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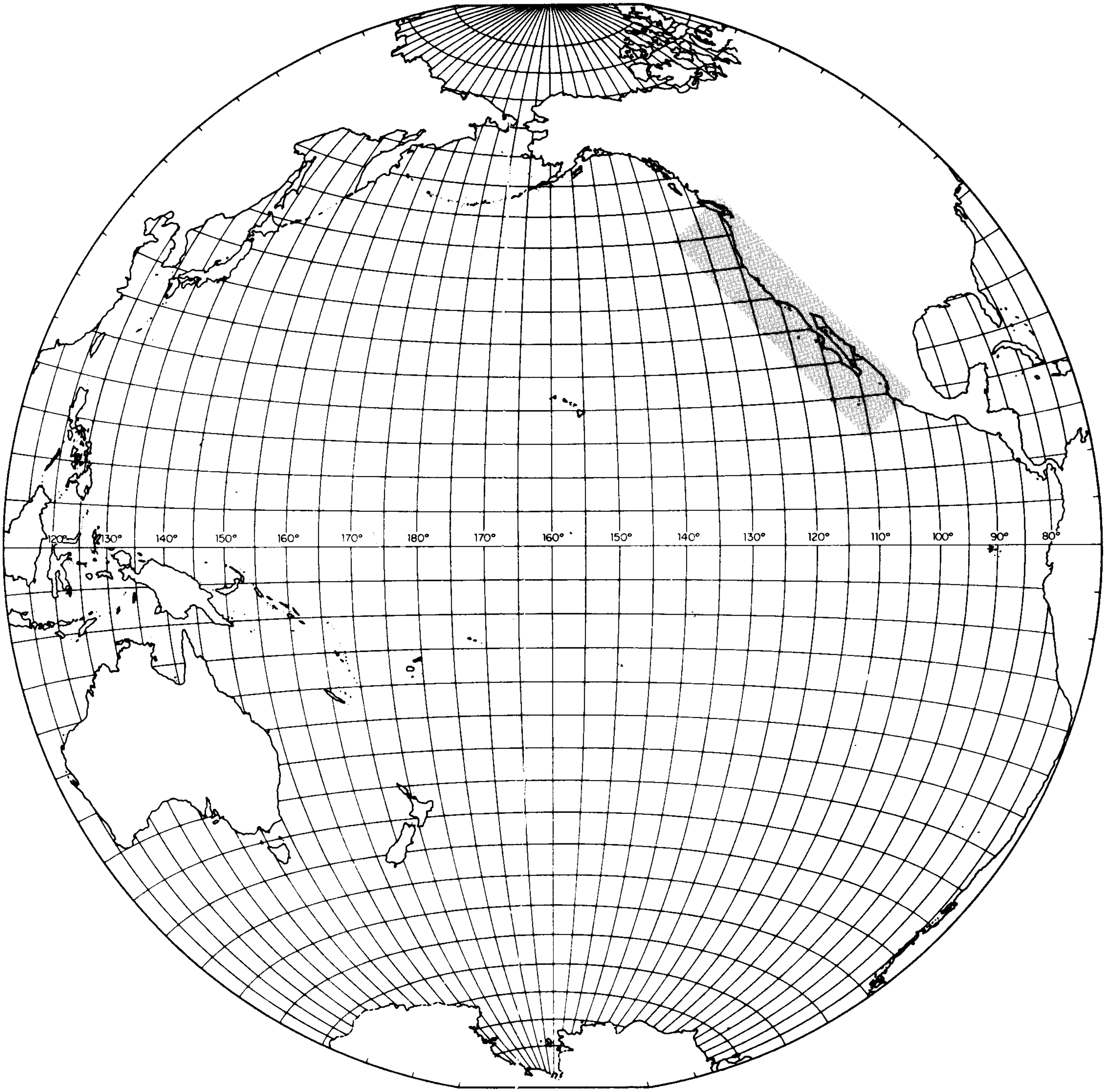
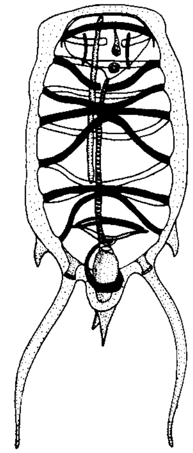


CALIFORNIA COOPERATIVE OCEANIC FISHERIES INVESTIGATIONS

ATLAS No. 21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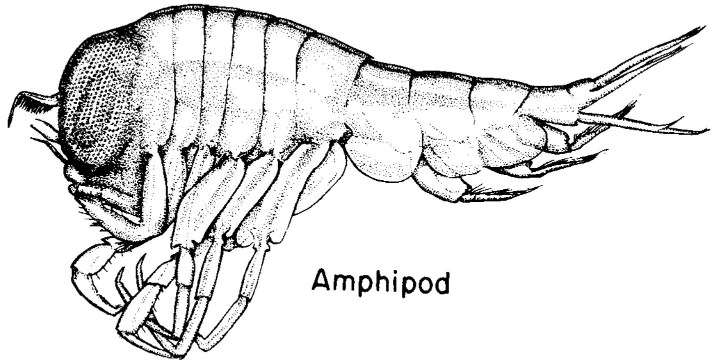
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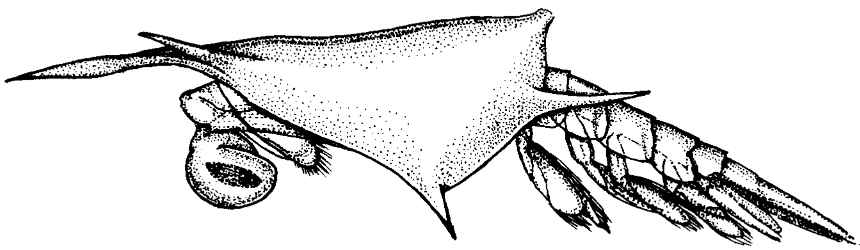
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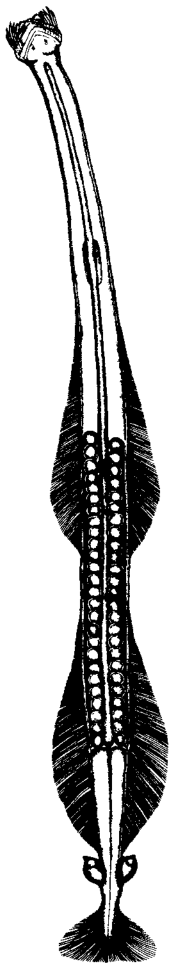
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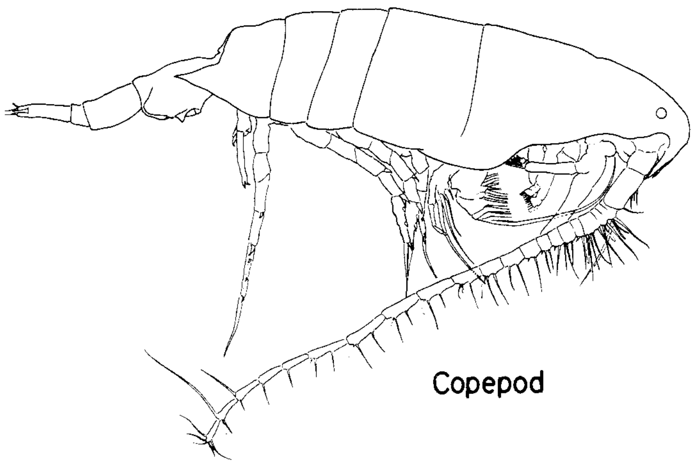
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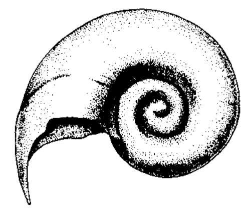
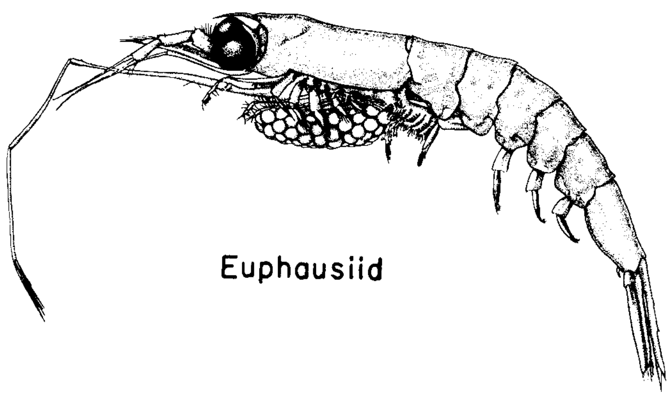

Pteropod


Euphausiid

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June, 1974

THE CALCOFI ATLAS SERIES

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

California Academy of Sciences
California Department of Fish and Game
Stanford University, Hopkins Marine Station
National Oceanic and Atmospheric Administration, National Marine Fisheries Service[2]
University of California, Scripps Institution of Oceanography

CalCOFI atlases[3] 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 John G. Wyllie, Editors

CalCOFI atlases in this series, through June 1974, are:

No. 1. Anonymous, 1963. CalCOFI atlas of 10-meter temperatures and salinities 1949 through 1959.
No. 2. Fleminger, A., 1964. Distributional atlas of calanoid copepods in the California Current region, Part I.
No. 3. Alvarino, A., 1965. Distributional atlas of Chaetognatha in the California Current region.
No. 4. Wyllie, J.G., 1966. Geostrophic flow of the California Current at the surface and at 200 meters.
No. 5. Brinton, E., 1967. Distributional atlas of Euphausiacea (Crustacea) in the California Current region, Part I.
No. 6. McGowan, J.A., 1967. Distributional atlas of pelagic molluscs in the California Current region.
No. 7. Fleminger, A., 1967. Distributional atlas of calanoid copepods in the California Current region, Part II.
No. 8. Berner, L.D., 1967. Distributional atlas of Thaliacea in the California Current region.
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No. 10. Isaacs, J. D., A. Fleminger and J. K. Miller, 1969. Distributional atlas of zooplankton biomass in the California Current region: Spring and Fall 1955-1959.
No. 11. Ahlstrom, E. H., 1969. Distributional atlas of fish larvae in the California Current region: jack mackerel, *Trachurus symmetricus*, and Pacific hake, *Merluccius productus*, 1951 through 1966.
No. 12. Kramer, D., 1970. Distributional atlas of fish eggs and larvae in the California Current region: Pacific sardine, *Sardinops caerulea* (Girard). 1951 through 1966.
No. 13. Smith, P. E., 1971. Distributional atlas of zooplankton volume in the California Current region, 1951 through 1966.
No. 14. Isaacs, J. D., A. Fleminger and J. K. Miller, 1971. Distributional atlas of zooplankton biomass in the California Current region: Winter 1955-1959.
No. 15. Wyllie, J. G., and R. J. Lynn, 1971. Distribution of temperature and salinity at 10 meters, 1960-1969 and mean temperature, salinity and oxygen at 150 meters, 1950-1968 in the California Current.
No. 16. Crowe, F. J. and R. A. Schwartzlose, 1972. Release and recovery records of drift bottles in the California Current region, 1955 through 1971.
No. 17. Ahlstrom, E. H., 1972. Distributional atlas of fish larvae in the California Current region: six common mesopelagic fishes—*Vinciguerria lucetia, Triphoturus mexicanus, Stenobrachius leucopsarus, Leuroglossus stilbius, Bathylagus wesethi* and *Bathylagus ochotensis*. 1955 through 1960.
No. 18. Brinton, E., 1973. Distributional atlas of Euphausiacea (Crustacea) in the California Current region. Part II.

No. 19. Bowman, T. E. and M. W. Johnson, 1973. Distributional atlas of calanoid copepods in the California Current region, 1949 and 1950.

No. 20. Thomas, W. H. and D. L. R. Seibert, 1974. Distribution of nitrate, nitrite, phosphate and silicate in the California Current region, 1969.
Owen, R. W., Jr., 1974. Distribution of primary production, plant pigments and Secchi depth in the California Current region, 1969.
Smith, P. E., 1974. Distribution of zooplankton volumes in the California Current region, 1969.

No. 21 Fleminger, A., J. D. Isaacs and J. G. Wyllie, 1974. Zooplankton biomass measurements from CalCOFI cruises of July 1955 to 1959 and remarks on comparison with results from October, January and April cruises of 1955 to 1959.

[1] Usually abbreviated CalCOFI, sometimes CALCOFI or CCOFI.
[2] Formerly called U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries.
[3] For citation this issue in the series should be referred to as CalCOFI Atlas No. 21

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ZOOPLANKTON BIOMASS MEASUREMENTS FROM CalCOFI CRUISES OF JULY 1955 TO 1959 AND REMARKS ON COMPARISON WITH RESULTS FROM OCTOBER, JANUARY AND APRIL CRUISES OF 1955 TO 1959

A. Fleminger, J. D. Isaacs and J. G. Wyllie

CalCOFI ATLAS NO. 21

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Data Collection and Processing Group
Marine Life Research Program
Scripps Institution of Oceanography
La Jolla, California
June 1974

ZOOPLANKTON BIOMASS MEASUREMENTS FROM CalCOFI CRUISES OF JULY 1955 TO 1959 AND REMARKS ON COMPARISON WITH RESULTS FROM OCTOBER, JANUARY, AND APRIL CRUISES OF 1955 TO 1959

A. Fleminger, J.D. Isaacs, and J.G. Wyllie[1]

Text

Charts

Introduction

This atlas presents the quantitative distribution of zooplankton taxa we call functional groups that were collected in the California Current region during July CalCOFI cruises in the years 1955 to 1959. Functional groups are unequal as to taxonomic rank and diversity but relate readily to trophodynamic categories within the pelagic ecosystem (cf. Isaacs, Fleminger and Miller, 1971: p vi).

The biomass of functional groups collected and analysed during the October, January and April cruises between 1955 and 1959 have been presented in previous atlases of this series (Isaacs, Fleminger and Miller, 1969, 1971). Addition of the July data completes our initial objective of obtaining a seasonally representative qualitative and quantitative estimate of zooplankton biomass over a time period spanning sequences of unusually cool and warm years as occurred between 1955 and 1959 (cf. Anon, 1963), for charts of monthly temperature anomalies relative to ten-year means at representative CalCOFI oceanographic stations). A more extensive discussion of the background and objectives of this study was presented by Isaacs, Fleminger and Miller (1971).

Materials and Methods

Isaacs, Fleminger and Miller (1971) described the procedures for collecting, measuring and displaying wet weight biomass measurements of CalCOFI zooplankton samples and for adjusting these measurements in the case of organisms known to undergo extensive diel vertial migrations greater than the 140m depth of the CalCOFI oblique tow routinely taken in those years (cf. Smith, 1971).

The unusually large number of stations occupied by the July cruises (Table 1) prompted us to reduce sample-processing time by limiting the search for rare or unusually large sized specimens not represented in the standard aliquot. A one-quarter or one-half fraction obtained by means of the Folsom splitter was examined instead of our previous practice of scanning the entire sample. Comparison of 13 samples representing the range of CalCOFI sample sizes and environmental localities indicates that differences between values obtained by the original and the modified procedures are negligible; in fact they do not exceed differences between replicate trials of the original procedure.

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1. Scripps Institution of Oceanography, University of California, San Diego, La Jolla, California 92037

Table 1. Number of standard CalCOFI zooplankton samples from July cruises processed to determine the wet weight per $1000m^3$ of each functional group.

CalCOFI cruise		Number of samples
5507		192
5607		202
5707		208
5807		255
5907		270
	Total	1127

Presentation of Results

The biomass of each functional group is shown separately, cruise by cruise (Table 2), as in the example given in Figure 1. Biomass estimates are expressed in grams (wet weight corrected for interstitial water) per $1000m^3$ sea water strained by a standard CalCOFI zooplankton net. Contour lines shown on the charts coincide with a sequence of values differing by a factor of four, as follows: 0.016, 0.062, 0.25, 1, 4, 16, 64, etc. No more than seven contour intervals are shown per chart, the sequence being chosen to fit the range of measurements obtained during a specific cruise. The highest and lowest estimates of biomass greater than zero are shown in arabic numerals to the right of the index of contour interval shadings in the chart legend. The charts have been arranged alphabetically by functional groups; the sum of all groups appears first under the heading, "All Taxa Combined."

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 (Fig. 1). The latitudinal distribution of biomass is compared by estimating the mean weight per station for 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 the actual proportions and as a percentage in a bar diagram located in the lower left margin of the chart.

Remarks on Seasonal and Year to Year Variations

The biomass measurements we present have been obtained from a biota of more than 545 species of planktonic invertebrates known to occur above a depth of 140m in the California Current region (cf. Isaacs, Fleminger and Miller, 1971: Table 1). Despite this high diversity only a very small number of species appears to contribute appreciably to the region's high biomass as noted below.

In general copepods, thaliaceans, euphausiids and chaetognaths together account for more than 75% of the mean biomass in each of the four months over the five year sequence (Fig. 2). Though differences in the relative proportions between years may vary widely (Fig. 3) copepods and thaliaceans are persistently the most important categories in terms of wet weight (Fig. 4). Copepods regularly comprise from at least one quarter to one third of the wet weight. Measurements of copepods however are likely to be underestimates since the mesh size of the CalCOFI nets permits escapement of organisms having a minimum cross section of less than 0.5mm.

During the sampling years of 1955 to 1959, which varied widely with respect to prevailing surface temperatures, fluctuations in the abundance of copepods and thaliaceans tend to parallel one another. In the relatively cool years of 1955 and 1956 when 10-meter temperatures were well below the ten year mean of representative stations (Anon., 1963), the biomass of copepods and thaliaceans month by month was roughly twice as high as estimates obtained from 1958 and 1959 when temperatures were considerably above the ten year mean. With few exceptions April and July cruises produced at least twice the biomass attained by either group during the October and January cruises (Figs. 3, 4). Cruise to cruise variation among the other two taxa, euphausiids and chaetognaths however, are slight and appear to be without a yearly or seasonal pattern (Figs. 3, 4).

Since thaliaceans and copepods are primarily small particle filter feeders and appear to vary similarly in abundance, the question of their horizontal distributions within the region deserves more than cursory attention. Visual cruise-by-cruise comparison of summary charts outlining their areas of high biomass values (Figs. 5 and 6) indicates they have pre-

Table 2. List of charts.

Cruise Number	5507	5607	Summer 5707	5807	5907
All Taxa Combined	2	3	4	5	6
Amphipoda	7	9	11	13	15
Amphipoda, Adjusted	8	10	12	14	16
Chaetognatha	17	18	19	20	21
Cladocera	22	23	24	25	26
Copepoda	27	28	29	30	32
Copepoda, adjusted				31	33
Crustacea larvae	34	35	36	37	39
Crustacea larvae, adjusted				38	
Ctenophora	40	41	42	43	44
Decapoda	45	47	49	51	53
Decapoda, adjusted	46	48	50	52	54
Euphausiacea	55	57	59	61	63
Euphausiacea, adjusted	56	58	60	62	64
Heteropoda	65	66	67	68	70
Heteropoda, adjusted				69	
Larvacea	71	72	73	74	75
Medusae	76	77	78	79	80
Mysidacea	81	82	83	84	85
Ostracoda	86	88	90	92	94
Ostracoda, adjusted	87	89	91	93	95
Pteropoda	96	97	99	100	102
Pteropoda, adjusted		98		101	
Radiolaria	103	104	105	106	108
Radiolaria, adjusted				107	
Siphonophora	109	110	111	112	113
Thaliacea	114	115	116	117	118

dominantly different though sometimes overlapping distributions. Large concentrations of thaliaceans are more frequently offshore, dominating the western and northern margins of cruises (Fig. 5). Large concentrations of copepods most frequently cluster near shore, particularly south of Point Conception.

When prominent at the northern end of cruises, copepod abundance diminishes more gradually offshore (Fig. 6) but only partially overlaps the areas of high thaliacean abundance. Annually, both functional groups tend to show higher biomass values in April and July coinciding with the familiar seasonal pattern of the region's coastal upwelling. Thus, environmental factors increasing nutrient concentrations and primary production appear to affect both inshore and offshore sectors of the California Current region.

In the laboratory herbivorous copepods from temperate and boreal latitudes prefer larger-sized species of diatoms (>20μm, the net phytoplankton; Frost, 1974). Thaliaceans are non-selective filter-feeders consuming a broad spectrum of micro-organisms from less than 1μm to greater than 1 mm (Madin, 1974). The ability of adult and juvenile thaliaceans to harvest the smallest planktonic forms (<20μm, the nannoplankton) is particularly interesting. The biomass of nannoplankton is the most important and quantitatively stable size class of the phytoplankton in both offshore and nearshore euphotic waters of the California Current region whereas net phytoplankton shows remarkable seasonal variation in synchrony with local episodes of upwelling (Malone 1971a, b). In nearshore waters thaliaceans must com-

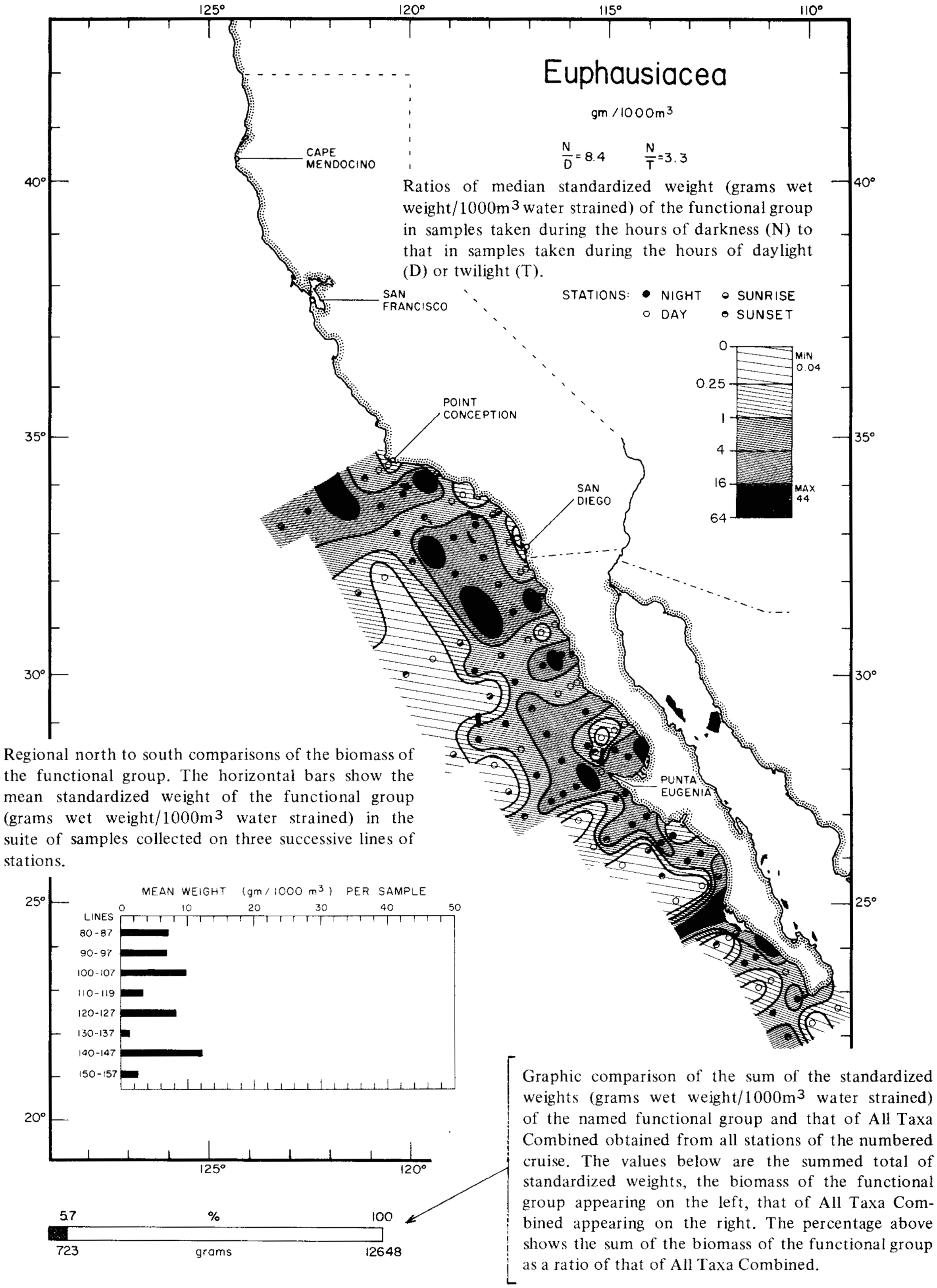

Figure 1. An example of the charts presented in this Atlas. Special quantitative summaries include: 1. ratio of quantity caught in night samples relative to that in twilight and day samples; 2. north to south comparison of abundance; 3. total amount of the functional group taken relative to that of the entire catch (All Taxa Combined).

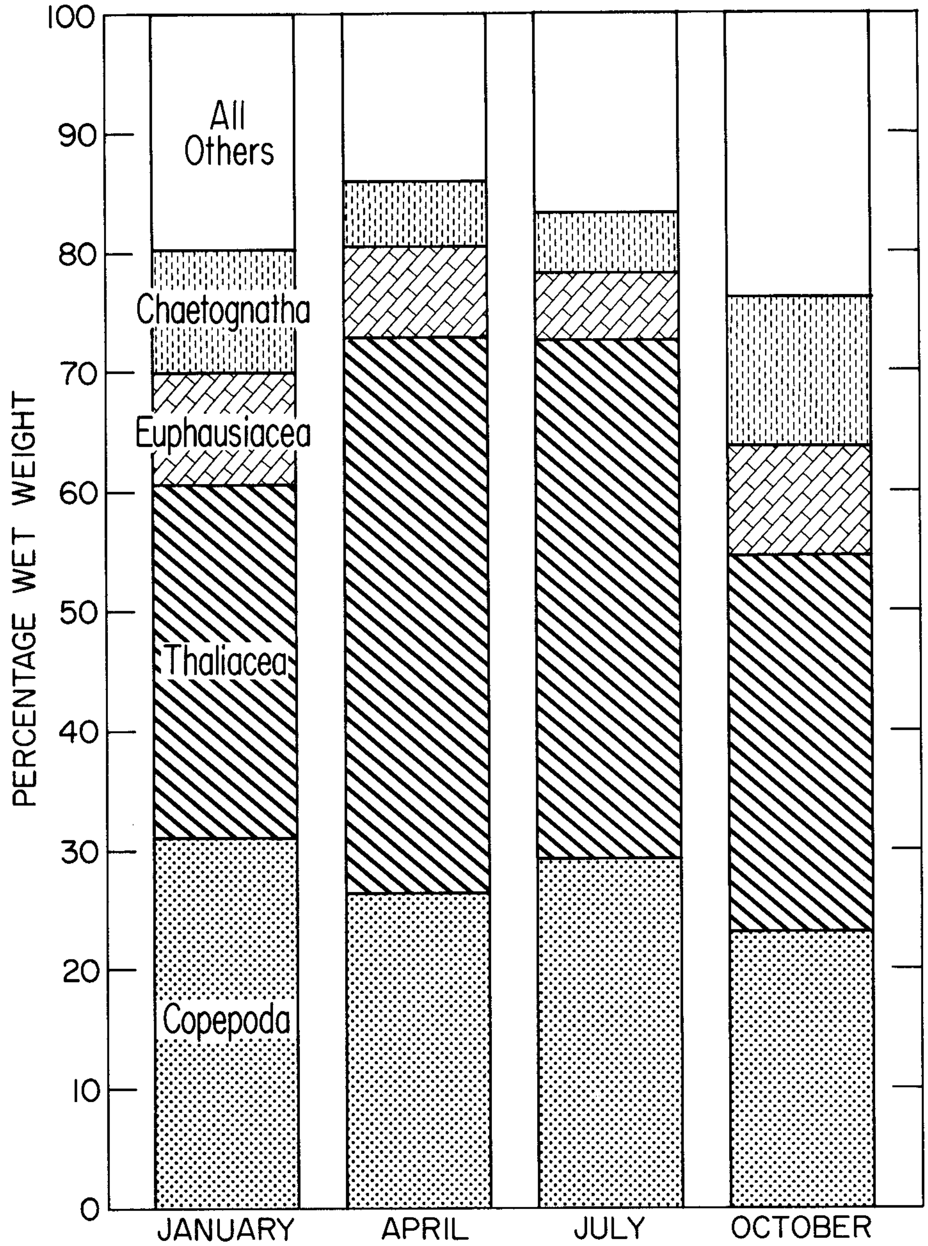

Figure 2. Mean seasonal percent wet weight of functional groups showing copepods, thaliaceans, euphausiids and chaetognaths, 1955-1959.

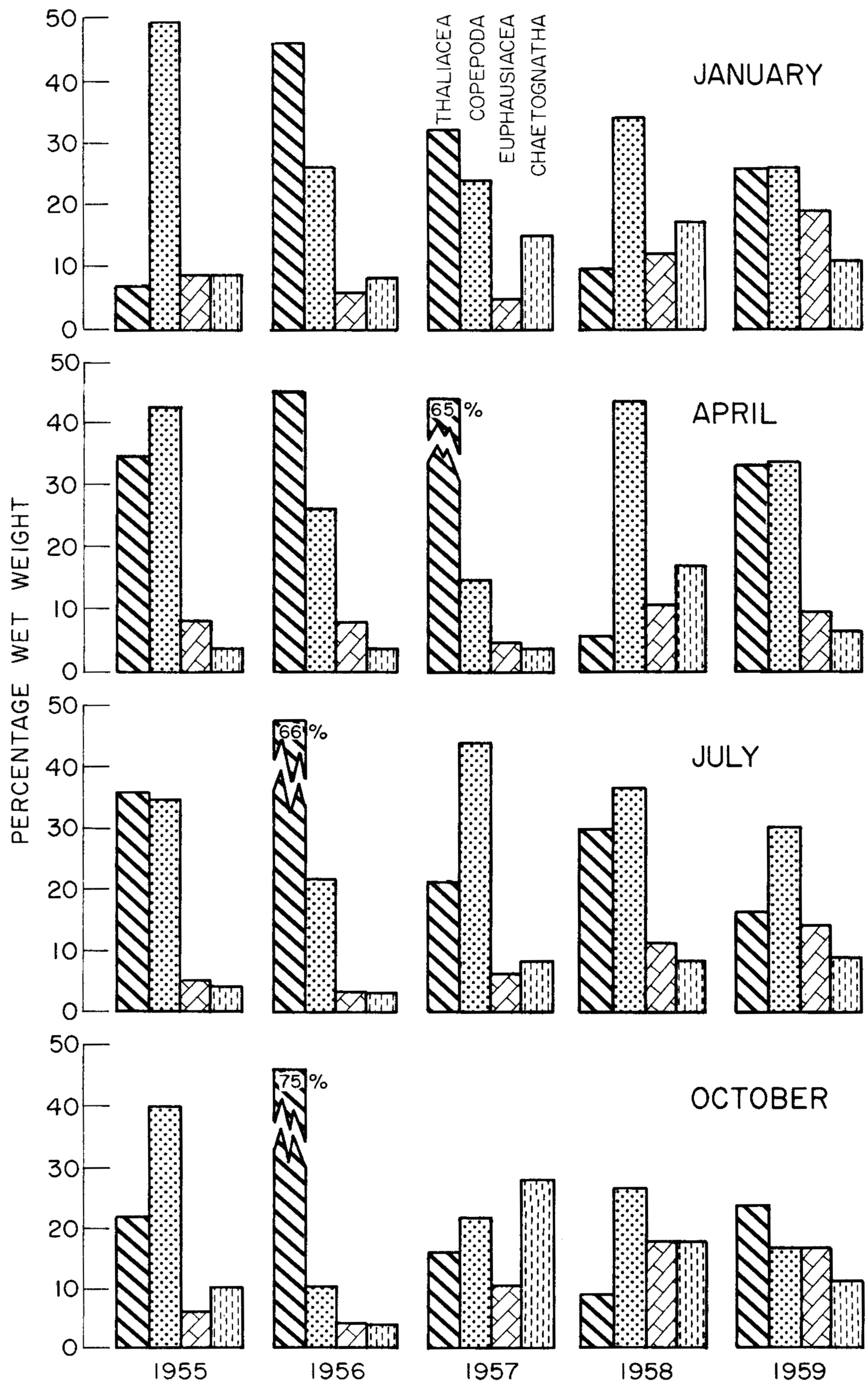

Figure 3. Percentage wet weight of functional groups by month and year.

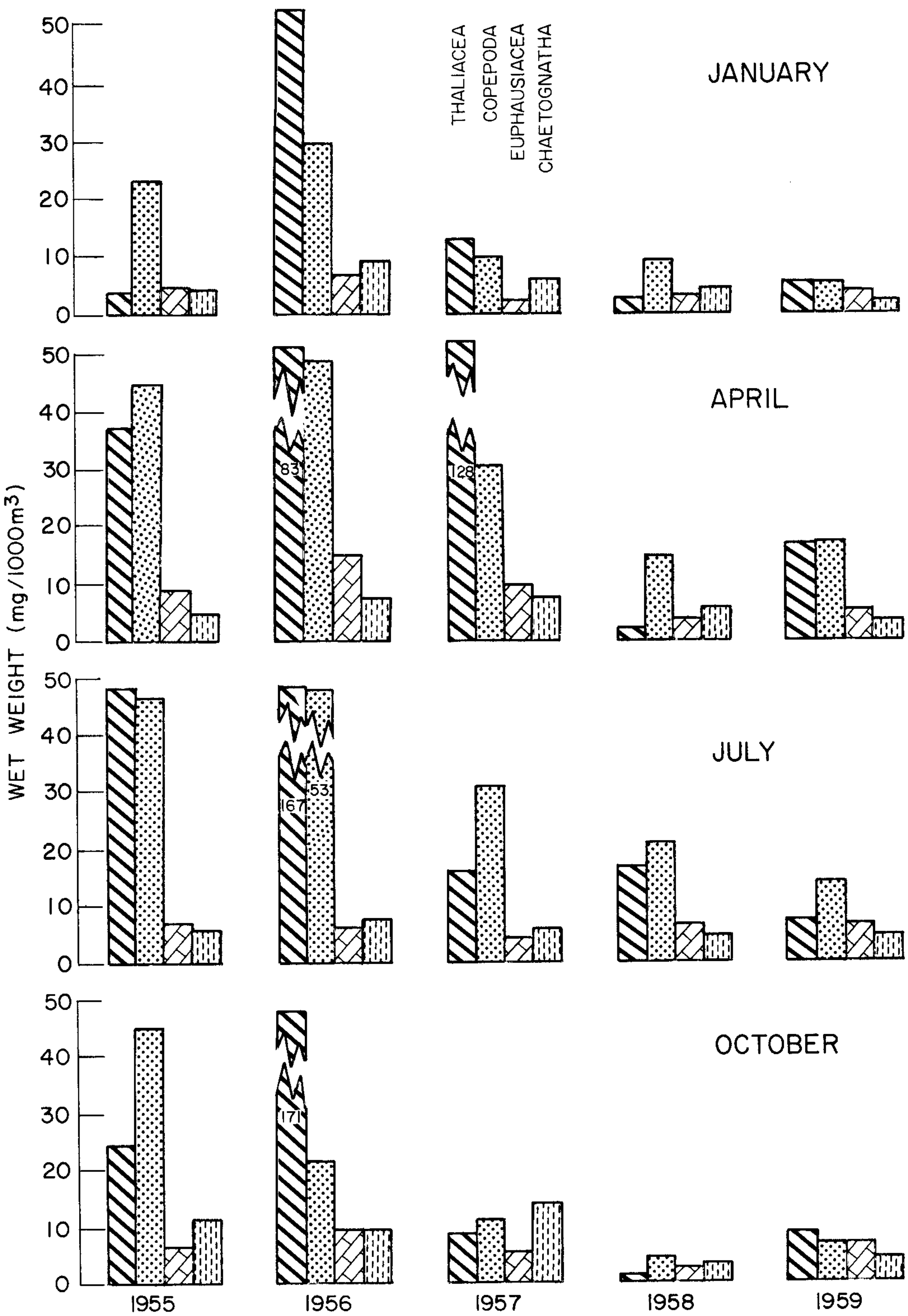

Figure 4. Mean biomass (mg/1000m^3) of functional groups by month and year.

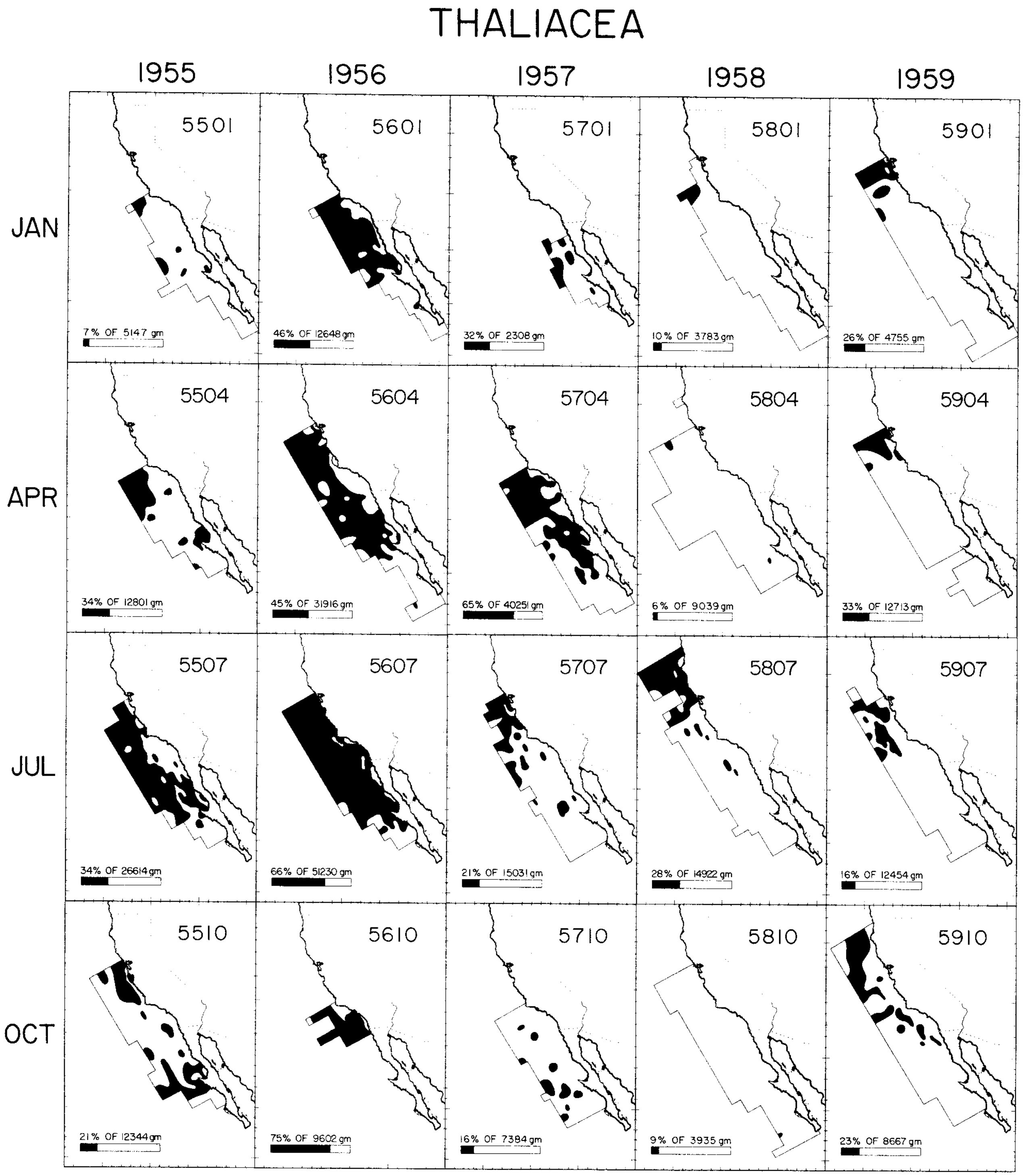

Figure 5. Blackened regions show occurrence of Thaliacea at or above 16mg/1000m^3. Area sampled by cruise delineated by thin line.

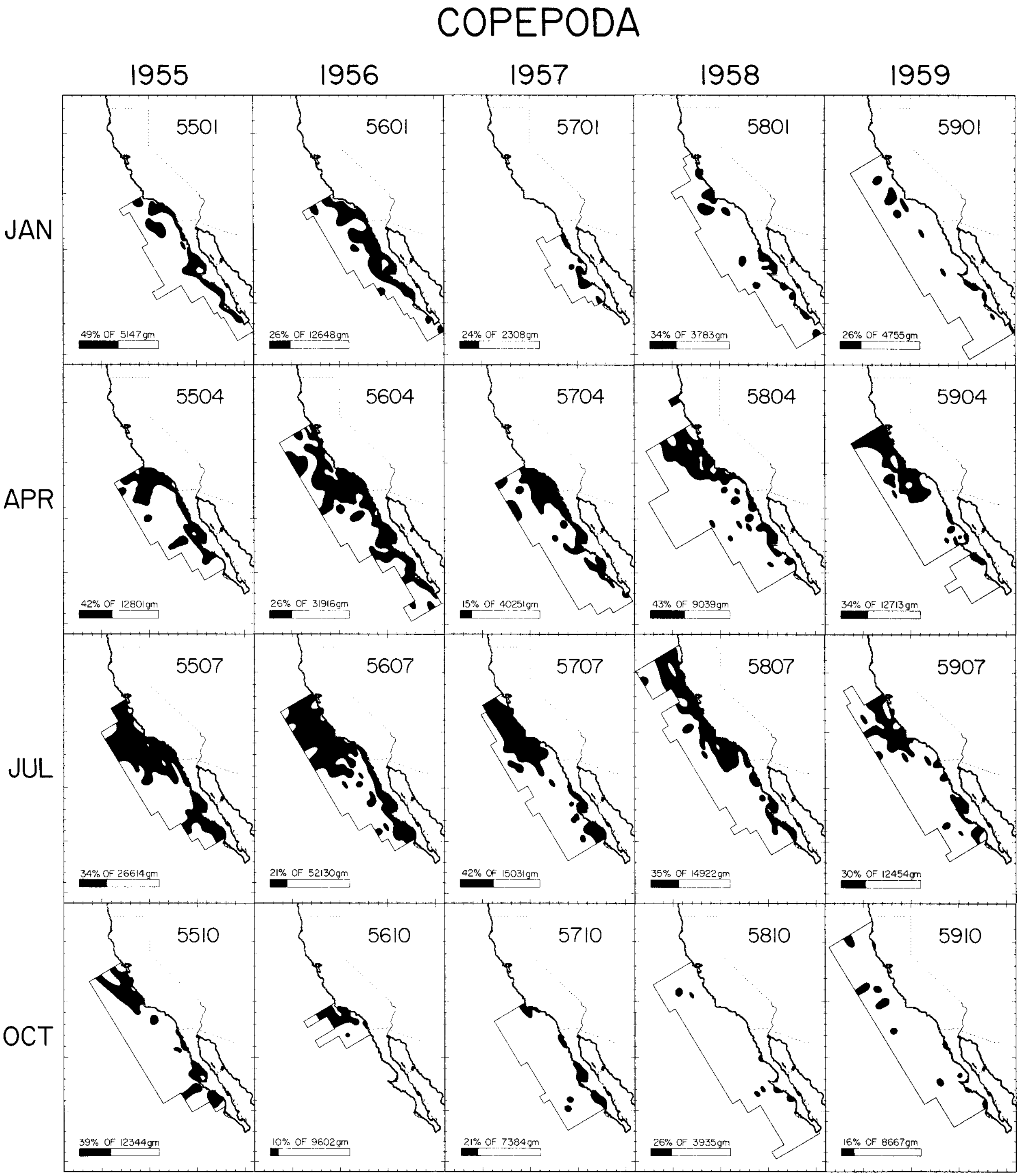

Figure 6. Blackened regions show occurrence of Copepoda at or above 16mg/1000m^3. Area sampled by cruise delineated by thin line.

pete with a larger biomass of microzooplankton (Beers and Stewart 1967, 1970) for the nannoplankton and with the larger numbers of herbivorous copepods for the seasonal pulses of net phytoplankton. Whether the distributional trends of thaliacean and copepod biomass reflect these trophodynamic relationships however is a question to be resolved by further studies on the kinetics of the pelagic food web.

No pronounced seasonal or spatial pattern is evident in the relatively small fluctuations shown by euphausiids and chaetognaths (Figs. 3, 4, 7, 8). High concentrations of chaetognaths more commonly appear in inshore patches and do not seem to be spatially coordinated with euphausiids. The absence of pronounced seasonal fluctuations in mean biomass values of these two functional groups may be related to their use of zooplankton as a major or exclusive food of adults.

Chaetognaths are known to be obligate predators but epipelagic euphausiids appear to be omnivorous feeders (Nemoto 1971/1972). The absence of seasonal fluctuations in the biomass of both taxa suggests that euphausiids may assume a predatory role when phytoplankton becomes scarce. By occupying a higher trophic level, euphausiids would be buffered from the immediate influence of strong seasonal fluctuations in primary production. In contrast fluctuations in primary production may be inferred as a partial basis for the strong seasonal changes in the biomass of copepods and thaliaceans, although primary production was not routinely measured, and, hence, such possible relationships of these data cannot be readily tested. If copepods are numerically significant in the diets of adult euphausiids and chaetognaths, this should be reflected in their distributional relationships. Euphausiids and chaetognaths might be at least partially separated by concentrating on different size classes of copepods. Time and space distribution analyses of the three groups in upwelling regions would contribute to these interesting questions of zooplankton trophodynamics.

Visual comparison of available monthly charts showing the quantitative distribution of individual species of copepods, thaliaceans, euphausiids, and chaetognaths, (Fleminger, 1964, 1967; Bowman and Johnson 1973; Berner, 1967; Brinton, 1967, 1973; Alvarino, 1965) suggests that the higher biomass concentrations of these functional groups in the California Current region consist largely of temperate boundary current (=Transition Current Zone) species: copepods include *Metridia pacifica, Calanus pacificus, Eucalanus californicus, Rhincalanus nasutus, Pleuromamma borealis;* euphausiids are *Euphausia pacifica, Nematoscelis difficilis* and *Nyctiphanes simplex;* chaetognaths are *Sagitta euneritica* and *S. bierii;* thaliaceans are *Salpa fusiformis, Thalia democratica* s.l., and *Dolioletta gegenbauri.* Many of these species appear to be indigenous to the temperate North Pacific Ocean and specially adapted to inhabit the temperate segments of this ocean's boundary current. Adjusting their vertical distribution so as to use vertical components of the boundary current circulation would permit them to persist in and exploit the eutrophic conditions characterizing these distinctive currents.

In view of their known spatial distribution in the North Pacific the numerically dominant planktonic animals of the California Current region represent a southward tongue of the temperate zone. Their known North Pacific distributions indicate that the temperate zone extends from Japanese coastal waters and across the North Pacific in the North Pacific Drift, the eastward flowing segment of the boundary current that approaches the North American coast off Washington and Oregon. The boundary current divides into northward and southward components, the latter forming the origin of the California Current. The distribution of species presented in earlier CalCOFI Atlases show in terms of the temperate planktonic fauna that the California Current is a broad, relatively homogeneous tongue south to Point Conception and usually extends over an appreciable portion of the Southern California Bight as well. South of this tongue, high concentrations of temperate boundary current species follow pronounced seasonal variations and occur in the vicinity of coastal areas where vertical temperature distributions provide evidence of pronounced upwelling. Coastal upwelling prevails typically from winter to late spring and produces environmental conditions characteristic of the California Current north of Point Conception. Coastal upwelling may thereby extend the physical-chemical environment of temperate boundary current species seasonally southward as far as southern Baja California. Evidence indicative of this phenomenon is provided by the dense localized concentrations of temperate copepods, chaetognaths, euphausiids and fish larvae usually appearing from early spring to summer along the coastline of Baja California (Fleminger, 1964; Alvarino, 1965; Brinton, 1967. 1973; Kramer and Ahlstrom, 1968; Bowman and Johnson, 1973). More southerly concentrations of these species correlate seasonally and geographically with the high biomass estimates for the respective functional groups along Baja California reported by Isaacs, Fleminger and Miller (1969) for April cruises and in the present atlas for July cruises.

Subtropical oceanic species characteristic of the North Pacific's Central Water zooplankton generally

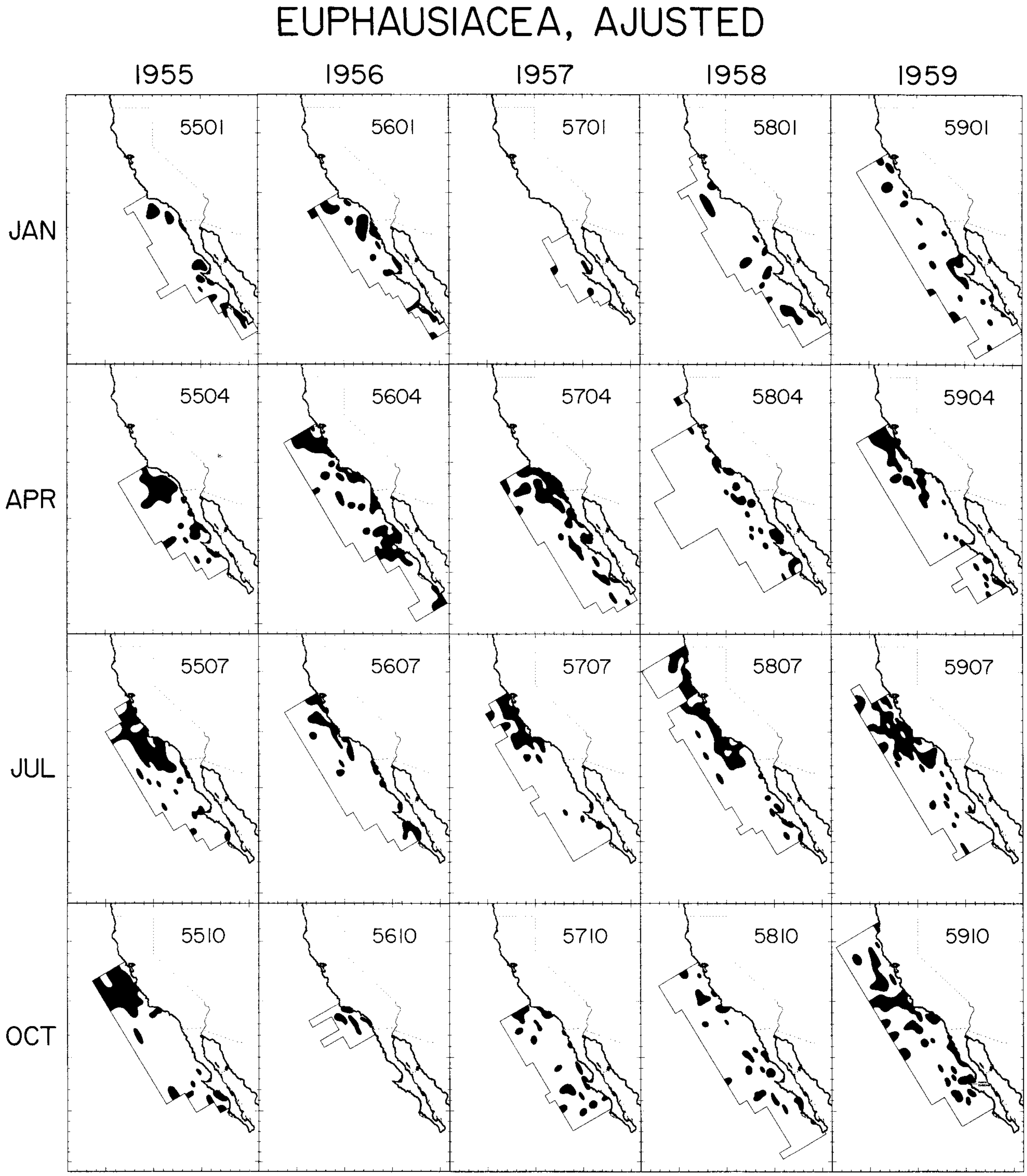

Figure 7. Blackened regions show occurrence of Euphausiacea (adjusted) at or above 16mg/1000m^3. Area sampled by cruise delineated by thin line. Day and twilight station values adjusted to estimated equivalent night catch values (cf. Isaacs, Fleminger and Miller, 1971: xiii-xvii).

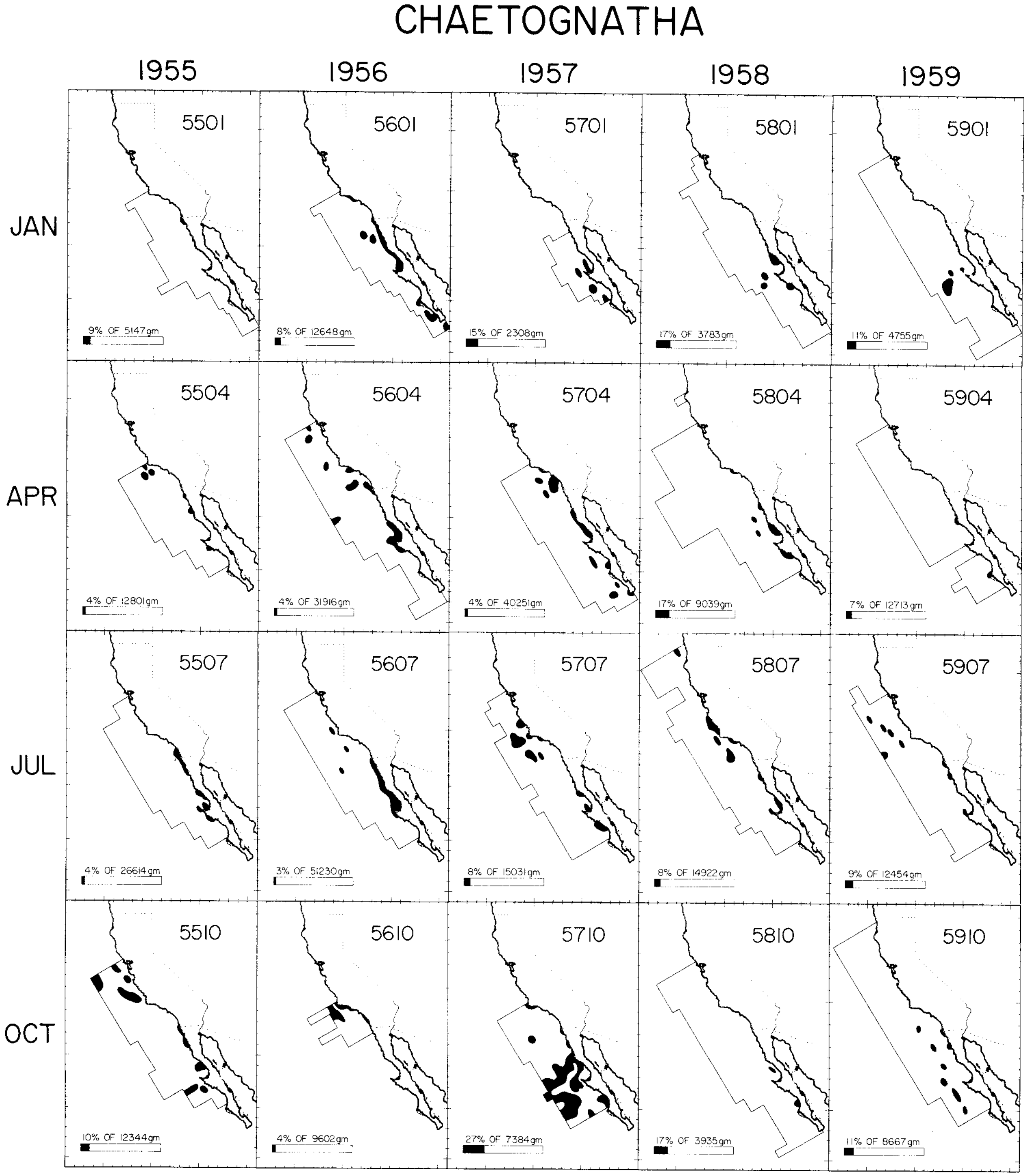

Figure 8. Blackened regions show occurrence of Chaetognatha at or above 16mg/1000m^3. Area sampled by cruise delineated by thin line.

appear between late summer and winter often dominating relatively near shore between the Southern California Bight and Punta Baja (roughly lat. 30°N). These periods of dominance tend to coincide with the relatively low biomass of copepods found south of Point Conception in the October and January cruises (Isaacs, Fleminger and Miller 1969, 1971). The presence of Central Water species suggests intrusions of Central Water disrupting the longshore distributions of temperate California Current species. South of Punta Eugenia tropical Pacific species occur in abundance except for localized nearshore concentrations of temperate California Current species associated with episodes of upwelling.

The patchy, seasonal, nearshore occurrences of crustacean biomass and large concentrations of temperate species between Southern California and Magdelena Bay prompt questions about the comparative roles played by local production and transport. We do not know to what extent these patches reflect local reproductive recruitment rather than southward transport or indeed how they relate locally to particular upwelling episodes. Notable, however, is the general coincidence of a variety of biotic and abiotic phenomena during the spring and summer off prominent headlands along the coast of Baja California that suggest upwelling plays the dominant role. Examples of these headlands are Cabo Colnett, Punta Baja, Punta Eugenia, Punta Abreojos and Cabo de San Lazaro. In addition to seasonal patches of high zooplankton biomass adjacent to these localities earlier atlases indicate that in spring and summer they are local centers of abundance of euphausiid larvae (Brinton, 1973: cf. esp. pp 81-108, 142-169) and of eggs and larvae of the northern anchovy, *Engraulis mordax* and the Pacific sardine, *Sardinops caerulea,* (Kramer and Ahlstrom 1968; Kramer 1970). Moreover, they have been found with relatively high quantities of nutrients, phytoplankton pigments and zooplankton volumes during the months of upwelling (Thomas, 1974; Owen, 1974; Smith, 1974). Finally during the upwelling season 10 meter temperatures at CalCOFI stations adjacent to these headlands are generally below the station's long-term mean (Anon., 1963). On the other hand initial concentrations of a species might aggregate along the margins of upwelling cells at least partly as the result of the transport effect on strongly vertical migrating species (Isaacs, Tont, and Wick, 1974).

Concern about the trophodynamic effects of these temporally and spatially localized nearshore regions of high zooplankton abundance points out several promising issues for future study. Cursory inspection of the known distribution of the larvae of planktophagous fish, e.g., the northern anchovy, the Pacific sardine, and the Pacific hake, *Merluccius productus* (Ahlstrom, 1969) off Baja California suggests seasonal and spatial correlation with the areas of high zooplankton biomass. These relationships deserve detailed analysis. For example, rigorous inspection of these features in conjunction with local meteorological conditions could provide a gross quantitative basis for estimating year class success of spawning epipelagic fishes off Baja California. To enhance general ecological understanding of the southern half of the California Current region, studies are also needed to determine the dependence of seasonally high numbers of Central Water zooplankton upon mixing processes that combine these usually sparse but highly diverse populations with waters enriched by the primary and secondary production of the California Current.

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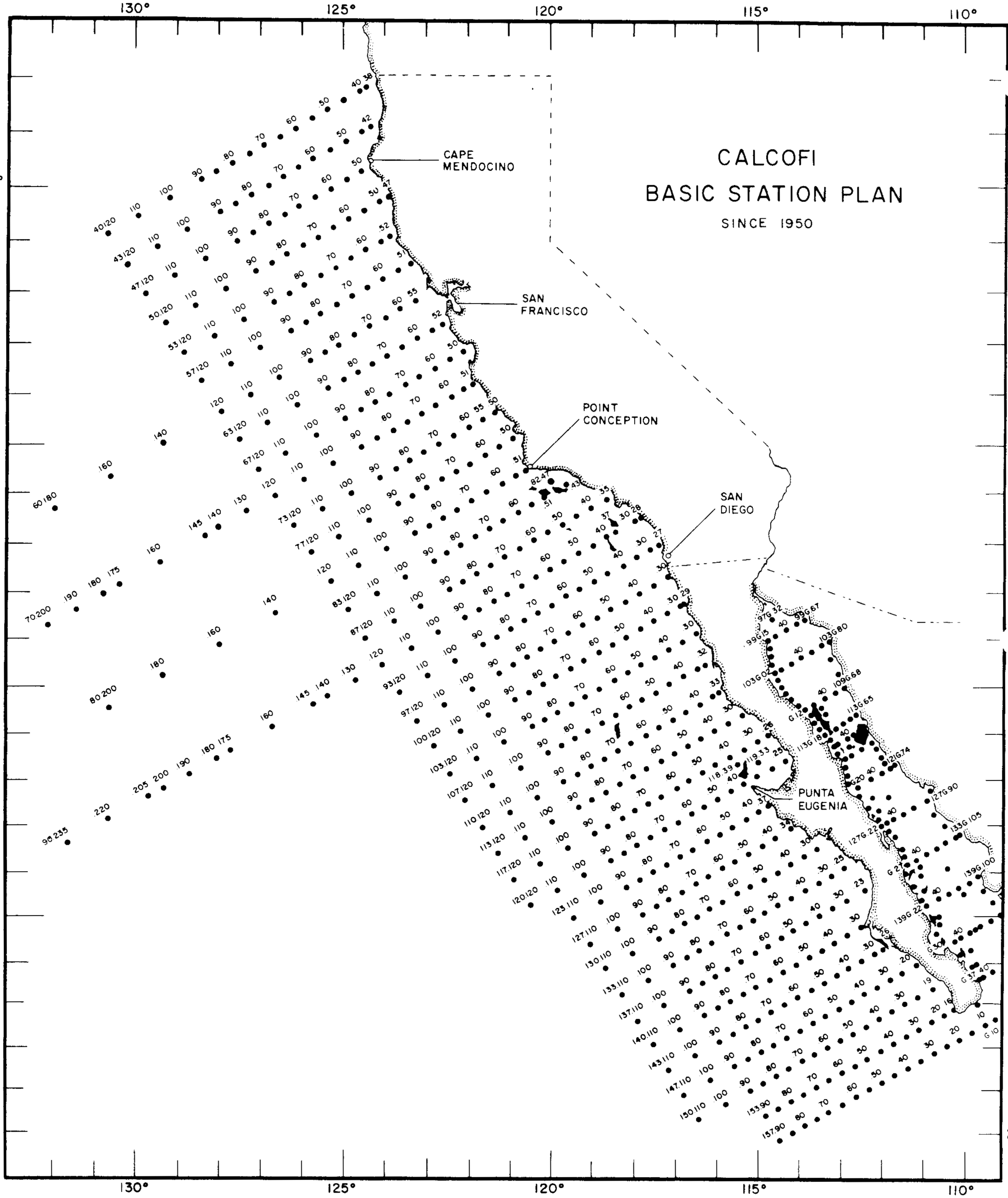


CALCOFI

BASIC STATION PLAN
SINCE 1950

All Taxa combined

Amphipoda

Chaetognatha

Cladocera

Copepoda

Crustacean larvae

Ctenophora

Decapoda

Euphausiacea

Heteropoda

Larvacea

Medusae

Mysidacea

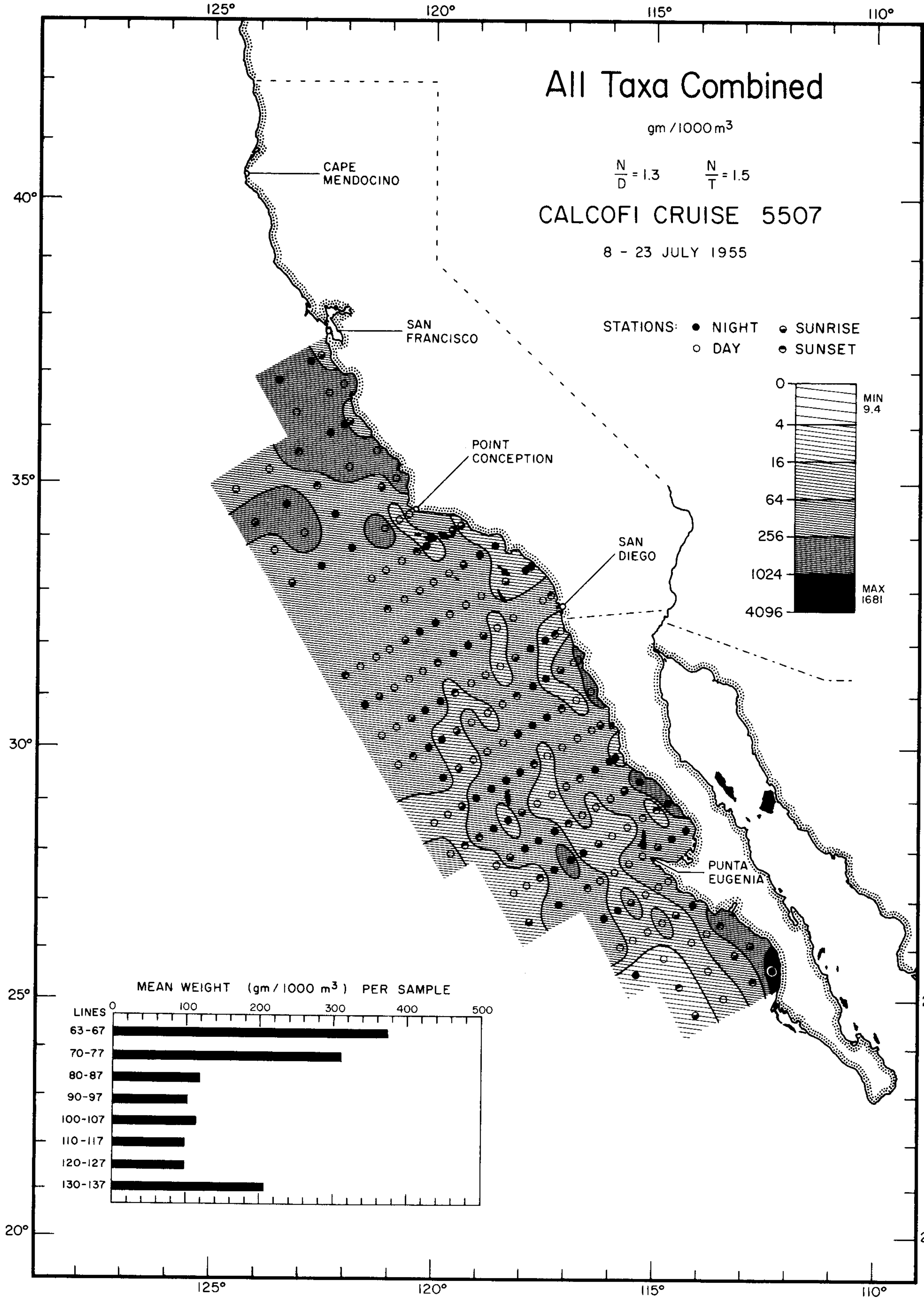
Ostracoda

Pteropoda

Radiolaria

Siphonophora

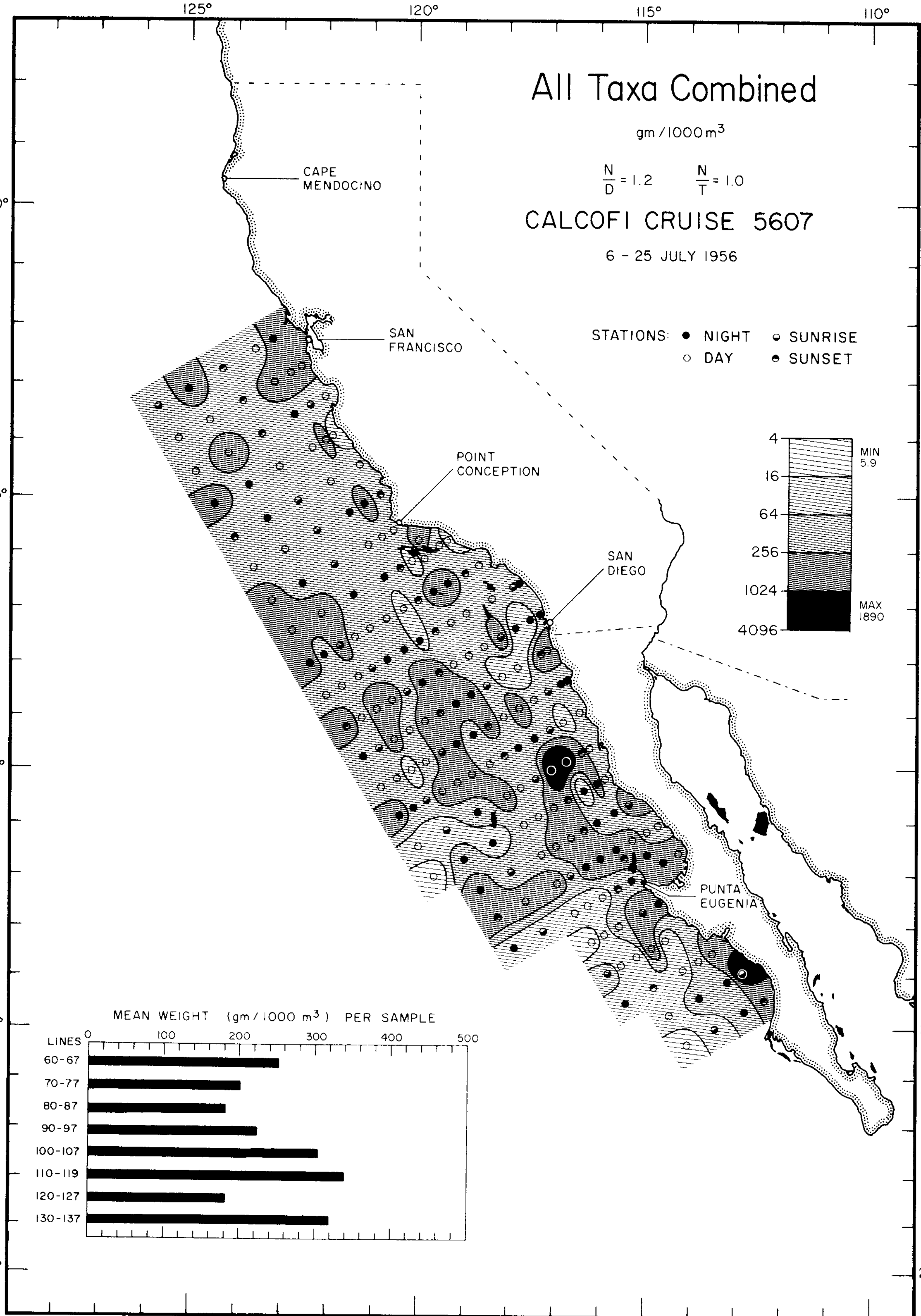
Thaliacea



Biomass

All Taxa Combined

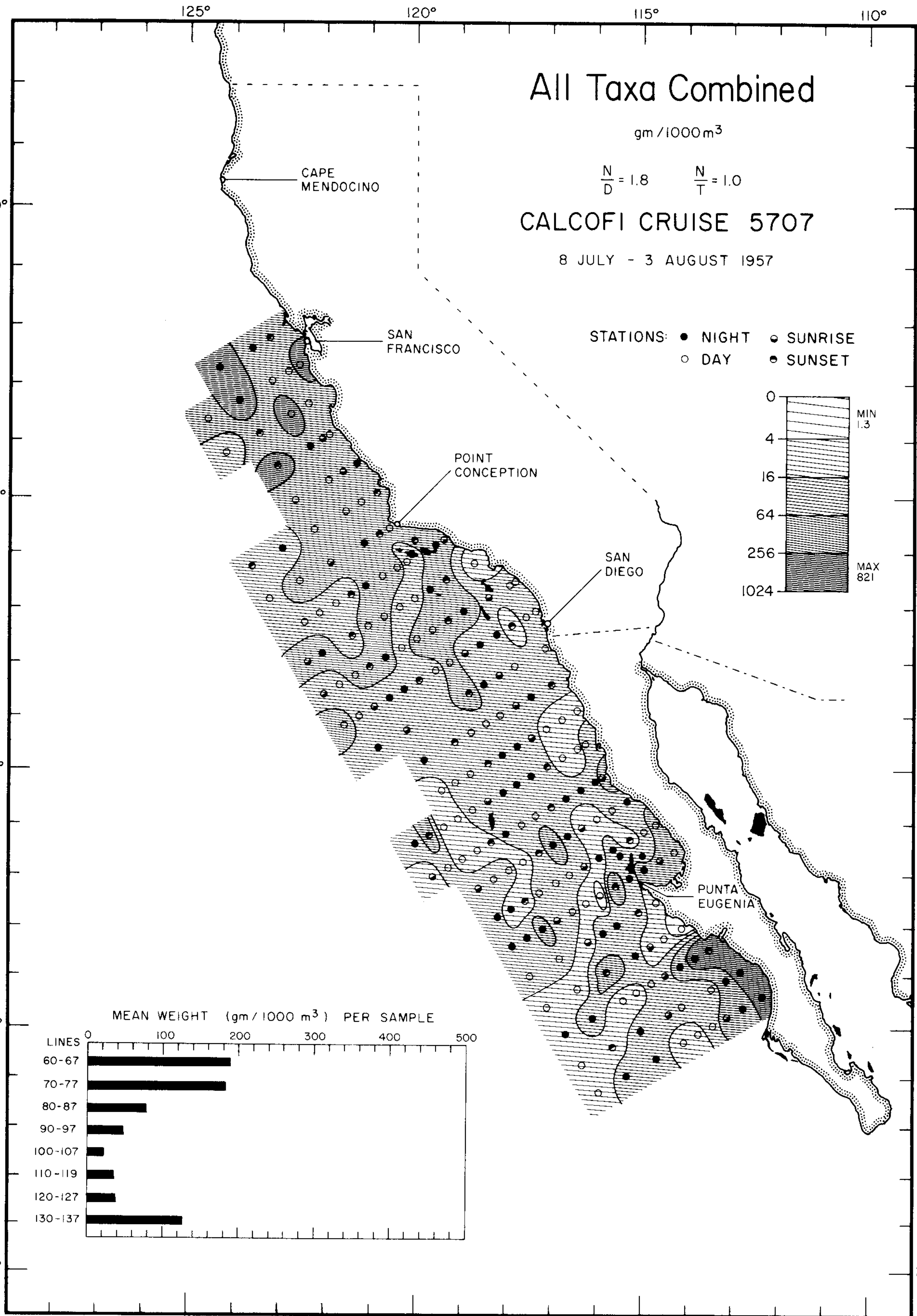
5507



Biomass

All Taxa Combined

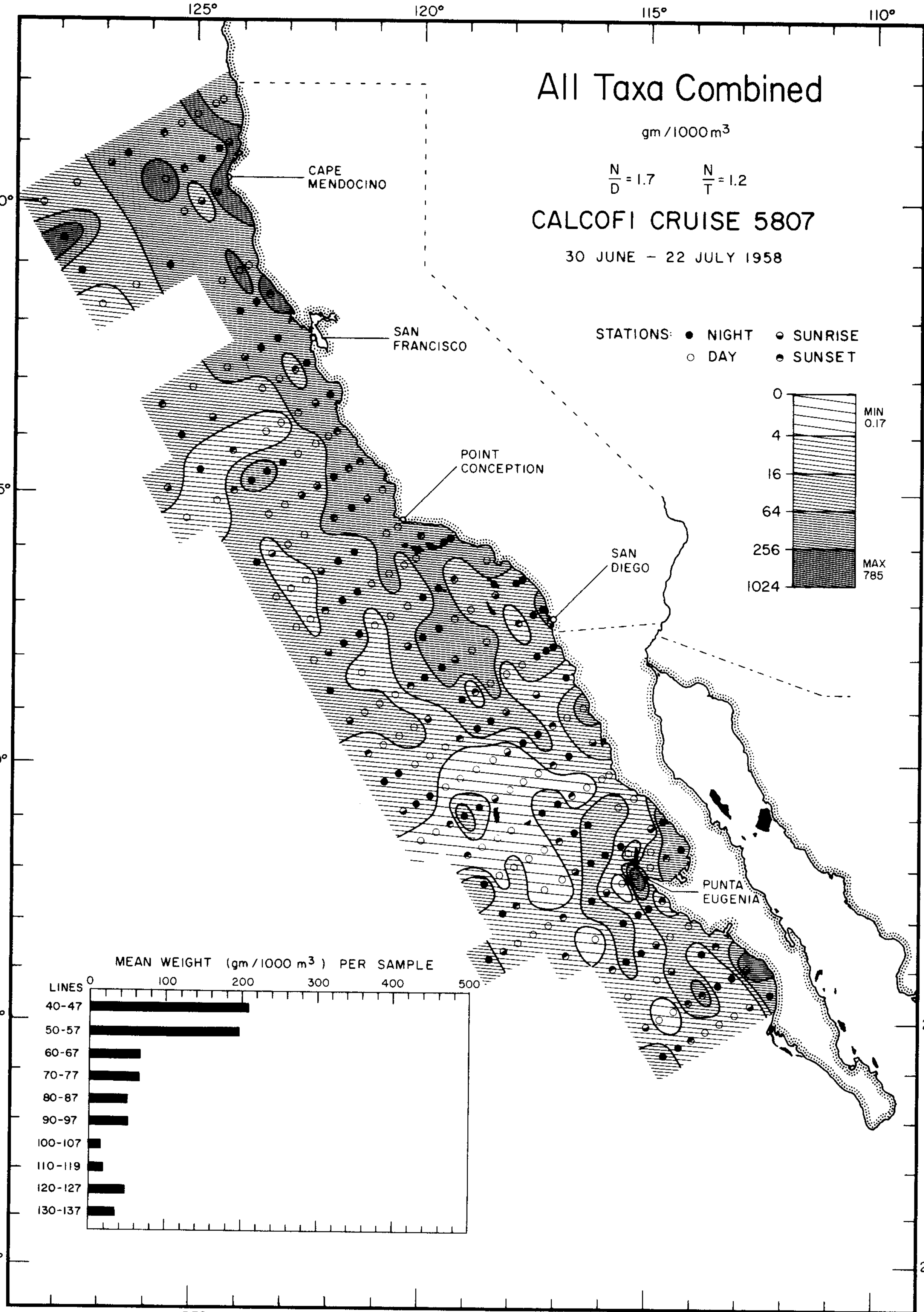
5607



Biomass

All Taxa Combined

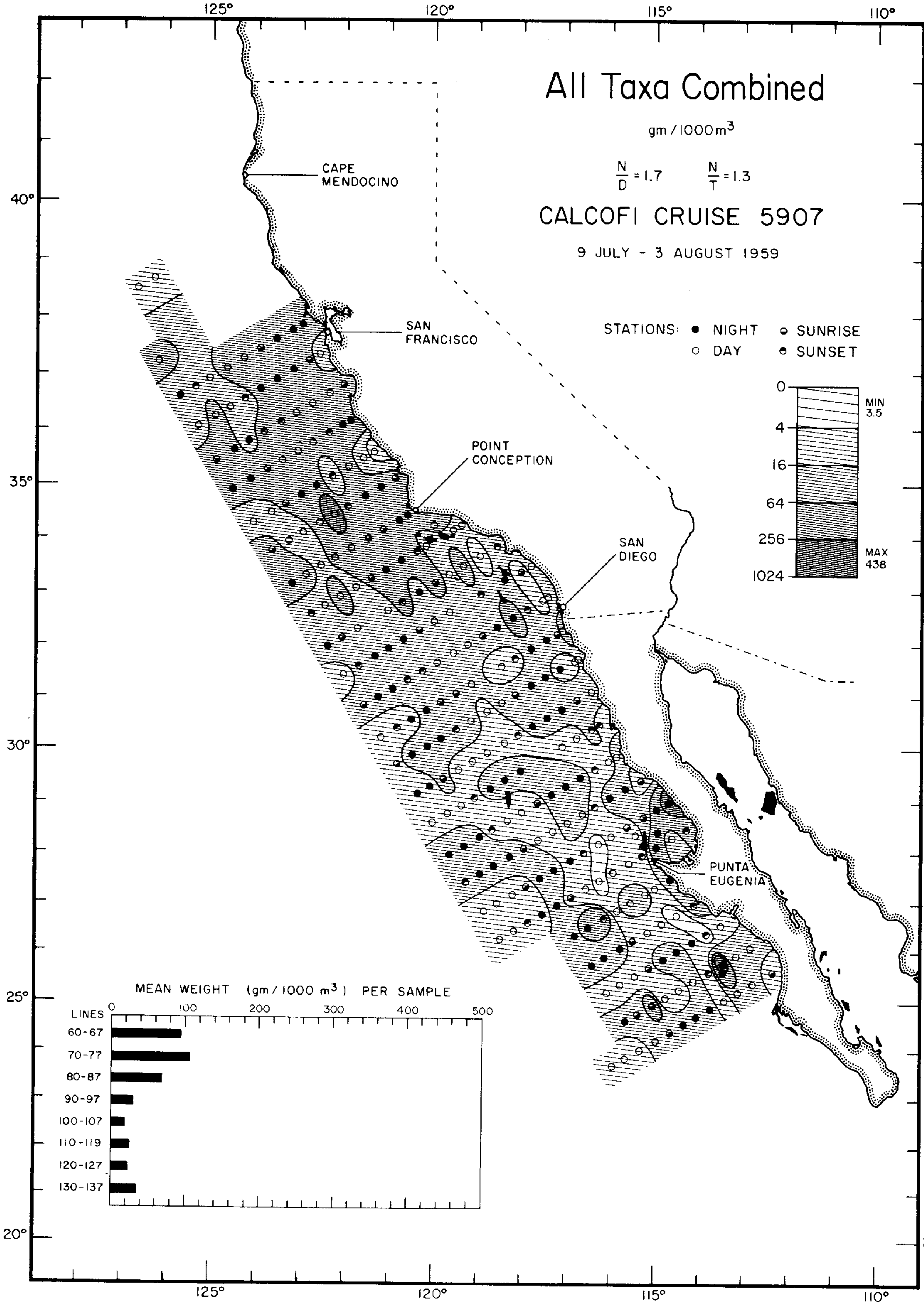
5707



Biomass

All Taxa Combined

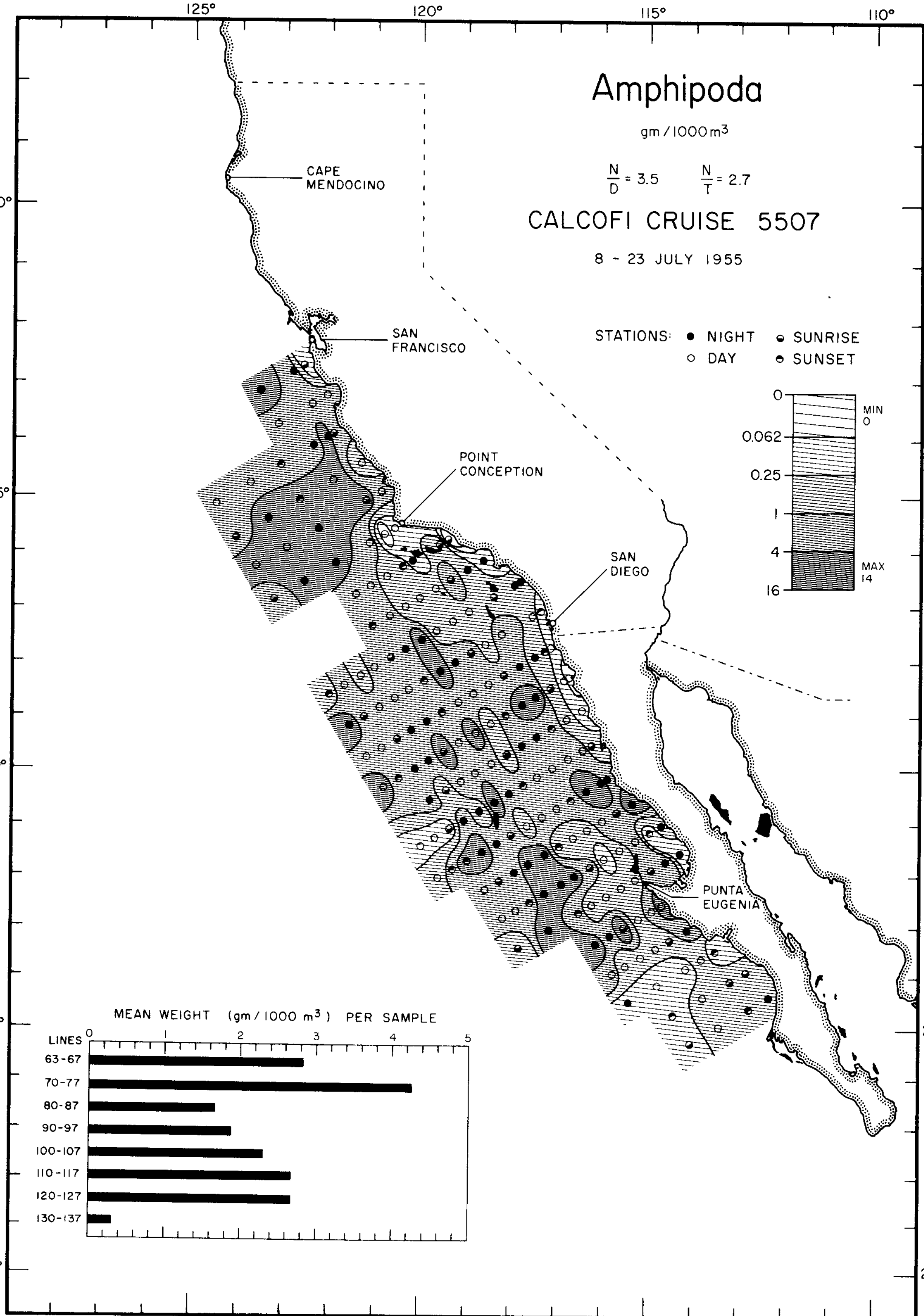
5807

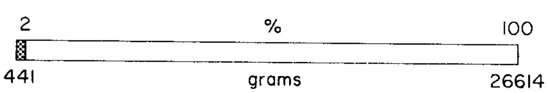


Biomass

All Taxa Combined

5907

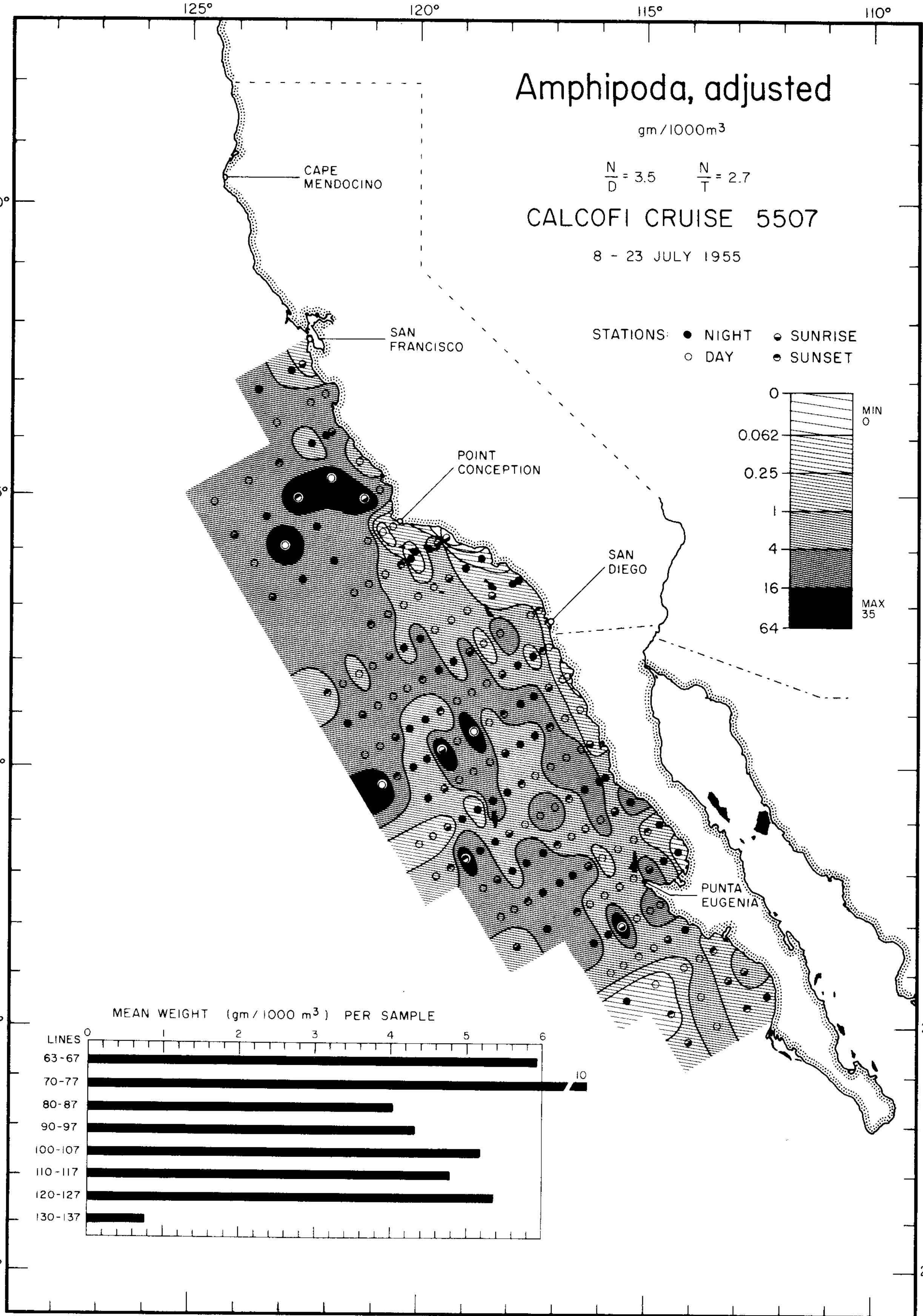




Biomass

Amphipoda

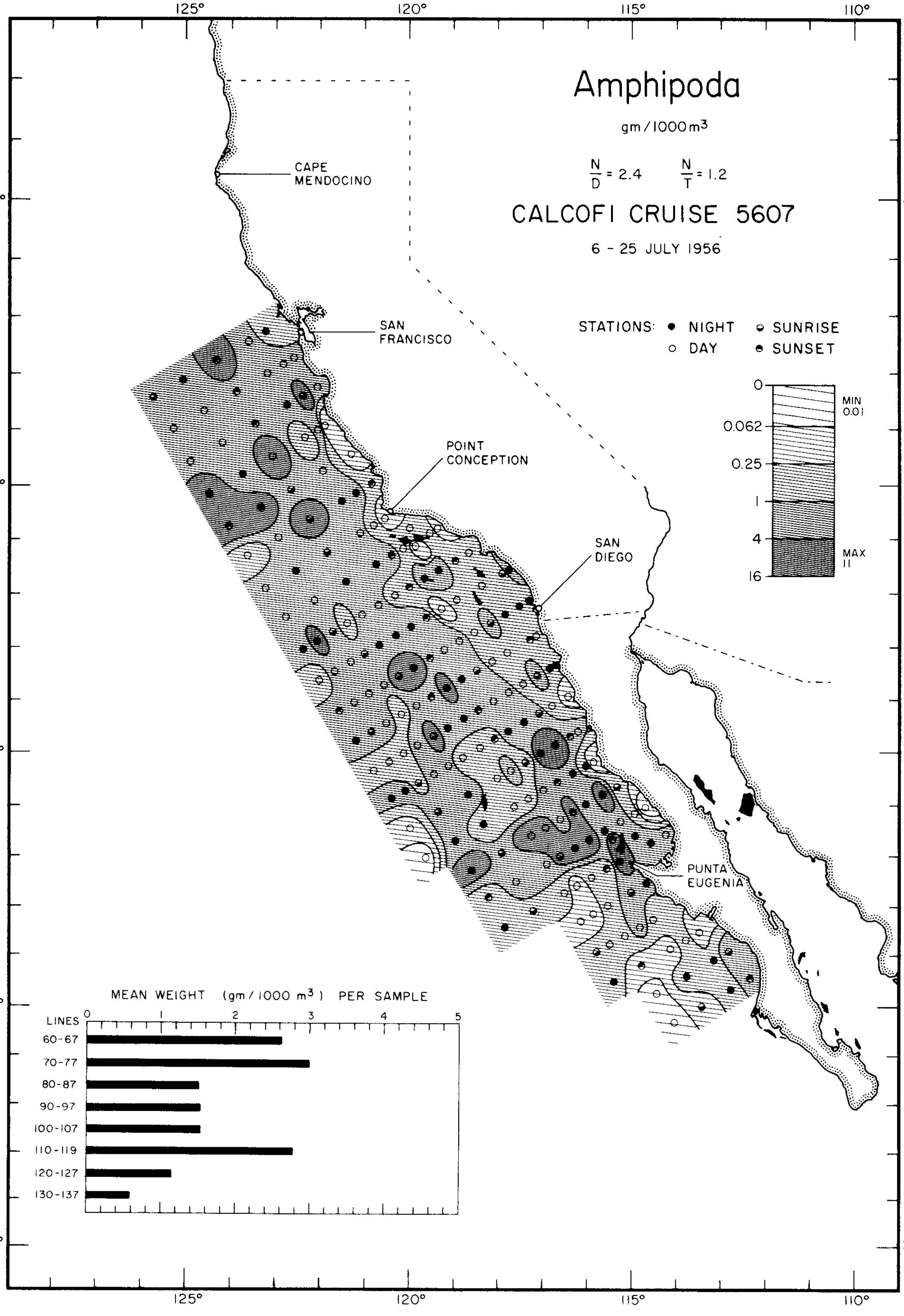
5507

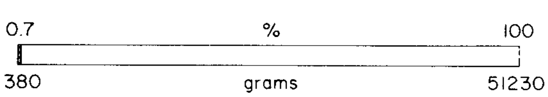


Biomass

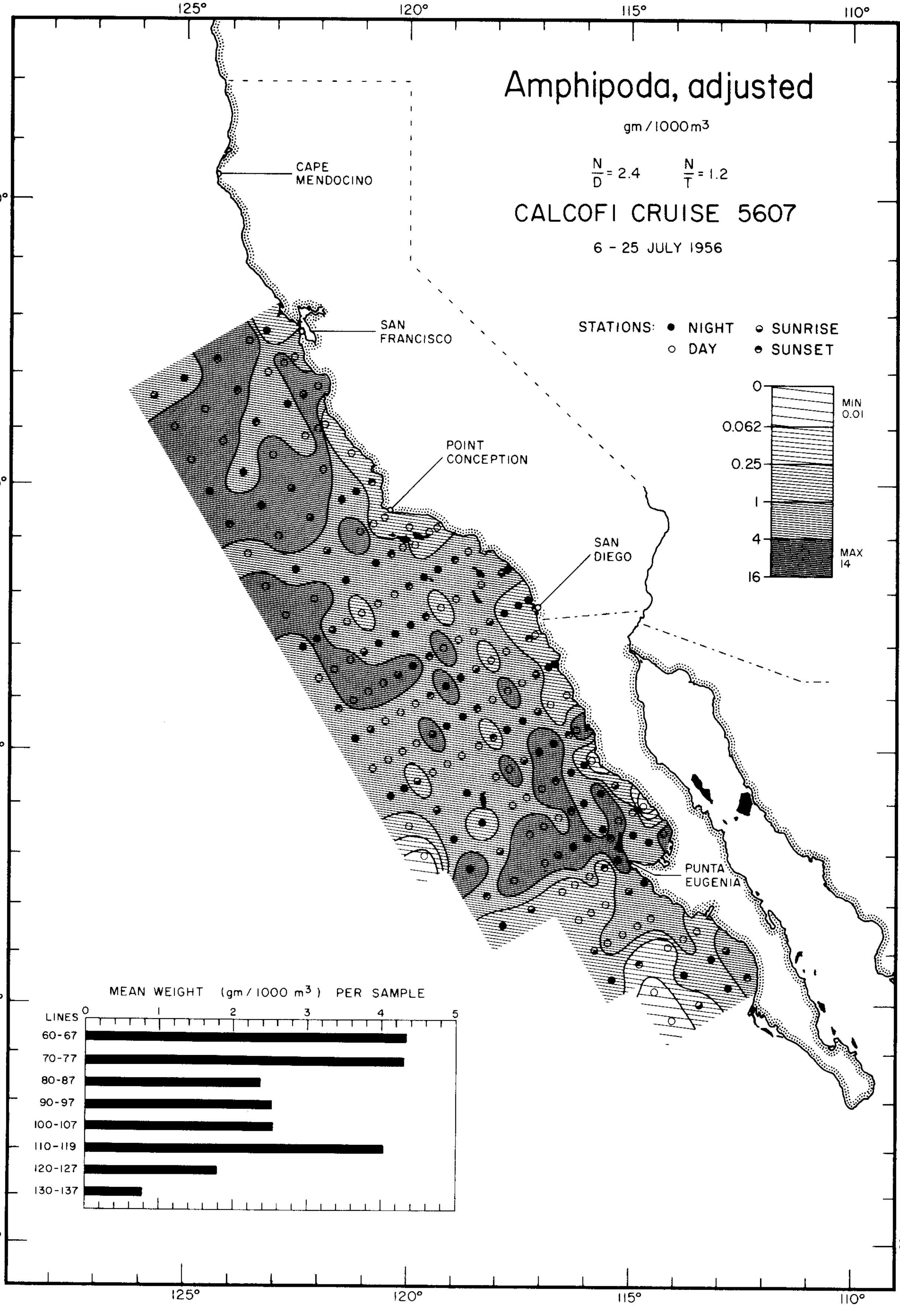
Amphipoda, adjusted

5507





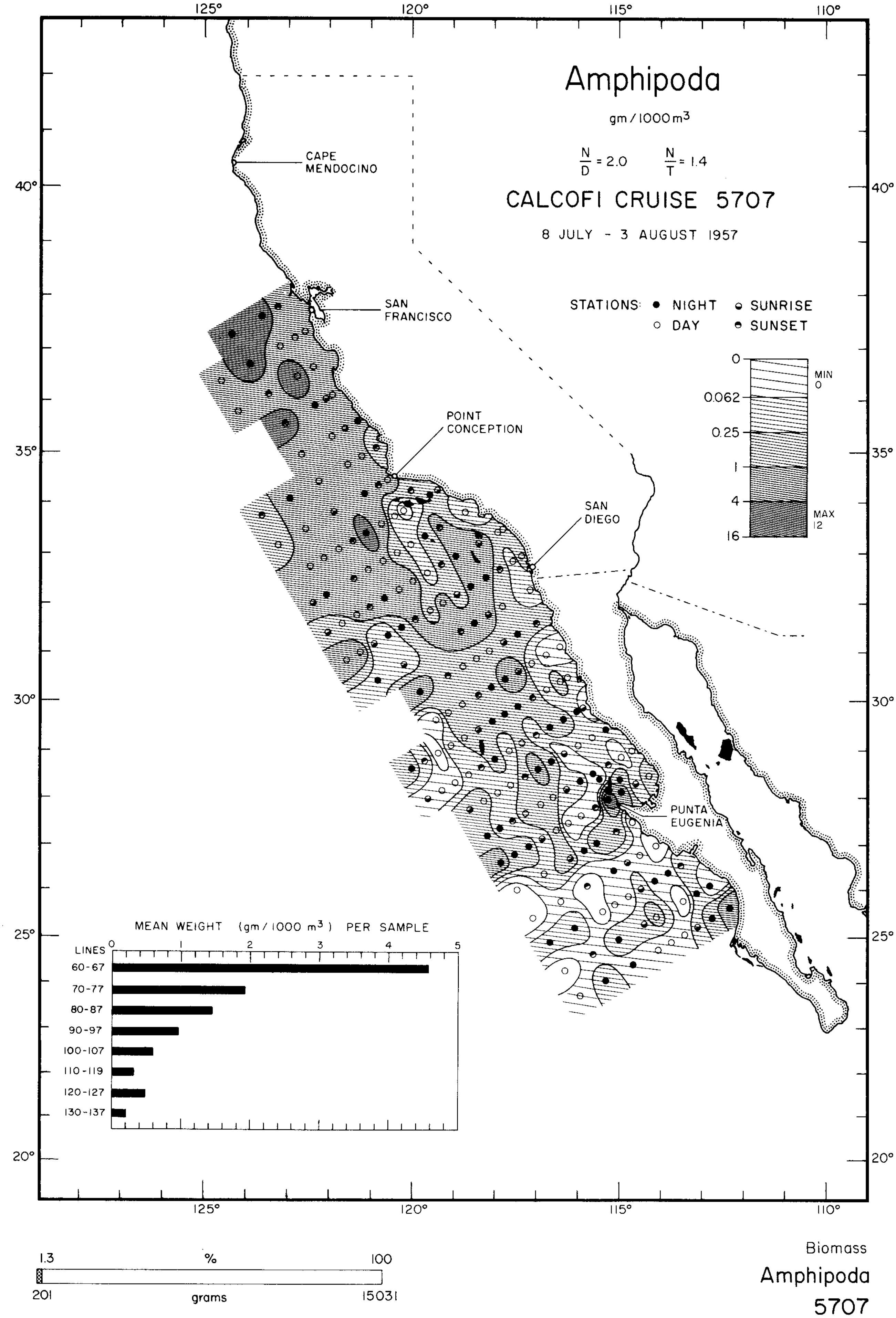
Biomass
Amphipoda
5607



Biomass

Amphipoda, adjusted

5607



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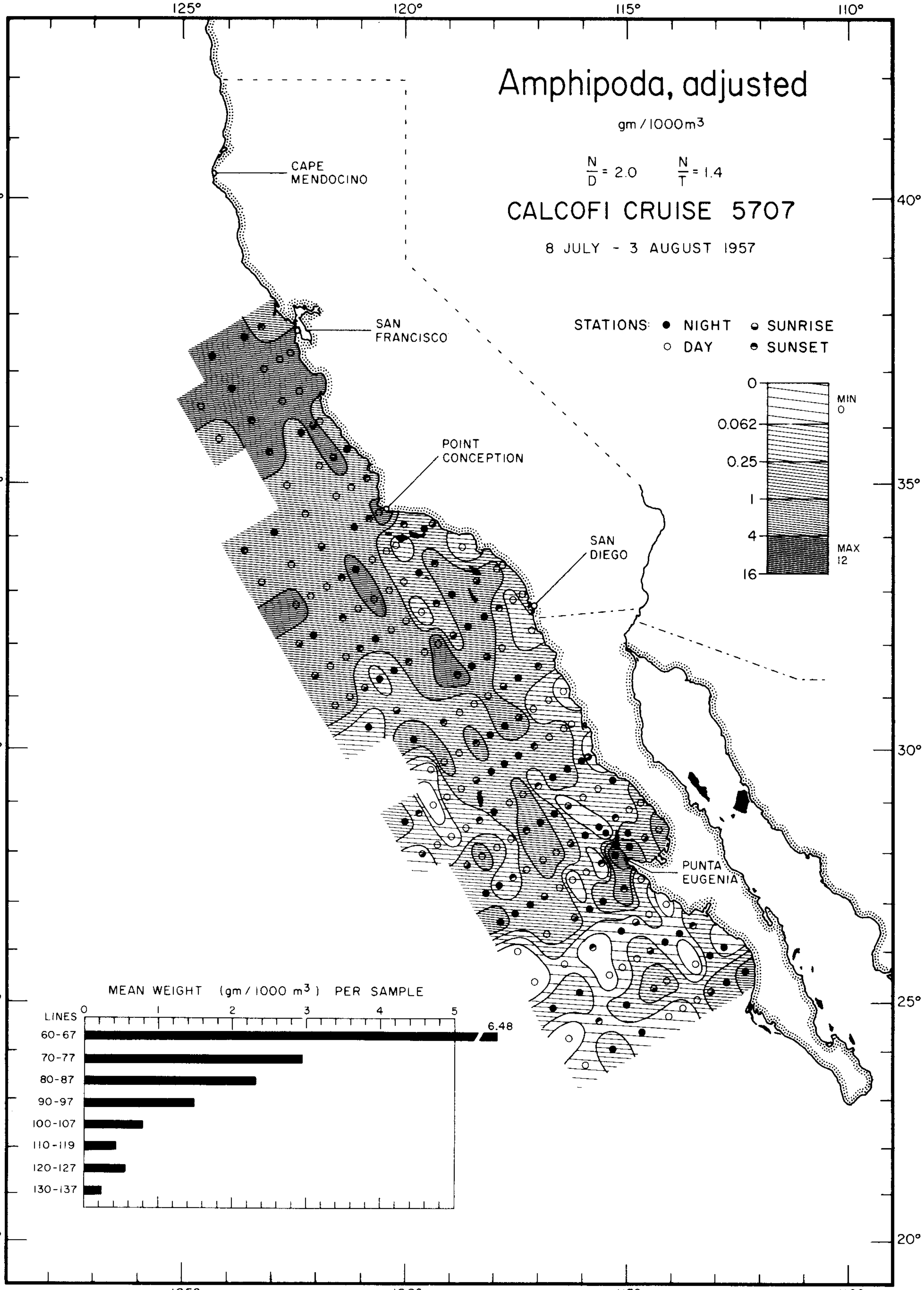
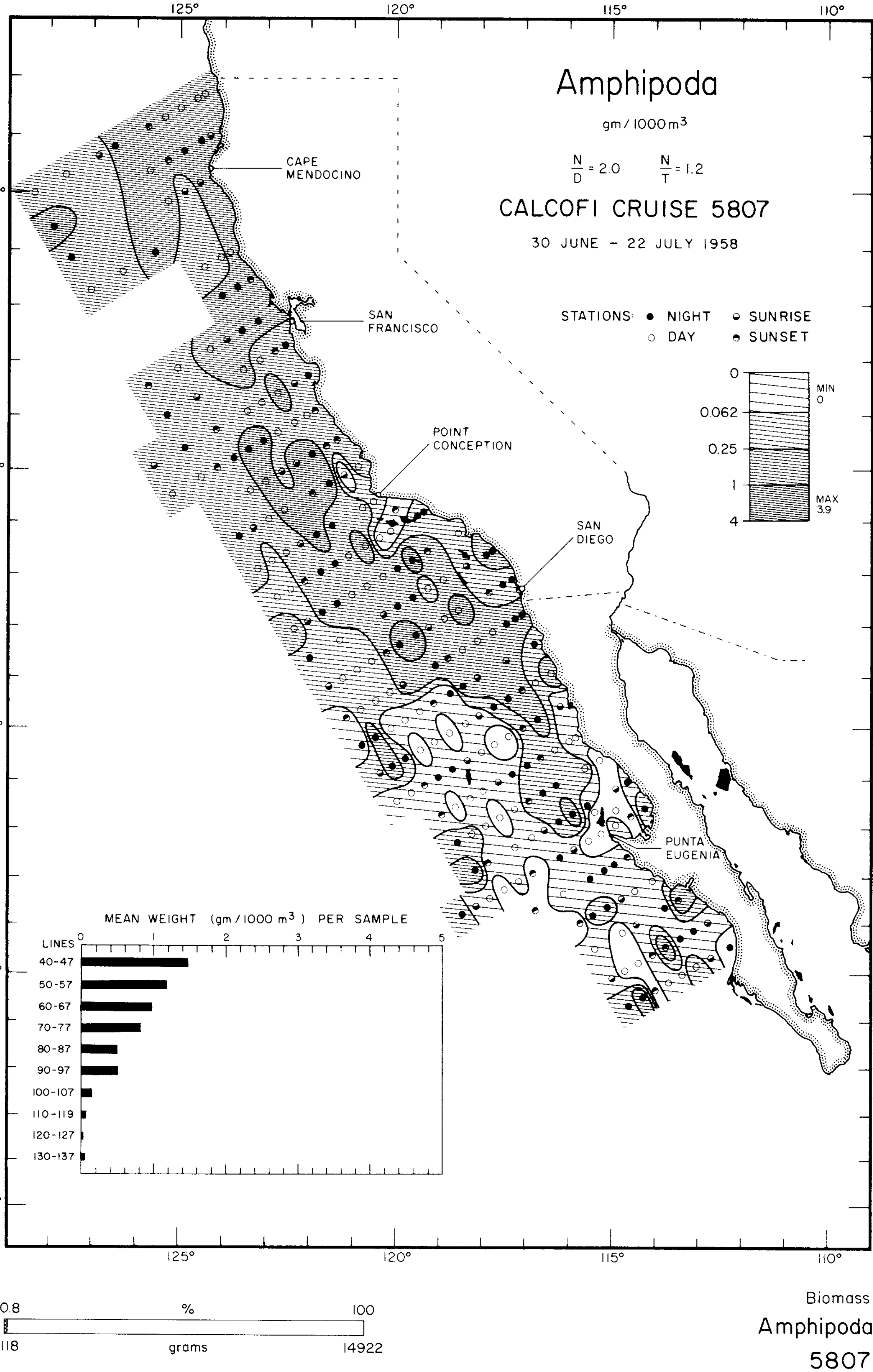
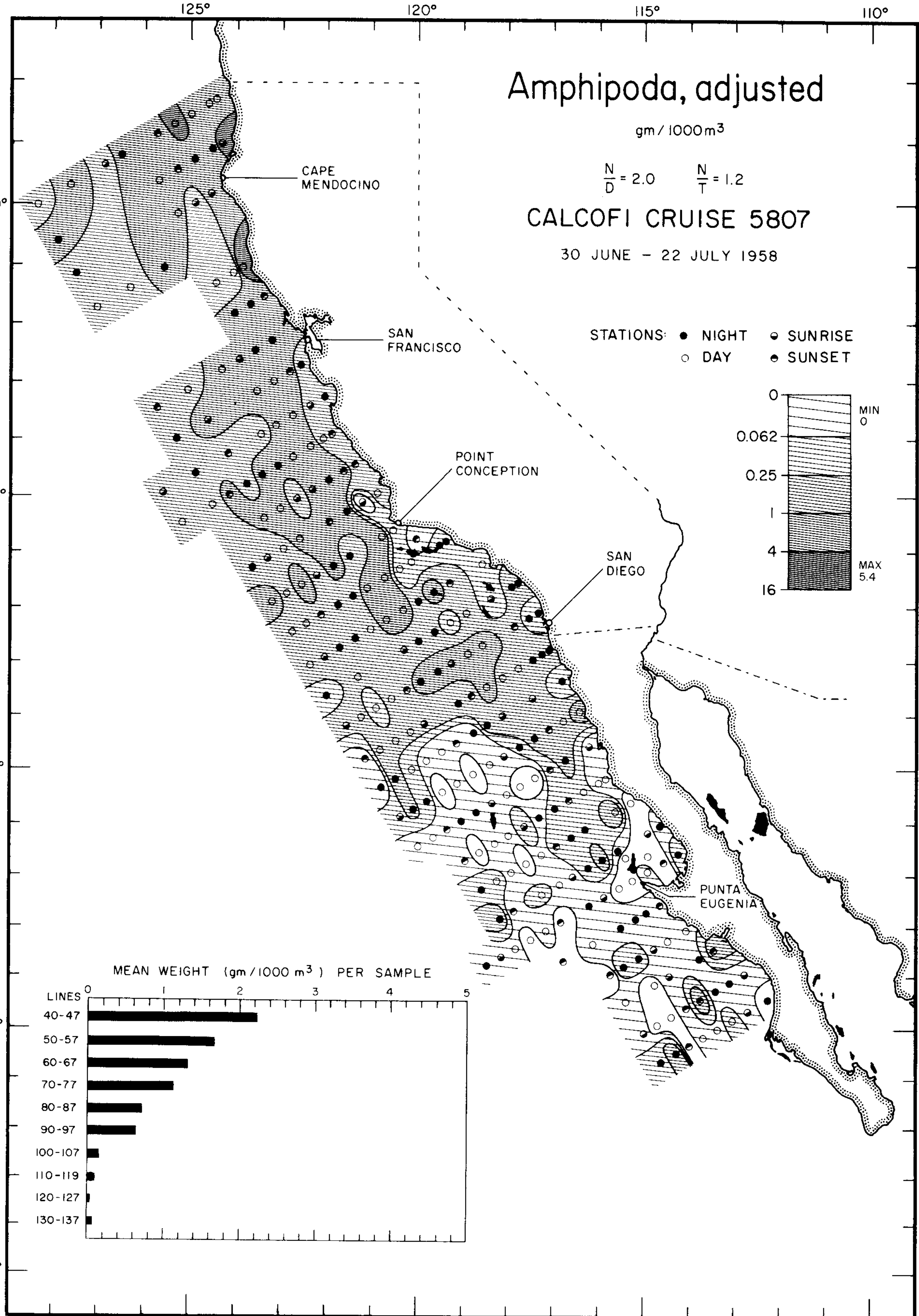
Amphipoda
5707



Biomass
Amphipoda, adjusted
5707



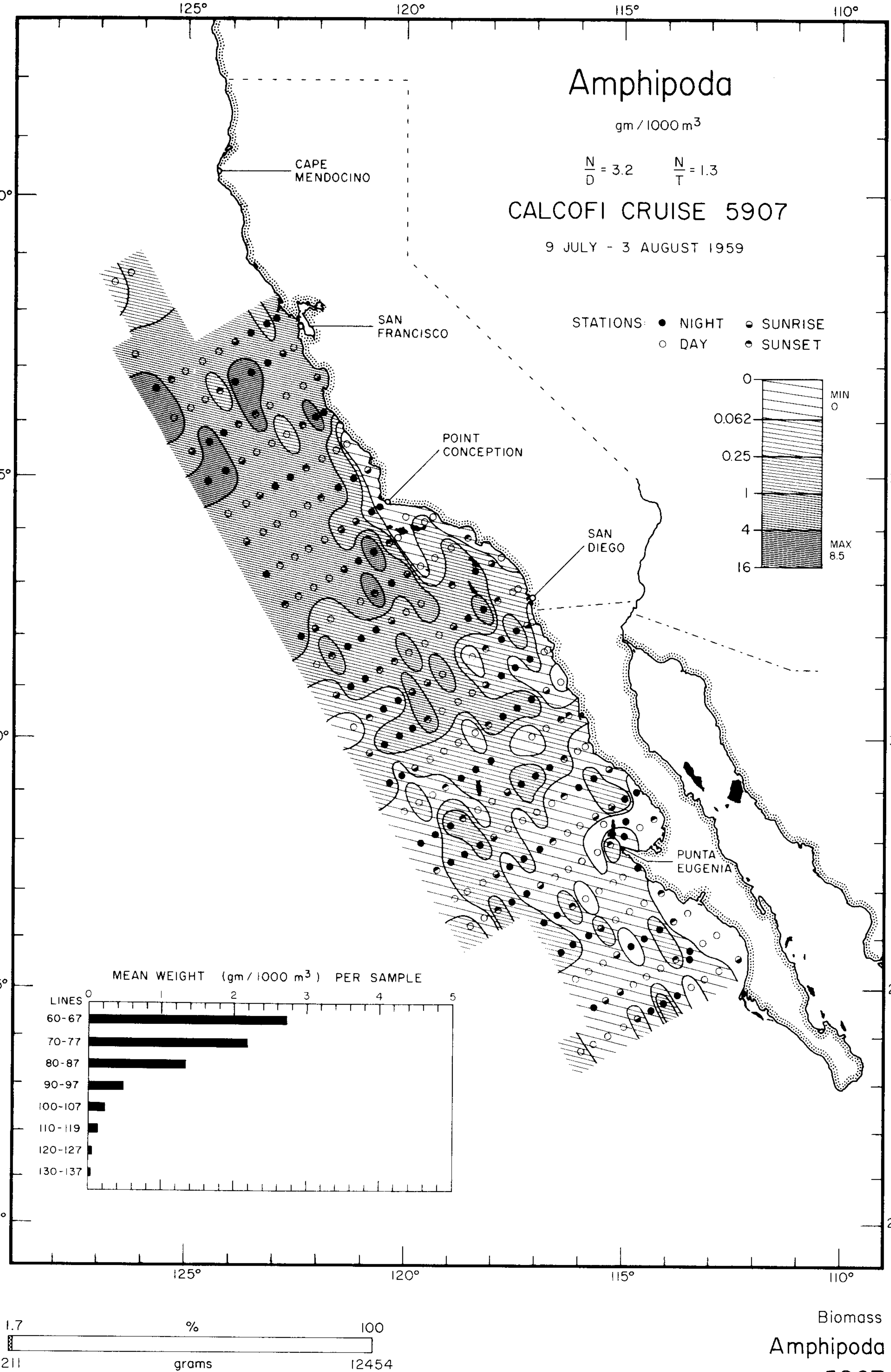
Biomass
Amphipoda
5807



Biomass

Amphipoda, adjusted

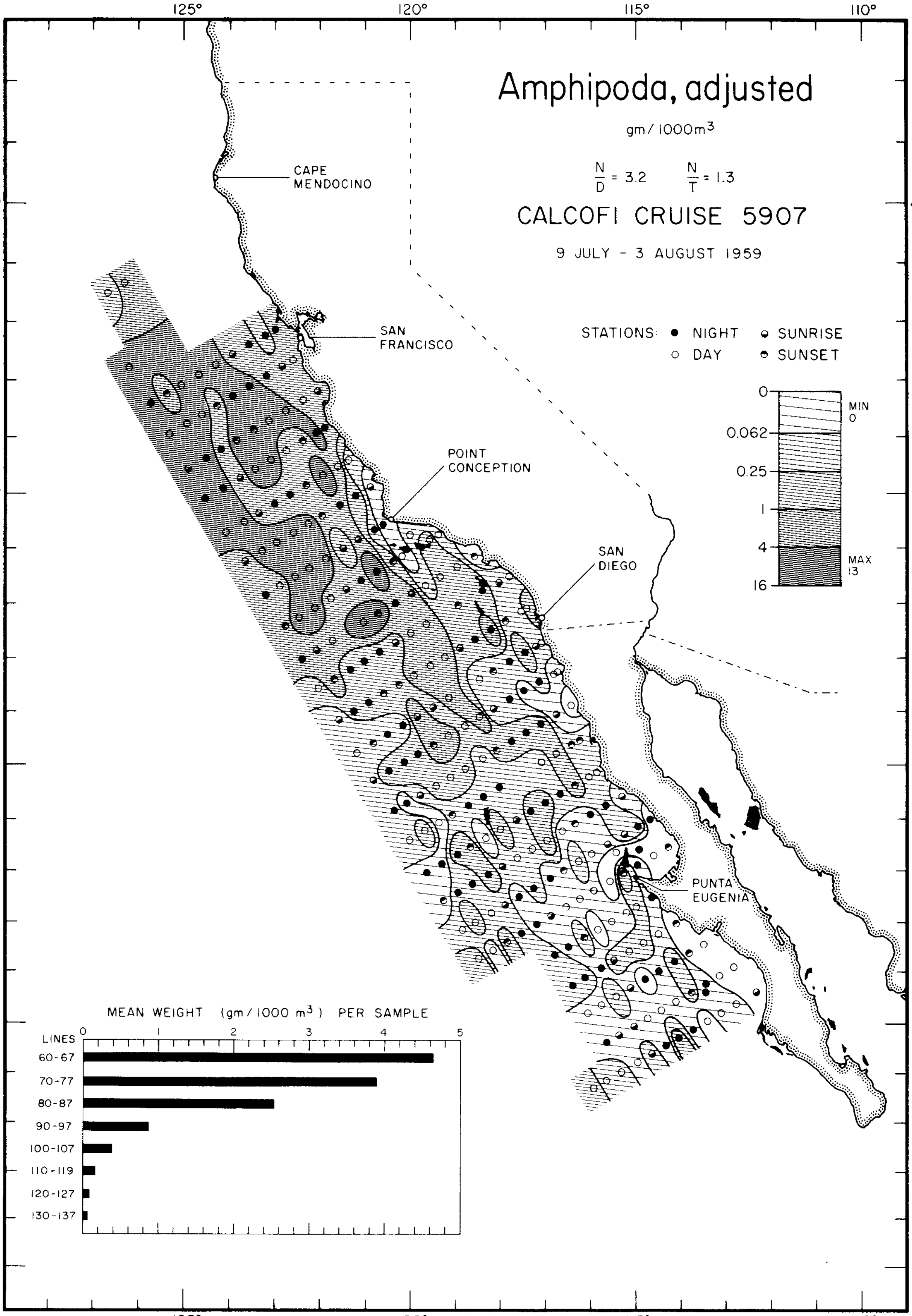
5807



Biomass

Amphipoda

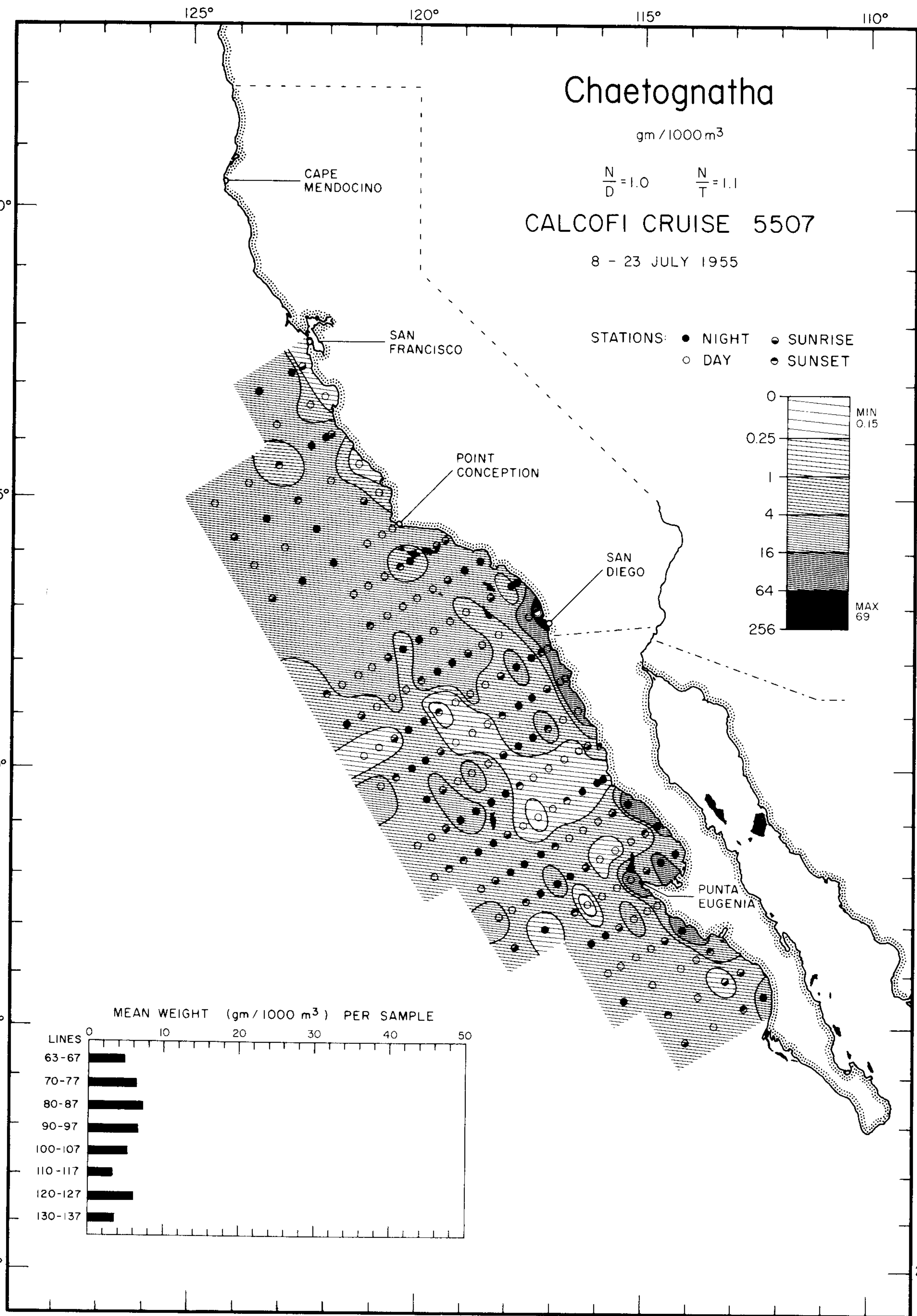
5907

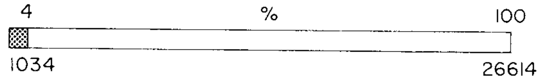


Biomass

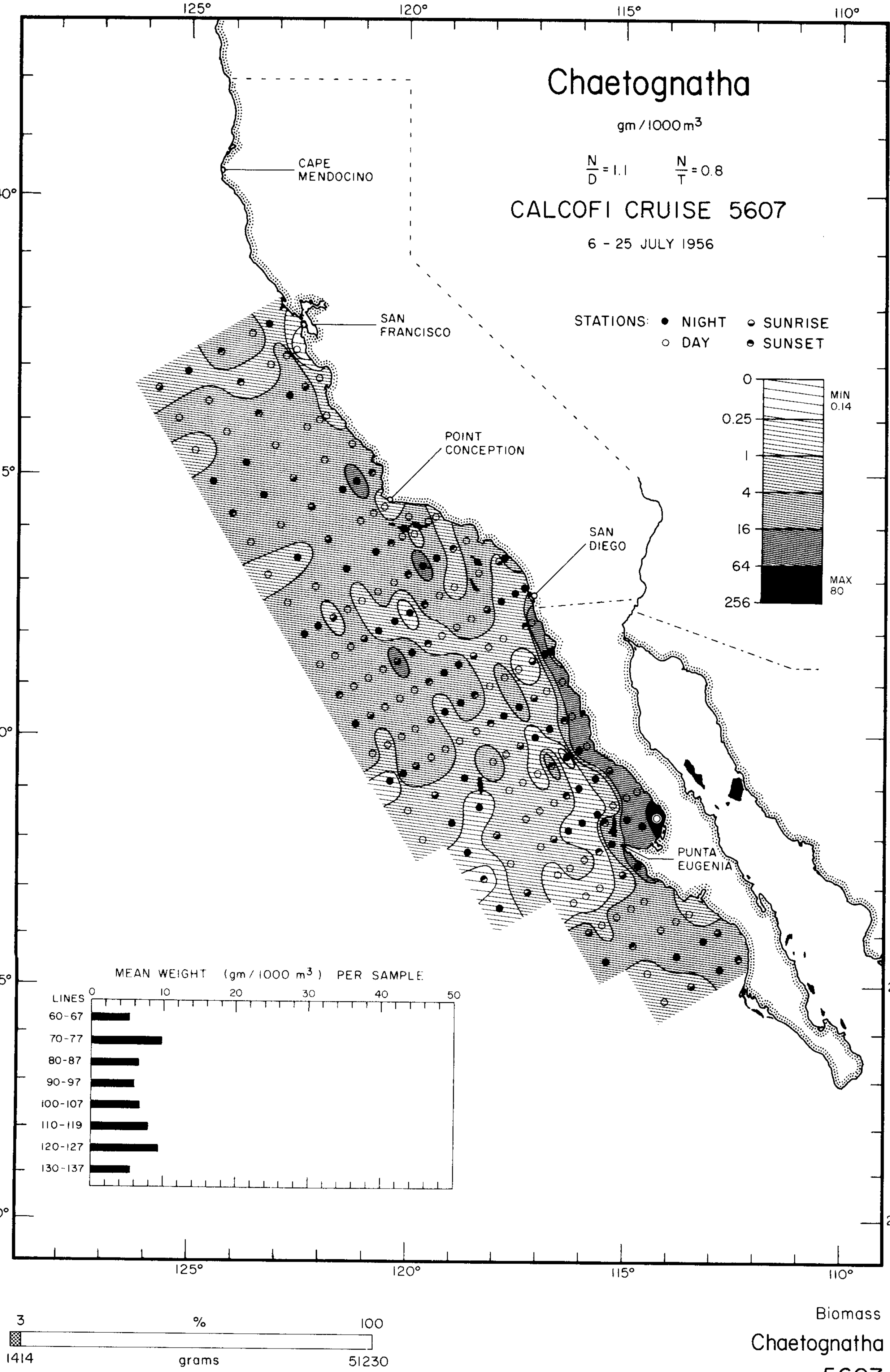
Amphipoda, adjusted

5907





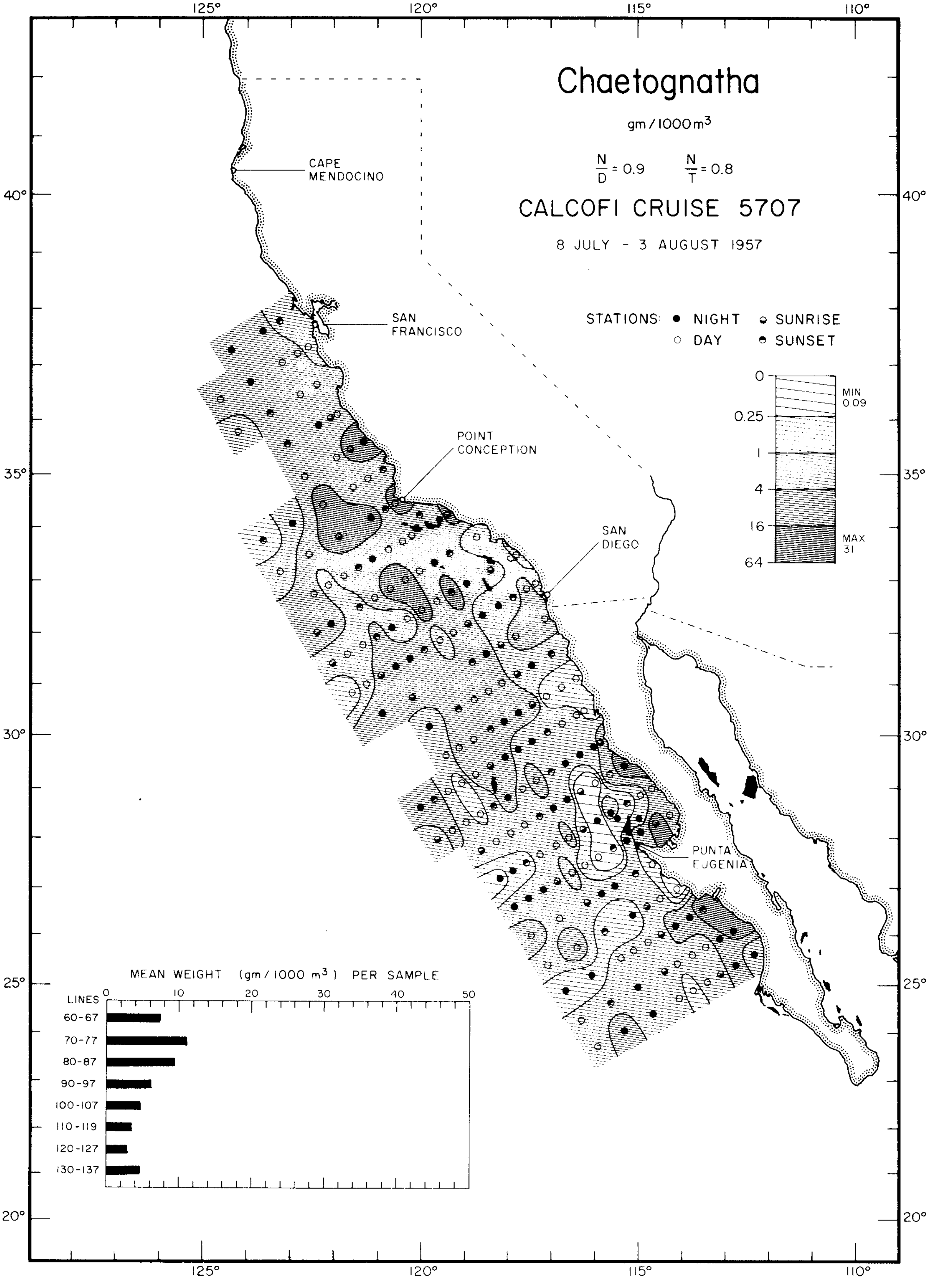
Biomass
Chaetognatha
5507



Biomass

Chaetognatha

5607



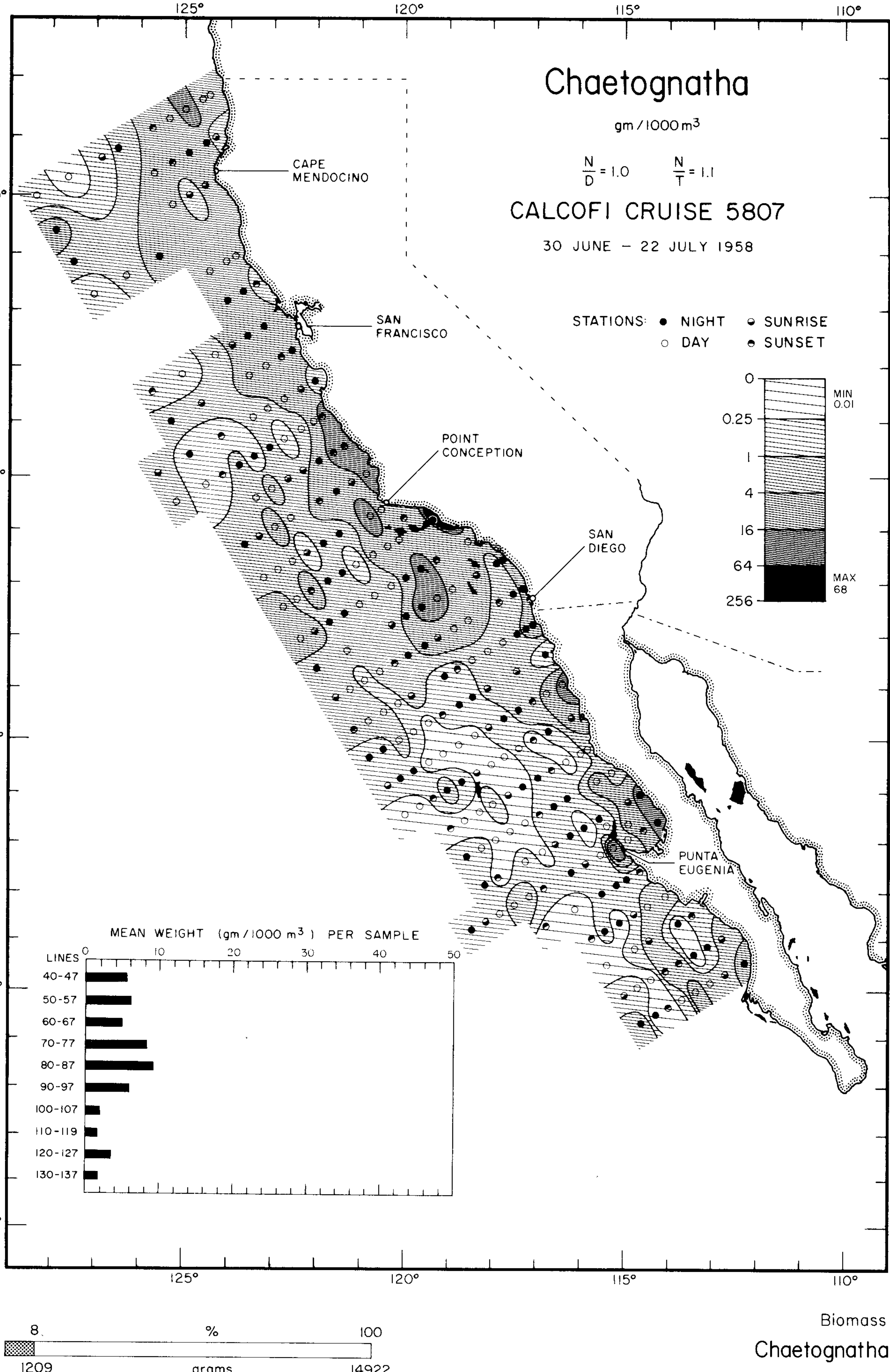
8 % 100

1179 grams 15031

Biomass

Chaetognatha

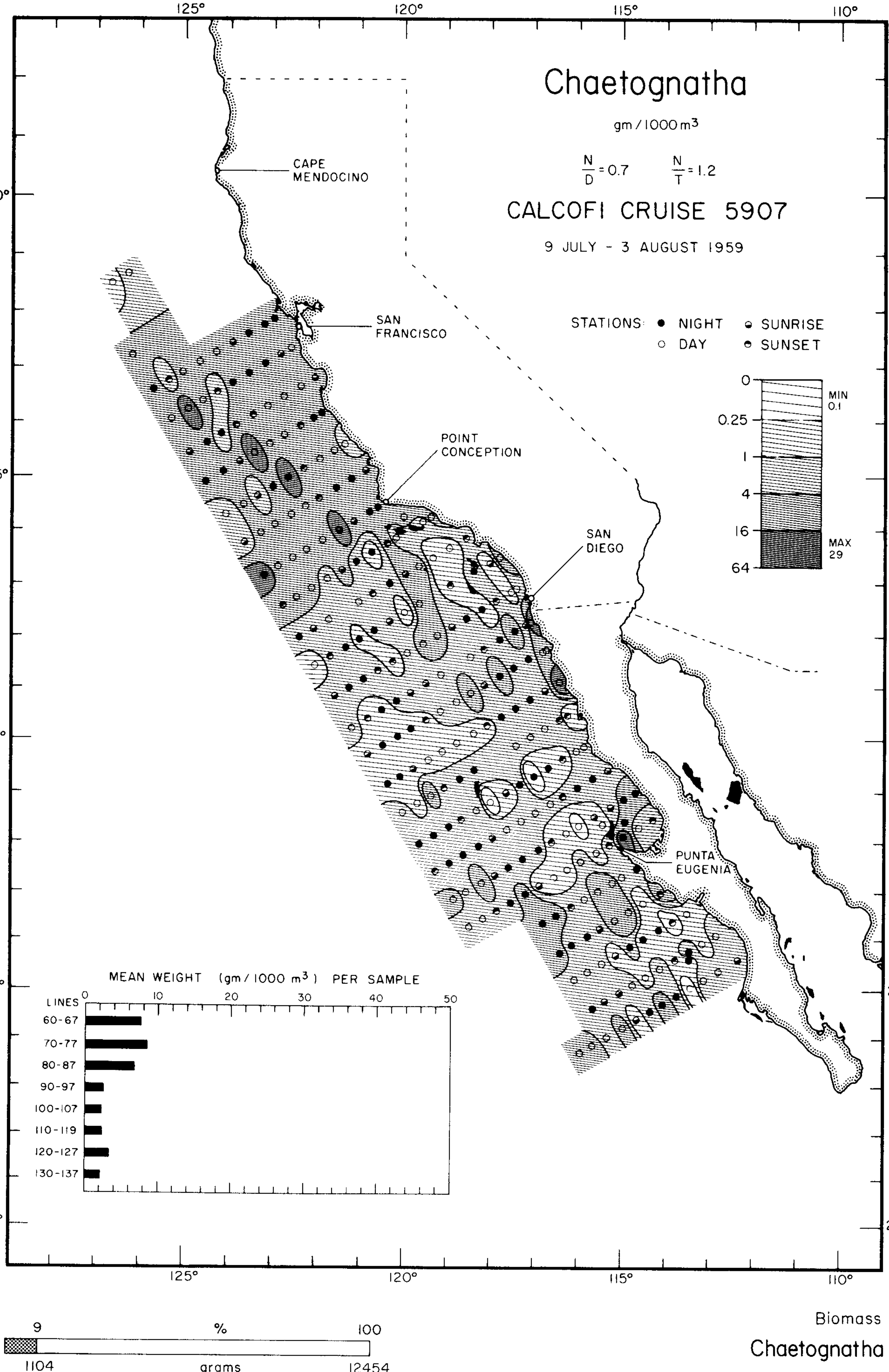
5707



Biomass

Chaetognatha

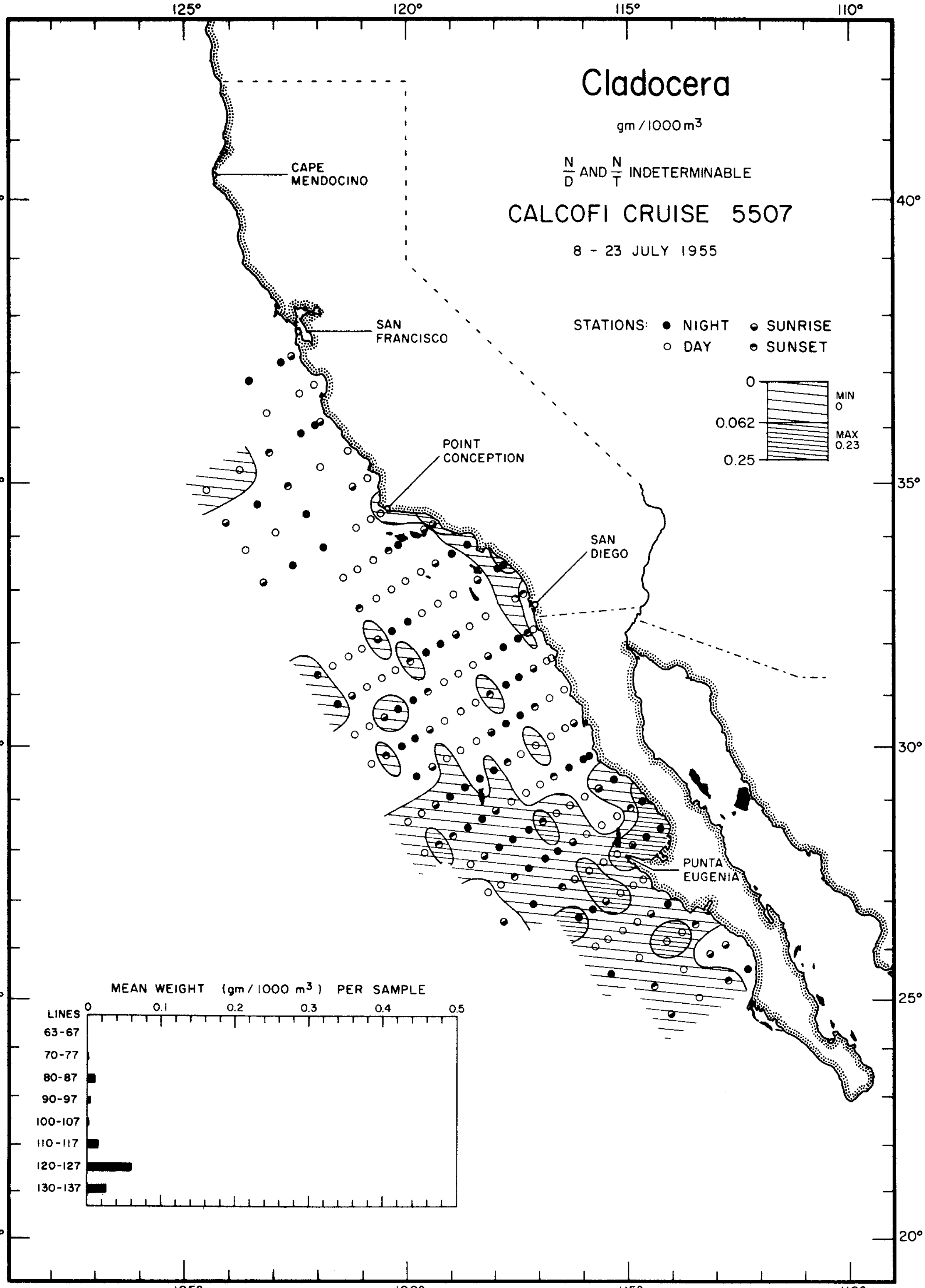
5807



Biomass

Chaetognatha

5907



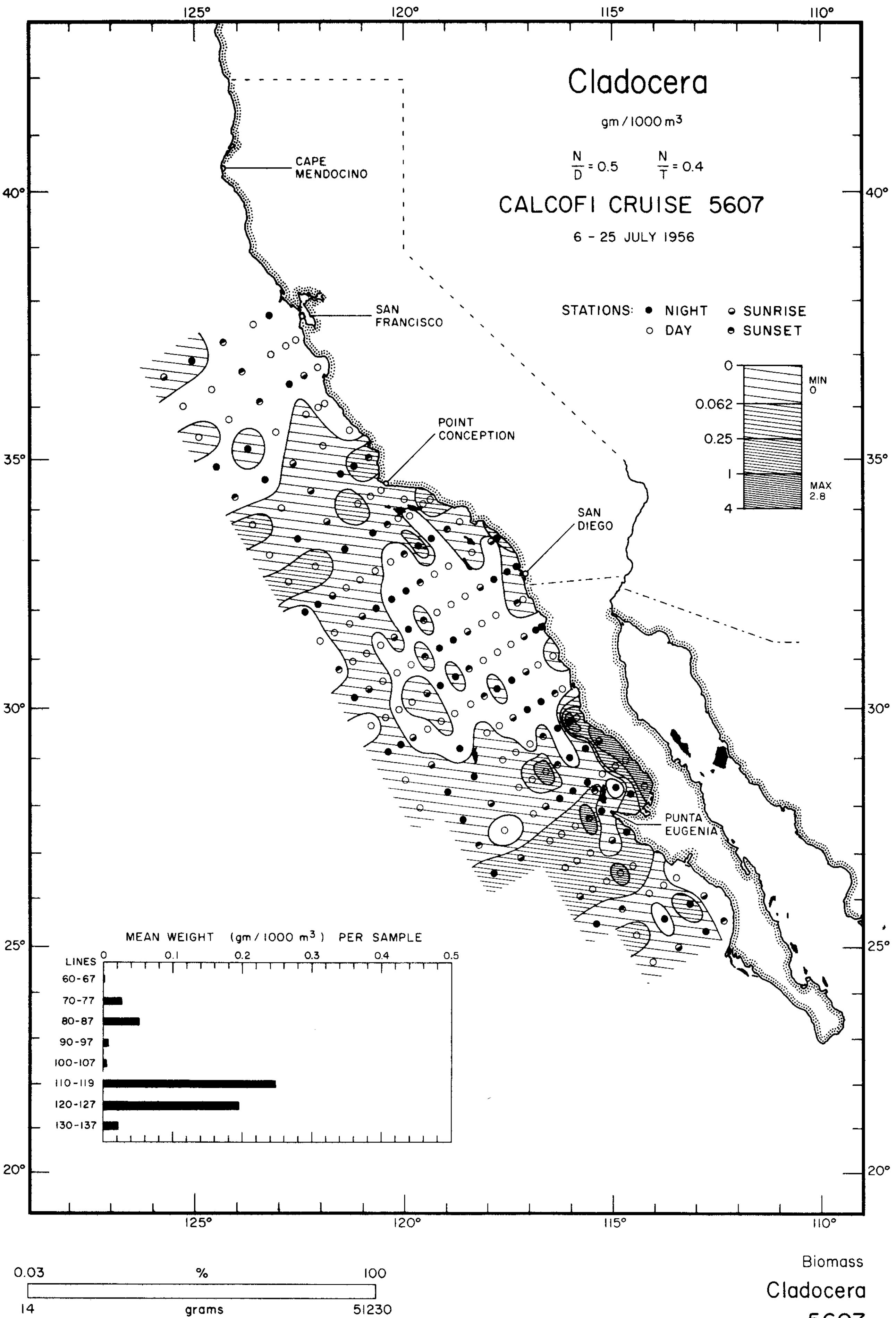
0.01 % 100

3 grams 26614

Biomass

Cladocera

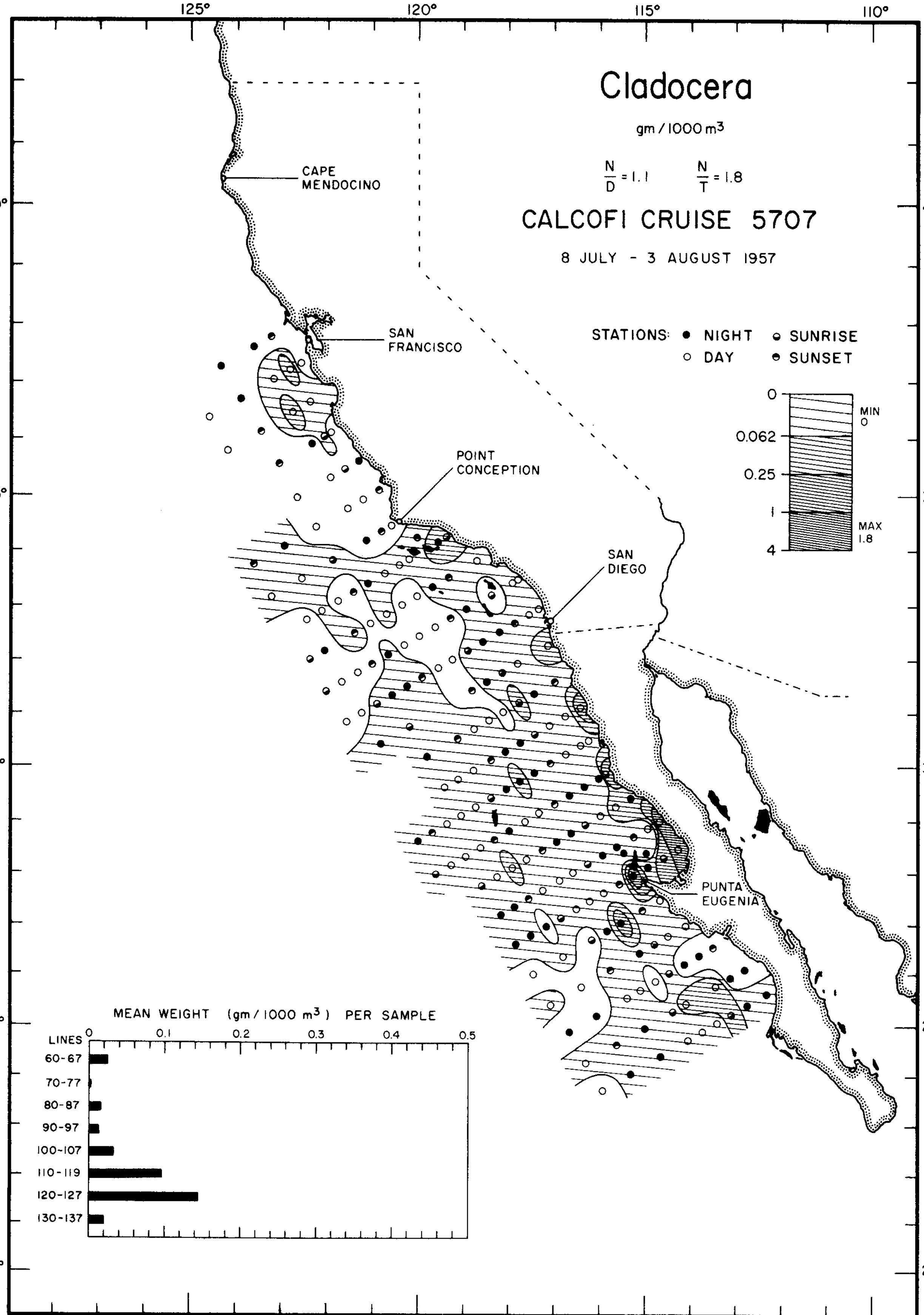
5507

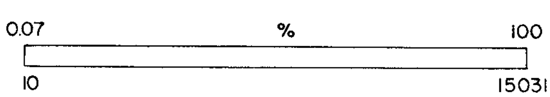


Biomass

Cladocera

5607





Biomass
Cladocera
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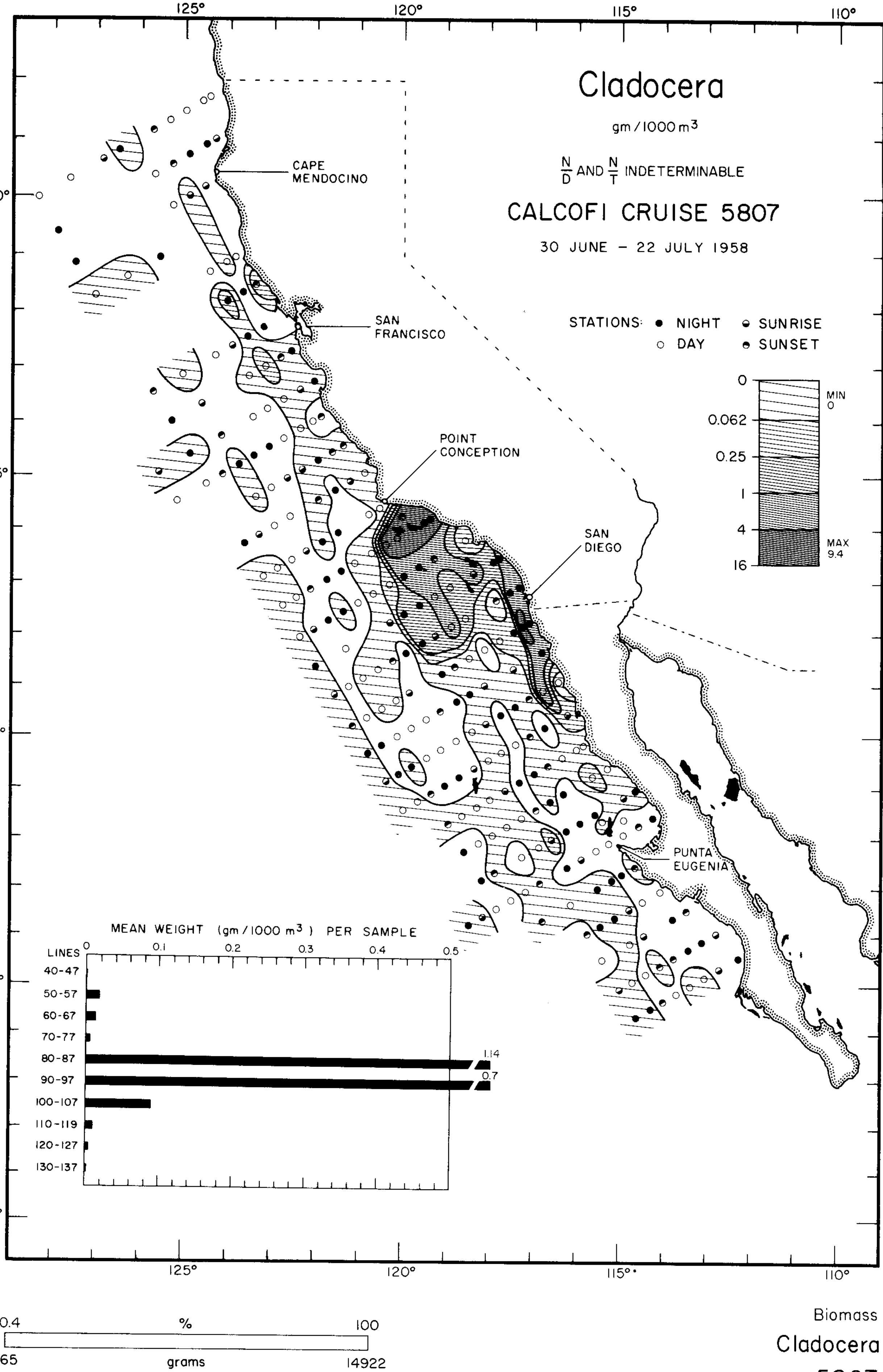
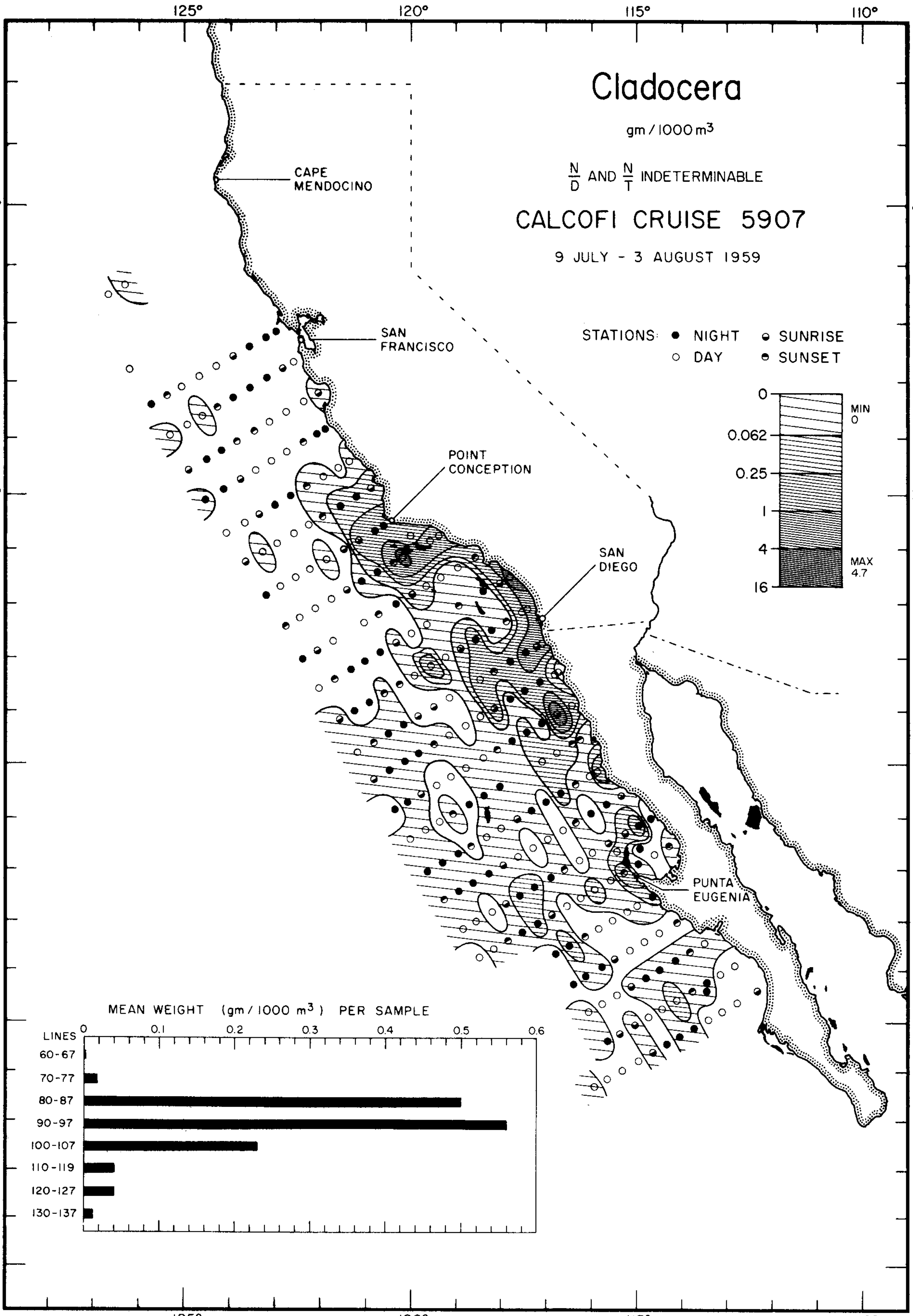


Biomass

Cladocera

5807



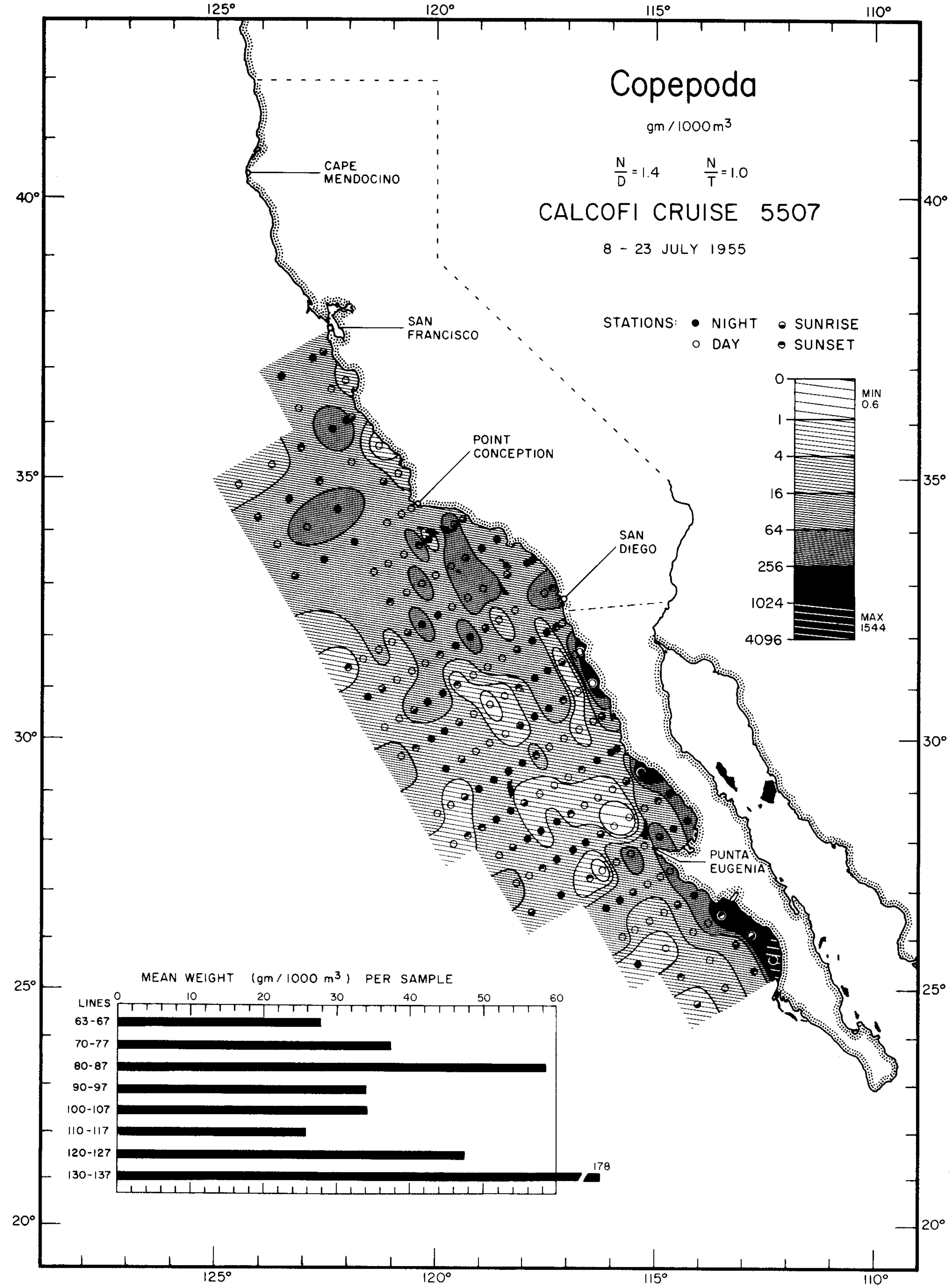
0.4 % 100

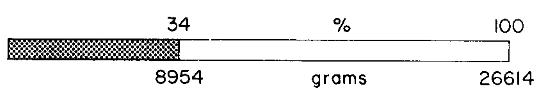
51 grams 12454

Biomass

Cladocera

5907

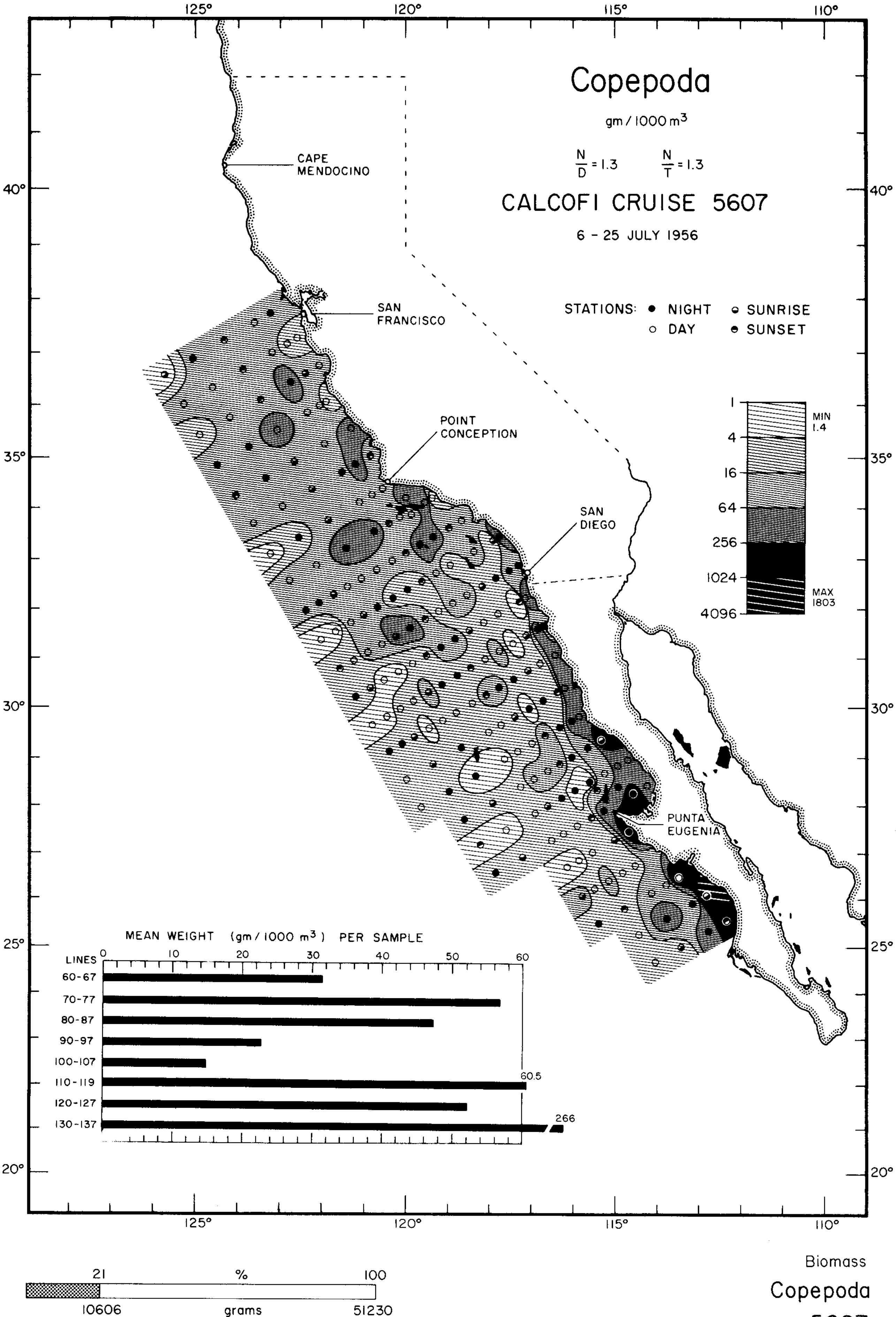




Biomass

Copepoda

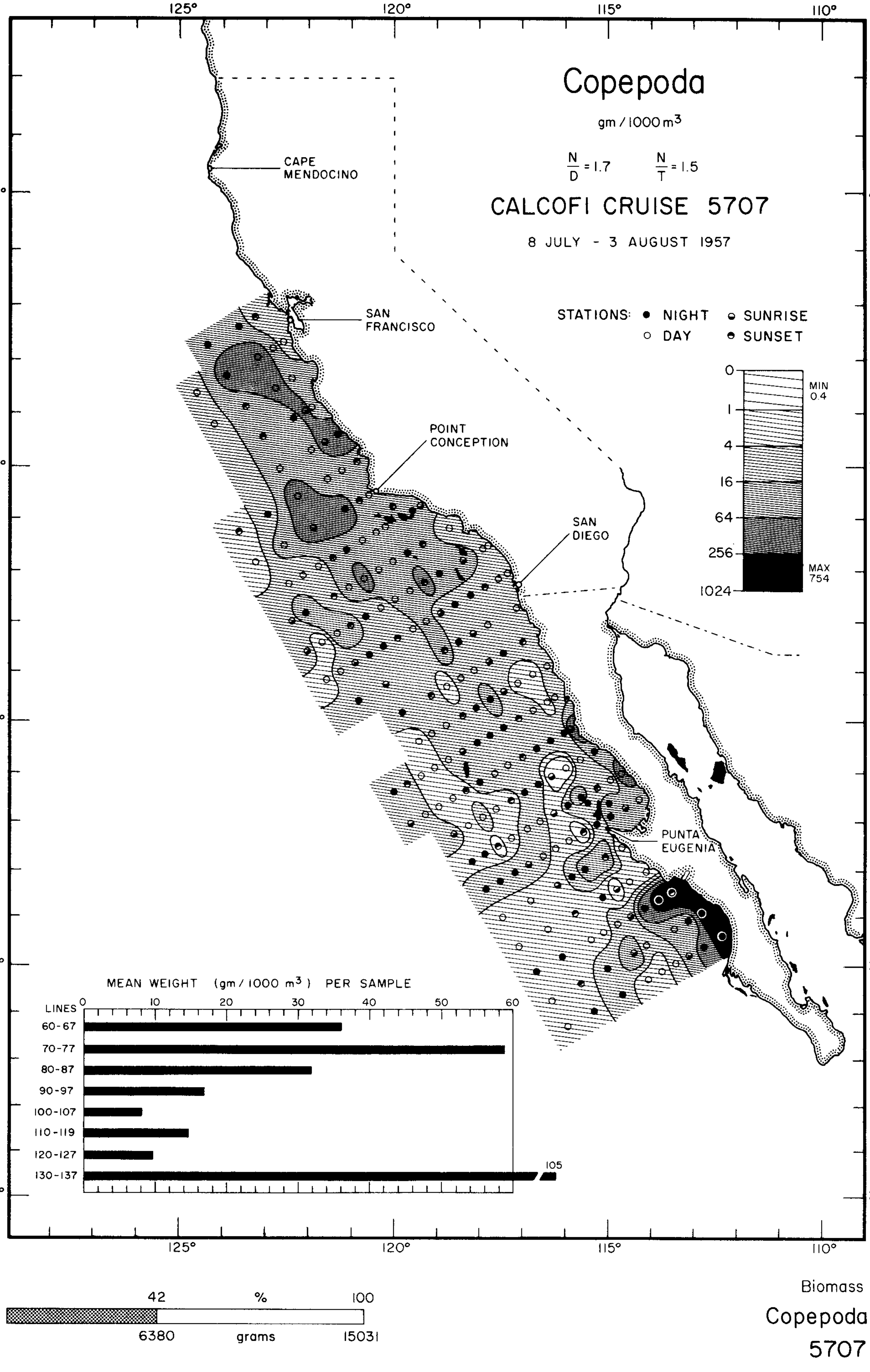
5507



Biomass

Copepoda

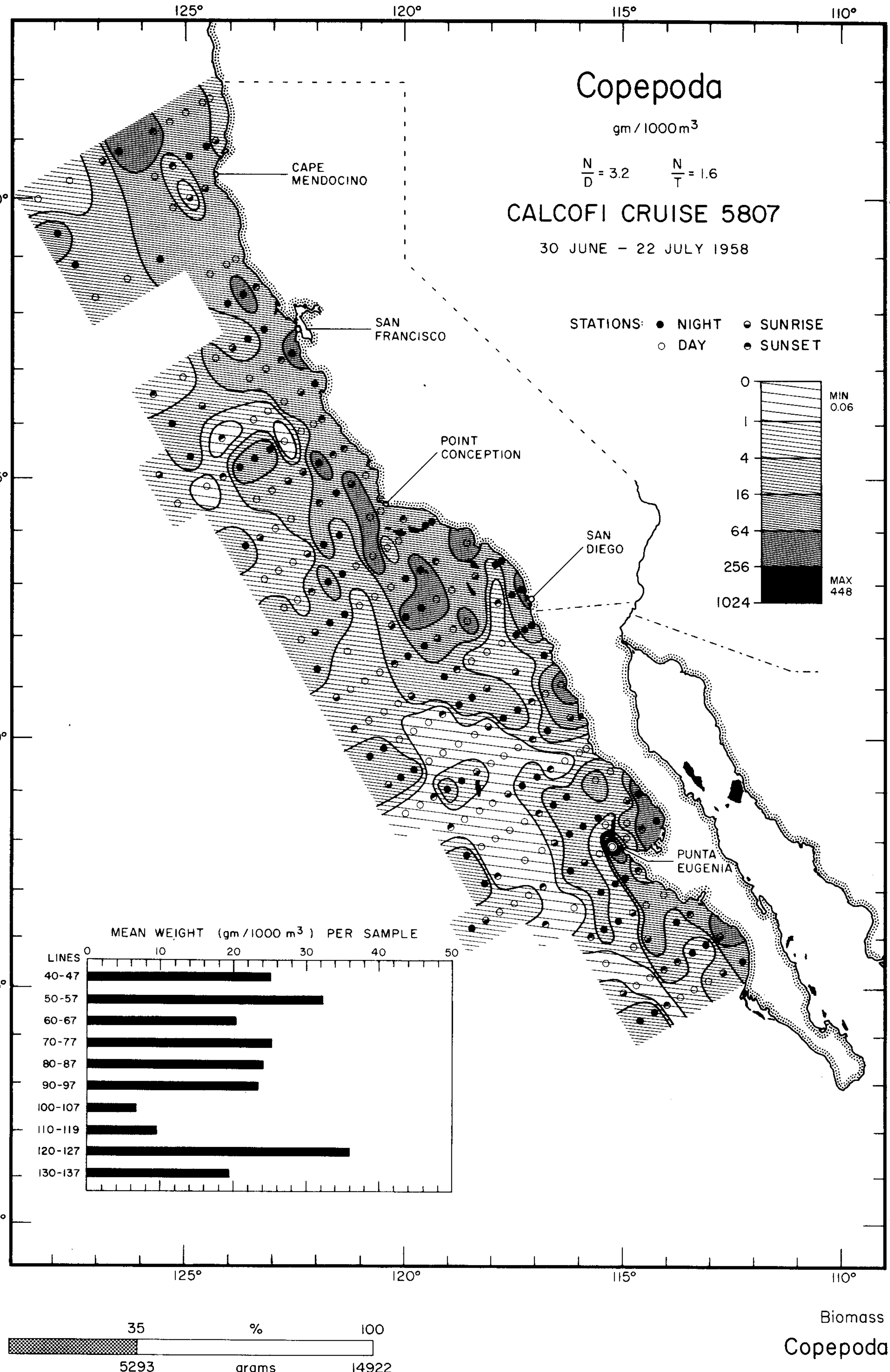
5607



Biomass

Copepoda

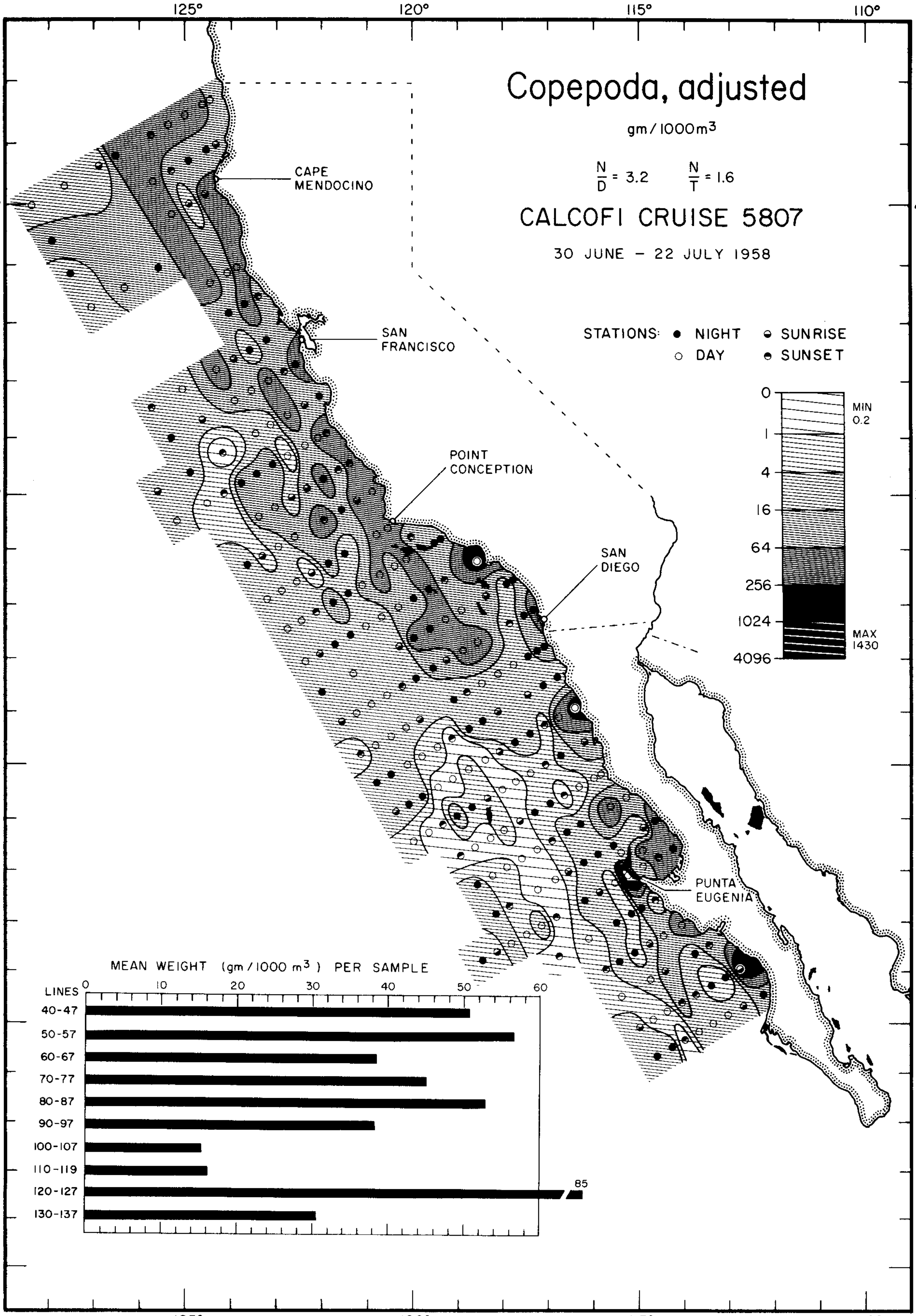
5707



Biomass

Copepoda

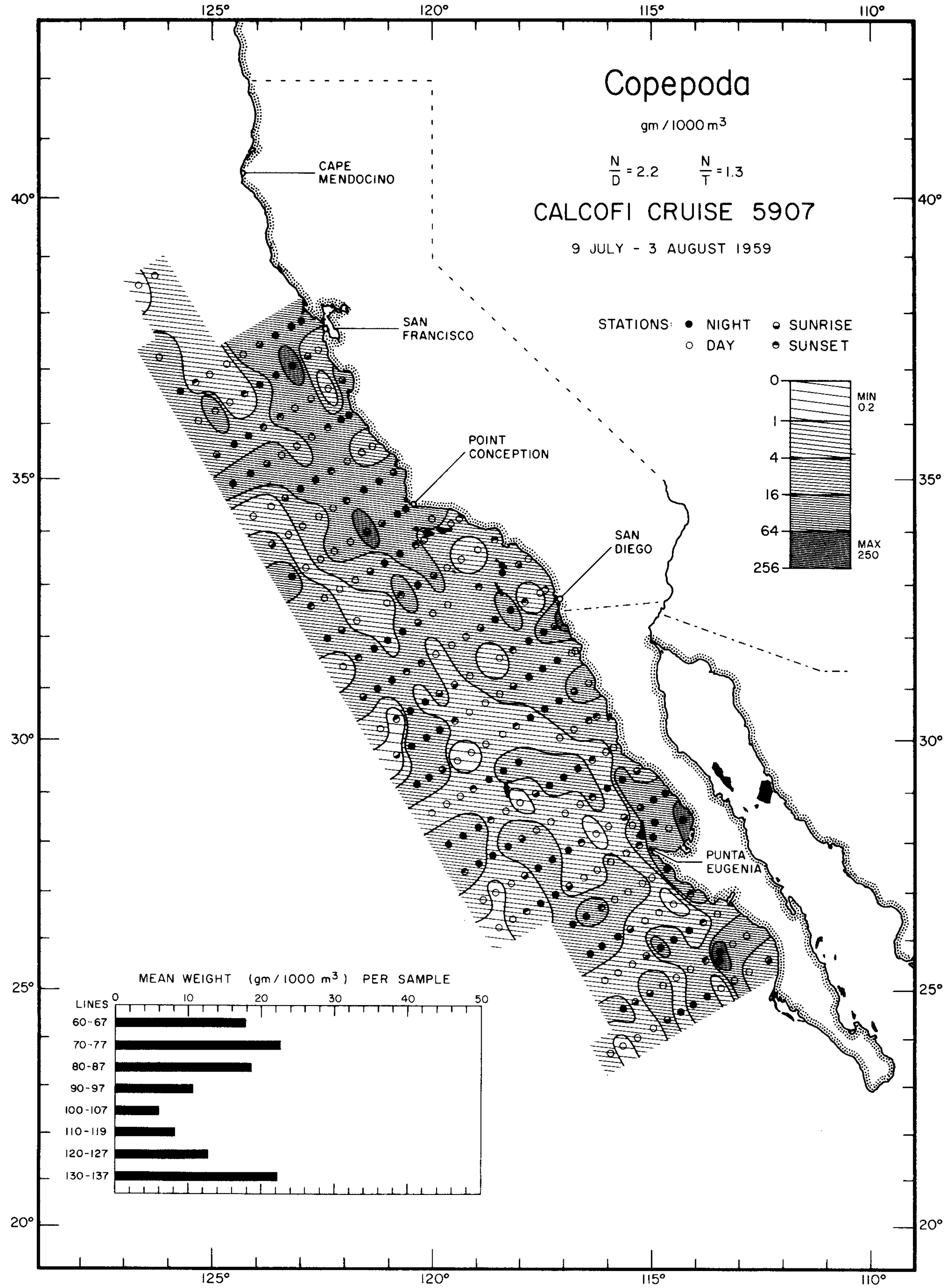
5807

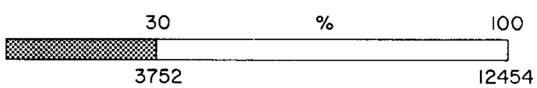


Biomass

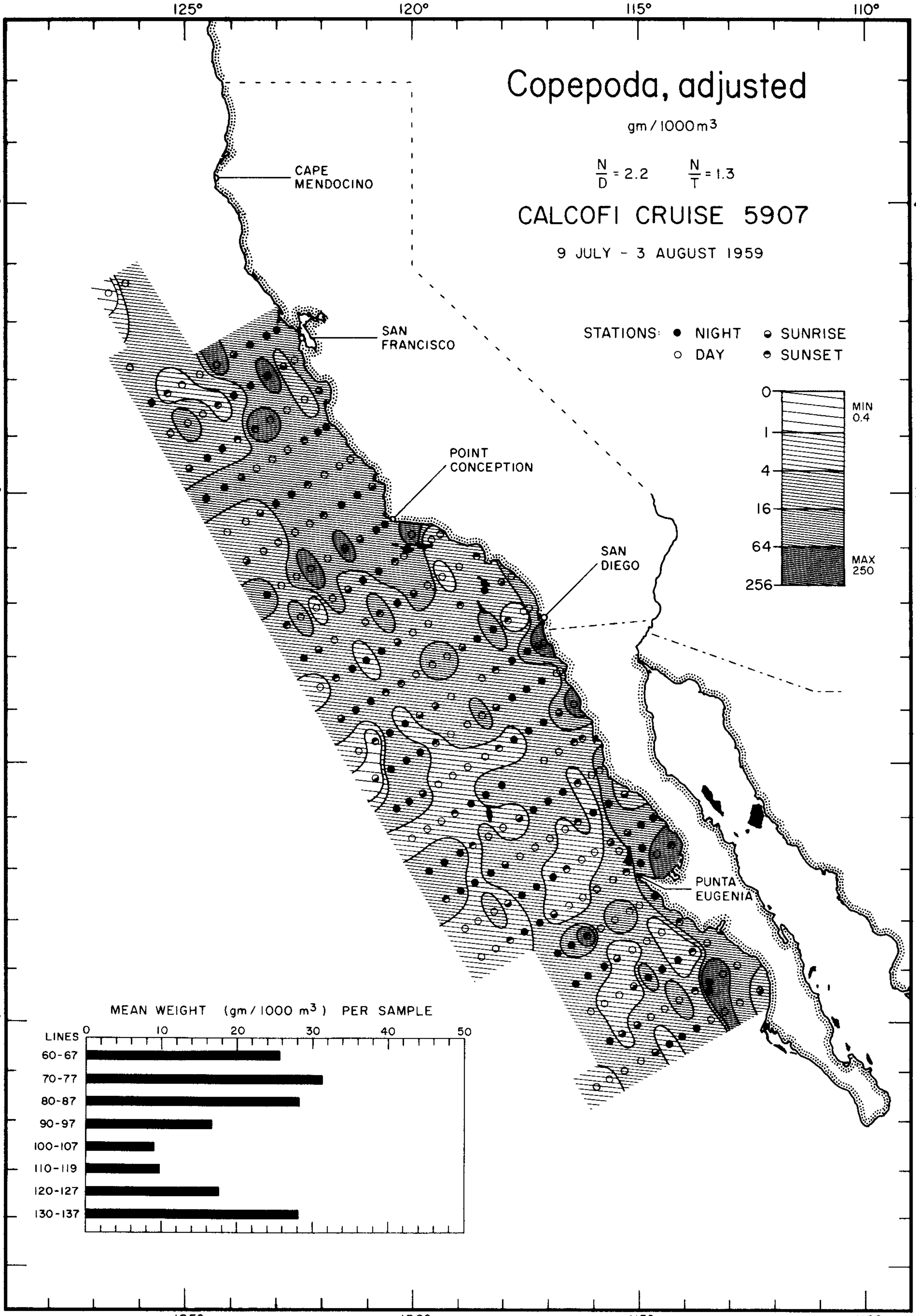
Copepoda, adjusted

5807





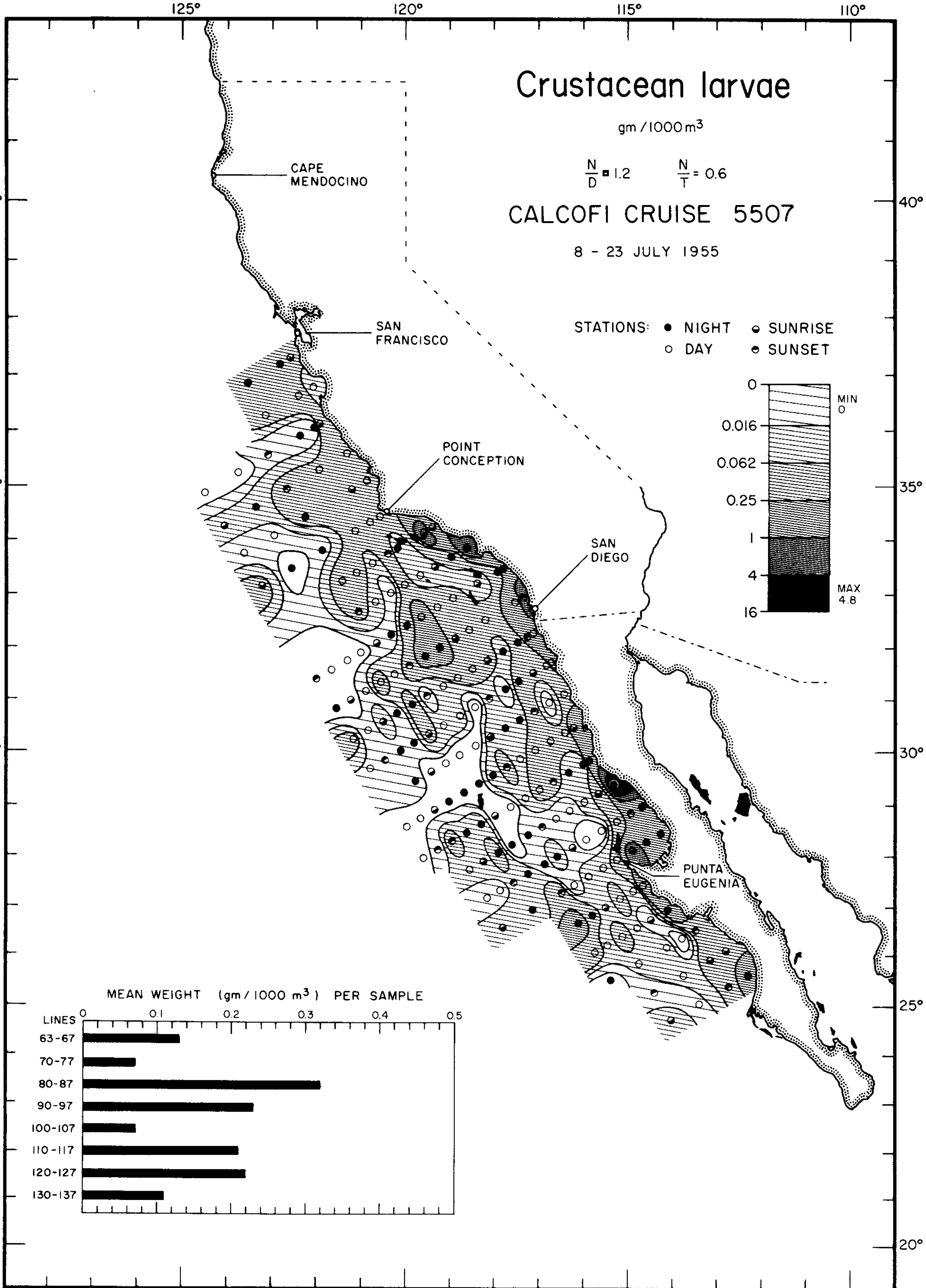
Biomass
Copepoda
5907



Biomass

Copepoda, adjusted

5907



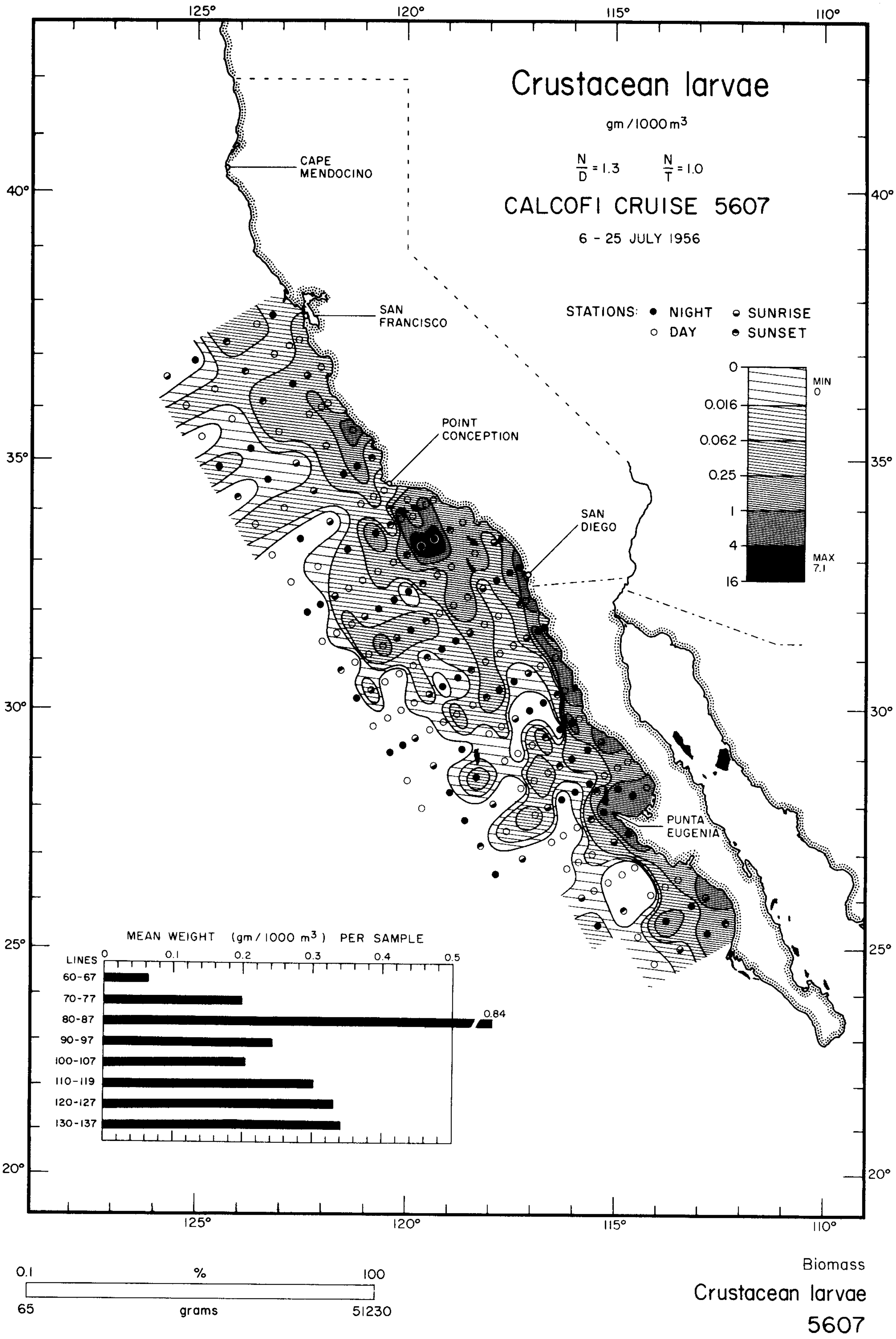
0.1 % 100

34 grams 26614

Biomass

Crustacean larvae

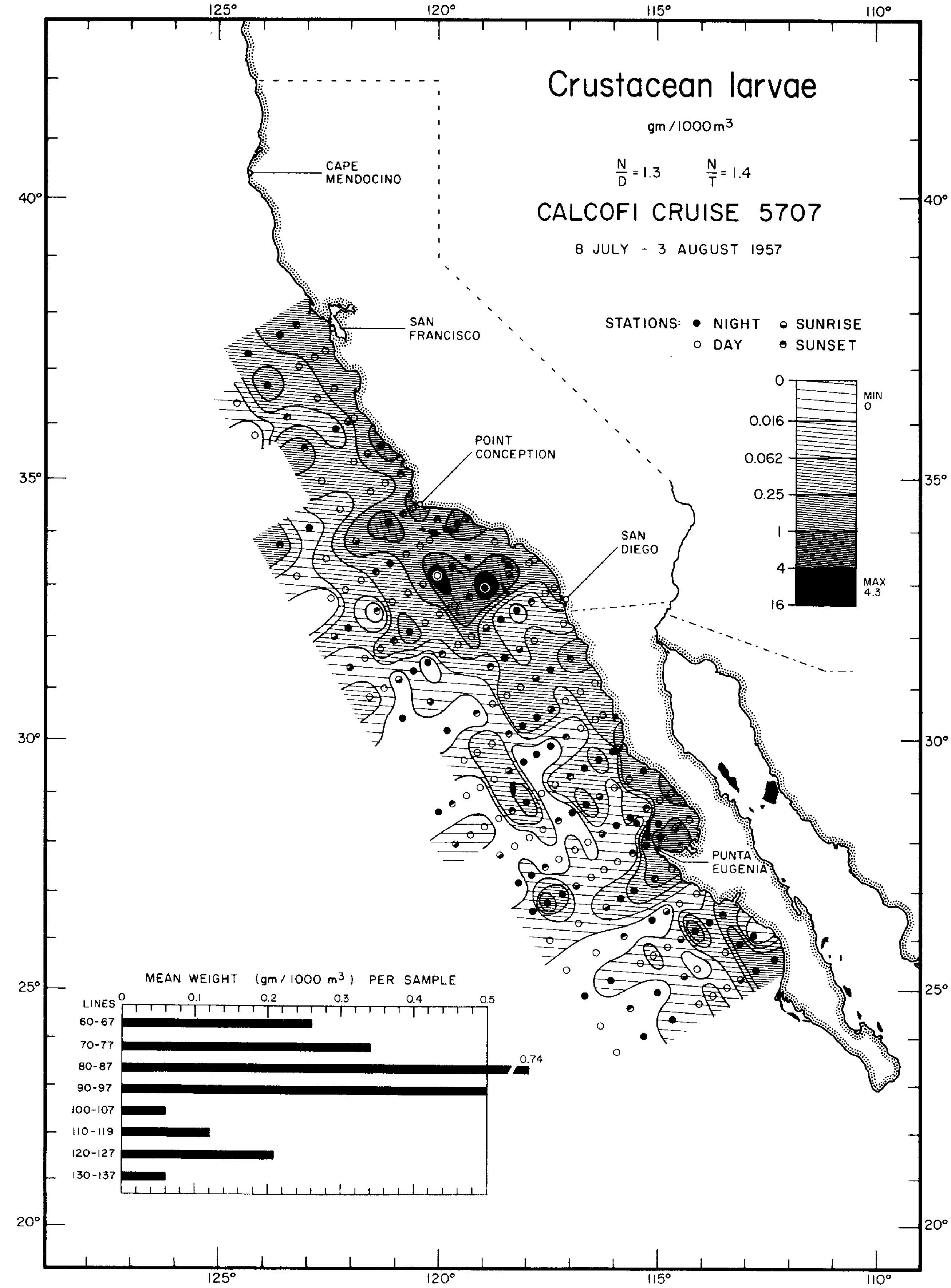
5507



Biomass

Crustacean larvae

5607



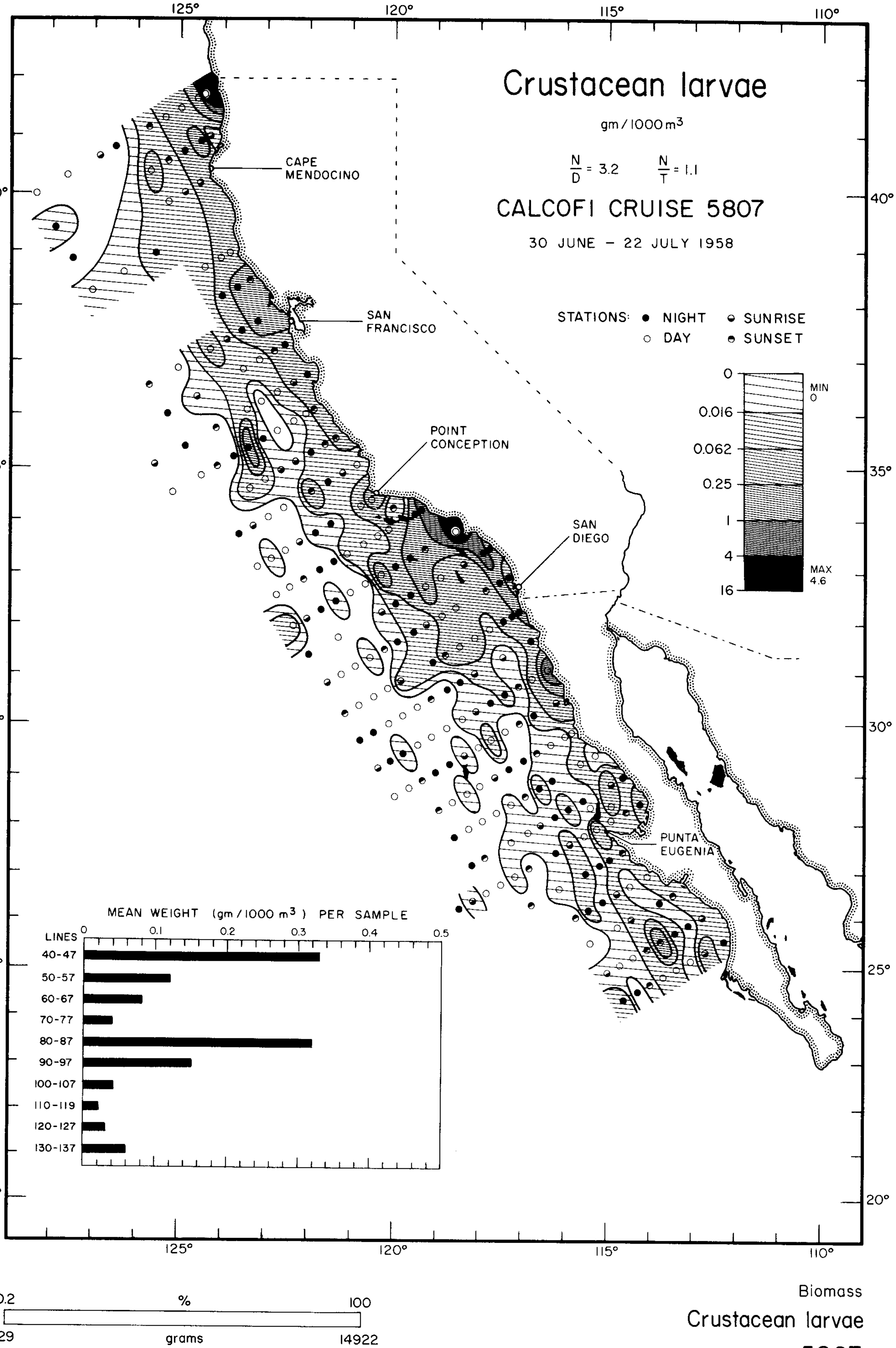
0.4 % 100

58 15031

Biomass

Crustacean larvae

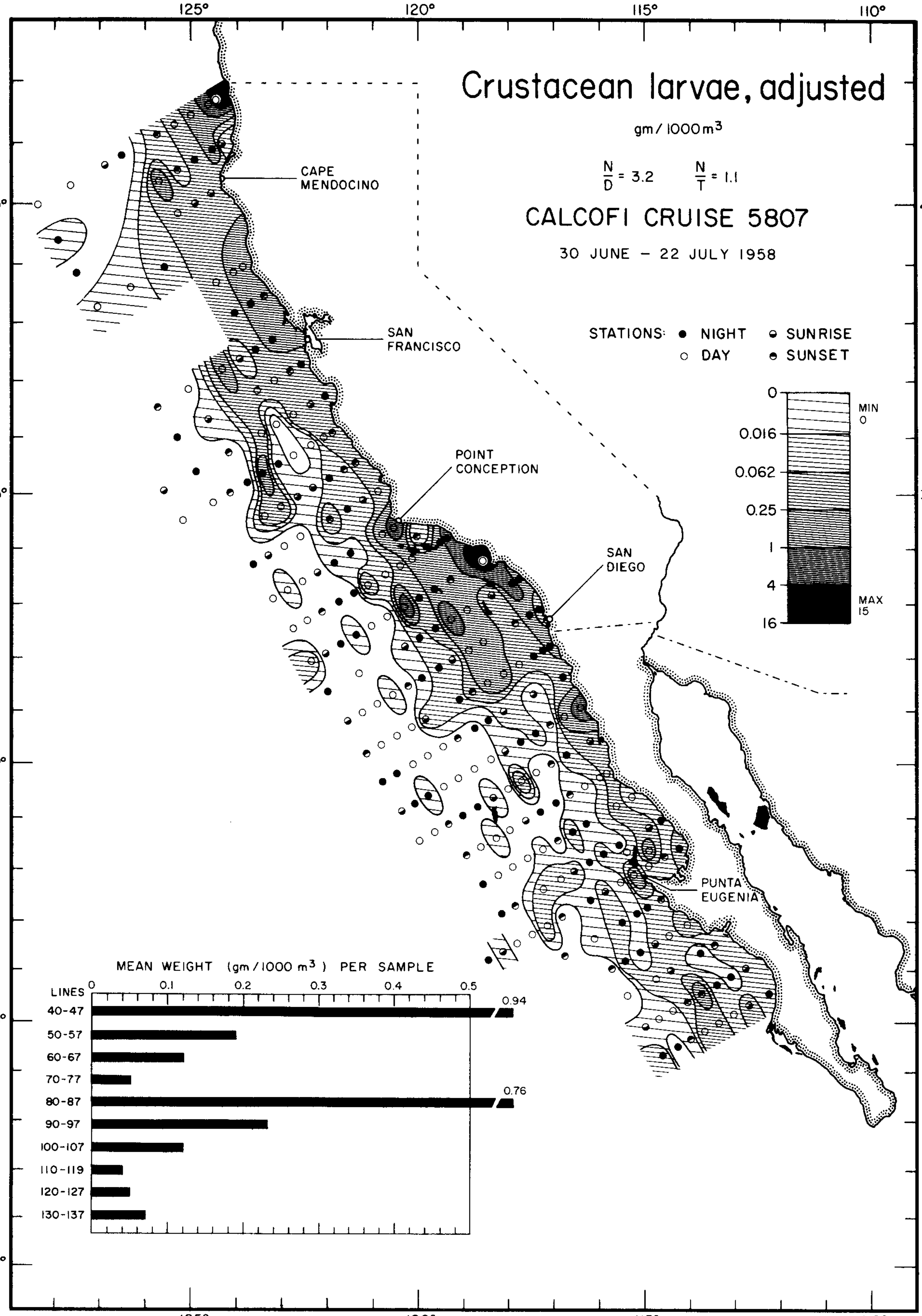
5707



Biomass

Crustacean larvae

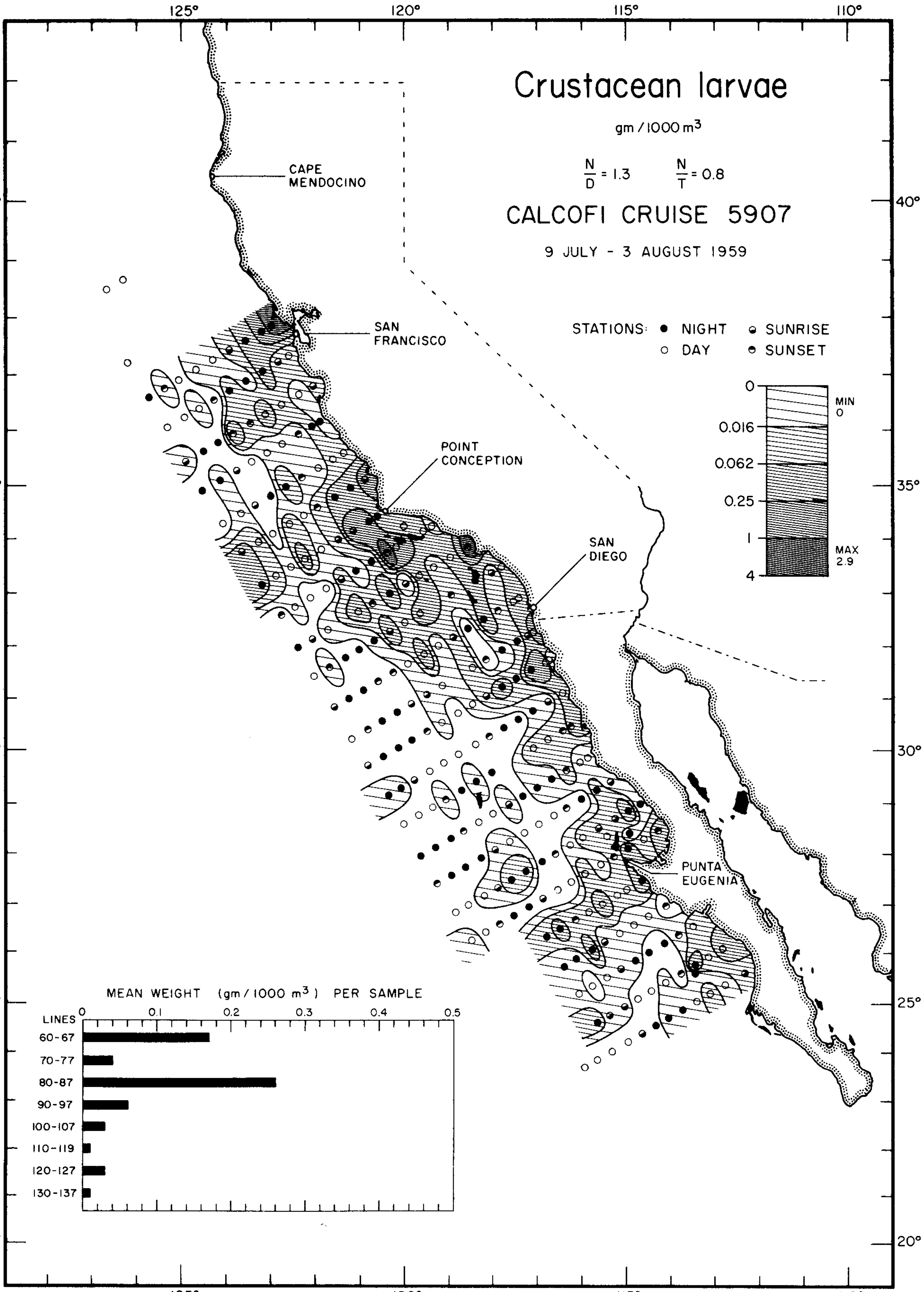
5807

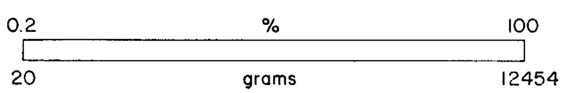


Biomass

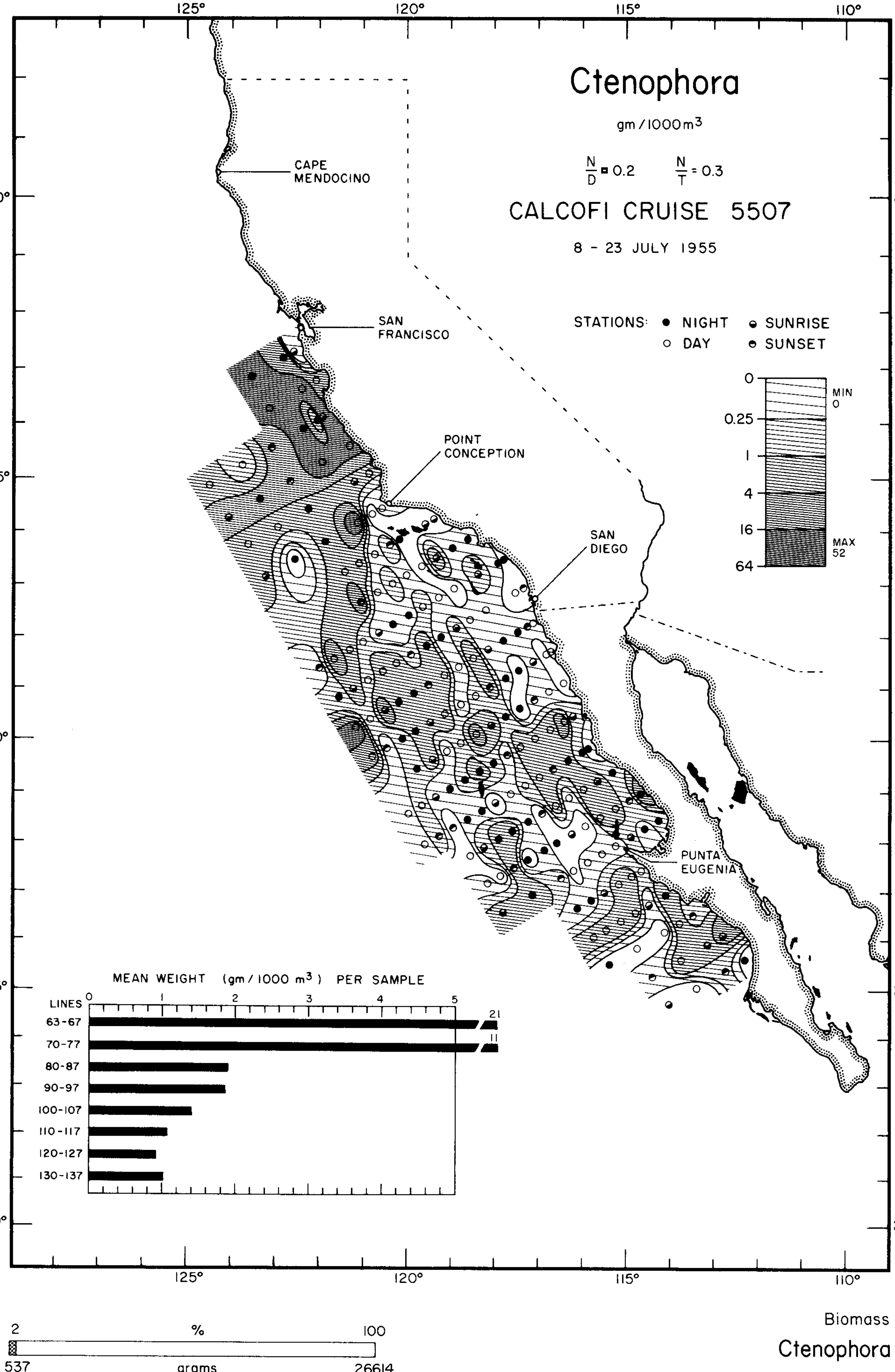
Crustacean larvae, adjusted

5807





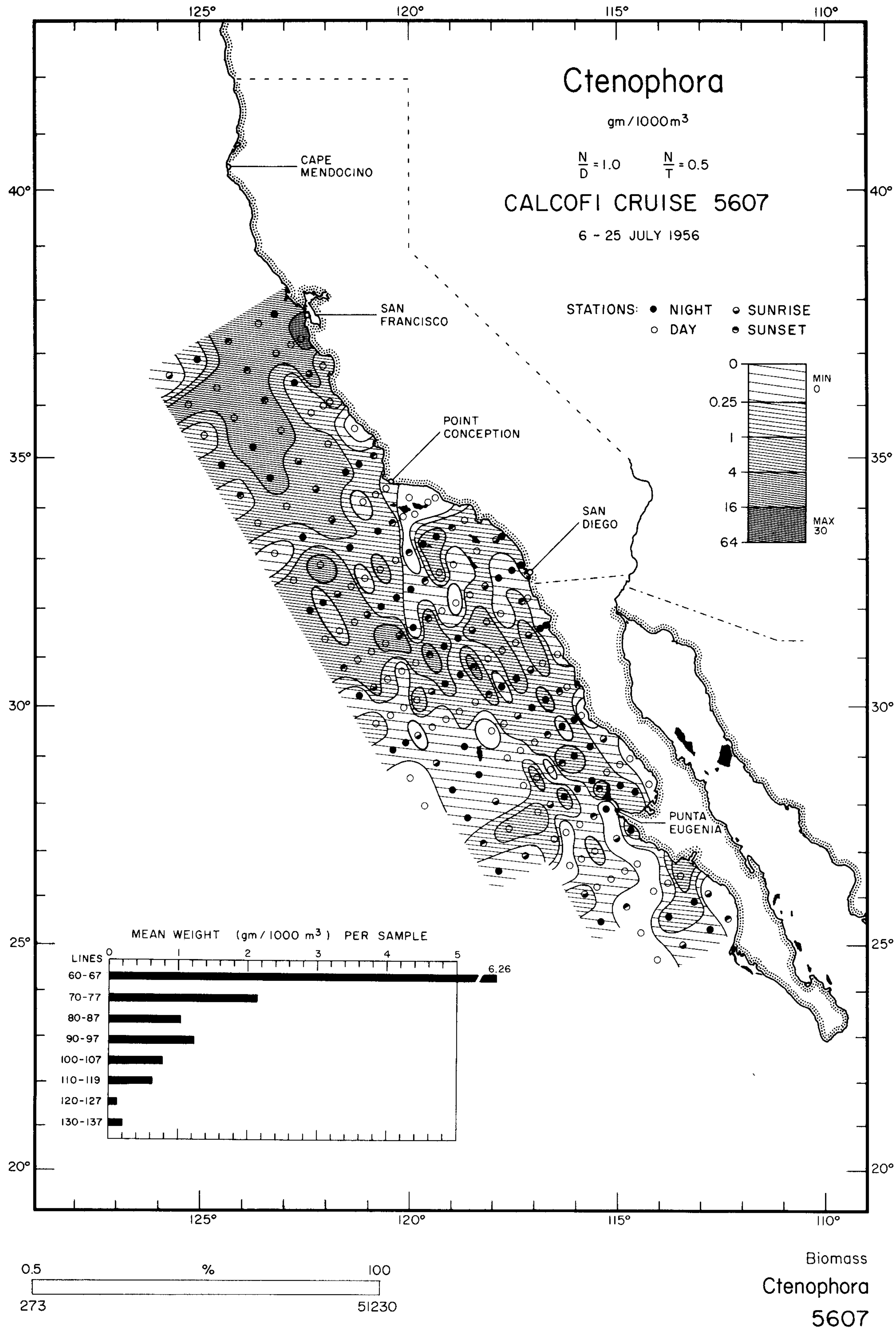
Biomass
Crustacean larvae
5907



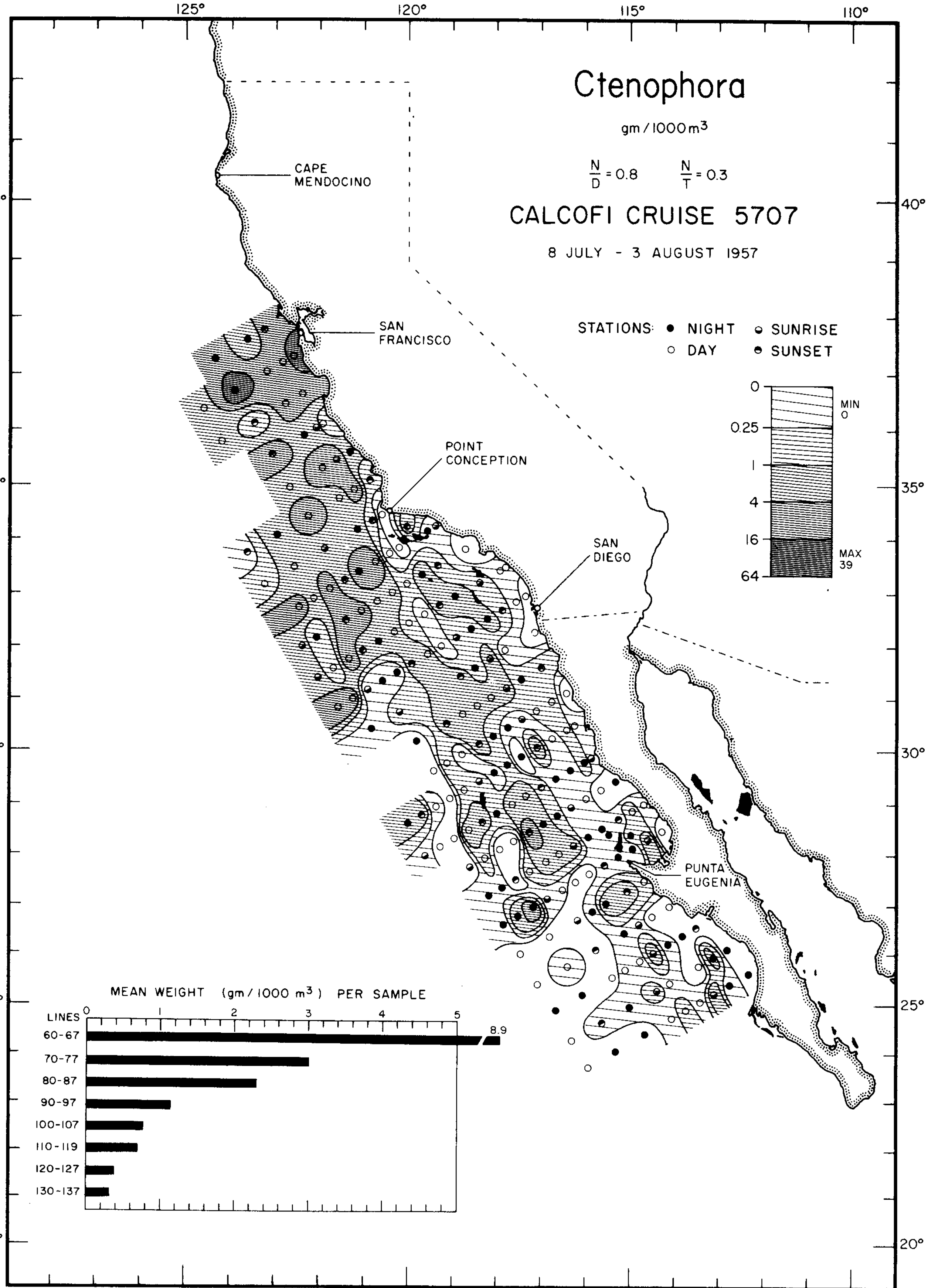
Biomass

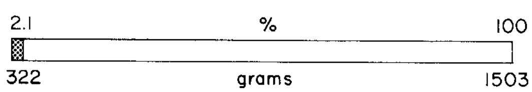
Ctenophora

5507



Biomass
Ctenophora
5607

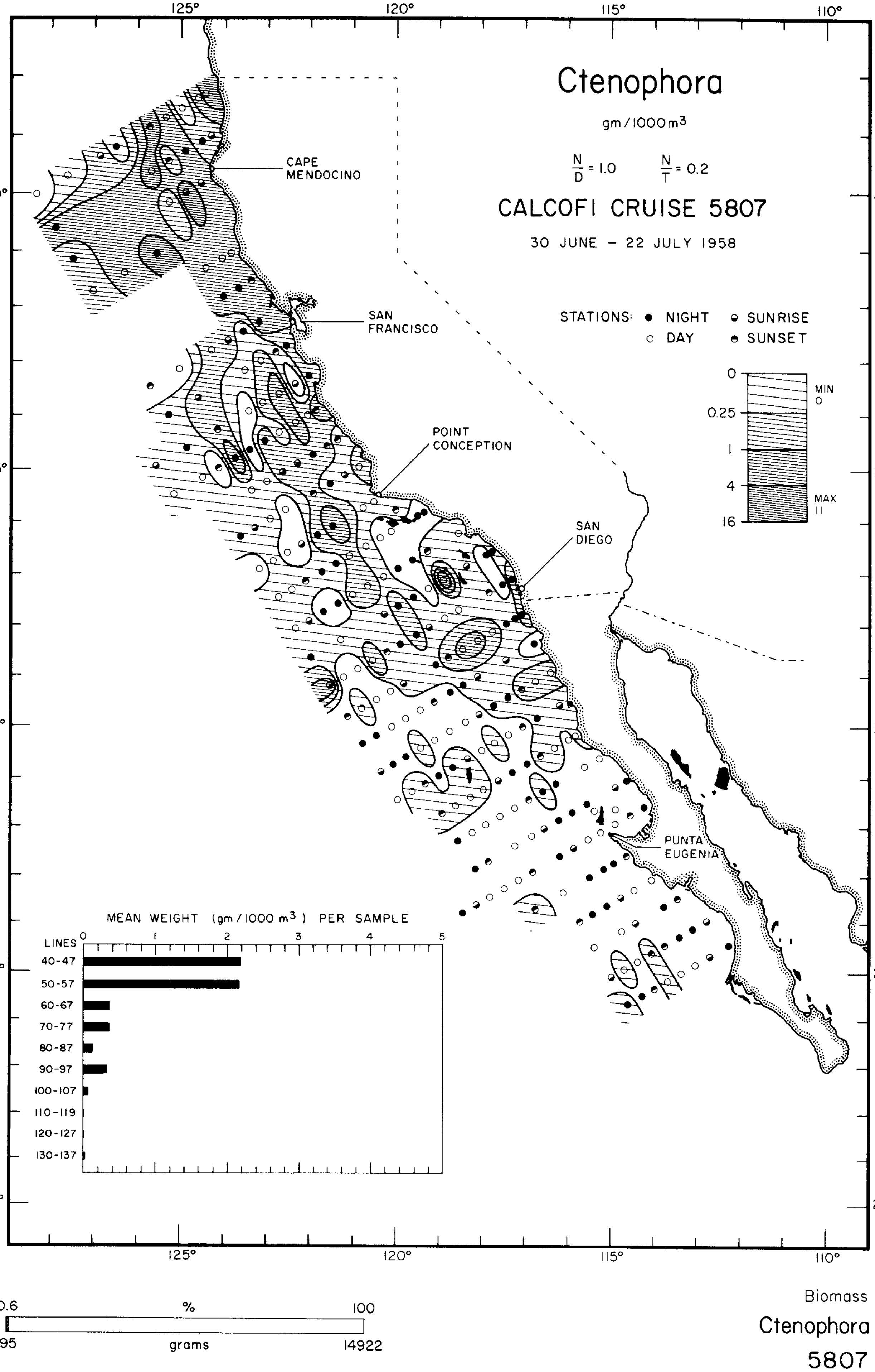




Biomass

Ctenophora

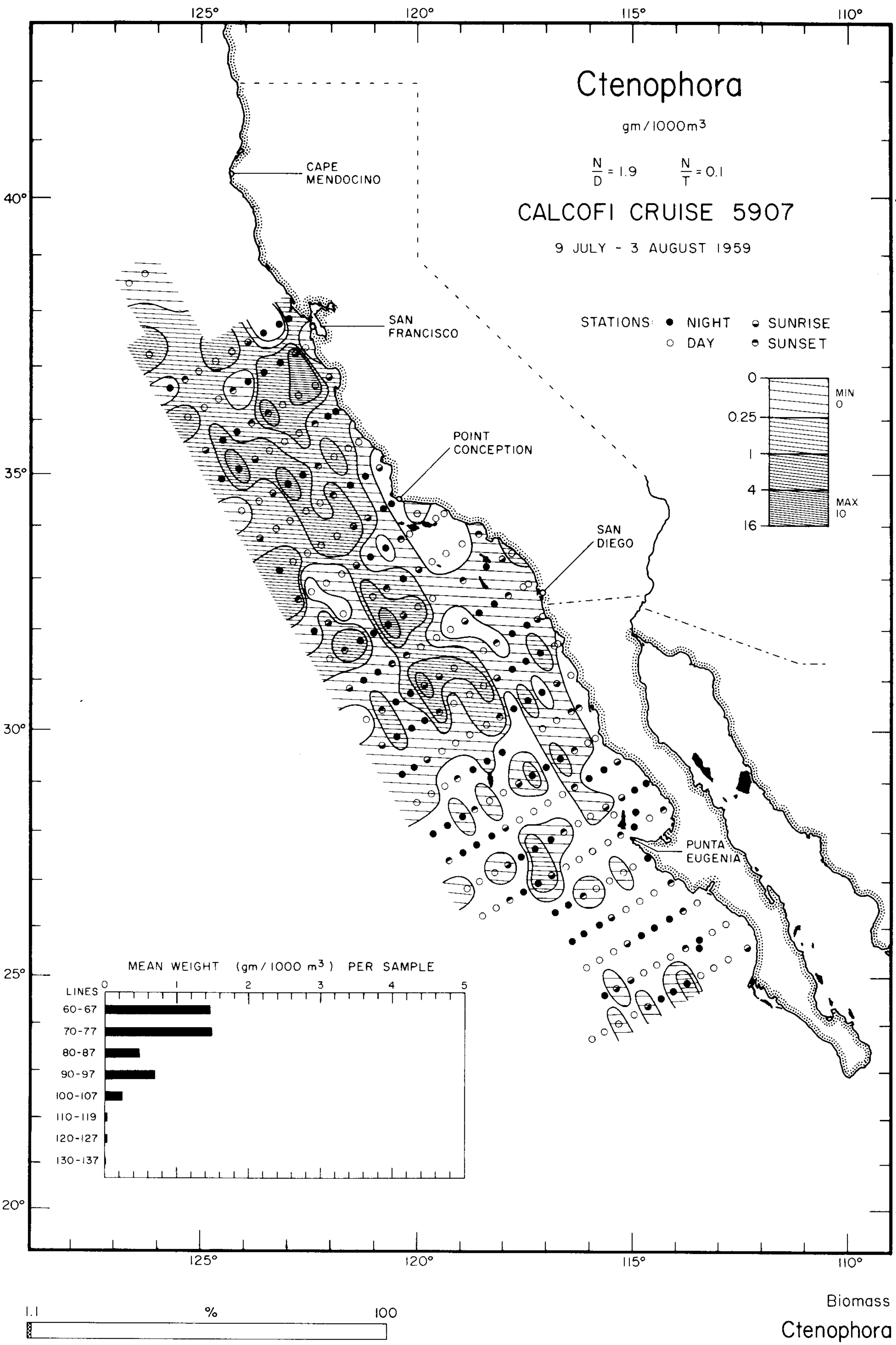
5707



Biomass

Ctenophora

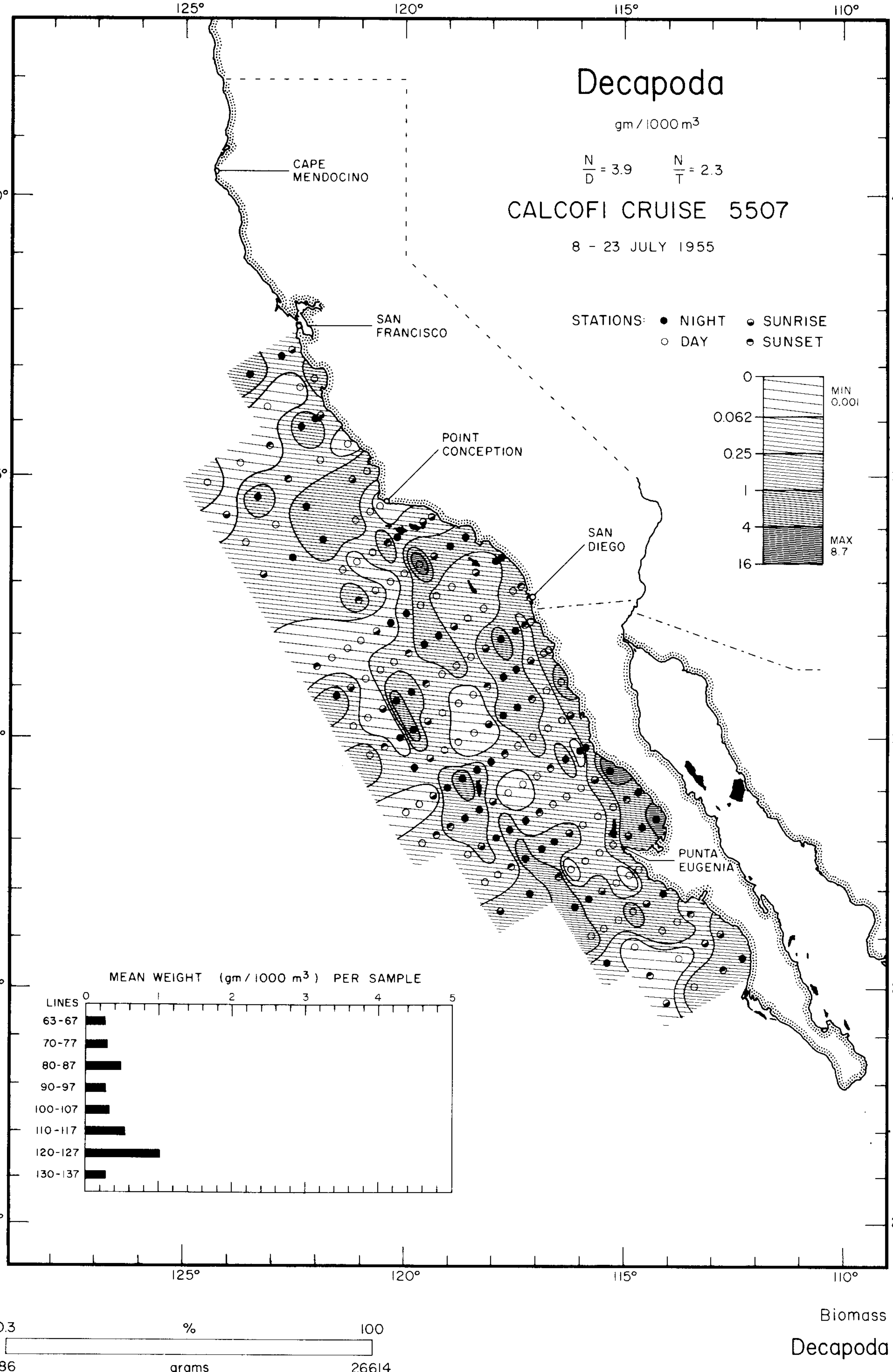
5807



Biomass

Ctenophora

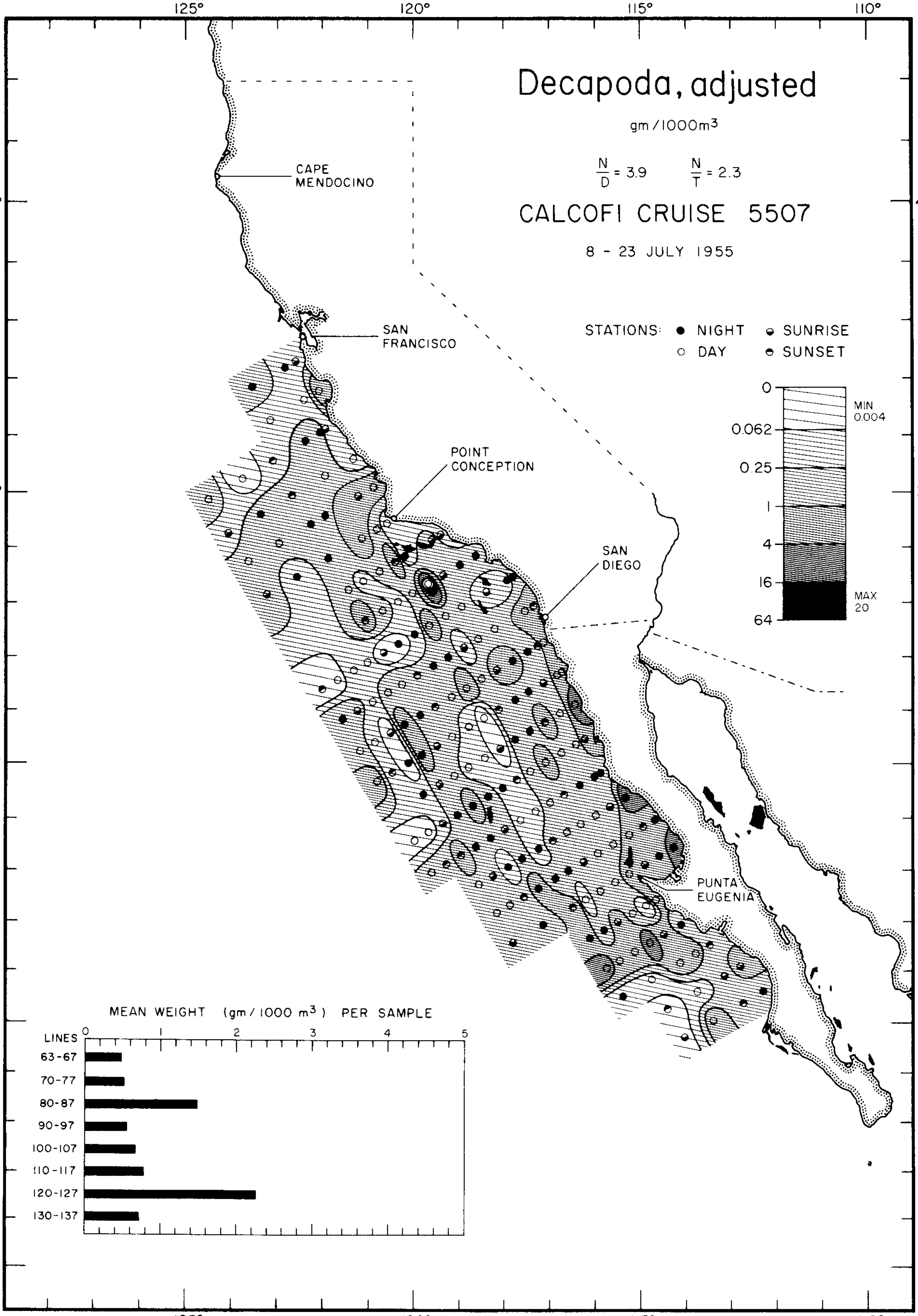
5907



Biomass

Decapoda

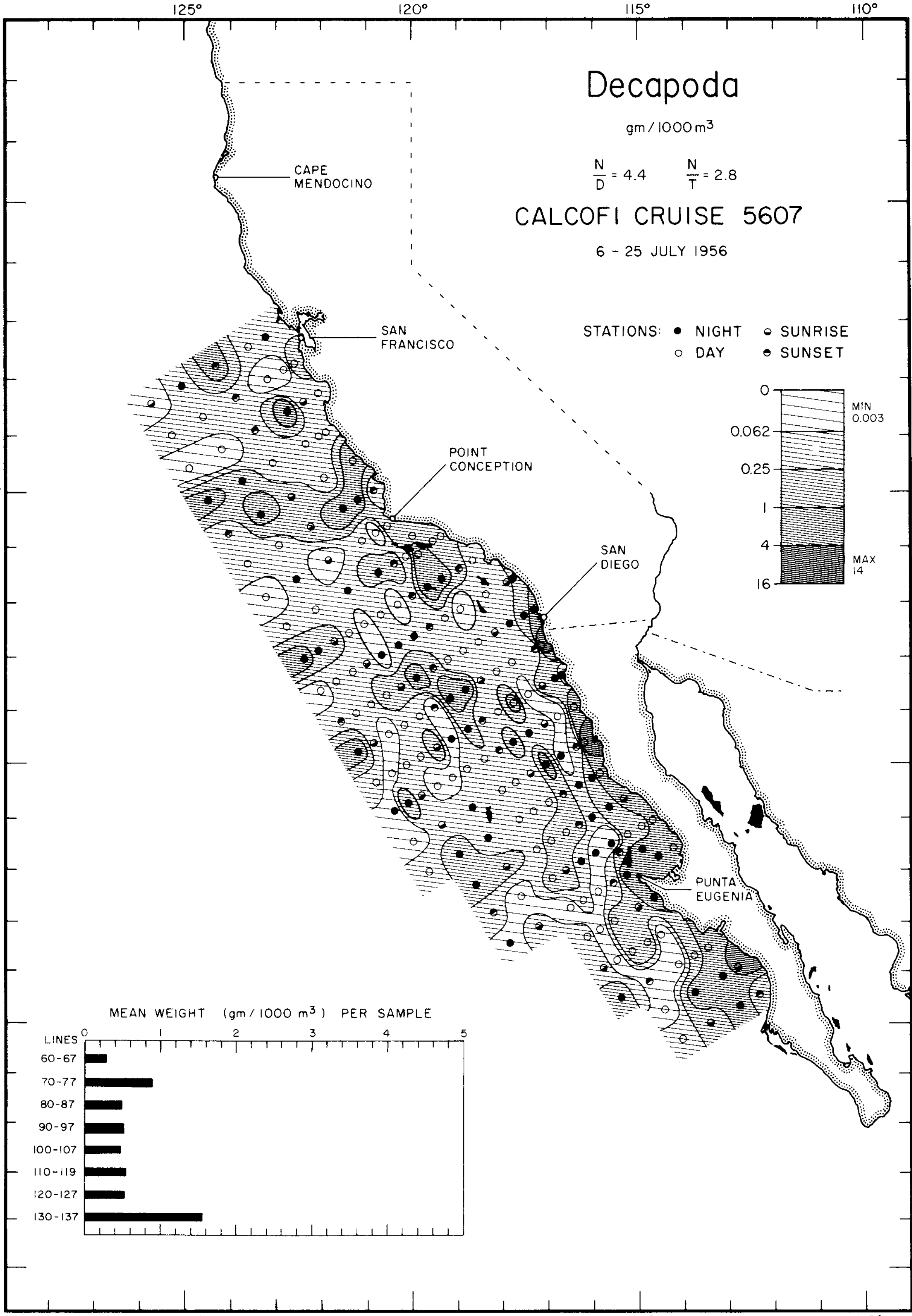
5507

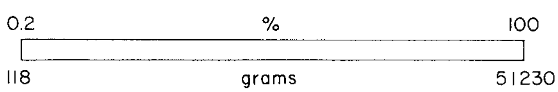


Biomass

Decapoda, adjusted

5507

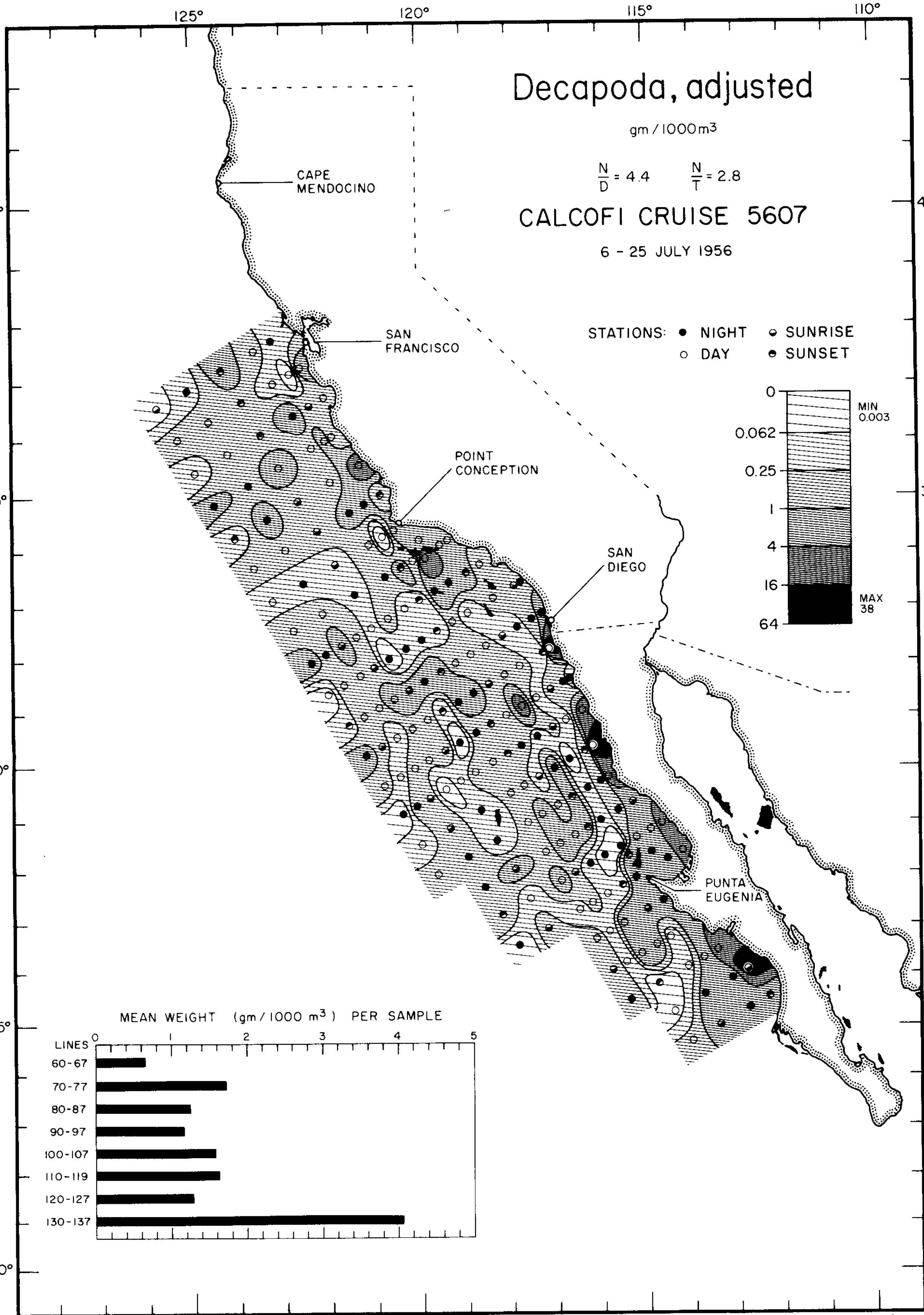




Biomass

Decapoda

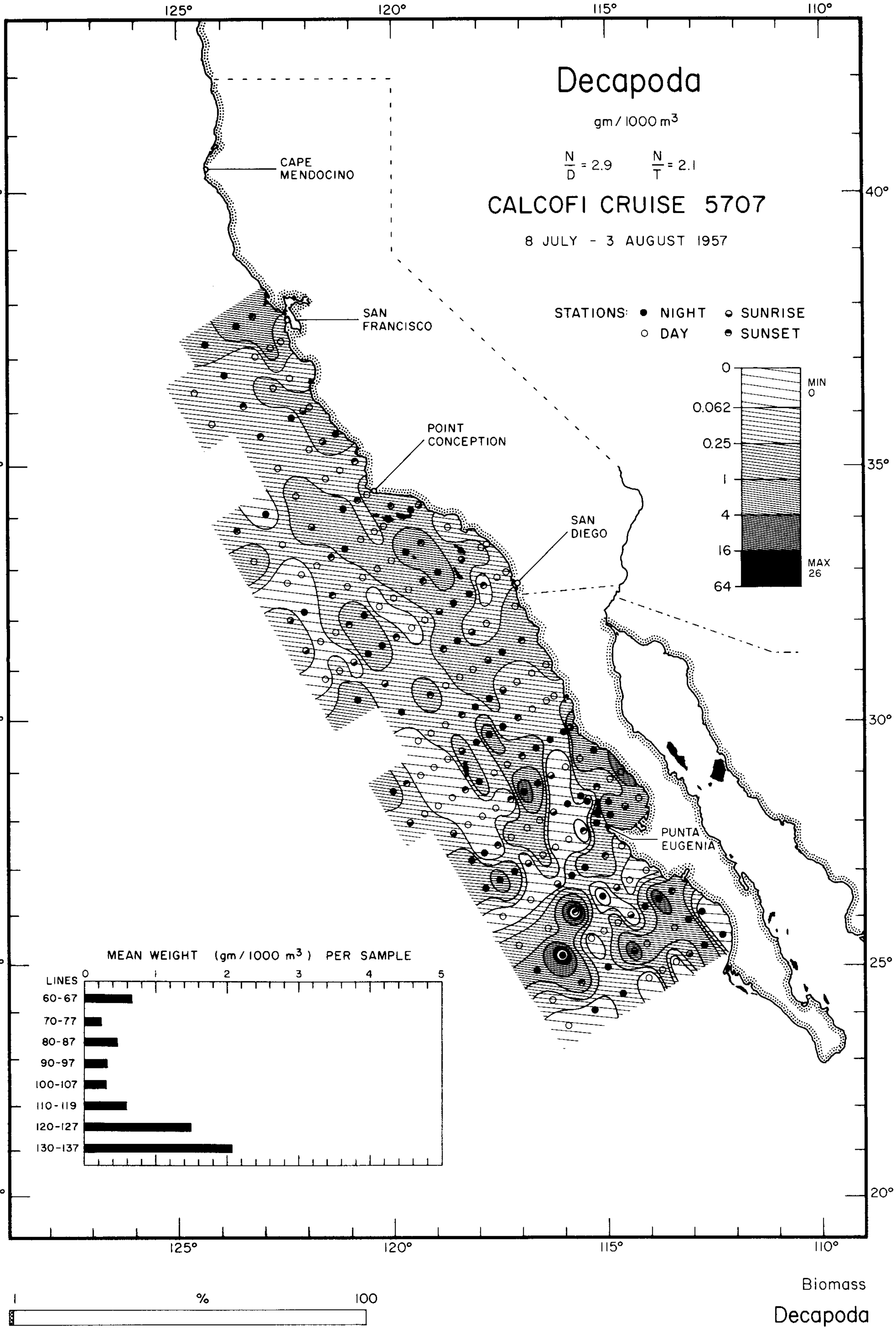
5607



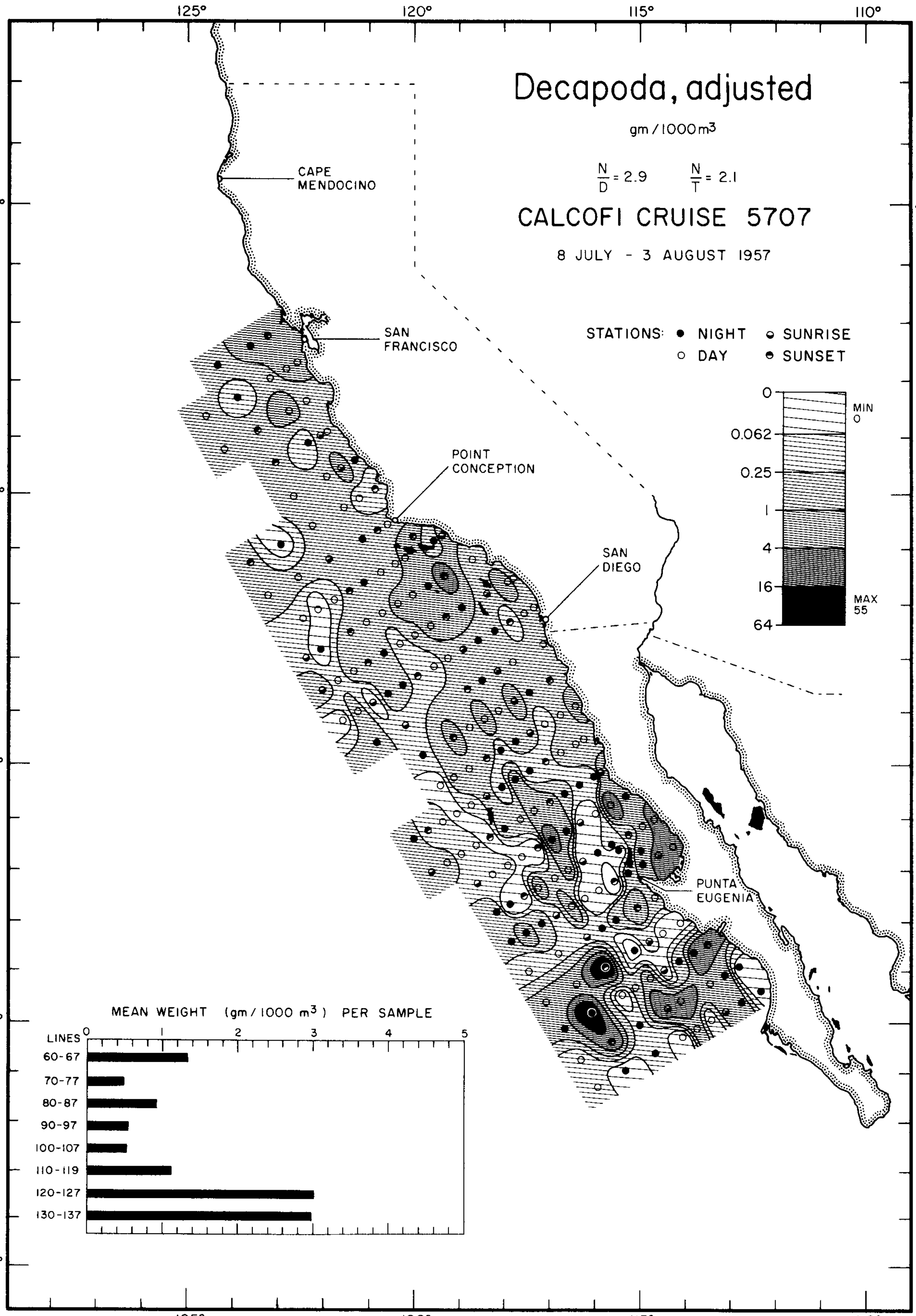
Biomass

Decapoda, adjusted

5607



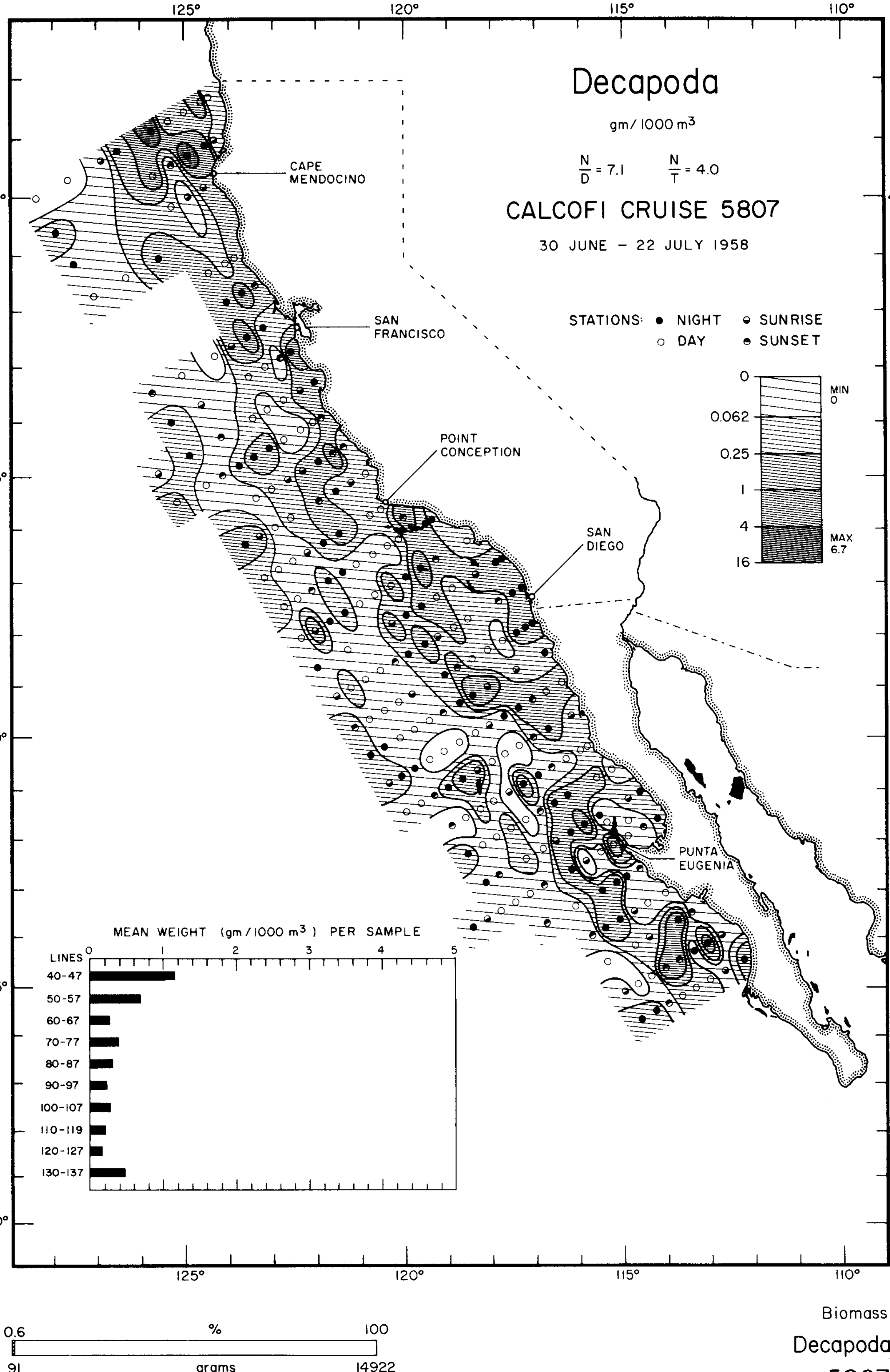
Biomass
Decapoda
5707



Biomass

Decapoda, adjusted

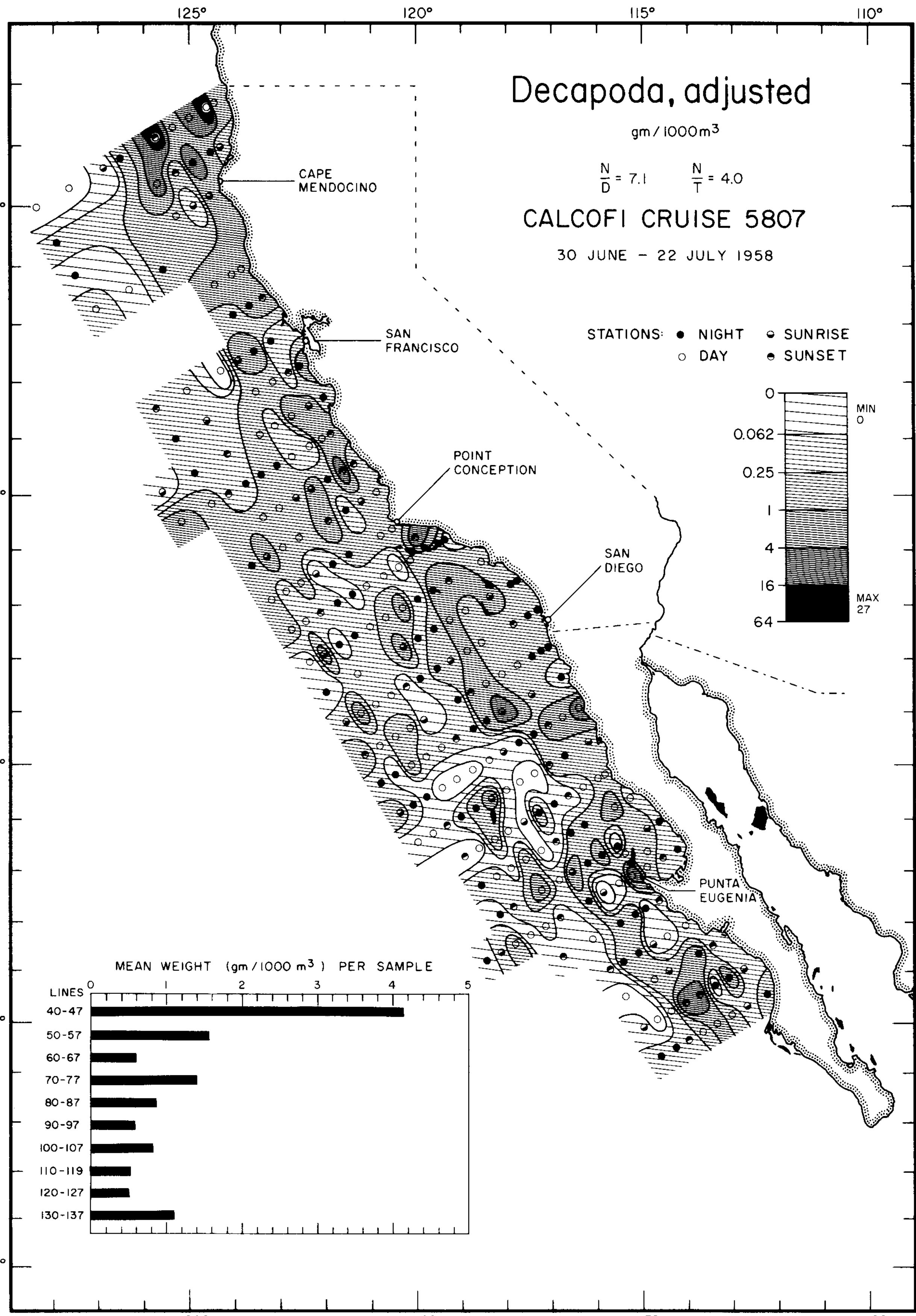
5707



Biomass

Decapoda

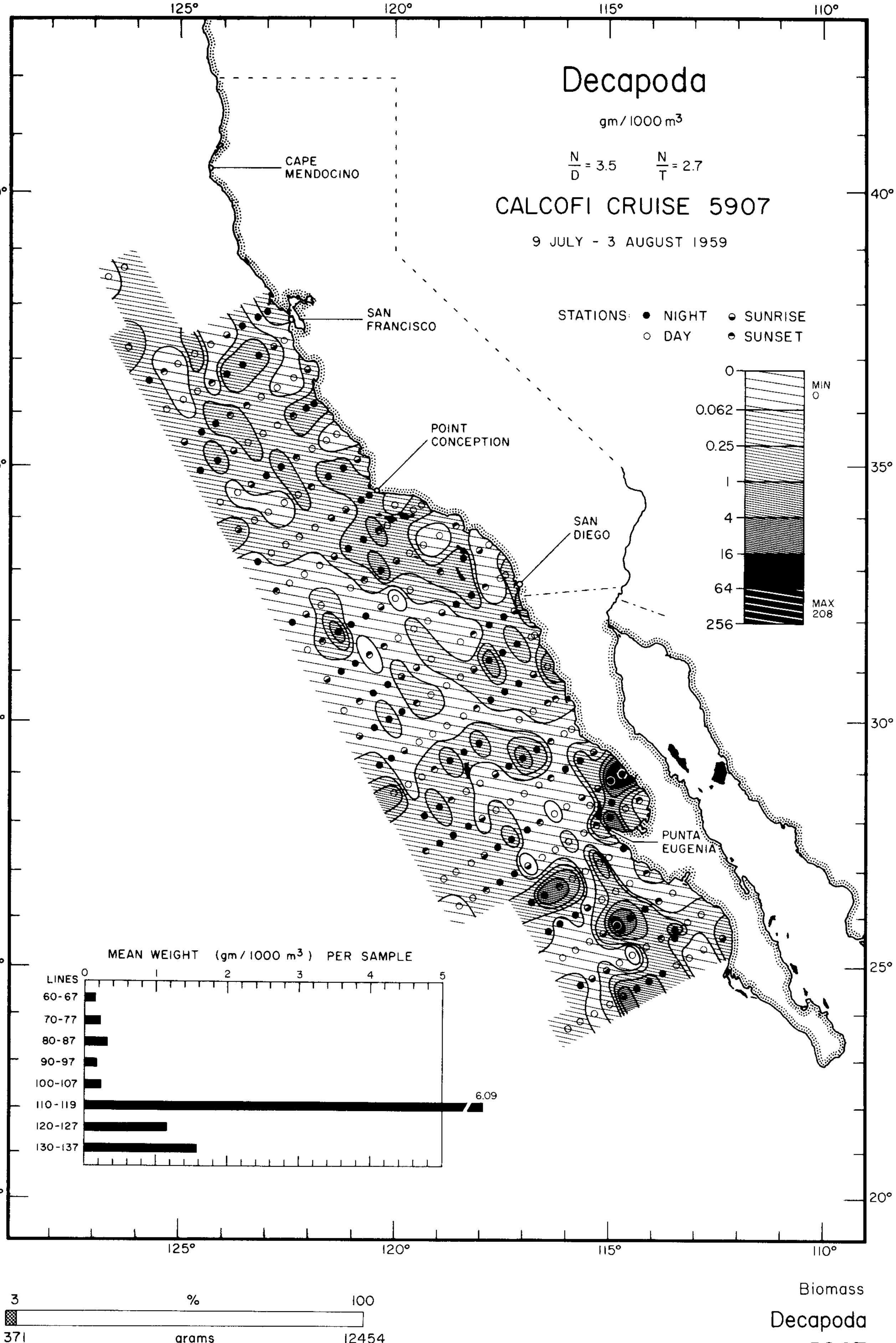
5807



Biomass

Decapoda, adjusted

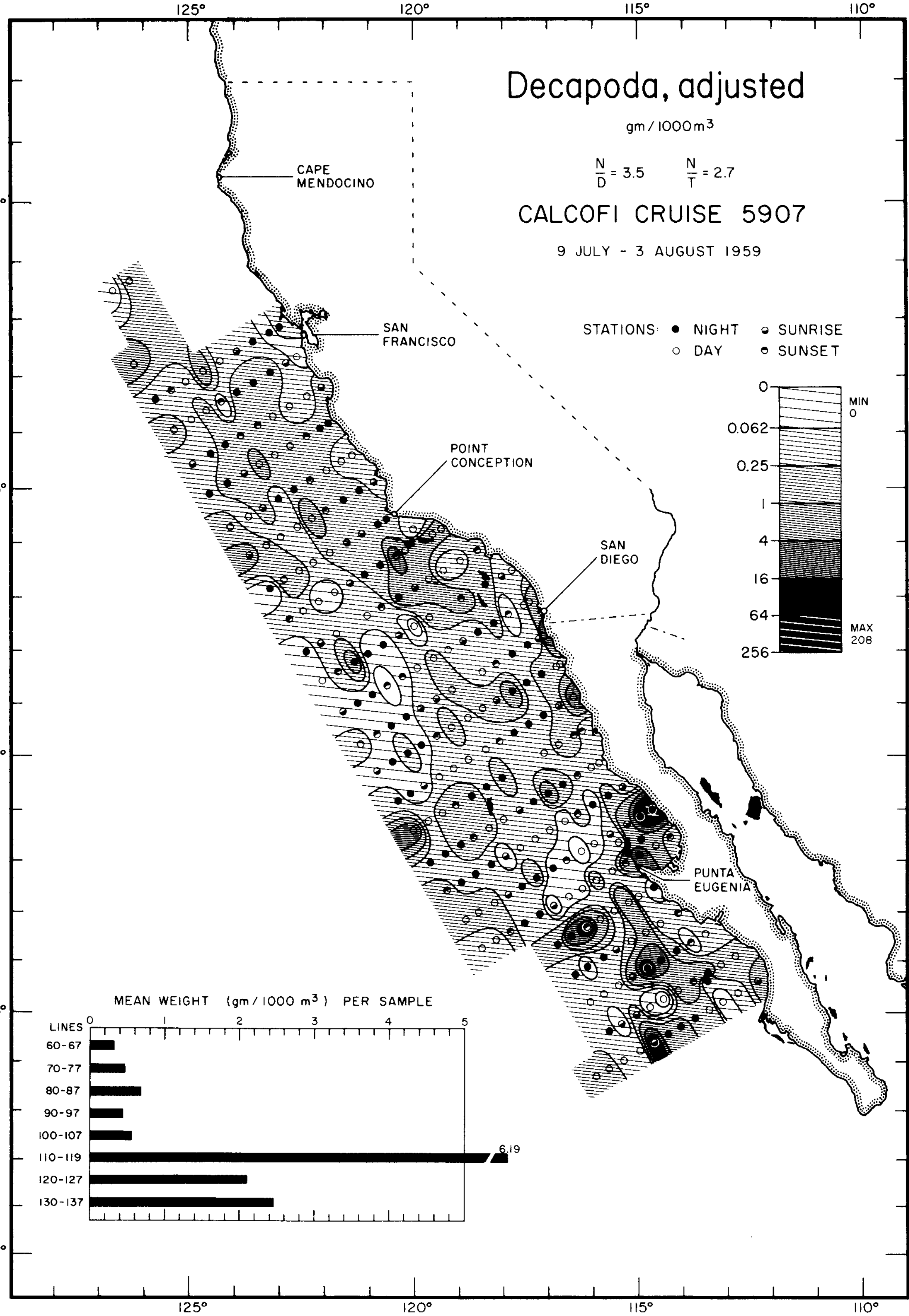
5807



Biomass

Decapoda

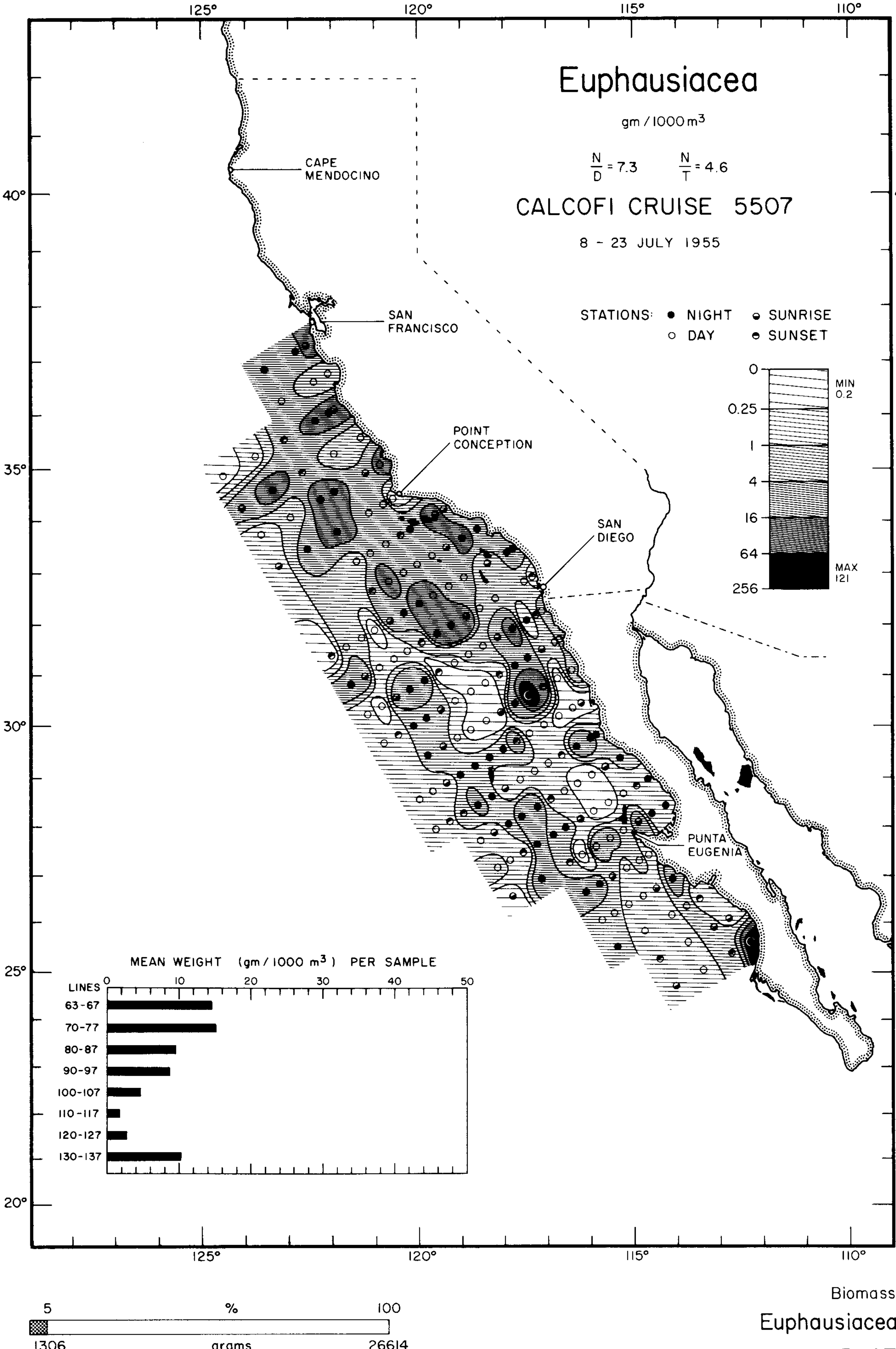
5907



Biomass

Decapoda, adjusted

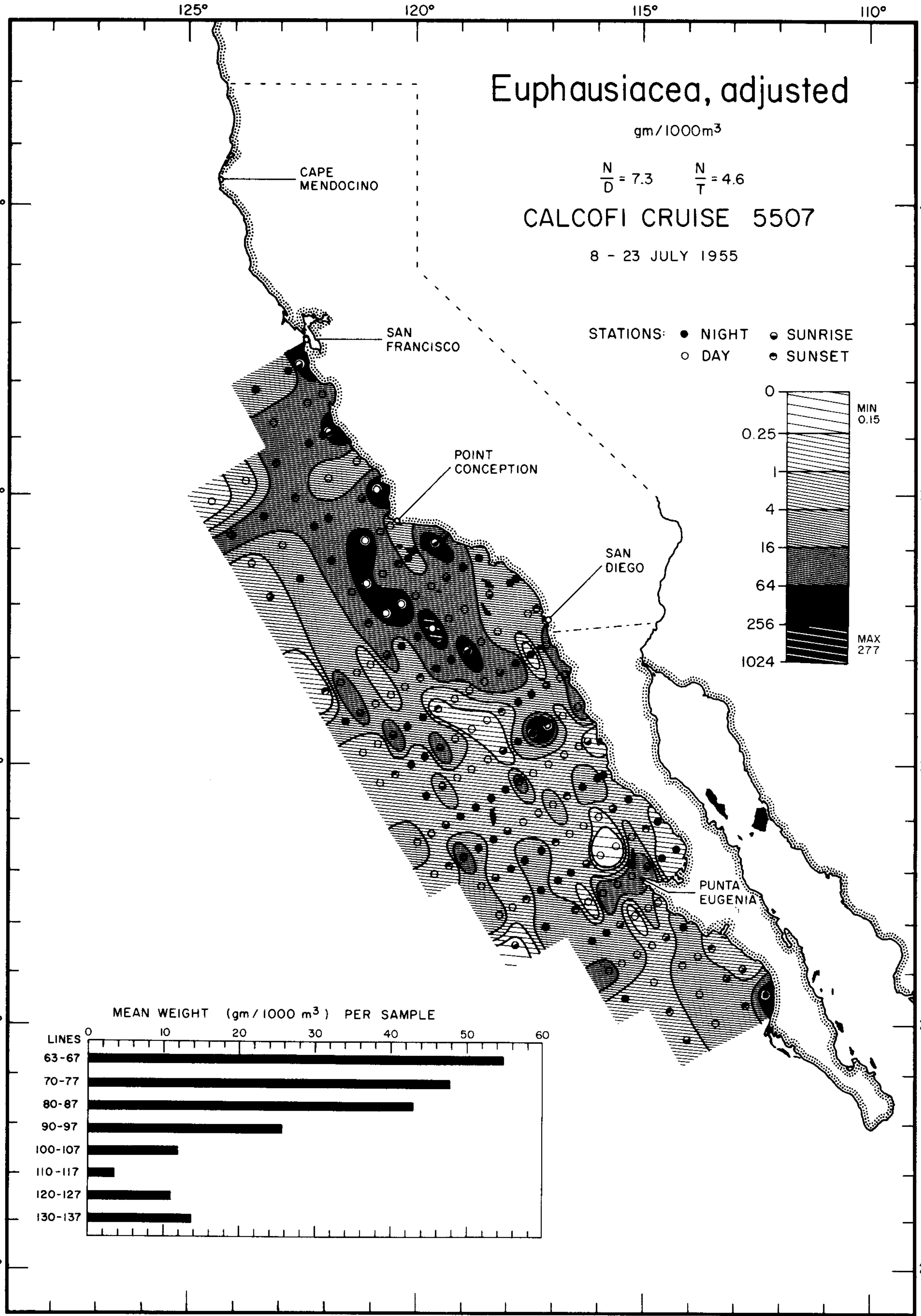
5907



Biomass

Euphausiacea

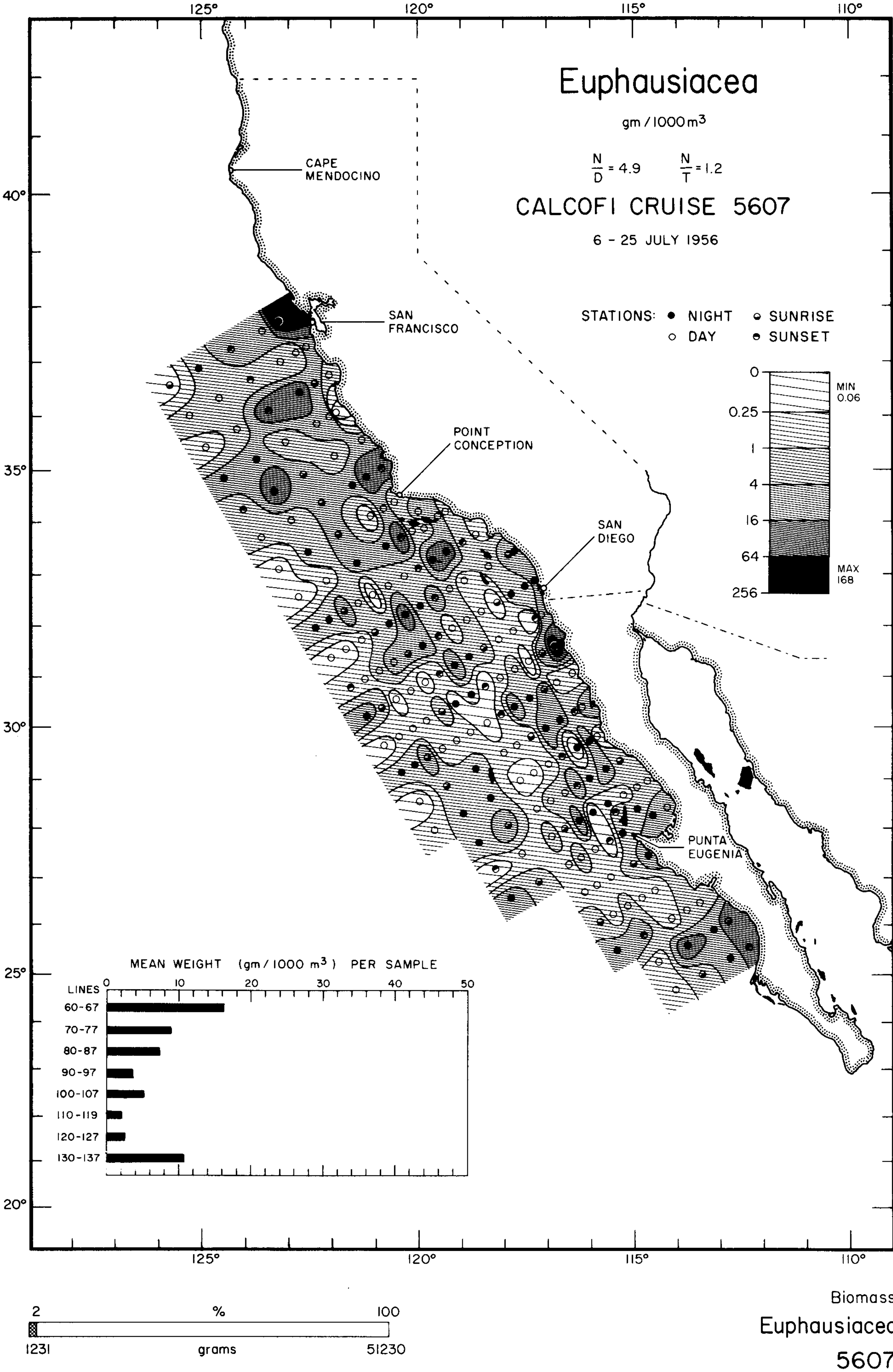
5507



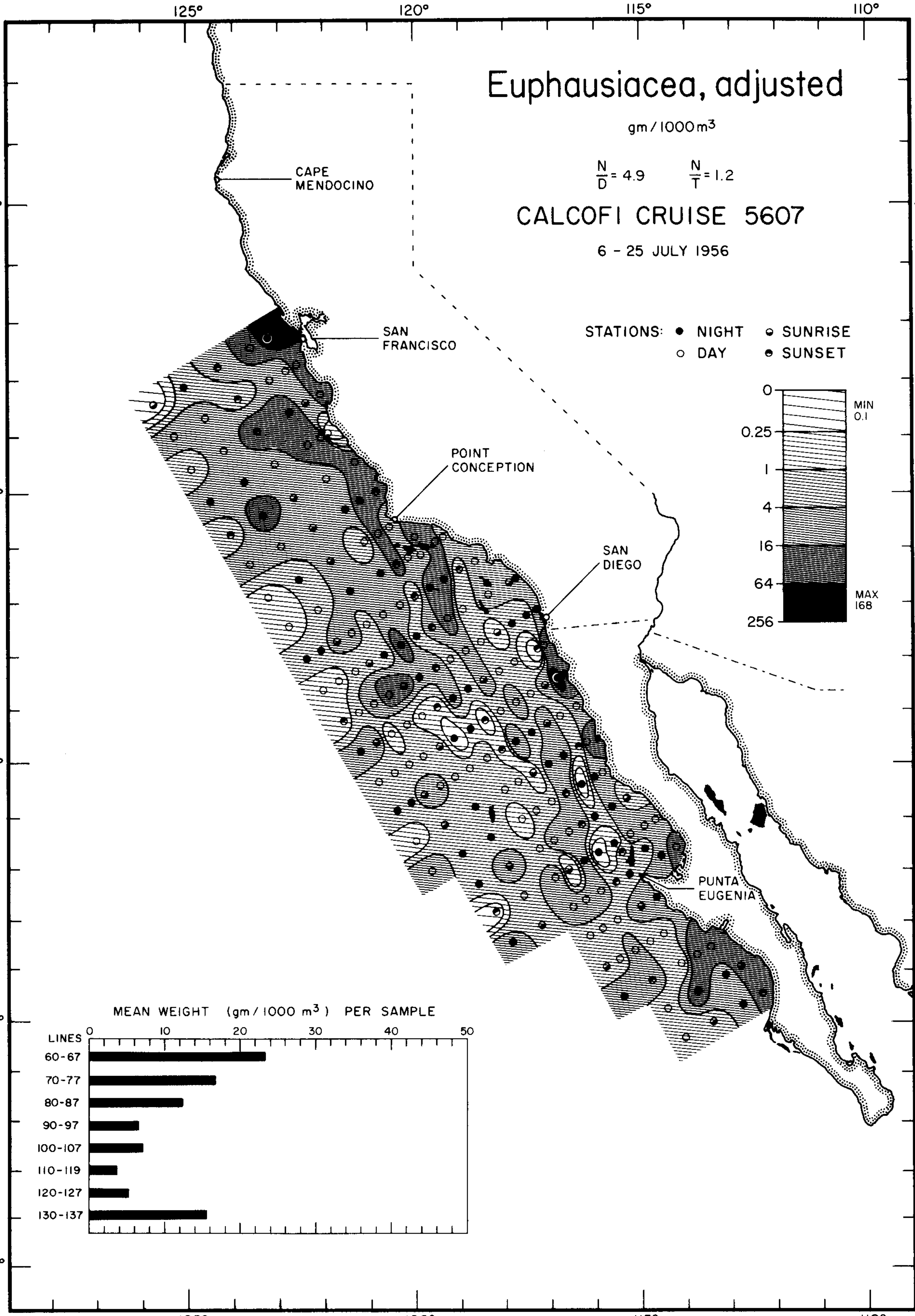
Biomass

Euphausiacea, adjusted

5507



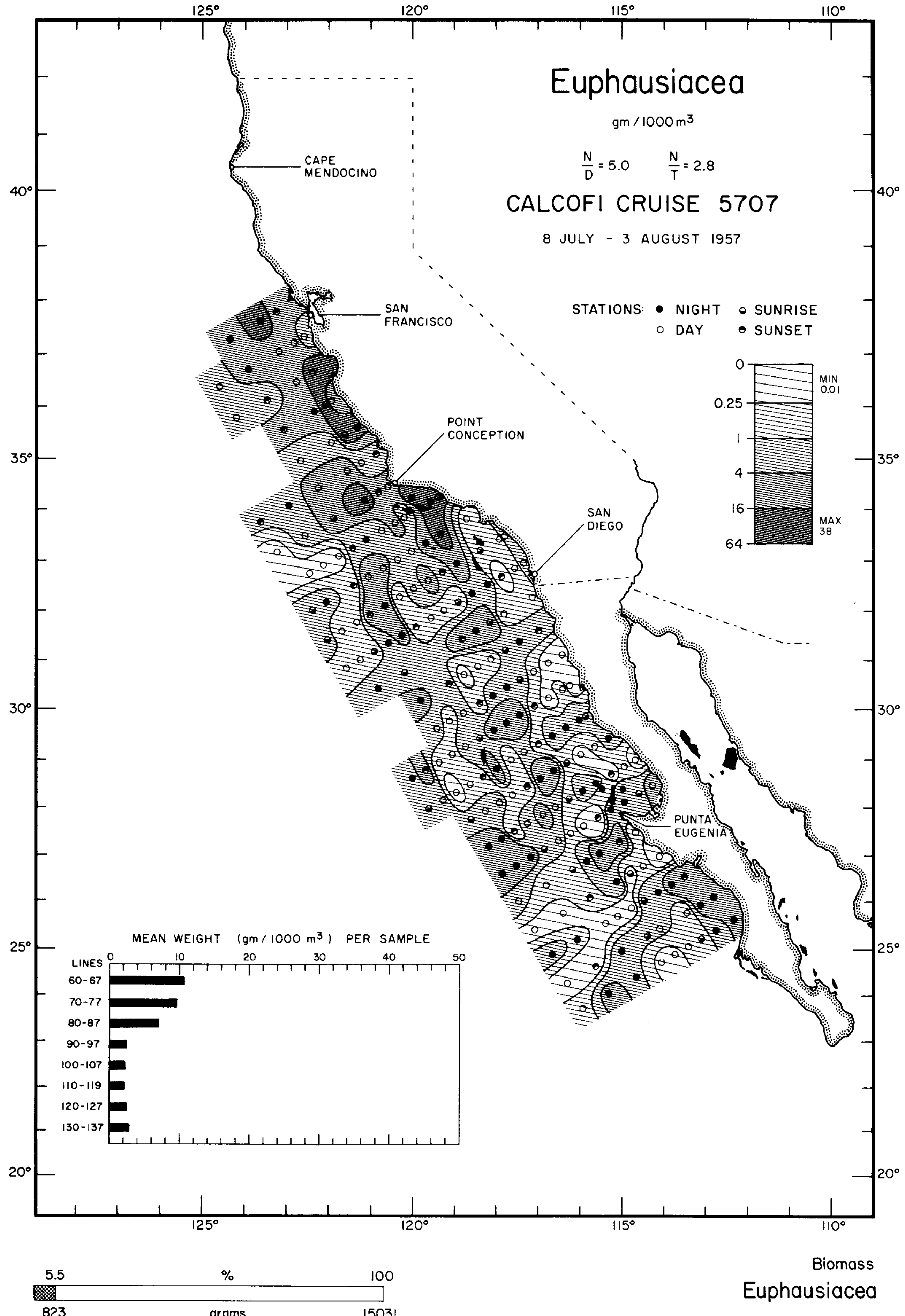
Biomass
Euphausiacea
5607



Biomass

Euphausiacea, adjusted

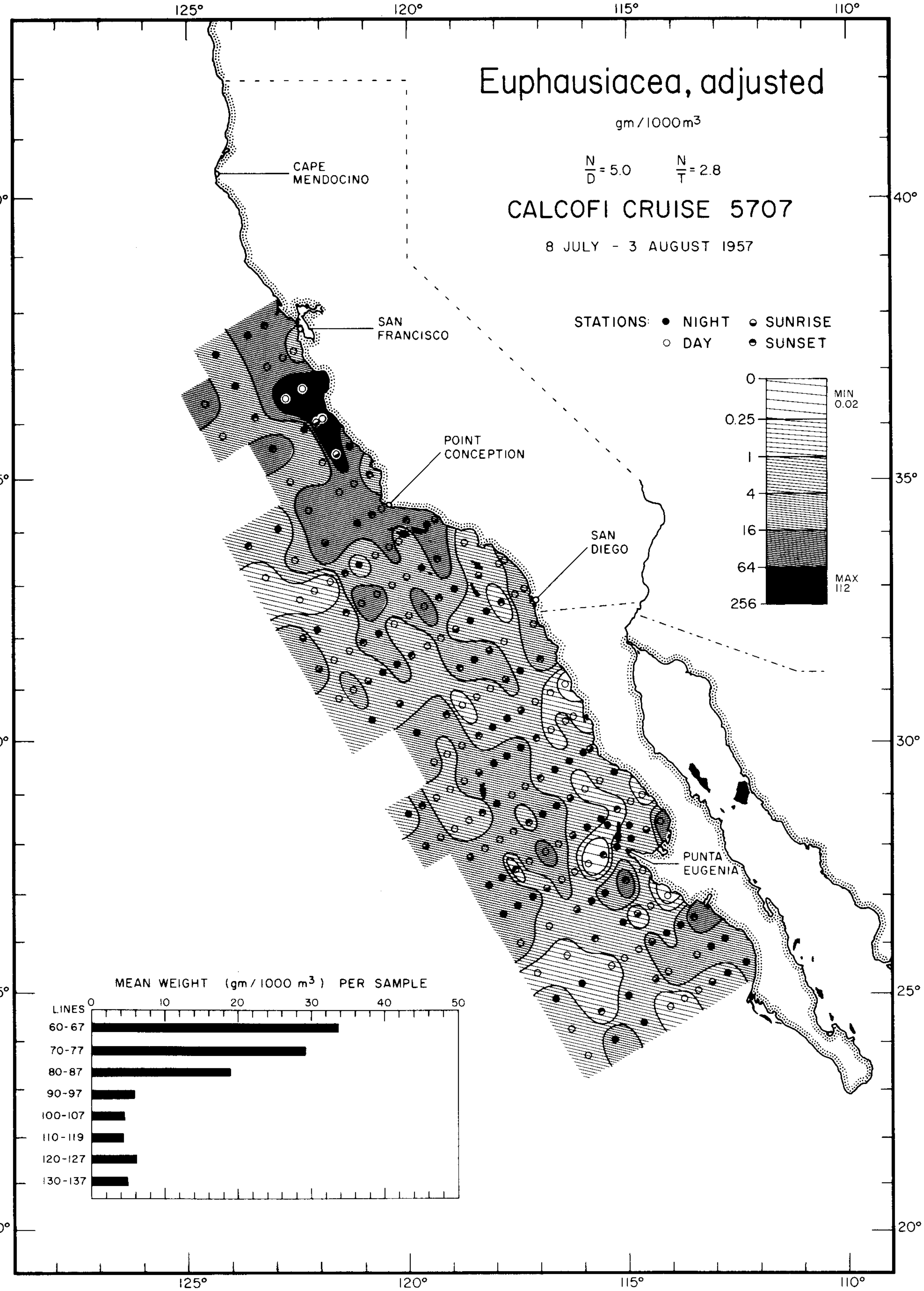
5607



Biomass

Euphausiacea

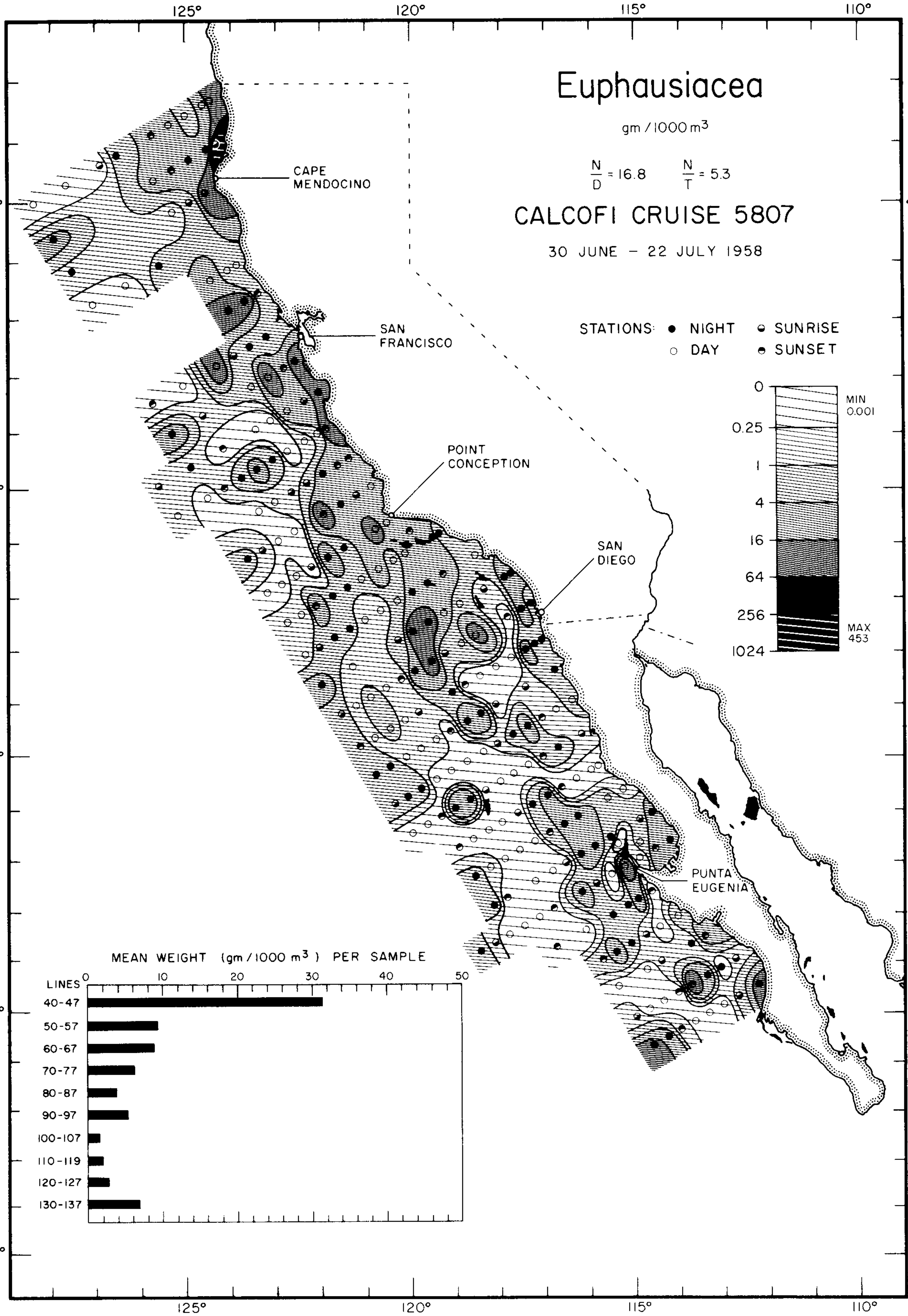
5707

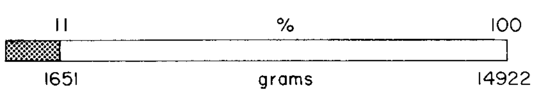


Biomass

Euphausiacea, adjusted

5707

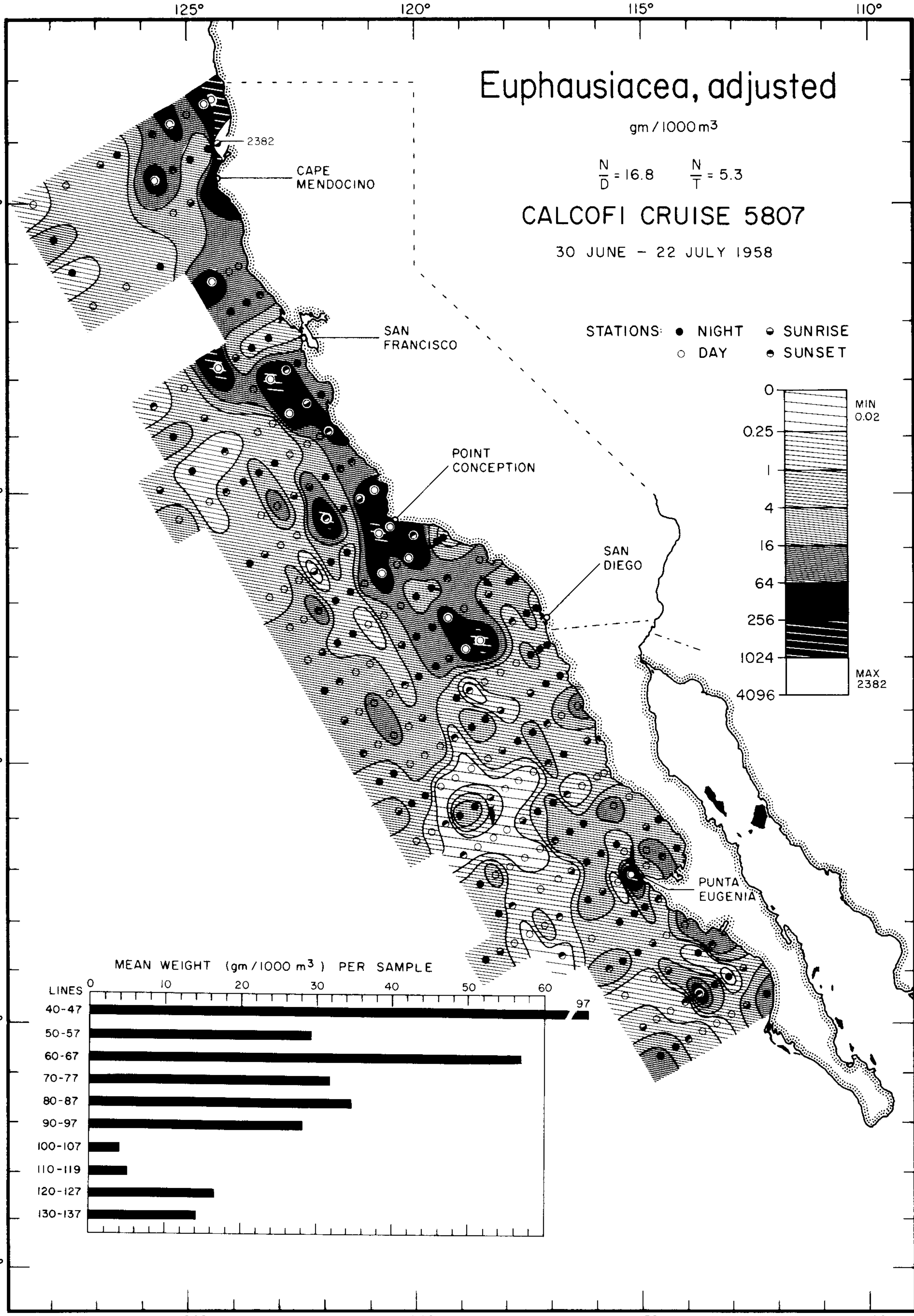




Biomass

Euphausiacea

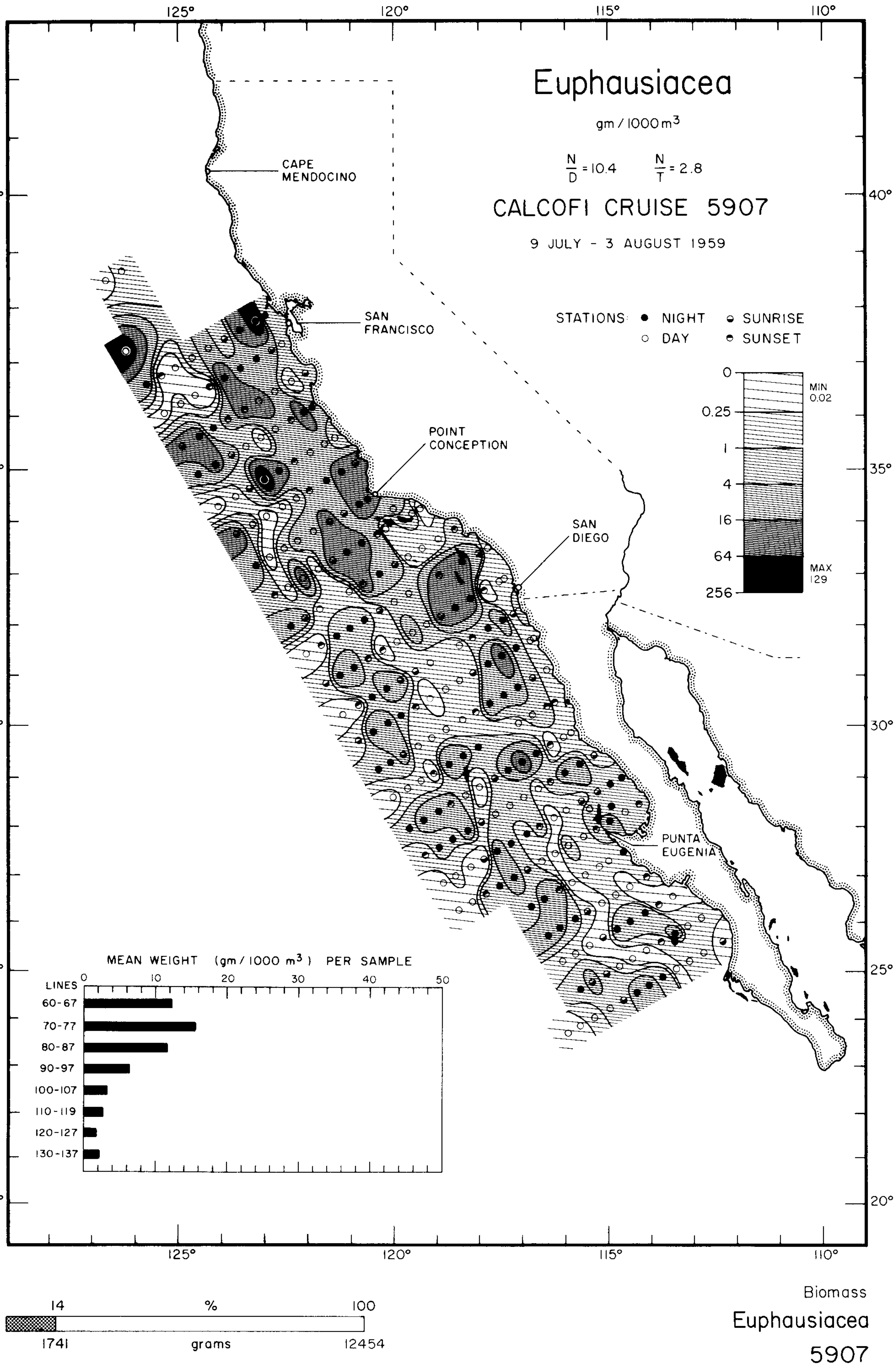
5807



Biomass

Euphausiacea, adjusted

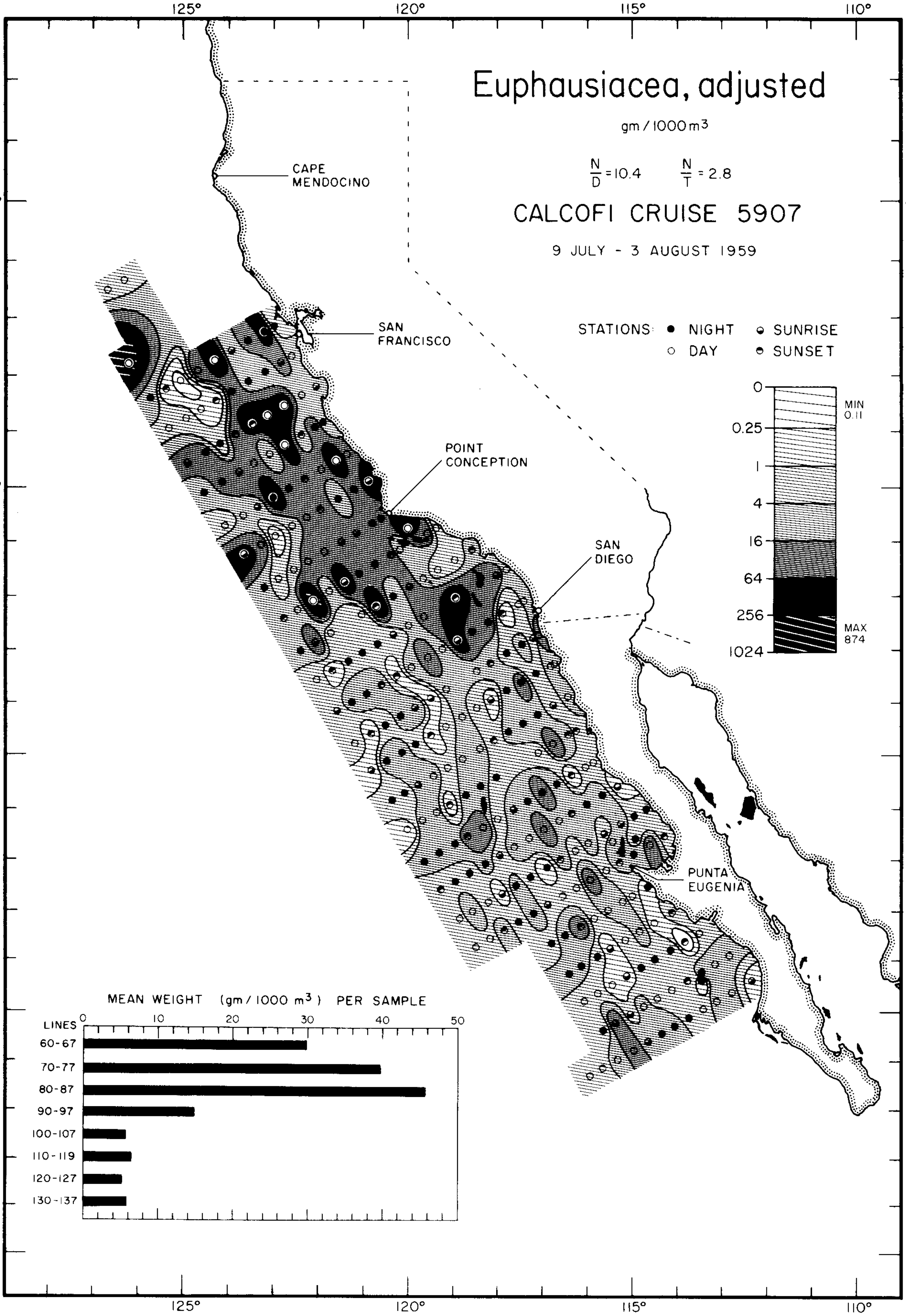
5807



Biomass

Euphausiacea

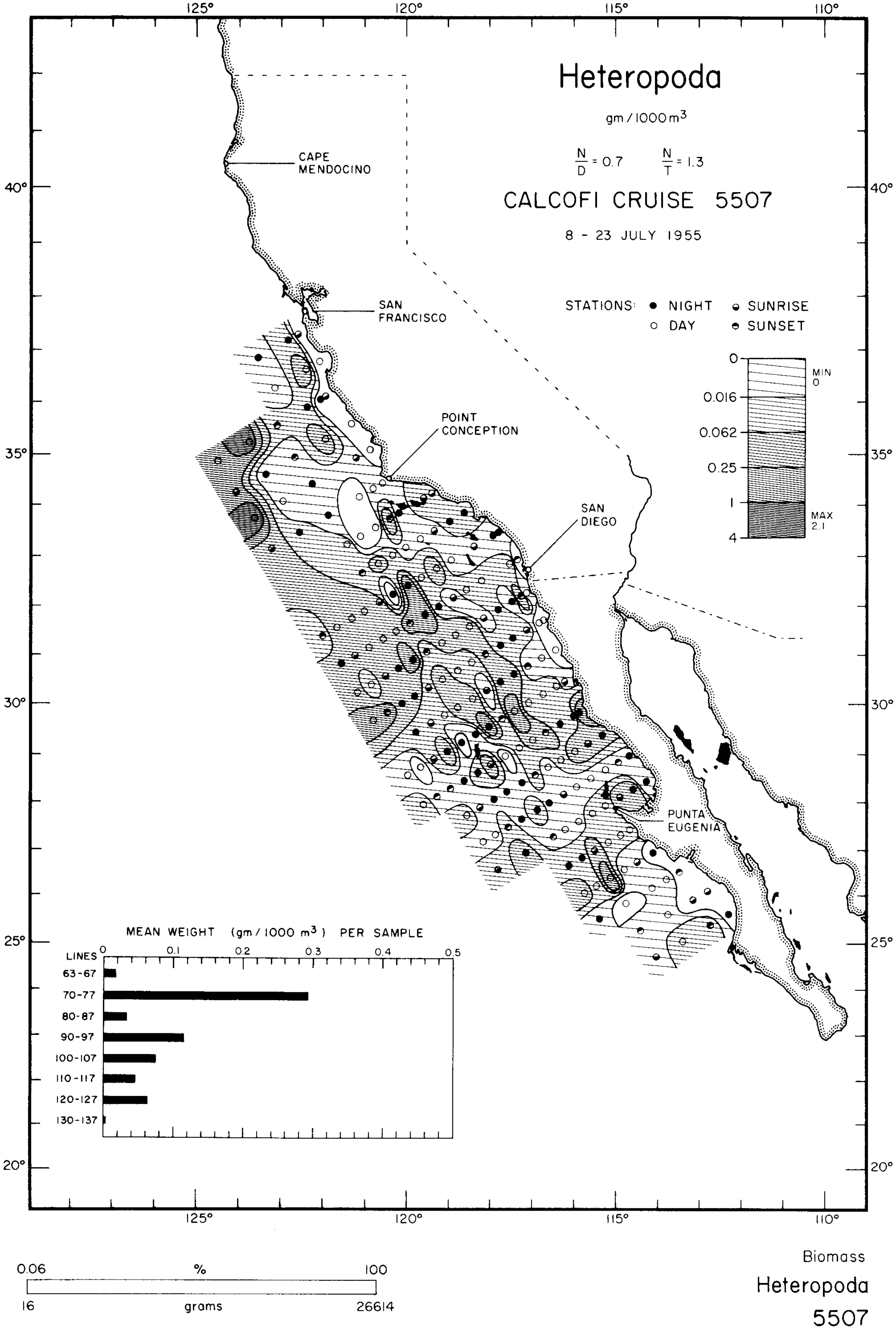
5907



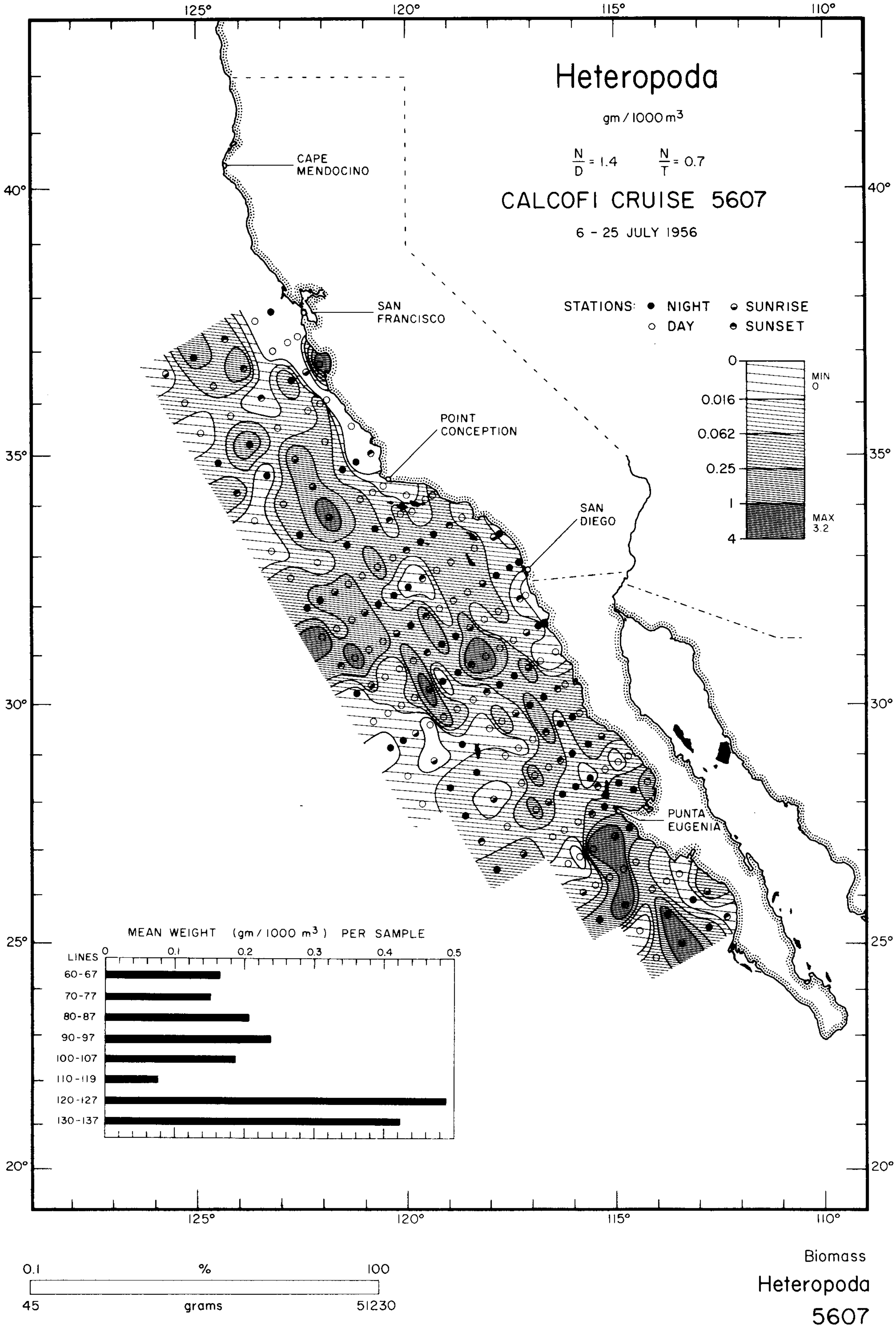
Biomass

Euphausiacea, adjusted

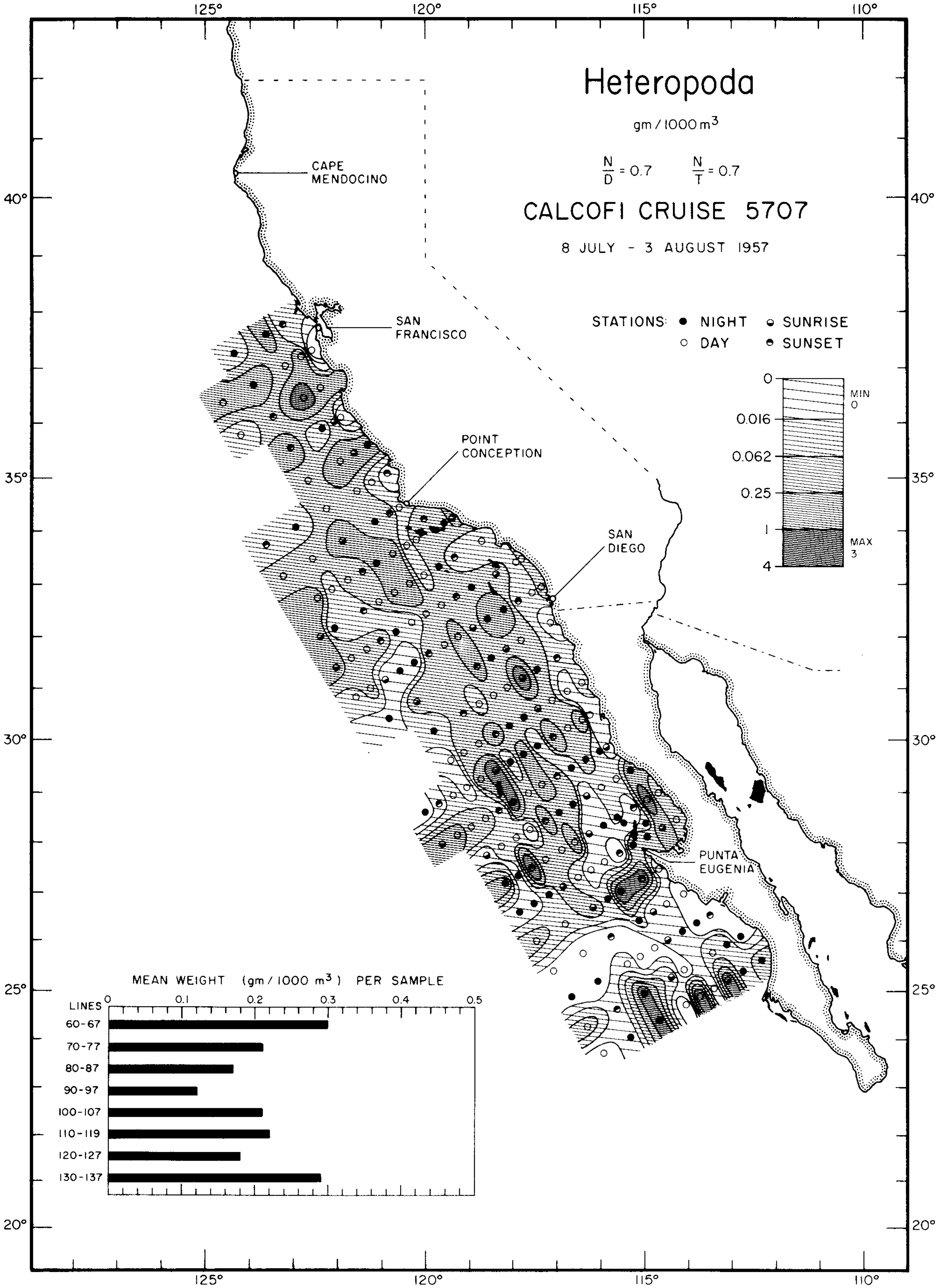
5907

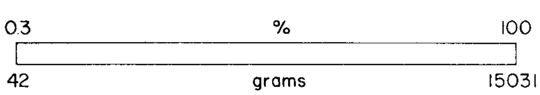


Biomass
Heteropoda
5507



Biomass
Heteropoda
5607

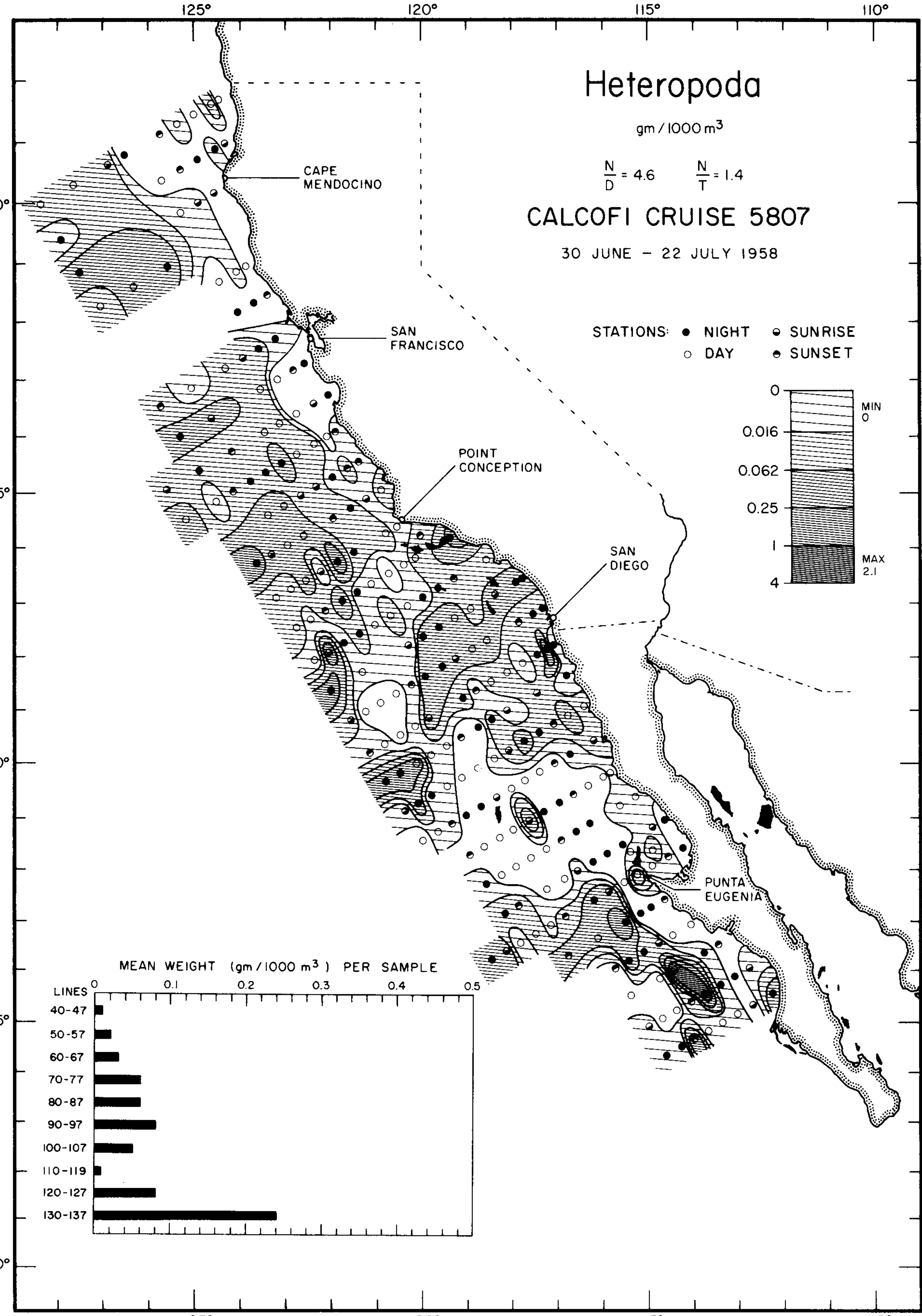




Biomass

Heteropoda

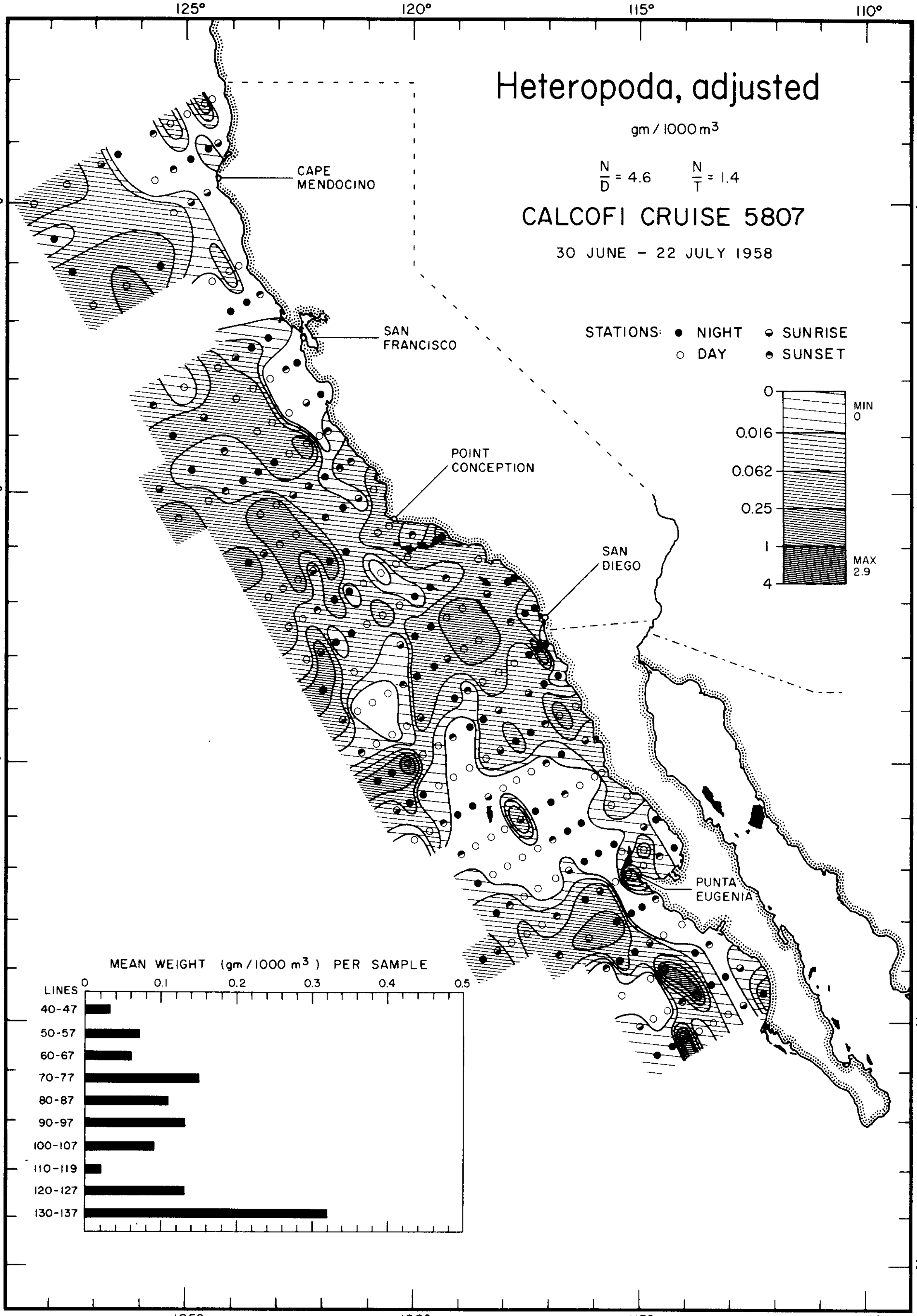
5707



Biomass

Heteropoda

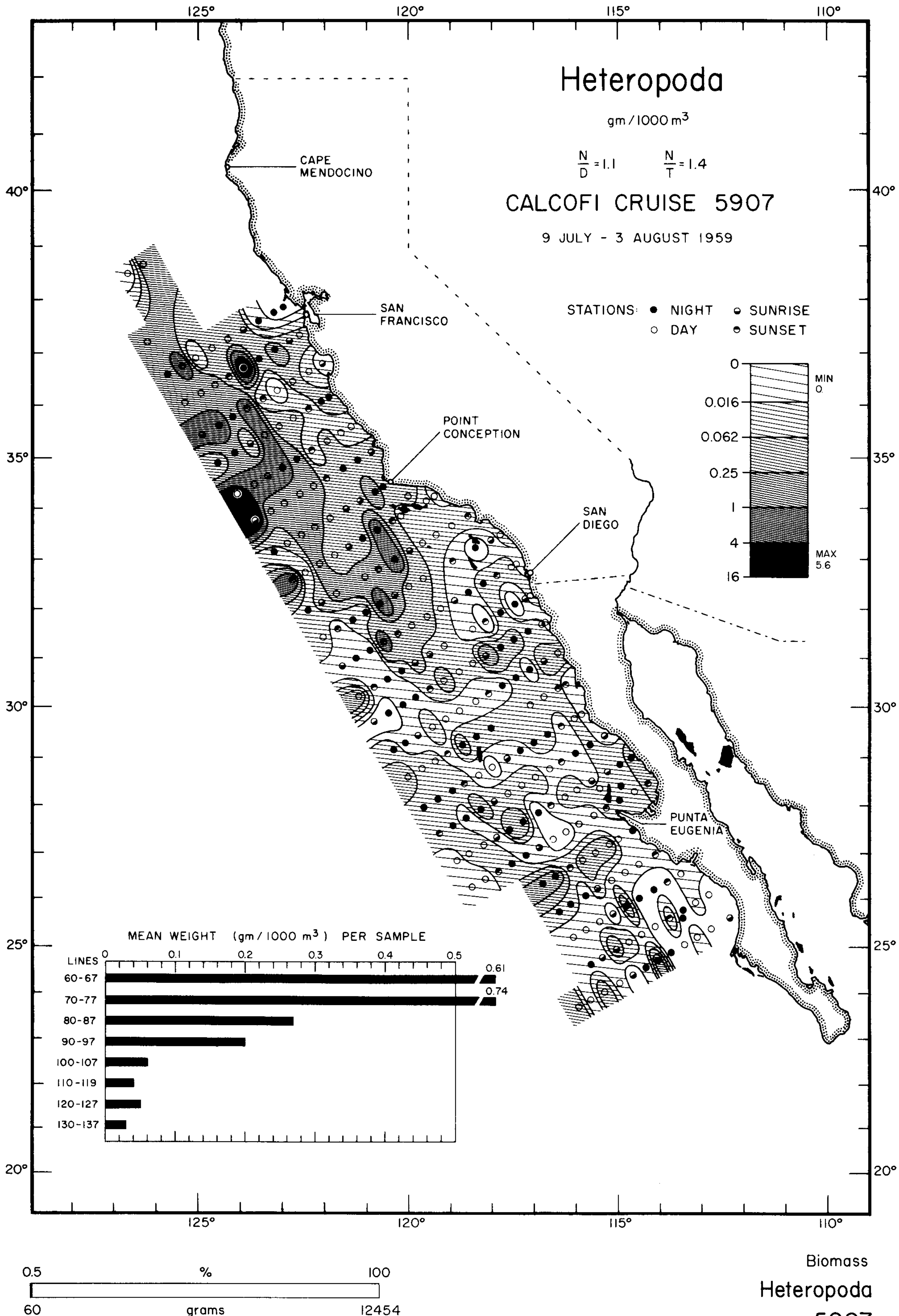
5807



Biomass

Heteropoda, adjusted

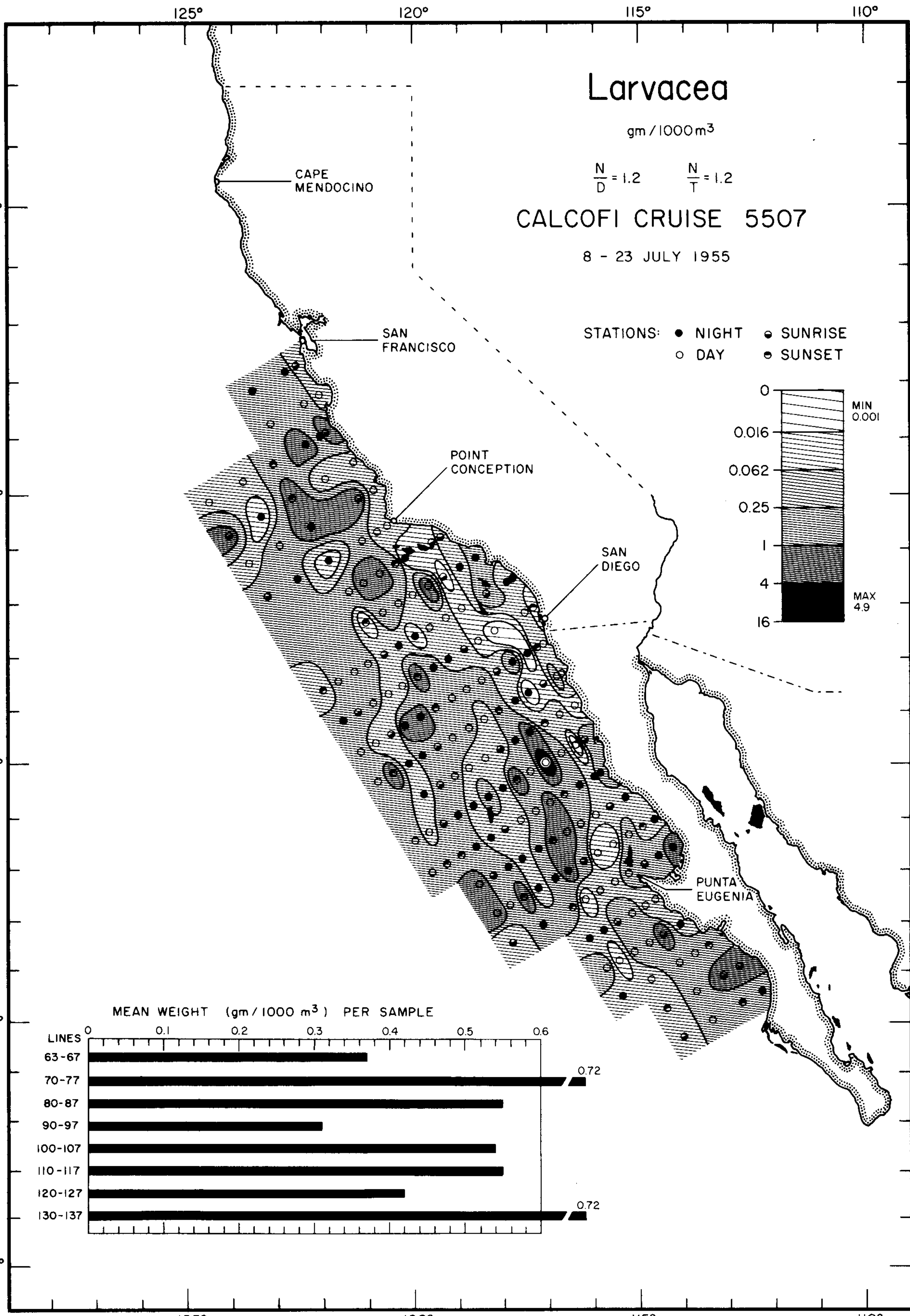
5807



Biomass

Heteropoda

5907



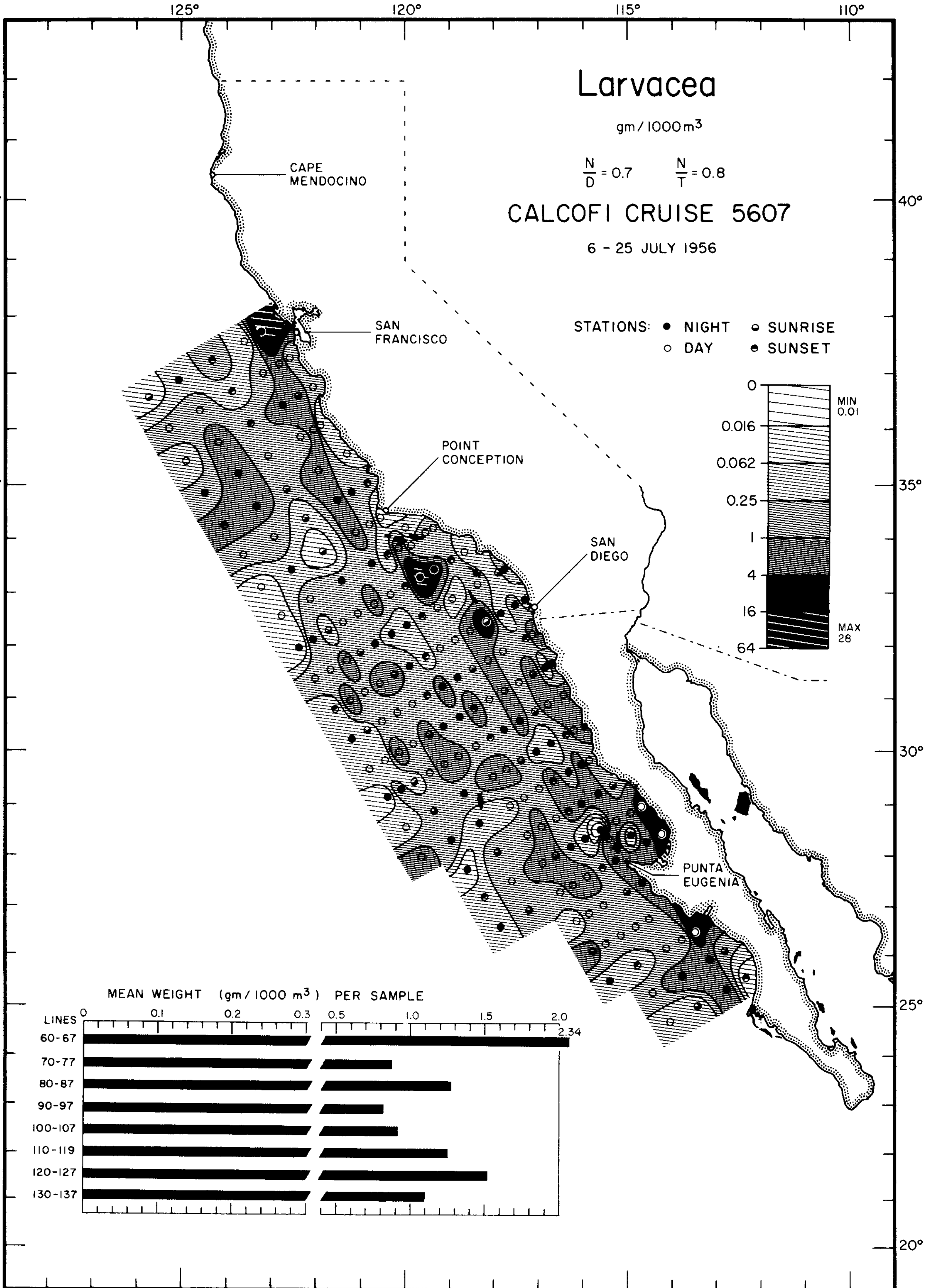
0.4 % 100

96 grams 26614

Biomass

Larvacea

5507



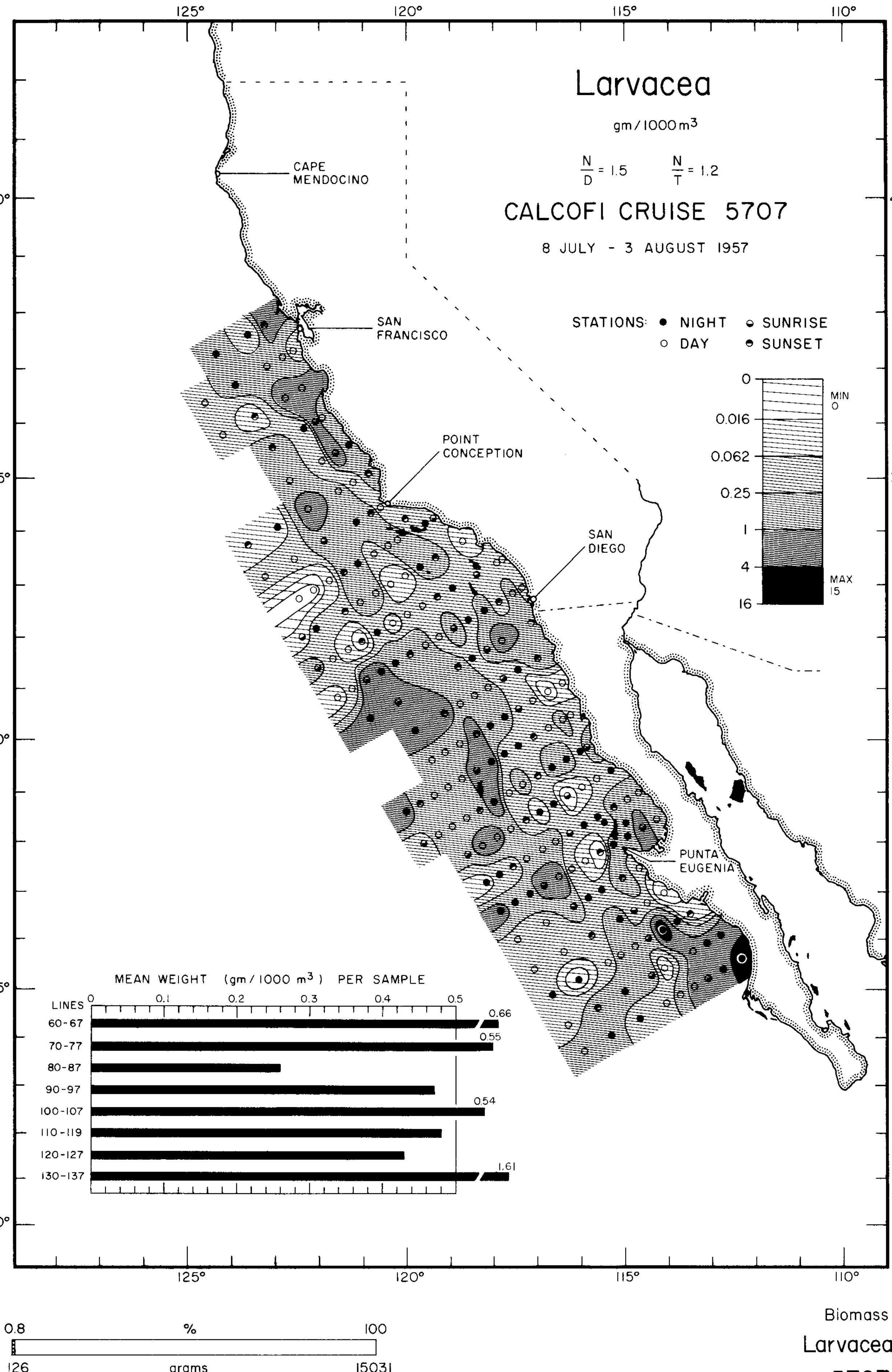
0.5 % 100

240 grams 51230

Biomass

Larvacea

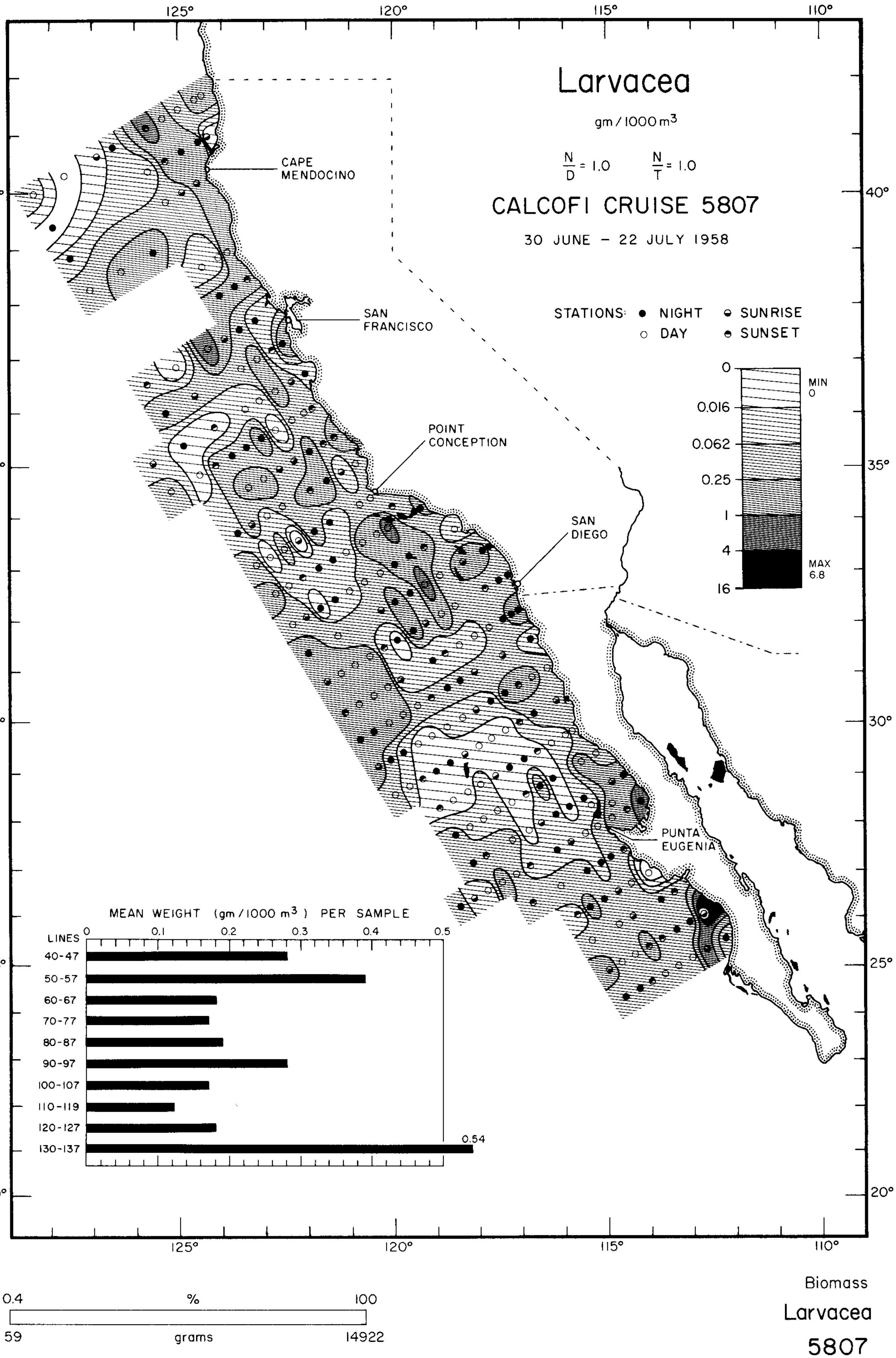
5607



Biomass

Larvacea

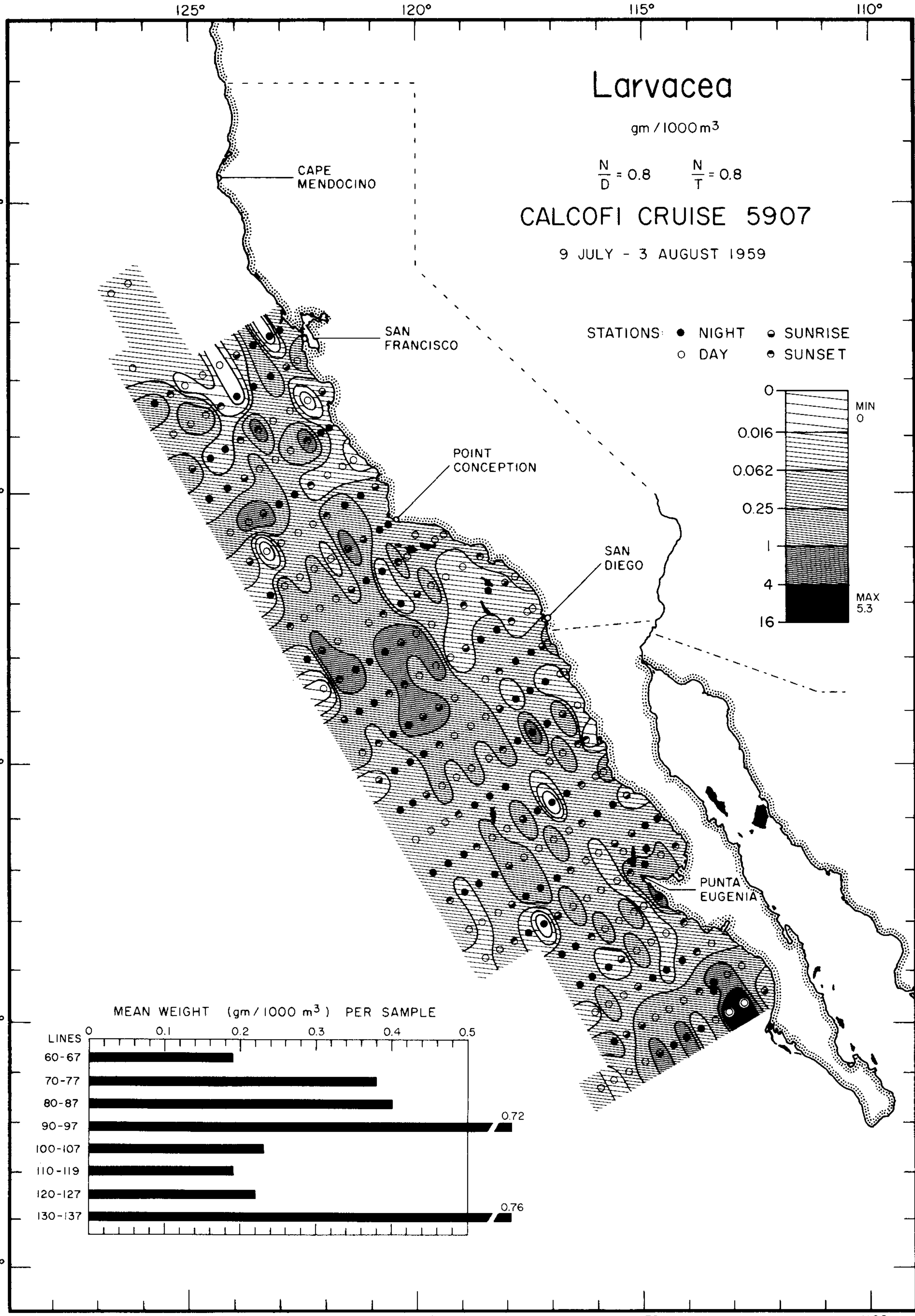
5707



Biomass

Larvacea

5807



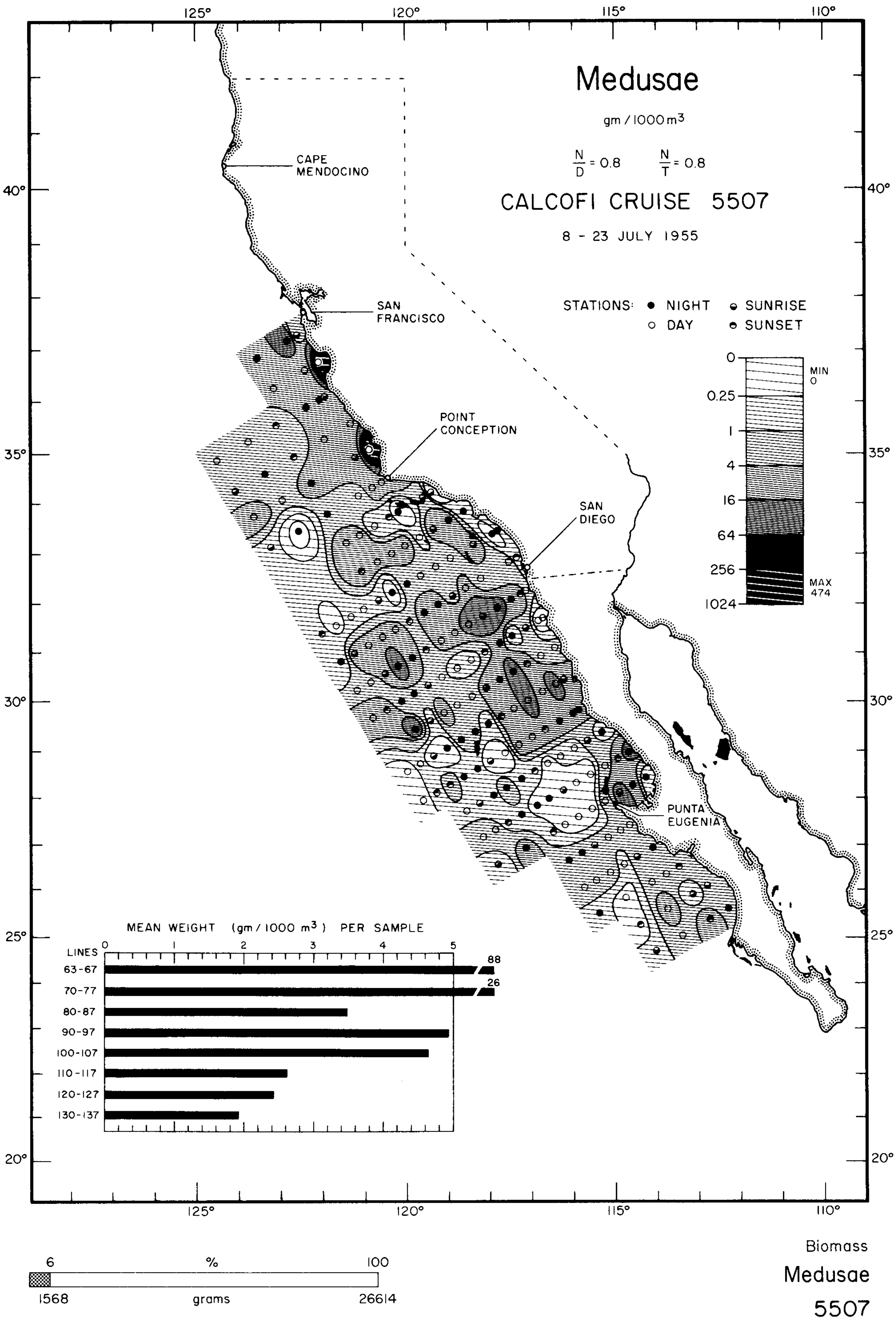
0.8 % 100

103 grams 12454

Biomass

Larvacea

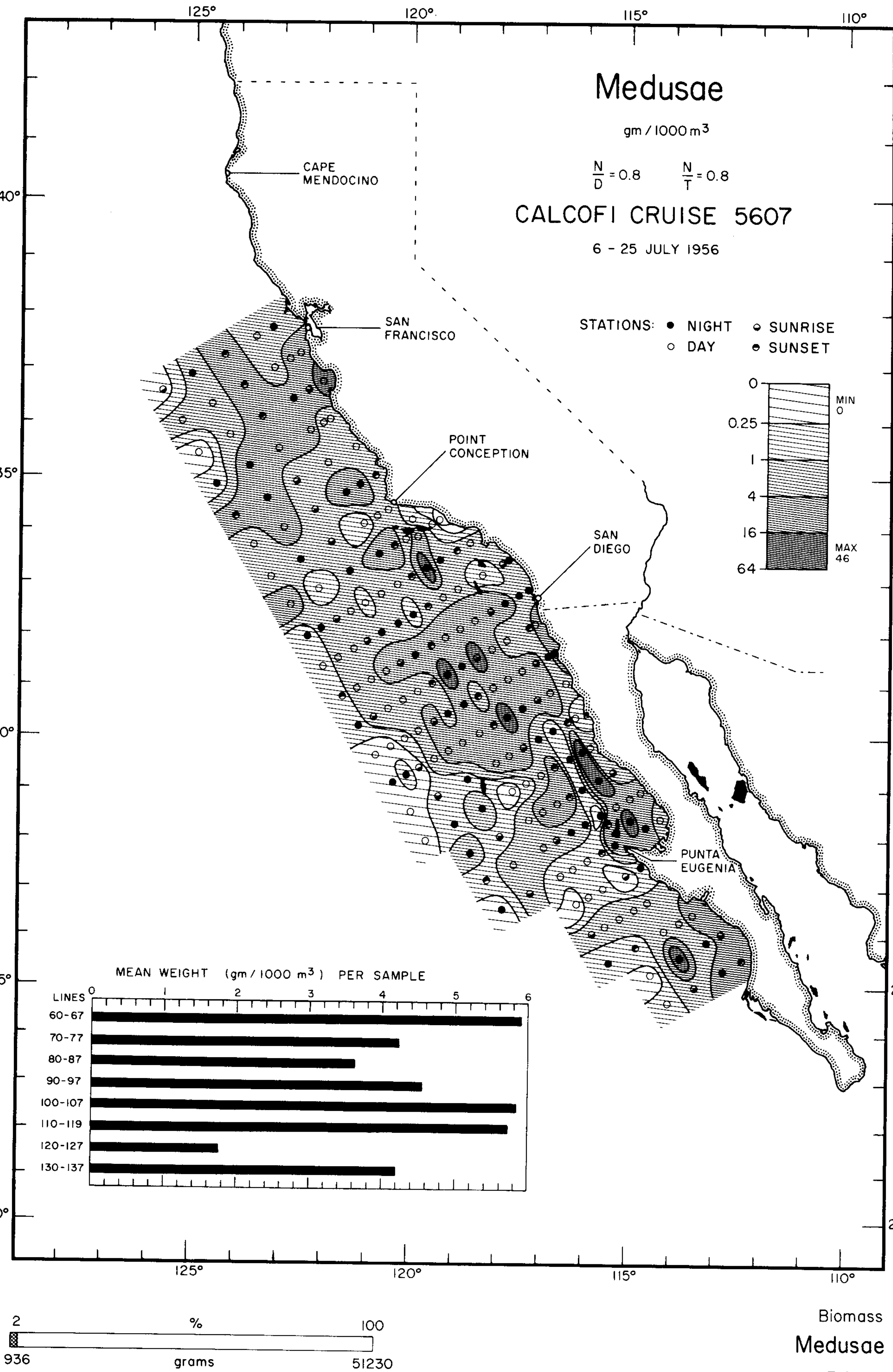
5907



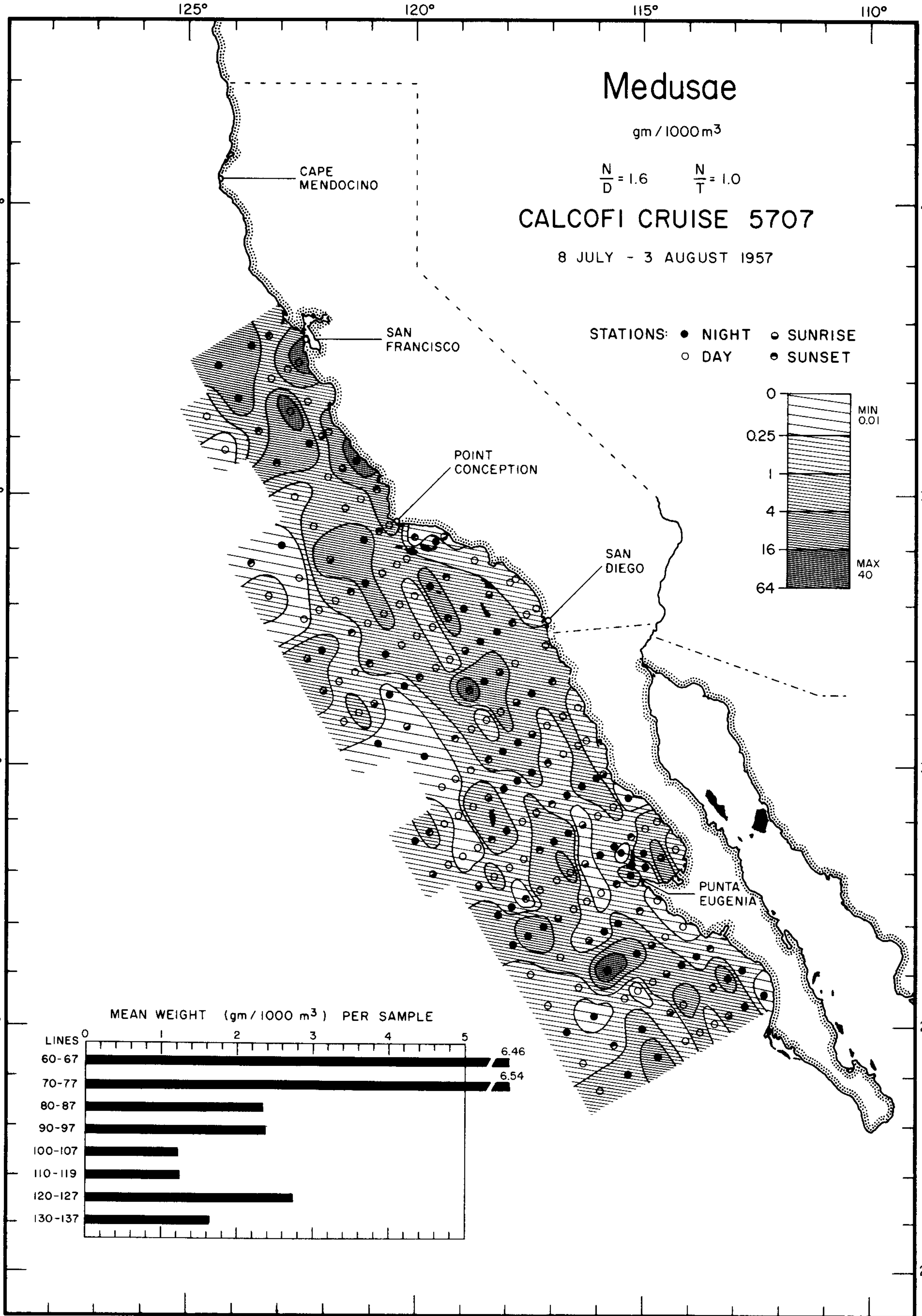
Biomass

Medusae

5507



Biomass
Medusae
5607



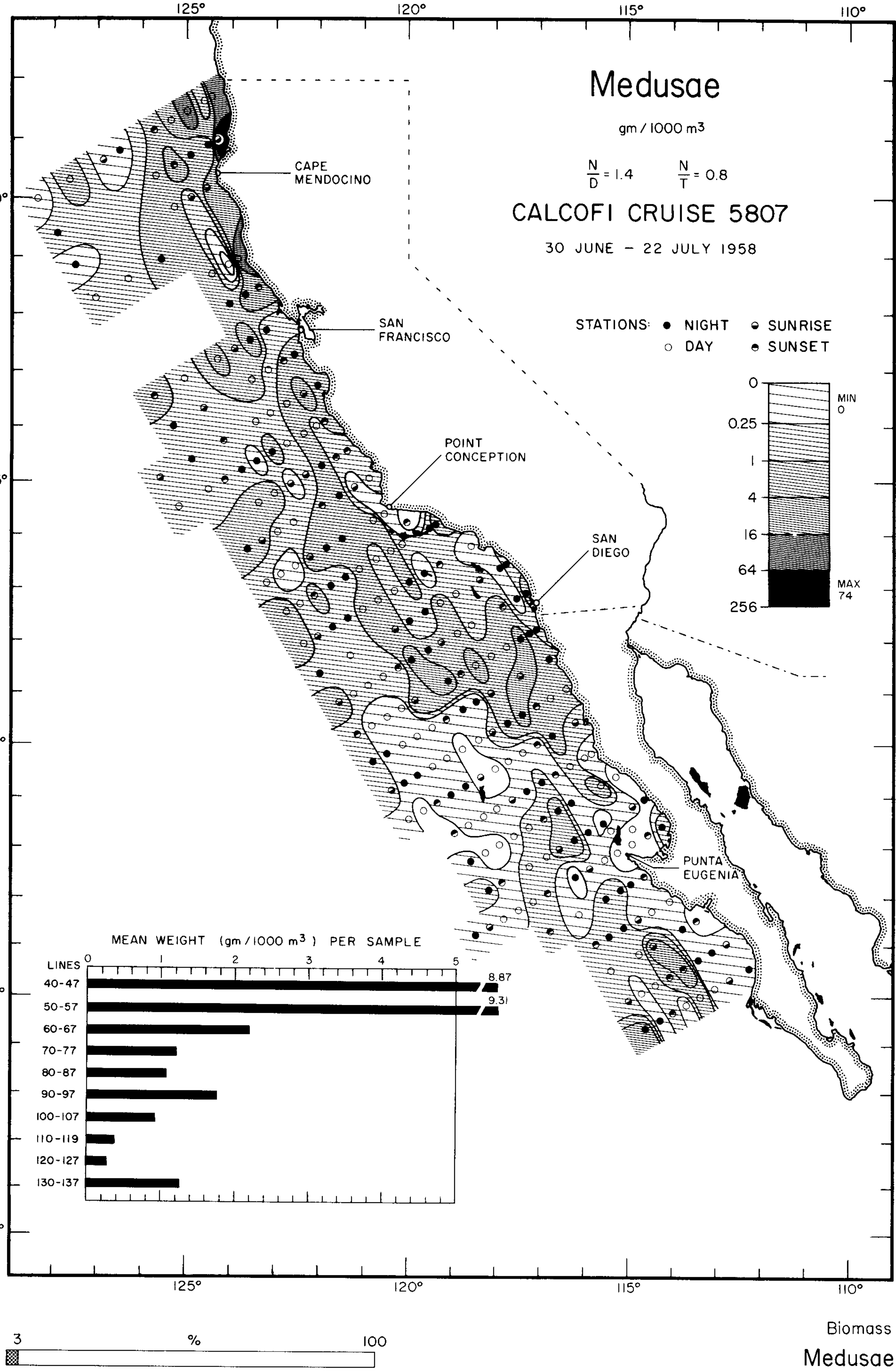
3.4 % 100

514 grams 15031

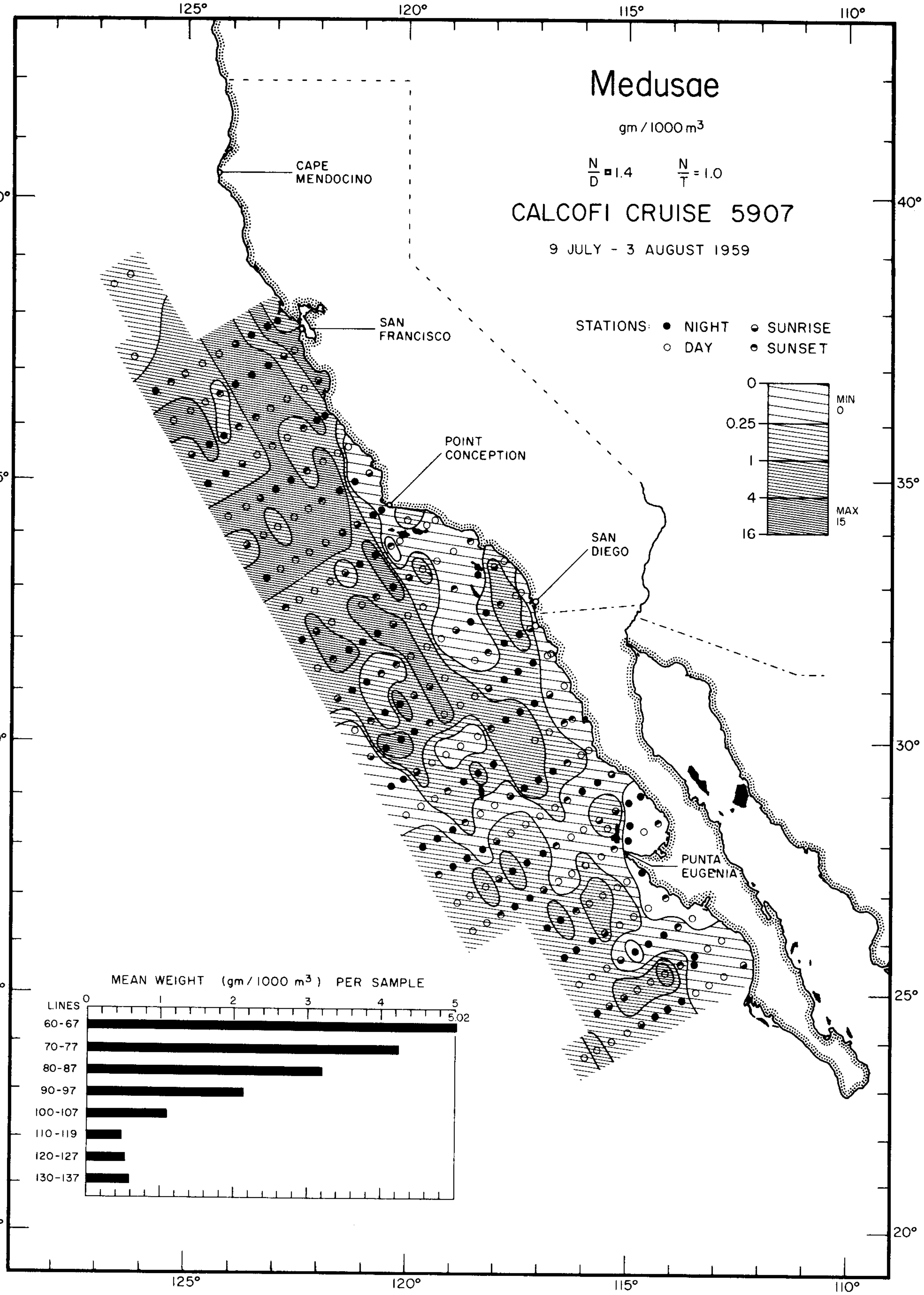
Biomass

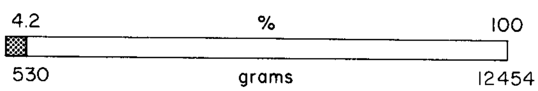
Medusae

5707

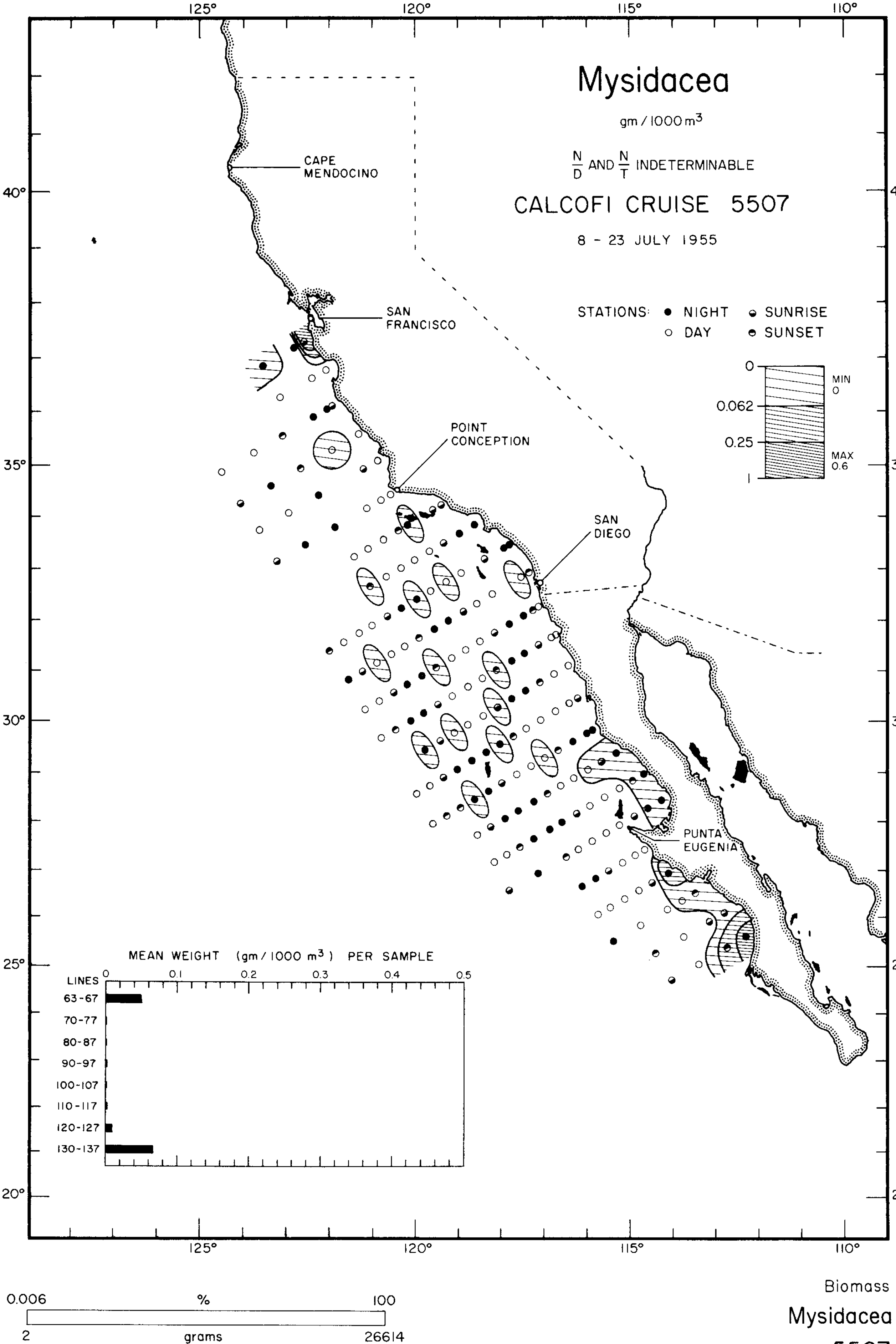


Biomass
Medusae
5807

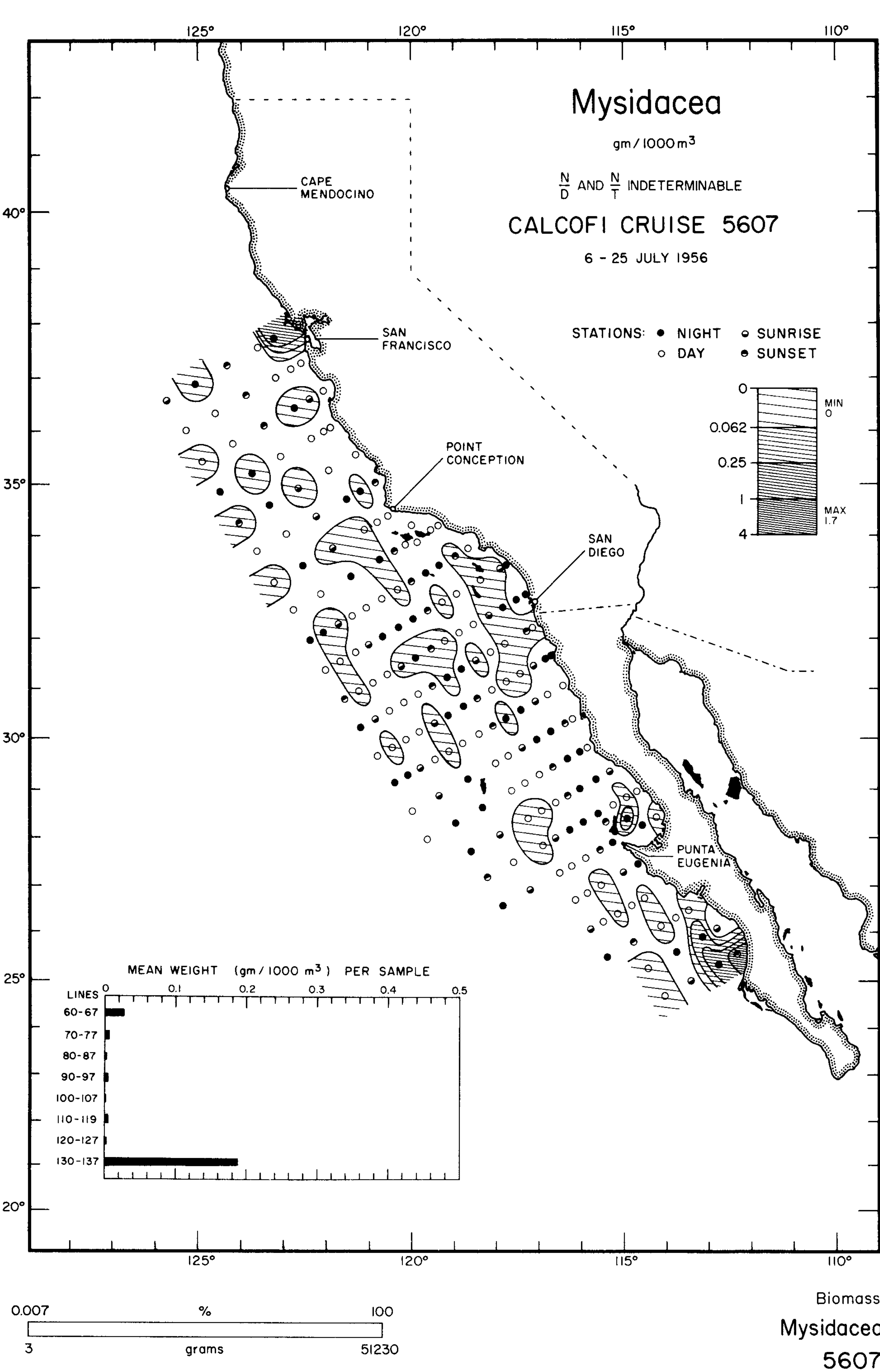




Biomass
Medusae
5907



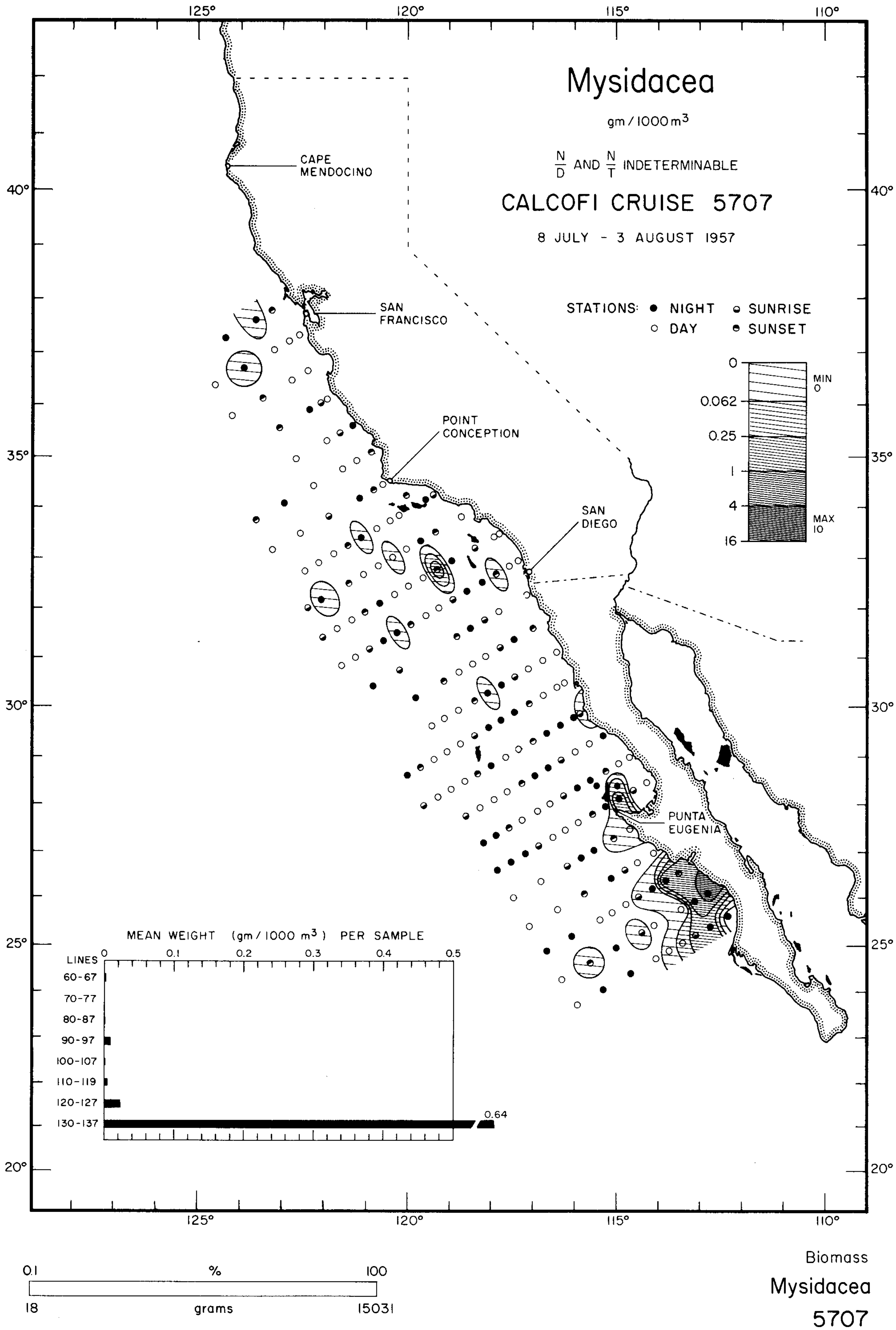
Biomass
Mysidacea
5507



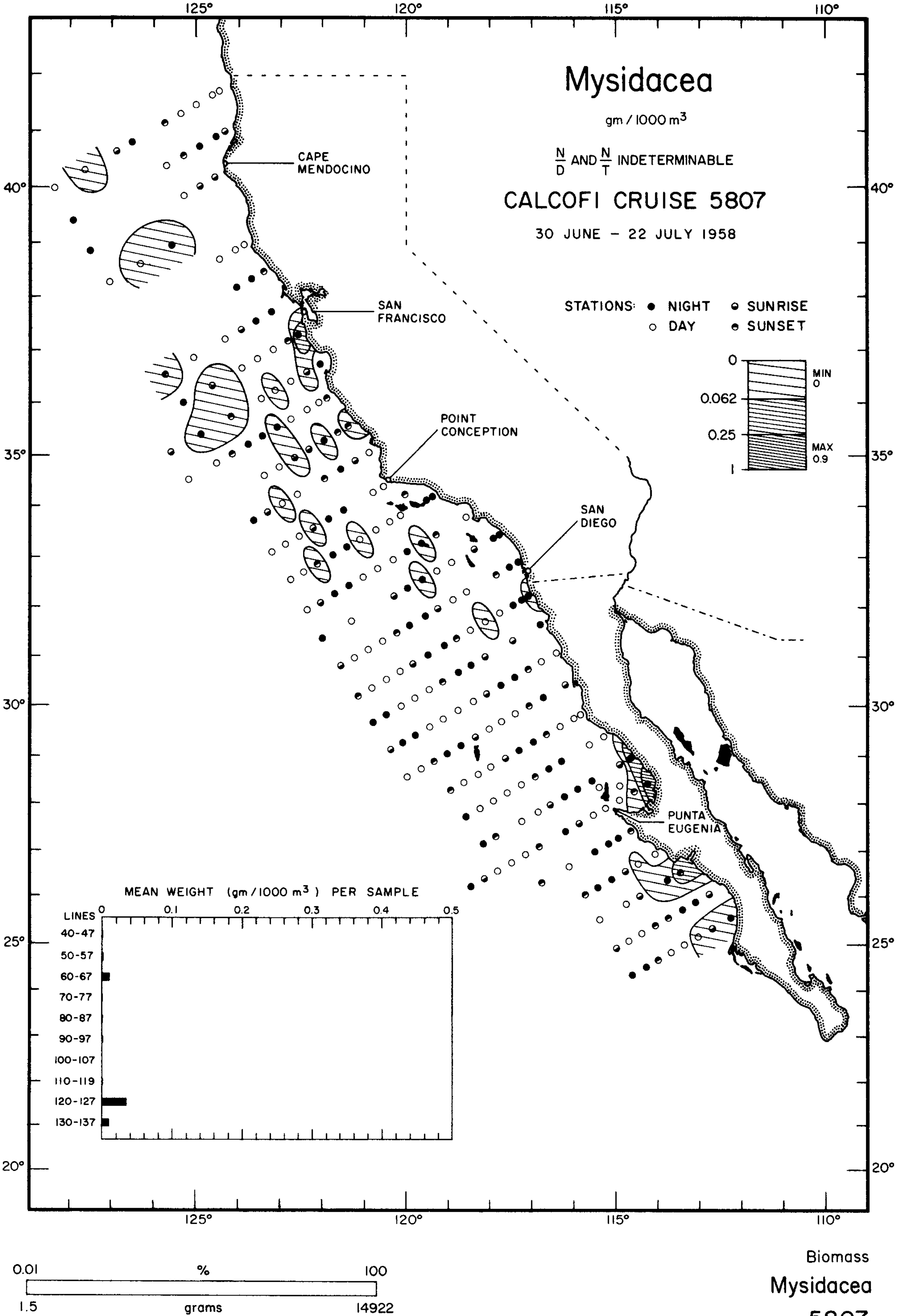
Biomass

Mysidacea

5607



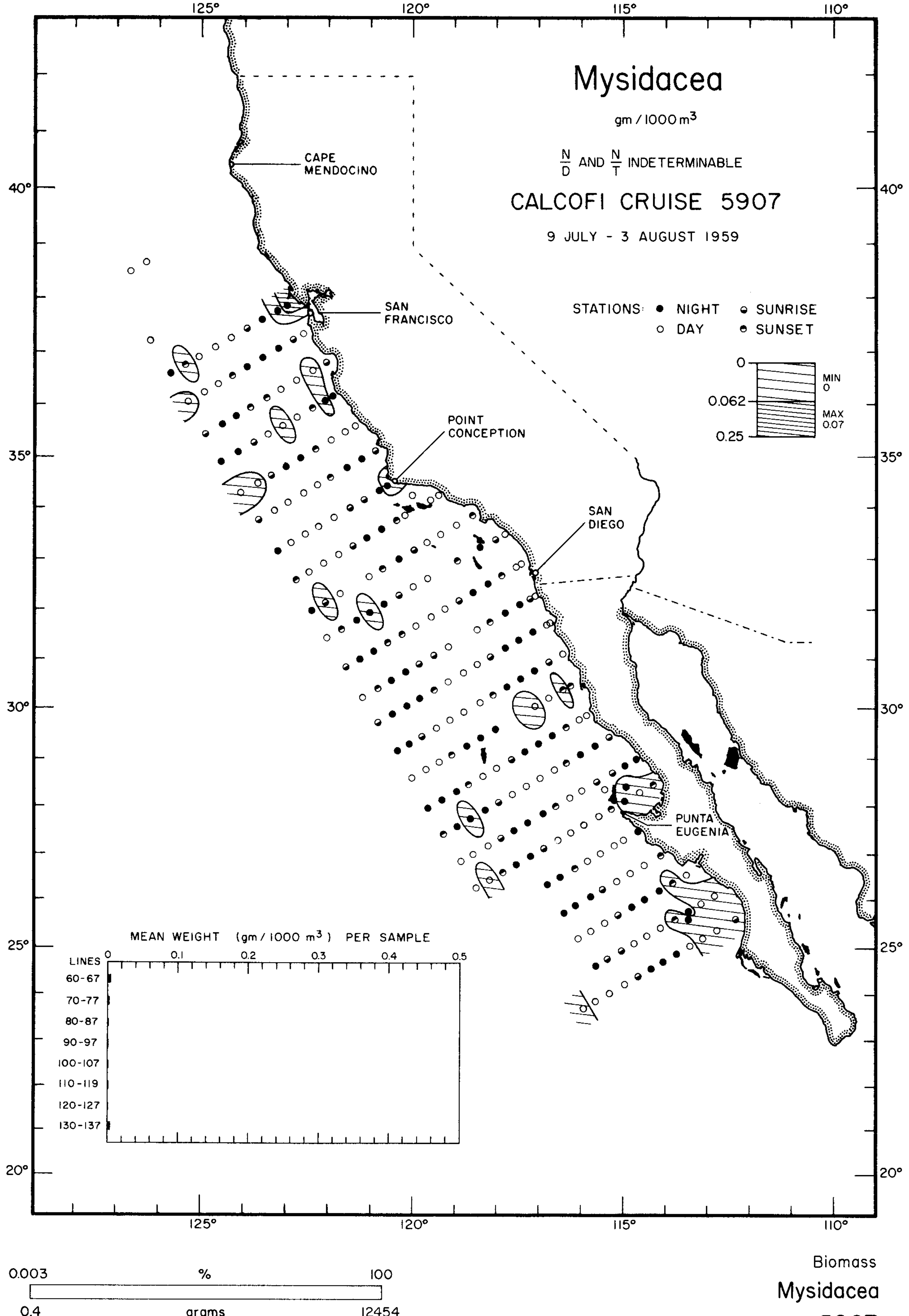
Biomass
Mysidacea
5707



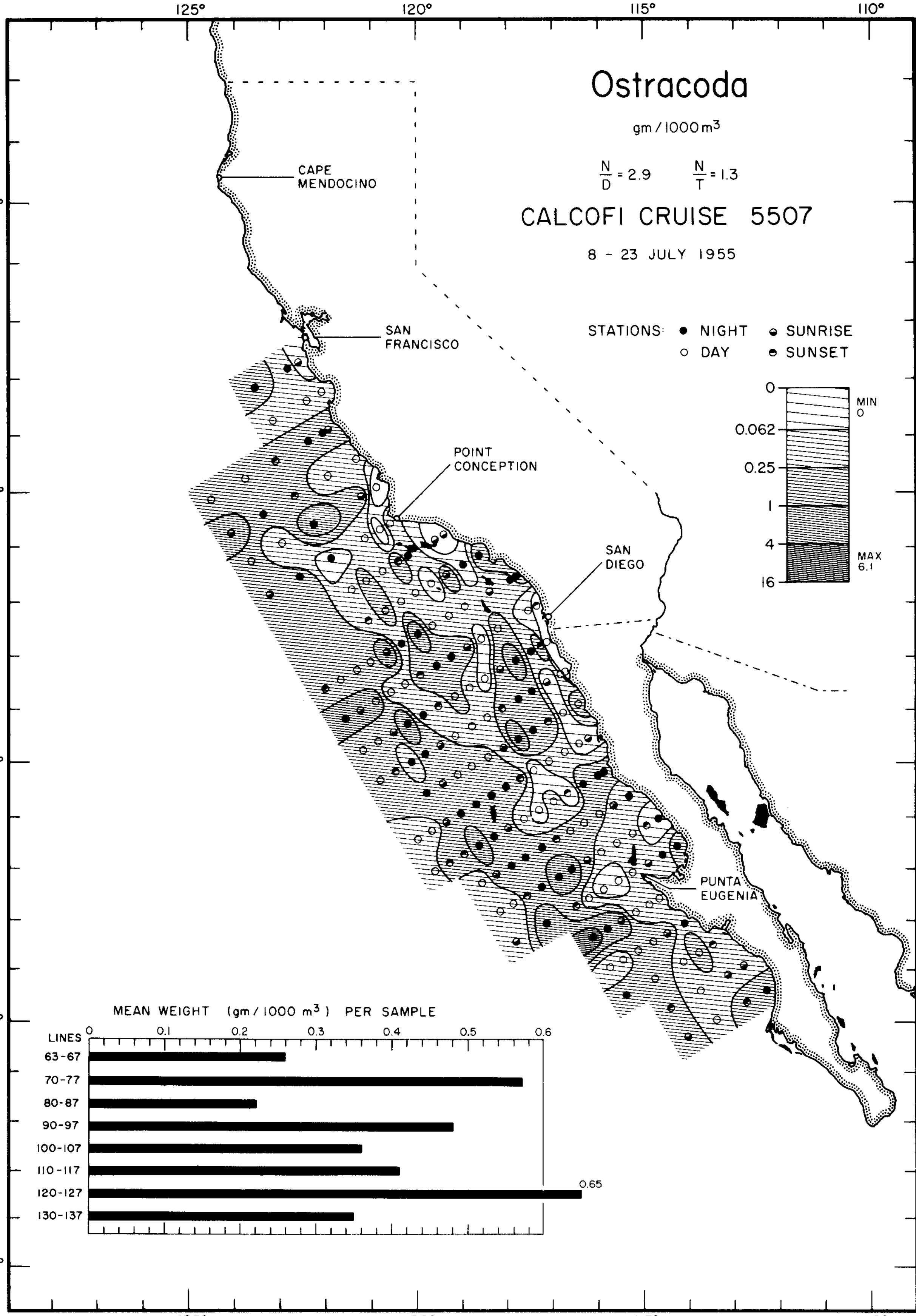
Biomass

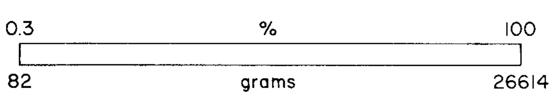
Mysidacea

5807

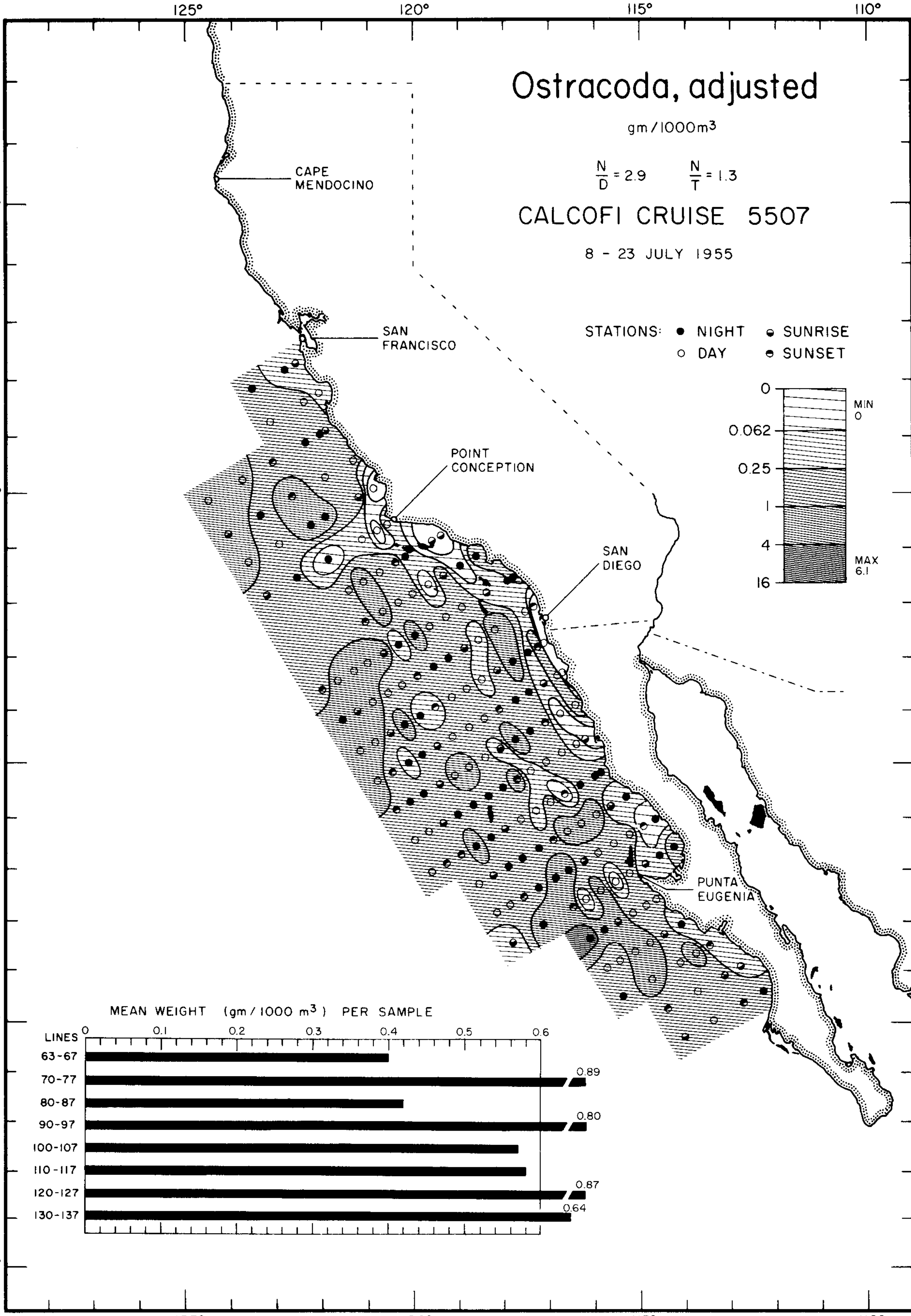


Biomass
Mysidacea
5907





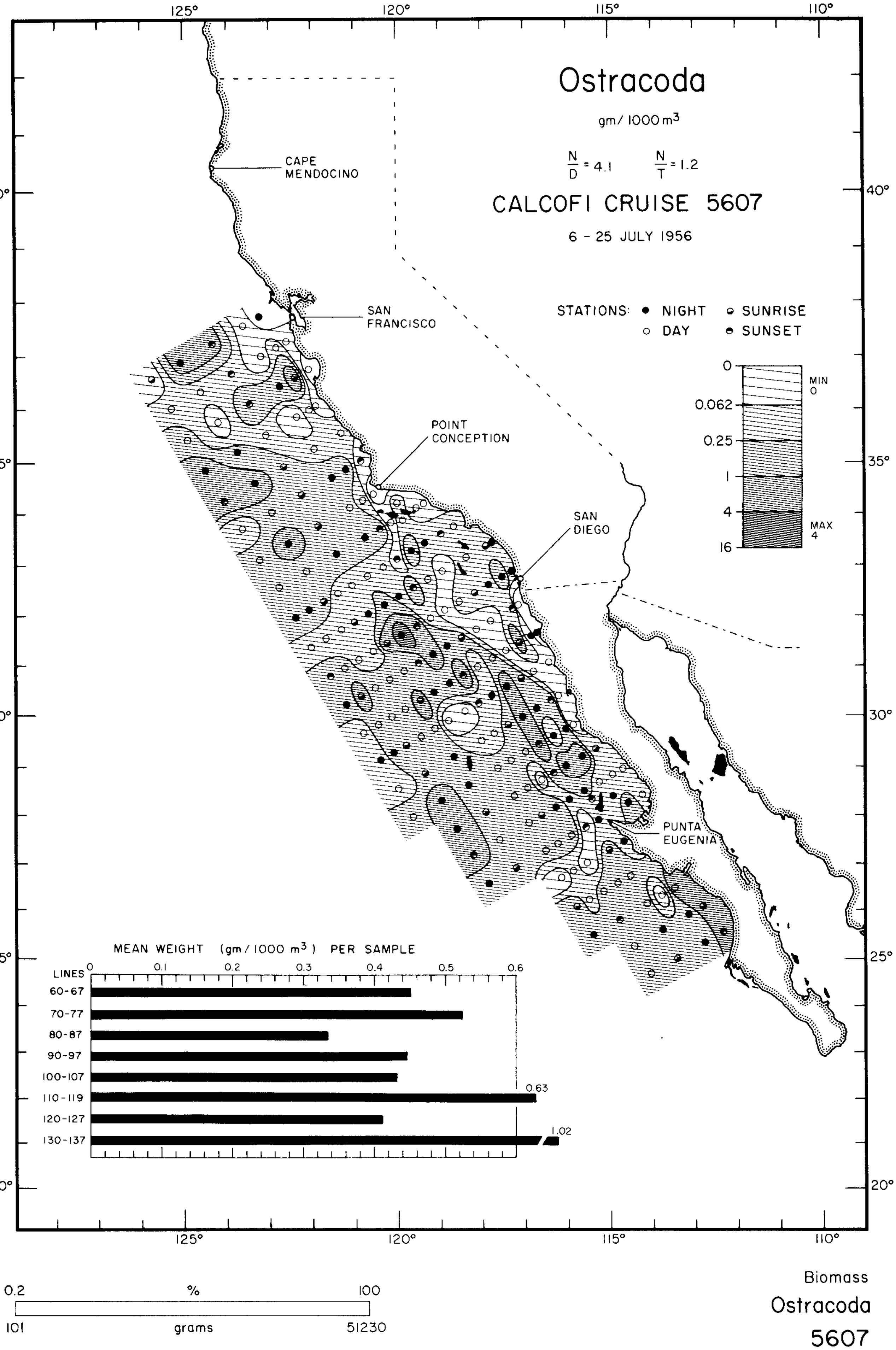
Biomass
Ostracoda
5507



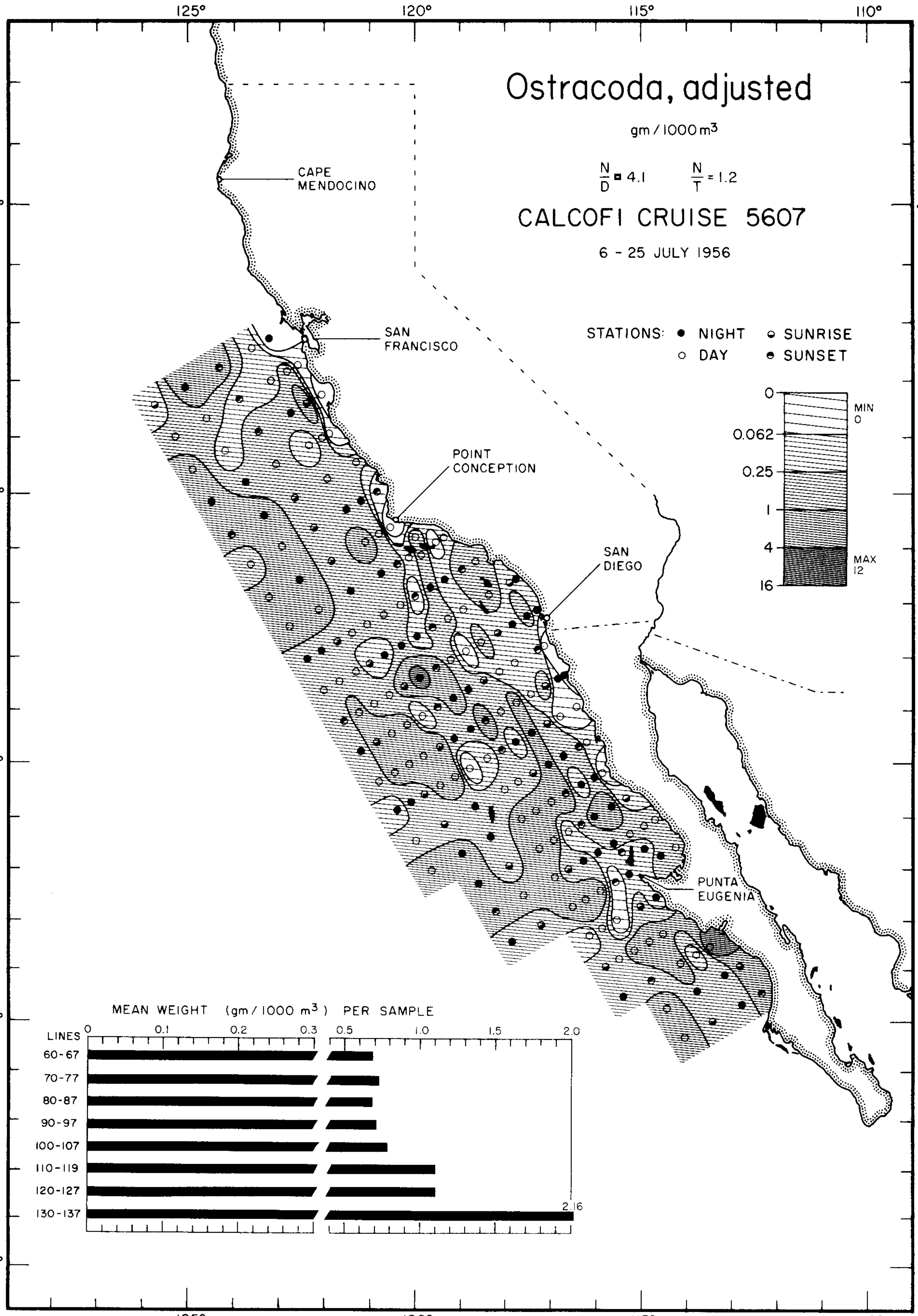
Biomass

Ostracoda, adjusted

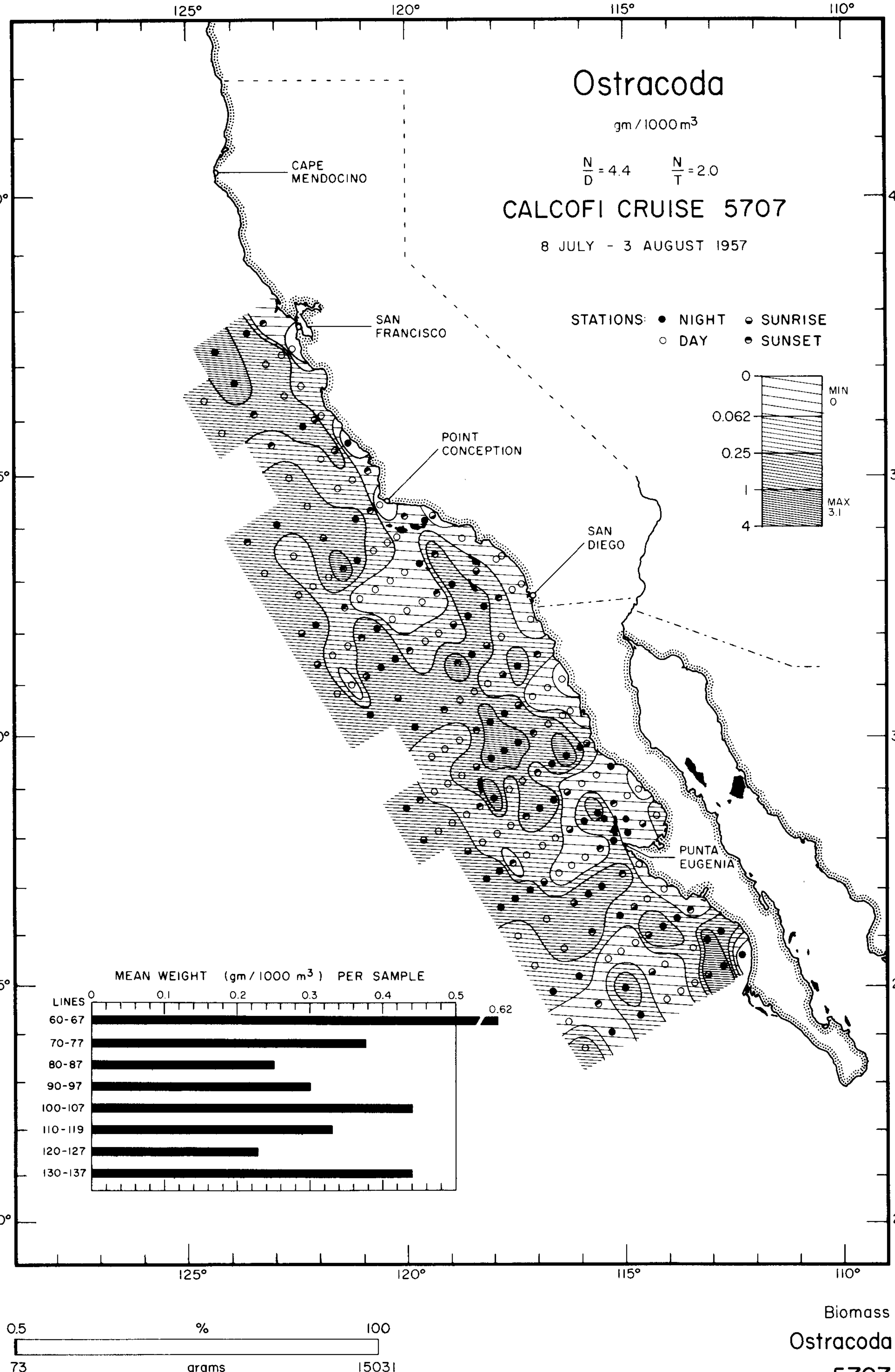
5507



Biomass
Ostracoda
5607



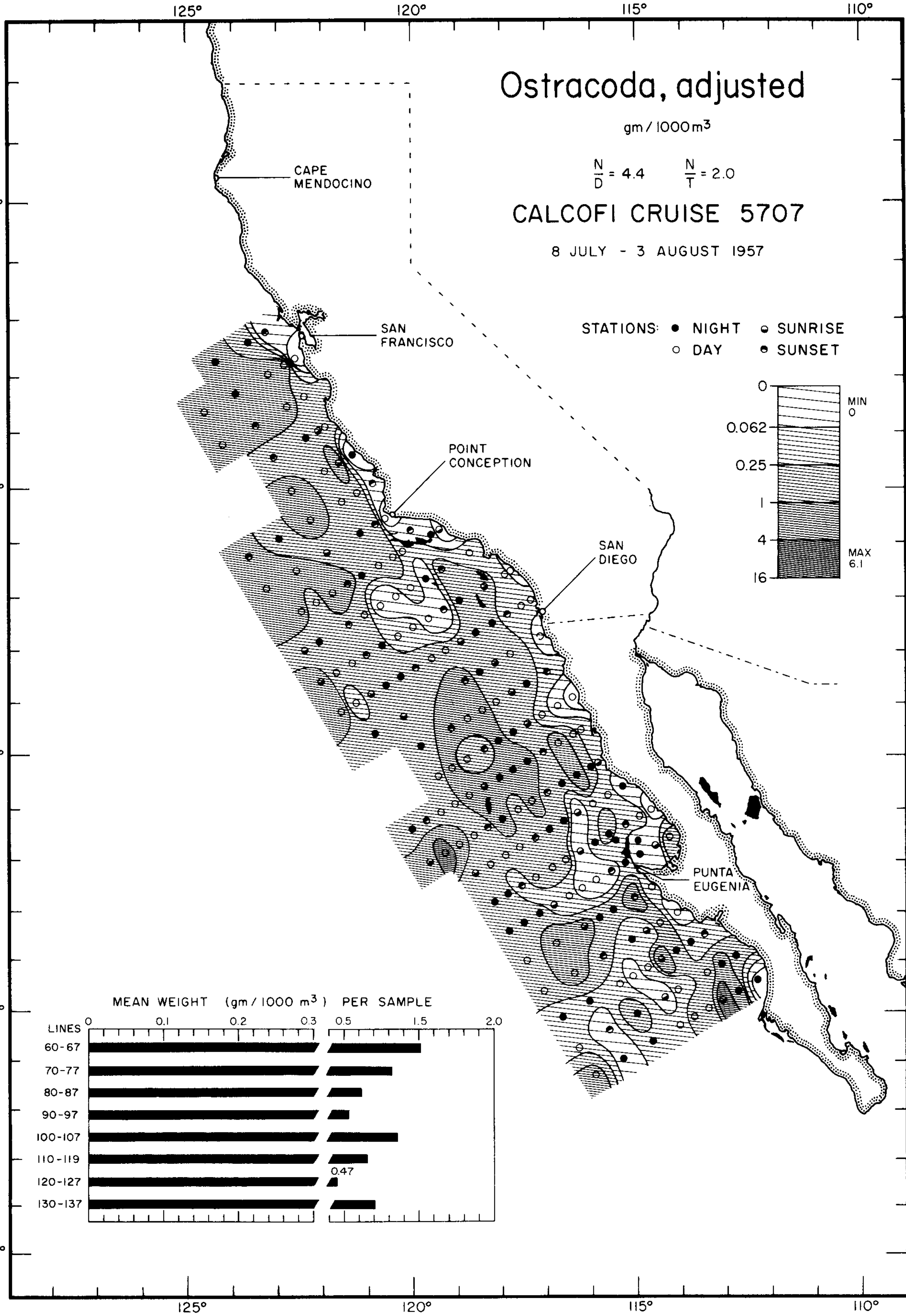
Ostracoda, adjusted
gm / 1000 m3
N/D = 4.1 N/T = 1.2
CALCOFI CRUISE 5607
6 - 25 JULY 1956
STATIONS: NIGHT SUNRISE DAY SUNSET
0
0.062
0.25
1
4
16
MIN 0
MAX 12
CAPE MENDOCINO
SAN FRANCISCO
POINT CONCEPTION
SAN DIEGO
PUNTA EUGENIA
125° 120° 115° 110°
40° 35° 30° 25° 20°
MEAN WEIGHT (gm / 1000 m3) PER SAMPLE
LINES
0 0.1 0.2 0.3 0.5 1.0 1.5 2.0
60-67
70-77
80-87
90-97
100-107
110-119
120-127
130-137
2.16

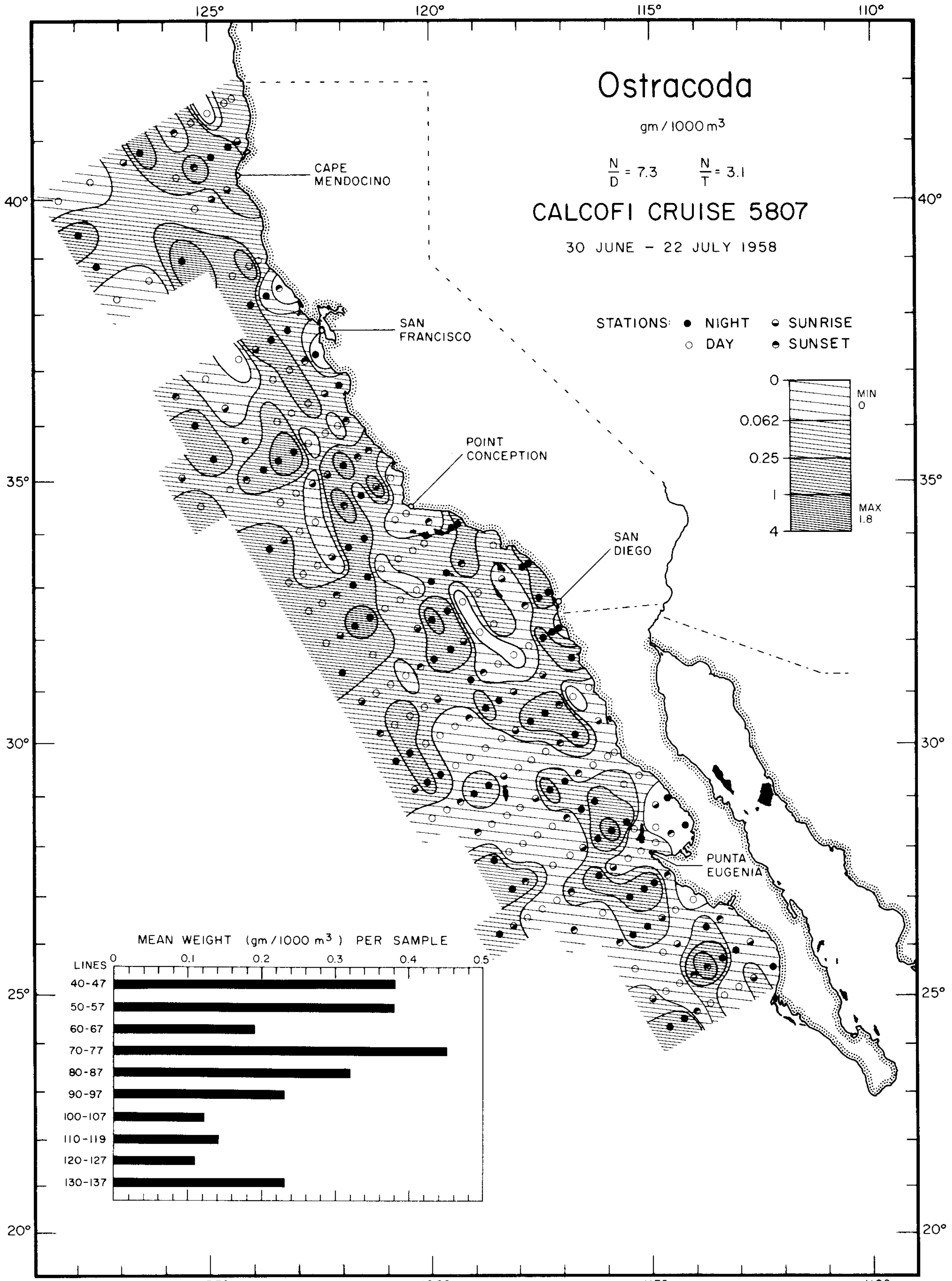


Biomass

Ostracoda

5707


Ostracoda, adjusted
gm / 1000 m3
N/D = 4.4 N/T = 2.0
CALCOFI CRUISE 5707
8 JULY - 3 AUGUST 1957
CAPE MENDOCINO
SAN FRANCISCO
POINT CONCEPTION
SAN DIEGO
PUNTA EUGENIA
STATIONS: NIGHT SUNRISE
DAY SUNSET
0
0.062
0.25
1
4
16
MIN 0
MAX 6.1
125° 120° 115° 110°
40° 35° 30° 25° 20°
MEAN WEIGHT (gm / 1000 m3) PER SAMPLE
LINES
0 0.1 0.2 0.3 0.5 1.5 2.0
60-67
70-77
80-87
90-97
100-107
110-119
120-127
130-137
0.47



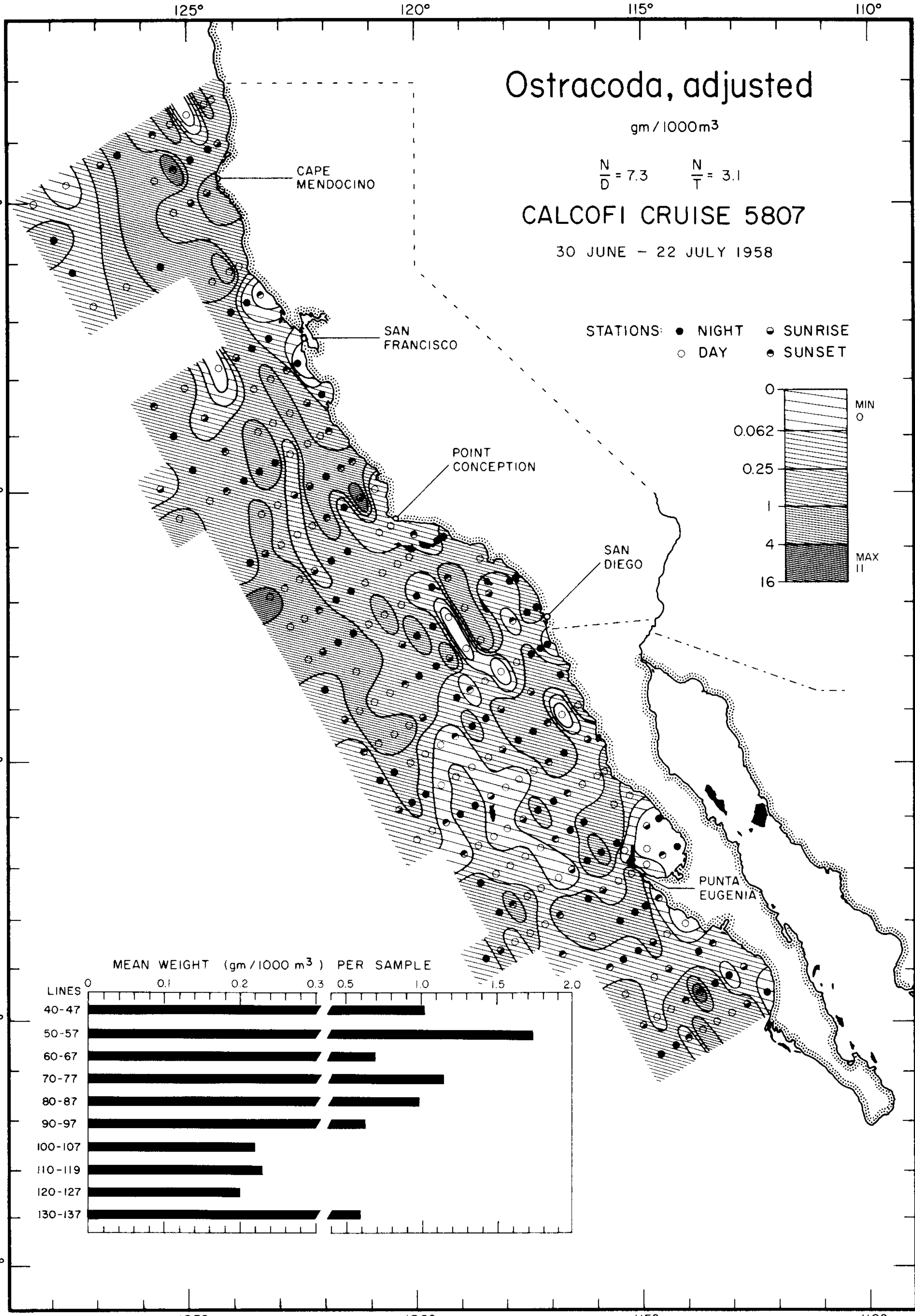
0.4 % 100

61 grams 14922

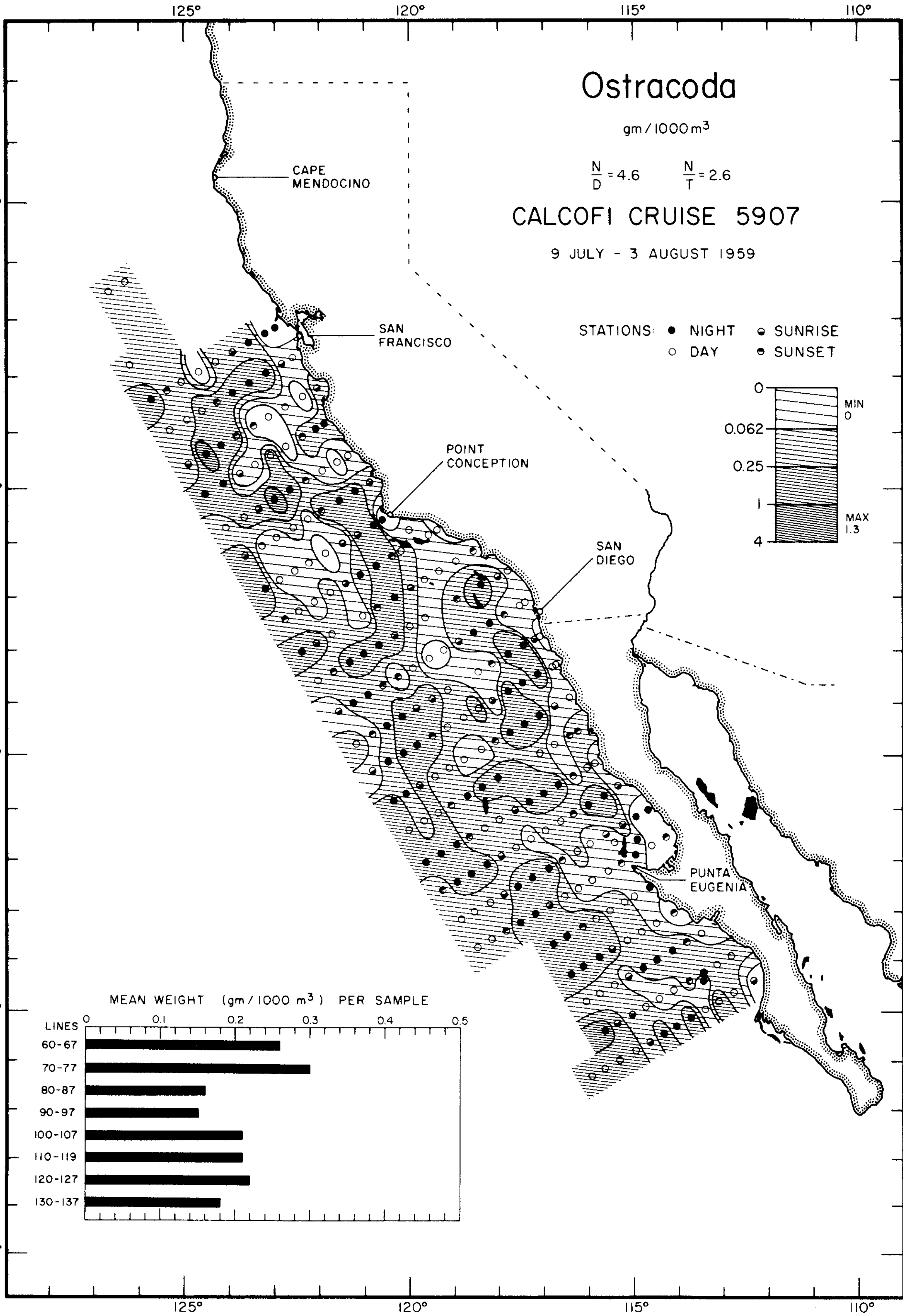
Biomass

Ostracoda

5807



Ostracoda, adjusted
gm/1000m3
N/D = 7.3
N/T = 3.1
CALCOFI CRUISE 5807
30 JUNE – 22 JULY 1958
STATIONS: ● NIGHT ○ DAY SUNRISE SUNSET
0
0.062
0.25
1
4
16
MIN 0
MAX 11
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
0.5
1.0
1.5
2.0
40-47
50-57
60-67
70-77
80-87
90-97
100-107
110-119
120-127
130-137



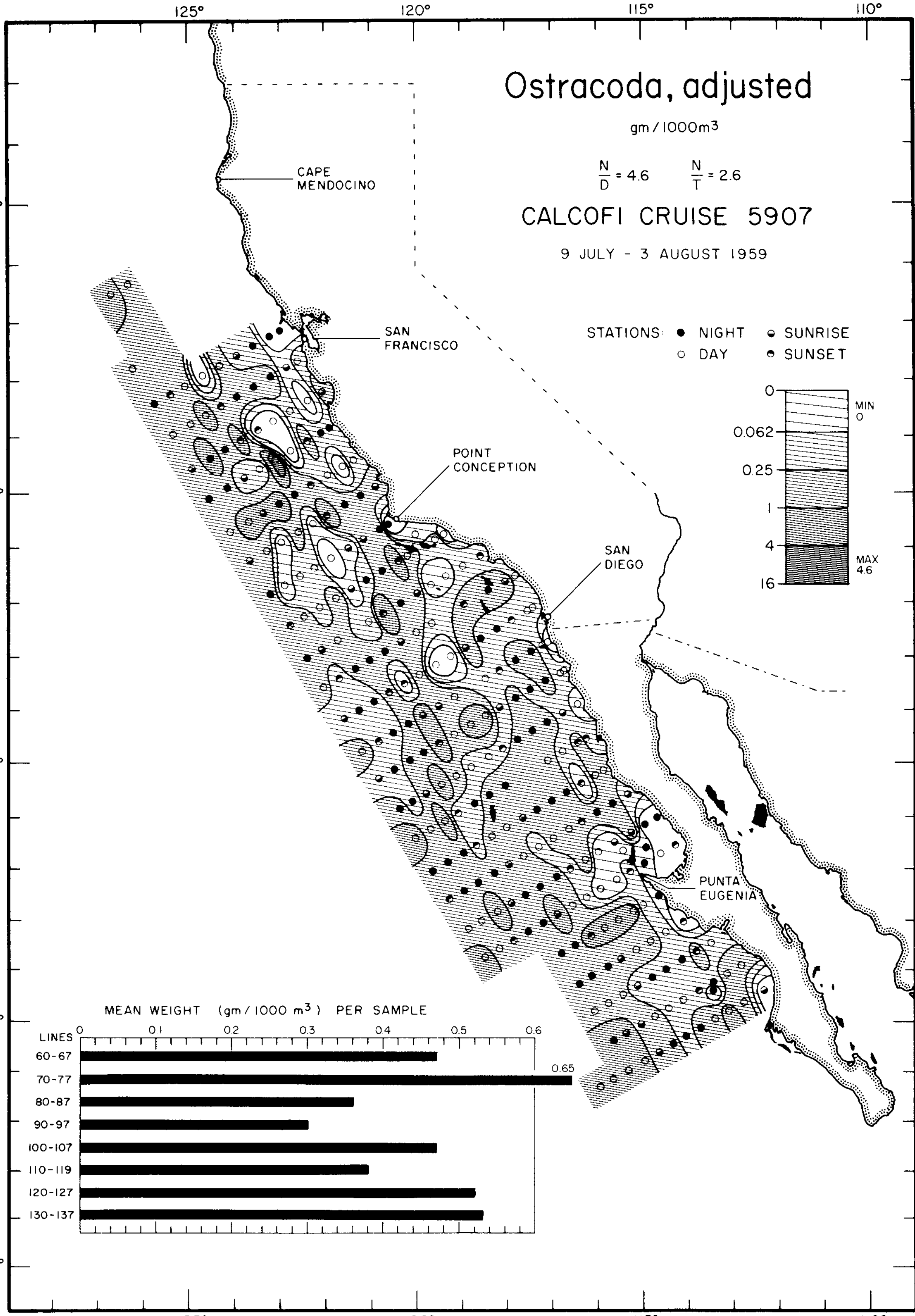
0.4 % 100

55 grams 12454

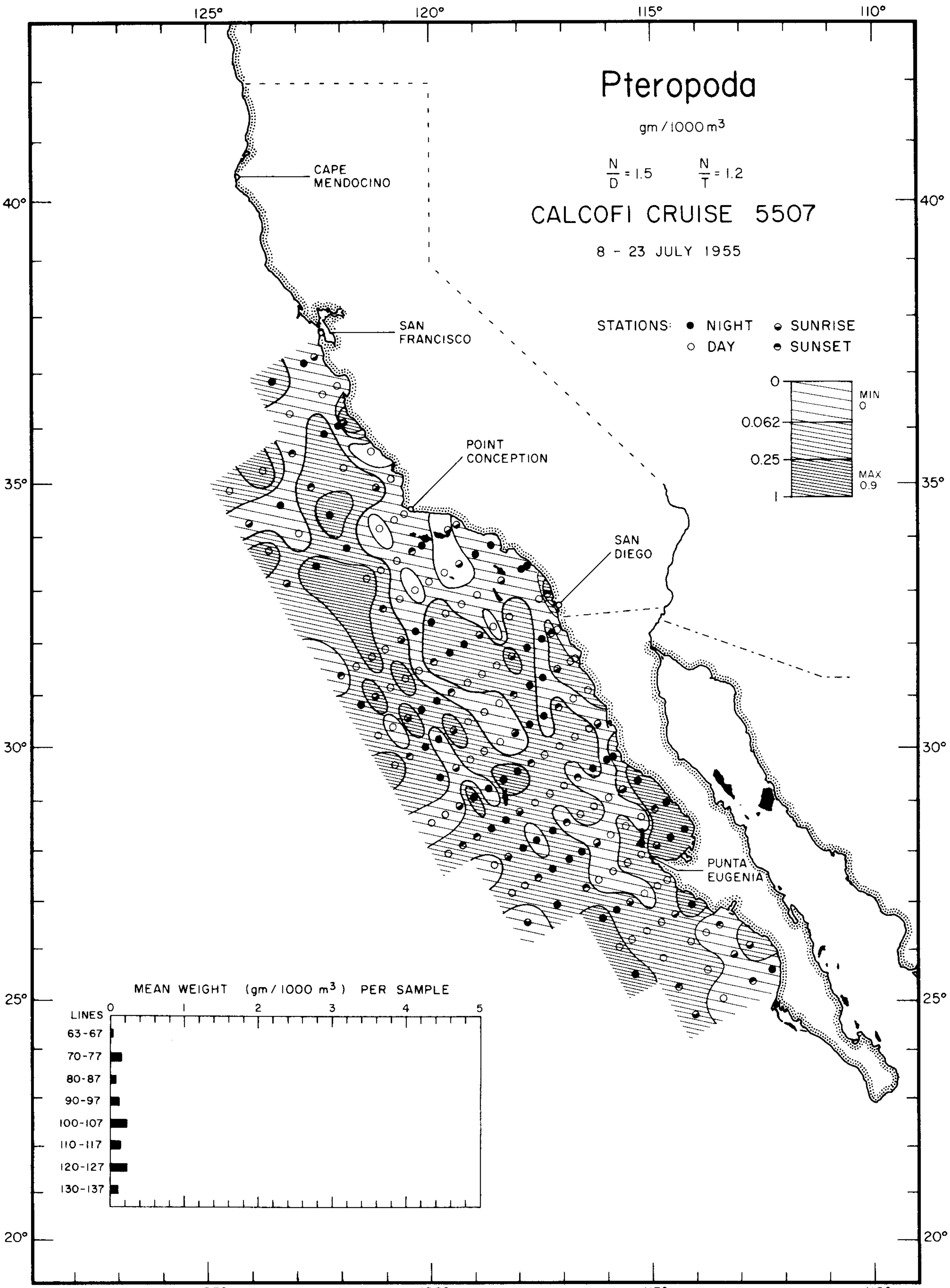
Biomass

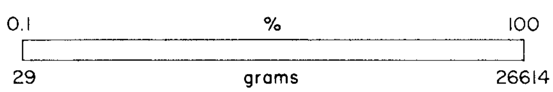
Ostracoda

5907



Biomass
Ostracoda, adjusted
5907

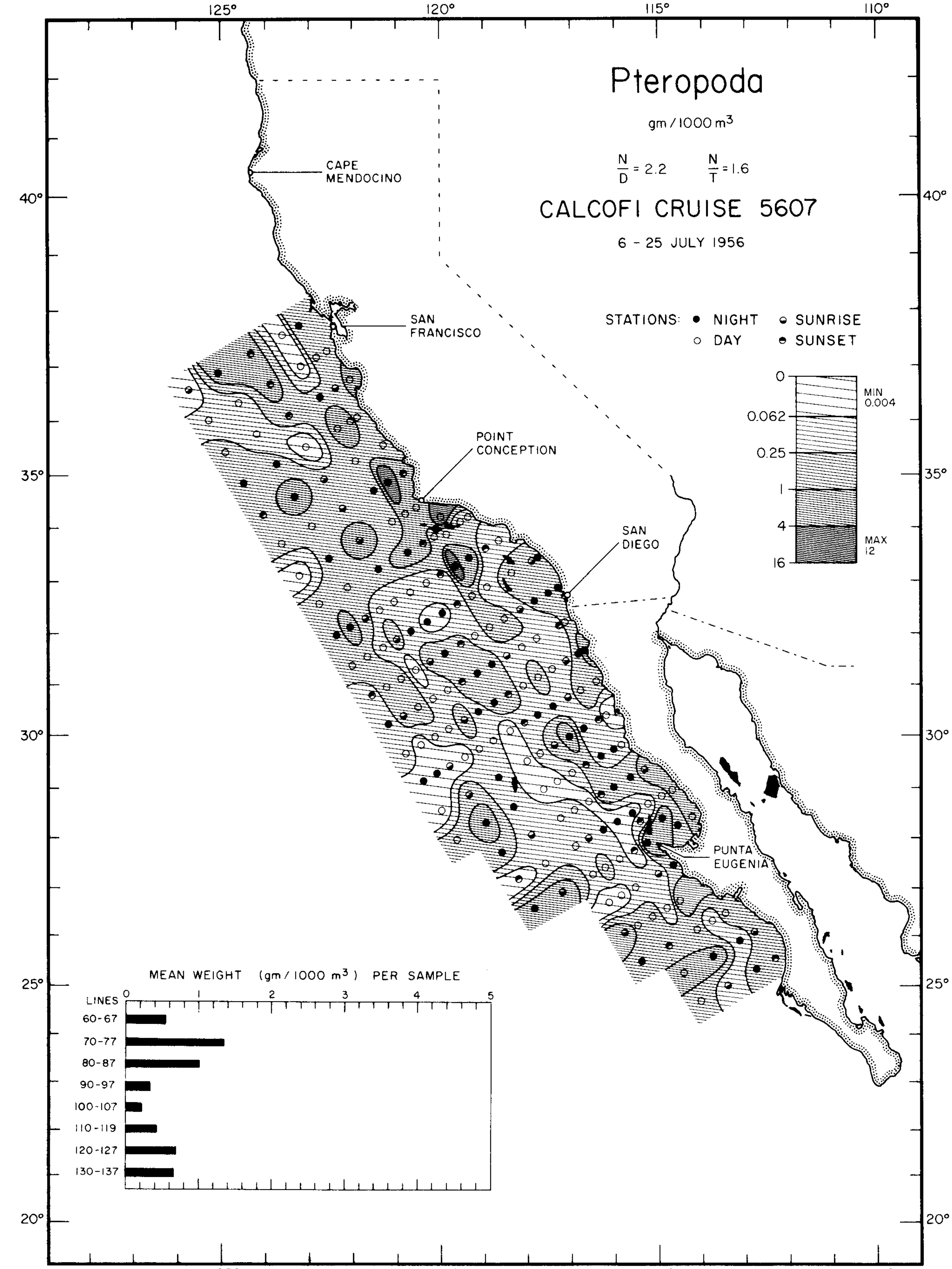


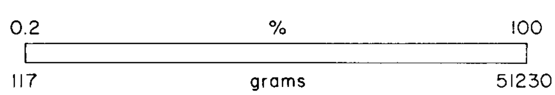


Biomass

Pteropoda

5507

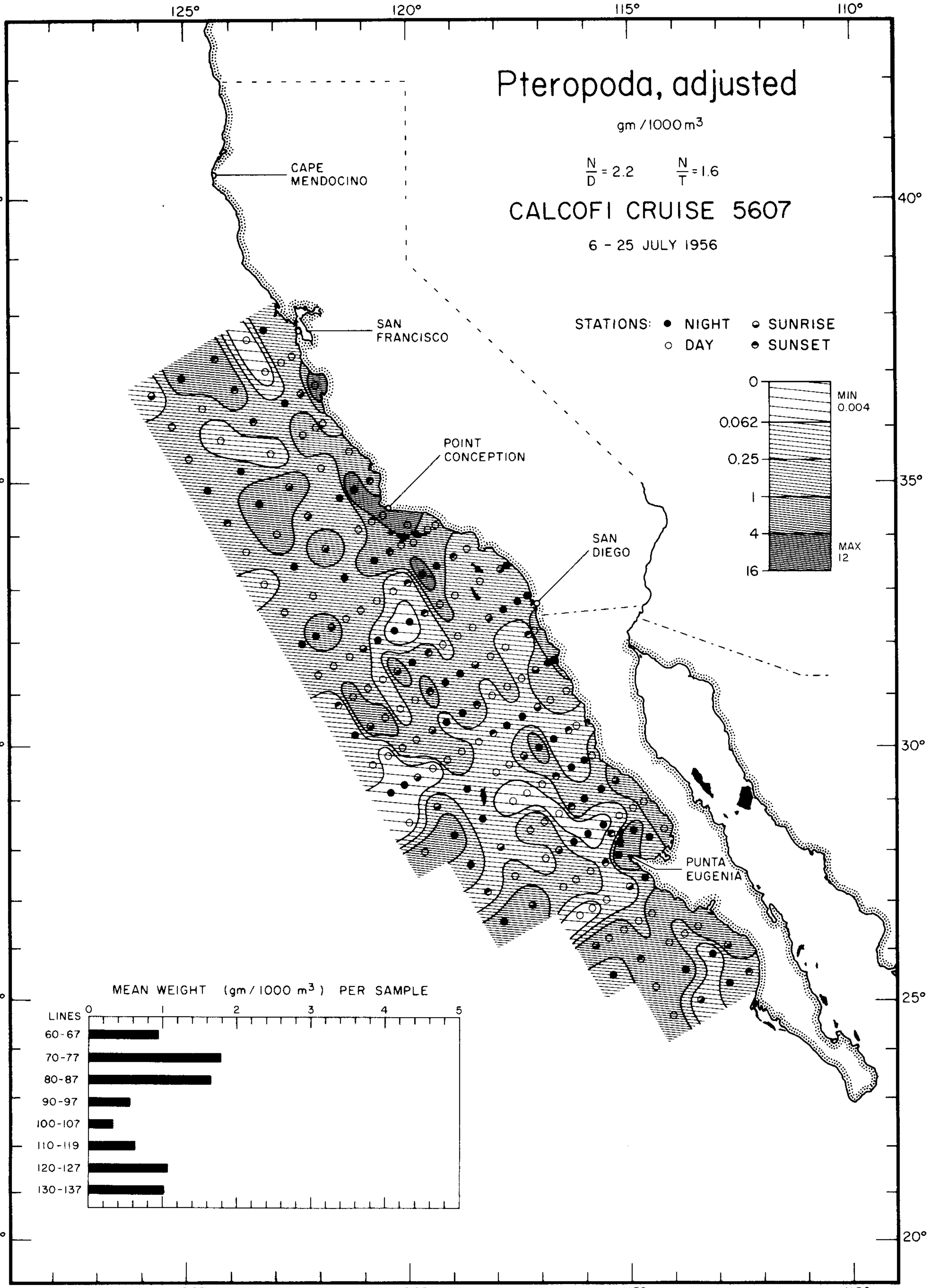




Biomass

Pteropoda

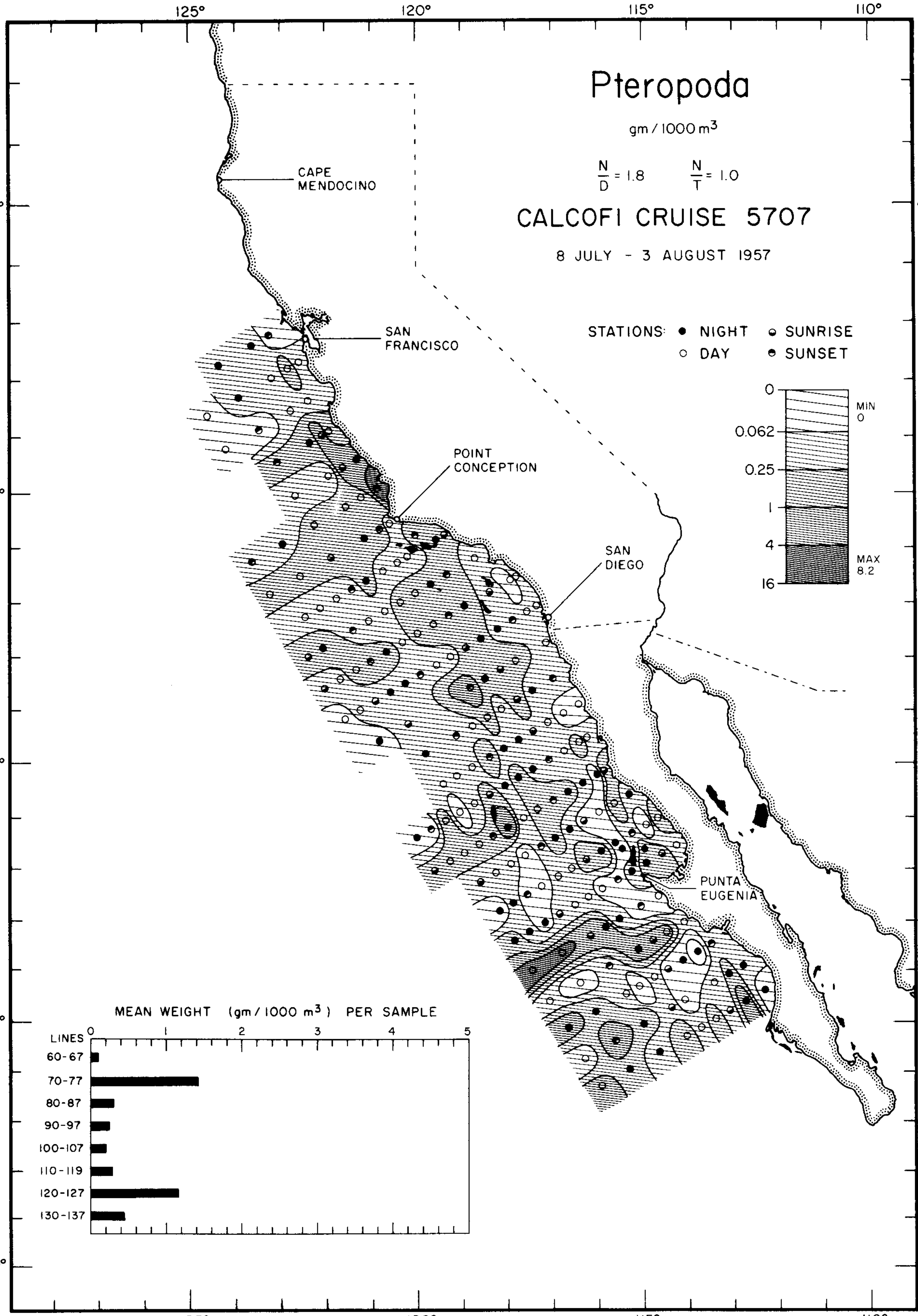
5607

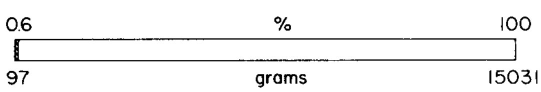


Biomass

Pteropoda, adjusted

5607

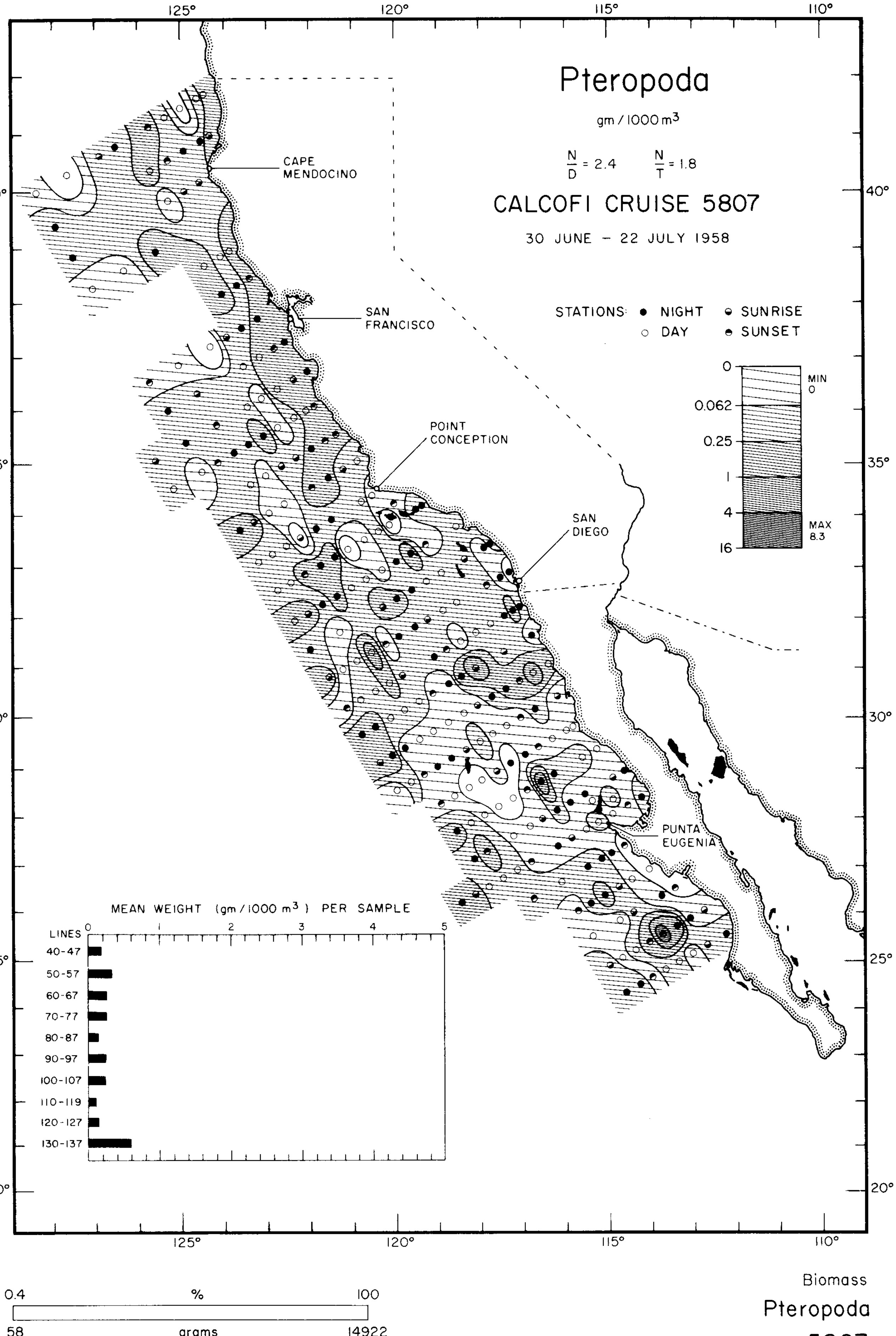




Biomass

Pteropoda

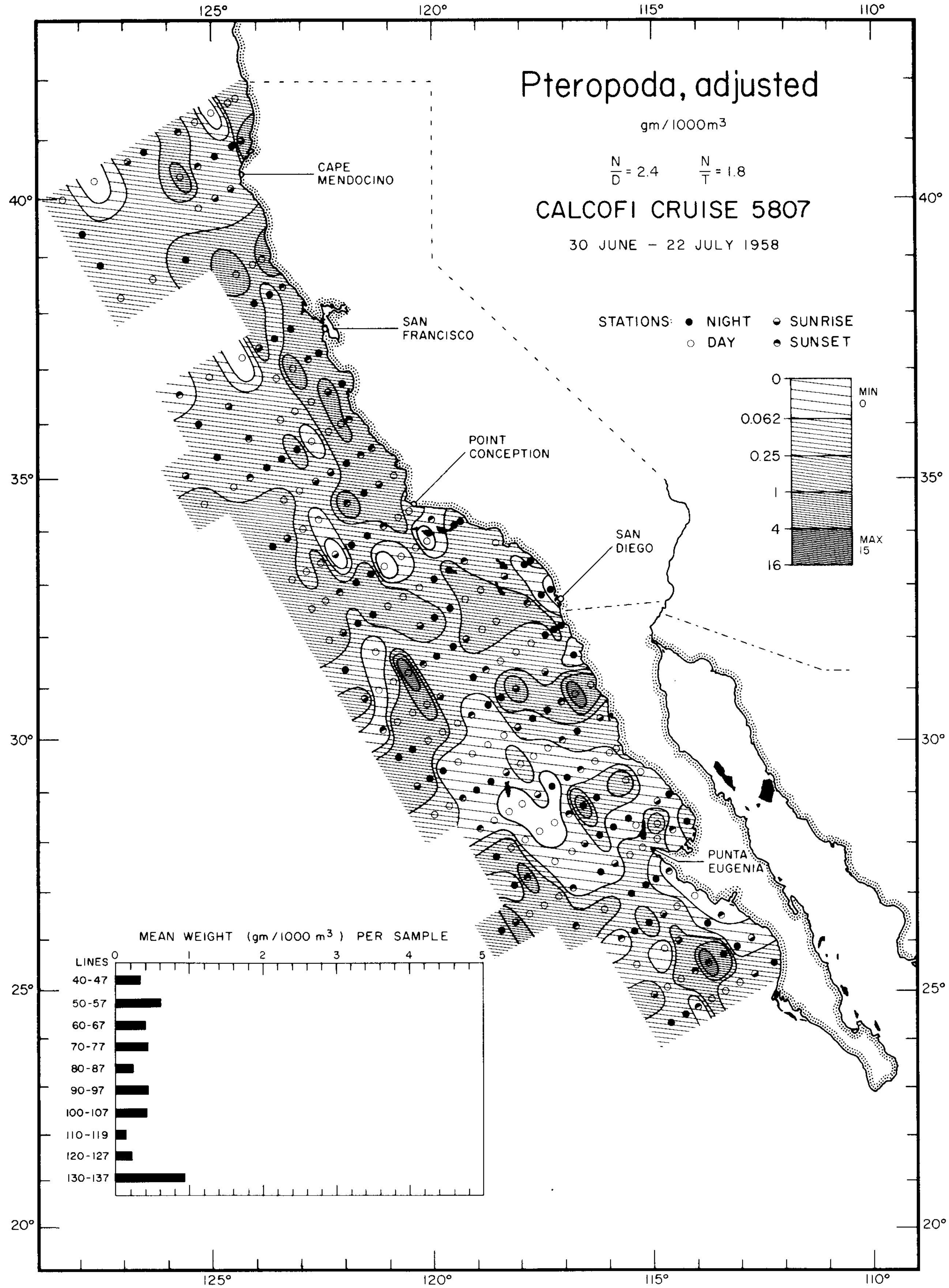
5707



Biomass

Pteropoda

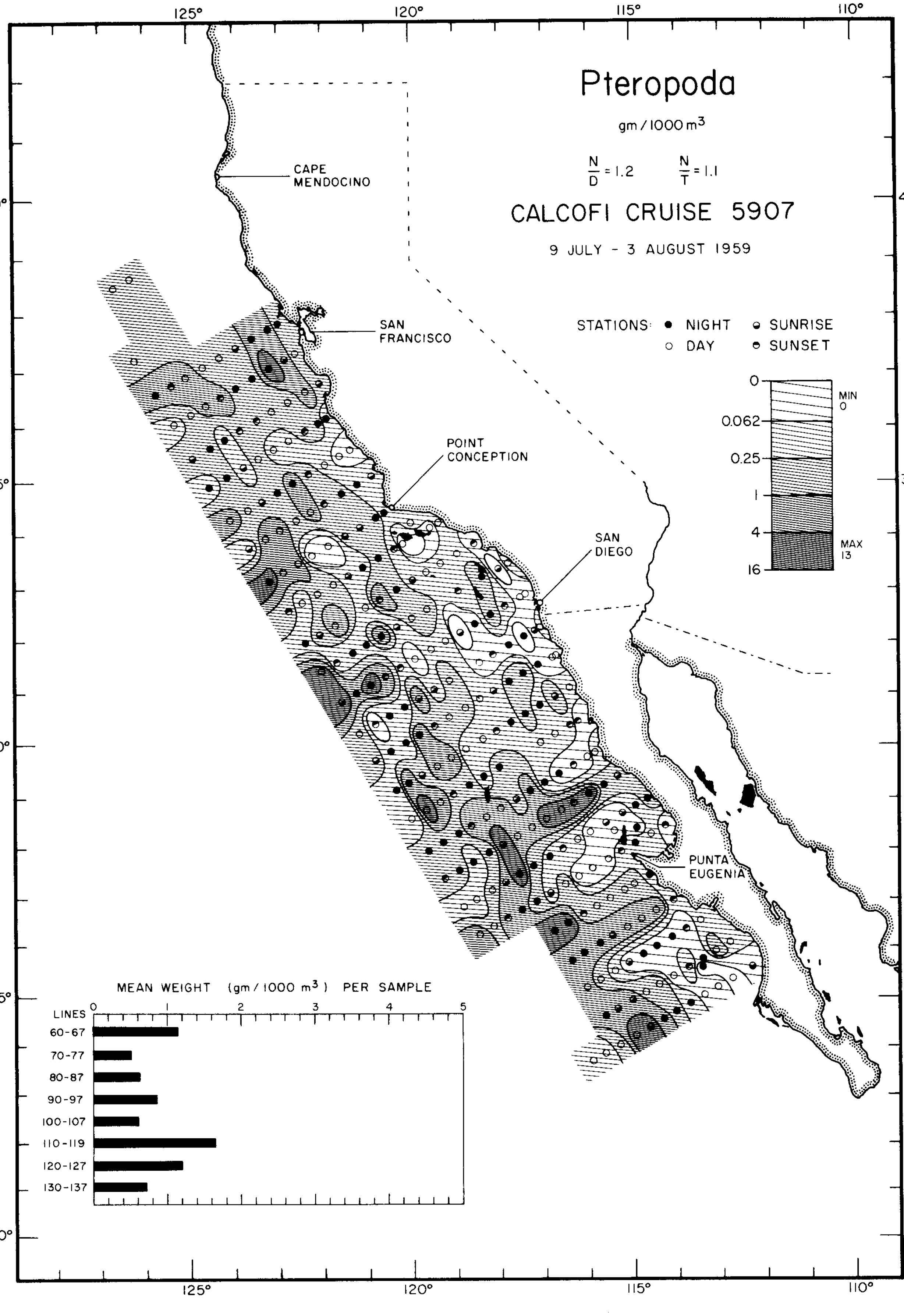
5807

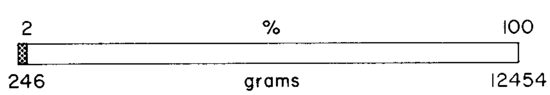


Biomass

Pteropoda, adjusted

5807

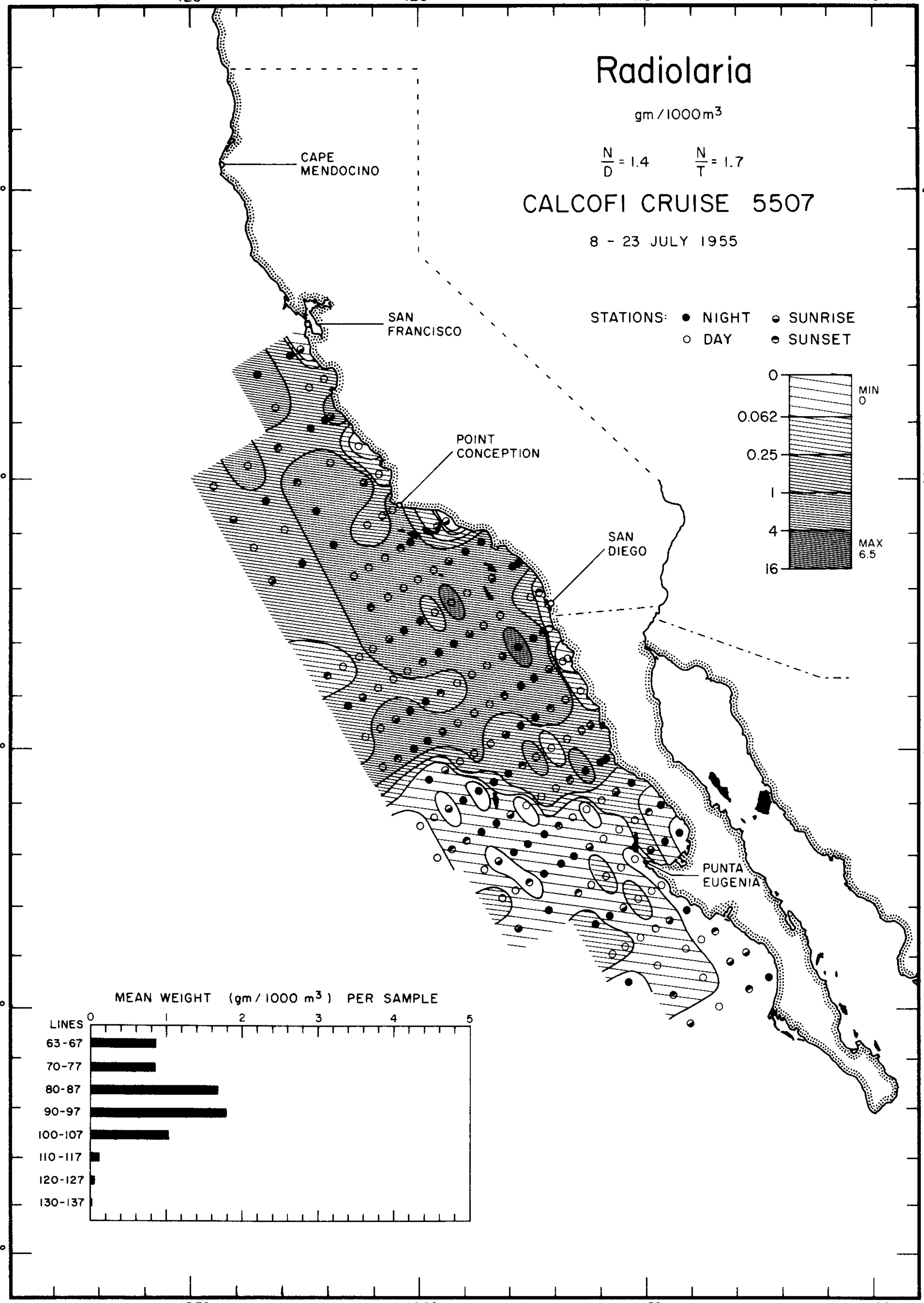




Biomass

Pteropoda

5907



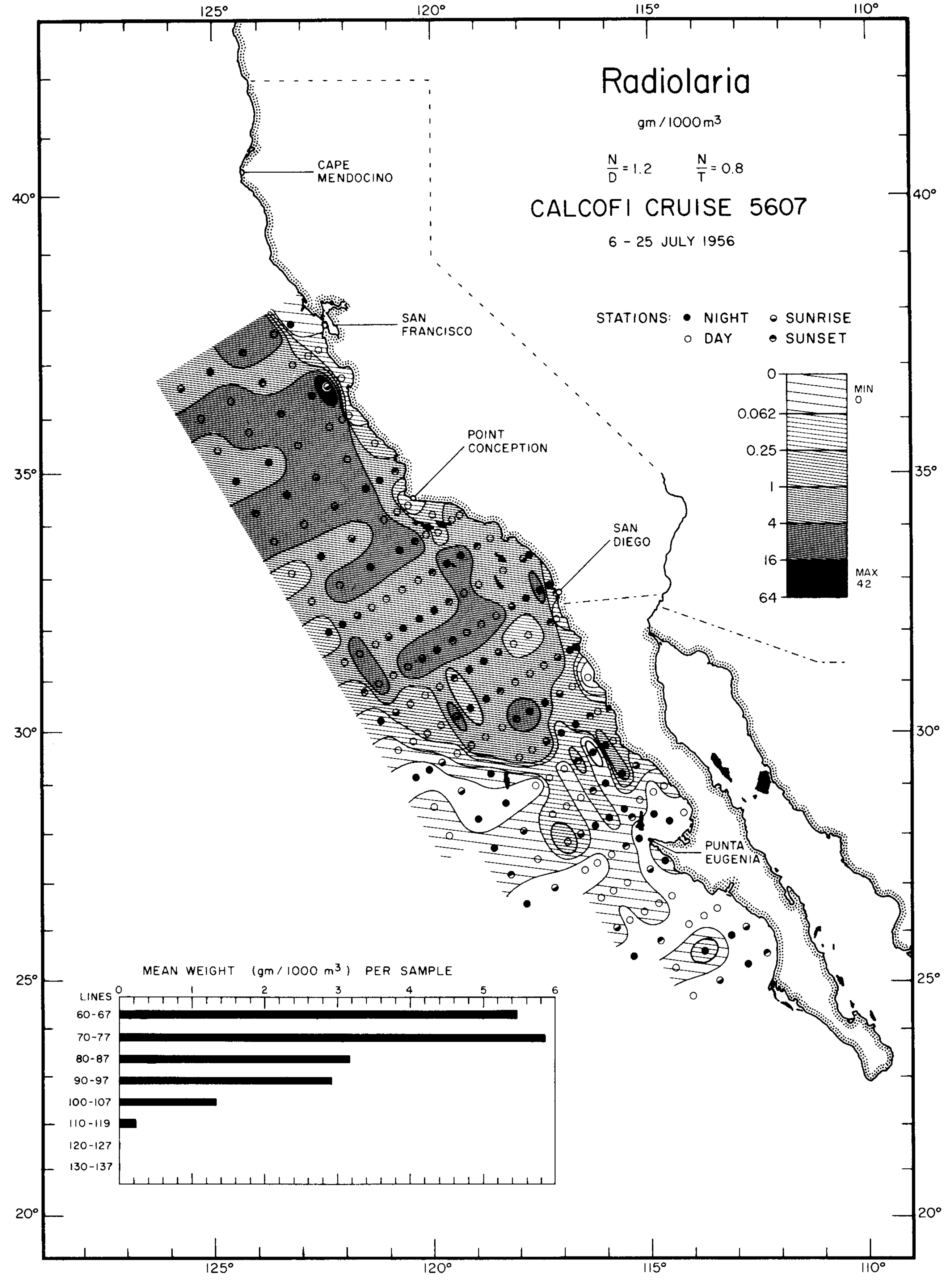
0.6 % 100

173 grams 26614

Biomass

Radiolaria

5507



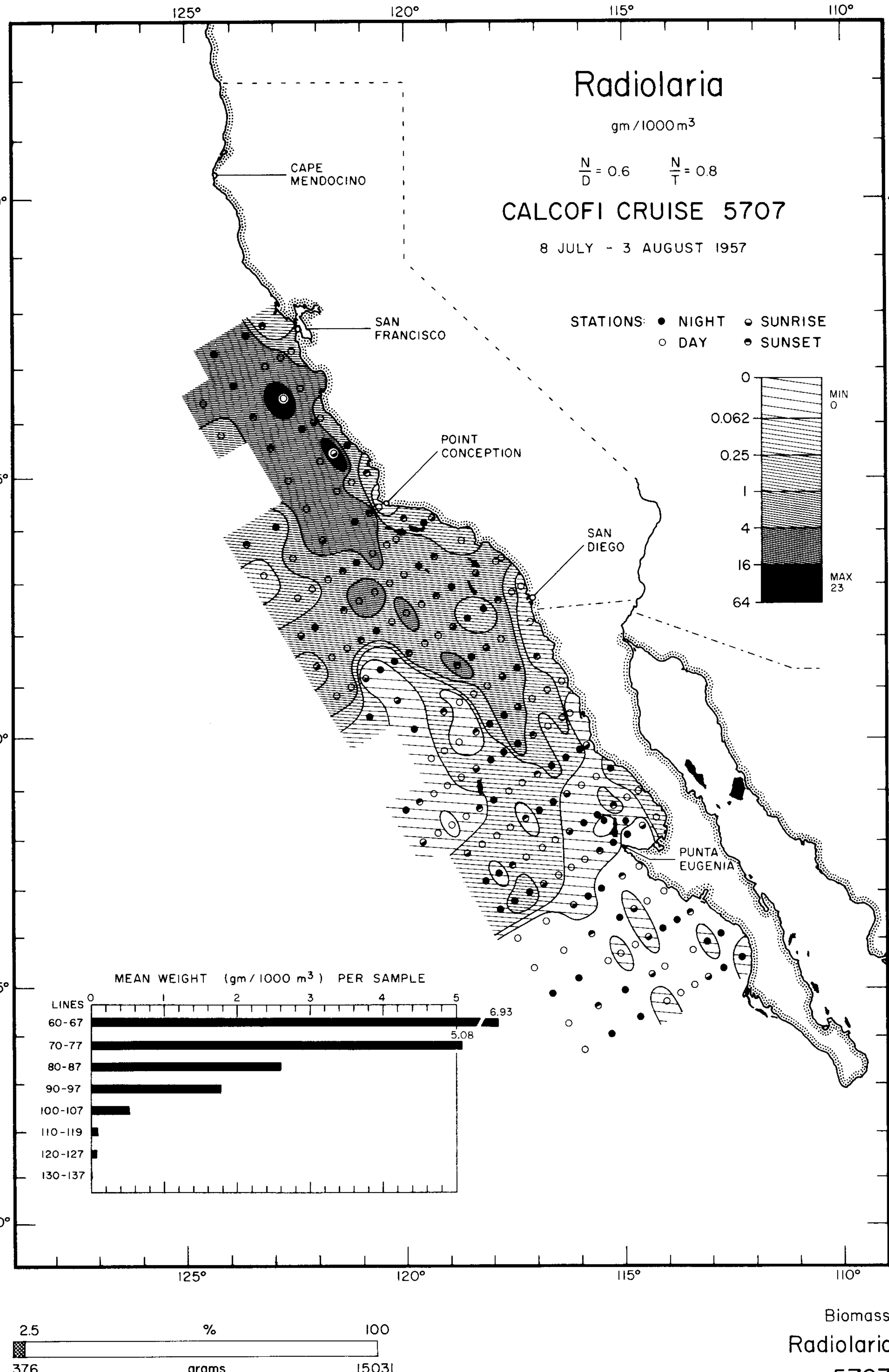
0.9 % 100

455 grams 51230

Biomass

Radiolaria

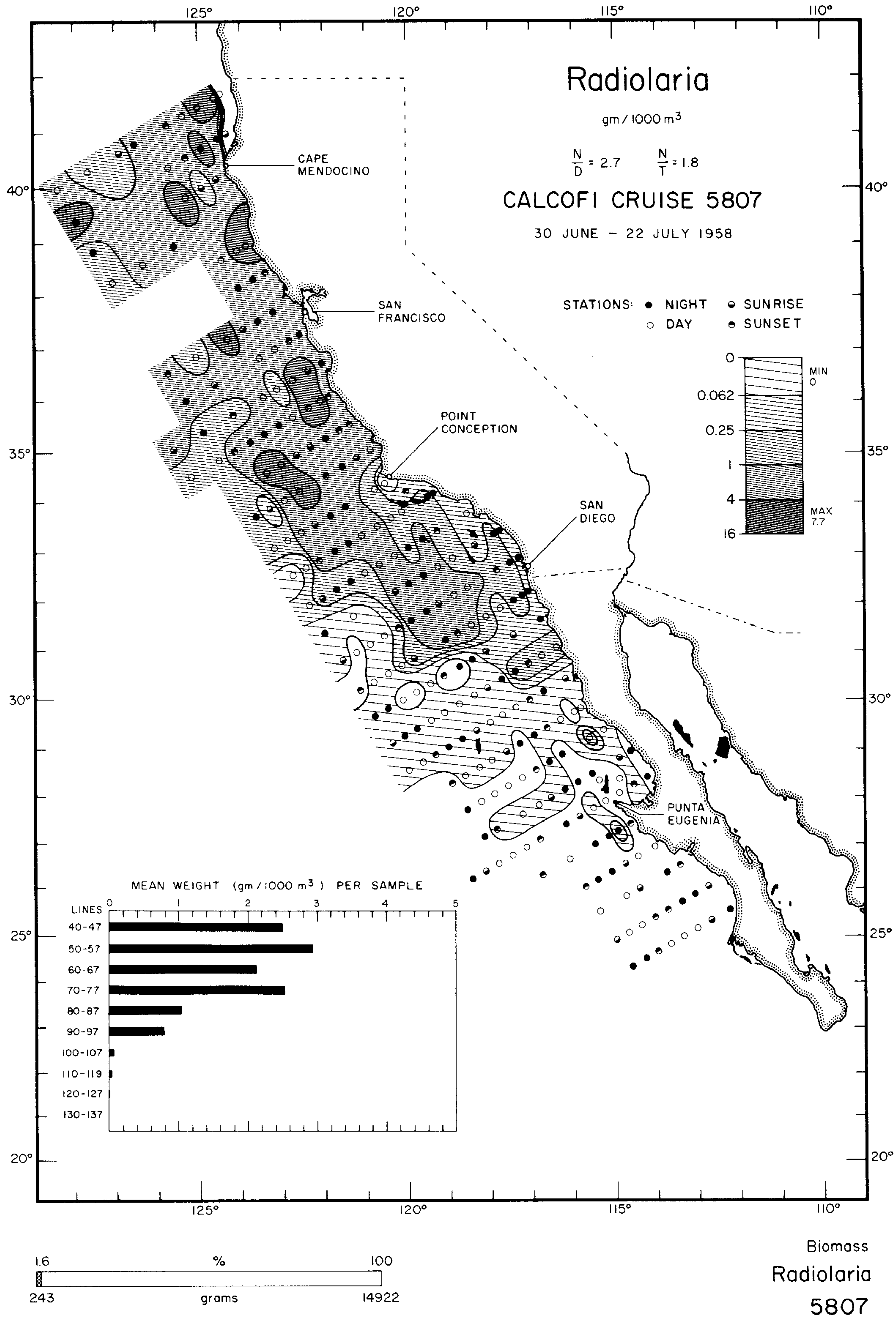
5607



Biomass

Radiolaria

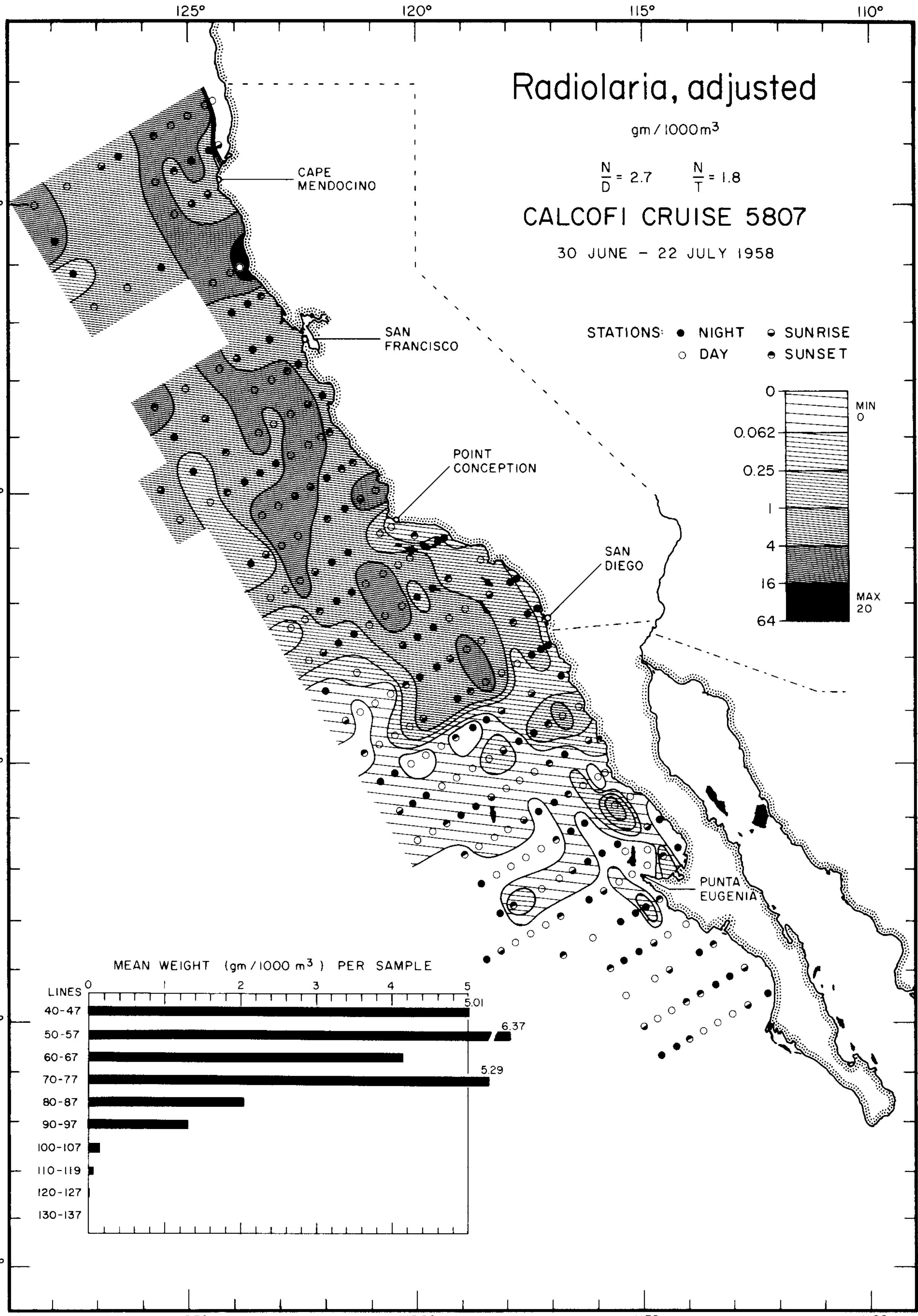
5707

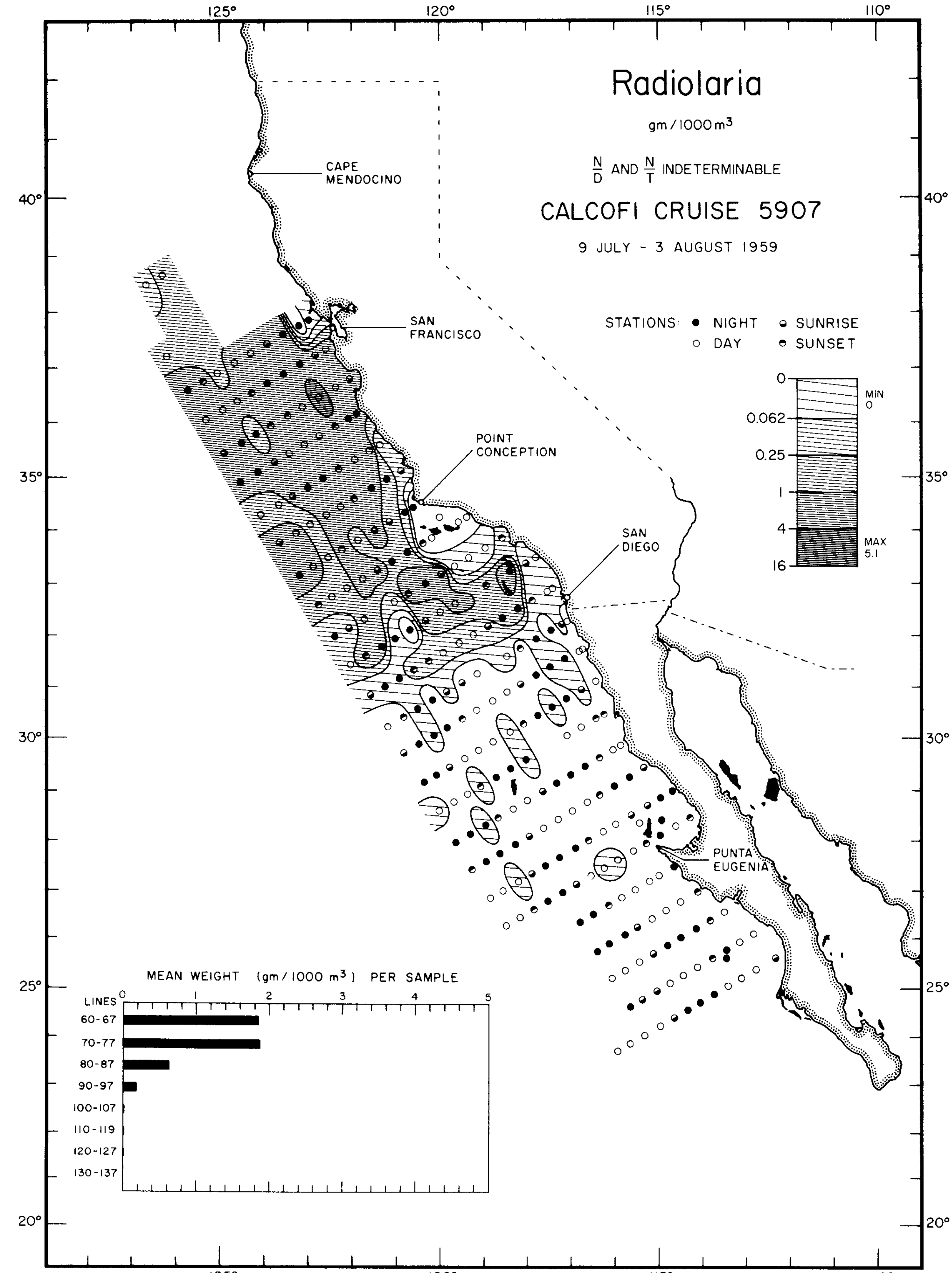


Biomass

Radiolaria

5807


Radiolaria, adjusted
gm / 1000m³
N/D = 2.7   N/T = 1.8
CALCOFI CRUISE 5807
30 JUNE – 22 JULY 1958
STATIONS: NIGHT SUNRISE DAY SUNSET
CAPE MENDOCINO
SAN FRANCISCO
POINT CONCEPTION
SAN DIEGO
PUNTA EUGENIA
0
0.062
0.25
1
4
16
64
MIN 0
MAX 20
125°
120°
115°
110°
40°
35°
30°
25°
20°
MEAN WEIGHT (gm / 1000 m³) PER SAMPLE
LINES
40-47
50-57
60-67
70-77
80-87
90-97
100-107
110-119
120-127
130-137
0
1
2
3
4
5
5.01
6.37
5.29



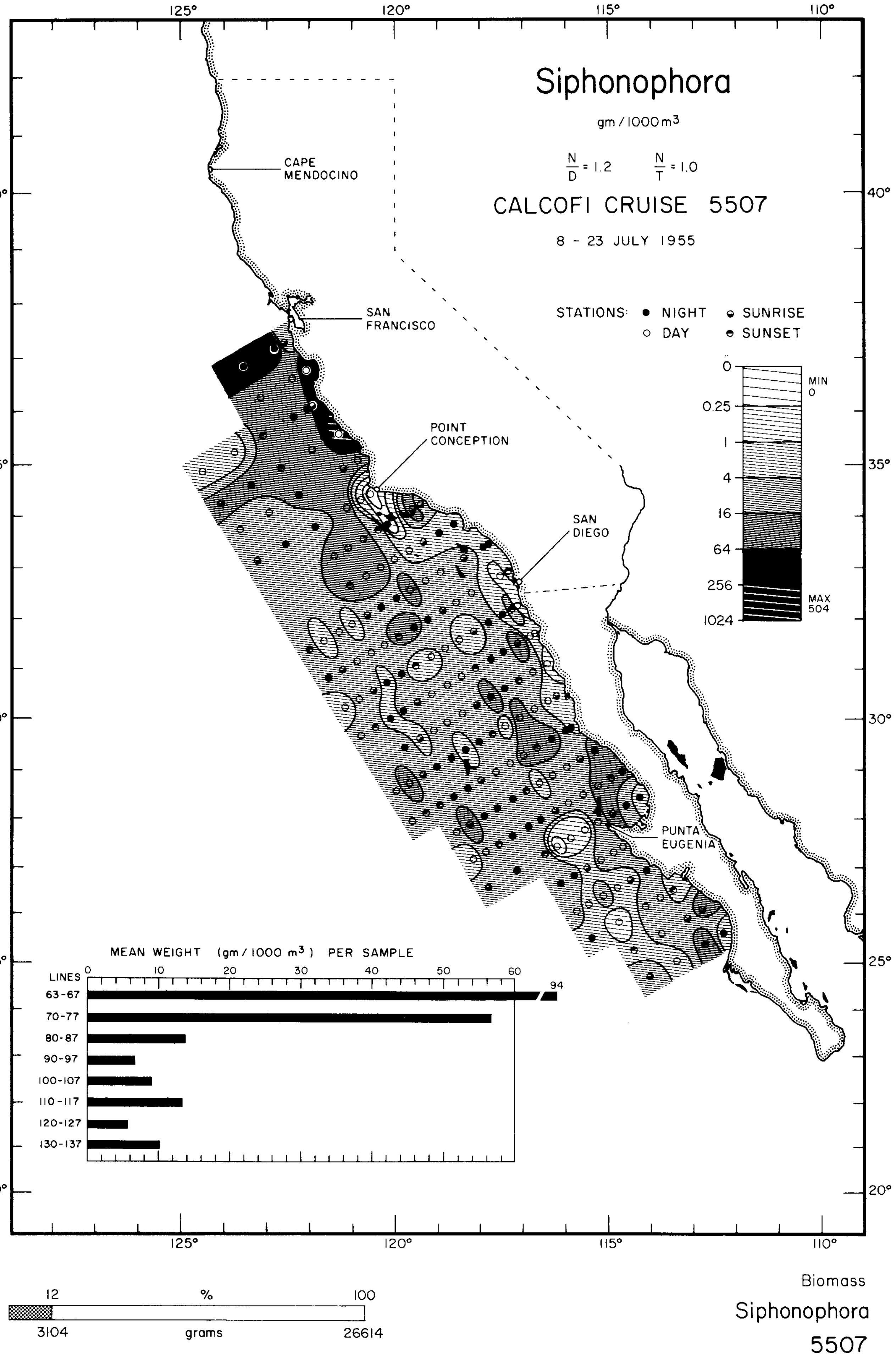
1.0 % 100

128 grams 12454

Biomass

Radiolaria

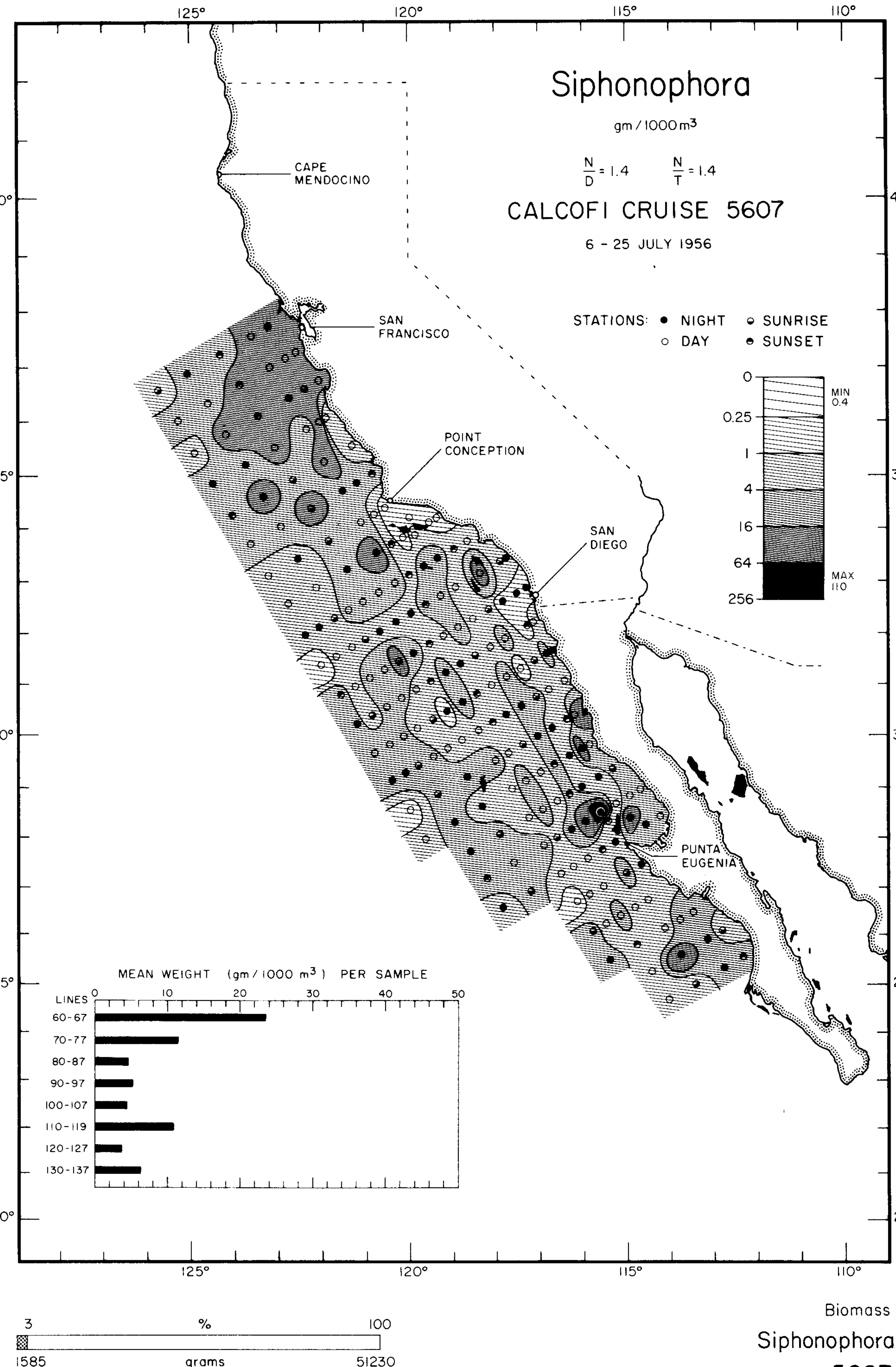
5907



Biomass

Siphonophora

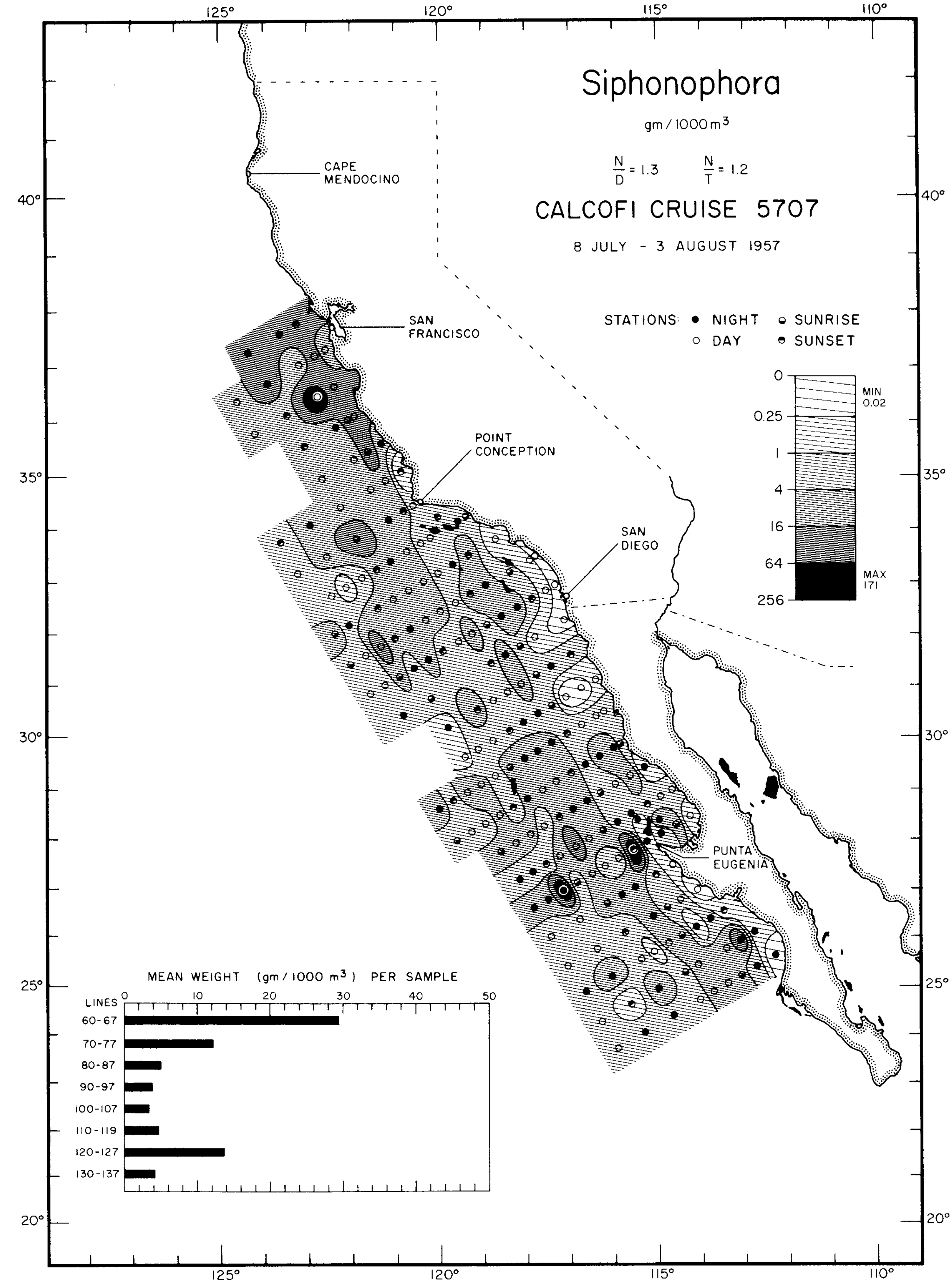
5507

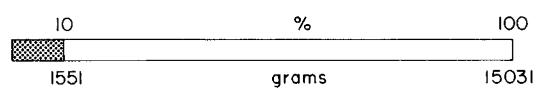


Biomass

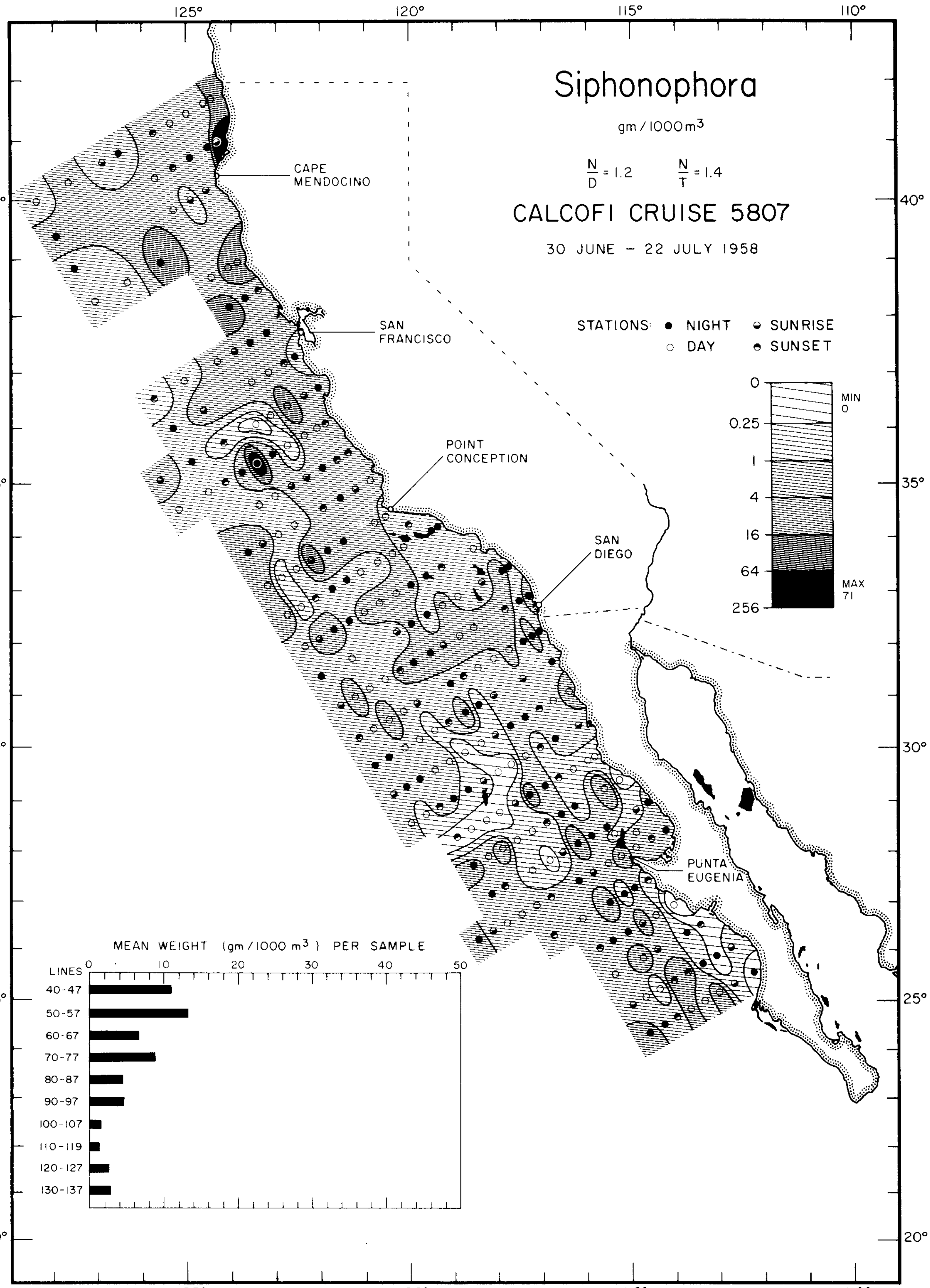
Siphonophora

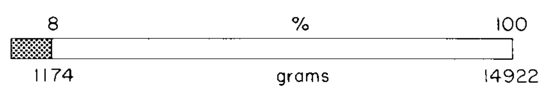
5607





Biomass
Siphonophora
5707

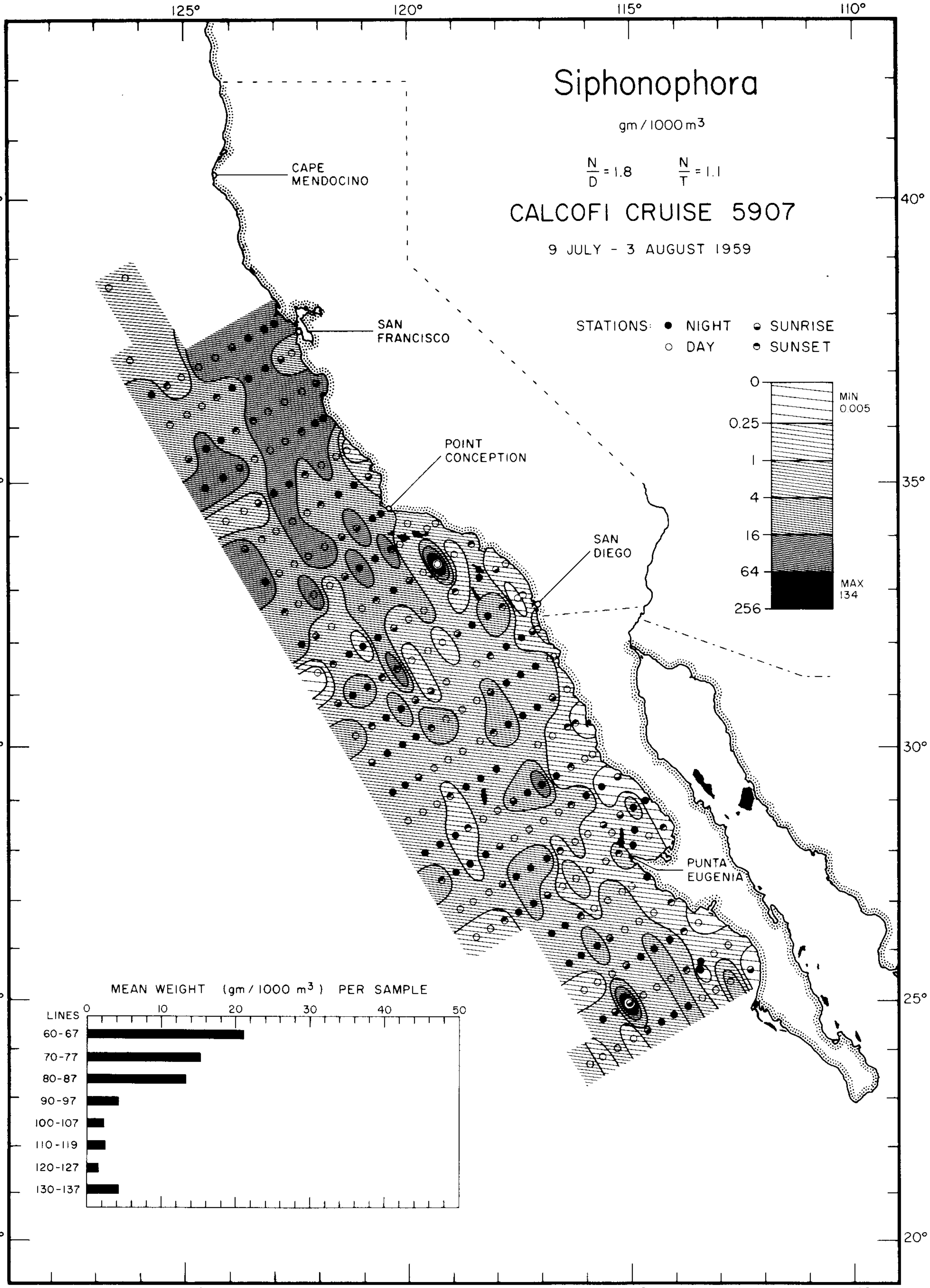


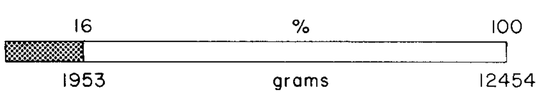


Biomass

Siphonophora

5807

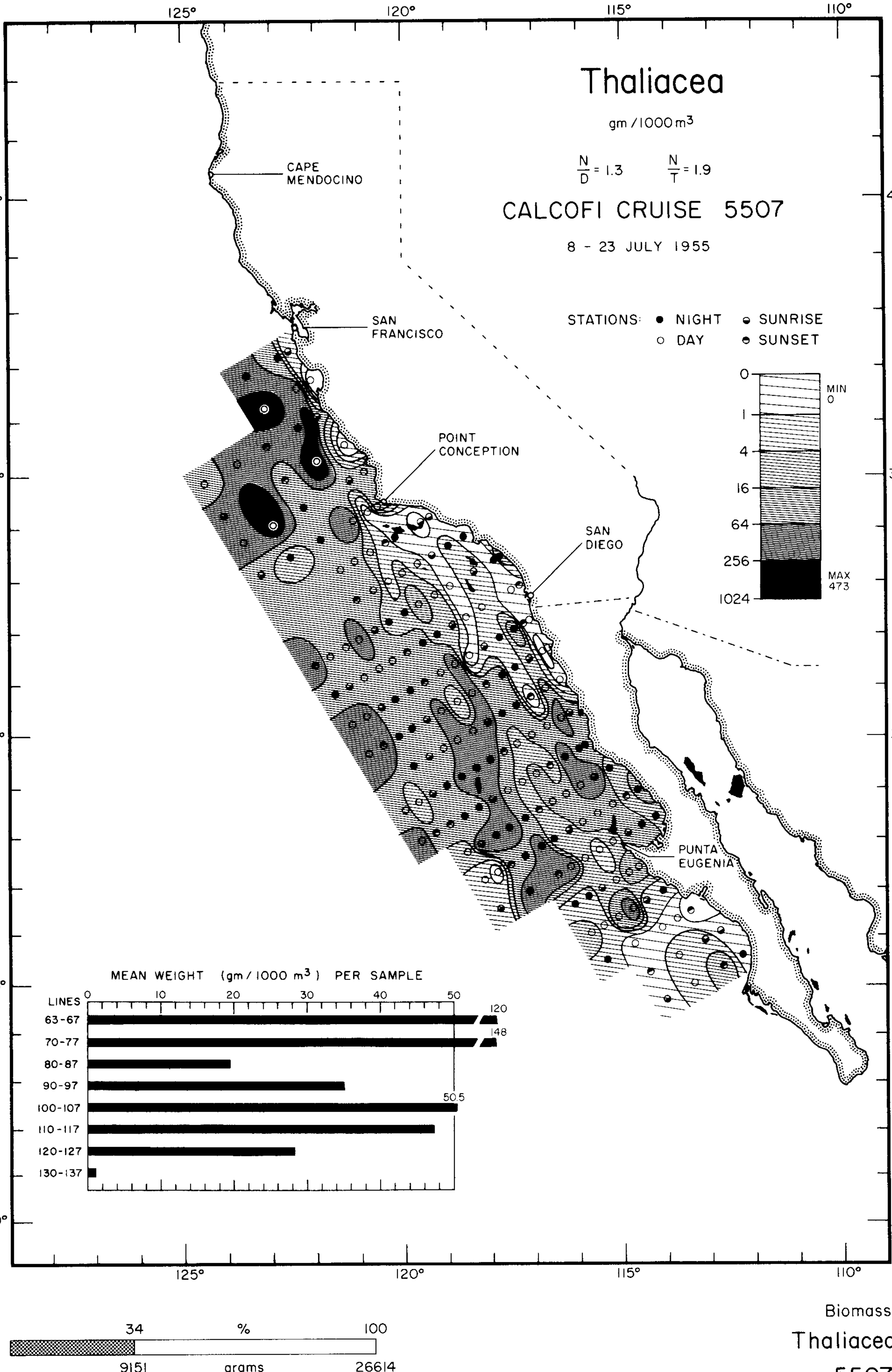




Biomass

Siphonophora

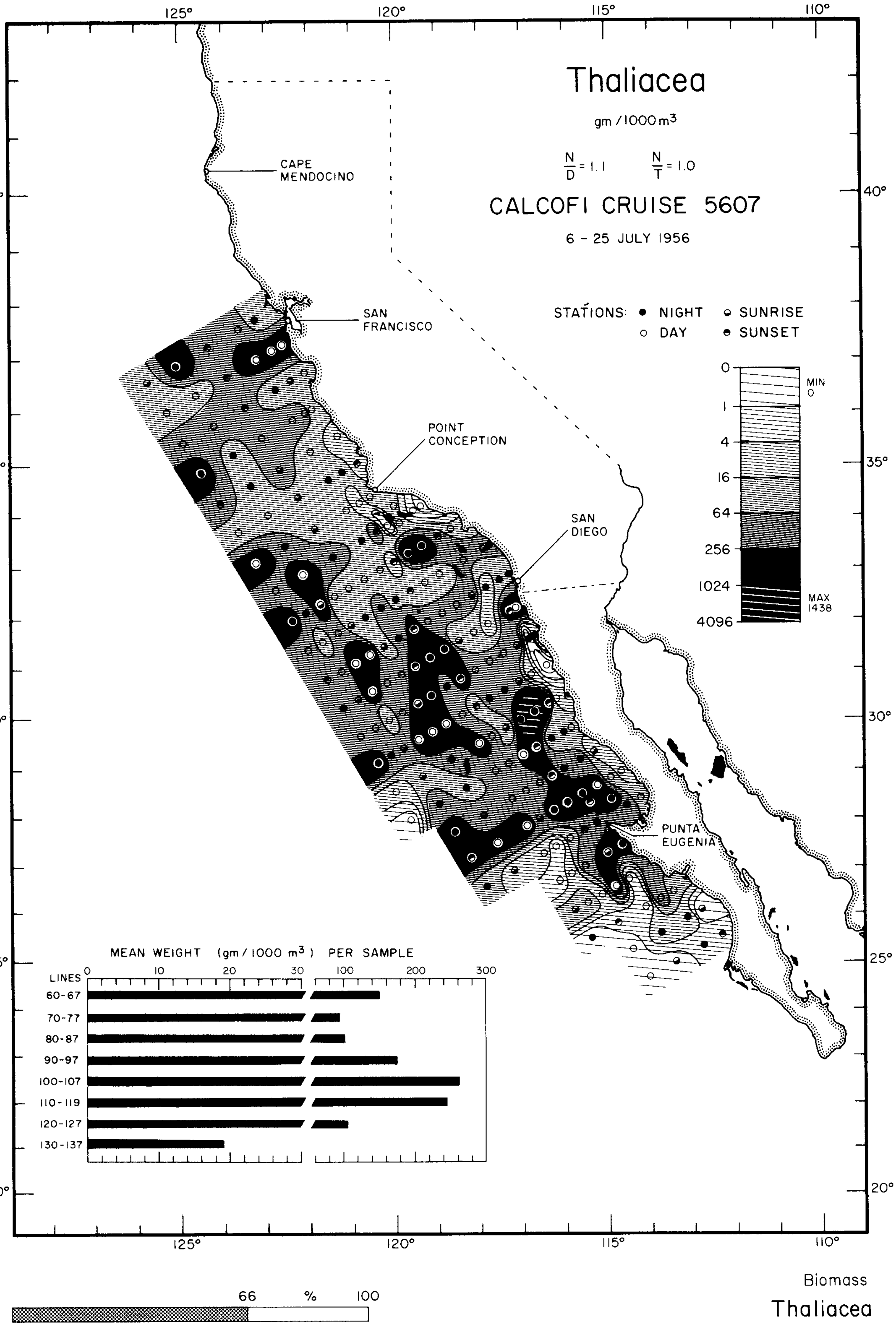
5907



Biomass

Thaliacea

5507



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Thaliacea

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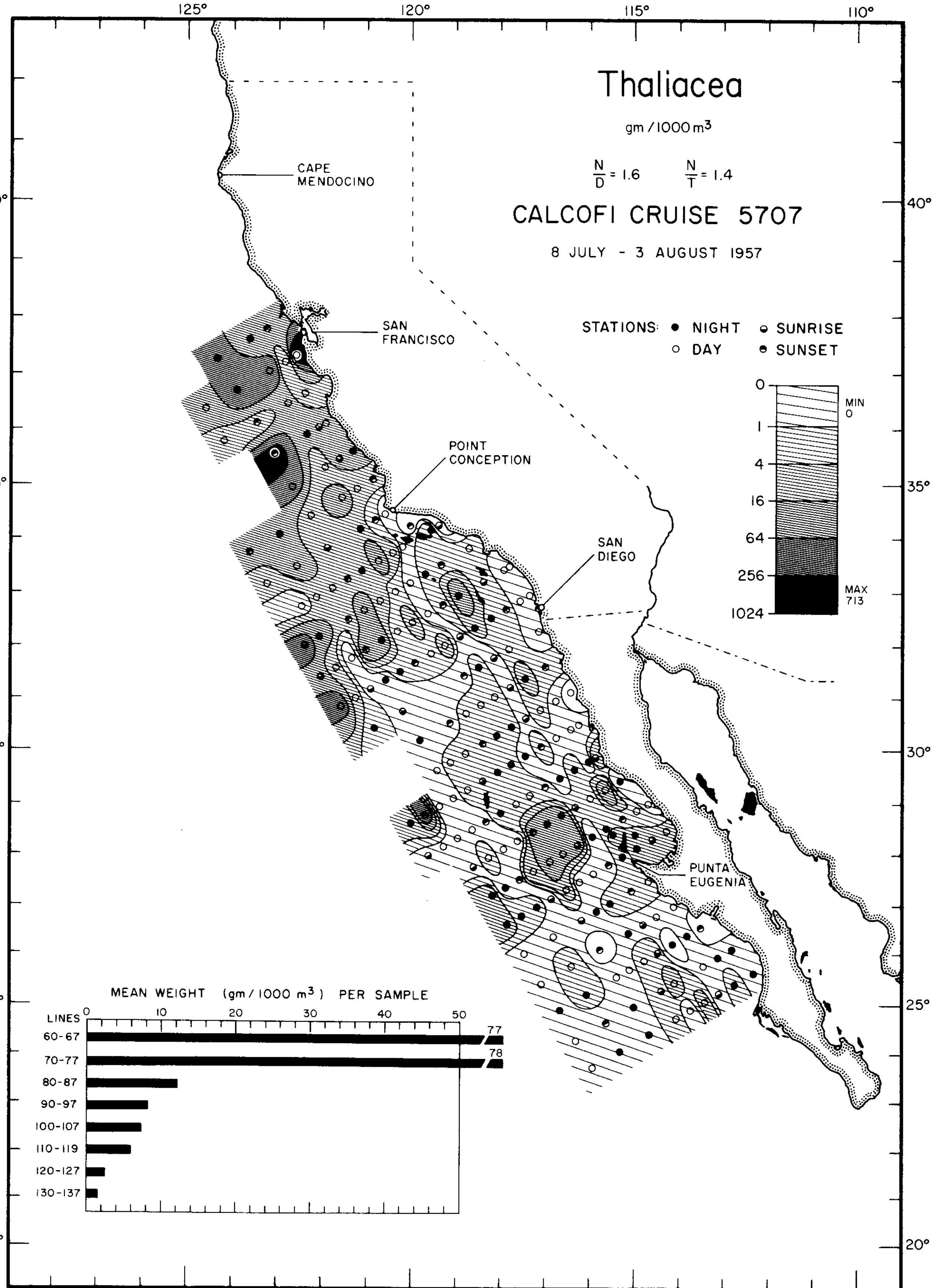
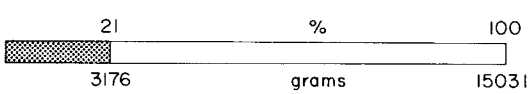
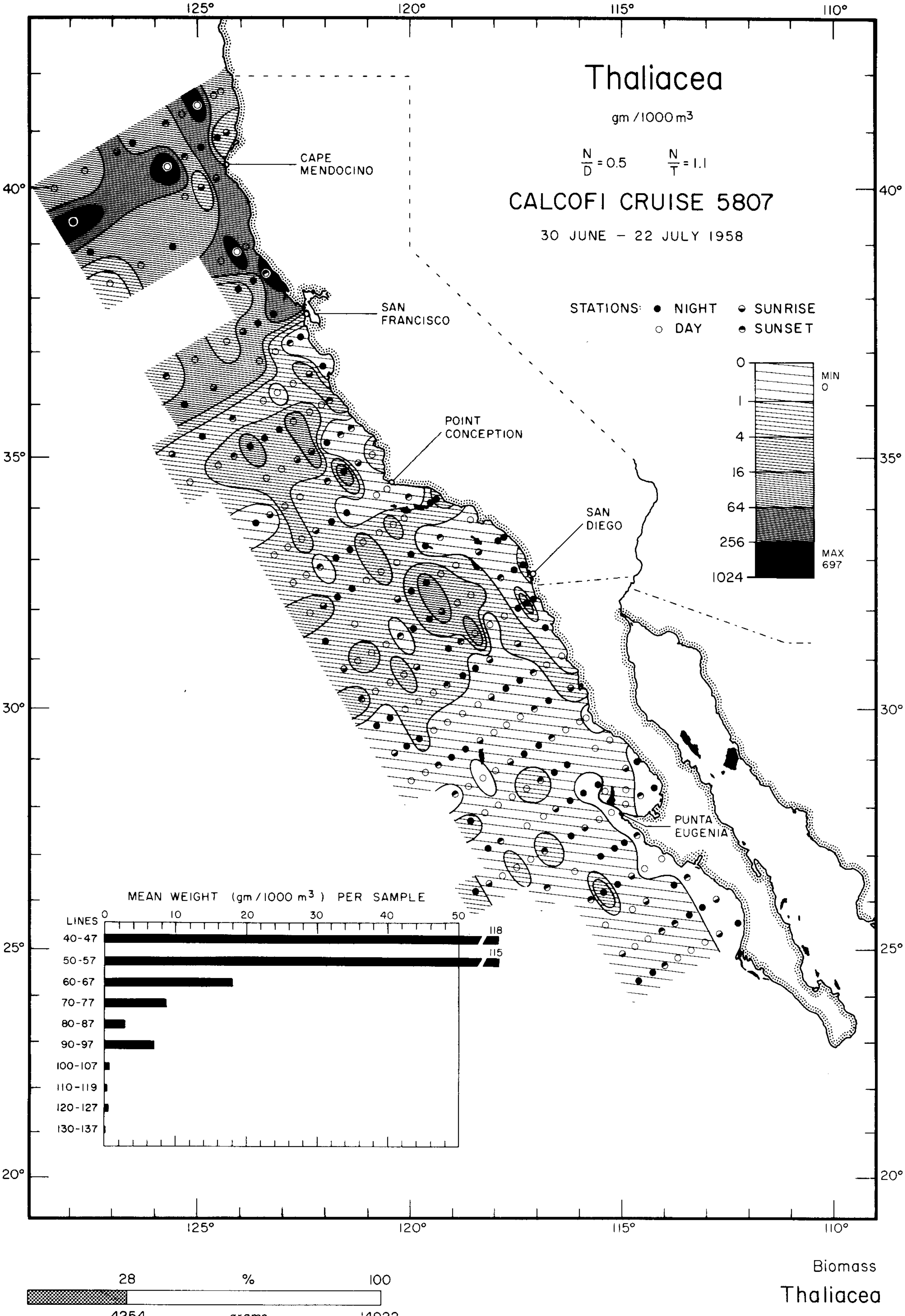




Biomass
Thaliacea
5707



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Thaliacea

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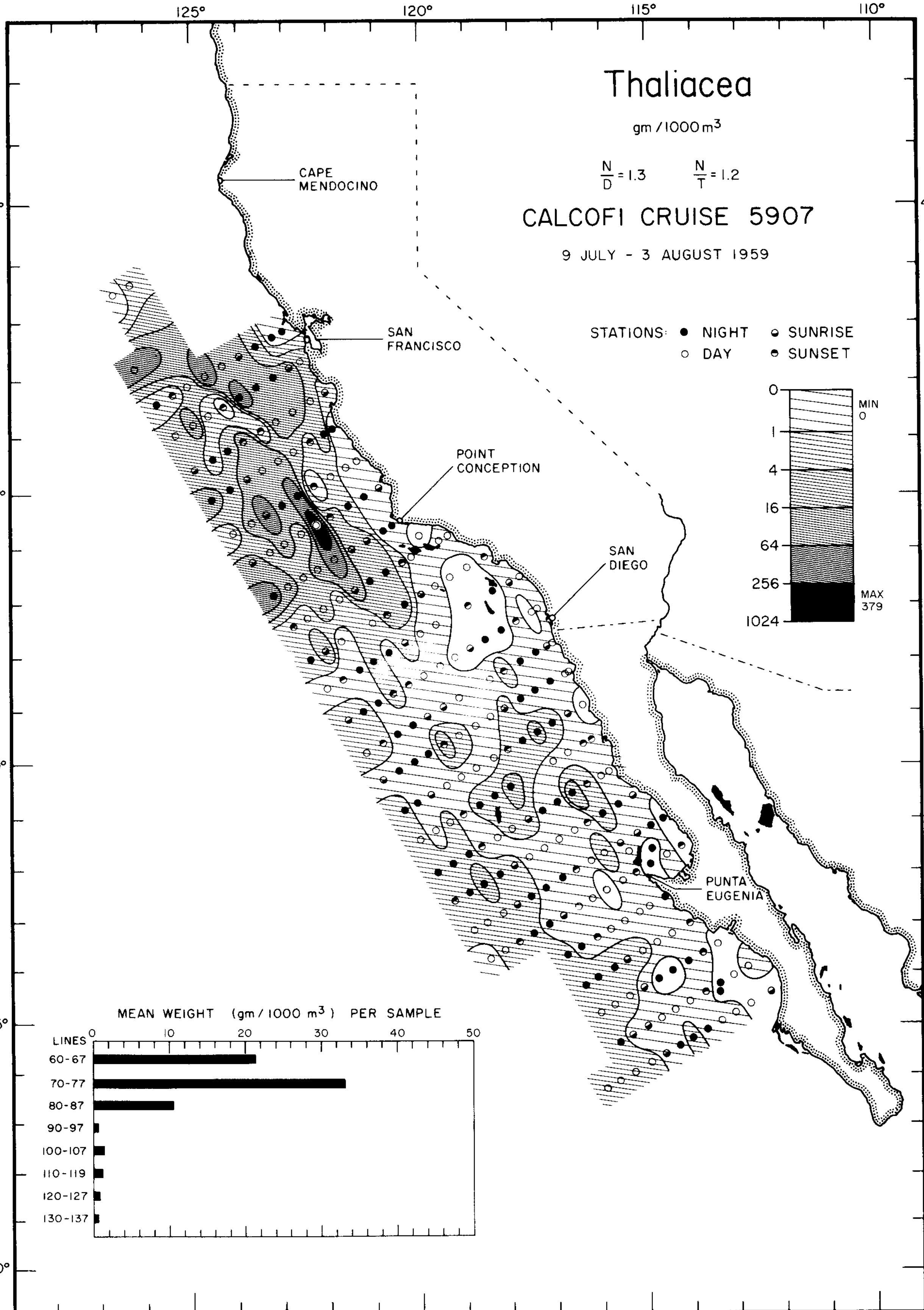

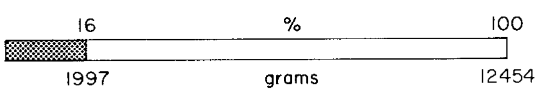

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Thaliacea

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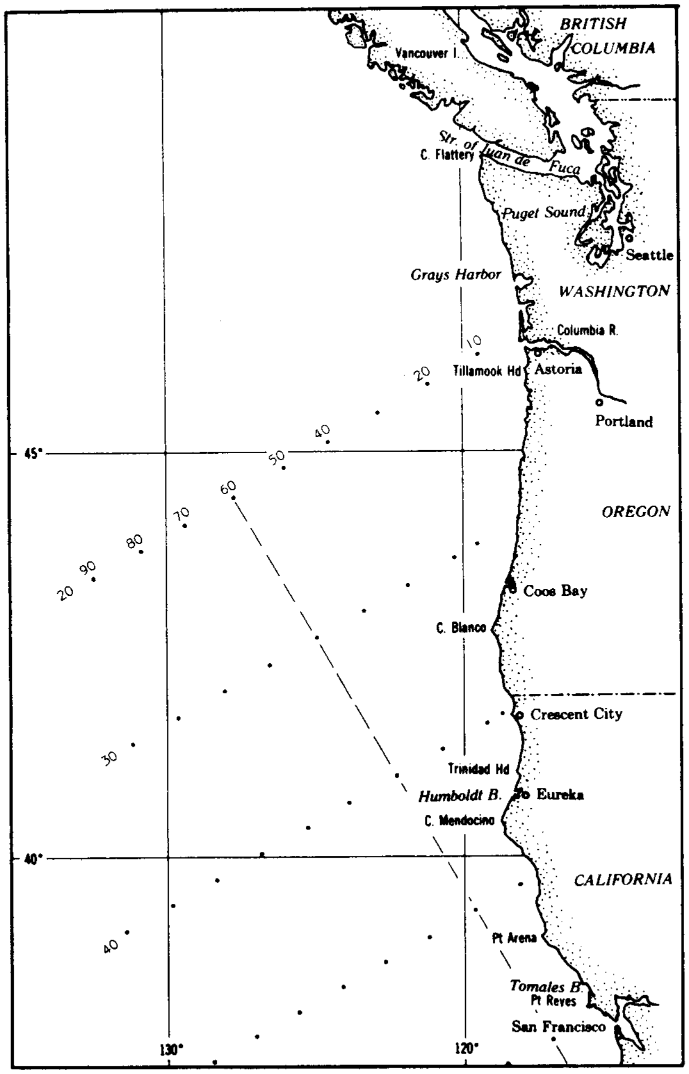

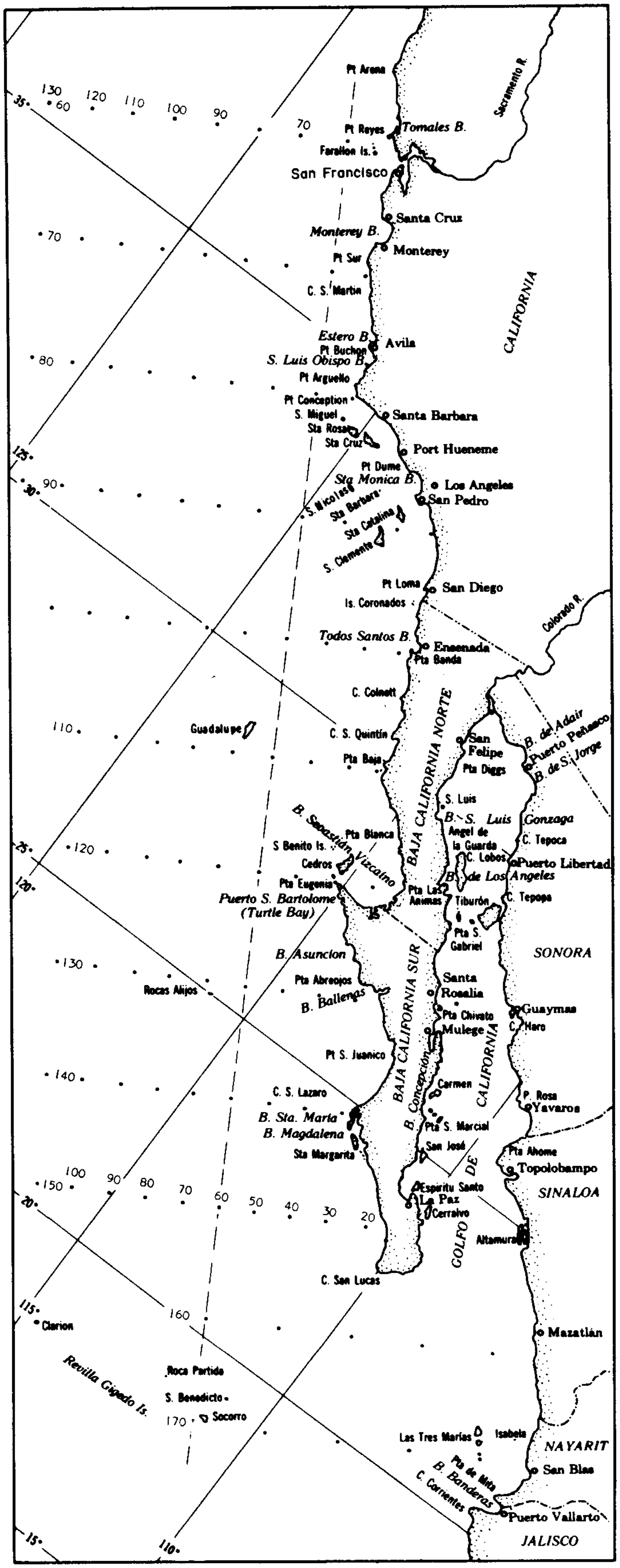

These maps are designed to show essential details of the area most intensively studied by the California Cooperative Oceanic Fisheries Investigations. This is approximately the same area as is shown in color on the front cover. Geographical place names are those most commonly used in the various publications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

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

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