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# SEASONAL AND LONG-TERM VARIABILITY OF RECRUITMENT IN FRENCH GUIANA SHRIMP FISHERY ON PENAEUS SUBTILIS

by

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ABSTRACT

A monthly recruitment index is calculated using catch statistics by commercial categories. Seasonal and interannual recruitment patterns are given and the correlation with rainfall and solar activity analysed. There appears to be nearly no relationship with rainfall from 1968 to 1971, a good and positive relationship from 1972 to 1976, and a good but negative one from 1977 to 1982. The long-term oscillations in recruitment in the French Guiana and Belem (Brazil) fishery data are similar.

RESUMEN

El index mensual de reclutamiento se calculó en base a las estadísticas de captura por categorías comerciales. Se describen los esquemas de reclutamiento a nivel estacional e inter-anual y se analiza sus relaciones con la pluviometría y la actividad solar. No parece existir una relación con las lluvias de 1968 a 1971; esta relación es buena y positiva para los años 1972 a 1976 y buena pero negativa para 1977 a 1982. Las variaciones de reclutamiento a largo plazo relativas a los datos de las pesquerías de Cayenne (Guyana Francesa) y de Belem (Brasil) son similares.

RESUME

Une indice mensuel de recrutement est calculé à partir des statistiques de capture par catégories commerciales. Les schémas de recrutement au niveau saisonnier et interannuels sont décrits et leur corrélation avec la pluviométrie et l'activité solaire est analysée. Il n'apparaît pas de relation avec les pluies de 1968 à 1971; cette relation est bonne et positive de 1972 à 1976 et bonne mais négative de 1977 à 1982. Les variations à long terme du recrutement dans les données relatives aux pêcheries de Cayenne (Guyane française) et de Belem (Brésil) sont similaires.



## 1. INTRODUCTION

The shrimp fishery on the Guiana-northern Brazil continental shelf started in 1959 in Barbados, Trinidad, Guyana and Suriname and spread eastwards very rapidly. A review of the fishery off the French Guiana can be found in Venaille (1979). The knowledge on these fisheries has rapidly expanded in the last years, as far as species composition, catches, efforts, etc., are concerned, but has remained surprisingly scarce as far as recruitment is concerned.

The paper presents the first attempt to describe seasonal and long-term cycles of recruitment of the most important species off French Guiana - Penaeus subtilis - and gives a puzzling account on the apparent effect of rainfall on annual recruitment indexes.

It is a very preliminary analysis which is only intended to generate interest and discussions about this important phenomenon, the understanding of which is vital for population dynamics and management of shrimp stocks. It raises probably more questions than it solves, but this in itself makes it, I believe, a useful paper.

## 2. MATERIAL AND METHODS

### 2.1 Recruitment Index

The main source of data used to estimate recruitment was the catch statistics by commercial categories available in Cayenne since 1968 and concerning the landings in this port. These landings refer to a fishing activity undertaken from Cayenne in French Guiana exclusively since 1978, but overlapping on Suriname and northeastern Brazil (Amapa region) before this date. They, therefore, concern a fishery operating mainly on the Penaeus subtilis stock which centre of gravity seems to be French Guiana (Kawahara, 1983).

The index of recruitment in the Cayenne fishery was calculated as the catch rate, in kilos/day of fishing of the shrimps falling in the smaller size categories, a very usual procedure. All shrimps smaller than the 50 tails/pound category, including the "broken" category which consists mainly of small damaged shrimps, were considered in this index. This was decided after having observed that there was some sort of inverse correlation between respective abundance of the "broken" and the 50-60 tails/lb category, leading to the suspicion that some abundance related changes in sorting practices might be affecting the relative importance of these two categories in the data.

It must also be noted that since 1978 new, lower-size categories (60-70 and 70-80 tails/lb) appeared in the statistics pointing toward either better sorting of catches of increased fishing on small sizes.

Similar data were available for the Brazilian fishery off Amapa State landings in Belem (SUDEPE, 1983) and a recruitment index is given by the landings of the 60-70 tails/lb category.

The data are affected by the following:

(a) Value of the recruitment index: Changes in the age at first capture have been observed (Garcia, Lemoine and Lebrun, 1984) and may affect the standardization of the recruitment index along the time period investigated. In particular the recruitment may be relatively underestimated in the first years considered.

(b) Origin of catches: Before 1978, the exact origin of the catches sampled in Cayenne is not precisely known although it is obvious that a very high proportion of the catches comes from the Guiana-Brazil sector. After 1978, all the catches sampled come from French Guiana nearly exclusively.

(c) Species composition: It is assumed that the small size categories are mainly Penaeus subtilis as juveniles of Penaeus brasiliensis are very rare off French Guiana and absent off Brazil.

Despite these limitations, the coherence of the recruitment cycles observed at seasonal level with the knowledge already available from direct but limited observations in the marshlands, as well as the similarity found between interannual variations of recruitment in the Cayenne and Belem fisheries, indicate that gross errors are unlikely.

### 2.2 The Rainfall Data

The average (1931-61) annual rainfall cycle is given in Figure 1, and it shows that the highest climatic variability occurs from January to April, a period corresponding to the time where the most important cohorts are growing in the estuaries and mangrove swamps.

Some interannual variability of recruitment must, therefore, be expected in relation to:

- variations in the conditions met by postlarvae during their migration into the nurseries. Migrations will be impaired by anomalously strong flushing out currents linked to exceptionally high rainfall;

- variations in survival of juveniles, in relation to the drying out of the marshland between successive spring tides when the rainfall has been scarce (this has been observed);

- natural variations of age at recruitment to the fishing grounds in relation with changes in the marshland ecosystem (salinity, draught, floods, etc.) as described by Garcia and Le Reste, (1981, p. 122).

The rainfall fluctuations must be carefully interpreted by want of a long enough time series to allow for an objective analysis and understanding of the long-term oscillations.

Figure 2 shows the available time series of rainfall from 1954 to 1982. The observed values and the smoothed curve (running average on three values) indicate oscillations which periodicity is far from clear. The curve of solar activity has been also drawn on the same figure for comparison. The severe rainfall anomaly of 1976 can be seen and has been well described (Dufresne, 1976). According to Boyé, Caboussel and Perrot (1978), the long-term variations show series of high or low rains every five, six or seven years. The observed peaks are said to correspond to half period of the solar activity and are usually found half way between the maximum and the minimum of the solar activity cycle (see, for example, the rainfall maxima of 1954-56, 1959-60, 1971).

Important peaks occur also at the maxima or minima of the solar cycle. All these anomalies generate noise which blurs any long-term oscillation and make it difficult to detect. Figure 2 also shows that rains were below the long-term average from 1956 to 1966 and above it from 1967 to 1977, suggesting that the data contain a longer-term variation possibly related to a cycle of about 20 years or the double of the solar activity cycle. This is only a speculation, however, as the data cannot prove that the variation is periodic.

A cycle of similar periodicity was suggested by Choubert and Boyé (1969) for the building up and subsequent erosion of the mud flats of French Guiana, through the analysis of incomplete historical data. This problem is, however, not yet solved as the work of the Delft laboratory of hydraulics concluded instead in 1962 (quoted by Turenne, 1978), on theoretical grounds, on the existence of a 30-year cycle. An indepth analysis of recent trends could help in deciding which hypothesis is the most likely, but the very exceptional building of mud flats in Cayenne in 1983, 30 years after the well documented maximum of 1953, could be in favour of the Delft hypothesis. Despite an obvious lack of data on this matter, the problem is worth mentioning here because of the potential interaction and synergic effects between rainfall and silting on the exchanges between the sea and the marshland and on the survival of larvae and the long-term changes in recruitment success.

## 3. RESULTS AND DISCUSSION

Figure 3 shows the time series of monthly recruitment indexes from 1968 to 1982. Figure 4 shows that the long-term variations of the total annual recruitment are very similar in the Cayenne and the Belem fishery. This indicates that the two fisheries exploit the same stock unit or that they exploit stocks with very similar long-term variations of recruitment. This also indicates that the recruitment index used here may be representative of the true phenomenon despite its obvious limitations. The recruitment appears also to be highly seasonal and variable. The average annual cycle is given in Figure 5 and indicates a main recruitment period from March to June. The seasonal variations of rainfall, abundance (cpue) recruitment and frequency of occurrence of recruitment peaks are given in Figure 6 and show that even in a true equatorial environment the phenomena are highly seasonal.

The relationship between annual indexes of recruitment and rainfall are given in Figures 7 and 8. When all data points are considered together no relationship is evident. Ibañez (1984) stressed that time series in oceanography show most frequently that their structure and interrelations are not stable with time and that a global processing of these data is not adequate. "The ecologist must, before all, identify stanzas corresponding to particular states of the ecosystem." In fact, a careful examination of the data shows that the time series could be truncated in three phases and that no relationship exists for the period 1968-71 (recruitment appears nearly constant and independent of rainfall), that the relationship is good and positive between 1972 and 1976 and, strangely enough, appears good but negative from 1974 to 1982.

It will be noted that the three sequences identified correspond as follows:

(a) 1968-71: to the end of a period of increase of rainfall and to a maximum of solar activity;

(b) 1972-76: to a rapid decrease of rainfall and solar activity - the 1976 rainfall anomaly corresponding to the minimum of solar activity was followed by an apparent reversion of the relationship;

(c) 1977-82: a rapid increase in solar activity, the reversion of the relationship corresponds to the reversion of the solar cycle, but no explanation can be offered.

Owing to the shortness of the data set, it is not possible to know if these apparent changes in the relationship are artefacts of real changes. It is also not possible to decide whether these changes are periodic and linked to the solar cycle or not. It is obviously not our intention to propose an explanation at this stage, and the above observations are offered only to show that

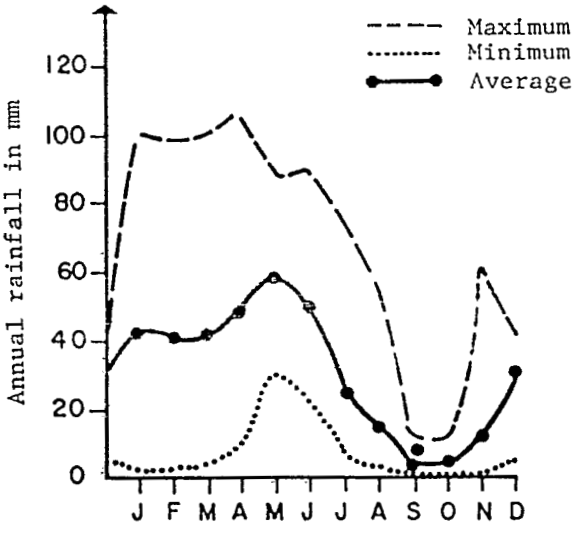


Figure 1 Average, minimum and maximum monthly rainfall, 1931-61. (Atlas Department Outre-mer. IV/Guyane, ORSTOM 1979)

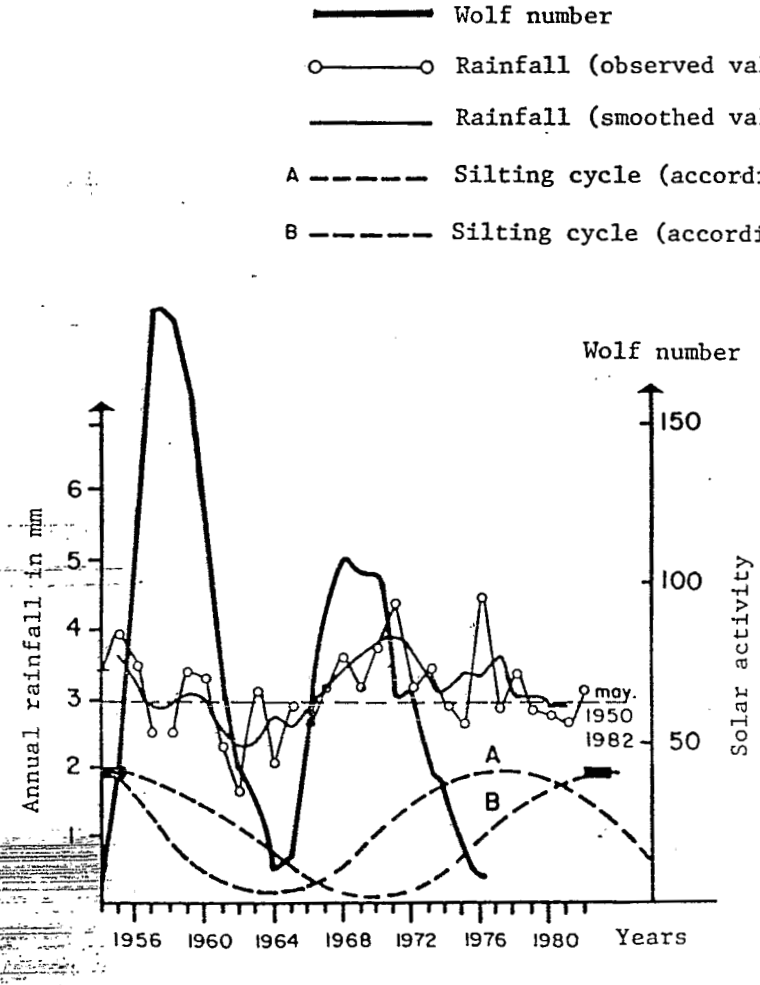


Figure 2 Annual rainfall (observed and smoothed values) and solar activity cycle. The rainfall data, 1954-72, are from Atlas Department. Outre-mer IV/Guyane, ORSTOM 1979 (the block rectangles indicate the observed maxima of silting)

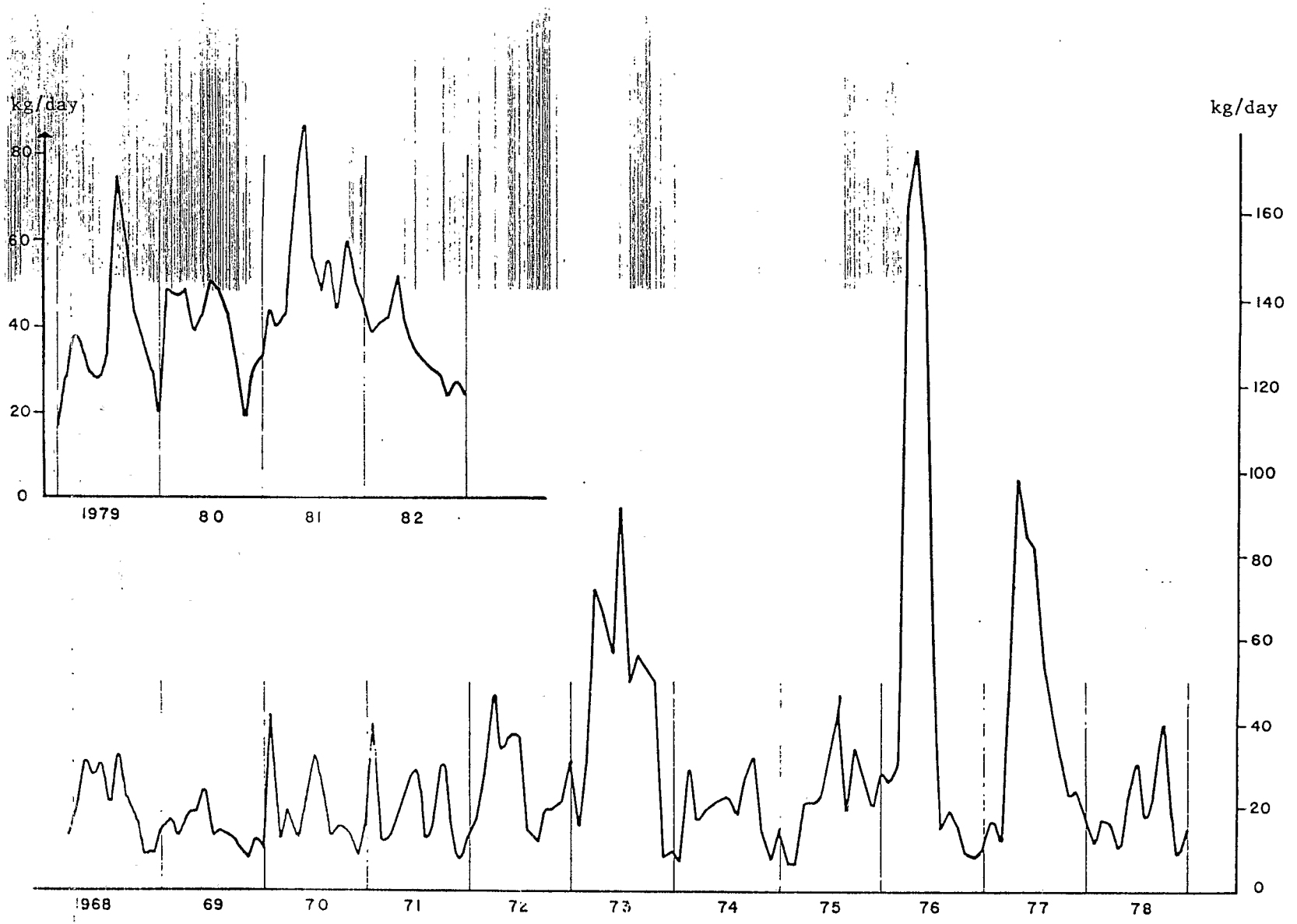


Figure 3 Recruitment index time series (kg/day $\geq$ 50-60 count and "broken")

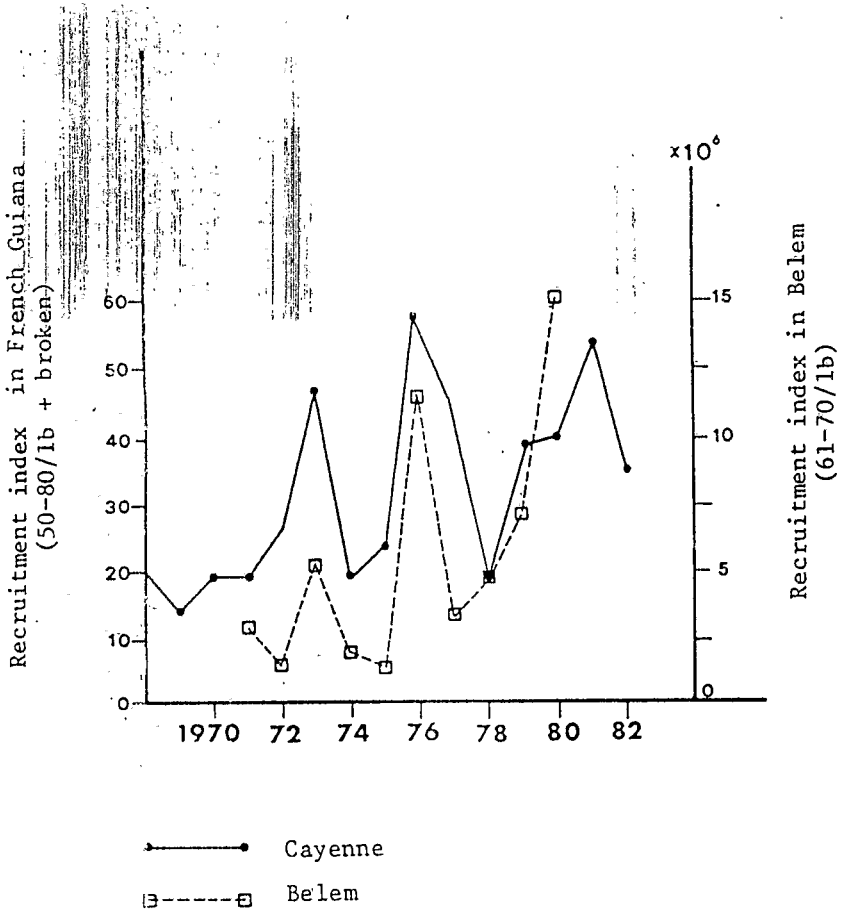


Figure 4 Comparison of long-term changes in recruitment in the Cayenne and Belem fishery (data from SUDEPE, 1981)

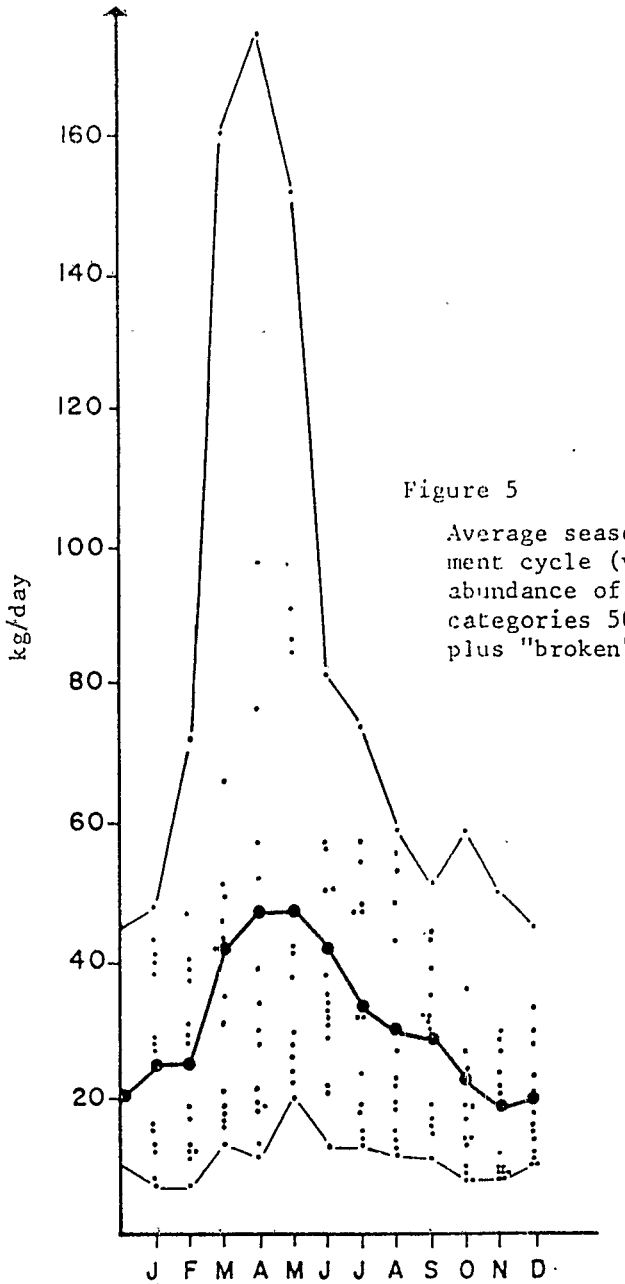


Figure 5

Average seasonal recruitment cycle (variations of abundance of commercial categories 50-60 to 70-80 plus "broken")

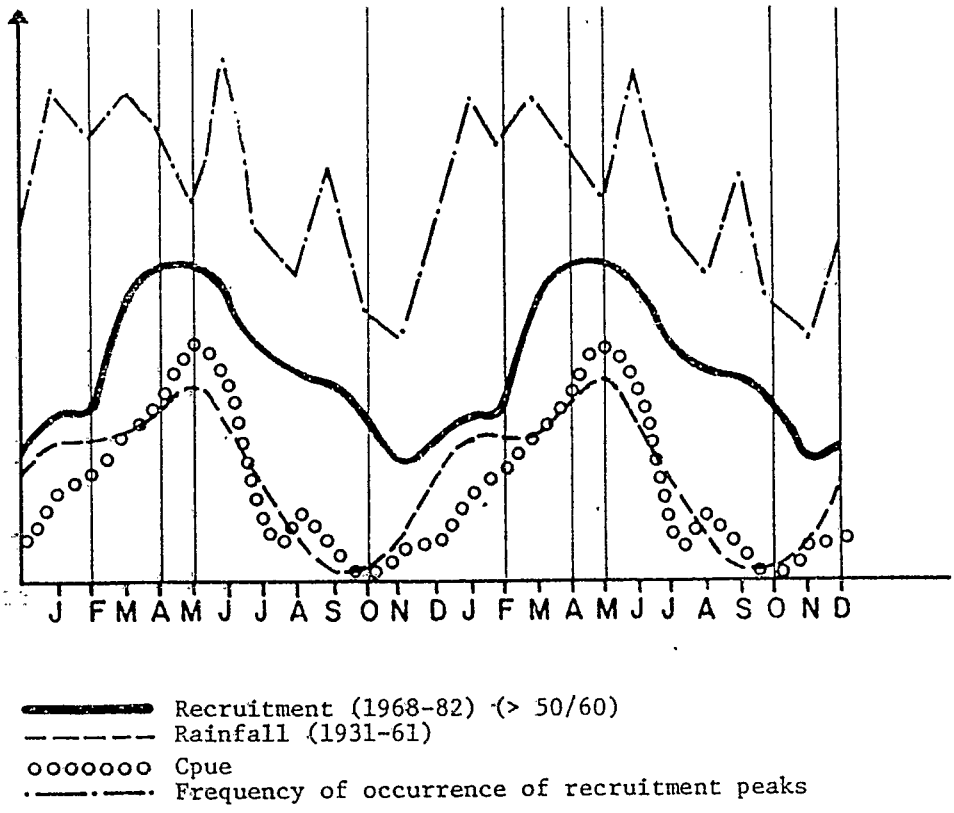


Figure 6 Seasonal cycles of some parameters (the annual cycle is repeated twice)

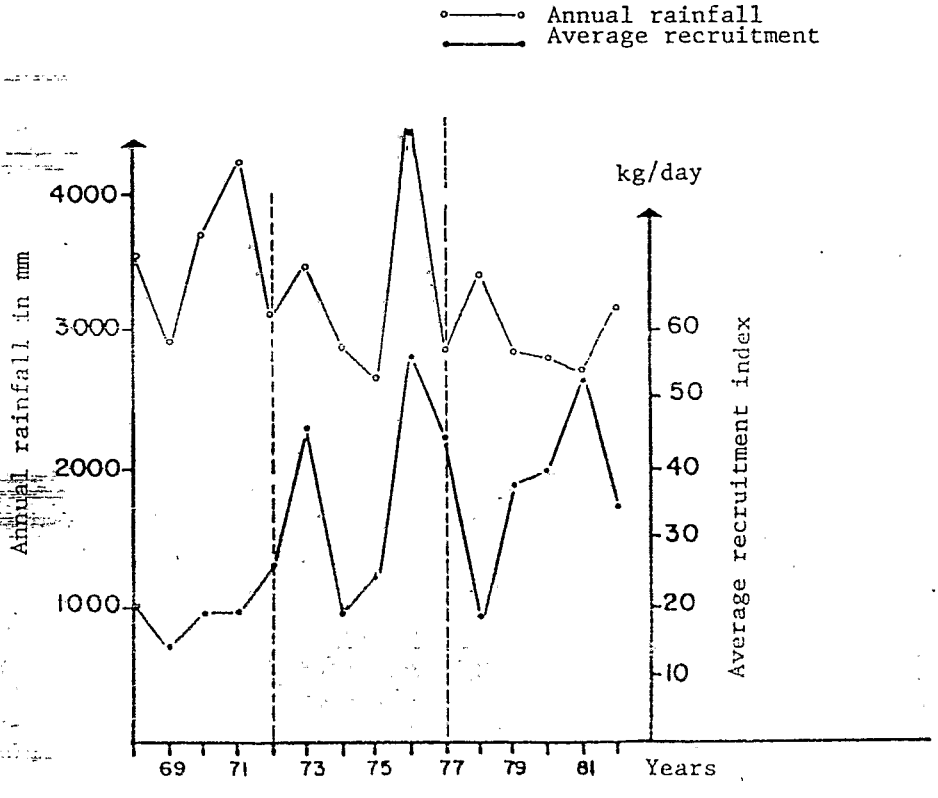


Figure 7 Recruitment indexes and annual rainfall

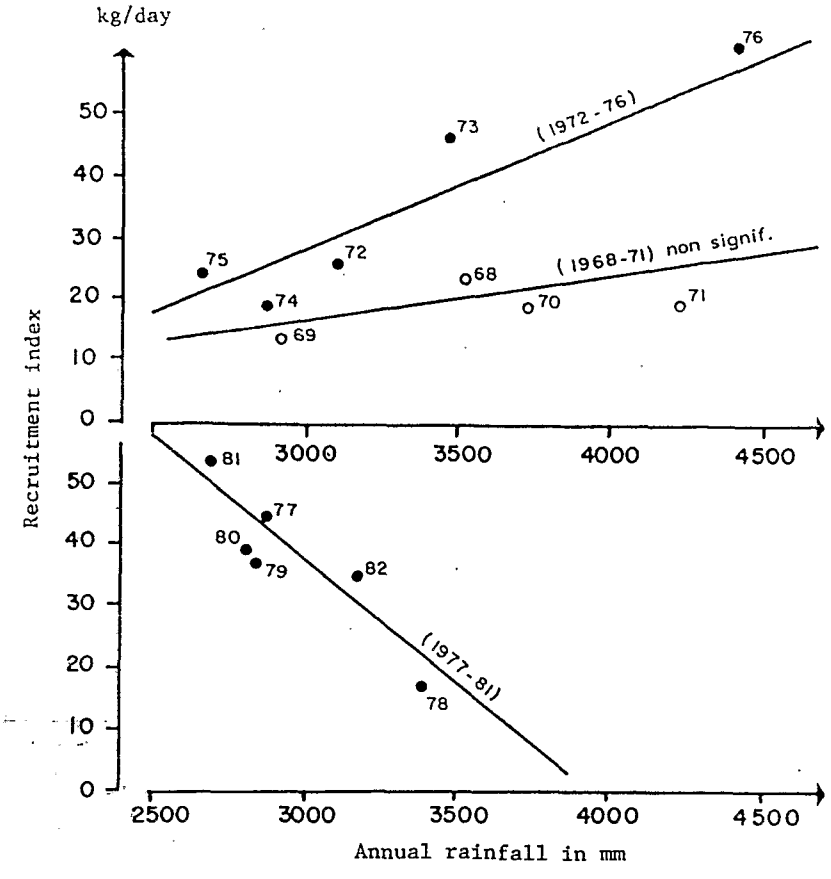


Figure 8 Relationship between recruitment and rainfall

a global conclusion that rainfall and recruitment are not related is not totally adequate and more research is needed.

The relationship between recruitment and rainfall, which cause and effect mechanism could possibly be foreseen, does not appear to be as simple in French Guiana as it is in other regions of the world (see Garcia and Le Reste, 1981, for a review). It is likely that the observed changing relationship is the result of the interaction with other parameters not taken into account and one can think to the existence of long-term cycles of building up and erosion of mud flats which is a major feature of the coast of this region and which effect on littoral shape and, therefore, on exchanges between coastal lagoons and the sea and on accessibility of marshland to larvae may not be negligible.

Further studies should be undertaken in two main directions in order to elucidate the phenomenon:

- analysis of mud-flat dynamics and their potential effect on recruitment;
- more detailed analysis on the seasonal effect of rainfall on recruitment using more refined indexes than just total annual values.

## 4. REFERENCES

Boyé, M., G. Cabaussel and Y. Perrot, Climatologie. In Atlas des Départements français d'Outre-Mer. IV La Guyane. Planches 7 et 8. Paris, Département français d'outre-mer
1978

Choubert, B. and M. Boyé, Envasements et dévasements du littoral en Guyane française. C.R.Hebd. Séances Acad.Sci.Paris, 249:145-7
1969

Dufresne, R., La pluviométrie exceptionnelle du premier semestre 1976 en Guyane. Météorologie (VIe Sér.), 6:27-29 No. Spéc. Météorologie tropicale
1976

Garcia, S. and L. Le Reste, Life cycles, dynamics, exploitation and management of coastal penaeid shrimp stocks. FAO Fish.Tech.Pap., (203):215 p. Issued also in French
1981

Garcia, S., M. Lemoine and E. Lebrun, Le recrutement de la crevette Penaeus subtilis en Guyane
1984 française. Rapp.Tech.ISTPM, (9):43 p.

Ibañez, F., Sur la segmentation des séries chronologiques planctoniques multivariables.
1984 Oceanologica Acta, 7(4):481-92

Kawahara, S., Japanese shrimp fishery off Guyanas and northern Brazil. FAO Fish.Rep./FAO Rapp.
1983 Pêches/FAO Inf.Pesca, (278) Suppl.33-4

SUDEPE, (Superintendencia do Desenvolvimento da Pesca), Relatorio da IV reunião do Grupo permanente
1983 de estudos sobre camarões, realizada em Santos/SP de 12 a 15 de Setembro de 1983. Ser.
Doc.Tec.SUDEPE, (33):175-263

Turenne, J.F., Sédimentologie (plaines côtières). In Atlas des Départements français d'Outre-
1978 Mer. IV La Guyane. Planche 6. Paris, Département français d'outre-mer

Venaille, L., La pêche de crevettes Pénéides du plateau Guyano-Brésilien. Sci.Pêche, (297):17 p.
1979