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Challenges for Management of the Fisheries Resources, Biodiversity and Environment of Lake Victoria

Editors:
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Fisheries Resources Research Institute

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UGANDA KENYA TANZANIA

LAKE VICTORIA ENVIRONMENT MANAGEMENT PROJECT LAVEMP FOR MAXIMUM SUSTAINABLE BENEFITS

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4.5. Evolution and management of the mukene (*Rastrineobola argentea*) fishery

S.B. Wandera

Introduction

Rastrineobola argentea locally known as mukene in Uganda, omena in Kenya and dagaa in Tanzania occurs in Lake Nabugabo, Lake Victoria, the Upper Victoria Nile and Lake Kyoga (Greenwood 1966). While its fishery is well established on Lakes Victoria and Kyoga, the species is not yet exploited on Lake Nabugabo. Generally such smaller sized fish species as *R. argentea* become important commercial species in lakes where they occur when catches of preferred larger-sized table fish start showing signs of decline mostly as a result of overexploitation. With the current trends of declining fish catches on Lake Nabugabo, human exploitation of mukene on this lake is therefore just a matter of time. The species is exploited both for direct human consumption and as the protein ingredient in the manufacture of animal feeds.

The introduction and subsequent establishment of the Nile perch, *Lates niloticus*, and the Nile tilapia, *Oreochromis niloticus*, resulted into the disappearance of many native species from Lakes Victoria and Kyoga, through predation and competition for space (Ogutu Ohwayo 1994, Witte *et al.*, 1992). *R. argentea* is presently the only indigenous fish species under commercial exploitation in these lakes. On Lake Victoria the species is ranked first in Kenya, second to the Nile perch in Tanzania and third after the Nile perch and Nile tilapia in Uganda. With the potential overexploitation due to increasing demand for the Nile perch and Nile tilapia, more attention is turning to *R. argentea* as a cheap source of fish protein for human and domestic animals. Its fishery has over the last two decades expanded, spreading to all waters where weather conditions allow light fishing on Lake Victoria and many parts of Lake Kyoga.

Fishing for *R. argentea* is done at night. Fish is attracted to light from kerosene pressure lamps floated on the lake. The congregated fish are hauled out using scoop, lift or seine nets (Okedi 1981; Wandera 1992; Witte and van Densen 1995). Light fishing was introduced into Lake Victoria in the mid 60's from Lake Tanganyika where this method of fishing was well developed targeting the clupeids *Limnothrissa miodon* and *Stolothrissa tanganicae* (Wanink 1998). Because of similar fishing methods, the Swahili name dagaa given to *R. argentea* in Tanzania is thus the same name used for the Lake Tanganyika clupeids. Mukene is rarely eaten fresh.

Plate 4.5.1. The Mukene enterprise - a new dimension in Lake Victoria fisheries

On landing the fish is sold out mostly to women for processing.(Plate 4.5.1). The fish is spread out in the sun to dry and at the end of a day or two it is packed in sacks ready for marketing. The expansion of the *Rastrineobola* fishery poses a number of problems both to the species itself and to the overall lake fishery. Following a drastic decline in stocks of the haplochromines formally the main food of the Nile perch in Lakes Victoria and Kyoga, *R. argentea* together with the freshwater shrimp *Caridina nilotica* form the bulk of the food for the Nile perch (Ogutu-Ohwayo 1985).

Increased human exploitation of *R. argentea* creates direct competition between man and the Nile perch for this resource and is, therefore, bound to affect the Nile perch fishery, the most important commercial fishery on the two lakes. Gears and methods used in the *Rastrineobola* fishery will inevitably capture juveniles of the larger fishes as by-catch species. Sustained high fishing pressure on *R. argentea* will lead to changes in biological parameters of the species, many of which could be detrimental to its fishery. Knowledge of the biology and ecology of the species can help in development of management strategies for sustainable exploitation of the fisheries in these lakes.

This section of the chapter outlines some basic information available on the biology and ecology of *R. argentea.* This information was collected over a period of about 15 years of research covering the Jinja waters of Lake Victoria (Fig.4.5.1). From this information, measures that may guide sustainable exploitation and management of the *Rastrineobola* fishery are suggested.

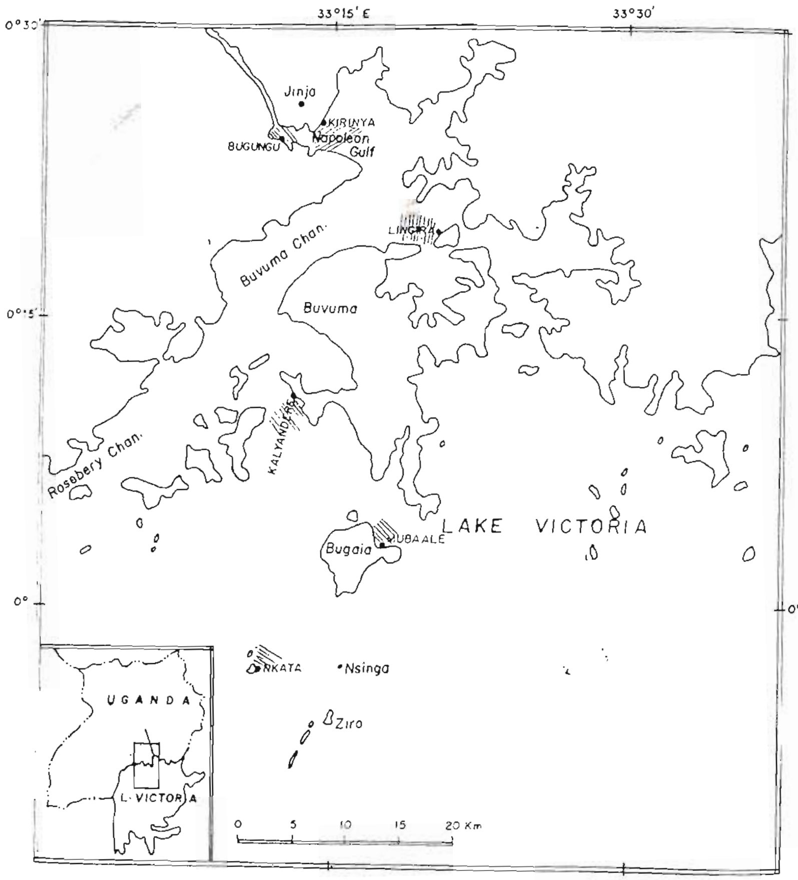

Fig. 4.5.1. Fishing ground of *Rastrineobola argentea* on Lake Victoria - Jinja

Evolution of Mukene Fishery on Lake Victoria

Fishing for *Rastrineobola* on Lake Victoria had been in existence long before the present commercial light fishery was introduced. At the turn of the twentieth century, the species was caught using long conical basket traps in shallow bays (Graham 1929). Commercial exploitation on Lake Victoria then targeted the endemic tilapiines, *Oreochromis esculentus* and *Oreochromis variabilis*, the catfishes, *Bagrus docmak* and *Clarias gariepinus* and the lungfish, *Protopterus aethiopicus*. The introduction and subsequent establishment of the Nile perch (*Lates niloticus*) and the Nile tilapia, *(O. niloticus)*. led to almost total disappearance of these indigenous species especially the haplochromines from the catches (Ogutu Ohwayo 1994, Witte *et al.,* 1992). Because the fisheries of the new fish species in the lake are targeting urban and the exports market, a fishery that would feed the local population had to develop. The increasing stocks of *R. argentea* then steadily filled the gap left by the diminishing stocks of the native cichlids. *R. argentea* is now the only endemic species landed in commercial quantities, second only to the introduced Nile perch on Lake Victoria.

The *Rastrineobola* fishery on Lake Victoria became commercially significant in the early 1970's and was first adopted by the Kenyans who in turn introduced it into the Ugandan waters in the early 1980's. Initially simple scoop nets were the gears in use. Over time, more efficient gears; the beach seines, boat (lampara) seine and lift nets have been introduced into the lake (Wandera 2000). The *R. argentea* fishery on the Ugandan portion of Lake Victoria can therefore be categorized into three recognizable phases of development.

The pre-perch period:

In the 1980s and prior to the establishment of the Nile perch, there was little pressure on *R. argentea* from both predation and the commercial fishery.

The transition period:

This period in the early 1980's were characterized by rapid perch colonization of the lake and the subsequent decline in biomass of the haplochromines, the initial food of the Nile perch. Stocks of *R. argentea* in the lake increased to take up the void left by the diminishing numbers of the haplochromines. The period marks the expansion of the *Rastrineobola* fishery in the lake. Stocks of the species were now subjected to pressure from both the artisanal fishery and predation by the Nile perch. Biological and other fishery parameters of *R. argentea* change in response to increased pressure on the fishery.

Period of intensive exploitation

After 1990, high fishing pressure is exerted on populations of the Nile perch due to demand by the export market. Because of the demand for local consumption, the *Rastrineobola* fishery is well established and expands to almost all fishable waters of the lake.

The biology of *R. argentea* in Lake Victoria

a) *Growth and population structure*

During the pre-perch period, *R. argentea* grew to a large adult size. The population caught in August 1970 shows a mean length of 60mm SL. This size in Napoleon Gulf for example reduced to 49 mm SL in 1989 and by 1992 had shrunk to 45 mm SL (Fig. 4.5.2). The mean length of the species in the gulf has further reduced to 41 mm SL in 2002 (Wandera and Taabu 2002). Over the same period other life parameters of the species have also undergone changes as shown in Table 4.5.1.

Table 4.5.1. Changes in life parameters of *Rastrineobola argentea* in Lake Victoria (Uganda)

Period	Population (SL) Mean length	Asymptotic length (SL mm)	Growth constant (K)	Size at first maturity (F, M)	Source
Pre- perch	60 mm	95.6	NA	44, 52mm	Okedi (1981)
Transition	49 mm	64.5	0.92 yr^{-1}	44, 41 mm	Wandera and Wanink (1992)
Intensive exploitation 1992	45 mm.	54.0	1.76 yr^{-1}	42, 41 mm	Wandera (2000)
Intensive exploitation 2002	41 mm			41 mm	Wandera & Taabu (2002)

b) Food and Feeding

In Lake Victoria adult *R. argentea* feeds primarily on zooplankton (Mwebaza-Ndawula, 1998). Copepods form the bulk of the food in the guts of these fishes. Two distinct populations of the species can be recognized in Lake Victoria (Wanink and Berger, 1998). The first is the main population of the adults exploited by the fishery. This population performs diel vertical migrations staying down the water column during the day and coming to the surface at night where it is exploited by the light fishery. This population feeds during daylight hours on zooplankton, which also perform similar migrations up and down the water column. At night when this population comes up the water column, it does not feed. Guts of *R. argentea* caught at night without the use of light, contain no food items. Samples obtained by light fishing, however, showed that insects that are attracted to light might be ingested. Even then the percentage of empty stomachs is still high in samples collected at night by light attraction. The second population consists of mainly the very young and those infected with tapeworms. This population stays near the surface all the time. From time to time the population may shoal towards the shores in search of food. Adults in this population feed mainly on insects. Such insects include Odonata (zygopterans) and ephemeropteran nymphs, trichopteran larvae, adult hemipterans (coryxids) and even adult lakeflies on days when swarms emerge. The young feed on rotifers, copepods and the early planktonic instars of aquatic dipterans (chaoborids and chironomids).

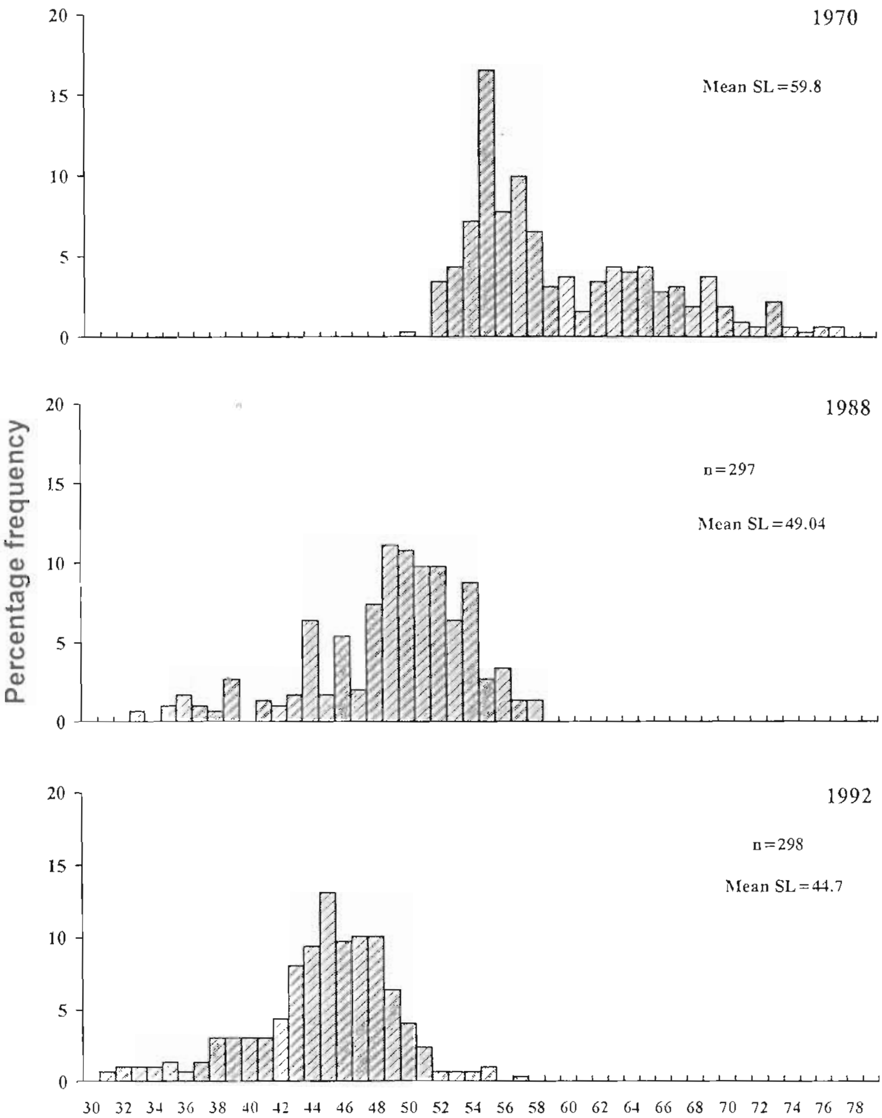

Fig. 4.5.2. Length frequency distribution of *R. argentea* from Lake Victoria in 1970, 1988 and 1992.

c) Reproduction

i) Size at first maturity and breeding

In 1988 size at first maturity of *R. argentea* from Buvuma Channel was estimated at 44 mm SL for females while males matured at 41 mm SL. All fishes would be mature by 47 mm SL (Wandera 1992). In 1993 (five years later), size at first maturity had stabilized at 42 mm SL for females. Males remained at 41 mm SL Although no data is available on size at first maturity of the species during the pre-perch period in this area, it must have been larger. Okedi (1973) reports *R. argentea* as maturing at 63 mm TL (55 mm SL) in Winam Gulf. The offshore population at Bugaia, however, in 1992 matured at a much smaller size of 36 mm SL. The commercial Nile perch fishery on Lake Victoria is currently based in offshore waters where large sized Nile perch occur. The effect of the abundant predators of *R. argentea* offshore is probably responsible for the smaller size at maturity of the species from these waters.

ii) Breeding periods

While *R. argentea* breeds throughout the year, peak breeding occurs twice a year, in August and in December/January (Fig. 4.5.3).

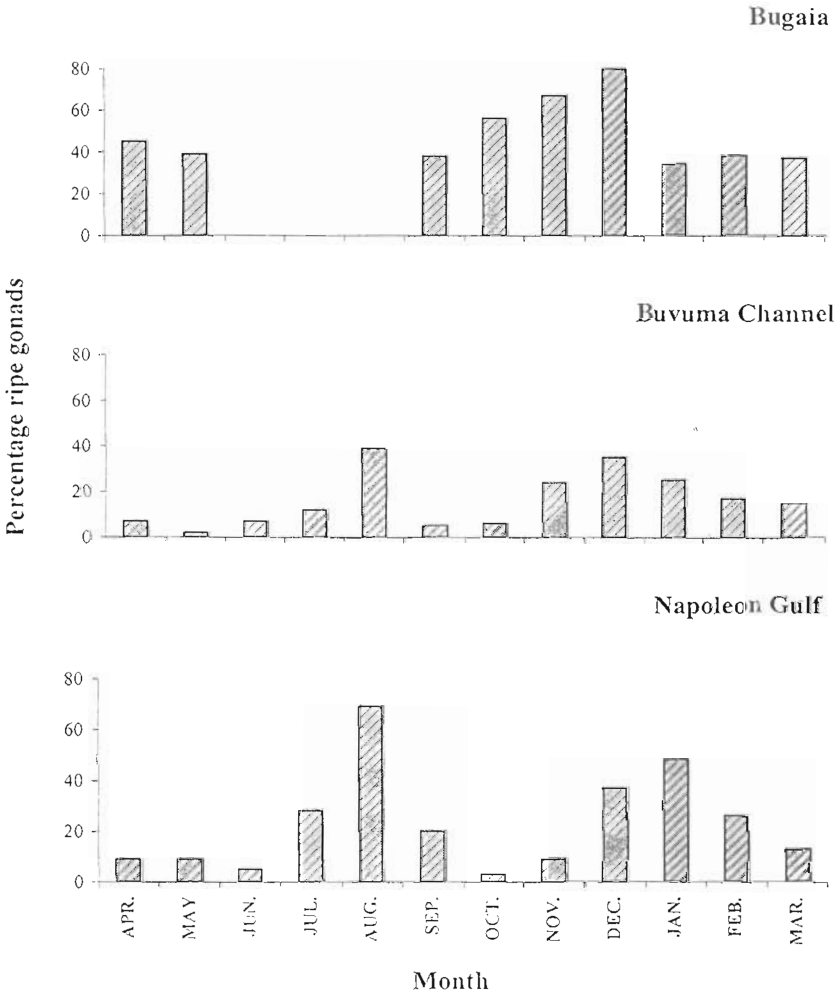

Fig. 4.5.3. Percentage of live gonards in *R. ageatea* from Lake Victoria.

The period March to July shows least breeding activity. Breeding throughout the year indicates that the species has high capacity to replace itself. Unlike many other fish species, which show peak breeding during the rainy seasons (Greenwood 1966), breeding peaks in *R. argentea* coincide with periods of dry weather in this region. On Lake Victoria, these are associated with periods following strong thermal mixing of the water column (Talling 1966). These are also periods of abundant food for both the breeding stocks and the young. Zooplankton abundance in the Jinja waters of Lake Victoria peaks around the months of July and August (Mwebaza-Ndawula 1998).

d) Parasite infection

R. argentea in Lake Victoria is infected by a cestode parasite *Ligula intestinalis*. This parasite destroys the host's gonads thus affecting its reproductive potential. A study conducted in the Jinja waters of Lake Victoria (Wabulya 1998) revealed that prevalence of infection by the cestode increases with length of the fish. The smallest fish found infected measured 35 mm SL and all fishes larger than 63 mm SL were infected. While the majority of infected fish had one parasite each, the highest number found in a single fish was eleven. Rates of infection are highest in least fished waters. Highest incidence of infection among the susceptible population was recorded at the open water station in Bugaia (6.7%), while the lowest was at Buvuma channel (3.1%). Napoleon Gulf recorded 5.1% infection. The proportion of infected fishes whose gonads appeared not damaged by the parasite was only 10.1%, the rest showed varying degrees of gonad damage with 19.4% totally damaged. Exposure to parasite infection naturally favors older fish and thus the highest prevalence in larger and older fish. Prevalence of infection is lowest in heavily fished grounds such as Lingira. Fishing removes from the system infected fishes with their parasites and therefore breaks the reproductive cycle of the parasite. Despite the presence in Lake Nabugabo of the hosts to various stages of life cycle of the parasite, *Ligula intestinalis* is absent from fishes in this lake. This is probably due to the chemistry of the Nabugabo waters (poor in salts thus low conductivity values (Mugidde & Magezi 2002), which may not favour development of the parasite.

There is yet no suitable method for the control of *Ligula intestinalis* on Lake Victoria. The life cycle of the worm involves two intermediate hosts (a copepod and *Rastrineobola*) and a bird as the definitive host. Targeting any of the above hosts as a control measure for this parasite is not easy let alone possible. It is, however, apparent that infection rates are lower in areas where the commercial fishery is intense. At infection rates of <10% of the population, infection by the parasite can still be kept low. Infected fishes are removed from the system during fishing and thus breaking the cycle. This is responsible for the low infection rates in areas with high fishing intensities.

So far, there is no evidence suggesting that the parasite might be harmful to the final consumer i.e. man and his domestic animals. The definitive host of *L. intestinalis* is a bird. The fish is also cooked before consumption. Sun drying kills the parasites that may not have found their way out of the fish on capture. This ensures that by the time *Rastrineobola* or any of its products is fed to domestic animals the parasite would have died.

Management of the fishery of *R. argentea*

Management of the *Rastrineobola* fishery on Lake Victoria requires measures that will ensure sustained exploitation of the fishery without harming stocks of other fish species that coexist with it. This essentially involves catching mature by-catch-free mukene. Among options considered as interventions to ensure this are:

a) Control of access to fishing grounds

This is the most important control measure that could avoid capture of immature *R. argentea*, Nile perch and tilapias is to limit fishing grounds. Many fish species, and their juveniles occur in sheltered bays and very close to the shores, areas they use as breeding and nursery grounds. They can be captured as by-catch (Plate 4.5.2) in the *R. argentea* fishery when these areas are fished.

Regardless of the mesh size used, size structure of *R. argentea* caught in closed bays for example at Bugungu and Kirinya in Napoleon Gulf shows high percentage of immature individuals.

Plate 4.5.2: *R. argentea* and by-catch

Likewise fish caught by the two nets in the open waters at Kalyandere and Nkata show low percentages of immature fishes (Fig. 4.5.4).

These small bays of less than 3 km in diameter and very inshore areas (less than 1.5 km from the shoreline) are unsuitable for mukene fishing and should therefore be declared closed fishing grounds on Lake Victoria. Open waters as those in Bugaia offer the best fishing grounds.

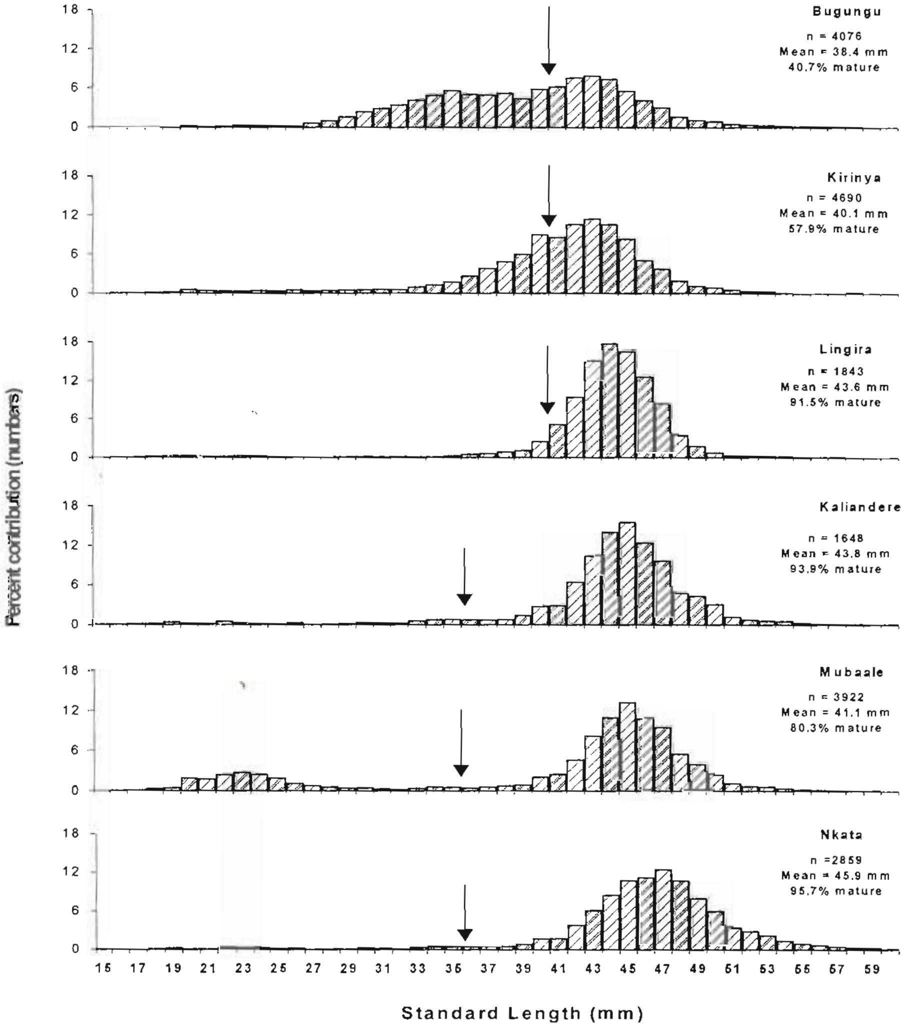

Fig. 4.5.4. Size structure of *R. argentea* harvested from various stations of Jinja waters of Lake Victoria. Arrows indicate size at first maturity.

b) Control of fishing gears and methods.

Fishing gears used in the capture of *R. argentea* on Lake Victoria include scoop nets, beach seines, lampara (boat) seine and lift nets. These gears are constructed using nets ranging in mesh sizes from 3 to 10mm stretched. Initially, beach seine nets in use were of stretched mesh size10mm. With the introduction of the lampara (boat) seine net, which required lighter material, the mesh size reduced to 5mm. The mukene fishery now employs 5 mm mesh nets. On Lake Kyoga, nets with meshes as small as 3mm are also in use.

Based on data collected in 1988, a 10 mm mesh net had been recommended as ideal for *R. argentea* exploitation (Ogutu-Ohwayo *et al.*, 1998). These data were however collected from a single fishing ground (Pilkington Bay) and covered one season. Data collected over a period of over one year (April 1992 to June 1993) from artisanal fishers using a 5 mm mesh net (Wandera 1999) and from experimental fishing using nets of the two meshes (Wandera and Taabu 2002) shows that these nets when operated in safe grounds may not be harmful to the *Rastrineobola* fishery. Much of the *Rastrineobola* presently with a mean size of 44 mm SL in the Ugandan part of Lake Victoria (Wandera & Taabu, op. cit.) is now smaller than 48 mm SL as it was in 1988. Most fish would now not be retained in the 10 mm mesh net and thus unprofitable for the fishermen. Due to the changes in size at maturity of *R. argentea*, size structure of catches from recommended fishing grounds in Lake Victoria shows that most fish currently retained in the 5 mm mesh nets are mature. The 3-mm mesh net is unsuitable for *Rastrineobola* fishing on Lake Victoria as it captures very high proportions of immature fish.

Because beach seines are operated from the shorelines, they capture high proportions of bye-catch. Juveniles of *Oreochromis* and *Lates*, which constitute the commercial fisheries in Lakes Victoria, Kyoga and Nabugabo, occur close to the shore and are therefore susceptible to beach seining. Using beach seine to catch mukene should therefore be discouraged. The lampara (boat seine) is a more suitable gear since it can be operated away from the beach and can thus avoid capture of near-shore dwelling fishes.

c) Establishment of closed fishing seasons

Recruitment periods, i.e. when high numbers of juvenile *R. argentea* are present in the fishery should be closed to fishing. While, as seen above, closed bays contain immature fishes throughout the year, Buvuma Channel and similar fishing grounds between Islands where the bulk of mukene fishing takes place on Lake Victoria experience high recruitment (juvenile *R. argentea* contributing more than 50% in the catches) only between November and December (Fig. 4.5.5). These months could be declared closed to *Rastrineobola* fishing. However the overall amount of juvenile *R. argentea* contributed by these months annually is not high enough to warrant closed season. As long as sheltered bays with high numbers of juveniles the whole year round are avoided, there should be no need for a season closed to *Rastrineobola* fishing on Lake Victoria.

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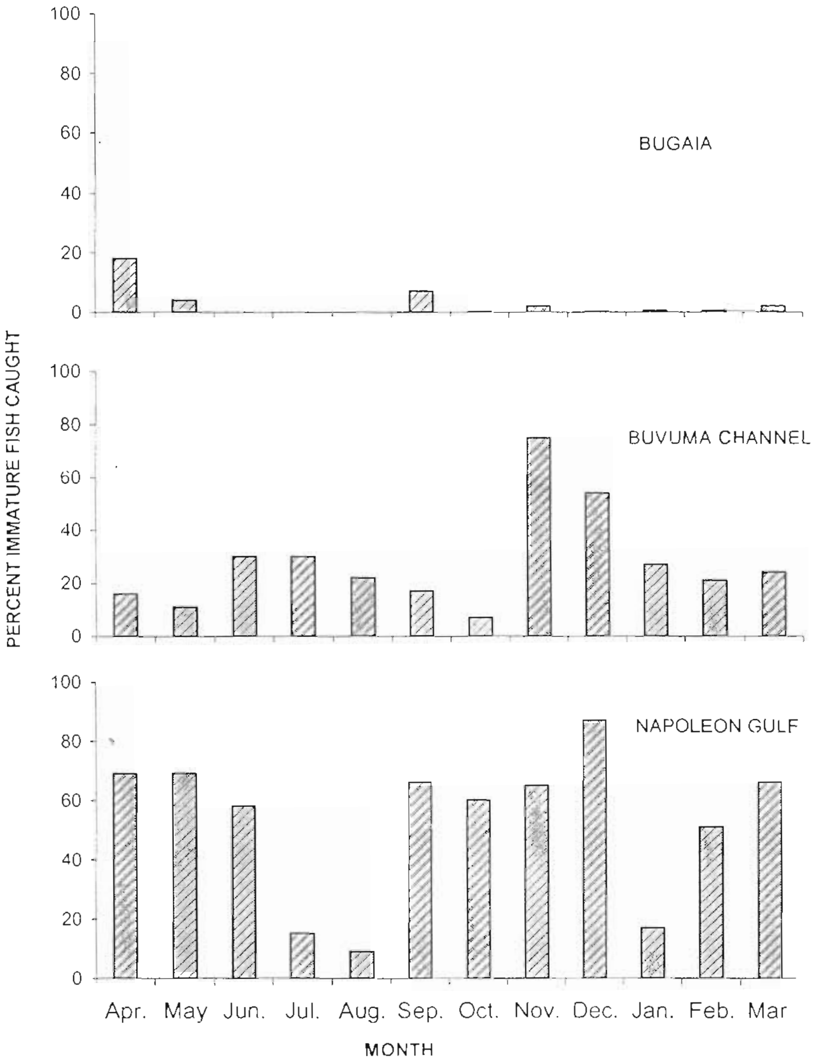

Fig. 4.5.5. Monthly percentage of immature *R. argentea* caught by artisanal fishermen in Napoleon Gulf Buvuma Channel and Bugaia

Conclusion and Recommendations

Fishing gears and methods for *R. argentea* on Lake Victoria have evolved from crude basket traps and scoop nets to beach seine, boat seine (lampara) nets and in some areas lift nets. Mesh sizes of these nets have also reduced from 10 mm stretched mesh to 5 mm.

Increased mortality due to the combined effect of increase in fishing pressure and predation by the Nile perch has led to changes in the life parameters of *R. argentea*. Population structure has changed from the predominantly large sized fishes to a smaller mean size. The species now grows faster and matures at a smaller size than before both the establishment of the Nile perch and the commercial fishery on Lake Victoria.

Zooplankton remains the main food of the species although lake fly larvae or pupae can be eaten when available. Two breeding peaks occur during the dry months of August and December/January, when zooplankton is abundant. Although *R. argentea* is infected by the parasite *L. intestinalis*, prevalence of infection by the parasite, is still low and likely to reduce further with increased fishing pressure. Fishing removes infected fishes thus breaking the reproductive cycle of the parasite.

Inshore waters and closed bays are nurseries for *R. argentea* and many other fish species. Fishing for mukene in these areas will capture large numbers of juvenile fishes. To avoid capture of juvenile *R. argentea* and other fish species as by-catch, fishing should be done in bays of more than 3 km in diameter and at least 1.5 km away from the shoreline. Thus closed bays and inshore waters should be avoided. Beach seines as gears for mukene capture should be discouraged since they are operated from near-shore waters that are nursery grounds to many fish species.