

TECHNICAL COOPERATION REPUBLIC OF MALAWI
FEDERAL REPUBLIC OF GERMANY

LAKE MALAWI FISHERIES
MANAGEMENT SYMPOSIUM
ABSTRACTS

4TH – 9TH JUNE 2001
CAPITAL HOTEL, LILONGWE

ORGANISED BY



Department of Fisheries

NATIONAL AQUATIC RESOURCE
MANAGEMENT PROGRAMME
(NARMAP)



Deutsche Gesellschaft für
Technische Zusammenarbeit

ACKNOWLEDGEMENTS

The Lake Malawi Fisheries Management Symposium was organised and funded by the GTZ supported NARMAP Programme of the Department of Fisheries. However, considerable inputs and support to participants was received from the SADC/GEF Project, the World Bank, ICLARM, JICA, Rhodes University, the EU and the ODG funded Malawi/Indonesia Fluctuating Fisheries Project. In addition, this symposium would not have been possible without the commitment of the authors, whose presentations are the basis for the symposium. We would also like to thank the Symposium committee for their committed work on this project.

ABSTRACTS

Overview Of Fisheries Research and Development In Malawi

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Historically, fisheries research and development in Malawi is strongly linked to Lake Malawi and the immense interest it aroused to the outside world due to its sheer size (28,780 km²). Consequently, universal interest in the fisheries of Lake Malawi cropped up spontaneously, and has led to a number of research projects being commissioned, beginning with the surveys of 1939, although earlier attempts at taxonomic studies can be traced to over a century ago. The paper outlines major fisheries research projects that have been undertaken in Malawi. An attempt is made to outline how project results have influenced fisheries management strategies and policies. In addition, the implications of management policy on research programs being undertaken is also highlighted. Current research programs and future plans are outlined and their relevance to fisheries management is evaluated.

Fisheries Development, Management, And The Role Of Government

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Studies conducted over the past decade have identified pelagic and deep demersal fish stocks in Lake Malawi capable of sustaining an annual yield in excess of 40,000 tonnes but only marginally exploited at present. In addition, there are underexploited stocks of small demersal cichlids in Lake Malawi in depths of less than 50m, and there are opportunities for increasing production from the existing artisanal fisheries of Lakes Malawi and Malombe by managing them better and by paying closer attention to the near-shore environment. From the standpoint of sustainable biological productivity there is no reason why annual production should not be at least doubled over current levels.

Translating biological potential into industrial output is not simply a matter of importing technologies and securing a source of investment capital. Development of the fishing industry will require at least as much attention to entrepreneurial development as to technological change. It is suggested that neither of the two smaller-scale categories of fishing business on Lakes Malawi and Malombe - artisanal and small-scale mechanised - function in the same way as enterprises of comparable scale in the fishing industries of developed nations. It will be necessary to break the barriers which currently limit the capacity of individual enterprises to expand, and prevent their graduation from one level to another. It will be necessary also to develop a vision for the industry which focuses on human resource development, foresees the creation of intermediate stages in business complexity so as to facilitate enterprise growth, and guides the acquisition and flow of information. The capture of information via short-term expatriate experts may be less efficient than the secondment of Malawian fishermen to overseas fishing industries and, under controlled

conditions, the encouragement of joint ventures with other fishing nations. To date, Malawi's efforts in fisheries development appear clumsy and poorly researched when compared to the sophistication of scientific studies on the resource base.

The market is unlikely to be a constraint to fisheries development. Nationally and regionally the demand for fish exceeds the supply by a substantial margin, and, in keeping with Malawi's strength as a trading nation, the fish trade has proved vigorous and extremely adaptable. That does not mean that it could not be improved, needs no support, or might not become a constraint at much higher levels of production; but the market must, for the present, be considered of secondary importance in conditioning the evolution of the sector.

Service provision has been a major issue in recent years. Experience gained since the early 1990s has shown that the withdrawal of government services to the fishing industry did little to stimulate entrepreneurial development but instead led to a discernible weakening of the sector, with negative economic and environmental consequences. Worldwide, fishing industries tend to comprise a patchwork of private sector and state-led elements, and it is considered normal for governments to intervene in areas unattractive to the private sector and to use direct cash transfers and subsidies, both as instruments of development (fleet renewal, new technology) and management (decommissioning and buy-back). Although private sector participation in the fisheries ancillary trades must be retained as a development goal, the Government of Malawi is now faced with the need to rebuild and expand upon its former services network if the production opportunities so clearly identified are to be exploited within the foreseeable future.

The development of new mechanised and artisanal fisheries has important implications for management if it is to avoid a harmful accumulation of effort on hard-pressed traditional stocks. There are encouraging signs that, despite the daunting size of the task ahead, Malawi is on the right course in implementing its co-management policy. But the handling of interactions between the anticipated future generations of mechanised and artisanal fisheries will require management skills of a higher order than those evident in recent years. The potential for increased economic rewards will be tempered by increasing risk as the complexity of the industry grows.

Economic Security and Sustainable Programmes for the African Great Lakes

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Unquestionably, the responsibility for research, management and conservation of the aquatic resources of any nation reside with that nation. If resources are shared, such as is the case where different countries border on a single lake or river, then the responsibility is shared and co-management is required. In much of Africa, full responsibility for national resources has not been achieved. During post-colonial eras work on aquatic resources remained disproportionately in the hands of foreign workers. Initially this was due largely to both the lack of skilled capacity in Africa and to the economic inability of the new governments to meet the costs of this work. While the capacity in African countries has grown, despite attrition through the "brain drain" of marketable graduates, the economies have not improved to the extent where the countries can be independent of donor participation.

A series of donor-driven, short-term projects, often delivered in stop-start cycles, have led to situations where sustainable programmes cannot be implemented, and long-term goals cannot be set nor achieved. The most pressing step is to provide financial security to research stations or conservation units to enable them to develop and progress towards the achievement of long-term visions. This step requires independent funding that so reduces reliance on their own and donor governments that financial security is obtained. Offshore investments that earn interest provide vehicles for such independence and could take the form of endowment trusts, section 21 companies or similar secure endeavours. Such funding, in addition to that of the government, would provide the firm foundation on which to launch sustainable programmes and around which to organise other, separately or jointly funded projects. Jointly funded projects are envisaged as partnerships between the national facility and donors or research organisations.

The mechanisms for establishing endowment funds will be discussed and several examples of successful schemes will be given.

Most donors and aid organisations are not favourably disposed towards making contributions to such funds, preferring rather to maintain the stop-start cycle of donor managed projects. It is questioned whether this approach is in the long-term interest of the countries receiving the support or whether it might be both advantageous and effective to persuade donors to think afresh. These issues are debated. It is concluded that long-term research, monitoring programmes and the achievement of conservation objectives are so dependent upon programmes that are driven by the nationals of the countries concerned, and funded in a secure manner for as long as funding is required, that it is necessary for those donors that are opposed to the establishment of investment funds to re-examine the situation and reconsider their policies. Ideally, to understand and manage the lakes, the programmes should have perspectives that embody the phrase "in perpetuity". And this phrase should be applied to both the nature of the work and the financial resources that support it.

Deciding on Cichlid Specific Reference Points for Management.

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Biological reference points (BRPs) are used to guide management decisions. BRPs are values that represent the state of a fishery or population, and whose characteristics are believed to be useful for the management of a unit stock. BRPs are most often expressed as a function of fishing mortality and are derived from models that describe the population dynamics of a resource. These models include dynamic pool, spawner-recruit and production models. Unfortunately, in the absence of data it is only the dynamic pool models, often termed as yield-per-recruit and spawner biomass-per-recruit, that are known with any degree of certainty. Quantifying and understanding the spawner-recruit relationship and the productivity of the resource at various abundances are, therefore, imperative. BRPs that have been proposed in the literature have been calculated for temperate marine species with life-history characteristics that include high fecundity, pelagic spawning and little or no parental care. In stark contrast, cichlids have relatively low fecundities

and have various levels of parental care ranging from guarding to mouth brooding. This paper examines the relationships between various BRPs for a wide variety of cichlid specific life-history parameters. The BRPs were shown to be highly dependent on the degree of density-dependence in the spawner-recruit relationship - an important consideration when comparing cichlids inhabiting rocky or sandy habitats.

The Need To Maintain Maximum Biodiversity In Lake Nyasa, Lessons Drawn From Other Biodiversity Disaster

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Lake Nyasa fish fauna comprises more than 1000 species mainly cichlids and is thus unique among freshwater lakes. But tension exists between motives either to conserve or exploit the fish resource. In Lake Nyasa small scale fishery exploits the inshore resources, principal fish taken are mainly cichlids with landings comprising up to 90% of the total landings. Cichlids have low fecundity and are k-selected therefore have low rates of recovery in face of stock collapse. Thus what is happening today in Lake Nyasa has great consequences for tomorrow. Such a scenario provides the motive and desire for conservation of the Lake Nyasa fish fauna.

We care about biodiversity and we wish to maintain or conserve it because we see value in biodiversity. The term, biodiversity has become so much of a buzzword dominated global environmental debate, that it is often difficult to focus on the critical issues that face society. The six categories of biodiversity values relevant to Lake Nyasa are presented and discussed.

Spatial And Temporal Distribution Of Some Commercially Important Fish Species In The Southeast And Southwest Arms Of Lake Malawi

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The spatial and temporal distribution of *Alticorpus mentale*, *Bucochromis lepturus*, *Copadichromis virginalis*, *Diplotaxodon elongate*, and *Oreochromis* spp. in the southeast and southwest arms of Lake Malawi were analysed using bottom trawl catch per unit effort (CPUE) data collected during the bi-annual demersal monitoring surveys of 1995 and 1999. Geostatistical techniques were used to (i) model and estimate the spatial structure of abundance and (ii) ordinary kriging was used to predict local abundance. Small-scale intra-area variation that was detected was used to model the spatial structure. Experimental variograms were calculated and fitted using spherical variogram model. Southwest and southeast arms of the lake were treated as separate regions due to differences in productivity and geographical orientation.

The structure of the variograms varied with population density. The results indicate that *A. mentale* mainly occurs in deep waters of southwest arm. In southeast arm there is localised occurrence in deep waters of Area C. *C. virginalis* principally occurred along the inshore waters of southeast arm

especially in Area C off Makanjila and in Area B off Masasa and Nkhudzi Bay on the western shore and off Kadango on the eastern shore. *D. elongate* was distributed widely occurring in offshore waters of southeast arm from Area A to Area C in relatively high densities. The species occurred in highest densities in Area B. The distribution in Area C was not as wide as it used to be. *Oreochromis* spp. occurred mainly in Area A and to a smaller extent in shallow inshore waters of Area B. Abundance and distribution patterns have greatly decreased showing evidence for contraction. *B. lepturus* was evenly distributed in shallow waters of both southeast and southwest arms. The 1999 distribution pattern indicates that the species has slightly declined in abundance in the south eastern part of Area C and Area A.

Although *R.V. Ndunduma* trawl surveys were not originally designed specifically for geostatistics, these results indicate that geostatistics can be successfully used to detect changes in the spatial and temporal distribution of fish stocks or species in lake Malawi using the existing data.

Status Of Small Scale Fisheries In Malawi

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Most of Malawi's population is dependent on fisheries directly or indirectly as a source of food security, livelihood and income. Total catch in the recent years for the major water bodies, Lake Malawi, Lake Malombe, Lake Chiuta, Lake Chilwa and the Upper and Lower Shire have declined from an average of 60 thousand metric tons in the period 1976-1990 to 49 thousand metric tons in 1991-1999. Over the same period, the number of fishermen has increased by 27% similarly the number of fishing gears and fishing crafts has also increased.

The aim of this report is to provide an account of the status of the different fisheries and fish stocks in Lake Malawi. Total catch in the small-scale fishery of Lake Malawi seems to be relatively stable although some specific species groups are declining e.g. *Oreochromis* species. The small-scale fishery, accounted for over 88% of the total landings in Malawi although there exists a large-scale commercial fishery. Total catches in the commercial fishery are showing a declining trend.

The State Of The Large Scale Commercial Fisheries On Lake Malawi

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The large-scale, mechanised commercial fisheries are based in the southern part of the lake. This report is based on the data collected from monitoring surveys as well as an analysis of fisheries statistics in the past decade. The data were analysed by area and depth ranges: shallow <50 m, 51-100 m and very deep >100 m. The catch was dominated by cichlids and the catch per unit effort (cpue) decreased with increasing in depth in both areas. Biomass estimates based on swept area methods and the principal precautionary approach, indicate that the fishery is not overexploited.

Effects Of Over Fishing On Reproductive Potential Of Major Cichlid Fish Species In Southern Lake Malombe (Malawi): Need For "Closed Area" Strategy As A Complementary Management Option?

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The three major species *Lethrinops* 'pinkhead', *Otopharynx argyrosoma* 'red' and *Copadichromis cf. virginalis*, which used to contribute about 75% to the total catches (by weight) of Lake Malombe in the past decade were investigated. The main aim of the investigation was to assess the impact of fishing intensity on reproductive potential of the three species. Fecundity, reproductive seasonality, sexual maturity, and sex ratio were related to habitat types of the south western side (heavily fished) and south eastern side (lightly fished).

Based on one-year data, results showed that in both sides of the lake, the three species have low fecundity and they are synchronous spawners, with a breeding peak during July to October period. It was also evident that females of all the three species mature earlier than males while the sex ratio of the three species was not significantly different from 1:1 (X^2 test; $P>0.05$) in both sides of the lake. The length-fecundity relationships for *L. 'pinkhead'* and *O. argyrosoma* 'red' indicated that fecundity was more closely related to length in the south eastern side than in the south western side. Furthermore, the frequency of occurrence of smaller mature females and juveniles was greater in the southern eastern side than in the western side of the lake. Juveniles of *Oreochromis* spp. (chambo) were also abundant in the south eastern side.

Considering the fact that the south eastern side of the lake is characterised by low fishing intensity, muddy substratum and aquatic macrophytes, it is apparent from this study that the south eastern side of Lake Malombe is functioning as a spawning area for *Oreochromis* spp. and nursery area for the three Haplochromine species. These findings provide room for the adoption of "closed area method" as a complementary management tool in Lake Malombe. It is anticipated that such a management option would protect juveniles and spawning stocks of the main species of economic value, hence meet the criteria of ensuring the sustainability and utilisation of fish stocks in Lake Malombe.

Determination Of Species Diversity In Various Areas Of Lake Malombe

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Lake Malombe is the third largest lake in Malawi and contributes substantially to the country's fish production. The lake's fishery started to decline since the early 1980s when the *Oreochromis Nyasalapia* species were replaced by the small cichlids collectively known as Kambuzi. The fishery has currently collapsed and in attempt to improve the situation, the Government of Malawi established a reserve area in the lake that acts as stock recovery area. The study assessed species

diversity in the eastern and western fishing sites and sanctuary area. A total of 39 species were sampled; 33 in the eastern side and 25 in the western side. Fish species diversity was high in the eastern than the western sites, mean H' value 2.127 and 1.77, respectively. Fish species are more abundant in eastern sites than western sites, mean D' value 3.93 and 2.57, respectively and more evenly distributed in eastern sites than western sites, mean J'' value 0.73 and 0.63, respectively. Laboratory studies are currently underway to determine whether the sanctuary is contributing to recruitment in the fishing grounds and if there is migration between the eastern and western sides.

Management Recommendations For The Nkacha Net Fishery of Lake Malombe

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Catches from the nkacha net fishery on Lake Malombe were sampled on a monthly basis from March 2000 to January 2001. Although more than 60 species were identified in the nkacha net fishery, the catch composition was dominated (80%) by only five species these were namely, *Copadichromis chrysonotus*, *C. virginalis*, *Lethrinops* spp. "pinkhead", *Otopharynx argyrosoma* and *O. tetrastigma*. This species composition was similar to that recorded in previous assessments and indicates a relative stability in the species that drive the nkacha net fishery. This paper investigates size selectivity for ¼ inch and ¾ inch mesh size nkacha nets from a yield-per-recruit perspective for three of these species. *C. virginalis*, *Lethrinops* spp. "pinkhead" and *Otopharynx argyrosoma*. Management recommendations for the Lake Malombe nkacha net fishery are made using two target reference points (TRP's) derived from the yield-per-recruit models.

Ecological Aspects Of The Ornamental Fish Of Lake Malawi And Their Implications In Relation To Exploitation And Conservation

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Lake Malawi has diverse ichthyofauna estimated at over 1000 species. The food fish industry (artisanal and mechanized commercial fisheries) exploit many species with the exception of the colourful rock dwelling cichlids locally known as mbuna. The mbuna are exploited by licenced exporters for the aquarium trade. The food fish exploitation industry has enjoyed monitoring and management attention from the Fisheries Department that the aquarium fish export industry has not. Management regulations of a fishery are based on the way the fish are exploited and the biological and ecological information concerning the fish. Due to this background some biological and ecological aspects of mbuna were studied at the three Maleri Islands in Lake Malawi National Park with a view to assessing the impact of their exploitation for ornamental trade. The mbuna were sampled by 1 hour gillnetting at 2, 5 and 10 m depths around the three Maleri Islands between January and May 2000. The following aspects were assessed: the distribution and relative abundance, female reproductive stages and size at maturity and sex ratios. Two licenced exporters of mbuna were visited to assess species and numbers exploited. All sites sampled had diverse fish species ranging from 19 to 25 mbuna species and 15 to 34 non-mbuna species per site. A majority

of these species were found at all three islands with a few restricted to one or two of the three islands. There were significant ($p < 0.0001$) variations in numerical proportions of different species with only a few species dominating specific islands. There were significant variations ($p < 0.05$) in numerical abundance among depths and in time but insignificant ($p > 0.05$) among sampling localities. Breeding occurred throughout the entire four months in almost all the species with varying temporal proportions of breeding individuals. Individuals of immature size were not common in all species. At any point in time there were significantly more males ($p < 0.05$) in breeding colour than ripe females. Visits to two licenced exporters of mbuna indicated that many species were exported but most of the trade names used are different from those scientifically described or temporarily used in scientific publications. The exporters of mbuna capture only those of mature size. The captured and exported for any species depended on the demand of that species on the export market and the more rare the species the more demanded it is. These results are discussed in relation to the effects this exploitation may have on the mbuna fish stock and to the existing fishery management and conservation strategy. Recommendations on how the ornamental fishery can be managed are suggested and they include: Fisheries Department to give same attention in the management of ornamental fish as the food fish, populations of mbuna in all places licenced exporters exploit to be monitored, quotas to be set for all species of restricted distribution and abundance, and involvement of a taxonomist in the ornamental fish industry to standardize trade names and scientific or temporal but recognised names of fish.

River Discharge And Water Quality

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Phytoplankton in Lake Malawi support a high fish biodiversity. On the other hand phytoplankton productivity and composition in the productive layer of the lake water is largely determined by nutrients availability. One of the major ways nutrient loading into the productive layer occurs is through river discharge. The level of nutrient loading by a river depends on land use and human activities in the watershed of the river. Deforestation, bush fires and washing away of farmland due to poor agricultural practices have been observed to increase nutrient levels in runoff to lakes. Such situations have led to eutrophication of the lakes and consequent decline and/or extinction of biodiversity as experienced in Lake Victoria.

The importance of rivers in respect of the foregoing was recognized by the SADC/GEF Lake Malawi Biodiversity Conservation Project. As such, Limnology section of the project sampled Lake Malawi rivers from 1996 through 1999 with the aim of:

Determining the annual loading of nutrients and sediments into the lake from the rivers for inclusion in the whole lake budget. Assessing the current water quality of the in-flowing rivers, especially for parameters such as phosphorus, nitrogen, silica and suspended solids that are most likely to affect the limnology of the lake and its budget. Suggesting sensitive chemical parameters that are particularly important to the lake's water quality and biodiversity and which should be the focus of the future monitoring/research programs.

Among the many findings are: No statistically valid relationship was observed to exist between daily river discharge and nutrient concentration. For all rivers the early part of the flow season exhibited a flushing effect for most nutrients. In December 1996, TSS, TDN and TDP were 79.03mg/l, 1.352 and 0.075 mmoles/m² lake surface area while in May 1997 concentrations were

0.45mg/l 0.138 and 0.005 mmoles/m² lake surface area. Loading of all nutrients and sediments was significantly higher in the southwestern catchment and northeastern catchment of the lake. Northwestern catchment accounts for only 6.3% of the total for all nutrients. Loading of all dissolved nutrients except SO₄ was similar in southwestern catchment and northeastern catchment, however loading of total suspended solids (TSS) and all suspended nutrients was higher in northeastern catchment than in southwestern catchment. Majority of the flux to the lake was in form of particulate nutrients, and the concentrations of total nitrogen (N), total phosphorus (P) and available silica (Si) were all correlated with suspended solids concentration.

NOTE: Southwestern catchment has Linthipe, Bua and Dwangwa rivers. Northwestern catchment has Songwe, South and North Rukuru rivers. Northeastern catchment has Ruhuhu river.

Metals, Pesticides And Other Persistent Contaminants In Water, Sediments And Biota From Lake Malawi/Nyasa

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Lake Malawi is a valuable resource to the populations along its shores in the riparian countries. Among the major resources are fish that provides about 75% of the much essential animal protein and water for irrigation, domestic use and recreation.

In the event of the availability of micro-contaminants such as PCBs and organochlorine pesticides at toxic concentrations in the lake, these uses would obviously constitute health risk for the people. Previous work elsewhere on PCBs and organochlorine pesticides has shown that they reach toxic concentrations through bioaccumulation in food chains as a result of their very strong persistency in soil, air and water. One strong effect of micro-contaminants such as these PCBs and organochlorine pesticides at toxic concentrations to fish in a lake is fish kills. In 1999, PCBs and organochlorines were linked, in the minds of some many individuals in Malawi, to the famous lake-wide fish kills experienced in Lake Malawi during the windy August - November period, which was unusually long.

One of the research interests of the SADC/GEF Lake Malawi Biodiversity Conservation Project was to determine the concentration of microcontaminants such as PCBs and organochlorine pesticides in fish, mud and wake water.

The project's research findings on PCBs and organochlorines in the lake water and fish biota did not confirm the fears and suspicions that they were a possible cause for the fish kills. Organochlorine pesticides and PCBs were detected at low concentrations in surface as well as in subsurface waters of the lake. PCBs were the major organochlorines in surface waters and their concentrations ranged from 165-854pg/l. Deep water samples (e.g. 80m) gave lower concentrations ranging from 100-187pg/l. Oftenly the results were found to be below the detection limit which is approximately 100pg/l.

Concentrations of persistent pesticides and PCBs in fish from Lake Malawi were low in all fish analysed. Examination of the Canadian Bureau of Chemical Safety's tolerable daily intakes (TDIs) of 1.0ug.kg body weight-1day-1 for PCBs and their concentrations in Lake Malawi fish revealed that a 60kg person can safely consume on a daily basis over a lifetime up to 34.6kg/day Mcheni, 235kg/day Chambo, 2.9kg/day Mpsa, 4.1kg/day Usipa and 17.7kg/day Kampango. This confirms

that consumption of Lake Malawi fishes does not pose any health risk to humans especially because fish is never consumed daily and in these quantities.

Decentralized Environmental Management And The Implications for Fisheries Co-management in Lake Malawi

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The Environment Management Act of 1996 placed responsibility for State of the Environment Reporting (SOER) and Environmental Action Planning (EAP) at the District level. The Act established a clear role for the participation in natural resource management (NRM) of the Area Development Committee (ADC) and Village Development Committee (VDC) and associated communities. It was however not until the Local Government Act of 1998 that decentralization became a national objective, and administrative authority was placed at the lowest appropriate level. The local government elections of 2000 lead to the formation of the District Assemblies and the legal framework is now in place to empower communities to take a more pro-active role in NRM. The Environment Act and Local Government Act have become integrated through the Environmental Affairs Department (EAD) strategy for decentralized environmental management. The SOERs and EAPs are now integral parts of the decentralized, District Development Planning (DDP) process.

In fisheries the implications are that the Beach Village Committees (BVC) now find an anchor point in the District Assembly for legal recourse to enforce their by-laws. In addition, the BVCs through participation in the SOER process are able to undertake a consultative situation analysis, to better understand their problems and to identify problem areas or environmental "hot spots" and bring these to the attention of the authorities. SOERs are published as district reports, consolidated into national reports and presented to Parliament every year. This provides communities a powerful tool to lobby at the highest level for support. SOERs allow community prioritisation of problems to be dealt with through EAPs. The participatory process of EAP preparation means that BVCs participate in planning and take ownership of their own remedial actions to mitigate against prioritised problems. Generally these are expressed in the form of environmental micro-projects and would be included in the DDPs. At an inter-district level, the 8 Districts surrounding Lake Malawi will be able to come together and their combined DDPs would make up a coherent and comprehensive Lake Malawi Management Plan. A similar initiative has already been completed for Lake Chilwa.

The DDPs provide the District Assemblies with a basis for seeking funding from government, donors and other agencies. Currently available to the Lake Malawi BVCs are potential environmental micro-project funds from Danida, World Bank, Malawi Environment Endowment Trust (MEET) and GTZ.

The paper elucidates the SOER, EAP and DDP process, its implications for the BVCs and the future role of community participation in the co-management of Lake Malawi.

Seeking Sustainability: Returning To Stakeholder Involvement In Fisheries Management

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In response to declining near shore fish stocks in the waters of Lakes Malawi and Malombe, the government and a foreign aid donor collaborated to create a new fisheries management approach. A co-management regime was introduced in a pilot programme at Lake Malombe. Fishers elected management committees ("beach village committees" or BVCs) to work with Fisheries Department (FD) staff in several phases of management. Extension education was organized and provided to fishers. Reviews of these efforts to date are mixed. BVCs are working with the FD but have unmet fishing needs. Expansion of co-management to Lake Malawi has been funded, and implementation is reported to be moving forward slowly. The co-management approach is being more widely employed as greater demands are placed on scarce government resources everywhere and the value of stakeholder involvement is recognized.

An Overview Of Indigenous Knowledge As Applied To Natural Resources Management

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Historically, rural communities have acquired detailed knowledge, skills and strategies based on their interaction with the local environment over long periods of time. Localised techniques and practices, which are essentially subsistence-oriented and are distinct to a particular social group and culture, have been developed and built up on centuries of years of experience and adaptation and are in harmony with the environmental conditions and constraints. This stock of knowledge is expressed in local languages and handed down from generation to generation. It is an expression of African tradition, rich in intricacies but when properly understood, it demonstrates the African appreciation and constant harmony the community strikes with nature, and how observations are precisely expressed for communication, such as through songs, taboos, totem animals, custom laws and practices, place names and nicknames, riddles and proverbs. This stock of knowledge permeates the social structure and may have been influenced by innovations emerging from within itself, from other indigenous systems and from external systems but it essentially originated locally. Such stock of knowledge, known as Indigenous Knowledge (IK), is the basis for local-level decision-making in agriculture, food security, natural resource management, and a host of other activities in the rural communities. IK, therefore, deals with folk beliefs, skills, methods and practices. Some of the practices have led to mismanagement of resources, some are less efficient than modern technologies, while IK is generally less precise as measured by international science. IK, however, offer insights into possible alternative approaches to interpreting environmental and development change. Previously, solutions offered by some development projects failed because they did not fit with the local knowledge and circumstances. It is now recognised that the local community's decisions to adopt or reject a new development project is strongly influenced by its existing skills, values and beliefs which are usually reflected in its indigenous knowledge.

Although integration of IK in natural resources management may not be the ultimate answer in itself, there is increasing recognition of the value of local knowledge in production systems and rural development and of the fact that rural people with their detailed, holistic, integrated knowledge of local ecosystems, are experts in their own right. Utilising IK in the development process requires identification, validation, documentation and integration. This paper advocates that the opportunity should be seized to utilise the available IK for the fisheries resource management, the stabilisation of land-use activities in the catchment, the integrated monitoring programme of the lake ecosystem, and for the design of the institutional arrangements in the Lake Malawi Environmental Management Project.

Lessons Of The Livelihoods Approach For Artisanal Fishing Policies

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The purpose of this presentation is to introduce those that are unfamiliar with it to the so-called livelihoods approach to rural poverty reduction, and to demonstrate what this approach can bring to improving our understanding of the livelihood patterns of artisanal fishermen, and to devising more relevant fisheries policies.

The livelihoods approach has its origins in a literature concerned with understanding the differential capability of rural families to cope with crises such as drought, floods, or plant and animal pests and diseases. This literature focuses especially on the assets of rural people, and how different patterns of asset holding (land, stock, food stores, savings etc.) can make big differences to the ability of families to withstand shocks. The basic principles of the approach have been utilised by major NGOs working on reducing the food insecurity of rural households for a long time. However, more recently, the approach has been adopted by several donor agencies as a guiding set of ideas for making poverty reduction policies more effective on the ground in rural areas.

Of relevance to a particular sector like fishing, the livelihoods approach moves away from the idea that you can solve the problems of poverty in fishing communities just by increasing the efficiency of fishing effort, while at the same time seeking to control behaviour that is considered to be adverse to the conservation of the resource. The livelihoods approach recognises straightaway that artisanal fishermen are mobile across seasons, space, and sectors; and their livelihood security is as much to do with the other things that they engage in when not fishing as to do with fishing itself.

The presentation defines the concept of a livelihood, provides an outline of the livelihoods framework in general terms, and applies these ideas to the livelihoods of artisanal fishing families. It then goes on to examine the insights that the livelihoods framework brings to bear on both conventional top-down fisheries management policy and community management policies. The presentation concludes with some ideas about future directions of fisheries management, bearing in mind key features of artisanal fishing as an occupation, and the need to focus scarce resources in places where they are likely to give effective results.

Fisheries Management And Uncertainty: The Causes And Consequences Of Variability In Inland Fisheries In Africa.

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Uncertainty pervades the management of fisheries. Scientific fisheries management over the last 50 years has been based on the premise that there exists an equilibrium relationship between fish production and the level of harvest that can be taken without depleting the stocks. These equilibrium 'surplus-production' and 'yield-per-recruit' models have served to establish the principle that unregulated fishing will deplete fish stocks and dissipate economic rents from the fishery, but they have been of limited applicability for practical fisheries management when their equilibrium assumptions are violated. The influence of equilibrium models has extended beyond stock assessment into management, such that many fisheries management measures are based on a 'steady-state' view of fishery resources even when most stakeholders are aware that the assumptions are untenable.

This paper makes the case that fish production in many African inland waters is driven by climate variations. For fisheries where stocks fluctuate independently of fishing effort, management for traditional sustained-yield type objectives is inappropriate. While there have been many studies attempting to elucidate the mechanisms for environmentally-induced fishery fluctuations, there have been fewer studies of the consequences of such variability for fisherfolks' livelihoods, and for the design of appropriate fishery management regimes. A study of the livelihood strategies of fisherfolk involved in the important fisheries for small pelagic species in Lake Malawi is used to make the case for management that supports opportunistic exploitation of fluctuating resources by enabling geographical and occupational mobility. Livelihood sustainability and resource conservation are best served by support for such flexible strategies. The interdependence of fishing and other sectors of the rural economy suggests that policies and development interventions aimed at raising fishermen's incomes without addressing the wider context of rural poverty are unlikely to be successful or sustainable. Species-based fisheries management and development focused on the fishing enterprise would benefit from re-conceptualisation within a broader natural resource management and rural livelihoods framework.

The Traditional Gillnet Fisheries In Metangula, Lake Malawi/Niassa, East Africa

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Metangula is the principal village on the Mozambique coast of Lake Malawi/Niassa. It has 9 human settlements where fishing occurs over about 40 km of shoreline. This village is one of the few places where the gillnet catches of *Labeo mesops* (nchila), and *Opsaridium microcephalus* (sanjika) occur, due perhaps to the low fishing pressure in that area. Although the gillnet fishery catches a wider variety of commercial fish than any other gear type used by the fishermen, nchila, and sanjika are the most important species in the catches. The seasonality of habitats appears to be a key factor affecting many interrelated aspects of life cycle for this species. Their movements to feed or spawn are tied up with seasonal and other changes in the environment.

The traditional fisheries of *Labeo mesops*, and *Opsaridium microcephalus*, mainly from gillnets, have decreased seriously in the past 10 years over the lake. These species are reported as being missed from the catches in gillnet fisheries of Malawi. Smith (1993a) found CPUE = 0 for those species in Chembe village. Few years ago, *L. mesops* was the most important fish in the riverine fishery in Malawi. It has been depleted due to intensive gillnetting of gravid individuals on breeding migrations.

This paper presents preliminary results on traditional gillnet fisheries in Metangula, focusing on 2 important commercial species referred above. I'm also trying to arise here the concrete need for fisheries management and biodiversity conservation particularly related to these species. It's not clear yet whether these species are represented by a single population that is widespread in the lake, or by different populations with distinctive morphometric, genetic and life history characteristics. Therefore, the studies in near future will focus on distribution along the shore, comparison of its morphometric and genetic characteristics, and life history, in order to know whether these species return to the same rivers for reproduction or they go to any river. The studies will also include issues of economic value and conservation status.

The Nkacha Net Fishery In Lake Malombe And In The Southeast Arm Of Lake Malawi.

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The nkacha net is an open water seine with a uniform mesh size ranging from 6 to 25 mm and is rectangular in shape. It is a main fishing gear in the small-scale fishery of Lake Malombe but its use is prohibited in Lake Malawi. However, this gear has been used illegally in the southeast arm of the lake since mid 1990s. This study compares catch and effort data as well as length frequencies of the main targeted species of the nkacha net fishery for Lake Malombe and the southeast arm of Lake Malawi. Higher catch per unit effort in the southeast arm as opposed to Lake Malombe might be the primary drive for this gear's usage in Lake Malawi. Species size-classes caught in the southeast arm are considerably larger than of those species constituting catches from Lake Malombe. This suggests that catches from the southeast arm might realize higher market prices than Lake Malombe catches. Considering the impact of the nkacha net with regard to growth over-fishing and habitat degradation, management recommendations are made for this fishery.

Gear And Species Selectivity Of The Chilimira Kauni Fishery In Lake Malawi

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Kauni fishing in Lake Malawi occurs by using a chilimira net (an open water seine net) at night using light from paraffin lamps to attract the fish. Kauni fishing occurs in both the south-east (SEA) and south-west arms (SWA) of Lake Malawi. Catches from kauni gears landing at Kela beach (SEA) and Msaka beach (SWA) were examined for a one-year period to determine the

potential effects on the fish stocks. Catch composition and length frequency assessments were performed. The kauni fishery in both areas was multi-species with 70 species recorded in the Kela fishery and 65 species in Msaka. At Kela the major genera targeted were *Rhamphochromis*, *Oreochromis* and *Copadichromis*, which made up over 75 % of the catch composition. At Msaka the major genera were *Rhamphochromis*, *Engraulicypris* and *Copadichromis*, which made up over 85 % of the catch. Length frequencies of *Oreochromis* spp, *Rhamphochromis* spp and *Copadichromis virginalis* are examined and recommendations for managing this fishery are made.

Gear And Species Selectivity Of The Gill Net Fishery In Lake Malawi

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Size selectivity of some important fish species caught in gill nets was estimated indirectly. Species composition of catches from gill nets with mesh sizes between 1 and 2 inches showed that the catch was dominated by *C. virginalis* (74%) and that Chambo contributed less than 0.2% to the catch of these small meshed gill nets. Chambo was not caught in these meshes because the size range of Chambo that would be susceptible to this gear inhabits shallow waters where small meshed nets are not set. The small meshed gill nets were considered ideal for catching offshore cichlids. Gill nets with mesh sizes between 2 and 3 inches selected Chambo at sizes corresponding with the size range at which this species migrates to deeper water. Since this migration occurs before maturity the use of gill nets with mesh size 2-3 inch is not recommended. Gillnets with mesh sizes between 3 and 4 inches were considered ideal since they select for mature chambo. However, the study showed that gillnet with the current mesh sizes in use do not catch mature catfish. For management purposes, development and adoption of distinct gill net fisheries for the specific target species is suggested.

An Assessment Of Resource Use Overlaps Between The Pair Trawl And Small-Scale Commercial Gears: Preliminary Results

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Since the development of the Pair trawl fishery, there has been a conflict between the small scale and this fishery. This study assesses the abundance, species composition and size distribution of fish exploited by small-scale and Pair trawl in Lake Malawi. Preliminary results have shown that pair trawlers appear to target some shallow-water fish species at small sizes. Furthermore there appear to be overlaps in the species harvested by the pair trawl and small scale fisheries.

Hard Choices In The Management Of Chambo In Area A Of The South East Arm Of Lake Malawi.

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Management of the fishery in Area A of the southeast arm of Lake Malawi (SEA) is complicated by multi-gear utilisation and by the multi-species nature of the catch. One option for management is to prioritise key species for management. The suitability of chambo (*Oreochromis*) species as a key management species group for area A is discussed. The stocks were modelled using multi-gear yield- and spawner biomass-per-recruit models to investigate four management target reference points (TRP's). These TRP's were F_{max} , $F_{0.1}$ and F_{SB40} and F_{SB50} . F_{max} corresponds with the asymptote of the yield-per-recruit curve and approximates Maximum Sustainable Yield, $F_{0.1}$ is the rate of fishing mortality at which the slope of the yield-per-recruit curve falls to 10% of its value at the origin, F_{SB40} and F_{SB50} are the points on the spawner-biomass-per-recruit curve corresponding to a reduction of 40% and 50% of the pristine spawner-biomass. It was estimated that the current fishing mortality rate (F) for Area A chambo approximated 0.34 yr^{-1} . This exploitation level was below the F_{max} TRP but exceeded the more conservative $F_{0.1}$ TRP. In addition, current exploitation rates exceeded both spawner biomass based TRP's. To attain the F_{SB40} TRP a 10% reduction in fishing effort was necessary and a 23% reduction in effort was necessary to attain the F_{SB50} TRP. Different management options taking into account the effect in total landings and employment are discussed.

Drifting Long Line, A Potential Fishing Method For The Northern Part Of Lake Nyasa.

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Fishing gears commonly used in the Tanzanian waters of Lake Nyasa consist of open water seine nets (Ndaturu/pajero) gillnets (vilepa) traps (migono) beach seine nets (kokoro) and hook and line (ndoano). These methods of fishing exploit mainly the nearshore and riverine species. Based on recommendations of the UK/SADC Pelagic Fish Resource Assessment Project on the use of drifting pelagic longlines to exploit offshore fish communities, trial fishing was carried out off Lupingu village in Tanzania. The results were encouraging and they are presented and discussed. This fishing method was later successfully demonstrated to three fishing villages along the Tanzanian waters of the lake. With a mean daily catch rate of 5.8 kg/100 hooks, this method proved to local fishermen to be more profitable and environmentally friendly than using the destructive beach seine net.

Are Complex Systems More Resilient Than Simple Systems? A Case Study Of Trawling Impacts On Two Demersal Fish Communities In Lake Malawi/Nyassa.

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There is a longstanding debate as to whether system complexity does, or does not, increase resilience to change. It has been suggested that in more speciose systems the effects of outside perturbations, such as caused by fishery extraction, will be dampened by the multitude of sideways impacts throughout their food webs. Cascading impacts will be further reduced if many species are opportunistic and can switch to new prey items. In this poster we present a case study, which compares the relative impacts of trawling on deep water and shallow water demersal fish communities in Lake Malawi, Africa. Fishing impacts are evaluated with reference to relative species richness within each community, and the degree of diet specialisation and opportunism exhibited by species within those communities. Change in species composition and/or trophic structure within each community is used as the measure of resilience to fishing.

Fisheries Management, Biodiversity Conservation And Genetic Stock Structure

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Given the immense difficulties of assessing and managing fisheries on Lake Malawi/ Nyasa, it seems likely that the present approach of using intuition and rules of thumb to derive management approaches is likely to continue. The delivery of accurate up to date information on fleet size, catch, effort, species composition, population parameters, gear selectivity etc is likely to remain beyond the capacity of the institutions of the riparian states for the foreseeable future. Thus, it is important that the 'rules of thumb' employed are as accurate as possible. At present, almost nothing is known of the migration patterns and movements of the major fish stocks in the lake. Both the collection of data and the setting of effort limits are presently based on rather arbitrary fishing areas. Local fisheries management will be largely irrelevant if carried out on wide-ranging stocks that are exploited elsewhere. Molecular analysis of population structure provides an effective tool for the assessment of fish movement patterns. The strengths and potential pitfalls of the method will be outlined, and examples given of studies implemented on Lake Malawi. A critical advantage of this kind of study is that the information it provides need not be updated by regular monitoring, but can be used to inform management decisions indefinitely.

Genetic Diversity Distribution Of Tasselled Tilapias (*Oreochromis nyasalapia* Spp.: Cichlidae) In Lake Malawi Using Microsatellite DNA Markers

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A study was carried out to investigate the genetic diversity distribution of three species of *O. Nyasalapia* in Lake Malawi. Five polymorphic loci were scored in 12 populations. The total

number of alleles ranged from 13.0(4.4 to 18.4(5.9; mean effective number of alleles ranged from 8.0(4.0 to 11.09(4.0 in *O. karongae*, 9.09(2.3 to 10.2(3.8 in *O. lidole* and 8.8(4.8 to 11.9(4.7 in *O. squamipinnis*. The mean heterozygosity per population ranged from 0.45(0.17 to 0.66(0.16, which is higher than reported in allozyme loci. There is high genetic variation in *O. squamipinnis*, followed by *O. karongae* and *O. lidole*. The populations are not highly differentiated. These results suggest that the *O. Nyasalapia* flock has still maintained a reasonable level of genetic variation in the face of intense fishing pressures.

Genetic Population Structure Of *Oreochromis mossambicus* In The Shire River System

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An investigation in the Lower Shire River fishery was carried out to assess the status of genetic variation of *O. mossambicus* using microsatellite DNA markers. Five polymorphic loci (OS08, OS64, OS75, UNH154 and UNH103) were scored in 11 populations. Number of alleles per locus ranged from 4 in OS64 to 40 in UNH154. Cluster analysis grouped populations into three, (1) those found in Chikwawa, (2) those that are found at Elephant Marsh and (3) those that are found at Ndinge Marsh.

Genepop program was used to calculate allelic diversity of each of the 11 populations. The mean number of alleles ranged from 8.2 to 11.0 with mean heterozygosity range of 0.48 to 0.68. All populations exhibited considerable genetic diversity. WHICHRUN program was used to assign individuals to their right strata/populations based multi-locus genotype data. Probability of assigning of a population to its right strata ranged from 52-100%. Probability of assigning of an individual to its right population ranged from 57-95%. Populations from the market were assigned to different sources than indicated by the fish traders and these tended to reduce the probability of right assignment of individuals to source.

Zoogeographical Distribution And Population Structure Of *Taeniolethrinops praeorbitalis* Exploited By Artisanal Fishermen In The Inshores Of Lake Malawi

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Lethrinops species flock (Chisawasawa/mbaba) is among the major commercially important fish species exploited in Lake Malawi. Their catches started declining as early as 1975 due to overexploitation especially in the southern part of the lake yet there are no deliberate measures put in place to conserve these vital populations. A study was carried out to determine the genetic diversity and population structure of *Taeniolethrinops praeorbitalis* populations in traditional fisheries of Southeast and Southwest arms of the lake, Mangochi District and Nkhota -kota lakeshore area. A total of 10 populations with 40 individuals as sample size were analyzed at 6 polymorphic microsatellite loci. The populations were not in Hardy-Weinberg equilibrium possibly

due to Wuhlund effect. This is supported by inter-deme migration of more than seven individuals per generation as determined by a multilocus estimate of number of migrants using private alleles method. However this rate of migration has not reduced population differentiation in *T. praeorbitalis*, mean F_{st} of 0.152.

Fisheries Activities In The Northern Part Of Lake Nyasa (Kyela District)

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When compared with the other East African Great lakes, the fisheries activities of Lake Nyasa are very low. This might be due to poor fishing vessels and gears used by the artisanal fishermen and the Ultra-Oligotrophic nature of the lake. The present paper looks at the trend of Lake Nyasa fisheries in Kyela district and recommend possible ways for rational exploitation.

Feeding Ecology Of *Bathyclarias nyasensis* (Siluroidei: Clariidae) In Lake Malawi

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The ecological role of *B. nyasensis* in Lake Malawi was identified from studies on life history traits, ecological and functional morphology in addition to diet and food habits of the species conducted between 1996-1998. The maximum age for *B. nyasensis* was estimated at 14 years. Growth was best described by the four parameter Schnute model:

$$l_t = \{42 + (81^{1.8} - 42^{1.8}) \times \frac{1 - e^{-0.05(t-1)}}{1 - e^{-0.05(11)}}\}^{1/1.8} \quad \text{for female and} \quad l_t = \{41 + (98^{1.2} - 41^{1.2}) \times \frac{1 - e^{-0.02(t-1)}}{1 - e^{-0.02(13)}}\}^{1/1.2}$$

for male fish. Age-at-50% maturity for females and males were estimated at 7 years and 4 years, respectively. Typically, fish grew rapidly in the first year, but slower during subsequent years. Smaller fish were found inshore while larger fish were found in offshore regions. It was hypothesised that the rapid growth in the first year and slower growth later is a consequence of change in diet from high quality and abundant food source to a more dilute food and that this may be associated with a shift in habitat.

Changes in fish growth synchronised with dietary changes and morphology particularly changes in buccal cavity volume. These changes occurred when fish reached 500-600 mm TL, concomitant with habitat shifts that probably imply a mechanism to open the inshore habitat to the next cohort, thereby maintaining a stable population. In inshore areas, *B. nyasensis* was primarily piscivorous and was zooplanktivorous in offshore regions.

On the basis of the theoretical migratory life history cycle of *B. nyasensis*, and “bottom-up” and trophic cascade theories, it is postulated that perturbations of the *B. nyasensis* stock would be

discernible both at the top and lower trophic levels. As a piscivore and therefore apex predator, effects of overfishing *B. nyasensis* in the inshore region could cascade to unpredictable ecological changes in inshore areas and, due to the ontogenetic habitat shift, in the offshore regions. It is recommended that the current interest in increasing fishing effort in offshore areas should proceed with caution.

The Biology And Ecology Of *Bagrus meridionalis* In Lake Malawi.

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The study investigated the endemic catfish, *Bagrus meridionalis* of Lake Malawi in order to understand their ecological relations, distribution, abundance and life history. The catfish are the second important group of fish on Lake Malawi in terms of income and source of food to the rural community. Surveys were done using the research vessel, *Ndunduma*, using a bottom and mid-water trawl from June 1994 to February 2000. The management implications of ecology in relation to development of the deep trawl fishery are discussed.

Otolith Growth Increments In Three Cyprinid Species In Lake Malawi And Information Of Their Early Growth

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Otoliths features and growth increments of three Malawian cyprinids, i.e. *Engraulicypris sardella*, *Opsaridium microcephalus* and *Opsaridium microlepis* were investigated. All species had the sagittae unsuitable for otolith increment reading due to the increment invisibility and fragile structures in rostrum portions. The lapilli of them had clear increments from the core to edge, and were considered to be the best otolith for increment analysis. The asterisci were not applicable otolith as well as the sagittae because of their ambiguous core structures and the fewer increment counts than the actual age or the ones in the lapilli. Based on the upper observations, the lapilli were employed to elucidate the reproductive periods and early growth patterns in *E. sardella* and *O. microcephalus* were described.

Land Use Patterns In The Domasi And Likangala Catchments And Their Effects On Soil Erosion, Water Quality, River Flow Rates, Siltation Rates And *Barbus* Reproduction In Lake Chilwa

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A study to examine trends in land use practices, and to establish linkages between river flow, soil erosion rates, catchment sediment yield, river water quality, migratory patterns and reproductive success of *Barbus* species in the Likangala and Domasi rivers was conducted between November 2000 and November 2001. Participatory rural appraisals, to obtain information on current and past land use and management practices and the effects of these practices on the river ecosystem health, were conducted in four villages in the Likangala catchment and in Mtwiche village in the Domasi catchment. Land use cover change analysis was accomplished by aerial photograph interpretation of black and white aerial photographs for 1982 and 1995 covering the study area. Soil erosion rates were estimated using the Soil Erosion Model for Southern Africa (SLEMSA) by delineating soil erosion management units with homogeneous areas with similar slope, class, soil group, annual mean rainfall, and vegetation cover type and density. Catchment sediment yields were obtained by multiplying the estimated soil loss for each soil erosion management unit with a delivery ratio, which was defined as the ratio of soil eroded that had been carried downstream to that remaining within the field. *Barbus* and water quality sampling in the Likangala and Domasi Rivers was conducted biweekly from December 2000 up to June 2000 and thereafter monthly until November 2001. The *Barbus* were sampled at the river mouth using a multi-mesh gillnet to determine their total number and they were assessed for their position in the net to determine direction of migration. Adult females were assessed for their gonadosomatic index. The gonadosomatic index was used to determine the seasonal reproductive status of *Barbus*. The water quality parameters measured were dissolved oxygen, electrical conductivity, pH and total suspended solids. River flow rate was measured using a current flow meter and the float method. Water quality, river flow, sediment yield, reproductive and fish migration data were subjected to multiple regression analysis to determine the major factors affecting reproductive status and migration. The land use analysis results showed that land use practices in the two catchments are characterized by a combination of destructive forces mainly the expansion and intensification of cultivation of maize on marginal land using inappropriate practices. The participatory rural appraisal sessions in both catchments revealed that the number of trees in the upland and along the rivers, the size and number of fish caught in the two rivers had drastically declined over the past fifty years. The highest amount of soil loss ($>100\text{t}\cdot\text{ha}^{-1}\cdot\text{yr}^{-1}$) was estimated in the upland areas of the Likangala River catchment and field walks in the area revealed wide spread evidence of very severe erosion, exposed soils and numerous deep gullies. The most critical factors contributing to high soil loss were rainfall high kinetic energy and poor vegetation cover. High vegetation cover and relatively flat plains resulted in low soil loss in the wetland. The Likangala River catchment had a higher annual sediment yield of $374\text{t}\cdot\text{km}^{-2}\cdot\text{yr}^{-1}$ compared to $315\text{t}\cdot\text{km}^{-2}\cdot\text{yr}^{-1}$ for the Domasi catchment. A situation analysis for the Likangala River catchment showed that increasing maize yield was more efficient in reducing soil loss than contour ridging, and the highest reduction in soil loss was predicted when a combined 20% increase of contour ridging, maize yield and tree canopy was assumed. Multiple regression analysis results showed that reproductive success of females migrating upstream was negatively

correlated with total suspended solids and positively correlated with electrical conductivity in the Domasi River. On the other hand, the upstream migration of *Barbus* juveniles was positively correlated to sediment yield in both rivers, and also to river flow rate in the Domasi River. The *Barbus* reproductive status was not correlated to any of the physico-chemical variables that were measured in the Likangala River. The major recommendations of the study were as follows: (i) land use practices that tackle the most critical soil loss factor should form an integral part of soil conservation measures in each soil erosion management unit; (ii) a combination of contour ridging, increases in crop yield and vegetation cover should be promoted as strategies for reducing soil loss in the Likangala River catchment; (iii) appropriate management actions that reduce fishing pressure on breeding *Barbus* females in the influent rivers should be formulated to ensure the success of spawning migrations of breeding females into the influent rivers, and (iv) marginal vegetation in the breeding grounds along the lake should be protected from burning and other forms of destruction in order to maintain breeding and feeding grounds for juvenile *Barbus* in the dry season.

Development Of African Catfish *Clarias gariepinus* Larvae During The Transitional Phase Between Endogenous And Exogenous Energy Intake

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Development of newly hatched African Catfish *Clarias gariepinus* larvae in an aspect of energy intake conversion was investigated. The mouth opened by 34 h after hatching and the onset of feeding was observed from day 3 (67 h) after hatching. Yolk of larvae was completely absorbed on day 7 after hatching (157 h after hatching). These observations demonstrated that the larvae had the transitional period to utilize both endogenous and exogenous energy sources for c. 90 h. Mass-mortality in larvae reared under starvation after hatching took place from day 11 to day 14, all specimens being dead on day 15. These phenomena indicated that the food-deprived larvae had survived using the energy sources in their body tissues after yolk absorption for more than 4 days (maximum 7 days). This fact showed the larvae of this species having a stronger starvation tolerance than the marine fish larvae reported in earlier studies.

Feeding Habit And Development Of Feeding-Related Morphological Characters In *Oreochromis shiranus* Larvae And Juveniles

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Stomach content, gut length, morphology of pharyngeal teeth and gill raker of *Oreochromis shiranus* larvae and juveniles were investigated in order to elucidate the relationship between feeding habit and the feeding-related morphological characters. Stomach content showed that the feeding habit of fish drastically changes between 14 - 20 mm TL from zooplanktivorous to

phytoplanktonivorous. Pharyngeal plate and teeth were already ossified in smallest fish used in this study (9.95 mm TL) and teeth number increased as fish grew. Percentage length of gut ((gut length/TL)x100) became more than 100 % when TL reached 15 - 20 mm, falling mostly under the size with feeding habit conversion. Gill rakers in 4th gill arch started appearing at 14 mm TL when the feeding habit started converting. Consequently, the conversion of feeding habit in *Oreochromis shiranus* started when the percentage intestine length became over 100 % and gill rakers in 4th gill started appearing, and pharyngeal teeth did not seem to relate directly with such feeding habit conversion.

Aquaculture Performance Of An Exotic Red Tilapia Compared To Indigenous Malawian Tilapias

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Results are presented on the growth rate of 3 Malawian tilapias in comparison to Red Tilapia an exotic species from Malaysia. The fish were stocked in a 1m³ concrete tank at 3fish/m³ in polyculture. The fish were fed a locally formulated feed with 30% protein content. The feed was given at 3% of the fish body weight per day, 3 times a day. The initial stocking weight was 0.33g for each species. After 3 months, the mean body weights for red tilapia, *O. karongae*, *T. rendalli* and *O. shiranus* were, 111.7g, 26.9g, 38.9 g and 41.7 g. These weights represents growth rates of 0.93, 0.22, 0.32 and 0.34 g/day, respectively. Results show that the growth rate of Malawian tilapias is lower than that of red tilapia. The results are discussed on the merits and demerits of introduced exotic tilapias in Malawi.

Gonad Maturation Of *Opsaridium microlepis* In Response To Pituitary gland Of Common Carp

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Opsaridium microlepis locally known as (Mpassa) is one of the Malawian cyprinid species which inhabits the areas near to the flow of big rivers into Lake Malawi e.g. Linthipe river in the central region and Songwe river in the Northern region.

The work was carried out at National aquaculture Centre to examine the response of *Opsaridium microlepis* to pituitary gland of Common carp. Mature males and females were collected from Linthipe river in Salima, average weight 600 gms.

Two injections were administered at a rate of 5 mgs/kg body weight. The prime dose was given at a rate of 10% and the resolution dose at a rate of 90% and the time interval between the two injections was 3 hours, 9 hours and 15 hours.

The results showed that there was no significant differences ($P < 0.05$) in the stage of gonad maturation to give the resolution dose at 9 and 15 hours, while there is a significant difference ($P < 0.05$) in stage of gonad to give the injection at 3 hours and the other two injections at 9 and 15 hours. This concludes that, the time interval between the two injections should be 9 hours at a rate of 5 mgs/kg body weight.

The Effect Of Temperature On Oocyte Development Of *Oreochromis karongae* (Trewavas)

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Oreochromis karongae (Trewavas) is one of the indigenous Tilapias that exhibits favorable traits for aquaculture in Malawi. However, fingerling production has been a problem. An experiment was therefore carried out to find the effect of temperature on oocyte development of the species. Female *O. karongae* were reared under two temperature regimes, room (20.28 (0.77oC) and raised (26.5 (0.5oC) for 90 days while changes in gonadosomatic index (GSI) and oocyte developmental stages were followed every 45 days. Fish samples from the pond in which experimental fish were collected were used for comparison. Results showed that raising temperature to 26.5 (0.5oC significantly enhanced oocyte development. Significantly higher GSI ($p < 0.05$) were obtained in fish cultured in raised temperature (0.817 (0.657 and 1.133 (0.471 %) than those from room temperature (0.057 (0.027 and 0.367 (0.045 %) after 45 and 90 days respectively. GSI of fish samples from the pond after 45 and 90 days (0.217 (0.012 and 0.257 (0.027 % respectively) were not significantly different ($p > 0.05$) from that of fish from room temperature. Abundance of mature oocytes was significantly higher ($p < 0.05$) in fish from raised temperature (60.42 (3.63 %) than in fish from room temperature (1.76(0.84 %) and pond (2.43 (1.38 %) after 45 days. After 90 days, the abundance of mature oocytes in fish from raised temperature was not significantly different ($p > 0.05$) from that in fish from the pond (8.68 (2.40 and 10.99 (3.41 % respectively). Fish from room temperature had a significantly low ($p < 0.05$) percentage of mature oocytes (3.12 (2.03 %). The results suggest that *O. karongae* has the potential to spawn throughout the year if temperature is manipulated.

The Effect Of Different Feeding Levels On Survival Rate Of African Cat Fish *Clarias gariepinus* At National Aquaculture Centre

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This study was carried out for 30 days at National Aquaculture Centre, and the aim of the study was to find out possible number of zooplanktons, which can be fed to African cat fish *Clarias gariepinus* larvae per milliliter of water in order to improve the survival rate from larvae to fingerling stage.

The four day old larvae were stocked in 12, 50L tanks at rate of 4 fish/m² . Four feeding levels were used, 0 zooplankton/ml (Treatment 1), 5 zooplankton/ml (Treatment 2), 10 zooplankton/ml (Treatment 3) and 30 zooplankton/ml (Treatment 4). Each treatment was replicated 3 times and samples were taken after every three days to check the survival rate of each treatment.

There is significance difference ($P < 0.05$) in feeding the fish with 0 zooplankton/ml against the other three treatments and that there is no significance difference ($P < 0.05$) in feeding the fish with 5 zooplankton/ml and 10 zooplankton/ml but there is a significance difference ($P < 0.05$) in feeding the fish with 10 zooplankton/ml and 30 zooplankton/ml and 5 zooplankton/ml and 30 zooplankton/ml.

In all the treatments survival rate increased with increasing number of zooplanktons/ml and in all the treatments apart from 0 feeding, the survival rate was up to 50% which is a good indication of survival.
