

GLOW 8

An international conference

Advancing the Ecosystem Health Approach: *Good Governance for Adaptation and Rehabilitation*

March 24-26, 2015, Mangochi, Malawi

Program



**AQUATIC ECOSYSTEM
HEALTH & MANAGEMENT SOCIETY**



Advancing the Ecosystem Health Approach: Good governance for Adaptation and Rehabilitation

**March 24-26, 2015
Mangochi, Malawi**

Organized by



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Welcome to beautiful Lake Malawi

Aquatic Ecosystem Health & Management Society established the “Great Lakes of the World (GLOW)” Working in 1996. Since then the AEHMS has launched a continuing series of international symposia in order to promote interaction and communication amongst various great lakes/large lakes researchers across the world. GLOW symposia were organized in the following locations:

- Victoria Falls, Zimbabwe
- Sligo, Ireland
- Arusha, Tanzania
- Bagayoma, Tanzania
- Addis Ababa, Ethiopia
- Nevada, USA
- Bujumbura, Burundi

The purpose of GLOW is to establish a global platform where ecosystem-based studies of structure, function and performance of large/great lake ecosystems are promoted, organized and synthesized. An integrated, multi-trophic and multi-disciplinary approach is encouraged. A majority of the great lakes/large lakes researchers, students and managers are aware of the GLOW series of symposia as well as the resulting peer-reviewed publications. So far the AEHMS has been instrumental in publishing a large number of peer-reviewed papers on Great Lakes, especially African Great Lakes. These publications include special issues of the journal AEHM as well as books (Tables 1 and 2).

This GLOW symposium in Mangochi, Malawi, is the 8th GLOW in the series, and will focus on Lake Malawi, similar to previous events on Lakes Victoria and Tanganyika. Once again it is being organized in Africa to ensure the participation of African scientists and colleagues. The Mangochi symposium could be a unique opportunity to discuss Lake Malawi, one of the deepest African Great Lakes (>700 m), with a very long retention time (750 yrs). The program has been categorized as described below:

1. Fisheries and management
2. Ecology of other large lakes
3. Panel discussion and synthesis
4. Field trip and excursion

We would like to thank members of various conference committees for their work towards the organization of this meeting, especially Dr. Martin Van der Knaap for, as always, going above and beyond in providing valuable assistance and advice. We appreciate the support of WorldFish, especially our co-chair Joseph Nagoli, and also the help of Grace Chizalema. Friday Njaya gave valuable assistance to the program and promoting the conference. Thank are due to AEHMS secretariat for the overall coordination of the GLOW symposium namely Lisa Elder, Jennifer Lorimer and Robin Rozon. We are optimistic that the GLOW VIII symposium in the beautiful surroundings of Lake Malawi will be productive, exciting and generate new momentum for the continued success of the AEHMS-GLOW Working Group and its activities.

M. Munawar

*Research Scientist: Fisheries & Oceans Canada
President: Aquatic Ecosystem Health & Management Society
Chief Editor: Aquatic Ecosystem Health & Management*



Table 1. Special issues of the Aquatic Ecosystem Health and Management (AEHMS, 2000-2014), devoted to Great Lakes.

Special issues	Volume	Year
Large Lakes of the World: Comparative Ecology	3(1)	2000
Ecosystem Health of Lake Baikal, Russia	3(2)	2000
Great Lakes of the World: Food Web, Fisheries, and Management	5(3)	2002
Comparing Great Lakes of the World	6(3)	2003
Coastal Wetlands of the Laurentian Great Lakes: Health, Integrity and Management	7(2)	2004
Emerging Issues in Lake Superior Research	7(4)	2004
Great Lake Victoria Fisheries: Changes, Sustainability, and Building Blocks for Management	10(4)	2007
Changing Great Lakes of the World	11(1)	2008
State of Lake Huron: Ecosystem Change, Habitat, and Management, Part I	11(2)	2008
Checking the Pulse of Lake Ontario	11(4)	2008
The State of Lake Huron: Ecosystem Change, Habitat and Management, Part II	12(1)	2009
Changing Great Lakes of the World and Rift Valley Lakes: Sustainability, Integrity & Management	13(1)	2010
Assessing Large and Great Lakes of the World	13(2)	2010
Ecology of Lake Superior	14(4)	2011
Great Lakes of the World (GLOW VI): Linking Ecosystem-Based Science to Management	16(3)	2013
GLOW VII: Protecting Great Lakes of the World: Managing Exploitation with Ecosystem-Based Science	17(1)	2014
State of Lake Vänern Ecosystem	17(4)	2014

Table 2. Books published under Ecovision World Monograph Series from 1995-2014.

Books	Year
The Lake Huron Ecosystem: Ecology, Fisheries and the Management	1995
Phytoplankton Dynamics in the North American Great Lakes, Vol. 1: Lakes Ontario, Erie and St. Clair	1996
The State of Lake Erie Ecosystem (SOLE): Past Present and Future	1999
Phytoplankton Dynamics in the North American Great Lakes, Vol. 2.: Lakes Superior, Michigan, North Channel, Georgian Bay and Lake Huron	2000
The Great Lakes of the World (GLOW): Food-web, Health & Integrity	2001
Ecology, culture and conservation of a protected area: Fathom Five National Marine Park, Canada	2001
State of Lake Ontario(SOLO): Past, Present and Future	2003
State of Lake Michigan (SOLM): Ecology, Health and Management	2005
Checking the Pulse of Lake Erie (CPOLE)	2008
State of Lake Superior (SOLS)	2009
Burning Rivers	2010
Bringing Conservation to Cities: Lessons from Building the Detroit River International Wildlife Refuge	2014



Advancing the Ecosystem Health Approach:
Good Governance for Adaptation and Rehabilitation

Please note:

All presentations and posters are the property of the presenter. Audio recordings, copying, videotaping or photography of the presentations is prohibited. Media should obtain the permission of the conference chair for use of any conference material.

We request participants to switch off mobile phones in the conference hall.

You should consider your personal name badge as your entry ticket. Please wear your badge at all times during the conference.

Liability: Neither the WorldFish, the AEHMS, nor any of the conference sponsors can be held responsible for damage, loss or theft during the conference. Please take precautions to ensure the safety of yourself and your valuables.

Program

Tuesday, March 24 th			
9:00	Registration desk opens		
10:00-10:50	Conference opening <ul style="list-style-type: none"> • Welcome by the M. Munawar, President of the Aquatic Ecosystem Health & Management Society (AEHMS) • Greeting by Sloans Chimatiro, WorldFish • Official conference opening Alexander Bulirani Director of Fisheries 		
10:50-11:10	Break		
11:10-11:50	K.1	<i>Keynote: Brown, E.</i>	<i>Changes in the Lake Malawi ecosystem: A physical and chemical limnological perspective</i>
Session 1. Fish and Fisheries African Great Lakes: Lake Malawi			
11:50-12:10	S1.01	Njaya, F.	Ecosystem approach to fisheries for the Southern Lake Malawi: Lessons on fisheries governance
12:10-12:30	S1.02	Hara, M.	Lessons from existing modes of governance in Malawi's small-scale fisheries
12:30-12:50	S1.03	Donda, S.	Indigenous fisheries knowledge in fisheries management on Lake Malawi
12:50-2:20	Lunch		
2:20-3:00	K.2	<i>Keynote: Chimatiro, S.</i>	<i>Fish trade in Africa</i>
3:00-3:20	S1.04	Kapute, F.	Lake Malawi fish kill
3:20-3:40	S1.05	Donda, S.	Defragmenting resource management on the South East arm of Lake Malawi: Case of fisheries
3:40-4:00	S1.06	Hara, M.	Between a rock and a hard place: The need for and challenges to implementation of Rights Based Fisheries Management in small-scale fisheries of Southern Lake Malawi
4:00-4:20	Break		
4:20-4:40	S1.07	Gabagambi, N.P.	Biological and ecological effects of a <i>Ligula intestinalis</i> (LINNAEUS, 1758) infestation in the fish host <i>Engraulicypris sardella</i> (GÜTTER, 1868) from Tanzanian side of Lake Nyasa
4:40-5:00	S1.08	Brown, E.	Land-use impact on the sediment influx to Lake Malawi
5:00-5:20	S1.09	Balarin, J.	The Malawi fish project: An integrative approach to the management of Malawi lakes
5:20-5:40	S1.10	Jamu, D.	Beyond fisheries ecosystems: A review of the evidence for climate variability and human –induced impacts on fisheries production in Malawi lakes



Wednesday, March 25 th			
9:00-9:40	K.3	<i>Keynote: Van der Knaap, M.</i>	<i>The cost of non-action in fisheries governance on Lakes Victoria and Tanganyika</i>
Session 2.	Other Great Lakes and Ecosystems: Ecology and Health		
9:40-10:00	S2.01	Etiegni, E.	Difficulties facing co-management: Illegal fishing in Lake Victoria (Kenya)
10:00-10:20	S2.02	Munawar, M.	Algal blooms in the Bay of Quinte, Lake Ontario: Structure, diversity and dynamics
10:20-10:40		Break	
10:40-11:00	S2.03	Mulimbwa, N.T.	The clupeid larvae fishery and its impact on exploitable biomass on Lake Tanganyika
11:00-11:20	S2.04	Kapute, F.	Effect of the Liwonde National Park on fish species diversity in the Shire River, Malawi
11:20-11:40	S2.05	Mugisha, A.	Lake Kivu monitoring programme: Lessons learnt form 6 years of monitoring for a safe and sustainable use of gas resource
11:40-12:00	S2.06	Van der Knaap, M.	On the status and trends in functioning, health and productivity of Large African lakes: International scientific developments versus ground-truthing
12:00-1:30		Lunch	
1:30-2:10	K.4	<i>Keynote: Munawar, M.</i>	<i>Exploring microbial-planktonic dynamics in the deeper strata of the Laurentian Great Lakes: Examples from Lakes Superior and Ontario</i>
2:10-2:30	S2.07	Nkalubo, W.	Temporal trends in catches and life history traits of traditional table fish species in Uganda's water bodies
2:30-2:50	S2.08	Mwadzaangati, G.	Factors influencing practice of floating island fishery in Lake Chilwa
2:50-3:10	S2.09	Mzengereza, K.	Apparent nutrient digestibility of plant based diets by <i>Tilapia rendalli</i> (BOULENGER, 1896)
3:10-3:30	S2.10	Nkalubo, W.	Changes in fish communities along a section of the Upper Victoria Nile, Uganda following dam construction
3:30-3:50		Break	
3:50-5:30	Panel discussion		
5:30-5:45	Publication Plans		



List of Presenters

	Name		Affiliation	Country
	John	Balarin	PACT Malawi	Malawi
Prof.	Erik	Brown	University of Minnesota Duluth	USA
	Sloans	Chimatiro	WorldFish	Zambia
Dr.	Steve	Donda	Department of Fisheries	Malawi
	Christine	Etiegni	Ministry of Agriculture, Livestock and Fisheries	Kenya
Mr.	Nestory	Gabagambi	Tanzania Fisheries Research Institute (TAFIRI)	Tanzania
Dr.	Mafaniso	Hara	Institute for Poverty, Land and Agrarian Studies, University of the Western Cape	South Africa
	Daniel	Jamu	Coastal Resources Center	USA
Dr.	Fanuel	Kapute	Mzuzu University	Malawi
	Ange	Mugisha	Energy Development Corporation Ltd - REG	Rwanda
Dr.	N'sibula T.	Mulimbwa	Center for Hydrobiological Research	Congo
Dr.	Mohiuddin	Munawar	Department of Fisheries and Oceans	Canada
	George	Mwadzaangati	Department of Fisheries	Malawi
Mr.	Kumbukani	Mzengereza	Mzuzu Unirvesity	Malawi
	Friday	Njaya	Department of Fisheries	Malawi
Dr.	Winnie	Nkalubo	National Fisheries Resources Research Institute	Uganda
Dr.	Martin	Van der Knaap	MAXILLION Consultancy	Netherlands

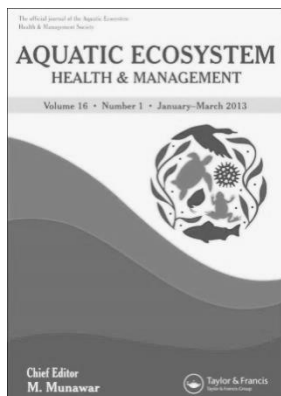
Publication Plans

The Publication and Production Committee of the AEHMS, chaired by Dr. M. Munawar, Chief Editor, will oversee the publication of selected manuscripts originating from the conference. The manuscripts will be considered for publication subject to peer review in a special issue of the ISI rated journal, *Aquatic Ecosystem Health and Management*, published by the AEHMS and Taylor & Francis, Philadelphia.

Please visit www.aehms.org for publication guidelines and instructions on the preparation of manuscript. Due to the large number of manuscripts expected the AEHMS has set page limit guidelines as follows: Keynote: 10; General: 8 printed pages including tables and figures.

Presenters are invited to submit a paper based on their presentation by the submission deadline of June 30th, 2015.

If you are interested in publishing your paper in the special issue devoted to the conference, please fill out the Publication Questionnaire at <http://conferences.aehms.org/glow8/publication-plans/>.



Aquatic Ecosystem Health & Management

The official journal of the Aquatic Ecosystem Health and Management Society (AEHMS).

A peer-reviewed, primary journal devoted to enhancing our understanding of the health, integrity, structure and function of marine and freshwater ecosystems of the world.

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Dr. M. Munawar

Chief Editor

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Objectives

The journal focuses on integrated, multi-disciplinary, multi-trophic and sustainable practices for the management, remediation and restoration of aquatic ecosystems. It provides a forum for scientists and managers to discuss hypotheses and ideas that address ecosystem science based concepts, approaches, methods, models and technologies.

The journal promotes publication of investigations and management practices designed to protect, restore, remediate, conserve and maintain the health and integrity of aquatic ecosystems.

AEHM seeks to foster international and cross-sectorial communications of important findings amongst scientists, managers, students, citizens, business, socio-economists, municipal agencies and politicians.

Scope

The journal publishes articles on the following themes and topics:

- Original concise manuscripts dealing with the health, integrity and performance of aquatic ecosystems
- Reviews on state of the art issues, strategies, techniques and models
- Ecosystem science based holistic treatments including physical, chemical and biological components and their interactions
- Invited essays from established scientists and experts on timely and emerging topics
- Special issues organized around unified themes, topics and ecosystems/habitats

Themes and topics

- Adoption of integrated, ecosystemic science-based approaches including physical, chemical, biological, ecological, eco-toxicological or modelling assessments from a holistic and sustainable perspective.
- Assessment of the impacts of environmental perturbations on the health and integrity of the structure and performance of the food web.
- Linkages between lower and upper trophic levels of the food web
- Bio-monitoring, bio-assessment, and bio-remediation techniques designed for the restoration of stressed ecosystems.
- Development of concepts, procedures and technologies appropriate to evaluate the recovery of ecosystems
- Development and contribution of environmental and ecological guidelines for national and international agreements aimed at protecting ecosystem health and integrity
- Consideration of linkages of aquatic health to socio-economic stressors and environmental ethics towards conservation of aquatic resources



Title of the Special Issue	Volume	Year
State of Lake Vänern Ecosystem	Vol 17(4)	2014
Application of Remote Sensing for Assessing Aquatic Ecosystem Health of China	Vol 17(3)	2014
Protecting Great Lakes of the World: Managing Exploitation with Ecosystem-Based Science (GLOW VII)	Vol 17(1)	2014
Ecology of the Mighty Ganges: health, fisheries and management	Vol 16(4)	2013
Great Lakes of the World (GLOW VI): Linking Ecosystem-Based Science to Management	Vol 16(3)	2013
Celebrating the 20th Anniversary of the AEHMS: The Aquatic Ecosystem Puzzle	Vol 16(2)	2013
Ecosystem Health and Recovery of the Bay of Quinte, Lake Ontario: Part II	Vol 15(4)	2012
Tropical Coastal Seas: Health and Management	Vol 15(3)	2012
Linkages of lakes, rivers, estuaries and oceans: Asia-Pacific focus	Vol 15(2)	2012
Changing Gulf Ecosystem: Ecology, Health and Management	Vol 15(S1)	2012
Marine Environmental Change of the South China Sea	Vol 15(1)	2012
Ecology of Lake Superior	Vol 14(4)	2011
J.R. Vallentyne & R.A. Vollenweider Memorial Issue	Vol 14(2)	2011
Ecosystem Health and Recovery of the Bay of Quinte, Lake Ontario	Vol 14(1)	2011
Ecosystem Health of the Majestic River Ganges	Vol 13(4)	2010
Assessing Great and Large Lakes of the World (GLOW V, Part II)	Vol 13(2)	2010
Changing Great Lakes of the World and Rift Valley Lakes: Sustainability, Integrity & Management (GLOW V, Part I)	Vol 13(1)	2010
Ecosystem sustainability & health of threatened marine environments (ESHTME)	Vol 12(4)	2009
The State of Lake Huron: Ecosystem Change, Habitat and Management, Part II	Vol 12(1)	2009
Checking the Pulse of Lake Ontario	Vol 11(4)	2008
State of Lake Huron: Ecosystem Change, Habitat, and Management, Part I	Vol 11(2)	2008
Changing Great Lakes of the World (GLOW IV)	Vol 11(1)	2008
Great Lake Victoria Fisheries: Changes, Sustainability, and Building Blocks for Management	Vol 10(4)	2007
The State of the Gulf Ecosystem: Future and Threats	Vol 10(3)	2007
Freshwater fishes of South America: Their biodiversity, fisheries and habitat	Vol 10(2)	2007
Sediment Quality Assessment: Watershed-Sediment Management from Source to Sink	Vol 10(1)	2007
Aquatic Ecosystems of Malaysia: Health, Sustainability and Management	Vol 9(2)	2006
Aquatic Ecosystems of China: Concerns, Technologies and Management	Vol 9(1)	2006
Aquatic Ecosystem Health: Scaling from Local to Global Perspectives	Vol 8(4)	2005
The Great Himalayas: Ecology, Health and Management	Vol 8(3)	2005
Assessing Risks and Impacts of Contaminants in Sediments (Continuation of papers from SQA5, Issue 7:3, 2004)	Vol 8(1)	2005
Emerging Issues in Lake Superior Research	Vol 7(4)	2004
Assessing Risk and Impacts of Contaminants in Sediments	Vol 7(3)	2004
Coastal Wetlands of the Laurentian Great Lakes: Health, Integrity & Management	Vol 7(2)	2004
Comparing Great Lakes of the World	Vol 6(3)	2003
Barometers of Aquatic Ecosystem Health and Integrity	Vol 6(2)	2003
Freshwater Biodiversity in Australia	Vol 6(1)	2003
Great Lakes of the World: Food Web, Fisheries, and Management	Vol 5 (3)	2002
Resilience and Integrity of Aquatic Ecosystems	Vol 5 (1)	2002
Freshwater Fish Habitat, Science and Management: A Global Perspective	Vol 4 (4)	2001
Aquatic Ecosystems of Tropical and Temperate Regions: Health and Management	Vol 4 (3)	2001
State of Brazilian Aquatic Ecosystems	Vol 3 (4)	2000
Ecosystem Health of Lake Baikal, Russia	Vol 3 (2)	2000
Large Lakes of the World: Comparative Ecology	Vol 3 (1)	2000
Sediment Quality Assessment: Tools, Criteria and Strategies	Vol 2 (4)	1999
Jack Christie Memorial Essays	Vol 2 (3)	1999
Integrated Toxicology	Vol 2 (1)	1999
Mexican Waters: Ecology Health and Management	Vol 1 (3-4)	1998
Managing Aquatic Ecosystems in Southern Africa	Vol 1(2)	1998

K.1

AUSTIN, J., BROWN, E., JOHNSON, T., KATSEV, S., KELLY, S., MINOR, L., NGOCHERA, M., RICKETTS, D., STEINMAN, B.

Large Lakes Observatory, University of Minnesota Duluth, USA

Changes in the Lake Malawi ecosystem: A physical and chemical limnological perspective

Many aspects of the physical limnology of large tropical lakes in general, and Lake Malawi in particular, remain poorly understood. A better understanding of nutrient cycles and biological productivity requires knowledge of the physical dynamics of the lake. This knowledge is also required for examination of the effects of ongoing climate change on the system. To address these need, the Large Lakes Observatory of the University of Minnesota Duluth deployed an array of moored instruments for observations of physical parameters and processes at two sites in Lake Malawi January 2011 through January 2015. Instrumentation included temperature recorders, an acoustic Doppler current profiler, and oxygen and turbidity sensor-recorders. This unique four-year dataset provides new insights into lake mixing and circulation dynamics, emphasizing the key role of internal waves and seiches. The dataset also allows evaluation of conditions that may have led to the May-July 2013 lake wide fish kill events.

K.3

VAN DER KNAAP, M.

United Nations Office for Project Services, Kenya

The cost of non-action in fisheries governance on Lakes Victoria and Tanganyika

The Lake Victoria Fisheries Organization (LVFO) and the Lake Tanganyika Authority (LTA), since their establishment, prepared a number of fisheries management plans for Lake Victoria's and Lake Tanganyika's fisheries with the view of involving the majority of the stakeholders in (co-) management and applying formal Monitoring, Control and Surveillance as well as community surveillance. The organizations made great efforts to harmonize the fisheries legislation; the recommendations, however, still require to be inserted in the legislations of the majority of the riparian countries. In the meantime the exploitation of juvenile fish continues with large numbers of different types of illegal gear. This article provides the data for fish harvest estimations, and their respective monetary value estimates. It is believed that by applying proper fisheries legislation and further awareness generation, in the overall fight against illegal, unregulated and unreported fishing, the total fish harvest could be multiplied not only in terms of tonnage but also in revenues. This increase in weight and value will be necessary in the forthcoming years and decades to provide minimum food security and food safety for the consumers inside as well as outside the Basins of Lakes Victoria and Tanganyika. On top of that, the national economies of some countries benefit strongly from the export of Nile perch products. The reduction in fish harvests is aggravated by water pollution, insufficient water and sanitation services and other negative impacts from external factors. The costs of non-action are estimated, which could be strongly reduced by the provision of seed money by financing agencies to implement the most up-to-date Fisheries Management Plans, including the International Plans of Action to manage the lakes' fishing capacities on the lakes.

K.4

MUNAWAR, M., FITZPATRICK, M., & NIBLOCK, H.

Fisheries and Oceans Canada, Canada

Exploring microbial-planktonic dynamics in the deeper strata of the Laurentian Great Lakes

Assessments of the microbial – planktonic food web in the North American Great Lakes have relied on vertically integrated water samples in order to achieve an appropriate spatial resolution of these vast water bodies. As a consequence, very little is known about the vertical distribution of microbial and planktonic communities of the Great Lakes. In order to address this knowledge gap, we undertook a study of the microbial – planktonic food webs of various pelagic strata in Lake Superior (2011), Lake Huron (2012) and Lake Ontario (2013). This includes microscopic assessments of the phytoplankton and microbial loop communities in addition to radioisotope tracer measurements of primary productivity and bacterial growth rates. At one deep water site in the central portion of Lake Superior (Aug. 2011), we found that primary productivity was highest in the hypolimnion (50 m) at $1.1 \text{ mg C m}^{-3} \text{ h}^{-1}$ compared to $0.5 \text{ mg C m}^{-3} \text{ h}^{-1}$ in the epilimnion. In contrast, we found primary productivity to be $0.6 \text{ mg C m}^{-3} \text{ h}^{-1}$ in the hypolimnion of a deep water site in eastern Lake Ontario (Aug. 2013) compared to $10.7 \text{ mg C m}^{-3} \text{ h}^{-1}$ in the epilimnion. The goal of the current paper is to consider both structural and functional parameters in assessing the dynamics of the microbial planktonic food web throughout the water column.

S1.01

NJAYA, F.

Department of Fisheries, Malawi

Ecosystem approach to fisheries for the Southern Lake Malawi: Lessons on fisheries governance

This paper analyses fisheries co-management in the southern Lake Malawi where chambo (*Oreochromis* spp) declined from annual landings of about 5,000 tonnes per year in the 1980s to 2,500 tonnes since the 1990s. The low production of chambo is attributed to various ecological and socio-economic issues like increased fishing effort, weak enforcement, aquatic weed removal due to development of cottages, conflicting policies, cultivation of crops in marginal areas and deforestation. Another key issue that was non-compliance to fishing regulations by the fishers hence promotion of community participation was recommended for increase legitimacy. A co-management arrangement was therefore introduced in the area in the late 1990s with establishment of Beach Village Committees (BVCs) to promote community involvement fish resource planning; formulation and enforcement of regulations; and message delivery. With continued chambo decline, an ecosystem approach to fisheries (EAF) is being considered for the fishing area. However we need to draw lessons from the on-going co-management arrangement in terms of its status after a decade of implementation, otherwise the same arrangement in EAF fashion would be championed. In the analysis, Fishery Performance Indicators based on secondary data and the Institutional Analysis and Development framework are applied. Some of the critical governance issues include partial implementation of policies and strategies, lack of incentives for local community participation; unclear decentralised structure; lack of management plans and agreements; and limited participation of key actors like district councils. A rights-based fisheries approach that takes into account climate variability or change is recommended for the chambo recovery.

S1.02

HARA, M.¹, DONDA, S.², & NJAYA, F.²

¹ Institute for Poverty, Land and Agrarian Studies (PLAAS), University of the Western Cape, South Africa

² Department of Fisheries, Malawi

Lessons from existing modes of governance in Malawi's small-scale fisheries

The small-scale sector lands over 95 percent of Malawi's fish catch and provides income and employment to about 65,000 fishers and over 500,000 people engaged in pre- and post-harvest activities. The sector contributes 4 percent to GDP and fish is the cheapest source of animal protein in the country. Annual production for the commercially important Chambo (*Oreochromis* species) has plummeted from 8,000 to less than 1,000 tonnes annually since the 1980s although recent years have witnessed a 60-70 percent increase in catch mainly of low value usipa. Most of the management problems in Malawi can be traced to problems of governance. Fisheries management still remains largely centralized under the Department of Fisheries. A number of co-management arrangements had been introduced in the 1990s such as in Lakes Malombe, Chilwa and parts of Lake Malawi with mixed results. Examples of organic community based management also exist such as on Lake Chiuta, which appear to be yielding very positive results from fishers' perspective. This chapter attempts to analyze the varying management outcomes under the three existing modes of governance (hierarchical, co-governance and self-governance) using the interactive governance framework's three components - governing system, system-to-be-governed and governing interactions. Such a critical analysis will contribute towards finding possible solutions to current management failures in Malawi fisheries and other small-scale fisheries with similar characteristics.

S1.03

DONDA, S.

Department of Fisheries, Malawi

Indigenous fisheries knowledge in fisheries management on Lake Malawi

Fisheries resources have existed on earth for centuries and their management has depended on the available knowledge to those that were and are entrusted with management responsibilities. Formal technical and indigenous knowledge have formed the basis for the formulation of fisheries management approaches. Whichever source of knowledge that has been used, the state of fisheries resources world-wide have changed from virgin stocks to exploited stocks, with some resources being exploited sustainably and others overexploited. The Malawi fisheries resources have also gone through the same path. There are different success stories on the management of fisheries resources on lakes Malawi, Malombe, Chilwa and Chiuta, which are the major water bodies in Malawi. These stories are based on the knowledge base used in managing the fisheries resources. Considering the timeframe of which the fish resources have been in existence, a greater part of fisheries management has been based on indigenous knowledge, which still exists up to now. The problem with indigenous knowledge is that it includes cultural beliefs and tacit knowledge which is rarely documented and slowly disappears as it gets orally passed on from one user to the other. This paper reviews the existing indigenous knowledge and its role in fisheries management in selected areas on Lake Malawi.

S1.04

KAPUTE, F., SINGINI, W., CHIRWA, E., MASUMBU, F., KAMANULA, J., THEGHA, M., & LUHANA, C.

Mzuzu University, Malawi

Lake Malawi fish kill

Communities along the shores of Lake Malawi reported fish deaths between June and July, 2013. It is reported that such phenomenon occurred in 1937, 1946, 1996, 2002 and 2010. Unlike the previous occurrences where mainly large bottom dwelling fish species died, many fish species were collected throughout the entire lake. The Department of Fisheries Science at Mzuzu University carried out a fact finding survey in the northern part of Lake Malawi in July, 2013 to establish the cause of the fish kills. Fish specimens and water quality samples were collected from several beaches and communities were also interviewed. Collected dead fish were observed on-site for abnormalities such as body tumors, discolorations, body lesions, loss of scales etc. Internal organs such as liver, kidney, heart, gut were also examined. The study established that fish kills were consistent with north-easterly (mwera) winds which usually blow during the cold months of June and July every year and is responsible for upwelling of the lake. Some fish were collected half dead and most people reported collecting many dead fish in the morning hours of the day. Some unconfirmed reports from the community were also that some fish had blood in the buccal (mouth) cavity. Most of the fish had sores on their tail fin, head and ventral part, as well as broken tail fin tips, drawing suggestions of a fungal attack or simply cannibalism. Majority of the dying fish species were generally small cichlids usually known as kambuzi and *Lethrinops* species. Communities also reported death of larger species such as *Bathyclarias*, *Bagrus*, *Tilapia* and large cichlids. Hydrogen sulfide levels were far below toxic levels to yield fish kill. The study suggested an in-depth analysis of the causes owing the fact that fish is the most affordable source of dietary protein in Malawi.

S1.05

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Defragmenting resource management on the South East Arm of Lake Malawi: Case of fisheries

The South East Arm of Lake Malawi catchment has a wide range of natural resources that require prudent management for sustainability and maximisation of benefits. Effective management requires an integrated approach. The current management practice is government sector based, with individual departments and ministries using their own policies, legislations and management approaches, yet dealing with the same composite resource and user communities. This has resulted in fragmentation in firstly, authority and responsibility for management, and secondly institutions and governance. The latter relates to the lack of alignment between formal and informal institutions, and contestation for power and authority for governance. Fragmentation is leading to increasing loss of resource rent. Based on results of action research with stakeholders, this paper looks at how and why management is fragmented in the South East Arm catchment and suggests how management could be defragmented, with special interest on fisheries. For example, activities with high negative impacts on fish as a resource include: high fishing effort and illegal fishing methods which are resulting in overfishing; agriculture and deforestation causing soil erosion which is resulting in siltation and turbidity of the lake; and agriculture fertilizers and insecticides, cage culture feeds and domestic waste which are causing chemical and organic pollution. Siltation, turbidity and pollution negatively impact fish productivity. Tourism impacts fisheries negatively mainly through competition for use of beaches with fishers.

S1.06

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Between a rock and a hard place: the need for and challenges to implementation of Rights Based Fisheries Management in small-scale fisheries of Southern Lake Malawi

There has been a declining trend of commercially valuable fish species, especially the Chambo (*Oreochromis* spp), in southern Lake Malawi. Although there might be lack of reliable and scientifically backed evidence, most experts and experienced fishers concur that productivity of most fish stocks in the area is much below par compared to their productivity about two to three decades ago. This leads to the hypotheses that the fish stocks are generally over-exploited. This trend will continue or their productivity will remain at these depressed levels unless bold and drastic measures are taken. This article argues that Rights Based Management (RBM) holds the best promise for moving towards sustainable fisheries management in the southern Lake Malawi (Southeast and Southwest Arms) area while recognizing the need for a broad human rights approach for fishing communities. Of note is that co-management was introduced in area in the early millennium as part of attempts to strengthen user fishing rights, local accountability and stewardship. It is realized though that the implementation of the RBM approach will not be easy given the historical developmental open access management approach and general unorganized characteristics of the small-scale fisheries sector.

S1.07

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Biological and ecological effects of a *Ligula intestinalis* (LINNAEUS, 1758) infestation in the fish host *Engaulicypris sardella* (GÜTTER, 1868) from Tanzanian side of Lake Nyasa

1: Introduction

The cyprinids fish *Engaulicypris sardella* in Lake Nyasa has been recently observed to be infested by a tapeworm parasite *Ligula intestinalis*. The tapeworm *L. intestinalis* is a cosmopolitan parasite in birds, with the larval stages in fish. It has a marked pathogenic effect on the fish host, suppressing growth of the gonads which results in castration. There are several reports where invasions of this parasite have led to a marked decline in the fish population.

2: Objective

The overall objective of this project study is to investigate the biological and ecological effects of a cestode, *L. intestinalis* to the host of the small endemic cyprinid fish, *E. sardella* in Lake Nyasa. Specifically, the project study will investigate if the prevalence and distribution pattern of *L. intestinalis* in Lake Nyasa is different. In addition, the project will evaluate the influence of the parasite on the reproductive biology of *E. sardella* and finally, will investigate if parasitized *E. sardella* could have been more vulnerable to predation.

3: Methods

Determination of parasite infestation on *E. sardella* will be calculated according to Bush et al (1997) and Kennedy and Burrough (1981). Parasite DNA detection in a predator fish stomach contents will be analysed through the application of a specific PCR targeting different genes of *L. intestinalis*. In addition to that, analysis of stomach contents for determinations of *E. sardella* weberian ossicles will be done. Presence of weberian ossicles in a predator fish stomach contents sample will hint predation. Finally, the project in question will study the behaviour changes of *E. sardella* under parasitism and predation risk.

4: Expected results

Results from this study, are expected to contribute to a better understanding of the potential effects of cestode *L. intestinalis* on the biology and ecology of *E. sardella* in Lake Nyasa.

S1.08

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Land-use impact on the sediment influx to Lake Malawi

We deployed instrumented moorings at two mid-lake locations in Lake Malawi, covering the period from January 2011 through December 2013. The north mooring was located at ~10° S, 34°15' E in 400 m water depth, and the south mooring at ~13°28' S, 34°43' E in 180 m water depth. Each mooring included internal-recording thermistors at 6-8 depths between the surface and lake floor and a time-series sediment trap (McLane Research Laboratories "Honjo-style" cone with ~1 m² opening) that collected integrated biweekly samples of particulate matter settling through 170 m (125 m) water depth at the north (south) mooring. The north basin trap displayed two seasons of high sediment accumulation, centered on April and November. By contrast, the southern trap displayed two periods of high sediment accumulation centered on March and June, with almost no sediment recovered in the latter half of the year. The sediment composition during peak flux is dominated by terrigenous silt and clay, with aquatic organic matter typically comprising 5 wt. %, and biogenic silica about 10 wt. % of the total sediment flux. The lithogenic flux achieved peak values of about 2000 mg/m²/day at both mooring sites. A sediment trap of identical design previously deployed in Lake Malawi's north basin from 1987 to 1992 recorded sediment peak fluxes (Pilska, 2004) that were roughly 7 – 10 times less than our observations for 2011-2013. Peak downward fluxes of biogenic silica and total organic carbon were about 3 and 4 times lower, respectively, in the earlier study. We attribute these dramatically higher sediment fluxes in recent years to the expansion of agriculture in the northern catchment of the Lake Malawi basin.

S1.09

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The Malawi fish project: An integrative approach to the management of Malawi lakes

Malawi's freshwater ecosystems are under considerable stress due to pressure from a growing population, a regulatory framework that largely allows for open access to fish resources that results in overfishing, environmental degradation of both land and water based habitats, and changes in climatic conditions. Past efforts to address problems besetting the lakes have achieved minimal results because of inadequate integration of socio-economic, governance and ecological issues in the management of these critical ecosystems. To address these issues, a consortium of partners led by Pact, working with Department of Fisheries, in partnership with University of Rhode Island – Coastal Resource Center (URI-CRC) and Christian Aid are implementing a 5 year (2014-2019) USAID funded project entitled “The Fisheries Integration of Society and Habitats (FISH)”. The overall goal of FISH is to see increased social, ecological and economic resilience of freshwater ecosystems and people who depend on them in the targeted project area of the South East Arm of Lake Malawi, and lakes Malombe, Chilwa and Chiuta. To reach this goal, FISH aims to achieve the two primary objectives of 1) increasing resiliency to climate change and 2) improving biodiversity conservation, by effecting systems, processes and actions for sustainable fisheries co-management. The FISH goal, objectives and programmatic components are linked through a theory of change that posits that if decisions around fisheries management are 1) based on shared, evidence-based objectives and learning, 2) are grounded in inclusive and effective ecosystem-scaled governance structure, and 3) strengthen the assets of communities, then Malawi's complex and diverse freshwater lake ecosystems can be sustained.

S1.10

JAMU, D., & TORELL , E.

Coastal Resources Center, USA

Beyond fisheries ecosystems: A review of the evidence for climate variability and human –induced impacts on fisheries production in Malawi lakes

The fishing industry in Malawi Lakes faces an uncertain future due to natural and human-induced changes to fisheries ecosystems. While it is clear that under normal conditions, fish production in Malawi Lakes is mainly driven by natural and environmental factors, there are human induced drivers, both local and global, that interplay to impact fish production and the resilience of these fisheries. A consortium of partners led by Pact, working with Department of Fisheries, in partnership with De University of Rhode Island – Coastal Resource Center (URI-CRC) and Christian Aid are implementing a 5 year (2014-2019) USAID funded project entitled “The Fisheries Integration of Society and Habitats (FISH)”. Through a literature review of documents spanning the period 1930 to present, FISH has examined the role of climatic variability and human induced changes in decoupling critical processes underpinning fisheries productivity in Malawi lakes. Our review indicates that human induced factors (overfishing, deforestation, and lakeshore development), unstable lake levels, declining river discharge of influent rivers interact to disrupt fish recruitment and production with mixed consequences on fish productivity and species biodiversity. Therefore, managing the fisheries productivity of Malawi Lakes and the benefits that they provide to the people of Malawi requires a holistic approach that focuses on improved governance of terrestrial and aquatic ecosystems.

S2.01

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Difficulties facing co-management: Illegal fishing in Lake Victoria (Kenya)

Illegal fishing remains one of the biggest challenges of co-management in Lake Victoria (Kenya), despite the fact that a key purpose of establishing decentralized Beach Management Units (BMUs) in 2007 was to reduce illegal fishing practices. BMUs were established with the belief that local governance structures would be more effective at combating illegal fishing, but these practices are still widespread, and existing regulations are not enforced. The goal of this paper is to explain why inclusion of BMUs in co-management has not eradicated illegal fishing in Lake Victoria (Kenya). We do this through identifying how perceptions of what is illegal and what is acceptable vary widely among stakeholders, and are shaped by socio-cultural norms, local institutions, and power relations. We document how stakeholders' understanding of fisheries regulations is shaped by both (1) government regulations and (2) fisher folks' cultural beliefs and norms with the later contributing greatly to illegal fishing activities witnessed in Lake Victoria. Based on this, we suggest the need to understanding informal institutions to eradicate illegal fishing in Lake Victoria, and a need to reconsider the nature of BMUs participation in co-management in order to promote sustainable fishing practices. A case study approach was used to explore perceptions on illegal fishing, how it is understood as a practice, and how these understandings vary among stakeholders, and subsequently influence compliance. Data collected through interviews, observations, document review and focused group discussions from four beaches on the Kenyan side of Lake Victoria from May 2013 to June 2014 is presented.

S2.02

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Algal blooms in the Bay of Quinte, Lake Ontario: Structure, diversity and dynamics

Eutrophication is one of the major beneficial use impairments affecting the Bay of Quinte and other Remedial Action Plan sites in the Laurentian Great Lakes. While algal blooms have been a common sight in the bay and the link to phosphorus loads has been well established, little effort has been made to define quantitatively and characterize the structure and function of individual bloom events and their distribution. During the summer of 2010, we analysed the phytoplankton community at 12 sites in the Bay of Quinte and found blooms (biomass >3 g/m³) occurring at 6 of those sites. The composition of the blooms was not the same and we observed that both Cyanophyta and Diatom blooms occurred simultaneously in contrast to the widely held notion that all blooms are unialgal. There is a great need for detailed assessments of the structure and function of algal blooms that go beyond simple measurements of chlorophyll and nutrients.

S2.03

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The clupeid larvae fishery and its impact on exploitable biomass on Lake Tanganyika

Apart from artisanal fisheries targeting adult clupeids and perch, an ad hoc fishery exists for clupeid larvae in the inshore waters of Lake Tanganyika. Women and children catch these fish when schools of larvae pass by in shallow waters. This article argues that this unregulated fishery has an impact on the adult biomass of clupeids, which is targeted by thousands of fishermen on the lake, and which is the mainstay for many fishing communities in the lake basin. Projections are presented on the quantity and value of the fish harvest in case of a total ban on this type of fishing. Preliminary data suggest that approximately half a year after a local ban the catch rates of the artisanal clupeid fishermen increase. The authors present recommendations for elucidating the migratory routes of the clupeids, whose knowledge would assist in adequately managing the clupeid fishery of Lake Tanganyika.

S2.04

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Effect of the Liwonde National Park on fish species diversity in the Shire River, Malawi

The Shire River is the only outlet of Lake Malawi and forms an important fishery below Lake Malombe. Recent collapse of the fishery in Lakes Malawi and Malombe has also affected the Shire River stocks. This study collected fish samples from selected areas in the southeast arm of Lake Malawi, upper Shire River, Lake Malombe and middle Shire River including areas around the Liwonde National Park. The park (about 580 sq km), lies to the eastern bank of the middle Shire River bordering Lake Malombe to the north. Fish were identified at species level. Length frequencies and catch data were raised to the total catch where sub-sampling was done. The type of fishing gear and area where fish were caught was also documented. The data were analysed for species composition (diversity), gear selectivity, size distribution and weight by species; and total length by gear by plotting length frequency histograms. Findings showed that fishers catch most of the fish in areas close to the park suggesting that it is a breeding area. Elsewhere, fish hardly have chance to breed because of the uncontrolled heavy fishing pressure. Also, catches from the southern part of Lake Malombe appeared better than the rest of the areas of the lake suggesting migration of fish from the park. It is concluded that the park is an important breeding area for fish that migrate to the southern part of Lake Malombe and the stretch of the Shire River downstream. Continued protection of the fishery in the park would therefore have far reaching advantages to the fisheries especially in the middle Shire River and southern part of Lake Malombe where heavy fishing is unabated.

S2.05

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Lake Kivu monitoring programme: Lessons learnt form 6 years of monitoring for a safe and sustainable use of gas resource

Lake Kivu is part of the East African Great Lakes, and is located between Rwanda and DR Congo. It is a deep (max. 489 m) meromictic lake, with an oxic mixolimnion up to 60 m, and a deep anoxic molimnion presenting important density and salinity gradients, as well as important amount of dissolved gases, among which methane. Recent estimation of CH₄ concentrations has indicated an increase of its production, which may increase the risk of explosion within this century (Schmid et al., 2005). Since 2008, exploitation of the methane resource has started in the Rwandese part of the lake. As waters have to be re-injected in the lake, it can affect the stability of the lake stratification and the ecology of the upper oligotrophic biozone, source of an important fishery activity for the 2 million surrounding population. The “Lake Kivu Monitoring Programme” has thus been established in 2008, at the onset of the first experimental gas extraction plant, with the aim to guaranty a safe and sustainable exploitation of the resource. After 6 years of monitoring around the extraction plant and in the whole lake, we have been able to localise and quantify the plume of the re-injected waters. We can now conclude that the gas extraction feeding a 3 MW power plant does not have a remaining impact on the physical and chemical structure of the lake. Possible long term effects of the gas extraction on the lake would be assessed in comparison of physical and chemical, as well as biological baselines, continuously recorded within a long term frame. In addition, the impact of extraction plants of several tens of MW production capacity, such as planned for a near future, still needs to be assessed.

S2.06

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² Deltares, The Netherlands

On the status and trends in functioning, health and productivity of Large African lakes: international scientific developments versus ground-truthing

Human-induced changes to climatic conditions in the Great Lakes region in Africa allegedly caused reduced production of Africa's Great Lakes. Temperature measurements on Lake Tanganyika over a one-century period show increases over time at different rates at different depths. Changes in wind patterns would have caused changes in upwelling intensity and frequency. Increased population pressure around the lake contributed to extra nutrient loads and pesticide and fertilizer run-off, which increasingly influence the lake's basins hydrology. The changes in the lake system's water quality could be considered a factor influencing the output of resource use around the lake, now and in the future.

The present paper summarizes recent climate change theories and actual developments and their potential effect on lake production.

Recommendations are provided to monitor a practical ecosystem- based indicators that allow better adaptive lake management with the increased sectoral developments in the whole of the East African lake region.

S2.07

BALIRWA, J., NKALUBO, W., TAABU-MUNYAHU, A., NAMULEMO, G., WANDERA, S., & NSEGA, M.

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Temporal trends in catches and life history traits of traditional table fish species in Uganda's water bodies

Uganda's water bodies harbour at least 500 species of fish, all of them edible. Of these, at least 12 traditional table fishes that grow to relatively larger sizes (30 - 150 cm in total length; 1 - 150 kg adult weight) have historically been a major source of fish food, income and employment for local communities. In this paper, we quantify catches and key traits of table fishes from Uganda's major lakes and make comparisons to historical data so as to detect and evaluate temporal patterns of change.

The decline in importance of some table fishes in the major lakes during the 1960s was accompanied by introductions and stockings with new species aimed at boosting production. For example, on Lake Victoria while a ten-fold increase in catches of just two introduced species (Nile perch and Nile tilapia) ensued in the 1980s and resulted into fish exports to regional and international markets, other traditional table fishes never recovered and have almost disappeared from the commercial catches. The high demand for fish associated with increasing harvesting pressure using illegal and destructive fishing gears and methods, habitat degradation, and pollution seem largely responsible for the declines in stocks of the traditional table fishes, and reductions in their biological parameters (population mean size, size at maturity) which could be detrimental to the subsequent stocks if not controlled.

Management measures and efforts that aim at restoration of the traditional fish stocks and catches are required to manage the drivers of change in most of Uganda's water bodies. Strategies and guidelines to enhance the productivity of these fishes in aquaculture also need to be developed.

S2.08

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Factors influencing practice of floating island fishery in Lake Chikwa

The Floating Island fishery (local name: Chimbowera) is of major concern due to its effect on overfishing as well as spread of communicable diseases amongst the fisher communities of Lake Chilwa, Malawi. This study attempted to explore main socio-economic factors that influence the Floating Island fishery in Lake Chilwa to recommend proper management measures. A total of 122 respondents were interviewed using a structured questionnaire. The socio-economic factors that influence fishers to practice Chimbowera fishery were examined using a Binary logistic model. Nine predictor independent variables were regressed against the binary dependent variable. The logistic regression model was evaluated using Goodness of fit Hosmer and Lemeshow (H-L) chi-squared, - 2 Log Likelihood, model coefficient Chi-Squared, and accuracy of prediction; overall. The goodness of fit Hosmer and Lemeshow (H-L) test yielded χ^2 (8) of 6.393 and was insignificant at $P < 0.05$. Accuracy of prediction; overall per cent correct of 95.1% was obtained. From the nine predictor variables fitted in the logistic regression model, three variables namely: distance from beach, weekly income and relative being a Chimbowera fisher were significant while six variables were not significant namely: age, position in society, level of education, household size, land holding size and better fish quality. It is recommended that viable income generating activities (IGAs) be explored and identified for the Chimbowera fishers so that their weekly incomes should come from those IGAs. Strong and continuous sensitisation campaigns against this fishery should be mounted on Lake Chilwa to ensure change of mind set of the people and finally, enforcement activities should be strengthened and given much support to ensure that the Chimbowera fishers are evicted from the waters of Lake Chilwa.

S2.09

MZENGEREZA, K., SINGINI, W., MSISKA, O., KAPUTE, F., KANG'OMBE, J., & KAMANGIRA, A.

Mzuzu University, Malawi

Apparent nutrient digestibility of plant based diets by *Tilapia rendalli* (BOULENGER, 1896)

Modern fish culture demands the reduction of the cost of feeds which can be achieved by minimal use of dietary animal protein. This study investigated the digestibility of diets formulated exclusively out of plant sources, by the herbivore *Tilapia rendalli*. The study was conducted at Nkhata Bay Fisheries Laboratory along Lake Malawi for 21 days. The experiment was laid out in a Completely Randomized Block design (CRD) using 30x30x35cm glass aquaria with each of the four experimental isonitrogenous diets containing varying plant sources replicated three times. Water from Lake Malawi was used in the glass aquaria and was drawn every day to replace the contaminated. Juvenile *T. rendalli* (25.0±1.0 g) were conditioned for 5 days to accept the artificial dry plant feed fed two times a day. Faeces were collected by stripping method using a tube and pipette, preserved in beakers and later analysed for chemical composition. An indirect method of measuring digestibility was used to calculate the apparent digestibility coefficients (ADCs) of the diets containing 1% chromic oxide and faeces. Water quality data was measured on daily basis using a spectrophotometer. Data was analyzed using Analysis of variance (ANOVA) at P=0.05 using R- statistical software. Protein digestibility coefficient ranged from 30.82% ± 0.81 to 29.21% ± 0.91. However, apparent digestibility coefficients for gross energy were slightly higher than those of other elements (protein, ash, fiber and fat). Lake Malawi water temperature records were 21-22°C, pH was 7 on average and conductivity mean was 300± (µmhos/cm). Results show that the nutrient content and its digestible value provide a good support for the development of a system of selecting ingredient for inclusion in fish diets. It can be concluded that water from Lake Malawi is ideal for the *T. rendalli* as the survival rate was 93% on average.

S2.10

NKALUBO, W., NAMULEMO, G., WANDERA, S., & NSEGA, M.

National Fisheries Resources Research Institute, Uganda

Changes in fish communities along a section of the Upper Victoria Nile, Uganda following dam construction

Fish communities along a stretch of Upper Victoria Nile were investigated at selected sites between Kalange (upstream) and Buyala (downstream) before (2001), during (2007-2012) and after (2013-2014) construction of the Bujagali hydropower dam. The study examined changes in fish species composition, abundance and distribution associated with construction of the dam across the river. Experimental gill-netting was conducted in a broad range of habitats up and downstream the dam.

With haplochromines taken as a single species group, a total of 18 fish species from ten families were recorded at the two sites before dam construction compared to 9 during dam construction and 7 after dam construction. Over the same period, a change in dominance of species from those adapted to fast flowing water (*Lates niloticus*, *Mormyrus kannume*, *Barbus altianalis*, *Bagrus docmak*) to those adapted to slowing of the flow velocity (haplochromines) was observed. This could be attributed to the reduction in water flow resulting from the erection of a barrier (dam) across the river and hence favouring the survival of selected species. The catch rates (in numbers) of most fish species caught overtime by gillnets declined with the disappearance of some species from sections of the river where they previously thrived.

The findings in this study highlight the role of anthropogenic activities in altering fish habitats and their populations. Strategies to protect fish species that have disappeared from this stretch of the Upper Victoria Nile in other river stretches where they are prevalent need to be developed.