International Symposium

Changing Great Lakes of the World

(GLOW IV)

State of Lake Tanganyika, a Case Study

Climate change, Food web alterations, Invasive species, and Management

PROGRAM

February 20th to 22nd, 2006
Bagamoyo, Tanzania

Organized by:
The Aquatic Ecosystem Health and Management Society (AEHMS)

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Sponsored by:
Great Lakes Fishery Commission,
U.S. Geological Survey,
International Joint Commission

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P.O.J. Bwathondi (Tanzania), M. Munawar (Canada),
M. van der Knaap (The Netherlands)

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Welcome to beautiful Tanzania!

On behalf of the Organizing and Program Committees, we welcome you to this exciting and interesting conference in beautiful Bagamoyo, Tanzania.

This conference will be the fourth in a series organized by the AEHMS to focus on the state of the Great Lakes of the World (GLOW). The first such conference, GLOW I, held in Zimbabwe during 1996, resulted in a special issue of the society's journal, Aquatic Ecosystem Health and Management (Munawar, 2000) and a peer-reviewed book under the Ecovision World Monograph Series (Munawar and Hecky, 2001).

After a modest beginning in Zimbabwe, GLOW II was held in Sligo, Ireland 2000, and played a significant role in bringing the Great Lakes community together for the first time from Africa, Europe and North America. Papers originating from the Sligo conference also resulted in a special issue of AEHM (Munawar, 2002).

The GLOW conference once again returned to Africa for the convening of GLOW III in Arusha, Tanzania, 2002. This conference too resulted in the publication of selected papers in a special issue of AEHM (Munawar, 2003). During GLOW III, an African Great Lake chapter was established by the AEHMS to continue the Society's activities in Africa, including the holding of regular GLOW meetings.

The program for the GLOW IV conference is quite interesting and contains a variety of topics and themes for the African Great Lakes, as well as other Great Lakes. The Lake Victoria ecosystem was a case study at GLOW III, whereas, Lake Tanganyika has been chosen this time. The program consists of approximately 43 oral (including 6 plenaries) and 21 poster presentations. They have been divided into three sessions namely, Lake Tanganyika ecosystem, Lake Victoria ecosystem, and Comparing Great Lakes of the World. All submitted abstracts were reviewed by the Program Committee, as well as the AEHMS secretariat. The abstracts were technically and linguistically edited by the AEHMS. To be environmentally friendly, the entire program and abstracts are included in a CD, and only the program is printed in a booklet form.

GLOW IV offers a unique opportunity to assess the status of the Great Lakes of the world in general and African lakes in particular. The Lake Tanganyika case study offers an excellent chance to review and evaluate progress made on the lake, which constitutes an important source of income, employment, drinking water and food for a multitude of people living on or near the lake. Our challenge is to convince the relevant authorities that the health of Lake Tanganyika's ecosystem is the key element in the sustainability of the resource use, and a prerequisite for both human health and development.

Traditionally AEHMS emphasizes publications of papers originating from its conferences and symposia. The AEHMS plans to publish peer-reviewed papers in a book as part of the Ecovision World Monograph Series and/or in a special issue of Aquatic Ecosystem Health & Management, depending on the nature and type of papers submitted. Therefore, we urge you to confirm your publication plans with the

Society by completing the publication questionnaire available at the registration desk.

On behalf of the AEHMS, and the GLOW IV Organizing and Program Committees, we are pleased to welcome you to the scenic surroundings of Bagamoyo. It is hoped that this conference will bring together experts from across the world on various issues related to the Great Lakes. Hopefully new insights, techniques and approaches may emerge from this conference which will be useful in the conservation and protection of precious aquatic resources. As the co-chairs of this conference, we are honoured and delighted to extend a warm welcome to all of you.

M. Munawar
Co-chair
President, AEHMS
Chief Editor, AEHM

Martin van der Knaap
Co-chair
Aquatic Resource Management Adviser

Professor P.O.J. Bwathondi
Co-chair

Munawar, M. (Ed.), 2000. Large Lakes of the World: Comparative ecology. Aquat. Ecosyst. Health Manage. 3(1), 1-189.

Munawar, M. (Ed.), 2002. Great lakes of the World: Food Web, Fisheries, and Management. Aquat. Ecosyst. Health Manage. 5(3), 243-393.

Munawar, M. (Ed.), 2003. Comparing Great Lakes of the World. Aquat. Ecosyst. Health Manage. 6(3), 229-356.

Munawar, M., R. Hecky (Eds.), 2001. *The Great Lakes of the World; Food Web, Health and Integrity*. Ecovision World Monograph Series. Backhuys Publishers, Leiden, The Netherlands.

General Information & Publication Plans

Official Language
The official presentation language is English. All lectures and documentation will be in English.

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

Lunch, coffee and tea breaks
Lunch and coffee/tea breaks are included with registration. The locations will be announced at the time of the conference.

Registration Desk
The conference will be held in the Oceanic Bay Hotel in Bagamoyo, Tanzania. The registration desk will be in the hotel lobby.

Publication Plans
Selected manuscripts originating from the conference will be considered for publication subject to peer review in the journal: Aquatic Ecosystem Health and Management and/or Ecovision World Monograph Series. Instructions to authors on the preparation of manuscripts can be found on the AEHMS website: www.aehms.org

Due to the large number of manuscripts expected the AEHMS has set page limit guidelines as follows: Keynote: 12; Oral: 6; Poster: 4 printed pages including tables and figures (Text: Times New Roman 11 pt, Margins: 2.7 cm (1"), Paper: letter size 21.6x28 cm (8.5x11")).

For more information please contact Jennifer Lorimer, AEHMS Coordinator (lorimerj@dfo-mpo.gc.ca).

Publication Questionnaire
The questionnaire must be completed and submitted to Jennifer Lorimer, AEHMS Coordinator (lorimerj@dfo-mpo.gc.ca) by ***March 15th, 2006***.

Safari field trip
The pick-up time for the Safari is tentatively set at 9:00 am on Thursday, February 23rd. Participants going on the safari will arrive back in Bagamoyo on the afternoon of Saturday, February 25th.

Liability
Neither the conference organization nor the AEHMS can be held responsible for damage, loss or theft during the conference.

Program-at-a-Glance

<table>
<tr><th>Time</th><th>Mon., Feb. 20th</th><th colspan="2">Tues., Feb. 21st</th><th colspan="2">Wed., Feb. 22nd</th></tr>
<tr><td>8:00 – 8:30 AM</td><td>Registration</td><td colspan="2">Plenary: R. Mugidde (Tanzania)</td><td colspan="2">Plenary: R.E. Hecky (Canada)</td></tr>
<tr><td>8:30 – 9:00</td><td>Opening Ceremony</td><td colspan="2" rowspan="3">Session II: Lake Victoria Ecosystem</td><td colspan="2" rowspan="3">Session III: Comparing Great Lakes of the World</td></tr>
<tr><td>9:00 – 9:30</td><td>Plenary: J. Sarvala (Finland)</td></tr>
<tr><td>9:30 – 9:50</td><td>Session I: Lake Tanganyika Ecosystem</td></tr>
<tr><td>9:50 – 10:20</td><td>Coffee & Tea</td><td colspan="2">Coffee & Tea</td><td colspan="2">Coffee & Tea</td></tr>
<tr><td>10:20 – 11:40</td><td>Session I</td><td colspan="2">Session II</td><td colspan="2">Plenary: D. Schornack (USA)
Session III</td></tr>
<tr><td>11:40 – 1:00</td><td>Lunch</td><td colspan="2">Lunch</td><td colspan="2">Lunch</td></tr>
<tr><td>1:00 – 1:30</td><td>Plenary: E. Reynolds (Italy)</td><td>1:00 – 1:30</td><td>Plenary: O. Mkumbo (Uganda)</td><td>1:00 – 1:30</td><td>Plenary: C. Krueger (USA)</td></tr>
<tr><td>1:30 – 2:10</td><td>Session I</td><td>1:30 – 2:50</td><td>Session II</td><td>1:30 – 2:10</td><td>Session III</td></tr>
<tr><td>2:10 – 2:40</td><td>Coffee & Tea</td><td>2:50 – 3:20</td><td>Coffee & Tea</td><td>2:10 – 2:40</td><td>Coffee & Tea</td></tr>
<tr><td>2:40 – 3:40</td><td>Session I</td><td rowspan="2">3:20 – 6:00</td><td rowspan="2">Session II</td><td rowspan="2">2:40 – 4:30</td><td rowspan="2">Panel Discussion, Synthesis & Summary</td></tr>
<tr><td>4:00 – 6:00</td><td>Poster Session</td></tr>
<tr><td>6:00 PM</td><td>Dinner</td><td colspan="2">Dinner</td><td colspan="2">Banquet</td></tr>
</table>

Pre-conference registration will be available on Sunday, February 19th (hours to be announced).

Detailed Scientific Program

Monday, February 20th

Morning Program

8:00 – 8:30 Registration

8:30 – 9:00 ***Opening Ceremony***

Session I: Lake Tanganyika Ecosystem

9:00 – 9:30 ***Plenary***
What are the mechanisms regulating pelagic fish recruitment in Lake Tanganyika?
Sarvala, J., Chitamwebwa, D., Kanyaru, R. Langenberg, V., Mulimbwa, N., Salonen, K. & Mölsä, H.

9:30 – 9:50 CLIMLAKE: Climate variability as recorded in Lake Tanganyika, (2001-2005)
Descy, J.-P., Plisnier, P.-D., Leporcq, B., Sténuite, S., Pirlot, S., Stimart, J., Gosselain, V., André, L., Alleman, L., Langlet, D., Vyverman, W., Cocquyt, C., De Wever, A., Stoyneva, M.P., Deleersnijder, E., Naithani, J., Chitamwebwa, D., Chande, A., Kimirei, I., Sekadende, B., Mwaitega, S., Muhoza, S., Sinyenza, D., Makasa, L., Lukwessa, C., Zulu, I. & Phiri, H.

9:50 – 10:20 ***Coffee & Tea***

10:20 – 10:40 Diversity and ecology of crabs in Lake Tanganyika
Marijnissen, S.A.E., Michel, E., Pereira, A.J., Bosch, K., Kamermans, M. & Cumberlidge, N.

10:40 – 11:00 The diversity of biodiversity: Species, distributions, genetics and the conundrum of conservation of Tanganyikan endemics
Michel, E., Todd, J.A., Marijnissen, S.A.E., Wagner, C.E., & Cohen, A.S.

11:00 – 11:20 Impact study of sedimentation on fish communities in the littoral zone of Lake Tanganyika: the case of rocky and mixed biotopes in the northern basin
Barengayabo, S., Nkurunziza, V., Ntakimazi, G. & Micha, J.-C.

11:20 – 11:40 The unique cichlid diversity of Lake Tanganyika: complex systematics with new perspectives
Snoeks, J.

11:40 – 1:00 ***Lunch***

Afternoon Program

1:00 – 1:30	***Plenary*** The Regional Programme for Integrated Management of Lake Tanganyika Reynolds, J.E.
1:30 – 1:50	Seasonal patterns in zooplanktivorous fish catches relative to abundance of zooplankton in northwestern Lake Tanganyika Mulimbwa, N.
1:50 – 2:10	Jellyfish, *Limnocnida tanganyicae* - a semiautonomous microcosm in the food web of Lake Tanganyika Salonen, K., Sarvala, J., Tarvainen, A., Tiirola, M. & Mölsä, H.
2:10 – 2:40	***Coffee and Tea***
2:40 – 3:00	A forgotten species flock from Lake Tanganyika: diversity and evolutionary history of *Synodontis* catfish Day, J.J.
3:00 – 3:20	Changes in species composition and abundance of commercially important pelagic fish species in Kigoma area, Lake Tanganyika, Tanzania Kimirei, I.A., Mgaya, Y.D., Plisnier, P.D. & Chande, A.I.
3:20 – 3:40	Lake Tanganyika ecosystem management strategies Nkotagu, H. H.

End of Session I

4:00 – 6:00	***Poster Session***

Tuesday, February 21st

Morning Program

Session II: Lake Victoria Ecosystem

8:00 – 8:30	***Plenary*** Eutrophication and ecosystem changes of Lake Victoria Gikuma-Njuru, P., Rutagemwa, D., Mugidde, R., Hecky, R.E., Mwebaza-Ndawula, L., Mwirigi, P.M., Abuodha, J.O.Z., Waya, R., Matovu, A. & Kinobe, J.
8:30 – 8:50	Photosynthetic efficiency along a nutrient and phytoplankton gradient in Nyanza Gulf, Lake Victoria Guildford, S.J., Gikuma-Njuru, P. & Müller, K.M.
8:50 – 9:10	Phytoplankton species composition and biomass in the southern part of Lake Victoria, East Africa Semili, P., Rutagemwa, D., Waya, R. & Mwanuzi, F.
9:10 – 9:30	Seasonal changes in relative abundance of zooplankton in Shirati Bay, Lake Victoria Waya, R. K., Shoko, A., Mbonde, A., Mzighani, S., Matola, H. & Mgaya, Y.
9:30 – 9:50	Distribution and abundance of invertebrates as indicators of water quality in Lake Victoria Mwebaza-Ndawula, L., Kiggundu, V. & Gandhi, W.P.
9:50 – 10:20	***Coffee and Tea***
10:20 – 10:40	The diversity of aquatic macro-invertebrates associated with Water hyacinth *Eichhornia crassipes* (Mart.) Solms. (Pontederiaceae) in Kenyan waters of Lake Victoria Muli, J.R.
10:40 – 11:00	Changes in the Yala swamp wetland: environmental degradation in operation Asila, A.A.
11:00 – 11:20	Mara River and associated wetland as a refuge of threatened indigenous tilapiines of Lake Victoria, Tanzania Chande, A.I.

11:20 – 11:40	The status of water quality and ecosystem health of Lake Victoria: implications on the fishery Gichuki, J., Ezekiel, C., Okello, W., Wanda, F. M. & Mugidde, R.
11:40 – 1:00	***Lunch***
	Afternoon Program
1:00 – 1:30	***Plenary*** The fisheries of Lake Victoria: Status and management initiatives for sustainable exploitation Mkumbo, Oliva, E.
1:30 – 1:50	Spatial comparison by GIS of fish community structure in three bays with varying catchments of land use, northern Lake Victoria, Uganda Sekiranda, S.B.K., Okot-Okumu, J., Bugenyi, F.W.B., Nsega, M. & Mwebaza-Ndawula, L.
1:50 – 2:10	Species distinction and the biodiversity crisis in Lake Victoria Witte, F., Wanink, J.H. & Kishe-Machumu, M.A.
2:10 – 2:30	Life-history responses of the Lake Victoria cyprinid *Rastrineobola argentea* to environmental changes Wanink, J.H., Hoogenboezem, W., Katunzi, E.F.B., Okedi, J.Y. & Witte, F.
2:30 – 2:50	Environmental factors that favour the distribution of introduced over endemic tilapiines in the Lake Victoria Basin Jembe, B.T., Boera, P. N. & Okeyo-Owuor, J.B.
2:50 – 3:20	***Coffee & Tea***
3:20 – 3:40	Is Western consumption of Nile perch from Lake Victoria sustainable? Van Der Knaap, M. & Ligtvoet, W.
3:40 – 4:00	Is Nile tilapia replacing Nile perch in Lake Victoria? What are the consequences? Njiru, M., Getabu, A., Ojuok, J. E., Muchiri, M., Okeyo-Owuor, J.B. & Cowx, I. G.
4:00 – 4:20	Documentation of fish diseases of the Lake Victoria Basin-Kenya, and the surrounding satellite lakes and dams Ogwai, C., Awuondo, Z. & Onyango, J.

4:20 – 4:40	Status of exploitation of the fisheries resources of Lake Victoria Muhoozi, L.I., Kamanyi, J.R., Nzungi, P.M., Othina, A., Wekesa, S.J., Lyimo, E., Wadanya, J., Msuku, B. S., & Rwekaza, E.
4:40 – 5:00	Gender participation in Lake Victoria's fishery resources (Kenya) Lwenya, C.A.
5:00 – 5:20	Socio-economic viability and sustainability of Beach Management Units (BMUs): Case study of the cross-border BMUs on Lake Victoria Abila, R., Odongkara, K. & Onyango, P.
5:20 – 6:00	Community-based aquaculture in Lake Victoria Basin (Kenya): Resource potential, opportunities and threats Okechi, J.K.

End of Session II

Wednesday, February 22nd

Morning Program

Session III: Comparing Great Lakes of the World

8:00 – 8:30	***Plenary*** Trophic dynamics of Lake Tanganyika and Lake Victoria and the importance of trophic structure in determining fisheries yields Hecky, R.E., Verburg, P., Silsbe, G. & Campbell, L.
8:30 – 8:50	Is eutrophication increasing the likelihood of a gas eruption from Lake Kivu? Schmid, M., Halbwachs, M., Wehrli, B. & Wüest, A.
8:50 – 9:10	Mesozooplankton of Lake Kivu (East Africa): diversity, abundance, spatial and temporal patterns, and impact of the Tanganyika sardine Isumbisho, M., Sarmento, H., Kaningini, B., Micha, J.-C. & Descy, J.-P.
9:10 – 9:30	The trophic role of fish communities in the Kyoga Basin lakes' food webs (East Africa). A stable isotope approach Mbabazi, D., Makanga, B., Orach-Meza, F., Hecky, R.E., Balirwa, J.S., Ogutu-Ohwayo, R., Verburg, P., Namulemo, G., Muhumuza, E. & Luyiga, J.
9:30 - 9:50	Ecological state and monitoring of limnological and biological parameters in Lake Ladoga Viljanen, M., Drabkova, V. & Kondratyev, S.
9:50 – 10:20	***Coffee and Tea***
10:20 – 10:50	***Plenary*** Binational strategies to protect the North American Great Lakes from aquatic invasive species Schornack, D.
10:50 – 11:20	Implications of the impact of exotic species on the food web dynamics in the North American Great Lakes Munawar, M., Mandrak, N.E., Munawar, I.F., Fitzpatrick, M. & Dermott, R.
11:20 – 11:40	Latitudinal variation in populations of Lythrum salicaria in Europe and North America: Joint international research and volunteer program Middleton, B.

11:40 – 1:00	***Lunch***
	Afternoon Program
1:00 – 1:30	***Plenary*** Rehabilitation of lake trout in the Great Lakes: past lessons and future challenges Krueger, C.C., Goddard, C. & Gaden, M.
1:30 – 1:50	Intergovernmental relations in Great Lakes fishery management: cooperation amidst political fragmentation Gaden, M., Krueger, C.C. & Goddard, C.
1:50 - 2:10	The importance of the U.S.-Canada Great Lakes Water Quality Agreement in protecting and restoring North America's Great Lakes, and the role of NGOs (non-government organizations) in negotiating amendments to the Agreement Eder, T. & Jackson, J.
	End of Session III
2:10 – 2:40	***Coffee & Tea***
2:40 – 4:30	***Panel Discussion, Synthesis and Summary***
6:00	***Banquet***

Poster Session

Great Lakes of the World

Management of a productive boreal lake (Pyhäjärvi, SW Finland): from fish introductions to biomanipulation
Helminen, H., Tarvainen, M., Ventelä, A.-M., & Sarvala, J.

Is the planktonic food web of Lake Superior changing?
Munawar, M., Munawar, I.F., El-Shaarawi, A., Heath, R., Niblock, H., Fitzpatrick, M., & Carou, S.

Life histories of pelagic fish – a comparison between boreal North European lakes and the tropical Lake Tanganyika
Sarvala, J. & Helminen, H.

Lake Victoria

An assessment of fisheries product values along Kenya's export marketing chain
Abila, R.O.

Fish community structure at the lake-river interphase in Lake Victoria, Kenya
Asila, A.A., Owili, M.A. & Omondi, R.

Food partitioning of fishes on the rocky shores of Usenge in Lake Victoria
Asila, A.A., Agembe, S. & Awuondo, Z.

Recent changes in ecology of Lake Sare, Lake Victoria Western Kenya
Gichuki, J., Maithya, J., & Masai, D. M

Phytoplankton of 11 satellite lakes of Lake Victoria basin (Uganda)
Kling, H.J., Almond, J., Mugidde, R., & Hecky, R.E.

The diet of detritivorous cichlids after the ecological changes in Lake Victoria
Kishe-Machumu, M., Witte, F., & Wanink, J.H.

The use of eutrophication effects to reveal the function of cichlid egg spots
Wanink, J.H., Goldschmidt, T., & Witte, F.

Status of Micro-contaminants of public health concern in Lake Victoria, Kenya
Werimo, K.

Lake Tanganyika

Nitrogen dynamics in Northern Lake Tanganyika: inputs by rivers and use by phytoplankton
Brion, N., Nahimana, D., Nzeyimana, E., Goeyens, L. & Baeyens, W.

Wind induced changes in physical, chemical and plankton-community structures in Lake Tanganyika
Langenberg, V.T., Tumba, J-M., Tshibangu, K., Lukwesa, C., Chitamwebwa, D., Bwebwa, D., Makasa, L., & Roijackers, R.

A conservation assessment of the freshwater crabs of Tanzania with special reference to Lake Tanganyika
Cumberlidge, N., Marijnissen, S., Reed, S.K., & Michel, E.

Underwater survey showing Cichlid species diversity between sandy and rocky shores in the Kigoma area, Lake Tanganyika, Tanzania
Mgana, H., Kimirei, I.A., Lyimo, J., Kimambo & A.I. Chande

Aquatic outreach & education in 'The Jewel of the Rift', Lake Tanganyika
Michel, E., Marijnissen, S.A.E., Kars, M. & Mtiti, E.

Nutrient excretion by littoral fishes in Lake Tanganyika: species, community, and ecosystem perspectives
Mcintyre, P.B. & Michel, E.

The Nyanza Project: Interdisciplinary research training in tropical lakes
Cohen, A., Michel, E., Lezzar, K., O'reilly, C., Russell, J., Nkotagu, Hudson, & Kimirei, I.

Primary productivity and phytoplankton species composition in the Malagarasi allied rivers and wetlands in Western Tanzania
Mwaitega, S.R.

Nutrient distribution and carbon dynamics in Northern Lake Tanganyika as studied from stable isotope geochemistry
Nahimana,D., Brion, N., Ntakimazi, G. & Baeyens, W.

The limnology of the Lake Tanganyika sub-catchment
Nkotagu H.H. & Athuman, C.B.

Alphabetical Listing of Oral Abstracts

ABILA, Richard, ***ODONGKARA, Konstantine & ONYANGO, Paul***

Kenya Marine and Fisheries Research Institute, Kisumu Research Centre, P.O. Box 1881, Kisumu, Kenya.
abilarichard@hotmail.com

Socio-economic viability and sustainability of Beach Management Units (BMUs): Case study of the cross-border BMUs on Lake Victoria

Beach Management Units (BMUs) are the community institutions in the new co-management arrangement for Lake Victoria fisheries. This study aimed to generate information for strengthening viability and sustainability of BMUs. Its objectives were to; identify functions of BMUs, assess their performance, identify resource constraints, income and expenditure patterns and produce indicators for evaluating BMUs.

The study was conducted on cross-border BMUs from six districts in Kenya, Tanzania and Uganda. Data was collected from May – August 2005 using three methods; a questionnaire-based survey involving 119 BMU members, key informant interviews and Focus Group discussions. Survey data was entered and analyzed in SPSS package to produce a regional report.

The most frequently done BMU activities were; resolving disputes, receiving visitors and arresting offenders. The worst performed activities are; operating savings and credit, collecting revenue, fish marketing and data collection. BMUs have adequate skills for conducting meetings and resolving disputes and have sufficient manpower and time for all activities. On the other hand they lack skills and legal power for operating savings and credit services, collection of revenue and data in order to prosecute offenders and confiscate illegal gears. Useful indicators for evaluating BMU performance seemed; the number and types of meetings held, gears confiscated; people visiting the beach, inventories kept, disputes resolved, offenders prosecuted, arrests made and by-laws formulated.

In conclusion, social sustainability benefits from the BMU activities. However activities crucial for securing their funds sustainably are done poorly and infrequently. There is need to build BMU capacity by providing relevant skills, equipment, awareness, legal empowerment, technical and financial resources.

ASILA, Andrew Atonga

Kenya Marine and Fisheries Research Institute, Kisumu Research Centre, P.O. Box 1881, Kisumu, Kenya
ajaoken@yahoo.co.uk

Changes in the Yala swamp wetland: environmental degradation in operation

Degradation of wetlands poses an environmental threat to the existence and biotic functions of these wetlands. Samples of environmental parameters were obtained at specific locations within the wetland through in situ measurements on a HYDROLAB SURVEYOR II for dissolved oxygen, temperature, conductivity, redox potential and basic nutrients. Fish samples were also obtained from the same stations where the environmental parameters were collected to determine fish diversity and spatial distribution. Several nutrients increased ten fold between 1981 and 2003. The endemic species once present in large numbers within the Yala wetland have been reduced greatly. The changes within the environmental could be attributed to anthropogenic activities within the wetland and its catchment.

CHANDE, Abdillahi I.

Tanzania Fisheries Research Institute, P. O. Box 90, Kigoma, Tanzania
abdichande@yahoo.com

Mara River and associated wetland as a refuge of threatened indigenous tilapiines of Lake Victoria, Tanzania

A study was carried out in the Mara River and Lake Kirumi in January/February, 2005 to investigate the importance of the wetland as a refuge site for indigenous cichlids, particularly tilapiines, which have either disappeared from Lake Victoria or are threatened. Fish samples were obtained using experimental gillnets whose stretched mesh sizes ranged from 25.4 to 101.6 mm. The nets were set in the evening and retrieved early the following morning. The catch was sorted into species and the proportions according to number and weight were determined. Gonadal maturity status and size structure were determined, and gut content was analysed. Parallel to fish sampling, environmental parameters were also recorded. These included; dissolved oxygen, conductivity, pH, concentration of silicon and phytoplankton composition.

The results showed that Mara River recorded a higher species composition (11 species) than Lake Kirumi (6 species). The most dominant fish species in Lake Kirumi was *Oreochromis niloticus* which constituted 63% by weight followed by *O. esculentus* (15%). *O. esculentus* is an indigenous cichlid in Lake Victoria that has completely disappeared there. The occurrence of *O. esculentus* is a result of the dominance of its preferred food item, the diatom *Aulacoceira nyassensis* which has disappeared from Lake Victoria. The diatom also dominated in the gut content of the fish species. Finally, proper management options for the wetland have been recommended.

DAY, Julia J.

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A forgotten species flock from Lake Tanganyika: diversity and evolutionary history of Synodontis catfish

One overlooked radiation from Lake Tanganyika includes members from the catfish genus *Synodontis*, a tropical pan-Africa group that occurs in the Great lakes and all major river basins. The radiation of these catfish in Lake Tanganyika is small in comparison to the cichlid flocks, and is represented by six endemic species. However, studying new faunal systems is critical if we are to understand the bigger picture of the causes of biological diversity within this lake. It enables biologists to determine the generalities common to different systems thereby greatly enhancing our understanding of speciation within tropical lacustrine environments. In order to examine the diversity and evolutionary history of this group mtDNA (Cytochrome *b*) was sequenced for approximately 40 endemic *Synodontis* taxa from multiple localities around the lake, with additional taxon sampling from Lakes Victoria and Malawi and fluviatile environments across Africa. The data were analysed using different phylogenetic methods to determine the robustness of relationships, which were found to be largely congruent under all methods and well supported. Phylogenetic inference of species-level relationships among *Synodontis* catfish reveals greater phylogenetic diversity than previously recorded from morphological studies and also hints that southern species in particular show greater haplotype variation. These catfish also provide a new faunal system in which to examine whether the origination of lake flocks form a single radiation or multiple invasion as has been demonstrated for the cichlid fishes of this lake. Results from the mtDNA tree show the flock to be polyphyletic, with *S. victoriae*, a species occurring in Lake Victoria and recorded from the Malagrasi River seeding a secondary invasion of the lake.

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CLIMLAKE: Climate variability as recorded in Lake Tanganyika (2001-2005)

The CLIMLAKE project involved an integrated approach combining hydrodynamics, nutrient distribution, plankton dynamics, geochemical signals and paleoecology for improving the understanding of Lake Tanganyika's variability and sensitivity to climate change. The project included a 3-year survey of the lake over the period 2002-2004, with the participation of Tanzanian (TAFIRI, Kigoma) and Zambian (DOF, Mpulungu) teams. Sampling and analyses were carried out at two stations, Kigoma (north basin) and Mpulungu (south basin), and three cruises between the two sites were organised. Based on different approaches, the project showed a substantial spatial and temporal variability, for instance in several limnological variables in phytoplankton composition and biomass. Measurements of chlorophyll *a*, light penetration and primary production allowed estimates of annual production in the two basins: these estimates were lower than those from previous studies. Picocyanobacteria were a major component of the autotrophic plankton, particularly in the south, and abundance of heterotrophic plankton was remarkably high, sometimes approaching biomass of autotrophic plankton. The geochemical signature of the lake has been mainly stable. However, although historical data may underestimate some regional and seasonal variability, surface Si concentration presented a threefold increase between the 1938-1975 period (9.5 ± 4.6 μmol L^{-1}) and the mean concentration for 2002 and 2003 (31 ± 11 μmol L^{-1}). Such an increase may have resulted from decreased diatom production, which is confirmed by a Si isotope fractionation study. The composition of the present diatom assemblage similarly points to significant changes in environmental conditions in the last decades. These changes may have resulted from increased surface temperature of the lake and reduced wind as a result of the effect of climate change in this region of Africa, as suggested in other studies.

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The importance of the U.S.-Canada Great Lakes Water Quality Agreement in protecting and restoring North America's Great Lakes, and the role of NGOs (non-government organizations) in negotiating amendments to the Agreement

The U.S.-Canada Great Lakes Water Quality Agreement (the Agreement) was originally signed in 1972 and was renegotiated in 1978 and 1987. The Agreement is a model for multi-national cooperation, coordination and management of shared water resources and provides valuable lessons for government and non-government institutions world-wide.

The impetus for the Agreement arose from concerns over degraded water quality in the five North American Great Lakes. Concerns over toxic chemicals reached their zenith in the 1980s as evidence of carcinogenic, developmental, and endocrine-system related effects in humans and wildlife came to light. The concerns of governments and citizens were mobilized in 1985 and 1986 leading up to review of the Agreement. Citizens' groups organized public meetings, solicited testimony and prepared reports. As a result, five NGO representatives participated in the negotiation of amendments signed in 1987. This unprecedented level of engagement continued in the early 1990s as the respective governments implemented the revised commitments.

Today, challenges facing the North American Great Lakes are more complex and include loss of habitat and degradation of biological diversity from more than 160 non-native species. Governments in the US are responding through various institutional mechanisms but lack effective, coordinated, bi-national institutional arrangements. The Agreement has limited utility in addressing the emerging challenges threatening the health of the Great Lakes. Great Lakes governments have begun a comprehensive review of the Agreement.

The authors each have more than 20 years' experience in Great Lakes management and were leaders of citizen involvement during the 1987 re-negotiation. This paper demonstrates the progress in protecting and cleaning up the Great Lakes resulting from the Agreement, and the means by which citizen involvement in bi-national instruments results in more effective and better funded government programs and actions to protect, restore and manage fresh water resources.

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Intergovernmental relations in Great Lakes fishery management: cooperation amidst political fragmentation

Management of the multi-jurisdictional Great Lakes fishery is a well-established non-federal responsibility. Eight Great Lakes states and the province of Ontario border the lakes, and those entities, along with some U.S. tribes, have the right to manage their piece of the fishery in the manner they choose. Today's ecosystem-thinking fishery manager knows that this political fragmentation is out of step with biological realities, as Great Lakes fish do not observe the basin's political boundaries. Just as jurisdictional lines carve up the region and invite parochialism, the interconnected fishery unites the Canadian and U.S. jurisdictions and makes some form of cooperative management all but inevitable.

In the absence of a strong federal presence—a presence that could help ensure consistent interjurisdictional policies—the state, provincial, and tribal fishery jurisdictions have developed a voluntary, consensus-based agreement to help them work together. This agreement, known as *A Joint Strategic Plan for Management of Great Lakes Fisheries*, is the regime under which the jurisdictions operate to develop and implement shared fishery policies.

This presentation discusses the relationship between the Canadian and U.S. federal and non-governmental organizations. It also discusses how the non-federal entities on the Great Lakes cooperate to achieve their shared objectives, how they use the Joint Strategic Plan to achieve intergovernmental relations, and how they keep the federal and non-federal responsibilities clear and complementary.

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The status of water quality and ecosystem health of Lake Victoria: implications on the fishery

This study was undertaken over a three year period to investigate the status of the water quality and its implications on the fish of Lake Victoria.

Results show that the southern zones of the lake are colder than the northwest and northeastern parts of the lake. This is associated with high concentrations of total suspended solids originating from influent rivers which trap sunlight energy. Inshore waters were more productive than offshore waters. The least productive areas were in the central parts of the lake. In general the Gulfs had elevated chlorophyll ***a*** values (range; 56.8 to 96.77 μg l^{-1}). During the August September mixing season, the lake was thermally mixed over the whole water column with dissolved oxygen concentrations higher than 3 mg/l even in the deep stations. Results of an analysis of the major plant nutrients showed that TN:TP ratios range from 4.8 in the Nyanza Gulf to 10.6 in three zones of the Ugandan waters with the overall average of 8:1 This favors the proliferation of the Cyanophytes (Cyanobacteria). The algal species identified were dominated by Cyanophyta. The dominance of Cyanophytes including toxic forms such as *Cylindrospermopsis africana*, may lead to reduction of available food for the native fish species. Zooplankton were composed of Copepoda, Cladocera and Rotifera. Copepoda and in particular cyclopoid copepods constituted the most widely distributed taxon. *Caridina nilotica* has a higher abundance in inshore waters compared to offshore waters. It also has a high fecundity which is good indication of sustained Nile perch food base. It contributed over 60 % in the diet of Nile perch in the range 1- 50 cm.

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Photosynthetic efficiency along a nutrient and phytoplankton gradient in Nyanza Gulf, Lake Victoria

Nyanza Gulf is a large shallow embayment connected to Lake Victoria by the narrow Rusinga Channel. On a three day cruise from the gulf to the open lake in November 2005 measurements of in situ fluorescence using a spectral fluorometer revealed that both the total chlorophyll concentration and the predominate phytoplankton groups along the gulf to lake transect were quite different and dynamic. High concentrations of Cyanobacteria dominated the shallow gulf station while the channel and open lake stations had lower total chlorophyll and more group diversity. Photosynthetic efficiency measured using pulse amplitude modulation fluorometry indicated that differences in phytoplankton groups and light and nutrient conditions resulted in measurable differences in photosynthetic efficiency. Cyanobacteria from surface blooms and from all depths at a mid gulf station in post bloom condition had dramatically lower photosynthetic efficiency than non bloom samples. Nutrient addition and uptake experiments indicated that the Cyanobacteria from the bloom were stressed by high light conditions while the phytoplankton from the channel were nitrogen and phosphorus deficient. The phytoplankton from the open lake station were nitrogen and phosphorus deficient and may have been light deficient as well. This short cruise reinforces the dynamic nature of the gulf phytoplankton community and the need for intensive spatial and temporal measurements to construct useful productivity models.

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Trophic dynamics of Lake Tanganyika and Lake Victoria and the importance of trophic structure in determining fisheries yields

The fisheries of Lake Tanganyika and Lake Victoria have grown remarkably over the past four decades to become the largest lake fisheries in the world. The two African lakes combine for a total catch in the 1990's nearly 10x the aggregate catches recorded on all the Laurentian Great Lakes during the decades of their maximum catch (1890's) despite the African lakes occupying less than half the area of the Laurentian Lakes. Although catches on both lakes were initially limited by effort, there is now concern about the sustainability of the current catches as effort continues to increase. Primary production sets theoretical upper limits on fish production, and those limits are modified by the trophic structure of the fishery. The two lakes have had radically different recent histories with Victoria undergoing strong eutrophication due to nutrient enrichment, as well as introduction of species, while Tanganyika may be becoming more oligotrophic in response to a warming climate. Victoria has always had higher primary productivity than Tanganyika, and that difference has been amplified over the recent period of rapid fisheries growth. However, areal yields on Tanganyika are higher than on Victoria indicating the importance of the trophic structure of the fishery in determining yields. We have used stable isotopes to characterize the food webs of both lakes that have the common feature of having species of Lates (Nile perch) as top piscivores, and Lates dominate the recent catches in both lakes. Both lakes have relatively short food chains to Lates as a result of omnivorous feeding by the perch, but Victoria is remarkable in having a disaggregated food web with underutilization of some abundant food resources by Lates. Despite being more productive, the highly eutrophic Lake Victoria has developed a relatively inefficient trophic structure leading to Lates.

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Mesozooplankton of Lake Kivu (East Africa): diversity, abundance, spatial and temporal patterns, and impact of the Tanganyika sardine

The zooplankton community was studied in Lake Kivu in order to characterize its state, four decades and a half after the introduction of the Tanganyika sardine (*Limnothrissa miodon*) into this lake. Plankton net samples were collected and analyzed during 3.5 years.

As in most large tropical lakes, pelagic zooplankton in L. Kivu is of low taxonomic diversity (18 taxa were identified). Rotifers were the more diverse group (11 taxa), but dominant taxa in terms of abundance and biomass were 3 species of cyclopoid copepods.

Daytime vertical distribution of zooplankton organisms was size-structured: the young stages of copepods occupied the top 20 m of the water column while the adult stages (for instance, *Mesocyclops* egg-bearing females) were present only in the deeper layers, as a result of dial vertical migration, presumably to avoid predators.

Zooplankton abundance exhibited significant seasonal variations, with numbers and biomasses during the dry season twice as high as those recorded during the rainy season. It exhibited a combination of regular as well as irregular short-term fluctuations in population size. Total crustacean zooplankton abundance increased to a distinct seasonal maximum associated with deep epilimnetic mixing in August-September. The dry season zooplankton peak closely followed the chlorophyll *a* maximum, which suggests that bottom-up effects controlled zooplankton dynamics in L. Kivu.

Compared to other African great lakes, L. Kivu is host to a zooplankton with similar diversity, but harbours lower biomass. A comparison with earlier studies on the zooplankton community in L. Kivu confirms previous reports about important changes following the sardine introduction, but suggests a more moderate impact on zooplankton structure than was previously forecast.

The seasonal component of mesozooplankton dynamics in the lake was similar to that in other great lakes of the Rift region.

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Environmental factors that favour the distribution of introduced over endemic tilapiines in the Lake Victoria Basin

The introduction and establishment of species populations into new habitats is largely dependent on environmental factors. Species of tilapiines introduced into Lake Victoria Basin have had varying successes in establishing viable populations. The domination of species such as *Oreochromis niloticus* (L) and *Oreochromis leucostictus* (G) over others (*Oreochromis esculentus, Oreochromis variabilis, Tilapia zillii* and *Tilapia rendalli)* was investigated to determine environmental factors which favored colonization and distribution. Environmental factors evaluated included conductivity, temperature, depth, Dissolved Oxygen (DO), turbidity, pH, total alkalinity and total hardness. Conductivity in the various habitats sampled ranged from 80 $\mu S\ cm^{-2}$ to 210 $\mu S\ cm^{-2}$, while temperature and turbidity estimates ranged from 20° C to 29° C. Turbidity varied from 40 to 120 NTU. Dissolved oxygen ranged from 5 mg L^{-1} to 9 mg L^{-1}, while pH values were 5.2 to 8.1. Total alkalinity and hardness estimates were 37-66 mg L^{-1} and 27- 38 mg L^{-1} as $CaCo_3$ respectively. Depth in the various habitats varied from 1.7 - 6 m.

Similarity in requirements expressed using ordination method infers that turbidity; conductivity and pH values influence distribution of *Oreochromis lecostictus, Oreochromis esculentus* and *Oreochromis variabilis*. The distribution of *Oreochromis niloticus* was widespread and was not strongly correlated to any of the environmental variables evaluated (P = 0.21-0.46), as further evidence of resilient nature. The two species groups demonstrated habitat preferences possibly to maximize efficiency in feeding, reproduction and growth. These factors are under the direct influence of environmental factors. They differed in their ability to establish themselves in some of the small bodies of water as was evident in Lake Simbi, which had no fish and had very high conductivity. It is evident therefore that while some environmental characteristics may adversely affect all the endemic species, some of the introduced species are less affected and continue to colonize more habitats within the basin.

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Changes in species composition and abundance of commercially important pelagic fish species in Kigoma area, Lake Tanganyika, Tanzania

The pelagic fishery of Lake Tanganyika provides employment to approximately 1 million consumers and protein to many more people living around the lake. It is based mainly on three commercially important fish species namely two clupeids *Stolothrissa tanganicae* and *Limnothrissa miodon* collectively known as "dagaa" and a perch *Lates stappersii*. A declining trend of the perch both in its composition and abundance in the pelagic fish landings is partly tied to local over-fishing and climate change. There are three important periods in the exploitation process identified as: (1) a traditional fishery period, the pre-1975 period marked by low catches of *Lates* spp. and a dominance of dagaa (clupeids); (2) an industrial fishery period (1975-1984) marked by high catches of *Lates stappersii* and high total landings; and (3) an artisanal fishery period (post 1984) with relatively low catches and high dominance of dagaa especially *Stolothrissa tanganicae*. Population growth, refugee influx from the politically volatile Burundi and Democratic Republic of Congo, all of which caused high fish protein demand, particularly for dried dagaa, together with changes in the rural economy caused by drought in the area are resulting into high exploitation pressure on the pelagic resources. Concerted efforts to prevent/reduce exploitation pressure on the pelagic fish resources should take into action a lake wide management strategy where by management issues in all the riparian countries should be harmonized. More effort should be geared towards preventing the use of beach seines and small meshed nets subsequently ensuring a sustainable utilization of the pelagic fish resources.

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Rehabilitation of lake trout in the Great Lakes: past lessons and future challenges

Lake trout in the Great Lakes historically inhabited a wide range of habitats. Commercial fishing for lake trout began in the 1800s. The industry continued to expand after World War II (1939-1945), while the technology improved greatly. With increasing effort and technology, most near-shore populations showed the effects of overfishing between the 1930s and 1950s. Between 1920 and 1940, the sea lamprey colonized the upper Great Lakes, contributing to the trout population's collapse during the 1950s. Rehabilitation programs began in earnest at this time with harvest restrictions, sea lamprey control, and the stocking of hatchery propagated lake trout. Stocked lake trout survived to maturity, but little natural reproduction was observed after more than 40 years outside of Lake Superior. Possible causes for the slow recovery include an inadequate number of spawners, inability to find spawning grounds, infertility of gametes, stocking of strains maladapted for survival and reproduction, and excessive predation of lake trout eggs and fry by non-native species. Evidence supports all of these explanations, but none fully account for the slow recovery. Successful population rehabilitation has occurred only in Lake Superior and in Parry Sound of Lake Huron. Fry, produced by hatchery origin lake trout, have been caught in lakes Huron, Michigan, and Ontario. Likewise, fertilized eggs have been recovered from spawning shoals in Lake Erie. Three non-typical approaches to rehabilitation management are proposed: the creation of artificial spawning areas, pulse stocking, and transplantation of wild adults. Important lessons for management are: lake trout harvest must be strictly controlled, non-native species pose serious threats to rehabilitation and further colonization by new species must be prevented, lake trout stocking must use strains suitable for available habitats, the long recovery period necessary for restoration requires strong commitments by management agencies and the public, and coordinated management is required in multi-jurisdictional rehabilitation programs. The most serious future threat to lake trout rehabilitation is the unpredictable ecological effects from new invading species from Eurasia.

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Gender participation in Lake Victoria's fishery resources (Kenya)

Gender plays an important role in the artisanal fisheries, therefore it is critical for both men and women to participate in fisheries management. This paper analyzes gender relationships in the context of their socio-cultural environment and suggests strategies to facilitate gender participation in co-management for Lake Victoria. Both primary and secondary data have been used. Results indicated that in Lake Victoria, there is a clear-cut division of labor differentiated by gender, which is culturally defined. Fishers have organized themselves into groups that act collectively. These organizations are crucial in the establishment of co-management for Lake Victoria. Although women have critical roles in managing the fishery, they are not economically empowered. The study observed that women's effective and meaningful participation in fishery management is greatly hampered by their subordinate positions at the household and community level. They have minimal access to and control over production resources and even much less, over benefits. Women should be empowered economically and socially to participate effectively in fisheries management. Further, they should be encouraged to organize themselves into support groups to attain access to credit and fishery resources, to encourage appropriate fishery practices, and to diversify in non-fishing activities to ease pressure on the fishery.

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Diversity and ecology of crabs in Lake Tanganyika

Freshwater crabs are abundant in Lake Tanganyika, occurring on a wide variety of substrates including rocky lakebeds in shallow and moderately deep water (0-40 m), turbid river mouths, beds of empty snail shells, and muddy lake floors at great depths (>150 m). Crabs play an important role in aquatic food webs serving as prey for fish, as predators on other invertebrates, and as detritivores, algivores, and omnivores.

Lake Tanganyika is the only lake in Africa that harbours an endemic freshwater crab genus (*Platythelphusa*), whose species show a large degree of morphological disparity. We tested whether endemic crab species diversity in Lake Tanganyika is related to ecological variables using data from systematic habitat surveys, functional morphology, gut content analyses, stable isotopes, and genetic sequences. The vulnerability of the lake crabs to habitat disruption is also discussed.

Analyses of sequences obtained from mitochondrial DNA indicate that the platythelphusid crabs of Lake Tanganyika diversified recently (estimated 2.5-3.3 Mya) and rapidly. Nine platythelphusid species can be distinguished morphologically, however mitochondrial haplotypes are shared between several of these species. Ecological data indicate marked differences in habitat preferences and trophic ecology between species.

Shifts in isotope signatures of species from different localities suggest that crabs can to some extent respond to alterations of their environment by adapting their diet, and foraging strategies can temporarily overlap. Although crabs appear to show short-term dietary flexibility to habitat disruption, the long-term effects of environmental alteration remain unknown. Changes in inter-specific competition resulting from ongoing environmental perturbations could ultimately affect species functioning of the crabs in Lake Tanganyika's intricate benthic food webs.

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The trophic role of fish communities in the Kyoga Basin lakes' food webs (East Africa). A stable isotope approach

Until 20 years ago, Lake Kyoga had similar fish fauna to that of Lake Victoria. Lake Victoria alone contained at least 500 fish species comprising at least 12 trophic groups out of at least 350 species, dominated by a monophyletic species flock of haplochromine cichlids, about 99% of them endemic exploiting virtually all food sources in the lake. Introductions of exotic species prompted by over-fishing, and habitat degradation fuelled by an expanding human population resulted in reductions of the native species and number of trophic groups, and led to the simplification of the lakes' food web and therefore reduced food chain lengths in the lake. Between 2001and 2004 this study examined the trophic structure of the fishes present in Lake Kyoga, and the less impacted satellite lakes in its basin, using stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopes. Stable isotope signatures of the fishes in the main Lake Kyoga ranged from –25.4 to –13.8 ‰ for $\delta^{13}C$ and 5.3 to 9.9‰ for $\delta^{15}N$. Among the satellite lakes, Bisina recorded the largest range both for $\delta^{13}C$ (–25.9 to –11.3 ‰) and $\delta^{15}N$ (3.2 to 10.4 ‰). Lakes Nawampasa and Nakuwa recorded the least ranges for $\delta^{13}C$ (-24.4 to -21.7 ‰) and $\delta^{15}N$ (4.1 to 6.3 ‰) respectively. Note worthily, Lake Nakuwa, with the least ranges in $\delta^{15}N$ like Lake Kyoga contains the predatory Nile perch. The broad ranges in ($\delta^{15}N$) indicate a more diverse trophic status in the Nile perch free satellite lakes. The broad ranges in ($\delta^{13}C$) indicate a wide range of food sources. The Kyoga satellite lakes are important refugia for species diversity lost in lakes Kyoga and Victoria and deserve targeted conservation measures to protect them.

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The diversity of biodiversity: Species, distributions, genetics and the conundrum of conservation of Tanganyikan endemics

The biodiversity of Lake Tanganyika is cause célèbre, but how close are we really to having an accurate representation of the structure of diversity in the littoral zone of this ancient lake? Our research group has addressed problems of species identification, distribution and population structure in several phyla, at a range of geographic and temporal scales, using molecular and morphological techniques. We have found that the species flocks present challenges to preconceptions in each case. We present examples from recent work on molluscs, fish, crabs, and ostracods that underscore the diversity of ways that Tanganyikan biodiversity is distributed. Some species that are readily differentiated by morphology have limited genetic differences, whereas in other cases conspecific populations are not in genetic contact. Neither geographic distribution nor phylogeny provide primary predictors, as sympatric sister species may have contrasting genetic structures. Simple correlates of life history and ecology with diversity patterns remain elusive.

The Tanganyikan fauna are likely to have evolved under a multiplicity of effects such as environmental vicariance, intense biotic interactions (competition, predation, sexual selection), and with lineages originating and going extinct throughout the lake's long history. This argues that we should be wary of generalizations based on a limited number of exemplar cases, and need to continue to seek integrative cross-taxonomic, cross-disciplinary approaches. The most critical end-users of these basic biology studies are conservation scientists and especially policy makers, whose decisions will determine the state of the lake for future generations.

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Latitudinal variation in populations of Lythrum salicaria in Europe and North America: Joint international research and volunteer program

Worldwide volunteer programs can be the only feasible way to collect information on the overall distribution and growth patterns of widespread invasive species. One such species, *Lythrum salicaria* is an invasive species of wetlands of northern North America that is a natural component of lake edges, and riparian floodplains in Eurasia, Australia and northern Africa. A worldwide analysis of this species in its native vs. invasive habitats is being conducted by volunteers. Volunteers collect data on the height in *Lythrum salicaria* around the world (North America, Eurasia, Australia) to determine how latitude and environmental factors limit this species in various continents. Seeds are collected, and these are used in molecular studies to determine the genetic relatedness and origins of populations. Growth chamber studies determine the growth patterns of genotypes in various environments, and relate the patterns to climate change. The goal of these studies is to gain a better understanding of the constraints of this *Lythrum salicaria* in its native environment (Eurasia, Australia) and give insight into its control in invasive environments. Preliminary results from the volunteer data collection in North America and Australia show variability in the height of individuals (45-291 cm vs. 75 cm, respectively) from various latitudes. Populations of *Lythrum salicaria* are sporadic in the southern United States indicating that the species may not be able to maintain itself in hotter climates. The volunteer research program represents an important worldwide collaboration in education and research to understand the *Lythrum salicaria* problem, but could also be used to understand other widespread environmental problems.

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The fisheries of Lake Victoria: Status and management initiatives for sustainable exploitation

Lake Victoria, the largest lake in Africa and the second world-wide has the most productive fresh water fishery in the world. The economic importance of the fishery has been increasing over the years and has assured it as a vital strategic resource in the region. Being a shared lake between Kenya, Tanzania and Uganda, management of the fisheries resources has been an underpinning concern among the Partner States. There have been collaborative efforts to collect data on the status of the resources, the exploitation levels and the characteristics of the effort to guide management of the resources. Such efforts undertaken by the members States of the Lake Victoria Fisheries Organization from the mid 1990s with different donor support are presented.

Fisheries independent data and information collected through Catch Assessment and Frame Surveys give signs of overcapacity especially for the Nile perch fishery. Fisheries dependent data from trawl and hydro-acoustic surveys indicate minimal declines in abundances over the years. However, the biological studies provide indicators of over exploitation for the Nile perch stock. The other two commercially important fisheries on *Oreochromis niloticus* depict localized over-exploitation while the *Rastrineobola argentea* fishery seems to be under exploited in some regional waters but also has a high turn-over rate. While a number of efforts are underway to have more effective MCS interventions under the Implementation of Fisheries Management Plan (IFMP) project, community involvement in management efforts is also being strengthened through the establishment of BMUs. Potential management measures to control effort are discussed. Some of the issues and pitfalls to sustainable exploitation of the fisheries resources of Lake Victoria are pointed out and options for way forward are presented.

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Eutrophication and ecosystem changes in Lake Victoria

When compared with 1950 to 60s data, studies conducted since the late 1980s into 2005 indicate increasing degeneration over the last 40 to 45 years as evidenced in water quality and reduction in biodiversity. Growing populations and their associated activities and economic developments as well as introductions of foreign species are responsible for the changes in the lake. Increased anthropogenic activity, increased inflow of nutrients, siltation and subsequently eutrophication and water related public health issues are some of the problems facing Lake Victoria. The littoral and pelagic areas of the Lake Victoria show marked spatial and temporal differences between and within the zones. Nitrate and phosphate-phosphorus concentrations ranged between 16.2 - 87.9 $\mu g\ L^{-1}$ and 39.6 - 92 $\mu g\ L^{-1}$, respectively, and were both highest in the northeast of the lake. Silica concentrations ranged between 0.525 and 0.902 mg L^{-1} and the values were higher in inshore than offshore waters. Total phosphorus in the pelagic waters ranged between 0.078 and 0.10 mg L^{-1} and total nitrogen between 0.53 and 0.83 mg L^{-1}. By the early 1990s, the lake's algal growth was nutrient saturated and high phosphorus concentrations favoured dominance of nitrogen fixing cyanobacteria. The high total phosphorus concentrations are associated with increased phosphorus loading and its enhanced recycling associated with increased anoxic conditions in the deep pelagic waters. In comparison with Talling's 1961 values, silica concentrations have decreased 3- to 8-fold while total phosphorus rose 2- to 3-fold. Stimulated by these nutrients, algal growth has increased and its community shifted towards dominance by cyanobacteria (always >50%). By the late 1980s, hypolimnetic anoxia had led to loss of deepwater fish habitat and was associated with periodic massive fish kills. In order to mitigate deterioration of lake water quality and improve ecosystem health, management of phosphorus loading into the lake should be given urgent priority.

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Status of exploitation of the fisheries resources of Lake Victoria

Information on trends of fishing effort and fish catches was not harmonised in the partner states sharing Lake Victoria until recently. Frame and Catch Assessment Surveys (CASs) through which the Partner States are monitoring exploitation of the fisheries resources of the lake are now harmonized. Biannual Frame surveys were carried out in 2000, 2002 and 2004 and monthly CASs were started in June 2005. The results of the three months CASs in the partner states have been collated to provide fresh understanding of fisheries production around the whole lake.

The current estimates of annual fish catches based on three month data are in the range of 804,000 t with a beach gross value of US $347,552,424. This is twice the peak of approximately 400,000 t estimated in the early 1990s. The bulk of the current production i.e. 495,000 t (62%) is contributed by *Rastrineobola argentea* and haplochromines whose beach value is only 20% of all the fish landed. The haplochromine fishery is coming up, especially in the Tanzanian part of the lake, contributing 14% of the total fish catches. The contribution of Nile perch is estimated at 233,000 t (29%) but with a beach gross value of 69% of all the fish landed.

The Frame survey data indicate widespread use of destructive illegal fishing gears although there was a decreasing trend. There is urgent need to wipe-out illegal gears to increase production of the highly priced Nile perch. There is also need to improve the processing of *R. argentea* and haplochromines to enhance the beach value of these abundant resources.

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The diversity of aquatic macroinvertebrates associated with Water hyacinth Eichhornia crassipes (Mart.) Solms. (Pontederiaceae) in Kenya waters of Lake Victoria

A survey of aquatic macroinvertebrates associated with water hyacinth *Eichhornia crassipes* (Mart.) Solms (Pontederiaceae) in Kenya waters of Lake Victoria was carried out from January to December 1998. Overall 130 taxa were collected during the survey. These fell within seven classes: Insecta; Crustacea; Oligochaeta; Hirudinea; Arachnida; Gastropoda and Bivalvia. Insecta dominated in species richness, abundance and biomass in all ecological zones. Adult coleopterans were significantly more in the landward side of hyacinth fringe than on the lake-ward side and in the free floating rafts ($F_{0.05(1),}$ 5, 198, $P < 0.05$).Overall, free-floating rafts harboured significantly more macroinvertebrates than fringe mats on the landward side ($F_{0.05(1),}$ 5, 61, $P < 0.05$).

Molluscs that are vectors of various flukes causing Schistosomiasis and related diseases in man and his domestic stock were collected. These were *Bulinus globosus, Bulinus nasutus, Bulinus ugandae* and *Biomphalaria pfeifferi*. *Lymnaea natalensis* a vector of flukes, which cause fascioliasis, was also found associated with water hyacinth. The distribution of the vectors can be used in the control of schistosomiasis. Other vectors of human diseases, which were found on water hyacinth, were larvae of mosquitoes of the genera *Anopheles, Aedes, Culex* and *Culiseta*.

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Seasonal patterns in zooplanktivorous fish catches relative to abundance of zooplankton in northwestern Lake Tanganyika

Lake Tanganyika is situated in the East African Rift Valley. The region near the lake has two seasons: a dry season from May to August characterized by prevailing south winds and lower air temperature, and a wet season during the rest of the year. Endemic fish species abound in the littoral, but fisheries are mainly based on pelagic fish, of which the two endemic clupeid species (*Stolothrissa tanganicae* and *Limnothrissa miodon*) are the most abundant. Here the seasonal patterns of clupeid catches are examined in relation to zooplankton abundance.

Fish samples were collected at landing beaches once a week. The total length of each individual was measured. Length at recruitment was given by the minimum length of sampled fish and recruitment seasons were evaluated from occurrence of the recruited length class. Total catch per fishing unit was recorded for fisheries statistics.

Samples of zooplankton were taken from May 1999 to 2001 using a net with a mesh size of 100 micrometer, towed vertically through a water column of 100 m. Individuals were identified as copepods, *Limnocnida tanganicae*, shrimps, fish eggs and fish larvae. Copepods peaked in June-September and November.

The monthly length frequency distributions showed a polymodal distribution for both species, suggesting multiple coexisting cohorts. For *S. tanganicae*, recruits consisting of fish less than 40 mm in length appeared in August, September, February and April, suggesting main hatching periods in May-June and December. For *L. miodon*, recruits less than 60 mm appeared in February and August, suggesting hatching in September and March. The monthly catch per unit effort showed peaks in September and February. The recruits from May-June seemed to especially affect the catch. The abundance of *Stolothrissa* recruits may be linked to the abundance of copepods.

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Implications of the impact of exotic species on the food web dynamics in the North American Great Lakes

During the past several decades, the North American Great Lakes have been exposed to various perturbations including eutrophication, contamination by toxic chemicals and the rapid establishment of exotic species. In accordance with the Great Lakes Water Quality Agreement, remedial action plans were undertaken to alleviate eutrophication and toxic contamination. However, the sudden invasion and expansion of exotic species has taken Great Lakes researchers and managers by surprise. Considerable research has been carried out in both Canada and the United States to assess the impact of exotic species on food web dynamics of the Great Lakes. Selected examples are given in this presentation to demonstrate the impact of exotics on lower and higher trophic levels in Lakes Ontario and Erie. The establishment of *Dreissenid* mussels in Lakes Ontario and Erie, for example, caused a drastic reduction in phytoplankton biomass and subsequent increase in water clarity. At the other end of the food web, exotic species such as alewife, rainbow smelt and white perch have become important to the Lake Erie commercial fishery, while other native fish have declined. Similarly the non-indigenous fish species have become a significant part of the Lake Ontario food web and several native species have been identified as being at risk. Ongoing and rapid changes to all components of the food web due to exotic species represent a serious threat to the integrity of the Great Lakes food web and require an integrated and concerted effort for their control and management from scientists, managers and governments.

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Distribution and abundance of invertebrates as indicators of water quality in Lake Victoria

Field observations on invertebrate spatial-temporal abundance patterns were made at selected littoral and pelagic sites in Lake Victoria between 2000 and 2004. Estimated abundance indicated generally higher densities of organisms and diversity indices in littoral compared to pelagic habitats. This pattern may be related to high algal biomass that often characterizes littoral areas of the lake which receives nutrients from adjacent hinterlands and stream inflows. Vertical distribution of zooplankton appeared to be correlated with temperature and dissolved oxygen profiles. The vertical distribution pattern at the deeper pelagic stations during periods of thermal stratification indicated concentration of zooplankton in mid- and surface water layers. This distribution pattern was correlated with low dissolved oxygen levels (<1.0 mg L^{-1}) in bottom water layers (hypolimnion). Such low dissolved oxygen conditions lead to loss of habitable space for invertebrates and other biota. However, certain invertebrates such as chironomid and chaoborid larvae and *Caridina nilotica* are known to thrive under such stressful conditions. These conditions appear to provide a safe haven (refugium) where tolerant organisms are protected from excessive predation by fish and other enemies.

The frequent encounter of these organisms in high abundance in the lake is a signal to deteriorating water quality conditions.

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Is Nile Tilapia replacing Nile Perch in Lake Victoria? What are the consequences?

Studies were done on biomass and distribution of *Oreochromis niloticus* collected by trawling from Lake Victoria between 1997 to 2000 and 2004 and 2005. Nile tilapia that constituted less than 1% of catches in 1980s-90s now contributes more than 25% of the catches in Lake Victoria. Nile tilapia previously distributed in less than 10 m was caught up to 20 m. Length frequency distribution and size at maturity depicts a stable population with high proportions of mature fish unlike Nile perch where more than 60% of the catches are juveniles.

The spread of tilapia into deeper waters and increase in biomass is attributed to declining stocks of predatory Nile perch, availability of suitable food, and the probability of occupying vacant niches left by reduction in indigenous species especially the haplochromines.

The catch contribution of predaceous Nile perch, *Lates niloticus* has reduced from 90% in 1990s to 52% in 2005 mainly attributed to overexploitation and ecological changes in the lake. Fishers targeting Nile perch have increased tremendously during the last decade. Increase in anoxic conditions in the lake is precluding Nile perch in several habitats where the tilapia easily survives. The previously herbivorous tilapia has shifted towards a more protein rich insectivorous and piscivorous diet. All these factors could be contributing to increase in Nile tilapia biomass in the lake. It has now become imminent that if management measures to reduce Nile perch exploitation are not put in place the next important fishery in Lake Victoria will be Nile tilapia. Drastic changes in a multimillion-dollar export industry of Nile perch will have several economic consequences.

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Lake Tanganyika ecosystem management strategies

Lake Tanganyika is a large East African rift valley system holding about 1/6 of the world's liquid fresh water with about 2000 species of organisms (fauna and flora) of which 700 are endemic. The lake faces a number of threats including excess sedimentation, over - fishing, pollution and habitat destruction along with climate change. Efforts to restore the lake involves assessment of the magnitude of the threats through the Lake Tanganyika Biodiversity project (LTBP) in which a number of outputs such as Draft convention, special study reports and Strategic Action Programme were achieved. The preparation of detailed projects to address the threats through the Lake Tanganyika Management Planning Projects (LTMPP) was another strategy and had catchment's management and pollution control along with fishing management projects prepared. It can be concluded that Lake Tanganyika faces essentially man-induced threats compounded by climate change all resulting in declining productivity of the lake. It is recommended that in order to sustainably manage the lake both regional and global joint efforts are necessary.

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Impact study of sedimentation on fish communities in the littoral zone of Lake Tanganyika: The case of rocky and mixed biotopes in the Northern Basin

Biodiversity in Lake Tanganyika is currently threatened, notably in the littoral zone, where eroded material from the catchments is brought in by run-off and inflowing streams. Two study areas, a rocky habitat and a mixed rock and sand habitat, have been selected to assess impact of siltation in the Lake. The rocky habitats are located at Gitaza, 30 km South of Bujumbura, one less impacted because the shore is still covered with vegetation, and another with its shores stripped by intensive agriculture. The mixed habitats are located at Kirasa, 25 km South of Bujumbura, where two sites exposed to different silting rates were sampled. Fish sampling was undertaken by day set gill nets.

In the rocky habitats, data analysis shows more fish species collected in the less impacted area (35 species), the most abundant of them being algae and zooplankton eaters. These species are *Neolamprologus brichardi, Xenotilapia flavipinnis, Lamprichthys tanganicanus* and *Perissodus microlepis.* Biodiversity in this area is quite high, as shown by calculated diversity indices (Shannon H': 3.651; Fisher α : 9.321). The species sampled in the most impacted rocky habitat (19 species) are mainly characteristic of soft bottoms; these are notably *Lepidiolamprologus cunningtoni*, *Grammatotria lemairii, Lamprologus callipterus, Enanthiopus melanogenys.* Calculated diversity indices are lower (Shannon H': 3.572; Fisher α: 6.259).

In the mixed substrate habitats, species richness is also higher in the less impacted area (38 species) compared to the most impacted one (17 species) where algae eaters could not be sampled. Diversity indices calculations give Shannon H': 4.429 and 3.354 and Simpson D: 0.930 and 0.848 for the least impacted area and for the most impacted area respectively.

It appears that silting due to land erosion in the catchment areas have a negative impact on diversity in rocky and mixed habitat fish populations in Lake Tanganyika.

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Documentation of fish diseases of the Lake Victoria Basin-Kenya, and the surrounding satellite lakes and dams

This paper presents the results of fish diseases encountered from January 2001 to December 2004, during biannual routine water quality surveys in the Lake Victoria basin, sponsored by the Lake Victoria environment management programme. Lakes Victoria, Kanyaboli, Sare, and Namboyo were sampled together with eight and seven small water bodies in the northern and southern Lake Victoria basin respectively. The observed fish diseases were broadly classified according to their causative agents. Documentation was done by taking photographs of the diseased fish, noting the locality through a GPS, and recording all the morphometric data. The fecundity status was compared with those of the healthy fish in selected species. Parasitic diseases were more frequent in the fishes examined, followed by skin ulcers, fin rots (fin erosion), and skeletal deformities in that order. Intensity of diseases was higher during the dry periods of the year and lower during the long rains of April to June. It was noted that cyprinid species were more susceptible to disease than other species of fish. The dominant food items in the guts were; plant materials, detritus, insect remains and insect larvae, and mud. Apart from the affected organs, the parasites were noted to induce gross pathological, physiological and behavioral changes in the host species. Finally, the causes of these diseases were believed to be multifactorial and could not be attributed to some specific water quality parameters.

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Community-based aquaculture in Lake Victoria Basin (Kenya): resource potential, opportunities and threats

The Lake Victoria catchment (Kenya) has a population of about 9 million people who depend on fish as a major source of protein and income. Due to unsustainable exploitation coupled with a high demand for fish, catches from the lake have dwindled over time. Apart from overfishing, factors such as pollution, invasive weeds among others have lead to environmental degradation resulting in a decline of catches. Most people especially in rural areas live in abject poverty despite the region being endowed with both fish and other natural resources such as wetlands and forestry.

Five major rivers (rivers Kuja, Sondu-Miriu, Yala, Nzoia and Sio), streams and man-made dams traverse the catchment. Indiscriminate agricultural practices in the catchment threaten the water bodies with a myriad of problems including nutrient loading and siltation. Neglected village water bodies, are infested with aquatic weeds providing breeding grounds for mosquitoes and snails which transmit prevalent diseases namely malaria and schistosomasis in the region.

There is need to put these water bodies into good use as well as manage them to improve the quality of the environment. One such way is aquaculture, for production of fish, both for human consumption and income. A recent survey indicates that there are about 131 dams and 6679 operational ponds of various sizes (owned by 4597 farmers). In the catchment most of the dams visited displayed lack of proper management. Siltation, caused by unprotected catchment areas and aquatic weeds are a major problem in most dams. Ownership has been found to influence the use of dams as well as their conservation and management. If well managed, dams have the potential for generating self-employment and improving food security of the rural poor as well as improving environmental conditions of the villages in the Lake Victoria basin.

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The regional programme for integrated management of Lake Tanganyika

Processes of ecosystem degradation and deterioration of livelihood conditions within the Lake Tanganyika Basin are mutually reinforcing. The underlying situation has worsened considerably as civil unrest and military conflict and the ravages of HIV/AIDS in many localities have compounded the effects of population growth to challenge food production capabilities. Because these challenges exist and interact on a basin wide scale, they must be addressed in an integrated and regional fashion.

Recognizing the need for close coordination of actions to deal with the multiple threats to the well-being of the lake's ecosystem and peoples, a "Lake Tanganyika Partners" group of international agencies, working in collaboration with the governments of Burundi, D.R. Congo, Tanzania and Zambia and with local stakeholders, has launched the "Regional Programme for Integrated Management of Lake Tanganyika." Partner agencies include the Food and Agriculture Organization of the United Nations (FAO/UN), the African Development Bank (AfDB), the Nordic Development Fund (NDF), the United Nations Development Programme/Global Environmental Facility (UNDP/GEF) and the World Conservation Union (IUCN).

The agreed programme framework, elaborated through Partner meetings since mid-2003, will allow complementary project contributions from each of the agencies. The overall programme aims at poverty reduction and socio-economic development within the Tanganyika Basin, and is comprised of four components – namely:

(1) Institutional strengthening and establishment of the permanent Lake Tanganyika Authority under terms of the Lake Tanganyika Convention;
(2) Fisheries management, with reference to the Lake Tanganyika Framework Fisheries Management Plan;
(3) Improvement of infrastructure and local development (e.g., health and education facilities and services); and
(4) Pollution control and environmental conservation (e.g., mitigation of erosion, wastewater and pesticide impacts, etc.).

The overall programme also aims at strengthening the regional cooperation and integration – a priority shared by the four lacustrine States. Full-scale activities are expected to commence by mid-2006.

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Jellyfish, Limnocnida tanganyicae - a semiautonomous microcosm in the food web of Lake Tanganyika

A jellyfish *Limnocnida tanganyicae* is one of the most visible components of the very simple pelagic zooplankton in Lake Tanganyika. It can feed on crustacean zooplankton, but it has no known significant predators. Therefore, it represents a closed end in the food web of Lake Tanganyika. In this study we found that *L. tanganyicae* can contain varying densities of < 1 μm diameter picocyanobacteria, which are sometimes so abundant that they render large jellyfish visibly pink in colour. Consequently, in adequate light, many jellyfish microcosms were net producers rather than consumers. At daytime, *L. tanganyicae* was absent from the uppermost water layers, but moved towards the surface in late afternoon. This behaviour not only protected jellyfish from lethal ultraviolet radiation, but also favoured picocyanobacteria by supplying them suitable light intensity. In addition to that the feeding of jellyfish on zooplankton draws nutrients which might then be internally circulated within the jellyfish microcosm. Thus, as a pelagic gardener, jellyfish has reached at least partly autonomous position in the pelagic ecosystem of Lake Tanganyika. The observed characteristics of *L. tanganyicae* can explain its success, but most of the aspects involved still remain to be quantified.

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What are the mechanisms regulating pelagic fish recruitment in Lake Tanganyika?

Fish catches from Lake Tanganyika are known to show wide and unpredictable fluctuations which cause problems to the fishery. Such fluctuations may arise from variable success in fish recruitment, which is affected in complex ways by physical, biological and fishing-related factors. The ongoing global climate change is likely to alter several of the limnological features of tropical lakes. In Lake Tanganyika, surface temperatures show a warming trend and this has been suggested to result in sharpening thermocline, increasing water column stability, reduced mixing of nutrients from hypolimnion, consequently decreasing productivity. Fish production is ultimately dependent upon food production, and thus subject to climate-induced changes. However, the path from hydrodynamics to fish yields is long and direct links may be difficult to identify.

In this study, data from the FAO/FINNIDA Lake Tanganyika Research Project (LTR) is used to examine whether variation in cohort strength of the small clupeid *Stolothrissa tanganicae* is linked to variation in food availability. *Stolothrissa* is the most important planktivorous fish in Tanganyika and spends most of its life in the pelagial, feeding mainly on copepod zooplankton. Succession of *Stolothrissa* cohorts can be followed from the catch-per-effort (CPUE) in the lift-net fishery and the length-frequency distributions of the catch. In the periods 1993-1996 and 1999-2001 *Stolothrissa* cohort strength was not predictable from copepod biomass either off Kigoma or Bujumbura. Neither could fish catch changes be linked to long-term trends in copepod zooplankton. Between-region comparisons also failed to show a direct connection between fish catches and food availability: copepods were most abundant off Bujumbura in the north where clupeid CPUE was low, while copepod biomass was low off Kigoma where clupeid CPUE was similar or higher than in the north.

Finally we examine some other possible mechanisms through which seasonal changes in hydrodynamics might affect cohort strength of *Stolothrissa*.

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Is eutrophication increasing the likelihood of a gas eruption from Lake Kivu?

The deep waters of the East African Rift Lake Kivu (Rwanda and Democratic Republic of the Congo) contain large amounts of dissolved carbon dioxide and methane. The release of a fraction of these gases, similar to the famous eruptions at Lake Nyos and Monoun (Cameroon), would have catastrophic consequences for the densely populated region. Presently, the concentrations in the lake are at a safe level and an extraordinary event would be needed to trigger a gas eruption. However, recent measurements indicate that the methane concentrations significantly increased by 15-20% during the last 30 years. Considering the fact, that the vertical exchange between the deep and the surface waters is very weak and the residence time of the deep waters is on the order of 1000 years, this fast change is surprising. Higher nutrient concentrations in the deep waters and lower concentrations in the surface waters as compared to measurements from the 1970's suggest enhanced nutrient export from the surface layer to the deep waters. Since the dissolved methane is mainly of biogenic origin, this increased export is most likely the cause for the rise in methane concentrations. Possible causes for the enhanced nutrient export from the surface layers are higher nutrient inputs into the lake due to the growing population to and changed lake-internal nutrient pathways due to the introduction of the fish species *Limnothrissa miodon*. As a consequence of the increased gas concentrations, the heat input needed to trigger a devastating gas release by a magma intrusion into the deep water has significantly decreased. With the estimated recent CH_4 production, the gas concentrations could approach the critical saturation levels within this century.

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Binational strategies to protect the North American Great Lakes from aquatic invasive species

Since the United States and Canada share the binational enclosed ecosystem of the Great Lakes, they must work together to achieve the most effective strategies to prevent further introductions of aquatic invasive species. To date, scientists have identified more than 180 aquatic invasive species in the Great Lakes, and new invaders are being identified at a rate of more than one per year. These invaders present threats to both the ecology of the lakes and the economy of the region. Estimates of the economic costs of species such the zebra and quagga mussels range from hundreds of millions to billions of dollars. Environmental costs include disruptions to the food web, making such invaders a key threat to biodiversity. A majority of invaders have arrived via the discharge of ballast water from ocean-going vessels while other invaders reached the lakes through other pathways including canals and connecting waterways. For example, the Asian carp currently threatens to reach the Great Lakes via a canal connecting the Mississippi River Basin with the Great Lakes basin. Both Canada and the United States are developing strategies to respond to the threat posed by aquatic invasive species. Most notably, both countries are engaged in setting a standard and designing a regulatory process to require treatment of ballast water before it is discharged into the lakes. Such a standard and regulatory regime would be most effective if included in a revision of the Great Lakes Water Quality Agreement, a binational accord between the two nations first signed in 1972.

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Spatial comparison by GIS of fish community structure in three bays with varying catchments of land use, northern Lake Victoria, Uganda

Fish community components including diversity, richness, dominance, equitability, abundance (CPUE) and similarity of spatial patterns were compared by Geographic Information Systems (GIS) among Hannington, Fielding and Murchison bays located in catchments of rural, semi-urban and urban land use influences respectively. Fish were collected eight times by graded gill nets of stretched meshes (2.54-12.7 cm) from June 2001 to April 2002.

Murchison Bay supported low fish diversity compared to Hannington Bay while that of Fielding Bay was moderate. The keystone fishes in terms of both numbers and weight were *Protopterus aethiopicus, Oreochromis niloticus*, *Lates niloticus*, *Astatoreochromis allauadi*, *Brycinus sadleri,* and haplochromine cichlids. Of these, haplochromine cichlids dominated in abundance across the three bays at all sites, followed by *B. sadleri*, except at Nakivubo channel mouth in Murchison Bay where *P. aethiopicus* and *Clarias allauadi* were numerically the most dominant fish species. The biomass of *Lates niloticus* was highest in Fielding Bay, followed by Hannington Bay, and least in Murchison Bay. Relatively, the highest and moderate diversity in Hannington and Fielding bays respectively could imply that these bays are less impacted by land use influences than Murchison Bay, where diversity was low. Knowledge of water quality (mainly trophic state) variations and comparability of fish distribution, abundance and diversity are essential information which managers and policy/decision makers require to manage the lake's resources.

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Phytoplankton species composition and biomass in the southern part of Lake Victoria, East Africa

Species composition and biomass of phytoplankton in relation to environmental factors was studied in both inshore and offshore regions of the southern part of Lake Victoria, over 5 years period (December 2000 to March 2005). The aim was to determine spatial and temporal changes in phytoplankton biomass and species composition in relation to nutrient availability. The phytoplankton community was diverse both in inshore and offshore. Cyanobacteria dominated other algal species and contributed a larger fraction (>50 %) of the total wet biomass and dry biomass of particulate nutrients (C, N, P). A general pattern of increasing dominance of N-fixing types (*Anabaena* and *Cylindrospermopsis*) in inshore and non-N-fixing types (*Aphanocapsa and Microcystis,* also referred to as the P-types) offshore was apparent in qualitative algal examination from the water samples. Overall 218 phytoplankton species were recorded during this study. Green algae recorded the highest number of species (110), followed by Diatoms (58), Cyanobacteria (41), Dinoflagelates (6) and Cryptomonads (3). The large filamentous cyanobacteria such as *Anabaena* and *Planktolyngbya* and the colonial mucilaginous forms such as *Aphanocapsa, Microcystis* and *Merismopedia* were the most common cyanobacteria while *Nitzchia, Cyclotella* and Navicula were the most common diatom observed during the whole study period. *Ankistrodesmus falcutas, Oocystis, Chordatella, Scenedesmus* and *Pediastrum* were the species of green algae that were frequently encountered. On average total abundance and wet biomass were approximately 5 times higher in the inshore shallow areas than in the offshore. Improved light conditions and relatively higher nutrients inputs in inshore shallow areas influenced the development of algal biomass, including N-fixing species such *Anabaena* and *Cylindrospermopsis.* Assessment of the current and published information on phytoplankton composition and biomass at both inshore and offshore regions confirms the eutrophic nature of Lake Victoria.

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The unique cichlid diversity of Lake Tanganyika: complex systematics with new perspectives

Lake Tanganyika is the oldest of the large African rift valley lakes that are all characterised by the presence of a unique endemic species-rich fauna of cichlid fishes. Its age is reflected in the composition of its fish fauna and the lake is currently regarded as an evolutionary reservoir of old lineages of cichlid fishes that have seeded the faunas of the lakes and rivers in the region. Current estimates of the number of cichlid species in Lake Tanganyika vary between 250 and 300.

The presence of geographic variation in the colour pattern of taxa such as *Tropheus* is already known for some decades but recently also small differences in morphology between conspecific populations have been documented by multivariate analysis of morphometric data. The genus *Ophthalmotilapia* is a case in point here. In order to better assess this variation, a multidisciplinary approach was taken. In some cases, this resulted in conflicting data sets, making it hard to define species and even genus boundaries. Adding to the complexity are two remarkable findings by molecular methods: the identification of several populations and species of hybrid origin and the evidence of a clear intraspecific genetic population structuring even over very short distances.

These challenging results underscore the importance of the detailed sampling programmes they are based on. A large effort has been done during the last fifteen years to sample the shallow-water rocky shores, but collections from the Congolese coast are lacking, while the sandy and deep-water habitats remain under sampled

All these recent developments are bringing down the image of well-defined, easily separated species and are putting some pressure on taxonomists because the 'customer' wants to be able to put every population or specimen he/she studies in the corresponding 'pigeon hole' with a unequivocal name on it.

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Is Western consumption of Nile perch from Lake Victoria sustainable?

The exploitation of Nile perch resources of Lake Victoria has strongly increased during recent years. This is apparent from decreasing catch rates and ever increasing numbers of fishermen, fishing craft and gears. Despite this it remains economically interesting to continue the exploitation and exportation of Nile perch products. Exports to the EU, however, seemed to have reached their maximum in 2003, which could have been due to competition from cheaper fish products from certain Asian countries as well as to market diversification by the East African exporting firms.

Fish prices paid to fishermen increased over time as a result of the success of the Nile perch fishery. The increased influx of money into the fishing communities did not necessarily lead to reduction of poverty. This could be due to the lack of saving and investment possibilities. In the absence of sufficient schooling the youth automatically enter the fishery sector as well and as a result of relatively low investment costs and high earnings the fishing effort will continue to increase until an open-access based management regime will be replaced by a licensing system. The role that Beach Management Units can play in managing the human and fisheries resources will have to be strengthened.

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Ecological state and monitoring of limnological and biological parameters in Lake Ladoga

Lake Ladoga (17 891 km^2) is the largest lake in Europe; its mean depth is 47 m, maximum depth 230 m, and its 258 000 km^2 drainage area extends to much of north western European Russia and eastern Finland. Ecosystem of Lake Ladoga has been systematically investigated since 1976 and sporadically since 1950s. Monitoring programs have included studies on hydrology, water chemistry and biology (phytoplankton, zooplankton, benthos, macrophytes and fish). The sampling frequency per vegetation season (spring, summer and autumn) has varied from 2 to 6 times. Water samples were collected at 20 – 60 fixed stations in the different zones of the lake. Long-term investigations, which cover 40 years, serve as good basis to understand the processes as well as for the assessment of the changes and the current environmental conditions in Lake Ladoga.

The ecological condition of Lake Ladoga is a concern to the 6 million inhabitants of St. Petersburg and Leningrad area for whom the lake is the only source of domestic and industrial water. Furthermore, the condition of Lake Ladoga affects water quality in the Neva River, the Gulf of Finland and the whole Baltic Sea. Until the early 1960s, Lake Ladoga was oligotrophic and characterized by good water quality, but within the past 20-30 years, as a result of human impact, the ecological state seems to have deteriorated. Especially since 1970s, its trophic state has changed to mesotrophic, with elevated nutrient concentrations and decreased transparency. Conditions at some of the worst polluted sites have actually improved in recent years, due to closing down some sources of industrial pollution. During the last decades, several planktonic, benthic and fish species sensitive for eutrophication have disappeared. The present species composition displays mesotrophic and eutrophic conditions in the coastal regions, whereas the pelagial areas are mainly oligo-mesotrophic.

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Life-history responses of the Lake Victoria cyprinid Rastrineobola argentea to environmental changes

A remarkable population increase of the Lake Victoria cyprinid (*Rastrineobola argentea*), locally known as dagaa, followed the upsurge of introduced predatory Nile perch (*Lates niloticus*) in the 1980s. The rise of dagaa, despite becoming an important prey for Nile perch, contrasted with the concurrent disappearance of many cichlid species. Competitive release probably contributed to the success of dagaa. Life-history responses by dagaa to increased predation pressure as supplementary factors have been investigated. Moreover, possible responses by dagaa to other constraining factors such as fishery, parasitism and hypoxia have been examined. Dagaa were collected during 1970/74, 1983, 1988, and 2001, fixed in 5% formaldehyde solution, measured, sexed, separated into 'unripe' and 'ripe' individuals, and checked for tapeworms (*Ligula intestinalis*). Eggs were counted and measured using a dissection microscope. Fecundity and egg size did not change between 1970/74 and 1988, despite increased fishing pressure over the whole period and strongly increased predation between 1983 and 1988. Though mean fecundity per clutch decreased, due to a decrease in average body size, a reduction in generation time strongly increased the total reproductive output. A simple model showed that this was the best strategy given the situation. In 2001 more and smaller eggs per clutch were produced than in 1988 when predation had dropped and fishing pressure risen sharply. Reducing the egg size may, however, have been a response to hypoxia rather than to fishing pressure, as no size reduction was found in parasitized females, which dwell in oxygen-rich areas. Due to a smaller ratio of egg surface area over volume, smaller eggs are supposed to be advantageous under poor oxygen conditions. Life-history flexibility must have played a crucial role in the ability of dagaa to cope with a mixture of environmental constraints.

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Seasonal changes in relative abundance of zooplankton in Shirati Bay, Lake Victoria

The zooplankton community of Shirati Bay was studied between October 2001 and April 2003 in order to identify its constituent groups/species, their abundance and seasonal changes in their structure. Zooplankton were taken from one station using plankton net (65µm mesh size) hauled vertically through the water column. The zooplankton community comprised mainly crustacea and rotifers and to a lesser extent early stages of aquatic insects. Cyclopoid copepods and their developmental stages were the most dominant group throughout the study period. In the population there were more females than males. Three peaks of zooplankton were observed in November 2002, and February 2002 and 2003. The highest abundance was recorded in November 2002 which reached 452,381m^{-2}. The lower abundance of zooplankton coincided with the highest peak of fish recruitment in March, April and May. In contrast with the idea that tropical zooplankton populations are stable, the zooplankton populations in Shirati Bay exhibited a combination of regular seasonal and irregular short-term fluctuations in size within the period of 18 months. These changes are discussed with respect to predation and food availability.

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Species distinction and the biodiversity crisis in Lake Victoria

Up to the 1970s the fish fauna of Lake Victoria was dominated by some 500 endemic haplochromine cichlid species, making up about 80% of the demersal fish mass. The cichlids were ecologically extremely diverse. However, the small diversity in gross morphology and the presence of intraspecific variation made it difficult to distinguish between species. In the first half of the 1980s, the Nile perch, an introduced predator, suddenly boomed and concomitantly the cichlids declined dramatically. In the same period eutrophication increased strongly. With the decline of the Nile perch catches in the 1990s, the cichlids showed some recovery. These events triggered many studies and debates. Disagreements about the seriousness and causes of the decline were often caused by considering the cichlid flock as single unit due to the lack of a proper taxonomic and ecological knowledge. By studying cichlid communities, trophic groups and individual species, differential impacts became apparent that help to unravel the causes of the changes. It seems that lake-wide, Nile perch predation and eutrophication had the strongest impact, while that of fishing pressure was just localized. Knowledge of the differential decline and recovery of the haplochromine cichlids and of the underlying causes is important for the proper management of biodiversity and the fishery in Lake Victoria. Consequently, knowledge of the systematics of the cichlids is a key issue in managing the lake.

Alphabetical Listing of Poster Abstracts

ABILA, RICHARD O.

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An assessment of fisheries product values along Kenya's export marketing chain

Kenya's fisheries sector is important as a source of food, employment, income, raw material and foreign exchange. This study was conducted to assess the production and marketing trends of Lake Victoria's fisheries under Kenyan jurisdiction and focuses on the valuation of fisheries products along the export marketing chain. Data were collected from both primary and secondary sources at all stages along the fish export marketing chain. Primary data came from interviews with key players in the industry, including: fishers, Fisheries Officers, marketers (middlemen), processors (both industrial and artisanal) and researchers. Secondary data came from published and unpublished manuscripts, existing databases and the internet. Kenya's Lake Victoria fisheries products have an annual market value of about Ksh 6.2 billion at landing. Of this, Nile perch constitutes Ksh 4.1 billion, and Ksh 2.1 billion is exported. Middlemen (agents) add Ksh 0.2 billion, making a pre-factory gate price of Ksh 2.3 billion, while the gross value of output by fish processing and exporting factories is Ksh 4.1 billion. The fishmeal industry adds about Ksh 418 million. This report shows that the fisheries sector contributes significantly to the local and national economy, hence, adequate resources should be allocated that is commensurate with its importance and to ensure sustained output.

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Fish community structure at the lake-river interphase in Lake Victoria, Kenya

Fish samples were obtained at four stations in each of the four rivers covered namely, Oluch, Awach, Sondu-Miriu and Nyando. In each river, two stations were positioned within the lacustrine habitat while two stations were within the riverine habitat. Environmental parameters (dissolved oxygen, pH, conductivity, turbidity and secchi depth) were sampled along with fish. Four species of fish were most commonly observed: *Lates niloticus*, *Rastrineobola argentea*, *Oreochromis niloticus* and *Barbus sadleri*. The highest catches of Nile perch were observed in lacustrine habitats (78%) compared to riverine habitats (22%). Sizes ranged from 9 mm to 82 mm in lacustrine habitats compared to 12 mm to 112 mm in riverine habitats. The size range for *R. argentea* was 13 mm to 58 mm in lacustrine habitats (63%) compared to 15 mm to 106 mm within in riverine habitats (37%). Dominant food items for Nile perch within the lacustrine habitat were cyclopoida copepods and *Moina micrura*. Insects and *Caridina nilotica* were more prominent in the diet of Nile perch within the riverine habitat. Large zooplankton (*Bosmina longirostris* and *Cerodaphnia cornuta*) were also selected within the riverine habitat. The size distribution of Nile perch within the interphase tended to be smaller within this habitat compared to sizes within the main lake. The structured population within the lake-river interphase could be a result of feeding on different food items within the same habitat.

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Food partitioning of fishes on the rocky shores of Usenge in Lake Victoria

Multimesh monofilament gillnets were used to determine the fish composition and the diet of the fishes on the rocky shores of Usenge during the day and night on the 12th and 13th of September 2003. Each set of the gill net was multi-mesh (ranging from 30 mm - 255 mm) of 20 metres long and 5 metres deep with equal area for each mesh size. Fish specimens caught were compared spatially and temporally in the four replicates for differences in sizes and food items between species and within species including the ontogenetic shift in the diet.

During daytime sampling Nile perch (54) were the most abundant fish followed by *Haplochromis* sp. (Red anal fin for males and yellow for females - 361), *Tilapia rendalli* (71), *Brycinus jacksonii* (4), *Oreochromis niloticus* (12), *Brycinus sadleri* (2), *Haplochromis* sp. (big eye, dark tail, dark nasal openings - 1) and *Haplochromis* sp. (Dorsal tips red, red tinge on tail - 22). Night catches were twice as much as the day catches.

Lates niloticus and *Haplochromis* spp. main prey were insects with specialization towards *Odonata* sp. by *Lates niloticus* and Ephemeroptera and Trichoptera by *Haplochromis* spp. making the specialization quite distinct in terms of food items. The index of resource overlap between *Lates niloticus* and *Haplochromis* sp. (Blue red anal fin for males and yellow for females) was found to be T = 0.182 with the food niche width (B) for *Lates niloticus*, B_{Lates} = 0.448 while for *Haplochromis* sp., B_{Hap} = 0.275 derived from Pielou index.

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Nitrogen dynamics in Northern Lake Tanganyika: inputs by rivers and use by phytoplankton

The Northern Lake Tanganyika is characterised by it's almost permanently stratified water column causing severe nutrient depletion in surface waters. Therefore, any external N source to the surface waters is of importance in sustaining the primary production. This work aimed to quantify the dissolved inorganic nitrogen (DIN) input by rivers to the waters of Northern Lake Tanganyika and the DIN uptake by surface phytoplankton. Results showed that the Rusizi River contributed more than 90% of riverine DIN to the northern Lake with 1810 T-N/year mainly under the form of nitrate. Phytoplanktonic nitrate and ammonium uptake rates were measured during 9 cruises and varied from 0.01 to 14.5 nM h^{-1}. Those values suggested a fast cycling of nitrogen species. N-uptake rates were often measured while no detectable levels of NH_4^+ and NO_3^- could be observed. Results obtained in these conditions showed that phytoplankton was able to respond very rapidly to an increased N-nutrient supply.

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Recent changes in ecology of Lake Sare, Lake Victoria Western Kenya

Studies on the ecology of Lake Sare were carried out to provide information on the ecological conditions before a major wetland reclamation project in the upstream of the lake. Results indicate that maximum depth had decreased by 0.9 m while Secchi depth readings had decreased by 0.1 m compared to historical values suggesting that the lake was undergoing siltation. pH values had increased from 6.80 to 7.58 which is associated with increased primary production. Conductivity had increased from 106 – 137 2 μS cm^{-1}. NO_3-N and PO_4-P had significantly increased from 0.8 μg N l^{-1} and 0.14 μg P l^{-1} to 23.90 μg N l^{-1} and 34.80 μg P l^{-1} respectively while chlorophyll *a* values reached values of 34.8 μg l^{-1}. The macrophyte environment was dominated by *Cyperus papyrus, Eichhornia crassipes, Phragmites australis, Typha domingensis,* and *Vossia cuspidata.* The study further observed macrophyte succession where the floating plants *Eichhornia crassipes* and *Pistia stratiotes* were gradually giving way to *Vossia cuspidata* in the Sare lagoon. The phytoplankton community was dominated by *Pediastrum* sp., *Pseudoanabaena, Synedra* sp. and *Cyclindospermopsis* sp. Zooplankton communities encountered were from the Copepoda, Cladocera and Rotifera genera. The fish community was dominated by *Lates niloticus* and *Haplochromine* sp which coexist in this ecosystem.

Lake Sare is a high priority ecological site for conservation and management of the resources of Lake Victoria basin. It has direct link with Lake Victoria. Fish populations stocked in Lake Sare are likely to find their way to Lake Victoria. As such, the lake can be used as a launch site for restocking Lake Victoria with juveniles of endangered fish species.

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Phytoplankton of 11 satellite lakes of Lake Victoria basin (Uganda)

Phytoplankton composition and biomass analyses were carried out on samples collected between April and June, 2004, from 11 satellite lakes within the Lake Victoria drainage basin in Uganda. There was a wide range in biomass in these lakes, 576 g L^{-1} (Lake Agu) - >25000 g L^{-1} (Kawai Lake). Cyanobacteria (bluegreen algae) dominated (69-99.1% of the biomass) the phytoplankton community in all lakes except Lake Nabugabo which was dominated primarily by desmids (chlorophytes 93%). Diatoms were never important in any of the lakes, and their biomass was usually less than 5%. However, dinoflagellates composed 14% of the biomass in Lake Agu, Chrysophytes (4%) were present in Lake Bisina, Euglenophytes composed 8% of the biomass in Lake Agu and Xanthophytes made up 3% of the biomass in Nawampasa. Cryptophytes were either not present, or only present in trace amounts. The current predominance of Cyanobacteria has become more common in many lakes around the world. Most of the dominating species are nitrogen fixers and potential toxin producers. This poster depicts the general composition of the 11 satellite lakes with an emphasis on the important Cyanobacteria species.

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Management of a productive boreal lake (Pyhäjärvi, SW Finland): from fish introductions to biomanipulation

Pyhäjärvi is a moderately large (155 km^2) but shallow (mean depth 5.4 m) lake in southwestern Finland (60°54´-61°06´N, 22°09´-22°25´E). This lake is famous for its flourishing fishery based on two coregonid species (whitefish, *Coregonus lavaretus*, and vendace, *Coregonus albula*), both introduced into the lake during the last century (whitefish starting from 1908 and vendace in 1948-1952). Since the 1960s, the main fishing method has been winter seining under the ice cover. In this lake seining is very efficient: typically 70-90% of each vendace year class is harvested during its first year. Vendace is also the key planktivore species which regulates the water quality of Pyhäjärvi. In the 1990s the vendace stock collapsed due to a combination of unfavourable weather patterns, increasing predation, eutrophication, and overfishing. This resulted in an expansion of other planktivorous fish stocks, with further deterioration of water quality. To remedy the situation, massive biomanipulation measures were started to improve water quality and to restore favourable living conditions for vendace. Intensified coarse fish fishery was effective, and in the 2000s water quality has significantly improved and the vendace stock has recovered. Our experiences from Pyhäjärvi during the last two decades suggest that conventional lake management and restoration policies are being challenged especially by climate change.

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The diet of detritivorous cichlids after the ecological changes in Lake Victoria

Originally the detritivores formed the most important guild of haplochromine cichlids in Lake Victoria, with more than 13 species making up 31% of the total cichlid biomass. Preliminary data analysis suggests that in recent years detritivores contribute only 5-10% to the cichlid biomass. One of the potential causes could be a change in the diet. In the past detritus, was their main food and mainly was made up of diatoms, which are now replaced by blue-green algae (cyanobacteria). However, other factors may be predatory behaviour of the introduced Nile perch and a decrease in oxygen concentration and water transparency.

Gut content analysis revealed a change in diet. Currently, detritivorous cichlids eat a wider range of food items than in the past such as detritus, insect larvae, zooplankton, shrimps and bivalves. The latter three were not encountered in their stomachs before. The combination of detritivory, shrimp eating, molluscivory and zooplanktivory feeding is remarkable as each mode of feeding requires a specific anatomy. The wide range in diet may have been caused by decreased competition, due to the disappearance of many of the specialized trophic groups, e.g. shrimp eaters and molluscivores. So far, the observations do not indicate that food is a cause of the decline of the detritivores.

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Wind induced changes in physical, chemical and plankton-community structures in Lake Tanganyika

From 28 August to 6 September 1995 we monitored the lake-wide physical, chemical and biological properties of the pelagic waters in Lake Tanganyika. The aim of this study was to examine the spatial environmental variability and its relation with fluctuations in plankton abundance and community assembly.

Trade winds had triggered an overall downward tilt of the isotherms, accumulation of warm surface waters and intensified stratification towards the north and on the other hand up-welling, increased mixing combined with decreased stratification towards the south. Dissolved oxygen, turbidity, conductivity, phosphorus and chlorophyll-*a* were higher whereas temperature and pH were lower in southern than in northern waters. We observed a transition zone (6 to 7 °S) where vertical water column structures changed from northern to southern conditions. This did not include the river Rusizi affected regions north of 4 °S.

High spatial heterogeneity in nutrient supply and degree of mixing had a strong impact on the plankton community. While the northern environments appeared to be based on reduced internal nutrient loading, lower phytoplankton biomass and smaller sized zooplankton with an important role of cyclopoids, the mixed environments in the south seemed to be based on increased phosphorus availability and larger sized zooplankton dominated by calanoid grazers.

We emphasise that wind-driven formation of a gradual change in physical and chemical properties of the productive zones along the north-south axis of Lake Tanganyika is of importance in regionally determining nutrient flows and consequently affecting plankton community structures and composition and therefore food web structure and functioning.

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A conservation assessment of the freshwater crabs of Tanzania with special reference to Lake Tanganyika

A recent taxonomic revision of the freshwater crabs of Tanzania recognized 25 species belonging to three genera (*Potamonautes, Platythelphusa,* and *Deckenia*) and three families (the Potamonautidae, the Platythelphusidae, and the Deckeniidae). Tanzania is home to fourteen species of *Potamonautes*, nine species of *Platythelphusa*, and two species of *Deckenia*, and this number is expected to rise as exploration continues and the taxonomy of this region becomes more refined. A large proportion (52%) of Tanzania's freshwater crabs are endemics, and the majority of these are found in Lake Tanganyika, which represents a biodiversity hotspot for the region. The conservation status of each of the 25 species has been assessed against the IUCN (2003) Red List criteria (based primarily on Extent of Occurrence). A preliminary assessment for Tanzania that takes into account recent field studies indicates that two species should be considered Endangered, nine Vulnerable, two Near Threatened, and 12 species of Least Concern. Of the ten species found in Lake Tanganyika, two species (*Platythelphusa denticulata* and *P. praelongata*) are considered to be Vulnerable, one (*P. immaculata*) is Near Threatened, and seven are of Least Concern. This study represents a first step toward developing a conservation strategy for this fauna. The results have been utilized by the IUCN for *Red Lists,* and may prove useful when developing a conservation strategy for East Africa's threatened freshwater crab fauna.

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Underwater survey showing Cichlid species diversity on sandy and rocky shores in the Kigoma Area, Lake Tanganyika, Tanzania

Littoral cichlid diversity was assessed at Gombe Stream National Park and Jacobsen Beach. The study aimed at understanding the cichlid diversity of these beaches as most of the earlier research done has focused on the pelagic fish species ecology and interactions. The study sites were classified as either sandy or rocky beaches. The study was done in the rainy (March) and dry (October) seasons; SCUBA diving was used as the field method.

In dry season Gombe National Park had higher diversity as compared to Jacobsen Beach while in wet season Jacobsen Beach had higher diversity. When looking at the individual habitats at each site, Jacobsen rocky habitats had higher diversity in wet season than Gombe, while in dry season Gombe had higher diversity. Jacobsen sandy habitat had higher diversity in wet season (H=0.226) than Gombe sandy habitat (H=0.042) while during dry season there were no significance differences between the two sites (H values 1.368 and 1.352, respectively). Jacobsen Beach showed low number of individual fish species in the wet season. Generally the rocky habitats of Jacobsen Beach showed higher diversity during the whole period of survey (H= 2.534) as compared to Gombe (H= 2.477), while the sandy habitats of Gombe Stream National Park had higher diversity (H=1.131) than those at Jacobsen Beach (H= 1.080).

In rocky habitats *Cythopharynx fulcifer* and *Opthalmotilapia* spp. were the dominant fish/cichlid species, while for sandy habitats *Grammatotria lemarii* and *Xenotilapia sima* were dominant at the Jacobsen and Gombe beaches, respectively. *Tanganicodus irsacae, Neolamprologus toae, Ectodus descampsi* and *Lobochilotes labiatus* were the less dominant fish species in the rocky habitats at Jacobsen Beach while *Simochromis marginatus* and *Tanganicodus irsacae* were the less dominant species in Gombe.

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Aquatic outreach & education in 'The Jewel of the Rift', Lake Tanganyika

If we were to describe to you the beauty and importance of Lake Tanganyika, Africa's oldest, deepest lake, whose clear waters are crowded with endemic colourful species that have evolved only there, you, as a reader of such superlatives would bring to mind an image of the habitat. If we told you this basin, which holds 18% of the surface fresh water, is subjected to threats of anthropogenic sedimentation (erosion runoff from non-sustainable farming practices), and that climatic warming has already been documented in its fisheries and productivity, you might well have an understanding of how land and water habitats can change through time, both on short and long time scales, with potential risks. You could consider your own perspectives on the scientific importance and aesthetic value of this system, and then respond in an informed way to questions of conservation. Yet, it is sobering to realize that most people living around the lake have never seen this aquatic wonderland, despite living within meters of the shore, and many are unaware of the concept of changing habitats and climates. Africans living in the Lake Tanganyika/Congo River drainage are the ultimate custodians of its conservation and stakeholders in its preservation, thus it is critical that they have a sense of both the hidden aquatic world and an understanding of the causes and consequences of habitat changes. We are preparing projects on local outreach for aquatic biodiversity awareness and conservation aimed at children and the general public. We are planning local museum displays and small publications, will organize teacher training so the message can be brought to schools. We will coordinate field experiences for children to see the living underwater world. We will screen the world-class documentary films on the lake, for example, the Surival Anglia film distributed by the BBC (*Little Fish in Deep Water*) & National Geographic (*Jewel of the Rift*). We are organizing Swahili translations for these films as part of the TACARE outreach programme that currently travels to the villages along the Tanzanian shoreline.

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Nutrient excretion by littoral fishes in Lake Tanganyika: species, community, and ecosystem perspectives

Lacustrine littoral zones host a great variety of consumer taxa interacting within complex food webs. The littoral faunas of the East African Great Lakes are particularly renowned for both species diversity and trophic diversity. This study presents data on liquid nutrient excretion by fifteen endemic species of littoral fishes in Lake Tanganyika. There is great variation among species in excreted nitrogen-phosphorus, in part reflecting differences between zooplanktivores and benthic consumers. Coupling excretion data with biomass estimates indicates that nutrient regeneration by these fishes plays a critical role in littoral nutrient cycling. Total nutrient excretion by fishes varies widely among sites as a function of both the biomass and composition of the community. The combination of among-species differences in excretion rates and among-site differences in community composition also creates spatial variation in the contributions of benthic and planktonic resources to regenerated N and P pools. This variability in nutrient regeneration may be sufficient to affect the balance between N and P availability on a local scale.

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The Nyanza Project: Interdisciplinary research training in tropical lakes

The Nyanza Project is a research training program for American and African students, run annually at Lake Tanganyika (LT), Kigoma, Tanzania. The Project's objective is to provide undergraduates, graduate students and secondary school teachers with the skills to plan and conduct interdisciplinary research on the paleoclimatology, geology, limnology, aquatic biology, and conservation of tropical lakes and to produce professional level science in the process. At a time of rapid global change there is a pressing need for young scientists trained to investigate environmental processes in an interdisciplinary framework. Training students to understand long-term changes in water availability, water quality and the relationship of aquatic ecosystems to rapid climate change represents a critical element of this societal need.

Since 1998, 147 students from the US and Africa (Tanzania, Burundi, Zambia, D.R. Congo, Kenya, and Burkina Faso) have participated. The first two weeks are an intensive LT scientific short course, followed by five weeks of directed research, written report preparation (www.geo.arizona.edu/nyanza/past.html) and symposium presentations. Focal research topics include: 1) East African modern and past climate changes using sediment cores and high resolution reflection seismic imaging, 2) rift basin analysis by mapping & interpreting the geologic structure and depositional processes in relation to the surrounding escarpments and watersheds, 3) the extremely diverse and largely endemic fish and invertebrate fauna found in the littoral zone of LT to understand species interactions, environmental controls on species distribution, and factors regulating species diversification, 4) the linkages between short-term climate variability, internal circulation in the lake, nutrient availability, and productivity in the open water (pelagic) and fish dynamics, and 5) the impacts of deforestation and soil erosion.

To date, the project has produced 33 articles in peer reviewed journals/edited volumes, 73 presentations at professional scientific meetings and 16 theses based on Nyanza work. Alumni surveys indicate that the Nyanza Project has significantly changed past student's approach to science and/or career directions.

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Is the planktonic food web of Lake Superior changing?

Lake Superior is the world's largest lake by surface area. Situated at the top of the Laurentian Great Lakes system, Superior contains 10% of the world's freshwater. Since intensive lakewide monitoring began in the 1970s, Lake Superior has generally been assumed to be a cold, stenothermic ecosystem that has remained largely unchanged. In part, this assumption is due to the fact that Superior has not been subject to the same anthropogenic stresses as the other Laurentian Great Lakes including eutrophication, contamination, phosphorus abatement and colonization by non-indigenous species. Our study, however, challenges the assumption that the lake is not changing. Primary productivity and total phosphorus concentrations have declined significantly since the early 1970s. Conversely, chlorophyll *a* has increased significantly. Phytoplankton biomass (summer mean) has increased from 0.2 g m^{-3} in 1970 to 1.3 g m^{-3} in 2001. Likewise, the relative composition of the phytoplankton community has changed from a dominance of Chrysophyceae, Cryptophyceae, and Diatomeae in 1970 to Diatomeae, Chrysophyceae, Chlorophyta and Dinophyceae in 2001. The primary productivity experiments indicated that there was a significant change in the size composition of the photosynthetic community. The paper is intended to offer state of the art knowledge about the Lake Superior planktonic food web; the largest and one of the most pristine aquatic ecosystems of the world.

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Primary productivity and phytoplankton species composition in the Malagarasi allied rivers and wetlands in Western Tanzania

As part of a limnological and biodiversity survey in the Malagarasi catchment area, the primary productivity and phytoplankton species composition at sites ranging from large rivers to small streams and shallow lakes and dams were assessed. The Malagarasi wetland is the largest in Tanzania, and designated as the world's second largest RAMSAR site.

Results showed that primary productivity was low compared with other tropical freshwater ecosystems, which might be attributed to light limitation or an ecosystem shift from light limitation to nutrient limitation. The phytoplankton species composition was dominated by species adapted to light-limited environments such as blue green algae, colony-forming small green algae, short forms and centric diatoms such as the *Cyclotella species* and floating species such as *Botrycoccus species.* I attempted to classify phytoplankton function groups according to habitat type and species composition and result showed that most of the groups were adapted to nutrient rich turbid environments, a sign for eutrophication.

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Nutrient distribution and carbon dynamics in northern Lake Tanganyika as studied from stable isotope geochemistry

A one year (September 2004 – August 2005) monitoring was performed on Northern Lake Tanganyika, at a station located in the pelagic area about 4 km off Bujumbura. Seasonal variations of depth profiles for nutrients (silica, ammonium, nitrate and nitrite) and organic carbon, as well as the natural ^{13}C isotope ratio in dissolved inorganic carbon (DIC) and particulate organic carbon (POC) allowed us to identify and highlight major controls on the carbon dynamics of the lake, including their seasonal variations. The northern part of Lake Tanganyika, off Bujumbura, has a relatively shallow depth compared to the rest of the lake (up to 1470 m) and is characterised by its long period of water stratification leading to surface waters depleted in nutrients and low productivity and deep waters richer in nutrients and almost anoxic. Occasionally during the dry season we show that surface water deepens down until the bottom, as a result of the dominating southwesterly winds. This leads to nutrient depletion and high dissolved oxygen levels throughout the whole water column. The variation of $\delta^{13}C$-DIC highlights the stratification of the water column and the primary production processes in the surface waters. On the other hand, $\delta^{13}C$-POC variations show the presence of organisms using C produced from fermentative processes in the anoxic bottom waters for short periods of the year.

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The limnology of the Lake Tanganyika sub-catchment

A limnological study covering the Lake Tanganyika sub-catchment was conducted during the dry season at 20 accessible sites on 8 rivers, 2 lakes and a dam. Standard methods were used to determine the levels of abiotic parameters from water samples. Physical parameters including dissolved oxygen (DO), electrical conductivity (EC), redox potential (Eh), turbidity, temperature, pH and secchi transparency were measured in situ while chlorophyll a was determined in the laboratory. Nutrients such as NO_3^-, SiO_2, PO_4^{3-} and Fe^{2+} were determined along with HCO_3^-. Significant changes in the levels of the abiotic parameters have been observed at various sampling sites throughout the study area. Variations in nutrient levels were noted at various depths throughout the sampling sites. The mean variation of NO_3^-, SiO_2, PO_4^{3-} and Fe^{2+} concentrations with depth ranged from 0.4 to 2.6 mg l^{-1}, 2.7 to 35.3 mg l^{-1}, 0.01 to 0.16 mg l^{-1} and from <0.010 to 0.020 mg l^{-1} respectively for the entire sub-catchment. Factor analysis resulted in four factors including increased primary productivity, redox conditions, dissolution, and reduction processes. However, data show that processes including dissolution, diffusion, adsorption, absorption, nitrification, denitrification, mixing and reduction along with the anthropogenic activities and increased photosynthetic activity of algae contribute to the variation of the abiotic parameters.

Data conclude that the limnological functioning of the Lake Tanganyika sub-catchment is strongly influenced by anthropogenic activities. It is recommended that quantification of river flows, sediment load and nutrient budget at various sampling points should be determined seasonally for proper evaluation of the hydrologic and limnological functioning of the sub-catchment ecosystems.

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Life histories of pelagic fish – a comparison between boreal North European lakes and the tropical Lake Tanganyika

Large northern lakes usually have low productivity and low temperatures, but clear seasonality. Their pelagic fish communities comprise only 1-3 planktivorous species (often coregonids) and 1-2 predatory species (often salmonids). In extreme cases, there is only 1 species occupying several feeding niches. Northern fish are well adapted to low temperatures and may have high growth rates during summer. Coregonids are autumn-spawners with moderate or high fecundity and medium-sized eggs. Age and size at maturity are flexible. In tropical African lakes temperatures are high, productivity is moderate or high, and seasonality is moderate. In Lake Tanganyika, the pelagic community is extremely simple, consisting of two planktivorous clupeids and four piscivorous species. Pelagic clupeids in Tanganyika are subject to very high predation rates by the piscivores in the warm water, while the pelagic fishes in northern lakes are only exposed to moderate predation pressure in the cold water. Clupeid growth in Tanganyika is not especially fast, probably as a result of high metabolic expenses at the high temperature, combined with high costs of avoiding the intense predation in the clear waters. The small planktivores are multiple spawners with low individual fecundity. Reproduction is continuous throughout the year, with variable seasonal peaks. The age and size at maturity are relatively constant in the almost constant environment.

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The use of eutrophication effects to reveal the function of cichlid egg spots

Lake Victoria's haplochromine cichlids are maternal mouth brooders without male parental care. Sexually active males possess pronounced ovoid orange-yellow spots on the anal fin which, to the human eye, resemble the eggs of the female. During spawning bouts the female lays one or a few eggs at a time, shortly afterwards snapping them into her mouth. Concurrently, the courting male displays its anal fin bearing the spots. After the female has picked up the eggs its attempts to grasp the anal spots orally. The anal spots have been assumed to function as stimulus "eggs" to enhance the motivation of the female to pick up its eggs as fast as possible to prevent egg snatching. This popular "egg dummy theory" regards the anal spots as accurate mimics of the eggs which stimulate sexually active females. Since long, however, this theory has been disputed and signalling, in relation to sexual selection, has been suggested as an alternative or additional function. The recent increase in eutrophication of Lake Victoria, causing reduced levels of dissolved oxygen and water clarity was used to investigate the two theories. Interspecific variation before the environmental changes showed a positive relationship between oxygen level and egg size and a negative relationship between water clarity and size of the egg spots. Within a species (*Haplochromis (Yssichromis) pyrrhocephalus*) of which the egg spots seemed accurately mimetic in the past was investigated. Eggs and egg spots of individuals collected before and after the environmental changes were compared. Though sample sizes of the post-eutrophication period are still small, the data suggest that egg size has decreased, while the size of the egg spots has increased. These results support the signalling theory, which is further supported by a suggested increase in the average number of egg spots per male.

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Status of micro-contaminants of public health concern in Lake Victoria, Kenya

This paper assesses the status of micro-contaminants of public health concern in Lake Victoria. Monitoring of environmental micro-contaminants of public health concern was conducted in Lake Victoria waters during the period 2003-2005.Sampling sites were selected based on possible sources of pollution such as agricultural practices, industrial sights and urban centers. Samples of water, sediment and fish were analyzed in order to explore levels of organochlorines, total mercury and total coliforms. Organochlorines were analyzed by Matrix Solid phase Extraction (MSPD) and Gas Chromatography; total mercury was analyzed by use of Atomic Absorption Spectropscopy. Total coliforms were analyzed by membrane Filtration method.

During the sampling period the concentration of fecal coliforms at different fishing grounds ranged from <1 cfu/100 ml H_2O to >600cfu/100 ml. The maximums corresponded with a series of storm events and catchments based activities such as urban discharges into the lake. Fecal coliform bacteria concentrations however, were lower than the US state class A (WW) standard of 200 cfu/100 ml H_2O from all the sites sampled.

Concentrations of 'total mercury' on water samples from all the stations were not detected while in sediments, only two sites showed traces of the metal. The levels in fish were all below minimum acceptable levels as recommended by the World Health Organization. The organochlorines screened were below detection limits.

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AQUATIC ECOSYSTEM HEALTH & MANAGEMENT

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All manuscripts relevant to the objectives of *Aquatic Ecosystem Health and Management* will be considered for publication. Manuscripts submitted to *Aquatic Ecosystem Health and Management* should be original and not being considered for publication elsewhere. The author(s) will be asked to transfer the copyright of the manuscript to the Aquatic Ecosystem Health and Management Society (AEHMS). The original, plus two complete copies of the manuscript, including tables and figures, as well as an electronic version (either in Wordperfect 6.0, Word 6.0) on diskette should be sent to:

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Manuscripts will be subjected to a standard peer review. All papers submitted for publication are processed/reviewed quickly by the editorial office for rapid publication. It is therefore necessary that the deadlines given to authors be respected. A systematic response and/or rebuttal to the referees is essential in speeding the evaluation process. If the revisions to the manuscript are returned after the given deadline, the manuscript may be treated as a new submission for the review process. Decisions of the Chief editor concerning the status of the manuscripts (acceptance/rejections, etc.) are final.

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Manuscripts must be typewritten with an 11 pt font size, double-spaced with wide margins, and printed single-sided. Good-quality printouts are required. The corresponding author should be identified (including a fax number and an e-mail address if possible). Full postal addresses must be given for all co-authors. Section titles/headings should always be placed on a separate line without accompanying text. Do not number section titles/headings. Every page should be numbered; however, there should be no reference in the text to page numbers. Authors should consult an issue of the journal for style and layout if possible. Do not use the wordprocessing software's facility for automatic word breaks, double columns, justification, or automatic paragraph number. The editors reserve the right to adjust the style to conform to the house style. Authors should keep a copy of their article since the journal cannot accept responsibility for damage or loss of papers. Original manuscripts are discarded one month after publication unless the publisher is asked to return original material after use.

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Text: The following order is used. *First page:* title, authors, addresses, (affiliations). The corresponding author should be identified with an asterisk and footnote. *Second page:* abstract, keywords. *Third and following pages:* text of article (e.g., introduction, methodology, results, discussion), acknowledgments, appendix, references. If footnotes are included in the text, they should be kept to a minimum and be identified with superscript numbers. Footnotes are not encouraged except those accompanying tables. Double quotation marks are used for quotations within the text. Use "and" instead of the ampersand (&).

Each of the following sections must begin on separate pages: figure legends; individual figures; table legends; individual tables including title and footnotes. Figures should be furnished in separate electronic files. Do not import the figures into the text.

Units and symbols: Use the SI system of unit symbols throughout the manuscript. The most commonly used unit symbols are: centimetre (cm); gram (g); hectare (ha); hour (h); joule (j); kilogram (kg); kilometre (km); knot (kn); langley (ly); litre (l); metre (m); microequivalent (μeq); microgram (μg); micrometre (μm); micromole (μmol); milligram (mg); millilitre (ml); millimetre (mm); minute (min); month (mo); nano (n); pico (p); second (s); tonne (t); week (wk); weight (wt); year (y). Note that symbols are to be written in full when used outside of an expression, e.g., 1-litre bottle, 1 litre of water, but 0.45 mg l^{-1}. Use positive exponents for quantities (m^3) and negative exponents for concentrations (mg l^{-1}) and rates (g m^{-3}, h^{-1}). Periods are not used in these expressions.

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[REPORT] Vollenweider, R.A., 1971. Scientific fundamentals of the eutrophication of lakes and flowing waters, with particular reference to nitrogen and phosphorus as factors in eutrophication. Organization For Economic Cooperation and Development, Paris.

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[CONFERENCE PRESENTATION] Smith, T., Jones, G., 1986. Title of presentation. p 216–225. In: T. Adams, (Ed.) Proceedings of a Conference on xxx. 1985 Nov 3–5. Publisher, New York City. New York.

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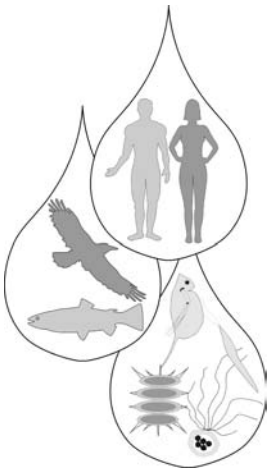

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Ecosystem Health of Large Rivers: The Majestic River Ganga	*2006*	*Patna, India*
State of Lake Huron	*September, 2006*	*Canada*
Sediment Quality Assessment—SQA 7	*November 28–30, 2006*	*Hong Kong, China*

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Second International Symposium on the Lake Huron Ecosystem:

The State of Lake Huron

Ecosystem Change, Habitat, Contaminants, and Management

October 11th – 13th, 2006
Delawana Inn, Honey Harbour, Ontario

Co-Chairs: Janette Anderson (Canada), Mohiuddin Munawar (Canada), Jamie Schardt (USA)

Background

Lake Huron is the second largest of the Great Lakes and fifth largest lake (surface area: 59 000 km2) in the world. It occupies the third position by volume, with a maximum depth of 229 m and mean depth of 59 m. Lake Huron is one of the least known lakes of the Great Lakes system in terms of limnology as well as food web dynamics. Consequently the Aquatic Ecosystem Health and Management Society (AEHMS) organized an international symposium in September, 1993, followed by the publication of a peer reviewed book "The Lake Huron Ecosystem: Ecology, Fisheries and Management" (Munawar, Edsall and Leach, 1995). Since then, little has been published in the Great Lakes literature about the Lake Huron ecosystem, although almost a decade has passed since the book was published.

The recent establishment of the Lake Huron Binational Partnership between Canada and the United States is very timely. The Partnership is focused on specific priority lake-wide ecosystem management and restoration issues in the Lake Huron basin. In response to a proposal from the AEHMS, the members of the Partnership agreed that this was an opportune time to convene a symposium dedicated to the assessment of the state of the Lake Huron ecosystem. The purpose of the Symposium is to bring together Great Lakes researchers and resource managers who are focusing on different aspects of the Lake Huron ecosystem, or whose findings are applicable to addressing key management themes for the lake and its basin.

Suggested Themes and Topics

- Structure, function of food web dynamics.
- Ecosystem change: physical, chemical and biological.
- Contaminants: sources, levels, trends and effects.
- Impacts of exotic species and biodiversity.
- Fish and Fisheries dynamics in a changing ecosystem:
  - Can we predict the future?
  - Integrative approaches to understanding populations.
  - Habitat, status and trends.
- Wildlife populations – status, trends.
- Remediation of Lake Huron Areas of Concern (AOCs).
- Coastal wetlands: stressors, protection and restoration.
- Inputs from rivers and tributaries.
- Watershed restoration: accomplishments and future goals.
- Algal blooms and toxins.
- Drinking and recreational water issues.
- Ecosystem sustainability – planning and management.
- Interface policy, management and science.
- Socio-economics, ecology and policy.
- Emerging issues.
- Novel techniques and tools.

For more information please send an e-mail to lorimerj@dfo-mpo.gc.ca.

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2005, 600 pages hardbound, 143 figures, 34 tables
ISBN 81-7898-458-X

This book is part of a series being published by the Ecovision World Monograph Series devoted to the state of lakes, and their ecology and integrity.

It is the formal outcome of an international symposium on Lake Michigan organized by the Aquatic Ecosystem Health and Management Society (AEHMS) and chaired by T. Edsall and M. Munawar. The symposium was convened as a special session at the 44th Conference on Great Lakes Research, Inter-national Association of Great Lakes Research.

This is the ninth in a series of books on the Laurentian Great Lakes produced by the editors, singly, jointly or in collaboration with others. This book reviews the status of the major Lake Michigan ecosystem components and provides a basis for evaluating the health of the lake and for promoting integrated management of this exceptional natural resource. The papers that this book comprises are invited, peer-reviewed presentations from professionals in the Great Lakes region who are recognized for their contributions to the advancement of Great Lakes science and management.

The book also includes an extensive subject index for convenience of use.

Sections include:

- Physical and chemical regimes
- Food web
- Water birds
- Wetlands
- Management and initiatives

This state-of-the-art collection of papers from various disciplines will permit a more holistic and integrated view of the Lake Michigan ecosystem and enhance our understanding of this unique and exceptional resource so that it can be more effectively protected and managed.

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