Inland Water Database

A *sine qua non* for fisheries development in Nigeria.

12th Inaugural Lecture
of the Federal University of Technology, Owerri (FUTO), Imo State.

Delivered on
Thursday, 7th of May, 2009

By **CHUKWUEMEKANIM SYLVESTER NWADIARO,**
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DEDICATION

This lecture is dedicated first and foremost to God Almighty, Maker of Heaven & Earth for his guidance, sustenance and grant of the destiny to qualify to give this lecture.

This work is also dedicated to my late parents
Chief Anene Samuel Nwadiaro (Ogbuagu, Oshiji & Damanze of Oguta & Madam Mary Rose Ishiodu Anene-Nwadiaro Nee Ajie Ossai Ebuzo of Umuatashia Royal kindred, Umuenu village, Oguta, Imo State
And my late uncle, Mr. Joseph Nwokocha Nwadiaro (Obi Nnsoro Ime) for their commitment to me.

ACKNOWLEDGEMENTS

My immense gratitude must go to my late uncle, Joseph Nwokocha Nwadiaro who used his first prize in the East Central State Lottery in 1971 to selflessly jump-start my university education when *all* financial hopes virtually failed. I owe it all to my parents who as agents of God, begot me in 1950 to Oguta community where by nature, my interest in aquatic sciences in general, and fish/fisheries work strictly predisposed me to. My indebtedness to Ifsie, my wife and my children Engr. Chinedum Ossai, Engr.(Mrs)Nkobana Chizoba Okorafor, Chineyem Ifsie, Chukwumemekanim Chukwudiegwu and the last but not the least, pretty darling Obianujum Kanene, cannot be over-expressed. They all acquiesced in my frequent absence for fieldwork and for providing the love, peace, conducive environment and understanding I needed to pursue academic work and research.

I thank the Federal Government of Nigeria for the scholarship given to me for my undergraduate studies, the University of Port Harcourt under its staff development award for my postgraduate studies, study leaves and leaves-of-absence for post-doctoral endeavours and research grants. My colleagues in the University of Port Harcourt provided the stimuli and encouragement for attainment of academic heights and excellence, particularly Prof. Samuel N. Okiwelu, now of the Dept. of Animal & Environmental Biology, a renowned entomologist.

I thank the Vice-Chancellor of the great Federal University of Technology, Owerri (FUTO) Imo State Professor Celestine O. E. Onwuliri, FAStan indefatigable, committed and richly endowed academic giant/reputable biological scientist) for letting me come to FUTO as Professor in 2006 to pioneer the development of Fisheries & Aquaculture Technology. In this regard, Professor Moses O. E. Iwuala celebrated medical entomologist, now the Director of Academic Planning & Development and University Orator, for his co-benefactor role in letting me come to FUTO.

Chairman & members of the Governing Council of this University
Mr. Vice-Chancellor Sir.,
Deputy Vice-Chancellors,
Other Principal Officers of the University,
Deans, Directors and Distinguished Professors of this University,
Heads of Departments and Coordinators of Units,
Distinguished and Special Invitees,
My Lords Spiritual and Temporal,
Staff and Students of the University,
Representatives of the print and electronic media,
Distinguished Ladies and Gentlemen.

I feel very highly honoured for this elitist opportunity that senior academics enjoy to share their thoughts in all or some aspects of their research discipline or areas of specialization. I am therefore very grateful to our Vice-Chancellor, the highly cerebral, energetic, indefatigable, innovative and pragmatic eminent scientist Prof. C.O.L. Onwuliri, FAS and the management team of FUTO for this privilege the privilege to deliver the 12th inaugural lecture of this great university. Irrespective of the various ways to define an inaugural lecture, it is an age-long academic tradition of Universities and intellectuals all over the world. It marks the beginning of the professing of a Professor in his discipline announcing himself into his new enviable status, inaugurating himself and allowing his peers to inaugurate him. It is a beginning outing, not an ending euphoristic ceremony of his career (not a valedictory rhetoric!). The inaugural lecturer bars his mind on ideas he holds very validly dear, emanating from his research experience, exposure and cognate discipline related world outlook. He defines and re-defines the problems, challenges and prospects and therefore identifies the plans to face the issues so as to consummate himself and consolidate his intellectual academic prowess. These represent my interpretation of the task I have before you today, my highly revered audience.
There are two formats of inaugural lectures in Nigerian universities according to Anikpo (1996). One is the traditional pattern where as Anikpo ***op cit*** citing Ezewu (1991) states is the one in which the

professor "reflects on his contributions to knowledge not only for building of theories in his chosen field but also for the solution of societal problems". The other, Anikpo (***op.cit***), continues quoting Oyeneye (1990) is the one in which "the inaugural professor becomes inexorably a reporter; a chronicler of what here are discrete studies, with continuous focus and what in all are a ***pot-pourir***, of competing ideas and findings". My lecture is therefore biased in favour of the second format but also embracing the first.

My choice of the topic *Inland water (limnological) database: a sine qua for sustainable fisheries resources development in Nigeria*" was decided on after several arduous options. The topic is a general and foundational recipe for fisheries resources development and management for the incredibly large inland surface water area of our country (Fig. 1a-i) especially in the area of the Lower Niger Delta, the 13,000km^2 ha surface of water that has remained unknown, untapped and unexploited while we focus on non-practical strategies bereft of data and problem solving. As the first inaugural lecturer by the first Professor of Fisheries & Hydrobiology in this University and the First Head of the youngest Department, Fisheries and Aquaculture Technology (FAT), in FUTO's School of Agriculture & Agricultural Technology (SAAT), it behoves on me to have no option of a topic other than the one I have chosen a foundation type, take off lecture. Thus, I crave your indulgence to first let you into fisheries science by the summary below but situate it in a fisheries research paradigm. According to Nauen (1992), the recent study of the Strategy of the International Fisheries Research (SIFR), it recognises "strategic research" (the investigation of basic scientific problems which cannot be handled without existing knowledge) and "applied research" which uses existing knowledge to solve specific problems including adaptive research to adjust known technology to local conditions. These two cannot be unambiguously distinguished and often goes ***pari parsu***. Nauen ***op.cit*** further states that "SIFR also underscores the benefits developing countries can derive from using existing knowledge, conducting research of their own and encouraging various types of research collaboration" as we (Dumont ***et al,*** (1994) did for the Lower Niger Delta freshwater floodplain lakes. As

followed in this lecture, SIFR advocates a new holistic approach to fisheries research so as to tackle the complexity of the resource systems and the needs of the beneficiary human beings.

1.0. The nature and scope of the science of fisheries (and aquaculture). Contrary to the understanding of the non-fisheries scientific public, natural wildlife fisheries resources science is highly interactive and integrative of all components of the aquatic ecosystem and the complexity of the food chain as shown in Figs.2a-d. No component can be taken in isolation of the other as you focus on the fisheries. That explains why you must look into all the components, establish the database before you can *"produce the fish or conceive a development /production/management strategy"*.

Fisheries and aquaculture are applied biological natural sciences concerned with the biology, production, population dynamics and management of fisheries, shellfisheries and other related aquatic animals used as food by man. Fisheries domiciles its activities in natural water bodies - rivulets, rivers, streams, ponds, swamps, estuaries, coastal waters, inshore and offshore marine ecosystems, oceans and lagoons, natural and floodplain lakes. Aquaculture's emphasis is on fisheries activities in man-made aquatic basins or fabrications. Fisheries uses and manipulates existing and developing knowledge of target exploitable fish species and their aquatic environment *sensu lato* to increase production (either in terms of biomass or number) and their catchability to man (fishermen) based on the effectiveness and technology of man's fishing gears. It follows that fisheries could be artisanal (subsistence low technology level), capture medium scale (motorized, dug-out canoe-based fisheries) and industrial trawler based offshore fisheries. The same scaling applies to aquacultural production wherein 1000, 10,000 and 100,000m^2 of pond surface basins refer to small scale (homestead), medium and commercial scale aquaculture ventures respectively. Fisheries and aquaculture are very multi-disciplinary sciences drawing on physics and chemistry and microbiology for water quality assessment of the medium of

production, algae and aquatic plants (macrophytes) for the fish and fisheries primary production food and feeding stuff, secondary level producer foods (either planktonic or benthic zooplanktonic rotifers, micro & macro crustacea, fish eggs, detritus) and even tertiary producers such as fish fry, juveniles or fingerlings. These aspects constitute the hydrobiology, limnology or oceanography that are usually inevitable adjuncts of fisheries/aquaculture sciences, giving the broad scope of the discipline. In these, the fisheries scientist/manager, like his colleagues in crop agriculture, poultry, goatery, piggery, etc must, should and does concern himself with the diseases that can and do militate against his anticipated animal production to optimal and maximum realizable levels. These apply to both his wildlife capture fisheries and in particular, the aquaculture/fish farming systems. In the latter, ascertaining the type and quality of the feed to be used to grow and fatten his target cultural species is a major concern for which immense expertise is required.

In wildlife natural water fisheries, the knowledge of the taxonomic composition and population, dynamics of the fishable stock in the fisheries constitute a *sine qua non* for his fisheries management. Herein comes in fisheries statistics, models and methods for stock population estimates, definitions of catch efforts, organization of fishermen crews and their gears, dedication of landing sites for catches (temporally and spatially), routine data gathering and statistics.

All in all, fisheries, not different from aquaculture is predicated on the basic sciences of the "fish" taxonomy, biology, anatomy, morphology, ecology, ethology, geography/distribution, breeding & genetics etc.

2.0.Before Nigeria's inland water (limnological) database can be catalogued, evaluated and the importance unravelled, Nigeria's geopgraphic setting must be summarized to put further discussions in its proper perspective as follows: Nigeria is the largest and most populous West African country, located between Long 2° 15' 14° 45' East and Lat 2° 15' 14° North (Adeniji, 1980), on the center of the west coast of the African continent, with the greatest east-west distance approximately 1,300km, north-south 1,100km; with a total surface area of about

923,700km^2 about 14.3% of West Africa's mainland surface area (Iloeje, 1981; comprising a total land area of 910,768km^2 and watersurface of 13,000km^2. The population is estimated at 140 million from the 2006 census.

Basement complex rocks are commonly found on the surface in the north-central, western and eastern parts of the country except when they are overlain in basins or down-warped areas by preserved sedimentary rocks. Such basins are the Sokoto, Chad, Niger/Benue and Lower Niger Delta. The highest highland areas of over 1,5000, 600 and 300m above sea level occur in the east, north and west respectively. The Plateau in the east are the southernmost Oban-Hills, Udi, Obudu and Adamawa, Plateau, Shebshi and Atlantika mountains. In the north are the north-central, Jos and Biu plateaux and the Mandara mountains, and in the west, the Western uplands. Sandwiching these areas of high relief are:

(i) Sokoto Plains which is about 1/20th of Nigerian surface area, with 150m a.s.l. on the average, except the 195m a.s.l. on the Danger cuesta; Rivers Sokoto, Rima and Zamfara draining into it.

(ii) Niger/Benue through at an average height of less than 300m a.s.l.

(iii) The Chad Basin - 1/10th the country's area, 45-60m above sea level, with long narrow ridges 12-30m high and 275-365m wide and lengths of between 0.80km and 12km.

(iv) The interior coastal lowlands of Western region and southeastern Nigeria-Cross River plains east of Enugu, scarplands west of Enugu and the southeastern coastal plains of tertiary rocks covering most of Imo State.

(V) The coastal margins and mangrove swampland of the Lower Niger Delta the lagoonal coast of the western plains Lagos, Lekki and Epe and the Delta *sensu stricto*.

2.1.Weather: The weather of Nigeria varies enormously between the northern and southern regions due to the influence of the Northeast Trade winds from the Sahara Desert and South-Westerly winds from the Atlantic Ocean. Temperature varies from 21-27° C in the other areas.

The regions are on average 24 - 33°C 21 25° C, 23 29° C and 24 -27° C respectively for Sokoto (13°N, 350m), Jos 9° 52' N, 1, 290m, Ibadan (7° 26' N, 2km) and Akassa (4° 78' N, 3m) (Illoeje, 1981). On the average, mean monthly temperature over a year exceed 27° C. The hottest months are March/April and October/November in the North, or November/December in the south. On the other hand, the coolest month is in August, the middle of the rainy season and also in December/January due to the Harmattan winds (Northeasterly Trade winds) and the absence of the sun from northern hemisphere.

The main wind masses that move over Nigeria are (a) the tropical maritime air mass which is warm and wet, and comes from the southern high pressure belt, crosses the equator, picks up moisture from the Atlantic as it enters Nigeria and causes rainfall throughout the country in July, (b) the tropical continental air mass from Eurasia/Arabian high pressure belt, which is usually dry and comes into Nigeria by October and establishes its influence as the dry Harmattan wind in December/January in over 90% of the country and (c) the equatorial easterlies from the east, sometimes undercutting the tropical continental air mass or the tropical maritime air mass.

Rainfall in Nigeria is either conventional, orographic or frontal. The rainfall varies with period of the year and part of the country, creating two major season dry season (November-March) and rainy season (April to October). The length of each season differs from the north to the extreme southern coasts, from an 8 month (October-May) dry season period in the northern end near the Sahel to only a month (December-February) dry spell in a coastal areas such as Bonny. In the dry season, rainfall ranges from zero in the north, through 0-25cm in the middle region to over 50cm in the coastal deltaic region. In the rainy season, rainfall height ranges from less than 100cm in the north eastern, north-central, northwestern and most of southwestern region through 100-300cm in middle Nigeria to over 300cm in the coastal deltaic areas (Iloeje, 1981). While Northern region experience clearly a two season year as defined, the south has more or less distinct four seasons long wet season (mid March July), short dry season August breaks, approximately of 1 month

duration), short wet season (September and October) and the long dry, Harmattan season (November mid March).

3.0.Historical and other factors in the development of inland water database in Nigeria: There is no doubt that limnology as a well articulated science started very late in Nigeria. Although a few related topics of limnological interest concerning Nigeria may have been mentioned before 1900, the history of the subject dated back to earlier part of the 20th century as Adeniji (1980) rightly asserted. These were very few, scattered and uncoordinated. In this category are the reports of Murray (1903) on rotifers from the old Calabar district of Nigeria (now in Cross River State), Brady 1910) on the Copepoda collected by one Dr. J. M. Dalziel from Yola in today's Adamawa State and the discovery and description to science then of the cichlid fish, ***Tilapia mariae*** Gervais from Lake Oguta in Imo State of Nigeria, by 1890's. Nearly two decades after these initial reports, Wright & Tressier (1928) described the diaptomid calanoid copepods known today as *Themodiaptomus yabensis* and *Tropodiatomus agegedenisis* from Yaba and Agege areas of Lagos State. Thus, pre-colonial era in Nigeria had little data in Nigerian limnology.

The most important factor that triggered off a systematically organized cognate work was the public health problem of guineaworm disease. This lead to the works of Onabamiro (1952, 1956) on the vectors of dracontiasis (guineaworm disease) and its associated taxonomic work on Nigeria's copepoda (Lindberg 1950, 1951). These studies made the middle 20th century the start of Nigeria inland waterdata gathering, Holden & Green (1960) and Green (1960, 1962 and 1963) followed but with a fisheries perspective, focusing on physical-chemical hydrology and plankton of River Sokoto system.

The second major factor was the formation of Nigerian's largest man-made reservoir, Lake Kainji. So remarkable is this factor that one can regard 1965-1975 as the Kainji Lake era in Nigerian limnology because so much of what we know about Nigeria is connected with it. These include the pre-impoundment studies of White ***et al*** (1965), and

Imevbore (1970) on the River Niger around the dam site. Other information that was yielded to this era were those of Imevbore (1965, 1967) on a water supply reservoir (Eleiyele) at Ibadan, and Ugborge 1970, 1972, 1974) on the River Osun. Following the commissioning of Lake Kainji in 1968, limnologically associated studies exploded on this major water body to cover all possible aspects (Henderson (1973) Karlman (1973) Adeniji (1973a, 1973b, 1975, 1977a, b, 1979, Adeniji et al (1976) Abiodun & Adeniji (1978) and Donner & Adeniji (1977) all these centred on the physico - chemical limnology and plankton; others like Bidwell & Clarke (1977) Clarke (1978) and Imevbore & Boszormenyi (1975) on the other limnological aspects. So much was the database that in 1969 the Nigerian government and the FAO of the United Nations Organization set up the then Kainji Lake Research Project. This led to the birth in 1975 of Kainji Lake Research Institute (today called the National Institute for Freshwater Fisheries Research,NIFFR), almost the first research institute devoted to inland water database research. Most of the numerous data that boomed with the Lake Kainji have been summarized by Imevbore & Adegoke (1975).

The creation of eleven water basin development authorities in 1978 throughout the country was the third identifiable factor in our inland water fisheries data acquisition. These bodies established by the Nigerian Federal Government, operated along the same lines as the water authorities in the United Kingdom. The river basin development authorities are for Anambra/Imo, Benin/Owena, Chad, Cross River, Hadejia/Jama'are, Lower Benue, Lower Niger Delta, Ogun/Oshun, Niger, and Upper Benue. Their mandate was extensive- fisheries database, agriculture, pollution control, and monitoring of the rivers and the waters in their area of jurisdiction. Very unfortunately, most of their activities have had no significant impact on the literature. Apart from the Kainji lake factor in Nigeria Limnology, the next most important consideration is the establishment of research institutes and universities with programmes that deal directly or indirectly with hydrobiological/inland water issues. The universities rose from one on 1948 to five in 1962, eleven in 1975 to over 35 in 1997 and now stand at 95. Most have programmes or staff with limnological leaning. To

appreciate how far or well we have gone with data acquisition, a quick categorization and review of Nigerian inland waters are given as follows:

4.0. Inland freshwater resources: Nigeria's enormous land mass supports an extensive and wide array of freshwater resources whose inventorization had been attempted by Ita, ***et al*** (1985). The comprise natural, non-floodplain lakes, man-made lakes/reservoirs dams /floodplain lakes, ponds, rivers and many lakes with which the lower delta of the River Niger in Nigeria is endowed, but unknown due to the remoteness, difficult location and non discrete, rainy/flood season status of most of these lakes. Tables 1, 2, 3 and 4 summarize the data that are now available on the numbers and total surface area of the various categories of these inland water resources, while Table 5 gives estimates of their potential fish yields.

4.1.Natural, non-floodplain lakes: The list of natural non floodplain lakes is given, state by state in Tables 1-4 According to these, there are clearly identifiable 116 natural lakes of non floodplain category with Bauchi & Gombe states and Adamawa & Taraba States owning 25 (21.55%) and 54 (46.55%) of the total respectively. This group of states with over 68% of the lakes are in the northern region of the country, and also an area with the highest surface spread of highlands from which many rivers and rivulets originate. It is also remarkable to note that it is within this geographical region (northeast) that the internationally bordered Lake Chad is located. No natural lakes can be identified in Edo, Delta, Oshun, Oyo States. For the other states where any lakes could be located, the ranking is as follows. Plateau/Nassarawa (11) which is most proximate to the lake-rich northern region, Imo and Abia States (7) and Anambra, Enugu and Ebonyi (4), the Kaduna/Katsina states complex (4) and Sokoto/Zamfara and Benue States with 3 lakes each. In terms of surface area, Lake Chad has a Nigerian area component of 550, 000 ha constituting about 98% of total lake surface area in Nigeria. Apart from the surface area occupied by Lake Chad, 7, 325ha or 70% of natural lake surface is located in the Adamawa/Taraba, Plateau/Nasarawa and Bauchi/Gombe states; all within the numerically lake richest north eastern region. This is followed by Kaduna and Katsina

states with 1, 543ha or approximately 14.8% outside that the Lake Chad.

4.2. Natural floodplain lakes: These lakes are found in thick clusters in the Lower Delta of the River Niger as is the case in the middle River Niger's internal delta (Dumont ***et al*** 1981 Figs. 1c and 1d). The Rivers Orashi and Niger sandwiched floodplain and that of the Cross River at its middle basin (Moses 1979, 1987) hosts nearly all the major floodplain lakes with a few from Anambra River. Most of these lakes during the rainy/flood season, become contiguous with each other. The lakes are located in Delta, Rivers/Bayelsa, Imo and Cross River States which from topographic/aerial maps of 1:50,000 scales, have approximately 330, 290, 44 and 36 lakes respectively. In Delta, Rivers and Bayelsa States, most of the lakes cannot yet be accurately named. From a 1994 enumeration, Deva 1996, these lakes total approximately 800. Inspite of the significant number, most are very small (5ha in dry season), very shallow (1-3m dry season maximum depths), turbid and of the whitewater classification (Welcome, 1975) except those of Cross River floodplain which are black waters. The dry season surface areas are as follows: Delta (3, 598ha), Rivers and Bayelsa (2, 559ha), Cross River (1, 414ha) and Imo (610ha Dumont ***et al***, 1996), given an approx. 7,580 ha. Apart from the Cross River, the drainage basin of these lakes constitute the areas of intense crude oil mineral exploration, exploitation and production in Nigeria. The floodplains and their associated lakes support intensive fishing and farming because of their high detritus- based productivity.

4.3. Man-made lakes, reservoirs and fish ponds: The detailed inventory of this category of inland waters has been given in the pioneer work of Ita *et al (op. cit.)*. A summary based on this work is presented in Table 4. The most outstanding of the man made lakes in Nigeria is the Lake Kainji which arose from the damming of the River Niger at Yelwa (Latitude 9° 30' 10".35'N, Longitude 4° 25'- 4°-35'E) and closed on the 2nd August, 1968 with a surface area of 127, 000ha, 137km length, and a maximum width of 24km. It is the second largest man-made lake in West Africa after the Lake Volta in Ghana. It serves principally as a source of hydroelectric power generation and secondarily for irrigation water and fisheries production.

With the establishment of the various regional river basin development authorities in the mid 1970s, a number of rivers were dammed to create many subsequent reservoirs and man-made lakes. Most of the notable ones occurred in the arid northern region of Nigeria in response to the need to irrigate their extensive, dry, agricultural land, supply potable water to cities and serve as ancillary fisheries production centers. Examples of the most prominent of these are as follows:

? Bauchi and Gombe States: Dadin Kowa (29,000ha), Gubi (600ha) and Kafia Zaki (22, 000ha).

? Adamawa and Taraba States: Kiri Dam reservoir (11, 500ha)

? Kano and Jigawa: Chalawa Gorge dam (10, 117ha) Gari (Audu Bako) Dam 3, 318ha) and Tiga (Yakubu Gowon Dam) 17,8706ha)

? Niger State: Jebba Dam (35, 000ha), Shiroro Dam (31, 200ha)

? Imo and Abia State: Igwu Dam (3, 500ha)

? Oyo and Oshun States: Asejire reservoir (2, 369ha) and Eleiyele 546).

? Plateau and Nassarawa States: Dom Dam (1, 200ha), Lamingo & Liberty.

? Sokoto, Kebbi and Zamfara States: Bakolori Dam (8000ha), Goronyo Dam (20, 000ha).

From the tables above, it can been seen that the total number of these man-made lakes/reservoirs identified so far, is 208 and cover an area of approximated 250, 475.6ha Although Kaduna/Katsina, Kano/Jigawa, Bauchi/Gombe, and Sokoto/Kebbi states have the highest surface areas (71, 944; 52, 280; 42, 623 and 34, 007ha respectively). Thus, whether on numberical or area basis, most of the man-made lakes, apart from Lake Lake Kainji occur in the northern region (50% by number and 80% by area), a development perceived more as a response to the increasing irrigation water needs of the region than any other factor.

On the other hand, the fish and flood ponds collated from Ita ***et al*** (1985) data, total 628 and cover only 7,208ha surface area. States down south have most of these ponds due most probably, to the high water table of

the southern region and the attraction/ease of securing a permanent water basin with minimal excavation. Another reason is the likely occurrence of ponds in the galloping rain forest depressions of the southern regions and their higher annual, almost all season rainfall. For the south-western area, Oyo state has the highest number of ponds (211), followed by Ondo (72), Benue (75), Rivers (55), Imo (500) and Delta (42).

4.4. Rivers: The main rivers of Nigeria can be seen in table Fig. 1b. The major ones with some known morphometric data are the Rivers Niger (length 4,183m, area 169,810 ha, catchment 281, 600ha, floodplain 300, 000ha), Benue (129, 000ha surface area and 1, 504, 400ha) and Imo (910, 000ha surface area and 1,505, 400ha catchment area), Cross River (3, 9million ha surface area) and Sokoto (630km length). The other relatively minor rivers can be divided into seven categories viz.

a. Southern sourced tributaries of the River Benue- Rivers Numan, Kam, Jalingo, Taraba, Suntai, Donga, Katsina-Ala and Ombi.

b. Northern tributaries of the Niger Benue- Gongola, Massuri-Pai, Wase, Shemankor, Dep and Mada.

c. Southern tributaries of the Niger-Moshi, Awun, Oyi and Oti.

d. Northern tributaries of the River Niger Gurara, Jatau, Kaduna, Kontangora and of course, Sokoto which is the most prominent.

e. Tributaries of the coastal lagoons-Shasha, Omi, Siluko, Ogbesse/Osse, Osiomo, Ogun, Oshun, Owena, Ohoo and Orunro.

f. Coastal Rivers: Most of these arise from coastal freshwater swamps and flow fore relatively short freshwater stretches before emptying via short, more expanse, brackish waters into the Atlantic ocean- Rivers Nun, Brass, Saint Nicholas, Santa Barbara, San, Bartholomeo, Sombreiro, New Calabar, Bonny, Andoni, Imo and Qua Iboe in the eastern section of the lower Niger Delta In the western section there are rivers Sangana, Fishtown, Kulama, Ikebiri, Bengotoro, Diagotoro, Ramos, Forcados, Escravos, and Benin. These rivers are listed in their order of occurrence from the eastern to the western extremities of the Niger Delta.

g. Inland rivers arising from and draining the north-central highlands and emptying into the Lake Chad on the northeastern tip Rivers Yobe and its various tributes.

5.0. STATUS OF FISHERIES-ASSOCIATED INLAND WATER DATABASE

5.1 Lotic habitats. The lotic systems in Nigeria for which there are yet some limnological data are Rivers Benue (Reid & Sydenham, 1979), Niger along its main channel (Martins and Co: 1982-1992 and around the Kainji Lake site (Imevbore, 1970), Sokoto (Holden & Green 1960, Green 1960, 1962, 1963), Oshun (Egborge 19071, 1972a,b) Ogun (Adebisi, 1981), Owena, Ohoo & Orunro (Ogunkoya & Adejuwon, 1990). The others are the Ikogosi warm spring in the extreme south-western edge (Rogers et al 1969), the Wikki Spring in the vicinity of the Yankari Reserve in the north-eastern end (Egborge & Fagade, 1979) and for the southeastern edge, only the Cross River (Moses, 1987) and the River Sombreiro (Nwadiaro 1984) have apparently been published. It is remarkable to note that most of the information on Nigeria's running waters are drawn principally from the southwestern region. The waters of the northwestern rivers as exemplified by the Sokoto and Niger show seasonal, "harmattan" related variability in temperature Secchi disc transparency of 0-3m and chemical features variable with the degree of rainfall and water level. The pH are more consistent on the alkaline side unlike those of the south-eastern and south-western parts and virtually none in the northern areas. The physical and chemical data on these lotic systems are summarized in Tables 6,7,8 and 9. The data show more clearly, the decrease from north to south and from the western edge to the eastern zone, in the ionic concentration and conductivity.

5.2 Lentic systems: The physical and chemical characteristics of most of Nigeria's lentic waters are known more than those of lotic water bodies. These include the international Lake Chad (Carmouze et al, 1983), Lakes Kainji (Imevbore, 1975), Opi (Hare & Carter 1984), Oguta (Nwadiaro 1987a, Nwadiaro & Umeham 1985, Nwadiaro & Odigi 1991, Odigi & Nwadiaro 1988, 1993), and Abadaba (Umeham et al 2001, Umeham & Nwadiaro 2007). Others

are the manmade reservoirs created for urban water supplies such as Eleiyele (Imvebore, 1967), Asejire (Egborge, 1979a,), Lamingo (Khan & Ejike 1984a, b, Khan, Fagbemi & Ejike 1983) and Shendam (Kemdirim ***et al*** 1989). The most recent data are based on the numberous floodplain lakes in the lower Niger Delta covering the major oil producing areas of the country (Nwadiaro ***et al***, 2006) and those of the middle Cross River basin floodplain lakes (Moses, 1987). The general features of the waters are of acid to neutral or slightly alkaline, poorly buffered waters with low concentration of dissolved minerals. This is reflected in the low conductivities and low concentrations of inorganic carbon, sulphates, phosphates and silicate ions. The paucity of dissolved ions and low pH is more prominent in the southeastern floodplain lakes which occur in the rain forest belt than in the northern systems which are in the savannah.

5.3 Biological data on Nigeria's inland waters

5.3.1. Phytoplankton and algal flora (Plates 1-9,12,13 and Figs. 3 and 4): Algae are basically chlorophyll-pigmented microscopic plants found in virtually all aquatic ecosystems, on humid rocks & the land surfaces, either free-floating in water and called "phytoplankton" or attached to all sorts of substrata and referred to as "periphyton" or benthic algae. Phytoplanktonic algae and indeed most algae, range in size from ultrananno plankton (< 2μm) to macroplankton (200-2,000μm). These algae are the 1stprimary producers of energy, at the base of the aquatic food for most of the surface water feeding fish and even the bottom benthic browsers. Examples here the fresh water sardines ***Pellonula leonensis, Sierrathrissa*** leonensis, the upside down catfishes ***Hemisynodontis membranaceus***, young of the year fish, etc. The importance of algae and the phytoplankton community in waters is underscored by the revolutionary re-stocking/seeding of the east African freshwater sardine ***Limnothrissa miodon*** into Lake Kivu (Zaire) from Lake Tanganyika (East Africa) in 1958 and that species exploitable fisheries stock population explosion (Fourniret, ***et al*** 1992). Aquaculture production of fish fingerling and adult tilapiine fishes depend on algae/phytoplankton, sometimes stepped up in

population by appropriate fertilization of the pond water. Aside, some are food for man ***Spirullina Oscillatoria platensis*** in Chad, ***Phylloderma sacrum*** in Japan and others mentioned in Nwadiaro (2009) and for poultry and livestock. Therefore, the development of algal data base is invaluable for fisheries production strategization but such information is very scanty for Nigerian inland waters.

Table 1 – Summary of water surface areas of lakes, reservoirs, ponds and major rivers in Nigeria (from Ita *et al*, 1985)

Water Body	Surface Area
Lake Chad (Nigerian Sector)	550,000.0ha
Kainji Lake	127,000.0ha
Anambra State	1,401,000.0ha
Benue River	129,000.0ha
Cross River	3,900,00.0ha
Imo River	910,000.0ha
Qua Iboe River	500,000.0ha
Niger River (less Kainji and Jebba	169,810.18ha
Lakes)	2,237,000.0ha
Ogun River	1,565,400.0ha
Oshun River	5,476.06ha
Fish Ponds	1,650.0ha
Flood Ponds	638.50ha
Cattle ponds	200,000.0ha
Miscellaneous stagnant pools of	275,534.91ha
seasonal rivers	515,000.0ha
Reservoirs	2.0ha
Flood plains	106.0ha
Burrow pits	
Mining paddocks	
Total	**12,487,817.65ha**

TABLE 2: Numbers and areas of natural lakes in different states of Nigeria (Ita *et al.* 1985)

STATES	NO.	AREA[ha]
ANAMBRA, ENUGU & EBONYI	4	54.5
BAUCHI & GOMBE	25	234.5
EDO & DELTA	-	-
BENUE	3	94.0
BORNO & YOBE (CHAD ONLY)	1	550,000.00
CROSS RIVER & AKWA IBOM	1	10.00
ADAMAWA & TARABA	54	6 250.00
IMO & ABIA	7	330.00
KADUNA & KATSINA	4	1,543.00
KANO & JIGAWA	2	150.00
KWARA	-	-
LAGOS	-	-
NIGER	1	300.00
OGUN, ONDO, OSHUN, OYO & EKITI	-	-
PLATEAU & NASSARAWA	11	840.00
SOKOTO & ZAMFARA	3	650.00
	116	**560,456.00**

TABLE 3: Natural non-flood plains lakes so far identifiable in Nigeria: their dry season surface areas [m] and location (modified from the data of Ita, *et al*, 1985).

NAME	AREA (ha)	LOCATION
I. Anambra, Enugu & Ebonyi States		
AGULU	24	AGULU
NIKE	20	ABAKPA
OKPURU	2.5	OKPURU
OPI [4 in No.]	8.0	OPI
Total (4)	54.5	
II. Bauchi & Gombe States		
AYABA	4	AYABA
BABU		
SUNA	5	BUSURI
BURI		
BURI	10	BURI
DADIN	-	DADIN
KOWA	5	KOWA
DIYA	60	DAMBAL
GAYIN	2	BURA
GUBI	8	GUBI
IKUNUM	26	YANA
KASHERU	8	PINDIGA
KWAYA	3	KWAYA
MALLARU	10	GAMBE-ABBA
RAFIN RABI	20	YAYU
RUA-UKU	1	BAJAMA
SWALA	3	KATANGA
TAKWAKULO	5	CHINADE
TSUMBA	16	-
WALAFA	3	BUSURI
WILTOYE		-
YAYU	7	YAYU
YARO-BARNO	2	BARNO
YOLO	2.5	GOMBER-ABBA
ZAGAMFARA	4	NINGA
AURMA	2	KATANGA WARJI
TOTAL: 25	234.5	
III. Delta & Edo States	None: only floodplain lakes	
iv. Benue [Now excludes Idah]		
AKETA	30	KATSINA-ALA
ATTA	60	IDAH
DEP	4	DEP
Total: 3	94	

Table 4: Summary of the numbers and dry season surface areas of reservoirs and ponds in Nigeria's various states. (Ita *et al*, 1985)

S/n	State	Man-made Lakes / reservoirs		Fish pond and natural flood-fish ponds	
		Total no identified	Total surface area [ha]	Total no. Identified	Total surface area [ha]
1.	Anambra & Enugu	15	5 011 25	9	1 705 66
2.	Bauchi	21	52,288.50	2	15.00
3.	Edo & Delta				
4.	Benue	10	329.30	42	392 00
5.	Borno	9	80.00	67	887 50
6.	Cross River	7	542 90	9	24 70
7.	Taraba & Adamawa	1	11,500 00	3	53.40
8.	Abia & Imo	9	3,523 5	50	134 99
9.	Kaduna & Katsina	39	14 011	2	14 00
10.	Kano	24	42,623	29	157 27
11.	Kwara				
12.	Lagos			13	23 42
13.	Niger	11	71 944	6	114 70
14.	Ogun	4	4,129	7	133 15
15.	Ondo	6	2 550	71	636 21
16.	Oyo	13	3,272 6	211	481 58
17.	Benue & Plateau	19	2,505	24	471 00
18.	Rivers	-	-	55	1,587 74
19.	Sokoto & Kebbi	15	34,007 3	9	295 4
	National Total	**208**	**250,475.6**	**628**	**7,208.43**

* States are grouped as they were before the 1991 states created exercise which led to the present 36 states structure plus Abuja as a Federal Capital territory.

* This includes chattel dams

* Has numerous floodplain lakes not considered here

* Most of the floodplain lakes not included.

Table 5: Estimated Fish Yield Potential of Nigeria Inland Waters (Ita *et al.* 1985)

S/n	Type of water body	Est mated Total Surface Area [ha]	Potential yield per ha and total annual yield [m.t.] (with little or no management)		Potential yield per ha and total annual yield (m.t.) (with adequate management).	
1.	Reservoirs, Lakes and Ponds					
	(i) Large reservoirs (e.g. Kainji)	250,387.0	60/kg/ha	15,023.2mt.	100/kg/ha	25,038.7mt.
	(ii) Small reservoirs (e.g. for water supply).	25,148.0	100kg/ha	2,515.8m t.	500kg/ha	12,574.0m.t.
	(iii) Major Lakes (e.g. Chad)	677,000.0	100kg/ha	67,700.0m.t.	120kg/ha	81,240.0m.t.
	(iv) Fish Ponds	5,476.0	500kg/ha	2,738.0 m. t.	3000kg/ha	16,428.0 m. t.
	(v) Cattle Ponds	639.0	100kg/ha	63.0m.t.	500kg/ha	319.5m.t.
	(vi) Mining Paddocks	106.0	100kg/ha	10.6m.t.	500kg/ha	53.0m.t.
	Total	958,756.00		88,050.5		135,605.5
2	Rivers					
	(i) Flood Ponds	1,650.0	100kg/ha	165.0m.t.	500kg/ha	825.0m.t.
	(ii) Main River Course	10,812,410.0	20kg/ha	216,248.3m.t.	30kg/ha	324,372.3m.t.
	(iii) Flood plain	515,000.0	50kg/ha	25,750.0 m.t.	60kg/ha	30,900.0 m.t.
	(iv) Stagnant Pools of seasonal Rivers	200,000.0	20kg/ha	4,000.0m.t.	100kg/ha	20,000.0m.t.
	Total	11,529,060.00		246,163.2		376,097.3
	GRAND TOTAL	12,487,816.0		334,213.7		511,702.8

Table 6: Physical and chemical characteristics of some Nigerian inland waters as collated from various sources

Values are in mg/l except otherwise stated (bd=bellow detection)

Water body and authors	Area[ha]	T°C	pH	Cond. (us/cm)	Alkalinity	Hardness	Tranpa-rency[m]	DO	PO_4-P [ug/l]	NO_3-N	Silica
R. Niger at Shagun [1]	-	-	6.6-8.0	-	20.5	-	-	6.2-10.4	10-1000	-	1-20
R.Sokoto [3]	-	18-30	7.0-8.3	-	42.5-128	27.5-103	0.1-3.4	0.1-5.0	100-1000	0.025-0.44	10-20
R. Oshun [3,4,5]	901,400	-	7.2-8.0	44.97	24.82	-	-	8.3-8.9	7-120	0.02-0.37	10-28
R. Ogun [6]	-	20-32	6.7-7.9	31-131	65.8-77.9	-	0.26-1.13	5.1-7.62	-	-	-
Lake Chad [7,8]	1.0-2.5 [million]	17.8-31	7.4-8.4	72-1251	20.6-416	-	0.05-5.90	-	500-3000	-	9.6-19.9
Lake Kainji [9]	128,000	22-32	7.1	35-72	15-40	28.5-35	-	2.6-11.9	690-1130	0.04-61	-
Eleiyele reservoir [10]	546	-	6.8-8.7	-	-	-	0.5-2.0	-	80-90	0.005-0.25	14-28
Lake Asejire [11]	1,640	21-32	5.9-8.7	118-134	51.1-51.1	-	-	-	220-477	0.04-0.22	-
Lamingo Dam Reservoir [12]	10	16-24	6.8-7.1	117-23	116-20	-	-	4.6-8.0	-	-	-
Opi Lake [13]	-	27.4-32.3	6-6.5	16-24	6-25	5-10	0.6-1.18	1-6	bd-150	0.48-0.75	-
Oguta Lake [14, 15 & 16]	300 [max]	26-31	5.1-8.4	8.6-16.5	7.6-28.3	-	0.9-4.0	3.4-7.0	bd-100	0.12-2.24	2.76-28
Abadaba Lake [17]	2.3	24-30	6.0-6.5	12-15.5	6-22	-	0.80-1.65	1.6-8.0	-	-	
River Swashi [1]	-	-	6.7-7.7	-	27-9.40	-	-	7.0-15.0	20-200	0.40-0.12	25-160
River Kpan [1]	-	-	6.9-7.7	-	23.8-130	-	-	2.8-7.5	bd-400	0.345-0.61	5-200
Wikki Spring [18]	-	-	4.4-5.1	38.5-32.9	16	-	-	3.0-7.0	400	0.01	-
River Owena [19]		32-34									

Table 7 The concentration of major cations and iron (mg/l) in the surface waters of some Nigerian rivers and lakes. Authorities (Sources) are same as in Table 4. bd – below detection

	Na	K	Ca	Mg	Fe
River Niger at Shagunu	2.20-7.05	1.45-4.00	1.70-6.89	0.26-3.93	0.02-10.00
River Swash	2.25-3.20	2.00-14.50	3.20-7.76	1.80-4.70	0.03-3.65
River Kpan	2.60-26.25	3.50-32.60	1.30-26.72	0.13-7.36	0.60-5.40
River Sokoto	3.10-11.00	2.80-13.20	10-42	2.00-10.00	0.20-1.40
River Oshun	-	-	5.94-11.02	1.60-5.60	0.25-3.60
River Owena	-	-	5.15-15.00	1.10-38.10	0.06-1.60
River Onoo	-	-	17.60-37.60	11.20-49.00	0.06-1.17
River Oruro	-	-	5.60-50.40	5.40-109.10	Bd-1.94
Rive Chad	3.80-223	2.70-63.80	6.40-25.90	0.70-19.90	-
Lake Kainji	3.80	32	5.40	2.70	0.20
Eleiyele Reservoir	-	-			
Opi lakes	1.80-4.30	1.70-2.80	1.80-3.20	0.13-0.76	1.00-8.00
Lake Oguta	0.80-1.00	0.30-0.40	0.20-0.70	0.10-0.16	Bd
Lake Lake Abadaba	0.32-8.90	0.20-4.10	Bd-7.16	0.08-2.20	Bd-8.32

TABLE 8 Physical and chemical features of some floodplain lakes in the northern tip (Ugada/Ogula Akri oil field) of the Lower delta of Nigeria in the dry season (From Dumont et al. 1996 Deva, 1995) Values in mg/l except where stated otherwise

S/N	Lakes	Owners	Shape	pH [range]	Cond. (mhalcm)	HCO_3^-	Inorganic Carbon	SO_4^{2-}	Silica	NO+3+- ug/l	PO_4^{3-} ug/l	DO
1	Oru-Akuku	Umuenu	Elongated	6.45	40	4	1.2	10	35	35	4.1	6.0
2	Azua	Umudei	Elongated	5.40	46	3	1.0	nd	40	40	4.0	5.0
3	Efuamuzo	Umudei	Elongated	6.10	40	5	1.3	10	40	40	3.0	5.5
4	Okwu-Okoro	Ogwu	Elongated	4.40	40	4	1.67	15	45	30	5.6	7.0
5	Obaramiyi	Ogwu	Circular	5.90	40	8	1.5	15	35	35	6.0	7.5
6	Utu-Enwerem	Ogwu	Elongated	6.90	45	6	2.5	50	30	40	4.5	7.5
7	Iyi-Ani	Ogwu	Elongated	4.96	60	3	0.5	45	60	40	3.5	5.5
8	Iyi-Akata	Ogwu	Elongated	5.65	60	5	0.4	35	60	50	2.1	6.0
9	Utu-Akata	Ogwu	Elongated	6.00	30	4	0.6	20	35	35	2.0	9.1
10	Inyima	Umuopu	Circular	7.10	30	6	1.5	50	35	60	3.5	6.2
11	Akita		Elongated	6.30	30	8	1.2	15	35	25	1.0	8.0
12	Ogini-Uzo	Umu-Nkwokomosh	Ox-bow	5.60	40	5	0.7	40	20	25	4.0	4.0
13	Inyi-Obioma	Umu-Nkwokomoshi	Elongated	5.10	55	6	0.5	10	35	15	5.5	8.5
14	Ede-Akpu	Umu-Nkwokomoshi	Elongated	4.91	45	3	0.7	nd	15	20	3.3	7.0
15	Nnam..oche	Umu-nkwu	Elongated	6.30	40	4	1.0	nd	35	35	4.0	8.0
16	Amaramajoqwu	Umuynkwu	Irregular	5.50	50	2	0.5	15	35	40	3.0	11.0
17	Okwu-Umuigbo	Umuigbo	Irregular	6.20	55	5	0.7	35	25	35	4.6	8.0
18	Abia	Umu-Nkwokomosh	Linear	6.00	45	3	1.2	30	20	25	5.0	5.5
19	Otita-Atu	Umunkwokomoshi	Circular	6.20	40	2	0.5	40	35	20	5.5	7.1
20	Ibina	Umuide	Irregular	5.80	20	3	0.7	40	41	35	7.0	6.0
21	Iyi Nkwu – 1	Okichi	Linear	5.42	20	4	1.1	35	15	20	11.0	8.90
22	Iyi-Nkwu – 2	Okichi	Linear	6.30	40	5	1.0	40	20	45	3.0	8.95

TABLE 8 Contd.

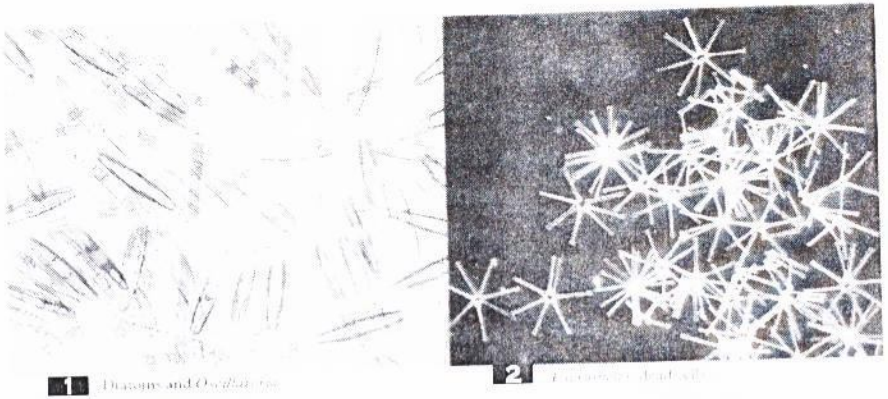
S/N	Lakes	Owners	Shape	pH [range]	Cond. (mha/cm)	HCO_3^-	Inorganic Carbon	SO_4^-	Silica	NO_3^- ug/l	PO_4^- ug/l
23	Ivi-Efi	Obutu	Linear	4.10	90	6	0.6	15	30	35	4.0
24	Azukabia	Apatu	Circular	4.85	55	6	1.0	15	35	25	5.0
25	Akika	Umuosu	Linear	5.51	40	3	1.0	51	10	35	2.0
26	Ntemmiri	Umude	Elongated	6.00	40	5	0.9	25	32	35	1.0
27	Aparri	Batu	Curved	5.60	30	5	1.4	50	45	20	nd
28	Akwoi	Umunsoha	Linear	6.10	40	3	1.4	10	55	15	2.5
29	Aniaassaah	Umu-Ajie	Circular	7.10	50	2	0.9	10	35	35	1.0
30	Ururu-Oha	Umu-Ajie	Square	6.00	20	3	1.0	45	25	40	1.5
31	Akpu-Uzo	Umu-Ajie	Linear	5.50	10	3	1.5	60	35	45	nd
32	Otaku	Umu-Ajie	Linear	5.30	40	4	2.0	25	45	60	1.0
33	Ofi	Egbema – Umuavata	Irregular	6.50	40	4	1.5	50	35	65	3.0
34	Ogiwoto	Umu-Ajie	Linear	4.95	45	3	0.8	35	40	11	3.5
35	Uchuchu	Umu-Ajie	Linear	5.33	40	2	0.7	25	40	10	1.0
36	Abaranta	Umu-Ajie	Linear	6.00	30	2	0.5	45	25	nd	1.5
37	Utu-Ugada	Egbema	Linear	6.10	60	3	1.0	45	30	70	3.5
38	Ukwutu	Egbema	Linear	5.10	55	3	0.7	10	35	45	3.0
39	Ukwutu-Nta	Egbema	Linear	6.00	30	5	2.5	61	20	15	3.5
40	Ichima	Egbema	Irregular	6.10	35	3	1.2	45	30	30	3.5
41	Ozaa-Ukwu	Egbema	Square	5.85	40	2	0.7	35	40	35	4.0
42	Ozaa-Nta	Egbema	Linear	6.10	30	4	0.7	25	60	40	1.0
43	Egbema East	Egbema	Triangular	6.00	40	3	1.0	45	30	45	3.0
44	Egbema II	Egbema	Irregular	6.10	40	6	0.7	10	40	55	3.0

TABLE 9. The concentration [mg/l] of the major cations and some trace elements in the floodplain lakes of the northern tip [Ugada / Oguta / Akiri oil fields] of the Lower Niger Delta [Dumont et al. 1996, Deva 1996]

S/N	Lakes of Lakes	Ca	Mg	K	Na	Mn	Fe	Cu	Zn
1	Oru-Akuku	1.63	1.60	3.40	3.2	0.01	1.54	0.01	0.01
2	Azua	1.75	1.47	3.6	3.6	0.01	2.68	0.01	0.01
3	Efuamuzo	0.30	0.55	3.80	3.6	0.01	1.70	0.01	0.01
4	Okwu-Okoro	0.38	0.36	4.00	5.9	0.01	1.33	0.01	0.01
5	Obaramiy	0.34	0.30	2.00	4.0	0.01	1.01	0.01	0.01
6	Utu-Emwerem	0.39	0.15	2.50	4.5	0.01	1.05	0.01	0.01
7	Iyi-Ani	1.06	0.20	2.50	4.2	0.01	2.13	0.01	0.01
8	Iyi-Akata	0.10	0.33	2.50	3.8	0.01	3.15	0.01	0.01
9	Utu-Akata	1.80	0.40	2.40	3.8	0.01	1.81	0.01	0.01
10	Inyima	1.20	1.10	2.70	3.8	0.01	1.81	0.01	0.01
11	Akata	1.40	0.20	0.80	4.0	0.01	2.20	0.01	0.01
12	Ogini-Uzo	1.82	1.46	2.80	4.4	0.01	2.26	0.01	0.01
13	Inyi-Obioma	0.60	0.50	4.50	4.0	0.01	1.10	0.01	0.02
14	Ede-Akpu	1.40	1.31	2.36	4.5	0.01	0.84	0.01	0.02
15	Nnanuoche	1.10	0.90	4.80	3.0	0.01	1.19	0.01	0.03
16	Amaramajogwu	1.05	0.95	10.00	2.5	0.01	1.10	0.01	0.01
17	Okwu-Umuigbo	0.68	0.55	3.400	4.5	0.01	0.20	0.01	0.01
18	Abia	1.10	0.65	2.66	4.2	0.01	0.23	0.01	0.01
19	Otita-Atu	0.80	0.75	2.50	3.9	0.01	0.20	0.01	0.01
20	Ibina	1.10	0.99	2.10	16.0	0.01	0.28	0.01	0.05
21	Iyi-Nkwu [Ede]	0.45	0.31	3.00	12.0	0.01	1.10	0.01	0.01
22	Iyi-Nkwu	0.60	0.75	3.01	11.5	0.01	0.88	0.01	0.02

TABLE 9 Contd.

S/N	Lakes of Lakes	Ca	Mg	K	Na	Mn	Fe	Cu	Zn
23	Iyi-Eri	0.30	0.25	2.60	11.5	0.01	0.95	0.01	0.01
24	Azukaba	0.50	0.40	3.00	10.00	0.01	0.30	0.01	0.01
25	Akika	0.05	1.51	2.00	3.8	0.01	0.56	0.01	0.01
26	Nnemmiri	0.20	0.20	3.40	5.2	0.01	2.01	0.01	0.01
27	Aparini	0.50	0.45	2.40	5.5	0.01	1.81	0.01	0.01
28	Akwoi	0.60	0.53	2.82	4.4	0.01	1.10	0.01	0.01
29	Anaassagh	1.61	1.00	2.70	4.2	0.02	0.02	0.01	0.01
30	Ururu-Ofia	1.78	1.48	2.63	4.1	0.01	0.03	0.01	0.02
31	Akpu Uzo	0.40	0.40	3.30	4.3	0.03	0.03	0.01	0.01
32	Otaku	0.42	0.22	3.30	4.4	0.01	0.05	0.01	0.01
33	Ofi	0.54	0.80	5.80	3.1	0.01	0.32	0.01	0.01
34	Ogwoko	0.46	0.44	1.85	2.8	0.01	0.75	0.01	0.01
35	Uchuchu	0.44	0.50	2.10	2.4	0.01	0.90	0.01	0.01
36	Abaaranta	0.65	0.75	3.60	2.4	0.01	0.85	0.01	0.01
37	Ufu-Ugada	1.40	1.08	3.7	0.9	0.01	0.96	0.01	0.02
38	Ukwutu	2.00	0.60	2.4	2.3	0.02	2.10	0.01	0.02
39	Ukwutu Nta	0.30	0.49	2.0	3.1	0.02	0.18	0.01	0.02
40	Ichima	0.64	0.84	3.0	3.2	0.01	2.18	0.01	0.02
41	Ozaa-Ukwu	0.61	0.55	1.5	2.9	0.02	0.88	0.01	0.02
42	Ozaa-Nta	0.75	0.70	2.3	2.8	0.01	0.65	0.01	0.02
43	Egbema East I	0.80	1.16	3.0	3.0	0.02	0.17	0.02	0.01
44	Egbema II	0.90	1.91	3.3	1.4	0.01	2.00	0.03	0.01



FBA/UK (1979)

Plates 1-6: *Examples of some phytoplanktonic algal taxa (primary producers and*

Plate 6: *A protozoon*

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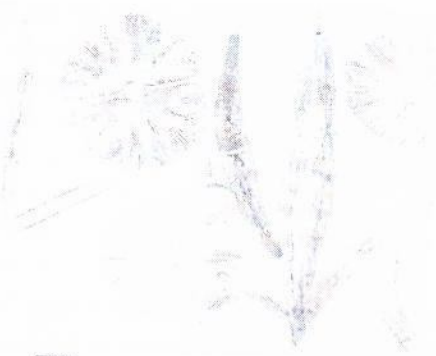

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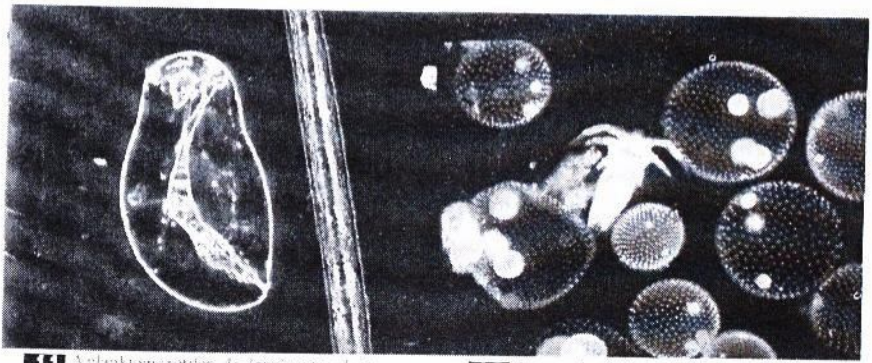

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Plates 7-12: *Some other microscopic algae rotifers, protozoa and aquatic submerged plant-food for fish* ***(FBA/UK, 1979***

The taxonomic composition of the phytoplankton and algal flora of Nigeria's inland waters are published for a few water bodies. Eleiyele reservoir (Imevbore 1965, 1967, 1968), River Oshun and its associated Lake Asejire (1973, 1974, 1979a), Ibadan freshwater systems (Egborge & Sagey, Egborge 1979) the fresh/blackish coastal Warri River (Mills 1932; Opute 1990, 1991, 1992, 2001) in the southwestern part of the country with the Chanomi creek, (Nwadiaro 1989) being the southwestern extremity studied. In Warri river, diatoms constituted 35 out of the 45 taxa that could be identified in the phytoplankton. In the Osun, 60 taxa could be identified with diatoms, green algae, desmids and blue-greens constituting 31, 20, 9 and 5 taxa respectively, Peridinium cinctum being the only dinoflagellate alga in the subsequent Lake Asejire, filamentous chlorophytes had second position. The green algae dominating were progressively joined by unicellular, colonial cyanophytes Microcystis aeruginosa and the filamentous types Oscillatoria spp. In the Ibadan area, diatoms predominated in the phytoplankton accounting for between 51% to 70in five out of the seven water bodies studied. The phytoplankton flora of Eleiyele reservoir followed a similar pattern of dominance by diatoms (Aulacouseira granulata varangustissima and Synedra acus) which were mostly responsible for the waters peak densities in October and January (1982/83 year) followed by cyanophytes (Anabena spiroides, Anabaenopisis raciborskii and Microcystis aeruginosa flos-aquae. The latter group together with desmids green algae became predominant subsequently, about 12 years after Imebore's (1067) studies (Egborge & Sagay, 1979). The Ikpoba reservoir supplying the city of Benin in the midwestern region of the country is another inland water whose phytoplantonic taxa have been described (Kadiri, 1991a, b; 1992, 1993a, b, c, 1996, 1999a, b, 2000 and Kadiri & Opute, 1999, 2000, 2003). Attention was paid on the desmid green algae of this lentic system with special reference to the genera Closterium (Kadiri, 1988), Cosmarium (Kadiri, 1991b and Micrasterias Kadiri & Opute, 1989).

From the southeastern sector of the country, information is available for New Calabar River (a small coastal fresh to brackish water river) (Nwadiaro & Ezefili 1986), Opi Lake (Biswas, 1984), Ogelube Lake,

Opi near Nsukka (Biswas & Neweze, 1990) and Oguta and nearby floodplain lakes (Nwadiaro 1989, Nwadiaro & Oji, 1986, Nwadiaro & Idabor, 1990 and Ziller & Economou-Amilli, 1998). The green algae and desmids in the upper freshwater stations, is clearly discernible. In the Opi Lakes, the green algae (chlorophytes) were the most abundant and taxonomically most diverse (John, 1986), 42 green algae and desmids, 9 blue green algal taxa, 5 euglenophytes, 3 dinoflagellates, 2 cryptophytes, one Xanthophyte Centrittactus and one Chrysophyte Denobryon with the green forming about 81% of the population and Euglenophytes 15% for Lake Oguta and the floodplain Lake Akika; the most remarkable feature being the presence in the phytoplankton of a macroscophic, algae association conveniently referred to as "unusual algal jellies" (Nwadiaro 1989, Nwadiaro & Idabor, 1990). These are floating jelly-like masses of algae-mostly blue-greens: Microcystis, Anabaena and Chroococcus, with some green algae (Spyrogira, Scenendemus) and pinnate diatoms (e.g.Navicula) rather epiphytic on the extra-cellular mucus formed by the blue-greens. These "unusual algae jellies" are similar in many respects to that reported by Compere (1979) from Kumamoto, Japan when it is edible and used as a soup condiment. The algae of non-jelly associated communities in lake Oguta plankton and those of the floodplain lakes in close proximity with Oguta have been tentatively studied by Ziller & Economou- Amilli, 1998. The inventory so far show that all the major groups of freshwater algae represented in Lake Oguta and five floodplain lakes sampled. The diatoms are taxonomically predominant with a total of 104 species so far recorded. Out of this, the pennate diatoms have as much as 84 species. Aulacoseira, granulate and other Aulacosiera spp: Eunotia E. asterionelloides, Anomoensis serians, Frustulia rhombodies and Stenopterobia

In the north-west, data exist for Rivers, Sokoto (Holden & Green, 1960) and the Kainji Lake (Eaton, 1965) although these are very scanty on the taxonomic composition. Adeniyi (1978) gave a comprehensive species list of the planktonic algae (306 species in 98 genera) in Lake Kainji. Within the first 18 months of the lakes life, blooms of Anabaena and Microcystis, Volvox and Eudorina occurred, although diatoms were reported to predominate but often with equal abundance as the

cyanophytes from June to October.

On the other hand, the northeastern zone has a comprehensive phytoplankton species inventorization for the Lake Chad basin (Gras et al 1967; Compere 1974, 1975a, b. 1977) because of the lake's strategic and international status and the sustained activities of the research institute (ORSTOM) which stationed at Ndjamena for several years. The lake Chadsis algal flora is the best known of any water body in tropical West Africa (John, 1986). Over 1000 species and infraspecific taxa have been recorded from Lake Chad basin with the figure rising to 1,500 when the associated main river flora are considered. The diversity is highest in the south-western basin (787 taxa) followed by the northern (628) and the south-eastern area with 461 taxa (John, 1986). Chlorophytes have 52% of the recorded taxa, followed by the diatoms (27%), the cyanophytes (13%) and others (8%). The desmids had taxa representing 60% of the green algal total taxa. Qualitatively, the diatoms are the dominant algal class but quantitatively, the blue green algae are more important due to their massive growth (John 1986). The picture of taxal dominance however varies from one area of the basin to the other and with the tributaries.

The Jos Plateau reservoirs (Lamingo and Liberty) are the other lentic system for which there are some algal flora data. 32 taxa were listed for Lamingo (Khan &Ejike, 1984). Khan (1984) published 48 taxa of desmids distributed in 12 genera. These were made of 16 species of Staurastrum and 14 Cosmarium species. The phytoplankton was dominated qualitatively and quantitatively by diatoms (Nitzchia, Synedra, Navicula and chlorophytes (mostly desmids Staurastrum, Cosmarium and Micrasterias.) The next most important group are the dinoflagellate Peridinim. Later, Khan (1987) descried the algal species composition of the phytoplankton of fish ponds in Panyam within the vicinity of Jos; contrasting with the floral paucity of the water supply reservoirs earlier studied. The population dynamics of the phytoplankton of these Jos reservoirs in association to the physical and chemical variation of their waters, has been described by Khan & Ejike (1983), Khan & Agugo (1990), Khan, et al (1983), Anadu et al (1990) and Chidobem & Ejike

Phytoplankton from Esthwaite: *Ceratium* and *Anabaena*.

Plate 13: *Examples of primary producer phytooplanktonic algae (from FBA/UK, 1979)*

(1986). Very little is known about the periphyton of these waters (except in Chad-Compere & litis, 1983) and the marginal intertidal sublittoral zone of Chanomi creek (Nwadiaro 1990).

5.3.2 Phytoplankton biomas, numbers and productivity: The biomass and productivity estimates given so far for the lentic systems are provided in only a few e.g. Kainji and Oguta. The impression is that of low productivity of phytoplankton down south, especially towards the Lower Niger Delta, while those towards the north have higher values of not only the productivity but also of the standing crop.

5.3.3. Aquatic macrophytes (Figs. 3 and 5a-e). Aquatic plants floating, submerged emergent of big sizes thus called aquatic macrophytes are of fisheries production value in much the same way as algae phytoplankton primary producers. Apart from this, they are of immense of ecological, environmental human food and public health values (Little, 1979) and details of their taxonomy, ecology, etc can be found in Raynal Roogues, (1980) and Little (op.cit) what follows therefore is what there is as database for this very critical fisheries development factor in Nigeria. There is very little habitat specific information on the aquatic macrophytes of Nigeria's rivers and lakes. The limited data are based on the River Niger in the Kainji Lake area and the subsequent Lake Kainji formed from damming that area of the River Niger (Cook 1965, 1968, Imevobore 1971, 1975; Imevbore & Bakare 1974; Hall 1975, Chachu 1979, Chaudhry & Chachu 1979). These have been reviewed by John (1986) not only for Nigeria but for all the inland waters of tropical West Africa. The very recent addition is that by Egborge (1994) on the freshwater stretch of Warri River in the south-western Niger. Table 10 summarizes taxa of aquatic macrophytes so far recorded ion the marginal areas of the waters, the emergent and free-floating types. Of particular ecological, economic and environmental importance is the water hyacinth Eichhornia Crassipes) which was reported first in Nigeria's inland waters in 1984 (Egborge 1994) and has spread fast into most of the coastal fresh waters, constituting its known nuisances. The control measures by the government have been summarized by egborge (1994).

The Lake Chad, the vast lake south of the Sahelian zone by four countries. (Niger, Chad, Cameroon and Nigeria) cannot be strictly considered as Nigerian in this review although its flora should be mentioned. According to John (1986) "the aquatic and semi-aquatic macrophytes grow in the coastal shallows, fringe the inlands, cover the shallow sand banks and from floating rafts or mats". The taxonomic composition of the plants in various associations of forms and in the various stages of the Lake Chad ("Normal" and "Little" phases) has been summarized by John (1986) with an illustrious of their distribution in the lake. The comprehensive accounts of the aquatic macrophytes have been given by illis & Lemoalle (1983). The current status is that aquatic macrophyte flora of Nigeria is known or have been studies in virtually only one system the Niger-Kainji Lake system (sensu lato).

5.3.4 **Zooplankton** (Plates 14, 15 & 16 and Figs. 4A): Zooplankton or planktonic fauna are like the phytoplankton; microscopic animals freely living in the open waters. Unlike the planktonic algae, they are the first tier secondary producers or primary consumers in the food pyramid. Zooplankton is a term used for a heterogenous, multi-phyletic/multi-taxonomic community of protozoa (amoeba of basic biology!), cnidaria (remember your hydra!), rotifers, larval molluscs, cladocera (water fleas), copepods, ostracods, larval decapoda(crayfishes!), larval insects, spiders, fish eggs & fry and sometimes, in shallow water bodies, "adventitious" bottom-living animals suspended temporarily by turbulence. Zooplankton serves several functions:

First, they are tools in answering biogeographic & palaeoclimatic questions (Dumont 1978, 1979).

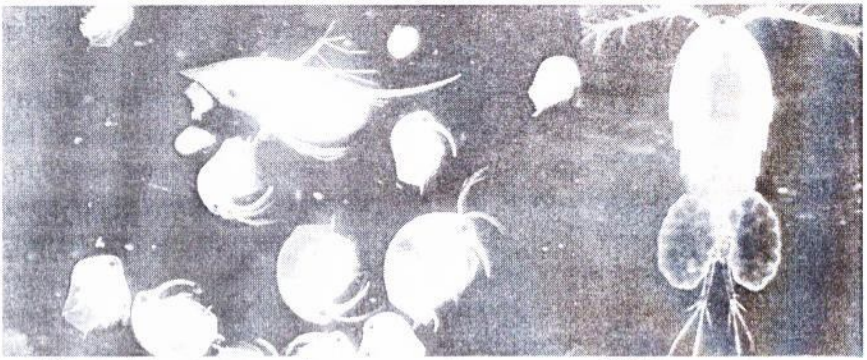
Secondly, zooplankton and their primary producer associates, the phytoplankton community are important in fish production of both temperate and tropical lacustrine systems. The volume of literature on food and feeding habits of fish is large and for reason which are validly those of basic ecological understanding, continue to increase above other aspects of fisheries ecology. Lauzanne [1988] is certainly one of the most concise reviews for African fishes in this respect with about 250

references out of the numerous pile of literature. Out of the seventeen families of importance in the fisheries yield of African freshwaters, only four can as yet be regarded as non-zooplanktiphagous. The others feed on the planktonic fauna either as young, adults or throughout their immediate post-alevin stages or at least, have some important representatives that show this food habit. To emphasize this point, the families are listed as follows: Osteoglossidae, the only species Heterotis/Clupisidus niloticus Ehrenberg, 1827, Mormyridae [Polimyrus, Petrocephadus, Brieonmyrus; the small-sized species, Clupeidae, the African sadines of Lake Tanganyika Stolothrissa tanganyicae and Limnothrissa miodon and other African lacustrine populations of Pellonula, Cynothrissa and Sierrathrissa young Tetradontidea, profundal Characidae of the genus Alestes and young Hydrocynus, Citharinidae (specifically) Citharinus, Cyprinidae (young and smaller-sized species), Bagridae (young Chrysichthys and Auchenoglanis), Mochokidae (Brachysyndontis batensoda and Hemisynodontis membranaceus), Cyprinodontidae (some zooplankti-vorous), Centropomidae[the pelagic larval forms] and the Cichlidae (many). In the numerous estuaries of Africa and the world in general, the Mugildae and the West African brackishwater sadine, Ethmalosa fimbriata are essentially planktophagous. The stocking of Lake Kivu in East Africa by the Lake Tanganyika sardine between 1958 and 1960 was aimed at exploiting the then rich/high zooplanktobiomass of Lake Kivu and converting the latter to ichthybiomass estimated to massive annual production of 15, 300 metric tons [Dumont, 1986]. This project though logical and eventually ecologically mis-directed as Dumont (1986) showed, proves the hope that may lie in the zooplankton surveys of waters for fish protein production in African lakes and the huge floodplains of many rivers. It is therefore difficult to appreciate any potential fisheries production resources surveys, management and utilization conceptualizations of tropical African reservoirs, natural lakes and floodplain ponds without a detailed taxonomy, ecology and population dynamics of the zooplankton community. Apart from wild fisheries management as surmised above in relation to plankton fauna, a lot of aquaculture of fish and other aquatic foods, especially at the larval rearing stages, all, rely on zooplankton for feeding [Hogendoon, &Vismans, 1980 Brown & Gatzet,

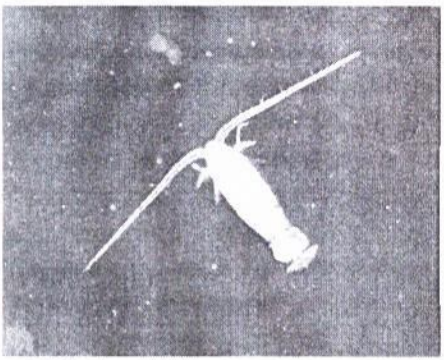
1979, Careen et al, 1976, Hetcht, 1981, Richter & van den Hurk, 1982] and in the sustenance of the fish aquarium industry, not to mention the damage by the parasitic groups [Kabata, 1978, Fryer, 1956, 1960, 1965, etc].

The third and probably the most demanding imperative for planktonic copepod study in tropical Africa and Asia is in their role as vectors in the epidemiology and distribution of the high morbidity disease dracontiasis caused by the nematode, the guineaworm [Dracunculus medinensis Linnaeus, 1758. This disease is contacted by drinking natural surface waters with infected copepods. The records, epidemiology and vector ecology of this disease in West African countries can be found in the works of Onabamiro [1950, 1951, 1952a, 1952b, 1952c, 1954, 1956, 1957] in southwestern Nigeria, Kale [1977], Abolarin [1981] and Abolarin [1981] and Abeniyi & Brieger [1983] also in southwestern Nigeria, Adekoluo John [1983] and Edungbola [1983] in the western edge of central Nigeria and Nwosu, Ifezulike & Anya [1982] and Udonsi [1987, 1988] in East. The other African countries for which dracontiasis has been reported are Togo [Amoussonga, 1960], Ghana [Burgis, 1981, Belcher et al 1975, Lyons, 1972, 1973, Scott, 1060], Burkina Faso [Demontellerie, 1972, Steib, 1985, Republic of Niger. Before this long list creates the impression of a West African endemic disease out of dracontiasis, there are Asian cases which have been covered by Moorthy [1938], Moorthy & Sweet [1936a, 1936b, 1938] and Lindberg [1935, 1936, 1950] for Iran.

The plankton fauna of Nigeria is the subject of a review by Jeje (1987, 1988, 1989) Jeje and Fernando (1987) and Nwadiaro (2007). These could be referred to for more information. Irrespective of the depth of the study, there is information on the zooplankton of only 32 biotopes. The review by Nwadiaro (2007) gives tables listing the known and valid species of larval insects, freeliving and parasitic copepods, Cladocera, Ostracoda, Protoza and Rotifera of Nigerian waters. 80 Copepod species are so far known. They consist of 13 Calanoid species of either Thermodiaptomus or Tropodiaptomus, 56 Cryptocyclops) and 8 Harpacticoida. These taxa originate from studies on 14 biotopes but



15 Calanoid copepod



16 Calanoid copepod *Diaptomus*

17 Stoneworts (*Nitella*)

18 Water plantain (*Alisma plantago-aquatica*)

Plates 14-18: Planktonic fauna (zooplankter (14, 15, 16) and macrophytic aquatic plants (17 & 18) FBA(UK) 1979

more intensively on the River Sokoto (Green, 1962), southern basin of Lake Chad (Robinson & Robinson, 1971), Oguta Lake (Maas et al, 1992) and small water bodies in and around Ibadan in connection with the guineaworm disease (dracontiasis) by the works of Onabamiro (op.cit.).

76 Cadocera species are known from only 14 water bodies. These are drawn from Sididae, Daphnidae, Moinidae, Podonidae, Macrothricidae, Chydoridae and Bosminidae, Chydoridare, are the most diverse with 3, 2 and 12 species respectively. Most of the biotope specific data derive from the studies on River Sokoto (Green 1962). Asejire (Egborge, 1981) coastal Western Nigerian rivers (Egborge & Onwudinijo 1994) and Oguta and its associated floodplain lakes and smaller freshwater biotopes (Dumont et al, 1996) New Chydorid records-Oxyurella tenuicaudis, Alona intermedia, A. costata and A. monacantha emerged for Nigeria from the Oguta Lake associated studies.

Perhaps, it is in the Rotifera that the highest diversity of the Nigerian zooplankton can be seen, with 250 species drawn from only 10 biotopes especially Lake Kainji (Donner & Adeniji, 1977), River Sokoto (Green, 1960), Oguta Lake and some floodplain lakes in the upper section of the lower Niger delta (Segers et al, 1993). In the latter group of biotopes, 207 out of the 250 species were recorded with 14 (mostly Lecane species) new to science (Segers 1993). The studies produced the two rotifer species richest lakes in the world-lakes Oguta and Tyi-Tfi (Dumont, et al 1996).

With regards to the other associated animals Ostracoda, planktonic insects and freshwater spiders (Arachnidae), there is very little work known in the literature either on the taxonomy or ecology. There is reference to Ostracoda for only 6 freshwater systems Yola area of River Benue (Brady 1910), Sokoto River (Green, 1962), Lake Kainji (Bidwell & Clarke 1977), Lake Opi (Hare & Carter 1987) and Wikki Warm Spring (Victor, 1987).
For the insect larvae (e.g. the glassworms Chaoboridae), the taxa in the plankton are known for only Lake Kanji, Opi, and Oguta. For the

Arachnidae only Lake Kainji has been reported on with only two taxa. Table 10 lists the Ostracoda, Chaoborid and Arachnidae so for recorded in Nigerian freshwater plankton communities.
The protozoan component often regarded as adventitious and temporarily suspended into the plankton, have been studied from only two systems Rivers Oshun (Egborge 1974), Sokoto (Green, 1960, 1962a,b, Holden and Green 1960).

Work on the ecology, life history strategies, seasonality and secondary production of zooplankters are few. The work of Clarke (1978) on the food of adult copepoda in Lake Kainji is probably the 1st followed by that of DeClerck, et al (2009) on the calanoid copepod crustacean zooplankton in Oguta Lake. These are probably the only of such studies for Nigeran waters. Seasonality in the aboundance and distribution of zooplankton as a community or for its key taxa, has been studied by Egborge (1974, 1981, 1987) for River Oshun, Lake Asejire and Warri River respectively. Holden & Green (1960) in River Sokoto, Imevbore (1967) in Eleyele resersvoir and Khan & Ejike (1984) in Jos Plateau reservoir. In all, hydrological factor leading to a rainy dilution or flood is shown to reduce the density of the plankton. As far as this lecturer presently knows, the only production estimates so far made is that by DeClerk (1994) for the calanoid copepod, Tropodiaptomus lateralis of Lake Oguta. Biomass were estimated to vary from 167 to 1,46 ug/litre with the productivities of 21-34 and 40-160ug/litre/day for rainy and dry seasons respectively.

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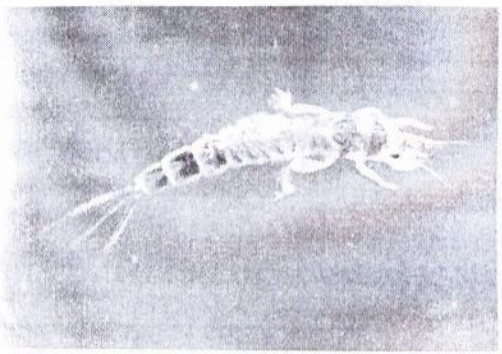

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From: FBA(UK) 1979

Plates 19 - 24: *Some benthic macro invertebrate animals used as food by fishes in biomass increase/growth*

TABLE 10: Rhizopod Protozoa [testacea] and minor organisms in the zooplankton of Nigerian inland waters from only 14 biotopes
(Nwadiaro, 2007)

Protozoa

- *Trigonopyxis arcula* (LEIDY) PENARD
- *Arcella vulgaris* var PENARD
- *Arcella lobostoma*
- *Arcella rotunda*
- *A. polypora* PENNARD
- *A. vulgaris* EHRENBERG
- *Centropyxis aculeate* EHRENBERG (STAIN)
- *C. arcleata oblongata*
- *C. arcelloides*
- *C. ecornis* [EHRENBERG] LEIDY
- *C. minuta* DELLANDRE
- *Cucurbitella mespiliformis* PENARD
- *Difulgia oblonga* EHRENBERG
- *Difflugia acuminate* EHRENBERG
- *Difulgia amphoralis* HOPKINSON
- *D. Corona* WALLICH
- *D. lobostoma var. globosus*
- *D. difficillis* [Thomas var. *ecornis* CHARDEZ]
- *D. elegans* [PENARD var. *angustata* DELLANDRE]
- *D. limnetic* [WALLICH] LEIDY
- *D. gramen* [PENARD]
- *D. limnetic* [LEVANDER]
- *Lobostoma* LEIDY
- *D. oblonga* EHRENBERG var. *cylindricus* THOMAS
- *D.O.* EHRENBERG var. *parva* THOMAS
- *D. Scalpellum* [PENARD]
- *D. pernardi* KOPKINSON
- *D. tuberculate* THOMAS
- *D. tuberculate* WALLICH
- *D. urceolata* CARTER
- *Difulgia* sp. X
- *D.* sp. Y
- *D.* sp. Z
- *Diplochalmys vestita* PENARD
- *Cyclopyxis impressa* DADAY
- *Euglypha acanthophora* [EHRENBERG]
- *E. tuberculata* DUJARDON
- *Lesquereusia modesta* RHUMBLER

- *L. spiralis* [EHRENBERG]
- *Nebella collaris* [EHRENBERG]

COELENTERATA

- *Limnocnida Victoria* GUNTHER [HYDROZOA, Limnomedusa]

OSTRACODA

- *Cytheridella tepida* VICTOR, 1987
- *Strandesia* sp 1 gen. STUHLMANN, 1888]
- *Zonocypris costata* [VAVRA, 1897]
- *Plesiocyprideopsis* cf. *laevigata* [KEIJ, 1935]
- *Cypris subovata* [BRADY, 1910]
- *Darwinula* sp. [G.W. BRADY & NORMAN, 1889]
- *Cyprideopsis aculeata* [BRADY, 1910]
- *Cyprideopsis* sp. [G.W. BRADY, 1970]
- *Cypreta globulosa* SARS
- *Stenocypris malcolmsoni* [BRADY]
- *Acocypris capillata* [VAVRA, 1897]
- *Physocypria manacapensis* [GREEN, 1962]

ARACHNIDA [ACARI] PROSTIGMATA-Unionicolidae]

- *Unionicola* s. str. *Dentifera* [COOK]
- *Neumania* sp.

MALACOSTRACA DECAPODA-ATYIDAE

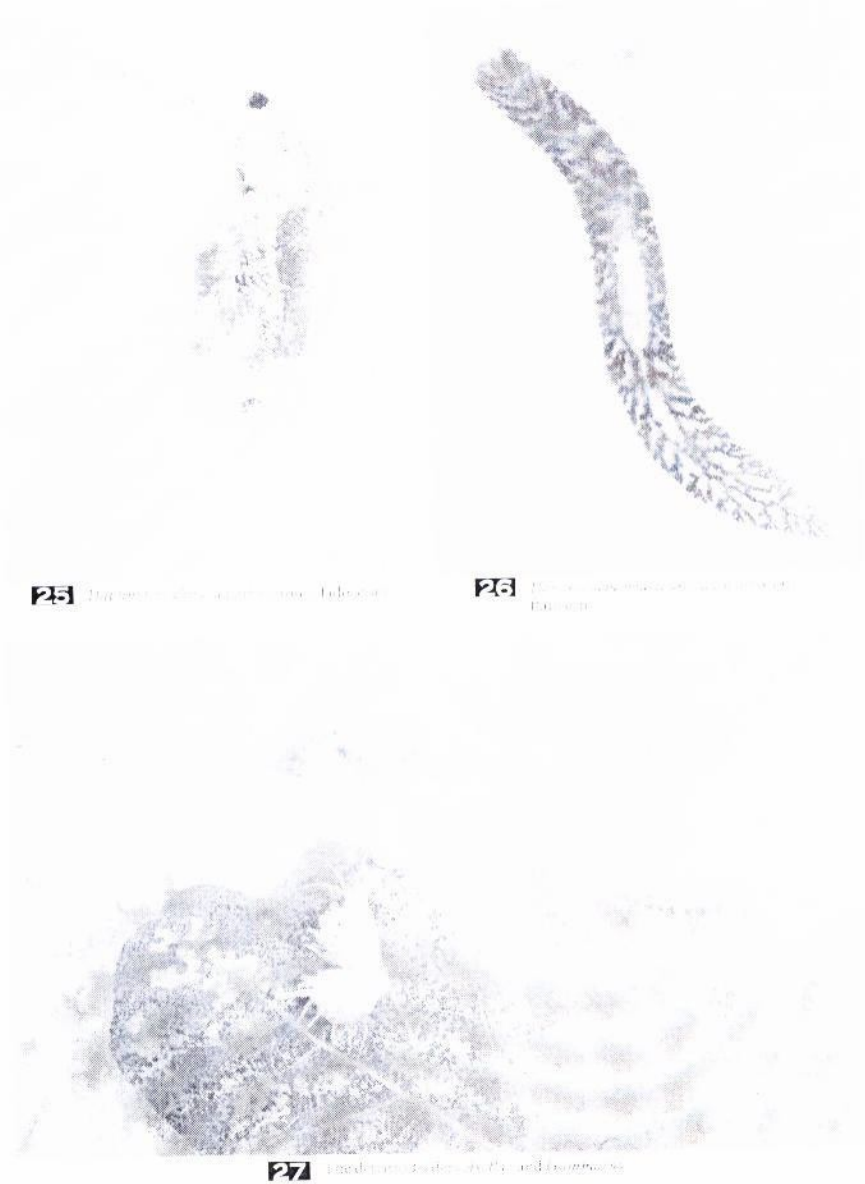
- *Caridina Africana* [KINGSLEY, 1882]

INSECTA [DIPTERA Larvae] - CHAOBORIDAE

- *Chaoborus anomalus* [EDWARDS]
- *C. edulis*
- *C. pallidipes*
- *C. ceratopogones*
- *C. turcanevis*

PHYLUM: CHORDATA

- Fish Lavae [Osteichthyes]



Plates 25-27: *Typical "text book" water flea (Pl.25), Flatworm and shrimp from FBA (UK) - 1979*

5.3.5 Macroinvertebrates (Plates 28 31 Figs. 4): As the term implies, are macroscopic animals without backbone, living mostly attached either on aquatic bottom substrata epipelic, episammic epiphytic muddy, sandy plant and bottom sediment surfaces. The composition ranges from sponges, various insect larvae (most prominently the mayfly nymph, ***Povilla adjusta***), annelid worms crabs, shrimps, snail related animals (mollusca), etc. This community of organisms constitute food for bottom feeding fish bagrid catfishes, prominent carnivores etc. Thus, a holistic management of waters requires database therefrom. Apart from this, macrobenthic fauna are critically invaluable tools for aquatic pollution bio-monitoring via various quantitative indices (Hellawell, 1978). Information on the benthic macroinvertebrates of Nigerian freshwaters appears limited only to Rivers Ikpoba in the southwest (Victor & Ogbeibu 1985, 1986; Victor & Dickson, 1985), River Sombreiro in the south east (Nwadiaro 1984), Lake Kainji (Lalsted 1977, Bidwell 1979, Bidwell & Clarke, 1977), Opi Lake in the upper limit of southeast (Hare & Carter 1986, 1987, Hare & Olisedu, 1987).

In the R. Ikpoba, 55 taxa were recorded. The Chironomid larvae, Baetid mayfly nymphs and Naidid oligochaetes constituted 34%, 24.8 and 26.2% of the 9,008 individual organisms recovered from the benthos. The other composite taxa of Diptera included Ceratopogonidae, Tanypodidae, Empidae, Anthomyidae and Simulidae. There were other mayfly nymphs such as the Tricorythidae, Leptophlebiidae, Caenidae, and Ecdyuonridae. Others included Cloeoptera, Odonata, Hemiptera, Decapoda and tibificid oligachaetes. The taxa richness index (D), Shanon Wienner Diversity index (H) and the Eveness index (E) of these benthic communities showed wide, monthly fluctuations. The diversity was low due to intense agricultural land use and its physical control status. Lake Opi benthos was dominated by dipteran insect larvae ***Chaoborus***, ***Chironomus***, ***Procladius***, and ***Tanypus*** in the mid-lake area, and a near shore community of some Chironomids Ephemeroptera, Odonata, Hydracharina and Oligochaetes. Seasonal variation in the density and biomass (dry weight) of the major composites ***Chaoborus*** and ***Chironomus*** insect larvae were given. The flutuations were approximately inversely related to seasonal changes in water level.

Hare & Carter (1986) described the vertical migration patterns of Chaoborus species showing the larval migration to the surface water at night and their within bottom residence of the burrowing mayfly, ***Povilla adusta*** with respect of the substrate relations.

Bidwell and Clarke (1977) is another comprehensive work on the benthic fauna of a Nigerian inland water resulting in a checklist (Bidwell & Clarke, 1977) and the associated list of molluscs (Halstead, 1977). Khan & Ejike (1984) subsequently gave preliminary notes on the benthic faunal communities of reservoirs in the central plateau region (Jos) of Nigeria showing the relative paucity of these vis-à-vis Lake Kainji. The work by Nwadiaro (1984) on the River Sombreiro in southeastern Nigeria is a catalogue of the macroinvertebrate taxa along the fresh to brackish water spectra of the river, with no quantitative assessment on the fauna. Knowledge of the data on benthic habitat of Nigeria's waters is limited in volume ad biotope spread even when the coastal lagoons are considered.

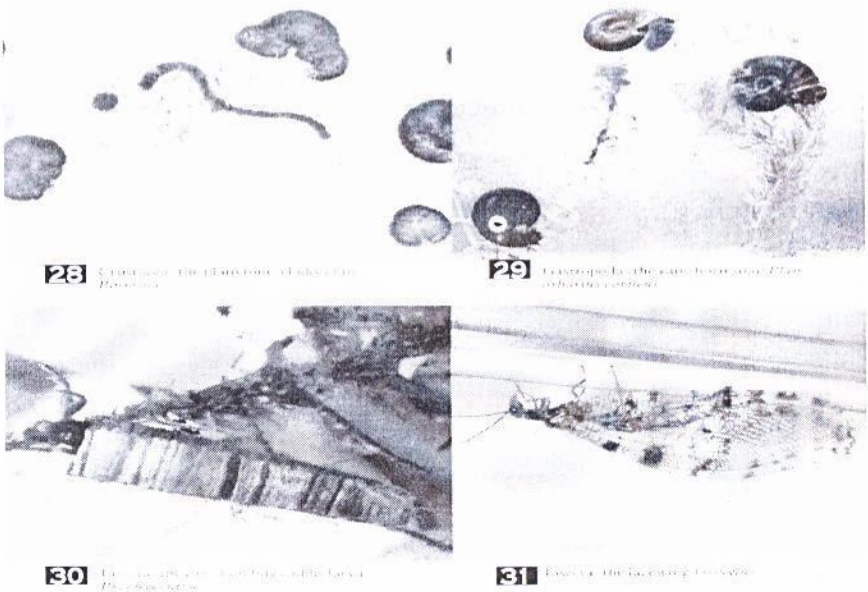


Plate 28-31: *Cladoceran zooplankter (28), freshwater snail (29), caddisfly larvae encased (30) and an adult inset of aquatic larval morph (31) taken from* ***FBA (UK) 1979***

5.3.6. Finfish, shellfish and fisheries: These are the main plank, endpoint of the task before us today: production of food from finfish, shellfishes, edible aquatic plants and animals, either through related wildlife natural aquatic resources management or aquaculture. Which of these would give us the needed quantum of fish for our over 140 million Nigerians? How do we realize this and combat the global food (fish!) crises if we have no database to plan and execute the fisheries development? How many of our numerous lotic systems (rivers, streams, etc) and lentic water bodies (ponds, natural, non-floodplain, floodplain lakes and man-made reservoirs) do we have any, current and subsisting fish database **sensu lato** for planning. These represent my worries. Possibly due to their economic importance and age-long history of exploitation, fish and fisheries constitute a popular area of limnological studies in Nigeria, and so have been rather extensively published. Egborge (1993) gave a succinct taxonomic history in this regard. In the colonial period, the first document with an overview of fish and fisheries of Nigeria's freshwaters was published by Welman (1948) with taxa most of whose names are now obsolete. Apart from Welman's (1948) work, no country - wide work exists on the ichthyofaunal composition. Some regional checklists are however, available. In the northern region, and because of the strategic importance of the River Niger and its tributaries, Rivers Benue & Sokoto, earlier account on fish and fisheries emerged from Holden (1963), Reed **et al** (1964), Reid & Sydenham (1979).

For the central region of Nigeria, checklists are available from Lowe-McConnell (1965, 1972), Lewis (1974 a,b), Lelek (1973, 1975) on the R. Niger & Kainji dam area and Arawomo (1987) for the Federal Capital Territory. In the southwestern zone, comparable data come from Sydenham (1975, 1976, 1977) for the Rivers Ogun / Oshun drainage basin, while the midwestern region is covered by Victor & Tetteh (1988), Victor & Matthew (1989), Victor & Fufeyin (1993) and Victor & Meye (1994) in and around Benin (Ikpoba River) and Odum (1995) for River Ethiope and Ogbeibu & Ezeunara (2002). Of the southeastern zone generally, ichthyfaunistic database comes from Orji & Akobuche (1989) Orji & Onyejiaka (1990) and Nwadiaro & Okereke (1993) on River Otamiri, Nwadiaro (1984) on the coastal River Sombreiro Nwadiaro

(1989, 2006) on Lake Oguta and associated floodplain lakes. Perhaps, the most comprehensive work on fish faunal composition is that on the Cross River drainage basin by Teugels **et al (1992),** of comparable quantity of data with that of Reid & Sydenham (1979) on R. Benue. A recent bibliographic analysis of finfish and fisheries research in Nigeria by Nwadiaro (2009) involving over 439 works assessed, shows all there is in the literature. It shows only about 80 water bodies studied (Table 11). The publication total skews in favour of the southeastern zone (approx. 52%) while the northern and southeastern zones have about 24% of the data each. Certainly, the take-off of a tertiary institution (University of Ibadan) in 1948 is the reason. Following the southwestern, is the River Niger in the Kainji Lake area in terms of the intensity of data so far acquired, numbers of biotopes and taxonomic units studied.

Most disheartedly is that only a few of the fish that are of freshwater fin-fisheries importance in Nigeria have usable biological database for planning and management for increased and sustainable production. These are the tilapines (Cichlidae), sardines (Clupeidae), elephant snouts, (Mormyridae), tigerfishes (Characidae), moonfishes (Citharinidae) and the "whiskered"/siluroid/catfishes (Bagridae, Schilbeidae, Clariidae, Mochokidae); only 9 out of 33 families of fisheries stocks.

There is the need therefore to scrutinize, evaluate, revise and update these inventories so as to galvanise them into one Nigerian ichthyofaunal checklist in the way that Reed **et al** (1967) did for Northern Nigeria. Daget **et al** (1986) gave an African freshwater fish checklist with seventy one families, broadly including estuarine species which do move inland to freshwaters for one reasons or the other. When matched against the Nigerian ichthyofauna as now known, about 50 of Daget **et al's** (1986) enlisted families, are represented. The freshwater data other than taxonomic catalogues are usually directed to groups selected from a community and have been tabulated in Table 11. It is discernible from this table that Lake Kainji and its vicinity (i.e. Kainji area of River Niger) have been the most studied, involving 27 (39%) out of the total (70) entries made. The other systems that follow (in the order of the intensity of fish related investigations) are the southwestern lagoons, Ogun/Oshun River and Sokoto. On the other hand, Siluroid fishers

(especially Bagridae and Schilbeidae) and Cichlidae have received more attention by researchers on Nigerian fishes than any other group of fishes.

Population dynamics of fishable stocks and documentation on fish landings, catch data and fisheries regulations are absent database. These give the impression of little or no routine fisheries documentation work for Nigeria's inland waters. In most of the waters no fishing regulations are enforced and no landing records are made.

Shell fisheries unlike finfisheries is concerned with the exploitation of other aquatic animal food resources. Shellfish comprises lobsters, shrimps and prawns, true crabs, stomatopods (all of Crustacea group), cuttlefishes, squids, octopuses, bivalve pelecypods, clams, oysters, snails (univalves, conches, whelks) (Mollusca group), turtles, crocodiles, alligators (Schneider, 1990). All these are well represented in estuarine, inshore and offshore / marine shellfisheries stocks. In the inland waters, only the snails & bivalve molluscs and decapods (shrimps and crabs) are represented. Nigeria's inland water shellfisheries data is very limited in terms of the biology and stock data. Powell (1982) made a checklist of the shrimps of economic importance in the Niger delta while biological studies have been conducted only on few species. **Macrobrachium** spp. in Lagos lagoon (Marioghae, 1982), **M. felicinum** in a southeastern river (Inyang 1984) and **Desmocaris** (Powell, 1977). Freshwater shrimp fisheries database is virtually non-existent in Nigeria. The marine crayfish fishery in 1980/84 constituted about 26% of the marine fish landings with over 10000 active fishermen in Cross River State (Nsentip, 1985). A lot of the research attempts and studies in the aquaculture sector are published in technical reports of research institutes and these are not easily available. On the hand, due to access to near and offshore trawler / artisanal fishermen catch landings, there are possibly more and better organized data in the estuarine coastal marine fisheries subsector in Nigeria. Not surprisingly, information is available for some shellfish species e.g. those on the bivalve, **Egeria, radiata** in the lower Cross River (Etim 1990, 1993, 1996; Etim & Akpan 1991; Etim **et al** 1991; Etim & Brey 1994; Etim **et al**, 1997 and Etim & Umoh 1990) and of another **Galatea paradoxa** (Etim & Enyennihi, 1990); all in the Cross

River lower reaches.

Considering the enormous surface area and numbers of discrete identifiable units of our aquatic biotopes utilizable for fisheries exploitation and production, there is little or no data base.

Table 11: Water bodies, their approximate map references and authors from whom the comparative summary of fish taxonomic composition

WATERBODY	MAP REFERENCE	AUTHOR(S)
Lake Chad	13° 14'N, 13° 1'E	Carmouze *et al*, 1983
Lake Kainji man made reservoir	10°00' – 10°50'N	Imevbore, 1975
Lake Oguta (natural non floodplain)	5°20' – 5°55'E	Nwadiaro, 1987
Lake Iyi Nkwu	5°44'N, 5° 47'E	
Lake Iyi Eli	5°4' N, 5° 46'E	Nwadiaro *et al* 2000
Lake Ibina	5°41' N, 6° 45'E	Nwadiaro *et al* 2000
Lake Akwu	5°42' N, 6° 45'E	Nwadiaro *et al* 2000
Lake Iyi Ohuoma	5°38' N, 6° 45'E	Nwadiaro *et al* 2000
Cross River floodplain Lakes	5°43' N, 6° 45'E	Nwadiaro *et al* 2000
Cross River basin waters	5°30' – 5° 05' N, 8°20' E	Moses 1979, 1989
River Otamiri	4°45' – 5° 02' N, 7°50'	Teugels *et al*, 1992
Ikpoba River	6°50'E	
River Sombreiro	5° 02' – 5° 32' N, 6°55'	Nwadiaro & Okeke, 1997
River Ogun	7°07'E	Victor & Teffers, 1988
Lower River Benue basin	6°30'N, 9°E	Nwadiaro, 1984
River Niger in Nigeria	4°30' – 6° 34' N, 5°40' – 8°50'E	Sydenham, 1977
Northern Nigerian water bodies	6°51' – 9° 00'N, 3°30'E	Reid & Sydenham, 1979 Imevbore 1970, 1975 Reed *et al*, 67
Tiga dam reservoir	9°15'N, 8° 30'E	
Asejire dam (bacteria)	7°46'N, 3° 48'E	Sturm, 1984
Bicycle reservoir		Fagade & Adebisi, 1979
Awba Dam		
Lekki Lagoon	11°20'N, 8°30'E	Ugwumba & Adeniyi, 1992
Lagos lagoon	7°35'N, 3°30'E	Fagade 1978
Epe Lagoon	7°00'N, 3°30'E	Fagade & Olaniyan, 1973
R. Kaduna – Ala	7°35'N, 4°30'E	Balogun, 1987
IITA lake, Ibadan		Oguen 2006
Lake Umuoseriche	6°20'N, 2°50'E	Fagade 1982, 1983
R. Ethiope	6°30'N, 5°60'E	Anene, 1998, 1999
River Sokoto / Rima basin floodplain		
River Kaduna / Zaria basin	7°35'N, 3°40'E	
Adada River		Hyslop 1986, 1987
Bonny River	4°15'N, 5°20'E	Olatunde 1984
Imo River		Olatunde & Moneke 1985
Ogba River	13°00'N, 5°25'E	Inyang & Anozie, 1987
New Calabar River estuary	10°5'N, 7° 30'E	King 1988
Niger Delta mangrove	6°10'N, 7°35'E	Oyo & Akolaye, 1990
Lake Alau	4°31'N, 7°10'E	
Nun River, Epie	5°10'N, 7°15'E	
Creek / floodplain		
Ondo State University farm	4°45'N, 7°06'E	
Aba lake	4°19' – 09'E & 6° 08'	
Bida floodplain	7°00'E	
Talabu Oramunukwa		
River Oramunukwa	5°25' – 5° 35' N &	
Andoni River	6°10' - 6°30'E	
River Eza	7°10'N, 4°50'E	
Opi lakes	8°40'N, 4°25'E	
Ilorin dam	9°10'N, 6°00'E	
Jebba lake		Araoye, 2004
ABU University dam reservoir	5°30'N, 7°10'E 4°35'N, 7°40'E	Ibiwoy *et al*, 2006 Daddy & Faleye 2005
Qua Iboe River & estuary	6°50'N, 7°25'E	Okorie, 2005 Francis & Sikoki 2005

Ceita pond	8°40'N 4°30'E	Unagwe & Erondu 1997
Anambra River basin	9°15'N 4°40'E	Onyemachi 1976
floodplain		Araoye 2005
Onah / Asaba lake	11°00'N 7°50'E	Ahmed & Aliyu 2005
Goronyo reservoir Sokoto	4°25'N 4°15'E	
Ado – Ekiti reservoir	7°45'N 8°00'E	
Oguree reservoir Plateau State		
Warri River		
Rockwater reservoir Jos	8°25'N 7°00'E	
Dadin Kowa lake Reservoir Bauchi State	6°20'N 6°45'E	
Wase reservoir dam, Kano State	13°00'N 5°20'E	Nwani *et al* 2006
Kigera reservoir	7°35'N 5°15'E	Okele & Obi, 2006
Okhuo River	10°00'N 8°50'E	
Niger Delta mangrove	5°35'N 5°40'E	Ipinjolu *et al* 1996
Federal Capital	9°50'N 8°55'E	Idowu & Ugwumba 2006
Territory Rivers		
Gubi Reservoir	10°20'N 9°53'E	Anthony *et al* 1966
Bauchi State	12°00'N 8°25'E	Ikomi 1993
Abala Creek Lower Niger Delta		Ufedike & Wada 1991
Uta Ewa, Ikot Abasi		
Doma Lake Nassarawa		Ufodike & Zakari 1992
Epie Nun River		Adikwu & Ibrahim 2004
floodplain		
Lagos harbour		Akintade Odiya & Nick 1995
Calabar Area	10°25'N 9°50'E	
Kubanni reservoir Zaria	5°30'N 4°40'E	-
Lower Niger Delta, Nigeria	4°45'N 7°50'E	Arawomo 1987
Aba River	8°40'N 7°50'E	Oguzie 1998, 1999
Okhuaihe River Edo State		Olaleye & Akinyemiju 1999
	5°25'N 3°24'E	Onuoha *et al*, 2007
	4°50'N 8°10'E	Mohammed & Omoregie 2004
	11°00'N 7°40'E	Etekhame & Sikoki 2005
	5°30'N 6°40'N 8°4.5'E	William, 1962
	5°10'N 7°45'E	Reid 1982
	5°30'N, 5°35'E	Anene & Bako 1998
		Wright 1980 & Boesman 1963
		Nwoke 1983
		Mvere 1985

5.4 Pollution, eutrophication and related aquatic ecosystem perturbations: The increase in the population of Nigeria over the last three decades (now over 140 million by the 2006 census) has expectedly put some stress on the inland water resources of the country. This has been effected through the totality of economic activities within the various drainage basins-disposal of domestic sewage and garbage, disposal of non-oil industrial effluents, use of agricultural chemicals, spillages of oil & effluents from petroleum industry activities.

From Nigeria's petroleum industry activities seismic, exploration, drilling, exploitation/production, distribution, refinery and petrochemical (downstream sectors), these appear the main causes of

the pollution. They are mostly accidental given the control by regulatory agencies or statutes. Road and bridge construction activities are no lesser culprits as the dredge spoils from canalization for waterways development. All these cause loss of biodiversity, depletion of fish and fisheries stocks of our inland waters via their physical & chemical impacts (sensu lato): buildup of hydrocarbons heavy metals, acidity & acid raid, heat-output, deforestation, siltation, cycle of solar irradiation, etc. Special mention must be made here of the blockade of the numerous interconnecting creeks between the floodplain lakes and the main river channels (Rivers Niger & Orashi) by operating oil companies Shell, Agip, Chevron, Addax) as they construct access roads to their oil wells and other facilities. These are done with or without cognizance of the EIA Act No. 86 of 1992, with or without adequate sizes and numbers of culverts to / allow water flows.

Apart from pollution per se, natural processes of aging of our lakes and rivers (eutrophication) is another issue to contend with in our inland water data base acquisition. My dear audience, the case of the first-order stream, Rivers Nworie/Otamiri in Owerri, Imo State which Chief (Sir) Godson Ikedi Ohakimled Imo State Government is dealing with now, is a quick instance for us. The question in the context of this lecture iswhat baseline data do we have or can access today on the pollution/eutrophication and related perturbations of our inland water for planning and fisheries management strategization" virtually none.
In the answer just given, I am not unaware of the numerous related baseline ecological environmental data in the very many EIA & PIA/EA statutory reports made by various oil companies in our country to the Federal Ministry of Environment. Very unfortunately, these are "secret" unavailable database, that are never published for scientific literature.

The activities/projects of the numerous government agencies/stakeholders on this issue are mostly unavailable, possibly usable database. Such agencies are the Federal Ministry of Environment, Federal Ministry of Agriculture, Water Resources & Rural Development, Federal Ministry of Transport (National inland Water Ways Authority (NIWA Lokoja), NIOMR, NIFFR, the eleven River Basin & Rural

Development Authorities, NOSRA, DPR, State Ministries of Agriculture/Environment/Ecology/Fisheries, Natural Resources Conservation Council, etc to mention just those that this lecturer quickly remembers. What of the defunct OMPADEC/NDDC and the state's Oil Producing Areas Development Commissions (ISOPADEC OF Imo State, DESOPADEC of Delta State, OSOPADEC of Ondo State)?. What of the possible data from the numerous associated scientific departments and research institutes of Nigeria's 95 accredited universities and several monoand polytechnics/colleges of education. Also to be queried is the degree of success in the enforcement of the provisions of various related statutes in our country.

- Agricultural Act Cap 121 LFN 1990
- Endangered Species Act Cap 108 LFN 1990
- Environmental Impact Assessment Act No. 86 of 1992
- Natural Resources Conservation Council Act, Cap 286, LFN 1990.
- River Basins Development Authorities Act, Cap 396, LFN 1990
- Wildlife/Animals Preservation Act, Cap. 132, LFN 1990
- Various fisheries bye laws

6.0 CONCLUSIONS AND RECOMMENDATIONS

Mr. Chairman Sir, the Vice Chancellor and revered audience, I am landing, perhaps with bombshells on the area I am professing and the one I am committed to continue working and professing on as follows:

i. A comprehensive/holistic database is virtually unavailable for all the inland waters of Nigeria for fisheries production planning & management.

ii. Most of the information on Nigeria's lentic system is, in one way or the other, associated with Kainji and its environs. Out of about 116 natural non-floodplain lakes, 800 floodplain lakes, 208 man-made lakes and reservoirs, data of some sort are available only from Oguta, Opi, Ogelube, Tiga, Asejire, Eleiyele, Lamingo and Liberty reservoir Kainji and Lake Chad.

iii. The lotic systems are also very little studied. There is little information for many of the river basins and the little there is, pertain to the rivers Niger at Kainji, Ogun, Oshun, Sokoto, Cross River, Orunro, Owena, Ohoo, Sombreiro, and New Calabar. Not much is known of the Lower Niger beyond the Kainji Lake Area.

iv. The present state knowledge of the freshwater fauna other than the zooplankton and fish, is very poor. Not much is known of the protozoa, Ostracoda, Anostraca, Notostraca, Conchostrata and Spinicaudata. The same situation exists for the macrophytes and periphytic algae.

v. Not much attention has been given to the physical and chemical features of the surface sediments, taxonomy and ecology of the benthic fauna, trophic dynamics, and production of the phytoplankton, zooplankton, macrobenthos and fish.

Vi. There is little or no published fish stock assessment or stock improvement plan for any of the rivers and lakes as the relevant agencies hardly have any routine fisheries programmes and associated data acquisitions.

vii. There is far more than adequate number of institutions in Nigeria to generate the needed data which are far below expected due to the abysmally low level of funding for any sustained work.

Viii. There is need for some institutional reorganization in order to create relevant data acquisition centres in the country, in line with the present geopolitical structure in Nigeria-northwestern, northcentral, northeastern, southwestern, south-south and southeastern zones. These should be affiliated with the universities. The research institutes at Kainji and Maiduguri could be dissolved and their activities subsumed in the new zonal fisheries centres. Research output from universities is higher than those of research institute because of the availability in the University of students, who in the process of acquiring expertise during training, provide easier and readily useable field and

laboratory manpower for a holistic multidisciplinary inland water database acquisition. The zonal fisheries research centres could be set up for the major basins in the way River Basin Development Authorities are, presently. Their mandate should be to cover the inland waters in their basins of jurisdiction via aggressive, holistic multidisciplinary and strictly quantitative data acquisition projects. Given the multi-faceted nature of fisheries science, the interconnectivity of the food chain/energy flow from detritus/ primary producers, through secondary producers / primary consumers to the tertiary level (fish included here) is another option.

ix. There is a grave problem in Nigeria as in most developing countries, with the dissemination of research findings. Most journals in which Nigerian data are published are never available locally and even the authors often cannot circulate their publications by themselves to their colleagues, within Nigeria. The centres as proposed can act as a repository of all the relevant hydrobiological publications or journals especially those with Nigerian information.

x. There are a number of ecological baseline, post-impact assessment and environmental impact studies executed by the various oil companies (Shell, Mobil, Agip, Chevron, Ashland, etc) with very useful inland water database on the Lower Niger Delta. These, like most undergraduate and graduate students thesis, are locked up in bookshelves. Efforts should be made to persuade the companies to assist scientific information dissemination by publishing these reports after appropriate reviews and editing.

Xi. Funding agencies for fisheries projects must predicate grants on comprehensive inter-disciplinary, collaborative proposals that are tied to specific water bodies if a drainage/catchment focus is too wide for invaluable intensive coverage. Good examples of such projects are:

- The Rio Doce Valley Drainage basin aquatic project in the River Amazon mega catchment in South America.

- The River Niger associated Kainji Lake Research Project in Nigeria between 1965 and 1970.
- The European Union sponsored project titled "Floodplain lake database and management of the Lower Niger Delta executed from 1990 to 1996. This was executed by three EU countries & Nigeria led by Prof. Henri J. Dumont (Rijksuniversiteit Ghent, Belgium), Profs. Maria-Rose Miracle & Eduwardo Vicente of the University of Valenciennes, Spain), Professor Athena Economou Amilli of the University of Athens, Greece and this inaugural lecturer (now Professor Chukwuemekanim S. Nwadiaro, then at the University of Port Harcourt) respectively.
- The moribund FUTO centre for water resources management had a mandate and mission similar to what this lecturer is advocating.

Xii. Finally, Sir, permit me to add a rather "bizarre" recommendation which may could jolt the minds of the Chairman (our Vice Chancellor), his management team and our University Orator/Director of Academic Planning & Development (Professor M.O.E. Iwuala). This concerns the present name of our Department of Fisheries & Aquaculture. I suggest, with utmost respect that a very serious consideration be given to changing the name to "Department of Fisheries & Aquatic Sciences Technology" (FAST) or "Department of Fisheries & Aquatic Resources Management" (FARM). This humble suggestion is in line with what I have tried to review or say in this lecture - a holistic aquatic resources database approach. The Rivers State University of Science & Technology (RSUST), Port Harcourt had to do a similar renaming of its erstwhile Department of Fisheries. It was guided by a thought along the lines I have so far shared with you. Moreover, Fisheries & Aquaculture is like the two sides of the same coin, a kind of tautological nomenclature.

Mr. Chairman, the Vice Chancellor Sir, members of the high table, dear fellow academics, my Lords Spiritual & temporal, fellow students, revered audience, ladies and gentlemen of the Press, I rest my case for now. But before I bow out here, let it be known that without a datapool as I preach, no meaningful inland water fisheries development can be attained. Thank you and God bless.

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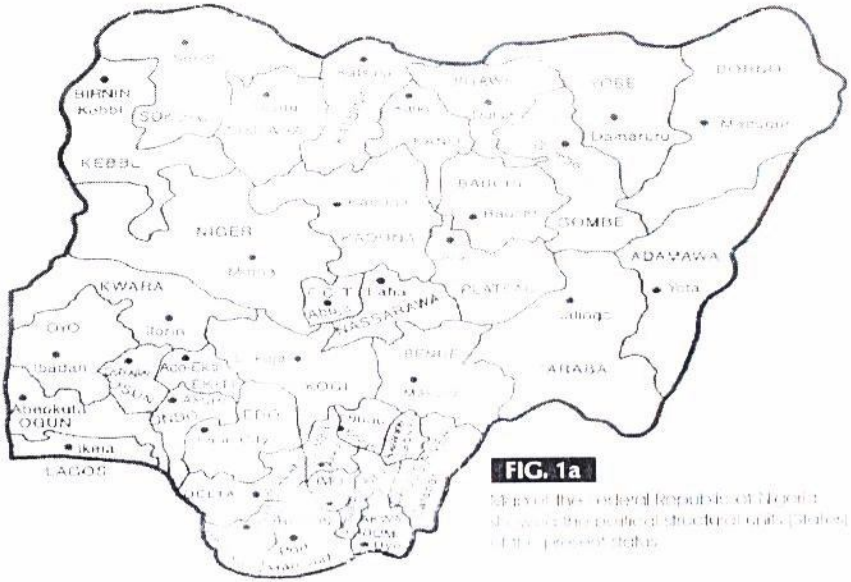
BIRNIN KEBBI
KEBBI
NIGER
KWARA
OYO
Ibadan
Abeokuta
OGUN
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BAUCHI
GOMBE
ADAMAWA
Yola
ARABA
Damaturu

FIG. 1a

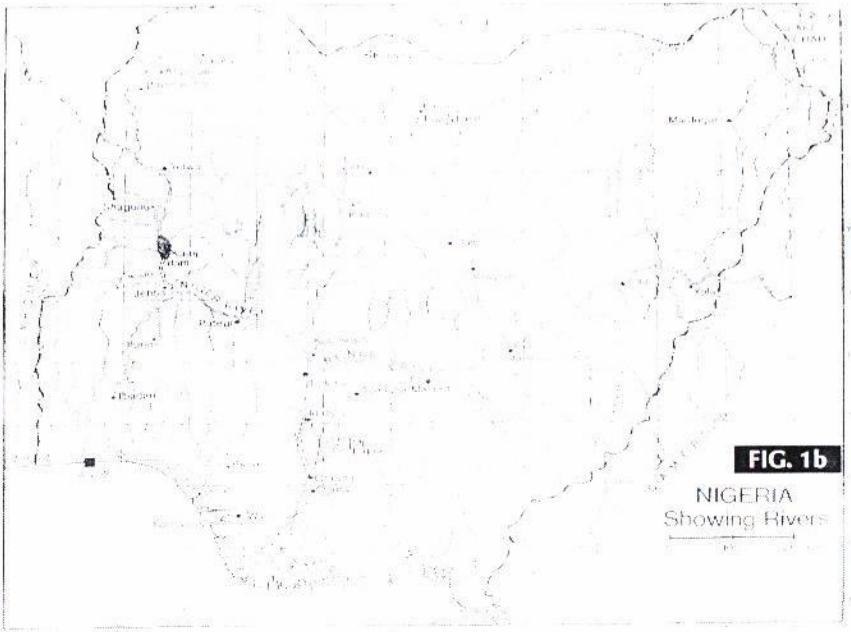

NIGERIA
Showing Rivers

FIG. 1b

FIG. 1c

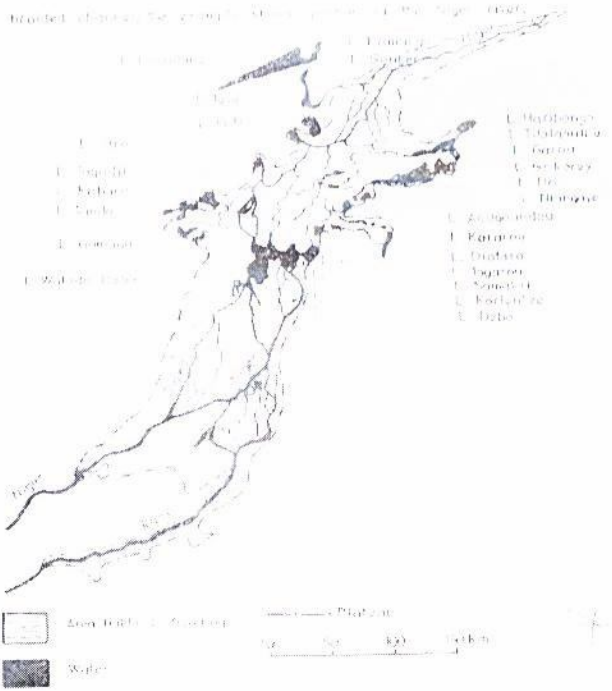


FIG. 1d

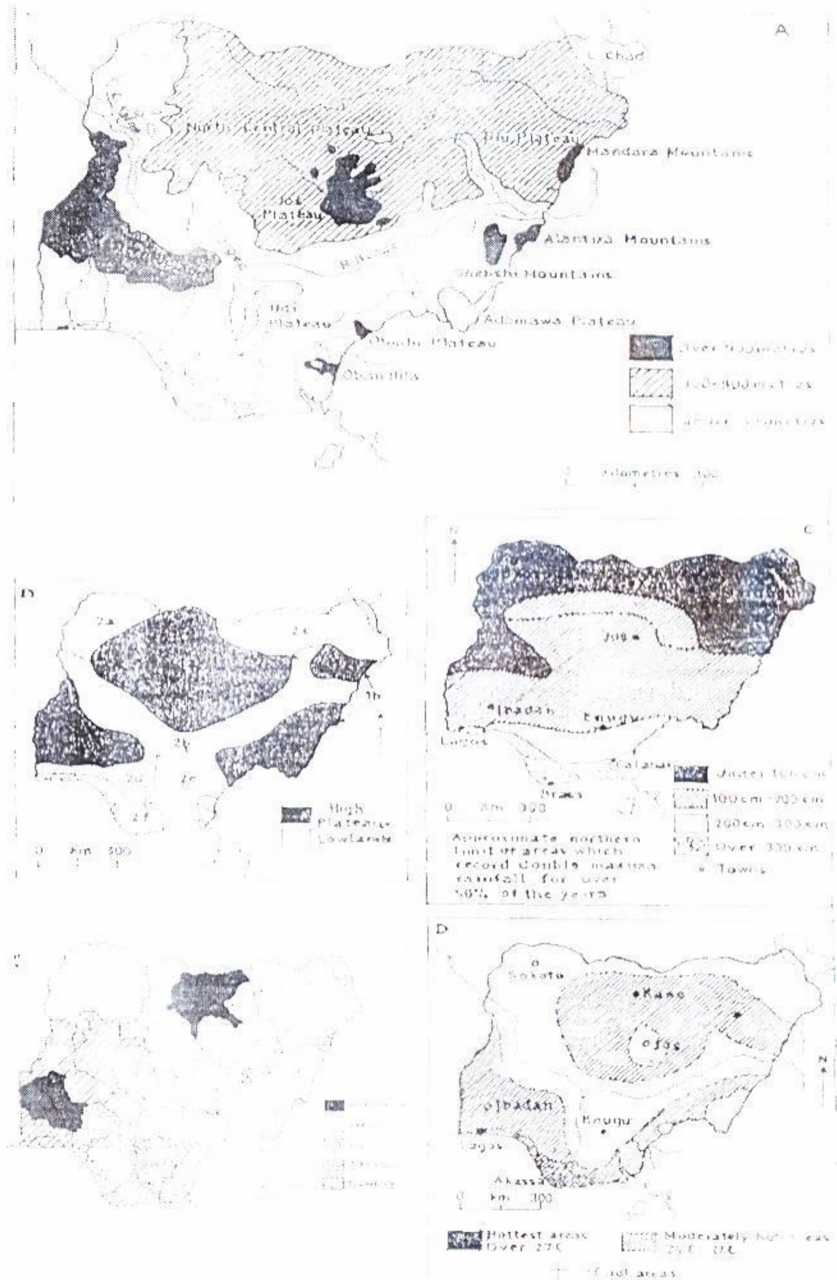
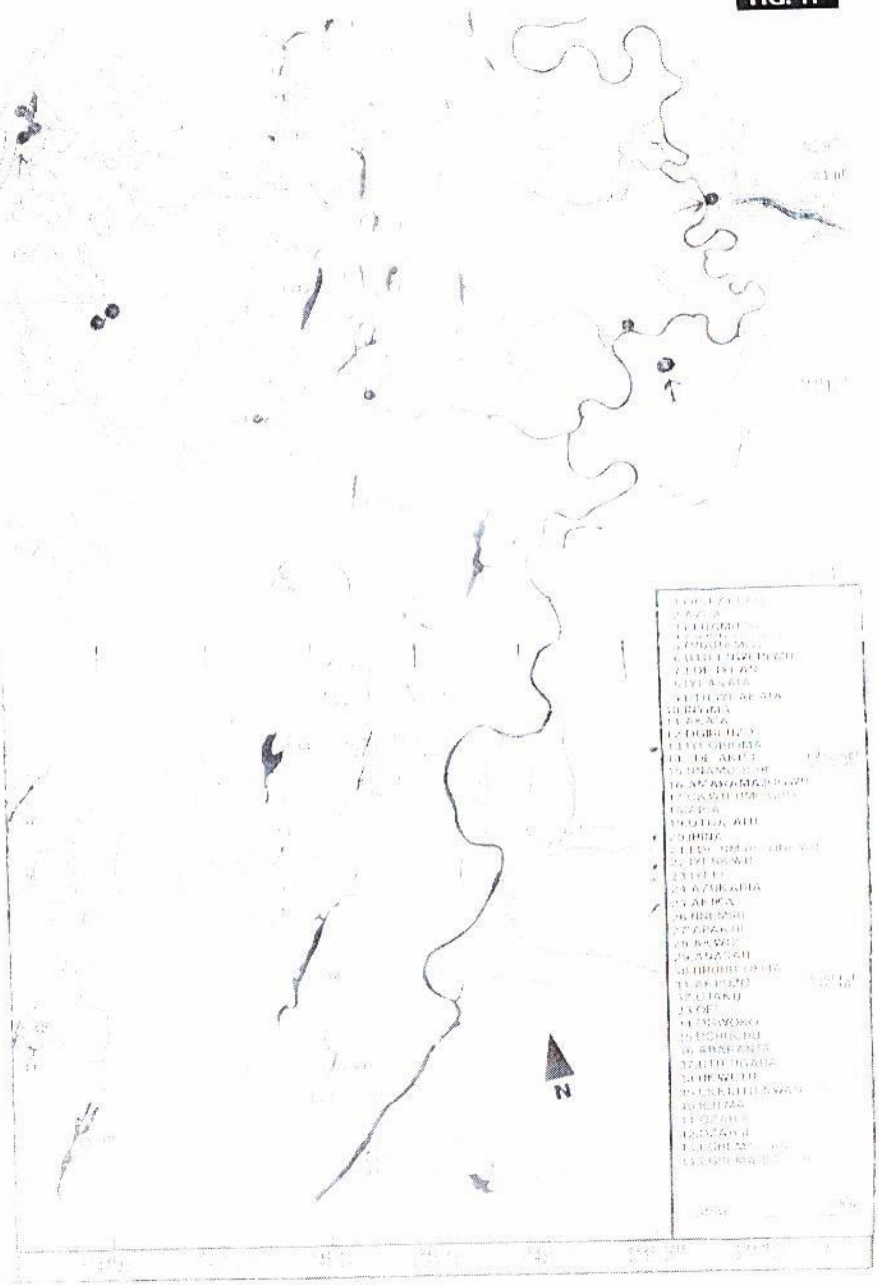

A
L. Chad
North Central Plateau
Biu Plateau
Mandara Mountains
Jos Plateau
Alantika Mountains
Shebshi Mountains
Udi Plateau
Adamawa Plateau
Obudu Plateau
Oban Hills
Kilometres 300
High Plateaux
Lowlands
Km 300
C
Jos
Ibadan
Enugu
Lagos
Calabar
Brass
100 cm - 200 cm
200 cm - 300 cm
Over 300 cm
Towns
Approximate northern limit of areas which record double maximum rainfall for over 50% of the year
D
Sokoto
Kano
Jos
Ibadan
Enugu
Lagos
Akassa
Km 300
Hottest areas Over 27C
Cool areas Less than 21C
FIG. 1e

FIG. 1f



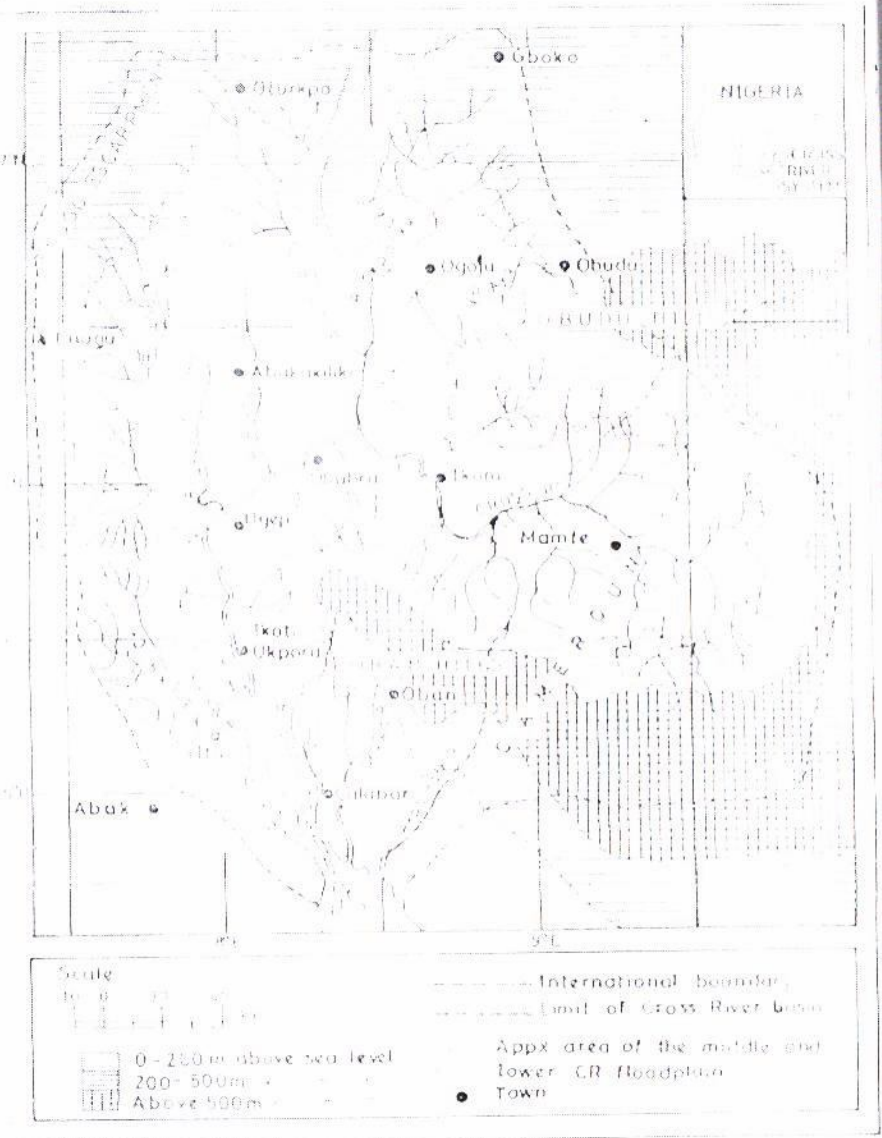


FIG. 1g Map of the catchment/drainage basin of the Cross River from its source in the Cameroun mountains to its mouth near Calabar (Taken from Moses, 1987)

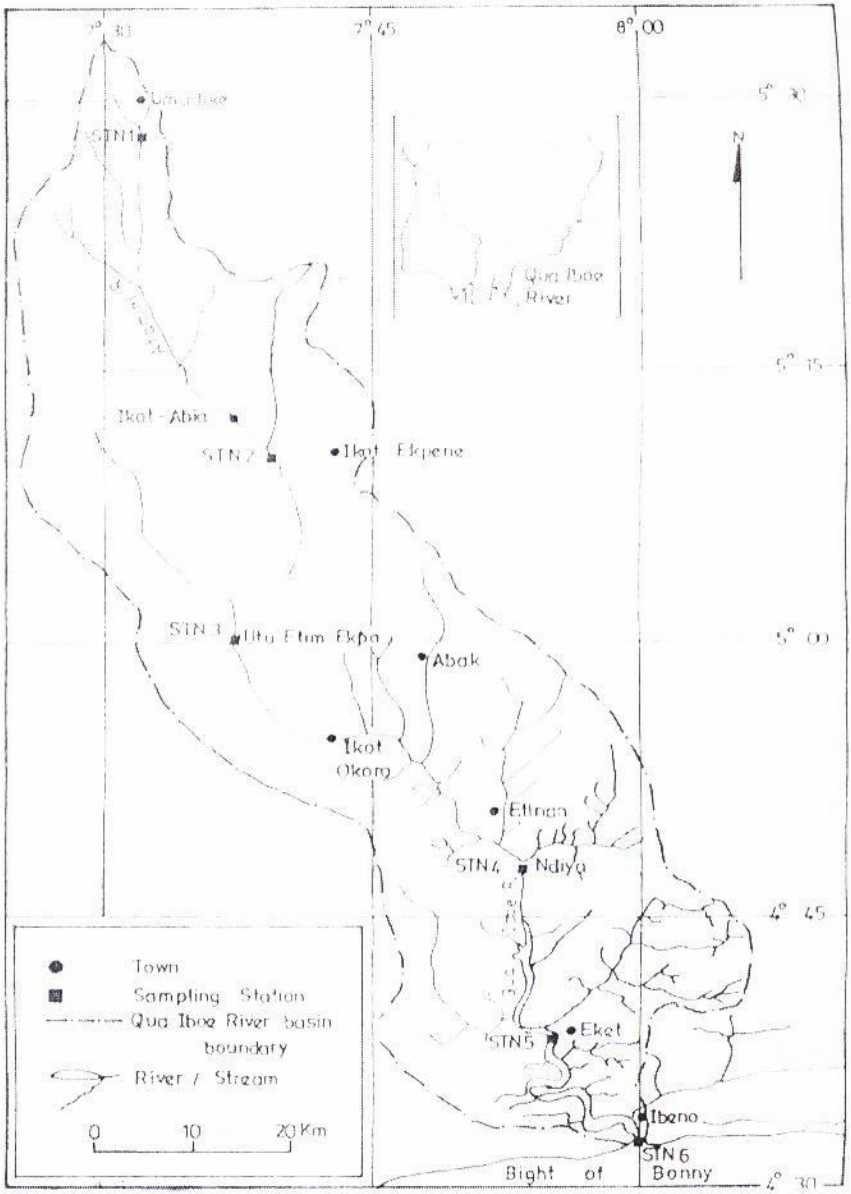


FIG. 1h The catchment drainage basin of the Qua Iboe River in the Cross River and Akwa Ibom States. (From Akpan 1992)

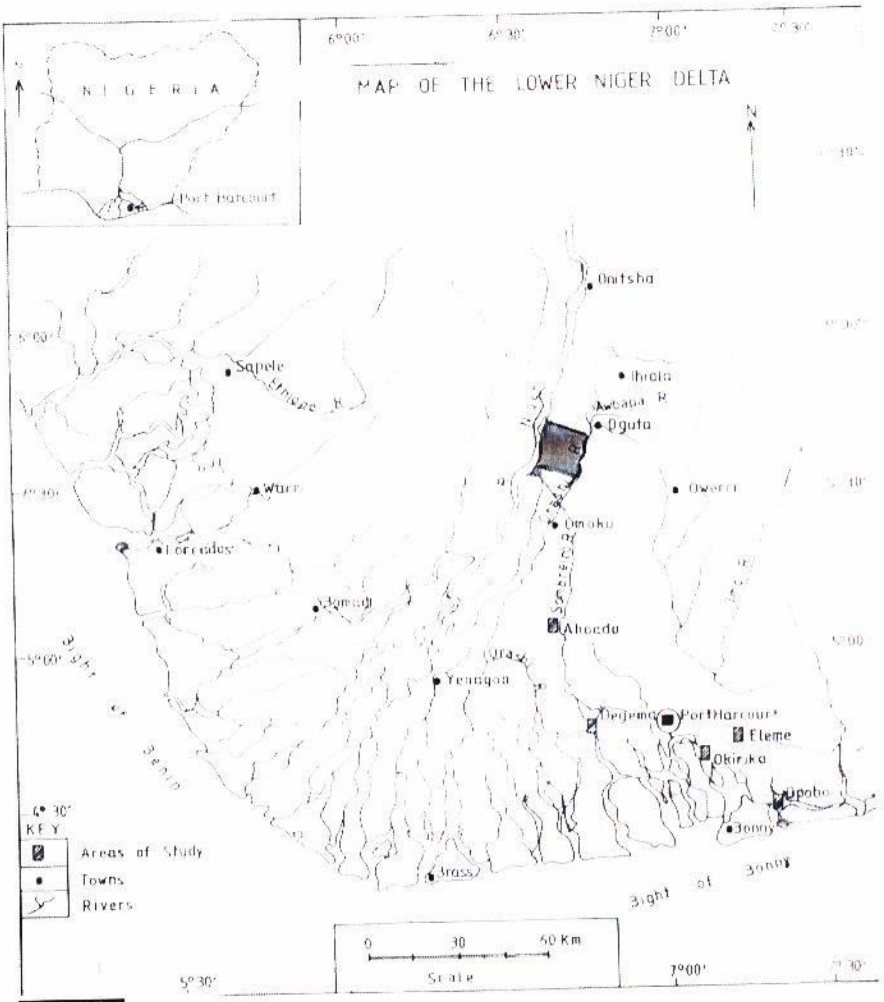


FIG. 1f

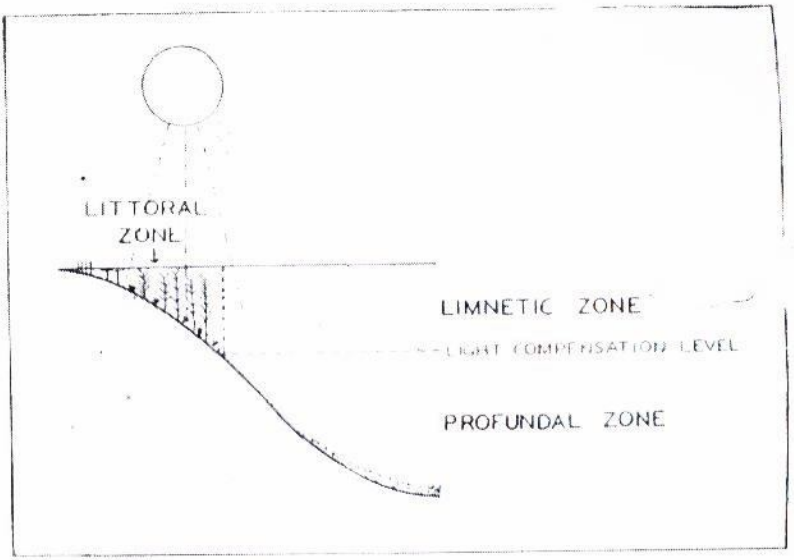


FIG. 2a The three major zones of a lake

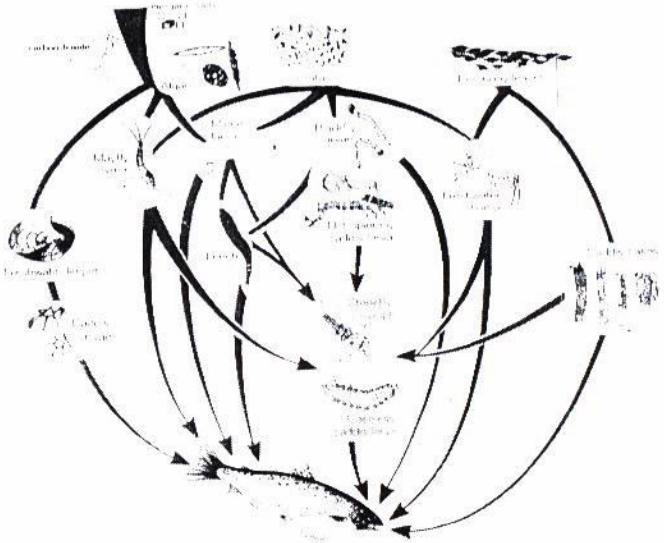


FIG. 2b A stony stream simplified food chain showing basic sources of food for fish/some invertebrates as carnivorous/tertiary producers

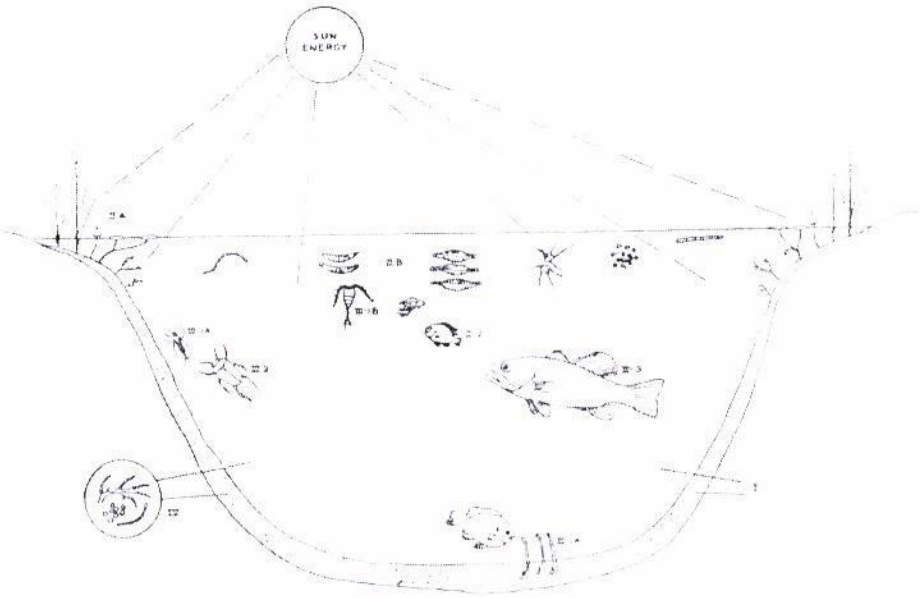


FIG. 2c A typical lacustrine pond ecosystem's interrelationship showing component units
– I: abiotic, basic inorganic & organic compounds;
ii a, b: primary producers (macrophytes, iia) and phytoplankton, iib);
iii Ia: primary consumer zooplankton herbivores bottom forms,
iii Ib: primary consumer zooplankton herbivores, iii 2: secondary consumer carnivores; iii 3: tertiary consumer secondary carnivores;
iv: saprotrophs (bacteria & fungi of decay). Adopted from Odum (1968)

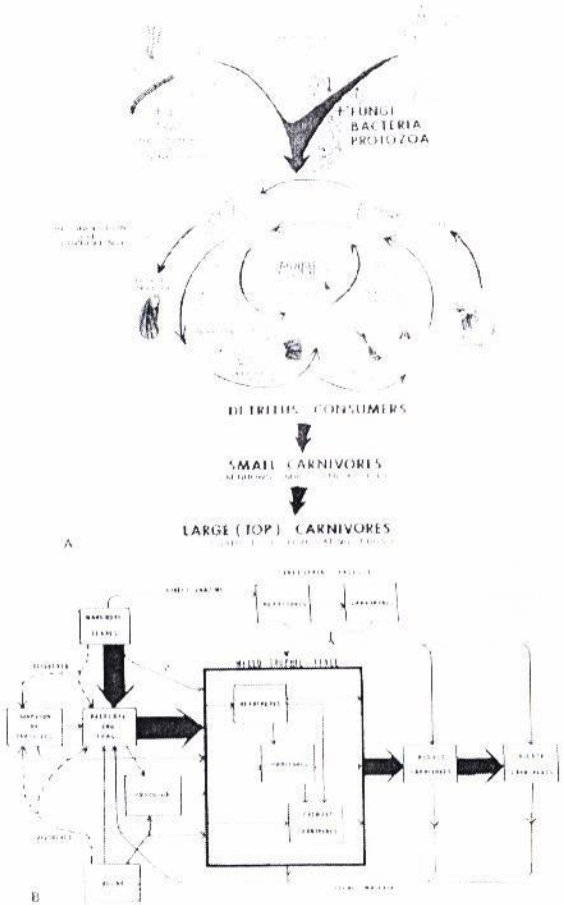


FIG. 2d A detritus food chain based on mangrove leaves which fall into shallow estuarine waters of south Florida. Leaf fragments acted on by saprotrophs and colonized by algae are eaten and re-eaten (coprophagy) by a key group of small detritus consumers which, in turn, provide the main food for game fish, herons, storks and ibis. A "picture model" of the food chain is shown in A (upper diagram) and a "compartment model" in B (lower diagram). (Redrawn from W. E. Odum 1970 A, taken from Odum 1968.)

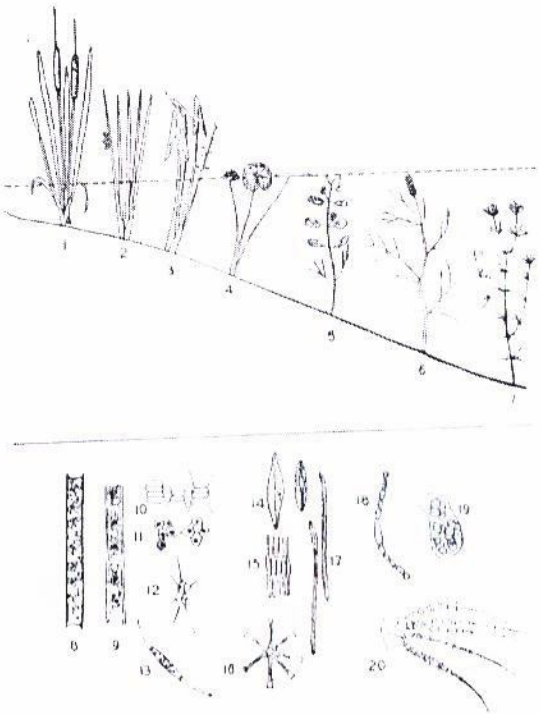


FIG. 3

Some producers of lentic communities, including emergent, floating, and submergent rooted littoral plant (1–7), filamentous algae (8-9) and phytoplankton (10-20). The phytoplankton include representative green algae (10-13), diatoms (14-17), and blue-green algae (18-20). Note that phytoplankton exhibit "flotation" adaptations which enable them to remain suspended or at least decrease markedly the rate of sinking (these organisms, of course, have no power of movement of their own) for example, reduction in integumentary material, flotation process and colonial life-habit, which increases surface area, and gas vacuoles indicated by black spots in the blue-green algae cells (18-20). Organisms diagrammed are: 1, cattail (Typha); 2, bulrush (Scirpus); 3, arrowhead (sagittaria); 4, water lily (Nymphaea); 5 and 6, two species of pond weeds (Potamogeton diversifolia, P. Pectinatus); 7, muskgrass (Chara); 8, Spirogyra; 9, Zygnema; 10Scenedesmus; 11, Coelastrum; 12, Richteriella; 13, Closterium; 14, Naviculs; 15, Fragilaria; 16, Asterionella (which floats in the water like a parachute); 17, Nitzschia; 18, Anabaena; 19, Microcystis; 20, Gloeotrichia (19 and 20 represent parts of colonies enclosed in a gelatinous matrix). 8-17 redrawn from Needham and Needham, 1941; 18 to 20 redrawn from Ruttner, 1963 And taken from Odum (1965)

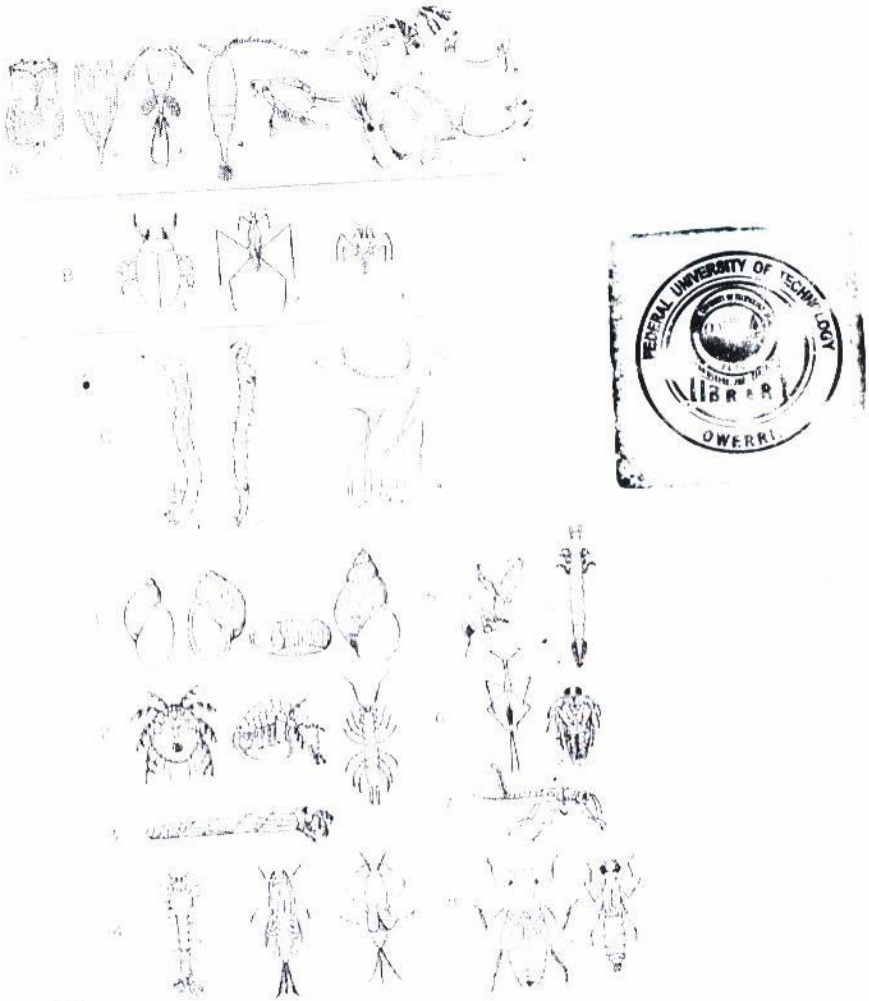


FIG. 4

Some representative animals of the littoral zone of ponds and lakes. (Series 1 to 4 are primarily herbivorous forms (primary consumers); series 5 to 8 are predators (secondary consumers). 1. Ponds snails (left to right): Lymnaea (pseudosuccinea) columella; Physa; ovir; Helisoma trivolvis; Campeloma decisum. 2. Small arthropods living on or near the bottom or associated with plants or detritus (left to right): a water mite, or Hydracarina (Mideopsis); an amphipod (Gammarus); an isopod (Asellus). 3. A pond caddis fly larva (Trianodes) with its thin, light portable case. 4. (Left to right) A mosquito larva (Gulex pipiens); a limnivorous or perchyte mayfly nymph (Choeon); a benthic mayfly nymph (Cacnis) - note gill covers which protect gills from silt. 5. A predatory diving beetle, Dytiscus, adult and (right) larva. 6. Two predaceous Hemipterans, a water scorpion Ranatra (Nepidae), and (right) a backswimmer, Notonecta. 7. A damsel fly nymph, Lestes (Odonata-Zygoptera); note three caudal gills. 8. Two dragonfly nymphs (Odonata-Anisoptera): Helocordulia a long legged sprawling type (benthos), and (right) Aeschna, a slender climbing type (periphyton). (Redrawn from Robert W. Pennak, "Freshwater Invertebrates of the United States" 1953, The Ronald Press Company)

FIG. 5a

FIG. 5b

FIG. 5c

FIG. 5d

FIG. 5e

Figs. 5a-5e: Aquatic macrophytes in and around Clough Creek (NAOC) flowstation, Ekeremor LGA of Bayelsa State, Nigeria