

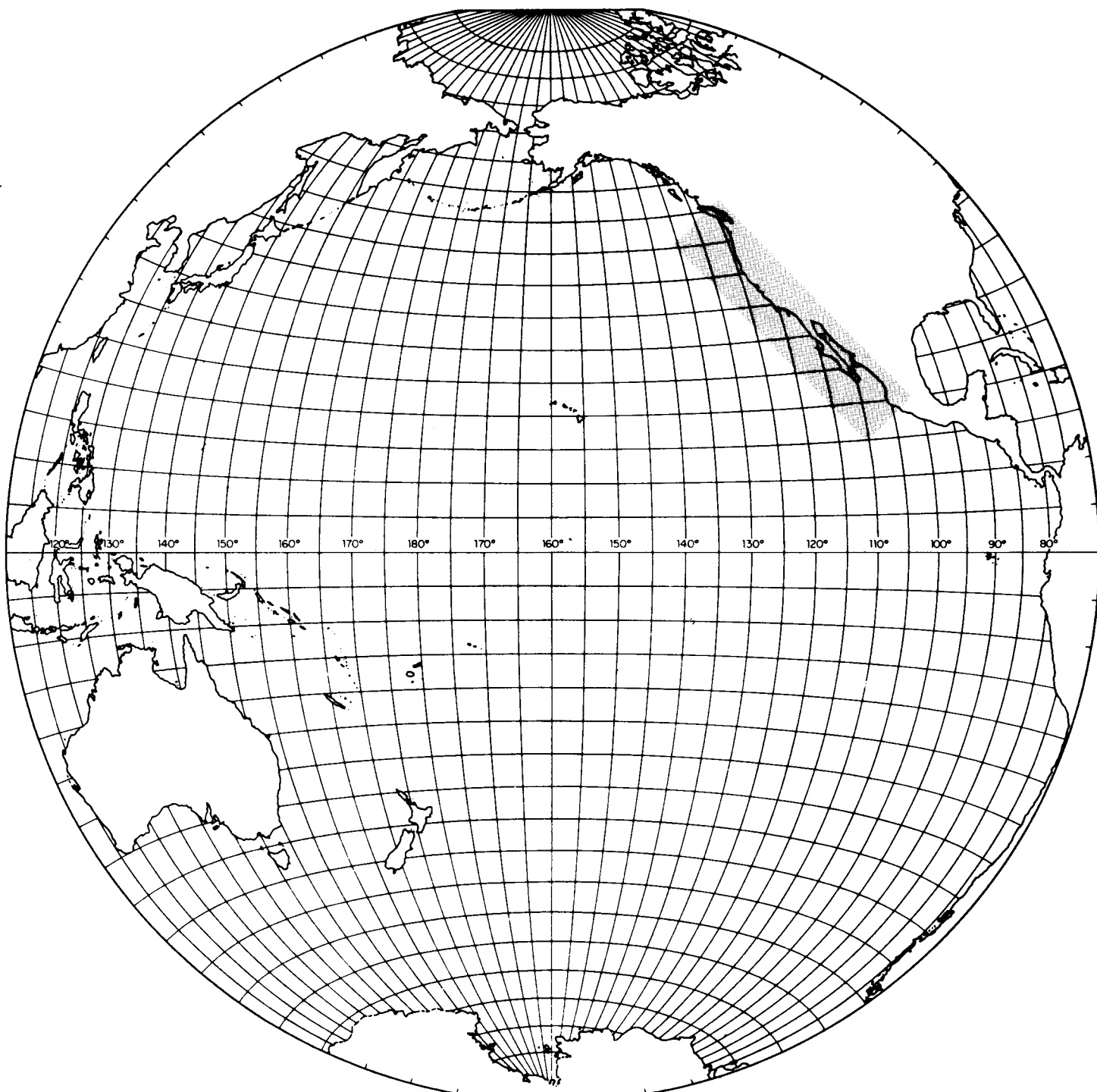
Atlas 28: Hewitt, R. Distributional atlas of fish larvae in the California Current region: northern anchovy, *Engraulis mordax* (Girard), 1966-1979. Published December 1980.

23 May 2007

References to the data, published in annual ichthyoplankton data reports are given in the introduction to the Atlas. In addition, these data are available in PDF format on the SWFSC web site at <http://swfsc.noaa.gov/publications/swcpub/qryPublications.asp>, enter "ichthyoplankton" in the Subject line and "California Cooperative Oceanic Fisheries Investigations" in the Title line. Checking the ALL YEARS button will produce the entire list of available data.

The report for each year usually is published about 7-9 months after the fall cruise, and includes notes about nomenclature changes, etc. The ultimate goal is to update the old ichthyoplankton identifications to current standards; the database is updated as re-identifications for each cruise are completed.

STATE OF CALIFORNIA



CALIFORNIA COOPERATIVE OCEANIC FISHERIES INVESTIGATIONS

ATLAS No. 28

CALIFORNIA
COOPERATIVE
OCEANIC
FISHERIES
INVESTIGATIONS

Atlas No. 28

Cooperating Agencies:

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

DECEMBER, 1980

THE CALCOFI ATLAS SERIES

This is the twenty-eighth 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. The cooperating agencies in the program are:

California Department of Fish and Game
National Oceanic and Atmospheric Administration, National Marine Fisheries Service²
University of California, Scripps Institution of Oceanography

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

This atlas was prepared by the Marine Life Research Group, Scripps Institution of Oceanography.

CalCOFI Atlas Editorial Staff:

Abraham Fleminger, Editor
Fred J. Crowe, cartographer

CalCOFI atlases in this series, through December 1980, 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 molluses 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.
- No. 9. Kramer, D., and E. H. Ahlstrom, 1968. Distributional atlas of fish larvae in the California Current region: northern anchovy, *Engraulis mordax* (Girard). 1951 through 1965.
- No. 10. Isaacs, J.D., A. Fleminger and J. K. Miller, 1969. Distributional atlas of zooplankton biomass in the California Current region: Spring and Fall 1955-1959.
- No. 11. Ahlstrom, E. H., 1969. Distributional atlas of fish larvae in the California Current region: jack mackerel, *Trachurus symmetricus*, and Pacific hake, *Merluccius productus*, 1951 through 1966.
- No. 12. Kramer, D., 1970. Distributional atlas of fish eggs and larvae in the California Current region: Pacific sardine, *Sardinops caerulea* (Girard). 1951 through 1966.
- No. 13. Smith, P. E., 1971. Distributional atlas of zooplankton volume in the California Current region, 1951 through 1966.
- No. 14. Isaacs, J. D., A. Fleminger and J. K. Miller, 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.
- No. 22. Namias, J., 1975. Northern hemisphere seasonal sea level pressure and anomaly charts, 1947-1974.
- No. 23. Ahlstrom, E. H. and H. G. Moser, 1975. Distributional atlas of fish larvae in the California Current region: flatfishes, 1955 through 1960.
- No. 24. Brinton, E., and J. G. Wyllie, 1976. Distributional atlas of euphausiid growth stages off southern California, 1953 through 1956.
- No. 25. Eber, L. E., 1977. Contoured depth-time charts (0 to 200m, 1950 to 1966) of temperature, salinity, oxygen and sigma-t at 23 CalCOFI stations in the California Current.
- No. 26. Ahlstrom, E. H., H. Geoffrey Moser, and Elaine M. Sandknop, 1978. Distributional atlas of fish larvae in the California Current region: rockfishes, *Sebastes* spp., 1950 through 1975.
- No. 27. Namias, J., 1979. Northern hemisphere seasonal 700 mb height and anomaly charts, 1947-1978, and associated North Pacific sea surface temperature anomalies.
- No. 28. Hewitt, R., 1980. Distributional atlas of fish larvae in the California Current region: northern anchovy, *Engraulis mordax* (Girard). 1966 through 1979.

¹Usually abbreviated CalCOFI, sometimes CALCOFI or CCOFI.

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

³For citation this issue in the series should be referred to as CalCOFI Atlas No. 28.

DISTRIBUTIONAL ATLAS OF FISH LARVAE
IN THE CALIFORNIA CURRENT REGION:
NORTHERN ANCHOVY, *Engraulis mordax* GIRARD,
1966 THROUGH 1979

ROGER HEWITT

CALCOFI ATLAS NO. 28

A. Fleminger, Editor
Marine Life Research Program
Scripps Institution of Oceanography
La Jolla, California

December, 1980

DISTRIBUTIONAL ATLAS OF FISH LARVAE IN THE CALIFORNIA CURRENT REGION: NORTHERN ANCHOVY, *Engraulis mordax* GIRARD, 1966 THROUGH 1979

Roger Hewitt¹

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Introduction

This atlas depicts the abundance and distribution of the larvae of the northern anchovy, *Engraulis mordax* Girard, in the region of the California Current off the Californias. The charts are drawn from the results of survey cruises conducted by the California Cooperative Oceanic Fisheries Investigations during the years 1966 through 1979. This atlas is the second of the series started by Kramer and Ahlstrom (1968).

I have followed the procedure of Kramer and Ahlstrom (1968) and present two charts for each cruise: one for the size group most adequately sampled (6.25 to 12.25 mm preserved length) and one for the total number of larvae caught.

Judgement should be exercised in the interpretation of these maps. They are gross distributions, useful for revealing broad gradients, and there is little assurance that a single station abundance is typical of the area it represents. However there is reason for confidence in major spatial and temporal features which are large enough to be described by several stations.

Methods and Materials

Details of the CalCOFI survey and sampling methodology have been described by Kramer et al. (1972) and Smith and Richardson (1977). The plankton net, with flowmeter, is lowered to depth and retrieved obliquely at a constant rate with a constant angle between the tow wire and the vertical. Rigorous procedures are employed to minimize variation in the volume of water filtered per unit depth. Ichthyoplankton are vertically distributed in layers; however the extent and position of these layers is often not known. Therefore considerable effort was exerted to sample each depth uniformly with a tow that vertically integrates catch to the surface. The samples are thus an estimate of the number of organisms beneath some measure of sea surface area.

Samples are standardized by adjusting to a standard unit of sea surface area. The standard unit is 10 m² and the adjustment (standard haul factor) is calculated as the ratio of a standard volume of water filtered per unit depth and the total volume of water filtered over the total depth. Thus:

$$\text{SHF} = \frac{\frac{10 \text{ m}^3}{\text{m}}}{\frac{\text{v}}{\text{d}}} = 10 \text{ d}$$

where v is the volume of water filtered, determined by flowmeter, and d is the depth fished, determined by the amount of wire out times the cosine of the average angle of stray from the vertical.

Sample counts were adjusted for fractioning (minimum aliquot was 25%) and standardized to each other. The charts are thus in units of the number of larvae under 10 m² of sea surface.

The net material was changed in 1969 from 0.55 mm mesh silk to 0.505 mm mesh nylon. Retention of small larvae increased slightly (Table 1). The net frame was changed in 1978 from a 1m ring with preceding bridle to a bridle-free bongo frame described by Smith and Richardson (1977). A decrease in net avoidance by larger larvae is evident in the size-specific night/day catch ratios for

¹National Oceanic and Atmospheric Administration, Southwest Fisheries Center, National Marine Fisheries Service, La Jolla, California 92038.

Table 1. Catch rate bias relative to 0.333 mm mesh nylon net.
Adapted from Zweifel and Smith (in press).

Preserved size (mm)	2.5	3.75	4.75	5.75	6.75	7.75
0.55 mm silk net	0.40	0.56	0.74	0.89	0.97	1.0
0.505 mm nylon net	0.43	0.63	0.83	0.95	0.99	1.0

each net (Figure 1). The ratios diverge with larval length; the bongo night/day ratio is half the 1m night/day ratio at 6.75 mm preserved length. The significance of the difference diminishes when one considers that the total catch of large larvae decreased exponentially with length (Zweifel and Smith, in press); larvae 6.75 mm and larger were approximately 10% of the catch. The 1978 and 1979 surveys probably sampled a slightly larger fraction of the larval anchovy population because of increased retention of small larvae and decreased avoidance by large larvae. Since the effects would have been trivial no adjustment was made in preparing the charts for the relative difference in gear catch rates.

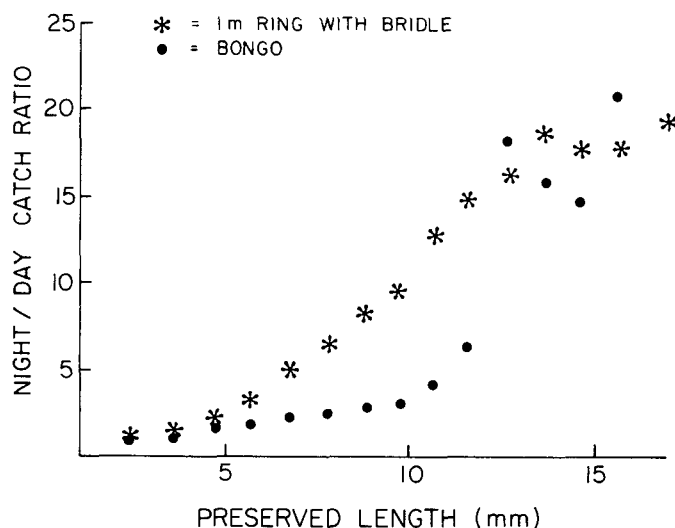


Figure 1.

Discussion

The charts may be considered analogue models of the actual distribution of the population and as such are potentially rich sources of information.

The highly patchy nature of plankton imposes a limit on interpretation, however, because of the uncertainty associated with any single observation.

Four general temporal and spatial features of anchovy spawning, from 1966 through 1979, are discussed briefly below. The charts were digitized by simply summing the larval catch over the area each station represented, from line 60 to line 110 (assumed to contain most or nearly all of the central population of the northern anchovy). Gaps in geographic coverage were accommodated by interpolation.

Table 2. Fraction of total larval catch.

	North of Pt. Conception	South of San Diego
1966	6%	11%
1969	2%	23%
1972	3%	41%
1975	<1%	59%
1978	4%	17%
1979	1%	51%

Anchovy spawning can shift in a north/south direction between years and sometimes within years. In Table 2 the fraction of spawn north of Pt. Conception and south of San Diego are listed for the years 1966, 1969, 1972, 1975, 1978 and 1979 (1967 and 1968 surveys were not included because of insufficient temporal coverage). A southern shift in spawning is apparent in 1972, 1975 and 1979, with 40% or more of the larval catch taken south of San Diego.

Larval abundance is plotted by survey in Figure 2. The peak in spawning activity appears to be in the winter quarter in 1969 and 1975 and shifted toward the spring quarter in 1966, 1972, 1978 and 1979. The peak is more pronounced and the spawning season appears more contracted in 1969, 1975 and 1978 relative to the other years.

Finally, integrating over the first four cruises of each year, a gross relative measure of larval production was estimated. The relative proportions of winter/spring larval production for the years 1966, 1969, 1972, 1975, 1978 and 1979 are 5, 6, 4, 7, 3 and 4 respectively.

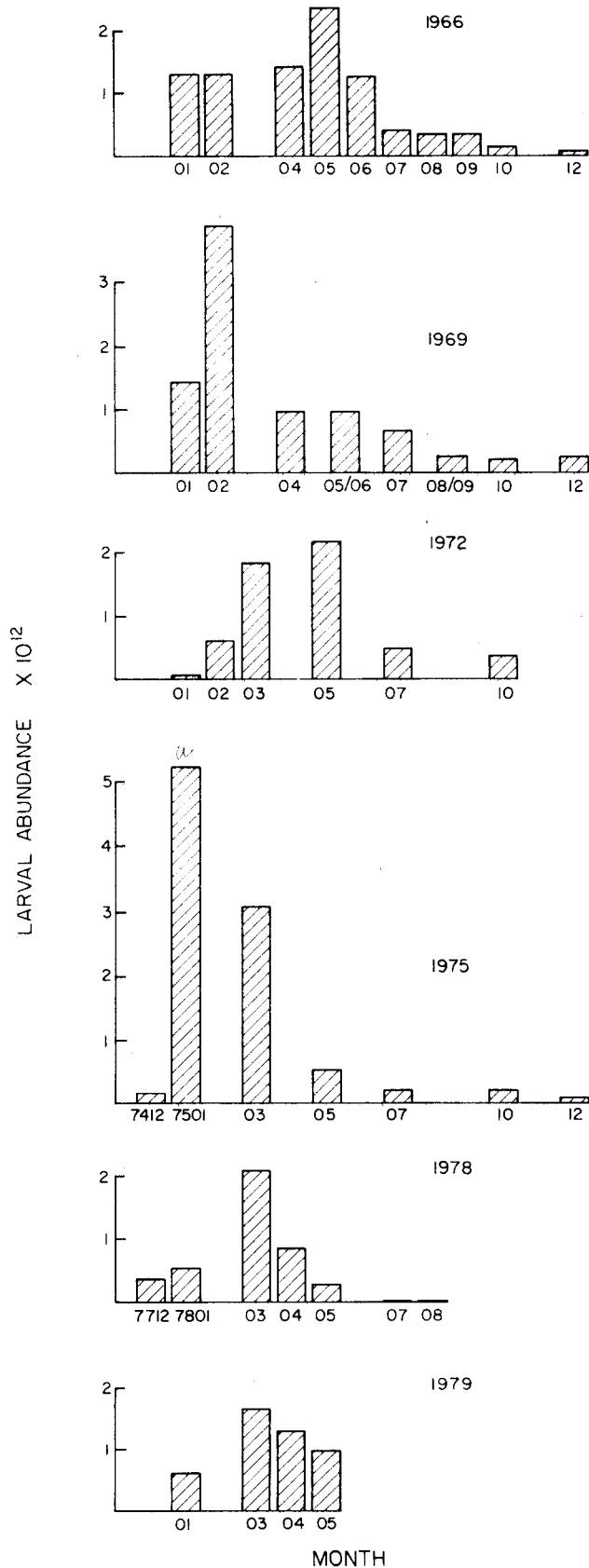


Figure 2.

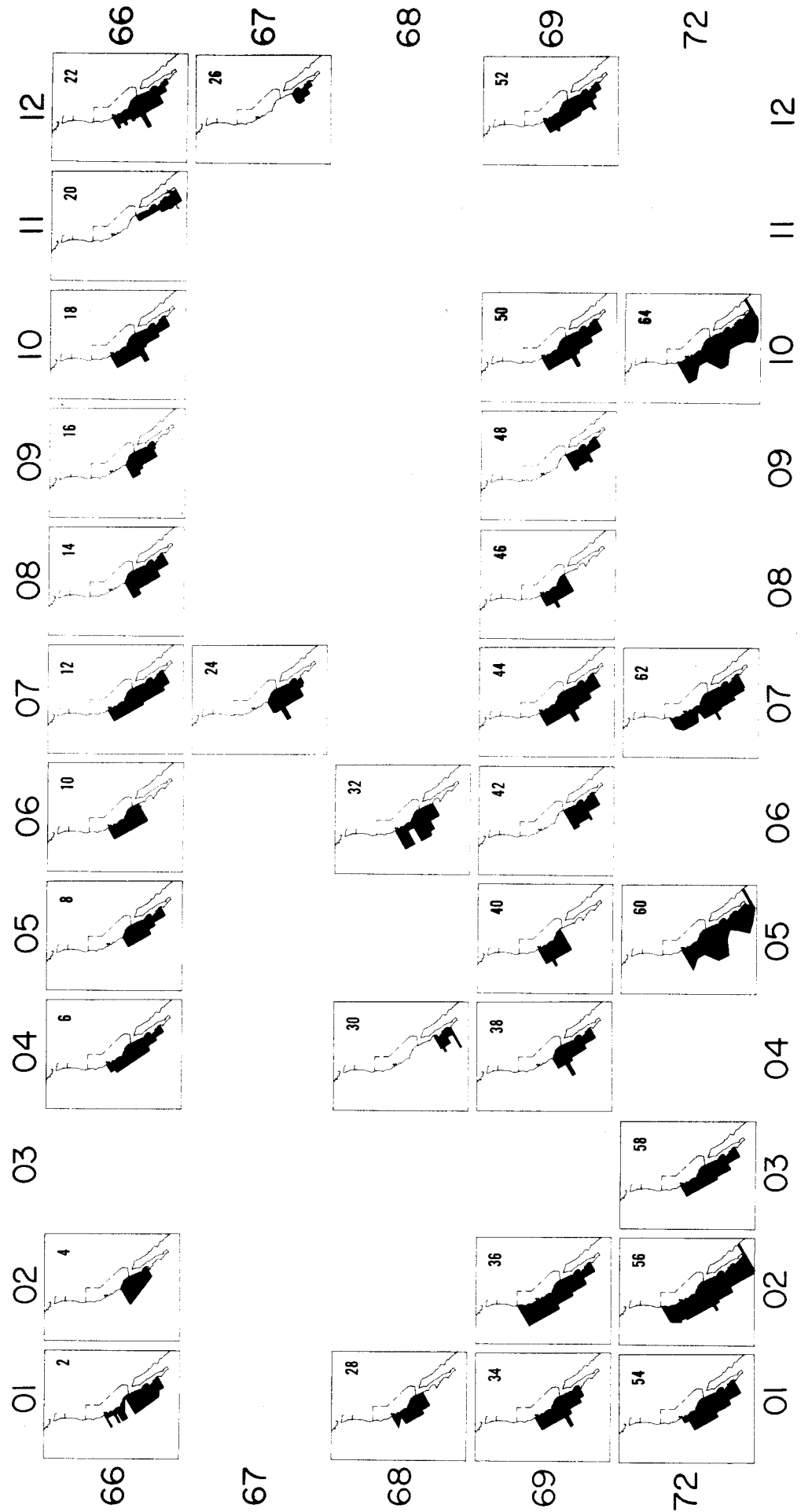
Acknowledgement

The maps presented here are the result of the collective effort of research ship's crews, marine technicians, plankton sorters, data processors and archivers, and graphic illustrators. Agencies of the United States, State of California, Republic of Mexico and United Soviet Socialist Republics were involved in the collection and processing of data. Drs. John H. Hunter and Paul Smith reviewed the introductory text.

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SAMPLING AREA BY CRUISE 1966-1979



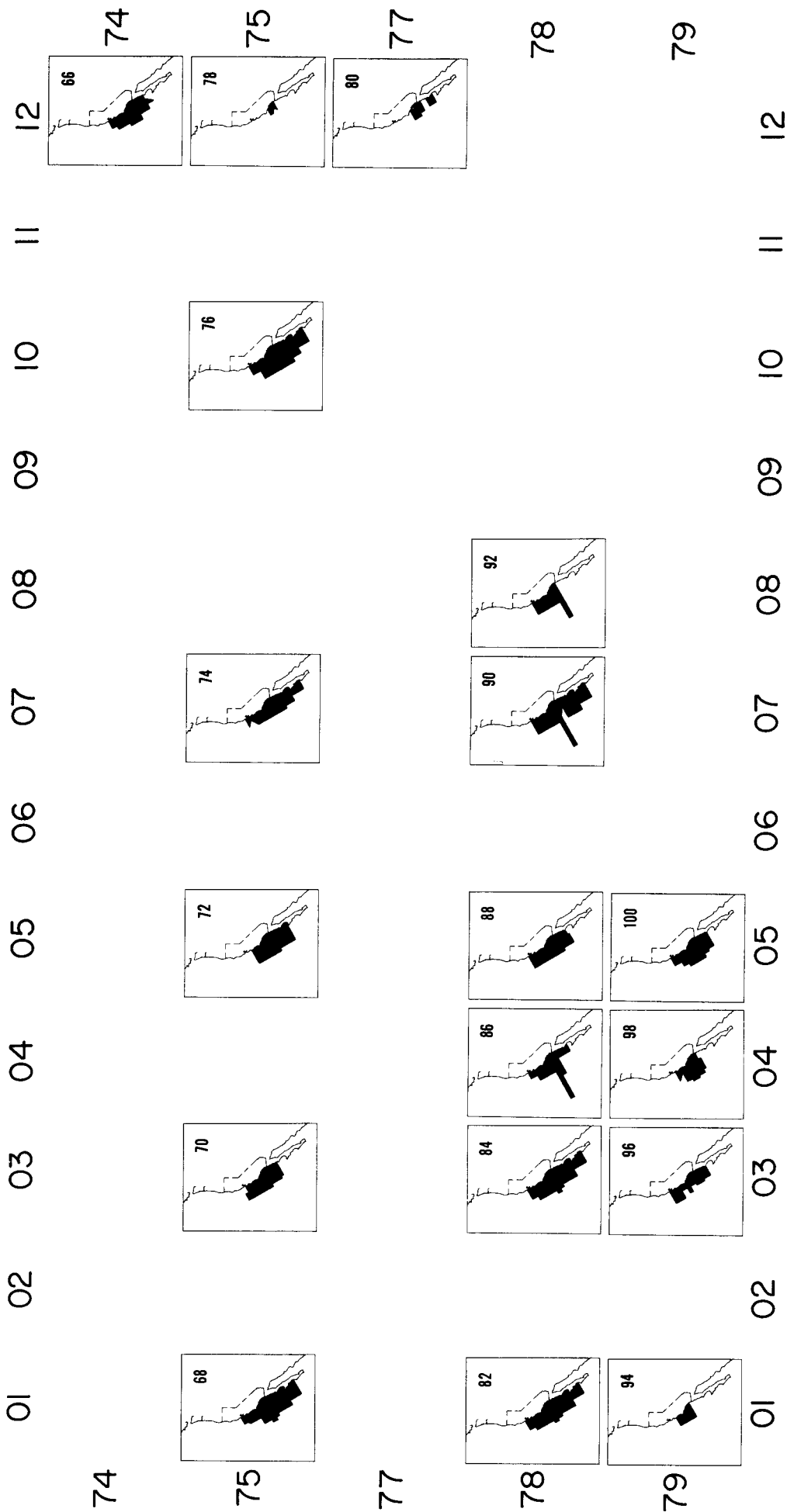
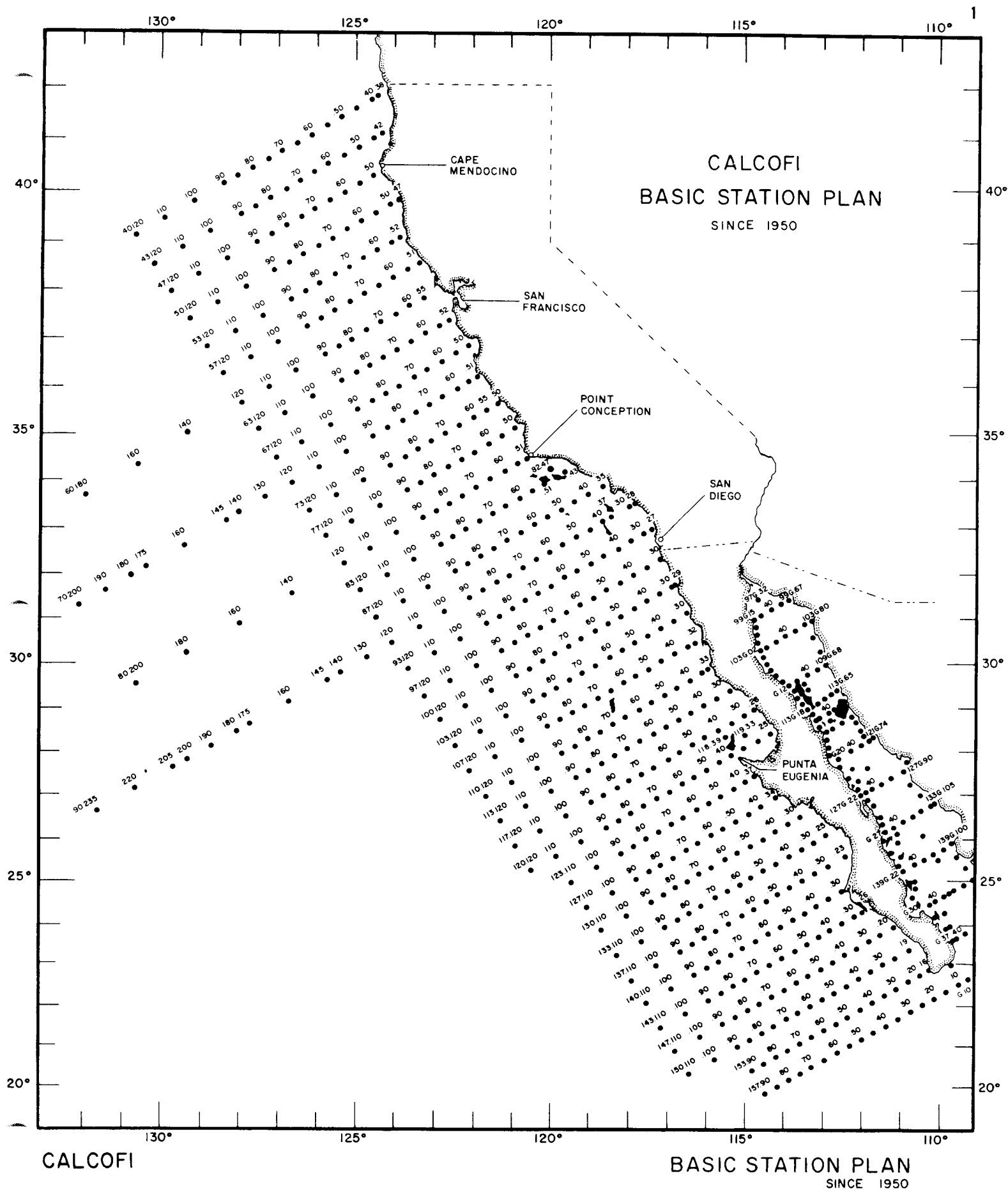
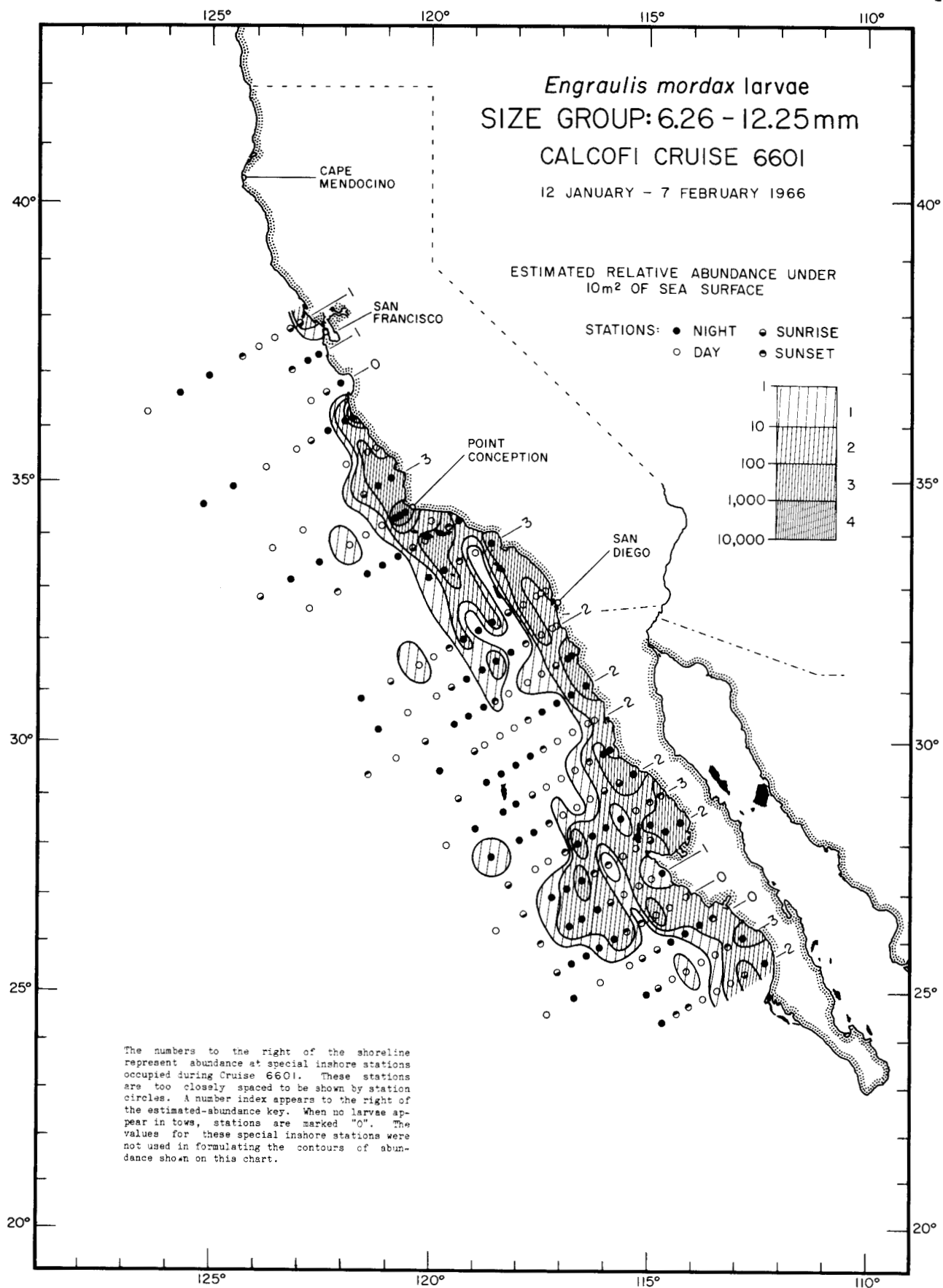
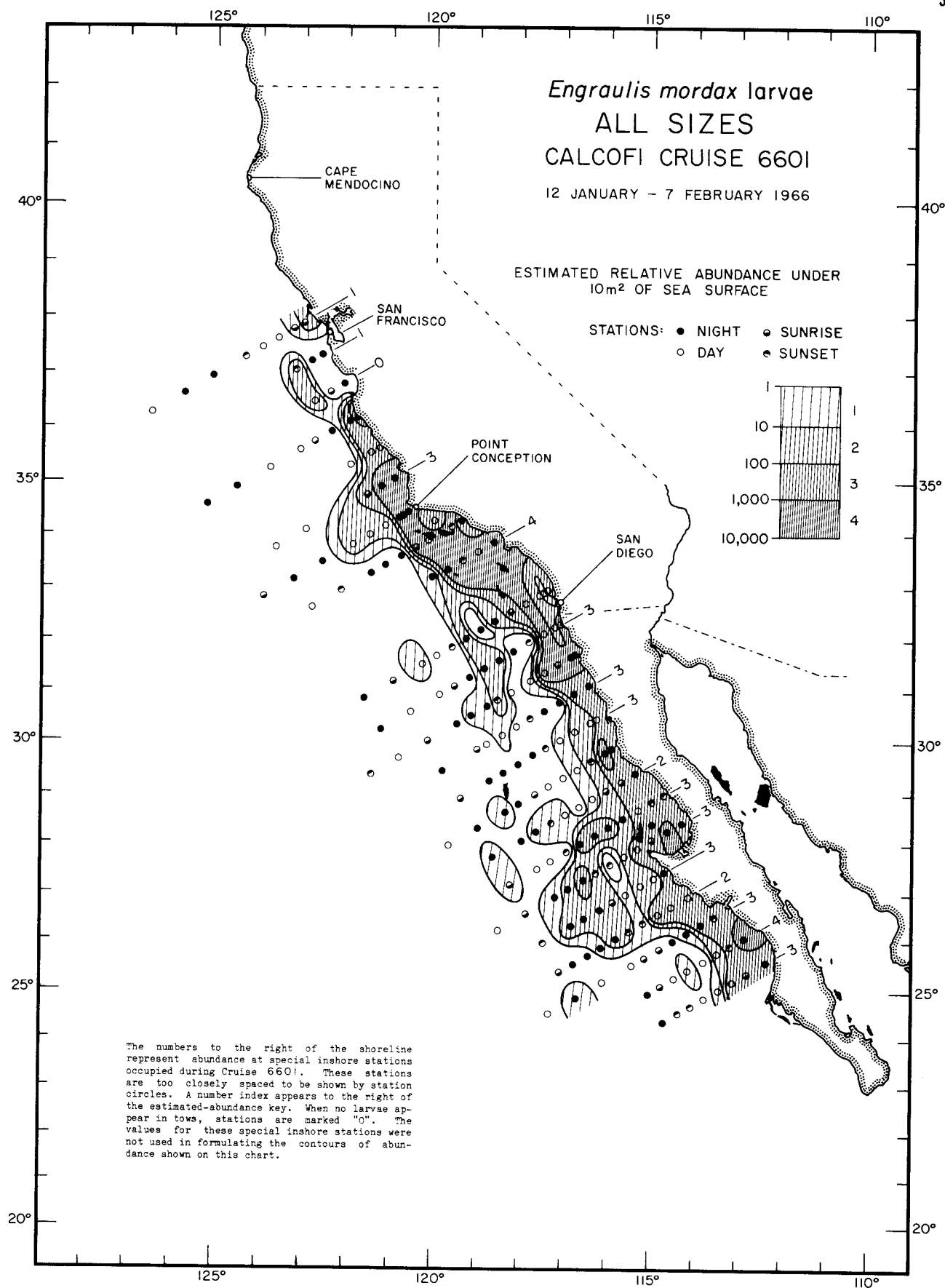


CHART NUMBER IN UPPER RIGHT CORNER
YEARS WITHOUT CRUISES (1970,'71,'73,'76)





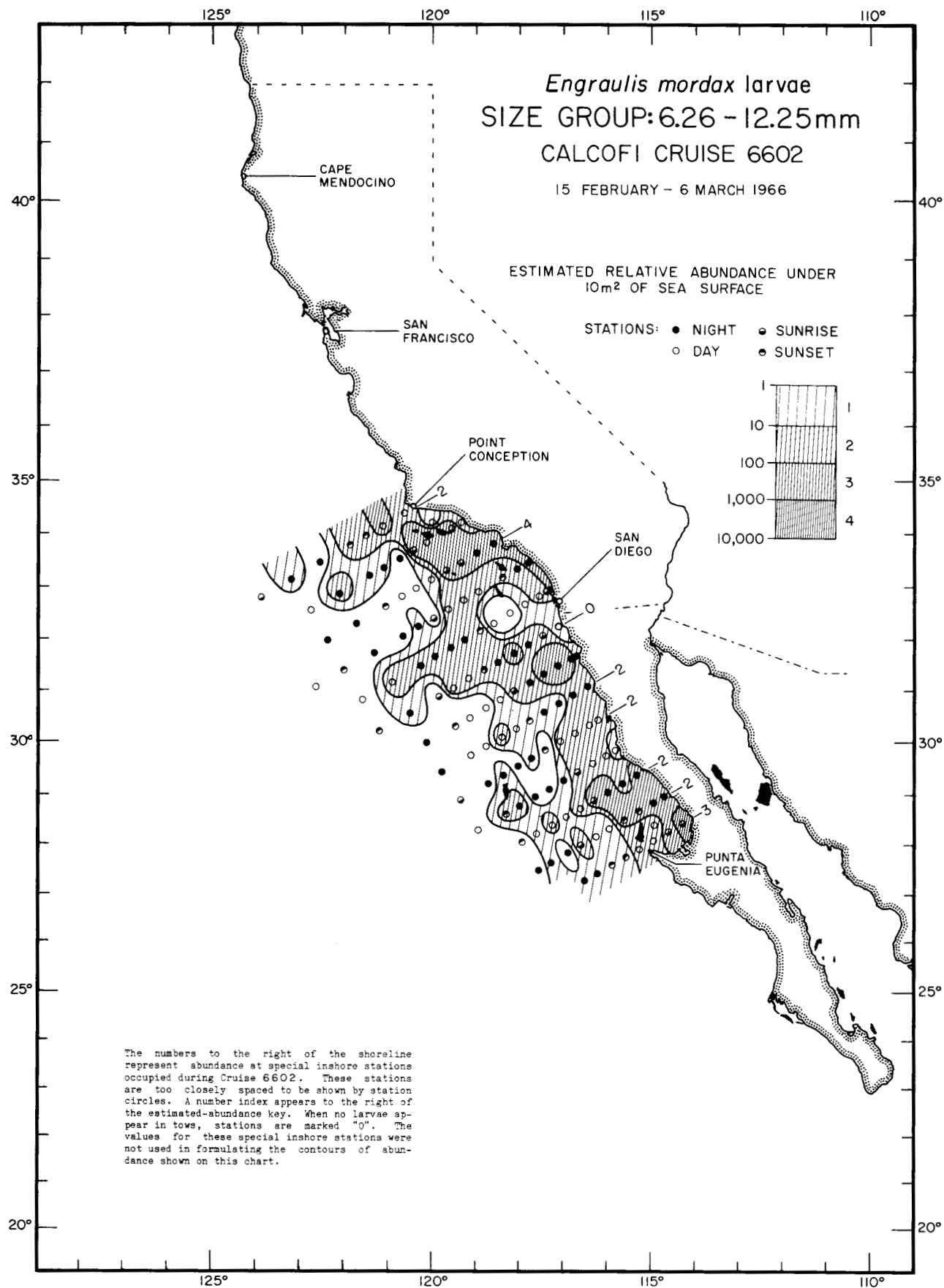
Engraulis mordax larvae
Size Group: 6.26-12.25mm
6601



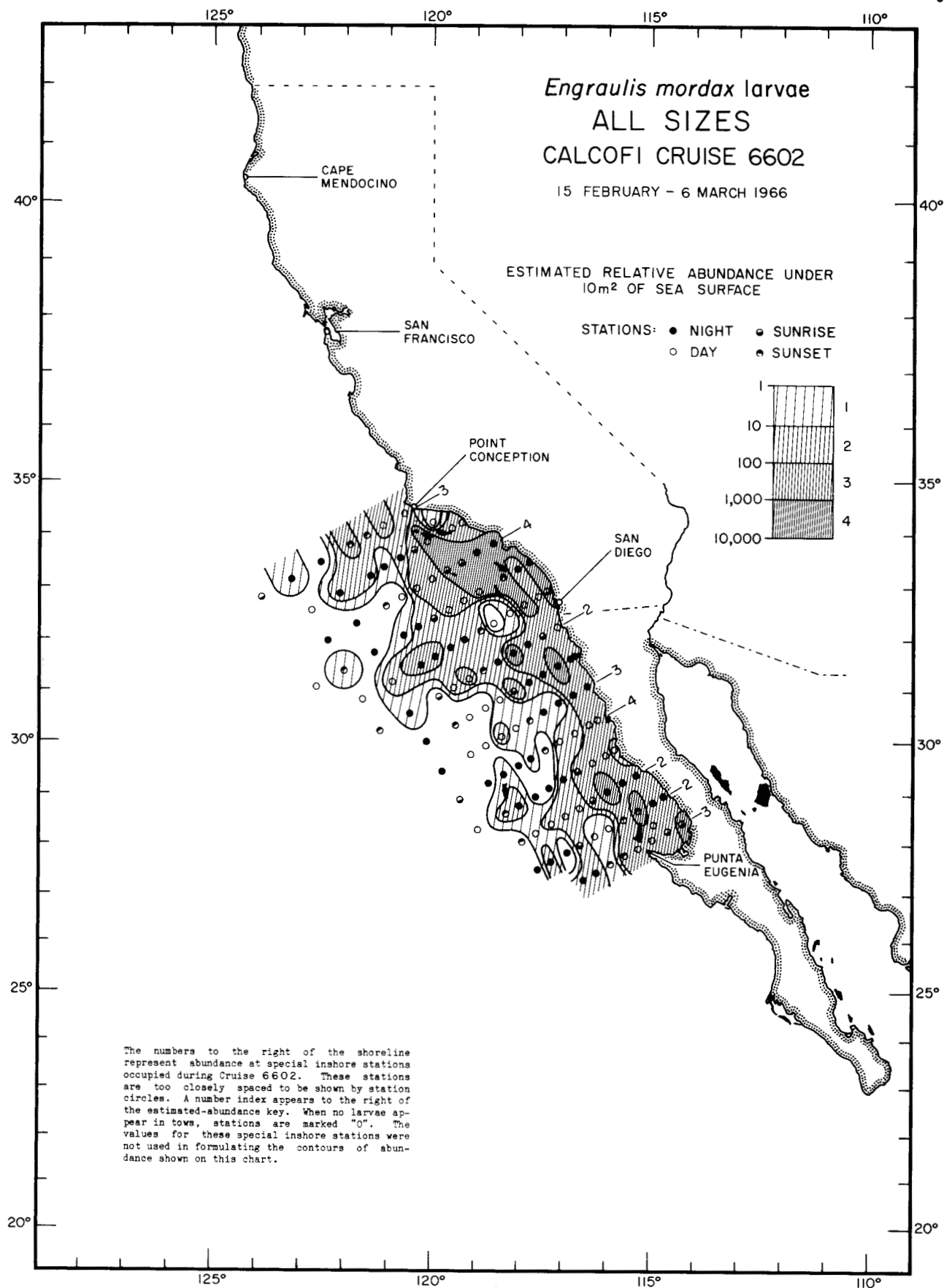
Engraulis mordax larvae

All Sizes

6601



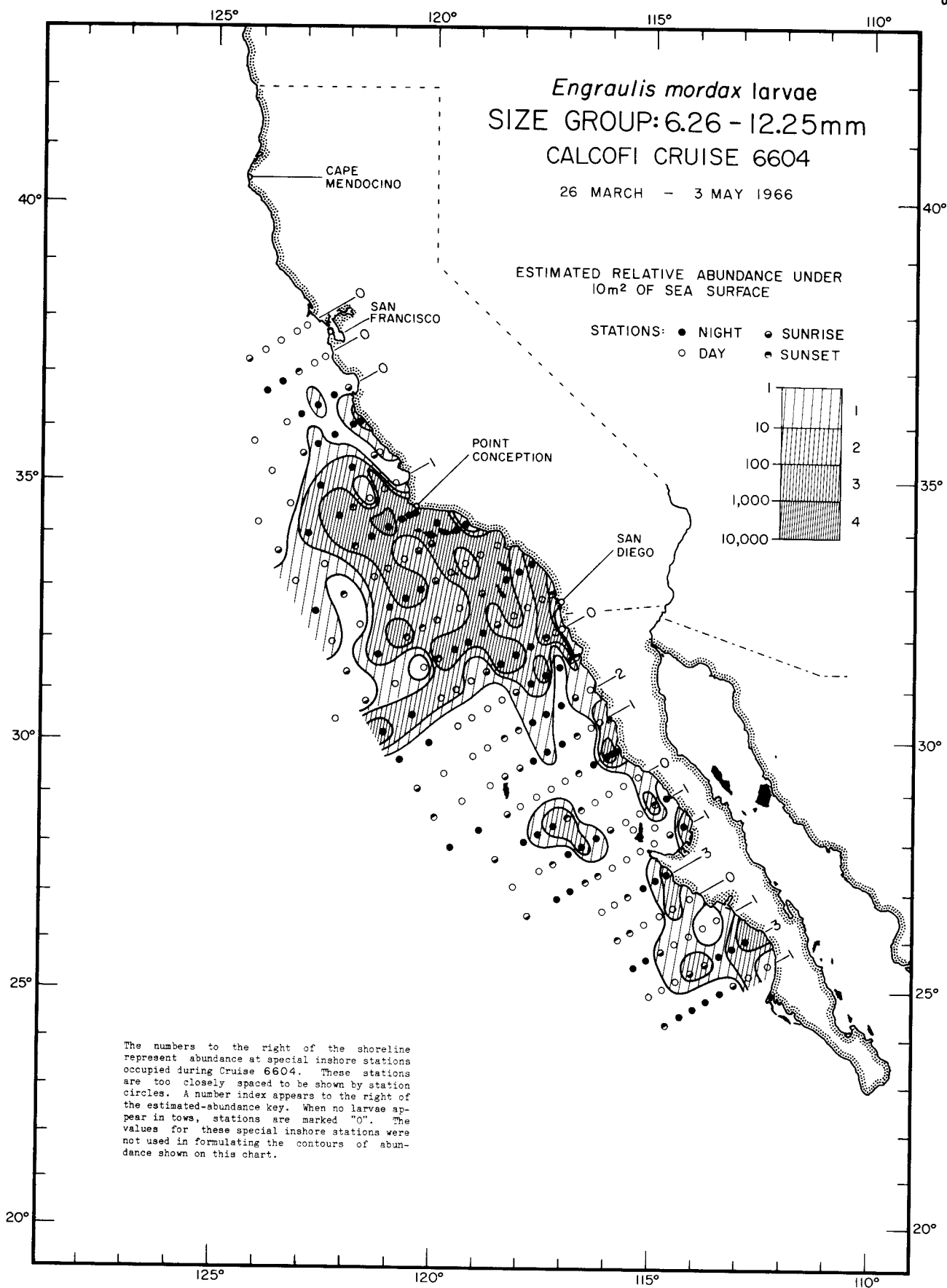
Engraulis mordax larvae
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6602



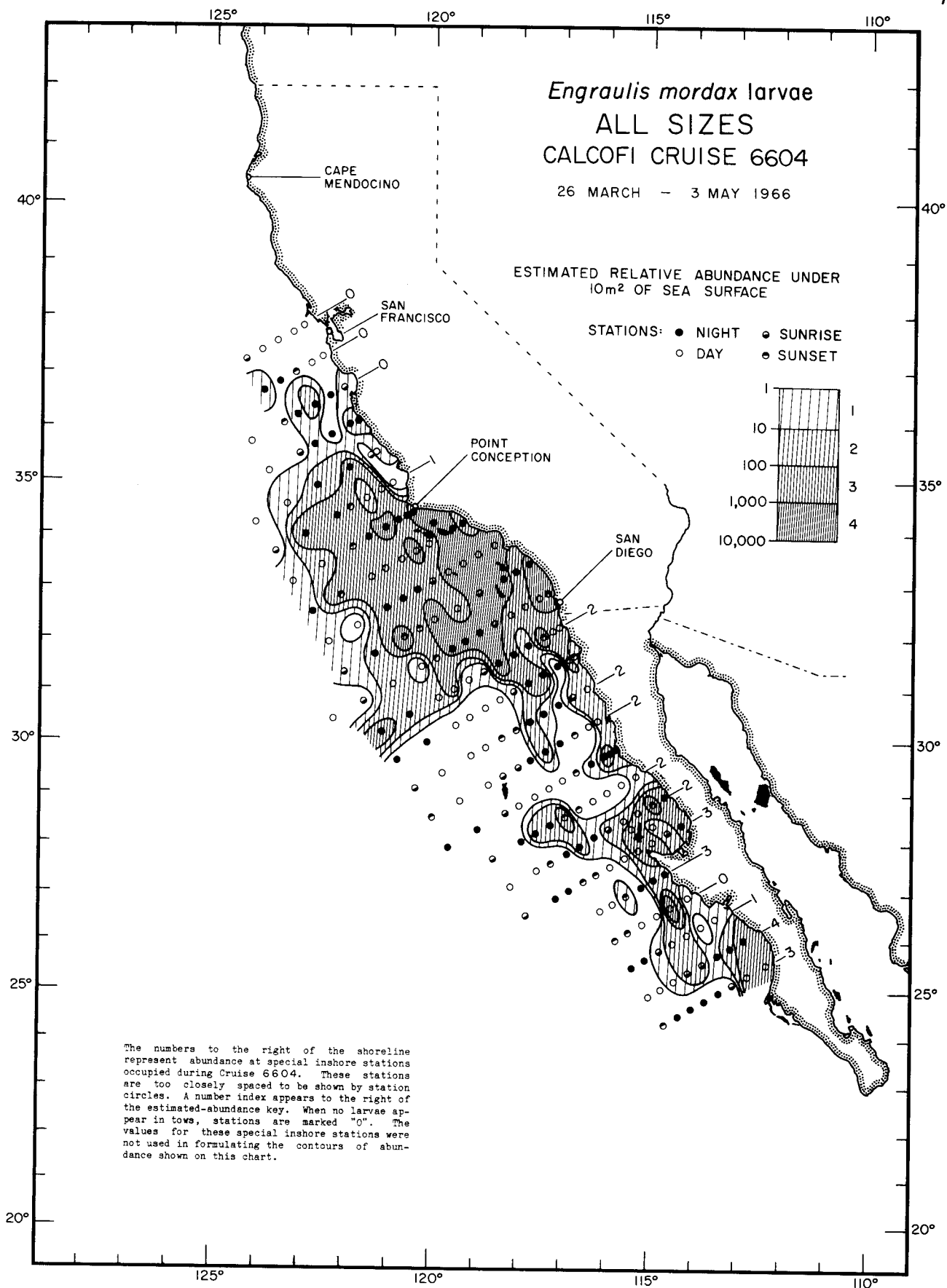
Engraulis mordax larvae

All Sizes

6602



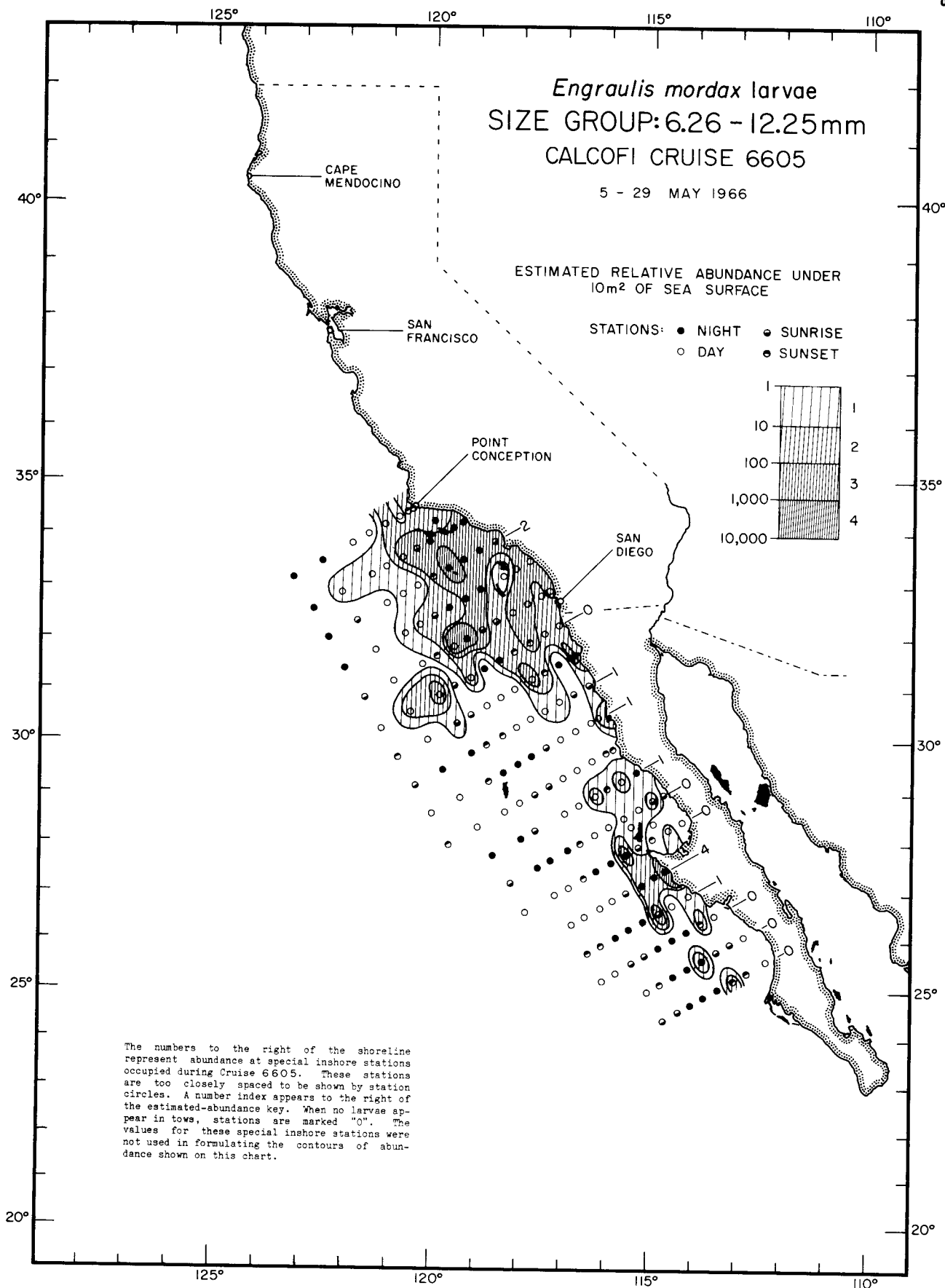
Engraulis mordax larvae
Size Group: 6.26-12.25mm
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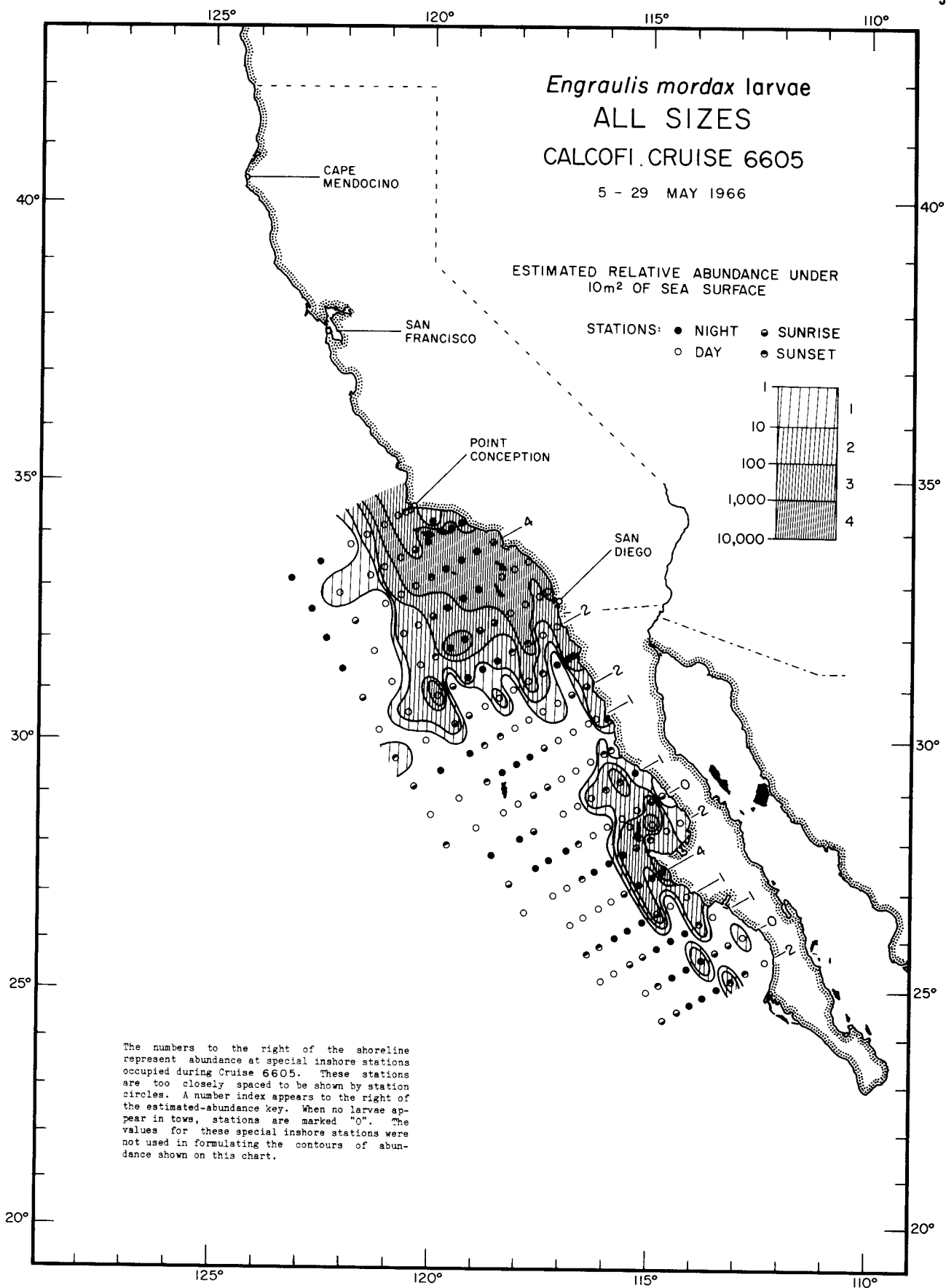
Engraulis mordax larvae

All Sizes

6604



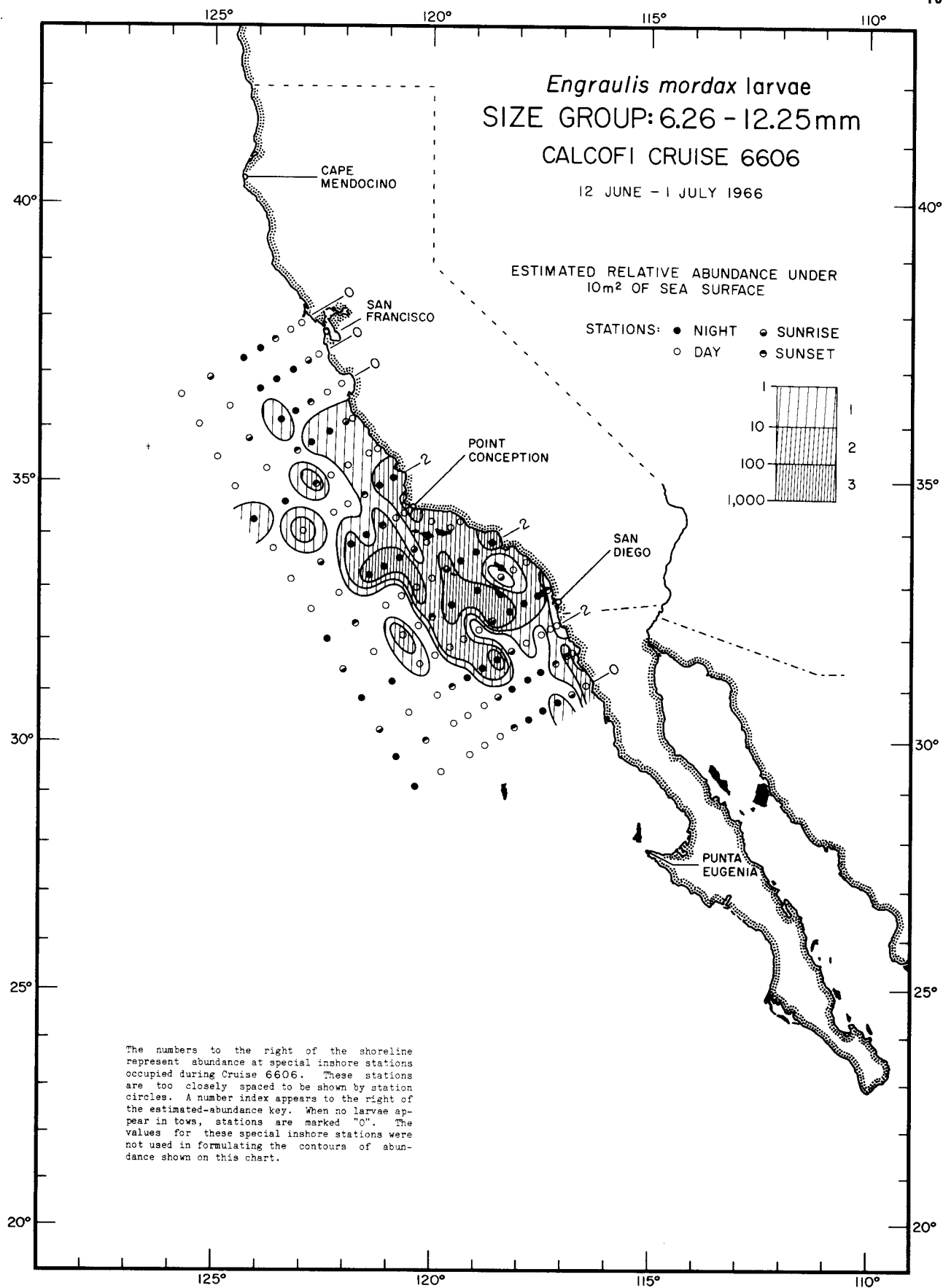
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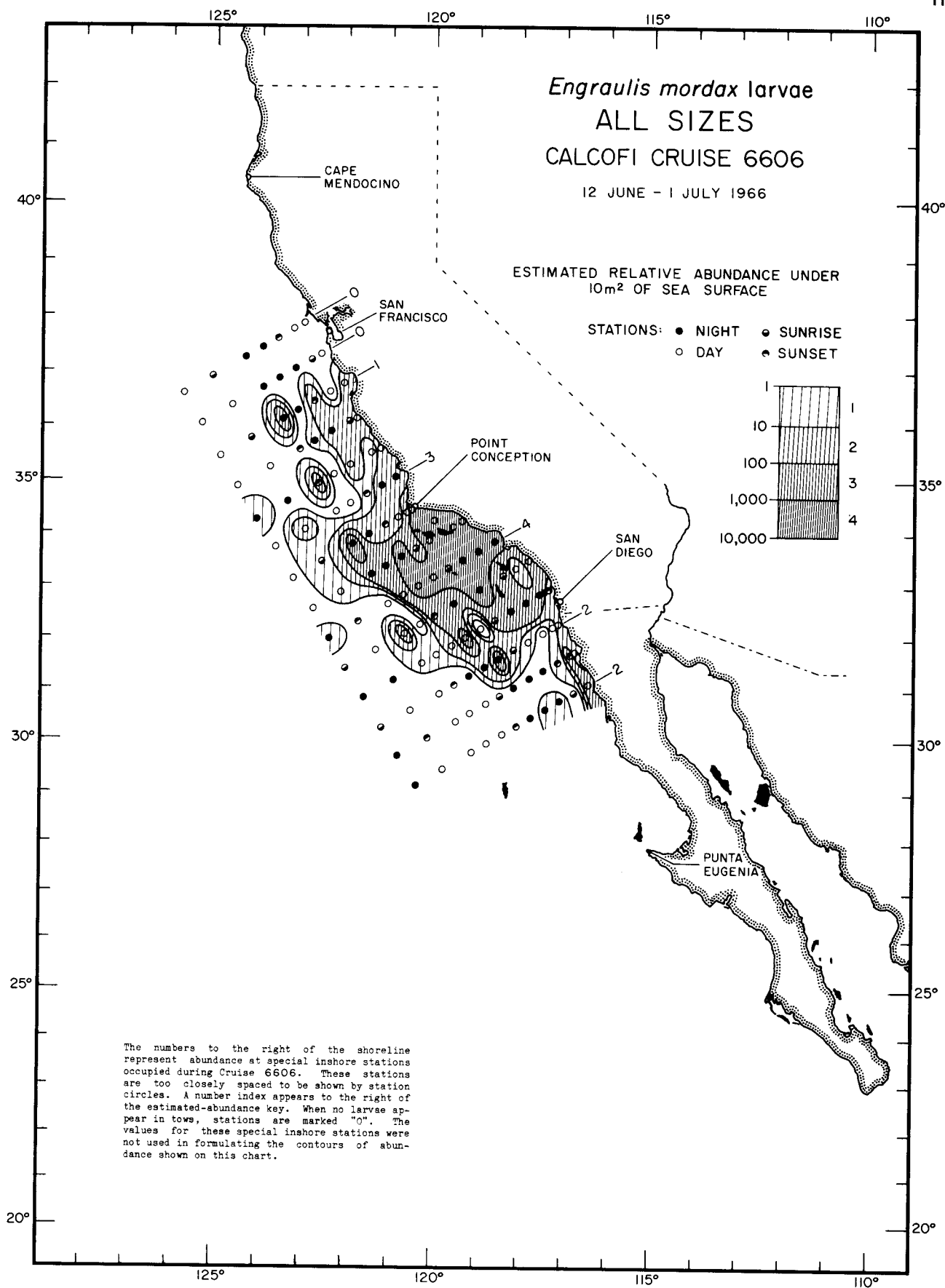
Engraulis mordax larvae

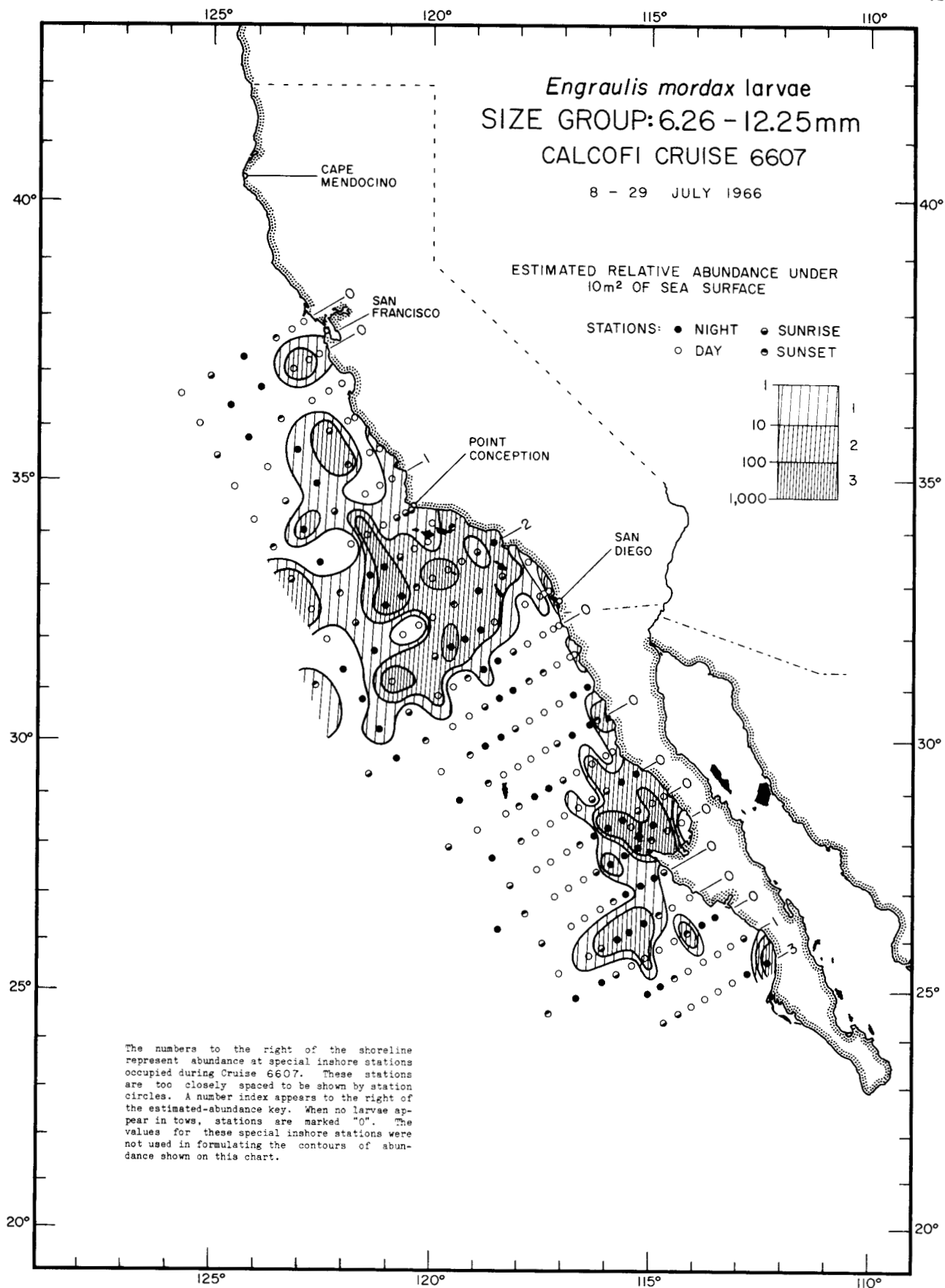
All Sizes

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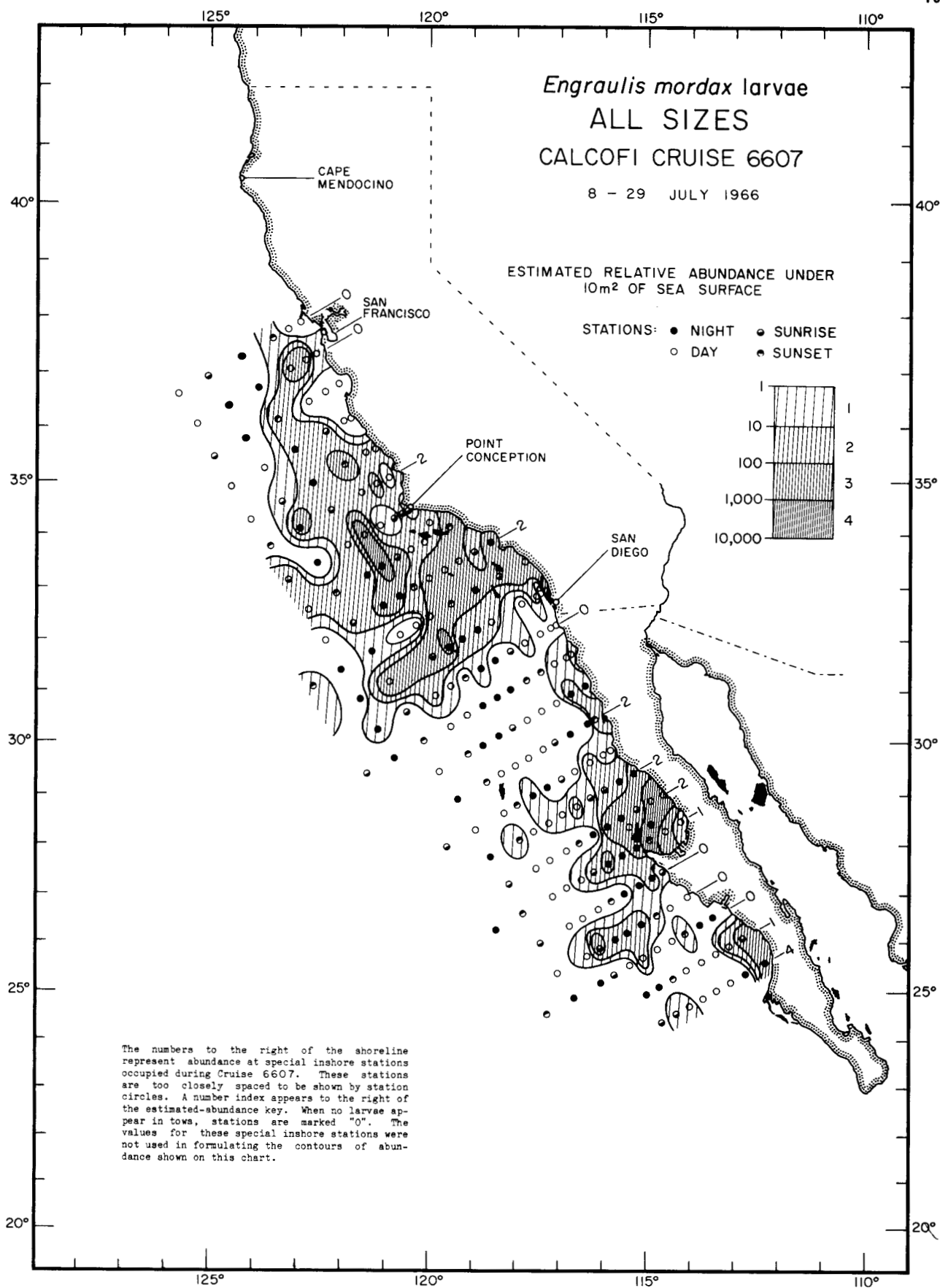


Engraulis mordax larvae
Size Group: 6.26-12.25mm
6606

*Engraulis mordax* larvaeAll Sizes
6606



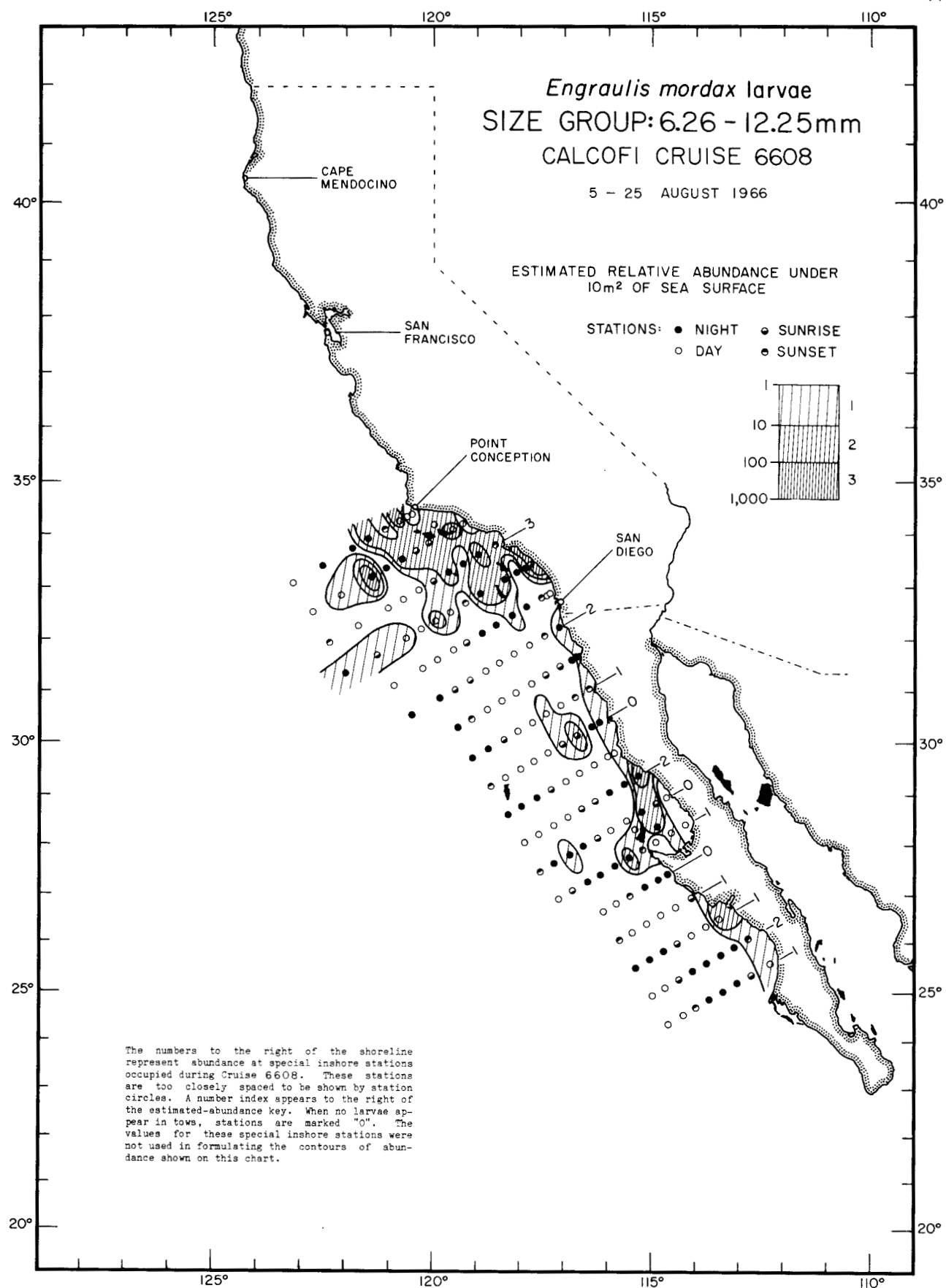
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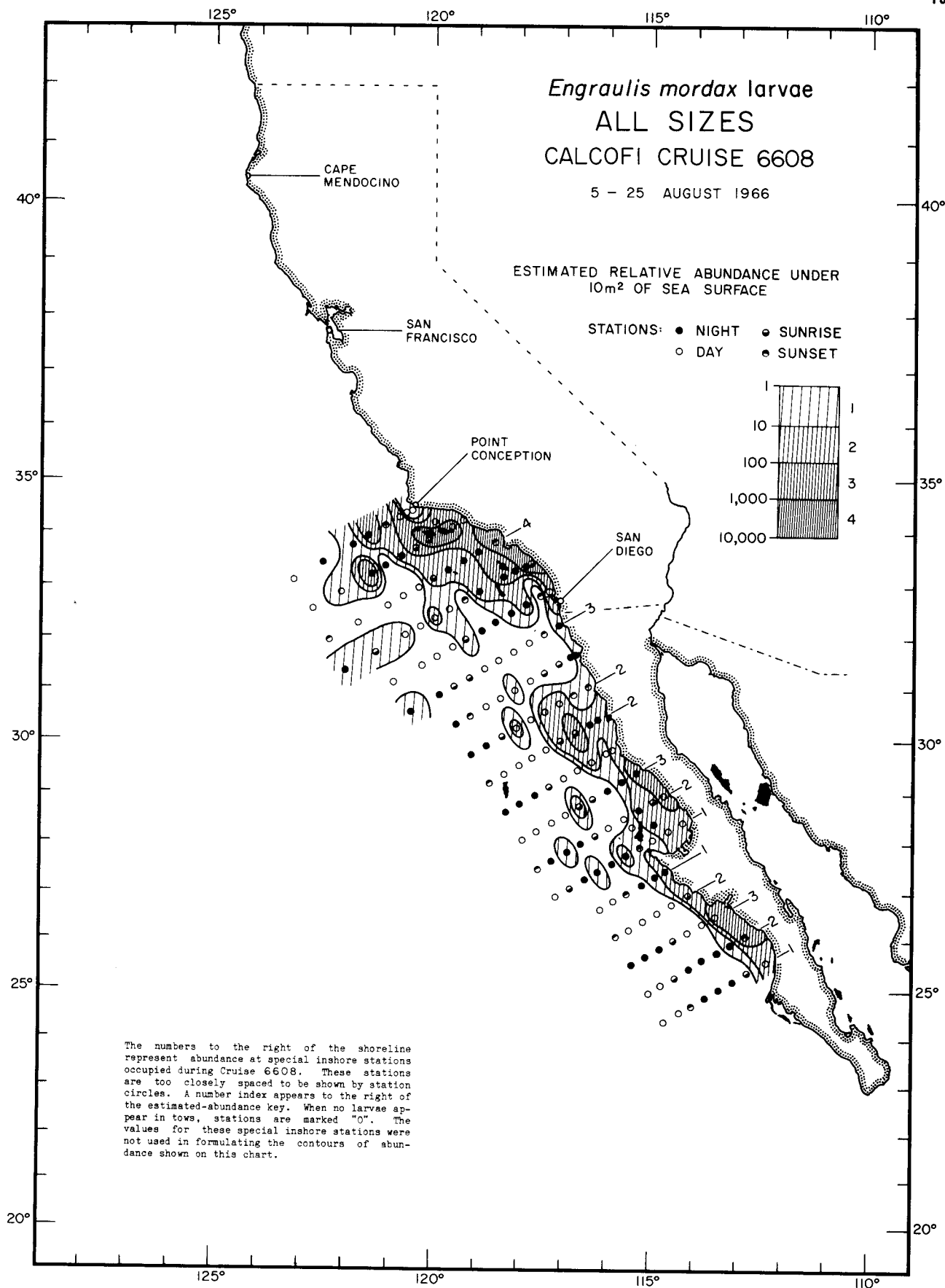
Engraulis mordax larvae

All Sizes

6607

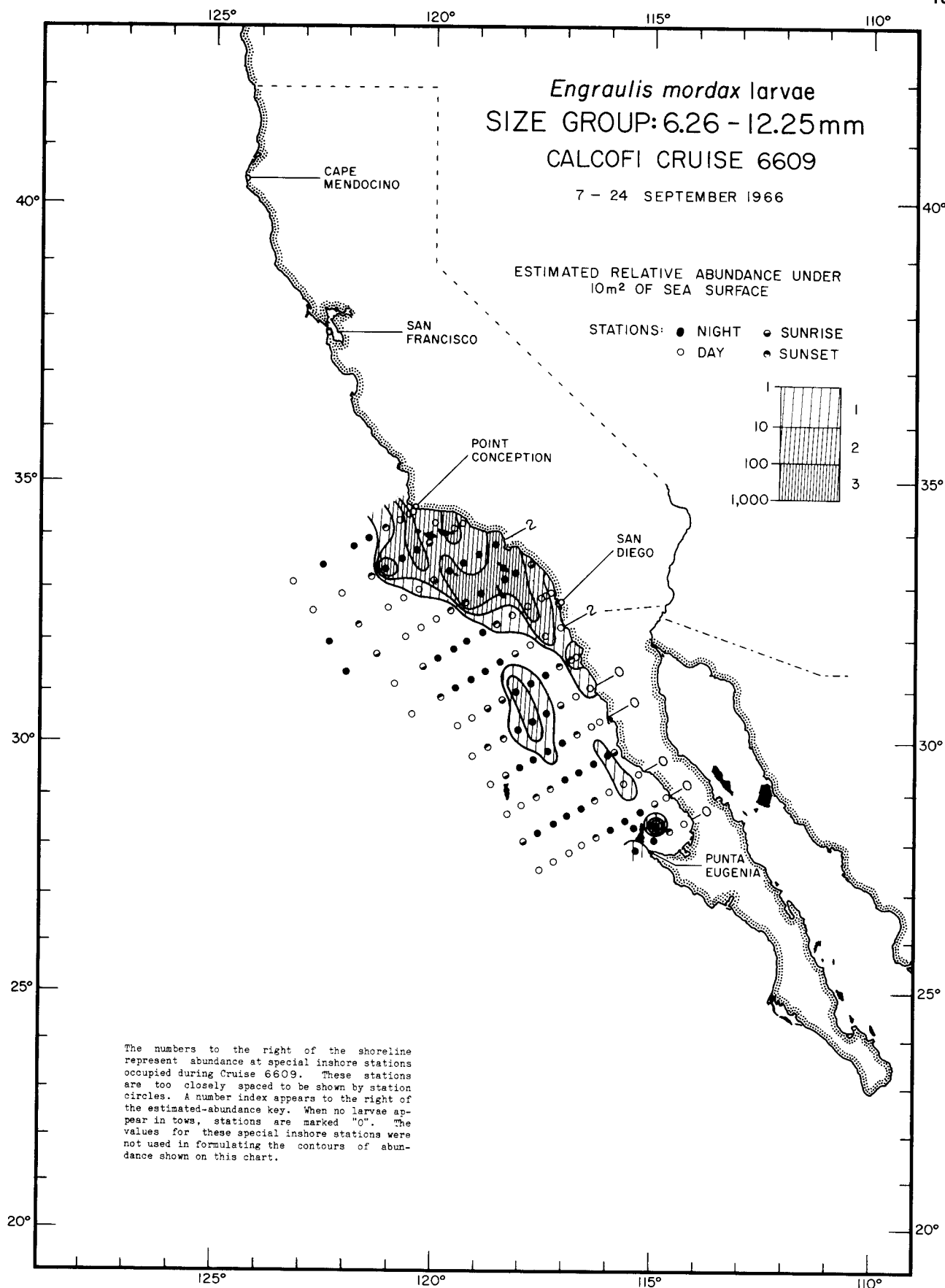


Engraulis mordax larvae
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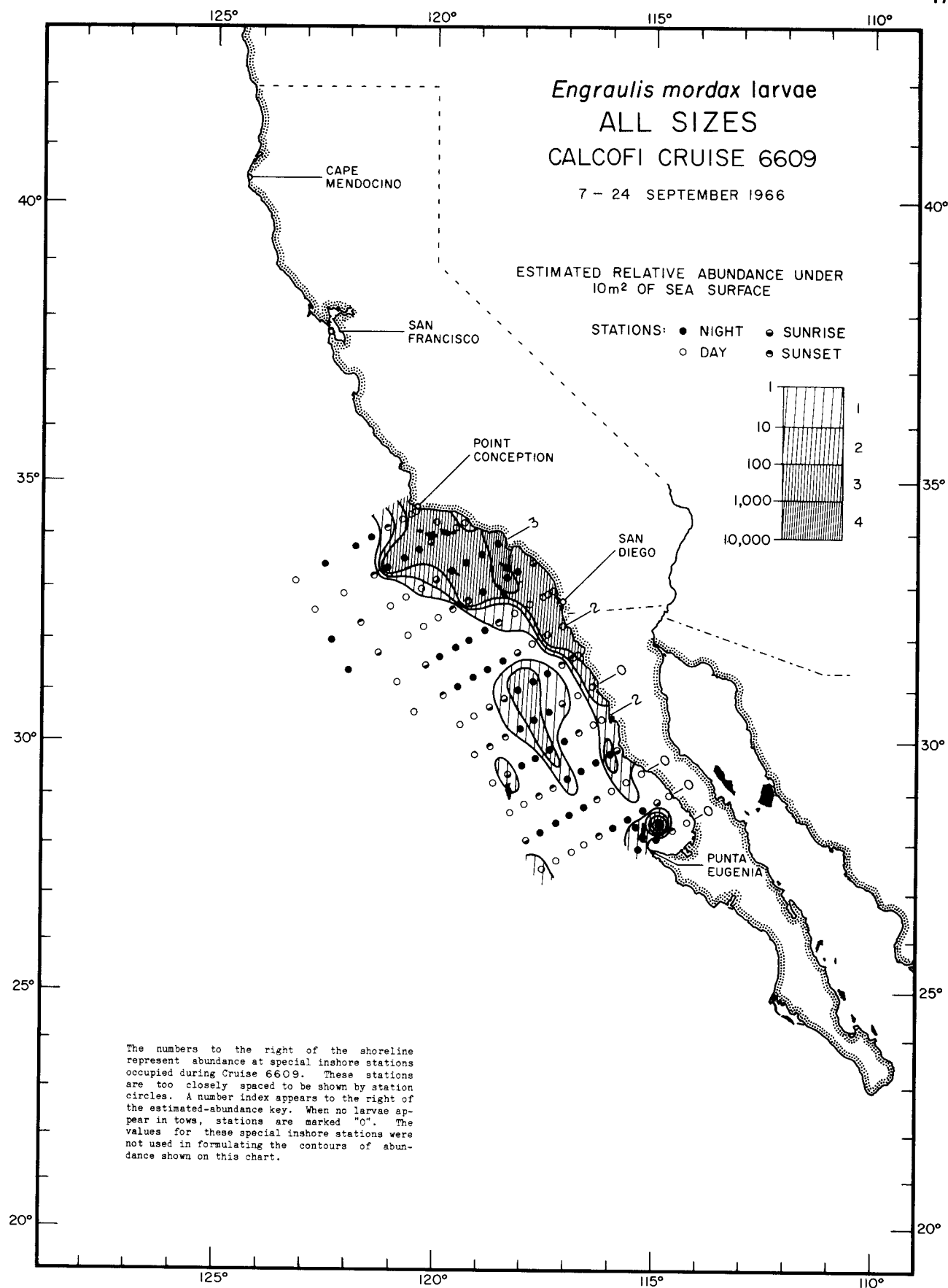
*Engraulis mordax* larvae

All Sizes

6608

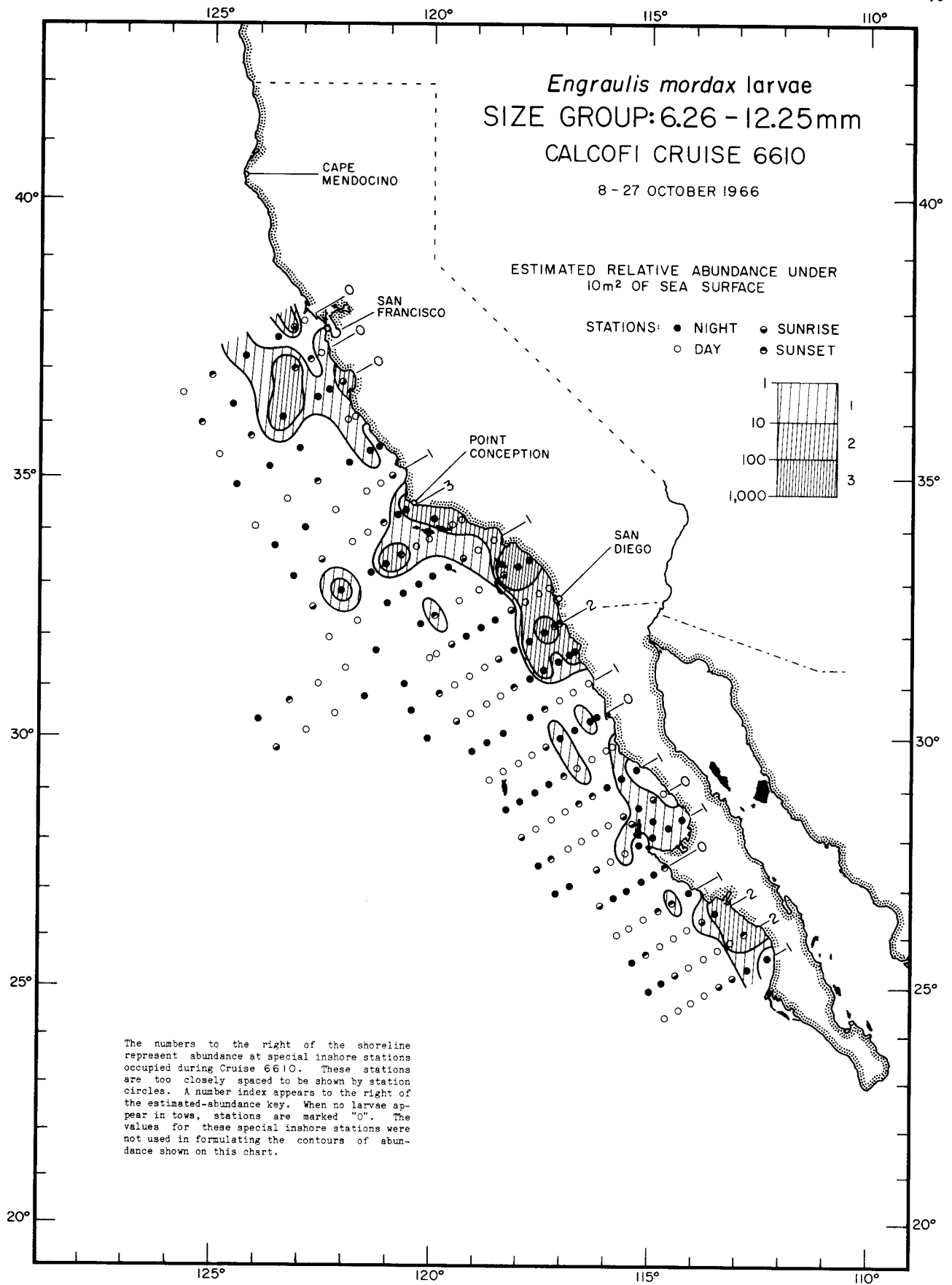


Engraulis mordax larvae
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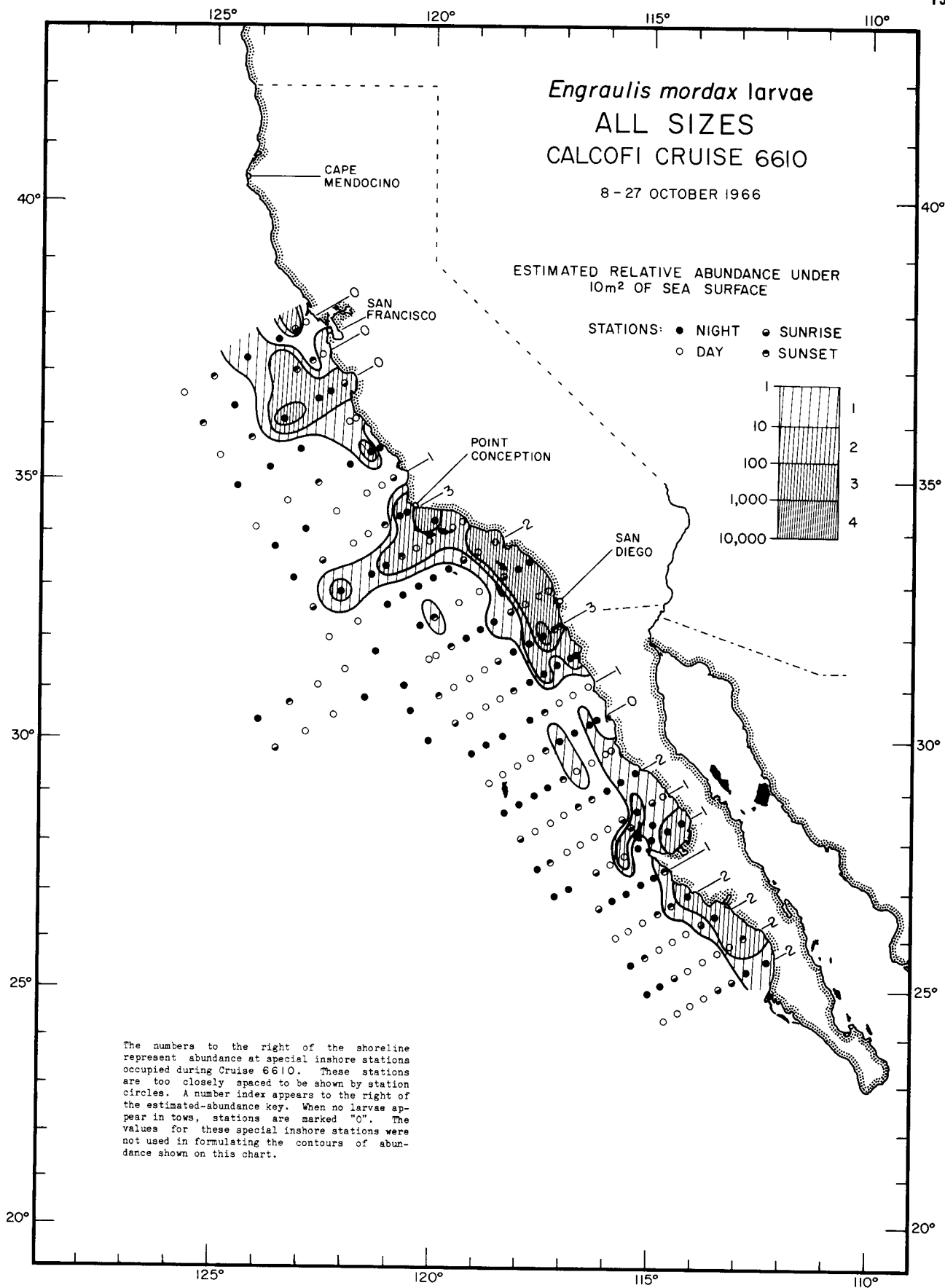
*Engraulis mordax* larvae

All Sizes

6609

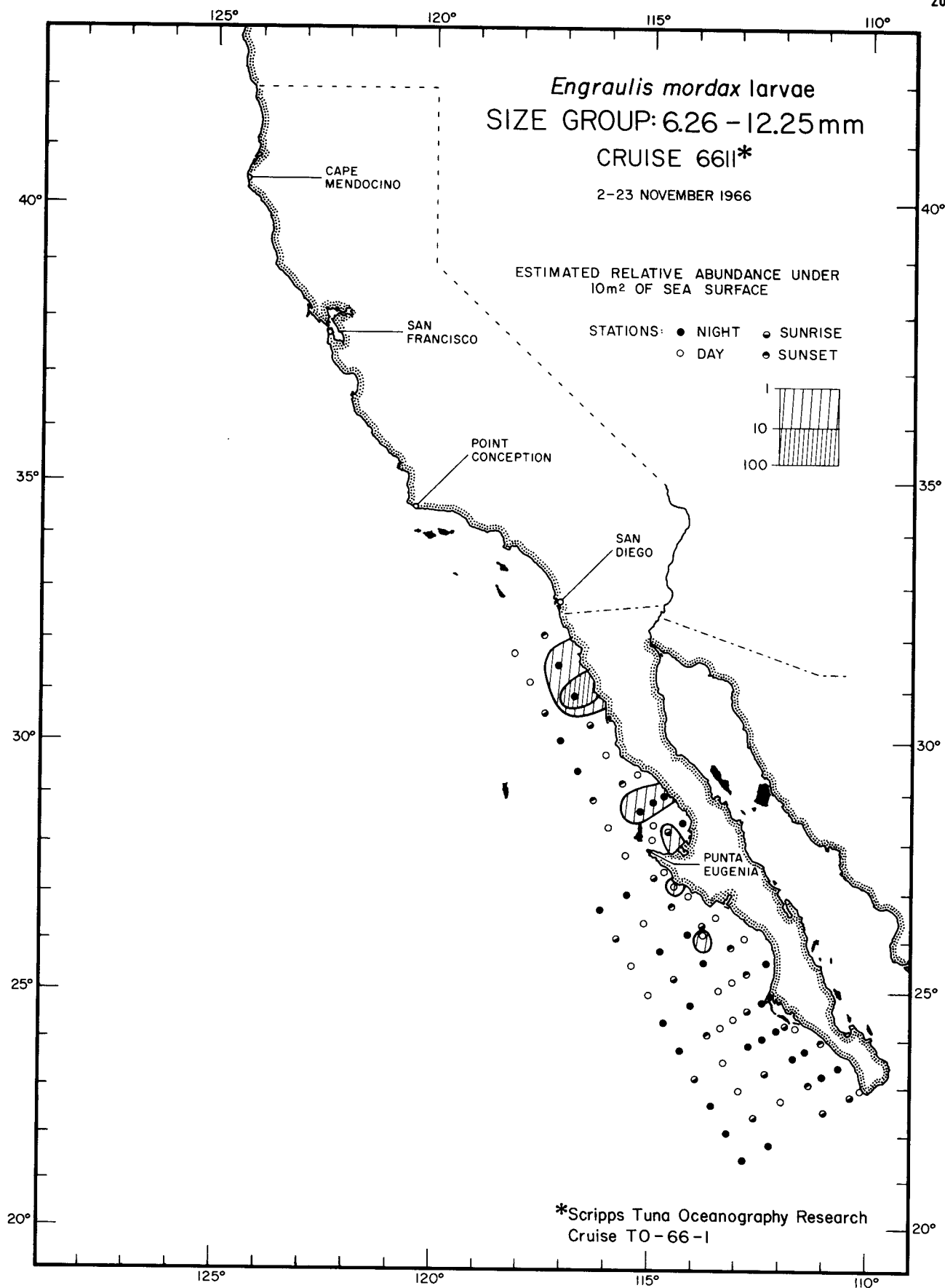


Engraulis mordax larvae
Size Group: 6.26-12.25mm
6610

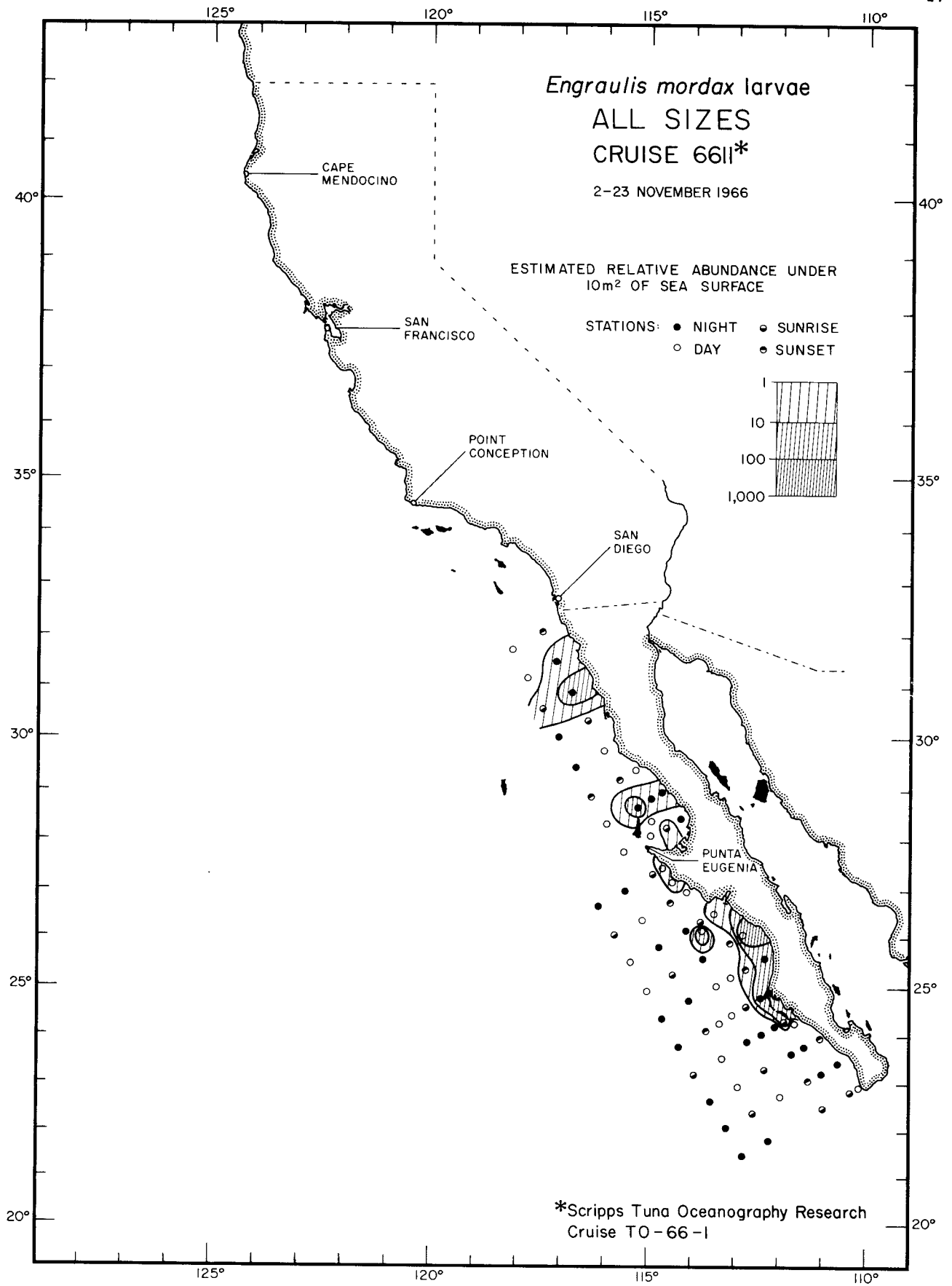
*Engraulis mordax* larvae

All Sizes

6610



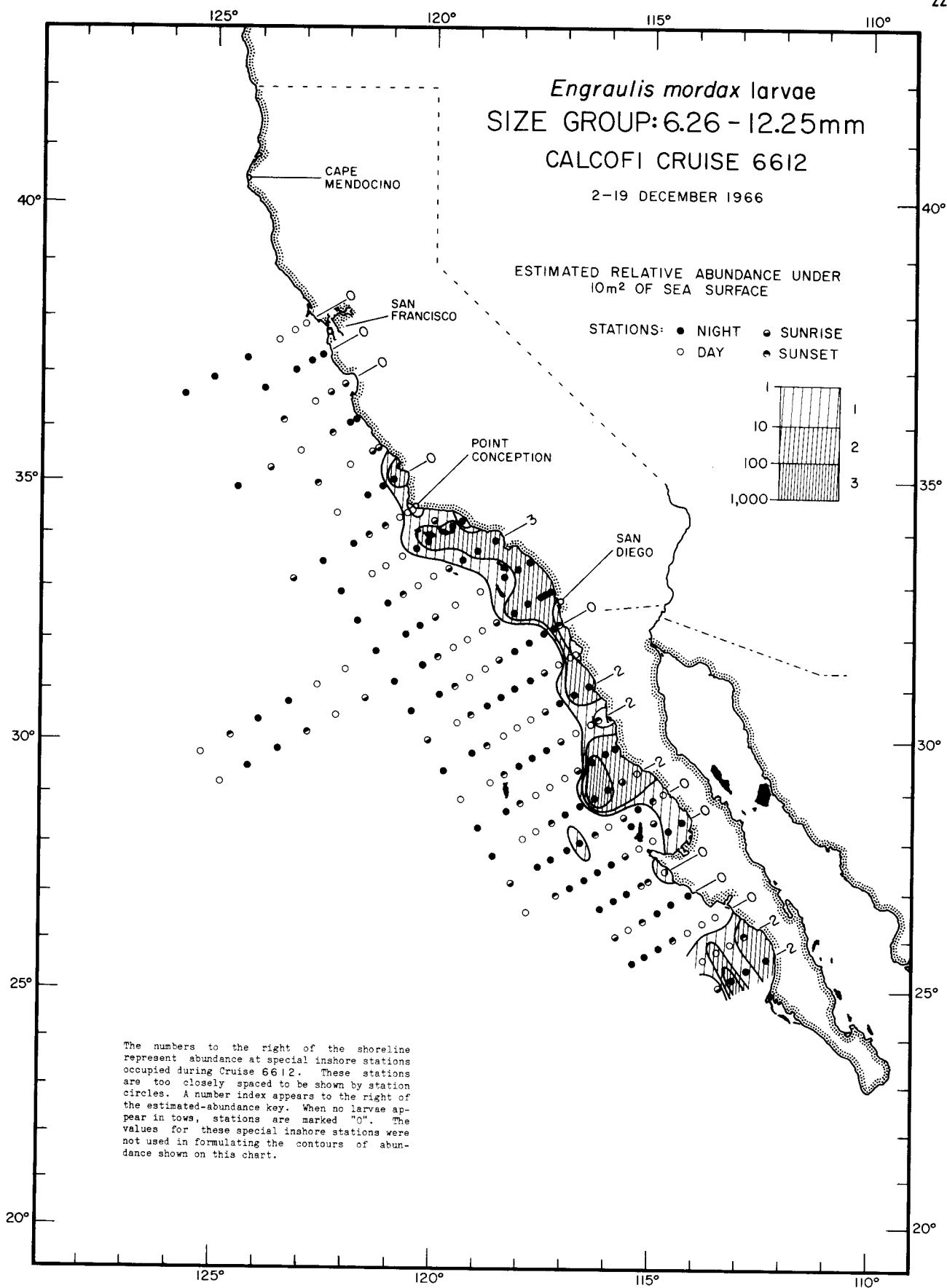
Engraulis mordax larvae
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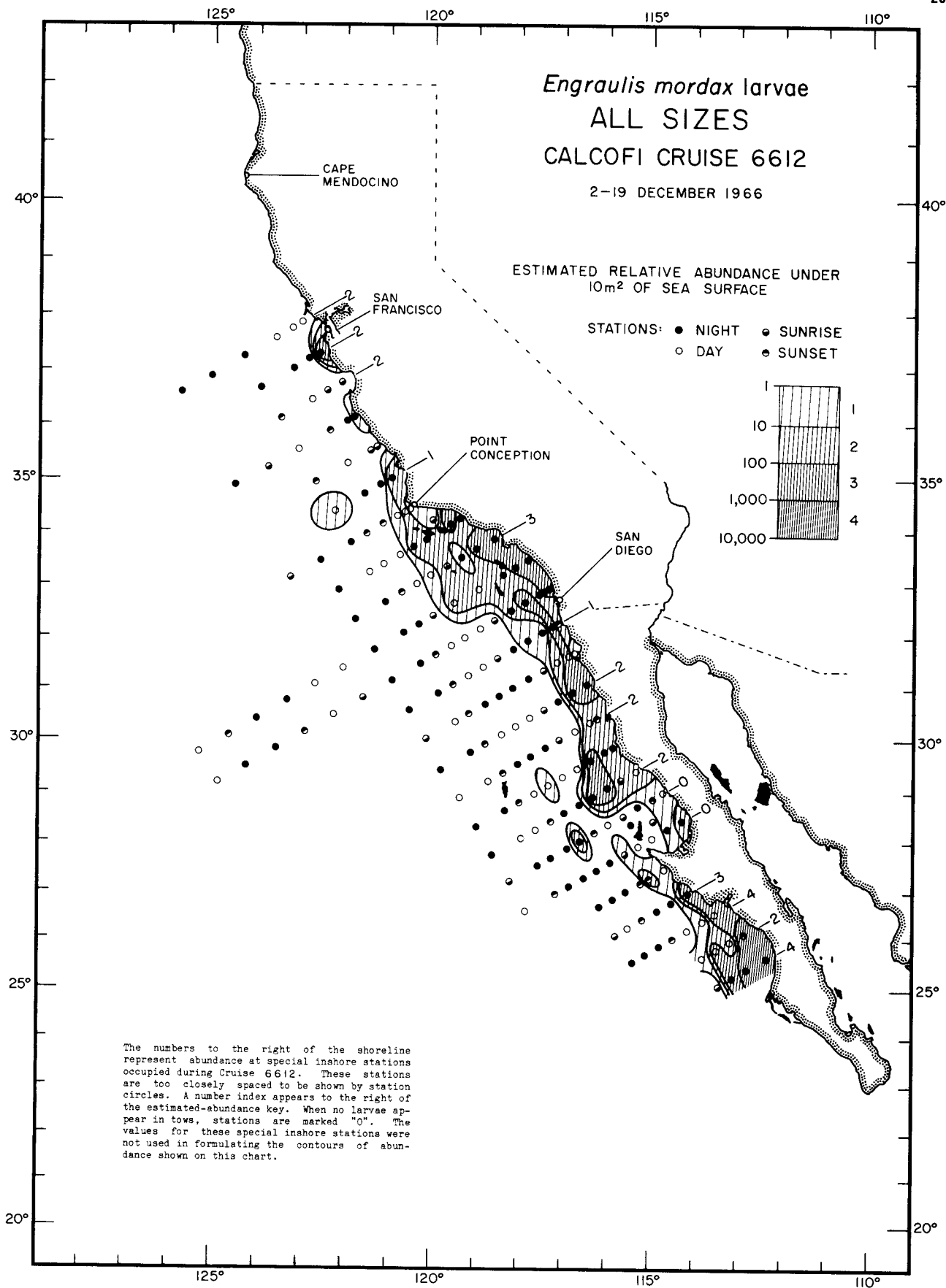
Engraulis mordax larvae

All Sizes

6611*

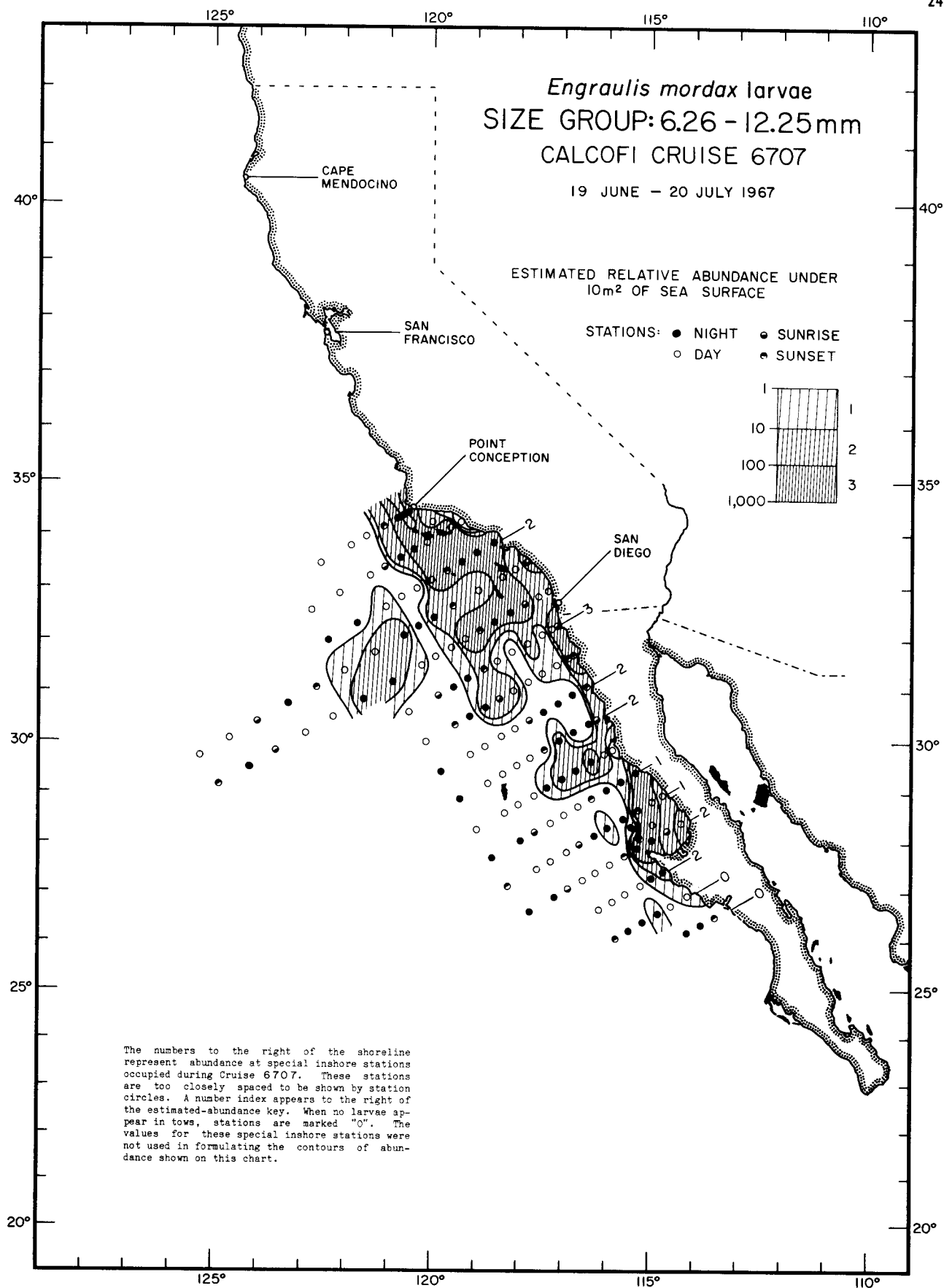


Engraulis mordax larvae
Size Group: 6.26-12.25mm
6612

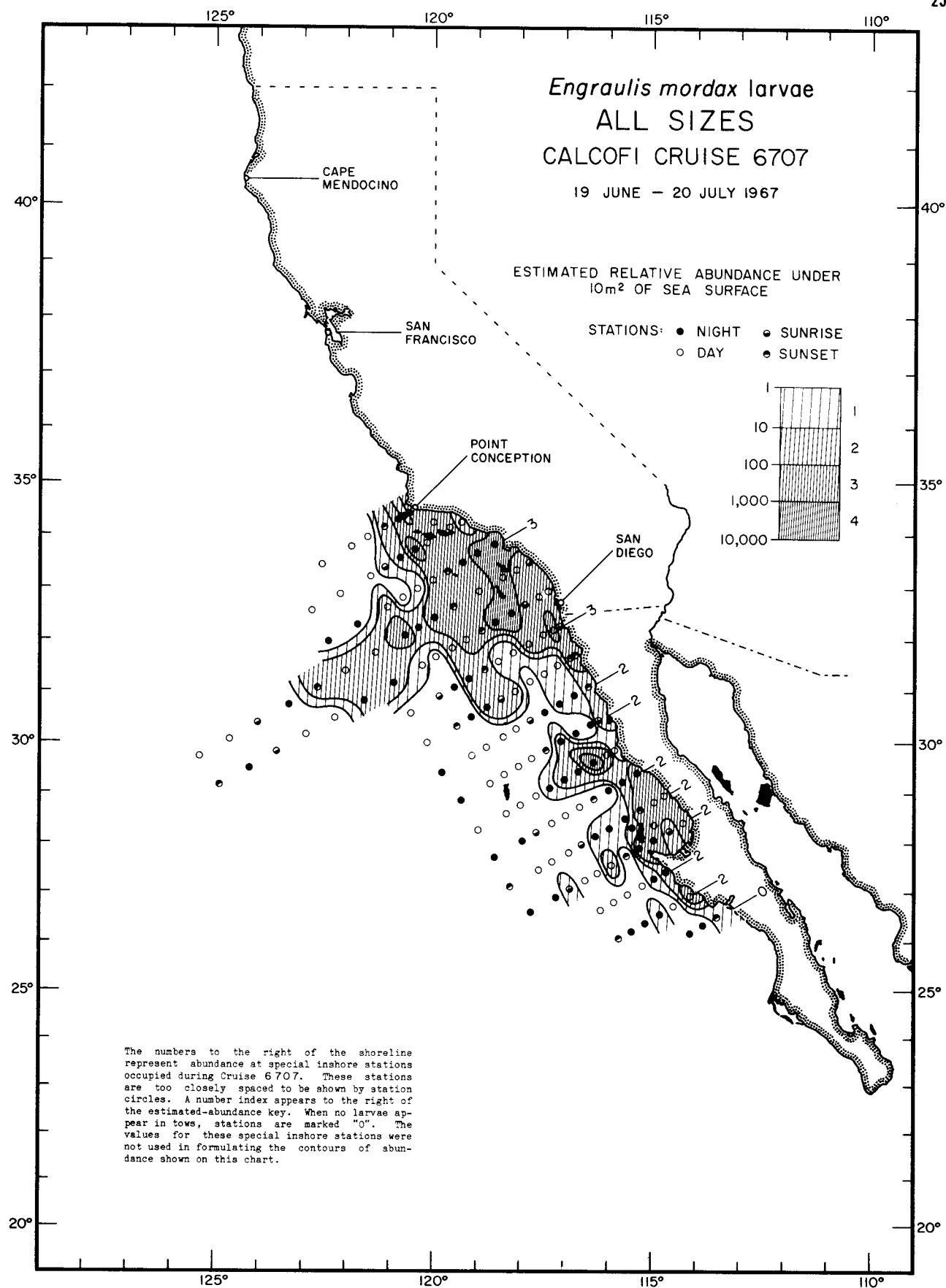
*Engraulis mordax* larvae

All Sizes

6612

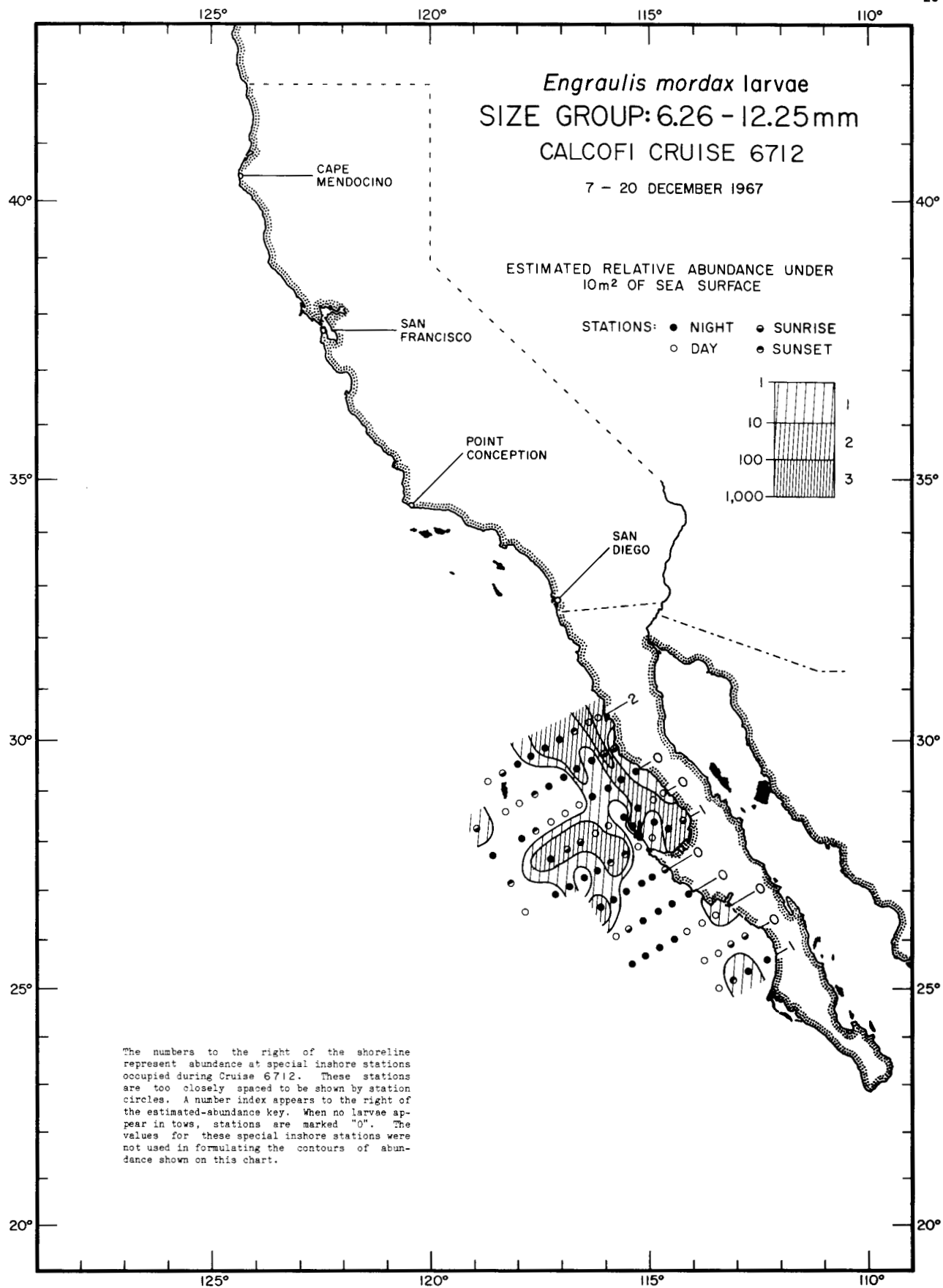


Engraulis mordax larvae
Size Group: 6.26-12.25mm
6707

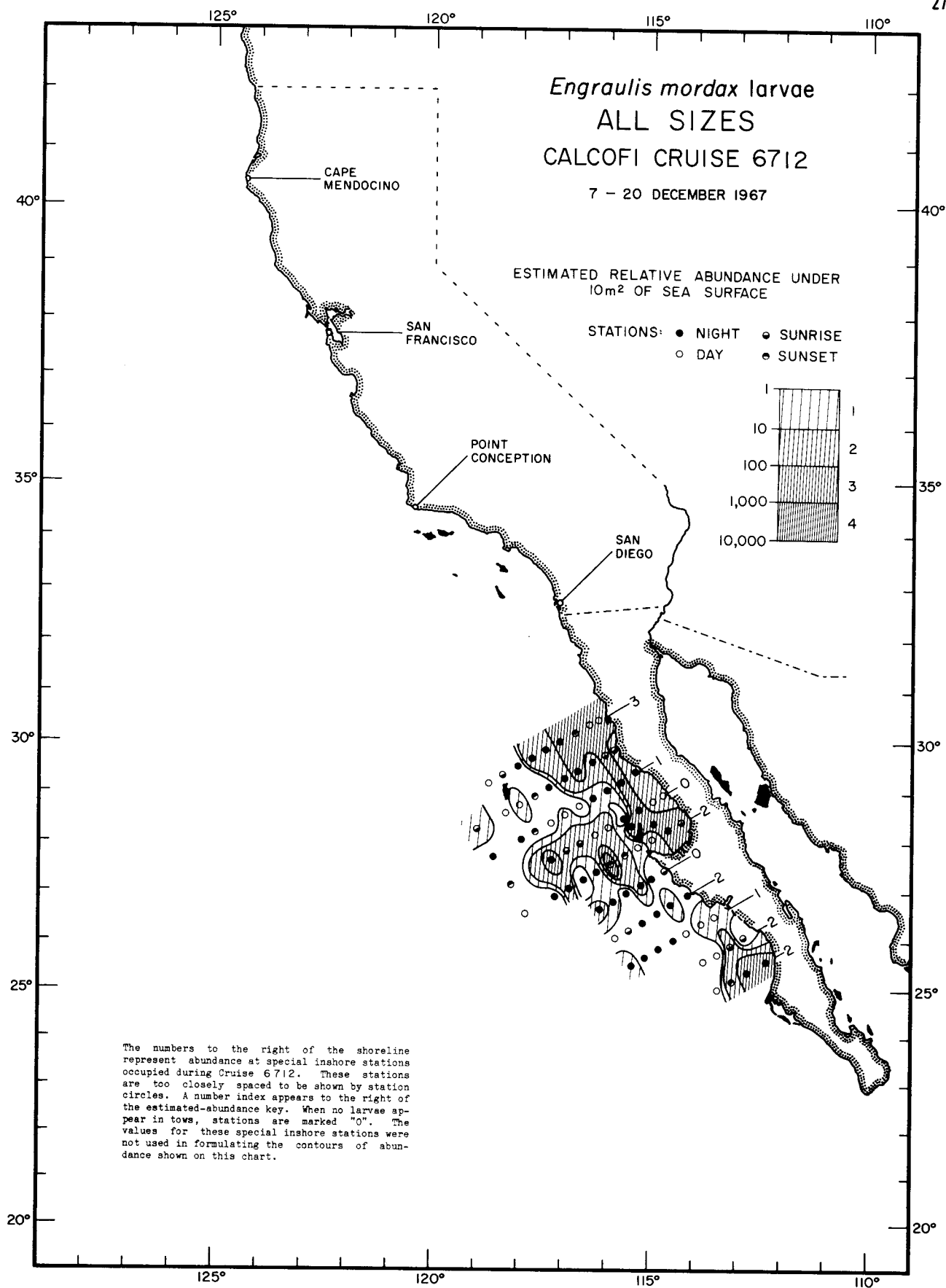
*Engraulis mordax* larvae

All Sizes

6707

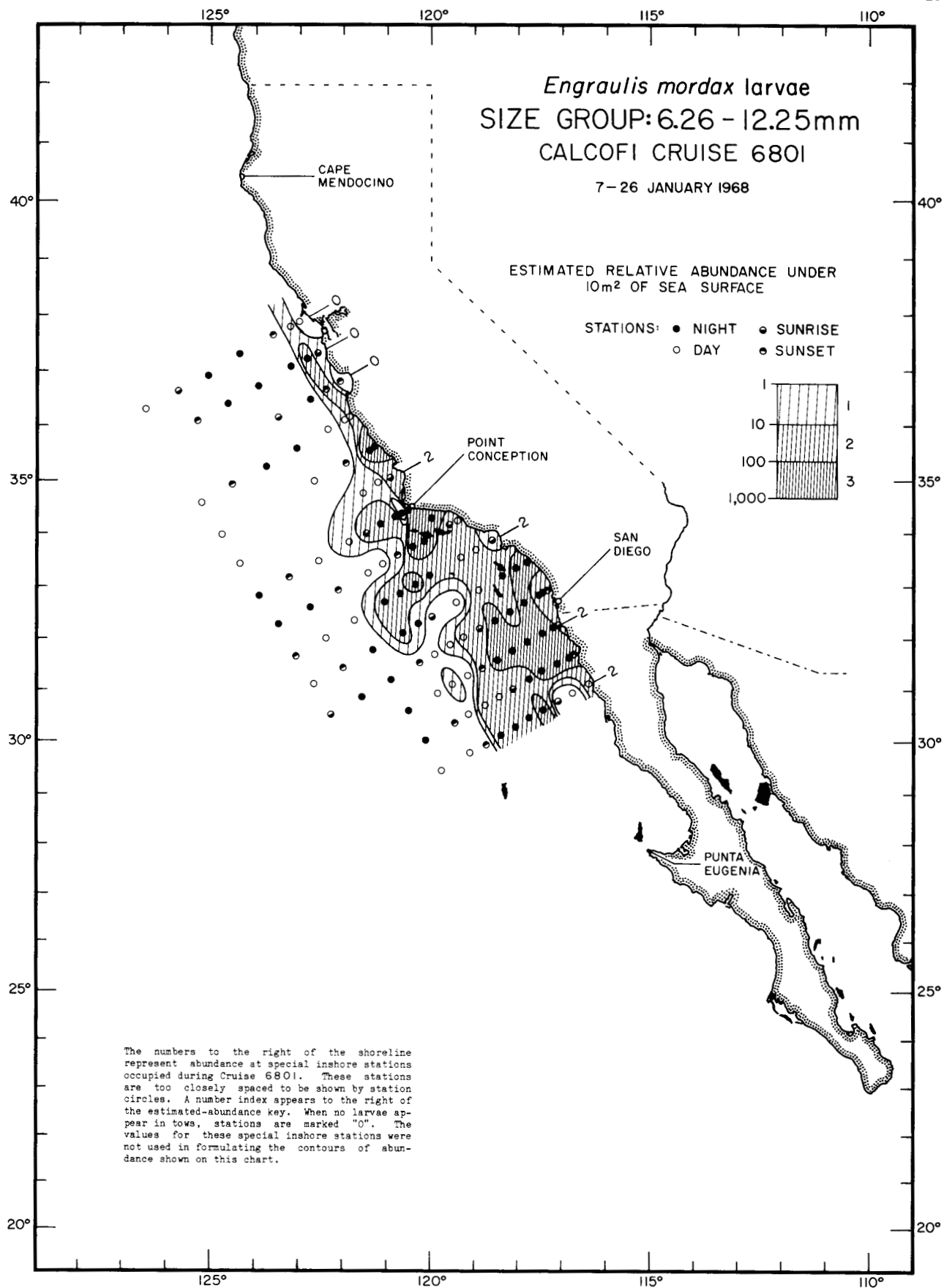


Engraulis mordax larvae
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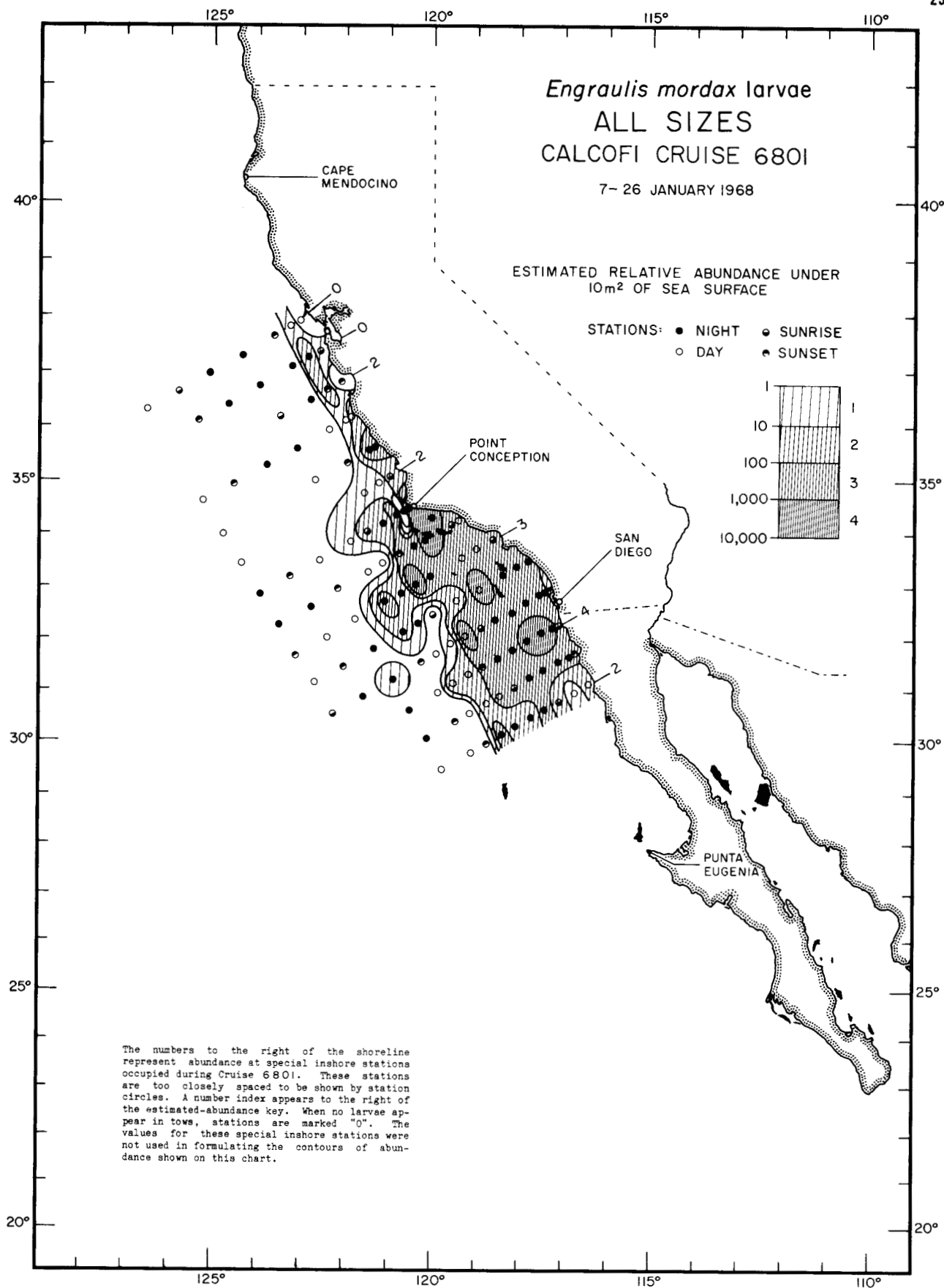
*Engraulis mordax* larvae

All Sizes

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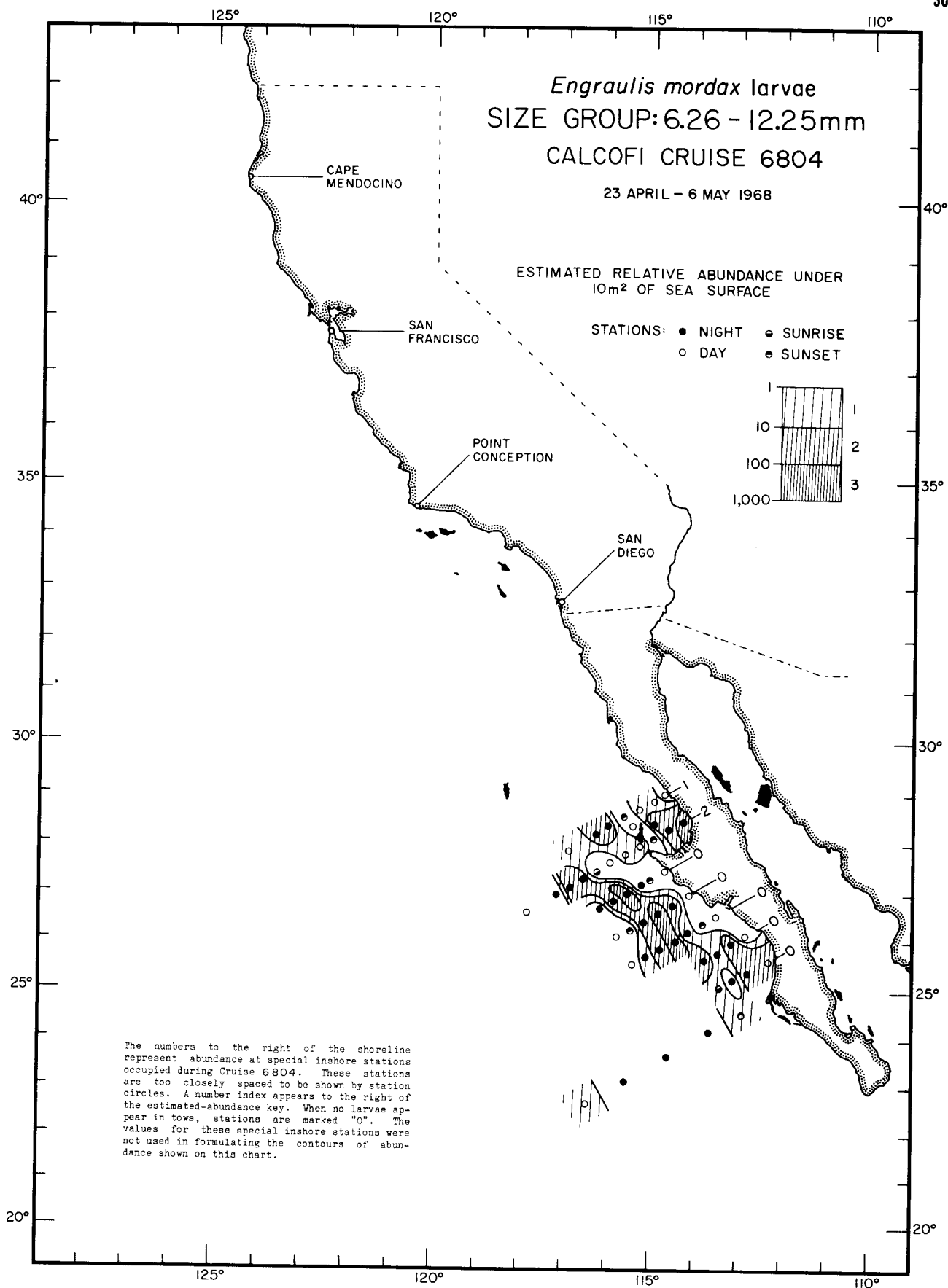


Engraulis mordax larvae
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6801

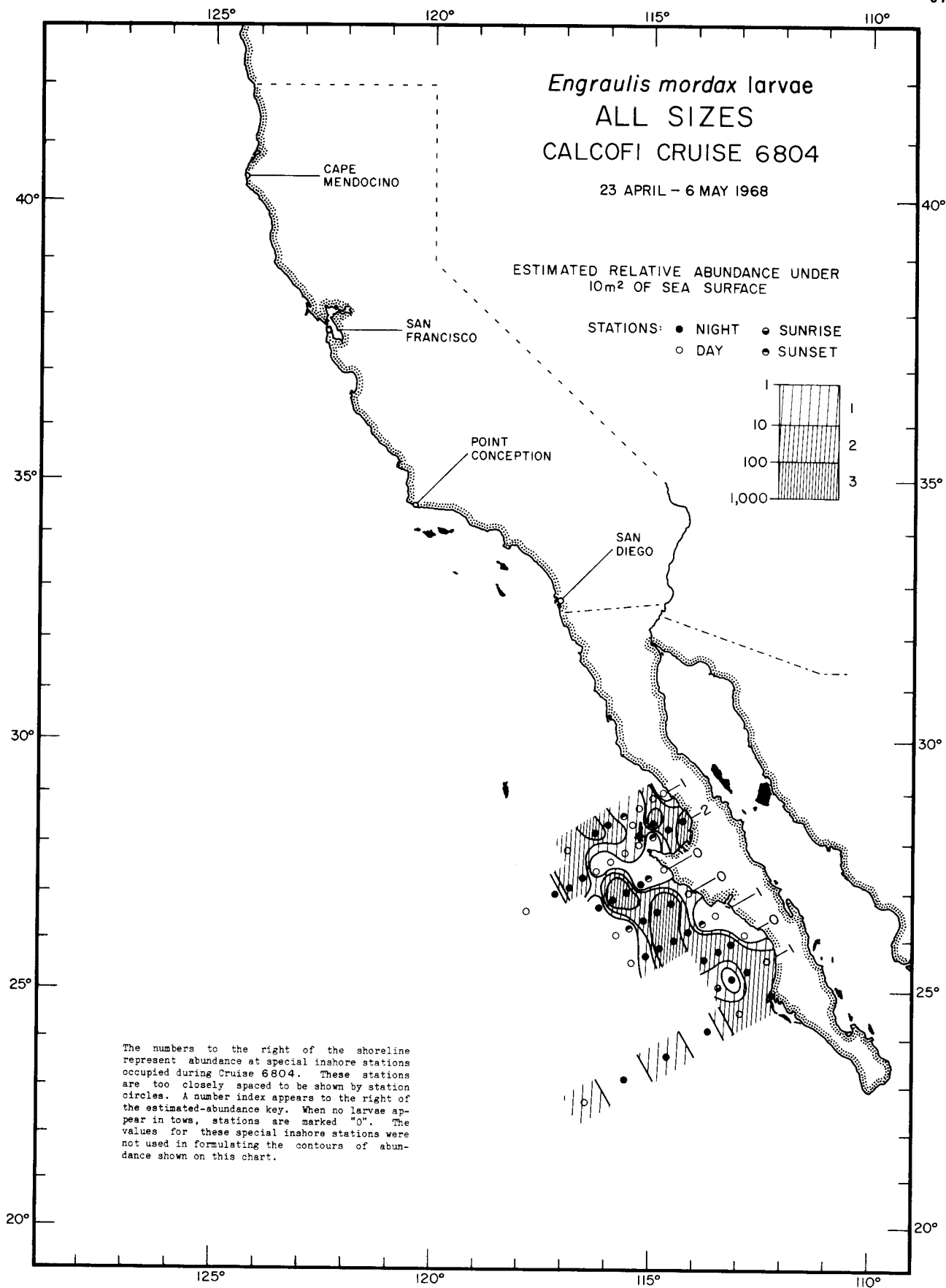
*Engraulis mordax* larvae

All Sizes

6801

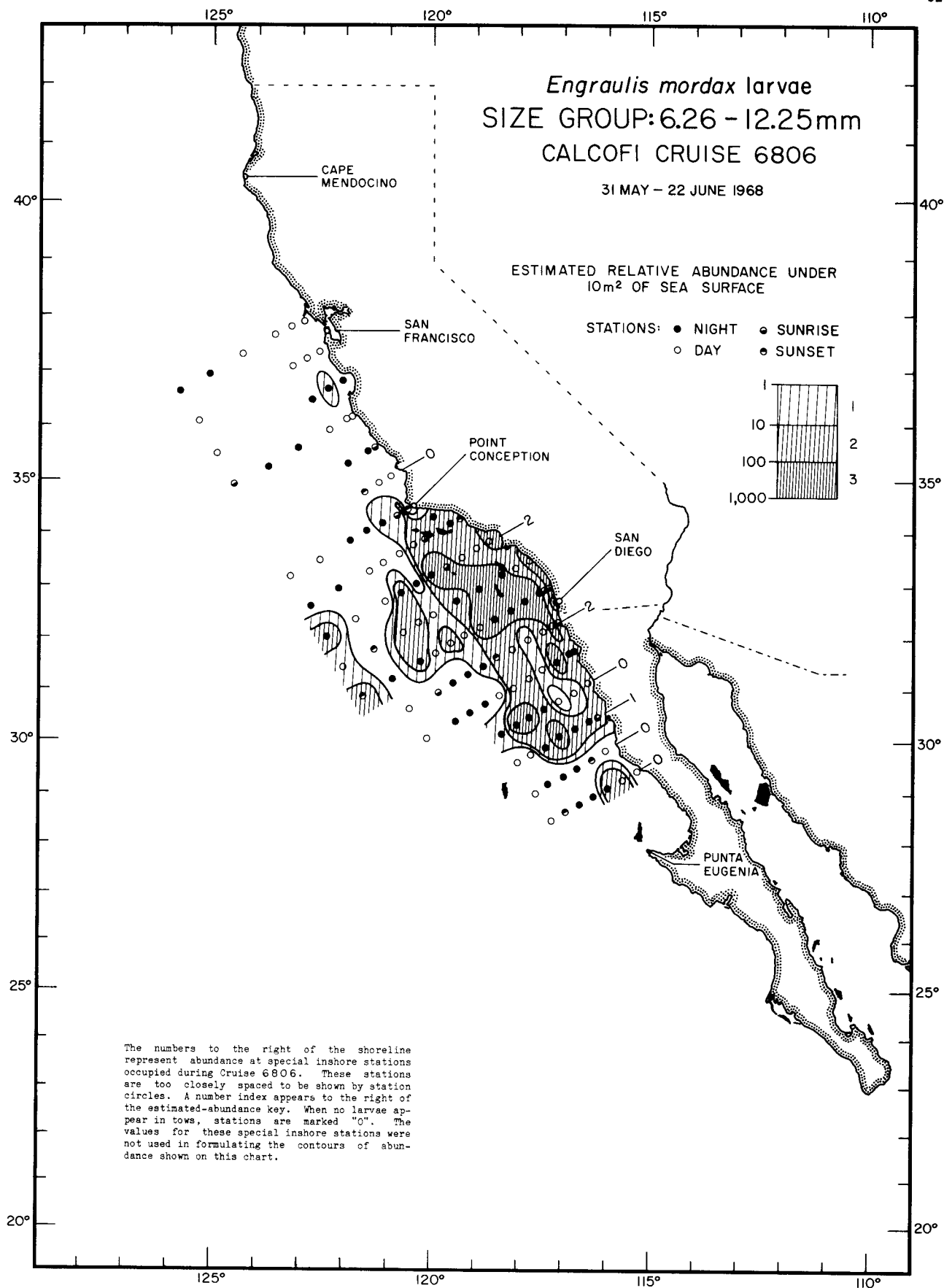


Engraulis mordax larvae
Size Group: 6.26-12.25mm
6804

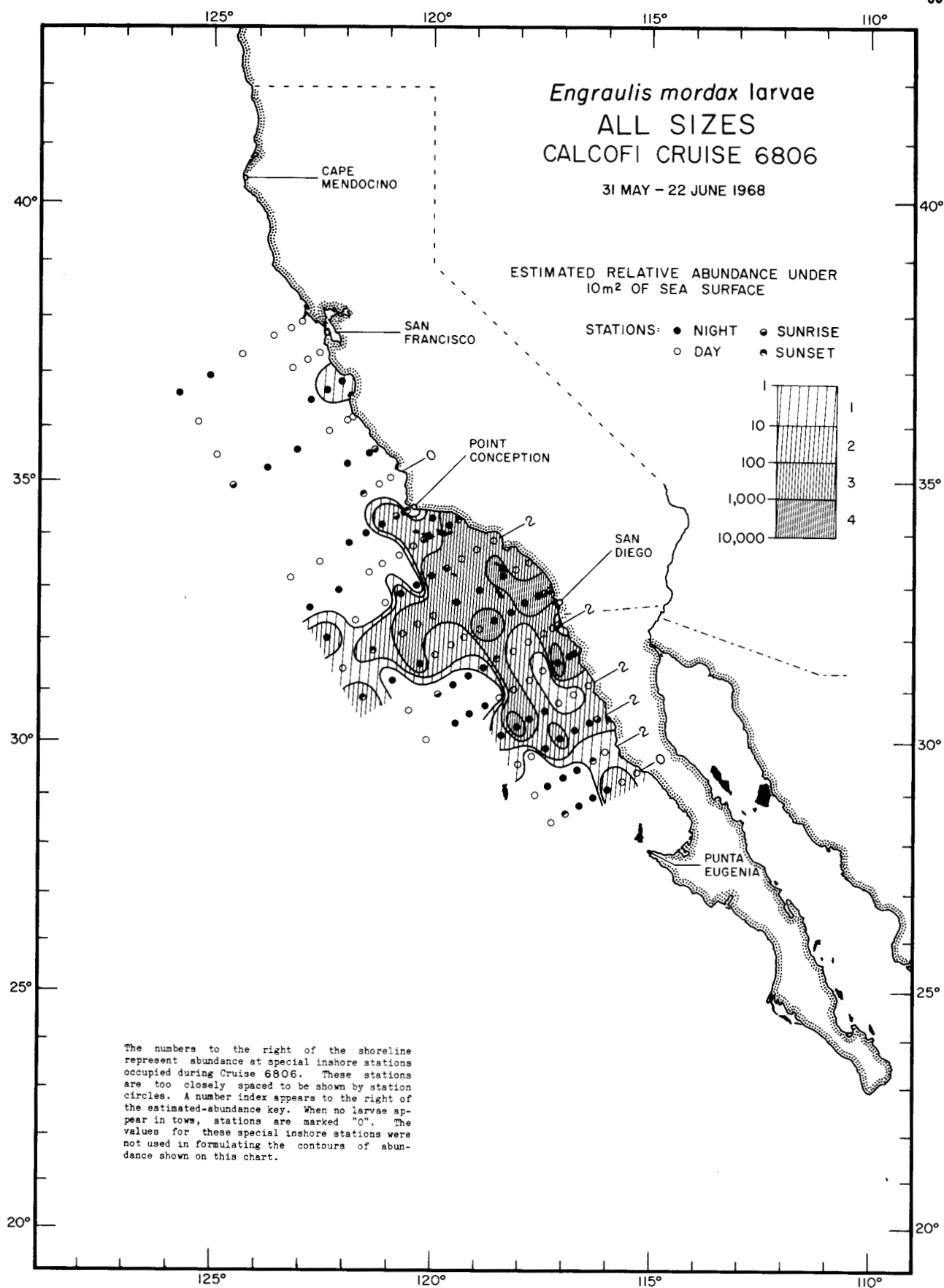
*Engraulis mordax* larvae

All Sizes

6804

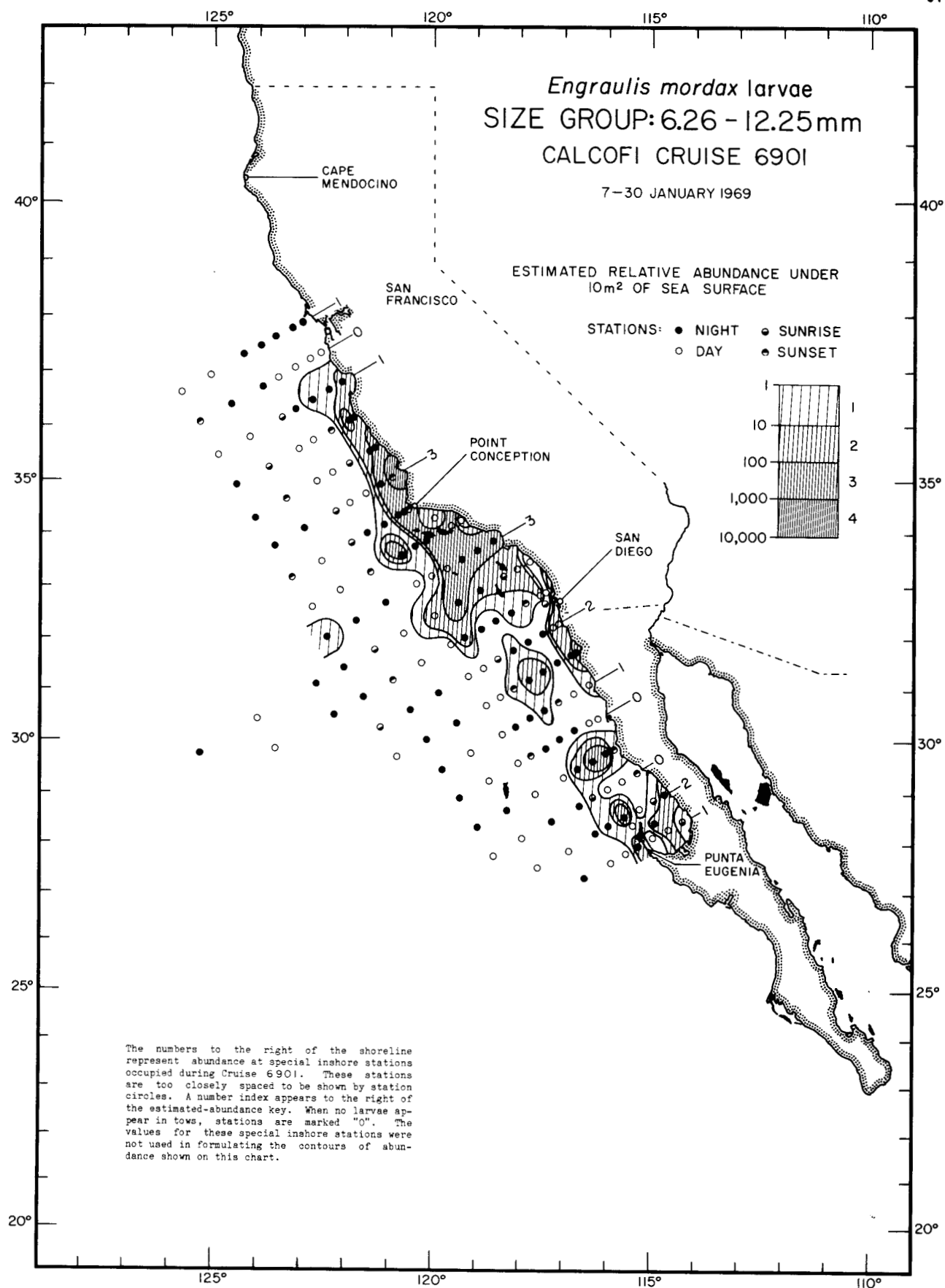


Engraulis mordax larvae
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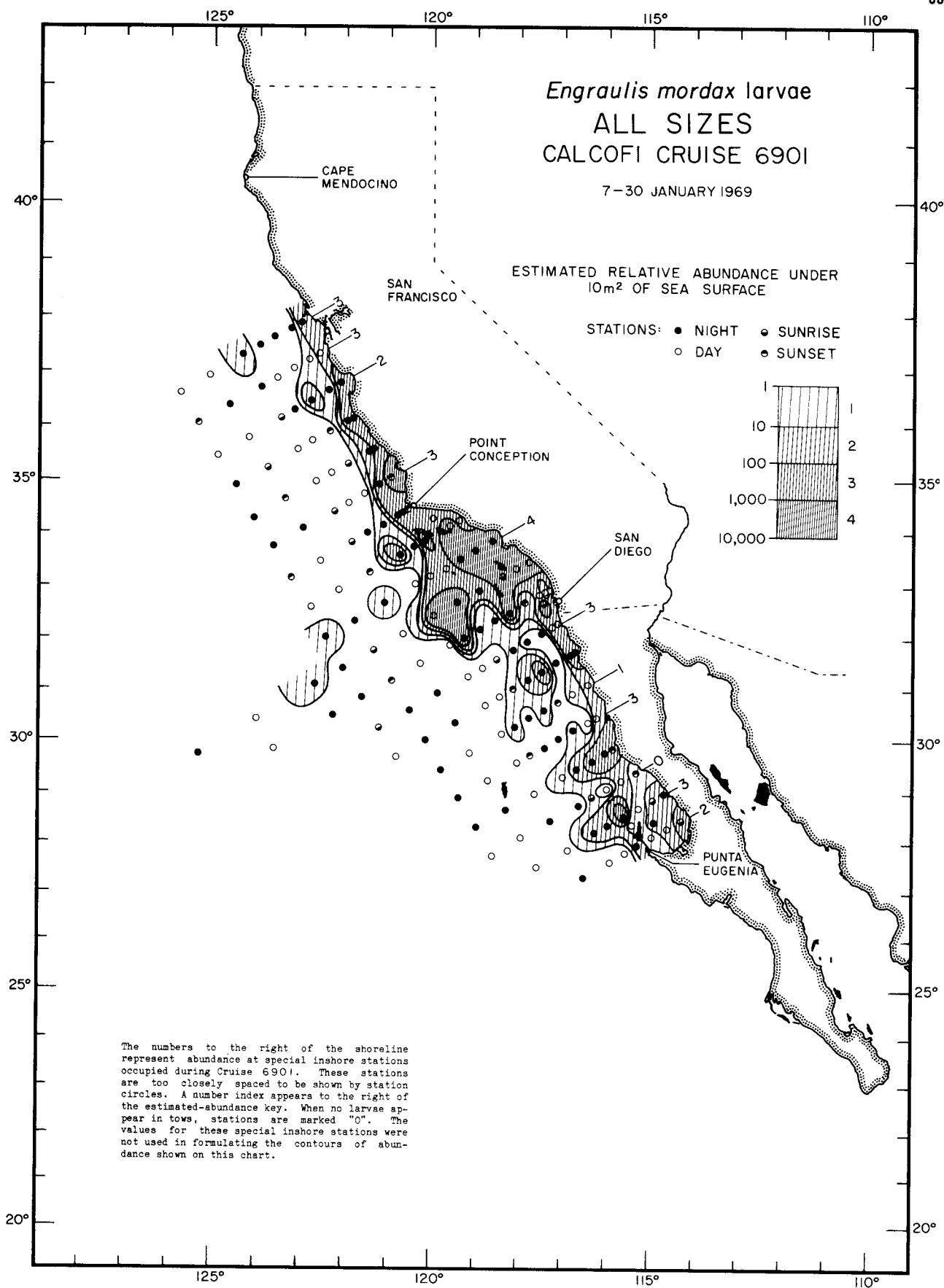
*Engraulis mordax* larvae

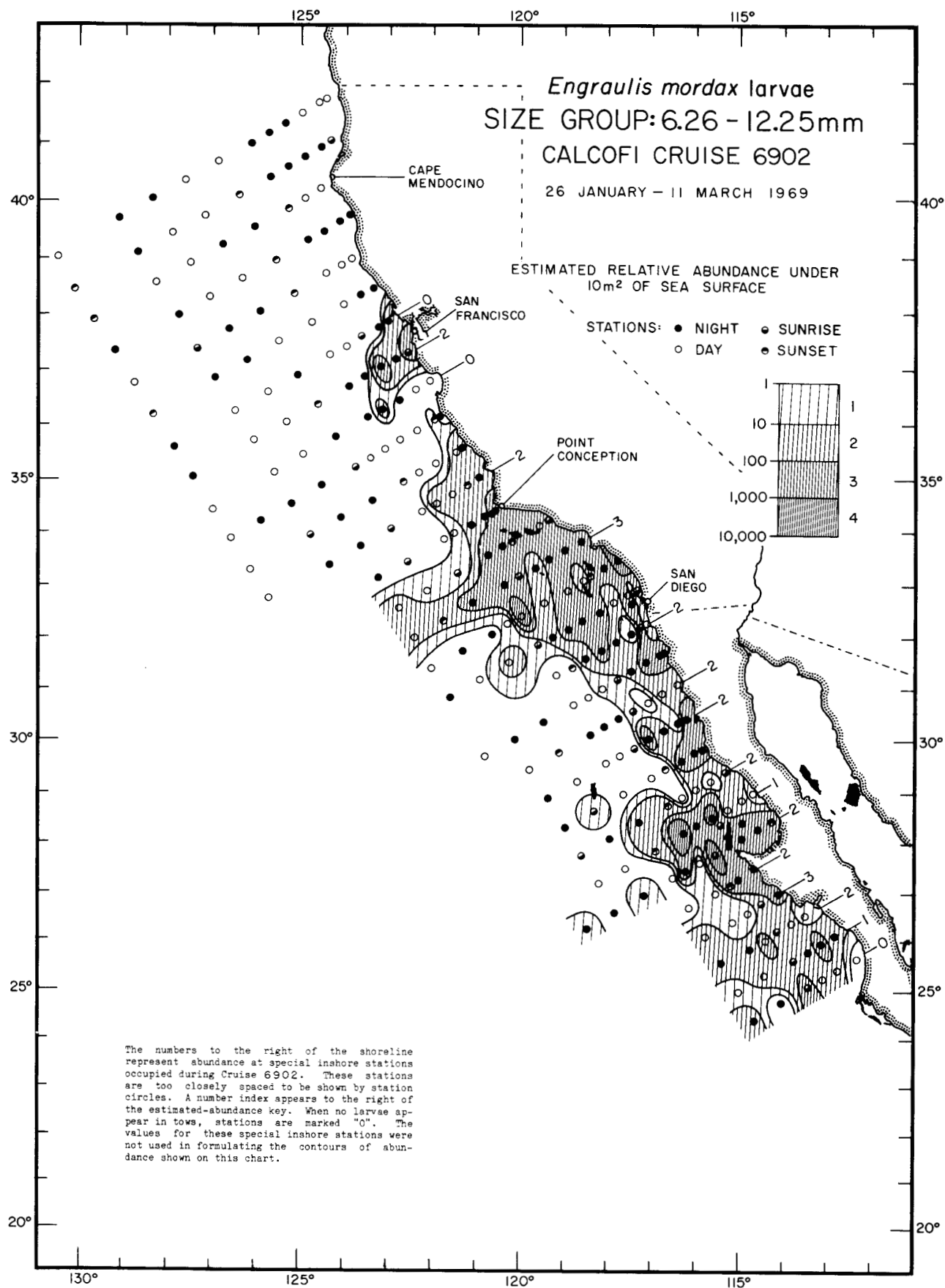
All Sizes

6806

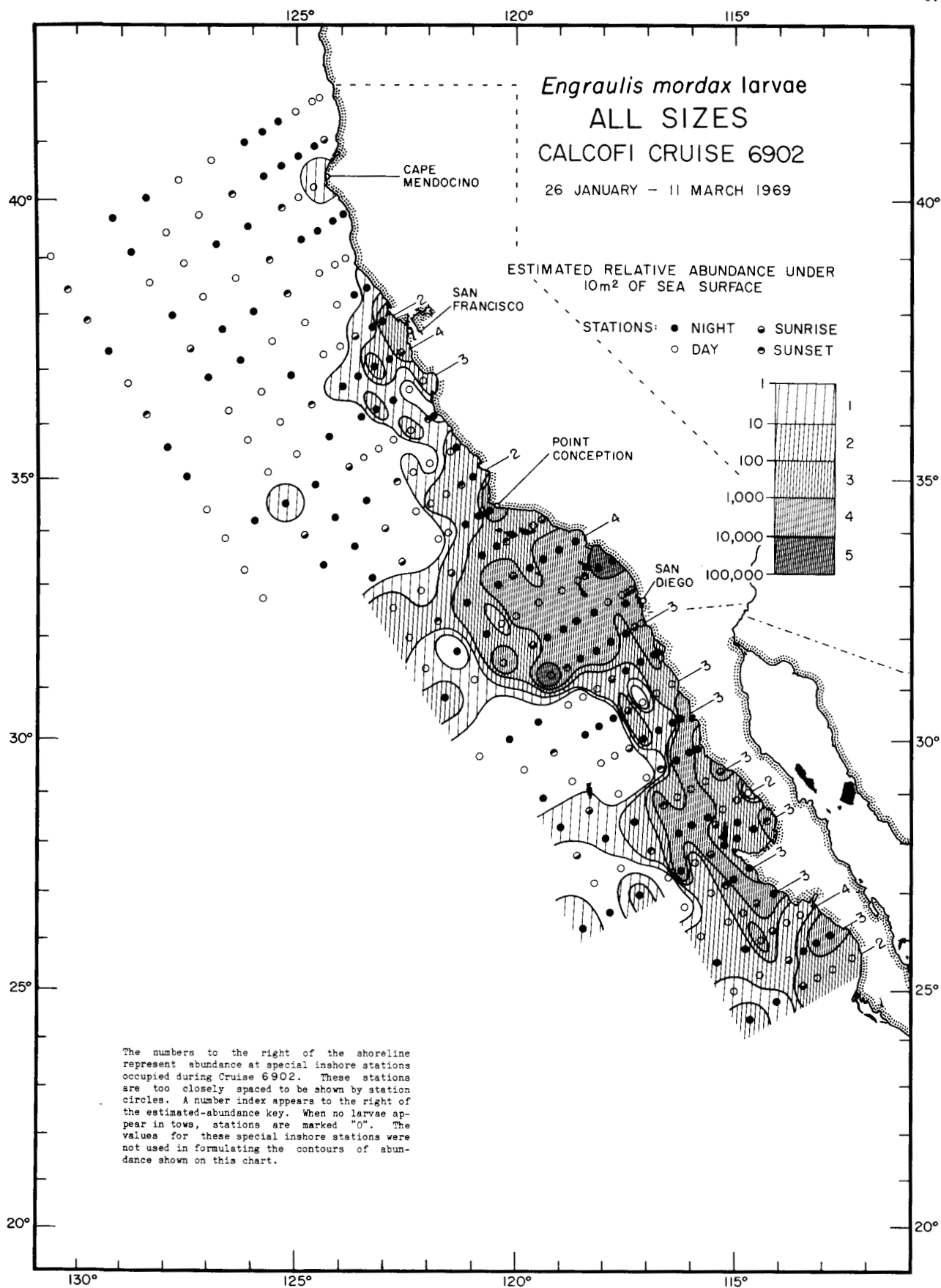


Engraulis mordax larvae
Size Group: 6.26-12.25mm
6901

*Engraulis mordax* larvaeAll Sizes
6901

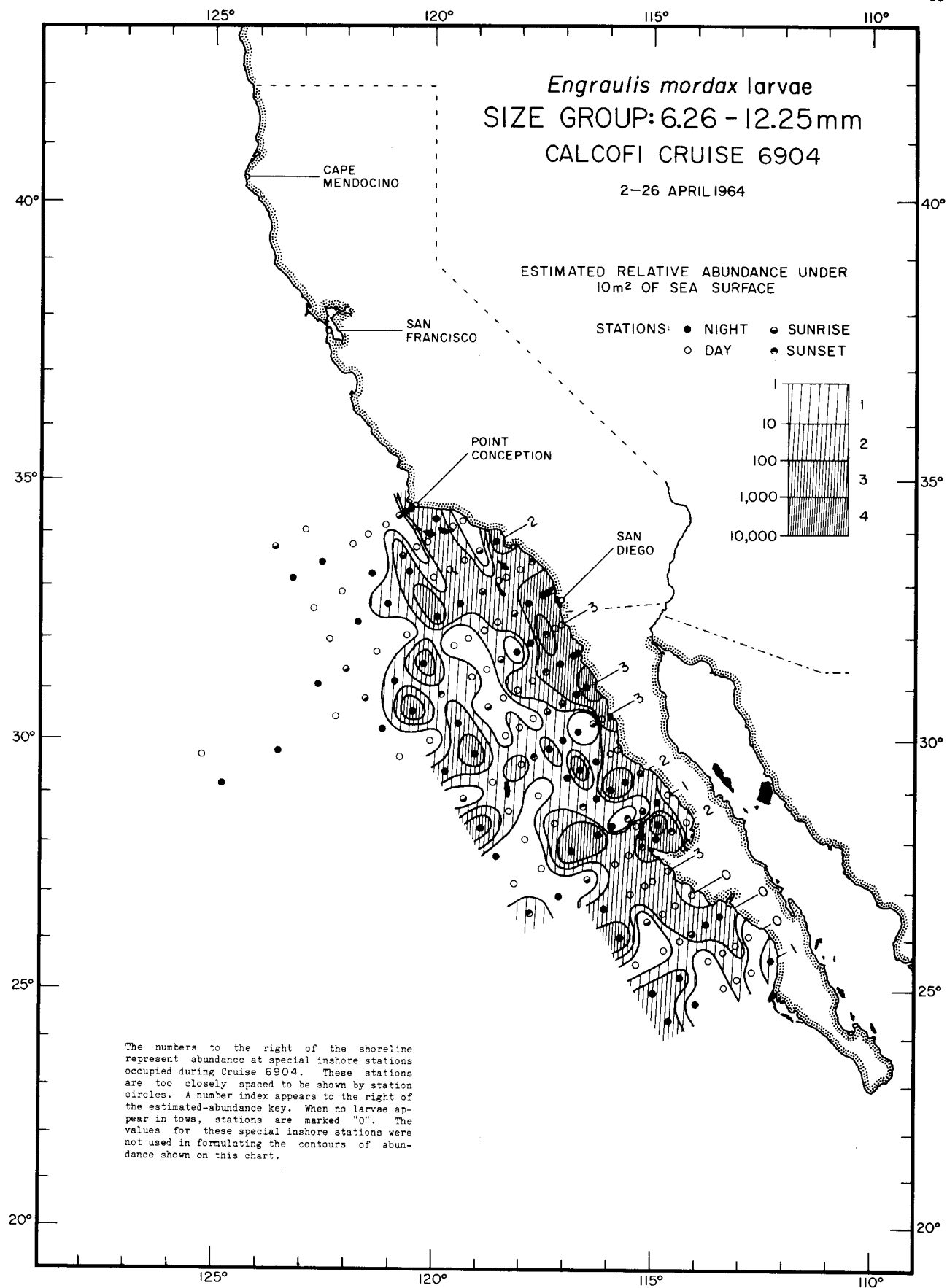


Engraulis mordax larvae
Size Group: 6.26-12.25mm
6902

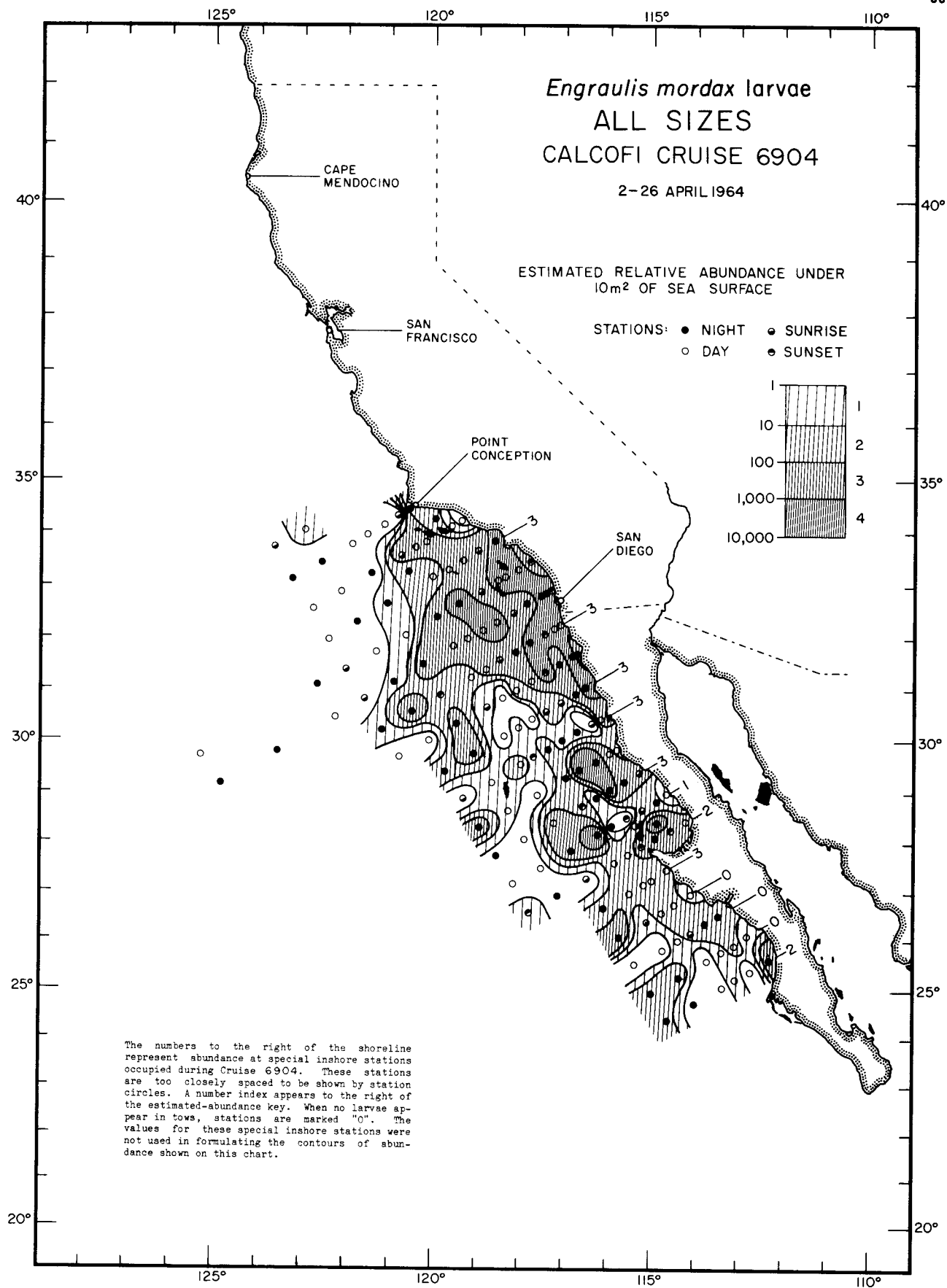
*Engraulis mordax* larvae

All Sizes

6902

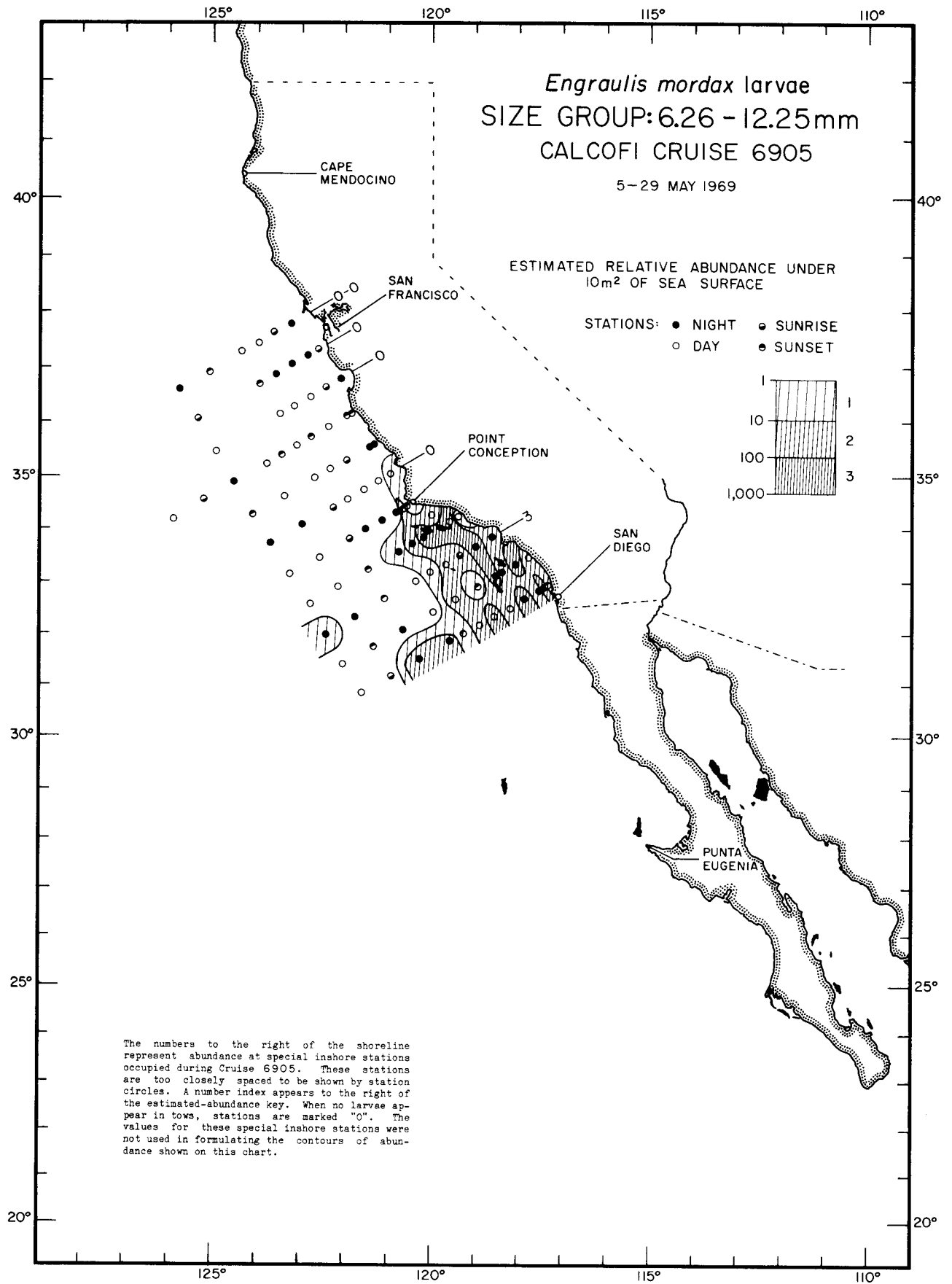


Engraulis mordax larvae
Size Group: 6.26-12.25mm
6904

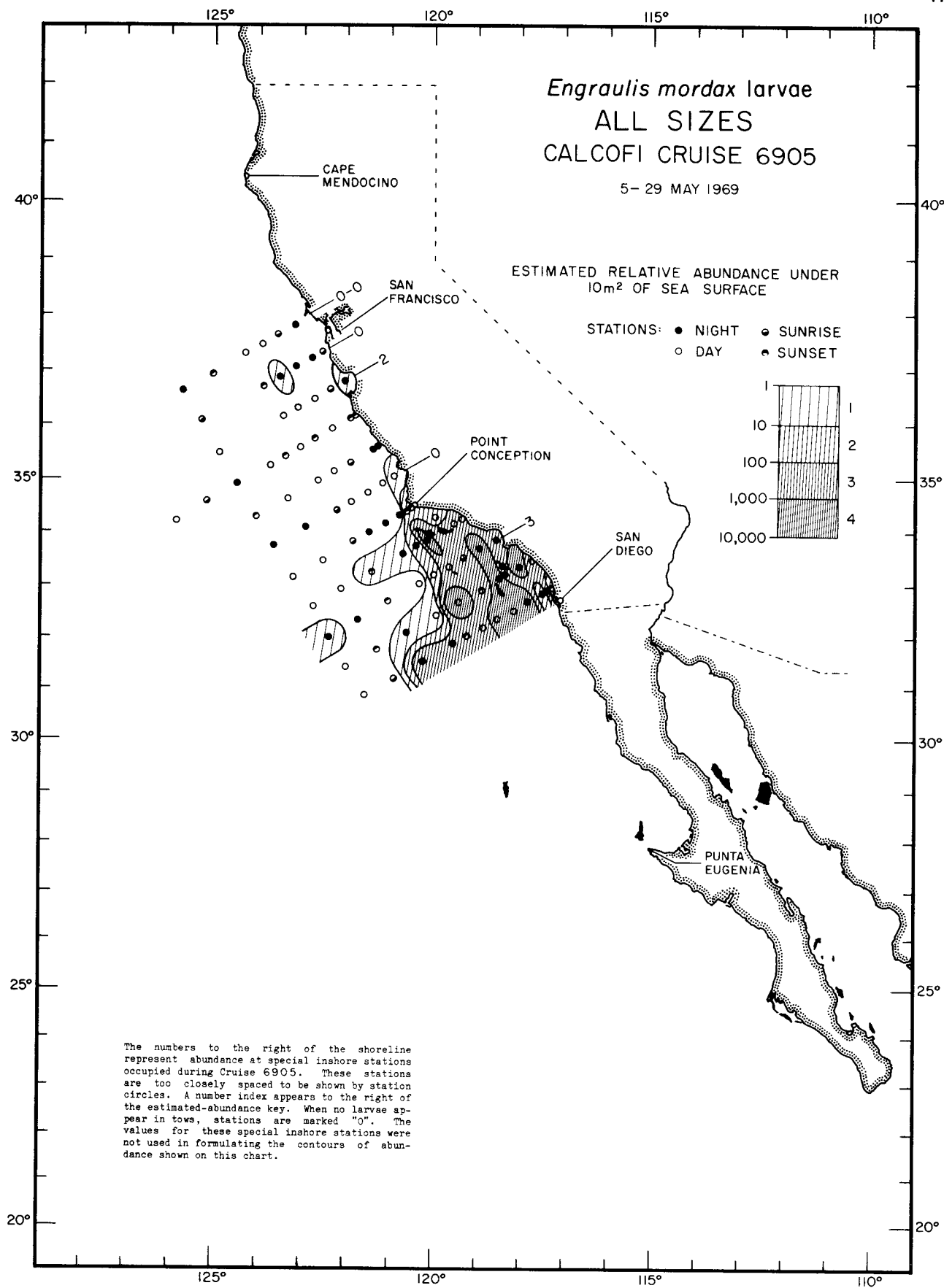
*Engraulis mordax* larvae

All Sizes

6904

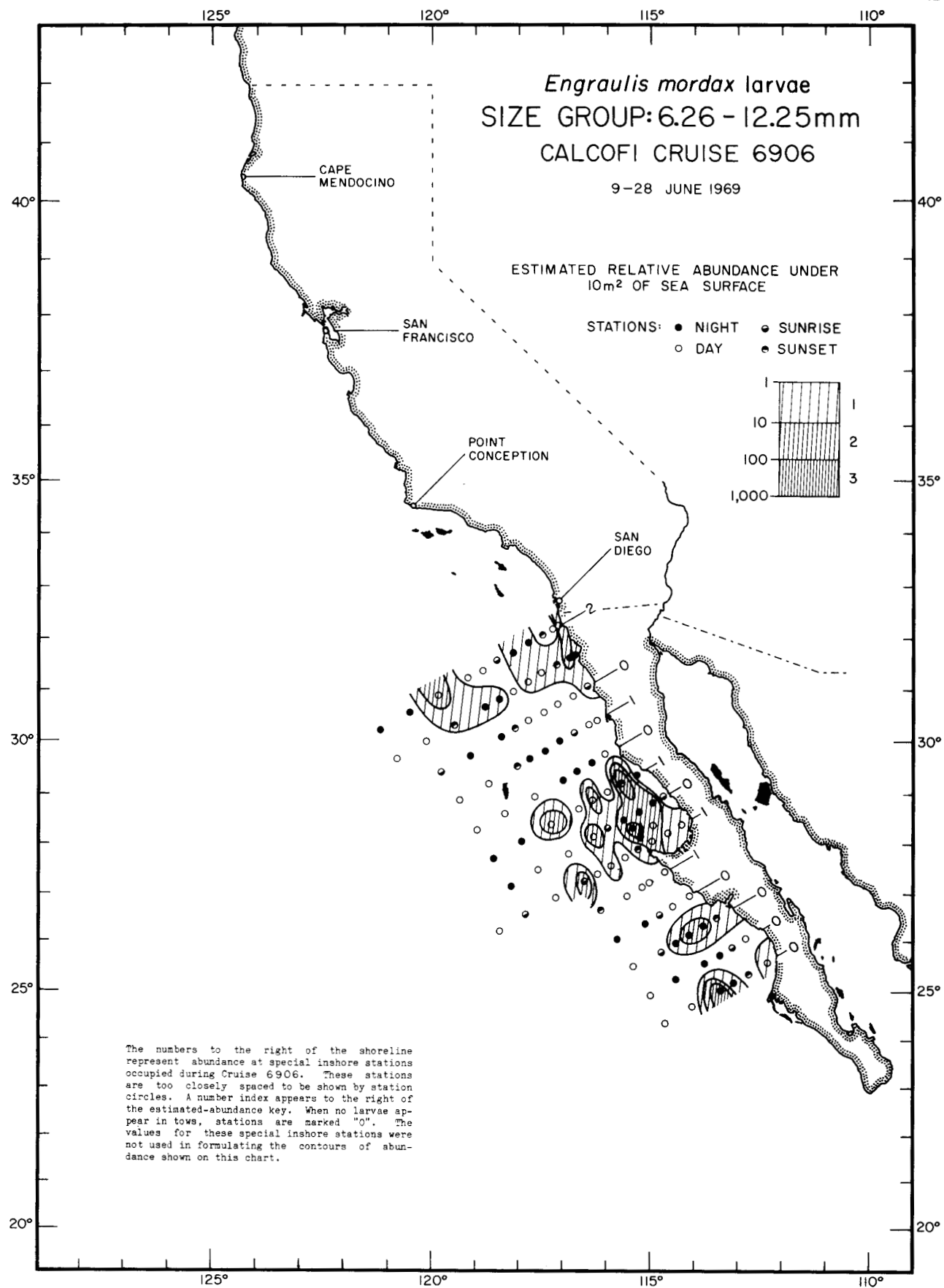


Engraulis mordax larvae
Size Group: 6.26-12.25mm
6905

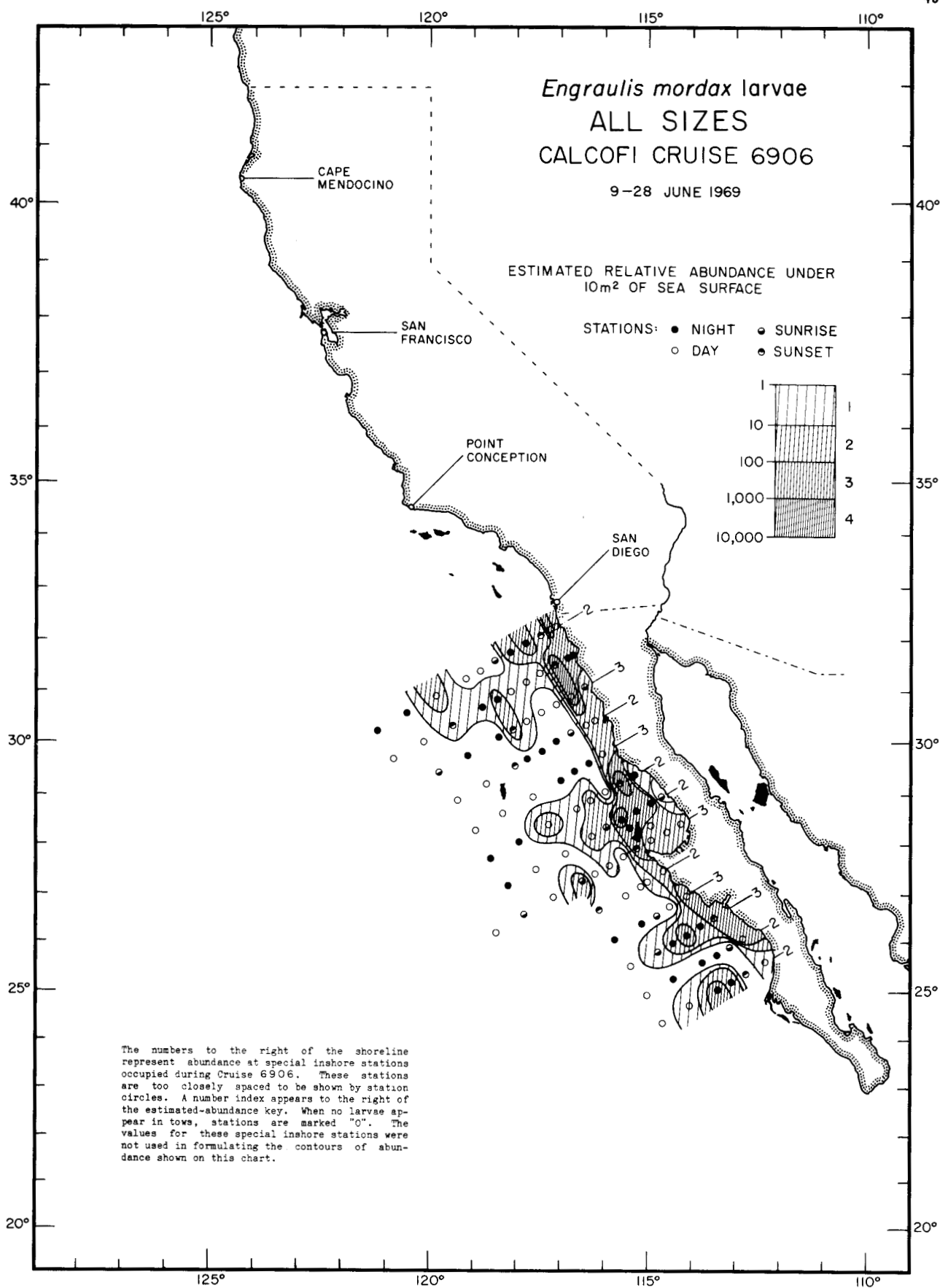
*Engraulis mordax* larvae

All Sizes

6905

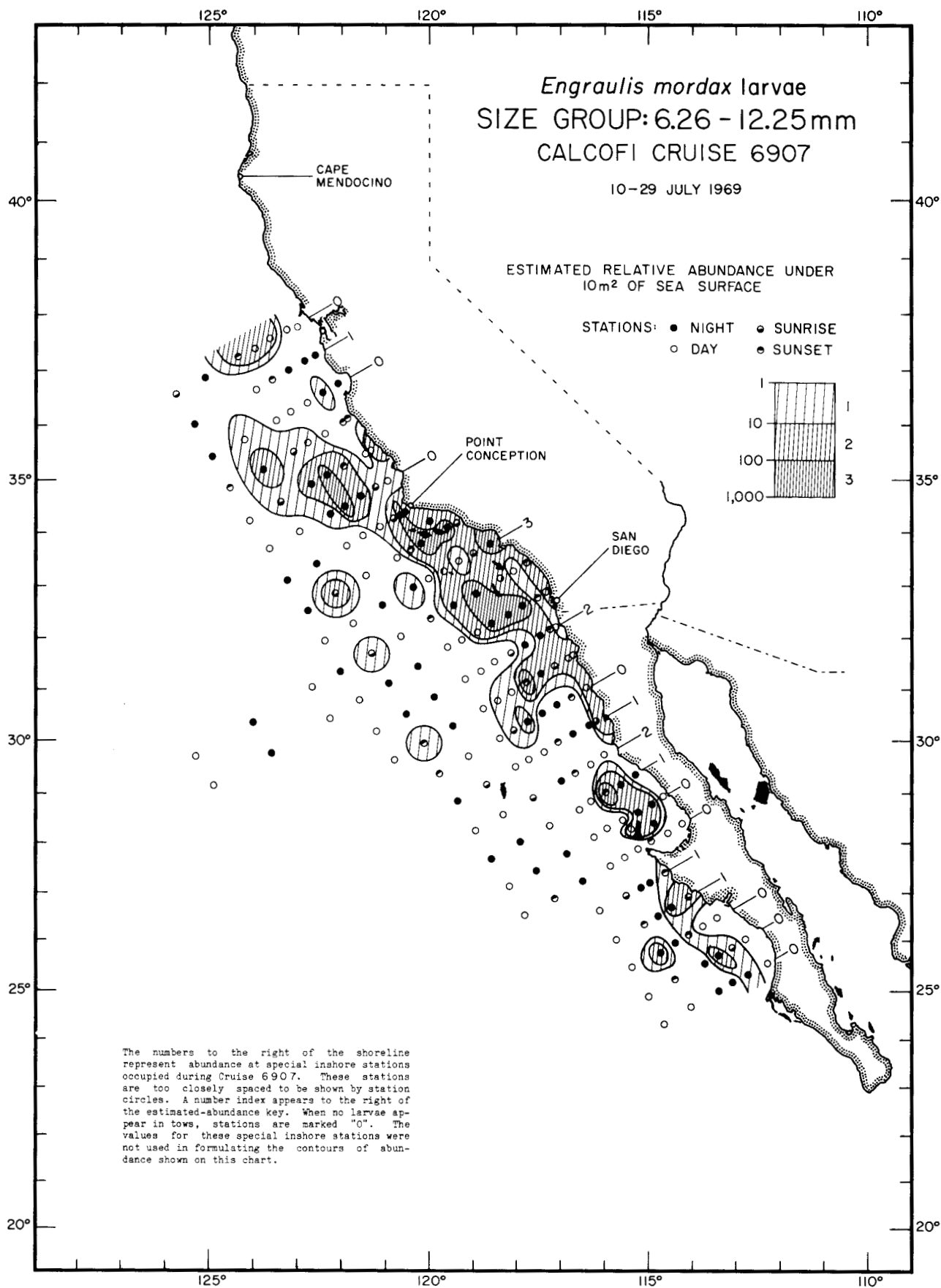


Engraulis mordax larvae
Size Group: 6.26-12.25mm
6906

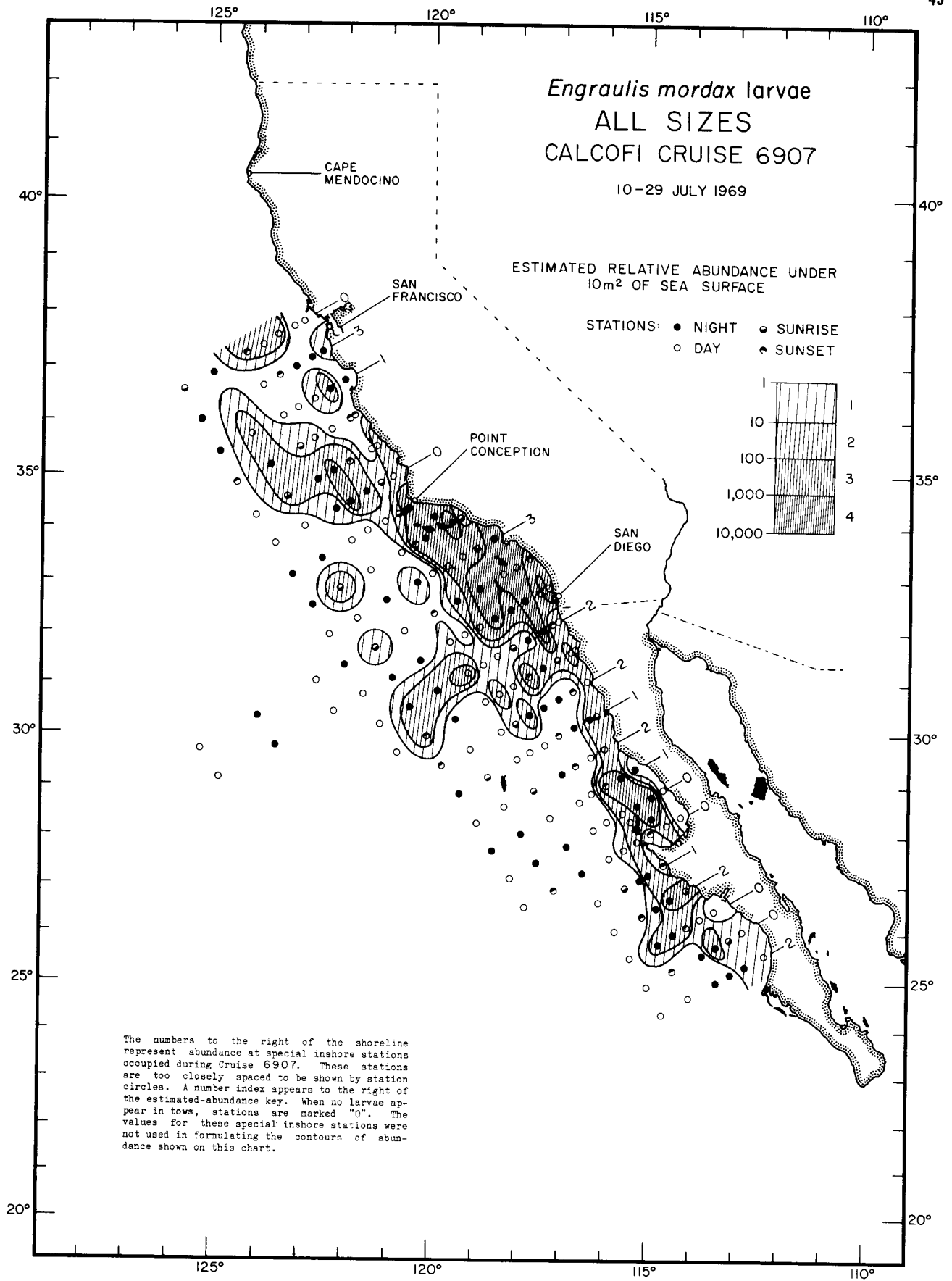
*Engraulis mordax* larvae

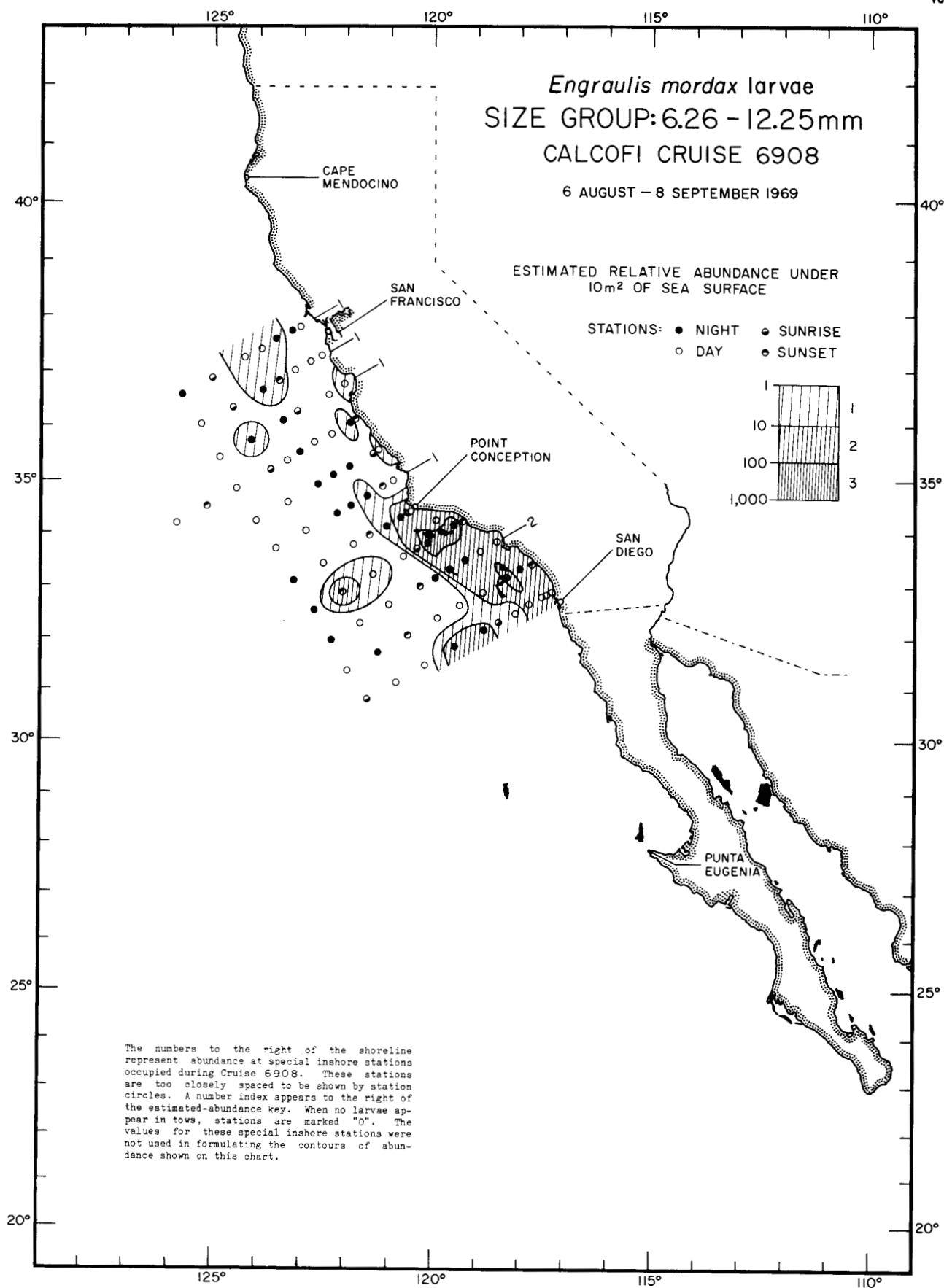
All Sizes

6906

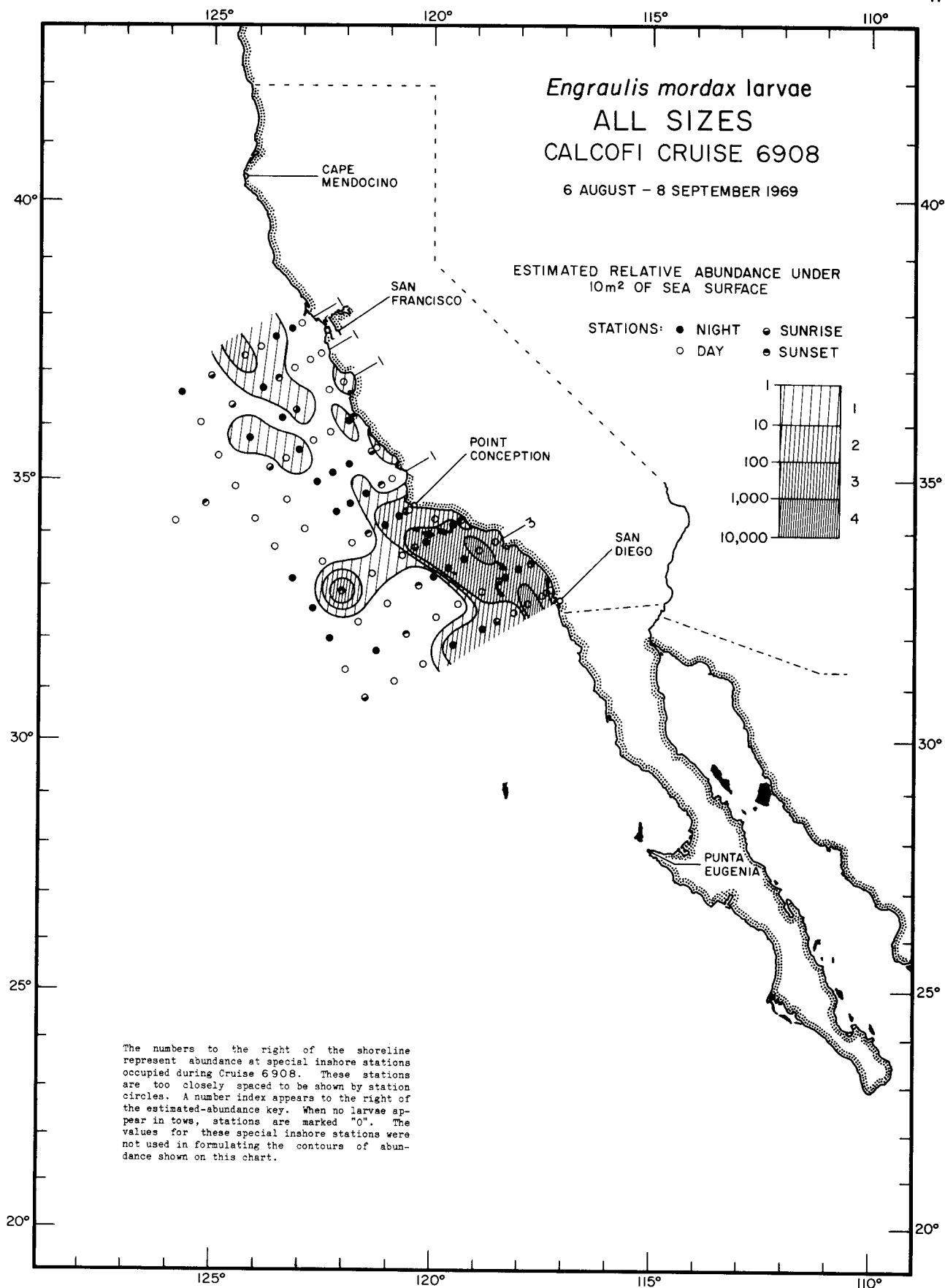


Engraulis mordax larvae
Size Group: 6.26-12.25mm
6907

*Engraulis mordax* larvaeAll Sizes
6907

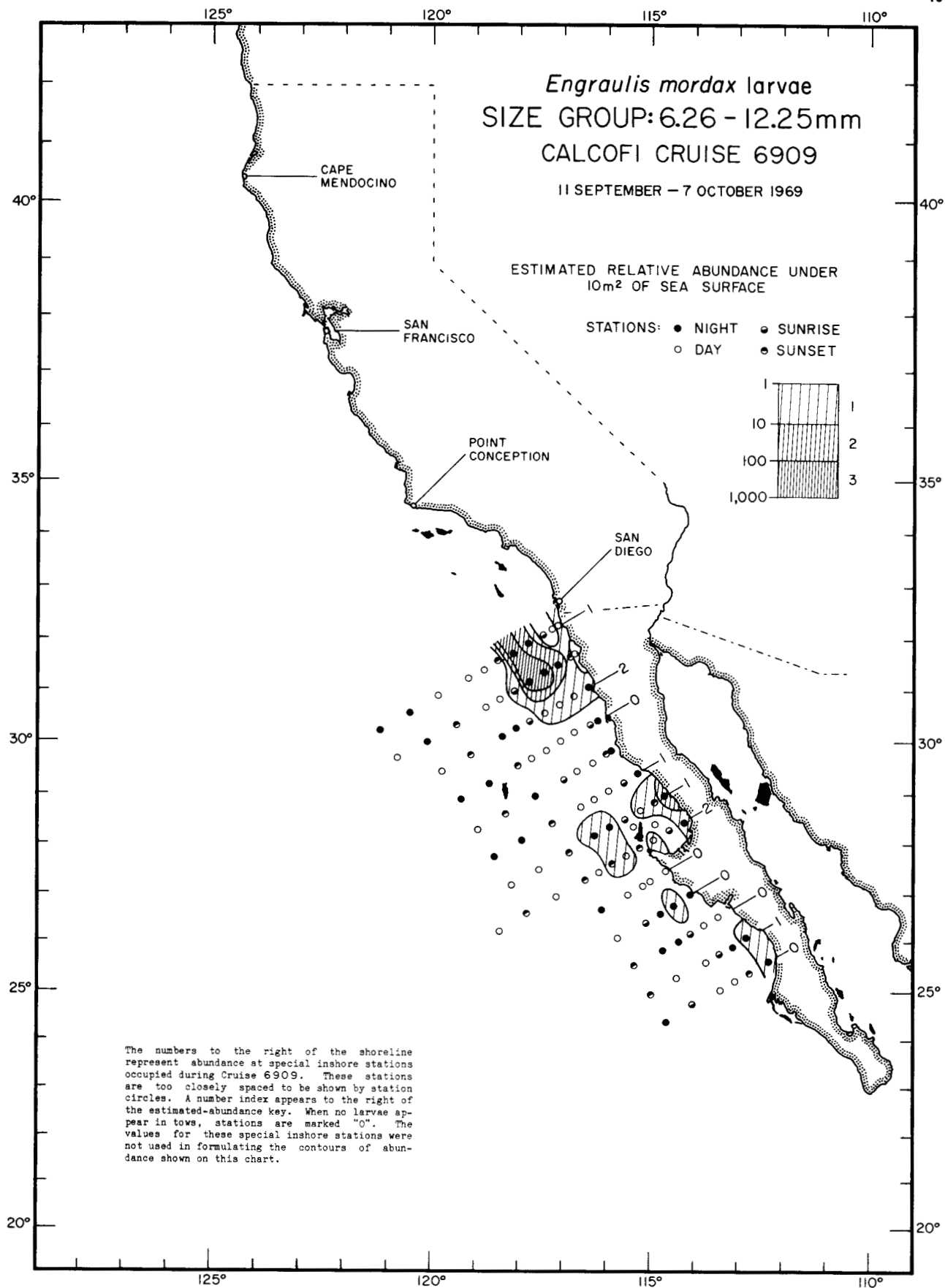


Engraulis mordax larvae
Size Group: 6.26-12.25mm
6908

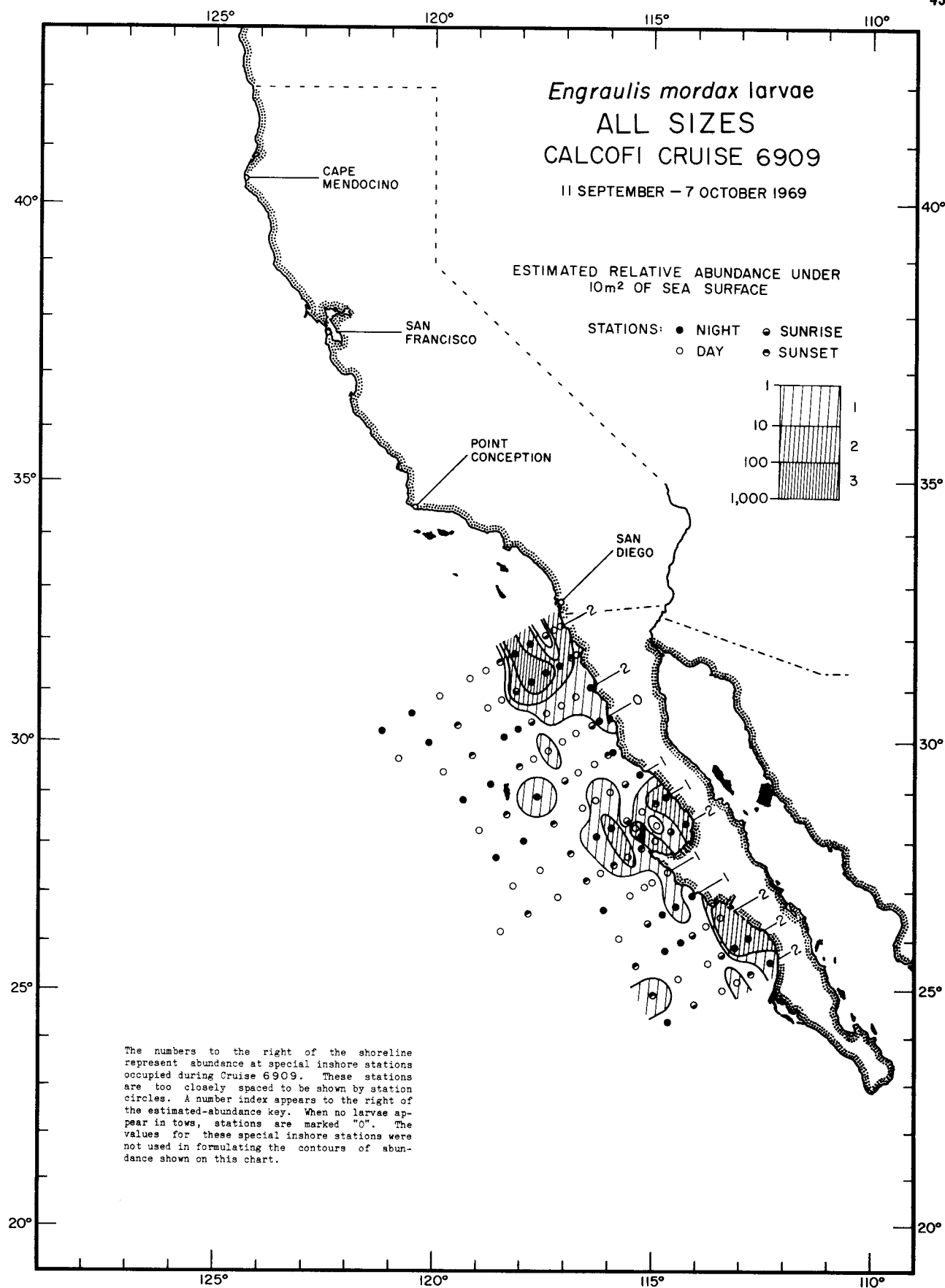
*Engraulis mordax* larvae

All Sizes

6908

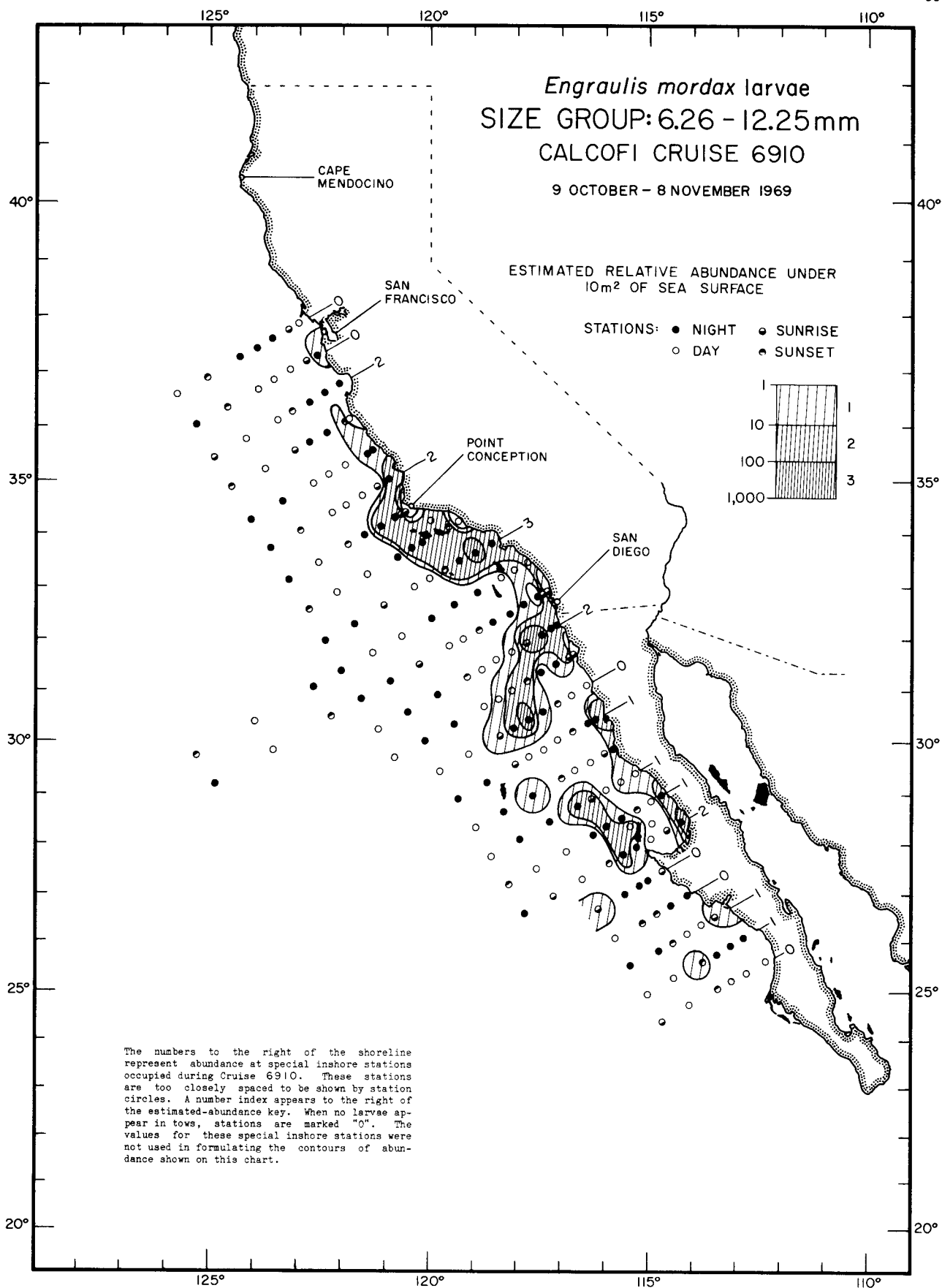


Engraulis mordax larvae
Size Group: 6.26-12.25mm
6909

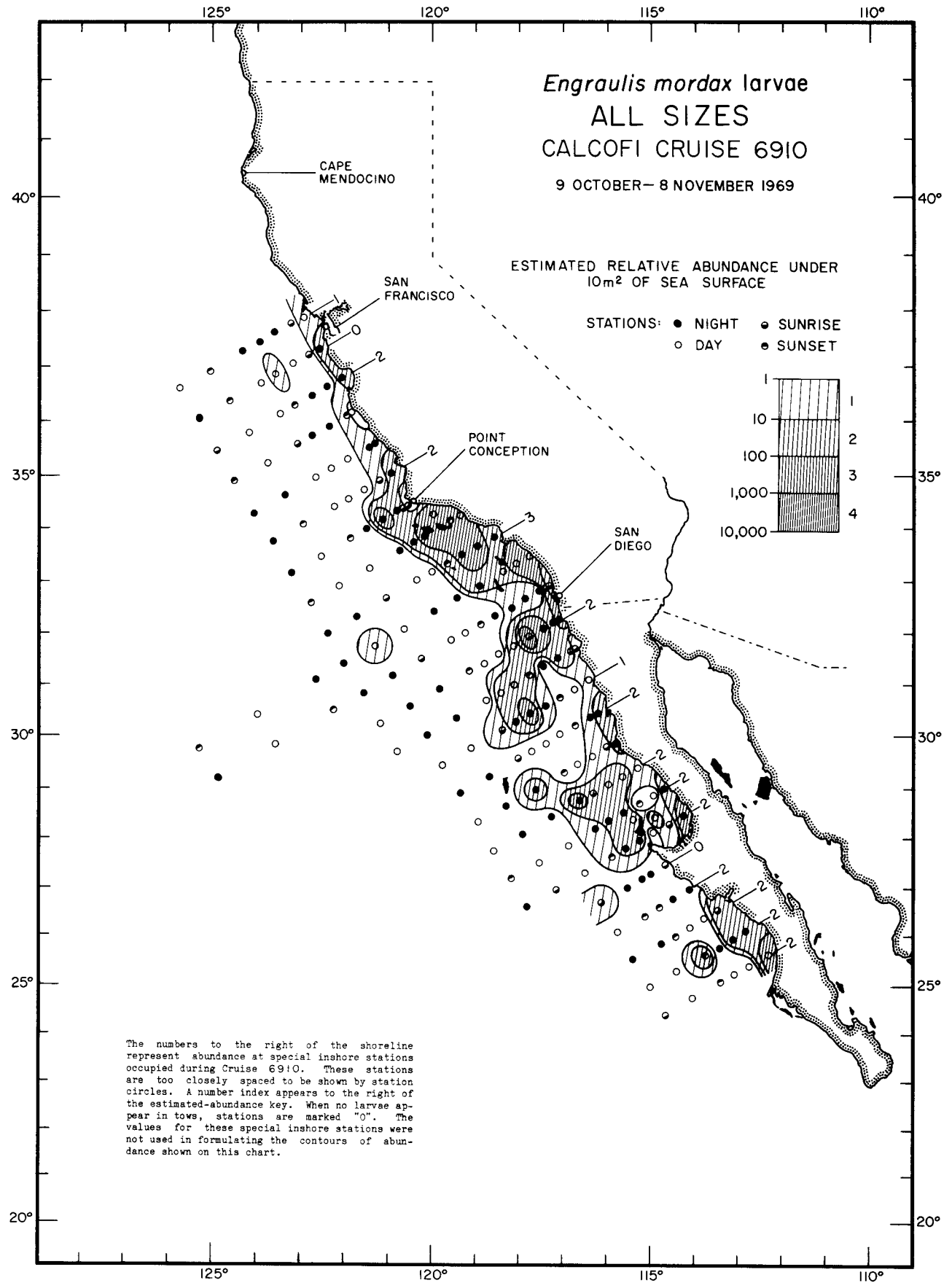
*Engraulis mordax* larvae

All Sizes

6909

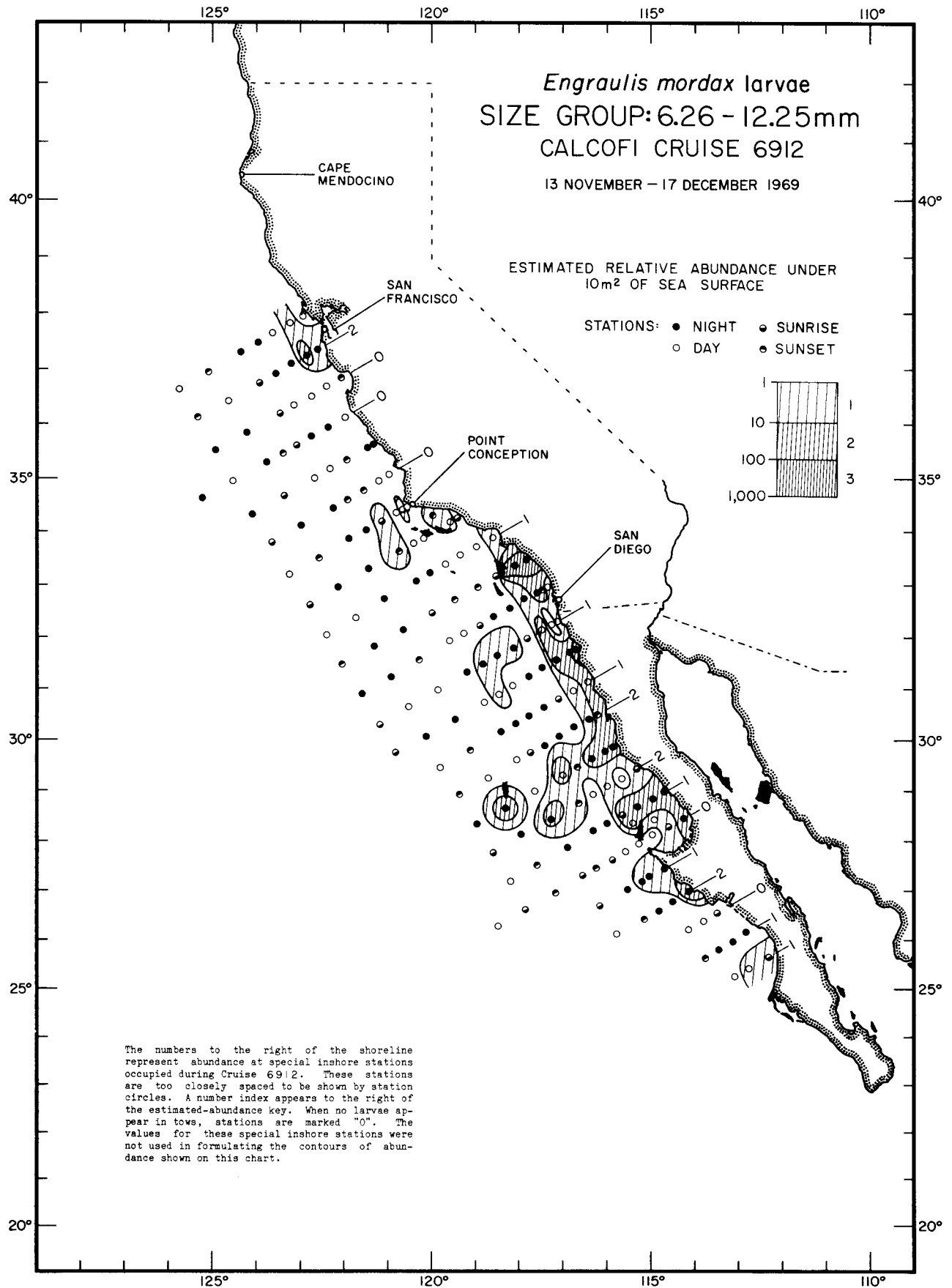


Engraulis mordax larvae
 Size Group: 6.26-12.25mm
 6910

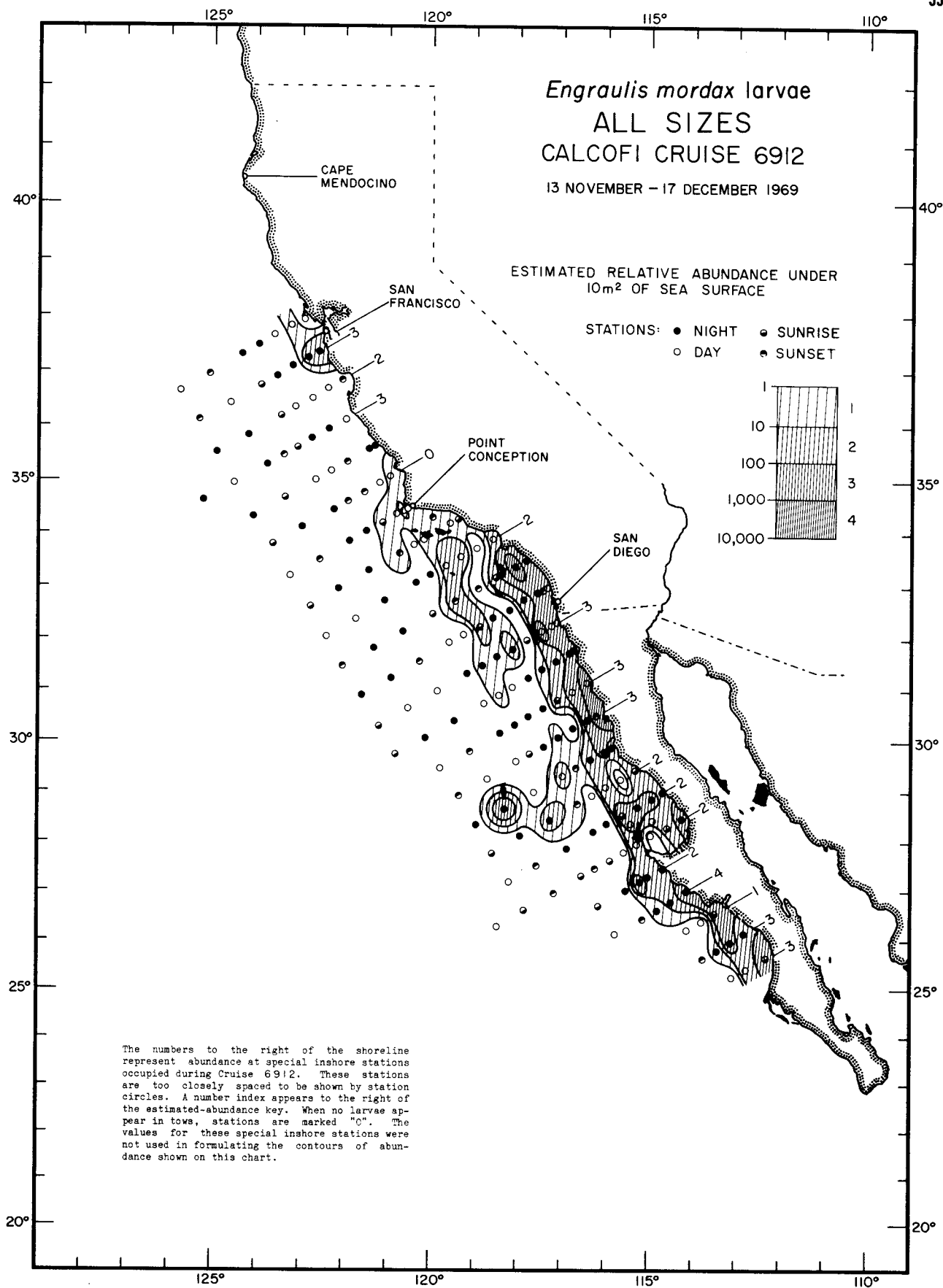
*Engraulis mordax* larvae

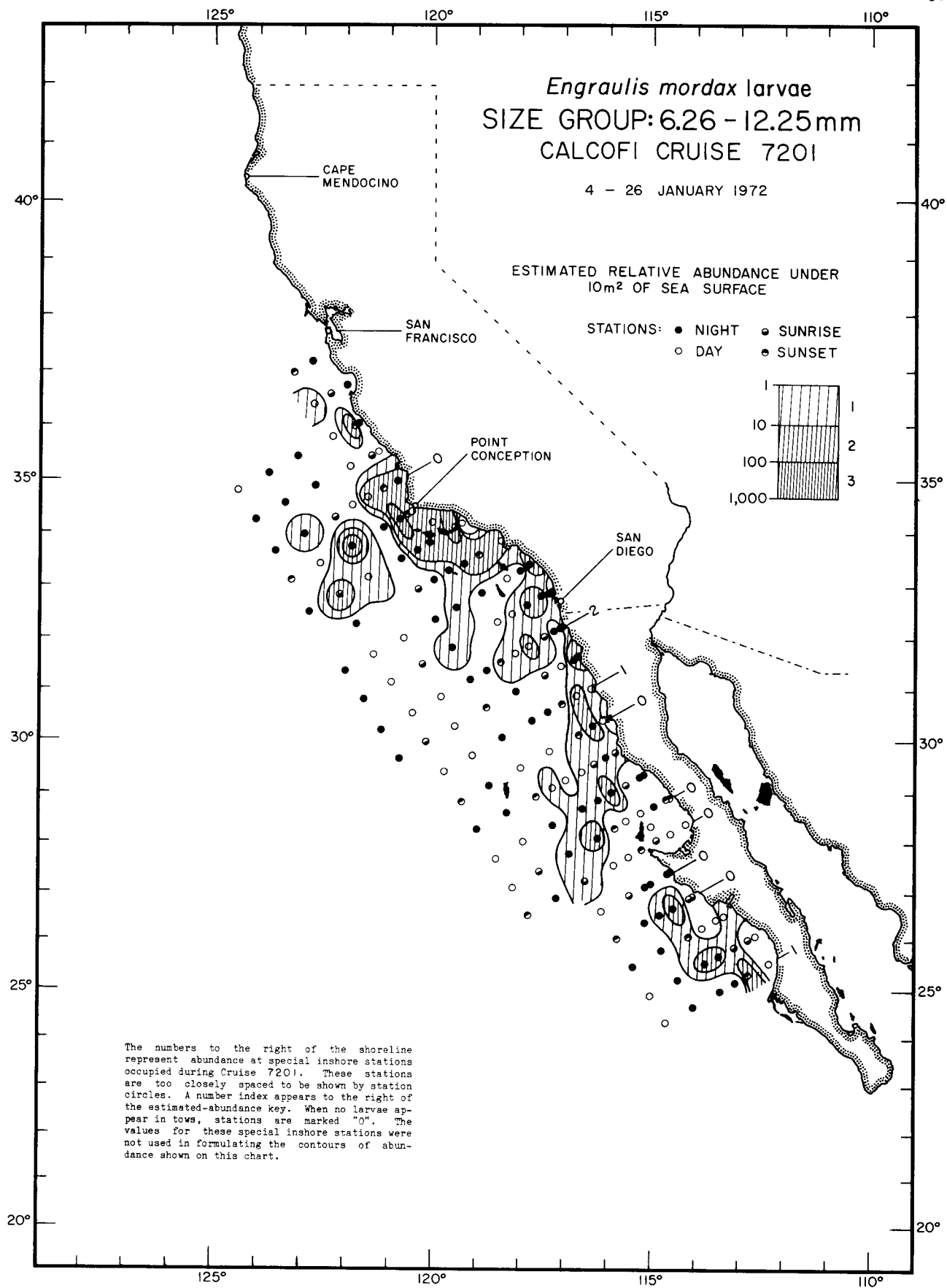
All Sizes

6910

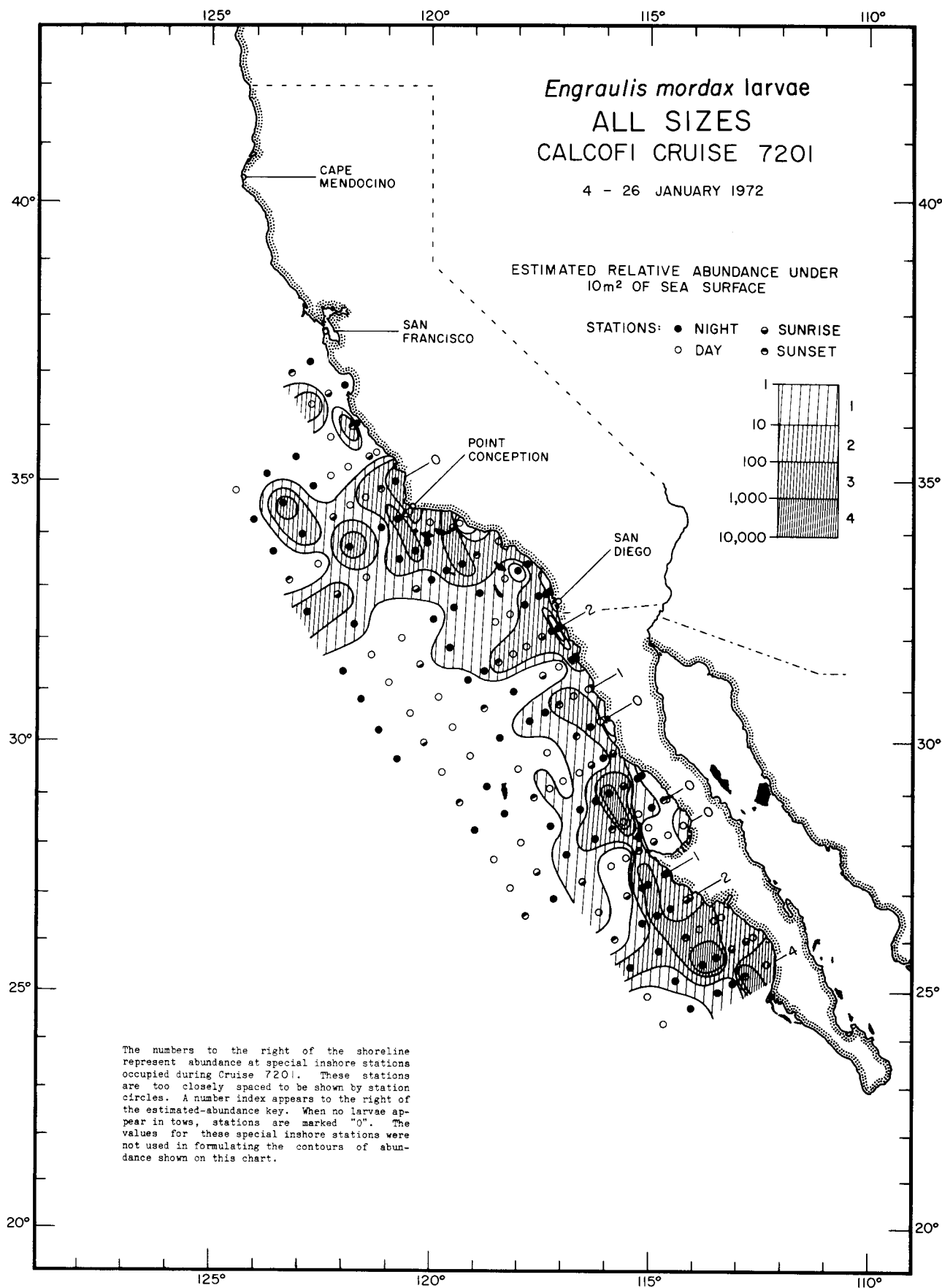


Engraulis mordax larvae
Size Group: 6.26-12.25mm
6912

*Engraulis mordax* larvaeAll Sizes
6912

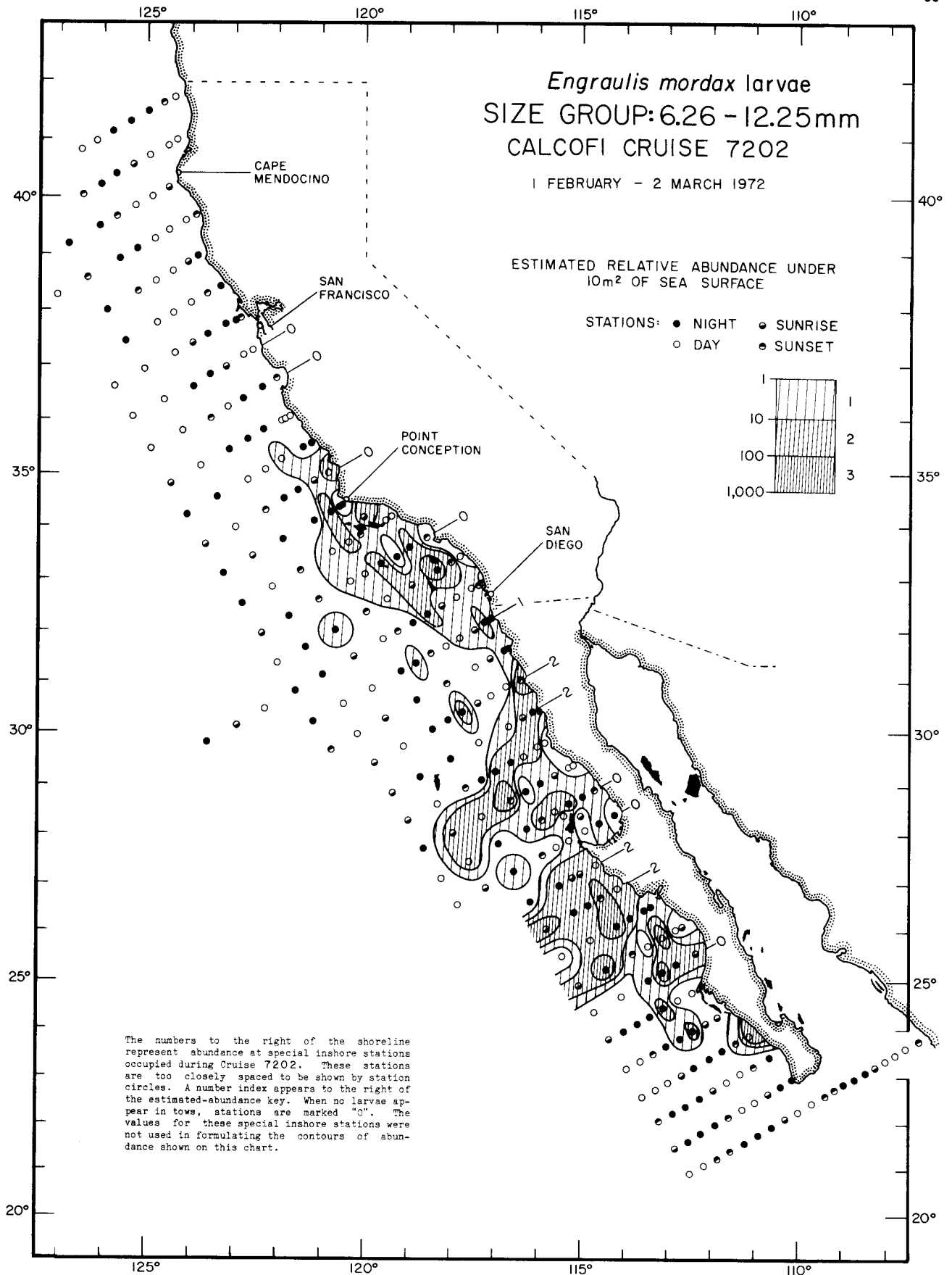


Engraulis mordax larvae
Size Group: 6.26-12.25mm
7201

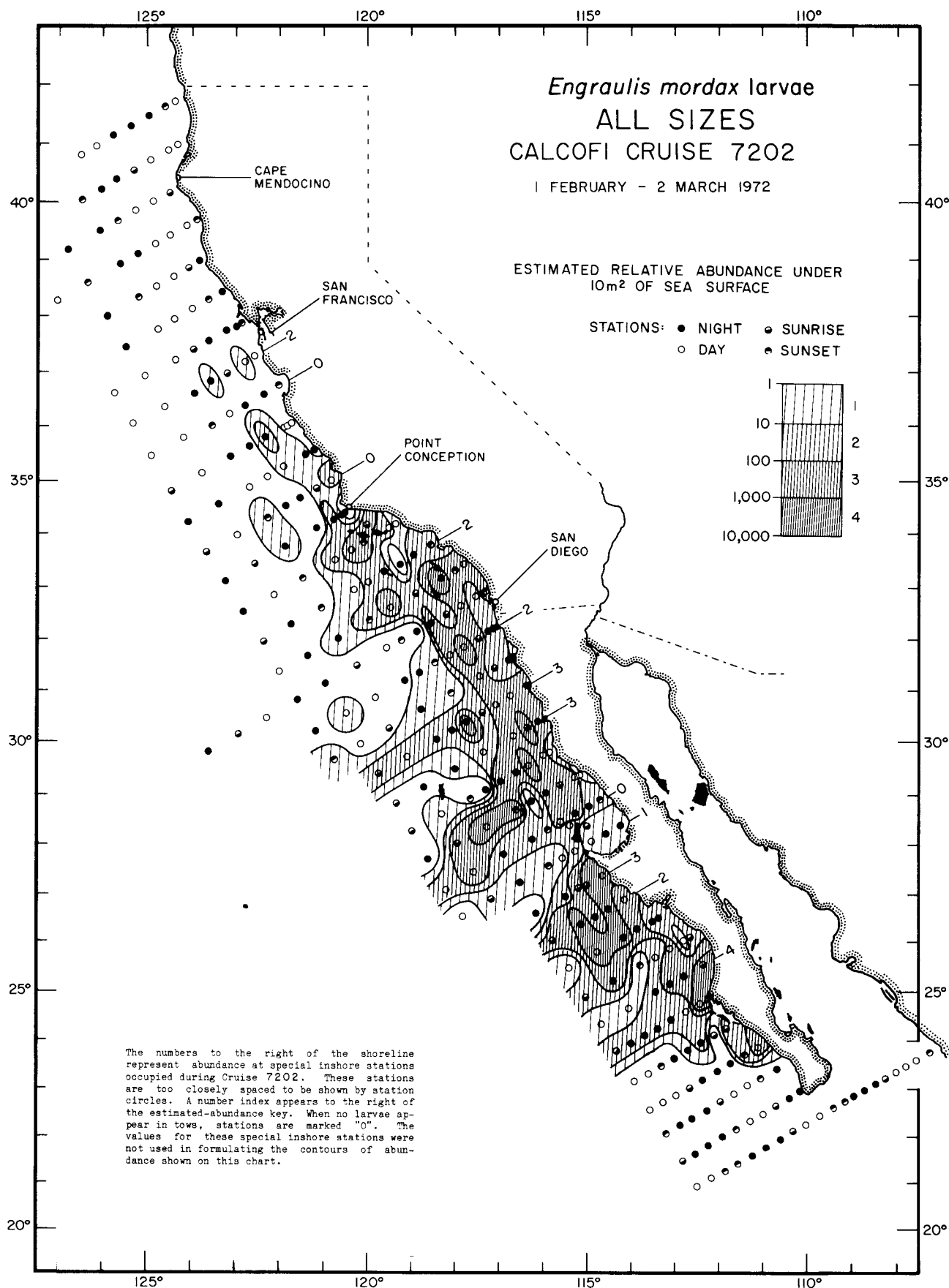
*Engraulis mordax* larvae

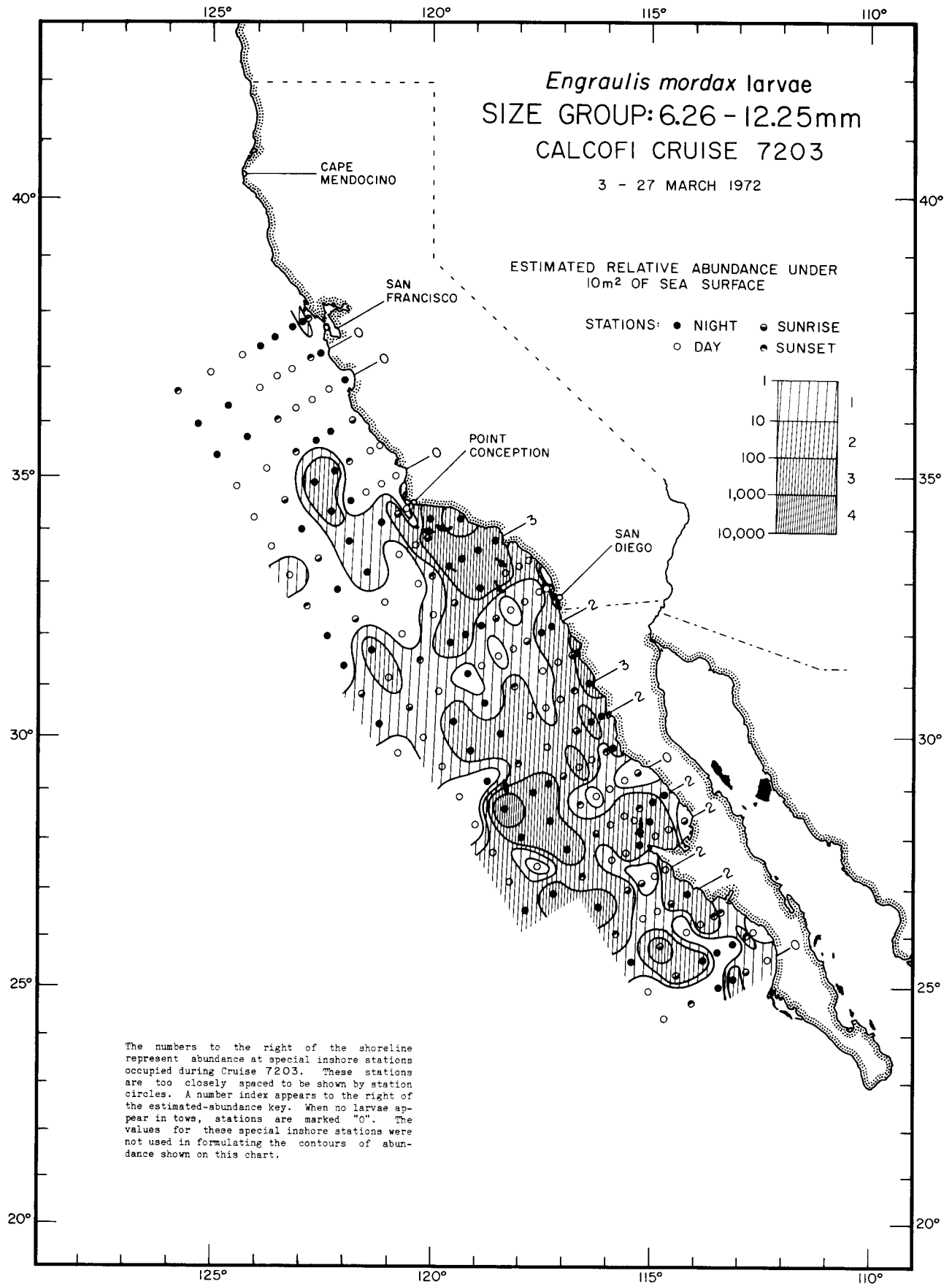
All Sizes

7201

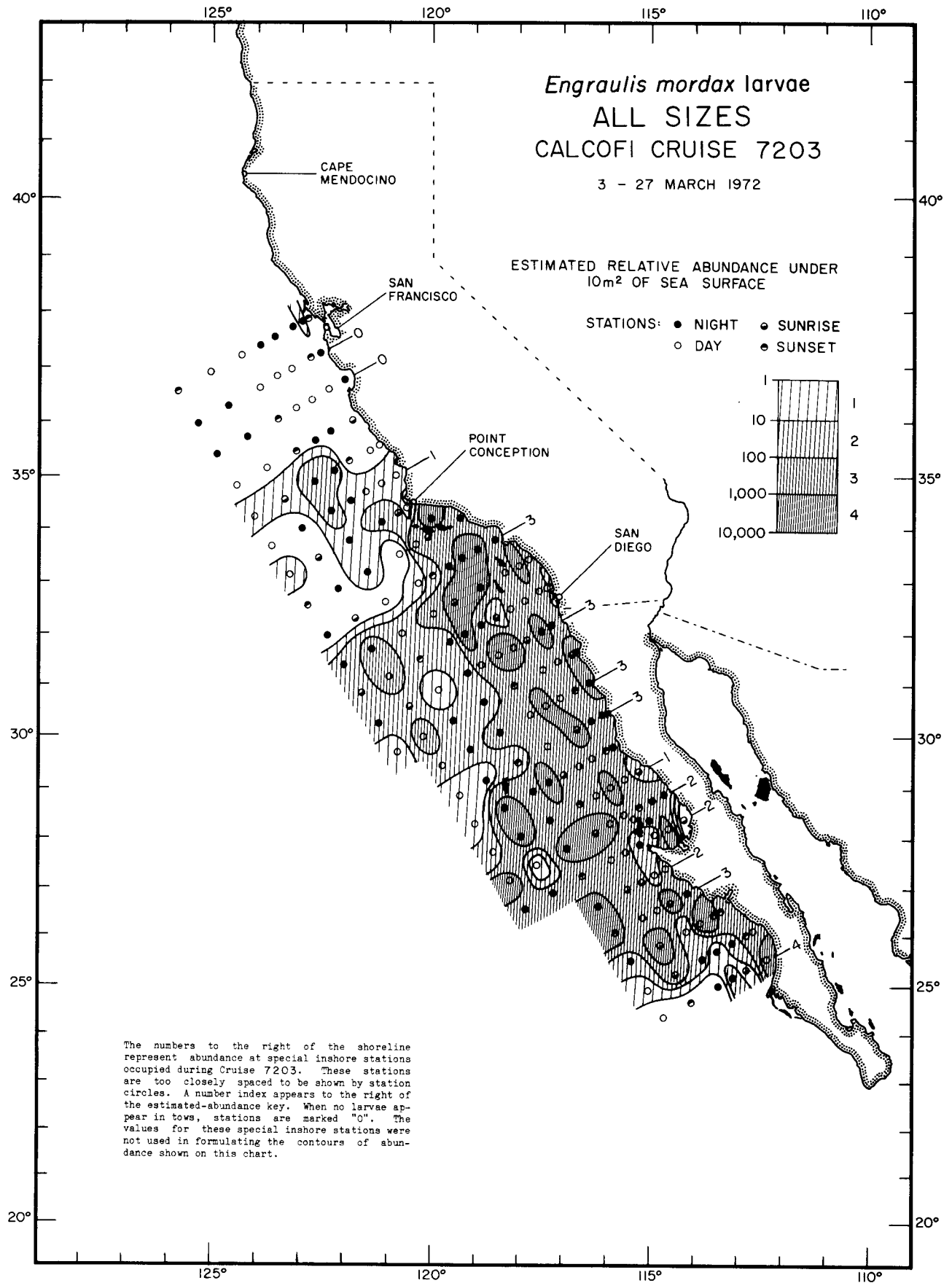


Engraulis mordax larvae
Size Group: 6.26-12.25mm
7202

*Engraulis mordax* larvaeAll Sizes
7202



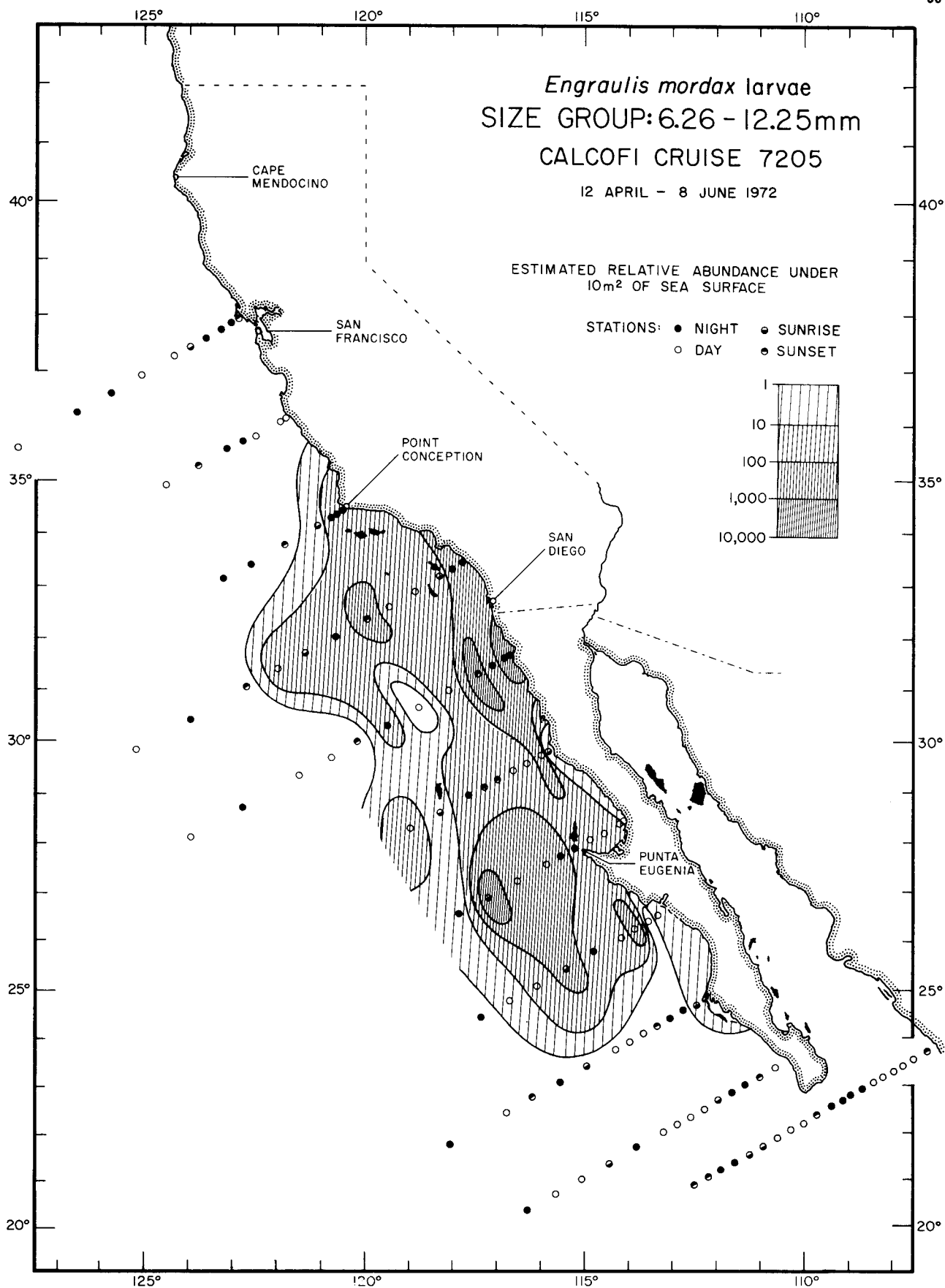
Engraulis mordax larvae
Size Group: 6.26-12.25mm
7203



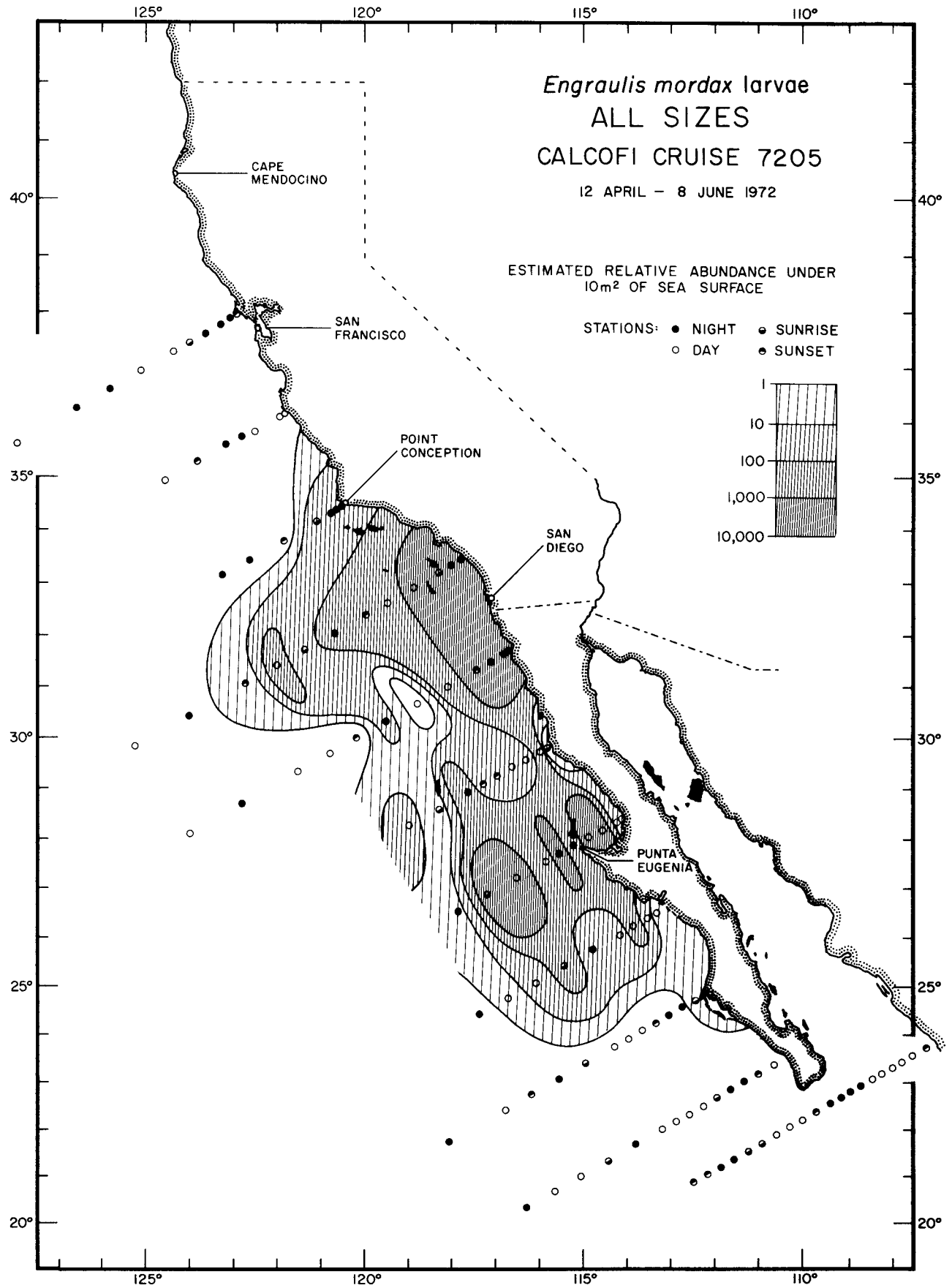
Engraulis mordax larvae

All Sizes

7203

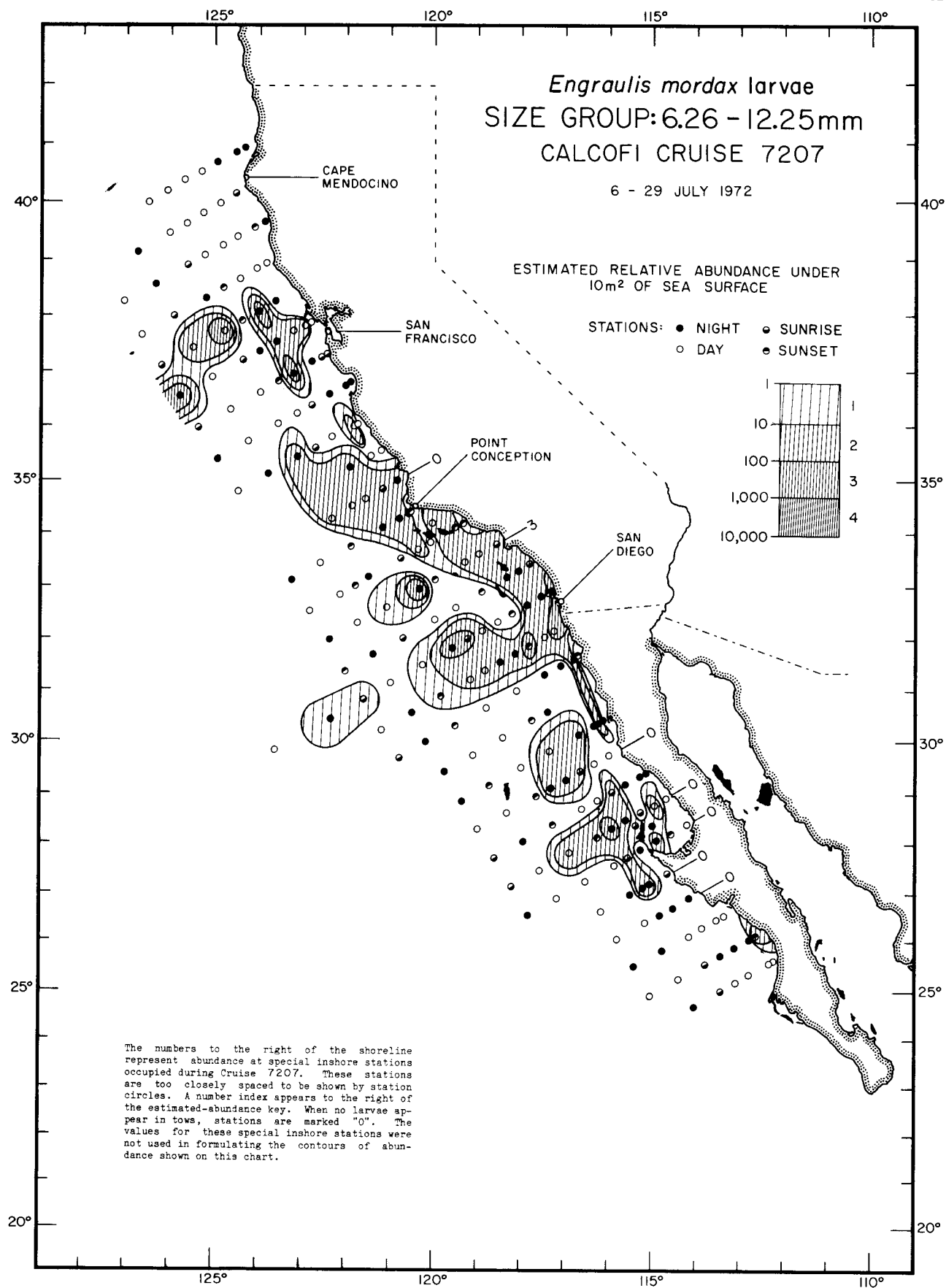


Engraulis mordax larvae
 Size Group: 6.26-12.25mm
 7205

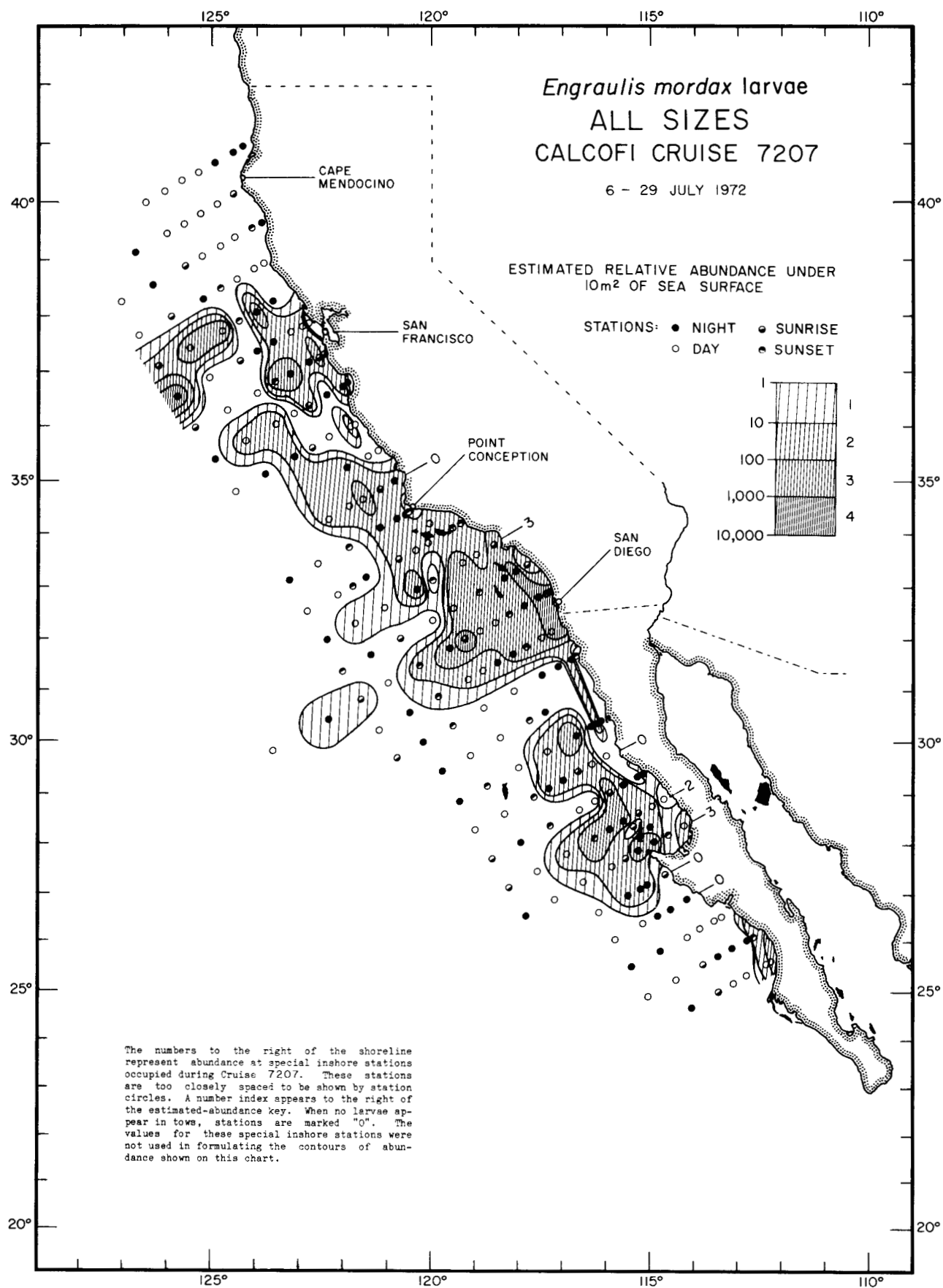
*Engraulis mordax* larvae

All Sizes

7205

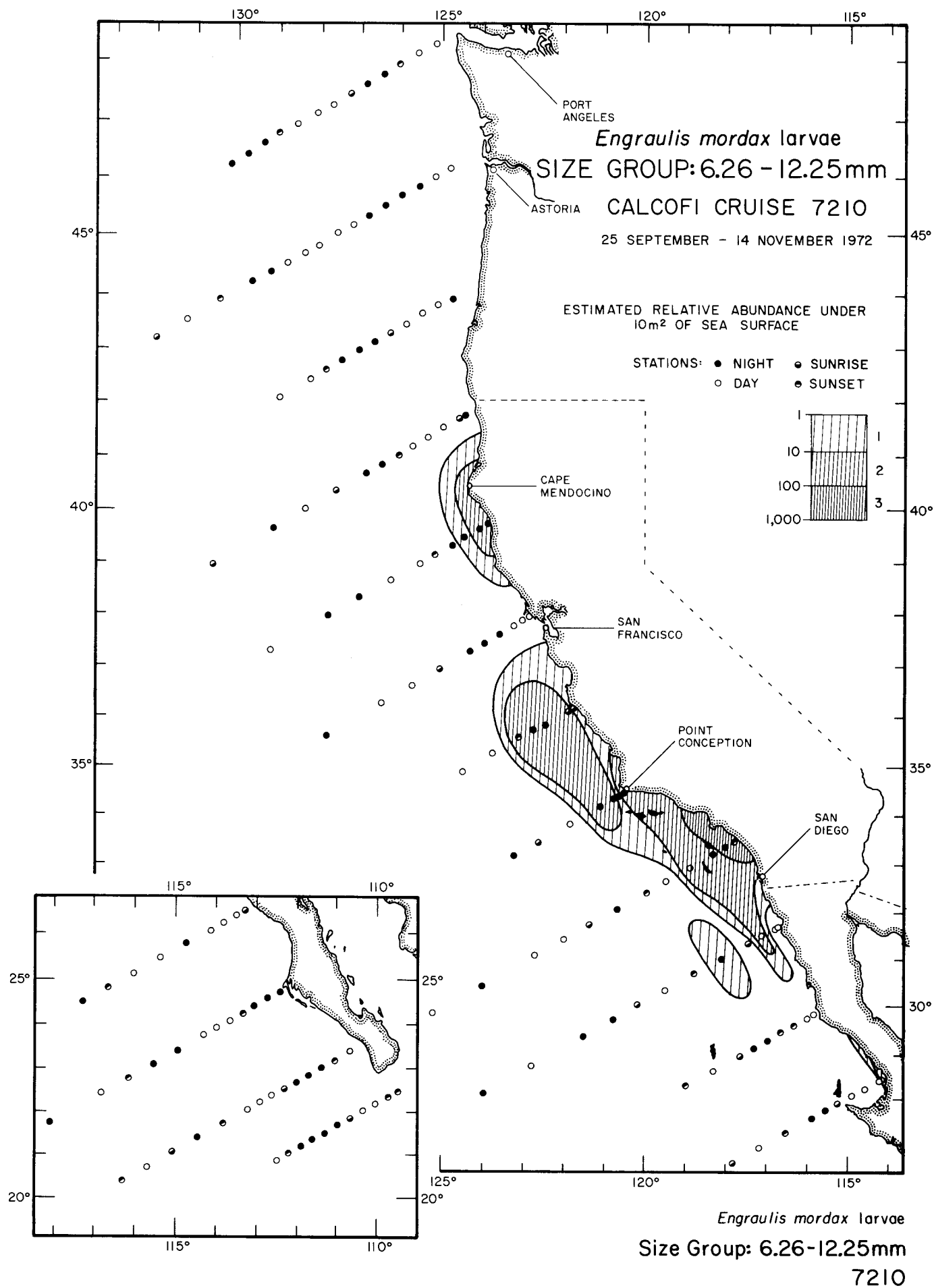


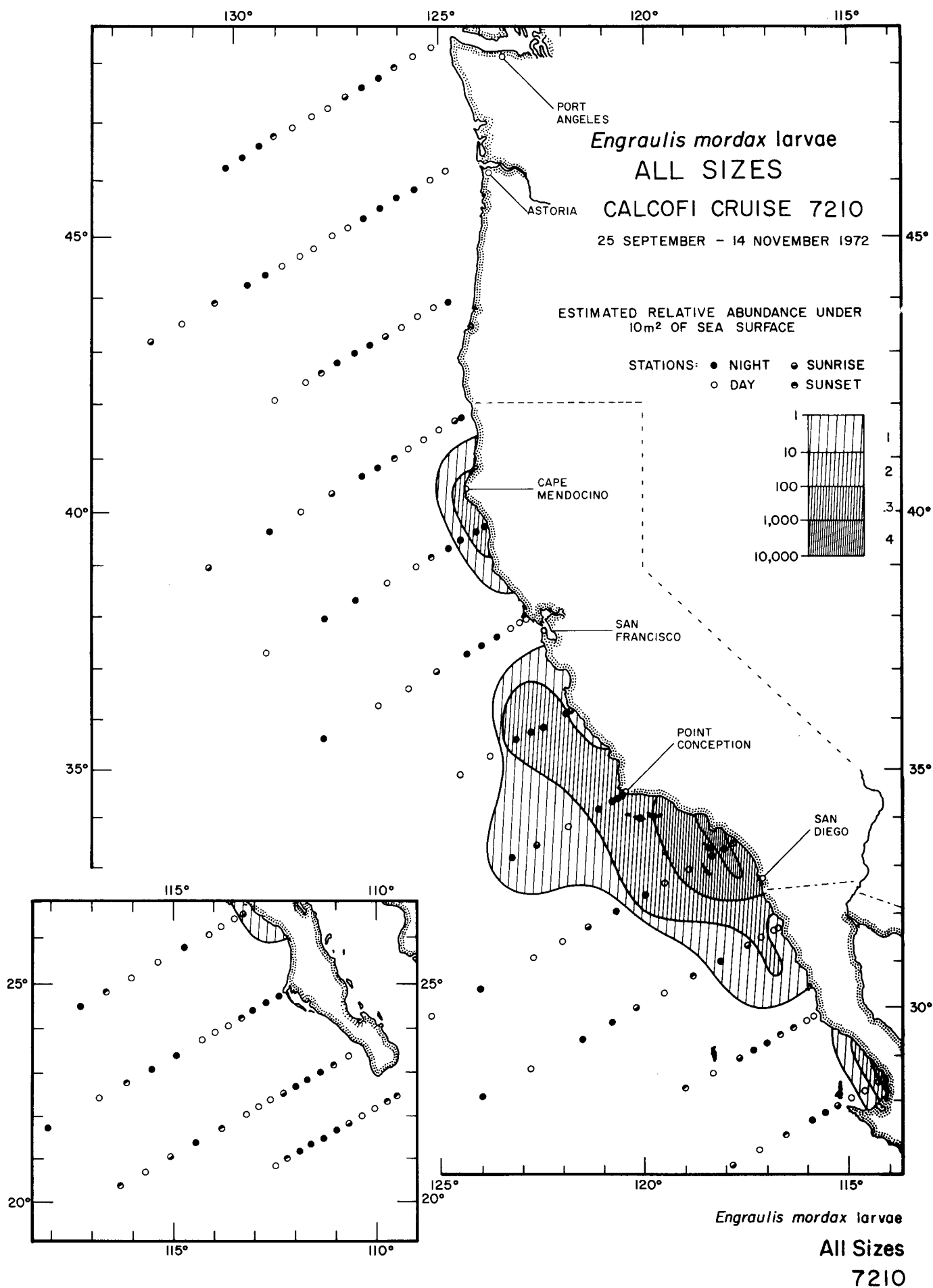
Engraulis mordax larvae
Size Group: 6.26-12.25mm
7207

*Engraulis mordax* larvae

All Sizes

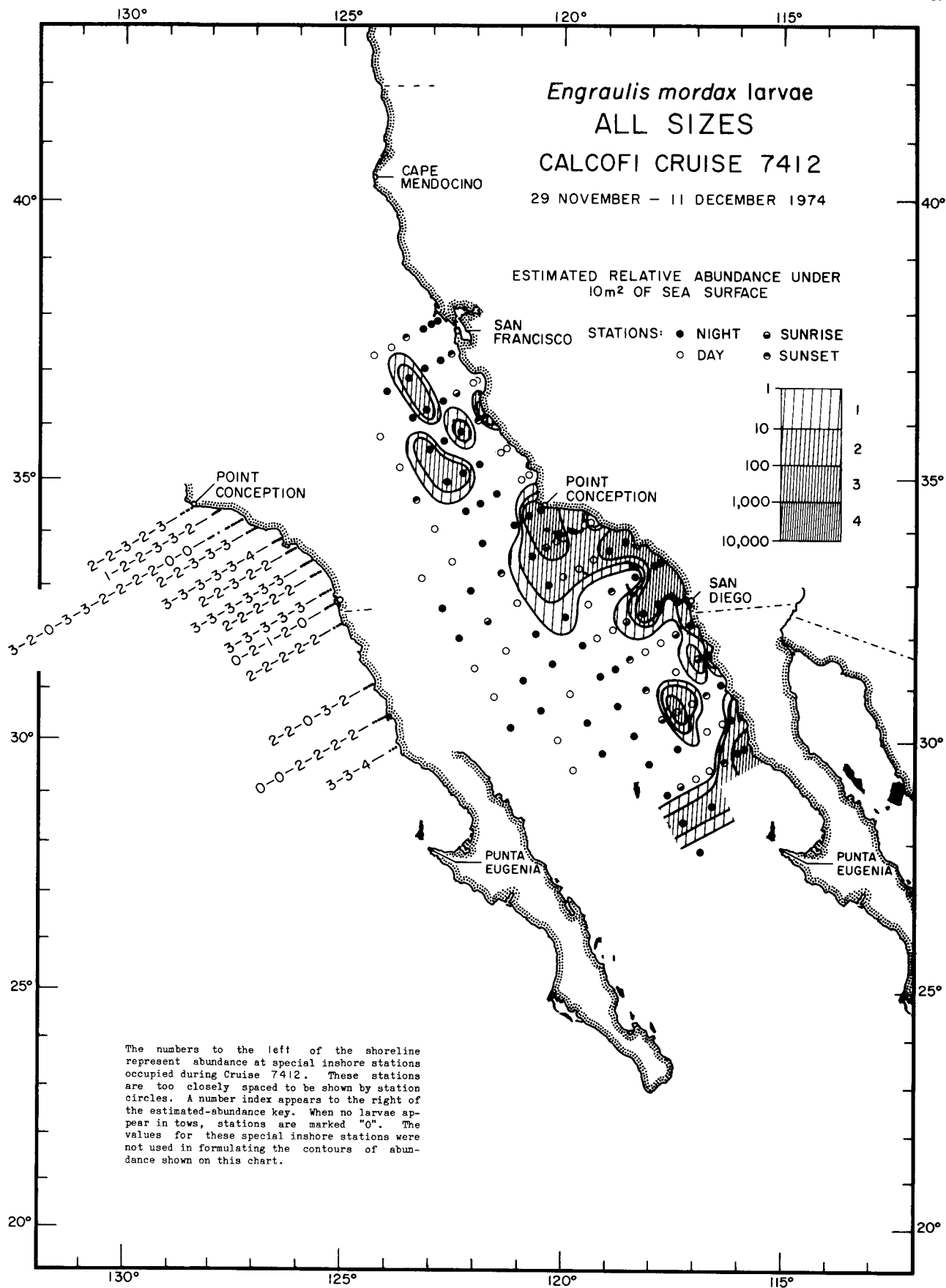
7207





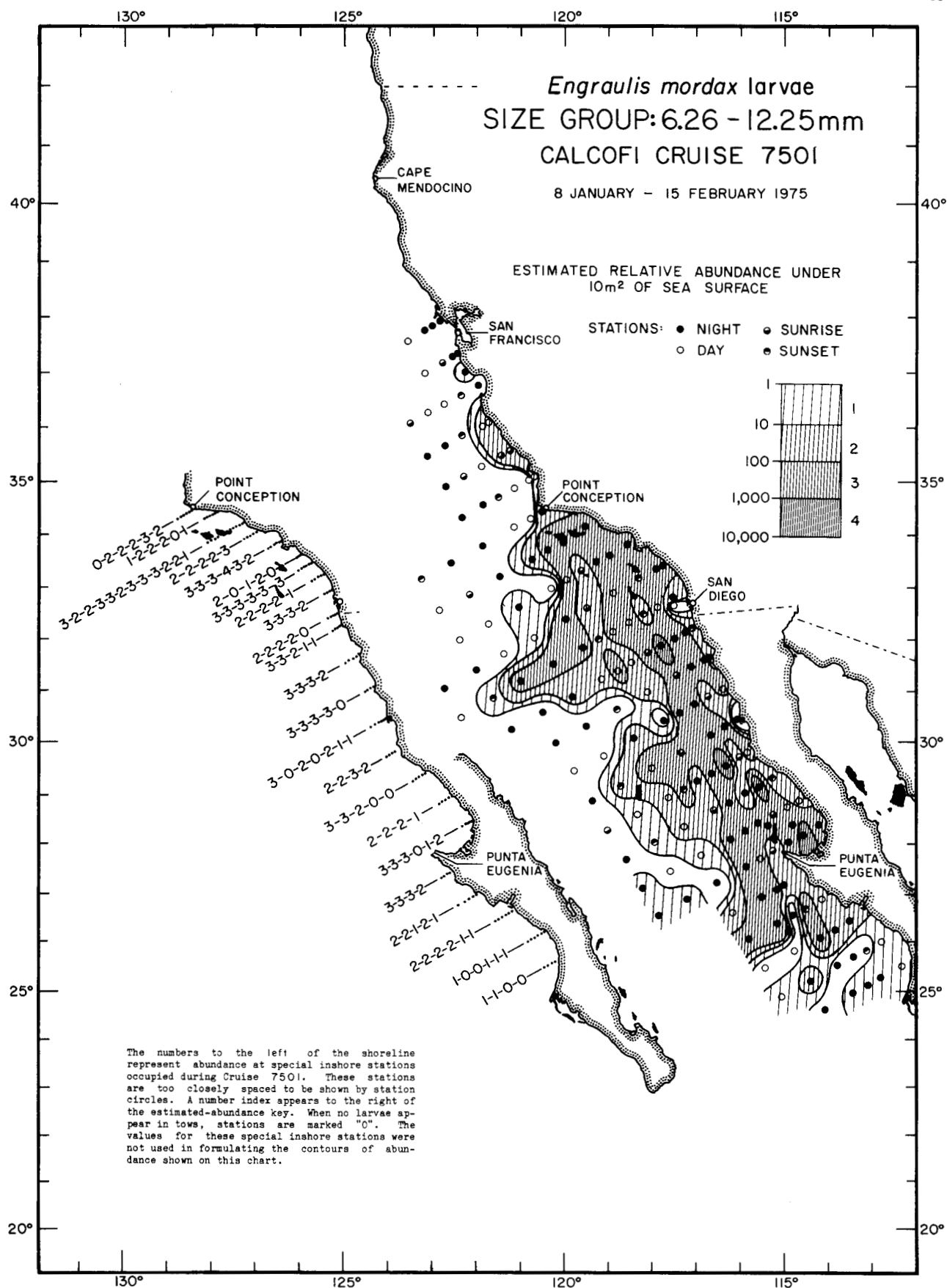
The numbers to the left of the shoreline represent abundance at special inshore stations occupied during Cruise 7412. These stations are too closely spaced to be shown by station circles. A number index appears to the right of the estimated-abundance key. When no larvae appear in tows, stations are marked "0". The values for these special inshore stations were not used in formulating the contours of abundance shown on this chart.

Engraulis mordax larvae
Size Group: 6.26-12.25mm
7412

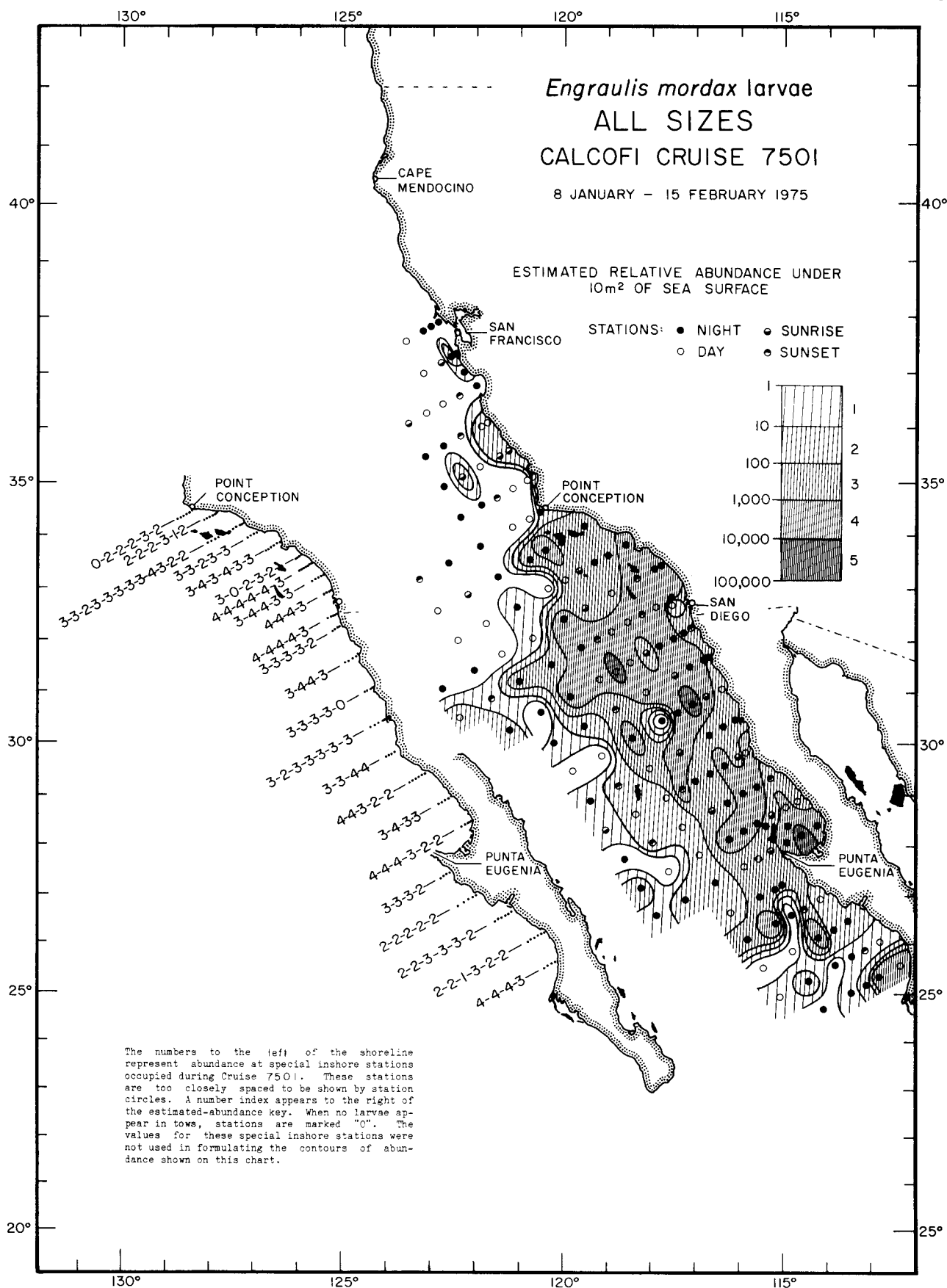
*Engraulis mordax* larvae

All Sizes

7412

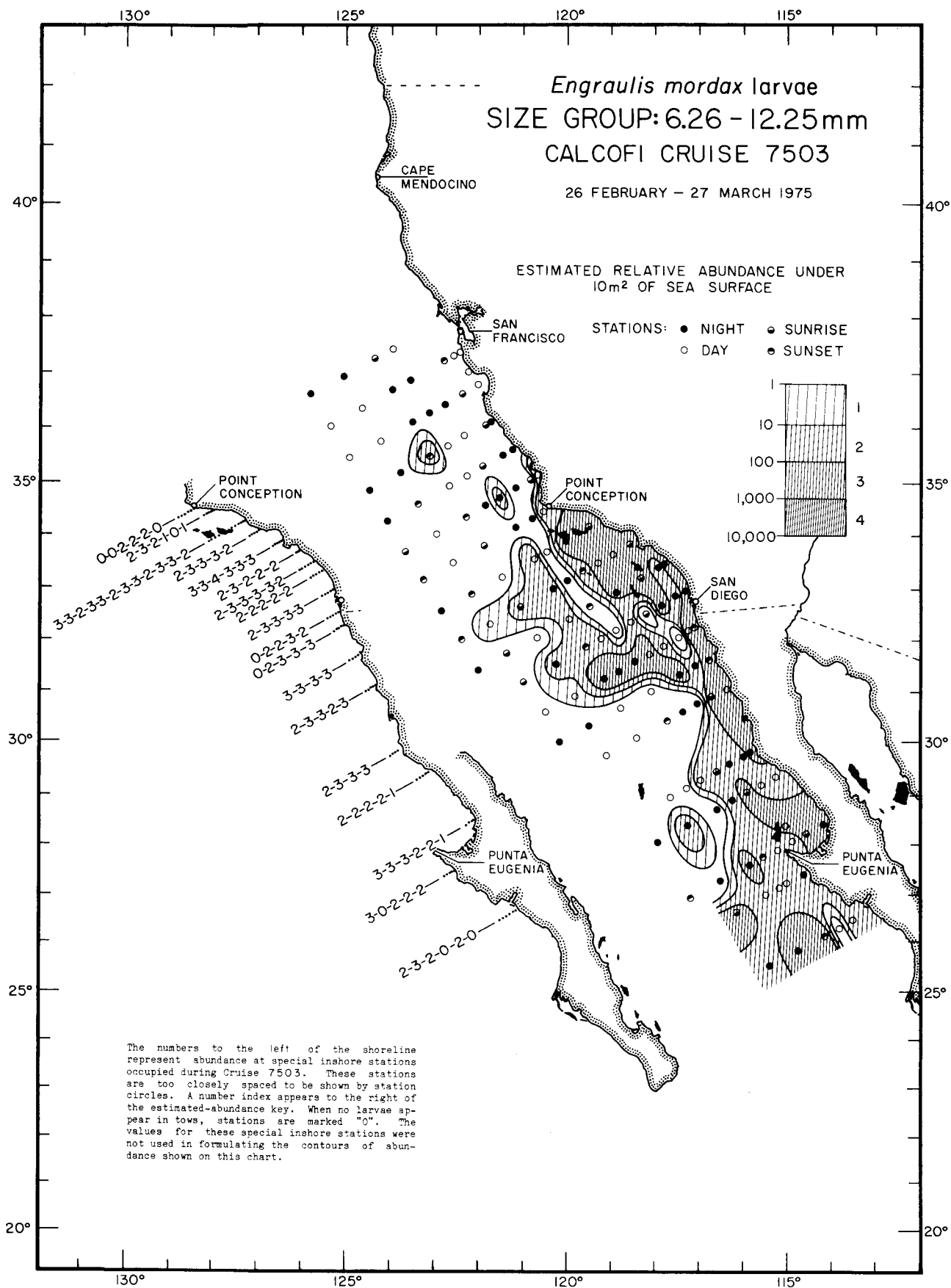


Engraulis mordax larvae
Size Group: 6.26-12.25mm
7501

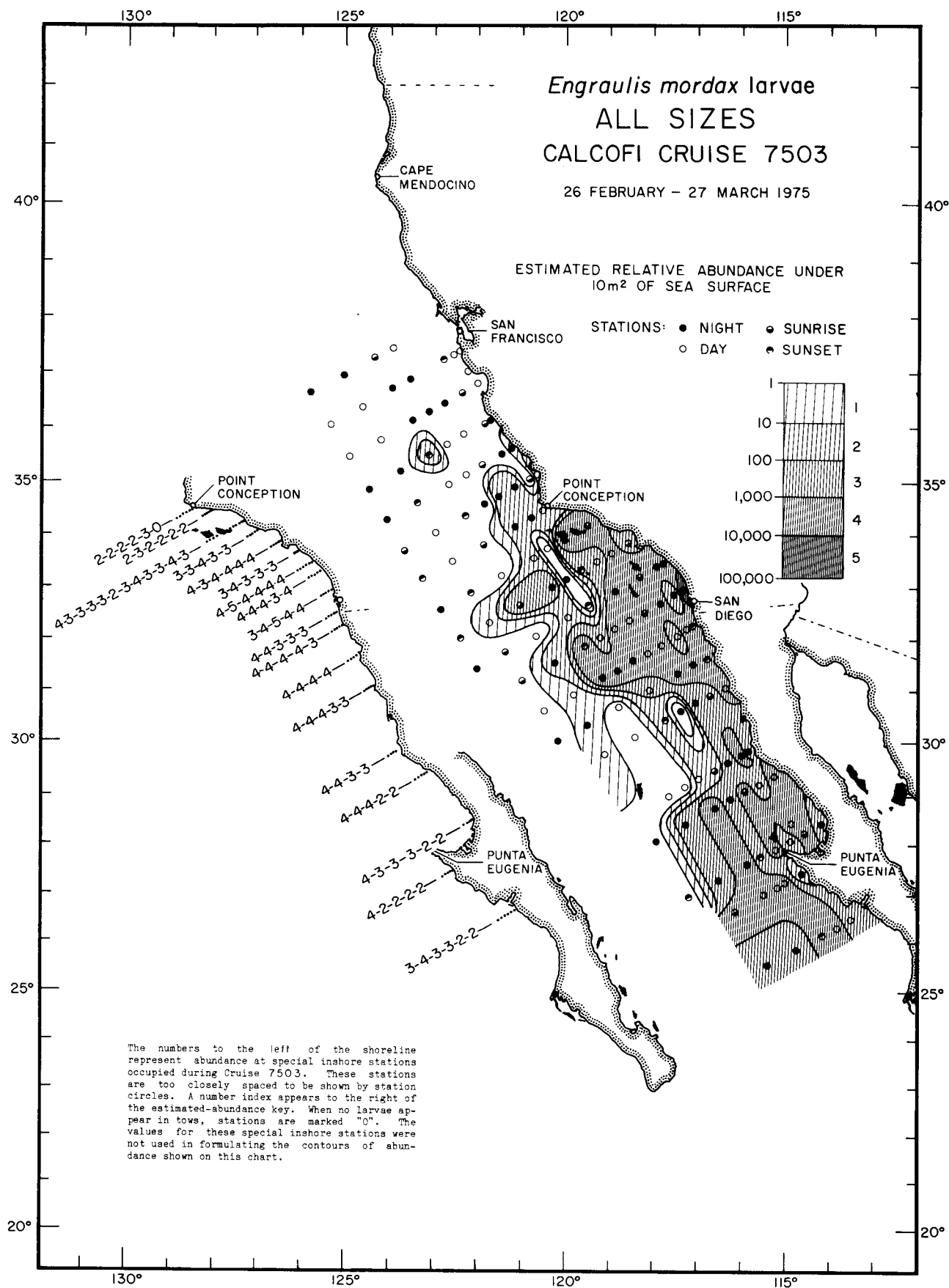
*Engraulis mordax* larvae

All Sizes

7501

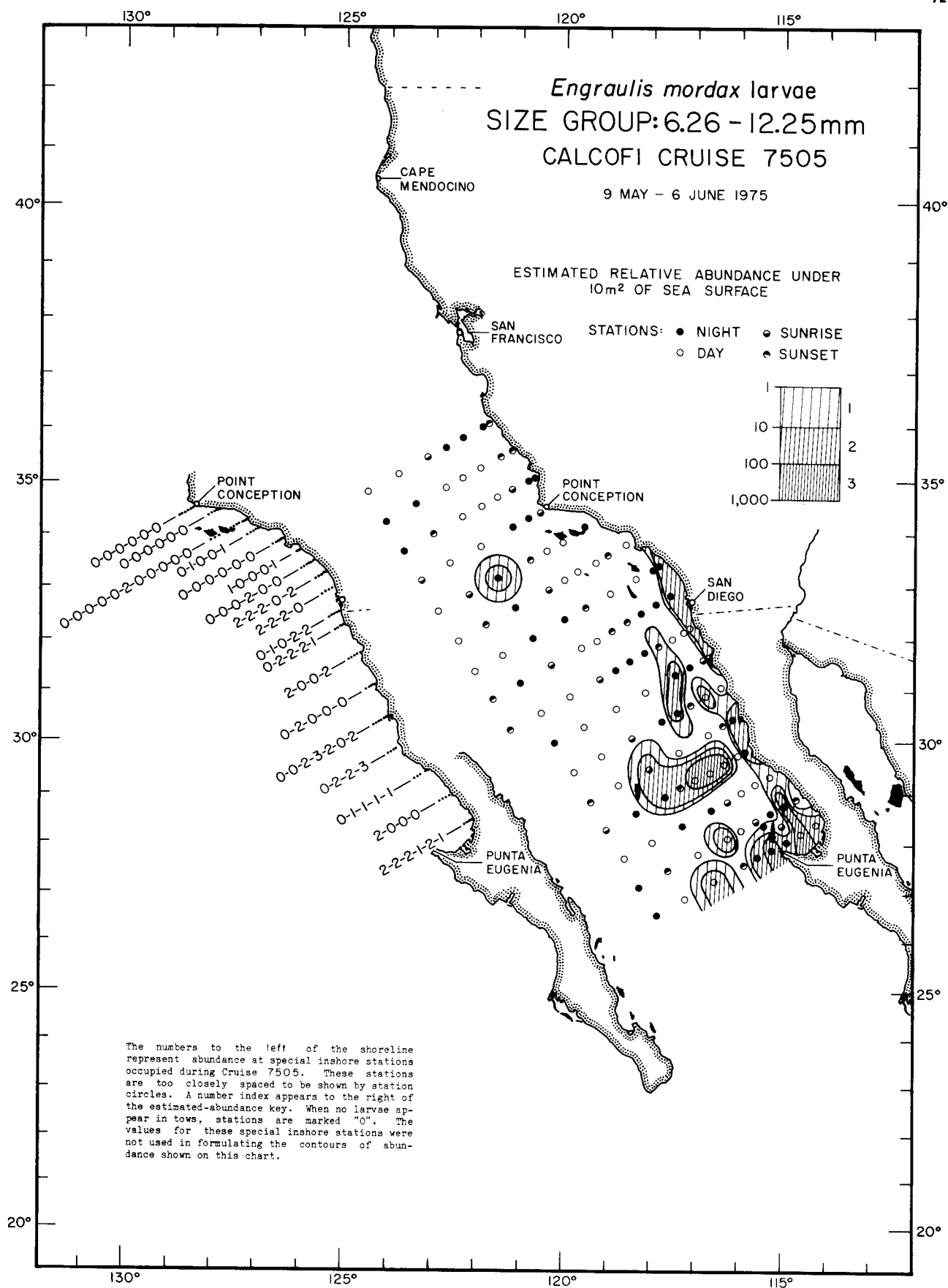


Engraulis mordax larvae
Size Group: 6.26-12.25mm
7503

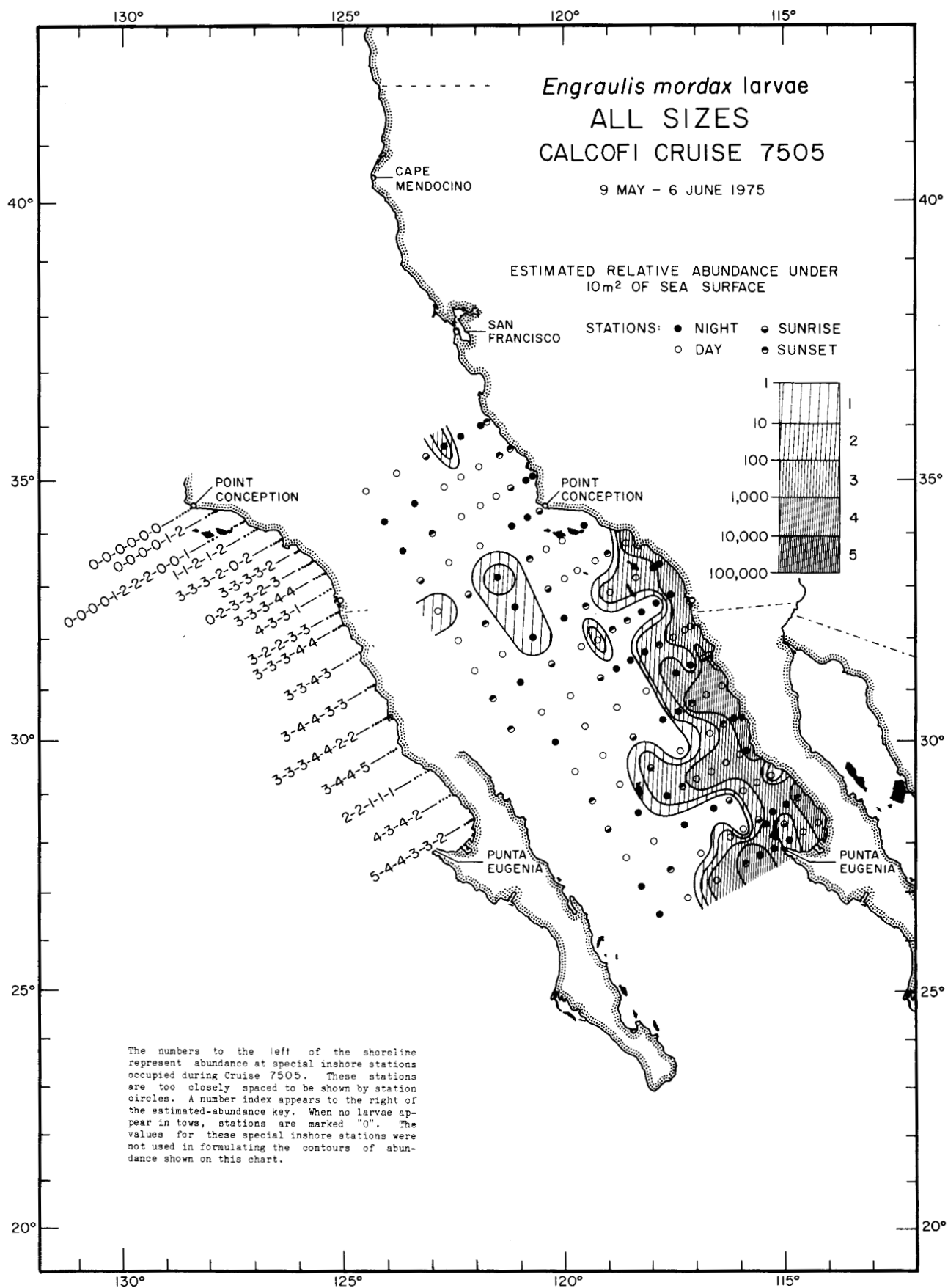
*Engraulis mordax* larvae

All Sizes

7503

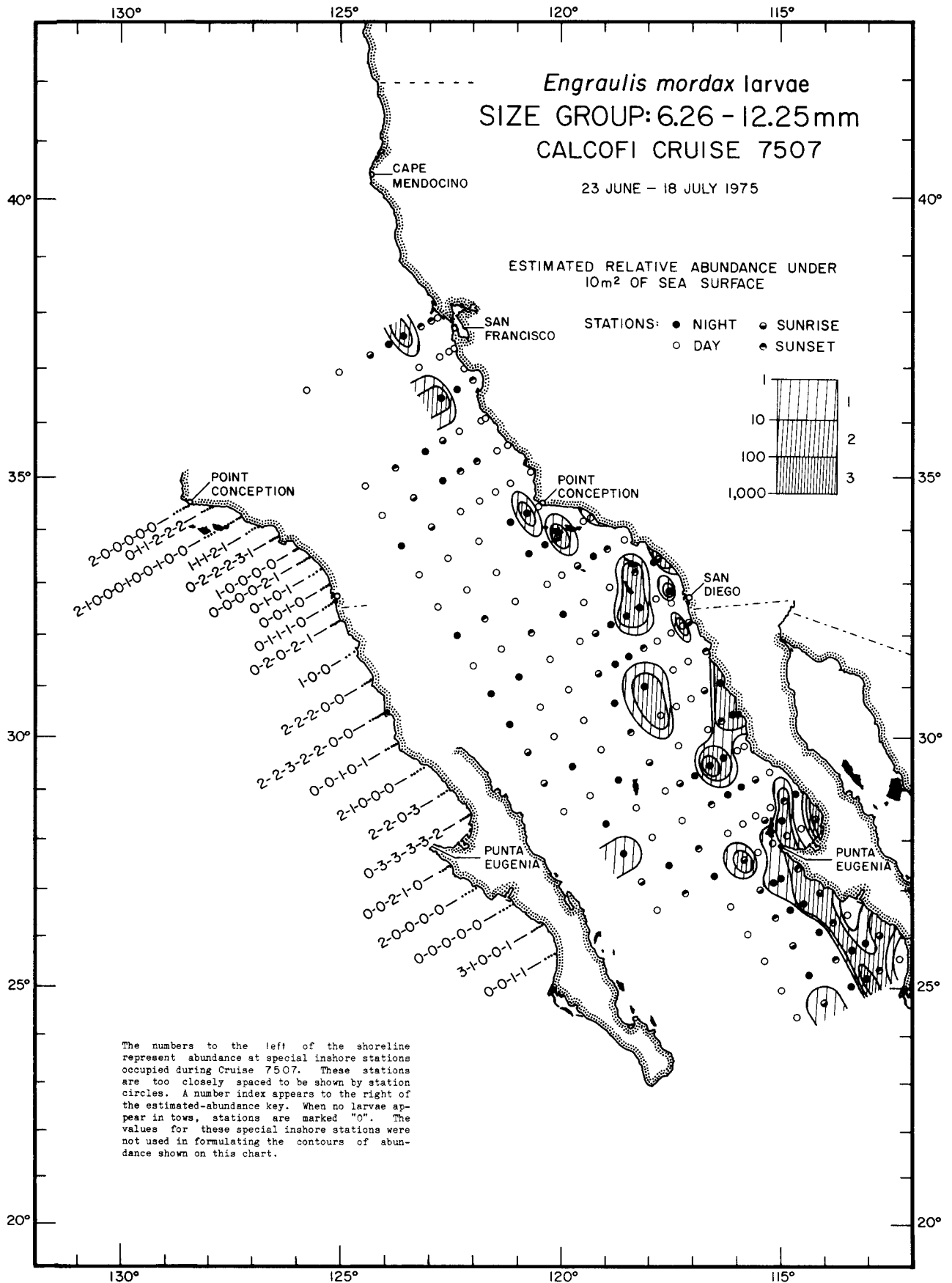


Engraulis mordax larvae
Size Group: 6.26-12.25mm
7505

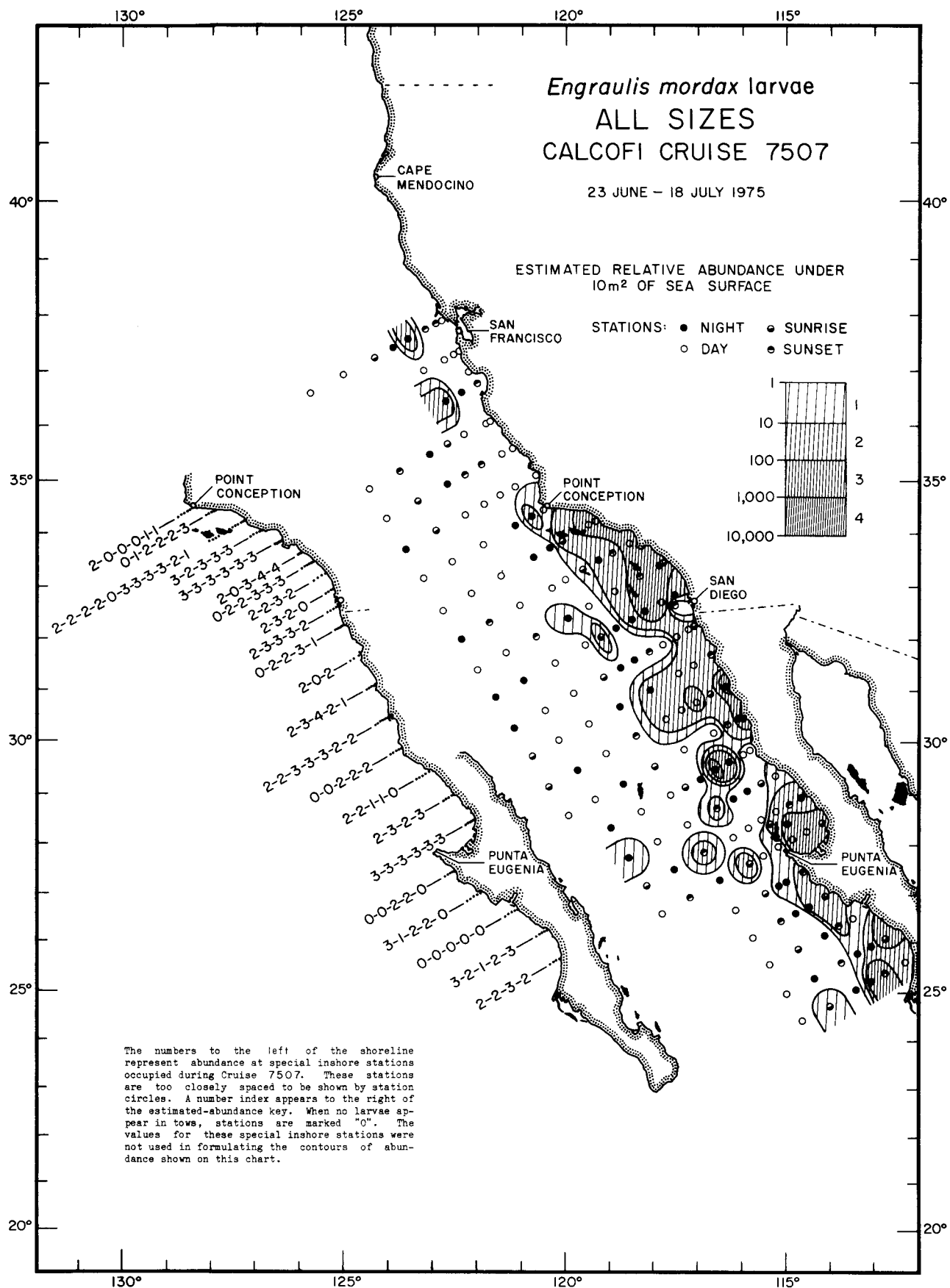
*Engraulis mordax* larvae

All Sizes

7505

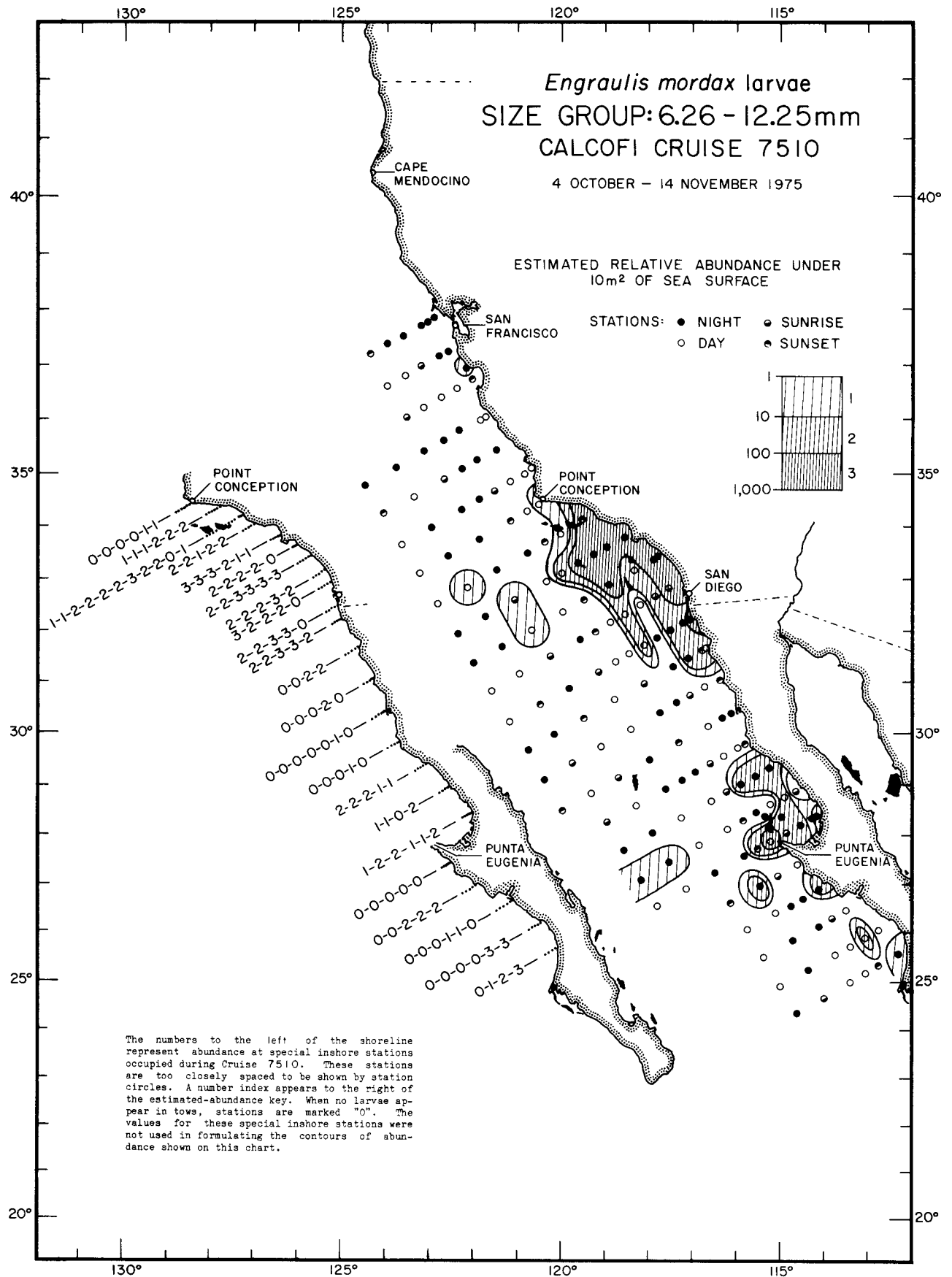


Engraulis mordax larvae
Size Group: 6.26-12.25mm
7507

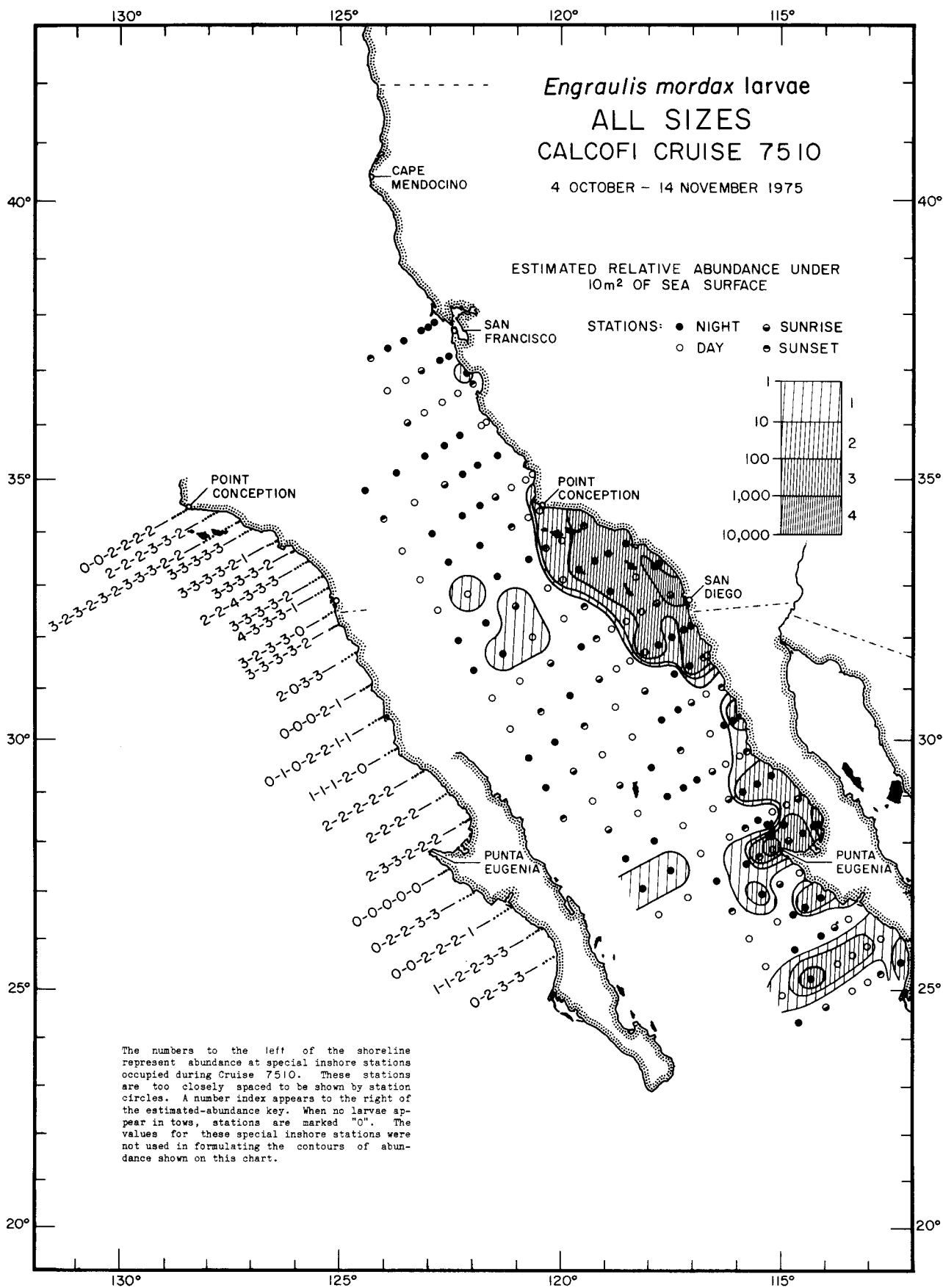
*Engraulis mordax* larvae

All Sizes

7507

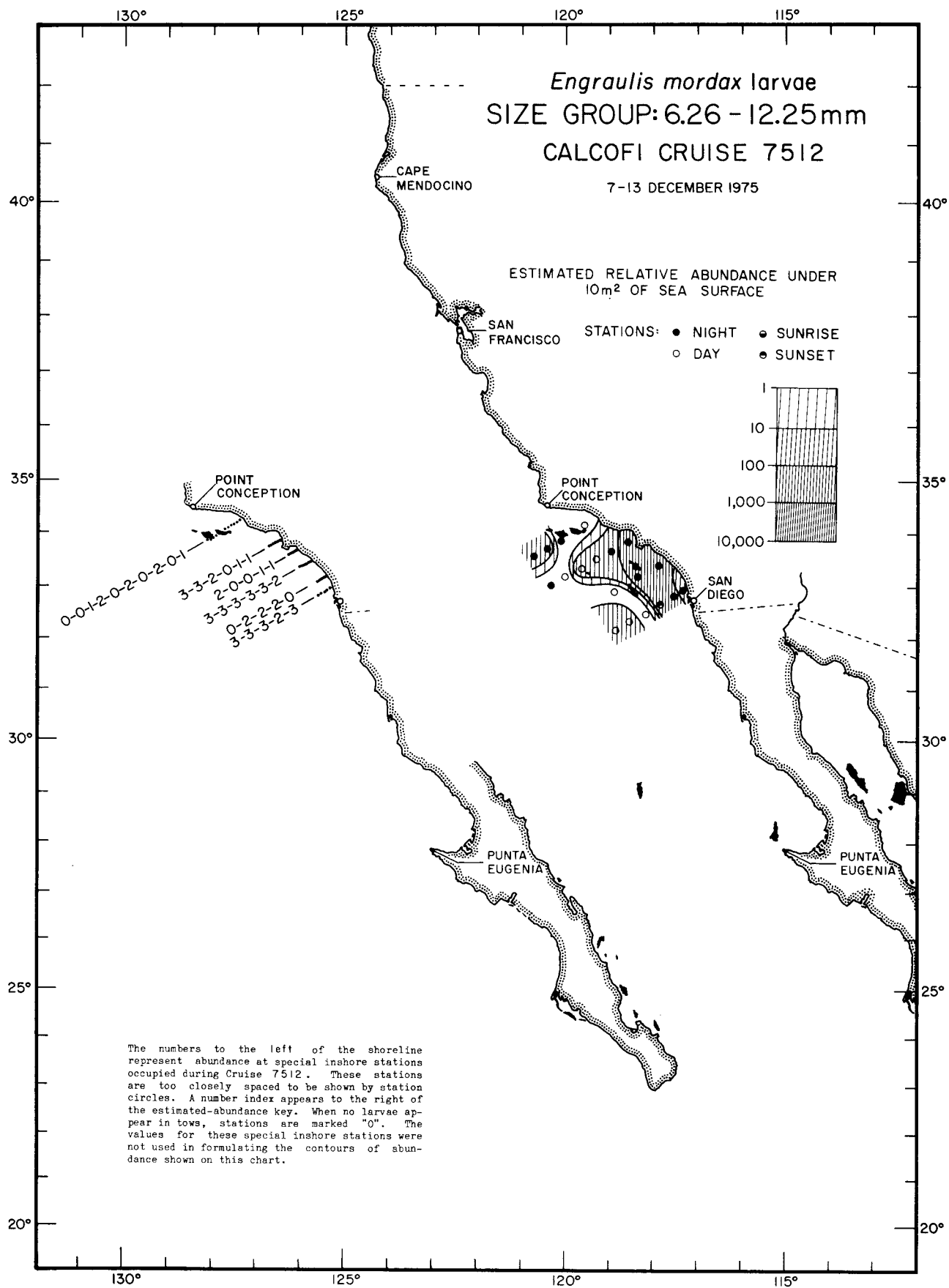


Engraulis mordax larvae
Size Group: 6.26-12.25mm
7510

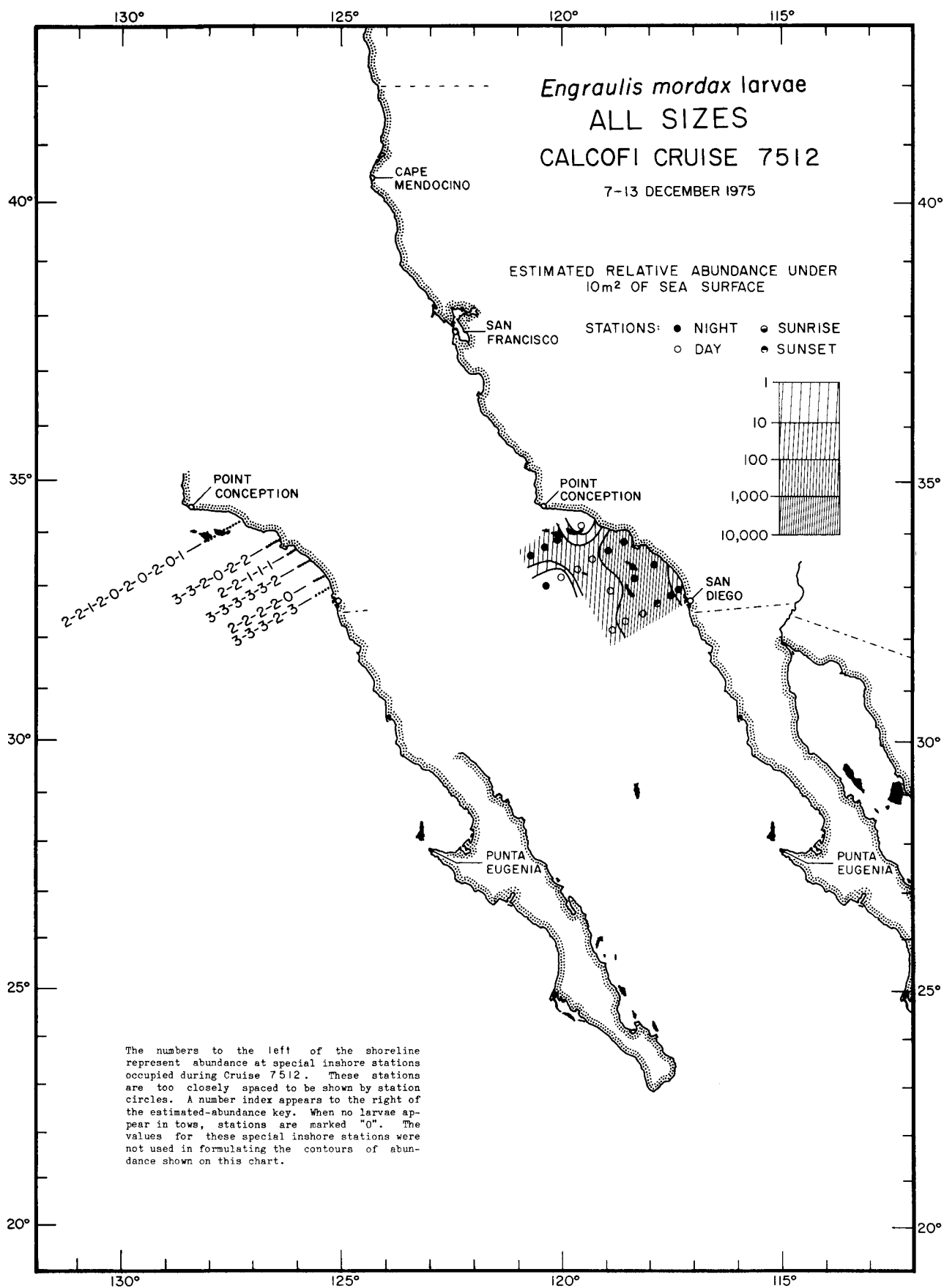
*Engraulis mordax* larvae

All Sizes

7510

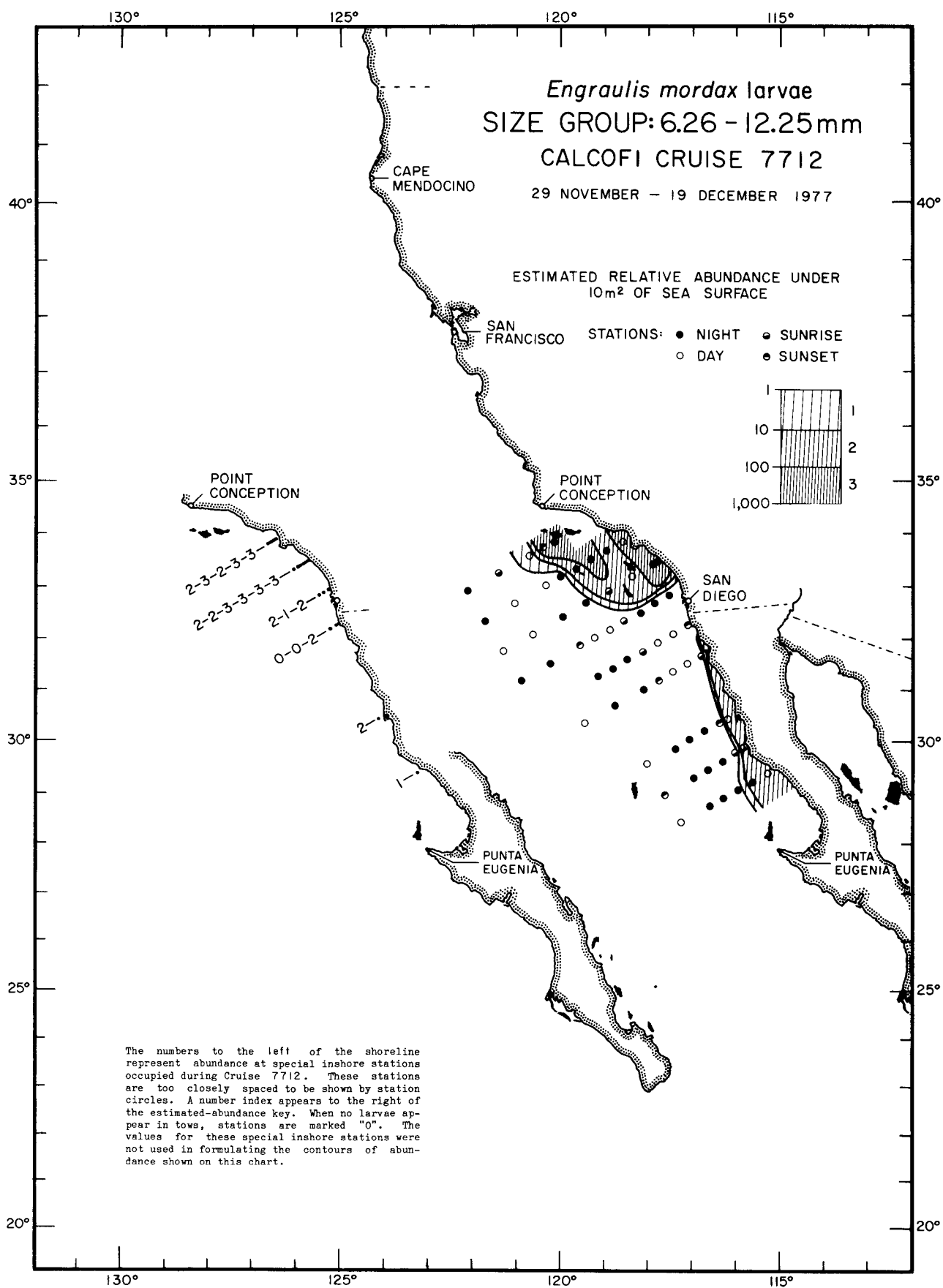


Engraulis mordax larvae
Size Group: 6.26-12.25mm
7512

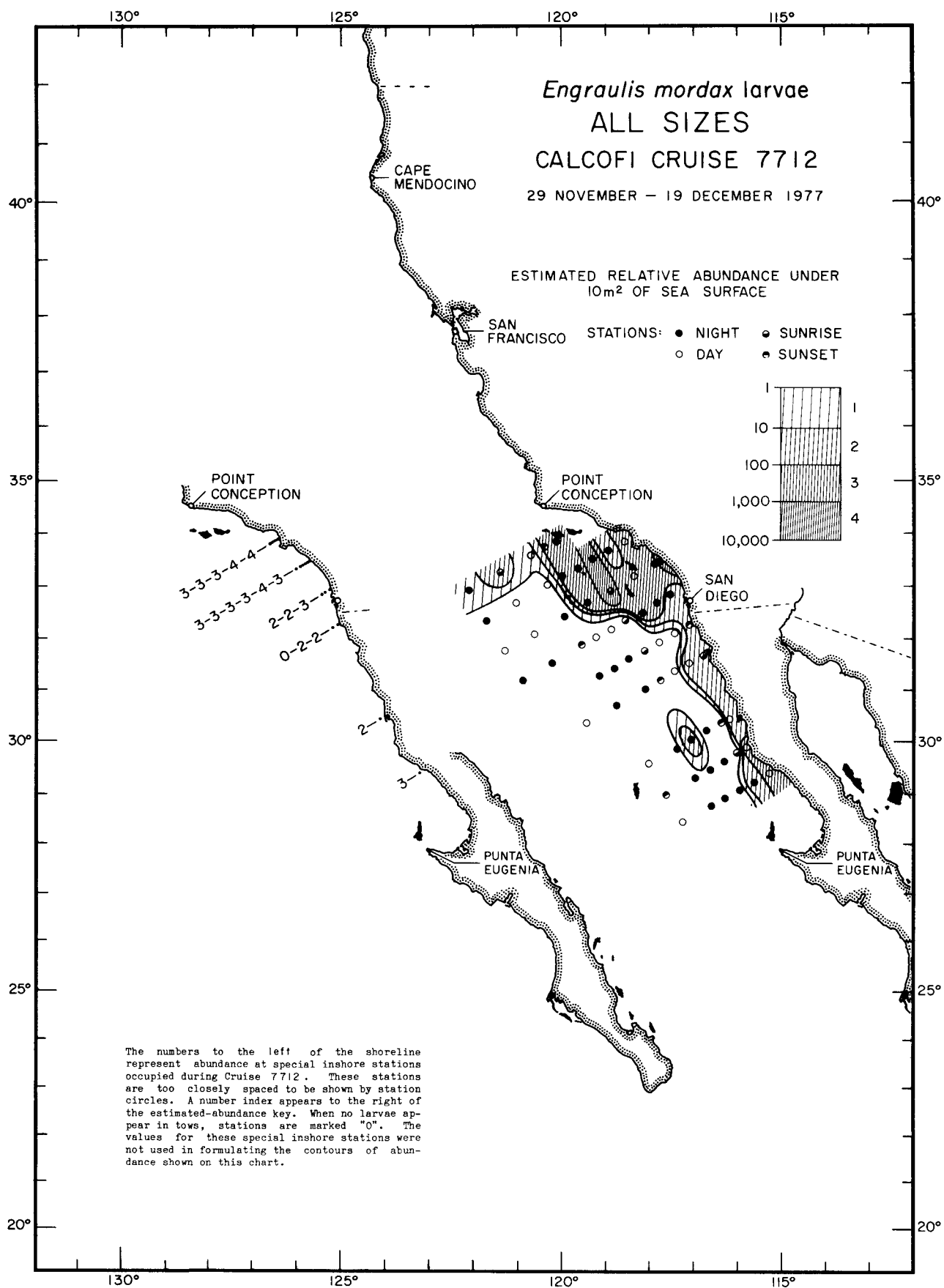
*Engraulis mordax* larvae

All Sizes

7512

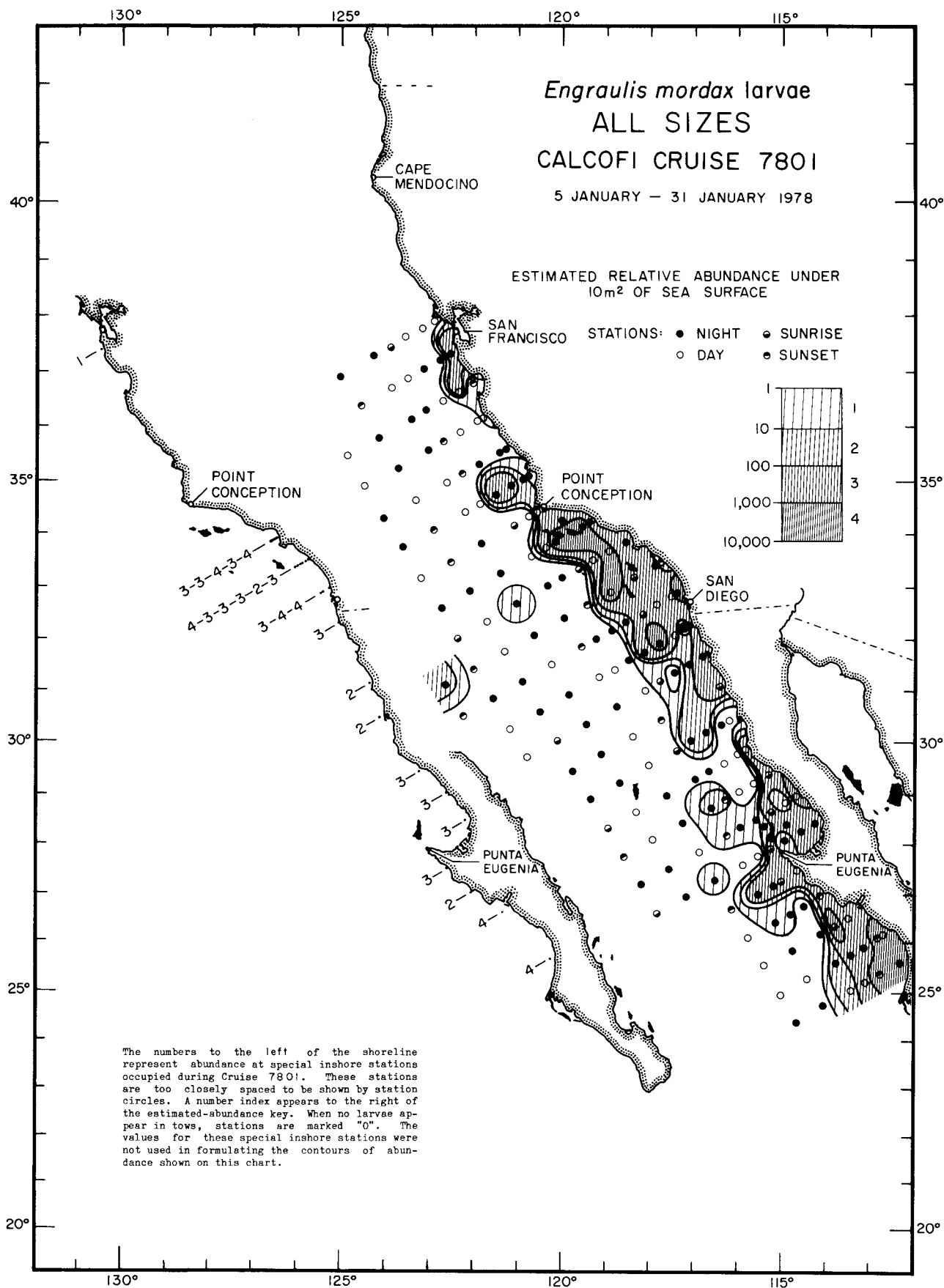


Engraulis mordax larvae
Size Group: 6.26-12.25mm
7712

*Engraulis mordax* larvaeAll Sizes
7712

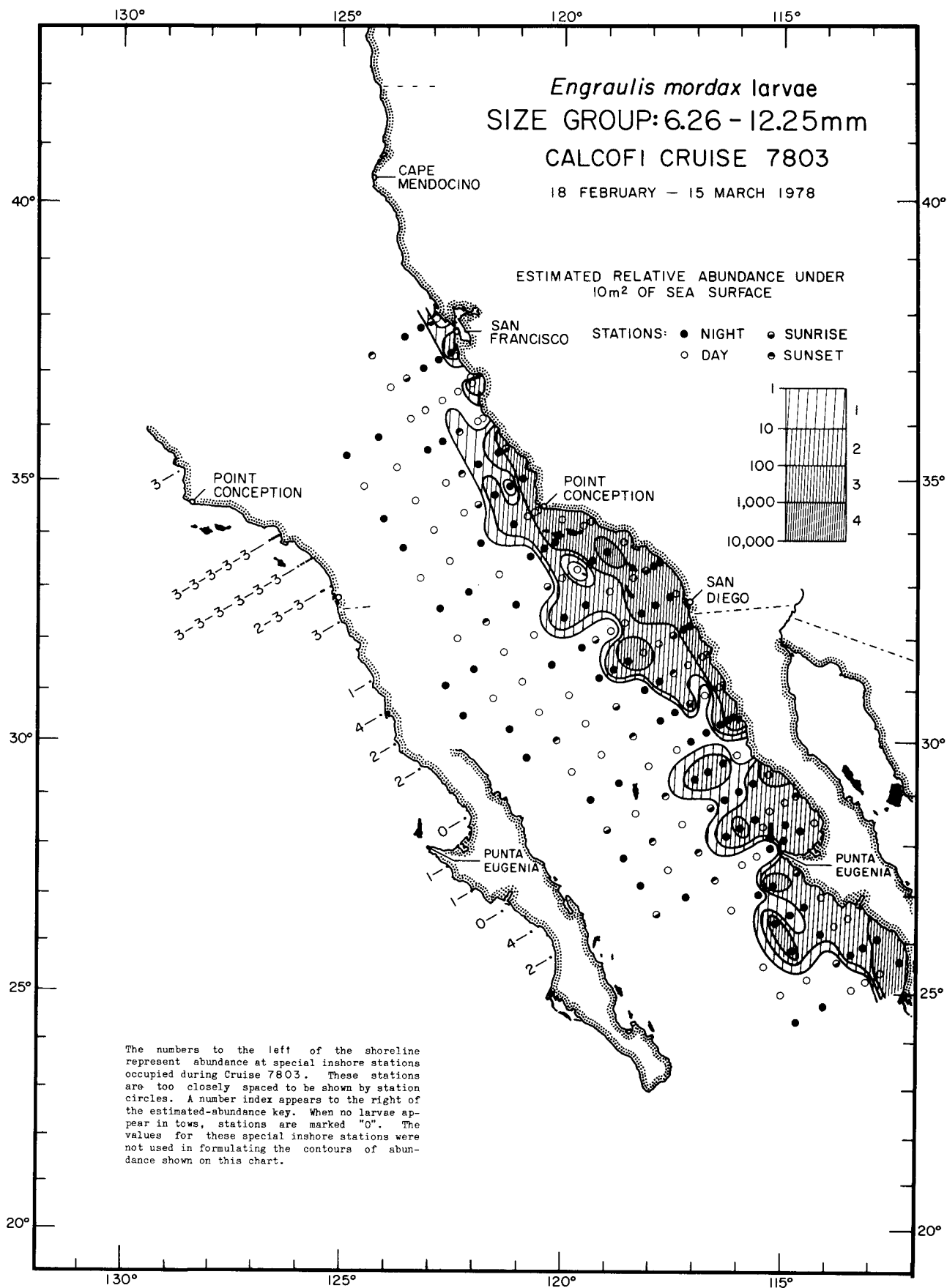
The numbers to the left of the shoreline represent abundance at special inshore stations occupied during Cruise 7801. These stations are too closely spaced to be shown by station circles. A number index appears to the right of the estimated abundance key. When no larvae appear in tows, stations are marked "0". The values for these special inshore stations were not used in formulating the contours of abundance shown on this chart.

Engraulis mordax larvae
Size Group: 6.26-12.25mm
7801

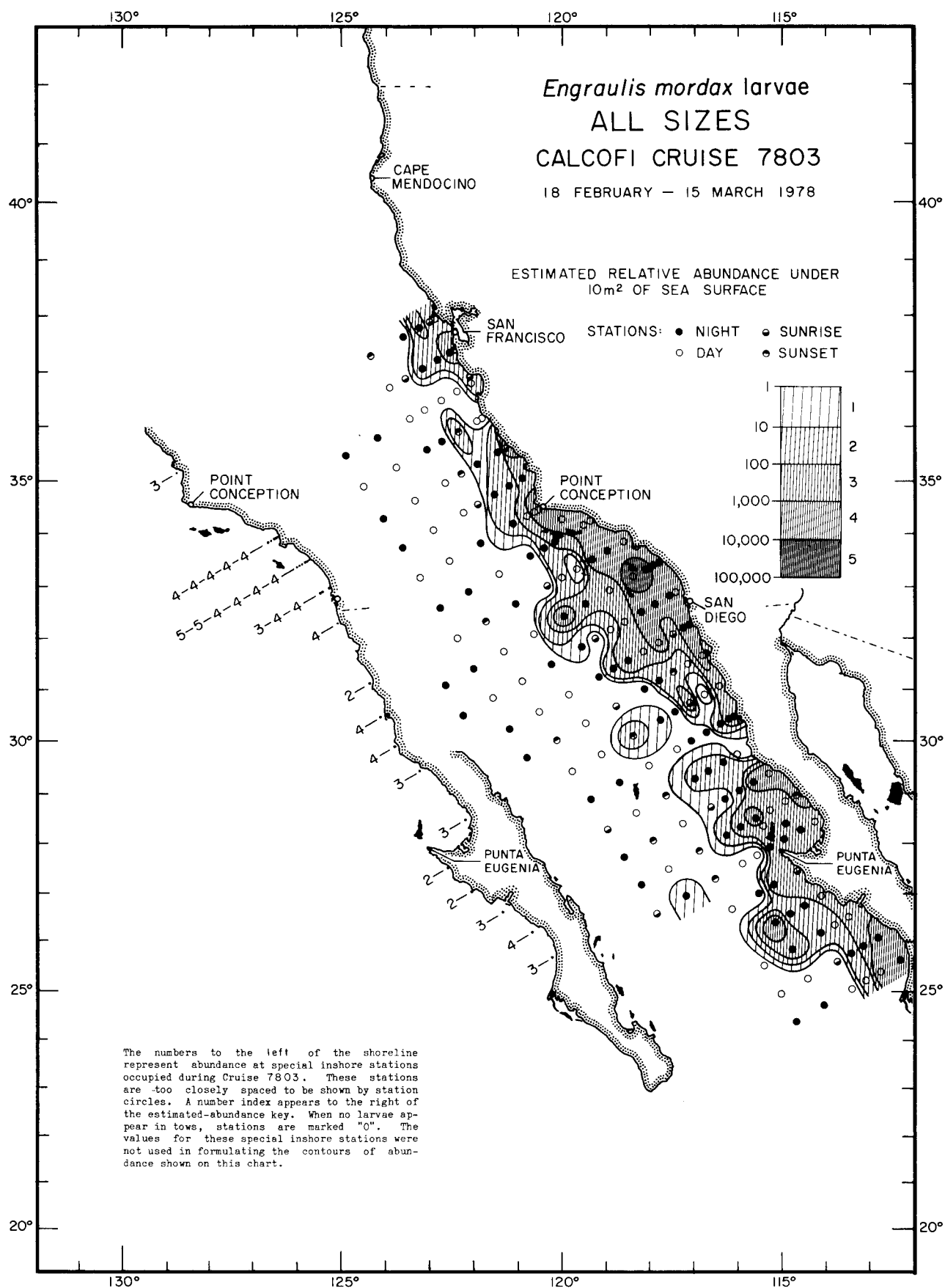
*Engraulis mordax* larvae

All Sizes

7801

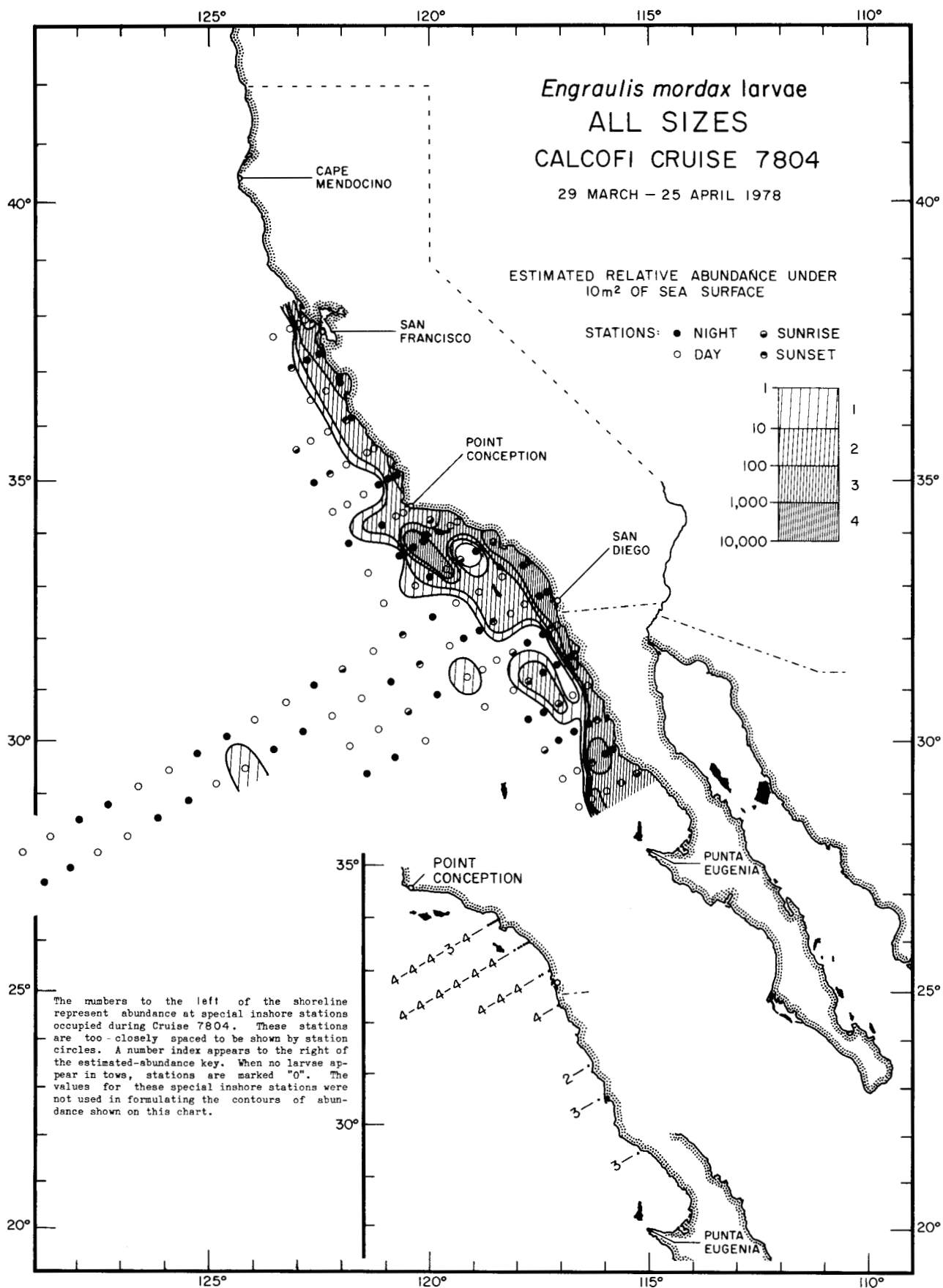


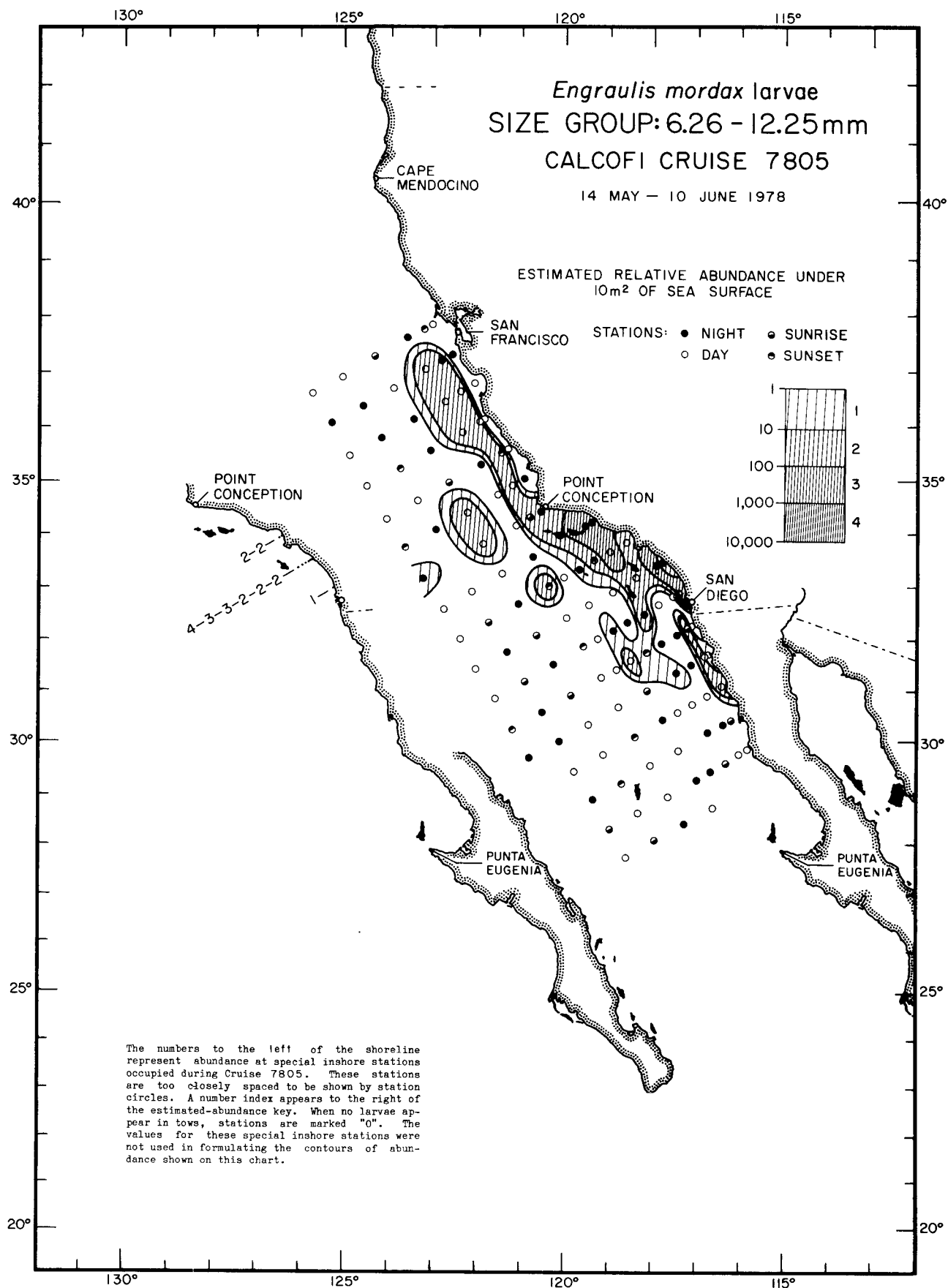
Engraulis mordax larvae
Size Group: 6.26-12.25mm
7803

*Engraulis mordax* larvaeAll Sizes
7803

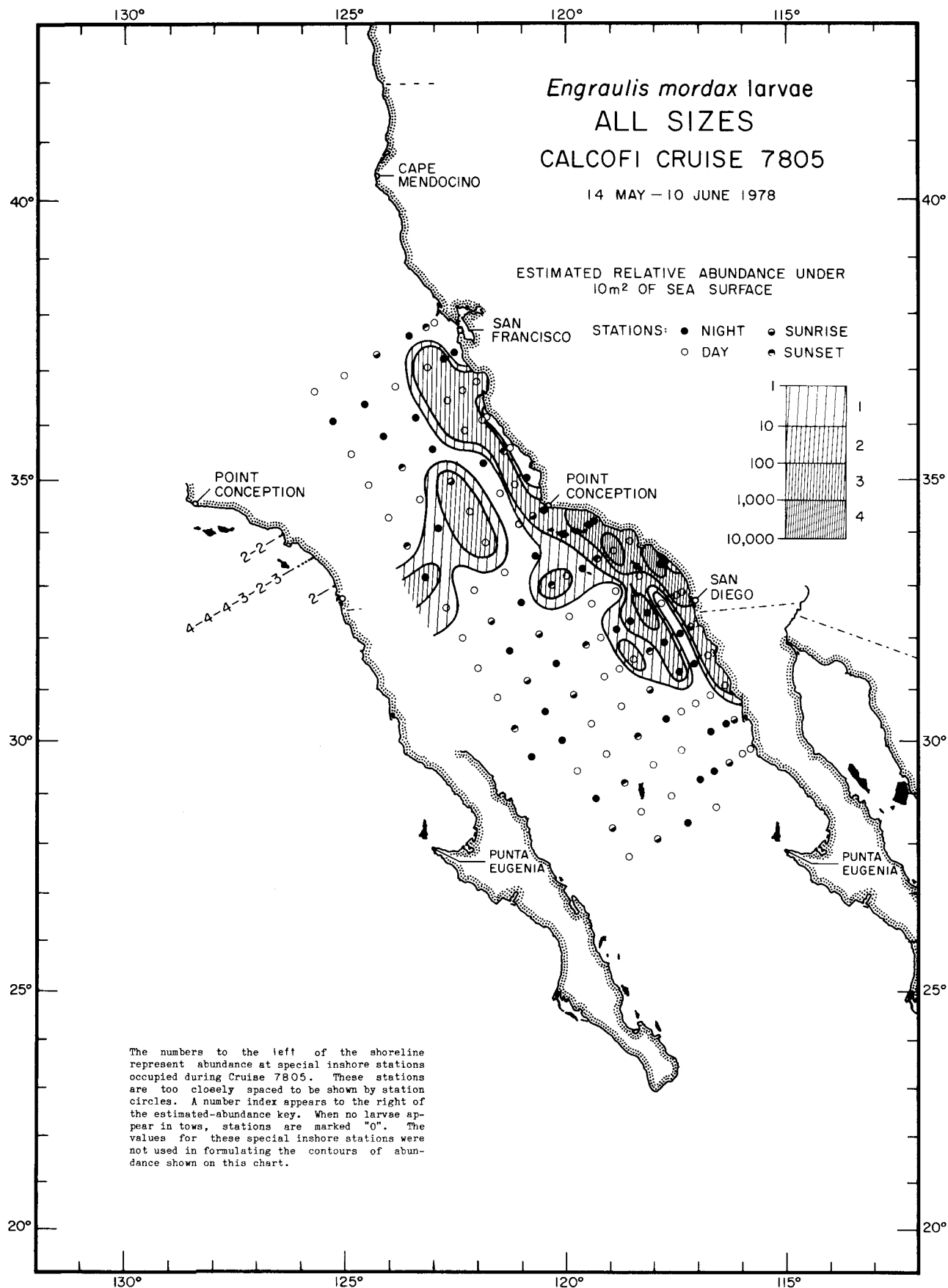
The numbers to the left of the shoreline represent abundance at special inshore stations occupied during Cruise 7804. These stations are too closely spaced to be shown by station circles. A number index appears to the right of the estimated-abundance key. When no larvae appear in tows, stations are marked "0". The values for these special inshore stations were not used in formulating the contours of abundance shown on this chart.

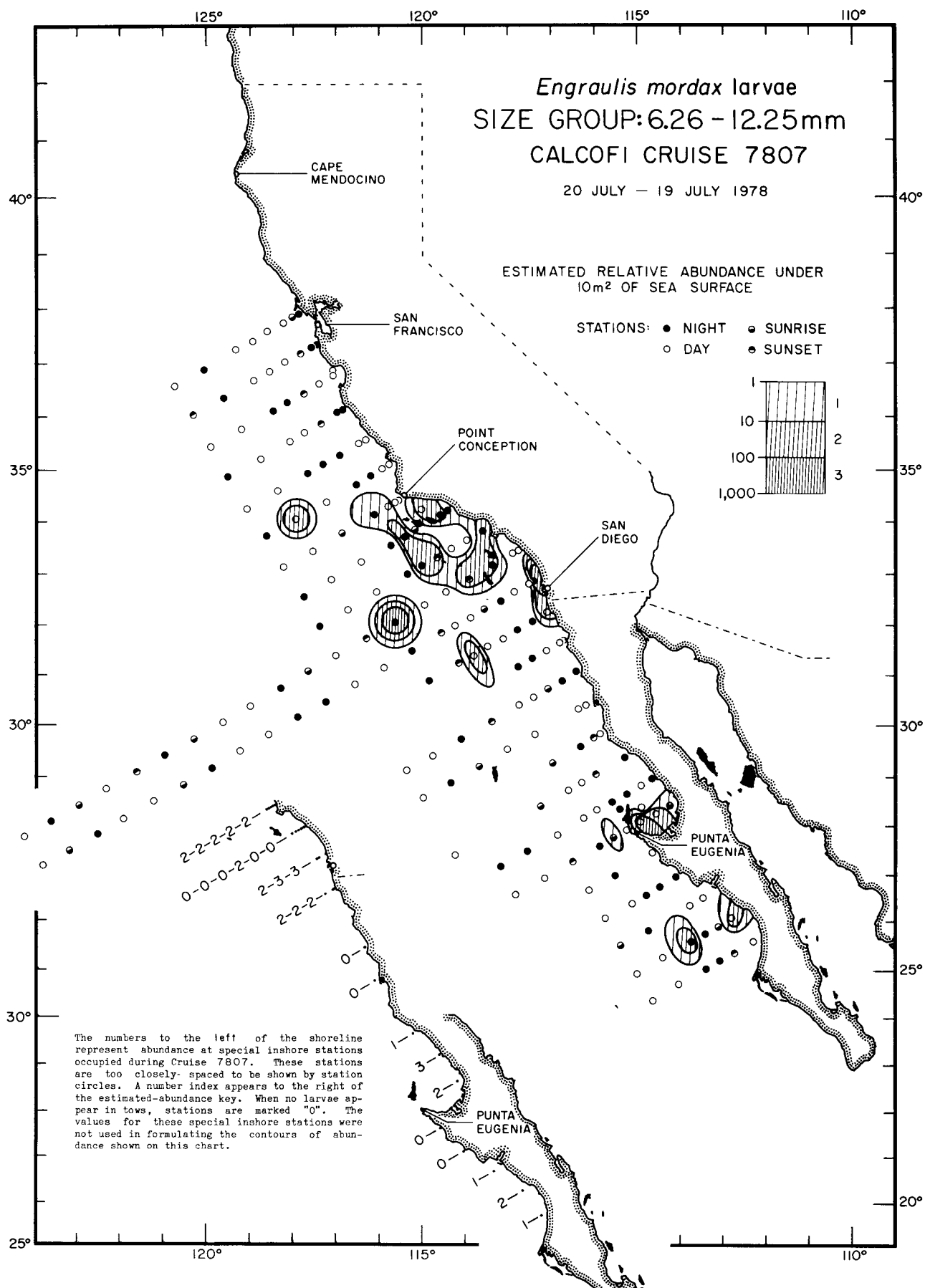
Engraulis mordax larvae
Size Group: 6.26-12.25mm
7804

*Engraulis mordax* larvaeAll Sizes
7804

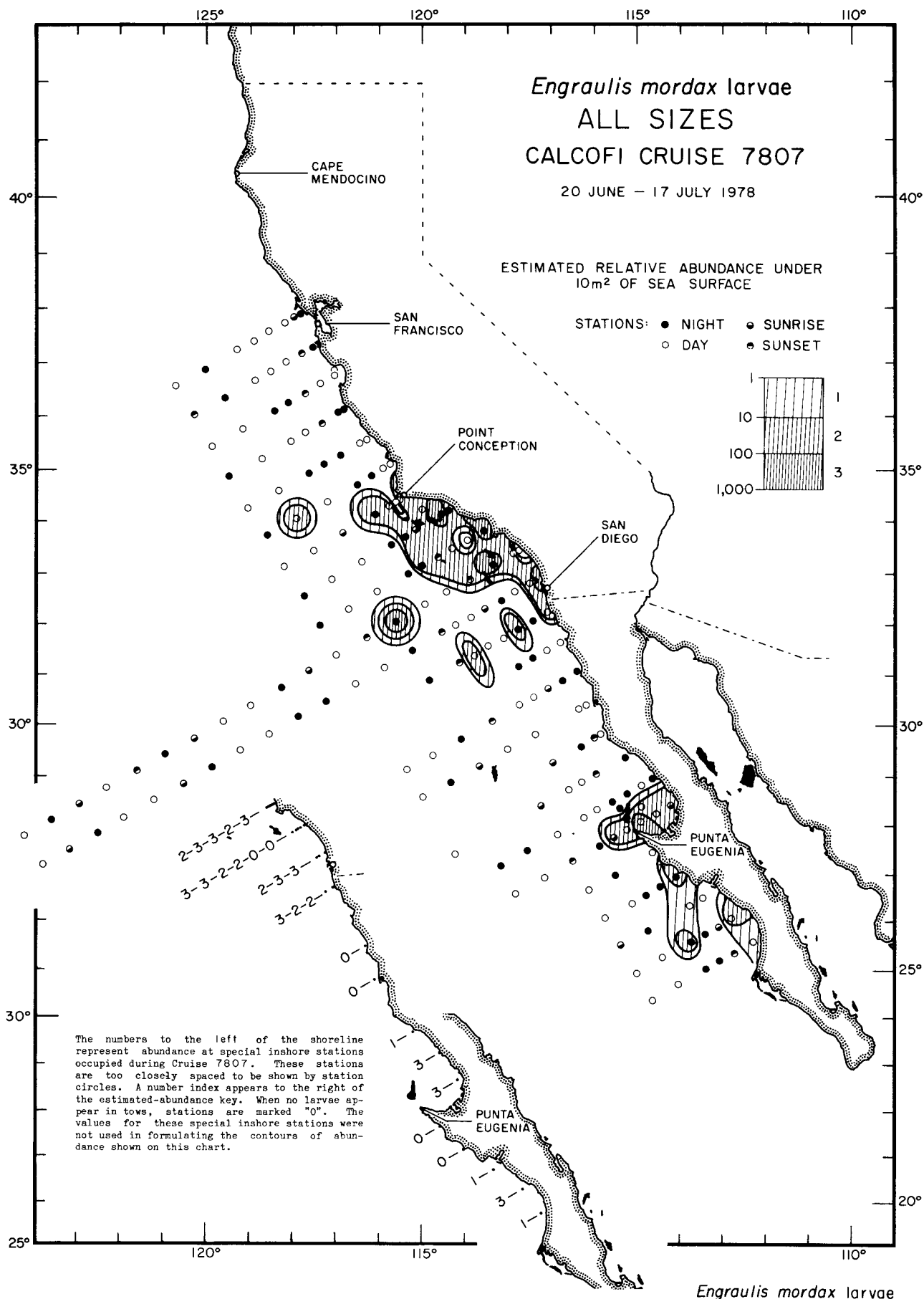


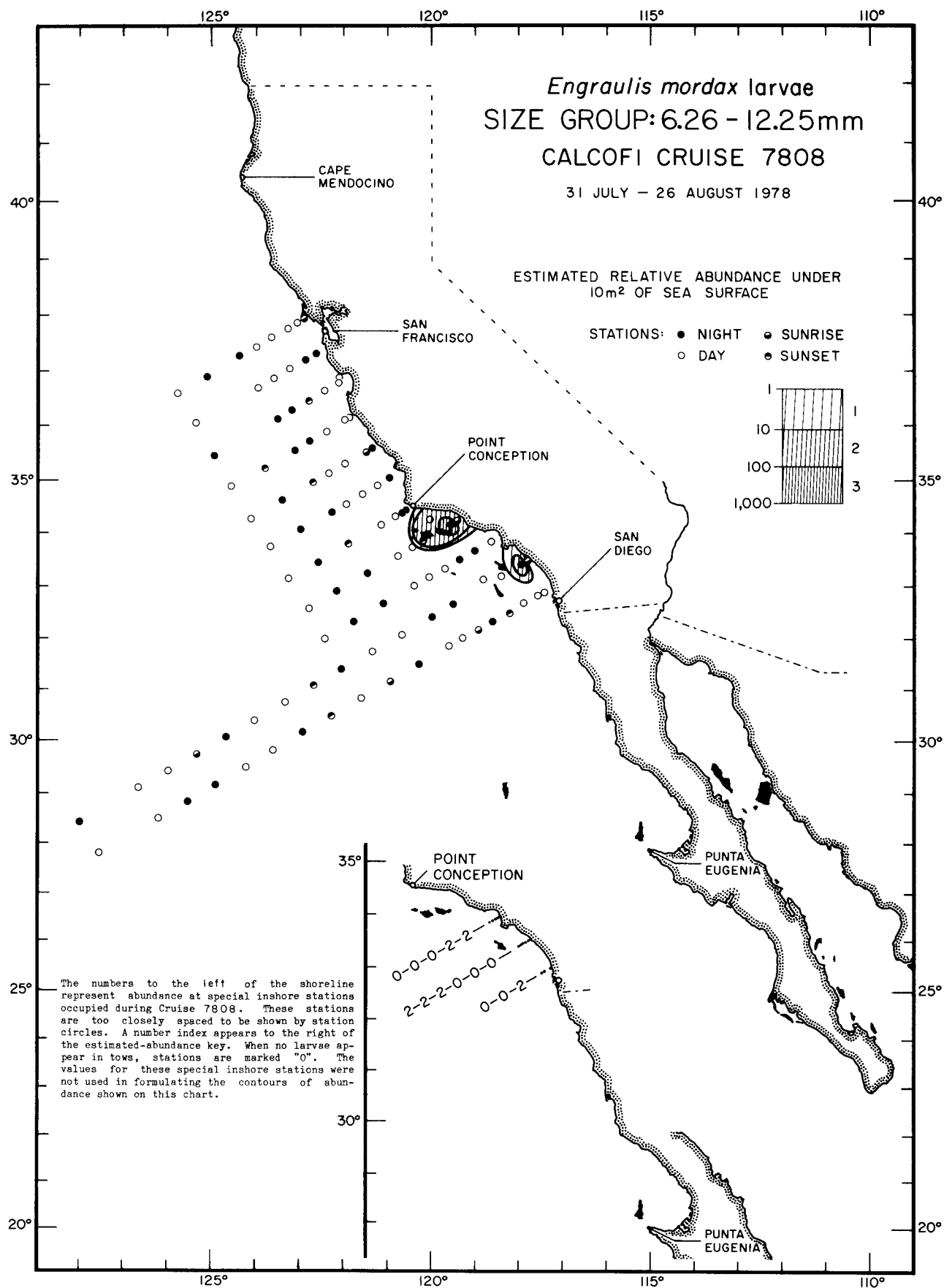
Engraulis mordax larvae
Size Group: 6.26-12.25mm
7805

*Engraulis mordax* larvaeAll Sizes
7805

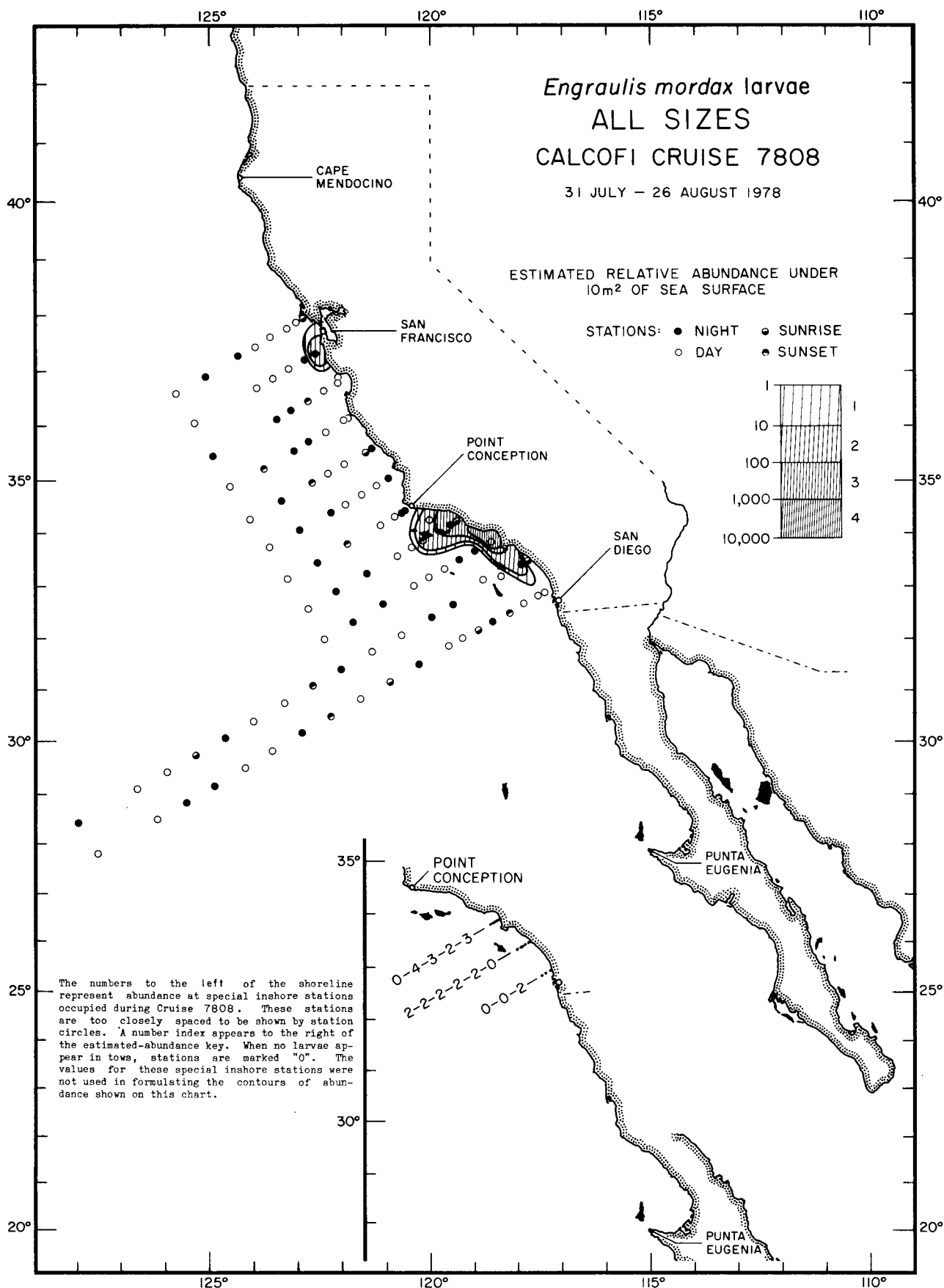


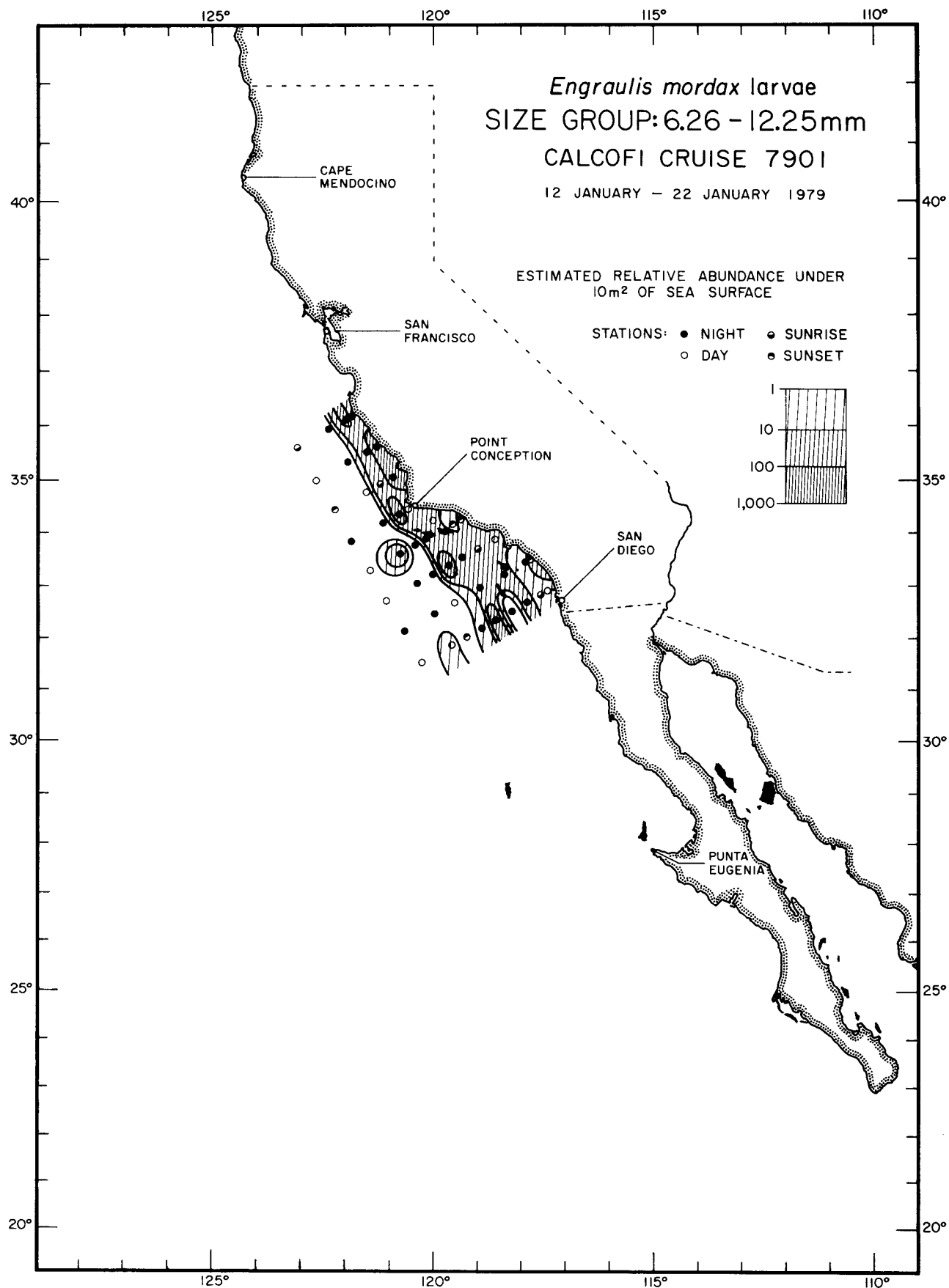
Engraulis mordax larvae
Size Group: 6.26-12.25mm
7807



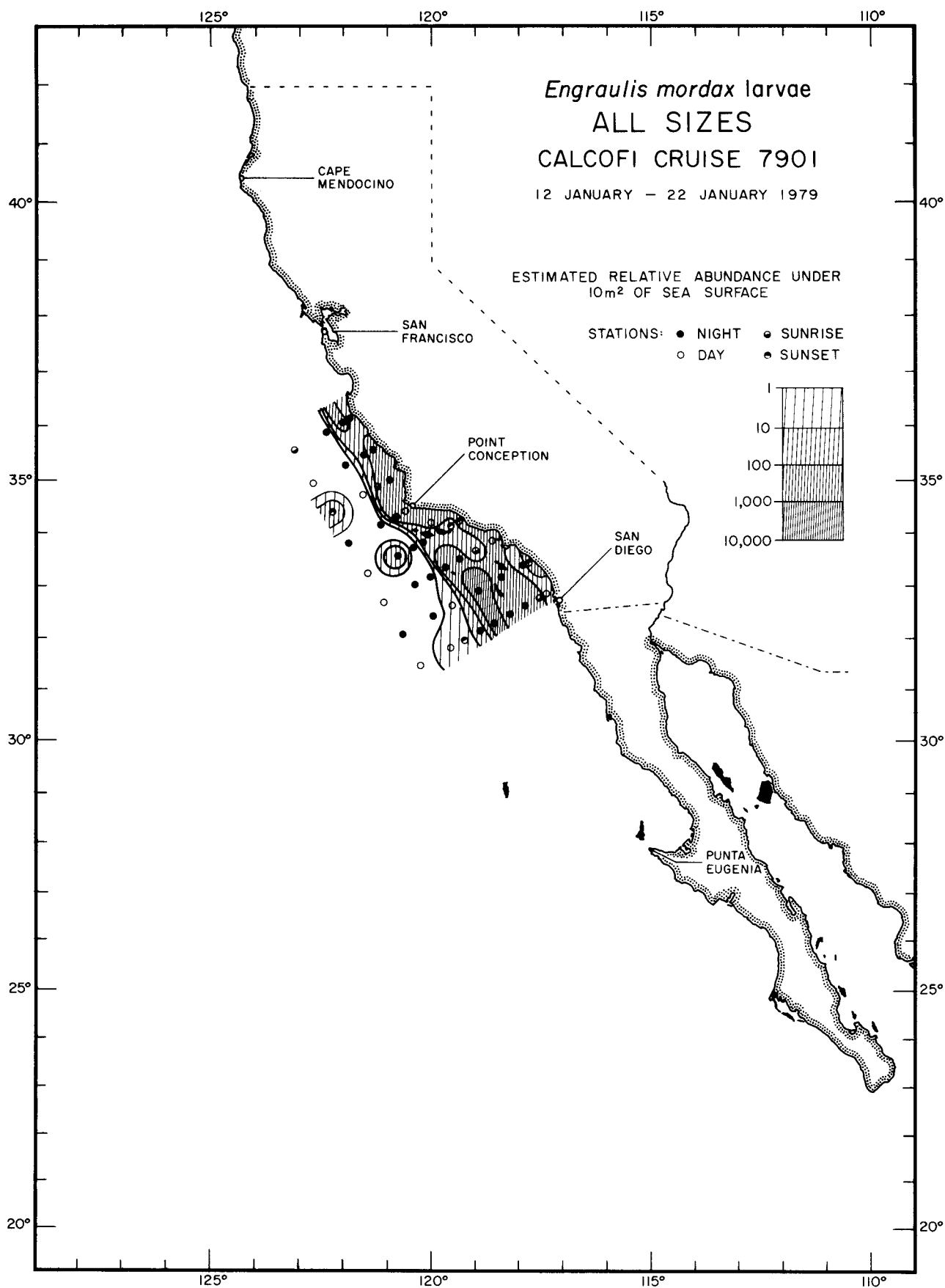


Engraulis mordax larvae
Size Group: 6.26-12.25mm
7808

*Engraulis mordax* larvaeAll Sizes
7808

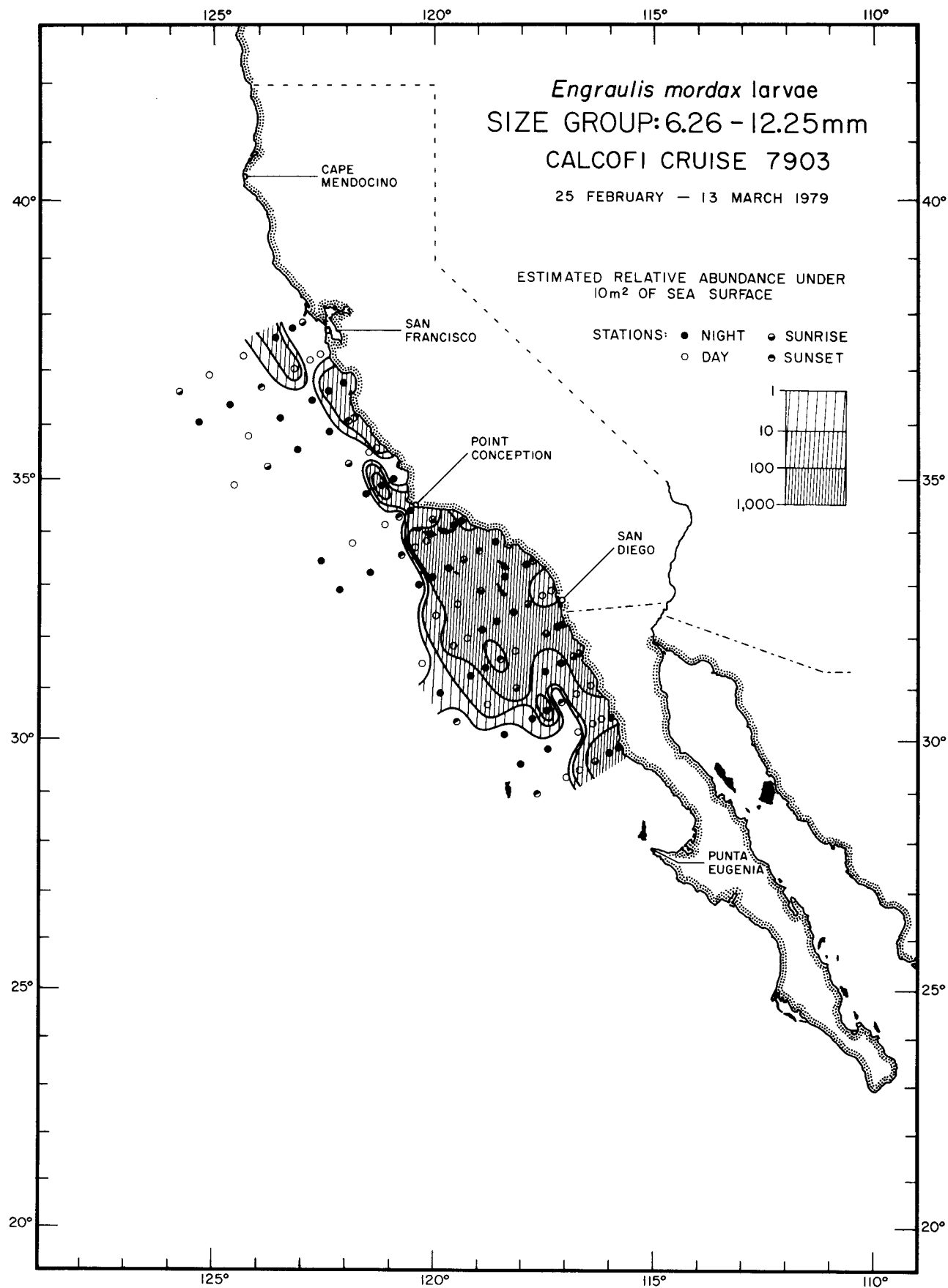


Engraulis mordax larvae
 Size Group: 6.26-12.25mm
 7901

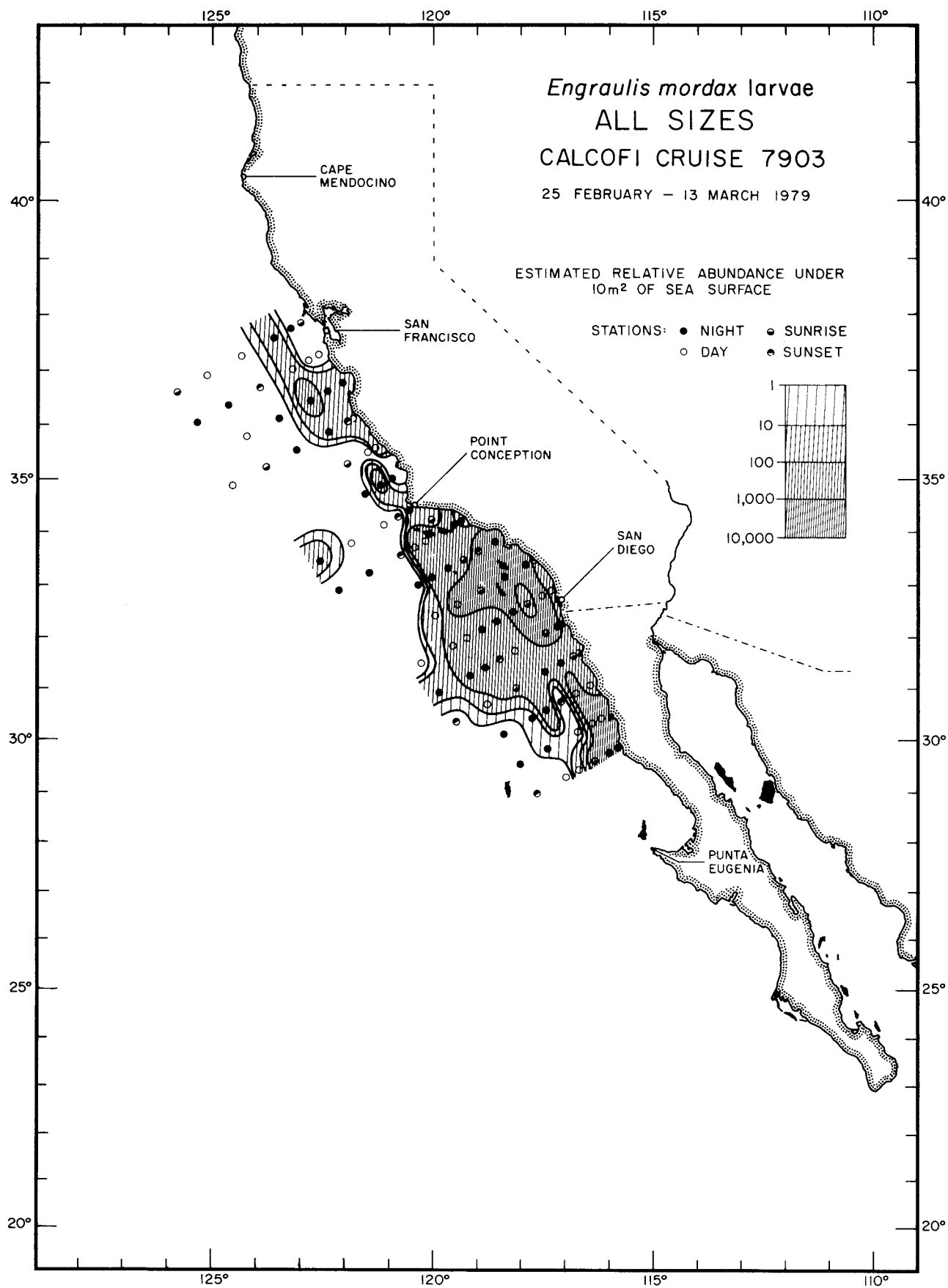
*Engraulis mordax* larvae

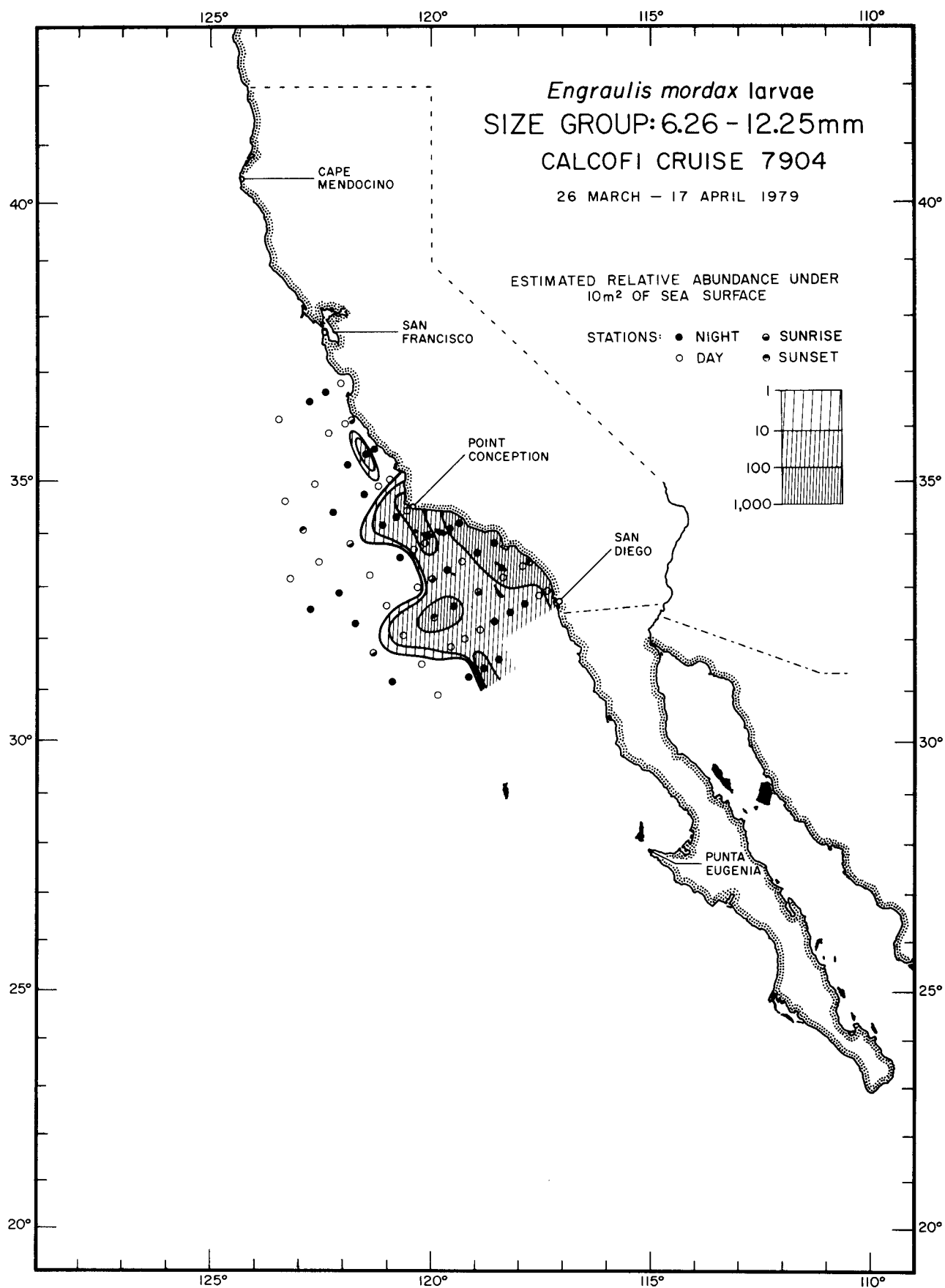
All Sizes

7901

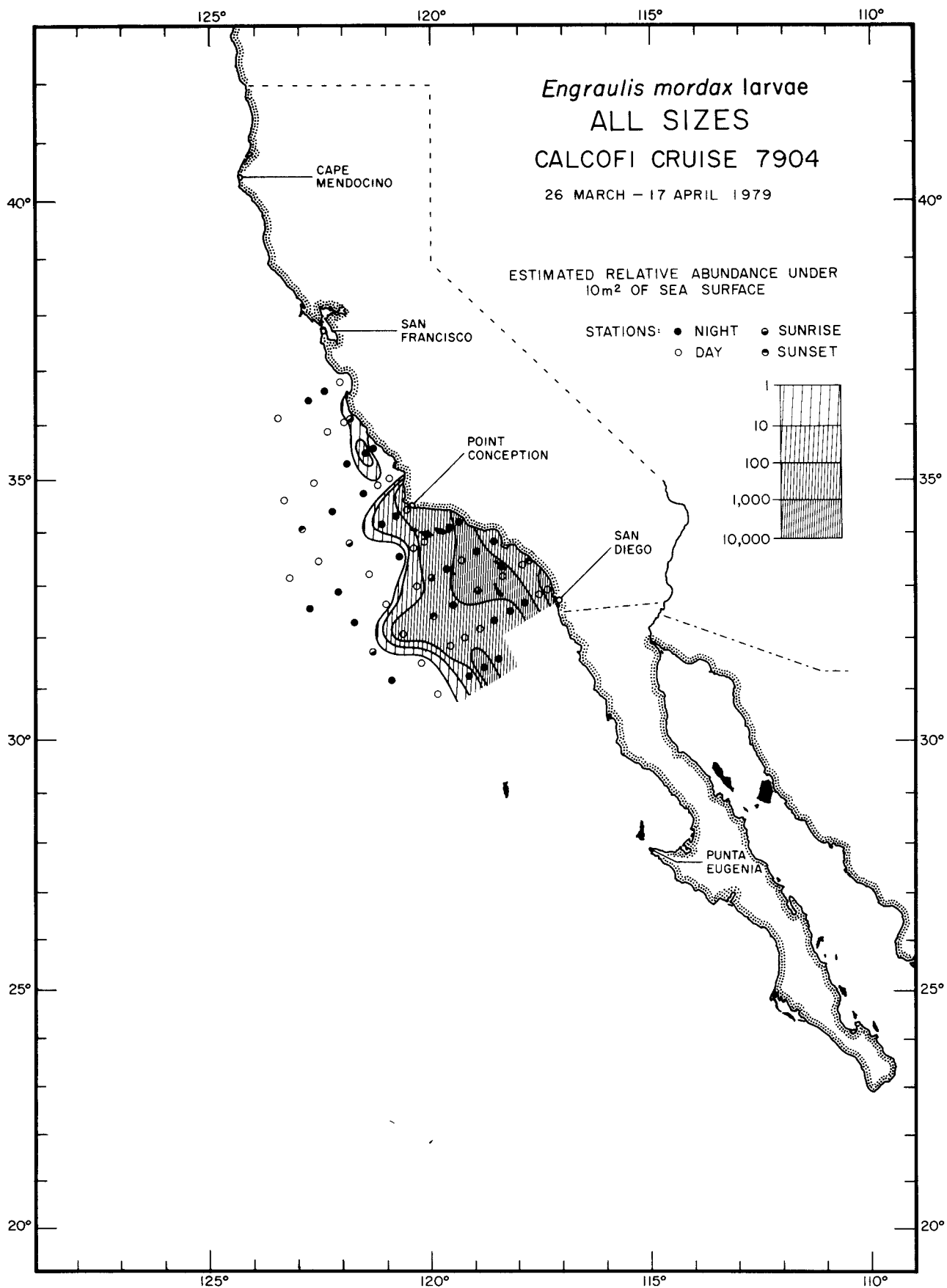


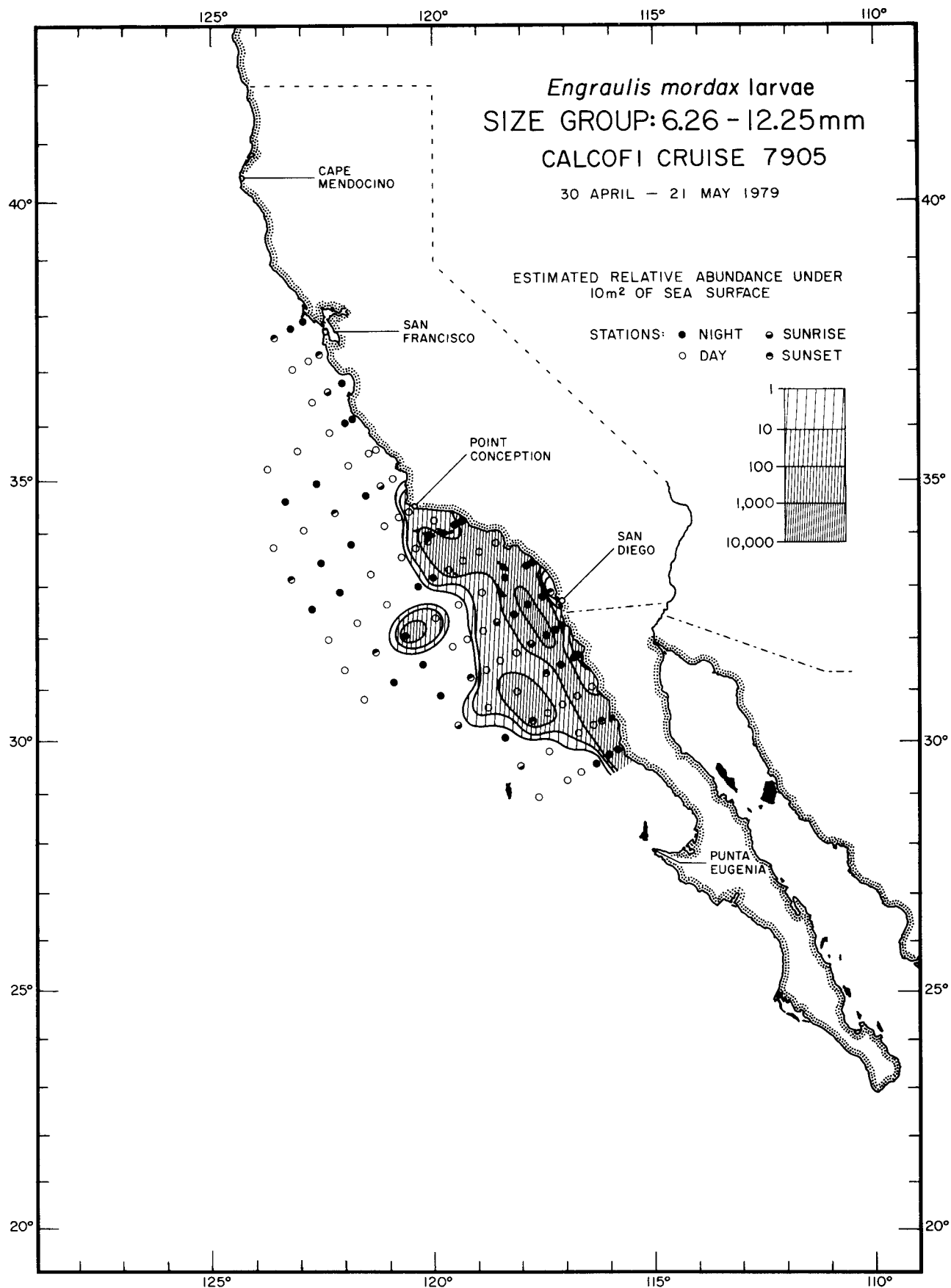
Engraulis mordax larvae
 Size Group: 6.26-12.25mm
 7903

*Engraulis mordax* larvaeAll Sizes
7903

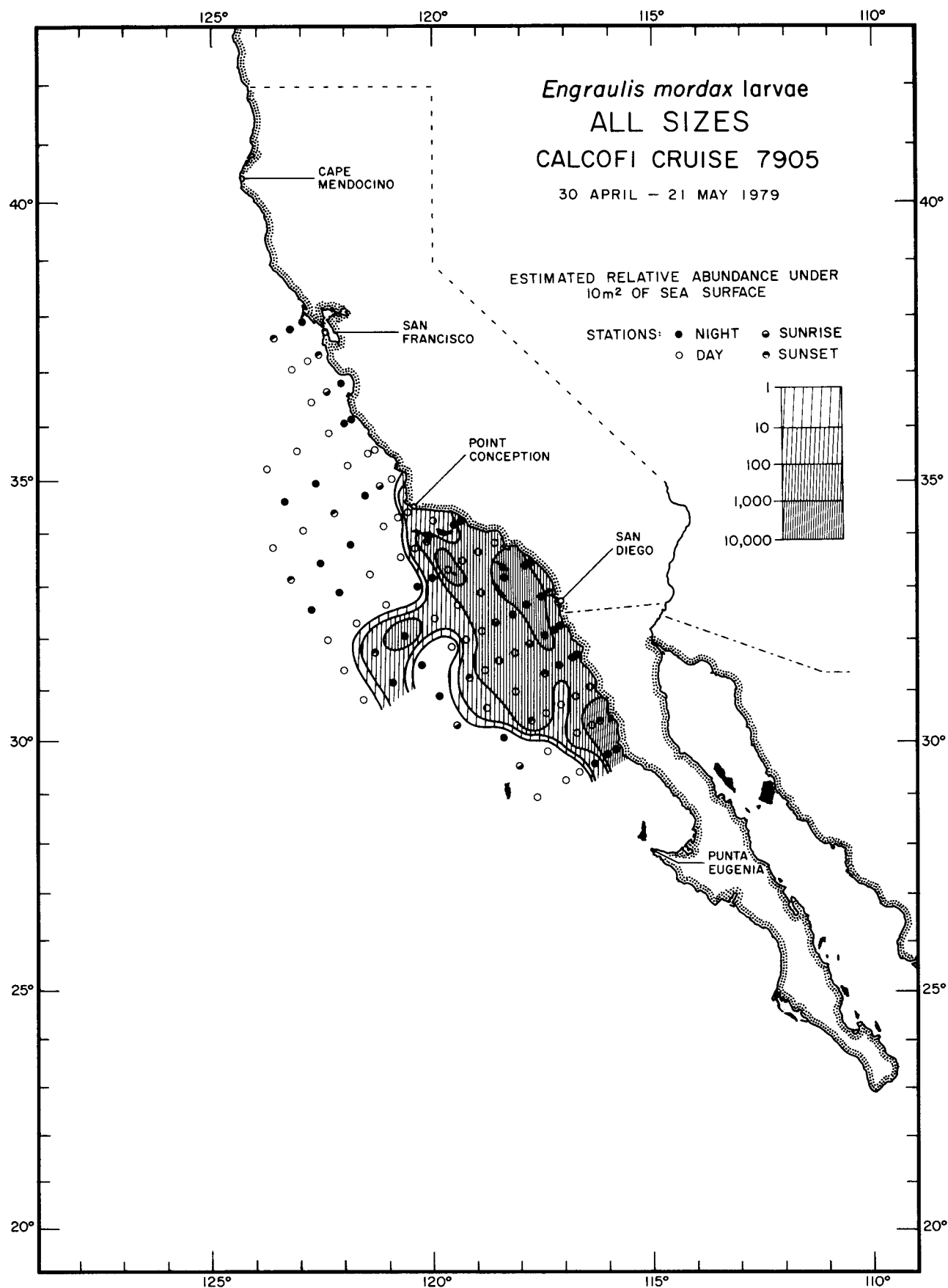


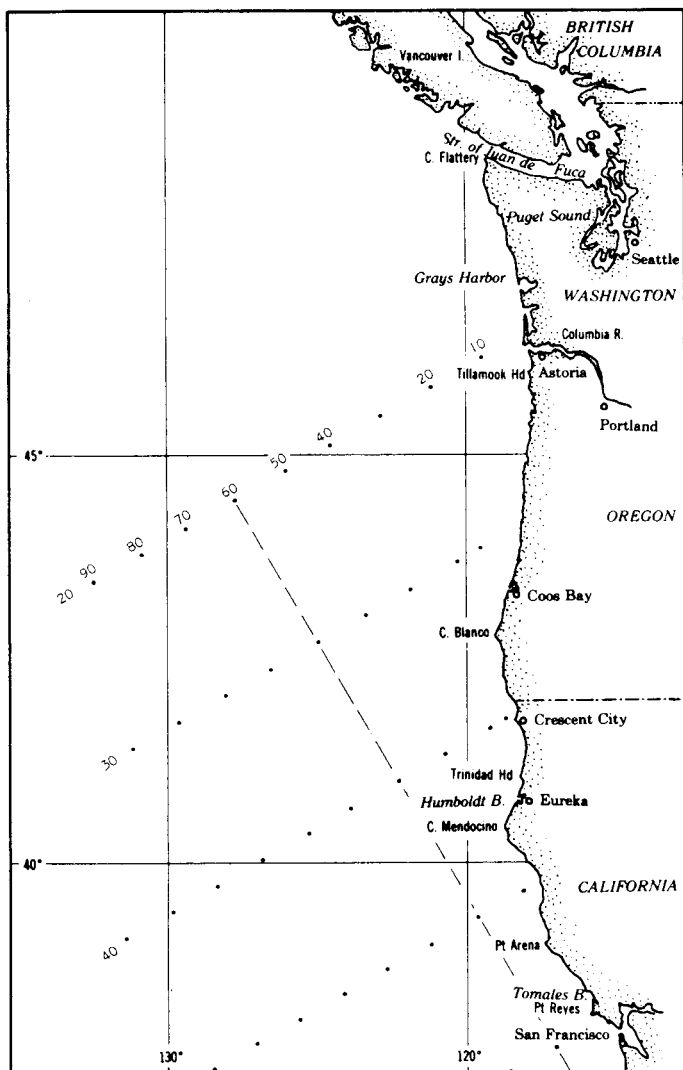
Engraulis mordax larvae
 Size Group: 6.26-12.25mm
 7904

*Engraulis mordax* larvaeAll Sizes
7904



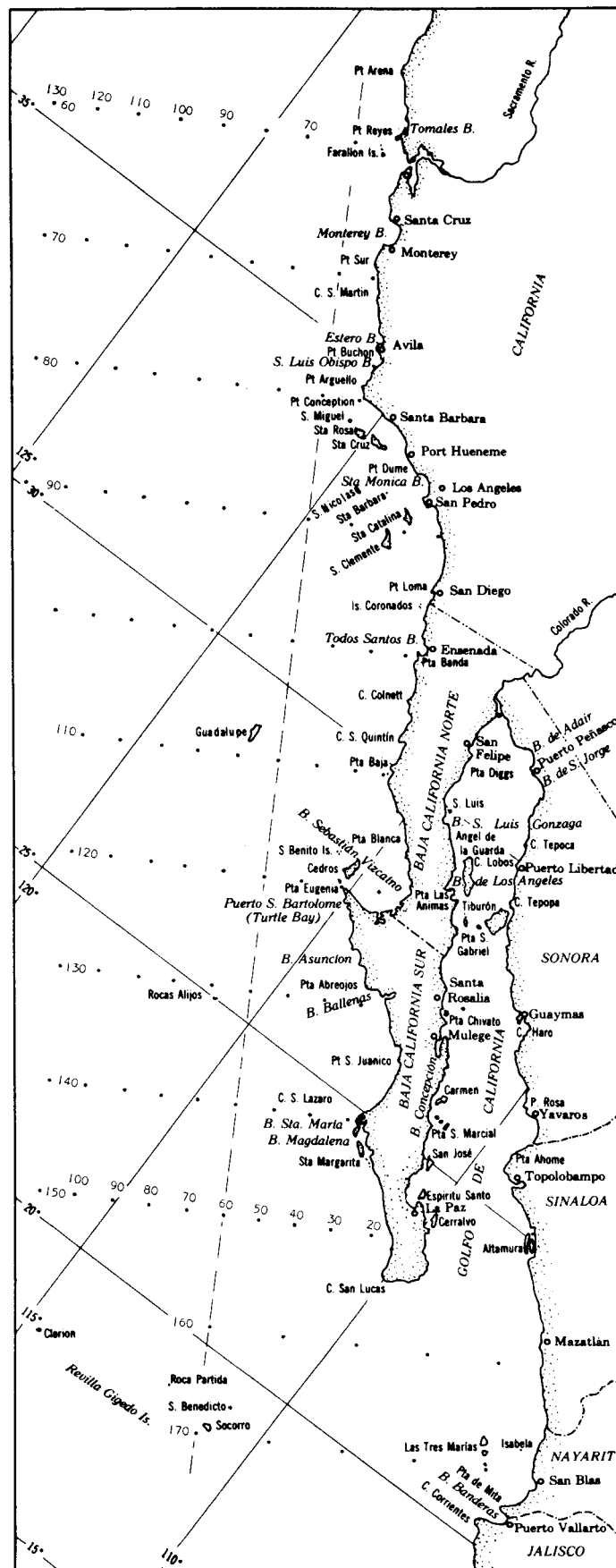
Engraulis mordax larvae
 Size Group: 6.26-12.25mm
 7905

*Engraulis mordax* larvaeAll Sizes
7905



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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Roger Hewitt

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