Socioeconomic & ecological considerations in the management of Lower Guinea rainforest rivers

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ABSTRACT

R.E. BRUMMETT & G.G. TEUGELS. 2005. Socioeconomic & ecological considerations in the management Lower Guinea rainforest rivers Low order rainforest streams in Central Africa represent the largest single riverine ecosystem on the continent. *J. Afrotrop. Zool* 1: xxx-xxx. Of the 8 million people who live in the Lower Guinea Rainforest, nearly 20% are more or less fulltime fishers and 90% fish at least seasonally. Estimates from Cameroon put the productivity of capture fisheries in forest rivers basins at 0.5 tons/km^2/yr or 260 000 tons with a cash value of over $500 million per year. The peculiar ecology of rainforest rivers generates and protects high levels of fish and other biodiversity, only a small percentage of which can be exploited directly for food. However, the retail value of many African rainforest fishes in the international ornamental fish trade is high, wholesaling for an average of $2.43 per fish. Despite these high values and reported high demand in Europe, the US and Asia, African fishes are in short supply due to the difficulty involved in their capture, holding and transport and the difficulty that overseas commercial breeders have had with their reproduction in captivity. To compete with established fish exporters and ensure that the resource is optimally exploited WorldFish is currently working with fishing communities in SW Cameroon rivers in Cameroon to organize villages, develop a business plan, establish protocols for culture of rare fishes and put in place an environmental monitoring plan to ensure sustainability.

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Key Words: sustainable exploitation, African rainforest, ornamental fish

R.E. BRUMMETT & G.G. TEUGELS. 2005. Socioeconomic & ecological considerations in the management Lower Guinea rainforest rivers Low order rainforest streams in Central Africa represent the largest single riverine ecosystem on the continent. *J. Afrotrop. Zool* 1: xxx-xxx. Le nombre de ruisseaux affluents de premier et secondaire niveau en zone forestière est évalué plus de 4 millions, équivalent à la moitié de celle de tous les cours d'eau africains réunis, ces ruisseaux constituent l'écosystème lotique le plus vaste du continent. 20 % des 8 millions de personnes habitant les forêts humides du Bas Guinée sont pêcheurs, et un autre 70% pêche périodiquement. Des estimations basées sur les plans d'eaux camerounais permettent d'évaluer la productivité des captures dans les bassins versants de ces fleuves à 0,5 tonnes/km²/an égal à 260 000 t. Ceci correspond à une valeur liquide de plus de US$500 millions par an, soit plus de 2 fois la valeur de tous les autres produits forestiers non ligneux réunis. L'écologie assez particulière des fleuves forestiers constitue engendre et protège une variété élevée de poissons et diverses autres composantes de la biodiversité, parmi lesquels un infime pourcentage peut être exploité directement pour la nourriture. Toutefois, la valeur individuelle de plusieurs de ces petits poissons (donc peu intéressant de valoriser comme aliment pour les humains) dans le commerce international des espèces aquariophiles est élevée. Malgré cette valeur élevée, liée à une forte demande sur les marchés européens, américain et asiatique, l'offre des poissons ornementaux d'Afrique reste faible en raison de la difficulté à les capturer, les conditionner et les transporter. De plus, les propriétaires d'écloseries à l'échelle commerciale rencontrent beaucoup de difficultés à les multiplier en milieu d'élevage. Affin de répondre à ces préoccupations, et partant contribuer à une exploitation plus optimale de la ressource, le WorldFish conduit actuellement des travaux avec des communautés de pêcheurs dans quelques cours d'eau au Cameroun, dans le sens d'améliorer les stratégies de capture, des manipulations, du conditionnement et du transport qui minimiseraient le stress et la mortalité. Lié à un plan de gestion durable, cela devrait déboucher sur une stratégie d'exploitation à extrapoler dans d'autres régions d'Afrique centrale.

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Mots Clé : gestion durable de pêches, poisson ornementaux, forêts Africain

INTRODUCTION

Since September 2000, the WorldFish Centre has been studying the biogeography and ecology of the rainforest rivers of the Lower Guinea Ichthyological Province in Southern Cameroon. A comprehensive review of the literature was published by Brummett & Teugels in 2004 and upon that base a series of field research projects have endeavoured to further characterize rainforest streams in terms of biotope and species diversity and abundance.

In partnership with the Organization for the Environment & Sustainable Development (OPED) a local non-governmental organization (NGO), a number of rainforest communities are being engaged in an effort to improve the efficiency and sustainability of river exploitation and management. The ultimate goal of this work is to establish functional village-based monitoring and management programs that would ensure the sustainability of commercialised and diversified natural resource exploitation. This paper is a synopsis of key findings to date and progress on the implementation of a socially, economically and ecologically sound management plan for Lower Guinea Rainforest rivers.

Rainforest Rivers

The Lower Guinea Ichthyological Province (Figure 1) extends over 500 000 km^2 (Mahé & Olivry 1999)in an arc along the NE corner of the Gulf of Guinea from the Cross River in the NW to just short of the Congo in the SE and includes some 50 major and minor rivers (Table 1). To the west and north, the Cross and Sanaga Rivers form the boundary with the Nilo-Sudan Province. To the east and south, lies the Congo basin, separated from Lower Guinea by a series of highlands, terminating with the Chaillu Mountains in the PR Congo.

Unlike the uplifting and rifting that affected eastern and southern Africa during the Miocene, the river courses in central Africa are extremely ancient, having not been substantially disrupted since the Precambrian (Beadle 1981, Peyrot, 1991a). The Lower Guinea Ichthyological Province corresponds closely with the extent of humid forest refugia during the last dry phase of the continent, 20 000 – 15 000 years bp (Maley 1987, Schwartz, 1991) and is similar to the distribution pattern of aquatic molluscs in the region (Van Damme 1984). It seems likely that a more broadly distributed group of archaic taxa related to the modern species in the Lower and

Upper Guinean provinces were repeatedly and/or progressively isolated during the several dry phases that reduced the extent of rainforest between 70 000 years bp and the present (Lévêque 1997), creating ideal conditions for both the preservation of archaic taxa and allopatric speciation.

Most Lower Guinean rivers are “blackwater”, with a mean pH between 5 and 6 and electrical conductivity between 20 and 30 μS/cm. Water temperature is always between 20 and 30° C. The water in these rivers is clear and tea-coloured as a result of the low dissolved nutrient concentration, low light (due to narrowness of valleys, canopy cover and often cloudy skies) and the large amount of allochthonous vegetative matter that falls or flushes into the water from the surrounding forest. Most of the larger rivers have a bimodal discharge pattern. In general, the magnitude of fluctuation is greater in the north (up to 8 m on the Lower Cross), while in the southernmost extent of the province, the partially spring-fed Niari and Nyanga exhibit minimal seasonality of flow (Peyrot 1991b).

Fish Biodiversity

In a review of West African riverine biodiversity, Hugueny (1989) found a strong correlation between species richness, watershed area and river discharge volume. Using these relationships, one finds that the fish fauna of the Lower Guinean Ichthyological Province’s river systems are disproportionally rich in relation to their sizes (Teugels et al. 1992). For example: the Cross River, with a watershed of 70 000 km^2, has an estimated 166 species (1 spp/421 km^2). The Nyong River has a watershed of only 28 000 km^2 and contains 107 species (1 spp/262 km^2). On the other hand, the Niger River, with a watershed of 1 100 000 km^2 has 254 species (1 spp/4 331 km^2). The Bandama, a rainforest river in Côte d’Ivoire with a drainage basin of 97 000 km^2, but with a fauna similar to that of the Nilo-Sudan, has only 95 species (1 spp/1 021 km^2) (Hugueny & Paugy 1995). Even the Congo River with a watershed of 3 550 000 km^2 and a very stable flow regime that has existed for at least 3 million years (Beadle 1981) has only 690 species (1 spp/5 145 km^2), although that figure is based on very inadequate sampling and will most certainly be found higher upon further exploration.

From the available literature, 29 families, 119 genera and some 500 species have been reported from the Lower Guinean Ichthyological Province (Brummett & Teugels 2004). Apart from the large number of small cyprinodonts (of which 70% are from the genus Aphiosemion), the freshwater fauna is dominated by the Siluriformes (6 families, 23 genera, ±100 species), the Characiformes (2 families, 20 genera, ±60 species), the Cichlidae (17 genera, ±50 species) the Cyprinidae (10 genera, ±80 species) and the Mormyridae (14 genera, ±50 species)[1].

Endemism in rainforest fishes seems to be relatively high (Teugels & Guégan 1994), although it is very difficult from the scanty documentation to determine exactly how many of the single reports for a species are due to endemism, lack of adequate distribution data or simple misidentification (Stiassny 1996). In particular, the Cyprinodontiformes are prone to endemism, with some species occupying only a few hundred square meters of bog, or an isolated creek. These small fishes, of which there are at least 100 species in the province, account for a substantial portion of the overall species richness.

A number of fishes move up and down the river according to their reproductive seasonality. Cyprinids and Citharinids, in particular members of the genera *Labeo* and *Distichodus,* are reported by fishing communities in the Upper Cross and Ntem Rivers of Cameroun to undertake spawning runs during the latter part of the long rainy season (October-December) when rivers are swollen and marginal forests are flooded, providing cover and food for larvae and fry (Lowe-McConnell 1975, du Feu 2001). The result of this is that species diversity measured over the year changes substantially according to which fishes are moving up or down stream at any particular point in time (Lowe-McConnell 1977).

The high fish biodiversity in the Lower Guinean forests is probably the result of three main factors: 1) the relative stability of the hydrological regime in these rivers since the Eocene (compared to the Nilo-Sudan zone), 2) the highly sculpted nature of the watershed (compared to both the Congo and Nilo-Sudan zones) and, 3) the large number of microhabitats created in rainforest rivers by the forest itself.

CURRENT EXPLOITATION

Welcomme (1976) estimated the total number of first order rainforest streams at over 4 million with a combined total length equal to half of all watercourses in Africa,

[1] The piscine biodiversity of the Lower Guinea Rainforest is not well sampled and what samples do exist are currently under review; hence the numbers indicated are only approximate.

making these the largest single riverine ecosystem on the continent. Of the 8 million people who live in the Lower Guinea forest, 20% are more or less fulltime fishers and another 70% (mostly women and children) fish seasonally. Estimates from Cameroon put the productivity of capture fisheries in forest river basins at 0.5 tons/km^2/yr (Mdaihli et al. 2003) or 260 000 tons for the entire forest. At the local wholesale price for fresh foodfish of approximately $2.00 per kg, this translates into a cash value of over $500 million per year.

Fishing in rainforest rivers is severely constrained by the large quantities of wood that decorate the streambed. By far the most common types of gear are passive set nets, traps and hook-lines of which there are a great variety in accordance with the diversity of the fish fauna. Also common, is a hook-and-line fishery dominated by small children and mainly targeting immature cichlids.

Fishing communities have learned to take advantage of spawning runs by constructing mesh barriers constructed of tree trunks and branches, bound together by vines and held in place by large stones. At the height of the rains, these structures are submerged and gravid adults pass easily over them. After spawning and spending several months upstream in flooded forests to forage, the adults once again head back downstream. However, by this time the water levels have declined and the fish find themselves trapped when they try to avoid the barrier. Juveniles apparently pass through the mesh without problem.

In Cameroon, reproductive migrations (“dok”) take place as waters rise in May and October. Doks involving *Labeo batesii* and *Distichodus spp*. have been documented in the Upper Cross and the Ntem, respectively. They typically last no more than a few hours or days. According to du Feu (2001), who interviewed fishers on the Upper Cross River, the village is alerted to the imminence of the spawning event by the upstream movement of fish. Two hours after the fish have passed, the water turns white with milt, at which time the villagers set nets to block the return of spent adults on their return downstream. Men do the fishing with cast nets or even clubs, while women clean and smoke the catch. Spawning sites, when known and sufficiently circumscribed, are generally protected or exposed to only limited exploitation (e.g., restricted access and/or gear).

There are at least two traditional fisheries that are allocated entirely to women. One, the “alok”, involves the construction of small earthen dams across first order forest streams during the dry seasons (January-April & July-August) to capture small Channids, Clariids and Mastecembelids (van Dijk 1999). As water levels decline, the dams prevent fish from migrating downstream. When the water gets low enough, the women wade in and bucket out the remainder, catching the fish by hand or with the help of baskets. This practice is widespread in both the Lower Guinean and Congo ichthyological provinces and adds substantially to the protein intake of forest communities. Another fishery that is the exclusive domain of women is the use of woven basket traps (“aya”) to catch the freshwater prawn, *Macrobrachium vollenhovenii*.

A small number (<5) of exporters currently dominate the limited trade in ornamental fishes. In general, the global average retail price for ornamental fishes is around $1.8 million per ton, compared to about $15,000 per ton for foodfish (Tlusty 2002). A small number of middlemen based in the commercial capital, Douala, leave orders for fish with the fishers who then enlist the assistance of village women and children to fill the order. Buyers generally provide basic equipment, including plastic bags, for holding. Captured fish are typically held in tanks in Douala for a period of days prior to packing and shipping by air to Europe, where the poor handling they endure often results in mortalities of up to 85%.

Access to a fishery is traditionally regulated by village leaders. Such management techniques as protecting spawning runs and the prohibition of certain gears are traditionally enforced through the use of magic charms or “ju-ju”. Members of the village are free to fish as long at they follow the basic regulations. Visiting fishers, of which there are considerable numbers (an estimated 80% of fishers on Cameroonian rivers are of Malian or Nigerian origin) must first seek permission of the village leadership and then pay a token fee, normally in the form of palm wine or a percentage of the catch.

Threats to the Resource

Increasing population and poverty, coupled with false valuations of rainforest biodiversity are leading causes of habitat destruction and over-exploitation (Stiassny 1996). Alien species (esp. *Oreochromis niloticus, Clarias gariepinus* & *Heterotis* *niloticus*), introduced for aquaculture and accidentally released into the Nyong River, have contributed to the disappearance of several indigenous species from commercial catches. In addition, the use of fish poisons has become increasingly frequent. Some of these are from local plants and cause only temporary harm, but most poisoners now use Lindane or Gammelin 20, an organochlorine insecticide used in cocoa production and highly destructive of the entire foodweb. Human deaths have been reported as a result of eating poisoned fish, and on the Ntem River in Southern Cameroon, insecticide fishing disrupted local aquatic ecosystems to the point where the electric catfish, *Malapterurus electricus* was able to extend its habitat into the small rivers where they were previously not found. Because of the powerful shocks emitted by this fish, women have been forced to abandon their traditional dam fishing in the area.

The greatest threat, however, comes from irresponsible logging. The Lower Guinea has already lost an estimated 46% of its forest cover to logging and conversion to agriculture and continues to lose forested watershed at an average rate of 7% per year (Revenga et al. 1998). In the process of removing the valuable timber, these (often illegal) logging operations also expose large amounts of bare earth and alter stream courses, increasing runoff and siltation. Road construction, saw mills and other infrastructure associated with logging attracts people into the forest, resulting in wholesale transformation of the ecosystem (Burns 1972; Garman & Moring 1993). Kamdem-Toham & Teugels (1999) described the changes that occur in and around the rainforest rivers in the Ntem River basin as a result of poorly managed logging operations:

- Absence of forest canopy above streams.
- Heavy siltation.
- Abundant primary production (algae).
- Uniform watercourse; absence of riffles; pools dominant habitat type.
- No cover/shelter for fish.

In terms of water quality, these changes in habitat resulted in large decreases in water clarity and dissolved oxygen, and proportional increases in temperature and conductivity. In undisturbed sites, water was clear brown with a mean temperature of 23.5°, dissolved oxygen between 2.5 and 4.2 mg/l (measured at noon) and electrical conductivity between 20 and 30 µS/cm. In sites affected by logging, the water was cloudy with a mean temperature of 34°, dissolved oxygen of <1.0 mg/l and average electrical conductivity of 48 μS/cm (Kamdem-Toham & Teugels 1999). Changes of this magnitude wreak havoc on aquatic life and may last for many years (Growns & Davis, 1991).

Currently, fishing communities have limited regulatory authority over the rivers they fish. Some traditional rules apply, but these are easily and often used to create inequalities by leaders who have mostly moved into town and exert their influence only through proxies. Logging companies have found an easy opportunity to exploit timber without regard for local communities or the integrity of the forest and the associated riverine ecosystem upon which they depend for their livelihoods.

SOCIOECONOMIC & ENVIRONMENTAL SUSTAINABILITY

A key aspect of sustainable management systems is the valuation of resources from the point of view of indigenous people (Sheil & Wunder 2002). For example, in the case of forests, timber may not be the largest potential source of local incomes (Peters et al. 1989), but since timber companies have already made substantial investments in equipment, infrastructure, and market development there is a comparative advantage of large-scale tree exploitation in terms of short-term realizable profits. Also, profits accrue at a level and in such a way that they are more accessible to tax collectors. A similar logic applies to large versus small-scale capture fisheries and, hence, the continued presence of foreign fishing fleets off the coast of Africa at a time when local fishing communities are suffering extreme poverty and declining catches. In contrast to these large-scale operations, the value of most non-timber forest products and artisanal fisheries accrue locally and in a disperse manner that makes accounting and taxation virtually impossible.

However, it has been shown that small businesses can produce wider economic growth and prosperity per dollar invested than larger enterprises. Delgado et al. (1998) reviewed results from Burkina Faso, Niger, Senegal and Zambia and found that "…even small increments to rural incomes that are widely distributed can make large net additions to growth and improve food security." Winkelmann (1998) identified interventions that lead to improved incomes at the level of the rural resource manager as "having a larger impact on countrywide income than increases in any other sector." Governments interested in fighting rural poverty should be seriously considering how smaller-scale investors can be brought to the fore in their natural resource exploitation strategies.

From the point of view of rural communities, directly confronting the timber and large fishing companies over ownership of resources is an uphill task. For artisanal fishers who are being required to increase mesh sizes and respect closed seasons, watching even small trawlers take several tons of fish with a single haul seriously undermines the credibility of regulatory bodies, whether local or national, whether the fish stocks are related or not. In fact, rather than struggling to protect remaining resources, local fishing communities confronted with expropriation have often joined in the ravaging of their own resources in order to capture whatever profit they can before the big companies arrive.

A first step in revaluing forest resources and enforcing sustainable management is the quantification of the biodiversity in question. Several attempts have been made at the generation of a workable Index of Biotic Integrity (IBI) such as that used to track changes in temperate zone streams, but parameterization has been a problem. The best effort to date in Central Africa is that of Kamdem-Toham & Teugels (1999), but gaps still exist. Existing datasets on aquatic biodiversity and ecology in Central Africa are weak, at best, and this makes it very difficult to develop quantitative tools (Lévêque 1997).

Coupled with this quantification/valuation exercise should be the development of improved management and exploitation strategies that could actually increase the value of aquatic ecosystems and justify their preservation, while at the same time improving rural livelihoods. Forest river ecosystems are currently unmanaged and unregulated in any formal sense. The Department of Fisheries in Cameroon does not even have a policy or planned program of work on riverine ecosystems outside of a few small dams (M.O. Baba, Director of Fisheries, personal communication, Yaoundé, April 2002). The most widely promoted method of increasing the productivity of aquatic ecosystems in Central Africa is to increase fishing pressure through the introduction of subsidies on motors and other fishing equipment, and this without any clear idea as to the size of the resource or level of current exploitation.

While some increased pressure might be warranted in some areas, the upper limit for this strategy is probably already in sight for most places. Careful regulation of fishing gear and seasons based on scientific data might be a more widely applicable strategy for increasing catches of certain species in some rivers. The greatest potential for improving profitability while conserving ecosystems might lie with species of value as ornamental aquarium fishes. These are unusually abundant in African rainforest rivers and wholesale at an average of $2.43 per fish. Keeping prices high and availability low is the difficulty involved in the capture, holding and transport or African river fishes. More importantly, reproduction of forest river fishes has been difficult or impossible for the large commercial breeders in Singapore and Florida, most likely due to the fact that outside of the special and complex rainforest ecosystem, these fishes seldom reach sexual maturity.

To investigate the potential for commercially viable and environmentally sustainable ornamental fisheries, WorldFish, has initiated a series of activities aimed at the development of community-level exploitation and management of ornamental fishes in SW Cameroon. Although the initial project is focusing on Cameroon, the results should be immediately relevant to many of the countries in the Lower Guinean forests. In addition, a similar style of commercial exploitation based on additional ecological data collection and monitoring could be adopted in the Congo Basin.

Community-Based Management

To justify conservation of aquatic biodiversity from the point of view of local communities, the value of resources must be substantial and accrue locally. There must also be a system of governance that empowers local communities and authorities to set and enforce exploitation methods and quotas. Adaptive co-management (ACM), where communities undertake to sustainably manage their own resources, is an emerging concept that has been used in a number of places (Bennum et al. 1995). By transferring management and enforcement to local communities, ACM aims to increase control over natural resources while reducing central government expenditures. ACM of freshwater capture fisheries is currently being tested in a number of African countries (Khan et al. 2004). To date, the track record of community management and conservation interventions is mixed, but new knowledge about how and why they might be made to work better and the time frames involved is encouraging (Hulme & Murphree 2001).

The typical problem facing small-scale natural resource businesses is competition with unregulated poachers and larger-scale investors once markets are developed and the profitability of a product demonstrated (Sunderland & Ndoye 2004). Luckily, or unluckily, a recent survey of low order forest rivers in SW Cameroon (Table 2) found that, the total value of the ornamental fish species existing in the wild at any of the sites sampled is insufficient to support any significant expansion of the exploitation rate. Most of these species have very low fecundity and cannot be expected to rapidly repopulate heavily exploited streams (Kamdem-Toham & Teugels 1998). Only *Benitochromis spp., Epiplatys sexfasciatus* and *Procatopus spp*. exist in any great numbers and even if the resource could support a total annual removal/replacement of the stock, only a few pristine sites within Korup National Park could return more than a few hundred dollars in annual revenue to villages.

On the other hand, among those identified in SW Cameroon, several genera are of particular interest to the ornamental fish trade, including: *Aphyosemion, Benitochromis, Brienomyrus, Brycinnus, Mastecembelus, Chiloglanis, Doumea, Parauchenoglanis, Pelvicachromis* and *Procatopus.* Retail value of these fishes range from $2.00 to $20.00 in Europe. Partial enterprise budgeting for a delivery of 8.5 kg of ornamentals (the minimum amount to obtain discounted air freight) sold wholesale at $1.00 per fish shows a substantial potential for profitability (Table 3).

A Plan for Action

Capture and export of wild-caught fish can only be profitable for a very few individuals, and is unlikely to add sufficient value at the community level to justify conservation. Worse, if a lucrative market were developed for these fishes, poachers or any large-scale fishery could put vulnerable species or populations at risk.

Aquaculture might represent a viable alternative. By using existing fish reproduction and nursing technology, sexually mature broodfish of rarer and more valuable species captured from rainforest rivers can be artificially reproduced. Subsequent export of only those individuals reared in captivity will not only protect against over-exploitation of natural stocks. Because sexually mature broodstock will continue to be available only from the wild, local incentives to protect the ecological integrity of the river will be strong. International oversight and certification of exported fish as cultured will help ensure a competitive advantage to those producers who operate responsibly.

To lay the basis for such a management plan, the above-mentioned ecological characterization of key river basins was conducted (Table 2). Sampling sites were carefully selected based on the range of biotopes, the stream order and the presence of natural and/or artificial barriers to the distribution of fishes. In each sampling locality, physico-chemical data were collected and the habitat described in detail, including depth, vegetation in the water, percentage of canopy cover and substrate type.

Using the data collected, a detailed monitoring program is being put in place at a selected number (4 or 5) of stations, the results of which will provide information on: 1) the zonation of fishes, 2) the diversity patterns of fish assemblages and, 3) patterns of microhabitat use. This information will in turn be used to develop an Index of Biotic Integrity (IBI) based on the fish assemblages for the assessment of the impact of anthropogenic activities. The IBI is based on three categories of metrics, all related to the fish population. These are: (a) species richness and composition; (b) trophic composition; and (c) fish abundance and condition. Each metric receives a score. The sum of the scores for each of the stations indicates the degree of environmental disruption. The IBI can then be used to develop a less intensive, but longer term, monitoring and evaluation program to certify the sustainability of the exploitation of each species captured and exported.

Ownership and control of resources are key issues for sustainable management. At present, forest rivers fall within the regulatory domain of the Ministry of Animal Industry and Fisheries (MINEPIA) not the Ministry of Environment and Forests (MINEF) and, unlike trees, do not qualify as community resources under recent community forestry legislation. Within this context, the WorldFish Centre, the Organization for the Environment & Sustainable Development (OPED) and two of the existing commercial ornamental fishers are working together with four villages on the Muyuka, Mungo, Koki, Mundame, Mpundo, Ombe, Moliwe and Limbe rivers to put in place a community management, environmental monitoring and business plan for sustainable ornamental fish exploitation. Overcoming the high level of distrust of government that exists in most African countries, and misunderstanding of the motivations for foreign experts to get involved in their internal affairs (many of which are illegal) requires extensive consultation and contact time. WorldFish and its collaborators in Cameroon, were in contact with these villages for nearly two years prior to suggesting any changes in their current exploitation strategy.

The first step in organizing the fishery has been the formation of legal entities to which regulatory authority can either be assigned or assumed. To achieve this, OPED has been using participatory learning and feedback mechanisms to assist in the setting of group objectives, the elaboration of by-laws and the formal application to government for legal status. In Cameroon, this process can take from six months to several years to complete.

As the legalization process moves forward, fishers receive training, also from OPED, in small business management, including bookkeeping, cash flow planning and marketing. Unfortunately, as is the case for many African villagers, the level of education among forest fishing communities is very low, seldom above the primary level. The majority of fishers are young men, between the ages of 15 and 25. Communication is difficult in terms of language, technology and culture. A heavy emphasis placed on the use of local knowledge, approaches and manpower has helped to resolve misunderstandings and avoid wasting time.

It is interesting to note that even with the limited training undertaken so far in these villages, the awareness of local ownership of natural resources is rapidly increasing. The main reason that forest river villages are interested in a fishery co-management initiative is economic. People see an opportunity to make money from the sale of these resources and they perceive a clear threat from outsiders who might like to cut in on the profits. Since the beginning of the group formation and awareness building meetings, many fishers have refused to fill orders coming from Douala and are instead looking for marketing alternatives, including roadside sales. This has created some conflict with existing exporters, but by and large these have been easy to resolve through discussion. As the wild stocks of most species have declined over recent years (according to the fishers themselves) almost all players in the business have come to see the need for management and regulation.

Of course, being organized in legal groups does not in itself protect natural resources from over-exploitation. To justify investments and determine the ultimate level of sustainable capture, one must have some idea of the total size of the resource. Likewise, a system for setting and enforcing catch limits will be crucial. It is upon the basis of the ecological studies and the IBI that this next, and arguably most critical, round of learning, training and collective action will be undertaken.

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Table 1. Major rainforest river systems in the Lower Guinean icthyological province. Main tributaries are in parentheses. From: Brummett & Teugels (2004).

River	Country	Length (km)	Watershed (km^2)	Discharge (m^3/s)	Number of Species
Cross (Manyu, Mbu, Mé, Mfi)	Nigeria – Cameroon	600	70 000	570	166
Ndian	Cameroon		>1 000		
Mungo	Cameroon	200	4 570	164	32
Wouri (Dibomba, Makombé, Menoua, Nkam)	Cameroon	470	11 500	308	51
Sanaga (Djerem, Lom, Mbam)	Cameroon	1 043	131 000	2 072	124
Nyong (Mfoumou, Kélé, So'o)	Cameroon	520	27 800	443	107
Kienké/Kribi	Cameroon	130	1 100		
Lobé	Cameroon	130	2 305	102	32
Ntem (Kom, Nlobo, Mboro. Mvila, Mvini)	Cameroon	460	26 300	290	110 +
Rio Muni (Mbini)	Equatorial Guinea	365			
Mitémélé	Equatorial Guinea				
Gabon (Mbé, Komo)	Gabon				
Ogooué (Abanga, Ayina, Dilo, Djoua, Ikoy, Ivindo, Lassio, Lébiri, Lekedi, Lékoko, Lékoni, Leyou, Lolo, Liboumba, Mounianzé, Mpassa, Mvoung, Ngounié, Nouna, Nsyé, Offoué, Okano, Oua, Sébé, Wagny, Zadié)	Gabon	920	205 000	4 400	185
Nkomi	Gabon				
Ngové	Gabon				

Ndougou	Gabon				
Mouklaba/Nyanga	Gabon				
Kouilou (Bouenza, Lékourmou, Louéssé, Mpoukou, Niari)	P.R. Congo	605	60 000	700	87

Table 2. Fish species by river and biotope in SW Cameroon, after Brummett et al. (in press).

River	**Moliwe**	**Koke/Ekona**	**Limbe**	**Mana**	**Iriba Inene**	**Okoto**	**Rengo**		**Akpasang**
Stream Order	**2**	**1**	**2**	**1**	**2.5**	**2**	**1**	**2.5**	**1**
Aphyosemion "akpa-yafe"									8
Aphyosemion	15								
Aphyosemion bivittatum				4	2		37	5	5
Awaous lateristriga			2						
Barbus batesii	3			8	38		1		
Barbus callipterus	48			63	39		181	27	17
Barbus camptacanthus	15	75		71	2	175	73	20	26
Barbus trispilomimus	52	11							
Barbus progenys					38				
Benitochromis conjunctus				2			19	23	
Benitochromis	35								
Benitochromis ufermanni				20	92		2		20
Brienomyrus brachyistus				3	7		21	5	
Brycinnus longipinnus			21						
Chiloglanis disneyi		16							
Clarias camerounensis		5			8			4	8
Doumea thysi					8		5		24
Eleotris vittata			8						
Epiplatys sexfasciatus	2	182			180	268	143	28	45
Hemichromis elongatus			97						
Labeo batesii					30		5	8	
Malapterurus electricus					3				
Mastecembelus spp.					3		3	3	8
Oreochromis niloticus	2								
Parauchenoglanis spp.						24			
Procatopus KORUP				230	87	225	40	17	
Procatopus similis	37	57							
Pelvicachromis taeniatus	5								
Sarotherodon			5						
Tilapia guineensis	1			2	10				
Varicorhinus spp.				3	51				5
Number of Species						**5**			
Shannon Index	**1.504**	**0.769**	**0.704**	**1.258**	**1.057**	**1.247**	**1.324**	**1.523**	**1.362**

Table 3. Partial enterprise budget for ornamental fish export from Cameroon to Germany	
Costs	
Shipping per 208.5 kg (100 l water + fish + containers ≈ 5 boxes) @ $3.00/kg	$ 600
Veterinary fees in Germany	$ 30
Local transport (300 km x $0.16/km)	$ 48
Fish feeds	$ 22
Maintenance	$ 100
Payment to fishers ($0.25 per fish)	$ 425
Government Tax (as of January 2005)	$ 100
Total	$1,225
Revenues	
Wholesale of 1700 fish (@ 5 g x $1.00 per fish)	$1,700
Profit per five boxes shipped	**$ 375**

Figure 1. The Ichthyological provinces of Africa, based on Roberts (1975) as modified by Lévêque (1997) and redrawn according to new hydrological basin mapping published by FAO (2000). 1 = Maghreb, 2 = Nilo-Sudan, 3 = Upper Guinea, 4 = Lower Guinea, 5 = Congo Basin, 6 = Quanza, 7 = Zambezi, 8 = East Coast, 9 = Southern, 10 = Malagasy.