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TR 79-02

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**SUMMARY OF AN EASTPAC
REFRACTIVE STRUCTURE CLIMATOLOGY**

Wayne Sweet
Naval Environmental Prediction Research Facility

NAVENVPREDRSCHFAC TR 79-02

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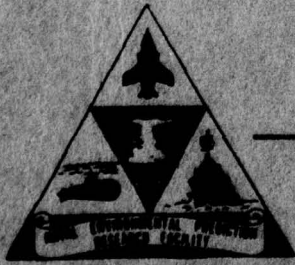
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report summarizes the most pertinent data and information contained in an earlier, in-depth refractive structure climatology, NEPRF TR 2-77 (MII), "Development of a Synoptic Climatology of Tropospheric Refractive Conditions for the Eastern Pacific Ocean off the West Coast of the United States - Tasks One and Two." Refractive structure data for five latitude zones of EASTPAC are given. Paragraph summaries discuss each of the selected statistics.		

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1. Subject reports in which pen and ink changes should be made are:

- AD-AD75456-
- a. TR 79-01, June 1979: Monthly climatology for evaporation duct occurrence in the North Atlantic Ocean
 - b. TR 79-02, July 1979: Summary of an EASTPAC refractive structure climatology
 - c. TR 80-01, February 1980: Anomalous microwave propagation assessment in the lower troposphere using a bulk meteorological parameter
 - d. TR 80-02, July 1980: Meteorological factors affecting evaporation duct height climatologies
 - e. TR 80-05, October 1980: Assessment/forecasting of anomalous microwave propagation in the troposphere using model output

2. On DD Forms 1473 of all subject reports listed in Para. 1 above,

Block 10 should read . . . PE62759N

Block 11 should read . . . Naval Ocean Systems Center
San Diego, CA 92152

Block 14 should read . . . Naval Material Command
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Washington, DC 20360

3. On p. 5 of TR 80-05,

Eq. (1) should read $\Delta N = N_w(T_a) - N_w(T_d)$

Eq. (2) should read $\Delta N = B \left[\frac{e(T_a)}{T_a^2} - \frac{e(T_d)}{T_d^2} \right] - \frac{B \Delta e}{T_a^2}$

adding Δ in Eq. (1), and deleting repeated expression $-\frac{e(T_a)}{T_a^2}$ in Eq. (2).

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1. INTRODUCTION

This technical report summarizes the statistics and the findings for Task One of NEPRF Technical Report TR 2-77 dated April 1977, a final report titled "Development of a Synoptic Climatology of Tropospheric Refractive Conditions for the Eastern Pacific Ocean off the West Coast of the United States" and hereafter referred to as TR 2-77.

Task One is defined as "Statistical Organizations of the Refractive Conditions, by Monthly Periods and Latitude Zones."

The present report considers only those data which are most useful for fleet application. The curves and distributions presented herein are condensed from data given in TR 2-77. Also included in the present report are some added analyses of the basic data input to TR 2-77.

The statistical presentation categorizes refractive structures as one of the following:

Normal -- Radar/radio propagation is normal; standard radar horizon applies.

Ducting -- Radars/radios located within ducting layers experience extended ranges; "holes," or greatly diminished coverage, occur in regions above ducting layer; multi-trip echoes possible.

Superrefractive -- Extended radar/radio horizon; extended target track capability.

Subrefractive -- Decreased radar/radio horizon; restricted target track capability.

2. DATA BASE

The data used to develop this climatology were radiosonde soundings plotted on WBAN-31A adiabatic charts. The radiosondes were launched from radar picket ships stationed off the U.S. west coast during the period 1956-65.

The ships originally were assigned to four stations in a line roughly north-south along longitude 130°W with a fifth station at about 33°N, 124°W; these stations were moved further west about midway in the reporting period. This reassignment, coupled with the vessels' normal 1-2° wandering to avoid bad weather, probably accounts for the geographical spread of soundings indicated in Fig. 1. The extreme outliers apparently indicate observations taken while the ships were in transit to/from their assigned stations.

Because of this scatter, reports were grouped into five latitude zones for statistical analysis as shown in Fig. 1:

- Zone 1 29°-34°30'N
- Zone 2 34°30'-37°30'N
- Zone 3 37°30'-41°N
- Zone 4 41°-46°N
- Zone 5 46°-51°N

This summary does not include the surface duct statistics. An analysis of the data revealed that the frequencies of occurrence of surface ducts given in TR 2-77 do not seem reasonable when compared with other sources of data (e.g., fleet experience in the SOCAL OPAREA). Among several possible reasons for this disparity is the radiosonde's inherent inability to assess the atmospheric

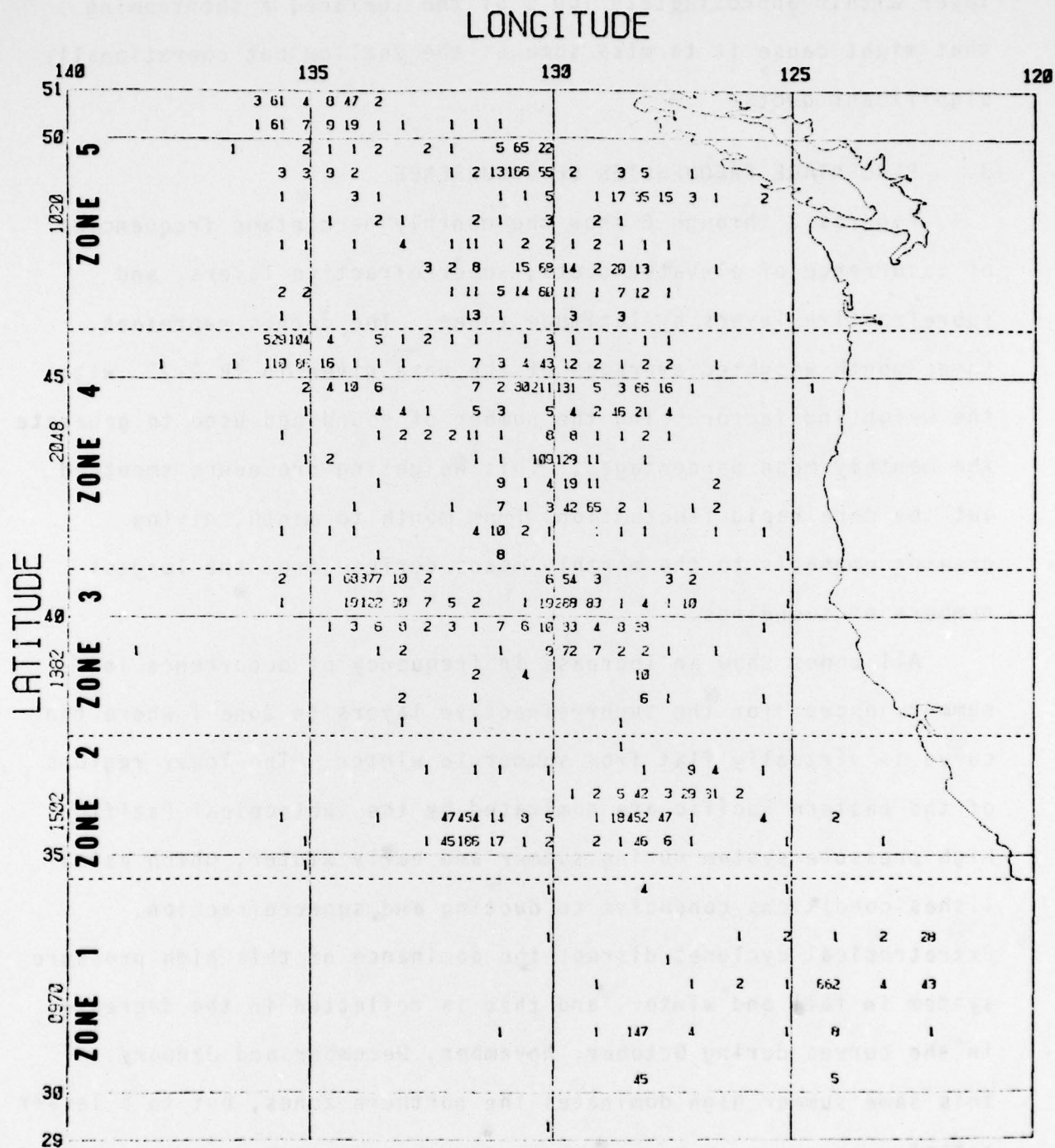


Figure 1. Geographical distribution of radiosonde reports for all months, October 1956-June 1965.

layer within approximately 100 m of the surface, a shortcoming that might cause it to miss some of the shallow but operationally significant ducts.

3. PERCENTAGE FREQUENCIES OF OCCURRENCE

Figures 2 through 6 show the monthly percentage frequencies of occurrence of elevated ducts, superrefractive layers, and subrefractive layers by latitude zones. The curves represent three-month weighted averages of the data given in TR 2-77, with the weighting factor being the number of soundings used to generate the monthly mean percentages. This weighting procedure smoothed out the more rapid fluctuations from month to month, giving greater emphasis to the monthly means derived from the largest numbers of soundings.

All zones show an increase in frequency of occurrence in summer, except for the superrefractive layers in Zone 1 where the curve is virtually flat from summer to winter. The lower regions of the eastern Pacific are dominated by the subtropical Pacific high pressure system during summer and early winter, which establishes conditions conducive to ducting and superrefraction. Extratropical cyclones disrupt the dominance of this high pressure system in fall and winter, and this is reflected in the decrease in the curves during October, November, December and January. This same summer high dominates the northern zones, but to a lesser extent.

The effects of latitude on percentage frequencies of occurrence are shown in Table 1. All three non-normal refractive classifications show a general and steady decrease as the latitudes

increase. This is to be expected, since the northern zones are more affected by the extratropical storm systems that break down the atmospheric stability necessary for ducting and superrefraction.

Table 1. Percentages of occurrence of elevated ducts, superrefractive layers, and subrefractive layers, by latitude zone, for all months.

Zone	Duct	Super	Sub
1	53	64	34
2	36	64	32
3	23	59	30
4	15	50	29
5	9	40	22

4. PERCENTAGE FREQUENCY DISTRIBUTIONS

The percentage frequency distributions of base heights and thicknesses of elevated ducts and superrefractive layers for the five latitude zones are shown in Figures 7 through 11. Only the distributions for the two extreme seasons of summer (June, July, August) and winter (December, January, February) are given, because spring and fall are largely transition seasons between the two extremes.

The heavy, dark line is the median of the distribution, which is determined by ranking the observed values in ascending order and determining the one value that has an equal number of observations above and below it. The mean, which is the average value of all observations, is more affected by infrequent higher ducts and thus is not a good statistic to use to quantify the distribution. The median, in contrast, is only very slightly affected by these rare events.

The interquartile range (IQR) is shown on the distributions by the lines labeled 25% and 75%. The 25% line indicates the point below which 25% of the observed heights occurred, and the 75% line is the point above which the upper 25% of the observed heights occurred. The middle 50% (the IQR) provides an indication of the spread in the distribution.

The modes, which are the most frequently occurring groups, are readily visible as the tallest bars on the graphs.

The design of Figures 7-11 thus allows four values of the refraction parameters of duct/layer base height/thickness to be defined in one diagram: median, the midpoint value; IQR, an indication of variation; mode, the values that occur most frequently; and the percentage frequency of distribution.

5. ELEVATED DUCTS

5.1 Heights

The percentage frequency distributions for elevated duct base heights (Figure 7) reveal broad interquartile ranges, and somewhat flatter distributions. With the exception of Zone 1, the summer interquartile range is slightly larger, which indicates a greater dispersion of the ducts' heights during the summer months. Most of the height distributions reveal no one single dominant mode, and some have several cells of equal frequency. The medians show a general but slight increase in height with increasing latitude. Conclusions:

(1) Elevated duct base heights for all five zones vary greatly, generally in the range 300-1400 m.

(2) The winter IQRs seem to have a narrower distribution (except in Zone 1).

(3) Bases above 1500 m are unlikely.

(4) The median value should be used as a starting point to check for anomalous propagation. A search 300-400 m each side of this value should be made, when real-time assessment is not possible.

(5) Fewer ducts can be expected in the higher latitudes, Zones 4 and 5 (also see Table 1).

5.2 Thicknesses

The thickness distributions of elevated ducts (Fig. 8) are more peaked than those for the base heights. A narrow IQR and a dominant mode are indicated by the data in most cases. Conclusions:

(1) A slight but general decrease in median thickness occurs with increasing latitude.

(2) The symmetrical distribution about the mode and median implies a preferred thickness centered on the median (with the exception of summer in Zone 5).

(3) A range of the median plus and minus 100 m can be used to estimate the probable thickness values.

6. SUPERREFRACTIVE LAYERS

6.1 Base Heights

The distributions (Fig. 9) are nearly flat (or uniform) with large IQRs. Medians are scattered about a range of values 1000-1400 m, with no apparent trend based on changing latitudes. Conclusions:

(1) Superrefraction can be expected at almost any altitude below 2000 m.

(2) No significant change in the distribution should be expected because of change in latitude.

6.2 Thicknesses

The layer thickness distributions (Fig. 10) have many of the same characteristics as those for duct thickness. Conclusions are basically the same, except that no latitudinal trend in the median is indicated.

7. SUBREFRACTIVE LAYERS

7.1 Base Heights

The distributions for the subrefractive layer base heights are virtually flat from above 50 m up to 3000 m, so their plots are not included. The IQR is 1000-1700 m, and the medians vary in the range 1600-2200 m. The data suggest no particular range of base heights, which seem to occur anywhere from 50 m up to 3500 m.

7.2 Thicknesses

The thickness distributions (Fig. 11) show a slight skewness. IQRs are 150-250 m, with medians centered around 150-200 m.

Conclusions:

(1) Subrefractive layers are equally likely to occur at any height below 3500 m.

(2) Thicknesses of these layers will be in the range 50-300 m.

(3) Layer occurrence is not dependent on either season or latitude.

8. SUMMARY

8.1 Elevated Ducts

Elevated duct base heights vary arbitrarily between 300 and 1400 m; bases above 1500 m are unlikely. IQRs for winter seem to have narrower distribution than those for summer. Fewer ducts occur as latitude increases.

Duct thickness distributions are more peaked than those of the base heights. Median thickness decreases slightly as latitude increases.

8.2 Superrefractive Layers

Height distributions are nearly uniform. Medians are scattered about values of 1000-1400 m and apparently are not latitude dependent.

Thickness distributions are much the same as those for elevated ducts, except that no latitudinal trends in median are evident.

8.3 Subrefractive Layers

Subrefractive layer heights show a nearly uniform distribution from about 50 m up to 3 km. IQRs are 1500-1700 m. Medians vary in the range 1600-2200 m. No preferred base heights are evident in the data.

Thickness distributions show a slight positive skewness, with a thickness variation of 50-300 m. No seasonal or latitudinal dependence are evident in the data.

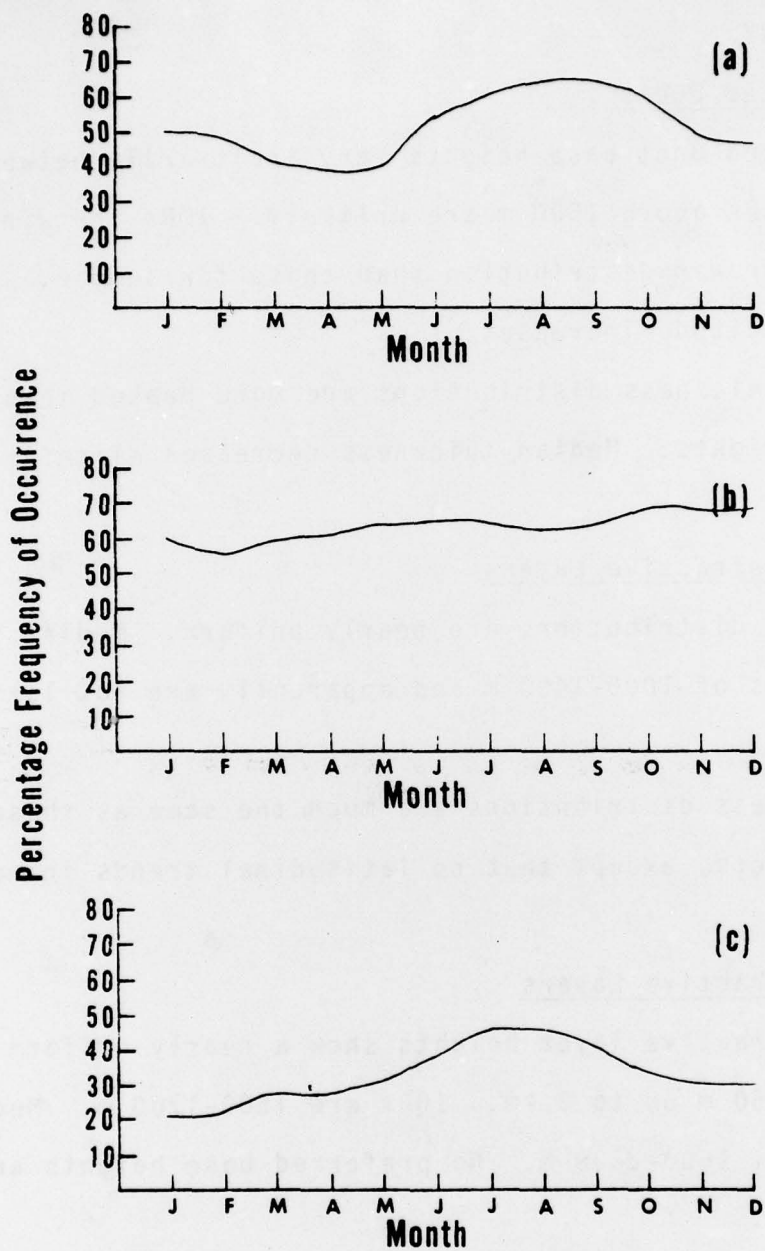


Figure 2. Monthly percentage frequencies of occurrence in Zone 1 of (a) elevated ducts, (b) elevated superrefractive layers, and (c) elevated subrefractive layers. Monthly figures = averages of three months weighted by monthly number of soundings.

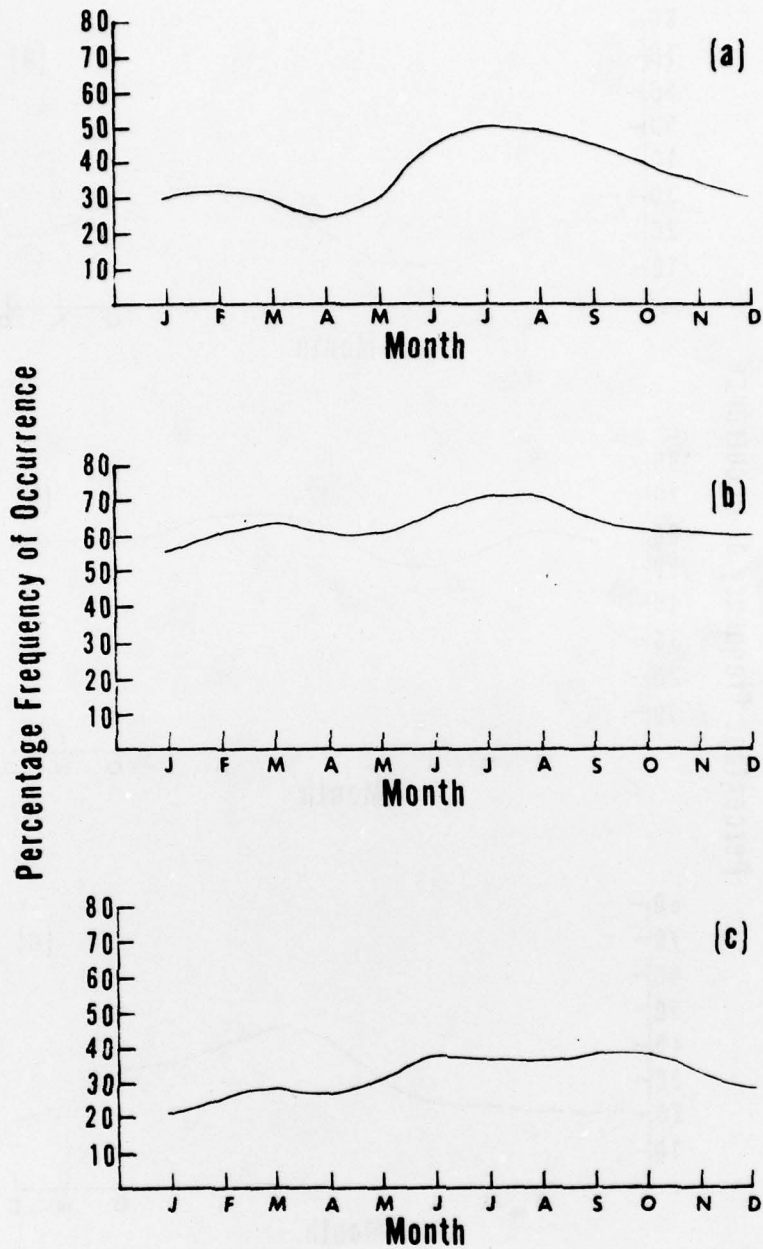


Figure 3. Monthly percentage frequencies of occurrence in Zone 2 of (a) elevated ducts, (b) elevated superrefractive layers, and (c) elevated subrefractive layers. Monthly figures = averages of three months weighted by monthly number of soundings.

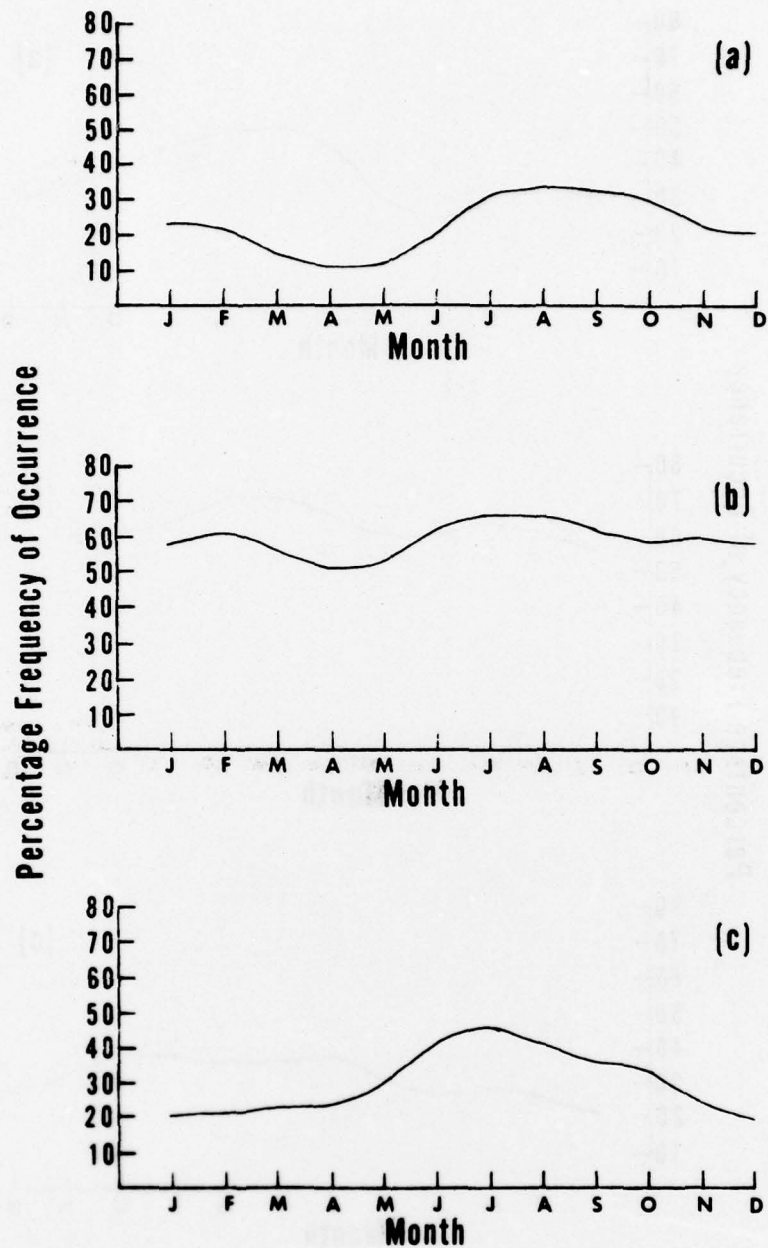


Figure 4. Monthly percentage frequencies of occurrence in Zone 3 of (a) elevated ducts, (b) elevated superrefractive layers, and (c) elevated subrefractive layers. Monthly figures = averages of three months weighted by monthly number of soundings.

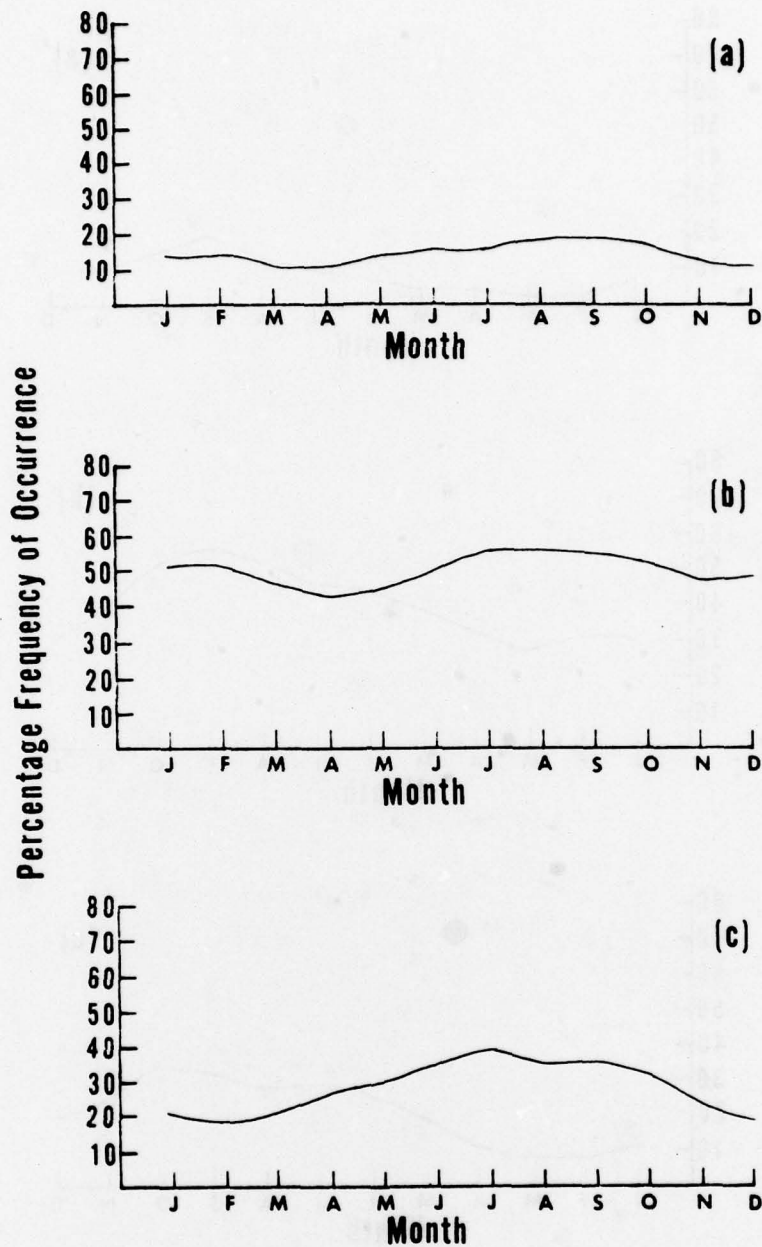


Figure 5. Monthly percentage frequencies of occurrence in Zone 4 of (a) elevated ducts, (b) elevated superrefractive layers, and (c) elevated subrefractive layers. Monthly figures = averages of three months weighted by monthly number of soundings.

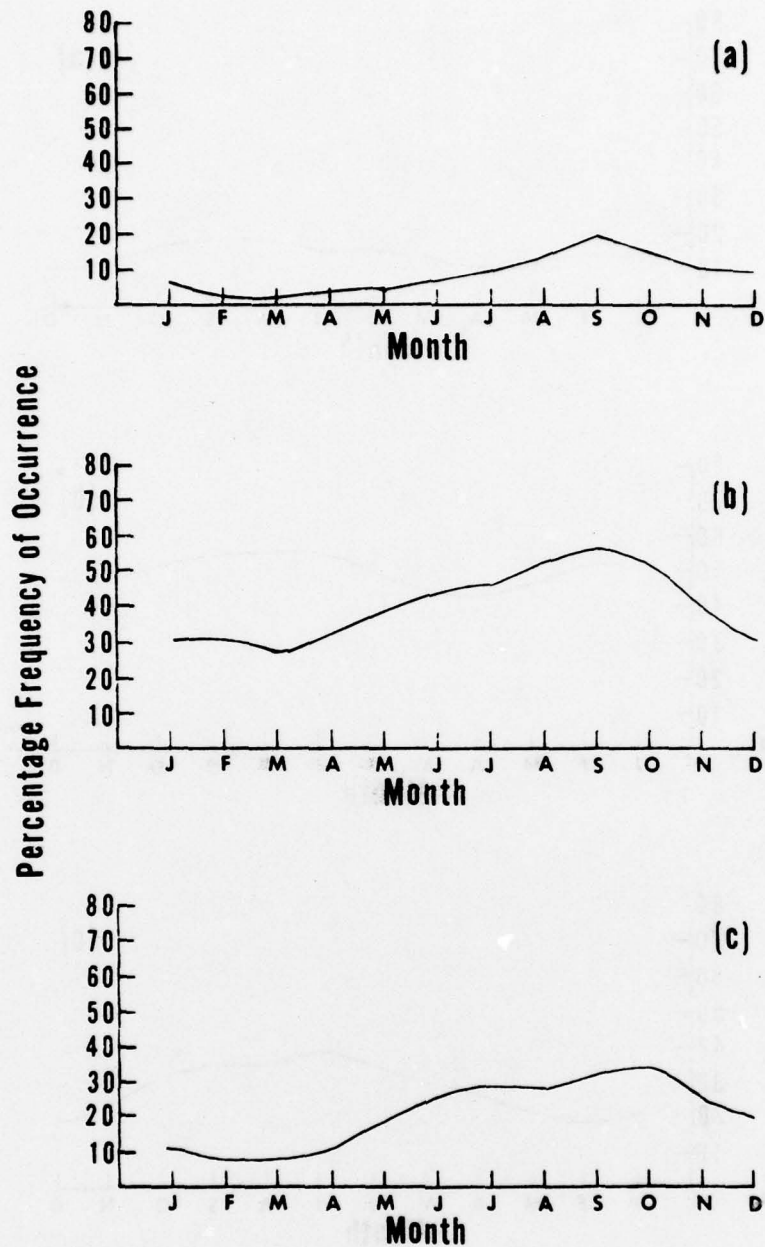


Figure 6. Monthly percentage frequencies of occurrence in Zone 5 of (a) elevated ducts, (b) elevated superrefractive layers, and (c) elevated subrefractive layers. Monthly figures = averages of three months weighted by monthly number of soundings.

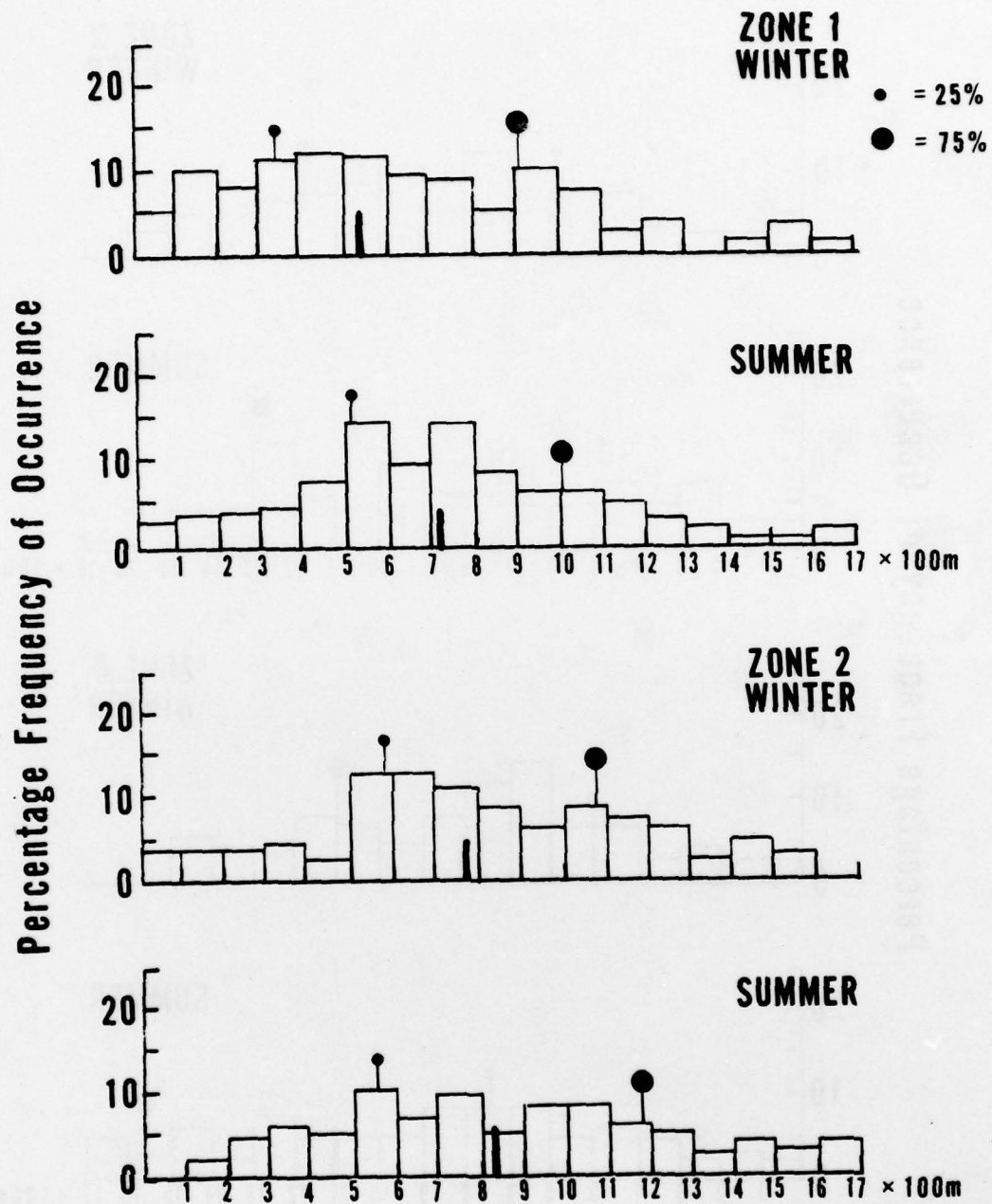


Figure 7. Percentage frequencies of occurrence of base heights of elevated ducts. Medians of distributions shown by $\bar{|}$. Lower and upper limits of interquartile ranges indicated by \bullet and \bullet . (See text, Para. 4.)

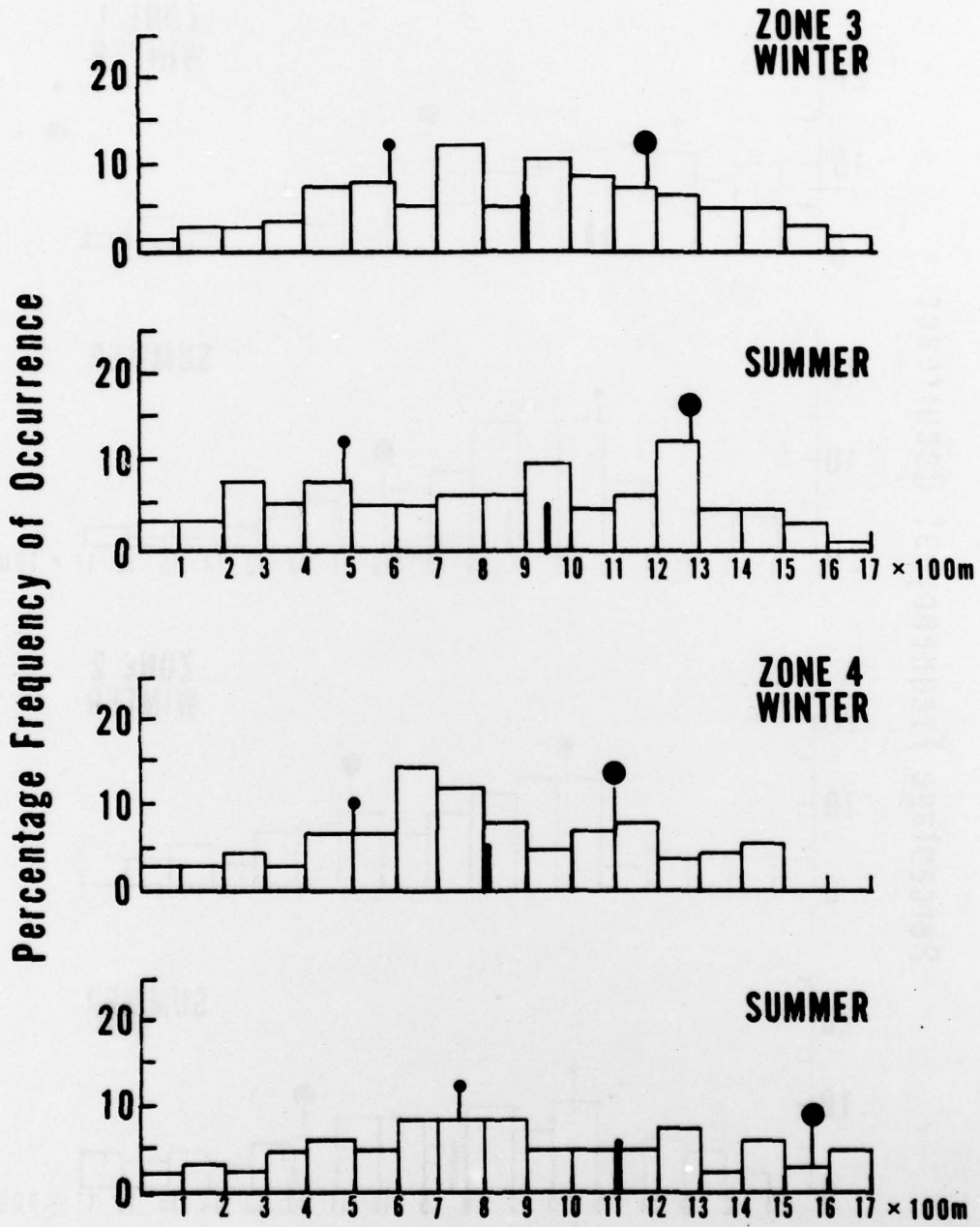


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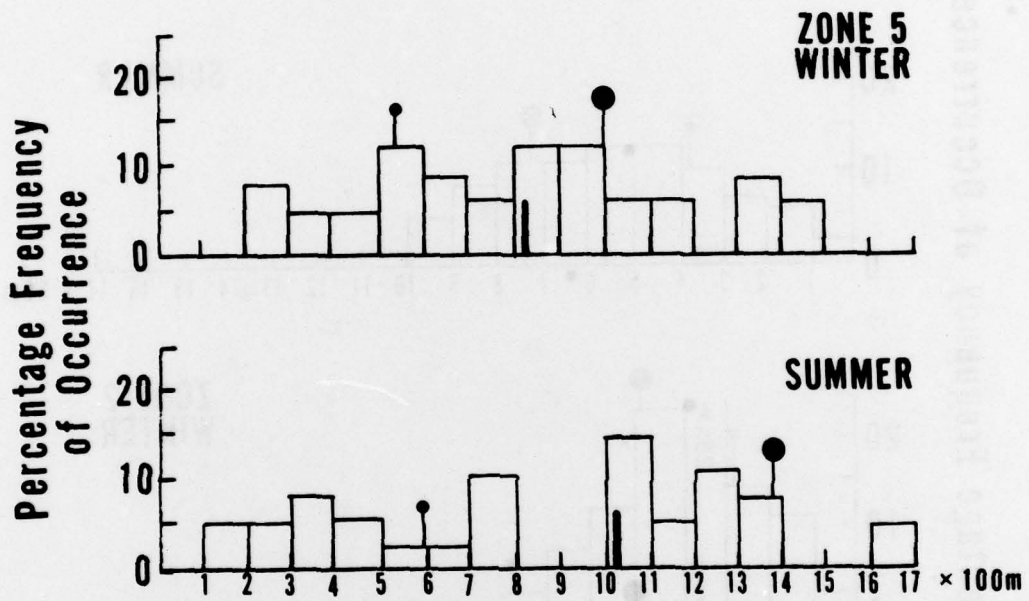


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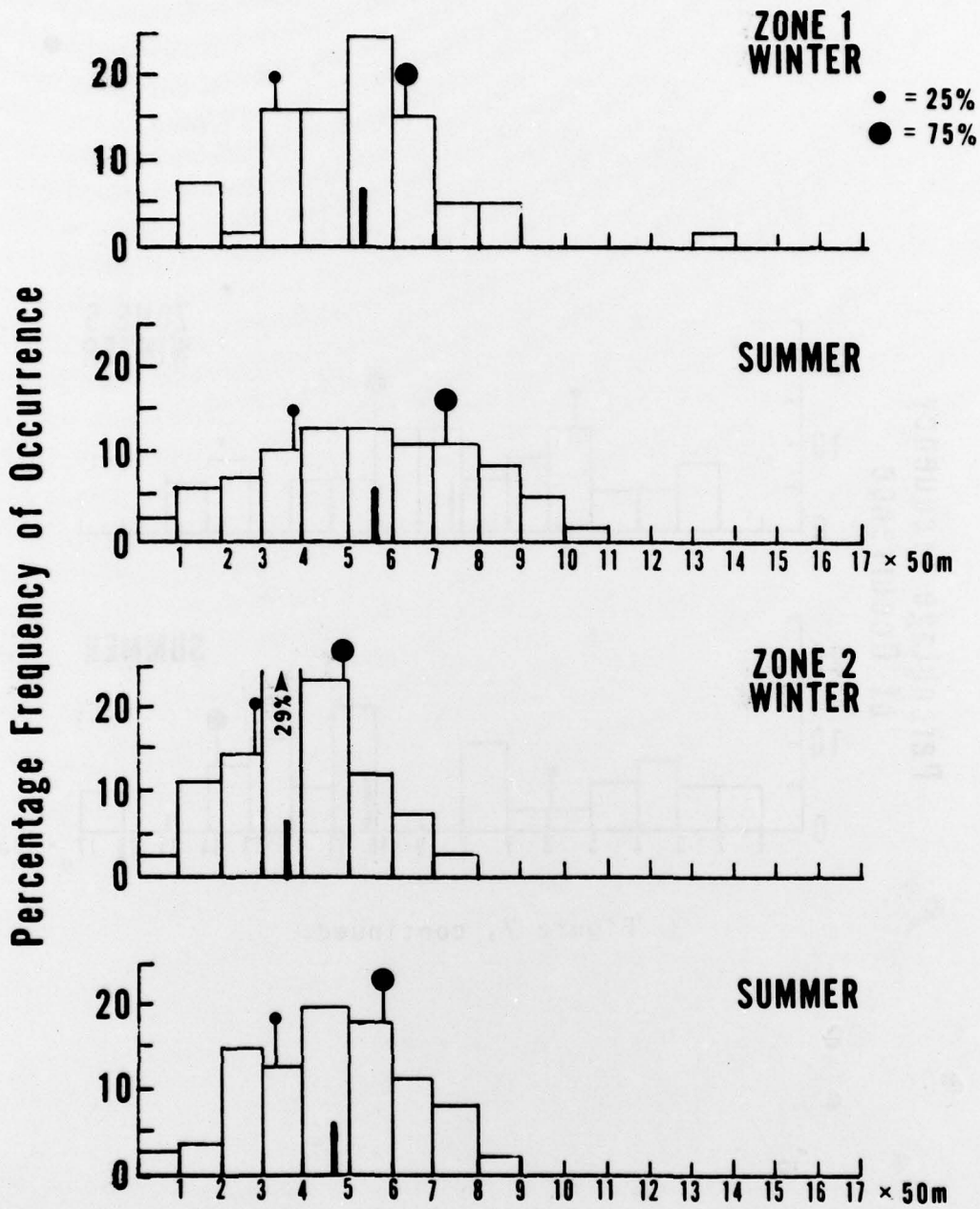


Figure 8. Percentage frequencies of occurrence of thickness of elevated ducts. Medians of distributions shown by |. Lower and upper limits of interquartile ranges indicated by • and ●. (See text, Para. 4.)

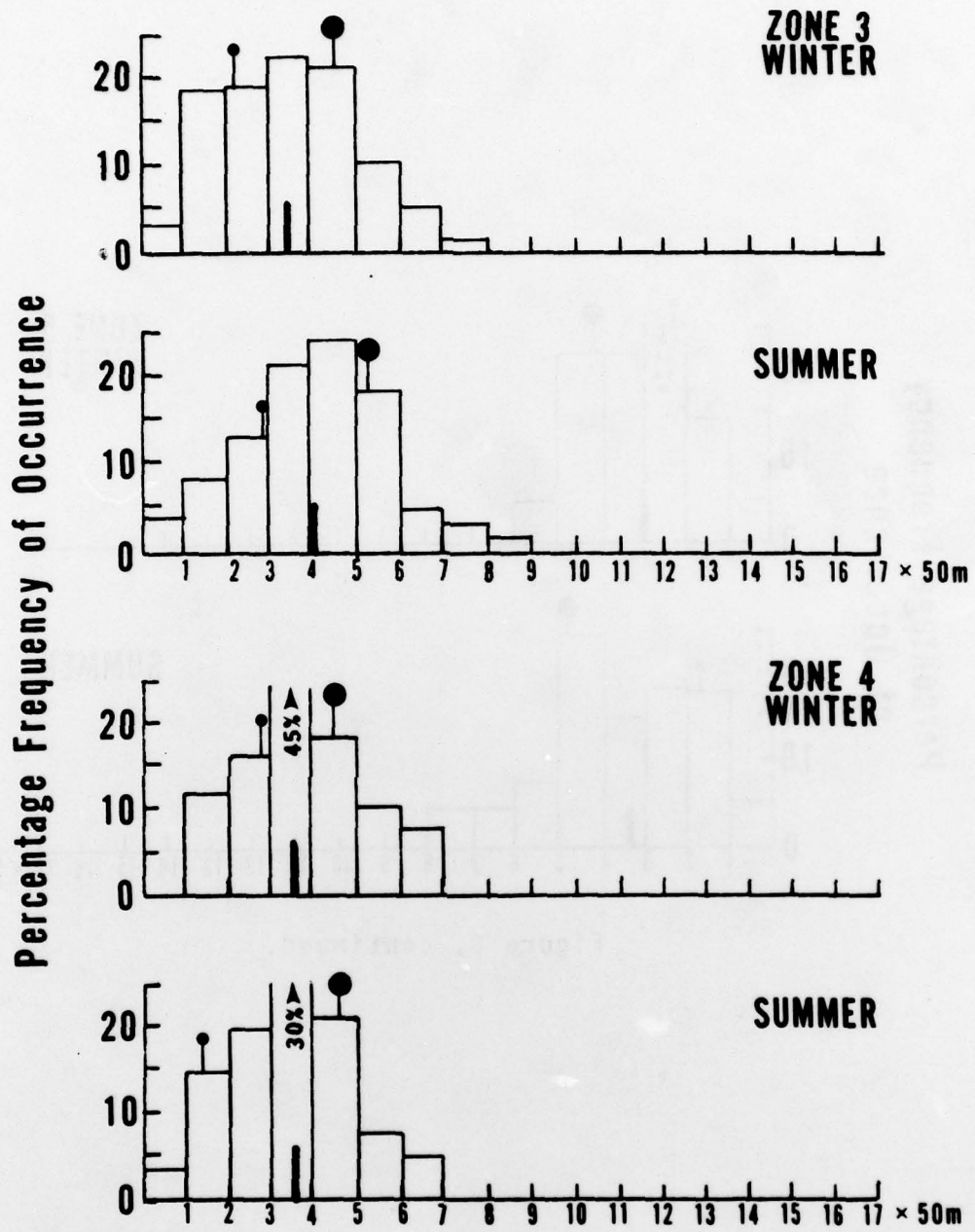


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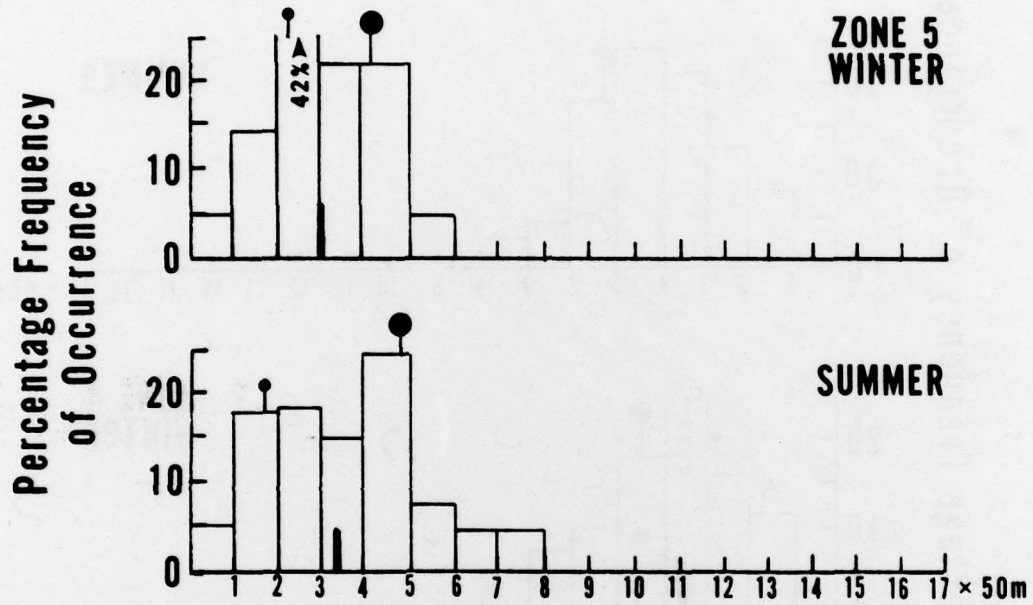


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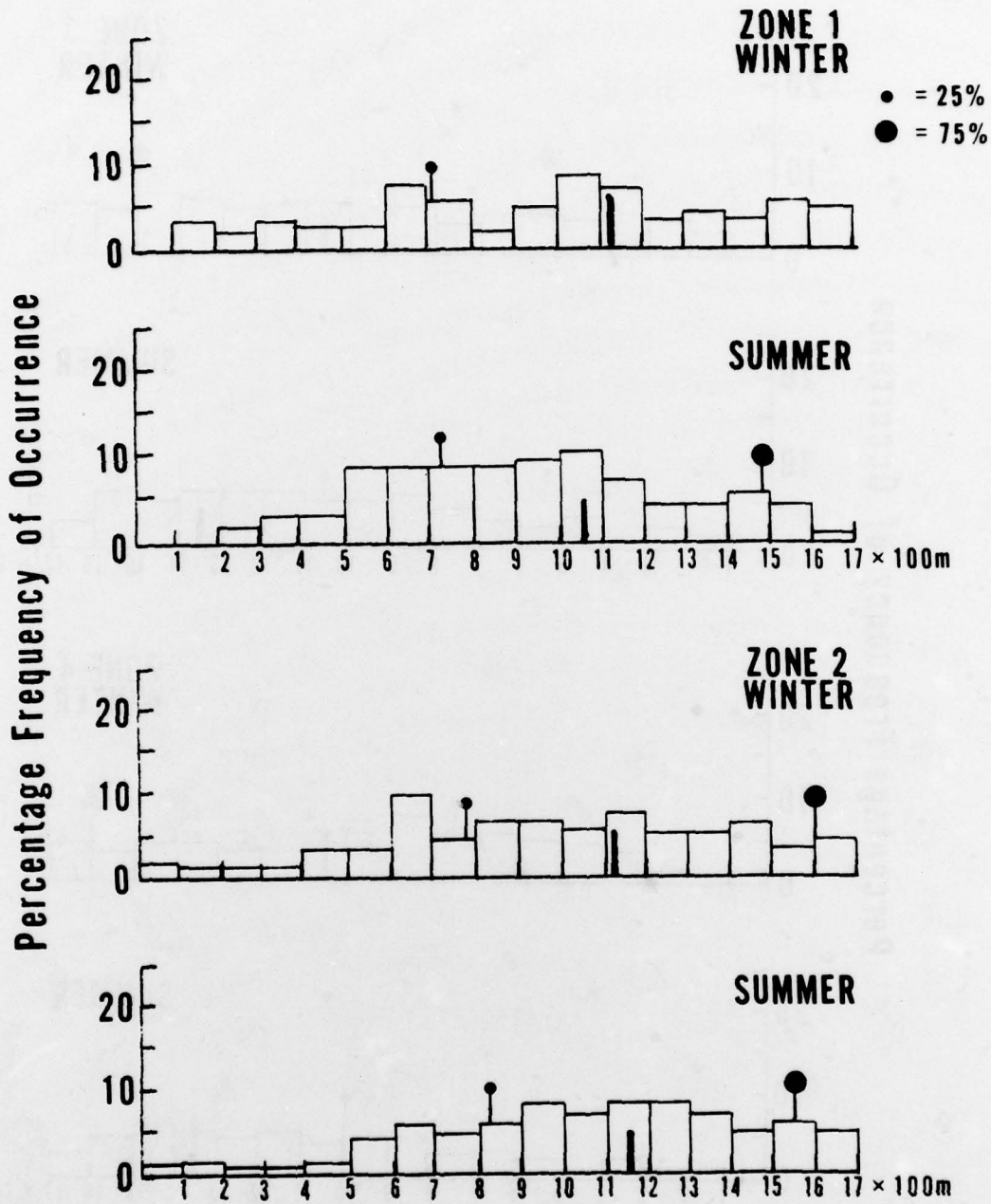


Figure 9. Percentage frequencies of occurrence of base heights of superrefractive layers. Medians of distributions shown by |. Lower and upper limits of interquartile ranges indicated by ● and ●. (See text, Para. 4.)

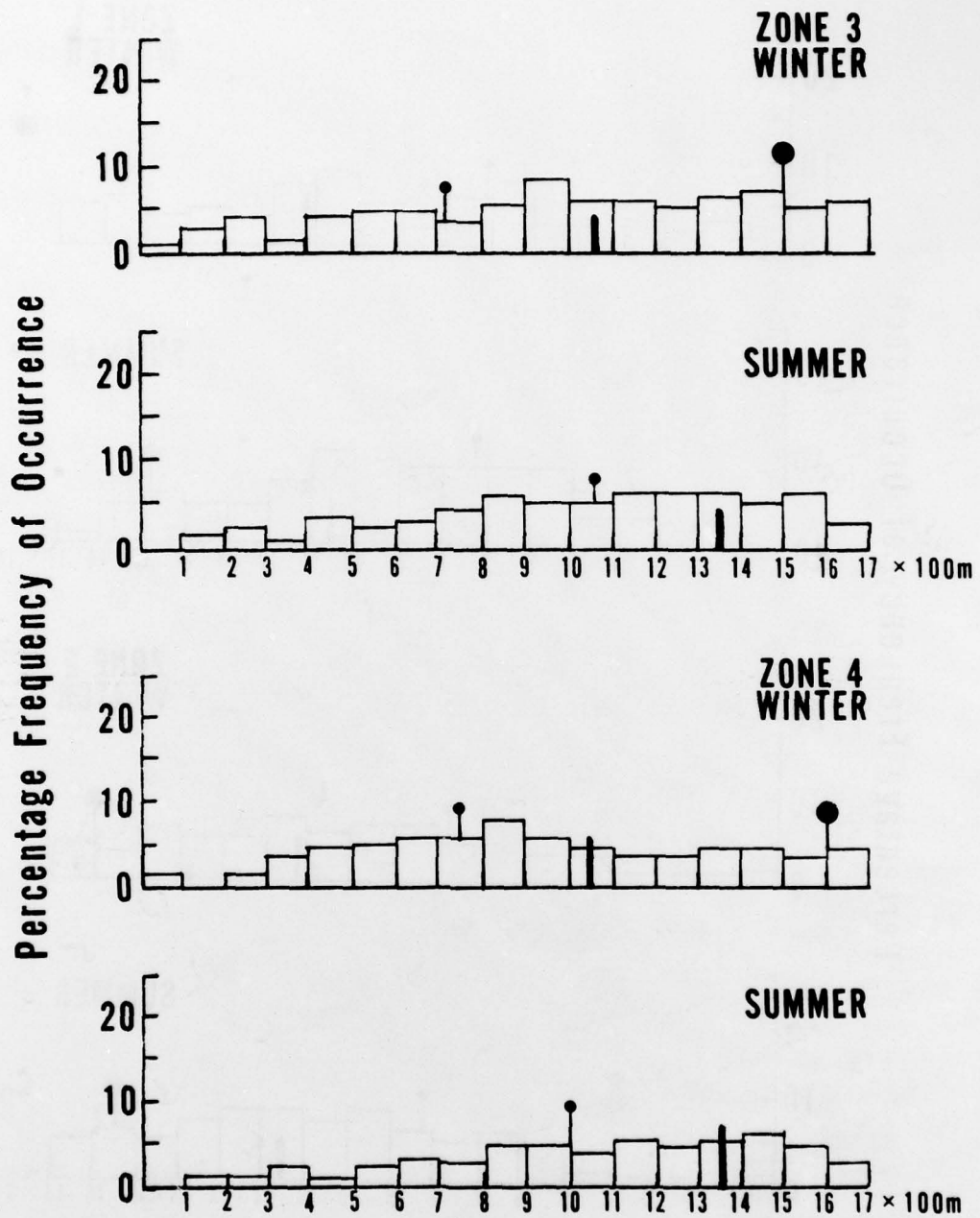


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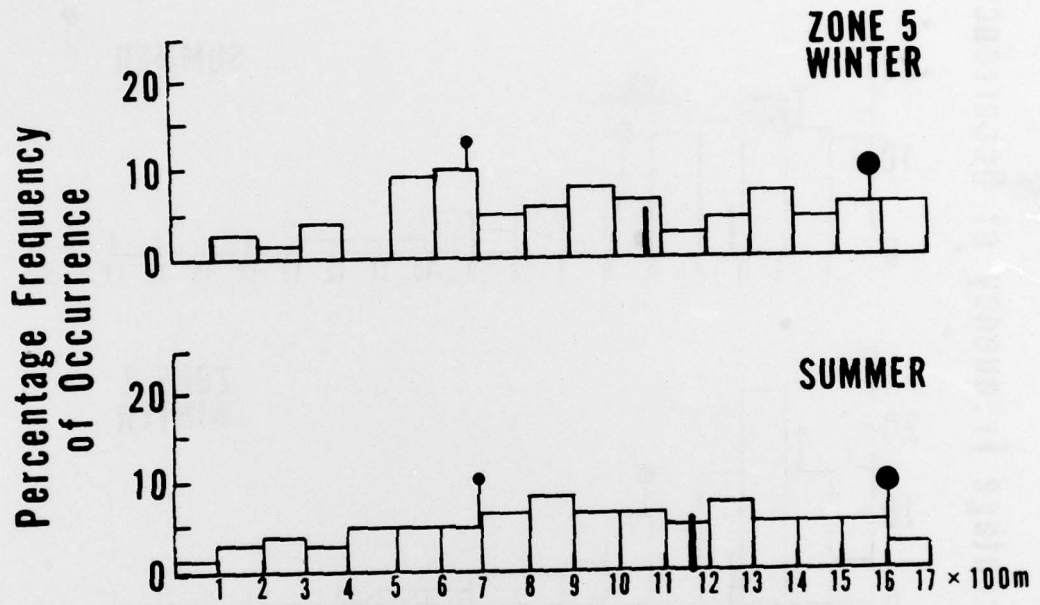


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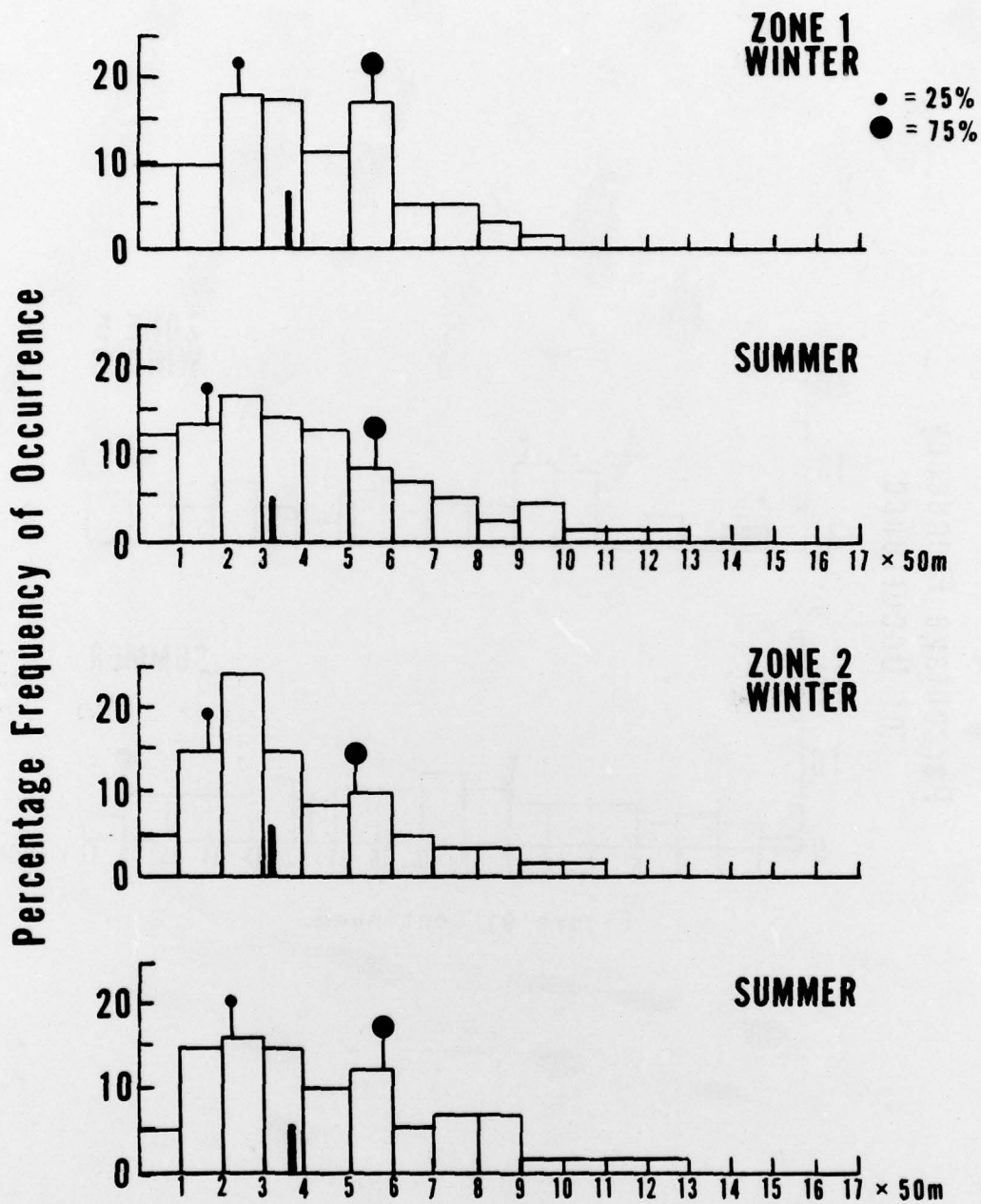


Figure 10. Percentage frequencies of occurrence of thickness of superrefractive layers. Medians of distributions shown by |. Lower and upper limits of interquartile ranges indicated by • and ●. (See text, Para. 4.)

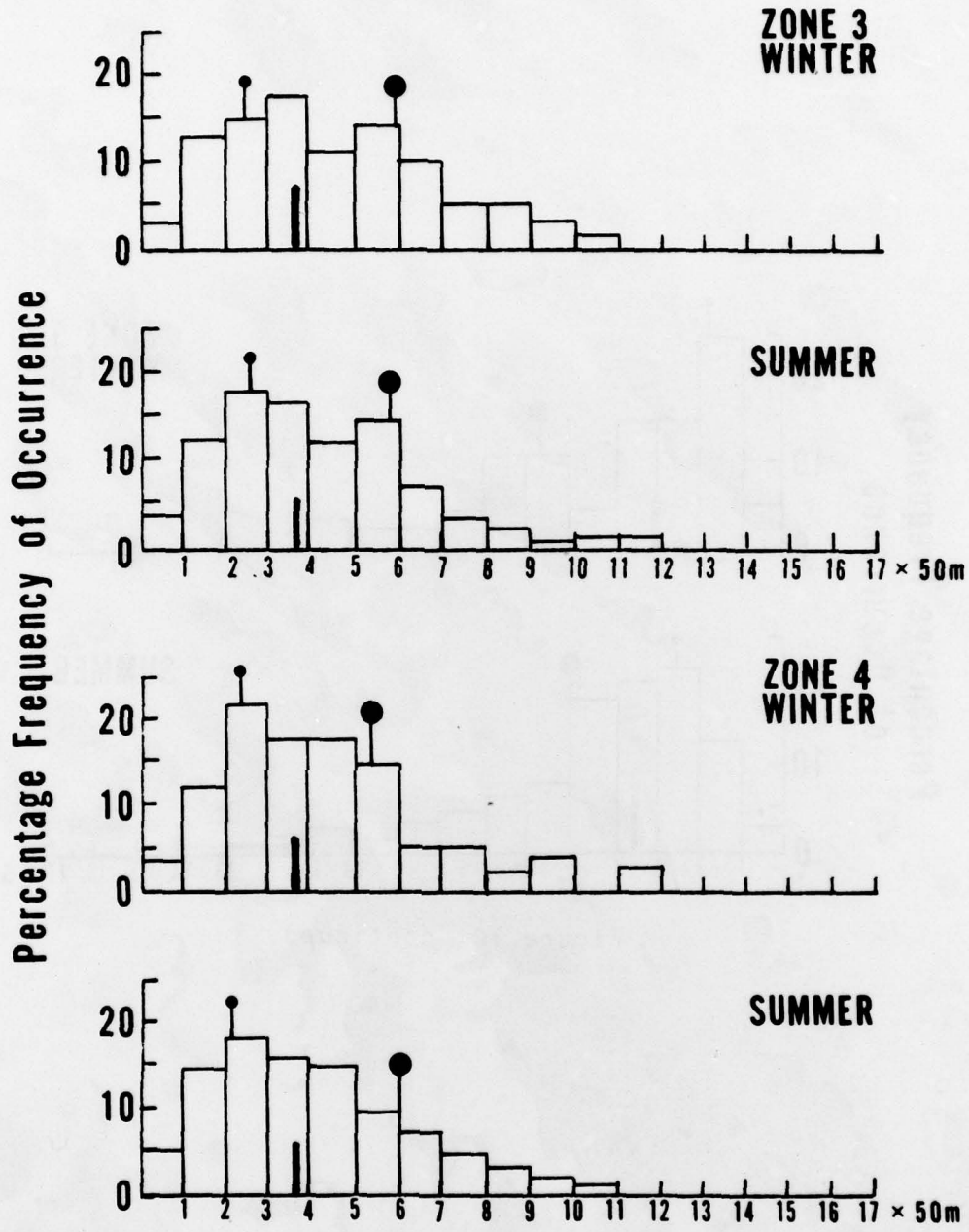


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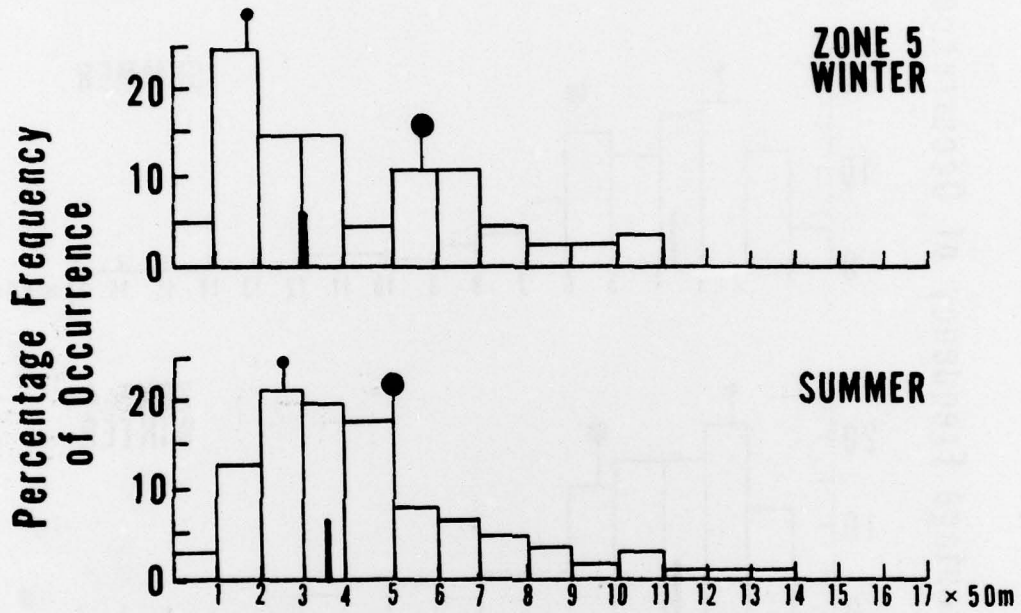


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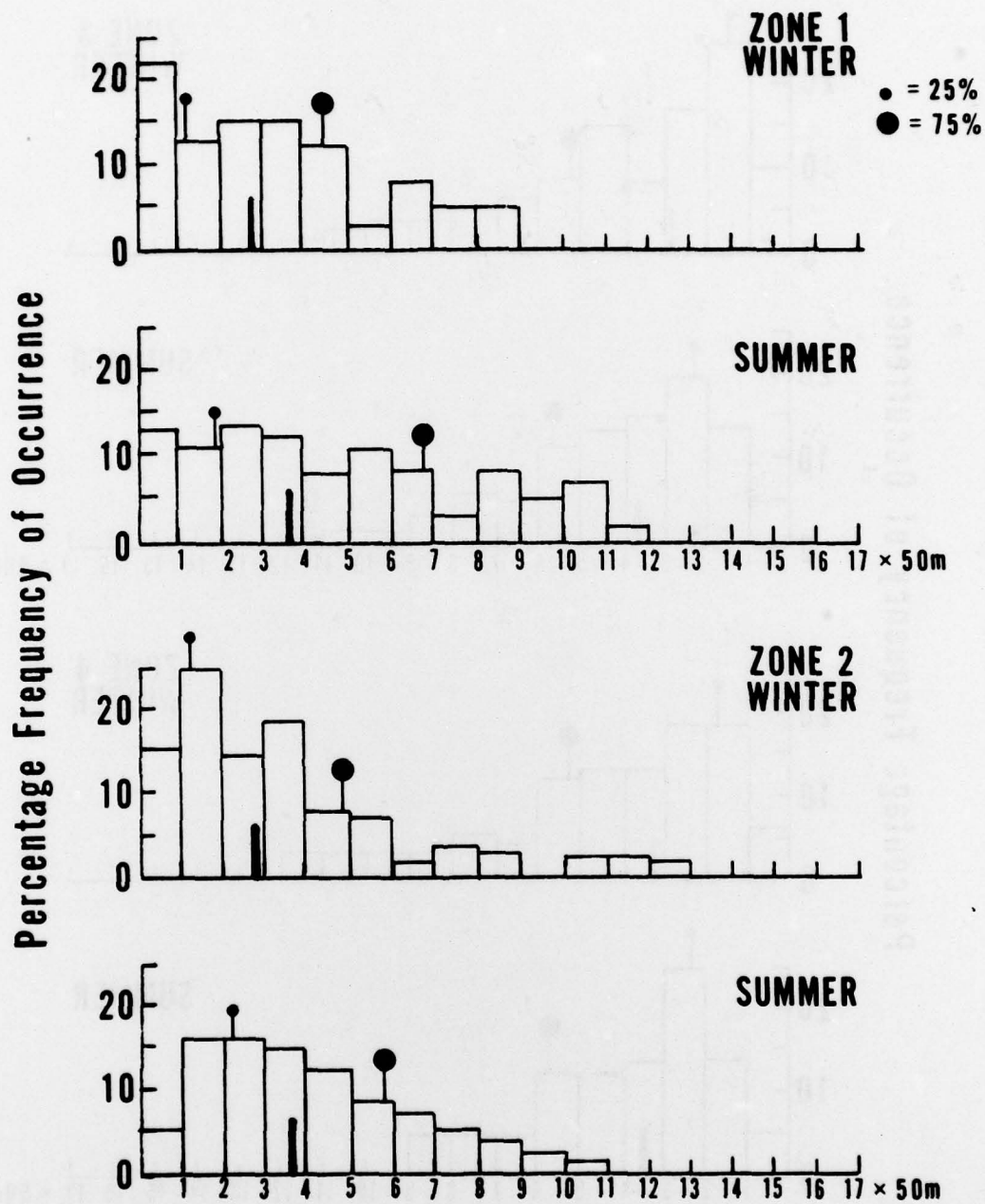


Figure 11. Percentage frequencies of occurrence of thickness of subrefractive layers. Medians of distributions shown by |. Lower and upper limits of interquartile ranges indicated by ● and ●. (See text, Para. 4.)

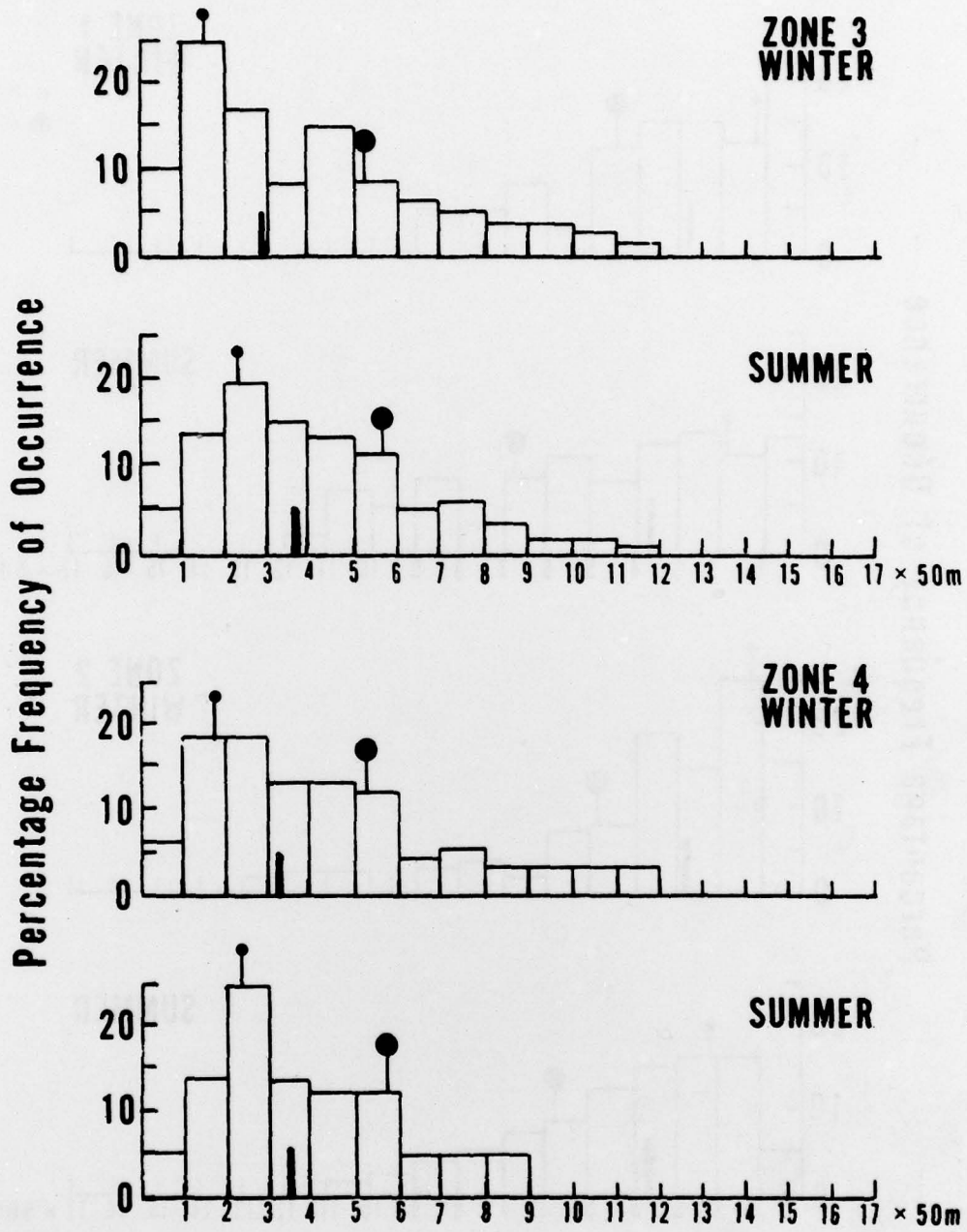


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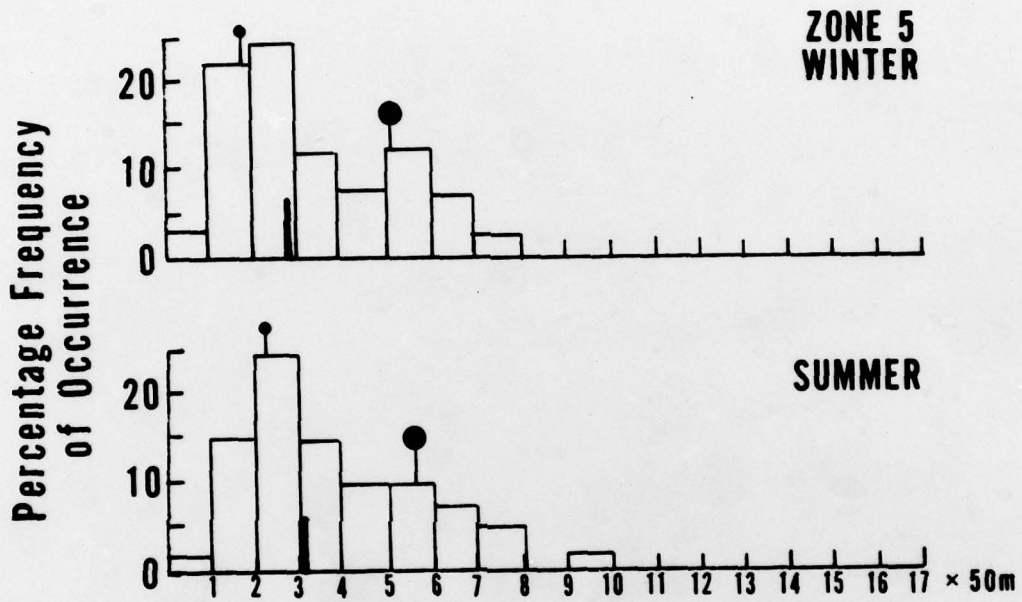


Figure 11, continued.

