Journal of

Fisheries and Aquatic Science

ISSN 1816-4927

Academic
Journals Inc.

www.academicjournals.com

Journal of Fisheries and Aquatic Science 6 (3): 202-211, 2011
ISSN 1816-4927 / DOI: 10.3923/jfas.2011.202.211
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Sustainable Fisheries Management through Efficient Fisheries Resources Data Statistics

Akeem Oladipupo Sotolu
Department of Forestry, Wildlife and Fisheries, Nasarawa State University, Keffi, Shabu-Lafia Campus, P.M.B. 135, Lafia, Nigeria

ABSTRACT

The changes that have taken place in Nigerian fisheries are reviewed with the major contributor to fish production in the Nigerian fishery sector which is the Artisanal fishery. From data accumulated over the years by Nigerian Institute for Oceanography and Marine Research (NIOMR) on fishery resources in our coastal waters, fish and shrimps are being over exploited that they no longer sustain the number of registered vessels. Consequently, the potential or maximum sustainable yields must be thoroughly examined on regular basis via sufficient data to determine the status of the fisheries resources and embark on necessary actions that ensure its sustainability. The important ability of fisheries statistics for sustainable fisheries management and under-explored potential of Nigerian waters is also highlighted. The need for human resources development (fisheries statisticians) at each national level was also enumerated and it was identified to operate at regional levels through government funding for joint effective participation. The need to adopt and develop strategies/technologies that ease addressing the present and uncertainties about future positions of our fisheries was emphasized. The advantages resulting for fisheries sciences are examined and illustrated with examples and the understanding of some alleged weaknesses in some popular concepts and theories would enhance technology adoption with adaptation in making explicit inferences and decisions for the sustainable management of both the present and future situation of our fisheries resources.

Key words: Fisheries resources, fisheries statistics, government funding, sustainability, Nigeria

INTRODUCTION

In Nigeria, fisheries' contribution to the Gross Domestic Product is about 1 billion dollars, while agriculture in general is estimated at 20 million dollars. Nigeria has the resource capacity to produce 2.4 million MT of fish every year, yet the country, as at 2007 is still a large importer of frozen fish annually from all sources (Fasakin, 2008). Fisheries, particularly the small-scale type characterized by the use of low technology fishing gear over a limited range, are fundamentally important in many regions of the developing world, providing important sources of protein and livelihoods for coastal and rural communities (FAO, 2004). The world has made a remarkable progress in increasing fish production towards reducing food insecurity but, the recent slowdown in the trend since 1990s (Delgado *et al.*, 2003) remains a major concern for fisheries scientists to come. Fisheries are not only about fishes and their competitors and/or predators, fisheries are intended to generate economic benefits, including employment for people (Sotolu and Adejumoh, 2009). With a growing world population, particularly in developing countries and an increasing demand for fish protein (Delgado *et al.*, 2003), there is a need to consider different ecological,

economic and social goals under a much higher pressure than earlier. Global food fish production was reported to have grown annually at the rate of 1.7% between 1985-1997 while an annual growth rate of 0.4% was projected for 1997-2020 (Delgado *et al*., 2003). Global total fish consumption increased from 12.8 to 15.7 (kg/capita/year) between 1985 and 1997 and an annual increase of 1.4 (kg/capita/year) was projected to 2020 under the same scenario. FAO (2004) has projected population growth in Africa at 1.9% from 2002 to 2015 going by the current population growth rate and therefore informed that fish production must increase by 27.7% over the same period just in order to maintain the current level of per capita supply. There is a growing interest in Ecosystem-Based Fisheries Management (EBFM) in recent years resulting from a better understanding of the near impossibility of optimally exploiting a number of target stocks (a common management goal) that interact with other target and non-target species (Walters *et al*., 2005). There is also an increase concern in the effect of fisheries on the habitats and on non-target species, mainly those long-lived and with low reproductive rates such as crustaceans, seabirds, sea turtles and sharks (Hall *et al*., 2000). Considering the importance of ecosystem modeling, several models have been built for Southern and Southeastern Brazil in the late 1990s and early 2000s (Rocha *et al*., 1998; Vasconcellos, 2000; Vasconcellos and Gasalla, 2001; Gasalla and Rossi-Wongtschowski, 2004; Gasalla, 2004; Velasco and Castello, 2005). However, most of them did not explore the capability of these models to be used in fishing policy exploration, except for the most recent ones. On the whole, the baseline information and projections identified so far from few reports such as Delgado *et al*. (2003) and Kinas and Andrade (2007) affirmed the growing importance of fisheries for food and national resource policies in both developing and developed countries. In this paper, the degree in which the current information allows for increasing fish supply as proposed by fisheries scientists was assessed. Some scenarios for future fishing policies were highlighted and the need for human resources development was enumerated.

TRENDS IN FISHERIES PRODUCTION AND GLOBAL ECONOMY

Global production of aquatic food products totaled approximately 93.2 million metric tons (mmt) in 1997 (Delgado *et al*., 2003) of which capture fisheries supplied 64.5 mmt and aquaculture 28.6 mmt. Table 1 and 2 show trends in total capture food fish and total production of food fish for 1973-1997, respectively. Inland fisheries resources are exploited for food and other products-mostly as a means of sustainable livelihood and for pleasure by recreational fisheries (FAO, 1996, 2006a). Recreational fisheries are not confined only to developed countries, the promotion of recreational fishing as a national and international income-generating activity is already practiced in many developing countries such as Brazil, Malaysia and Zimbabwe. Inland water fisheries have also been recognized as a good source of supply of animal protein in human's diet especially, in Low Income Food Deficit Countries (LIFDCs) such as Nigeria (Sotolu, 2008; Sotolu and Adejumoh, 2009). Recreational fisheries are not confined only to developed countries, the promotion of recreational fishing as a national and international income-generating activity is already practiced in many developing countries such as Brazil, Malaysia and Zimbabwe.

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Table 1: Production of food fish from capture fisheries (1973-1997)

Region	Total production (million metric tons) 1973	1985	1997	Annual growth rate (%) 1985-97
China	1.0	3.4	19.5	15.6
Southeast Asia	0.4	0.9	2.3	7.6
India	0.2	0.6	1.9	9.6
Other South Asia	0.1	0.1	0.5	10.5
Latin America	--	0.1	0.7	19.4
West Asia and North Africa	--	0.1	0.2	9.2
Sub-Saharan Africa	--	--	--	11.7
United States	0.2	0.3	0.4	1.9
Japan	0.4	0.7	0.8	1.6
European Union 15	0.5	0.8	1.2	3.3
Eastern Europe and former Soviet Union	0.2	0.4	0.2	-6.4
Other developed countries	--	0.1	0.6	17.8
Developing world excluding China	0.8	2.3	5.9	8.4
Developed world	1.3	2.3	3.2	2.7
World	3.1	8.0	28.6	11.2

Source: Adapted from Delgado *et al*. (2003)

Table 2: Global production of food fish by IMPACT* category (1973-1997)

Commodity	Global production (million metric tons) 1973	1985	1997	Annual growth rate (%) 1985-97
Aquaculture	3.1	8.0	28.6	11.2
Low-value finfish	1.7	4.9	17.2	10.9
High-value finfish	0.1	0.3	1.4	13.4
Crustaceans	--	0.3	1.3	13.3
Mollluscs	1.3	2.5	8.8	11.1
Capture	44.5	56.3	64.5	1.1
Low-value finfish	18.6	24.7	27.1	0.8
High value-finfish	20.8	23.8	24.9	0.4
Crustaceans	2.3	3.1	5.7	5.2
Mollluscs	2.7	4.6	6.8	3.3

Source: Adapted from Delgado *et al*., (2003). *IMPACT: International Model for Policy Analysis of Agricultural Commodities and Trade

mostly small-scale fishers, farmers and entrepreneurs majority of who live in the riverine and coastal communities (FAO, 2005). Besides, fish has become a leading export commodity for Africa, with an annual export value of US$ 2.7 bn (FAO, 2005, 2006b). However, these benefits are at risk especially in the face of the current global climate change (Infofish, 2008) as the exploitation of natural fish stocks is a major source of fish supply worldwide (Faturoti, 2000; Tacon *et al*., 2006). Freshwater and marine habitats are also being destroyed by pollution, infrastructure development and human settlements (Nwanna *et al*., 2008; Fapohunda and Godstate, 2007). Apart from being used as food, fish is also increasingly demanded for use as feed ingredient in the livestock (FAO, 1996; Delgado *et al*., 2003; Sotolu, 2009) and manufacturing industries (Infofish, 2008). Based on the numerous advantages and roles played by fisheries in human existence and nation development, sustainable exploitation of fisheries resources becomes imperative.

POTENTIALS OF FISHERIES RESOURCES OF NIGERIA

Nigeria lies between longitudes 2°49'E and 14°37'E and 4°16'N and 13°52' North of the equator. The climate is tropical characterized by high temperatures and humidity as well as marked dry and wet seasons, though there are significant variations between South and North. Total rainfall decreases from the coast Northwards. The South (below latitude 8°N) has an annual rainfall ranging between 1,500 and 4,000 mm and the extreme North between 500 and 1000 mm. Nigeria is blessed with a vast expanse of inland freshwater and brackish ecosystems which are contained within 320 nautical miles (667 km). Their full extent cannot be accurately stated as it varies with season and from year to year depending on rainfall. However, as shown in Fig. 1 these water resources are spread all over the country from the coastal region to the arid zone of the Lake Chad Basin. The country has an extensive mangrove ecosystem of which a great proportion lies within the Niger Delta and are also found mostly in Rivers, Delta, Cross River, Akwa Ibom, Lagos and Ondo States. They lie between latitudes 3° and 7°6' North and are estimated to cover between 500,000 and 885,000 ha. Freshwaters start at the Northern limit of the mangrove ecosystems and extend to the Sahelian region.

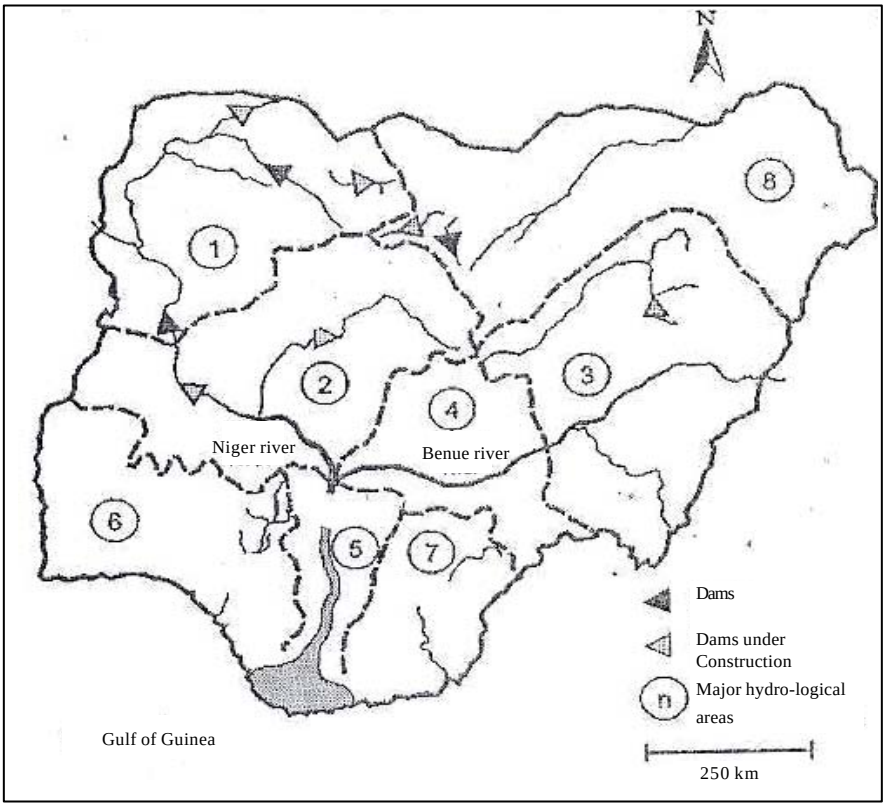

Fig. 1: Map of Nigeria showing major rivers and hydrological basins. 1: Niger North (Sokoto-Rima river basin), 2: Niger Central (Kaduna river), 3: Upper benue (Gongola river), 4: Lower benue (Benue river), 5: Niger South (Anambra river basin), 6: Western littoral (Ogun river basin, Osun river basin and Osse river basin), 7: Eastern Littoral (Cross river basin), 8: Lake Chad (Hadejia river basin). (Anukam, 1997)

Table 3: Major inland water resources of Nigeria

Types of water bodies	Approximate surface area (ha)
Major rivers	
Anambra river	1,401,000
Benue river	129,000
Cross river	3,900,000
Imo river	910,000
Kwa Iboe river	500,200
Niger river (less Kainji and Jebba)	169,800
Ogun river	2,237,000
Oshun river	1,565,400
Sub-total	10,812,400
Major lakes and reservoirs	
Lake Chad (Natural)	550,000
Kainji lake (Man-made)	127,000
Jebba lake (Man-made)	35,000
Shiroro lake (Man-made)	31,200
Goronyo lake (Man-made)	20,000
Tiga lake (Man-made)	17,800
Chalawa Gorge (Man-made)	10,100
Dadin Kowa (Man-made)	29,000
Kiri (Man-made)	11,500
Bakolori (Man-made)	8,000
Lower Anambra (Man-made)	5,000
Zobe (Man-made)	5,000
Oyan (Man-made)	4,000
Sub-total	853,600
Total A+ B	11,666,000
A+B as % of total area of Nigeria (94,185,000 ha)	12.4%

Source: Adapted from Ita *et al.* (1985)

The approximate extent of the major inland water systems is shown in Table 3. The major rivers, estimated at about 10,812,400 ha, make up about 11.5% of the total surface area of Nigeria which is estimated to be approximately 94,185,000 ha. Thirteen lakes and reservoirs with a surface area of between 4,000 and 550,000 ha have a total surface area of 853,600 ha and represent about 1% of the total area of Nigeria.

In terms of species diversity index, Kainji Lake had the highest value of 101 species followed by Jebba with 52 species (Ita *et al.*, 1985). The high diversity index recorded for Kainji Lake is not unconnected with the intensity of investigations conducted in the lake since 1969. Jebba Lake, which extends from the outflow of Kainji Lake for about 100 km to the dam, is expected to harbour as many species as Kainji Lake if not more. However, on account of the paucity of investigations conducted on this reservoir, only about half the numbers of species in Kainji Lake have been documented for Jebba Lake. Although Kainji Lake still retains some riverine features along its northern arm, a reduction in fish species diversity was recorded after impoundment from over 120 species to about 97 species (Ita *et al.*, 1985). Apart from the major rivers and lakes shown in Table 3, there are other small lakes and perennial streams around in the country among which are Asejire dam and Eleyele Lake in Ibadan (South-West Nigeria) Fapohunda and Godstates (2007) and Doma dam and Hunki Lake (North-Central Nigeria) Sotolu and Sule (In Press). These water

bodies usually take their course from nearby big rivers and are invariably richer in diversity of both shell and fin fish species (Tobor, 1991; FDF, 1995; Faturoti, 2000). Constant and regular fishing activities of shell fish, fin fish (pelagic and off-shore pelagic, demersal) and crustaceans are going on around existing water bodies in Nigeria. The reports of Fapohunda and Godstates (2007) indicated that Owena reservoir of approximately 600,000 m^3 in South-West Nigeria harbours 14 fish species belonging to 9 families and its yield assessment is on the decline. In the Lagos lagoon reports showed that the brackish water body is known to be rich in several shrimp species among which are the Pink shrimp *Penaeus notialis*, *P. duorarum* dominant in 10-50 m depth of water, the tiger shrimp, (*P. kerathurus*) which is as large as the pink shrimp but of far less abundance and economic value. *Parapenaeus longirostris* occurs in abundant quantity in coastal shallow water, 0-20 m depth and commands a local economic importance. The bonga fish occurs along the whole length of tropical West Africa coastline and it is the most valuable and abundant fish in the artisanal fisheries in Nigeria (Tobor, 1991; Dublin-Green and Tobor, 1992). Off-shore pelagic resources include tuna and tuna-like fishes are reported to be the most important of all fisheries resources in terms of commercial value in West Africa. The paucity of reasonably accurate fisheries statistics in Nigeria, which is of national and international concern (Boniface, 2000; Faturoti, 2000) has persisted hence complicating the problems of biodiversity conservation and sustainable management of our fisheries resources over decades (Nwanna *et al*., 2008; Sotolu, 2010). In addition, the problem of poor fisheries data collection statistics for commercial fishing activities has rendered the sector irrelevant in the determination of the country's Gross Domestic Products.

IMPLICATIONS OF VARIOUS METHODS OF ASSESSMENT OF FISHERIES RESOURCES ON NIGERIAN FISHERIES

There are many several existing models being used in fish stock assessment according to fisheries scientists. The simulation study demonstrated that assessments are sensitive to underlying structural features of fish stocks and fishery practices, such as natural mortality, age selectivity, catch reporting and variations in these or other quantities (NRC, 1998). Model performance, use of harvest strategies, new assessment techniques, periodic review and quality control of assessments and assessment methods are some of the methods being used in fish stock assessment as enumerated by Bonfil (2007). Bayesian statistical methods is another useful tool for fisheries risk assessment, estimation, decision analysis and management strategy evaluation (Freire *et al*., 2007). The Bayesian methods was reported to have practical applications to fisheries stock assessment and providing quantitative decision support to non-governmental organizations, corporate clients, intergovernmental organizations and government agencies (Freire *et al*., 2007). In Nigeria and till date, the most extensive work been carried out so far in fisheries management was between 1969 and 1991. Various models for fisheries assessment have analysis of 23 year (1969-1991) catch-effort statistics of the artisanal fisheries of South-Eastern Nigeria, using both the linear and the exponential surplus production models and it showed that the pelagic, demersal and crayfish resources available to the artisanal fisheries have been overfished; the stocks were most seriously depleted between 1984 and 1987 (Ajayi, 1982; Mabawonku, 1986). It was revealed that auxiliary information in the form of indices or survey estimates of abundance, population structure information and accurate estimates of other population parameters (e.g., natural or fishing mortality, growth, catchability) improves the accuracy of fisheries assessments (Tobor, 1991). However, the use of computer models (Bayesian method) for estimating direct impacts of fisheries on individual fish stocks and indirect impacts of fisheries on the surrounding ecosystem have not

been utilized in the management of fisheries resources of Nigeria unlike its reported applications by Punt and Hilborn (1997) and Hilborn and Mangel (1997). In fisheries, the most used procedure has been Markov chain Monte Carlo (MCMC) (McAllister and Ianelli, 1997; Schnute *et al.*, 2000; Kinas, 2002) because of computational efficiency and the growing popularity of software WinBUGS. Other procedures like Sampling Importance Resampling (SIR) (Kinas, 1996) and Adaptive Importance Sampling (AIS) (Kinas, 1993) seem to be more appropriate where multimodality in the posterior is expected, but still need to acquire more computational efficiency and user-friendly display. The popular Ecopath with Ecosim (EwE) modeling software includes the Ecoranger module which implements a SIR scheme to derive Bayesian posteriors for ecosystem trophic mass balance analysis. The Quantitative Modeling Group develops mathematical models to help fisheries biologists and resource managers adapt in the face of the extreme uncertainty that characterizes many marine ecosystems such as Nigeria. Computer models are also used to examine spatial management options such as closed areas and the effects of space-time variation in primary productivity on the distribution and production of marine organisms. This is a common trend among researchers in all fields were training in orthodox statistics still dominates, since there has been a tendency to proceed rapidly into advanced statistical methods without spending enough time with the basic tools of probability calculus. To effectively improve the management of fisheries resources therefore, training of personnel (fisheries statisticians) is of great importance apart from formulating policies and establishing harmonious partnerships for the development and sustainability of our fisheries.

NEED FOR HUMAN RESOURCES DEVELOPMENT (HRD)

With 2015 just five year away, it seems unlikely that Africa meets the Millennium Development Goal (MDG) targets for eradication of extreme poverty and hunger. Despite the huge fisheries resources Nigeria is endowed with, low yield, deplorable state of the fisheries resources in the country due to human activities, poor data statistics for proper planning and management especially in the face of climate change effects pervade the fisheries sector of Nigeria. Human Resources Development (HRD) has been identified as a vital tool for efficient fisheries management and development (Tobor, 1991) thereby ensuring sustainability for achieving food security (Jones, 2007). In the training of personnel however, it is expected that knowledge about utilization of modern facilities and relevant statistical tools and computer models for fish stock assessment be acquired. There may be need for collaboration between countries especially, those that share the same water boundary whereby gathering and storage of fisheries statistics could be harmonized vial commonly assessable data base. Such a system could eventually transform into a regional fisheries information system backed up with appropriate technology (user friendly) and government and intergovernmental policies without fear or bias. Management and sponsoring of the trainees would require adequate sponsorship through researches and the government should be ready to invest in HRD. The Africa as continent is far behind the industrialized nations such as Europe and America, therefore establishing such partnerships in regional fisheries data base would be applicable to countries on the same continents for reliability and sustainability purposes.

In conclusion, proper education and development of regional fisheries data base managed by trained fisheries statisticians is of paramount need to the effective management of our fisheries resources. Therefore, there is the need for embarking on indigenous personnel training who understand the terrains with the utilization of adaptable technologies for ensuring reliability and sustainability of the system.

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