LASKER GATES BETWEEN MIXING EVENTS FROM THE FRENCH BORDER REGION TO THE CANARY ISLANDS - 1988 AND 1989 AND INTERANNUAL AND SEASONAL CHANGES OF THE WIND INDICES 1967-1989

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I. INTRODUCTION

In a series of remarkable laboratory and field investigations in the 1970's (Lasker, 1975; Lasker, 1978; Lasker, 1981a; Lasker, 1981b) Lasker produced first-feeding anchovy larvae in the laboratory and used them to assay the quality of food in the surface and shallow chlorophyll 'a' maxima in the nearshore habitat of the Southern California Bight. He found that there were only a few strata in the water column which would support the first feeding of the larval anchovy. Of more importance, in terms of variability of recruitment, Lasker found that a storm mixed the water column and dispersed the critical layers.

In a series of studies of anchovy larval growth, (Methot and Kramer, 1979) and growth rates, ages and birthdate distribution of anchovy larvae and juveniles (Methot, 1981; Methot, 1983) Methot found that variations in juvenile survivors per unit of larval production as a function of time of year was nearly sufficient to account for variations of recruitment in the same years. Methot found that the larval production in 1978 and 1979 varied by only about 2% but the 1978 year class was about twice as large as the 1979 year class.

Following the work of Lasker about the stable ocean and Methot on seasonality of recruitment success, Bakun and Parrish (1980) in a series of publications (Parrish, Nelson & Bakun 1981; Bakun & Parrish 1982; Parrish et al 1983; Bakun 1985; Bakun 1986) explored in detail the existing data sets on the eastern boundary currents in the world and the assemblage of fishes in each zone with emphasis on the sardine and anchovy. In general, it was found that the spawning period of the schooling, coastal, pelagic fishes in each eastern boundary area was timed to the climate of turbulent mixing and offshore transport, in each case centered on the minimum of each of these variables. Peterman and Bradford (1987) found that the survival rate of early larvae of the northern anchovy (Engraulis mordax) was correlated with the number of periods, 4 days in length, without a wind over 10 ms^{-1} in each month. They found that the daily mortality rate for anchovy larvae was 0.3 with 12 calm periods per month and 0.1 with 26 calm periods per month. Mendelsohn and Mendo (1987) explored data on Peruvian anchoveta recruitment and wind speeds among other variables. They found that the data was dominated by still periods and that no relationship existed among these and the recruitment rate of Peruvian anchoveta (Engraulis ringens).

They used the definition of 4 days with no wind above 5 ms^{-1}, and referred to the interval as a Lasker 'event'. Wooster, Bakun and McLain (1976) described the seasonal upwelling cycle along the eastern boundary of the Atlantic Ocean. Wooster[1] found that interannual variability in upwelling off Spain was negatively correlated with sardine recruitment. He referred to the 'Stable Ocean Paradigm' of Lasker and the offshore transport which accompanies upwelling as possible factors related to poor recruitment. The purpose of this study is the make available, and briefly describe, the geostrophic winds in 9 regions, along the Atlantic coastline of Spain, Portugal, and Morocco from the French border to the Canary Islands. The nominal spacing of each region is three degrees latitude. Each data set is made up of 6 hourly observations between January 1, 1967 and July 31, 1989, 32,988 observations for each of 9

[1] Wooster, W. S., unpublished manuscript, Institute for Marine Studies, University of Washington, Seattle, WA 98195

regions. Each observation contains a north-south component and an east-west component. This document is to be included in a compilation of reports of work on the egg production method of estimating spawning biomass and the birthdate distribution of the pilchard, Sardina pilchardus, stock off the Atlantic coastlines of Spain and Portugal.

II. METHODS

This report is a description of a data set with limited analysis performed as part of this report. The data set (in ASCII characters) can be obtained in its entirety by sending formatted floppy disks (five 3.5 inch double-sided high density, five 5.25 inch double-sided high density or fifteen 5.25 inch double-sided double density). In this form, the missing values are filled with as single asterisk. The data can also be sent on magnetic tape. The format we received the data in was an 8-character date time group yrmodahr and 18 4-character including sign, columns in pairs of n-s and e-w components for each of 9 regions. In this form the missing values can be noted by missing sequences of date/time groups. The positive values are winds to the north and to the east in tenths of meters per second.

A. Lasker Gates

For this report, the Lasker 'Gate' is defined as an 'open' which is four days with no wind over the threshold and a 'close' which is a wind event. For each month in which a 'close' has occurred we have plotted the time elapsed in days between wind events in excess of 10 ms^{-1}. This differs from the Peterman and Bradford (1987) definition which is the number of overlapping 4-day periods without a wind event in excess of 10 ms^{-1}. The Peterman & Bradford number of 2 overlapping 4-day periods would be a 5-day Lasker Gate in this system. A ninety-day Lasker Gate in this system would be 3 months of 26 high wind-free periods per month.

B. Regionality

The regions chosen for this study are arbitrary 3-degree rectangles extending from the French border with Spain to the Canary Islands along the Atlantic coastline of Spain, Portugal and Morocco. The regions are centered on 45, 42, 39, 36, 33, 30, and 27 degrees north latitude. There are three regions at 45 degrees north; 2, 5, and 8 degrees west in the Cantabrian Sea and Bay of Biscay (Figure 1). The statistical summary of the regions will consist of monthly means and cross-correlation coefficients among the regions following removal of the seasonal trends.

C. Seasonality

Seasonality is estimated by integrated periodograms of each region of the monthly means. The seasonality is reported as the proportion of the total variance over the entire period of the time series.

III. RESULTS

A. Seasonality

It is necessary to quantify seasonality to determine the degree of correlation among deviations of wind components in adjacent regions. Once the influence in seasonality is removed it is possible to see the agreement among the regional anomalies. The contribution of seasonality to the components of the wind and the wind speed cubed are shown in table 1.

B. Regionality

Table 2 lists the correlations among the regions with reference to turbulence or wind speed cubed with seasonality removed. The three regions (regions 1,2,3) at 45 degrees north latitude along the southern margin of the Bay of Biscay, the Cantabrian Sea, are closely linked in the time series. More than 2/3 of the changes within this set could be predicted from other areas in the set (r^2). With this close linkage in the aseasonal time-series and the high fraction of variance which is seasonal (=>50% table 1) it would be expected that Lasker 'Gates' would be rather similar for the entire spawning population in that large region. The 2 regions at 42 and 39 degrees north, on the west-facing Atlantic coast of Spain and Portugal are not closely related on an annual basis to the Cantabrian sea wind indices. Less than half of the variability in the Vigo region could be predicted from the Cantabrian indices and about half of the variation of the Lisbon region could be predicted from the Vigo region. The Gibraltar area, which probably represents the sardine spawning area off the south coast of Portugal, is barely related to the Lisbon region and all the areas to the south appear quite different from the areas to the north. The region off Casablanca shows no seasonality and the two regions to the south of that, Agadir and Canary Islands show progressively more seasonality but with the high winds in summer and low in winter, the reverse of the Cantabrian Coastline.

C. Lasker Gates

The incidence of Lasker 'Gates' varies by season and region in 1988-1989, the period of the Spanish-Portuguese SARP work. The period covered by this study is for birthdates from January 1988 through July 1989. All nine areas have been evaluated.

San Sebastian (Region 1) - There were 5 short gates and 1 long gate in the first four months of 1988. After May there was a succession of long gates persisting until September after which there was a succession of 4 gates of long or medium length. In 1989 there were 6 gates in the first four months, one long ending in February and one medium ending in April. After May there were no gate closings.

Asturias (Region 2) - There were 5 short gates in January through March, 1988 and relatively continuous gates from April through October. In 1989, there were 8 gates, 1 long in February and one medium in April, in January through April. No gates were closed by July 1989.

La Coruñna (Region 3) - Compared to regions 1 and 2, there appears to be much more turbulence activity in region 3 at all times of the year and in both 1988 and 1989.

Vigo (Region 4) - In 1988 the extent of the turbulence activity appears similar to La Coruna. In 1989, however, there appears to be an extended gate through May and part of June.

Lisbon (Region 5) - In 1988 there appears to be a trend of lengthening gates through April. In 1989, there is a gate which ends in June which originated in May. No gate closed in May.

Gibraltar (Region 6) - In 1988, there was one long gate over six months long which persisted from April through October. In 1989, there was one gate open after May.

Casablanca (Region 7) - In 1988, the gates appear to be increasing in duration from January to March with a similar set increasing from March to May. One gate, more than 2 months long, ended in November. Another gate, nearly a month long ended in February 1989 and another must have persisted most of March. April and May had a small number of relatively short gates and longer gates again characterized June and July of 1989.

Agadir (Region 8) - In 1988, January and February had long gates while March was characterized by more short gates. They again lengthened in April through July and following a short gate ending in August, the rest of the year was characterized by a single long gate, more than 2 months long. In 1989, the region was characterized by many short and medium length gates.

Canary Islands (Region 9) - January and February of 1988 were dominated by gates and March through June provided a few small gates. July and August must have been too turbulent to provide any gates and October through December were characterized by long gates. All of 1989, through July could be characterized as having many short gates.

Based on the analysis of seasonal and regional differences in wind speed cubed climatology and Lasker 'Gates' in the two years under study it would appear that the primary areas for survival of larval stages which require dense aggregations and layers of food are in the Cantabrian Sea (Regions 1 and 2) and the Lisbon region (Region 5). Survival of the weakest swimming stages of the sardine larvae in the La Coruna and Vigo regions would likely be more episodic than in the surrounding regions based on the Lasker 'Stable Ocean Hypothesis'.

IV. DISCUSSION

This preliminary examination of wind speed cubed indices for the region between the French border with Spain and the Canary Islands along the Atlantic coastline, with special reference to the Lasker 'Gates' has shown seasonal, regional and interannual differences which are likely to be important to the degree of stability and mixing in the upper layers of the coastal areas. As we learn more about the seasons, regions, and interannual changes in the formation of successful cohorts of sardine year classes, it is possible that these changes can be related to recruitment strength among the coastal areas.

While it may not be difficult to assemble and maintain meteorological indices, there is still a lot of biological supporting work which must be done to obtain cause-effect relationships which could lead to successful recruitment prediction. For example, the Lasker hypothesis is based on the first days after the onset of feeding, following the absorption of the yolk-sac: this is the beginning of several life-stages with changing but specific requirements for survival. We do not know for any habitat whether 6 four-day 'gates' is the equivalent of a single 24-day 'gate'. The eastern boundary current habitat of the schooling, coastal pelagic fishes appears to combine the high productivity of a large-scale upwelling and equatorward transport area with mesoscale intermittent stability. With the long gates in this record, it would seem worthwhile to check that productivity is not impaired in these long periods. It may be that the intermittency is important to maintain productivity in the turbulent period and maintain structure of the food horizons in the still period. Where the high wind speeds accompany upwelling and offshore transport, the drift of the eggs and larvae will have to considered in this context.

There are important differences in the sardine life cycle and the previously studied anchovy life cycles. It is possible that long stable periods could build the numbers and the rate of parasitism of the ooparasite. Also, the sardine egg appears to be deposited deeper in the water column and closer to the continental shelf than the anchovy. This could lessen the degree of dispersal and possibly prolong cannibalism in the egg and larval stages. It would appear that there should be some laboratory studies of sardine larva food requirements followed by surveys capable of determining the volume of water which will support sardine larvae at several stages of life including first-feeding and the larval growth phase.

The timing of spawning of the sardine (Sardina pilchardus) in these regions supports the stable ocean hypothesis (Lasker, 1981; Parrish, Bakun, Husby, and Nelson, 1983). It would therefore seem worthwhile to continue the establishment of birthdate proportions by recruit birthdate analysis (Alvarez and Butler, this volume) and monitor the wind indices for the spawning areas. If it is found that a disproportionate share of spawning is found near small coastal areas (Canyons, Capes etc.) the Bakun Wind Indices, which have a spatial resolution of ca. 300 km should be augmented by direct local wind estimates.

It appears that some areas of intensive spawning do not support the larger sardine larvae (Garcia & Cunha). This provides an opportunity for directed larval ecology studies in these areas to establish the causes of the deficiency of survival. The Iberian peninsula provides ample variety of oceanographic conditions for comparative work: the Asturias, Vigo, Lisbon and Gibraltar coasts could provide sites for tests of turbulence and larval survival hypotheses.

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TABLE 1

PROPORTION OF VARIANCE WHICH IS RELATED TO SEASONALITY OF COMPONENTS OF THE WIND AND WIND SPEED CUBED

REGION	NORTH-SOUTH	EAST-WEST	WIND SPEED CUBED
1	0.43	0.35	0.55
2	0.42	0.38	0.50
3	0.30	0.27	0.55
4	0.46	0.15	0.35
5	0.55	0.05	0.40
6	0.47	0.09	0.50
7	0.67	0.16	0.05
8	0.71	0.16	0.30
9	0.79	0.23	0.50

TABLE 2

CROSS CORRELATION AMONG ASEASONAL ANOMALIES FOR REGIONS ON THE ATLANTIC COASTS OF SPAIN, PORTUGAL AND MOROCCO FROM THE FRENCH BORDER TO THE CANARY ISLANDS

REGION	1	2	3	4	5	6	7	8	
1 San Sebastian	-								
2 Asturias	.96	-							
3 La Coruna	.84	.93	-						
4 Vigo	.60	.64	.69	-					
5 Lisbon	.30	.27	.25	.73	-				
6 Gibraltar	.08	.07	.05	.26	.59	-			
7 Casablanca	.07	.09	.07	.17	.43	.79	-		
8 Agadir	.13	.12	.06	-.06	.12	.43	.70	-	
9 Canary Islands	.14	.13	.09	-.15	-.16	-.06	.07	.61	-

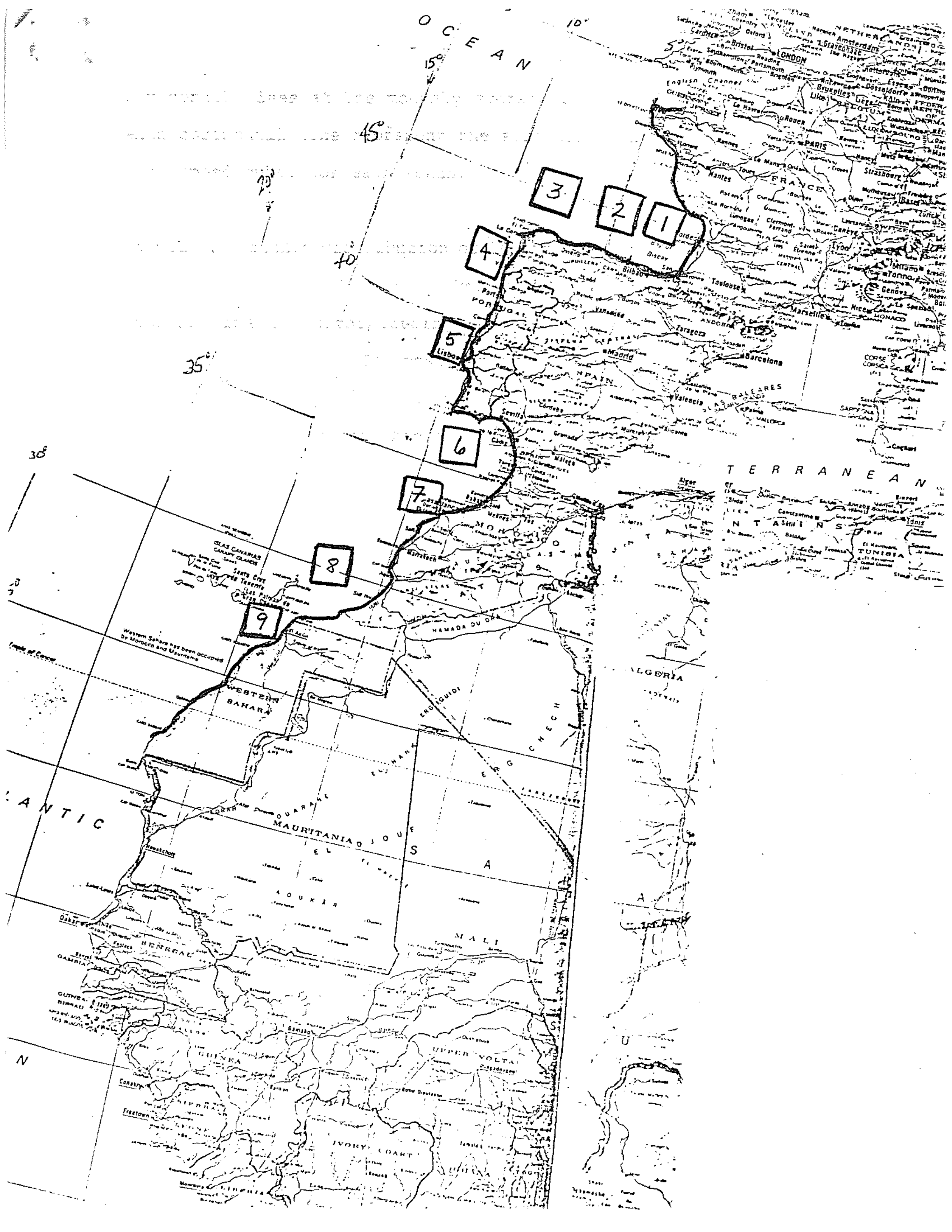
FIGURE CAPTIONS

Figure 1. Regional map with positions used for estimating the wind speed cubed.

Figure 2. The relative importance of seasonality in variability of wind speed cubed. The curve is the integrated value of variability from long-term to short term. The length of the sharply ascending line at the position of 0.083 cycles per sampling interval (The reciprocal of 12 sampling intervals per cycle) for this set of monthly averages represents the fraction of variability attributable to seasonality. The central diagonal line represents 'white noise' or variability evenly distributed among the frequencies. The lines parallel to the center line represent 75% and 95% limits of white noise given the number of observations in the time series. The lines above the diagonal show the significance of 'red' noise (shifted to longer frequencies) and the lines below the diagonal show the significance of 'blue' noise (shifted to shorter frequencies). The ordinate is in relative proportional units from 0 to 1.

Figure 3. The interannual (A) and seasonal (B) data for the wind speed cubed statistic by region. The interannual data have had the seasonality removed by subtraction of the monthly average from each month and the short-term variability has been reduced by using a running average of the value and the 6 values preceding and succeeding the value (13). The seasonal plot is represented by 12 horizontal lines at the monthly averages. The vertical lines at each horizontal line represent the successive annual estimates of wind speed cubed for each month.

Figure 4. Monthly distribution of Lasker 'gates' by length in days for 1988 (A) and 1989 (B). The smallest gate is 4 days (the nominal time for first feeding larvae to survive). There is no maximum gate length. The position of the gate is in the month of the close of the gate by a wind event exceeding 10 meters per second. 'Gates' longer than a month will have opened in previous months.



OCEAN
ANTIC
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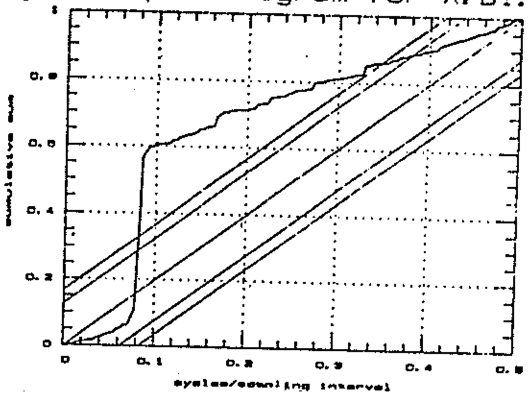
LONDON
PARIS
FRANCE
Bay of Biscay
Bilbao
Toulouse
Marseille
Zaragoza
Madrid
Barcelona
SPAIN
Lisboa
Sevilla
Valencia
ISLAS BALEARES
ISLAS CANARIAS
Santa Cruz de Tenerife
Las Palmas de Gran Canaria
HAMADA DU DRA
ALGERIA
Western Sahara has been occupied by Morocco and Mauritania
WESTERN SAHARA
MAURITANIA
ERG CHECH
MALI
SENEGAL
GAMBIA
GUINEA
UPPER VOLTA
IVORY COAST
TUNISIA
TERRANEAN

FIG 2

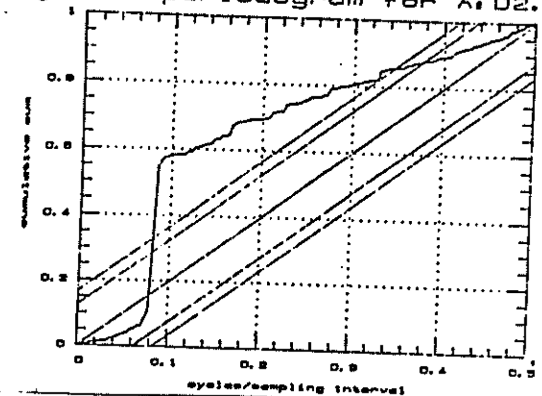
SAN SEBASTIAN

Integrated periodogram for A: D1. output



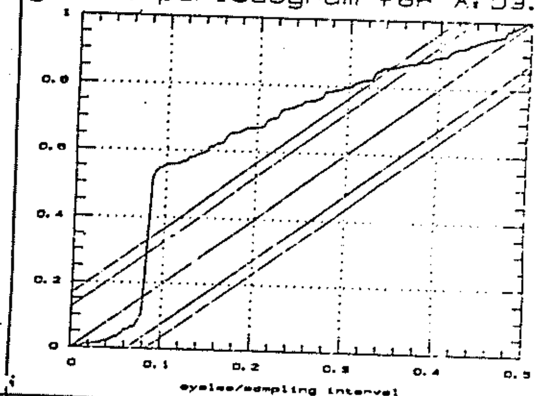
ASTURIAS

Integrated periodogram for A: D2. output



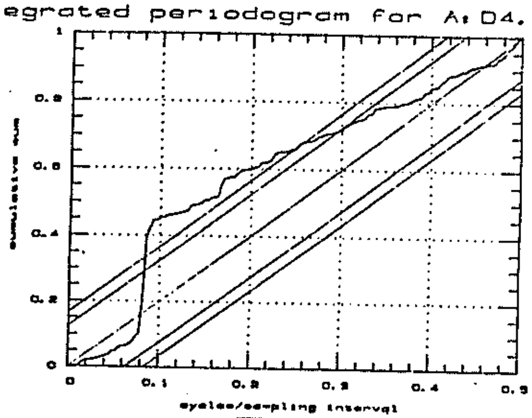
LA CORUÑA

grated periodogram for A: D3. output



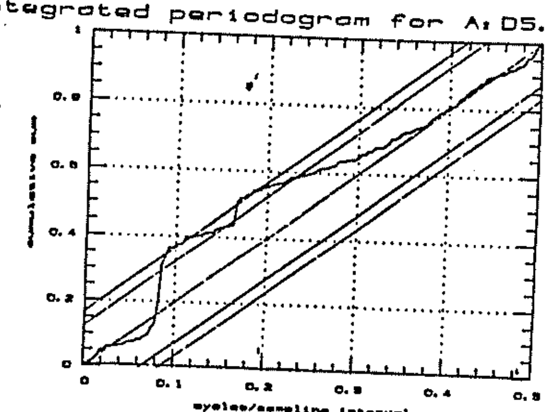
VIGO

Integrated periodogram for A: D4. output



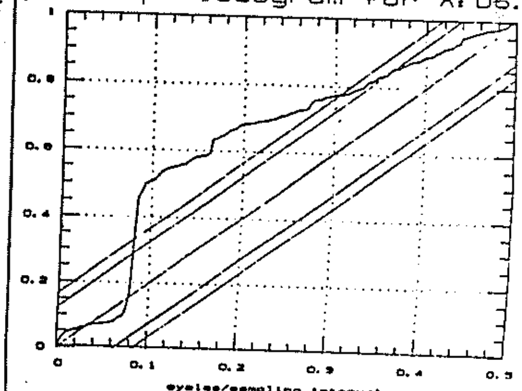
LISBON

Integrated periodogram for A: D5. output



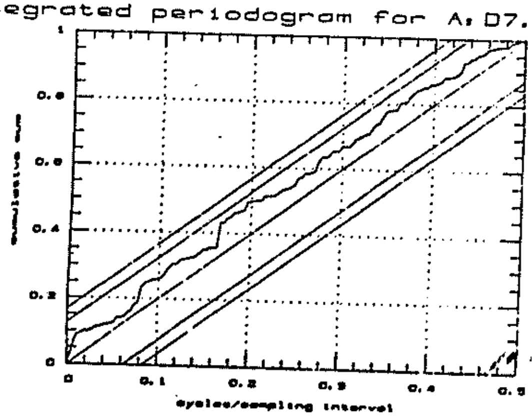
GIBRALTAR

grated periodogram for A: D6. output



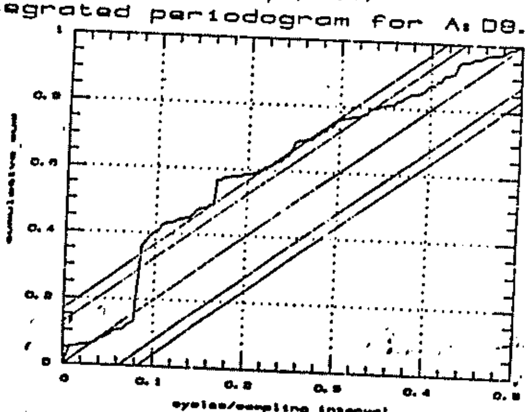
CASA BLANCA

ntegrated periodogram for A: D7. output



AGADIR

Integrated periodogram for A: D8. output



CANARY ISLANDS

grated periodogram for A: D9. output

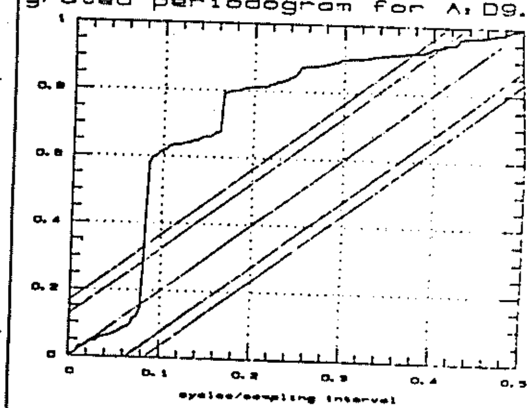
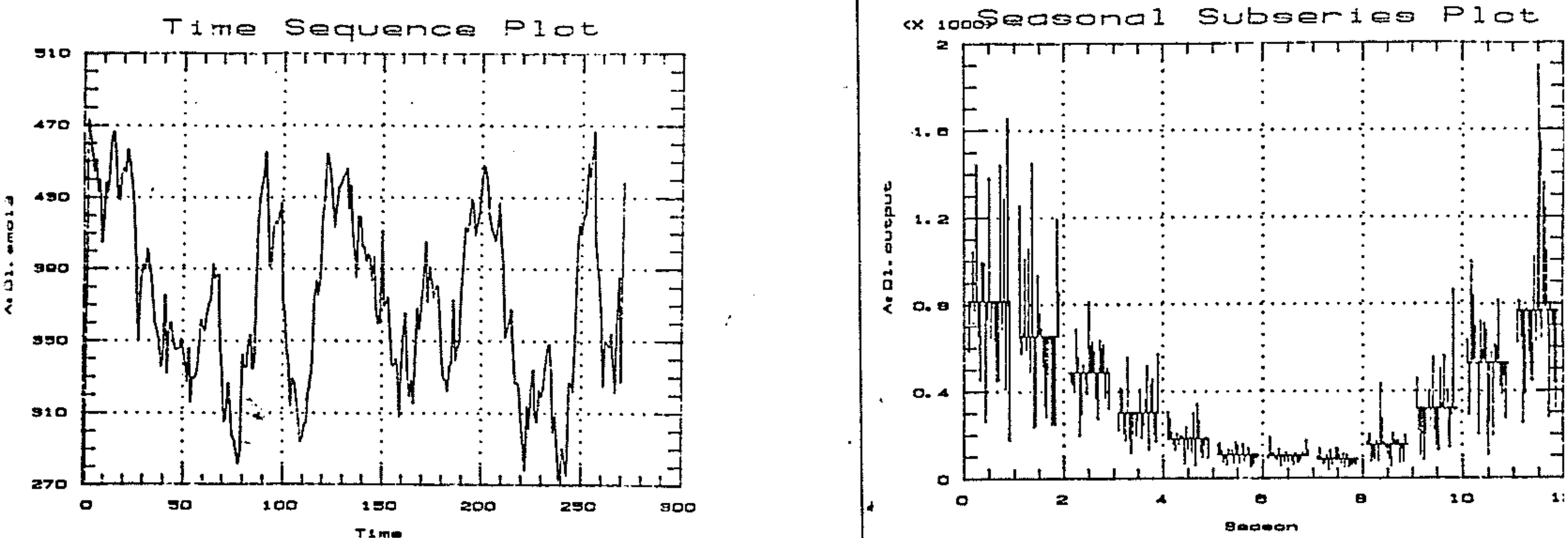
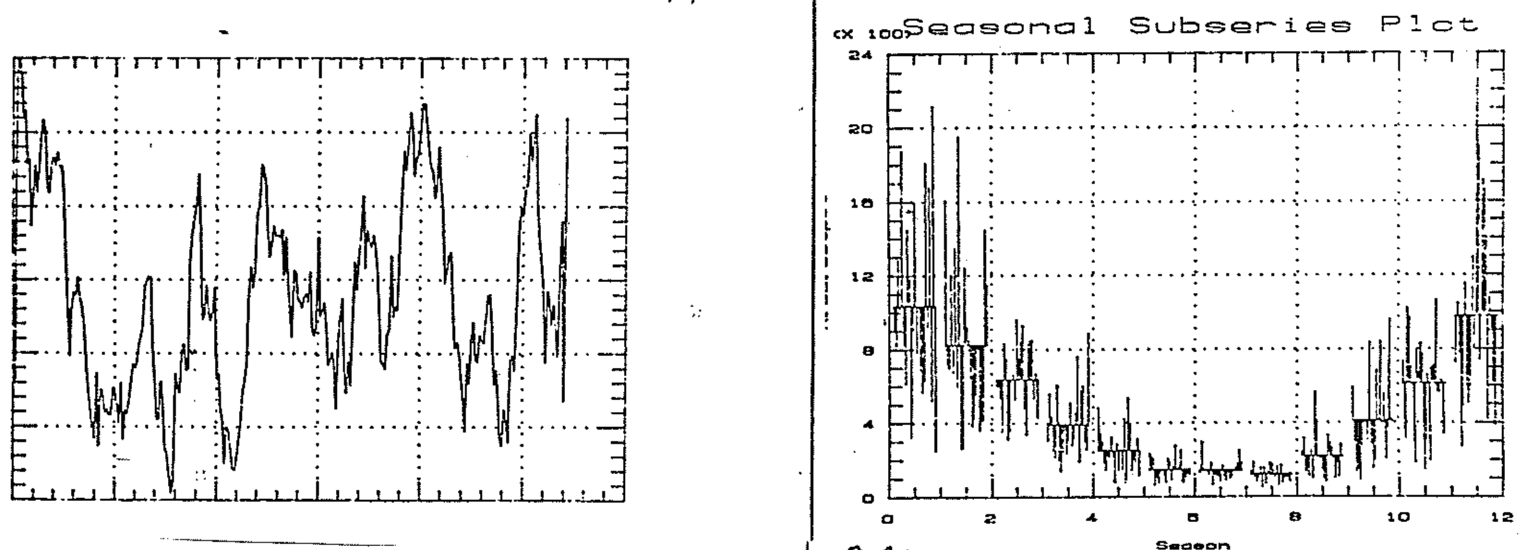


FIG.3

SAN SEBASTIAN



ASTURIAS



LA CORUÑA

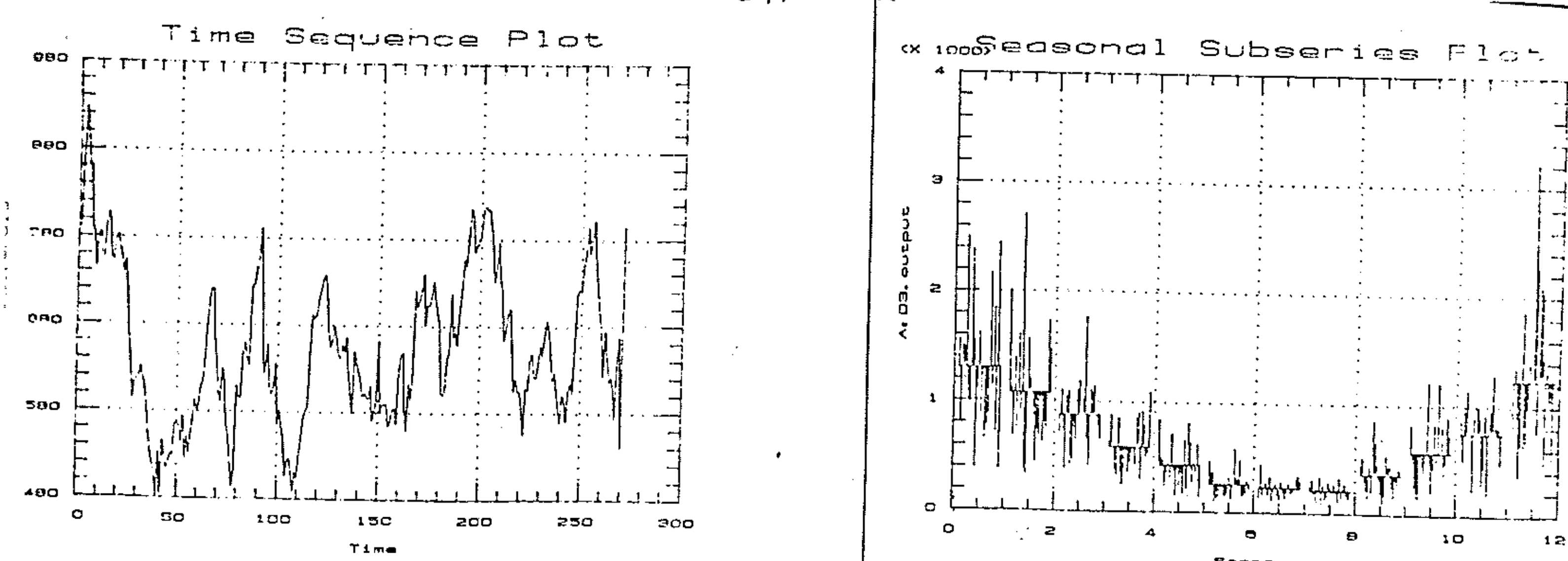
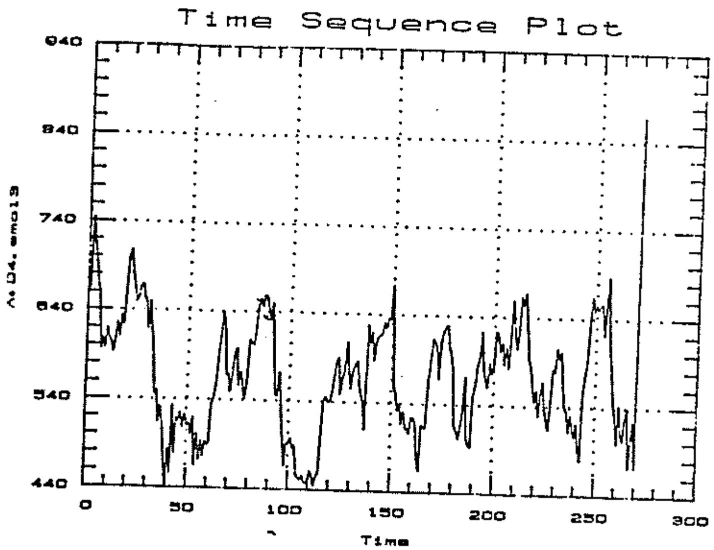
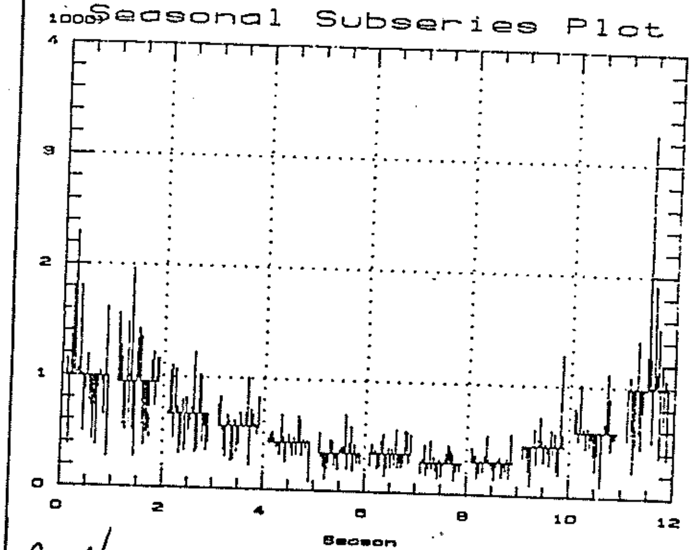


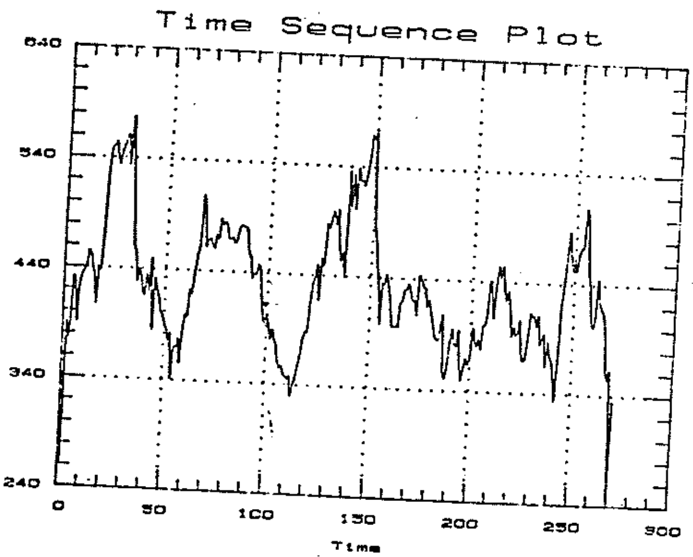
FIG.3 CONT.

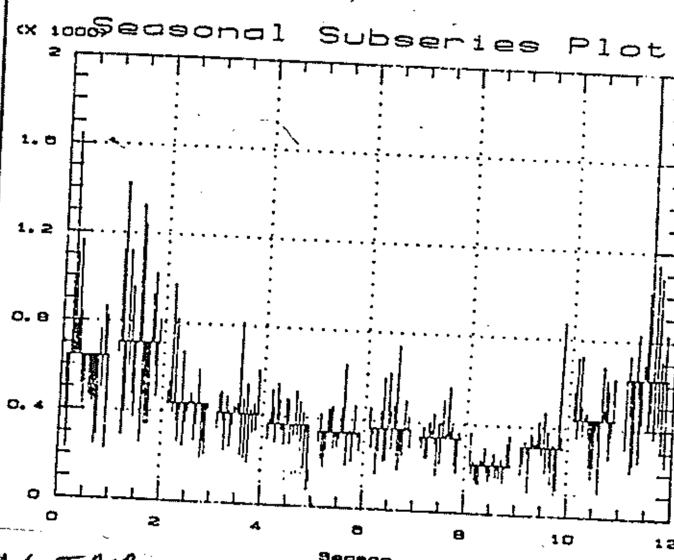
VIGO



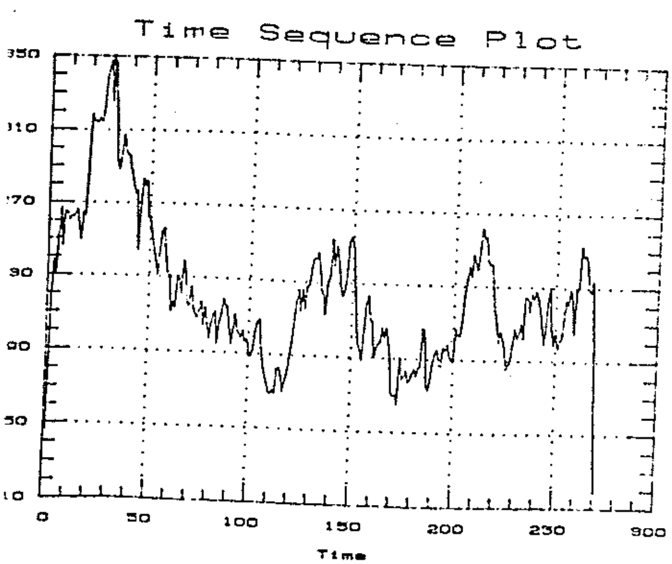


LISBON





GIBRALTAR



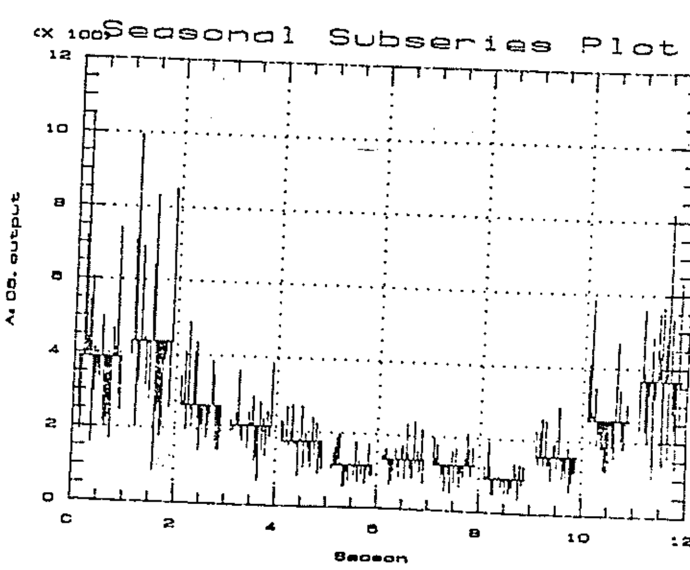


FIG. 3

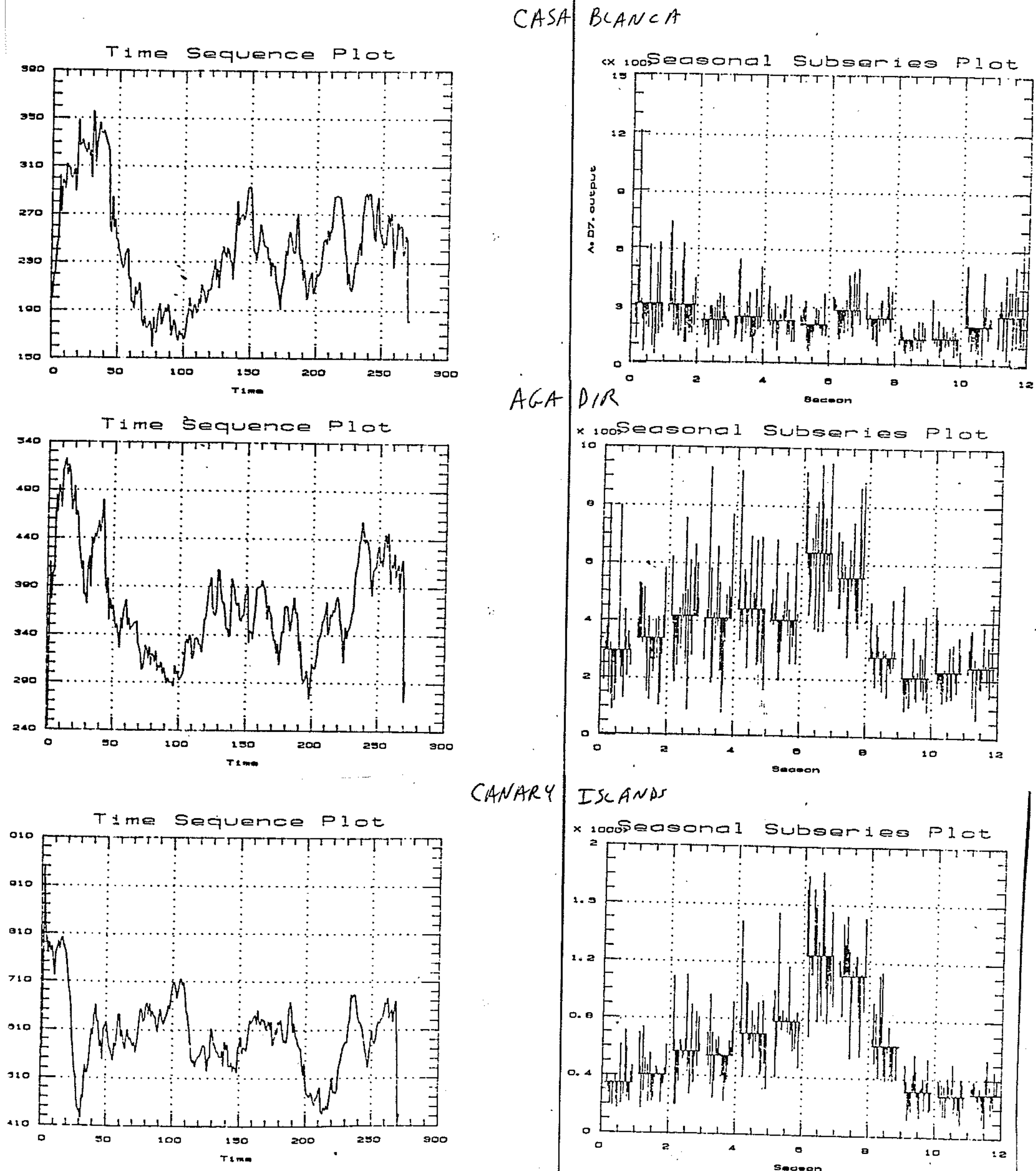
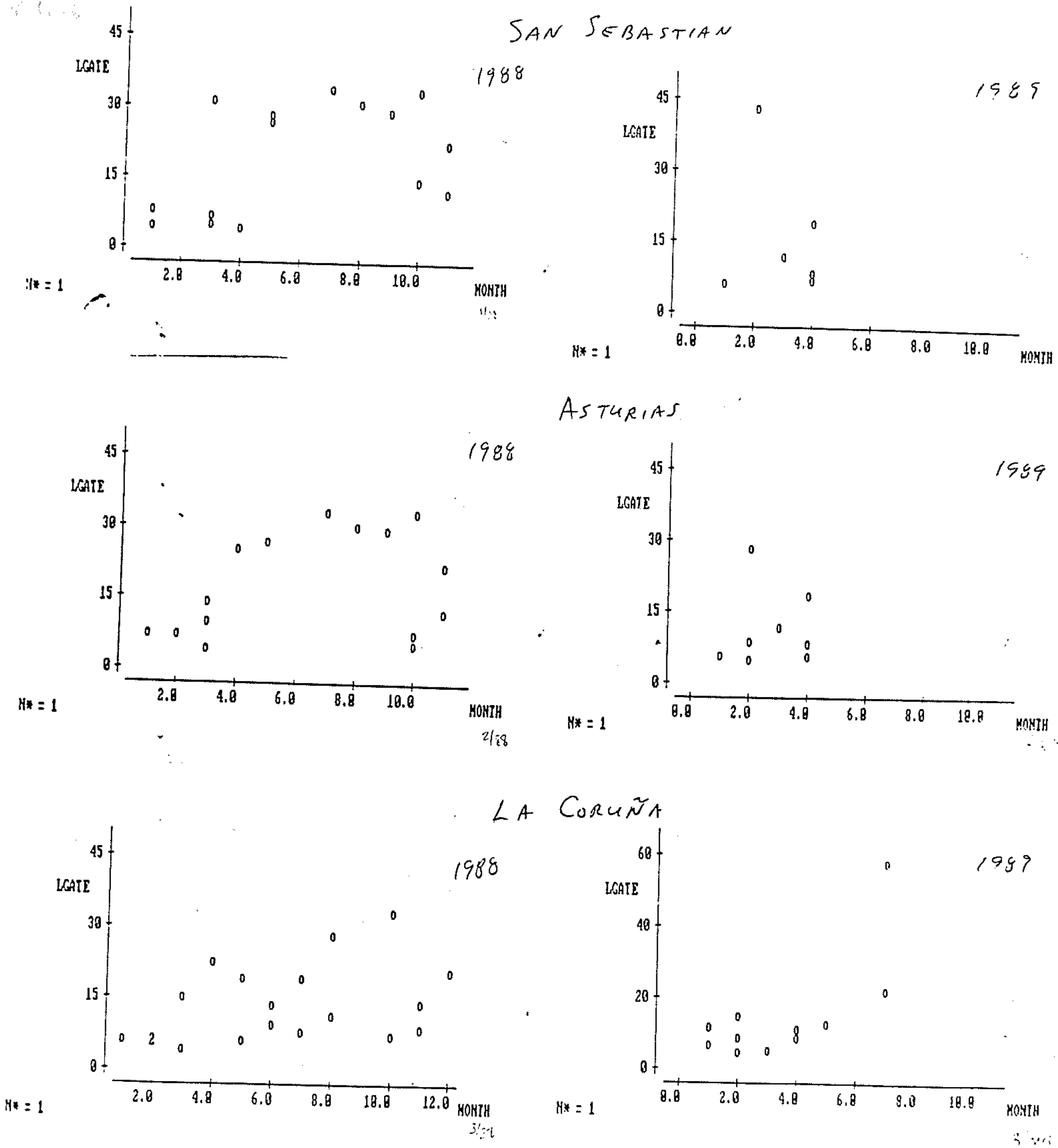

CASA BLANCA
Time Sequence Plot
Time
(x 100) Seasonal Subseries Plot
Season
AGADIR
Time Sequence Plot
Time
x 100 Seasonal Subseries Plot
Season
CANARY ISLANDS
Time Sequence Plot
Time
x 1000 Seasonal Subseries Plot
Season

FIG 4


SAN SEBASTIAN
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ASTURIAS
1988
1989
LA CORUÑA
1988
1989
LGATE
MONTH
N* = 1
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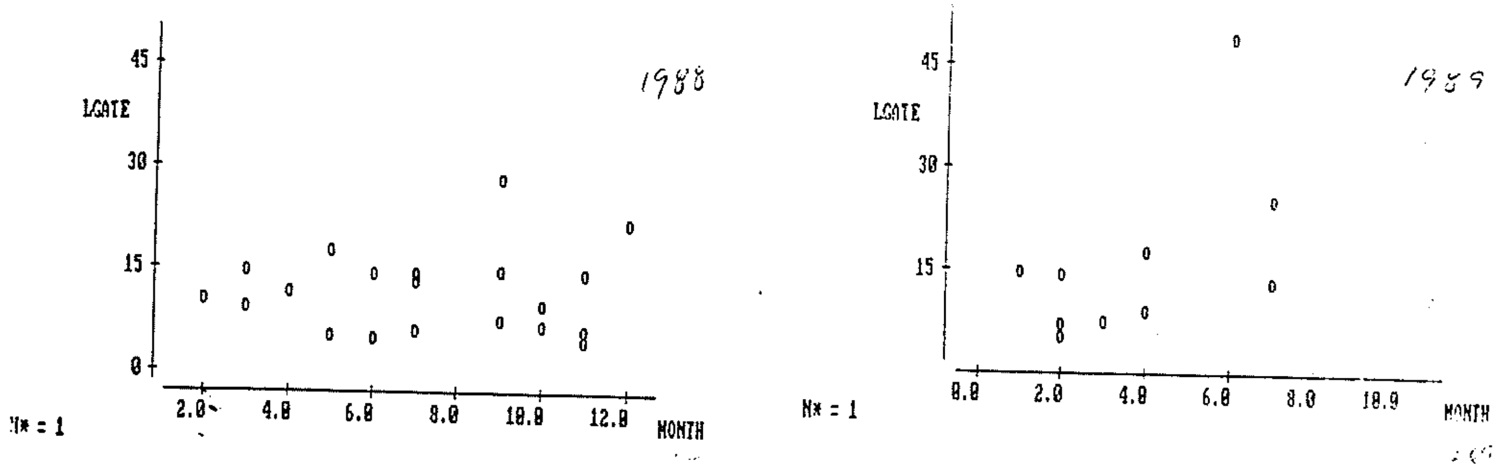
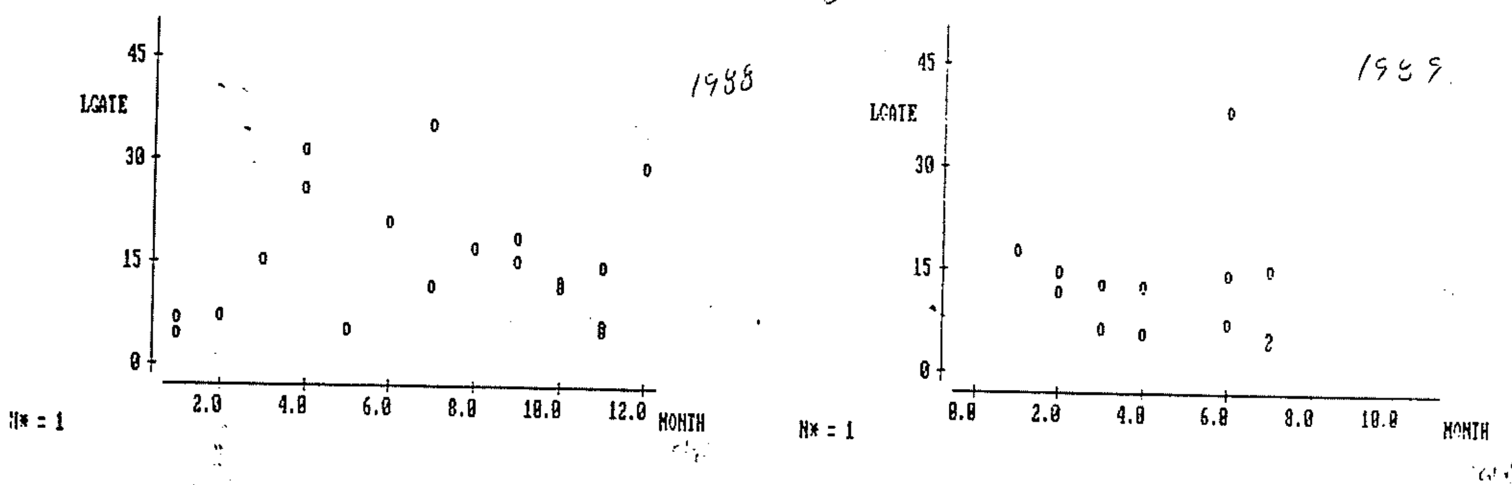
20
0.0
2.0
4.0
6.0
8.0
10.0
12.0

FIG 4 cont

VIGO



LISBON



GIBRALTAR

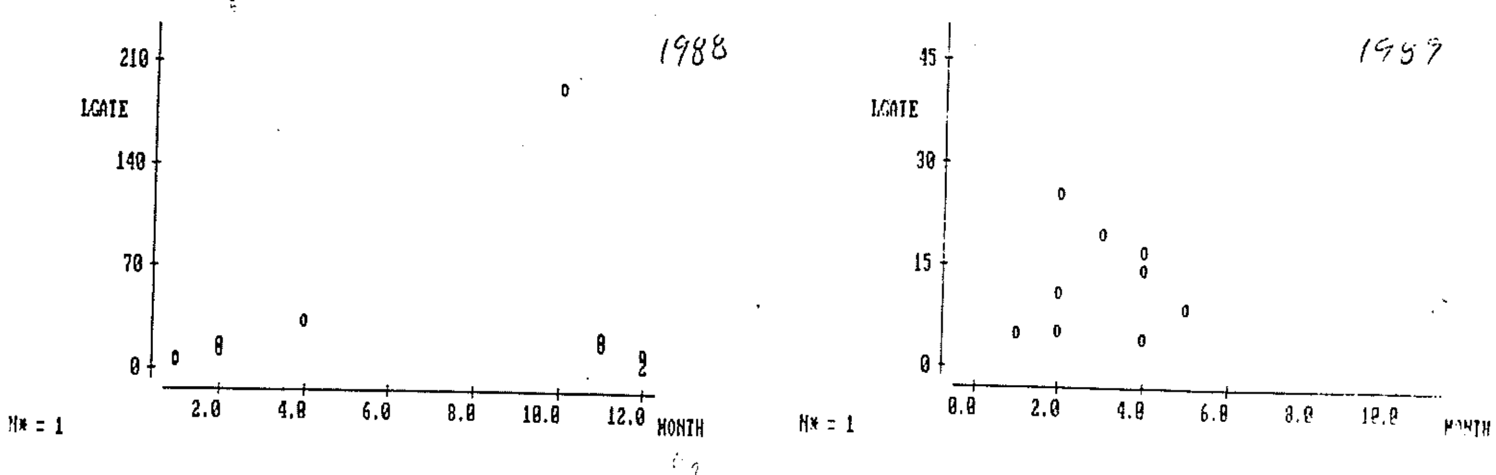
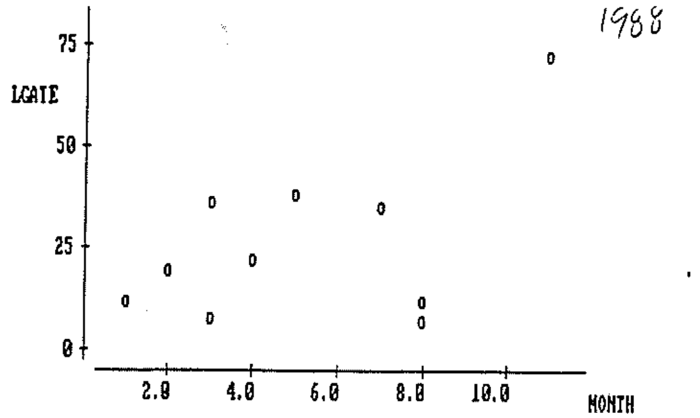
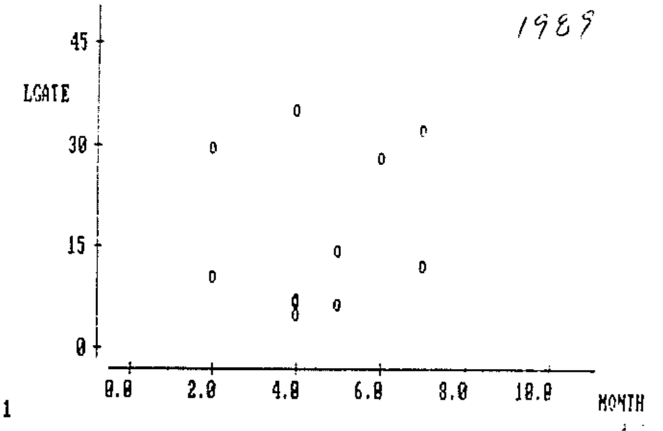


FIG 4 (CONT)

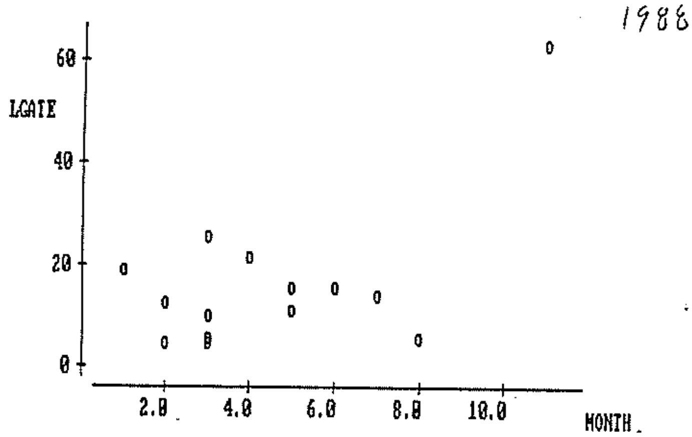
CASABLANCA



N* = 1

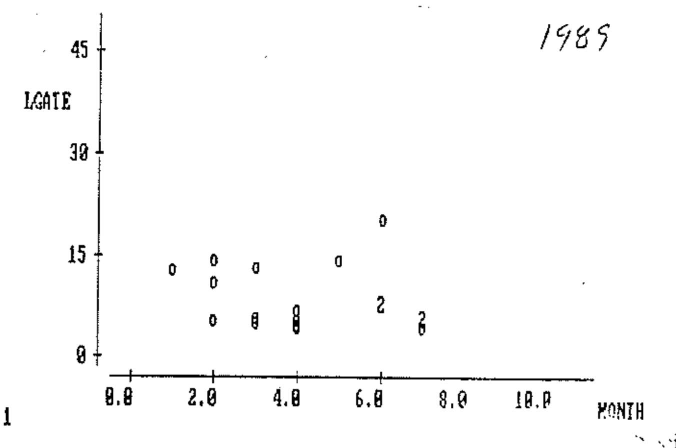


AGADIR

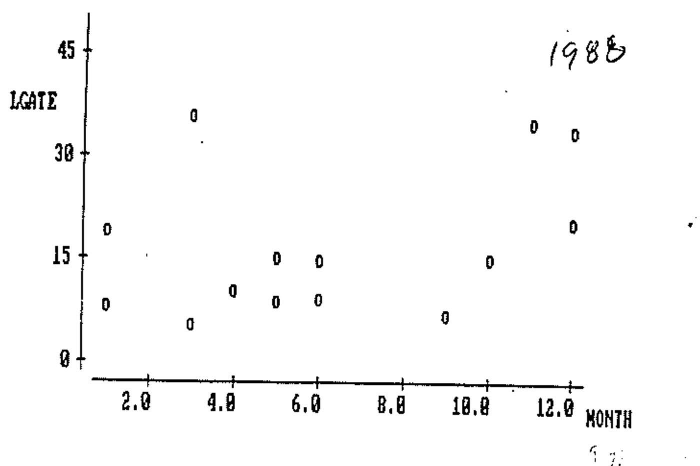


N* = 1

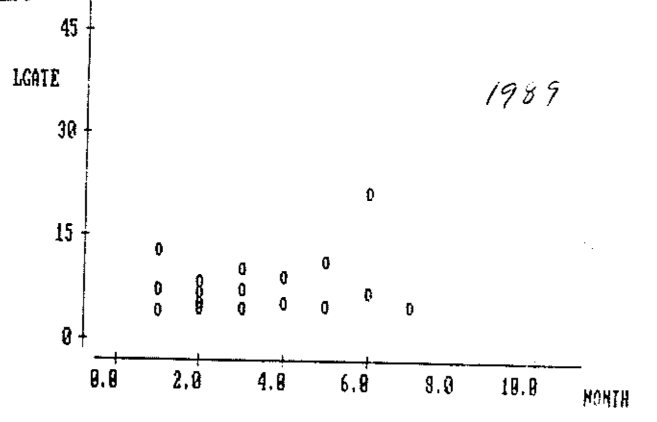
N* = 1



CANARY ISLANDS



N* = 1



N* = 1