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Biomass Estimates of Pseudocalanus C VI in the North Sea 1958 - 75

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Abstract

The Continous Plankton Recorder (CPR) is used to sample zooplankton on a routine basis, the Oceanographic Laboratory (1973). These data for 1958-75 were used for estimating the biomass of Pseudocalanus C VI in six standard area into which the North Sea has been split for this analysis. Estimates for nearly every month-area combination are presented. The seasonal maximum is found to be o.o5-o.5 g/m^2

An analysis is presented for two counts from the CPR material: Pseudocalanus C VI counted directly and the Para-Pseudocalanus count. These two estimates differ by a factor of 2 to 3.

Introduction

The zooplankton populations of the North Atlantic have been sampled over a long series of years by the Institute of Marine Environmental Research Plymouth England formermely Edinburgh, Scotland the Oceanographic Laboratory (1973). This sampling is conducted using the Continous Plankton Recorder (CPR), Rae (1952).

The data were placed at our disposal by the courtesy of IMER when one of the authors (Hans Lassen) visited IMER in 1976.

The objective of the present investigation is to establish a procedure to calculate total biomass estimates for a specified area in a specified period.

The routine analysis of the CPR samples produces a count of the number of specimen found per 3 m^3 in a depth of 1o m,Colebrook (1975a). The data are referred to whether taken by night or day to month and to rectangle (1^o latitude x 2^o longitude).

Raising these data to total biomass involves estimates of the weight and length distributions as well as the vertical distributions. Such data have been obtained from published material.

Pseudocalanus was picked as an example due to its high abundance and because the size range of Pseudocalanus focus attention on the selectivity of the CPR. Pseudocalanus has been studied thoroughly, Corkett and Mc Laren (1978). Colebrook (1975b) has studied Pseudocalanus counts in the CPR material and Robertson (1968) estimated based on the CPR material the biomass of some calanoides, amoung those Pseudocalanus.

Two counts of Pseudocalanus are available in the CPR material: A direct count of Pseudocalanus elongatus CVI and a count of all Pseudocalanus and Paracalanus stages together with other small calanoides. This count is called p-p in the subsequent sections. We have restricted ourself to the North Sea although the material covers the entire North Atlantic.

The estimation of the total biomass for the Pseudocalanus through two different counts indicates the precision obtained within the sampling method. Any bias due to the CPR will not elucidated through the comparison presented.

Theory

The counts from the CPR silks are recorded in a category system, table 1 Colebrook (1975a). The interval length is such that $\log_{10}$ (upper limit-lower limit) = o.3. Previous analyses of the CPR material employ transformations of the counts by $\log_{10}$ (1+count), the count being the accepted mean of the category. The objective of this paper, however requires that arithmetic values e.g. back transformed from logaritmic values, be obtained.
The logarithmic transformations are discussed by Colebrook (196o) and are introduced to stabilize the variance (making variance independent of the mean), to transform the original sample distribution into an approximation of a normal distribution of observations and to reduce the error introduced by the category system of counting. The present study uses the first two properties in the specific analyses.

The category system and the accepted values for each category are discussed by Rae (1952). The accepted value is obtained as the mean in each category from material actually counted. The mean from the categorized and non - categorized data should therefore be the same.

The sample distribution for <u>Pseudocalanus</u> in the North Sea is of negative binomial type Colebrook (1975b) Then the arithmetic mean is the maximum likelihood estimator of the mean in parent distribution. Anscombe (195o)

The assumption about sampling distribution being negative binomial, relates the variance of the observations V to both mean m and the second parameter k of the negative binomial distribution

$$V = m + m^2/k \ .$$

If however the relationship is

$$v = \lambda^2 m^2$$

then the transformation

$$\log_{10} (x+1)$$

is appropiate as a variance stabilizing devices Kempthorne (1952). This means that for $k \sim 0.8$ as found by Colebrook (1975b) and $m > 10$ the logaritmic transformation will be appropiate. The mean values range from o to several hundred and the condition $m > 10$ is fulfilled for the cases where the Pseudocalanus is abundant.

Colebrook (1975b) for Pseudocalanus in North Sea estimates $k = 0.8$ for the period 1948 - 1969 and gives the relationship

$$\text{logmean} = 0.0096 + 0.5867A + 0.14A^2$$

$$A = \log (\text{Arithmean} + 1)$$

However the arithmetic mean is an unbaised maximum likelihood estimator of the population mean and the number of samples is fairly large, all together about 17ooo samples are used in the analyses, we have therefore preferred to base the estimates upon straight forward arithmetic means and avoid backtransformation and the problems inherent herein.

The procedure used subsequently is simply to calculate average values using the accepted value of each category. It is obvious from table 1 that for high densities of Pseudocalanus the ability to distinguish between two levels of abundance is low.

The category system and the variance of the estimates.

The category system, table 1, is a grouping of the observations and therefore give raise to some loses of information. The variance of the sample calculated from the accepted values, table 1, will be an underestimated of the variance in the population. Let the ungrouped observation be x, the accepted value of category c be v_c and nothing that Ex = Ev, it is found that

$$v(x) = Ex^2 - (Ex)^2 = Ev^2 - (Ev)^2 + \sum_{C} \sum_{x \in C} (x-v)^2 \quad Px$$

Where the last term is the contribution due to the category grouping. Assuming the sample distribution to be negative binomial and K = o.8, the grouping effects to the variance of the observations as a function are shown on fig. 2.

The data material give counted means in the range of o to 5o individuals which shows that the grouping effect is less than 15 % of the theoretical sample variance.

Instrument considerations.

The CPR samples a water volume through the opening ($1.61.cm^2$). However whether a Pseudocalanus specimen situated in the water volume just in front of the opening is actually sampled depends on the efficiency of the CPR, big zooplankters are not sampled adequately. However no estimates of the efficiency to the CPR appear to be available.

The sampled water stream passes a silk (6o meshes/inch) and the Pseudocalanus may be retained dependent on the length of the specimen. Robertson (1968) has for the CPR estimated the retention of the zooplankton as function of the cephalothorax lenght see fig. 3. The retention of the CPR is only about 8o % even for the largest size while the retention by a 6o meshes/inch net is 1oo % Saville (1958). This suggests that some loss other than the selection by the silk exists within the CPR.

No correction for the efficiency of the CPR appears to be available. It is however possible to correct for the loss within the CPR for the selection of the silk. In the subsequent analyses correction will be done using fig. 3.

Classification of the samples

The samples are classified according to whether the sample was taken during nights or day, by rectangle (1^{o} latitude x 2^{o} longitude) and by year and month.

The objective of this paper is to establish a biomass estimate for a specific month for each fairly homogeneous area. Therefore any diurnal effect should be eliminated, and the North Sea shall be split into suitable areas.

Diurnal variations in abundance of Pseudocalanus

The diurnal variations in the CPR counts may be corrected for. The corrections were found from analysis of variance, GLM procedure of the SAS computer package Helwig and Council (1979), employing the model

$$\log(1+x) = \text{intercept} + \mu(\text{month}) + \nu(\text{night/day}) + \text{error}$$

where x is the accepted value of each category. Each combination of month and area was analysed separately.

The corrections are

night observation − $\frac{K-1}{2k} + \frac{1+K}{2k}$ x accepted value

day observation + - $\frac{K-1}{2} + \frac{1+K}{2}$ x accepted value

The K values for those combinations of month and area, where diurnal effect was found to be significant at a 5 % significance level, are given in table 2. It will be noted from the above formulae that an accepted value of zero may give a negative corrected value.
When the resulting mean is negative, this mean is set at zero.
It should further be noted that the correction procedure applied, requires that both night and day sample are available for each month - area combination. This condition is fullfilled in the CPR data.

Grouping of Rectangles into Areas

Althrough the CPR material presents about 17ooo samples it is not possible to use rectangles and months as the basic grouping of the data as many month - rectangle combinations are without sampling.

The CPR material is in the routine analyses grouped into standard areas, Colebrook (1975a) The effect of this grouping may be investigated by analysis of variance. The objective of such analyses would be to demonstrate a much smaller sample variance within each area than between the areas. At the same time the grouping of rectangles should be such that the variance within each area cannot be reduced to any major extend by a further area breakdown.

The analysis has been conducted on the <u>Pseudocalanus</u> C Vl count after this count was corrected for the diurnal variations as described in the next section. The GLM procedure of the SAS system Helwig and Council (1979) was used.

The effect of the grouping by the standard areas was demonstrated by applying the model

$$\log(1+x) = \text{intercept} + \mu\,(\text{month}) + \nu\,(\text{std. area}) + \text{error}$$

x being the accepted value of each group. It was found that all 6 areas differ from each other, see text table below

Analysis of Variance

source	df	F		df	MS	F
area	5	139.12	Model	16	676.86	1962o
month	11	224.46	error	17151	3.45	

For F values for the sources refer to the test of an source effect provided that the other effect is as estimated. All F values are significant at a o.1 % level. The estimated parameters for the areas are:

area	1	2	3	4	5	6
parameter	- .27	-.54	.2o	-.15	.76	.o

with a standard error of the parameters of about o.o6. It is therefore concluded that no aggregation of these areas would be advisable. It should be noted that the variations between monts is only slighly bigger (o to 2) from above anlysis than that between these areas (-o.54 to o.76).

Analysis of variance within each area and month combination was used to investigate whether a further breakdown of the areas could reduce the variances significantly. The text table below shows the results, + signifies that the test for rectangle differences was significant a 5 % level.

Area Month	1	2	3	4	5	6
Jan	-	-	-	-	+	-
Feb	-	-	+	+	+	-
Mar	+	+	+	+	+	-
Apr	-	-	+	+	-	+
May	-	+	-	-	+	-
June	+	+	+	+	+	-
July	+	-	+	+	-	+
Aug	+	-	+	+	-	-
Sept	-	+	+	+	+	-
Oct	+	-	+	-	-	+
Nov	-	-	-	-	-	+
Dec	-	-	-	-	-	-

For these analyses about 2oo samples per combination were available. For area 3 (Eastern Central North Sea) the analysis may suggest a further breakdown. However detailed analysis of the structure of the rectangle parameters revealed no obvious structure. An attemt to aggregated the four rectangles in the North - east corner of area 3 still showed differences among the rectangles. We have therefore adopted the standard areas of the routine analyses of the CPR data as appropriate for the further consideration.

Length and Stage Composition

The length dependent selectivity of the CPR makes allowance for the size composition in the stock of Pseudocalanus necessary in the estimation procedure.

Deevey (196o) found that the seasonal variations in size in Loch Striven, (Marshall (1949)) in Eastern North Sea, (Adler and Jespersen (192o)) and in the English Channel, (Digby (195o)) show similar patterns. Evans (1977) in the western North Sea confirms this observation. The maximal size of Pseudocalanus is observed in spring (april) and the size then gradually decreases during summer reaching the smallest size in autumn and winter.

The variation in size from one year to the next is found to be small, Adler and Jespersen (192o) who report cephalothorax lengths for the period 1911 - 1914. We shall ignore such annually variations.

The Pseudocalanus CVI is dominated by females, while CVI and CV have a sex ratio of about 1:1. Females are longer than males and the application of female data on cephalothorax lengths of CVI will lead to overestimation of retention in the CPR i.e. underestimation of abundance, and overestimation of biomass per individual. These effects to some extend counteract. No data appear to be available which allow a split into sexes.

It will be assumed that the same size composition is applicable to all six standard areas and that are size composition be applicable to the stock.

Table 3 shows the cephalothorax lengths by stage (CIII-CVI) applied in the biomass estimation. The data are extracted from Adler and Jespersen (192o), Marshall (1949), Digby (195o) and Evans (1977).

The estimation of Pseudocalanus CVI from the p-p count requires that data on the stage composition in either the CPR samples or in the stock be available. Data on the stage composition in the stock are obtained from the same sources as were the lenght data.

The generation time of Pseudocalanus in the North Sea may be as short as one month, Evans (1977). This causes varying stage composition over the year. The stage composition applied in the estimation is given monthly, table 3..

Weight - Length Relationship

Kamshilov (1951) as cited by Winberg (1971) gives for Copepods the following relationship between dry weight and cephalothorax length.

$$\text{Dry wt in mg} = 0.0242 \times (\text{cephalothorax length in mm})^{2.984}$$

The equation was fitted on data on all copepodid stages.
Inspection of Kamshilovs paper shows that the original equation is in wet weight and total length. Such an equation produces much too low wet weights and it is suggested that winberg's (1971) interpretation is the more likely.
Robertson (1968) gives dry weight to cephalothorax length relationship for the <u>Paracalanus</u> <u>Pseudocalanus</u> p-p count applicable for the size range 0.70-0.91 mm.

$$\text{Dry wt in } \mu g = 0.074 \times (\text{cephalothorax length in } 100\,\mu m)^{2.39}$$

Mclaren (1969) and Krylov (1968) have determined the weight-length relationship using formalinpreserved specimens.
These two later expressions may introduce a bias in estimation of the dry weight as unpreserved animals may differ significantly from preserved specimens.
Evaluation of Kamshilov (1951) and Robertson (1968) shows only minor differences for the range 0.70 - 0.9 mm, maximal differences is 4 µg or 20 %.
The cephalothorax length's have been converted to dry weight using the Kamshilov equation, which has been fitted to the larger size range, table 3.

Vertical Distribution

The CPR samples together with the assumed length composition and length - weight relationship makes an estimate of the concentration per volume unit (mg/m^3) possible. The next step is to convert this mg/m^3 into mg/m^2 taking the vertical distribution of <u>Pseudocalanus</u> C VI into account. The CPR samples at a depth of 10 m. Rae and Fraser (1941) have analysed the vertical distribution of the p-p group and found that the concentration in 10 m depth is a good approximation to the concentration to be expected provided the vertical distribution from top to bottom is random. The ratios between the observed concentration at 1o m dept and the value from the random distribution ("1o m values") are given below from Rae and Fraser (1941)

June	August	September	October	Mean
o.9o	o.83	1.2o	1.o2	o.98

Reanalysis of the data of Rae and Frasers (1941), Savage (1931) shows 1o m values of o.75 for day samples and 1.13 for night samples. Correcting for the number of day and night samples leaves the mean 1o m value virtually unchanged, but the seasonal variation is less than found by Rae and Fraser (1941).

Williams (1977) measured the vertical profiles of zooplankton in The Flex box in the northern North Sea. He reports on one sample in March, four in April and fifteen in May. Paracalanus parvus and Pseudocalanus was counted seperately. The mean 1o m value for the whole period is 1.53 for Pseudocalanus and 2.28 for Paracalanus parvus with a mean for the group Paracalanus - Pseudocalanus of 1.76.

Seasonal variation in the 1o m value may occur. Corkett and Mclaren (1978) suggest that seasonal descent of resting overwintering stages may be the rule among Pseudocalanus populations in temperate waters. In the shallow water region of the Southern North Sea this may possible be without significance while an effect could be expected in the deeper areas of the northern North Sea.

The effect of a depressed abundance of Pseudocalanus will probably be evident in autumn and winter. This however is a period where abundance is low and will therefore not bias the estimates to any major degree.

Biomass Estimates

The biomass estimation procedures are summarized in this section. The resulting biomass estimates in mg/m^2 for the six area the North Sea has been split into, are given in fig. 4 (Pseudocalanus CVI count) and fig. 5 (p-p count) for the period 1958 - 75. January 1958 is month 1 while december 1975 is month 216.

Estimating biomass of Pseudocalanus CVI from the count of Pseudocalanus CVI.

The first step in estimating biomass is to correct for the effect of diurnal variation. Each night and day observation was corrected by the correction factors derived from table 2. As 8o % of stage CVI was retained by the recorder, fig. 3, the day/night corrected count was divided by o.8o to give the numbers per 3 m^3 at 1o meters depth. In order to estimate the abundance per m^2 the numbers per 3 m^3 at 1o meters depth were divided by the 1o meters value (table 3) and by 3 and multiplied by the water depth. In area 1 and 2 the depth was put at 12o meters in area 3 and 4 at 7o meters and in area 5 and 6 at 35 meters. These corrected counts were converted to biomass estimates by multiplying each by the corresponding mean dry weight per individual (table 3). The average biomass for each area-year-month was obtained from single calculation of the arithmetic mean over all samples in the relevant combination.
The results are shown on fig. 4.

Estimations Biomass of Pseudocalanus CVI from the p-p count.

Each sample count was corrected for the day/night effect by the factors derived from table 2.
Calculation of the number of Pseudocalanus CVI in the stock involves both the length dependent selectivity and the stage composition as the day/night corrected p-p count was multiplied by

$$\frac{\text{CVI stage contribution (\%)}}{\sum_{i=I}^{VI} \text{Ci retention} \times \text{Ci stage contribution (\%)}}$$

The retention and stage contribution are given in table 3.

The remainder of the procedure resemble that of raising the Pseudocalanus CVI count to biomass per area.
The results are shown on fig. 5.

Discussion

The biomass estimates of Pseudocalanus CVI for the North Sea through the direct count and through the p-p count differ markedly, the main difference being in the overall level of abundance.

In the texttable below the means of annual averages of the two estimates are compared

Area	1	2	3	4	5	6
Ratio	o.52	o.49	o.44	o.33	o.49	o.37

The ratio is the estimate from the direct count divided by the estimate from the count. It will however be seen from fig. 4 and fig. 5 that the monthly variations appear to follow the same pattern.

The discrepancy may be explained by faulty assumptions when raising the p-p count to biomass estimates of Pseudocalanus CVI. These assumptions are: The p-p count is dominated by Pseudocalanus, and the selectivity corrections and stage compositions applied are as given in table 3. Further the same corrections have been applied for the entire year-span allowing for seasonal variations alone.

There are further assumptions in the procedure concerning the vertical distribution and the length-dry weight relationship but these are common to both estimates.

The p-p count may contain a significant contribution of other calanoids copepods than Pseudocalanus. These alternatives are, apart from Paracalanus parvus, Microcalanus and possibly other small copepods.

These however are of a size which is well below 5o % retention point of the selection curve fig. 3. *Paracalanus parvus* have occassionally been found to be abundant Digby (195o), Marshall (1949) and Williams (1977) but the cephalothorax length is a at most o.8 mm. Digby (195o) and *Paracalanus parvus* may therefore not contribute significantly to the p-p count see fig. 3. The stage composition, table 3 is probably the most shaky assumption. Data on stage composition were only available from one site in the North Sea and had to be collaborated with observations taken outside the area of interest. It may therefore be concluded that the estimates derived from the p-p count are liable to major uncertainties.

The biomass estimates obtained from the *Pseudocalanus* CVI count involves fewer asumption than the estimates from the p-p count do. The vertical distribution assumed, when converting counts per volume into counts per area unit is a crucial point. Little information appears to be available and nothing can be inferred about annual or areal variations. The CPR samples show a high degree of variability, even after grouping into areas and correcting for the diurnal effects. These problems together with the each of knowlegde about the efficiency its variation of the CPR makes it impossible to give any precise evaluation of the accuracy of the estimates. It is however believed that only an order of magnitude is estimated.

The biomass estimates in fig. 4 may be compared with other estimates available. The peak abundance from fig. 4 is o.o2-o.37 g dry weight/m^2 of *Pseudocalanus* CVI. Table 4 shows the comparison with Evans (1977) who found about o.5 g /m^2 in April-May compared with our estimate of o.o5 g/m^2 the data of Cushing and Vucetic (1963) may be converted to give about o.2 g /m^2 in May-June, their data refer to a zooplankton patch in 1954. Robertson (1968) working on the CPR data (p-p counts) reports on 3-6 mg/m^3 for *Pseudocalanus* CV-CVI or about o.1 g/m^2 for CVI. Digby (195o) reports o.3 g/m^2 from the Plymouth area, see table 4. It should be noted when comparing biomass estimates of zooplankton that major uncertainties are likely to arise from the sampling. Bougis (1976), table 9-2, surveys the problem and shows that any estimation has an uncertainty of at least a factor of 2.

The only set of data where direct comparison can be made is Evans (1977). In this case the difference is an order of magnitude. This is probably beyond the bound of uncertainty in both estimates. It should be noted that the CPR covers some transect of the entire area while Evans (1977) samples some well defined stations in a limited area. To what degree such samples are comparable should be investigated more closely.

It should be pointed out that any interpretation of any of the above mentioned estimates must take these major uncertainties into account.

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Table 1. The category system used in counting the number of specimen on the CPR silks. The accepted values (arithmetic mean) in each category are also given. From Colebrook (1975a)

Category	Number of specimen	accepted value
0	0	0
1	1	1
2	2	2
3	3	3
4	4-11	6
5	12-25	17
6	26-50	35
7	51-125	75
8	126-250	160
9	251-500	310
10	501-1000	640
11	1001-2000	1300
12	2001-4000	2690

Table 2. K used in the correction for the diurnal variations. Evaluated from analysis of variance, only those month-area combinations where the diurnal effect was signifient at a 5 % level are included.

P-P count

	Area					
Month	1	2	3	4	5	6
Jan	│	│	│	-	│	│
Feb	│	│	│	1.482	│	│
Mar	│	│	2.039	2.184	3.492	1.955
Apr	│	3.097	1.816	3.653	2.613	-
May	│	3.906	2.077	3.717	│	3.409
June	│		2.571	1.827	│	│
July	│	4.200	-	3.075	│	│
Aug	│	2.570	1.737	1.823	│	│
Sep	0.135	│	│	1.656	│	│
Oct	│	│	│	1.940	│	│
Nov	│	│	│	│	│	│
Dec	2.805	│	│	│	│	│

Pseudocalanus CVI

	Area					
Month	1	2	3	4	5	6
Jan	│	│	│		│	0.674
Feb	│	│	│	1.223	│	│
Mar	│	│	│	1.598	2.312	│
Apr	│	1.726	1.749	2.291	3.955	│
May	│	│	-	4.454	│	3.427
June	│	│	3.226	1.859	│	-
July	│	2.002	2.051	2.656	│	2.124
Aug	│	│	2.295	1.858	│	│
Sep	0.122	│	│	│	0.320	│
Oct	│	0.469	│	│	│	│
Nov	│	│	│	│	│	1.789
Dec	│	│	│	│	│	-

Table 3. Data on <u>Pseudocalanus</u> applied in the biomass estimations. For references, see text. The stage composition is in per cent of total CIII - CVI.

Mounth	Cephalothorax length (mm)				Selection % retained				Stage composition (%) in the stock				Dry weight (µg)	The 10 m value, see text,	
	Stages				Stages				Stages				Stage VI	Area	
	III	IV	V	VI	III	IV	V	VI	III	IV	V	VI	per specimen	1-4	5-6
Jan	.55	.62	.70	.86	4	10	30	80	10	10	45	35	15.4	1.76	0.98
Feb	.58	.65	.77	.85	7	14	67	80	12	12	40	36	14.9		
Mar	.60	.70	.80	.89	8	30	77	80	10	20	30	40	17.1		
Apr	.66	.75	.86	1.08	16	55	80	80	20	25	25	30	30.4		
May	.61	.72	.77	.99	9	38	67	80	20	25	25	30	23.5		
June	.58	.67	.72	.90	7	18	38	80	20	25	25	30	17.7		
July	.58	.67	.72	.90	7	18	38	80	20	30	20	30	17.7		
Aug	.55	.63	.70	.85	4	10	30	80	20	45	20	15	14.9		
Sept	.55	.62	.69	.83	4	9	25	80	15	45	25	15	13.9		
Oct	.55	.61	.69	.87	4	9	25	80	5	15	65	15	16.0		
Nov	.55	.61	.70	.86	4	9	30	80	5	10	70	15	15.4		
Dec	.55	.61	.70	.87	4	9	30	80	5	10	70	15	16.0		

Table 4. Biomass of Pseudocalanus CVI (g/m^2) by month. Estimates derived from Cushing and Vucetic (1963) and Evans (1977). Both estimates refer to area 4 map see fig. 1

Biomass estimates from the Plymouth area, Digby (195o) are also shown.

	Cushing & Vucetic (1963)	Evans (1977)	CPR	Digby (195o)
Jan	I	I	I	o.o4
Feb				o.1
Mar	o.o			o.o3
Apr	o.o6			o.2
May	o.2	o.5	o.o5	o.3
June	o.2	o.2	o.o8	o.3
July	I			o.2
Aug		o.1	o.o2	o.o8
Sep				o.o3
Oct		o.o	o.o1	o.o4
Area	4	4		Plymouth
Sampling Period	1954	1971		-

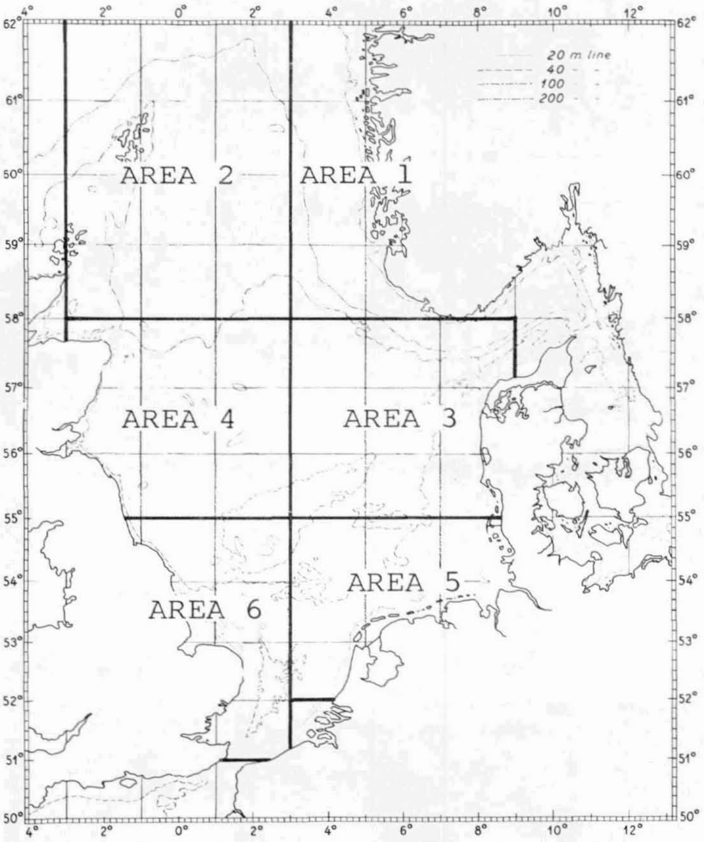

Fig.1.

Chart showing the rectangles and areas in the North Sea applied in the estimation of biomass of Pseudocalanus CVI.

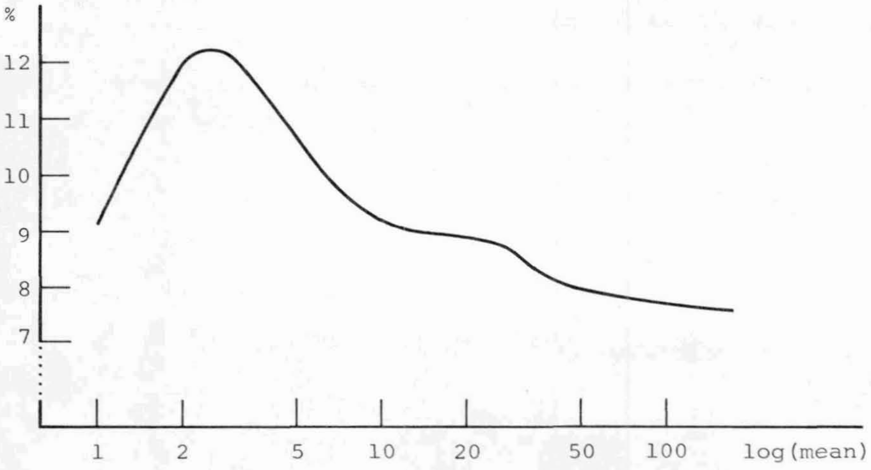

Fig.2.

Relative underestimation of the sample variance(%) from the category system as function of the logarithm of the mean.

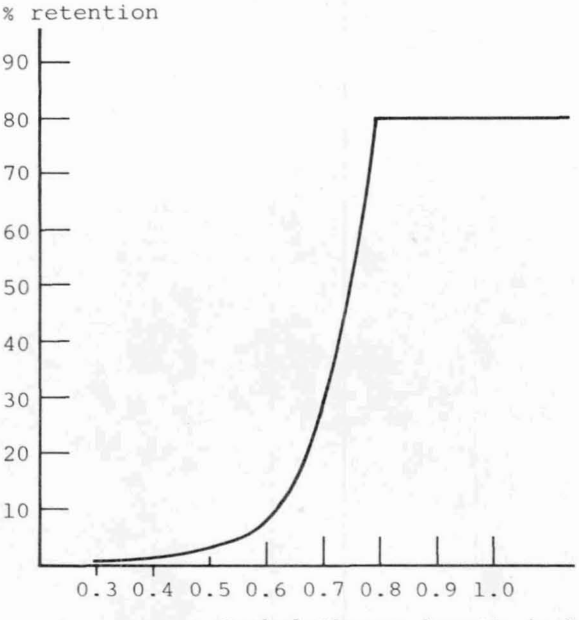

Fig.3.

The relation between the percentage retention by the CPR and the cephalothorax length(mm).
(After Robertson,1968).

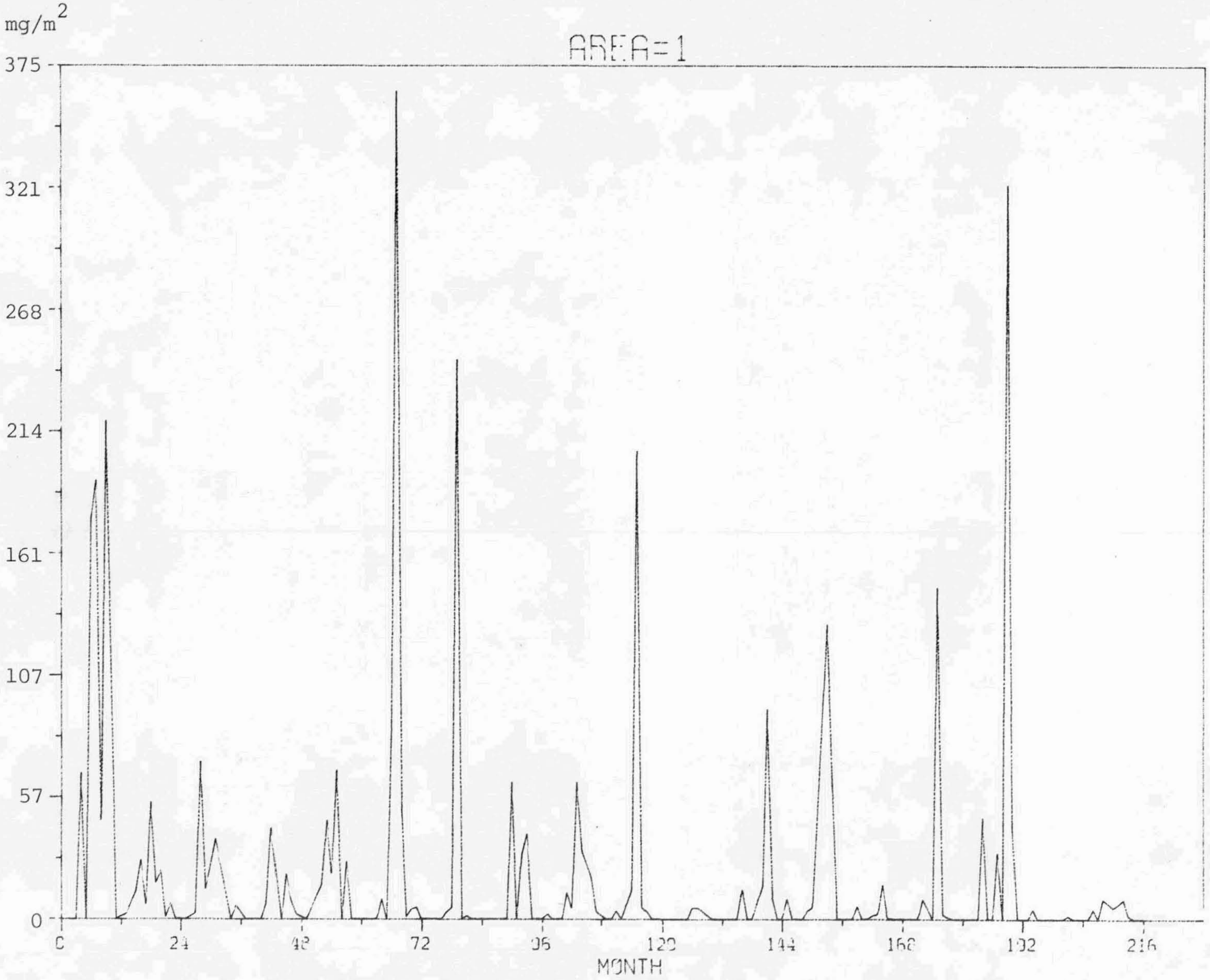

Fig.4. Estimate of biomass (dry weight in mg/m^2) of Pseudocalanus elongatus CVI from the CPR count of Pseudocalanus elongatus CVI. Given for each area. For definition of the areas, see fig.1. The month 1 is January 1958.

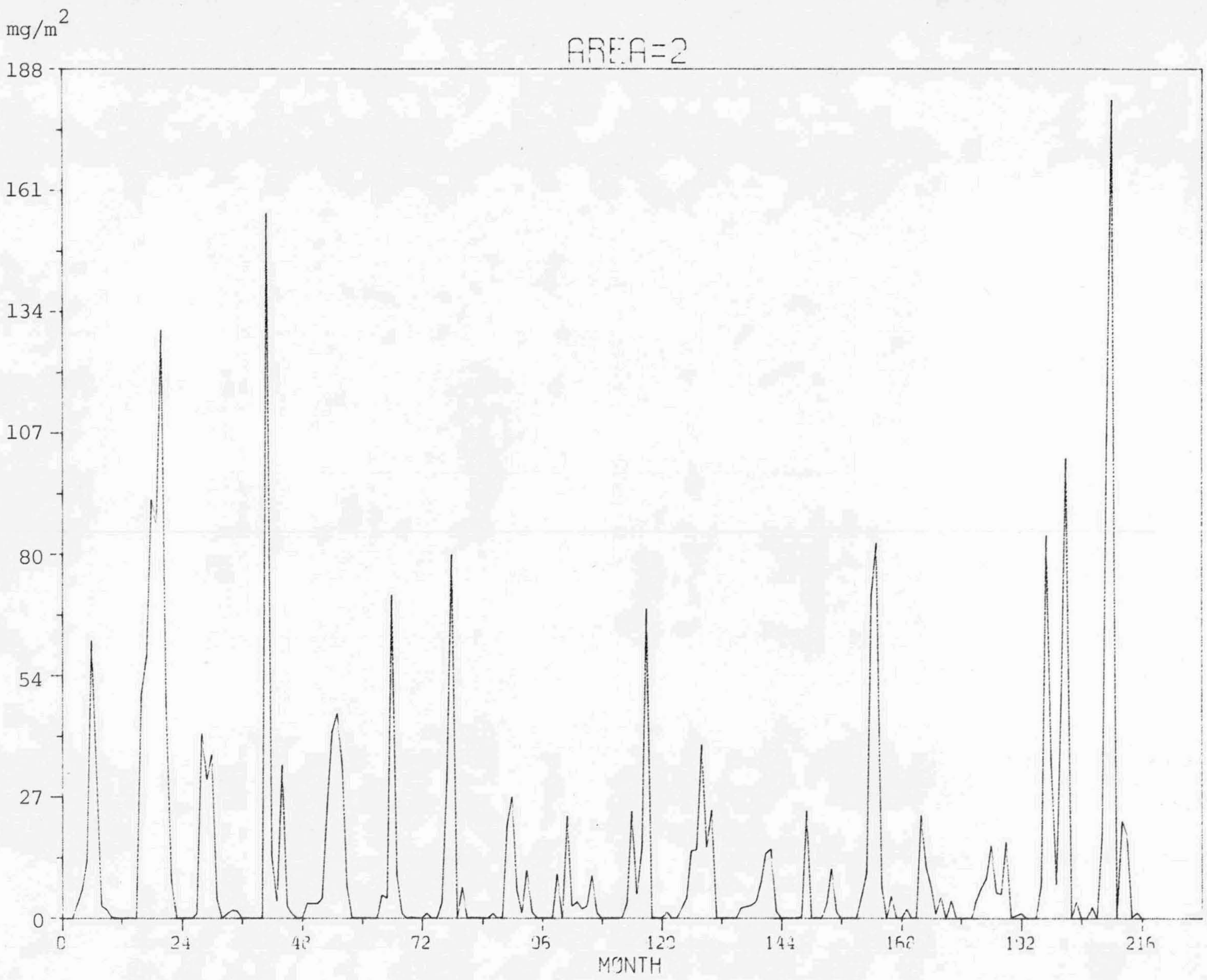
mg/m2
AREA=2
188
161
134
107
80
54
27
0
0
24
48
72
96
120
144
168
192
216
MONTH

Fig.4. (cont'd)

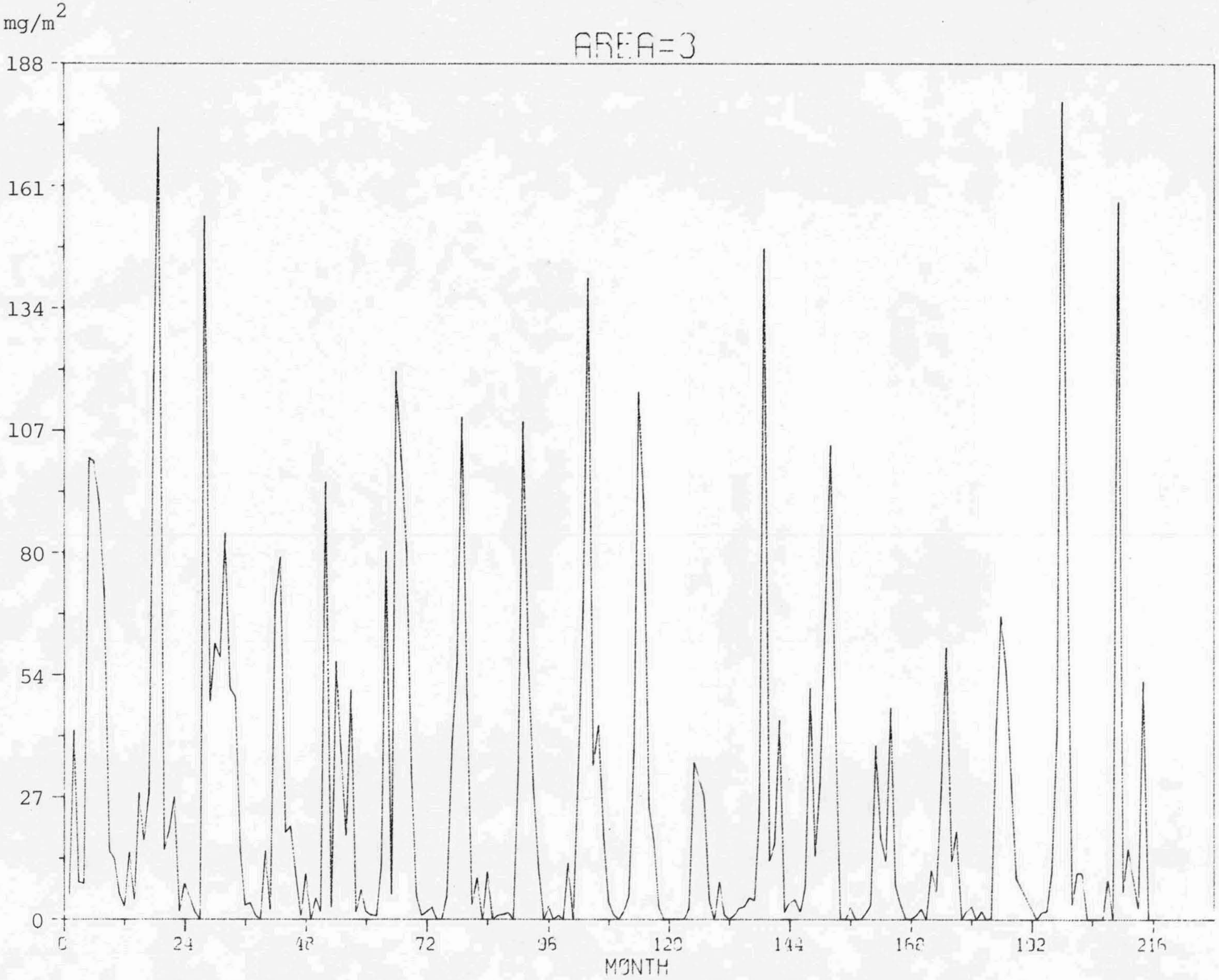
mg/m2
AREA=3
188
161
134
107
80
54
27
0
0
24
48
72
96
120
144
168
192
216
MONTH

Fig.4. (cont'd)

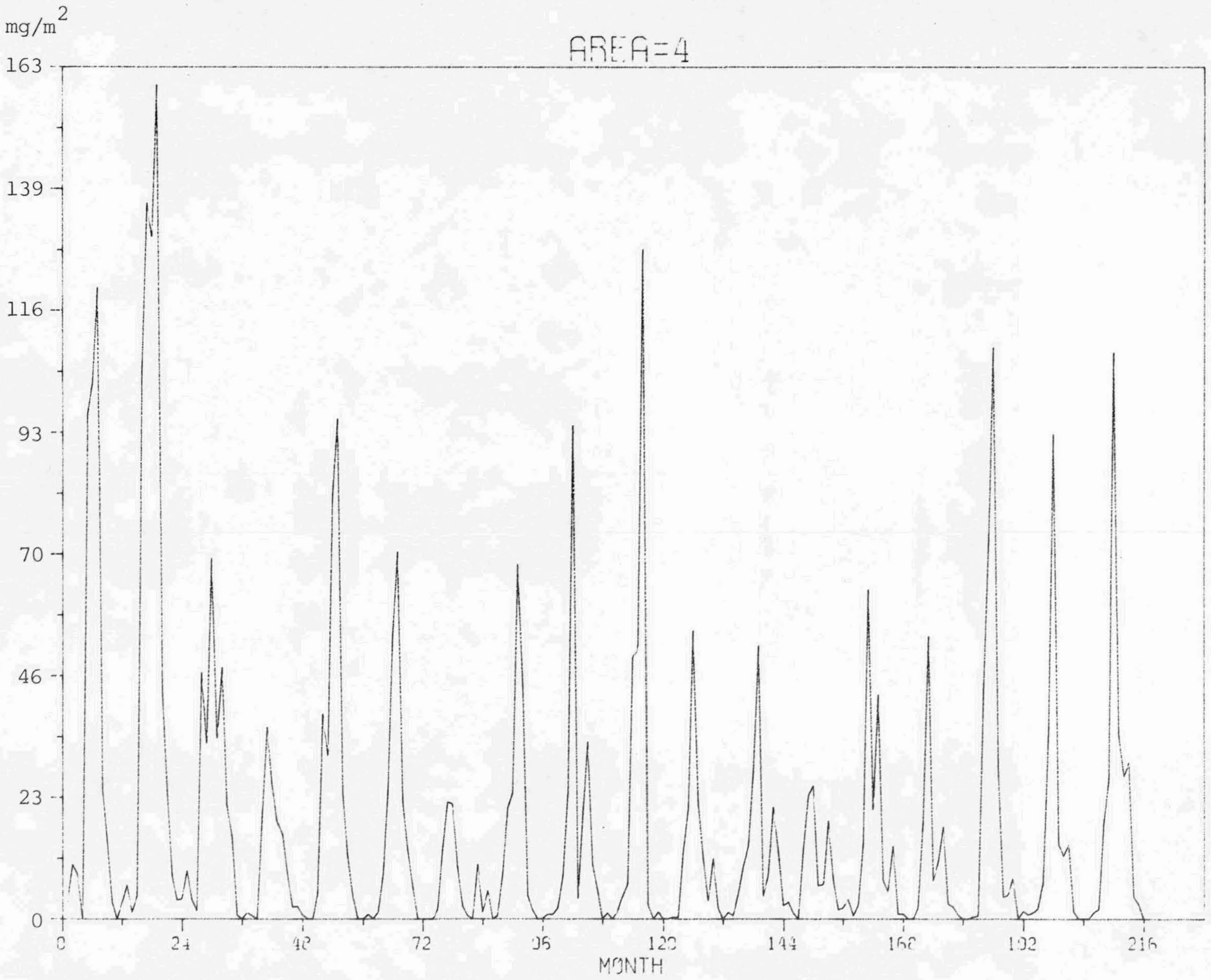
mg/m^2
AREA=4
163
139
116
93
70
46
23
0
0
24
48
72
96
120
144
168
192
216
MONTH

Fig.4. (cont'd)

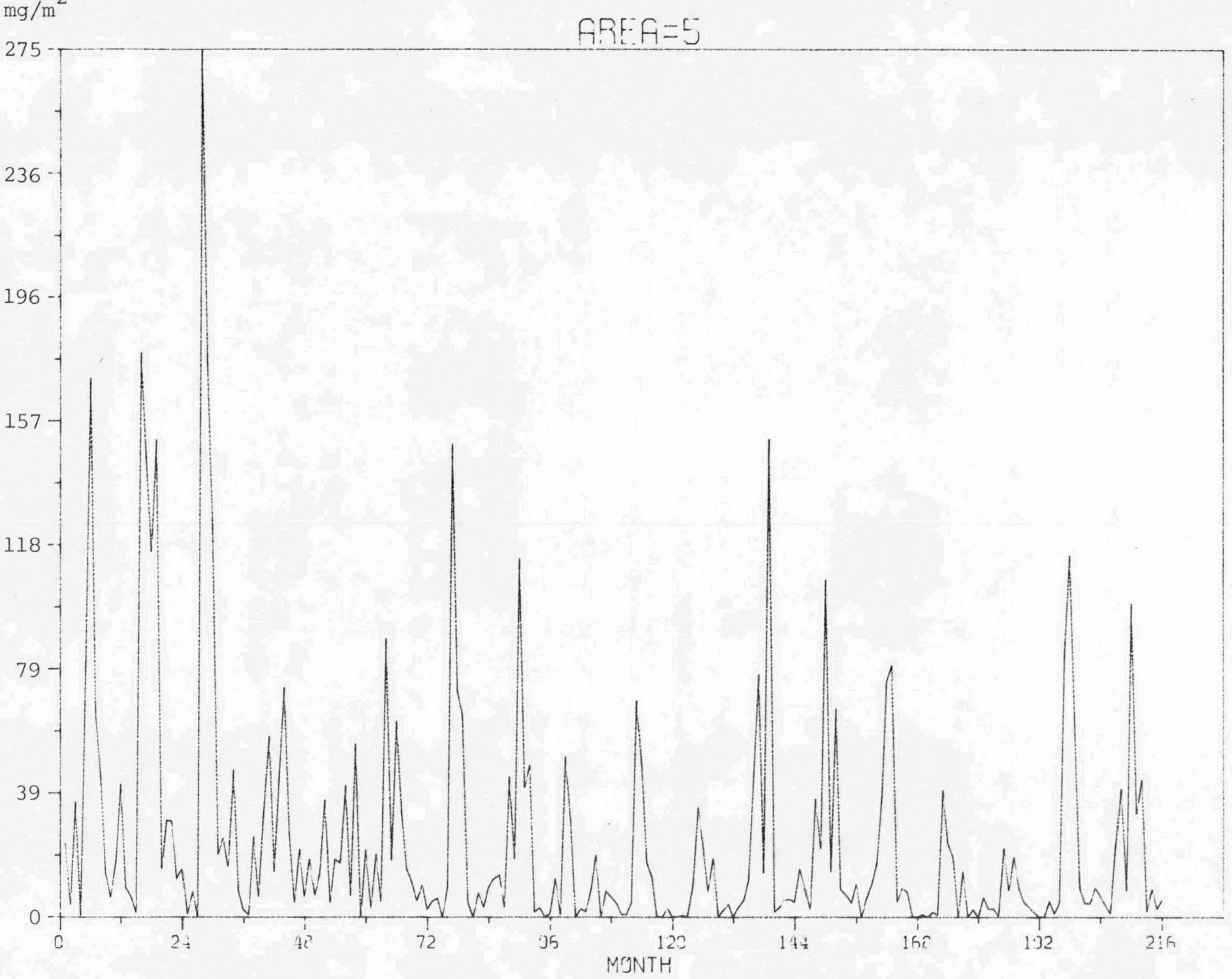
mg/m2
AREA=5
275
236
196
157
118
79
39
0
0
24
48
72
96
120
144
168
192
216
MONTH

Fig.4. (cont'd)

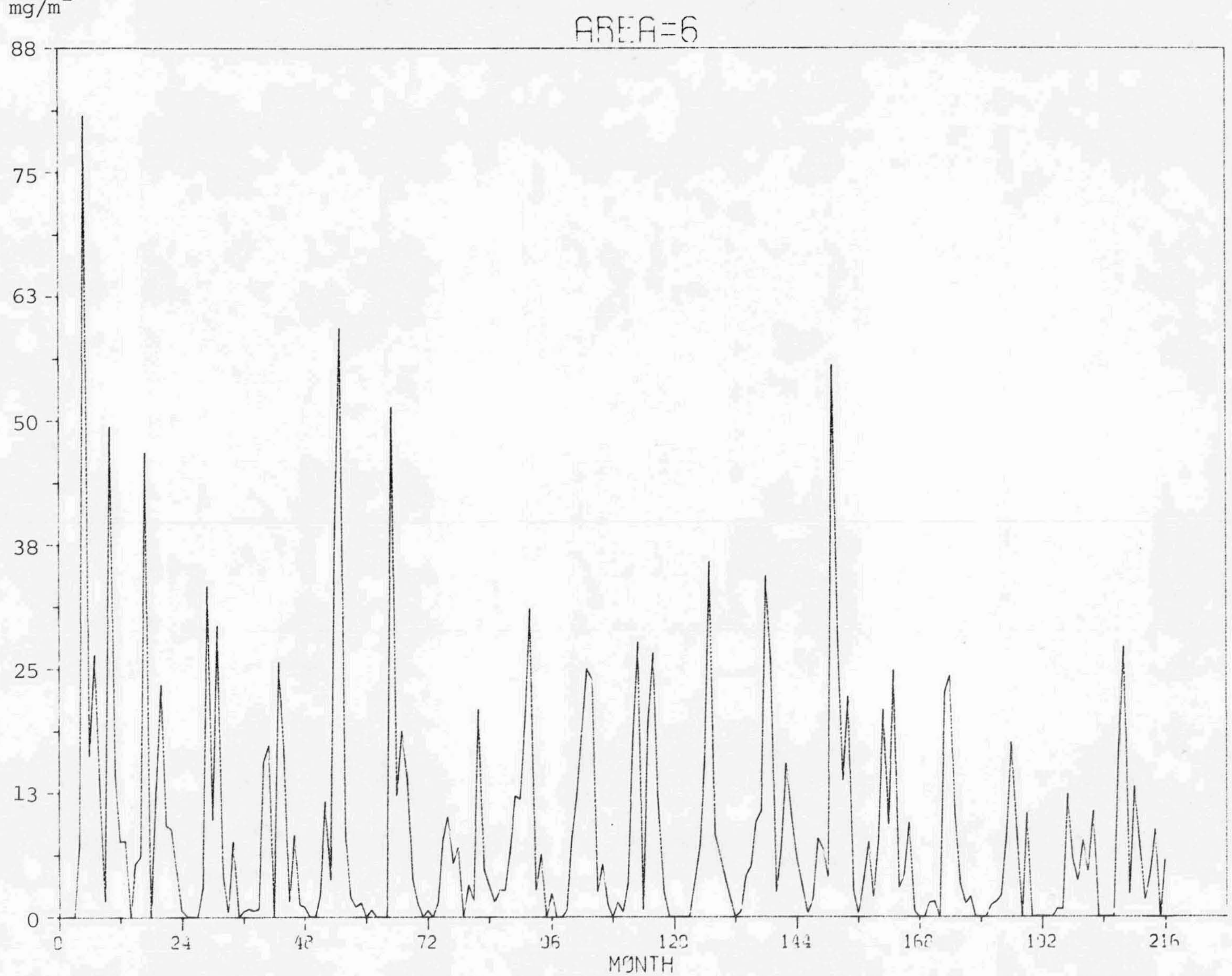
mg/m^2
AREA=6
88
75
63
50
38
25
13
0
0
24
48
72
96
120
144
168
192
216
MONTH

Fig.4. (cont'd)

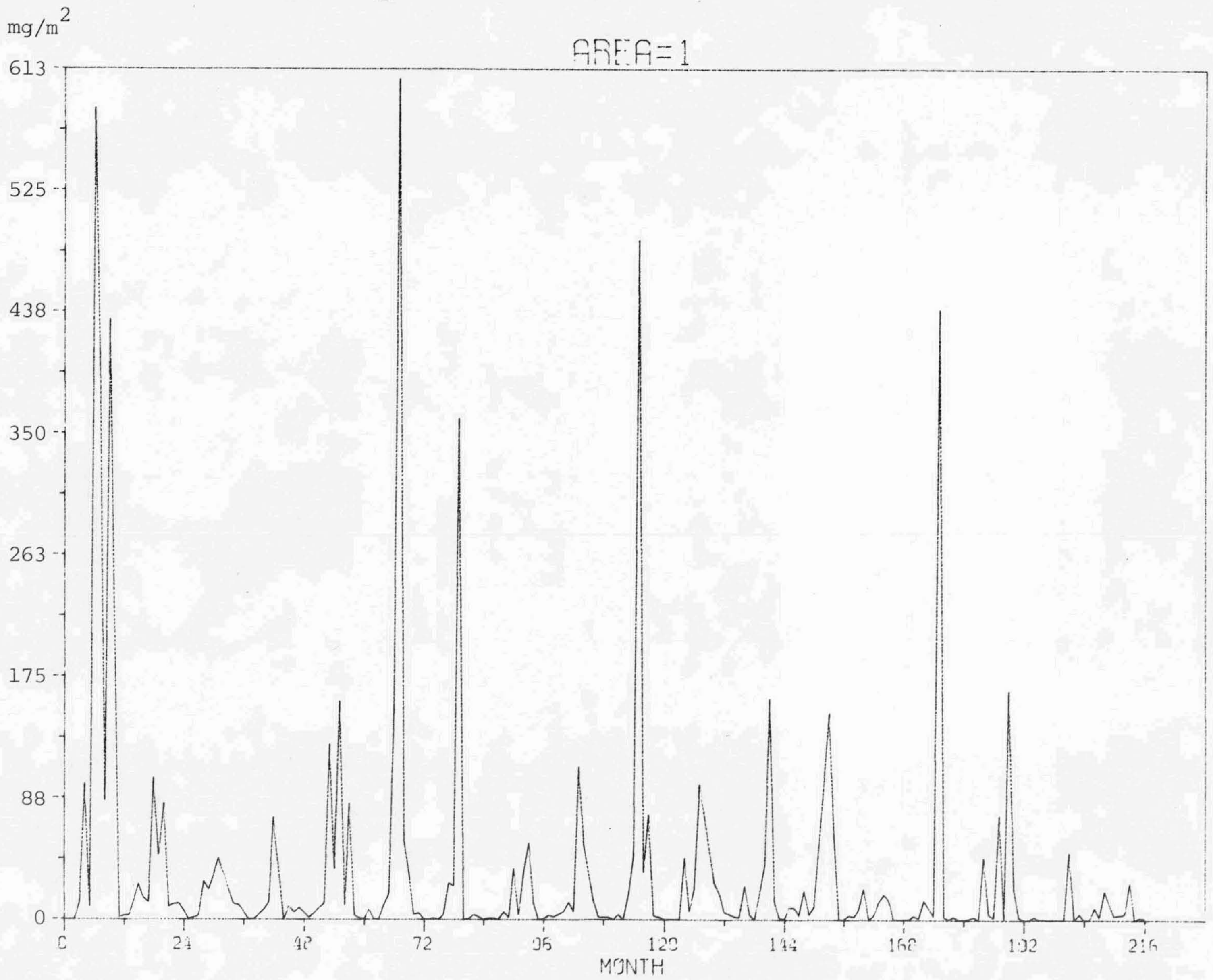

Fig.5. Estimate of biomass (dry weight in mg/m^2) of Pseudocalanus CVI from the CPR count of Para-Pseudocalanus. Given for each area. For definition of the areas, see fig.1. The month 1 is January 1958.

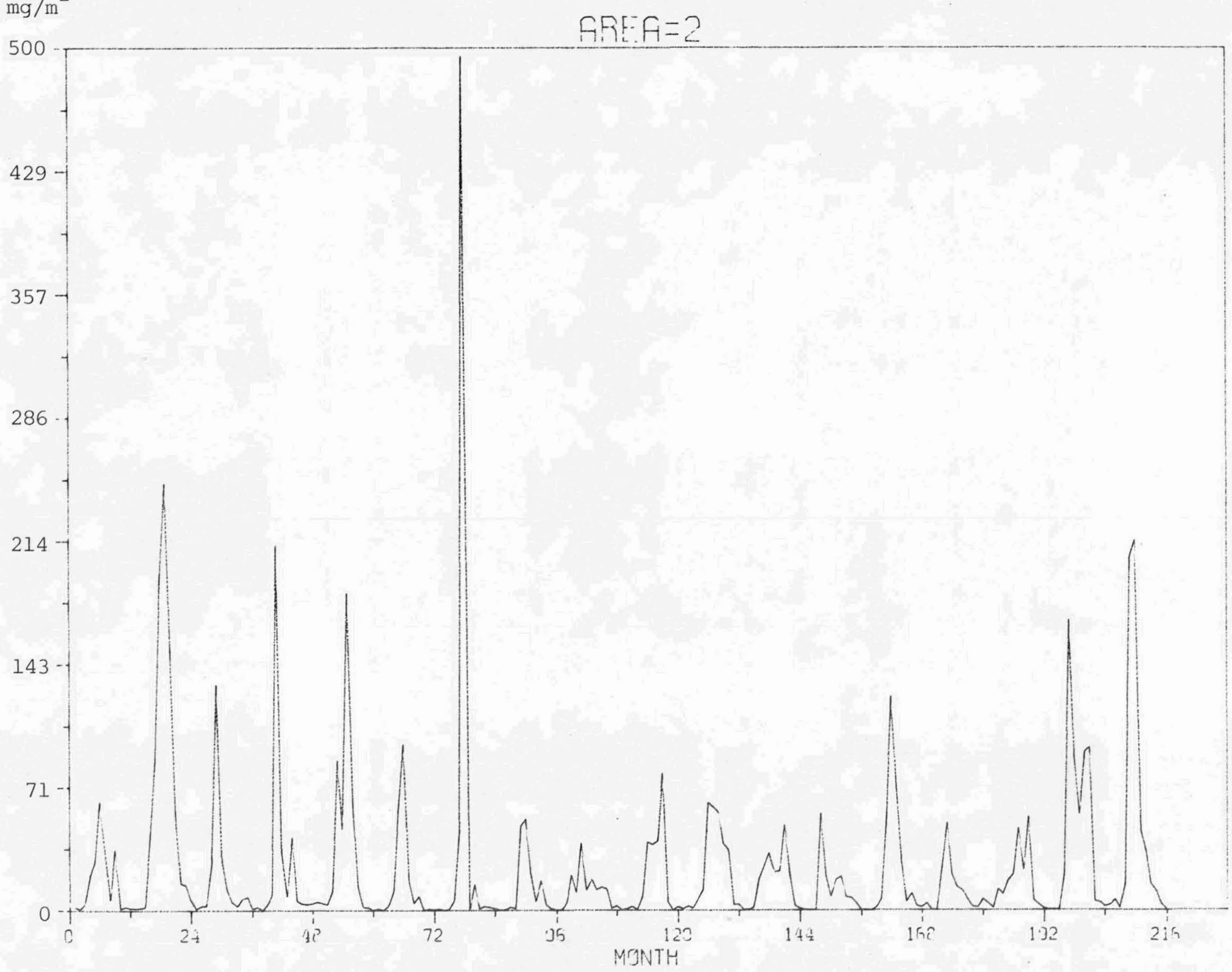
mg/m2
AREA=2
500
429
357
286
214
143
71
0
0
24
48
72
96
120
144
168
192
216
MONTH

Fig.5. (cont'd)

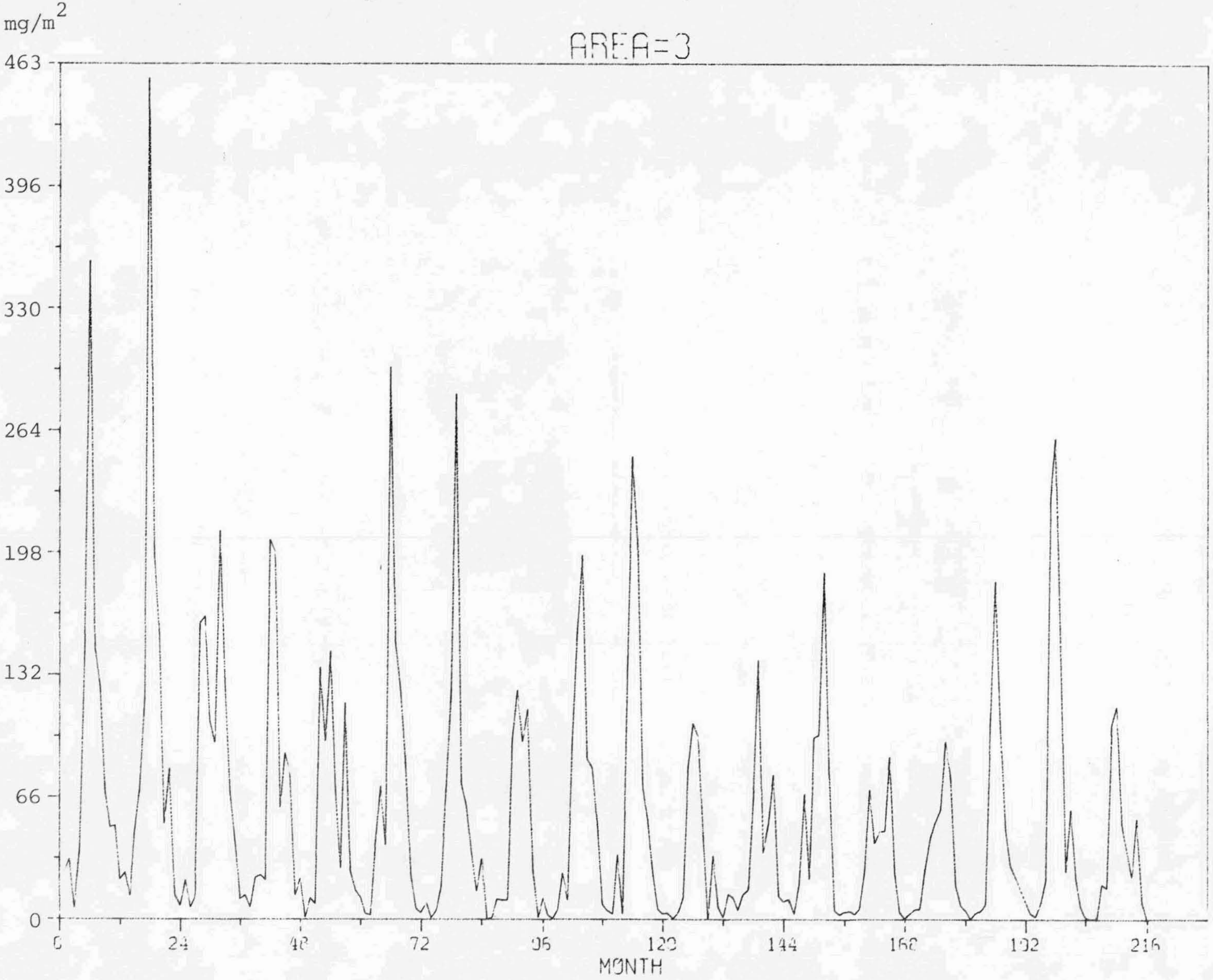
mg/m^2
AREA=3
463
396
330
264
198
132
66
0
0
24
48
72
96
120
144
168
192
216
MONTH

Fig.5. (cont'd)

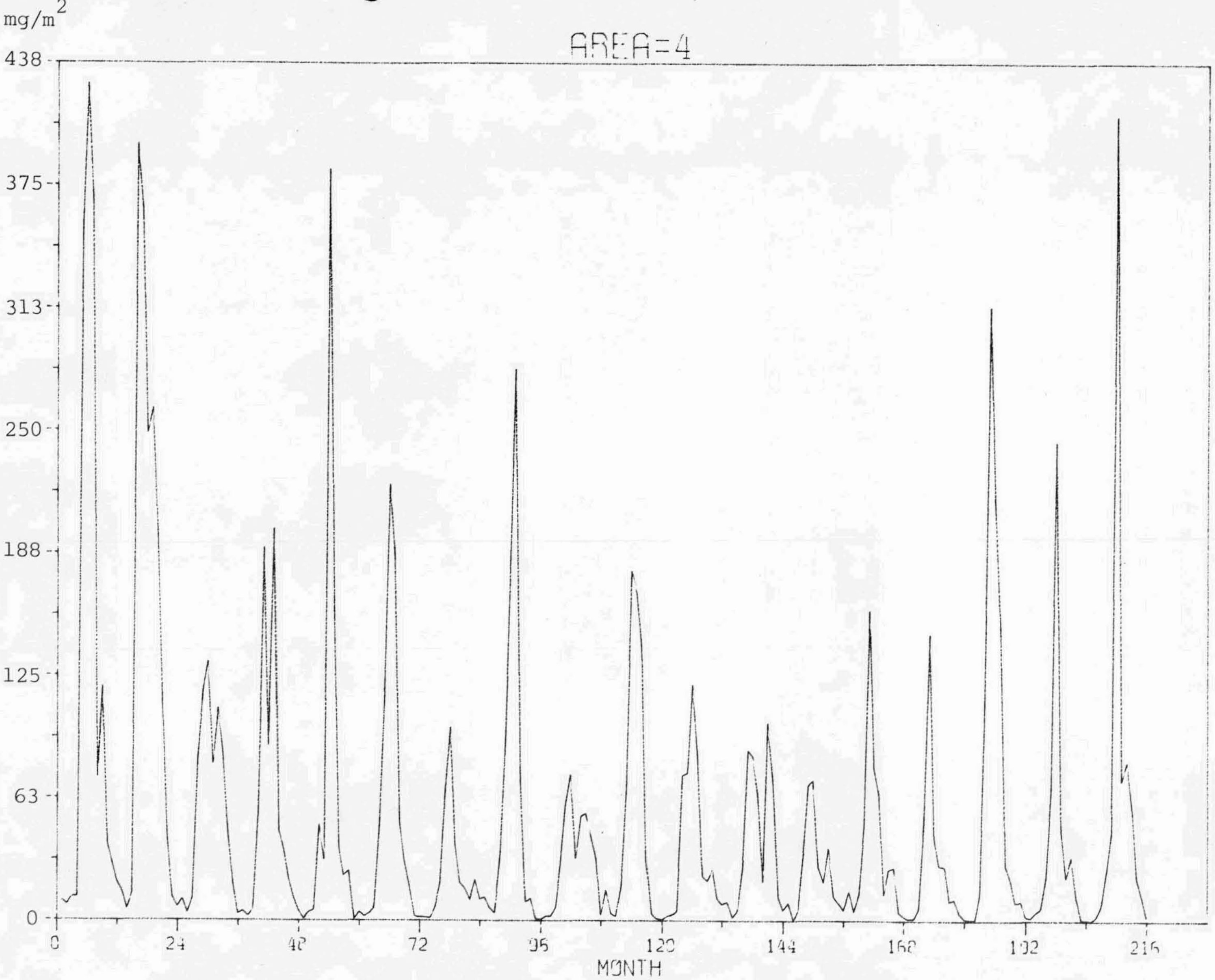
mg/m^2
AREA=4
438
375
313
250
188
125
63
0
0
24
48
72
96
120
144
168
192
216
MONTH

Fig.5. (cont'd)

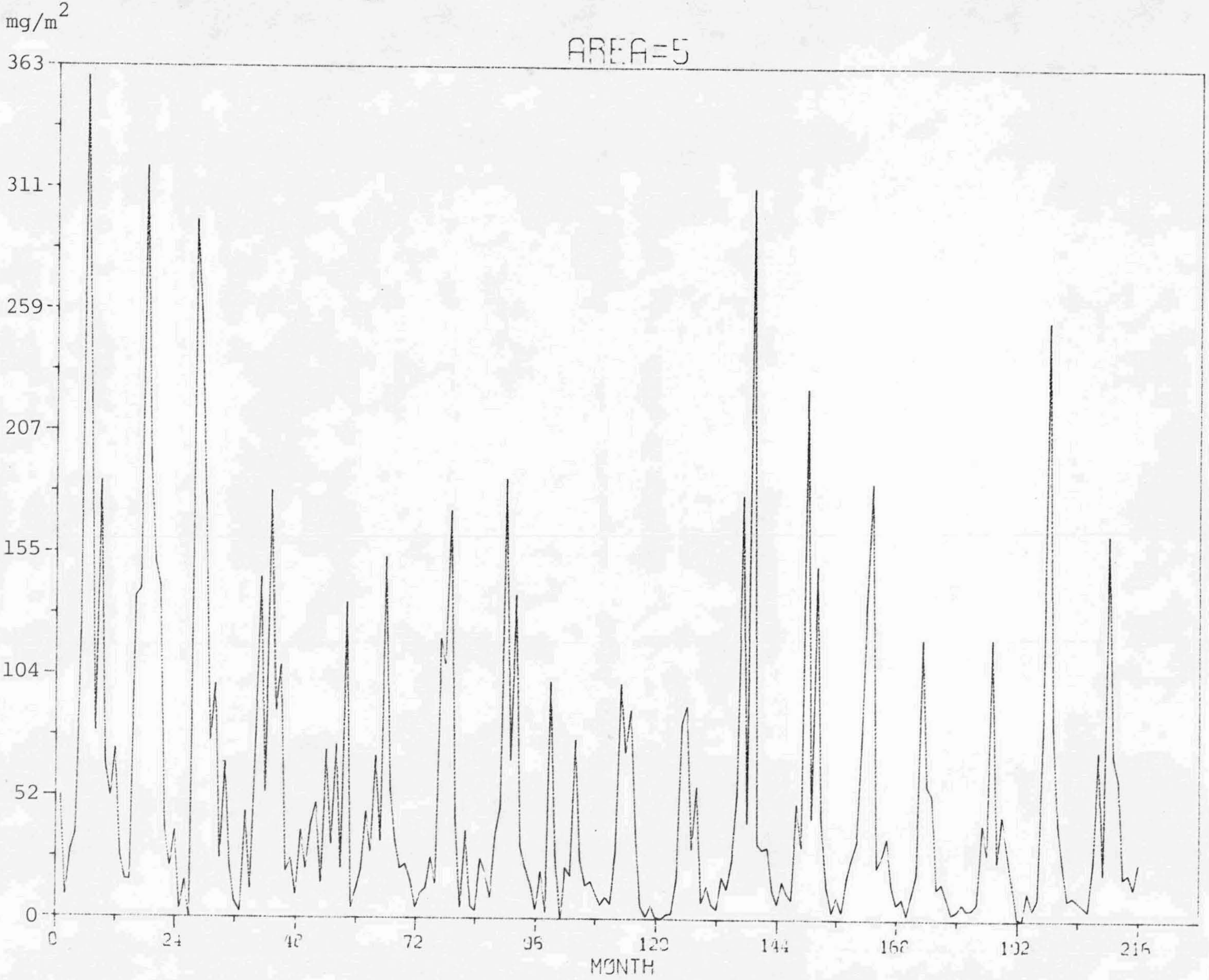
AREA=5
mg/m^2
363
311
259
207
155
104
52
0
0
24
48
72
96
120
144
168
192
216
MONTH

Fig.5. (cont'd)

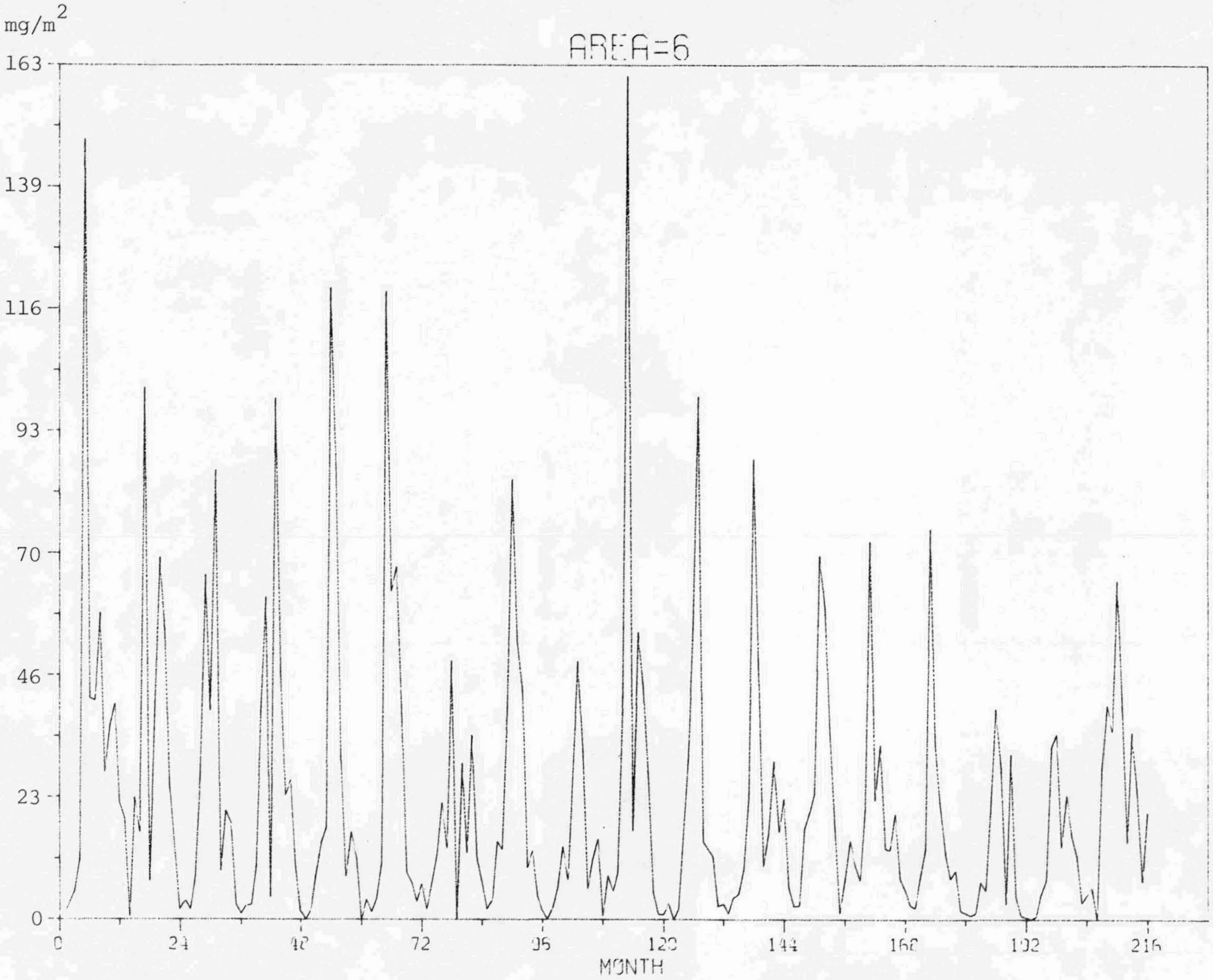
mg/m^2
AREA=6
163
139
116
93
70
46
23
0
0
24
48
72
96
120
144
168
192
216
MONTH

Fig.5. (cont'd)