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Faculty of Science DESCRIPTION DESCRIPTION Science Description The Department of Zoology is a research active department and during the past 43 years almost a during the past 44 y

The Department of Zoology is a research active department and during the past 43 years almost a 1000 manuscripts have been published by researchers and postgraduate students. The Department is well known for its work in freshwater biology, specifically with regard to biodiversity of freshwater animals and the effect of pollutants on the histology, morphology and physiology of animals. A number of indices have been developed. Almost 400 honours students, more than 200 masters and more than 100 doctorate students have obtained their qualifications from this Department. Currently the Department has 10 academic staff members; 5 with NRF ratings, 6 support staff members, one research and three administrative staff members. The Department lectures in Zoology, Human Physiology, Human Anatomy, Ocular Anatomy and Physiology and Microbiology – a total of 17 semester courses to the almost 750 undergraduate students and has almost 60 postgraduate students, two postdoctoral fellows and two research centres (one shared with Botany).



Back: Ms Yolandi Cloete, Mr Smart Maswanganyi, Dr Cobus van Dyk, Mr Switch Kwapa, Dr Richard Greenfield, Prof Victor Wepener, Prof Herman van der Bank Middle: Ms Pietro de Lange-Jacobs, Dr Erna Bruwer, Ms Edie Lutsch, Ms Susann Breytenbach, Ms Lerato Masetle, Ms Lolo Mokae Front: Ms Lindie de Villiers, Prof Johan van Vuren, Prof Annemarie Oldewage (HOD), Prof John Maina, Dr Ina Wagenaar Absent: Dr Francois Durand, Mr Moses Mathonsi



Heyns Certificate



Prof Annemarie Oldewage (HOD)

The Department has a rich history and previous colleagues are commemorated by the introduction of a Schoonbee medal for exceptional postgraduate research as displayed in a thesis and the Juan Heyns certificate for the best postgraduate presentation during a departmental colloquium.



Schoonbee medal

CURRENT RESEARCH IN GENETICS

The African Centre for DNA Bar-coding has had a good last few months with regards to sample collection. 125 species of freshwater fish and 142 species of marine fish were sampled as well as 199 species of marine gastropod. Three main sampling trips were taken this year: one trip to Namibia and the Cunene River Mouth where both marine and freshwater fish, gastropods (snails) and some crustaceans (crabs) were sampled. Three previously unsampled species have been collected, one not

appearing in any of the field guides. It is suspected to be a new locality description for the species. A wide variety of crustaceans have also been collected and bar coded from the Namibian and South African coastlines. A gap exists in the Kwazulu-Natal region regarding the sampling effort, which will be addressed towards the end of this year with the Toyota Enviro Outreach, one of the centre's sponsors for 3 years.

The second major sampling trip for the year took place about 70 km north of Xia-Xia in Mozambique. A large number of specimens were sampled and almost everything was a new species in the collection. The Mozambique trip was also rewarding with respect to the fact that most of the fish sampled were purchased from the local fishermen on the shore line, so the fish were fresh, the locality was precise and the community gained some upliftment from the sampling effort as well.

The third trip was to a national heritage site. A survey and DNA barcoding

of the molluscs and barnacles of Robben Island was done by Prof Van der Bank and Dr Greenfield. This pioneer study was done to identify the alien, native and introduced species that inhabit the island. DNA barcoding will ensure correct identification of the species. The information will contribute to the global biodiversity fauna data and will enhance future efforts in conservation and management.



Prof Herman van der Bank and Ms Tanya Zeelie



Current students under the supervision of Prof van der Bank include:





Francois Roux (PhD): Ecological Aspects of Tigerfish (*Hydrocynus vittatus***) in the Incomati River System South Africa. This project initially started with a pilot project in conjunction with NINA (Norwegian Institute for Nature Research) when the feasibility of such a project was tested over a three-month period through the deployment of eight small transmitters on Tigerfish (***Hydrocynus vittatus***) in the lower Crocodile River close to the confluence with the Komati River. The main objective during this pilot project was to determine if it was possible to track Tigerfish and to test their response to the attachment procedures. During this phase, various habitat assessment models were tested to establish protocols. Furthermore, VI Tags (visible implant tags) were attached to Tigerfish in order to determine the population size, as well as additional movement data of Tigerfish in the Incomati River System.**

Johannes Hendrik Koekemoer

(PhD). A fish ecological study will be conducted on seven selected dams, in order to assess the current status of the fish communities and to evaluate the trophic structures in the seven dams for the purpose of food web manipulation. Two surveys will be conducted per dam for comparison reasons in terms of seasonal trends (this is to make provision for seasonal induced distribution of fish species, as fish distribution plays a major role in population dynamics assessments), and to build comprehensive data sets for analysis and interpretation of results. The results will be used as guidelines in the design and implementation of a remedial bio-manipulation programme where the harvesting of fish biomass is to be considered as the key component of such a programme.

Philippa Zena Nel Franzini (MSc).

Genetic, morphologic and behavioural study of Cyrtophora species in South Africa (Araneae: Araneidae). Spiders of the genus Cyrtophora form part of the family Araneidae and are commonly called tent-web spiders due to the unique shape of their web. A total of 41 Cyrtophora spp are known throughout the world and five of them have been recorded from Africa, but none formally from South Africa. The only species of Cyrtophora so far suspected to occur in South Africa is the cosmopolitan species C citricola. In South Africa, they are frequently found on aloes and cycads and live solitary or in small groups to large aggregations. This social behaviour offers many advantages but also opens the community up to threats such as birds. A behavioural trait that is fairly uncommon in spiders but is exhibited by Cyrtophora is that the webs are only repaired, when small holes are made due to prey capture. New webs are built above the old webs in cases were larger damage occurs. Physiologically the males are always smaller than the female and both have the ability to alter the degree of colour in the abdomen in response to the environment. No formal studies have been done on this genus in South Africa or on genetic analysis of this genus. In South Africa field observations have indicated that there might be more than just C citricola present and that other species are present in the country through importation and other means. The species present were determined using barcoding of the mitochondrial gene Cytochrome Oxydase 1.

The international Barcoding of Life Database (iBOLD) was used for construction of the phylogenetic tree. Several other genes were analysed in the laboratory using a Qiagen DNA mini extraction kit. Behavioural studies were undertaken through observation of a study site, collection data and photographs to determine general characteristics of their behaviour, which may be used for conservation and identification. Results have shown that several different species can be identified using genetic barcoding. Morphological differences are numerous between and within the different species especially where the abdomen shape is concerned. Behavioural characteristics were found

to differ from previous research with many new characteristics being observed. In conclusion it is important for more studies to be done on this genus as much more can be learnt on the variation within this genus and the behavioural characteristics which have not yet been documented.

Tanya Zeelie (MSc).

The behavioural and morphological assessments, including the DNA barcoding with the use of the cox 1 gene, on Thomisus (Araneae: Thomisidae). Members of the family Thomisidae are ambush hunters and well known for their coloration and the role it play to aid in ambushing their prey. It is a large family mainly found on plants and in this study, members of the flower crab spider genus Thomisus are going to be studied. Sexual dimorphism is a marked characteristic for this genus, with the males differing in size, shape and colour. Unless collected together, it is difficult to group males with their respective females. Presently 15 species of Thomisus occurs in South Africa but some of them are only known from one sex. Specimens will be collected to study their behaviour and DNA samples will be analysed for DNA barcoding using the standard cox 1 gene (mitochondrial cytochrome c oxidase subunit I). This technique is used for DNA sequencing of a portion of a single gene region in order to identify

species. It is also rapid and relatively inexpensive. With the use of DNA barcoding, studies of their morphology and behaviour, species will be compared and the data used to assist in species identification. New species will be described and the distribution range of known species extended. Several behavioural aspects will be investigated such as the role they play in pollination of flowers, when and how long it takes for colour changes to take place. Aspects about their biology such as mating, egg laying and feeding will also be investigated. Little is still known about the behaviour of *Thomisus* species and this study will contribute and expand our knowledge about them.





Lamproglena clariae burrowed into the gills of an African catfish; showing the egg sacs and the blood filled intestine.



Fluorescence of eggs shells indicating presence of metals.

Fish parasites and their application as indicators of water quality is the focus of this group. Studies are organised into two main topics, i e application of parasites as water quality sentinels and a study of basic biology of parasites in order to provide background understanding for the use of parasites as effect indicators. Resulting from studies in the Olifants River, a model was developed which showed that the number of parasites and their species composition could be utilised to distinguish between fish from two dam and two river sites with 95% accuracy. It was possible to trace each fish to its collection site with reference to their parasites. The parasite population differed significantly between the various sites although they were only a few kilometres apart, in the same river and climatic range. This was reiterated in another study in the Vaal River and correlated with differences in water quality. Parasite distribution in the location and on the host as well as the effect on the host is also studied. It was, for instance, shown that the size of Lamproglena clariae is directly related to the size of the host and not dependent on the genetic makeup of the parasite; the host size therefore also impacts on the fecundity of the parasite. Seasonality, gender preference and various other factors are studied including description of the pathology.

It is clear that parasites have value as effect indicators but that they also have potential as accumulation sentinels and fishes in the Vaal Dam harbour large numbers of tapeworms, *Bothriocephalus acheilognathi*. The occurrence and prevalence of the tapeworm in two yellowfish species was reported. We showed that *Bothriocephalus* accumulate metals to higher concentrations than the host and that the concentration is influenced by season. Twenty-three different metals were recorded and the metal concentration varies between the various body sections of the tapeworm. After development of a fluorochrome technique it was possible to visually show that some metals occur in the egg shells.





Fluorescence of sclerites inhaptor to show morphology

Paradiplozoon and a Diplozoon species were collected from the gills of the yellowfish and labeos, respectively. Most of the taxonomic studies on the Diplozoidae have focussed on the unique ultra-structure of the sclerites situated in the attachment clamps. A new method for Fluorochromy was developed to visualize this part of the parasite's micromorphology.

Recent, collaborative work on the Branchiura included phylogenetic reconstruction based on three molecular markers (mitochondrial 16S rRNA, nuclear 18S and 28S rRNA) and transmission electron microscopy of the digestive glands to understand wound inflicting and pathology. The work showed that *Argulus* transfer sperm by means of spermatophores contrary to believe for the last 200 years.



Fish parasitology research group: Mr Beric Gilbert, Prof A Avenant-Oldewage, Ms Lourelle Everts, Mr Ebrahim Hussain and at the back Ms Sandra Malgas. Absent in the picture Ms Esmari Kilian, Mr Dionne Crafford, Ms Mangoako Dikgale.

Current students under the supervision of Prof Oldewage include:

Mr D Crafford (PhD): Monogenean fauna of the Vaal River system

Monogeneans are flatworms of which most are parasites on the external surfaces of vertebrates, including fish. Limited availability of South African baseline data is an important current constraint with regards to general advancement in parasitic monogenean research on freshwater fish in this country. Monogeneans from *Labeo* spp hosts are a point in case. Out of 27 *Dactylogyrus* species described from African *Labeo* spp hosts, only one species have been described from South Africa. As a result this project aims to generate parasitic monogenean species composition and infection level baseline data for the Vaal River system, and to relate results to aspects of parasite biology and related ecological variables. In short: What do we have and what do we need to know? It is envisioned that this project shall provide a platform from which additional aspects can be investigated.



Quadricanthus sp from African sharptooth catfish (Clarias gariepinus)



Dogielius sp from the Orange River mudfish (Labeo capensis)



Miss L Everts (PhD): Aspects of the Biology of Branchiura

Branchiura is a class of Crustacea that parasitize fish, frogs, salamanders and alligators. There are four genera in this class, namely *Argulus* Muller, 1785, *Dolops* Audouin, 1837, Chonopeltis Thiele, 1900, and *Dipteropeltis* Calman, 1912 of which *Argulus, Chonopeltis* and *Dipteropeltis* are the focus of this project.

This project will study the *Argulus* pathology and *Chonopeltis*, reproductive systems Furthermore, a *Dipteropeltis* will be described morphologically.

Argulus japonicus adult male



Ms Esmari Kilian (MSc): Aspects of the biology of *Ergasilus* sp found in Lake Tanganyika.

Four species of *Ergasilus* have been described from fishes in Lake Tanganyika. During a recent survey specimens of *Ergasilus* sp were found in three localities. Gills were removed after the fish were killed by severing the spinal cord. Parasites were fixed intact on the gills in an acetoformaldehyde alcohol solution and preserved in 70% ethanol. This study will elucidate ergasilid infection biology. It is hypothesised that these parasites can cause major pathological alterations in their host which can result into death. The prevalence of the parasite is 100% on the samples that where collected.



Lake Tanganyika.

Mr B M Gilbert (MSc): Metal bioaccumulation in an endoparasite, Bothriocephalus acheilognathi

Interest into the application of parasites as sentinel organisms for monitoring environmental degradation has increased. Many parasite pollution studies have shown that parasites accumulate heavy metals at greater concentrations than their hosts. Studies have shown that fish intestinal helminths have an ability to concentrate heavy metals above concentrations present in the ambient environment and to levels that are several - fold higher than those present in the host tissues. Further research into the ability of intestinal helminth parasites to accumulate heavy metals has revealed a partitioning in the metal concentrations between the anterior and posterior body segments. In South Africa, work has been carried out on metal bioaccumulation in the tapeworm Bothriocephalus acheilognathi Yamaguti, 1934 from the Vaal Dam. The results of this study showed that the tapeworms accumulated heavy metals to concentrations above those present in the host fish, Labeobarbus kimberleyensis (Gilchrist and Thompson, 1913) and the water and sediment. The aims of this study are therefore 1) to identify the metals that are present within the different body sections of *B* acheilognathi in comparison to those metals present in the tissues of the host fish, L kimberleyensis 2) to determine whether a difference occurs in the concentrations of the metals present in each of the different body sections of *B* acheilognathi. In a nutshell this study will demonstrate whether the different segments of B acheilognathi have varying potentials for the accumulation of heavy metals due to the fact that the different body segments are of varying age and have therefore been exposed for varying periods of time.



Mr Ebrahim Hussain (MSc): The use of the *Diplozoon* species as a sentinel organism for heavy metals

Diplozoon is a monogenean ectoparasites on the gills of cyprinid fish. Many studies have already been conducted on the use of endoparasites as sentinels for heavy metals. It has been observed that cestodes and acanthocephalans accumulate metals in higher concentrations than both the host fish and the surrounding environment. There has been no conclusive results regarding the use of ectoparasites as sentinel organisms, thus during the course of this study the potential use of the *Diplozoon* species as a sentinel species for heavy metal pollution in the Vaal Dam will be assessed. This is done by analytical analysis of the metals found in both the parasites and their respective fish hosts. The concentrations of the various metals found in the parasite will be compared to that of the fish host and from this, we will be able to assess the viability of using the *Diplozoon* species as a sentinel organism for heavy metal pollution.



Centre for Aquatic Research members and associates during a research fieldtrip to the Okavango River. Back row: Prof Nico Smit (NWU), Dr Steve Mitchell, Mr Gordon O'Brien (PhD student), Prof Victor Wepener, Dr Glyn Howatson (Research fellow), Mr Ruan Gerber (PhD student), Dr Richard Greenfield. Front row: Dr Wynand Vlok (Research fellow), Prof Johan van Vuren, Dr Jan Roos (Research fellow).

THE CENTRE FOR AQUATIC RESEARCH (CAR)

Since its founding almost 40 years ago, the Department of Zoology has been at the forefront of aquatic research in South Africa. Over the last 20 years, a group of scientists in the Department have developed a branch of aquatic research into the field of freshwater and estuarine ecotoxicology. Ecotoxicology is the science that studies the influence of human activities (from global, eg global warming to a more local perspective, eg multiple stressors in the Vaal Barrage) on the environment. Research in the Department has been active in all disciplines of ecotoxicology ranging from toxicant identification and environmental distribution (ie quantify and qualify levels) to biological / environmental effects (ie at different levels of biological organization from subcellular to ecosystem responses) to management implications (eg through ecological risk assessment paradigm).

Current researchers participating in CAR are a blend of experienced (NRF-rated) and upcoming researchers. Each participant contributes a specific field of expertise that, when combined creates the most comprehensive research group of its kind in Africa. Currently the research centre consists of four Faculty members, three researchers, one short course coordinator, one post-doctoral fellow, three research fellows and 35 full- and part time postgraduate students. Training and services within the niche are represented at three different levels; ie research-based Masters and PhD projects, a tutored Masters programme in riverine and wetland ecology in conjunction with the UNESCO/Flemish Government/WRC funded FETWater programme and specialist aquatic consulting services through Econ@UJ.

The centre is headed by Prof Victor Wepener, who leads the ecological risk assessment component of the research. Prof Johan van Vuren leads the ecophysiological and biomarker research and is actively involved in EDC research activities. Dr Ina Wagenaar leads the histopathology research, while Dr Martin Ferreira is responsible for the ecologically-related research activities. Some of the research activities that have been initiated within the niche since 2009 include international collaboration with the Centre for Marine Environmental Research and Innovative Technology, City University of Hong Kong on the application of artificial devices in environmental monitoring of marine waters (Prof Wepener), developing an EU-COST Action project entitled Quality Assessment of Fish Gametes (Dr Wagenaar), assessing the aquatic effects of pharmaceuticals associated with cattle feedlots in conjunction with the Faculty of Veterinary Sciences, Hokkaido University (Prof Van Vuren) and largescale interdisciplinary and inter-institutional projects on tigerfish biology in the Kruger National Park (Water Research Commission) and Lake Pongolapoort Dam (IRD-Aires du-Sud) in conjunction with the Water Research Group at Northwest University under the leadership of Prof Nico Smit.

To date, three research associates have been included as part of the research strategy of the Centre. They are Dr Glyn Howatson (University of Northumbria – stress physiology), Dr Wynand Vlok (BioAssets Consultants - fish ecology) and Dr Niel Bruce (Queensland Museum invertebrate taxonomy) and their main role in CAR is to assist with training and supervision of postgraduate research projects. Dr Vlok and Dr Jan Roos are involved in the tutored MSc (FETWater) programme and assist with student supervision in this programme. ECON@UJ members (Martin Ferreira and Wynand Malherbe) are responsible for the applied component of the research in the Niche. Their involvement also crosses to the teaching and fundamental research side of the Centre where they assist in the supervision of students involved in CAR projects and the FETWater programme.



Hartbeespoort Dam Water Monitoring and Algae Management Program

Hartbeespoort Dam water quality is hyper-eutrophic due to continuous inflow of excess phosphate from sewage and via sediments. Yearly, phosphate input is around 200 tons. Further nutrients are being released from lake sediments adding to the phosphate excess. The nutrient excess leads to rapid growth of water hyacinth and periodic algal blooms, mainly in summer, with an estimated 10000 - 15000 tons of algal biomass being produced per year. However, 200 tons of phosphate could give rise to at least 20000 - 40000

tons of biomass per year, indicating other limitations on biomass growth or only partial removal of the biomass growing in the lake, limitations that have to be overcome for effectively reducing the lakes nutrient load. Since surplus plant material decomposes and sinks to the bottom, nutrients are accumulating in sediment that is continuously stirred up by bottom feeding fish. The major algae bloom is caused by Microcystis, a cyanobacterium that can produce powerful toxins that results in the lake water

being unfit for human and animal consumption. On the other hand, balanced algal growth coupled with biomass harvesting from the lake is an efficient bioremediation strategy, as algal biomass removed from the lake is equivalent to nutrient removal. Algal biomass harvested from the lake may be applied for biofuel or electricity generation or used as fertilizer in agriculture. The ultimate purpose of this program is maximal bioremediation of lake water by controlled algal cultivation and harvesting, avoiding

the development of algal blooms and toxin production. Researchers from the Centre for Aquatic Research are involved in a collaborative research project together with Prof Sammy Boussiba, the leading world authority on algal biotechnology from Microalgal Biotechnology Laboratory of the Jacob Blaustein Institutes for Desert Research, Ben-Gurion University. The project is funded through Friends of the Ben-Gurion University in South Africa.



Crocodile River below the Hartbeespoort Dam wall.



The application of passive artificial devices for monitoring of metallic and organic pollutants along the South African coastline.

A drastic increase in the construction of industries, domestic development and tourism demands have altered the landsea interface to alarming proportions. With 65% of South Africa's coastline threatened by pollution, anthropogenic waste in the marine environment is a growing cause for concern due to its adverse effects on the health, productivity and biodiversity of our coastal ecosystems. Bivalves such as mussels have traditionally been used as biomonitors of pollutant exposure. However due to a number of intrinsic biological factors such as age, sex, species differences, etc, erroneous conclusions can be made regarding the body levels of chemicals representing the external exposure pollutant concentrations. Together with research collaborators from the Marine Environmental Research and Innovative Technology (MERIT) Centre at The University of Hong Kong and City University of Hong Kong, researchers from the Centre for Aquatic Research are applying specialised monitoring devices that were designed to overcome these limitations. These are two types of passive artificial devices, the artificial mussel for heavy metals and the

semi-permeable membrane device for organic pollutants. This study involved the deployment of the artificial devices in four major harbours along the South African coastline. In addition, mussels from a reference (clean site) were transplanted in the four harbours as well. After an exposure period of seven weeks the artificial devices and transplanted mussels were removed and transported to the laboratories at UJ and MERIT for metal and organic residue analyses respectively.

The aspirations of this project extend beyond contributing to marine research. With the White Paper for Sustainable Coastal Development in South Africa obtaining legal status, there is a national responsibility to initiate a monitoring programme that assesses the level of coastal contamination and there is no denying that there is a dire need for a coordinated national marine monitoring network if we are to achieve our commitment to protecting our marine environment. It is hoped that results of this study will effectively convince relevant organisations that the use of this technology is a step towards developing a sound monitoring programme, thereby exemplifying a core fundamental research project through applicable achievement. This project was funded by the NRF South Africa-China bilateral research grant. Researchers involved in this project are MSc student Natalie Degger, Dr Richard Greenfield, Prof Victor Wepener, Dr Bruce Richardson and Prof Rudolf Wu.

Ecological Risk Assessment framework for pesticides at Vaalharts Irrigation Scheme

Water resources are under severe pressure in South Africa and the protection of it is of vital importance for the future sustainable use of our water resources. One pressure on our water resources is the use of pesticides in agriculture. Little is known about the effects these pesticides have in our local aquatic ecosystems as well as the risks they may pose to the aquatic environment. Therefore, a pesticide risk

assessment framework has been adapted for our local conditions that can determine these risks. This framework is currently in the process of being validated in the Vaalharts Irrigation Scheme. The scheme is situated in the Northern Cape Province and receives water from the Vaal River. The intensive agriculture and the arid nature of the area were the criteria used to select it as a validation study for the framework. The Vaalharts Weir channels water into a canal system that provides water for 40 000ha of agricultural land. The return flow of the irrigation scheme runs into the Harts River which joins the Vaal River downstream of the Vaalharts Weir. Crops

are planted throughout the year with wheat (36%), maize (23%) and groundnuts (22%) being the dominant crops. Cotton, soft fruits, citrus fruits, vineyards and olives are also being farmed.

The framework that has been developed depends initially on the input of local farmers for information on the local usage of pesticides. This data is then combined with secondary data on the pesticide characteristics which results in a preliminary risk assessment. This is then compared to the actual pesticide values measured in the environment as well as field monitoring results of various aquatic biota, eg diatoms, fish and macro-invertebrates. All

the information gathered from the different phases feeds into an integrated risk assessment that forms part of a decision support system.

The outcome of the project will provide a validated pesticide risk assessment framework and the decision support system for South Africa. The decision support system will be able to communicate to all stakeholders of the Vaalharts Irrigation Scheme the potential risk of pesticides to the aquatic environment of the Harts River. The project is supported through an NRF Focus Area research grant and researchers involved in this project are Wynand Malherbe (PhD student) and Prof Victor Wepener.



Marine fish parasitic isopods from Southern Africa

Parasitic isopods are rarely studied in South Africa and thus little information is available on the biodiversity of these parasites regarding their occurrence, distribution and hosts. This data is necessary to understand the effects these parasites will have on the South African fish populations and the aquatic environment as a whole. These isopods infect a number of different species in the marine and estuarine environments and have been recorded to have negative impacts on the fish industry

when encountered in large infestations. This is due to the isopods causing skin damage, lesions, and anemia, and may even lead to the death of the host in extreme cases.

According to Kensley's (2001) Indian Ocean check-list for marine Isopoda, only 16 (5.3%) of these isopods are cymothoids collected from South Africa, which is very low considering the high marine invertebrate diversity in this country. Thus, an in-depth study on the biodiversity of these parasites is necessary to compile data on their occurrence, distribution and hosts. Furthermore, there is no information available on the genetics of cymothoid isopods which could assist in identification and

phylogenetic relationships. Our parasitic isopod project thus aims to rectify this and address all the issues related to the biodiversity, ecology and genetics of these enigmatic animals.

Cymothoidae are amongst the largest ectoparasites found in the world, being easy to spot with the naked eye and thus a large number of these isopods have been deposited in the South Africa Museum by fishery scientists as well as the general public. Since Kensley (1978), no one has studied this large collection of parasitic isopods and thus a complete study of all of these deposited materials will be undertaken. Fresh material, specifically for genetic studies, will be collected from the west,

south and east coasts of South Africa through participation in the surveys and angling competitions. All specimens collected will be studied following standard established taxonomic and molecular methods.

This project is funded by the National Research Foundation and the University of Johannesburg's URC and has also benefitted from travel grants to Kerry Hadfield by the Parasitological Society of Southern Africa and the South African Biodiversity Institute. Researchers involved in this project are Prof Nico Smit (Northwest University), Dr Niel Bruce and Kerry Hadfield (PhD student).

Conservation of tigerfish, *Hydrocynus vittatus*, in the Kruger National Park

South Africa's premier wilderness area, the Kruger National Park (KNP), is worldwide renowned for its conservation of Africa's big five. However, equally important, but less known to the national and international visitors, it also plays a very important role in the conservation of tigers, but not the fury kind, rather the scaly type! Tigerfish, Hydrocynus vittatus, one Africa's premier freshwater fishes, are present in most of the main rivers of the KNP, but unfortunately, their

numbers are declining, not due to lack of protection in the KNP, but rather a result of the deterioration of the water quality and quantity of the rivers before they enter the park. The challenge for the conservation of this and other freshwater inhabitants of Kruger's rivers is much bigger than that of the terrestrial species.

It is generally accepted that the biological indicator approach is an effective method to determine organism response to changes in environmental conditions. The indicator species selected for this study is the tigerfish, since it is clear that this species can be regarded as a species of concern. Two river systems were selected for this study, i.e. the Olifants and Luvuvhu rivers. The Olifants River has known migration barriers to the east, within, and on the western boundary of the KNP, whereas the Luvuvhu River has no migratory barriers to the east or within the KNP. This allows for an assessment of the influence of flow and migratory barriers on the occurrence and distribution of the indicator species. With regards to water quality, the Olifants River is regarded as a contaminated system with a high potential for sediment contamination. The Luvuvhu River is not as contaminated as the Olifants River and this allow for a comparison in general indicator health and population structure in relation to water quality conditions.

Therefore the aim of this study is to investigate the suitability of the tigerfish (Hydrocynus vittatus) as

indicator of unacceptable changes in water quantity and quality in the Olifants and Luvuvhu rivers. This will be done through a multi-metric approach that represents different levels of biological organization ranging from sub-cellular to population level. This three year project (2009-2011) is funded by the Water Research Commission and supported by the Kruger National Park Scientific Services. Researchers involved in this project are Prof. Nico Smit (Northwest University), Prof Victor Wepener, Prof Johan van Vuren, Dr Ina Wagenaar, Dr. Richard Greenfield, Dr. Wynand Vlok, Ruan Gerber (PhD student) and MSc students (Chris Renshaw, Warren Smith, Eve Fisher and Sarah Dyke).



Tongue replacement isopod.

Tigerfish sampling using artificial lures in the Kruger National Park.

Ecological health monitoring of pans on the Mpumalanga highveld

Perennial pans are regular features of the landscape in the Mpumalanga Province of South Africa. They are classified as wetlands and are therefore protected by the various acts and laws that protect wetlands in general. The problem is that the ecology of these ecosystems has not been well studied. Our knowledge of pans is limited to the ephemeral pans of the drier parts of our country and effective management tools related to perennial pans do not currently exists in South Africa.

The aim of the study is thus to develop effective tools and to increase the current knowledge on the ecology of perennial pans by assessing the spatial and temporal trends amongst seven perennial pans in Mpumalanga. Several of these pans are located in the Lake Chrissie area and are not influenced by human activities. Pans that are impacted by coal mining and agricultural activities have also been included in the study. To achieve the aim of the study, various

components of the selected pans needs to be studied. These include abiotic factors like water quality, sediment characteristics and surrounding land-use and various biotic components like vegetation and very importantly, the aquatic invertebrates.

Preliminary results indicate a large degree of variation in the abiotic and biotic components of the various pans. Results of water quality analysis has indicated that pans can be separated based on water colour and nutrient concentrations, with these factors influencing both diversity and abundances of the aquatic invertebrates

found in these systems. The large variation observed in the water quality and invertebrate communities makes the separation of natural changes and changes induced by human activities quite difficult. To effectively determine the impacts of mining and agriculture, the focus may need to change from diversity of invertebrates to the role of the different taxa in the community. This project was funded through the IFS programme and researchers involved in this project are Dr Martin Ferreira, Prof Victor Wepener and Prof Johan van Vuren.



Brachiopod crustaceans from pans on the Mpumalanga highveld.



Ecological risk assessment of multiple stressors in aquatic environments

Gone are the days when pollution of freshwater and marine ecosystems could be attributed to the release of a few toxicants into the environment. Aquatic ecosystems are increasingly under threat from multiple stressor sources releasing unknown compounds into the environment. The process that is used to assign magnitudes and probabilities to the adverse effects of anthropogenic activities or even natural catastrophes is referred to as ecological risk assessment (EcoRĂ). Different forms of EcoRA can be utilised, eg the Regional Scale Ecological Risk Assessment Methodology (RRM) is used on a defined regional or spatial scale of an ecosystem consisting of multiple habitat components, one or more of which is being impacted upon by multiple stressors from multiple locations or sources. The risk assessment makes use of various lines of evidence (LoE) to relate the stressor exposure to the affected components (ie biological responses) of the system. The

LoEs in an EcoRA are based on characteristics of exposure (quality of water and sediment) and characteristics of effects (eg fish biology, toxicological assessments, diatom community structures, general health and condition of fish, etc.).

Researchers from the Centre for Aquatic Research with a wide range of scientific expertise are involved in a variety of different research projects that make use of EcoRA methodologies to address complex environmental issues. These projects include the development of a risk assessment framework for the pulp and paper industry (conducted for SAPPI), identifying risk factors responsible for the fish kills in the Vaal barrage (conducted for the Department of Water Affairs, SASOL and Rand Water), Klip River aquatic health assessment (Department of Water Affairs) and risk assessment of industrial contaminated sediments in freshwater ecosystems (SASOL). Researchers involved in these studies are Prof Victor Wepener, Prof Johan van Vuren, Dr Ina Wagenaar, Dr Cobus van Dyk, Ms Yolandi Cloete, Mr Gordon O'Brien, Dr Martin Ferreira and Mr Wynand Malherbe.

Growth stimulants from cattle feedlots and the aquatic environment

Residue amounts of pharmaceuticals used by humans have been widely detected in surface water. The use of pharmaceuticals is not limited to human consumption since a number of veterinary pharmaceuticals are used as growth promoters in cattle feedlots. Concerns about the possible harmful effects of these growth promoters in the aquatic environment developed in the last 10 years.

The growth promoters are used by livestock producers to increase meat production and the efficiency of converting feed energy into meat. Different hormones are presently used in beef production to stimulate growth. Residue amounts of the hormones were not restricted to the meat that is consumed by the user, but is also excreted in cattle manure from where it can contaminate surface and ground water. Concerns developed on the effect thereof on organisms in the aquatic environment.

Biomarkers may offer relevant information regarding the potential toxic effect of growth stimulants on freshwater fish. Carefully selected biomarkers are used to study possible cellular alterations that may occur as a consequence of the chronic exposure to the growth stimulants. Cellular alterations may lead to abnormal physiological responses in organs. Clarias gariepinus is a suitable fish species to use in research where these physiological changes are determined in sub-lethal exposure experiments. Tissue from the liver and kidneys of the fish are used to measure the changes in the values of biomarkers

to show the effects on the normal functioning of important organs. Exposure concentrations are in line with expected levels of the growth stimulants in the natural stream receiving effluent from cattle feedlots. The effect of the hormones on other aquatic organisms eg water insects (macroinvertebrates) is also studied. The effects of feedlot effluent on the water quality and the habitat integrity of the receiving stream are included in the research programme. The project is done in collaboration with researchers at the University of Pretoria and funded by UJ and the Water Research Commission. Researchers involved in the study are Prof Johan van Vuren, Prof Victor Wepener and MSc students (Michael Tresise, Michiel Jonker and Marco Alexandre).





Sustainable utilisation and conservation of tigerfish *Hydrocynus vittatus* in the Phongolo River and Pongolapoort Dam



Dr Richard Greenfield and project leader Prof Nico Smit waiting for the "big one" to take the lure.

Conservation of natural aquatic systems of South Africa can only be achieved through the proper management of our aquatic biodiversity. Included in this management, and in many cases depending on it, is the sustainable utilisation of natural resources through non-destructive system utilisation practices, which offer sufficient social and economic returns to the stakeholders.

The ecology of the Phongolo floodplain is finely tuned, but is increasingly being disturbed, firstly by the damming of the Phongolo River at Jozini and secondly through the increasing population and agricultural pressure on the floodplain. Although it has a huge impact on the Phongolo floodplain, the Jozini Dam (also known as the Pongolapoort Dam) completed in the 1960's, is one of the recreational fishing hotspots of South Africa and definitely the most popular place in South Africa to land a record size tigerfish (Hydrocynus vittatus Castelnau, 1861). Tigerfish is not only the most sought after freshwater angling fish in Africa, but is also one of the most important predators in African waters. Although abundant in certain areas throughout Africa, numbers have declined in many rivers, due to water extraction. pollution and obstructions like dams and weirs.

The upper catchment of the Phongolo River is subjected to intensive agricultural activities, whereas the floodplain region below the Jozini Dam falls within the DDT malaria control region. As such, aquatic organisms are at risk due to environmental exposure of these contaminants. This study specifically addresses all the factors that might influence the health and conservation of tigerfish and will provide valuable insight into the current exposure levels and future risks to the populations of this and other aquatic species. Research outputs from this work on the tigerfish of Phongolo will also serve as a case study for sustainable utilization and conservation of freshwater

angling resources in southern Africa.

This three year project (2009-2011) is supported by Ezemvelo KZN Wildlife and funded by AIRES-Sud, a programme of the French Ministry of Foreign and European Affairs implemented by the Institut de recherche pour le Développement (IRD-DSF). Researchers involved in this project are Prof Nico Smit (Northwest University), Prof Victor Wepener, Prof Johan van Vuren, Prof Herman van der Bank, Dr Ina Wagenaar, Dr Richard Greenfield, Dr Cobus Van Dyk and MSc students (Michelle Soekoe, Kyle McHugh, Russell Tate and Eve Fisher).



Development of a conservation plan for the Lowveld Largescale yellowfish in the Crocodile River, Kruger National Park.

The Lowveld Largescale yellowfish (Labeobarbus polylepis) is currently widely distributed and the populations within this distribution area are abundant. However, the continued population stability and viability of some of these populations is threatened due to increased human pressures on their habitats. One population that has recently received attention is the Lowveld Largescale yellowfish population that occurs within the Crocodile River that forms the southern boundary of the Kruger National Park. Although Lowveld Largescale vellowfish individuals were obtained from two of the three sampling sites selected on this system during a recent survey, the stability of this population has been questioned and

remains uncertain in light of the excessive overutilization of the goods and services provided by the Crocodile River by water resource users.

Currently, there is no management and / or conservation plan for this species and the potential use of this species as an indicator species for the conservation and management of the Crocodile River as a whole has not as yet been addressed. Researchers from the Centre for Aquatic Research are evaluating three complementary approaches to measure the exposure of the Lowveld Largescale yellowfish to stressors impacting on the ecosystem structure and function of the Crocodile River. These approaches involve the assessment of the

change in the behaviour of a population of the Lowveld Largescale yellowfish to altered habitat and flow conditions in the Crocodile River using biotelemetry. A bioaccumulation and biomarker-based assessment will be carried out to determine the extent of water quality related stressors impacting on the population of the Lowveld Largescale yellowfish.

This study is funded through the Water Research Commission and is undertaken by an MSc student (Matthew Burnett) who is based in the Kruger National Park. The project is carried out in collaboration with SANPARKS and researchers involved in the study are Prof Victor Wepener and Gordon O'Brien.

Histology-based fish health assessments of indicator fish species from selected freshwater impoundments in the North West Province

Pollutants in freshwater ecosystems become distributed within abiotic components within the system and can ultimately have an impact on the biota. It is the nature and extent of this impact on aquatic organisms which is of concern and needs to be determined. Histopathology is a useful biomonitoring tool to assess the effects of pollutant exposure on the cellular level of target organs of exposed organisms.

The aim of the research is to investigate the relationship between the aquatic pollution of selected freshwater impoundments and the health of fish that inhabits these systems. The research approach is to determine the type and extend of microscopic and macroscopic abnormalities that are present in resident fish and to measure the levels of contaminants in water, sediment and tissue samples. Chemicals tested for include endocrine disrupting

chemicals (EDCs) and metals. Selected impoundments include the Hartbeespoort, Klipvoor and Bospoort Dam impoundments. The aim is to determine whether the abnormalities that occur in fish are related to the toxicants in the water.

The methodology used to assess the health of the fish is a Histology-based Fish Health Assessment (HBHA) protocol that includes a necropsy where each fish is examined macroscopically to identify any external or internal abnormalities, parasites or injuries, and a microscopic investigation of selected target organs by means of a qualitative and quantitative light microscopy analysis.

The study is funded by the Department of Water Affairs and the researchers involved are Dr. Ina Wagenaar, Dr Cobus van Dyk and the MSc students Byron Bester, Amanda Mooney and Ngcebo Sikhakhane.



Mr Byron Bester (MSc) with a carp Cyprinus carpio before the necropsy procedure



Measurement of water quality parameters



Ms Amanda Mooney (MSc) collecting a blood sample from a Mozambique tilapia Oreochromis mossambicus

CENTRE FOR AQUATIC RESEARCH: INTERNATIONAL COLLABORATORS



Dr Niel Bruce (Museum of Tropical Queensland, Queensland Museum, Australia), world expert on marine isopod crustaceans, is a Research Fellow in the Department of Zoology. Together with Prof Nico Smit and his postgraduate students they are working on diverse aspects of fish parasitology, including research into the biology, ecology and systematic of fish parasitic isopods. Niel has particular expertise on the taxonomy of those groups, and some 25 years of experience.

A prime part of the visit was to share and impart knowledge of taxonomic methods, techniques and principles with the students, and to jointly map a collaborative future in this area of research through co-supervision of appropriate students. While at the Department of Zoology, time was spent in discussing taxonomy as a process, and also developing an outline research program for student Kerry Hadfield, including the relevance of the software program DELTA as a taxonomic tool. As a result of these early planning and scoping meetings, it was decided that Kerry Hadfield would benefit from time spent at Niel's lab in Townsville Australia, particularly developing a deeper knowledge of fish-parasitic isopod systematics.

There is a wider interest in marine isopod systematics in South Africa, and Prof Smit together with Niel Bruce, where discussion research development options in that area. Isopod systematics, other than occasional papers, really stopped with the publication of *Guide to the Marine Isopods of Southern Africa* in 1978, but there are still large gaps in knowledge of South Africa's marine isopod fauna. The field trip to Tsitsikamma was primarily to continue ongoing isopod parasite work, but Niel Bruce together with PhD candidate Kerry Hadfield took the opportunity to make some simple baseline collections, which immediately provided exciting results, namely an apparently common and hitherto undescribed genus of Sphaeromatidae from high shore (supra-littoral) habitats previously not known to have isopods, some undescribed species, and also a specimen of a new species of isopod from a family not previously recorded in southern Africa.

Dr Glyn Howatson (Northumbria University) is a Research Fellow with the Department of Zoology. As an exercise physiologist, his research involvement is to expand on the data from previous field work examining the physiological stress response of Tigerfish catch-and-release techniques used by recreational anglers. Tigerfish not only help provide homeostatic balance within the ecosystem, but also form a valuable part of the local people's diet and attract large numbers of anglers every year which generates huge sums of money that helps drive the local economy through tourism. There are currently no data documenting these physiological responses to catch and release, so it was imperative to elucidate the mortality of these important top predators.



Dr Glyn Howatson with one of the tigerfish that did not get away.



Prof Victor Wepener with Prof Rudolf Wu and Dr Bruce Richardson at Hout Bay during the artificial mussel project deployment fieldtrip.

Prof Angela Davies is a Visiting Professor to the Department of Zoology and has had research links with South Africa since 1996. In 2008 she spent three weeks with researchers from CAR to catch up with work progress in the Department of Zoology, where she shares supervision of MSc and PhD research students with Prof Nico Smit. She also joined Prof Smit, some of his colleagues, and students, on a marine field trip to Tsitsikamma National Park to assist in the research projects that are undertaken in this marine protected area.

Prof Angela Davies (second from left) with the group of postgraduate students and researchers at Tsitsikamma National Park.

Prof Paul van den Brink is no stranger to the members of the Department of Zoology. He is a researcher at Alterra and a Professor in stress ecology in the Department of Aquatic Ecology and Water Quality Management, Wageningen University, The Netherlands. He is regarded as one of the world authorities on semi-field based effects assessments of pesticides in the aquatic environment. He is a research collaborator on a recently completed SANPAD funded research project on ecological risk assessments of pesticides in South Africa. As part of the project he was the PhD co-supervisor of Dr Tahla Ansara-Ross. Prof Van den Brink has presented two workshops on the application of multivariate statistical techniques in ecological effects assessment studies. These workshops were attended by postgraduate students from the University of Johannesburg, researchers from industry, government and other academic institutions. Prof Van den Brink was a keynote speaker at the Southern

African Society of Aquatic Scientists, which was organized by CAR. His expertise in semi-field mesocosm studies was utilized in the design of the mesocosm facilities on UJ Island, which form part of the pesticide and nanomaterial risk assessment projects that are being conducted by members of the CAR.

Researchers from CAR (Prof Victor Wepener and Ms Natalie Degger) and the Centre for Marine Environmental Research and Innovative Technology (Merit), The University of Hong Kong (Prof Rudolf Wu), initiated a project on the use of artificial devices to monitor organic and inorganic pollutants along the South African coastline. Three papers emanating from the project were published in the prestigious ISI journal, Marine Pollution Bulletin. Prof Wu is the Director of the School of Biological Science, The University of Hong Kong and since the commencement of this particular project, the Department of Zoology has entered into collaboration agreement with HKU.





Prof Lieven Bervoets and Prof Victor Wepener sampling fish in the Olifants River in the Kruger National Park.

Prof Lieven Bervoets and his PhD student (Maartin de Jonge) from the Department of Biology at the University of Antwerp are involved in the Kruger National Park tigerfish project. Their involvement in the project is to assist with the metal bioavailability in sediments and organic residues in tigerfish from the Olifants River. As part of the research collaboration, an MSc student (Ms Sarah Dyke) spent three weeks in the analytical laboratories of the Department of Toxicology at the University of Antwerp. During this period, she prepared and analysed the levels of persistent organic pollutants in fish tissue and sediment from the Olifants River. The research collaboration between the CAR and the Ecophysiology, Biochemistry and Toxicology research group in the Biology Department at Antwerp has been ongoing for the past 15 years. Prof Wepener is also a quest lecturer in the Oceans and Lakes tutored Masters programme that is copresented by three Flemish universities.

ECOLOGICAL RISK ASSESSMENT OF NANOMATERIALS IN THE AQUATIC ENVIRONMENT

Nanotechnology has taken the world of science by storm since it allows for the development of new materials with extraordinary properties. Examples of novel nanotechnology applications include the development of highly accurate and sensitive medical diagnostic devices, new ways of disease therapy, and the monitoring and remediation of basic water supplies. With the rapid graduation of nanotechnology from laboratory to industrial applications and commercialization of products, the risks that may be associated with nanomaterials requires attention at its infancy phase to ensure safe and responsible long-term development of this novel technology.

The science of nanoecotoxicology is at its infancy, not only in South Africa, but

also internationally. All of the ecotoxicological knowledge on metal and organic pollutant bioavailability and the cellular uptake and mechanisms of toxicity is based on the traditional bulk metal ion or organic compound properties. The Centre for Aquatic Research (CAR) has been involved in ecotoxicological research for the past 15 years and has extensive experience in linking environmental metal and organic pollutant exposure (through bioaccumulation studies) to ecological effects at different levels of biological organisation (from mortality tests to sub-lethal endpoints such as DNA damage, enzyme activities, metabolomics, etc). Since nanomaterials are in essence particles associated with metal or organic compounds, the bioaccumulation and cellular distribution processes cannot be described using the methodologies developed for their bulk equivalents. It has become increasingly evident that more innovative analytical techniques are required to address the mechanisms associated with nanoparticle bioavailability, uptake, elimination bioaccumulation and ultimately cellular interactions.

The CAR is the leading nano-ecotoxicology research group in Africa. The CAR currently leads the ecotoxicological component of the OECD nanoGold (nAu) research project and is also a co-proponent on the EU 7th Framework Programme: NanoSolutions (NMP.2012.1.3-1) dealing with nano-ecotoxicology. Prof Wepener, the leader of CAR, also serves on the DST Nanomaterials Health Safety and Environment Advisory Committee and

is the project leader of a Water Research Commission funded project to identify the research needs for ecological risk assessment of nanomaterials in the waters of South Africa. Researchers and postgraduate students from CAR are involved in a collaborative programme together with the CSIR (Dr Ndeke Musee) and the Centre for Nano Materials Science (Department of Chemical Technology) to develop a framework to study the aquatic ecological risk assessment of selected nanomaterials. Researchers involved in these studies are: Prof V Wepener, Prof B Mamba, Prof R Krause and Dr N Musee. Three PhD students, Dumsile Nyembe, Lungile Lukhele and Tarryn Botha are undertaking research on aspects of carbon nanotuble and nanogold ecotoxicology.



Prof Victor Wepener with PhD students, Dumsile Nyembe and Lungile Lukhele preparing a laboratory exposure experiment.



Mr Switch Kwapa, Mr Smart Maswanganyi, Dr Richard Greenfield and Mr Moses Mathonsi

The aquarium is fully equipped to provide the Zoology staff and students with what ever is needed for conducting both laboratory and field-based studies. There are three full-time employed staff members in the aquarium. Two are responsible for maintaining equipment, cleaning of systems, breeding of fish, and providing assistance to staff and students alike with experimental work. The other is responsible for the above

mentioned tasks as well as the day to day management of the aquarium, vehicles, and field trips that need to be arranged. Within the aquarium, the Department of Zoology is fortunate to have ten environmental rooms. In these rooms the temperature can be controlled, as well as the light exposure period to provide standardized test conditions by minimizing the number of variables present in the system. The aquarium also has a reverse osmosis

unit which enables the use of the purest water possible for conducting exposure tests. On the main floor there is approximately 20 000 liters of water heated to 25 degrees Celsius for holding and maintaining exposure stock. All systems are set up with biological filtration units to minimize the use of water and energy needed to keep it warm. The aquarium also boasts two rooms equipped for the breeding of exposure stocks. If the

aquarium cannot manage to provide enough stock, then there is also the necessary equipment to transport fish, using two 1000 liter transport tanks. There is a large variety of relevant field equipment including a research caravan, trailers, boats and three 4x4 vehicles. All this equipment facilitates both field sampling and laboratory-based experiments for a variety of different research projects.

FETWATER PROGRAMME IN RIVERS AND WETLANDS

The Foundation for Education and Training in the Water Sector (FETWater) is a programme that was developed to stimulate effective cooperation in research, education, training and capacity building initiatives to achieve integrated water resource management in South Africa. The programme provides institutional support and financing in the form of seed funding to encourage the creation of training networks as a method for effective co-operation between universities, research institutions, and the public and private sectors in South Africa. Phase II of the programme was initiated in 2007 and consists of three main programme partners, namely the Flemish Government, UNESCO and the South African Government (Department of Water





Affairs). The Wetland and River Network (WRN) was one of the first Phase II networks to be funded and is made up of academic departments from Johannesburg, Free State, Venda and Limpopo universities. The tutored MSc programme in Aquatic Health that is presented by the University of Johannesburg's Research Niche in Aquatic Ecotoxicology, was used as the launching pad for the modules that were developed by the WRN. In addition to the modules being presented in the tutored MSc, they were also presented as standalone short courses. The programme consists of 7 and 8 modules for the short course and MSc degree, respectively. The courses provided training at a professional scientific level in managing riverine and wetland ecosystems. The courses were presented at a variety of venues including the University of Johannesburg (APK), UJ Island, the Magaliesberg Conference Centre and Lajuma Nature Reserve.

Participants are evaluated for each module in the form of theory and practical assignments. The 7 theoretical modules are on Functional freshwater and wetland ecology, Water quality and pollution, Monitoring of wetlands and rivers, Estuaries and the near-shore marine environment, Legislative aspects related to rivers and wetlands, Wetland and river management and Wetland and river remediation and rehabilitation.

Since its first intake of four MSc students in 2008, it has grown and there are currently 20 MSc students registered and three students have graduated. In addition, 27 participants have completed one or more of the individual short courses for non-degree purposes. The majority of the MSc and short course students are part-time students and are undertaking the training as part of their daily work requirements in the Department of Water Affairs, South African National Botanical Institute, provincial Nature

Conservation authorities and environmental consultancies.

Highlights of the course include the presentation of the module on estuaries and the near-shore marine environment at the Tsitsikamma National Park. This module is divided into estuarine and marine lectures. Prof Nico Smit presented the marine lectures with quest lectures by Prof Gray Williams (Swire Marine Institute of Marine Sciences, The University of Hong Kong) and Dr Niel Bruce (Queensland Museum). Prof Victor Wepener headed the estuarine part of the module with guest lectures by Prof Janine Adams (Nelson Mandela Metropolitan University). Practical lectures were presented by Prof Brian Allanson and Prof **Richard Barnes (Cambridge** University) who imparted their wealth of experience and expertise on the Knysna Estuary. The participants spent the day carrying out salt marsh ecology surveys and sample analyses in the Knysna Basin Project field laboratory. The participants

completed an estuarine fish and benthic invertebrate practical at the Groot River (West) Estuary (Natures Valley). The past two year's postgraduate students from The University of Hong Kong participated in the module. Their participation provided the South African and Chinese students with the opportunity to exchange views on current trends in estuarine/marine ecology, their research projects and their cultures in general. The theoretical modules are ended off at Lajuma in the Soutpansberg west. The focus of this module is on remediation and rehabilitation of wetlands and rivers. This module is headed by Dr Wynand Vlok together with Mr Marius Snyders (SANParks Biocontrol and rehabilitation). Prof Ian Gaiger of the Lajuma conservation and education centre who is a well-known fish ecologist, gave participants additional lecturers on some topics relevant to this module.



STUDENT AND RESEARCH EXCHANGE WITH THE UNIVERSITY OF HONG KONG

In August 2008 student exchange and research collaboration was initiated with the Division of Ecology & Biodiversity (DEB) at The University of Hong Kong (HKU). Since then, a number of different activities have been undertaken in conjunction with staff and students. The three top UJ Zoology Honours students participated in the annual HKU field courses during October 2009 and 2010. During these week long courses, the UJ students acted as demonstrators for the marine ecology components (by virtue of their third year experience gained at the Tsitsikamma course) and participated in the freshwater, mangrove and terrestrial ecology courses. During each course, a UJ staff member also presented a lecture series on South African ecosystems and the research that is conducted at UJ. The staff member was also one of the course presenters in his field of expertise. Three HKU postgraduate students attended the 2010 and 2011 annual Zoology marine ecology excursion and tutored MSc estuarine and marine ecology module at the Tsitsikamma National Park. They participated in the MSc module lectures and practicals and upon completion received the module certificate. Prof Gray Williams (Director of the Swire Marine Institute of Marine Studies) attended the

excursions and presented lectures in intertidal ecology and acted as co-supervisor of a Zoology Honours project.

During March and April 2010, Dr Tak-Cheung Wai from DEB participated in field surveys to the Phongolapoort Dam and the Luvuvhu River during March/April 2010. He initiated the stable isotope research component of these projects. The first results from these surveys are currently being analysed. Another HKU staff member, Dr Nancy Karraker, participated in a field survey to the Kruger National Park as part of an amphibian project. Dr Karraker assisted in the formulation of the PhD research project of a UJ student (Charon Farquharson)

and will also act as cosupervisor of her PhD. Dr Richard Greenfield from the Department of Zoology attended a training session at HKU during November 2009 for stable isotope sample collection while Zoology PhD student, Wynand Malherbe, participated in a two week summer course on Environmental and Human Health: Impact Assessment at City University of Hong Kong from 4 to 10 July 2010. This course was attended by selected PhD students from all over the world and lectures were presented by world-leaders in the particular topics. The risk assessment has particular relevance to the PhD of Mr Malherbe.



Hong Kong University postgraduate students together with the UJ tutored MSc students photographed with Prof Brian Allanson and Dr Richard Barnes during the saltmarsh practical session in Knysna.

RESEARCH IN FISH HISTOPATHOLOGY AND REPRODUCTIVE BIOLOGY



Ms Mokae, Dr Wagenaar and Dr Van Dyk



Fish histopathology and reproductive biology research group: Amanda Mooney, Byron Bester, Bosupeng Motshegoa, Dr Cobus van Dyk, Jamie-Lee Szamosvari, Dr Ina Wagenaar



Ms Jamie- Lee Szamosvari with an anaesthetized leopard before sample collection

The fish histopathology and reproductive biology research group of Dr Ina Wagenaar strives to do high quality research on the cause-and-effect relationship between toxicant exposure and the associated histopathological and/or reproductive effects in fish. The research approach includes both field surveys of wild fish inhabiting rivers and dams, as well as controlled laboratory exposure studies. The applied methodology involves a histologybased fish health assessment protocol that allows the identification of abnormalities on cellular level using light microscopy analysis, and is applied to all major organ systems including the identification of hepatic, renal, respiratory, reproductive and cardiac responses. The research focus of Dr Cobus van Dyk, senior researcher in the Department, is on toxicological pathology of fish with a special interest in the quantitative analysis of neoplastic and nonneoplastic lesions.

Current students within this group include Ms Lolo Mokae, lecturer and PhD student, assessing the health status of five economically important fish species from the Okavango Delta, Botswana. Mr Warren Smith's (MSc) study is on the histopathology of selected target organs of the tigerfish Hydrocynus vittatus as a biomonitoring tool in the Olifants and Luvuvhu rivers in the Kruger National Park as an indicator of the water quality. Mr Ngcebo Sikhakhane (MSc) is currently completing a study on the fish health assessment on two indicator fish species inhabiting the eutrophic Hartbeespoort, Klipvoor and the Bospoort Dam impoundments located in the North West Province. Three MSc students, Ms Amanda Mooney, Mr Byron Bester and Ms Bosupeng Motshegoa are currently assessing the health status of fish from three impoundments in the North West Province, as well as the edibility of the fish and the associated human health risk.

Dr Wagenaar's research is also focussed on reproductive health of fish and mammals, with special interest in gonadal histopathology and spermatology. Students who recently completed their research projects in fish histopathology and spermatology are Ms Tarryn Botha (MSc) and Dr Marcelle Cochrane (PhD). These studies focussed on sperm motility parameters and testicular histopathology as reproductive indicators of the effect of pollutants. Tarryn worked on the sentinel species *Clarias gariepinus* from the Hartbeespoort Dam and Marcelle worked on *Clarias gariepinus* and *Oreochromis mossambicus* in a DDT-sprayed area in the Limpopo Province.

Research in reproductive health included the characterization and functional evaluation of antelope epididymal spermatozoa following cryopreservation in South Africa (Fungayi Chatiza, PhD) and a quality assessment of cryopreserved spermatozoa of the blesbuck (*Damaliscus pygargus phillipsi*) blue-wildebeest (*Connochaetes taurinus*) and African buffalo (*Syncerus caffer*) by Neil Mynhardt (MSc). Jamie-Lee Szamosvari (MSc) is currently studying the reproductive physiology of the Leopard, *Panthera pardus*.

Prof Maina working at Lake Magadi early this year

RESEARCH IN COMPARATIVE RESPIRATORY FUNCTIONAL MORPHOLOGY

Respiration and with it the acquisition of molecular oxygen and removal of carbon dioxide is vital to life. Oxygen is continually taken-up and utilized for energy production. Energy is required mainly to drive the physiological processes that maintain homeostasis. In terms of modern means of economic transactions, figuratively, energy is the currency that animal cells use to purchase and procure services. Metabolic rate defines the pace at which energy is mobilized, transformed, and utilized by an organism to build, service, and maintain its infrastructural integrity. While most animals will live for weeks without food and days without water, most of them will only survive a few minutes

of asphyxia (lack of oxygen): life has become permanently inscribed on molecular oxygen. In complete contrast to processes like feeding, thermoregulation, locomotion, and reproduction that can be adjusted, delayed or even stopped altogether without long-term harm, acquisition of oxygen (a process generally termed breathing or respiration) is a continuous activity. The importance of continually accessing oxygen in sufficient amounts comes into personal focus when you grasp the fact that if breathing was to stop as you read this line, irreversible damage, starting with that of the most sensitive tissues/ organs like the brain and the heart, would occur within 3 to 4 minutes and death is

certain in ~5 to 6 minutes.

Prof JN Maina has extensively researched the area of comparative respiratory functional morphology and developmental biology. Animals at different phylogenetic- and developmental levels, those that pursue different behaviours and lifestyles, and those that inhabit diverse ecological environments and habitats, especially the extreme (severe) ones, have and continue to be investigated. The following questions have directed his research inquiry: How? Why? and When? have gas exchangers (respiratory organs/structures) adaptively and developmentally evolved and formed to provide the necessary demands for

molecular oxygen? Insights into the mechanism(s) and the processes by which gas exchangers inaugurated and refined to their high fidelity modern states have and continue to be gained using microscopic, stereological (morphometric), molecular biology, mathematical and computational modelling, and three-dimensional reconstruction techniques. Other areas of research include cellular defences of the respiratory systems and the effects of inhaled pathogens and particulates on them, the basis of the mechanical strength of the blood-gas barrier, and the adaptive respiratory physiology of the Lake Magadi extreme tilapia fish, Alcolapia grahami.



Prof Maina and students







Trona (soda ash) covering the surface of Lake Magadi

COLLABORATION WITH THE UNIVERSITY OF HOKKAIDO, SAPPORO, JAPAN

Many different types of contaminants present in the environment with potential adverse effects on wildlife, are particularly of serious concern. Freshwater fish are in direct contact with the affected water and the effects of these compounds pose a threat to their health. Studies in the ecotoxicology and ecophysiology laboratories focus on the survival mechanisms used by fish exposed to these conditions. These studies include work on the effects of metals, growth stimulants and endocrine disrupting chemicals. The objectives of the large number of completed projects concentrated on sub-lethal effects of selected contaminants with high toxicity and marked effects on physiological functioning of organs and organ systems. The stress effects of chronic and periodic exposure

are studied in different environments to determine physiological changes on cellular and sub-cellular levels of organisation. Chronic or sub-lethal effects are in general more subtle and qualitative, and difficult to monitor at population and community level. A variety of carefully selected biomarkers are used to show changes in the physiology of an organism that may lead to serious impairments of normal metabolic pathways and reactions that compromise the health of the exposed organism. The need to detect and assess the influence of pollutants at low concentrations and in complex mixtures, has led to the development of a wide range of biomarkers of exposure and effect. Rapid measurements of cellular responses to contaminants assist to identify critical levels below which the health of organisms remains

normal. Biomarkers of exposure show the effects on biotransformation while biomarkers of effect show changes in energy allocation and synthesis of molecules. Organisms living in chronically contaminated aquatic environments use adaptive mechanisms including genetic changes to survive. Changes in biomarker values are used to identify and predict the effects of contaminants on fish physiology and therefore survival.

Current projects of Prof Johan van Vuren aim to increase the existing suite of biomarkers and the accuracy of predicting whether biomarker values are increasing or decreasing after exposure to selected contaminants. Information provided by these analyses is used to verify and expand existing knowledge. The last two years collaborative

research has been established with colleagues at the Laboratory of Toxicology, Department of Environmental Veterinary Science, School of Veterinary Medicine, University of Hokkaido, Japan. Procedures developed to determine the values of new and more advanced biomarkers are used to assess the biochemical and physiological specific chemical contaminants eg growth stimulants and pesticides. Levels of persistent organic pollutants (POPs) are determined in the sediment and fish tissue sampled in the Luvuvhu and Olifants Rivers in the Kruger National Park as well as the Phongolo River, KwaZulu-Natal. Biomarker responses are interpreted in relation to the concentrations of the contaminants.



Sampling site in the Luvuvhu River at Bobomene, Pafuri, in the Kruger National Park



Research team at the Mamba weir in the Olifants River in the Kruger National Park



Prof van Vuren and students