# SOME BIOLOGICAL AND ECOLOGICAL CONSIDERATIONS FOR RESEARCH IN THE MANAGEMENT OF THE FISHERIES OF LAKES VICTORIA AND KYOGA

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AT

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## INTRODUCTION

There is little doubt that the exploitation of the current fisheries of Lakes Victoria and Kyoga requires close monitoring with a view to enforce adherence to prudent management practices. Many indigenous fishes have gradually disappeared from the commercial fishery of both lakes. In the Uganda portion of Lake Victoria for instance Okaronon and Wadanya (in press) have shown that:-

1. The once preponderant haplochromiine taxon ceased to feature in the commercial catches in 1979.

2. The lung-fish (*Protopterus aethiopicus*) which formerly contributed significantly to the commercial landings had declined to minor species status by the mid 1980s.

3. The catfishes *Clarias mossambicus* and *Bagrus docmac,* formerly major fish species, contributed insignificant quantities to the commercial fishery since the early and mid 1980s, respectively.

Similar trend have been reported in the Kenya and Tanzania portions of Lake Victoria (Bwathondi, 1985; Mainga, 1985, Witte and Goudswaard, 1985).

On the other hand since their establishment all round the lake in the early to mid 1980s some introduced fishes namely Nile perch (*Latęs niloticus*) and Nile tilapia (*Oreochromis niloticus*) built up impressive stocks in Lake Victoria (Ssentongo and Welcomme, 1985, Okaronon et al. 1985; Okaronon and Wadanya, in press). Togetther with the native pelagic cyprinid *Rastrineobola argentea* or Dagaa/Mukene the introduced fishes have contributed unprecidented catches, stimulating vibrant commercial fisheries which have yielded significant social economic benefits to the peoples of the three states riparian to the Lake (Reynolds and Greboval, 1988; Kudhongania et al in press). The impressive landings particularly of the Nile perch and Nile tilapia have also led to rapid industrialisation of fish processing in East Africa mainly for the export market. Fish export has now the potential of a major foreign exchange enterprise in the region.

However, there is further cause for caution regarding the management of the fishery resources of Lake Victoria. The reviews and discussions by Bugenyi; Kudhongania and Coeneen; Ssali et al; and Twongo et al (all inpress), at the recent FAO sponsored National Seminar on the "Development and Management of the Fisheries of Lake Victoria (Uganda)" clearly illustrate the need for concern and caution. In brief the following were highlighted:-

1. The highly limited fund of knowledge on the ecology and dynamics of the vast lake's ecosystems:

- the fragmentary knowledge about its limnology,
- the ignorance about the fish stock situation in the distant and deep off-shore.
- the limited knowledge so far gathered on the biology and dynamics of the two introduced fishes currently dominating the fishery.

2. The gradual but apparently steady eutrophication of Lake Victoria involving changes in the physical chemical and biological limnology that may adversily affect biodiversity and hence the fish stocks.

3. The reckless yet wide spread exploitation of fishery resources often using detrimental fishing gears and methods such as seines, undersized gillnets castnes and undersized mosquito seines for Mukene/Dagaa.

4. The ever increasing pressure on the fisheries resources, influenced by:-

(i) the social and economic factors which dictate dependence on fish, the most affordable source of animal protein, and on fishing which is a major source of livelihood for large numbers of people around Lake Victoria.

(ii) the need to involve fish in a diversified foreign exchange base. This factor has led to such an escalation in the number of fish processing plants around the lake that the venture if not controlled, threatens to undermine the interests of the traditional artisanal fisher-folk and consumer.

The purpose of the above detailed introduction is to focus attention on to the increasingly upredictable future of the fisheries resources of Lake Victoria, and hence highlight the need to reassess current approaches to their management. In that connection, this paper discusses several biological and ecological considerations, notably those relating to reproduction, feeding and growth that fishery scientists and administators out to study more fully, and apply more resolutely in the management of the resources of the lake.

Although this workshop is specifically on Lake Victoria examples on the fisheries of Lake Kyoga will be discussed in view of the similarity of the indigenous fish species, the common history of fish introduction involving the same fish species, and the subsequent trends in the evolution of the commercial fishery in the two lakes.

## 2. SOME BIOLOGICAL AND ECOLOGICAL ASPECTS FOR STUDY

### 2.1 Reproduction

Reproductive strategy and the attendant reproductive success of fish species plays a key role in the competitive ability of the species in a multispecies fishery. The ecological success of the Nile perch in Lakes Victoria and Kyoga where the fish was introduced has been attributed to its prolific fecundity among other qualities, which include lack of natural enemies even at juvenile stage and fast growth rate (Ogutu-Ohwayo, 1988; Acere, 1985). Similarly the Nile tilapia owes its recruitment success in the same environment to protective mouth brooding of the eggs and fry until the latter are capable of scaping most natural enemies. The vigorous and fast growth rate and aggressive attributes of the species have also been sited to contribute considerably to the competitive advantage of the Nile tilapia over other fish species in the same habitats (Fryer and Iles, 1972).

#### 2.2.1 Scientific Studies

The importance of reproductive processes in fishery science is reflected by the attention devoted to this subject by earlier scientists in East Africa who studied various aspects of fish reproduction including age at first maturity, fecundity, breeding behaviour as well as brooding and nursery grounds for the commercially major species (Lowe McConnel, 1955; 1959; Fryer, 1961; Welcomme, (1964). Investigations by Welcome (1967) for example showed that various cichlids in Lake Victoria preferred particular beach types for nursery grounds and that the preference was determined by various factors including types of the beach, temperature gradient and vegetation cover.

However, recent research in East Africa appears to have paid limited attention so far to the study of reproduction in even the three most important commercial species in Lakes Victoria and Kyoga namely Nile perch, Nile tilapia and Dagaa. While sex ratios, age at first maturity, fecundity and general spawning patterns have been studied for the Nile perch, the Nile tilapia and Dagaa Ogutu-Ohwayo et al 1989, Wandera, 1990; Twongo, unpublished data), breeding patterns and behaviour of these major species have yet to be systematically researched and are currently a matter for conjencture and guesswork. There has been little or no effort to locate the spawning and nursery areas for Nile perch and Dagaa, nor have factors influencing suitability of those environments been established. Yet at that early stage in their development these larval fish are most vulnerable. Management practices could greatly benefit from detailed knowledge about the lake environments where they occur, and the macro-environmental conditions that influence their development.

## Feeding and Growth

Feeding: A considerable fund of knowledge has been gathered over the years on the food and feeding habits of major commercial fishes of Lakes Victoria and Kyoga (Fish 1951; 1955; Corbet 1961; Welcomme, 1967). More recently particular interest has been placed on the study of the food habits of the Nile perch owing to the impact of its predatory habits in these lakes (Okedi, 1971; Ogutu-Ohwayo, 1985;) and on the Nile tilapia the second species of commercial significance (Moriety, 1973; Balirwa, 1990). The apparent lack of interest in early studies on the food of Dagaa was probably due to the fact that this fish has only recently attained lake-wide reputation as a major commercial species. To date, detailed studies on the food of this pelagic cyprinid have just began and they include current work, yet to be published, by Wandera of UFFRO.

Areas for further study on the food of the commercial fishes in Lakes Victoria and Kyoga include detailed information on the spacial and temporal variations, as well as on the antogenic shifts in food habits, especially for the Nile perch, in order to assess the possible ecological requirements and impact of the species. Studies on food rations of *Lates* would be vital for the above purpose.

**Growth:** Very few detailed studies on growth parameters of the fishes of Lake Victoria appear to have been made. The work of Garrod (1959) on *Oreochromis esculentus* (then *Tilapia esculenta*) appears to be an isolated case illustrating the difficulties of growth studies in tilapias which reproduce throughout the year. This little progress may be attributable to lack of suitable 'tools' to facilitate the studies under the relatively constant temperature conditions of the tropics (c.f. regular seasonal ring formations in the hard parts of temperate fishes). Mathematical methods have often been used to study fish growth and their population dynamics, and in Lake Victoria the attempt by Acere (1985) is a recent example. However many would be investigators in this area are often intimidated by the apparent mathematical mystery that shrouds these methods. Fortunately the advent of personal computers plus packages like the ELEFAN appear to be opening up this area to non-mathematical students as well. However, well organized tagging programmes appear to be the best possibilities yet for obtaining data on age and growth parameters in tropical fishes.

The lack of data on fish growth and population dynamics has considerable management implications which are no doubt insufficiently appreciated by my lay perspective. One of the most notable implications is the inability to do various stock assessment computations due to lack of data on parameters such as growth and mortality rates. Inability to tell with sufficient certainty how long Nile perch, for example, will take to grow to a given length, or to reach "first maturity" is often quite

frustrating to researchers and managers. Therefore, growth studies on the fishes of Lakes Victoria and Kyoga need much more attention than currently availed.

## 3. APPLIED ASPECTS

One of the primary objectives of studying fisheries biology and ecology is the search for information that can be used for rational fisheries management. Applied biological information on fishes most often comes from the study of reproductive processes and strategies, study of food and feeding habits as well as growth; while ecological studies reveal useful data on the interactions and interrelationships of a given fish species with the environment and with other organisms in it. The study of reproductive processes with respect to the fisheries of Lakes Victoria and Kyoga has many potentially useful applications to the management of these fisheries especially at the current phase of uncertainty in their evolution.

### 3.1 Size at first maturity

The size at which fish of a given species mature determines the start of reproduction, that is the beginning of the species contribution to successive generations. That period is of fundamental significance in fisheries management especially in intensity exploited fisheries because size at first maturity is usually the basis for determining the minimum mesh size of the gears such as gillnets to be allowed in the fishery. It is in fact one of the fundamentals to the concept of renewability of rationally exploited fisheries. However, this important phenomenon is not often fully considered nor does it appear to be taken seriously by both scientists and administrators with respect to rational management of the fishery resources of Lakes Victoria and Kyoga. This fact is illustrated below.

Comprehensive data on size at first maturity together with data on catch characteristics for gillnets of various sizes (Fig.1, 2 and 3) have been compiled for the Nile perch, Nile tilapia and Dagaa in Lakes Victoria and Kyoga by a team of UFFRO (Uganda Freshwater Fisheries Research Organization) scientists (Ogutu-Ohwayo et al, in press). This information has been circulated to the relevant authorities in the States riparian to Lake Victoria. However, current fishing methods do not appear to take into consideration the minimum gear mesh size limits recommended in the above publication. For instance a large number of seine nets with codends of average mesh size five to seven centimetres has for a long time now been operational in the fisheries of Lakes Victoria and Kyoga. A recent survey of these gears in Lake Kyoga calculated a mean weight of about 150g for the Nile perch caught by the seine (ADP/FS, unpublished data). This mean weight converts to less than 23cm total length (Fig.4) as compared to total length of 50cm at which male Nile perch matures (Fig.1). (Note that male Nile perch mature earlier than the females). The survey found also that the majority of

gillnets in use on Lake Kyoga at that time were of a smaller mesh size than the recommended 127 mm (Ogutu-Ohwayo, 1989; see also Fig.2). Most of the catch in the gillnet fishery at the time was, therefore, immature. In similar fashion, the Dagaa fishermen on Lake Victoria have shifted from the recommendable mosquito net with a mesh of 10mm in preference for the 'hurry up' net with a mesh size of 5mm shown to harvest mainly immature fish (Wandera, 1990; see also Fig. 3).

Personal observation by this author at various fish landings on Lake Victoria - Uganda revealed the use of gears similar in size to those described above. Large quantities of immature Nile perch and Nile tilapia are being fished to the extent that there has even been public outcry against the practice in the local press. It is most probable that the use of under-sized gears has been widespread in Kenya and Tanzania portions of this lake as well.

Clearly, widespread use of the above gears at current high fishing pressure is contrary to rational fishery management because there can be no possibility for renewability in a living resource where reproduction is systematically hindered. Yet this fundamental truism appears to be currently quite elusive to fishery scientists and administrators, the 'front line' managers of the fisheries expected to educate the fishing community on rational fishery management and implement the relevant regulations. In this connection it is reassuring to note that fishery managers in Uganda have recently renewed their effort to control the capture of immature fish.

### 3.2 Spawning and nursery processes

The need to carefully study the spawning and nursery processes of a fishery should increase with man's involvement with the fishery through fishing, and other multipurpose uses for the aquatic environment such as transport, waste disposal and agricultural practices.. These and other activities by man affect the spawning and nursery processes of fish in various ways which lead to environmental degradation. Therefore, detailed knowledge on the spawning behaviour and the ecological/environmental requirements and influences at the brooding (for some fishes) and nursery sites would enable fishery managers to assess availability of suitable areas for these reproductive processes in a given water body. The information and knowledge would also make it possible to create conditions that facilitate or enhance the reproductive processes. However, for Lake Victoria and Kyoga this knowledge is highly limited even for the major commercial fish species. Therefore:-

(i) it is not practical yet to institute a 'closed area' management strategy to protect the breeding of the Nile tilapia and Dagaa to aid stock enhancement in areas where intense fishing pressure has drasticaly reduce the brood stock. This is due to

the fact that the breeding and nursery areas of these two species are not accurately known and hence cannot be demarcated with certainty.

(ii) while it was observed quite early that recruitment in the tilapia fisheries of Lake Victoria was limited by availability of nursery areas (Beauchamp, 1954), the suggested modification of suitable beach areas to provide extra nursery sites would not be successful without a thorough understanding of the ecology of larval tilapia. On the other hand, it is currently difficult to assess beyond speculation the impact of widespread beach vegetation clearing around Lake Victoria on the brooding and nursery activities of various fishes in the lake.

(iii) although the massive fish kills which have become an annual phenomenon on Lake Victoria in recent years might be taking an extremely heavy toll on fish embryos and larvae. Few people have stipulated on this possibility which if actual would have considerable impact on fish stocks. Again very little information and data is available in this area.

One example of practical application of knowledge on reproductive processes is the use of acadjas or brush parks in lake-based aquaculture systems to enhance the stocks of tilapiines. this method which also exploits knowledge on the food habits of tilapiines is widely used in Benin, and it could be of considerable practical value in situations where high fishing pressure hinders adequate reproduction to sustain recruitment. The method could also be used to create suitable conditions for various fish species in aquatic environments with low productivity.

Secondly, the high reproductive potential of the Nile perch is of practical management consideration. Ogutu-Ohwayo et al (in pree) recommended the of a minimum mesh size of 127mm in the Nile perch gillnet fishery even though this gear capture immature females (Fig.1). This is largely because the fecundity of the fish is so high (in millions of eggs) and the juvenile survival rate so favorable that relatively few females escaping capture would sufficiently contribute to the subsequent generations of the species. However, one should bear in mind the need to strictly watch the fishing pressure on the Nile perch so as not to allow reduction of the brood stock below the critical level. This would likely be possible through careful monitoring of catches.

**Feeding considerations.**

Nile tilapia: The food and feeding of tilapia appear to present relatively fewer management problems probably because phytoplankton which forms the basic food ingredient (even for detritus) is often quite plentiful in the aquatic environment. Cases of stunted growth of tilapiines attributed to a combination of over-crowding and possibly insufficient food have been noted

in poorly managed acquaculture systems. And in nature stunted growth of the Nile tilapia in Lake Wamala (Uganda) is suspected to be due to insufficient food caused by reduced water volume under drought conditions (Okaronon, personal communication).

The recent observation in the shift of the food habits of the Nile tilapia of Lake Victoria to include a large proportion of detritus and invertebrates (cf. Lowe McConnel, 1959; Welcomme, 1967 and Balirwa, 1990) has been attributed to the greater availability of these food items in the environment due to greatly reduced fish species diversity. This demonstrated trophic plasticity in the Nile tilapia is of considerable scientific and management interest particularly with respect to the species role in the trophic dynamics of the greatly altered Lake Victoria ecosystem. No doubt it partly explains the success of the Nile tilapia in Lakes Victoria and Kyoga.

**Nile perch:** Prey availability is particularly important to the success of a predator. But the success of the Nile perch in Lakes Victoria and Kyoga has been greatly enhanced by the ability of the species to exploit a diverse array of prey organisms by shifting from one group of food items to the other as the fish grows (Ogutu-Ohwayo, 1985). Indeed the initially large number of alternative prey in lake Victoria would have contributed to the build up of huge stocks of Nile perch in Lake Kyoga in the late 1970s and in Lake Victoria in the late 1980s.

The question of whether the big stocks of Nile perch will be sustainable is one of food availability, and it is of great scientific and management interest. However, answers to this question have yet to be researched in various areas of study including the ecology and dynamics of the various prey species, and the food ration characteristics for the Nile perch. In the meantime the generally accepted idea that the predator was largely responsible for the catastrophic decline of haplochromiine cichlids in Lake Victoria (see reviews by Ogutu-Ohwayo, 1990, 'Kudhongania et al, in press) must be a constant source of nervousness to investors who have put their money into Nile perch. Clearly there is no way of telling yet whether the stocks of Nile perch in Lake Victoria will be sustained and at what level.

**Dagaa:** Studies on the trophic dynamics of Dagaa in Lake Victoria deserve greater attention in view of the importance of the species as food for the Nile perch on the one hand, and on the other as one of the three major commercial species in Lake Victoria. such studies would also provide data to assess the possible impact of the current changes in the limnology of lake Victoria (Bugenyi and Magumba, 1990) on Dagaa stocks.

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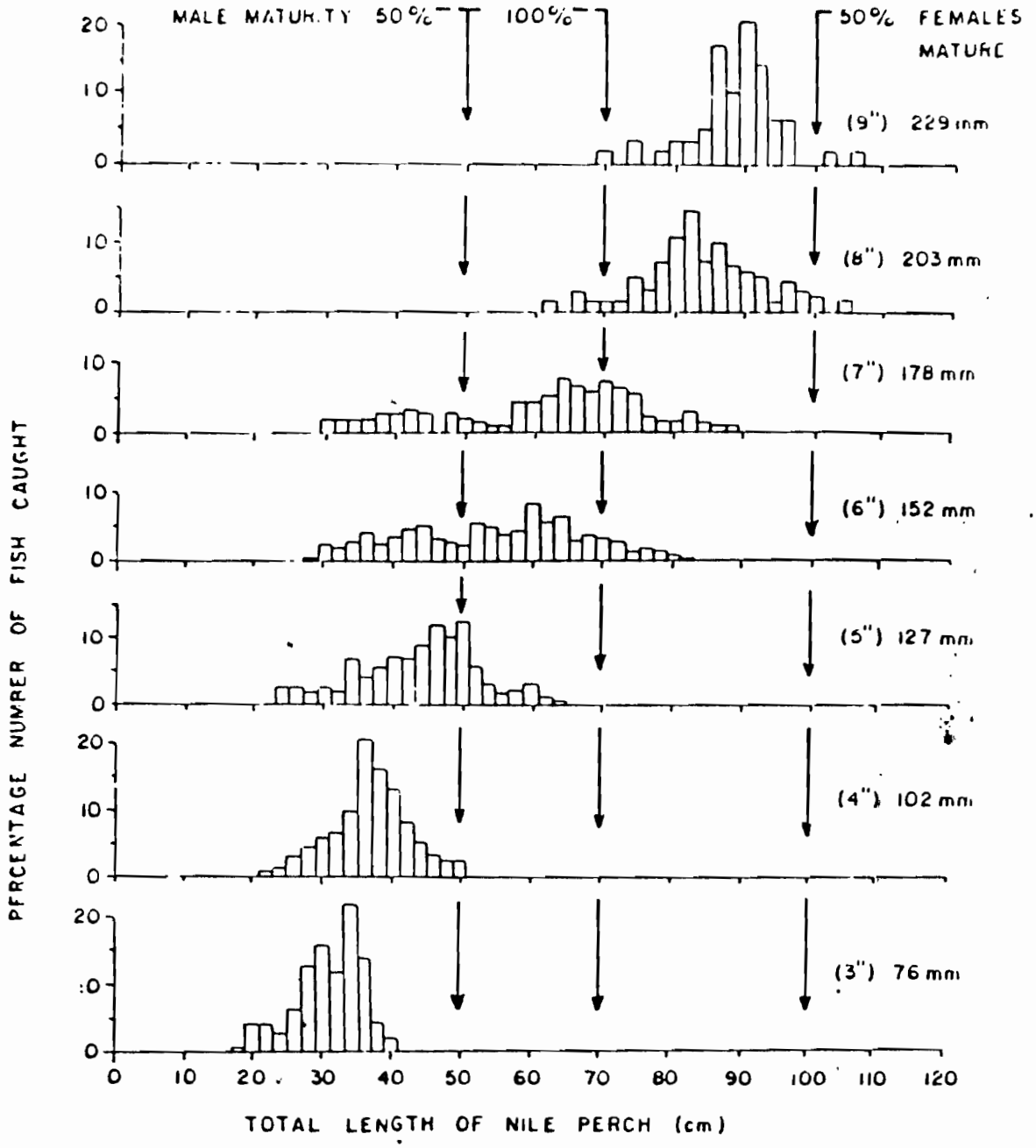


Figure 1. The length frequency distribution of Nile perch caught by gillnets of different mesh sizes expressed as a percentage of the catch for each 2 cm length classes of the fish for each mesh size.

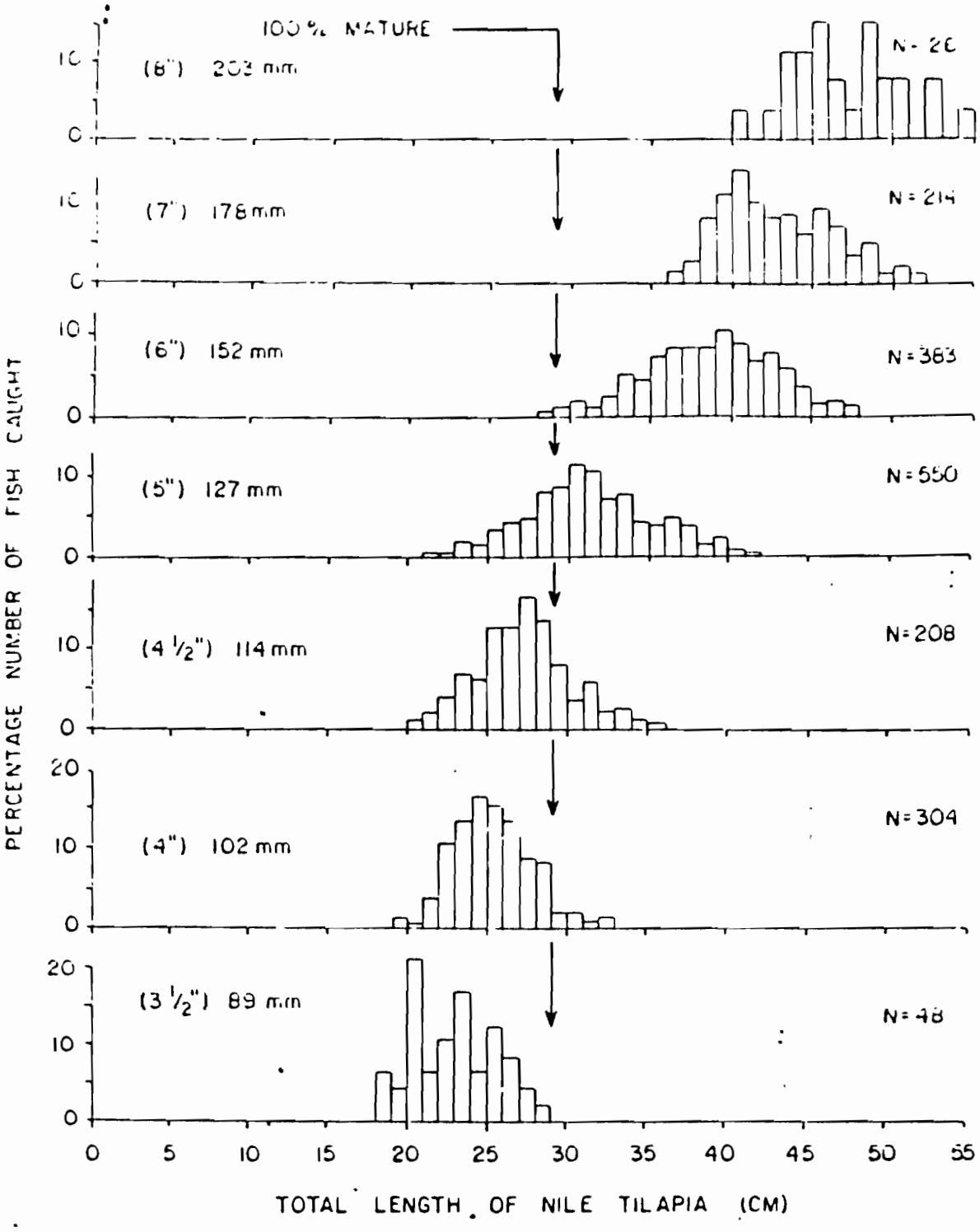


Figure 2 The length frequency distribution of Nile tilapia caught by gillnets of different mesh sizes expressed as a percentage of the catch for each 1 cm length classes of the fish for each mesh size.

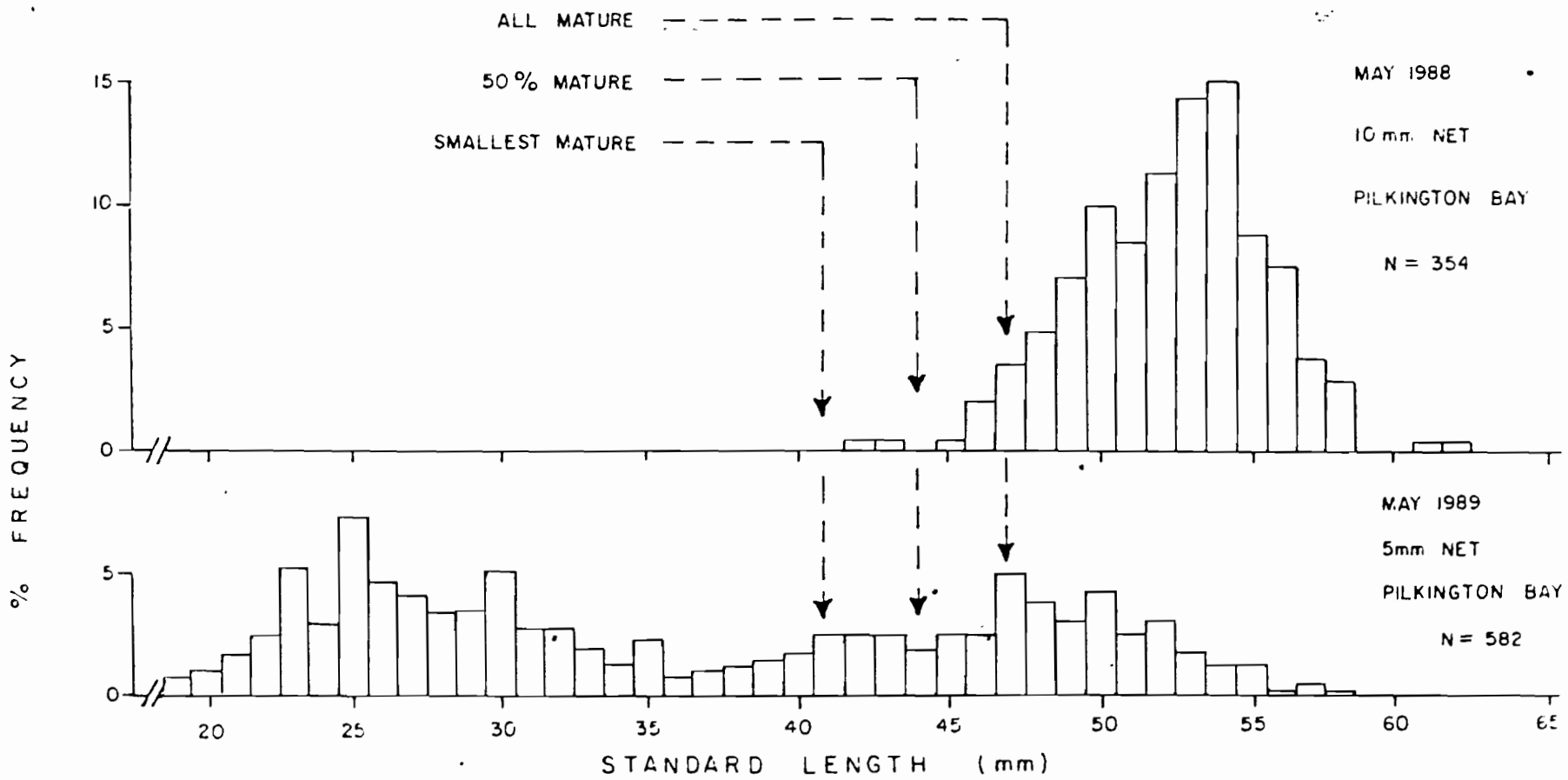


Figure 3. The length frequency distribution of Mukene retained in commercial seine nets in Lake Victoria. The sizes at which 50% and all fish are mature and those of the smallest mature individuals are indicated.

# Fig 4. LENGTH/WEIGHT RELATIONSHIP