# Department of Ichthyology and Fisheries Science

Photograph by CLW Jones

# Research Report Series 25

**RHODES UNIVERSITY**
Department of Ichthyology and Fisheries Science
P.O. Box 94, Grahamstown 6140

**October 2013**
**(Version 1)**

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**October 2013**
**(Version 1)**

**Edited by: C.L.W. Jones & C. Stewart**

# Schedule of Events/Table of Content

## Wednesday 16 October 2013

## 08h10-08h20: Welcome by Prof. Warwick Sauer (Head of Department)

## Honours seminars (Chair: Cliff Jones)

### 08h20-08h40: Richard Taylor (BSc Honours student) - Brewery effluent grown duckweed as a tilapia feed supplement

Supervisors: Dr CLW Jones (c.jones@ru.ac.za); Prof. PJ Britz (p.britz@ru.ac.za)

Funder: Water Research Commission (K5/2008)

Algal ponding systems have been used to treat brewery effluent, but harvesting the algae remains a bottle-neck in the process. Duckweed could potentially be used as an alternative to algae in the treatment of post-anaerobically digested brewery effluent. Duckweed has been used for wastewater renovation in the past, is easy to harvest and has been used to supplement animal feed due to its high protein and carbohydrate content. This study aimed to evaluate the nutrient removal efficiency of duckweed grown on brewery effluent and its quality as a tilapia feed supplement by conducting two experiments.

In the first experiment duckweed was grown in 40 L containers filled with brewery effluent or a nutrient solution that represents river water (control). The change in dissolved phosphorous (P) and dissolved nitrogen (N) in its various forms where recorded. In the second experiment tilapia growth was compared between five feeding treatments. In treatment 1 tilapia where fed excess brewery effluent grown duckweed. Tilapia in treatment 2 where fed control grown duckweed in excess. In treatment 5 tilapia were fed commercial feed slightly in excess. Tilapia in treatment 3 and 4 where fed 50% of feed given in treatment 5 and brewery effluent grown duckweed or control duckweed in excess.

Duckweed and its associated micro-organisms were efficient at removing dissolved N and P from brewery effluent. They removed on average 3.14 ± 0.54 mg/L/d of dissolved N and 1.38 ± 0.25 mg/L/d of dissolved P which equated to an average of 95.28% ± 1.89% of total dissolved N and 90.79% ± 4.11% of dissolve P being removed.

At the beginning of experiment 2 there was no significant difference in the weight of tilapia between the five treatments (18.32 ± 1.94 $g.fish^{-1}$; ANOVA, $p = 0.05$). After 42 days fish fed brewery effluent grown duckweed only and control duckweed only where significantly smaller (23.53 ± 1.15 $g.fish^{-1}$; 22.82 ± 3.88 $g.fish^{-1}$) than fish fed commercial feed supplemented with brewery effluent grown duckweed (37.78 ± 2.00 $g.fish^{-1}$) control duckweed (39.38 ± 2.94 $g.fish^{-1}$) and commercial feed only (41.46 ± 4.53 $g.fish^{-1}$) (ANOVA, $p = 0.0001$). There was no significant difference in the weight of tilapia fed commercial feed only and tilapia fed commercial feed supplemented with brewery effluent grown duckweed and control duckweed after 42 days (ANOVA, $P > 0.05$).

Duckweed grows on brewery effluent and removes dissolved N and P. Tilapia readily eat brewery effluent grown duckweed. Duckweed cannot be used as 100 % replacement for commercial tilapia feed but can be used as a partial supplement.

Key words: freshwater; aquaculture; wastewater

### 08h40-09h00: Bruce McClure (BSc Honours student) - Seaweed inclusion in formulated feeds of *H.midae*

Supervisors: Mr J Kemp (groovypalm@gmail.com); Prof P Britz (p.britz@ru.ac.za)

Funders: Rhodes University Research Committee; Marifeed (Pty) Ltd.

Seaweed (SW) is the dominant component of the diet of the abalone *Haliotis midae* in its natural environment. In contrast, the majority of commercially farmed abalone are now fed on formulated pelleted feeds. Seaweed, in the form of the brown phaeophyte kelp *Ecklonia maxima*, has been included in commercial pelleted abalone feed for several years. Inclusion has been shown to improve growth of abalone, especially in diets with relatively low protein inclusion levels (26 %; as compared to the industry standard 34% protein diet Abfeed ® S34). Kelp is included fresh, with the maximum inclusion level limited by the amount of associated moisture that accompanies the kelp, and its subsequent effect on the manufacturing process. The use of dry seaweed meal over fresh seaweed would allow the inclusion level to be greatly increased. However, there is anecdotal evidence to suggest that the water stability of pelleted feed is compromised with increased dry seaweed inclusion. Furthermore, it is postulated that seaweed can act as a feed attractant and that the feed consumption of *H. midae* may be improved with higher inclusion levels.

In order to determine the effect of seaweed inclusion level on the water stability and feed consumption of a pelleted feed, 6 isonitrogenous diets (26 %) were formulated with graded SW inclusion levels of 5 %, 10 %, 15 %, 20 %, 25 % and 30 %. Two further diets were formulated to control for SW inclusion (26% protein, 0 % SW) and protein level (34% protein, 0 % SW). The seaweed used in the formulation were equal proportions of dried *Ulva sp.* and *Gracilaria sp.* meal. A feeding experiment with three replicates (5 abalone per replicate) per treatment was conducted in a temperature controlled room in a recirculating aquaculture system (RAS). Culture conditions were maintained at 18$^{o}$C water temperature, >90% dissolved oxygen saturation and Total Ammonia Nitrogen (TAN) of >0.1 mg/l. Abalone were fed daily at 4 pm and uneaten food removed the following morning at 9 am. Uneaten food was oven dried to determine dry weight and allow for the calculation of daily feed intake per replicate. The trial was conducted for 28 days.

Furthermore, a 48 hour leeching trial was conducted for all diets to determine the effect of submergence time on dry matter leeching from the experimental diets. This allows the generation of a leeching correction factor for the feed consumption trial. Initial results indicate that after 28 days, *H.midae* consumed significantly more of the 25% and 30% SW inclusion diets. A further correction factor taking into account the feed removal method (siphoning) is currently being determined before the final feed consumption can be accurately calculated. Full results from this trial will be presented.

Key words: mariculture; aquaculture; *Haliotis midae*; formulated feed; seaweed inclusion

**09h00-09h20: Kyle Lloyd (BSc Honours student) - Does the feeding behaviour of farmed *Haliotis midae* differ at various stocking densities?**

Supervisors: Dr CLW Jones (c.jones@ru.ac.za); M Naylor (matt@hik.co.za)

Funders: HIK Abalone Farm (Pty) Ltd; Rhodes University Research Committee

Space for the farming of South African abalone *Haliotis midae* is limited, so stocking density needs to be optimised to better use available space on existing abalone farms. Farms currently stock their abalone at around 18 % surface area of baskets covered by animals. However, recent observations suggest that *H. midae* are not evenly distributed within baskets and that growth is compromised at densities above 18 %, even when water quality is maintained at optimal conditions. These findings, as well as behaviours such as stacking and blocking witnessed by Nicholson (Unpublished) and Huchette *et al* (2003), suggest that there are density dependent changes in behaviour at higher stocking densities.

The aim of this research was to develop a better understanding of why the growth of farmed *H. midae* is compromised at higher stocking densities, even when water quality is maintained at optimal levels. A second aim was to find out how often and for how long animals were feeding on Abfeed ® and if these behaviours differed at different stocking densities.

Four baskets were stocked at 18 % and four at 24 % of the available surface area, with 70-80 g animals. One animal from each basket was tagged using reflector tape so that these individual animals could be viewed easily at night. The abalone in each basket were fed at 0.06 % body weight per day with the Abfeed®-S34 leaf pellet. The feeder plates were filmed for 60 days (infrared cameras were used at night). In addition, hourly snapshots were taken at 7:00 pm, 9:00 pm, 11:00 pm, 1:00 am and 3:00 am and the proportion of the total number of animals above the feeder plate was calculated for each density.

There was no significant difference in the average time spent feeding between tagged abalone stocked at 18 and 24 % (32.01±16.78 min; $t=1.34$, $p=0.23$). There was also no significant difference in the time between feeding, with an overall average of 5.09±2.86 d between feeding events ($t=-1.63$, $p=0.99$). Abalone were most active above the feeder plate at 9:00 pm and least active at 3:00 am throughout the eight week trial (multifactor RM-ANOVA, $F_{(28, 192)}=10.37$, $p<0.0001$). There were proportionately more abalone above the feeder plate in the low stocking density treatment, and this was the same at all times of day with the exception of 3:00 am (multifactor RM-ANOVA, $F_{(4, 192)}=5.97$, $p=0.00015$). Rainfall had an effect on activity above the feeder plate, with significantly higher numbers above the feeder plate 10 minutes before it rained compared to the number above the feeder plate while it was raining (ANOVA, $F_{(5, 30)}=24.51$, $p=0.001$), and the same was found for both stocking densities (multifactor RM-ANOVA, $F_{(5, 30)}=0.25$, $p=0.93$).

Abalone did not feed on the formulated diet every day as previously thought and stocking density did not influence this behaviour. The reason for the decline in growth at the higher stocking density might be related to fewer abalone accessing the area above the feeder plate at that density. Abalone were sensitive to rainfall events and appear to be less active above the plate when it rains.

Key words: marine; aquaculture; abalone; rainfall

**09h20-09h40: Willem Malherbe (BSc Honours student) - Genetic variation among geographically-separated populations of a freshwater fish (*Barbus pallidus*; Cyprinidae) in South Africa**

Supervisors: Dr A Chakona (a.chakona@saiab.ac.za); Dr G Gouws (g.gouws@saiab.ac.za)

Funder: South African Institute for Aquatic Biodiversity

A freshwater minnow belonging to the goldie barb group, *Barbus pallidus* has a disjunct distribution that can be broadly divided into inland and coastal populations. Inland populations occur throughout tributaries of the Vaal River system while coastal populations occur in the Eastern Cape rivers from the Krom to the Great Fish. As a result of this large perceived distribution, *B. pallidus* is currently classified as Least Concern in the IUCN List of threatened taxa. The huge geographic distance between these two populations and the fact that they were previously considered to represent different species provided ample motivation to undertake this study. Sequence data from the cytochrome *b* gene region was used to assess genetic differences between inland and coastal populations of *B. pallidus*.

Samples of *B. pallidus* were collected from 8 localities spanning 7 different river systems and muscle tissue was taken for DNA analysis. DNA extraction and amplification was done at the South African Institute for Aquatic Biodiversity (SAIAB) and the PCR products were sent to Macrogen (South Korea) for sequencing. A total of 24 sequences were generated. A haplotype network was constructed using the program TCS and a maximum likelihood tree was constructed using the program MEGA. A genetic distance matrix was calculated in PAUP and haplotype diversity, nucleotide diversity and mean pair-wise differences were calculated using DnaSP.

The parsimony network revealed two disjointed clades: one comprising of all coastal populations and another one comprising of all inland populations. Mean pair-wise differences (*d*) revealed deep divergence between the two lineages (4.31%), while *d* within each lineage was much less (0.63% and 0.24% for inland and coastal lineages, respectively).

These preliminary results suggest that what is currently described as *Barbus pallidus* from both inland and coastal regions display significant genetic differences from each other. Corroboration of these findings with similar morphological results may therefore constitute enough evidence for separating these populations into two species. Should this happen it will mean an immense reduction in the current area of occurrence of *B. pallidus*, with a revision of its conservational status required.

Key words: freshwater; conservation; genetic diversity; phylogeography; South Africa

**09h40-10h00: Simon Leigh (BSc Honours student) - Behavioural and respiratory responses of naive chubbyhead barb *Barbus anoplus* to conspecific alarm substances and predator odour**

Supervisors: Prof. T Booth (t.booth@ru.ac.za) ; Dr W Kadye (kadyew@yahoo.com)

Funder: Rhodes University Research Committee

Chubbyhead barb, *Barbus anoplus,* is the most common minnow south of the Limpopo River. Little is known about its predator evasion behaviour and its potential responses to their odours. It is hypothesised that chubbyhead barbs can detect both the scent of a predatory fish and the alarm substances, known as schrekstoff, released from conspecifics

Chubbyhead barbs were sampled from the Makazana River, near Adelaide in the Winterberg Mountains and largemouth bass, *Micropterus salmoides,* were sampled from small dams around Grahamstown. For the behavioural experiment, a fish (wither small or large) was placed into glass aquarium tanks that contain a gravel substrate, filtered with an under gravel filter and containing a PVC pipe for refuge. The experiment was conducted for 60 individual fish. All experiments were conducted in a constant-environment room at a temperature of 20°C and a 12h:12d photoperiod. Fish were acclimated for two days, after which four water treatments (water from the chubbyhead barb tank; water from a tank containing bass; alarm substance in the water of a separate tank with bass, and water from the first bass tank) were introduced sequentially. Each treatment lasted a day. Data were collected four times a day (twice during the day and twice at night). Data collected included the position of each fish in the tank and their activity level. A repeated measures GLM was applied to the data to determine the effects of refuge usage (inside the pipe or not) or the activity lever to the water treatment, photoperiod, size of the fish.

Respirometry is still to be conducted. Individual fish will be placed in the respirometer and allowed to acclimate for 12h before the water treatments will be flushed through the respirometer every 2h. Average metabolic rates for each treatment will be used to determine the effects of each treatment on the metabolic rates

Chubbyhead barbs were found to be nocturnal. During the day, for all treatments, 85 to 100% of the fish selected the pipe refuge and exhibited low activity levels by hovering above the substrate. At night, 78 to 83% of fish were outside of the pipe and had significantly higher ($p < 0.01$) high activity levels. The introduction of the alarm substance and bass water treatment invoked a response similar to that observed during the day, with significantly more ($p < 0.01$) fish (71%), found inside the pipe. There was no significant change to the control ($p > 0.05$) with the re-introduction of bass water from the bass tank.

These results show that chubbyhead barbs do not recognise bass odour as a predator scent and only react significantly to the inclusion of a conspecific alarm substance. The inability of fish to learn a behavioural response to the repeated bass water treatment suggests that fish are unable of receipting bass scent. Further research could be conducted on the long term exposure of chubbyhead barb alarm substance and predator odour to determine if learning takes a longer period or an increased number of treatments.

Key words: freshwater; ecology; schrekstoff; nocturnal

**10h00-10h20: Dylan Howell (BSc Honours student) - Movement behaviour of largemouth bass *Micropterus salmoides* in Wriggleswade Dam, Eastern Cape, South Africa**

Supervisors: Dr O Weyl (o.weyl@saiab.ac.az); Dr P Cowley (p.cowley@saiab.ac.za)

Funders: South African Institute for Aquatic Biodiversity (SAIAB); The DST-NRF Centre of Excellence for Invasion Biology; South African Netherlands Research Programme on Alternatives in Development (SANPAD)

Largemouth bass *Micropterus salmoides* are a popular sport-fish for recreational anglers but are invasive in South African freshwaters where they are considered a major threat to native aquatic biota. To better understand their movement behaviour, this study used data from 10 individual largemouth bass (310 - 385 mm FL) that were surgically implanted with individually coded transmitters and monitored for 9-months (May 2010 to January 2011) using an array of five moored acoustic data logging receivers in the Kubusi arm of Wriggleswade Dam, Eastern Cape, South Africa. The aim of this work was: (1) describe area-use and (2) investigate the influence of air and water temperature, water flow and lake level on the movement behaviour of largemouth bass.

Area-use by bass was observed to change over time. Bass spent little to no time in the shallow areas above the array during colder time periods (<12.5°C), however as water temperature increased utilisation of these areas increased significantly (Chi-square, $p < 0.01$). General Linear Model results demonstrated that the daily area-occupied by largemouth bass was only significantly affected by water temperature on ($p<0.01$) and that air temperature, day length, river flow or dam level did not. Bass were observed to track daily changes in mean water temperature with fine scale movement as measured by average daily area-occupancy, with fish moving to deeper zones in response to decreasing temperatures and shallower zones when temperatures increased. It was also found that fish with home ranges in shallow areas were much more impacted by temperature change and showed a higher degree of movement than bass that had home ranges close to deep water. The results from this study therefore demonstrated the importance that environmental drivers, in this instance changes in water temperature, have on largemouth bass movement.

Key words: freshwater; ecology; acoustic telemetry; area-occupancy; invasive fish

## 10h20-11h00: Tea break

## Honours seminars continued (Chair: Cliff Jones)

### 11h00-11h20: Paul Danckwerts (BSc Honours student) - Turbidity as an ecological determinant of predation success and standard metabolic rate in the non-native sharptooth catfish *Clarias gariepinus*

Supervisors: Prof. AJ Booth (t.booth@ru.ac.za); Dr Wilbert Kadye (kadyew@yahoo.com)

Funder: Rhodes University Research Committee

High turbidity is a common feature of many southern hemisphere inland waters and is largely influenced by the nature of the catchment. Increasing anthropogenic pressure on limited freshwater resources primarily through poor land-use practices will inevitably exacerbate the turbidity of many freshwater systems. This study aims to elucidate the potential impact of turbidity on both predation success and standard metabolic rate of sharptooth catfish *Clarias gariepinus*.

For both experiments, fish were acclimated to one of two treatments: turbid (40 NTUs) and non-turbid (0 NTUs) water. Laboratory conditions were kept constant at 20ºC and a 12 h: 12 h photoperiod. Fish were fed to satiation once daily on commercially-available fish flakes. For the predation success experiment, all fish were individually weighed (g) and measured (mm), placed into single tanks and starved for 48h. A total of 10 turbid-water-acclimated fish were placed in either clear (5 fish) or turbid (5 fish) water, and 10 clear-water-acclimated fish were placed in either clear (5 fish) or turbid (5 fish) water. A total of 10 damselfly larvae were placed into each tank as prey. After an hour, the tanks were sieved with a handnet and the remaining larvae counted. Predation was recorded as the number of larvae consumed. This experiment was repeated in triplicate.

Under both acclimated and non-acclimated conditions, more damselfly larvae were consumed in turbid water (3.46 ± 0.93; 1.93 ± 0.49) than clear water (3.26 ± 0.73; 0.8 ± 0.26) with significantly more larvae consumed in acclimated fish (Two-way ANOVA, p, 0.01). The lowest predation success was from turbid-acclimated fish placed into clear water.

Metabolic rate was determined using computer automated intermittent-closed respirometry. A respirometry chamber was placed in a covered clear-water bath, and a single turbid water-, and clear-water-acclimated fish placed into a respirometer for 4 h to achieve basal metabolic rate. Each fish was then either exposed to clear-water or turbid water. In total, five fish were exposed to each of the two acclimation and two treatment combinations. Initial results suggest that turbidity increases mean $O_2$ consumption and that acclimation to treatments reduces mean $O_2$ consumption.

The results of these experiments on a generalist species suggest that the impact of turbidity on more sensitive species would be substantially more profound, and possibly detrimental to whole fish communities.

Key words: freshwater; physiology; ecology; respirometry; acclimation

**11h20-11h40: Matthew Farthing (BSc Honours student) - Age and growth of Cape Stumpnose (*Rhabdosargus holubi*) (Pisces: Sparidae) from estuaries and surrounding areas in the Eastern Cape, South Africa**

Supervisors: Dr N James (n.james@saiab.ac.za); Dr W Potts (w.potts@ru.ac.za)

Funder: Rhodes University Research Council

The Cape stumpnose *Rhabdosargus holubi* is a principal ichthyofaunal component of Eastern Cape estuaries, and represent 15.6% of the number of fish landed. It has become increasingly important to recreational and subsistence anglers, however there is little age and growth information available. This study aimed to describe the growth of this species using otolith-based ageing techniques.

Fish were collected opportunistically in the Kowie (n = 15), Kariega (n = 58) estuaries, in the inshore coastal zone around Port Alfred (n = 8) and in the enclosed Marina Martinique (n = 21). Fish were measured and the sagittal otoliths were removed. The otoliths were sectioned through the nucleus using a diamond edge, double blade saw. Sections were mounted onto observation slides and the number of opaque zones between the nucleus and edge of the otolith was enumerated by three independent readers using a dissection microscope at between 10 and 40X magnification. Inclusion of the otolith in the model required two out of three readers to agree, otherwise it was rejected. Growth ring deposition periodicity was validated using oxytetracycline (OTC), which was used to mark fish in Marina Martinique during early 2011 (n = 30). Analysis of sectioned otoliths from recaptured fish (n = 2) revealed one opaque zone was deposited annually. The age and growth was described by a Von Bertalanffy model, fitted using an iterative least squares procedure. Model parameters of males and females were compared using a likelihood ratio test. A parametric residual bootstrap was employed to estimate the error in the model.

Age estimate reproducibility was described using the index of Average Percentage Error (APE = 20.35%) (n = 100). Cape Stumpnose growth was described by a Von Bertalanffy model of the form $L_t = 344.1\ (1 - e^{-0.26\ (t\ -0.83)})$ mm FL (n = 102), with a maximum age of 18 years. Female growth was described as $L_t = 384.6\ (1 - e^{-0.19\ (t\ -1.19)})$ mm FL, and male growth as $L_t = 341.7\ (1 - e^{-0.28\ (t\ -0.77)})$ mm FL. A likelihood ratio test showed significant differences between all parameters ($p < 0.01$) for males and females.

The APE was relatively high, but indicated the high number of young fish included in the model. Cape stumpnose otoliths were considered easily readable by three independent readers. The growth was slow and similar to other small Sparids, such as blacktail (*Diplodus capensis*). The growth differed significantly between sexes, with males growing faster than females. The annuli deposition periodicity validation was the first for this species. This study provided the first age and growth information of Cape stumpnose beyond their first year of life, and this can be used to inform managers of the resilience of the species to exploitation.

Key words: estuarine; fisheries management; conservation; otoliths; validation

**11h40-12h00: Jessica Joyner (BSc Honours student) - An evaluation of the current marine fisheries management and governance measures, in dynamic times in South Africa**

Supervisor: Prof. K Cochrane (k.cochrane@ru.ac.za); Prof. W Sauer (w.sauer@ru.ac.za)

Funders: Rhodes University

Since 1998 the Marine Living Resources Act (MLRA) has been the primary legislative work which governed the marine fisheries in South Africa. However, the act was the first of its kind drawn up in a democratic South Africa, and some inconsistencies and omissions have since been discovered. The Small Scale Fisheries Policy (SSFP) was recently promulgated in 2012 by the Department of Agriculture, Forestry and Fisheries (DAFF). In addition the Department of Environmental Affairs (DEA) is in the process of drawing up the National Environmental Management of the Oceans (NEMO), and the National Development Plan (NDP) has recently been completed. The number of different initiatives, often running concurrently, provides challenges in ensuring due process is followed and that the different initiatives complement one another, and the various international laws and codes of conduct currently endorsed by South Africa are adhered to.

Three policies (MLRA, NEMO and SSFP) were compared to the objectives set out by the FAO Code of Conduct for Responsible Fisheries as well as objectives set out in the NDP of 2013 of South Africa. Three methods were used; the first was a semi quantitative comparison of the objectives of the FAO Code of Conduct and the NDP and the three policies. The second involved a questionnaire being developed and sent to 14 key individuals familiar with the policies or act. These results were then merged and obvious patterns were described. The third method involved obtaining additional information to fill gaps identified from the initial results, and interviews were conducted to gain insight from members of DAFF, fisheries lawyers and members of the NGO Masifundise and a stakeholder meeting for NEMO was attended to gain further insight into the policy. These interviews were used to form background knowledge of the current views of the people from the participating departments and to provide information to assist with the discussion of the results.

From the results it can be concluded that the current acts and policies do have some highlighted weaknesses. At the stakeholders meeting, the DEA stated that they are planning on incorporating the NEMO plan into existing plans rather than putting it forward as a separate policy. All the policies have problems with the transparency and openness of management actions as well as the objectives lacking clear long term objectives. It also appears that the policies do not include the views of the stakeholders adequately and do not provide guidelines for the management of stocks, fleets and gear sufficiently. The monitoring control and surveillance is not managed effectively by the policies. The three policies are largely found to fit the requirements of the NDP although the MLRA is a bit weaker in this aspect.

Key words: marine; fisheries management; South Africa; marine living resources act; small scale fisheries policy; national environmental management of the oceans

**12h00-12h20: Tia Jordan (BSc Honours student) - Estimating changes in the size frequency and geographical distribution of overexploited linefish species; using a content analysis of the popular print angling literature.**

Supervisor: Dr W Potts (w.potts@ru.ac.za)

South Africa's marine recreational linefishery is a socially and economically important sector. Unfortunately, the majority of fishes captured in this fishery are over-exploited, despite the value of the fishery. The development of alternative, less prohibitive methods of examining trends and estimating the stock status of South Africa's recreational linefish species may be valuable step forward to inform managers of stock status. This study aimed to evaluate the quality of media content data from two popular print media sources to monitor changes in stock status of several linefish species. The objectives were to quantify trends in the maximum size, average size and the distribution of these fishes.

Two print media sources, "Tight Lines" and "Ski-boat" which were published monthly from 1960 and bimonthly from 1985, respectively, were obtained from the Margret Smith Library in the South African Institute for Aquatic Biodiversity. Ten linefish species were selected for this study based on their exploitation status and popularity in the recreational linefishery. All boat-based catches were excluded from the "Tight Lines" dataset in order to examine the trends in the shore-based fishery, while the data from "Ski-Boat" was used to examine trends in the boat-based fishery. General trends of maximum and average size of fish were fitted using linear regression. The location of captured fish was mapped; the distance between the furthest locations was measured for each year. The trend for each species was examined using linear regression.

A total of 1689 shore-based catches were recorded. This included dusky kob, *Argyrosomus japonicus* (37.8%), black musselcracker, *Cymatoceps nasutus* (18.9%), leervis, *Lichia amia* (16.9%), pignose, *Lithognathus lithognathus* (6.6%), galjoen, *Dichistius capensis* (6.5%), white musselcracker, *Sparodon durbanesis* (5.4%), elf, *Pomatomus saltatrix* (4.1%), red steenbras, *Petrus rupestris* (2.1%), and geelbek, *Atractoscion aequidens* (1.7%). Generally, maximum size and average size of all species remained stable between 1960 and 2009. However, a significant reduction in maximum size was found for red steenbras ($y = -0.5534x+1121.8$, $p=0.04$). Distance between the furthest captured locations remained stable for all species. A total of 333 boat-based catches were recorded. This included red steenbras (37.5%), black musselcracker (33.1%), leervis (17.1%), geelbek (10.5%), and pignose (1.8%). Generally, maximum size and average size of all species remained stable between 1985 and 2004. However, a significant reduction in the maximum size ($y = -3.4745\ x^2+7011.5$, $p<0.01$) and average size ($y = -3.475\ x^2+7011.3$, $p<=0.01$) was found for red steenbras after 2004.

This study demonstrated that media content analysis can be used to show trends in the status of recreational linefishes. However, unless these techniques are refined, trends may only be apparent in fishes where populations are significantly depleted (such as the red steenbras). Several other confounding factors, such as gear technology creep, changing perceptions, the development of photographic technology, should also be considered if this method is to be used to assess fish stocks.

Key words: marine; fisheries management; line fish; content analysis

**12h20-12h40: Nomonde Ndlangisa (BSc Honours student) - Assessing the information requirements for effective co-management: a case study of the small-scale mussel fishery at Hamburg**

Supervisors: Prof. P Britz (p.britz@ru.ac.za); Dr S Raemaekers serge.raemakers@gmail.com

Funders: THRIP; Lidomix (Pty) Ltd

The sustainable management of small scale fisheries requires much forethought, and throughout the world, co-management has been accepted as a good policy to adopt. A major problem which impedes co-management is the accessibility of information for all the relevant stakeholders of a fishery resource. The small scale mussel fishery at Hamburg (Eastern Cape South Africa) was assessed to evaluate the accessibility of information among the stakeholders of this fishery. The methods included fishery monitor data analysis, semi-structured interviews and participatory action research with stakeholders. These stakeholders are the harvesters, community catch monitors and the Department of Agriculture, Forestry and Fisheries (DAFF).

The study was conducted in three phases; the first of these was to examine the existing data for that fishery, which was collected by the community catch monitors. The second phase of the study was conducted through questionnaires and focus groups with the harvesters and monitors to gain their perspective of the fishery. Information from the first two phases was then condensed and presented back to the stakeholders.

Assessment of the existing data collected by the monitors revealed that there was very little formal information about the fishery. The dataset contained data for no more than 20 days over a one year period, which is not a true reflection of the level of activity in the fishery. Phase two of the study was then carried out to assess community perceptions of the monitoring programme. It was found that monitors and harvesters do not have a clear understanding of the monitoring program and its importance in providing information to assist in the management of the resource. Furthermore, data collected by the monitors has never been fed back to the community by the fisheries authority.

With the Small Scale Fisheries Policy entering its implementation phase, co-management has been recognised as being of importance in the management of our small scale fisheries. In order for co-management to work, all stakeholders need to have access to relevant information to make informed contributions to their respective fisheries.

This study indicates that community monitoring programmes have the potential to provide relevant information to fishery stakeholders, if they are carried out well. There is a need to build capacity in rural communities such as Hamburg, and making relevant information available to these communities is vital if they are to be included in managing the resources they depend on for their livelihoods.

Key words: marine; fisheries management; monitoring; co-management; information

**12h40-13h00: Elethu Duna (BSc Honours student) - Identifying unique lineages, possible cryptic species and hybridization in the sharptooth cardinalfish, *Cheilodipterus quinquelineatus*, in the Western Indian Ocean**

Supervisor: Dr G Gouws (g.gouws@saiab.ac.za)

Funder: WIOMSA-MASMA (MASMA/OR/2008/07)

*Cheilodipterus quinquelineatus* Cuvier, 1828, from the family Apogonidae, is distributed throughout the Indo-Pacific region. These fishes occur in tropical and temperate waters, and inhabit coral and rocky reefs. A large-scale study of connectivity and genetic differentiation in the Western Indian Ocean (WIO) provided preliminary evidence (from genetic data of the ATPase 6, cytochrome *b* and S7 gene regions) that the sharptooth cardinalfish is represented by two distinct lineages. These lineages seem to be mostly allopatrically distributed; with one lineage occurring in the northern and the other in the southern/central portion of the WIO. These lineages may represent a cryptic species complex. Evidence of possible hybridization was also found in Kenyan waters where the two lineages occur sympatrically.
The objectives of this study were to determine if the two lineages represent distinct species. It also aimed to confirm hybridization among these two lineages. This study combined genetics, and morphology to reach these objectives. This study considered, using this cumulative evidence, whether *C. quinquelineatus* should be considered as a single species across the WIO.

DNA sequence data from a mitochondrial (COI) and nuclear gene (S7) were generated using standard approaches from 31 WIO samples. Sequence divergences were calculated and neighbour-joining analyses was performed. In the morphological analysis, 13 meristic characters were counted and 30 morphometric characters measured from 92 specimens. These were analysed using Principal Components Analysis.

Neighbour-joining trees constructed from Kimura two-parameter sequence divergence show two distinct clades. Contrary to prior assumptions about their distribution, these clades seem to overlap. These two clades showed clear genetic distinction through the amount of sequence divergence between them. The average divergence in one clade is 0.6% and 1.5% for the other, for COI. This is slightly lower for S7; the one clade is 0.1% and the second is 0.2%. The average divergence between the clades is 11.6% and 2.1% for COI and S7, respectively. DNA barcoding studies have shown that sequences in the genus *Apogon* have an intraspecific divergence between 0-1% while interspecific divergence is between 5-25%. Clearly these two clades represent the divergence of two species. The barcoding of marine fishes has been a window to the biodiversity of these species. Cryptic species continue to be discovered at increasing rates, this is due to the limitations of morphological-based identification system. Principal Component Analysis of the morphometric characters revealed that the two lineages overlap morphologically and also that the morphological variation the “northern” lineage WAS restricted compared to the “southern” lineage. Hybridization was not extensive with only one additional hybrid identified. Because of the overlap among the lineages, hybrids do not seem to align to any particular lineage in terms of morphology. These findings have contributed to the understanding of the diversity of the cardinalfishes and recommend that these be considered different species.

Key words: marine; systematics; genetics; Western Indian Ocean; cryptic; morphology

## 13h00-14h00: Lunch break

## Ichthyology and conservation (Chair: Alex Winkler)

### 14h00-14h20: Pholoshi Maake (PhD student) - Description of three new species of *Marcusenius* Gill 1862 (Teleostei: Mormyridae) from South Africa and Mozambique

Supervisors: Dr G Gouws (g.gouws@saiab.ac.za); Mr O Gon (o.gon@saiab.ac.za); Dr E Swartz (ernst.swartz@gmail.com

Funder: National Research Foundation (FA200705100020)

The family Mormyridae comprises of 18 genera and over 200 species of freshwater fishes endemic to tropical Africa. They have been of widespread interest ever since Lissmann (1951) discovered that they produce and receive weak electric signals for the purposes of mating, communication and object-location. The electric signal or discharge (EOD) is also species specific and has been used as a taxonomic character in systematic studies of this family. The genus *Marcusenius* Gill, 1862 is the largest of the family, currently with over 37 valid species widely distributed from the Nilo-Sudan to South Africa. *Marcusenius pongolensis* has been the southernmost species of the genus, and the only one known from South Africa. It was recently discovered that local populations of *M. pongolensis* exhibited unusual variability in molecular genetics, morphology and EOD, implying that species-level differentiation may exist in South African *Marcusenius*, but little was known of the extent of this differentiation. Other populations of the formerly widespread *M. macrolepitodus* species, such as those from the Rovuma River System, northern Mozambique, were morphologically different from the South African ones, indicating that the former might contain even more taxa that are presently not recognized. Consequently, the present study is a detailed morphological examination and genetic analysis of *Marcusenius* populations in South Africa, including Rovuma samples, to determine the extent of their differentiation and taxonomic status.

During surveys, samples from different river systems or different major branches received higher priority than samples from sites in close proximity. The morphology and molecular genetics data were analysed using various statistical and phylogenetic packages. Standard DNA isolation methods were used to isolate DNA from muscle tissue preserved in 100% ethanol. Three species in South Africa are well differentiated in morphology and genetics, and differentiation is also present in EODs. *Marcusenius pongolensis* is widespread throughout the Limpopo, Incomati, Pongola and Kosi Systems. A new species, *M. krameri*, is endemic to the Limpopo River System, and is closely related and form a sister taxon to *M. caudisquamtus* sp. nov. from Nseleni and Mhlatuze Rivers in KwaZulu-Natal. In morphology and genetics, the Rovuma River specimens proved well differentiated from all South African species, and are recognised as *M. lucombesi* sp. nov. Molecular phylogenetics confirmed that the three new species, with *M. altisambesi* from Upper Zambezi, form a monophyletic clade, sister to the group of *M. pongolensis* and *M. macrolepidotus*. Morphological adaptations to life in a slow flowing water seem to be present in *M. krameri* sp. nov. and *M. lucombesi* sp. nov. when compared with *M. pongolensis* and *M. caudisquamatus* sp. nov. which live in river systems with rapid water flow and rocky substrate.

Key words: freshwater; systematics; Limpopo River System; molecular genetics; morphometrics; Rovuma River System; Southern Africa

**14h20-14h40: Kerry-Ann Van der Walt (MSc student) - Is there genetic evidence for differential dispersal in three headwater fish species in the Groot Marico catchment, North West Province, South Africa**

Supervisors: Dr OLF Weyl (O.Weyl@saiab.ac.za); Dr ER Swartz (ernst.swartz@gmail.com)

Funders: South African Institute for Aquatic Biodiversity; Rhodes University JRC; Water Research Commission (K5/2008); Centre for Invasion Biology (CIB)

The Groot Marico Catchment in the North West Province represents unique landscape features with unique biodiversity and has been identified as biodiversity special features of special ecological significance. There is little information on the distribution of the species inhabiting the catchment. Three native freshwater species have high local conservation importance, namely *Amphilius uranoscopus*, *Chiloglanis pretoriae* and *Barbus motebensis. Barbus motebensis* is endemic to the catchment and is IUCN-listed as vulnerable (VUL). These three species are thought to be impacted by natural discontinuities which can impact an organism's preferred habitat and result in population fragmentation. Furthermore, these three species may be impacted by non-native largemouth bass, *Micropterus salmoides* which through predation pressure may further fragment tributary populations of these species.

Therefore, the main problem is to distinguish between recent and historical fragmentation caused by either natural or human mediated processes, or a combination of both. Knowledge of the population history of the native species is important to determine the severity of such impacts. This project aims to determine population histories of the three native species in order to compare hypothetical past distribution to present distribution patterns. In addition, by assessing the genetic diversity of the indigenous fishes, it will be possible to determine whether tributary populations comprise of one population or are genetically distinct populations. Therefore, giving rise to the null hypothesis that there is no genetic differentiation between tributary populations.

In total, 240 individuals were sampled, targeting at least 10 individuals per population of each of the three species within a total of 7 tributary populations and the Groot Marico main stem. Samples were collected by electrofishing and specimens were euthanized using an overdose of clove oil. A sample of muscle tissue was removed for genetic evaluation and the remainder of the specimens served as voucher specimens. For the genetic evaluation, mitochondrial (ND2, cyt *b*) and nuclear (S7) genes were used. Genetic techniques included DNA extraction, polymerase Chain Reaction (PCR), purification and Sequencing. Statistical analysis included looking at cleaned sequences in order to obtain models using MODELTEST (version 3.06) and phylogeographic analysis was performed in PAUP. Population structuring and phylogeographic analysis was performed in Arlequin (version 2000), TCS and PAUP.

Results indicate that for *B. motebensis* the null hypothesis as there were two distinct lineages (the Draai and Eastern lineages) that demonstrate major divergence in both ND2 and S7 genes, suggesting historical isolation. The low divergence in mitochondrial cytochrome *b* suggests the isolation is not very old and is probably not comparable to species level differentiation. For both *A. uranoscopus* and *C. pretoriae* the null hypothesis could not be rejected as there was no genetic differentiation between tributary populations and they consist of one panmictic population.

Keywords: freshwater; conservation; DNA; ND2; S7

**14h40-15h00: Mpho Ramoejane (PhD student) - Evolution and conservation of Southern African *Labeo* fishes in relation to water management**

Supervisors: Dr O Weyl (o.weyl@saiab.ac.za); Dr E.Swartz (e.swartz@saiab.ac.za)

Funders: National Research Foundation; South African Institute for Aquatic Biodiversity; Center for Invasion Biology

*Labeos* are an important food source in developing countries and are used occasionally for angling, spear fishing and in commercial and subsistence fisheries. *Labeos* are known for their specialized sucker lip mouths with which they feed on algae and detritus, thereby playing an important role in controlling the abundance of algae in ecosystems. In Africa, they are divided into six groups according to their morphology and four of these groups are present in Southern Africa. The *Labeo umbratus* group (*L. umbratus*, *L. capensis*, *L. seeberi* and *L. rubromaculatus*) is endemic to South Africa. The other groups are Pan African groups, namely the *Labeo niloticus* group (*L. altivelis*, *L. rosae* and *L. ruddi*), *Labeo coubie* group (*L. congoro*) and *Labeo forskahlii* group (*L. cylindricus*, *L. molybdinus*, *L. lunatus* and *L. ansorgii*). Apart from the morphological revision done by Reid, very little is known about the phylogenetic relationships between Southern African *Labeo* species. In addition, little is known about the evolutionary processes that have led to the current diversity in southern Africa. Some of the species are also under threat due to predation by alien fishes, habitat alterations, man-made barriers to migration and hybridisation with closely related introduced species.

Objectives of the study are: (1) To identify and map the distribution of *Labeo umbratus* genetic lineages; (2) relate the population history to known climatic and geological events; (3) assess which evolutionary processes have been responsible for genetic diversity patterns; and (4) to construct a phylogeny of the Southern African *Labeo* species.
To assess the geographic distribution of genetic diversity, more than 600 base pairs of the mitochondrial cytochrome *b* gene were sequenced for 275 specimens and about 630 base pairs of S7 gene were sequenced from 49 individuals. Phylogenetic trees and networks have been constructed to illustrate genetic distances among lineages.

Nuclear S7 gene showed no differentiation between *L. umbratus* populations. Mitochondrial cytochrome *b* gene showed differentiation between populations of *L. umbratus* from the Orange and southern flowing river systems. There was very little divergence (0.7-1.2%) among these systems. The divergence seems to have happened during Pleistocene. Past fragmentation and/or long distance colonization and restricted gene flow/dispersal but with some long distance dispersal could have been the evolutionary processes that were responsible for current genetic diversity patterns. However, several alleles were restricted to single river systems, indicating a lack of current gene flow. Private alleles in the suspected alien populations suggest that these might be natural populations and that *L. umbratus* might have a much wider natural range than previously thought. *Labeo umbratus* migrate up-stream during flooding and could have used these means to move across currently isolated systems during the Pleistocene. Even though the difference between these populations is low, there is still a need to protect them in order to conserve local genetic variations.

Key words: freshwater; conservation; phylogeny; phylogeography

**15h00-15h20: Michelle Soekoe (PhD student) - Allopatric variation in *Triakis megalopterus* populations isolated by the Benguela Current**

Supervisors: Dr WM Potts (w.potts@ru.ac.za); Dr MJ Smale (msmale@bayworld.co.za)

Funder: National Research Foundation

The formation of the cold Benguela Current approximately 2 million years ago led to a marked change in the distribution and abundance of fishes along the west coast of southern Africa. Warm water fishes were restricted to either side of the Benguela Current as its cold water formed a barrier to gene flow between these populations. With the timing of the allopatry similar across species, it is possible to quantify the rate of adaptation of the populations in response to the disparate environmental conditions across a range of marine species. Thus, it is possible to better understand the evolutionary processes affecting regional biodiversity by quantifying and comparing the differences in the genotypic and phenotypic adaptation of these species. With a characteristically slow rate of phenotypic change and evolution, Elasmobranch species provide a baseline with which other marine organisms can be compared. Therefore, the aim of this study is to examine the genotypic and phenotypic variation between southern Angolan and South African *Triakis megalopterus* (spotted gully shark) populations. The results presented in this abstract will concentrate on preliminary results from a new protocol allowing the reconstruction and analysis of truss networks in Elasmobranchs. Truss networks are not currently applied to sharks. Size and shape of Elasmobranchs makes it difficult, if not impossible, to accurately measure diagonal lines across the body. For the same reason, photography and digitising will also not be feasible. Therefore, techniques need to be developed to allow the study of body shape between species and possibly between populations of Elasmobranchs.

A total of 10 *T. megalopterus* and 10 *Mustelus mustelus* were collected between the Cunene River and Namibe, southern Angola. Using the methods outlined FAO species catalogue for sharks, 102 measurements were recorded from the left lateral aspect of each specimen (Compagno 1984). The dorsal view of each specimen was then reconstructed in AutoCAD 2011 architectural software and a truss network comprising 18 characters was developed for each specimen. To remove variation caused by allometric growth, all measurements were adjusted to an overall mean precaudal length of 1029.8 mm (Simon *et al.* 2010). A stepwise discriminant analysis (DFA) was performed on 18 truss characters and three were extracted as important for differentiating between the species (Wilks' Lambda, $p < 0.05$). DFA showed the classification success of the sharks was 94.4%, with only one *M. mustelus* misclassified. . Although this protocol shows much promise, future work will attempt to refine the truss system and will include estimating the classification success of lateral profile trusses.

Compagno, L.J.V. (1984). FAO species catalogue. Vol. 4. Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Part 1. Hexanchiformes to Lamniformes. FAO Fish Synop., (125) 4 (1): 10-12.

Simon, K.D., Bakar, Y., Temple, S.E., and Mazian, A.G. (2010). Morphometric and meristic variation in two congeneric archer fishes *Toxotes chatareus* (Hamilton 1822) and *Toxotes jaculatrix* (Pallas 1767) inhabiting Malaysian coastal waters. Journal of Zhejiang University-SCIENCE B (Biomedicine & Biotechnology) *2010 11(11):871-879.*

Key words: marine; morphology; elasmobranch; truss; spotted gully

# Thursday 17 October 2013

## Aquaculture and water management (Chair: Mpho Ramoejane)

### 08h00-08h20: Rogan Field (MSc student) - Inter-basin water transfer schemes and hybridisation within the genus *Labeo*

Supervisors: Prof. H Kaiser (h.kaiser@ru.ac.za); Dr OLF Weyl (o.weyl@saiab.ac.za)

Funder: National Research Foundation Competitive Grant (UID 73667)

Due to the scarcity of fresh water in South Africa; inter-basin water transfer schemes (IBTs) have been established in order to provide fresh water throughout the country with water being pumped or channelled from areas of perceived excess to those of known deficiency. Consequently the transfer of previously isolated fish populations has occurred posing a potential threat to biodiversity increasing the risk of invasions and hybridisation.

Within the genus *Labeo* the potential for hybridisation is high as these *Cyprinid* fish exhibit similar life histories, occupy equivalent habitat niches and display comparable spawning strategies. Genetic research has confirmed the occurrence of hybridisation between *Labeo umbratus,* native to the Fish River System and the introduced *Labeo capensis* of the Orange River System. This project aims to identify key differences in hybrid morphology and gonad histology when compared to genetically pure specimens, provide a practical means of identifying hybrids in the wild and will attempt to validate a photographic technique for the construction of truss networks and morphometric analyses.

Preserved specimens with known genetic history (*L. capensis* n=26; *L. umbratus* n=50 ; *L. Hybrid* n=21) were used. A truss network was constructed through the identification of 14 landmarks resulting in 22 truss measurements made in millimetres and accurate to two decimal places. I addition standard morphometric measurements were taken. These were analysed using generalised linear models (GLM) and principal component analysis (PCA). Each specimen was digitally photographed and will be analysed with sigma scan. A section of gonadal tissue was removed, mounted in wax and sectioned for histological comparison.

Results suggest little morphological differences between pure genetic stocks when compared to hybrids; however some key differences are apparent. GLM homogeneity of slopes test show a significant difference at dorsal fin length T12 ($p=0.01788$), dorsal to caudal T13 ($p=0.04526$) and T19 caudal to anal fin ($p=0.02993$). These results suggest that deferential growth rates are expressed in these areas. The use of these unique identifying truss measurements allows for accurate identification of hybrids in the wild. Further investigation may illicit differences within species and between locations. Due to the inherent plasticity of *Cyprinid* fish we find marked differences in morphology within species and these differences can be strongly correlated to habitat, substrate composition and flow rate.

Keywords: freshwater; aquaculture; *Labeo umbratus; Labeo capensis;* hybridisation; inter-basin water transfer; biodiversity; truss networks; morphology; histology

**08h20-08h40: Sean Power (MSc student) - Hydroponic crop production in partially treated brewery effluent**

Supervisors: Dr CLW Jones (c.jones@ru.ac.za); Prof. PJ Britz (p.britz@ru.ac.za)

Funders: Water Research Commission (K5/2008; K5/2284); SAB Ltd.

Breweries consume vast amounts of freshwater. Some of the most efficient breweries in the world discard 65% of the freshwater they buy as nutrient enriched waste water. The nutrient rich waste water requires treatment before disposal into the environment. Water efficiency is a key aspect of the industry's sustainability goals. Harnessing the nutrient and water supply in brewery effluent offers a unique opportunity to improve the water use efficiency of the industry as well as reducing the energy consumption and financial cost of traditional waste water treatment.

This particular brewery currently disposes of around 450 kilolitres of anaerobically digested brewery effluent per day. This is the volume of water potentially available for hydroponic production. Finding a productive use for this effluent stream could save the brewery up to R4000.00 per day in municipal water treatment costs.

The brewery effluent is treated in an anaerobic digester (AD) and a high rate algal ponding (HRAP) system as part of an alternative waste water treatment strategy. Previous work used this HRAP treated water to produce hydroponic lettuce. The observed growth deficiencies, nutrient deficiency symptoms and specimen mortalities showed that this was not an ideal nutrient source for some lettuce plants. Initial tests for this project suggested that the anaerobic digestate, without additional nutrients or pH correction, can support the growth, flowering and fruiting of at least three different cultivars of tomato (*Moneymaker, Heinz 1370* and *Rodade*).

The first trial used effluent drawn from before and after the algal ponds with duplicate systems testing the effect of adding phosphoric acid to the effluent as a pH correction. The results confirmed that effluent can support the growth, flowering, and fruiting of *Moneymaker* tomatoes. The manipulation of the effluent pH significantly improved the growth and development of the plants. Water quality tests revealed that the plants were consuming all of the available nitrogen however phosphate levels were extremely high. This was to be expected given the addition of phosphoric acid.

The second trial excluded effluent treated in the algal ponds and only used effluent drawn from the primary facultative pond. Based on the previous nitrogen limitation identified in the first trial, nitric acid was included as an alternative pH reducer. The nitric acid did not significantly improve the performance of the plants which points towards a broader nutrient deficiency or plant stress. The management and instability of the pH of the effluent is a potential problem. The effluent is extremely alkaline, which is a consequence of numerous upstream factors including the crucial anaerobic digestion of the raw effluent. Managing the effluent alkalinity, nutrient deficiencies and limiting downstream nutrient releases are the key challenges to using brewery effluent as a hydroponic water resource.

Key words: freshwater; effluent management; hydroponics; plant nutrition

**08h40-09h00: Catherine Greengrass (PhD Student) - Development of a business model for small-scale aquaculture for the creation of sustainable livelihoods**

Supervisor: Prof PJ Britz (p.britz@ru.ac.za)

The South African government recently prioritised aquaculture as an agricultural activity and the means to address the potential shortfall between capture fisheries and future demand for fish products locally. Aquaculture has also been recognised as a critical economic activity to create wealth and livelihoods, and attract investment. In order for this opportunity be realised, sound business planning will be imperative. While common practice in large-scale venture's, small, medium and micro-sized enterprises (SMMEs), emerging farmers and poor community-based enterprises, often lack the capital and skills required to develop viable, profitable business models, making it difficult to source funding, and leaving them vulnerable to failure in the future.

The aim of the PhD will be to develop a principle-based business model for small-scale aquaculture enterprises, for the creation of sustainable livelihoods. The principle-based business model will become a tool for new entrants, community organisations and project implementers to develop project-specific business models and business plans that are feasible, profitable and provide sustainable livelihoods.

The objectives of the study will be to:

- Determine a business modelling approach and key business model aspects appropriate for small-scale aquaculture. Methodologies include comprehensive literature review and focused interviews with relevant stakeholders groups (business school/experts, government departments, financial institutions, funding agencies, development agencies).
- Evaluate South African small-scale aquaculture enterprises (existing and collapsed) in terms of the key business model aspects identified, in order to determine critical success/risk factors associated with each aspect. Participatory Action Research (PAR) and surveys/interviews will used to gather information for analysis.
- Identify and critically evaluate mechanisms for involving beneficiaries in small-aquaculture (examples include shareholding, ownership, employment, or community-public-private-partnership) and determine the most preferable. This will be an important focus of the project. The most suitable methodologies will include PAR with existing and potential beneficiaries to gain their insights and apply these in improving/tailor making existing organisational structures.

The final deliverable will be the principle-based business model for small-scale fisheries, with specific focus on the inclusion of beneficiaries. In addition to this, methodologies/processes for regular review and improvement of the principle based model will be recommended.

Key words: freshwater; aquaculture; business model; small-scale aquaculture; beneficiaries

**09h00-09h20: Melissa Mayo (MSc student) - Phytoplanktivorous**Error! Bookmark not defined.
**fish: An alternative for the removal of algae from high rate algal ponds?**

Supervisors: Dr CLW Jones (c.jones@ru.ac.za); Prof. PJ Britz (p.britz@ru.ac.za)

Funders: Water Research Commission (K5/2284); SAB Ltd.

Although efficient in nutrient removal from brewery effluent, the harvesting of microalgal cells from a liquid medium is both difficult and expensive, often presenting a "bottle neck" in unicellular algal production. As an alternative to conventional physical and chemical methods, this project proposes the use of phytoplanktivorous fish as biological agents in the removal of algae, and in doing so, generate a new and readily harvestable form of protein.

Preliminary experiments in 50 L tanks were designed to measure the species-specific rate of algal removal, and to quantify, with videography, the feeding behaviour of four different fish species:

- *Clarias gariepinus*;
- *Oreochromis mossambicus*;
- *Cyprinus carpio*; and
- *Mugil cephalus*.

Optimization-phase experiments in 50 L tanks were designed to determine the maximum algal biomass that can be fed to fish per day, and the long-term effects this has on fish health and growth. These experiments will be conducted utilizing the fish species that exhibits the fastest algal removal performance.

Prior to the preliminary experiments, the high rate algal ponds were emptied, cleaned and re-inoculated. This process involved the generation of a new nutrient medium consisting of 85% post-primary facultative pond (PFP) effluent (850 L), and 15% algal culture (150 L). After an incubation period of 7 days, the culture was fed equally into all four trains (A1, B1, A2 and B2), before the effluent supplied from the anaerobic digestion (AD) tank was allowed to flow through at a rate of 1000L/day.

Both of the aquaculture systems were drained and thoroughly cleaned before being filled up with municipally treated water and effluent treated water respectively, the latter being used for the duration of this study.

The work is on-going.

Key words: freshwater; aquaculture; algal removal; phytoplanktivorous fish; fish health

## Mariculture (Chair: Mpho Ramoejane)

### 09h20-09h40: Kerry Pieterse (MSc student) - Blood profiling dusky kob *Argyrosomus japonicus* for use in aquaculture health diagnostic techniques and potential for immunomodulation

Supervisors: Prof. H Kaiser (h.kaiser@ru.ac.za); Dr W Vermeulen (fsiwim@gmail.com)

Funders: Welbedagt Research and Manufacturing; Rhodes University JRC; Eastern Cape Development Corporation

In recent years great progress has been made in understanding the immune functioning of fish which may benefit the growing aquaculture industry worldwide. Haematological indices and blood profiles have been established in a number of fish abroad as a diagnostic tool to identify adverse conditions in the aquaculture industry. The aquaculture industry in South Africa is growing rapidly, and one example is the farming of kob in the Eastern Cape. One of the main hindrances of aquaculture, however, is disease, usually as a result of stress when fish are exposed to adverse conditions. The use of monitoring fish health via blood parameters may provide a useful diagnostic tool as a management practice on aquaculture facilities. Additionally, there is some potential for the use of immunostimulants administered to juvenile kob to boost the immune system and improve survival.

A haematological profile has been established in dusky kob, *Argyrosomus japoicus*, to include the size and morphology of red blood cells, a differential cell count of the relative numbers of white blood cells (leucocytes), the relative size and morphology of the different leucocyte cell types as well as an identification guide for the various leucocytes. The mean red blood cell diameter was established as $9.47 \pm 0.10$ µm ($n = 111$) and small lymphocyte as $6.11 \pm 0.28$ µm ($n = 12$). Mean haematocrit using 358 healthy kob was established as $29.6 \pm 2.04$ % and a B cell lymphocyte to T cell lymphocyte ratio of 3.9 : 1. The other leucocytes present in kob blood are neutrophils, monocytes and eosinophils, but occur in lesser numbers than the lymphocytes. The presence of eosinophils, a white blood cell that assists in combating pathogens and allergens, was strongly correlated with stressful conditions in the experimental studies (ANOVA: $F_{8,98} = 7.49$; $P < 0.01$) .

Additionally, an experiment was run to evaluate the efficacy of the immunostimulant Fish Assist® on fish health. The immunostimulant was administered orally via the artificial feed. Fish Assist® administration was found to significantly improve condition factor ($P = 0.01$) and the T to B cell lymphocyte ratio ($P < 0.01$) in juvenile kob. No significant differences were found between the experimental treatments of fish fed Fish Assist® and the control for haematocrit values and growth.

Basic knowledge from this study is important for haematological research and clinical diagnosis. This will benefit the aquaculture industry to monitor the health status of fish and to identify the presence of adversities in the aquaculture environment.

Key words: marine; aquaculture; dusky kob; haematology

**09h40-10h00: Warren Witte (MSc student) - Abalone stock enhancement at Cape Recife: The potential for commercial scale ranching in the Eastern Cape Province of South Africa**

Supervisor: Prof P Britz (**p.britz@ru.ac.za**)

Funders: THRIP; Lidomix**Error! Bookmark not defined.** (Pty) Ltd

Abalone stock enhancement in the Eastern Cape province of South Africa has the potential to be successful as a commercial scale operation. In August 2010, the Department of Agriculture, Forestry and Fisheries (DAFF) published guidelines for abalone ranching or stock enhancement in South Africa. Area bound access rights provide a management framework within which rights holders are provided an exclusive right to commercial seeding and harvesting of abalone in a defined area, creating the incentive to invest in rebuilding the resource in a manner that promotes both resource sustainability and maximises economic rents. The abalone resource in South Africa has suffered extensive poaching causing many areas to suffer complete stock collapse. Abalone ranching has the potential to rehabilitate these worst hit areas where natural recruitment has been severely compromised. To date, abalone ranching has been undertaken on an experimental basis, and although the results are promising, existing ranching protocols need to be improved and commercialised. Furthermore, to ensure the success of the new sub-sector, there is a need to develop a better understanding of the biological interactions and limitations to ranching, the economics of the ranching operations, and social impacts and issues accruing to the promulgation of area bound access rights. This research and development programme is designed to focus on these core developmental issues, and provide the industry with appropriate bio-economic models.

The research objectives are:

- Optimise seeding protocols to maximise the survivorship, and improve our understanding of the complex ecological interactions that affect the efficacy of seeding programmes;
- Establish optimal carrying capacities and stocking densities based on substrate types;
- Establish growth rates and survival rates of different size classes of seeded abalone;
- Develop harvesting models based on the biological carrying capacities, growth rates and the economics of the seeding operations;

To achieve these objectives small-scale experimental plots based on a split plot design will be seeded with varying densities and size classes of abalone in two distinct habitats. After a 6-month period plots will be destructively sampled and growth and survival will be measured. The outcome it is hoped will inform appropriate size classes and densities in which to seed juvenile abalone as well as establish the prime seeding habitats. This will inform the larger commercial seeding operations to maximise economic returns.

Key words: marine; aquaculture; Cape Recife; abalone ranching

## 10h00-10h40: Tea break

## Marine ichthyology/biology (Chair: Michelle Soekoe)

### 10h40-11h00: Moqebelo Morallana (MSc student) - Regional differentiation, connectivity and biogeography of *Lutjanus* species in the Western Indian Ocean

Supervisors: Dr G Gouws (g.gouws@saiab.ac.za); Dr M Mwale (m.mwale@saiab.ac.za)

Funders: DST-African Coelocanth Ecosystem Programme (ACEP); South African Institute for Aquatic Biodiversity (SAIAB)

The genus *Lutjanus* has 65 species, with 27 of these found the Western Indian Ocean (WIO). Previous studies involving other snappers (*Lutjanus kasmira*) revealed limited spatial genetic differentiation, while others (*L. fulviflamma*) showed high connectivity in the region. It is unknown whether other species will show similar patterns. Two molecular phylogenies were published for the genus, including species from across the Indo-Pacific (IP), but excluding species from the WIO. This prompted investigation of the relationship between WIO and IP snappers and to resolve the taxonomic relationship of the Caesionidae to the Lutjanidae.

This study examined (1) the phylogeographic patterns in *L. bohar*, *L. fulviflamma* and *L. lutjanus* to understand the origins and factors influencing the distributions of diversity in the WIO, (2) how the physical environment, biological and ecological factors influence genetic diversity, (3) the placement of WIO snappers in the context of the IP, as well as the placement of taxa not included previously, (4) the extent of differentiation among conspecifics from the two regions, and among the three species, and (5) the relationship of Caesionidae to the Lutjanidae.

Samples were sourced from across the WIO and from peripheral localities where possible. DNA sequence data was generated from two mitochondrial gene regions (Cyt-*b* and NADH-2) and a nuclear gene region (S7 intron 1). Data was analysed under a phylogeographic framework to examine genetic structure, diversity and differentiation among identified regions for each of the three species. Other sequence data were generated from two mitochondrial gene regions (COII and 16S) to examine the phylogenetic placement of WIO snappers in context of the IP snappers and the relationship of the Caesionidae to the Lutjanidae.

*Lutjanus bohar* and *L. fulviflamma* displayed high genetic diversity, but lower diversities were observed for *L. lutjanus*. Differentiation was found between the WIO and IP in *L. bohar* and *L. fulviflamma*. Within WIO, the differentiation of Mozambique (all three species), South Africa and Mauritius (*L. fulviflamma*) and Maldives (*L. bohar*) was observed. Overall, low genetic differentiation and high connectivity was observed for the three species. This may result from intrinsic features of the species and extrinsic features of the environment, whereas the connectivity is mainly influenced the pelagic larval duration. The patterns of differentiation are in accordance with the proposed vicariant biogeographic hypothesis for the origins of regional faunas of the IP. Phylogenies were similar to those published, with additional taxa not altering the groupings. Conspecifics from the two regions clustered together, with varying differentiation depending on the species. Members of the Caesionidae were nested within Lutjanidae, suggesting that morphological characters separating the two families are taxonomically insignificant. This affirms previous notions that the Caesionidae should be a subfamily within the Lutjanidae.

Key words: marine; genetics; phylogeography; biogeography; mitochondrial DNA; nuclear DNA

**11h00-11h20: Sisanda Mayekiso (MSc student) - Genetic structure and biogeography of three wrasse species (Labridae) within the Western Indian Ocean**

Supervisors: Dr G Gouws (g.gouws@saiab.ac.za); Dr M Mwale (m.mwale@saiab.ac.za)

Funders: DST-NRF African Coelacanth Ecosystem Programme (ACEP); South African Institute for Aquatic Biodiversity (SAIAB)

Two competing biogeographic hypotheses, involving dispersal and vicariance, have been proposed to explain the establishment of the various regional components that show substantial endemism in the Western Indian Ocean (WIO). However, the role that historical events, oceanographic processes and life history features have played in shaping genetic variation of marine fish species remains unresolved. The WIO is an exceptional model for studying the influence of physical complexities and biogeographic breaks in shaping patterns of regional differentiation. Three reef associated labrid fish, *Thalassoma lunare*, *T.hebraicum* and *Cheilio inermis,* with different distributions across the WIO regions, were selected to examine the factors that have influenced the contemporary distribution of genetic diversity. A molecular genetic approach was used to provide insight into patterns of contemporary and historical connectivity, and the origins and relationships of the WIO faunas. This will provide accurate interpretation of the origins and relationships for the WIO faunas. The objectives of this study were to examine genetic differentiation and the relationships among the different geographic regions in the WIO for each target species, to determine whether the intrinsic and extrinsic factors affect genetic differentiation of each species and to determine genetic diversity across each species' distribution and establish whether the three wrasses harbour cryptic species. Specimens were collected from numerous WIO localities. DNA sequence data were generated from two mitochondrial genes (cytochrome *b* and ATPase 6) and one nuclear gene (the first intron of the nuclear S7 ribosomal protein gene). Traditional population genetic analyses were used to calculate genetic diversity indices within species, which were then compared among species. Population structure was analysed using AMOVA, and pairwise $\Phi_{ST}$ was used to compare and calculate differentiation among the WIO regions. The genealogical relationships among haplotypes and alleles were reconstructed using median joining network. AMOVA showed little regional differentiation among grouped localities. Pairwise $\Phi_{ST}$ showed little to moderate genetic structuring among regions. These labrid fish were characterized by widely distributed haplotypes and alleles in the median joining network, indicating little genetic differentiation among the separated localities of the WIO. A unique lineage of *Thalassoma hebraicum* was found in the Seychelles, this might be maintained by the South Equatorial current (SEC), whereas there is connectivity along the eastern and southern mainland. These results provide overall evidence of connectivity, but with some genetic structuring, supporting dispersal in producing these observed patterns. The intrinsic features such as life history features and extrinsic features (oceanographic features) may have facilitated dispersal of these fish species in maintaining genetic homogeneity. The distribution of the wrasses showed no concordance with the historical events and they revealed not be genetically distinct across the WIO. This suggests that the distinct localities of the WIO are connected by the exchange of pelagic larval phase.

Key words: marine; ichthyology; molecular genetics; regional differentiation; connectivity

**11h20-11h40: Tshoanelo Moloi (PhD student) - Molecular systematics and antifreeze biology of sub-Antarctic notothenioid fishes**

Supervisors: Dr M Mwale (m.mwale@saiab.ac.za); Mr O Gon (o.gon@saiab.ac.za); Prof. C-H. Cheng (c-cheng@uiuc.edu)

Funders: South African National Antarctic Program/ National Research Foundation (SNA 2006042100003); United State National Science Foundation-Office of Polar Program grant (ANT 0636696 and ANT 1142158); South African Institute for Aquatic Biodiversity

Notothenioidei is a suborder of perciform fish dominating the cold water of the Southern Ocean. These fishes have evolved antifreeze glycol-proteins (AFGPs) in their blood and body fluids that enable them to survive in freezing environment. The suborder consists of eight families, including several wide-ranging species distributed north and south of the Antarctic Polar Front. Previous studies split widespread notothenioid species into separate species or subspecies; eg. *Notothenia coriiceps* was divided into *N. neglecta* in the south Atlantic islands and *N. coriiceps* in south Indian Ocean islands. These splitting of widely distributed notothenioid species were largely based on morphological characters. The most common problem associated with this splitting was that small samples were used for comparison. Molecular genetics studies previously conducted concentrated more on the species in the Atlantic Ocean sector. Therefore, this aspect of the study aims to address the taxonomic issue of these widespread notothenioid species at DNA level, by comparing the Atlantic and Indian Ocean species. The specific objective is to review the taxonomic status of three widespread nototheniids; *Lepidonotothen squamifrons*, *L. larseni* and *Gobionotothen marionensis*. These three species are found in both Atlantic and Indian Ocean sectors of the Southern Ocean, where they were previously divided into different species or subspecies. Tissue samples for these three nototheniids were collected from South Georgian and South Sandwich Islands in the Atlantic Ocean sector (ICEFISH 2004) and Marion Island (2011 and 2012 relief cruise) in the Indian Sector. DNA was extracted from collected tissue samples, and mitochondrial [Cytochrome oxidase subunit 1 (COI) and NADH dehydrogenase subunit 2 (ND2)] and nuclear (S7 ribosomal nuclear intron) genes were amplified and sequenced. Parsimony and maximum likelihood phylogenetic tree were constructed from the aligned sequences. The evolutionary distance over sequence pairs between study localities and within species were estimated. Phylogenetic trees resulted from the three genes had different relationships within all three nototheniid species. The estimated sequence divergence between study localities varied from 0.0-0.7%, with S7 nuclear gene results for *L. squamifrons* showing the lowest sequence divergence of ≤0.1%. Similarly, S7 gene results had the lowest estimated sequence divergence within *L. squamifrons* individuals (≤0.3%), while the higher percentages were obtained by COI gene for all three species (≤1.1%). The estimated sequences divergence values observed between localities and within species are low enough to suggest that the Atlantic and Indian Ocean species have evolved around the same time and share a most recent ancestor.

Key words: marine; molecular systematics; Nototheniidae; South Georgia; Marion Island

**11h40-12h00: Chenelle de Beer (MSc Student) - Comparison of the morphometric and genetic variation of *Octopus vulgaris* in the Benguela Current region**

Supervisors: Dr WM Potts (w.potts@ru.ac.za); Dr R Henriques (rhenriques@sun.ac.za)

Funder: NRF- KFD- South African Biosystematics Initiative (SABI) (74457)

The cold Benguela Current, which formed approximately two million years ago, is located on the south-western coast of the African continent. The establishment and intensification of this eastern boundary current has triggered allopatric events resulting in genetic and/or phenotypic differentiation for many of the warm-temperate organisms that previously had continuous distributions along the south and west coast of southern Africa. However, since many of these species have responded differently, despite similar isolation times, research in this region provides a unique opportunity to increase our understanding of evolutionary processes. The common octopus (*Octopus vulgaris*, Cuvier) is a coastal, sedentary species, inhabiting coral reefs or rocky environments at depths of up to a 100m. It is considered to be one of the most extensively studied cephalopod species due to its worldwide distribution. However, very little research has been conducted on *O. vulgaris* in southern Africa. In order to gain a holistic understanding of the effects of the Benguela Current on population connectivity, genetic and phenotypic diversity, and evolutionary history of *O. vulgaris,* a comparative genetic and morphological study was conducted across the Benguela region.

A total of 168 specimens of *O. vulgaris* were collected from four different regions across the Benguela system. A small tissue sample was preserved in ethanol for molecular analysis and the rest of the animal was frozen for a morphometric analysis. A total of 52 soft and 8 hard part measurements were carried out. A principle component analysis (PCA) and discriminate function analysis (DFA) were used to examine morphological differentiation between the populations. Counts of the meristic characters including the number of gill lamellae and suckers were also made. The genetic population structure and evolutionary history was investigated using a 580bp fragment of the mitochondrial cytochrome *b* (cyt*b*) gene.

While the morphological analysis indicated little differentiation, in soft part, hard part or meristic characters, the molecular results from the AMOVA and pairwise $F_{ST}$ analyses identified significant genetic differentiation corresponding to a northern and southern Benguela clade. Estimates of time since most common recent ancestor, based on biogeographical calibrators and coalescent analyses, indicated that isolation between the northern and southern populations occurred between 460KYA -1MYA, which corresponded with the Pleistocene epoch. Reconstruction of phylogenetic relationships within the *Octopus* genus, using *cytb* and *COI* suggested that *O. vulgaris* is not a monophyletic group and a major systematic revision is required for this species complex. The lack of phenotypic variation, despite genetic divergence, highlights the importance of multi-method approaches in gaining a holistic understanding of the taxonomy and biogeography of species and suggests that a taxonomic revision of the *O. vulgaris* complex is required.

Key words: marine; morphology; molecular genetics; *Octopus vulgaris*; South African Biosystematics Initiative

**12h00-12h20: Denham Parker (PhD Student) - An assessment of the long-term monitoring of the subtidal reef fish community in the Tsitsikamma Marine Protected Area**

Supervisors: Dr A Götz (albrecht@saeon.ac.za); Dr H Winker (henning.winker@uct.ac.za)

Funder/s: Deutscher Akademischer Austausch Dienst/National Research Foundation; Rhodes University (Henderson Scholarship); Ernst and Ethel Eriksen Trust; South African Environmental Observation Network (SAEON)

Tsitsikamma is the oldest, and one of the largest (350km$^2$) 'no-take' marine protected areas (MPAs) in Africa. After 50 years of protection, the communities here are stable and provide the best example of pre-exploitation inshore ecosystems available today. The South African Environmental Observation Network (SAEON) has established a long-term project which monitors the subtidal reef fishes in the Tsitsikamma MPA. The research project uses standardised controlled angling methods to sample fish communities in the nearshore reef ecosystems with biannual sampling trips (summer/winter) and is in its 7$^{th}$ year. To date, a total of 243 fishing stations have been completed and 2,746 fish belonging to 44 different species have been caught and released. This dataset already represents the longest and most comprehensive subtidal reef fish abundance estimate in Southern Africa. The primary objectives of the research project will be to optimise sampling methodology, describe the temporal and spatial variability associated with each sampling technique and assess the possible impacts that climate change may have on the subtidal reef fish communities in the Tsitsikamma MPA.

Preliminary analysis of the controlled angling data revealed high levels of spatial variability which may compromise the accuracy of observed temporal trends. Controlled angling was also found to be highly selective with five species comprising 85% of the catch. One species, *Chrysoblephus laticeps*, accounted for 61% of the catch. This bias misrepresents the ichthyofaunal diversity and may potentially exclude keystone species which are not always the most abundant or available. In addition, fish mortalities associated with controlled angling further compromise monitoring efforts, the effects of which will be compounded over time. These potential methodological shortfalls highlight the need to constantly adapt with technological advances in order to optimise sampling efforts.

The suitability of baited remote underwater stereo-video systems (stereo-BRUVs) for long-term monitoring is being assessed to overcome the inadequacies of controlled angling mentioned above. Stereo-BRUVs are currently considered to be the most technologically advanced and cost-effective sampling technique. Preliminary results suggest that it is extremely effective, and 26 deployments produced a total of 658 observed fish lengths from 41 different species. Despite this small initial sample size the results suggest that stereo-BRUVs are far superior to controlled angling.

Key words: marine; ecology; stereo-BRUV; controlled angling; MPA; Tsitsikamma; climate change; long-term monitoring

## Marine/estuarine ecology (Chair: Michelle Soekoe)

### 12h20-12h40: Taryn Murray (PhD student) - Influence of environmental factors on the movement and habitat use of juvenile leervis *Lichia amia* (Teleostei: Carangidae)

Supervisor: Dr P Cowley (p.cowley@saiab.ac.za)

Funders: Deutscher Akademischer Austausch Dienst – National Research Foundation Joint Scholarship Programme; Rhodes University Research Committee Grant; South African Institute for Aquatic Biodiversity

The influence of environmental factors on the movement patterns of estuarine fish species is poorly understood. In order to understand the influence fluctuating environmental factors characteristic of estuaries have on estuarine fish movement, one requires knowledge on the real-time movement of these fishes. Despite evidence of overlap in the use of estuaries and the nearshore coastal zone, limited information exists on the area use within estuaries as well as the movements of juvenile leervis *Lichia amia* between these habitats. The aims of this were to (i) describe the spatial and temporal patterns of area use within an estuary, (ii) determine the degree of connectivity between estuarine and neighbouring marine environments, and (iii) investigate the influence of fluctuating environmental factors on the movements and habitat use patterns of leervis, a common piscivorous predator.

Twenty data-logging receivers (VR2Ws), spaced approximately 1 km apart, were deployed in the Kowie Estuary in January 2013 to monitor the movements of 20 acoustically-tagged juvenile leervis (303 – 464 mm FL). In addition, seven HOBO® loggers were deployed every 3 km in the estuary to record hourly temperature and conductivity (salinity) values. Additional acoustic receivers and temperature loggers were also deployed in the mouths of several adjacent estuaries, as well as the Ngqura and Port Elizabeth harbours to determine the degree of connectivity between the Kowie Estuary and adjacent sheltered environments.

Preliminary results suggest that despite their tolerance to fluctuating environmental conditions, typical of estuarine environments, the movements of juvenile leervis in the Kowie Estuary are influenced by temperature variations. The dominant behaviour observed by tagged leervis was a continuous movement up and down the estuary. The mean length of the estuary used by tagged leervis over the study period was 17 km (± S.D. = 2.91 km). However, some leervis (15%) displayed restricted movements and were confined to a 4-km stretch of the estuary. Despite these different movement behaviours, all tagged fish displayed a distinct circatidal activity pattern. While most leervis remained in the Kowie Estuary, three individuals left the estuary and were recorded on acoustic receivers in the adjacent Kariega Estuary (23 km away), Swartkops Estuary (130 km away) and Gamtoos Estuary (216 km away). The findings of this study will contribute to a better understanding of the behaviour and ecology of estuarine associated fishes.

Key words: estuarine; ecology; fisheries management; acoustic telemetry; Kowie Estuary

**12h40-13h00: Craig Midgley (MSc student) - Long-term changes of the fish assemblage structure in three South African transition-zone estuaries. Can these trends be linked to climate change?**

Supervisors: Dr NC James (n.james@saiab.ac.za); Prof. AK Whitfield (a.whitfield@saiab.ac.za); Dr SJ Lamberth (stephenl@nda.agric.za)

Funders: National Research Foundation (NRF), Department of Agriculture, Forestry and Fisheries (DAFF)

Estuarine environments and their associated fish taxa are distributed unevenly within three biogeographic regions along the South African coastline: subtropical, warm-temperate and cool-temperate. Estuaries occurring between two biogeographical regions are areas of ecological transition and are areas of high species richness. These transitional environments are ideally placed to document shifts in species diversity, distribution and abundance of estuarine fish taxa which may arise from climate change. There is very little research on the impacts of climate change on fish species, especially within transition zones, and much of the knowledge of the potential impacts of climate change on coastal and estuarine fish species has been inferred from research on the role of climate or environmental variability in structuring biological communities. This approach requires time-series of biological and physical data covering more than one cycle of the climate variability pattern. However, adequate medium to long-term estuarine data sets are scarce. The main aim of this study was to assess changes in the Breede Estuary fish assemblage structure over a 10 year period related to climate or environmental variability. This estuary occurs near the cool-temperate and warm-temperate biogeographic boundary.

Summer data (January – March) collected between February 2002 and February 2012 were utilised in this study. A seine net was used to sample littoral habitats at 24 sites during daylight hours. Gill nets were used to sample the ichthyofauna at fixed localities during daylight hours in the channel at each site. Physico-chemical parameters were recorded at each seine net site.

The Breede Estuary summer fish assemblage structure was stable ($W$ = 0.74) during the study period despite year-to-year variation in abundance of individual species. The fish communities within each estuary reach were similar each year (Global $R$ >0.7; $P$ <0.01). Highly significant dissimilarities were evident between the three estuary reaches, with the most dissimilarity occurring between the upper and lower reaches. Salinity and temperature were the most important environmental variables influencing the spatial structure of the fish assemblage. In terms of biogeographic origin, temperate taxa dominated the relative abundance and overall proportion of species during summer. The number of both tropical and temperate species recorded each year showed no obvious trend related to sea surface temperature (SST). However the abundance of tropical species was lowest in 2009 (1.7 fish haul $^{-1}$), which coincides with the coldest SST during the study period, and the highest abundance was recorded in 2003 (20 fish haul $^{-1}$), which coincides with the highest SST recorded.

The results from this study highlight the importance of continuous long-term estuarine fish studies for conclusive climate related trends. The impact of climate change on estuarine ichthyofauna is often recorded after several decades of sampling.

Key words: estuarine; ecology; biogeography; temporal changes

## 13h00-14h00: Lunch break

## **Marine ecology (Chair: Matthew Parkinson**Error! Bookmark not defined.**)**

### 14h00-14h20: Alexander Winkler (PhD student) - The long shore migratory patterns and inshore habitat usage of the Leerfish, *Lichia amia* (Teleostei: Carangidae), in southern Angola using acoustic telemetry techniques

Supervisors: Dr W Potts (w.potts@ru.ac.za); Dr A Childs (a.childs@saiab.ac.za)

Funders: NRF/DAAD Freestanding Bursary; Ocean Tracking Network; National Research Foundation (Rated Researcher Grant); Flamingo Lodge; Ministry of Fisheries, Angola; Rhodes University Research Committee

*Lichia amia* (Linnaeus, 1758), or leerfish, is distributed from the Mediterranean along the west coast of Africa to the east coast of South Africa with a gap in its distribution between southern Namibia and the Cape of Good Hope. It supports recreational, subsistence and commercial inshore fisheries throughout its global distribution. This species is highly abundant off the southern Angolan coastline, attracting large numbers of foreign anglers, raising its estimated recreational value to be in excess of US$ 243 per harvested kg. Despite the overwhelming recreational value of the species, very little is known about their regional connectivity and movement patterns. Current molecular evidence and tag recaptures suggest that the species has a separate South African and Namibia/Angolan population and this is thought to be due to an allopatric event coinciding with the formation of the cold Benguela Current approximately 2 million year ago. Movements between Namibian and Angola seem to be driven by the shifting Angola-Benguela Frontal Zone (ABFZ). Although, both populations are genetically distinct they share very similar life history strategies with the exception of estuarine dependence found within the South African population. The aims of this study are to investigate the movement behaviour of juvenile, sub-adult, and adult *L. amia*, in an attempt to understand their habitat utilization in the absence of estuaries, circannual movement patterns in relation to environmental cues and to compare the behavioural effect of allopatry with its South African conspecific population.

Forty one acoustic listening stations where deployed along a 150 km stretch of coastline in southern Angola covering varying habitat types from coastal embayments to exposed coastline. Listening station arrangement was designed to monitor long shore migrations from shore to a depth of 60 m as well as higher resolution movements within differing habitat types of fishes. Twenty mature (760 mm – 1020 mm FL) *L. amia* where tagged with coded Vemco V 16 (4H; 55 s nominal delay;) acoustic transmitters in the immediate vicinity of Flamingo Lodge, Southern Angola in 2013. Preliminary range testing conducted over a six day period during varying sea conditions predicted a detection probability of (92 - 100 %) at a distance of 600 m from listening stations. Based on these results listening station curtains where deployed 1.2 km apart. Environmental variables such as temperature will be recorded by 22 underwater temperature loggers as well as by satellite derived data (SST, chlorophyll). A further 20 juvenile and sub-adult fish will be tagged in June 2014 and the data will be downloaded during June 2014, March 2015 and September 2015. Time spent in different environments (eg. embayments) will be estimated using an algorithm in R. Circular statistics will be used to determine the impact of rhythmical variables on behavioural changes. The timing, duration and frequency of visits to different environments between seasons will be analysed using general linear models. Randomisation tests will be used to determine if changes in environmental variables influence movements and generalized additive models will used to analyse the drivers influencing the presence or absence of fish.

Key words: marine; ecology; *Lichia amia*; acoustic telemetry

**14h20-14h40: Matthew Parkinson (PhD student) - Understanding the migration patterns and inshore habitat use of west coast dusky kob *Argyrosomus coronus* in southern Angola using acoustic telemetry techniques**

Supervisors: Dr WM Potts (w.potts@ru.ac.za); Prof AJ Booth (t.booth@ru.ac.za)

Funders: Ocean Tracking Network; National Research Foundation (Rated Researcher Grant); Flamingo Lodge; Ministry of Fisheries, Angola; Rhodes University Research Committee

The west coast dusky kob *Argyrosomus coronus* Griffiths & Heemstra 1995 is a warm- temperate coastal sciaenid (occurring to a maximum depth of 100 m) found in northern Namibia and Angola. They are exploited by diverse fisheries (artisanal, recreational and commercial) during most life history stages and although there is biological information available, information on their movement patterns and migrations is limited. Conventional tagging information showed that juveniles (<600 mm TL) are more resident (57 % recaptured at release site), while sub-adults and adults are more mobile (13 % recaptured at release site). Adults are thought to undergo a seasonal migration, following the shifting Angola-Benguela Frontal Zone (ABFZ) into northern Angola in winter and into northern Namibia in spring. There is no information on their fine-scale movements and habitat utilisation. *Argyrosomus coronus* is closely related to the South African *A. japonicus* and is thought to have been separated from it as recently as 2 million years ago during the formation of the Benguela Current. Although the life history of these species is similar, *A. japonicus* has a juvenile estuarine-dependent phase, which is most likely different to *A. coronus* since there is only one functioning estuary throughout its distribution range. The aims of this study are to investigate the movement behaviour of juvenile, subadult, and adult *A. coronus*, determine their juvenile habitat utilisation in the absence of estuaries, understand environmental triggers and the influence of environmental variables on movement patterns, and to compare the behaviour of this species with its South African congener.

Acoustic telemetry equipment was deployed in three regions encompassing the full range of habitats including sections of exposed coastline and two coastal embayments in southern Angola. The acoustic receiver array was designed to monitor movements and migrations, determine the importance of large coastal embayments and examine the fine-scale movements of fishes. Range tests were conducted during a rough sea period in winter to provide information for the receiver array design. The detection probability was high (92-100%) at a distance of 600 m over 6 days. Based on this, the distance between receivers in the curtains, which are used to monitor longshore migrations, was set at 1200 m. Oceanography equipment (22 underwater temperature recorders) was deployed with the telemetry equipment and their data will be used with satellite derived data (SST, chlorophyll) for the analyses. Twenty mature (760-1155 mm TL) *A. coronus* were tagged with coded Vemco V16 (4H; 55 s nominal delay) acoustic transmitters at Flamingo Lodge, southern Angola during August 2013. A further 20 juvenile and sub-adult fish will be tagged in June 2014. All data will be downloaded during June 2014, March 2015 and September 2015. Time spent in different environments (eg. embayments) will be estimated using an algorithm in R. Circular statistics will be used to determine the impact of periodic variables on behavioural changes. The timing, duration and frequency of visits to different environments between seasons will be analysed using general linear models. Randomisation tests will be used to determine if changes in environmental variables influence movements and generalised additive models will used to analyse the drivers influencing the presence or absence of fish.

Key words: marine; ecology; acoustic telemetry; migration

**14h40-15h00: Enrico Gennari (PhD student) - Thermal physio-ecology of the white shark (*Carcharodon carcharias*)**

Supervisors: Dr P Cowley (p.cowley@saiab.ac.za); Mr R Johnson (r.johnson@oceans-initiative.com)

Funders: Oceans Research; South African Institute for Aquatic Biodiversity; Padi Aware

The white shark is one of few elasmobranch species capable of maintaining parts of its body warmer than the surrounding environment. Very little is known about the thermal physiology of white sharks in the wild, since studying these large, highly mobile and potentially dangerous predators, often in rough sea conditions, is challenging.

This project has made use of anatomical dissections and acoustic telemetry to understand the thermal anatomy of white sharks and to determine their habitat use, movement patterns and thermal ecology in Mossel Bay (South Africa). A new prototype acoustic transmitter was designed and manufactured to monitor the muscle temperature of the tagged sharks. At the same time, a tag (with temperature and depth sensors) was externally attached and a transmitter (with a temperature sensor) was fed (in a piece of bait) to each of the studied sharks. This provided, for the first time, a means to assess simultaneously the complete thermal profile of a white shark from water temperature through the warmer white muscle to the warmest body core temperature of the stomach.

To date, sixteen white sharks have been dissected to look at the morphology and distribution of the suprahepatic and subcutaneous *retia mirabilia*. At the same time, six white sharks (TL= 1.5, 2, 2.5, 3, 3.5, 4 m size classes) have been triple tagged with a cumulative tracking effort of 722 hours. This included two continuous tracking sessions of 107 and 106 hours on two individuals. The intensive tracking protocol has produced large amount of data (~5.2 million rows) that were filtered and analysed using a protocol created in R. The movement patterns of tagged sharks were described in three dimensions by combining data from positional fixes (X and Y co-ordinates) taken with a GPS on board the tracking boat and the swimming depth sensor (Z co-ordinate). Behavioural patterns (e.g. hunting, resting and moving) were described using three dimensional rates of movement, which were then linked to the thermal variables (stomach and muscle temperature).

Preliminary analysis of the physiological data indicates that white sharks are able to raise body core (stomach) temperature and white muscle temperature by up to 17.3 ºC and 11 ºC above surrounding water temperature, respectively. Muscle temperature resembled environmental conditions and fluctuations, whereas stomach temperature appeared to be independent of environmental conditions and ontogenetically constant.

Positive ontogenetic variation in stomach temperature elevation after feeding permits size related variation in the diet of the white shark and the feasibility of more complex migratory behaviours in adults. Positive ontogenetic variation in white shark body core temperature allows size related ecological niche expansion toward colder and more suitable hunting grounds. On the other hand, smaller conspecifics are forced both behaviourally and physiologically towards warmer waters more suitable for quicker grow rates.

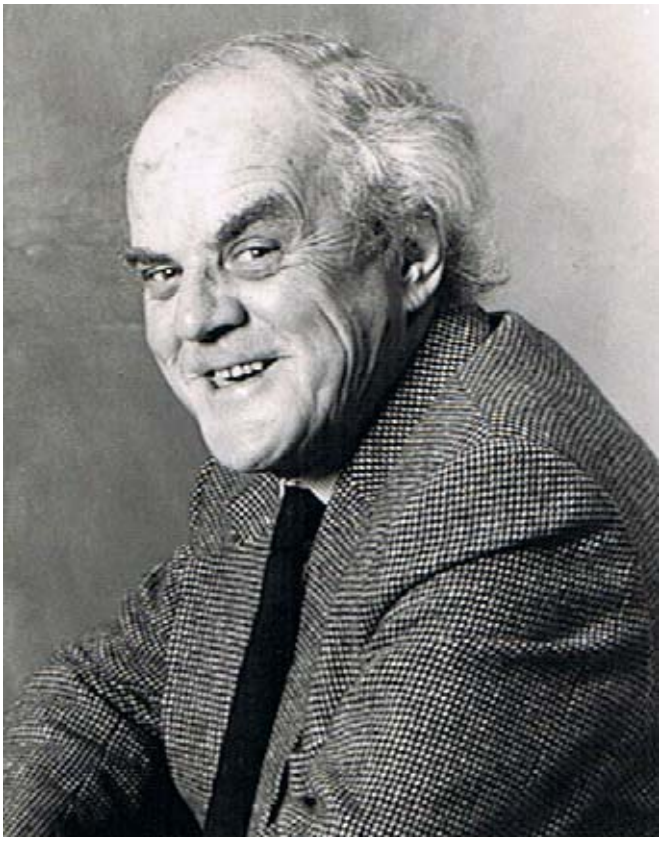
Key words: marine; ecology; acoustic telemetry; thermal physiology; habitat use; white shark

## Friday 18 October 2013

## Humphry Greenwood Guest Speaker (Chair: Prof. Warwick Sauer)

**08h30-08h40: Welcome and introduction by HOD**

**08h40-09h30: Dr Johann Augustyn – Chronicles of a Government Marine Scientist**



Dr Humphry Greenwood

## Marine fisheries management (Chair: Tshoanelo Moloi)

**09h30-09h50: Ross Rutherfoord-Jones**Error! Bookmark not defined. **(MSc student) - Movement, migration, residency and genetic stock assessment of Santer/ Soldier (*Cheimerius nufar*)**

Supervisors: Dr G Gouws (g.gouws@saiab.ac.za); Dr P Cowley (p.cowley@saiab.ac.za)

Funder: South African Institute for Aquatic Biodiversity (SAIAB)

Santer has been fished commercially since the 1930s, however, a stock assessment has never been done on this species. Despite 75 tonnes being caught annually in the past few decades by the commercial line fishery, little is known as to the current state of the stock. This MSc aims to investigate the length variations and catch trends (biomass) from the commercial fishery, the movement and migration patterns from research tagging programmes and, lastly, the genetic variation between individuals caught at various locations along the coastline.

The National Marine Linefish System (NMLS) database was used in the analysis of catch trends. It was found that there is a vast increase in CPUE after 2000, but there is little change in the total landed catch for Santer reported. After the linefish crisis in 2000, the commercial fleet was reduced, so it is likely that the CPUE increase is due to the fact that there are fewer boats competing for the same resource. Additionally, Santer seems to make up a "catch weight deficit" rather than being a primary target species. The average lengths of landed fish do not change much from 1985 to present, around 30 cm total length, and that small Santer fetch a low market price. This is good news for Santer as 50% sexual maturation occurs when the fish are approximately 250 mm total length, Most Santer caught would've had a chance to reproduce in their lifetime.

The tagging programme data from research programmes Tsitsikamma National Park (TNP) an Algoa Bay, and the volunteer ORI tagging programme have shown a high degree of residency for Santer with 80% of fish moving within in a range of 5 km from when they were first caught. This seems to be a common trait for residency amongst demersal reef fishes. In the TNP programme, which was as shore angling programme, Santer are only caught when there are cold upwelling in the region ,as Santer take refuge in warmer shallower water during a cold upwelling.

The mtDNA control region was selected for the generic stock assessment. A set of primers was designed based on the consensus sequences for the flanking tRNAs from other sparids using the NCBI database. It was found that the control region for Santer is approximately 1200 bp in length. The newly designed forward primer was used for the sequencing of the control regions of 10 samples from along the coastline as a preliminary test. A haplotype network was made using these preliminary data and it seems likely that Santer is a single panmicitic stock. The remaining 200 Samples, representing 4 equidistant regions of the east coast from Cape Agulhas to Richards Bay are currently being processed/analysed.

Key words: marine; fisheries management; NMLS; catch variations; tagging; mtDNA; panmixia

**09h50-10h10: Roy Bealey (MSc student) - Life history variations of a cosmopolitan species, *Pomatomus saltatrix*, in a climate change hotspot**

Supervisor: Dr W Potts (w.potts@ru.ac.za)

Funder: Rhodes University Research Committee

Angola has a dynamic marine environment with the confluence of the cold Benguela and warm Angola currents forming the Angola Benguela Frontal Zone (ABFZ) in the region. The area is also considered a climate change "hotspot" due to rapidly (0.7°C/decade) increasing water temperatures. Examining thermal responses of species in global hotspots is considered a way of obtaining predictive information on the response of fishes in areas that are warming at slower rates. Besides a changing environment, Angola's coastal fisheries have grown rapidly following cessation of its civil war in 2002. *Pomatomus saltatrix* is a warm-temperate marine fish species that forms an important component of fisheries throughout its broad distribution. *P. saltatrix* is a migratory, predatory species and with globally variable growth rates and sizes at maturity it is an ideal candidate to study the impacts of exploitation and a changing climate.

The aims of this study were to provide the first scientific description of the biology of *P. saltatrix* in Angola and examine recent changes in the biology of the species in an attempt to uncouple fishery from climate driven changes. Samples of *P. saltatrix* were collected monthly using standardised biological methods from June 2005 to December 2006 (1$^{st}$ period) and from June 2012 to February 2013 (2$^{nd}$ period). The average (508mm – 1$^{st}$ period, 462mm – 2$^{nd}$ period) and maximum (760mm – 1$^{st}$ period, 746mm – 2$^{nd}$ period) size of *P. saltatrix* was smaller during the second period. However, fish grew faster (K = 0.14 – 1$^{st}$ period, K = 0.16 – 2$^{nd}$ period), matured at a larger size (238mm - 1$^{st}$ period, 292mm - 2$^{nd}$ period) and older age (157days -1$^{st}$ period, 208days – 2$^{nd}$ period) during the second period. Peaks in reproductive activity remained similar (November) during both periods. The sardinella species, *Sardinella aurita* also remained the dominant prey item during both periods.

Angolan *P. saltatrix* grew relatively slowly when compared to other populations, including the geographically proximate populations of South Africa and Senegal, and were most similar to those of the east Australian population. Size and age at maturity were also relatively small when globally compared with other populations. Theoretically, fishes should grow faster and to smaller maximum sizes in warmer water temperatures. However, fishing pressure has also been show to increase the growth and decrease the maximum size of fishes. Therefore the combined impact of warming and fishing pressure is likely to have resulted in the faster growth and reduced size of *P. saltatrix* in Angola. The larger size at maturity during the second period was surprising, particularly since life history theory predicts that maturation will occur at a smaller size under warmer conditions and fishes normally respond to fishing pressure by reducing their size at maturity. Increasing water temperatures are predicted to continue causing faster growth to smaller maximum sizes of *P. saltatrix* populations globally. With changing life history characteristics, the Angolan fisheries targeting *P. saltatrix* require control measures to ensure future sustainability.

Key words: marine; fisheries management; ecology

**10h10-10h30: Nicola Downey (PhD student) - A first description of the offshore reef environment off the Eastern Cape coast, South Africa, with reference to deep spawning chokka squid (*Loligo reynaudi* D'Orbigny, 1839)**

Supervisors: Prof W Sauer (w.sauer@ru.ac.za); Prof M Roberts (squid@metroweb.co.za)

Funders: National Research Foundation (KFD2008062700004); South African Squid Management**Error! Bookmark not defined.** Industrial Association (Project 18)

The South African chokka squid, previously thought to be a shallow water inshore spawner, has also been found to spawn at depths of 60 to 270 m. Inshore spawning aggregations have been studied in detail. Deep spawning in this species however, is still very much an unknown phenomenon. The aim of this work was to determine the location, extent and potential significance of deep spawning, determine the dispersal, transport and survival of deep spawned paralarvae and provide a first description of the offshore spawning environment.

Analysis of demersal research survey data was used to determine the location and abundance of shallow and deep spawned chokka squid eggs. The contribution of deep spawned eggs to total egg biomass was also calculated. Individual-based models were used to investigate the transport of paralarvae from both inshore and offshore spawning sites. The effect of seasonality and spawning location on paralarvae transport and survival were also investigated. Individual-based models were also used to determine the origin of paralarvae collected on the Central Agulhas Bank by way of bongo samples. Ships CTD, ADCP and echosounder data, benthic survey video footage and environmental mooring data (temperature and turbidity) were used to describe and compare the inshore and offshore spawning environments. Squid movement on and between the inshore and offshore environments was determined using filament and acoustic (active tracking) tagging.

The analysis of demersal research survey data showed spawning intensity markedly decreases at a depth of 70 m, suggesting delineation between the inshore and offshore spawning grounds. This may be linked to a change in the environment (i.e. temperature, light, turbidity). Very little spawning occurs deeper than 130 m. Within the inshore area there appears to be a preferred depth range for spawning between 41 and 50 m, with egg densities three times greater than that found in strata on either side. Mid-shelf spawning appears to peak between 101 and 110 m. Despite this trans-shelf spawning, the calculation of total egg biomass in strata shallower and deeper than 70 m indicates the former to be much more strongly favoured, i.e. 82 vs. 18%, respectively. Individual-based modelling studies factored in as many aspects relevant to the early paralarvae life stage as is currently possible, regarding not only paralarvae characteristics and behaviour but also those aspects critical to their survival. Both large and smaller oceanic features influenced transport and hence recruitment. Results indicated the Western Transport Hypothesis previously described for inshore spawned paralarvae (transport from the south coast to the Cold Ridge feeding grounds) also applies to deep spawned paralarvae. Deep spawning off the Tsitsikamma and Knysna coasts, particularly during the colder months, can contribute significantly to recruitment. The deep spawning environment differs markedly from the inshore environment in terms of substrate and bottom morphology, fish communities, temperature, turbidity and oxygen. Surprisingly, bottom temperatures offshore were at times warmer than those inshore. Filament tagging showed movement of adults between the offshore and inshore environments and active tracking revealed similar nocturnal behaviours on both the inshore and offshore spawning grounds.

Key words: marine; fisheries management; *Loligo reynaudi*; deep spawning

## 10.30-11.00 Tea Break

## **Mariculture - Abalone (Chair: Pholoshi Maake**Error! Bookmark not defined.**)**

### 11h00-11h20: Georgina Robinson (PhD student) - Highly diverse microbial communities in the sand substrate of tank cultured sandfish (*Holothuria scabra*) revealed by 16S rRNA pyrosequencing

Supervisors: Dr CLW Jones (c.jones@ru.ac.za); Prof. S Stead (selina.stead@newcastle.ac.uk); Prof. G Caldwell (gary.caldwell@newcastle.ac.uk)

Funders: Biotechnology and Biological Sciences Research Council (BBSRC), U.K.; HIK Abalone Farm (Pty) Ltd; Rhodes University Research Committee

Understanding the sediment microbial communities present in sandfish culture tanks is key to explaining differences in the biogeochemical cycling that underpins the growth performance of the animals. The study used high-throughput next generation 454 gene sequencing to examine bacterial diversity and assemblage patterns within culture tank sand substrates subject to different redox conditions.

Two different redox regimes were created within a substrate of four centimetre fine (125 – 250 μm) calcium carbonate sand. 'Treatment tanks' were fitted with a plenum and airlift pump to create a fully oxic substrate while 'Control tanks' provided a naturally stratified oxic-anoxic substrate. Replicate tanks (n=3) were stocked with juvenile sandfish (n=4) with a mean initial weight of 14.98±0.42 g. After 84 days, core substrate samples were collected from each replicate tank and sectioned at depth intervals of 0 cm, 2 cm and 4 cm. Genomic bacterial DNA was extracted from 250 mg of substrate sample using a PowerSoil™ DNA isolation kit. The 16s rRNA gene was amplified using fusion primers, containing Multiplex Identifier Tags and subjected to emulsion PCR before sequencing using GS Titanium Sequencing (OTUs).

There was a significant difference in the mean number of OTUs observed between the two different redox regimes (multi-factor ANOVA, $F_{(1,10)}$=33.22, p=0.00018), with 585.57±52.00 OTUs in the treatment tanks (oxic) compared to a mean of 321.55±37.16 OTUs in the control tanks (oxic-anoxic substrate). The diversity of bacterial communities also differed significantly with depth ($F_{(2,10)}$=5.36, p=0.02612) with the highest diversity at the mid (2 cm) and base (4 cm) layers of the substrate with 489.83±80.71 OTUs and 472.50±111.07 respectively, compared to a mean of 360 ± 53.93 OTUs at the surface (0 cm). No significant interaction was found between the redox regime and depth ($F_{(2,10)}$=1.49, p=0.27).

Fourteen taxonomic groups were recovered from the samples with over 75% of 16S rRNA gene sequences belonging to two major phyla, the Proteobacteria (44.60±0.92 %; n=16) and Bacteroidetes (31.29±2.24%; n=16). Nitrite-oxidising bacteria belonging to Nitrospirae and nitrate-reducing bacteria belonging to the phylum Deferribacteres were found in treatment tanks that had fully oxic substrates but were not present in the control tanks.

There was no significant difference in growth rate of sandfish between the control (0.43±0.07 g $day^{-1}$) and treatment tanks (0.31±0.06 g $day^{-1}$; t=1.23, p=0.28) after 84 days, although the animals in the control tanks achieved a higher mean density (1028±117.46 g $m^{-2}$ vs. 837.96±99.71 g $m^{-2}$).

Overall, the results suggest a higher complexity of the bacterial communities in the substrates that were maintained under a fully oxic regime than in the control tanks that contained a naturally stratified oxic-anoxic substrate.

Keywords: marine; aquaculture; holothurians, bacteria; diversity; substrate; redox

**11h20-11h40: Devin Ayres (MSc student) - The effect of diet and sex sorting on gonad development and histology in farmed South African Abalone, *Haliotis midae***

Supervisors: Prof. H Kaiser (h.kaiser@ru.ac.za); Dr CLW Jones (c.jones@ru.ac.za)

Funders: National Research Foundation; THRIP; Marifeed (Pty) Ltd; HIK Abalone Farm (Pty) Ltd; Aquafarm Development (Pty) Ltd; Roman Bay Sea Farm (Pty) Ltd.

Abalone, *Haliotis midae*, farmers in South Africa that rely on the locally produced formulated feed, i.e., Abfeed®, reported a periodic drop in growth likely to be due to increased gonad growth. This reduced rate of growth appears to occur just after winter. Since abalone that are fed formulated feeds show increased gonadal growth, it was hypothesized that formulated abalone feeds, include compounds such as soya that enhance gonadal development.

All experiments were conducted in flow-through systems at HIK Abalone Farm in Hermanus, Western Cape. Abalone (50-70 g abalone$^{-1}$) were fed to satiation every day on a diet containing soya and fishmeal (SF) as a protein source and another isonitrogenous and isoenergetic diet without soya (F34). Abalone were acclimated then allocated to 18 standard farm tanks (nine tanks per diet) and stocked at 18% of the available surface area. Every month three males and three females were randomly selected from each tank to calculate a gonad bulk index (GBI) analysis. Another three males and three females were randomly sampled every month from each tank to obtain weight and length measurements of the whole abalone, dry mater of meat and visceral mass, and shell mass. Another three males and three females from each diet were randomly sampled every month for histological examination of the gonad tissue.

The sex sorting experiment was conducted in 18 tanks (0.9 x 0.6 x 0.6m) stocked at a density of 18% of the available surface area and abalone (71-80 g abalone$^{-1}$) were fed to satiation daily with the SF diet. Abalone were sorted into three groups of males only, females only and mixed sexes with equal numbers of males and females, each group replicated six times. Every month four randomly selected abalone were sampled for GBI analysis, weight and length measurements of the whole abalone, dry mater of meat and visceral mass, and shell mass.

Trials commenced in July 2012 and carried through to June 2013. There was no significant difference in the mean gonad bulk index (mm$^3$ g $^{-1}$ ) between the diets over time ($F_{11,374}$ = 1.46, p =0.14). The mean GBI for the SF diet was 27.25 ± 6.4 mm$^3$ g $^{-1}$ and the F34 diet illustrated a mean GBI of 23.15 ± 5.19 mm$^3$ g $^{-1}$ . There was no significant difference in the percentage of meat mass ($F_{11,759}$ = 1.42, p = 0.16). The diets did not affect water retention in the meat and viscera tissue as there was no difference in the water lost from these tissues ($F_{11,374}$ = 1.7, p = 0.07 for meat; $F_{11,374}$ = 1.4, p = 0.17 for viscera). Results from the sex-sorting trial showed percentage of viscera to whole body weight did not differ between the mixed- and single-sex groups ($F_{11,242}$ = 0.9, p = 0.53 for females; $F_{11,242}$ = 0.7, p = 0.73 for males). GBI was not significantly different between all sex groups ($F_{22,231}$ = 0.7, p = 0.83).

These results suggest that soybean meal present in the artificial feed affected gonad development in *Haliotis midae*. Gonad development appears to be unaffected by sex-sorting.

Keywords: marine; aquaculture; soya; reproduction; gonad bulk index; growth

**11h40-12h00: Gareth Nicholson (MSc student) - Investigating the effects of stocking density on the health, growth and production of South African abalone (*Haliotis midae*)**

Supervisors: Dr CLW Jones (c.jones@ru.ac.za); Prof. H Kaiser (h.kaiser@ru.ac.za)

Funders: THRIP; Marifeed (Pty) Ltd; Aquafarm Development (Pty) Ltd; HIK Abalone Farm (Pty) Ltd; Roman Bay Sea Farm (Pty) Ltd

The profitability of abalone farms is heavily influenced by their production per unit of grow-out space. With farms having physically expanded to the maximum, and with increasing production costs, the only realistic way for farms to increase their production is through optimizing stocking densities. The effect of stocking density on *H. Midae* performance is undocumented and optimal stocking densities for this species have not been determined.

This study aims to determine the effect of stocking density on the growth, health and production of different size abalone when water quality is not a confounding factor and to investigate the behaviour of abalone under different densities.

Experiments were conducted on the Aquafarm Development Abalone farm in Hermanus. The effects of four different stocking densities (16%, 20%, 22% and 24% of available surface area) were tested on three different size classes of abalone (15-35 g, 45-65 g, and 70-90 g start weight). Each treatment was replicated four times and trials ran over a period of eight months with measurements being made at four month intervals. Abalone behaviour was observed during the trials in the experimental tanks.

Weight gain per abalone decreased with an increase in density for all size classes ($40.32 \pm 1.41 - 19.00 \pm 0.66$; $42.81 \pm 1.69 - 36.92 \pm 2.33$; $63.74 \pm 2.93 - 52.20 \pm 2.25$ g.abalone$^{-1}$ for the 15-35, 45-65 and 70-90 g classes respectively, with an increased density of 16-24%). However, total biomass gain remained unaffected in the 15-35 g ($10.32 \pm 0.15$ kg/tank) and 45-65 g ($7.75 \pm 0.15$ kg/tank) treatments ($p > 0.05$) but increased significantly from $8.66 \pm 0.18$ to $10.66 \pm 0.16$ kg/tank with an increase in density from 16% to 24% for the 70-90 g size class. Stocking density had no effect on the condition factor or health indices of the tested abalone.

Behaviour observations demonstrated that a higher proportion of animals are found above the feeder plate, and on the feeder plate at higher densities ($p > 0.05$). Despite this, the proportion of animals on feeder plates which are on Abfeed ® remained the same at all densities ($p < 0.05$). Animals above the feeder plate were more active and more likely to have their access to feed restricted at higher densities ($p > 0.05$).

Although individual growth is negatively affected, it may be possible to increase production by increasing stocking density. A cost analysis will determine the viability of increasing farm densities for different size abalone. With a better understanding of abalone behaviour we are able to investigate options which could counter the reduction in growth at high stocking densities.

Keywords: marine; aquaculture; production; health; behaviour

**12h00-12h20: Justin Kemp (PhD student) - The effect of seaweed / formulated feed combination diets on abalone *Haliotis midae* growth, biochemical and physiological parameters**

Supervisor: Prof P Britz (p.britz@ru.ac.za)

Funders: Rhodes University Research Committee; Marifeed (Pty) Ltd; Skye Foundation; National Research Foundation (NRF); Department of Agriculture, Forestry and Fisheries (DAFF)

Abalone are herbivores in their natural rocky shore environment, consuming a variety of brown, red and green seaweeds. However, the rapid development of abalone culture in South Africa (300 tons in 2005 to 1070 tons in 2010) was based initially on a single species of wild-harvested kelp *Ecklonia maxima* and is now dominated by the use of formulated feeds. These feeds offer a number of advantages for abalone farmers including comparable growth rates to fresh seaweed, ready supply in the face of dwindling kelp resources, ease of transport and feeding, and improved canning yields. When compared to formulated feed, seaweed can be considered as a nutrient-poor feed, particularly in terms of protein and energy content.

Despite this, abalone have been shown to grow particularly well on a diet of mixed seaweeds under culture conditions. Furthermore, protein utilization of formulated feed has been shown to improve with fresh seaweed supplementation. A 12-month growth trial assessing the role of fresh seaweed supplementation into the diet of animals fed a formulated feed was conducted under controlled conditions at the Port Alfred Marine Research Laboratory. Five graded supplementation levels of a "mixed bag" of fresh seaweed (*ulva sp*., *gracilaria sp*. and kelp) were tested over a 12 month growth-period during which production, metabolic, biochemical, histological and product quality indicators assessed. Initial results indicate a strong positive correlation between seaweed inclusion level and abalone growth. Furthermore, the inclusion of fresh seaweed into the diet of pellet fed abalone affects, amongst other factors, overall protein utilization, canning yield and food conversion reatio. This trial also formed an extended acclimation period for physiological trials investigating the effect of diet on postprandial oxygen consumption, ammonia excretion and haemolymph glucose levels. A selection of results from both the growth and physiological trials will be presented.

Key words: marine, aquaculture, *Haliotis midae,* forumated feed, fresh seaweed supplementation

**12h20-12h40: Alida Pieterse (PhD student) - The physiological effect of kelp *Ecklonia maxima* on the digestion and nutrition of cultured South African abalone *Haliotis midae***

Supervisors: Prof. P Britz (p.britz@ru.ac.za); Dr S Jackson (sjack@sun.ac.za)

Funders: Marifeed (Pty) Ltd; Marine Living Resources Fund (DAFF); Technology and Human Resources Programme (TP2011072100025)

*Haliotis midae* fed a combination of seaweed and formulated feed display higher growth rates compared to those fed only formulated feed or a single species of seaweed, but the reason for this is unknown. Seaweed is rich in fibre and complex polysaccharides. Laminarin and fucoidan from brown seaweeds has shown a prebiotic effect in weaning piglets (O'Doherty *et al*. 2010). The effect of prebiotics has not been tested for abalone, but abalone gut-microbial diversity and enzyme activity changes in response to seaweed in their diet. Prebiotics modify intestinal mucosa villi and microvilli length in fish (Sweetman *et al.* 2008), but the effect of prebiotics on abalone gut morphology is unknown. Locally, the brown seaweed incorporated into commercial abalone feed is the kelp, *Ecklonia maxima*. The combined optimal inclusion level of kelp and protein in the feed, based on on-farm growth trials, has not been established.

To test the effect of a possible interaction of kelp and protein level on growth, an eight-month growth trial was started on a local abalone farm in July 2013. Abalone with an average mass and length of 18.5 g (± 4.5 S.D.) and 42.9 mm (± 4.0 S.D.) respectively are fed diets with three different protein levels and four kelp levels, in addition to two reference diets. Each diet treatment has six replicate abalone baskets within different tanks. Mean masses will be recorded for each abalone basket every four months, with sub-samples weighed and measured individually. To test the effect of formulated feed and kelp on the development of abalone digestive physiology, early juvenile abalone will be weaned onto formulated feed and fresh kelp.

After eight months, abalone from both age groups and specific diets will be moved to a laboratory for a two-month growth trial where they will remain on their specific diets. Metabolic and feeding efficiencies will be compared between abalone on the different diets. A prebiotic effect and differences in digestive enzyme activity will be tested by comparing gut-bacterial proportions between abalone on feed supplemented with kelp to those without, by using 16S rRNA gene sequencing and enzyme assays respectively. Enzyme activity will be linked to a possible bacterial origin with molecular techniques. Seaweed's effect on gut morphology will be established by comparing intestinal mucosa villi and microvilli lengths between diet treatments, using light microscopy and transmission electron microscopy.

Key words: marine; aquaculture; abalone; seaweed; nutrition; prebiotics

References:

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Sweetman, J., Dimitroglou, A., Davies, S., Torrecillas, S. 2008. Nutrient uptake. Gut morphology: a key to efficient nutrition. International Aquafeed 26: 26–30.

**12h40-13h00: Adejoke Adesola (PhD student) - Nutrient digestibility in South African dusky kob (*Argyrosomus japonicus*)**

Supervisors: Dr CLW Jones (c.jones@ru.ac.za); Dr TA Shipton (t.shipton@ru.ac.za)

Funders: Department of Agriculture Forestry and Fisheries; THRIP

Dusky kob (*Argyrosomus japonicus*) is a carnivorous marine finfish with high potential for aquaculture in South Africa. Typically feed costs in aquaculture account for between 40-60% of production costs, and the development of cost-effective feeds that satisfy the nutritional requirements of a culture species is prerequisite to the development of a financially viable production model. As protein is the most expensive dietary component and is central to growth, developing an understanding of the protein and amino acid dietary requirements of a culture species is important for developing cost–effective feeds. Currently, fishmeal is used as a major protein source in compounded aquafeeds for carnivorous marine finfish, including the dusky kob. Concerns about future fishmeal supply and costs is increasingly focusing research efforts to identify alternative protein sources to fishmeal. This study will focus on determining the protein and essential amino acid (EAA) requirements of the dusky kob with a view to developing least-cost, nutritionally balanced diets using locally available feedstuffs. Initial experiments will be conducted to develop a reliable digestibility technique to evaluate nutrient digestibility in compound feeds. Three faecal collection methods (modified Guelph system, dissection and stripping) and three digestibility markers (chromic oxide, acid insoluble ash and tritium oxide) will be assessed for their efficacy in determining protein and amino acid digestibility coefficients. The technique will be used to establish the apparent and true availability of protein and EAAs in selected feed ingredients. Selection criteria for inclusion of potential protein sources will be based on their local availability, price, and nutrient profile. An evaluation of the essential amino acid requirements of the species will be undertaken by establishing the dietary lysine requirement and using the EAA profile of the animal to provide an indication of the requirements for the remaining nine EAAs relative to lysine. This approach assumes that lysine is the first limiting EAA in formulated feeds for the species. Crystalline L-lysine (0.9 % - 6.0 % of dietary protein) will be added to a basal diet in graded levels resulting in six dietary lysine levels. The growth response to the graded L-Lysine combined with a L-lysine blood serum extinction analysis will be used to provide an indication of the dietary lysine requirements. Finally least-cost dietary formulations based on digestible EAA availability in selected feed ingredients and the dietary EAA requirements of the species will be evaluated.

Keywords: marine; aquaculture; feeds; markers; protein; amino acids; lysine faecal

## 13h00 DIFS PHOTOGRAPH

## Non-presenting students

### Ann Wu (MSc student) - The effect of phytoestrogens on the growth, gonad development and histology of *Haliotis midae*

Supervisors: Dr CLW Jones (c.jones@ru.ac.za); Prof. H Kaiser (h.kaiser@ru.ac.za)

Funders: Aquafarm Development (Pty) Ltd; HIK Abalone Farm (Pty) Ltd; Marifeed (Pty) Ltd; Roman Bay Sea Farm (Pty) Ltd; National Research Foundation; THRIP

Farmed abalone, *Haliotis midae*, fed a formulated diet that includes soya have been found to produce enhanced gonads during the reproductive season. As a result, production to market size is taking longer. Soya beans contain isoflavones, a class of phytoestrogens, which have the ability to cause estrogenic and/or antiestrogenic effects. These isoflavones include daidzin, genistin, glycitin, daidzein, genistein and glycitein. The inclusion of these isoflavones in a fishmeal only diet will be used to determine whether or not phytoestrogens in the soya are causing enhanced gonad development.

Animals weighing between 40-50 g will be fed one of seven isonitrogenous and isoenergetic diets:

- Fishmeal and soya (100% soya)
- Fishmeal and soya (50% soya)
- Fishmeal and soya (25% soya)
- Fishmeal only with phytoestrogen equivalent to the amounts in 100 % soya
- Fishmeal only with phytoestrogen equivalent to the amounts in 50 % soya
- Fishmeal only with phytoestrogen equivalent to the amounts in 25 % soya
- Fishmeal only

A preliminary leaching trial was done to determine the percentage of isoflavone that may leach after feeding. A fishmeal and soya diet and fishmeal only diet with equivalent amounts of isoflavones were made. The diets were leached in seawater for 8 hours and dried. Dry feed, leached feed as well as soya bean meal were sent for isoflavone assays.

Analysis indicated that daidzin, genistin and glycitin leached between 33 and 35 %, while dadizein, genistein and glycitein were undetectable by the assay as there were only trace amounts. The amounts of isoflavone required in the final diets were determined by the remaining isoflavones in the fishmeal and soya diet after 8 hours of leaching. The proportions of isoflavones lost in the fishmeal and isoflavone diet were determined and used to calculate how much additional isoflavones would be needed to compensate due to leaching. The trace amounts of daidzein, genistein and glycitein were added to the diet by calculating the proportion of the three different isoflavones in soya bean meal, these proportions were used to calculate quantities at the same proportion from the total isoflavones present in the fishmeal and soya diet.

Data will be collected every forty five days for six months, including gonad bulk index (GBI), dry weights, individual growth rates, gonad histology and estradiol levels in the hemolymph. Water quality parameters (dissolved oxygen, pH, temperature and ammonia) will be monitored weekly.

Key words: marine; aquaculture; abalone; nutrition; isoflavone; soya; fishmeal

**Chris Gornall (MSc student) - The effect of stocking density on the growth and behaviour of the South African abalone (*Haliotis midae*)**

Supervisors: Dr CLW Jones (c.jones@ru.ac.za); Prof. H Kaiser (h.kaiser@ru.ac.za)

Funders: DAAD-National Research Foundation; THRIP (TP2011071800030)

The profitability of abalone farms in South Africa is influenced by their production per unit grow-out space. Production is a function of abalone growth and stocking density. We know very little about the relationship between abalone growth and stocking density. The knowledge obtained from research into this topic will assist in the competitive growth of the South African abalone. The overall aim of this study was to better understand the factors causing reduced growth at elevated densities. This aim was addressed by a number of objectives. The first of which was to document abalone behaviour by defining behaviours and trends at different densities. The second objective was to quantify differences in behaviour and growth at a low (18% surface area or 9kg per basket) and high density (25% SA or 13 kg per basket). The third objective was to investigate the presence of a growth inhibitory substance released at higher densities. This objective was addressed by quantifying growth and behaviour (appetite and activity).

Trials are being conducted at HIK Abalone Farm (Pty) Ltd in production tanks whereby water quality was excluded as a confounding factor by setting flow rates at 20L/kg/hr. Other parameters such as feeding are being kept in accordance with current farm protocols. Objectives one and two are being addressed through the use of photography and videography, whereby footage is being analysed using compositional data analysis to determine differences and trends between behaviours observed at high and low density. To quantify growth, abalone were weighed at two months and will further be sampled at 4, 6, 8, 10 and12 months. At the two month growth sampling 30 animals were sampled per basket, totalling 180 animals per tank. Each treatment consists of four tanks. At the 4, 8 and 12 month grading events (animals will be weighed and re-stocked at the original 9 and 13kg's), the animals in excess will be sampled and yield data will be collected (meat weight, shell weight, visceral mass, dry weights, canning yield, GBI).

At the two month sample the mean weight of animals in the high density (65.7 ± 5.6g) treatment was not significantly different to that of the low density (65.9 ± 5.7g) treatment ($p = 0.44$). Various behaviours, trends in activity and interesting phenomena have been observed; these trials are on-going.

Keywords: marine; aquaculture; photography

**Sarah Halse (MSc student) - An assessment of stereo-video techniques to sample shallow and deep reef-fish assemblages**

Supervisor/s: Dr A Gotz (albrecht@saeon.ac.za); Dr A Bernard (ant@saeon.ac.za)

Funder/s: NRF; SAEON Elwandle; SAIAB; British Ecological Society; University of Western Australia; WIOMSA

Over the last few decades it has become evident that both the management and monitoring of reef fish resources have been inadequate, or inappropriate, to ensure the sustainable utilisation of target species, and the conservation of biodiversity. Stereo baited remote underwater video systems (stereo-BRUVs) are globally recognised as one of the best techniques to determine reef fish abundance and sizes, as the data have minimal biases and data can be collected across a broader range of depths and habitats than conventional non-destructive fisheries independent methods. This monitoring method is novel to both South Africa and Africa and as a result the methodology needs to be optimised to enable effective sampling of the reef fish populations in the Agulhas Ecoregion.

This thesis is an investigation of the methodology of stereo-BRUVs with emphasis on:

- Bait types; whilst it is an accepted standard to use pilchard in BRUVs, research suggests inconsistency in species composition with non-carnivorous trophic groups under-represented. Alternate baits (squid & bivalves [oyster or mussels]) are being investigated to determine which bait is most effective and where or not these alternatives are suitable to monitor different trophic groups. Preliminary analyses suggest that bivalve baits are an ineffective bait type whilst squid is a successful bait type however more in-depth analysis is required to determine a significant difference in sardine and squid bait types.
- Light sources are required when conducting video work in the subphotic zone. It is suggested different colour lights can have different effects on fish communities and different efficacies as light sources. White light is said to alter fish behavior whilst red light has been used successfully as a non-invasive light source in terrestrial studies but its short wave lengths suggest it will attenuate in water, losing its range. Alternatively blue light has a longer wavelength, has no recorded effect on fish behavior and may prove to be a successful substitute.
- Observer bias is assumed to be low in video monitoring, as videos are archived and analysis can be conducted within the analysts preferred time and videos can be re-analyzed for quality control. This being said to ensure accuracy of the method the observer bias must be investigated. A double observer method will be used to investigate this.

To date progress has gone as planned with data collected and analyzed for bait type analysis, with the remaining data to be collected and analyzed by March 2014.

Key words: marine; conservation; fisheries management; ecology; stereo-video; monitoring; MPAs; ichthyofaunal composition; ichthyofaunal size structure

**Mmathabo Mogane (MSc student) - Treatment of anaerobically digested brewery effluent using high rate algal ponds: identification of microbial species and nutrient removal mechanisms**

Supervisors: Dr CLW Jones (c.jones@ru.ac.za); R Laubscher (r.laubscher@ru.ac.za)

Funders: Department of Agriculture, Forestry and Fisheries; Water Research Commission (K5/2227); Rhodes University Research Committee

The removal of nutrients from wastewater using high rate algal pond (HRAP) system has been demonstrated through research in many countries. In the case of the South African Breweries (SAB) Ltd, in Port Elizabeth, HRAP were used to treat a portion of AD effluent on an experimental scale. These HRAP systems were efficient in removing nutrients from effluent. However, mechanisms responsible for nutrients removal are not fully understood. An understanding of nutrients removal, microbial complexes involved and changes in environmental parameters will give an insight into biotic and abiotic interactions in HRAP. It will provide wastewater treatment plants the tools to better manage ammonia ($NH_4$-N) and phosphate ($PO_4$-P) using HRAP.

Brewery effluent was previously treated in municipal sewage systems which restricted reuse for other activities. With water crises in South Africa, challenges prevail in equal distribution of water to citizens, hence a need to explore alternative wastewater treatment methods to recycle and conserve water.

This study aims to create an understanding of the physicochemical changes in the HRAP at different times and flow rates throughout the year. It also aims to reveal mechanisms responsible for $NH_4$-N and $PO_4$-P from effluent. The specific objectives are to:

- establish the identity of microorganisms in HRAP and compare community changes at different times and flow rates using molecular taxonomy; and
- determine effects of different levels of light, temperature and pH on microbial's ability to remove nutrients from effluent.

The first experiment is designed to elucidate microbial community dynamics at different times and flow rates. It assesses microbial activity and establish their identity using a microscope and molecular techniques. Samples are being collected monthly from HRAPs. In mid-summer and winter, flow rates will be increased when a steady state is reached from a specific flow rate. $NH_4$-N, $PO_4$-P and chemical oxygen demand (COD) are being measured using a spectrophotometer and commercial test kits. Temperature and electrical conductivity (EC) are measured using a Hanna temperature and EC probe respectively. Filtered samples are incubated in an oven for 24 hours and subsequently weighed for algal biomass. Other samples are used for chlorophyll analysis by recording absorbance with a spectrophotometer. The second experiment is designed to determine mechanisms responsible for nutrients removal from effluent. With all possible combinations of three light and pH intensities, microorganisms will be incubated under three different temperature ranges for a week. Photosynthetically active radiation will be measured with a quantum meter, temperature recorded using a hygrothermograph and pH with a pH meter. Algal biomass, EC, rate of ammonia and phosphate removal and COD will be measured.

Keywords: freshwater; aquaculture; SAB Ltd; effluent, microorganisms identification

**Brendon Dredge (MSc student) - Fish invasion state of five lentic water bodies in the Western Cape, South Africa**

Supervisors: Dr OLF Weyl (O.Weyl@saiab.ac.za); Dr KL Cochrane (k.cochrane@ru.ac.za)

Funders: Centre for Invasion Biology; Cape Nature; South African Institute for Aquatic Biodiversity (SAIAB)

Freshwater fish are the most imperilled vertebrate group in the world, and are impacted by various anthropogenic activities, one of them being the introduction of non-native species. Non-native sport fish were introduced into the Western Cape Province in the late 1800s primarily for recreational purposes. Their status has not been assessed since the relative abundance and diversity of fish were last determined through surveys in the late 1970s. As a result, the current state of many introductions and subsequent invasions is unknown. The primary objective of this research project is therefore to develop a baseline on the relative abundance and fish species composition in four Western Cape dams: Theewaterskloof, Clanwilliam, Quaggaskloof, and Voelvlei and a natural lake, Groenvlei.

To do this, water bodies will be sampled using a seasonally and geographically stratified sampling design from April 2013 to November 2014. Sampling will be conducted in autumn (April/May) and spring (September/October). Because these are essentially biodiversity surveys, six different gear types will be used in order to sample as great a size range of fish over a wide range of habitats as possible. These gear types include backpack electro fishing, seine netting, long-lining, angling, gill and fyke netting. Fish captured during sampling will be measured, weighed, counted and identified to species level. In addition, data will be collected from various angling tournaments to identify trends in catch rates and sizes of fish caught in the respective dams.

To date, surveys have been completed for Groenvlei (April 2013) and for Theewaterskloof, Clanwilliam, Quaggaskloof, and Voelvlei in September 2013. Few native fish were sampled and it was only in Quaggaskloof where native whitefish *Barbus andrewi* dominated catches. Alien fishes were present in all water bodies surveyed. Common carp *Cyprinus carpio* (all water bodies), largemouth bass *Micropterus salmoides* (4/5 water bodies sampled) and African Sharptooth catfish *Clarias gariepinus* (4/5) were the most widespread, followed by smallmouth bass *Micropterus dolomieu* (3/4), Bluegill *Lepomis macrochirus* (3/5) and Mozambique tilapia *Oreochromis mossambicus* (2/5).

Keywords: freshwater; fisheries management; invasion; state: assessment

**Bruce Ellender (PhD student) - Ecological consequences of non-native fish invasion in Eastern Cape headwater streams**

Supervisors: Dr OLF Weyl (o.weyl@saiab.ac.za); Dr ER Swartz (ernst.swartz@gmail.com)

Funders: The DST-NRF Centre of Excellence for Invasion Biology; Water Research Commission (K5/1957//4); Rhodes University; National Research Foundation; SANPAD 10/06

The introduction and spread of non-native species resulting in the homogenization of the Earths biota has been dubbed one of the least reversible human-induced global changes. Range restricted South African endemic headwater stream fishes are increasingly being threatened by these human mediated impacts such as invasion by non-native fishes and habitat destruction. Two headwater species, the Eastern Cape redfin *Pseudobarbus afer* and the Border barb *Barbus trevelyani* are IUCN redlisted as 'endangered' primarily due to these factors. The aim of this study was to provide a literature review on non-native fish invasions in South Africa. Furthermore, using two case studies on the headwaters of the Keiskamma and Swartkops River systems, investigate the naturalisation–invasion continuum and provide a holistic view of the invasion process by: (1) Reviewing current knowledge on invasive impacts in South Africa; (2) Investigating invasibility of headwater stream environments; (3) Determining the establishment of non-native species, (4) Assessing the spatial and temporal impacts of invasion; (5) Understanding mechanisms responsible for impacts; (6) Investigating the threat of non-native invasion on the genetic diversity of two headwater fishes. South Africa has a long history of non-native fish introductions, spanning two and a half centuries. Currently in South Africa 55 species have been introduced or translocated. A review of their impacts indicated that they can be particularly severe and span multiple levels of biological organisation. Reviewed studies placed emphases on invasive impacts and the transport, introduction, establishment and spread stages of the invasion process were largely ignored. The Swartkops and Keiskamma Rivers were heavily invaded and numbers of introduced species surpassed that of natives. Headwater streams had varying invasibilty and a number of non-native species were successfully established. The remainder of the invasions were casual incursions into headwater streams from source populations in mainstream and impoundment environments which were invasion hotspots. Irrespective of establishment, four predatory invaders (*Micropterus salmoides*, *Micropterus dolomieu*, *Salmo trutta* and *Oncorhynchus mykiss*) impacted heavily on native fish communities. Impacts included changes in community structure, extirpation from invaded stream reaches resulting in contracted distribution and isolation and fragmentation of native fish populations. Two broad types of invasion were documented, downstream invasion by non-native *O. mykiss* and *S. trutta* and upstream by *M. salmoides* and *M. dolomieu*. The distribution of genetic diversity for *B. trevelyani* also indicated an imminent loss of diversity without conservation interventions. Both native species exhibited contracted distributions (>30% habitat loss). Upstream invasion by centrarchids isolated and fragmented *P. afer* populations into headwater refugia while top down invasion by salmonids excluded *B. trevelyani* from invaded, more pristine reaches by forcing the species into degraded unsuitable lower stream reaches. While *P. afer* exhibited little within or between drainage genetic structuring, *B. trevelyani* was >4% divergent between drainages and up to 2% between streams within the Keiskamma River system.

Key words: freshwater; conservation; ecology; invasive impact; *M. salmoides*; *O. mykiss*

**Evans Simasiku (MSc student) - Assessment of the Lake Liambezi fishery, Caprivi Region, Namibia**

Supervisors: Dr OLF Weyl (o.weyl@saiab.ac.za); Mr D Tweddle (Namibian Nature Foundation / SAIAB)

Funders: Namibia Ministry of Fisheries and Marine Resources (MFMR), Deutscher Akademischer Austausch Dienst (DAAD), South African Institute for Aquatic Biodiversity (SAIAB), Namibia Nature Foundation (NNF)

Lake Liambezi in the Caprivi Region in Namibia is shallow (<6m deep) and characterised by cyclic episodes of filling and drying. When full the lake supports a highly productive fishery and when dry the lake is completely dry and used for agriculture and grazing. In 2009 the lake filled and the aim of the current research project was to contribute to understanding the fishery dynamics during a flooding phase by investigating: (1) the littoral and offshore species composition; (2) comparing the efficiency of monofilament and multifilament gillnets and (3) estimating the total yield from the lake.

Seine net surveys demonstrated that Lake Liambezi littoral zones were dominated by fishes of the family Characidae (59.7%) while Cichlids were the most diverse family. Juvenile *Tilapia rendalli* and *Oreochromis macrochir* were among the five most important species in the littoral zone, indicating that these commercially important species use the littoral zone as a nursery ground. As *T. rendalli* and *O. macrochir* are commercially important species, seine nets should not be allowed in the fishery.

Experimental fishing trials showed that monofilament gillnets catch per unit effort (CPUE) was four times higher than that of multifilament gillnets for *Oreochromis andersonii, O. macrochir, T. rendalli*, *Serranochromis macrocephalus* and *Clarias* spp.

The Lake Liambezi Fishery was explored by means of creel surveys at landing sites. CPUE was 15kg/canoe/day. Using these CPUE data in conjunction with market survey data the annual average catch from the lake was estimated at 3193 tons which results in an estimated production of 106kg/ha/yr. This is within the expected range for African inland lakes.

Fisheries management recommendations arising from this work were to: (1) restrict gears used to gill nets as seine nets operate in littoral areas which are used by juveniles of the commercially important species; (2) restrict mesh size to 3 ½ inch as the selectivity of this gear approximates maturity for the commercially important cichlids and (3) limit access to ensure good catch rates for the fishers currently operating on the lake.

Key words: freshwater; fisheries management; recommendation; cichlid; CPUE; Caprivi

**Geraldine Taylor (PhD student) - Understanding the variation in growth rates of the fishes of the Zambezi, Chobe and Kwando rivers, Zambezi Region, Namibia**

Supervisors: Dr OLF Weyl (o.weyl@saiab.ac.za); Dr CJ Hay (clinton.hay@gmail.com); Dr JM Hill (jaclyn.m.hill@gmail.com)

Funders: South African Institute for Aquatic Biodiversity; Press Family Trust; Southern African Science Service Centre for Climate Change and Adaptive Land Management; Nedbank Namibia Go Green (SASSCAL)

Floodplain river systems are characterised by a seasonal flood cycle, during which the rivers overtop their banks, inundating the aquatic terrestrial transition zone, creating complex habitats and nutrient rich nursery areas for diverse fish communities (Flood Pulse Concept). As a result of this seasonal inundation, floodplain systems are known for their productive multispecies fish faunas which support subsistence and artisanal fisheries providing food, employment, income and livelihoods for riparian communities. Globally floodplain system integrity is being severely threatened as a result of water abstraction, resource utilisation and climate variability. Research on the drivers of productivity and fish growth on these ecosystems is therefore essential for understanding floodplains, their fisheries and their response to changes in the natural hydrological regime.

The Zambezi Region of Namibia is home to three large floodplain river systems: the Zambezi, Chobe and Kwando rivers. Prior research has identified growth rate differences of important fisheries species between the systems, and it is hypothesised that differing top down (predation related) and bottom up (productivity related) drivers influence these systems resulting in variable growth rates. The aim of this research is to contribute to understanding African floodplain fish ecology by investigating the cause of the variation in growth rates of fishes representing the three life history strategies opportunistic, periodic and equilibrium, in the three floodplain rivers. To achieve this aim: fish community structure, nutrient inputs and productivity, and food web dynamics will be quantified and compared between systems.

To date otoliths and scales have been collected from ten species from the Kwando River, and are being used to determine age. Hard structures are still to be collected from the Zambezi and Chobe rivers, used to determine age and growth and compared between systems. Fish community structure will be described and compared between systems using experimental gillnet catch data collected by the Ministry of Fisheries from 2007-2012, and those to be collected in 2013 and 2014. Nutrient inputs and productivity will be measured using $C^{13}$ enrichment experiments during peak and low flow periods in each river system in 2014. The food web dynamics will be described using stable isotope analysis and compared between systems. For this 403 samples of fish, plant, invertebrate, mollusc, and crustacean species, detritus and particulate organic matter have been collected from the Kwando River, and whole ecosystem samples are still to be collected from the Zambezi and Chobe rivers.

Key words: freshwater; ecology; fisheries; growth; food web analysis; nutrients; productivity

**Richard Peel (PhD Student) - Colonization and succession of fishes in Lake Liambezi, an ephemeral floodplain lake in northeastern Namibia**

Supervisors: Dr OLF Weyl (o.weyl@saiab.ac.za); Dr S Kaehler (s.kaehler@ru.ac.za); Dr CJ Hay (clinton.hay@gmail.com)

Funders: Southern African Science Service Centre for Climate Change and Adaptive Land Management; Nedbank Namibia Go Green; South African Institute for Aquatic Biodiversity/National Research Foundation

Lake Liambezi is a large (300 $km^2$), ephemeral floodplain lake in northeastern Namibia. It is fed on an irregular basis by floodwaters from the Zambezi and Kwando rivers, and undergoes cyclical phases of flooding and drying in relation to climatic wet and dry cycles. The lake dried up in 1985 and remained so until the early 2000s. It eventually filled in 2009 after exceptionally high floods in the Zambezi and Kwando rivers, and filled again in 2010 and 2011. The floodwaters brought with them a diverse fish fauna that quickly colonized the newly flooded environment, and has undergone significant changes as the lake has matured. The aim of this research is to describe and understand the colonization process and species successions by assessing the recruiting fish fauna from the Zambezi and Kwando, describing trends in species composition since inundation in 2007, assessing the life-histories of species representative of different life-history strategies, and analysing the food web using stable carbon and nitrogen isotopes.

The colonising fish assemblage was dominated by *Barbus paludinosus*, *Barbus poechii*, and the catfishes *Clarias gariepinus* and *Schilbe intermedius*. After filling completely in 2009, the abundance of *C. gariepinus* declined markedly, and the barbs were rapidly replaced by two small characins *Brycinus lateralis* and *Rhabdalestes maunensis*. The tilapiine cichlids on which the fishery is based, and several other larger, slower growing species including *Serranochromis macrocephalus* and *Hepsetus cuvieri* have increased more gradually in abundance since inundation. Preliminary food web analysis showed that the food chain is short and influenced primarily by bottom-up (productivity related) factors. Consumer $\delta^{13}C$ values indicate that algal primary production (associated with particulate organic matter) contributes most to consumer biomass, while $C_3$ macrophytes and detritus contribute relatively little. Further analysis will investigate the potential role of competition and predation species successions.

The composition and abundance of recruiting fish fauna will be assessed during the 2014 and 2015 floods. Recruitment will be quantified by up-calculating relative abundance estimates over the brief flooding period to give species specific abundance and biomass estimates. The life-history traits, including age, growth, maturity, fecundity, spawning season and mortality, of twelve species representative of opportunistic, periodic and equilibrium life history strategies, will be assessed in relation to colonisation and establishment rates.

Keywords: freshwater; ecology; colonization; succession; life-history; food web analysis

**Christine Coppinger (MSc student) - Assessing the genetic diversity of catface rockcod *Epinephelus andersoni* in the subtropical Western Indian Ocean and modelling the effects of climate change on their distribution**

Supervisors: Dr NC James (n.james@saiab.ac.za); Dr M Mwale (m.mwale@saiab.ac.za)

Funders: Western Indian Ocean Marine Science Association (WIOMSA-MASMACC201007); National Research Foundation; DAAD

*Epinephelus andersoni* is restricted to the south-east coast of Africa ranging from Quissico in Mozambique (subtropical) to Knysna in South Africa (warm-temperate). Its complex life history, long-lived nature and high residency make *E. andersoni* potentially vulnerable to overexploitation. *E. andersoni* is an important fishery species and has shown signs of depletion. Due to inadequate information necessary for management and conservation, further research is vital, particularly in the face of potentially significant climatic changes, which could put further pressure on *E. andersoni*. The aims and objectives of this study were to describe the genetic structure and diversity of *E. andersoni* and to determine possible range shifts of *E. andersoni* with future changes in sea surface temperature. Genetic samples were collected throughout the distribution of *E. andersoni*. Standard DNA extraction protocols were used and PCR was done using universal primers. Nuclear (S7 intron 1) and mitochondrial (cytochrome *b*) data were analysed to determine the genetic diversity of the *E. andersoni* population. A combination of nuclear and mitochondrial markers was used to ensure that the results were robust. S7 haplotype diversity was high (0.801) and an AMOVA on the S7 data showed significantly high among group variation ($\Phi_{CT} = 0.204$, $p < 0.05$) between five groups: 1. Quissico to Inhaca; 2. Cape Vidal to Port Edward; 3 Port St Johns to Coffee Bay; 4. Mbashe; and 5. Port Alfred. This geographic structuring could be attributed to low gene flow across barriers such as the Port Alfred upwelling cell, the Mozambique Channel eddies and smaller more localised upwelling cells such as the Port St Johns cell. The cytochrome *b* results contrastingly indicate low haplotype diversity (0.309) and no differentiation ($\Phi_{CT} = 0.265$, $p = 0.074$) between groups and support the hypothesis of a historical population bottleneck. This is probably due to the unusually slower mutation rate of the cytochrome *b* region than the S7 region, which means that the S7 results show a more recent picture of the state of the population. Niche modelling techniques were used to determine range shifts of *E. andersoni* with future temperature changes using species distribution and sea surface temperature data. The ensemble model indicated contraction of the *E. andersoni* distribution, probably as a result of seasonal cooling in the region of the Port Alfred upwelling cell. Due to the low gene flow across these barriers this intensification could decrease the resilience of *E. andersoni* in dealing with environmental changes, as its range becomes more limited by ocean warming and regional cooling. The genetic data and modelling results combined provide useful information on which to base future fisheries management.

Key words: marine; fisheries management; climate change; population structure; population genetics; niche modelling

**Frikkie van der Vyver (MSc student) - Investigating area-disaggregated models for management of the chokka squid *Loligo reynaudii* resource**

Supervisors: Prof. WHH Sauer (w.sauer@ru.ac.za); Ms J Glazer (JeanG@nda.agric.za)

Funder: South African Squid Management Industrial Association**Error! Bookmark not defined.**

Genetic and morphometric results from previous *L. reynaudii* population studies revealed a potentially complicated stock structure, with possible boundaries occurring somewhere between Tsitsikamma and the Western Agulhas Bank (Shaw et al. 2010, Stonier unpublished). Clearer evidence of isolated stocks may require a change in the current resource assessment given that it is an area-aggregated model. The study thus aims to provide new data on separated stocks to investigate management of the resource on an area-disaggregated basis. This may potentially allow for spatial management of the resource, perhaps separating the fisheries into distinct geographical zones.

Specific objectives are to:

- Test for separated squid stocks using morphometric techniques.
- Provide a first assessment of the resource on an area-disaggregated basis.

1073 morphological samples were collected from 68 localities on the west and southern Cape coast, and from southern Angola, between April 2011 and July 2012. Samples were collected onboard research trawl vessels and commercial jig vessels. In addition, 73 Angolan samples were collected at a fish market in Namibe. 43 hard and soft part morphological characters were measured using the bodies, arms, sucker rings, gladius, beaks, and statoliths. The morphological measurements were analysed using multivariate techniques (Linear and quadratic discriminant function analysis, principal component analysis, and some other relevant multivariate visualization and analytic tools) to assess the existence of distinction among groups of samples collected from the different localities. Soft part analysis indicated clear differences between samples from Angola and the south and west coast of South Africa.

The latest jig and trawl CPUE catch trends (Glazer & Butterworth 2012), as well as previous genetic and new morphological information will be used in an area-disaggregated model to assess possible consequences of separate stocks for the management of the resource.

Keywords: marine; fisheries management; stock identification

**Dr Willem Vermeulen (PhD student) - Erythropoiesis in rainbow trout *Oncorrhynchus mykiss* vertebral bone**

Supervisor: Prof. H Kaiser (h.kaiser@ru.ac.za)

Funder: Welbedagt Research

For more than 150 years the anterior part of the kidney was thought to be the primary organ of haematopoiesis in bony fish. Electron microscopy could only show eosinophylic normoblast cells in the kidney, which represents the final step incorporating haemoglobin into the cytoplasm, just before the cell is released into the circulation as a mature erythrocyte. These eosinophylic normoblasts lose their ability to multiply when haemoglobin synthesis commences. They thus represent the last step in the erythropoiesis chain. The kidney lacks the haematopoietic precursor cells, i.e., erythroblasts and basophilic normoblasts and it can thus be hypothesised that these cell lines are formed in another organ system. In mammals the bone marrow is responsible for this function.

I studied the osteology, histology, anatomy and cytology of the inner body of the vertebral bone. Preliminary osteology in rainbow trout showed an anatomical difference in the last three posterior vertebrae, anterior to the tail vertebrae. In this area we observe a micro-foramen that penetrates the dorsal vertebral bone and connects to the central area of the vertebral bone. It also appears that it is only in this area where the kidney protrudes into the direction of the vertebral foramen.

Preliminary histological sections through vertebral bones representing different areas throughout the whole vertebral column show lacunae in the central areas of these three vertebrae, filled with cells that are histologically very similar to bone marrow tissue.

Cytological aspirates from these areas show cells resembling erythropoietic precursor cell lines.

Specific immune-histological stains will be used to verify the erythroid bone marrow tissue and new histo-anatomical sections through vertebral bones.

Key words: freshwater; aquaculture; bony fish; red blood cell formation

**Siyabonga Maliza (MSc student) - Development of probiotic diets for the South African abalone *Haliotis midae* industry**

Supervisors: Prof. H Kaiser (h.kaiser@ru.ac.za); Dr CLW Jones (c.jones@ru.ac.za); Prof. PJ Britz (p.britz@ru.ac.za)

Funders: Department of Agriculture Forestry and Fisheries; National Research Foundation; THRIP; Marifeed (Pty) Ltd

Physiological stress in farmed abalone can lead to immunosuppression and increases the susceptibility to bacterial, viral and parasitic disease, often followed by mortality. Thus, handling and poor water quality can reduce farm production efficiency. Probiotics in aquaculture have been effective in a wide range of species in enhancing immunity, survival, improving feed utilisation and growth. Three putative probionts identified as a result of *in vitro screening* were beneficial to laboratory-reared abalone.

The aim of this study was to produce an abalone feed that contains a suite of probionts that promote abalone growth and health under the stress of farming conditions. The objectives were to a) compare growth, survival and physiological responses of abalone fed Abfeed ®S 34 and probiotics (i.e., the probiotic diet) to abalone fed Abfeed ®S 34 as a control treatment in a factorial design with handling stress as the second independent variable.

Growth experiments were conducted at HIK Abalone Farm (Pty Ltd) and Roman Bay Sea Farm (Pty) Ltd after which haemocyte and phagocytosis counts were done. To determine the effect of probiotic diet on abalone growth and health under presumed stressful conditions, abalone at HIK Abalone Farm were fed either the test or the control diet and subjected to normal farm handling or to additional handling stress.

At HIK there was no significant interaction between diet and handling on average length and weight gain month$^{-1}$ after 4 and 8 months ($p>0.05$). Average length (stressed = 73.9 ± 0.52, unstressed = 75.8 ± 0.57 mm) and weight gain (mean: stressed = 68.5 ± 1.20, unstressed =74.3 ± 1.86) increased significantly in unstressed animals after 8 months ($p<0.02$). After 8 months phagocytosis count was significantly different between dietary treatments with values of 74 and 53.5 counts per sample for the probionts and control treatment, respectively ($p<0.02$). There was no effect of stressor application ($p = 0.14$) and no interaction between dietary treatment and stressor application for this variable ($p = 0.61$). There was no difference in feed conversion ratio between treatments with values ranging.

At Roman Bay Sea farm, average length (68.183±1.460) and weight (53.560±4.272) of animal fed probiotic diet significantly improved over time ($p<0.00001$), compared to those fed the control with length (67.856±1.516) and weight (52.450±3.616) after 8 months. There was no significant difference in haemocyte counts between animals fed either probiotic or control diet after 4 and 8 months ($p>0.05$).

The non-specific immune response in abalone fed the probiotic diet after four months, given as phagocytosis count, differed between dietary treatments, while after eight months there was no difference at HIK Abalone Farm. There was no difference in average haemocyte counts between animals fed either probiotic or control diet after 4 and 8 months on both farms. Abfeed ® S34 enriched with a mixture of probionts showed a significant improvement in growth and survival of farmed abalone. Probiotics showed no significant improvement on health parameters examined in this study after eight months.

Key words: marine; aquaculture; stress; probiotic; immunity; health

**John Filmalter (PhD student) - Investigating the role of fish aggregating devise (FADs) in the ecology of juvenile silky sharks *Carcharhinus falciformis* in the western Indian Ocean**

Supervisors: Dr P Cowley (p.cowley@saiab.ac.za); Dr L Dagorn (laurent.dagorn@ird.fr)

Funders: EU FP7 project MADE (Mitigating adverse ecological impacts in open ocean fisheries); International Seafood Sustainability Foundation

The silky shark *Carcharhinus falciformis* forms the primary elasmobranch bycatch in tuna purse seine fisheries using fish aggregating devices (FADs) in all of the world's tropical oceans. Its life-history traits of slow growth, late maturation and low fecundity make it vulnerable to over exploitation, as is apparent from historical bycatch trends. Very little is known about the associative behaviour of this species with floating objects, information which is essential in formulating effective mitigation and management measures. This study aims to address this knowledge gap through the use of various electronic tagging techniques in conjunction with dietary analysis.

Fine scale behavioural data from silky sharks associated with drifting FADs were collected through the use of acoustic telemetry techniques. Acoustic tags (V13 and V13P, Vemco, Canada) were implanted into 39 silky sharks (69-116 cm TL) at eight FADs. FADs were equipped with satellite linked acoustic receivers (VR4-GLOBAL, Vemco, Canada) and abandoned to drift freely. Presence/absence and swimming depth data were telemetered via the Iridium satellite system over periods ranging from several days to several months. A total of 329.5 days of behavioural data were collected from 21 tagged individuals. Preliminary analyses suggest that individuals remain associated with the same FAD for extended periods (min = 2.84 d, max = 30.60 d, mean = 15.69 d). Strong diel patterns were observed in both association and swimming depth. Typically individuals moved away from FADs after sunset and return later during the night, then remain closely associated until the following evening. Vertical behaviour also changed around sunset with sharks remaining at fairly constant depths, within the upper 25 m, during the day and switching to rapid vertical movements during the night, with dives in excess of 250 m recoded. Broader scale movement behaviour was investigated using pop-up archival satellite tags (PATs and MiniPATs, Wildlife Computers, USA). Tags were deployed on 53 silky sharks (86-285 cm TL) for a total of 1750 d. The tags released after a predetermined number of days and proceeded to transmit archived data via the ARGOS satellite system. These data included water temperature, depth and light readings, used to calculate geolocation estimates and reconstruct the sharks' trajectories. Preliminary analyses indicate that silky sharks are capable of undertaking extensive horizontal movements, with an average track length of 3240 km during an average tag deployment of 44.02 d. In addition to tagging, dietary data were collected from 246 silky sharks caught at FADs by tuna purse seine vessels. This data will be analysed in conjunction with the behavioural data described above to provide an understanding of the role that floating objects play in the ecology of juvenile silky shark in the Indian Ocean.

Key words: marine; ecology; tuna fisheries; tagging; behaviour; bycatch

**Murray Duncan (MSc student) - The genetic stock structure of *Chrysoblephus puniceus*, a commercially important Sparid in the South Western Indian Ocean**

Supervisors: Dr M Mwale (m.mwale@saiab.ac.za); Dr S Fennessy (seanf@ori.org.za); Dr N James (n.james@saiab.ac.za)

Funders: Western Indian Ocean Marine Science Association (MASMACC201007); South West Indian Ocean Fisheries Project (SWIOFP); Deutscher Akademischer Austausch Dienst (DAAD)

The slinger, *Chrysoblephus puniceus*, a seabream of the family Sparidae, is an important commercial linefish species in South Africa and Mozambique. Previous stock assessments based on catch data have indicated that *C. puniceus* stocks are over exploited in both countries. These assessments are being updated; however, the degree to which this species is shared between both countries needs to be determined as their management strategies are not aligned. The aim of the project was to assess the levels of gene flow and genetic connectivity throughout *C. puniceus*' distribution and use the findings to compliment management.

A total of 284 genetic tissue samples were obtained at sites throughout the distribution of *C. puniceus*. The mitochondrial control region and ten microsatellite loci were used to estimate gene flow and genetic connectivity between sampling sites.

The majority of microsatellite and mtDNA pairwise population comparisons were not significant ($P > 0.05$) but Xai Xai and Inhaca populations did show some significant population comparisons for mtDNA ($P < 0.05$). AMOVA did not explain any significant variation at the between groups hierarchical level for any pre-defined groupings except for a mtDNA grouping which separated out Xai Xai and Inhaca from other sampling sites. SAMOVA was unable to identify biologically meaningful groups with greater variability than the overall sample. There was no relationship between geographic distance and genetic differentiation using a mantel test ($P > 0.05$) and no significant positive spatial autocorrelation at 100 km distance classes. A single population of *C. puniceus* was identified by the structure analysis as the most likely situation using *–ln likelihoods*. The principle component analysis did not find any clusters of samples with geographic patterns. The migrate-n analysis provided evidence of current driven larval transport, with net migration rates influenced by current dynamics.

The results of the microsatellite analysis indicate that there is no genetic structuring throughout *C. puniceus*' core distribution suggesting a single well mixed stock. The mtDNA analysis revealed some historic genetic structuring around Xai Xai and Inhaca probably due to the Delagoa Bight upwelling cell. The trans-boundary nature of *C. puniceus* raises some important issues with regards to the management of a shared resource and highlights the need for co-management to sustainably harvest this resource.

Key words: marine; fisheries management; linefish; genetic**Error! Bookmark not defined.** connectivity**Error! Bookmark not defined.**; stock structure

**Nhlanhla Ginindza (MSc student) - Effect of lipid inclusion levels in aquafeed on production performance, quality change during storage and nutrient excretion in dusky kob *Argyrosomus japonicus***

Supervisors: Prof. P Britz (p.britz@ru.ac.za); Dr T Probyn (TrevorP@daff.gov.za)

Funders: Department of Agriculture, Forestry and Fisheries; Parliament of the Republic of South Africa

Dusky kob *Argyrosomus japonicus* is an important aquaculture species in that has drawn attention from local investors and researchers to investigate its culture on a commercial scale. This study sought to test the effect of lipid levels in aquafeeds fed to dusky kob juveniles on: (i) growth performance, feeding efficiency, tissue composition and economic implications, (ii) the chemical changes and shelf-life of refrigerated fillets, and (iii) metabolic rates and nitrogen excretion. Dusky kob juveniles (mean 35.12 g) were fed 4 feeds in triplicates with varying lipid levels containing 8%, 12%, 16% and 20% in a semi-recirculation system for 15 weeks. The effects of feeds containing 22 mg.kJ-1, 24 mg.kJ-1, 26 mg.kJ-1 and 28 mg.kJ-1 protein:energy (P:E) ratios on production performance were also determined. At the end of the growth trial, 9 fish fillets per treatment were stored at 6.6±1.5°C for 18 days and sampled at 4 day interval to determine changes in quality indicators. The 4 feeds were fed to four groups of juvenile dusky kob in a respirometer to measure excretion and metabolic rates.

Due to a factory artefact, protein content in feeds was not according to planned formulations, hence, may have influenced results. The specific growth rate (SGR) and feed conversion ratio (FCR) were best (ANOVA, $P<0.05$) in the 8% treatment. SGR decreased linearly ($r=-0.91$; $P=0.09$) while FCR increased linearly ($r=0.917$, $P=0.083$) with the increase in dietary lipid level. SGR and FCR were best (ANOVA, $P<0.05$) in the 28 mg.kJ-1 and worse at lower P:E ratios. Tissue concentration of both monounsaturated and polyunsaturated fatty acids were different (ANOVA, $P<0.05$) and showed relatively weak negative ($r=-0.85$, $P=0.15$) and positive ($r=0.75$, $P=0.25$) correlations, respectively. The incidence cost increased (ANOVA, $P<0.05$) with increasing lipid levels in diet. TVBN values were different (ANOVA, $P<0.05$) throughout storage and higher in the 16% and 20% treatments. Free fatty acids increased (ANOVA, $P<0.05$) in all treatments and generally correlated positively with dietary lipid levels. Excreted nitrogenous metabolites were lowest at the 20% treatment and correlated positively with P:E levels. These experiments have shown that an increase in lipid levels in diet increases the concentration of tissue polyunsaturated fatty acids and lowers nutrient loss into water. However, there are higher costs that arise from slower growth rates and shorter storage life. Further studies are thus required expand on the information obtained from this study.

Key words: marine; aquaculture; dusky kob; quality loss; nitrogen excretion

**Devin Isemonger (MSc student) - Modelling the spatial and genetic response of the endemic sparid: *Polysteganus praeorbitalis* (Pisces: Sparidae) to climate change in the Agulhas Current system**

Supervisors: Dr M Mwale (m.mwale@saiab.ac.za); Dr N James (n.james@saiab.ac.za)

Funders: Western Indian Ocean Marine Science Association (WIOMSA) (MASMACC201007); South African Institute of Aquatic Biodiversity (SAIAB)

The Scotsman, *Polysteganus praeorbitalis*, is a large, slow growing Sparid endemic to the Agulhas Current system in the Western Indian Ocean (WIO). Relatively little research has been conducted on this species despite its importance to line fisheries in South Africa and drastic declines in CPUE recorded since the 1940's. Changing sea temperatures as a result of global climate change are expected to affect the distribution and abundance of many fish species based on their thermal tolerances, life histories and population structures. A combined approach utilising species distribution models (SDM's) and genetic was used to investigate the potential effects of climate change on the distribution and genetic diversity of species.

An ensemble SDM based on 205 occurrence records and 30 years of Reynolds Optimum Interpolated sea surface temperature data was constructed .This SDM projected the current range of *P. praeorbitalis* to be only 1500km$^2$ and underestimated the northern range edge of this species by approximately 5° latitude when compared to literature. A range contraction of 30% occurring at both the northern and southern range edge of *P. praeorbitalis'* current range and range fragmentation occurring, towards its northern range edge by 2030, was predicted. These changes appear to be the results of cooling around the Port Elizabeth/Port Alfred upwelling cell and warming predicted to occur north of the Natal Bight.

Genetic analyses of the nuclear S7 intron 1 and mitochondrial DNA control region genes were carried out using 118 tissue samples of *P. praeorbitalis* collected at four main localities: The Eastern Cape, Transkei, southern KwaZulu-Natal and northern KwaZulu-Natal. The majority of this species genetic diversity appears to reside towards the centre of its range in southern KwaZulu-Natal and northern Transkei where it is most abundant. Pairwise comparisons revealed evidence of low levels of population differentiation in the nDNA dataset occurring between the Eastern Cape and Transkei ($F_{st}$ = 0.039; $p$ <0.05), and the northern KwaZulu-Natal ($F_{st}$ = 0.045; $p$ < 0.05). This might be the result of the effects of the Port Elizabeth/Port Alfred upwelling cell on dispersal and gene flow or the possibility of more than one spawning ground for this species promoting sub-structuring.

The removal of the peripheral localities predicted to be affected by climate change on the edges of this species distribution resulted in only a 5.3% decrease in haplotype diversity in and mtDNA dataset. These results indicate that *P. praeorbitalis* is vulnerable to range loss as a result of climate change, but that genetic diversity is unlikely to be greatly affected due to high levels of gene flow and a concentration of genetic diversity towards the centre of its distribution.

Key words: marine; Western Indian Ocean; climate change; genetics; species distribution modelling

**Fabien Forget (PhD student) - The diversity of pelagic fish assemblages around Fish Aggregating Devices with focus on the ecology of two major associated species and bycatch of purse seine fisheries: *Elagatis bipinnulata* and *Canthidermis maculatus***

Supervisors: Dr P Cowley (p.cowley@saiab.ac.za); Dr L Dagorn (laurent.dagorn@ird.fr)

Funders: EU FP7 project MADE (Mitigating adverse ecological impacts in open ocean fisheries); International Seafood Sustainability Foundation

The diversity of pelagic marine fishes remains relatively poorly studied on a global scale, with most data originating from fisheries. Fish Aggregating Devices (FADs), used widely in the pelagic environment to enhance fisheries, provide a means to survey pelagic fish diversity and address questions on the behavioural ecology of FAD-associated species.

In this study Underwater Visual Census (UVC) was used as a fishery independent method to investigate the spatio-temporal patterns of pelagic fish assemblages at anchored FADs in the western Indian Ocean (Maldives, Seychelles and Mauritius), while acoustic telemetry was used to study the behavioral ecology of two major aggregating species, the oceanic trigger fish (*Canthidermis maculatus*) and the rainbow runner (*Elagatis bipinnulata*). The feeding and reproductive biology of the *C. maculatus* and *E. bipinnulata* were also investigated from samples captured in the fishery.

Results from the UVC revealed differences in species richness between the three countries with Maldives having a higher richness (22 species), followed by Mauritius (21 species) and the Seychelles (15 species). A Principle Coordinates Analysis (PCoA) based on Bray-Curtis distances revealed significant differences in assemblages between the three countries, while there were no differences in assemblages between seasons within each country. Fifty-seven oceanic triggerfish (290-365mm TL) and 27 rainbow runners (170-725mm FL) were acoustically tagged at drifting FADs and individuals were passively monitored between 3 and 85 days. Both species remained associated with the FADs for prolonged periods and displayed limited horizontal movements away from the FADs. Distinct diel changes in vertical movements were observed for both species. The biological data showed that most individuals associated with FADs are sexually mature, while dietary analyses revealed that both species feed extensively on pelagic crustaceans. The findings of this study suggest that FADs play a key role in the life cycle of these pelagic species and should be considered in the management of bycatch for FAD based fisheries.

Keywords: marine; ecology; UVC; pelagic diversity; bycatch; acoustic telemetry; FADs; Indian Ocean

**Thomas Keet (MSc student) - Optimisation of dusky kob (*Argyrosomus japonicus*) pond culture technologies**

Supervisors: Dr T Shipton (ihts@imaginet.co.za); Prof. H Kaiser (h.kaiser@ru.ac.za)

Funders: Oceanwise (Pty) Ltd; THRIP

The dusky kob (*Argyrosomus japonicus*) is a new culture species in South Africa. Currently, commercial culture is restricted to the eastern and western Capes. During 2007-8, an investigation into the feasibility of pond kob farming in Kwa-Zulu Natal (KZN) demonstrated that the warmer waters in the Province promotes faster growth than that recorded off the cooler Eastern and Western Capes, and in many respects the higher ambient water temperatures and improved growth rates attainable in KZN provide a significant competitive advantage over the other coastal provinces. While the study demonstrated the potential to develop a pond culture industry in the Province, there remain a number of unresolved bio-technical issues. These pertain to production-related variables including as growth rates, optimal stocking densities, water flow and effluent streams, and fish physiology issues such as the species' oxygen requirements at elevated temperatures and the effect that periodic exposure to high temperatures has on their growth and survival. Globally, there is very little experience in farming the *Sciaendae* in ponds at high temperatures (periodically >30°C). The purpose of this study is therefore to improve our understanding of the environmental conditions under which kob can be cultured in ponds in the province, and to establish their physiological response to high culture temperatures.

This study was initiated in October 2013.

Keywords: marine; mariculture; pond culture; fish physiology; dusky kob

**Steven Weerts (PhD student) - The influence of connectivity on the fishes of selected estuarine ecosystems in KwaZulu-Natal, South Africa**

Supervisors: Dr AK Whitfield (a.whitfield@saiab.co.za); Prof. DP Cyrus (cyrusd@unizulu.ac.za)

Linkages amongst freshwater, estuarine and marine systems are primary drivers of fish assemblages in estuaries. These linkages essentially define "connectivity" amongst these systems and are affected by, amongst other things, the nature of an estuaries mouth, hinterland gradient, bathymetry, tidal exchange and freshwater flows. These factors in turn are all affected by natural and anthropogenic influences. Biological responses are confounded by a multitude of species specific life histories over different time scales. While South African estuaries and their ichthyofauna are relatively well studied, surprisingly little research has been conducted into this aspect of estuarine ecology. This work addresses estuarine connectivity using datasets gathered over the last 20 years. It focusses on representative subtropical systems of KwaZulu-Natal.

Estuarine embayments: The influence of month on populations of closely related fishes with different life history strategies is investigated in adjacent estuarine embayments. Recruitment via a relatively constricted estuarine-marine connection does not limit abundance of estuarine dependent fishes. Differences in recruitment abundances are influenced more by habitat and physico-chemistry. Habitat differences play a key role in some species, especially at the early life stages, and this has impacts on abundances of older fishes. Physico-chemical differences are also important and these are affected by connectivity.

Estuarine lakes: Fish assemblages are investigated in a natural linked lake system. There are significant differences in fish assemblages in different lakes. This is reflected mostly in different abundances of species within a common set of taxa. Fish assemblages from modified coastal lakes are also investigated and a significant impact of flow barriers to the distribution of fishes is demonstrated. The influence of reduced connectivity from marine waters over geological time scales due to natural sea level fall as well as over much shorter contemporary time scales due to anthropogenic impacts (weirs and barrages) is to be explored.

Temporary open-closed estuaries: Mouth condition plays an important role in influencing populations of marine spawned fishes in estuaries and the structure of estuarine fish communities. In South Africa, where estuaries are numerically dominated by temporary open-closed systems, this is an important consideration. This aspect of estuarine connectivity is explored by investigating fish community structure in multiple systems in a single biogeographical zone that range from almost permanently open to almost permanently closed. Species most responsible for community differences are identifiable and their response to mouth closure is predictable.

Key words: estuarine; fisheries management; connectivity; life histories

**Lisolomzi Fikizolo (PhD student) - Towards effective monitoring, control and surveillance policy and implementation in Southern Africa**

Supervisors: Prof. KL Cochrane (k.cochrane@ru.ac.za); Prof. WHH Sauer (w.sauer@ru.ac.za)

Funder: Rhodes University Research Committee

All coastal states, in particular fishing nations, have in their government departments units that are charged with the responsibility for fisheries management. Fisheries management units have a primary purpose, that of ensuring sustainable exploitation and utilisation of all marine living resources. That is underpinned by a system of governance which has pre-determined objectives as developed from fisheries science, stakeholder consultation and the fisheries policy and regulation framework. For these objectives to be achieved, it is necessary to ensure and monitor compliance by all active participants through a well-structured system of Monitoring, Control and Surveillance (MCS). Therefore the objectives of this research are to investigate the current status of the Southern African Development Community (SADC) coastal states MCS policy frameworks. SADC coastal states that are central in this research are Namibia; South Africa; Mozambique and Tanzania. Results yielded out of this research will assist in the development of a regional MCS policy framework that could enable SADC coastal member states to adopt and implement a standardized MCS system. Such a situation would improve both compliance and enforcement in the region, thus helping to protect the marine living resources as well as the integrity of the regional MCS institutions, the Republic of Namibia's fisheries sector preliminary performance analysis has been completed, in which the following were examined:-

- fisheries and their contribution to Namibia's GDP
- the Namibian policy framework and its implementation
- institutional arrangements and MCS operations in Namibia
- cost of MCS operations in Namibia
- the strength of Namibian MCS efforts including the training and levels of skilled personnel within
- strengths and weaknesses of MCS in Namibia

Analysis revealed that although from 1991 there has been a concerted effort from the Namibian central government in the development and implementation of a marine living resources legislative framework coupled with active participation in fisheries management platforms in the SADC region, and globally, to improve domestic MCS efforts they have not been entirely successful. As examples, and according to the research findings of Sumaila and others, the Namibian sardine stocks remain depleted despite conservative management policy, while the orange roughy fishery blossomed and collapsed in just four short years. Namibia has only two landing sites, Walvis Bay and Lüderitz. As a result of the harsh coastline there are no traditional artisanal fisheries and the small scale fishery is mainly limited to shore angling and some ski-boats. There is also a strong recreational fishery. This arrangement allows for efficient and effective monitoring of the commercial fishing fleet that dominates the fisheries sector of the country.

Key words: marine; fisheries management; monitoring, control and surveillance (MCS); fisheries policy; regulatory framework; Southern Africa Development Community (SADC); governance, policy, implementation

**Rory Scheepers (MSc student) – Report not available**

**Siviwe Babane (MSc student) – Report not available**

**Zyangani Chirambo (MSc student) – Report not available**

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