SASAQS 2014 CONFERENCE 22-26 JUNE 2014

SOUTHERN AFRICAN SOCIETY OF AQUATIC SCIENTISTS

ABSTRACTS

WATER RESEARCH COMMISSION

agriculture, forestry & fisheries
Department: Agriculture, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
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UFS·UV
NATURAL AND AGRICULTURAL SCIENCES
NATUUR- EN LANDBOUWETENSKAPPE

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CONFERENCE SECRETARIAT

SAVETCON
event management

Mrs Petrie Vogel - Registration and administration
Tel: +27 (12) 346 0687
Fax: +27(12) 346 2929
Email: petrie@savetcon.co.za

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PROGRAMME

SUNDAY 22 JUNE 2014		
16:00	**Registration**	
18:00	Welcoming function & dinner	
MONDAY 23 JUNE 2014		
07:00	**Registration**	
Session 1	**Aquatic Ecology & Management (SASAqS 1)**	
Chair:	**Jo van As**	
08:00	Welcoming	Prof. Neil Heideman (Dean: Natural & Agricultural Sciences, UFS)
08:15	**KEYNOTE: A Tale of Six Kalahari Rivers**	**John Mendelsohn**
08:55	An Inventory of Fish from Tete, the Lower Zambezi, Mozambique. Taxonomic notes and New Records	Warren Aken
09:15	Historical Aerial Photographs trace the Urbanisation of the Moreleta Spruit Catchment of Roodeplaat Dam	Mike Silberbauer
09:35	Protecting Habitat Diversity in Estuaries	Janine Adams
09:55	Monitoring of the Mdlotane Estuary and the Analysis of the Preliminary Water Quality Results	Nolusindiso Jafta
10:15	**TEA**	
Session 2	**Using Transdisciplinary Research to Build a New Practice in South Africa Water Resource Management (SASAqS 1)**	
Chair:	**Gerhard Cilliers**	
10:45	Towards a New Paradigm for Integrated Water Resource Management: An Integrated research Program	Tally Palmer
11:20	Local Government, Water Resource Management and Water Service Delivery	Matthew Weaver
11:40	Building a Co-operative Water Quality Management Process in the Crocodile River Catchment	Tally Palmer
12:00	A Green Drop Support Process for Waste Water Treatment Works in Mbombela, Mpumalanga	Victor Munnik
12:20	Co-operative Water Quality Participation by the Sugar Industry, Crocodile River Catchment	Asiphe Sahula
12:40	User friendly Water Quantity-Quality Modelling for Participatory Water Quality Management	Hugo Retief
13:00	**LUNCH**	

Session 3	**Aquatic Parasitology (SASAqS 1)**		**Aquatic Ecology and Management (SASAqS 2)**	
Chair:	**Liesl van As**		**Chris Curtis**	
14:00	The Crustacean Fish Parasite *Lernaea barnimiana* in the Eastern Cape of South Africa: Indigenous or Alien?	Kyle McHugh	Hartbeespoort Dam Integrated Biological Remediation Programme (HDRP) from Water Desert to Diversity (2008 to 2014): A Successful Test Case for Managing a Hypertrophic Sub-Tropical Impoundment by Applying Biological Principles to Support Aquatic Ecosystems	Peet Venter
14:20	Introduced Protozoan Fish Parasites in Southern Africa	Linda Basson	An Ecological Assessment of Endorheic Pans in the Free State, North West and Mpumalanga Provinces	Lizaan de Necker
14:40	Peritrich Ectosymbiont of a Planktonic Calanoid Copepod	Deidré West	Real-Time, Remote Fish Behaviour and Water Physico-Chemical Variable Monitoring to Evaluate the Biological Consequences of Habitat, Flow and Water Quality Changes in Rivers	Gordon O'Brien
15:00	The Health Status of *Oreochromis mossambicus* and *Tilapia rendalli* in a Conservation Area of the Phongolo River, South Africa	Jurgen de Swardt	Hartbeespoort Dam Integrated Biological Remediation Programme (HDRP) from Water Desert to Diversity (2008 to 2014): Nutrient Distribution a Key to Unlock Understanding of a Sub-Tropical Impoundment in Applying Biological Principles to Support Aquatic Ecosystems	Peet Venter
15:20	Experimental Infection Models and Diagnosis of Epizootic Ulcerative Syndrome in Three-Spot Gourami (*Trichogaster trichopterus*) and Rainbow trout (*Oncorhynchus mykiss*)	Christiaan Fry	The Compliance/ Incompliance of the Kruger National Park Rivers to the Set Macroinvertebrate TPCS from 2010 to 2013	Hendrik Sithole
15:40	**TEA**			
Session 4				
Chair:	**Jo van As**			
16:10-17:30	Round Table: Alien Invasions			
19:00	**DINNER**			

TUESDAY 24 JUNE 2014				
07:00	**Registration**			
Session 5	**Inland Fisheries, Aquaculture and Fish Health (SASAqS 1)**		**Pollution & Ecotoxicology (SASAqS 2)**	
Chair:	**Nico Smit**		**Johan van Vuren**	
08:00	Present Status and Future Management of Black Bass (*Micropterus* spp.) in South Africa	Olaf Weyl	Ecosystem Health and DNA Damage in Human Liver Cancer Cells (HEPG2): A Comparative Approach to Investigating the Impacts from Acid Mine Drainage in the Western Basin, South Africa	Maronel Steyn
08:20	The Phylogeny of Southern African Labeos	Mpho Ramoejane	Investigating the Influence of Hydrological Phase on Baetidae and Simuliidae Species Composition in a South African Non-Perennial River: the Seekoei River	Ina Ferreira
08:40	Fish, Now with Added Essential and Toxic Elements	Sean Marr	Detecting Endocrine Disrupting Effects in Abiotic Matrices of the Phongola Floodplain	Rialet Pieters
09:00	Species Composition and Relative Abundance of Fishes in Four Dams and a Natural Lake in the Western Cape	Brendon Dredge	The Ga-Selati Chemical Spill: A Threat to the Aquatic and Terrestrial Biodiversity	Kris Bal
09:20	Use of Larval Ageing to Determine the Spawning Period of Two Cyprinid Fish Species in the Senqu River System, Lesotho	Joppie Schrijvershof	From Drakensberg Tarns to Lowland Rivers: Aquatic Ecosystem Sensitivity to Atmospheric Deposition of Sulphur and Nitrogen Compounds	Chris Curtis
09:40	Aquaculture and Inland Fisheries: A Free State Perspective	Leon Barkhuizen	Time Lags, Multiple Sources, Mixing and More: The Complications of Conducting Long-Term Research on Rivers	Thabo Mohlala
10:00	The Concern for Human Health Effects in Communities after Consumption of Fish Harvested From the Albasini Dam in the Luvuvhu River Catchment	Irene Barnhoorn	The Response of In-Stream Biota to a Major Flood Event and Anthropogenic Land Use Changes in the Luvuvhu River Catchment, South Africa	Paul Fouche
10:20	DDD's Fish Parasite Diversity of the Dams in the Free State Should we be concerned? Parasites on Fish from Flag Boshielo Dam, Olifants River, Limpopo Province	Pieter Swanepoel Millicent Kekana	DDD's Metal Contamination of Sediments and Fish from the Vaal River, South Africa Detection of Oestrogen Active and/or Inhibitive Compounds in the Phongola Flood Plain Using the MVLN Reporter Gene Assay	Wihan Pheiffer Simone Prinsloo
10:30	**TEA**			

Session 6	**Using Transdisciplinary Research to Build a New Practice in South Africa Water Resource Management (SASAqS 1)**	
Chair:	**Tally Palmer**	
11:00	Evaluating the Decision to Build the De Hoop Dam in the Steelpoort River Catchment	Ian Preston
11:20	Towards a New Paradigm in Eutrophication Management	Carin van Ginkel
11:40	Ways to Increase the Recovery of Municipal Charges in Areas of High Poverty in a Socially Responsible Manner: The Case of the Sundays River Municipality	Lisa Maholo
12:00	The Mining Water Quality Activity System in the Upper Olifants River Catchment	Gareth Thomson
12:20	Access to Land, Water and Ecosystem Services: Identifying Sources of Innovation which Increase Human Well-Being	Karabo Chadzingwa
12:40	Catalysing Support Towards a New Paradigm Process	Tally Palmer
13:00	**LUNCH**	

Session 7	**Aquatic Ecology & Management (Freshwater) (SASAqS 1)**		**Aquatic Ecology & Management (Estuaries) (SASAqS 2)**	
Chair:	**Olaf Weyl**		**Denise Schael**	
14:00	Rehabilitation and Management of River and Wetland Systems in Cape Town – 4 Success Stories	Candice Haskins	Amphipod Estuarine Sediment Toxicity Testing with Cu and Zn: an Overview from the Past 10 Years	Refiloe Mofokeng
14:20	Temporal Changes of Fynbos Riparian Vegetation Communities on Selected Upland Rivers in the Western Cape, South Africa	Mia Otto	Pristine to Degraded- The Use of Macrophyte Habitats to Determine the Health and Importance of KwaZulu Natal's Estuaries	Meredith Cowie
14:40	Community and Food Web Structure in the Keiskamma River System, Eastern Cape, South Africa	Terence Bellingan	The Impact of Disturbance on the Salt Marsh – Terrestrial Ecotone	Dimitri Veldkornet
15:00	Species-Specific Impacts of Introduced Largemouth Bass in the Groot Marico Freshwater Ecosystem Priority Area	Peter Kimberg	Mgobezeleni Estuary: a Small, but Important, Groundwater Dependent Black Water System in Northern KwaZulu Natal	Guy Bate

15:20	DDD's A Semi-Quantitative Survey of Macro-Invertebrates at Selected Sites to Evaluate the Ecosystem Health of the Olifants River	Mathilde Kemp	A Numerical Prioritisation Model for the Selection of Estuaries for the National Estuarine Monitoring Programme in South Africa	Gerhard Cilliers
	Preliminary Assessment of the Water and Sediment Quality of the Olifants River, Limpopo Province, South Africa	Antoinette Jooste		
	Resource Quality Objectives for the Olifants Catchment: Balancing Water Resource Use and Protection	Gordon O'Brien		
	Resource Quality Objectives for the Upper and Lower Vaal Catchments: Balancing Water Resource Use and Protection	Gordon O'Brien		
	Spatial and Temporal Variations of Selected Abiotic Factors and Metals in the Water and Sediment of Crocodile (West) River, South Africa: A Baseline Study	Jazel Zaayman		
	Analysis of Active Rotenone Concentration During Treatment of the Rondegat River, Cape Floristic Region, South Africa: Evaluation of the Minimum Effective Dose (MED)	Martine Jordaan		
15:40	**TEA**			
Session 8	Chair: Gordon O'Brien			
16:10-17:30	Round Table: Inland Fishery Bio-assessment			
18:00	**Blue Movie**			
19:00	**DINNER**			
WEDNESDAY 25 JUNE 2014				
07:30	**Registration**			
Session 9	**Hydrology + Water Availability, Quality and Management (SASAqS 1)**			
Chair:	**Linda Basson**			
08:00	**KEYNOTE: Shale Gas Development and the Environment of the Karoo – Can the Two be Compatible?**			Danie Vermeulen
08:40	The Hidden Hydrology of Groenvlei			Roger Parsons
09:00	The Mgobezeleni Catchment Study – an Integrated Hydrology-Ecology Study in The Mozambican Coastal Plain			Ricky Taylor
09:20	PROBFLO: The Formal Integration of the Ecological Risk Assessment Techniques Incorporating Bayesian Network Modelling within the Ecological Limits of Hydrological Alteration Framework to Determine Ecological Flow Standards for Riverine Ecosystems			Gordon O'Brien
09:40	The Usefulness of Bioaccumulation as a Pollutant Monitoring Tool: The Kruger National Park Experience			Victor Wepener
10:00	Determining Resource Quality Objectives – Lessons Learnt from South Africa			Gordon O'Brien
10:20	**TEA**			

Session 10	**Aquatic Alien Invasions (SASAqS 1)**		**Bio-indicators (SASAqS 2)**	
Chair:	**Leon Barkhuizen**		**Roger Parsons**	
10:50	Existing and Emerging High Impact Invasive Species are Characterised by Higher Functional Responses Than Natives	Mhairi Alexander	The Impact of Environmental Stressors on Biomarkers in *Clarias gariepinus* and *Oreochromis mossambicus* in Ndumo Game Reserve	Mary Mkhonto
11:10	The Management of Aquatic Weeds in the North West and Gauteng Provinces.	Ilomé Lessing	Biomarkers of Pollution in *Synodontis zambesensis* and *Hydrocynus vittatus* in the Lower Pongola River and Floodplain	Claire Edwards
11:30	Using Multiple Lines of Evidence to Understand the Vulnerability of Headwater Stream Fishes to Non-Native Predatory Fish Impacts	Bruce Ellender	The Application of a Macro-Invertebrate Trait Database as Bioindicator for Salinity and Pesticides in South Africa	Wynand Malherbe
11:50	Economic Impact of Smallmouth Bass Sport Fishing Provides Invasive Species Management Insight	Olaf Weyl	The Physico-Chemistry and Heavy Metal Content of Tissue and Gill of Fish (*Oreochromis niloticus*, Linnaeus, 1958) from Water Body Receiving Industrial Effluent in Lagos, Nigeria	Prince Ndimele*
12:10	Do Invasive Trout Alter Aquatic Energy Flux to Riparian Consumers?	Michelle Jackson	Use of Fish Swimming Performance and Oxygen Usage as Biomarker of Effect: Exposure to Nanogold as Case Study	Nico Smit
12:30	The Lower Sundays River System: A Natural Laboratory for Investigating the Ecology of Fish Invasions	Darragh Woodford	Biomarkers of Pollution in *Tilapia rendalli* from the Nyamithi Pan, Phongolo River and Lake Jozini: A Comparative Study	Gregg Jansen van Rensburg
12:50	DDD's Assessing the Biology of the River Goby as a Proxy to Understand Global Goby Invasions What are the Impacts of Riparian Tree Invasions on Stream Food Web Structure and Ecosystem Processes?	Luba Mofu Michelle Jackson	DDD's Bioaccumulation of Metals in Two Edible Species of the Nyl River System A Baseline Study of Metal Contamination Along the Namibian Coastline for *Perna perna* and *Choromytilus meridionalis*	Ryo Musa Simone Dahms
13:00	**LUNCH**			
Session 11	**Aquatic Ecology & Management (SASAqS 1)**			
Chair:	**Janine Adams**			
14:00	**KEYNOTE: Aquatic Science in South Africa: Past and Future Challenges**			**Peter Ashton**
14:40	A Refined Method for Determining Appropriate Buffer Zones for Wetlands, Rivers, and Estuaries			Ian Bredin
15:00	Ecological Integrity Assessment of the Lower Phongolo River and Floodplain			Wynand Vlok
15:20	Scale and Environmental Influences on the Distribution and Structure of Temporary Wetlands in Nelson Mandela Bay (NMB)			Brigitte Melly
15:40	**TEA**			
16:10-17:30	**AGM**			
19:00	**GALA DINNER**			
THURSDAY 26 JUNE 2014				
08:30-10:00	**Departure**			

PRESIDENT'S MESSAGE

Dear SASAqS members and conference delegates

It is indeed a momentous occasion as we move into the 51st year of the SASAqS. We look forward to a great 2014 conference hosted by the Department of Zoology and Entomology of the University of the Free State and the Biodiversity Research Division: Department of Economic Development, Tourism and Environmental Affairs (FS DETEA). A particular word of welcome to our keynote and plenary speakers. We pride ourselves on being a student-friendly society and hope that this will be an enriching experience for first-timers. The **Water Research Commission** (WRC) is thanked for the sponsorship of student registration. The financial support from the **Department of Agriculture, Forestry and Fisheries** (DAFF) and the **Dean of the Faculty of Natural and Agricultural Sciences**, UFS, is also appreciated.

The conference will provide a forum for discussion on aquatic science topics ranging from ecology and management to fisheries, parasitology, pollution and alien invasive species. It is important that our science is published so please consider submitting your presentation as a paper to African Journal of Aquatic Science. The journal has had a growth spurt in 2014 from three to four issues.

Thanks to the organizing committee for the enthusiastic and efficient approach to the hosting of this conference. In particular the efforts of Prof Liesl Van As, Deidré West and Petrie Vogel of SAVETCON are acknowledged.

Hope you all have a fantastic conference and please join the society if you are not a member (see website http://www.riv.co.za/sasaqs).

Janine Adams
President

FOREWORD

SOUTHERN AFRICAN SOCIETY OF AQUATIC SCIENTISTS

Dear colleagues and students

Welcome to the Free State, situated in the heart and centre of South Africa. Our province lies between the Vaal River in the North and the Orange River in the south, it is characterised by grasslands, crop fields as well as goldfields (with more than enough Van Der Merwe jokes about being able to see the next day approaching, due to the flatness of our landscape). But sandstone mountains in the Northeast and dolomite rantjies throughout our province, prove these jokes to be wrong. The Mangaung municipality comprises Bloemfontein, Botshabelo as well as Thaba Nchu.

Located about 80 km east of Bloemfontein one will find Thaba Nchu, which was officially established in 1873 and is one of the oldest settlements in the Free State. A famous landmark of this region is Thaba Nchu Mountain (in Sotho *Thaba Ntsho* means 'black mountain'). The town became the trading and administrative centre for a large section of Tswana speaking people, after it was founded by Rev. James Archbell in 1833.

The summers are warm and perfect for outdoor activities, which can be found just next door to Black Mountain Leisure and Conference Hotel, at Maria Moroka Game Reserve, named after the political town heroin Dr. Maria Moroka. A variety of wildlife and bird species are found here, there are hiking trails and traditional Tswana sites. The winters are cold, but most of the time the days are bright and sunny.

I trust that we will have a magnificent conference, with a very full program (87 abstracts) focussing on Ecotoxicology, Bio-indicators, Aquatic Parasitology, Water Ecology and Management (Freshwater/Estuaries) and Aquaculture to name but a few. Two sessions will deal with South Africa's Water Resource Management, using trans-disciplinary research and the round table discussions will focus on Alien Invasions and Inland Fisheries.

On behalf of the organising committee, I wish you a splendid and most memorable stay in the Free State.

Local Organising committee: Prof Liesl van As, Prof Jo van As, Me Isabel Human, Me Deidre West, Mr Leon Barkhuizen, Mr Katlego Mogorosi & Mr Pieter Swanepoel. Conference Secretariat: Me Petrie Vogel.

KEYNOTE SPEAKERS

JOHN MENDELSOHN (PhD)

As a young boy and later as a student, John began his professional interests working at the then Transvaal Museum. That was followed by research on a variety of groups with most of the emphasis on morphology, systematics, behaviour, and energetics during his tenure at the Durban Natural History Museum, where he was also the Acting Director for 5 years. From 1988 to 1991 he was Chief Curator of Natural Sciences and later Director of the National Museum of Namibia. During this period he was responsible for overall management and served on national bodies to establish research institutes, museum associations, and the National Art Gallery of Namibia.

John at the Cuito River, Angola.

He was Senior Education Officer in the Namibian Ministry of Education & Culture until 1996, where he developed a geographical information system on education and Namibian demography to provide information on demands for education and the planning of schools.

Since March 1996 John has been self-employed as the owner of RAISON (Research and Information Services of Namibia) offering research and analytical services in various social and environmental disciplines. Most of his work has been in Namibia, but various projects were completed in Angola, Bolivia, Botswana, Democratic Republic of Congo, Ghana, Indonesia, Lesotho, Liberia, Malawi, Nigeria, Palestine, Somalia, South Africa and Tanzania.

John has written or co-authored more than 70 scientific papers and technical reports, over 40 popular articles and 22 books, and has edited several scientific journals. Invited papers have been presented at conferences in many countries.

DANIE VERMEULEN (PhD)

Danie matriculated in Carnarvon. After studying geology at the University of Stellenbosch, he started work as a mining geologist, after which he farmed in the North-Eastern Cape and started drilling for water for 18 years. Due to his interest in drilling and mining, he obtained an honors and masters degree as well as a doctorate in geohydrology from the University of the Free State. Since 2002 he lectures at the university and is currently the director of the Institute for Groundwater Studies at the University of the Free State.

He has compiled more than 200 geohydrological reports and reviews, published more than 30 papers in peer reviewed journals and chapters in mine water related books and presented more than 40 conference papers both locally and internationally. Danie has a broad range of professional interests but specializes in mine water related issues, especially in coal mines and related industries. He presents invited

public talks on mine waters and shale gas on a regular basis. Danie has visited the USA in 2011 and 2012, and Europe in 2013 to study the hydraulic fracturing process. He also visited Australia on a study tour to visit UCG and coal seam gas sites.

Danie is a registered SACNASP Earth Scientist and a Fellow of the Water Institute of Southern Africa and is a member of the Ground Water Division of South Africa. Danie is also a member of the International Association of Hydrogeologists, an executive council member of the International Mine Water Association as well as a council member of the Fossil Fuel Foundation, and serves on the editorial board of Water SA.

PETER ASHTON (PhD)

Peter Ashton is an aquatic ecologist with a special interest in water quality and river basin management issues, and the assessment of impacts on water quality, with over 43 years of work experience. He obtained his PhD in aquatic ecology at Rhodes University, Grahamstown, and worked at the CSIR from January 1975 until September 2012.

He has worked on water-related projects in 26 of the 49 mainland African countries. He has a special interest in the role of social and ecological issues in decision-making processes for conflict prevention and the management of water resources in shared river basins. Peter Ashton was an Honorary Professor of Water Resources Management at Pretoria University from 2000 until 2010.

From 2010 to 2013 he served on the National Water Advisory Council, tasked with advising the Minister of Water Affairs on strategic issues related to water quality, water resource management and water supply in South Africa.

CONTENTS

ABSTRACTS

MONDAY 23 JUNE 2014

SESSION 1: AQUATIC ECOLOGY AND MANAGEMENT

A Tale of Six Kalahari Rivers

Mendelsohn, J.M.
Research and information Services of Namibia, Windhoek, 9000.
john@raison.com.na

Six rivers or river networks drain an area spanning about 800 km east-west and 1,000 km north-south in the central Kalahari Basin. All flow south from the Great Equatorial Divide in Angola and Zambia to lower areas of the Basin. Four of the drainages (Cuvelai, Cubango-Okavango, Cuito and Kwando) end within the Basin, while two others (Cunene and Zambesi) have recently been captured out of the Basin to flow west to the Atlantic and east to the Indian Oceans, respectively. Most of the rivers' tributaries drain expanses of arenosol sands, and their waters are therefore largely devoid of suspended solids or dissolved minerals. Three of these rivers (Cubango-Okavango, Cuito and Kwando) also terminate in areas where arenosols predominate, allowing much of their water to permeate into the underlying sand, rather than evaporating. As a consequence, these three rivers end in freshwater alluvial fans (Okavango Delta and Linyanti Swamps). By contrast, much of the water of the Cuvelai comes off rocky ground, and its waters carry silt which forms an impermeable capping once it has settled. Most water in the Cuvelai therefore evaporates, which has led to the formation of Etosha and its many associated salt pans. Similar processes probably led to the development of the Makgadikgadi Pans. Biological production is low in the six rivers, particularly in waters that drain arenosols and accumulate in perennial wetlands where most nutrients are captured by macrophytes. However, variations in rainfall have led to the formation of several ephemeral wetlands, which become extremely productive following periods of desiccation, such as Lakes Liambesi and Ngami, the Mababe Depression and the Bulozi Floodplains.

An Inventory of Fish from Tete, the Lower Zambezi, Mozambique. Taxonomic notes and New Records

1. Aken, W.R. and 2. Bills, R.
1. Golder Associates Africa (Pty.) Ltd, Halfway House, South Africa
2. South African Institute for Aquatic Biodiversity, Grahamstown
waken@golder.co.za

The Zambezi River is the fourth largest river in Africa flowing some 2700km from north-western Zambia to the Indian Ocean. Along its length it runs through six countries and seventeen ecoregions and has been harnessed in Zimbabwe and Mozambique at Lake Kariba and Cahora Bassa Dam respectively. The Lower Zambezi River, consisting of the 650km from the Cahora Bassa Dam to the Indian Ocean is largely regulated by the upstream impoundments. This section

the river is generally sandy, with low, well vegetated banks. The only major fish collection of the Lower Zambezi River was carried out by the German herpetologist Wilhelm Peters in 1844/45. Many of the Zambezi River (middle and lower) endemics and other more widespread Zambezian species were discovered by Peters during this expedition and thus the Lower Zambezi River is the type locality for large number of Zambezi fishes. Most of the fishes collected by Peters were deposited in the Berlin Natural History museum and up until recently few scientists have revisited the region and documented the findings. With the development of the coal resource located in the Tete area, the opportunity for further studies has been possible. Golder Associates Africa has conducted ten (10) field collections since 2008-2013. This data is long overdue and important in understanding the fishes of the Tete area. Numerous species have been recorded during these surveys, providing information into new distributions, type specimen DNA collection and a new Synodontis species.

Historical Aerial Photographs trace the Urbanisation of the Moreleta Spruit Catchment of Roodeplaat Dam

Silberbauer, M.J.
Resource Quality Services, Department of Water Affairs, Pretoria
SilberbauerM@dwa.gov.za

Geometric processing of 32 digitised aerial photographs taken in 1939 of the Moreleta-Hartbees headwater catchments feeding into Roodeplaat Dam near Pretoria yielded a continuous monochrome image of the land cover. Georeferencing of the image allowed direct comparison with other data sources, such as orthophotos from 2001 and Google Earth images dated 2000 to 2013. The state of the Moreleta-Hartbees catchment is important because it contributes about one third of the riverine inflow to Roodeplaat Dam, which supplies water to the north-east of the City of Tshwane. The historical aerial photographs provide a snapshot of the catchment at the outbreak of the Second World War. Draping the images over a digital elevation model adds a striking landscape dimension to the landcover information. The photos show that much of the catchment had already undergone transformation to agriculture by 1939, and less than 4% was urban. Within twenty years, suburban housing was extending across the catchment and by 2001 a large proportion of the catchment was under low density housing, with areas of commerce and light industry. The images suggest that, despite the loss of habitat, large pockets have survived, especially along river courses. With the continued efforts of the residents, municipal managers and businesses, these areas of terrestrial and aquatic habitat within the urban area will become ever more valuable constituents of the biodiversity, health and aesthetics of South Africa's administrative capital.

Protecting Habitat Diversity in Estuaries

Adams, J.B. and Veldkornet, D.
Department of Botany, Nelson Mandela Metropolitan University, Port Elizabeth
janine.adams@nmmu.ac.za

The conservation and management of estuaries in South Africa requires detailed information on biodiversity. This study investigated the area and species composition of different habitats across estuary types and biogeographical zones. In the cool temperate, warm temperate and subtropical regions estuaries with the largest habitat areas were the Berg, Bot and St Lucia estuaries. Macrophyte species richness in estuaries of the cool and warm temperate zones was significantly higher than that in subtropical estuaries. No single species occurred in all estuaries and some species occurred in only one estuary. The number of species in estuarine bays, estuarine lakes and permanently open estuaries was similar but significantly higher than that of river mouths

and temporarily open/closed estuaries. All data form part of an estuarine botanical database that can be used to retrieve information as a baseline for further monitoring. These findings have already found application in the management of estuaries in South Africa as they have been used in the National Biodiversity Assessment and estuary management plans. The National Estuary Biodiversity Plan (SANBI, Department of Environmental Affairs) has identified 133 priority estuaries to be assigned protection status in order to meet defined biodiversity targets. Local management actions are needed to protect estuaries as well as adequate quantity and quality of freshwater inflow. This requires co-operation amongst national, provincial and local government authorities as a major pitfall in achieving biodiversity protection is the fragmentation of estuary management. The Integrated Coastal Management Act strives to achieve cooperative governance through the development of estuary management plans. The contribution of these plans to protecting habitat diversity will be discussed.

Monitoring of the Mdlotane Estuary and the Analysis of the Preliminary Water Quality Results

Jafta, N.1, Roberts, G.2 and Bachoo, S.3
1. Department of Water Affairs, Resource Quality Services, Pretoria.
2. Zinkwazi Blythedale Conservancy, Zinkwazi
3. Ezemvelo KwaZulu Natal Wildlife, Durban
jaftan@dwa.gov.za

Two known fish kills occurred in the Mdlotane Estuary in 2013; one was in April and the other in November. Though water quality analyses could not be done in April, a long-term monitoring programme was later initiated in the estuary, the National Estuaries monitoring programme. It is a product of the Department of Water Affairs, which is based on implementing nationally coordinated monitoring programs on various systems along the South African coast. The aim is to monitor estuaries of different types, functioning, and with various levels of baseline data. To build up on data, understand the functioning and inform management decisions. In the Mdlotane Estuary, the programme involved the sampling and analysis for nutrients (Orthophosphate, Nitrate and Nitrite and Ammonia), phytoplankton biomass (chlorophyll-a), and system variables (pH, temperature, dissolved oxygen, salinity and turbidity). Only the dataset for the August and November sampling trips were investigated due to financial constraints. The results indicate very high ammonia concentrations; between 3.75 and 4.85 mg/L in August and between 1.43 mg/L and 1.57 mg/L in November, after a fish kill event. The phytoplankton biomass was higher in November, with an average of 15.90 µg/L, compared to 9.67 µg/L in August. What can be deduced is that there is input of a high nutrient source which increases primary productivity and alters the physicochemical nature of the estuary. This needs to be investigated further, with continuous monitoring and solutions investigated. What the data also suggests is that prolonged exposure to high concentrations of un-ionised ammonia could have affected the fish community and led to the fish kill events. Increases in temperature and the pH also impact on the $NH_4^+ – NH_3$ balance and thus affect the ecosystem. However, fish ecologist need to be consulted for further investigations. The continuation of the long-term monitoring of this estuary is imperial. The DWA plans to continue supporting the NESMP, especially to implement it in systems like these ones and those that a data poor.

SESSION 2: USING TRANSDISCIPLINARY RESEARCH TO BUILD A NEW PRACTICE IN SOUTH AFRICA WATER RESOURCE MANAGEMENT

Towards a New Paradigm for Integrated Water Resource Management: An Integrated research Program

Palmer, C.G.
Unilever Centre for Environmental Water Quality (UCEWQ), Institute for Water Research, Rhodes University, Grahamstown
tally.palmer@ru.ac.za

South African has seen two decades of unprecedented change. The changes were driven by the move to a democratic country and hopes for the emergence of social and ecological justice. Change has not delivered everything hoped for. The National Water Act (No 36 of 1998) (NWA) is based on the principles of equity and sustainability, and the two successive National Water Resource Strategies have not yet enabled an experience of justice and equity by all people, nor a national spread of ecosystems able to deliver services out of a full range of ecosystem health conditions. The NWA was globally acclaimed as progressive and visionary. It still is. The challenge is to make its intentions real in the lives of people and in the aquatic ecosystems we depend on. This paper presents the vision, concepts, approaches, methods and practices from a variety of academic disciplines and water resource practitioners that demonstrate how to take decisions and actions that take us directions we hope, and plan for. These concepts, and associated methods, include complex social ecological systems, systems thinking, strategic adaptive management, social learning and resilience. They are organised into grounding and operational philosophies, leading to policy and implementation action is achieved through a learning and unlearning-based adaptive practice, underpinned by reflection and revision.

Local Government, Water Resource Management and Water Service Delivery

Weaver, M., O' Keeffe, J.H. and Hamer, N.
Unilever Centre for Environmental Water Quality (UCEWQ), Institute for Water Research, Rhodes University,Grahamstown
mjtweaver@gmail.com

Local Municipalities (LM) throughout South Africa face challenges to practice effective Water Resource Management (WRM) with consistent and equitable water service delivery a major concern. Makana LM, particularly Grahamstown is increasingly associated with ongoing water issues. To improve WRM towards a more integrated and sustainable approach, an initial requirement is to develop an understanding of the system. The Makana water system is a complex social ecological system comprising of many different interlinking elements and processes. Context is a critical component in understanding complex systems (Cilliers 2001). A review of the historical narrative of WRM in Grahamstown enables a better understanding of how the present day situation came about. From this review it is clear that the challenges Makana face now: the inequity of service delivery between Grahamstown East and West; an out-dated and poorly maintained reticulation system and insufficient municipal personnel with the required technical capacity are recurring problems throughout the past 200 years of the town's growth. Through engagement with the Makana LM and the community, the Makana case study team of WRC's "Towards a new paradigm" project is investigating how meta-theories such as complexity theory, systems thinking, transdisciplinarity and resilience can be implemented through substantive theories such as strategic adaptive management, social learning, social-ecological systems, and appreciative

inquiry to improve local water governance and management. Predetermined indicators of well-being, co-identified by researchers as well as municipal and community stakeholders, are being progressively analysed to measure change in the Makana water social ecological system.

Building a Co-operative Water Quality Management Process in the Crocodile River Catchment

1. Palmer, C.G., 2. Munnik, V. and 3. Du Toit, D.
1. Unilever Centre for Environmental Water Quality (UCEWQ), Institute for Water Research, Rhodes University, Grahamstown
2. Independent Research for Water, Climate and Environmental Justice, Nature and Society, Witwatersrand University
3. AWARD - The Association for Water and Rural Development, Hoedspruit
tally.palmer@ru.ac.za

This paper presents the process and conceptual framing of a project that is building a co-operative, implemented Integrated Water Quality Management Process (IWQMP) in the Crocodile River Catchment. The process will be a prototype for application, first in the other Inkomati Basin Catchments and then more widely. The project has as its lead partner the Inkomati Catchment Management Agency (ICMA). Project researchers and students join ICMA staff and stakeholders in acting to manage water quality, working towards protecting the Crocodile catchment to a range of levels agreed by the stakeholders. The project includes industry partners and other stakeholders who have particular water quality requirements and legal obligations, and who are currently negatively affected by deteriorating instream water quality. This paper presents how a set of water users are co-operating to act collectively to improve in-stream water quality for their individual and community benefit; and demonstrates the value of a transdisciplinary action research practice and processes.

A Green Drop Support Process for Waste Water Treatment Works in Mbombela, Mpumalanga

Munnik, V.
Independent Research for Water, Climate and Environmental Justice, Nature and Society, Witwatersrand University.
m.wolff@ru.ac.za

A crucial part of developing a co-operative Integrated Water Quality Management Plan (IWQMP) is the participation of local government and their water service providers in the management of waste water treatment works (WWTW). The South African Department of Water Affairs' incentive-based management process: Green Drop, offers a practical intervention point for improving the performance of WWTW, and contributing to the development and implementation of the IWQMP. This paper presents an action research project to develop and run a Green Drop support campaign in Mbombela, Mpumalanga. The core of action research is the idea of understanding a problem while dealing with it, while Cultural History Activity Theory (CHAT) offers methods that allow the analysis of people, interventions and actions towards particular goals. The Crocodile Catchment Green Drop Support Project drew on a history of stakeholder engagement in the catchment and acts to enable civil society to actively support an improvement in the performance of WWTW through working with local municipalities and the regulator within the framework of the catchment forum, and the catchment management agency, within Green Drop. The project has started with a Green Drop Support Campaign (GDSC). Its longer term objective is to shift power and conflictual relations towards realising social and ecological goals. The support process involves: 1. Scoping the felt need and enthusiasm for the campaign. 2. Establishment of a mandated, inclusive working

group to build capacity in a Green Drop framework. 3. Visit WWTWs, understand and listen to operators' challenges. 4. Use the Green Drop inspection process for analysis, where necessary bringing in national support. 5. Co-develop solutions across all partners. 6. Publicise outcomes and acknowledge participants. 7. Analyse and replicate more broadly.

Co-operative Water Quality Participation by the Sugar Industry, Crocodile River Catchment

Sahula, A.
Unilever Centre for Environmental Water Quality (UCEWQ), Institute for Water Research, Rhodes University, Grahamstown
asiphesahula@gmail.com

Water quality deterioration is reaching crisis proportions in South Africa. Many South African catchments are over-allocated, and decreasing volumes of source water mean increasing concentrations of pollutants. Low source water quality is becoming a critical risk in terms of costs and productivity to many industries in the Crocodile River Catchment in Mpumalanga province, South Africa. Specific in this study, it reduces the productivity of sugar cane and this is a risk to the export quality of sugar. In order to address this problem there is a need to develop a co-operative process that will assist with compliant control of water use and waste disposal in the catchment. This will reduce costs of enforcement, and industrial risks will decrease as water quality compliance, and therefore source water quality improves. The sugar industry is downstream within the catchment and thus affected by the activities of upstream water users, and dependent on the stakeholders upstream participating in the effective management of the resource. This study examines how the sugar industry can contribute to the development of an integrated water quality management process to secure their water needs. The results of the study describe the disturbances within the sugar industry activity system in relation to the development of the integrative water quality management process for the catchment.

User friendly Water Quantity-Quality Modelling for Participatory Water Quality Management

Retief, D.C.H., Slaughter, A.R. and Hughes, D.A.
Unilever Centre for Environmental Water Quality (UCEWQ), Institute for Water Research, Rhodes University, Grahamstown
g09r1860@campus.ru.ac.za

The Crocodile River Catchment (CRC), which is located within the Mpumalanga Province of South Africa, has been experiencing a decline in water quality as a result of the point source input of a cocktail of pollutants, which are discharged from industrial and municipal wastewater treatment plants, as well as from diffuse source runoff and return flows from the extensive areas of irrigated agriculture and mining sites. The decline in water quality has profound implications for a range of stakeholders across the catchment. A combination of deteriorating water quality, and the lack of tools and understanding of the relationships of water quantity and quality (Palmer *et al.* 2013) for determining compliance/non-compliance in the CRC, has seen the collaboration of stakeholders, willing to work in a participatory and transparent manner to create an Integrated Water Quality Management Plan (IWQMP). Water quality models can be used to investigate the implications of management scenarios as well as understanding the relationships between water quantity and quality, and are therefore useful tools within water resource management and in the development of the IWQMP. However, continuous or reliable observed data that can be used to calibrate existing water quality models are lacking for most catchments within South Africa. The Water Quality Systems Assessment Model (WQSAM) was developed to address South African

management requirements for water quality management, utilising limited observed data and quantifying risk by the duration of exceedance of certain water quality thresholds, or thresholds of potential concern.

SESSION 3: AQUATIC PARASITOLOGY

The Crustacean Fish Parasite *Lernaea barnimiana* in the Eastern Cape of South Africa: Indigenous or Alien?

1. McHugh K.J., 2. Weyl O.L.F. and 1. Smit N.J.
1. Unit for Environmental Sciences and Management, North West University, Potchefstroom
2. South African Institute for Aquatic Biodiversity, Grahamstown,
23538872@nwu.ac.za

Research into fresh water fish parasites in the Eastern Cape (EC) of South Africa is scanty, with only a few records primarily focused on eel parasites. During a fish health survey to Sandile Dam in July 2011 and March 2012, an ectoparasite was discovered on the skin of Labeo umbratus during the macroscopic examination for external abnormalities and parasites. The parasite was identified as *Lernaea barnimiana* (Hartmann, 1870). As members of the genus *Lernaea* are known to cause great pathology on their none natural hosts, especially when invasive, this discovery prompted the following questions: What is the effect on the health of this parasite on its host; what is the natural host of *L. barnimiana* in the EC and is *L. barnimiana* an indigenous or translocated species in EC? To answer these questions a full health assessment was done on a total of 30 *L. umbratus* following standard techniques. Results showed that the fish were all in a healthy state (Average FHAI score = 10.33 - 11.88) and *L. barnimiana* were in a very low abundance (3 fish infected with 1 parasite each) indicating that it is possibly infesting its natural host. Whether *L. barnimiana*, is an indigenous or translocated species is still very difficult to answer as it has previously been recorded from *Labeo umbratus* from Boskop Dam, North West Province and Chubu, Eastern Cape Province. Therefore this answer will depend on whether its host, *L. umbratus*, is indigenous or translocated to this locality in the Eastern Cape.

Introduced Protozoan Fish Parasites in Southern Africa

Basson, L. and Van As, J.G.
Department of Zoology and Entomology, University of the Free State, Bloemfontein
Bassonl@ufs.ac.za

Southern Africa contains less than 250 species of true freshwater fishes. Our fish fauna represents less than 10% of the continents biodiversity of fish, while southern Africa comprises 16% of the continent's surface area. Both fish numbers and diversity declines in southern Africa from north to south. Some 61% of the subcontinents fish are endemic with the largest concentration surprisingly in the "depauporate" Cape Region. Humans have been responsible for the introduction of at least 23 fish species, while several indigenous species have also been translocated. Both introduced as well as translocated fishes create various problems, such as: they threathen local species by competing directly for food and habitat, predator species feed on local species, some may interbreed with local species and lastly these species pose a serious threat due to the parasites and diseases they introduce or translocate. For the purpose of this presentation, the focus will be on the protozoan parasites that were introduced with various fishes, as well as the potential

impact these have had and may still have on our local fish fauna. Several parasite species have been reported in southern Africa as introduced during the last 25 years, but the data needs updating. These protozoan parasites have received more attention from scientists during the last few years and therefore a more informed decision can now be made on the list of introduced and / or translocated fish protozoans present in southern Africa.

Peritrich Ectosymbiont of a Planktonic Calanoid Copepod

West, D.T., Basson, L. and van As, J.G.
Department of Zoology and Entomology, University of the Free State, Bloemfontein
west.deidre@gmail.com

During surveys of plankton in the ephemeral systems of northern Botswana, a population of calanoid copepods in the Nata River were found to host an episymbiont of the genus *Trichodina*. All specimens examined were infested with at least one epibiont, which was dried and impregnated in the standard way of dealing with these peritrichs. This is an exceptional case as there are only five other records of this trichodinid worldwide. It was recorded from calanoid species in the Czech Republic, South Africa, Australia, South America and North America in 1960, 1991, 2000, 2009 and 2011, respectively. Based on morphological features it seems to be the same species which raises interesting questions about its mode of distribution. The Nata River dries during the dry season, forming pools which become increasingly saline as water evaporates. Mobiline peritrichs are not known to have overwintering stages which poses the question: how do they survive when the river dries?

The Health Status of *Oreochromis mossambicus* and *Tilapia rendalli* in a Conservation Area of the Phongolo River, South Africa

1. De Swardt, J.J.S., 1. McHugh, K.J., 2. Fouche, P.S.O. and 1. Smit, N.J.
1. School of Environmental Sciences and Development, North West University, Potchefstroom
2. Department of Zoology, University of Venda, Thohoyandou
jjsdeswardt@gmail.com

Oreochromis mossambicus and *Tilapia rendalli* are the preferred species of subsistence fishers in the lower Phongolo River. The health of these species in the Phongolo system has never been assessed. Fish were collected from Nyamiti Pan in the Ndumo Game Reserve using a 35m seine net, identified, measured, weighed and the condition factor (K) calculated. The health status of the fish was assessed using the fish Health Assessment Index (HAI). Results show that in low flow periods (September) the condition of *O. mossambicus* was significantly lower ($K = 1.94 \pm 0.19$) than during the high flow (April) ($K = 3.74 \pm 0.40$) and lower than that of aquarium reared specimens ($K = 3.67 \pm 0.10$). There was no significant difference ($p > 0.05$) in condition of *T. rendalli* collected in high ($K = 4.45 \pm 0.59$) and low flow periods ($K = 3.85 \pm 0.25$). The health assessment index (HAI) scores showed that T. rendalli (40 ± 10) was significantly healthier than *O. mossambicus* (111 ± 10). The high HAI score of *O. mossambicus* was attributed to a heavy infestation by a crustacean parasite, with parasite loads of up to 43 parasites per specimen. These parasites could also be the cause of the very low condition factor of *O. mossambicus*. The poor condition and health status of *O. mossambicus* in the pan is of great concern and further research is required to determine the impact this could have on the population structure and reproduction success of this economically important species.

Experimental Infection Models and Diagnosis of Epizootic Ulcerative Syndrome in Three-Spot Gourami (*Trichogaster trichopterus*) and Rainbow trout (*Oncorhynchus mykiss*)

Fry, C.
Department of Zoology, University of Johannesburg, Auckland Park, Johannesburg
004fry@gmail.com

Aphanomyces invadans is an oomycete associated with epizootic ulcerative syndrome (EUS). It affects more than a 100 freshwater and estuarine species of fish and is a serious threat to aquaculture and natural aquatic ecosystems. Currently, cases of EUS have been reported across Asia, Australia, North America and more recently Southern Africa. Diagnosis of *A. invadans* is usually based on clinical signs and confirmed by demonstrating the presence of mycotic granulomas in histological section. Demonstrating typical asexual characteristics by inducing sporulation allows identification of the oomycete to the genus level. After inducing sporulation, the zoospores can be isolated for use in clinical infection of fish through subcutaneous injection or bath challenge systems. The aim of this study was to perform different infection trials on EUS in two susceptible fish species, three-spot gourami, *Trichogaster trichopterus*, and rainbow trout, *Oncorhynchus mykiss*. Through initial trials, three-spot gourami was established as a suitable positive control species. Subsequently, hyphae were successfully re-isolated from infected fish and demonstrated as *A. invadans*, which was used in a further inoculation trial. Rainbow trout were challenged with *A. invadans* through intramuscular inoculation revealing varying degrees of susceptibility at different water temperatures. Detection of fungal hyphae and mycotic granulomas in tissue sections was achieved through histopathological examination, including the use of birefringence and fluorescents. Confirmation of *A. invadans* DNA in the various infection trials was done through PCR analyses. A histological grading system is proposed which will allow simplification of large scale qualitative microscopic analyses and identification of histological trends within a data set when analysing suspected cases of EUS.

SESSION 3: AQUATIC ECOLOGY AND MANAGEMENT

Hartbeespoort Dam Integrated Biological Remediation Programme (HDRP) from Water Desert to Diversity (2008 to 2014): A Successful Test Case for Managing a Hypertrophic Sub-Tropical Impoundment by Applying Biological Principles to Support Aquatic Ecosystems

Venter, P.S.
Department of Water and Environmental Affairs, Hartbeespoort
venterp@dwa.gov.za

The main components of the dam basin projects introduced to support the foodweb restructuring plan (removing bottom feeding fish species - Carp and Catfish) are the rehabilitation of aquatic fauna and flora along the shoreline; artificial shoreline (floating wetlands); removal of algae, hyacinths, debris and sediments. The clear water states that became more prevalent and prolonged since 2009, are also accompanied with the dominant algae species being the more desirable long stranded filamentous algae *Spirogyra* sp. An ongoing plant succession with colonization of previously barren areas by *Spirogyra* sp., is now being followed by the true aquatic plants *Potamogeton pectinatus* (fennel-leaved pondweed) and *Potamogeton crispus* (curled pondweed), which is expected to become dominant over time. With more nutrients utilized, fewer nutrients

become available for blue-green algae. Significant increases in both zooplankton species diversity and numbers were noticed throughout the dam. A large increase in zooplankton and macro-invertebrate diversity and densities has been observed under the floating wetlands as opposed to comparative open water samples. The increase predator fish numbers and species and increase bird numbers (>4 600 red knobbed coot) and species are confirmation of the improved energy flow through the system as detected since 2009. The further occurrence of aquatic vegetation abundance is strongly related to the increased abundance in fish and water fowl. The positive results from the foodweb restructuring noticed within 18 months (mid 2009) by the increased numbers and species of phytoplankton, vegetation succession, fish and water birds, are at times overshadowed by the impacts from the catchment if considered that between 40 to 60% of the annual nutrient load are introduced during rainfall events, with the additional hydraulic energy that also mobilisation additional nutrients from the internal load.

An Ecological Assessment of Endorheic Pans in the Free State, North West and Mpumalanga Provinces

1. de Necker, L., 1. V Vuren, J.H.J., 1. Malherbe, W. and 2. Ferreira, M.
1. Department of Zoology, University of Johannesburg, Auckland Park Johannesburg
2. Engineering and Environmental Consulting, Sunninghill, Johannesburg
lizaan.denecker@gmail.com

Pans are natural shallow depressions in the surface of the earth, which flood during the rainy season, have no outlets and usually dry up seasonally due to evaporation. These systems are unique and so act as a habitat to unique biodiversity. Pans in South Africa had been neglected until recent interest in opencast mining in the Mpumalanga Lake District (MLD) brought about new studies on these aquatic systems as mining poses a serious threat to the natural habitat. Ecological assessments of pans are difficult as not enough information about pans is available for comparison and consequently dissimilar systems such as lakes or ponds are used. This is problematic as pans are distinct from any other wetland. The aim of this study was to determine whether spatial variations between pans from different Provinces exist. In order to accomplish the aim the following goals were set out: 1.) sample and analyse water for nutrients, 2.) sample and identify invertebrates to lowest taxon possible. Preliminary results indicated spatial variation between the three Provinces in terms of water and invertebrate communities. Saline systems such as that of the Free State had different invertebrate communities compared to the systems found in Mpumalanga as well as the freshwater lake system of the North West. These findings are not conclusive as only one pan from both the Free State and North West were used and so further studies are needed to confirm whether spatial variation does exist. Results from this study still aids in filling the gap of knowledge about pans.

Real-Time, Remote Fish Behaviour and Water Physico-Chemical Variable Monitoring to Evaluate the Biological Consequences of Habitat, Flow and Water Quality Changes in Rivers

1. Jacobs, F. and 2. O' Brien, G.C.
1. Wireless Wildlife (Pty) Ltd., Noordbrug, South Africa
2. Institute of Natural Resources, Pietermaritzburg
gobrien@inr.org.za

Fish behaviour is extensively used as a measure to evaluate the ecological consequences of habitat, water physico-chemical variable and flow variable state alterations to aquatic ecosystems. Fish behavioural monitoring techniques include the use of acoustic, radio and combination telemetry technology. In lotic ecosystems where natural acoustic noise is high radio telemetry

monitoring techniques are used. Our approach makes use of radio telemetry tracking techniques developed by Wireless Wildlife to track the location, movement, activity and habitat use of fish tagged with small transceivers (tags). This can be achieved manually or remotely in real time with data storage capabilities if the tags are out of range of receivers. In addition to fish our approach makes use of water physico-chemical probes that monitor the temperature, depth and conductivity of aquatic ecosystems. This approach has been tested in various lentic and lotic ecosystems in southern Africa and has proved to be suitable for remote, real-time monitoring of water habitat, water physico-chemical variable and flow variable changes in rivers and lakes. The approach incorporates the use of univariate and multivariate statistical techniques and probability modelling techniques to relate the behavioural changes to environmental variable changes. In this paper we will demonstrate the use of this remote monitoring approach from a range of case studies undertaken from 2012 to date.

Hartbeespoort Dam Integrated Biological Remediation Programme (HDRP) from Water Desert to Diversity (2008 to 2014): Nutrient Distribution a Key to Unlock Understanding of a Sub-Tropical Impoundment in Applying Biological Principles to Support Aquatic Ecosystems

Venter, P.S.
Department of Water and Environmental Affairs, Hartbeespoort
venterp@dwa.gov.za

Catfish, Carp and Canary Kurper have benefited the most from the Hypertrophic state of the dam by not only dominating the system, but also contribute negatively by stimulating the release of the nutrients from the sediments (internal load) and predation on zooplankton further blocking the energy flow through the foodweb. By controlling hyacinths with chemicals over >20 years further destroyed the shoreline vegetation, contribute to sustain the distorted state. Since 2009 the appearance of more numbers and species on all trophic levels confirmed the increased energy flows desired to sustain more efficient nutrient sequestration throughout the foodweb. More profound is the improved diversity of higher order species which is the strongest indicator of measuring the success achieved. If considered that these results were achieved in spite of to the ongoing degradation of the upper catchments (reduced filtering capacity of rivers, wetlands, land use) and growing nutrient loads (>3x), it become more remarkable. Continuous monitoring results over 3 years gave significant insight to understand the difference in nutrient distribution between ‘cold’ and hot (sub-tropical) lakes. Contrary to what was expected / accepted, the temperature of inflowing water is consistently lower than the dams surface temperature, and even >90% of the time colder than even the 12m depth in the dam. Instead of spreading the incoming / external nutrient load on the surface (photic zone) making it immediately available for algae growth, it is distributed 12m and deeper into the dam. The nutrient availability becomes restricted and delayed. Bigger flood events course more turbulence overcoming this restriction to some extent.

The Compliance/Incompliance of the Kruger National Park Rivers to the Set Macroinvertebrate TPCS from 2010 to 2013

1. Sithole, H. and 2. Mohlala, T.
1. Scientific Services, SANParks, Kimberley
2. SAEON NDLOVU node Phalaborwa KNP Scientific Services
hendrik.sithole@sanparks.org

The anthropogenic activities taking place upstream of all main rivers flowing through the Kruger National Park have deteriorated the riverine ecosystems of the park. To mitigate further deterioration,

ecological specifications (EcoSpecs) that are required for conserving these ecosystems, have been set. Each EcoSpec has an accompanying Threshold of Potential Concern (TPC) to warns when the conditions are about to infringe the EcoSpec. Average of four EcoSpec and TPC indices have been set in each reach of a river. These are suitable SASS 5 Score and ASTP, Ecological Class, water flow, habitats and key macroinvertebrate taxa. We here present the set EcoSpecs and their TPCs, and state their conditions as being compliant and/or incompliant from 2010 to 2013. Majority of the TPCs have been compliant in most time in Sabie and Luvuvhu rivers while the majority of Olifants River has been frequently incompliant. Crocodile and Letaba rivers have mixed conditions.

TUESDAY 24 JUNE 2014

SESSION 5: INLAND FISHERIES, AQUACULTURE AND FISH HEALTH

Present Status and Future Management of Black Bass (*Micropterus* spp.) in South Africa

Weyl, O.L.F. Woodford, D.J. and Ellender, B.R.
Center for Invasion Biology, South African Institute for Aquatic Biodiversity, Grahamstown
o.weyl@saiab.ac.za

South Africa has a long history of non-native sport fish introductions because native fish faunas contained few species that had sport fishing potential. After the successful introduction of trout (*Oncorhynchus mykiss* and *Salmo trutta*) in the 1890s, four *Micropterus* species were introduced to create angling opportunities in warmer lowland rivers and impoundments. Largemouth Bass *Micropterus salmoides*, Spotted Bass *M. punctulatus,* Smallmouth Bass *M. dolomieu* and Florida Bass *M. floridanus* were imported between 1928 and 1980. Establishment was very successful and most river basins now contain at least one *Micropterus* species. This resulted in the development of a vibrant sport fishery that, through associated expenditure, contributes significantly to the South African economy. The South African recreational bass fishery is almost identical to that in the USA including formal ties between the South African Bass Angling Association and the Bass Anglers Sportsman Society in the USA. Black bass are, however, a major threat to aquatic biodiversity in South Africa because their predation on and competition with native fishes and invertebrates has impacted negatively on aquatic community structure and has fragmented native fish populations. Black bass are therefore specifically listed in the national Environmental management: Biodiversity Act as requiring management. Implementation measure include import and movement controls and eradication from conservation priority areas. I provide and overview of *Micropterus* introductions, impacts and fisheries in South Africa with emphasis on existing and evolving legislation, conflicts and potential management strategies for Black bass populations in South Africa.

The Phylogeny of Southern African Labeos

1,2. Ramoejane, M., 1. Swartz, E.R., 1. Weyl, O.L.F. and 1Makinen, T.
1. South African Institute for Aquatic Biodiversity, Grahamstown
2. Department of Ichthyology and Fisheries Science, Rhodes University, Grahamstown
m.ramoejane@saiab.ac.za

Four Labeo species groups are found in southern Africa, namely the *Labeo umbratus*, *Labeo niloticus*, *Labeo coubie* and *Labeo forskahlii* groups. These groups are pan African, except for the *Labeo umbratus* group that is endemic to South Africa and Lesotho. Apart from morphological studies, very little is known about how species of these groups relate to each other and whether the proposed groups are monophyletic. Understanding the species relationships would not only help in the understanding of the systematic diversity of this genus in Africa but also in predicting the vulnerability of its species to hybridisation. Five *Labeo* clades instead of four suggested by morphological studies were found in the analysis of two mitochondrial (cytochrome *b* and COI) genes of 62 individuals sampled across southern Africa, but with low bootstrap support. In contrast, the clades were polyphyletic when analysed with the nuclear Rag1 gene. The *Labeo forskalii* group is divided into two separate clades. The *Labeo coubie* group is not monophyletic, but groups with the *Labeo niloticus* group. Unidentified specimens from Angola form a separate clade and are closely related to the two *Labeo forskalii* clades. Species within closely related clades may be more vulnerable to hybridisation.

Fish, Now with Added Essential and Toxic Elements

Marr, S.M., Jooste, A. and Addo-Bediako, A.
Department of Biodiversity, University of Limpopo, Sovenga
sean.marr@ul.ac.za

Proposals to develop the fishery potential of impoundments in South Africa have historically not evaluated whether the fish from the impoundments are suitable for human consumption. A human health risk assessment of fish from impoundments in the middle/lower Olifants River (Limpopo River basin) identified that lead, antimony and chromium were above acceptable levels for human consumption based on a weekly 150 g fish meal. Researchers predict that the levels of pollution in the Olifants River will increase, resulting in more metals and metalloids exceeding the acceptable levels for human consumption. Increasing rural poverty and cost of protein are expected to result in increased reliance on freshwater fish to supplement dietary protein in rural communities. If fisheries are developed at polluted impoundments, it is imperative that suitable standards be available to evaluate whether the fish are safe for human consumption. In South Africa, levels for safe consumption of fish are only available for arsenic, cadmium, lead, mercury, and tin. Internationally, this list is not much longer. We predict that other elements such as antimony, cobalt, and vanadium could exceed levels for safe consumption of fish from the Olifants River. There is therefore a need to establish limits for a greater suite of elements for South Africa. Here we review the current status of levels for safe consumption and propose levels for a number of elements based on the USEPA human health risk assessment and reference doses.

Species Composition and Relative Abundance of Fishes in Four Dams and a Natural Lake in the Western Cape

1. Dredge, B.N., 1. Weyl, O.L.F., 2. Cochrane, K.L. and Impson, N.D.
1. Centre for Invasion Biology, South African Institute for Aquatic Biodiversity, Grahamstown 2. Department of Ichthyology and Fisheries Science, Rhodes University, Grahamstown
3. Cape Nature, Stellenbosch
bren.dredge@gmail.com

Non-native sport fish were introduced into rivers and dams in the Western Cape Province from the late 1800s primarily for recreational purposes. The impacts of these introductions on relative abundance and diversity of fish in public dams was last surveyed in the late 1970's. As a result, fish introductions and subsequent invasions since then have been undocumented and species compositions in many impoundments were unknown. The primary objective of this research project was thus to develop a baseline on the fish species composition in four Western Cape dams (Theewaterskloof, Clanwilliam, Quaggaskloof, and Voëlvlei) and a natural lake (Groenvlei). These water bodies were sampled using an electrofisher, seine net, long-line, angling, gill nets and fyke nets. Additional data were collected from recreational angling tournaments. Overall, survey data indicated a higher relative abundance of non-native than native fish in all five water bodies. For example, largemouth bass *Micropterus salmoides*, bluegill sunfish *Lepomis macrochirus* and African sharptooth catfish *Clarias gariepinus* were recorded in four of the five water bodies, while common carp *Cyprinus carpio* were present in all of them. Smallmouth bass *Micropterus dolomieu* were present in three dams and Mozambique tilapia *Oreochromis mossambicus* found in only two. Native fish were generally uncommon. On comparison with data from a 1970 survey, gill net catch composition in Clanwilliam and Quaggaskloof Dams differed between 1970 and 2013 ($\chi 2 = 88.8$ $p < 0.001$ and $\chi 2 = 25.3$ $p < 0.001$ respectively), with two species of endangered native fish disappearing from catches in Clanwilliam Dam and an increase in abundance of the native Endangered Berg-Breede whitefish *Barbus andrewi* in Quaggaskloof Dam. The loss of native fish and increased abundance of non-native fish in most of the water bodies demonstrates the ongoing spread of alien fish in Western Cape impoundments.

Use of Larval Ageing to Determine the Spawning Period of Two Cyprinid Fish Species in the Senqu River System, Lesotho

1. Schrijvershof, J., 1. Smit, N.J. and 2. O' Brien, G.C.
1. Unit for Environmental Sciences and Management, North-West University, Potchefstroom
2. Institute of Natural Resources, Scottsville, Pietermaritzburg
21649065@nwu.ac.za

The Senqu River system in Lesotho is an important resource that supplies South Africa with water and hydro-electric power. A paucity of information exists on the ecology, breeding behaviour and effect of water abstraction of migrating cyprinids in this system. Thus in the light of the potential impact of the existing and future dams on the fishes' ecology, it is important to determine the spawning period of the two large cyprinids found in the Senqu River. Larvae of the Vaal-Orange Smallmouth Yellowfish (*Labeobarbus aeneus*) and the Orange River Mudfish (*Labeo capensis*) were collected for age determination during August 2013 (n=4) and January 2014 (n=108) from five sites. Otoliths were removed and viewed under a light microscope to determine the age and age-length relationships. Results show that *L.. aeneus* with lengths (SL) 18mm-19mm were 35-46 days old, 20mm-25mm were 45-67 days old and 26mm-30mm were 56-70 days old. This suggests that the main spawning event of *L.. aeneus* occurred from late November to early December. *Labeo capensis* with lengths of 25mm-30mm were 45-60 days old indicating that their main spawning period stretches from early to middle December. Primary requirement of *L. aeneus* occurs predominantly in the upper Senqu River while *L. capensis* dominated the lower

reaches of the river. Access to the upper spawning areas for *L. aeneus* is thus far more important than *L. capensis,* and the current reduction in flows and future exacerbation of flow reductions may be negatively affect *L. aeneus* recruitment into the Senqu River.

Aquaculture and Inland Fisheries: A Free State Perspective

1. Barkhuizen, L.M., 2. Van As, J.G. and 3. Weyl, O.
1. Free State Department of Economic Development, Tourism and Environmental Affairs
2. Department of Zoology-Entomology, University of the Free State, Bloemfontein
3. South African Institute for Aquatic Biodiversity, Grahamstown
barkhl@dteea.fs.gov.za

A recent literature review by Mc Cafferty *et.al* (2012) demonstrated that there is a general lack of information on inland fisheries in South Africa. Data on previous fisheries developments are usually kept in files at government institutions where they are mostly inaccessible or difficult to obtain. Despite this lack of information there have been various initiatives to investigate, and promote inland fisheries in South Africa because inland fisheries are considered under-developed. This development initiative is largely fuelled by the mandate for inland fisheries and freshwater aquaculture being moved from Provincial conservation authorities to the Department of Agriculture, Forestry and Fisheries. As a result there has been a re-emergence in the promotion of fisheries and aquaculture projects in South Africa because inland water bodies are seen as the “golden goose that will lay the golden eggs” in terms of job creation, economic development, poverty alleviation and food security. The current paper assesses data on fisheries that have been collected since 1979 from more than 30 permits issued for commercial harvesting of freshwater fish at state dams. In reality there are few examples where fisheries were able to operate for more than only a few years. Similarly, in the aquaculture sector there are few positive outcomes from initiatives in the Free State Province. This paper presents a critical review of inland fisheries and aquaculture initiatives in the Free State Province with specific regard to highlight the challenges and problems faced and will try to answer the question if inland fisheries and freshwater aquaculture is the “golden goose”?

The Concern for Human Health Effects in Communities after Consumption of Fish Harvested From the Albasini Dam in the Luvuvhu River Catchment

Barnhoorn, I.E.J.
Department of Zoology, University of Venda, Thohoyandou
irene.barnhoorn@univen.ac.za

The Albasini Dam is situated in the upper reaches of the Luvuvhu River west of the area where spraying with DDT-occurs. Uncontrolled fish harvesting is a common practise at the Albasini dam (Personal observation and communication with owners of lake side properties) and people from the surrounding communities purchase catfish *Clarias gariepinus* and Mozambique tilapia (*Oreochromis mossambicus*) from roadside sellers (personal observation). A survey of the literature shows that very little is known about the water quality, and the level of pollution, of the Albasini Dam and nothing is known about the level of bio-concentrated levels of contamination in *C. gariepinus* and *O. mossambicus* in the dam. Therefore the levels of pesticides, veterinary drugs, personal care products and metals will be determined in the muscle from the two selected fish species. The levels of phosphates and nitrates will be determined in order to establish the trophic status of the dam. A Human Health Risk assessment on the people utilising the fish resources of the Albasini Dam will be conducted. A preliminary fish advisory for the Albasini Dam for later incorporation in the catchment area will be developed.

Fish Parasite Diversity of the Dams in the Free State

Mogorosi, L.K., Swanepoel, P.J. and Van As L.L.
Department of Zoology and Entomology, University of the Free State, Bloemfontein
swanepoelpj@ufs.ac.za

There are 12 dams in the Free State, each harbouring different fish species and in most cases the diversity overlaps amongst the dams. A few species are endemic or indigenous, such as *Labeobarbus kimberleyensis* and *Labeo umbratus*, whilst nine species are alien to the Orange-Vaal River. The current study focused on parasite diversity found associated with fish species in 12 dams in the Free State and to determine the presence of alien parasites and the effect on native fish species. It is also worthwhile to note that the dams have different characteristics with respect to depth, size, altitude, pollution and human impact; these characteristics influence fish and parasite diversity. The fish were caught using drag, gill, trawling and scoop nets. The fish were examined for parasites directly after capture using dissecting and compound light microscopes at temporary laboratories set up at each dam. During the parasitological surveys that were carried out from November 2012 to March 2013, in total sixteen of the twenty fish species that occur in the Orange-Vaal system were examined (n= 288). Various parasites are found associated with fish, but the main concern is the alien ones that were introduced along with the alien fish species. The majority of the fish examined were found to be infested with alien parasites. These were *Argulus japonicus*, *Bothriocephalus acheilognathi*, *Lernaea cyprinacea* and *Trichodinella epizootica* which are now frequently found infesting and infecting native fish species in very high proportions.

Should we be concerned? Parasites on Fish from Flag Boshielo Dam, Olifants River, Limpopo Province

Kekana, M.B., Jooste, A., Luus-Powell, W.J., Addo-Bediako, A. and Marr, S.M.
Department of Biodiversity, University of Limpopo, Sovenga
barileng@gmail.com

The Olifants River system is one of the most polluted rivers in South Africa. Rural communities in this catchment are increasingly reliant of fish to supplement their daily protein requirement. Impoundments in the middle Olifants River were selected to monitor the impact of water quality on fish health and parasites. Results from this study have shown that fish from these impoundments are not suitable for human consumption due to high levels of lead, antimony, chromium and cobalt in their muscle tissue. However, large numbers of parasites were also recorded from these fish. We investigated whether parasites collected on *Labeo rosae* and *Schilbe intermedius* at Flag Boshielo Dam could pose an additional threat to human health. Seasonal surveys were conducted from July 2009 to April 2010. A total of 10 fishes per species were collected in each survey. The abundance of parasites for both species was determined in the field by a careful examination of each fish. A total of 144 parasites were collected from *L. rosae* comprising five ectoparasite and two endoparasite species. From the 40 *S. intermedius* examined, 2473 parasites were collected, of which two species (one genus) were ectoparasites and three species endoparasites. The highest parasite prevalence recorded from *S. intermedius* was the *Contracaecum* larvae. In *L. rosae*, *Nematobothrium* sp. had the highest prevalence infestation. New parasite records for Southern Africa, *Nematobothrium* sp. and *Ergasilus* sp., were recorded during this study. The digenean larvae have the potential to develop in humans because of their zoonotic nature.

SESSION 5: POLLUTION AND ECOTOXICOLOGY

Ecosystem Health and DNA Damage in Human Liver Cancer Cells (HEPG2): A Comparative Approach to Investigating the Impacts from Acid Mine Drainage in the Western Basin, South Africa

1. Steyn, M., 1Oberholster, P.J. and 2. Botha-Oberholster, A.M.
1. CSIR, NRE, Stellenbosch
2. Department of Genetics, Stellenbosch University, Stellenbosch
msteyn@csir.co.za

Acid Mine Drainage (AMD) and the potential devastating impacts on the environment has received ample government, media and research attention in South Africa in recent years. The Witwatersrand, where decant has taken place since August 2002, presents the most urgent risks associated with acid mine drainage in South Africa. AMD typically forms when sulphide minerals are exposed to air, water and certain microorganisms, causing oxidation and resulting in water with a very low pH, high sulphate concentrations, elevated dissolved metal concentrations, low alkalinity and high conductivity. The effect of AMD on aquatic ecosystems is threefold, namely: a) impacted communities experience lethal levels of pH and metals, which lead to a decrease in biota richness and diversity, b) communities are restricted to tolerant organisms which are able to survive in these conditions, and c) alteration in nutrient cycles and abiotic changes may occur. Whilst the impact of AMD on the environment has been described, the human health impacts of AMD are not well understood and the links between environmental levels of AMD and eventual health outcomes are complex. *In vitro* test systems making use of cell lines are widely employed for detection of potential environmental contaminants. The advantages of these in vitro tests are that they are quick, relatively inexpensive, and specific mechanisms of action can be tested. HepG2 cells are a highly differentiated human hepatoma cell line representing a suitable *in vitro* system for studying (geno)toxicity in humans. As part of a bigger CSIR study, this project compared the findings from a newly developed ecotoxicological screening tool for AMD for South Africa, SASS5 ratings and DNA damage in human liver cancer cell lines (HepG2) exposed to AMD drainage at 7 sites in the Western Basin. Global methylation as well as apoptosis, by means of flow cytometry, was used to determine the DNA damage of the cells after exposure to AMD at 30 minutes, 2.5hrs, 24hrs, and 96 hrs. Study results indicate that improvement in the SASS5 index downstream from the decant site and after pH treatment (e.g., the addition of lime) of the AMD water, did not necessarily match the more sensitive genetic impacts observed in the *in vitro* test system, indicating possible long term genetic impacts. Study results could potentially serve as evidence in the development of policy guidelines to assist government departments in terms of setting standards during treatment of AMD water to minimize the associated human health risks in water end-users (i.e., households).

Investigating the Influence of Hydrological Phase on Baetidae and Simuliidae Species Composition in a South African Non-Perennial River: the Seekoei River

Ferreira, I.S. and Watson, M.
Centre for Environmental Management, University of the Free State, Bloemfontein
FerreiraIS@ufs.ac.za

SASS 5 (South African Scoring System version 5) is the standard rapid bio-assessment method used to determine the present state of macroinvertebrates in South African rivers. The SASS 5 method was, however, developed for use in perennial rivers, and regardless of its inaccuracy in non-perennial rivers is still used in these rivers. This study tested the hypothesis that the SASS 5 biomonitoring method does not consider natural changes caused by the hydrology in non-perennial rivers and that family level identification is not accurate enough to reflect the changes in the state of the river. Two macroinvertebrate families, Simuliidae and Baetidae, were used to determine the influence of species identification on the interpretation of biomonitoring data in non-perennial rivers. The results showed that species within the same family have certain flow and habitat preferences, which would not be detected using family-level data. This should be kept in mind when these rivers are managed. This study concluded that the information available from species-level analysis is important during the management of non-perennial rivers and therefore species-level data together with family-level data should be considered for use.

Detecting Endocrine Disrupting Effects in Abiotic Matrices of the Phongola Floodplain

Pieters, R. Delport, M., Hannam, M. and Prinsloo, S.
Unit for Environmental Sciences and Management, North-West University, Potchefstroom
rialet.pieters@nwu.ac.za

Many organic chemical pollutants occur at low environmental levels, not causing acute toxicity to the biota. However, continuous exposure to them might have detrimental effects. Possible consequences include carcinogenicity, immunosuppression, and endocrine disruption. Chemicals capable of mimicking hormones - endocrine disrupting compounds - bind to endogenous hormone receptors activating them, switching on the downstream events. Alternatively, the xenobiotic inhibits the receptor, preventing endogenous hormones from binding to it. Here, we report on receptor binding activity of compounds extracted from water and sediment that were collected from the Phongola floodplain in two seasons. Sediment samples were extracted and tested for aryl hydrocarbon receptor (AhR) as well as androgen (AR), and oestrogen receptor (ER) binding activity. Water samples were only investigated for androgen and oestrogen activity. Three reporter gene cell lines were used: the H4IIE (AhR), MDA-kbluc (AR) and MVLN (ER). All three have been genetically modified with the firefly luciferase gene. The volume of light the cells emit correlated with the pollutant concentration. Responses elicited by the samples are expressed in terms of the maximum activation by the positive control for the respective cell lines and is referred to as bioassay equivalents (BEQs). Not one sample showed any (anti-)androgen activity. Some sites had oestrogenic activity (53 pg to 113 ng BEQ/ℓ) for the water samples and 1 120 ng to 3 920 ug BEQ/g for the sediment. More sites contained AhR ligands and responses ranged from 7.53 to 31.8 pg BEQ/g). AhR-ligands include the dioxin and dioxin-like compounds as well as the polycyclic aromatic hydrocarbons.

The Ga-Selati Chemical Spill: A Threat to the Aquatic and Terrestrial Biodiversity

1. Bal, K.D., 2. Swemmer, T.,1. Marr, S. and 1. Jooste, A.
1. Department of Biodiversity, University of Limpopo, Sovenga
2. SAEON, Ndlovu Node, Phalaborwa
kris.bal@ul.ac.za

The Ga-Selati River is one of the major tributaries of the Olifants River System in the Limpopo Province. Its confluence with the Olifants River is just upstream of the Kruger National Park (KNP). The Ga-Selati has historically had a major impact on the water quality in the KNP. In the mid 2000s, DWAF prohibited the releases from tailings dams in the Phalaborwa Industrial Complex (PIC) resulting in improvements in the water quality in the KNP. The water quality in the Ga-Selati is impacted by agricultural activities and water abstraction in the upper catchment and by informal settlements and industrial activities at Phalaborwa. Following heavy rains over the 2014 New Year, a tailings dam in the PIC spilled into the Ga-Selati. Unbeknownst to the managers, the tailings dam was contaminated with high concentrations of acid. The tailings dam spilled for 5 days before the contamination was observed, reducing pH values of the river water to values of 2.8 (spill site) and 4.5 at Mamba Picket, in the Olifants River. A fish kill in the KNP alerted researchers to the impacts of the spill. Fish and aquatic invertebrates were eliminated but a slow recovery of the aquatic communities is being observed. A second spill occurred in mid-January 2014, was less severe but in this case the heavy metal concentrations exceeding the recommended guidelines for drinking water. Here, we present results demonstrating the impact of the chemical spill on the water quality and aquatic biota of the lower Ga-Selati.

From Drakensberg Tarns to Lowland Rivers: Aquatic Ecosystem Sensitivity to Atmospheric Deposition of Sulphur and Nitrogen Compounds

Curtis, C.J. Dunnink, J. and Lenkwe, A.
GAES, University of the Witwatersrand, Johannesburg
christopher.curtis@wits.ac.za

In South Africa, only a few recent studies into the ecosystem effects of acid deposition have been published for surface waters, focused mainly on the Highveld regions of relatively high sulphur and nitrogen deposition. However, there are historic studies of acid deposition going back to the 1980s, for example from certain long-term mountain catchment monitoring programmes, and the potential for ecosystem impacts has been recognized since then. Despite these historic deposition studies, there have been few systematic attempts to identify surface waters that may be impacted or to quantify their sensitivity using critical load approaches. Here we summarise the results of preliminary critical load studies in selected regions of South Africa from the upland tarns of Lesotho to the rivers of the Highveld and the lowlands of Kwa Zulu Natal.

Time Lags, Multiple Sources, Mixing and More: The Complications of Conducting Long-Term Research on Rivers

Mohlala,T.D. and Swemmer, A.M.
South African Environmental Observation Network (SAEON). Kruger National Park, Phalaborwa
thabo@saeon.ac.za

The biodiversity of freshwater ecosystems (rivers, wetlands and estuaries) is declining faster than any other type of ecosystem. In South Africa, contamination of rivers with man-made pollutants has occurred for decades, with extensive and increasing agricultural, industrial, mining and residential development within the catchments of all our major rivers. The causes of declining water quality are also well known, and often widely publicised, and the legislation to prevent water pollution is well establish. So why the need for scientific research, of the type SAEON is involved, on the topic? The Lower Olifants River monitoring project, conducted by the SAEON Ndlovu Node, is an attempt at providing some of the research results needed. A multitude of other pollution inputs have gone unnoticed and unpunished in the past, and their impacts on the aquatic ecosystems of the Lowveld rivers has been detrimental. The Selati, and the Olifants River in Kruger downstream are barely understood, these impacts are extremely difficult, if not impossible, to determine retrospectively. Data pooled together for SASS results from a site on the Selati upstream of Phalaborwa mines and industries are often the same, or even lower, than those downstream of the mines. This indicates that a significant amount of pollution is entering the river upstream, and the faulty sewerage works of Phalaborwa are the obvious source This makes research on the impacts of the Selati-borne pollutants even more difficult to determine, as the variety of pollutants is substantially broader than those from the industrial-mining complex alone. It also leads to questions regarding who is to blame when detrimental effects are detected downstream. Are the current low values in the Olifants (at Mamba) a result of pollution from the Phalaborwa industrial complex, or the sewerage inputs upstream? Or a combination of both? And how far downstream do these various pollutants affect the aquatic ecosystems in Kruger ? Is it just near the Kruger boundary, or do their long-term impacts extend all the way to Mozambique? The complicated results emerging from this long-term project, and the long list of questions they generate, highlight the need for a fresh look at water quality monitoring and the effect of pollution on aquatic ecosystems.

The Response of In-Stream Biota to a Major Flood Event and Anthropogenic Land Use Changes in the Luvuvhu River Catchment, South Africa

Fouche, P.S.O. and Foord, S.H.
Zoology Department, University of Venda, Thohoyandou
paulus.fouche@univen.ac.za

Freshwater ecosystems, which represent less than 1% of the earth's surface area, are potentially the most threatened. Monitoring the response of biological communities to disturbances of increased amplitude and duration provide crucial understanding of ecosystem change. The long term response of fish and macro-invertebrates to two contrasting disturbance events, a major flood event and longer term land use changes, were investigated in a catchment characterised by agricultural intensification and rapid rural development. Variation and change in abundance of functional groups, based on sensitivity to flow rate and water quality, were assessed. At the same time river health was assessed using indices based on the two taxa. Results show that flooding negatively affected diversity and abundance and that, contrary to other studies, impacts increased downstream. All affected metrics recovered to pre-flood conditions within one year after the flood, indicating that the system was resilient to flooding. Land use changes effected significant deterioration in most fish metrics with species richness on the decrease and a functional shift with flow intolerant and water quality sensitive species being replaced by flow tolerant taxa and species

associated with impaired water quality. Invertebrate assemblages responded in contrasting ways, with an increase in taxon richness but sensitive taxa significantly decreasing. The decline in river health, and the associated degradation of in-stream habitat, is most certainly approaching a threshold and the resilience of the system to future disturbances in terms of its health is therefore questioned.

Metal Contamination of Sediments and Fish from the Vaal River, South Africa

1. Pheiffer, W., 1. Pieters, R., 2. Van Dyk, J.C. and 1. Smit, N.J.
1. Unit for Environmental Sciences and Management, North-West University, Potchefstroom
2. Department of Zoology, University of Johannesburg, Auckland Park, Johannesburg
wihan.pheiffer@nwu.ac.za

Mining and other economic activities have led to the pollution of the Vaal River with metals of mainly industrial origin, but the consequences of this for animal and human health are unknown. Based on chemical analysis and histological examination, we report the contamination with 15 metals (chromium, cobalt, nickel, copper, zinc, arsenic, selenium, silver, platinum, gold, cadmium, mercury and uranium) of river sediments and organs (liver, kidney and gills) of sharptooth catfish *Clarias gariepinus* from four widely separated sites along this important South African waterway, sampled in the spring of 2010. The levels of the metals were compared to international sediment quality guidelines, and sediment quality indices (enrichment factor [*Ef*], geo-accumulation index [I_{GEO}], pollution load index [PLI], sediment quality guideline index [SQG-I] and sediment quality index [SQI]) were calculated. Although some metals proved to be highly enriched, the fish organs showed no histological alterations that could be related to metal exposure. However, when the levels of metals (Hg, Ag, Se, As and Cr) that accumulated in *C. gariepinus* were used in a theoretical scenario, these concentrations signalled a potential threat to human health.

Detection of Oestrogen Active and/or Inhibitive Compounds in the Phongola Flood Plain Using the MVLN Reporter Gene Assay

Prinsloo, S.E. and Pieters, R.
School of Biological Sciences, North-West University, Potchefstroom
22136657@nwu.ac.za

Increasing rates of urbanization, industrialisation, population growth and agricultural demand in South Africa have significantly decreased water quality leading to different forms of water pollution, which might be the case for the Phongola floodplain. Endocrine disrupting compounds (EDCs) are synthetic chemicals that interfere with endocrine system in organisms. Dichlorodiphenyl-trichloroethane (DDT), a known EDC is prevalent in the Phongola area for malaria control. The present study investigated the extent of oestrogen active and/or inhibitive compounds in the aquatic environment of the Phongola area. Sediment and water samples were collected from the Nyamiti Pan, the Phongola River, and the Namaneni Pan. The water samples were extracted using solid phase extraction cartridge and eluted with methanol:methyl-tert-butyl-ether mixture. Sediment samples were extracted using an accelerated solvent extractor in a dichloromethane: acetone solution. Clean-up steps involved solid phase extraction and gel permeation chromatography steps. These extracts were analysed with the MVLN reporter gene bio-assay for both activation and inhibition of the oestrogen receptor. The results concluded that the oestrogen receptor was activated for sediment and water during both the sampling events. Inhibition occurred at different sites and at different events. Samples from the second sampling event had the highest percentage of activation.

SESSION 6: USING TRANSDISCIPLINARY RESEARCH TO BUILD A NEW PRACTICE IN SOUTH AFRICA WATER RESOURCE MANAGEMENT

Evaluating the Decision to Build the De Hoop Dam in the Steelpoort River Catchment

Preston, I.
Unilever Centre for Environmental Water Quality (UCEWQ), Institute for Water Research, Rhodes University, Grahamstown
ian.preston96@gmail.com

When deciding whether or not to build a dam, The World Commission of Dams (2000) recommended among other things that a 'balanced and comprehensive assessment of all options should be conducted, giving social and environmental aspects the same significance as technical, economic and financial factors' and that infrastructure projects should be based on a catchment wide evaluation of the river ecosystem. This study looks retrospectively at the options considered when the decision to build De Hoop Dam was made; what perceived alternative scenario may have been considered; and what other scenarios could have been considered. The study area is the Steelpoort sub-catchment, which is part of the Olifants catchment. The Steelpoort River is a tributary of the Olifants River, one of the most polluted and overused rivers in South Africa (CSIR, 2012). The Millennium Ecosystem Assessment (MEA, 2005) framework was used to identify and analyse the ecosystem services present in the Steelpoort sub-catchment at the time that the decision to build De Hoop Dam was made, the present ecological state and recommended ecological state. Furthermore a valuation of ecosystem services in the catchment have been done, and added into a redesigned construction cost of the De Hoop Dam. The redesigned construction cost has then been compared to the actual cost of construction of the De Hoop Dam. This comparison, using unit reference values, evaluates the decision-making behind the construction of De Hoop Dam with goals set by Government in legislation drafted in the National Water Act and the National Water Resources Strategy among others (DWAF, 2004).

Towards a New Paradigm in Eutrophication Management

Van Ginkel, C.E.
Cripsis Environment Rietfontein, South Africa
carin.vanginkel@gmail.com

South Africa, as a semi arid country, needs to utilise fresh water resources, and therefore, water was impounded on a large scale to enable further development in all parts of the country. During the past 60 years, eutrophication has become an increasing threat to the usability of South African freshwater resources, especially in the systems downstream of large urban developments. The focus of the eutrophication theme of Case Study 3, as part of the larger TNP project, is on the Loskop Dam and the Upper Olifants River Catchment, that is, like many other systems in the country, an extensively used system. This case study will include the inter-linked social and ecological systems within the Upper Olifants River Catchment regarding eutrophication related issues, to ensure the availability of water of good quality for human well-being downstream, on a sustainable basis. To build a new discourse for the eutrophication related management issues the project team work towards mutual understanding of the catchment issues that also need to be generally applicable to other catchments through integration, reflection and collaboration. This will be done by encouraging mutual stakeholder respect, understanding and cooperation by using adaptive management techniques, resilience, transdiciplinarity and understanding the complexity

through systems analysis. The outcomes will include the consideration of legislation needs, management practices, methodologies to improve stakeholder participation through e.g. 'Water for Dignity', make provision for environmental requirements of impoundments, consider monitoring and laboratory requirements, determine stakeholder information requirements and ensure that the necessary funding and management capacity tools will be available for implementation.

Ways to Increase the Recovery of Municipal Charges in Areas of High Poverty in a Socially Responsible Manner: The Case of the Sundays River Municipality

Maholo, L., Noqayi, A. and Hefer, J.
Department of Management, Rhodes University, Grahamstown,
lisanompu@gmail.com

Water is acknowledged as one of the most fundamental and crucial of all natural resources for human survival. However, municipalities such as the Sundays River Municipality and many others in South Africa are struggling to provide this basic service adequately and sufficiently for the benefit of all its citizens. In the Sundays River Valley Municipality, amongst many other issues, they are faced with the issue of low cost recovery rates of municipal charges from consumers. This problem has affected the whole community negatively as the lack of income has led to aging and inadequate infrastructure. Higher recovery rates should enable the municipality to improve service delivery to the poor. This research paper focuses on possible ways to improve the recovery of municipal charges for water in areas of high poverty in a socially responsible manner. Respondents indicated that funding was a significant challenge. It also appeared from the interviews with the respondents that they may need to face these challenges in a more holistic way. Interventions such as ring fencing, contracting out, concessions, leasing, privatization, and management contracts have been said to help improve low cost recovery rates in other cases. These interventions are long term focused and should benefit municipalities over a given period of time. No standard method has been found to address the issue of low cost recovery; however an aligned mixture of the different interventions should improve the current state.

The Mining Water Quality Activity System in the Upper Olifants River Catchment

Thomson, G., Munnik, V. and Palmer, C.G.
Unilever Centre for Environmental Quality, Institute for Water Research, Rhodes University, Grahamstown,
gareth.thomson90@gmail.com

Water resource use drives the economy, and the mining sector is a traditional economic driver in South Africa that depends heavily of water abstraction, waste disposal and landscape alteration. While a mosaic of agri-tourism and conservation often offer alternative land-use and economic development options, it has proved difficult to plan effectively for selecting among development options. At present prospecting and mining licensing processes appear to threaten possibly more sustainable and less water-intensive development in many parts of South Africa. There is an urgent need to evaluate mining and mining-related licensing processes and their related water use scenarios, in relation to the biodiversity and conservation goals of water resource protection. This MSc project seeks to address the contested arena of mining in relation to water resource and biodiversity protection by developing and testing an integrated water resource quality management plan that would facilitate streamlining of conservation mandates, minimise duplication of effort, and clearly specify roles and responsibilities of different authorities. It will make use of and help develop a new modelling structure: activity systems. The overall aim of the MSc project will be: To

investigate and evaluate the decision making processes followed in issuing mining authorization, and to determine the relationship between licensing processes and ecological infrastructure from a landscape and connectivity perspective. I will be presenting on the institutional mining lifecycle in terms of the enforcement process in the context of integrated environmental water quality.

Access to Land, Water and Ecosystem Services: Identifying Sources of Innovation which Increase Human Well-Being

Karabo Chadzingwa
Department of Environmental Science, Rhodes University, Grahamstown
karabo.chadzingwa@gmail.com

Identifying opportunities to promote change in systems that exhibit high levels of resilience is a key challenge. In developing countries struggling with historical legacies of inequality, attention must be paid to breaking down resilience in a way that will allow for desired social-ecological transitions. In South Africa, despite strenuous efforts towards social, political and economic changes in the past two decades, severe inertia has been experienced particularly in efforts to increase access to land and water. Equitable access to ecosystem services is closely tied to this land and water nexus. In order to understand the impacts in which the use of both land and water resources concurrently, has had on individuals over time, a host of narratives must be considered at multiple scales, and through multiple perspectives. Based on a combination of in-depth family histories, archival research, key informant interviews and household surveys, this research explores the ways in which access to land and water over time has influenced current levels of human well-being for previously disenfranchised families in the Lower Sundays River Valley, South Africa. The case study was selected because it displays resistance to change, to the extent that communities have mobilised to force the state to deal with their claims for land. Plausible and desirable pathways out of the current situation, which support more equitable access to ecosystem services and increased human well-being, were identified together with community and government participants. The research offers both theoretical and methodological insights.

Catalysing Support Towards a New Paradigm Process

Palmer, C.G. and Rogers, K.
Unilever Centre for Environmental Quality, Institute for Water Research,
Rhodes University, Grahamstown,
tally.palmer@ru.ac.za

The Water Research Commission has recently funded a project: *Integrated Water Resource Management: towards a new paradigm in South Africa*. The foundational concept is that water is located in catchments, where all humans live, and that catchments are complex social-ecological systems. This recognition challenges us to change the way we think about catchments, and our use and protection of, dependence on, and connection with water resources. Water resource management has traditionally drawn mainly on the natural and physical sciences and engineering to solve problems. The 'new paradigm' envisages people accepting the concept of complex social-ecological systems and being willing to draw on wide-ranging kinds of knowledge, being willing to listen and learn from a wide range of knowledge and practice sources. Working towards human and bio-physical well-being (or social and ecological justice, or sustainability) requires skills in building teams with the broadest range of knowledge, in an ability to communicate, and integrate knowledge intelligently, understanding the conceptual and practical history of different thinking and practice traditions (for example science, social science and the creative arts). Early findings of working within in this new paradigm, point to the importance of social, practice-based learning and of adaptive responses; as well as an understanding of transdisciplinarity. In this

paper we discuss the process of supporting a broad, deep and embedded understanding of this 'new paradigm' of thinking and practice within the South African water sector.

SESSION 7: AQUATIC ECOLOGY AND MANAGEMENT (FRESHWATER)

Rehabilitation and Management of River and Wetland Systems in Cape Town – 4 Success Stories

Haskins, C.
Catchment, Stormwater and River Management, City of Cape Town, Cape Town
candice.haskins@capetown.gov.za

The City of Cape Town is responsible for the management of numerous river and wetland systems within its jurisdiction. However, commitment and engagement with a diverse suite of stakeholders is becoming an essential component of urban ecosystem management and can no longer be the sole responsibility or domain of government. The City's Catchment, Stormwater and River Management Branch provides engineering, ecological and water quality management expertise regarding urban rivers and wetlands to line functions such as Biodiversity Management, Parks, Water and Sanitation, and external environmental interest groups. Over the years, there have been several successful aquatic ecosystem rehabilitation and management initiatives that have been achieved through such multi-partner cooperation. This paper describes the rehabilitation work undertaken on four rivers and wetlands and highlights both the successes and challenges of these projects. Improvements in biodiversity, aquatic habitat, water quality and aesthetic and social amenity value of these urban systems was achieved. These projects and the lessons learnt will guide the future implementation of similar projects in Cape Town and could prove valuable to other municipalities.

Temporal Changes of Fynbos Riparian Vegetation Communities on Selected Upland Rivers in the Western Cape, South Africa

1. Otto, M., 1. Jacobs, S., 2. Brown, C. and 2. Reinecke, I.
1. Department of Conservation Ecology and Entomology, University of Stellenbosch, Stellenbosch
2. Southern Waters Ecological Research and Consulting, Cape Town
ottoM@ufs.ac.za

Spatial and temporal scales have significant influence on the community composition of fynbos riparian structure and form an integral part of ecological theory, environmental management and restoration practices. The lateral riparian plant communities are shaped by many natural disturbances such as flood, fire and drought. These disturbance processes are important for nutrient cycling, primary production processes, competition, diversity and succession within ecosystems, especially in riparian ecosystems. In rivers, physical interactions occur in three spatial dimensions: laterally across the floodplain, vertically between the surface and groundwater, and longitudinally down the river's length. These spatial interactions are embedded in a fourth dimension, which is time. Spatial and temporal scales are central to the framework of ecological inquiry and the dynamic character of natural ecosystems often makes it difficult to pinpoint the state to which an impacted environment should be restored. The aim of this study was to determine changes in riparian community composition over time and ascertain what implications this have for use of

reference conditions. Also how does the change in reference conditions compare to changes in sites subjected to fire and sites recovering after clearing of woody alien invasive species? Historic sites were re-sampled and datasets used for temporal comparisons between undisturbed sites, sites recovering after clearing and sites affected by fire. Sites had stronger similarity to data collected during the same sampling period, than with historic data. The overall relative species abundance did not show significant change to be present at a site scale. The changes in community composition were in fact due to a lateral zone scale variation in species abundance. As expected the undisturbed rivers showed less variation in species responsible for temporal changes than the recovering and fire-exposed rivers. Species responsible for changes in relative abundance at a lateral zone scale were *Metrosideros angustifolia*, *Morella serrata*, *Brabejum stellatifolium*, *Isolepis prolifera*, *Elegia capensis*, *Prionium serratum* and *Calopsis paniculata*. Due to the species diversity not changing much temporally but the relative abundance of specific species showing much variation over time it can be concluded that the changes seen in Multidimensional Scaling and Cluster analyses are not diversity based but instead driven by changes in relative abundances of species typical for a lateral zone. A reference condition used for restoration and environmental management purposes may be more optimally derived from a general community description for a specific area rather than using historical data and descriptions.

Community and Food Web Structure in the Keiskamma River System, Eastern Cape, South Africa

1. Bellingan, T.A., 2. Jackson, M., 1. Woodford, D.J., 3. Villet, M.H.V. and 1. Weyl, O.L.F.
1. Centre for Invasion Biology, South African Institute for Aquatic Biodiversity, Grahamstown
2. Department of Zoology, University of Pretoria, Pretoria
3. Department of Zoology and Entomology, Rhodes University, Grahamstown
g04b1386@gmail.com

The Cata, Mnyameni and Gwilli-Gwilli tributaries of the Keiskamma River are small first order streams that stem from the Amathola Mountains. The upper reaches are largely pristine, and have a history of salmonid fish stocking dating back as early as 1898. Brown trout (*Salmo trutta*) and Rainbow trout (*Oncorhynchus mykiss*) are found in the Cata and Mnyameni rivers respectively, while the Gwilli-Gwilli contains only native fish species, the Border barb (*Barbus trevelyani*) and the Chubbyhead barb (*Barbus anoplus*). Invertebrates were sampled quantitatively using a box sampler in each of the streams, while a three pass electro-fishing method was employed to collect trout for calculating density per reach of stream. Stable isotope samples were collected from each stream; these included terrestrial vegetation found along the stream edge, particulate organic matter, periphyton from the surfaces of stones, invertebrates from all available functional feeding groups, amphibians and fish. This was undertaken for exploring food-web structure within each stream, where trout were absent, present and where only native fish were present. Trout were present at an average density of four and two fish per ten meters of stream for brown trout and rainbow trout respectively. Multivariate analyses suggest that invertebrate community structure is driven by biotope availability and this will be discussed with reference to the impact of native and non-native fish on the food web using isotope analysis. We hypothesized that the presence of predatory fish would result in a shift in food-web structure where they occur.

Species-Specific Impacts of Introduced Largemouth Bass in the Groot Marico Freshwater Ecosystem Priority Area

Kimberg, P.K.1, Woodford, D.J.2,3, Roux, H.4 and Weyl, O.L.F.2,3
1. Hydrocynus Consulting, Kyalami
2. South African Institute for Aquatic Biodiversity, Grahamstown
3. Centre for Invasion Biology, South African Institute for Aquatic Biodiversity, Grahamstown
4. Department of Economic Development, Environment, Conservation and Tourism, North West Provincial Government, Mahikeng
peterkimberg@hotmail.com

North American Largemouth bass (*Micropterus salmoides*) are considered one of the world's 100 worst invaders and have been shown to negatively affect aquatic biodiversity in many parts of the world where they were introduced for angling. In South Africa there is a paucity of empirical studies describing their impacts, and our understanding of their impact on native ecosystems is therefore sparse. Largemouth bass have been present in the Groot Marico catchment, a National Freshwater Ecosystem Priority Area (FEPA), for over 20 years. We assessed the impact of this invasive predator on a fish community in an otherwise near-pristine river ecosystem. Fish surveys were conducted in 2012 and 2013 throughout the tributaries and mainstream of the Groot Marico River. Fish were counted using multiple survey techniques and their association with key habitat variables and the presence or absence of bass were assessed. A total of 10 native fish species were recorded, along with the introduced bass, which occupied the majority of the mainstream and several tributaries downstream of barriers to upstream movement. Canonical correspondence analysis showed only one native species, the Marico barb (*Barbus motebensis*) to have a negative spatial association with bass in the catchment. Assessment of relative distributions showed this species to be excluded by bass from invaded river reaches, whereas the other native species were not visibly affected by the invader. The implications of this species-specific impact are discussed in terms of best practice recommendations for managing Largemouth bass within the Groot Marico FEPA.

A Semi-Quantitative Survey of Macro-Invertebrates at Selected Sites to Evaluate the Ecosystem Health of the Olifants River

Kemp M., Wolmarans, C.T. and de Kock, K.N.
Unit for Environmental Sciences and Management, North-West University, Potchefstroom
20797192@nwu.ac.za

This study was conducted to evaluate the ecosystem health of the Olifants River by means of semi-quantitative surveys of the macroinvertebrates at 7 selected sites in the catchment. These surveys were performed during the high- and low-flow seasons for 2 consecutive years. Macroinvertebrates were collected by using a net consisting of a 30 cm square steel frame with a sturdy handle, to which a Perlon gauze net with a mesh of 1 mm was attached. Semi-quantitative surveys were done by sampling the vegetation, as well as the substratum, with the net at each site for approximately 15 min. The pH, water temperature and conductivity were measured in situ at each site during the different surveys. Samples were fixed and preserved in 90% ethanol and thereafter sorted, identified up to family level and counted. The specimens were categorised as tolerant, moderately sensitive or highly sensitive, according to the guidelines set by the South African Scoring System Version 5 (SASS5). Although a total of 95 taxa were recovered during this study, only 7 of these taxa were categorised as highly sensitive. It can be concluded that the water of the Olifants River is in a poor state of health as revealed by the macroinvertebrate assemblages.

Preliminary Assessment of the Water and Sediment Quality of the Olifants River, Limpopo Province, South Africa

Jooste, A., Marr, S.M., Addo-Bediako, A. and Bal, K.D.
Department of Biodiversity, University of Limpopo, Sovenga
antoinette.jooste@ul.ac.za

The Olifants River System in the Limpopo and Mpumalanga provinces has been systemically impaired by acid mine drainage, industrial, agricultural, and domestic pollution and is now one of the most polluted rivers in South Africa. Acid mine drainage has mobilised metals from the sediment in the Upper Olifants sub-catchment. Most of these precipitate from the water column and accumulate in the sediment, some remaining bio-available. There is evidence that metals are entering the food chain and exerting a toxic effect on rural communities reliant on aquatic resources from the Olifants River. Most studies on the Olifants River have, however, focussed on water quality while sediment quality has been largely ignored. We have initiated a long-term study of water and sediment quality of the main-stem of the Olifants River between Flag Boshielo Dam and the Mozambique border. We measure physico-chemical parameters in situ and collect water and sediment samples during high- and low-flow. The water and sediment samples are analysed for metals using ICP-OES. We plan to investigate the bio-availability of metals in the sediment, analyse the mineralogy of the sediment and compare the contribution of the major tributaries to the metal load. Here we review the limited sediment quality data for the Olifants River, discuss trends in water quality, and present preliminary results from our monitoring programme. The water quality of the middle and lower Olifants River continues to deteriorate as a result of metal mobilisation in the upper catchment.

Resource Quality Objectives for the Olifants Catchment: Balancing Water Resource Use and Protection

1. Dickens, C.W.S., 1. O'Brien, G.C., 1. Pringle, C., 1. Mzobe, P.N., 2. Macfarlane, D.,1. Stassen, R., 3. Dennis, R., 1. Gola, P. and 4. Rose, R.
1. Institute of Natural Resources, Scottsville, Pietermaritzburg
2. Eco-Pulse, South Africa
3. North West University, Potchefstroom
4. Geowater IQ, Kuilsriver
gobrien@inr.org.za

The National Water Act requires water resources to be sustainably used, managed and controlled for the benefit of all users. To achieve this, a series of protection measures have been established by the Department of Water Affairs. These include setting the Ecological Reserve, the classification of significant water resources and, the determination of Resource Quality Objectives (RQOs). Resource Quality Objectives are management goals that give direction to resource managers as to how the resource needs to be managed in accordance with established management classes. The highly utilised, Olifants River is a tributary of the Limpopo River and in South Africa is extends across Gauteng, Mpumalanga and Limpopo. For the Olifants River catchment the seven steps RQO determination process was followed, with some additional developments for Rivers, Wetlands, Dams and Groundwater resources. The process resulted in the determination of 494 RQOs for the Olifants River for various quantity, quality habitat and biota components of the catchment. In particular 212 RQOs were determined for rivers, 80 for wetlands, 69 for dams and 133 for ground water ecosystems. These RQO will be formally gazetted and with their numerical limits will be used to balance the use of water resources in the catchment with an appropriate level of protection.

Resource Quality Objectives for the Upper and Lower Vaal Catchments: Balancing Water Resource Use and Protection

1. Dickens, C.W.S., 1. O' Brien, G.C., 1. Pringle, C., 1. Mzobe, P.N., 1. Bredin, I.B., 1. Stassen, R., 2. Dennis, R., 1. Gola, P. and 3. Rose, R.
1. Institute of Natural Resources, Scottsville, Pietermaritzburg
2. North West University, Potchefstroom
3. Geowater IQ, Kuilsriver
gobrien@inr.org.za

The National Water Act requires water resources to be sustainably used, managed and controlled for the benefit of all users. To achieve this, a series of protection measures have been established by the Department of Water Affairs. These include setting the Ecological Reserve, the classification of significant water resources and, the determination of Resource Quality Objectives (RQOs). Resource Quality Objectives are management goals that give direction to resource managers as to how the resource needs to be managed in accordance with established management classes. The Upper and Lower Vaal Catchments (excluding Middle Vaal) are highly utilised water management areas of South Africa where a balance between the use and protection of water resources is urgently required. For these water management areas the seven steps RQO determination process was followed, with some additional developments for Rivers, Wetlands, Dams and Groundwater resources. The process resulted in the determination of 472 RQOs for these water management areas (354 for Upper Vaal and 118 for Lower Vaal) for various quantity, quality habitat and biota components of the catchment. For the Upper Vaal 137 RQOs were determined for rivers, 60 for wetlands, 62 for dams and 95 for ground water ecosystems. For the lower Vaal 28 RQOs were determined for rivers, 24 for wetlands, 29 for dams and 37 for ground water ecosystems. These RQO will be formally gazetted and with their numerical limits will be used to balance the use of water resources in the catchment with an appropriate level of protection.

Spatial and Temporal Variations of Selected Abiotic Factors and Metals in the Water and Sediment of Crocodile (West) River, South Africa: A Baseline Study

Zaayman, J.L., De Kock, K.N., Wepener, V. and Wolmarans, C.T.
Unit for Environmental Sciences and Management, North-West University, Potchefstroom
20764413@nwu.ac.za

Metals are pollutants of environmental concern due to their persistence, toxicity to aquatic ecosystems, non-biodegradability, and ability to be incorporated into the food chain. Declining water quality due to increasing pollution enhances the need for the conservation of aquatic resources. Sediments are regarded as a sink for a variety of environmental contaminants, such as metals, and generally contain pollutant concentrations that are far higher than the water column concentrations. The condition of the Crocodile River varies from poor to fair, and the main reason for this is that it has been under severe threat of pollution from various land uses such as mining, agriculture, urbanization, raw sewerage, all of which have a detrimental effect on aquatic ecosystems. The aim of the study was to evaluate the metal concentrations and selected abiotic parameters in water and sediment samples of the Crocodile River, in a low and high flow period that could become environmentally available and may have an impact on aquatic ecosystems. Seven localities along the course of the Crocodile River as well as one in Bierspruit, were selected as sampling sites. Water and sediment samples were collected and analysed using ICP-MS to determine metal content. Somemetal concentrations in the water were greater than the target

water quality range (TWQR) values for aquatic ecosystems. Although seasonal differences of metal composition could be observed in water samples, no differences could be seen in sediment samples.

Analysis of Active Rotenone Concentration During Treatment of the Rondegat River, Cape Floristic Region, South Africa: Evaluation of the Minimum Effective Dose (MED)

1. Jordaan, M.S., 2. Slabbert, E. and 3. Weyl, O.L.F.
1. CapeNature Scientific Services, Stellenbosch
2. Department of Microbiology, University of Stellenbosch, Matieland
3. South African Institute for Aquatic Biodiversity, Grahamstown
mjordaan@capenature.co.za

The piscicide rotenone has proven to be useful as a biodiversity restoration tool for aquatic ecosystems invaded by non-native fish species. The Rondegat River in the Cederberg was the first river in the Cape Floristic Region (CFR) where rotenone was used to remove alien invasive smallmouth bass *Micropterus dolomieu* (Lacepede, 1802) and thereby allowing the indigenous fish community to recover. Following the initial treatment of the river with rotenone in 2012, a follow-up treatment was scheduled in alignment with standard operating procedures (SOPs). Following the first treatment, concerns emerged about discrepancies between the application concentration and the actual concentration and resultant effects on non-target aquatic organisms. As a result the second treatment was scheduled to include monitoring of rotenone concentrations at selected sites (n=10) and time intervals (n=9) during the treatment. High pressure liquid chromatography (HPLC) was used to analyse water samples taken from the initiation of treatment until 48h after treatment. The measured rotenone concentration during treatment was consistently lower that the application concentration of 37.5 mg/L and at some sites dropped below the minimum effective dose (MED) of 12.5 mg/L. This is likely due to the biological demand for rotenone in the ecosystem. The results further indicated that instream habitat affected the travel time of rotenone in the water column and that active rotenone still remained in the river 48h after treatment.

SESSION 7: AQUATIC ECOLOGY AND MANAGEMENT (ESTUARIES)

Amphipod Estuarine Sediment Toxicity Testing with Cu and Zn: an Overview from the Past 10 Years

1. Mofokeng, R., 2. Vijvir, M., 1. Vivier, L and 1. Cyrus, D.P.
1. Zoology Department, University of Zululand, KwaDlangezwa
2. Institute of Environmental Science, Universiteit Leiden, Leiden
refiloemofokeng@yahoo.com

An overview on amphipod toxicity bioassays using Cu and Zn over the past 10 years (1993-2013) was conducted with the aims to report on the general sensitivity (LC50) of amphipods for the two metals and to report on the frequency of use of various endpoints (fecundity, accumulation, growth and behaviour) as well as to investigate whether there has been an increase in chronic bioassay reports. Amphipods were found to be generally more sensitive to Cu than Zn. With *C. volutator*,

however, a lower LC50 value for Zn (10.03 µg/g-1) than that of Cu (26.07 µg/g-1) was recorded. Fecundity was the most reported endpoint with *C. volutator* being the most used amphipod in the past ten years. It was concluded, however, that no one amphipod species can represent all other species as amphipods tend to adapt deferentially to their immediate environment. Chronic bioassays were found to have been most reported (55%) as compared to acute (29%) and life-history (26%) bioassays.

Pristine to Degraded- The Use of Macrophyte Habitats to Determine the Health and Importance of KwaZulu Natal's Estuaries

Cowie, M. and Adams, J.B.
Botany Department, Nelson Mandela Metropolitan University, Port Elizabeth
meredith.cowie@nmmu.ac.za

The small estuaries of KwaZulu-Natal (KZN) have historically supported restricted macrophyte communities as they tend to be perched with steep channels and narrow riparian areas. Most are temporarily open/closed systems and thus do not have the habitat or suitable environmental conditions (tidal inundation and salinity) to support salt marsh or mangroves. Submerged macrophytes are also uncommon due to turbidity and sedimentation caused by high natural river inflow. This study investigated the health and importance of the 64 KZN estuaries occurring within the Mvoti-Umzimkhulu Water Management Area. A desktop assessment showed that on average the health scores for macrophytes were equivalent to that of the 2011 National Biodiversity Assessment with only nine estuaries moving to a lower Ecological Class. Most estuaries are degraded due to pressures from development (especially the N2 road bridges) and sugarcane cultivation. Important estuaries were identified as those that still supported swamp forest, mangrove or submerged macrophytes. Detailed studies on the Mvoti and Mkomazi estuaries showed that the floodplain areas have been extensively transformed, invasive plants are abundant and little natural vegetation remains. This study contributes to the knowledge of these small, mostly rural systems and serves to highlight the value of historical descriptions and long term monitoring for the assessment of estuarine condition, particularly in systems that no longer resemble their natural conditions.

The Impact of Disturbance on the Salt Marsh – Terrestrial Ecotone

Veldkornet, D.A., Padayachy, R. and Adams, J.B.
Department of Botany, Nelson Mandela University, Port Elizabeth
Dimitri.velkdornet@nmmu.ac.za

The impact of disturbance on vegetation structure and occurrence of alien invasive plants across an ecotone was investigated. Ecotone vegetation is sensitive to changes in environmental conditions and can thus serve as an important indicator. Plant cover and richness were quantified using line transects in disturbed and undisturbed sites across a salt marsh-terrestrial gradient. Disturbance was evaluated from a list of impact criteria based on visual assessment and scoring. Terrestrial invasive plants were dominant in the ecotone at sites disturbed by urban development and cultivation. Common reed *Phragmites australis* was present in disturbed ecotones where there was freshwater run-off. Where native species richness and cover was high invasive species richness and abundance was low. The ecotone was mostly invaded when the adjacent vegetation was disturbed. However some sites were noticeably disturbed by human activities but they did not support any alien invasive plants. This occurred where high groundwater salinity (pristine = 0.69 $\pm$ 0.21 $mS.cm^{-1}$, disturbed = 15 $\pm$ 3.52 $mS.cm^{-1}$) excluded non-halophytes from these extreme habitats. Disturbance led to the formation of new boundaries with different environmental characteristics that encouraged the encroachment of terrestrial species. This study also showed

that development has decreased the resilience of the salt mash ecotone which may limit the landward migration in response to changes in sea level.

Mgobezeleni Estuary: a Small, but Important, Groundwater Dependent Black Water System in Northern KwaZulu Natal

1. Bate, G., 2. Taylor, R. and 3. Kelbe, B.
1. Department of Botany, Nelson Mandela Metropolitan University, Port Elizabeth
2. University of Kwazulu Natal
3. University of Zululand
Guy.Bate@nmmu.ac.za

The Mgobezeleni is a small estuary that draws all its groundwater from a catchment of ~8000ha. There are two lakes in the catchment (Lake Mgobezeleni and Lake Shazibe) that are also totally groundwater dependent. There are no rivers entering the area from outside. The catchment falls partly into the iSimangaliso Wetland Park and is near to the town of Mbazwane that has recently expanded greatly by people lured by the financial stimulus of tourism created by the fishing activities at Sodwana. The estuary is a black water system but one that is different to those found in the Western Cape, in that the latter are mostly very acidic. The black water of the Mgobezeleni Estuary has a pH of ~6-7. The expanding population is reliant to a great extent on ground water although some water is piped in by the Department of Water Affairs from Lake Sibaya which lies north of the Mgobezeleni catchment. The research underway is funded by the Water Research Commission and is investigating, inter alia, The linkages between hydrological, ecological and biological drivers and the future for pollution from septic tanks and small industry discharging into the groundwater, as well as small scale gardening that is utilising the areas of accumulated peat in the small valleys. Being a very small estuary there is the potential that pollution might change its existing characteristics.

A Numerical Prioritisation Model for the Selection of Estuaries for the National Estuarine Monitoring Programme in South Africa

Cilliers, G.
Resource Quality Information Services, Department of Water Affairs, Pretoria
cilliersg@dwa.gov.za

The National Estuarine Monitoring Programme of South Africa has been designed in order to collect long term data for informed, future management of estuaries in South Africa. In order to ensure that the primary objectives of the monitoring programme are met and due to financial constraints it is critical to ensure that estuaries are correctly prioritized for the implementation of the monitoring programme. A numerical prioritisation model was developed to ensure that estuaries are selected in an objective manner, without prejudge. Application of this model is discussed and conclusions are made on the future use of this model.

WEDNESDAY 25 JUNE 2014

SESSION 9: HYDROLOGY AND WATER AVAILABILITY, QUALITY AND MANAGEMENT

Shale Gas Development and the Environment of the Karoo – Can the Two be Compatible?

Vermeulen, P.D.
Institute for Groundwater Studies, University of the Free State, Bloemfontein
VermeulenD@ufs.ac.za

South Africa is a country blessed with minerals, but without oil and conventional gas resources. During the period 1965 to 1975 Soekor explored for oil and gas in the Karoo, a pristine semi-desert area in South Africa. Gas was found in the tight shale formations of the Ecca Supergroup, between 2500 and 4000 m below surface. It has been calculated by the Kuuskraa report (2011) that this deposit may be as large as 485Tcf, and that the worst case scenario will be 32 Tcf (which makes it the fifth largest deposit in the world). Exploration companies applied for exploration licences, but due to an uproar by environmental groups an initial moratorium was placed on any activities, which was later lifted. The biggest issue, apart from environmental negatives, was the shortage of water resources. What also differs from other places in the world is the presence of dolerite dykes and sills in these formations. This paper will deal with the different views in South Africa regarding proposed regulations, the availability of water, how to deal with the dolerite, the visual impact on surface, possible pollution of the very valuable drinking water and the other unknowns. The proposed way forward will also be discussed.

The Hidden Hydrology of Groenvlei

Parsons, R.
Parsons and Associates Specialist Groundwater Consultants, Pringle Bay, South Africa
roger@pasgc.co.za

Groundwater is not a topic that features highly in the field of aquatic science and limnology, yet a recent study of Groenvlei in the southern Cape suggests it should. Eight of the 21 wetlands in South Africa designated by RAMSAR as wetlands of international importance are located in similar geohydrological settings as Groenvlei, but few have been subject to detailed geohydrological assessment. In the case of Groenvlei, this has led to misconceptions about the vlei being endorheic in character and being sustained by Table Mountain Group aquifers. Also, use of a rainfall-runoff model was found to be inappropriate to quantify the hydrology of Groenvlei as it is neither fed nor drained by rivers. Direct rainfall onto the vlei accounts for the greatest contribution to the system, with groundwater playing a supporting role. The reed collar plays an important role in controlling both seasonal evaporation losses and the chemistry of the water body. The results of the research demonstrated Groenvlei has long since lost its connection to the marine or estuarine environments, with a new equilibrium being reached within 120 years of disconnect. The young lake is dynamic in character and rapidly responds to hydrological change. In its short history, Groenvlei has adapted and responded to changes in both sea level and climate, collectively resulting in the present-day system. Sound conceptualisation - backed up by scientific evidence - is required to understand the role of groundwater in sustaining wetlands, highlighting the need for greater interaction between geohydrologists and other aquatic scientists.

The Mgobezeleni Catchment Study – an Integrated Hydrology-Ecology Study in The Mozambican Coastal Plain

1. Taylor, R., 2. Bate, G., 3. Kelbe. B. and Simonis, J.
1. Univeristy of KwaZulu Natal
2. Department of Botany, Nelson Mandela Metropolitan University, Port Elizabeth
3. University of Zululand
ricky.h.taylor@gmail.com

The Mozambican Coastal Plain is affected by many development pressures. Increasing numbers of people are settling in the coastal plain; with them there is development of infrastructure, housing, industry, tourism and intensive agriculture. The coastal plain is a sand aquifer from which groundwater is being pumped and it is lost through transpiration from *Eucalyptus* plantations. This presentation describes the interdisciplinary research in a small catchment which is experiencing all the above pressures. The study area is the 8000ha Mgobezeleni Catchment (at Sodwana, NE South Africa). The core of the study is to understand the water dynamics and how the natural environment responds to changes. Our approach is to obtain the detailed monitoring and topographic information needed to develop a suite of interlinked groundwater, surface water and estuary hydro-models to simulate water levels, water flows and movements of pollutants. Simulations will be used to examine wetland responses to development impacts. The catchment is well suited to study change as half of it has been settled in recent decades by >6000 people and there has been a tourist boom. The rest of the catchment is within a protected area. We are creating a framework of databases, GIS and baseline information which will attract self-funded research projects that will benefit from collaborations with this programme. A large thrust of the programme is post-graduate field training. An integrated lecture course will be given on site to teach theoretical and practical aspects of hydrology and ecology. A similar course will be given to land-managers.

PROBFLO: The Formal Integration of the Ecological Risk Assessment Techniques Incorporating Bayesian Network Modelling within the Ecological Limits of Hydrological Alteration Framework to Determine Ecological Flow Standards for Riverine Ecosystems

1,2. O' Brien, G.C., 1. Dickens, C.W.S., 3. Hines, E., 1. Stussen, R. and 3. Landis, W.G.
1. Institute of Natural Resources, Scottsville, Pietermaritzburg
2. School of Life Sciences, University of KwaZulu-Natal, Pietermaritzburg.
3. Institute of Environmental Toxicology and Chemistry, Huxley College of the Environment, Western Washington University, Bellingham, Washington, USA
gobrien@inr.org.za

The ecological limits of hydrologic alteration (ELOHA) is an international environmental flow assessment framework (EFA) which is based on a synthesis of a number EFA techniques that are used support comprehensive regional flow management. The four main components of the ELOHA framework include; river type considerations, measures of flow alteration, flow alteration-ecological response relationships and environmental flow standards. To integrate these components the ELOHA framework promotes the use of scientifically valid flow alteration-ecological response probability modelling techniques that are transparent and adaptable. The Regional-Scale Risk Assessment approach incorporating the Bayesian Networks (RRM-BN) probability modelling techniques is a suitable risk modelling technique which is also able to describe the inherent uncertainty of an assessment and is based on international best-practice principles. In this paper we describe how we have formally integrated the RRM-BN approach into the ELOHA framework to evaluate the socio-ecological consequences of flow alterations in the Senqu River due to the

construction and operation of the Polihali Dam. In this case study a range of social and ecological endpoints have been selected to represent the management objectives of the regulators of the Polihali Dam. The risk of flow and flow related environmental variable alterations to the endpoints have been modelled and evaluate using BNs. The threat distributions of the endpoints per region, per scenario have been integrated using a Monte-Carlo Latin Hypercube Sampling technique using 10,000 iterations.

The Usefulness of Bioaccumulation as a Pollutant Monitoring Tool: The Kruger National Park Experience

1. Wepener, V., 2. Van Vuren, J.H.J. and 1. Smit, N.J.
1. Unit for Environmental Sciences and Management, North-West University, Potchefstroom,
2. Department of Zoology, University of Johannesburg, Auckland Park,
victor.wepener@nwu.ac.za

Measurements of pollutants such as metals and pesticides by direct chemical analysis in water and sediment are limited in reliability. This led to the realisation that living organisms are able to integrate uptake of pollutants over rime and could therefore be used as indicators of pollutant exposure. Since the development of the Mussel Watch programme in the mid-1970s, bioaccumulation monitoring has become a routine environmental monitoring tool. However very often the suitability of this tool is misunderstood and therefore misused. The first application of bioaccumulation monitoring in the Kruger National Park was undertaken in the early-1990s in the Olifants River as part of the Kruger National Park Rivers Research Programme. Subsequently a few small student research projects and more recently two large Water Research Commission projects have studied aspects of pollutant bioaccumulation in aquatic biota of rivers in the Park. With nearly 20 years' bioaccumulation data, the question can rightly be asked about he application value of conducting bioaccumulation monitoring. In this presentation we deal with three aspects related to the usefulness of this monitoring tool, i.e. indicating pollutant exposure, pollutant bioavailability and trophic transfer of pollutants. To illustrate these aspects we draw on results from previous and current studies. We discount some of the myths related to the Olifants River being the most pollutant river in the Park and caution against misuse of results to indicate biological/ ecological effects of pollutant exposure. Finally the management application of bioaccumulation data to develop site/river specific quality criteria for metals in the KNP is dealt with.

Determining Resource Quality Objectives - Lessons Learnt from South African Case Studies

Pringle, C. & O'Brien, G. and Dickens, C.
Institute of Natural Resources, Scottsville, Pietermaritzburg
kpringle@inr.org.za

Resource Quality Objectives (RQOs) facilitate effective management of water resources and give effect to the Water Resource Classification thereby ensuring a balance between resource protection and resource development and utilisation. A seven step procedure has been developed for the determination of RQOs and forms part of a classic adaptive management cycle with some additional steps. Overall the procedure involves defining the resource, setting a vision, determination of RQOs and Numerical Limits, gazetting this and then moving to implementation, monitoring and review before starting the process all over again. The determination of RQOs has commenced for several Water Management Areas (WMAs) across South Africa including the Olifants, Upper and Lower Vaal WMAs. Some challenges have been encountered during the initial application of the RQO determination procedure in these WMAs and relate to all water resource types. These include challenges with alignment between RQOs other processes particularly the

Water Resource Classification, the scale at which to set RQOs, the selection of the components and sub-components that best reflect the use and protection requirements of the water resource, and the level at which to set the respective RQOs and associated numerical limits. In this paper we present the experiences in the Olifants, Upper and Lower Vaal WMAs and provide useful examples of how these challenges can be met without compromising the overall philosophy which underpins the RQO procedure.

SESSION 10: AQUATIC ALIEN INVASIONS

Existing and Emerging High Impact Invasive Species are Characterised by Higher Functional Responses Than Natives

1. Alexander, M.E., 2. Dick, J.T.A., 3. Weyl, O.L.F., 1. Robinson, T.B. and 1. Richardson, D.M.
1. Centre for Invasion Biology, Department of Botany and Zoology, Stellenbosch University
2. School of Biological Sciences, Queen's University Belfast, Northern Ireland, UK
3. South African Institute for Aquatic Biodiversity, Grahamstown
m@sun.ac.za

Predicting ecological impacts of invasive species and identifying potentially damaging future invaders are research priorities. Since damage by invaders is characterized by their depletion of resources, comparisons of the 'functional' (FR: resource uptake rate as a function of resources density) of invaders and natives might predict invaders impact. We tested this by comparing FRs of the ecologically damaging "world's worst' invasive fish, the largemouth bass (*Micropterus salmoides*), with a native equivalent, the Cape kurper (*Sandelia capensis)* and an emerging invader, the sharptooth catfish (*Clarias gariepinus)* with the native river goby (*Glossogobius callidus*), in South Africa, a global invasion hotspot. Using tadpoles (*Hyperolius marmoratus*) as prey, we found that the invaders consumed significantly more than natives. Attack rates at low prey densities within invader/native comparisons reflected similarities in predatory strategies; however, both invasive species displayed significantly higher Type II FRs than the native comparators. This was driven by significantly lower prey handling times by invaders, resulting in significantly higher maximum feeding rates. Comparative FRs may be rapid and reliable method for predicting ecological impacts of emerging and future invasive species.

The Management of Aquatic Weeds in the North West and Gauteng Provinces

Lessing, I.E.
Working for Water, Department of Environmental Affairs, Pretoria
ilomelessing@gmail.com

There are numerous aquatic alien invasions, however this talk will be focusing on aquatic alien plants also known as aquatic weeds. The talk will discuss the impact aquatic weeds have on our water systems, the four control methods of these alien species and propose a way forward. Aquatic weeds are a serious threat to water systems and must be controlled effectively. The top five most threatening aquatic weeds in South Africa are the Water Hyacinth (*Eichornnia Crassipes*), Parrots feather (*Myriophyllum aquaticum*), Kariba weed (*Salvinia molesta*), the Water lettuce (*Pistia stratiotes*) and Hydrilla (*Hydrilla verticillata*) in no particular order. Some of these species, for instance the water hyacinth (*Eichornnia crassipes*) is very aggressive and can double their numbers in two weeks, they are also the most damaging aquatic weed. These aquatic

weeds have an impact on South Africa and even surrounding countries who share the same water systems. For instance, these weeds invade major rivers, lakes, dams and irrigation canals. They have an impact on the biodiversity, water availability and water quality. These weeds disrupt fishing, navigation and recreational activities. Aquatic weeds also have an impact on waterflow and pose a serious threat to hydro-electric installations. Much can be said about Biological control which is one of the four methods used to control aquatic weeds. To be efficient in controlling aquatic weeds, one needs to know what we are dealing with, plan how to control these weeds and implement these strategies in an economical way.

Using Multiple Lines of Evidence to Understand the Vulnerability of Headwater Stream Fishes to Non-Native Predatory Fish Impacts

1. Ellender, B.R., 1. Weyl, O.L.F., 1. Woodford, D.J., 2. Alexander, M.E., 3. Luger, A.M. and 3. Nagelkerke, L.A.J.

1. South African Institute for Aquatic Biodiversity, Grahamstown

2. Centre for Invasion Biology, Department of Botany and Zoology, Stellenbosch University, Stellenbosch

3. Aquaculture and Fisheries Group, Wageningen University, Wageningen, Netherlands

bru.ellender@gmail.com

Observational evidence suggests that South African headwater stream fishes are highly vulnerable to non-native fish invasions due to high levels of endemicity, isolation in upper catchment streams and restricted geographical ranges, however, this remains largely unquantified. This study uses multiple lines of evidence to document the invasion process, quantify impacts and understand why native headwater stream fishes are so vulnerable to invasion by predatory non-natives. Invasion fronts move in from downstream (centrarchids) and upstream (salmonids) directions and both forms significantly decrease available habitat for native fishes. Multiple studies on predatory fish invasions across South Africa demonstrated that these resulted in changes in community structure and fish assemblages, behavioural changes, decreased abundance and local extinction of native fishes. Laboratory experiments suggest that the mechanisms responsible for these impacts were related to the significantly higher Functional Responses (FR; resource uptake rate as a function of resource density) of non-native predators than the native comparators. Further, prey handling times indicated that native Cape kurper *Sandelia capensis* were poor piscivores compared to non-native largemouth bass *Micropterus salmoides*. Evolved predator avoidance behaviour was observed during day and night snorkelling observations where native minnows (*Pseudobarbus afer*) were observed actively feeding during the day and suspended motionless in the water column at night. This was postulated to be an evolutionary response that lets native minnows avoid native eel (*Anguilla mossambica* and *A. marmorata*) predation, but predisposes them to predation by non-native fishes. These data indicate that native fishes have very little resistance to non-native fish invasions and highlights the threat posed by non-native fishes when they invade headwater environments.

Economic Impact of Smallmouth Bass Sport Fishing Provides Invasive Species Management Insight

1. Barrow, S., 2. Weyl, O., 1. Esler, K. and 3. Jordaan, M.
1. Centre for Invasion Biology, Department of Conservation Ecology and Entomology, Stellenbosch University, Stellenbosch
2. South African Institute for Aquatic Biodiversity, Grahamstown
3. CapeNature Scientific Services, Assegaaibosch Nature Reserve, Jonkershoek
stuba@live.co.za

Many invasive aliens are potential conflict species, providing resources and benefits while simultaneously impacting biodiversity and ecosystem services. Globally, non-native sports fish were actively introduced to rivers and dams for their perceived benefits to anglers, but negative impacts to native biodiversity have resulted in efforts to eradicate them. To provide context for any management effort, the economic impact of such actions needs consideration. Clanwilliam Dam in the Western Cape is considered by many anglers to be South Africa's premier smallmouth bass fishing destination and many angling competitions are held on the dam. By conducting interviews at two of these competitions, this study describes the typical angler taking part in them and documents the economic impact of these anglers on the town of Clanwilliam. It is estimated that due to these competitions R373 000 was spent in Clanwilliam which would otherwise not have been spent there. Additionally, the annual angling related expenditure of a typical competition angler is estimated to be R22 650 per annum- most of which is spent in the region where the angler comes from. Therefore, typical competition anglers have a significant expenditure in the region where he or she fishes and in the region where they come from. This indicates an important economic impact. These findings point to the need for smallmouth bass to be managed in a way which would reduce impacts on biodiversity whilst maintaining the benefits associated with the species.

Do Invasive Trout Alter Aquatic Energy Flux to Riparian Consumers?

1. Jackson, M.C., 2. Woodford, D.J., 2. Bellingan, T., 1. Chimimba, C. and 2. Weyl, O.
1. Centre for Invasion Biology, Department of Zoology and Entomology, University of Pretoria
2. South African Institute for Aquatic Biodiversity, Grahamstown
mjackson@zoology.up.ac.za

Predicting the impacts of biological invasions on biodiversity and ecosystem functioning is increasingly important in our changing world. Invaders may interrupt resource flows and disrupt natural ecological relationships instigating trophic cascades which can propagate across ecosystem boundaries, resulting in far reaching changes in food webs. Here, we quantify the impact of invasive trout (*Oncorhynchus mykiss* and *Salmo trutta*) on the diversity, biomass and size-structure of emerging insects in streams across South Africa. We then determine how any variation in the community structure of the emerging insects influences riparian spider abundance and diet. Using stable isotope techniques, it is possible to establish the proportion of aquatic compared to terrestrial carbon assimilated by individual spiders and, therefore, we use this method to quantify the impact of the invaders at the individual level in adjacent habitats.

The Lower Sundays River System: A Natural Laboratory for Investigating the Ecology of Fish Invasions

1. Woodford, D.J., 2. Measey, J., 2. Jackson, M.C., 2. Hui, C. 2. Richardson, D.M. and 1. Weyl, O.L.F.
1. South African Institute for Aquatic Biodiversity, Grahamstown
2. Centre for Invasion Biology, Stellenbosch University, Stellenbosch
d.woodford@saiab.ac.za

The invasion of river networks by alien fish species is an on-going biodiversity crisis in many parts of the world. The unaided dispersal of introduced fish can be mediated by both human infrastructure and natural habitat variability. The lower Sundays River catchment, comprising the Sundays River downstream of Darlington Dam, its tributaries within Addo Elephant National Park (AENP), and the Sundays River Irrigation Network (SRIN), represents a complex network of natural and artificial waterways that introduced fishes continue to disperse through. This system provides several unique opportunities to study the fundamental processes of alien fish dispersal, arrival, and establishment within new environments. Research conducted within the SRIN has demonstrated that propagule pressure from irrigation canals is a driving force behind the establishment of fishes within irrigation ponds, provided they are capable of reproducing within the ponds. On-going research will assess early successional dynamics of fish and frog communities, and whether introduced fishes alter their roles within aquatic food webs when moving from a natural river environment to the novel environments of the ponds. The irrigation network has also enabled encroachment by one species, the extra-limital sharptooth catfish, into the Uie and Coerney Rivers of AENP. These streams are naturally intermittent and are home to threatened native redfin minnows. Our present research seeks to understand how the flooding and drying of these rivers drive the availability of invasion pathways within these tributaries, as well as to assess the implications of such invasions for native fish conservation.

Assessing the Biology of the River Goby as a Proxy to Understand Global Goby Invasions

Mofu, L., Woodford, D.J. and Weyl, O.L.F.
South African Institute for Aquatic Biodiversity, Grahamstown.
l.mofu@saiab.ac.za

The River Goby (*Glossogobius callidus*) is native to rivers and estuaries along the coastline of South Africa, but appears to display several traits in common with the invasive Ponto-Caspian Round Goby (*Neogobius melanostomus*). In the Sundays River valley, Eastern Cape, the fish utilizes water transfer infrastructure to disperse among irrigation impoundments, and is a rapid and successful coloniser of these novel habitats. Little is known about its reproductive biology or feeding ecology, except a few studies on the geographical distribution, description and ecology of the larvae. Round Goby, a key invasive species in both Europe and North America which has used the shipping canals and inter-basin water transfer schemes (IBWT) to reach and subsequently dominate aquatic communities in the Baltic Sea, Laurentian Grate Lakes. Given the apparent similarity in colonization success displayed by the River Goby relative to the Round Goby presents a potential ecological proxy species, whose biology may offer new insights into why freshwater gobies like the Round Goby make good invaders. The aim of this project is to determine the growth rates, reproductive biology and feeding biology of the River Goby in an irrigation network in the Sundays River catchment in the Eastern Cape, South Africa. The attained information will provide information on the general biology of *G. callidus* and explore the biological factors that mediate successful establishment of introduced fishes in new environments. Furthermore this study will offer insight on mechanism of goby invasions.

What are the Impacts of Riparian Tree Invasions on Stream Food Web Structure and Ecosystem Processes?

Fourie, H., Chimimba, C. and Jackson, M.
Department of Zoology and Entomology, University of Pretoria
mjackson@zoology.up.ac.za

Invasive species have negative consequences for native diversity and can reduce the availability of exploitable natural resources. Riparian plant invasions may alter the quality and biomass of food and energy resources which enter freshwater habitats, which will have consequences for stream food web structure. Further, riparian plant invasions can change the amount of shading a stream receives and reduce water availability, which will have implications for important stream ecosystem processes, such as productivity. Here, using a field survey across invaded and un-invaded sites, we identify how invasive riparian trees in North West Province alter resource exchange between terrestrial and aquatic environments and examine how these changes influence stream food webs.

SESSION 10: BIO-INDICATORS

The Impact of Environmental Stressors on Biomarkers in *Clarias gariepinus* and *Oreochromis mossambicus* in Ndumo Game Reserve

Mkhonto, T.M.
Zoology Department, University of Johannesburg, Auckland Park, Johannesburg
marymkhonto@hotmail.com

The Lower Phongola Region has undergone great development and has had increases in agriculture, industry, tourism and tribal settlements. Previous studies have shown concern over ongoing pressures on the system, thus making recent updated information a necessity for ongoing management. The aims of this study are as follows: 1) evaluating the impacts of environmental stressors and pesticides on the Phongolo River and floodplains; 2) the use of two fish species, *Oreochromis mosambicus* and *Clarias gariepinus* as bio-indicators of pollution and environmental stress; 3) identification of contaminating compounds in water and sediment; 4) The determination of bio-accumulation levels in fish. It is hypothesized that *O. mossambicus* and *C. gariepinus* as bio-indicators will signify the adverse affects of environmental stressors and pesticides on the current state of the Lower Phongolo River and floodplain. The harmful impacts on Phongola were mainly assessed on fish biomarkers while water, sediment and DTT results will be provided by other projects in the same system to support these findings. Biomarkers analysed according to standard procedures included CEA, MT, AChE, PCs, Cyt P450, MDA, GSH, CAT and SOD. Results indicated greater environmental stress and the presence of metals and pesticides during April high flow season. Increased stress levels were observed at two sampling localities for *O. mossambicus* and only at one for *C. gariepinus*. It is difficult to conclude specifically which stressors are affecting the fish in Pongola until water, sediment and DDT results are obtained and assessed.

Biomarkers of Pollution in *Synodontis zambesensis* and *Hydrocynus vittatus* in the Lower Pongola River and Floodplain

Edwards, C.M.
Zoology Department, University of Johannesburg, Auckland Park, Johannesburg
claire.m.edwards@gmail.com

Concern has been shown by Ezemvelo KZN Wildlife for the state of the Lower Pongola River and Floodplain due to the ever increasing urban and industrial development in the area. This increase in development poses a threat to the fish populations within the system and their ability to support the surrounding communities. Continued spraying of pesticides and DDT within the area are adding to stresses placed on the fish populations through decreasing water quality. The effectiveness of environmental water flows suggested by White *et al.* (1984), have never been assessed by conservation authorities. This means that the authorities have been unable to fulfil their legislative obligations to establish management and conservation plans (Bruwer *et al.* 1996). Work on the biological responses of fish to anthropogenic stressors such as organic pollutants and metals, will be conducted by a group of experts in the field of ecological health. This project will focus on two fish species found within the study area, *Hydrocynus vittatus* and *Synodontis zambezensis* which will be used for biomarkers and tissue chemical levels. Tests on water and sediment quality will allow for the linkage of the biomarker responses. This project will deal mainly with the health of the organisms and the quality of the wetland, river and floodplain system.

The Application of a Macro-Invertebrate Trait Database as Bioindicator for Salinity and Pesticides in South Africa

1. Malherbe, W., 1. Wepener, V. and 2. van Vuren, J.H.J.
1. Unit for Environmental Sciences and Management, North West University, Potchefstroom,
2. Department of Zoology, University of Johannesburg, Auckland Park, Johannesburg
wynand.malherbe@nwu.ac.za

Chemical monitoring within aquatic ecosystems is often insufficient to determine quality as it does not take into account higher level effects on biota, instream speciation of chemicals, interactions with other physical impacts and variations due to longitude and time. To overcome this, instream biota are used as environmental indicators as they can integrate all of these higher level effects. However, many indices of biotic integrity are not sensitive enough to isolate community effects as the communities respond to anthropogenic and natural stressors. A bioindicator system making use of macro-invertebrate traits that is pesticide and salinity specific was therefore developed in Europe and Australia to overcome some of these challenges. The system, called SPEAR (SPEcies At Risk), has been applied as an indicator to link pesticide exposure and effects to insecticide toxicity. The aim was to apply the SPEAR system in South Africa to determine its applicability and effectiveness at linking pesticide exposure and salinity to changes in the macro-invertebrate community. For the purposes of this initial study, it was decided to use both the European and Australian SPEAR databases to determine if there are any differences between the results. This would in turn help to determine which database would be better suited for application within South Africa. The SPEAR systems indicated differing results when using the European and Australian databases with the Australian database indicating poorer ecological condition. These differences can possibly be attributed to the differing sensitivities between the two continents as studies have shown that there are differences between the sensitivities of tropical and temperate biota. It may also be that the Australian and European databases are not representative of the macro-invertebrate sensitivities to pesticides in this particular region. Further studies in different regions with more data points are needed to determine whether the SPEAR system is effective in South Africa.

The Physico-Chemistry and Heavy Metal Content of Tissue and Gill of Fish (*Oreochromis niloticus*, Linnaeus, 1958) from Water Body Receiving Industrial Effluent in Lagos, Nigeria

Ndimele, P.E., Kumolu-Johnson, C.A. and Pedro, M.O.
Department of Fisheries, Faculty of Science, Lagos State University, Ojo, Lagos, Nigeria
drpendimele@yahoo.com, emeka.ndimele@lasu.edu.ng

Some physico-chemical parameters and heavy metal content of water, sediment as well as tissue and gill of *Oreochromis niloticus* from a section of the Lagos Lagoon complex were studied for ten months (July, 2012 – April, 2013) spanning wet and dry seasons. Three sampling stations were used; Ologe, which is the closest to the effluent discharge point from Agbara Industrial Estate, Ijon is located upstream before the point of discharge of industrial effluent, Etegbin is downstream and have a lot of human activities like selling, recreation, washing etc. The heavy metals investigated are Cu, Zn, Pb and Fe while the physico-chemical parameters are temperature, pH, conductivity, total dissolved solids (TDS), total suspended solids (TSS), salinity, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), and alkalinity. All the physico-chemical parameters except temperature and biological oxygen demand exhibited significant ($p<0.05$) monthly variation. However, four (conductivity, total suspended solids, total dissolved solids and salinity) of the ten physico-chemical parameters investigated representing 40% showed significant ($p<0.05$) seasonal variation. All the heavy metals studied showed significant ($p<0.05$) monthly and seasonal variation in sediment, tissue and gill of *Oreochromis niloticus*. However, only Zn showed significant ($p<0.05$) monthly and seasonal variation in the water column of the sampling stations. The range of concentrations of Cu, Zn and Fe in the tissue and gill of *Oreochromis niloticus* in this study are higher than the limits recommended by World Health Organisation. Therefore, regular monitoring of these water bodies is essential to prevent heavy metal-related disorders.

Use of Fish Swimming Performance and Oxygen Usage as Biomarker of Effect: Exposure to Nanogold as Case Study

Smit, N.J., Du Plesis, K. and Wepener, V.
Unit for Environmental Sciences and Management, North West University, Potchefstroom
nico.smit@nwu.ac.za

Nanotechnology is a growing industry worldwide but the effects of these materials on the environment are still largely unknown. Fishes can be used as an effective test organism to determine the effects of nanomaterials on aquatic ecosystems. The aims of this study were therefore to determine if nanogold (nAu) has an influence on oxygen uptake by the gills and whether this has an influence on the fitness of *Tilapia sparrmanii*. Fish were exposed to 5 mg/l nAu and 0.5 mg/l ionic gold for 96 hours. Oxygen consumption and critical swimming speed were measured in Loligo chambers. Mortality of fish exposed to ionic gold after a period of 52 hours showed that ionic gold is more toxic than nanogold. When compared to control fish (no Au exposure) no statistical significant differences were found in the oxygen consumption or swimming performance of exposed fish. However trends following the short term exposure period were seen. Oxygen consumption decreased in fish exposed to both ionic (mean decrease of 0.0021 mg/L/min/g) and nanogold (0.0173 mg/L/min/g). A mean decrease of 0.496 body lengths/second was seen in the swimming performance of fish exposed to nanogold. It is therefore possible that long-term exposure could result in impaired fitness.

Biomarkers of Pollution in *Tilapia rendalli* from the Nyamithi Pan, Phongolo River and Lake Jozini: A Comparative Study

Jansen van Rensburg, G.R. and Van Vuren, J.H.J.
Department of Zoology, University of Johannesburg, Auckland Park, Johannesburg
greggvr@gmail.com

The lower floodplain of the Phongolo River is heavily utilized by rural communities. Concern has been raised over the use of organophosphate pesticides, from crop spraying and organchlorine pesticides for malaria vector control, as they may be contaminating the system. The study hypothesizes that Lake Jozini will be less impacted as it is upstream of many anthropogenic impacts. *Tilapia rendalli* was the species chosen for the comparison and sampled from Lake Jozini (2009), and two pans within the Ndumo Game Reserve namely Nyamithi Pan (2012/2013) and the 2nd called site 8 (2013). Seven biomarker assays were conducted, two biomarkers of exposure i.e Acetylcholine esterase (AChE) and Metallothioneins (MT), with Catalase (CAT); Superoxide dismutase (SOD); Malondialdehyde (MDA); Protein Carbonyls (PC) and Cellular Energy Allocation (CEA) as the biomarkers of effect. No statistically significant differences were found between AChE and SOD levels. Differences in lipid and glucose reserves were only statistically significant between the two surveys in the Nyamithi Pan. Statistical analysis showed MDA content and MT were higher in Nyamithi Pan than Lake Jozini. Overall CEA and CAT were highest in Lake Jozini. PC content was statistically lowest in Lake Jozini. There is no clear evidence from the results that Lake Jozini is in better conditions that the downstream sites. This may be because the Ndumo Game Reserve is a RAMSAR site which aims to protect and conserve wetlands through sustainable usage. However the results do establish spatial and temporal variations in the lower parts of the Phongolo system.

Bioaccumulation of Metals in Two Edible Species of the Nyl River System

Musa, R.S. and Greenfield R.
Department of Zoology, University of Johannesburg, Auckland Park, Johannesburg
ryaz.musa@gmail.com

Due to limited water sources in South Africa and increased population growth, adequate management of wetlands is crucial. Increased anthropogenic activity leads to elevated amounts of metals introduced into these fragile aquatic ecosystems. High metal concentrations cause bioaccumulation in the fish species, having toxic effects on the organism. It is thus imperative to measure the concentrations of metals in both the fish tissues as well as the background waters. This paper discusses the accumulation of 7 metals (Al, Cr, Cu, Fe, Mn, Sr, Zn) in two edible fish species, namely *Clarias gariepinus*, and *Oreochromis mossambicus* at two sites in the Nyl River system, before and after the town of Modimolle. This study was undertaken to determine the state of the fish within the lotic system and if the fish were safe for human consumption. Gills, liver, skin and muscle tissue were analysed for metal concentration using standard microwave digestion and Inductively Coupled Plasma Mass Spectrometry. The results indicate that Nylsvley has higher concentrations of metals in comparison to Donkerpoort Dam. This proves that Modimolle does in fact play a role in introducing metals into the system. However the concentrations found are still below WHO and FDA guideline levels for human consumption, rendering the fish tissue still safe for human consumption.

A Baseline Study of Metal Contamination Along the Namibian Coastline for *Perna perna* and *Choromytilus meridionalis*

Dahms, S., van der Bank, F.H. and Greenfield, R.
Department of Zoology, University of Johannesburg, Auckland Park, Johannesburg
sdahms4@gmail.com

The use of bivalves such as the brown mussel (*Perna perna*) and the black mussel (*Choromytilus meridionalis*) is common in the study of marine pollution and the effect of these pollutants on ecosystems. Both *P. perna* and *C. meridionalis* are species important in both economic and ecological roles. Namibian marine ecosystems are threatened by pollution from mining, commercial fishing and population growth. No studies have been found documenting the metal pollution levels along the coast of Namibia using bivalve molluscs. The aims of this study were to determine baseline metal concentrations by means of Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) to determine spatial variation and to determine variation between species. The metals included in the analysis were: Al, Cd, Cr, Co, Cu, Fe, Mn, Pb and Zn. Metal levels in *C. meridionalis* from Guano Platform (GP) is the lowest of all the sites. The most polluted sites are Rocky Point (RP), Halifax Island (HIL) and between Walvis Bay and Swakopmund (WS). Conditions in the Walvis Bay harbour (WBH) were found to be beter than anticipated, with only Cu levels being significantly higher than the rest of the sites. When comparing the bioaccumulation of metals between *P. perna* and *C. meridionalis* it was discovered that results are not uniform for all metals. Overall the study indicates the condition of the coastline to be mostly normal, with Cd and Pb levels being of concern.

SESSION 11: AQUATIC ECOLOGY AND MANAGEMENT

Aquatic Science in South Africa: Past and Future Challenges

Ashton, P.
P.O. Box 905-502, Garsfontein West, 0042, Pretoria
carolash@iafrica.com

The last century has been marked by numerous changes to the type and complexity of the challenges that South African practitioners of aquatic science face have had to face. While our knowledge and understanding of water resource systems has grown, the scope and intricacy of the problems that now face us require new types of responses. The original, relatively straightforward, technological challenges have been amplified, broadened and become more complex with the inclusion of economic, social and political dimensions. While the earlier focus on solving intricate problems and measuring our success through peer-review mechanisms is still important, aquatic scientists must now also practice their science in the service of society. These changes require us to place greater emphasis on multidisciplinary, inter-disciplinary and inclusive approaches to solving the problems that face our country and our science. These broader approaches to aquatic science have also allowed us to reflect on, respond to, and support the dramatic political, social and economic transformations that have taken place in our country. The seasonal and inter-annual climatic patterns that characterize South Africa are reflected in, the distribution, availability and accessibility of our water resources. While our past reliance on massive water storage reservoirs and water transfer systems to provide adequate and reliable water supplies will continue into the foreseeable future, we now also need to derive new sources of water and improve the ways that we use water if the social and economic development aspirations of society are to be met. If we simply follow a ‘business as usual’ approach, our country’s existing water resources will be unable

to meet the needs of society by 2030 – or sooner if the region experiences prolonged droughts. The resulting social and economic problems will be worsened by more frequent incidents of water pollution and rising costs of water treatment, as well as the anticipated effects of global climatic changes, with equally bleak prospects for our neighbours. The increasing social and economic pressures on our aquatic systems have resulted in a progressive decline in the volume of water and deterioration in the quality of water in these systems. Some of these changes have been both deliberate and desirable; others have been unintended, unavoidable and unwelcome Many of the unintended changes have caused dramatic changes to the ecological systems that characterize our water resources; sensitive species have been lost or replaced, ecological processes have been altered or extinguished, and many aquatic ecosystems have been irreversibly changed. This situation cannot continue indefinitely and it is time for us all to embrace a fresh new 'water ethic' where we appreciate the true value of water, we act more prudently and responsibly to avoid unnecessary and wasteful uses of water, and we prevent contamination of water that would ultimately increase damage to aquatic ecosystems and require expensive treatment before it can be used by society. We must also develop and implement new legal instruments, create new institutional structures, derive new technological solutions and increase the numbers of trained, competent individuals who have to implement legislation, treat wastes and supply potable water to society. In parallel, we must collectively seek ways to improve our ability to sustain the delicate balance between conserving water resources and exploiting the benefits we derive from these resources.

A Refined Method for Determining Appropriate Buffer Zones for Wetlands, Rivers, and Estuaries

1. Bredin, I.P., 2. Macfarlane, D., 1. Dickens, C., 3. Adams, J.B. and 3. Bate, G.
1. Institut of National Resources, Scottsville, Pietermaritzburg
2. Eco-Pulse Consulting, South Africa
3. Department of Botany, Nelson Mandela Metropolitan University, Port Elizabeth
ibredin@inr.org.za

To date, good progress has been made to define and delineate wetland and riparian areas. This progress has culminated in the production of useful tools to assist in identifying and delineating wetland and riparian areas. However, limited guidance has been provided for the establishment of buffer zones. The objective was to address this gap by developing a method for determining appropriate buffer zones, which could be consistently applied to guide land use decision making around South Africa's wetland, river and estuarine resources. The method developed included a tiered approach to facilitate decision making. The relationships of the criteria used to model the buffer zone requirements, which include identifying core habitat areas, and the levels of risk associated with the proposed activity on water resources were the primary drivers. Site-based modifiers were developed to address site specific characteristics, which were identified to have either a reduced or enhanced effectiveness on buffer zones. Additionally, alternative mitigating measures, which are more effective at addressing a range of impacts, were investigated to support the development of buffer zones. Ultimately, the method for determining buffer zones aims to help reduce the impacts of adjacent land uses on wetland, river and estuarine resources.

Ecological Integrity Assessment of the Lower Phongolo River and Floodplain

1. Vlok, W., 2. Fouche, P.S.O., 3. Vivier, L. and 4. Greenfield, R.
1. BioAssets, 40 Polokwane
2. Zoology Department, University of Venda, Thohoyandou
3. Zoology Department, University of Zululand, KwaDlangezwa
4. Department of Zoology, University of Johannesburg, Auckland Park, Johannesburg
wynand.vlok@gmail.com

For this component of the larger Phongolo Floodplain project the EcoStatus protocol as described by Kleynhans and Louw (2007) was followed and is used as part of the ecological classification process. The Present Ecological State (PES) was determined and selected biophysical attributes of rivers were determined in order to categorise and compare the natural or close to natural reference conditions (RC). This was done to gain insight and understand the causes and sources of deviations from the RC and based on the findings it was possible to derive desirable and attainable future ecological objectives and management goals for the system. For this component the following indices were applied: Geomorphological Driver Assessment Index (GAI), Index of Habitat Integrity (IHI), Fish Response Assessment Index (FRAI), Macro-invertebrate Response Assessment Index (MIRAI) and Riparian Vegetation Response Assessment Index (VEGRAI). This paper will highlight current changes on the floodplain and how the habitat is modified as a result of the anthropocentric impacts. Most of the habitat changes are related to flow modifications, land-use practices and agricultural impacts related to the use of pesticides and herbicides and the application of fertilisers for the intensive farming activities on the floodplain.

Scale and Environmental Influences on the Distribution and Structure of Temporary Wetlands in Nelson Mandela Bay (NMB)

Melly, B.L., Schael, D.M. and Gama, P.
Botany Department, Nelson Mandela Metropolitan University, Port Elizabeth
brigittemelly@gmail.com

As part of an on-going Water Research Commission project on ephemeral wetlands in Nelson Mandela Bay (NMB), a in depth look at landscape processes in shaping wetlands was undertaken. NMB has a wide range of rainfall, geological, geomorphological and vegetation types within a relatively small area (1951 km2). A desktop analysis and ground-truthing of data has shown that there are over 1600 wetlands in NMB, primarily comprised of natural ephemeral systems dominated by three hydrogeomorphic (HGM) units: depressions, wetland flats and seeps. This study looked at the driving factors behind the formation of these three HGMs as well as the interaction between these HGM units and the underlying geology, sediment and wetland position within the NMB landscape. Results indicate strong associations between a HGM unit and the underlying geology, soil texture, groundwater and rainfall. These associations suggest larger landscape elements, combined with the position of a wetland within a landscape, influence the structure of a wetland. Subsequently, it is suggested that the resultant structure of a wetland will then influence the associated local biotic communities (vegetation) and abiotic processes. These data will provide information towards understanding the spatial scale at which the landscape processes are influencing wetland distribution patterns, structure and function. This will aid in determining the resolution at which management (conservation and rehabilitation) of these systems needs to occur.

DELEGATE LIST

Title	Prefered name	Last name	Practice	Telephone	Email	Address	City	Code	Country
Prof	Janine	Adams	NMMU	27 0415042429	janine.adams@nmmu.ac.za	Department of Botany Nelson Mandela Metropolitan University Port Elizabeth	E Cape	6031	South Africa
Prof	Abe	Addo-Bediako	University of Limpopo	27 0152683145	abe.addo-bediako@ul.ac.za	Department of Biodiversity University of Limpopo Polokwane	Limpopo	727	South Africa
Mr	Warrem	Aken	Golder Associates Africa (Pty) Ltd	27 0112544800	waken@golder.co.za	PO Box 6001 Halfway House	Gauteng	1685	South Africa
Dr	Mhairi	Alexander	Stellenbosch University		malexander@sun.ac.za	Department Botany and Zoology Stellenbosch University	Western Cape	7602	South Africa
Mr	IAN	Bailey	Umgeni Water	27 0333411342	ian.bailey@umgeni.co.za	Box 9 Pietermaritzburg	KZN	3200	South Africa
Dr	Kris	Bal	University of Limpopo	27 0767546425	kris.bal@ul.ac.za	Libralaan 10 Polokwane	Limpopo	699	South Africa
Mr	Leon	Barkhuizen	FS DETEA	27 0514004787	barkhl@dteea.fs.gov.za	Private Bag X20801 Bloemfontein	Free State	9300	South Africa
Prof	Irene	Barnhoorn	University of Venda	27 0159628041	Irene.barnhoorn@univen.ac.za	Private Bag X5050 Thohoyandou	Limpopo	950	South Africa
Prof	Linda	Basson	University of the Free State	27 0514013244	BassonL@ufs.ac.za	Dept of Zoology & Entomology PO Box 339 B Bloemfontein	Free State	9300	South Africa
Prof	Guy	Bate	NMMU	27 332391810	guy.bate@nmmu.ac.za	10 Midmar Gardens Howick	KZN	3290	South Africa
Mr	Terence	Bellingan	SAIAB/Rhodes University	27 0466037469	g04b1386@gmail.com	Calata House Desmond Tutu Hall. Rhodes University Grahamstown	Eastern Cape Province	6140	South Africa
Mr	Ian	Bredin	Institute of Natural Resources	27 0333460796	ibredin@inr.org.za	PO Box 100396 Pietermaritzburg	KwaZulu-Natal	3209	South Africa
Ms	Karabo	Chadzingwa	Rhodes University	27 0466222428	m.wolff@ru.ac.za	PO Box 94 Grahamstown	Eastern Cape	6140	South Africa
Dr	Kevin	Christison	DAFF	27 0214307010	KevinCH@daff.gov.za	Private Bag X2 Roggebaai Cape Town	Western Cape	8012	South Africa
Mr	Gerhard	Cilliers	Department Water Affairs	27 0128089554	cilliersg@dwa.gov.za	DWA RQS Private Bag x101 Pretoria	Gauteng	-	South Africa
Ms	Meredith	Cowie	Nelson Mandela Metropolitan University	27 0413672898	s209077201@live.nmmu.ac.za	11 Pamela Cresent Walmer Downs Port Elizabeth	Eastern Cape	6070	South Africa
Prof	Chris	Curtis	Wits University	27 0114864812	christopher.curtis@wits.ac.za	GAES Private Bag 3 WITS 2050 Johannesburg	Gauteng	WITS 2050	South Africa
Ms	Simone	Dahms	University of Johannesburg	27 115592441	sdahms4@gmail.com	35 Ray Street Triomf Johannesburg	Gauteng	2093	South Africa
Ms	Lizaan	de Necker	University of Johannesburg	27 0117935235	lizaan.denecker@gmail.com	PO Box 524 Auckland Park Johannesburg	Gauteng	2006	South Africa
Mr	Jurgen	De Swardt	North West University	27 0182852279	21869499@nwu.ac.za	Private Bag X6001 Potchefstroom	North West	2520	South Africa
Mr	Brendon	Dredge	SAIAB	27 0723040083	bren.dredge@gmail.com	13 Worcester Mews Grahamstown	Eastern Cape	6140	South Africa

Title	Prefered name	Last name	Practice	Telephone	Email	Address	City	Code	Country
Ms	Claire	Edwards	University of Johannesburg	27 117931084	claire.m.edwards@gmail.com	PO Box 140 Ferndale Johannesburg	Gauteng	2194	South Africa
Dr	Bruce	Ellender	South African Institute for Aquatic Biodiversity	27 0466035800	bru.ellender@gmail.com	Private Bag 1015 Grahamstown	Eastern Cape	6140	South Africa
Dr	Martin	Ferreira	Jeffares @ Green	27 0118070660	ferreiram@jgi.co.za	37 Sunninghill Office Park Johannesburg	Gauteng	2191	South Africa
Prof	Paul	Fouche	University of Venda	27 0159628453	paulus.fouche@univen.ac.za	Private Bag X 5050 Thohoyandou	Limpopo	950	South Africa
Ms	Ina	Fourie	University of Pretoria	27 0176484442	hermina.fourie@zoology.up.co.za	Hatfield Campus Pretoria Pretoria Hatfield	Gauteng	28	South Africa
Mr	Christian	Fry	University of Johannesburg	27 n/a	christian.fry@digbywells.com	P.O Box 92 Ngodwana	Mpumulanga	1209	South Africa
Dr	Danny	Govender	SANParks	27 0137354240	danny.govender@sanparks.org	Private Bag X402 Skukuza	Mpumalanga	1350	South Africa
Mr	Byron	Grant	Strategic Environmental Focus	27 0123491307	byron@sefsa.co.za	PO Box 74785 Lynnwood Ridge	Pretoria	40	South Africa
Dr	Richard	Greenfield	University of Johannesburg	011 0115592444	rgreenfield@uj.ac.za	PO Box 524 Auckland Park	Gauteng	2006	South Africa
Ms	Thulani	Guzana	Dept of Water Affairs	27 0415010706	Guzanat@dwa.gov.za	Private Bag X6014 Port Elizabeth	Eastern Cape	6001	South Africa
Ms	Candice	Haskins	City of Cape Town	27 021 400308	candice.haskins@capetown.gov.za	PO BOX 298 Cape Town	Western Province	8000	South Africa
Mr	Pieta	Hoffman	University of the Free State	27 0514013938	HoffmanPA@ufs.ac.za	University of the Free State Centre for Environmental Management (67) PO Box 339 Bloemfontein	Free State	9300	South Africa
Ms	Isabel	Human	University of the Free State	27 0514012427	humanci@ufs.ac.za	Nelson Mandela Drivd Bloemfontein	Free State	9300	South Africa
Dr	Michelle	Jackson	University of Pretoria	27 0739150170	mjackson@zoology.up.ac.za	7 Via Veneto 53 Athol Oaklands Road Johannesburg	Gauteng	2196	South Africa
Ms	Nolu	Jafta	Department of Water Affairs	27 0128089511	jaftan@dwa.gov.za	Private Bag X313 Pretoria	Gauteng	-	South Africa
Mr	Gregg	Jansen van Rensburg	University of Johannesburg	27 0118023737	greggvr@gmail.com	PO Box 524 Auckland Park	Johannesburg	2006	South Africa
Prof	Antoinette	Jooste	University of Limpopo	27 0152682743	Antoinette.Jooste@ul.ac.za	P/B X1106 Sovenga	Limpopo	727	South Africa
Ms	Millicent	Kekana	University of Limpopo	27 0152684000	barileng@gmail.com	University of Limpopo Department of Biodiversity P/Bag X1106 Polokwane	Sovenga	727	South Africa
Ms	Hilde	Kemp	NWU	27 0182992380	20797192@nwu.ac.za	Walter Sisulu 121 Potchefstroom	NW	2520	South Africa
Mr	Peter	Kimberg	Private	27 824179191	peterkimberg@hotmail.com	330 Percheron street Beaulieu Estate Midrand Midrand	Midrand	1618	South Africa
Mr	Alvar	Koning	GCS Water & Environmental	27 0118035726	alvark@gcs-sa.biz	Po Box 2597 Rivonia	Gauteng	2128	South Africa
Dr	KJ	Kumolu-Johnson	Lagos State University Ojo Lagos State. Nigeria	234 01	drkumolu@gmail.com	Department of Fisheries Faculty of Science Lagos State University Ojo Lagos State. Nigeria Ojo	Lagos	23401	Nigeria

Title	Prefered name	Last name	Practice	Telephone	Email	Address	City	Code	Country
Ms	Ilome	Lessing	Environmental Affairs	27 0123921400	ilessing@environment.gov.za	P.O Box 32459 Pretoria	Gauteng	135	South Africa
Ms	Lisa	Maholo	Rhodes University	27 0466222428	m.wolff@ru.ac.za	PO Box 94 Grahamstown	Eastern Cape	6140	South Africa
Ms	Andiswa	Makam	Department of Water Affairs	27 0137597460	MakamA@dwa.gov.za	Private Bag X11259 Nelspruit	Mpumalanga	1200	South Africa
Dr	Kele	Malepe	DAFF	27 0123197512	KeleabetsweM@daff.gov.za	cnr Annie Botha and Union Str Riviera	Gauteng	-	South Africa
Dr	Wynand	Malherbe	North-West University	27 0182852279	wynand.malherbe@nwu.ac.za	Unit for Environmental Science and Management Private Bag X6001 Potchefstroom	North West	2520	South Africa
Dr	Sean	Marr	University of Limpopo	27 0152683317	sean.marr@ul.ac.za	Department of Biodiversity University of Limpopo P. Bag X1106 Sovenga	Limpopo	727	South Africa
Ms	Nam	Mbona		27 0128435294	n.mbona@sanbi.org.za	P bag X 101 Pretoria	Gauteng	-	South Africa
Mr	Kyle	McHugh	North West University	27 0182992101	23538872@nwu.ac.za	Private Bag X6001 Potchefstroom	North West Province	2520	South Africa
Ms	Brigitte	Melly	NMMU	27 0415813372	brigittemelly@gmail.com	Room GO02 Botany Department NMMU South Campus Port Elizabeth	Eastern Cape	6001	South Africa
Dr	John	Mendelsohn	RAISON	264 061254962	john@raison.com.na	PO Box 1405 Windhoek	Namibia	9000	Namibia
Ms	Mary	Mkhonto	Unemployed	27 0119744940	marymkhonto@hotmail.com	13 Mahogany Croydon Kempton Park Johannesburg	Gauteng	1619	South Africa
Mr	Luba	Mofu	SAIAB/Rhodes University	27 0466035800	l.mofu@saiab.ac.za	672 Extension 6 Grahamstown	Eastern Cape	6139	South Africa
Mr	KG	Mogorosi	university of the free state	27 0514012440	mogorosilk@ufs.ac.za	university of the free state bloemfontein	Free state	9300	South Africa
Mr	Thabo	Mohlala	SAEON	27 0137353535	thabo@saeon.ac.za	Kruger National Park Phalaborwa	Limpopo	1390	South Africa
Dr	Girley	Moroe-Rulashe	DAFF	27 0123197537	MmalencoeM@daff.gov.za	Private Bag X 138 Pretoria	Gauteng	-	South Africa
Dr	Tumi	Motsisi-Mehlape	Department of Agriculture Forestry and Fisheries	27 0123197648	BoitumeloMOT@daff.gov.za	Private Bag X 138 Pretoria	Gauteng	-	South Africa
Mr	Ryo	Musa	University of Johannesburg	27 N/A	ryaz.musa@gmail.com	PO Box 524 Auckland Park Johannesburg	Gautend	2006	South Africa
Dr	Emmy	Ndimele	Lagos State University Ojo Lagos State. Nigeria	234 01	drpendimele@yahoo.com	Department of Fisheries Faculty of Science Lagos State University Ojo Lagos State. Nigeria Ojo	Lagos	23401	Nigeria
Dr	Gordon	O'Brien	Institute of Natural Resources	27 0333473169	gobrien@inr.org.za	PO Box 101583 Scottsville	KwaZulu-Natal	3209	South Africa
Ms	Mia	Otto		27 0514366784	mia2911@hotmail.com	71 Lucas Steynrd Bloemfontein	Free State	9301	South Africa
Prof	Tally	Palmer	Rhodes University	27 0466222428	tally.palmer@ru.ac.za	PO Box 94 Grahamstown	Eastern Cape	6140	South Africa
Dr	Roger	Parsons	Parsons & Associates	27 0282738676	roger@pasgc.co.za	PO Box 151 Pringle Bay	Western Cape	7196	South Africa
Mr	Robin	Petersen	SANParks	27 0137354189	robin.petersen@sanparks.org	PO BOX 317 SKUKUZA	MPUMALANGA	1350	South Africa

Title	Prefered name	Last name	Practice	Telephone	Email	Address	City	Code	Country
Mr	Wihan	Pheiffer	NWU	27 0182992379	20545959@nwu.ac.za	Private Bag X6001 Potchefstroom	North West Province	2520	South Africa
Dr	Rialet	Pieters	North-West University	27 0182992379	rialet.pieters@nwu.ac.za	North-West University; Private Bag X6001; Unit for Environmental Sciences and Management Potchefstroom	North West Province	2520	South Africa
Mr	Ian	Preston	Rhodes University	27 0466222428	m.wolff@ru.ac.za	PO Box 94 Grahamstown	Eastern Cape	6140	South Africa
Ms	Simone	Prinsloo	NWU	27 0187885651	22136657@nwu.ac.za	North-West University Institutional Office Private Bag X1290 Potchefstroom	North West	2520	South Africa
Mr	Mpho	Ramoejane	South African Institute for Aquatic Biodiversity	2773 0466035800	icebeast2001@gmail.com	19 Hodges Street GRAHAMSTOWN	Eastern Cape	6139	South Africa
Mr	Phetole	Ramollo	Environmental Affairs	27 0538077430	ramollopp@gmail.com	P/Bagx6102 Kimberley	Northern Cape	8300	South Africa
Dr	Darsh	Reddy	Department of Agriculture Forestry and Fisheries	21 0123197630	DarshanaR@daff.gov.za	Delpen Bulding c/o Annie Botha and Union Streets Riviera Pretoria	Gauteng	-	South Africa
Mr	Hugo	Retief	Rhodes University	27 0466222428	m.wolff@ru.ac.za	PO Box 94 Grahamstown	Eastern Cape	6140	South Africa
Ms	Asiphe	Sahula	Rhodes University	27 0466222428	m.wolff@ru.ac.za	PO Box 94 Grahamstown	Eastern Cape	6140	South Africa
Dr	Denise	Schael	NMMU	27 0415044790	denise.schael@nmmu.ac.za	PO BOX 77000 NMMU Botany Department Port Elizabeth	Eastern Cape	6031	South Africa
Mr	Joppie	Schrijvershof	North West University	27 0182852279	21649065@nwu.ac.za	Private Bag X6001 Potchefstroom	North West Province	2520	South Africa
Mr	Steven	Shibambu	Department of Water Affairs	27 0152901200	shibambus@dwa.gov.za	49 Joubert Street Polokwane	Limpopo	699	South Africa
Dr	Mike	Silberbauer	Department of Water Affairs	27 0128074814	Michael.Silberbauer@gmail.com	Resource Quality Services Department of Water Affairs Private Bag X313 Pretoria	Gauteng	-	South Africa
Mr	Hendrik	Sithole	South African National Parks	27 0538325488	hendrik.sithole@sanparks.org	P.O.Box 110049 Kimberley	Northern Cape	8306	South Africa
Mr	Hendrik	Sithole	South African National Parks	27 0538325488	hendrik.sithole@sanparks.org	P.O.Box 110049 Kimberley	Northern Cape	8306	South Africa
Dr	Nadene	Slabbert	Department of Water Affairs	27 0128089619	slabbertn@dwa.gov.za	Private Bag X313 Pretoria	Gauteng	-	South Africa
Prof	Nico	Smit	North West University	27 0182992128	nico.smit@nwu.ac.za	Private Bag X6001 Potchefstroom	North West Province	2520	South Africa
Ms	Maronel	Steyn	CSIR Stellenbosch	27 0218882499	msteyn@csir.co.za	PO Box 320 Stellenbosch	Western Cape	7599	South Africa
Mr	Connor	Stobie	University of Pretoria	27 0124206747	connor.stobie@up.ac.za	Room 7-28 Agricultural Sciences Building University of Pretoria Lynnwood Road Pretoria	Gauteng	28	South Africa
Mr	Pieter	Swanepoel	UFS	27 0514012440	swanepoelpj@ufs.ac.za	POBox 11 Smithfield	Free State	9966	South Africa
Dr	Ricky	Taylor	Independent	27 0353401061	ricky.h.taylor@gmail.com	PO Box 324 Mtunzini	KwaZulu-Natal	3867	South Africa
Mr	Gareth	Thomson	Rhodes University	27 0466222428	m.wolff@ru.ac.za	PO Box 94 Grahamstown	Eastern Cape	6140	South Africa

Title	Prefered name	Last name	Practice	Telephone	Email	Address	City	Code	Country
Prof	Jo	van As	University of the Free State	27 0514013637	vanasjg@ufs.ac.za	University of the Free State Bloemfontein	Free state	9300	South Africa
Prof	Liesl	van As	University of the Free State	27 0514013460	vanasll@ufs.ac.za	Department of Zoology & Entomology Bloemfonten	Free State	9301	South Africa
Dr	Carin	van Ginkel	Rhodes University	27 0466222428	m.wolff@ru.ac.za	PO Box 94 Grahamstown	Eastern Cape	6140	South Africa
Prof	Johan	van Vuren	University of Johannesburg	27 0115592441	johanj@uj.ac.za	Dept of Zoology PO Box 524 Auckland Park Johannesburg	Gauteng	2006	South Africa
Ms	Lani	van Vuuren	Water Research Commission	27 012 330034	laniv@wrc.org.za	Private Bag X03 Gezina Pretoria	Gauteng	31	South Africa
Mr	Dimitri	Veldkornet	NMMU	27 0415043869	dimitri.veldkornet@nmmu.ac.za	Department of Botany NMMU Port Elizabeth	Eastern Cape	6031	South Africa
Mr	Petrus	Venter	DWA	27 0122079911	venterp@dwa.gov.za	P/Bag X352 Hartbeespoort	North West	216	South Africa
Prof	Danie	Vermeulen	University of the Free State	27 0514012482	VermeulenD@ufs.ac.za	PO Box 339 Bloemfontein	Free State	9300	South Africa
Mr	Matthew	Weaver	Rhodes University	27 0466222428	m.wolff@ru.ac.za	PO Box 94 Grahamstown	Eastern Cape	6140	South Africa
Prof	Victor	Wepener	North-Weste University	27 0182992385	victor.wepener@nwu.ac.za	Private Bag X6001 Potchefstroom	North-West	2520	South Africa
Ms	Deidre	West	University of the Free State	27 0514012370	west.deidre@gmail.com	PO Box 339 Bloemfontein	Free State	9300	South Africa
Dr	Olaf	Weyl	South African Institute for Aquatic Biodiversity	27 0466035800	o.weyl@saiab.ac.za	P Bag 1015 Grahamstown	Eastern Cape	6140	South Africa
Dr	Darragh	Woodford	SAIAB	27 0466035800	d.woodford@saiab.ac.za	SAIAB PO Box 1015 Grahamstown	Eastern Cape	6140	South Africa
Mr	Sipiwo	Xongo	Dept of Water Affairs	27 0415010726	Xongos@dwa.gov.za	Private Bag X6041 Port Elizabeth	Eastern Cape	6001	South Africa
Ms	Larissa	Zaayman	North West University	27 0182992380	20764413@nwu.ac.za	Private Bag X6001 Potchefstroom	North West	2531	South Africa