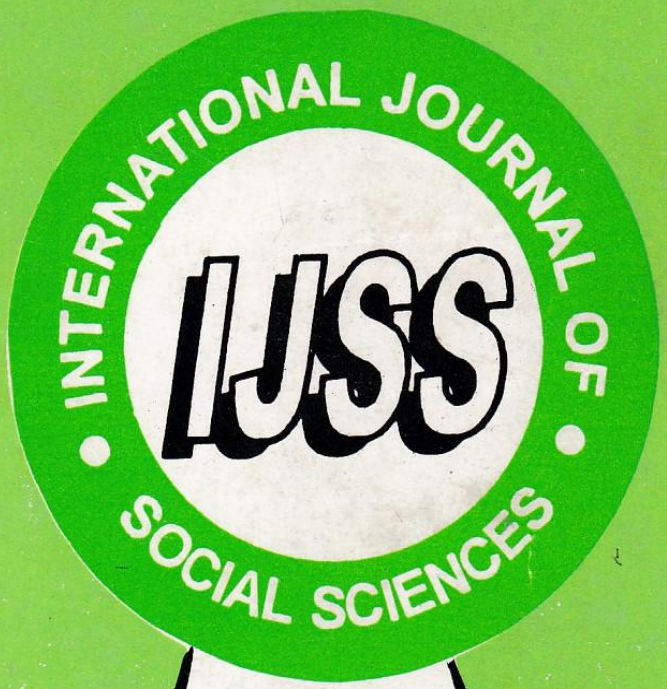
ISSN 1119 - 4898

International JOURNAL of SOCIAL SCIENCES



FACULTY OF SOCIAL SCIENCES
UNIVERSITY OF UYO
UYO

Volume 2, Number 1, June 2000

International Journal of Social Sciences (2000) 2:32 - 39

The climatic environment and fisheries

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ABSTRACT - Fisheries with climatic studies is a recent one. There is a clear relationship between climate, fish behaviour and fishing. There is the need for physical Oceanographers to be involved with biologists and co-operate with climatologist in the pursuit of the climate - fish environmental studies. The objective of this study is the examination of the application of climate information to fisheries management and operations. This will help bridge the gap in knowledge between climatic variations and fishing. This paper, in pursuit of the above objective discusses the place of climate in the fisheries system. Emphasis is placed on the role of the sea surface temperature; the wind and sea level pressure; light and its effect in fish production; rainfall, salinity and fish availability, and the climate service for fisheries.

The paper concludes that fishing activities could be planned in order to manage the best yield as climate information and prediction, which are natural, and the fishing activities and management which are human, influences the abundance, catchability and mortality of fish.

INTRODUCTION

Fisheries studies as it relates to climatic environment has been recent. One reasons for the prevalence of this condition has been unavailability of data. There has been less emphasis on the climate in particular on biological productivity. Studies show clear linkage between fisheries and climatic variation, (Moses 1987). Fish behaviour in relation to is environment is an aspect which requires inter-disciplinary collaboration. Physical oceanographers need to be more involved with biologist and they need to cooperate with the climatologist in particular. The results of such inter-disciplinary studies on the environment would help to provide useful information on the effect of the environment on fish behaviour, and such information could help in fish stock management.

The objectives of the present study are to examine the applicat on of climatic information to fisheries management and operation. This is to bridge the gap in understanding between climatic variation and fishing. This paper also focuses on the direct impact of climate on fisheries. Indirect

impact are none the less important since they impose seasonal effects on fisheries:- fishermen may not be able to fish when and where the winds are too strong as the sea would be too rough.

Climatic services may include, the application of past climatological records, contemporary monitoring and expected future conditions to socio-economic and agricultural sectors including fisheries. The later consists of many components ranging from deep sea, near shore fisheries, marine, fresh-water (in land) fisheries to aqua-culture. Many different fish species are concerned, each having their own behavioural response to variation in their environment. However, the general feature of climate services relevant to all fisheries are discussed.

CLIMATE AND FISHERIES

The fisheries system is composed of the fish, their environment and the fisherman. The influence of climate on the stocks of fish and their distribution can be direct through water properties, variation or indirect through fishing activities dependent on weather conditions.

The environment of the fish is the sea water through air-sea interactions, and sea water is the medium between the fish and the climate. The parameters which have an effect on the fish's behaviour are those which characterize its habitat. The habitat can be defined as the ecosystem in which the fish should find optimal conditions for feeding and for reproduction. The conditions include, the water temperature, its dissolved oxygen content and its nutrient and food concentration. It is clear that these parameters are dependent on the exchange of properties through the air-sea boundary layer, on current and on turbulence within the ocean. Currents are mainly wind-driven in the upper layer of the ocean and ruled by thermohaline circulation in sub-surface layers. Thus, the fish is directly related to the climate of the atmosphere and its interaction with the ocean.

There are physical environmental parameters that are relevant in the environment - fish relationship. These include:

SEA SURFACE TEMPERATURE (SST)

Temperature, an aspect of climate has pronounced influence on fisheries. The cycle of climate events emanating from increased rainfall, with resulting increase in water level and decreased temperature have been found to be signals that trigger off spawning migration for most fishes in the tropics. Moses, (1977); found that, the boom harvest of Catfish *Chrysichthys nigrogiditatus* along the Cross River during the months of June/July was attributed to the aforementioned climatic changes.

Temperature affects water chemistry and function required by acquatic organism. Water temperature affects:-

(i) The amount of oxygen that can be dissolved in water (as temperature increases, dissolved oxygen level decreases) (Blanc, 1977).

(ii) The rate of photosynthesis by algea and other aquatic plants (as tempeorature increases, photosynethesis increases) (Blanc 1997).

(iii) The metabolic rates of organisms to toxic wastes, parasites and diseases. SST is the parameter which has been most measured, first directly and now by remote sensing. Therefore, there are a lot of available SST data as it is easy to study correlation between this parameter and fisheries statistics. studies of the ecology of tuna have shown that in some cases, warm SST enables them to heat-up their bodies after spending sometimes in cold deep water (Fonteneau 1996; Blanc 1997).

The 21°C appears often to be a limit for the presence of tuna in the Atlantic, and some catches are specific to cold waters (10-20°C) (Banc 1977). These examples show that SST is an important factor in fisheries but the functional relationship are not always understood.

A direct influence of temperature on the bodily activity and physiology of the fish can affect the behaviour of the fish, example, the migration of fish from one location to another may be started up by changes in temperature. An upwelling, within the tropics when cold water upwells from deeper layers to the surface, that cooling effects coupled with the nutrients which come up to the surface influences and triggers nutrition of the fish. Temperature also has an effect on the rate of fish feeds. It temperature is not favourable, feeding rate may be slow and food quotient or food conversion may be low. It has been found that cod fish (Gadus Sp) will not feed at a temperature of 1°C and below. Abnormally high temperature weakens the fish. The El-Nino effects off peru, that is the intrusion of the hot current up the Perurian Coast causes high temperature and fish move away because they cannot feed. Phytoplannton also drift away and birds that feed on the fish disappears.

Temperature also affects the distribution of demersal fishes (fishes found at the bottom). A typical example is the distribution of demersal ishes in the Gulf of Guinea (Tropical West-Africa) which has been studied by several fisheries scientists. It has been found that demersal fishes in the Gulf of Guinea appear in two distinct assemblages or fauna (the croaker fauna and the snapper fauna). The croaker fauna appears in shallow water only above the thermocline and only soft mud and muddy deposits. The snapper fauna is distributed both above and below the thermocline: above the thermocline it is found only on relatively clean sand and hard deposits (Corals, gravels,

shells etc). Below the thermocline, because it is no longer in competition with the croaker fauna, the snapper spread out on all types of bottom. Clearly the distribution of demersal stocks of fish in the Gulf of Guinea is influenced not only by the type of bottom deposit of the continental shelf but also by the temperature gradient as well as the interaction or competition for space and food by the two groups of faunas.

The Tuna fishes, of the *scombre dae* family is a cold water loving fish and as such is supposed to be out of the reach of fishermen in Nigerian ocean waters. Recent investigation by the Nigerian Institute for Oceanography and Marine research, Lagos using a Fish Aggregating Device (FAD) attracted and landed heavy catches of the tunas. This suggests that cold water masses surge into our Exclusive Economic Zone (EEZ) making the fish migrate to the Nigerian waters.

The thermocline is a sharp temperature gradient separating the surface water from the sub-surface water; from the sub-surface and deep waters. The depth of the thermocline, the temperature gradients and the depth of the maximum gradient influences the vertical distribution of biomass and of fish and consequently affects their catchability. That is where ocean currents upwelling play significant roles. Oceans currents affects the productivity of the sea and the fishes by keeping the water mixed thus influencing the distribution of heat, salinity and oxygen.

The thickness of the surface mixed-layer (ranging from 50-200 meters and sometimes more) is a factor for the concentration of food and Pelazio fish-generally, the thinner it is the more concentrated it becomes (Blanc 1997).

WIND AND SEA LEVEL PRESSURE

The sea-surface temperature (SST) and the thermocline are subject to the action of wind and sea level pressure (SLP). sea level pressure gradients produce winds which drive ocean surface currents. Due to corrolis force, surface waters will be advected and will either converge or diverge.

The upper oceans circulation changes SST fields through adventure and convection processes. Convergence or divergence of the surface waters are associated with thermocline adjustments. Convergence will lower the thermocline and advergence will raise it up to the surface (Blac, 1997; Tait, 1980). One can thus understand how the air-sea interaction links oceans dynamics with climate and ultimately with fish ecology.

One dynamic response of the ocean to wind stress is the upwelling. The process of upwelling has been useful in bringing up locked nutrients at deep layers to surface layers to assist in productivity. In the phenomenon, off shore

winds set the surface water in motion which may cause water from deeper levels to be drawn up to the surface.

Upwelling occurs in low latitudes along the west coast of continents to replace the westward flowing surface water in the equational currents. This upwelling water probably does not rise from depth greater than some 100-200 meters but this is deep enough to supply nutrients to the current, (Tait, 1980). Fish are attracted to these areas because of the availability of nutrients.

When there is a divergent flow in surface waters, an upward vertical motion of cold sub-surface water is generated and the thermocline rises up. Horizontal thermal gradient or fronts (which might be observed on satellite imaging), sometimes indicates the contact between cold upwelled waters and surface ambient waters. Local winds can induce coastal upwelling through a process called "Ekman Pumping" (named after the scandinavian scientist who first described wind-indiced oceanic circulation). These are generally situated in eastern oceans; boundary currents along the western cost of Peru. Chile, Mauritania, Namibia, Ecuador and California but can also be found along Somalia coasts which is an abnormally since in that case, the coastal upwelling is found on the eastern side of the African continent due to the monsoon regime (Glanz, 1994). Almost half of the commercial fish landings are taken from coastal upwelling areas which represent only a small fraction (about 1.0%) of the worlds ocean (Gantz, 1994). The biological productivity of coastal upwelling regions results from a set of natural condition namely:

(i) Offshore blowing winds
(ii) The earth's rotation generally corrolis force
(iii) The flow of cold, nutrient-rich, deep water up to the sun lit upper-ocean's surface where photosynthesis takes place (Glantz, 1994).

In conclusion, if the winds are too weak to enable sufficient upwelling, the water may be lacking in plankton and the larvae would die. There is and optimal environment "window" for the conditions leading from spawning to recruitment (Curry and Roy, 1989; Buckley and Loug, 1987). The sensitivity of the larvae to temporal variability in stratification, such as that caused by wind events, has been shown to be detrimental to larvae feeding and growth (Lasker, 1978; Peterson and Bradford, 1987).

Recent theoretical and observational studies hypothesize that certain levels of Turbulence enhance the encounter rate between predators and prey and promotes growth of the predator (Rothschild and Osborn, 1983; Sunby and Fossom, 1990; Davis *et al* 1991). Models of climatic change suggest that even subtle changes in relationship between buoyancy and heat input might have significant effect on the turning and character of the stratification process and on the availability of food organism to larval fish.

LIGHT AND FISH PRODUCTION

Light has been found to aggregate fish to ease catchability, But moon light is a nuisance to fishing, as visibility is increased. The result is that fishes easily see fishing nets and attempt an escape. (Baranov, 1976; Brandt, 1969).

RAINFALL, SALINITY AND FISH AVAILABILITY

During the rainy season, heavy discharge from the rivers through the estuaries into the oceans decreases the salinity of the coastal areas of the marine environment. The result is that the barge fish (*Ethmalose (Fumbriata)* which is a delicacy to the coastal states and which is high salinity loving, migrates away from the coastal zone offshore. Accessibility to the arctisanel fishers now becomes difficult. However as the dry season commences and the rains reduces, discharge decreases, salinity in the coastal zones increases and once again the fishes are accessible to the local fisher for exploitation.

CLIMATE SERVICES FOR FISHERIES

Routine weather reports and forecasts give useful information in fishing conditions (winds, sea state, sea level pressure, fog, storm and hurricanes). Each of this climate phenomenon has great influences on either the availability of fish or the performance of the fishermen. Nowadays, ship can also obtain real time remote sensing information such as SST, water colour, and wind stress. In principles this could provide indications on the potential areas of fish concentration. In practice, however this information has not been used for planning long term fisheries management. Remote sensing products are beginning to become widely available. Satellite measurements of SST, winds and sea colours are provided by mercator map productions available on internet. Such maps could be available to fisheries on a real-time basis since they cover large areas in a short time. They could be used for taking immediate operational fishing decisions or for short term fishing management. The data products currently available to users are SST maps delivered from digital images acquired by the Advanced High Resolution Radiometer (AVHRR) carried on board the NOAA-11 NOAA-12 and NOAA-14 polar orbiting satellites.

For daily and long term weather forecasting to global climatic studies knowledge of the energy exchange at air-sea interface (through friction) is very important. The oceans surface wind are a key parameter influencing the coupling of energy between the oceans and the atmosphere. Thus, a global monitoring of the ocean surface winds is of importance to the scientific research community, and for some practical operations.

SUMMARY AND CONCLUSION

The discussion above deals mainly with the scientific aspects of the problem of environmental impacts on fisheries. Since the possibility to take into account those impacts is relatively recent, the links existing between fish and climate are described in this study, in order to synthesize the up-to-date knowledge on the matter which may then be used as a reference for future application. The link between climate and aquatic biological productivity need to be better understood and subjected to continuous research. However, available information about primary productivity to the users in a format adapted to the region and suitable to be applied to the issues at hand is also very relevant

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