Department of Ichthyology and Fisheries Science

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Edited by: A-R. Childs and C.L.W. Jones Error! Bookmark not defined.

Schedule of Events/Table of Content

Wednesday 8 October 2014

08h30-08h40: Welcome by Prof. Warwick Sauer (Head of Department)

Honours seminars (Chair: Warren Potts)

08h40-09h00: Matthew Machell-Cox (BSc Honours student) - The effect of temperature on growth and nutritional indices of juvenile Mozambique tilapia *Oreochromis mossambicus*

Supervisor: Dr T Shipton (ihts@imaginet.co.za)

Funder/(s): Rhodes University Research Committee

Tilapia, members of the tropically and sub-tropically distributed Cichlidae family, have become the most important warmwater aquaculture fish group in the world. They can withstand a wide range of environmental conditions including temperature and salinity fluctuations, low dissolved oxygen, as well as having generalised feeding behaviours. These traits allow for tilapia species to be cultured in extensive operations around the world. *O. mossambicus* occur naturally in fresh and brackish water systems on the south-east coast of Africa and are a suitable candidate species for freshwater aquaculture in South Africa. Temperature is the single most important abiotic factor affecting growth, food intake and feed conversion of fish. Therefore, an understanding of the thermal biology of a fish species intended for use in aquaculture is a priority. In the sub-tropical/temperate climate of South Africa fish farmers often experience sub-optimal temperatures for the culture of tilapia. This often leads to slower than expected growth and unrealistic production schedules, which ultimately results in short-term losses and long-term failure of many operations. A study was conducted to assess the effect of temperature on the growth of juvenile *O. mossambicus* in order to establish a thermal growth coefficient (TGC) that can be used by potential tilapia aquaculturalists to better predict production.

Six week old *O. mossambicus* (n=300) were placed into 15 glass aquaria (70l volume; 3 replicates per treatment) at a stocking density of 20 fish.tank^{-1}. Aquaria were housed in a controlled environment room, each with two aquarium heaters, biological filter and an airlift pump. Experimental treatments were set up with water temperatures of 18, 21, 24, 27 & 30˚C. Fish were weighed (g) and measured (TL) on Day 0, 30, 60 & 90. Fish were fed twice daily to satiation at 09:00 and 16:00. Feed was weighed monthly to determine feed intake per tank. Water temperature was recorded daily while ammonia (TAN), nitrites, nitrates, pH and phosphates were measured weekly for each tank.

There was no significant difference between the size of fish in each tank on D0 ($F=0.557$; $p=0.699$). Temperatures were maintained within 0.5˚C of desired treatment temperature. There were no differences ($p>0.05$) in water quality between any of the tanks. After 60 days there was a positive relationship between temperature and mean mass gain (g.fish^{-1}) ($R^2=0.82$; $p<0.001$) and an ANOVA revealed that fish in treatment 27˚C and 30˚C had grown significantly larger (g.fish^{-1}.tank^{-1}) than in the other three treatments ($F(4, 9)=19.472$; $p=0.00019$). These results concur with similar studies conducted on *O. mossambicus* indicating an optimum growth temperature of 27-30˚C. From these results a TGC can be developed that will facilitate more accurate production schedules for tilapia farmers. There were a number of limitations to this study, and further research should consider tanks that more closely resemble the production environment and a longer experimental period.

Key words: freshwater; aquaculture; thermal biology; sub-optimal temperatures; thermal growth coefficient

09h00-09h20: Stephen Dünser (BSc Honours student) - The effect of feeder plate surface characteristics on the feeding behaviour of 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: HIK Abalone Farm (Pty) Ltd**Error! Bookmark not defined.**

In South Africa the farming of the local abalone species Haliotis midae represents over 90% of the aquaculture sector and brings in over R355 million of foreign revenue. Extensive abalone farming in South Africa only developed during the 1990s during which time a lot of research has looked at the nutrition, transport, reproduction and general husbandry techniques. This project was designed to quantify behaviour of farmed abalone with the aim of improving current farming practices.

An experiment was designed under farm conditions to test the effect of feeder plate surface characteristics on the feeding behaviour and activity of H. midae. Currently farmers use a clean feeder plate while this experiment tested a feeder plate comprising of two parts, i.e., one half was clean (control) and the other had a layer of diatoms. The abalone occurred at higher numbers on the side of the feeder plate that had a layer of diatoms ($F_{4, 472} = 3.57$, $p \leq 0.007$; RM-ANOVA). For the second part of the experiment focus animals were chosen on either side of the feeder plate and observed for 15 minutes to record the following behaviours:

- total time grazing;
- total time feeding on AbFeed®;
- total time spent on either the control or treatment side of the feeder plate; and
- number of times the focus animals moved directly over a pellet.

The time spent by the abalone on the feeder plate was significantly longer for focus animals on the side of the feeder plate with diatoms ($t_{78} = 3.44$, $p \leq 0.0009$; t-test) with an average time of 569 seconds. These grazed for an average of 324 seconds. No significant difference was found between the control and treatment in the total time spent feeding on AbFeed®. Animals moved directly over AbFeed® without a feeding response significantly more often on the control side ($t_{78} = -4{,}53$, $p \leq 0.0001$), which suggests that a feeder plate with a layer of diatoms increases the feeding response of active abalone.

Diatoms on the feeder plate may increase feeding behaviour and their accessibility to food by keeping the abalone on the feeder plate for longer. Further studies should test whether chemical or tactile cues from diatoms may increase feed uptake and whether this may lead to an increase in abalone growth. Such studies will aid the abalone farming sector in South Africa.

Key words: marine; aquaculture; diatoms; feeding behaviour; abalone

09h20-09h40: Bernard Erasmus (BSc Honours student) - The effect of disturbance on the behaviour of farmed abalone, *Haliotis midae*

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

Funder/s: HIK**Error! Bookmark not defined.** Abalone Farm (Pty) Ltd**Error! Bookmark not defined.**

Abalone farming practices include the handling of stock and moving, grading, feeding and cleaning of abalone baskets. This study investigated the effect of disturbance on the number of abalone on the feeding plate and the walls and the rate of encounter with food and pellet consumption by simulating three handling practices at HIK Abalone Farm (Pty) LTD (Hermanus, South Africa). The objective of this study was to investigate the effect of disturbance on the level of emergence of abalone and to test how disturbance influenced abalone feeding behaviour. Three kinds of mechanical disturbances were tested:

1) Turning over of the feeder plate;
2) Turning of the feeder plate and shaking it rapidly for 10 seconds by moving it from side to side in the water;
3) Lift basket out of the water for 40 seconds and return it to its original position;
4) A control, in which abalone were not disturbed.

Replicates were assigned to treatments in a randomised block design while creating a buffer zone between treatments. Treatments were replicated in fourteen tanks dispersed throughout the farm. Disturbance was administered at 4:00 pm on the first day of the experiment and was followed by nightly observations for six days. Data collected: a) number of abalone on the feeder plate, b) number of abalone on the basket wall (above the feeder plate level), c) number of abalone feeding on Abfeed®, and d) number of pellets left on the feeder plate the next morning. Physical and chemical water quality variables were determined regularly.

Significant increases in emergence of abalone onto the walls and feeder plate of the basket, in the first two days post disturbance was observed. On the day of disturbance the average proportion of the abalone in the basket that emerged was significantly greater for disturbance (D) than control (C), with an average of 18 more emerged abalone ($\bar{x}$ emergence: C = 20.64 ; $\bar{x}$ emergence D = 39.07). There was no significant difference between control and disturbance 6 days post disturbance in proportion of emerged abalone. A subsequent increase in number of abalone feeding at time of observation and pellets consumed was observed for the first two days following the disturbance. Number of emerged abalone had a significant effect on pellets left, with less mean pellets left on plate on the day of disturbance (C = 53.86, D = 41.76) compared to six days after disturbance (C = 60.5 and D = 56.05). Average number of abalone feeding appeared significantly greater on day 1 after disturbance (C = 1.39 and D = 2.30) than 6 days post disturbance (C = 0.89 and D = 0.94). Baseline behaviour occurred after approximately 4 days. Future trials will include the effects of prolonged disturbance on feed consumption.

Key words: marine; aquaculture; handling; emergence

09h40-10h00: Emily Moxham (BSc Honours student) - The effect of simulated rainfall on the behaviour of farmed abalone, *Haliotis midae*

Supervisors: Dr CLW Jones (c.jones@ru.ac.za); Mr. M Naylor (matt@hik.co.za); Prof. H Kaiser (h.kaiser@ru.ac.za)

Funder/s: Department of Agriculture Forestry and Fisheries (DAFF); HIK**Error! Bookmark not defined.** Abalone farm (Pty) Ltd; Rhodes University Research Committee

Anecdotal evidence indicates abalone *Haliotis midae* move away from the water surface during rainfall events. This may decrease farm production efficiency due to less contact time with feed that is placed on a feeder plate situated close to the surface of the water. Thus, the effect of rainfall needs to be investigated.

Experiment 1 - Simulated rain did not influence the distribution of abalone while it rained or 20 min post rainfall (n=20 tanks). In the proportion of abalone on the side of the basket (ASB) and abalone on the feeder plate (AFP) combined (total abalone above the feeder plate; TAFP), there was no difference between the control (no rain) and fresh water rain treatment (FW), with an overall mean (± standard deviation) of 9.42±5.18% (RM- ANOVA, $F_{(6,11)}$=0.54, p=0.73).

Experiment 2 – When it rained, the TAFP was not influenced by an interaction between the change in salinity and particulate matter (PM) in the simulated rain with an overall mean of between 9.37±8.79% and 10.18±8.71% (multifactor RM-ANOVA, $F_{(3,108)}$=2.18, p=0.11; n=40). Particulate matter alone did not affect distribution of abalone, with an overall mean of between 9.38±8.79% and 10.18±8.72% (multifactor RM-ANOVA, $F_{(3,108)}$=0.40, p=0.70). However the salinity of the rain affected the distribution of the TAFP significantly, with a mean of between 9.38±11.28% and 10.86±10.95% for simulated salt water rain (SW) and a mean of between 9.08±5.62% and 9.78±5.08% for FW (multifactor RM-ANOVA, $F_{(3,108)}$=3.94, p=0.02).

Salinity and PM did not interact to influence the distribution of AFP, with an overall mean of between 3.51±3.32% and 3.70±3.53% (multifactor RM-ANOVA, $F_{(3,108)}$=0.03, p=0.98). A change in salinity alone and PM alone, showed no change in distribution in the proportion of AFP (multifactor RM-ANOVA, $F_{(3,108)}$=1.46, p=0.24; multifactor RM-ANOVA, $F_{(3,108)}$=0.30, p=0.77 respectively).

The proportion of ASB was influenced by a significant interaction between salinity and PM of the simulated rain (multifactor RM-ANOVA, $F_{(3,108)}$=3.63, p=0.02). There were proportionately more ASB with the addition of FW rain with NP, whereas the opposite was found when the rain included salt: the percent of ASB was greater with SW rain with PM. In the SW and PM treatment a significant increase of abalone both at 20 min (9.04±8.54%) and 30 min (9.02±9.25%) in comparison to 0 min (6.63±9.55%) was found (Turkey HSD; p=0.001). In conclusion salt water causes an increase in TAFP, and ASB increases when SW with PM is added. Further research is necessary to explain this finding.

Key words: marine; aquaculture; abalone; behaviour; rainfall; salt water; particulate matter

10h00-10h20: Tea break

Honours seminars continued (Chair: Warren Potts Error! Bookmark not defined.**)**

10h20-10h40: Nicholas Schmidt (BSc Honours student) - The influence of bait on the sensitivity of abundance and size data to measure change in reef fish community structure recorded from baited remote underwater stereo-video systems

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

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

The application of bait when surveying the fish community with baited remote underwater stereo-video systems (stereo-BRUVs) can potentially bias data on community structure as it influences fish behaviour. Although stereo-BRUVs are advocated as a highly suitable method to survey reef fish throughout their depth distribution, the effect of bait bias still needs further clarification. A field study was conducted in the Algoa Bay and Tsitsikamma region to quantify the extent to which bait can bias data that are obtained from this method.
The objectives of this study were to:

- Compare the baited (stereo-BRUVs) and unbaited (stereo-RUVs) version of the method to determine if the presence of bait has a significant effect on the observed size-frequency distribution of the fish assemblage, and;

- Compare the baited (stereo-BRUVs) and unbaited (stereo-RUVs) version of the method to determine if the presence of bait has a significant effect on the abundance of species, and the sensitivity of the data to detect change in reef fish community and populations size structures across known fish density gradients.

The experiment consisted of the baited and unbaited treatments which targeted four sites (two marine protected areas (MPAs) and two exploited sites) in the Algoa Bay and Tsitsikamma region. From 60-minute deployments at each site the fish density and size structure were extracted during video analysis. Data from the baited and unbaited treatments was compared within each region to determine if the fish density gradients between the MPA and the exploited sites showed consistent patterns.

Overall 60 deployments were analyzed during this study with a total of 2,033 fish from 23 families and 57 species observed, of which 605 individuals were accurately measured. The results show that for the examined commercially important reef fish species the effect of bait is consistent throughout all treatments irrespective of location or management type (protected/exploited) by producing fish assemblages of higher diversity and species abundances. In conclusion, the addition of bait to stereo-RUVs is a reliable and powerful approach for the sampling of reef fish communities and can provide accurate information on the state of commercially important reef fish populations.

Key words: marine; ecology; fisheries; marine protected area; stereo-BRUVs

10h40-11h00: Roxanne Juby (BSc Honours student) - Effect of an electric shark repellent device on the behaviour of reef fishes

Supervisors: 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)

The effect of electric shark repellent devices (ESRDs) on reef fish behaviour is poorly understood. Their wide use during marine activities therefore raises concerns about the effectiveness as a safety measure, unknown ecological effects and influence on reef fish behaviour during scientific underwater surveys. This study aims to determine the effect a ESRD has on the behaviour of reef fish communities in the Tsitsikamma National Park (TNP) marine protected area (MPA) using baited and unbaited remote underwater stereo-video systems (stereo-BRUVs). Objectives for this study include:

1. To determine the voltage output of Shark Shield^{TM} and whether this changes with time (experiment 1);
2. To determine if ESRDs affect the behaviour of elasmobranchs? (experiment 2);
3. To determine if ESRDs affect the behaviour of teleosts? (experiment 2).

Experiment 1 was carried out in the laboratory prior to the field phase (experiment 2). A repeated measures design was employed for experiment 2 and involved the demarcation of a 6 km^2 study area of discrete reef in the TNP MPA. In the study area, eight deployment sites were randomly selected according to habitat stratification criteria (reef profile and depth). At each site, four treatments were randomly and repeatedly applied on different days at roughly the same time of day. The treatments included 'unbaited system with deactivated Shark Shield$^{TM'}$ (UB; control), 'unbaited system with activated Shark Shield$^{TM'}$ (UB-SS), 'baited system with deactivated Shark Shield$^{TM'}$(B), and 'baited system with activated Shark Shield$^{TM'}$ (B-SS). Each sample comprised a one hour video which was analysed by identifying all species and determining the relative abundance for each species using the maxN approach. In addition, the distance to the bait canister of each individual and its size (FL) were recorded per species at its maxN measure. Multivariate statistics (permanova in PRIMER) were applied to compare the fish community structure among the different treatments.

Of 32 samples, 44 reef fish species consisting of 14 chondrichthyes and 30 teleosts were recorded. Both B and B-SS were characterised by higher species richness than the UB and UB-SS. Videos derived from the B-SS had recorded the highest species richness (34 species, consisting of 25 teleosts and 9 chondrichthyes). The B produced a comparable species richness for chondrichthyes (9 species). The UB-SS produced the lowest species richness consisting of 16 teleosts and zero chondrichthyes. Statistical analyses showed significant differences in maxN of chondrichthyes between B and UB ($p=0.038$), as well as between B-SS and UB-SS ($p=0.037$) treatments. The Shark Shield^{TM}, however, had no effect on the maxN of chondrichthyes as no significant differences were found between B and B-SS ($p=0.985$) or UB and UB-SS ($p=0.673$) treatments. Similarly, no significant differences in maxN of teleosts among treatments were found, except between B and UB-SS treatments ($p=0.034$). Distance to the bait canister at maxN for both classes showed no significant differences among all treatments and a similar result was apparent for the lengths of both classes.

Key words: marine; ecology; Tsitsikamma National Park; shark repellent device

11h00-11h20: Rachel Mullins (BSc Honours student) - Towards understanding the spatial overlap of water users and white shark *Carcharodon carcharias* habitat use in Mossel Bay, South Africa

Supervisors: Mr E Gennari (e.gennari@oceans-research.com); Prof. W Sauer (w.sauer@ru.ac.za)

Funder/s: Oceans Research; Rhodes University Research Committee

Shark attacks receive substantial media coverage, and as a result have a detrimental socio-economic effect on coastal communities, resulting in a need for government bodies to take measures to reduce the probability of attacks. Shark attacks are unpredictable, and therefore difficult to prevent; however the probability of encounter of a white shark can potentially be estimated and as a result, attacks reduced. The white shark *Carcharodon carcharias* is a shark species for which a large proportion of shark attacks on humans has been attributed to. This study aims to determine if it is possible to develop a method to model probabilities of spatial overlap between white sharks and different water users (swimmers, surfers and paddlers), off the coast of Mossel Bay, South Africa.
Shark movement data was obtained prior to the study period by manual tracking of 19 white sharks tagged with acoustic transmitters. Water users' movement data was obtained during the study, during the months of April, May, June and July, by observation off two swimming beaches using a theodolite to determine exact positions. Positions obtained were converted to GPS co-ordinates using the programme Pythagoras, and then mapped, along with the shark movement data, for the coastline of Mossel Bay using the programme ArcGIS. The 'Join' function on ArcGIS was used to determine the distance of each data point to the coastline. Density functions of distance from the shore of sharks and each water use group were calculated. To determine the probability of overlap of a white shark with each activity, the area of overlap was determined by integration of the area of overlap between activity and white shark density curves (using the program R), and divided by the total area occupied by that activity.

Integration of the areas of overlap for each water use activity with the area of white sharks in Mossel Bay, indicate that highest degree of overlap with white sharks exists for paddlers (16.94% of the total area occupied by the group), with less overlap existing for surfers and swimmers (1.13% and 0.61% of each respective group's total area). This may serve to explain the low occurrence of attacks by white sharks in this region. In order to develop an inclusive model for probability of encounter, the methods used in this study can be expanded on, to include further data on temporal and spatial variability within Mossel Bay, and thus provide the first estimates for encounter probability of white sharks for different water use classes. If proven successful, this method could be expanded to other areas to provide an alternative tool in the effort to reduce the occurrence of shark attacks.

Key words: marine; conservation; shark attack; overlap; white shark

11h20-11h40: Mike Dames (BSc Honours student) - Area use and movement behaviour of *Argyrosomus japonicus* (Pisces: Sciaenidae) in the Sundays Estuary, Eastern Cape, South Africa

Supervisor/s: Dr A-R Childs (a.childs@ru.ac.za); Dr PD Cowley (p.cowley@saiab.ac.za)

Funder/s: National Research Foundation (NRF); Norwegian Research Council (SA/Norway programme for research co-operation)

Dusky kob *Argyrosomus japonicus* (Temminck & Schlegel, 1844) is one of South Africa's most sought-after linefish species, targeted by recreational, commercial and subsistence fisheries. The collapsed stock status of this species has been ascribed to growth overfishing of estuarine-dependent juveniles. Although the biology of dusky kob is well understood, their movement behaviour within South African estuaries has received limited research attention. To address this knowledge gap, this study aimed to investigate aspects of the spatial ecology of dusky kob within an estuarine environment.

Passive acoustic telemetry techniques were used to track 66 juvenile, sub-adult and adult dusky kob (237 – 1110 mm TL) in the Sundays Estuary. Three independent batches of fish were tagged and monitored over a period of three years (2008 – 2010) using an array of 16 acoustic receivers moored approximately 1 km apart, ranging from 2 km from the mouth to 21 km up river. Five temperature loggers were also strategically moored throughout the estuary. Data was downloaded every two months over the three year period. A series of ANOVAs were used to ascertain if differences in area utilisation occurred between different seasons and different size classes. A generalised linear mixed model (GLMM) was used to investigate the effects of water temperature, river inflow, batch and fish size on the daily movements, where (i) mean daily position was the response variable, (ii) water temperature, river inflow, batch and fish size were fixed effects, and (iii) fish ID was a random effect.

Dusky kob utilised the entire length of the estuary. There were changes in area-use between seasons, with fish utilising the upper reaches more during the summer months and the lower/middle reaches during cooler winter months. Dusky kob also spent a large proportion of time in areas with deeper water. Differences in area-use were also apparent among different size classes. Juvenile fish (< 500 mm TL) were widely distributed throughout the estuary and spent considerably more time in the upper reaches. Larger juveniles (500 mm – 700 mm TL) spent the majority of their time within the lower/middle reaches with further upriver utilisation only occurring during spring and early summer. Sub-adult/adult fish (> 700 mm TL) mostly utilised the lower reaches of the estuary with limited upriver utilisation only occurring during spring. The results of this study have improved our knowledge of the spatial and temporal movement behaviour of dusky kob in their nursery habitats. This information can be used to evaluate the effectiveness of spatial-based management of this important fishery species.

Key words: estuarine; ecology; fisheries management; movement behaviour; acoustic telemetry

11h40-12h00: Tea break

Honours seminars continued (Chair: Warren Potts)

12h00-12h20: Yonela Sithole (BSc Honours student) - A taxonomic re-evaluation of *Serranus cabrilla* (family: Serranidae) in southern Africa

Supervisor: Dr M Mwale (m.mwale@saiab.ac.za)

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

Serranus Cuvier 1816 is the only genus of the subfamily Serraninae found in South Africa. The barred rockcod *Serranus novemcinctus* Kner 1865 and the comber *S. cabrilla* (Linnaeus 1758) are the two recognised species in South Africa. However, there is taxonomic uncertainty among population of *Serranus cabrilla,* the most common and widely distributed (Eastern Atlantic to KwaZulu-Natal). The species is a complex with numerous synonyms and only one is described from South Africa (Knysna), the African seabass *Serranus knysnaensis* Gilchrist 1904. Confusion between the two was noted as *S. knysnaensis* is likely to be endemic to South Africa. Furthermore, DNA barcodes using the mitochondrial DNA cytochrome oxidase I (COI) gene have found genetic variation within South African populations of the comber. The study therefore aimed to re-evaluate the taxonomic status of *Serranus cabrilla* and its synonym *S. knysnaensis* in South Africa by re-evaluating the morphological characteristics of *S. cabrilla* and *S. knysnaensis* and the levels of genetic variation using DNA barcoding.

The analyses of morphological characteristics of 13 *Serranus* species were done for 129 specimens. The comparison of 18 meristic characters looking at the range among species revealed overlap in counts and little distinction between species. However, there were some interspecific differences in some meristic characters (lateral line scales and scales around caudal peduncle). For example, *Serranus cabrilla* (n=53) (excluding *S. knysnaensis*) formed two groups based on differences in the count of scales around caudal peduncle. There were also intraspecific differences between *S. knysnaensis* (n=7) samples from Tugela banks (barcoded) and the type locality. Multivariate analysis of 26 morphometric characters was done using principal component analysis (PCA) in STATISTICA v12, to compare the variation among the species and populations. The plot of the first two factors (PCA=50.73%) for all *Serranus* species showed considerable overlap in morphometrics between most species with few being distinct. A plot of only *S. cabrilla* and *S. knysnaensis* revealed differences among and within some localities, most notably were the two distinct groups *of Serranus cabrilla* from SWIO.

DNA sequences were obtained from barcode of life database (BOLD) system and GenBank for inter specific genetic diversity analyses. The constructed (MEGA6) neighbour-joining tree showed that all *Serranus* species are genetically distinct with the sequence divergence ranging from 2.2-25.5 % Sequence divergence between *S. cabrilla* and *S. knysnaensis* was 2.2 %. *Serranus cabrilla* formed three clades nested with South African species. *Serranus cabrilla, S. novemcinctus* and *S. knysnaensis* shared the most recent common ancestor (100% bootstrap).

The genetic distinction between *Serranus cabrilla* complex and *Serranus knysnaensis* was supported by some of the morphological characters. Furthermore, the distinction between *Serranus knysnaensis* localities and the type locality suggests that there is intraspecific diversification that also requires verification in RSA. This data indicates that *Serranus novemcinctus* and *Serranus knysnaensis* are valid South African species. More data is required for confirmation.

Key words**:** marine; fisheries; *Serranus;* genetic analyses; morphological analyses; divergent

12h20-12h40: Adrian Astier (BSc Honours student) - A systematic investigation into the *Barbus eutaenia* Boulenger complex in southern Africa

Supervisors: Prof. PH Skelton (p.skelton@saiab.ac.za); Dr A Chakona (a.chakona@saiab.ac.za)

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

Orangefin barb *Barbus eutaenia* is a small cyprinid that is widely distributed across southern African river systems. The wide range of *B. eutaenia* across the systems includes the Congo basin, Okavango, Zambezi, Cunene, and Limpopo catchments. This unusually widespread distribution for a freshwater fish has raised much interest among researchers and taxonomists. Described by Boulenger in 1904 from a sample collected within the Cunene River system, this species was often misidentified because of its morphological similarities with the zigzag barb *Barbus miolepis* and the redspot barb *Barbus kerstenii*.

Preliminary DNA barcoding results have revealed the existence of unique and deeply divergent genetic lineages within southern Africa, suggesting that the orangefin barb could be a species complex. Various collectors have also identified variation in body form and colour pattern among populations from different river systems. The aim of this study was to investigate the hypothesis that *B. eutaenia* contains morphologically cryptic species.
Specimens were collected during river surveys throughout southern Africa between July 1983 and July 2012. Sampling involved various methods ranging from hand nets, seine nets, fyke nets and electrofishing. All samples were fixed in formalin in the field and preserved in 70% ethanol upon returning to the SAIAB laboratory for long-term storage. Only 21 out of the 34 measurements were used for the present report. Further in depth measurements were done using photographs and x-ray images providing morphometric shape and skeletal meristic information.

Specimens from the Kabompo and Luele Rivers are distinguished from those collected from the other populations by having longer posterior barbels (4.0-6.6 mm) and fewer scales on the lateral line (21-22). Ruo River specimens are morphologically different from all the other populations considered in the present study, except for the Nkomati and Zambezi/Kabompo. Ruo River specimens are distinguished by compressed body form characterized by a broader body width and the shortest pre-dorsal length. Fusiform body shapes were seen in upper-Zambezi, upper-Okavango, Nkomati and Ruo samples, expressed by the longer head and pre-dorsal length. Luapula samples also indicate a morphological difference from the Ruo and upper Okavango, expressed by longer head length. Samples from Rufilyo River indicate morphological separation from Ruo, upper Okavango, upper-Zambezi and Nkomati, expressed by longer pre-dorsal and head length with a lower body width. Findings of present study will feed into a broader project that aims to revise the taxonomic status of *B. eutaenia*. Additional measurements within the head region, caudal fin and pigmentation should be analyzed and taken into consideration for further studies.

Key words: freshwater; taxonomy; morphological divergence; x-ray; widespread species

12h40-13h00: Timothy Smith (BSc Honours student) - Morphological and genetic variation between populations of blacktail seabream *Diplodus capensis* (Smith, 1844) in southern Africa

Supervisors: Dr WM Potts (w.potts@ru.ac.za); Dr G Gouws (g.gouws@saiab.ac.za)

Funder/s: Rhodes University Research Committee

The blacktail seabream *Diplodus capensis* has a warm-temperate distribution across southern Africa, with disjunct populations being found in southern Angola, South Africa, and south-east Madagascar. Recent morphological and genetic research has shown that the Angolan and South African populations show some degree of differentiation, but not sufficient to designate them as separate taxa. The Madagascan population has received little attention, and since it is separated from the African mainland by many kilometres of ocean and unsuitable habitat, it is most likely isolated from the other southern African population. The aim of this study was to determine the taxonomic placement of the Madagascan population in relation to the other two southern African populations through morphometric and genetic analyses.

Specimens and DNA samples from all three southern African populations were available in the collections of the Department of Ichthyology and Fisheries Science and the South African Institute for Aquatic Biodiversity. Morphometric analysis was conducted using traditional morphometrics, meristics and digital TRUSS methods. These data were transformed and statistically analysed using discriminant function analysis, principal component analysis and ANOVA. Genomic DNA was extracted, a fragment of the mitochondrial Cytochrome Oxidase 1 region was amplified using a polymerase chain reaction and sequenced then sequenced by Macrogen Inc. (South Korea).

Meristic characters between all populations overlap strongly and cannot be used as identification characters. Using morphometric data, the discriminant function classification matrix was able to identify to 100% accuracy the localities of each specimen with transformed data, and on average approximately 87% accuracy using meristic data ($p < 0.05$ in Mahalanobis Squared Distance tests for both data sets). ANOVA conducted on each of the measurements showed significant ($p < 0.05$) differences in a few of the measurements, with highly significant differences ($p < 0.01$) between the Madagascan and Angolan specimen measurements. The principal component analysis revealed overlaps in the populations, particularly between the Angolan and South African populations, with both the morphological and meristic data sets; the Madagascan specimens mildly overlapped with the other populations. However, Madagascan blacktail seabream could be distinguished from the Angolan population by their proportionately smaller head- and tail-regions.

While the DNA results are yet to be analysed, these results suggest that there is some morphological divergence between the populations. However, the overlap in the morphological characters between all three populations suggests that divergence is not sufficient to classify them as separate species.

Key words: marine; taxonomy; biogeography; morphometric analysis; genetic analysis

13h00-13h20: Judge Inglis (BSc Honours student) - Aspects of the biology of the Janbruin seabream, *Gymnocrotaphus curvidens* (Pisces: Sparidae) along the Eastern Cape coast, South Africa

Supervisor/s: Dr WM Potts (w.potts@ru.ac.za)

Funder/s: Rhodes University Research Committee

The linefish of South Africa are in a state of crises with many of the species being over-exploited. However, accurate biological information, which is required to determine sustainable management strategies remain elusive for some of these species. The Janbruin seabream (*Gymnocrotaphus curvidens*) is endemic to the South African coastline yet almost nothing is known about its biology. Although *G. curvidens* are not heavily targeted by recreational anglers, as fishing pressure continues to increase it is likely that this species may become more important as the numbers of the more popular linefish species decline.

Samples were collected for three seasons during 2014 i.e. summer, autumn and winter using spearfishing, linefishing and opportunistic sampling during a fish kill. A full biological analysis was conducted on all specimens in the laboratory and the sagittal otoliths were removed and stored for later analysis. Unfortunately due to time constraints, we were unable to collect a spring sample, which was critical for the validation of the periodicity of ring formation in the otoliths.

The length-weight relationship for male and female *G. curvidens* was $Wt(g) = 8E\text{-}06FL(mm)^{3.2299}$ and $Wt(g) = 8E\text{-}06FL(mm)^{3.2397}$, respectively. It was assumed that *G. curvidens*, like all closely related fish in the family Sparidae, deposit one opaque growth ring per year. Based on this, the growth was best described using a von Bertalanffy growth model as $L_t = 285.35\ (1 - e^{-0.18(t-2.82)})$ mm FL (fork-length) for females and $L_t = 370.21\ (1 - e^{-0.11(t-3.25)})$ mm FL for males. Maximum age for both males and females was 29 years. Male *G. curvidens* attained 50% maturity at a length of 230mm FL and age 6.1 years while females attained 50% maturity at 190mm FL at an age of 5.3 years. Based on these findings a minimum size limit of approximately 250 mm FL would be recommended for the recreational fishery.

Future research should focus on establishing the periodicity of otolith ring formation using both marginal zone and chemical marking techniques. A histological analysis of the gonads will assist in the determination of the reproductive style, while a genetic study should be used to confirm or reject the assumption of panmixia.

Key words: marine; fisheries management; age and growth; blue-eye JB; janbruin

Thursday 9 October 2014

Freshwater/marine ichthyology (Chair: Justin Kemp)

09h00-09h20: Lubabalo Mofu (MSc Student) - Assessing the biology of the River Goby as a proxy to understand global goby invasions

Supervisor/s: Dr OLF Weyl (o.weyl@saiab.ac.za); Dr DJ Woodford (d.woodford@saiab.ac.za)

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

The River Goby (*Glossogobius callidus*) is native to rivers and estuaries along the coastline of South Africa, but appears to display several traits in common with the invasive Round Goby. The Round Goby (*Neogobius melanostomus*), a key invasive species both in Europe and North America, has used shipping canals and Inter-Basin Water Transfer schemes (IBWT) to dominated aquatic communities in the Baltic Sea and the Laurentian Great Lakes. Similarly, the River Goby has utilised water transfer infrastructures in the Sundays River Valley to disperse among irrigation impoundments and has subsequently colonized these novel habitat. With this similarity in colonization success the River Goby has shown potential as a proxy species to understand global Goby invasions. This study aims to understand the fundamental biological factors that make Gobiidae good colonizers and potential invaders. With the use of a native species (the River Goby) to attain detailed knowledge on population dynamics, morphology and reproductive biology. As these have major contributions to the success of invasive fishes such as the Round Goby. The Sundays River Valley Irrigation ponds were investigated to determine the reproductive biology of the River Goby.

A thirteen months sampling period has been conducted (August 2013- September 2014) and will be continued monthly till March 2015. Gonads were removed and weighed to the nearest 0.001g and preserved in 70% ethanol for egg counts, the gonadosomatic index (GSI) was used to assess the breeding season of *G. callidus* (GSI = Gonad mass/ Eviscerated mass x 100) . Eggs were counted with the aid of a stereomicroscope to estimate fecundity. Both macroscopic and histological assessments of gonad stage were performed. Stage data was also used to calculate age at 50% maturity for males and females. To date a total of 1203 gobies have been collected and dissected. Preliminary analyses have so far revealed that the River Goby are multiple spawners with GSI peaking late spring and midsummer. Logistic ogive described maturity at first 50% as LM50 = 70 mm for both males and females which rather illustrated late maturity. Individually fecundity ranged between 100 and 950 eggs and was significantly correlated with fish size (r^2 = 0, 74). Total fecundity was TF = -3173.8 + 45.577*Length represented positive correlation between total fecundity and length. These results suggest that the River Goby is a multiple spawner, as is the invasive Round Goby. In contrast, the Round Goby tends to mature rather early compared to the native River Goby, Thus it can so far said that the River Goby shares some but not all the attributes of the invasive Round Goby. Research over the next year will focus on age and growth, which will be fundamental in understanding population dynamics of gobies.

Key words: freshwater; ecology; Gobiidae; Sundays River Valley; colonizing; reproductive biology; maturity

09h20-09h40: Brendon Dredge (MSc student) - Species composition and relative abundance of fishes in four Western Cape dams and a natural lake in the Western Cape

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

Funder/s: Centre for Invasion Biology; Cape Nature

Non-native sport fish were introduced into rivers and dams in the Western Cape Province from the late 1800s primarily for recreational purposes. The impacts of these introductions on relative abundance and diversity of fish in public dams was last surveyed in the late 1970's. As a result, fish introductions and subsequent invasions since then have been undocumented and species compositions in many impoundments were unknown.

The primary objective of this research project was thus to develop a baseline on the fish species composition in four Western Cape dams (Theewaterskloof, Clanwilliam, Quaggaskloof, and Voëlvlei) and a natural lake (Groenvlei). These water bodies were sampled using an electro-fisher, seine net, long-line, angling, gill nets and fyke nets. Additional data were collected from recreational angling tournaments.

Overall, survey data indicated a higher relative abundance of non-native than native fish in all five water bodies. For example, largemouth bass *Micropterus salmoides*, bluegill sunfish *Lepomis macrochirus* and African sharptooth catfish *Clarias gariepinus* were recorded in four of the five water bodies, while common carp *Cyprinus carpio* were present in all of them. Smallmouth bass *Micropterus dolomieu* were present in three dams and Mozambique tilapia *Oreochromis mossambicus* found in only two. Native fish were generally uncommon. On comparison with data from a 1970 survey, gill net catch composition in Clanwilliam and Quaggaskloof Dams differed between 1970 and 2013 ($\chi 2 = 78.47$ $p < 0.001$ and $\chi 2 = 87.28$ $p < 0.001$ respectively), with two species of endangered native fish, the Clanwilliam sawfin *Barbus serra* and the Clanwilliam sandfish *Labeo seeberi* disappearing from catches in Clanwilliam Dam with an increase in abundance of the native Endangered Berg-Breede whitefish *Barbus andrewi* in Quaggaskloof Dam.

The loss of native fish and increased abundance of non-native fish in most of the water bodies demonstrates the ongoing spread of alien fish in Western Cape impoundments.

Keywords: freshwater; fisheries management; utilization of alien fish; age validation

09h40-10h00: Mpho Ramoejane (PhD student) - Evolution and conservation of Southern African Labeo fishes in relation to water management

Supervisor/s: Dr OLF Weyl (o.weyl@saiab.ac.za); Dr E Swartz (ernst.swartz@gmail.com), Dr B Sidlauskas (brian.sidlauskas@oregonstate.edu).

Funder/s: National Research Foundation (NRF/CPR UID73667); South African Institute for Aquatic Biodiversity (SAIAB)

Labeos are an important food source in developing countries and are used occasionally for angling, spear fishing and in commercial and subsistence fisheries. Labeos are known for their specialized sucker lip mouths with which they feed on algae and detritus, thereby playing an important role in controlling the abundance of algae in ecosystems. Four Labeo species groups are found in Southern African. The four groups are the South African *Labeo umbratus* group (*L. umbratus, L. capensis, L. seeberi* and *L. rubromaculatus*) and three Pan-African groups, namely the *Labeo niloticus* (*L. altivelis, L. rosae* and *L. ruddi*), *Labeo coubie* (*L. congoro*) and *Labeo forskahlii* (*L. cylindricus, L. molybdinus, L. lunatus* and *L. ansorgii*) groups. Very little is known about how Southern African Labeos relate to each other except for the morphological study of Reid (1985). Understanding how these species relate to each other would not only help in the understanding of the systematic diversity of this genus in Africa but would also help in understanding the vulnerability of its species to hybridisation. Some of the species are under threat due to predation by alien fishes, habitat alterations, man-made barriers to migration and hybridisation with closely related introduced species.

Objectives of the study were to:

- construct a phylogeny of the Southern African Labeo species; and
- test if the morphological groups proposed by Reids (1985) or if the two major divisions of the African Labeo species (Tshibwabwa and Teugels 1995) are monophyletic using southern African taxa.

To construct the phylogenetic relationships two mitochondrial DNA (cytochrome band cytochrome c oxidase subunit 1) and one nuclear DNA (recombination activating gene 1) genes were sequenced for 275 specimens. Maximum likelihood and parsimony were performed and phylogenetic trees constructed to illustrate species relationships and groups.

Five Labeo clades instead of four suggested by Reid (1985) were found from the analysis of two protein coding mitochondrial (cyt b and CO I) genes on 62 individuals, but with poor bootstrap support. In contrast the clades were polyphyletic on the analysis of protein coding nuclear (Rag 1) gene. The Labeo forskalii group is shown to be divided into two clades instead of one and, *Labeo coubie* group is not monophyletic but forms one clade with *Labeo niloticus* group. Unidentified specimens from Angola formed a clade and were closely related to the two *Labeo forskalii* clades. Species within clades are closely related to each other and therefore may be vulnerable to hybridisation.

Key words: freshwater; conservation; fish; phylogeny; mitochondrial DNA; nuclear DNA

10h00-10h20: Sisanda Mayekiso (MSc student) - Population genetic structure and biogeography of three wrasse species within the Western Indian Ocean

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

Funder/s: DST-African Coelacanth Ecosystem Programme (ACEP); South African Institute for Aquatic Biodiversity (SAIAB)

There is a lack of knowledge on the biogeography of wrasses within the Western Indian Ocean (WIO), with regards to genetic differentiation or connectivity among the regions of the WIO. The WIO is a good model for studying the influence of physical complexities and biogeographic breaks in shaping patterns of differentiation in wrasses. Three reef associated fishes, *Thalassoma lunare, T.hebraicum and Cheilio inermis,* were selected to examine the factors that have influenced patterns differentiation. A molecular genetic approach was used to provide insight into patterns of contemporary and historical connectivity of the three species.

The objectives of this study were to examine genetic differentiation and the relationships among the different geographic regions in the WIO for each target species, and to determine whether the physical complexities of the environment or biological processes of the species affect genetic differentiation in each species.

Specimens were collected from numerous WIO localities. DNA sequence data were generated from two mitochondrial genes (ATPase 6 and cytochrome *b*) and one nuclear gene (the first intron of the nuclear S7 ribosomal protein gene). Traditional population genetic analyses were used to calculate genetic diversity indices within species, which were then compared among species. Population structure was analysed using AMOVA and pairwise Φ_{ST} to compare and calculate differentiation among the WIO regions. The relationships among haplotypes and alleles were reconstructed using median joining networks.

High genetic diversities (h = 0.74 to 0.97) were revealed by median-joining networks; there were many private haplotypes. Connectivity was restricted among localities, even between geographically close localities. Most of the pairwise Φ_{ST} values indicated high genetic differentiation (Φ_{ST} = 0.25 to 0.70) among localities. However, AMOVA of the three genes did not find variation among grouped localities. Regional differentiation was confirmed for the three species within the WIO. This genetic differentiation could be caused by oceanographic features and physical barriers across the species distribution range and the dispersal capabilities and life history features of the species. In addition, *Thalassoma lunare* revealed genetic isolation between the WIO and Red Sea, which is probably due to shallow strait Bab al Mandab and upwelling cells.

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

10h20-10h50: Tea break

Aquaculture and water management (Chair: Aldi Nel)

10h50-11h10: Mmathabo Mogane (MSc student) - Treatment of brewery effluent using high rate algal ponds: establishing the identity of microorganisms in algal ponds and creating an understanding of nutrients removal

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

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

The removal of nutrients from wastewater using high rate algal ponds (HRAPs) system has been demonstrated through research in many countries. In the case of the South African Breweries (SAB) Ltd, in Port Elizabeth, HRAPs were used to treat a portion of anaerobically digested (AD) brewery effluent on an experimental scale. The HRAPs were efficient in the removal of ammonia (NH_4-N) and phosphate (PO_4-P) from effluent. However, the microbial species involved and how nutrients were removed is not fully understood. It is believed that an understanding of nutrients removal, microbial complexes involved and changes in environmental parameters will give an insight into biotic and abiotic interactions in HRAPs. Once understood, it will provide wastewater treatment plants the tools to better manage NH_4-N and PO_4-P using HRAPs. Brewery effluent was previously treated in municipal sewage systems which restricted reuse for other activities. With water crises in South Africa, challenges prevail in equal distribution of water to citizens, hence a need to explore alternative wastewater treatment methods to recycle and conserve water. This study aims to create an understanding of the physicochemical and biological changes occurring in HRAPs at different times and flow rates throughout the year. It also aims to reveal ways responsible for NH_4-N and PO_4-P removal from effluent.

The specific objectives are to:

- compare the physicochemical and biological changes occurring in HRAPs at different times and flow rates throughout the year; and
- compare the effects of light, temperature and pH on microbial's ability to remove nutrients from effluent.

The first experiment was designed to elucidate physicochemical and microbial changes at different times of the year. Between October 2013 and July 2014, the HRAP had mean ($\pm$ standard error) NH_4-N concentrations that range from 0.15 ± 0.05 to 3.86 ± 0.61 mg/L. The NO_2-N and NO_3-N ranged from 0.32 ± 0.1 to 3.28 ± 0.77 mg/L and from 5.1 ± 1.30 to 182.53 ± 18.72 mg/L respectively. The concentrations of PO_4-P ranged from 46.00 ± 2.70 to 100.30 ± 3.55 mg/L. The highest chlorophyll *a* concentrations and algal biomass was 1.57 ± 0.03 μg/L and 0.87 ± 0.01 g/L between October 2013 and March 2014. Algal species found in the HRAPs included *Scenedesmus sp., Chlorella sp, Diatoma sp., Synechoccocus sp., Phormidium sp., Haematococcus sp., Nitzschia sp., Navicula sp., Spirulina sp., Pediastrum sp, Euglena sp.* and *Stigeoclonium sp.*

The second experiment was intended to explain changes in HRAPs at different flow rates. This work is currently ongoing. The third experiment was designed to determine how nutrients are removed from effluent. Microorganisms were cultivated under different intensities of light, temperature and pH for a week. This work is currently ongoing.

Key words: freshwater; aquaculture; water quality; wastewater treatment; water reuse

11h10-11h30: Melissa Mayo (MSc student) - Phytoplanktivorous fish: an alternative method in the removal of microalgae from biologically treated brewery effluent?

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

Funder/s: Water Research Commission (K5/2284); Rhodes University Research Committee

High rate algal pond technology is a sustainable and environmentally friendly method of treating industrial effluent, and is complemented by the inherently high source of protein and lipids of the microalgal cells, making them a valuable secondary product. However, due to their small size and being suspended in a liquid medium, the removal of the cells remains a costly process, resulting in a bottleneck in unicellular algal production. Fish with the ability to filter feed (Oreochromis mossambicus) were investigated as an alternative mechanism of microalgal removal.

Batch-fed experiments were designed to determine the rate of microalgal removal (a comparison of treatments 2, 4, 5 and 6) and the effect of microalgal supplementation on fish (treatments 1 to 4):

- Treatment 1 – fish + highly concentrated algal + fish food
- Treatment 2 – fish + highly concentrated algal + no fish food
- Treatment 3 – fish + low concentration algal + fish food
- Treatment 4 – fish + low concentration algal + no fish food
- Treatment 5 – no fish + highly concentrated algal + no fish food
- Treatment 6 – no fish + low concentration algal + no fish food

Preliminary findings suggest that the rate of algal removal was higher in treatments 3 and 4 (i.e. low algal concentration; 0.40±9.04 and 6.16±5.79 mg/L/kg/h) when compared with treatments 1 and 2 (i.e. high algal concentration; 0.74±4.95 and 5.32±3.89 mg/L/kg/h); $p<0.05$), suggesting higher filtering efficiency when the concentration of microalgal cells was lower. The absence of fish (treatments 5 and 6) lead to accumulation of microalgae and, in some instances, increased productivity (i.e. production of algae). Poor fish growth was due to low feeding rates of commercial fish food. The average daily feed consumption rate, as a percentage of fish biomass, was 1.5±0.61%; much lower than the recommended amount of 4-3 g for 20-100 g fish. Repressed feeding was likely a result of high unionized ammonia, with an average of 2.35 mg/L in the tanks; exceeding the level of 0.08 mg/L where reduced feeding has been reported in tilapia.

Stable isotope analysis, fish gut content analysis, macroscopic and morphologic evaluation of heart, liver and gills, microscopic evaluation of liver, visceral and hepatosomatic index, blood constituent analysis, fish condition factor and growth are also being investigated.

Mozambique tilapia are capable of removing microalgae from the water column, however, their highly suppressed growth rates make the combined effort of fish culture and microalgal removal in the current system an unfeasible option if the objective is to simultaneously farm fish. The rate of algal removal using these fish needs to be compared with other removal mechanisms.

Key words: freshwater; aquaculture; algal ponding; Mozambique tilapia; *Oreochromis mossambicus*

11h30-11h50: Adejoke Adesola (PhD student) - Dietary lysine requirement of juvenile dusky kob (*Argyrosomus japonicus*)

Supervisors: 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); THRIP; Marifeed (Pty) Ltd

The use of protein-rich plant ingredients have received increasing attention as potential substitute for fish protein in practical fish feeding. However, plant protein often shows deficiencies in some essential amino acids (EAAs) such as lysine, methionine and arginine. Of all the essential amino acids, lysine is often the first limiting amino acid in the ingredient used to prepare fish diets. The ideal protein concept uses lysine as a reference amino acid, with the requirement for all other EAA expressed as a percentage of lysine. Thus, if the requirement of dietary lysine is known, the requirements of the remaining EAAs can be accurately estimated from the ratio of the whole-body amino acid pattern (A/E ratio) of specie. Therefore, an optimal dietary inclusion level of lysine is required in advance to formulate nutritionally complete and cost effective fish feeds.

This study was conducted to determine dietary lysine requirement of dusky kob and to estimate the requirement for other EAA using ideal concept. Six isonitrogenous and isoenergetic diets were formulated to contain a combination of fish meal and soybean as protein sources. Crystalline L-lysine was added to the basal diet to replace glutamic acid/aspartic acid at six graded levels from 0 to 3.3 % dry ingredient to maintain dietary protein level. The lysine levels in the six experimental diets were 1.11, 1.77, 2.43, 3.09, 3.75, and 4.41 % dry diet. Each diet was randomly assigned to triplicate groups of 12 fish (4.5 ± 0.2 g.fish^{-1}; 66.5 ± 1.1 mm.fish^{-1}). Dusky kob was fed to apparent satiation by hand twice daily for 12 weeks. The temperature and dissolved oxygen levels averaged 24.1 ± 0.2 ^{o}C and 4.7 mg L^{-1} and NH_4-N remained below 0.1 mg L^{-1}.

Fish fed lysine at a level of 2.43 % dry diet (DL_3) showed the highest specific growth rate (SGR). Live weight gain (LWG) of fish increased with increasing levels of lysine up to 2.43% dry diet and peaked at 445.8 % ($P<0.05$), beyond which it showed a declining tendency. A similar trend was observed for protein efficiency ratio (PER). Fish fed lysine 1.77 % dry feed and 3.09 % dry feed dry diet had highest (26.72 g) final mean weights. The most efficient FCR and the highest PER were observed in groups fed 2.43 % dry feed (DL_3). No significant difference in survival rates were found between dietary treatments. A second order polynomial regression analysis based on SGR, indicated that the lysine requirement of dusky kob was 2.25 % dry diet corresponding to 5.2 % of dietary protein. On the basis of the body profile of dusky kob, the A/E ratio for each EAA was calculated. Based on those values and on the determined lysine requirement, an estimation of the requirements for other EAA was calculated.

Keywords: marine; aquaculture; nutrition; essential amino acid

Fisheries Science (Chair: Aldi Nel)

11h50-12h10: Ross Rutherfoord-Jones (MSc Student) - Movement, migration, residency and genetic stock assessment of Santer/Soldier (*Cheimerius nufar*)

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

Funder/s: South African Institute for Aquatic Biodiversity (SAIAB); Rhodes University Research Committee

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

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

The tagging programme data from research programmes in Tsitsikamma National Park (TNP) and Algoa Bay, and the volunteer ORI tagging programme have shown a high degree of residency for Santer with 80% of fish moving within in a range of 5 km from when they were first caught. This is indicative of typical sparid residency patterns. In the TNP programme, which was as shore angling programme, Santer were only caught when there are cold upwelling events in the region as Santer take refuge in warmer shallower water during periods of cold upwelling.

The cytochrome oxidase subunit 1 (COI) gene was chosen for the genetic stock assessment; 220 samples yielded 138 sequences of 377 base pairs. Within these sequences there were 16 polymorphic sites, identifying 16 haplotypes. The haplotype network revealed a geographically unstructured population. An AMOVA conducted on the sequences, now divide into five separate regions, showed that there were no significant genetic differences between the geographically selected areas. This data suggest that Santer consists of a single panmitic stock, which is the case in many other sparid species.

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

12h10-12h30: Sarah Halse (MSc student) - Towards standardized biodiversity monitoring; the effect of bait type on reef-fish assemblage structure observed with a stereo-video technique

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

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

In recent years it has become evident that both, the management and monitoring of fish resources have been inadequate, or inappropriate, to ensure the sustainable utilisation of target fish species, and the conservation of biodiversity. The single and multi-species approach of traditional management is now considered outdated, particularly for reef fish, and there is a drive to implement holistic ecosystem based fisheries management, such as marine protected areas (MPAs). Long-term monitoring and research is crucial for adaptive and effective management of MPAs and suitable methods must be comprehensive, easily standardized, non-invasive, non-destructive and without depth restrictions. Baited remote underwater stereo-video systems (stereo-BRUVs) are a relatively new tool that satisfy such method requirements. Stereo-BRUVs were developed to determine fish abundance and size structure in an unbiased, and relatively non-invasive manner across a broader range of depths and habitats than conventional methods (i.e. controlled angling, underwater visual census and fishtraps), characteristics particularly useful in MPA research. The method is novel to South Africa and the methodology is yet to be fine-tuned for the warm-temperate Agulhas ecoregion and its fish communities.

One key component of the methodology is that it requires bait to attract fish into the field of view. Whilst it is an accepted standard to use pilchard *Sardinops sagax* for stereo-BRUVs, its suitability has never been tested comparatively to other bait types for local conditions. This project aimed to investigate the effect of different bait types, namely pilchard, squid *Loligo reynaudi*, mussels *Perna perna* and oyster *Crassostrea gigas* on the observed fish assemblage structure and determine which bait type provided the most comprehensive and cost-effective assessment of reef fish biodiversity when sampling with stereo-BRUVs.

Variation in bait performance was found during bait type comparisons. Mussels, pilchard and squid all produced samples with high species richness. Oysters, however, produced samples with low species richness and also appeared as an outlier in a canonical analysis of principal coordinates suggesting it is an ineffective bait type. Oysters also proved to sample significantly less commercially important species than mussels ($p=0.0064$). Despite this, mussels attracted on average only half the amount of fish when compared to pilchard and squid as attractant. Both, pilchard and squid can be considered effective bait types with no significant difference in performance between them. Both bait types can be locally sourced, however, squid is a less cost-effective bait in comparison and is subject to availability. It is therefore suggested that pilchard is the most appropriate bait, in terms of effectiveness, cost and availability for the Agulhas ecoregion.

Key words: marine; monitoring; MPA; stereo-BRUVs

12h30-13h50: Lunch break

Marine and estuarine ecology (Chair: Enrico Gennari)

14h00-14h20: Chantel Elston (MSc student) - The ecology of stingrays (Dasyatidae) in the St. Joseph Atoll, Seychelles

Supervisors: Dr PD Cowley (tagfish@gmail.com); Dr RG von Brandis (rainervonbrandis@gmail.com)

Funder/s: Deutscher Akademischer Austausch Dienst – National Research Foundation Joint Scholarship (DAAD-NRF); Save Our Seas Foundation

Populations of elasmobranchs are declining given their vulnerability to overfishing because of their k-selected life histories. However, effective management conservation strategies are hindered by a lack of baseline ecological and biological information for many species. In particular, the Dasyatidae (whiptail stingrays) are largely overlooked as research efforts have focussed on larger shark species. This project aims to provide ecological information for two abundant Dasyatid species in the St. Joseph Atoll, Seychelles. Specific objectives are to perform a dietary study on the porcupine ray *Urogymnus asperrimus* and a spatial ecology study on *U. asperrimus* as well as the mangrove whiptail *Himantura granulata*.

To determine the diet of *U. asperrimus* the non-lethal method of gastric lavage was employed i.e. a plastic hose connected to a bilge pump was inserted into the stomach of the ray which was flushed with seawater to induce regurgitation of stomach contents. Sediment cores were taken to determine prey selectivity. Prey items were identified to the lowest possible taxon. The percentage of total volume (%V), the frequency of occurrence (%F), and the Index of Importance (IoI) (which combined %V and %F) was calculated to determine the importance of prey items. Thirty Vemco acoustic tags were surgically implanted into *U. asperrimus* and *H. granulata* to track their movements. An extensive array of acoustic receivers was already present in the atoll prior to this project.

Polychaetes were the most important dietary item for *U. asperrimus;* in particular the family Capitellidae occurred with high frequencies and volumes. Cumulatively crustaceans also formed an important dietary component, however individual families each contributed little to the diet in terms of frequency and volume. Given that almost all prey items were eaten infrequently at low densities, *U. asperrimus* can be considered a generalist feeder with specialisation on one polychaete family (Capitellidae). *U. asperrimus* was found to feed on Capitellidae with a moderate preference given the high ambient densities of the polychaete, but there seems to be a high preference for crustaceans giving their presence in the stomach sample but complete absence (other than one individual) in the sediment cores. Multivariate analyses provide initial support for ontogenetic, but not sex-related, shifts in diet. The first acoustic receiver data download is only set to take place in November 2014 so results are not yet available.

Key words: marine; ecology; Dasyatidae; gastric lavage; acoustic tracking

14h20-14h40: Taryn Murray (PhD student) - Estuarine space use and movement behaviour of a piscivorous predator *Lichia amia* (Carangidae), determined by passive acoustic tracking

Supervisors: Dr PD Cowley (p.cowley@saiab.ac.za); Dr A-R Childs (a.childs@ru.ac.za)

Funder/s: Deutscher Akademischer Austausch Dienst/National Research Foundation Joint Scholarship Programme (DAAD-NRF); Rhodes University Research Committee Grant; South African Institute for Aquatic Biodiversity (SAIAB)

Leervis *Lichia amia* is a sought-after estuarine-dependent fishery species targeted by recreational line- and spearfishers and coastal subsistence fishers throughout its local distribution. Increasing levels of juvenile exploitation in estuaries highlight the need to better understand the spatial and temporal aspects of estuarine-dependency. Similarly, there is a need to understand the effect rhythmic cycles have on the movement behaviour of juvenile leervis, as well as the influence environmental factors have on movement patterns. Therefore, this study aimed to (i) describe spatial and temporal movements and area use patterns within an estuary, (ii) determine the effect of rhythmic cycles, tidal phase, time of day and lunar phase on estuarine and marine excursions, and (iii) investigate the effect changes of temperature (river and sea), river inflow and additional weather parameters (e.g. wind direction, wind speed, wave height) have on estuarine movements and marine excursions.

An array of 20 Vemco VR2W acoustic receivers, spaced 1 km apart, was used to record information on movement patterns of juvenile leervis (303-464 mm fork length, n = 21) in the Kowie Estuary, Eastern Cape Province, from January 2013 – January 2014. Results suggest that daily movements corresponded with the tide and its associated changes in salinity and temperature, and that tagged fish display distinct circatidal activity patterns, with certain individuals utilising longer stretches of the estuary on the spring tides.

Key words: estuarine; ecology; acoustic telemetry; circatidal rhythms; estuarine-dependence

14h40-15h00: Alexander Winkler (PhD student) - The long shore migratory patterns and inshore habitat use of the Leerfish, *Lichia amia* (Teleostei: Carangidae), in southern Angola using acoustic telemetry techniques

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

Funder/s: NRF/DAAD Freestanding Bursary (DAAD-NRF); Ocean Tracking Network (OTN); National Research Foundation (Rated Researcher Grant**Error! Bookmark not defined.**) (NRF); Flamingo Lodge; Angola Ministry of Fisheries; Rhodes University Research Committee

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. Despite the high recreational value of the species, very little is known about their regional connectivity and movement patterns. 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 Namibian/Angolan populations. Despite genetic structuring, both populations share very similar life history strategies with the exception of estuarine dependence found within the South African population. The aims of this study are to investigate the movement behaviour of sub-adult, and adult *L. amia*, in an attempt to understand their habitat utilization in the absence of estuaries, circannual movement patterns in relation to environmental cues and to compare the behavioural effect of allopatry with its South African counterpart.

Thirty nine acoustic listening stations where deployed in September 2013 along a 150 km stretch of coastline in southern Angola covering exposed coastline (Flamingo Lodge (FL)), a large coastal embayment (Bia dos Tigres (BT)) and a small coastal embayment (Tombwa bay (TB)). Twenty mature (670 mm – 1020 mm FL) *L. amia* where tagged internally with coded VEMCO V 16 (4H; 55 s nominal delay, 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) where tagged in June/July of 2014 with VEMCO V 13 (1H; 65 s nominal delay, 1 year battery life) acoustic transmitters. The acoustic receivers were serviced in June 2014. Fish movement and temperature data for the nine month period was secured.

Of the 20 tagged fish, 85% (n=17) were detected on the array, with 11 fish being detected on the FL array, 10 detected in and around BT and none in TB. Two fish remained within the FL area for the entire 9 month period. In contrast, five of the fish found in the FL array also utilised BT for some period of time. Of the 10 fish utilising BT, four were only detected for no longer than a few consecutive days. The other six individuals utilised BT for up to four months between October and May. The next data collection will take place in June 2015. Time spent in different environments (e.g. embayments / different depth profiles) will be estimated using an algorithm in R. While the timing, duration and frequency of visits to different environments between seasons will be analysed using a series of generalised linear models, generalised additive models will most likely be used to identify the environmental drivers, such as temperature, photoperiod or chlorophyll that influence the presence or absence of fish.

Keywords: marine; ecology; *Lichia amia*; acoustic telemetry; West Africa

15h00-15h20: Matthew Parkinson (PhD student) - Understanding migration patterns and inshore habitat use of west coast dusky kob *Argyrosomus coronus* in southern Angola using acoustic telemetry techniques

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

Funder/s: Ocean Tracking Network (OTN), National Research Foundation Angola-South Africa Joint Collaboration (NRF), Flamingo Lodge, Angola Ministry of Fisheries, Rhodes University Research Committee

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

Acoustic telemetry equipment and temperature loggers were deployed in 2013 in three regions encompassing the full range of habitats including sections of exposed coastline and two coastal embayments in southern Angola. Twenty mature (760-1155 mm TL) *A. coronus* were tagged with coded VEMCO V16 (4H; 55 s nominal delay) acoustic transmitters at Flamingo Lodge, southern Angola during August 2013. A further 10 juvenile and sub-adult fish (460-765 mm TL) were tagged with coded VEMCO V13 (1H; 60 s nominal delay) transmitters in June 2014.

Adult west coast dusky kob in southern Angola exhibited a partial migration pattern, whereby a proportion of the population undergo a migration while the rest remain in their home area. Evidence of an upper thermal preference was noted, with tagged individuals only detected in water cooler than 24.8 °C, while water temperature in the area peaked at 26 °C (5 Mar 2014). Tagged fish did not exhibit avoidance of the coolest waters recorded (15.6 °C, 24 Sep 2014). Home range analysis, based on the minimum convex polygon, revealed that the average home range size of adults and sub-adults was 18.5 km^2.

Key words: marine; ecology; acoustic telemetry; migration; southern Angola

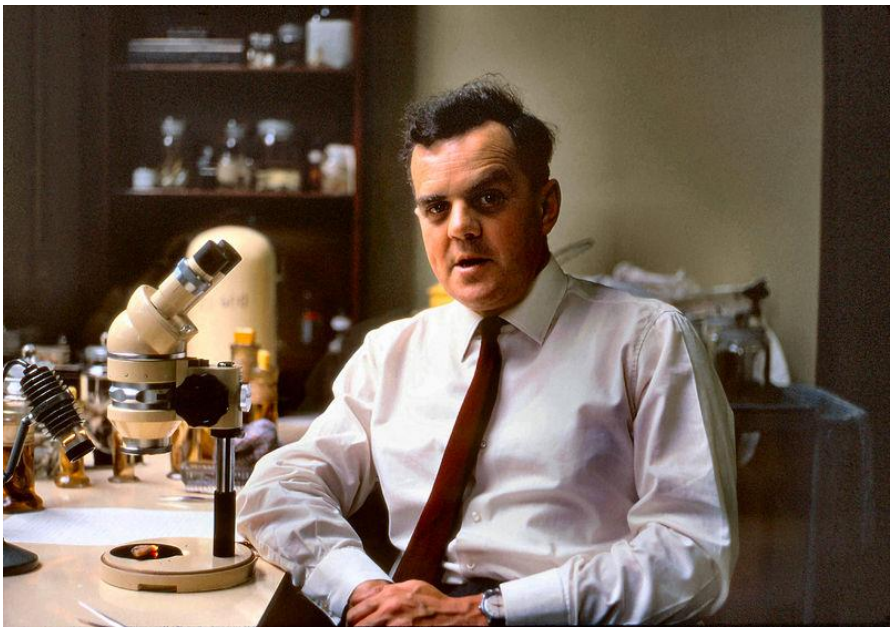
Friday 10 October 2014

Humphry Greenwood Guest Speakers (Chair: Warwick Sauer Error! Bookmark not defined.**)**

08h50-09h00: Welcome and introduction by HOD

09h00-09h30: John Duncan - Marine conservation in South Africa: challenges and opportunities

09h30-10h15: Dr Larry Oellermann - How to plan an accidental career



Student seminars first session (Chair: Warwick Sauer)

10h15-10h35: Justin Kemp (PhD student) - The basket ecosystem - using stable isotopes as a tool to track nutrient utilisation in cultured abalone fed combination diets

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

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

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

Despite this, abalone have been shown to grow particularly well on a diet of mixed seaweeds under culture conditions. Furthermore, protein utilization of formulated feed has been shown to improve with fresh seaweed supplementation. A growth trial assessing the role of fresh seaweed supplementation into the diet of animals fed a formulated feed was conducted under controlled conditions at the Port Alfred Marine Research Laboratory. Five graded supplementation levels of a "mixed bag" of fresh seaweed (*ulva sp*., *gracilaria sp*. and *E. maxima*) were tested over a 12 month growth-period. Under this experimental design, abalone were exposed to multiple nutrient sources in their baskets, ranging from multiple macroalgae classes through terrestrially derived plant products to marine fish-based proteins. This provided an interesting scenario to investigate the use of stable isotopes, a technique usually associated with food web ecology, as a tracing tool to evaluated nutrient deposition in abalone.

Biological samples were taken from abalone foot muscle tissue and all feed sources and analysed for stable isotope ratios using mass spectrometry. Analysis on foot muscle samples taken at the conclusion of the growth trial (54 weeks) show significant differences in the δC^{13} (ANOVA, $F(4, 145) = 151.75$, $P = 0.0000$) and δN^{15} (ANOVA, $F(4, 145) = 308.74$, $P = 0.0000$) values for abalone from differing dietary treatments. These data were incorporated into a mass balance mixing model, Stable Isotope Analysis in R (SIAR), in conjunction with literature derived $\Delta\delta C^{13}$ and $\Delta\delta N^{15}$ values in order to determine the contribution of dietary components to muscle deposition. The resulting model outputs were then integrated into known dietary contribution values calculated from feed consumption data to highlight scenarios where there may be unbalanced consumption / assimilation ratios. Initial results indicate the potential selective deposition of C and N from *Gracilaria sp*. as well as a trend of decreased deposition of formulated feed C and N with decreasing fresh macroalgae supplementation.

Key words: marine; aquaculture; *Haliotis midae;* formulated feed; fresh seaweed supplementation; stable isotopes

10h35-10h55: Enrico Gennari (PhD student) - Thermal physio-ecology of the white shark *Carcharodon carcharias*

Supervisors: Dr PD Cowley (p.cowley@saiab.ac.za); Mr RL Johnson (info@ryan-johnson.org)

Funder/s: Oceans Research; South African Institute for Aquatic Biodiversity (SAIAB); PADI Aware

The white shark *Carcharodon carcharias* is one of few elasmobranch species capable of maintaining parts of its body warmer than the surrounding environment. Very little is known about the thermal physiology of white sharks in the wild, since studying these large, highly mobile and potentially dangerous predators, often in rough sea conditions, is challenging.
This project made use of multi-sensor acoustic telemetry to determine the white shark habitat use, movement patterns and thermal ecology in Mossel Bay (South Africa). This provided, for the first time, a means to assess simultaneously the complete thermal profile of a white shark from ambient water temperature through the warmer white muscle to the warmest body core temperature of the stomach.

A total of six white sharks (TL= 1.5,2, 2.5, 3, 3.5,4 m size classes) were triple tagged with a cumulative tracking effort of 775 hours. This included two continuous tracking sessions of 107 and 106 hours on two individuals. Generalized Additive Models were used to interpolate the stomach, white muscle and water thermal profiles. Semi-unsupervised Behavioural Change Point Analysis and Bayesclust Analysis (using R Packages) were applied to movement data to define behavioural classes. Mixed models were used to investigate the influence of variables on the probability of being assigned to a given class. The variables included wind strength, tidal phase, time of the day and the interaction of location and size (to look at ontogenetic habitat use). Finally, a behavioural transition matrix was used to corroborate the described behavioural classes.

This study provided the first evidence of post-prandial stomach thermal increment (HIF or SDA) and physiological thermoregulation in white sharks. The findings were used to describe several examples of convergent evolution with bluefin tuna *Thunnus thynnus*. It is also hypothesized that the white shark ontogenetic thermal niche expansion observed worldwide can be explained by the increase in basal thermal excess with body size. Additionally, a meal-dependent increase in basal metabolism was assessed for the first time in a Lamnid shark. Furthermore, when the stomach thermal increment reaches its functional upper limit, white sharks possess the ability to switch to an energy saving behaviour. Five distinct behavioural movement classes were identified (maximum posterior probability = 99.4%). It is suggested that even though the ontogenetic dietary shift is behaviourally driven, the motivation behind the shift is physiological, which provides the first indication of potential influence of post-prandial metabolism in an animal's dietary choices.

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

10h55-11h30: Tea break

Mariculture - abalone (Chair: Matthew Parkinson)

11h30-11h50: Warren Witte (Msc student) - Abalone stock enhancement at Cape Recife: The potential for commercial scale ranching in the Eastern Cape Province of South Africa

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

Funder/s: THRIP; Lidomix (Pty) Ltd

The abalone resource in South Africa has suffered extensive poaching causing many areas to suffer complete stock collapse. It has been said that these hard hit areas may never recover without intervention. Abalone ranching has the potential to rehabilitate these worst hit areas where natural recruitment has been severely compromised. To date, abalone ranching has been undertaken on an experimental basis, and although the results are promising, existing ranching protocols need to be improved and commercialised. Furthermore, to ensure the success of the new sub-sector, there is a need to develop a better understanding of the biological interactions and limitations to ranching, the economics of the ranching operations, and social impacts and issues accruing to the promulgation of area bound access rights. This research and development programme is designed to focus on these core developmental issues, and provide the industry with appropriate bio-economic models.

The research objectives are:

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

To achieve these objectives small-scale experimental plots based on a split plot design have been seeded with three densities and two size classes of abalone in two distinct habitats. In October and December 2014, 6 months post seeding, the plots will be destructively sampled and growth and survival will be measured. The outcome it is hoped will inform appropriate size classes and densities in which to seed juvenile abalone as well as establish the prime seeding habitats. In addition to the small experimental plots much larger commercial scale seeding operations have been undertaken. Over 4.5 tons and 125000 abalone have been seeded onto reefs off Cape Recife as of the 25th September 2014. Research techniques such as videoing the seeding process have allowed insights into the predator interaction and initial settlement of abalone. Further a video time lapse was set up over 90 minutes, which obtained interesting post seeding behaviour of large (80-95mm) abalone. 24-hour post seeding mortality, using dead shell counts, on 80-95mm abalone ranged from 1% - 6.5% with an average of 2.6% mortality across 5 different sites. Monitoring of select large-scale commercial sites has just got underway and results are expected to yield data that will better inform interested parties as to the economic feasibility of abalone ranching.

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

11h50-12h10: Chris Gornall (MSc Student) - The effect of stocking density on the growth and behaviour of the South African abalone (*Haliotis midae*)

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

Funder/s: DAAD-National Research Foundation (DAAD-NRF**Error! Bookmark not defined.**); THRIP (TP2011071800030); Marifeed (Pty) Ltd; HIK Abalone Farm (Pty) Ltd**Error! Bookmark not defined.**; Aquafarm Development (Pty) Ltd; Roman Bay Sea Farm (Pty) Ltd.

Farmed abalone production is related to growth and stocking density. The aim of this study was to develop a better understanding of abalone behaviour at different stocking densities and to possibly link these changes with differences in growth at these densities. The objectives were to compare growth and behaviour of abalone farmed at a low (17% of surface area SA, 9kg per basket) and high density (25% SA, 13 kg per basket).

Trials were conducted on HIK Abalone Farm (Pty) Ltd in production tanks, at a flow of 20L/kg/h and using farm production protocols. The abalone position in the baskets at the high (HD) and low (LD) density was determined using photography. Abalone were weighed every two months for eight months by sampling 30 animals per basket (n=180/tank). Each treatment was replicated four times. At the 4-month grading event animals were weighed and re-stocked at densities of 17 and 25 % SA.

Growth was estimated as Weight = 55.62 + 0.17 days (r^2 = 0.97). The model for the LD treatment was Weight = 55.29 + 0.19 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.

Results from a behavioural study are preliminary. The percentage of abalone on the mesh walls at night decreased for both treatments over the course of 240 days. This distribution decreased on average from 25 to 30% at the start of the experiment to around 10 to 12 % at the end. This change corresponds with a change in use of the rack inside the basket. Approximately 53 to 57% of the abalone were found on the rack at the start of the trial and this increased to about 68 to 70 %. An explanation for this shift requires further investigation.

In a second trial, observation of abalone at both densities were conducted using a clear-sided tank by observing focal animals (n=384) for twenty minutes over twelve days during four observation periods per day. Behaviour was categorised into those not involving other abalone (e.g. movement, feeding, grazing) and those involving other abalone, termed interactions where orientation, the surface on which interaction occurred, duration and outcome were recorded. All behaviours were identified and the duration and frequencies recorded. Two hundred and eighty two interactions were recorded over twelve days. Data are currently being analysed.

Keywords: marine; aquaculture; photography; observation

12h10-12h30: Ann Wu (MSc student) - The effect of phytoestrogen on the growth, gonad development and histology of farmed abalone, *Haliotis midae*

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

Funder/s: Marifeed (Pty) Ltd; THRIP; HIK Abalone Farm (Pty) Ltd**Error! Bookmark not defined.**; Aquafarm Development (Pty) Ltd; Roman Bay Sea Farm (Pty) Ltd; Rhodes University Research Committee

Abalone *Haliotis midae* fed a formulated diet that included soya had larger gonads during the reproductive season than abalone fed no soya (Ayres 2013). This does not translate into income for the farmers since the gonads are discarded when abalone are canned. Also, dietary soya resulted in superior meat mass gain so the removal of soya from the feed is not desirable.

Soya beans contain isoflavones (ISO), a class of phytoestrogens with estrogenic and/or antiestrogenic effects. This study determined to what extent phytoestrogens found in soya induced gonad development and to compare growth, gonad development and histology of animals fed diets containing no phytoestrogens with animals fed graded levels of soya and graded levels of ISO. Animals (40-50 g abalone^{-1}) were fed seven isonitrogenous and isoenergetic diets, i.e., fishmeal (FM) only, FM with graded inclusions of soya (25, 50, 100%), and FM with equivalent inclusions of ISO. Whole weight, meat mass (wet and dry), shucked mass (i.e. soft tissue mass), shell mass, shell length and visceral mass (wet and dry) were collected every 45 days between September 2013 and March 2014.

Mean monthly weight gain of animals fed FM only and FM with graded levels of ISO were not influenced by the inclusion of ISO ($p > 0.05$), while males and females fed graded levels of soya were influenced differently by dietary soya levels ($y = 3.25 + 0.00082\,x$, $r^2 = 0.19$; $F_{(1, 38)} = 10.28$, $p = 0.003$). Mean male monthly weight gain increased with an increase in dietary soya ($y = 3.24 + 0.002$ x, $p = 0.03$; $r^2 = 0.23$). Similarly, only male meat mass, visceral mass and gonad bulk index (GBI) increased with increasing soya inclusion rates. Growth was similar for FM only and FM with the addition of graded levels of ISO, but at certain times of the year males had higher mean whole mass, visceral mass, visceral index and GBI. Length gain was not influenced by the addition of ISO and soya. Visceral water loss was higher in males for all treatments, with females fed soya diets decreasing as a function of increasing dietary soya ($y = 75.17 – 0.0004$ x, $p = 0.049$; $r^2 = 0.20$). Preliminary histology results suggest that the prevalent mature stage (7) increases with increasing dietary soya level.

It can be concluded that ISO in the FM diet did not increase gonad development and that it is probably not the isoflavones in the soya that were responsible for increased gonad development when soya is fed to abalone. Future studies should test which compounds in soya might be responsible for gonad growth.

Key words: marine; aquaculture; isoflavone; oestrogen

12h30-12h50: Aldi Nel (PhD student) - The role of a kelp-supplemented artificial feed in the digestive physiology of the cultured South African abalone, *Haliotis midae*

Supervisor: Prof. PJ Britz (p.britz@ru.ac.za); Prof. B Pletschke (b.pletschke@ru.ac.za)

Funder/s: Marifeed (Pty) Ltd; Marine Living Resources Fund (DAFF); THRIP (TP2011072100025)

Cultured *Haliotis midae* fed formulated feed supplemented with dried kelp display higher feed conversion rates compared to those fed a base formulated feed comprising plant and animal proteins and refined starches with a terrestrial plant origin. The kelp, Ecklonia maxima, which is added to formulated feed as a supplement, consists of complex polysaccharides with biochemical properties that are very different from the other starch ingredients. In addition, kelp as an algal fibre and abalone gut microbes form a symbiotic association as microbes aid in the digestion of the relatively nutrient-poor algal substrate. Apart from enzymology and microbial-community (metagenomic) studies on the response of abalone to either diets of seaweed or formulated feed, little is understood about an abalone's physiological response to a combination of kelp and formulated feed and its effect on enhanced digestive efficiency.

This study aims to characterize the effect of dietary algal fibre on morphological, bacterial and enzyme parameters of the abalone gut. To distinguish between active enzymes of bacterial and endogenous origin, sub-samples of experimental abalone on each diet (the base diet and the kelp-supplemented diet) will be treated with antibiotics prior to enzyme analyses. Gut-bacterial sequencing of abalone on both diets will determine if algal fibre as a prebiotic causes a shift in the abalone's gut bacterial community. Microscopy will establish the sites of residency for bacterial groups and possible alterations in gut morphology. Thus far, this study has established the commercial application of diets with varying kelp inclusion levels for different protein levels (another determinant of abalone growth).

In August 2013, farmed abalone (18.5 g ± 4.5 S.D.) were started on a diet with different protein levels (22, 24 and 26 %), each with a different kelp level (0.44, 0.88, 1.76 and 3.53% dry weight). Each diet was fed to randomly distributed replicate abalone baskets (N = 6). After eight months, the effect of protein level on abalone growth (% mass gain) was independent of kelp level as no interaction was found between the two (factorial ANOVA, $F_{12, 120} = 0.71$, $p = 0.74$), but growth (%) increased with increased dietary protein ($F_{4,120} = 11.81$, $p < 0.00001$). Within the 26% protein level, kelp inclusion had a significant effect on mass gain (%) (One-way ANOVA: $F_{4,25} = 8.4$, $p = 0.00019$). The control diet (0% kelp) had the lowest mass gain (41.9 ± 7.3 %) compared to the diets with each of the four kelp levels (65.7 – 74.5 %).

In summary, the best abalone growth was obtained when kelp was included in the diet, but the level of kelp did not affect growth. Currently, ground work is being done for genomic bacterial and enzymology analyses. For these analyses, samples of the guts of abalone fed a base diet (26% protein and 0% kelp) and a kelp-supplemented diet (26% protein and 0.88% kelp) will be collected from a commercial farm during mid-October 2014.

Key words: marine; aquaculture; digestive physiology; gastropods; prebiotics

13h00 DIFS PHOTOGRAPH

Non-presenting students

Elethu Duna (MSc student) - Progress in implementation of ecosystem approach to fisheries in South Africa: principles and practice

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

Funder/s: DAFF; WWF

Fisheries have been for many years providing livelihood, employment and food security for humans. For many years the negative impacts of the human footprint on the oceans resulting from fisheries was never fully understood. In addition to direct effects on target resources: these include by-catch of non-target species including vulnerable and endangered species, destruction of benthic habitats due to destructive fishing methods and disturbance of food chains resulting from removal of predatory species from the ecosystem. The ecosystem approach to fisheries (EAF) calls for a holistic approach in managing human activities on the ocean, through reducing negative impacts of fisheries on ecosystems, rebuilding damaged ecosystems and ensuring optimal, sustainable benefits for human beings.

The key questions are the following: 1) to what extent do South Africa's national policies and legislation address the need to implement EAF in the country's marine fisheries; 2) what progress has been made in implementation of EAF; 3) how does progress vary between different fisheries and has there been a change in progress in implementation of EAF over time; 4) are there differences in progress between data rich and data poor fisheries; and 5) in what aspects of EAF has progress been most limited, and what are the barriers to improved implementation?

The study therefore focuses on two components: the incorporation of EAF into legislation and implementation in practice. Joyner (2013) undertook an assessment of the Marine Living Resources Act and the Policy for the Small Scale Fisheries Sector in South Africa. For the first component of my study, I am reviewing and extending this assessment using the criteria she developed and also comparing South African fisheries policies and regulations to those of countries leading in the implementation of EAF, such as USA, Australia and Namibia.

For the second component, a minimum of 20 fisheries assessed by the South African Sustainable Seafood Initiative will be used. The assessments contain three categories: (i) stock status, (ii) ecological impacts of the fishery and (iii) management measures in place for the fishery. The stock status category is divided into three sections to separate fisheries with defined reference points and regularly conducted assessments to those with minimal or no reference points and stock assessments. The assessments contain 14 questions with between 3-5 possible answers for each. The assessment results will be quantified using non-parametric statistical tests on R to determine if differences exist between different fisheries, between the data poor and data rich fisheries, and if there have been trends over time. A further 5 fisheries will be assessed in depth using available ecological risk assessments, available literature and in consultation with relevant stakeholders to track progress of implementing EAF in practice.

Key words: marine; fisheries management; ecosystem approach to fisheries; policy; SASSI

Matthew Farthing (MSc student) - Description, seasonality and habitat preference of larval ichthyofauna occurring in the surf zone on the southern Angolan coastline

Supervisors: Dr. WM Potts (w.potts@ru.ac.za); Dr. N Strydom (nadine.strydom@nmmu.ac.za)

Funder/s: Flamingo Lodge, Angola; Rhodes University Research Committee

The importance of understanding the entire lifecycle of fishes is well known, and consequently science has recognized the need to investigate even the earliest stages of fish development. Contrary to what was previously thought, modern day ichthyology has established that exposed beach surf zones represent a useful nursery habitat for many juvenile and larval fishes. This paradigm shift has seen increased interest in determining the presence and behavior of early stage fishes in these complex habitats. Several recent 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.

The aim of this study is to describe the larval fishes occurring in a southern Angolan surf zone. The study will also assess the habitat preference and the seasonality of the larval fish assemblage. This is the first work in the region to focus on fish larvae, and therefore stands to make a meaningful contribution to our understanding of the early life stages of its fishes.

Six randomly stratified (by substrate type and wave energy) sites were selected along a 25 km section of coastline. Larval fish are being sampled using a 5 m x 1.5 m rectangular seine net with a 0.5 mm square mesh monthly from June 2014 - May 2015. The net is towed for 25 m alongshore in water approximately 1 m deep by two field researchers. A further 8 sites are sampled quarterly in a nearby coastal embayment using the same methods. Larvae are stored in 5% formalin/seawater solution for analysis and identification will take place under laboratory conditions.

Preliminary results (three months of sampling) suggest that larval density in the coastal embayment far exceeds that of the exposed beaches. While the species composition is yet to be compared it is possible that the "estuarine dependent" species in this region make use of coastal embayments instead of estuaries in there early life stages.

Key words: marine; ecology; larvae; Angola; warm-temperate; surf zone

Gareth Grant (MSc Student) - Movement patterns of *Rhabdosargus holubi* in the Kowie Estuary, South Africa

Supervisors: Dr PD Cowley (tagfish@gmail.com); Prof. AK Whitfield (a.whitfield@saiab.ac.za)

Funder/s: Rhodes University Research Committee; South African Institute for Aquatic Biodiversity (SAIAB)

Rhabdosargus holubi is a ubiquitous estuarine-dependent fishery species endemic to southern Africa. Although aspects of their recruitment dynamics from sea to estuary have received considerable research attention, little is known about their movement behaviour within estuarine systems. Fishery surveys have revealed that *R. holubi* is a dominant catch species of recreational and subsistence fisheries within several temperate estuaries in South Africa. Therefore, investigating movement behaviour is fundamental to understanding its ecology and implementing effective fisheries management strategies. Making use of acoustic telemetry, this study aims to gain a better understanding of the spatial ecology of juvenile *R. holubi* within the permanently open Kowie Estuary.

Previous studies have shown that adverse effects on physiology and behaviour increase as the ratio of the transmitter weight to fish weight increases. Due to the small size of juvenile *R. holubi* a tag effect experiment to test for adverse effects of transmitter presence was necessary. Dummy tags were surgically implanted into juvenile *R. holubi* to evaluate tag retention rate and the effects of the transmitters on recovery, growth and survival. A total of 42 individuals were caught using conventional fishing tackle and kept in three $1m^3$ holding cages in the Kowie Marina. Fourteen individuals were assigned to each cage and split into two groups: seven control individuals and seven individuals for dummy tag implantation. After 96 days all individuals were sacrificed to assess long-term internal and external effects of the tags. Tag retention was 100% and no mortality was recorded for all three groups. Apart from one individual, which did not expel its sutures and had some inflammation around the wound area, all tagged fish were in a healthy condition and did not appear to be affected by the presence of the tag. These results suggest that transmitter presence has little effect on juvenile *R. holubi* and that it is a good candidate for telemetry studies.

A field experiment in the Kowie Estuary will commence in October 2014. The objectives will be to determine whether *R. holubi* exhibit site fidelity or ranging behaviour, and to assess the effects of diel, circatidal, lunar and other environmental factors on movement behaviour. Juvenile *R. holubi* will be tagged with Vemco V7 coded transmitters and monitored by 20 stationery data-logging receivers moored approximately 1km apart in the estuary. The results of the field experiment will be used to gain a better understanding the movement patterns of juvenile *R. holubi*. This is fundamental to studying its ecology and implementing effective conservation management strategies.

Key words: estuarine; ecology; acoustic telemetry; *Rhabdosargus holubi*

Tia Jordan (MSc student) - An assessment of the small-scale fisheries in the Kogelberg district of the Western Cape

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

Funder/s: World Wide Fund (WWF)

Small-scale fisheries play a critical role in communities as a major source of income, food security, and poverty alleviation. There is an urgent need to improve living conditions in most if not all of the small-scale coastal fishing communities in South Africa. In order to do this it is necessary to improve current knowledge of the human dimensions of these fishery systems and of the management processes being applied, both of which also have important implications for sustainability of the resources and fishery. This study is investigating the value chain and economic benefits to the Kleinmond fishing community from the local small-scale fishery, with an overall goal of developing an understanding of the total economic value of the harvest of the community. It is investigating whether there are options for improving the benefits while also ensuring the sustainability of the fishery.

The Kleinmond fishery consists of two groups of right holders, 75 near shore commercial right holders and 45 interim relief permit holders. Kleinmond has one of the two public launch sites in the Kogelberg area, which is shared with other communities and fisheries. The Kleinmond small-scale fishers mainly harvest West Coast rock lobster *Jasus lalandii*, and line-fish species (in particular snoek *Thrysites atun*, hottentot *Pachymetopon blochii*, geelbek *Atractoscion aequidens*, and red roman *Chrysoblephus laticeps*). Several of the species are currently over-exploited and are widely distributed. The wide distribution means that management of the Kleinmond fishery must include effective local management that is also integrated into an effective national governance system.

The research project is being undertaken in cooperation with WWF South Africa, which is providing funding and support. The project is currently synthesising the results of a number of previous studies and will make use of focus groups of small-scale fishers and rights holders, interviews with other stakeholders within the value chain, and landings data from DAFF. The research will acquire qualitative and quantitative data, analysis which will require both parametric and non-parametric statistical methods. A simple economic model of benefits and costs to the fishery is being constructed.

The results and conclusions from this research will not only be useful for the community and those involved in the development of Kleinmond, but will also provide a valuable case study that may provide, useful insights and lessons for other fishing communities in South Africa.

Key words: marine; small-scale fishery; value-chain; food security

Jessica Joyner (MSc Student) - An investigation into the relationship between climate change and the abundance of chokka squid, *Loligo reynaudii*, off the Eastern Cape of South Africa

Supervisors: Dr MJ Roberts (squid@metroweb.co.za); Prof WHH Sauer (W.Sauer@ru.ac.za)

Funder/s: South African Squid Management Industrial Association; National Research Foundation (91335) (NRF)

The chokka squid (*Loligo reynaudii*) is a commercially important species in the Eastern Cape of South Africa, providing many families with the means to survive. In the past two years the industry has seen a marked decrease in the abundance of squid resulting in record low catches. This led to the industry undergoing a voluntary closed season of three months over autumn and early winter in 2014. Due to the low catches, speculations have been made about the cause of the low abundance, one of which is the effect of climate change on the productivity of the squid. This study is being conducted in order to establish whether there is a relationship between temperature, upwelling events, wind patterns, chlorophyll-a concentrations and squid abundance.

In order to conduct this study underwater temperature recorder data was obtained from the Department of Environmental Affairs, catch data was obtained from the Department of Agriculture, Forestry and Fisheries, wind velocity and direction data was obtained from the South African Weather Service and chlorophyll-a concentration was obtained from NASA. Due to the lack of updated UTR data an additional diving trip will be conducted in October to dive out the UTR and obtain the latest data. Due to the data being sourced from multiple sources; extensive manipulation and collaboration of the data has been done in order for further investigation into the relationship to be done. The monthly variation in temperature and wind direction and velocity is being used, while monthly average catches are being utilised. The monthly average chlorophyll-a concentration is also being used. This manipulated data will then be used in a statistical program such as R to run a general additive model to attempt to find a quantifiable relationship between environmental parameters and *L. reynaudii* abundance.

This project hopes to find a relationship between climate change and squid abundance in order to provide for a greater insight into the fishery. This could lead to adjustments which could be made to the management measures currently implemented in the fishery and potentially provide the industry with a more sustainable management plan.

Keywords: marine; fisheries management; squid; *Loligo reynaudii*; chokka; environment; climate change

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

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

Funder/s: THRIP (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 water quality parameters 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 stocking densities, 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. Ten identical round tanks with conical bottoms will be used for the trial. Five randomly selected tanks will be subjected to the standard marine finfish larvae feeding regime currently used in the industry, while the remaining five will be subjected to a new feeding regime that seeks to take advantage of the findings of Musson & Kaiser (2014). Feed availability and quantity will be as comparable as possible between the two treatments. The difference between the two treatments will lie in the timing of first introduction of *Artemia salina* nauplii and then the artificial weaning diet. All other parameters under artificial control will be maintained at a uniform level throughout all 10 experimental units.

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

Key words: marine; aquaculture; larviculture

Rachel Kramer (MSc student) - An evaluation of a spatially-based conservation planning framework for the management of estuarine-dependent fishery species

Supervisors: Dr PD Cowley (tagfish@gmail.com); Dr A-R Childs (a.childs@ru.ac.za)

Funder/s: National Research Foundation (NRF), Norwegian Research Council; SA/Norway programme for research co-operation; National Research Foundation-DAAD (DAAD-NRF)

Estuaries are productive habitats and biologically important ecosystems as juvenile nursery areas and feeding grounds for adults from a host of fish species. However, they are also threatened habitats, exposed to increasing human disturbance and exploitation. The stocks of several South African estuarine-dependent linefish species are considered as either overexploited or collapsed, including four of the major targeted species; spotted grunter *Pomadasys commersonnii*, dusky kob *Argyrosomus japonicus*, white steenbras *Lithognathus lithognathus* and leervis *Lichia amia.* It is clear that their dependence on estuaries would warrant the inclusion of these ecosystems into marine reserve planning exercises.

Since traditional management strategies (e.g. bag and size limit restrictions) have proven ineffective for estuarine fisheries, there is a need for alternative management measures, such as spatial and temporal restrictions, to ensure increased survival of juveniles and recovery of adult breeding populations. A better understanding of spatial characteristics of these species such as; estuarine dependency, habitat use patterns and multiple habitat connectivity are required for effective management. However, systematic conservation planning for estuarine ecosystems requires a holistic approach by including not only biological characteristics of theses fishery species, but also socio-economic pressure and ecosystem indicators.

This study investigates the potential effectiveness of the spatial-based management software, MARXAN for the conservation of important estuarine-dependent fishery species in the Sundays Estuary, Eastern Cape. This software is specifically designed to aid systematic zoning and spatial management appraisals, and is aimed to find the most cost efficient scenario suitable for marine conservation areas which meet the desired ecological, social and economic objectives. MARXAN has the power to incorporate large quantities of information, allowing for the investigation and comparison of numerous scenarios.

Parameters obtained from the fish telemetry studies (i.e. diel and seasonal movement patterns, habitat and space use patterns, home range size and location, estuarine residence time and multiple habitat connectivity) and fishery dynamics (e.g. catch and effort data) collected from fishery surveys conducted on the Sundays Estuary will be included to model different scenarios to test the potential effectiveness of estuarine protected areas. These parameters will be scaled according to importance of conservation and cost associated with their inclusion in the planning process and output analysis in MARXAN.

Ultimately, this project will identify priority areas for conservation and will be used to develop and improve fisheries management strategies for these and other estuarine-dependent fishery species in South Africa.

Keywords: estuarine; fisheries management; estuarine fish; protected areas; fisheries; MARXAN

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

Supervisors: 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 have been shown to be the primary driver of the degradation of fish populations through the reduction of abundance and spawning potential of the targeted species. As a result, Marine Protected Areas (MPAs) have become widely used as management and conservation tools to protect the populations of exploited fish species and their habitats. Unfortunately, many of these MPAs still require better long-term monitoring and research to assess their effectiveness. The De Hoop MPA is one such MPA where little to no published data on the current state of the subtidal fish community exists.

This project aims to assess the effectiveness of the De Hoop MPA in protecting fish stocks and biodiversity and detect any potential benefits to the surrounding fisheries. Baseline fish assemblage data will be established using baited remote underwater stereo-video systems (stereo-BRUVs) while catch data from the surrounding fisheries is being analysed to investigate patterns of exploitation outside the MPA.

Research trips will be conducted in December 2014 and March/April 2015. Stereo-BRUVs deployments will focus on areas inside and outside the MPA to allow for a comparison of exploited and non-exploited conditions. Fisheries catch data from the Nation Marine Line-fish System (NMLS) database for the areas surrounding De Hoop was analysed by means of General Additive Models (GAMs) with integrated smoothness estimation. The catch data was separated into two categories, ‘catch surrounding the MPA’ and ’catch away from the MPA’ which was determined using the NMLS grid as spatial reference. These GAMs were then examined for any trends in catch data for the period from 1985-2012, with focus placed on the exploited reef fish in the area.

Preliminary analysis indicated some trends in catch-per-unit-effort (CPUE) for certain reef fish over the examined period. Both fishing areas, around the MPA and away from the MPA, showed a decline in CPUE in the years from 1985-1996. Subsequently, the CPUE away from the MPA began to increase, but continued to decline for areas around the MPA until the year 2000. After 2001 both areas showed an increase in CPUE and, after 2008 CPUE values reached similar levels to those from 1985.

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

Kyle Lloyd (MSc student) - Determining the lysine requirement in *Haliotis midae*

Supervisors: Dr CLW Jones (c.jones@ru.ac.za); Dr TA Shipton (ihts@imaginet.co.za)

Funder/s: THRIP; Marifeed (Pty) Ltd; Rhodes University Research Committee

The World Wildlife Fund (WWF) has set a target that all aquaculture species should have a forage fish efficiency ratio (FFER) less than one. The FFER is the wet weight of an aquaculture product divided by the wet weight of fish used to make the fish meal eaten by the cultured fish in its lifetime. The abalone farming industry is motivated to reduce the volume of fishmeal within their diets to satisfy the demand placed on them by the WWF and consumer, whilst not compromising the growth and health of abalone. This has resulted in increased research into the use of commercially produced crystalline amino acids (AA) in feed formulation in order to quantify the amino acid requirements in aquaculture species. In common with other water soluble nutrients, leaching of crystalline amino acids from diets prior to ingestion is of concern in an aquatic environment. Microencapsulation techniques have been successfully employed to restrict micronutrient leaching, and thus improve ingestion rates. Shipton *et al* (2002) encapsulated crystalline lysine with both gelatine/acacia colloid and cellulose acetate phthalate, however there were still leaching losses and lysine failed to promote a growth response.

In this experiment, poly-L-lysine (PLL) with a molecular weight of > 70 000 (less soluble) will be encapsulated using electrostatic spraying. The PLL will be mixed with calcium and dropped into an alginate solution, resulting in beaded encapsulation of the AA. These beads (>100µm) are then extruded into a pellet form. A leaching experiment will be conducted in order to determine leaching rates, where pH of the water where the pellet is suspended will be measured. If the encapsulated lysine is leaching out of the pellet, we will expect to see an increase in pH, as poly-L-lysine is strongly basic. If the encapsulation is successful, and the PLL remains water stable, an experiment designed to determine the lysine requirements for *H. midae* using cottonseed meal/fishmeal based diets supplemented with incremental levels of encapsulated PLL will be conducted. Diets enriched with 5.5, 6.5, 7.5, 8.5, 10.5, 12.5% PLL in triplicate will be fed to 20 *H. midae* (±10mm SL) and weight and shell length measured every 30 days. Feed conversion ratio, protein efficiency ratio as well as mean daily feed consumption will be calculated.

Shipton T, Britz P, Walker R. 2002. An assessment of the efficacy of two lysine microencapsulation techniques to determine the quantitative lysine requirement of the South African abalone , *Haliotis midae* L. *Aquaculture nutrtion* 8: 221-227.

Key words: marine; aquaculture; abalone; nutrition; poly-L-lysine; microencapsulation

Willem Malherbe (MSc student) - Vulnerability assessment of Malagasy coastal communities in light of climate change

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

Funder/s: Belmont Fund; National Research Foundation (NRF)

The Global Understanding for Local Solutions (GULLS) project is a scientific collaboration between seven countries aimed at reducing the vulnerability of marine-dependent coastal communities. Having identified a number of regions which are at risk of increased oceanic warming, global hotspots have been recognized where resource dependent communities are most likely to be affected.

Hotspots are characterized by communities with different stages of social and economic development which relates to differences in the communities' reliance on resources. By assessing the differences in community adaptation techniques at each hotspot, GULLS hopes to develop a climate change adaptation framework for other communities characterised by similar stages of development. Participating experts across various scientific fields will combine to achieve an interdisciplinary approach which includes biological, physical, social and economic considerations before seeking solutions with practical application to vulnerable communities. Solutions will ultimately include providing and implementing adaptation tools to affected communities in order to lower their vulnerability to climate change.

The focus point of the study will be the South Western Madagascar hotspot, with this region being identified as an area of considerable future oceanic warming. Villages in the South Western region are dominated by fishery related activities which provide the majority of household income. The high reliance of these rural communities on coastal resources, accompanied with the predicted impacts of climate change, would suggest high vulnerability. The following assessments will be done throughout this study: i) vulnerability assessment, ii) identifying of community objectives, iii) community decision making and scenario modelling and iv) value chain analysis. Data collection will occur at the start of 2015 and will primarily be done through household surveys, focus groups and key informant interviews. Secondary data will be gathered through partnering with a local non-governmental organisation, Blue Ventures, which has been conducting long term baseline monitoring in the region. Secondary data will then be used in constructing the vulnerability assessment, while primary data will be used to assess community responses to impacts, possible adaptation strategies and the viability of management options.

Key words: marine; fisheries management; climate change; vulnerability

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

Supervisors: 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 for maintaining and developing food security and the livelihoods of those who utilise these resources. In rural small scale fishing communities, proposed stock enhancement and ranching of species such as abalone *Haliotis midae* carries potential to improve the state of the resource while also acting as a driver of rural community development. The objectives of this study are 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, to optimise socio-economic gain from the project.

There are two main components to this study; the first is to assess the state of the resource. To date, two inshore sites have been assessed, this is done during spring low tides at wading depth, no more than 1.5m. The surveys are conducted in the infralittoral zone where two 30m transects are laid parallel to the shore at each site. 15 – 1m^2 quadrats are sampled at random within each transect. Abalone shell length is recorded to the nearest 0.1mm and counts are taken within each quadrat and a record of habitat type is noted. These results will be compared to a similar study conducted in 2006 to evaluate how the resource has changed in the last eight years.In the recently promulgated small scale fisheries policy, co-manangement is recognised as the most appropriate management approach for small scale fisheries. The second componenet of this study is to make use of participatory action research methods to build capacity among all the relevant stake holders involved in this partnership.

The biological surveys done on the two sites assessed to date have shown that the densities of abalone are not significantly different between the sites ($F= 1.324$, $P = 0.256$, $df = 1$). Maximum sizes between sites were also not significantly different ($F= 0.063$, $p = 0.802$, $df = 1$). No emergent abalone have been found at any of the sites, the maximum size of abalone found has been 100mm. Further analysis needs to be done once all the sites have been assessed. Preliminary interviews and focus groups with stakeholders indicate that there is a need to focus participatory action research activities around the function of each stakeholder group within the partnership. Particular emphasis has been put on the need to build capacity within the co-operative through which the Hamburg community will participate in the project. Work done to date shows that there is a need to understand small scale fisheries holistically as socio-ecological systems.

Key words: marine; fisheries management; participatory action research; development

Richard Taylor (MSc student) - The use of brewery effluent as a soil amendment

Supervisors: Dr CLW Jones (c.jones@ru.ac.za); Prof. MD Laing (Laing@ukzn.ac.za)

Funder/s: Water Research Commission (K5/2284); SAB Ltd; Rhodes University Research Committee

Breweries are a major consumer of resource water and producers of nutrient rich wastewater. This wastewater is liability to the company since it poses an environmental threat, so it has to be treated prior to disposal. The treatment process is costly and energy expensive, however, alternative technologies exist that could make the water and nutrients in the effluent available for re-use or for use in other downstream applications. The nutrient and water in brewery effluent could be used to irrigate crops and increase soil fertility. It is necessary to ensure that there will be no negative side effects that will compromise crop health or soil structure and fertility when brewery effluent is used in agriculture. Therefore, a treatment process that ensures that the use of treated effluent does not compromise the integrity of the crop and soil needs to be developed.

Brewery effluent can be treated using technologies such as anaerobic (AD), facultative ponds (PFP), high rate algal ponds (HRAP) and constructed wetlands (CW) at the experimental wastewater treatment plant at Ibahyi Brewery (SAB Ltd). There is potential to use this treated brewery effluent as a water and nutrient source in agriculture (i.e. production of crops in soil). However, each of these effluent treatment processes results in brewery effluent having a different set of water quality parameters such as pH, form and concentration of nitrogen, concentration of phosphorous and electrical conductivity (EC). These parameters have been found to affect plant growth and soil fertility. It is therefore essential that the most suitable pre-treatment method of brewery effluent is found so that the nutrients in the effluent are made accessible to the plants without compromising the environment in any way.

The aim of this study is to determine the best pre-treatment method or combination of pre-treatment methods required to make brewery effluent suitable for crop irrigation. This is being done by comparing the change in soil characteristics and growth of crops irrigated with effluent to crops irrigated with a conventional irrigation solution. Cabbage is being grown in a drip irrigation system fed with brewery effluent subject to either AD, PFP, HRAP, CW or a commercial nutrient solution, with and without pH adjustment. The mass, height, weight, diameter and health of the plants under each irrigation treatment are being determined and compared between treatments. Physical, chemical and biological properties of the soil are also being recorded to determine the effect each irrigation water has on the soil fertility.

Key Words: freshwater; aquaculture; effluent treatment; waste water; soil; irrigation

Chénelle Lesley de Beer (PhD student) - Investigating the life history and movement patterns *Loligo reynaudii* in southern Angola

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

Funder/s: NRF**Error! Bookmark not defined.**/DAAD Freestanding Bursary (DAAD-NRF)

Loligo reynaudii, commonly referred to as lula, plays a critical role in the livelihoods of subsistence and artisanal fishermen in southern Angola. The fishery is currently unmanaged and although there have been several unsuccessful attempts to develop a commercial fishery for this species using fishing techniques developed for the South African squid fishery, these have been met with limited success. This commercial fishery primarily targets squid on their spawning aggregations and it is thought that the reproductive behavioral traits in Angola may be different. Comparative morphological and molecular investigations on *L. reynaudii* from southern Angola and South Africa have suggested that was indicative of a single genetic population despite the presence of three distinct morphological stocks (Angola, the South African west coast and south coast). However, despite several published papers for South Africa, there is no information on the life history and reproductive behavior of this species in Angola.

As a semelparous species, *L. reynaudii* are highly susceptible to environmental fluctuations. The southern Angolan region is situated at the convergence of the cold, northward flowing, Benguela Current and the warmer, southward flowing Angola Current and forms what is known as the Angola Benguela Frontal Zone (ABFZ). This area is subject to large-scale interannual and decadal fluctuations, and is a recognized ocean warming hotspot. The area therefore provides an ideal site to examine the influence of environmental variability on the life history and reproduction of *L. reynaudii*. This project aims to describe the reproductive characteristics, reproductive behaviour and general movement patterns of southern Angolan *L. reynaudii* and correlate these with key environmental variables that are known to influence the species. The information collected will be used to make recommendations for the development and management of the lula fishery in southern Angola.

To date, monthly biological samples (Jun-Sep) have been conducted on squid collected from two sampling localities, Namibe and Tombua in southern Angola. Initial results indicate that this species reaches maturity at approximately 121.87mm ML and that spawning takes place in all of the months sampled. The biological analysis will continue until May 2015. An acoustic telemetry and a visual observation experiment will be conducted over a one month period during the peak spawning season in Tombua Bay during 2015.

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

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

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

Funder/s: MADE project - EU(FP7); International Seafood Sustainability Foundation (ISSF); SWIOFP

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

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

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

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

Jade Maggs (PhD student) - An evaluation of movement patterns of important fishery species in coastal waters of southern Africa

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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 dispersing 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 (i) synthesize what is currently known of fish movement and migration patterns in South Africa, (ii) investigate the connection between movement patterns and certain life-history characteristics and environmental factors, (iii) generate a classification of movement patterns, and (iv) evaluate the implications for fisheries management.

This study will make use of unpublished and published data on the movement patterns of selected coastal fish species occurring in southern African continental shelf waters. The Oceanographic Research Institute's Cooperative Fish Tagging Project (ORICFTP) contains a wealth of data, some of which will be used in this study. Due to the voluntary participation by recreational anglers, the ORICFTP data suffers from certain biases, such the occasional incorrect species identification, inaccurate measurements and inconsistent tagging techniques with unknown consequences. A comparison with several dedicated scientific tagging studies, including telemetry studies that generate fewer but better quality data, will allow for the filtering of poor quality data for certain species on the ORICFTP database.

Currently, a review of South African fish movement research is being undertaken. Thus far, South African fish movement research has largely been applied science, generating knowledge on important fishery species (predominantly teleosts) to improve management. Historically, it was primarily large commercial stocks that were investigated, but more recently recreational species have received increasing attention. Additionally, a large amount of fish movement research has also been directed at evaluating the role of marine protected areas. The first tagging initiative by South African researchers took place in 1934 on Cape snoek *Thyrsites atun*. Since then, tag types used to track individual fish have evolved considerably with the developments in electronic technology, yet older conventional methodologies remain in use due to various reasons.

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

Denham Parker (PhD Student) - The long term monitoring of subtidal reef fishes in the Tsitsikamma National Park marine protected area

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Funder/s: DAAD/NRF**Error! Bookmark not defined.** Postgraduate Scholarship (DAAD-NRF); Rhodes University Henderson Postgraduate Scholarship; E&E Eriksen Trust; SAEON

Tsitsikamma is the oldest, and one of the largest (350km^2) 'no-take' marine protected area (MPA) in Africa. After 50 years of protection, the communities here are stable and provide the best example of pre-exploitation inshore ecosystems available today. The South African Environmental Observation Network (SAEON) has established a long-term monitoring (LTM) programme to observe the subtidal reef fishes in the Tsitsikamma MPA. The research uses standardised controlled angling to sample fish communities in the nearshore reef ecosystems and is in its 7th year, with biannual sampling trips (summer/winter). To date, more than 200 fishing stations have been completed, and a total of 2,257 fish belonging to 43 different species have been caught and released. This dataset already represents the longest and most comprehensive subtidal reef fish abundance estimate in Southern Africa.

Definitive spatial structuring, in the form of spatial autocorrelation, was evident for most species analysed. Subsequent fine scale spatial analysis provided important ecology information for the optimization of LTM programmes. The shift in viewing spatial dependency as a statistical obstacle to a source of ecological information has created a new avenue of data inference, which this study has shown to be effective in assessing the influence of environmental variables and habitat on fish abundance. The statistical methods explored to account for spatial autocorrelation are applicable to a wide range of LTM programmes in the marine environment, and it is recommended that they are applied wherever spatial dependencies exist. The study emphasized the need for accurate *a priori* bathymetric information for subtidal habitats, as fish communities are undoubtedly linked to localised habitat.

A temporal analysis revealed highly stable fish populations, as can be expected from a 'no-take' MPA established 50 years ago. All analyses point to an established community that exhibits little temporal variation in species abundance and size structure. Dageraad was the only species to exhibit a definitive temporal trend in their length frequencies, which was attributed to recruitment behaviour independent of exploitation.

The study also highlighted the inadequacy of controlled angling as an ecosystem monitoring method on a variety of fronts. A subsequent comparison of sampling methods concluded Stereo-Baited Remote Underwater Video (stereo-BRUV) was preferred technique for monitoring subtidal reef fish in the TNP MPA. Stereo-BRUVs were able to survey a significant larger proportion of the ichthyofauna than angling with minimal length selectivity biases and a higher power to detect changes in abundance. Recent information regarding mortality rates of fish hooked at depth due to barotrauma further justifies the use of stereo-BRUVs in MPAs.

Keywords: marine; ecology; stereo-BRUV; controlled angling; long-term monitoring

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

Supervisors: Dr OLF Weyl (o.weyl@saiab.ac.za); Dr 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; National Research Foundation/South African Institute for Aquatic Biodiversity (SAIAB)

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

The colonising fish assemblage was dominated by *Barbus paludinosus*, *Barbus poechii*, and the catfishes *Clarias gariepinus* and *Schilbe intermedius*. After filling completely in 2009, the abundance of *C. gariepinus* declined markedly, and the barbs were rapidly replaced by two small alesteids, *Rhabdalestes maunensis* and *Brycinus lateralis*. The tilapiine cichlids on which the fishery is based, and several other larger, slower growing species including *Serranochromis macrocephalus* and *Hepsetus cuvieri* have increased more gradually in abundance since inundation. Food web analysis showed that the food chain is short and influenced primarily by bottom-up (productivity related) factors. Consumer $\delta^{13}C$ values indicate that algal primary production (associated with particulate organic matter) contributes most to consumer biomass, while C_3 macrophytes and detritus contribute relatively little. Low levels of isotopic niche overlap between barbs and robbers suggests competition was not an import factor in their succession. Competition may, however, have played a role in the succession from *R. maunensis*, which initially replaced the barbs, to *B. lateralis* which now dominates experimental gillnet catches.

The composition and relative abundance of recruiting fish fauna from the Zambezi and Kwando rivers will be assessed during the 2015 floods. Otoliths have been collected from nine species representative of opportunistic, periodic and equilibrium life history strategies to investigate age, growth, maturity, and mortality in relation to colonisation and establishment rates. Algal productivity will be assessed using C^{13} enrichment experiments in November 2014.

Keywords: freshwater; ecology; recruitment; age; growth; food web analysis

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

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

Funder/s: National Research Foundation (NRF)

The formation of the cold Benguela Current approximately 2 million years ago led to a marked change in the distribution and abundance of fishes along the west coast of southern Africa. Warm water fishes were restricted to either side of the Benguela Current as its cold water formed a barrier to gene flow between these populations. With the timing of the allopatry similar across species, it is possible to quantify the rate of adaptation of the populations in response to the disparate environmental conditions across a range of marine species. Thus, it is possible to better understand the evolutionary processes affecting regional biodiversity by quantifying and comparing the differences in the genotypic and phenotypic adaptation of these species. With a characteristically slow rate of phenotypic change and evolution, Elasmobranch species provide a baseline with which other marine organisms can be compared. Therefore, the aim of this study is to examine the genotypic and phenotypic variation between southern Angolan and South African *Triakis megalopterus* (spotted gully shark) populations. The results presented in this report concentrates on the feeding and associated tooth morphology of *T. megalopterus.*

The teeth and stomachs of 119 *T. megalopterus* were analysed from Angola (AN; n = 40), Western Cape (WC; n = 33) and Eastern Cape (EC; n = 46). Prey was identified to species level and diets quantified according to frequency of occurrence (%F), numerical importance (%N), gravimetric importance (%M) and index of relative importance (%IRI). Teeth were removed from the lateral-superior, medial-superior, lateral-inferior and medial-inferior jaw quadrants, photographed under a microscope and measured using SigmaScan Pro 5.

A stepwise discriminant analysis (DFA) of the tooth morphology of *T. megalopterus* tooth morphology correctly classified the small (98.3%) and medium/large specimens (96.6%). This correlates with the predominantly durophageous diet of small individuals with the addition of soft bodied prey in the diets of medium and large specimens. This shift in feeding is evident in the tooth morphology of *T. megalopterus.* Small sharks have dorsoventrally flattened and molariform teeth which are suited for crushing, while teeth of medium/large specimens broaden at the base and lengthen to form a cusp used to grasp/clutch and manipulate soft prey. Although dietary differences were evident between the three populations of *T. megalopterus* (AN, EC and WC), particularly in the crustacean only diet in WC, the tooth morphology DFA incorrectly classified 80.6% of the AN specimens as WC specimens. However, the DFA did classify 86.4% of the specimens from WC and 78.0% of the specimens from the EC correctly. This suggests that tooth morphology is very plastic and has limited value in distinguishing between populations of *T. megalopterus.*

Other results include the development of a truss morphology protocol for the comparison of body shape of Elasmobranchs. Future work will include a comparative traditional morphology, life history, mitochondrial genetics and microsatellite marker analyses for the three populations of *T. megalopterus.*

Key words: marine; ecology; feeding; morphology; elasmobranch; spotted gully

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

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

Funder/s: National Research Foundation/South African Institute for Aquatic Biodiversity (SAIAB); Rhodes University Research Committee; Southern African Science Service Centre for Climate Change and Adaptive Land Management; Nedbank Namibia Go Green Fund

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

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

Otoliths have been collected from six species, and used to determine age. Growth rates have been compared for four of these species. *Serranochromis macrocephalus* and *Brycinus lateralis* grow fastest in the Zambezi and Kavango rivers, and slowly in the Kwando River, whereas the growth rates of *Schilbe intermedius* and *Clarias gariepinus* are more variable. Age validation by mark recapture of chemically tagged fish and edge analysis is underway and will be completed by April 2015. Fish community structure will be described and compared between systems using experimental gillnet catch data collected in 2013 and 2014. Nutrient inputs and productivity will be measured using C^{13} enrichment experiments in each river system in November 2014. Whole ecosystem stable isotope samples have been collected from the three rivers, and will be used to describe and compare their food web dynamics. This will be supported by stomach content analysis, for which samples have been collected from the six species under study from the three river systems.

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

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

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

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

Nhanhla Gnindza (MSc student) - Report not available

Lwazi Nombembe (MSc student) – Report not available

Nomxego Lungelwa (PhD student) - Report not available

Catherine Greengrass (PhD student) – Report not available

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