M. Silberbauer

SOUTHERN AFRICAN SOCIETY OF AQUATIC SCIENTISTS

35 TH ANNUAL CONFERENCE

RESEARCH, CONSERVATION AND MANAGEMENT OF AQUATIC RESOURCES IN SOUTHERN AFRICA

SWAKOPMUND 27 JUNE - 1 JULY 1999

PROCEEDINGS AND LIST OF DELEGATES

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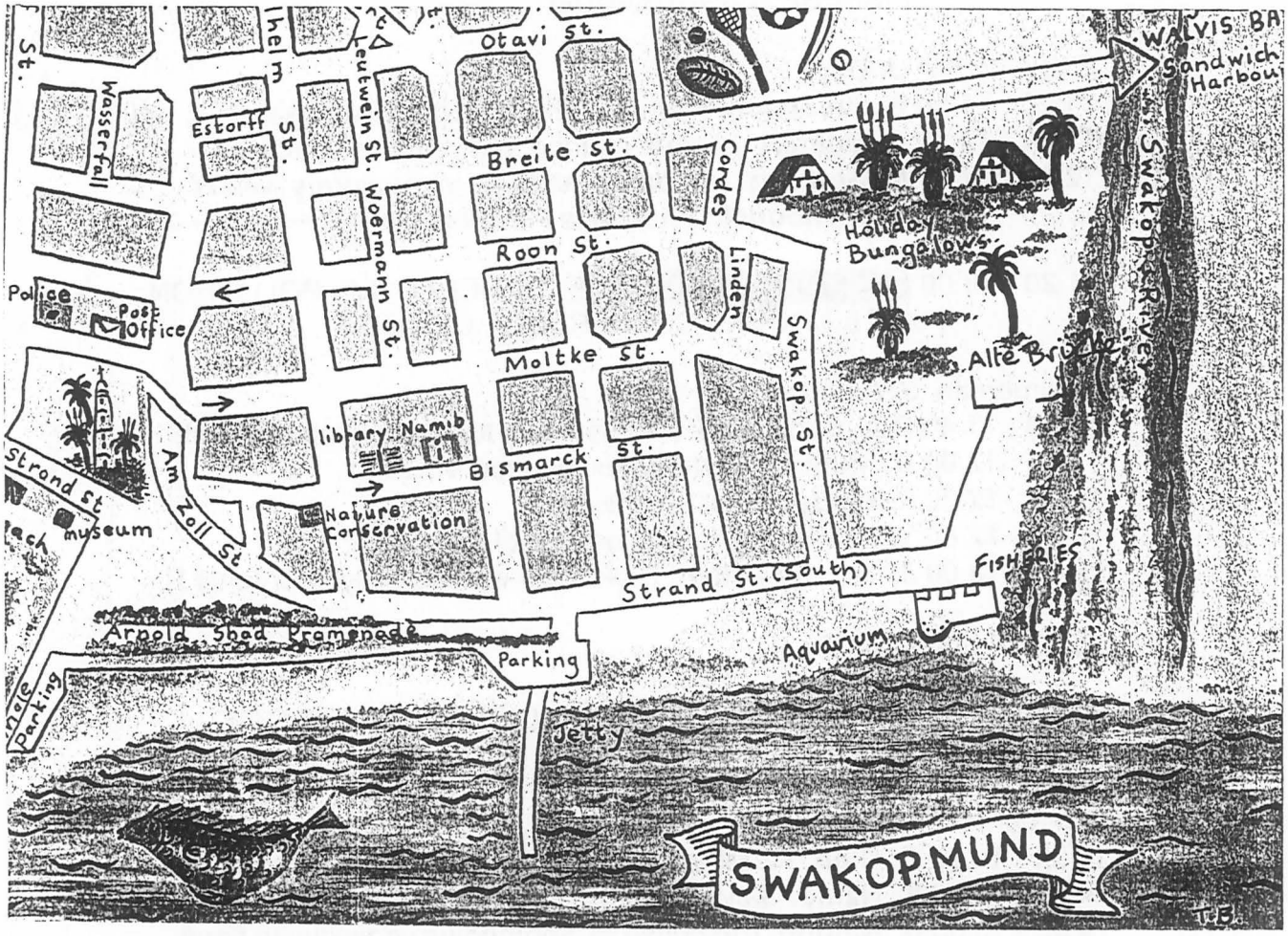
SUNDAY 27 JUNE

09.00 - 17.00 REGISTRATION AT ALTE BRÜCKE CONFERENCE CENTRE, SWAKOPMUND.

19.00 - WELCOMING FUNCTION - ALTE BRÜCKE



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MONDAY 28 JUNE

08.00 - 09.30 SESSION 1 PLENARY: INTRODUCTION & WELCOME
FISHERIES AUDITORIUM

President of SASAQS: **C. Dickens**: Water the common element.
Stamp launch; Mayor of Swakopmund welcome
Minister of Agriculture, Water & Rural Development opening address

09.30 - 10.00 REFRESHMENTS

10.00 - 11.15 **MANNED POSTERS** (listed at end of programme)

11.20 - 13.00 SESSION 2a PARALLEL: EPHEMERAL WATERS
FISHERIES AUDITORIUM

Chairperson: **J. Day**
11.20 - 11.50 **P. Jacobson**: Keynote: The Namibian Perspective.
11.50 - 12.10 **A. Mostert**: Climate change and water resources.
12.10 - 12.30 **M. Seaman**: Inundation patterns in temporary waters.
12.30 - 12.50 **L. Brendonck**: Anostraca in rock pools

11.20 - 13.00 SESSION 2b PARALLEL: TOXICOLOGY - POLLUTION
ALTE BRÜCKE CONFERENCE CENTRE

Chairperson: **J. Adams**
11.20 - 11.40 **P-A. Scherman**: Developing a toxicity testing protocol.
11.40 - 12.00 **N. Muller**: Invertebrates in effluent testing.
12.00 - 12.20 **P. Wade**: Metal toxicology.
12.20 - 12.40 **T. Palmer**: Salinity tolerance of a mayfly.
12.40 - 13.00 **J. van der Molen**: Diatoms & water quality in Olifants R.

13.00 - 14.00 LUNCH

14.00 - 16.00 SESSION 3a PARALLEL: PLANTS & LIMNOLOGY
FISHERIES AUDITORIUM

Chairperson: **W. Ellery**
14.00 - 14.20 **R. Glen**: *Azolla* taxonomy in Southern Africa.
14.20 - 14.40 **K. Naidu**: *Salvinia* control in Moremi Game Reserve.
14.40 - 15.00 **G. Naidoo**: Response of *Sporobolus virginicus* to floods.
15.00 - 15.20 **M. Graham**: Modelling water quality and algae in lakes.
15.20 - 15.40 **C. van Ginkel**: Algae and limnology of Grootdraai Dam.
15.40 - 16.00 **C. Thirion**: Biomonitoring protocol for dams.

14.00 - 16.00 SESSION 3b PARALLEL: PHYSICAL ENVIRONMENT
ALTE BRÜCKE CONFERENCE CENTRE

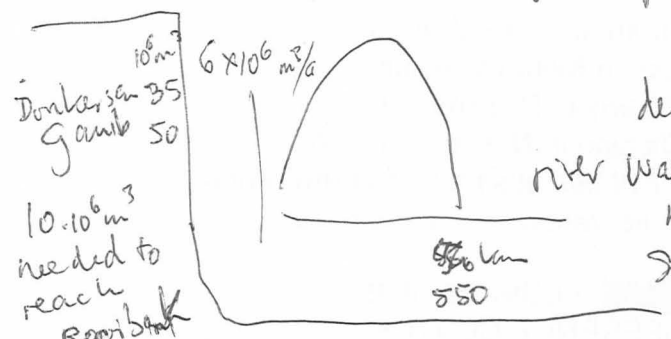
Chairperson: **P. Heyns**
14.00 - 14.20 **R. Wadeson**: Hydraulic biotopes. Midmar → Albert Falls. Digital camera
14.20 - 14.40 **E. Dollar**: Dominant discharge determination. Mkomazi Flow analysis
14.40 - 15.00 **H. Malan**: Linking water quality and water quantity. Very useful.
15.00 - 15.20 **G. Venter**: Water quality of Upper Orange R. Doing MSc on WQ of Orange R.
15.20 - 15.40 **N. Koning**: Water quality of Modder R.
15.40 - 16.00 ~~**J. King**~~ Cate Brown: Lesotho Highlands: hydraulic habitat data. Also mapping
16.00 - 16.30 TEA

16.30 - 18.30 WORK GROUPS (topics listed at end of programme)

18.30 **SASAQS COUNCIL MEETING** - ALTE BRÜCKE; FREE EVENING

local DTM
sediment transport
(substrates) (flow types)
Move posters to library.

rivers hydrological decay (flood passage down ephemeral river)



debris piles retain water
river waters have highest DOM in world
mushrooms
Swakoppoort Dam: 100 x reduction in flood peak

Temporary waters @ Bains Vlei Pan
@ top of W FS mountain
Single-event inundation ≤ 19d, 1985-95
pools at top of granite hill
Dispersal by wind, overflow.

TUESDAY 29 JUNE

07.45 - 08.00 ANNOUNCEMENTS

08.00 - 10.00 SESSION 4 PLENARY: PERENNIAL WATERS
FISHERIES AUDITORIUM
Chairperson: **R. Hart**
08.00 - 08.30 **P. Skelton**: Keynote address: Flagships and Fragments.
08.30 - 09.00 **C. Breen**: Sustainable rivers.
09.00 - 09.20 **K. Rowntree**: Geomorphological index of river health.
09.20 - 09.40 **K. Snaddon**: Interbasin water transfer.
09.40 - 10.00 **W. Ellery**: Okavango: vegetation, hydrology & sediment.

10.00 - 10.30 TEA

10.30 - 12.30 SESSION 5a PARALLEL: FISH
FISHERIES AUDITORIUM
Chairperson: **M. Angliss**
cancelled x 10.30 - 10.50 **W. Kudoja**: Management of Lake Victoria.
10.50 - 11.10 **M. Coke**: Red data fish in KwaZulu-Natal.
11.10 - 11.30 **W. Mhlanga**: Fish of Sanyati R. Zimbabwe.
11.30 - 11.50 **N. Nicolaai**: Gill net fishing in N. Province, SA.
11.50 - 12.10 **L. Scott**: GIS-based FW fish atlas for southern Africa.
12.10 - 12.30 **R. Sinyinza**: Fish conservation in L. Tanganika.

10.30 - 12.30 SESSION 5b PARALLEL: FLOW REGIMES
ALTE BRÜCKE CONFERENCE CENTRE
Chairperson: **M. Graham**
10.50 - 11.10 10.30 - 10.50 **C. Brown**: Instream flow requirements. Desired future state. Concentrate on hydrology
11.10 - 11.30 10.50 - 11.10 **D. Louw**: Beyond instream flow requirements.
11.30 - 11.50 11.10 - 11.30 **F. de Moor**: Kunene R. invertebrate communities.
cancelled x 11.30 - 11.50 **W. Shivoga**: Flow regimes in two Kenyan streams.
11.50 - 12.10 **J. O'Keeffe**: Modified flow and ecological stress. Leaving Neels
12.10 - 12.30 **P. Ashton**: Water transfer from the Okavango R.

13.00 - 14.00 LUNCH

14.00 -16.00 SESSION 6a PARALLEL: FISH
FISHERIES AUDITORIUM
Chairperson: **Paul Skelton**
14.00 - 14.20 **E. Bruwer**: *Synodontis* phylogenetics.
14.20 - 14.40 **E. Swartz**: Genetics of minnows in Olifants R.
14.40 - 15.00 **D. Impson**: Conservation ~~status~~ of Cape FW fish. Planning region
15.00 - 15.20 **J. Cambray**: Breeding behaviour of 2 Anabantidae.
15.20 - 15.40 **W. Vlok**: Fish populations of G. Letaba R.
15.40 - 16.00 **D. Okeyo**: Fish culture in nutrient-rich wastewater.

14.00 - 16.00 SESSION 6b PARALLEL: WATER QUALITY
ALTE BRÜCKE CONFERENCE CENTRE

Chairperson: **T. Palmer**

14.00 - 14.20 **P. Cilliers**: SASS4 on streams in N. Kwazulu-Natal.
14.20 - 14.40 **C. Phiri**: Water quality & invertebrates (SASS)
14.40 - 15.00 **D. Grobler**: Habitat integrity of Sand River.
15.00 - 15.20 **R. Heath**: Water quality in Katse Dam.
15.20 - 15.40 **M. Uys**: Surface waters and waste sites.
15.40 - 16.00 **K. Schachtschneider**: Groundwater monitoring, Bass L.

16.00 - 16.30 TEA

16.30 - 17.50 SESSION 7a PARALLEL: FISHERIES
FISHERIES AUDITORIUM

Chairperson: **B. van Zyl**

16.30 - 16.50 **T. Andrew**: Small-scale fisheries.
16.50 - 17.10 **M. Angliss**: Guidelines on FW fish use
17.10 - 17.30 **B. van der Waal**: Fish resources in rural areas.
17.30 - 17.50 **L. Vivier**: Dams & fish populations - Pongola/Bivane R.

16.30 -18.10 SESSION 7b PARALLEL: INVERTEBRATES
ALTE BRÜCKE CONFERENCE CENTRE

Chairperson: **R. Owen**

16.30 - 16.50 **C. Lugo-Ortiz**: Baetid mayflies of the world.
16.50 - 17.10 **H. Barber-James**: Kunene R. Ephemeroptera.
17.10 - 17.30 **R. Hart**: Two copepods in two lakes.
17.30 - 17.50 **S. Daniels**: Genetics of *Potamonautes*.
17.50 - 18.10 **G. Gouws**: River crabs of KwaZulu-Natal.

18.30 - 20.00 **AGM** - ALTE BRÜCKE; FREE EVENING

WEDNESDAY 30 JUNE

07.45 - 08.00 ANNOUNCEMENTS

08.00 - 09.00 SESSION 8 PLENARY: WALVIS BAY
FISHERIES AUDITORIUM

08.00 - 08.20 **K. Wearne**: An overview of Walvis Bay wetlands.
08.20 - 08.40 **R. Simmons**: Linking birds, bays & the Benguela.

08.30 - 19.00 EXCURSION TO WALVIS BAY
12.30 - LUNCH AT YACHT CLUB WALVIS BAY
17.00 - TEA WITH THE MAYOR OF WALVIS BAY
19.30 - FISH BRAAI - ALTE BRÜCKE

THURSDAY 1 JULY

07.45 - 08.00 ANNOUNCEMENTS

08.00 - 10.00 SESSION 9 PLENARY: MARINE AND ESTUARINE
FISHERIES AUDITORIUM
Chairperson: **H. Jerling**
08.00 - 08.30 **B. Allanson**: Keynote address: Estuaries of South Africa.
08.30 - 08.50 **P. Froneman**: Plankton distribution in S. Atlantic.
08.50 - 09.10 **D. van Driel**: Estuary habitat assessment.
09.10 - 09.30 **R. Hattingh**: Estuarine ground water flux.
09.30 - 09.50 **V. Wepener**: Biomarkers - fact or fiction.

10.00 - 10.30 TEA

10.30 - 12.50 SESSION 10a PARALLEL: FAUNA
FISHERIES AUDITORIUM
Chairperson: **V. Wepener**
10.30 - 10.50 **J. Adams**: Effects of Mpofu Dam on Kromme Estuary.
10.50 - 11.10 **U. Scharler**: Water release in the Kromme Estuary.
11.10 - 11.30 **H. Champion**: Maturity in Penaeid prawns.
11.30 - 11.50 **A. Viljoen**: Fauna of *Eichhornia* in coastal lakes.
11.50 - 12 10 **R. Owen**: Distribution of burrowing crabs.
12.10 - 12.30 **F. Mackay**: Reduced run-off and estuarine benthos.
12.30 - 12.50 **B. Currie**: Namibian intertidal fauna.

10.30 - 12.30 SESSION 10b PARALLEL: WATER MANAGEMENT
ALTE BRÜCKE CONFERENCE CENTRE
Chairperson: **K. Rowntree**
10.30 - 10.50 **T. Turton**: Water policy in southern Africa: driving forces.
10.50 - 11.10 **A. Joubert**: Multi-criteria analysis for management.
11.10 - 11.30 **M-J. Gabriel**: Grassroots river health programme.
11.30 - 11.50 **M. Uys**: Urban stream restoration.
11.50 - 12.10 **M. Wishart**: Evolutionary importance of catchments.
12.10 - 12.30 **O. Msiska**: Relevance of training in aquatic sciences.
12.30 - 12.50 P. Wade: Ecological Risk Assessment
13.00 - 14.00 LUNCH

14.00 - 16.00 SESSION 11a PARALLEL: MARINE & ESTUARINE
FISHERIES AUDITORIUM
Chairperson. **K. Snaddon**
14.00 - 14.20 **H. Jerling**: Zooplankton of Richards Bay.
14.20 - 14.40 **G. Cilliers**: Benthos of Richards Bay.
14.40 - 15.00 **B. van Zyl**: FishBase demonstration.
15.00 - 15.20 **P. Froneman**: Energy dynamics of two estuaries.
15.20 - 15.40 **P. Morant**: Do the Orange & Kunene form estuaries?
15.40 - 16.00 **H. Kolberg**: Transborder parks; e.g. the Orange R.

14.00 - 16.00 SESSION 11b PARALLEL: WORK GROUPS
ALTE BRÜCKE CONFERENCE CENTRE

16.00 - 16.30 TEA

16.30 - 18.30 WORK GROUPS

19.30 - ANNUAL DINNER - SWAKOPMUND HOTEL

FRIDAY 2 JULY

08.30 - EXCURSIONS

Rössing Mine - morning only.
Gobabeb - overnight - return late 3 July.
Damaraland - weekend - return late 4 July.

SUGGESTED WORK GROUPS

C. Breen - A SADC Rivers Research Programme.
C. van Ginkel - Book on limnology of southern African impoundments.
T. Lepono - Biomonitoring.
D. Okeyo - Fish production in oshanas.
P. Wade - Society of Environmental Toxicology & Chemistry - African chapter
D. van Nieuwenhuizen: Aquatic systems in the Cape floristic region.

Desmond Morris Naked Ape
George Orwell 1984 Doublethink
Douglas Adams HHGG
Sci. American Parking territoriality
Acacias Very map moderate tech

LIST OF POSTERS

I. Barnhoorn: Two techniques for measuring metals in fish.
J. Buckle: Whacking wattles for water: Albany working for water project.
P. Buthelezi: Effects of zinc on *Oreochromis mossambicus.*
R. Glen: Pollination in aquatic plants of southern Africa.
B. Gratwicke: The effect of season on SASS for two Zimbabwe rivers.
L. Grobler: Statistical significance of sampling locations on Loch Vaal.
A. Jooste: Toxic spills in the Klein Nyl River.
V. Kilian: Determination of the ecological reserve for water resources.
J. Koekemoer: Importance of freshwater fish in eastern Caprivi.
L. Le Roux: Influence of *Azolla filiculoides* on freshwater ecosystems.
T. Lepono: Water quality in the Vaal R. barrage catchment by SASS4.
S. Mabaso: Amphipods as bioindicators of copper contamination.
L. Makasa: Annual variation in water levels in L. Tanganika 1960-98.
A. Maritz: Algal index for water purification and recreation.
P. McMillan: Stream habitat assessment.
T. Mlilo: Influence of pH on zinc speciation and toxicity.
N. Motteux: People-centred approach to management - the Kat River.
S. Pithey: Enabling urban catchment management.
L. Polling: Water qualities in the Ga-Selati River.
N. Rayner: Distribution of Paradiaptominae.
W. Roets: Ecological importance of tributaries of the Berg River.
J. Roos : Harvesting of *Spirulina* for pollution control in Kamfers Dam.
M. Silberbauer : GIS coverages for drainage basins in S. Africa.
M. Smidt: Habitat integrity of rivers in southern Africa.
C. Todd: Sediment toxicity testing protocol for S. Africa.
F. van der Bank: Genetic variation in the orange roughy of Namibia.
D. van Nieuwenhuizen: Conservation of aquatic systems in the Cape.
E. van Wyk: Protocol for water management in the Sabie catchment.
F. Venter: Towards a management plan for Olifants River.
D. Weeks: Geomorphology in the Sabie River Lowveld, S. Africa.

ORAL PAPERS

The effect of a freshwater release from the Mpofu dam on the saline Kromme estuary

Adams, JB, GC Snow & GC Bate

Department of Botany, Institute for Coastal Resource Management, University of Port Elizabeth.

The combined storage capacity of two large dams (133 x 10^6 m^3) on the Kromme River, South Africa, exceeds the Mean Annual Runoff (MAR) of 106 x 10^6 m^3 from the catchment. The larger Mpofu dam (100 x 10^6 m^3) is 18 km from the coast and 4 km above the tidal head of the estuary. Because of the severe reduction in the natural supply of freshwater, marine conditions now dominate the estuary for extended periods (years). During summer, the upper reaches may become hypersaline.

In November 1998 water was released from the dam (2 x 10^6 m^3) and the short-term response patterns of abiotic and biotic estuarine components were investigated by a multi-disciplinary team. The responses of the estuarine microalgae are delt with in this paper.

Two hypotheses were tested:

- As a result of the freshwater release average water column chlorophyll-a concentrations would increase from 5 µg l^{-1} to 20 µg l^{-1}.
- There would be a twofold increase in benthic chlorophyll-a concentrations.

Results showed that:

- There was no significant increase in water column chlorophyll-a probably because an axial salinity gradient (river-estuary interface) was only maintained for approximately 7 days.
- Average intertidal benthic chlorophyll-a concentrations doubled for sites in the middle and upper reaches of the estuary from 35.6 $\pm$ 11.4 mg m^{-2} to 63.3 $\pm$ 9.3 mg m^{-2}. This probably occurred in response to the increase in nitrate concentrations in the surface water.

The study has shown that a release of 2 x 10^6 m^3 had little effect on the marine dominated estuary. In order to maintain a salinity gradient and high water column productivity the estuary would probably require a consistent base flow from the dam to create a salinity gradient, a river seawater interface zone and a favourable environment for estuarine biota. Pulses of freshwater would also be needed to introduce nutrients and stimulate water column productivity and community succession. The impact of similar dam developments at other systems should be properly assessed before being implemented, as changes similar to those of the Kromme estuary can be expected.

Estuaries of South Africa

Professor Brian Allanson

Honorary Fellow of the Institute of Water Research, Rhodes.
Allanson Associates, PO Box 1186, Knysna 6570, South Africa. Tel: 044 382 5107,
e-mail: ba11@pixie.co.za

A new volume on The Estuaries of South Africa has recently been published by Cambridge University Press. This volume reviews the reserach results of work done since the publication of John Day's in 1981. Of particular note is the quantity and quality river inflows into estuaries and the role such inflows play in the sustainability of the estuarine ecosystem. The factors involved are assessed and their respective impacts upon estuarine operation evaluated.

Can small-scale fisheries contribute to poverty alleviation in traditionally non-fishing communities ?

T.G. Andrew, Q. Rouhani and S. Seti
Dept. of Ichthyology & Fisheries Science, Rhodes University, Grahamstown, S.A.

Throughout South Africa impoundments and rivers support extensive stocks of both indigenous and exotic freshwater fish species. Many rural areas such as in the Eastern Cape are populated by communities who have not traditionally utilised these fish resources. High poverty levels in many rural areas and a degraded environment have stimulated the search for alternative forms of natural resource use. This paper reports on a number of case studies where communities have been encouraged to utilise suitable freshwater fish resources in the Eastern Cape to improve food security and income generation.

A guideline procedure for assessing the commercial use of freshwater fish stocks in inland water bodies.

M.K. Angliss[1] & P. de Villiers[2]
[1]Northern Province, Dept. of Agriculture, Land and Environment, Private Bag X573, Giyani 0826. Fish@pixie.co.za
[2]Dept. of Environmental Affairs and Tourism, Free State, PO Box 264 Bloemfontein 9300.

Throughout the world, there is a growing realisation, that small water bodies (SWB's) can provide a valuable source of protein, through the exploitation of wild fish stocks. However, there are a number of environmental implications which need to be addressed when considering the potential exploitation of these stocks, and the subsequent approval of such permit applications.

Internationally, the harvesting of fish from SWB's is often administered as a sister component to aquaculture, and this function regularly falls under either agriculture or fisheries department, while only the impacts of such an operation are assessed by an environmental body.

In South Africa, the management and regulation applying to fauna and flora of water bodies is delegated from the national Department of Environmental Affairs and Tourism, to the respective provincial environmental administrations. Many water bodies are centred upon, or cross provincial boundaries, and it is therefore necessary that a standardised guideline procedure be designed to assess the complicated environmental, economic and social considerations, of commercial fishing operations, to ensure the wise use of these national aquatic resources.

These guidelines have been compiled, based on prior successes and failures of commercial fishing operations throughout South Africa. Whilst this document is primarily designed to address the exploitation of fish stocks, it is recognised that other potential aquatic stocks, such as aquatic plants may be addressed using the same procedures.

Potential environmental impacts associated with the abstraction of water from the Okavango River in namibia

Peter Ashton
Division of Water, Environment & Forestry Technology
CSIR, P.O. Box 395, Pretoria 0001

The Namibian Department of Water Affairs has faced considerable pressure to relieve the water shortages caused by recent droughts. One of the options considered aimed to abstract some 17 Mm3 of water per year from the Okavango River at Rundu, and transfer this via a

260 km long pipeline to the head of the Eastern National Water Carrier (ENWC) at the town of Grootfontein. Part of the overall evaluation of this scheme included an assessment of the potential environmental impacts which could arise. The environmental evaluation was conducted from a point approximately 40 kilometres upstream of Rundu in Namibia, to the distal end of the Okavango Delta at Maun in Botswana.

Hydrological studies showed that the proposed abstraction represented a reduction of approximately 0.32 % in the mean annual flow of the Okavango River at Rundu. The abstraction represents 0.17 % of the mean annual flow at Mukwe, downstream of the Cuito River confluence. The adverse effects of the proposed water abstraction scheme would be extremely small along the Okavango River in Namibia, whilst outflows from the lower end of the Okavango Delta to the Thamalakane River would be reduced by some 1.44 Mm3/year (11 %). Additional studies showed that these effects could be reduced by some 15 % if abstraction was confined to the falling limb of the hydrograph.

Hydrological simulations have shown that the maximum likely loss of inundated area in the Okavango Delta would total approximately 7 km2 out of a total area of some 8,000 km2. This potential loss in inundated area would be concentrated in the lower reaches of the seasonal swamps and seasonally inundated grasslands, specifically in the lower reaches of the Boro, Gomoti, Santantadibe and Thaoge channels. However, these effects would be expressed as a shoreline effect, with the loss in area spread out over the shoreline and islands and would not be restricted to a specific area. This anticipated loss in inundated area is unlikely to have measurable impacts on environmental components.

Overall, the study found no "fatal flaws" which would prevent the water abstraction scheme from proceeding. Overall, the anticipated effects on the Okavango system are more likely to be seen in the Okavango Delta, rather than along the Okavango River. The anticipated ecological implications of the scheme were small in spatial extent and were well within the natural year-to-year variability of the Okavango system. However, public perceptions of the proposed water transfer project were strongly negative; it is likely that any adverse effect recorded in the future would be attributed to the abstraction scheme, whether this were true or not. These negative perceptions of the desirability and acceptability of the proposed scheme could adversely affect the tourism industry along the Okavango River and in the Okavango Delta, with a consequent adverse effect on local residents.□

A preliminary survey of the Mayflies (Ephemeroptera) of the CuneneRiver, Namibia.

Helen M. Barber-James

Albany Museum, Grahamstown, H.James@ru.ac.za <mailto:H.James@ru.ac.za>

The Cunene River has suffered considerable human impact since the completion of the hydroelectic power station at Ruacana Falls in the1960's. At one site sampled, about 35km downstream of the falls, a daily fluctuation in water level of 1.1m was recorded. This has a major effect on the aquatic biota, resulting in the fauna being confined to the thalweg. These unnatural conditions cause the fauna to be subjected to flow fluctuating daily between deep and shallow water. This also means that much of the colonisable substrata in the riverbed is lost. Natural flood conditions may occasionally result in similar conditions, so a portion of the fauna would be preadapted to survive this flow pattern. Surveys of the aquatic fauna were carried out in 1997 and 1998. No surveys were carried out prior to construction of the hydroelectic power station, so it is impossible to know exactly how the fauna has been influenced. Despite these effects, the mayfly fauna of the Cunene River is proving to be very interesting, with several species being collected which are new to science. There is a strong tropical component to this fauna, with certain species until now recorded only from west and east Africa. This includes many of the torrent-loving Tricorythidae - *Tricorythus tinctus*, *Machadorythus maculatus* and *Dicercomyzon* sp., and the heptageniid *Afronurus ungandanus*. The Heptageniidae are also represented by a new species of *Composneuria*. An undescribed genus and species of Baetidae was collected from the river near the Epupa

Falls. Generally, the Baetidae do not dominate the mayfly fauna in this river as they do in the majority of rivers in South Africa. This may be an effect of the fluctuating flow conditions, and it is interesting to note a corresponding absence of Simuliidae (Diptera). The only burrowing mayfly species recorded so far is the widespread *Ephoron savignyi*. At least two species of Caenidae represent species that are undescribed as nymphs, and these need to be correlated with the adult stage since many tropical African Caenidae have been described as adults only. The Prosopistomatidae are represented by the widespread *Prosopistoma crassi*. The Cunene River supports a diverse population of mayflies, which has been affected by the unnatural widely fluctuating flow caused by the hydroelectic power station. The findings of these surveys greatly increases the number of mayflies species previously recorded from this river.

Managing for sustainable rivers.

Charles M. Breen
Institute of Natural Resources, University of Natal, P.Bag X01, Scottsville 3209, S.A.

In South Africa rivers have been managed as if they were conduits for delivery of water from one place to another. River systems, however, have value in their own right. Acknowledgement of this led to initiation of the Kruger National Park Rivers Research Programme (KNPRRP). The philosophy and approach adopted are outlined. A conceptual (decision support) and a geographic (Sabie river) focus was used to promote communication between researchers from different institutions and disciplines. This was augmented by using a management framework to determine research priorities, to schedule research and to emphasise process in addition to products. Strengths and weaknesses of the approach are considered.

Persistence of *Branchipodopsis wolfi* (Anostraca) in very short-lived rock pools.

Brendonck, Luc[1] and Bruce Riddoch[2]
[1]*Laboratory of Aquatic Ecology, KULeuven, De Beriotstraat 32, B-3000 Leuven, Belgium email: Luc.Brendonck@bio.kuleuven.ac.be*
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On a granite escarpment in subtropical south-eastern Botswana, rock pools fill erratically and only last, depending on pool size and rainfall pattern, for a few days or weeks after a successful inundation. Early drying of pools after limited rains (< 10 mm) is a major threat to pool biota through abortive hatching from the resting egg bank. The fairy shrimp *Branchipodopsis wolfi* is a striking inhabitant of these small pools and served as a case for studying some mechanisms that aid to persist in this unpredictable environment with serious time constraint. Egg banks of *B. wolfi* are often substantial and varied according to pool and season/year between about 1,000 and 220,000 eggs per m^2. This converts to about 200 and 500,000 viable diapausing eggs per rock pool.
Hatching is cued by ecologically relevant environmental variables such as light, conductivity and temperature. Within a temperature range of 5-30°C, maximal emergence (up to 80%) occurred at 15°C, which is below the natural minimum during the rainy season. At this temperature, eggs hatch faster at a low conductivity (5-20 µS cm^{-1}) but cumulative (3d) hatching percentages are comparable in the natural conductivity range of 5-60 µS cm^{-1}. Low temperature and conductivity values, which only occur when pool basins fill, are considered reliable triggers for synchronising the life cycle of *B. wolfi* to the short suitable growth period. Eggs furthermore only responded to the initial incubation temperature; no stimulus occurred by transferring inundated eggs after three days to a 5°C lower temperature. Emergence is almost entirely inhibited in darkness probably to prevent hatching of buried eggs.
Due to the conditional responsiveness to environmental variables, only part of the egg bank hatches at any occasion. Under laboratory conditions (27°C), there was still significant hatching after 16 subsequent inundations with early drying. The hatching fraction at

environmentally relevant temperatures corresponded with the chances for successful reproduction as estimated from long-term rainfall patterns.
Depending on age and site, animals matured in 4-7days and broods of 5-80 cysts were deposited daily. Egg banks with conditional responsiveness and early maturation allow *B. wolfi* to persist in one of the most extreme of temporary habitats: small desert rock pools.

Downstream Response to Imposed Flow Transformations (DRIFT) - Modifications to the Building Block Methodology

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In the last decade, the Building Block Methodology (BBM) has become the standard methodology used for determining instream flow requirements for rivers in southern Africa. As its name suggests, the BBM is a 'bottom-up' approach. The methodology centres around a specialist workshop, at which river scientists with multidisciplinary knowledge of the river in question construct a modified flow regime that will facilitate maintenance of that river in some predetermined condition. Two of the difficulties of applying the BBM reflect its origin as a response to DWAF-driven requests for guidance. These are: the need to identify that predetermined condition before the workshop, without a clear understanding of who should make that decision or how the condition should be described; and the ensuing lack of flexibility for creation of more than one scenario, by only having one modified flow regime described and justified.
In an effort to deliver a more dynamic final product in Instream Flow Assessments (IFA), Southern Waters Ecological Research and Consulting has developed an IFA process that does not require pre-identification of a desired river condition, and does allow the consequences of any number of future flow regimes to be described.
The new process has been called the Downstream Response to Imposed Flow Transformations (DRIFT).
DRIFT and the widely-recognised Building Block Methodology (BBM) share many features in common. Like the BBM, DRIFT centres around a specialist workshop, attended by river scientists from many disciplines with specialist knowledge of the river in question. The essential differences between the two processes are (1) the BBM "builds up" a recommended flow regime from scratch, whereas DRIFT takes the present-day flow regime as a starting point, and describes the consequences for the river of further reducing (or, if relevant, of increasing) the flow in different ways.
The paper will describe DRIFT at its present stage of development, its information requirements, the DRIFT Workshop, data management and the construction of scenarios.

Phylogenetic relationships between *Synodontis* species

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Synodontis Cuvier, 1816 (Teleostei, Mochokidae) are weakly electric fish species that are extremely difficult to identify from their morphology. The aim of the study is to find genetic markers to identify squeakers (*Synodontis* species). The genetic analysis was done using allozyme data of eight of the nine species from southern Africa, *S. njasae* from Lake Malawi and *Parauchenoglanis ngamensis* as outgroups. We have obtained fixed allele mobility differences at eight of the 25 loci studied, and genetic markers were found to distinguish between two of the ingroup species. Twenty-one genetic markers were found that separated the outgroup from the ingroup taxa. Preliminary results show that it is possible that less species exist than described. This result will be verified by DNA sequence analyses.

Breeding behaviour of the Afro-Asian Anabantidae with special reference to the southern African *Sandelia* species.

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An understanding of the breeding behaviour of the two southern African *Sandelia* species is an important link in furthering our understanding of the interrelationships of the Anabantidae. The members of the Anabantidae have previously been split into two major breeding behavioural groups, the bubble nesters with brood care and the other group consisting of species such as the Asian *Anabas* spp. and some of the African *Ctenopoma* that have no nest or brood care. Within the *Ctenopoma* complex both groups are present. The brood care group build bubble nests and take care of the young such as *C. intermedium*. Theo ther group have a brief courtship display, release their gametes near the substratum without any nest building or subsequent brood care, for example *C. kingsleyae*. Within this last group some of the species have contact organs behind the eye as well as on the caudal peduncle. In the fast swimming (stretched) *Ctenopoma* such as *C. multispine* there are only the anterior spiny patch of scales. There are anterior contact organs on male *S. bainsii* which are not as prominent on the females. *Sandelia capensis* do not have any contact organs at all. The two *Sandelia* species do not fit into either of the two major recognised Anabantidae breeding behavioural groupings. *Sandelia capensis* males make a shallow nest and guard their young. This behaviour does not fit into either breeding style noted above for the *Ctenopoma* species. Recent work also indicates that they do not have the typical anabantoid embrace. After a lengthy prenuptial display the female swims slowly into the breeding arena, contracts, releases eggs and the male then chases her away. Whereas *S. bainsii* has been recorded as having the typical anabantoid embrace. The males of both species of *Sandelia* guard their nests. These new findings add to the previously known 14 apomorphic characters which support the monophyly of *Sandelia*.

Morphometrics as a means of determining reproductive maturity in penaeid prawns.

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Determining the size at which many penaeid species attain maturity is complicated by the inability to distinguish first-time from repeat spawners. In addition, obtaining information on certain deep water species, like *Haliporoides*, has been confounded by poor evidence of ovary development. A useful tool in maturation studies would therefore result if it could be shown from body measurements that changes in proportions coincide with the onset of maturity.

Evidence of such a relationship is suggested by changes which have been found in the abdominal length - carapace length relationships of *Penaeus indicus* and *Metapenaeus monoceros* respectively. In both instances, the relationships are represented by inflected linear regressions with the inflection point at 39mm carapace length in *P.indicus* and 34mm in *M.monoceros*, corresponding to size at maturity as reflected by ovary condition. The study needs to be extended to other species for confirmation that this is indeed a reliable indicator of the attainment of maturity.

The benthic community of Richards Bay Harbour.

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Richards Bay Harbour and Durban Harbour together handle roughly 75% of all incoming and outward-bound ship-borne cargo in South Africa. It is clear that the Richards Bay Harbour will in future play an important role in the economic growth of KwaZulu-Natal and South Africa as a whole. Harbours also play an important ecological function in providing sheltered refuges, nursery grounds and feeding areas for a wide array of marine and estuarine dependant organisms. A baseline study was undertaken for Portnet in order to determine the state of various biotic communities within the Richards Bay Harbour. In the light of the future development that is planned within this harbour, the data would be important in order to determine any future impacts on the natural environment. Quarterly benthic samples were collected at nine sites from April 1996 to December 1997. In terms of abundance the benthic community was dominated by polychaetes. Temporal and spatial variability in community composition were related to natural as well as anthropogenic factors. It would appear that the benthic community of the Richards Bay Harbour was very diverse, and thus merits further study when planning future development within the harbour.

The efficiency of sass4 rapid bioasessment in determining the health of aquatic ecosystems in kwazulu-natal

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A KwaZulu-Natal river was studied by applying the SASS4 rapid bio-assessment protocol. SASS4 (South African Scoring System Version 4) was assessed in terms of its adequacy in determining the health of aquatic ecosystems. An attempt was made to test a new proposed method of reference site selection. It was however found that this method could not be applied to rivers in the study area due to inappropriate SASS4 and ASPT mimima as identified by in recent research. The ability of indices used in the SASS4 rapid assessment protocol to detect changes in community structure was tested by non-parametric multivariate methods. It was found that the biotic indices ASPT, SASS4 and number of taxa were able to distinguish changes in community patterns but that the secondary Habitat Quality Iindex (HQI) was unable to accomplish this. The influence of spatial and temporal patterns in community structure, taxonomic resolution, additional families and relative abundances on SASS4 results, were investigated by using non-parametric multivariate methods. It was found that incorporating higher taxonomic resolution, relative abundances, and additional families respectively did not make a significant change to SASS4 results. The ability of the SASS4 rapid assessment protocol to detect changes in physical chemical water quality was tested by comparing results obtained from the classification of sites on the basis of physical chemical water quality and in terms of the macroinvertebrate community respectively. It was found that in the case of communities dominated by tolerant taxa, slight changes in water quality did not affect community structure and thus SASS4 scores. Results also indicated that changes in flow and the subsequent change in conductivity and TDS seemed to be the most important driving variable in the KwaZulu-Natal river system studied. Recommendations in terms of regional specific alterations to the SASS4 protocol are discussed.

RED DATA FISH IN KWAZULU-NATAL

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Twenty-one Red Data fish species were recorded from KwaZulu-Natal by Skelton (1987), including six estuarine and 15 freshwater or freshwater-tolerant species. This paper considers the distribution and abundance of our Red Data fish species and presents comments on their conservation status. Some species, particularly the estuarine ones, have been recorded very seldom, probably because most of our estuaries have been poorly surveyed. However, that situation is now improving. On the other hand freshwater species such as *Clarias theodorae*, *Hypseleotris dayi,Silhouettea sibayi* and *Redigobius dewaali* have recently been found to occur more widely and sometimes in fair numbers. *Pseudobarbus quathlambae* has recently been deleted from the KZN fish list as being either extinct in the province or, more probably, never occurred there. *Hypseleotris dayi* is known to occur from Kosi Bay, where shoals have been seen, to Umtamvuna. Old collections from the Pongolo floodplain have recently been found to include numbers of *Redigobius dewaali*, revealing more about their response to floods. *Silhouettea sibayi* has been found to occur much further south than previously known, although its numbers still appear limited. Populations of *Brycinus lateralis* have been found in the Mkuze catchment, where anglers were even using them as live-bait. Numbers of *Clarias theodorae* have recently been found around Empangeni and the species' southern distribution limit has been extended to the Mhlanga river just north of Durban.

Namibian Intertidal Fauna

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The Namibian shore fauna is distinctly temperate in character and typical of the Benguela system. Three zoogeographical areas are distinguishable :
1. the southern region is continuous with the Namaqua province of South Africa and extends to Silvia Hill
2. a central north temperate zone extending northwards to Rocky Point
3. a transition zone which varies in its southern limit. It bridges the transition from the temperate fauna of the Benguela, to tropical Angolan fauna.
The southern and central areas show different dominant species, zonation patterns and community structure. The Namibian coastline is relatively straight and exposed to heavy wave action; sheltered areas are scanty. Despite the plentiful food supply of an upwelling system, the natural environmental and high variability of the northern Benguela impose stresses on the sessile shore fauna, resulting in low diversity but high biomass.
Interesting correlations to the coastal fauna of the Humboldt system off Chile, and possible influences of the inshore sulphide eruptions, are mentioned.

Biochemical and morphometric variation among two closely related species of freshwater crabs (Decapoda: Potamonautidae: *Potamonautes*) from South Africa:

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A sample programme of freshwater crabs was recently initiated in an attempt to clarify the systematics of this group as freshwater crabs often exhibits considerable morphological variability between populations. The current study on freshwater crabs has to led to the discovery of several new species. Among the species that were recently described is *Potamonautes unispinus*. This species exhibits considerable morphological variation over its

distribution range and is morphologically very similar to *P. warreni*. This sparked a debate as to whether *P. unispinus* is a 'true' species or represents a morphological variety of *P. warreni*. We used nuclear genetic markers (allozymes) to investigate the genetic relationship among these two species. Multivariate statistical analyses were used to quantify the morphological differentiation between these two species. The genetic results indicates that these two taxa are true species, although closely related. The morphological results indicate a close morphological similarity between these two species. The current research on freshwater decapods are of particular relevance as it indicates that the systematics of freshwater invertebrates are particularly outdates and in dire need of study.

The macroinvertebrates of the Cunene River from the Ruacana Falls to the river mouth and an assessment of the conservation status of the river.

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The proposed construction of a second hydroelectric power-generating dam on the Cunene River more than 100 km downstream of the Ruacana hydroelectric power plant will have a major influence on the aquatic biota of this river. In order to assess the potential impact of this impoundment an inventory of the biota in the river prior to this development had to be made. Surveys between November 1997 and November 1998 were conducted at a number of sites along the river as well as along a number of spring-fed tributaries of the Cunene River.

The Cunene River is predominantly swift-flowing with many rapids, chutes and waterfalls along its course on the northern border of Namibia. The macroinvertebrate biota clearly reflect this characteristic and are represented by numerous filter feeding species. Considering the gradient and swift-flowing nature of the river the numerical abundance of filter feeding invertebrates was notably low. Of particular concern in this respect was the dearth of Simuliidae which were only recorded in abundance downstream of the Epupa Falls. The more than one metre daily fluctuation of the water level caused by hydroelectric power generation leaves large areas of riverine substrata alternatively inundated and desiccated on a daily basis. This not only causes a severe reduction of suitable colonisable substrata for sedentary filter feeding macroinvertebrates, but also decreases the self purification capacity of the river.

Besides sedentary and active filter-feeding invertebrates there are also detritus-feeding invertebrates in slower-flowing reaches of the river indicating that sediment deposition and processing in pools is also an important functional ecological activity in the river. The many spring-fed tributaries along the course of the river also harbour a diverse fauna of macroinvertebrates which are very different to those found in the Cunene River. The majority of species identified in this survey represent new distribution records for Namibia and in many instances species new to science.

Water - the common element

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The chief pursuit of all aquatic science is to come to know the rules that govern aquatic systems. In this pursuit many scientists move in the direction of greater diversity, where the laws that govern ecosystem relationships become increasingly confined to specific circumstances. Uncovering these types of laws can provide useful information for specific cases but it is necessary to balance this type of convergent investigation with work that goes in the opposite direction i.e. towards the common laws. Knowledge of these laws is more widely applicable and indeed becomes increasingly so the closer they are to the "centre of the circle". This type of pursuit was, and still should be, the function of the University, which seeks to find the unity in diversity.

This talk will take a philosophical look at the laws, on the causal, subtle and gross levels, that govern water in all its forms. It will seek to illustrate how these laws that make water what it is, spread throughout the natural environment, lending qualities to all systems that are dependent on water. The consequences of disrupting the natural laws of water on these systems will be discussed.

The application of dominant discharge concepts to river management with particular reference to the Mkomazi river.

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This paper attempts to show how the concept of dominant discharge can be applied to South African rivers to aid river conservation and management. The South African Water Bill recognises an ecological and basic human needs reserve. To a large extent, the physical structure of the channel determines the available aquatic habitat, and hence, knowledge of the magnitude and frequency of flows (both in terms of discharge and sediment load) that maintain the physical structure of the channel is required. In a geomorphological sense, the dominant discharge is the discharge, or range of discharges, that is most responsible for maintaining channel equilibrium. Data is presented from a case study of the Mkomazi river in Kwazulu-Natal. The Mkomazi, as yet (a dam is due to be built in the next few years), does not have any major impoundments and as such serves as a good case study of an un-impacted river. Using cross-sectional data, hydrology, hydraulics and salient bed load transport equations, the relationship between channel form and bed flow discharge is determined. The determination of the dominant discharge for the Mkomazi is discussed in the context of contemporary international thinking. It is argued that the concept of dominant discharge can be used to aid the management and conservation of South African rivers.

Vegetation, hydrology and sedimentation patterns on the major distributary system of the Okavango Fan, Botswana: Control of a river system by vegetation.

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Classification of the most widespread vegetation communities in the channel fringes of the Okavango and Nqoga Rivers, which presently represent the major distributary system of the Okavango Delta, is described in this study. Eight communities were recognised, dominated respectively by *Pennisetum glaucocladum*, *Phragmites mauritianus, Cyperus papyrus*, *Cyperus papyrus* and *Miscanthus junceus, Miscanthus junceus, Imperata cylindrica, Pycreus nitidus* and a mixed bog community. The distribution of these channel margin communities is explained on the basis environmental characteristics. Factors affecting vegetation distribution include patterns of water loss, sediment deposition, variation in the duration and depth of flooding, fire, nutrient availability and historical changes in water flow.
The plant community dominated by *Phragmites mauritianus* occurs largely in the Panhandle where channel margins have a high clay content, and where the soils are aerially exposed for lengthy periods. Fires are widespread in the Panhandle, and these destroy species that have aerially exposed shoots, such as *Cyperus papyrus*. In contrast, *C. papyrus* dominates in situations where it can colonise areas of open water in the channels in the Panhandle, where current velocities are sufficiently low to enable the extension growth of papyrus into the channel. This situation exists in areas where channel avulsion has recently taken place and where discharge has been reduced substantially as a consequence of flow being diverted into an alternative channel. As such, channel width in these areas is controlled by the growth of

papyrus in the channel margin. Papyrus also dominates the middle and lower reaches of the Nqoga River, where the deposition of bed-load sediment leads to channel aggradation. Papyrus is ideally suited to a gradually rising water level as it grows as an entangled mat of rhizomes which do not necessarily need to be rooted in a fixed substratum.
The occurrence of the community dominated by papyrus in areas where water is being lost from channels, promotes sediment deposition within channels, and results in increasing water loss. Over time this must account for the gradient downstream along the channel axis becoming progressively shallower. As such, papyrus exerts a major control not only on channel width, but also on gradient.

Miscanthus junceus occurs in areas where the nutrient status of water is low, where seasonal changes in water level are negligible, and where the water level is constant in the medium term (decades). It occurs some distance from the channel on the upper reaches of the Fan, and progressively closer to the channel downstream, such that it is the dominant channel fringe species on the Maunachira River in the distal reaches of the study area. This pattern of distribution is similar for communities dominated by *Imperata cylindrica* and *Pycreus nitidus*. This suggests that environmental gradients (probably nutrient supply) at right angles to the channel axis of the major distributary channels are steep, and that they are mirrored by long range environmental gradients downstream. This illustrates the importance of channels as systems which deliver water and nutrients to distal channel reaches.

Energy dynamics of two contrasting estuaries on the south coast of South Africa

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The energy dynamics of two hydrodynamically contrasting estuaries, the Kariega and Great Fish River estuary, along the south coast of South Africa were investigated. The two estuaries differ from one another in respect of their freshwater inflow. The Kariega river estuary is regarded as being a homogeneous marine system as result of its low freshwater impute while the Great Fish river estuary is characterised by high freshwater inflow. Total pigment concentration and daily production in the Kariega estuary were low, generally < 1 $\mu g\ l^{-1}$ and < 1 $g\ C\ m^2\ d^{-1}$, respectively. At all stations in the Kariega estuary, small nano- (2.0- 20µm) and picophytoplankton (< 2.0µm) dominated phytoplankton biomass and production. In the Great Fish river estuary, total pigment concentration was always > 1.5µg l^{-1} while daily production rates generally exceeded 2g $C\ m^2\ d^{-1}$. Microphytoplankton (> 20µm) represented the most important contributor to biomass and production in the Great Fish river estuary. The predominance of small phytoplankton cells and the low productivity in the Kariega river estuary appeared to be related to nutrient availability which is largely mediated by freshwater inflow. Due to the low freshwater inflow, the Kariega river estuary can be regarded as an oligotrophic system. The differences in the contribution of the various size classes of phytoplankton to total biomass and production between the two estuaries has important implications for the food web structure and subsequent energy flow in the two systems. In the Kariega river estuary the microbial loop, comprising bacteria and protozooplankton, appeared to represent the sink for daily phytoplankton production. The microbial loop in turn represents an important source of carbon for the large zooplankton. In contrast in the Great Fish river estuary, metazoans comprising mainly copepods represented the most important grazers of daily phytoplankton production. The implications of the different food web structure for the two estuaries are discussed.

Biogeography of the south Atlantic and Atlantic sector of the Southern Ocean

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The surface distribution of phytoplankton and zooplankton in the south Atlantic and Atlantic sector of the Southern Ocean was investigated during eight cruises of the South African National Antarctic Programme (SANAP) conducted over the period 1992 to 1998. Numerical analyses identified distinct plankton communities in the various water masses separated by oceanic fronts. There is also some evidence to suggest that unique plankton communities are associated with the fronts proper. The analyses suggest that the major permanent biogeographic barriers to the distribution of plankton species in the Southern Ocean are the Subtropical Front (STF), the Sub-antarctic Front (SAF) and the frontal region associated with the most northern extent of the winter sea-ice, the so called "Ice Front". In the high Antarctic region, the seasonal sea-ice which can extend as far north as 55°S, appears to be particularly important in structuring the plankton community size structure and species composition. In the permanently open waters, however, spatial covariance between temperature, water column stability and nutrients appear to be the main factors accounting for the differences in the plankton community structure in the various water masses. The fronts themselves are thought to represent important barriers due to their strong horizontal gradients in temperature and salinity. Oceanic processes such as eddies, particularly in the region south of Africa, and/or cross frontal mixing resulting from variability in mesoscale oceanographic conditions facilitate, the transfer of planktonic species across the strong biogeographic barriers represented by oceanic fronts. These features are also responsible for the inter-annual variability in the biogeographic zonation in the Southern Ocean.

Implementation of the Grassroots Communication and Environmental Education (GCEE) of the River Health Programme (RHP) in Cork Village, Hazyview, South Africa: A pilot study.

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Historically, water resources in South Africa were not easily accessible to grassroots communities. This has since changed and water has been recognised as a natural resource that belongs to all people and that everyone has the right to equal access to it. However, because water is scarce, the management and protection of water resources is necessary to ensure sustainability of the water resources. There is a need to educate water users especially grassroots communities on basic water awareness and generating a sense of responsibility and ownership of our water resources.

The River Health Programme (RHP) is a collaborative effort by several government departments, universities and consultants, which aims at using standardised and proven scientific techniques to measure the health of all major rivers in South Africa. The Grassroots Communication and Environmental Education Programme (GCEE) is a component of the RHP which aims at informing grassroots communities on the RHP programme and other water-related issues. This is in accordance with the National Water Act which states that any matter connected with water and water resources should be made available to the public.

The communities dependant on the rivers that are studied in the RHP are targeted by the GCEE. A set of criteria was developed for the selection of a suitable community. These include:

1. that the community lies within the target catchment area;
2. the community is situated next to one of the rivers where active biomonitoring is occurring;
3. the members of the community have the willingness, ability and readiness to participate in the programme.

The Sabie, Crocodile and the Olifants rivers were selected for the development of procedures for regional implementation and maintenance of the RHP. Three communities were identified, of which Cork village was selected for the pilot study for the implementation of GCEE. Cork village is situated 15 km west of the Kruger National Park just outside the town of Hazyview, close to the Sabie River.

Several meetings with the local leaders of the Cork community were held. There was a need to establish the relevance of the RHP to the needs of the community. A workshop was held where the needs and as well as other potential constraints were identified by means of using the Participatory Rural Appraisal Method and Participatory Mapping.

AZOLLA IN SOUTHERN AFRICA: THE THREE GRACES

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Azolla filiculoides is the world's smallest and economically most useful fern. It is utilised extensively as a green manure, especially in rice paddies, since it has a symbiotic cyanobacteria *Anabaena azollae*, which fixes nitrogen. More scientific publications have been written about this aquatic fern than about any other fern. Worldwide there are six species of *Azolla*, three of which occur in southern Africa: *Azolla nilotica*, *Azolla pinnata* var. *africana,* both indigenous, and *Azolla filiculoides*, introduced from South America. This alien species was first observed in the Colesberg area in 1949, where it remained fairly dormant until the late 1980s when it suddenly started spreading. Presently it is invading the subtropical areas of South Africa, Malawi, Zambia and Mozambique. Rare and endangered aquatic species are being threatened, farmers suffer stock losses due to drowning, animals refuse to drink the infested water and pumps are blocked. Biodiversity of the aquatic habitat is drastically reduced by the presence of *Azolla filiculoides.* Why is a plant that is acclaimed worldwide as economically the most useful fern causing such destruction in southern Africa? Before an answer could be found, a biocontrol organism was released in 1997 in an effort to control this invasive fern. The state of the *Azolla* species in southern Africa now depends upon the three graces, namely:

FAITH: Faith that the *Azolla* species, indigenous to the African continent, especially *Azolla nilotica*, survives the whole ordeal.

HOPE: Hope that an international monitoring programme would be established soon to understand the main causes of *Azolla* behaviour in southern Africa, helping the biocontrol agency to develop more accurate measures in the field and to conserve the indigenous species, before the "*Azolla filiculoides* nightmare" ends up as an environmental disaster detrimental to the aquatic environment of southern Africa.

CHARITY: With very careful management these aquatic ferns, especially *Azolla pinnata* var. *africana,* can "provide" a continent suffering from continuous famine the means to grow better,

cheaper food. The strain of *Azolla filiculoides* in South Africa has a higher nitrogen fixation capacity and nitrogen content than other strains. With discreet cultivation and management this strain could further relieve food shortages in other countries where it is not a problem plant.

Freshwater crabs (Brachyura, Decapoda, Potamonautidae) of KwaZulu-Natal, South Africa.

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A study was initiated in 1992 to broaden taxonomic knowledge of freshwater crabs of the southern African subcontinent, and to determine the extent of morphological and genetic differentiation between and within these taxa. This talk represents a summary of the focus of the broader project on KwaZulu-Natal.

Populations of *Potamonautes sidneyi* and an unidentified form were collected from patches of swamp forest in northeastern KwaZulu-Natal. The two forms were genetically distinct, with fixed allele differences indicating reproductive isolation of each form in the sympatric populations. The unidentified form is described as *Potamonautes lividus*. Two morphotypes from the upper tributaries of the northern Drakensberg were originally identified as *Potamonautes depressus depressus*. However, genetic analysis revealed four distinct taxa, with fixed allele differences indicating reproductive isolation between these groups. The southernmost taxon was identified as *P. depressus depressus*, with the northernmost form being regarded as a new species, *Potamonautes clarus*. Abrupt changes in allele frequency and the presence of hybrizymes suggest that the taxa from intermediate localities may have a reticulate or introgressive origin.*Potamonautes sidneyi* is thought to form a morphological cline with *Potamonautes perlatus* from the Western and Eastern Cape. This was investigated genetically using 26 populations collected along a 2,300 km transect. Allele frequencies suggest a diffuse species boundary in the Eastern Cape. Moderate genetic differentiation in *P. sidneyi* is evident between the lowland populations and the Drakensberg populations. Five species of river crab are presently recognized from KwaZulu-Natal, with three of these being endemic.

Modelling Water Quality in Dams in the Umgeni Water Operational Area

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Based on numerous years worth of water quality (including algal) data available at Umgeni Water this study was undertaken to better understand the water quality relationships in lakes within the company's operational area. The broad aims were; to identify the key environmental variables that were affecting algal populations in lakes, and if these were significant; to establish predictive models relating algae to the water quality. Semi-quantitative statistical models were developed relating algal abundances with key elements in their environment. In most cases, the models developed were related to algae that were known to adversely affect water treatment. This was through the algae producing either taste and odour forming compounds (requiring advanced water treatment e.g. use of activated carbon), or their ability to clog sand filters and so reduce filter run times (requiring more frequent back washing of sand filters). Each set of analyses and models revealed a different aspect of how environmental variables were influencing the distribution and abundance of algae. Interpretations were then made about the conditions favouring problematic algae.

The habitat integrity status of the Sand River, Free State Province, South Africa.

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The riparian zone and instream habitat integrity of the Sand River were assessed based on the qualitative procedures developed by Kleynhans (1996). The major disturbance factors that were assessed include water abstraction, flow regulation, inundation and water quality. Other disturbance factors also included are vegetation removal, erosion, bed and channel modification, exotic macrophytes and fauna, and solid waste disposal. It was found that the deterioration of the habitat integrity can be ascribed to water abstraction, flow modification and inundation. This has resulted in the cessation of flow in the river downstream of the Allemanskraal Dam and impacts on the system to the confluence with the Vet River. The poor water quality in the lower section of the catchment also adds to the deterioration of the instream habitat integrity. Other factors affecting the habitat integrity are erosion in the upper catchment, exotic vegetation and the impact of the urban developments in the Virginia urban and mining complex.

Two calanoids, two lakes - and a decade or two. An update on species switches, seasonal alternations, colonizations and local extinctions of *Tropodiaptomus* and *Metadiaptomus* in Midmar and Albert Falls.

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Records of species switches and seasonal alternations in co-existing populations of *Metadiaptomus meridianus* and *Tropodiaptomus spectabilis* determined during comparative studies of Lakes Midmar (29 ^{o} 30 ' S, 30 ^{o}12 ' E) and Albert Falls (29 o 26 ' S, 30 o 26' E) between 1989 and 1999, along with historical records for Midmar extending back to 1978, are updated (from Hart 1994) and re-evaluated in light of subsequent and additional findings. In the longer term, an "exclusive" occupancy by one or other species has been maintained in these and other inter-leading impoundments on the quasi-subtropical Mgeni River. Sympatry was either brief (as in several transitional in Midmar), or, when protracted over several years (1990 to 1994 in Albert Falls), involved seasonal separation. Possible influences of parasitism, changes in water turbidity or *p*H, dependent or independent of inter-basin water transfers, and such water transfers of themselves, are explored and rejected as proximal causes of species replacement.

Experimental studies of demography reflect remarkable similarity in competitive potential (as measured by food thresholds for population increase), although ontogenetic differences in carbon incorporation rates were revealed especially between naupliar stages of the two species, in which *T. spectabilis* performed better. Species abundances also differed *in situ* according to turbidity, with *M. meridianus* appearing more tolerant of higher suspended sediment load. Discrimination between resting and subitaneous eggs in both preserved and live samples provides little evidence that emergence from diapause could serve as a source of re-colonisation. The guild complement of invertebrate planktivores is comparable in both lakes. While, as argued previously (Hart 1994a, b), allopatric occurrences and seasonal separation in sympatry are consistent with marginal differences in the species' thermal optima, no causal explanation for the species replacements observed in Midmar, apart from the untestable influence of accidental human translocation, has been substantiated from a decade of study. The dilemma arises of whether or not to continue anticipatory monitoring for an uncertain event?

Groundwater flux in a shallow, temporarily open/closed east coast estuary

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Nhlabane estuary is a shallow, temporarily open/closed system situated in northern Kwa-Zulu Natal. The estuary was included in the Estuarine Flow Requirement study conducted under the auspices of the DWA&F and Mhlathuze Water. During this study the estuary perimeter, volume and bathymetry was determined. Additional data that were available included estuarine levels measured at 10 minute intervals over a period of several months.

The key geomorphological feature in the immediate vicinity of the estuary is the recent (Holocene) age dune cordon, underlain by Pleistocene age sediments. The permeability of the Holocene dunes is relatively high (in excess of 15-20 m per day), which, coupled to the relatively low permeability in the Pleistocene sediments, results in high groundwater flow velocities bounded by the latter sediments. The regional water table for some few hundred metres adjacent to the estuary is of the order of 3.0 mamsl, with gentle slopes towards the high dune areas immediately east and west of the estuary.

Several natural breaching events took place during the study period. In order to calculate flux, four discrete recharge events after breaching events were identified and analysed. In all four events there are two distinct types of flux present. The first event takes place from the lowest level to approximately 2.4 mamsl, and is relatively fast. The second event occurs from 2.4 mamsl to 2.8 mamsl and is relatively slow. There is considerable variation in the rate of recharge over time. When the rate of recharge is plotted over time, and a linear regression performed on the data, a correlation coefficient of 0.95 is found, indicating a high correlation between the rate of recharge and time. Groundwater flux tapers off over time, with the system fully recharged over a period of days. Peak flux was calculated to be of the order of 20 000 cubic metres per day, or 10% of the total volume of the estuary at full post-closure level (approximately 3.0 mamsl). The mechanism of post-closure level control is considered to be driven by the hydrogeological properties of the ephemeral sandbar forming across the mouth linked to the regional groundwater table.

There are several implications for shallow, temporarily open/closed systems. In systems where high fluxes are present, the additional supply of water need to be considered in conjunction with the surface runoff properties of the system. There could be considerable consequences on the estuarine ecology, for example, the nutrient load in the groundwater contribution in this case is negligible, since the area is completely undeveloped in terms of agriculture. That may however not be the case in agriculturally active areas, or where informal sanitary arrangements are in use. It is therefore recommended that South African estuaries be assessed, at least on a regional scale, in terms of their potential groundwater fluxes, and that this be included in estuarine flow requirement studies in especially temporarily open/closed systems.

The water quality of the Katse Dam and the implications for drinking water treatment in South Africa.

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The Katse Dam, as part of Phase 1a of the Lesotho Highlands Water Project (LHWP), is the most important reservoir in the whole water project as ultimately all the water that is to be delivered to South Africa passed through this dam and is delivered via the intake tower. The water that enters South Africa is to supplement the water requirements in the industrial heartland of South Africa.

The water quality in the Katse Dam needs to be of an "acceptable quality" according to the inter-governmental treaty signed in 1986. In order to determine the water quality of the Katse Dam during its filling phase Rand Water (the major user of the LHWP) and Lesotho Highlands Development Authority (LHDA) have been collaborating in a monthly limnological monitored programme since May 1996.

The broad objectives of this monitoring programme are to determine the following:-

to establish the water quality of the feeder rivers,
to establish the water quality of the dam at different sites and depths,
to establish the quality of water that is to be transferred to South Africa,
to detect pollution in the dam,
to train LHDA staff in sampling, equipment operating and maintenance, data management and motor boat operating,
promote a good working relationship between LHDA and Rand Water staff, and
to periodically report and discuss the status of the water quality.

The water quality results for the Katse dam and major tributaries for the period May 1996 to May 1999 will be presented in this presentation. The trends of the first three years will be extrapolated to predict the mature water quality status of the dam, taking into account the proposed development along the shores of the dam. The current treatability, of the Lesotho water delivered to South Africa, to international drinking standards will be discussed. Rand Water's future planned treatment options and transfer schemes will be presented as well as these cost estimates.

The primary freshwater fishes of the Cape Floristic Region: conservation needs for a unique and highly threatened fauna

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Distribution records and associated information of primary freshwater fishes of the Cape Floristic Region (CFR) were reviewed to identify biodiversity hotspots and determine an appropriate conservation status for these fishes. This review forms an important part of the ongoing Cape Action Plan for the Environment (CAPE), a strategic biodiversity conservation planning exercise for the CFR which is funded by the Global Environment Facility.

The review showed that 16 of the 19 indigenous freshwater fish species of the CFR are endemic and 73% of species are threatened. Forty one river areas were identified as being of significant importance to the survival of these species with the Olifants, Breede, Gourits and Gamtoos River systems having most of these. Formal conservation areas, particularly provincial nature reserves, play an important role in conserving these fishes (17 of 19 species recorded here) although significant deficiencies are present. Other constraints to conserving these fishes were highlighted, in particular insufficient capacities and funding at conservation agencies.

The review showed that freshwater fishes are a priority group for conservation in the CFR. The successful implementation of CAPE offers perhaps the best opportunity for securing their future.

Research, conservation and management of ephemeral waters in southern Africa: a Namibian perspective.

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Ephemeral and intermittent rivers drain more than a third of the Earth's land surface. Despite their abundance, however, comparatively little is known about their ecological functioning relative to their more mesic counterparts. Dryland rivers may support much of the regional biodiversity while simultaneously supplying water and other resources essential for human occupation. Faced with increasingly scarce resources and rapidly growing human populations, an understanding of their ecosystem dynamics is essential to guide effective management. We studied a series of ephemeral rivers within the drylands of western Namibia. Current concepts of lotic ecology, such as resource-spiraling and flood-pulses, provided hypotheses to examine these ephemeral river systems. In contrast with perennial systems, mean annual discharge decreases in a downstream direction, giving rise to distinct patterns of materials transport and disturbance important in structuring ephemeral river ecosystems. Although biological communities and ecosystem dynamics are dominated by terrestrial biota, they are maintained by fluvial processes such as flood-pulse interactions between the channel and floodplain. Resource spiraling was observed but material transport, which occurred during floods, was uncoupled from material processing, which occurred terrestrially, after flooding. Nonetheless, the ecological significance of retentive obstacles and associated organic debris is clearly a feature common to all fluvial ecosystems, irrespective of their hydrologic regime. Given that a strong link exists between the hydrologic regime and the distribution and abundance of organic matter and moist microhabitats, the frequency and magnitude of flood pulses are a key determinant of decomposition and secondary production within ephemeral river ecosystems. Changes in the hydrologic regime of ephemeral rivers, particularly decreases in the frequency and magnitude of flooding, will thus have a severe negative impact on the biotic communities within these water-limited fluvial ecosystems. Such changes will not only alter organic matter transport and retention patterns, shifting the distribution and availability of key resources (i.e., food and habitat), but will also disrupt the biological and physical processing of organic matter. In turn,

any alteration of the hydrologic regime will produce a concomitant shift in the structure, productivity, and distribution of these fluvial ecosystems.

An increasing body of evidence suggests that the natural flow regime of virtually all rivers is inherently variable, and that this variability is essential to the maintenance of ecosystem structure and function. To protect and properly manage fluvial ecosystems, it is necessary to preserve their natural flow regime. Herein lies the greatest challenge for the road ahead, as we attempt to maintain the natural flow regime while simultaneously satisfying growing human water demands.

THE ZOOPLANKTON OF RICHARDS BAY ESTUARY 25 YEARS AFTER HARBOUR CONSTRUCTION.

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Construction of the harbour at Richards Bay started in 1970. During that time, before any major constructional changes occurred, quarterly quantitative zooplankton samples were collected by Grindley and Wooldridge (1974). The harbour was constructed in the northern section of the estuary with the original mouth now serving as the entrance to the harbour. The southern section of the original estuary was earmarked as a "sanctuary" area with no development. A new mouth was constructed and the Mhlathuze estuary canalised to flow into the new estuary.

For the present study a series of monthly, quantitative zooplankton samples were collected during 1996 and 1997. The zooplankton community structure as represented by these samples is compared to that of the pre-harbour community. Already before construction of the harbour tidal exchange was singled out by Grindley and Wooldridge (1974) as the most important controlling factor of the zooplankton community. Results of the present study suggest that this situation was aggravated after construction of the new estuary. Siltation led to increasing restrictions of the available open water body. A permanent salinity gradient along the axis of the main water body is not evident. The estuary is at present marine dominated with a strong tidal exchange, which prevents the establishment of a healthy estuarine zooplankton community.

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Using Multi-Criteria Analysis in Catchment Management: Sand River case study

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Recent studies have found that multi-criteria analysis (MCA) techniques can provide support to organisations involved in catchment management activities. This support comes from structuring problems and making them manageable, providing information to decision-makers about the trade-offs implied by different choices, and by allowing meaningful participation of stakeholders in the analysis of alternatives. We worked with a team who had been tasked to develop an integrated catchment management plan with associated landcare and water conservation plans for the Sand River catchment, Mpumalanga. Some techniques of MCA and scenario based planning were used to develop and analyse hypothetical land-use scenarios for the catchment. The consequences of the scenarios were examined in terms of terrestrial and aquatic ecology, profits and income earned from different land-uses both formally and informally (through harvesting of secondary and natural products), levels of

employment and other social consequences. These issues formed the criteria by which the scenarios were evaluated by the project team. The quantitative or qualitative evaluations were based either on data arising from the study and previous studies or on the expert opinion of the relevant project team member based on their previous experience and work in the area. The evaluations could be integrated to allow preferred scenarios or "directions of preference" to be identified for different zones in the catchment to guide future decision makers. In work carried out subsequent to this project, other multi-criteria techniques (so-called "filtering" techniques) are being developed which will allow new scenarios to be evaluated relative to these, without the necessity of all the project team meeting again. Once initial evaluations have been performed, the filtering technique allows any new scenario introduced, to be categorised as falling within the preferred area or not. These MCA and associated techniques closely resemble common-sense approaches used in various applications, the main advantage being that the theoretical basis may help to avoid some of the pitfalls of less rigorous approaches. The use of MCA, scenario based planning techniques and the new filtering approach should find potential applications in a wide variety of water management fields such as catchment planning, the determination of Instream Flow Requirements and the Reserve, and the prioritisation of rivers or estuaries. Some thoughts on these are briefly mentioned.

Instream flow assessments for the Lesotho highlands water project: Incorporating hydraulic habitat data

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The Orange River flows through southern Africa. A main objective of the Lesotho Highlands Water Project is to dam in Lesotho several headwater tributaries of the Orange River, and transfer the water to South Africa. In 1997, an international team of river scientists began an instream flow assessment for the rivers downstream of the one extant dam and of further planned dams. The South African Building Block Methodology is being used for the assessment, with refinement of some components, including that dealing with instream hydraulic conditions.
For each of eight strategically placed river sites, hydraulic conditions are described in three main ways. Each site is mapped and then digitised at fine scale, producing distributions and proportions, on a base map, of eight substratum categories and, on an overlay map, of 14 categories of visually distinct flow-type. Additional flow-type maps are produced for a range of discharges. To inform on water depths, up to six cross-sections are also surveyed in at locations chosen by the team, and stage-discharge relationships developed. Finally, to provide more detail on the rest of the site, three major areas of different hydraulic conditions are delineated. In each, hydraulic and relevant ecological data are recorded from a matrix of grid points, over a range of discharges.
Data from cross-sections and grid points are used to describe the proportions of different depths, velocities and substrata at measured discharges. These data are used by the ecologists to aid assessment of the biotic responses to changes in flow regimes. The final output of the assessment is a number of scenarios, each with its ecological, social and economic consequences.

Establishing and managing Trans Boundary Conservation Areas, with particular reference to the Orange River Mouth

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This paper looks at the establishment and management of nature reserves that cross international boundaries. The Orange River Mouth is a unique habitat in the regional context

due to various biological factors. The Orange River Mouth Wetland Reserve is a planned trans-boundary reserve between Namibia and South Africa. Various aspects that need to be taken into consideration to establish this reserve, such as cooperation between two sovereign countries and financial input are discussed. Since the Orange River Mouth is the "endpoint" of a river catchment covering almost one million square kilometres, this brings with it some unique management problems. Some of these are local, e.g. law enforcement, whilst others are regional, e.g. water supply. These problems are discussed with the draft management plan as a background.

WATER QUALITY OF THE MODDER RIVER

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The Modder River is a relatively small river which drains an area of 7 960 km^2, in the central region of the Free State Province, South Africa and has a mean annual runoff of 184 x 10^6 m^3. Botshabelo is a city, which was developed in the catchment area of the river, and its sewage outflows are discharged into the Klein Modder River, a tributary of the Modder River. This study was conducted in order to determine seasonal and spatial patterns in the system, the influence of Botshabelo's sewage outflow on the water quality of the river, as well as the presence of any toxic compounds. It was determined that the Modder and Klein Modder Rivers do not follow distinctive seasonal patterns in terms of chemical parameters, however, NO_3-N and PO_4-P concentrations usually increased with increasing flow. Physical parameters such as turbidity, flow and temperature followed distinctive seasonal patterns. Phytoplankton growth also showed distinctive seasonal patterns, with low chlorophyll-*a* concentrations in the winter and higher during spring, when temperatures became more favourable. In the Klein Modder River, algal blooms occurred more frequently, and the algal biomass was higher than in the Modder River. This could be ascribed to the higher nutrient concentrations and lower flow velocities in the Klein Modder River. There were periods when the nutrient concentrations in the waters of the Modder and Klein Modder Rivers were low. However, treated wastewater discharge from Botshabelo led to enrichment of the water. The inflow of the Klein Modder River into the Modder River caused on average, a 112% increase in PO_4-P, a 171% increase in NO_3-N and a 50% increase in chlorophyll-*a* concentration. Based on toxicity tests performed with *Selenastrum capricornutum* and *Daphnia pulex*, no high concentrations of potentially toxic compounds were found in either the Klein Modder or Modder Rivers. Bacteria concentrations were high in both rivers and may pose a threat to human and animal health.

MANAGEMENT OPTIONS OF LAKE VICTORIA

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Lake Victoria with its 30 million inhabitants in the riparian region is facing management problems. The Nile perch (*Lates niloticus*) which was introduced in 1958 increased the productivity of Lake Victoria from150,000 metric tons to 500,000 metric tones. Meanwhile it destroyed the fisheries biodiversity from about 300 species to hardly 10 species today. Water hyacinth which was first sighted in Lake Kyoga in 1987 is now estimated to occupy 10,000 km2 of Lake Victoria. It is impeding fishing, navigation, hydroelectric power generation and has rendered the water unfit for domestic use. At present there is a World Bank funded Project which aims at restocking the Lake with "lost" fish species. It is still not clear whether the restocked "lost" fish species will be safe from the voracious predator when even its stock remains unknown. The occurrence of water hyacinth is now very closely associated with the emergence of "lost" fish species e.g. *Protopterus aethiopicus* (Lungfish), *Labeo* spp (ningu),

Schilbe spp (nembe), *Bagrus docmac* (Semtundumboja), *Alestes* spp (Sire), *Clarias gariepinus* (Kambale), all of which were considered delicacies in the region. The question now is whether water hyacinth should be removed completely or some should be left to act as refugia for the "lost" fish species.

BEYOND INSTREAM FLOW REQUIREMENTS (IFRs)

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The process of determining Instream Flow Requirements (IFRs), or Ecological Quantity Reserve as now more frequently referred to, has been well developed to the provision of an IFR table which quantifies the temporal distribution of discharge, upon which the modified flow regime is based. During the last 3 years, the process has been further developed by linking the IFRs (using the IFR model) to a historical time series and a natural flow trigger. The current output from an IFR study is a daily or monthly time series which can be summarised as a flow duration curve (FDC) for each month.

It has however become imperative that the liaison between IFR specialists and developers of the methodology should not end here, as some of the most important requirements for supplying the IFR include the determination of the yield of a system as well as the design and ultimate operation of storage structures.

The yield of a proposed project is determined to assess the overall available volume and assurance of supply. The new Water Act has led to IFRs (and basic human needs) to be assessed as a first priority. It is therefore necessary to be able to model the IFRs to determine this yield, and the Water Resources Yield Model (WRYM) has been adjusted to accommodate the IFRs as supplied by the IFR model. Further liaison is also required to investigate whether any small changes in the IFR could have a major influence on the yield of the dam. This is undertaken at the so-called scenario meetings where different IFR scenarios are investigated, the ecological impacts of each specified, and the scenarios ranked. Informed decision-making regarding the final yield of the dam can then be undertaken.

The design of dams has traditionally been undertaken in isolation from the provision of water for the riverine environment. Recent liaison between dam designers and IFR specialists has led to a mutual understanding of the issues and a more integrated process. Designers present the IFR specialists with various options of supplying IFRs, taking into account the IFR requirements, the dam safety considerations, and the manner of supply of water. Issues such as the dam height, the sizes of outlets, the combination of multi-level outlets and bottom outlets, the necessity of a tailpond dam is considered.

Once the dam design and yield have been established, the actual operation of the dam to supply the IFRs at certain points downstream of the dam has to be considered. The most important starting point is linking the operation of the dam with regard to IFR releases to a natural trigger. Other factors that require consideration include, for example, run of the river abstractions and flood attenuation.

The yield, design, and operations link with IFRs described above are in development and are being incorporated as part of the process of determining the Ecological Reserve. The processes have been applied on the Thukela and Sabie Rivers and these worked examples will be used as illustration.

Global biodiversity of the mayfly family Baetidae (Ephemeroptera): a generic perspective

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Eighty-seven genera of small minnow mayflies (Ephemeroptera: Baetidae) are currently known from throughout the world. Thirty-seven genera occur in the Afrotropics, 27 in the Neotropics, 21 each in the Nearctic and Orient, 14 in the Palearctic, and nine in Australia (including Papua-New Guinea). The Afrotropics currently have 84% endemic genera, the Neotropics 63%, Australia 44%, the Orient 43%, and the Nearctic and Palearctic 14% each. Coefficients of similarity among the six biogeographic regions indicate that the Holarctic (Nearctic + Palearctic) and Orient are most similar in generic composition. The Afrotropics demonstrate considerable insular evolution, but widespread Holarctic and Oriental genera are also found there. The Neotropics demonstrate the highest degree of insular evolution, and although South America essentially has not been colonized by genera from outside its region, certain Neotropical lineages have infiltrated the Nearctic since the Pleistocene. Australia remains poorly documented, but available data suggest that it has been considerably influenced by dispersal from the Oriental region. Problems and prospects for the further study of the global biodiversity of baetids are discussed. Baetids from the now poorly known areas of western Africa, Australia and India in general, and northeastern South America may significantly add to an overview of diversity and biogeography of the family.

The potential impact of reduced river runoff on the macrobenthic fauna of the Thukela estuary

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The increased demand on South Africa's freshwater resources has emphasised the urgent need to determine the effects of a reduction in surface water supplies. A study to ascertain the freshwater requirements of the Thukela Estuary was commissioned to determine abiotic and biotic responses of the system to a potential reduction in flow and increased frequency of mouth closure. This paper reports on the results of monthly macrobenthic surveys from April 1997 to March 1998. The purpose of the study was to predict the effects of reduced runoff scenarios and mouth closure on the macrobenthic fauna. To achieve this a comprehensive data set of the fauna was required, and spatial (distributional) and temporal (seasonal) variability of the communities had to be ascertained.

Although not rich in estuarine species or as abundant as other systems along the same stretch of coast, the macrobenthos was not as depauperate as was previously thought. The Thukela was found to support in excess of 150 taxa of which the majority were freshwater in origin. The dominance of the freshwater component was a function of the physical state of the estuary. The presence of estuarine fauna in lower densities was ascribed to their recruitment via the mouth during periods of decreased river flow, and a corresponding increase in tidal influence. None of the macrobenthic species recorded were considered unusual or atypical of any other local freshwater dominated system. Unique to the system, was that these freshwater fauna were entirely dominant in what was the 'estuarine' area of the system.

It was estimated that a reduction in freshwater flow and a corresponding increase in the salinity regime would result in the loss of current macrobenthic assemblages. The colonising fauna responding to the alteration of the physico-chemical environment would be estuarine dominated, and have a species composition similar to other estuaries in the area. Besides a complete change in the state of the macrobenthos, no other major effects of reduced runoff were envisaged. However, reduced flows resulting in mouth closure would severely limit

recruitment from the marine environment, eventually resulting in a very poor representation of estuarine species.

The Thukela is the principal river system in KwaZulu-Natal, the only river mouth opening into the Indian Ocean within South Africa and supports a fairly diverse faunal population. Its conservation status should therefore be high with a management plan that heeds this.

Linking water chemistry and water flow: Towards quantitative predictions of water chemistry

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Through use of instream flow methodologies, estimations of the amount of water required for maintenance of ecological functioning in rivers can be made. Although the Building Block Method (BBM) is well established in South Africa for assessment of instream flows, thus far the effect of changes in discharge on water quality is not adequately addressed. At the moment, predictions of changes in concentrations of chemical components and in levels of physical variables are made purely on a qualitative basis using expert judgement. Since optimum aquatic ecosystem functioning is dependent not only on a suitable hydrological regime, but also on suitable water quality, there is an urgent need to incorporate quantitative prediction methods into the instream flow assessment protocol. This is even more important in the light of South Africa's new Water Act (1998) and will assist in the determination of the Reserve for freshwater ecosystems.

This paper reports on preliminary efforts to predict the effect of changes in flow on the concentration of chemical components and values of physical variables in rivers. As part of a WRC-funded project a literature survey has been conducted to examine flow-concentration relationships and some of the general trends will be discussed. In addition, preliminary simulations from water quality modelling of the Palmiet River (Cape), illustrating the effects of changes in discharge on selected water quality variables, will be presented.

An assessment of the fish population of the lower reaches of the Sanyati River, Zimbabwe.

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The fish population of the lower reaches of the Sinyati River in Zimbabwe was studied using multifilament gill nets. Monthly sampling was conducted over 24 consecutive months. The Shannon-Wiener diversity index was estimated. A total of 16 fish species belonging to 7 families were observed. The most abundant species was the Tigerfish (*Hydrocynus vittatus)*.

There were significant variations in monthly catches and catch per unit effort ($P>0.01$). Inter-annual variations in catches were also observed. The five most common species exhibited a seasonal breeding pattern with most breeding occurring in the rainy season. Significant variations were also observed in the condition of the fish ($p>0.01$). The reasons for the observed patterns are discussed.

Estuaries of Namibia

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The Cunene and the Orange rivers, forming respectively parts of the northern and southern borders of Namibia, are the only perennial Namibian rivers that enter the sea. The two systems are compared with particular emphasis on the ecology and function of their lowermost reaches and mouths. The question as to whether they form estuaries is discussed in the context of accepted definitions of such systems.

Possible effects of climate change on water resources in Namibia, a semi-arid country.

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Namibia being the driest sub-Saharan country, is characterised by semi-arid to arid climatological and hydrological conditions. Rainfall is highly variable, both spatially and temporally, and occurs from October to April as short convective showers.

The middle Kuiseb River, which is situated in the centre of the country, has two identified potential dam sites, which were selected to study the possible effect of climate change on available water resources.

A rainfall - runoff model, **NAMROM**, which takes into account a negative inter-seasonal runoff correlation caused by vegetation persistence, was calibrated and run for the proposed dam sites and safe yields were determined for each of them, Like the other western flowing rivers in Namibia, the Kuiseb River sustains sensitive environments, on which the establishment of a major impoundment may have adverse impacts. The model was therefore also used to analyse the effect of the presence of each of the dams on the flows downstream of the dam, both in frequency and in magnitude.

Following the original analysis, the **NAMROM** program was modified to be able to simulate reduction in rainfall. The rainfall - runoff model was re-run with a range of reduced rainfalls to estimate the changed runoffs and safe yields. Typical runs showed that a reduction of 5% rainfall might reduce runoffs and safe yields of the dams by 5-10%. This reduction is more than proportional due to the non-linear relation between rainfall and runoff, but it is also not exponential, because the model incorporates that lower rainfalls result in less vegetation interception and a higher runoff potential.

Training in aquatic sciences in the SADC region: experiences from the University of Namibia.

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Few studies have been devoted to quality and relevance of training in aquatic sciences in the SADC region.

Given the historical developments, it is understandable that various paths have been followed to develop institutions of higher learning in aquatic sciences. However, not many of the programmes receive critical review of their relevance to changing needs.

Recent experience at the University of Namibia show the value of regular evaluations to upgrade and re-structure the courses in order to maintain relevance and keep pace with changing fisheries regimes. In some courses, this might involve harmonisation of artisanal and commercial fisheries aspects, while in others it might make sense to include management and socio-economic aspects. Furthermore, the discussion concerning broad-based versus more specialised orientation at undergraduate training has not been sufficiently advanced to benefit those institutions who plan to include aquatic sciences in their programmes.

Perhaps this association provides a good forum for such discussions.

A comparison of indigenous macroinvertebrates and *Daphnia pulex* in acute whole effluent toxicity testing

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A purely chemical analytical approach is unable to protect the aquatic environment, especially as some chemicals may be present at levels too low for detection but could have an adverse effect in the environment. Bioassays, complemented by chemical analysis, are essential tools for the assessment of effluents: both biological and chemical data together are important for the management of the quality of effluent and receiving water bodies. Several overseas countries have implemented strategies to reduce the toxicity of effluent by including whole effluent toxicity tests in effluent permits to ensure that the permitted discharge levels do not adversely affect aquatic life. The objective of these toxicological assessments for effluent discharge permits is to maintain, or improve, the quality of the receiving water. The permits are site-specific and include specification on the frequency of testing, the organism/s to be used and the LC50 for the effluent.

Aquatic toxicity tests in South Africa have traditionally used standard laboratory test organisms, *e.g. Daphnia pulex*, although it is not yet certain whether guidelines set using *D. pulex* will adequately protect South Africa's water resources and aquatic organisms. The aim of this project was to investigate the standard laboratory organism, *D. pulex*, and site-specific indigenous macroinvertebrates as biological indicators of water quality in the Vaal River by identifying test industries and assessing the relative toxicity of their effluents using receiving water as the test medium. The role of indigenous macroinvertebrates and *D. pulex* in whole effluent toxicity tests and setting industry and site-specific water quality guidelines were evaluated by carrying out comparative experiments using indigenous macroinvertebrates, in recirculating artificial streams, and *D. pulex*. The application of the use of indigenous macroinvertebrates in the recirculating artificial streams for their inclusion for toxicity testing in effluent permits is evaluated.

Morphological and physiological responses of *Sporobolus virginicus* to flooding.

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Flooding responses in *Sporobolus virginicus*(L.) Kunth., a perennial C4 grass, were examined in a glasshouse study over 42 days. Flooding significantly reduced soil redox potential, induced adventitious root development, shifted resource allocation from below- to above-ground components without affecting total biomass accumulation and significantly decreased below-ground/above-ground biomass ratios. Although soil waterlogging significantly increased alcohol dehydrogenase activity (ADH) after 30h, significant increase in central air space by 45-50% of >the cross-sectional stem area eliminated root hypoxia, and ADH activity decreased to levels equivalent to drained controls after 42 days. In addition, flooded plants exhibited significantly higher carbon dioxide assimilation rates but similar relative growth rates (RGR) to

drained controls. The results indicate that *S. virginicus* responds to flooding by a combination of metabolic, morphological and anatomical mechanisms, which may account for its widespread distribution in coastal lagoons, estuaries and marshes.

Biological Control of *Salvinia molesta* in some parts of Moremi Game Reserve, Botswana

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The Curculionid weevil, *Cyrtobagous salviniae* (Calder & Sands) has long been established in *Salvinia molesta* infested regions of Botswana. The primary study was to determine the intensity of weevil activity in number/kg fresh weight of the weed at the margin and centre of the four sites *viz.*, Paradise Pools, MGR 6 HATAB, Dombo lediba and Khwai streams that fall under Khwai system of the Moremi Game Reserve. The rate at which the weed was controlled varied with the mat density, weevil population, the sites and the different months of the year, 1998. While the biological control at Paradise Pools was always maintained with significant correlations between mat density and the weevil number/m^2, the Khwai streams showed an instability in the control of the weed. The adult weevils remained extremely low at Dombo lediba in the first nine months of 1998 by increasing the mat density but the weevil number surprisingly shot up to 155 at the margin and 457 at the centre of the lediba, crashing down the mat density to absolutely minimum levels. A well balanced control at HATAB with 53 to 78 weevils/kg fresh mats from January to March resulted in the disappearance of the weed from April 1998. The results further revealed that the water temperatures might indirectly influence the weevil activity. The greater effect of *C. salviniae* by detaching roots from the rhizomes and causing damage to buds and leaves when they were present at requisite population, may explain its success as a biological control agent. It is concluded that the natural breeding nurseries of weevils as was observed in Paradise Pools, could have been established in many parts of the *Salvinia* infested regions.

A quantitative assessment of gill net fishing in a sub-tropical lake in the the Northern Province, RSA

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2760 fish were caught during January 1998 to January 1999 using 2 multi-filament gill net fleets consisting of six 15x2m (30m^2) panels with stretched mesh sizes of 30, 50, 70, 90, 110 and 130mm. Gill nets were set in Lake Tzancen (Northern Province) between 16h00 and 18h00 and collected no later than 8h00 the next morning. The water temperature decreased from 28^{0}C in summer to 16^{0}C in winter, while rainfall decreased from 225.1mm in January 1998 (summer) to 9.5mm in August 1998 (winter) and increased again to 440.4mm in January 1999. All fish were identified, with the following species dominating the catches: *Schilbe intermedius, Oreochromis mossambicus, Clarias gariepinus, Barbus marequensis* and 2 mormyrid species (*Petrocephalus catastoma* and *Marcusinius macrolepidotus*).

The fish were then measured to the nearest millimetre standard length (SL) and weighed whole (g), then dissected and sexed. 79% of the total catch of January 1998 to January 1999 consisted of females. Catch per unit effort (CPUE) were calculated monthly (gmh^{-1}) for the same period. The highest CPUE in spring were associated with the lowest dam level, increasing water temperature and increasing rainfall. Whereas, the lowest CPUE were associated with the highest dam level, decreasing water temperature and low rainfall. However, with the same effort (36 hours with 270m net) in January 1999 a significantly low CPUE was found. Reasons for this decline in fish caught are still being investigated,

January, March, July, September, November and December 1998 were dominated by fish with a standard length of 11-20cm. May 1998 was equally dominated by fish with a SL of 11-20cm and 21-30cm. Furthermore, an increasing amount of fish in SL 0-10cm was present during the early months of 1998 and 1999. CPUE are thus influenced by recruitment and gonad development, since all species caught spawn during spring and summer in the rainy season.

Linking ecological stresses to modified flow regimes

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Methods for the assessment of the Ecological Reserve (required by the new South African Water Act) are being developed to determine the water quantity and quality requirements of aquatic ecosystems. Most of the methods in use at present rely heavily on the experience and judgement of a few specialists..

This paper suggests a framework for Reserve assessment methods which will help to reduce the subjectivity and inconsistency inherent in the present methods. The framework is based on risk analysis and linking the flow-related stresses experienced by the riverine biota directly to the hydrology of the system, and at present will be developed for low-flow conditions in rivers, concentrating on the effects on the instream biota (fish and invertebrates).

As base flows are reduced in rivers, habitats become more restricted and the instream biota experience increasing stress. Some species are well adapted to coping with low flow conditions and will experience less stress than others, which require for example fast flowing and/or deep water. IFR specialists have implicitly used this assumption in setting flow requirements for rivers, but have expressed these requirements as thresholds - for example a fish may be characterised as requiring a minimum of 0.5 m depth of water. In fact, the fish may continue to survive in much shallower habitats, but may not grow as fast, or breed as prolifically, or maintain as healthy a state. A more accurate definition of the fish's requirements would be that the risk to the maintenance of the species' life-cycle is increased as the flow is reduced.

This paper suggests some preliminary definitions for a generic stress index which can be applied for different flows to the communities in different reaches of rivers to provide stress curves which describe the increase in stress with decreasing flows. Such stress curves can then be linked to hydrological time series to provide a stress profile, describing the frequency and duration of different levels of stress for any flow regime. Stress profiles for different flow regimes can be analysed statistically to compare the risk to the biota of different flow modifications. Natural flow regimes normally include low flow episodes which cause stress to elements of the biota (equivalent to components of the natural disturbance regime) and a natural stress profile can therefore be calculated against which to test the stress levels caused by present and proposed future flow regimes. Such an analysis will provide the basis for an objective assessment of the quantity component of the Ecological Reserve which will impose the least additional stress to the biota.

The application of the zero emissions research and initiatives (ZERI) concept in an integrated industry-polyculture -farm system in Namibia.

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One major area dealt with by the concept of Zero Emissions Research and Initiative (ZERI) is the utilization of huge volumes of nutrient-rich waters, from household toilets, kitchen sinks, and municipal and organo-industries for integrated purposes. The old Chinese technique has been borrowed which utilizes waste water for growing fish without adding any feed

supplement; various plankton and invertebrates produced naturally serve as feeds for various kinds of fish feeding at different trophic levels. The arrangements at the Tunueni Sorghum Brewery, Tsumeb, Namibia is such that wastewater is utilized in the polyculture of locally available riverine fish species in large (3000 square metres; 120 m long X 25 m wide), deep (3 metres) earthen pond. The waste water, however, passes through a series of biosystem processes, such as mushroom and earthworm beds, pig sty, anaerobic and aerobic digester and algae ponds, before reaching fish ponds. A pH of about 8.0 is desirable for maximum fish production, in the large (9000 cubic metres) fish ponds. Variety of locally available riverine fish species of different trophic levels are desirable for sustainable stocking in the ponds; no feed supplement is necessary. Various plankton and invertebrates are produced naturally as feeds for the various kinds of fish feeding at different trophic levels, avoiding purchase of costly artificial feeds which make fish culture uneconomical. Fish wastes are naturally mineralized in the pond into nutrients, and the nutrient-rich water support phytoplankton, zooplankton and invertebrates all of which promote different trophic food chain, supporting the fish growth.

Physical determinants of the distribution and abundance of the burrowing crab *Paratylodiplax blephariskios* in the St. Lucia and Mhlathuze estuaries, KwaZulu-Natal, South Africa.

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The burrowing ocypodid crab, *Paratylodiplax blephariskios*, is endemic to the south-east coast of southern Africa where it forms an important component of the estuarine benthic fauna in muddy substrata. At St. Lucia, the crab occurs in the tidal portion of the system, called the Narrows, which are characteristically muddy, but does not occur in the lake compartments of the system, which although generally sandy, include areas of mud. The Mhlathuze estuary is much smaller than the St. Lucia system and includes both muddy and sandy substrata. While the nature of the substratum appears to be an important determinant of the distribution and abundance of the crab, this relationship has hitherto not been quantified.

Grab samples collected at eight sites in the St. Lucia Narrows between May 1994 and December 1996, and at seven sites in the Mhlathuze estuary between April 1996 and December 1997 were related to salinity, temperature, distance from the mouth, and sediment parameters including median particle size (phi value), sorting coefficient and organic content. Multifactor analysis of variance and stepwise regression revealed that median phi value, sorting coefficient and distance from the mouth were significantly related to crab abundance in both estuaries.

While crab densities at St. Lucia declined from the lower to the upper Narrows, the substratum was generally muddy along its 20 km length, which indicated that distance from the mouth rather than the nature of the substratum was the main determinant of crab distribution in this estuary. This contrasted with the situation in the Mhlathuze where the substratum was much patchier, with crabs only being recorded from the three muddier sites which were located furthest from the mouth. The combination of median phi value and sorting coefficient provided the best indicator of the distribution of crabs in the two estuaries, and indicated that crabs at St. Lucia could inhabit poorly sorted, fine sand which included a greater mud content than the better sorted fine sands of the Mhlathuze, which were devoid of crabs. The absence of the crab from the St. Lucia lake indicated that its distribution is tidal, and that the crab has an obligate marine phase.

The salinity tolerance of the mayfly *Tricorythus nr. tinctus*, from the Sabie River (Kruger National Park, South Africa): connections with water quality guidelines, thresholds of probable concern, and the ecological Reserve

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Salinity tolerances of a population of the mayfly nymph *Tricorythus nr. tinctus*, collected from a riffle site in the Sabie River, in the Kruger National Park (KNP), South Africa, have been investigated annually since 1994. Nymphs were exposed to elevated salinities (NaCl, Na_2SO_4, KCl, $CaSO_4$, and $MgSO_4$) for periods ranging from 4 days (acute exposure) to 12 days (chronic exposure). Salinity was measured as conductivity (mS/m). These studies revealed that the main stress to the mayflies from increasing salinity was osmotic; that sulphate had an exacerbating synergistic effect; and that calcium had an ameliorative effect, on mortalities. Tolerances (LC_{50} values) differed from year to year, and the mean acute and mean chronic LC_{50} value for NaCl, Na_2SO_4 were calculated, and used to derive the AEV (acute effects value) and CEV (chronic effects value). The derivation of these values is discussed, and the values (AEV - 26.5 mS/m, CEV 9.5-25 mS/m) compared to the 1991 Guidelines for the KNP (16 mS/m); the 1996 South African Water Quality Guidelines for Aquatic Ecosystems (7 - 17 mS/m); and the 1997 thresholds of probable concern (80-90 mS/m). These results are discussed in the context of quantifying the water quality aspects of the ecological Reserve in the National Water Act (no. 36 of 1998) in South Africa.

A comparative assessment of the water quality of the Gwebi and Makuvisi rivers (Harare) based on selected physical and chemical variables and their macroinvertebrates.

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The aim of this study was to assess and compare the water quality of two rivers, the Gwebi and Mukuvisi, within the vicinity of the City of Harare on the basis of selected physicochemical variables and the macroinvertebrate community structure. The water variables analysed were the concentrations of iron, chromium, zinc, lead, copper, manganese, chloride, fluoride, sulphate, total phosphate, nitrate, ammonia, total dissolved salts, dissolved oxygen, biological oxygen demand, as well as the pH, conductivity, temperature and water discharge. On three separate occassions between January and July 1998, water and macroinvertebrate samples were collected from five sites along both rivers. Along the Gwebi River the concentration of most of the variables remained relatively similar, whereas along the Mukuvisi River there were drastic increases in the levels of iron, chromium, chromium, copper, zinc, chloride, fluoride, sulphate, and ammonia. Thus generally, the two rivers were different with respect to the chemical variables. There was a sharp decline in the number of macroinvertebrate taxa along the Mukuvisi River. The lower courses of the Mukuvisi were dominated by the oligochaetes, which are tolerant of oraganic pollution, and the chironomidae, which are toleranat of heavy metal pollution. A biotic index, the South African Scoring System Version 4 (SASAS4) and three diversity indices, the Margalef, Shannon, and Simpsons=s indices where used to analyse the macroinveterbrate communities of the two rivers. Sample score clasasification based on the SASS4 showered that much of the Mukuvisi River had very poor water quality whilst Gwebi River had fair quality. Classification based on the average score per taxon (ASPT) of the SASS4 did not show any differences along and between the two rivers. Both the sample score and ASPT were negatively and significantly ($p<0.05$) correlated to most of the physicochemical variables, although the variables accounted for only 61.1% and 59.0% of the differences in the sample score and ASPT respectively. There was a marginal decrease in the Margalef and Shannon indices along the Gwebi River, but the Simpson=s index remained relatively constant. Along the Mukuvisi River, there was clear and distinct decrease in the

magnitude of all three indices. The variation in the physicochemical variables accounted for 61.3%, 69.2% and 87.2% of the change in the Margalef, Shannon, and Simpson=s index respectively. The study provides evidence that the decline in water quality along the Mukuvisi River has led to changes in macroinvertebrate community structure and reduced diversity. On the Gwebi, water quality has not been the main factor determining macroinvertebrate community structure.

A geomorphological index for the assessment of river health

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An Index of Stream Geomorphology has been developed as a component of the South African River Health Programme. This index is designed to serve two purposes: to provide a system for the geomorphological classification of biomonitoring sites (river typing) and to provide an index of channel condition. Data collection for classification takes place during the site rating or baseline survey, channel condition is assessed during routine monitoring. The Geomorphological Index is presented as a six digit number composed of separate indices for channel classification (river zone and channel type), channel condition (bank stability, bed erosion, bed deposition), and morphological change due to direct anthropogenic disturbance. Data pertaining to channel geomorphology will be archived in a data base.

Channel morphology represents the dynamic response to both natural and anthropogenic disturbance and therefore can be expected to be subject to change over the time span of the biomonitoring programme. The difficulty is to distinguish cyclical change from a long term shift towards a new equilibrium condition representing a degraded system. It is also important to recognise that the equilibrium channel condition, measured in terms of erosion and deposition, depends on the geomorphological characteristics of the reach in question. Satisfactory interpretation of the index can only be achieved within the context of long term geomorphological change coupled with the propensity for change as determined by the river zone/channel type combination. The data base will be used to evaluate the expected conditions for different geomorphological river types against which observed conditions at a particular site can be assessed.

Development and application of the index should not only assist in the interpretation of other biomonitoring indices, both in terms of between site comparisons and at-a-site changes over time, it will also aid the assignment of present state classes and management classes relating to the assessment of the Ecological Reserve as required by the South African Water Law.

Groundwater quality monitoring around Bass Lake, Betty's Bay

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The aim of the honours project was to monitor groundwater quality around Bass Lake and to look for evidence of sewage pollution from septic tanks that are situated upstream of the lake. The study was conducted in the 1998 winter season, taking regular water samples from Bass Lake and eight well points that were placed between the lake and the houses with the septic tanks. The samples were analysed specifically for traces of fecal pollution, using tests such as total and fecal coliform counts, anion analyses that established the nutrient concentrations in the water, pH and conductivity measurements and other field observations. Since not much is known about the study site other data was collected that might be influenced by sewage pollution, such as algal growth and vegetation patterns in the Bass Lake area.

The results of the study show that the water conditions are very clear in winter and only one sampling point had sufficient evidence to suggest that sewage contamination occurs. It is expected that heavy contamination only occurs in the summer season, when the visitor rates are high and the septic tanks receive heavier inflows. Further monitoring of the well points as well as the municipal toilet are necessary to come to any further conclusions about the situation around Bass Lake.

The effect of a single freshwater release on the physico-chemical properties of the freshwater-starved Kromme Estuary, St. Francis Bay, South Africa

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The natural runoff from the Kromme River catchment area has been severely restricted by impoundments with storage capacities exceeding the MAR. As a consequence, freshwater input into the Kromme estuary has been drastically reduced and the estuary itself has been labelled 'freshwater-starved' following various studies on biotic and abiotic components. The annual allocation of storage water to the estuary (2 x 106 m3) has been released from the Mpofu dam as a single release. The impact on various physico-chemical parameters as well as inorganic dissolved nutrients (phosphate, nitrate, nitrite, ammonia) in the estuary has been investigated with regards to the magnitude, persistence and management of future releases. The impact on dissolved nutrient concentrations was short-lived (less than 7 days), and pre-release concentrations were quickly re-established. The release enhanced especially nitrate and nitrite concentrations, because of elevated concentrations in the storage water, but slightly diluted phosphate concentrations in the estuary. N:P ratios indicated phosphate limitation, while ammonia showed no direct response to the release. Natural runoff reaching the estuary appears to be more beneficial, especially in terms of phosphate, than illustrated by this once-off release experiment. This experiment showed no long lasting effect on the estuary in terms of inorganic dissolved nutrients, and it becomes apparent that its nutrient status can only be enhanced under a continuous release strategy.

The development of a protocol for acute toxicity testing using indigenous organisms and recirculating artificial stream systems

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The use of aquatic toxicology as a tool for water quality management is widely used internationally, but relatively new in South Africa. In SA, toxicity testing is limited to the use of standard laboratory organisms, such as *Daphnia pulex*. The use of toxicity data for these organisms may not be protective of riverine biota, and tolerance information for indigenous organisms is therefore essential. The *South African Water Quality Guidelines for Aquatic Ecosystems,* published in 1996, are based largely on international toxicity data bases, and provide the first quantified set of water quality objectives for the protection of aquatic ecosystems.

The Protocol to be presented provides the information necessary to undertake short term (acute - 96 hour) toxicity tests, using indigenous South African riverine invertebrates as test organisms, in a range of recirculating artificial streams. The Protocol was prepared by staff of the aquatic toxicology group of the Institute for Water Research, Rhodes University, for the Institute for Water Quality Studies, DWAF, South Africa.

The data produced by this Protocol will contribute to:

I. improving the accuracy of the numerical values (e.g. target water quality criteria) listed in the *South African Water Quality Guidelines for Aquatic Ecosystems*,
II. setting site-specific guidelines (for situations where more specific, local, information is required to check whether the general guideline value is appropriate),
III. quantifying the water quality aspects of the Ecological Reserve, and
IV. developing the methodology for toxicity-based waste discharge licenses (licenses which specify toxicological end-points, or licenses which specify toxicological auditing).

The Protocol provides practical information about the following:

I. types of artificial streams;
II. the kind of facilities needed to undertake this kind of toxicity testing;
III. the kinds of experimental design which can be followed;
IV. the selection, collection, transport and treatment of test organisms;
V. the acute toxicity test procedure;
VI. data sheet design and data collection;
VII. data analysis options and procedures;
VIII. quality assurance and reporting.

The development of a GIS based atlas of freshwater fishes in southern Africa and its application to analysis of fish distribution patterns.

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An atlas of fish distribution has been compiled for the southern African region from museum collection data. Working in association with ALCOM, records from the JLB Smith Institute, the Albany Museum, the Royal Ontario Museum, the Windhoek Museum and the Bulawayo Museum were used to create a database of freshwater fish of southern Africa. The atlas of freshwater fish in conjunction with the water resources database (ALCOM) and a geographic information system (GIS) has proved a valuable tool for the study of freshwater fish distribution.

Each record in the freshwater fish database has a unique georeferenced point location that can be mapped using a GIS. These point locations have been assigned to catchments and hence to megabasins, or large drainage areas. The degree of species commonality between megabasins of the southern African region is discussed with reference to Roberts' ichthyofaunal provinces.

Inundation pattern in temporary waters - some thoughts on models

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Following work carried out by Seaman, Kok and Meintjies (1995) and De Vries, Seaman and Brendonck (in preparation) on models for two specific types of temporary waters (a set of pans and a set of rock pools respectively), it is possible to draw out some generalities. It is evident that such models are needed, firstly because the life histories of organisms and the succession of communities are governed by the period and pattern of inundation. Secondly, though one might know that a pool has a temporary nature, one seldom knows with any confidence how temporary, because long-term records (months or years) of depth, volume and surface area are seldom available. Thirdly, logistic problems make the following of such inundations very difficult. However, if one would be able to quantify the morphology of a water body, rainfall, catchment size, loss in catchment, evaporation, overflow and other losses, one can develop a model. While most of these are constants need to be established once only, one can be highly predictive of long-term inundation patterns if only daily or weekly rainfall and monthly evaporation values are used as inputs. Consequently one can develop theories on the life-history strategies of the organisms living in these waters. Examples will be given.

The effects of variable flow regimes on invertebrate communities in two Kenyan streams

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Stream faunal abundances and composition were studied in the Baharini, Springbrook and Njoro River. The streams have significantly different flow regimes and consequently surface stream flow related factors especially duration, intermittence or permanence and spates are important in structuring their faunal communities. Baharini is perennial, slow-flowing with a low steady discharge attributed mainly to groundwater recharge component from alkaline springs. Njoro is intermittent, fast-flowing with a higher and highly variable discharge. Discharge in Njoro River is a function of rainfall and therefore the stream is characterised by highly variable

mean annual flow duration, spates, cessation of flow and being completely dry and sun-baked in the dry season. Due to permanence and steady surface stream flow, Baharini has a higher number of species and higher abundances than Njoro River. However, in spite of the intermittent nature of Njoro River, the composition of its fauna is similar to that of Baharini during periods of relatively steady discharge. Similarity in the substrate characteristics of the two streams and their close proximity is a possible explanation for the close relationship in their faunal composition. At the onset of flow after a drought, fast colonisation of the lowland intermittent stretch of Njoro River occurred probably by drift from upstream perennial sections and/or from the hyporheos. Initial small spates at the onset of surface flow seem not to affect invertebrate abundance. But later bigger spates during and after much heavier rains reduce the faunal abundance significantly. The recovery of faunal abundance to pre-flood levels in Njoro was completed in 27 days. Taxon richness was, however, less affected by the spates.

Linking birds, bays and the Benguela

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Walvis Bay and Sandwich Harbour wetlands regularly support more birds than any other coastal wetland in southern Africa. Why is the central Namibian coast so productive, how does it relate to oceanic conditions and do the bays at Walvis and Sandwich account for these trends? Several large scale ocean upwellings occur around the world and each is associated with enhanced primary productivity, large near-shore fish populations, sedentary seals and large numbers of birds. On the African coast, the strong winds off the western Sahara coast create upwellings associated with the cold Canary current and supports over 2 million waders at the Banc D'Arguin. Sandwich Harbour is the only other coastal wetland where similar wader densities (but not total populations) are recorded and it is also associated with the cold Benguela Current and the Lüderitz upwelling. Surveys of wading birds along the entire Namibian coast reveal a rapid increase in bird densities from both the north and south to peak densities in central regions. Since bird densities are highest some 500 km north of the upwelling itself, a delayed blooming effect of phytoplankton may account for this displacement effect. High densities of birds occur beyond the influence of the bays at Sandwich and Walvis, suggesting coastal morphology cannot account for the high densities. However, north-south density patterns of macro-invertebrates eaten by some waders, and of fish-eating Damara Terns along the coast are identical to that found for wading birds, suggesting the delayed blooming effect of the Benguela upwelling and the inshore winds in central Namibia have widespread effects and may explain most of the higher productivity occurring here.

Threats to fish and conservation approaches in Lake Tanganyika (Zambia)

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Lake Tanganyika on the Zambian side consists of about 6% of the whole lake. The lake's fish species of clupeids and *Lates* are of economic and dietary importance. Over the last fifteen years, the number of fishing vessels in the pelagic zone has risen with a fall in the catch per unit effort (CPUE). This is perceived as one of the reasons for the reduced catches.

The littoral zone is exploited by traditional and artisanal fishermen lacking appropriate gear and craft to exploit the pelagic zone. The littoral zone is sensitive and of higher diversity than the pelagic. Artisanal fishing practices have been considered to have a negative impact on the catches. The question is: What has caused the fall in catch per unit effort and what management designs have been put forward to manage the lake on a sustainable basis?

The paper outlines historical catches, trends of industrial fishing, artisanal fishing practices and catch trends, fisheries regulations and activities being carried out to co-manage the lake on a sustainable basis.

Flagships and Fragments

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The contributions of ichthyology to the conservation of southern African freshwaters - a personal perspective.
Systematic ichthyology played a pioneering role in the scientific exploration of southern African freshwaters. Initial conservation efforts were also channeled through ichthyological pathways. Several thresholds of mindsets and attitudes had to be overcome before the more advanced approaches of ecological and sociological management could be achieved. This paper will consider the progress made in the ichthyology of southern African freshwaters and the prospects for the science in the 21st Century. Ichthyology is seen to have played a leading role in focussing attention on conservation issues of freshwater systems, at first through the light of threatened species and more recently through attention to ecological and life-history studies in relation to human-induced impacts on rivers. Flagship species continue to play an important role of focusing public attention on the conservation needs of freshwaters in southern Africa.

What happened to the catchment? Inter-basin water transfers and the implications of the proposed water management areas.

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It has been suggested by various authors that, in terms of physico-chemical and biotic attributes, inter-basin water transfers (IBTs) represent discontinuities along the river continuum, similar to those caused by impoundments. Evidence in support of this has emerged from a recent study in the Western Cape Province of South Africa, where riverine macro-invertebrate communities downstream of an IBT outlet in the upper Berg River catchment resembled those typical of lake or reservoir outlets. In summer, when water is transferred into the river from a neighbouring catchment, the Riviersonderend, increases in particulate organic matter and the transfer of zooplanktonic groups from the donor reservoir, have led to increased numbers of hydropsychids and simuliids (collector-filterers) below the outlet.

However, in a global review of the effects of IBTs on the rivers donor and recipient rivers, it has become clear that the differences between river impoundment and IBTs are manifested at the scale of the catchment. Thus, significant differences in variables such as water quality, flow regime, geomorphology and biota between catchments will increase the severity of the effects of water transfer.

The significance of these findings is viewed in the light of the proposed delineation of water management areas (WMA's) in South Africa, according to the new Water Act (1998). Many South African river ecologists were intimately involved in the review of the old Water Act, and one of the major changes that were strongly recommended was the consideration of the catchment as the unit of management. This indeed became one of the water law principles. However, the current Water Act proposes the development of a national water resource strategy which addresses issues of water surplus and deficit according to water management

areas, and not catchments. Further, catchment management agencies would manage WMA's and not catchments.

There is little point in managing each and every catchment as an individual unit, but the development of WMA's must be approached with caution, and with due consideration of the work that has been done on the delineation of bioregions and water chemistry management regions. Such regional boundaries are based on differences in the same variables that are affected by water management options such as IBTs.

Population genetics of the minnows of the Olifants River System, Western Cape.

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Pseudobarbus phlegethon, Barbus callidus, Barbus erubescens (Teleostei: Cyprinidae) and are endemic fishes of the Olifants River System (Western Cape, South Africa), which are being threatened by exotic fish, water extraction and pollution. The minnow populations are isolated in tributaries of the Olifants and Doring Rivers due to predation by exotic bass (*Micropterus salmoides*, *M. dolomieu* and *M.punctulatus*). The isolation of the populations can cause loss of genetic diversity. In order to assess the genetic divergence within and among the species, enzyme electrophoresis was carried out. This showed a clear divergence within *P. phlegethon* between the Olifants- and Doring Rivers. *B. calidus* and *B. erubescens* are genetically depauperate and are closely related to each other. There is low migration among tributaries and there seems to have been population bottlenecks in the Doring River System.

A new biomonitoring protocol to determine the ecological integrity of impoundments using artificial substrates

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Although biomonitoring of rivers focuses on benthic macroinvertebrates, lakes and reservoirs present problems. The main drawbacks are the sampling methods and the anaerobic bottom layers that occur in most impoundments during summer. To overcome these problems the colonisation potential of macroinvertebrates was measured using artificial substrates. Artificial substrates consisting of 12 mm mesh bags filled with stones were suspended 1.5 m deep for a six-week period. The macroinvertebrates colonising the substrates were identified to family level in the field. These substrates were tested on three highveld impoundments (Hartbeespoort, Roodeplaat and Bronkhorstspruit Dams).

As an indication of the general conditions existing in the three impoundments, physical, chemical and biological measurements were taken. These results indicated that Bronkhorstspruit Dam was an amictic, mesotrophic impoundment, while Hartbeespoort and Roodeplaat Dams were both monomictic, eutrophic impoundments. Bronkhorstspruit Dam had the best water quality and the smallest algal population, comprising mostly of different diatom species. Hartbeespoort Dam had the most saline water, while Roodeplaat Dam had the highest nutrient concentrations. Both Hartbeespoort and Roodeplaat Dams had large algal populations that resulted in very alkaline water during summer. Microsystis dominated the phytoplankton population in these two impoundments during summer and autumn, while green algae and diatoms were dominant during winter and spring.

The ecological integrity was determined using two different biotic indices. Two modifications of the Belgian Biotic Index and a modification of SASS4 were tested. The South African Scoring System for Deep Water (SASSD) score was calculated by adding the weights of all

the taxa that were present. The average score per taxon (ASPT) was calculated by dividing the SASSD score by the total number of taxa present. The ASPT was used to give an indication of the sensitivity of the organisms present in the sample. Three integrity classes were suggested for SASSD scores and ASPT values.

It is concluded that artificial substrates with SASSD (& ASPT) as a biotic index can be used to determine the biological integrity of impoundments, but that refinement of the index is needed.

Water Policy in Southern Africa: A Brief Synopsis of Some of the Macro Driving Forces

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Southern Africa as a regional entity has a number of rather unique features. Firstly, it consists of a number of developing countries, which gained their independence relatively recently. Secondly, it consists of a number of countries that are arid or semi-arid in nature. Thirdly, there is reasonably heavy dependence on shared water resources. Fourthly, the history of close cooperation is not that strongly developed. Fifthly, there is a great discrepancy between the spatial distribution of people and precipitation, necessitating complex water transfer schemes that in turn impact heavily on the environment. Against this background, there is a wave of water-sector reforms that are taking place.

This paper traces some of the macro forces that are currently at work in the water sector within the international environment. These forces are analyzed in terms of their impact on the international water discourse that is currently taking shape. There are certain key determinants of this new discourse that will be isolated. One of these elements can be traced back historically to man's desire for the control of nature. To this end, the early writing of Francis Bacon (1620) which proclaims that "noble discoveries" will "renew and enlarge the power of the human race itself over the Universe", have formed the philosophical basis of many modern scientific endeavors.

The birth of the ecological movement as a discursive instrument will be traced to show to what extent it challenged the prevailing "sanctioned discourse" of the 1970s. Intellectually, this gave birth to a movement that is now known as "political ecology". At the Stockholm Conference on the Environment in 1972, the first attention was given globally to water pollution by industrialized states. This paved the way for the first UN Conference on Water at Mar del Plata, Argentine in 1977. Yet the discursive forces dictated that the subsequent Bruntland Commission Report of 1987 (Our Common Future) virtually ignored water. The initial agenda for the 1992 UNCED Conference also excluded fresh water, but after lengthy negotiations, Agenda 21 was born. Occurring at the same time, the Dublin Conference played a major role in defining what can now be described as the principles of water and "sustainable development". The Global Water Partnership Framework for Action seeks to take these processes into the new millenium via three critical initiatives: the Cairo Conference that was held in March 1999 under the auspices of the World Water Vision; the Stockholm Conference that will be held in August 1999; and the 2nd World Water Forum to be held in The Hague in the year 2000.

This paper will place these global developments into the perspective of SADC and will seek to map out the way in which the water discourse is likely to develop in Southern Africa in the short to middle-term future. At the normative level, what is now being described by some authors as the second contradiction of capitalism - the abuse of the environment - will be placed in the philosophical context that Man's attempt to control nature has in fact merely damaged it. Ecologists have therefore now established themselves firmly as one of the discursive elites within the water sector.

Rehabilitation of an urban stream: Starting Small

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The Inhlanza is a small urban stream which has its source in the suburb of Vincent, which is now acknowledged to be one of East London's CBDs. This heavily impacted stream flows into the sea at Nahoon Beach, a world famous surfing and tourist location. The stream is perceived to be a security and health hazard, and at present serves no recreational function for the surrounding surburbs. Over past decades, the Inhlanza has been diverted, canalised and concrete-enclosed along certain sections of its length, to accommodate the commercial and urban development of Vincent. Stormwater pipes (often carrying sewage loads) alongside the river regularly overflow into the stream through manhole covers, and discharges of undesirable substances have been reported from pipes adjacent to the stream. Recently, a number of concerned individuals and specialists in the City have met with the intention of forming an Inhlanza River Watch to investigate steps in the rehabilitation and upkeep of the river and its surrounds, together with the appropriate authorities. The proposal is that the residents, schools, churches, organisations, commeroial interests and media in the vicinity of the stream either participate in, or contribute to the forum. The intention of the technical advisors of the forum will be to investigate present and historical channel form, riparian vegetation, water quality, hydrology and instream habitat to formulate an appropriate and achievable vision, set of objectives, design, plan and programme for the rehabilitation of the stream and its banks. The project represents a small first in achieving community participation in river health and rehabilitation in the East London area.

Computerizing environmental information systems for a regional waste site project

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The East London Regional Waste Disposal Site is due for development late in 1999. The Operating System for the site will comprise a Technical Management System, an Environmental Management System (EMS, and an Environmental Monitoring Programme. The aim is to develop the entire Operating System for the site as a computer-based Management Information System (MIS). The advantages of an MIS are discussed in the context of present developments in information transfer. The first phase of designing the Operating System involves the development of an MIS for the Environmental Monitoring Programme, which has three components: Baseline Monitoring, Long-term Monitoring, and the (external) Monitoring Committee. The design will be such that the MIS is user-friendly to the target audience as an information system, and to the monitoring specialists to log/store data, as a form of information transfer to all interested and affected parties, to track the development of the site, and to identify environmental impacts throughout the lifetime of the site. The MIS will be PC-based and will operate from any drive, or via a network. It will be modular so that sections can be used as stand-alones and be distributed independently. Either the entire system or specific modules can be transferred to CD's for distribution to both decision makers and the general public.

Diatoms in relation to water quality in the upper Olifants river catchment, Mpumalanga.

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The epilithic and epipelic diatom flora in relation to water quality was studied in the upper Olifants river, during two surveys in June and August 1998. Sampling was conducted in co-operation with the field surveys of the National Aquatic Ecosystem Biomonitoring Programme(NAEBP). The composition of the diatom communities in both the epilithon and epipelon showed some remarkable differences between impacted and unimpacted sites. Individual diatom species were found to correlate with changes in alkalinity, nitrite and nitrate, phosphorus and silica. For those species, indicator values could be calculated with the method of weighted-averaging. A comparison between observed conditions and indicator values calculated with the Van Dam index, a diatom index designed for fresh and brackish waters in the Netherlands, showed no significant correlation. However, once diatom indicator values are calibrated for the conditions in South African rivers, they have the potential of providing additional information on that given by the biological indicators that are currently used within the NAEBP.

Fish as a resource in a rural river catchment in northern South Africa

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A large portion of the rural population of South Africa is in some way directly dependent on natural resources for subsistence from their environment. Fisheries in smaller rivers are generally not considered important and benefits to local communities ignored in planning and management. This results in neglect of important resources to the communities living around rivers and gradual deterioration of the rivers themselves. A study of fish eating and fishing of a rural population around the Mutshindudi River (tributary of the Levuvhu River, Limpopo system) formed part of a larger research programme on the socio-biological study of the aquatic resources and their utilization in an underdeveloped rural region. By means of questionnaires the attitude towards fishing and fish consumption was determined. This survey in 1995 covered 542 households and revealed that 85% of the people accept fresh water fish as food, but that tinned pilchards (Lucky Star) is the most commonly eaten fish. Fish is eaten in 80% of the homes at least once per week; fresh water fish in 26%.

Fishing is done by one or more members in 57% of the households. Reasons for fishing include the collection of food (74%), sale(20%) and recreation (6%). The fishers have a mean age of 22y with a low participation by females. Older fishers were often unemployed and a high proportion of the learners were busy or had just finished writing matriculation exams. Eighteen fish species were caught by fishers, using nine different fishing methods, of which fishing with a line and hook, was the most important (80%), followed by miniature gill nets, draw nets and traps of modern materials. The dominant species caught include three tilapia and three species of small barbs. In terms of weight however, the tilapia are followed by the sharptooth catfish and carp. The length distribution histograms of the catches indicate healthy fish populations with no indication of overexploitation as larger specimens were well represented in catches. The catch per unit effort is however lower (55g per hour or 162g per trip per fisher) than reported for other (albeit larger and less heavily exploited) systems and the average size small, only 26g. The gill nets were selective for larger large scale yellowfish (*Barbus marequensis*) and labeo (*Labeo molybdinus* and *L. cylindricus*). Small mesh draw nets selected small tilapia and barbs.

The mean investment of R1-50 in fish hooks and fishing line compensated amply in the value derived from the fish caught - the investment was repaid by the value of fish caught in two fishing trips, but then not accounting time spent. Only 6% of the fishers indicated that they regularly sell fish. So the fishery on the Mutshinduai can be characterised as a subsistence fishery.

An attempt was made to determine the fish population of two pools by collecting to depletion using a set of graded gill nets over a 24h period. Not all fish could be removed however and no attempt can be made of the biomass in pools in the river. A comparison between fish catches by fishers and these gill net catches indicated that some fish species may experience a fishing pressure by the present fishing effort, including tilapia and catfish. Fish species that were clearly not fishing target species, were quite common in the pools: Bulldog (*Marcusenius macrolepidotus*,) Churchill (*Petrocephalus catostoma*) and labeos. The annual total harvest from the river (75km long) is estimated at 2500kg.

The fish life of the river itself, is presently harvested optimally, with some signs of overexploitation. Control measures are now required, including licensing (acceptable to 55% of the fishers) stocking of desirable fish species that presently seem overexploited, and a ban on dragnetting.

Support monitoring for estuary classification

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According to the National Water Act (Act 36 of 1998), water resources must be classified. The same applies to South Africa's some 300 estuaries, which are now regarded as a part of the national water resource, and hence qualifies for the same level of aquatic environment protection measures as the fresh water resource. In the current developmental stage of these measures, conservation status seems to be the underlying rationale for estuary classification. The deviation due to human impact from a reference conservation status prior to any human impact forms the basis of classification. In order to visualise the reference status of an estuary, a wide variety of physical, chemical and biological attributes are taken into consideration, especially since historical data and information are not available in many cases. Subsequently, the deviation is determined through scientific monitoring and investigation. This allows natural resource managers to contrast the present conservation status against a higher, desired status, also called a management class, and then formulate accordingly specific environmental remediatory and impact abatement actions to arrive at the elevated conservation status. The progress towards this goal could then be scientifically monitored and the abatement actions modified according to monitoring results.

In the past, a similar procedure has been followed, aptly named the estuarine flow requirement (EFR). The emphasis has been on the negative environmental effect of water abstraction from rivers entering estuaries, thereby determining limits of abstraction rates. The habitat assessment procedure for rivers, as applied by the Department, has been adapted for estuaries and subsequently successfully tested on the Zwartkops Estuary. This is a relatively cheap and rapid procedure, utilising existing information and not relying on new field measurements. It is hoped that this would contribute towards the standardisation of the EFR procedure, now named the estuarine reserve determination. The procedure integrates a wide variety of impacts into a single index figure. Since single index figures omit underlying data, scientists often question its validity. To counter this criticism, the procedure requires a description of the index components, hence emphasising those aspects most in need of management. Index values are readily transferable into present conservation status, also called present habitat integrity class, and therefore fit in well with the requirements of the National Water Act.

The relative contributions of index components are reflected by numerical component weights. In the same manner, a variety of indices could be combined into a single index value. The

prerequisites for this approach are that all indices measure deviation from benchmarks with a common datum and that the weights all add up to 1. A number of estuary scientists have already expressed their willingness to co-operate within the framework this approach has to offer. It allows for co-ordinated in-depth investigation of the hydrology, water quality, physical and biological aspects superficially touched upon during estuary habitat integrity assessments. A number of indices already exist, e.g. water quality, toxicological and biological indices. New indices would have to be devised for those aspects crucial to estuary functioning, such as hydrology and sedimentology. It is believed that the addition of more indices would contribute towards the reliability of overall present estuary integrity estimations. The correct numerical weighting of indices could spark some intense debate among scientists. Each could claim that their field of interest warrants a larger slice of the available weight, thus reflecting its perceived importance in estuary functioning.

Towards the assessment of the trophic status of selected South African impoundments for management purposes

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The 1 mg/(phosphate standard (1 mg/(P-Std) legislated in South Africa in 1980 in seven sensitive catchments, and ad hoc eutrophication-related requests, initiated the monitoring of 53 impoundments throughout the country. Variables that were monitored, and are still being monitored in some cases, included nutrients, chlorophyll a, algal identification, suspended solids and other major inorganic constituents. Temperature and oxygen profiles were measured on an ad hoc basis, when the sites were visited. The results, as determined from data collected between 1989 and 1998, indicated a range of trophic status from oligotrophic to hyper-eutrophic in the sensitive catchments. The catchments that were covered in the survey are: the Vaal River, Crocodile River (North West), Pienaars River, Olifants River (Mpumalanga), Letaba River, Buffalo River, Berg River, White Mfolozi River, Mgeni River, Mlazi River and the Molopo River catchments.

Existing data were processed in order to assess the extent of compliance with the 1 mg/(P-Std. Furthermore, the extent to which problem algal species were present in the respective catchments was also determined.

The trophic status of selected impoundments was determined by using the mean total phosphorous (TP) concentrations, the nitrogen to phosphorous ratio, the mean chlorophyll a concentration, the presence of Cyanobacteria and the turbidity (measured by means of Secchi disc readings) of the system. This information is presented on a GIS-based platform. The potential management and information transfer applications of such a tool are discussed.

FishBase

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FishBase is the world's most comprehensive electronic encyclopaedia on finfish. This electronic software tool was conceived in the mid 1980s as a database that would contain biological information, including growth and mortality parameters of fish, to facilitate management-oriented research on major commercial species. In this light the emergence of FishBase went beyond that of the computerised fisheries databases then existing, which were barely annotated lists of names or limited to bibliographies. To date FishBase's relational character allows the user to combine the contents of its various tables, and thereby generate new products and insights. This advanced tool is a repository of all available information on finfish and brings the world's literature on fish to your desk. It contains more than 22,000

species of the existing 25,000 Pisces arranged in 55 subject tables. These tables range from taxonomy, physiology, morphology, ecotoxicology, population dynamics, reproduction, aquaculture and numerous more. Fishbase has grown enormously since it was originally designed. This is due both to data inputted by the FishBase team, equivalent to about 50 person-years of data encoding, and, increasingly, also to complementary databases supplied by collaborators, jointly corresponding roughly to another 50 person-years worth of encoding. FishBase can thus be defined as a fisheries resources management tool accessed through user-friendly software on a CD-ROM.

Preliminary observations on the Water Quality of the Upper Orange River

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The Upper Orange River can be defined as the region between the source in the Drakensberg (Lesotho) and the Orange-Vaal confluence. Information on water quality and the effect on the water ecology in general, of the Upper Orange River are limited. In 1998 this study was conducted in order to determine seasonal and spatial patterns in the system, as well as the influence of the tributaries and the two major dams, on the water quality of the river. Chemical, physical and biological factors were taken into account. The quality of water in the Upper Orange River is deteriorating because of the withdrawal of water for irrigation and also backflow water. Salinity levels, above the dams, were on average 18.9 $mS.m^{-1}$, and below the dams 30 $mS.m^{-1}$. The main importance of the high salinity below the dams is evidently the influence it has on turbidity and the possible clarification of the water-column. This could result in a deeper euphotic zone and favourable conditions for photosynthesis followed by a biomass build-up of phytoplankton. Chlorophyll-a concentrations above the dams were on average 6.7 $\mu g.l^{-1}$ and below the dams 16.5 $\mu g.l^{-1}$. Because of the high nutrient concentration and relatively low turbidity of the water, in and below the dams, algae blooms are occasionally observed. Algae have a detrimental effect on water quality, clog water filters and may even be toxic to animals. Spring blooms of blue-green algae, such as *Anabaena*, as well as summer blooms of *Microcystis* have been observed in the Gariep Dam.

Invertebrate fauna collected from *Eichhornia crassipes* roots in two coastal lakes in northern Kwazulu-natal

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The floating water hyacinth, *Eichhornia crassipes*, is an exotic macrophyte from introduced from south America into several parts of the world where it has become an economic and ecological problem. However, *Eichhornia* mats are rich in aquatic invertebrates that are mainly associated with the roots hanging in the water.

Lake Cubhu and Lake Nsezi are both freshwater coastal lakes formed by glacioeustatic changes in sea level and situated in the Richards Bay area in northern KwaZulu-Natal (South Africa). Lake Nsezi was formed as a "drowned valley lake" and Lake Cubhu as a relict estuarine lake that formed part of a greater estuary prior to being cut-off from the sea.

Sampling was carried out on a monthly basis for both systems, Lake Cubhu during 1987 and Lake Nsezi during 1996. Plants were collected from an area of a $0.5m^2$ and their roots rinsed over a benthic net with a mesh size of 500μm. Invertebrates were collected and identified and densities were transformed to number of individuals per square meter. The PRIMER® statistical package was used to create Bray Curtis similarity matrices and dendrograms from which non-metric multidimensional scaling ordinations (NMDS plots) were performed.

Analyses revealed that there were significant differences in species composition between the two lakes. These differences were mainly attributed to the presence of some estuarine relict species (*Corophium triaenonyx* and *Grandidierella lignorum*) in Lake Cubhu that were absent in Lake Nsezi. These differences reflect on the geomorphological of these lakes. Furthermore there were differences in species distribution within the two systems. Species distribution in Lake Cubhu followed a spatial pattern as opposed to the temporal pattern found in Lake Nsezi. These differences were related to the underlying substrate in the two systems. As Lake Nsezi has a fairly consistent substrate (mostly fine mud) no differences other than seasonal variation should be expected. But Lake Cubhu has several different substrate types (mud, detritus and sand) that would affect densities and species distribution in the overlaying *Eichhornia* mats.

Impoundments and sustainable freshwater fish populations – The Pongola/Bivane River story.

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Populations of freshwater fish in southern African rivers are being more and more affected by the construction of dams and weirs in rivers. Many freshwater fish species are obligatory migrators in order to satisfy specific habitat requirements for successful breeding. The presence of many dams and weirs have often resulted in a substantial reduction in the distribution and population size of many fish species in rivers. In view of the construction of the Paris Dam, a large reservoir being built in the Bivane River, a major tributary of the Pongola River, a sampling program of the fauna of the system was initiated in 1998. As part of this, the fish community of the Pongola/Bivane River system upstream of the Pongolapoort Dam was sampled quarterly at nine stations using seine netting and electro-shocking.

A total of 22 species were recorded, including two rare species. Spatial and temporal analyses showed delineation of the river into compartments with specific fish communities. The effect of the existing weirs in the system and the potential impact of proposed new weirs and the dam will be discussed as well as the importance of maintaining habitat integrity and flow diversity in a regulated riverine environment.

The ecology of the Groot Letaba River in the Northern Province, RSA

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The aim of the study was to evaluate the current ecological status of the river, and compare the information with historical data. Over the last years, many weirs and dams have been constructed in the Groot Letaba River, impacting on the flow regime and migrating potential for many fish species. None of these structures have a fish way to ensure that fish are able to scale the weirs or dams. Tiger fish (*Hydrocynus forskalli*) and the large scale yellowfish (*Barbus marequensis*) are two of the more prominent species negatively influenced by these structures.

The water of the Groot Letaba River is not highly polluted, but the decline in flow seems to be a greater threat to the system. During a preliminary study to determine the IFR (Instream Flow Requirement) of the Letaba River in the Kruger National Park, it was calculated that the demand during the wet seasons is 61,5 million m^3/annum and during the dry seasons 12,8 million m^3/annum. It was found that the ad hoc allocation from Tzaneen Dam was only 14,8 million m^3/annum (wet and dry seasons).

The factors influencing the water quality of the Groot Letaba River and the impact of the various impoundments on the fish population will be discussed.

Dependence of Toxicity on Metal Ion Concentrations - A Study of Zinc and Calcium with Daphnia pulex

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Daphnia pulex were exposed to zinc in acute mortality tests.
In all tests, calcium was present, in an attempt to quantify the antagonism of hardness on metal toxicity.
Chemical speciation calculations yielded the concentrations of free zinc and free calcium ions.
The resulting fractional mortality vs free ion concentration data was analysed with respect to three toxicological models - the *assumption of occupancy* model, the probit and the logit transform, with untransformed and log-transformed concentration.
The toxicity models were combined with thermochemical equations in an attempt to yield the conditional metal binding constants with the site of toxic action on the invertebrates.
Limited success was obtained in deriving such constants. The mechanistic toxicity equations representing the assumption of occupancy, probit and logit mortality transformations were very stable with respect to direct concentration of occupied sites on the invertebrates, and were very unstable with respect to logarithm of the concentration of occupied sites.
The response of Daphnia to zinc in the presence of calcium exhibited high stochasticity, particularly when challenged by waters of high hardness.
The conditional logK(Zn2+-Daphnia/mol.R-1) = 5.3±0.2 and the conditional logK(Ca2+!Daphnia/mol.R-1) = 4.01±0.07.

The application of a hydraulic biotope matrix to the assessment of available habitat: potential application to IFRS and monitoring river health

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In an attempt to meet the requirement of the new South African Water law a number of initiatives are under way to determine the flow requirements for our rivers. An essential component of this initiative is to determine the influence of changing flows on instream habitat. Two components need to be assessed: change in the aerial extent of habitat and change in habitat diversity. This paper presents a technique that aims to address qualitative and quantitative changes in instream habitat in response to changing flow discharge.

A hydraulic biotope classification based on a matrix of substrate and flow type has been developed by the authors in conjunction with stream ecologists. Verification of the significance of this classification in terms of the distribution of instream biota awaits the results of a research project by King and Schael, but early indications are encouraging. Hydraulic biotope diversity has been studied in the Buffalo River and results show how the composition of hydraulic biotopes depends on both the channel morphology and the discharge. These findings complement parallel studies carried out by Padmore and Newson in the United Kingdom. The classification system promises to provide a useful way to describe discharge related changes in habitat.

Early research by Wadeson and Rowntree was based on point surveys and ignored the spatial distribution and aerial extent of hydraulic biotopes. King and Schael have developed a mapping technique to describe the distribution of hydraulic biotopes, but its application is limited by time and manpower requirements. This paper demonstrates a relatively simple field

technique based on overhead photography which is under development. The technique allows a quantitative assessment of the changes in the aerial distribution of hydraulic biotopes in response to changes in discharge. The potential application of this technique to both IFR assessments and the River Health Programme is discussed.

Biomarkers in environmental research: Fact or Fiction?

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The use of biomarkers as bioindicators of environmental conditions is receiving a lot of attention (and funding). Although biomarkers have potential they are currently being "oversold" for a variety of reasons. The potential can only be realised once specific biomarkers can be linked to higher level effects and shown to provide early warning of adverse effects, not just exposure. The danger of inappropriate use of biomarker information lies in exchanging intermediate measures for the primary effects of concern. This does not imply that biomarkers are of no use at all in environmental monitoring since they can serve as a useful screening tool. However, a single biomarker should not be used in isolation, as no single biomarker is sensitive to all pollutants. Therefore tools need to be developed and/or adapted to interpret biomarker data. One such tool that has been applied with success involves using multi-dimensional scaling techniques. The application of these techniques to laboratory-based bioassay biomarker data are illustrated using examples of fish exposed to different metals and physical conditions. The interpretation of field-based monitoring biomarker data is discussed using the marine bivalve, *Perna perna* as an example. The results are displayed using a similarity matrix to highlight differences in responses. The data were also multi-dimensionally scaled to highlight similarity in biomarker responses.

The integrity and evolutionary importance of catchments: genetic differentiation and dispersal of the mountain midge, *Elporia barbardii* (Blephariceridae).

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River basins, by virtue of definition, provide natural isolating mechanisms which, safeguard genetic diversity and provide the template for evolution through genetic divergence. In dryland regions across the globe, inter-basin water transfers (IBT's) are increasingly being used to reconcile and to rectify the problems posed by the uneven distribution and paucity of permanent surface waters, transcending these natural isolating barriers. As a species with limited dispersal the mountain midge, *Elporia barbardii,* was used to examine the level of genetic differentiation between catchments in the south-western Cape. Allozyme electrophoresis and mitochondrial DNA were employed to examine populations from six rivers. Results from the allozyme electrophoresis show high levels of differentiation not only between different rivers but also between populations within the same river. Analysis of mitochondrial DNA shows a high level of within-species divergence for populations on Table Mountain, suggesting no gene flow for more than two million years. These results are examined within the context of the problems facing river management and conservation in southern Africa such as the establishment of potential avenues for gene flow between historically isolated populations through inter-basin water transfers, compromising of catchment integrity and the possible long-term evolutionary implications of such developments.

POSTER PAPERS

A comparison of two techniques for the quantification of metals in fish tissue.

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Metal pollution in South African waters has increased rapidly over the past few years. This is mainly caused by growing industrial, agricultural and mining activities. Although animals need trace concentrations of metals for normal physiological functions it can have detrimental effects in exceeded concentrations. In previous research projects the metal concentrations in the tissue samples of fish were determined by Atomic Absorption Spectrophotometry (AAS) alone. This method includes processes such as acid digestion and filtration. The process as a whole could be seen as time and money consuming as well as hazardous. In recent years the Energy Dispersive X-ray Scanning Electron Microscope (EDX) was used to qualify and quantify elements from organic and inorganic samples. Most of these studies for biological specimens include intense preparation techniques to retain all elements of interest at their in vivo locations and to allow identification of cellular structures at the level of analytical resolution required.
The purpose of this study is to find a more time and rapid assessment technique to determine metal concentrations in fish tissue. The questions to be ask is as follows:

Can the EDX be used to determine metal concentrations in bulk samples?
Is there a correlation between the concentrations found in the tissue after AAS monitoring and EDX monitoring of the same sample?
Is this process more time effective and less hazardous?
Which technique has the lowest detection limit?

Wacking wattles for water -Progress of the Albany Working for Water Project.

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The Working for Water Project is a tool for rehabilitive water resource management while at the same time serving as an empowerment vehicle for previously disadvantaged people. This poster gives a report on the progress of the project. The steep slopes of Albany district of the Eastern Cape landscape has posed some unique problems. We highlight success full aspects as well as problems which have been encountered in the last three years of the project.

LEARN TO VALUE WATER
PROJECT COORDINATOR
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http://www.ru.ac.za/departments/law/SAenviro/saep.html
http://www.ru.ac.za/departments/law/SAenviro/saep.html.
The home page where you can find AND send information relating to matters environmental.
http://www.ru.ac.za/departments/IWR/welcome.html
http://www.ru.ac.za/departments/IWR/welcome.html
the home page for IWR where current staff and project information can be seen.

The sublethal effects of zinc at different water temperatures on the haematology of *Oreochromis mossambicus*.

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Trace metals such as zinc, copper, manganese and iron play an important role in the normal metabolic functioning of all organisms. However, they can become toxic if they exceed background concentrations in the environment. Metals enter ecological systems from industrial and agricultural areas as effluents and runoff. In all non-salmonid species temperature seems to have no direct correlation with zinc toxicity, however, poisoning is more harzardous at high than low temperatures due to the increase in metabolism at high temperatures. This study investigated the sublethal effects of zinc on the haematology of *Oreochromis mossambicus* at different water temperatures.

Fish were exposed to sublethal zinc concentrations of 40µg/l (mean zinc concentration measured from the Mhlathuze River) for a period of 96hr at different water temperatures (18°C, 24°C, 28°C and 32°C). The haematological parameters measured were: red blood cell count (RBC), mean cellular haemoglobin concentration (MCHC), mean cellular haemoglobin (MCH), mean cellular volume (MCV), haematocrit (Hct), haemoglobin (Hb), white blood cell count (WBC), blood glucose, blood lactate and plasma ions (K^+ and Na^+).

At low temperatures (18°C and 24°C) slight increases in the RBC, MCHC, Hb, WBC, glucose, sodium and potassium values were found. Insignificant drecreases in MCV, Hct, MCH and lactate values were also recorded. At 28 °C there were significant ($P<0.05$) increases in RBC, MCHC, Hb, glucose and potassium, and a significant decrease in MCH, MCV, lactate and sodium. At high temperatures (32°C) all haematological parameters were elevated, and there was a decrease in MCV, Hct, lactate and potassium.

Exposure to zinc at 28 and 32 °C resulted in the most pronounced haematological changes in *O. mossambicus*. The erythrocytotic conditons found following exposure to zinc can be attributed to damage to the gill surface. The ensuing hypoxic conditions are aleviated through the release of large amounts of immature RBC into the circulatory system.

The leucocytotic conditions support the findings of damage to the gill surface. The increased glucose concentrations were attributed to a general adaptation response whereby metabolites are mobilized to meet increased energy demands during periods of stress. The changes in Na^+ and K^+ levels in the plasma of *O. mossambicus* can be attributed to stimulation of Na-K ATPase activity in the gill tissue and leakage from cells into the blood, respectively.

Pollination mechanisms in the aquatic plants of southern Africa

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Aquatic plants have evolved from diverse terrestrial ancestors at different times, adapting vegetatively to survive in an aquatic environment. However, most of them have retained the pollination mechanism of their terrestrial ancestors. Many aquatics are autogamous or can be autogamous or develop cleistogamous flowers underwater. Generally outbreeding is rare and there are few self-incompatible aquatics. Worldwide, about 83 angiosperm families and 407 genera include aquatic species. Of these 407 genera, about 42% are pollinated abiotically, about 36% by wind (anemophily), about 6% by water (hydrophily). The rest of the aquatic plants (excluding Podostemaceae of which the pollination biology is virtually unknown) are pollinated biotically. Emergent aquatic plants such as *Typha capensis* and *Phragmites*

australis are pollinated by wind. Aquatic plants bearing flowers above the water surface are either wind- or insect- pollinated. In all instances the flowers must be elevated above the surface, adapting to these pollination syndromes in various ways: peduncles with specialised supporting tissues (species of *Potamogeton,* anemophily); a modified aerenchymatous collar of tissue below the flower (*Ottelia,* some species entomophily); the inflorescence supported by floating leaves attached to the base of the cluster of flowers (*Nymphoides*, entomophily). Insect-pollinated flowers have nectaries and are strongly scented (*Aponogeton distachyos* , entomophily), or the pollinators are attracted to their smell and the food value of the stamens (*Nymphaea* species, entomophily), or the flower has bright yellow markings that function as "honey guides" to visiting bees (*Eichhornia crassipes*). Submerged aquatic plants have a unique pollination system which involves water as the vector that transfers the pollen (hydrophily). Pollination takes place either on the surface of the water - epihydrophily (*Lagarosiphon major*) or in the water - hypohydrophily (*Thalassodendron ciliatum* and species of *Ceratophyllum* and *Zostera).*

This poster illustrates various pollination mechanisms of some of the southern African aquatic plants (excluding apogamy and cleistogamy). The aim is to create an awareness of the different hydrophilous pollination mechanisms and how little is known about the pollination biology of these plants in southern Africa, especially of the indigenous species (*Hydrostachys polymorpha* and *Potamogeton thunbergii*). The information for this poster was retrieved from research carried out in other countries. To conserve the aquatic flora of southern Africa it is essential that we improve our knowledge of the biology of these plants that play a major role in biodiversity of wetlands.

The effect of season on a biotic water quality index: A case study of the Yellow Jacket and Mazowe Rivers, Zimbabwe.

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The effect of season on the South African Scoring System (SASS) biotic index for rapid assessment of water quality using benthic macroinvertebrates was investigated using the Yellow Jacket and Mazowe rivers in Zimbabwe as a case study. Several impacts in the area degraded water quality. These were habitat destruction, acid mine drainage and organic pollution. SASS score at all sites changed with season. At and downstream from polluted sites, water quality determined using SASS was best at the end of the rainy season and it deteriorated steadily into the dry season. SASS scores from the sites upstream of pollution appeared to improve towards the end of the rainy season. Average Score Per Taxon (ASPT) indices did not have a significant pattern of seasonal variation. SASS was designed to monitor water quality in South African rivers , so when implementing any monitoring programme, selection of sampling season and interpretation of results in areas with similar climate patterns should take seasonal effects into account. It must be appreciated that water quality at impacted sites is a dynamic variable related to activities of both polluters and season.

Selection of statistically significant sampling localities in the loch vaal : a multivariate approach.

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To investigate the extensive blooms of *Microcystis aeruginosa, Anabaena circinalis* and *Oscillatoria simplicissima* Rand Water has been monitoring ten sampling localities in the Loch Vaal for the past ten years. Recently it was decided to evaluate the need for ten sampling

localities in this small, shallow man-made lake as sampling and analyses is time consuming and expensive. Data on the abiotic and biotic variables analyzed during this period were used in a multivariate approach to determine significant differences between the water quality of the ten sites. Principal Component Analysis (PCA) were performed on physical, chemical and chlorophyll-*a* data, while Correspondence Analysis (CA) were performed on the phytoplankton species data. The PCA's performed on the physical and chemical environmental data identified three significantly different regions in the Loch Vaal, while the CA's performed on the phytoplankton species data and the PCA's performed on the chlorophyll-*a* data identified only two significantly different regions in the Loch Vaal. One region was identified by both the physical/chemical and phytoplankton data to be significantly different from the rest of the Loch Vaal. This region is situated at the inflow from the Riet Spruit and has very high nutrient concentrations. Because of all the noise associated with multi-species data it was decided to accept three different regions in the Loch Vaal although the biological data indicated two different regions. These regions have been identified as the inflow, the outflow and the middle region. To select specific sampling localities for further monitoring, the following criteria was used: firstly, the region in which it occurred, secondly the different variables monitored at each locality and thirdly, the specific location of the sampling locality in the main stream of water flow in the Loch Vaal. The monitoring of three localities is also suggested because the Loch Vaal is a popular recreational facility. It is thus suggested that in future the following localities be monitored in the Loch Vaal : LV6 (representing the inflow) and LV10 (representing the outflow). In the middle region it is suggested that LV8 be monitored, as it is located in the main stream of the Loch Vaal and the results of LV8 are reported by Rand Water in the weekly recreational report. Thorough monitoring will enable management to be aware of rising blue-green algal concentrations at different regions of the lake.

Aftermath of simultaneous toxic spills in the Klein Nyl River, Northern Province, RSA

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Towards the end of August 1998, due to a mechanical malfunction, a massive quantity of untreated sewage from the Nylstroom sewage treatment plant overflowed into the Klein Nyl River. This disaster occurred downstream of Nylstroom. Unknown at that time, approximately 5 km upstream of Nylstroom, a 25 litre canister, containing an aromatic hydrocarbon, leaked its contents into the same river.

The combination of the sewage spill and its consequences, of which depleted oxygen levels was most prominent, and the toxic chemical eroded the already overstretched gills even further resulting in a massive fish kill over approximately 17 km of river.

Immediate emergency actions and the ecological consequences for the RAMSAR site "Nylsvley", downstream of Nylstroom and in the direct path of any mismanagement upstream, are discussed.

Resulting from this disaster, a number of research projects have been initiated by the Limnological group of the Department of Zoology, UNIN, in order to rehabilitate the downgraded river and establish permanent protection to "Nylsvley" and other downstream users.

Protocols for the determination of the ecological reserve for different water resources according to the National Water Act for South Africa

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The National Water Act (Act 36 of 1998) and the Water Law Principles (1996) set the path for future Water Resource Management in South Africa. The key to Water Resource Management is the protection of its natural resources and the management of its users.

This protection of sustainable water resources is defined in the Water Act as the Reserve, being the water quantity and quality required to meet the basic human needs for all people, who are or may be supplied from water resources, and to protect aquatic ecosystems in order to secure ecologically sustainable development and use of water resources. According to the Water Act, section 17, water for the Reserve enjoys priority of use by right, and must be determined before water use authorisations can be issued to water users.

This shift in emphasis to the Reserve has led to the need for documented protocols for determining the Reserve (water quantity and quality), that can be used for licensing of water use. For the purpose of this poster, the focus will be on the Ecological Reserve determination for the different water resources (rivers, groundwater, estuaries and wetlands). Primarily the different levels of tools for determining the Ecological Reserve will be discussed, with the emphasis on the 6-step-generic procedures which was developed for the Planning Estimate, Preliminary Reserve and Comprehensive Reserve. These generic procedures will indicate the relation between setting Resource Quality Objectives and the evaluation of licences.

A suite of methodologies have been developed by DWAF and its consultants, ranging from desktop to more intensive (varying in the degree of data input and confidence), which will be appropriate for different kind of impacts, and development options.

Central to all methods being considered for the determination of the Ecological Reserve is the determination of a management class. This management class is determined by a set of rules and criteria to set the class for a water resource.

Overall, the assignment of a specific management class to a water resource gives a clear message to both users and impacters regarding the social, economic and ecological value of the water resource, and the accepted risk associated with the level of protection for that management class.

The importance of freshwater fish in the Eastern Caprivi

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The Eastern Caprivi wetlands were studied to determine the importance of freshwater fish in the region. The distribution of 81 fish species from 15 families was recorded in the Zambezi, Chobe and Kwando rivers. Internal water bodies such as Lake Lisikili were also studied. The study was conducted on a seasonal basis during 1997 and 1998. During the study period two flood seasons and two dry seasons were studied and the species distribution varied between seasons. Freshwater fish are important in the Eastern Caprivi as a protein supplement. Local catches were studied as well as the local fish market in Katima Mulilo. All species of fish are caught and sold, but some species are preferred such as the Cichlidae. Catfish is even transported to the Oshakati market. Average fish prices were studied and prices varied with season. The average price for fresh fish is N$8. Local fishing methods differed between seasons and the flood cycle.

The influence of *Azolla filiculoides* Lam. on freshwater ecosystems

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Azolla filiculoides Lam. (red water fern / rooivaring) is a genus of small, free floating, aquatic ferns widely distributed on water bodies, throughout South Africa. *A. filiculoides* recently has become a dominant macrophyte in dams and rivers in the Free State, South Africa. Problems associated with *A. filiculoides* invasions are that it clogs waterways for irrigation purposes, provides shelter for mosquitoes and bilharzia-carrying snails and prevents birds, animals and man optimally utilizing the water. Livestock losses, caused by drowning, were also reported by farmers. In the present study, the impact of *A. filiculoides* on the physicochemical characteristics of the water and on the phytoplanktonic community, in a lentic freshwater system, was determined. Most of the problems associated with the free-floating *A. filiculoides* fern, arise from its high growth rate resulting in a huge amount of biomass (approximately 7 kg/m^2 wet mass) spread over the water surface. Thick mats limit sunlight from penetrating the water, resulting in lower water temperatures. Furthermore, the thick biomass cover led to an increase in sedimentation of organic matter and restricted oxygen transfer from the atmosphere into the water. Decomposition processes were encouraged and near anaerobic water conditions occurred with accordingly pH changes in the water. During these conditions nutrients, particularly phosphorus and nitrogen were liberated from the sediments and decaying plants, resulting in higher nutrient concentrations underneath an *A. filiculoides* mat. Silica silicon concentrations beneath an *A. filiculoides* cover was unusually high and the average levels of faecal coliforms and faecal streptococci were also higher in an impoundment covered by *A. filiculoides*. The decaying plant cover produced an obnoxious smell to the water and a aesthetical unacceptable darker colouration of the water. The anaerobic, light restricted and nutrient rich environment below the mats represented an ecosystem, which was restricted to only the hardiest of biota. The presence of *A. filiculoides* was probably controlled by phosphorus concentrations of the water and a suitable undisturbed habitat. *A. filiculoides* infestations caused a decrease in freshwater quality and therefore should it be controlled and eradicated or maybe utilized as green manure or biogas.

Water quality impairment in the Vaal river barrage catchment as depicted by sass4 results.

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The Vaal River Barrage is an important recreational area and also serves as a source of potable water, drinking water production and irrigation for downstream users. However, the Vaal River Barrage catchment is severely impacted by anthropogenic activities including industrial development, mining and urban sprawl. Rand Water has initiated various activities including aquatic biomonitoring to assess and monitor these impacts. As part of the biomonitoring programme, SASS4 surveys are undertaken. In the present study the initial results of the Klip River, Rietpruit and Taaibosspruit biomonitoring are presented.

The SASS4 and ASPT scores obtained for the selected sites in these rivers were lower than that of the preferred state (reference site at the Suikerbosrand River). At several sites on this catchment, some of the SASS4 scores were even lower than five. Habitat assessment as indicated by the Habitat Quality Index (HQI) shows that at some of the sites, poor habitat availability can contribute to low SASS4 scores, however, poor water quality appears to be a major contributor. From the data gathered it can be concluded that several sections of the river are severely impacted by the various anthropogenic activities.

The investigation into the use of two species of amphipods, *Grandidierela lignorum* and *Corophium triaenonyx*, as suitable bioindicators of copper contamination in Nhlabane Estuary.

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The rapid industrial development and extensive use of heavy metals in modern civilisation has resulted in the enhanced concentrations of these metals in aquatic environments. Aquatic organisms have been found to be useful as bioindicators of heavy metal contamination in aquatic systems. The use of bioindicators reflect the availability of contaminants in these systems.

The study was undertaken to investigate the suitability of two species of amphipods, Grandidierella lignorum and Corophium triaenonyx, as bioindicators of copper contamination in the Nhlabane estuary. The Nhlabane estuary in northern KwaZulu-Natal is situated in a dune-mining lease area where a variety of metals are mined. The two species of amphipods were chosen because they conform to many attributes that describe a good bioindicator in an estuarine environment, e.g. abundant, tolerant to salinity fluctuations.

Copper concentrations in the estuary were determined using sediment, water and amphipods samples. Copper concentrations in the estuary water were very low whereas concentrations in the sediment ranged between 2.65-4 mg/l Cu. Copper concentrations in G. lignorum and C. triaenonyx ranged between about 5-70 ug/l. In laboratory bioassays only G. lignorum was used. The bioassays showed that there was no active uptake of copper from the water, but copper concentration in G. lignorum showed a significant increase with increasing copper content in the sediment (30-300 mg/l Cu), indicating possible bioaccumulation of copper.

ANNUAL VARIATION OF WATER LEVEL SOUTH PART OF LAKE TANGANYIKA FROM 1960 TO 1998.

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Tanganyika plays an important role in the ecosystem surrounding area. The water level had been fluctuating from year to year. The water level in the south part of Lake Tanganyika rose by over 3m between March 1960 and Sept. 1963. Following a slight fall in water level, it rose again by almost one metre in 1968. The water level started falling slightly up to Sept 1978, then it rose by 1m in 1979. Falling slightly up to 1988 reaching almost the peak 1978. In 1998 the water level rose after the heavy rainfall reaching almost the peak of 1989.In this paper I try to investigate possible causes in variation of water level. In this investigation Relative Humidity, Wind Gust, Air Temperature and Rainfall data had been investigated in order to explain the water level variations. The irregular fluctuation of the water level has also an impact on the lake ecosystem and on the production of some species of fish.

An algal index to predict algal related problems for water purification and recreation

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The Vaal Dam and Vaal River Barrage are important reservoirs for water supplied to potable water purification works. These sources also supply potable water to several large power

stations, industries and agriculture. Apart from these direct uses the whole length of the Vaal River is used for recreational purposes. The intense exploitation and contact by both humans and animals makes management of the catchment area imperative. Predictive tools and guidelines are thus required to facilitate the management process with respect to the various uses.

Rand Water monitors the Vaal Dam and Vaal River Barrage Reservoir for the presence of harmful conditions and organisms, such as algae, viruses and bacteria that can potentially affect the public=s carefree utilisation of the Vaal River Barrage and Vaal Dam. The monitoring of algae especially blue-green algae is of special concern as blue-green algae can form massive blooms and scums in eutrophic waters and it has the ability to produce low molecular weight toxins. Not all blue-green algal blooms are toxic, but the occurrence of toxic blooms in water bodies used for potable water, aquaculture and recreation can constitute a hazard to human and animal health through contact and ingestion of cells or released toxins. To be able to manage phytoplanton related water quality problems, routine monitoring of phytoplankton species, composition and biomass concentration in raw water is necessary. This information is assimilated in weekly and monthly reports as well as in the form of an algal problem index. To develop the algal problem index the following criteria were considered to be of importance such as Cyanobacteria presence, chlorophyll-*a* concentrations, algae indicating water purification problems, eutrophication and inorganic pollution. A weight was given to each of these criteria. A higher weight was given to the more problematic groups due to the fact that a greater health risk exists when this group is present in the water. The final API value were modified depending on the number of algae observed per field. Factors were ascertained depending on cells observed per field and the final API value was multiplied by certain factors.

Guidelines were used to classify the results into 5 categories ranging from blue that were acceptable to red that were not acceptable. The lower the API value the better the water quality in terms of algae.

This index was implemented on a pamphlet that indicate potential algal problems that can be experienced in Rand Water's water purification processes and in source waters utilised for recreational purposes. This pamphlet provide management, the recreational users and other interested parties with condensed and appropriate information concerning water quality in terms of the algal types identified. Furthermore, the awareness of the quality of surface water among the general public is increased, which in it self helps to protect our surface water.

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

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Rapid Biological Assessment (RBA) using SASS4 is now an established method of sampling rivers and streams; both for research and catchment baseline studies, and for industrial consultations, monitoring and water quality evaluations.

In the early days of SASS, little time was devoted to the assessment of habitat potential. This meant that the comparison of SASS scores from different sites became a matter of personal perception, and even ranged as low as ignoring habitat completely. On a practical level, sites DO need to be compared to each other, and often have different habitats. Note this actual scenario taken from McMillan 1998:

A stream with a rocky bed and lush vegetation enters some disused mining property, and is tested using RBA just inside the mine boundary fence. The same stream as it leaves the mine area has changed its characteristics, and is now mostly sandy bottomed, with no fringing vegetation. The SASS4 score as it enters the property is good, and as it leaves the property is poor. How much of the change in SASS4 score is due to mine seepage, and how much can

be attributed to the absence of two key habitats? A mine manager would quite rightly not accept the findings unless a recognised habitat interpretation was included in the report.

As the SASS system filters down to the practical level, issues like the above need to be clarified very quickly. The Invertebrate Habitat Assessment System (IHAS) is specifically designed for the SASS method, and is presently undergoing countrywide testing for consistency among users. Consistency among users was one of the main criteria in the 'quick and easy' monkey puzzle design of IHAS. The IHAS scoring also offers a bonus provision of modifying or 'adapting' the SASS score according to the habitat potential, to ease the comparison of different sites and make them consistent.

Ref: McMillan, P H (1998). *An integrated Habitat Assessment System* (IHAS v2), *for the Rapid Biological Assessment of Rivers and Streams*. A CSIR research Project, number ENV-P-I 98132 for the Water Resources Management Programme, CSIR. 44pp.

Metal Speciation and Toxicology: Influence of Water Hardness and Alkalinity on Metal Toxicity

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The aim of this study is to use a geochemical speciation model to predict the bioavailability of zinc and copper ions at various levels of water hardness and alkalinity. The toxicity of the metals to selected riverine Ephemeroptera will be assessed by acute toxicity testing and the results compared to those predicted by the model.

In South Africa an increasing emphasis is being placed on the protection of aquatic ecosystems as a result of deteriorating water quality through pollution from various sources. One of the standard methods used to test the effects of chemicals on organisms is aquatic toxicology, which is the qualitative and quantitative study of the adverse effects of chemicals on aquatic organisms. However, in water, chemicals can exist in a range of physicochemical forms (ionic species), a process known as chemical speciation. Some of these ionic species are in a form that can be taken up by the organism through a number of pathways. These bioavailable ionic species result in acute or chronic effects to the exposed organisms.

This study will involve an investigation into the toxic effects of zinc and copper, at various levels of hardness and alkalinity, on two indigenous aquatic invertebrates. Toxicity tests will be conducted using recirculating artificial streams in an unreplicated regression experimental design. The aquatic organisms will be exposed to the toxicant for a 96 hour (acute) period. Mortality will be used as the measureable endpoint and LC50s determined. The organisms to be used are riffle-dwelling macroinvertebrates, *Adenophlebia auriculata* and *Afroptilum sudaficanum* from the Palmiet river outside Grahamstown (Eastern Cape).

The geochemical speciation model MINTEQA2 will be used to identify the bioavailable ionic species responsible for the observed mortalities. Data required by the speciation model includes zinc and copper concentrations, which will be obtained using Atomic Absorption Spectrophotometry (total concentrations) and Anodic Stripping Voltammetry (concentrations of the free ions), and full chemical profiles of the water samples. The predictiveness of the model will be tested by monitoring the effect of changing water hardness and alkalinity levels on the bioavailability of zinc and copper and assessing the resultant biotic response.

River management orientations: the move towards a people-centred approach in the Kat River valley

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Research conducted in the Kat River valley of the Eastern Cape has explored the environmental awareness of marginalized rural communities with a view to assessing the potential for rehabilitating degraded river environments. Research in the area has shown that the historic and present relationships between local people, their natural environment and their role in managing that environment are impacted on by various external forces. Critical to understanding these relationships is a knowledge of the prevailing orientation of management agencies-, an orientation fixed by the dominant set of values and assumptions embodied within conventional scientific thinking.

During the course of the research it became clear that, if outside agencies are to play an effective role in encouraging 'grass roots' rehabilitation of the environment, they must have an awareness of the often negative impact that the values of the modern, dominant orientation have had on local knowledge. For sustainable rehabilitation and/or environmental management to become a reality there must be a shift to a people centred (or alternative) orientation that empowers rural people by recognising rather that marginalizing their wisdom and experience. This creates the opportunity for a meaningful dialogue between local and external knowledge.

The poster focuses first on the influential and eroding effects that the dominant, modernistic orientation has had on marginalised people and on their resource management. Second, the use of appropriate, people-centred methods is explored as a way to reorientate assumptions concerning environmental management. The case-study illustrates that a shift to an alternative mind-set is critical for promoting sustainable environments and improving the capacity of both traditional communities and outside experts to jointly address environmental issues.

Enabling urban catchment management - A Local Government Perspective.

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Amidst continual alignment to emerging water- and environment-related legislation, local government has to continue managing the risks and benefits associated with urban watercourses. The National Water Act, 1998 has pioneered integrated management strategies for declared Water (catchment) Management Areas and provided for the establishment of statutory Catchment Management Agencies to manage the resources in these areas. In the absence of implementation strategies for Integrated Catchment Management in the urban context, the recently established Catchment Management Department of the Cape Metropolitan Council is in the process of developing and implementing a strategy aimed at stakeholder participation in the management of urban catchments. This poster will explore the process and the associated structures developed for major catchments within the Cape Metropolitan Area. Practical examples will be used to highlight the opportunities and envisaged future alignment of this local initiative with emerging legislation.

Who is to blame? Water qualities in the Ga-Selati River, Northern Province, RSA.

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The Ga-Selati River is well known to add considerable quantities of pollutants to the Olifants River, of which it is a tributary. The question is: who is to blame for this pollution.?

Water qualities, obtained from an intensive study over a two year period are presented.

Factors influencing water qualities in the Ga-Selati River and the flow of nutrients and pollutants through the aquatic ecosystem as well as their impact on the ecosystem will be discussed.

The distribution of the Paradiaptominae (Copepoda: Calanoida)

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The Paradiaptominae, a subfamily of the large Diaptomidae family, are a small group of freshwater calanoids of which 23 species in four genera have been described. They are endemic to Africa with the exception of four species, *Metadiaptomus asiaticus* (Asia and Mongolia), *M. gauthieri* (Africa and Madagascar), *Paradiaptomus greeni* (India and Sri Lanka) and *Neolovenula alluaudi* (Canary Islands, Baltic and Mediterranean countries). The paradiaptomids are widely distributed in semi-permanent water bodies in the drier areas of Africa although most individual species have a restricted distribution. Only a few species have the ability to colonise permanent waters and these are usually located at higher altitudes. Paradiaptomids have not been recorded from the wet equatorial lowland areas of Africa. Its seems likely that they are Gondwanian in origin as evidenced by their distribution (Africa, Madagascar, India and Sri lanka). *Neolovenula alluaudi* (Mediterranean) shares morphological characters tenuously linked to other species in the group and may have a different origin.

Evaluation of the ecological importance of tributaries of the Berg River System of the Western Cape Province, South Africa.

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Several of the major tributaries of the Berg River System were evaluated to establish their ecological importance according to guidelines laid down by the National River Health Program. The habitat integrity and fish indices were used for this purpose.

Results showed that higher up sites, usually in the mountain stream and foot hill zones, were more ecologically important. This was due to most sites being in a relatively undisturbed condition with better habitat availability and containing fish species sensitive to habitat and water quality (e.g. Berg River redfin and rainbow trout). Lower down, most tributaries entered heavily farmed areas and had far lower ecological importance scores. The main impacts were found to be water abstraction, weirs, bulldozed banks, invasion of the riparian zone by alien vegetation and alien fishes.

Harvesting of Spirulina - solution for pollution in Kamfers Dam?

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Kamfers Dam is a large (440 ha) natural pan (wetland) on the outskirts of Kimberley. The main attraction of this pan is its thousands of Lesser and Greater Flamingos, which often number more than 10,000 birds. Available data for Kamfers Dam indicate that the system is highly polluted and eutrofied as a result of partially treated sewage water being discharge into the dam. Kimberley citizens frequently complain about bad smells from the pan that are perceivable over kilometres. Recognising these problems, it is essential, to find restoration strategies and a management plan to restore the water quality. A preliminary study was done during 1998 and 1999 to investigate an in-lake control measure of eutrophication. The harvesting of algae to remove nutrients from a lake is not a new concept, but technical difficulties in harvesting have precluded practical in-lake applications. However, we could reach a 80 % harvesting efficiency by filtration through a 60 µm followed by a 30 µm phytoplankton net that yields 250 g wet mass (25g dry mass) per m3 with an average chlorophyll-a concentration of 300 µg/l. The dominant phytoplankton was the filamentous Spirulina platensis. Spirulina is a very nutritious organism, rich in protein and low in fat, and is used as animal feed and in a major health food industry. The average total phosphorus (TP) concentration in the pan was 2.5 mg/l, which means that the total amount of TP in the pan is about 7,500 kg. Therefore, to remove 1kg P/day, one need to filter about 4,000 m3 of water, i.e. about 167,000 l/h!, which will yield about 100 kg dry mass/day of Spirulina. This could be a very expensive operation, however, the price of Spirulina powder can reach up to R300/kg which can make it economical feasible. Several questions, however, remains to be answered, e.g. will Spirulina dominate year round? Is phosphorus the limiting factor in the pan? What would be a 'desirable' TP concentration in the pan? It would appear that further investigation is required before algal harvesting can be applied on a large scale.

GIS river (and lake) coverages for South Africa and adjacent drainage basins

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The river network forms the basis of much geospatial water resource analysis both in the Department of Water Affairs & Forestry (DWAF) and elsewhere. For this reason, DWAF has put a great deal of effort into capturing South Africa's rivers in digital form. The first national coverages available in the early 1990s were at coarse scales, for example 1:2 500 000 or 1:1 000 000 ("Digital Chart of the World"), but geoanalysts required much greater detail for regional and catchment studies. DWAF's GIS section (now the Geomatics directorate) and the Chief Directorate of Surveys and Mapping in the Department of Land Affairs combined forces. They first concentrated on digitising the 1:500 000 scale rivers and then the much more arduous task of scanning and vectorising the blue plates of the country's nearly two thousand 1:50 000 topographical map sheets. In 1994 and 1995 the DWAF's Institute for Water Quality Studies (IWQS), with the help of consultants (GisLAB), completed editing the 1:500 000 map layer to produce a drainage network with stream ordering, correct flow direction and consistent naming (but with positional errors of up to 800 metres). By 1998, the scanning and vectorising of the 1:50 000 blue plates were complete, resulting in a highly detailed representation of river courses and other details such as lakes and pans. However, this coverage is not yet a network and the task of adding such intelligence will take several years to complete using existing techniques and data. New methods using a detailed elevation model of the country may become available but in the interim the IWQS is preparing an adjusted 1:500 000 river network, spatially corrected to the 1:50 000 coverages. Drainage regions B, X, G and part of A are complete.

A summary of the Habitat Integrity of Rivers in South Africa, 1998

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Habitat Integrity refers to the maintenance of a balanced, integrated composition of physico-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of that region (Kleynhans, 1996). In order to assess the habitat integrity of rivers, rivers were divided into 5 km reaches and a qualitative assessment was made of the habitat for each reach. The geographic information system *Arc/info* was used to present the riparian and instream habitat spatially. The assessment was converted into a numerical format and transferred to a GIS database, linked to a river coverage in *Arc/info*. Colour coding shows the different integrity classes. Individual factors contributing to the habitat integrity scores are also presented for a selected river. The instream and habitat integrity for all rivers in South Africa, which have been completed are presented. These include the Lephalala, Luvuvhu, Sand, Vet, Olifants, Vaal, Mutshindudi and the Berg rivers. The maps show the effect of human activity, and in some cases, the river's ability to partially recover downstream. Further studies currently being conducted include the Lethaba, Tugela, Mooi, Doring, Wilge, Elands and the Crocodile rivers.

Development of a Sediment Toxicity Testing Protocol for South Africa.

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In terms of the new Draft Water Bill (March 1998), the integrity of the entire aquatic ecosystem, comprising the "Reserve" must be protected. The sediment phase of aquatic ecosystems has been recognized as an important component of the aquatic ecosystem.

Little is known in South Africa about factors contributing to the health of sediment-dwellers. The CSIR, and the Institute for Water Quality Studies (IWQS), and other organizations, are collaborating to investigate the toxicity of sediments.

Anthropogenic metal contaminants enter the aqueous environment in a number of different ways. The sediment phase is in intimate contact with the water column phase of the aquatic environment. Under typical conditions, the sediment phase binds metals more strongly than the aqueous phase. This means that there is a continuous migration of metal from the aqueous to the sediment phase. Thus, under historical and currently acceptable water management criteria, the water column toxic metal concentrations might be maintained at a safe level for the preservation of water column biota, while the sediments become enriched with respect to the toxic metals.

Sediment-dwelling organisms are an important part of the aquatic ecosystem. In addition to providing nutrition for other organisms higher in the food chain, the larval stages of many important water column or terrestrial dwellers may be sediment-burrowers. If the sediments are rendered toxic, these components of the aquatic ecosystem might vanish, with unpredictable consequences on the integrity of the entire aquatic ecosystem.

Historically, the assessment of sediment quality has often been limited to chemical characterizations. It is thus vital that toxicity tests and bioaccumulation studies be conducted, in order to establish the relationship between concentrations of contaminants in sediment and their bioavailability to sediment dwelling organisms.

The technology employed in more sophisticated countries is often too expensive to be afforded by South African scientists and water resource managers. Sediment toxicity testing

must involve indigenous South African organisms. Aspects governing the implementation of cost-effective sediment toxicity testing with local invertebrates in an Ecological Risk Based framework are discussed.

Key Words: Sediment Toxicity Testing, Invertebrates, Methodology, South Africa

Genetic variation in two populations of the orange roughy (*Hoplostethus atlanticus*) from Namibia

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The orange roughy (*Hoplostethus atlanticus*) is a relatively new commercially exploited fish species, but it is currently ranked third amongst the world's top five seafood products. Gene products of 22 protein coding loci in two populations off the coast of Namibia were studied by horizontal starch gel electrophoresis. Values of 31.8% and 40.9% (0.95 criterion), and 0.137 ((0.0.47) to 0.143 ((0.042) were obtained for the percentage of polymorphic loci and the average heterozygosity of the two populations respectively. The unbiased genetic distance was 0.004 between the populations and the average fixation index (FST) value was 0.019. These values are comparable with results obtained in a similar study of orange roughy near New Zealand, where the percentage of polymorphic loci ranged from 22.7% to 38.1% (0.95 criterion) and heterozygosity values ranged from 0.104 (±0.037) to 0.125 (±0.044). The genetic differentiation observed between the populations precludes the possibility of a global total allowable catch quota for orange roughy off the Namibian coastline and we recommend that each of the populations be managed individually using the "adaptive management" strategy recommended by similar fishery endeavours in New Zealand.

Conservation of aquatic systems in the Cape floristic region.

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The Cape Action Plan for the Environment (CAPE) aims to design a reserve configuration that is representative of the species and habitats of the Cape floristic region. A poster will inform delegates of the study area, classification of rivers and the identification of priority areas.

Towards Integrated Water Resource Management in South Africa: Developing a protocol in the Sabie Catchment.

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Recent changes to the South African Water Law spell out fundamental changes in the way in which the country's water resources will be managed in the future. One of the most significant mandates is the establishment of Catchment Management Agencies (CMAs) and the delegation of water resource management responsibilities to these catchment-based institutions. Within the context of the new legal framework, there is a great need for support to CMAs, particularly in providing them with procedures for the optimal management of water resources in order to ensure the balance between sustainable use and protection of the resource. This paper describes a research project which aims to develop a protocol for integrated water resource management on a catchment basis, by using South Africa's Sabie

catchment as a case study. The Sabie Catchment, on the north eastern boundary of South Africa, was selected:

1. because of the large number of water resource related initiatives present in the catchment [such as the Working for Water Programme (alien plant clearing), the River Health Programme (river quality assessment) and The Kruger National Park Rivers Research Programme (a rivers management programme)],
2. because of the diversity of stakeholders and land-use issues in the catchment,
3. because it is rich in information relating to water use and protection and
4. because the catchment has a self-organized water management body which serves as a CMA precursor. This research project aims to produce and implement a set of generic steps and principles which will best combine and integrate the catchment's water resource initiatives and available technologies in order to maximise the benefits in support of integrated water resource management (IWRM). This paper reports on the project development during its first phase, describes the next steps in the research process and provides a conceptual framework of how the research team envisages the practical implementation of the IWRM protocol.

Towards a management plan for the Olifants River.

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INTRODUCTION

The information in this paper is the result of collaboration between the Kruger National Park Rivers Research Programme, the Olifants River Forum, the Department of Water Affairs and Forestry and the South African National Parks.

The aim of this initiative was to work towards a shared vision and objectives amongst stakeholders in the Olifants River. This was pursued by developing an Objective Hierarchy according to protocols developed by Bestbier, Rogers, Blackmore, Kruger, Nel & Biggs (1996) and Rogers and Bestbier (1997). The development of an Objectives hierarchy was aimed at facilitating the implementation of a management plan for the Olifants River Catchment. It is envisaged that a stage will be reached when the Olifants River Catchment Management Agency systematically addresses these goals by means of a management plan. This plan will be used to act as a basis of participation and to give focus and direction.

THE OLIFANTS RIVER OBJECTIVES HIERARCHY

The vision

To manage the Olifants River Catchment[1] in order to maintain (and where necessary to restore) the integrity and diversity[2] of natural resources to meet the socio-economic[3] needs of society on a sustainable[4] basis

Footnotes:

[1]There is a need to integrate with land-use management, but the central concern is always the river and its management.
[2]Includes biodiversity according to Noss (1990) and spatio-temporal flux.
[3]All needs, including cultural and political needs.
[4]Sustainable - must be justifiable and realistic.

Under the vision eight themes have been identified. They are:
Impacts; Institutions; Awareness; Legal aspects; Biodiversity; Resources; Land-use; and Human population issues

Each of these has been developed into objectives, sub-objectives, sub-sub-objectives and goals, to form an Objectives Hierarchy as described by Rogers and Bestbier (1997).

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Modelling Fish Response to Changing Hydrology and Geomorphology in the Sabie River Lowveld, South Africa

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The aim of this study was to integrate the abiotic and biotic information and knowledge collected within the Kruger National Park Rivers Research Programme (KNPRRP) into a suite of models which will improve the ability of researchers and resource managers to predict biotic response to geomorphological and hydrological changes in the Sabie River. Several innovative methods and techniques were explored. These include; 1) The use of qualitative rule-based models (QRBMs) to simulate changes in geomorphology, fish and riparian vegetation, 2) The development of new techniques for relating fish habitat to river channel morphology & 3) The use of recent computing advances, such as graphical programming, hypertext documents and the internet, to aid in the transfer of data and information and the visualisation of model results.

The Geomorphological Model: In order to relate habitat suitability to river channel morphology, some form of geomorphic predictive system was required in order to provide input to the fish models. We developed a QRBM in which rules, based on the expert knowledge of geomorphologists familiar with the Sabie River, are used to predict the dynamics of a selected representative reach of the river.

The Fish Model: The fish model is another version of a QRBM. It uses "rules" to predict the responses of specific fish groups to varying flow conditions in the catchment and potential changes in the channel type of the representative reach. It is the changing patterns of abundance established for these groups, both for normal and extreme seasonal conditions, which form the basis of the predictive model. The model output is presented in a graphical form consisting of an hypertext trace of the rules invoked at each time step, and an output file of the abundance of each fish group for each time step.

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