

Department of Ichthyology and Fisheries Science



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**Department of Ichthyology
and Fisheries Science**

Research Report Series 2016

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Edited by: A-R Childs & K Hekendorn

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Wednesday 12 October 2016

08h20-08h30: Welcome by Prof. Warwick Sauer (Head of Department)

Honours seminars (Chair: Dr Cliff Jones)

08h30-08h50: Suzanne Redelinghuys (Honours student) - Stable isotope mixing models in determining rates of dietary turnover in *Oreochromis mossambicus*

Supervisor/s: Dr W Kadye (w.kadye@ru.ac.za); Prof. T Booth (t.booth@ru.ac.za)

Funder/s: National Research Foundation (NRF)

Stable isotopes of carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) are frequently used to determine the relative contributions of different food sources to the diets of consumer animals by comparing consumer tissue isotopic ratios to those of their potential prey. Stable isotope mixing models are used in determining the relative contributions of different food sources to consumer diets. A mixing model can estimate the proportional contributions of two or more sources either by using one element's isotope signature or by using the isotopic signature of two elements.

Field- and laboratory-based experiments were conducted to determine whether stable isotope mixing models accurately reflect a consumer's food sources. Information on trophic interrelationships in wild was based on *in situ* samples that were collected for stable isotope analysis. These included fish, aquatic invertebrates, zooplankton, phytoplankton, macrophytes, and algae. For the laboratory experiment, 150 *Oreochromis mossambicus* individuals were fed five formulated diets (diet 1, diet 2, diet 3, diet 4, and mixed diet) with different carbon and nitrogen values in isolation. Fish were sampled every 10 days for 60 days using a lethal dose of 2-phenoxy-ethanol, and a dorsal muscle sample and caudal fin clip taken. To assess the effect of diet, the condition factor for each fish was determined for all treatments. The results showed no significant difference in condition factor among diets (ANOVA, $F_{4,145} = 0.12$, $P = 0.96$).

Stable isotope analysis of the data sampled from the wild indicated that algae, periphyton, and potamogeton each contribute a significant proportion (>10%) towards the diet of *Oreochromis mossambicus*. These primary producers appeared to drive the food web in Makanzana Dam, supporting the primary consumers (zooplankton, invertebrates) and the secondary consumers of *Oreochromis mossambicus*, *Micropterus salmoides*, *Tilapia sparrmanii*, and *Glossogobius callidus*. *Oreochromis mossambicus*' trophic niche overlapped with that of *T. sparrmanii*, with the latter having a wider trophic niche compared to the former. *Micropterus salmoides* had a higher $\delta^{15}\text{N}$ value than the tilapia species owing. Zooplankton contributing a higher proportion toward its diet. *Glossogobius callidus* had the highest $\delta^{15}\text{N}$ signature of the four fish species.

The stable isotope results of the laboratory experiment are pending.

Key words: freshwater; ecology; mixing models; stable isotopes, isotope ratios, *Oreochromis mossambicus*, food web analysis

08h50-09h10: Delsy Sifundza (BSc Honours student) - Trophic and molecular analyses to investigate the feeding habits of invasive sharptooth catfish (*Clarias gariepinus*)

Supervisor/s: Dr W Kadye (w.kadye@ru.ac.za); Dr A Chakona (a.chakona@saiab.ac.za)

Funder/s: Rhodes University; South African Institute for Aquatic Biodiversity

Studies on trophic ecology are central in examining predator-prey interactions within different ecosystems. In aquatic ecosystems, several studies on trophic ecology have been conducted using either one or two methods to examine predator-prey interactions. Due to the increasing concern about the impact of non-native predators within aquatic ecosystem, there is a need to examine the trophic ecology of such species using different methods in complement. In order to achieve this, this study investigated the diet and trophic ecology of the invasive sharptooth catfish *Clarias gariepinus* by integrating three methods; stomach content, stable isotope and DNA analyses. This was done in order to provide a better understanding of both the impact caused by the non-native catfish predator and its predator-prey interactions.

Sharptooth catfish together with its potential prey were sampled in the Great Fish River, Eastern Cape, between March and April 2016. Potential prey for the catfish included fishes, macroinvertebrates, detritus and plant matter. Individuals of sharptooth catfish were categorised as juveniles (< 20 cm) and adults (> 20 cm), and their diets were assessed using stomach content analysis and DNA metabarcoding. DNA was extracted and sequenced for all potential prey items to create a DNA barcode library. Dorsal muscle tissue samples of sharptooth catfish and samples of its potential prey items were assessed using stable isotope analysis based on carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) isotope values. Stomach content analysis showed that the sharptooth catfish feed on a wide range of prey items from detritus to fish. Aquatic invertebrates were, nevertheless, the dominant prey in sharptooth catfish diets. Principal component analysis, based on frequency of occurrence, showed an ontogenetic difference in prey items between juveniles and adults. Juvenile catfish had a wide prey range that included primary producers, invertebrates, and fish. By comparison, adults had a narrow prey range and fed mostly on fish. Stable isotope analysis indicated that adult catfish were more enriched in $\delta^{15}\text{N}$ compared to juveniles. In contrast, juvenile catfish had a wide range of $\delta^{13}\text{C}$ compared to adult catfish. Furthermore, stable isotope analysis revealed that juvenile catfish had a wider trophic niche compared to adult catfish, a pattern that was consistent with stomach content analysis. DNA laboratory results are pending.

Key words: freshwater; ecology; stomach content; stable isotope; catfish diet; ontogenetic shift

09h10-09h30: Apelele Zonda (BSc Honours student) - Assessing the evolutionary distinctiveness of *Pseudocrenilabrus philander* (Fowler 1897) in southern Africa

Supervisor/s: Dr A Chakona (a.chakona@saiab.ac.za), Mr R Bills (r.bills@saiab.ac.za)

Funder/s: Rhodes University; Technology and Human Resources for Industry Programme (THRIP);
Ulwandle (Pty) Ltd, Wild Coast Abalone

Pseudocrenilabrus philander is one of the most widely distributed freshwater fishes in southern Africa. Its distribution range extends from southern KwaZulu Natal and spans major river systems including the Orange, Limpopo, Save, Zambezi and Congo, extending into Lake Malawi. Previous and ongoing genetic studies are revealing strong genetic subdivisions within almost all freshwater fishes that were previously thought to have broad distribution ranges in southern Africa, indicating that the current taxonomy underestimates the region's ichthyofaunal diversity. To test the hypothesis that *P. philander* may harbour hidden diversity, the present study used 254 bp of the mitochondrial DNA control region to examine the genetic distinctiveness of allopatric populations throughout the species' range.

A total of 33 new sequences were generated from tissue samples available in the National Fish collection at the South African Institute for Aquatic Biodiversity and 162 additional sequences were downloaded from GenBank. Preliminary phylogenetic analyses revealed two major clades within *P. philander*. The first clade comprised predominantly of samples from the Congo system, while the second clade contained samples from the Zambezi south-wards to southern KwaZulu Natal. There is considerable sub-structuring within each of these major clades, suggesting presence of previously unknown diversity within *P. philander*.

The aim of this study was to undertake a preliminary investigation into the degree of genetic structuring within *P. philander* to provide some insights into future research required to shed more light on the evolutionary history of *P. philander* sensu lato and to resolve the taxonomy of this complex. Future research should incorporate additional genetic markers and evaluate the degree of morphological divergence among the identified lineages within *P. philander*.

Key words: freshwater; taxonomy; phylogeography, southern Africa, *Pseudocrenilabrus*, genetic diversity

09h30-09h50: Siyamthanda Landzela (BSc Honours student) - The effect of a seaweed diet on abalone growth and gut physiology

Supervisor/s: Prof. P Britz (p.britz@ru.ac.za); Dr CLW Jones (c.jones@ru.ac.za); Dr A Nel (aldapietersel@gmail.com)

Funder/s: Department of Science and Technology (DST)

The South African abalone farming industry has become the largest producer outside Asia and the third largest in the world. A rapid decline in wild abalone fisheries has led to farming dominating the export market in South Africa. Nutrition and health are cited as some of the factors impeding development in this aquaculture sub-sector. The perlemoen abalone, *Haliotis midae* feeds on seaweed, but performs poorly on single-species macroalgae diets in terms of growth and meat yield on processing. On-farm in South Africa, abalone are fed a commercial formulated pellet feed. The presence of kelp in abalone diets is believed to offer beneficial health and nutrition effects acting on the gut microbiome. This study evaluated the effects of gut-bacterial community profile and dynamics of weaning abalone fed different diets using DNA species identification and quantified the effects of the changes on abalone growth performance.

The study used samples of cultured, weaning, juvenile abalone from HIK abalone farm in Hermanus, Western Cape. The trial ran for five months from March 2016-July 2016. Gut bacterial samples and growth measurements were taken at the start of the trial and again at the end of the trial. The four diet treatments included; fresh kelp only, kelp supplemented formulated feed (Abfeed®-S34K), formulated feed (Abfeed®-S34) with fresh *Ulva* and formulated feed only (Abfeed®-S34). Preliminary results show a significant difference between the treatment diets in terms of length growth ($F_{3, 390} = 78.553$, $p = 0.0000$) and mass growth ($F_{3, 390} = 49.979$, $p = 0.0000$). The kelp only control diet revealed to be significantly different from the other diets (Tukey HSD; $p < 0.000008$) confirming the poorer growth from a single-species seaweed diet. Although metagenomic analysis is yet to be completed, it is expected that the inclusion of kelp or seaweed in the diet of *Haliotis midae* has beneficial effects on growth and stability of the gut microbiota.

The results suggest that formulated feed can continue to be used as the major feed used in farming the perlemoen abalone, however seaweed inclusion in the diet can be a mitigating factor against nutritional and health problems.

Key words: marine; aquaculture; abalone; seaweed; formulated feed

09h50-10h10: Jessica Brown (BSc Honours student) - Salt removal from brewery effluent

Supervisor/s: Dr CLW Jones (c.jones@ru.ac.za), Mr R Taylor (g10t0620@campus.ru.ac.za)

Funder/s: Research Technology Fund (RTF)

The salinity of wastewater is the major limitation for its sustainable use for irrigation purposes. This is because the build-up of salts in soils is a major cause of decreased yields in agriculture worldwide. Soil salinity has been shown to decrease crop yield and health due to the increase in energy required for water and nutrient uptake from saline soils and by decreasing the availability of certain plant nutrients. Salinity has also shown to affect the physical structure and biological activity of the soil.

The brewery effluent has been shown to have electrical conductivity ($3379,75 \pm 57,53 \mu\text{S}/\text{cm}^2$). The brewery also produces large quantities of waste water daily that need to be effectively treated before release which can be very costly.

Two experiments were designed in order to test the best method for salt removal from brewery waste water. There were 10 replicated for each treatment, five of which had lucern planted in the buckets. The first used soil amendment, gypsum mix in the soil, spent grain mixed in the soil and gypsum added directly to the irrigation water, a control with no amendment was also used. The second three irrigation regimes were developed 0.5, one and two litres. For both experiments the leachate was collected from each and tested using a spectrophotometer. At the end of the experiment, all of the lucern was harvested sent to the lab for analysis. A soil sample was taken from each of the replicates and sent to the lab for analysis. Soil stability analysis was also done.

Lucern increased the sodium in the leachate for all treatments (p-value 0,04 and p-value 0,31), lucern appeared to increase sodium leaving from the soil slowing down sodium build up. Spent grain increase the infiltration rate significantly ($\pm 107,28$), however due to the brewing process it also increase the electrical conductivity and sodium levels of the leachate. spent grain amendments had the highest productivity in experiment one ($\pm 149,5/\text{m}^2$). The two litre irrigation had the highest productivity ($\pm 153,72\text{g}/\text{m}^2$) with the control having the lowest productivity in both experiments, however the gypsum added to the soil was not significantly different from the control.

Key words: freshwater; aquaculture

10h10-10h30: Kurt Andersen (Honours Student) - Evaluating the age and growth of hottentot (*Pachymetapon blochii*) before and after the recognised South African line fish state of emergency in 2000

Supervisor/s: Prof. WM Potts (w.potts@ru.ac.za); AC Winkler (alexwinkrsa@gmail.com)

Funder/s: National Research Foundation (NRF)

The hottentot (*Pachymetapon blochii*) is a small sized Sparid fish that is important in the small scale line fishery of the Western Cape. There is some information on their biology, but the study that examined their age and growth used poor techniques and it is likely that these fish have been under-aged. This study forms part of a joint project with the Department of Agriculture Forestry and Fisheries (DAFF) and aims to provide a first comprehensive description of the age and growth of this species before and 10 years after a reduction in commercial line fishing effort in 2000.

Technicians from DAFF have collected a comprehensive collection of otoliths (including Oxytetracycline injected individuals, which were used to validate growth ring periodicity) in two periods (Period A: 1999-2000, Period B: 2009-2010). A random, representative (by 50mm length class) and standardised subsample of 250 fish otoliths were elected from each period. These were sectioned transversely at 0.4mm thickness using a twin blade diamond edge saw. The sections were mounted on glass slides using DPX mountant to enhance visibility of the annuli. Readings were taken by three readers independently, under low magnification (10x) using transmitted light, and readings were accepted when the two experienced readers readings matched (<10 years old), or when they differed by two or less (>10 years old) in which case an average was taken when necessary.

A likelihood ratio test was used to compare the Von Bertalanfy growth curves of males (n=102) and females (n=89) from period B. This indicated that the growth curves were not significantly different (LRT, d.f = 3, p=0.07) between the two sexes. Based on these preliminary results, the sexes will be pooled when the growth rates between the two periods are compared.

Key words: marine; fisheries management; marine line fishery, age and growth, Von Bertalanfy Growth curve, *Pachymetapon blochii*

10h30-11h00: Tea break

Honours seminars continued (Chair: Dr Cliff Jones)

11h00-11h20: Samantha Mannheim (BSc Honours student) - Examining the diet of the Cape fur seal *Arctocephalus pusillus pusillus* in its northernmost distribution

Supervisor/s: Prof. WM Potts (w.potts@ru.ac.za); Dr A-R Childs (a.childs@ru.ac.za)

Funder/s: Rhodes University Research Council, Angolan Ministry of Fisheries

The Cape fur seals *Arctocephalus pusillus pusillus* population at Ilha dos Tigres off the coast of southern Angola is expanding rapidly. As an apex predator, the ecological impacts are expected to be significant, while anecdotal reports indicate a considerable increase in the conflict between Cape fur seals and artisanal fishers. Up to now there is no biological information on the Ilha dos Tigres seal population and this lack of information on the northernmost population, hinders our understanding of the ecological and fishery impacts of the expanding population. The aim of this study is therefore to describe the diet of the northernmost population of the species and to compare the diet with the catch of the local fisheries.

The diet was described using a seal scat analysis and hard part identification. A total of 104 seal scat samples were collected on Ilha dos Tigres in July 2014. The scats were rinsed through sieves (~10µm) and hard parts of prey were removed and stored in envelopes. Hard parts were identified using a range of keys and enumerated. Diet was quantified using indices including percentage frequency of occurrence (%FO), corrected percent numerical abundance (%N) and percent reconstituted mass (%M). A total of 89 scats contained identifiable hard-parts and a total of 414 prey items were identified. Diet was found to consist of 12 different organisms. The small pelagic species, *Trachurus trachurus* (59%N, 67.4%FO), *Engraulis japonicus* (16%N, 19.1%FO) and *Sardinops occellatus* (9%N, 15.7%FO) were the dominant prey items. Cephalopods including *Octopus spp.* (6%N, 10%FO) and *Loligo spp.* (1%N, 3.4%FO) also made up a considerable proportion of the diet. Important artisanal fishery species, such as *Dentex macrophthalmus* (2%N, 5.6%FO) and *Merluccius paradoxus* (2%N, 4.5%FO) were not important dietary components.

When diet composition was compared to that of the Cape fur seal in southern populations it was found that small pelagic species are dominant prey items throughout Cape fur seal populations. Slight variation in species can be attributed to distribution. Southern populations did not consume cephalopods as frequently as the northern population, which can be attributed to the high abundance of cephalopods off the coast of Angola. Southern populations of Cape fur seal feed on a greater variety of benthic fish species when compared to their northern counterparts. There was little direct overlap between the dominant fishery catch and the diet of Cape fur seals. While this indicates that a growing seal population is unlikely to negatively reduce important artisanal fish stocks, the incidences of conflict, such as fish being eaten while in fishing gear, are likely to increase. This will no doubt place pressure on the Angolan government to initiate a culling program for this population.

Key words: marine; fisheries management; Cape fur seal; northernmost population; scat analysis

Mariculture (Chair: Mogebele Morallana)

11h20-11h40: Nyiko Mabasa (MSc student) - The effect of carbohydrates on *Argyrosomus japonicus* fed complete pelleted diets

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

Funder/s: Department of Science and Technology (DST)

The dusky kob, *Argyrosomus japonicus* is becoming an increasingly important marine aquaculture species in South Africa. Attributes such as fast growth rates, tolerance to sibling density and easy adaptability to intensive aquaculture conditions are what make it a good candidate. Feed, the largest running cost in any aquaculture operation is a limiting factor in dusky kob production. In South Africa there is no locally produced feed for kob and farmers either have to import high quality feed (which is expensive), pay high prices for locally produced feed or use low quality feed ingredients which may compromise the growth and health of the fish. The focus is now on the development of locally produced, least cost and sustainable feed that will support the growth and health of dusky kob. Protein/energy requirements for kob have been established in earlier research, the work was then used to develop a product that compared positively with the international product. The formulated product was however found to be expensive and unsustainable since it relies on a fishmeal source of protein. Carbohydrates are a less expensive source of energy which had not been tested in dusky kob diets. The aim of this study was to determine the efficiency of dusky kob to utilize graded levels of carbohydrate in pelleted diets. Specific objectives were to determine i) the effect on growth performance and feed utilization, ii) the effect on post prandial blood glucose and iii) assess the effect on health and liver glycogen content of juvenile dusky kob fed diets containing different levels of pregelatinised maize starch (PGMS).

Juvenile dusky kob (5 g) obtained from Pure Ocean, East London (Pty) were acclimatized in the tanks subsequently used for the experiments. They were fed trout crumble starter feed for 3 weeks before the start of the feeding experiment. Five diets containing 5, 10, 20 and 30% PGMS were formulated with fishmeal as the main protein source. A 3 month growth trial was conducted in an aquaculture recirculating system where the fish were fed formulated diets twice daily, to satiation. Fish response was monitored to determine the effect of the diets on growth and feed utilization. At the end of the growth trial some of the fish were sacrificed and liver dissected for histology and glycogen content analysis. Blood samples were drawn from the remaining fish at 1, 3, 6, 12, 24 and 48 hours after feeding to determine the rate of glucose clearance from the blood. Blood samples were also taken before feeding to get the resting glucose concentration.

The results showed a significant difference in the specific growth rates and feed conversion ratios between the 4 diets. The diet with 20% starch had the best specific growth rate of 1.84 ± 0.05 % body weight/day, and the lowest feed conversion ratio of 1.28 ± 0.08 . There were noticeable differences in the liver histology structure between the different diets but no significant differences in glycogen content. The rate at which glucose was cleared from the blood differed significantly between diets. The diet with 30% starch had the slowest rate of glucose clearance from the blood as glucose did not return to the resting concentration after 48 hours. The results show that dusky kob can digest up to 20% carbohydrate without adverse effects. This finding will be important in helping reduce feeding costs in dusky kob farming.

Key words: marine; aquaculture; carbohydrate; pregelatinised maize starch

11h40-12h00: Adejoke Adesola (PhD student) - Apparent protein digestibility and amino acid availability from feed ingredients for dusky kob *Argyrosomus japonicus*

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

Funder/s: Department of Agriculture Forestry and Fisheries (DAFF); MASSIF

Generally, the amino acid availability of ingredients is rarely estimated, with most researchers opting for developing the apparent protein digestibility of feedstuffs because it is easier and less expensive than amino acid digestibility. High protein digestibility by itself does not give a good indication of the availability of essential amino acids. In order to provide adequate but not excessive levels of essential amino acids for fish, it is important to formulate diets based on available essential amino acids rather than protein digestibility. Knowledge on essential amino acid availability of feedstuffs is important in formulating fish diets since the minimum quantity of high-protein feedstuffs is included to meet the requirement for essential amino acids. This will aid selection of appropriate ingredients and formulation of a cost-effective diet. Three experiments were conducted to determine the apparent protein digestibility and amino acid availability of some feed ingredients for dusky kob. Faeces were collected by settlement method using acid-insoluble ash as the marker. Experiment one determined the apparent digestibility of protein and amino acid availability in two types of fishmeal, poultry meal and pork meal for dusky kob by using single protein source in a test diets. Apparent protein digestibility values were 84.5 %, 83.8 %, 85.8 % and 83.1 % for fishmeal-prime, fishmeal-standard, poultry meal and pork meal respectively. Apparent protein digestibility values for poultry were comparable to those of fishmeal, which indicate its potential for the replacement of fishmeal in the diets of dusky kob. The second experiment determined the apparent protein digestibility and availability of amino acids availability from canola meal, corn gluten meal, soybean meal, sunflower meal, blood meal, poultry meal and pork meal. These ingredients were included at 30 % into a practical reference diet (70 %). The apparent protein digestibility was significantly different ($p=0.000$) from each of the ingredient tested. Apparent protein digestibility values ranged from sunflower meal (92.4 %) to poultry meal (77.3 %). Apparent availability of most essential amino acid exceeded 90 % in all the plant protein sources evaluated with the exception of histidine, which was relatively low (72.4 % - 87.0 %). In a third experiment, the assumption that digestibility of a nutrient in one ingredient does not interact with the digestibility of the same nutrient in another ingredients was tested by comparing differences between the single protein source and fishmeal based digestibility values of feed ingredients. There were no significant differences ($p>0.05$) in most of the EAA between the predicted and measured values. The present study indicated that essential amino acid supply in a fishmeal-based diet could be predicted from digestibility of single protein source diet. Based on the favorable essential amino acid profile and high availability values, poultry meal, blood meal, soybean meal and canola meal has a great potential for replacing fishmeal in the diet for *A. japonicus*.

Keywords: marine; aquaculture; protein; digestibility; amino acids

12h00-12h20: Ngoako William Selapa (PhD Student) - Determination of the lethal ammonia concentration (LC₅₀) for dusky kob, (*Argyrosomus japonicus*), in static aerated water tanks

Supervisor/s: Prof. PJ Britz (p.britz@ru.ac.za); Dr CH Fouche (ChrisF@daff.gov.za)

Funder/s: Department of Agriculture, Forestry and Fisheries (DAFF)

The challenges facing the dusky kob industry include the regulation of water quality parameters in recirculation aquaculture systems (RAS). The water quality parameter requirements and tolerances for the production of dusky kob have not been studied. This study was aimed determining the lethal ammonia concentration (LC₅₀) for dusky kob, (*Argyrosomus japonicus*), in static aerated water tanks. Dusky kob fingerlings averaging (16.91± 4g) in weight were exposed to different concentrations of total ammonia nitrogen (0, 1, 2, 4, 6 and 8 mg/l) in eighteen fibreglass aquaria (70 litres) for 96 hours. Water quality parameters (pH, dissolved oxygen, temperature, salinity and TAN) were recorded at 0, 12, 24, 48, 72 and 96 hour time intervals. The results showed that dusky kob fingerlings exposed to 0 to 2 mg/l TAN demonstrated no signs of stressed behaviour. The difference in behaviour could be observed in higher TAN concentrations (4-8mg/l). However, none of the TAN concentrations resulted in lethal effect. The study recommends inclusion of further higher levels to determine the lethal ammonia concentration (LC₅₀) for dusky kob. The data will be utilized for a consecutive study aimed at determining the effect of sub-lethal unionized ammonia concentrations on growth rates, physiology, and survival of dusky kob.

Key words: marine; aquaculture; dusky kob; water quality; unionized ammonia

12h20-12h40: Ann Wu (PhD student) - Holistic approach in determining the effect of soya on the gonad development of farmed abalone *Haliotis midae*

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

Funder/s: Department of Science and Technology (DST); Department of Agriculture, Forestry and Fisheries (DAFF); Rhodes University Research Council

The growth of farmed abalone has been accelerated with the use of formulated feed, particularly feeds fortified with soya. However, the inclusion of soya as a dietary protein source in the formulated feed, Abfeed®S34 (Marifeed Pty (Ltd), Hermanus) for farmed abalone, *H. midae* has resulted in larger gonads during reproductive seasons compared to gonads of abalone fed kelp or diets that included only fishmeal as the main protein source. This change in the investment of energy into gonad growth rather than somatic growth is not beneficial in abalone farming when abalone are processed and canned after the viscera (digestive gland and gonad) have been discarded. It was suggested that phytoestrogens in soya may be responsible for an increase in gonad mass of *H. midae*. However, findings from using crystalline phytoestrogens in a “fishmeal only” diet did not support this hypothesis. Therefore, the question of what influences gonad development remains unanswered.

The aim of the study is to determine which compounds in soya accelerates gonad development and how this is accomplished. Stable isotope analysis will be used to determine the relative contribution of soya and fishmeal for gonad growth of both male and female abalone. To discern the nutritional aspect of soya, compound-specific stable isotope analysis will be used to trace the source of nutrients, i.e., amino acids and fatty acids. Hormone assays will be conducted on the haemolymph and gonad tissue of abalone to determine the endocrinological effects of soya on gonad development and lastly, histological assessments will be conducted on gonads of males and females to determine investment into gametogenesis. Abalone (50-60 g abalone⁻¹) will be fed one of three isonitrogenous and isoenergetic diets (fishmeal only, soya only, combination of fishmeal and soya) and an additional diet of kelp/gracilaria for one year. Every 45 days FCR, growth rate, length gain, whole body mass, meat mass, visceral mass, gonad bulk index, visceral and meat index and water loss will be determined.

The findings will assist the farmers in refining the abalone diets depending on season and abalone size. We also expect to better understand the physiology of abalone growth and maturation.

Key words: marine; aquaculture; abalone; soya; reproduction; stable isotope analysis; compound-specific stable isotope analysis; endocrinology

12h40-13h00: Stephen John Dünser (MSc student) - The influence of stocking density on the behaviour of the South African abalone, *Haliotis midae*

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

Funder/s: National Research Foundation THRIP, Marifeed (Pty) Ltd, HIK Abalone Farm (Pty) Ltd

The South African abalone industry, which started in the early 1990s, has become the most valuable aquaculture sector in South Africa. Currently, the abalone sub-sector produces approximately 1500 t abalone annually accounting for $\pm 50\%$ of the total production in the marine aquaculture sector. The growing market has resulted in land-based abalone farming becoming space limited. This has resulted in research aimed at optimising stocking density. Currently, little is known about the behaviour of farmed abalone and how stocking density affects abalone behaviour regarding time or activity budgets.

Haliotis midae are stocked according to the total available surface area (3.2 m²) in oyster-mesh baskets containing a 7-plate, vertical, plastic rack. Industry uses a stocking density of 18% of the total available surface area; however, studies have found that abalone weighing 45-65 g abalone-1 show decreased growth at stocking densities $>16\%$.

An experiment was designed to investigate the effect of stocking density on abalone behaviour. An observation system was built consisting of 12 polyvinyl chloride (PVC) tanks with four viewing sides. Modified baskets, reduced proportionately in dimensions, with one plastic rack-plate inside were stocked at 18% (LD) and 25% (HD) of total available surface area (0.46 m²) with abalone between 50 and 60 g abalone-1 in weight. Instantaneous and continuous behavioural sampling methods were used to record the behaviour of three marked abalone per basket. Each marked abalone being observed for 15 minutes. Observations were made during the day and at night. Data collected at night resulted in no significant differences on the proportion of time spent on any of the ten identified state behaviours (behaviours with a duration) at C.I. (95%) after twenty-four replicates of each stocking density. It was found that the largest proportion of time was spent stationary and inactive, 42.7%-time LD and 45.5%-time HD. Abalone were found to spend more time feeding on diatoms, 14.0%-time LD and 15.7%-time HD, as compared to feeding on AbFeed®, 2.3%-time LD and 4.7% HD.

No significant differences at C.I. (95%) were observed for event behaviours (behaviours without a measurable duration). Four initial interaction behaviours were identified along with twelve outcomes. Interactions made by abalone either resulted in aggressive or passive outcomes. Passive outcomes were more frequently observed.

Thus far it seems that abalone behaviour is not be affected by stocking density. Additional repetitions analysis of daytime data and analysis of proportional data and sequential behaviour data may provide further clues as to why the South African abalone, *H. midae* show decreased growth at higher stocking densities.

Key words: marine; aquaculture; abalone; time-budget; intraspecific competition

Thursday 13 October 2016

Marine Ecology (Chair: Katrina Heckendorn)

08h30-08h50: Rachel Mullins (MSc student) - Re-examining the population structure of yellowfin tuna (*Thunnus albacares*) off South Africa using a population genomics approach provides support for a revised management boundary between the Atlantic and Indian Oceans

Supervisor/s: Prof. WHH Sauer (w.sauer@ru.ac.za); Prof. PW Shaw (pws3@aber.ac.uk)

Funder/s: Western Indian Ocean Marine Science Association; Marine Stewardship Council; National Research Foundation (NRF); Rhodes University Research Council

Yellowfin tuna (*Thunnus albacares*) is a commercially and economically important fisheries species in southern Africa, comprising the second largest component of the South Africa's catch of tuna and tuna-like species. It is assessed and managed as two separate units in South Africa, based on an early genetic study of the species' global population structure, which found Atlantic and Indian Ocean populations to be genetically distinct, and the confluence of these two oceans off the Western Cape of South Africa. As a result, the catches of the species in the Western Cape are reported to and assessed by the Atlantic Ocean regional fisheries management organisation (RFMO), the International Commission for the Conservation of Atlantic Tunas (ICCAT), while those caught in the Eastern Cape and KwaZulu-Natal are reported to the Indian Ocean RFMO, the Indian Ocean Tuna Commission (IOTC). Evidence from a recent genetic study, however, suggests that yellowfin tuna in the Atlantic Ocean waters off South Africa may originate in the Indian Ocean. Yellowfin tuna exhibits shallow genetic structuring among isolated populations; this is largely due to its large effective population sizes and limited time since population expansion, which prevent the accumulation of significant genetic differentiation, as well as its life history traits (specifically its highly migratory nature and pelagic larval dispersal) which might allow for a small number of migrants per generation, homogenising the gene pool. Based on this shallow structure, the results of population genetic analyses of the species depend on the resolution of molecular markers to detect fine-scale genetic structuring. In this study, an array of molecular markers, including highly variable genome-wide nuclear single nucleotide polymorphisms (SNPs), in both neutral and adaptive genomic regions, were used to better define the population structure of yellowfin tuna off southern Africa. Using restriction-site associated DNA (RAD) sequencing, a next-generation sequencing (NGS) technology that allows for the screening of organisms' entire genomes, and which has not previously been applied in population genetics studies in the Benguela system, approximately 12,000 SNPs were identified in yellowfin tuna individuals from sampling sites in the Atlantic and Indian Oceans. Population genetics analyses and statistics were performed on SNP datasets to test the null hypothesis of a panmictic yellowfin tuna population off southern Africa. Results obtained provide strong evidence for the origin of Western Cape yellowfin tuna in the Indian Ocean. This suggests a need to re-define the assessment and management boundary between the Atlantic and Indian Ocean stocks of yellowfin tuna, and a revision of the reporting strategy of South Africa's yellowfin tuna fisheries, with all catches being reported to the IOTC.

Key words: marine; fisheries management; population genomics; next-generation DNA sequencing;

08h50-09h10: Emily Moxham (MSc student) - Spatial ecology of bonefish *Albula glossodonta* in the St. Joseph Atoll, Seychelles

Supervisor/s: Prof. PD Cowley (tagfish@gmail.com); Dr R von Brandis (rainervonbrandis@gmail.com)

Funder/s: Save Our Seas Foundation; Aba and Bertie Levenstein; South African Institute for Aquatic Biodiversity; Rhodes University

Bonefish (*Albula spp.*) support valuable recreational and artisanal fisheries worldwide. Reports of declining stocks at certain localities have been noted, thus jeopardizing a multimillion dollar industry. In particular, tourism-based fly fishing contributes significantly to the economy of many isolated tropical islands and atolls. Despite their economic value, little is known about bonefish in the Indian Ocean. The aim of this study was to contribute to the understanding of bonefish ecology in the Indian Ocean. Specific objectives included (1) a review of literature identifying knowledge and area gaps in research, (2) assessing the survival rate of tagged bonefish, and (3) understanding the movements and space use patterns of tagged bonefish.

A review of published literature on bonefish indicated that considerable biological and ecological research has been conducted on this species complex in the Pacific Ocean but virtually no research has been conducted in the Indian Ocean. To address this research gap, an acoustic telemetry study was initiated at the remote St. Joseph Atoll (Seychelles) with an array of 88 Vemco VR2W receivers. Thirty *A. glossodonta* were surgically tagged with Vemco V13 acoustic transmitters in 2015. Only 10% of the tagged bonefish were tracked for more than two weeks. Mortality (predation by sharks) was clearly evident when the final 100 hours of movement data obtained from fish that were detected for less than two weeks were compared to those that survived and were detected for longer periods. Differences in area use patterns, speed of movement (velocity) and residency index were observed. The three surviving bonefish were tracked for between 210 and 367 days. These individuals remained resident to the atoll and showed high use of the marginal habitats between the shallow sand flats and the lagoon. No tide related movements were observed, however this may be due to detection range efficiency, particularly on the sand flats. Movements to the outer rim of the lagoon during the waning gibbous lunar phase was observed, possibly indicative of spawning behaviour, however due to the low sample size and lack of visual evidence this cannot be confirmed. The high predation rate of post-release bonefish has fisheries management implications. Limitation of fishing effort needs to be considered as unmonitored fishing, even if catch-and-release, in near-pristine predator rich areas is likely unsustainable.

Key words: marine; ecology; *Albula*; acoustic telemetry; predation bias; catch-and-release

09h10-09h30: Matthew Farthing (MSc student) - The composition, seasonality and habitat utilisation of the larval and early juvenile ichthyofaunal community from a surf zone and nearby coastal embayment in southern Angola.

Supervisor/s: Prof. WM Potts (w.potts@ru.ac.za); Prof. Nadine Strydom
(nadine.strydom@nmmu.ac.za)

Funder/s: Flamingo Lodge

The importance of understanding the early development of fishes is well documented. Studies in the warm-temperate waters of the Eastern Cape, South Africa have found that surf zone habitats host large numbers of larval fishes, including a limited number of “estuarine dependent” species. This study aims to investigate the other warm-temperate biogeographic region in southern Africa, namely the southern Angolan coastline. This region is unique as it contains only one functional estuary, the Cunene, and therefore it is likely that the “estuarine dependent” species may have evolved to utilize the surf zone habitats. The South African and southern Angolan warm-temperate biogeographic zones were linked prior to the formation of the Benguela Current system. With the rapid ocean warming observed along the southern Angolan coastline, research on the response of fishes will insight into the adaptability of several important South African fish species to rapid environmental change.

This study aims to describe the composition, seasonality, estuarine dependence and habitat utilisation of the larval and early juvenile ichthyofauna occurring in the surf zone and a nearby coastal embayment in southern Angola. This is the first work in the region to focus on coastal fish larvae, and therefore stands to make a meaningful contribution to our understanding of the early life stages of its fishes. A 13-month study was conducted along a 25km section of coastline, sampling sandy troughs and mixed shore habitats using a two-person operated seine net in the primary surf zone. Six sites (three sandy; three mixed shore) were selected and triplicate tows (25m alongshore) were performed using a 5m x 1.5m beach seine (500µ). A further eight sites were sampled bimonthly in the wet and dry season in a nearby coastal embayment using the same methods. Four sites were within the shelter of the bay, and four were in the immediately adjacent surf zone. Larvae were stored in 5% formalin/seawater solution, and turbidity, salinity and temperature observations were recorded.

The surf zone hosts a distinct ichthyoplankton community dominated by postflexion stage larvae. This community varies seasonally based on oceanographic changes associated with the shift of the ABFZ. The surf zone community is dominated by marine estuarine opportunists, and it appears that species with this level of estuarine dependence have adapted to utilize alternative nursery habitats. Only one marine estuarine dependent species was observed, which suggests that other marine estuarine dependent species may not have adapted to the loss of functional estuaries during the formation of the Namib desert. This study provides tentative evidence for the nursery importance of the surf zone to several important fishery species, particularly *Diplodus sargus*. In contrast to the surf zone, the results suggest that nearby coastal embayment supports a significantly different ichthyofaunal community. This is dominated by early juveniles of taxa from marine and marine estuarine opportunist guilds and suggests that this environment fulfils an important nursery function for many fishes in this region.

Key words: marine; ecology; warm-temperate; larval ichthyofauna

09h30-09h50: Matthew Parkinson (PhD student) - Investigation of area use of west coast dusky kob *Argyrosomus coronus* in southern Angola using acoustic telemetry techniques

Supervisor/s: Prof. WM Potts (w.potts@ru.ac.za); Prof. AJ Booth (t.booth@ru.ac.za)

Funder/s: Ocean Tracking Network; National Research Foundation Angola-South Africa Joint Collaboration; Flamingo Lodge; Angolan Ministry of Fisheries; Rhodes University Research Council; NRF Innovation Scholarship; Ernst & Ethel Eriksen Trust

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. It is exploited by many fisheries (artisanal, recreational and commercial) during most of its life history stages and, although there is biological information available, knowledge of their movement patterns and migrations is limited. Conventional tagging information showed that juveniles (<600 mm TL) were more resident (57 % recaptured at release site), while subadults and adults were more mobile (13 % recaptured at release site). Conventional tagging and catch-per-unit-effort data suggest that adults undergo a seasonal migration, following the shifting Angola-Benguela Frontal Zone (ABFZ) into Angola in winter and into northern Namibia in spring. There is no information on their fine-scale movements and area use. This study aimed to address this knowledge gap.

Acoustic telemetry equipment and temperature loggers were deployed in 2013 in three representative regions including sections of exposed coastline and two coastal embayments, in southern Angola. Twenty subadult/adult (760-1155 mm TL) fish were tagged with coded acoustic transmitters at Flamingo Lodge, southern Angola, during August 2013. A further 10 juvenile/sub-adult fish (460-765 mm TL) were tagged in June 2014. The majority of tagged individuals were only detected in the Flamingo array. Adult fish exhibited a partial migration pattern, whereby a proportion (16.5 %) of tagged fish underwent a southerly migration. During the 2013-2014 period, three adult fish (>960 mm FL when tagged) undertook a southerly excursion, and were detected in Tombua Bay, and during the 2014-2015 a further three adults (>1050 mm FL when tagged) made a similar trip. Roughly one third of the juvenile fish left the array between October 2014 and January 2015, with the same fish returning between March and April 2015. Within the Flamingo array juveniles used small areas, near to tagging sites. Adults and subadults exhibited greater area use. Adults' area use varied with trends in water temperature. Fish aggregated in the mid-region of the Flamingo array, with a concomitant inshore bias in their area use, during cold periods of the year. Their distribution during warm periods of the year was more widely dispersed. This aggregation behaviour was likely linked to spawning and/or access to food which may be more abundant at this site during these periods. Juveniles and subadults were not detected for long enough to infer temporal area use patterns. They did, however, exhibit a stronger offshore presence, during cold periods when adult fish were largely inshore. This ontogenetic niche separation may be a mechanism to reduce intraspecific competition, or avoid cannibalism of small juveniles by larger adults.

Key words: marine; ecology; area use

09h50-10h10: Alexander Winkler (PhD student) - Acoustic telemetry reveals behavioural complexity in the Leerfish, *Lichia amia* (Teleostei: Carangidae), in southern Angola.

Supervisor/s: Prof. WM Potts (w.potts@ru.ac.za); Dr A-R Childs (a.childs@ru.ac.za)

Funder/s: NRF/DAAD Freestanding Bursary, Ocean Tracking Network, National Research Foundation (Rated Researcher Grant), Flamingo Lodge, Angolan Ministry of Fisheries, Rhodes University Research Council

Lichia amia (Linnaeus, 1758), or leerfish, supports an important recreational, subsistence and commercial inshore fisheries throughout its global distribution. Off the southern Angolan coastline, this species is highly abundant, attracting large numbers of foreign anglers, raising its estimated recreational value to be in excess of US\$ 243 per harvested kg. Current molecular evidence as well as conventional tag recaptures in Namibia from Angola suggests seasonal longshore migrations between these two regions and isolation from the South African population. This population structuring is thought to be a consequence of the cold Benguela Current acting as biogeographic barrier between the South African and Angolan populations. The aim of this study is to investigate the movement behaviour of sub-adult, and adult *L. amia*, using a multi method approach (population genetics, tag recapture, CPUE, acoustic telemetry) in an attempt to understand their habitat utilization, circannual movement patterns in relation to environmental cues. The conventional tagging data set comprised of 1677 Angolan fish and the CPUE data set comprised of 14137 angler hours and 2070 captures from Angola. Thirty nine acoustic listening stations were deployed in September 2013 along a 150 km stretch of coastline in southern Angola covering exposed coastline (Flamingo Fishing Area (FFA)), a large coastal embayment (Baia dos Tigres (BT)) and a small coastal embayment (Tombwa bay (TO)). Twenty mature (670 mm – 1020 mm FL) *L. amia* were tagged internally with coded VEMCO V 16 (2 year battery life) acoustic transmitters in the immediate vicinity of Flamingo Lodge, southern Angola between August and September of 2013. Twenty-two underwater temperature loggers were also deployed throughout the array. An additional batch of ten fish (570 mm - 886 mm FL) were tagged in June/July of 2014 with VEMCO V 13 (1 year battery life) acoustic transmitters. The acoustic receivers were serviced in June 2014 and July 2015. Both acoustic telemetry and fisheries-dependent data suggested partial migration, where a portion of the population migrates and the rest remain resident. Acoustic telemetry however, revealed behavioural complexity where migrating fish exhibited differing levels of affinity to BT during the summer months. Migrating fish arrived back to the FFA in June each year, where they overwintered and are thought to spawn. The acoustic telemetry results from this study support the contingent hypothesis, suggesting that individuals in a population remain distinct by maintaining divergent migration pathways that intersect on a common spawning ground. Migratory and resident individuals were observed in temperatures ranging from 15.5 °C - 22 °C and 15.5 °C - 25.5 °C, respectively. Based on the rapid ocean warming observed in the area, it is likely that further warming will lead to an earlier, extended and possibly farther southward migration by the migratory individuals. However, thermal physiology research or higher in-situ temperatures will be required to understand the thermal limits of the resident individuals.

Key words: marine; ecology; conventional tagging; acoustic telemetry; West Africa

10h10-10h40: Tea break

Climate Change (Chair: Chris Bova)

10h40-11h00: Carla Edworthy (MSc student) - The metabolic physiology of early stage *Argyrosomus japonicus* with insight to the potential effect of $p\text{CO}_2$ induced ocean acidification

Supervisor/s: Dr N James (n.james@saiab.ac.za); Prof. WM Potts (w.potts@ru.ac.za)

Funder/s: Sandisa Imbewu; National Research Foundation (NRF)

The topic of climate change and the impacts it has on earth's biological systems has received increasing research attention and the effect that ocean warming has on marine organisms is well documented. However, ocean acidification, a secondary consequence of increasing atmospheric CO_2 , has only recently been identified as a threat to marine organisms. Global ocean pH is expected to decline by 0.3 units within the next century and this is likely to have detrimental consequences to those marine organisms that are unable to adapt. Calcifying organisms, for example, have been shown to be particularly vulnerable to ocean acidification and the development of the larval stages in many keystone species is severely impaired. Despite these findings, there has been less research effort to address the effect that ocean acidification may have on fishes.

Eco-physiology has recently become a popular tool for understanding the organism level mechanisms of response to changes in environmental conditions. Understanding the fundamental metabolic structures can inform how the organism partitions energy to life sustaining processes, which ultimately translates to survival and fitness. The larval stages of many species show reduced metabolic scopes for activity and are therefore likely to be more physiologically vulnerable to changes in their environment. The most vulnerable life stages are likely to show the lowest metabolic scope which thereby identifies these life stages as potential survival bottlenecks.

The aim of this study was 1) to assess the metabolic structure of the early developmental stages of *Argyrosomus japonicus* in order to provide an indication of energy allocation throughout early development and determine which life stages are potentially most vulnerable to change. Following this 2), the metabolic structure of early stage *A. japonicus* was assessed under ocean acidification treatments predicted for the next century.

Fertilised *Argyrosomus japonicus* eggs were obtained from the Pure Ocean aquaculture facility and raised under optimum conditions from hatching to the settlement stage. Static respirometry was used to assess the oxygen consumption rate of the larvae during each life stage. Oxygen consumption data was used to calculate standard, active and routine metabolic rates of the larvae at each life stage. Following the initial study, metabolic rates of *A. japonicus* raised under three pH treatments were compared at each life stage.

The metabolic rate of early stage *A. japonicus* increases gradually in the early stages and rapidly towards the settlement stage. Metabolic scope showed a distinct reduction in the flexion stage after which it increases dramatically. This reduction is attributed to a decline in active metabolic rate during flexion, where development is energetically demanding. This suggests that the flexion stages are likely to be most vulnerable to adverse environmental conditions. Preliminary results from the pH treatments study suggest that there may be an increased metabolic vulnerability to treatments of reduced pH in the later developmental stages of *A. japonicus* (flexion – post-flexion), with the early stages showing no response to treatments of reduced pH. This suggests the potential of an ontogenetic bottleneck in response to ocean acidification.

Key words: marine; climate change; eco-physiology; ocean acidification; ichthyoplankton

11h00-11h20: Bernard Erasmus (BSc student) - Assessing heightened $p\text{CO}_2$ on the early development of dusky kob, *Argyrosomus japonicus*

Supervisor/s: Prof. WM Potts (w.potts@ru.ac.za); Dr N James (n.james@saiab.ac.za); Prof. H Kaiser (h.kaiser@ru.ac.za)

Funder/s: National Research Foundation (FAX2220000794X2F), Rhodes Sandisa Imbewu

Marine biota are considered vulnerable to the effects of rising seawater carbon dioxide concentrations. Owing to the paucity of ocean acidification research, the impact of changing seawater chemistry on the morphology of fish during early development is unclear. The aim of this project is to test the effects of increased carbon dioxide on the early life development, hatching success, growth, survival, skeletal development and otolith development of a long-lived, economically important, estuarine-dependant fish, *Argyrosomus japonicus*. This study reared *A. japonicus* from eggs in three CO_2 treatments for 30 days and examined their development at key life stages. This study selected near future $p\text{CO}_2$ treatments as this is of most interest. Treatments include current day $p\text{CO}_2$ as a control, medium treatment reflecting year 2050 $p\text{CO}_2$ according to the International Panel on Climate Change (IPCC) “business as usual scenario” and extreme $p\text{CO}_2$ treatment reflecting the most likely IPCC scenario for the year 2100.

There were significant differences in the growth and survival between treatments (1050 $\mu\text{atm } p\text{CO}_2$, RM ANOVA $p < 0.0005$). Post-hoc tests indicated that the growth and survival fish was significantly higher in the 2050 $p\text{CO}_2$ treatment than the other two treatments. Bone development was also significantly faster in fish reared in medium carbon dioxide concentrations (ANOVA $p = 0.04$), but there was no significant difference between present day and the 2100 $p\text{CO}_2$ conditions. Mortality was 100% in the 2100 $p\text{CO}_2$ treatment by the end of the study. The results from this study suggest that growth of larval dusky kob will be enhanced initially as carbon dioxide concentrations increase, but if levels rise beyond 1050 μatm the survival and growth of dusky kob larvae may decrease. Since fish in this study were reared under optimal, controlled, laboratory conditions, it is likely that the fluctuating environmental conditions and the associated stressors (predators, fluctuations in food availability) of the natural environment may yield different results. Therefore, future research should test the long-term effect of elevated carbon dioxide concentration exposure on the early life stages of fish in a more variable environment that includes predator and food limitation stress.

Key words: marine; climate change; ecophysiology; ocean acidification; early development; fish

11h20-11h40: Kerry-Ann Van der Walt (PhD student) - Thermal tolerance and the potential effects of climate change on coastal and estuarine organisms in the Kariega Estuary and adjacent intertidal coastline

Supervisor/s: Dr N James (n.james@saiab.ac.za); Prof. WM Potts (w.potts@ru.ac.za); Dr F Porri (f.porri@saiab.ac.za)

Funder/s: NRF research development grant for y-rated researchers; NRF Innovation Doctoral Scholarship

Temperature is one of the primary factors controlling physiological and life history functions in aquatic organisms. Presently temperature changes are evident, yet not similar, on all continents and in the oceans. Temperature changes are responsible for causing shifts in aquatic organisms' phenologies, physiological and behavioural traits, geographic ranges, productivity, and the disruption of diverse species interactions. Understanding the effects of climate change on the physiology of organisms is therefore one of the many urgent challenges faced by contemporary science. Furthermore a systemic, rather than specific approach, like incorporating several taxonomic groups to thermal tolerance studies, would holistically enable to identify which community components are more vulnerable to climate change.

The main aim for this study is to determine the limits of thermal tolerance of various warm-water endemic, cool-water endemic and tropical fish and invertebrate species from different habitats occurring in the warm-temperate Kariega Estuary and the adjacent intertidal environment. To achieve this, the following objectives are being pursued: to 1) Analyse long-term water temperature records from temperature loggers in the Kariega Estuary and adjacent intertidal gullies; 2) Determine the limits of temperature tolerance of cool-water endemic, warm-water endemic and tropical fish and invertebrate species from different habitats; 4) Compare long-term water temperature records from different habitats to upper and lower temperature tolerance of fish and invertebrate species to determine which species live closer to their upper and lower thermal optimal temperatures.

Fish and invertebrate species will be collected using seine nets, cast nets, dip nets and/or by hands. Organisms will be transported live in aerated containers from the Kariega Estuary to the Ecophysiology Lab in Grahamstown. CTMax, CTMin and cortisol levels will be used to determine the sub-lethal limits of thermal tolerance and stress in organisms. In addition, Star-Oddi loggers will be inserted in larger fish individuals to monitor their heart rate and identify physiological stress levels in relation to temperature.

In the first half of 2016, the experimental tanks were constructed. During the second half, preliminary trials on *Diplodus capensis* (blacktail) were conducted. Results show that the CTMax for *D. capensis* during the winter season is 34°C. Further cortisol analyses is however needed to effectively establish the onset of thermal stress. Additional preliminary trials will be conducted for the remainder of the year to achieve this aim and determine the CTMin for this species. In addition, preliminary trials on a targeted invertebrate species will also be conducted. In 2017, experimental trials will be performed for both summer and winter for all targeted fish and invertebrate organisms. The outcome of the PhD will be to contribute to the limited estuarine and marine-ecophysiology linked climate change research in South Africa, as well as to provide new information on the temperature tolerances of a range of estuarine and marine organisms.

Key words: estuarine; climate change; ecophysiology; thermal tolerance; cortisol

11h40-12h00: Murray Duncan (PhD Student) - Thermal physiology of the South African linefish; *Chrysoblephus laticeps* in context of localised exploitation and global change

Supervisor/s: Prof. WM Potts (w.potts@ru.ac.za); Dr NC James (n.james@saiab.ac.za); Prof. SE Kerwath (SvenK@DAFF.gov.za); Dr A Bates (A.E.Bates@soton.ac.uk)

Funder/s: Rhodes University Sandisa Imbewu; NRF

Two of the biggest threats to capture fisheries in the world are human exploitation and climate change. Synergistic interactions between these threats has been suggested to amplify species responses making them more vulnerable to disturbances. An understanding of the pattern and process of vulnerability to climate change in relation to exploitation is required to disentangle their effects on fish stocks and improve the predictive accuracy of species vulnerability assessments.

Population wide responses to changing sea surface temperature (SST) affects the balance between rates of mortality, growth and reproduction, ultimately resulting in distribution and abundance changes. Changes in physiological rates occur as a first response and underlie observed effects. An understanding of the physiological mechanisms driving responses to climate change is therefore important when predicting population wide responses. Investigating the interaction of exploitation rate and thermal physiology is also required to elucidate whether spatial protection is an effective means to mitigate the effects of climate change on fish populations.

A multi method approach, using the South African linefish species; *Chrysoblephus laticeps*, will be applied to investigate thermal sensitivities of growth (dendrochronology), recruitment (larval thermal tolerance), metabolism (respirometry) and distribution (physiological based modelling). By comparing specimens from one of the oldest marine protected areas in Africa (Tsitsikamma MPA) and a nearby exploited population (Noordhoek) I hope to elucidate the effects of exploitation on *C. laticeps*' sensitivity to climate change.

To date an otolith collection has been obtained from Noordhoek and Tsitsikamma MPA dating as far back as the 1970's. Shed 7 has been converted into two temperature controlled laboratories (a holding system and experimental system). Noordhoek and Tsitsikamma live specimens have been caught and successfully transported to the holding system and respirometry trials are set to begin in October and November. Spawning will be attempted in January.

Key words: marine; ecology; physiology; red roman; global change; exploitation; vulnerability

Honours seminar (Chair: Dr Cliff Jones)

12h00-12h20: Brett Johnstone (BSc Honours student) - Quantifying observer bias in determining the size and gender of *Carcharodon carcharias* from chumming vessels

Supervisor/s: Prof. W Sauer (w.sauer@ru.ac.za); Dr E Gennari (e.gennari@oceans-research.com)

Funder/s: Oceans Research; Rhodes University Research Council

Carcharodon carcharias, or White sharks, are listed as “Vulnerable” on the ICUN Red List of Threatened Species (Category VU A1cd + 2cd). White sharks are large and elusive marine apex predators. There is a need to obtain robust estimates of population numbers for white sharks. Majority of population studies involving aquatic mega-fauna such as the White shark involve the use of visual observations in the field to obtain estimates of the size and/or sex of each individual. However, misidentification during visual observation has the potential to be a major source of bias in the abundance estimators used in the population studies. This study explored the effect of the observer’s level of experience and position on the chumming vessel on the accuracy of size and gender estimations of white sharks. Data was collected for 186 sightings of white sharks between May and July 2016 at Seal Island, Mossel Bay, South Africa.

This study highlights the need for experienced observers when conducting visual estimates of size and sex of white sharks from chumming vessels. The potential for observer induced bias in the determination of white shark size and gender is inversely proportional to the observers’ level of fieldwork experience. A minimum of 1 year of fieldwork experience working closely and consistently with white sharks is required in order to reduce the bias associated with visual estimates made from chumming vessels. Observers with more than a year of experience tended to over-estimate the size of white sharks ($12 \pm 29\text{cm}$), whereas observers with more than a month experience and observers with less than a month experience had the tendency to underestimate white shark size ($-13 \pm 37\text{cm}$ and $-18 \pm 49\text{cm}$, respectively). The position of the observer had no significant effect on the accuracy of white shark size estimations ($p = 0.320708$). This study provides further evidence of the inaccuracy of using visual gender determination from chumming vessels. Observers with more than a year of field work experience were able to determine the sex of individuals more frequently during a chum trip ($40 \pm 25\%$) than observers with more than a month experience ($26 \pm 35\%$) and observers with less than a month of experience ($26 \pm 24\%$). Furthermore, observers with more than a year of experience were considerably more accurate in the determination of shark gender ($90 \pm 5\%$) than observers with more than a month experience ($62 \pm 13\%$) and less than a month experience ($67 \pm 13\%$). Future population studies on marine mega fauna incorporating visual size and gender estimates should incorporate this potential bias in the study or use only experienced field specialists when obtaining visual estimates of shark size or sex.

Key words: marine; fisheries; *Carcharodon carcharias*; observer bias; population studies.

12h20-14h00: Lunch break

Systematics and Biology (Chair: Matthew Parkinson)

14h00-14h20: Bosupeng Motshegoa (PhD student) - Systematics and biogeography of the mountain catfishes of the genus *Amphilius*, in southern Africa

Supervisor/s: Dr A Chakona (a.chakona@saiab.ac.za); Dr FDP Cotterill (fcotterill@gmail.com)

Funder/s: National Research Foundation (SFH14080888899); NRF-FBIP (IBSG13060718663); Rhodes University Research Council

Mountain catfishes of the genus *Amphilius* (sub-family Amphilinae) are found throughout much of the African continent where they occur in several major river systems. Fishes of this genus have highly conservative morphology, a fact which has hampered accurate species delineation due to subtle morphological differences. As a result, the taxonomic diversity of mountain catfishes, which until recently was thought to be relatively well known, is represented by relatively few species when compared with other fish genera with similar Afro-tropical distribution.

A recent comprehensive molecular study revealed that mountain catfishes belong to two monophyletic groups which are consistent with previous studies which divided the genus *Amphilius* into the Lower Africa (characterised by presence of an epidermal fold on the caudal fin) and Higher Africa (lacks epidermal fold on caudal fin) groups. Substantial levels of undocumented taxonomic diversity was found within the Lower Africa group, and suggested that mountain catfishes in the Higher Africa group do not belong to the genus *Amphilius*. A suggestion was made to transfer mountain catfishes in the Higher Africa the previously described genus, *Anoplopterus*.

To date, only a few genetic studies have been conducted in mountain catfishes of the Higher Africa group. The diversity and distribution of mountain catfishes in this region therefore remains poorly documented. There are currently only three recognised species of *Amphilius* in southern Africa (defined here as Zambezi system southwards down to Mkomazi system): *A. laticaudatus*, *A. natalensis* and *A. uranoscopus*. The present research undertakes a comprehensive genetic study to: (i) identify cryptic diversity in mountain catfishes in southern Africa (from Zambezi system to the Mkomazi system), (ii) determine their evolutionary relationships, and (iii) assess the processes that drove diversification and shaped their contemporary distribution patterns.

In addition to the samples collected in field surveys, additional material was obtained from GenBank and the BOLD databases. These covered most of the river systems that represent the geographic ranges of the *Amphilius* in southern Africa. A Bayesian inferred phylogenetic tree obtained from analysis of the generated gene regions (COI and Cytb) support the hypothesis that there is hidden diversity within the mountain catfishes of southern Africa. The estimated times of divergence for the newly discovered lineages correspond to the tectonic axes of flexure which led to the establishment of contemporary drainage networks. These geological processes which occurred in the Plio-Pleistocene period, possibly resulted in the current distribution and diversity of the *Amphilius* in southern Africa.

Keywords: diversity; molecular systematics; monophyletic; population structure; species complex

14h20-14h40: Yonela Sithole (MSc student) - Morphological and genetic variation of *Gymnothorax undulatus* (Anguilliformes: Muraenidae) in the western Indian Ocean

Supervisor/s: Dr M Mwale (MonicaM@nzc.ac.za); Dr G Gouws (g.gouws@saiab.ac.za)

Funder/s: Department of Agriculture, Forestry and Fisheries (DAFF); SeaKeys (SANBI-NRF Foundational Biodiversity Information Programme); South African Institute for Aquatic Biodiversity

Gymnothorax is the largest genus of the family Muraenidae (moray eels) and has been widely used as a “catch all” genus. However, the taxonomy of most species in this genus is uncertain and in need of revision. This is because differentiating moray eel genera and species is difficult, due to overlapping external characters. Most of the described species of *Gymnothorax* are known only from single, inadequately-described specimens, suggesting many inaccuracies. An example is *Gymnothorax undulatus*, an Indo-Pacific coral reef fish species currently identified only by its variation in colour patterning. Misidentifications of this species are common throughout its distribution range as there are no specific distinguishing features. This study therefore aims to re-evaluate the taxonomic status of *G. undulatus* using morphology and genetics.

A total of 99 specimens from several areas, grouped according to marine biogeographic boundaries and proximity in the Western Indian Ocean (WIO), resulting in nine geographic regions, were examined. Additional specimens from two extralimital regions (Persian Gulf and Red Sea) were also examined for comparison. Eight morphological characters commonly used for moray eel taxonomy were subjected to multivariate principal component (PCA) and discriminant function analyses (DFA) in PAST and STATISTICA. This was done to determine the morphological differences between the specimens from geographic regions and to graphically represent these relationships. Meristic characters (vertebrae and dentition) were also examined. DNA sequence data from one mitochondrial gene (COI) were analysed using standard phylogenetic procedures (neighbor-joining) in MEGA7.

The multivariate results revealed considerable overlap among specimens of some of the geographic regions, but with little to no overlap for three distinct regions (Comoros, Madagascar and southern Africa). These grouping accounted for 83.53% of the total variation with 57.58% overall classification success of individuals to their original geographic regions, which was significant ($p < 0.05$). Furthermore, analysis of the total vertebrae count produced similar clusters to the PCA and DFA multivariate analyses. Comparison of colour patterns distinguished most of the southern African specimens from those of all other regions. The neighbour-joining tree also showed strong bootstrap support for variation among regions within *G. undulatus*. A distinct clade containing samples from southern Africa was revealed in this phylogenetic tree, supporting the morphological analysis. Therefore, morphological and genetic analyses suggest the existence of a species complex in what was considered as a single species, *G. undulatus*.

Key words: marine; taxonomy; morphology; moray eel; phylogenetics

14h40-15h00: Timothy Smith (MSc student) - Investigation into the morphological and molecular variation of southern African *Nannocharax* (Characiformes: Distichodontidae)

Supervisor/s: Dr A Chakona (a.chakona@saiab.ac.za); Dr E Vreven
(emmanuel.vreven@africamuseum.be)

Funder/s: The South African Institute for Aquatic Biodiversity (SAIAB)

Nannocharax is a genus of small, African freshwater fishes distributed throughout most of sub-Saharan Africa as well as extending up to the Nile River. At present, there are 40 known species of *Nannocharax*, with their centre of diversity being the Congo River Basin. Over the past decade, 7 new species of the genus have been discovered. Southern African *Nannocharax* currently comprise 4 species, one of which was described in the past two years. Field observations by collectors and scientists of the variation among southern African species indicates that there may be more species in this region than are currently acknowledged. The purpose of this study is to determine the extent of the variation observed, using both morphological and molecular techniques, as well as to determine the relationships among southern African *Nannocharax*.

The study used historical material collected over the past 30 years and deposited into the National Fish Collection Facility at the South African Institute for Aquatic Biodiversity (SAIAB). The study used representative specimens and DNA tissue samples from much of the genus' distribution range in southern Africa. Morphological measurements were taken following traditional methods using callipers and taking notes of meristic values and pigmentation patterns. Molecular methods were employed by extracting and amplifying the mitochondrial cytochrome oxidase I gene. Sequencing was done at SAIAB, and additional sequences were downloaded from BOLD.

The genetic results indicate that southern African *Nannocharax* show some degree of geographical structuring, with the exception of *N. machadoi*. Those populations closer to the Zambezi/Congo watershed appear to share a greater affinity with populations from the Congo system than they do with some other Zambezi populations, or those from the Okavango. Molecular results support the *N. dageti* clade as a related but distinct group from *N. macropterus*. The use of genetic techniques has also allowed for correction of errors noted in the identification of physical specimens. While the morphological results are preliminary, considerable morphological variation is evident. Colour pattern appears to be an important tool in differentiating populations. Scale counts and fin ray counts have also shown promise in correctly identifying populations.

Finally, results of the morphological study have alluded to the presence of species currently known but not traditionally recognised as being present in southern Africa, although this needs to be confirmed with more comparative material.

Key words: freshwater; taxonomy; genetic analysis; morphology; species complexes

**15h00-15h20: Ndaleni Phumza (MSc student) - Biology and ecology of bluegill sunfish
Lepomis macrochirus populations in the Kariega river system, South Africa**

Supervisor/s: Prof. OLF Weyl (o.weyl@saiab.ac.za); Dr R Wasserman (ryanwas21@gmail.com);
Dr B Ellender (bru.ellender@gmail.com)

Funder/s: CIB DST-NRF Centre of Excellence for Invasion Biology; South African Institute for
Aquatic Biodiversity

The impact of alien invasive species on recipient ecosystems is one of the greatest threats to freshwater biodiversity. Bluegill sunfish *Lepomis macrochirus* is native to Central and North America and was introduced in South Africa in 1939. This research project aims to contribute towards better understanding the biology and ecology on this species by: (1) assessing the distribution and relative abundance of the fish species in the Kariega River system, Eastern Cape; (2) determining its diet and (3) using functional response (FR) experiments to compare the FR of bluegill with that of co-occurring fishes (*Tilapia sparrmanii*, *Micropterus salmoides* and *Pseudocrenilabrus philander*).

To determine distribution > 100 sites were sampled from the head waters down to the estuary of the Kariega River. Results showed that native fishes were mostly present in the head waters with the majority of sites dominated by non-native fishes. Bluegill were present through a large portion of the system and inhabited both riverine sites and dams.

Bluegill diet was determined by examining stomach contents. Diet analyses showed that the bluegill are omnivorous and its diet depends on fish size and prey availability. In winter fish ate predominantly sididae as juveniles before shifting to the larger libellulids (benthic feeding) and chironomids as adults. In summer fish shifted from a crustacean dominated diet to a fish egg dominated diet in adults. This diet was similar to that of some co-occurring fish species.

For FR experiments, predators were size matches and presented live prey (day-old *Oreochromis mossambicus*) at densities of two, four, eight, sixteen, thirty two, and sixty four prey/predator. Overall FR was highest for *M. salmoides* and lowest for *T. sparrmanii*. Results showed an overlap in the attack rates for *M. salmoides*, *P. philander* and *L. macrochirus* indicating no significant difference between these species. Attack rate for *T. sparrmanii* displayed significantly lower attack rates than the other predators. Prey handling time for *M. salmoides* was higher than that of *L. macrochirus* and *T. sparrmanii* that of *P. philander* was intermediate. Overall, this indicates that bluegill impacts will be similar as those observed for *P. philander* but lower than that of *M. salmoides*.

Key words: freshwater; ecology; distribution; diet; functional response; dams; river sites; alien invasive species and native species

15h20-15h40: Modiegi Bakane (MSc student) - Biology and management of threespot tilapia *Oreochromis andersonii* (Castelnau, 1861) in the Chobe District, Botswana

Supervisor/s: Prof. OLF Weyl (o.weyl@saiab.ac.za); Mr D Tweddle (d.tweddle@saiab.ac.za)

Funder/s: Government of the Republic of Botswana; Ministry of Environment Wildlife and Tourism, Department of Wildlife and National Parks

The threespot tilapia *Oreochromis andersonii* is one of the flagship ichthyofauna species. It is common in commercial fishermen's catches, recreational catches and aquaculture production in the Chobe District of Botswana. Regionally, it is widely distributed in the Cunene, Okavango Delta, Kafue and Upper Zambezi. Inland water fisheries in Africa are threatened by human activities such as pollution, water diversion, eutrophication, invasive species and overexploitation. In the Zambezi Basin overfishing is the primary threat. This is due to commercialisation, use of destructive fishing methods and use of more efficient monofilament gillnets which has resulted in intense exploitation of fisheries resources. The study aimed to develop management recommendations for the threespot tilapia fishery, based on its biology and its relative abundance in fish communities in Chobe District of Botswana.

Various gears were employed between September 2014 and April 2015 for sampling a total of 7992 fish weighing 1095 kg and comprising of nine families and 37 species. Fish species composition differed according to stations and habitats. In this study, large cichlids were not among the top five most important species according to Index of Relative Importance (IRI) at any site. The five most important species in the Chobe River were *H. vittatus* (IRI=30%), *S. intermedius* (13%), *B. lateralis* (13%), *Synodontis* species (10%) and *Enteromius radiatus* (7.8%). In Zibadianja Lagoon, the five most important species were *S. intermedius* (47%), *M. altisambesi* (16.2%), *B. lateralis* (14%), *C. gariepinus* (13%) and *C. ngamensis* (2%). In the Savuti River were *C. gariepinus* (40%), *M. altisambesi* (30%), *S. intermedius* (8%), *E. paludinosus* (7%) and *B. lateralis* (6%) dominated. Biomass in unexploited areas (Zibadianja Lagoon gill net CPUE = 38 ± 31 kg/net.night⁻¹ and Savuti River = 25 ± 19 kg/net.night⁻¹) than in exploited areas (e.g., Chobe River = 6 ± 3 kg/net.night⁻¹). The mean CPUE of *O. andersonii* (0.8 ± 0.8 kg/net.night⁻¹) was highest in Savuti River, followed by Zibadianja Lagoon (0.4 ± 0.5 kg/net.night⁻¹) and Chobe River had lowest (0.002 ± 0 kg/net.night⁻¹). The protected areas also enhanced fish longevity with three spot tilapia in protected areas were longer lived than those in exploited areas e.g., the maximum age in Zibadianja Lagoon (8 years) and the Savuti River (8 years) was older than in the Chobe/Kavimba floodplains (6 years). Biological contributions were estimates of growth and maturity for threespot and redbreast (*Coptodon rendalli*) tilapia. In summary, the Von Bertalanffy growth equation from otolith derived length at age was $L_{t(mm)} = 298 (1 - e^{-0.59(t-0.98)})$ for three-spot and $L_{t(mm)} = 337 (1 - e^{-0.20(t-2.35)})$ for redbreast tilapia. The length at 50% maturity was 250mm L_T for threespot and 210mm L_T for redbreast tilapia. As a result, I recommend that the current mesh size of four inches (100mm) should be maintained to allow fish to mature and breed before being harvested.

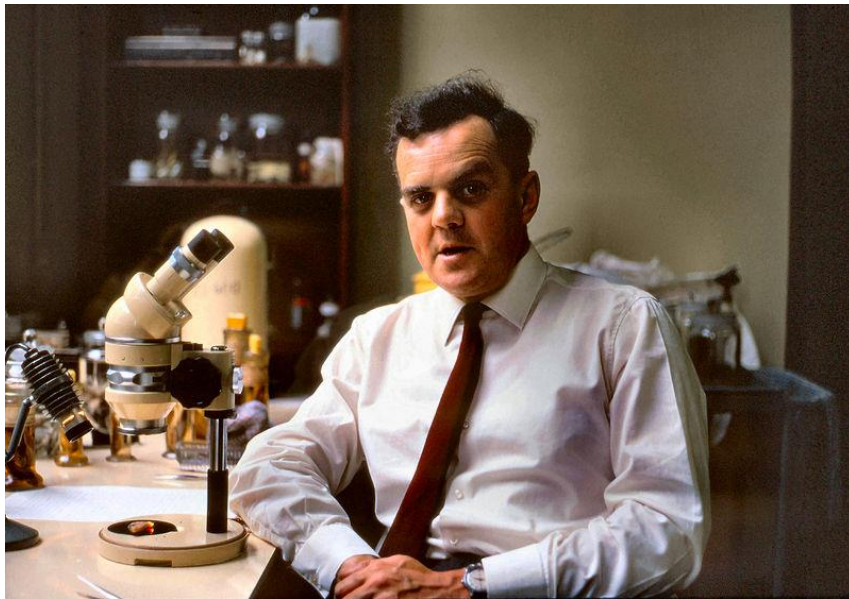
Key words: freshwater; fisheries management; Botswana; cichlid

Friday 14 October 2016

Humphrey Greenwood Guest Speaker (Chair: Prof. Warwick Sauer)

08h30-08h40: Welcome and introduction by HOD

08h40-09h30: Dr Ané Oosthuizen – From squid to penguins, but mostly people in between!



Fisheries Management (Chair: Alex Winkler)

09h30-09h50: Christopher Bova (PhD student) - A new approach to changing compliance behaviour within South Africa's recreational fishery

Supervisor/s: Prof. WM Potts (w.potts@ru.ac.za); Prof. S Aswani (s.aswani@ru.ac.za)

Funder/s: National Research Foundation (NRF)

Poor compliance to fisheries regulations has been well documented in South Africa and throughout the world. South African recreational fishers are regulated by permits, bag-limits, size limits, prohibited species and closed seasons, closed areas and restrictions on bait and tackle. Contravention of these regulations, whether accidental or deliberate, poses a serious threat to the sustainability of the recreational fishery as well as competing fishing sectors. Traditionally, non-compliance has been addressed based on Gary Becker's deterrence model, which assumes that people are rational actors and will respond to increased penalties or increased enforcement by decreasing criminal behaviour. Increased penalties will not result in a behaviour change if detection of the illegal activity is perceived to be low due to limited enforcement. Due to the complex and cost prohibitive nature of enforcement activities throughout South Africa's extensive and often inaccessible coastal areas, increased enforcement is not a sustainable long term option. Including a normative approach toward increasing compliance may be a more feasible approach. People's behaviour is often shaped by their perception of how those around act and deem to be desirable. The normative approach uses a manipulation of social norms to create a cognitive change in compliance behaviour. This research combines a portion of Becker's model of deterrence with Berkowitz's Social Norms Approach to evaluate the efficacy of the normative approach to non-compliance and attempt to correct non-compliant behaviour within the recreational fishery. Due to the complexity of the recreational fishery, data were only collected from rock & surf fisherman. A total of 464 face-to-face baseline surveys, measuring the rate of compliance and the behavioural drivers behind compliance were completed along the coast line of Kwa-Zulu Natal, Eastern Cape and Western Cape Provinces. Nearly 51% of the respondents indicated that they had committed at least one violation of the recreational fishing regulations. Keeping undersized fish was the most common violation (~19.6%), followed by fishing without permits (~16.9%), exceeding bag limit (~12.9%), using prohibited bait or tackle (~11.9%), keeping a prohibited species including those kept during their closed season (~8.1%), selling their catch (~4.7%) and fishing in a closed area (~2.4%). Responses indicate that perceived chances of detection for illegal activities is low to very low (~60.3%) and that there is a significant pluralistic ignorance existing within the norms of the fishery. This may indicate that increased enforcement and the social norms approach may be able to correct non-compliant behaviour. Following further analysis of the baseline, specific interventions will be created in areas that show suitability for an intervention. For instance, areas where there is insufficient knowledge of the regulations will be provided a notice board with the regulations outlined on it. For areas with a high level of pluralistic ignorance, the difference between what people think other people should do compared to what they actually do, a structured informational campaign on the norms present in that area will be undertaken. After the implementations have been in place for 12 months, the initial survey will be conducted again in the same locations to determine whether there is any indication that the interventions may be successful, understanding that longitudinal data is required to provide any proof of this success.

Key words: marine; fisheries management; deterrence; recreational fishery; social norms; compliance behaviour; intervention

09h50-10h10: Richard Llewellyn (MSc student) - The effectiveness of the De Hoop Marine Protected Area in the conservation of reef fish and as a tool for fisheries management

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

Funder/s: National Research Foundation (NRF); South African Environmental Observation Network (SAEON)

Fisheries are considered a primary driver of the degradation of fish populations. As a result, Marine Protected Areas (MPAs) have been widely implemented as management and conservation tools to protect the populations of exploited fish species and their habitats. Despite this, the scientific basis for an anticipated beneficial effect on fisheries needs to be strengthened. This project aimed to assess the effectiveness of the De Hoop MPA in protecting exploited reef fish stocks and reef biodiversity, as well as to detect any potential benefits from the MPA to the surrounding fisheries. To achieve this, catch data from the surrounding commercial fisheries were analysed to investigate long-term trends in catch per unit effort (CPUE) outside the MPA. In addition, baseline fish assemblage data from inside and outside of the MPA were collected using baited remote underwater stereo-video systems (stereo-BRUVs).

Fisheries catch data from the Nation Marine Line-fish System (NMLS) database for the areas surrounding De Hoop were analysed by means of Generalised Additive Models (GAMs) with integrated smoothness estimation. The results from the GAMs were then examined for any trends in CPUE data for the period from 1985 (start of the data series and implementation of De Hoop MPA) and 2012 (end of currently available data series), with focus placed on the resident reef fish. The data for reef fish showed a steady decline in CPUE until 2000 with a subsequent recovery in later years. The CPUEs was generally similar or higher around the MPA than away from the MPA, with the exception of carpenter where higher catches were recorded away from the MPA. The baseline stereo-BRUVs survey was conducted in March/April 2015, with a total of 102 samples collected first from areas open to fisheries exploitation ($n = 53$) and then inside the De Hoop MPA ($n = 49$). Videos from the stereo-BRUVs were analysed using EventMeasure to extract species composition, abundance (MaxN) and lengths. To investigate the effect of protection *Status* (exploited or protected) on the reef fish community a two-way permutational multivariate analysis of variance (PERMANOVA) and canonical analysis of principal coordinates (CAP) were performed on multivariate community MaxN and biomass data in Primer V6 with the PERMANOVA add-on package.

Analysis of stereo-BRUVs data indicated that *Status* and *Bottom type* had a significant effect on the abundance ($p < 0.005$) and biomass ($p < 0.005$). While interaction between *Bottom type* and *Status* only had significant effect on the abundance ($p < 0.0001$). Fish communities differed between exploited and protected. However this result appeared to be driven by the differences in habitat between the two areas. Although every effort was made to sample similar habitat types, very little sub-tidal reef could be located in the De Hoop MPA, while expansive reef systems were found in the areas open to fisheries exploitation. As such the fish community inside the MPA was dominated by sand associated species, including numerous species of shark, while that outside the MPA was dominated by typical reef fishes. It is recommended that a follow up survey be conducted to sample sand habitats outside of the MPA, as well as the very shallow (2-10m) subtidal reefs from both inside and outside of the MPA.

Key words: marine; conservation; MPA; fisheries management; stereo-BRUVs

10h10-10h30: Warren Witte (MSc student) - The Potential for Commercial scale ranching in the Eastern Cape Province in South Africa

Supervisor/s: Prof. PJ Britz

Funder/s: THRIP; Lidomix (Pty) Ltd

Abalone ranching is a potential solution to replenishing depleted abalone stocks along the South African coastline where poaching of the resource has led to drastic declines in abundance and compromised recruitment. Hatchery reared abalone of varying sizes were released onto depleted reefs using either hand seeding or surface scatter methods. 36 small-scale experimental sites were seeded over two broad habitat areas with varying densities and sizes of abalone. Results have shown minimum survival rates of 18% in habitat 1 after 8 months with growth rates of 1.2mm.month^{-1} and 15% in habitat 2 after 9 months with growth rates of 1.61mm.month^{-1} . The large variation in growth between the two habitat types appears to be related to food availability, while survival differences appear to be related to search ability and collection conditions.

Abalone were also seeded on a large-scale using the surface scatter method which has effectively seen 1.4 million (29 tons) abalone released onto 160 sites around Cape Recife in the Eastern Cape province of South Africa. Survival rates for abalone of average size of 37mm ranged between 4% 450 days post release to 27% 666 days post release on sites. Larger abalone of 75mm archived survival between 12%-23% after 600 days at large on sites. Survival estimates appear to be linked tightly to habitat type, as well as seeding method. Video evidence suggests that high loss of abalone initially on a site is due to the high levels of fish predation and the high rate of movement induced by the disturbance following outplanting.

Along with the successful employment of private security to protect the resource, it appears that ranching may be a viable alternative to current fisheries management approach, whereby privatising the resource and giving exclusive access rights to user groups will ensure continued investment through reseedling. The economic incentive using sustainable harvesting levels will ensure the long-term growth of the fishery that is currently in deeply troubled waters.

Key words: marine; mariculture; abalone ranching; restocking

10h30-10h50: Moqebelo Morallana (PhD student) - Can abalone larvae be used to augment natural populations?

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

Funder/s: Technology and Human Resources for Industry Programme; Wild Coast Abalone Farm (Pty) Ltd

South African abalone *Haliotis midae*, is a large marine snail that is highly prized as seafood delicacy in the Far East. It is one of five species found along the coast, and the only one exploited commercially. Massive decline in the resource led to the closure of the fishery, but poaching continues to put more pressure on the resource and could potentially drive wild stocks to extinction. Abalone ranching offers a viable solution to re-building declining wild stock populations. However, using large seed for ranching is expensive, and these seed are being targeted by predators during these seeding events; thus, reducing the number of available seed considerably. In an attempt to reduce the costs and to maintain a sustainable ranching venture, this study aims to test abalone ranching using abalone larvae to try and re-build wild abalone stocks.

Abalone larvae can be mass produced, is relatively cheap, easy to handle, and can be re-introduced back in the wild at a fraction of a cost than using large seed. Abalone larvae will be batch-tagged with a fluorochrome, calcein [$C_{30}H_{26}N_2O_{13}$], that will be incorporated in their growing shells. Larvae would be immersed in different concentrations and time periods in calcein, and survival of settled larvae and subsequent juveniles would be observed. Calcein is non-toxic, does not affect developmental growth has been used successfully in many molluscs species. The usage of calcein offers a way to establish which abalones are wild and which originates from the farm once seeded in the wild. Periodic sampling and long-term monitoring will be established to monitor whether these abalone contributes to the establishment of wild stock population stocks.

Key words: marine; fisheries management; abalone; poaching; ranching; calcein

10h50-11h20: Tea break

Behavioural Ecology (Chair: Kerry van der Walt)

11h20-11h40: Roxanne Juby (MSc student) - Investigating the possible interactions of diel fish activity patterns and photic preferences that drive Algoa Bay's observed reef fish assemblage, using baited remote underwater stereo-video systems

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

Funder/s: National Research Foundation (NRF); Elwandle Node South African Environmental Observation Network (SAEON); South African Institute for Aquatic Biodiversity

Our understanding of South Africa's warm temperate rocky reef fish communities is based largely on studies that have been limited to day time sampling. As a result, diel variation in these fish communities and the associated drivers of these changes are poorly understood.

In order to gain a more comprehensive understanding of the dynamics of these communities, this study used baited remote underwater stereo-video systems (stereo-BRUVs) to test the hypothesis that diel variation in fish community composition and structure exists at shallow (10-30m) and deep aphotic (55-100m) sites along two rocky reefs in Algoa Bay. Furthermore, the research tested whether diel fish movement between shallow and deep aphotic reef sites is occurring, and whether the observed assemblages are the result of these activity patterns. Diurnal fish communities inhabiting the shallow reef zone were the most distinct community, with a significantly richer and more abundant assemblage than those recorded at other treatment groups ($P < 0.001$). Seventeen species belonging to 11 families were exclusively recorded at the shallow zone during the day. Of these, eight species belonged to the family Sparidae. A negative binomial generalised linear model conducted on a grouped abundance of all Sparids revealed a significant positive effect of the shallow day environment ($P < 0.05$), relative to the deep and nocturnal samples. These results indicated that the Sparids that dominate the shallow day community have a strong preference for the photic environment and its associated conditions. The absence or substantially reduced abundances of these Sparids was largely responsible for the significant differences in assemblage composition and abundance detected between day and night at shallow reefs (overall community abundance (a): $P = 0.001$; composition (b): $P = 0.0001$), at deep aphotic reef sites ((a) $P = 0.001$; (b) $P = 0.0001$) and also between deep and shallow diurnal communities ((a) $P = 0.01$; (b) $P = 0.01$). The significant diel variation in communities inhabiting the shallow zone was also attributed to substantial higher abundances of *Galeichthys ater* and *Pagellus bellotti natalensis* at night. Significant diel variation at deep aphotic reef sites ((a) $P = 0.001$; (b) $P = 0.0001$) were largely driven by two Sparids that are typical of deep water assemblages (*Pterogymnus lanarius* and *Argyrozona argyrozona*) being more abundant in the diurnal communities, while *G. ater* and *Squalus* sp. had increased abundances at night. These observations revealed a highly significant positive effect of night for *G. ater* ($P < 0.001$). Furthermore, a preference for aphotic environments was revealed for *Squalus* sp. as a significant positive effect for the shallow zone at night was revealed ($P < 0.006$). This suggested that this species undergoes diel movement into the shallow depth zone in response to the reduced ambient light. This study showed that by including nocturnal sampling in ecological studies our understanding of fish community dynamics may be enhanced.

Key words: marine; ecology; stereo-BRUVs; diel variation; movement patterns; rocky reefs

11h40-12h00: Nicholas Schmidt (MSc student) - What effect does bait have, when sampling with remote underwater stereo-video systems, on the association between fish and habitat type over fine spatial scales?

Supervisor/s: Dr A Bernard (a.bernard@saiab.ac.za); Dr E Heyns-Veale (elodieheyns@gmail.com); Dr A Götz (albrecht@saeon.ac.za)

Funder/s: National Research Foundation (NRF); South African Environmental Observation Network (SAEON)

The use of bait when sampling with baited remote underwater stereo-video systems (stereo-BRUVs) can potentially alter fish-habitat associations. Habitat information, including substrate type and macrobenthic invertebrate (i.e. macrobenthos) cover, can be used as a covariate to explain the variation seen in the fish community structure. However, with baited sampling methods it does not take into account that bait may attract fish species from neighbouring habitats. This could potentially hide the exact nature of the relationship between fish and their habitats. To determine the extent to which bait effects fish-habitat associations, a field study was conducted in the Tsitsikamma National Park MPA. The objectives of the study were to: i) define the fine-scale benthic habitats, taking into account substrate type, depth and macrobenthos cover within the study area, and ii) utilising the habitat types defined above, determine if there is a relationship between fish and habitat type, and measure the effect of bait on the observed relationship? The field study consisted of a detailed drop camera survey to sample the macrobenthos followed by an assessment of the fish community employing baited and unbaited (stereo-RUVs) remote video sampling techniques. The photo quadrats collected from the drop camera were used to create a habitat map which showed the distribution of macrobenthos and substrata within the study area. Five distinct habitat types were described, separating out reef and reef edge habitats from shallow and deep sand habitats. The reef habitats showed depth driven differentiation with the macrobenthos assemblages differing between shallow ($\leq 14.7\text{m}$) and deep reef ($> 14.7\text{m}$). Highly significant difference in fish community structure between habitat types were identified, for both baited and unbaited samples. Furthermore bait was found to significantly alter the species assemblage structure within habitats. This difference was driven by changes in abundance of *Chrysoblephus laticeps*, *Boopsoidea inornata*, *Spondyllosoma emarginatum* and *Chirodactylus brachydactylus*, together with the presence of elasmobranchs in the baited samples. The results further demonstrated that the effect of depth was consistent between the baited and unbaited samples with a significant negative effect on species richness. However, by using bait, significantly higher species richness was recorded. The results clearly demonstrated that both the baited and unbaited methods were able to detect species habitat associations expected within reef fish communities. While bait greatly increased the diversity and abundances of fishes, it also reduced variability between samples. In contrast, the fish assemblages identified with the unbaited method were highly variable resulting in less distinct habitat associations. While bait undoubtedly alters the observed fish assemblage, relative to unbaited techniques, the stereo-BRUVs appear to be a robust method to detect species habitat relationships.

Key words: marine; ecology; macrobenthos; fish-habitat association; stereo-BRUVs

12h00-12h20: Mike Dames (MSc student) - Factors affecting estuarine and coastal connectivity of an estuary-dependent species *Pomadasys commersonnii* (Haemulidae)

Supervisor/s: Prof. PD Cowley (tagfish@gmail.com); Dr A-R Childs (a.childs@ru.ac.za); Dr RH Bennett (rhettroman@gmail.com)

Funder/s: South Africa-Norway programme for research co-operation (SANCOOP); National Research Foundation (NRF)

Spotted grunter *Pomadasys commersonnii* (Haemulidae), is an important linefish species targeted by the recreational and subsistence fisheries in South Africa. Movement studies suggests that they display high residency to estuarine environments. However, information on connectivity among multiple estuaries and the degree of utilisation of the marine environment is lacking. To address this knowledge gap, this study aimed to investigate multiple habitat (estuaries and the marine realm) connectivity in *P. commersonnii*. Passive acoustic telemetry was used to track 26 individuals (281 – 522 mm TL) tagged in the neighbouring Kariega ($n = 15$) and Bushmans ($n = 11$) estuaries. Longshore and “estuary hopping” movements were recorded on an array of receivers spanning 271 km of coastline. Tagged *P. commersonnii* spent most of their time in their respective tagging estuaries (Kariega: 55%, Bushmans: 85%) followed by time at sea (Kariega: 30%, Bushmans: 15%), and time in other estuaries (Kariega: 15%, Bushmans: < 1%). They also showed high levels of connectivity with 93% and 60% of sea-going fish from the Kariega and Bushmans, respectively, visiting neighbouring estuaries. Most visits were undertaken to the Swartkops ($n = 22$), Bushmans ($n = 14$, for “Kariega” fish) and Kowie ($n = 14$) estuaries, although cumulatively most time outside of their tagging estuaries was spent in the Sundays Estuary (5%). For fish tagged in the Kariega Estuary, most of the time spent outside of their tagging estuary was spent in the neighbouring Bushmans Estuary (6%), yet no fish tagged in the Bushmans visited the Kariega Estuary. Thirty-nine percent and 52% of all sea trips were return trips, from and returning to the same estuary, Kariega and Bushmans, respectively. The mean duration of sea trips from the Kariega and Bushmans estuaries were 25 days (SD 17) (range: 3 – 55) and 12 days (SD 8) (range: 2 – 22), respectively. *Pomadasys commersonnii* tagged in the Kariega and Bushmans estuaries moved, on average, distances of at least 201 km (range: 0 – 519) and 184 km (range: 0 – 529) during the study period, respectively. Cyclical variables (i.e. time of day and tidal phase) had no significant effect on arrivals and departures to and from the tagging estuaries and other estuaries for both Kariega and Bushmans tagged fish. However, for season, Kariega tagged fish showed significant findings for departures from both the Kariega Estuary (mean month: December, $p = 0.00$) and other estuaries (mean month: February, $p = 0.00$). Kariega tagged fish also showed significant results for arrivals to other estuaries (mean month: February, $p = 0.00$) and the Kariega Estuary (mean month: January, $p = 0.04$). However, for Bushmans tagged fish, no significant effects were found for season on arrivals and departures to and from the Bushmans Estuary and other estuaries. This study will also investigate the effects of environmental variables (i.e. temperature, wind, barometric pressure, rainfall and photoperiod) on departures from and arrivals to their tagging and other estuaries. The high levels of time spent within their tagging estuaries and the high levels of connectivity to neighbouring estuaries highlights the dependence of *P. commersonnii* on estuaries, particularly to a single “tagging” estuary, and the importance of these habitats for this species.

Key words: estuarine; ecology; marine; connectivity; acoustic telemetry

12h20-12h40: Jade Maggs (PhD student) - Movement patterns of important fishery species in coastal waters of southern Africa

Supervisor/s: Prof. PD Cowley (tagfish@gmail.com)

Funder/s: South African Institute for Aquatic Biodiversity (SAIAB)

Movement of fishes is an integral part of their daily life, but has significant implications for fishery management. In South Africa's multi-user, multi-gear, multi-species fishery, management is challenging. To complicate matters further, many of the targeted species exhibit complex movement behaviour. Individuals may be highly resident for extended periods before travelling long distances over short periods of time. Many species also participate in annual migrations, sometimes covering thousands of kilometres along the South African coastline. It is hypothesized that, in this region, certain commonalities exist in fish movement patterns. Understanding these commonalities will aid in the planning of future spatial and temporal management initiatives. This study will synthesize what is currently known of fish movement and migration patterns in South Africa, will develop a classification system of fish movement, investigate intra-population variability and discuss fishery management in the context of fish movement behaviour.

A review of South African fish movement research yielded 101 marine and estuarine fish movement studies from southern Africa published over 87 years from 1928 to 2014. From 2000, onwards fish movement research featured more often as the primary topic of a publication in contrast to the previous periods where it was more often included as an auxiliary topic within biological or ecological publications. Studies focused on the subtropical and warm-temperate region between Cape Point and Kosi Bay. Ten movement themes were identified in the surveyed literature, including broad-scale movement patterns, which featured in 68% of studies, followed by fine-scale habitat usage (33%) and protected areas (26%). Major knowledge gaps include a classification of movement types, factors influencing movement behaviour and the occurrence of partial migration.

An empirical classification of fish movement has been developed using mark-recapture data from the Oceanographic Research Institute's cooperative fish tagging project (ORITag). The classification procedure, built from the results of an ordinal regression model, identified two primary groups of species according to movement. Residents had a very high probability of being recaptured within 5 km of the tag-release site after a period 365 days. Wide ranging species had a much lower probability of being recaptured within 5 km after the period. The scale of long range movements was also much greater in wide ranging species, with a relatively high probability of being recaptured more than 50 km away from the tag-release site. Differences in the scale of movements have implications for the way these species are managed. Life stage (juvenile/adult) and time at liberty were found to be statistically significant ($p < 0.05$) factors associated with the scale of movement. Body size and trophic level were also found to be associated with mobility. Knowledge of these two factors may assist in predicting movement behaviour, and thus preferred management regimes, in other species where movement is poorly understood. Partial migration describes the coexistence of resident and migratory behaviour within a population. With the study species classified as resident or wide ranging, the occurrence of partial migration among these species is now being investigated using ORITag data.

Key words: marine; fisheries management; fish movement; fish tagging; fish tracking

12h40-13h00: Ralph Watson (PhD Student) - Movement behaviour and trophic ecology of two endemic catsharks (Scyliorhinidae) from South Africa

Supervisor/s: Prof. PD Cowley (tagfish@gmail.com); Dr E Gennari (e.gennari@oceans-research.com)

Funder/s: National Research Foundation (SFH14073184380) (NRF); Oceans Research; South African Institute for Aquatic Biodiversity, Save Our Seas Foundation

Nowhere else in the world is the endemism of catsharks (Scyliorhinidae) higher than off the coast of southern Africa. Despite having over 16 species of catsharks, of which 10 are endemic, knowledge of these animals is severely lacking. The purpose of this study is to contribute to the understanding of the spatial and trophic ecology of two common congeneric sympatric inshore benthic species, namely the pyjama catshark (*Poroderma africanum*) and the leopard catshark (*P. pantherinum*). More specifically, the study will investigate the movement and trophic ecology, habitat (reef) connectivity, trophic niche overlap and relative abundance of these two co-occurring species in Mossel Bay.

Movement ecology will be studied using acoustic telemetry. The existing network of acoustic receivers under the auspices of the Acoustic Tracking Array Platform have been complemented with an additional five receivers that have been deployed at strategic sites in Mossel Bay, including shallow reefs and the harbour, the latter as a possible anthropogenic food source. A total of 19 individuals (divided between species and sex) have been internally tagged with VEMCO V16-4H coded transmitters and will be tracked over a two year period. Trophic ecology will be examined by analysing the stomach content collected through gastric lavage. Prey will be analysed to the lowest possible taxon and quantified by number (N), weight (W) and frequency of occurrence (F). The Index of Relative Importance (IRI) as a percentage will then be calculated using $\%IRI = (\%N + \%W) * \%F$. The marine fish assemblages and relative abundance of these catshark species will be studied using Baited Remote Underwater Video Systems (BRUVS) deployed at selected reef sites in the bay. Using this multi-method approach, a number of research questions will be addressed to gain a better understanding of the spatial and trophic ecology of these ubiquitous, yet under studied, catshark species.

Preliminary results suggest that *P. africanum* display ranging behaviour, returning occasionally to individual home reefs. While natural prey items in the stomachs of *P. africanum* was dominated by teleosts, the prevalence of bait organisms is suggestive of scavenging behaviour. *Poroderma pantherinum* are more generalist feeders on crustaceans, molluscs and teleosts. The relative abundance of the two species was fairly homogeneous across the studied reefs, with *P. africanum* in higher abundance than *P. pantherinum*.

Key words: marine; ecology; acoustic telemetry; diet; gastric lavage; BRUV

13h00 DIFS Photograph

Non-presenting students

Lesley Bloy (MSc student) - The effect of water temperature on the distribution of the Eastern Cape redfin minnow *Pseudobarbus afer*

Supervisor/s: Prof. OLF Weyl (o.weyl@saiab.ac.za); Dr Helen Dallas (helen@frcsa.org.za)

Funder/s: Henderson Postgraduate Scholarship; South African Institute for Aquatic Biodiversity; Freshwater Research Centre; Water Research Commission (K5/2337)

This study aims to increase the understanding of factors influencing the limited distribution of the endangered Eastern Cape redfin minnow *Pseudobarbus afer*. With non-native fish invasions being a primary threat to this species, it is important to grow the understanding of what environmental factors determine both native and non-native fish distributions. The main objectives of this study are to i) use snorkel surveys contextualise the distribution of both native and non-native fishes in headwater streams to assess whether the downstream distribution of *P. afer* and the upstream invasion fronts are likely to be influenced by temperature; ii) conduct an experiment to determine the preferred and critical temperatures of *P. afer* and; iii) investigate whether temperature is limiting across a river scape.

Snorkel surveys were conducted in headwater tributaries of the Swartkops and Gamtoos river systems in December 2015. In these systems mainstem populations of non-native predatory species, such as those from the *Micropterus* genus, are known to act as source populations for headwater invasions. These invasion fronts are fluid in space and time. Preliminary analysis of the distribution data suggests that, in the absence of non-native predatory species, native fishes have the potential to inhabit pools throughout the system right to the confluence.

Thermal experiments have been conducted in the Groendal Wilderness area with fishes collected from the Fernkloof River. In order to investigate thermal tolerance, a Julabo circulating heater was used and the temperature was ramped at a rate of 0.3°C/minute. Non-lethal endpoints, which were defined as the loss of equilibrium and self-righting ability, were used as cues to terminate the experiment. Preliminary data suggests that *P. afer* has an upper thermal tolerance of 29.9°C which is independent of size (p-value =0.73) while *Sandelia capensis* has an upper thermal tolerance of 32.1°C which appears to be influenced by size (p-value =0.019). After preliminary analysis, the thermal preference of *P. afer*, tested in choice chambers in the field, appears to be influenced by acclimation temperature. The mean acclimation temperature in summer was 22.9°C and the mean preferred temperature was 25.3°C, while in winter the mean acclimation temperature was 11.8°C and the mean preferred temperature was 18.6°C.

Snorkel surveys will be conducted in December 2016 to determine whether there have been any further shifts in invasion fronts and consequent changes in species distributions. Furthermore, Hobo logger data from long term monitoring sites will be collected and therefore allow for an understanding of the thermal profile of the streams. This data will be analysed and with na understanding of the thermal range of *P. afer*, provide context as to whether the presence of non-native predatory species or temperature of the driving factor of native species distribution.

Key words: freshwater; ecology; invasion fronts; thermal tolerance; headwater tributaries

**Edward Butler (MSc student) - Aspects of the life history of the giant African threadfin
Polydactylus quadrifilis in the Kwanza River, northern Angola**

Supervisor/s: Prof. WM Potts (w.potts@ru.ac.za); Dr A-R Childs (a.childs@ru.ac.za)

Funder/s: Kwanza Tarpon Lodge

The giant African threadfin *Polydactylus quadrifilis* is the largest member of the family Polynemidae. The species is important to local subsistence and small scale commercial fisheries along Africa's west coast from Senegal to Angola. Anecdotal evidence from the Kwanza River area has suggested that local fishing pressure, in the form of gill-nets, longlines and conventional methods, are increasing steadily and that *P. quadrifilis* are seldom female unless large (> 120 cm). To date, there is limited biological information on the species. This study aims to investigate the basic biological traits of the giant African threadfin that are found in and around the Kwanza River. Biological information was collected by a field assistant at the Kwanza River between 2007 and 2014 and includes 87 *P. quadrifilis* sagittal otoliths with corresponding size and weight information. Additional samples (n = 100) *P. quadrifilis* were collected from the Kwanza River between the 21st of June and the 15th of September 2016. Fish were either caught on conventional tackle or bought from local gill-net or longline fishermen. Fish were measured (FL & TL, mm) and weighed (kg) before being dissected. Fish were sexed and maturity-staged and the liver and gonads were weighed. The stomach contents were identified as far as possible and weighed. Fish were then reweighed to give the eviscerated mass and the sagittal otoliths were removed and stored in manila envelopes for otolith sclerochronology at a later date. Gonads were stored in a 10 % formalin solution for later histological analyses. A total of 93 *P. quadrifilis* caught on conventional gear were measured, tagged (Hallprint PDA dart tag) and injected with oxytetracycline (OTC 30 mg/kg) before being released. It is hoped that one of these fish will be captured in 2017 for use in validating the periodicity of otolith ring formation.

The initial 87 otoliths were sectioned transversely at 0.5 mm following the results of a pilot study. The otoliths were read by three readers and a von Bertalanffy growth equation of $L(t) = 134.4(1 - e^{-0.26(t+1.94)})$ was acquired. Of the 100 fish that were dissected, 84 fish were male (mean FL = 832 mm, range = 436 – 1120 mm), 12 were female (mean FL = 1181 mm, range = 825 – 1360 mm) and four were intersex (mean FL = 904 mm, range = 880 – 925 mm). The diet of *P. quadrifilis* was made up of crabs (2 spp., 26.2 % of stomachs) and clupeid fishes (3 spp., 16.3 % of stomachs). The next research phase will focus on fish ageing and the histological analyses which will be used to verify the reproductive style of this species.

Key words: estuarine; fisheries; Kwanza River; life-history; protandry

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

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

Funder/s: DAAD-National Research Foundation; THRIP (TP2011071800030); Marifeed (Pty) Ltd; HIK Abalone Farm (Pty) Ltd; Aquafarm Development (Pty) Ltd; Roman Bay Sea Farm (Pty) Ltd.

The profitability of abalone farms is influenced by production per unit grow-out space. Production is a function of abalone growth and stocking density, yet little is known about abalone behaviour. The aim of this study was to gain a better understanding of the behaviour of South African abalone, *Haliotis midae*. Two objectives were formulated. Firstly, to determine how stocking density affects the growth and use of space in the abalone basket; secondly, to characterise abalone behaviour and compare behaviour at a low (18 % of the available surface area, SA) and high (25.5% SA) stocking density.

The first objective was investigated by quantifying the position of abalone in baskets using snapshot photograph over an eight month trial. The behaviour of abalone changed over the course of the trial. The percentage of animals seen on the walls of the basket during night time observations decreased linearly over the 240 days of the experiment (HD: $y = 0.058x + 24.74$, LD: $y = 0.066x + 29.20$). Further changes in behaviour on the rack were observed. Growth was estimated as $\text{Weight} = 55.62 + 0.17 \text{ days}$ ($r^2 = 0.97$). The model for the LD treatment was $\text{Weight} = 55.29 + 0.19 \text{ days}$ ($r^2 = 0.98$). There was no significant difference in mean individual weight after eight months ($t_6 = 2.01$, $p = 0.09$). The biomass gain per basket was significantly higher (for the HD treatment 9.16 ± 0.57 kg/basket) than the LD treatment (6.82 ± 0.39 kg/basket; $t_6 = 6.74$, $p < 0.001$). This difference equates to 14 kg production in a six basket HD tank when compared to an LD tank.

The second objective was quantified using focal animal follow protocols and quadrat sampling through a clear-sided PVC tank. There appears to be a trade-off between the percentage of abalone locomoting (L) and grazing (G). The ratio of abalone L(%):G(%) was significantly higher at HD (74:18) when compared to LD (49:42) (Chi-square = 11.14, Chi-square (table) = 3.841, $P < 0.005$). When comparing the proportion of time abalone spent locomoting at night, abalone at HD spent on average 18% more time locomoting when compared to LD (T-test, $t_{46} = 2.67$, $p = 0.01$).

Results demonstrate that abalone are more active (i.e. expend more energy moving around the basket) at a higher density and that they spend less time grazing on diatoms at higher densities than at lower densities. These factors in combination have the ability to influence the growth rate of abalone. Data are currently being analysed.

Key words: marine; aquaculture; photography; observation

Bianca Hannweg (MSc student) - An analysis of observation methods, behavioural studies and habitat usage of *Pseudobarbus afer* in the Swartkops River system in the Eastern Cape, South Africa

Supervisor/s: Prof. OLF Weyl (o.weyl@saiab.ac.za)

Funder/s: South African Institute for Aquatic Biodiversity; Water Research Commission

Headwaters are typically surveyed using techniques such as seining, fyke netting, snorkel surveys and electrofishing. Some of these techniques have been identified as potentially harmful to fishes. This can be considered problematic when working with imperilled species such as *Pseudobarbus afer* (Peters, 1864) and alternative techniques should be explored. Recently, the use of underwater video analysis (UWA) has become more popular with the use of action cameras which allow for time-lapse photography as an additional potential technique. This provides a more benign alternative to classic sampling techniques. Furthermore, an understanding of habitat utilisation is required in order to inform the potential conservation of *P. afer*. This can be obtained by observing *P. afer* in their natural habitat.

The aims of the present study were to, 1) determine the most suitable method determining fish abundance, 2) use UWVA to assess habitat use by *P. afer* and, 3) assess habitat preferences experimentally by natural habitat manipulation and substitution with artificial habitats.

To date, ten Pools in total have been examined, seven in the Fernkloof and three in the Blindekloof tributaries. Pools were assessed using a two-pass snorkel survey and UWVA. Action cameras were set up in each pool and filmed for a total of 18 minutes taking photos concurrently every five seconds. MaxN (the total number of species seen in one frame at a certain time) was determined separately for videos and photos. Length and average widths of each pool were measured to express fish density per m for snorkel surveys. Abundance of *P. afer* ranged from 0.795 to 2.073 fish/m. Comparisons between snorkel surveys and UWV are currently underway.

For assessments of habitat use, preliminary winter video samples have been collected. This involved using three cameras per pool and filming in four pools at midday for three consecutive days (n=4). Focus was placed on three habitat types: the middle, branch debris and fern overhangs. Water quality parameters were taken three times a day each day using a HANNA. Habitat maps were created with pool measurements and habitat types found in each pool. These habitat maps will aid in determining where cameras should be placed for summer filming according to where *P. afer* are found in each pool. Summer samples are still to be collected which will include filming in four pools, three times a day for three consecutive days. For the collection of summer samples, five cameras in each pool will be used for filming instead of three. This will be done in the same four pools examined in the winter sampling process.

Analysis of videos and photos from winter samples is ongoing to understand behaviour of *P. afer*. All work for habitat manipulation and habitat recreation will take place in early 2017.

Keywords: freshwater; ecology; Swartkops; MaxN

Manda Kambikambi (MSc student) – Multi-tissue turnover rates using stable isotopes to quantify resource use by chubbyhead barb

Supervisor/s: Dr W Kadye (w.kadye@ru.ac.za); Dr A Chakona (a.chakona@saiab.ac.za)

Funder/s: -

Stable isotope analysis is frequently used to assess the trophic ecology and characterize the food webs of river, lake and terrestrial ecosystems. Such information can be used as a guide for conservation of vulnerable species. For freshwater fishes, current methods on trophic ecology rely on muscle data, and the sampling of such data involve either euthanasia or muscle biopsy that may be inappropriate for small-sized and endangered fishes. A number of studies have investigated the applicability of non-lethal tissues such as blood, mucus, scales and fins as possible substitutes to white muscle when dealing with endangered fish species. In order to contribute towards trophic ecology studies on endangered freshwater taxa, this study explores the use of non-lethal fin tissue for trophic studies on chubbyhead barb *Enteromius anoplus*. Chubbyhead barb is comparable in size to most of the threatened minnows in Southern Africa, is abundant and of least concern.

To achieve this, this study uses a two-pronged approach based on laboratory and field experiments to examine isotopic turnover rates of muscle and fins. For the laboratory experiment 250 chubbyhead barb were collected from the headwaters of the Koonap River. Controlled laboratory feeding experiments using two isotopically distinct feeds are currently being carried out in order to: (i) determine the turnover rates of fin and muscle tissue of chubbyhead barb and (ii) to determine if fin tissue can be a substitute for muscle tissue in trophic studies of chubbyhead barb. Fish are randomly selected and sacrificed at various days to assess the $\delta^{13}\text{C}$ & $\delta^{15}\text{N}$ stable isotope ratios of fish over time. For the field experiment $\delta^{13}\text{C}$ & $\delta^{15}\text{N}$ of primary producers and consumers, which include chubbyhead barb and aquatic invertebrates, are being investigated seasonally in order to describe the food web in the headwaters of the Koonap River. Specific objectives are to (i) investigate the seasonal changes in food web and resource availability for chubbyhead barb and (ii) identify the organic matter sources and supporting consumers in the headwaters of the Koonap River.

Overall, by characterizing the food web in the headwaters of the Koonap River, this will lead to an understanding of how energy is transferred in similar headwaters streams. Furthermore, determining turnover rate of fin tissue could be assessed as an alternative for white muscle in trophic studies of chubbyhead barb and related endangered minnows.

Key words: freshwater; ecology; conservation; stable isotope analysis; food web analysis

Thomas Keet (MSc student) - Larval-rearing techniques for *Argyrosomus japonicus*, with specific focus on a novel feeding regime

Supervisor/s: Dr T Shipton (ihts@imagnet.co.za); Prof. H Kaiser (h.kaiser@ru.ac.za)

Funder/s: Technology and human resources for industry programme (TP1208015347)

One of the biggest limiting factors in marine finfish aquaculture in RSA is the low survival rate of early stage larvae. Most mortalities can be ascribed to the poor nutritional value of live feeds, cannibalism, and various stressors that result in swim bladder hyperinflation and/or starvation during the larval stage. Opinions in the relevant literature on the best timing for artificial feed introduction and the ideal water quality parameters and management techniques for good survival and growth rates in dusky kob larvae vary. The main objective of this trial is to improve survival rates.

The main experiment will focus on a new feeding regime during the weaning of larvae onto an artificial diet. This is based on findings and recommendations made by Musson & Kaiser (2014). Histological preparations of the development of the gastrointestinal tract of dusky kob larvae from day 1 to 30 after hatching indicate that larvae possess a fully developed fundic stomach and pyloric caeca around 16 DAH. This enables longer feed storage time, more extensive mixing of feed with digestive enzymes and an increased absorption area. An earlier weaning period should increase survival and growth rates, while reducing the labour costs associated with a lengthy period of live feed cultivation.

The relatively short time period needed to conduct the experiment, 30 days, enables replicate trials. Throughout these replications, parameters such as temperature, water turbidity, photoperiod and light intensity can be manipulated to find a set of parameters that maximise survival and growth rates. These inter-trial comparisons are an auxiliary outcome of the main experiment.

The findings suggest that kob larvae could be weaned onto dry food earlier than the strategy commonly used on farms. Morphometrics of larvae at different stages of development will be reported in the thesis.

Musson M, Kaiser H (2014) Development of the digestive system in dusky kob, *Argyrosomus japonicus*, larvae. *Aquacult Int* 22: 783-796

Ballagh D A *et al.* (2010) Weaning requirements of larval mullet, *Argyrosomus japonicus*. *Aquaculture Research* 41, 493-504

Key words: marine; aquaculture; larviculture

Pule Mpopetsi (MSc student) - Interacting effects of elevated temperature and acidification on early life history stages of dusky kob *Argyrosomus japonicus*

Supervisor/s: Prof. WM Potts (w.potts@ru.ac.za); Dr A-R Childs (a.childs@ru.ac.za); Dr NC James (n.james@saiab.ac.za)

Funder/s: Sandisa Imbewu (Rhodes University)

Changes to the marine environment caused by global climate change have been recorded. These include increases in average sea temperatures as well as ocean acidification. Most studies on the effects of these two environmental parameters on aquatic organisms have focused on one variable at a time, either temperature or pH alone. There are few studies on the interacting effects of these two parameters on aquatic organisms, and even fewer on marine vertebrates such as fish.

The overall aim of this study is therefore to look at the interacting effects of elevated temperature and acidification on the early life history stages of dusky kob *Argyrosomus japonicus*, a commercially and recreationally valuable fish species found off the coast of South Africa. Adults of this species are found in the marine environment and spawn in the nearshore. Postflexion larvae and juveniles (± 20 mm in length) recruit into estuarine nursery areas where they remain until approximately 150mm in length after which they migrate back to sea.

This study will simulate temperature and pH (CO₂-induced acidification) levels predicted for the year 2100. Early life stages of dusky kob, egg and larvae (0 to 20 days post hatch, dph) will be exposed to these conditions and some of the biological responses then measured. These will include metabolism (CO₂ consumption), growth rates and survival.

Two measurements will be taken for the three post-hatch life stages, preflexion, flexion and postflexion. Larvae will be transferred from the rearing tank to the respirometer with water conditions, temperature and pH resembling that of the rearing tank and will be left to acclimatise for 24 hours. The respirometer will then be closed and the rate of dissolved O₂ consumption will be measured. Each trial will consist of larvae from all three treatments. A sample of 30 or more larvae per tank will be taken at 0, 14 dph and last day of the experiment for growth measurements. The total length of the larvae will then be measured to the nearest 1 mm under a light microscope and averaged per tank and treatment. The data will be used to estimate the average growth rate for each treatment. Survival studies will be done by estimating stocking density per tank over time. Three random samples per tank will be taken at 0 and 14 dph and the last day of the experiment. The estimated survival rate will then be the number of estimated larvae at the start subtract the remaining at the end of the experiment, taking into account the number of larvae removed from the tank throughout the course of the experiment.

Data from this study can be used to make inferences about the potential impacts of global climate change on this species and other aquatic organisms, especially those of marine origin.

Key words: marine; climate change; ecology; fisheries

Nomonde Ndlangisa (MSc student) - Stock enhancement of abalone in a rural coastal village, with community development in mind: A pilot study at Hamburg, Eastern Cape, South Africa

Supervisor/s: Prof. PJ Britz (p.britz@ru.ac.za); Prof. M Roodt (m.roodt@ru.ac.za)

Funder/s: THRIP; Lidomix (Pty) Ltd

Along the South African coastline, the harvesting of various molluscs and bivalves is important to food security and the livelihoods of those who utilise these resources. In rural small scale fishing communities, stock enhancement and ranching of species such as abalone *Haliotis midae* has the potential to improve the state of the resource while also acting as a driver of rural community development. The objectives of this study were to assess the state of the inshore abalone resource along the coast line at Hamburg Eastern Cape, develop tools to implement a co-management arrangement between the community, industry and government institutions and develop a business model that links the project into value and distribution chains, optimising socio-economic gain from the project. There were two main components to this study; the first was to assess the state and potential of the resource. This was done by conducting biological surveys which were compared to a previous study at the same location. Reefs supporting abalone with the potential for abalone stock enhancement were identified and mapped using satellite imagery and local knowledge. The second component of this study was to make use of participatory action research to determine ways to build capacity among all the relevant stake holders involved in this partnership. In the small scale fisheries policy promulgated in 2012, co-management is identified as the way forward for effective management of small scale fisheries. Through observations at government and community meetings, interviews and focus groups, concepts for an implementation strategy for co-management, particularly through public-private partnerships were derived.

The biological survey produced similar results to the study conducted in 2006. A low density of juvenile abalone was observed in the infralittoral zone and no emergent abalone were found in any of the quadrats suggesting heavy harvesting pressure by small scale fishers. The participatory action research confirmed that public private partnerships are a useful tool to drive co-management. With low capacity observed at the community level, poor implementation at the government level and a desire from industry to increase their role in development, rural small scale fisheries provide an ideal environment for partnership. The current policy informing small scale fisheries which has shifted from being purely biological in focus, remains a hindrance to this process as it still employs a top-down management approach, not based on community needs. Public private partnerships create a platform for co-management through skills transfer as they are inclusive, purpose driven and value adding, rather than the rigid cooperative model we see blue printed in the regulations to small scale fisheries released this year.

Key words: marine; fisheries management; participation; development

Martinus Scheepers (MSc student) - Population genetic structure and dispersal in relation to mating system in clinids

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

Funder/s: National Research Foundation (NRF) (Scarce skills scholarship: Grant 100196); National Research Foundation Incentive Funding for Rated Researchers (Grant 96148)

Klipfishes are viviparous fish of the family Clinidae, with around 42 species in 14 genera that are endemic to South Africa. Males possess an intromittent organ and fertilization is internal. Breeding seems to occur throughout the year with females carrying broods at different stages of development, a phenomena called superfetation. Superfetation, as seen in clinids, occurs in some other viviparous fishes, and is probably an adaptation to decreased fecundity experienced by live bearing fish. Whether the different “broods” are the consequence of polyandry, sperm storage from a single copulation, or multiple copulations with the same male is an interesting question. Polygynandry or promiscuity seems to occur in *C. cottoides*, and sperm storage has been observed in *Fucomimus mus* whether the sperm is from a single or multiple males remains unknown. By carrying young internally, parentage assessment of offspring is fairly straightforward, making clinids an ideal group of fishes to study the effect that mating systems may have on dispersal and population genetic structuring.

Using two genetic markers (Amplified Fragment Length Polymorphisms and microsatellites), paternity, skew in reproductive success, levels of inbreeding, sex-biased dispersal, gene flow (contemporary and historical), and levels of structuring across multiple spatial scales (100m to 200km) will be quantified for *Clinus cottoides*, *Clinus superciliosus*, and *Cirrhibarbis capensis*. If there are differences in mating systems between the studied species, the effect thereof on population genetic structuring and genetic diversity will be compared. To date I have concluded two field trips and collected 561 clinids, representing eight species from six genera. Six localities have been sampled between Knysna and Skoenmakerskop, with one locality left to be sampled in the near future. DNA has been extracted from over 300 individuals so far. Microsatellite primers for twelve loci have been obtained, and I’m in the process of optimising reaction conditions, and ascertaining levels of polymorphism at each locus.

Key words: marine; population genetics; gene flow; microsatellites; AFLP; parentage

Sheena Talma (MSc student) - Fly fishing in the Seychelles Archipelago and genetic connectivity of bonefish: implications for fisheries management

Supervisor/s: Prof. PD Cowley (tagfish@gmail.com); JR Glass (jessica.glass@yale.edu)

Funder/s: South African Institute for Aquatic Biodiversity; Western Indian Ocean Marine Science Association.

Bonefishes (*Albula* spp.) have a global warm water distribution and are most commonly found in sheltered, clear water habitats. The *Albula* species complex supports fisheries worldwide at a subsistence, commercial and, primarily, a recreational level. Due to their popularity as a recreational fly fishing species, they contribute significantly to local tourism-based economies throughout their distribution. The importance of bonefish to ecotourism-based fisheries has attracted significant research attention in the Pacific Ocean particularly in regard to the status of their stocks, movement behaviour and genetics. The Seychelles and other countries in the Indian Ocean are also home to flourishing fly fishing industries. However, the bonefish species (*Albula glossodonta*) known from Seychelles waters has received no research attention and the impact of local recreational fisheries remains unregulated, unreported and unknown.

The first aim of this study is to characterize the fly fishing industry in the Seychelles, using existing data collected over the past five years from recreational fly fishery operators based at several islands. Data collected includes catch composition, catch rates per species, number and nationality of guests, destination and seasonality. Questionnaires have also been handed out to fly fishing guides to gather additional information on the dynamics of the fishery. Since little is known about the recreational fishery, the study will be implemented using semi-structured interviews with charter companies and industry representatives located in the Seychelles. All surveys will relate to the 2016 fly fishing season and it is expected that data collection will be completed by January 2017. Secondly, this study aims to delimit and investigate the genetic connectivity of *A. glossodonta* in the Seychelles, using genetic markers such as microsatellites and amplification of the cytochrome b gene. Fin clips have already been collected throughout the Seychelles Archipelago and Mauritius. It is expected that all laboratory work will be completed by March 2017. The results will be disseminated in the form of popular talks, articles and scientific papers.

Key words: marine; ecology; bonefish; fly fishing; genetics; connectivity

**Jefferson Luke van Staden (MSc student) - Identification of settlement-inducing substances
for South African abalone, *Haliotis midae*, larvae**

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

Funder/s: Department of Science and Technology (DST); HIK Abalone Farm (Pty) Ltd

Haliotids are a valuable marine resource. The value attached to these animals is ascribed to their status as a delicacy in many eastern nations. The life history characteristics of abalone, which are long-lived and slow growing, do not lend themselves to wild harvesting to sustainably meet the market demand. Declining wild populations, fishery closures and reduced quotas created an opportunity for abalone farming.

The species cultured in South Africa is *Haliotis midae*. Research into their captive propagation began in the 1980s. The larvae from the first propagation research in 1988 were raised applying the currently used industry method of settling them onto plates with a diatom biofilm grown in seawater. Settlement is a critical stage in the production cycle of abalone farming and traditional methods of settling abalone are variable with generally low settlement success. To continue growth of the abalone sector and increase efficiency in abalone production, research into the improvement of settlement rates is required.

This project aims to identify the settlement-inducing ability of various biofilm treatments, to determine to what extent certain biofilm conditions are conducive to the settlement of larvae when compared to traditional practices. Total numbers of settled abalone, growth and progression through the stages of larval settlement; (i) attachment, (ii) initiation of metamorphosis and (iii) completion of metamorphosis, will be determined in trials and compared to a control treatment (industry standard method). Observations will be made using both photographic methods and microscopy.

A system was designed for larval settlement tests, and a prototype has been tested. Larvae were inoculated into experimental settlement cups. Observations 16 days post-settlement showed that larvae had fully metamorphosed, survived and that they were feeding. This indicates the systems suitability for settlement assays lasting for a 10-day trial. The success of the prototype system has now led to the construction of five more systems. A settlement plate conditioning system was also designed and is nearing the final stages of construction. In total, the six settlement systems will comprise of 90 settlement cups per trial.

A pre-trial study was conducted to develop a method that would provide the most consistent and precise number of larvae for inoculations. This was done by performing larval counts at three sampling volumes for two days. The least variable method of inoculating larvae into settlement cups was to leave the larvae in the larval cones one day longer than the farm currently does, and to inoculate in volumes of 0.5 ml as opposed to either 1 ml or 0.33 ml.

Key words: marine; aquaculture; abalone; *Haliotis midae*; settlement; biofilm

Chénelle Lesley de Beer (PhD student) - An assessment of the biology and fishery of *Loligo reynaudii* in southern Angola

Supervisor/s: Dr WM Potts (w.potts@ru.ac.za); Prof. W Sauer (w.sauer@ru.ac.za); Dr M Lipinski (mrlipinski@nashuaisp.co.za)

Funder/s: NRF/DAAD Freestanding Bursary

Loligo reynaudii, commonly referred to as Lula, plays a critical role in the livelihoods of subsistence and artisanal fishermen in southern Angola. There have also been several unsuccessful attempts in recent years to develop a commercial fishery for this species using fishing techniques developed for the South African squid fishery. Unlike South Africa, the Angolan fishery has not yet been described in any detail, and is currently unmanaged. Comparative morphological and molecular investigations on *L. reynaudii* from southern Angola and South Africa indicate a single genetic population despite the presence of three distinct morphological stocks (Angola, the South African west coast and South African south coast). As a semelparous species, *L. reynaudii* are highly susceptible to environmental fluctuations, with the Angola Benguela Frontal Zone (ABFZ) providing a highly dynamic environment, subject to large-scale interannual and decadal fluctuations. Currently there is no information on the life history and reproductive behavior of Lula in southern Angola, providing an ideal opportunity to examine the life history and reproductive characteristics of this species in this dynamic region.

Preliminary results show Lula to be present only in the south of Angola and undergoing an annual migration; arriving inshore on the fishing grounds in May as sea temperatures become cooler, and departing as temperatures increase in October. Initial results from biological samples collected from the two primary fishing localities (Namibe and Tombua) indicate males to reach maturity at 245.9 mm, and females at 173.2 mm, with a peak in maturity for both sexes coinciding with the movement of squid away from the fishing grounds in October. Interviews with local fisherman, exploratory dives and searching for spawning aggregations using echo sounders in the three primary fishing areas, produced no signs of spawning squid or egg masses; it therefore appears that squid utilize these areas for feeding. Further analysis of the biological and environmental data collected is underway. Questionnaire interviews with fishermen are planned for late 2015, and will provide social and economic information on the importance of the fishery for the livelihoods of those dependent on Lula in southern Angola.

Key words: marine; fisheries; ecology; *Loligo reynaudii*

Chantel Elston (PhD student) - The trophic and spatial ecology of a multi-species stingray community at the remote St. Joseph Atoll, Seychelles

Supervisor/s: Prof. PD Cowley (tagfish@gmail.com); Dr RG von Brandis (rainervonbrandis@gmail.com)

Funder/s: Save Our Seas Foundation; National Research Foundation; South African Institute for Aquatic Biodiversity

Despite being the fifth most threatened chondrichthyan family, there is a paucity of information on the ecology of tropical stingrays at a global scale. Stingrays are considered to play an important ecological role through their bioturbative feeding behaviour and through occupying the position of mesopredator within food webs. As such, a better understanding of the trophic ecology of stingrays is vital. In addition, knowledge of their habitat use patterns and movements are important to identify critical habitats, such as nursery areas, for improved conservation efforts.

The remote St. Joseph Atoll in the Seychelles plays host to an abundance of stingrays, in particular, juveniles of the cowtail ray *Pastinachus sephen*, mangrove whiptail *Himantura granulata*, and porcupine ray *Urogymnus asperrimus*). This study aims to investigate the trophic and spatial ecology of these three stingray species within this atoll. Focus will be placed on elucidating how they co-exist and what effects they may have on this isolated and relatively contained ecosystem, as well as determining whether this atoll is serving as a nursery area to these species. Specific objectives to be investigated include (1) dietary preferences of the three species, (2) trophic niche overlap between these species, (3) size-related shifts in diet within each species, (4) levels of residency to the atoll, (5) spatial overlap and connectivity between species, and (6) variability in movement patterns in response to environmental variables.

A combination of stomach contents and stable isotope analyses will be used to understand the dietary preference as well as intra- and inter-specific variability in diet. Stomach contents were collected using a non-lethal gastric lavage technique and will be identified to the lowest possible taxonomic level and quantified for an assessment of their dietary habits. Stingray muscle tissue and potential prey items were collected for stable isotope analyses to assess size-related shifts in diet and to understand the food web structure within the atoll. A long-term acoustic telemetry dataset (\pm 3 years) will be used to assess spatial and temporal movement patterns. Sixty stingrays have been surgically implanted with acoustic transmitters and are being passively monitored by an array of 88 acoustic receivers deployed throughout the St. Joseph Atoll and the greater Amirantes Bank, where the atoll is located.

The findings of this study will not only add to our understanding of the function of the St. Joseph Atoll and its inhabitants, but also add to the global knowledge on these stingray species that have wide-ranging distributions.

Key words: marine; ecology; Myliobatiformes; diet; stable isotopes; acoustic telemetry

Victoria Erasmus (PhD student) - Uncoupling the exploitation and climate change effects on the biology of *Lophius vomerinus* in the northern Benguela current ecosystem (Namibia)

Supervisor/s: Prof. W Sauer (w.sauer@ru.ac.za); Prof. WM Potts (w.potts@ru.ac.za); Dr A-R Childs (a.childs@ru.ac.za)

Funder/s: Seaflower Group of Companies

Lophius vomerinus (Regan, 1903), has been a commercially important fish species in Namibia for decades, historically as a by-catch and recently as a target species. With increasing levels of exploitation and unprecedented climate change associated with the Anthropocene epoch, an understanding of the long-term biological parameters of this species is critical. To date there are few comprehensive studies that have examined the biology of *L. vomerinus*. This project aims to examine the trophic adaptability, reproductive scope and the changes in life history parameters of *L. vomerinus* and relate these to exploitation and climatic variability in the northern Benguela region. This will be done through comparisons of the feeding, reproduction and growth between contemporary and historical times. Specimens of *L. vomerinus* were collected from three length classes based upon length-at-maturity ogives estimates; juveniles (<L₅₀, 36cm), sub-adults (L₅₀–L₁₀₀, 36–47cm) and adults (>L₁₀₀, 47cm). For each specimen, the liver, gonads and stomachs were collected and frozen at -20 °C to stop bacterial digestion in the fish stomachs. The samples were collected monthly.

For stomach content analysis, 319 stomachs have been removed and contents weighed. Prey items have been sorted, identified to the lowest taxon possible, enumerated, weighed by prey category, and measured if possible. All prey items in digestive stage 1 (fresh) were excluded, as they might have been ingested in the net. Prey importance was determined from percentage of frequency of occurrence, calculated as: %FO = $n_i/N \times 100$. Muscle samples of *L. vomerinus* and their dominant prey will be collected during monthly sampling and annual research cruises. The isotopes of nitrogen (15N) and carbon (13C) in the muscle tissue will be measured using a mass spectrometer. The findings of the feeding study will be compared with available historical dietary information.

For maturation dynamics, gonads of the fish will be collected, stored in formalin, staged macroscopically and validated using histological analyses to determine the timing of reproduction (presence of individuals with ripe gonads). The increment widths of historical (1992, 1993, 1997) and contemporary otoliths of the oldest fishes will be examined. The relative growth rates will be related to available information on the environment and relative abundance of *L. vomerinus*.

Preliminary results from the feeding study identified a total of 36 prey species from the stomach content of *L. vomerinus*. 30.4% of stomachs analysed were empty, however all empty stomachs were recorded in winter and spring. Most stomachs had *Merluccius spp* (15.8%), *M. paradoxus* (11.7%) and *H. dactylopterus* (7.8%). The highest percentage of prey numbers were those of *Merluccius spp* (13.8%), *M. paradoxus* (11.9%) and *C. agassisi* (8.0%). These results only represent the immediate diet of fishes, the isotope data will provide evidence for the diet of the fish through its lifetime, and its trophic linkages. In addition, historical feeding data will provide information on potential long-term changes in the diet of these fish and their trophic adaptability. It is envisaged that this study will provide insights into the potential impacts of climate change and exploitation of this commercially important fishery species.

Key words: marine; fisheries management; northern Benguela; feeding; trophic; maturity; age

Catherine Greengrass (PhD student) - Potential for Freshwater Crayfish Farming in South Africa Focusing on *Cherax cainii* Aquaculture Development

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

Funder/s: Agriculture Research Council; National Research Foundation (NRF); Department of Science and Technology (DST)

Farming of the Western Australian crayfish, Smooth Marron *Cherax cainii*, has been practiced in Australia over 40 years and has spread to several countries, including South Africa., Despite its high value (US\$ 37.60 / kg), international production is still low (66 t). Research on farming technology for Marron is considered ‘developmental’ globally, requiring further research on production related aspects. Farming in South Africa has been practiced since the 1970s on a small-scale – peaking around 2006 with 20 farmers (30 – 40 tonnes) but declining to one farmer producing 3-4 tonnes per year. Marron presents an opportunity for diversification of aquaculture species and development of a high-value niche product.

A research project at the Agricultural Research Council (ARC) is currently underway that will focus on i) feeding behaviour - feeding time, duration, handling/ingestion associated with different diet treatments (pelleted, organic matter with/without biofilm) and preference between combinations of diet treatments, ii) impact of provision of shelter on growth and survival and potential to use shelter to scale up production capacity in tank culture, iii) impact of supplementation of pelleted feed in communal tank culture with organic matter with/without biofilm on growth and survival, iv) development of a local pelleted feed and benchmarking growth and survival, iv) using findings to generate and test a production model for tank culture and vi) economic feasibility of pond and tank culture within the context of the South African value-chain, including potential for reuse of waste water for hydroponic/aquaponics plant production.

Experiments will be conducted in a recirculating aquaculture system (RAS) under a shadenet structure, equipped with a heat pump to moderate water temperature. Tanks in the RAS will be split into experimental units through the use of baskets in which the crayfish will be enclosed.

To date crayfish have been acclimated to the system and observational findings indicate that survival in the ARCs RAS is good and the system is appropriate for the experiments proposed. Experiments are due to start in October/November 2016.

Key words: freshwater; aquaculture; crayfish; marron; *Cherax cainii*; recirculating aquaculture system

Philip Haupt (PhD student) - Characteristics and distribution patterns of benthic biotopes and fish assemblages at Aldabra atoll, Seychelles

Supervisor/s: Dr A Bernard (ant@saeon.ac.za); Prof. J Turner (j.turner@bangor.ac.uk)

Funder/s: NRF Innovation Doctoral scholarship; Henderson Postgraduate Scholarship

Coral reefs are important global resources providing food, economic revenue and storm protection but are degrading due to climate change and overfishing. Aldabra is a near pristine atoll providing an ecological reference point for regional conservation and management planning. Utilizing Aldabra as a reference point, the aim of the study is to characterise coral reef biotopes, determine the effect of wave action and sedimentation on reef communities, and to quantify the relative abundance and distribution patterns of fish in relation to biotopes.

Surveys were conducted on the outer reef from walked and towed video transects. Benthic composition was calculated from the images using a random point frequency assessment. Hierarchical cluster analysis was used to derive a habitat classification scheme, and develop spectral signatures for habitat types. Supervised habitat classification was applied to geo- and radiometric corrected satellite imagery to map the reef habitats. SIMPER analysis of geomorphic zones and habitat types were used to characterise biotopes and multivariate models were used to assess the effect of wave action and sediment on habitat distribution.

RUVs (Remote Underwater Video systems) and BRUVs (baited RUVs) were deployed on the outer reef on all sides of the atoll to estimate fish diversity and relative abundance. Richness and trophic indices and functional feeding groups were assigned to the species recorded. Multivariate statistics were used to compare the effect of unbaited and baited samples on the fish community. The effect of the tides and time of day on the fish assemblage were assessed from B/RUVs deployed at high and low tide on a spring tide and fish assemblage data were compared for the same site and depth during the morning and afternoon hours on days when two high tides occur.

The relationships between the fish community and biotope, structural complexity, depth and wave exposure and spatial distribution of artisanal fishing pressure were assessed using multivariate statistics to detect the patterns of fish community groupings nested within these.

Eleven habitat classes were derived and the map validation resulted in 73% producer error. Species richness was higher for BRUVs (283, $n = 74$), than RUVs (276, $n = 68$) and 346 species were identified overall, with 46 species recorded during BRUVs not in RUVs samples, e.g. *Gymnothorax* spp and *Galeocerdo cuvier*, while RUVs included 36 species that were not recorded in BRUVs samples, e.g. *Oxycheilinus digramma*, were present in RUVs, and not in BRUVs. Species richness was not significantly different between baited high tide, 205 ($n = 24$), and low tide, 203 ($n = 15$), while fewer species (185, $n = 22$) were recorded during unbaited high tide than at low tide 208 ($n = 25$).

Key words: marine; ecology; coral reef; habitat map; Aldabra; BRUVs; tide; biotope; fish

Katrina Heckendorn (PhD student) - Determining and promoting resilience in artisanal fishery social-ecological systems in Pemba Bay, Cabo Delgado, Mozambique

Supervisor/s: Prof. S Aswani (s.aswani@ru.ac.za); Prof. W Sauer (w.sauer@ru.ac.za)

Funder/s: Currently unfunded

Understanding the interactions between humans and ecosystems is becoming increasingly urgent as human use and overexploitation causes deterioration of ecosystems and this in turn causes declines in human wellbeing. This pattern is often seen in artisanal fisheries where many small scale fishers become trapped in poverty traps with ecosystems deterioration and human desperation caught in deleterious feedback loops. In these systems, human decision making has not been adequately studied. Human fishing decisions create a strong link between social and ecological systems, and most management depends on changing human behaviors. Unfortunately, we do not understand the factors that influence human decisions well. We also do not have many data on how the effects of specific fishing decisions feedback into future fisher decisions. The goals of this study are to understand: (1) the factors that influence fishing decisions and how their effects feedback to future decisions; (2) how important fishing behaviors are in determining the interactions between the social and ecological aspects of the fishery; and (3) how or if human behaviors affect the resilience of the fishery's social-ecological system and ways to increase that resilience.

We will use a combination of social, ecological, qualitative, and quantitative data to determine how fishing decisions are made and their effects. We will use interviews, fishing observations, participant workshops, and ecological surveys. In workshops, we will use collaborations to allow researches and other stakeholders to interact with different forms of knowledge and combine them into a more complete picture of the fishery. Data will be collected and analyzed simultaneously so that it can be shared with local stakeholders during workshops as appropriate based on workshop activities. This will allow collaboration between researchers and local stakeholders and for the different knowledge bases to complement each other.

Data collection can begin in Pemba Bay, Mozambique in March 2017, and will continue in the area for 18 months until the end of August 2018. We expect to have our first set of data collected and analyzed by the end of July 2017. This will include initial ecological surveys (20 from each ecosystem), interviews (30), and observations (30), and the first stakeholder workshop. Thereafter we expect to complete about the same amount of data collection and analysis every four months ending in July 2018. Preliminary write-up and final stakeholder workshop will be in August 2018. Final write-up will be done in Grahamstown from September to December 2018.

Key words: marine; fisheries management

Jessica Joyner (PhD Student) - The effects of climate variability on the spatial and temporal reproductive patterns of chokka squid, *Loligo reynaudii*.

Supervisor/s: Prof. W Sauer (w.sauer@ru.ac.za); Dr M Roberts (Mike.Roberts@nmmu.ac.za); Dr J Githaiga-Mwicigi (JeanGM@daff.gov.za)

Funder/s: National Research Foundation (NRF) (102335); Rhodes University Prestigious Scholarship

The chokka squid, *Loligo reynaudii*, is the fourth most important commercial fishery in South Africa. The resource, like other cephalopod species, is renowned for a high variability in catches. This variability is thought to be environmentally driven and as a result extensive research into the relationship between the environment and the chokka abundance has been conducted. Previous studies, however, have not succeeded in defining the relationship. Since 2002 studies have largely focussed on the influence of the environment on the spawning, hatching and the survival of the paralarvae. However, none of these studies have taken into account environmentally driven shifts in the timing and location of chokka spawning. This study therefore hypothesises that a relationship between the environment and the timing and location of the spawning exists. The study aims to provide further information on the spawning behaviour of chokka in relation to the environment with the hopes that this information will add to the ability to predict future catches based on environmental data.

An experiment has been designed in which the timing and location of the spawning will be defined. This will be done by obtaining squid from the fishing industry. These will be sexed, dissected and macroscopically and microscopically staged. Data from several environmental parameters which have previously been proven to be important in ecological modelling will be collected. These include temperature, turbidity, thermocline, current, wave height, wind activity, location, lunar cycle and season. These environmental parameters will then be correlated to the spawning cycle of the chokka.

This study hopes to define and quantify the relationship between chokka spawning behaviour and key environmental links. Furthermore, the study potentially could provide a more accurate predictive model than has been previously constructed. A potential further study on the correlation between turbidity and historically available environmental parameters such as wave height could be constructed based on the outcomes of this project, allowing for a larger historical data set to be utilised in the quantification of the environment-abundance relationship.

Keywords: marine; fisheries management; chokka; spawning; environment

Dumisani Khosa (PhD student) - The current distribution of black bass *Micropterus* species in South Africa

Supervisor/s: Prof. OLF Weyl (O.Weyl@saiab.ac.za); Dr RJ Wasserman (ryanwas21@gmail.com)

Funder/s: National Research Foundation (NRF)

Freshwater ecosystems are the most threatened ecosystems in the world. The threats can be attributed to habitat fragmentation and degradation; hydrological alteration and overexploitation; and species introductions and translocations. South Africa introduced four black bass species to boost recreational angling, largemouth bass *Micropterus salmoides*, smallmouth bass *M. dolomieu*, spotted bass *M. punctulatus* and Florida bass *M. floridanus*. Since then, the species have been introduced into different catchment areas in the country. In accordance with the National Environmental Management: Biodiversity Act, there is a need to control and manage their movement.

This PhD thesis aims to better understand the dynamics of black bass introduction in South Africa. In 2016 my research has focussed on mapping the current distribution of the four black bass species in the country by using catch records from angling tournaments events, published and unpublished scientific literature, angling magazines, social network sites (e.g. Facebook and YouTube), museum specimen records, collection records from the South African Institute for Aquatic Biodiversity and biodiversity databases such as the Global Biodiversity Information Facility and the FishBase. A mapping software QGIS v 2.14.3 was then used to populate the distribution of black bass *Micropterus* species in the country using the recorded GPS coordinates of the collection sites. Preliminary analysis of the collected distribution data reveals that the species are predominantly distributed in the coastal areas, with the largemouth bass dominating catch records followed by the smallmouth bass and the spotted bass. However, there is paucity of distribution records of the black bass species in the inland areas of South Africa, more specially the Orange catchment, where only one record of largemouth bass has been documented. Given this lack of distribution records in the inland catchment areas, there is an urgent need for further assessment of the inland catchment areas in order to establish the distribution status of the species in those areas.

Key words: freshwater; ecology; invasion biology; catch records; catchment areas

**Daniel Nkosinathi Mazungula (MSc student) - Genetic and morphological variation of the of
Natal Mountain catfish, *Amphilius natalensis* in southern Africa**

Supervisor/s: Dr A Chakona (a.chakona@saiab.ac.za)

Funder/s: Rhodes University remission of fees for staff; South African Institute for Aquatic
Biodiversity core funding (Training budget)

Accurate documentation of biodiversity and knowledge of species distribution ranges is a fundamental requirement for various fields of biological research including evolutionary theory, ecology and conservation. However, species delineation is challenging for taxa that exhibit high levels of morphological conservatism. Within southern Africa, a major obstacle in setting effective conservation priorities, particularly for freshwater fishes, is the degree of unrecognised diversity hidden within complexes of morphologically similar species that are currently perceived to have broad distribution ranges. Given that freshwater fishes represent one of the highly threatened groups of animals in the region, the inability to diagnose their true diversity has serious conservation implications. This is particularly true for highly threatened ecosystems such as montane regions which are undergoing rapid habitat degradation through deforestation, replacement of indigenous vegetation with monoculture plantations, hydrological alteration and introduction of invasive fish species.

The aim of this study is to integrate molecular and morphological data to examine the genetic and morphological distinctiveness of allopatric populations of the Natal Mountain catfish, *Amphilius natalensis*. *Amphilius natalensis* was described from the Kranskloof River, a tributary of the uMgeni River system in KwaZulu Natal. The species as currently described exhibits a disjunct distribution which follows an archipelago of mountains from KwaZulu Natal through the Eastern Highlands of Zimbabwe to the Ruo River in Malawi. Results presented in this report include all known populations of *A. natalensis* (except the Ruo). Phylogenetic and haplotype network analyses suggest that *A. natalensis* consists of four isolated, cryptic evolutionary lineages which are separated by substantial genetic divergences (6.6-12.3%). Lineage N1 (*A. natalensis* sensu stricto) is restricted to the uMkhomaas, uMgeni and Tugela River systems, while lineage N2 occurs in the Inkomati River system. Lineage N3 was collected from multiple localities across the Pungwe River system and also occurs in the Gairezi River, a tributary of the Lower Zambezi River. Lineage N4 occurs in the Haruni and Rusitu Rivers (Buzi River system) which drain the Chimanimani Mountains in the Eastern Highlands of Zimbabwe.

These results indicate that *A. natalensis* as presently described represents a complex that comprises one previously described species and at least three candidate taxa. An evaluation of the taxonomic integrity of these newly identified lineages is being done through integration of several species delimiting approaches and generation of comprehensive morphometric and meristic data sets.

Key words: freshwater; conservation; *Amphilius natalensis*; hidden diversity; taxonomy

Lubabalo Mofu (PhD Student) - Using functional responses to assess interactions between alien and native species introduced through human-activities

Supervisor/s: Prof. OLF Weyl (o.weyl@saiab.ac.za); Dr DJ Woodford (darraghwoodford@hotmail.com); Dr RJ Wasserman (ryanwas21@gmail.com)

Funder/s: CIB DST-NRF Centre of Excellence for Invasion Biology; South African Institute for Aquatic Biodiversity (SAIAB)

Predicting and understanding future invaders is essential as new invasion threats continue to emerge through human activities. This study will assess the competitive interactions between successfully establish species in novel environments. This year the research has focussed on using functional response experiments to assess for competitive interactions.

For functional response experiments a minimum of 100 individual samples of *Glossogobius callidus*, *Oreochromis mossambicus*, *Gambusia affinis* and *Gilchristella aestuaria* were collected using a 30 m × 2 m seine net with 12 mm meshes wings and an 8 mm mesh size cod-end from irrigation ponds in the Sundays River catchment in the Eastern Cape, South Africa. Upon capture the samples were transported and housed in separate 100 L aerated tanks at the South African Institute for Aquatic Biodiversity (SAIAB). Prior to the feeding trails all fish were allowed to acclimate to the system for at least 1 week. Predators were sized-matched with respect to total length (TL), individual fish predators were randomly selected a day prior to the experiment and placed in the 20 L grey buckets to reacclimatize. After the reacclimation period, fish were presented with chironomids at eight prey densities (2, 4, 8, 16, 32, 64, 96, and 192) with five replicates per density treatment combination. To date feeding trails were run for four hours, after which prey consumption was examined. The length, weight and dissolved oxygen (DO) was measured before and after the experiment. Later experiments will be conducted on mixed predators to determine which species are responsible for prey consumption in the heterospecific combinations, fish will be anaesthetized with an overdose of 1mg L⁻¹ clove oil and preserved in 10% buffered formalin for stomach contents analysis. Each gut will be subsequently dissected and all chironomids will be counted. The functional responses of all the predators will then be predicted by summarizing the responses, the predicted combined consumption will be calculated using multiplicative models. Future research will assess the abundances and population dynamics of *O. mossambicus*, *G. affinis*, *G. callidus* and *G. aestuaria* in irrigation ponds; determine biological rates of growth, maturity and mortality and assess diet and inter-specific competition in the wild.

Key words: freshwater; conservation; *Glossogobius callidus*; *Oreochromis mossambicus*; *Gambusia affinis*; *Gilchristella aestuaria*; Functional response and Age and Growth

Phakama Nodo (PhD student) - Nursery function of estuaries and near shore marine habitats for coastal fishes, with emphasis on the recruitment mechanisms in Algoa Bay, South Africa

Supervisor/s: Dr NC James (n.james@saiab.ac.za); Dr A-R Childs (a.childs@ru.ac.za); Dr P Patrick (p.patrick@saiab.ac.za)

Funder/s: National Research Foundation; South African Institute for Aquatic Biodiversity

Coastal marine habitats are known to play an important role in the early life history of many marine fish species. These include estuarine and nearshore marine ecosystems which have extremely high primary and secondary productivity and support a great abundance and diversity of fish and invertebrates. However, the importance of marine nearshore environment as nursery areas has received less attention. Despite a plethora of historical and contemporary literature on the fish fauna within estuarine and marine habitats, there is limited empirical information on the nursery habitats and recruitment processes of the early life history stages (from post-flexion larvae to early juveniles < 30 mm TL) of exploited species. The identification of essential nursery habitats and factors governing the recruitment of species into nursery areas for these critical life history stages is vital to fully understand their life cycle, and to better manage and conserve these species. Therefore, the aim of this study is to re-assess the degree to which coastal and estuarine habitats provide nursery areas for estuary-associated marine species, and the degree of overlap in fish assemblages between coastal and estuarine habitats in Algoa Bay.

The specific objectives will be to determine which habitats serve as important nursery areas within Algoa Bay for these species by (i) assessing the abundance, composition and estuarine use of coastal marine species in relation to physical and biological parameters, and by (ii) determining which physical cues/odours that larvae and early juveniles use in finding their way into their nursery habitats and factors that govern the successful recruitment of larvae and early juveniles into nursery habitats.

Fish species will be sampled monthly at sites in Algoa Bay over a period of one year using a modified version of a 1 m, conical shoeless beam trawl net. Experimental analysis in the laboratory will also be used as an additional method to test the recruitment response of estuary-dependent marine species to water from both estuaries and the nearshore environment. This study is vital for the conservation and management of these important systems and also to improve our understanding of the role of coastal habitats to fishes.

Key words: marine; ecology; coastal habitats; juvenile fishes

Richard Peel (PhD Student) - Colonization and succession of fishes in Lake Liambezi, a shallow ephemeral floodplain lake in southern Africa

Supervisor/s: Prof. OLF Weyl (o.weyl@saiab.ac.za); Dr JM Hill (j.m.hill@gmail.com); Dr CJ Hay (clinton.hay@gmail.com)

Funder/s: Southern African Science Service Centre for Climate Change and Adaptive Land Management; Nedbank Namibia Go Green Fund; Namibia Nature Foundation/European Union Community Conservation Fisheries in KAZA Project; National Research Foundation (NRF)/South African Institute for Aquatic Biodiversity

Lake Liambezi is a large (300 km²), ephemeral floodplain lake in northeastern Namibia that is fed on an irregular basis by floodwaters from the Upper Zambezi and Kwando rivers. It 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, when it was partially inundated and subsequently dried on several occasions before eventually filling in 2009. The aim of this study was to contribute toward the understanding of fish colonisation patterns, and the drivers of community succession following flooding in Lake Liambezi. The central hypothesis of the study was that: the hydrological regime, life-history adaptations and trophic dynamics interact to determine fish colonisation patterns and drive community succession.

The fish fauna of Lake Liambezi displayed remarkable resilience to drying, with a diverse range of species colonising in large numbers during each of three discrete flooding events in 2001, 2004 and 2007. The colonising fish communities differed from their source populations in the Upper Zambezi and Chobe rivers as a result of interspecific differences in the propensity and ability to undertake lateral migrations. The colonising fish communities were consistently dominated by two opportunistic cyprinids *Enteromius paludinosus* and *Enteromius poechii*, and two catfishes with a periodic life-history strategy, *Schilbe intermedius* and *Clarias gariepinus*. The abundance of these species declined rapidly in the first two years after inundation 2007. After refilling in 2009 the barbs were replaced by two small alestids, *Rhabdalestes maunensis* and *Brycinus lateralis*. Larger, slower growing species such as the predatory *Serranochromis macrocephalus* and *Hepsetus cuvieri* have increased more gradually in abundance since refilling. The stable lake conditions favour equilibrium strategists such as cichlids, which have thrived. Periodic strategists such as *Schilbe intermedius* show large recruitment pulses in years of inflow from neighbouring floodplains, but poor recruitment in non flood years. Opportunistic strategists have shown mixed responses to increasing stability. Cyprinids have disappeared in the absence of predictable, seasonal flooding while alestids have thrived. Stable isotope analysis indicated that consumer biomass was supported by phytoplankton and, to a lesser extent, aquatic macrophytes. Three food chains were identified, two of which were supported by phytoplankton, and one by macrophytic detritus. Predators fed across all three food chains, but more so on benthic food chains dominated by aquatic insects and tilapiine cichlids. Colonisation patterns and species successions in Lake Liambezi were significantly influenced by species life-history strategies and their adaptations to the hydrological regime, and to a significantly lesser extent by interspecific biotic interactions.

Key words: freshwater; ecology; community structure; life history; food web analysis

Richard Taylor (PhD Student) - The use of anaerobic digestate in aquaculture and algal production systems and the influence of these algae on the production rates of methane in anaerobic digestion

Supervisor/s: Dr CLW Jones (c.jones@ru.ac.za), Mr R Laubscher (r.laubscher@ru.ac.za), Prof.K Cowan (a.cowan@ru.ac.za).

Funder/s: Department of Science and Technology (DST); National Research Foundation (NRF), Levenstein Bursary.

Project Eden is an experimental treatment facility at Ibhayi brewery where alternative, energy efficient and income generating effluent treatment technologies are tested. High rate algal ponds (HRAP) that are used at the research site act as an alternative to activated sludge (AS) systems in conventional effluent treatment plants, due to their lower energy consumption. Our HRAP system has treated brewery effluent to the same quality and often more consistently, compared with post AS effluent. There is a need to find an economic value for the algae produced in HRAP. This can be achieved by the conversion of algal biomass to methane during anaerobic digestion (AD). The methane produced can be used to run motors, heat facilities and provide revenue for the treatment plant. This PhD aims to quantify the net energy balance of the HRAP followed by the AD of the culture algae and determine what pre-treatment procedures and co-digestion strategies can be used to optimise methane production during the AD of algae.

The first digestion trials will investigate what pre-treatment processes can be used to speed up and increase methane production during the anaerobic digestion of algae. The second set of trials will identify which mixtures of algae, yeast and effluent generate the highest amount of methane and most stable digester conditions. Continuously stirred bench-top digesters (5 L) with gas storage tanks have been set up and various combinations of brewery effluent, algae and spent malt from the brewery will be co-digested. These digesters will be operated in a temperature controlled room (36 °C) at Ibhayi brewery. Semi-continuous feeding will be used to feed the digesters where they are fed once a day, following the removal of the same volume of effluent. The amount of methane, carbon dioxide and other gases produced over daily intervals will be recorded. Daily gas production will be measured using water displacement. The concentration of methane and carbon dioxide in the gas produced by the digesters will be analysed using a gas chromatographer. The carbon/nitrogen ratio of the pre-digested effluent solution will be calculated to determine the optimum C/N ratio for maximum methane production. Total organic carbon, Kjeldahl nitrogen, total alkalinity, chemical oxygen demand, ammonia, pH, volatile fatty acids, temperature and conductivity of the digestate in the digesters will be recorded. These trials will be done in triplicate to account for any variances in the anaerobic digestion process.

This project aims to demonstrate an energy efficient income generating effluent treatment process where the water can be reused in downstream agriculture. The technologies developed from this study do not only apply to brewery effluent and can be used to treat any effluent that contains carbon, nitrogen and phosphorous.

Key words: freshwater; aquaculture; anaerobic digestion; algal ponds; waste water treatment

Geraldine Taylor (PhD student) - Comparative fish ecology in three periodically connected rivers in the Upper Zambezi and Okavango ecoregions

Supervisor/s: Prof. OLF Weyl (o.weyl@saiab.ac.za); Dr JM Hill (j.hill@ru.ac.za); Dr CJ Hay (clinton.hay@gmail.com)

Funder/s: National Research Foundation (NRF)/South African Institute for Aquatic Biodiversity; Rhodes University Research Council; Southern African Science Service Centre for Climate Change and Adaptive Land Management; Namibian Nature Foundation/European Union Community Conservation Fisheries in KAZA Project

The Upper Zambezi, Kavango and Kwando rivers are three periodically interlinked floodplain rivers which share the same ichthyofauna. The aim of this research was to compare the biology and ecology of the fish communities, to test the hypothesis that fish community composition and assemblage structure, fish diets, food web structure and trophic dynamics, fish growth rates and total mortality are influenced by the differing flood magnitudes of the three rivers, in support of the flood pulse concept. The Zambezi River had the largest flood (6.14 m), followed by the Kavango (3.80 m) and Kwando (0.65 m) rivers. Fish assemblage structures varied seasonally in the Zambezi and Kavango rivers, where they were most similar, differing greatly from the Kwando River assemblages.

The diets of *Brycinus lateralis*, *Clarias gariepinus*, *C. ngamensis*, *Hepsetus cuvieri*, *Schilbe intermedius* and *Serranochromis macrocephalus* were described and compared between rivers. Differences in diets were attributed to seasonal prey abundance, with prey fishes abundant during falling and low water when the Zambezi and Kavango rivers were sampled, while invertebrates were abundant during rising and high water when the Kwando River was sampled.

Whole ecosystem stable isotope analysis revealed that the Zambezi and Kavango river food webs were supported by ^{13}C enriched resources such as C_4 and C_3 riparian vegetation from the floodplain, while the Kwando River food web was based on ^{13}C depleted resources such as filamentous algae and aquatic macrophytes. The Zambezi River food web had a restricted nitrogen range, with reduced food chain length. This was attributed to the overfishing of the primary and tertiary consumers in the Zambezi River, a phenomenon known to reduce food chain length. Information on the habitat use, feeding habits and trophic niches of a number of predatory species added valuable information on their interactions and ecology in the differing rivers.

Age was determined using sectioned sagittal otoliths for *C. gariepinus*, *C. ngamensis*, *S. intermedius* and *S. macrocephalus* and using whole asteriscus otoliths for *B. lateralis* and *H. cuvieri*, and growth was modelled using the von Bertalanffy growth equation. Growth performance was high in the Zambezi and Kavango rivers, and lower in the Kwando River, most likely in response to the varying flood magnitudes. Total mortality rates, estimated using Hoenig's maximum-age based equation, were high in the Zambezi River as a result of the high fishing pressure on this river. Overall, floodplain fish ecology in the Zambezi, Kavango and Kwando rivers was influenced by the flood pulse, as was predicted by the flood pulse concept. Data also suggested that Zambezi River food web structure and fish mortality rates have been impacted by overfishing, for which more information is needed to conserve and manage this system.

Key words: freshwater; ecology; flood regime; nutrients; diet; food web analysis; growth

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

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Funder/s: -

Connectivity amongst freshwater, estuarine and marine systems is a primary driver of fish assemblages in estuaries and estuarine lakes. Connectivity is defined by a set of linkages that are affected by, amongst other things, the nature of an estuaries mouth, bathymetry, tidal exchange, distance from the sea, hinterland gradient and freshwater flows. These factors in turn are all affected by natural and anthropogenic influences. It is important that the relationship between connectivity and estuarine fish faunas is understood in order to better manage marine, estuarine and freshwater resources. Biological responses, however, 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; ecology; fish; connectivity; life histories

Post-doctoral Fellows (Non-presenting)

Dr Nicola Downey-Breedt (Post-doctoral fellow) - Modelling the larval transport of important fishery species in the Mozambique Channel and Agulhas Bank.

Academic host/s: Prof. W Sauer (w.sauer@ru.ac.za)

Funder/s: National Research Foundation (NRF)

The climate across the globe is undoubtedly changing. Changes in ocean temperature can have a number of detrimental effects including shifts in fish distribution and reproductive patterns. Although very little research on climate induced circulation changes exist, widespread changes can be expected. In coastal marine species with limited adult movement, the pelagic larval phase is often the primary opportunity for widespread dispersal. Changes in adult distribution, reproductive patterns and circulation will influence the dispersal and local retention of larvae. This study used Individual-Based Models (IBMs) to simulate larval dispersal from Southwest Madagascar and on the Agulhas Bank (South Africa). The main aims were to investigate larval source-sink relationships, the influence of meso-scale circulation on dispersal, dispersal distances and population connectivity. Results were also discussed in terms of the potential impacts of climate change.

IBMs were developed using Ichthyop 3.2, a tool designed to study the effects of physical and biological factors on ichthyoplankton dynamics. The SWIM (South-West Indian Ocean Model) and SAFE (Southern African Experiment) Regional Ocean Models Systems were used to drive the simulations for the Mozambique Channel and Agulhas Bank, respectively. The IBMs simulated the transport of *Octopus cyanea*, shrimp and rock lobster off south Madagascar, cross channel connectivity in the Mozambique Channel, and the dispersal of squid *Loligo reynaudi* and hake *Merluccius capensis* and *M. paradoxus* larvae off South Africa.

The distribution of shrimp and octopus species throughout the West Indian Ocean and cross channel connectivity may indeed suggest mixing between populations, and that females contribute to stocks throughout the region. However, the large degree of retention on the shelf of Madagascar, as well as limited mixing between Malagasy west and east coast populations observed in the IBMs suggests a number of self-seeding octopus and shrimp populations could occur around Madagascar. Simulations also indicate connectivity is largely confined to the channel narrows, i.e. Northern Mozambique and Northwest Madagascar, further supporting the possibility of distinct populations along the Malagasy coast. Rock lobster IBMs indicate the Mozambique Channel does not play a role in the pelagic larval phase, with the majority of phyllosoma exiting the model domain as they are transported southwards. Off southern Africa, hatching site was found to significantly influence larval dispersal and recruitment, but more interesting was the limited northwards transport of squid paralarvae up the west coast. Unlike hake larvae, model results indicate squid paralarvae are retained in South African waters and are not transported north to Namibia. The specific source and sink areas, main drift routes and dispersal distances identified in this study have important implications for the development of Marine Protected Area networks, specifically when considering the potential impacts of climate change on distribution and dispersal.

Keywords: marine; Individual-Based Modelling; ROMS; Mozambique Channel; Agulhas Bank

Dr Anne Lemahieu (Post-doctoral fellow) - Documenting Indigenous Ecological Knowledge of coastal fishing communities and perceptions to climate changes in Southern Africa

Academic host/s: Prof. S Aswani (s.aswani@ru.ac.za); Prof. W Sauer (w.sauer@ru.ac.za)

Funder/s: Rhodes University, Sandisa Imbewu fund; Ecosystem Services for Poverty Alleviation (ESPA), United Kingdom

Indigenous Ecological Knowledge (IEK) is the understanding, belief, and practices that human societies develop longitudinally in relation with their natural environment, and which are dynamic, and co-evolving with social and ecological changes. IEK's contribution to the conservation of biological diversity has been well established. In a maritime context, authors also have a long history of advocating for the use of local and indigenous knowledge for resource management and adaptive conservation. In developing countries where many communities still rely on marine resources for subsistence, documenting IEK is fundamental for an effective, adaptive and participative management of resources. In this study, experiences from Madagascar, Mozambique and Angola are compared to identify the drivers of adaptation strategies and resilience to climate change.

As a first part of the project, data were collected in two coastal villages in Southeast Madagascar in June 2016. People perceptions of changes were gathered using a semi-direct questionnaire. The unit of analysis was at the household level and a systematic sampling technique was employed. Respondents were asked to identify the various dimensions of their environment (e.g. lagoon, fore-reef, forest) and whether or not they detected a change over their lifetime. The periodicity, nature of, cause of, and adaptation to the quoted changes were documented and results were analysed using descriptive statistics.

A total of 48 surveys were administered over 8 days of sampling (Ambola n=26, Ambotsibotsiky n=23). Many of respondents were livelihood fishers (56 and 52.2 % respectively) and 84% in Ambola and 95.6 % in Ambotsibotsiky participated in a fishing activity. Compared to the other village, Ambola showed signs of a richer environmental knowledge as 32% of the respondents (against 4.3% in Ambotsibotsiky) identified 6 or more dimensions and stratas in their environment. The most recurrent change reported by the villagers in both villages was a decrease of fish and sea products. In both villages adaptation of fishing techniques was cited as a coping strategy, with a number of respondents mentioning the establishment of marine reserves in Ambola, demonstrating the influence of NGO interventions. Because of its proximity to a tourism market, respondents from Ambotsibotsiky cited "activity shifting" as a response to changes, demonstrating better diversification of skills compared with Ambola where villagers said they were rather shifting their diet (to more land products), implying a change in local trade between villages in the region.

Key words: marine; conservation; indigenous ecological knowledge; climate changes; adaptive resource management; sustainable resources management

Dr Aldi Nel (Post-doctoral fellow) - The effect of kelp-supplemented formulated feeds on the gut microbiota of cultured abalone *Haliotis midae*

Academic host/s: Dr CLW Jones (c.jones@ru.ac.za); Prof. PJ Britz (p.britz@ru.ac.za)

Funder/s: Department of Science and Technology (DST/CON 0268/2015); Research and Technology Fund (RTF)

The inclusion of seaweeds in the diet of cultured abalone fed formulated feeds can improve abalone health and feed utilisation efficiency (Bansemer et al. 2014). The kelp *Ecklonia maxima* is included in abalone feeds (Abfeed®-K26) as a dietary supplement. Kelps have a low nutrient density but they form a major component of the natural diet of wild *Haliotis midae* abalone that occur on the southwest coast. They are rich in complex polysaccharides such as laminarin and alginate. Seaweed polysaccharides are associated with enzyme-secreting bacteria in the guts of abalone (Sawabe 2006), and it is therefore likely that dietary kelp inclusion will have an effect on the abalone gut microbiota.

An honours project that aims to compare gut-bacterial communities for *H. midae* spat (0.015 ± 0.0002 g S.E.; 2 – 3 mm) weaned onto either kelp-supplemented formulated feed (Abfeed®-S34K), non-supplemented formulated feed (Abfeed®-S34) or fresh kelp was undertaken by Mr Siyamthanda Landzela. The study was conducted at HIK abalone farm (Hermanus, Western Cape) and samples were collected after eleven weeks (25 April – 11 July 2016). Whole shucked abalone samples were used for DNA extraction and DNA was sent to MR DNA (Shallowater, Texas, USA) for 16S rRNA microbiome analysis. Aldi has overseen the field and lab work during this study which will continue beyond the course of Siyamthanda's project.

To compare the temporal stability of the gut microbiota of abalone between diets, Aldi will collect another set of samples from the same treatment groups in November 2016. Kelp, as a component of abalone's natural diet, is expected to promote gut-bacterial community stability in cultured abalone. Aldi will submit the work for publication.

As part of DST-funded research and a MSc project undertaken by Miss Nyiko Mabasa, Aldi is overseeing a study that investigates the effect of artificial feeds on the gut microbiota of juvenile dusky kob (*Argyrosomus japonicus*). DNA extracted from the fore and hind intestines of kob fed graded levels of carbohydrates will be analysed through 16S rRNA microbiome analyses. This work will be submitted for publication during the next four months. During her fellowship, Aldi has prepared two papers from her thesis on the subject of kelp supplementation in formulated feeds and its effect on the abalone gut microbiome. These will be submitted within the next two months.

Bansemer, M. S., Qin, J. G., Harris, J. O., Howarth, G. S., & Stone, D. A. J. (2014). Nutritional requirements and use of macroalgae as ingredients in abalone feed. *Reviews in Aquaculture*, 5, 1–15.

Sawabe, T. (2006). The mutual partnership between *Vibrio halioticoli* and abalones. In *The Biology of Vibrios*. Thompson, F. L., Austin, B. & Swings, J. (Eds.). ASM Press, Washington, D. C., pp. 219–230.

Key words: marine; aquaculture; formulated feed; gut microbiota; 16S rRNA microbiome analysis

Dr Kelly Ortega-Cisneros (Post-doctoral fellow) - Modelling the impacts of climate change and variability on the southern Benguela system

Academic host/s: Prof. K Cochrane

Funder/s: National Research Foundation through the Belmont Project 'Global learning for local solutions: Reducing vulnerability of marine-dependent coastal communities' (GULLS).

The Atlantis modelling framework is an end-to-end model, which includes information from the abiotic environment to the human component of a system. An application of the Atlantis modelling framework for the Benguela and Agulhas Currents (ABACuS) was updated and validated against time series of biomass and catch (1990-2013). To evaluate model performance, a skill assessment of model hindcast compared observational data (total biomass, catch and proportion of a species' biomass in each box) to model outputs. The average error, average absolute error, root mean squared error, modelling efficiency and the Spearman correlation coefficient were calculated to determine model skill. Modelled biomass of sardine, round herring, shallow- and deep-water hake ranked high in terms of model skill, while the biomass of anchovy, snoek, horse mackerel and cephalopods had the lowest skill.

A sensitivity analysis focused on the growth rate of small and large phytoplankton, and large zooplankton was conducted to evaluate the influence of these parameters on the ABACuS model outputs. A total of 26 alternative model parameterisations based on a variation of $\pm 20\%$ around the input growth parameter of the selected groups were compared to the baseline model. Large variations in biomass were observed among the sensitivity runs compared to the baseline. The most marked differences in relative biomass among runs were attributed to changes in the growth rate of large zooplankton and small phytoplankton.

The effects of climate change under emission scenarios RCP 2.6 and 8.5 were simulated using time series (2000 to 2050) of temperature, salinity, pH and hydrodynamic data derived from the NEMO – MEDUSA 2.0 model. The ABACuS model was forced with the above-mentioned time series to evaluate the possible effects of climate change on the different groups in the southern Benguela system. The effects of fishing were also evaluated. A control or hypothetical scenario where no fishing and other stressors take place was first simulated. This control run was compared to the outputs from runs including acidification, fishing and warming to determine their potential effects on groups in the southern Benguela. In terms of individual drivers, warming had the strongest effect on the biomass of several groups in the southern Benguela under both emission scenarios. The combined effect of acidification, warming and fishing was mainly amplified or dampened when interacting compared to the effect of individual stressors.

No Reports available

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Melissa Mayo MSc student)
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Thembani Manyefane (PhD student)
Lungelwa Nomxego (PhD student)
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