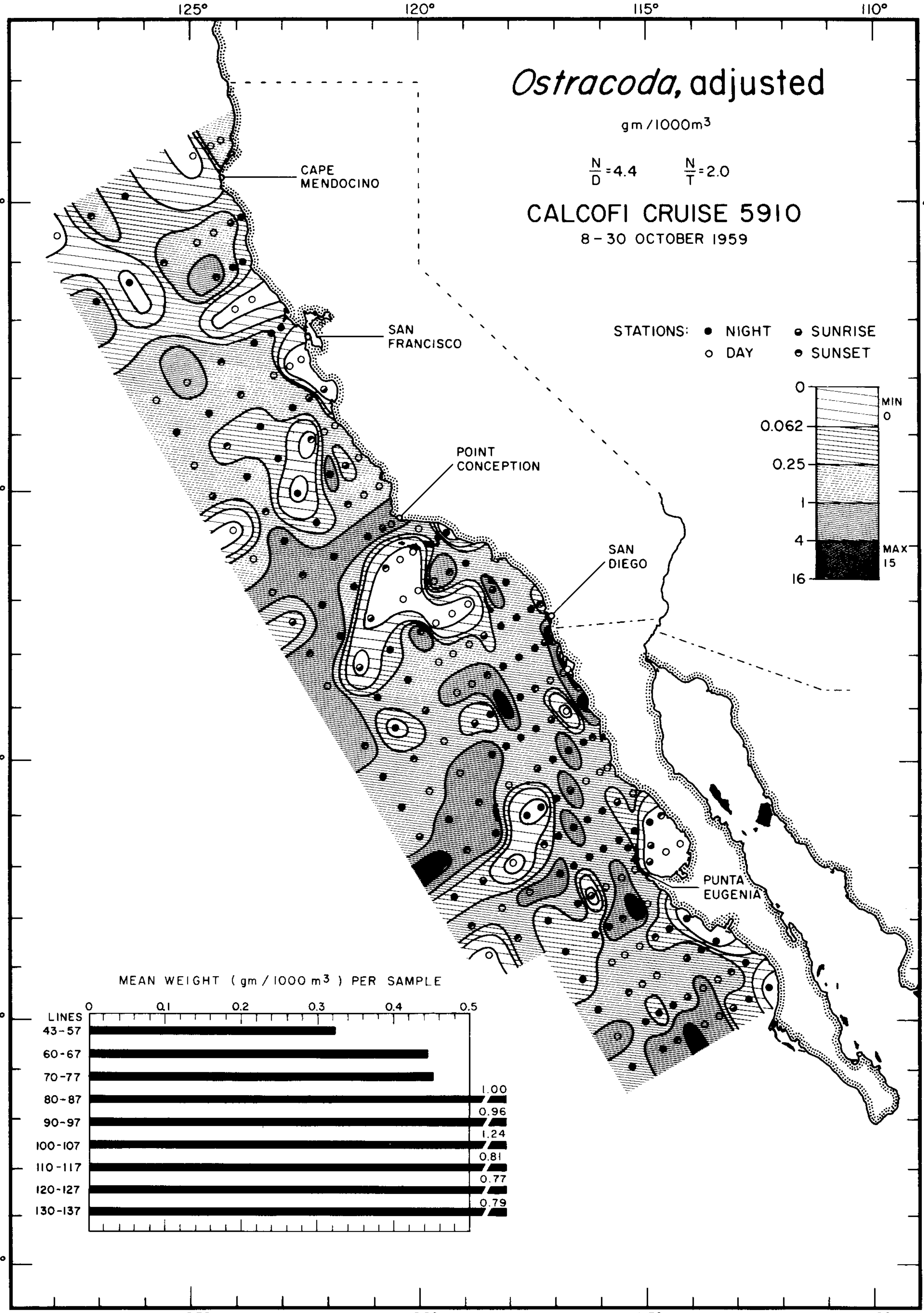
5810



Biomass

Ostracoda

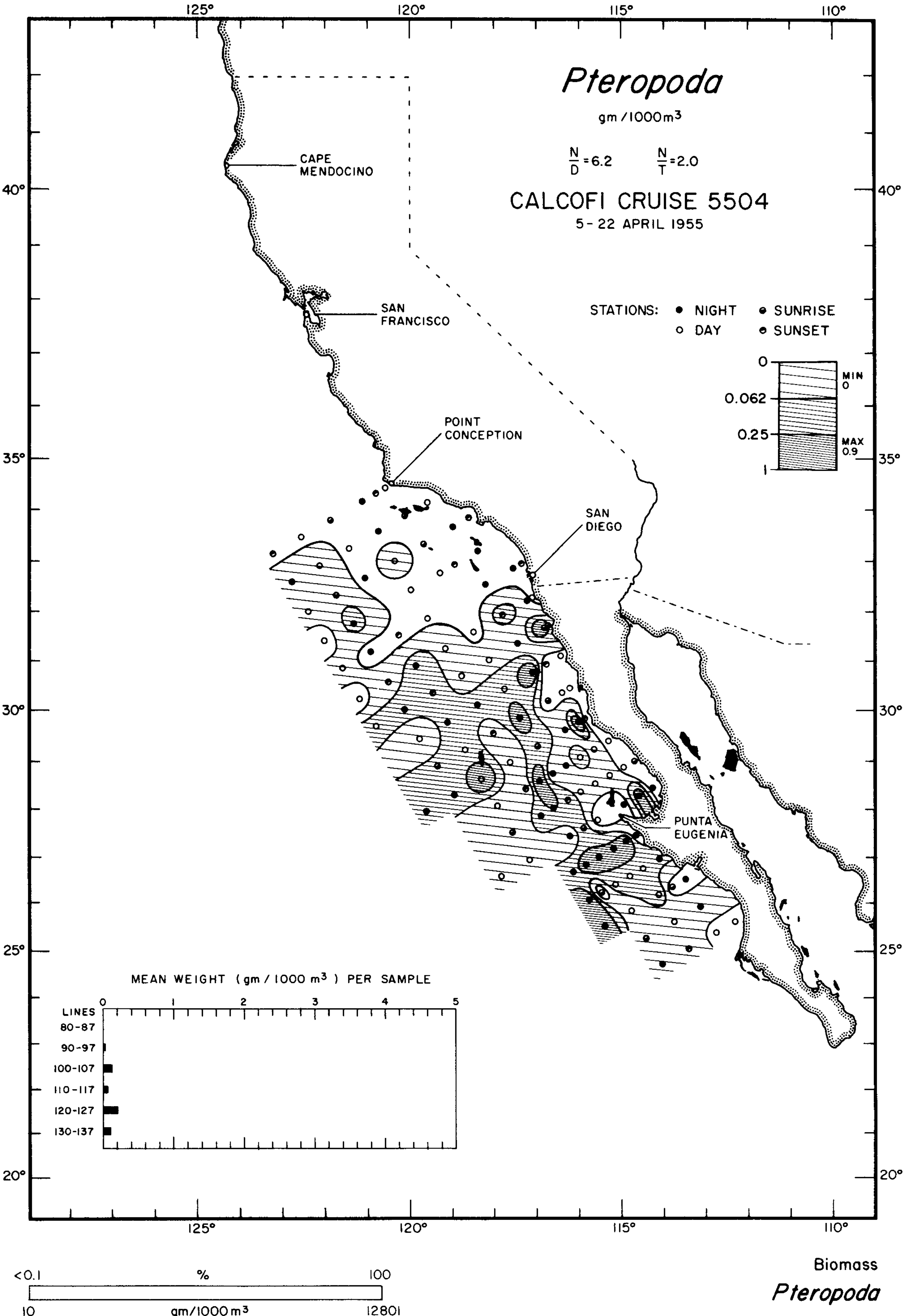
5910



Biomass

Ostracoda, adjusted

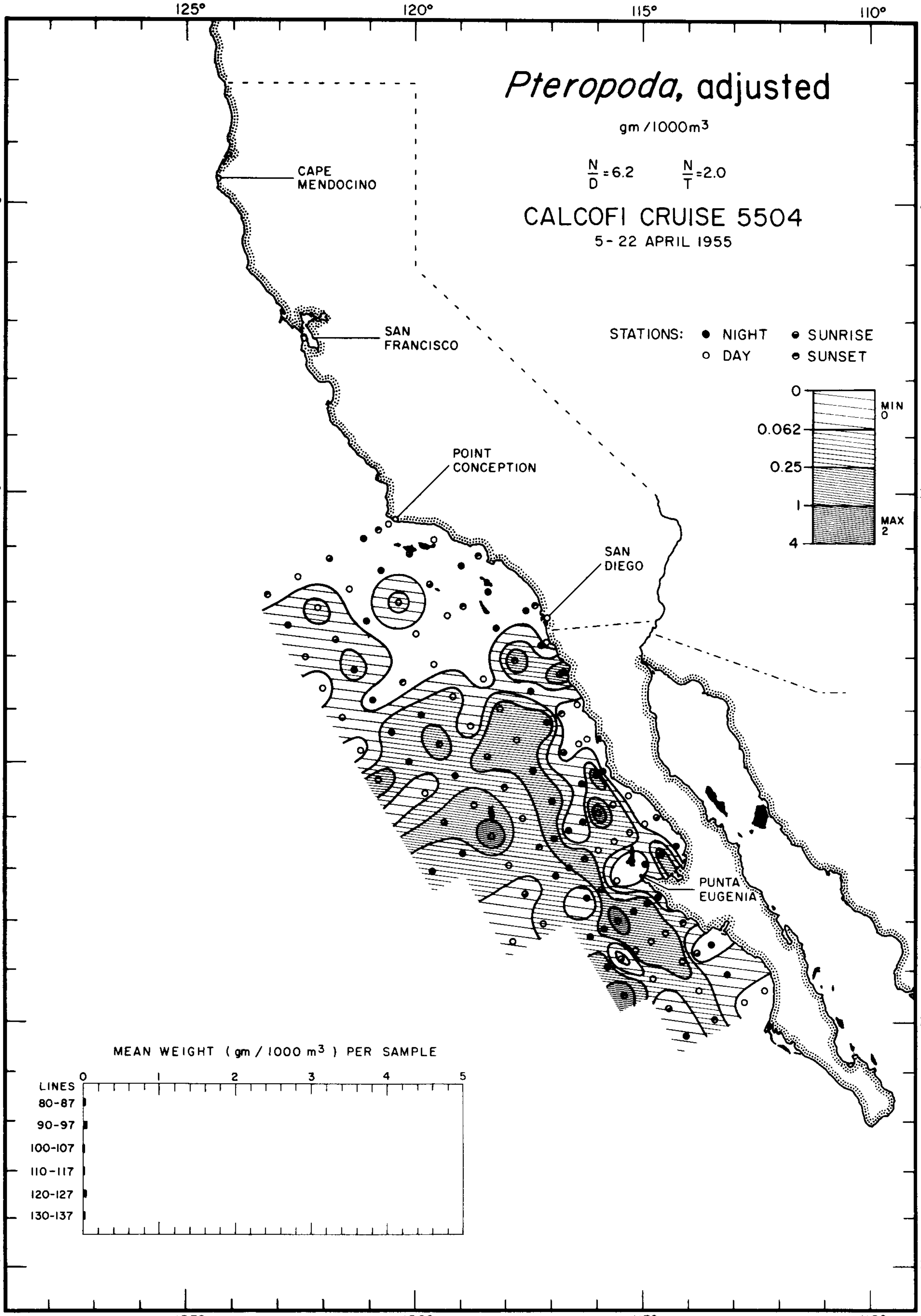
5910



Biomass

Pteropoda

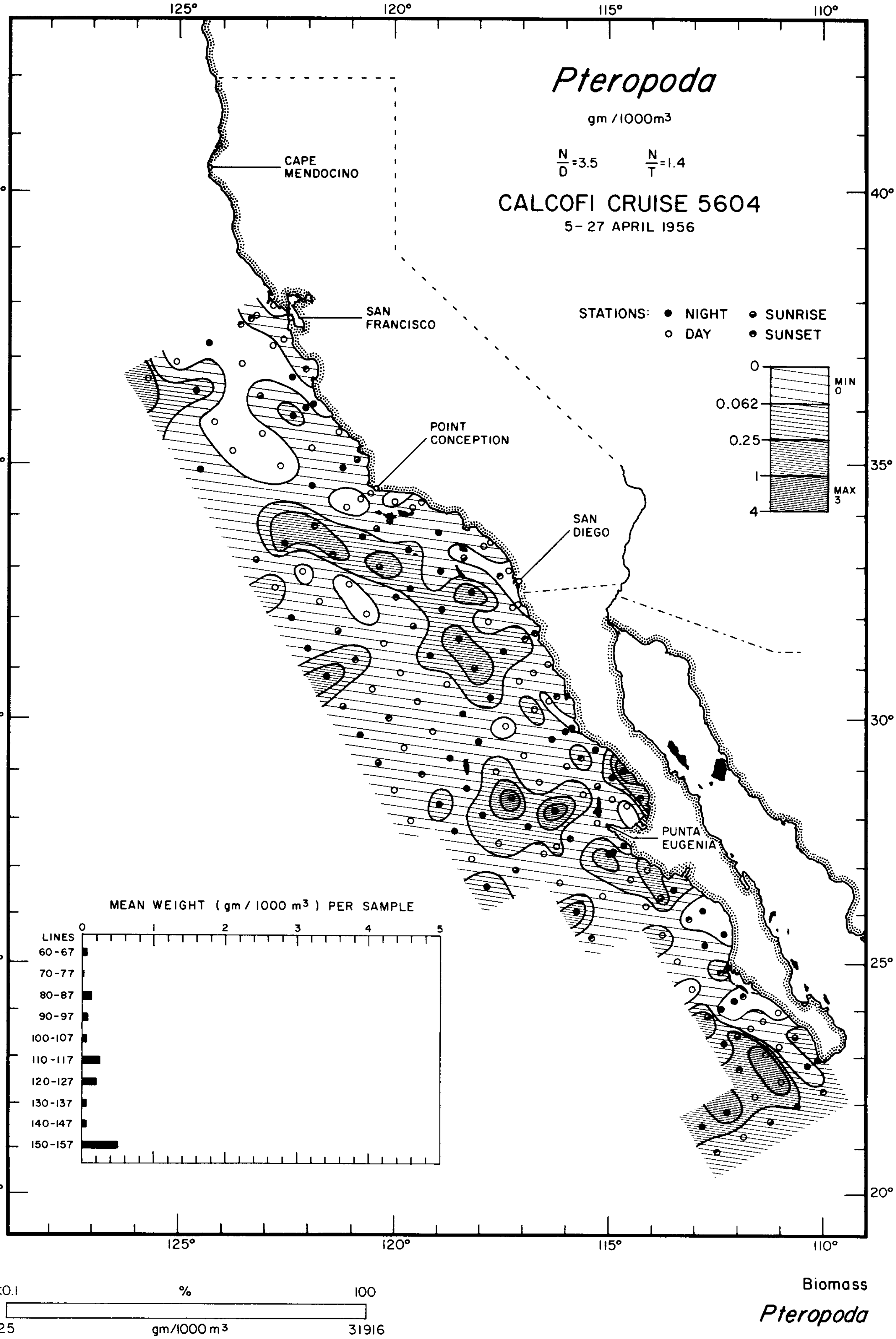
5504



Biomass

Pteropoda, adjusted

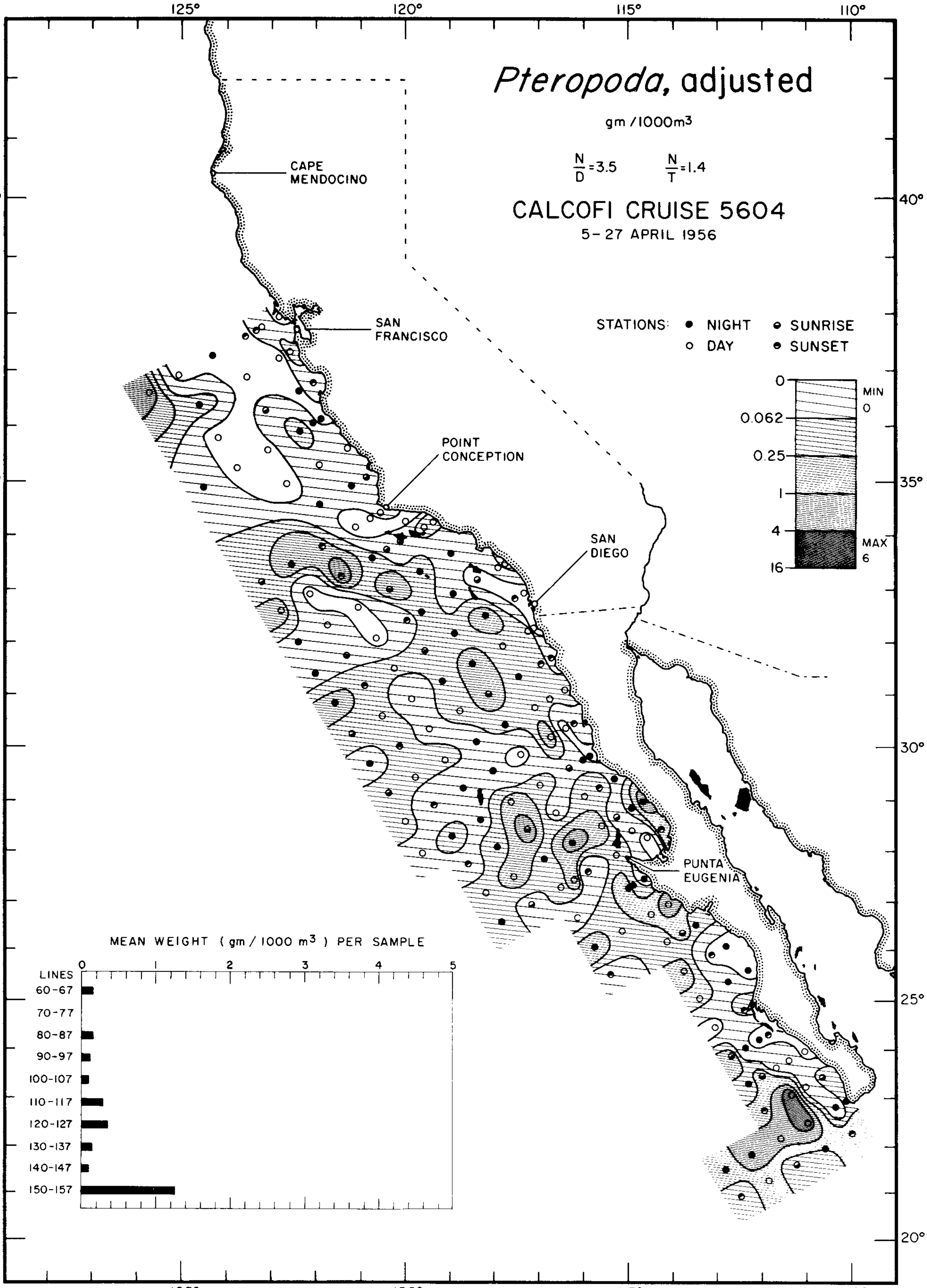
5504



Biomass

Pteropoda

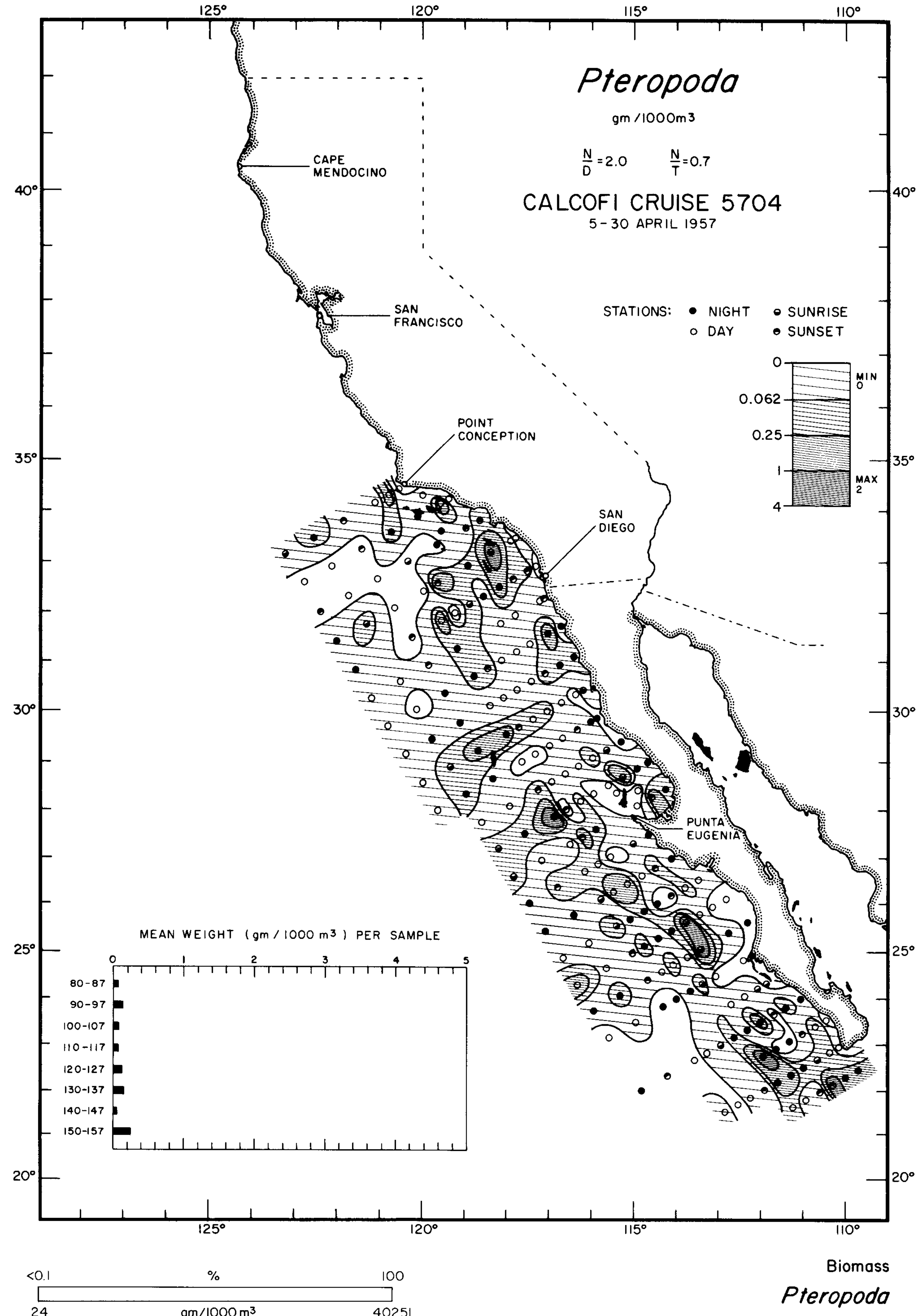
5604



Biomass

Pteropoda, adjusted

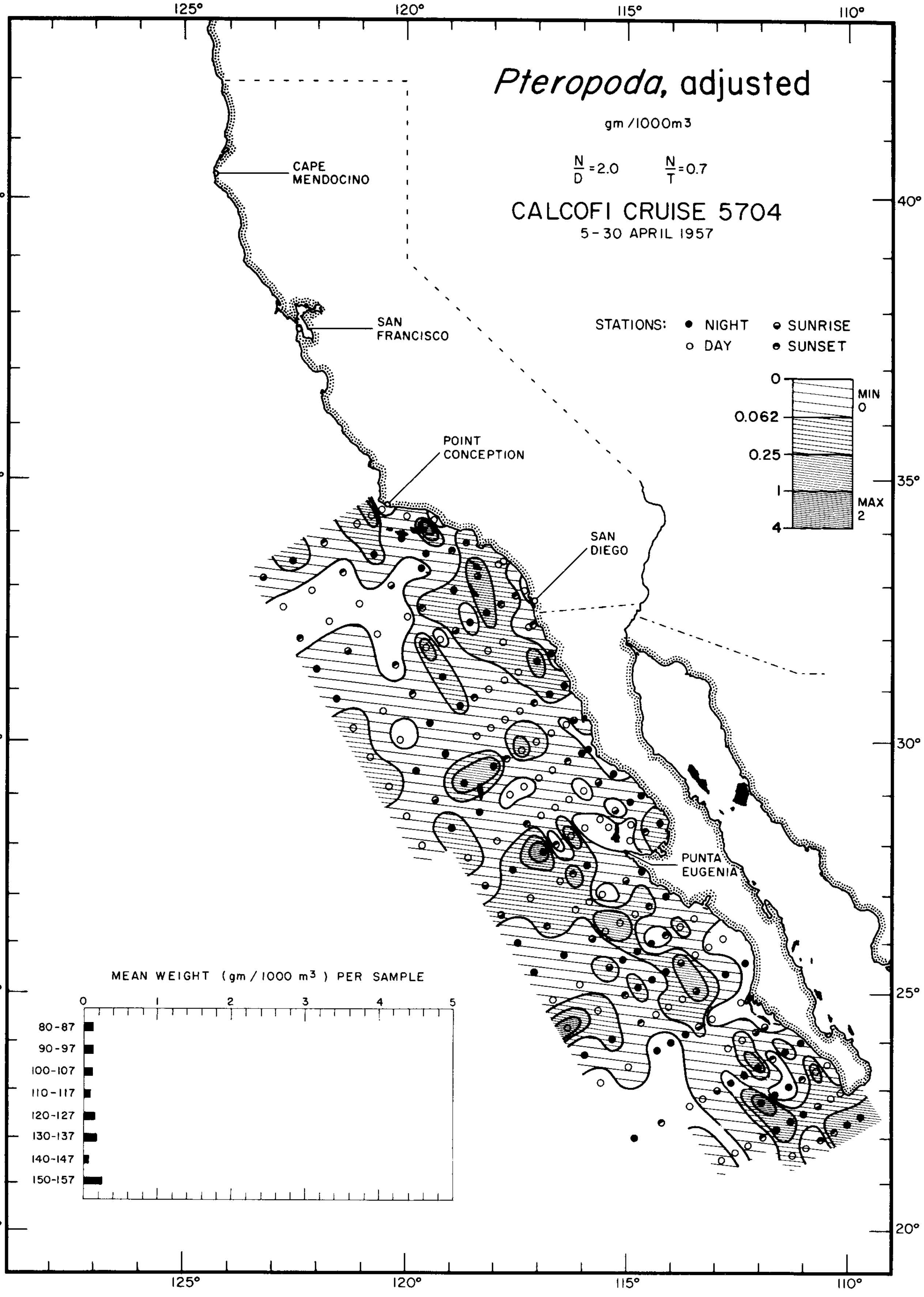
5604



Biomass

Pteropoda

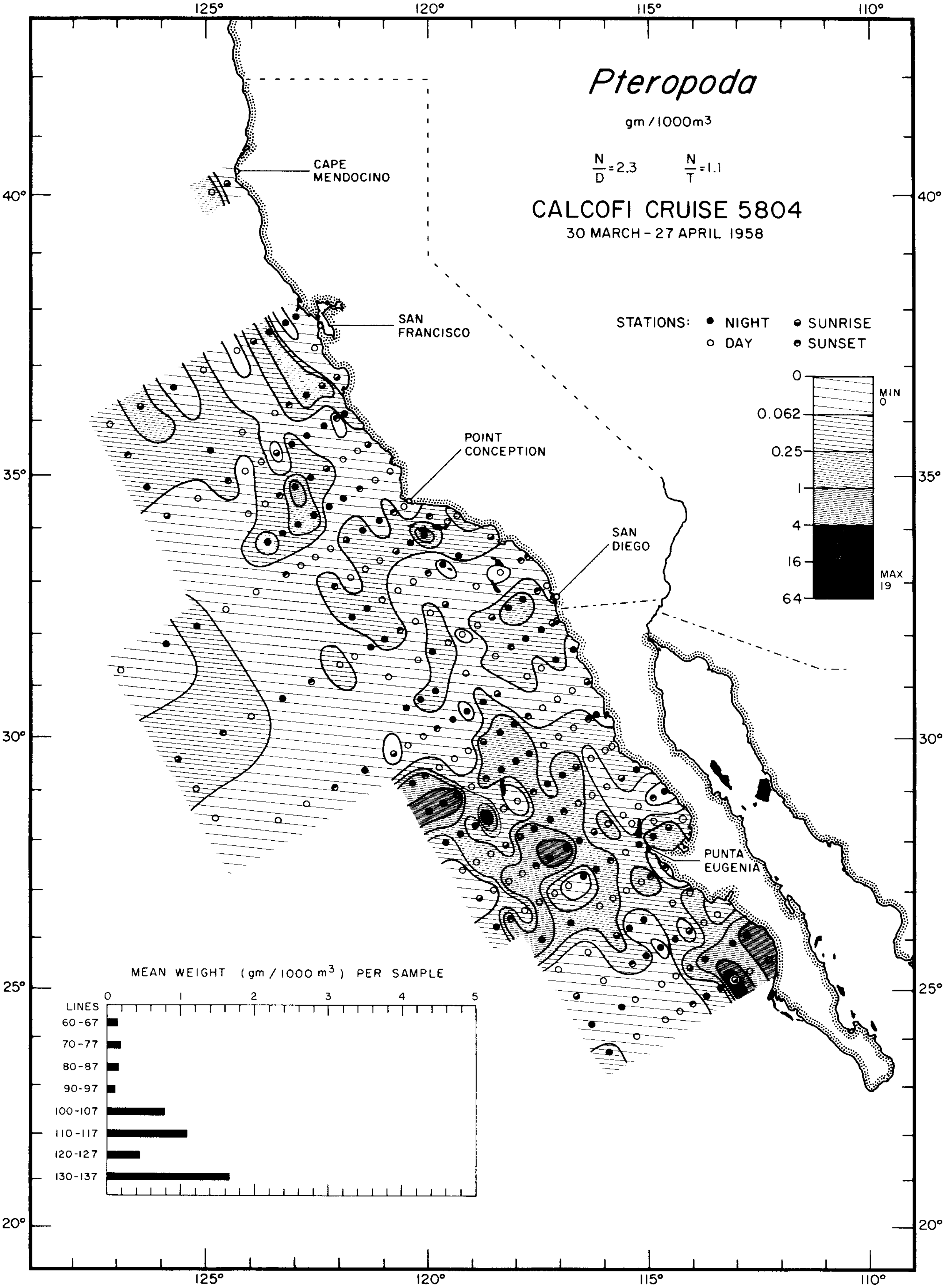
5704

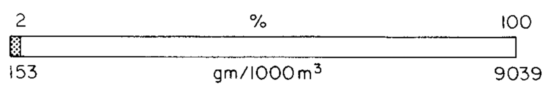


Biomass

Pteropoda, adjusted

5704

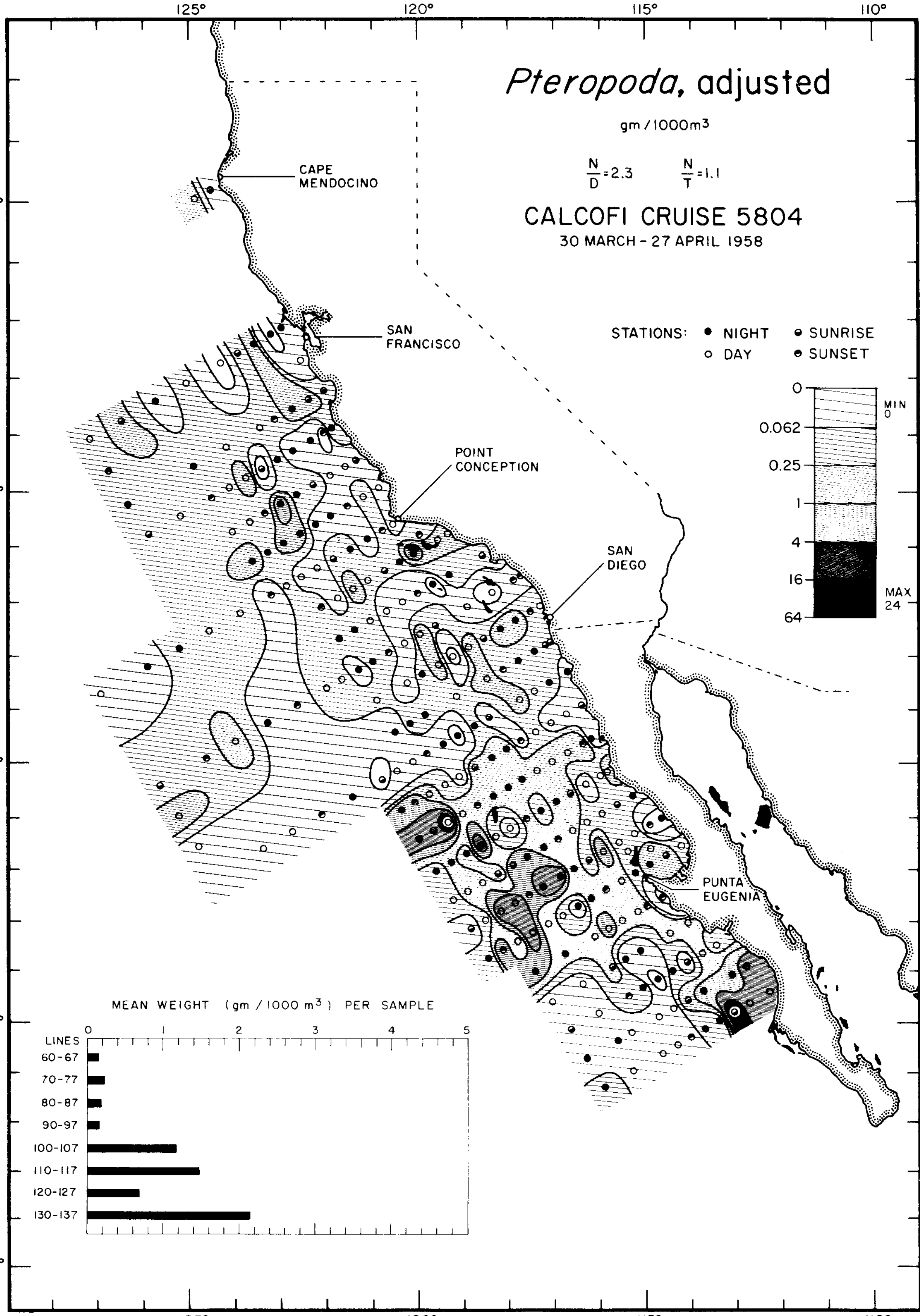




Biomass

Pteropoda

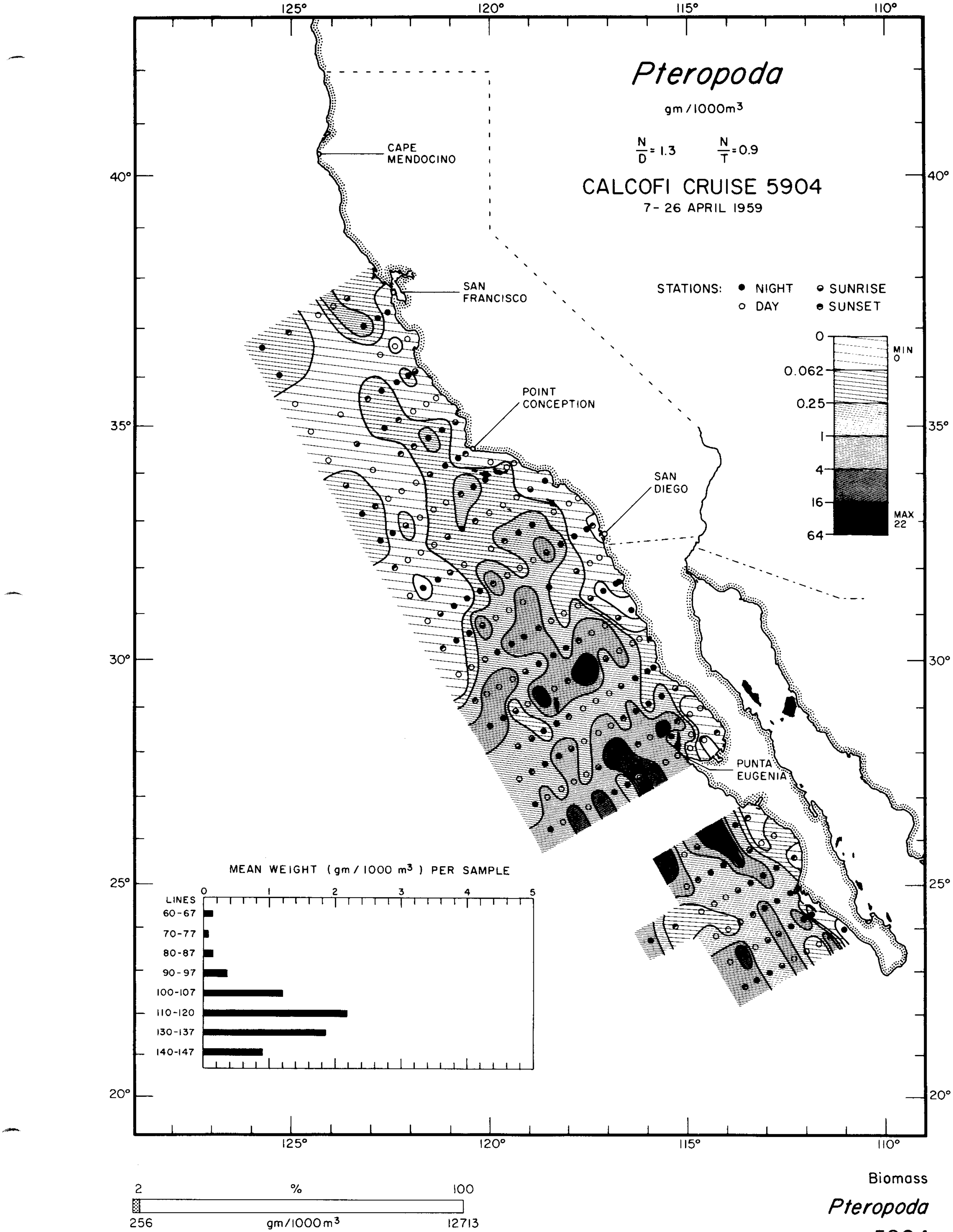
5804



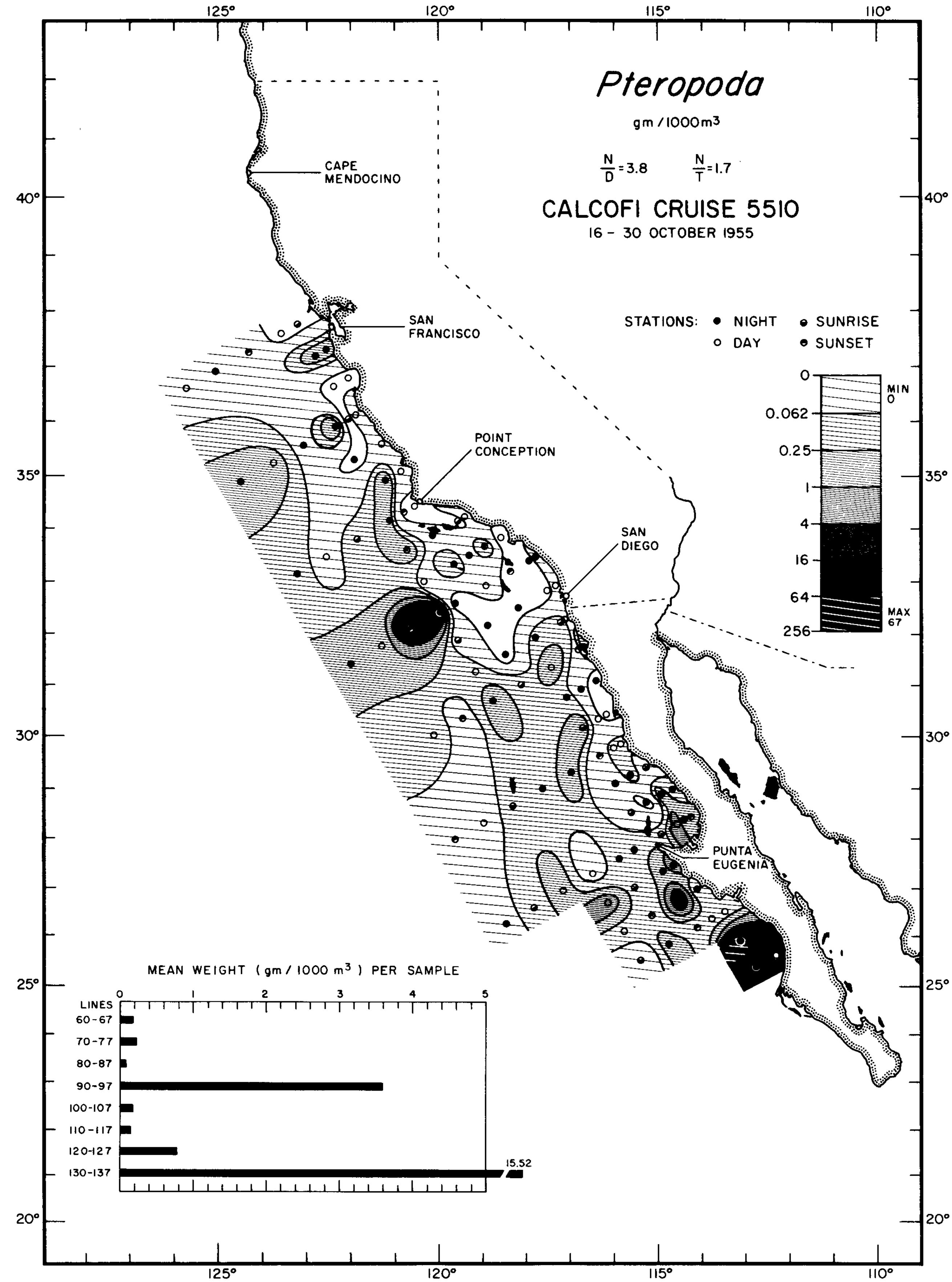
Biomass

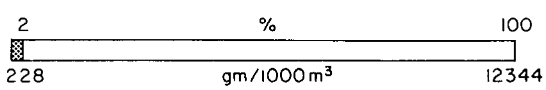
Pteropoda, adjusted

5804



Biomass
Pteropoda
5904

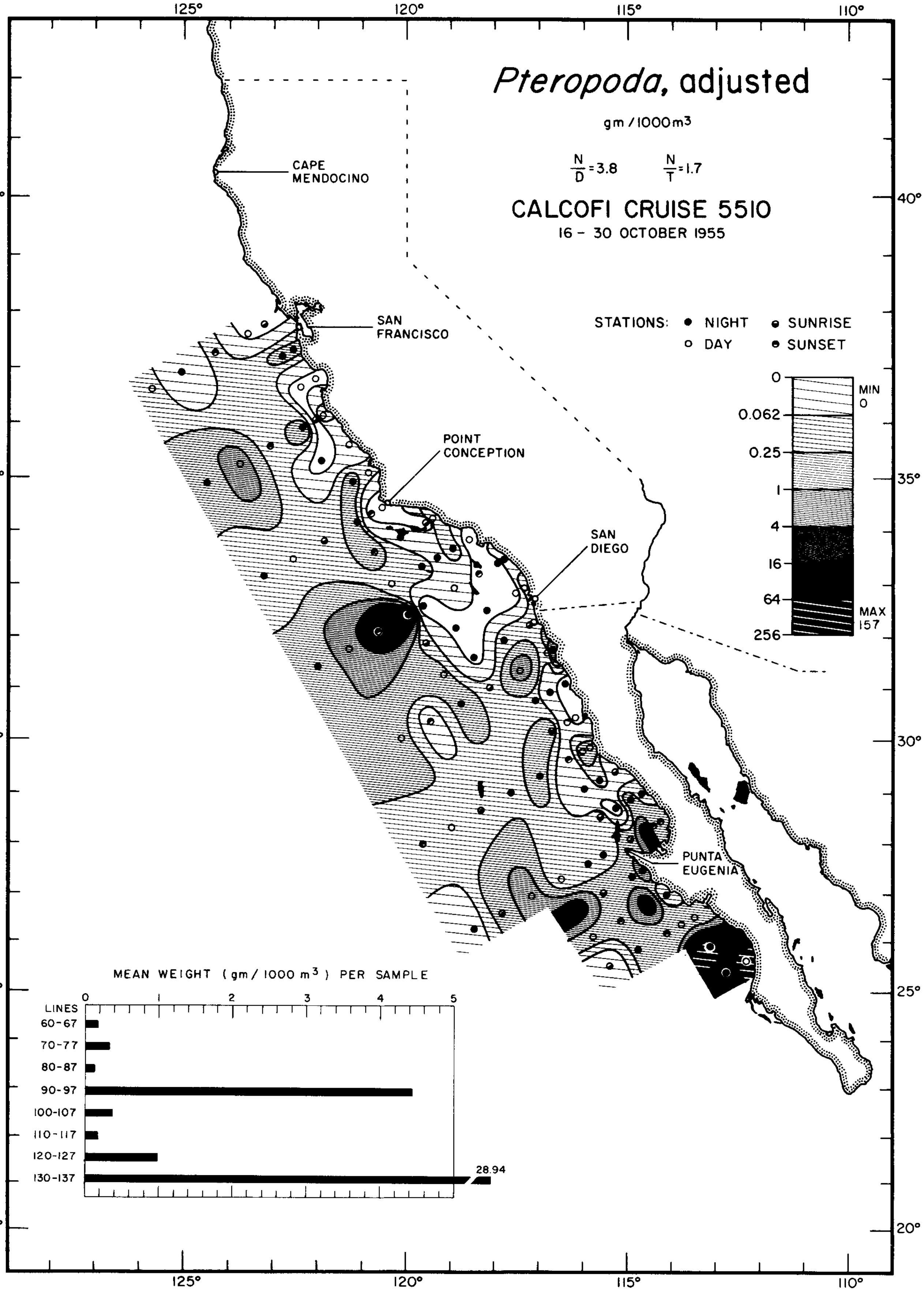




Biomass

Pteropoda

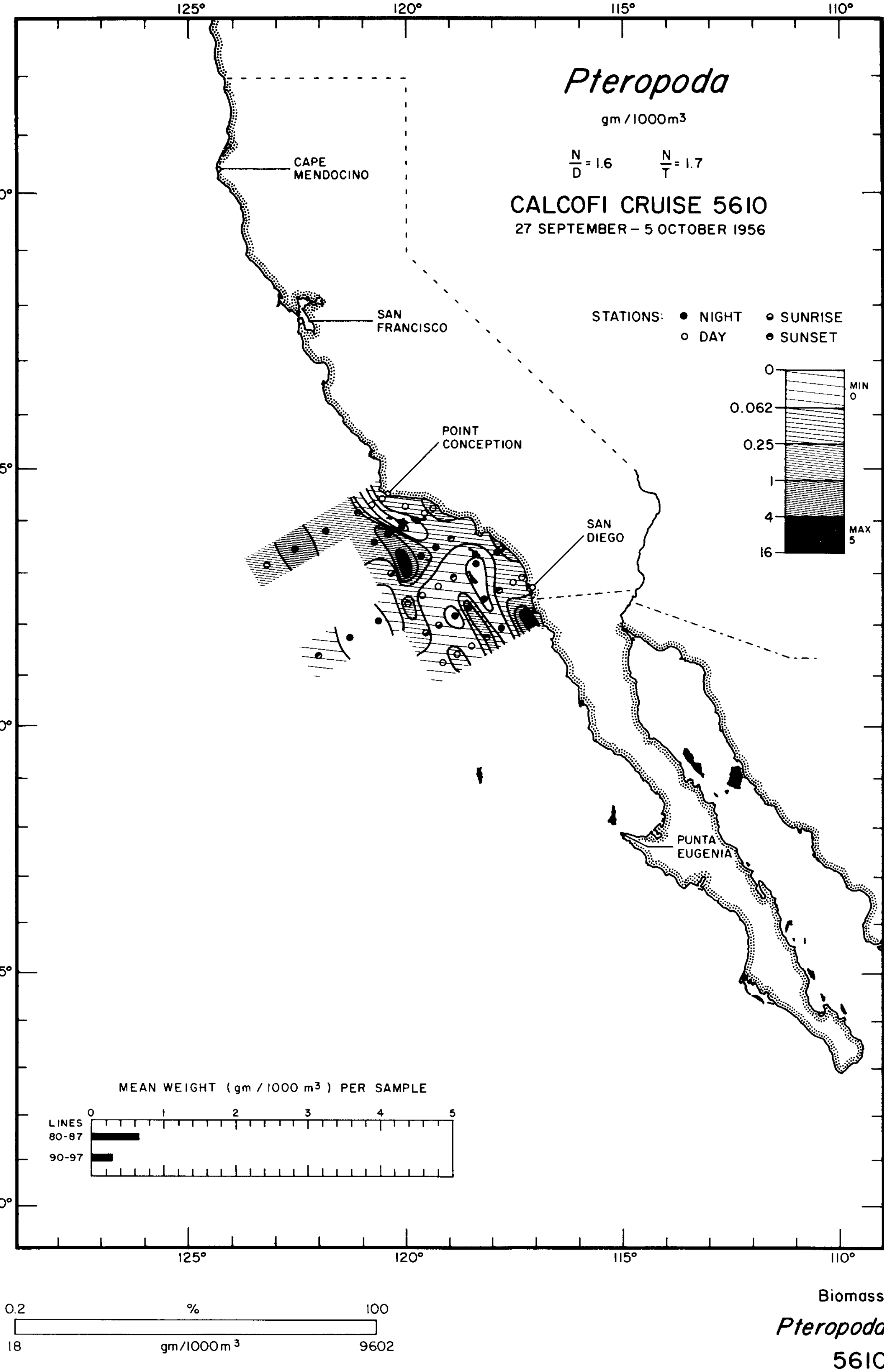
5510



Biomass

Pteropoda, adjusted

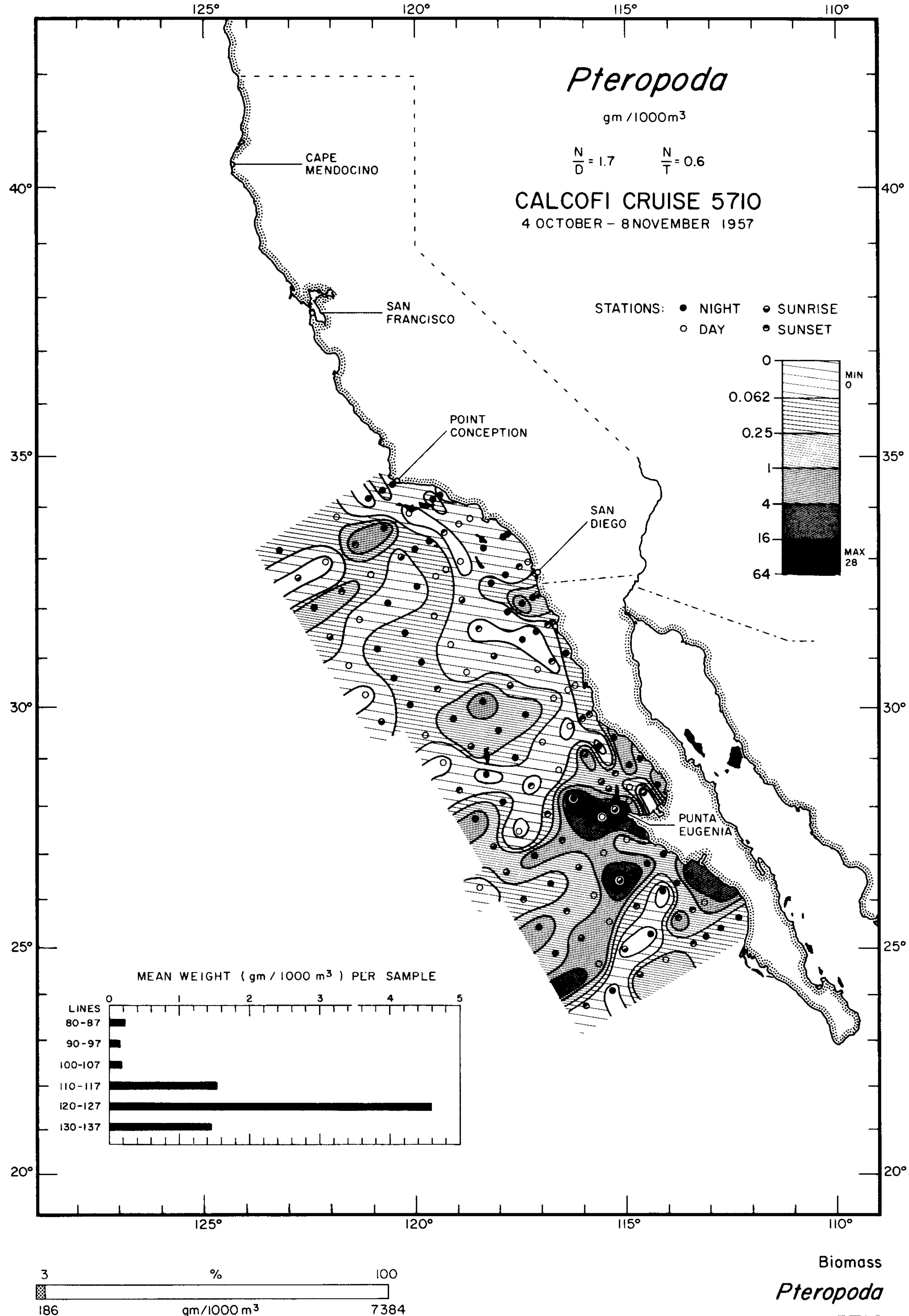
5510



Biomass

Pteropoda

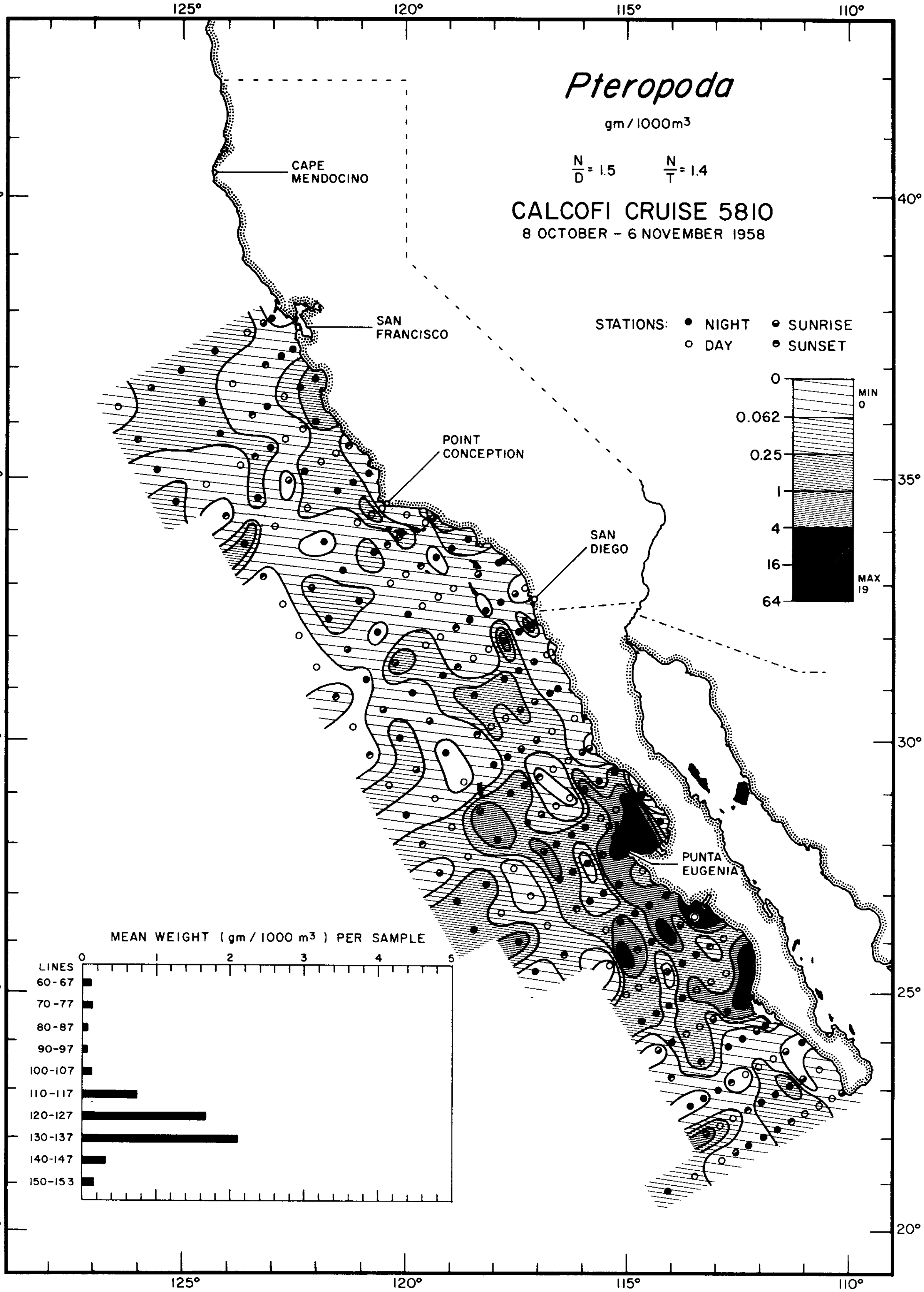
5610



Biomass

Pteropoda

5710



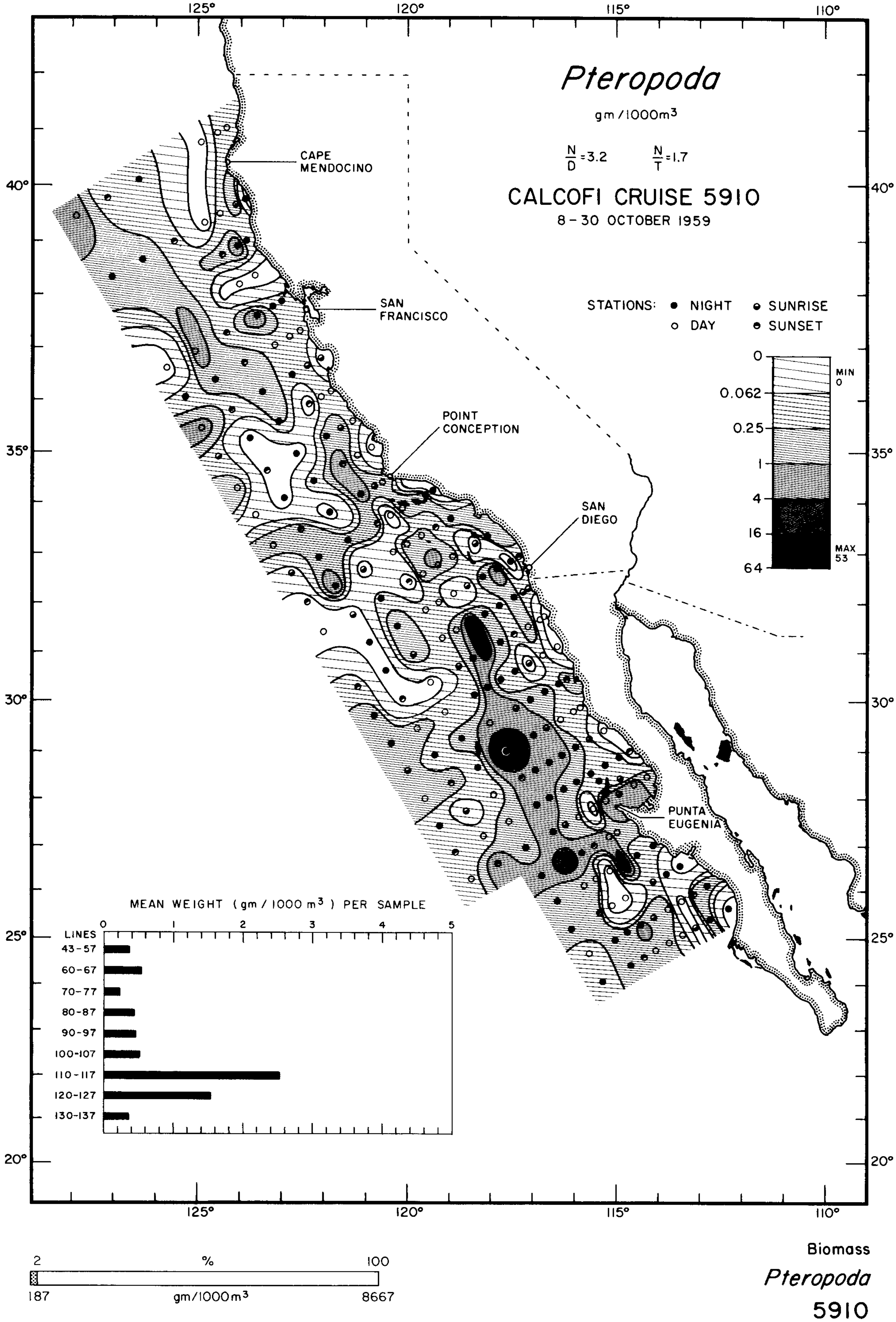
3 % 100

137 gm/1000 m³ 3935

Biomass

Pteropoda

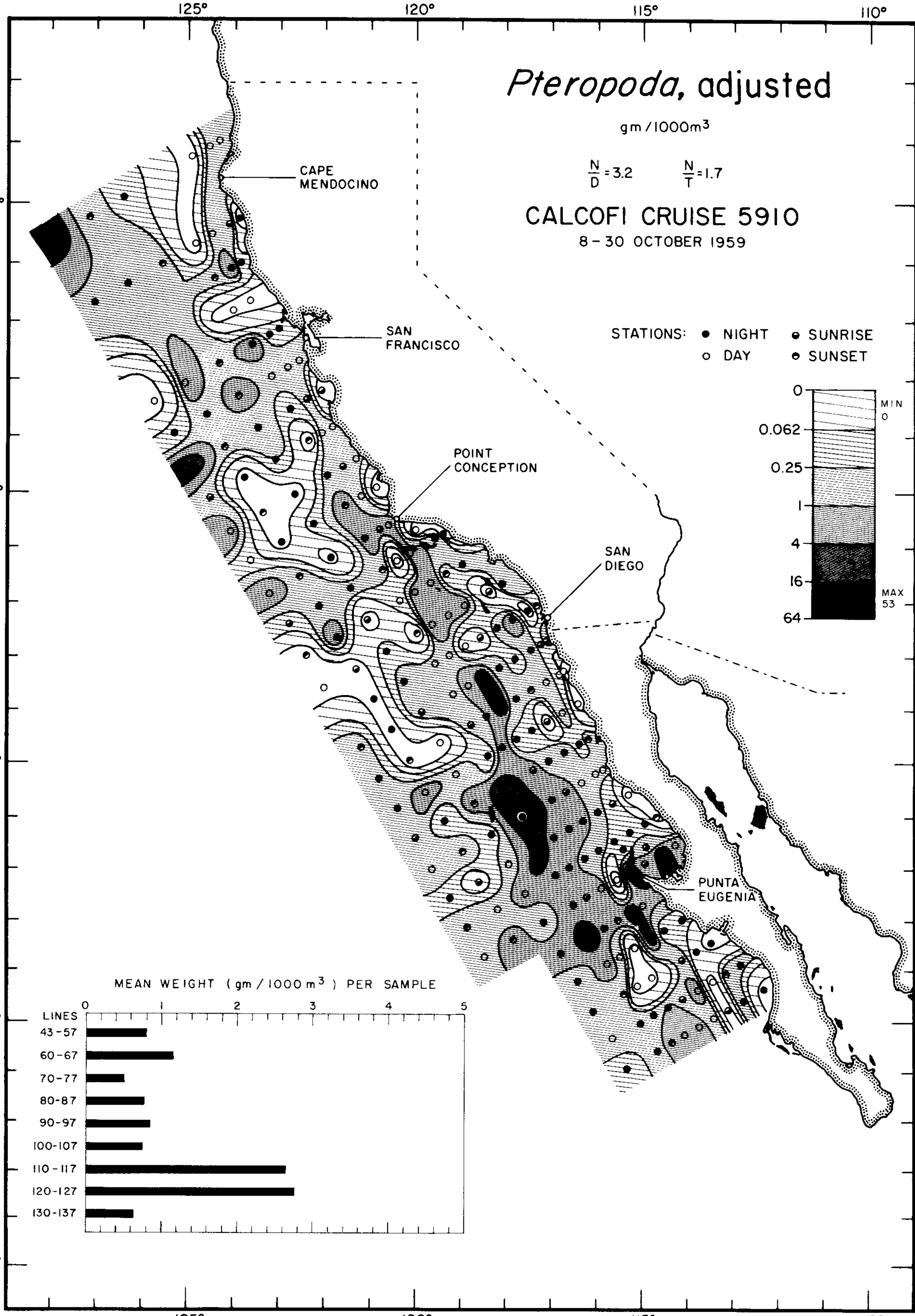
5810



Biomass

Pteropoda

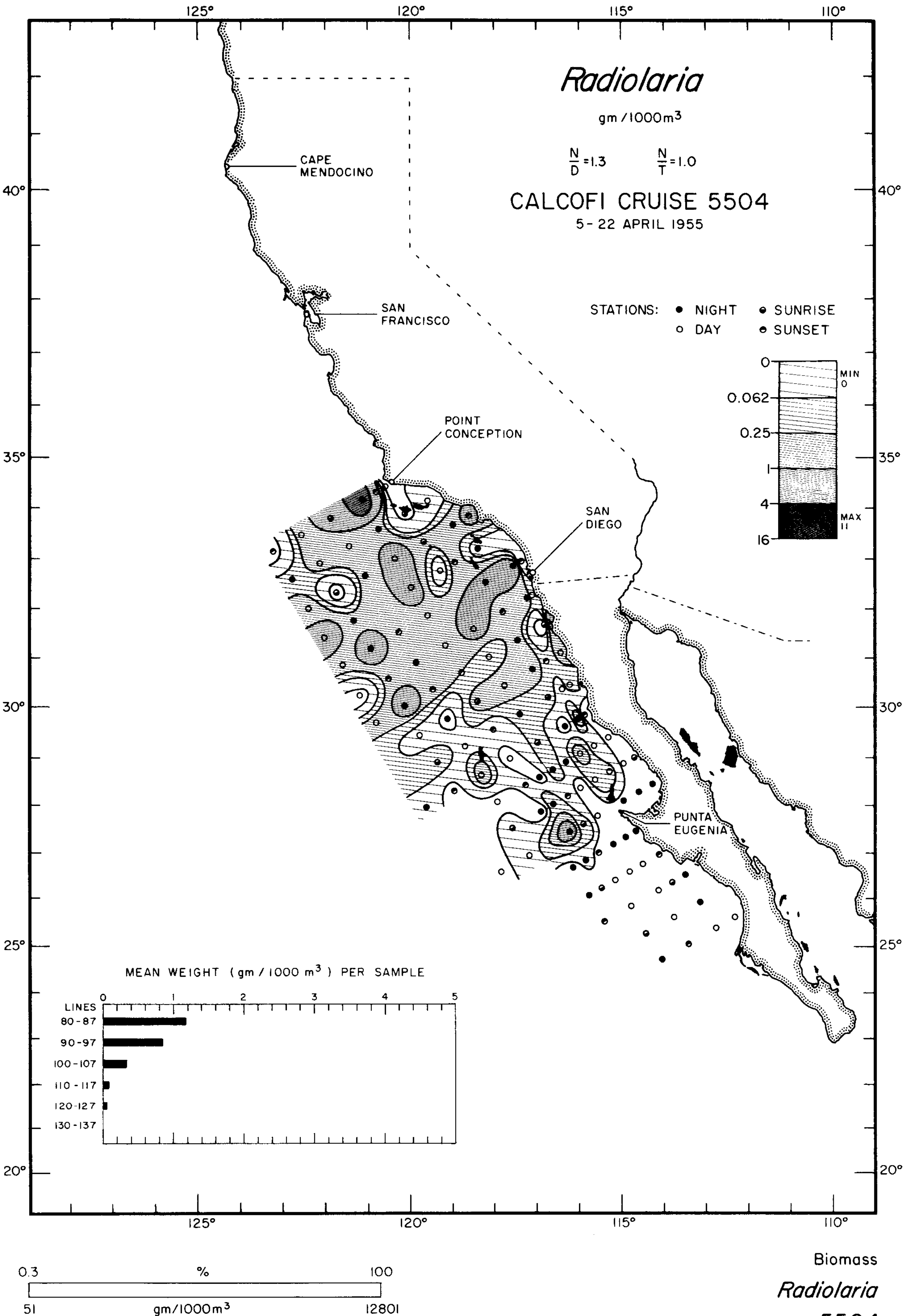
5910



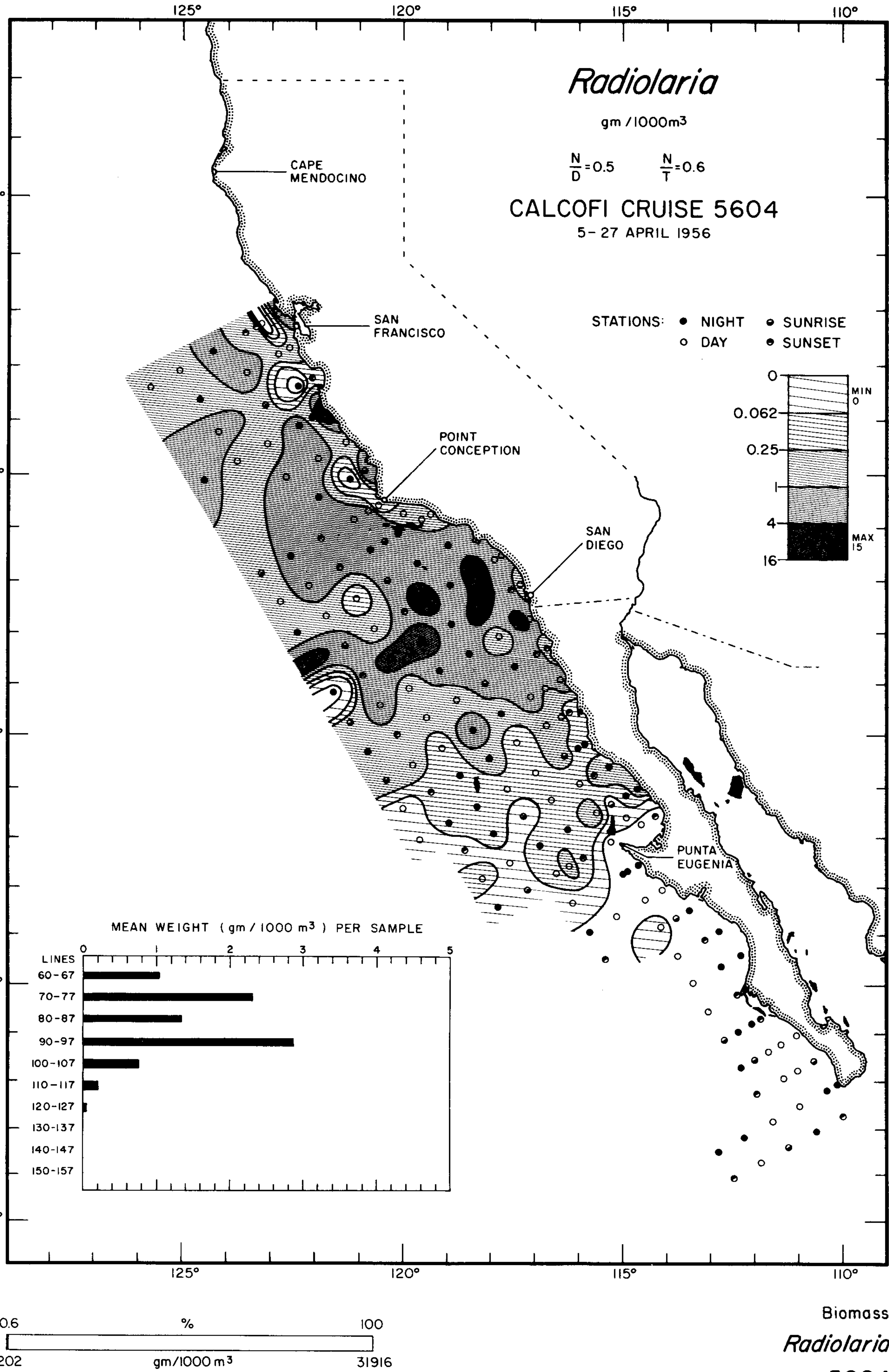
Biomass

Pteropoda, adjusted

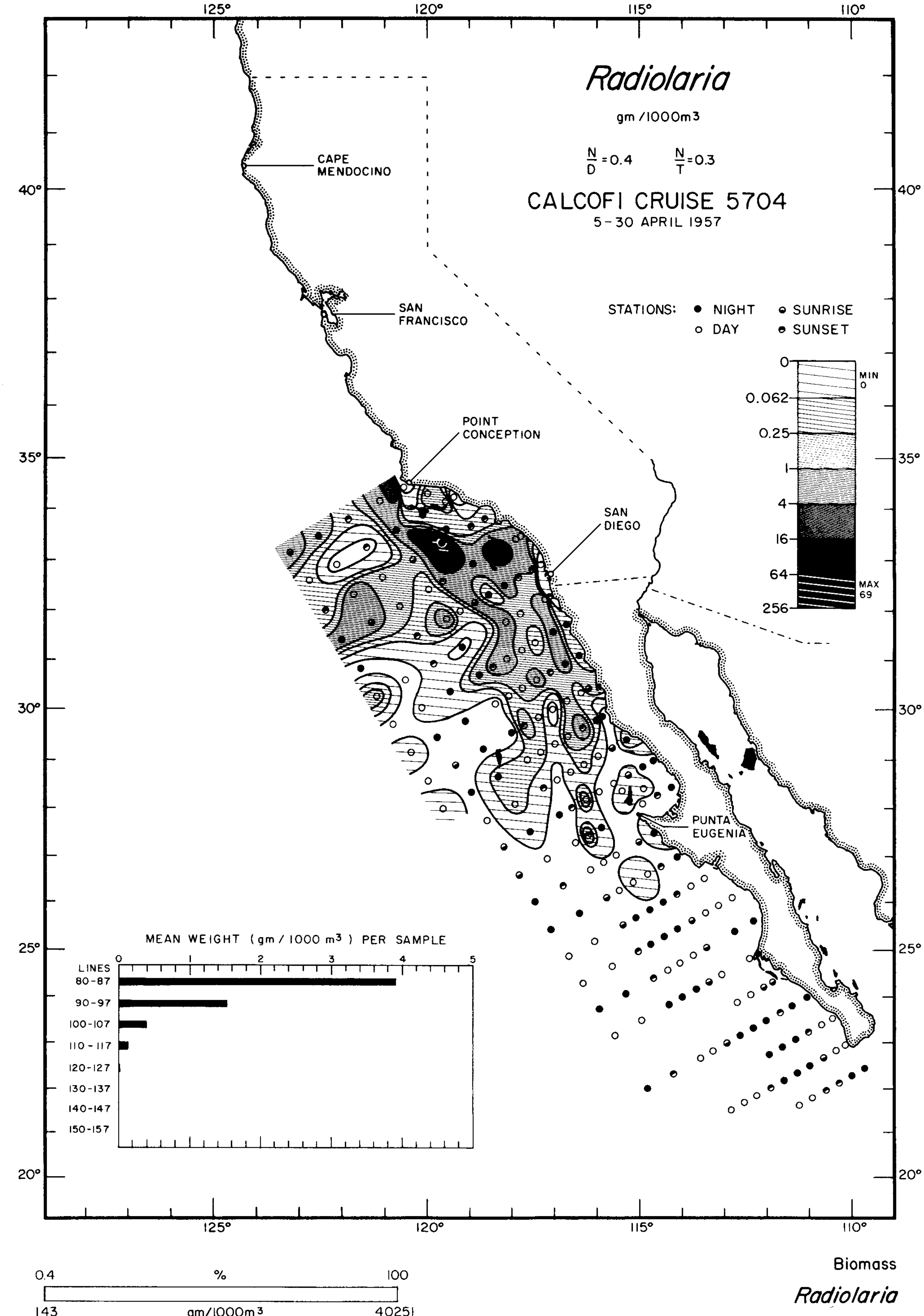
5910



Biomass
Radiolaria
5504



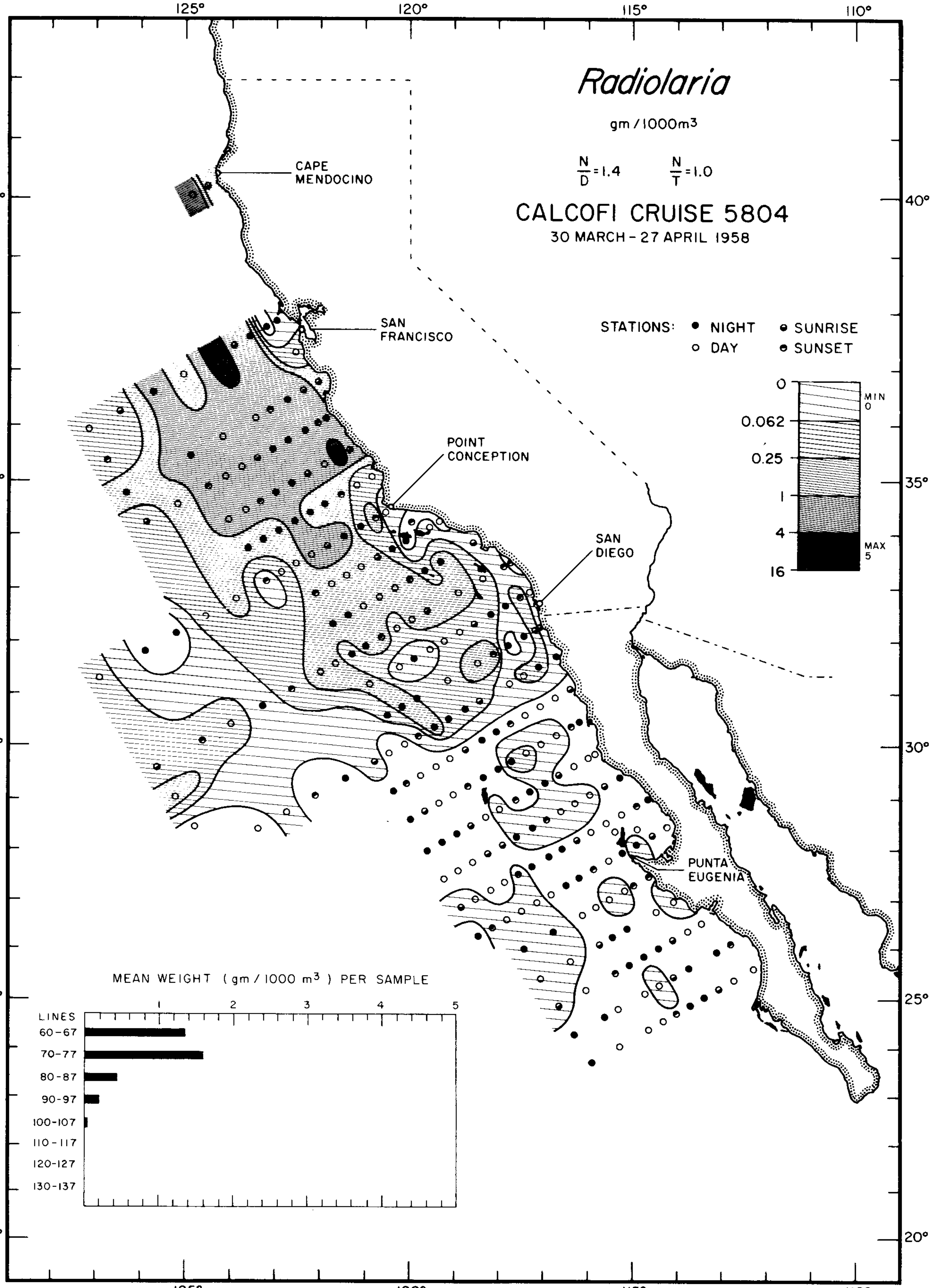
Biomass
Radiolaria
5604

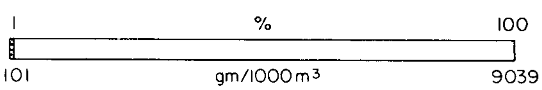


Biomass

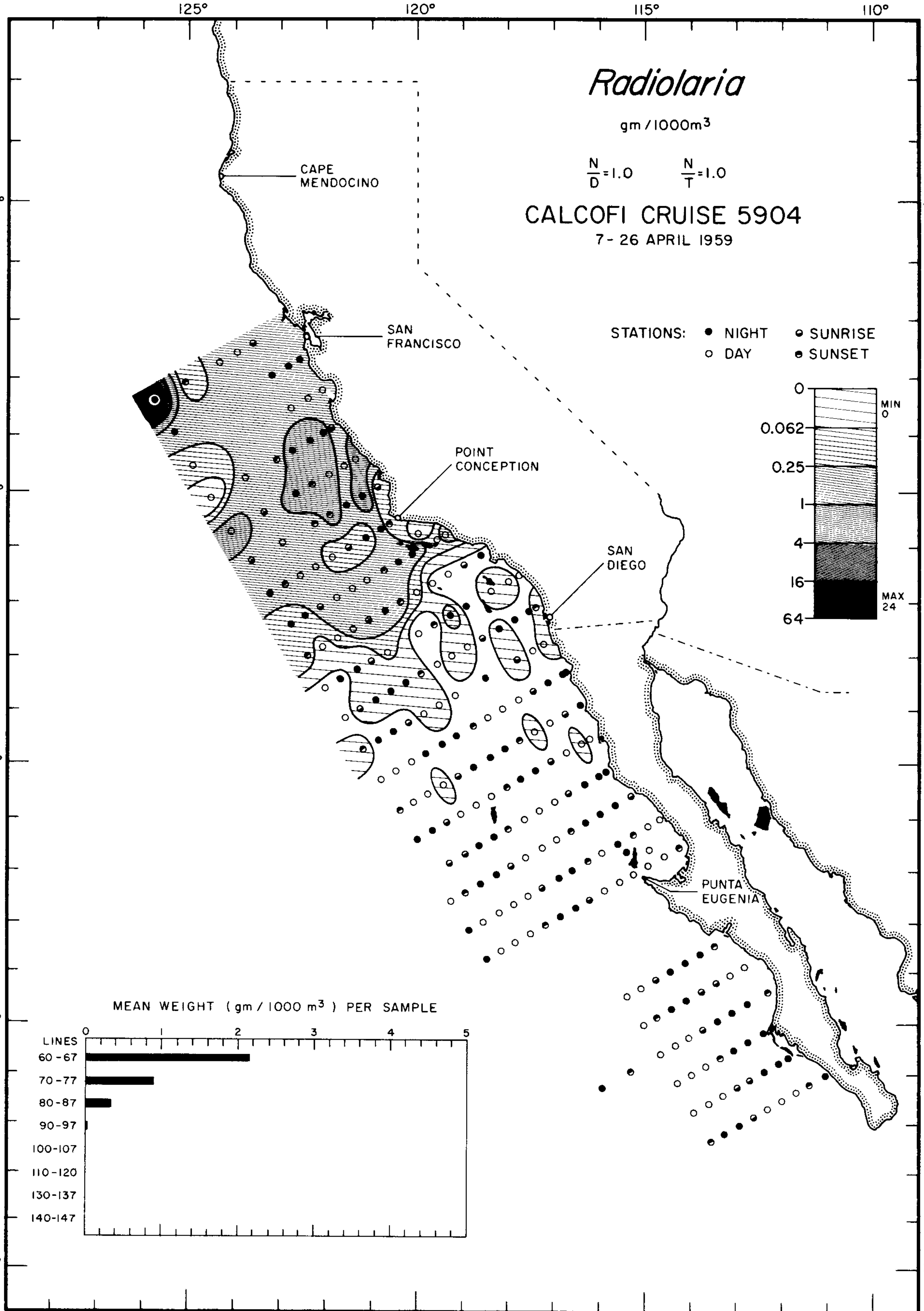
Radiolaria

5704





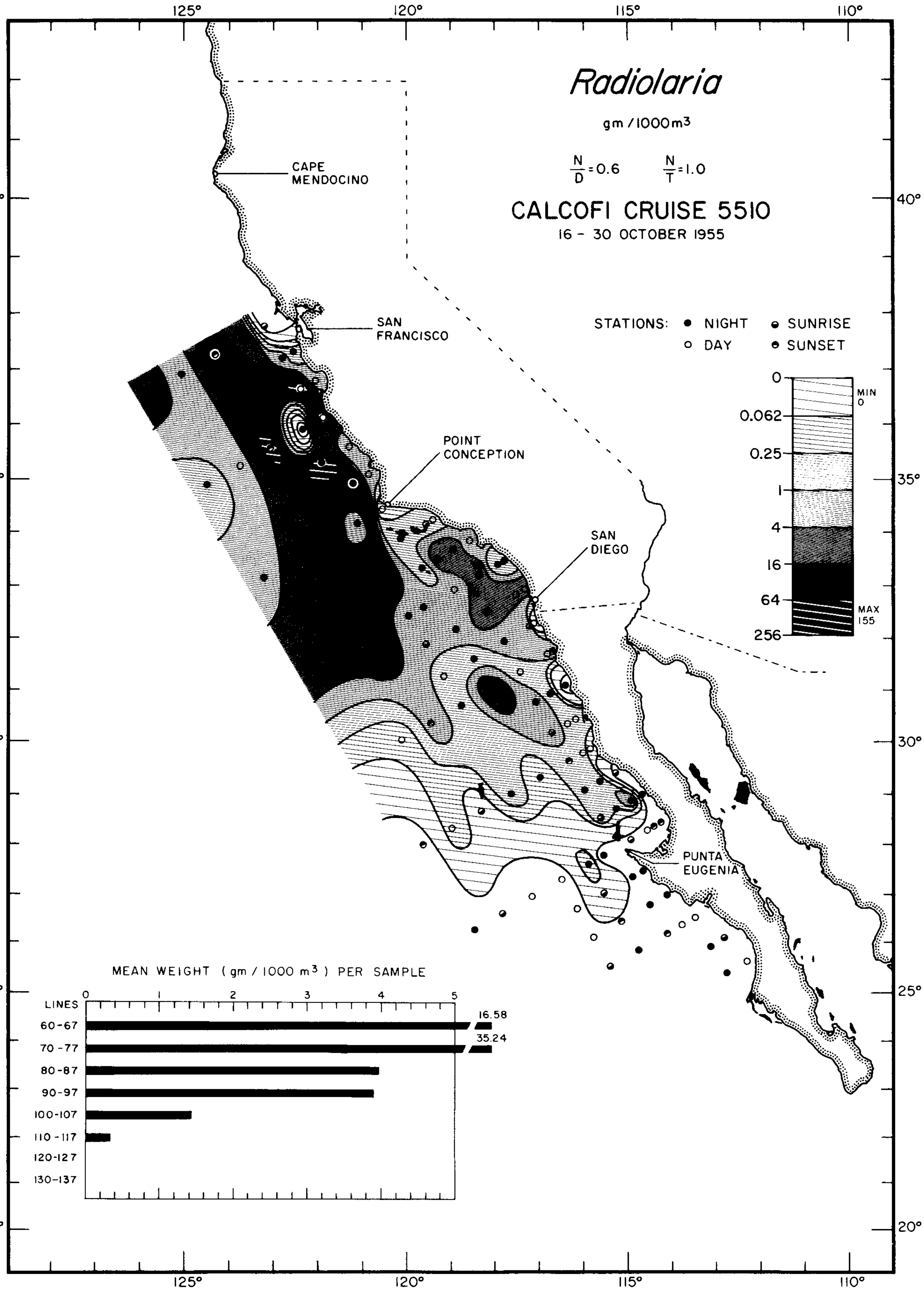
Biomass
Radiolaria
5804

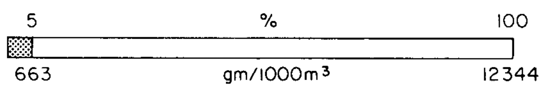


Biomass

Radiolaria

5904

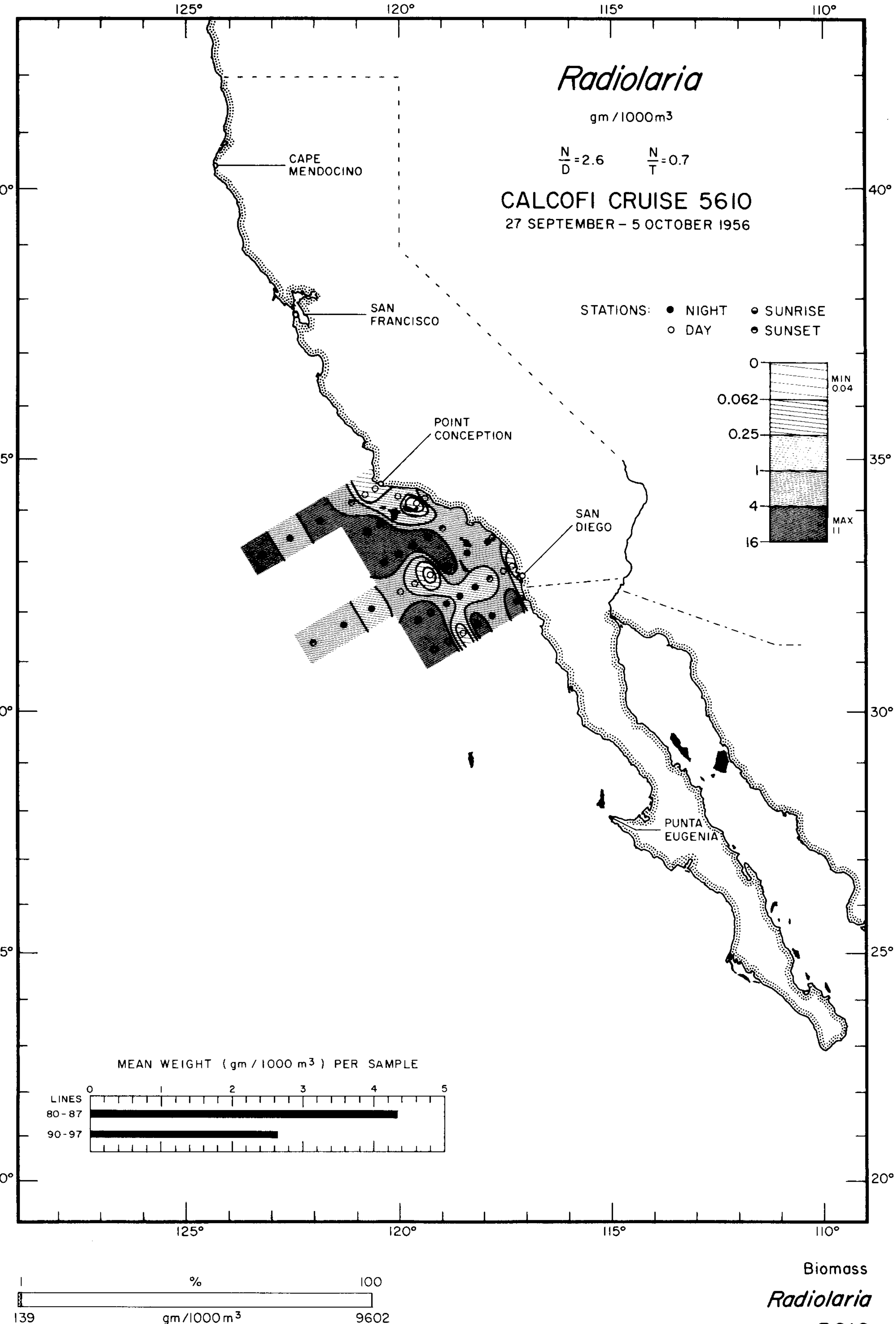




Biomass

Radiolaria

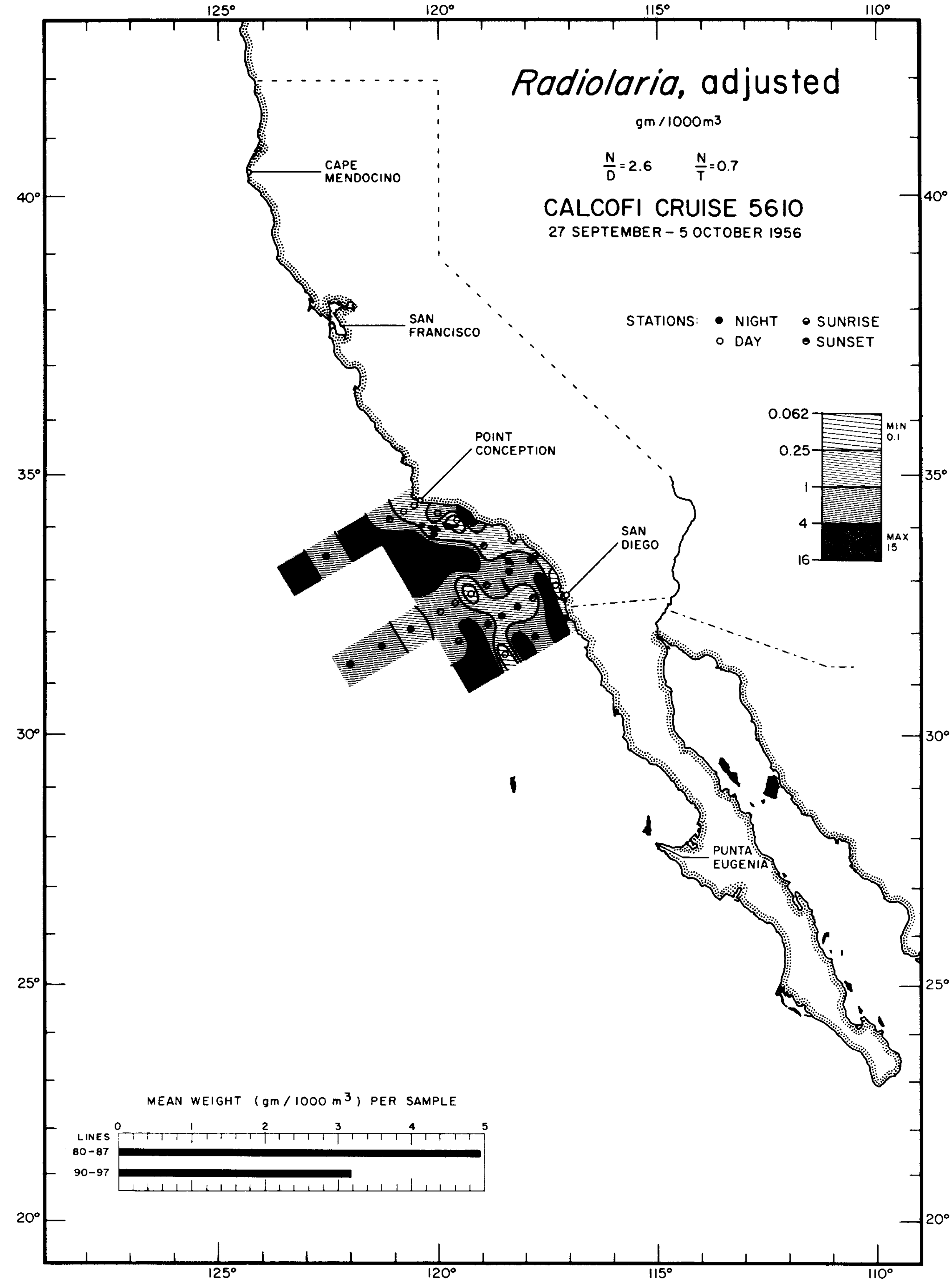
5510



Biomass

Radiolaria

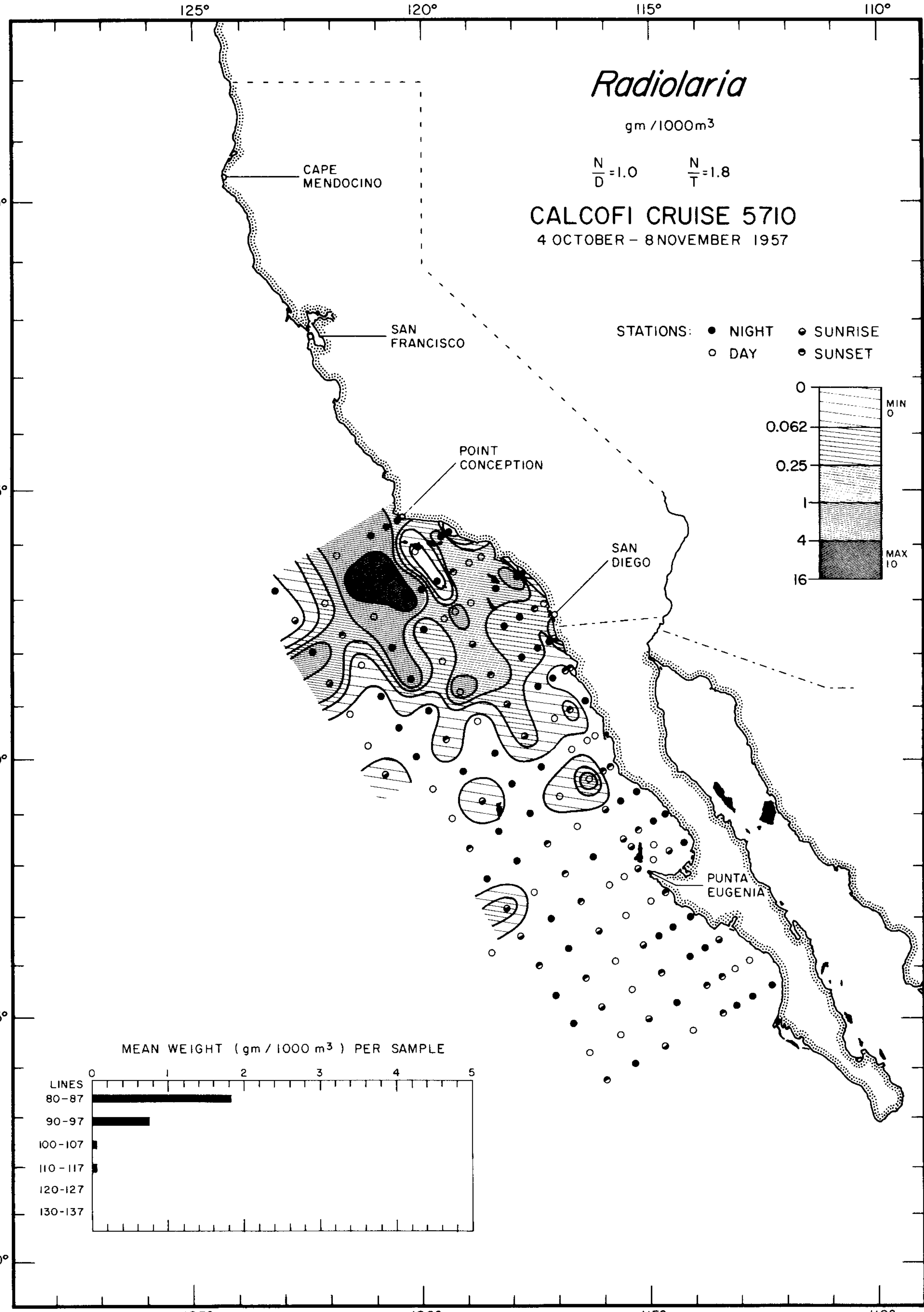
5610

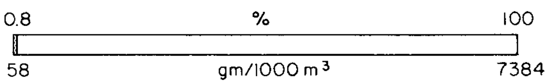


Biomass

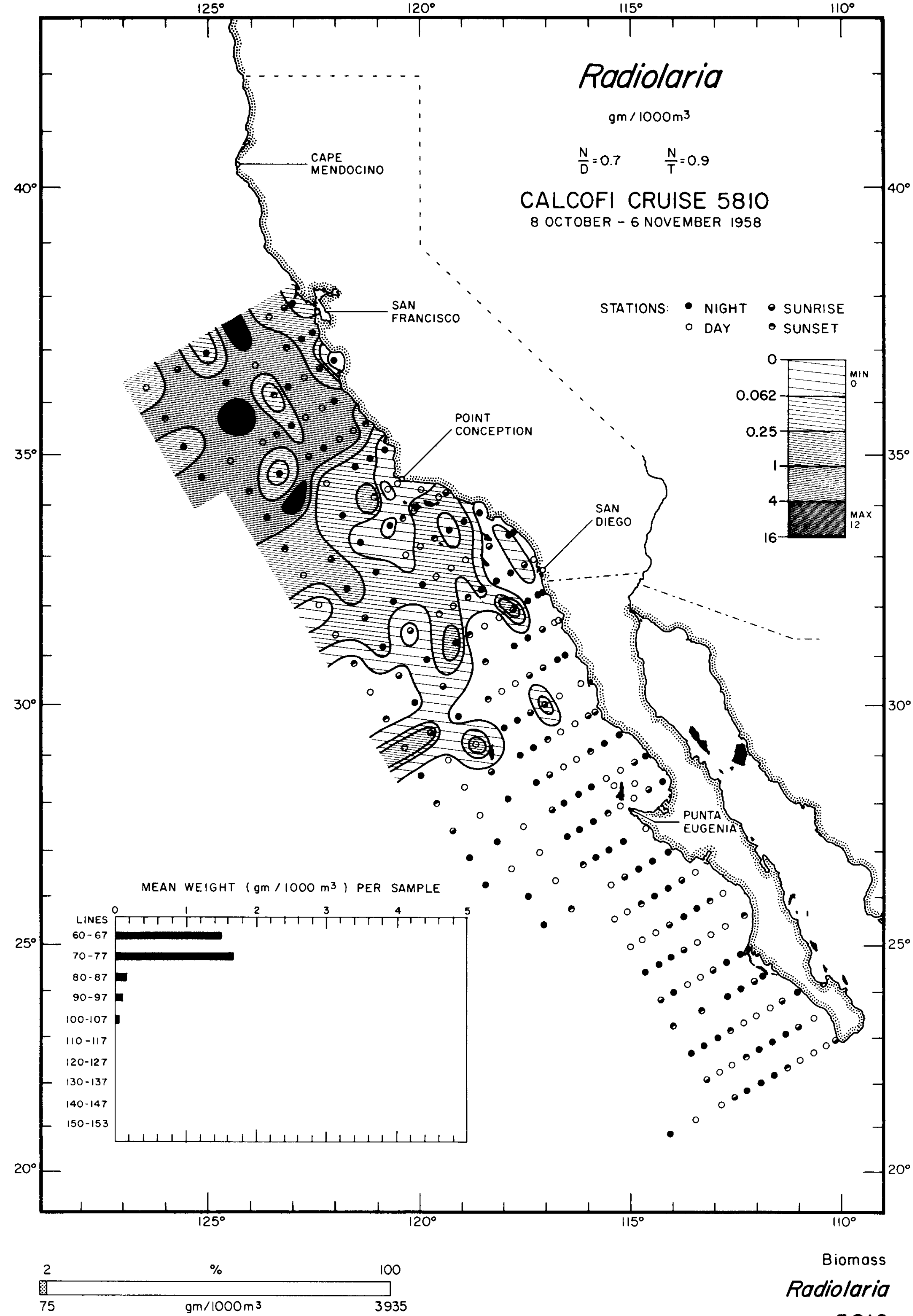
Radiolaria, adjusted

5610





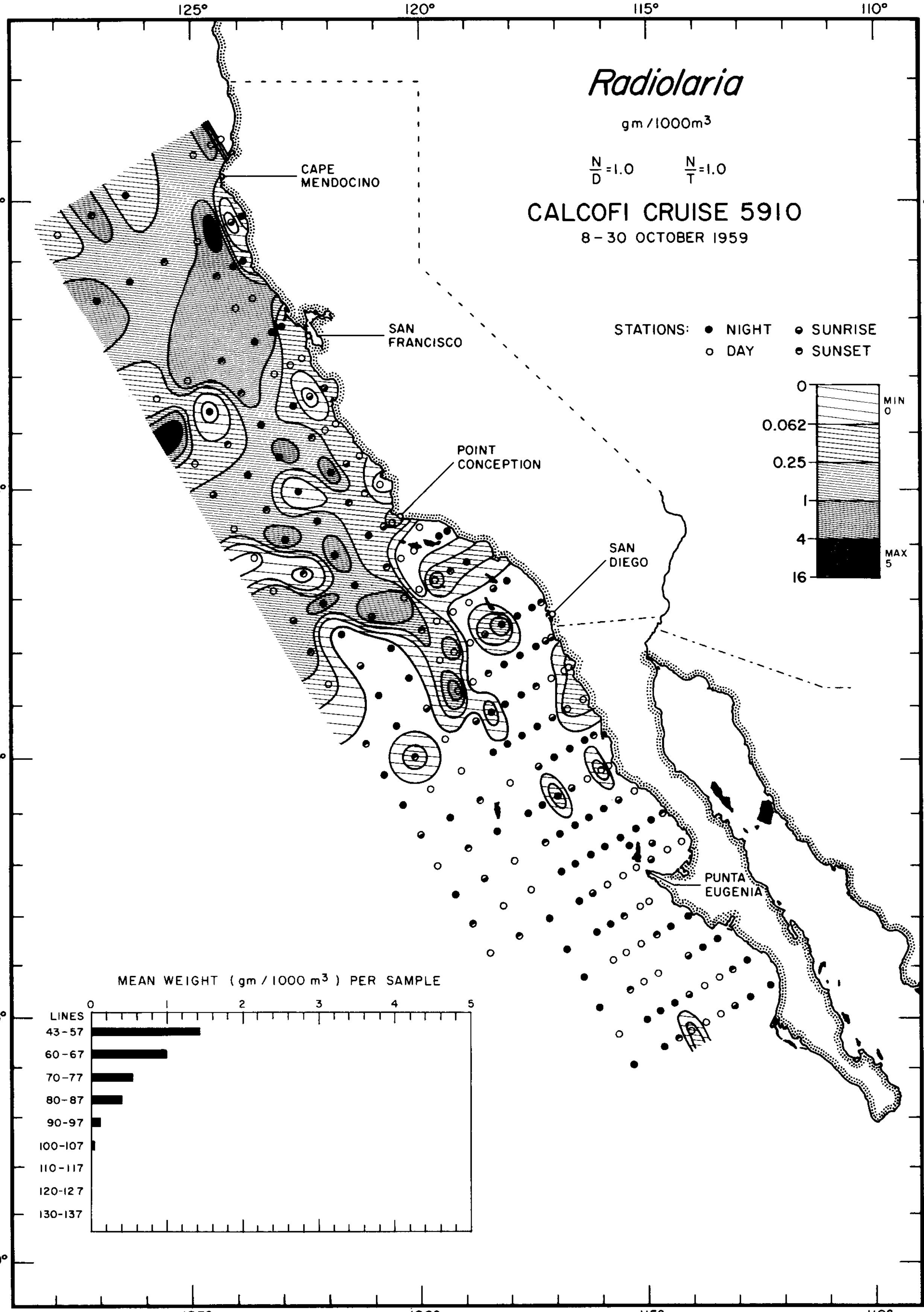
Biomass
Radiolaria
5710

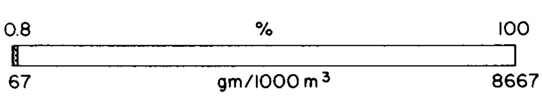


Biomass

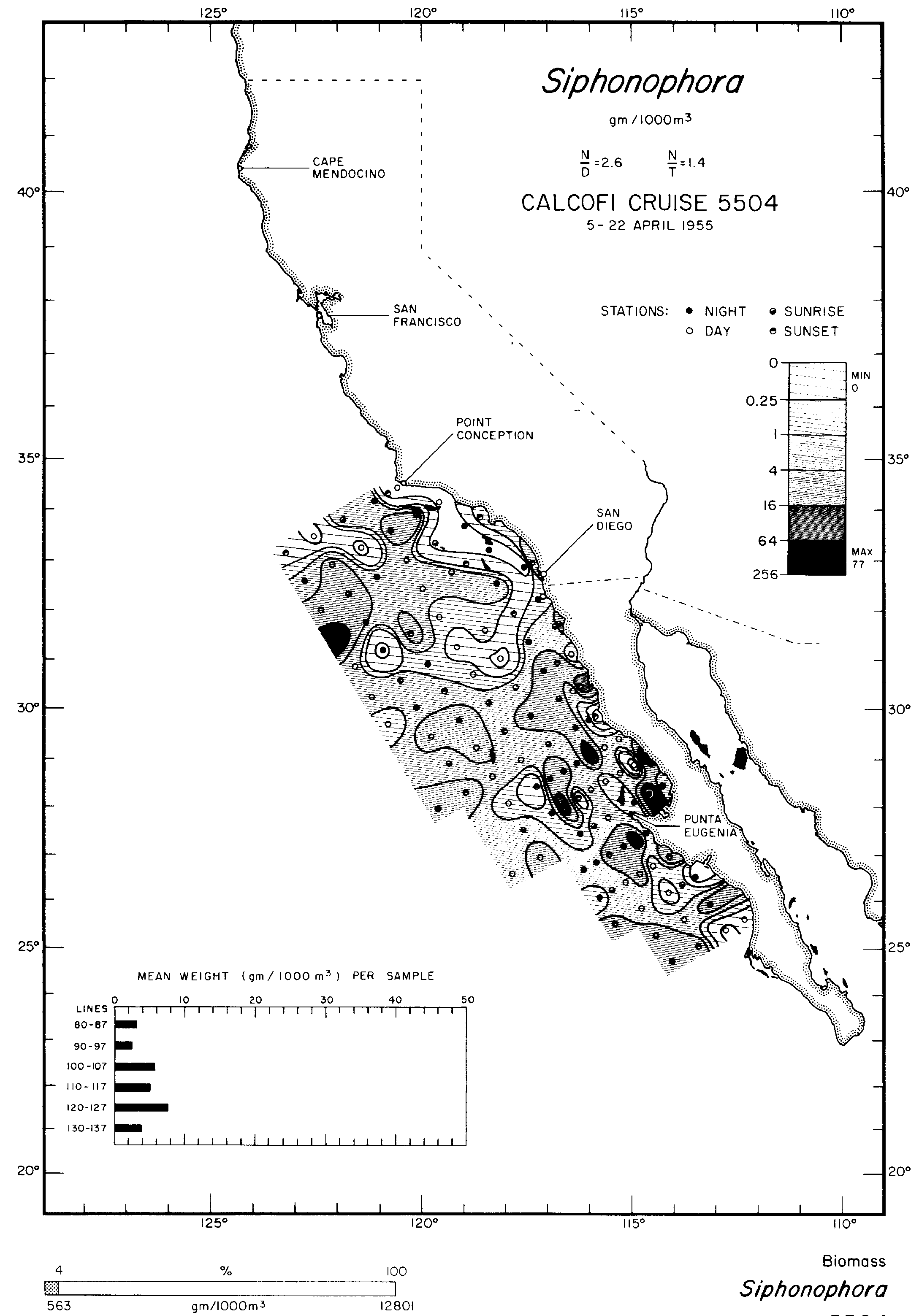
Radiolaria

5810





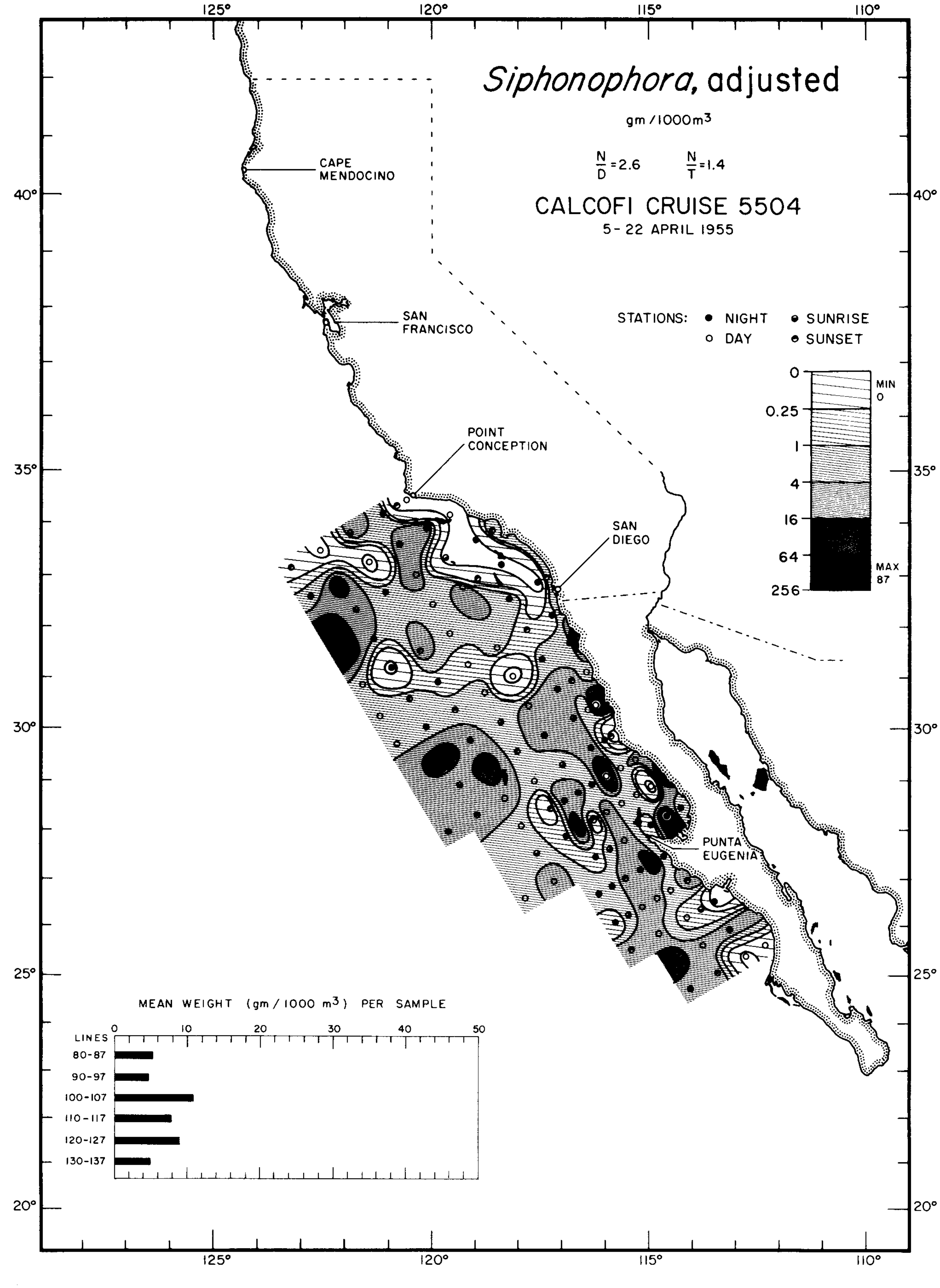
Biomass
Radiolaria
5910



Biomass

Siphonophora

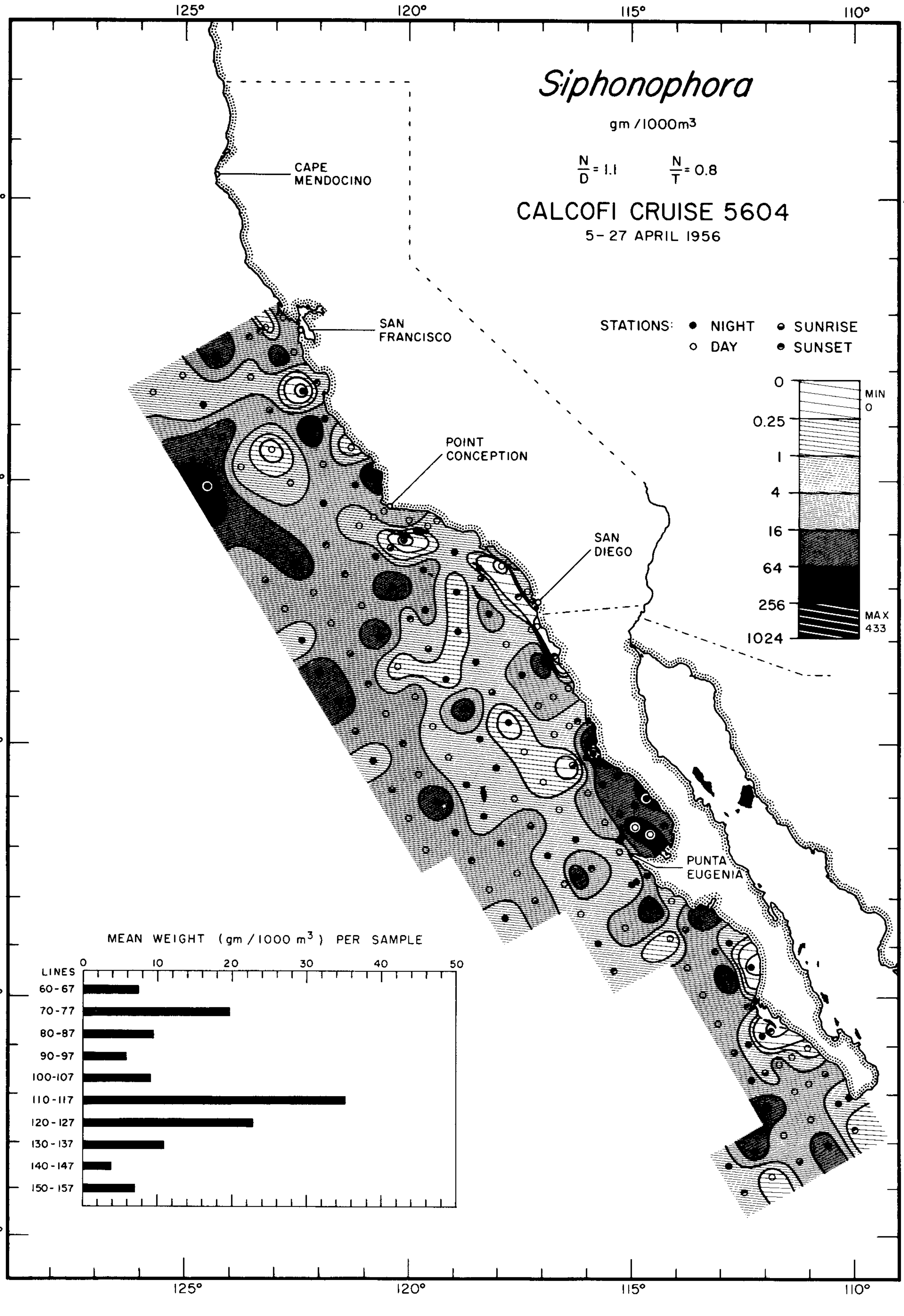
5504

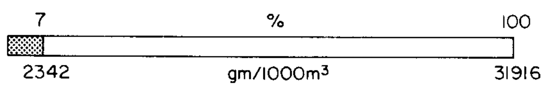


Biomass

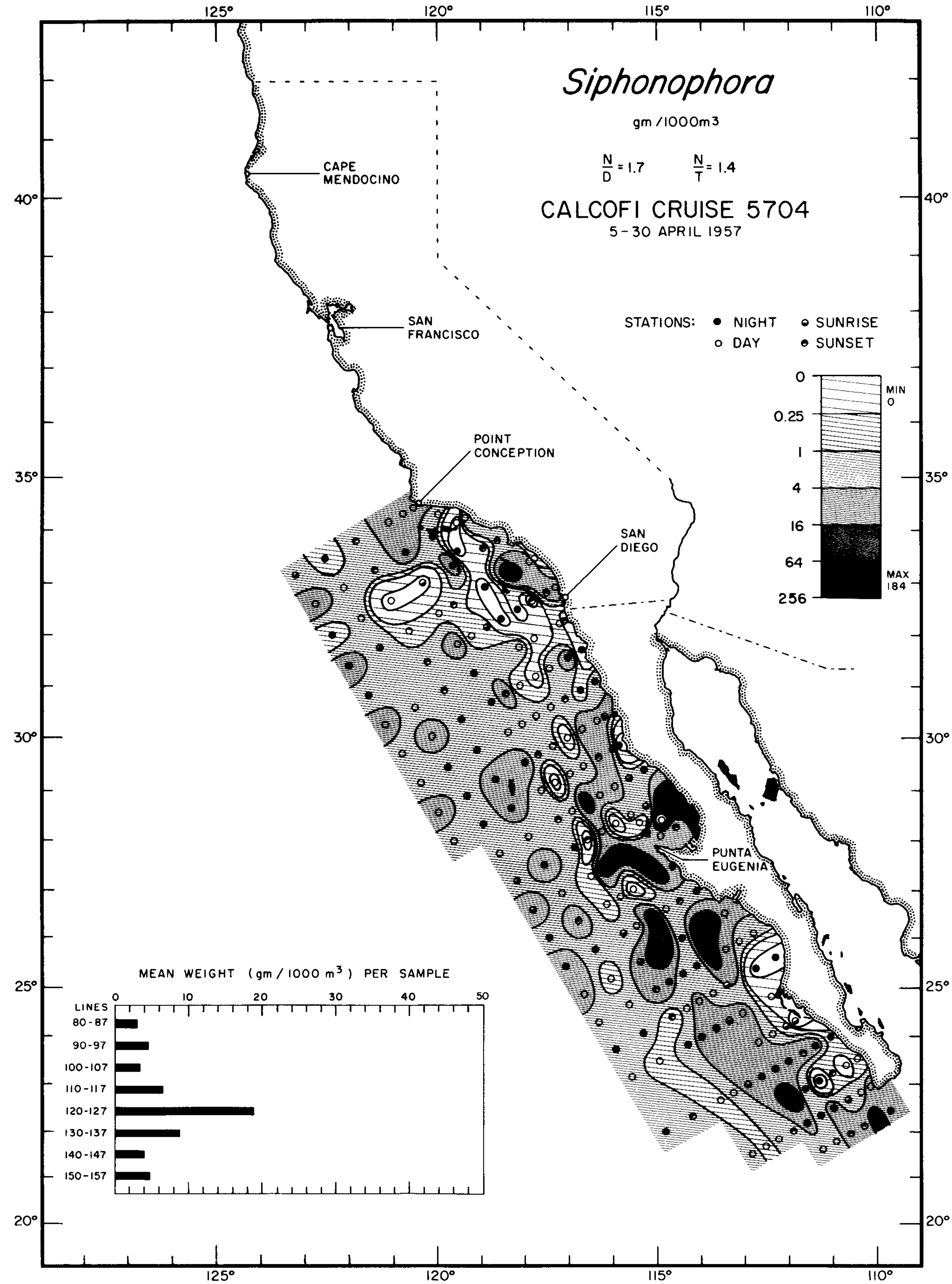
Siphonophora, adjusted

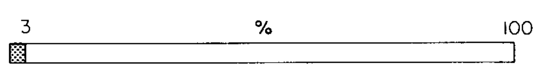
5504



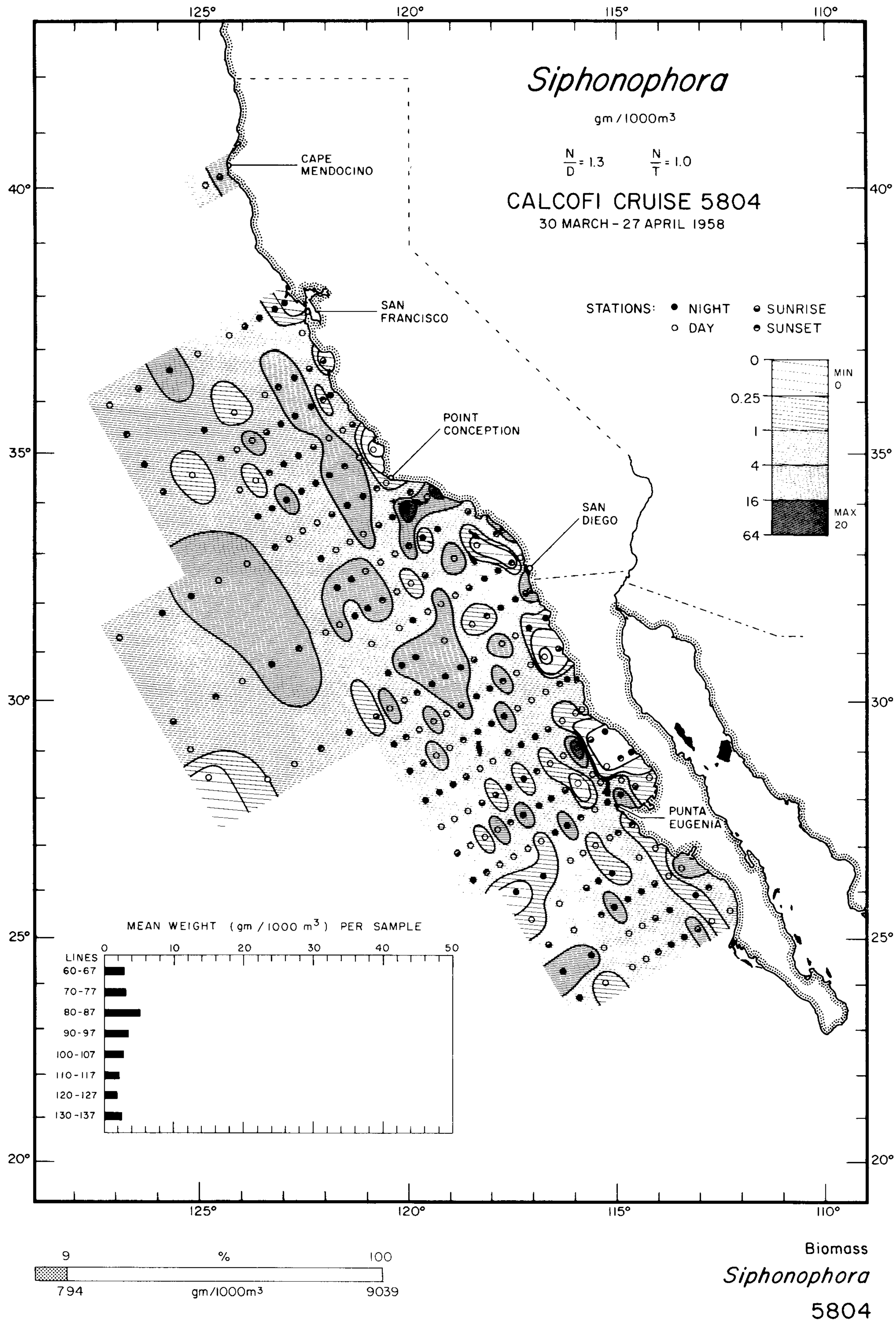


Biomass
Siphonophora
5604

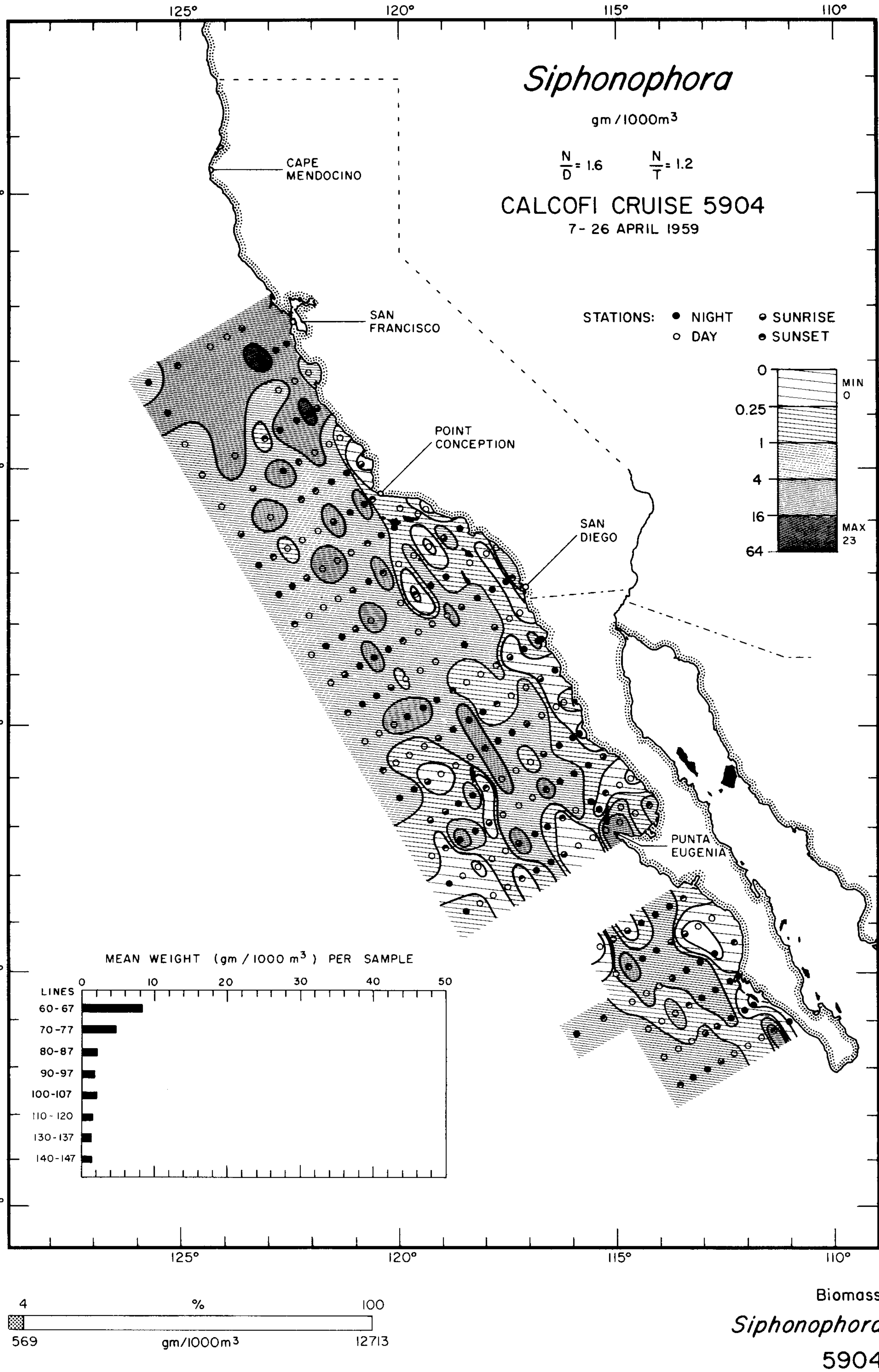




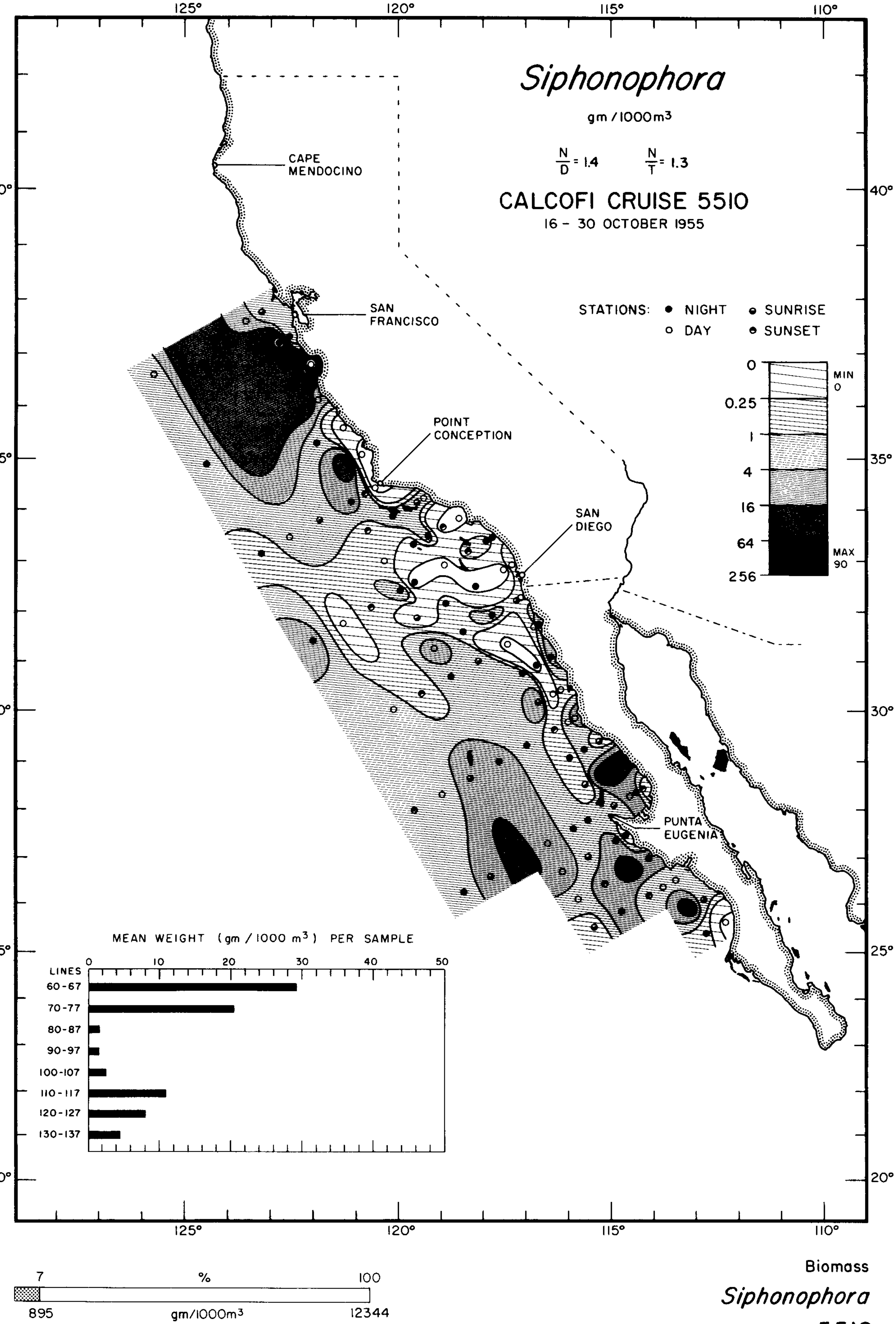
Biomass
Siphonophora
5704



Biomass
Siphonophora
5804



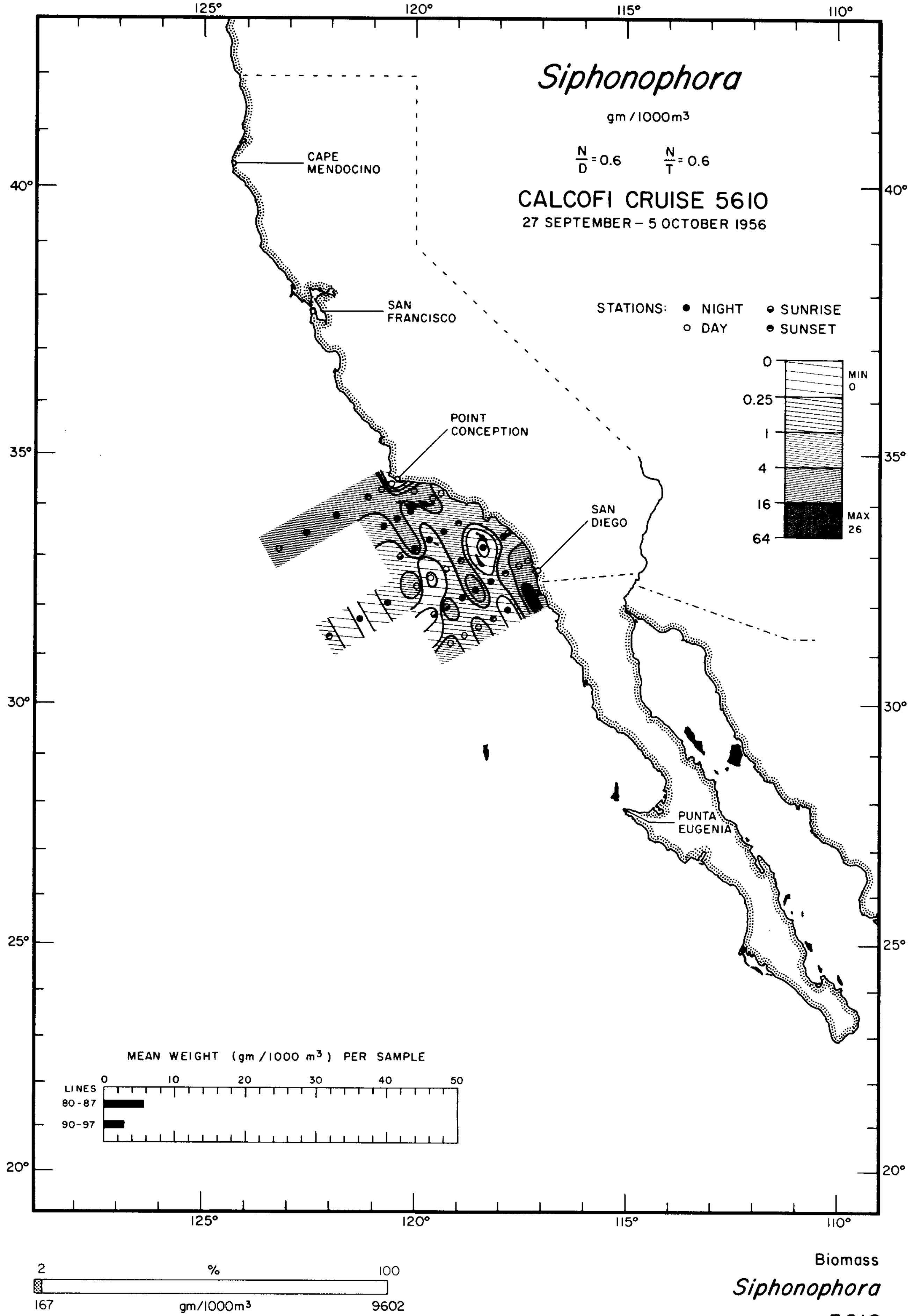
Biomass
Siphonophora
5904



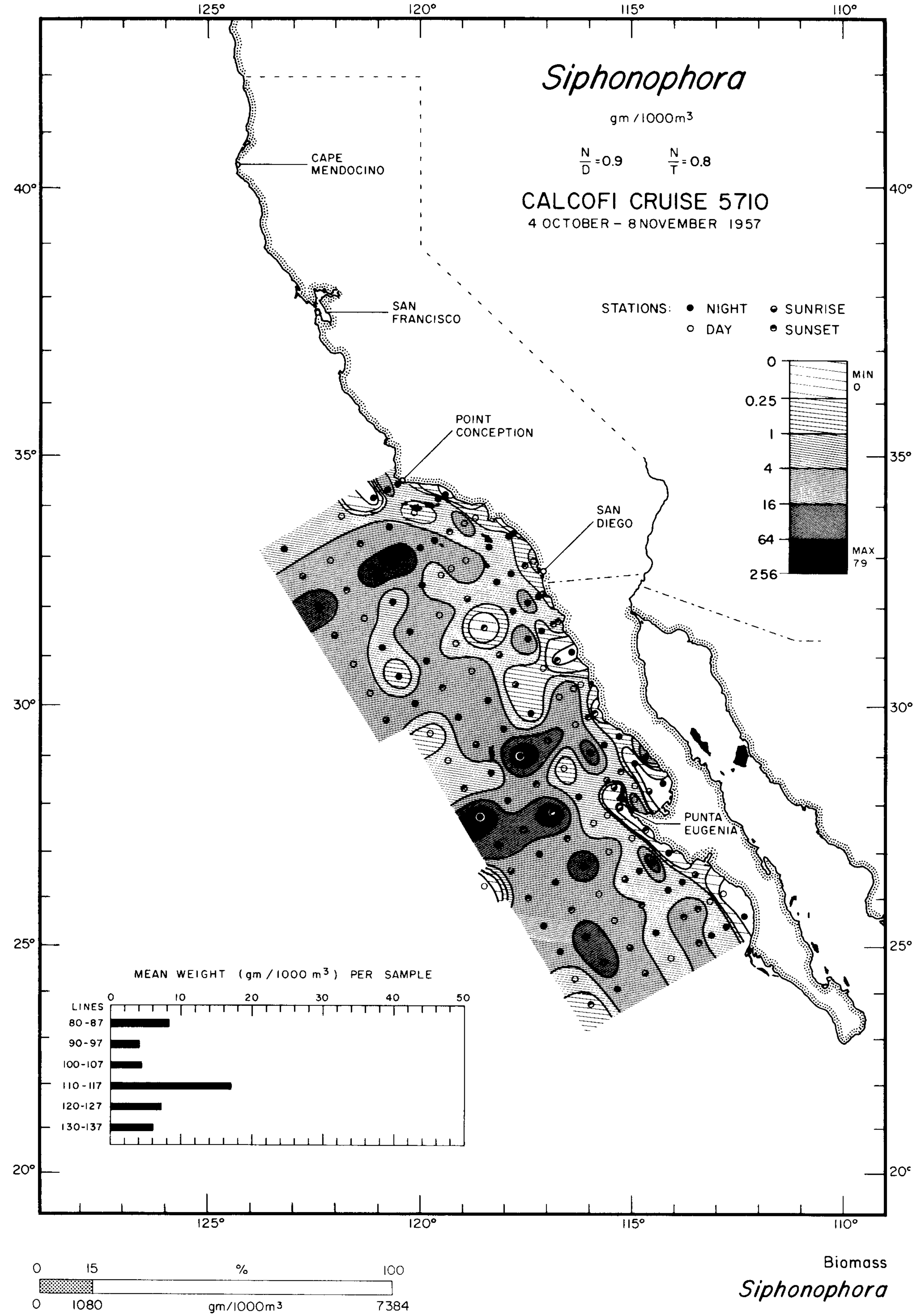
Biomass

Siphonophora

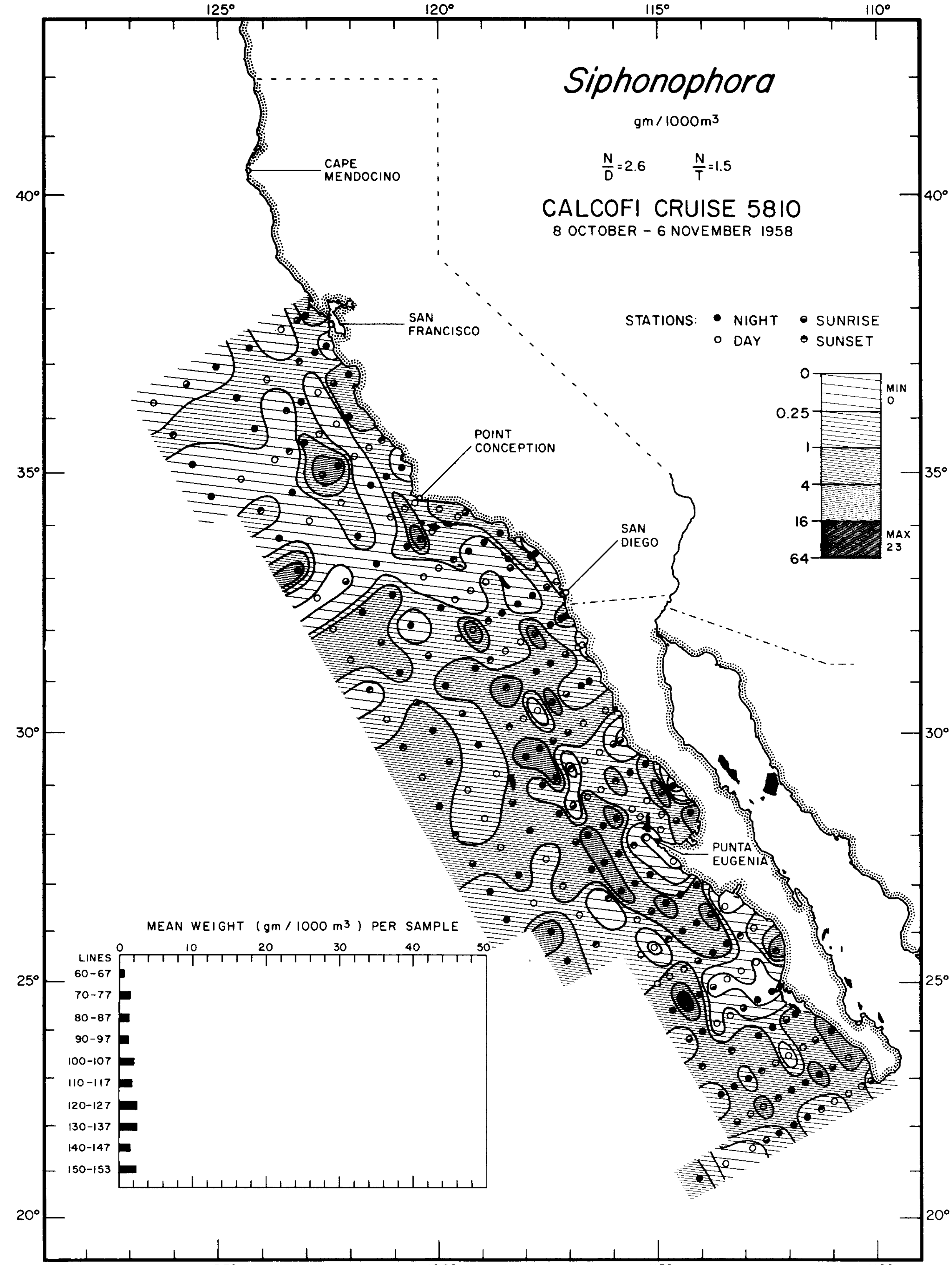
5510

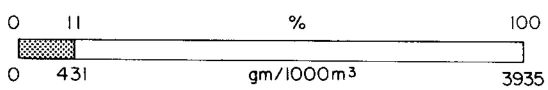


Biomass
Siphonophora
5610



Biomass
Siphonophora
5710

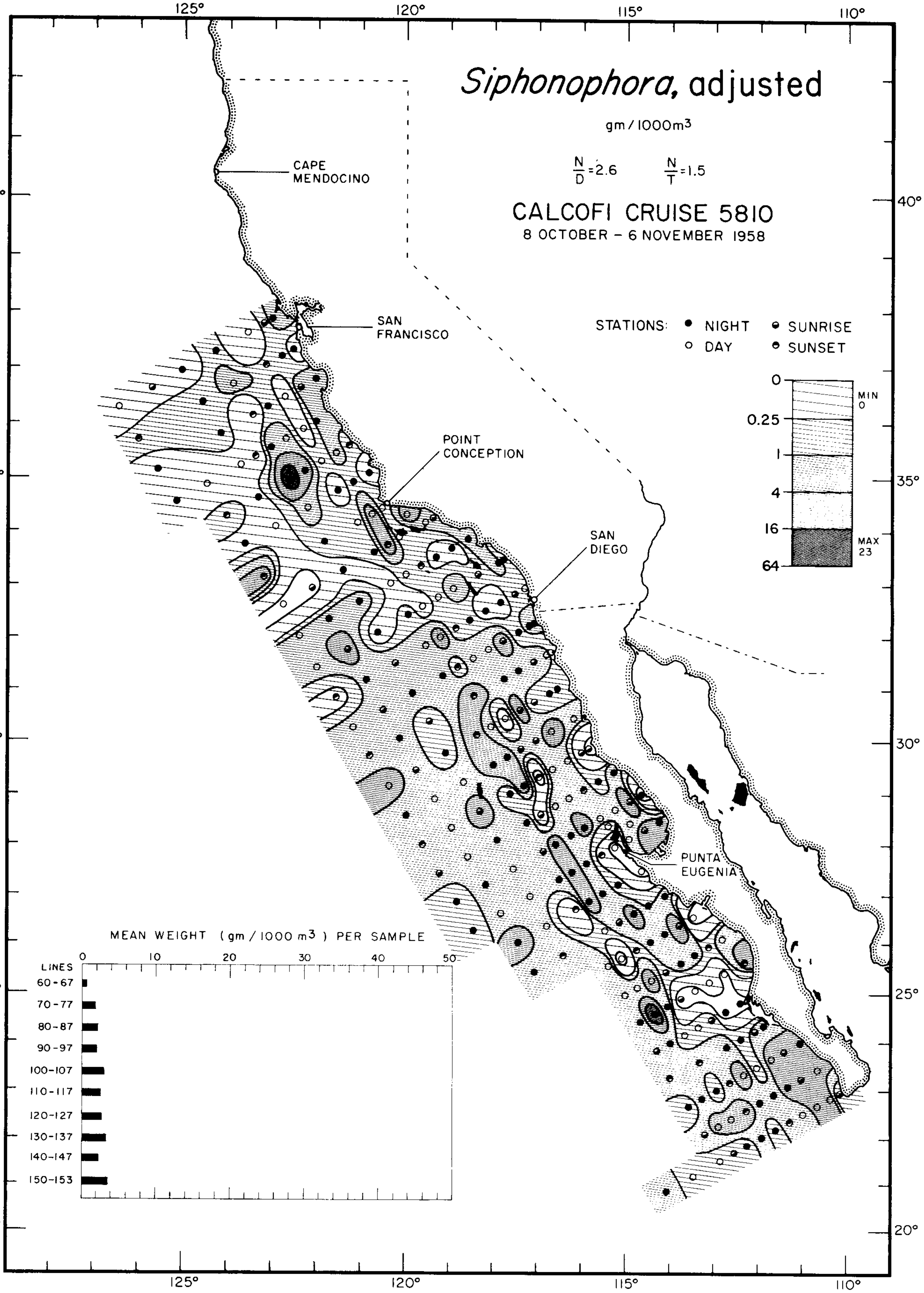




Biomass

Siphonophora

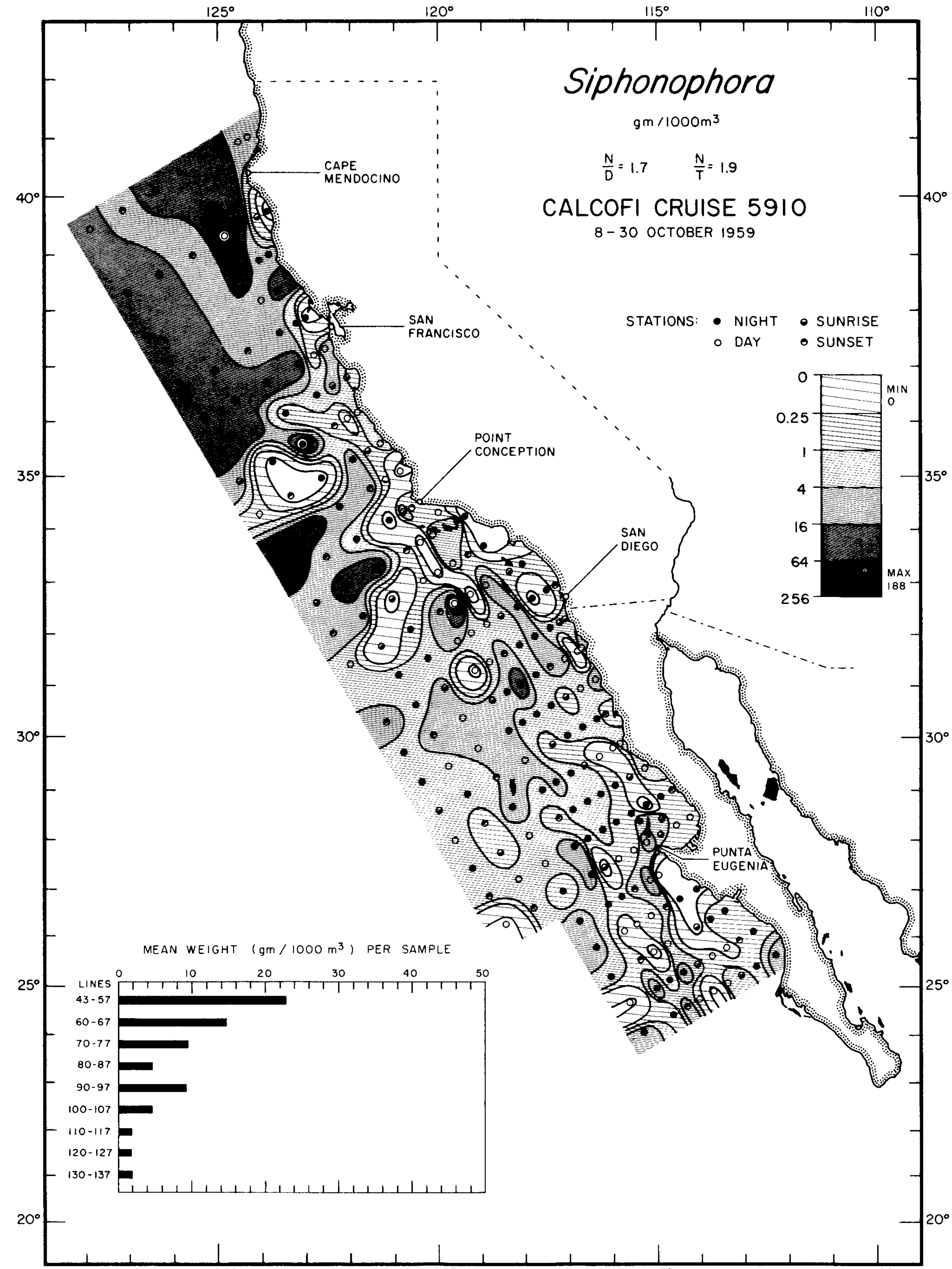
5810



Biomass

Siphonophora, adjusted

5810



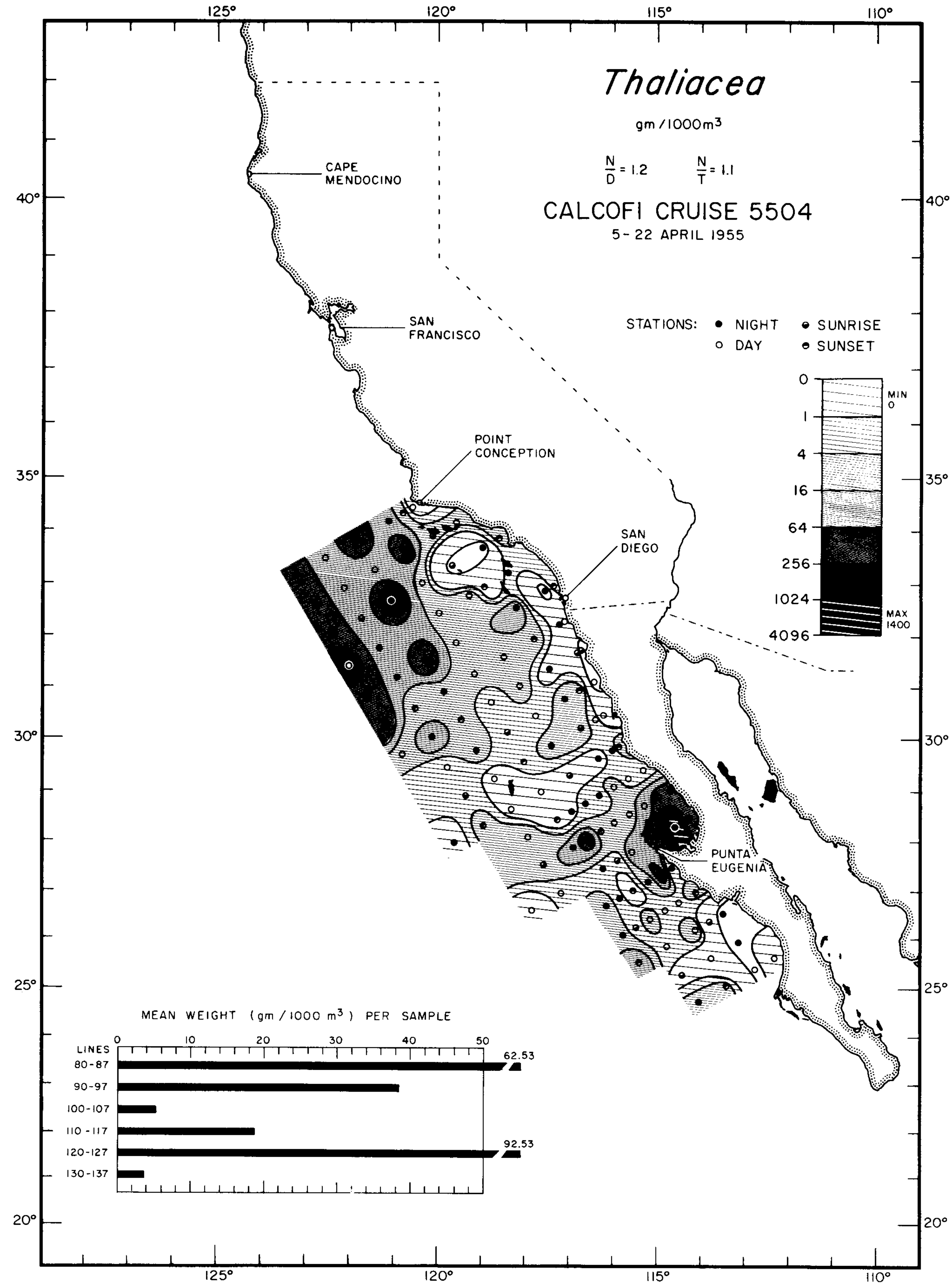
0 17 % 100

0 1479 gm/1000m³ 8667

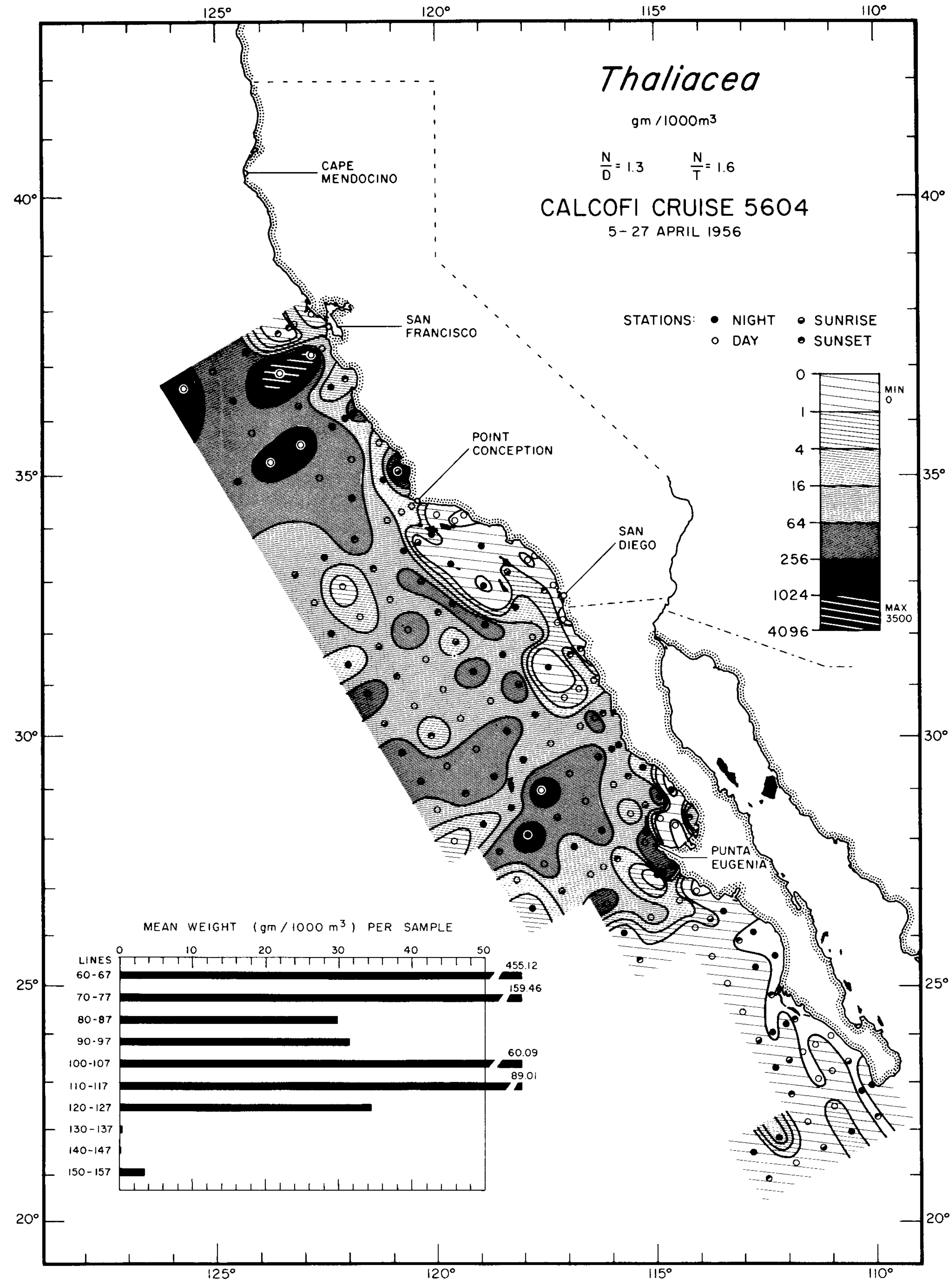
Biomass

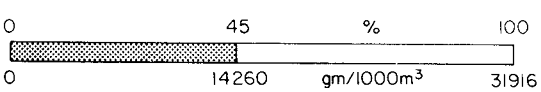
Siphonophora

5910

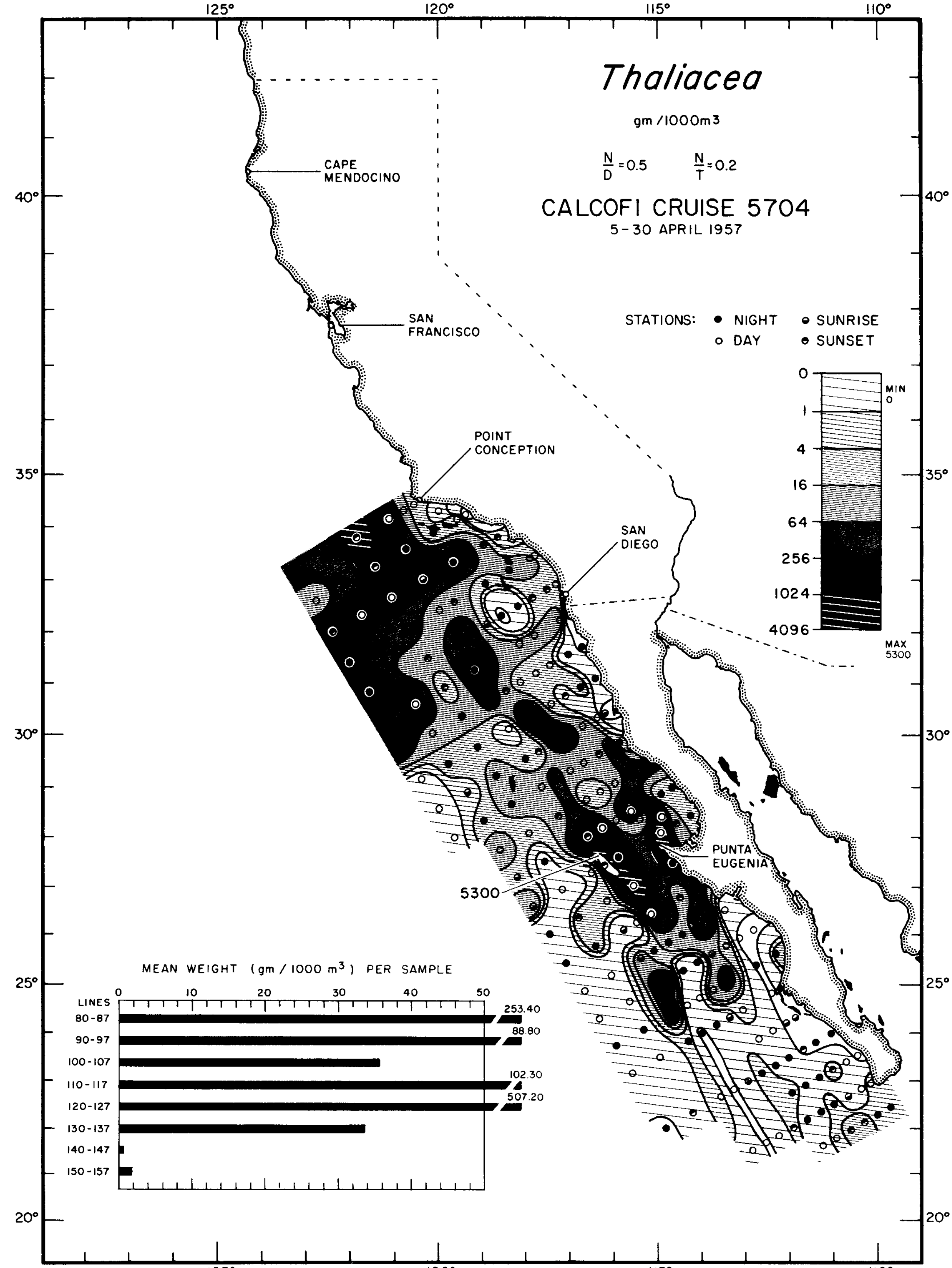


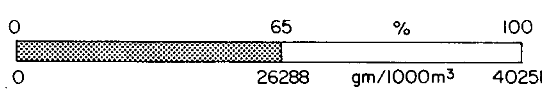
Biomass
Thaliacea
5504



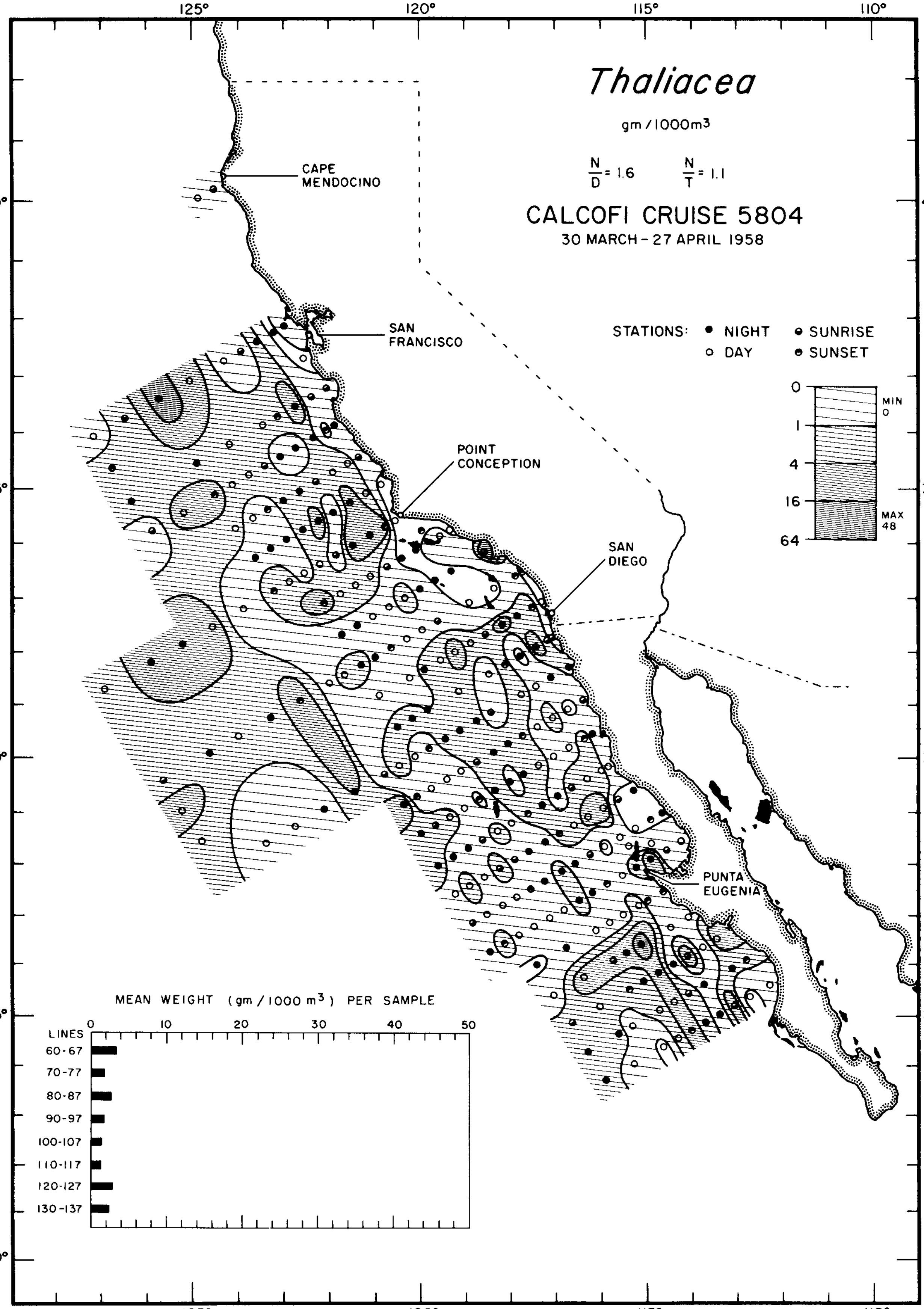


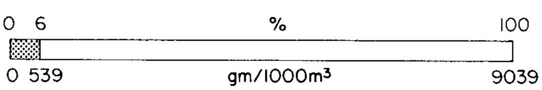
Biomass
Thaliacea
5604



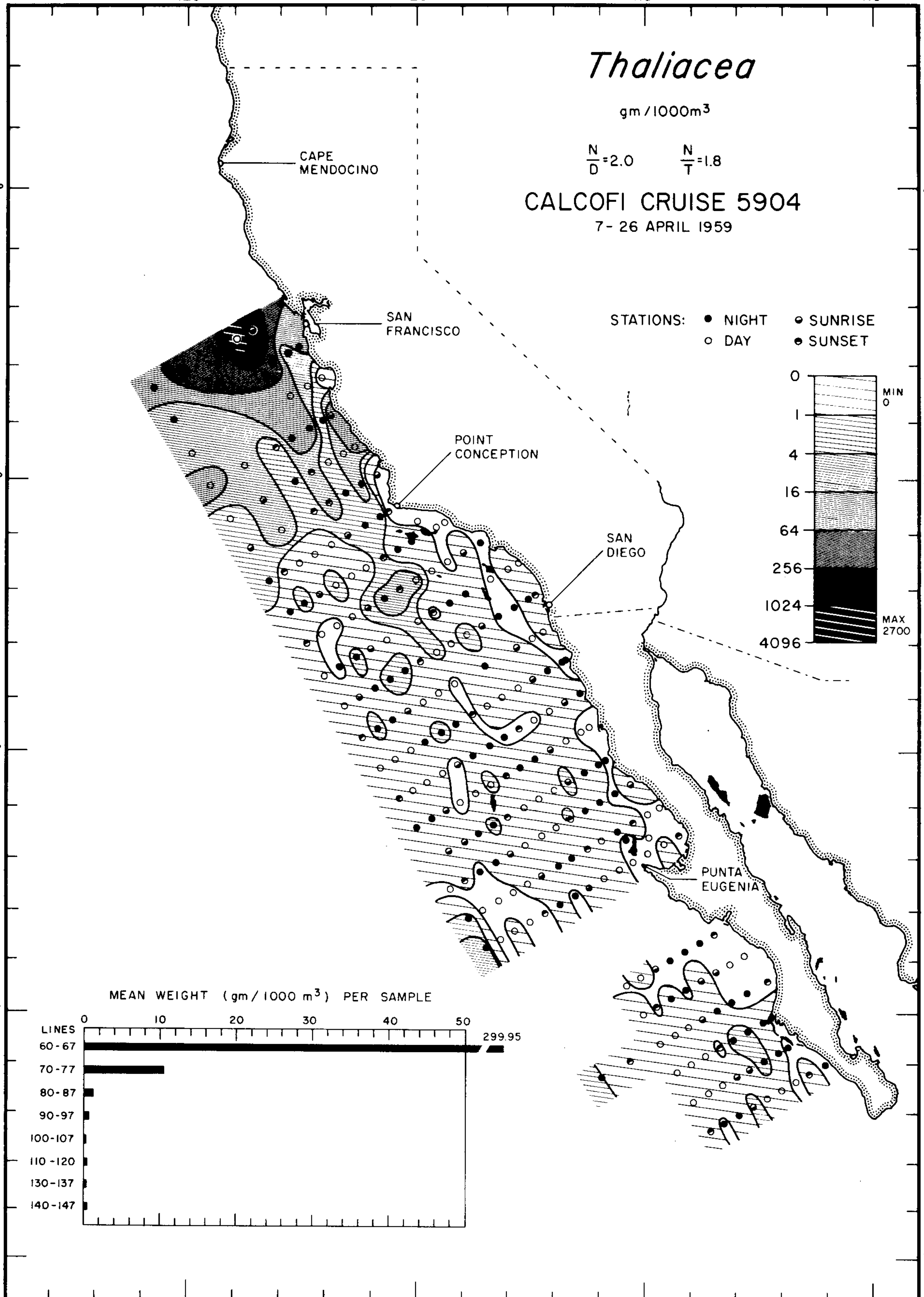


Biomass
Thaliacea
5704





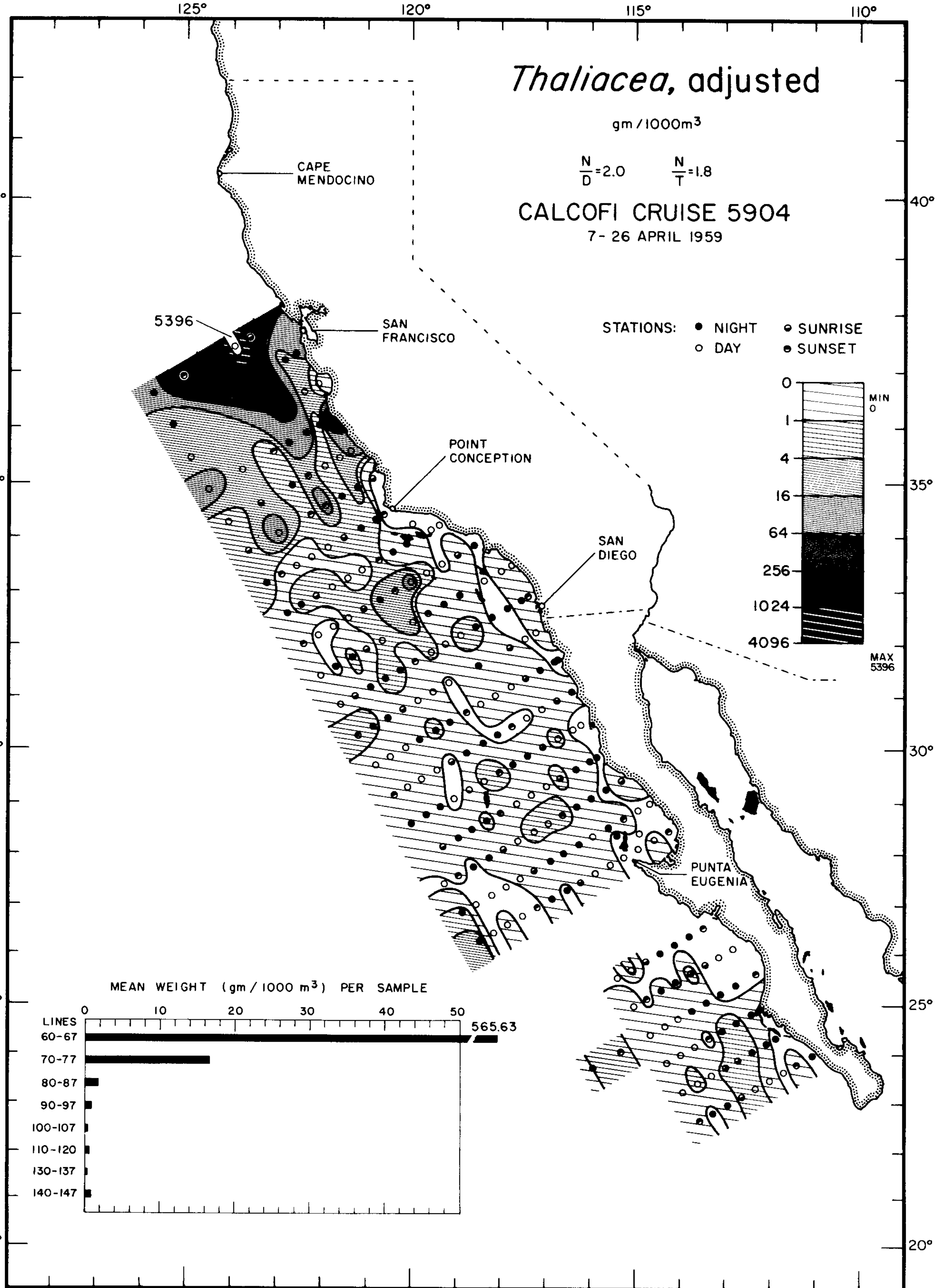
Biomass
Thaliacea
5804



Biomass

Thaliacea

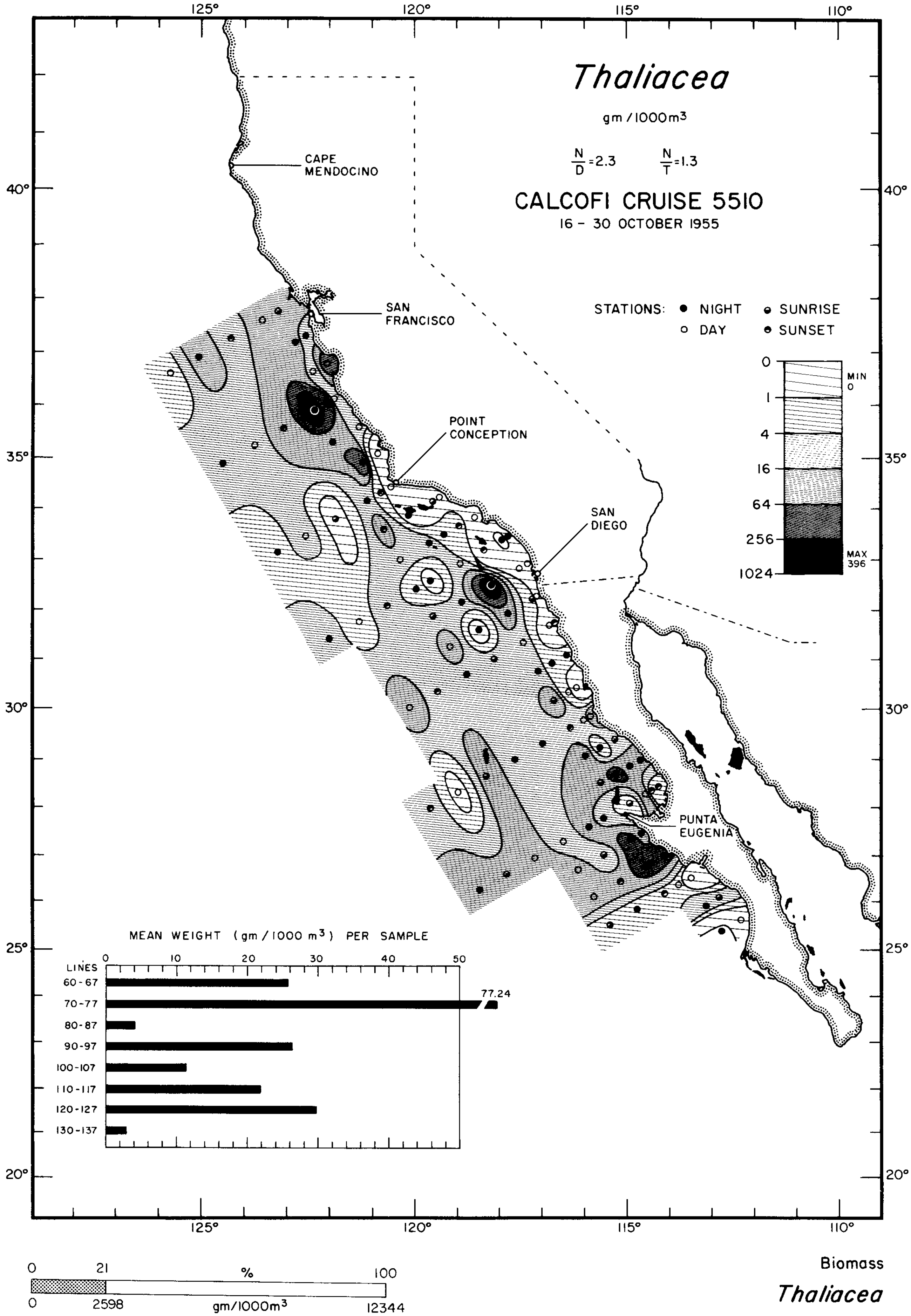
5904



Biomass

Thaliacea, adjusted

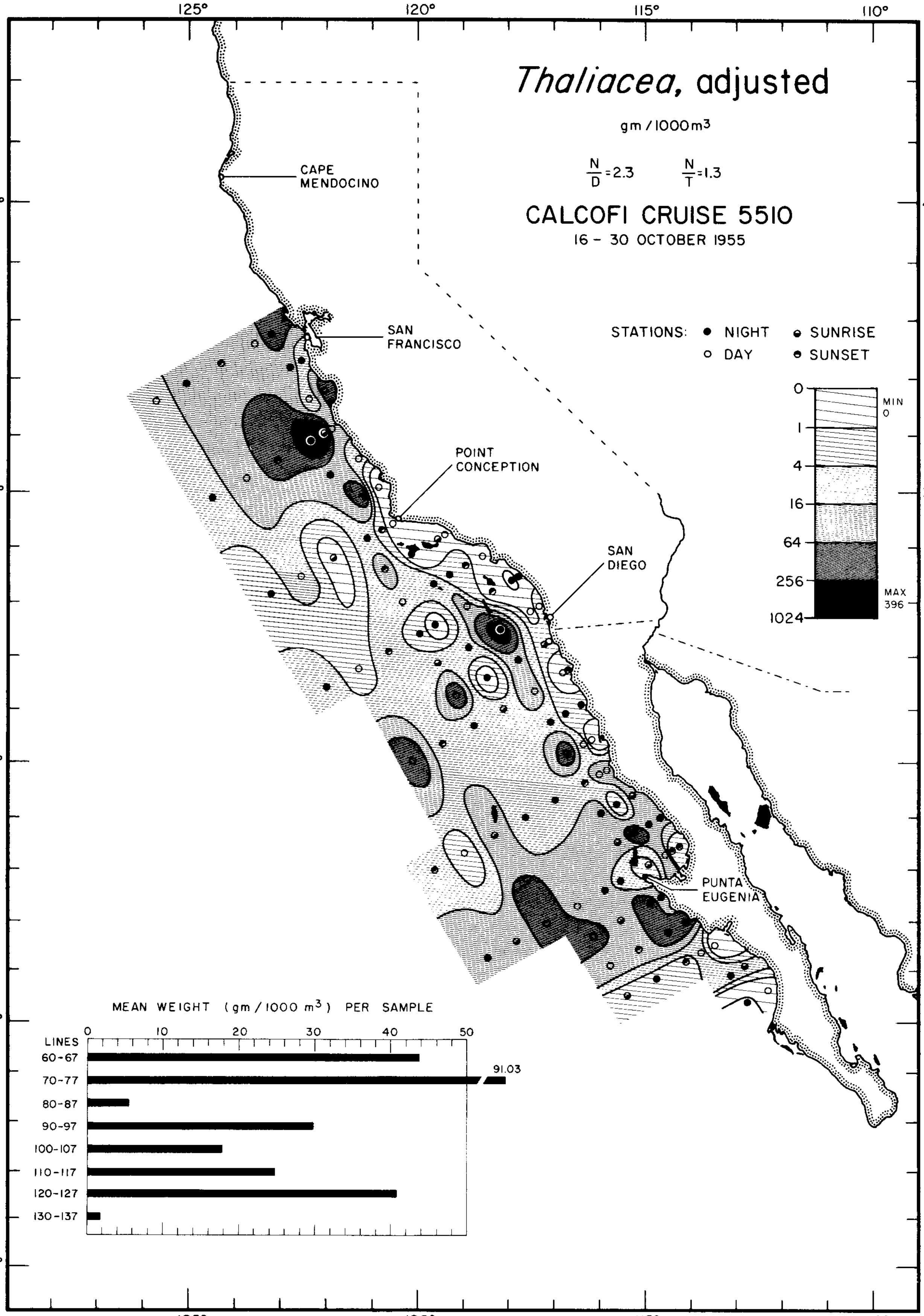
5904



Biomass

Thaliacea

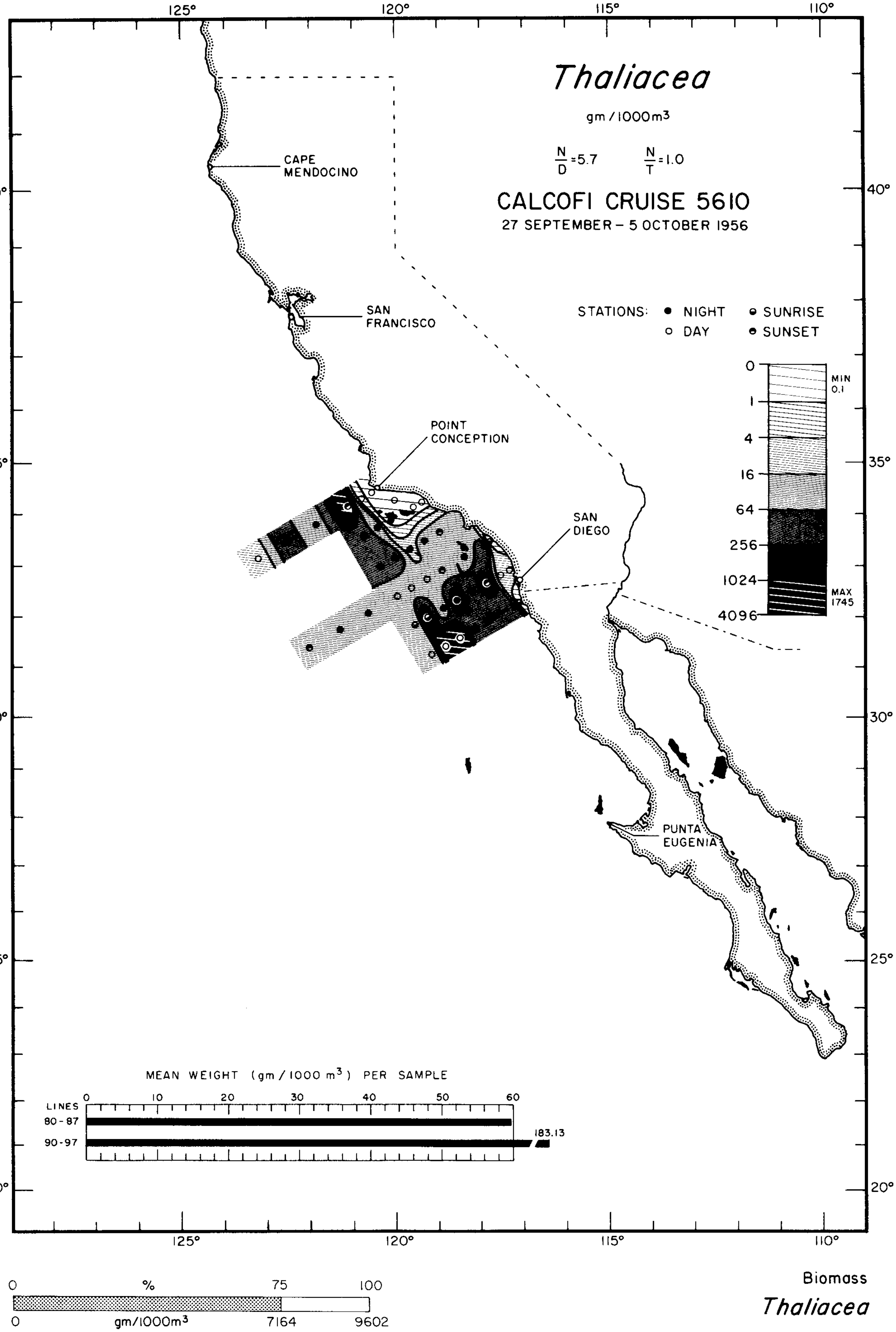
5510



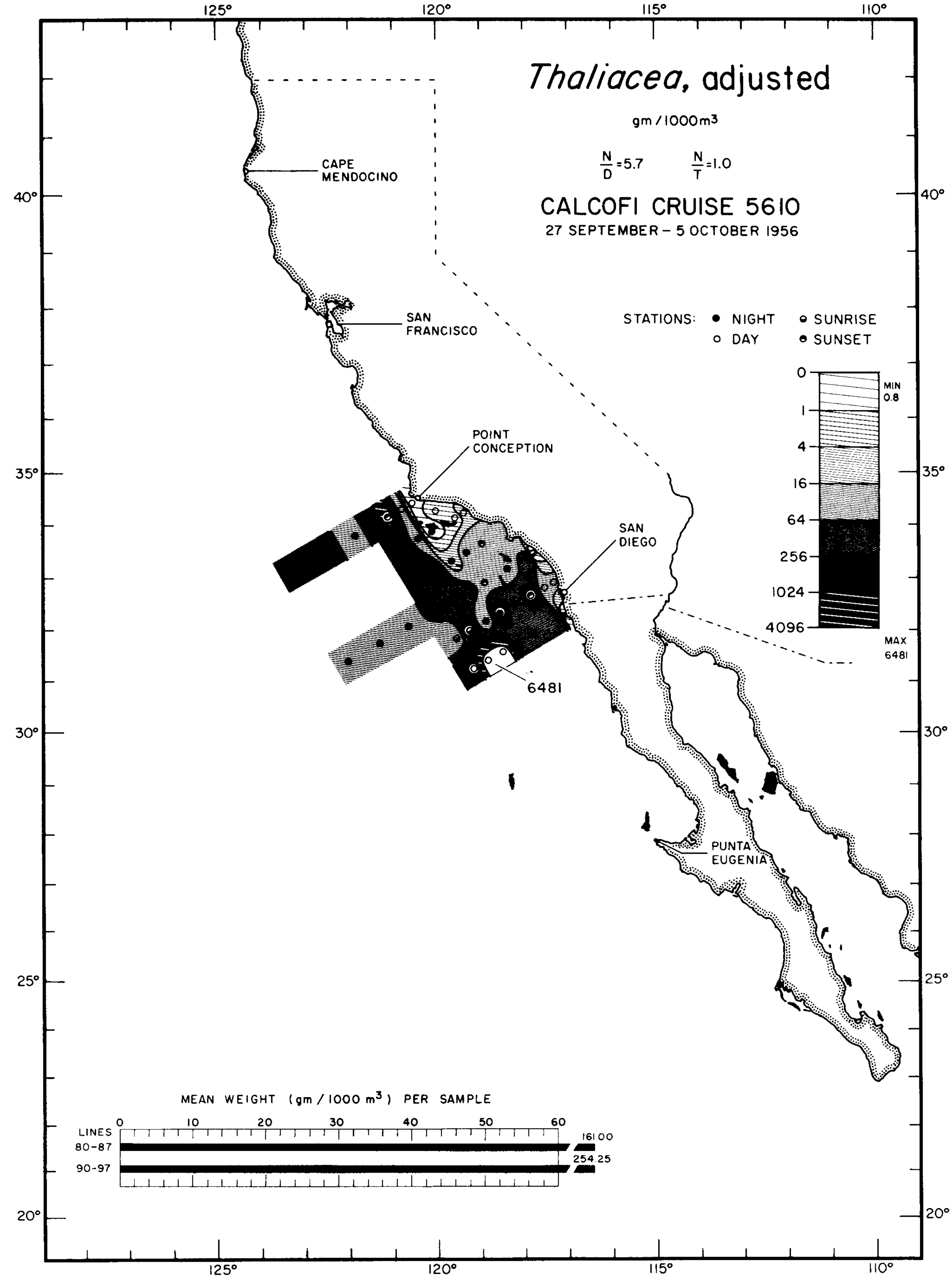
Biomass

Thaliacea, adjusted

5510



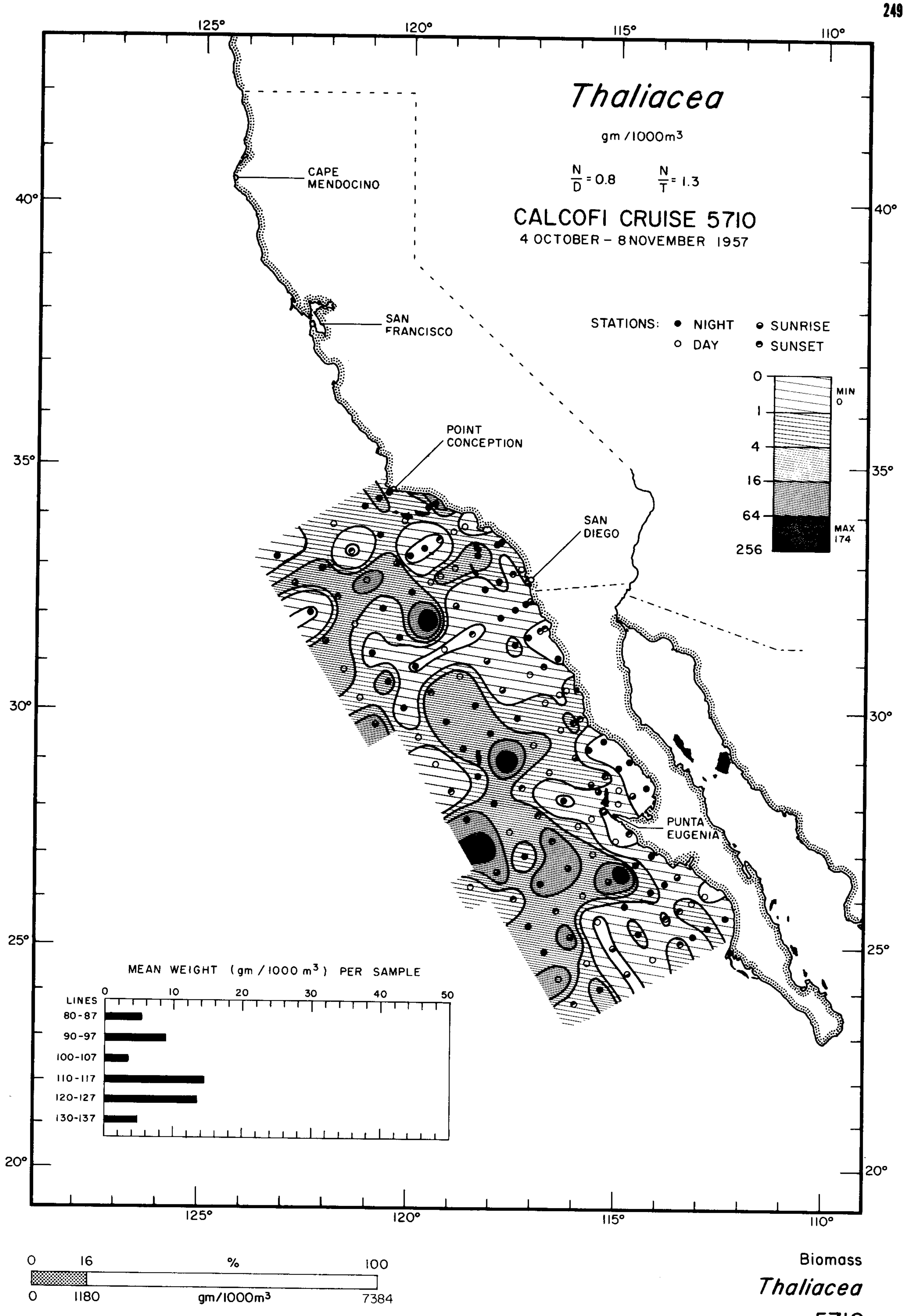
Biomass
Thaliacea
5610



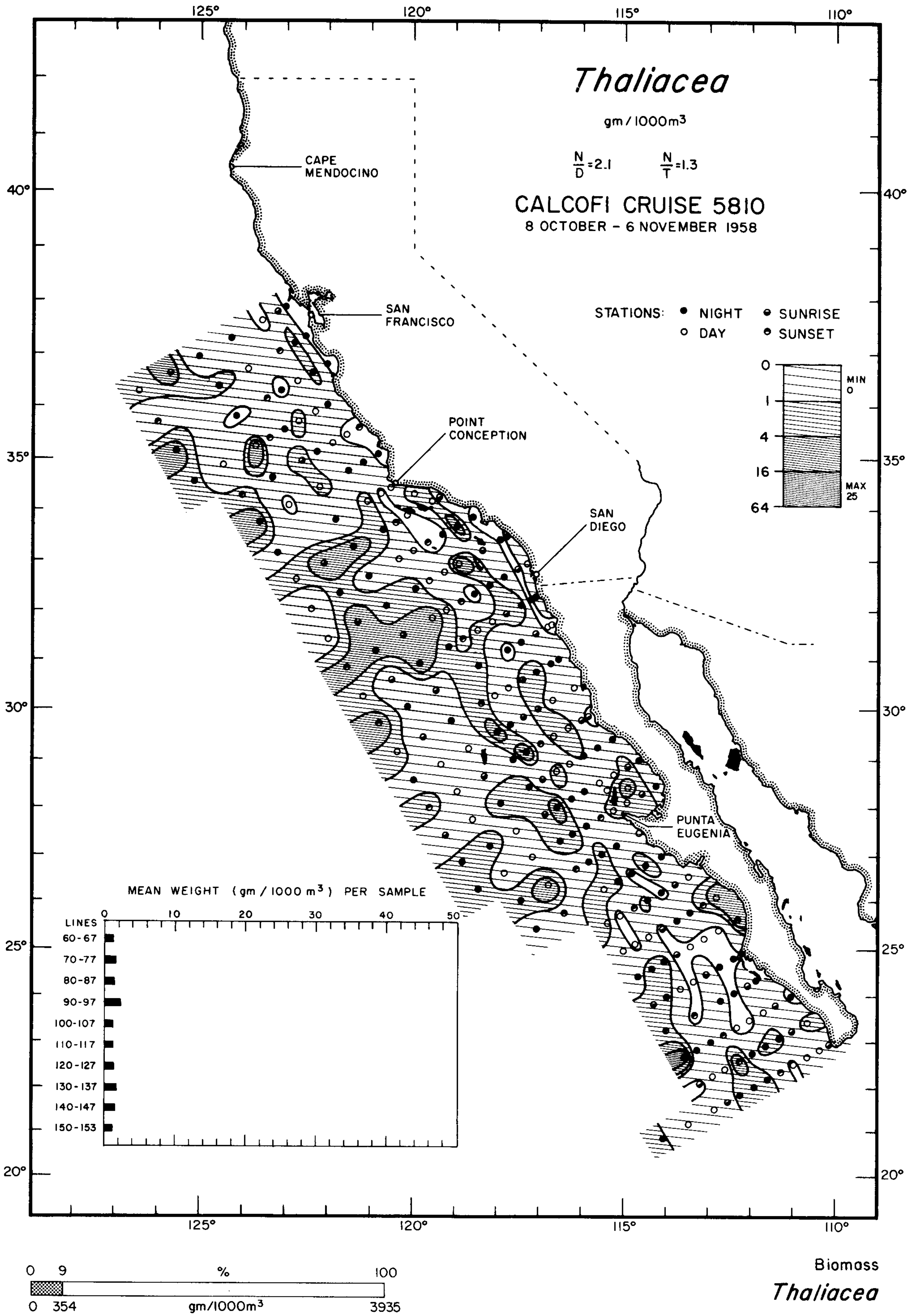
Biomass

Thaliacea, adjusted

5610



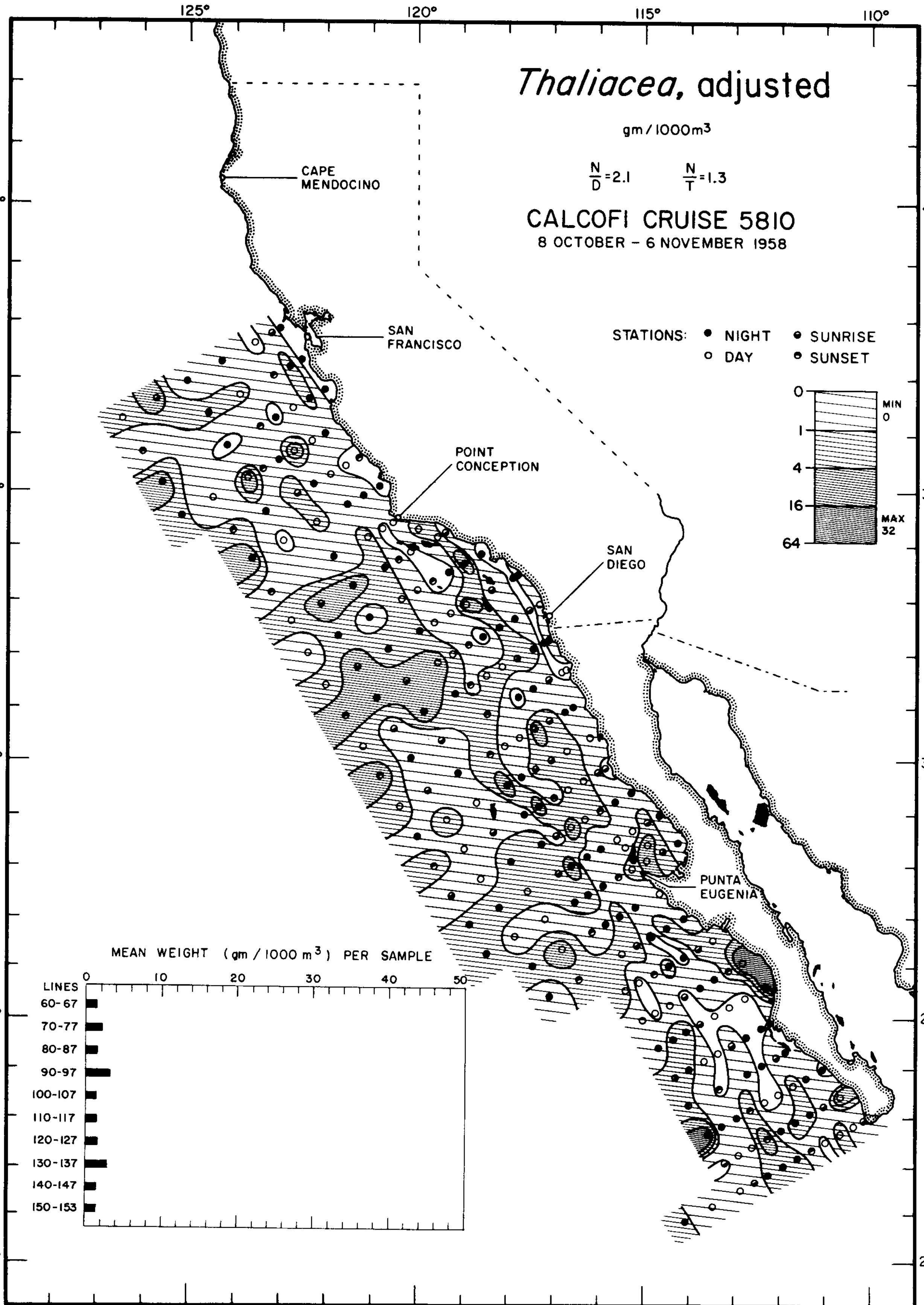
Biomass
Thaliacea
5710



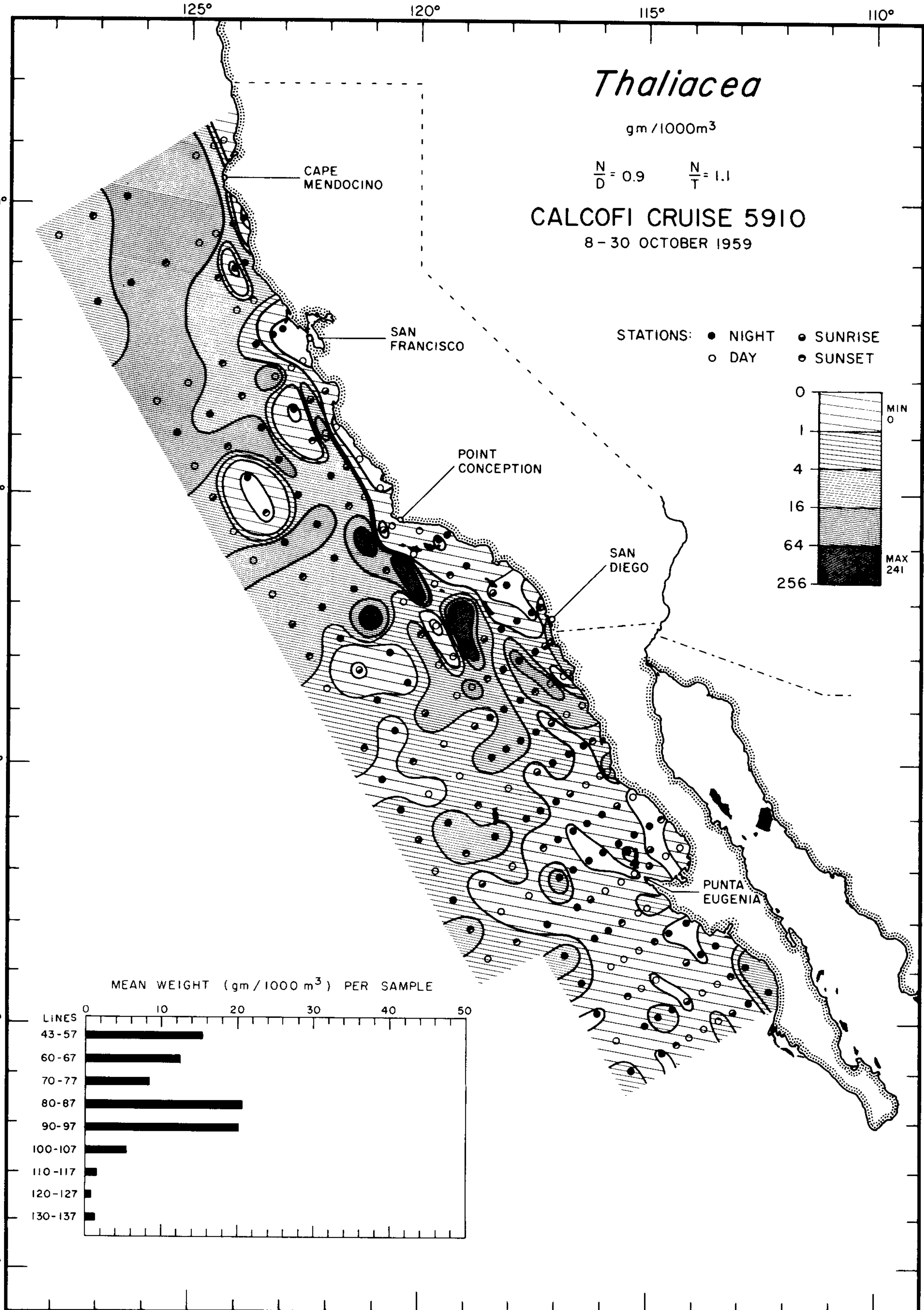
Biomass

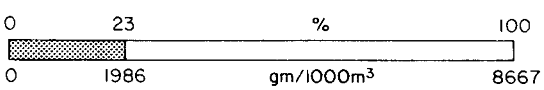
Thaliacea

5810



Biomass
Thaliacea, adjusted
5810

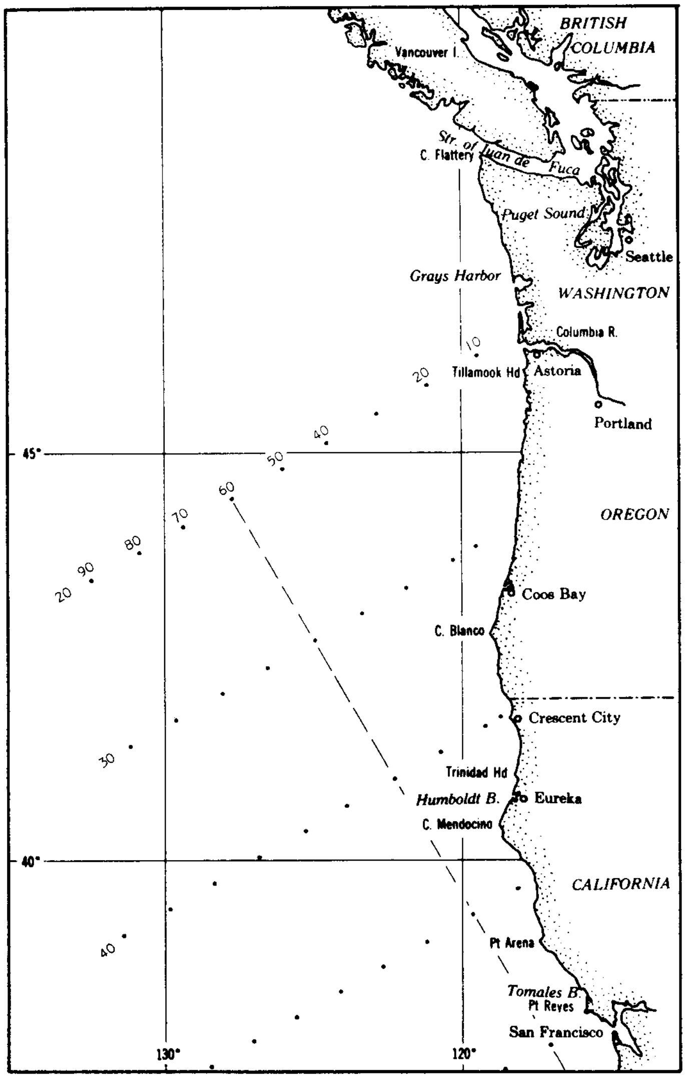


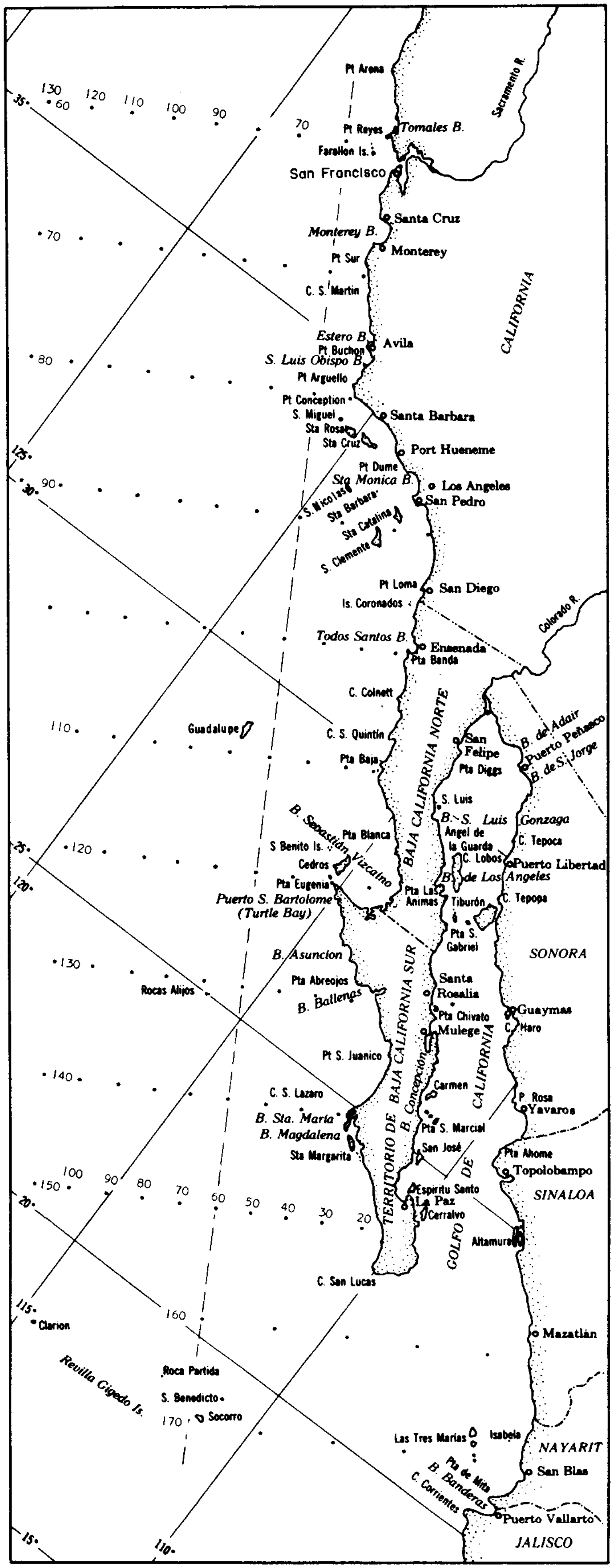


Biomass

Thaliacea

5910





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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