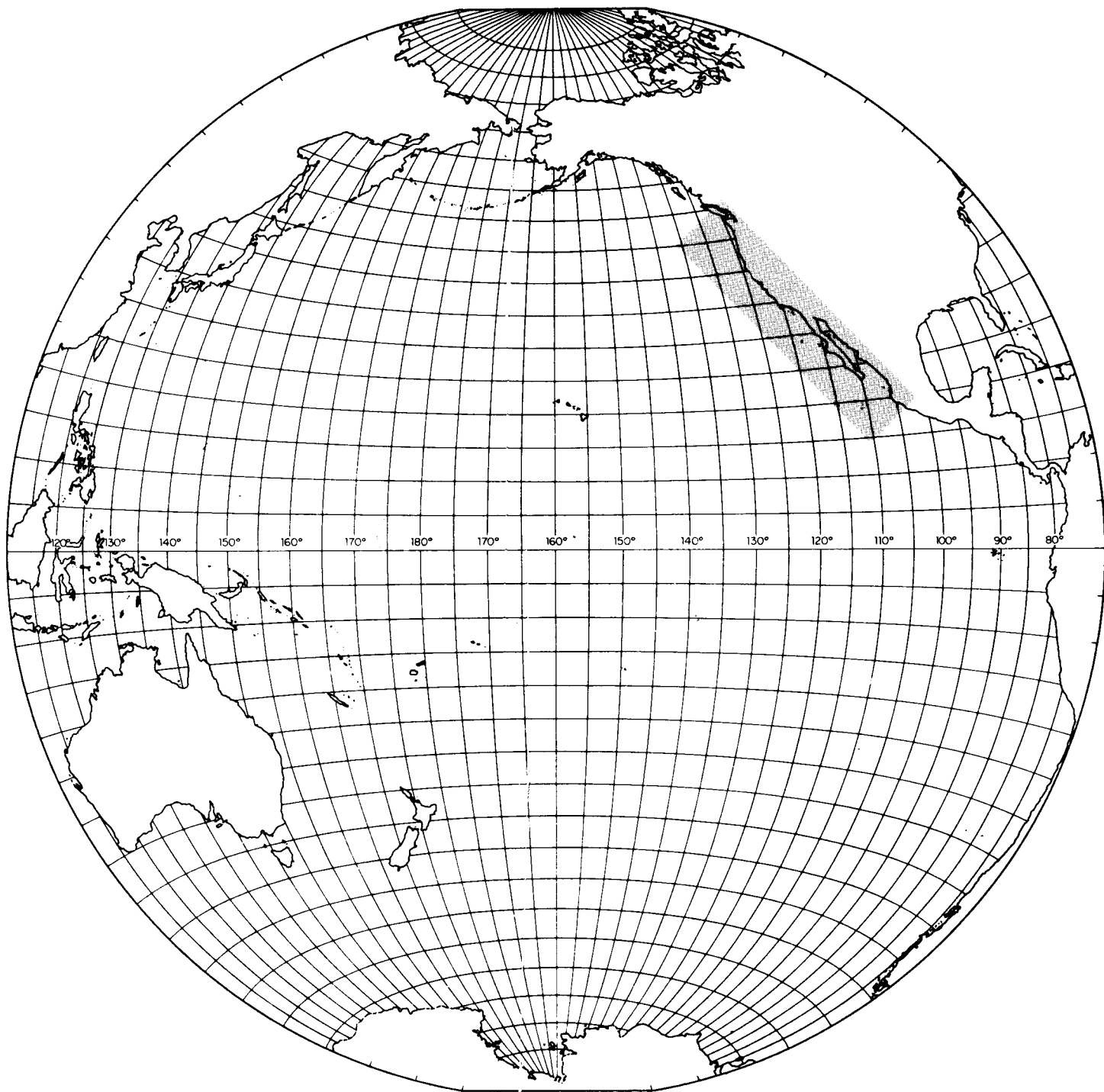
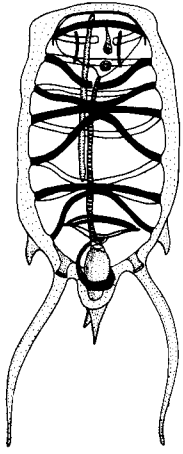


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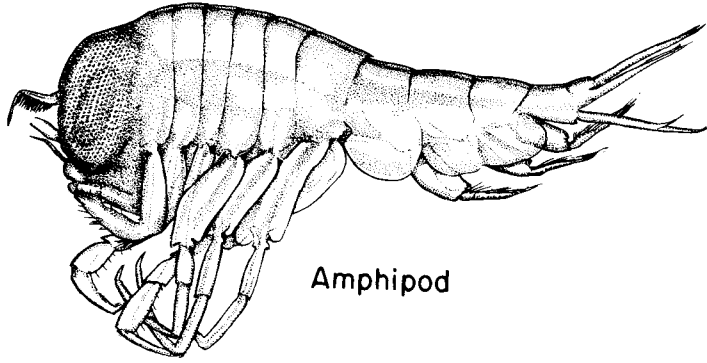


# **CALIFORNIA COOPERATIVE OCEANIC FISHERIES INVESTIGATIONS**

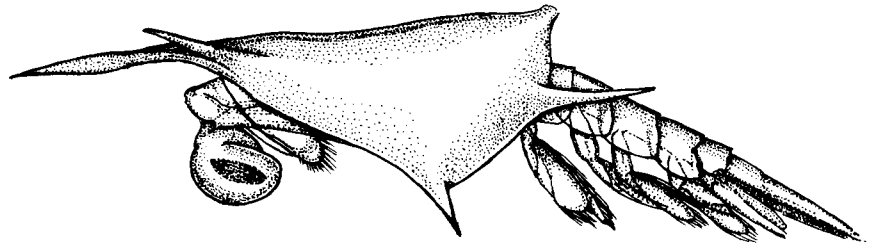
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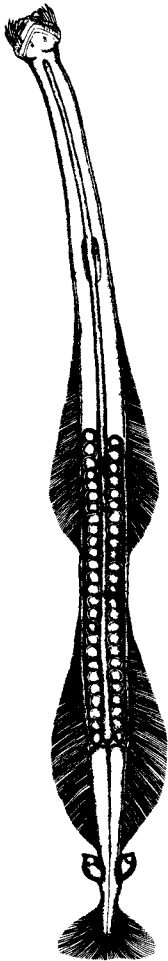
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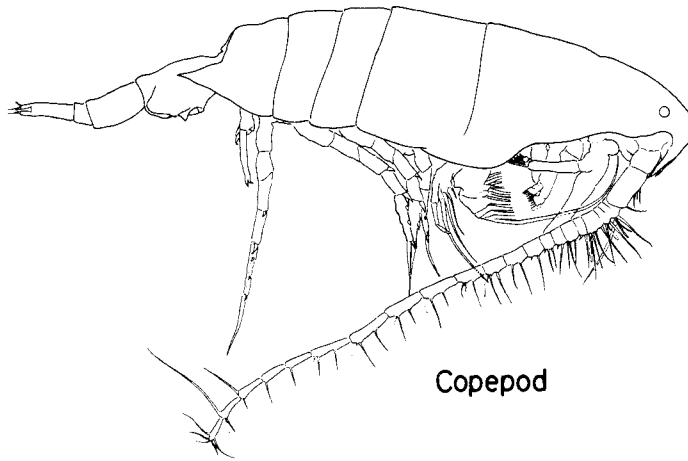
Amphipod



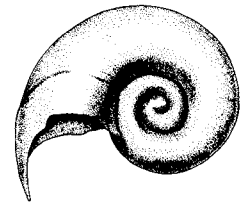
Crustacean larva



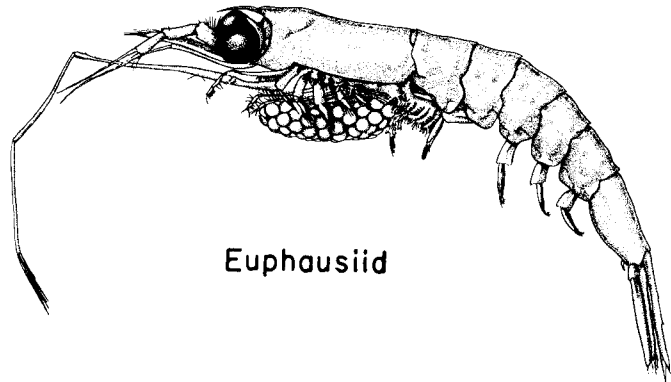
Chaetognath



Copepod



Pteropod



Euphausiid

CALIFORNIA  
COOPERATIVE  
OCEANIC  
FISHERIES  
INVESTIGATIONS

*Atlas No. 21*

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, NATIONAL MARINE FISHERIES SERVICE  
UNIVERSITY OF CALIFORNIA, SCRIPPS INSTITUTION OF OCEANOGRAPHY

June, 1974

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## 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,<sup>1</sup> 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<sup>2</sup>  
University of California, Scripps Institution of Oceanography

CalCOFI atlases<sup>3</sup> 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.
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- No. 13. Smith, P. E., 1971. Distributional atlas of zooplankton volume in the California Current region, 1951 through 1966.
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- 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 Fleming, 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.

<sup>1</sup> Usually abbreviated CalCOFI, sometimes CALCOFI or CCOFI.

<sup>2</sup> Formerly called U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries.

<sup>3</sup> 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**

**A. Fleminger and J. G. Wyllie, Editors  
Data Collection and Processing Group  
Marine Life Research Program  
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La Jolla, California  
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A. Fleminger, J.D. Isaacs, and J.G. Wyllie<sup>1</sup>

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Chaetognatha . . . . .	17
Cladocera . . . . .	22
Copepoda . . . . .	27
Crustacean larvae . . . . .	34
Ctenophora . . . . .	40
Decapoda . . . . .	45
Euphausiacea . . . . .	55
Heteropoda . . . . .	65
Larvacea . . . . .	71
Medusae . . . . .	76
Mysidacea . . . . .	81
Ostracoda . . . . .	86
Pteropoda . . . . .	96
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**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 vertical 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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**Table 1.** Number of standard CalCOFI zooplankton samples from July cruises processed to determine the wet weight per 1000m<sup>3</sup> of each functional group.

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

### 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<sup>3</sup> 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-



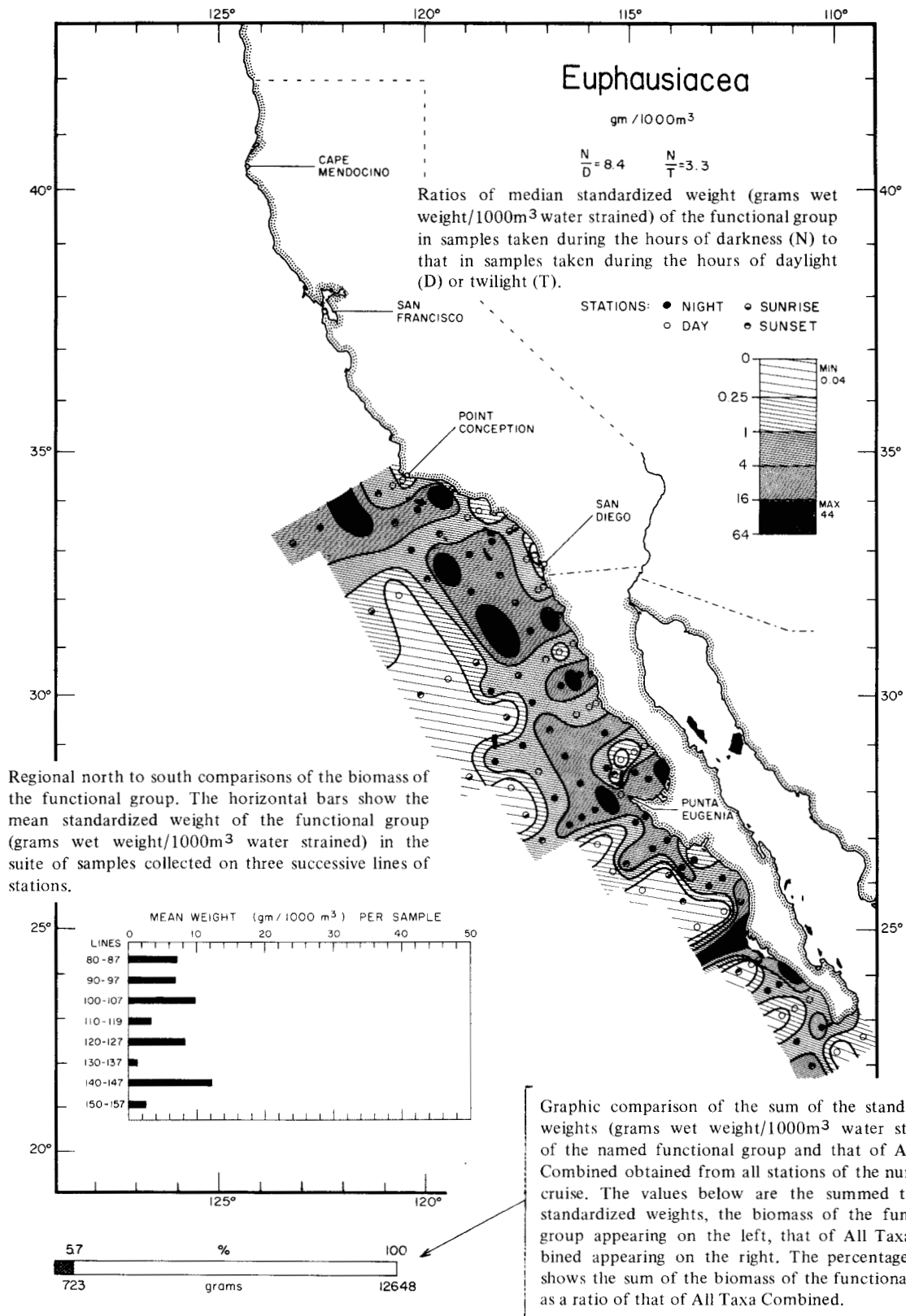
**Table 2.** List of charts.

Cruise Number	Summer				
	5507	5607	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

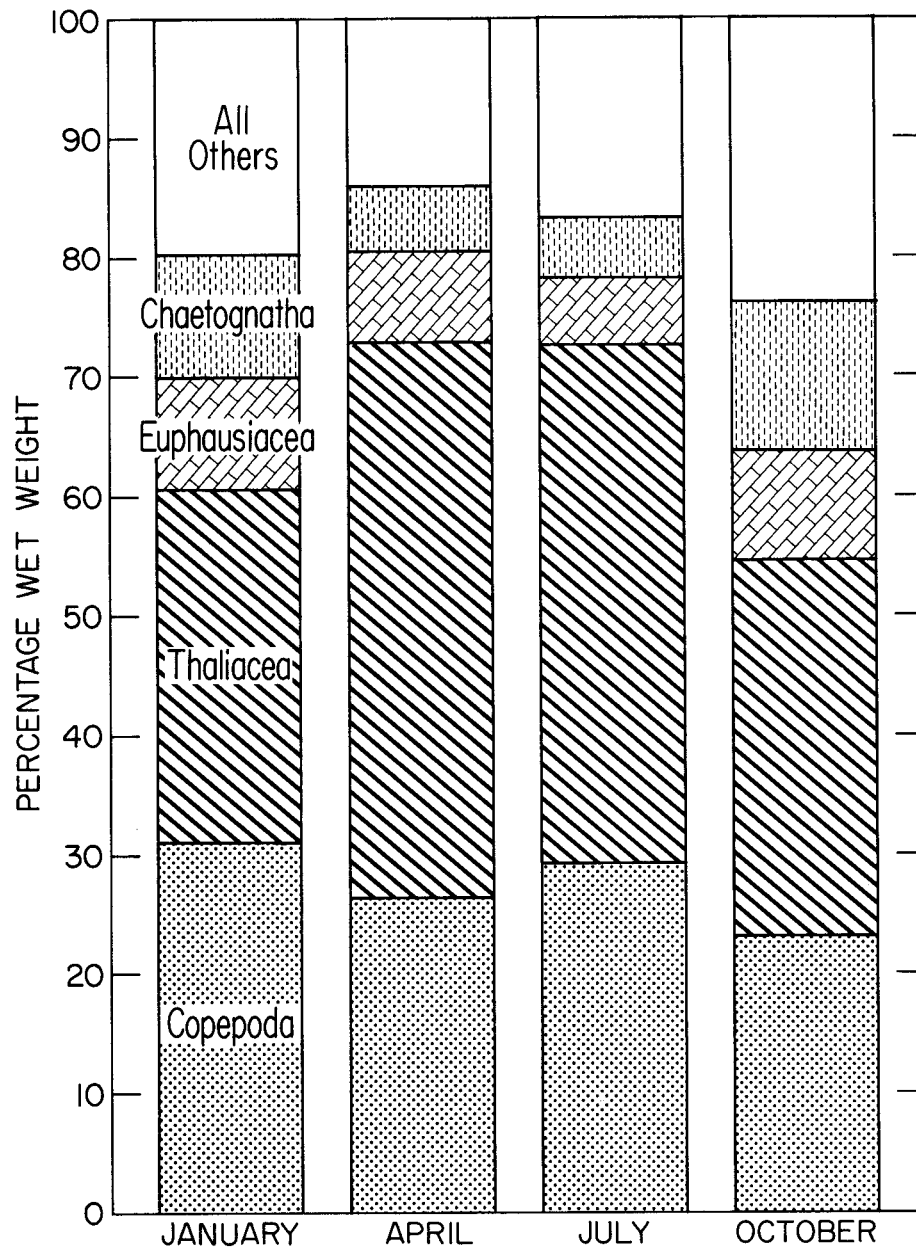
dominantly different though sometimes overlapping distributions. Large concentrations of thaliaceans are more frequently offshore, dominating the western and northern margins of cruises (Fig. 5). Large concentrations of copepods most frequently cluster near shore, particularly south of Point Conception.

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 ( $>20\mu\text{m}$ , the net phytoplankton; Frost, 1974). Thaliaceans are non-selective filter-feeders consuming a broad spectrum of micro-organisms from less than  $1\mu\text{m}$  to greater than 1 mm (Madin, 1974). The ability of adult and juvenile thaliaceans to harvest the smallest planktonic forms ( $\leq 20\mu\text{m}$ , the nanoplankton) is particularly interesting. The biomass of nanoplankton 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.

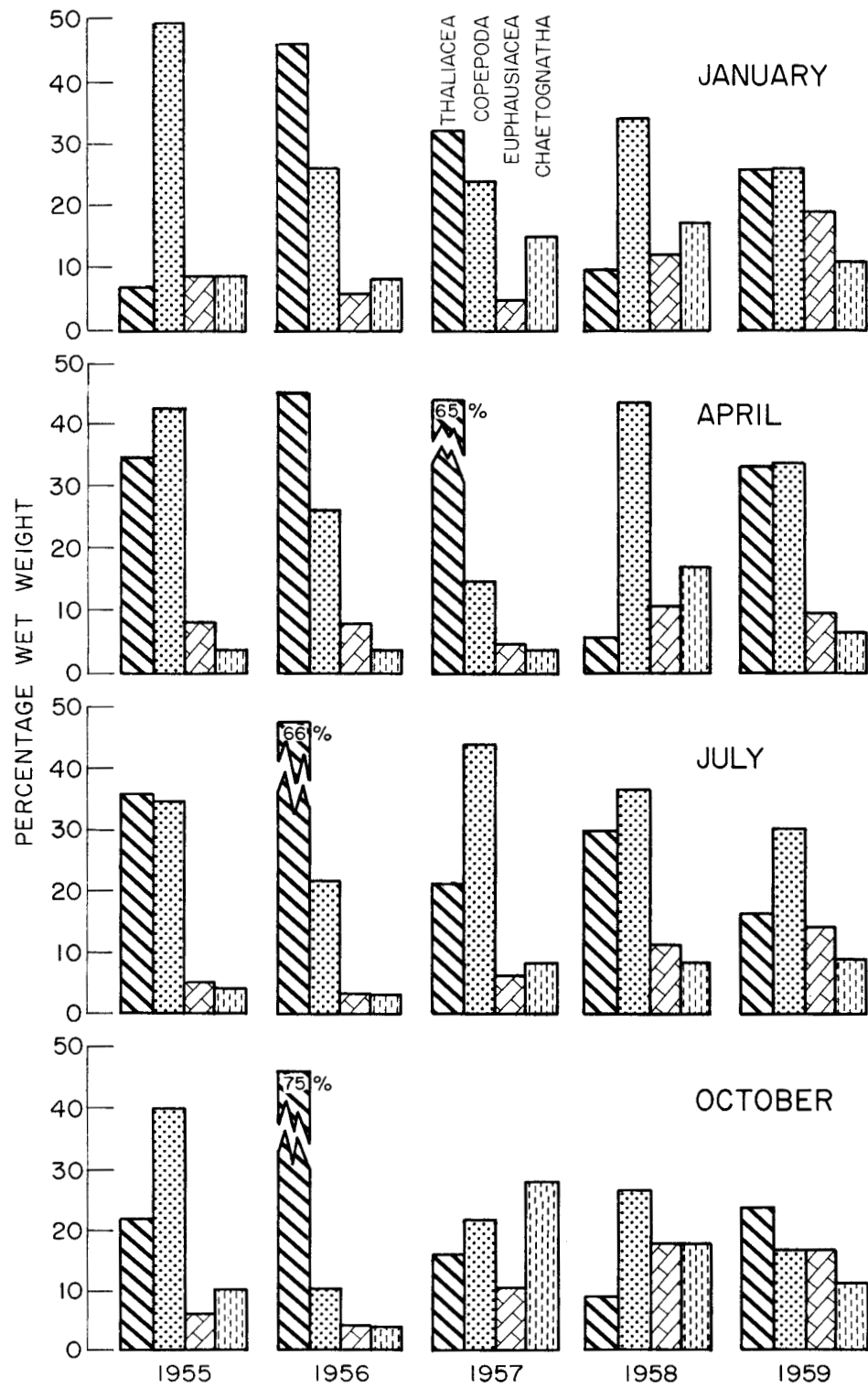


Figure 3. Percentage wet weight of functional groups by month and year.

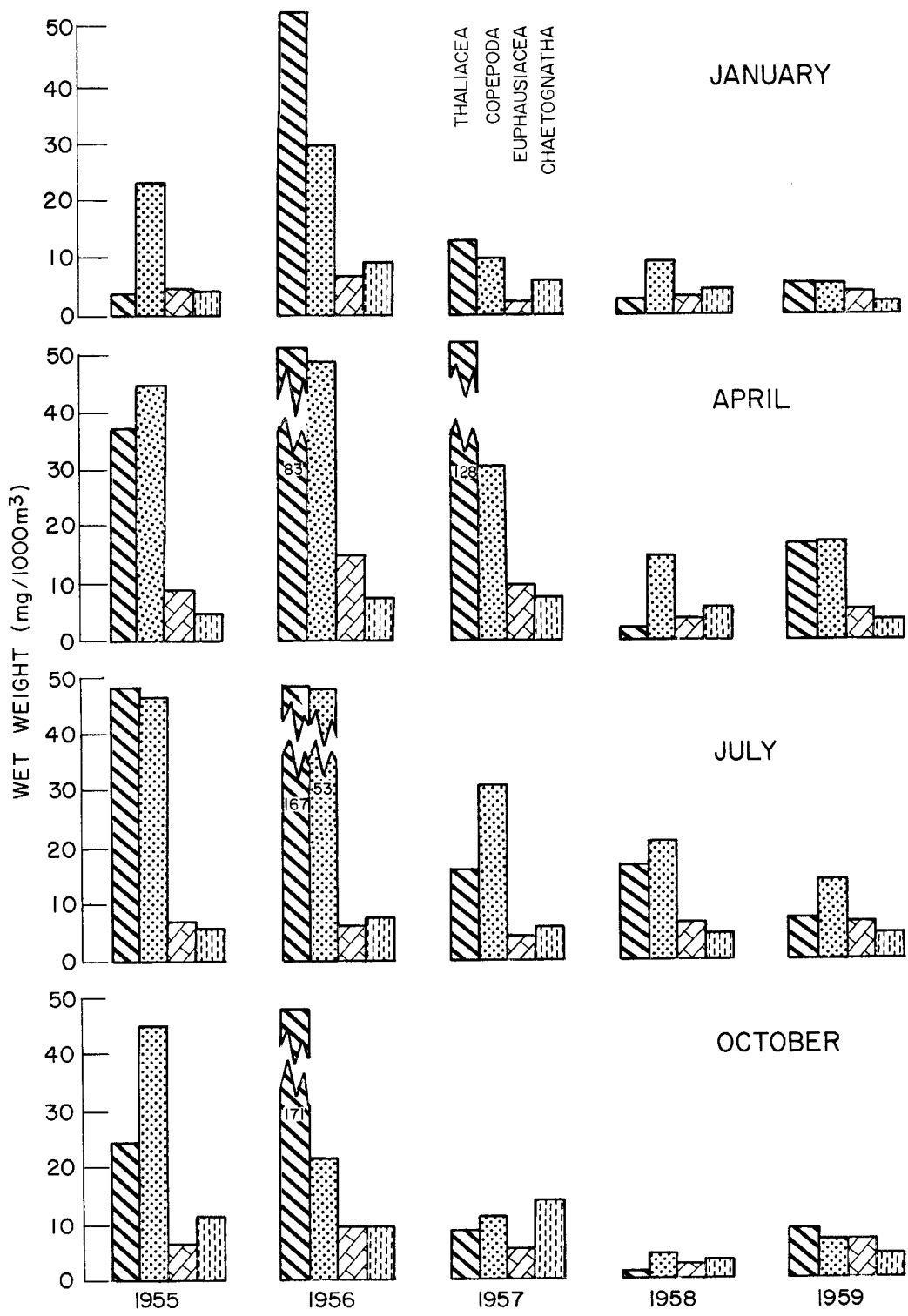


Figure 4. Mean biomass (mg/1000m<sup>3</sup>) of functional groups by month and year.

# THALIACEA

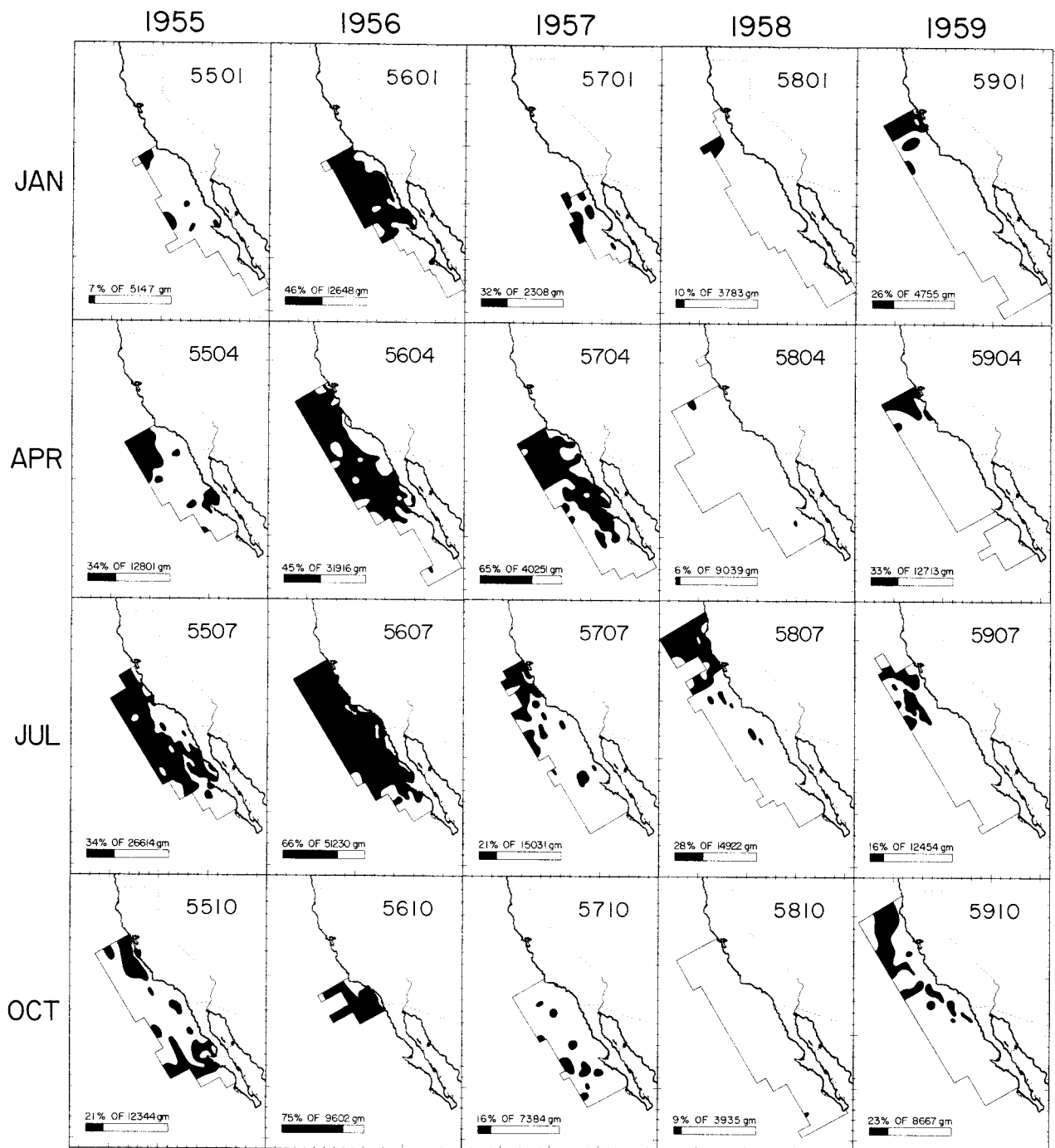
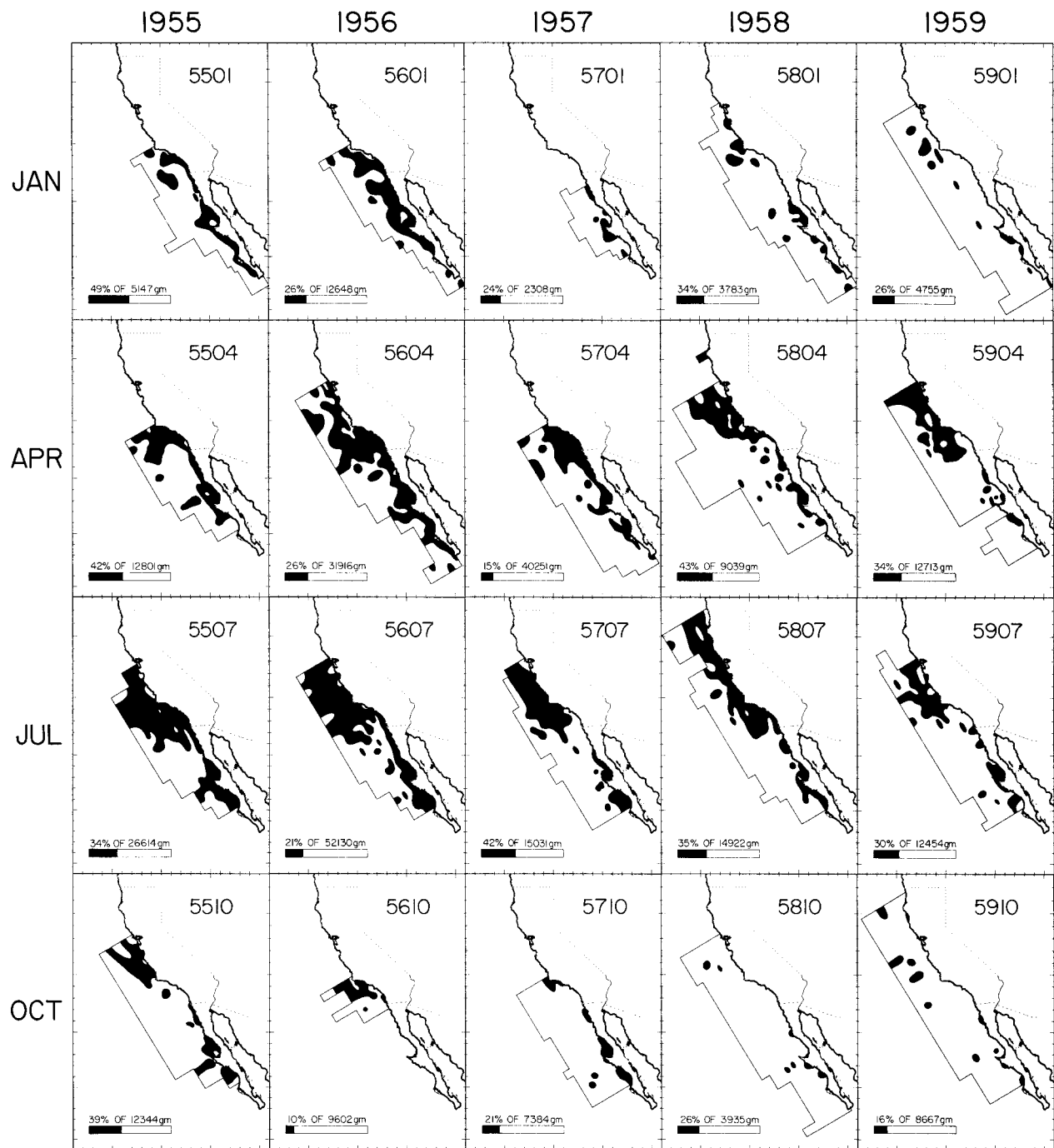


Figure 5. Blackened regions show occurrence of *Thalassia* at or above  $16\text{mg}/1000\text{m}^3$ . Area sampled by cruise delineated by thin line.

# COPEPODA



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

pete with a larger biomass of microzooplankton (Beers and Stewart 1967, 1970) for the nanoplankton 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

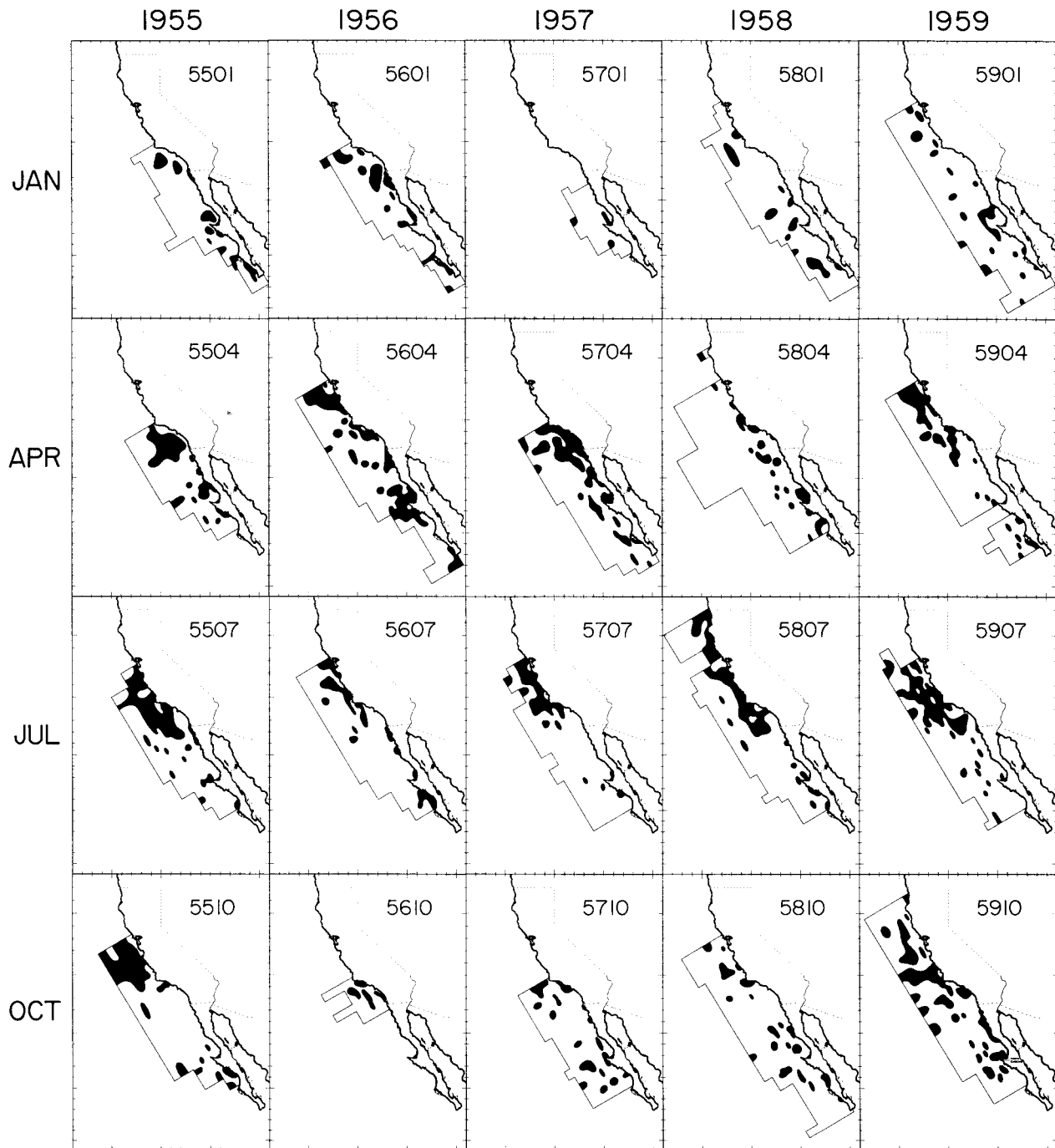
*Sagitta euneritica* and *S. bierii*; thaliaceans are *Salpa fusiformis*, *Thalia democratica* s.l., and *Dolioletta gegenbauri*. Many of these species appear to be indigenous to the temperate North Pacific Ocean and specially adapted to inhabit the temperate segments of this ocean's boundary current. 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

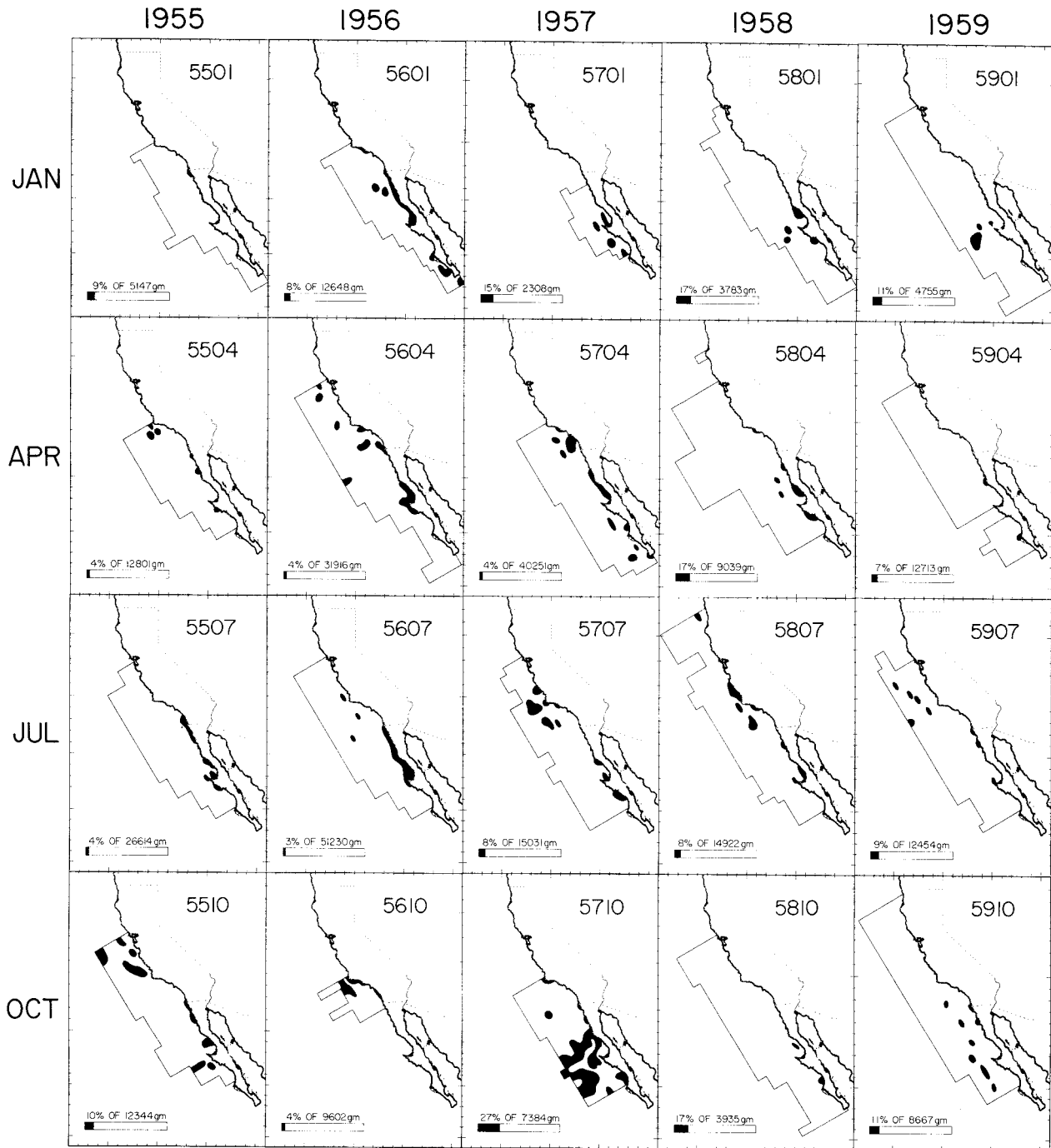


# EUPHAUSIACEA, AJUSTED



**Figure 7.** Blackened regions show occurrence of Euphausiacea (adjusted) at or above 16mg/1000m<sup>3</sup>. Areas 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).

# CHAETOGNATHA



**Figure 8.** Blackened regions show occurrence of Chaetognatha at or above 16mg/1000m<sup>3</sup>. 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 Magdalena 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.

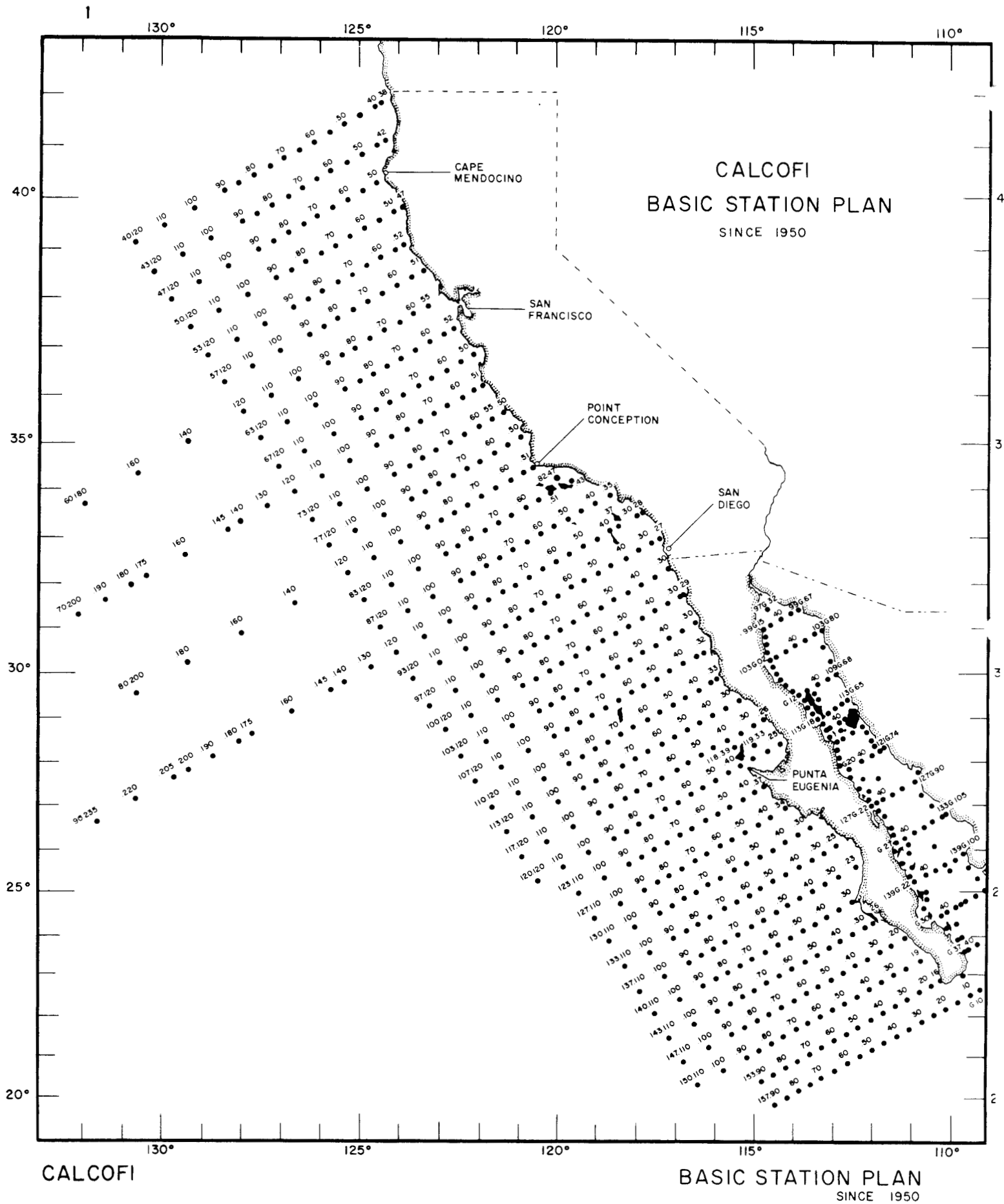
#### Acknowledgements

E. H. Ahlstrom, P. E. Smith and M. M. Mullin read a draft version of this introduction. We thank them for their encouragement and helpful recommendations. Participation of A. Fleminger in this study was partially supported by the National Science Foundation (GB 42521X).

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All Taxa combined

Amphipoda

Chaetognatha

Cladocera

Copepoda

Crustacean larvae

Ctenophora

Decapoda

Euphausiacea

Heteropoda

Larvacea

Medusae

Mysidacea

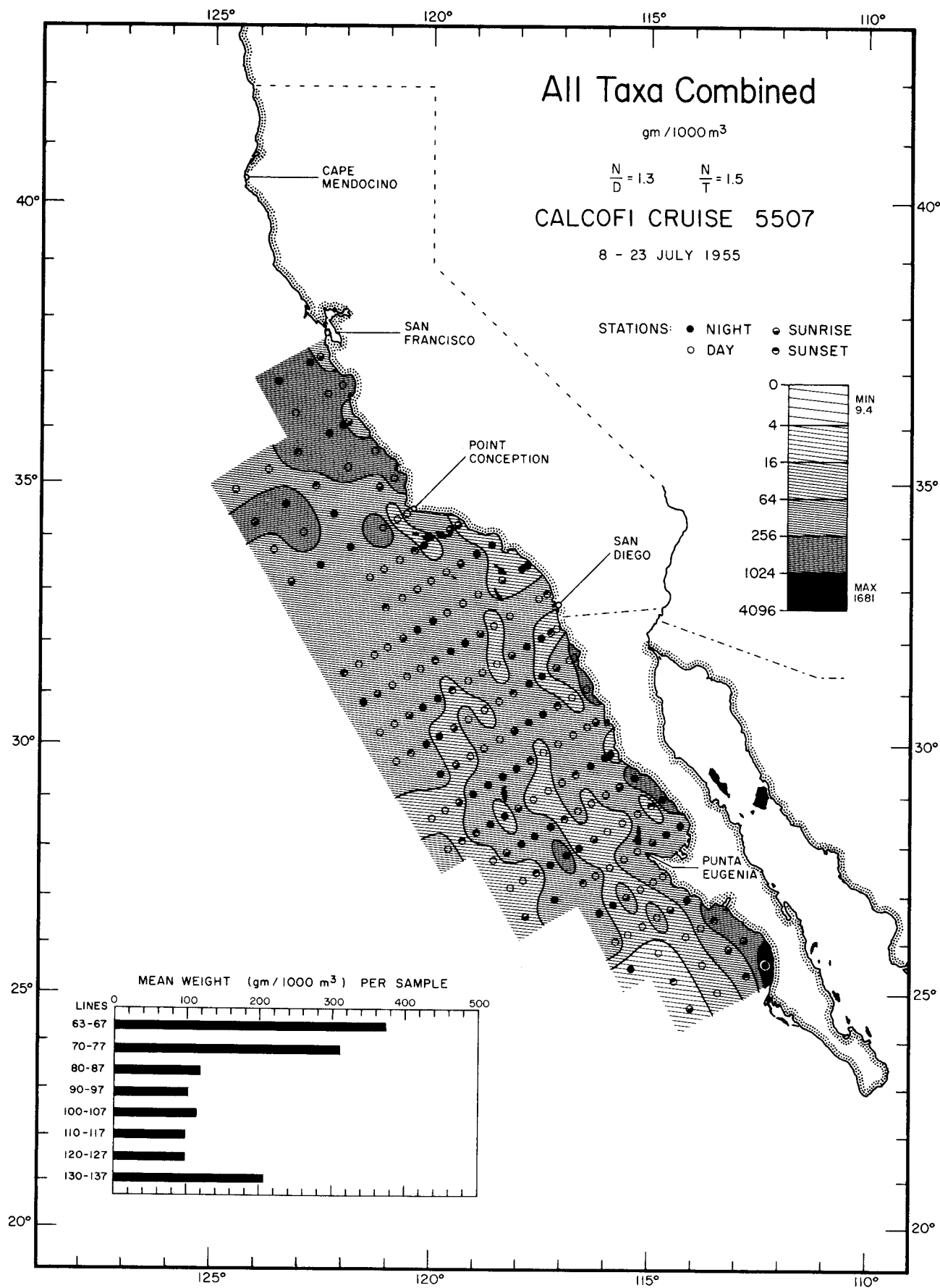
Ostracoda

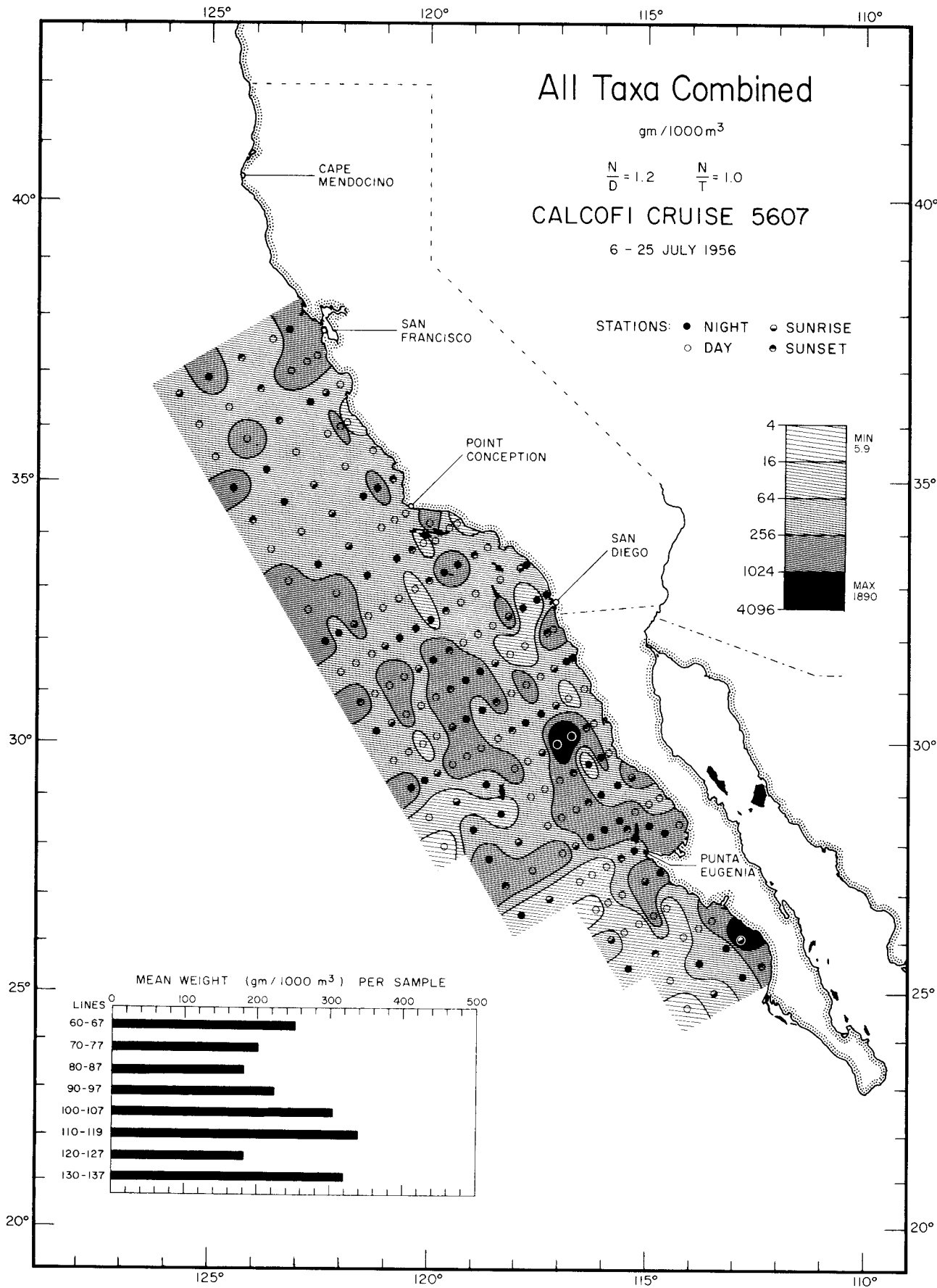
Pteropoda

Radiolaria

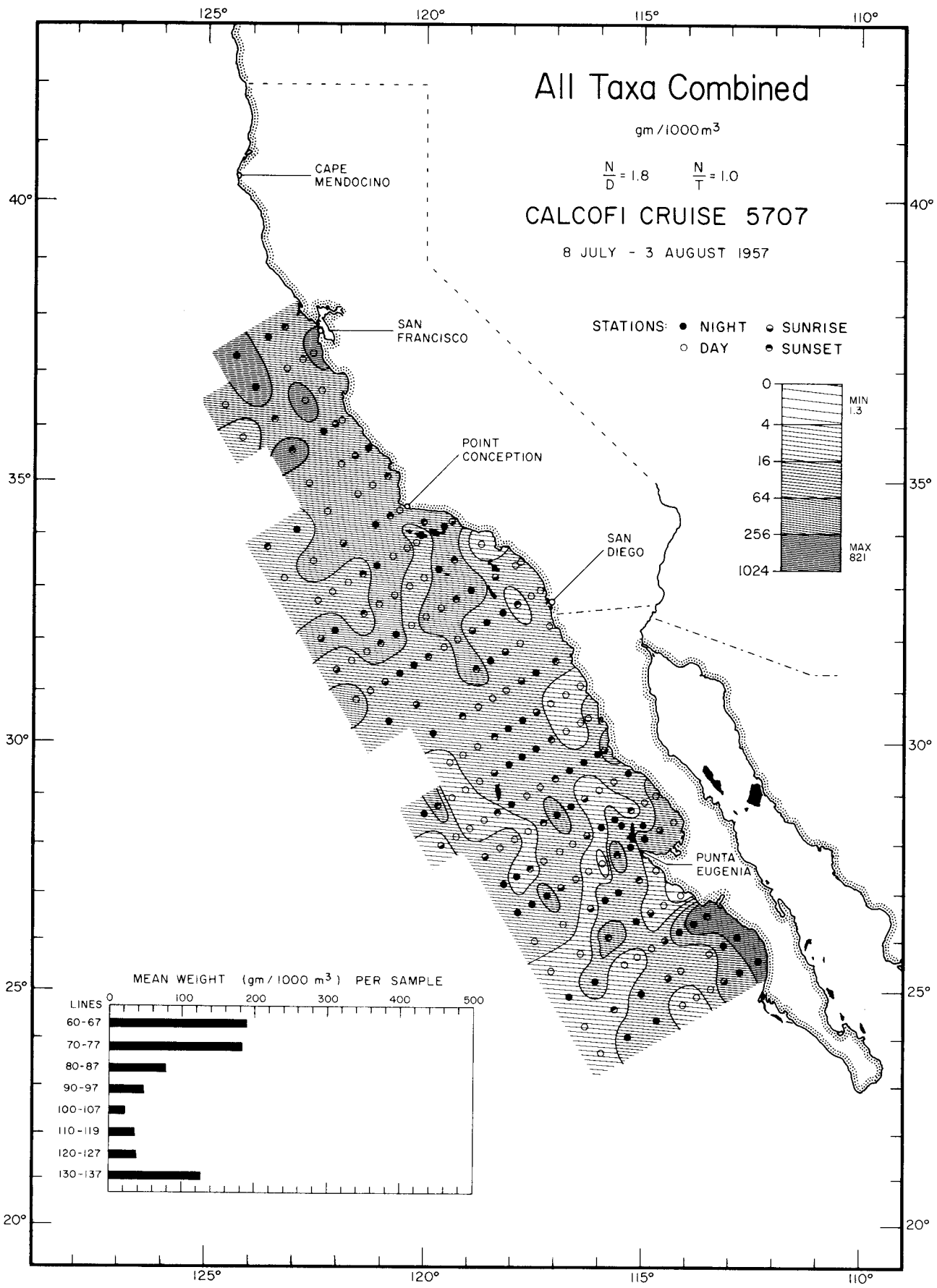
Siphonophora

Thaliacea

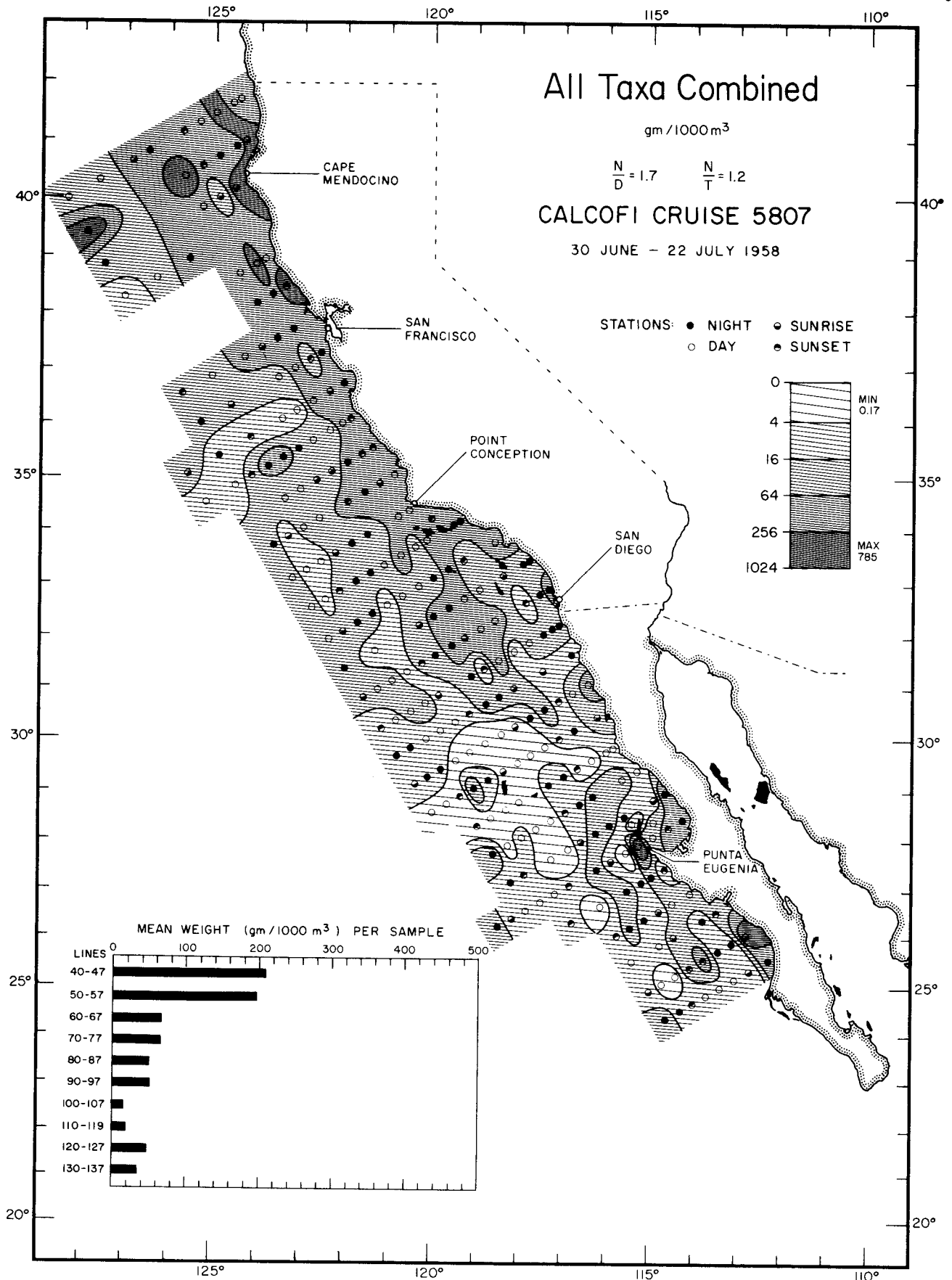




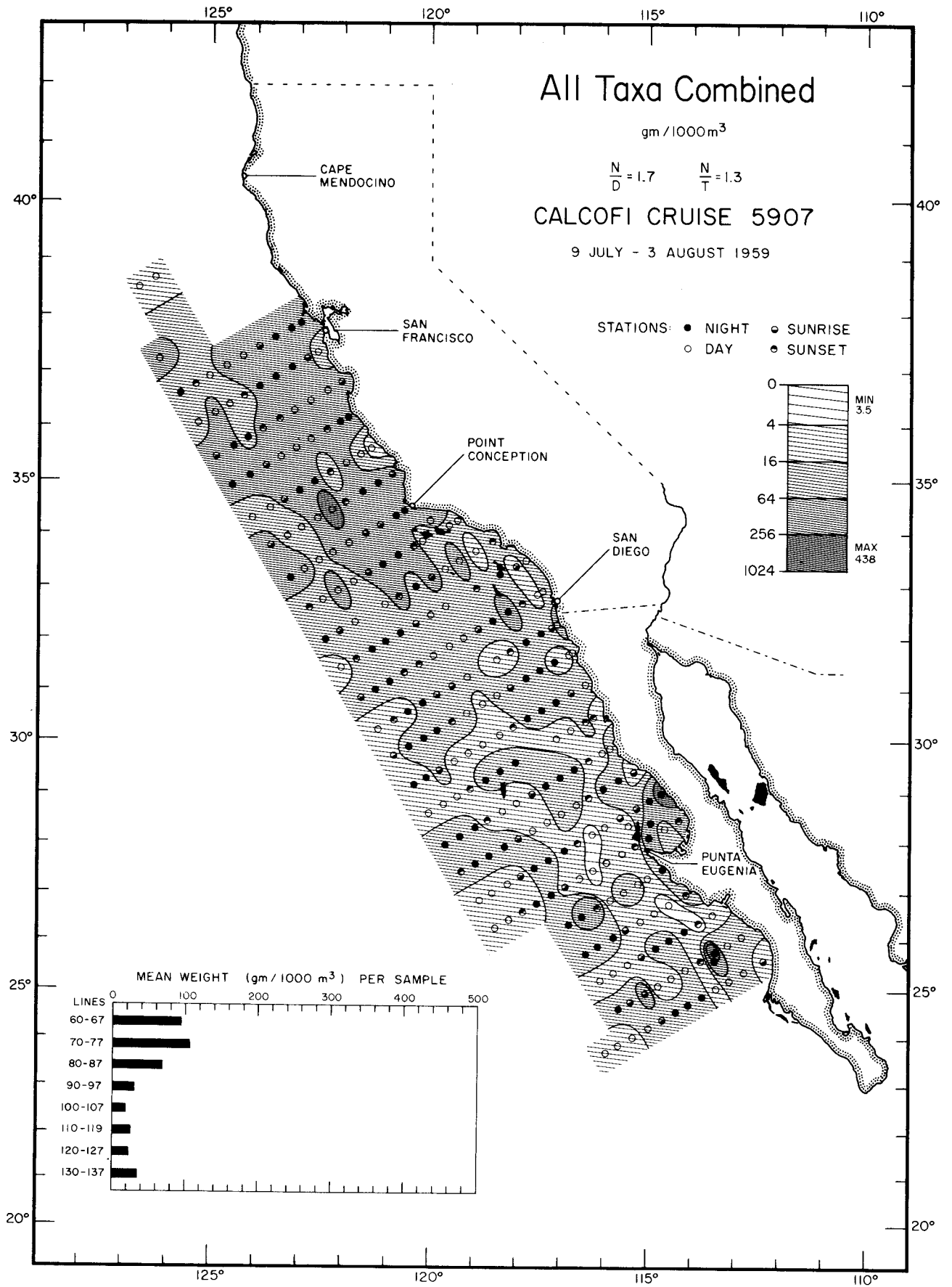




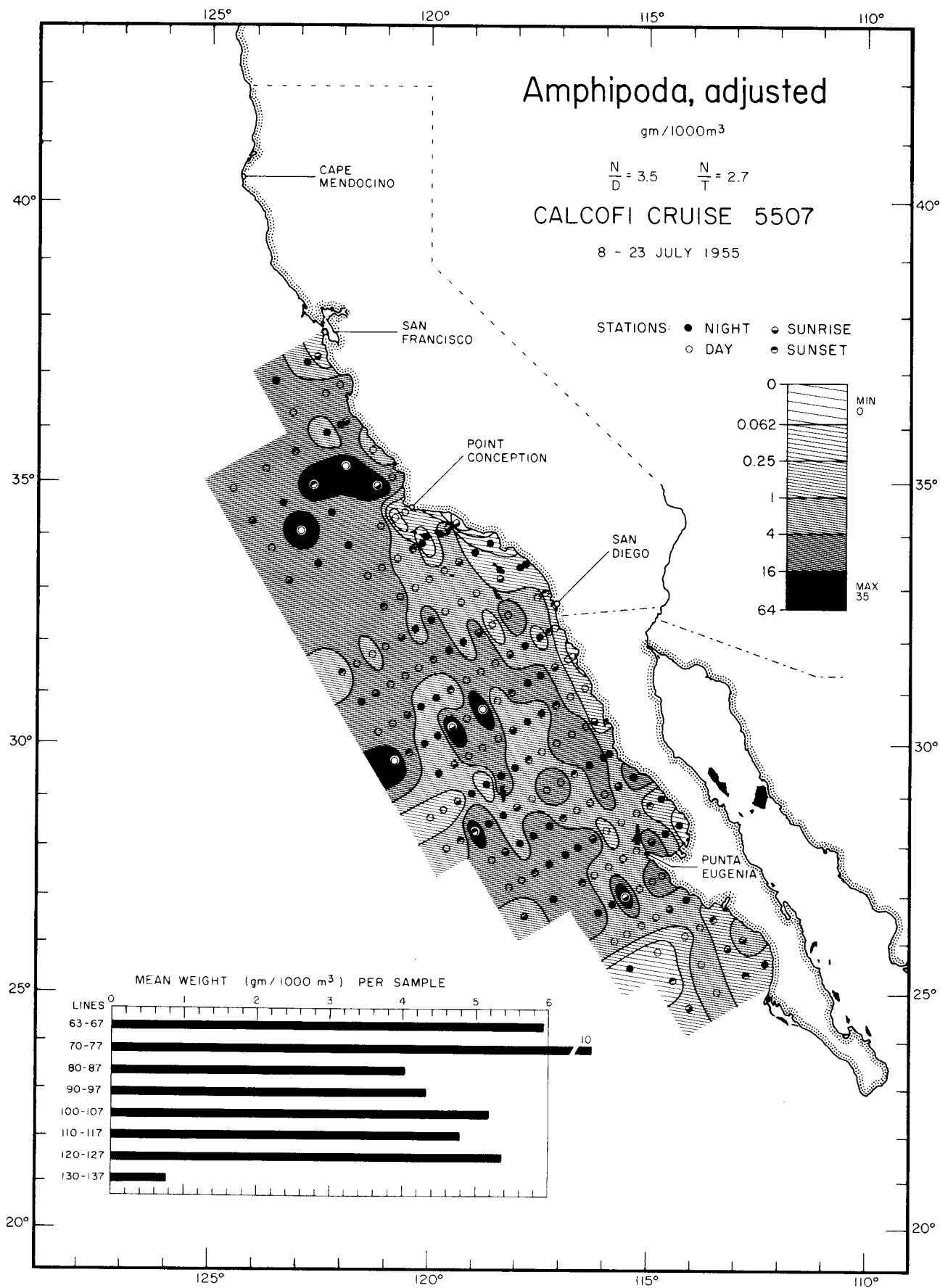
Biomass  
 All Taxa Combined  
 5707



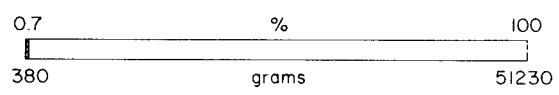
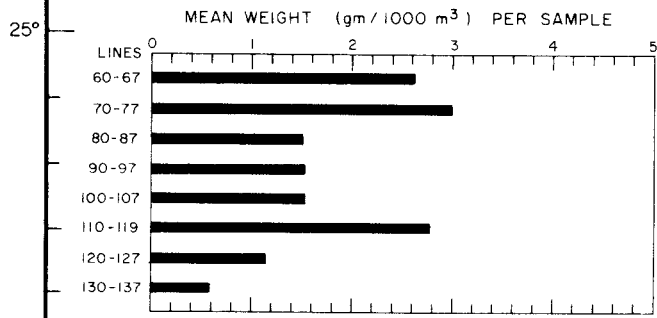
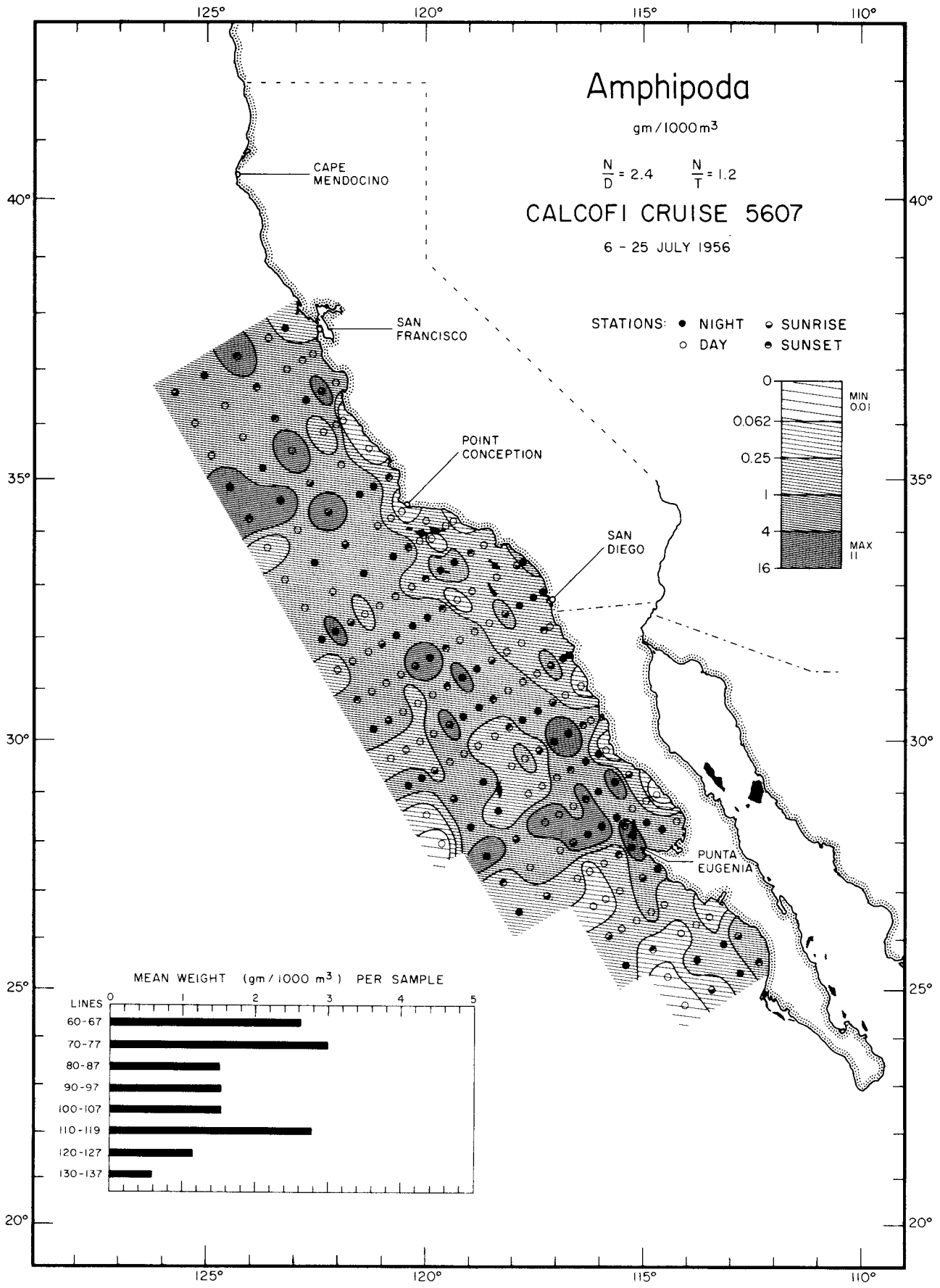
Biomass  
 All Taxa Combined  
 5807



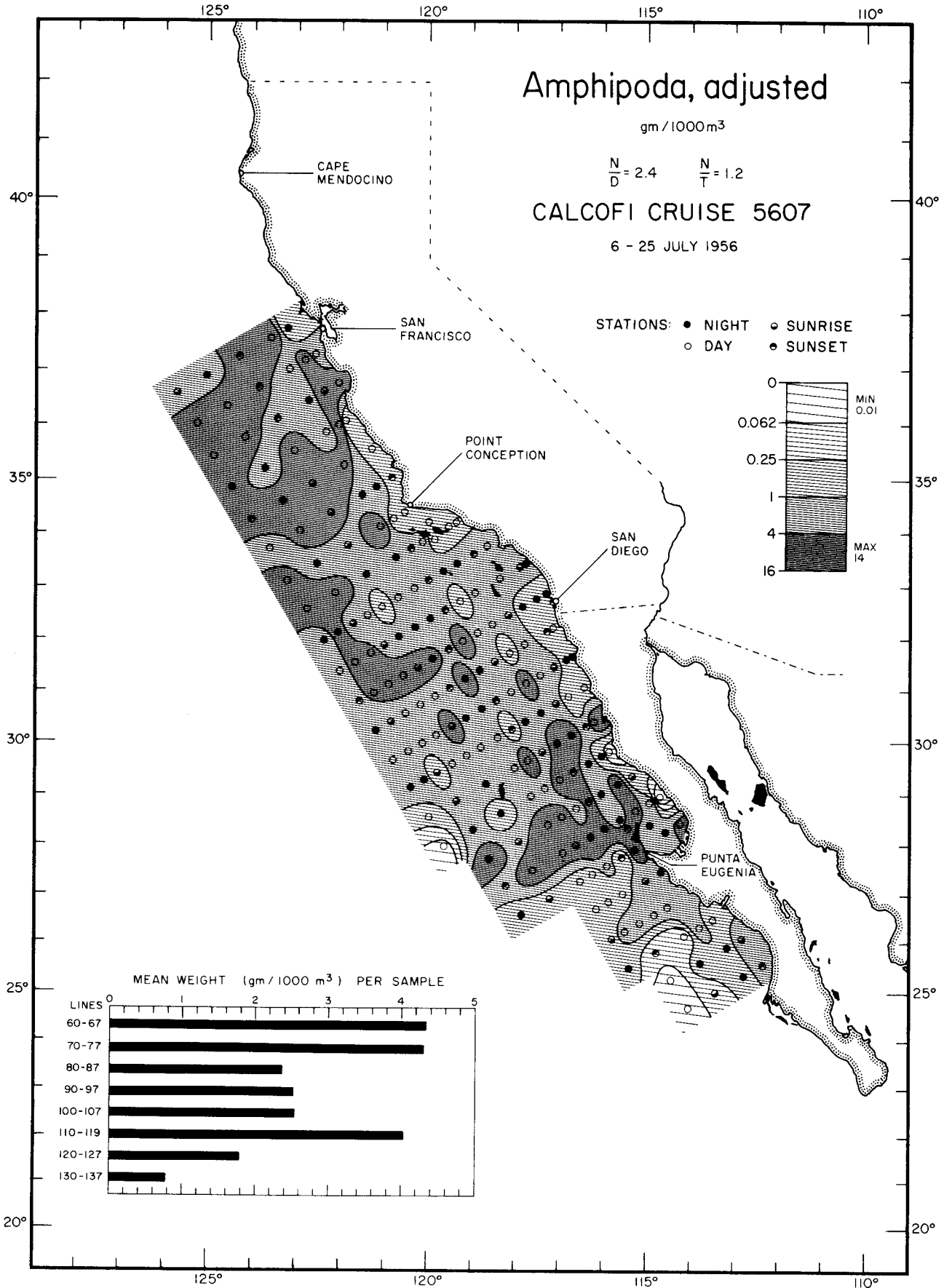




Biomass  
 Amphipoda, adjusted  
 5507



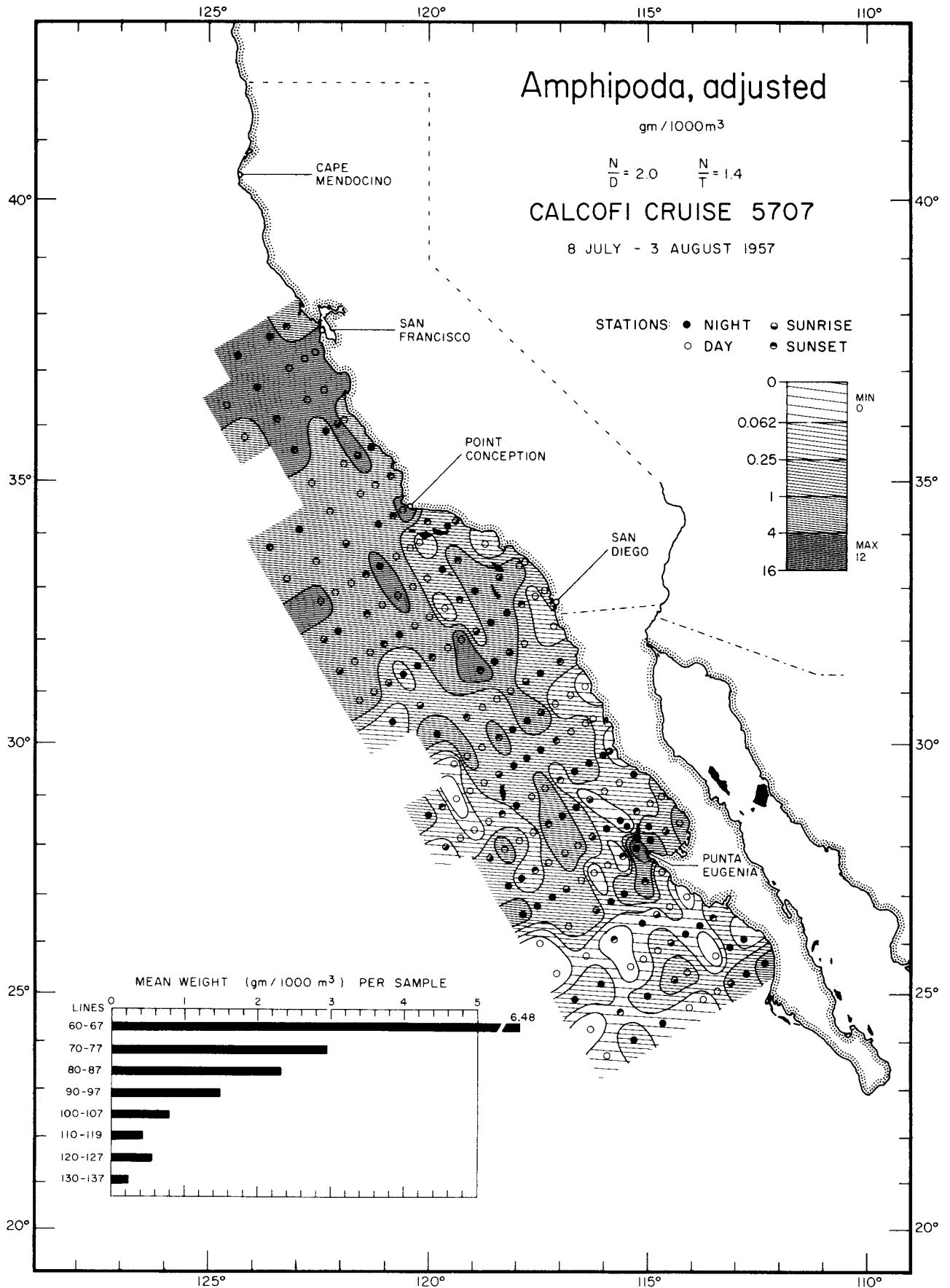
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Amphipoda  
5607



Biomass  
 Amphipoda, adjusted  
 5607

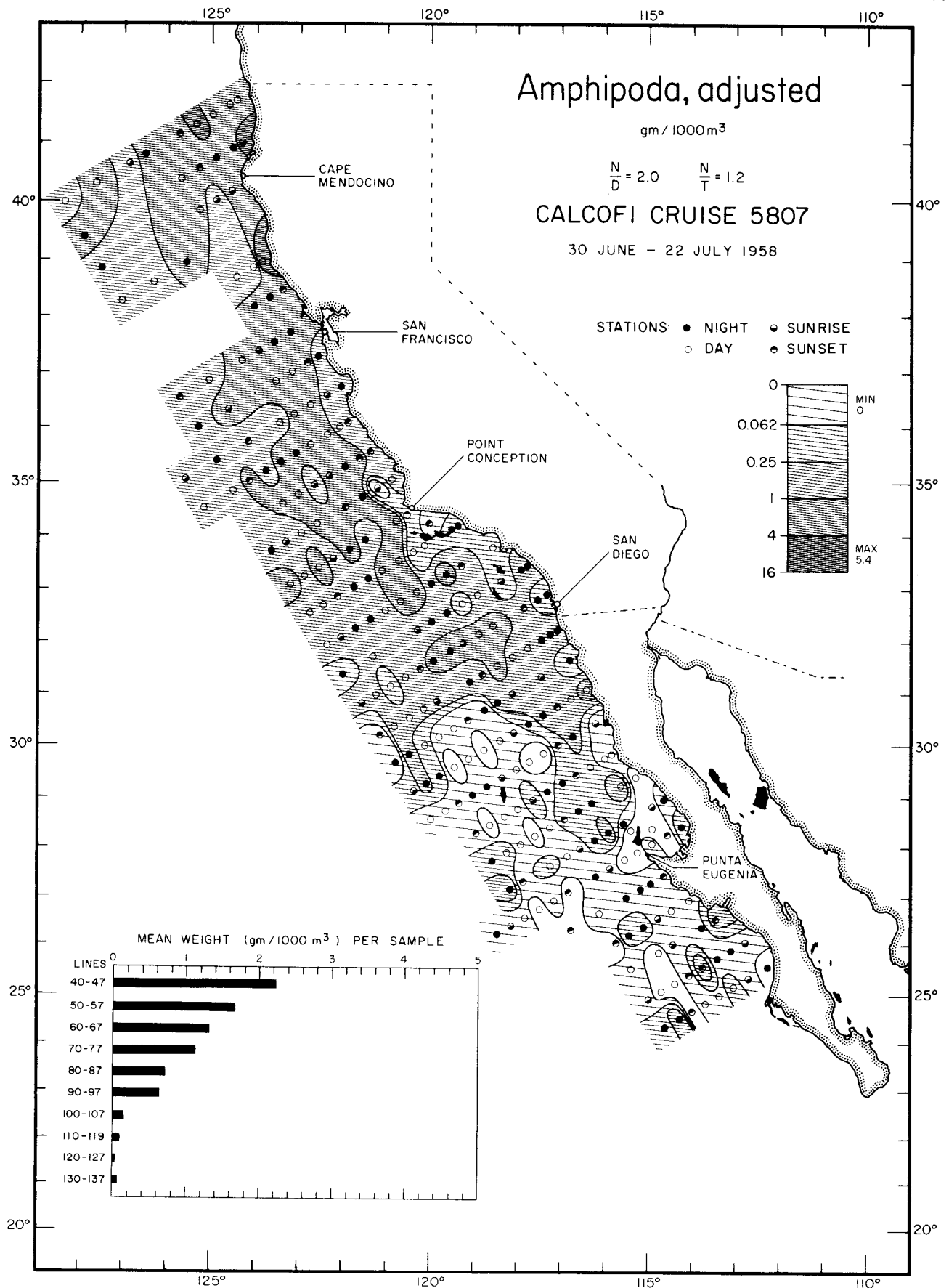




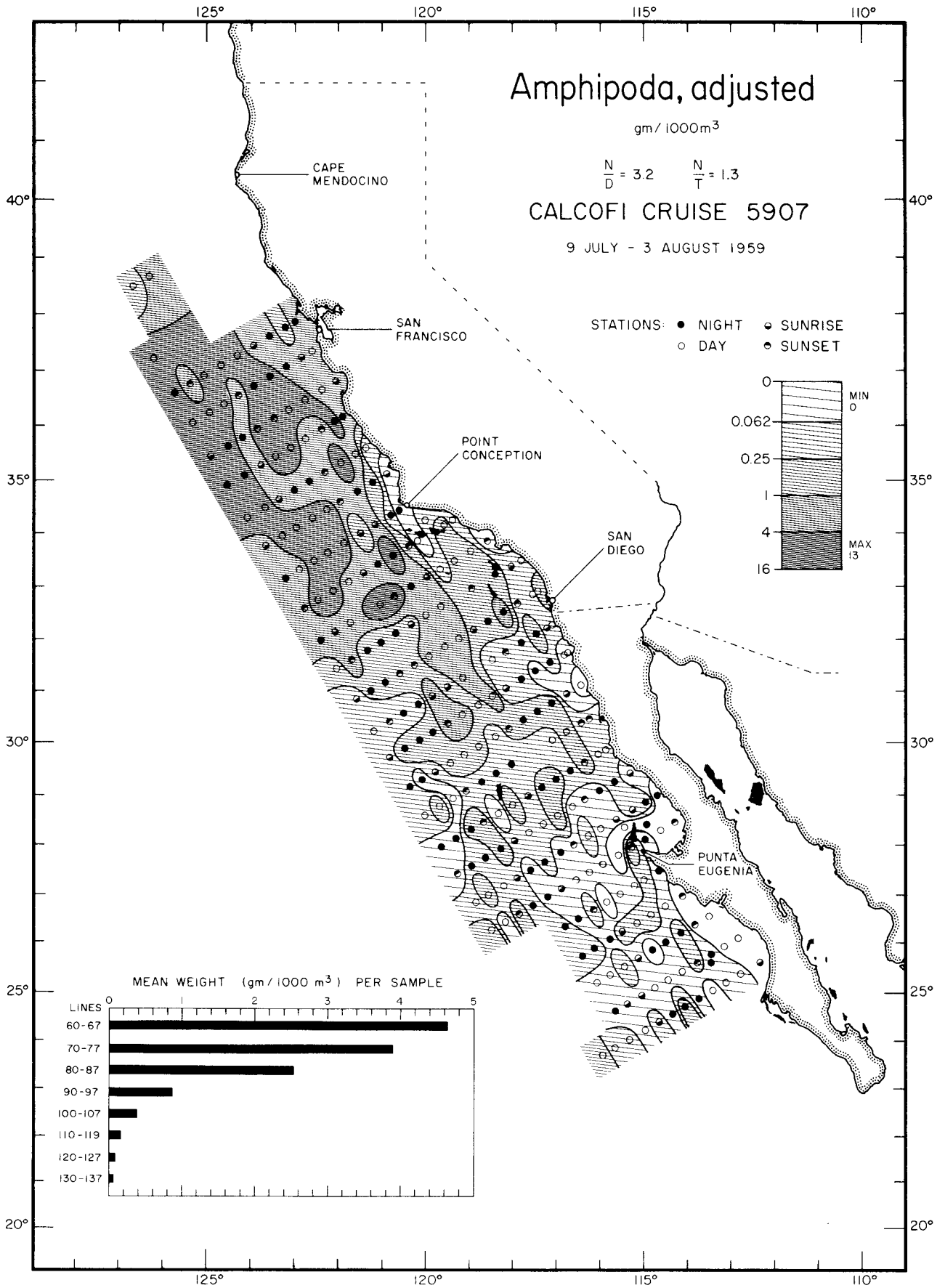


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 Amphipoda, adjusted  
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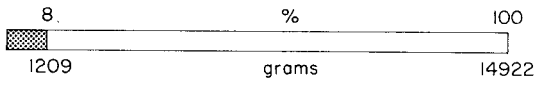
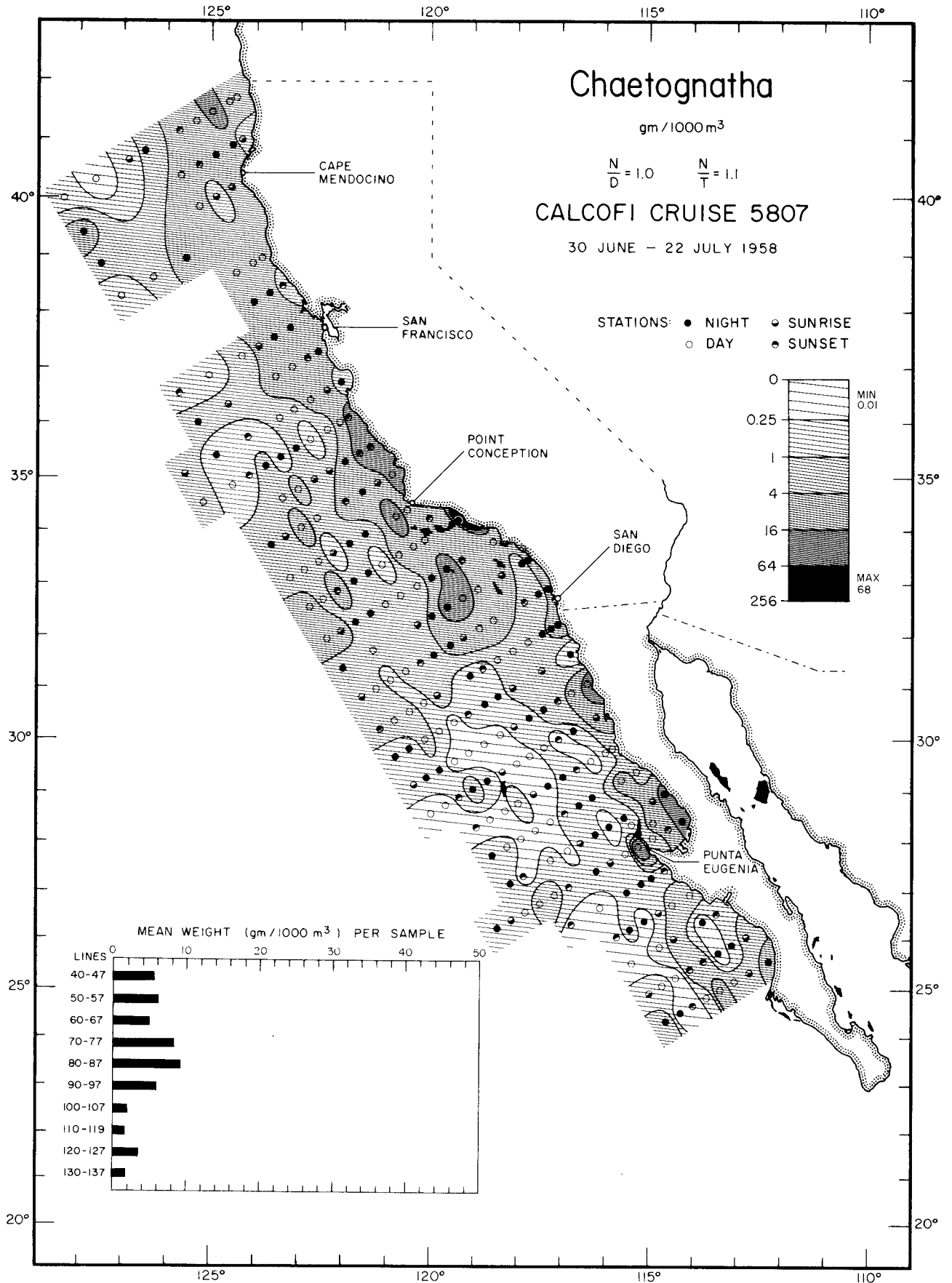




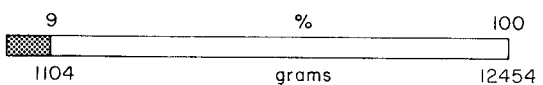
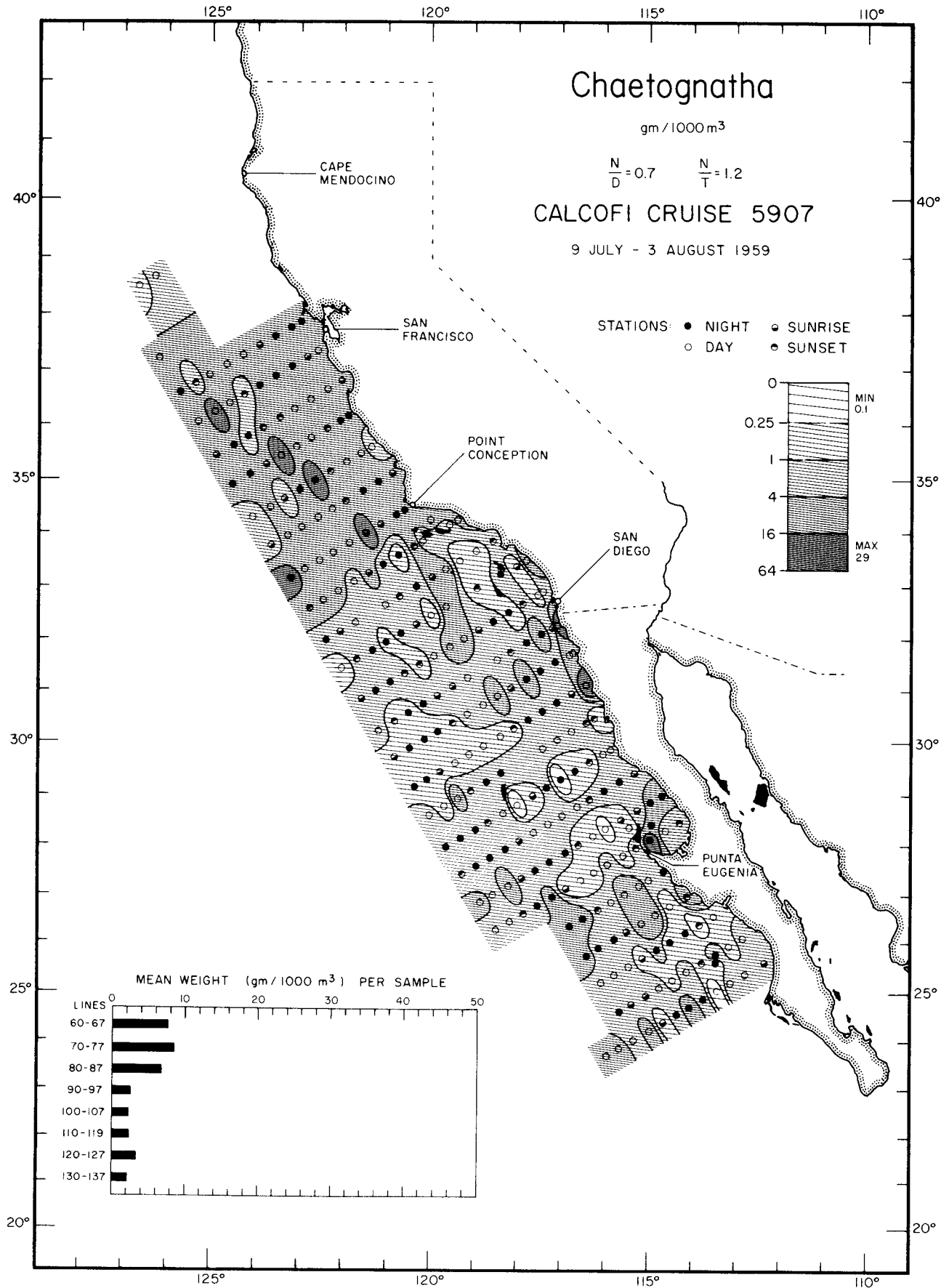




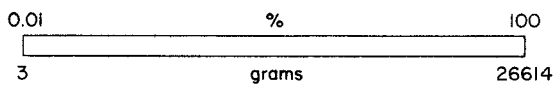
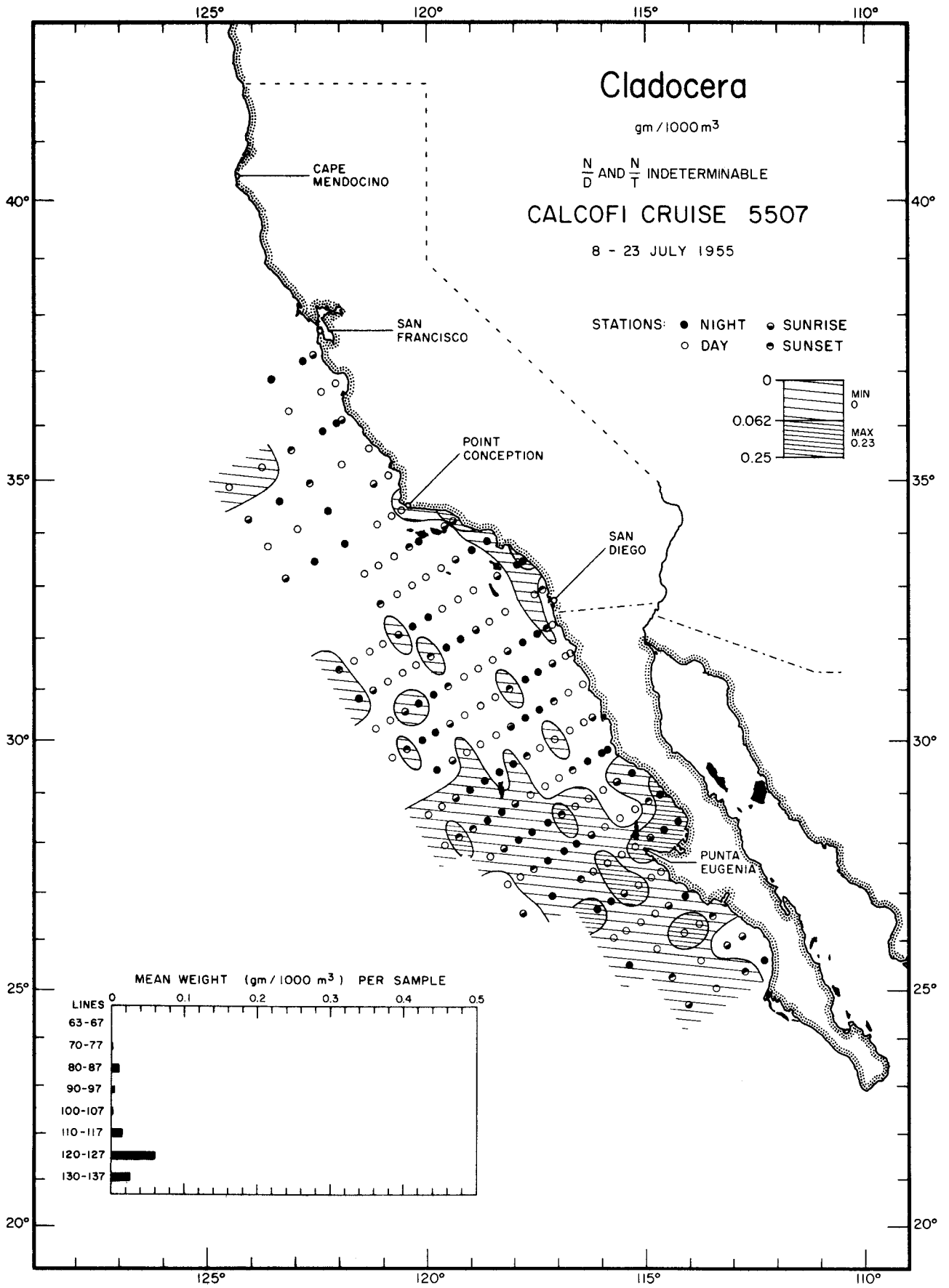




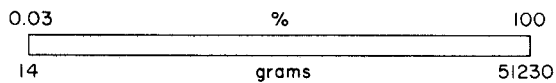
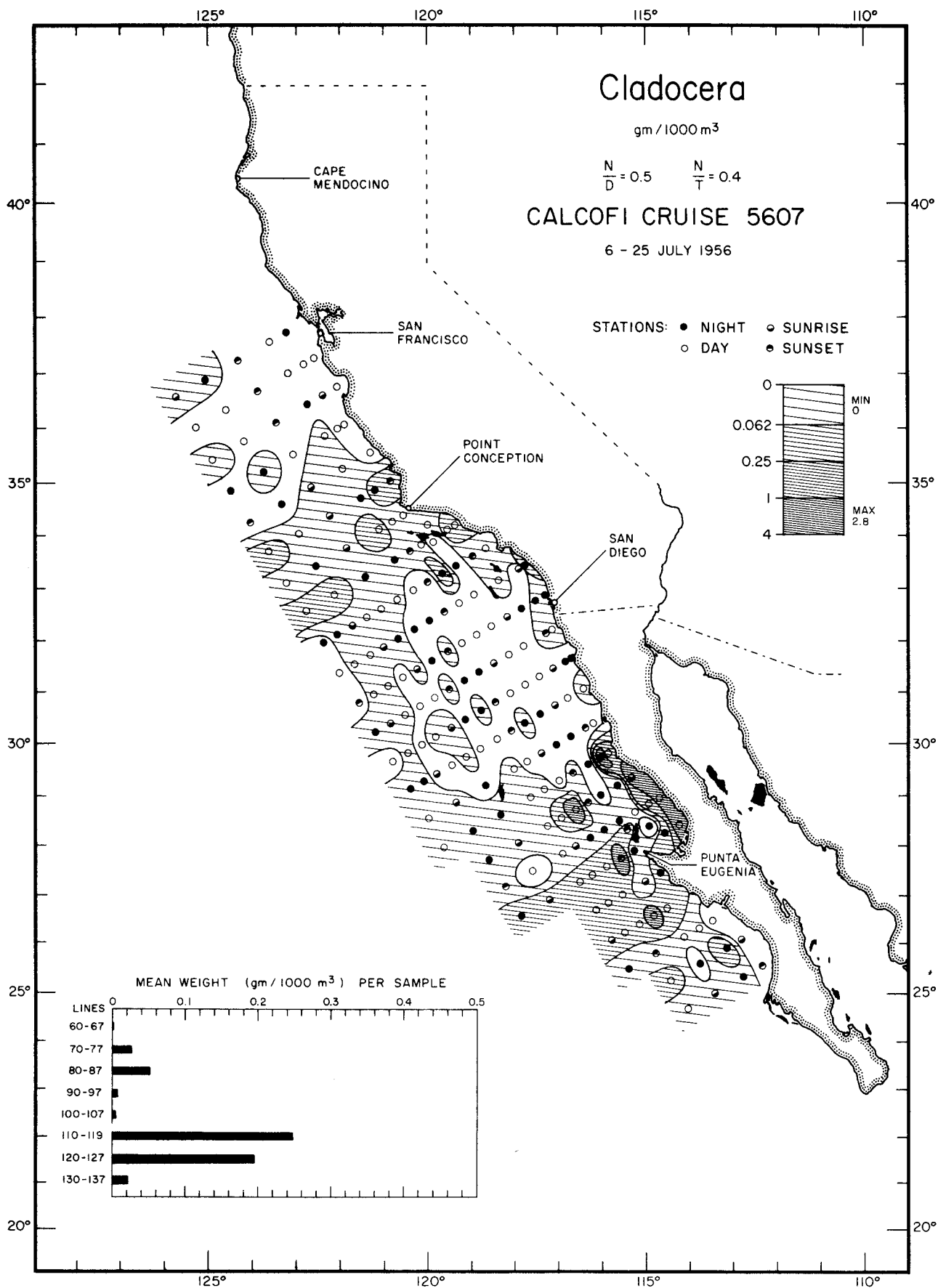
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**Chaetognatha**  
**5807**



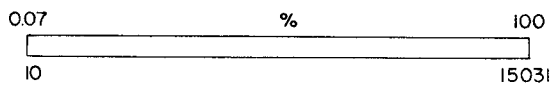
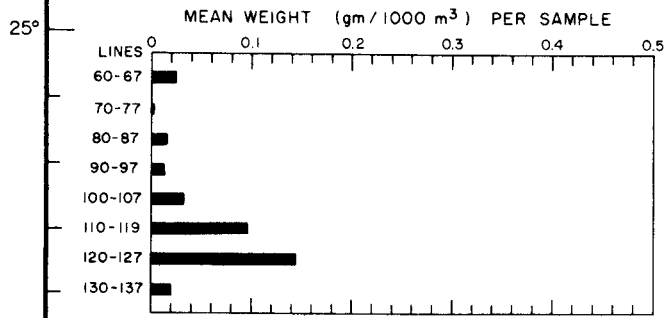
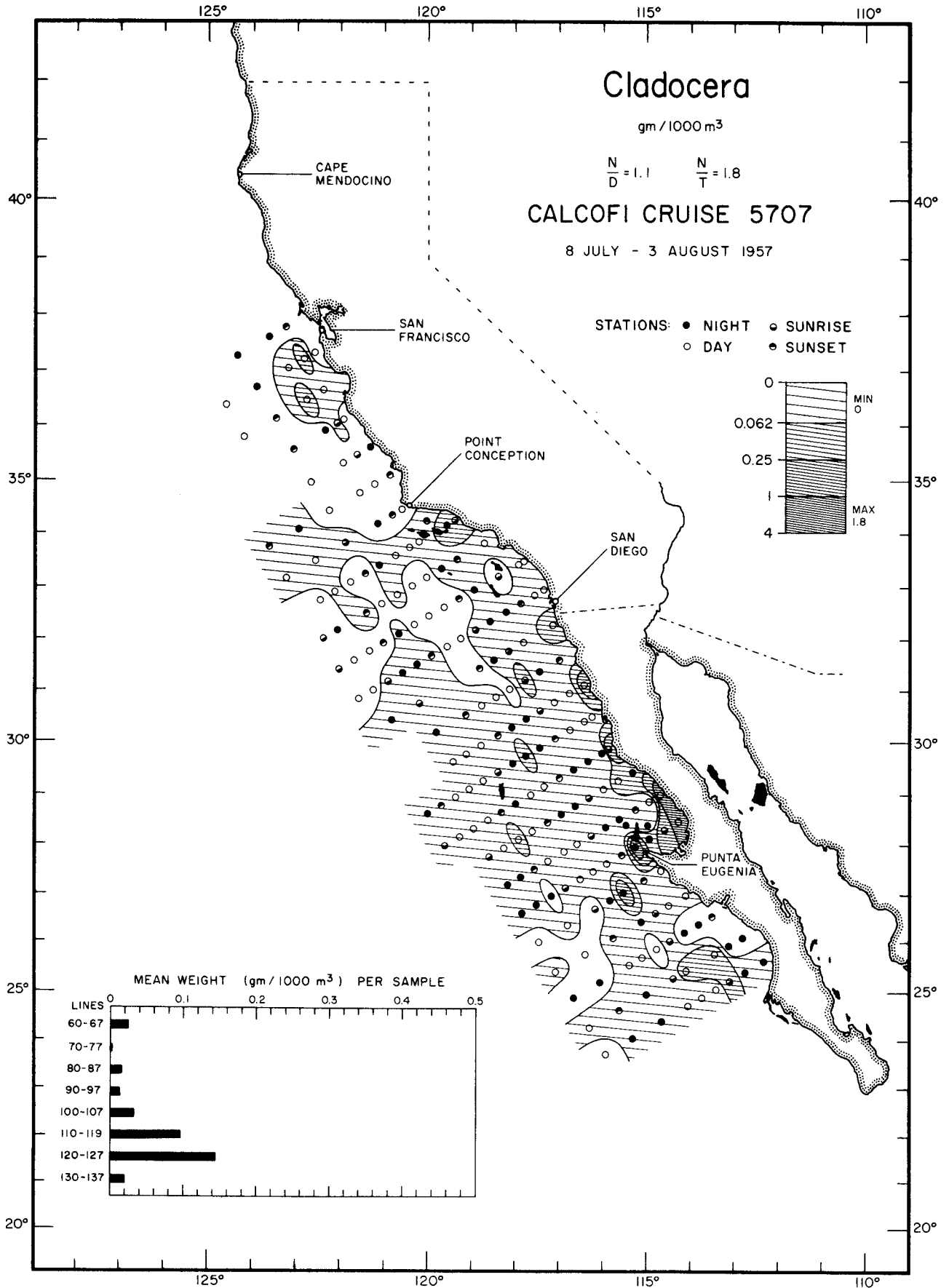
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**Chaetognatha**  
**5907**



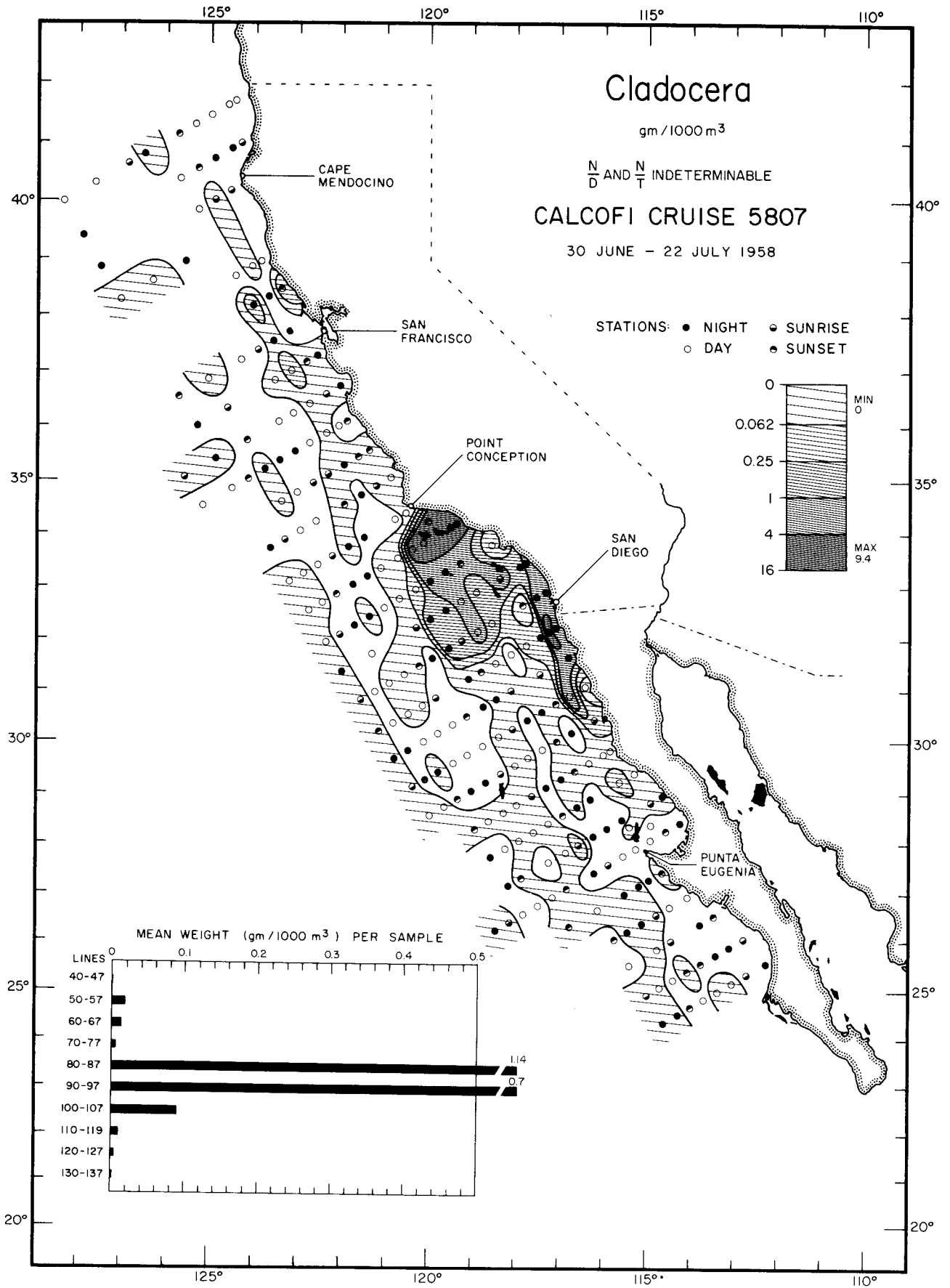
Biomass  
Cladocera  
5507



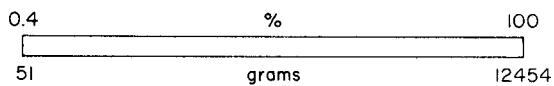
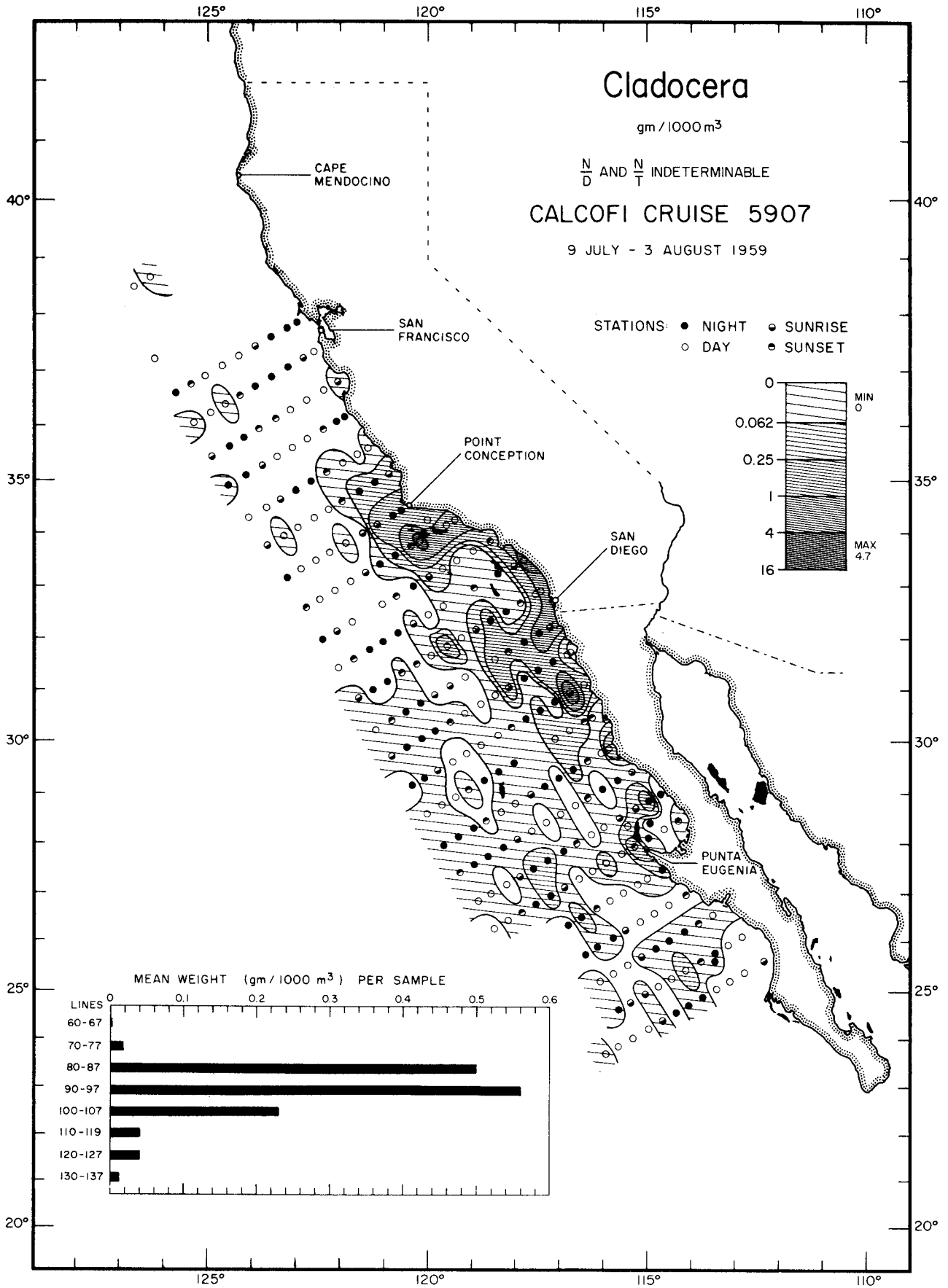
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Cladocera  
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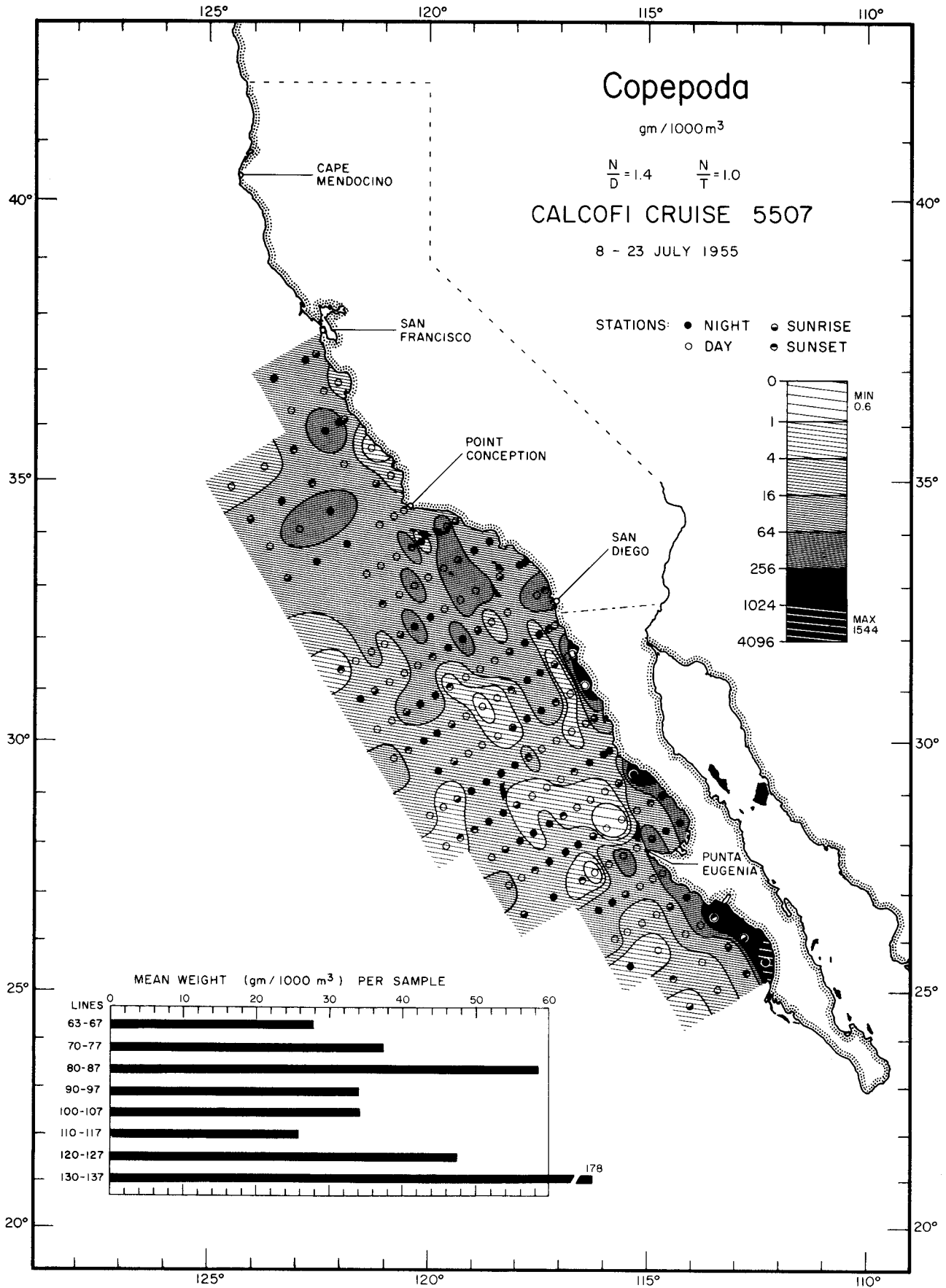
Biomass  
Cladocera  
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Biomass  
Cladocera  
5807

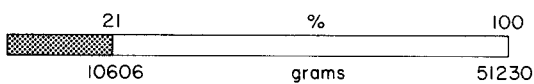
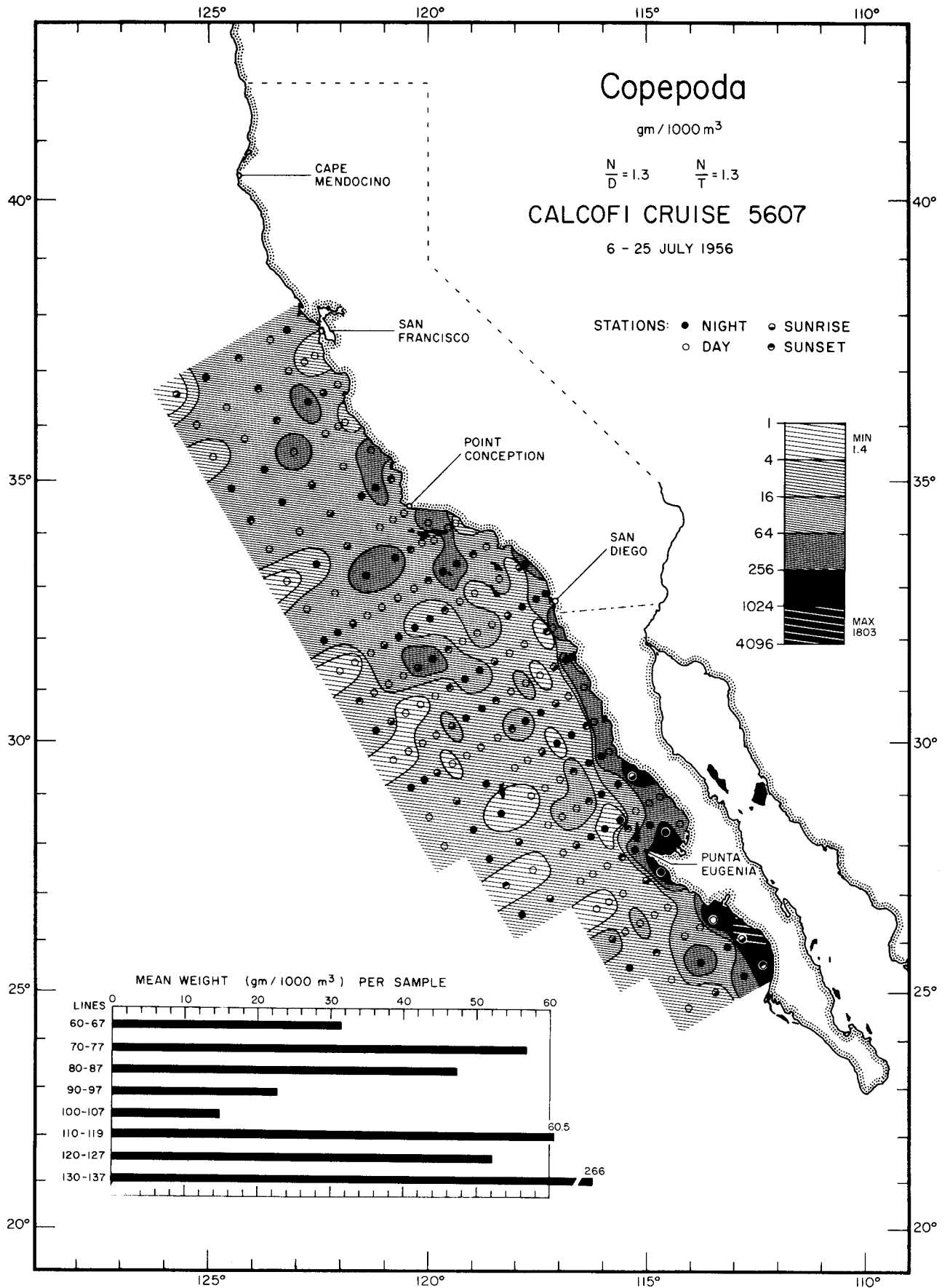


Biomass  
Cladocera  
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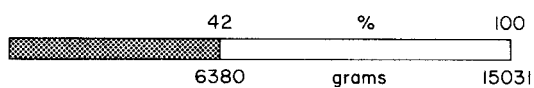
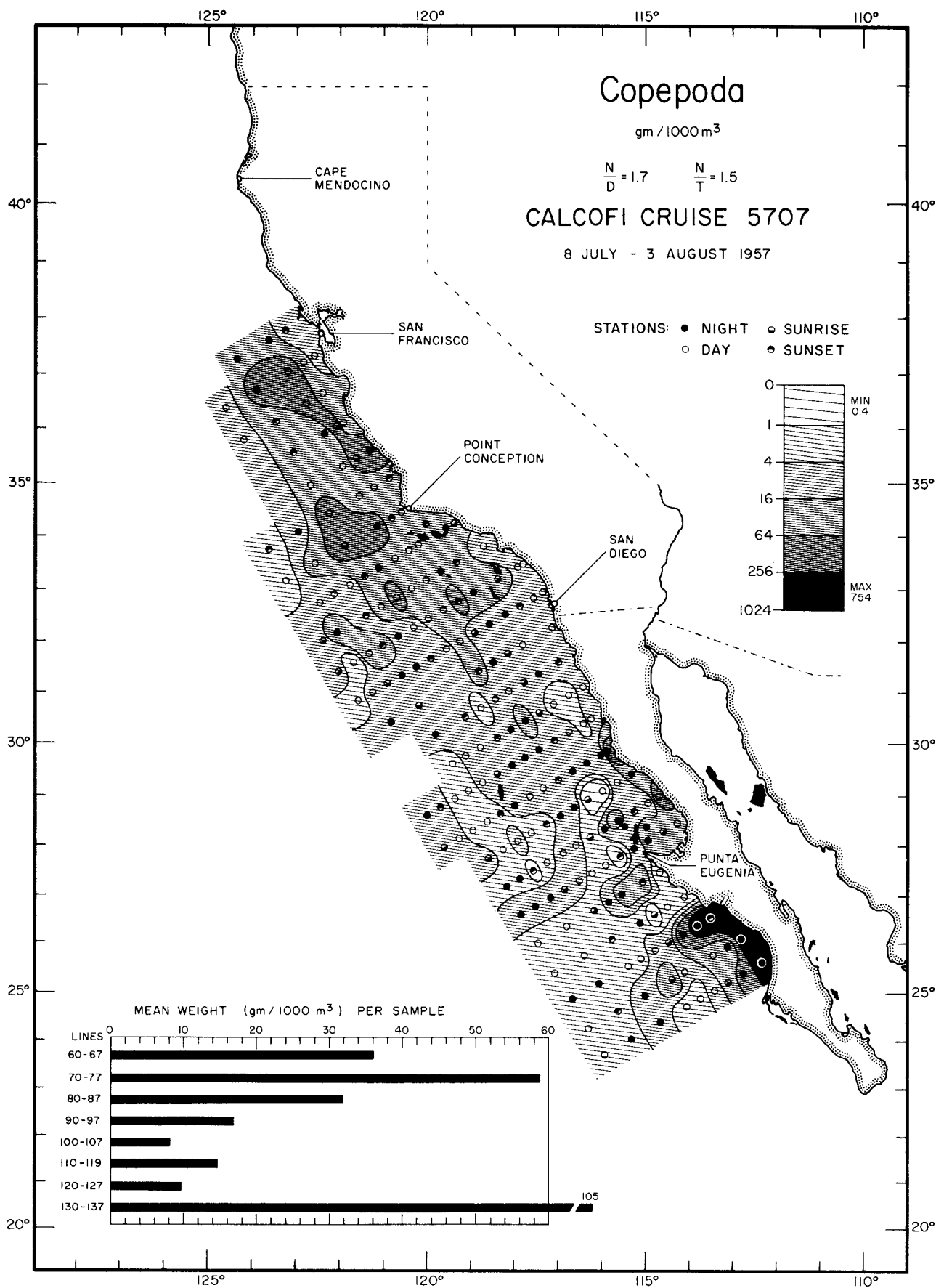


Biomass  
Copepoda  
5507

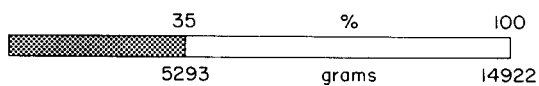
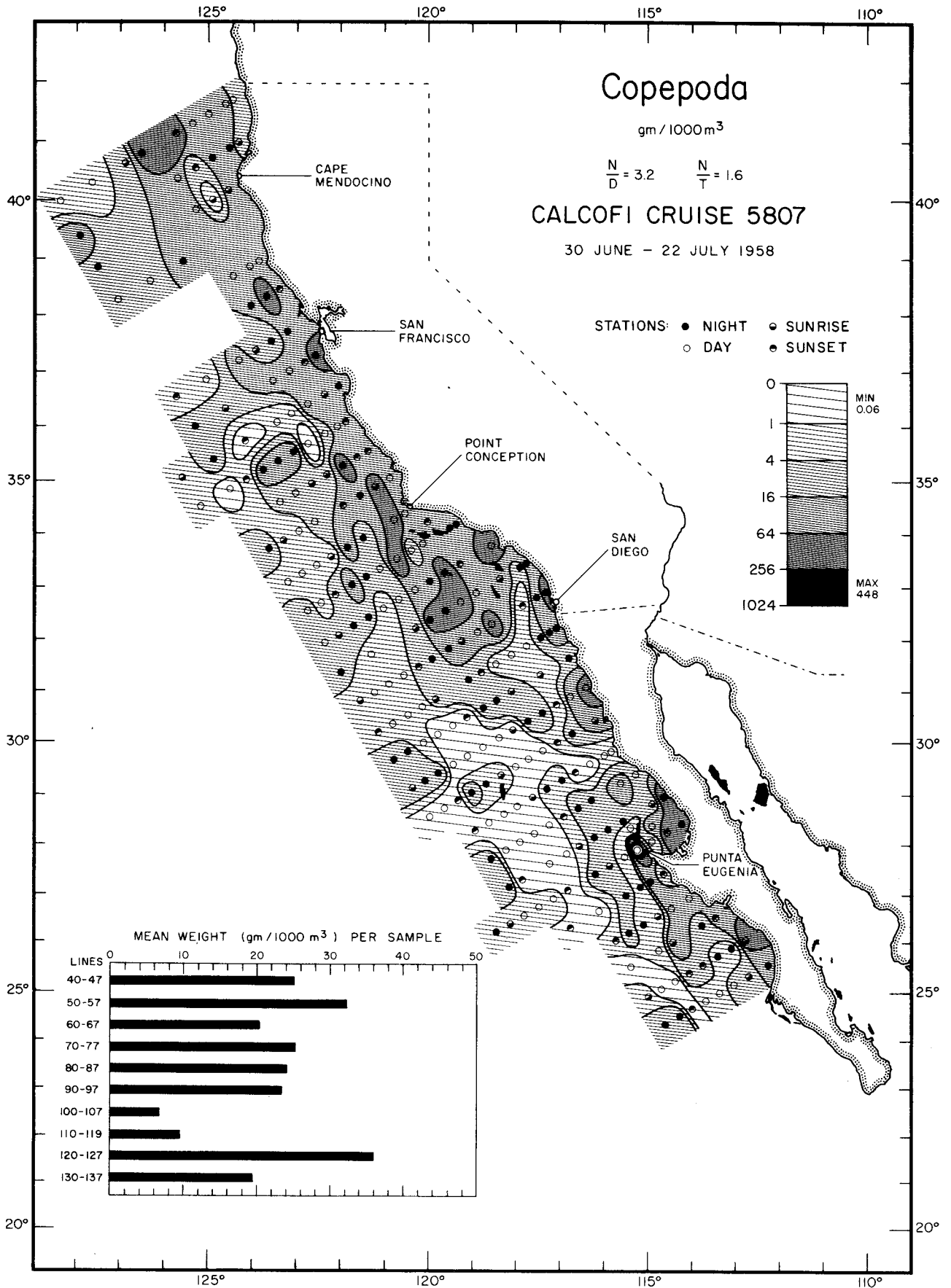




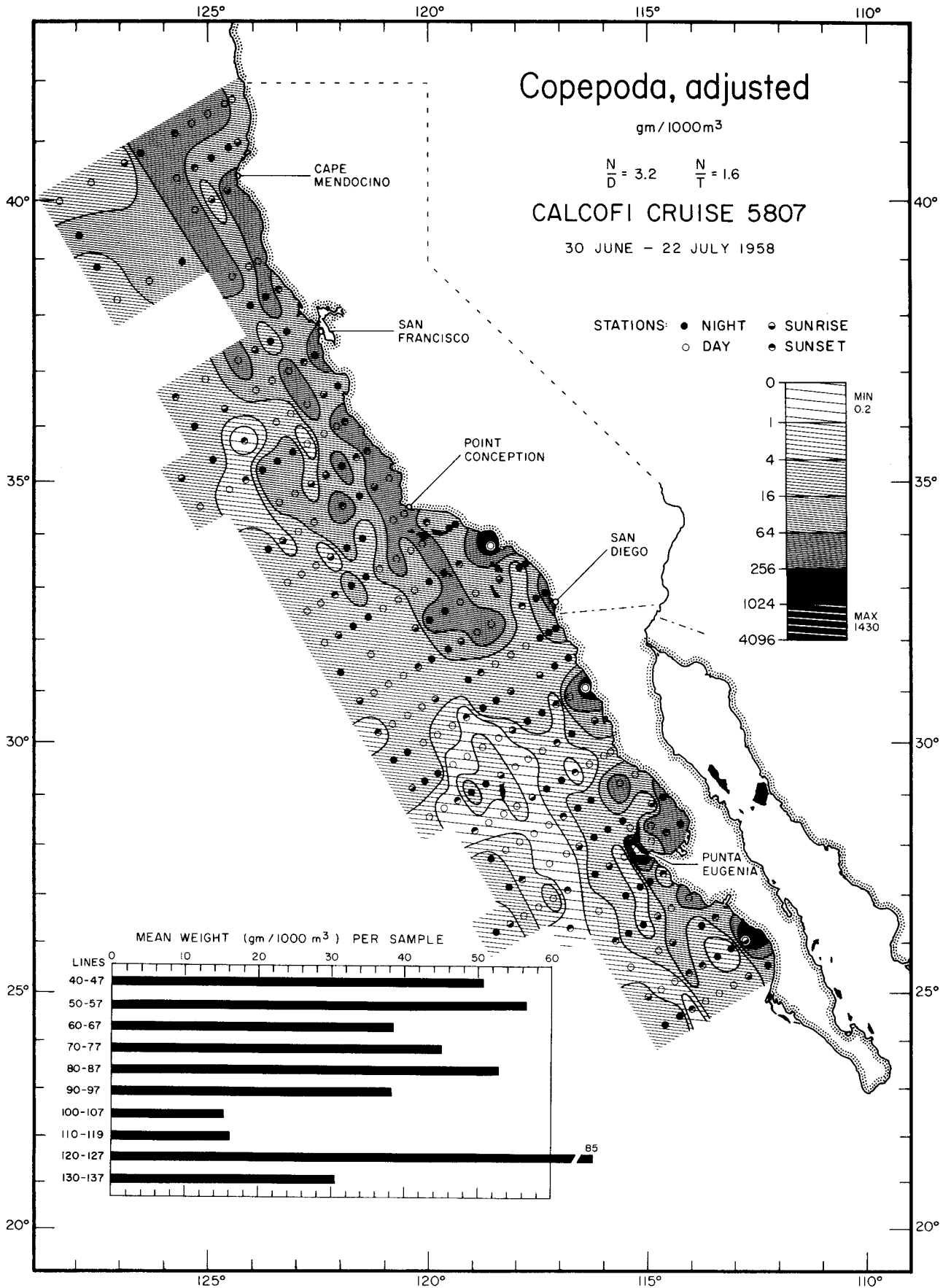
Biomass  
Copepoda  
5607



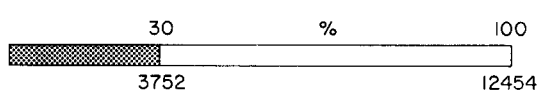
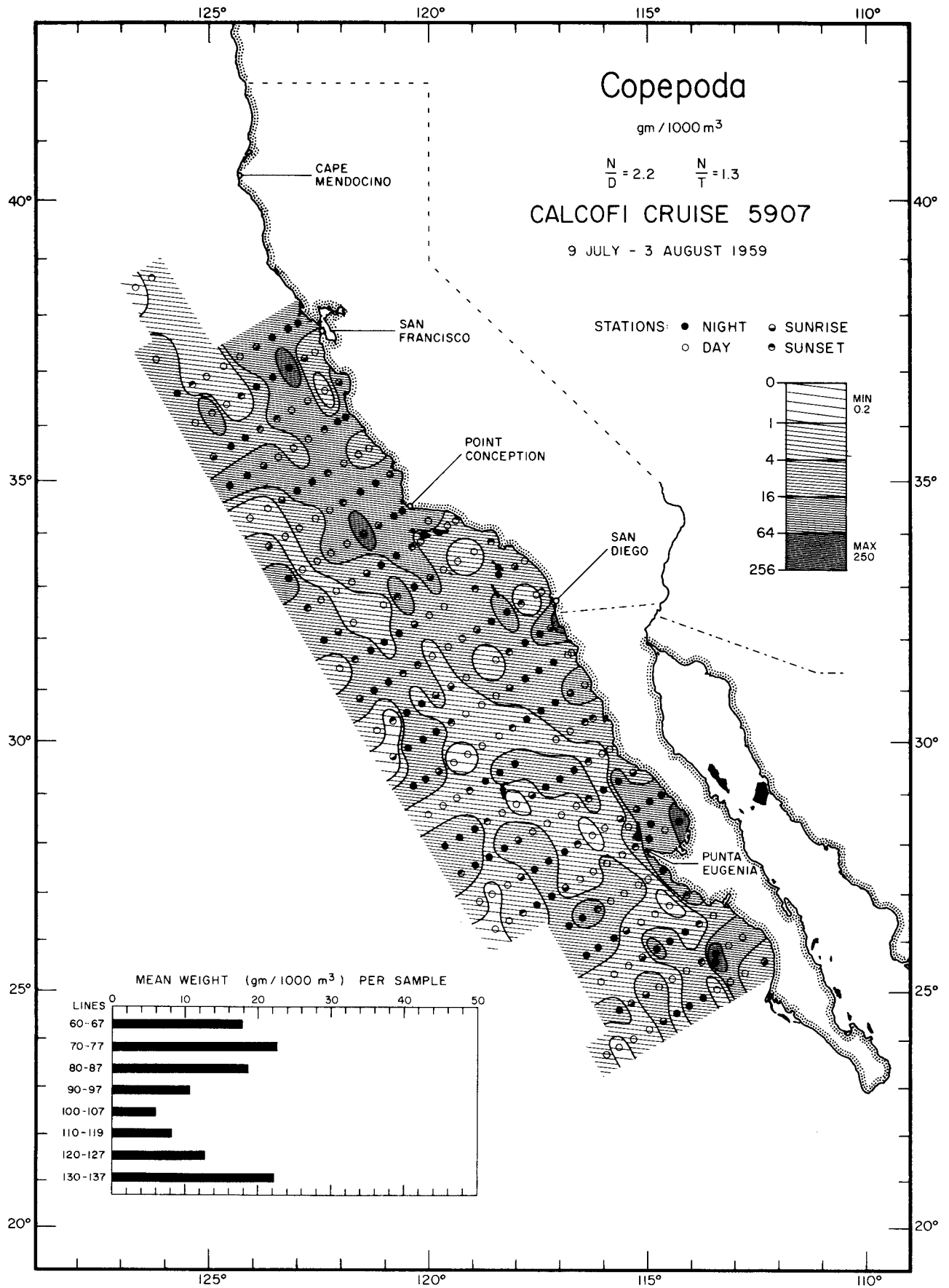
Biomass  
Copepoda  
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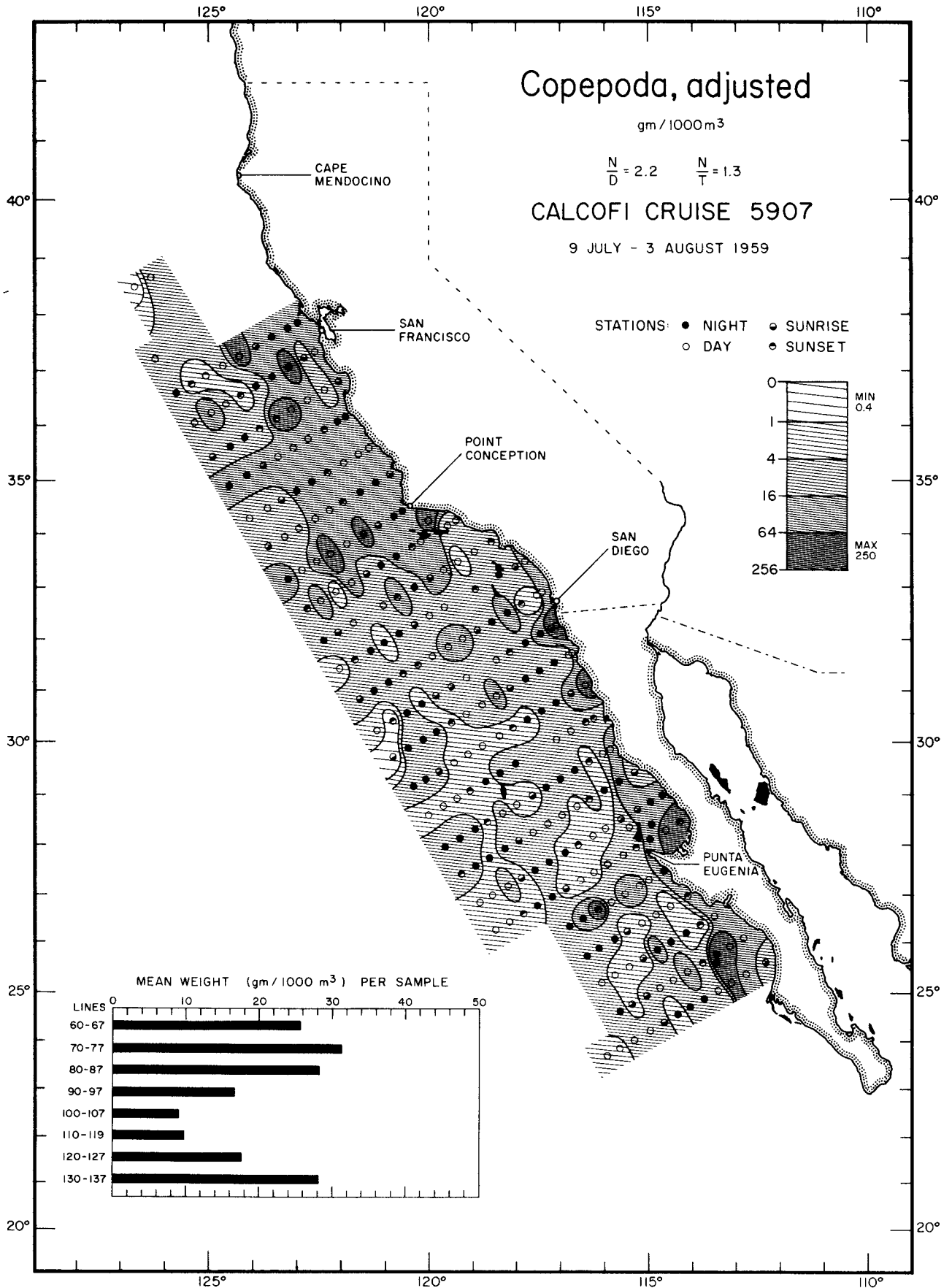
Biomass  
Copepoda  
5807



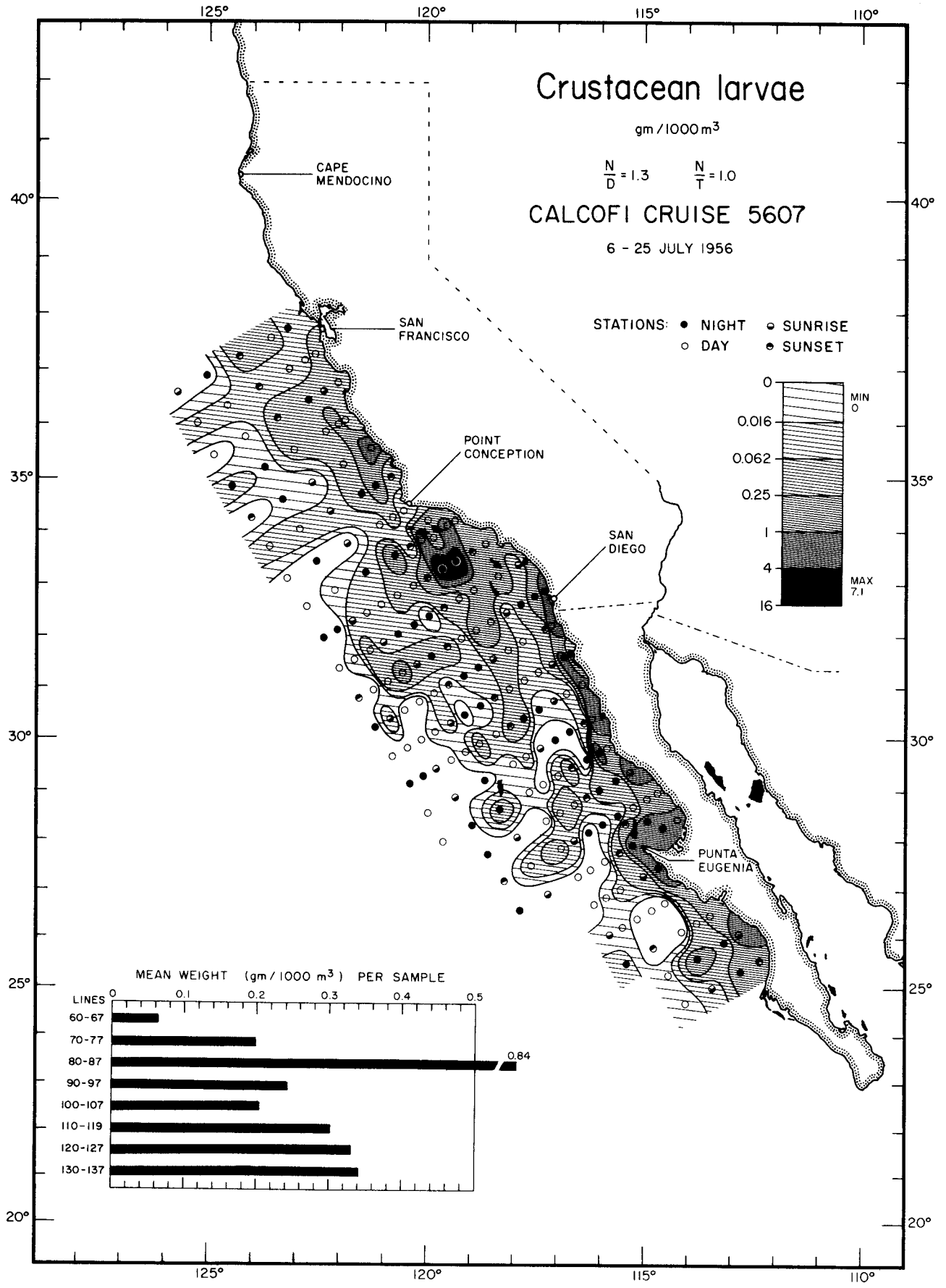
Biomass  
 Copepoda, adjusted  
 5807



Biomass  
Copepoda  
5907







# Crustacean larvae

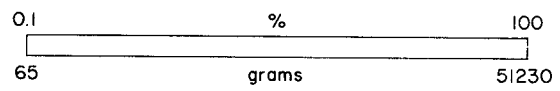
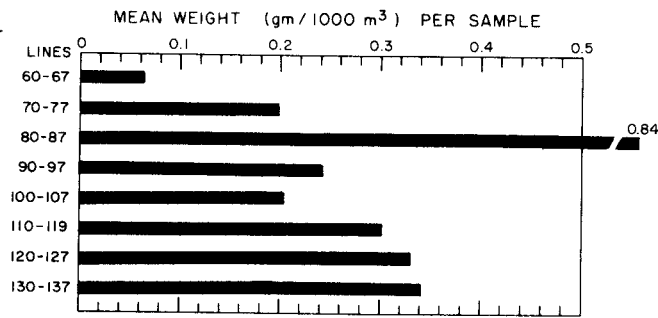
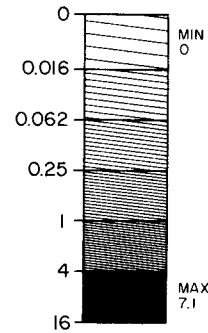
gm / 1000 m<sup>3</sup>

$\frac{N}{D} = 1.3$      $\frac{N}{T} = 1.0$

## CALCOFI CRUISE 5607

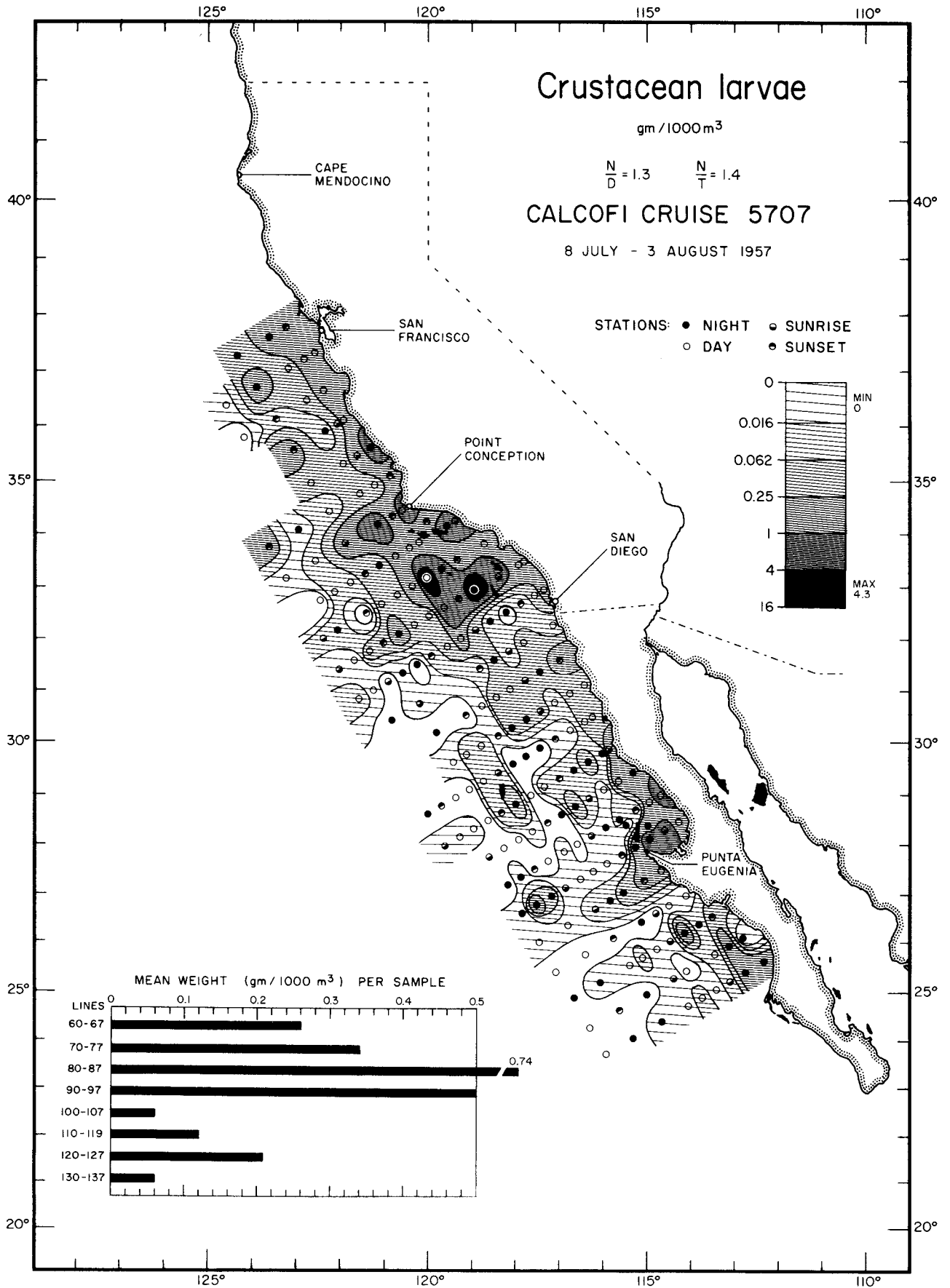
6 - 25 JULY 1956

STATIONS: ● NIGHT    ○ SUNRISE  
○ DAY    ● SUNSET



Biomass  
Crustacean larvae  
5607





# Crustacean larvae

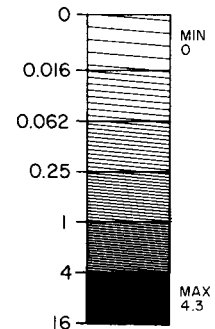
gm / 1000 m<sup>3</sup>

$\frac{N}{D} = 1.3$      $\frac{N}{T} = 1.4$

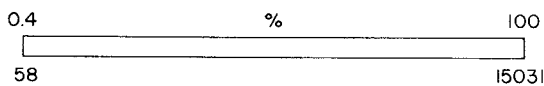
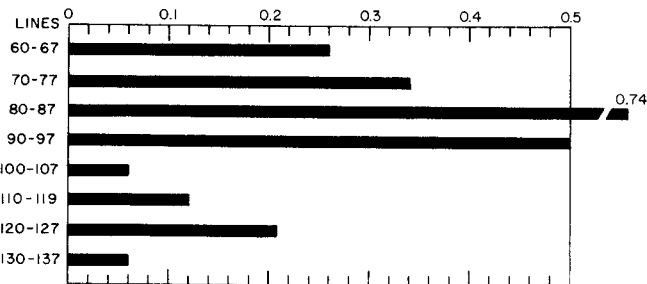
## CALCOFI CRUISE 5707

8 JULY - 3 AUGUST 1957

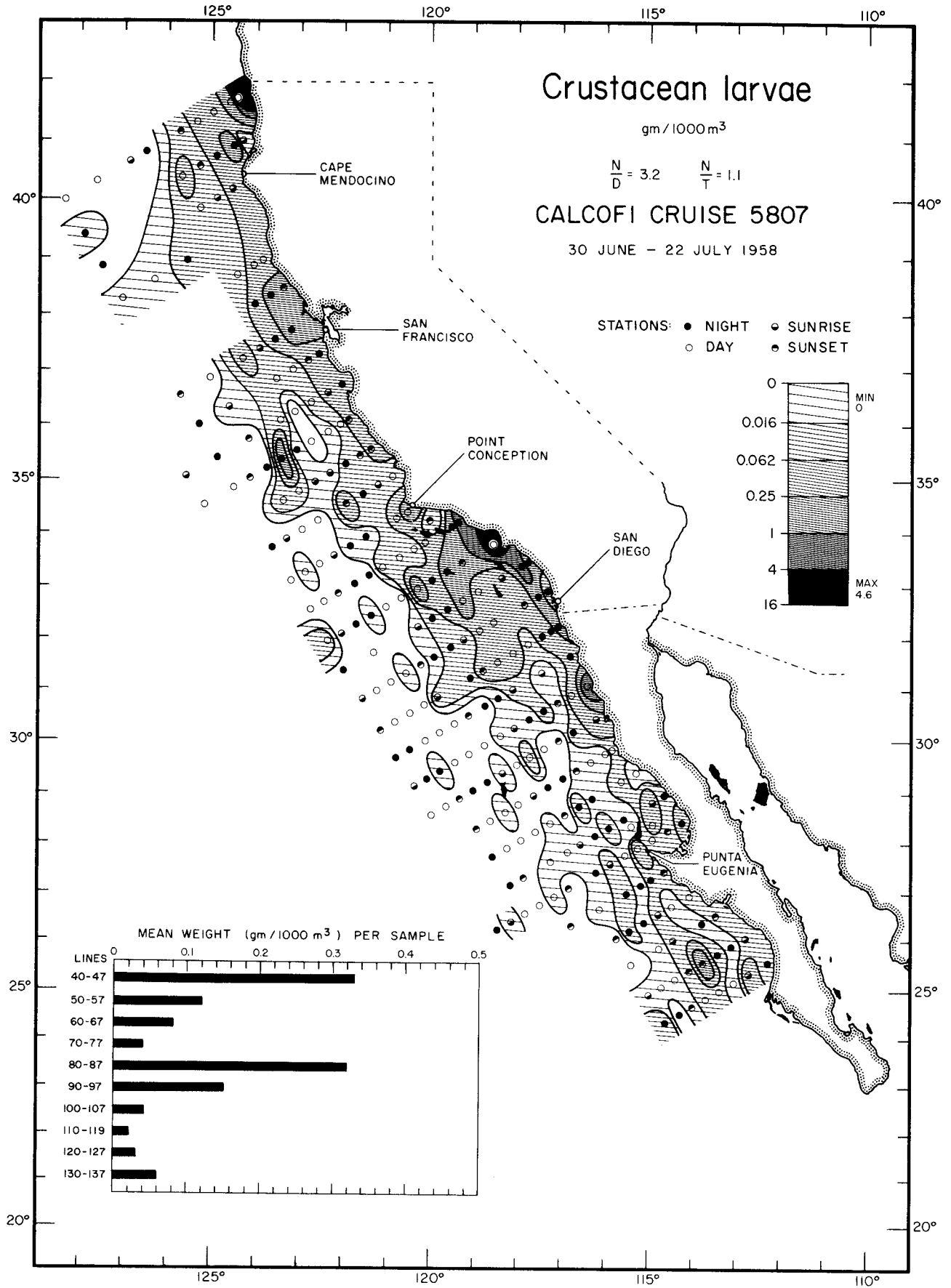
STATIONS: ● NIGHT    ○ SUNRISE  
○ DAY    ● SUNSET



MEAN WEIGHT (gm / 1000 m<sup>3</sup>) PER SAMPLE



Biomass  
Crustacean larvae  
5707



# Crustacean larvae

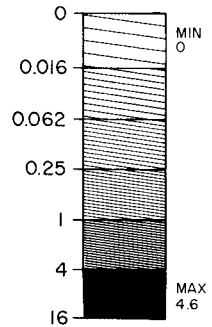
gm / 1000 m<sup>3</sup>

$$\frac{N}{D} = 3.2 \quad \frac{N}{T} = 1.1$$

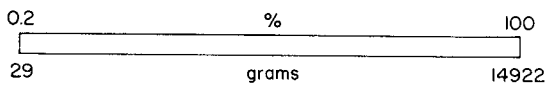
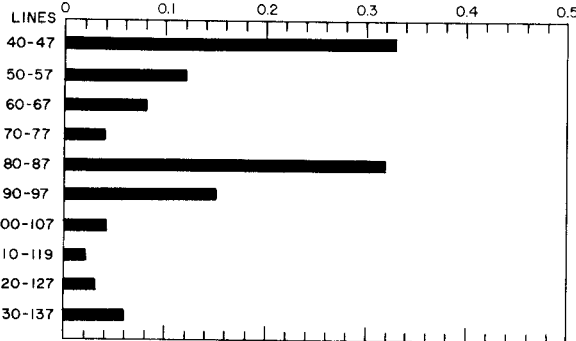
## CALCOFI CRUISE 5807

30 JUNE - 22 JULY 1958

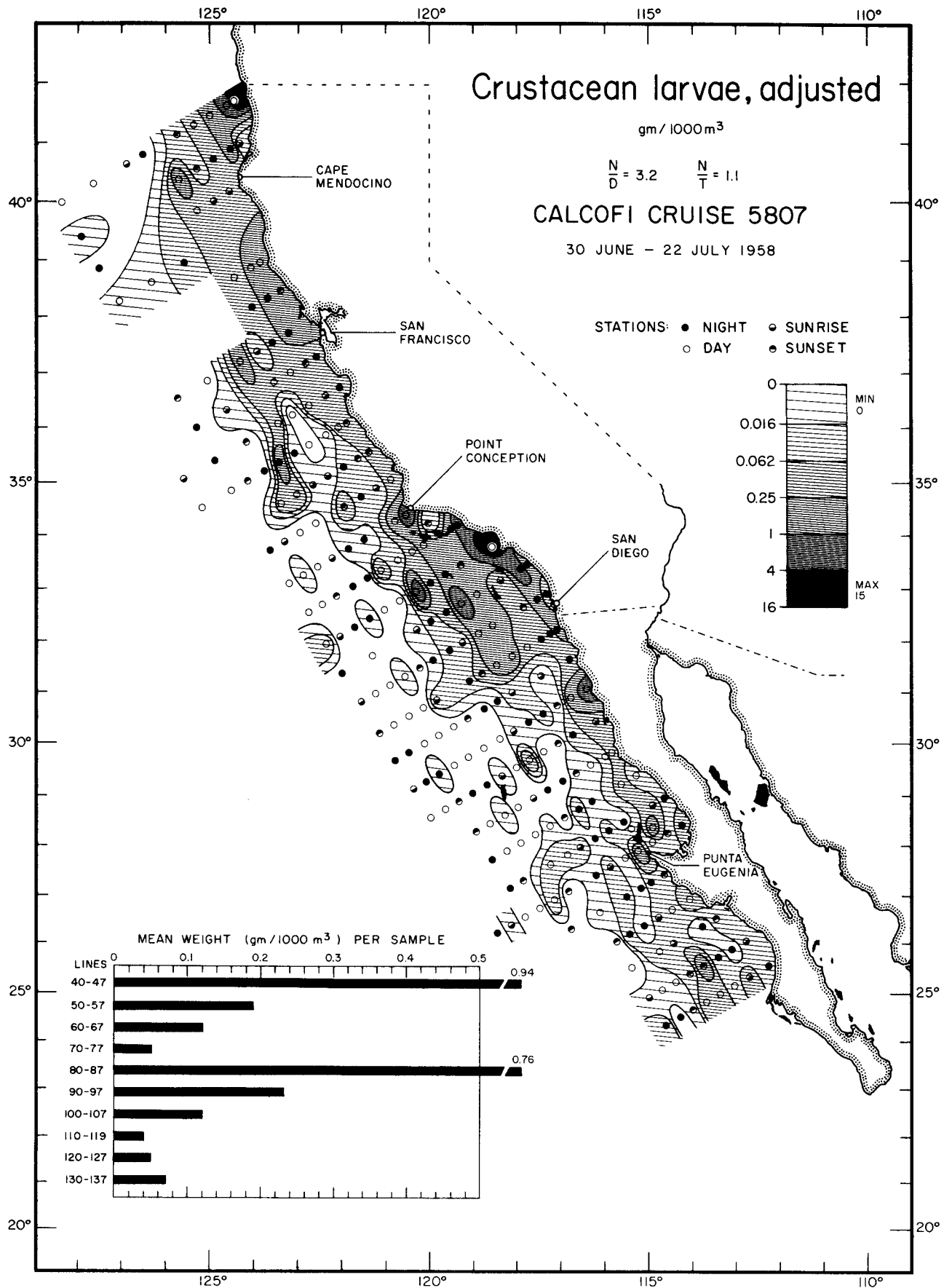
STATIONS: ● NIGHT ○ DAY  
 ◐ SUNRISE ◑ SUNSET



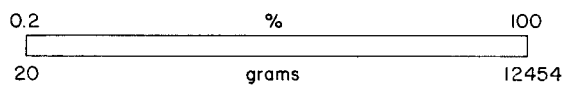
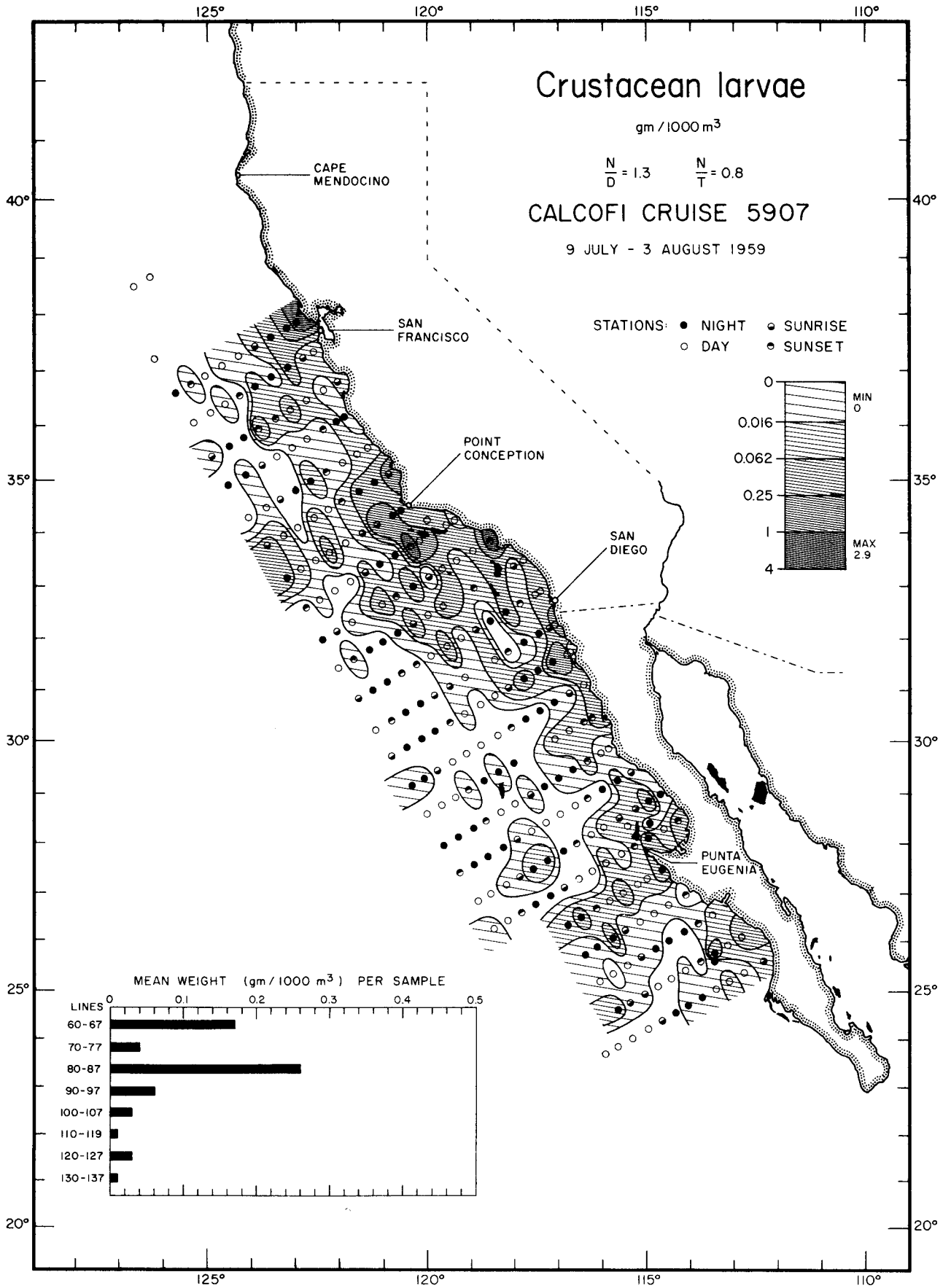
MEAN WEIGHT (gm / 1000 m<sup>3</sup>) PER SAMPLE



Biomass  
 Crustacean larvae  
 5807

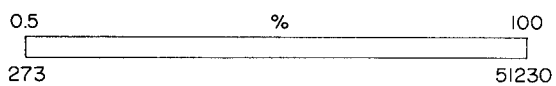
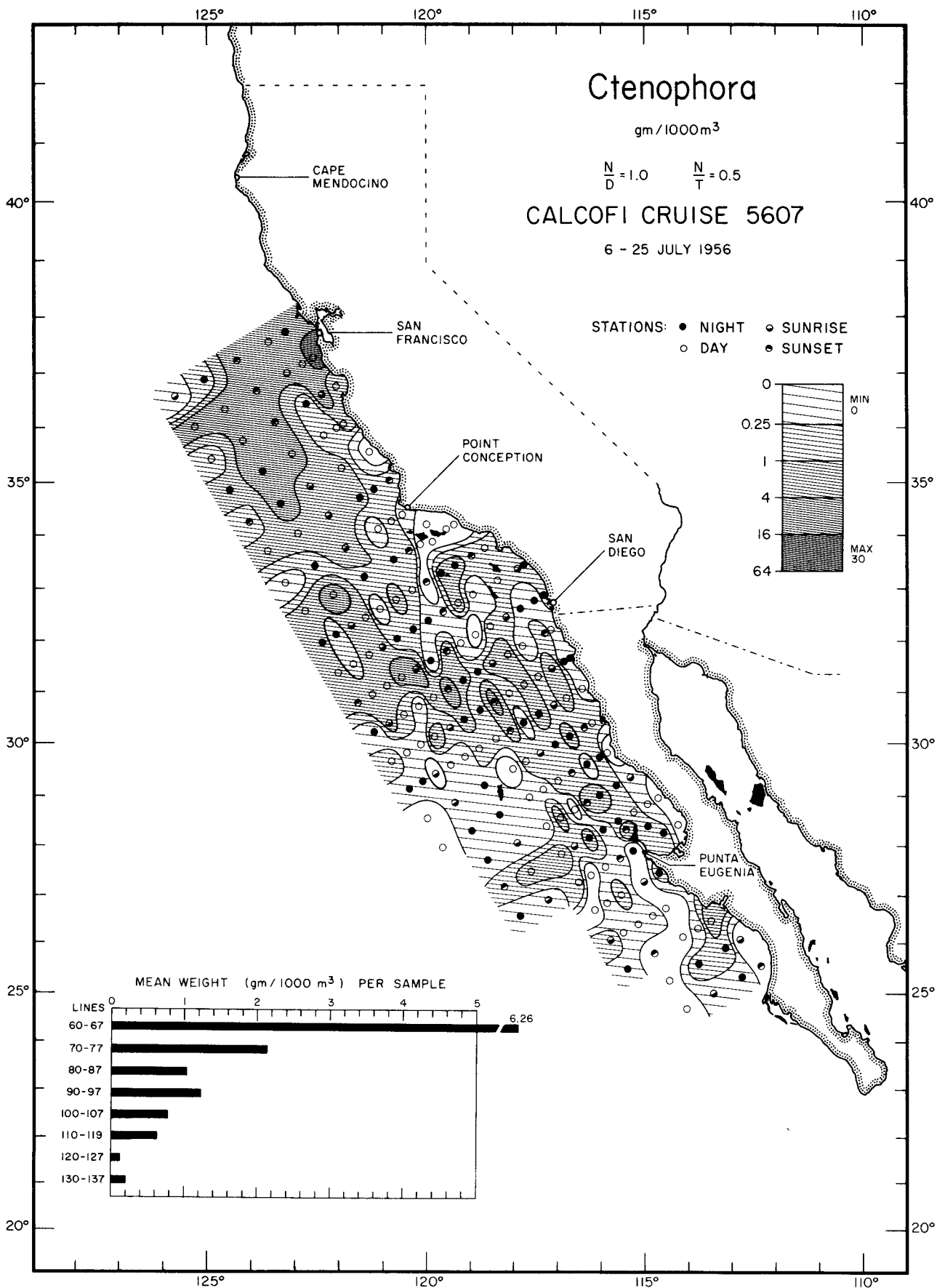


Biomass  
 Crustacean larvae, adjusted  
 5807

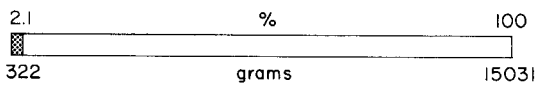
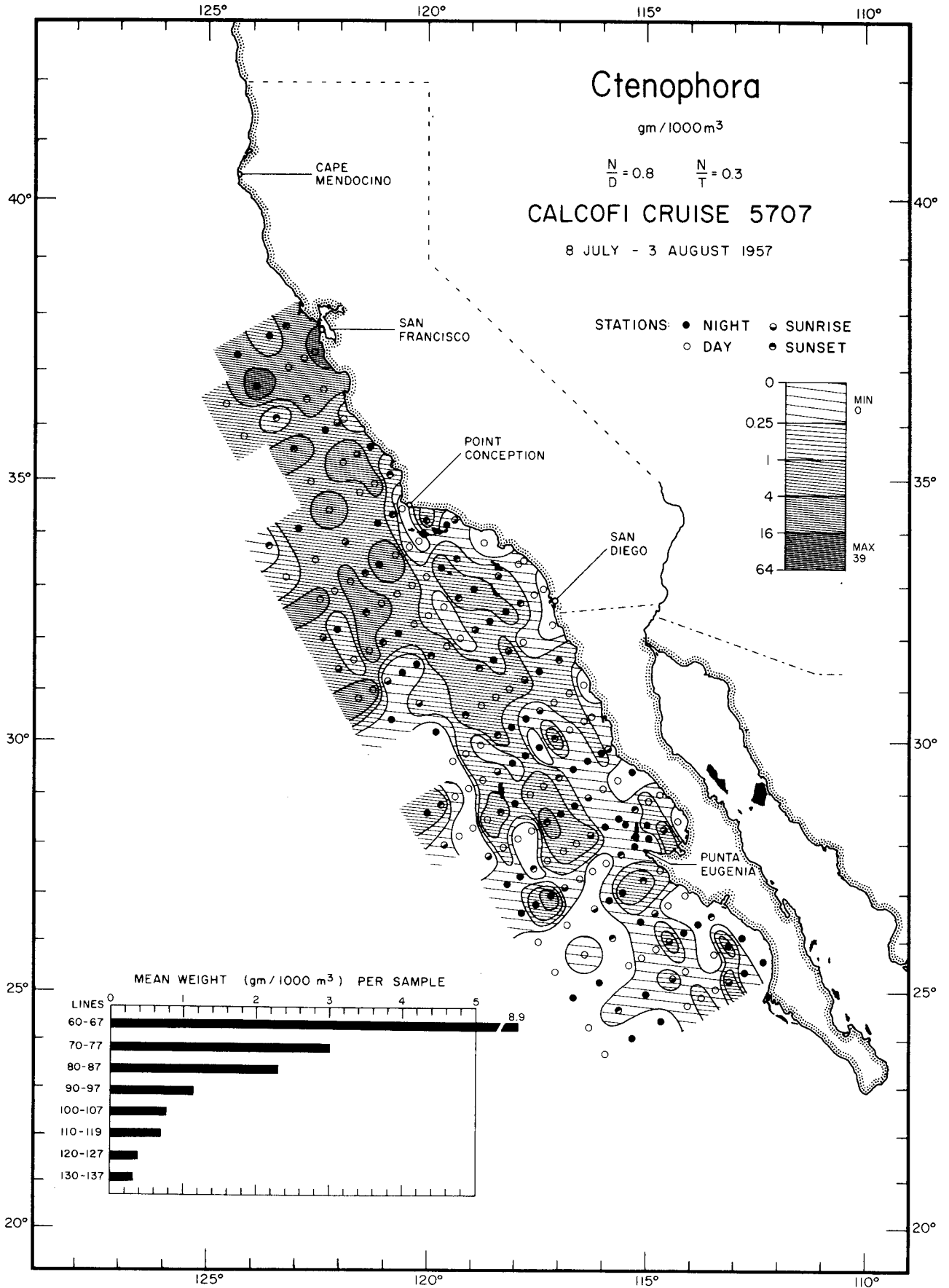


Biomass  
 Crustacean larvae  
 5907

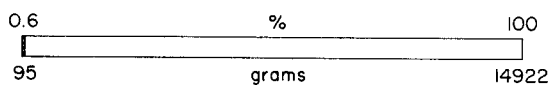
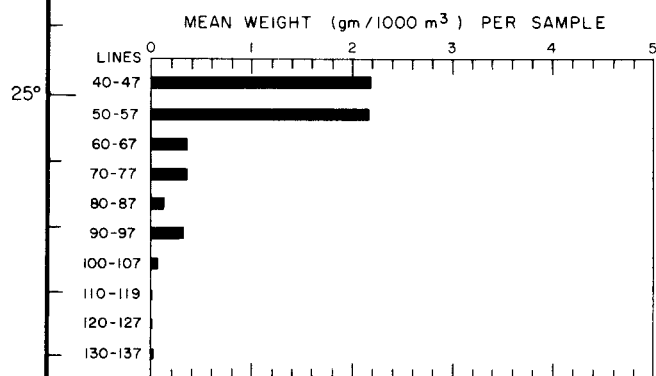
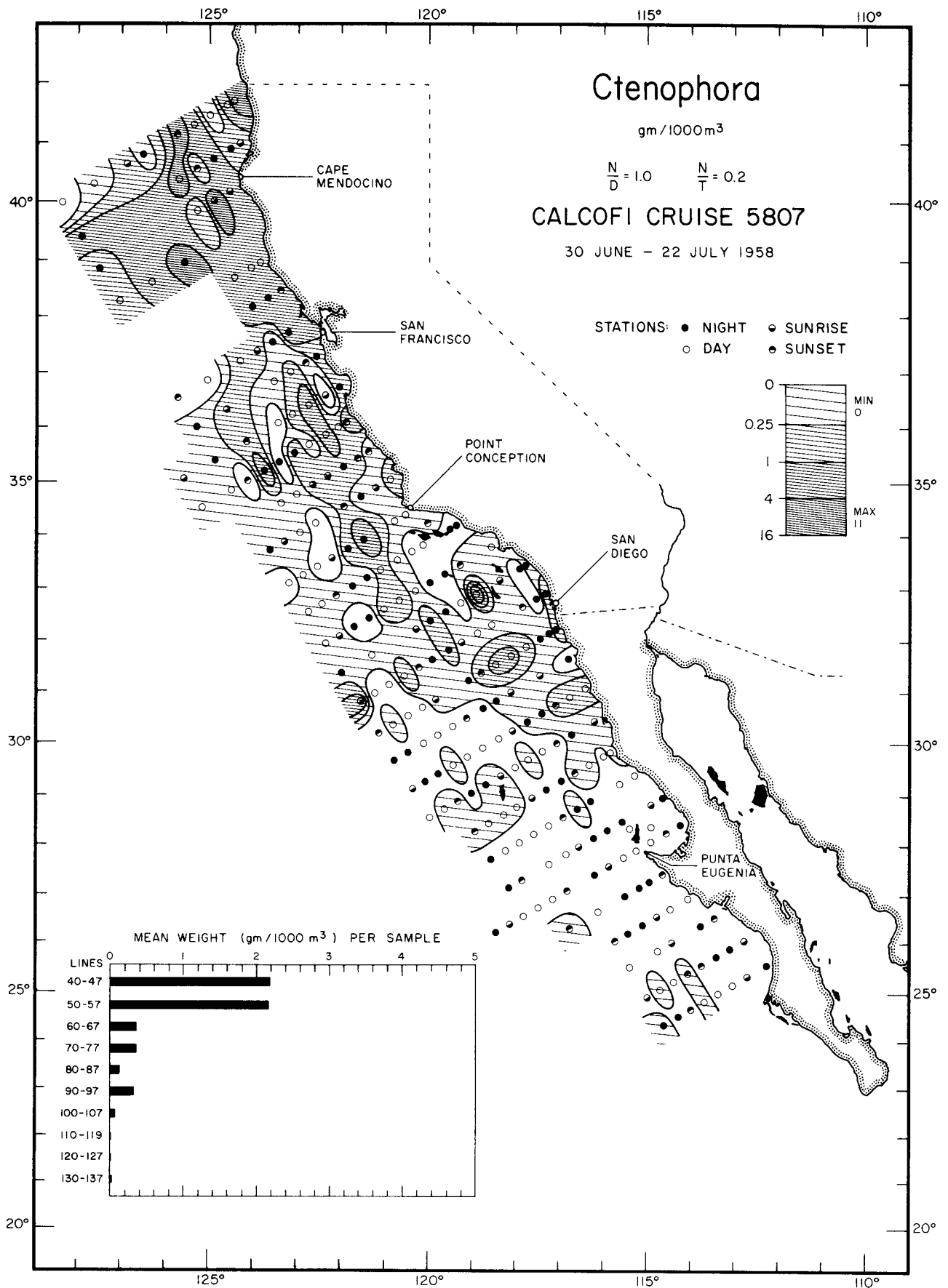




Biomass  
**Ctenophora**  
**5607**

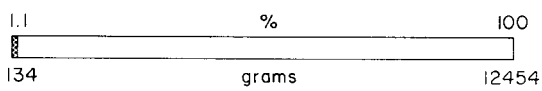
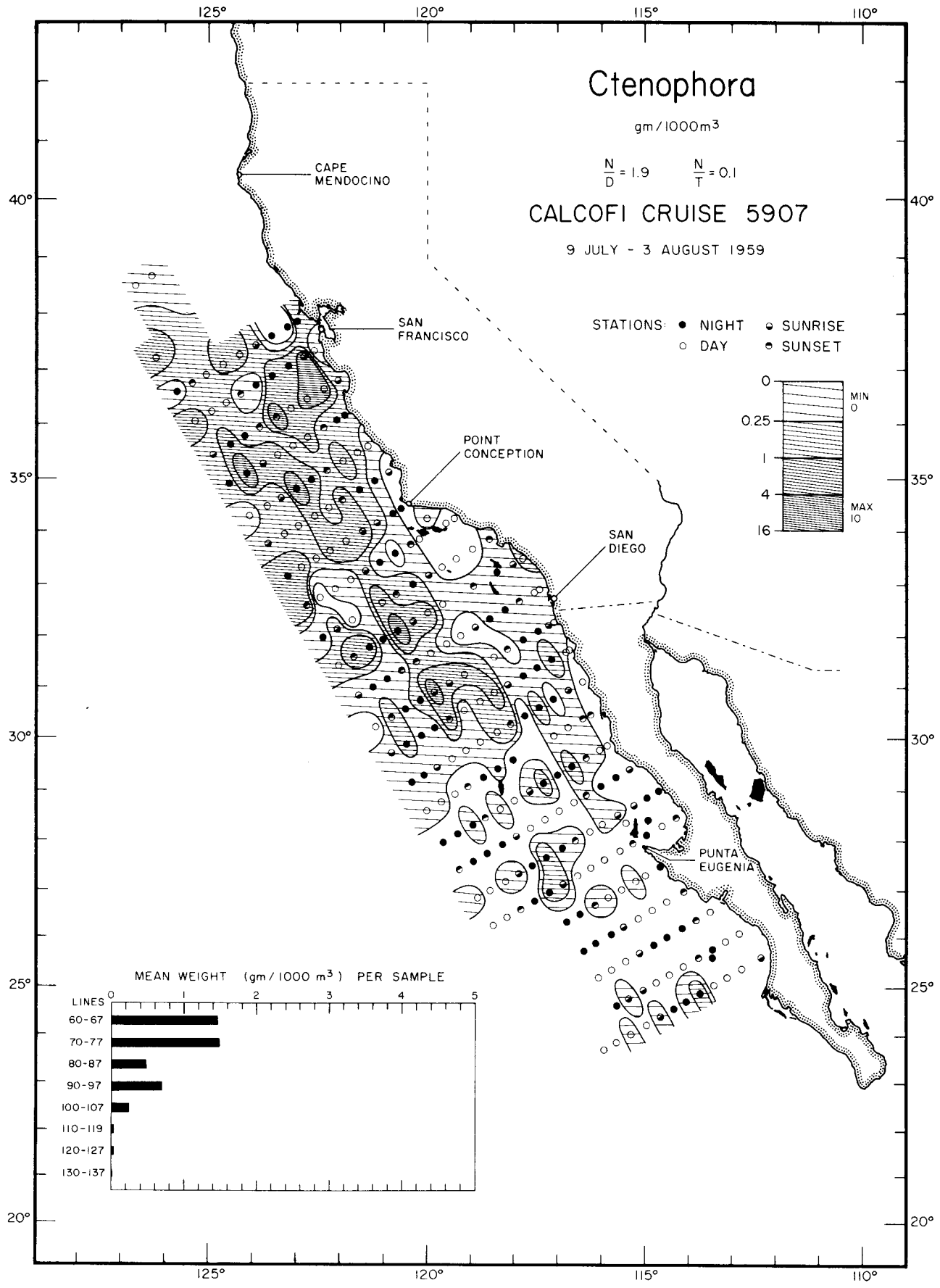


Biomass  
Ctenophora  
5707



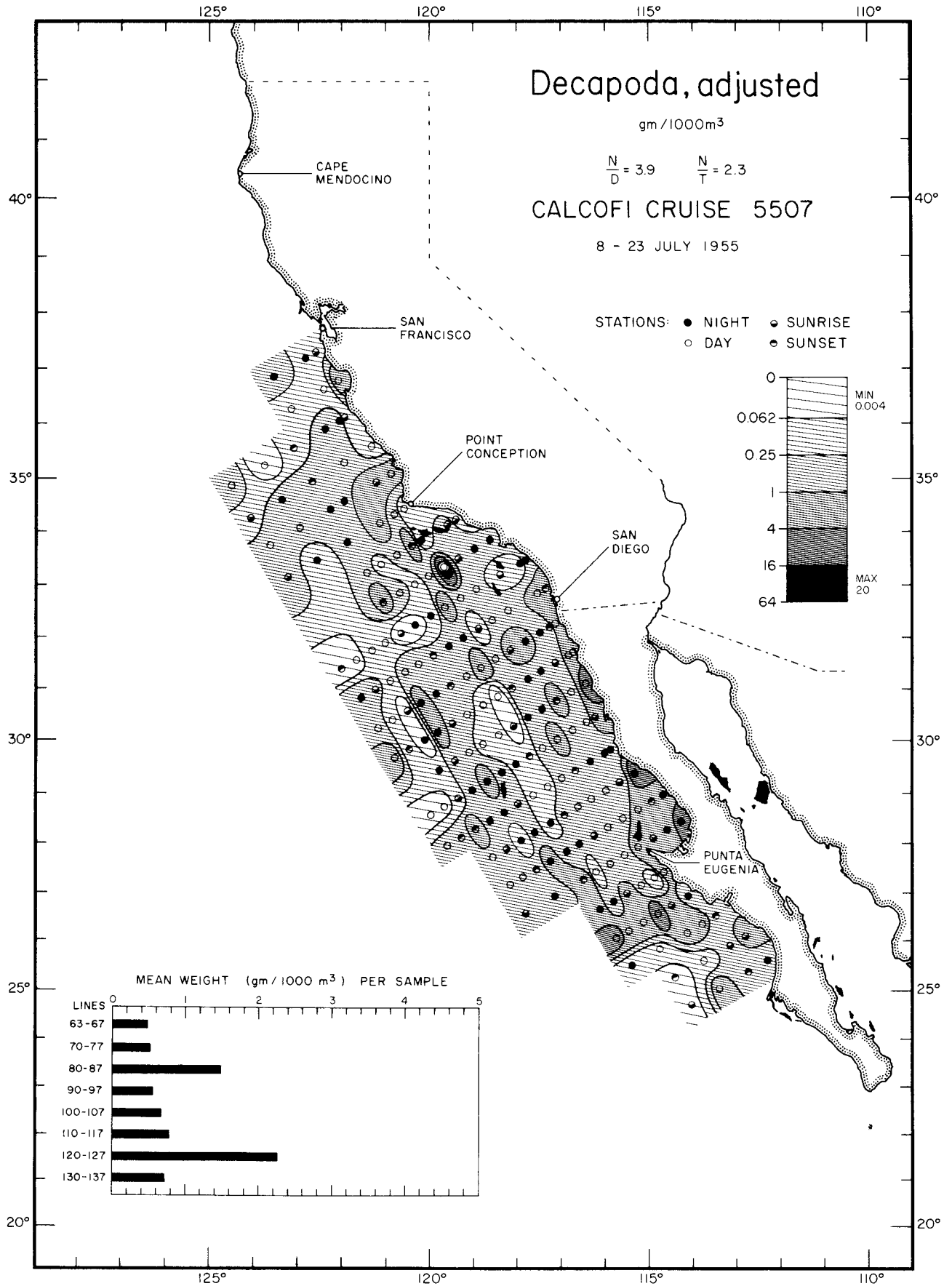
Biomass  
Ctenophora  
5807



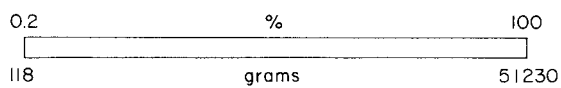
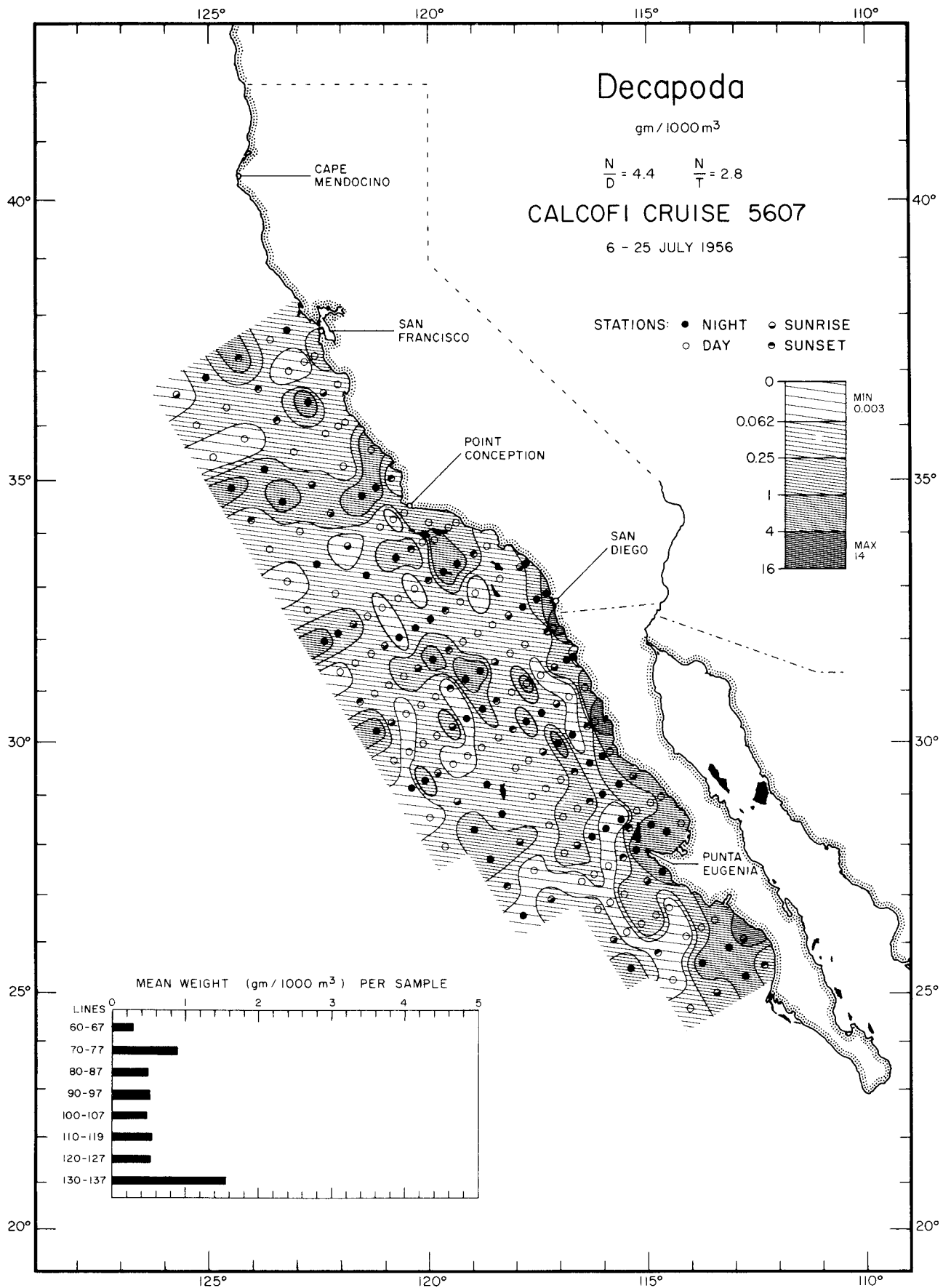


Biomass  
**Ctenophora**  
5907

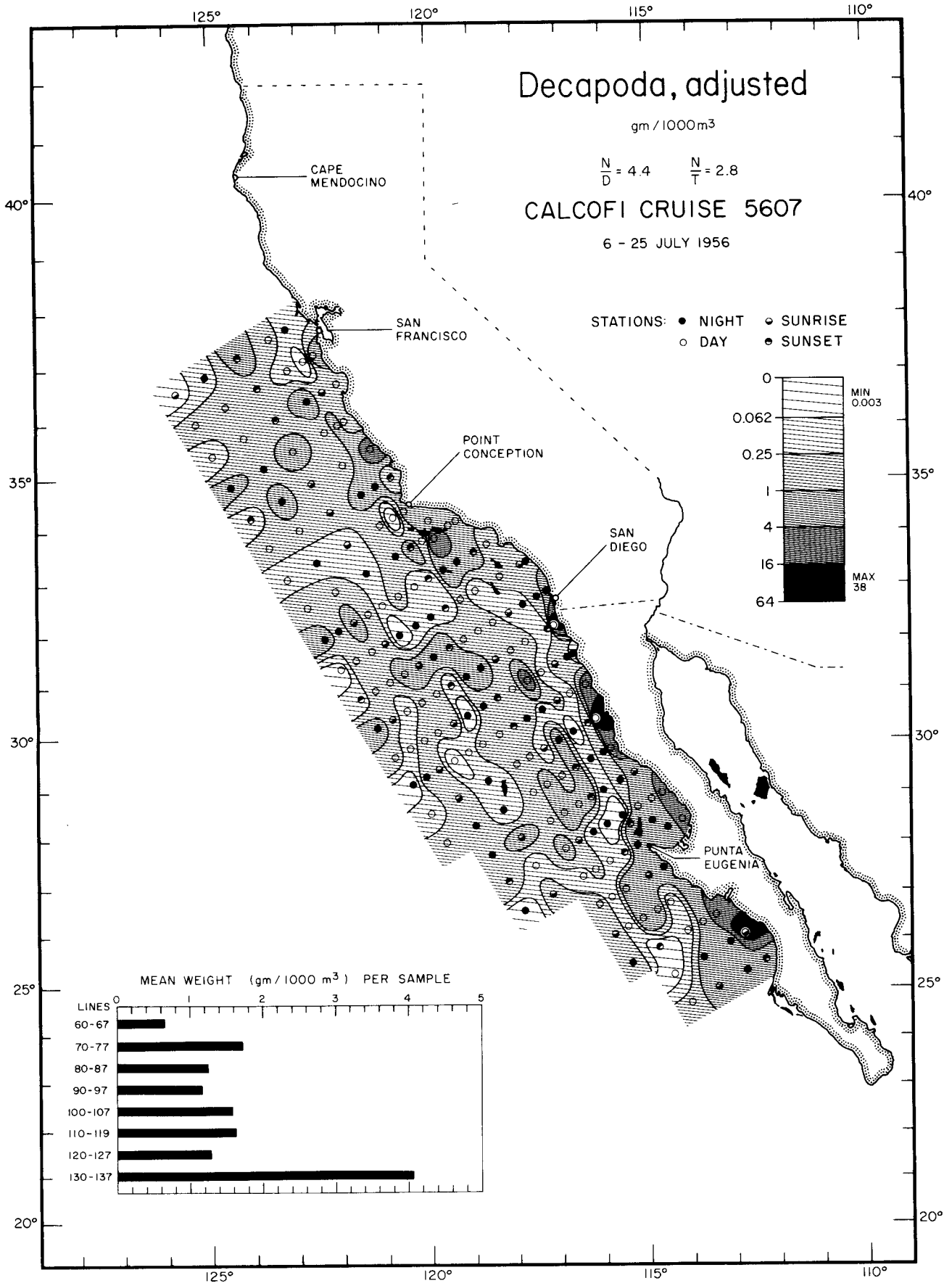




Biomass  
 Decapoda, adjusted  
 5507

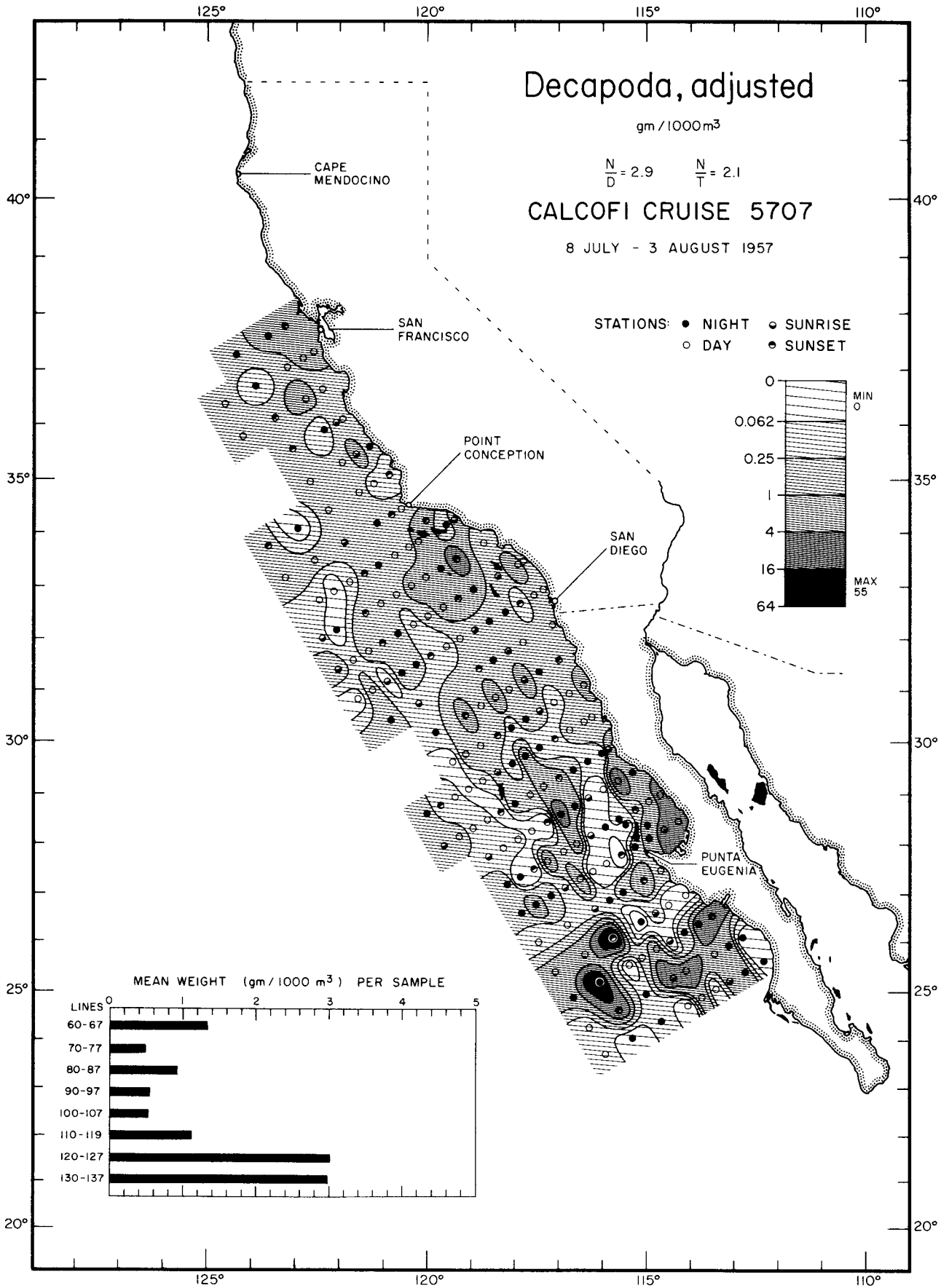


Biomass  
 Decapoda  
 5607



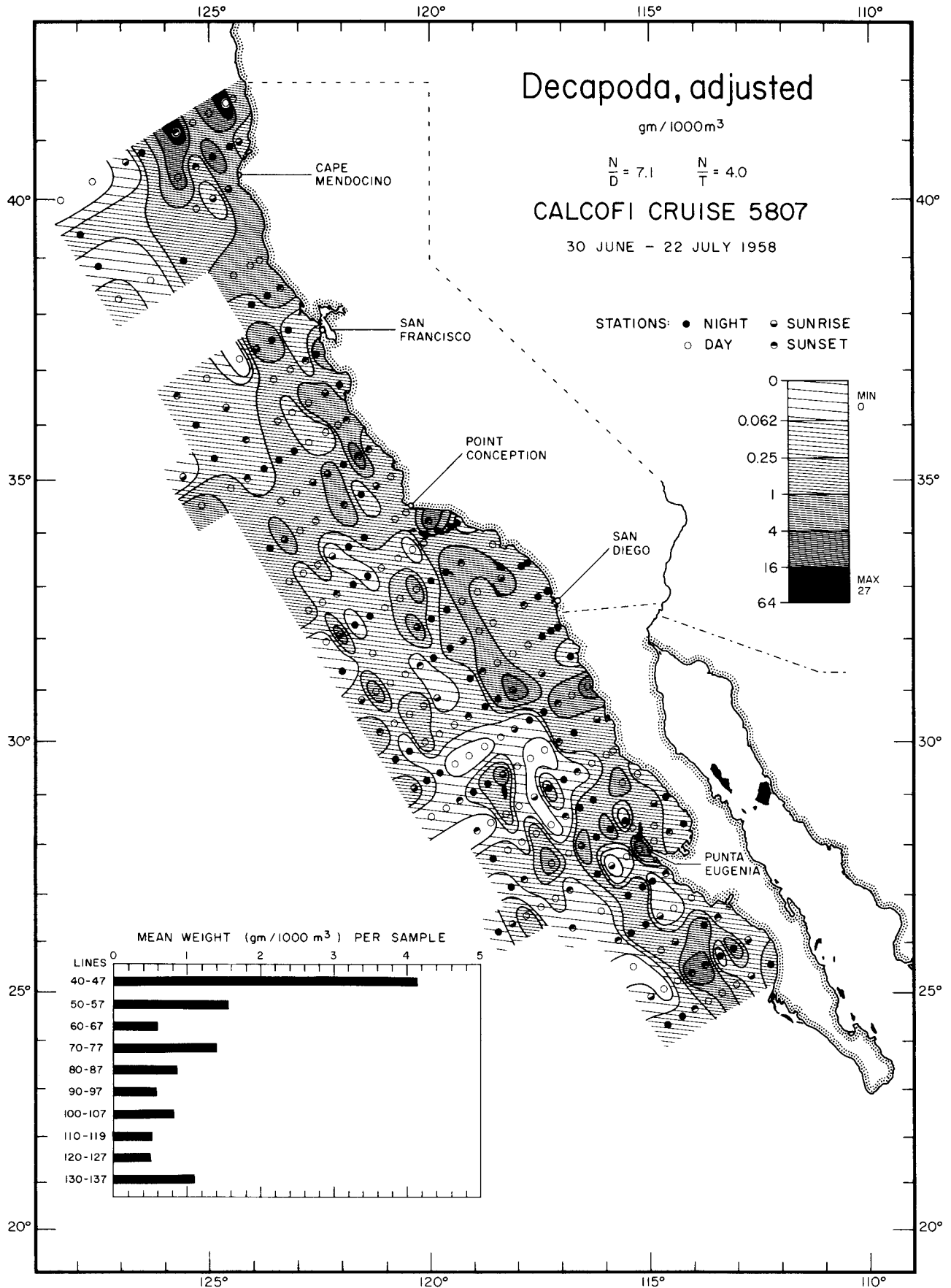
Biomass  
 Decapoda, adjusted  
 5607

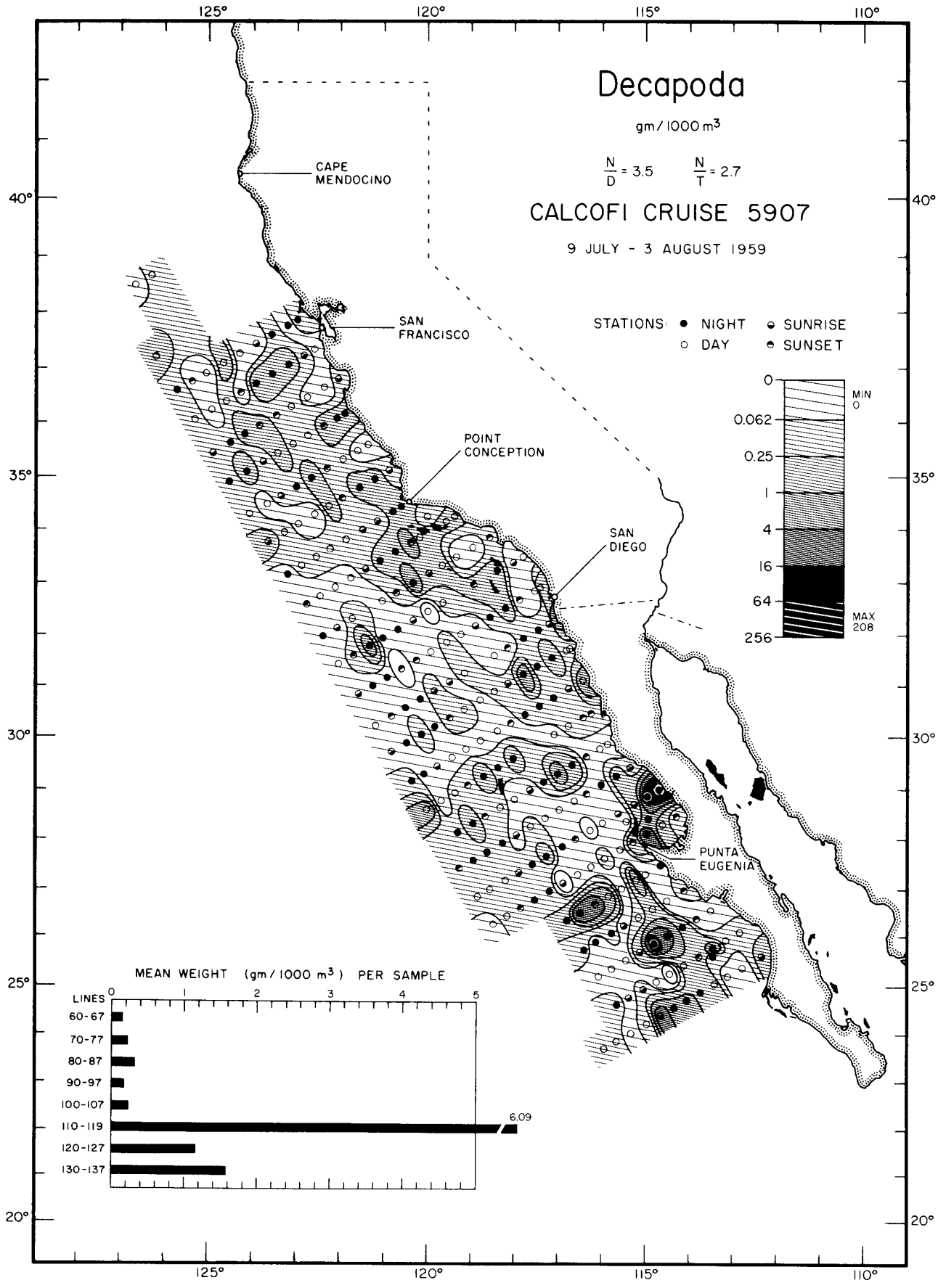












# Decapoda

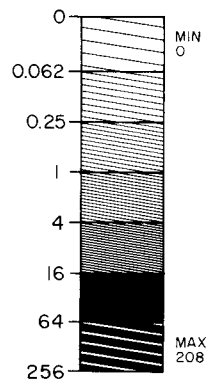
gm/1000 m<sup>3</sup>

$$\frac{N}{D} = 3.5 \quad \frac{N}{T} = 2.7$$

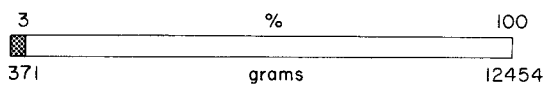
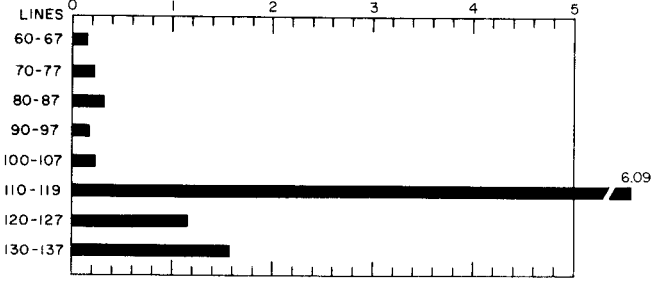
## CALCOFI CRUISE 5907

9 JULY - 3 AUGUST 1959

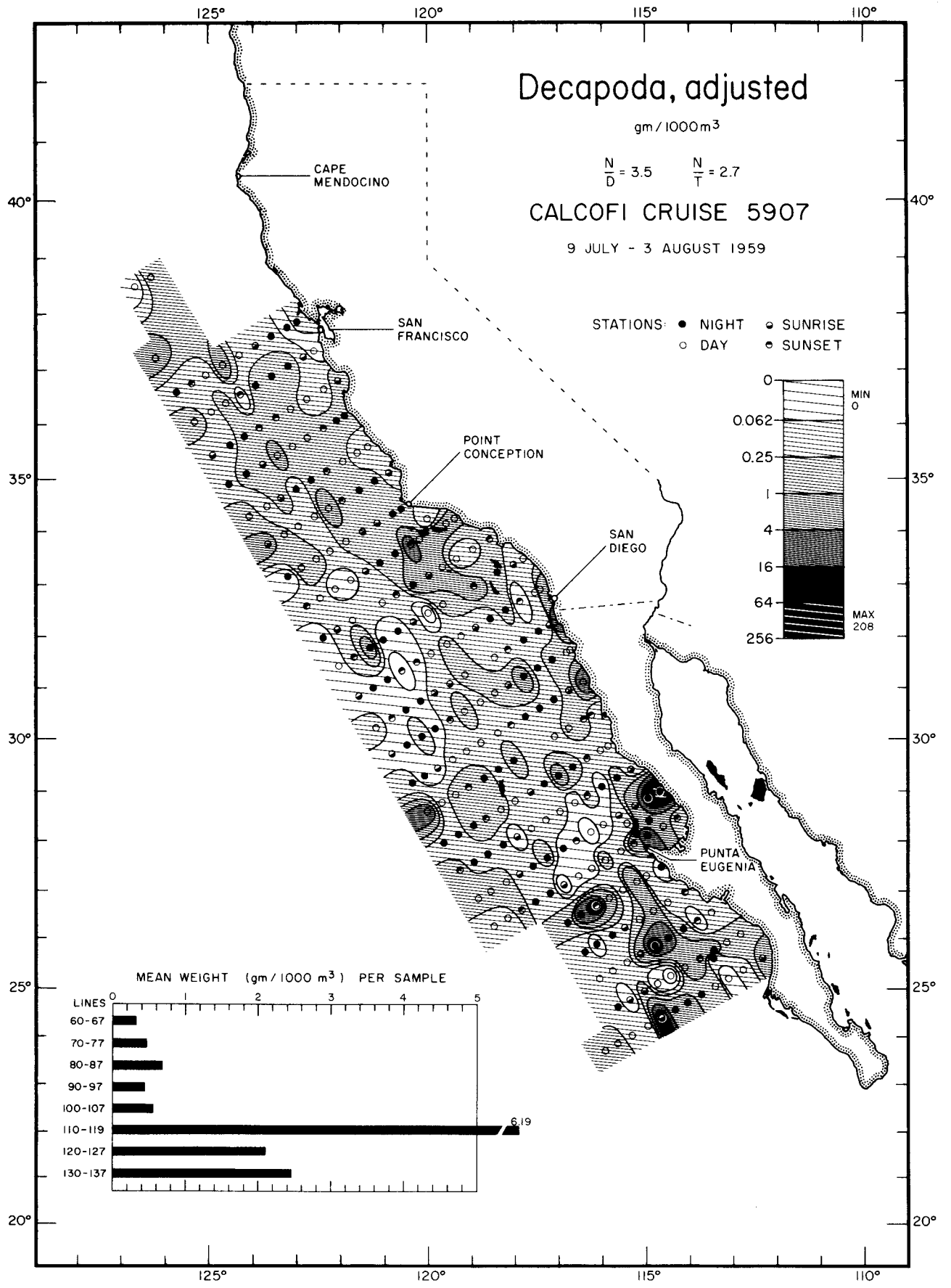
STATIONS: ● NIGHT ○ DAY ● SUNRISE ○ SUNSET



MEAN WEIGHT (gm/1000 m<sup>3</sup>) PER SAMPLE

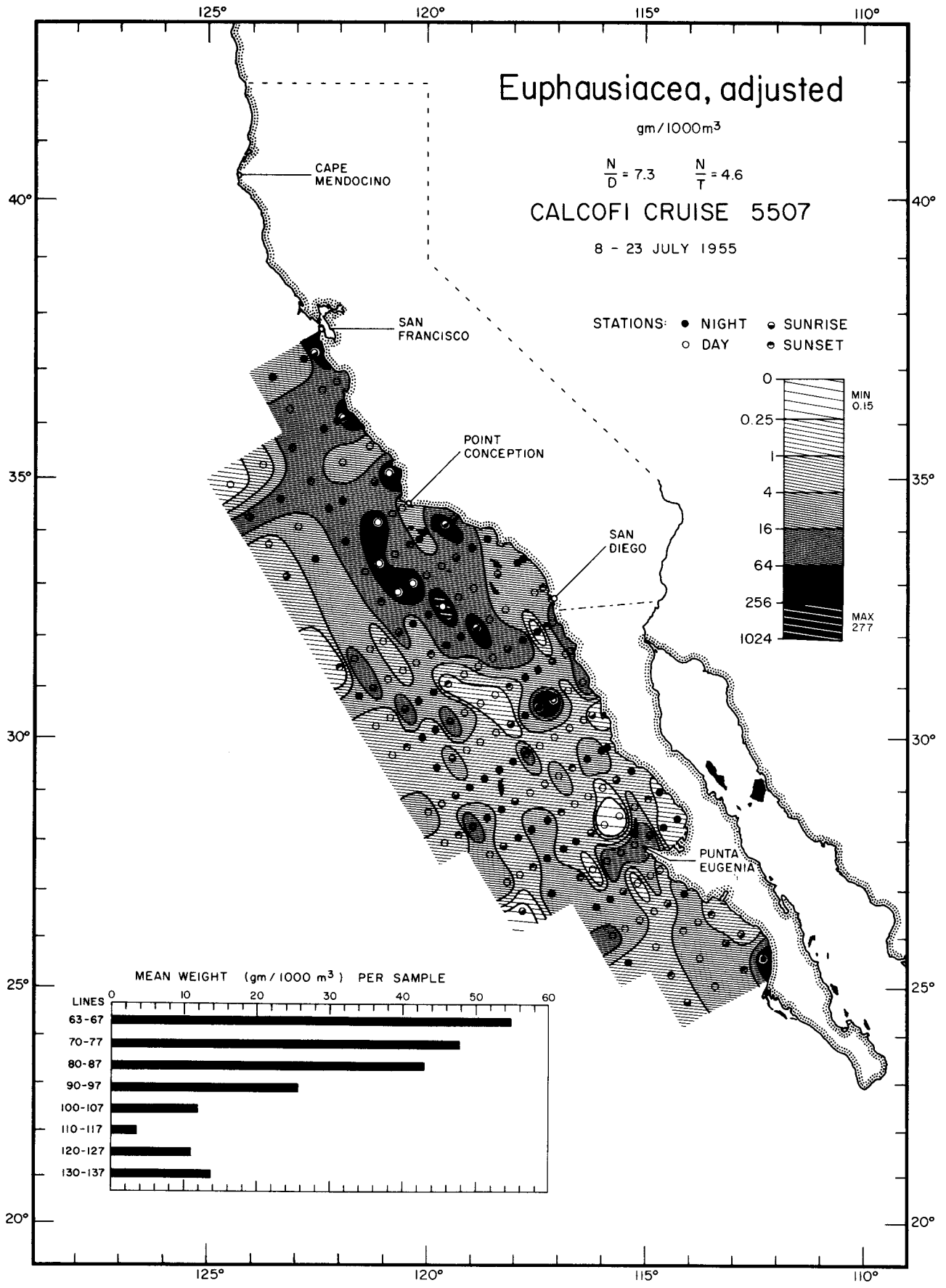


Biomass  
Decapoda  
5907



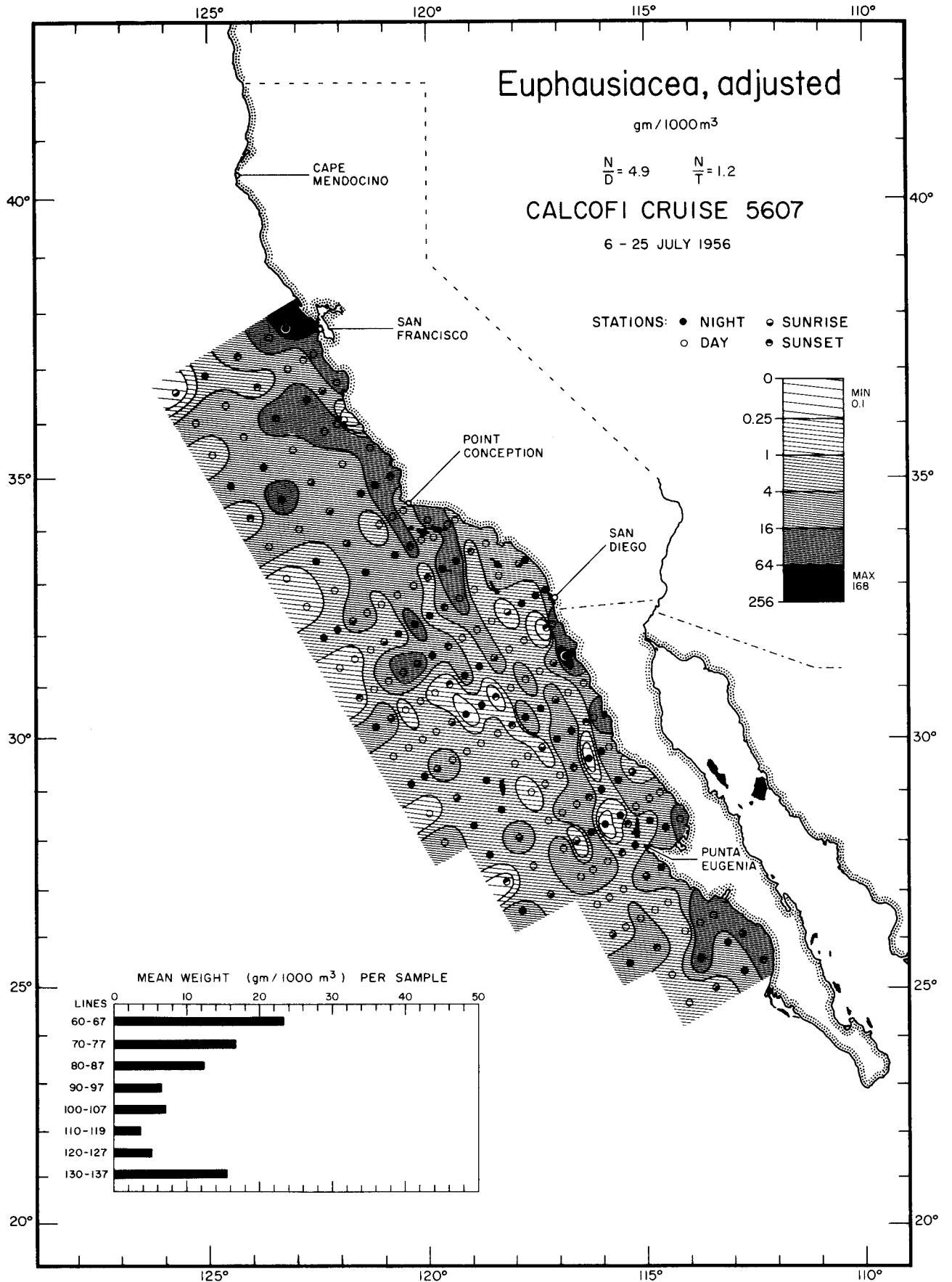
Biomass  
 Decapoda, adjusted  
 5907





Biomass  
 Euphausiacea, adjusted  
 5507

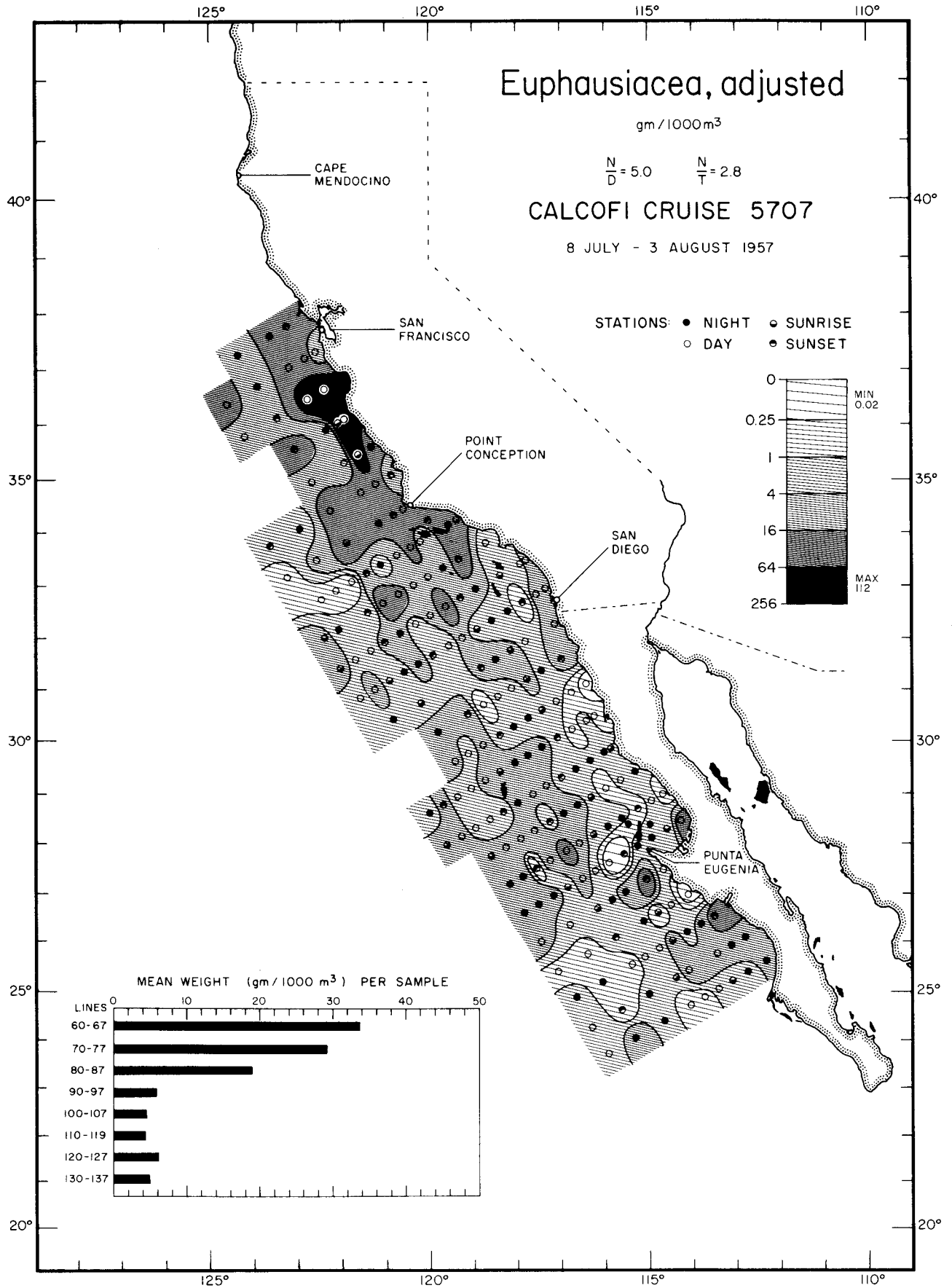




Biomass  
 Euphausiacea, adjusted  
 5607

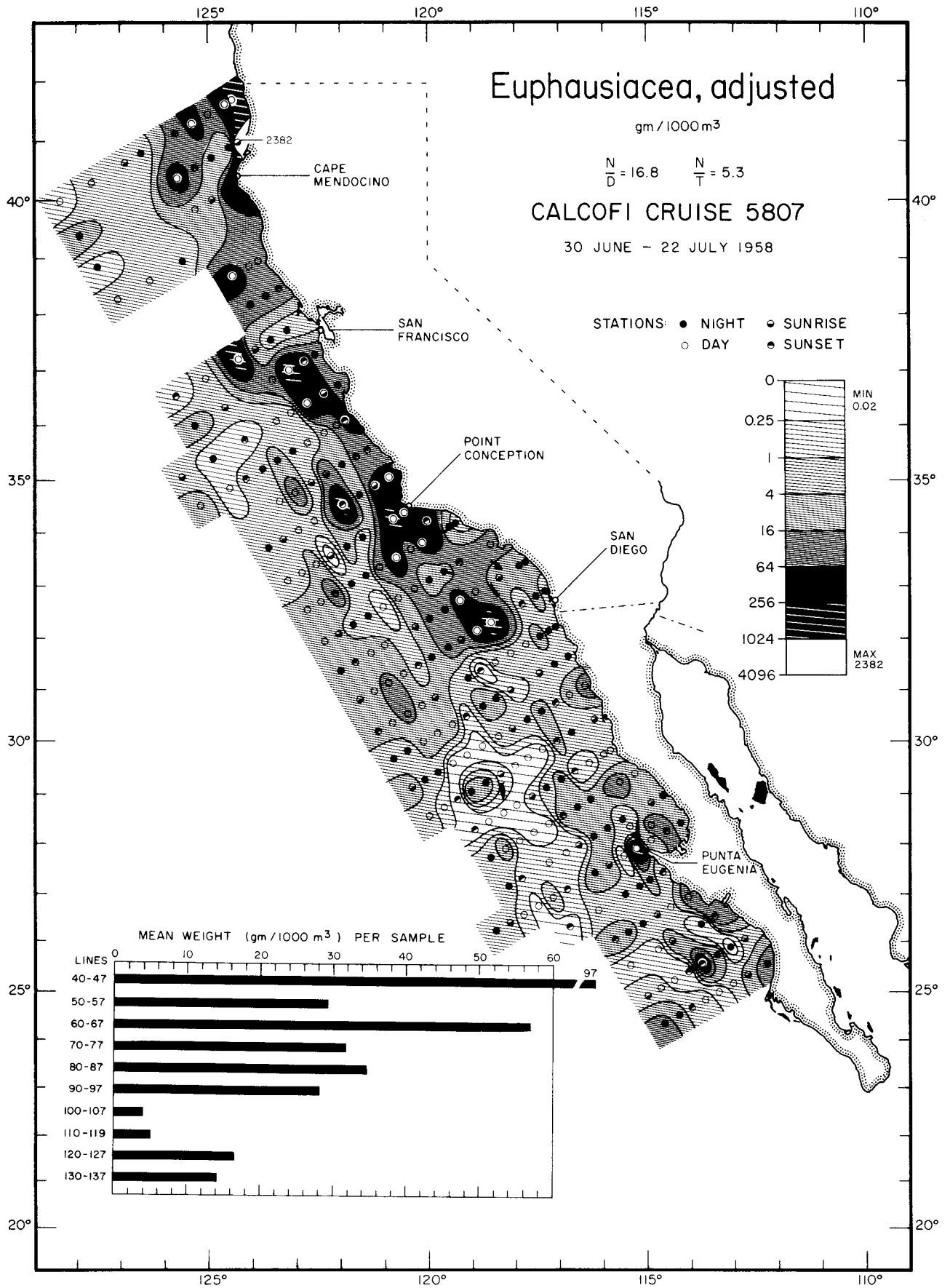






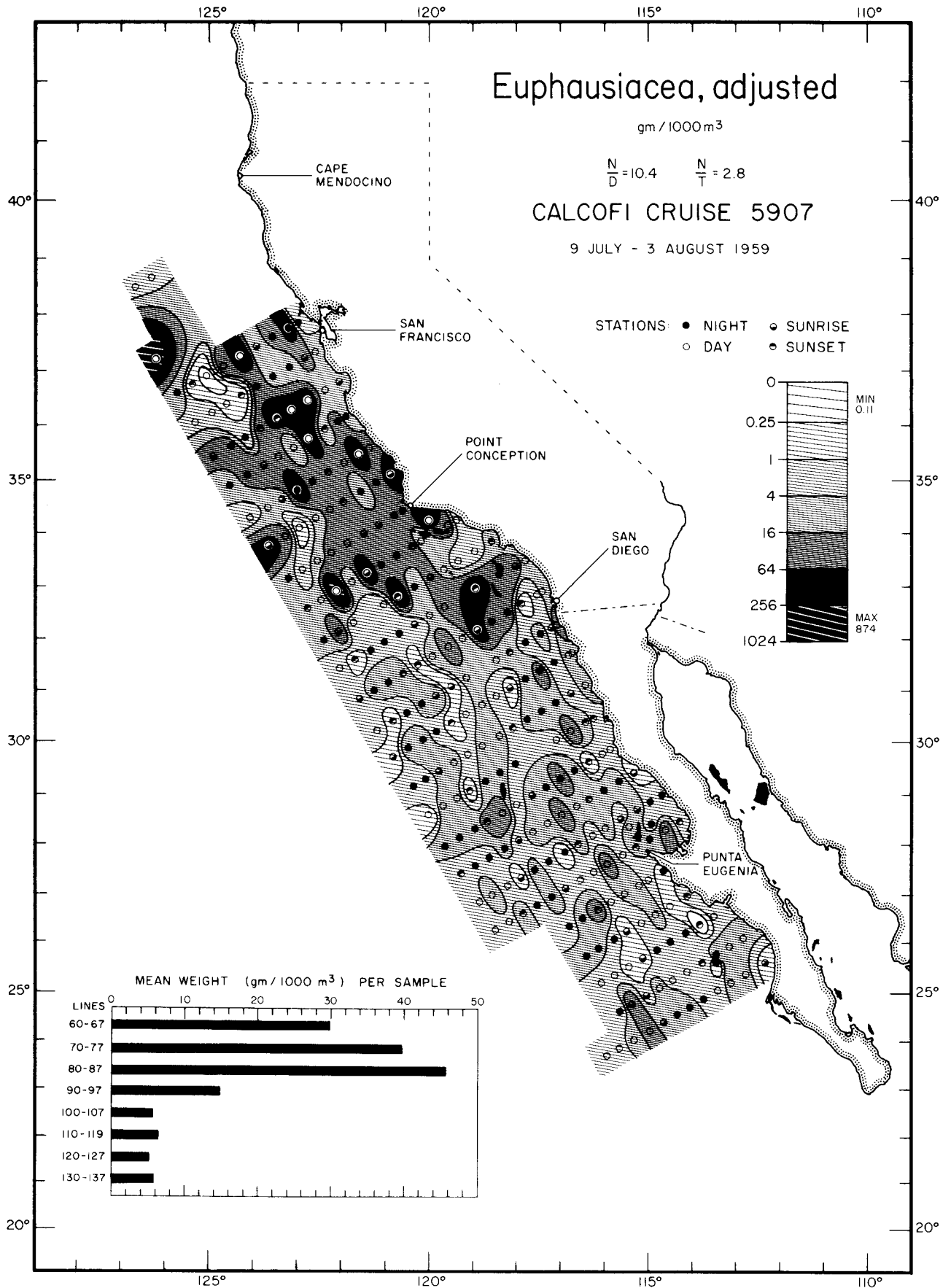
Biomass  
 Euphausiacea, adjusted  
 5707



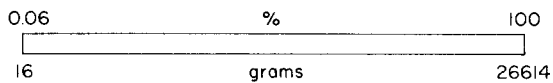
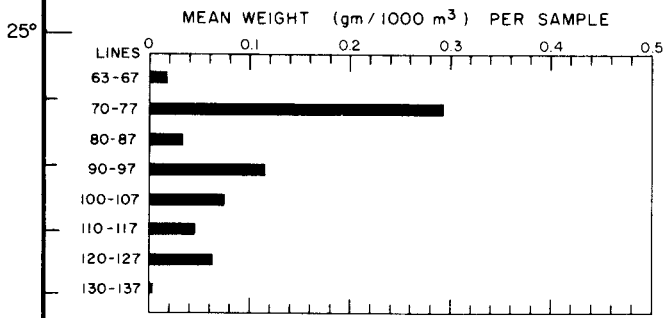
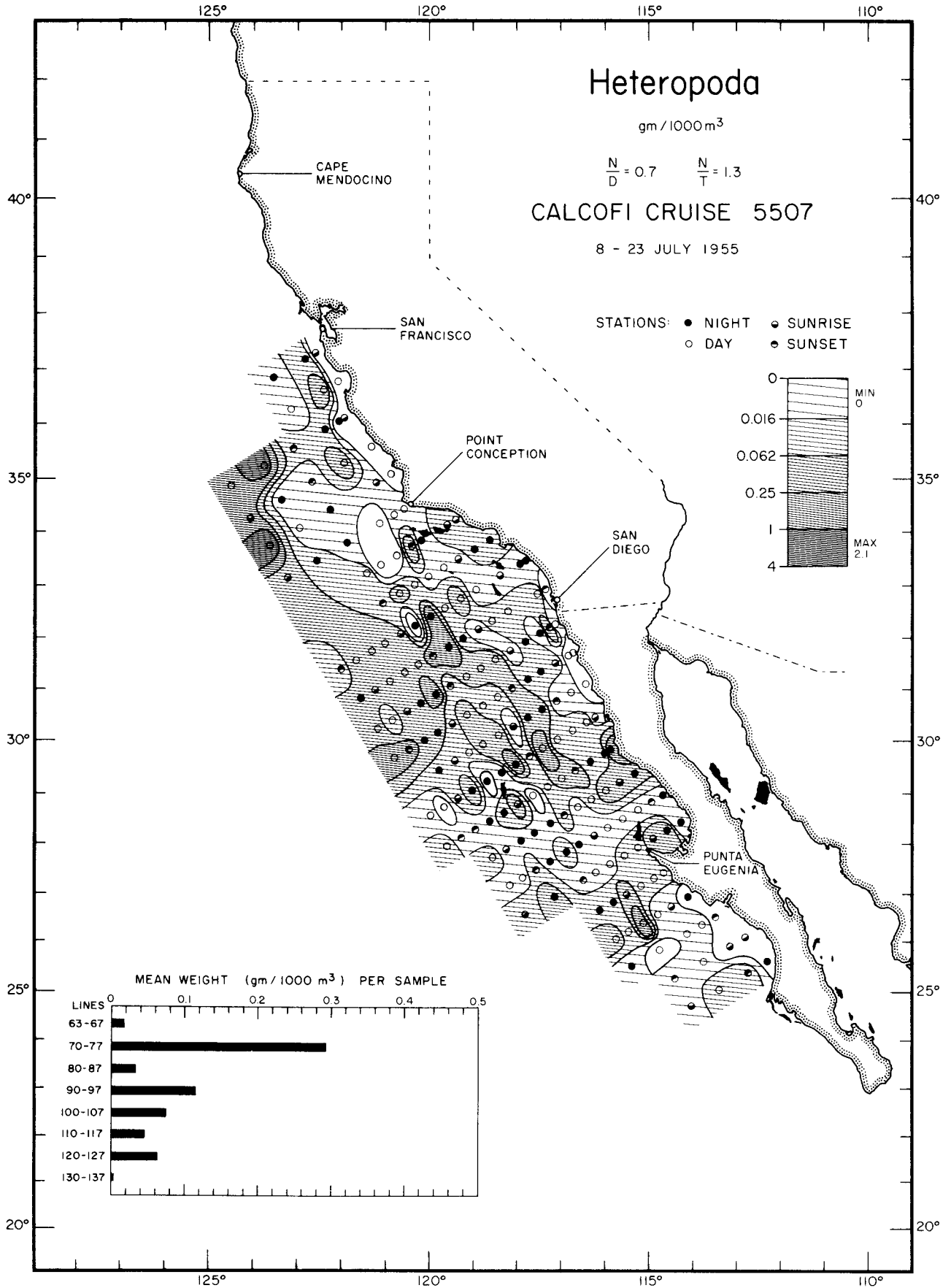


Biomass  
 Euphausiacea, adjusted  
 5807





Biomass  
 Euphausiacea, adjusted  
 5907



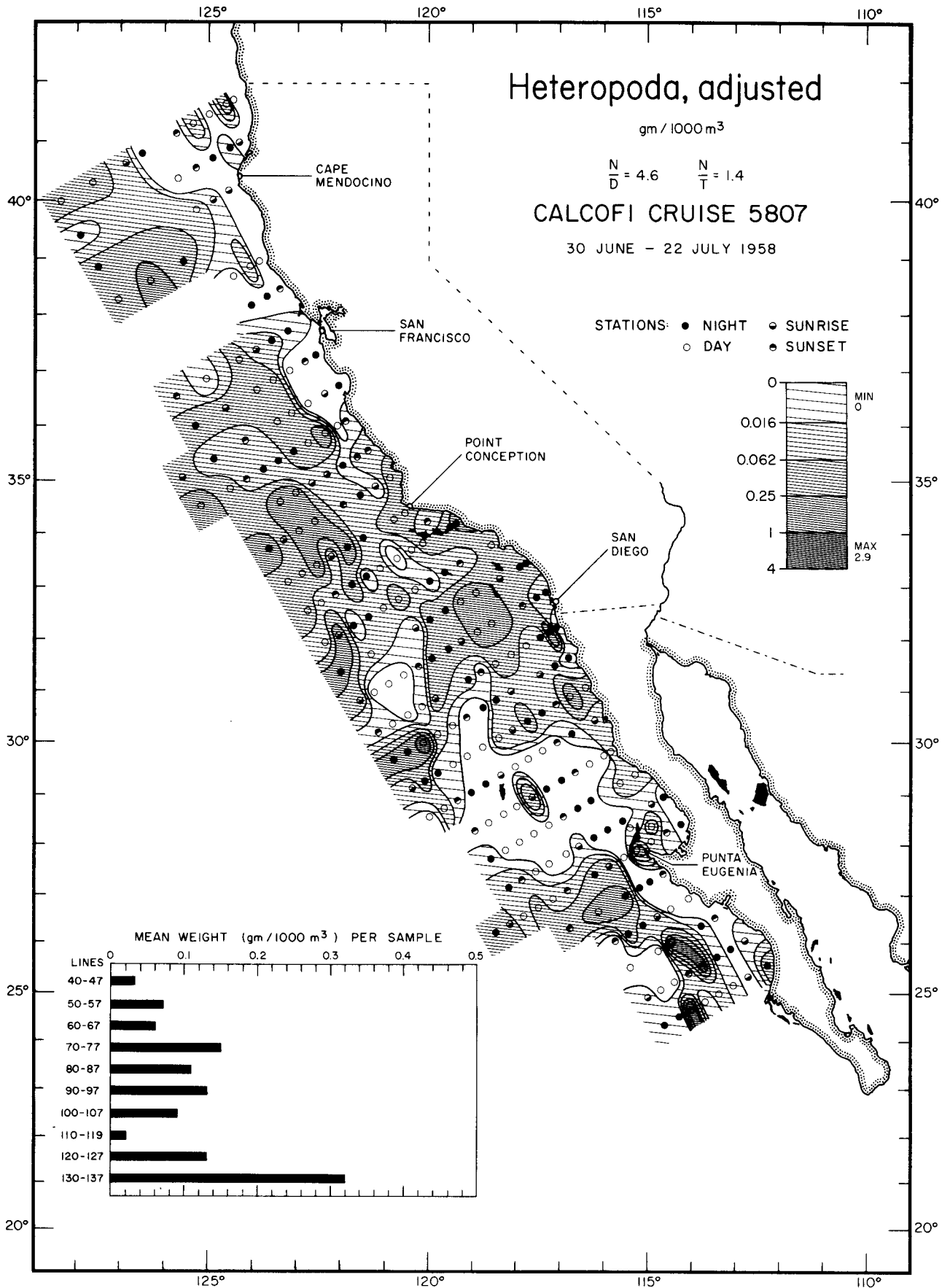
Biomass  
**Heteropoda**  
**5507**



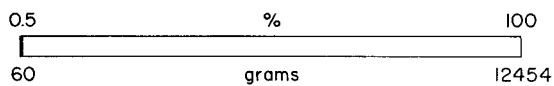
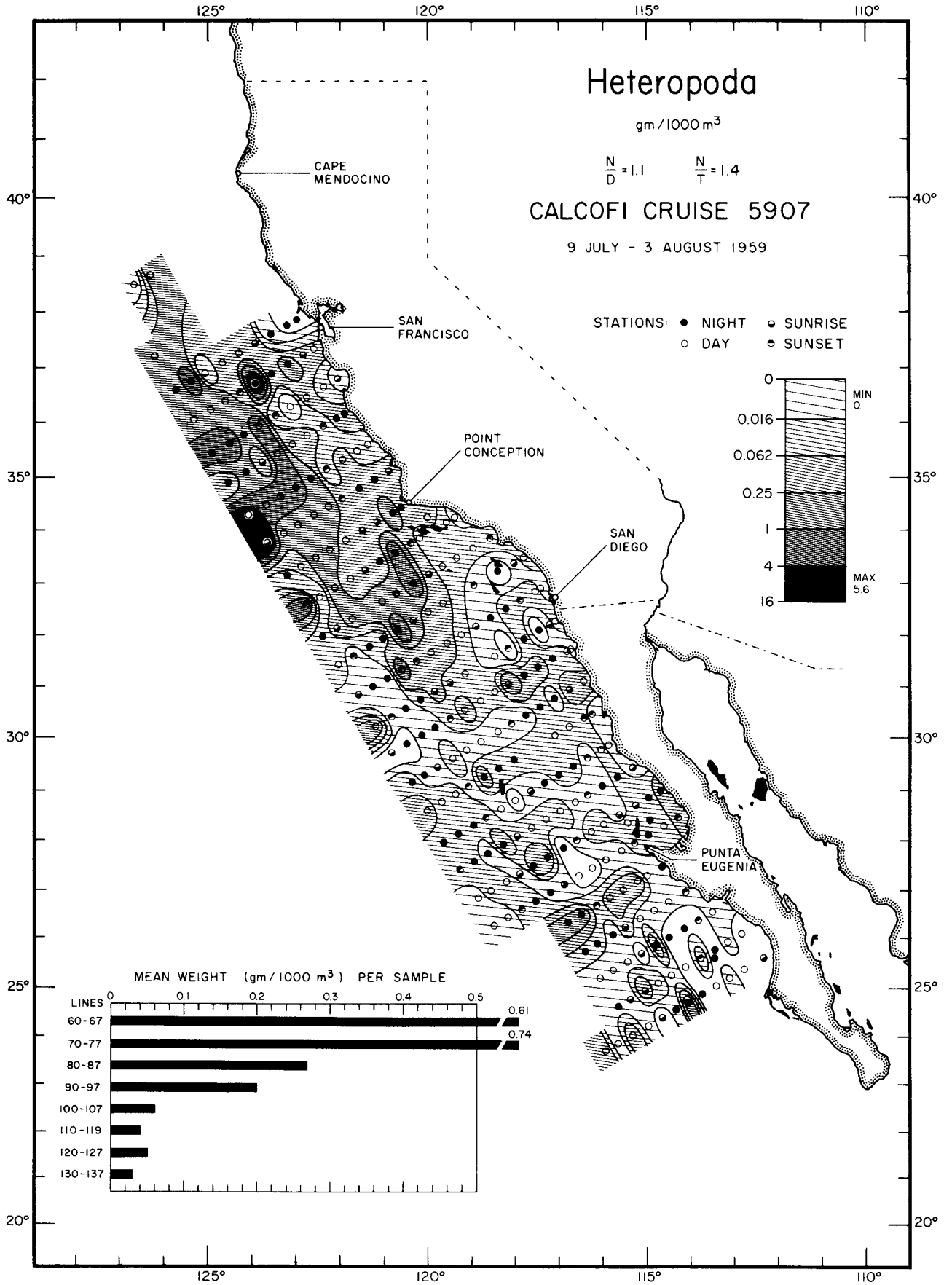




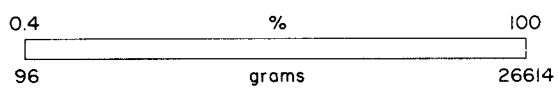
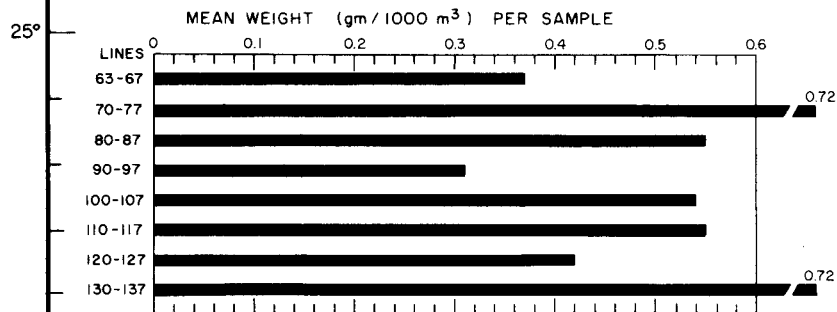
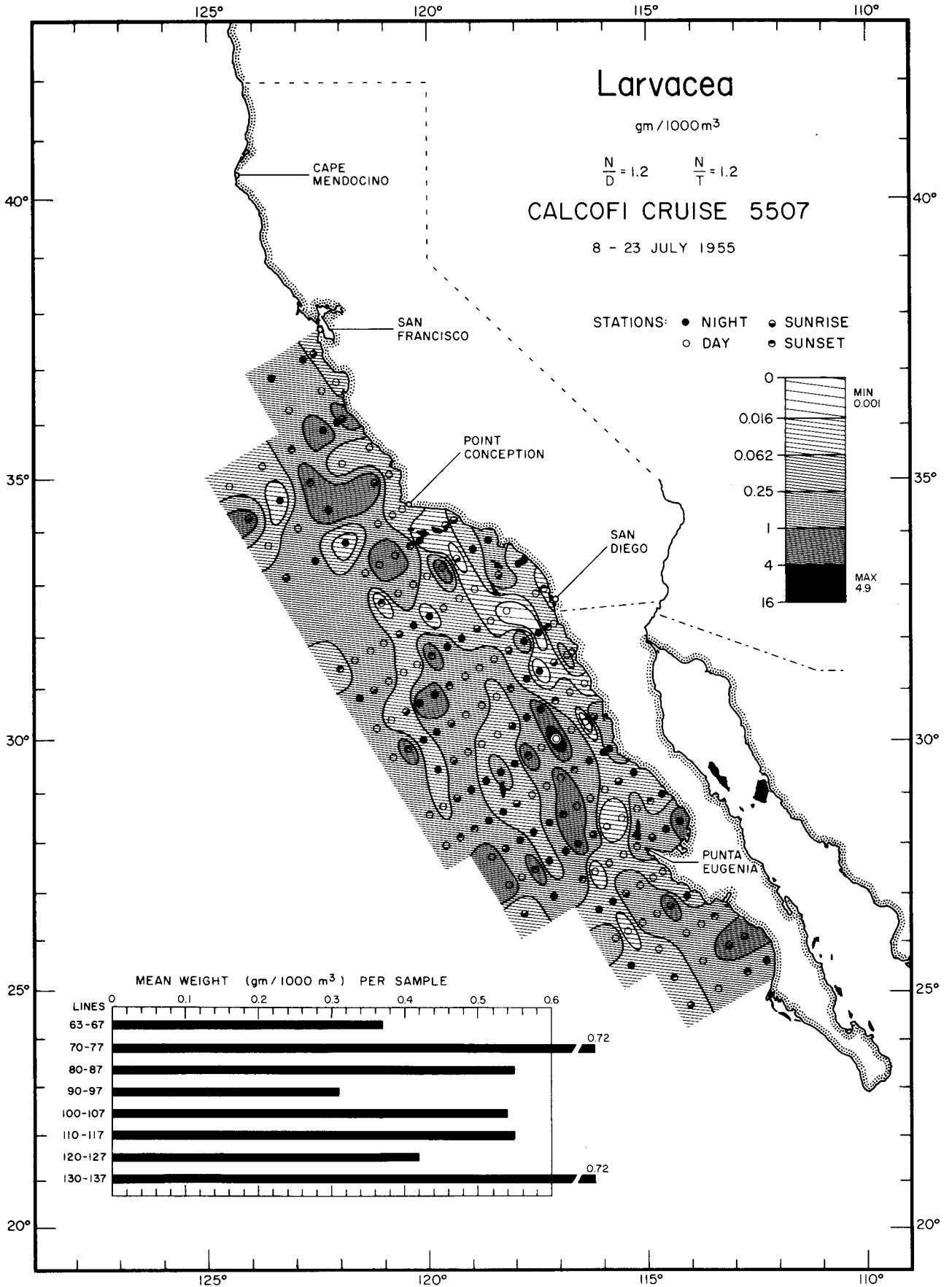




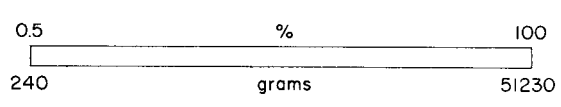
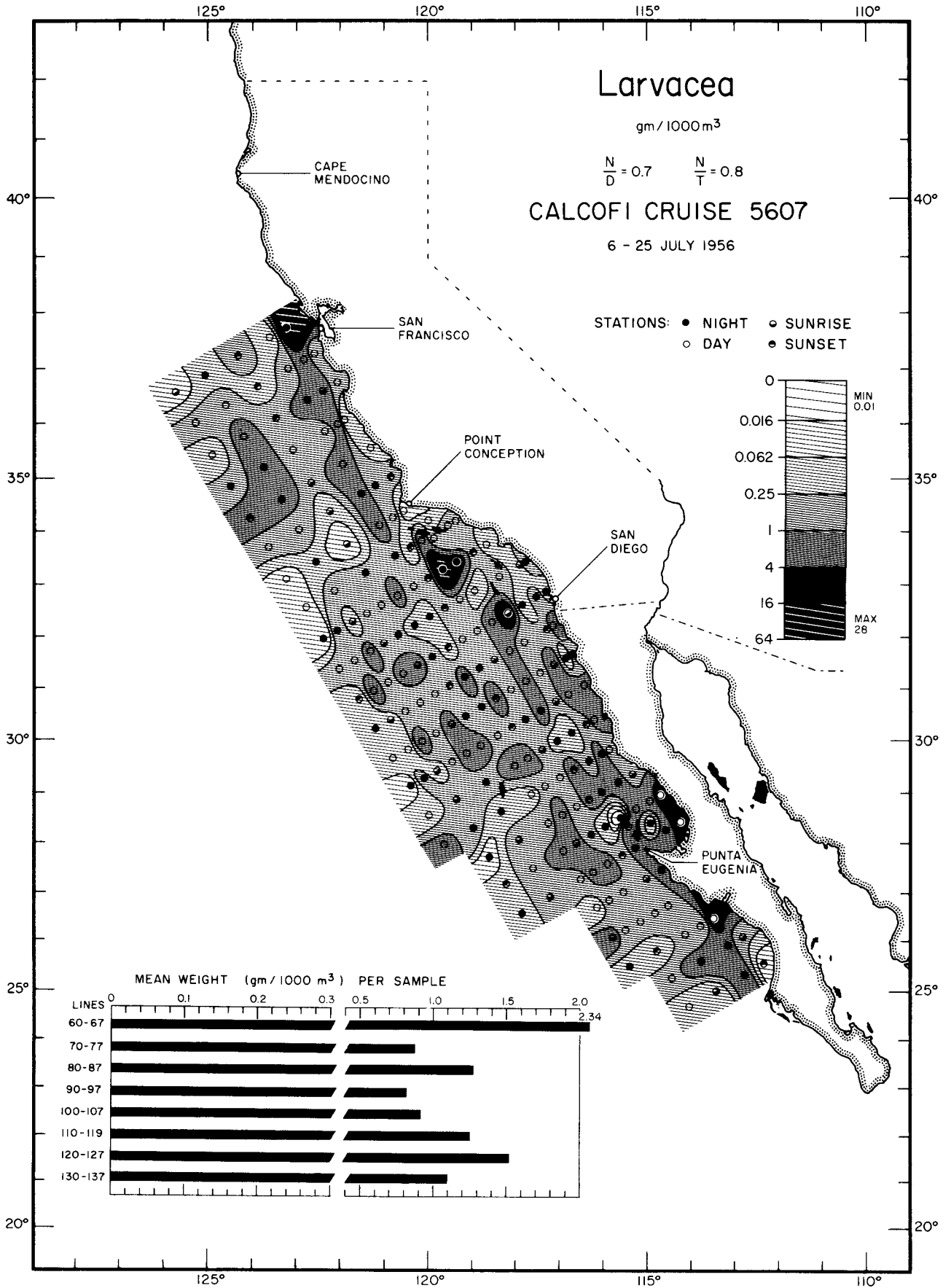
Biomass  
 Heteropoda, adjusted  
 5807



Biomass  
**Heteropoda**  
**5907**



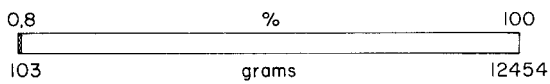
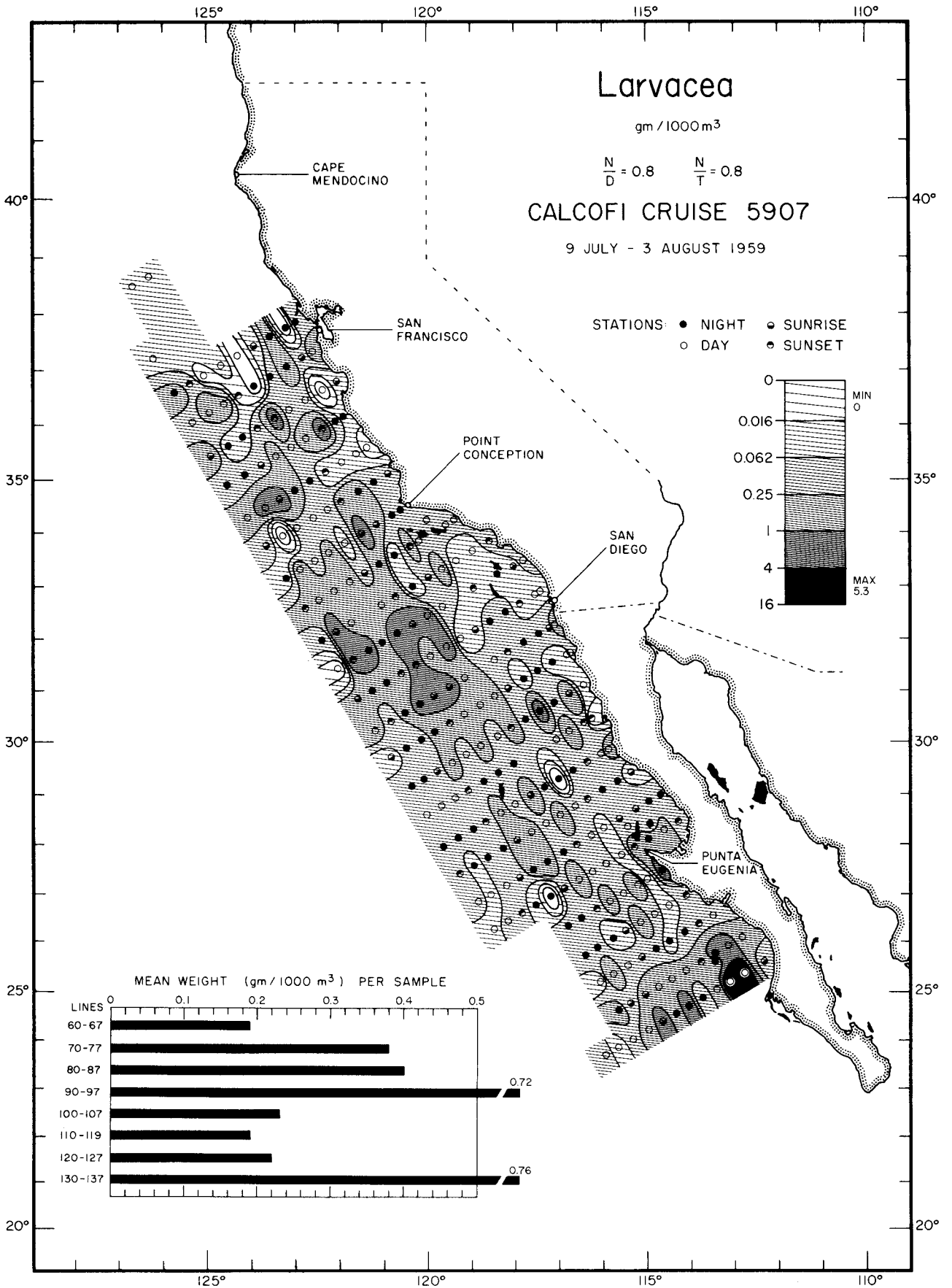
Biomass  
Larvacea  
5507



Biomass  
Larvacea  
5607

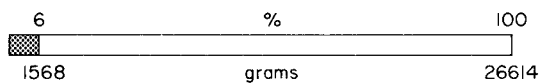
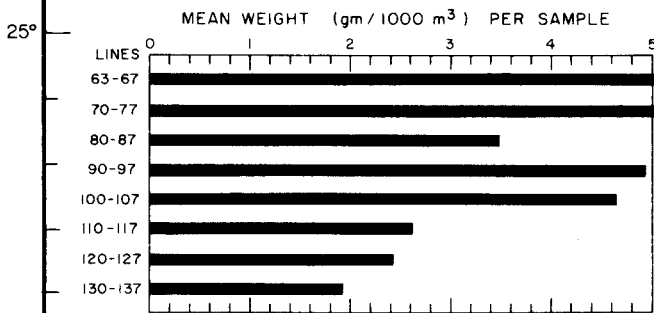
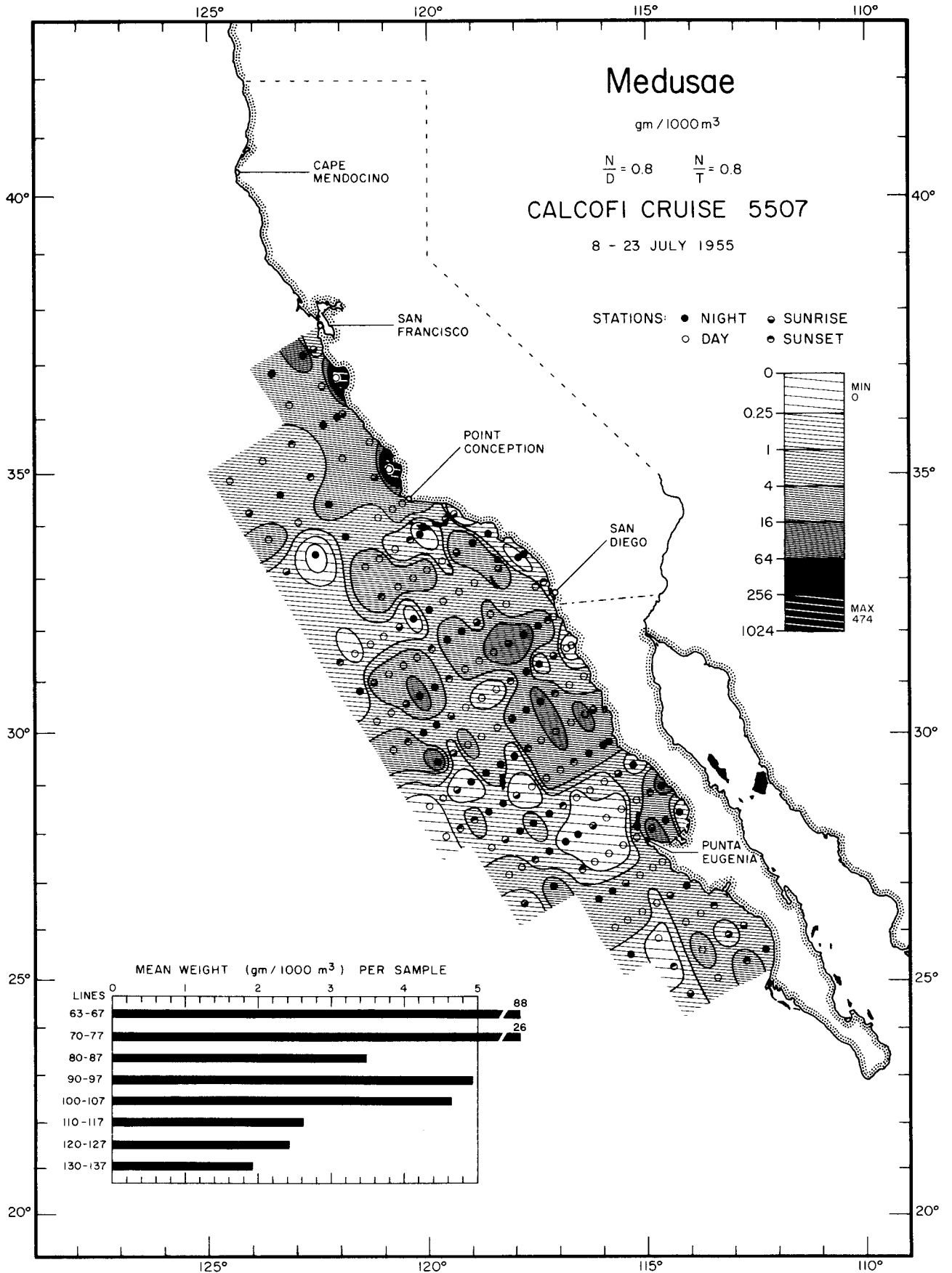






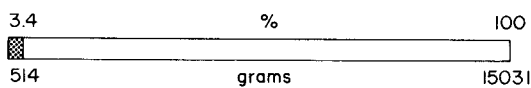
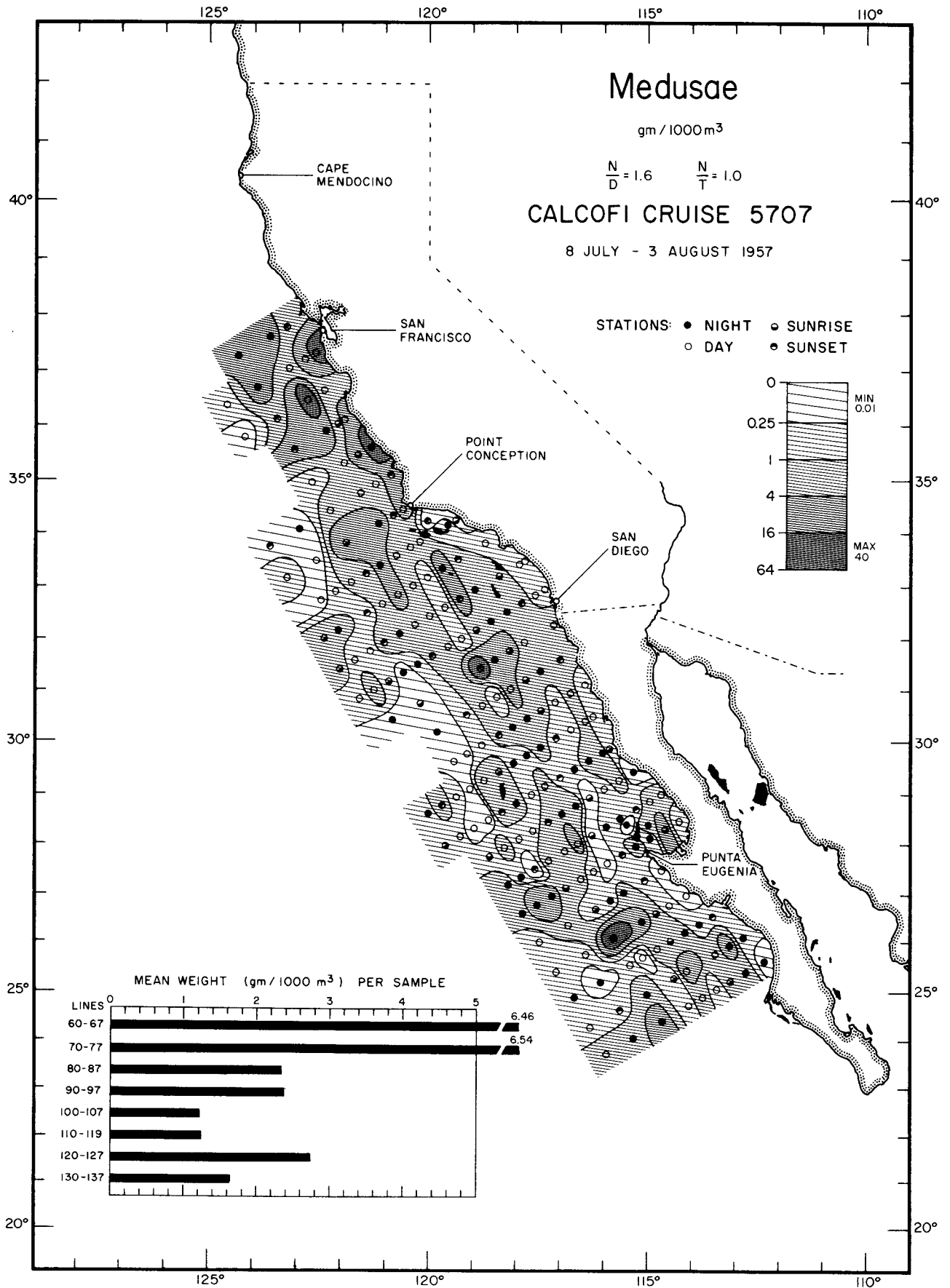
Biomass  
Larvacea  
5907



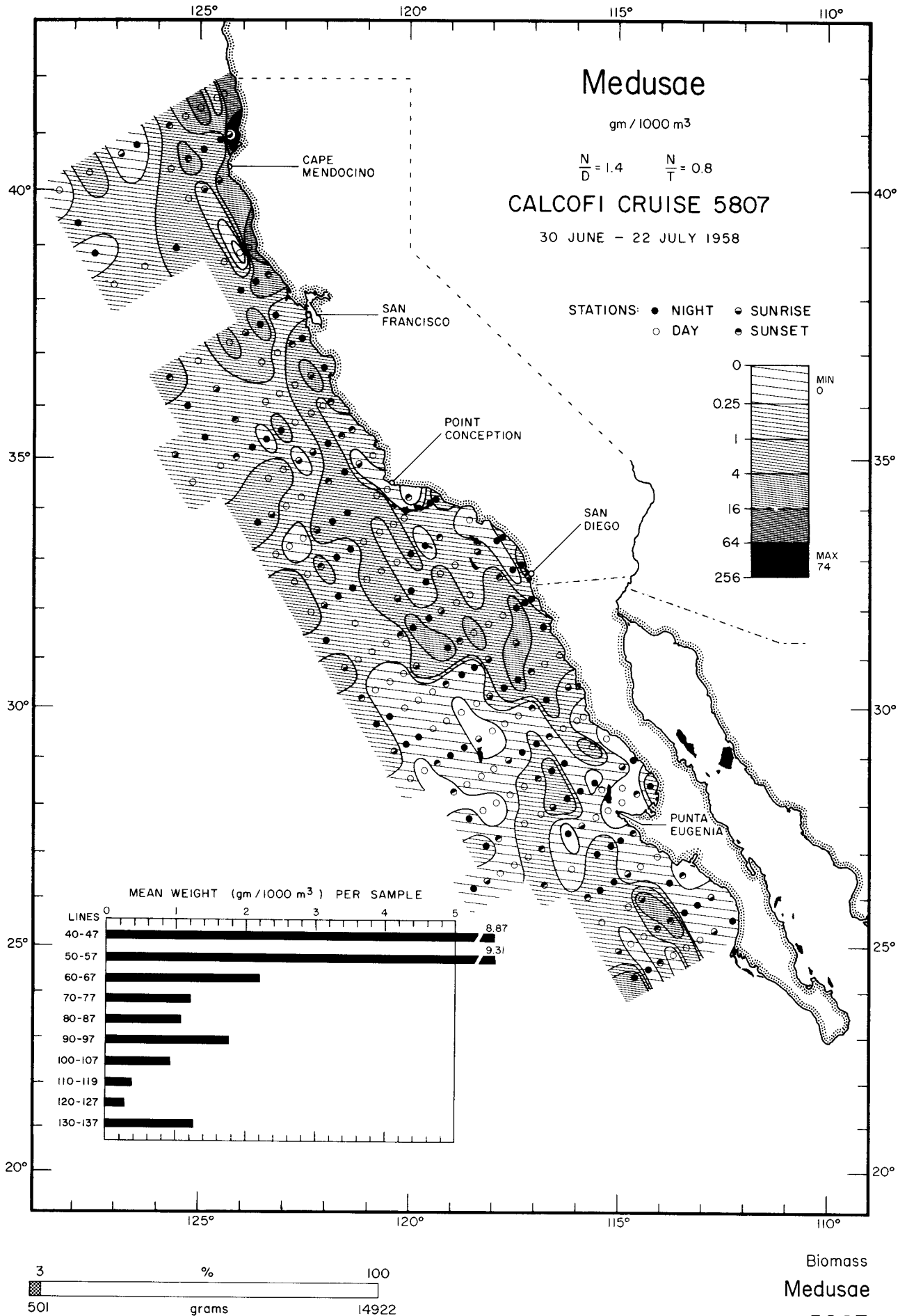


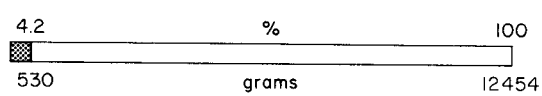
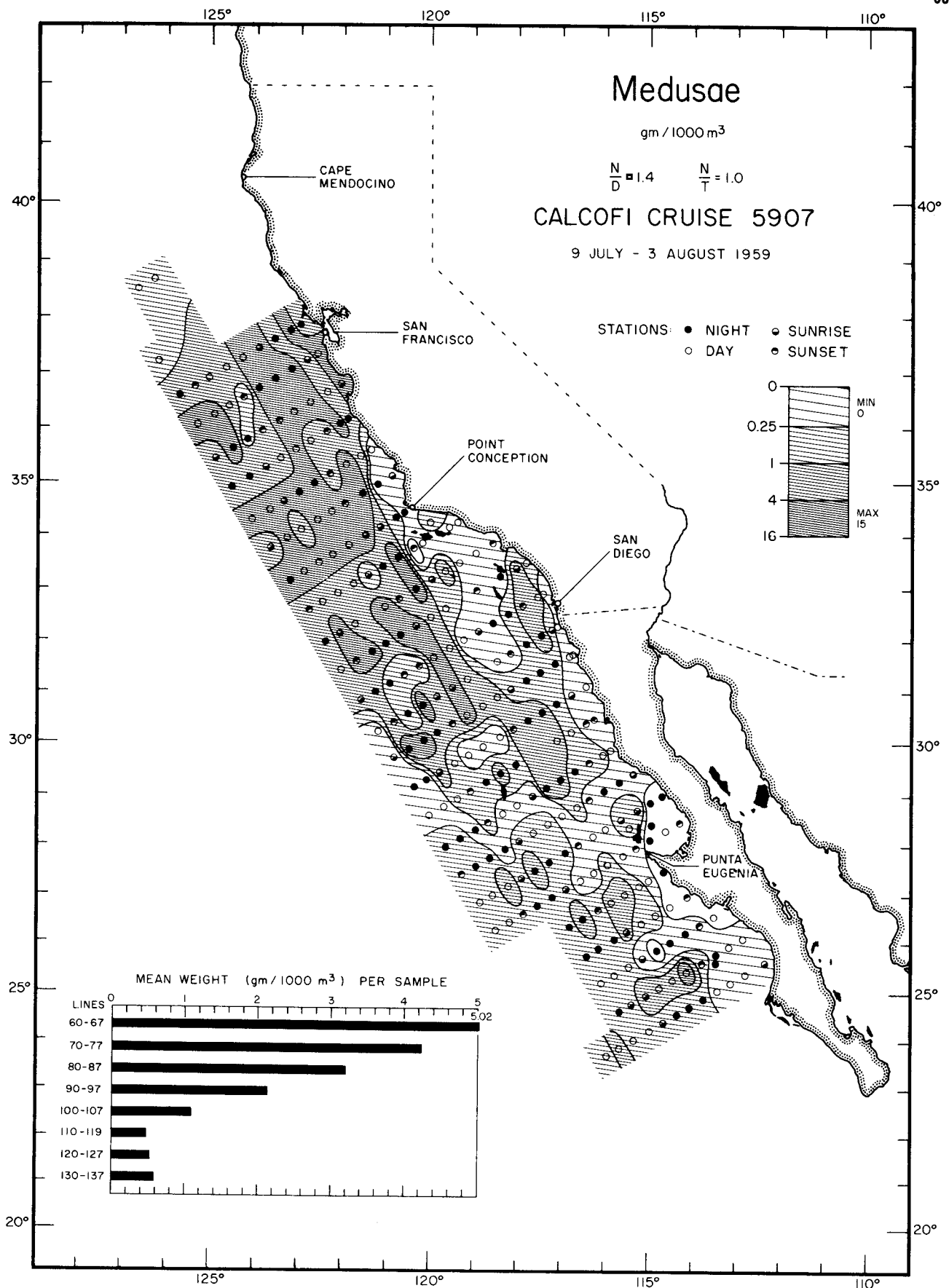
Biomass  
Medusae  
5507



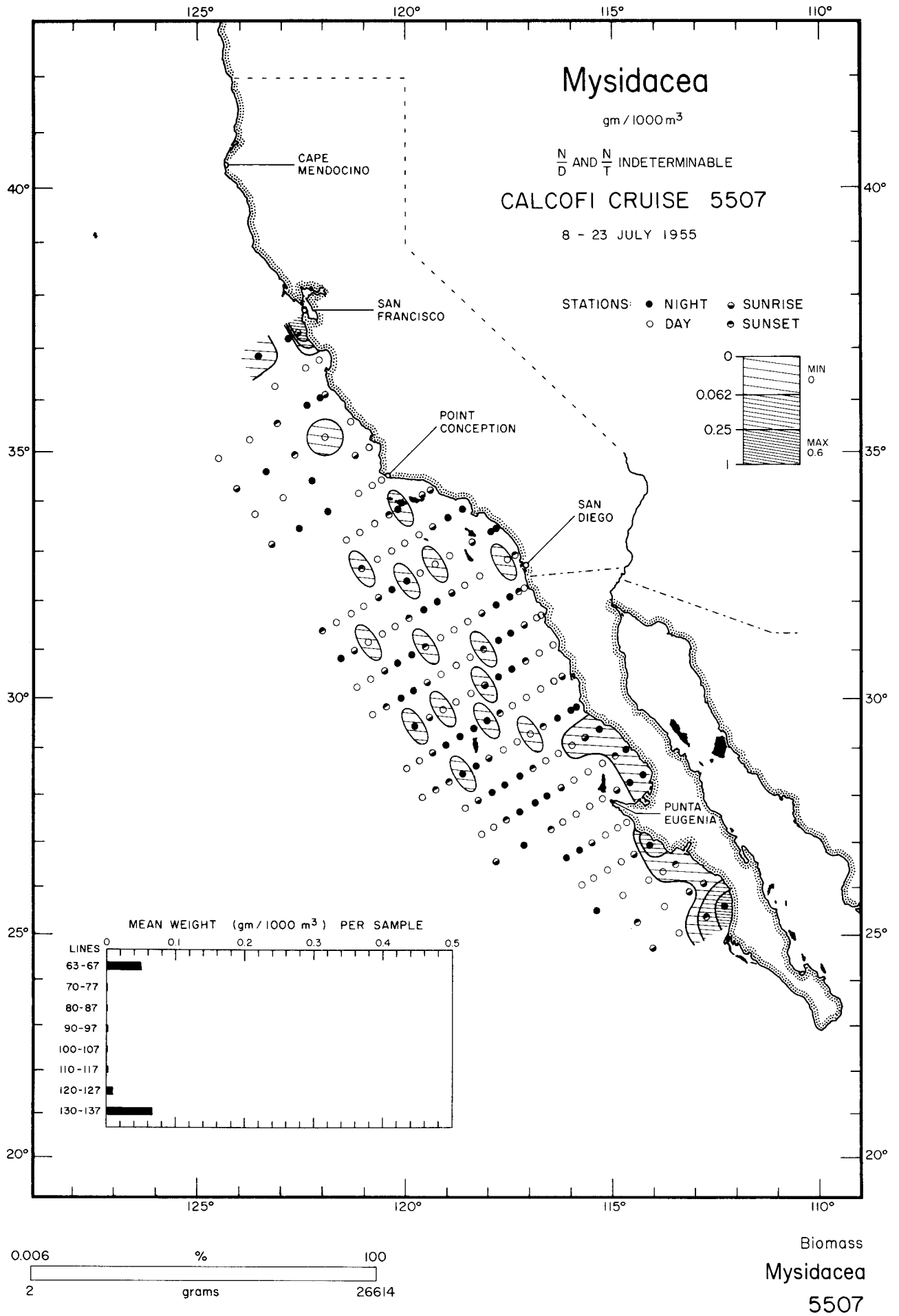


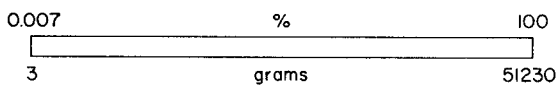
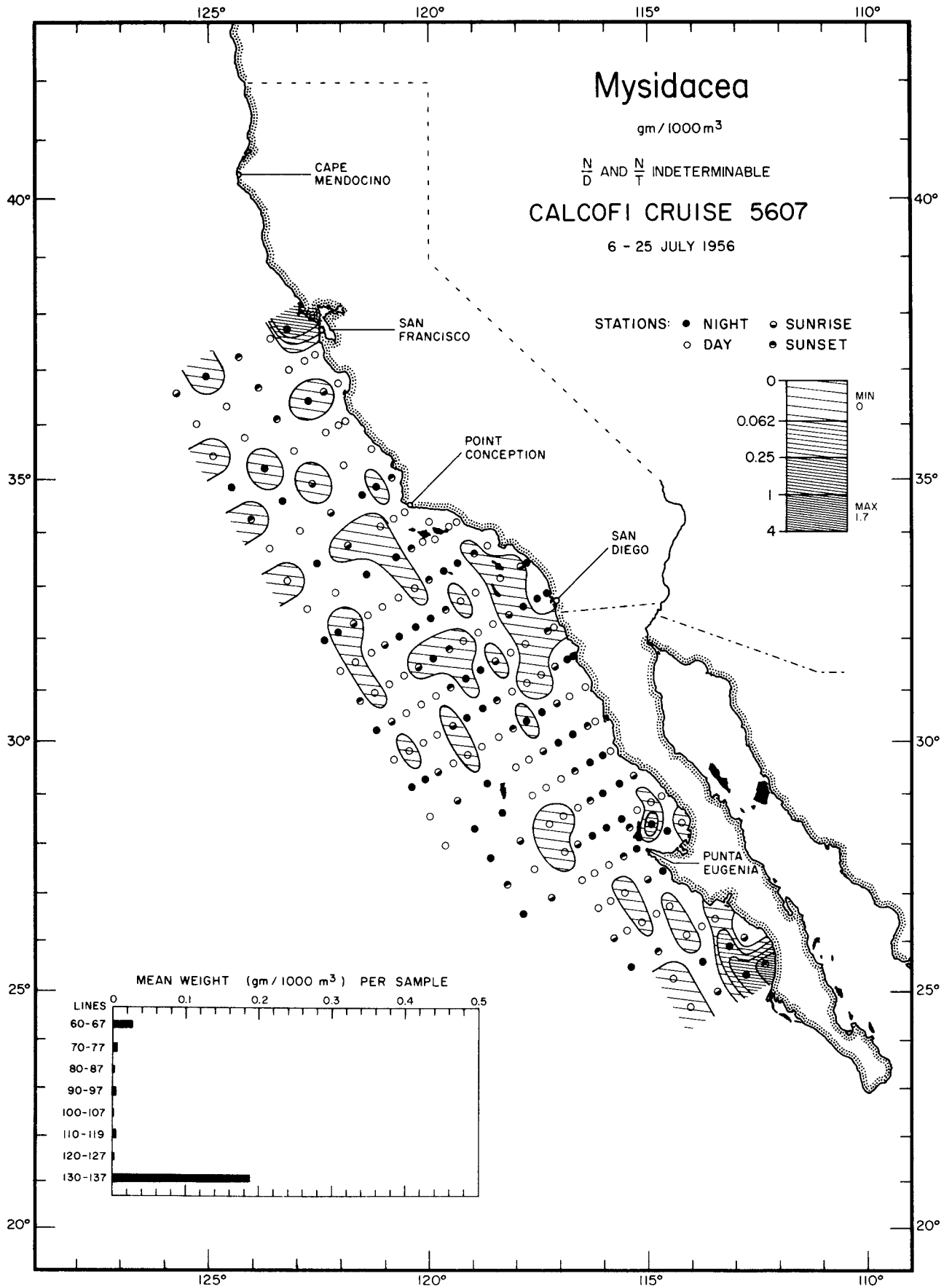
Biomass  
**Medusae**  
**5707**



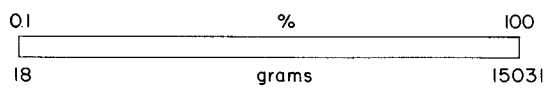
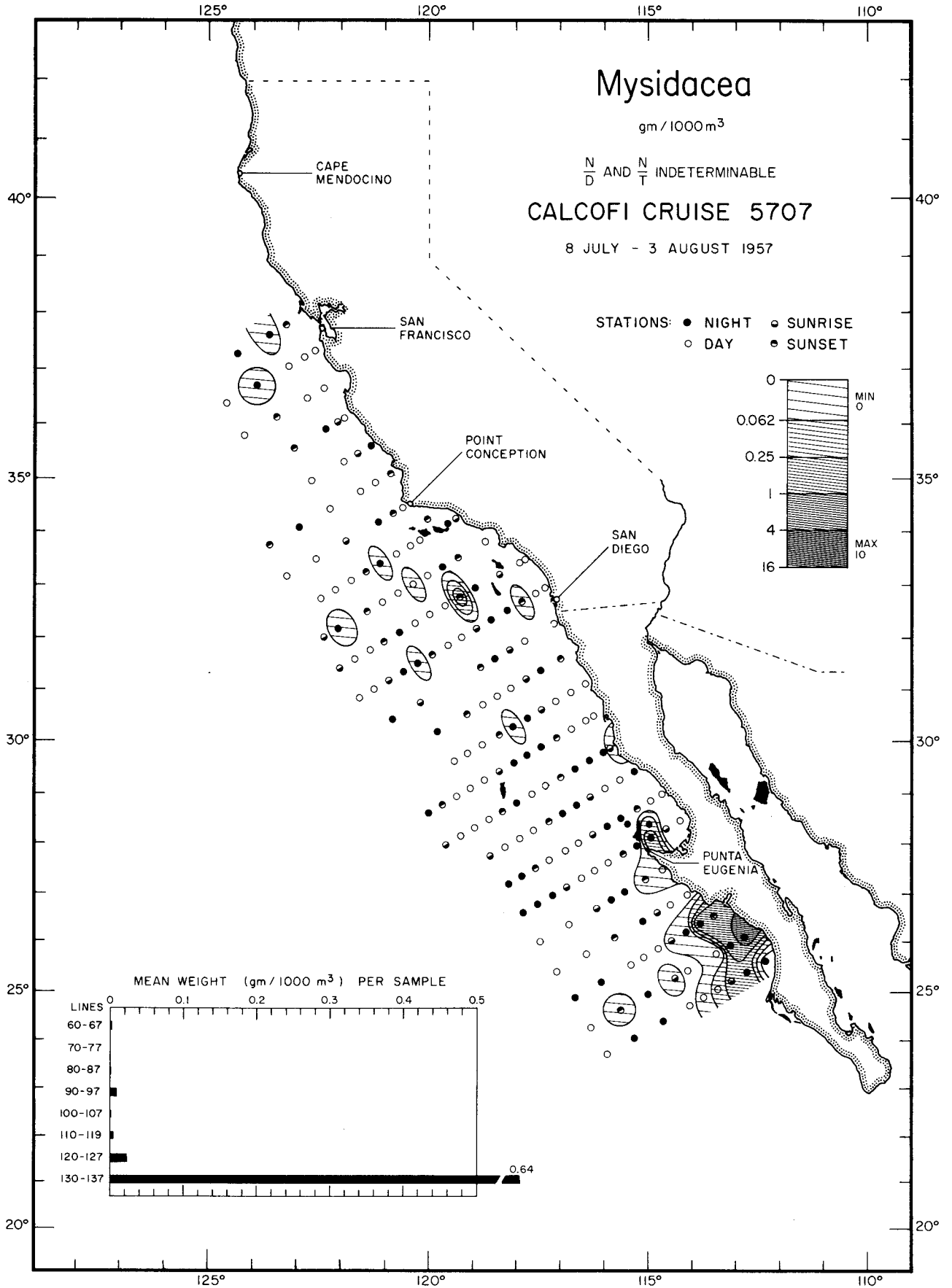


Biomass  
Medusae  
5907





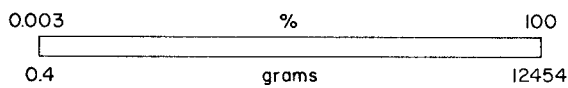
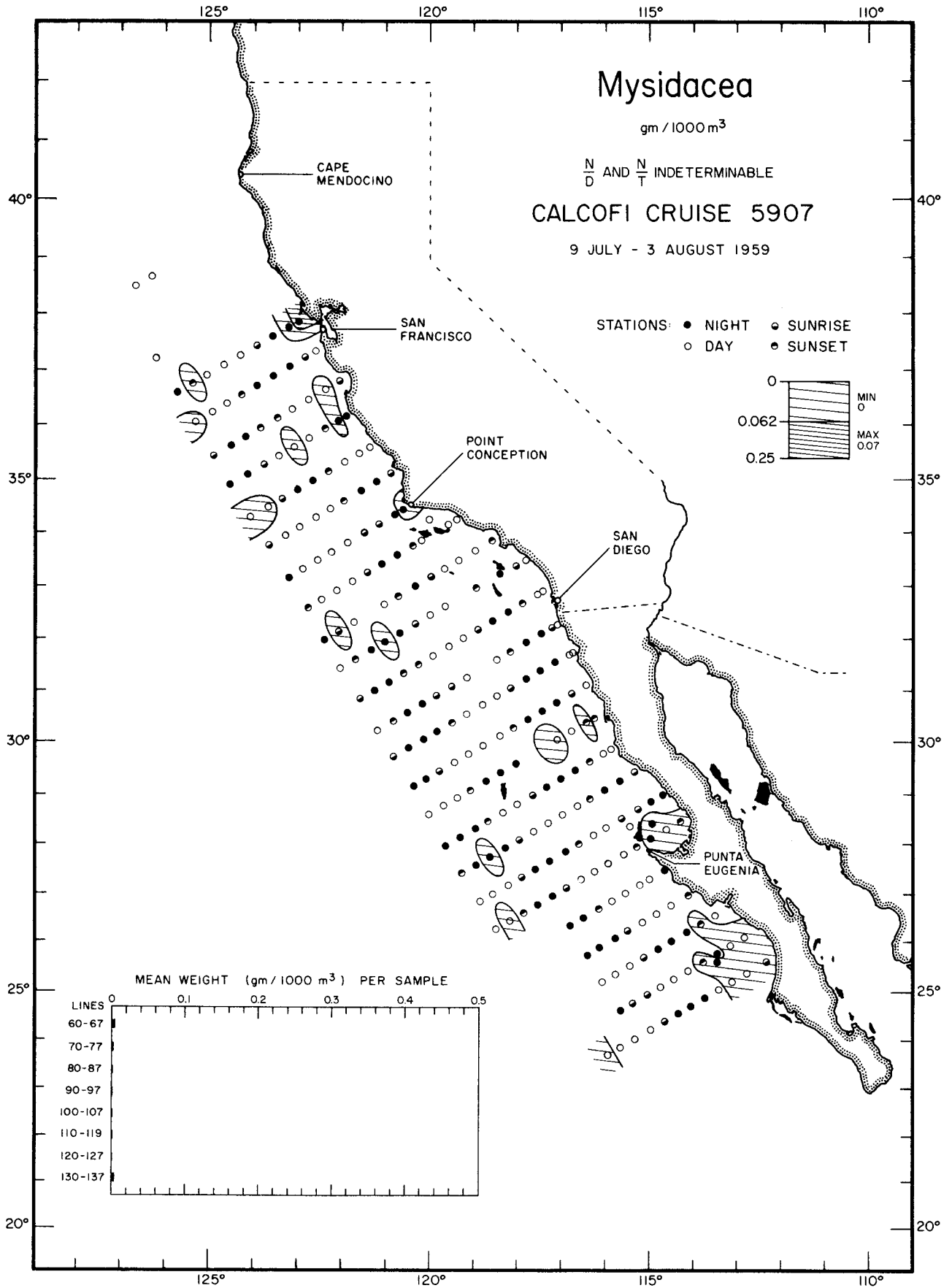
Biomass  
**Mysidacea**  
**5607**



Biomass  
**Mysidaceae**  
**5707**

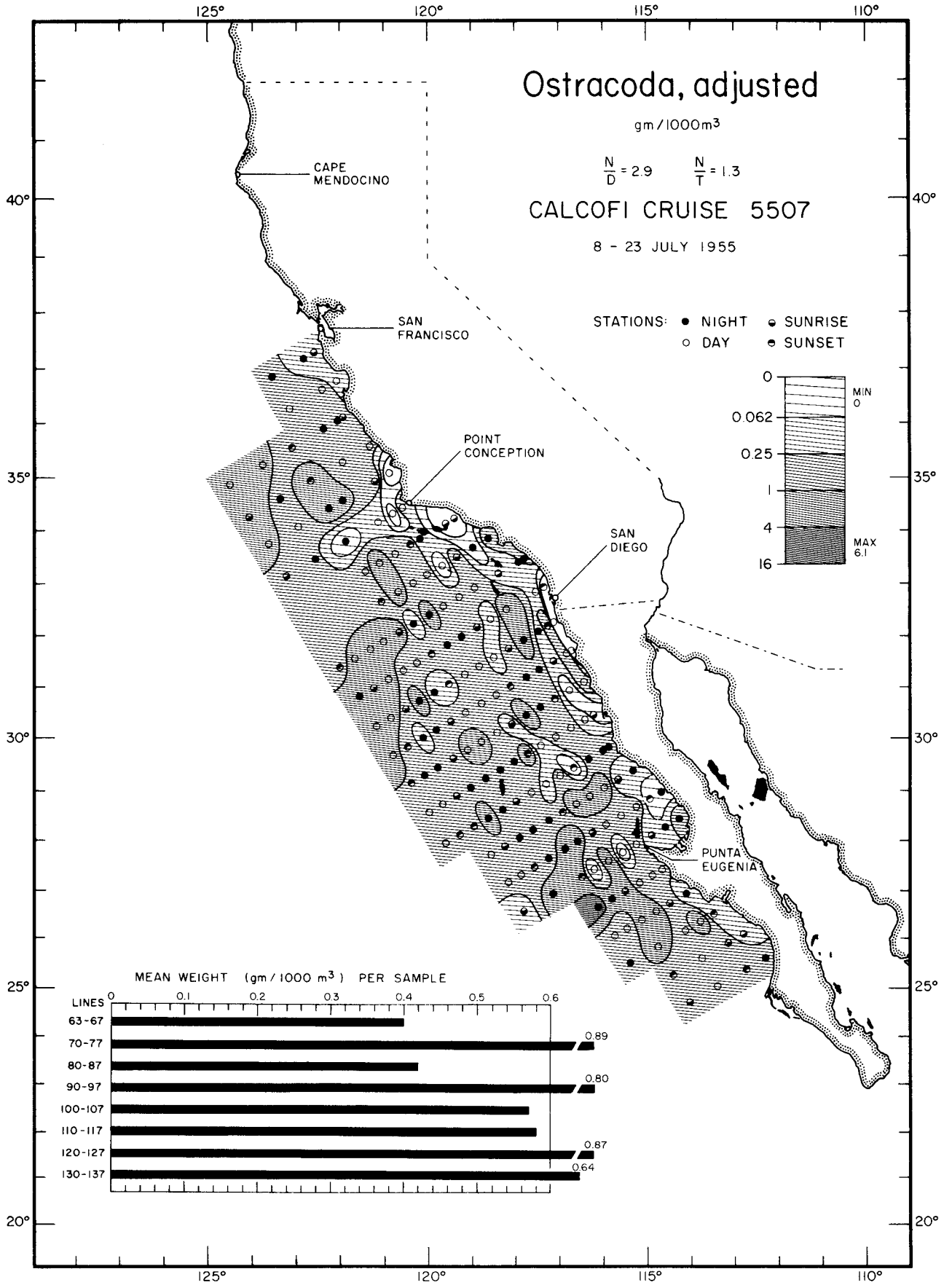






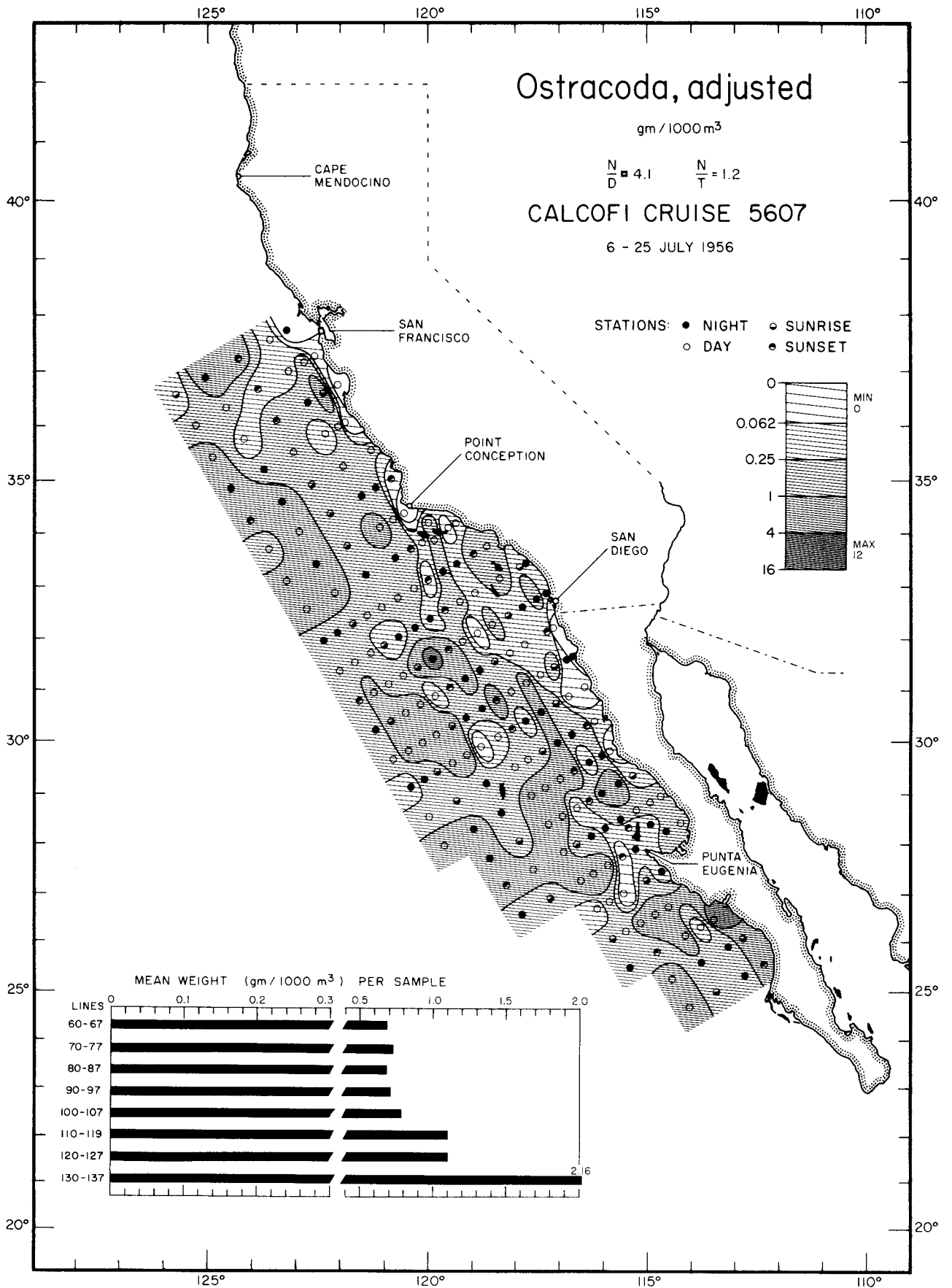
Biomass  
**Mysidacea**  
**5907**



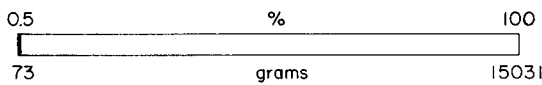
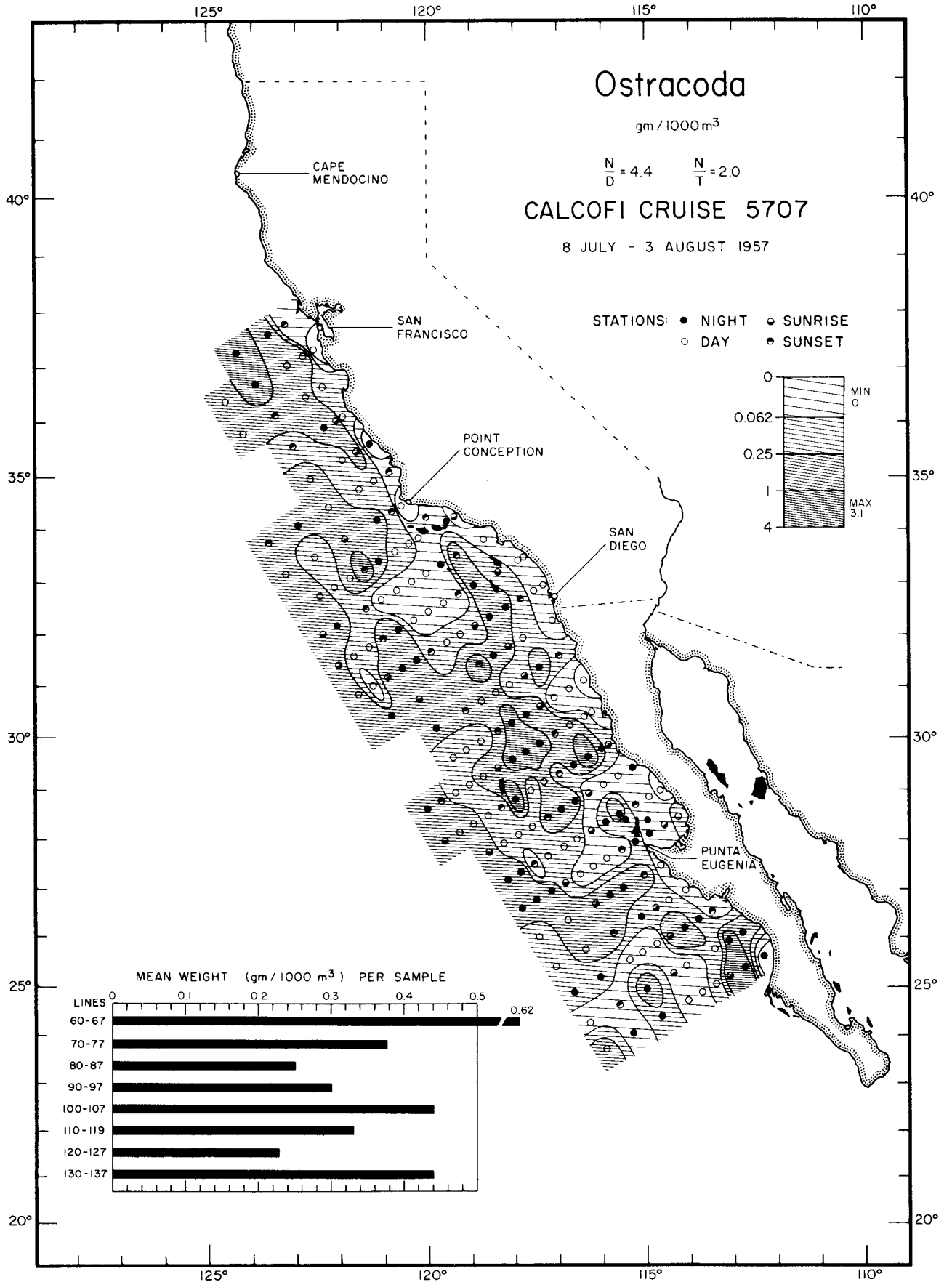


Biomass  
Ostracoda, adjusted  
5507

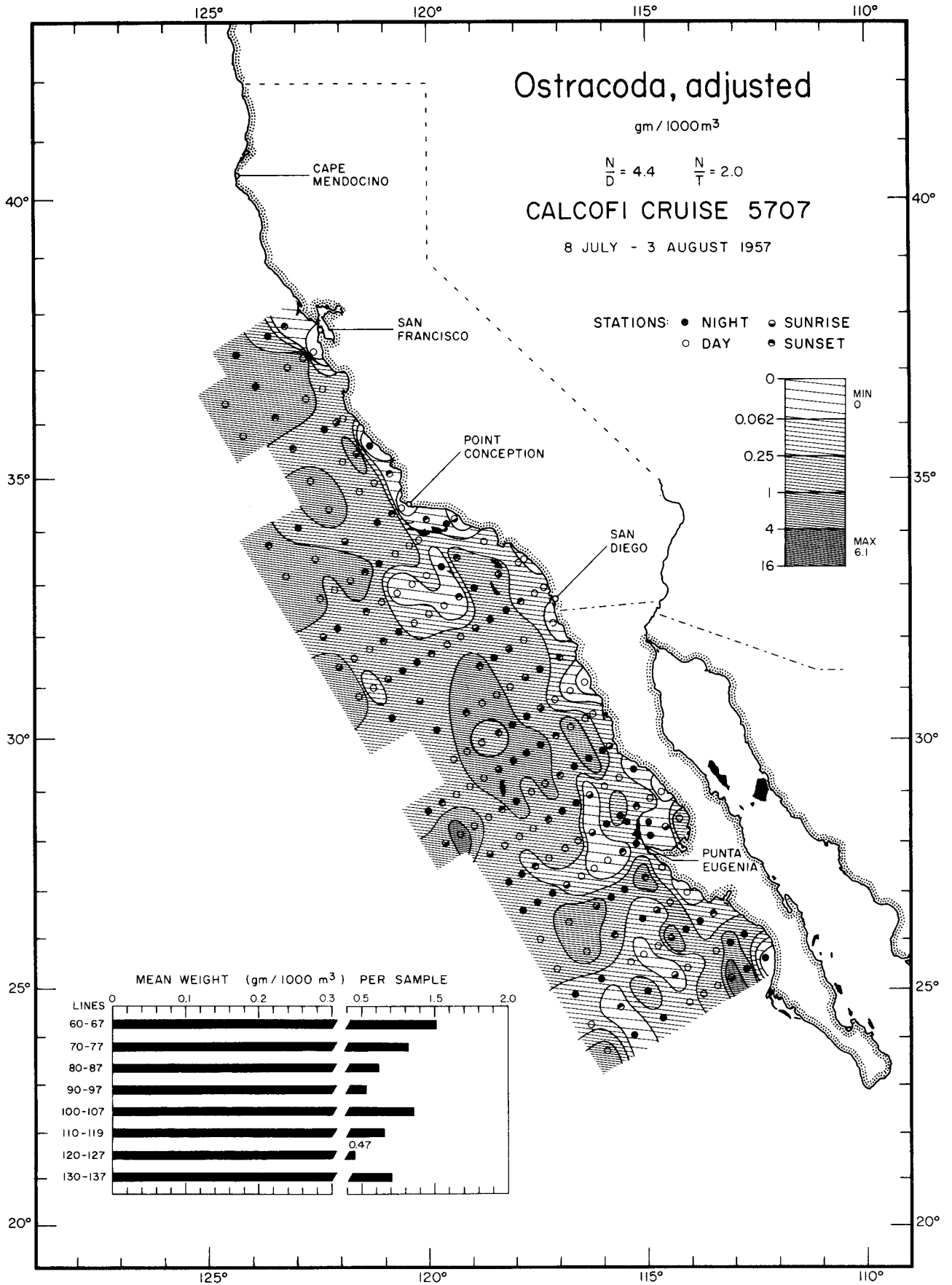




Biomass  
Ostracoda, adjusted  
5607



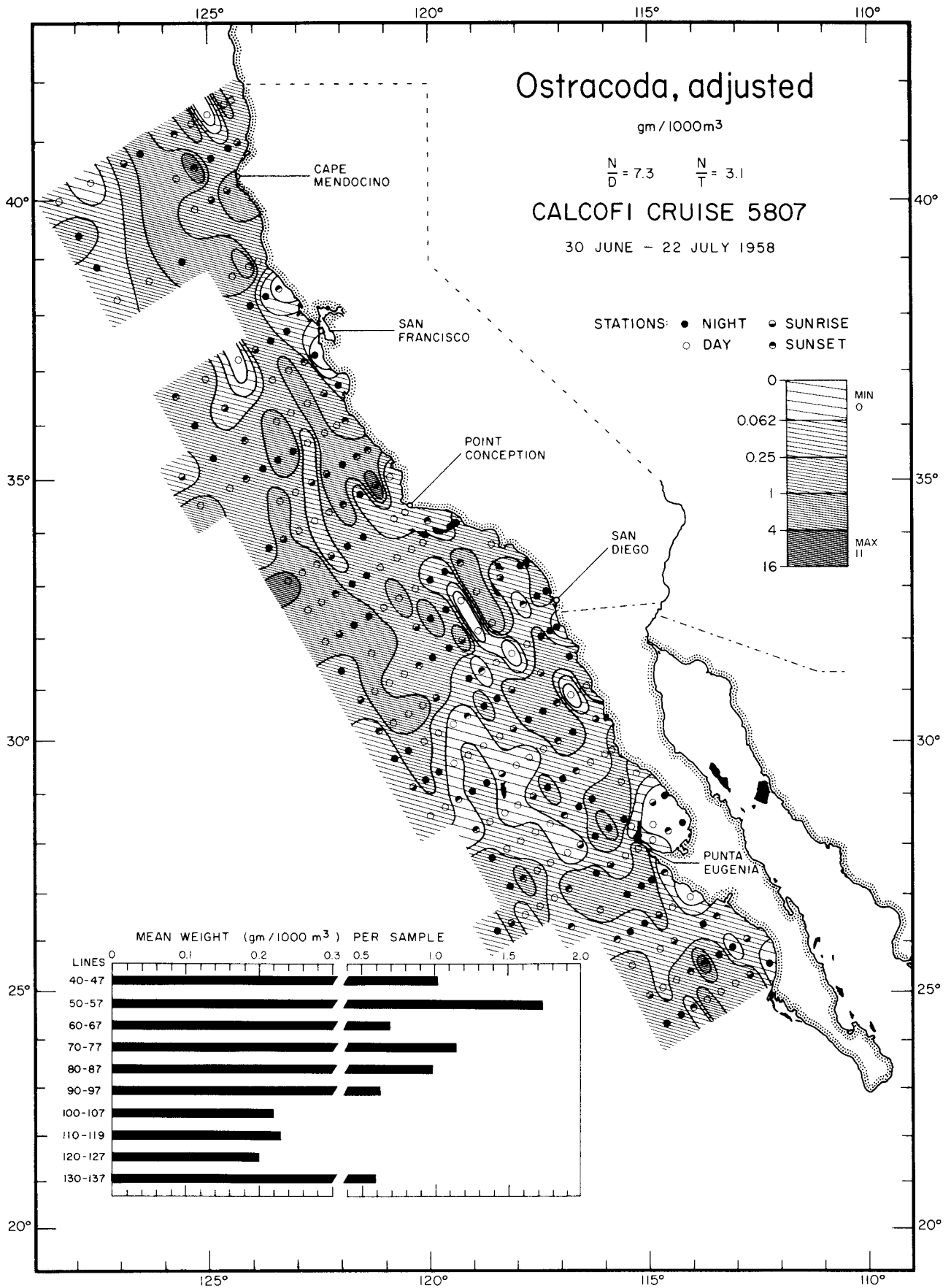
Biomass  
Ostracoda  
5707



Biomass  
 Ostracoda, adjusted  
 5707

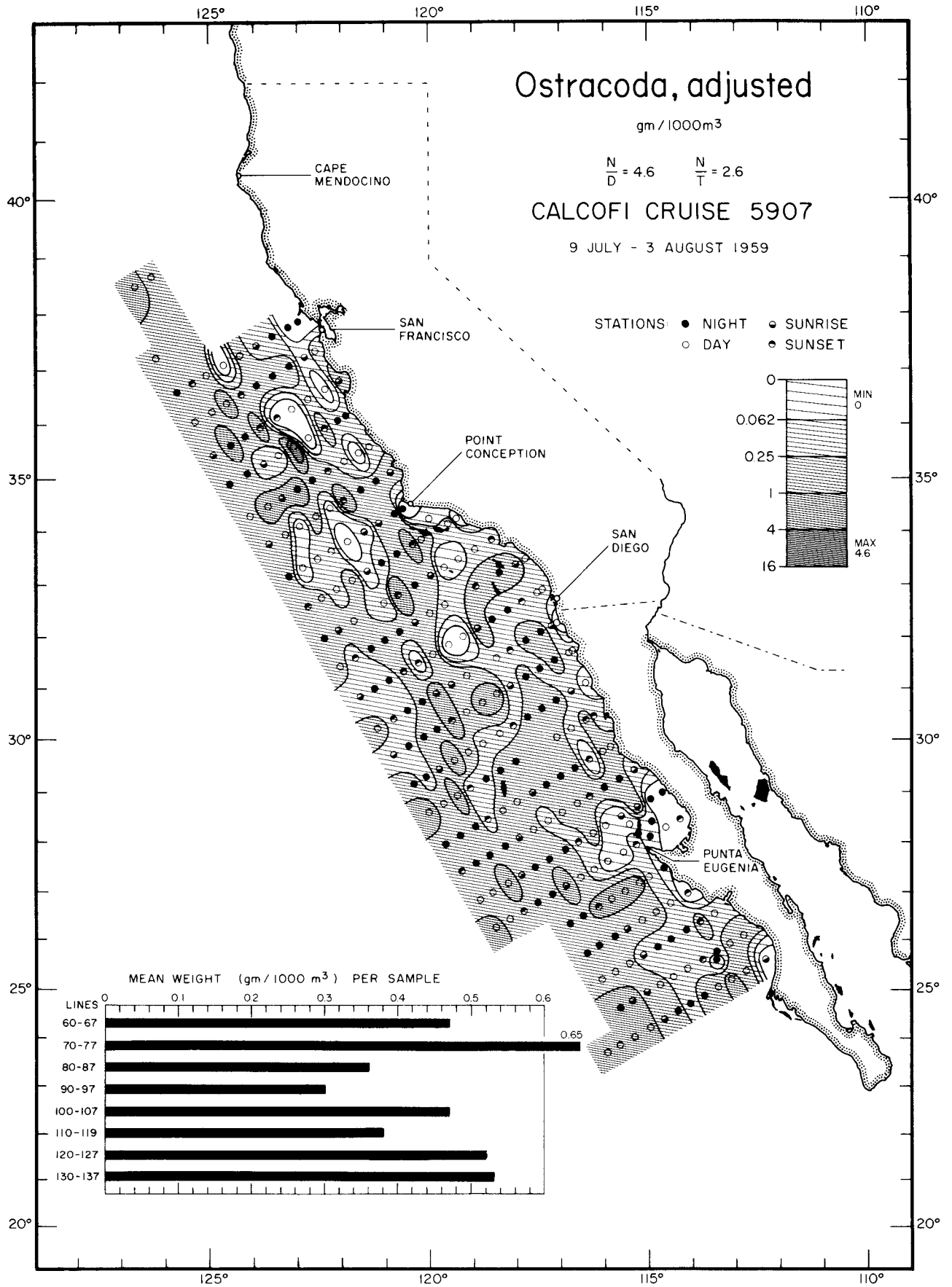




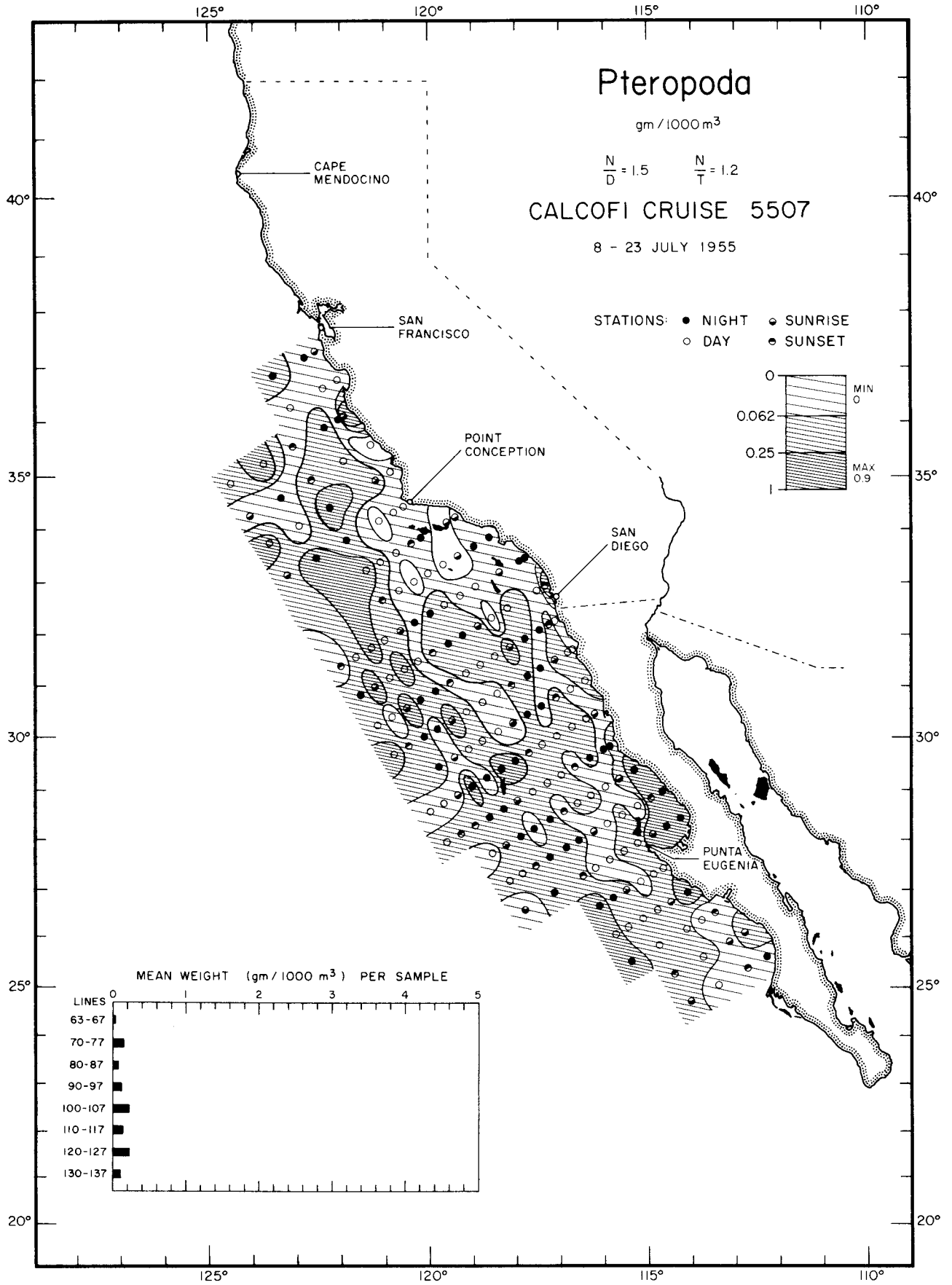


Biomass  
Ostracoda, adjusted  
5807



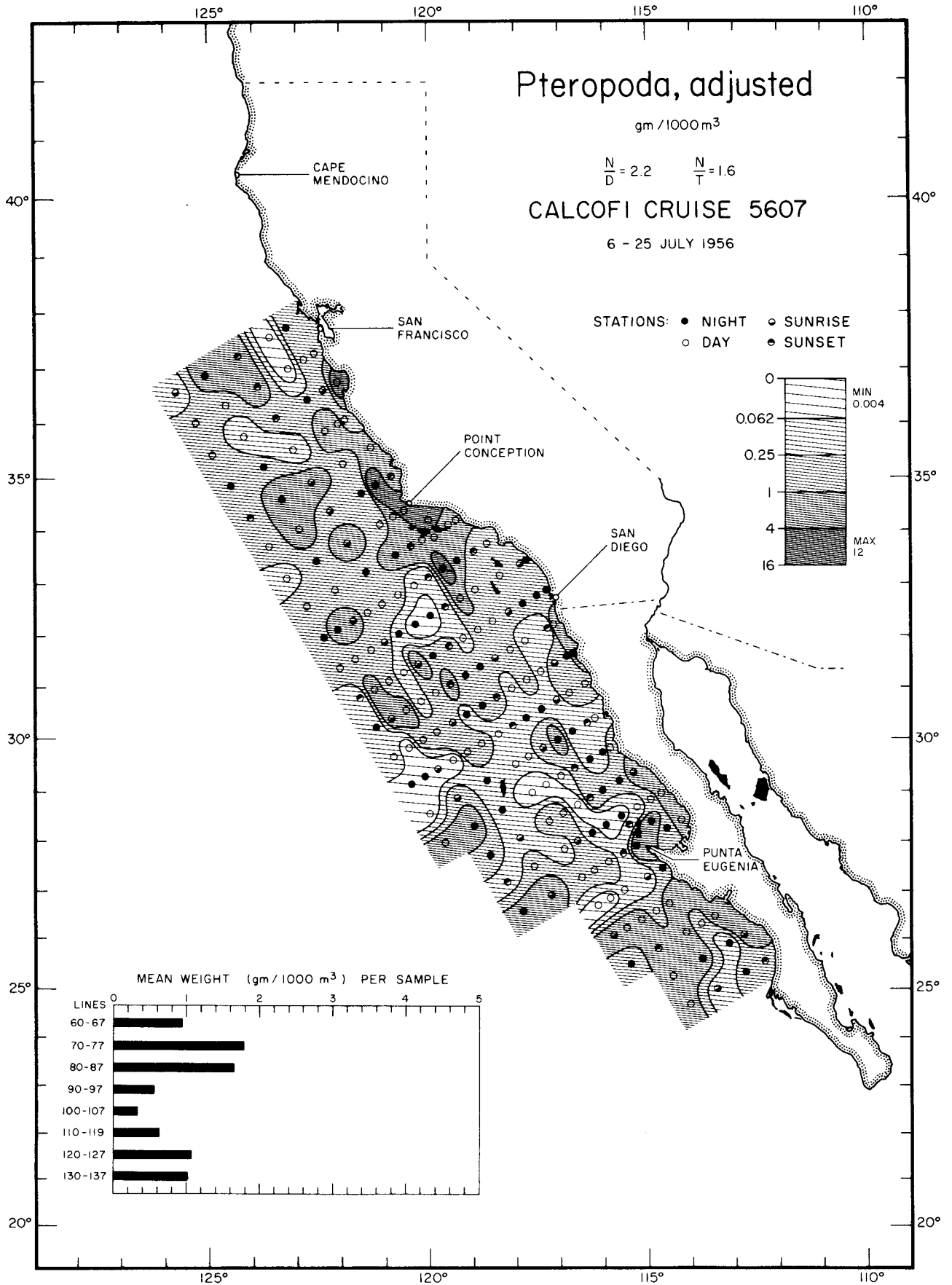


Biomass  
Ostracoda, adjusted  
5907

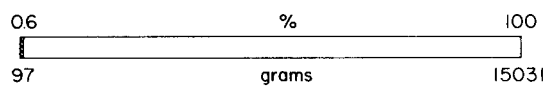
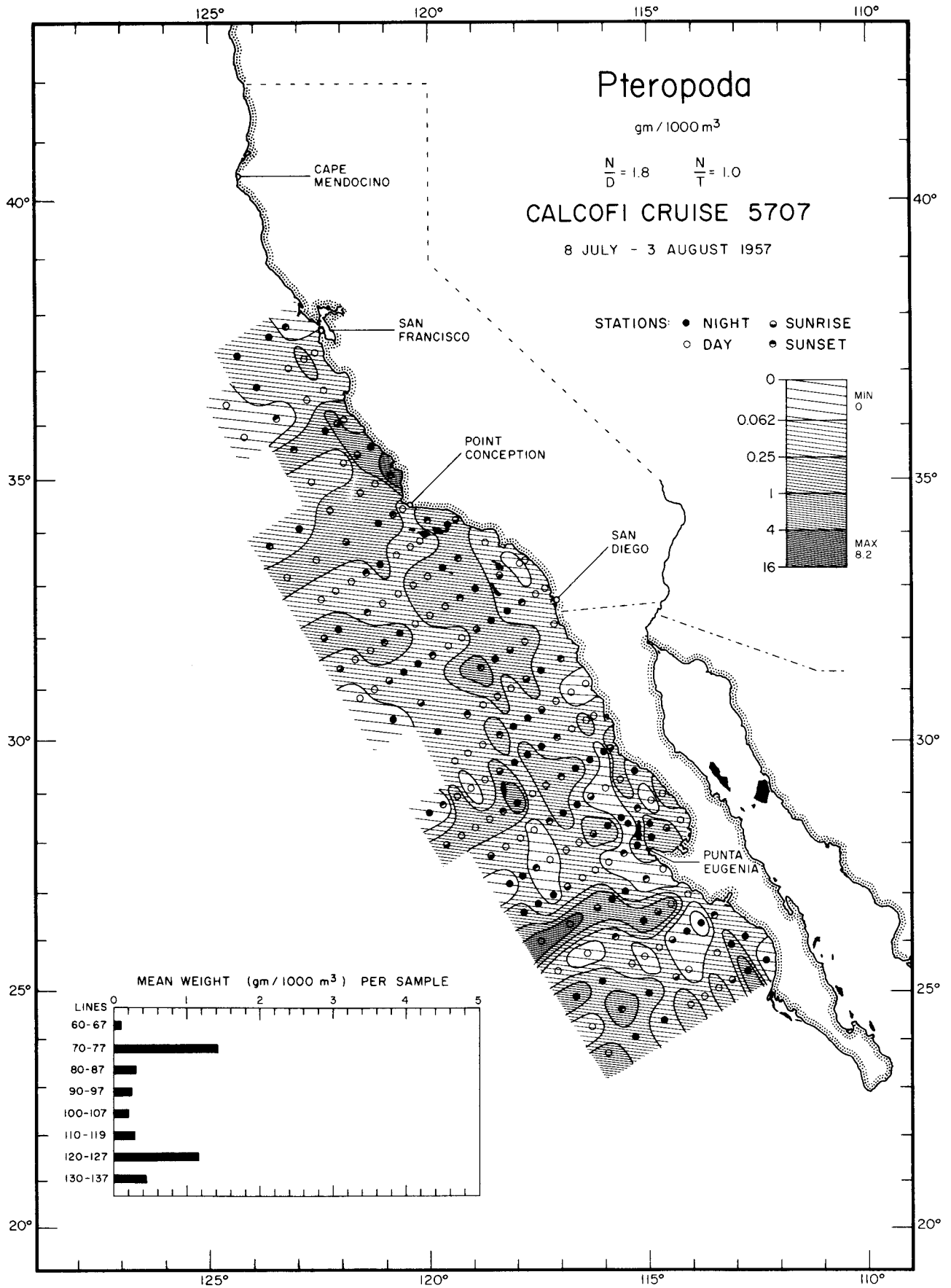


Biomass  
**Pteropoda**  
**5507**





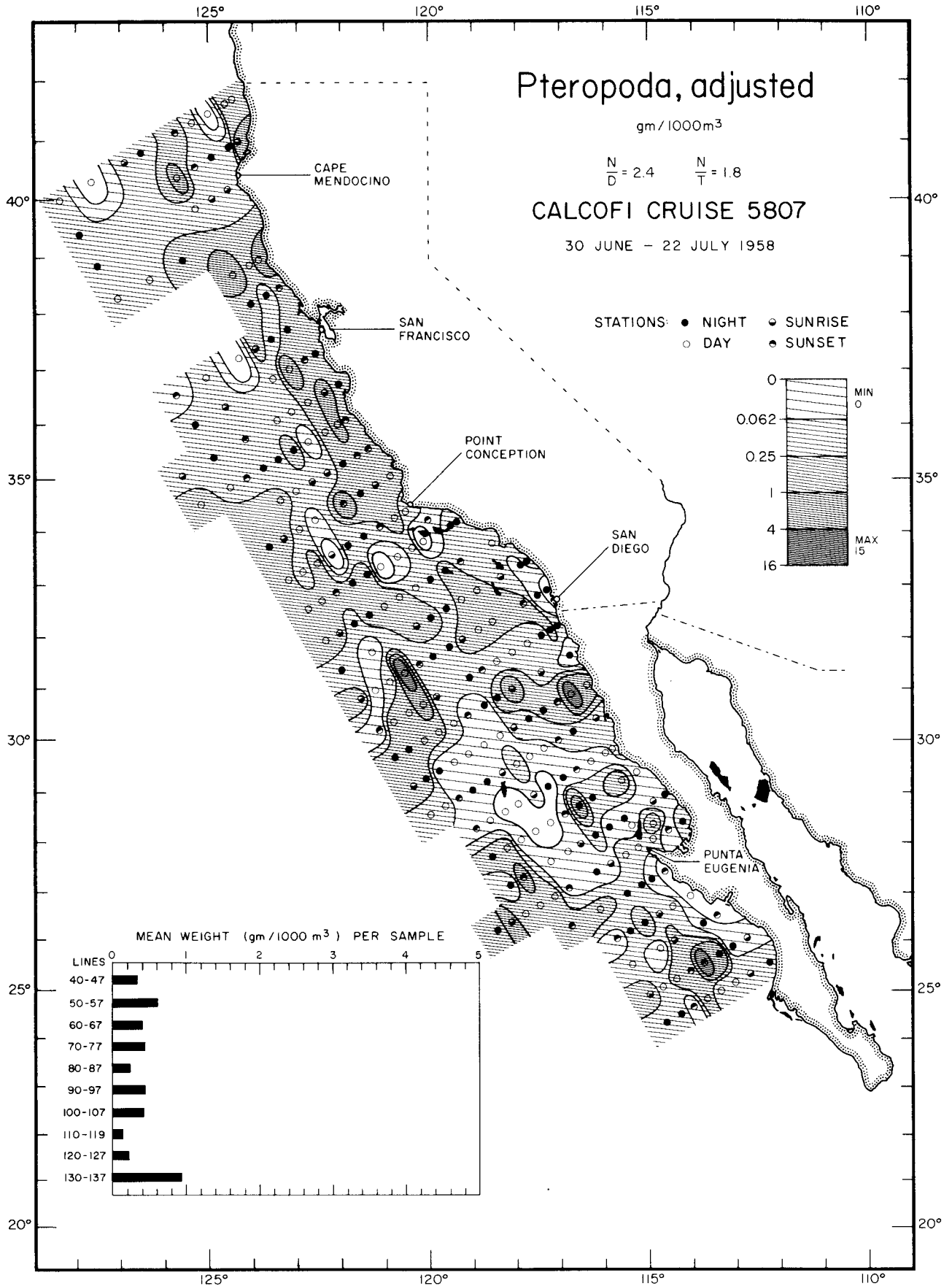
Biomass  
Pteropoda, adjusted  
5607



Biomass  
**Pteropoda**  
**5707**



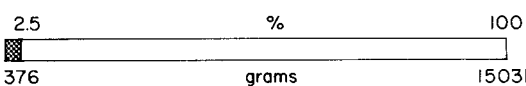
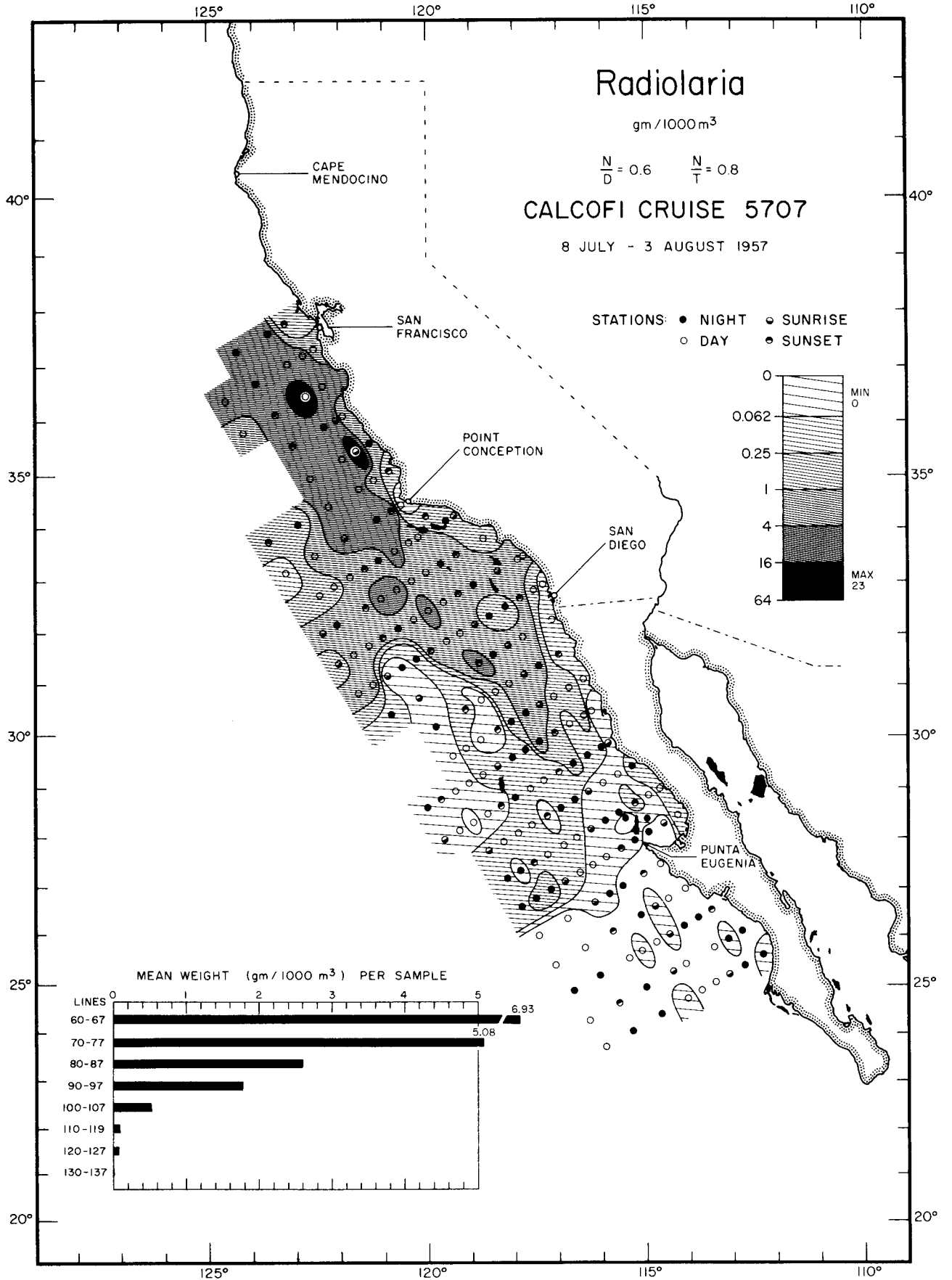






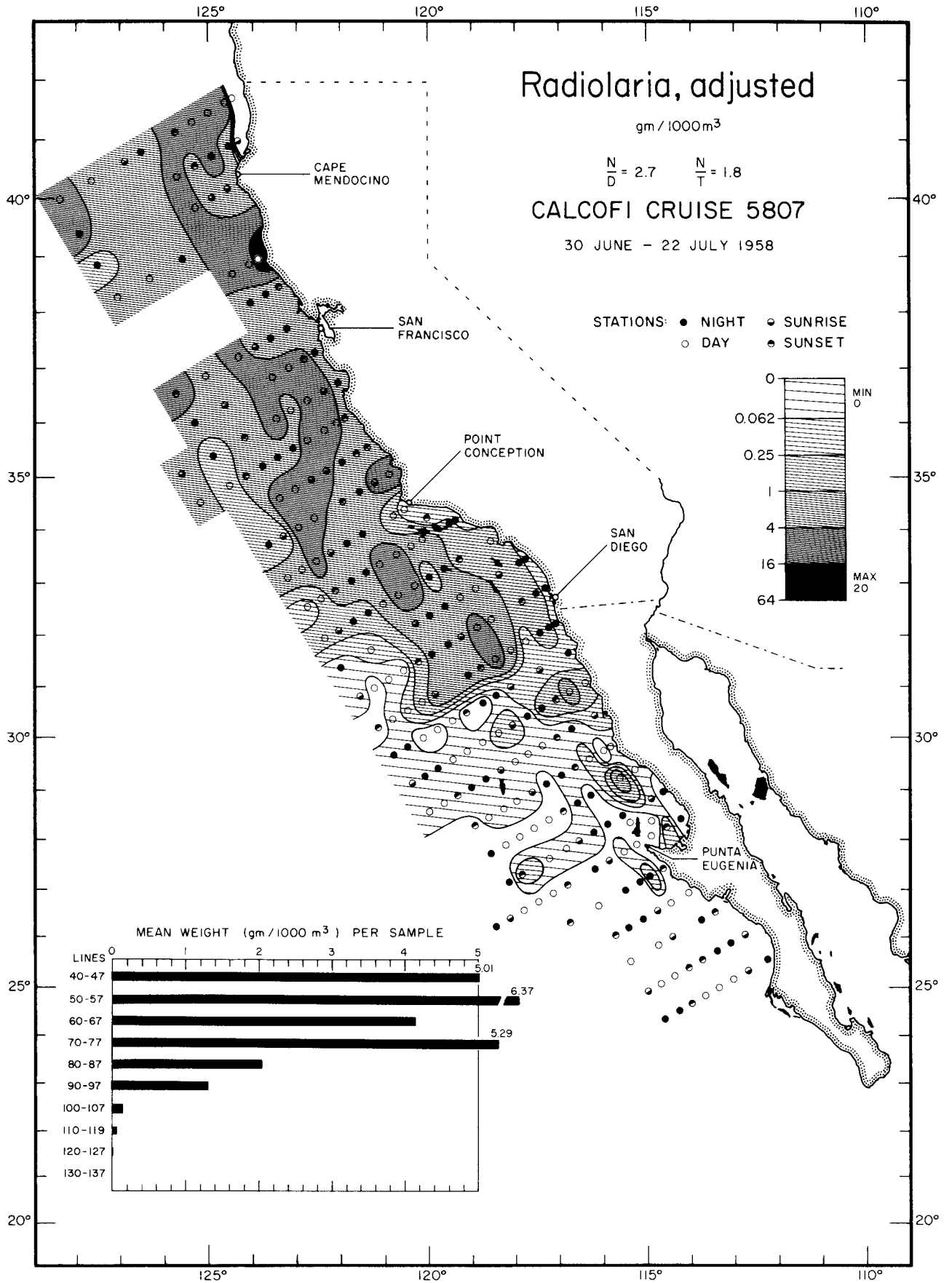




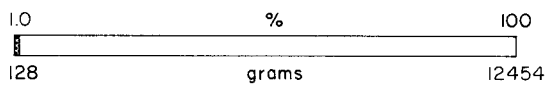
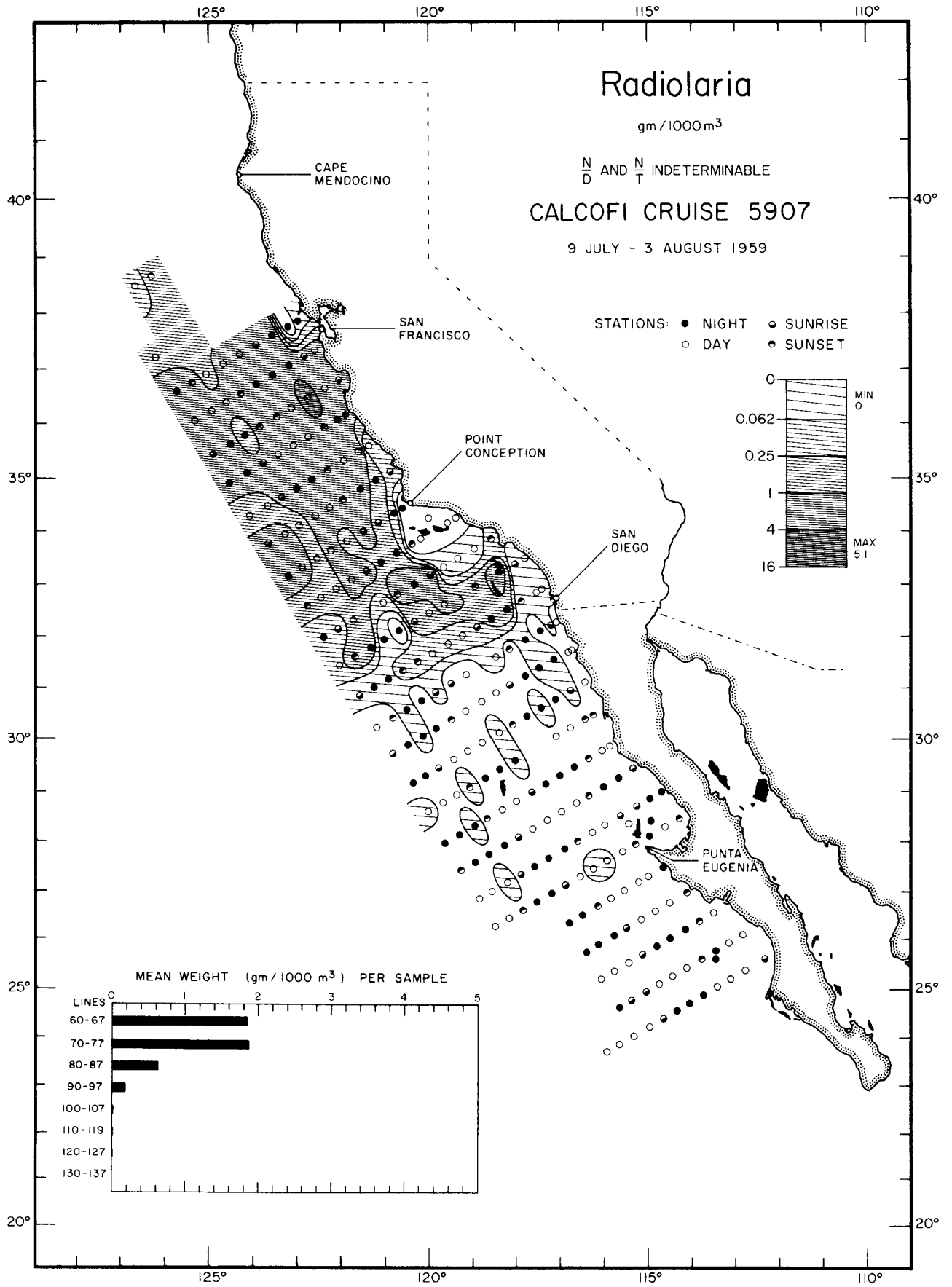


Biomass  
Radiolaria  
5707

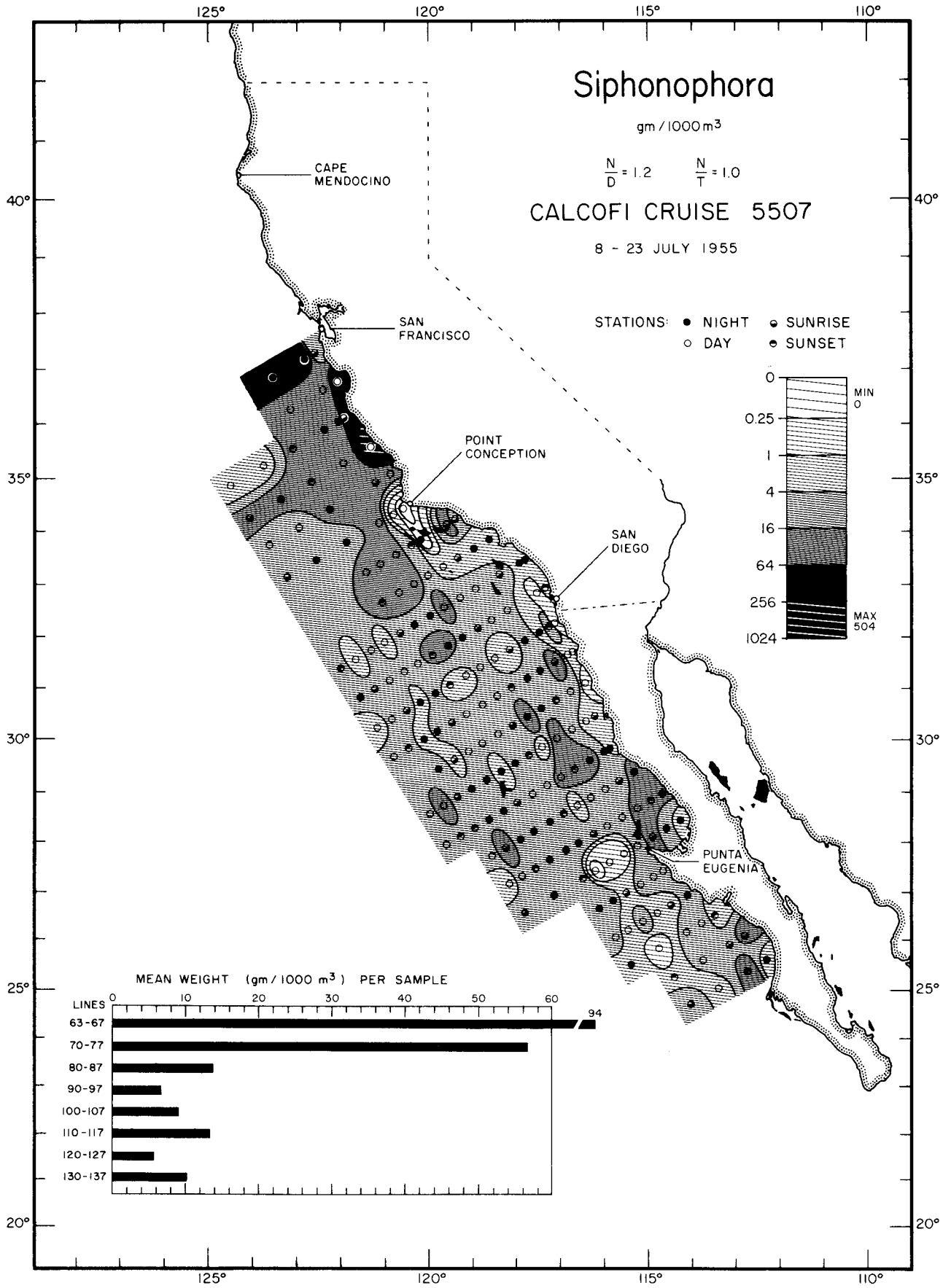






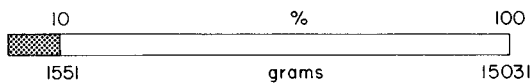
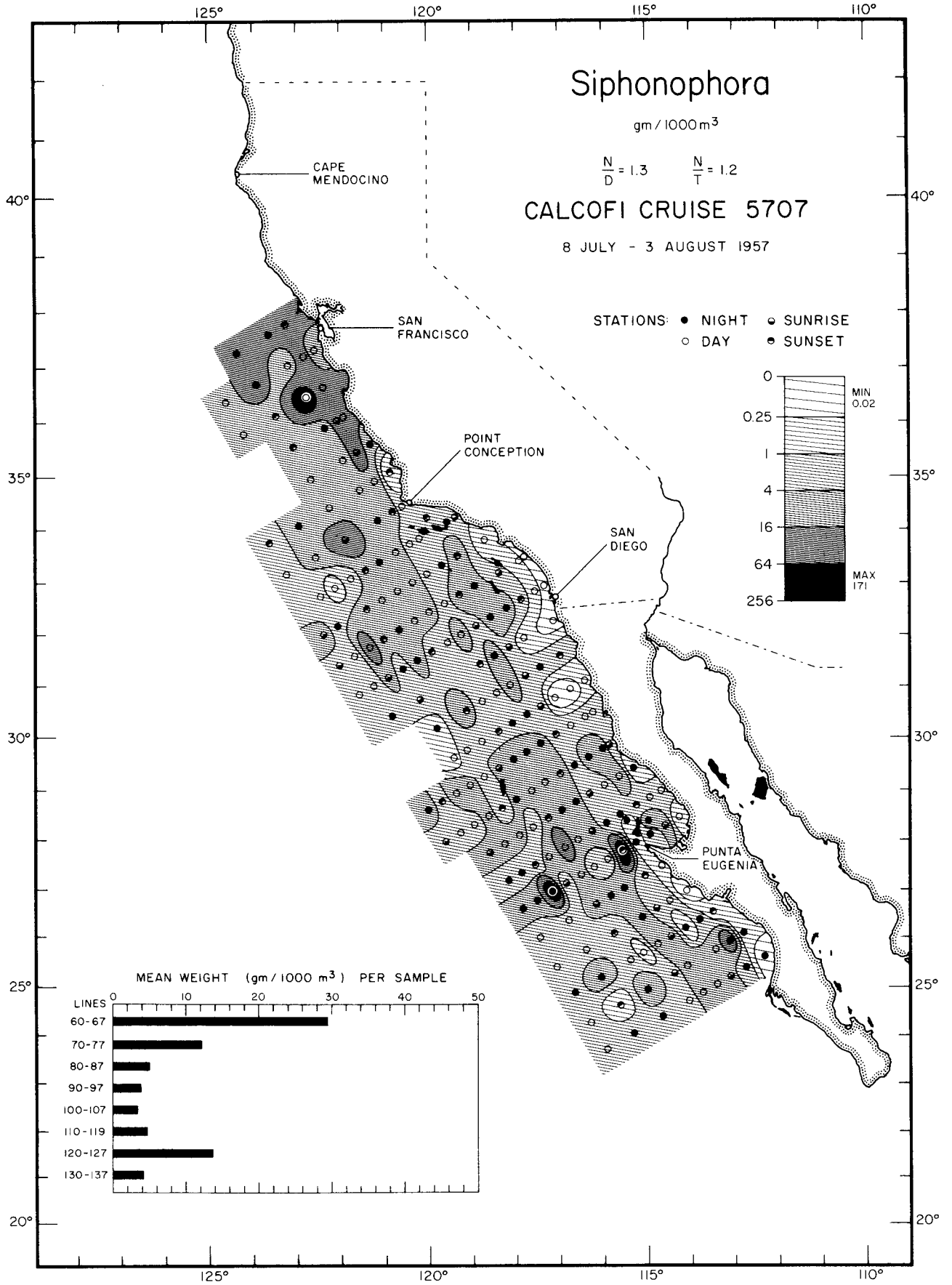


Biomass  
**Radiolaria**  
5907



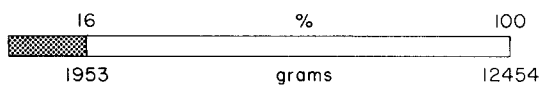
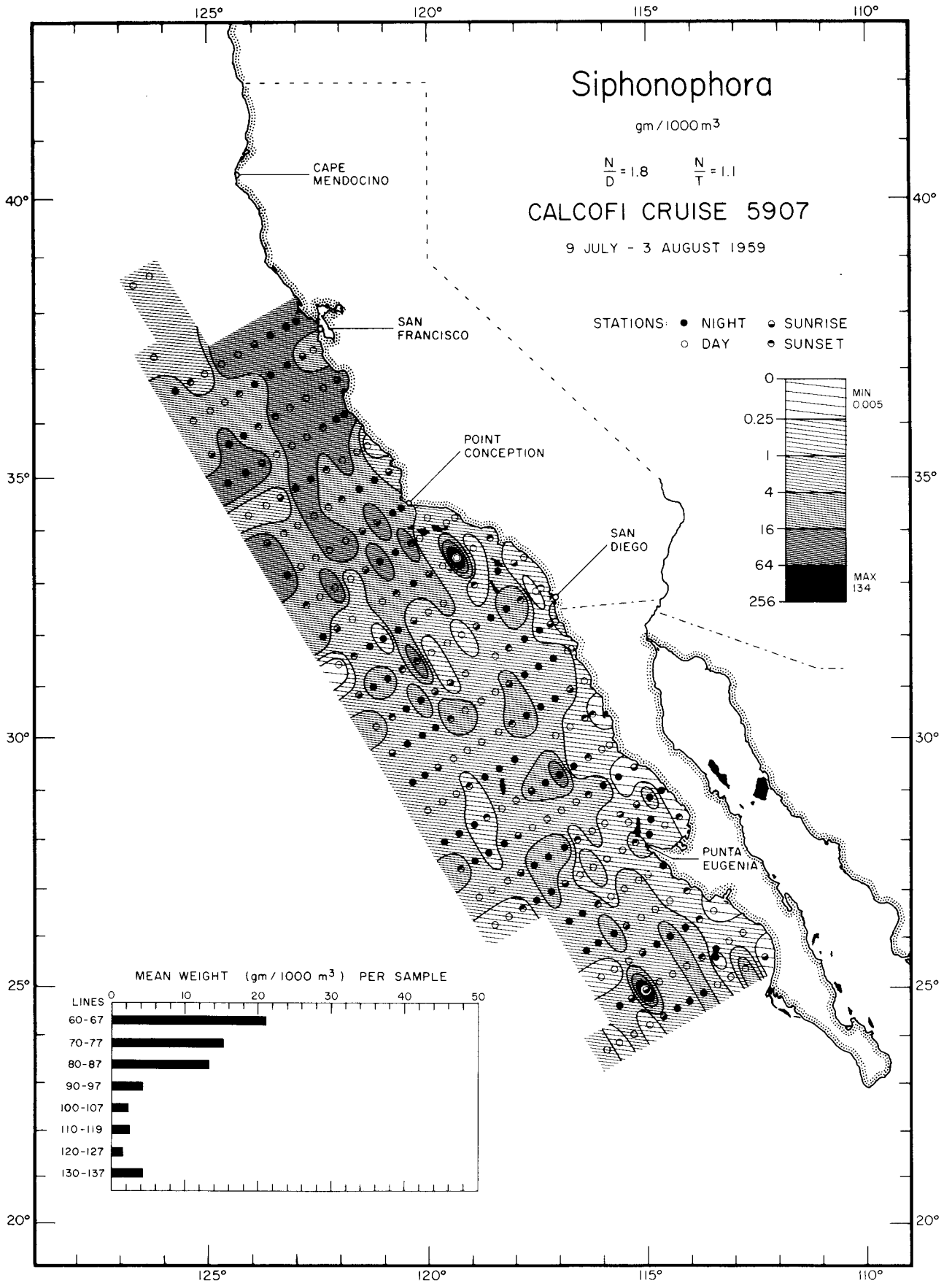
Biomass  
Siphonophora  
5507



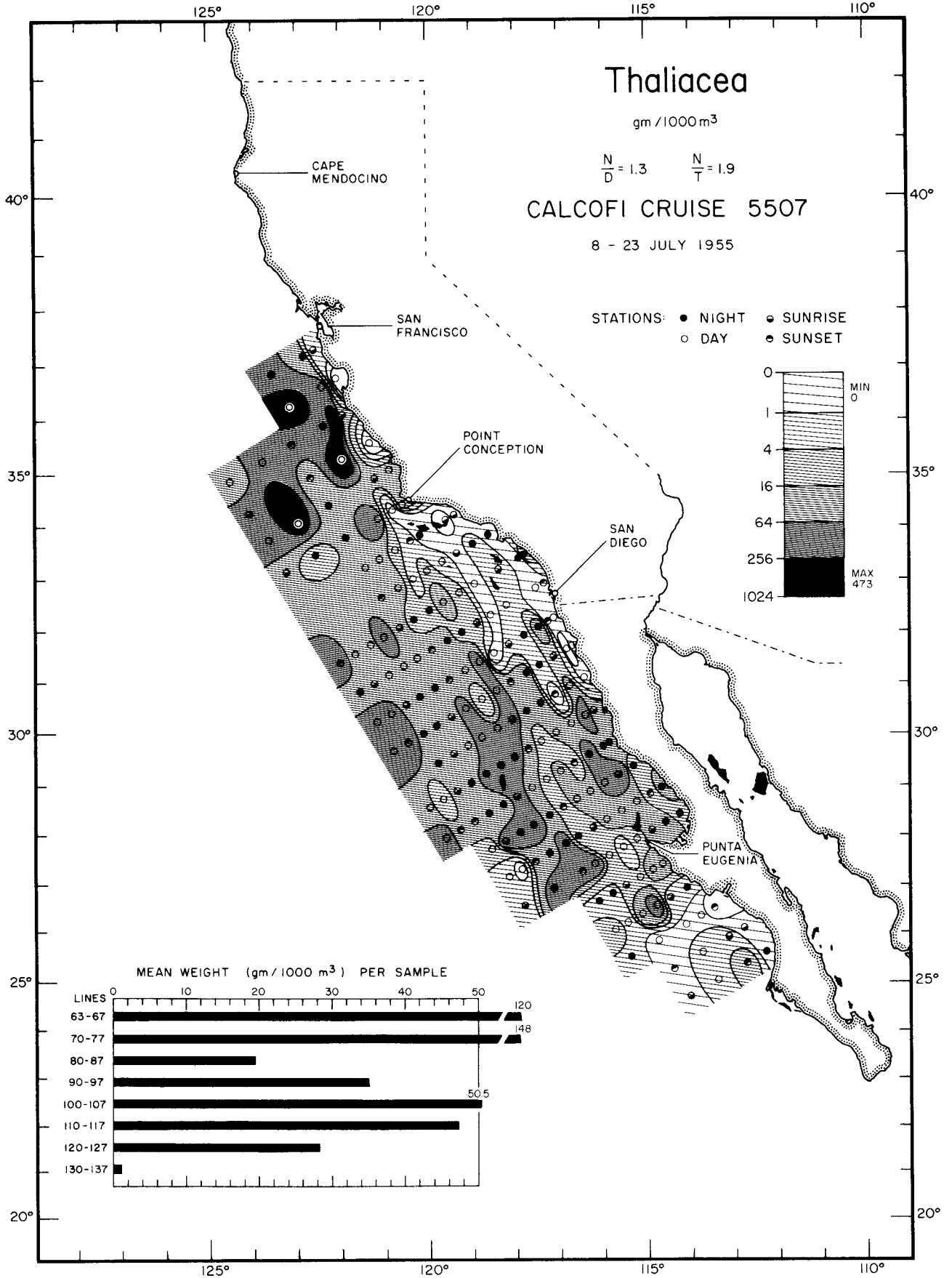


Biomass  
Siphonophora  
5707



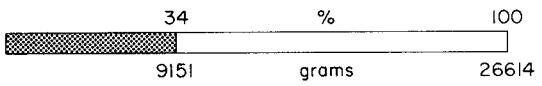
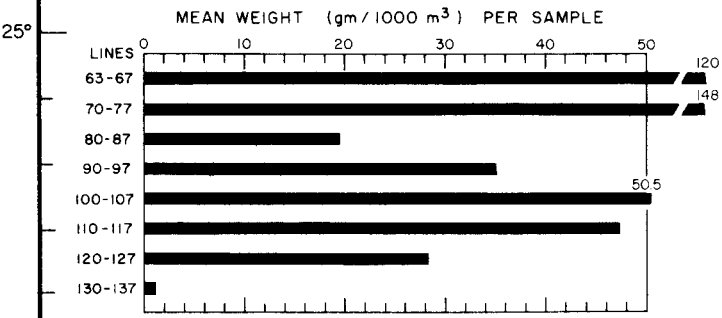
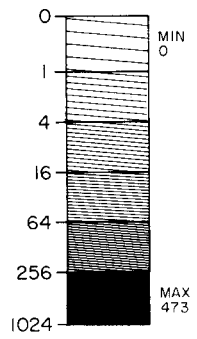


Biomass  
Siphonophora  
5907

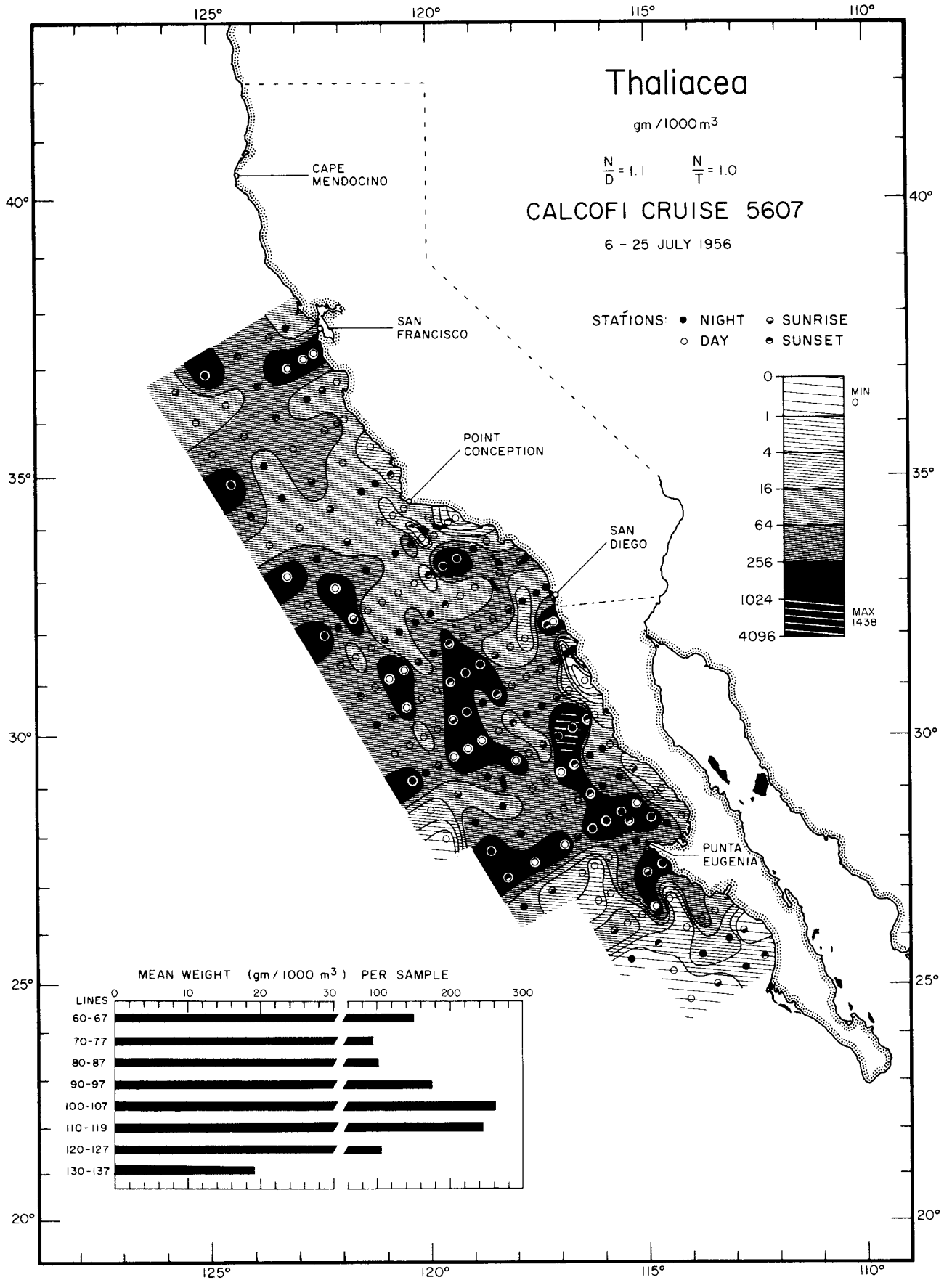


**Thaliacea**  
 gm / 1000 m<sup>3</sup>  
 $\frac{N}{D} = 1.3$      $\frac{N}{T} = 1.9$   
**CALCOFI CRUISE 5507**  
 8 - 23 JULY 1955

STATIONS: ● NIGHT    ● SUNRISE  
 ○ DAY            ● SUNSET

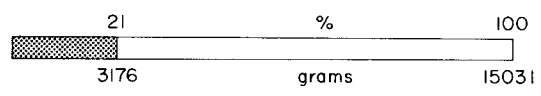
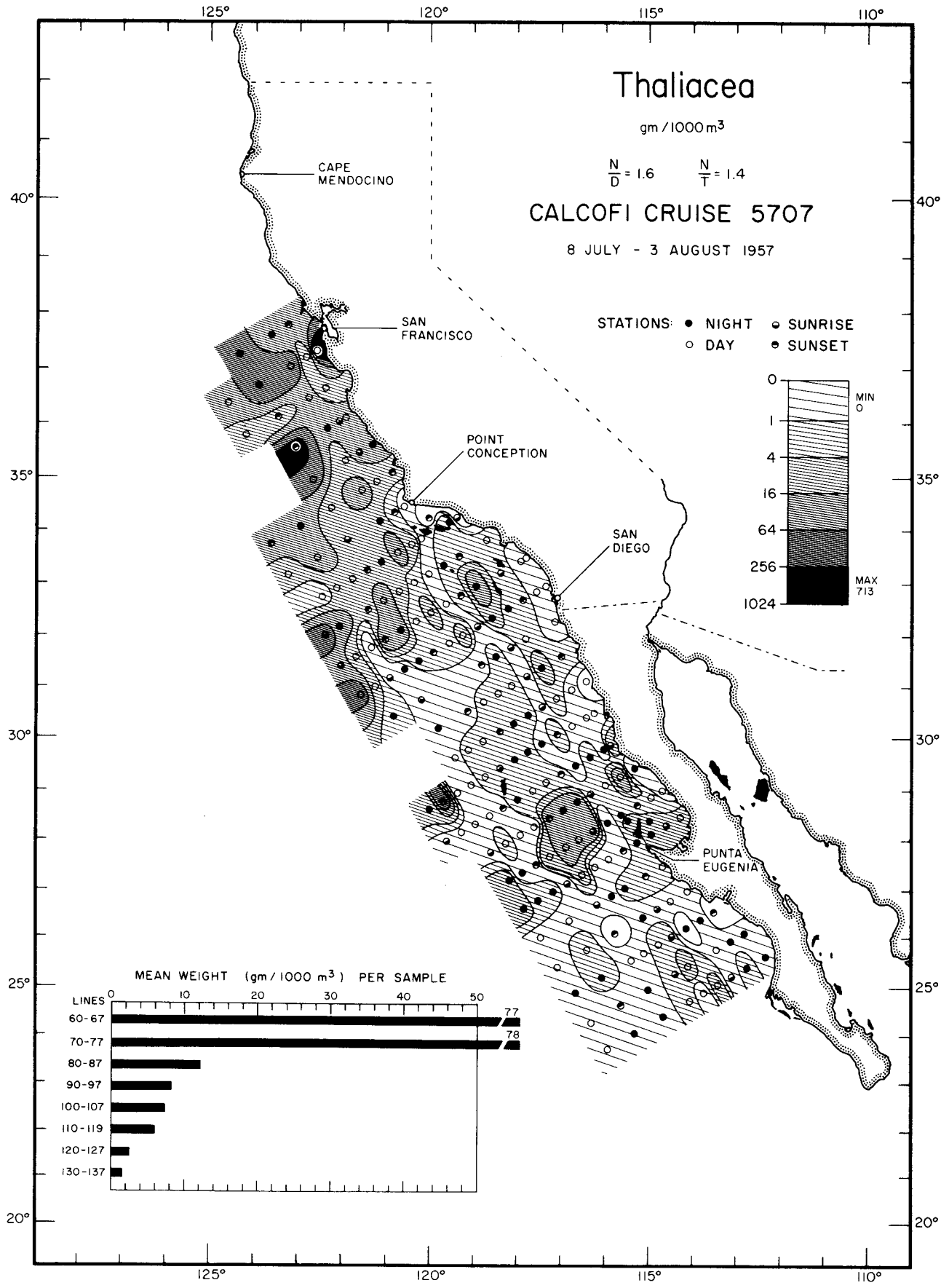


Biomass  
**Thaliacea**  
**5507**

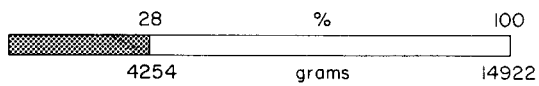
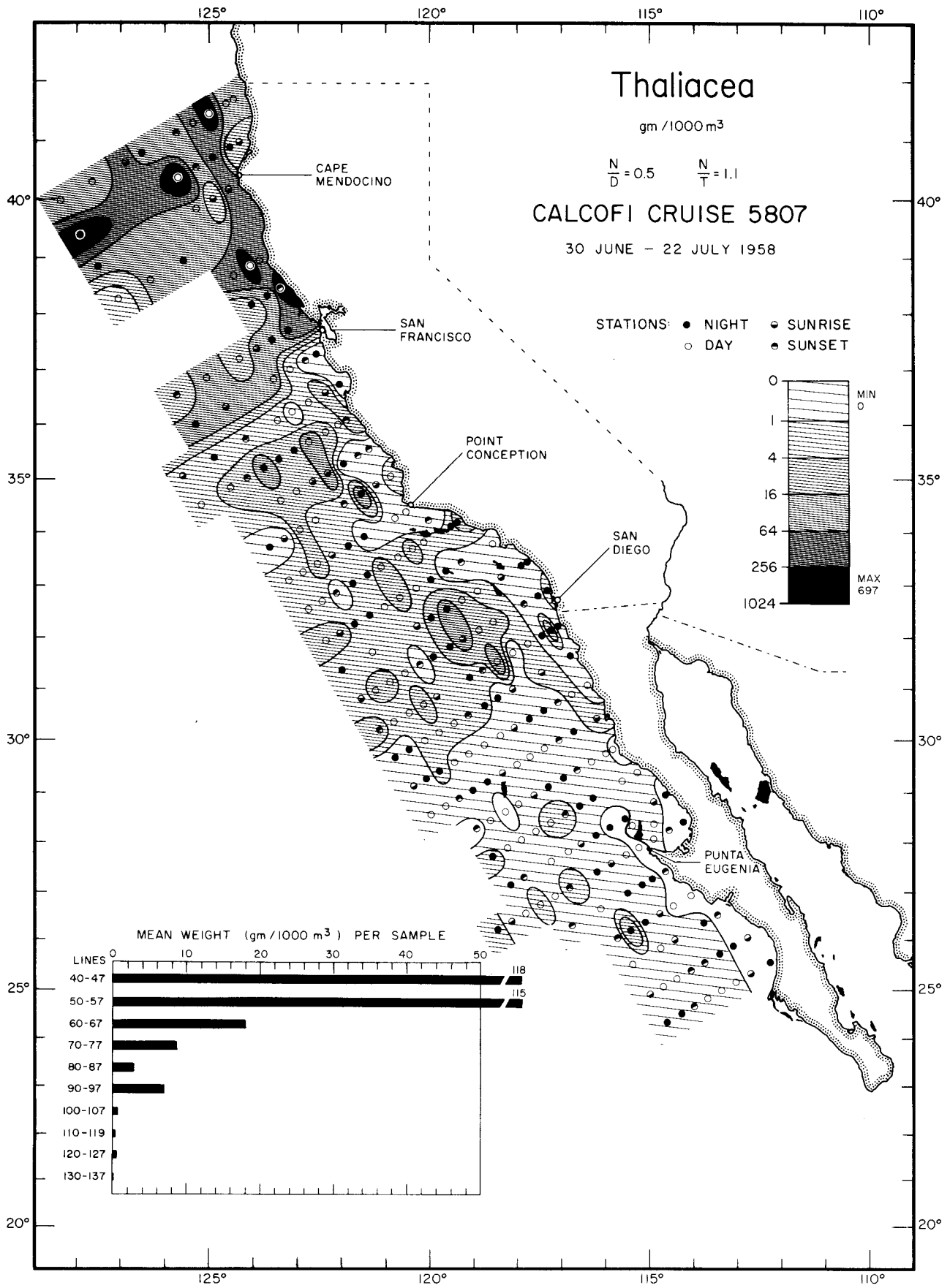


Biomass  
Thaliacea  
5607

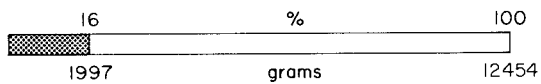
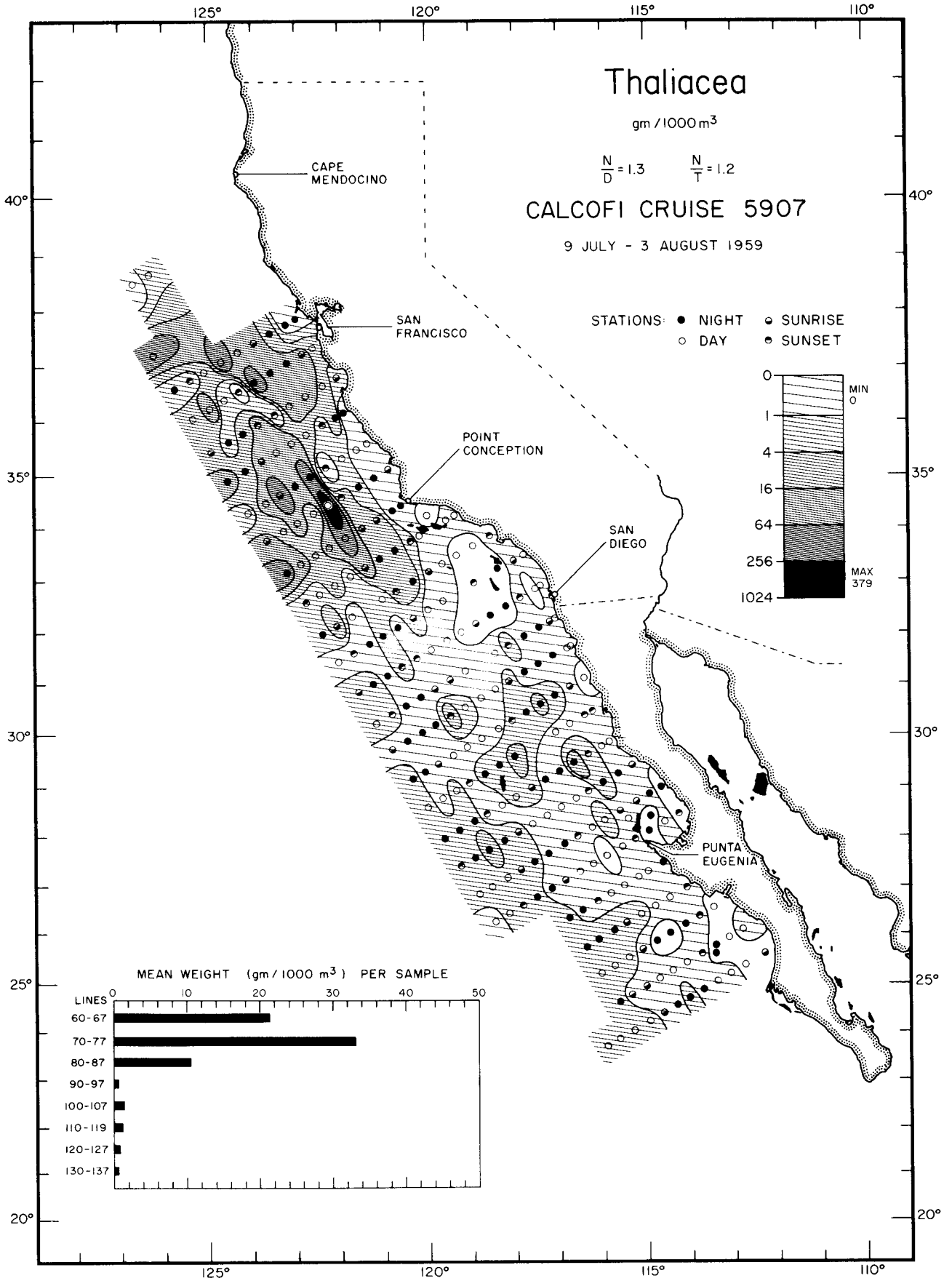




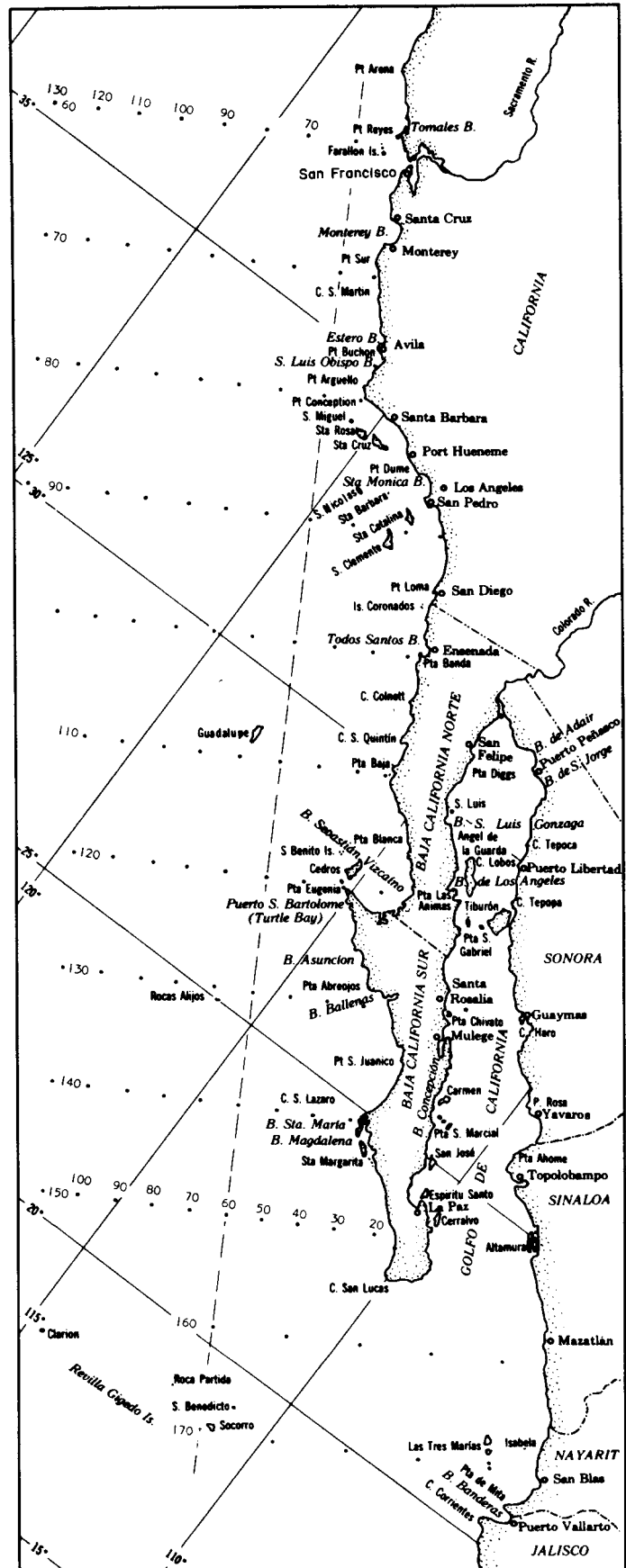
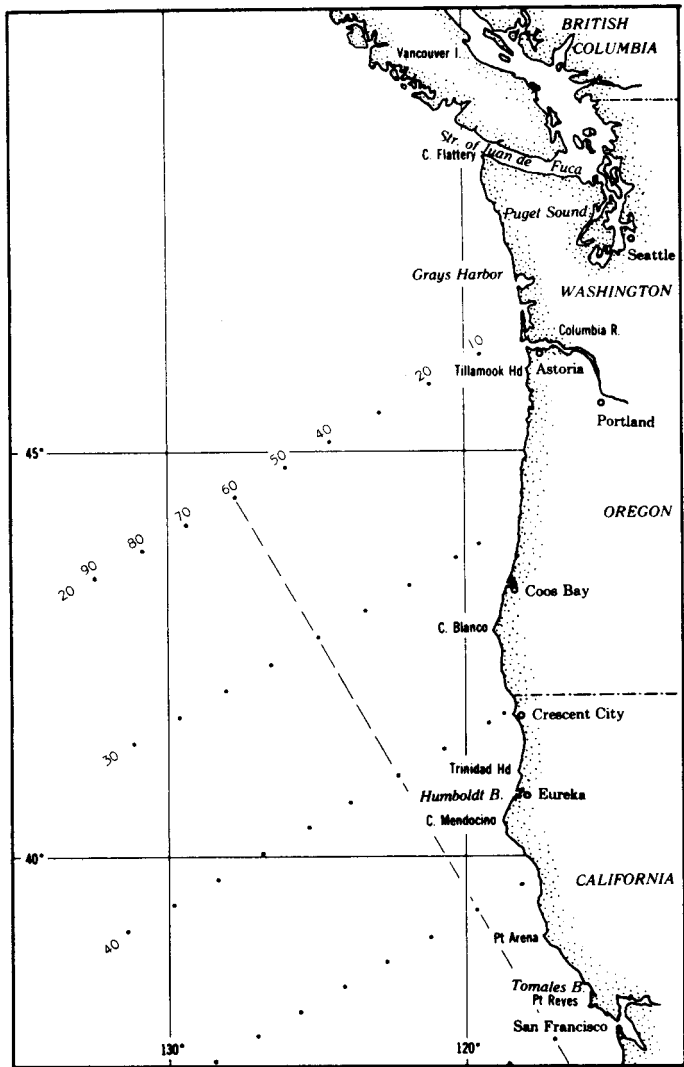
Biomass  
**Thaliacea**  
**5707**



Biomass  
**Thaliacea**  
**5807**



Biomass  
**Thaliacea**  
5907



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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