EDITORIAL

The January 1995 issue of *Naga* featured two major FAO documents on the status of the world's fisheries. One, by Garcia, S.M. and C. Newton ("Current situation, trends and prospects in world capture fisheries"), to be published as an FAO Fisheries Technical Paper, documents the precarious status of most of the fisheries from which the present global catches, ranging from 90 to 100 million tonnes per year, are extracted. The other (Alverson, D.A., M.H. Freeberg, J.G. Pope and J.A. Murawski. 1994. A global assessment of fisheries by-catch and discards. FAO Tech. Pap. 339, 233 p.) shows that the discarded by-catch of these fisheries, earlier assumed to be of the order of 5 million tonnes per year is most likely six times higher than that. Jointly, these studies thus account for a global annual catch of 120-130 million tonnes, within 20-30 million tonnes of the potential yield estimated two decades ago by various authors, notably W.E. Ricker, based on primary productivity and trophic considerations. However, it is very probable that the true world catch is even greater than this, as a substantial fraction of true catches consists of fish which slip through the net of official recording systems and/or which are caught and sold legally or quasilegally.

It is therefore highly probable that world fisheries has reached the carrying capacity of our oceans and freshwater bodies, as also suggested by the large fraction of global primary production required to sustain exploited food webs (Pauly, D. and V. Christensen. 1995. Primary production required to sustain global fisheries. Nature, (16 March 1995) Vol(374):255-258).

The Fisheries Centre, University of British Columbia (Vancouver, B.C., Canada) and ICLARM have begun a global study on the magnitude of unrecorded fish landings. By "unrecorded landings" we mean those fish or shellfish that are brought ashore but not included in the figures used to assemble FAO's Catch and Landing Statistics. They remain unrecorded for one or more of a number of reasons. Either:

a) they are caught and sold illegally;
b) the national catch recording system does not cover all landings from all crafts or gears; or
c) there is accidental or deliberate misrecording of landings.

We are asking for information on unrecorded catches from any fishery, anywhere in the world. Ideally, what we are looking for is the tonnage of unrecorded catches by species, fishery type and area. Proportions or ratios are also useful as are any ideas that you might have on this topic. The main thrust of this project is to compare information that we receive with official catch statistics and calculate the ratio of recorded to unrecorded landings for as many fisheries in as many areas as possible. We hope that this will enable us, after proper stratification, by species and area, to arrive at a reasonable estimate of unrecorded landings and hence of true global fish catch.

Clearly this is a sensitive issue and so we hasten to assure you that all information you may provide will be used in strictest confidence. We guarantee absolute anonymity for all our sources, and this will be strengthened by presenting our results only by groups of countries and/or by fishery type so that no source of data will ever be traceable to any individual, organization or country.

If you have any information that you are prepared to contribute to this study (even anonymously), please send this to me here at ICLARM or to Martin Esseen, Fisheries Centre, University of British Columbia, 2204, Main Mall, Vancouver, B.C. Canada, V6G 1K5, Tel (604) 822 0681, Fax (604) 822 8934; e-mail esseen@unixg.ubc.ca.

Preliminary results of this study will be presented in *Fishbyte*. In the meantime, you might wish to enjoy our usual mix of articles. ***D. Pauly***

An Analysis of the Multigear, Multispecies Fishery in the Kenyan Waters of Lake Victoria

C.O. RABUOR
J.J. POLOVINA

Abstract

Catch rates for both Nile perch (*Lates niloticus*) and dagaa (*Rastrineobola argented*) from Kenyan waters of Lake Victoria have steadily increased through the 1980s, even though fishing effort also increased during the same period. However, analysis of catch and effort data within and outside the Nyanza Gulf suggests an increase in catch rates due to a shift in effort from the inshore Gulf region to higher catch rates in the offshore region, rather than an increase in abundance.

Analyses of catch rates by gear type both in and outside the Nyanza Gulf show that 1991 catch rates are lower than 1989 levels—by 60-80% in some instances. Since the fishing power of these gears has increased during this period, it is likely that fish abundance declined more than catch rates.

A dynamic population model is used to simulate Nile perch dynamics. It indicates that a decline in catches should be anticipated.

Introduction

The Study Area

The Kenyan portion of Lake Victoria (Fig. 1) comprises only 6% (4,100 km^2) of the entire lake (68,000 km^2), which also includes a Tanzanian (48%) and an Ugandan sector (46%). Nyanza Gulf (1,400 km^2) includes very productive fishing grounds due to several rivers which flow into it. Detailed descriptions of the Gulf are given by Rinne and Wanjala (1982), Ogari (1984), Ogari and Dadzie (1988) and Okatch and Dadzie (1987).

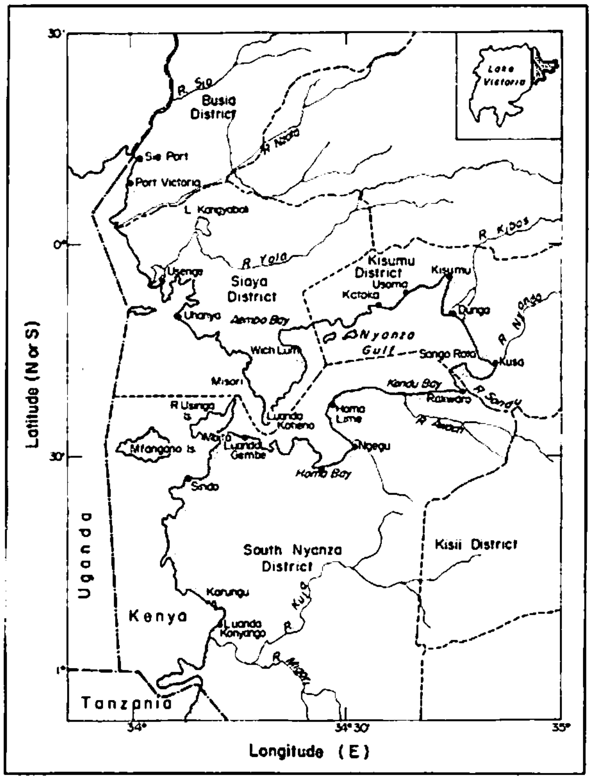

Fig. 1. Nyanza Gulf and Kenyan portion of Lake Victoria.

Description of the Fishery

The Lake Victoria fishery constitutes the most important fishery in Kenya (Hoekstra et al. 1991), contributing about 92% of total fish production by weight (Adhiambo 1991). It is a multispecies fishery dominated by Nile perch (*Lates niloticus*) (60%); *Rastrineobola argentea* (35%) and tilapias (*Oreochromis* spp.) (2.5%).

Four major types of fishing gears are used in the Kenyan waters of Lake Victoria: longlines, gillnets, beach seines and mosquito seines. The mosquito seines are fine meshed, and primarily used to catch *R. argentea* as small pelagic cyprinid (see Wandera and Wanink 1995). The longline and gillnet harvest adult Nile perch with mean size ranging from 70 to 80 cm TL, while the beach seines harvest mainly juvenile Nile perch and tilapias.

Since 1989, detailed catch-and-effort statistics by fishing gear have been recorded from 22 landing beaches in the Kenyan portion of the lake by staff of the Kenya Marine and Fisheries Research Institute (KMFRI) at Kisumu. This paper analyzes the data for the period 1989-1991. A simple dynamic population model is also used to simulate a possible response of Nile perch to a rapid increase in its exploitation rate.

Materials and Methods

Sampling Methodology

The KMFRI catch-and-effort assessment survey was conducted at 22 fish landing beaches, 11 in Nyanza Gulf and 11 outside the Nyanza Gulf, following the design of Bazigos (1970, 1974) as illustrated by Rabuor (1988, 1991). A subsample of fishing vessels is used to estimate catch/effort (C/f, in kg·boat-day^{-1}) each month by gear. Total monthly catch by gear is computed as the product of monthly effort and C/f.

Results

Fishing effort at the 11 landing sites in the Nyanza Gulf has approximately doubled from 1989 to 1991, while fishing effort approximately tripled, from 1989 to 1991, at the 11 landing sites outside Nyanza Gulf. Gillnets and mosquito seines account for about 70% of fishing effort both inside and outside the Nyanza Gulf. There has been no significant change in the distribution of effort by gear type over the three years in either region (Tables 1 and 2).

C/f is at least two to three times higher outside Nyanza Gulf than inside the Gulf for all gear types (Table 3). C/f in 1991 was lower than in 1989 for all gears inside and outside the Gulf except for gillnets inside the Gulf (Table 4). The greatest decline in C/f since 1989 was for gillnets outside Nyanza Gulf, where the 1991 C/f is 59% of the 1989 level (Table 4). Outside Nyanza Gulf, about half of the fishing effort is due to gillnets (Table 2).

Table 1. Annual fishing effort and percent of effort by gear at 11 landing sites in the Nyanza Gulf, 1989-1991.

Year	Annual effort (1,000 boat-days)	Percent effort by gear			
		Longlines	Gillnets	Beach seines	Mosquito seines
1989	23.5	16.7	29.8	11.9	41.7
1990	38.2	18.6	40.1	7.9	33.5
1991	48.9	21.5	39.9	9.4	29.2

Table 2. Annual fishing effort and per cent of effort by gear at 11 landing sites in Kenyan waters outside the Nyanza Gulf, 1989-1991.

Year	Annual effort (1,000 boat-days)	Percent effort by gear			
		Longlines	Gillnets	Beach seines	Mosquito seines
1989	32.9	9.8	61.3	7.2	21.7
1990	87.3	21.1	58.5	8.1	21.2
1991	109.5	13.5	47.7	16.8	22.0

Since 1980, there has been a rapid increase in Nile perch landings from Kenyan waters, generally attributed to a rapid increase in fishing effort (Fig. 2). The dynamic simulation model was driven with a hypothetical trajectory of fishing mortality increasing over 10 years from 0.1·year^{-1} after which it was held constant (Fig. 3A).

Simulation Model

Over the past 10 years there has been a large increase in fishing effort and hence fishing mortality directed on the Nile perch population. Further, diet composition studies have shown that juvenile Nile perch form a substantial component in the diet of adult Nile perch (Hughes 1986; Ogari 1984; Ogari and Dadzie 1988; Ogutu-Ohwayo 1990). Thus a simple dynamic model is used to simulate the catch and population size of a population with strong density dependent recruitment subjected to a rapid increase in fishing mortality. Specifically, let the exploitable population size at time t_1 (Nt) be described by the following:

$$N_t = N_{t-1} e^{-(F_{t-1}+M)} + \alpha N_{t-2} e^{-\beta N_{t-1} - \frac{(F_{t-1}+M)}{2}}$$

where:

F_t and M are fishing and natural mortality, respectively, and

α and β are constants which define the recruitment relationship.

The model determines N_t as the portion of (N_{t-1}) which survives from (t-1) to t plus the recruitment to the exploitable population, which is proportional to the spawning population (N_{t-2}) and inversely proportional to the predator population (N_{t-1}). Similar models have been used earlier by Holden and Raitt (1974), Ricker (1975), and Gulland (1983) to determine population changes in fish stocks.

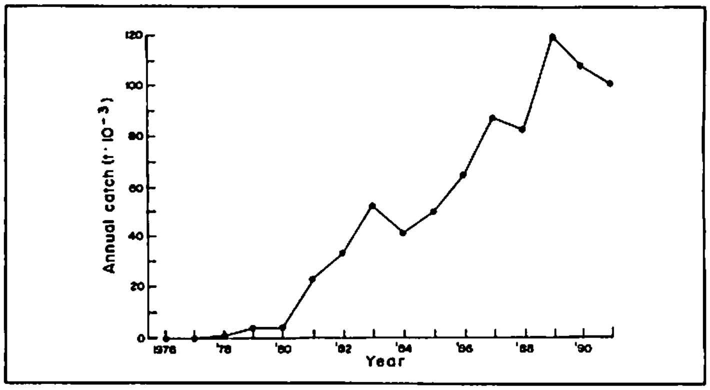

Fig. 2. Nile perch landings from Kenyan waters, Lake Victoria (1976-1991).

The population size, fishery catch and C/f were computed from the simulation model based on the fishing mortality trajectory (Fig. 3A) with a natural mortality (M) of 0.6·year^{-1} and the recruitment parameters α and β fixed at 3.0 and 0.01, respectively. The simulation model shows that catch increased fivefold during the first five years then dropped by almost 50% as fishing mortality increased from 1.0 to 2.0 year^{-1} (Fig. 3B). After the tenth year, when fishing mortality remained constant, catch continued declining to one-third the level of the 10th year.

Discussion

For seven out of eight of the gear- and area-specific C/f values, the 1991 levels ranged from 59 to 94% of the 1989 values. However, it is likely that changes in the gears and their use have resulted in less decline in C/f than in fish

Table 3. Annual catch/effort (kg·boat·day^{-1}) by gear from 22 landing sites in the Kenyan waters inside and outside Nyanza Gulf, 1989-1991.

	Longlines		Gillnets		Beachseines		Mosquito seines	
Year	Gulf	Outside	Gulf	Outside	Gulf	Outside	Gulf	Outside
1989	44.7	81.1	22.4	131.2	72.8	527.3	113.4	316.8
1990	34.2	84.2	27.2	101.6	62.2	643.6	105.8	337.1
1991	32.0	79.9	25.1	77.6	61.9	410.3	95.1	292.9

Table 4. Catch/effort as a per cent of 1989 C/f from 22 landing sites by gear, inside and outside Nyanza Gulf, 1990-1991.

	Longlines		Gillnets		Beaschseines		Mosquito seines	
Year	Gulf	Outside	Gulf	Outside	Gulf	Outside	Gulf	Outside
1990	77	104	121	77	85	122	93	106
1991	71	94	112	59	85	78	84	93

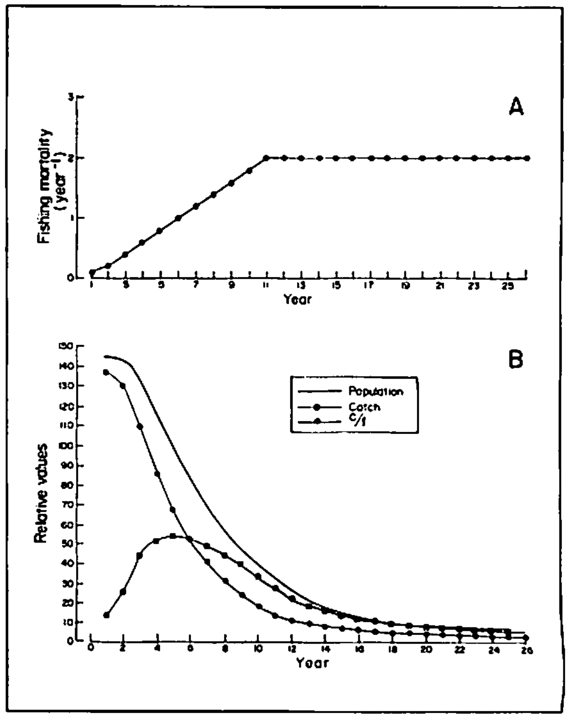

Fig. 3. A) A hypothetical trajectory of fishing mortality over time. B) Population size, catch and c/f from the fishing mortality trajectory shown in A.

density. Changes in gear aimed at maintaining C/f levels might include smaller mesh size for gillnets and beach seines, increasing the length of nets, seines, and longer longlines and soak times. Thus, declines in C/f by gear is only an upper bound on the decline in fish density.

The decline in gillnet C/f suggests the adult population of Nile perch outside the Gulf has been reduced to at least 60% of its 1989 density. Declines in beach seines C/f suggest a decline in juvenile Nile perch abundance and hence, further declines in longline and gillnet C/f, since they exploit the older fishes.

The simulation model allows several inferences pertaining to the Nile perch fishery. First, an initial increase in fishing effort will produce a sharp increase in catch since a reduction of adult fish reduces the predators on the juveniles and hence increased juvenile survival and recruitment to the fishery. A second reason for catches increasing sharply is that the unfished population goes through a period during which older individuals, not previously subjected to fishing mortality, are taken. As fishing mortality continues to increase, the reduction in spawning stock abundance reaches a level so low as to result in less recruits being generated, and hence leading to a decline in catch levels. After fishing mortality has been held constant for the tenth year, catches continue to decline as the population gradually reaches an equilibrium level.

While this simulation model is not fully realistic for Nile perch, it does raise several concerns. First, the high catches achieved during the fishing up phase of the fishery may not be sustainable. Secondly, even when fishing mortality is held constant, catches will continue to decline until a lower equilibrium level is reached.

In summary, from 1989 to 1991, the density of adult Nile perch outside Nyanza Gulf has probably been reduced by at least 40% and it is likely that the 1989 density was well below the unexploited density as a result of prior exploitation. Thus, concerns exist about whether the current spawning biomass of Nile perch is sufficient to prevent recruitment overfishing. The rapid increase in fishing effort from 1989 to 1991 provides evidence that the fishery and population are not in equilibrium and hence, as the simulation model suggests, substantial declines in catch can be expected.

Acknowledgements

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C.O. RABUOR *is from the Kenya Marine and Fisheries Research Institute, Sang'oro Laboratory, P.O. Box 136, PAP-ONDITI, Via, AHERO, Kenya, while* J.J. POLOVINA *is from the National Ocean and Atmospheric Administration (NOAA), National Marine Fisheries Science Center, 2570 Dole Street, Honolulu, Hawaii 96622-2396, USA.*