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Participation of local fishermen in scientific fisheries data collection: a case study from the Bangweulu Swamps, Zambia

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Abstract The feasibility of participation by local fishermen in scientific fisheries data collection for stock assessment is described. Artisanal fishermen from the Bangweulu Swamps, Zambia, collected length-frequency data for 1 year from their catch using the main fishing methods employed in the swamps as well as experimental gears. It is shown that with this method, it is possible to obtain large quantities of reliable and relatively cheap length-frequency data that allow for a full length-based stock assessment, including cohort analysis.

There are also indications that with a proper feedback of the findings by the research institutions to the fishing communities, this sampling method might enhance the awareness of exploitation patterns and the management consequences. This may be seen as a first step in preparing the communities to take up their role in a community-based approach in the management of the fish resources.

KEYWORDS: artisanal fisheries, community-based management, length-frequency data, stock assessment, tropical fisheries.

Introduction

Fisheries scientists and managers spend much of their time collecting data by a variety of techniques for a variety of reasons. Efficient and effective data collection is fundamental and can mean the difference between a successful management or research effort and one that ends in inconclusive or useless information (Williams 1977; Johnson & Nielsen 1983). Traditionally, fisheries data used for estimates of annual fish production, species composition and effort, etc., in inland African fisheries are collected by research officers and assistants from governmental research institutes. The methods used in the various countries are usually quite similar and originated from proposals by the UNDP / FAO Fisheries Division in the 1970s (Bazigos 1974;

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Caddy & Bazigos 1985). The methods used are mainly experimental gillnet surveys (GNS) for biological parameters and fishery-independent data such as frame surveys (FS) for inventories of all fish production factors, and catch and effort surveys (CAS) for daily catches and effort data. Due to excessive costs, the collection of regular data typically follows a stratified simple random design (Bazigos 1974; Caddy & Bazigos 1985), where intensity is heavily dependent on available manpower and economic resources. The precision, accuracy, usefulness and cost-efficiency of these methods have some times been questioned (Orach-Meza 1991) and the reliability of landing statistics is a notorious problem in many African inland fisheries. However, few other sampling alternatives have been developed or tried out (Cowx 1996).

In Lake Bangweulu, Northern Zambia, the same established data-collection methods and sampling design (Bazigos, Grand & Williams 1975) have been employed for many years. Multi-mesh experimental gillnet surveys, operated by the Department of Fisheries (DoF), have been used for biological data collection in the open waters since 1971 and CAS surveys have been performed at various landing places. However, the frequency and consistency at which sampling was done varied greatly over the years, depending on availability of financial and manpower resources, making the data too sparse or unreliable to allow for meaningful analysis.

When experimental GNS started for the long-neglected Bangweulu Swamps in 1993, it soon became apparent that the number of fish of different species caught in these gill nets was inadequate to allow for a realistic assessment of fish stocks in the swamps. The results during the first 4 months of sampling, at an intensity of 6 days per month, showed that only a tremendous increase of fishing effort, i.e. more nights with more nets, would result in sufficient data for some of the species. However, manpower resources at the station were limited and the surveys would become too expensive. In addition, field trips into the Bangweulu Swamps are strenuous. These considerations made an extended sampling schedule undesirable.

To solve the problem, it was decided that a number of full-time professional fishermen living in the swamps should be selected and engaged to carry out part of the sampling, in parallel with the already established monthly experimental GNS by the DoF. Each person fishing received a basic monthly fee for measuring and recording his catches. Some would use their own gear and some would be issued with experimental gill nets, but the fish caught would belong to the fisherman and he would be free to fish when and where he wanted, as long as some basic information was recorded.

The objectives of this paper are to describe and evaluate this new sampling strategy, where local fishermen participated independently in a scientific data-collection programme, to obtain large enough quantities of reliable catch data and length frequencies for stock assessment purposes. The approach was called the fishermen data-collection system (FDC) to separate it from the traditional GNS.

Material and methods

Study area

The Bangweulu Swamps, where the sampling was carried out, are part of a large complex of rivers, shallow lakes, floodplains and swamps in Northern Zambia (Fig. 1). This huge and

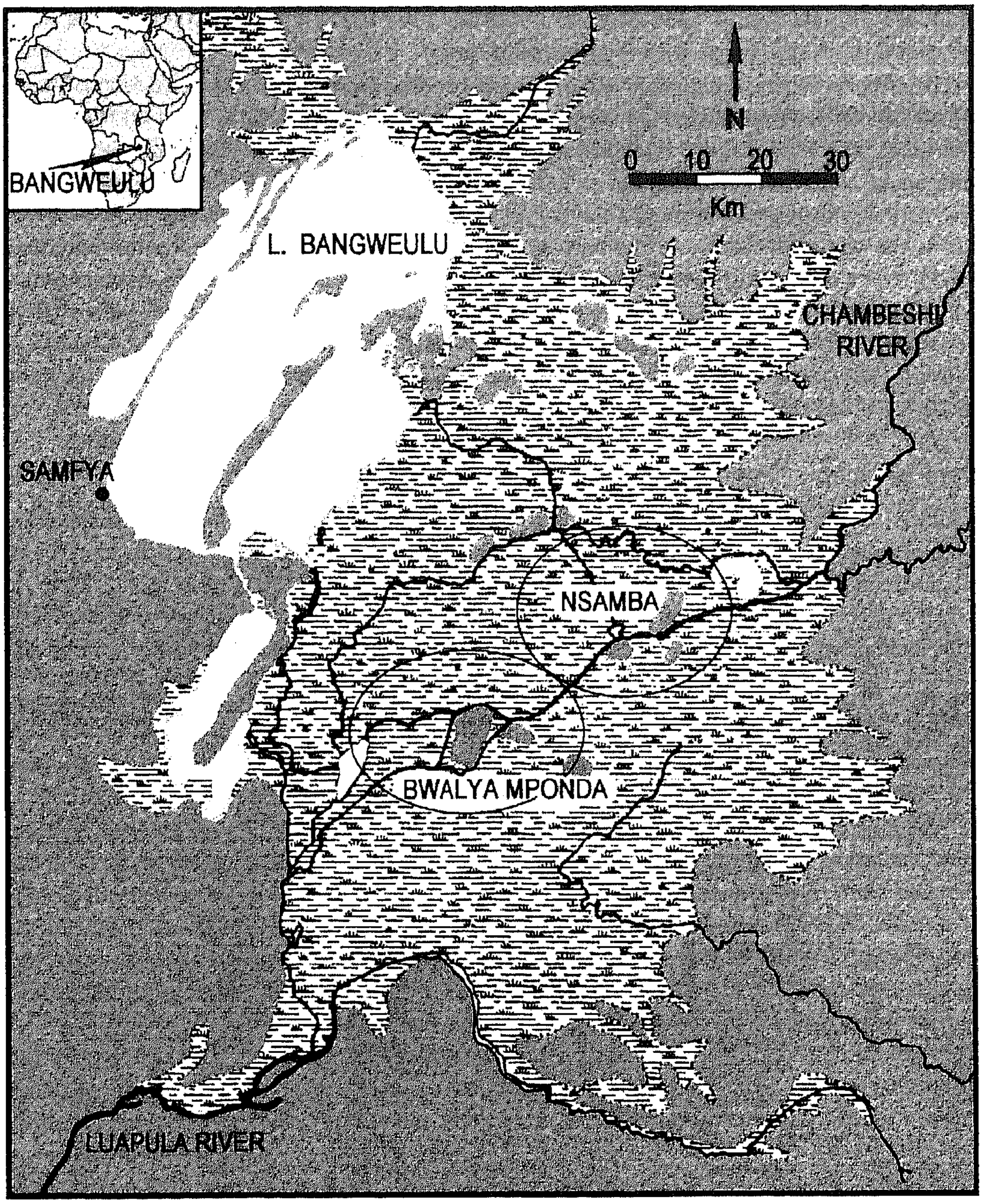

Figure 1. Map of Lake Bangweulu and the swamps in Northern Zambia with indication of sampling areas (map drawn by Elin Holm).

inaccessible area is around 790 000 ha, of which 520 000 ha are permanent swamps (D. W. Evans, unpublished data). The swamps produce the bulk, i.e. as much as 70% in 1993, of the total yield in the Bangweulu fishery (Toews 1977; J. Lupikisha, unpublished data). The estimated average annual yield between 1966 and 1991 varied around 12 000 t with a range of 7500 to 15 700 t (J. Lupikisha, unpublished data).

The fishery in the Bangweulu Swamps can be characterized as an artisanal, small-scale gillnet fishery. Dugout canoes are the main fishing crafts, representing 97% of all boats used. The most important fishing methods are stationary gill nets, beach seines and lake seines, kutumpula, and weirs. Kutumpula is a fishing method by which gill nets are set in close association with vegetation in shallow water. The fish, mainly cichlid species, are then driven out of the vegetation and into the nets by striking the water with knobbed poles (Mortimer 1965). Weirs are fishing devices used in floodplains. They consist of an earth dike across the floodplain which is intersected by a number of channels, blocked by valved conical traps (Bell-Cross 1971). Weir fishing is highly seasonal and restricted to the flood season.

In the latest census, about 10 200 people were involved in fishing activities, using a total of 21 000 gill nets (H. J. Ticheler & B. Chanda, unpublished data).

Data collection

Initially, 12 literate, well-known, and established fishermen in the local swamp communities were selected for participation in the sampling programme. Their fishing practices represented the traditional fishing activities in two sections of the Bangweulu Swamps (Fig. 1). Of the 12 fishermen, six were given a set of standard experimental gill nets (25–140 mm stretched mesh, with increments of 12.5 mm) as used by DoF. Among these six fishermen (Table 1), one also

Table 1. Number of records collected by fishermen (FDC) and the Department of Fisheries (GNS) in the period from July 1994 to July 1995

Fisherman ID number[1]	Fishing method	No. of months sampled	Total no. of records	Mean no. of records month^{-1}	Total mean method^{-1}
1	Experimental	12	24 515	2043	
2	Experimental	12	17 854	1488	
3	Experimental	11	23 413	2128	
4	Experimental	10	27 173	2717	
5	Experimental	12	41 097	3425	
6	Experimental	11.5	38 702	3365	2528
2	Commercial	3.5	2920	834	
6	Commercial	11	61 003	5546	
8	Commercial	11	10 100	918	2433
2	Kutumpula	5.5	2435	443	
8	Kutumpula	12	14 231	1186	815
1	Seine	12	64 084	5341	
7	Seine	11	35 213	3201	4271
DoF	Experimental	12	8140	678	678
			Total: 370 880		Mean: 2145

[1]The first column shows the identification number of the fishermen using one or more different types of fishing gear (column 2). Fishermen with ID numbers 9–12, including both using weirs, are dismissed from the study (see the results) and are not included in this table.

recorded his own seine catches, and one included his own commercial gillnet and kutumpula catches (non-experimental gill nets are subsequently referred to as commercial gill nets). The six remaining fishermen recorded only catches from their own fishing gears which were: weirs (two fishermen), commercial gill nets (one fisherman), seines (two fishermen) and kutumpula (one fisherman). Thus, inclusion in the sampling programme of all major fishing gears employed in the Bangweulu fishery was attempted.

The information collected by the fishermen was kept to a minimum and made as simple as possible. For each catch, only date, time of fishing (day or night), fishing method, and locality were recorded. Each individual fish caught was recorded by species, mesh size in which it was caught, and the length to the nearest centimetre. Settings with no catches were also recorded. It was unrealistic to ask the fishermen to record an unbiased subsample of the catch only. Neither were they requested to take gonadal stages nor measure weights, because measuring the whole catch for all these parameters was too time consuming, with the risk that they would lose interest in the work. In addition, the maintenance and calibration of weights, and the subjectivity in gonad interpretation, would be a potential problem.

A one-day training session on data collection was organized for all the fishermen and their assistants. Main components of the training were: (1) to explain the background of the data collection; (2) to check on their ability to identify fish species; and (3) to provide instructions on the measuring of fish and the recording of data. Vernacular names were used for species identification and recording. For that reason, a checklist with vernacular and scientific names was compiled for the data entry. The fishermen were instructed to take fork length from species with forked caudal fins, while for the other species, total length was used. Each fisherman was issued with a locally made measuring board, a data-recording book, a ruler and pencils. Mounting of both the experimental and commercial nets was done according to the preference of the individual fisherman. The area of each net was measured after mounting.

Direct benefits for the fishermen who participated in this programme were free supply of fishing gear for the six fishermen with experimental gill nets, a fixed monthly sampling wage for fishermen who would fish with their own gear (initially set at K 8000; 1000 Zambian Kwacha (K) was approximately equivalent to US$ 1), and all fishermen would receive an additional sampling bonus of maximum K 4000 per month for persistent and good-quality data.

Monthly supervisory visits were made to the fishermen in conjunction with the ordinary DoF gillnet surveys. Each fisherman was checked on how he was measuring and recording fish, fishing nets were inspected regularly, and the recorded data were collected during these visits, exchanging the data record books for new books. Emphasis was always put on the quality of the records and not the number of records so it was stressed that performance would be continuously checked.

In between two supervisory visits, the data were entered into PASGEAR (Gayanilo 1995; J. Kolding, unpublished data) at the DoF station. This software is a customized database package for experimental fishery data and designed for fast and easy data entry. In addition, it gives a series of first-level analyses, e.g. length-frequency distributions by mesh sizes or time, which enables the realism of the data recorded by the fishermen to be assessed. Data entered into PASGEAR can subsequently be aggregated in various forms and directly exported to LFSA (Sparre 1987), ELEFAN (Gayanilo, Soriano & Pauly 1989) and FiSAT (Gayanilo, Sparre & Pauly 1996), or other standard statistical packages for further analysis.

Results

Quality of the data

A major concern was that the fishermen would produce false and unreliable data which would be of no use. However, although the collection scheme was kept as simple as possible, the individual recording of species, length, gear and mesh size was detailed enough to check the quality of the data. The basis of this presumption was that it was considered nearly impossible for a local fisherman to generate a series of false catch-curves in a range of mesh sizes, and furthermore record these data in a random manner. Therefore, by simply plotting the length frequencies against the various mesh sizes (Fig. 2), a first impression of the quality was easily

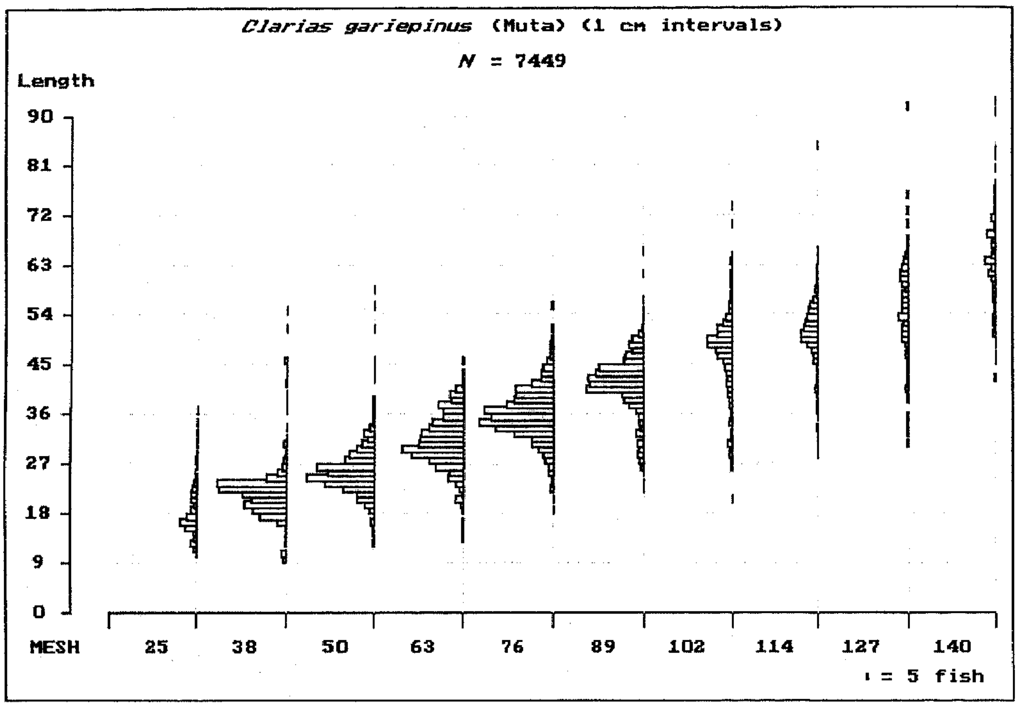

Figure 2. Example of catch data from experimental gear collected in the Bangweulu Swamps by local fishermen. Length frequencies of African catfish, *Clarias gariepinus* Burchell, by individual mesh sizes. This plot helps to assess the quality of the data. Vertical axis is length in cm. Horizontal axis shows mesh size and individual histograms the length frequency at each mesh size.

established. In addition, given the above considerations, then adding the probability of being capable of modifying the false catch-curves with changes in growth would seem even more unlikely. Therefore, plotting the length-frequency data over time intervals (Fig. 3) gave a second possibility for examining the incoming data. Lastly, comparing relative abundance, species composition, and the length-frequency curves among the different fishermen and with those from GNS would also reveal irregularities.

By using these methods there were, with a few exceptions mentioned below, no indications

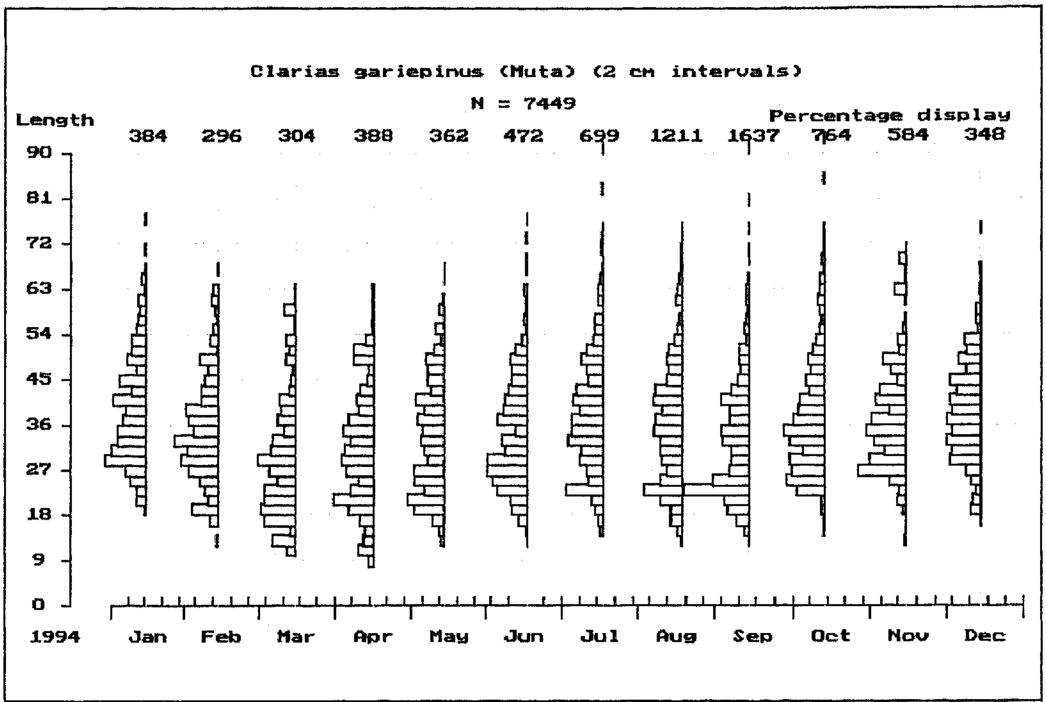

Figure 3. Pooled length frequencies by time intervals (months) for visual examination of modal progression. *Clarias gariepinus* data collected by local fishermen using experimental gears in Bangweulu Swamps. Vertical axis is length in cm; length-frequency histograms (bar width, 2 cm) are expressed in percentage of monthly numbers shown at top. The monthly length frequencies are positioned on the horizontal axis according to the weighted number of observations within a sampling month. The minor tickmarks on the horizontal axis indicate the weeks within a year. Note that in this figure data from 1994 and 1995 are combined.

that the data collected by the fishermen were falsified throughout the sampling period. On the contrary, the fishermen managed within a year to collect nearly 400 000 individual fish records (Table 1). Unfortunately, however, both weir fishermen had to be laid off at an early stage because they did not grasp the concept of data recording and tended to select and record the large specimens only. No proper replacement could be found for this fishing category, mainly due to the greater inaccessibility of the weir fishing areas. Three other fishermen, who were detected producing unrealistic data and admitted this on inquiry, were discharged from the sampling programme at a later stage. The first one was found recording false data and the book already contained records for days still to come. The second fisherman recorded extremely large numbers of big fish in nets with small meshes. The third fisherman simply copied fish records from one page to the other and always changed the species at exactly the end of the page, showing that he was either not measuring the whole catch or just making up data. This fisherman, using a seine, was replaced and the remaining fishermen produced sound and reliable data. These checking methods were considered effective and easily applied.

Inputs and outputs of the two sampling methods

Initial capital inputs for both the old (experimental gillnet surveys) and the new (involving local fishermen) sampling methods were similar. In each case, a boat with an outboard engine and camping equipment was required. Investments in fishing nets were also practically identical for the two methods because the nets used by the Department, although fewer in number, were much bigger.

An annotated comparison of recurrent costs of the two methods is made in Table 2. Although the number of staff and field days (Table 3) for FDC was less than for GNS, total costs were still higher, because of the wages of the fishermen and the overtime needed to pay fisheries assistants to enter the large amount of data collected. However, looking at costs per individual fish record (Table 3), then data collected with FDC were nearly 60% cheaper compared with GNS records.

Table 2. Overview of monthly running costs (in US$) for the two different survey methods

Cost category	GNS	FDC	Comments
Staff	210	160	Only extra costs involved in fieldwork are considered, i.e. allowances and not salaries
Fuels	150	120	GNS covers longer distances
Stationery	5	20	Mainly data-recording books for fishermen
Wages/bonus	–	152	Does not apply for GNS
Data entry	30	234	Overtime paid to fisheries assistants
Net mending	42	14	GNS employs one person for net mending, FDC supplies only twine to the fishermen
Miscellaneous	10	5	
Total	447	705	

Table 3. Comparison of the two sampling methods as staff requirements and data output

	GNS	FDC
Number of staff required	4	2
Number of field days required	6	4
Number of gear types sampled	1	4
Average number of records per month	678	2512
Cost per record (US$)	0.66	0.28

After a 12 month period of data collection, the number of records collected by fishermen per fishing unit greatly exceeded the number of records collected by DoF. Only one fisherman (no. 2, Table 1), employing three different methods, collected fewer records than DoF in his kutumpula nets. In general, seine nets produced the highest number of records, and GNS by DoF the lowest number of records per fishing unit and per month (Table 1).

One unexpected result of the new data-collection method was the relatively large discrepancy in the catch composition between the GNS surveys and the FDC data using the same

Table 4. Relative catch composition, percentage numbers, for the different sampling gears used in this study. Data collected from July 1994 to July 1995, FDC broken down by method

		FDC			
Species	GNS 720[1]	Experimental 10 339[1]	Commercial 818[1]	Kutumpula 283[1]	Seine nets 423[1]
Alestes macrophthalmus Günther	18.8				
Barbus aff. unitaeniatus Günther	16.8	1.6			1.3
Schilbe mystus Linnaeus	15.1	9.9	5.2		
Barbus paludinosus Peters	11.3	4.6	12.3		
Petrocephalus catostoma Günther	10.0	19.8	26.0		9.2
Tilapia sparrmanii Smith	5.3	19.5	24.4	9.3	4.9
Marcusenius macrolepidotus Peters	4.1	14.5	14.9	1.2	54.0
Hydrocynus vittatus Castelnau	3.8				
Serranochromis mellandi Boulenger	2.7	3.5	6.1	3.3	6.0
Tylochromis bangwelensis Regan	2.5			7.0	
Auchenoglanis occidentalis Valenciennes	1.6				
Clarias gariepinus Burchell	1.4	4.3	1.7		
Barbus trimaculatus Peters		7.0			
Serranochromis angusticeps Boulenger		4.3	3.6	10.3	1.6
Synodontis nigromaculatus Boulenger		1.7			
Ctenopoma multispine Peters		1.5			
Serranochromis robustus jallae Boulenger		1.4	1.0	8.0	
Hippopotamyrus discorhynchus Peters		1.1			13.6
Tilapia rendalli Boulenger				47.1	2.1
Oreochromis macrochir Boulenger				10.3	1.6
Serranochromis macrocephalus Boulenger				2.2	
Marcusenius monteiri Günther					1.6
Other species	6.6	5.3	4.8	1.3	4.1

[1]Number of settings.

experimental gill nets (Table 4). Furthermore, a good number of economically important species, which were difficult to sample adequately by stationary gill nets, were caught by the Kutumpula and seine nets. Firstly, this clearly demonstrated that the GNS catches were not representative of the overall species composition in the area, and secondly, the structure of the commercial (artisanal) catches was not reflected in the data collected by DoF.

Discussion

Comparing the two approaches is not an either/or situation because the data from the two methods are complementary. Individual fish variables collected by GNS include (in addition to length, station and gear data) the weight, sex, and gonadal stages. These data are important for establishing length–weight relationships and determining the spawning periods. However, the number of records is generally too few to be used in length-based stock assessment. The fishermen only recorded locality, mesh in which caught, and length, but the large number of data records make these suitable for growth and mortality estimates. In addition, the FDC provided direct insight into the local fishermen's catch composition, catch per unit effort, gear selectivity and thus exploitation pattern by length groups for the commercial fishing methods. Combined with an inventory of total number of gears and fishing intensity from a frame survey, the FDC data provided the necessary input data for a fully length-based stock assessment, including cohort analysis (J. Kolding, H.J. Ticheler & B. Chanda, unpublished data). Thus the FDC and the GNS are interrelated and complementary to a much higher degree than the traditional sampling design consisting of CAS and GNS.

The participation of local fishermen in collecting scientific fisheries data proved to be a highly successful method of obtaining large quantities of reliable length-frequency data from both the experimental and the commercial fishery in the Bangweulu Swamps. The data were relatively cheap to obtain and the quality and quantity allowed for length-based stock assessment which is still, for many tropical fisheries, the most appropriate approach to stock assessment (Pauly & Morgan 1987; Sparre & Venema 1992). In a large, inaccessible area, such as the Bangweulu Swamps, the involvement of local fishermen in the data collection was the most cost-effective way for large and intensive coverage of the fishery.

The method can be easily adopted and implemented in other fisheries. It is already used on Lake Mweru, 300 km north of the Bangweulu fishery in Zambia. The results from Lake Mweru are equally promising, so far, with: good-quality data; large numbers of records; and fishermen who take a keen interest in participating in the programme (C.K. Kapasa & P.A.M. van Zwieten, personal communication).

However, the simplicity of the data-recording system, to secure reliable data and prevent cumbersome delays for the fishermen, necessarily has limitations and the approach should not stand alone. Information, such as weight and sex of fish, is not collected by fishermen for reasons given above. Therefore, regular gillnet surveys carried out by the DoF are still important for more detailed data and for cross validation of the data collected by fishermen.

Another aspect of the new sampling scheme is that it is hoped that involving fishermen in data collection will narrow the traditional gap between fisheries resource managers and resource users. The systematic recording of catch data, and in that way paying special attention to what is actually caught and how, may change the fishermen's perception of the resource and the way it is being exploited. This, combined with a proper feedback from the DoF to the fishermen in the form of easily understandable, tabulated statistics of their own recordings, and the outcome of the scientific analyses (i.e. during a workshop presenting and discussing the results from the data the fishermen collected), may enhance the awareness of exploitation patterns and the management consequences amongst the fishing community.

There is a growing recognition amongst wildlife and fisheries managers worldwide that users' cooperation in the management of natural, renewable resources is essential to make law and regulations work (Ramberg 1993; Pomeroy & Williams 1994). It is believed that the participation of the fishing community in fisheries research will lead to a better understanding of management strategies resulting from it. In the Bangweulu Swamps, this recognition became apparent with the pride and keen interest the fishermen showed in the data-collection programme. Pomeroy & Williams (1994) stated that self-involvement of the fishing community in the management of the resource will lead to a stronger commitment to comply with the management strategy and sustainable resource use. The involvement of fishermen in the data collection may be seen as a first step in preparing the communities to take up their role in a community-based approach in the management of the fish resources.

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