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INFLUENCES OF CLIMATIC VARIABILITY ON COASTAL OCEANOGRAPHY OF BENIN

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In article are analyzed temporary ranks for average monthly air temperature at Cotonou station Kazhekhun (06 ° Nord, 002 ° 23 East) during 10 years (from 1975 to 1984) with every fifteen days discretization of counting in. For same the period are used average monthly temperatures of the ocean surfaces near the capital of the Republic of Benin, Cotonou. Authors calculated correlation coefficients for humidity of air; air temperature; sea surface water temperature. Research of interrelations between sea surface water temperature variations and salinity changes on depth, allow to identify a mesolimnion zone; gives the chance to understand distinctions within a year, concerning lifting of deep waters (upwelling). Also authors carried out calculations of correlation coefficients between monthly bioproduction of a pelagic species of fish (Sardinellamaderensis), as «the upwelling indicator», with air temperature. In addition in article are represented fields of sea water temperatures and the salinity, received with use of SURFER program.

Keywords: Republic of Benin, temporary ranks, air temperature, correlation analysis, salinity, lifting of deep waters (upwelling), temperature of a surface of the ocean, bioproduction, Sardinella maderensis

ВЛИЯНИЕ КЛИМАТИЧЕСКОЙ ИЗМЕНЧИВОСТИ НА ПРИБРЕЖНУЮ ОКЕАНОГРАФИЮ БЕНИНА

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В статье проанализированы временные ряды для среднемесячной температуры воздуха на станции Котону Кажехун (06 ° Nord, 002 ° 23 East) за период 10 лет (с 1975 по 1984 г.) с дискретностью отсчета в пятнадцать дней. За этом же период использованы данные по среднемесячным температурам поверхности океана в районе столицы Республики Бенин, г. Котону. Авторами рассчитаны коэффициенты корреляции влажности воздуха с температурой воздуха и воды на поверхности моря. Исследование взаимосвязей между вариациями температуры воды на поверхности моря и изменений солености по глубине позволяет идентифицировать термоклинную зону; даёт возможность понять различия в течение года в отношении подъёма глубинных вод (апвелинга). Также авторами были проведены расчеты коэффициентов корреляции между ежемесячной биопродукцией пелагического вида рыбы (*Sardinellamaderensis*) как «индикатора апвелинга», с температурой воздуха. Дополнительно в статье приведены поля температур морской воды и соленостей, полученные с использованием программы SURFER.

Ключевые слова: Республика Бенин, временные ряды, температура воздуха, корреляционный анализ, соленость, подъём глубинных вод (апвелинг), температура поверхности океана, биопродукция, *Sardinella maderensis*

Introduction. The climatic variability coastal zones of African countries are very important for population; decision-making, connected with business development in this zones, including agriculture; catching of fish and so on.

Republic of Benin is located at the east part of the Gulf of Guinea and has a coastline of approximately 125 km, opened on the Atlantic Ocean. The majority of the descriptive studies on the Benin Coastal Oceanography relate as well as the Gulf of Guinea Countries.However, since 1985 and 1986 systematic oceanographic surveys were undertaken by Special Centre in Benin, in cooperation with the French Research Organisation, ORSTOM in the Benin seawater. From 1990 to 1997, other fisheries and oceanographic surveys have been realized with the Canadian Agency (CIDA) support.

Many others very important regional surveys have been realized (Nansen Program and FAO: 1999, 2000 and 2002). During this surveys researches have been got many oceanographic and biological data in the form of parallel time series. The goal of this work – an attempt to apply methods of correlation analysis to part of data, collected during this surveys. Also authors show possibilities of evident representation by means of fields isolines for parameters, received by means of the SURFER program.

Material and Methods. Several types of data were used for the study in this article.

*Air temperature; wind velocity; rainfall height data over 10 years (collected at the Cotonou station from 1961 to 1984).

* Sea Surface Temperature for the same period .

* Sea water temperature and salinity variation according to the depth of the sea at the point of investigation.

* Monthly data on the annual pelagic species (*sardinella maderensis*) production.

Some additional characteristics of collected data are mentioned in introduction to this article.

For calculations with numerical authors used electronic worksheet «Microsoft Excel». The advantage of «analysis tool pack» of this worksheet – researcher can calculate not only Pearson's correlations coefficient for two numeric series, but a matrix of correlation coefficient for set of numeric series.

The «statistical significance» of calculated correlation coefficients can be evaluated with special statistical tables.

For evident representation of «parameters fields», based on collected data sets, authors used a program «Surfer».

Results and discussion.

Climate at Benin coastal zone. The Benin coastal zone experience a tropical climate coasting of rainy seasons (December to March, August to September). The climate characteristics of the area are influenced tropics associated with the movement of the sun and the relative position of the Inter-tropic Discontinuity (ITD). It is also governed by two air masses – the south «westerlies» and the north east «harmattan» dry wind.

Time variations of main parameters are shown at Fig. 1a & b.

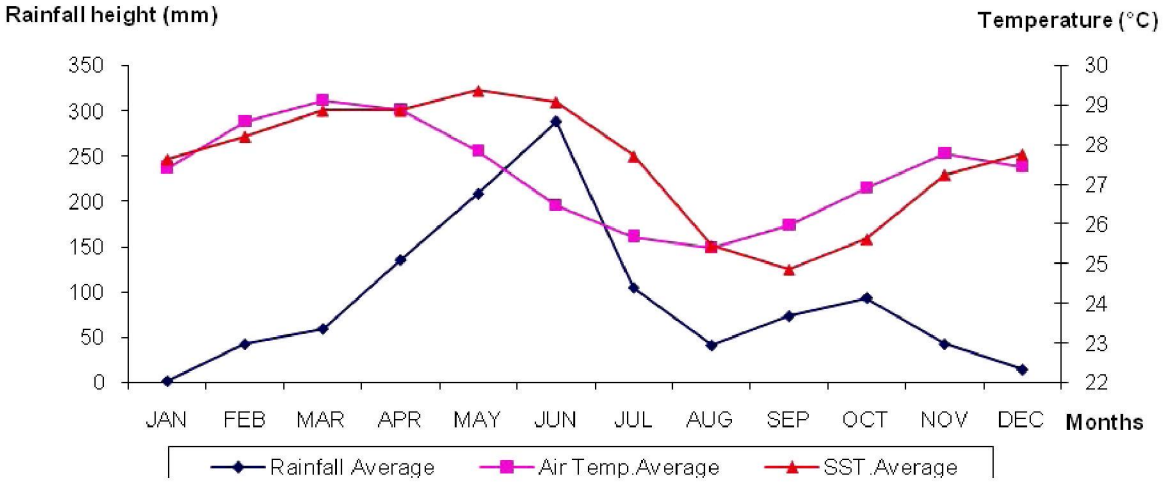


Fig. 1. Rainfall, Air temperature and Sea surface temperature (SST) variation during a year (average values for the period of investigations)

The results of correlation coefficients calculations for this data are represented in table 1.

Table 1

Matrix of Pearson's correlation coefficients for temperatures and raifall

	Rainfall Average	*Air Temp.Average*	*SST.Average*
Rainfall Average	1		
Air Temp.Average	-0,086	1	
SST.Average	0,460	0,632	1

Results of the correlation analysis show moderate positive interrelation between temperatures of air and sea surface. It can be explained with influence of vertical movement of water masses in the sea.

At the same time interrelation of precipitation values with sea surface is weaker. There is no significant interrelations between «Air Temprature» and «Rainfall» – the correlation coefficient is nearly zero.

Statistical importance assessment of these correlation coefficients with standard method for 12 members of row is not expedient to carry out, because it is the average values for some years.

Air Temperature. Temperatures in the Benin Coastal zone are relatively high, they varying from 25,4°C to 30°C.

Highest values are recorded in February, March, April. Lowest temperature – between 25,4°C and 26,9°C are recorded in July August, September.

Surface Wind. *Benin coastal area experiences mainly the southwesterlies which are on shore confirmed generally to azimuths 22° – 27° with velocity of 4–6 m/s.*

Rainfall Regime. Seasonal variations in rainfall are controlled by the seasonal displacements of the ITCZ [6]. Maximum rainfall occurs in the coastal area, where the thickness of the humid southwesterly monsoon air mass is greater than 15 km. There are two period of peak rains: «May – June» and «October – November» (Fig. 1).

The Coastal rainfall is a modulated also by the coastal ocean temperature.

The concept of dry season is this relative in the zone, it does not have there a really dry season because the dry season of winter and of summer bring week precipitations [7].

The analysis of precipitations mode leads us to think that they could be the modifications of the zone circulation of the atmosphere and witch could be mainly responsible for space-temporal variations of rainfall.

The influence of the continental wind at the end of the course of harmattan reaches only exceptionally the coast, in a variable way according to years and strength of the generating Sahara Anticyclon.

Principal water masses. The various categories of water, defined in the Gulf of the Guinea concerning Benin continental shelf [3], are.

- Guinean water hot and freed of salt (temperature higher than 24°C, salinity lower than 35‰) [1];
- hot tropical water, salted, especially on the areas of strong insolation and weak precipitations located below hot water.

Comparison of temperatures and salinity variations (Fig. 2a and Fig. 2b) show:

- Salinity variation precede temperatures variation at least a month for the first two phases and more than two months for the two last months;
- Strongest salinities are recorded in August, the highest temperatures are generally observed in April.

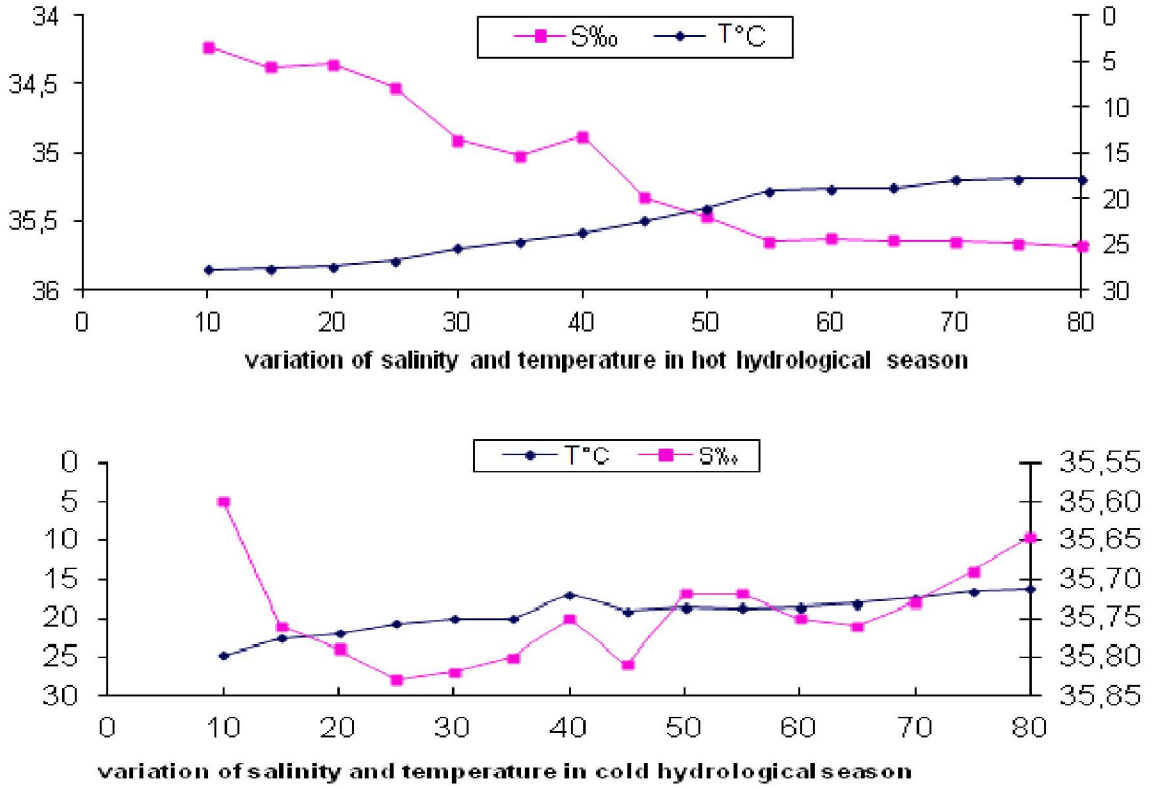


Fig. 2. a, b: Temperature and salinity according to the depth

The correlation coefficient for «hot season» is «-0.978» (that corresponds to «very strongly» inversely proportional communication). The correlation coefficient for «hot season» is «+0.073» – it has to be interpreted as lack of correlation communication.

The coastal hydrological mode is characterized by four distinct periods:

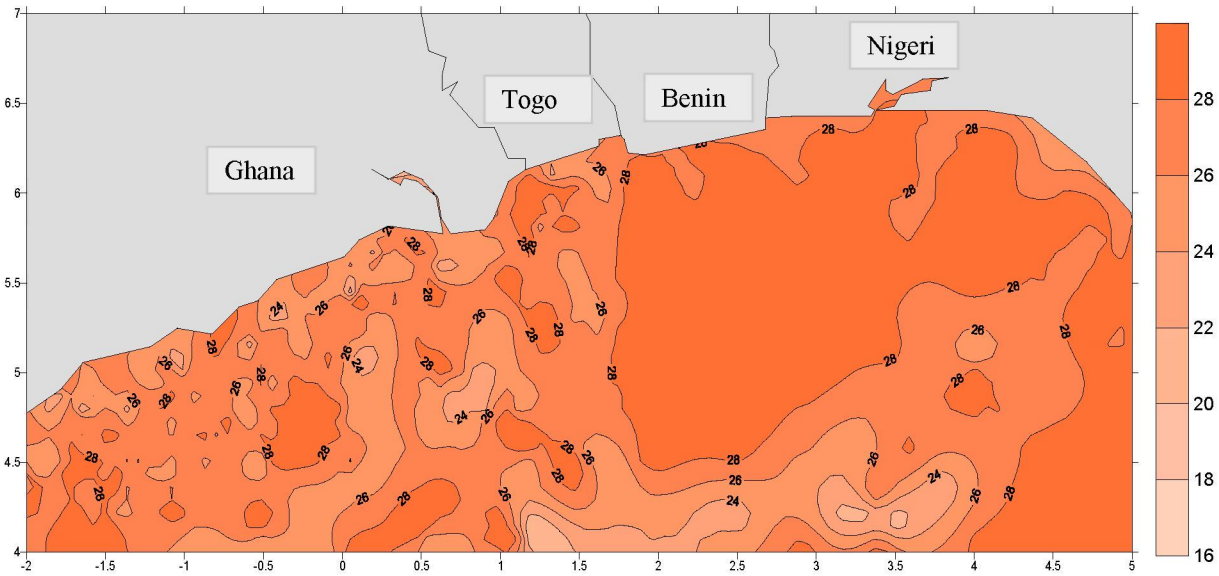
- salinity lower and water cooling for three month;
- water reheating (four months) and salinity increasing (two months);
- salinity reduction (four months) and water cooling (two months);
- salinity rise (three months) and water reheating (three months).

Temperature and salinity variations causes the phenomenon, called «upwelling».

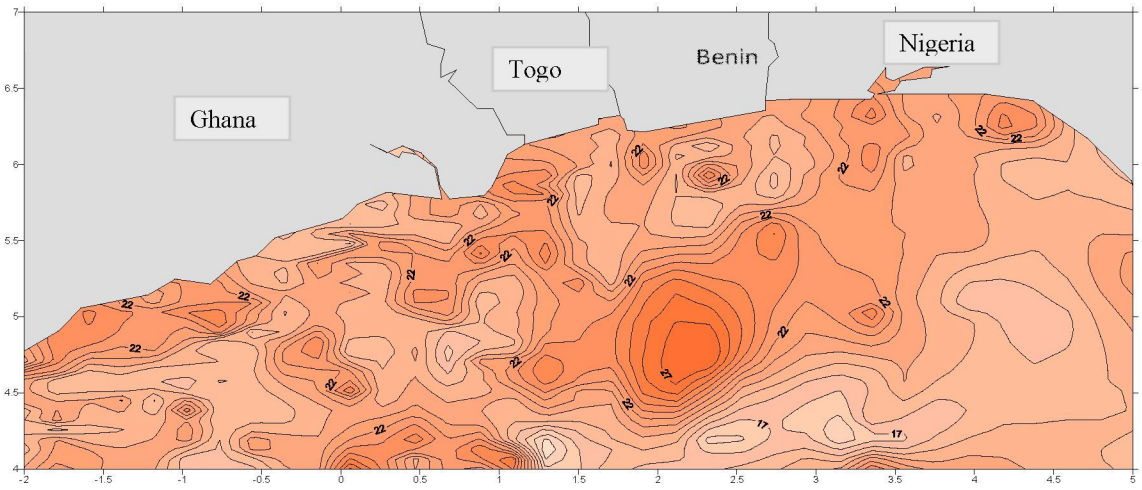
Temperatures and salinities vary in the same direction for five months; they grow in February, March and August, and decrease during May and June. Temperature and salinity graph in 50m depth show that in July, August and September, there is a salted cold water invasion.

By means of the «Surfer» program authors constructed fields of temperatures for the sea surface (fig. 3a) and 50 meters depth (fig. 3b).

Similar fields for the same set of points were constructed for salinity of sea water (Fig. 4) – the same basemap source.

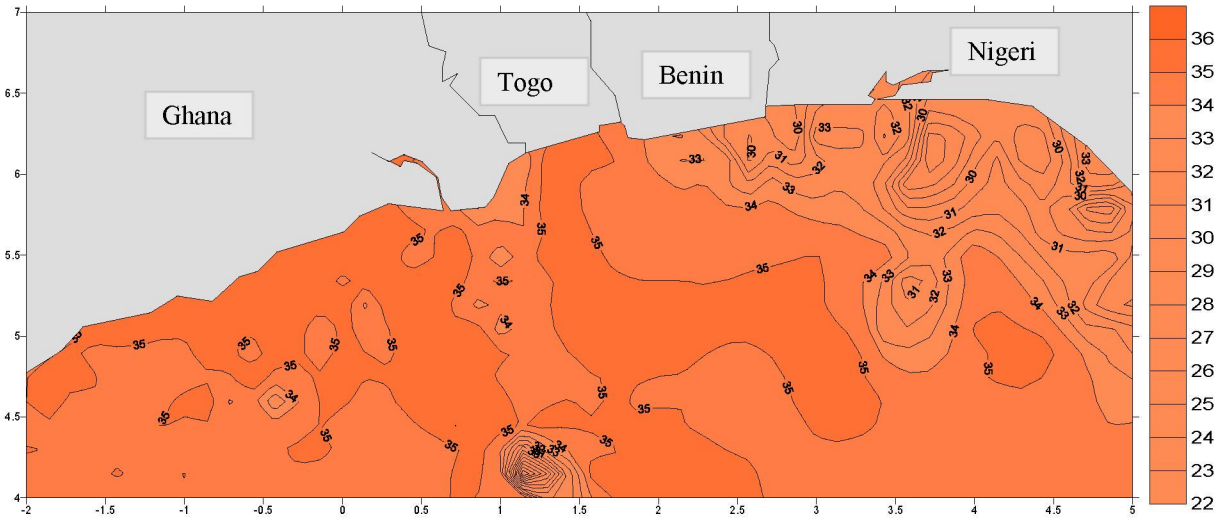


a) for sea surface

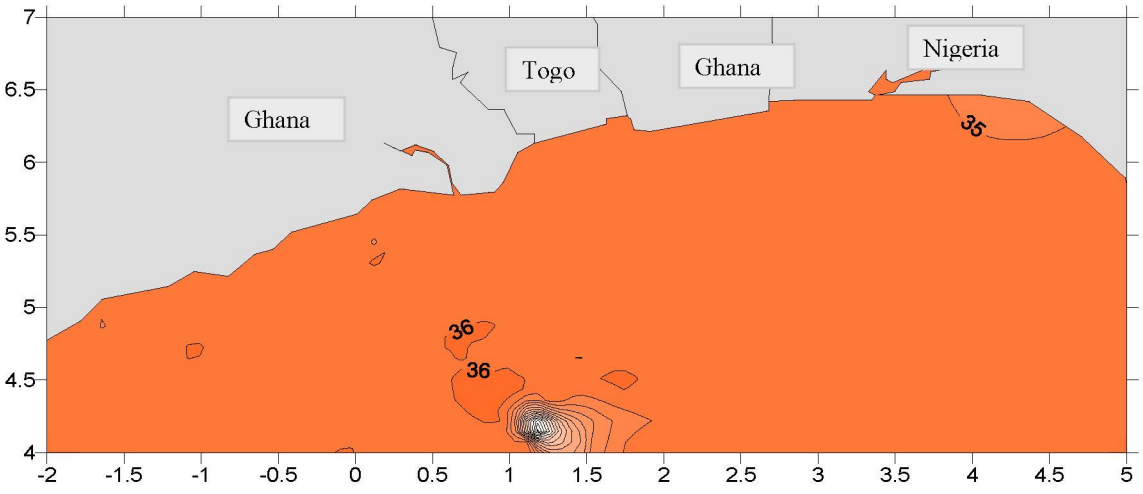


b) for 50 meters depth (temperature color coding is the same, as for «a»)

Fig 3. The temperature fields constructed by means of Surfer program.
Basemap source: form DIVA-GIS – (http://www.diva-gis.org). Data source: WOD01



a) sea surface



b) deph 50 meters (the same salinity code coloring)

Fig. 4. The salinity fields, constructed by means of Surfer program

The provided images confirm important influence of circulating currents on a temperature mode of the sea and levels of salinity of its water masses.

Temperature and salinity variation (Fig. 2) have some effect on the fishes production – for example *Sardinnella maderensis.* Capture of this fish depends of the variation of two parameters. Temporal distribution of this species as a pelagic fish, depends of sea surface temperature which is in relationship with air temperature (Fig. 5) and table 2.

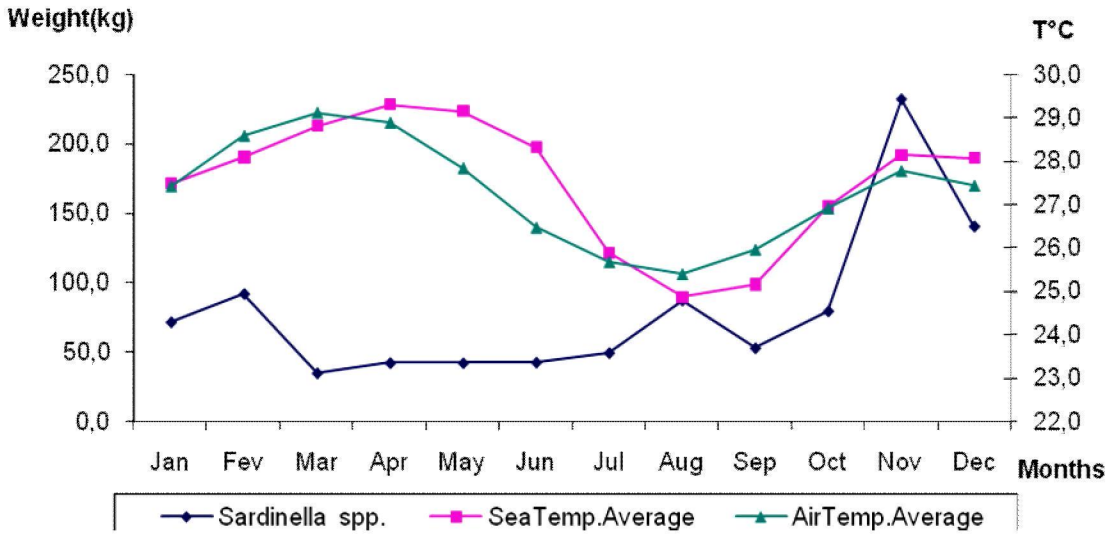


Fig. 5. Weight of monthly average sardinella control catch, sea temperature and air temperature variations (temperatures – for the zone of fish catching)

Table 2

Matrix of Pearson's correlation coefficients for temperatures and weights of sardinella (for data at figure 5)

	Sardinella m. (ton)	*SeaTemp.Average*	*AirTemp.Average*
Sardinella m. (ton)	1		
SeaTemp.Average	0,013	1	
AirTemp.Average	0,046	0,858	1

Leroux M. indicates that there is no simple and direct relation between sea temperature and littoral rainfall [7]. However, the sequence of processes, that determines rain, shows the existence of different rainy equations depending on specifically tropical structural conditions.

Bjerkness J. observe a strong correlation between rainfall height and sea surface temperatures in some tropical islandsand coastal stations [2].

Instead of it, Mr.Dorotnotes write that «... the correlation coefficientis lower than the significant limit» [5]. According to him «there is no correlation between the two parameters» on the coasts of West Africa.

In the future, this relationship can continue to be studying in detail.

Conclusion. Benin is under the southern mode influence. This mode is hot period centred over February and cold period – in August.

The Western part of the continental Benin Shelf belongs to the zone of «Upwelling» phenomenon. The rainfall regime, as well as the temperature patterns, the winds determine the hydrological characters and consequently the favour periods for the Fishing.

The influence of the rainfall regime is determining by the characters of continental and marine hydrology, biology of species.

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