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An Analysis of the Relationship between Temperature Variation and Fish Production in Lagos, Nigeria

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Abstract: *The study examines the relationships of changes in temperature on artisanal fish production in Lagos. Data on the impact of sea surface temperature on the annual yield of artisanal fishes during the period 1995 to 2007 was analysed. The major statistical methods employed was the correlation analysis and result shows that there was a significant correlation between average annual sea surface temperature and annual fish yield or catch with r = 0.576 and a coefficient of determination of 34% which was significant. The study also revealed a decrease in total amount of fish caught, decreasing from 30951 tonnes in 1999 to 10434 tonnes in 2000, showing a decline of 20517 tonnes in just over a year period. The analysis further indicates that changes in sea surface temperature alter fish yield while recognizing that other factors such as overfishing have influence on fish yield. Our recommendationsinclude proper fishing management, installation of environmental warning and monitoring system, establishment and maintenance of more training and demonstration facilities etc. The implementation of these measures are required to alleviate or even stem the challenges posed by temperature variation on fish production*

Keywords*: climate, artisan, sea, fish, yield.*

I. Introduction

Temperature changes are important concepts in development because it affects either positively or negatively various aspects of socio-economic life of a people. It is an aspect of climate change which refers to any change in climate overtime whether due to natural variability or as a result of human activity. Temperature change is the alteration of the temperature of an area over some length of time. However, when the duration is over a long period of time, say 35years or more then it becomes one of indices of climate change. The current change in climate is, however, largely attributed to human activities which includes fossil fuel burning that affects the concentration of the atmospheric constituents. Some of these constituents promote increase in surface temperature of that affect the life or organisms and general life in water. For example, IPCC (1998) noted that changes in temperature affect habits of fisheries by altering their availability and quality. Such studies which include those of Sharp and Carke, (1983); Beukema et-al, (1990) and Chowdhury et-al (2010) highlighted that temperature changes produce changes in the abundance of species, sometimes of many orders of magnitude because of its impacts on water masses and hydrodynamics, as well as adversely affecting fish physiology like growth, reproduction and general activity. It is intuitively to expect pole-ward range movement of species or migration to cool water environment with increasing temperature in the tropics or an area within the water body (Shuter and Post 1990). Greg (2010) found that fish in an area with extreme temperature tolerance range always migrate to areas with tolerate temperature. The long term impact of temperature change on coastal areas or marine ecosystem is sea level rise. The coastal area including its mangrove environment has a significant role as a nursery ground for many deep sea fishes and shrimps. Sea level rise may destroy the mangrove forest and its immediate wetland resulting in the destruction of marine fishery nursery ground. Quite earlier, Sullivan (1954) had summarized the findings of many workers on the effect of temperature on the movement of fish and on its influence on the distribution of fish and discussed the role of the receptor mechanism of the central nervous system in the fishes temperature response. 1-le was of the view that fishes select a certain temperature because of the effect of the temperature on their movement. However, it is not only temperature that affects the production of fish. According to Ayub, (2010) changes in temperature and rainfall alters the catch of some fishes but other factors such as over fishing, pollution and reduction of fresh water flow may have influence on the quantity of fish catch.

Furthermore, differences in SST have been shown in many studies as having great effect in fish production (Sharp and Clerk, 1983; Kawasaki et al, 1991; Beakama et-al 1991). The IPCC (1998) noted that temperature changes will likely cause collapse of some fisheries and expansion of others, and it may be one of the most important factors affecting fisheries now and in the next one hundred years. Fish is a poikilothermic animal that cannot regulate their body temperature through physiological process but they try to maintain preferred temperature through behaviour. Fish physiology like growth, reproduction and activity are directly influenced by changes in temperature (Chowdhury et-al, 2010). Thus fisheries, therefore, seek habitat close to

the optimum temperature for growth, foraging success and protection (Magnuson et-al, 1990).Regional impact of sea surface temperature on fishery production could be beneficial or adverse. Regier and Holmes (1991) stated that warming in high latitude should lead to longer growing period, increased growth rates and perhaps increase in the general productivity of the region. This according to Akra (2013) is not the same with the tropics where fish species are near their maximum tolerance range.

The influence of temperature on fish behaviour is most pronounced during spawning. Grego (2014) explained that temperature prior to spawning are highly significant since they influence the ripening of the sexual products. Chorbley (2011) was of the view that rates of feeding, metabolism and growth are affected by the water temperature because at the temperature lower than optimal, feeding activity is usually reduced. A thorough knowledge of the optimum temperature for nearly all fish stock is necessary for the prediction of fish concentration. With such knowledge prediction of temperature either statistically or synoptic can be used for predicting the seasonal abundance of a give stock of fish (Laevasty and Hela 1970). This is further complicated by the environmental requirements of fish change during the various stages of growth. Also some investigations indicate that the temperature requirements of certain specie also change seasonally (Devoid, 1959). This view was recently canvassed by Chowb, (2014) who noted that the temperature of African cart fish indeed change seasonally in the coastal areas of Dakar, Senegal. He expatiated that at least this is in connection with spawning, seasonal and year - to - year variations on thermal and other conditions which will result in varying distribution and abundance of fish on a given fishing ground. Consequently according to Ezenwaji (2006), many fish species make seasonalmigrations towards the poles during the summer and towards the equator in winter. Thus these migrations are likely to be temperature - dependent.

Moreover, temperature seems to also affect coastal offshore distribution of some fishes. Baxter (1967) indicated that fish recovery becomes less available in inshore waters but more numerous in offshore waters when water temperatures are warmer than average.

In conclusion, apart from the effects of temperature variation on fish production, there are other factors which might be affecting this sector such as technological factors, changes of government policies, resource over exploitation, ecological factors etc.

Water temperature, therefore, is one of the most important factors affecting growth and other physiological performance in aquatic ecotherms. Many studies have empirically demonstrated that temperature fluctuations have a significant effect on the growth of fish. Some of these studies employed statistically derived models to examine this relationship (Welcomme, 1980, Garcia and Le Reste, 1981, Gabros, 2008 and Supernol, 2013).

From the above literature review, it is obvious that there have been many studies about the effects of temperature fluctuations on fish production in many parts of the world; no such study has been conducted in Lagos, Nigeria. This study will as already indicated empirically determine this relationship by the use of appropriate statistical methods and thereby help to increase knowledge in this area.

Fish make up asignificant part of food supply in Nigeria and a reduction in fish stock will have a great effect on the protein supply of consumers. Nigeria, a densely populated nation has about one-third of its protein supply from fish intake (Hersong, 1995). This same situation applies to Lagos, which is the most populous town in Nigeria. According to Ube (2013), over 8millionLagosians which is 75% of its 12million people daily depend on fish. A lot of studies have investigated the effect of temperature changes on fish production. For example, Ayub (2010) studied the effect of temperature and rainfall as components of climate changes on fish and shrimp catch in Pakistan, Mugete (2012) looked at river flow and temperature changes in Mombasa coastal area, Kenya. Furthermore, Donkor (2013) examined the spatial effects of river temperature on fish catch in some perennial rivers of Upper-Volter, Ghana. However, no work known to the authors has been done on the effect of temperature on fish production of Lagos city in Nigeria. The purpose of this work is to fill this obvious gap in knowledge by determining to which extent temperature changes have affected the fish industry in Lagos.

II. Materials And Methods

Area of Study

Lagos is located approximately between Latitude 6°22'N and 6°52'N and Longitude 2°42'E and 3°42'E on the southern-western part of the country (Fig. 1). The southern boundary of the city is formed by a long coastline of about 180km; its Northern and Eastern boundaries are shared with Ogun State while on the Western side the State is bordered by the Republic of Benin. Lagos is blessed with a maze of creeks, Lagoons, estuaries and of course the shallow inshore ocean which constitutes a major source of fish and fisheries product sought by artisanal fishermen. The coastal zones including Lagos city remains the base for these artisanal fishery resources.

The climate of Lagos is that of Tropical Savanna Climate, Aw, according to Koppen's climatic classification. It is characterized by two district seasons, wet and dry seasons. The wet season experiences double maxima rainfall regime. Monthly rainfall between May and June averages over 300mm while in August

and September it is down to about 75mm. The average temperature in January is 27°C and in July about 25°C. On the average, the hottest month is March with a mean temperature of 30°C

Although, Lagos has a small land area of 365,861 hectares, out of which 75,755hectares are wetlands (Lagos State Government, 2014), it is the town with the highest population in Nigeria with over 20 million people. The UN Habitat study and the UNDP assisted Regional Master Plan estimated the population of Lagos in year 2000 at 13.4 million and about 15million in 2004. The metropolitan Lagos with 39% of the land area is home to over 85% of the city's population. The city has a population growth rate of about 600,000 persons per annum with a population density of about 4,193persons per square kilometre. The built up area of Lagos city harbours an average density of 200,000 persons per square kilometre (UNDP, 2004). The UN study (1991) expected the city of Lagos to hit 20 million population mark in 2010. Thus progressively reaching 24.5 million population in the year 2015 at which time it is expected that Lagos will be the third most populous city in the world.

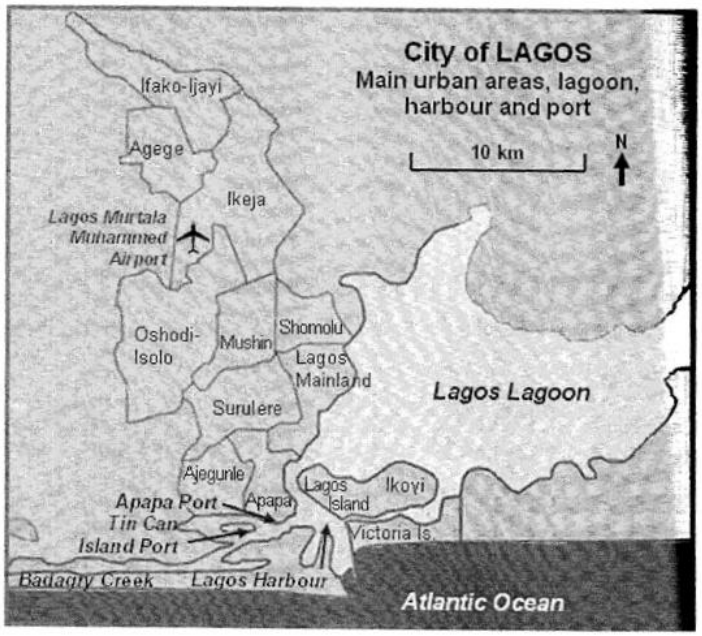

Fig. 1: Map of Lagos Metropolitan Area

Data Collection

The data employed for this study were collected from two sources namely primary and secondary sources. However, the main source of data is from the secondary sources which arethe Federal Department of Fisheries Victoria Island Lagos and the Nigerian Meteorological Agency (NIMET), Oshodi, Lagos. The data collected include the volume fisheries landed annually in Lagos for a period of 13years (1995 - 2007) and the mean monthly Sea Surface Temperature (SST) from (1995 - 2007). Other secondary data includes published literatures ranging from text books, WMO publications, IPCC publication etc.The data collected is presented in Table 1.

Table 1: Lagos Marine Sea Surface Temperature

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1995	28.7	29.4	29.7	30.6	30.5	29.4	27.9	27.8	28.4	28.7	29.8	29.7
1996	29.6	30.3	30.8	30.7	30.1	29	28	27.3	26.9	27.4	28.2	28.1
1997	27.8	27.1	28.2	28.7	28.8	28.7	26.6	26.4	27.7	29.1	29.8	30
1998	28.5	30.2	30.9	31.2	30.9	29.8	26.8	25.8	26.6	28.6	30.8	29.9
1999	29.4	30.1	30.7	30.4	30.4	29.7	27.5	25.8	25.5	26.4	27.8	27.8
2000	27.9	25.8	26.9	27.1	26.2	26	26.8	25.9	26.5	27.5	28.6	28.2
2001	27.8	28.4	30.8	29.5	29	27.2	26.1	24.6	25.3	26.8	28	29.4
2002	27.7	28.6	28.1	28.8	29.7	28.5	26.9	25.7	26.1	27.7	29.1	28.8
2003	27.4	28.6	29.1	29.9	29.7	28.28	26.9	25.8	26	27.8	29.1	28.6
2004	28.5	28.9	29.3	29.6	29.1	27.8	25.7	25.8	27.2	28.2	29.1	28.9
2005	26.65	28.83	29.84	29.93	29.29	27.81	26.18	25.19	26.35	26.37	26.7	26.9
2006	28.67	29.44	29.72	30.11	29.31	28.79	27.5	25.98	26.45	27.9	29.37	29.074
2007	28.03	28.5	29.36	29.52	29.24	28.31	26.7	26.6	27	28.1	28.9	28.9

III. Data Analysis

The major statistical techniques employed in the research include mean and bivariate correlation analysis. The mean was as usual obtained by adding all scores and dividing the sum by the total number of the distribution and was utilized in calculating the annual mean temperature. Furthermore, the bivariate correlation analysis reflects the extent to which a change by a change in the other set. In this work, it was utilized to establish the relationship between temperature variations and changes in fish production. However, through this statistical technique we will be able to show the magnitude and direction of the perceived association of the sea surface temperature and fish production. The correlation method employed is the Pearson's Product Moment Correlation (PPMC) which is regarded as the most powerful correlation statistics which is mathematically expressed as

$$r = \frac{\sum xy - \frac{\left(\sum x\right)\left(\sum y\right)}{n}}{\sqrt{\left[\sum x^3 - \frac{\left(\sum x\right)^2}{n}\right]\left[\sum y^2 - \frac{\left(\sum y\right)^2}{n}\right]}} \quad (1)$$

Furthermore, Student t-test was used to determine the significance of the correlation and expressed as

$$t = r\frac{\sqrt{n-2}}{1-r^2} \quad (2)$$

All statistical analysis was undertaken with the aim of Minitab Version 18 statistical package.

IV. Result And Discussion

The fish production or catch statistics and water temperature (SST) data presented in Table 2. The fluctuation in SST during the period 1995 – 2007 is shown in Figure 2.

The highest average SST of in 1995 and 1998 respectively, while the lowest average SST of 26.9°C was observed in 2000. The average SST was found to have decreased by 0.8°C over the study period as shown in Table 3. The highest fish catch was 30,951tons observed in 1999 at the SST of 28.5°C and lowest catch of 10,434 tons and was observed between 1995 and another drop could be seen between 2001 and 2004 when it the production went down from 17,054 to 11,409.

Table 2: Fish Production in Lagos and Sea Surface Tenperature of Lagos coastal waters 1995 - 1997

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
SST(°C)	29.2	28.9	28.2	29.2	28.5	26.9	27.7	28	28.1	28.2	27.5	28.5	28.3
Fish catch in tons	19,534	16,342	28,605	28046	30,951	10,434	17,054	15,549	15,409	11,409	18,356	20,037	22,191

Source: Lagos State Ministry of Water Resources and Cooperation- Fishery Department

The highest decline in fish catch statistics of 20,5l7tons was recorded between 1999 and 2000. This appears to coincide with the highest decline in temperature statistics of 1.6°C between 1999 and 2000. From 2005, a continued increase in fish catch production was observed as shown in Table 3.

Table 3:

Period	Average SST (°C)
1995 -1998	28.9
1999-2002	27.8
2003- 2006	28.1

A correlation analyses was performed to shown the relationship between thecatch statistics and SST. The result of the analyses is presented in Table 4 where it is revealed that there is a significant positive correlation between fish catch and sea surface temperature shown. (r = 0.576, p = 0.05, N = 13).

Table 4: Pearson Correlation Coefficient (r) between Temperature (x) and fish catch (y) during the period 1995 to 2007 (p = 0.05)

Fish Catch	**Fish Catch**	**Temperature**	**CD**	**N**
	1.000	0.576	34%	13

This result may be explained by the fact that temperature has a major impact upon the richness and diversity of fish in African estuaries (Whitfield, & Harrison, 2003). This can be better explained asthe coefficient of determination indicates that 34% of variations in fish yield is attributable to variation in SST. This positive relationship between annual catch and temperature is in support of Whitfield and Harrison (2003) and Ayub (2010). Ayub (2010) affirmed that temperature and rainfall altered the catch of some fish species notably mullet, barramundi and shrimp in Pakistan. Studies have shown that water temperature is one of the most important factors affecting growth and physiological performance of fish in aquatic êcothern (Cox and Coutant, 1981; Magnuson et at, 1990; Chowdbury et al, 2010). FAQ (2008) however, noted that change in water temperature consequent upon climate change alter the body temperature of fisheries, impacting on their metabolism, growth rate, reproduction and susceptibility to disease and toxins. These acts of temperature in fish combine to affect their general annual productivity, availability and distributions in given locations. In the present study, while changes in many different aspects of climate change may at least partially drive changes in the aquatic ecosystem, emphasis is on the role of temperature change. Some recent studies have shown the possible impacts which other aspects of climate change such as rainfall could have on fishery resources. These studies noted that coastal rainfall, stimulate nutrient export into coastal water through coastal drainage basins and adjoining mangrove swamps fresh water which provides food for fish (Ayub, 2010 &Hoguare, 2012).

Moreover, while there is increasing evidence of climate change impacts by various studies, separating climate related stresses from other stressors is of paramount importance. Some stressors or factors may have influenced fish catch while data on them are not readily available. Some of these factors include pollution, overfishing, use of harmful fishing gear, reduction in fresh water flow, salt water incursion due to sea level rise, changes in atmospheric CO_2 concentration which affects pH of oceans. Some of these factors are noted to have led to deteriorate the condition of creeks and estuaries upon which fisheries depend during their life cycle as their breeding and nursery ground. Therefore, this shows that along with temperature and otherclimate change variables which is influencing the catch or yield of fish, these other stressors are another set of factors influencing the catch of fish, resulting in possible reduction in fish production.

V. Recommendations

The depletion of fish stock around climatic variability makes it necessary to manage fish production sustainably. In the light of this, the following recommendations based on the study are made.

1. There should be improvement in the acquisition and availability of temperature data and information which will undoubtedly lead to better decision making on how best to respond to the potential effects of temperature variation. The installation of environmental warning and monitoring systems are highly recommended.
2. There is need for the establishment and maintenance of more training and demonstration facilities in the area of fish production for easy transfer of technology and development of competent and experienced manpower.
3. Government should develop policies that will ensure the reduction of overfishing such as in restricting each trawler of the quantity of fishes caught and the kind of fishing gear threats posed to the replenishment of stocks.
4. Improvement in the supply of quality fish seeds that can withstand variations in temperature and ensure improved yield.

VI. Conclusion

The present study has shown that water temperature variations has a positive relationship with the productivity of fisheries as evidenced by a recorded decline of 20,517tonnes on fish production in 2000 as a result of temperature decline of 1.6°C which is the highest over the study period. Thus with the onset of general warming trend due to climate change, fish productivity can increase or decrease in certain areas depending on the maximum tolerance range of these fisheries resources (Shuter and Meisner, 1992).

The depletion of fish stock around the world in the period of global climate change makes it necessary to manage fishery production sustainably. There is a need, therefore, for proper fisheries management and monitoring to meet the challenges of global climate change as well as other environmental issues (Ayub, 2010) Hoguare (2012) noted that in order to adopt sustainable management measures of the fisheries resources, we need to understand the factors that determine their distribution and availability. In other words, a more integrated approach will suffice. However, Garaia et al (2003) proposed a new systems approach termed

Ecosystem Based Fisheries Management that integrates a set of interactions from biophysical, tropodynamic and exploitative drivers into management strategies.

Furthermore, this study provides a veritable tool for decision making for relevant Government Agencies and based on the findings, the following recommendations are made: government should enact policies aimed at tackling overfishing that will provide restrictions on type of fishing gear in order to reduce threats posed to the replenishment of stocks; improvement in the supply of qualify fish seeds capable of withstanding variations in climate change; establishment of more training and demonstration facilities in area of fish production is necessary while installation of environmental warning and monitoring systems to checkmate pollution is highly recommended.

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