Department of Ichthyology and Fisheries Science

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Research Report Series 24

RHODES UNIVERSITY
Department of Ichthyology and Fisheries Science
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(Version 2)

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Edited by: CLW Jones and C Stewart

Schedule of Events/Table of Contents

Wednesday 10 October 2012

08h50-09h00: Welcome by Prof. Warwick Sauer (Head of Department)

Honours seminars (Chair: Dr Warren Potts)

09h00-09h20: Brendon Dredge (BSc Hons student) - Does eurythermy explain the distribution patterns of chubbyhead barb, *Barbus anoplus* and largemouth bass *Micropterus salmoides*?

Supervisor: Prof. AJ Booth (t.booth@ru.ac.za)

Funder: Rhodes University Research Committee

Chubbyhead barb *Barbus anoplus* is a common, widely-distributed and ubiquitous South African minnow. A common predator within these systems is invasive largemouth bass *Micropterus salmoides.* In an effort to understand chubbyhead barbs' ability to colonise and survive different habitats this study investigated aspects of their metabolic requirements and responses to various thermal environments. The natural thermal range for these fish was used in the experiments to assess the ability of the fish to cope in their natural environment. Intermittent-flow respirometry at temperatures ranging between 15 and 30 ^{o}C was utilised to determine standard metabolic rate (SMR), maximum metabolic rate (MMR) and metabolic scope (MS). MS is the difference between SMR and MMR and is the surplus metabolism available for growth and reproduction. MS provides a proxy for determining a fish's optimal temperature ranges.

Largemouth bass were found to have significantly lower maximum metabolic rates at all temperatures than chubbyhead barbs ($p < 0.01$). Both chubbyhead barbs and largemouth bass were found to have similar optimum temperature ranges of 18 – 28 ^{o}C and 20 – 30 ^{o}C, respectively, both with a maximum metabolic scope of 25 ^{o}C. Q_{10} was 1.06 ± 0.013 for bass throughout the temperature range examined, whilst the chubbyhead barbs decreased from 2.09 at 15 ^{o}C to 1.37 at 30 ^{o}C.

These results from the largemouth bass confirm those found from other studies. It was noted that only fish > 50 g survived at 30 ^{o}C after being exhausted where as smaller fish died after only a few hours in the chambers. The survival of larger fish at these temperatures illustrate that this temperature is near its thermal maximum and with additional stress at these temperatures only the more mature fish can survive. Elevated stress levels from recreational fishing at these temperatures could lead to mortalities in the smaller bass. The similarity in thermal preference and lower dissolved oxygen requirements between largemouth bass and its prey, the chubbyhead bard, confirms its predation potential if both species are sympatric.

09h20-09h40: Albert Snyman (BSc Hons student) - Characterizing an invasive smallmouth bass *Micropterus dolomieu* population in an invaded South African stream

Supervisor: Dr OLF Weyl (o.weyl@saiab.ac.za)

Funders: Center for Invasion Biology; SAIAB; Water Research Commission (K8/922); CapeNature

Smallmouth bass, *Micropterus dolomieu* are native to North America where they are important fresh water angling species. Smallmouth bass are currently invading South African freshwater ecosystems where they impact on native biota through predation. Their biology in South African streams has never been assessed and the aim of this study is to contribute to the knowledge on their biology in invaded environments.

The sample comprised the total fish population that were removed from the Rondegat River in the Western Cape during a Cape Nature initiated rotenone operation in February 2012. Fish were aged using saggital otoliths, growth was modelled using the von Bertalanffy growth model, length at maturity was estimated using a logistic ogive and diet was assessed from stomach content analysis.
A total of 169 male and 201 female fish were collected during the rotenone operation. The average length for males was 122 mm FL and females averaged 118 mm FL. Males reached a larger size (285 mm FL) compared to females (259 mm FL) but there was no significant difference in length structure between sexes. Age ranged from 0 to 4+ years. There was a significant difference between male and female growth rates and were found that males grew faster than females. Females attained 50 % maturity at 154 mm (FL) at an age of 1 year. Gut content analysis for two size classes (< 99 mm FL and > 99 mm FL) demonstrated that in small fish the diet was dominated by insects and that larger fish also included fish, crab and juvenile bass in their diet. In conclusion smallmouth bass has successfully established in the Rondegat River but that the prey resources in the invaded stream are unable to sustain normal growth rates which has resulted in a stunted population.

09h40-10h00: Sarah Halse (BSc Hons student) - The social and perceived norms of compliance in the Eastern Cape recreational rock and surf fishery

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

Funder: Rhodes University Research Committee

Recreational fishing has become an accepted part of South African culture and plays an important role in both local and national economies. However declining catches threaten the coastal recreational fisheries in South Africa. Much of the decline can be attributed to overexploitation, which can, amongst other things, be ascribed to poor compliance with fishing regulations. Traditionally compliance in South Africa has been proportional to the level of enforcement. However, due to budgetary constraints and reduced political will, it is unlikely that recreational fishery enforcement will improve. This suggests a need for alternative strategies to improve compliance. Socialization can be defined as the acquisition of culture. We learn through observing the behavior of others and associate those behaviors to roles within society; thus one learns the norms of social life. The human psyche is a powerful tool and misinterpretations of the social norm by South African anglers can significantly influence their own compliance behavior. Contrariwise, addressing misinterpretations of social norms or the "perceived" norm could be an important way of improving compliance in recreational fisheries. The aim of the study was to determine if there is a difference between the social norms and perceived norms associated with compliance in the Eastern Cape (EC) rock and surf fishery.

Data collection consisted of roving and point access interview surveys along the EC coastline. The survey included the collection of demographic information, classification of the anglers as competitive or non-competitive, information on their personal compliance, perceived compliance of close friends and South African anglers as well as their attitudes towards the current fishery regulations.

Comparison of own angler behaviour and that of close fishing friends showed no significant difference in over-all compliance ($\chi^2 = 0.90$). Therefore, under the assumption that anglers were as compliant as their close friends, we assumed that the anglers were honest about their own compliance. Using bag limits as an example, the social norm for compliance by competitive (75 %) and non-competitive (69 %) anglers was far higher than the perceived norm for South African anglers (31 %). Only 23 % of anglers disagreed with current regulations, but 95 % felt that anglers should be more involved in directing scientific research priorities.

These results suggest that non-compliance is a self-fulfilling prophecy where the perceived norm of poor compliance amongst anglers naturally shifts their behaviour toward rule breaking. Addressing these misconceptions may be an important method of improving compliance in the Eastern Cape rock and surf fishery. Results from this study showed that if information on the true social norms were published in "Tight Lines", this information could reach up to 45 % of EC rock and surf anglers.

10h00-10h20: Ann Wu (BSc Hons student) - The effect of a plenum on the growth and behaviour of cultured sandfish, *Holothuria scabra*

Supervisors: Dr CLW Jones (c.jones@ru.ac.za); G Robinson (georgi@hik.ac.za)

Funders: HIK Abalone Farm (Pty) Ltd; THRIP

Little is known about intensive culture technology for sandfish also called sea cucumber. The addition of formulated feed in intensive cultivation results in the formation of anoxic zones within the sand substrate. The inclusion of a plenum or false-bottom may increase circulation throughout the sand to prevent this. The effect that a false-bottom has on growth and behaviour of sandfish is not known. The objectives were to compare the growth, survival and behaviour of sandfish under two different tank designs: false-bottom (FB) and no false-bottom (no-FB) tanks.

Hatchery reared juvenile sandfish (n = 24) were grown in a semi-closed, recirculating system for 81 days. The system included six tanks with three replicates of each treatment. Sandfish were gut-evacuated and weighed on days 0, 27, 54 and 81. The burial state, position in the tank and activity of the animals were recorded every 15 min for 24 h.

The mean (± standard error) wet weight of sandfish was similar in both treatments at the start of the trial (7.57 ± 0.27 g sandfish^{-1}, t = -2.03, p = 0.11). Survival was 100 % in all treatments. There was no significant difference in sandfish weight between FB and no-FB (19.60 ± 1.44 g individual^{-1}, t = -0.08, p = 0.94) or growth rate (0.15 ± 0.02 g individual day^{-1}, t = -1.27, p = 0.15) after 81 days. A FB influenced the behaviour of sandfish. There was a significant difference in the average number of animals that were on the open sediment (> 1 cm away from tank structures) between FB and no-FB (2.25 ± 0.09 and 1.18 ± 0.11 individual h^{-1}, $t_{(sep.\ var.\ est.)}$ = 3.69, p = 0.00003) in the early night (7 pm – 11 pm). The average time sandfish spent in the open sediment before changing positions in the tank was significantly difference in FB and no-FB (1.15 ± 0.06 and 0.60 ± 0.01 h day^{-1}, t = -4.16, p = 0.01). There was a significant difference in the average number of animals in FB and no-FB tanks resting (3.97 ± 0.01 and 3.15 ± 0.10 individual h^{-1}, $t_{(sep.\ var.\ est.)}$ = 3.97, p = 0.01) and feeding levelled (0.00 and 0.58 ± 0.09 individual h^{-1}, $t_{(sep.\ var.\ est.)}$ = -3.32, p = 0.02) in the morning (7 am – 11 am). The average time spent feeding in a horizontal position before changing activity was significantly different between FB and no-FB (4.75 ± 0.17 and 2.66 ± 0.25 h day^{-1}, t = -3.51, p = 0.02). Sandfish resting in shallow depressions on the surface were only observed in no-FB tanks. There was no significant difference in mean (± standard deviation) water quality parameters between FB and no-FB tanks: pH (8.39 ± 0.03, t = 0.00, p = 1.00), temperature (25.54 ± 0.14 ºC, t = -2.34, p = 0.09), ammonia (0.0018 ± 0.0001 µg L^{-1}, t = -0.99, p = 0.38) and dissolved oxygen (6.68 ± 0.12 mg L^{-1}, t = 0.99, p = 0.75). Anoxic sediments were not observed in FB tanks; however an average of 76 % of the sediments were anoxic in no-FB tanks.

The presence of a FB did not affect the growth of sandfish; however, certain behaviours were affected, probably due to the difference in substrate quality since the sediment in the no-FB treatment was anoxic.

10h20-11h00: Tea break

Honours seminars continued (Chair: Dr Warren Potts)

11h00-11h20: Aron Simmons (BSc Hons student) - The effect of diet on foot muscle glycogen levels in the cultured South African abalone, *Haliotis midae* (L.)

Supervisors: Prof. PJ Britz (p.britz@ru.ac.za); J Kemp (groovypalm@gmail.com); Prof. B Pletschke (b.pletschke@ru.ac.za); S Van Dyk (s.vandyk@ru.ac.za)

Funders: Marifeed (Pty) Ltd; THRIP

The commercial culture of the indigenous abalone *H.midae* in South Africa has grown rapidly over the last 20 years. Research on artificial feeds for abalone culture has to date focused on diet formulation, primarily through gaining an understanding of ingredient digestibility and optimising ingredient inclusion levels. However, little is known about the intermediary metabolism of these molluscs. Abalone may store up to 28 % of their body mass as glycogen in their foot muscle tissue. Furthermore, it has been suggested that glycogen can be used as a determinate of abalone nutritional status. The aims of study were twofold: (1) to test two contrasting glycogen assay methods for abalone tissue and (2) assess the effect of diet on foot muscle glycogen content.

Two fundamentally different glycogen assay procedures where adapted for this study, namely the chemical and enzymatic method. Duplicate samples from abalone previously fed a mixed diet of seaweed and formulated pellet were tested using both the chemical and enzymatic method. The chemical method uses an Iodine reagent to stain the glycosidic bonds between the glycogen molecules. The enzymatic method uses the enzyme *amyloglucosidase* to breakdown free tissue polysaccharides into glucose which can then be converted to glycogen using glucose: glycogen conversion equation. The glycogen concentration within the tissue samples was then determined for both methods using a glycogen standard curve prepared using refined oyster glycogen.
Glycogen yield between the two methods were not significantly different from each other ($df = 31$; $P = 0.08$; $T = 1.78$) with mean glycogen yields of 5.44 ± 0.43 mg/g and 6.75 ± 0.64 mg/g (mean ± SE) for the chemical and enzymatic assay methods respectively. The chemical method was selected to test that effect of diet on foot muscle glycogen concentration as when compared to the enzymatic method it required less analysis time, specialised laboratory equipment and assay steps, reagents were more affordable and results obtained were comparable with enzymatic method. Despite there being no significant difference between the two methods, the enzymatic method did result in an 8 % higher glycogen yield than the chemical method; however this could be adjusted for using an appropriate conversion factor.

Abalone were fed five diets namely seaweed (P-0), formulated feed (P-100), and three combination diets consisting of formulated feed fed to excess combined with a supplementation of seaweed fed at 25 % (P-75), 50 % (P-50) and 75 % (P-25) of a full ration. The lowest glycogen yield was found in the P50 diet. P50 mean glycogen yield of 14.54 ± 3.52 mg/g (mean ± SE) was significantly different from the other ($df = 75$; $P = 0.0006$; $F = 5.57$) diet treatments. All other diets namely P0, P25, P75 and P100 did not differ significantly in mean glycogen yield. P75 had the highest mean glycogen yield of 27.99 ± 3.23 mg/g (mean ± SE), signifying that the addition of a 25 % seaweed ration may produce higher levels of glycogen within the animals.

The chemical assay for glycogen could be used in industry to access glycogen levels within the foot muscle tissue of abalone. The method is quick and repeatable therefore allowing a researcher to run large sample batches.

11h20-11h40: Chris Gornall (BSc Hons student) - The effect of handling and anaesthesia on the feeding behaviour of juvenile dusky kob, *Argyrosomus japonicus*

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

Funders: National Research Foundation (personal bursary); Rhodes University Research Committee

Dusky kob, *Argyrosomus japonicus*, is traditionally an important species in recreational angling and it has become an aquaculture species. Handling has been shown to have consequences for feeding and other physiological responses. The aim of the study was to determine the combined effect of handling and anaesthesia on juvenile kob feeding behaviour.

Four treatments were used; 1) Handling and anaesthesia; 2) No handling and anaesthesia; 3) Handling and no anaesthesia; and 4) No handling and no anaesthesia. For each treatment 4 fish of a similar size were acclimated in a 10-L glass tanks for two days. Fish were fed at 3.6 % body weight (BW) per day over 3 feedings (morning, noon and afternoon). The handling treatment entailed fish being exposed to air in a net for 40 seconds, while the no handling treatment consisted of fish being netted and moved as fast as possible with less than 2 seconds of exposure to air. Care was taken to ensure that fish in the no handling treatments were handled as fast and gently as possible. Anaesthesia was achieved by netting fish from the glass observation tanks into a plastic bag with a concentration of $50\mu lL^{-1}$ of clove oil for five minutes. The behaviour of the fish was recorded for ten minutes after the feed was supplied and uneaten pellets were siphoned from the tank 30 minutes after feeding. Four trials were conducted over a period of one month, with each trial comprising 3 replicates per treatment combination, totalling 12 replicates of each treatment combination. Fish were weighed at the end of the trial and fish biomass per tank was calculated. Measurements were made by observing a focal fish for two minutes from video footage, and the measurements included: 1) number of "feeds" (pellets ingested and consumed); 2) number of "rejects" (pellets ingested and 'spat out'); 3) "number of pseudo-feeds" (any behaviour of a fish approaching a pellet, but not ingesting it); 4) percentage BW consumed per day. Values are means ± standard error.

Measurements were compared between treatments using repeated measures ANOVA. Data from the four trials were pooled prior to analysis. The mean number of "feeds" observed at the first feeding after the treatments (1.10 ± 0.2) was significantly lower (Tukey's test: $p < 0.05$) than the morning and noon feeds on the day after the treatments (morning 2.31 ± 0.23, noon 2.35 ± 0.21). The number of "feeds" observed in the evening (day 1; 0.56 ± 0.1 and day 2; 0.54 ± 0.12) were significantly lower than morning and noon feeds, however not significantly different to the noon feed after treatments. The number of "rejects" and "pseudo-feeds" followed similar patterns to "feeds". For all measurements there was no significant effect of any of the two main effects (handling or anaesthetic) on the dependent variables ("feeds", etc), and there was no interaction been main effects. The % BW consumed per day followed a similar pattern as the number of "feeds", however in this case the feed directly after treatments (0.56 ± 0.03 %) was significantly higher than the evening feeds (day 1; 0.35 ± 0.03 %, day 2; 0.30 ± 0.04 %), and significantly lower than the morning values (0.85 ± 0.04 %) and noon feeds (0.78 ± 0.04 %) on day 2. Therefore after handling fish consumed 28 % less feed when compared to the feed consumption at the noon feed on the day after treatment. Therefore, fish could be fed 28 % less food during the first feed after handling.

Freshwater Fisheries (Chair: Amber Childs)

11h40-12h00: Carl Huchzermeyer (MSc student) - An assessment of the fish diversity and artisanal fishery of the Bangweulu floodplains, Zambia; developing suitable management recommendations

Supervisors: Dr OLF Weyl (o.weyl@saiab.ac.za); Dr RJ Bills (r.bills@saiab.ac.za)

Funders: Bangweulu Wetlands; African Parks; National Research Foundation/SAIAB/DAAD Bursary

Bangweulu Wetlands is a conservation area encompassing a large part of the south-eastern swamps and floodplains of the Bangweulu system, on the Congo River catchment, in Zambia. The ecology of the area is driven by the annual flood cycle (mean amplitude 1.2 m). Flat topography makes flooding extensive. The floodplains support a rich artisanal fishery, and are home to an estimated 75 000 endemic black lechwe antelopes (*Kobus lechwe smithemani*) and a significant population of the threatened shoebill stork (*Balaeniceps rex*).

Conservation and tourism goals frequently clash with fishing activities when sensitive species are disturbed, or fishing becomes unsightly and small species in the catch give an impression of unsustainable harvest. The aim of this study was to contribute to the management of the fishery by assessing the utilisation of the fish resource by residents living inside the conservation area. Research included assessing the fish fauna of different habitats, describing the fishing methods used, measuring and identifying catches, determining seasonal harvesting patterns and understanding the organisation of fishing groups.

Fishing activities focus on receding water over the seven month dry season. Fishing is done both for subsistence, localised barter trade and commercial trade at times when catches are high. The main fishing gears used on the floodplain are reed basket traps and mosquito-net funnels set in earthen 'fish-weirs', small mesh-size multifilament gillnets, seine nets and hook long-lines. Of the 45 fish species recorded in the area, 25 were part of the catch in the floodplain environment. These were all typical floodplain species, generally with low trophic rank, small size at maturity and rapid growth.

The bulk of fish caught are then dried for sale, home consumption and local trade. Fish are sundried or smoked, and contribute to local and regional food security. Fish from the study area were sold for R7.09 ± 1.68/kg at source and for R12.67 ± 5.82/kg at market (wet weights). A large variety of measuring units, prices, products and species are used in the trade.

Preliminary results indicate an average catch of 7 kg/day/fishing unit (fisherman and family and/or assistants), over a seven month season. The total yield of the 500 fishing units operating in the ca. 23 000 ha study area was estimated at 800 t representing a formal income of ca. R6.34 million. Subsistence consumption is estimated at 100 t per season.

Currently the fishery is community managed. Fishermen inherit and own sections of floodplain, and traditional fishing leaders are the authority. They allocate rights, settle conflict and collect tribute. Resource ownership and the traditional leadership represent opportunities for sustainable management but further research into the system (ecosystem functioning, resource dependence and socio-economic factors) will be needed to refine the management tools for the area.

12h00-12h20: James Kinghorn (MEcon student) - Valuing non-native fish populations: a study of recreational angling in the Amathole District

Supervisors: Prof. JD Snowball (j.snowball@ru.ac.za); Prof. PJ Britz (p.britz@ru.ac.za)

Funders: South Africa Netherlands Research Partnership on Alternatives in Development (10-06); Rhodes University Sandisa Imbewu Scholarship

Management of non-native fishes in South African waters is centred on their eradication and the mitigation of their negative ecological impacts. Little attention has been paid to their benefits, particularly their ability to support economic development and even contribute indirectly to ecosystem functioning. Further research into the benefits which they provide is needed for the development of holistic fisheries and environmental management policy. This thesis considers the value of two distinct inland recreational fisheries situated in the Amathole District of the Eastern Cape Province in South Africa. The first is a club run bass fishery located at Wriggleswade Dam, and the second a community run trout fishery in the streams surrounding Cata. While a key objective of the study is to estimate in part the benefits which these fisheries provide to the regional economy and to anglers themselves, the thesis is also a methodological comparison: contrasting the empirical pragmatism of two widely used revealed preference methods with the more qualitative, but equally popular method, the local economic development framework.

Economic impact analysis was used to isolate the monetary flows which accrue to the Amathole District as a result of the 2012 Amatola Classic and the 2011 Eastern Cape Divisional Tournament. The travel cost method was employed to estimate the net benefit which anglers derive annually from the Amatola Classic. Four models were tested: two variations of Poisson model and two variations of the Negative Binomial model. Data for these methods were obtained from 131 interviews. Lastly, the development of a community run business, Amatola Wild Trout, was analysed through the lens of local economic development literature. Interviews with four stakeholders informed the analysis.

The combined regional economic impact of the two angling tournaments hosted by Wriggleswade was estimated at R62 560. In the case of the travel cost analysis, the Poisson model corrected for endogenous stratification and truncation of non-users performed best, with a pseudo R^2 of 1.35 and a χ^2 of 94.92 (significant at 1 %). The net benefit which accrued to anglers who participated in the Amatola Classic between the years 1999 and 2012 was estimated by this model at R9 091 per angler per trip. In its first year of business, Cata Wild Trout raised R6 900. While the two fisheries were not shown to provide substantial monetary benefits to the Amathole District, Cata Wild Trout shows potential for future growth. Both fisheries provided the associated communities with significant intangible benefits such as improvements in human capital and integration into the global economy. Lastly, the study has revealed how the economic value associated with two fisheries might be used to incentivise catchment restoration and management, demonstrating how non-native fish populations can be used indirectly to enhance ecosystem functioning.

12h20-12h40: Geraldine Taylor (MSc student) - The biology and ecology of largemouth bass *Micropterus salmoides* in aquatic ecosystems within South Africa

Supervisors: Dr OLF Weyl (o.weyl@saiab.ac.za); Dr PD Cowley (tagfish@gmail.com)

Funders: Press Family Trust; South Africa Netherlands Research Programme on Alternatives in Development; National Research Foundation/SAIAB

Largemouth bass *Micropterus salmoides* is a non-native freshwater piscivore introduced into South Africa in 1928 to develop opportunities for angling. It is now widespread inhabiting all the major southern African catchments. Management of this species is essential as it is both a potential threat to native biota and a valuable sport fish. This study aims to contribute to the understanding of *M. salmoides* biology and ecology in South Africa through assessing age and growth, reproduction, feeding, movement and utilisation.

Micropterus salmoides were sampled from Wriggleswade and Mankazana Impoundments in the Eastern Cape monthly from February 2011 until March 2012 by angling, gill, fyke and seine nets. Fish were aged using sagittal otoliths and scales to determine the most appropriate structure, and growth zone formation was validated for otoliths using the mark recapture of chemically tagged fish and edge analysis. Growth was modelled using the von Bertalanffy growth model, the spawning season was identified and age and length at maturity estimated using a logistic ogive. Diet was assessed using stomach contents analysis and the utilisation and dispersal of *M. salmoides* was examined using catch data and a tag recapture experiment.

On comparison, scales were the less precise structure for ageing all age groups of *M. salmoides* and due to inconsistencies in the readings many were rejected from the analysis. A Bowker's test showed that the error around the agreed age (otolith age = scale age) was not symmetrical, and graphically scales tended to underestimate the age of largemouth bass of 5 years and older. Sagittal otoliths were the preferred structure for aging *M. salmoides* and the periodicity of growth zone formation was validated as annual. Growth was faster and fish reached longer lengths in Mankazana compared to in Wriggleswade, and growth performance of both populations (phi prime: 2.80 - 2.99) was similar to other non-native temperate populations. The spawning season was clearly defined by a peak in reproductive activity in October in both impoundments, and fish matured at shorter lengths in Wriggleswade (Lm_{50} = 259 mm) compared to Mankazana (Lm_{50} = 290 mm), and age at maturity was similar at two years. Stomach content analysis revealed a well-defined ontogenetic shift from zooplankton and insects to fish and crabs at 160 mm FL in Mankazana and a less distinct shift at 100 mm FL in Wriggleswade. An assessment of movement using dart tags demonstrated that *M. salmoides* in Wriggleswade dispersed up to 14 km from a release site and dispersal distance was independent of fish size or time. Catch data indicated a slight decrease in the size of fish in recent years. In conclusion, life history and trophic plasticity is comparable to that of other populations of this species.

12h40-13h00: Zyangani Chirambo (MSc student) - Governance in South Africa's inland fisheries: a case study of the north Keiskammahoek fishery (Amatola wild trout fishery) in the Eastern Cape Province

Supervisors: Prof. PJ Britz (p.britz@ru.ac.za); Prof. MJ Roodt (m.roodt@ru.ac.za)

Funders: Rhodes University Research Committee; Water Research Commission (K5/1957/4)

South Africa's 1996 Constitution and environmental laws place a strong emphasis on the equitable utilisation and sustainable of natural resources; such as inland fisheries to achieve economic and social development. Previous studies have described South Africa's inland fisheries as being undeveloped or underutilised in comparison to inland fisheries elsewhere in Africa. The lack of development is attributed to challenges such as the lack of an inland fisheries policy, which is exacerbated by weak institutional arrangements. For example, the legislative and administrative framework applicable to inland fisheries is fragmented between several government agencies and does not recognise fishing for livelihoods, resulting in the criminalisation of subsistence fishing. There is a general paucity of information on inland fisheries especially in the context of governance. Therefore this study seeks to gain an understanding of how the governance structures currently in place affect inland fisheries development. It has three broad objectives which are:

- understand the role of community structures in inland fisheries governance;
- evaluate South African legislation and its impact on inland fisheries development; and
- analyse the role of relevant statutory government bodies and traditional authorities.

This qualitative research project will employ a case study approach to study the Keiskammahoek trout fishery at Cata. The fishery was initiated and is managed by the Cata community through a local governance structure called the Communal Property Association. The community lacks exclusive rights as the resource is a defacto common pool resource. Data will be collected using detailed interviews of community members and government officials while observation and focus group discussions will be conducted within the community. Document analysis will focus on legislation affecting inland fisheries. All data collected will be analysed inductively, generating themes and categories as they emerge.

The study will generate an understanding of the role of local community structures in fisheries governance in view of the Constitution and environmental legislation's principles of equity, sustainability and participation. It is hoped that the case study will help identify the constraints affecting implementation of these principles for effective realisation of inland fisheries development. Analysis of legislation is expected to yield insights for development of guidelines for inland fisheries management or a review of legislation to suit fisheries development and management. These outcomes will be submitted to the respective audience such as Department of Agriculture, Forestry and Fisheries, Department of Water Affairs and Water Research Commission. It is anticipated the study will also generate further research topics on inland fisheries in South Africa.

13h00-13h20: Evans Simasiku (MSc student) - Assessment and management recommendations for the Lake Liambezi Fishery Caprivi Region, Namibia

Supervisors: Dr OLF Weyl (o.weyl@saiab.ac.za); D Tweddle (d.tweddle@saiab.ac.za)

Funders: National Research Foundation/SAIAB; Namibia Nature Foundation; Government of Namibia, Kamutjonga Fisheries Research Institute (KIFI)

Lake Liambezi formed a very important part of the Caprivi fishery until it dried up in 1986. The lake has completely refilled in 2008, but little work has been conducted to asess the new fishery. The study explores the inshore and offshore species composition and distribution based on extensive beach–seine and gill net surveys in order to help develop management recommendations for the fishery. The specific objectives of this study are to assess the inshore community assemblages and to compare selectivity and the catch efficiency between mono - filament and multi - filament gillnets in the offshore waters.

Seine net surveys yielded 1756 specimens, representing four families, (Cichlidae, Characidae, Cyprinidae, and Poeciliidae) and gillnets caught 4149 specimens, represented by seven families (Cichlidae, Characidae, Cyprinidae, Poeciliidae, Schilbeidae, Mormyridae, Distichodontidae and Clariidae) between May 2011 and April 2012. Cichlids formed the most diverse and second most abundant by number in seine net catches. Cichlids also dominated the gill net catches by number, particularly *Oreochromis andersonii* (36.9 %), *Serranochromis macrocephalus* (20.1 %) and *O. macrochir* (16.6 %). Length frequency analysis for commercially important species in seine net catches indicated that *Oreochromis andersonii,* and *O.macrochir* juveniles formed a single cohort whereas multiple cohorts of *T. rendalli* were observed. These results imply that *T. rendalli* has a much longer spawning season than *O. andersonii,* and *O. macrochir*.

Mean catch per unit effort by number and weight was significantly higher in monofilament gill nets than in multifilament nets. The current minimum legal gillnet mesh size under the regulations for the Inland Fisheries Resource Act in Namibia is 3 inch (76 mm). This mesh size selected for *O. andersonii, O. macrochir* and *T. rendalli* at lengths between 112 mm and 200 mm (Total length TL). The length at maturity for these species in Lake Liambezi is between 212 and 254 mm TL. This indicates that nets of the legal minimum mesh size select for juveniles of these species. Hence, there is a need to regulate the legal minimum mesh size as an initial management step towards protecting immature fishes. Future research will focus on assessing the effect of water level, moon phase and different habitat zones on gillnet catch rates.

Thursday 11 October 2012

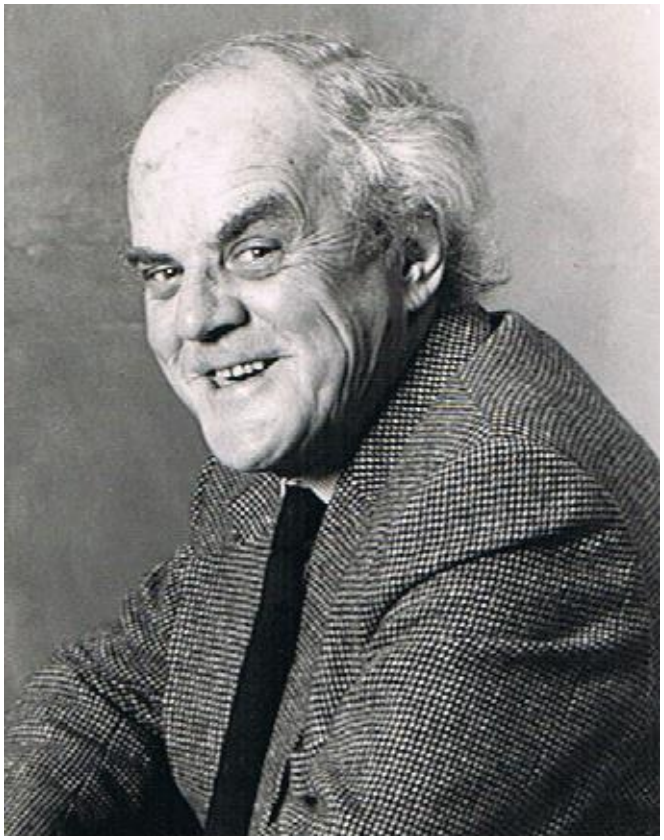
Humphry Greenwood Lecture (Chair: Prof. Warwick Sauer)

08h25-08h35: Welcome and introduction by HOD

08h35-09h20: Prof. Paul Skelton – Change is a constant

Peter Humphry Greenwood (1927-1995)

Humphry Greenwood was born in the UK (1927) but spent much of his youth in Johannesburg, South Africa, where he attended St Johns College, and later Michaelhouse in KZN. In 1942 he joined the SA training school for the SA Navy (General Botha) for 6 months before returning to school (Krugersdorp High School). In 1944 he joined the SA Navy where he was seconded to the Royal Navy for service in WWII. After the war he studied zoology at WITs graduating with honours in 1950. He then trained under Dr Ethelwyn Trewavas at the British Museum (Natural History) and spent time on Lake Victoria where he began his lifelong studies on haplochromine cichlids. He returned to the BH (NH) in 1957 where he remained until retirement in 1989. After he retired he spent much of his time in Grahamstown, working at the JLB Smith Institute of Ichthyology and in association with RU DIFS. Humphry was a top-rated international ichthyologist contributing greatly to African freshwater ichthyology through studies on cichlids, as well as other taxa (cyprinids and osteoglossiform fishes feature). His greatest contributions however probably revolve around phylogenetic ichthyology beginning with his 'classic' 1966 paper co-authored with Drs DE Rosen, SH Weitsman and GS Myers titled "Phyletic studies of teleostean fishes with a provisional classification of living forms". This paper is considered the foundation or initiation of modern classification of fishes which has been largely a product of Phylogenetic or 'Hennigian-cladistic' philosophy. Humphry made several key contributions to the re-classification of fishes through studies on basal taxa such as the Osteoglossomorpha, Elopomorpha and Clupeomorpha. Humphry played a key role as Chair from 1968-1973 in the IBP (International Biological Programme) Lake George project, and also served as the President of the Linnean Society from 1976-79. He was hugely respected internationally for his scholarship and leadership and received many highly rated awards and honours such as the Scientific medal of the Zoological Society of London, the Linnaeus Medal, and an honorary DSc from Rhodes University. He was elected a Fellow of the Royal Society in 1985. He trained several leading ichthyologists and scientists and contributed enthusiastically to teaching students here in Grahamstown at the Institute and DIFS. His infectious and mischievous sense of humour is legendary.



Freshwater Conservation/Ecology (Chair: Nicola Downey)

09h20-09h40: Gamuchirai Mataruse (MSc Student) - Phylogeography and conservation of a newly discovered *Galaxias* species from the Joubertina area in the Eastern Cape Province of South Africa

Supervisor: Dr ER Swartz (e.swartz@saiab.ac.za)

Funder: National Research Foundation/SAIAB

The dispersal of freshwater fishes in the Cape Floristic Region of South Africa has been attributed to river capture events and confluence of rivers during sea level regression. The role of low drainage divides and inter-basin water transfers have received less attention. A recently discovered lineage of *Galaxias zebratus* (hereafter the Joubertina galaxias) occurs in two currently isolated river systems, the Gamtoos and Krom. The present study mapped the distribution of the Joubertina galaxias and used mitochondrial and nuclear DNA sequences to assess the processes that could have influenced its current distribution pattern. Analyses of both mitochondrial cytochrome *b* and nuclear (S7) sequences revealed that observed genetic differentiation cannot be explained by isolation between the Gamtoos and Krom river systems. No genetic differentiation was found between the Krom River system and the Twee River (a tributary of the Gamtoos River system). Shallow genetic differentiation (0.4 % for cytochrome *b* and 0.3 % for S7) was found between the Krom and the remaining populations in the Gamtoos River system. High levels of genetic structuring were observed within the Gamtoos River system with most tributaries having one or more unique alleles. Inter-basin dispersal during pluvial periods or recent human mediated translocation seems to be the most plausible explanation for the present distribution of the Joubertina galaxias in the two river systems. The present study also assessed the threats and habitat preferences of the Joubertina galaxias. This study also evaluated the conservation status of this lineage. The Joubertina galaxias is threatened mainly by alien fish invasion, habitat loss and loss of genetic diversity due to fragmentation of its populations. Due to its very restricted geographic range, small known population sizes and the intensity of threats to this lineage's survival, this lineage has preliminarily been assessed as Endangered. The lineage had a restricted Area of Occupancy (AOO) and Extent of Occurrence (EOO). The extent of occurrence has declined in all tributaries and is continuing to decline in the other tributaries, except in the Granaat and Wabooms tributaries which are secure. The lineage may have had natural fragmentation among its populations, but recent threats have completely isolated the populations. The threats affect the lineage's survival potential in the other four tributaries which have small populations that are not viable long-term. The densities observed for the Joubertina galaxias ranged from 0.16 - 1.3 fish/m^2 and the number of mature individuals for the whole population seems to be less than 2500 mature individuals. It is therefore important to liaise with conservation agencies and stakeholders to ensure that the information generated by the present study is included in management plans for the species.

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

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

Funders: National Research Foundation/SAIAB

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

The objectives of the current study are: (1) to identify and map the distribution of *Labeo umbratus* genetic lineages; (2) relate the population history to known climatic and geological events; (3) assess which evolutionary processes have been responsible for genetic diversity patterns and (4) to construct a phylogeny of the Southern African *Labeo* species.

To assess the geographic distribution of genetic diversity, more than 600 base pairs of the mitochrondrial cytochrome *b* gene were sequenced for 275 specimens. Phylogenetic trees and networks were constructed to illustrate genetic distances among lineages. Genetic patterns, inferred populations histories and evolutionary process were then compared to palaeoriver systems reconstructed for the Last Glacial Maximum 18,000 years ago. This was done to assess the role of climatic and geological change in shaping the population histories of these two species.

Preliminary results show differentiation between the Orange and southern flowing river systems for *L. umbratus*. There was very little divergence among southern flowing river systems for this species. However, several alleles were restricted to single river systems, indicating a lack of current gene flow. Private alleles in the suspected alien populations suggest that these might be natural populations and that *L. umbratus* might have a much wider natural range than previously thought. There was very little structuring in *L. capensis*, suggesting high levels of gene flow in this species across the Orange River system. It is possible that at least *L. umbratus* was introduced to Hardap dam, because of extensive hybridisation with *L. capensis* in this reservoir and due to their natural absence from the lower Orange below Augrabies waterfall.

10h00-10h20: Kerry-Ann van der Walt (MSc student) - Is there genetic evidence for differential dispersal in three headwater fish species in the Groot Marico catchment, North West Province, South Africa?

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

Funders: National Research Foundation/SAIAB; Rhodes University Research Committee; Water Research Commission (K5/2008)

The Groot Marico Catchment in the North West Province represents unique landscape features with unique biodiversity and has been identified as biodiversity special features of special ecological significance. There is little information on the distribution of the species inhabiting the catchment. Three native freshwater species have high local conservation importance, namely *Amphilius uranoscopus*, *Chiloglanis pretoriae* and *Barbus motebensis. Barbus motebensis* is endemic to the catchment and is IUCN-listed as vulnerable (VUL). These three species are currently thought to be impacted by non-native largemouth bass, *Micropterus salmoides* which through predation pressure may fragment tributary populations of these species. Knowledge of the population history of the native species is therefore important to determine the severity of such impacts.

This project aims to determine population histories of the three native species in order to compare hypothetical past distribution to present distribution patterns. In addition, by assessing the genetic diversity of the indigenous fishes, it will be possible to determine whether tributary populations comprise of one population or are genetically distinct populations separated by natural barriers.

Samples of the three native species were taken from three localities in each of eight tributaries in the Groot Marico catchment. Samples were collected by electrofishing. In total, 80 individuals per species were sampled (targeting at least 10 individuals per population with a total of 8 populations). Specimens were overdosed in a concentration of clove oil. A sample of muscle tissue was removed for genetic evaluation and the remainder of the specimens served as voucher specimens. For the genetic evaluation, the potential genes that have been focused on include CO1, Cytochrome *b*, S7 and ND2. Genetic techniques include DNA extraction, Polymerase Chain Reactions (PCR), Purification and Sequencing. Sequence results have been received from Macrogen (South Korea) and will be analysed using models of sequence evolution in MODELTEST version 3.06 and phylogenetic analysis will be performed in PAUP*. Population structuring and phylogeographic analysed will be performed in Arlequin version 2000, TCS, GEODIS version 2.0 and PAUP* in order to identify evolutionary processed that will have to be conserved in genetic diversity is to be maintained.

Preliminary results using the ND2 gene indicate that there is regional structuring for *Barbus motebensis* within tributary streams. With a similar analysis strategy, *Amphilius uranoscopus*, showed no genetic variation. Preliminary results for *C. pretoriae* are still inconclusive. Preliminary results therefore suggest that *B. motebensis* and *A. uranoscopus* have different genetic diversity patterns and may therefore have been influenced differently by landscape features.

10h20-10h40: Bruce Ellender (PhD student) - Ecological consequences of non-native fish invasion in Eastern Cape headwater streams

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

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

The ecological impact of biological invasions is the most poorly understood aspect of the invasion process, however, non-native fish invasion is considered a primary threat to headwater stream fishes. This research investigates the ecological consequences of non-native fish invasion in the headwaters of the Swartkops River system where endangered *Pseudobarbus afer* are threatened by *Micropterus salmoides*, *Micropterus dolomieu* and *Clarias gariepinus* and in the Keiskamma River system where endangered *Barbus trevelyani* are threatened by *M. salmoides*, *Oncorhynchus mykiss* and *Salmo trutta*. The research includes five components. (1) Evaluating underwater video analysis (UWVA) as an alternative to electrofishing for assessing diversity and relative abundance of imperilled fishes (*P. afer*, *Sandelia capensis*): Detection rates using UWVA were higher, relative abundance estimates were significantly correlated and the attractive effect of the camera was negligible. Therefore, UWVA is considered a suitable method for estimating relative abundance of fishes in small, clear headwater streams. (2) Assessing the re-invasion and establishment of non-native fishes in the Blindekloof stream after their eradication in 1989, from source populations in the mainstream Swartkops River: All but one (*Cyprinus carpio*) non-native species invaded the Blindekloof stream, only *Tilapia sparrmanii* were successfully established and the invasion by *M. salmoides*, *M. dolomieu* and *C. gariepinus* was casual. (3) Distribution and abundance of indigenous fishes in relation to non-native fishes: 75 stream sites and four instream impoundments were surveyed in the upper reaches of the Keiskamma River system. Impoundment fish assemblages consisted primarily of non-natives, while only *O. mykiss* and *S. trutta* had established in headwater streams. *Barbus trevelyani* was limited to non-invaded stream segments and the primary factor influencing their distribution was the presence of *O. mykiss* and *S. trutta*. In the Swartkops River system, 69 sites were surveyed. Predation by non-native *M. dolomieu* and *M. salmoides* was the primary factor limiting indigenous fish distribution. *P. afer* co-occurred with all other species but never with either of the two centrarchids. (4) Assessing temporal invasive impact: Following a major flooding event where *P. afer* populations were re-distributed throughout invaded stream reaches, invaded (bass zone; below bass zone) and non-invaded (redfin zone) stream reaches were monitored for six months. *Pseudobarbus afer* abundance was significantly lower in the bass zone and all adults were extirpated by the end of the study period, however, recruitment was independent of stream zone. (5) Research results highlight the importance of understanding landscape level factors such as dispersal and environmental stochasticity to the persistence of headwater fishes. The consequences of isolation and fragmentation of populations is currently being investigated by undertaking genetic assessments to determine how non-native fish predation is likely to impact on the genetic diversity of *P. afer* and *B. trevelyani* stream populations.

10h40-11h20: Tea break

Freshwater Ichthyology & Estuarine Ecology (Chair: Michelle Soekoe)

11h20-11h40: Pholoshi Maake (PhD student) - Systematics and phylogeography of mormyrid fishes in South Africa

Supervisors: Dr. G Gouws (g.gouws@saiab.ac.za); O Gon (o.gon@saiab.ac.za)

Funder: National Research Foundation

The family Mormyridae comprises of 18 genera and about 200 species of freshwater fishes endemic to tropical Africa. Mormyrids are unusual in having an electric organ that they use for communication and object location. Two genera of mormyrids, each with a single species, have been recognized from South Africa, *Marcusenius pongolensis* and *Petrocephalus wesselsi*. Local populations of the *M. pongolensis* in South Africa exhibited unusual variability in molecular genetics, morphology and electric organ discharge (EOD), but little is known about the characteristics of *P. wesselsi* populations. This systematic study aimed to incorporate morphology, genetics and EOD studies to provide a better understanding of the taxonomy, biogeography and phylogenetic relationships of these mormyrid fishes.

During surveys, samples from different river systems and/or different major branches received higher priority than samples from sites in close proximity. The genetic data and EODs were analysed using various statistical and phylogenetic packages. Standard DNA isolation methods were used to isolate DNA from muscle tissue preserved in 100 % ethanol. Phylogeographic analyses identified two genetically divergent forms of *Marcusenius* in South Africa. The one form can be linked to the name *M. pongolensis* and is widespread throughout the study area. An undescribed form occurs in the Limpopo and Mhlatuze systems in KwaZulu-Natal. Sequence divergence between the two species was 2 % and analyses of the EOD pulses of the two species are congruent with the genetic dataset. The new form is deeper bodied, possibly reflecting adaptation to floodplains and slow moving backwaters. The slim body form of *M. pongolensis* is possibly an adaptation to the faster flowing habitats in which they occur. The phylogeny and biogeography of *Petrocephalus* and *Marcusenius* revealed species level differentiation between different river systems. *Petrocephalus catostoma* complex is not monophyletic and separated into the southern and Eastern clades. Type materials are closely related to the South African population, *P. wesselsi*, and a resurrected East African species. *Marcusenius* species from the eastern part of Africa are not monophyletic, rejecting the hypothesis of single geographic point of evolution for the East African mormyrids. New genetically divergent *Marcusenius* lineages could be identified (i.e. from Rovuma River, *M. sp* "Rovuma", Luapula River, *M. sp* "Luapula" and the Limpopo/Mhlatuze systems *M. sp.* "deep-body"), none of which are monophyletic with the formerly widespread *M. macrolepidotus*. The results also indicate that populations from the Congo basin are most likely ancestral to both genera in southern and eastern Africa. A separation time of at least 1-5 mya is in agreement with geological data, indicating that the evolution of major river systems has been important in facilitating dispersal and isolation leading to speciation.

All morphological data collection and analyses for a systematic review of *M. pongolensis* in South Africa are ongoing.

11h40-12h00: Rogan Field (MSc student) - Inter-basin water transfer schemes and hybridisation within the genus *Labeo*

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

Funder: National Research Foundation Competitive Grant (UID 73667)

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

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

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

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

12h00-12h20: Taryn Murray (PhD student) - Habitat use patterns, movement behaviour and migrations of leervis *Lichia amia* (Teleostei: Carangidae)

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

Funders: Deutscher Akademischer Austausch Dienst; National Research Foundation/Joint Scholarship Programme/SAIAB

Leervis *Lichia amia* is a highly sought-after estuarine-dependent sport fishery species targeted by all facets of South Africa's recreational linefishery. Although aspects of the biology and population dynamics of this species are well-documented, limited information exists on its habitat use patterns and movement behaviour. Adult leervis are known to undertake a winter spawning migration to KwaZulu-Natal waters, with a return migration to Cape waters during the summer. However, little is known about the movement behaviour of juvenile individuals and their lifetime dependency on estuarine habitats as well as their connectivity between multiple habitats (i.e. sea vs. estuary) and multiple estuaries. This study will make use of acoustic telemetry and conventional mark-recapture techniques to investigate information gaps related to the movement behaviour and habitat use patterns of leervis throughout ontogeny.

Acoustic telemetry will be used to determine the fine-scale habitat use patterns and behavioural ecology of juvenile leervis in the permanently open Kowie Estuary. Acoustically tagged fish will be monitored over a one-year period using an array of moored automated data-logging receivers. The influence of environmental factors (e.g. temperature, salinity etc.) and natural rhythmic cycles (e.g. diel, circatidal and season) on their behavioural patterns will be evaluated. To assess multiple habitat (estuary) connectivity, acoustic receivers have also been deployed in the mouths of several adjacent estuaries as well as the Coega and Port Elizabeth harbours. Long-shore movements, migration speeds and homing of adult leervis in the marine environment will be elucidated using acoustic telemetry. Twenty adult leervis will be tagged with long-life transmitters and will be monitored for multiple years. Curtains of acoustic receivers placed off Mossel Bay, Algoa Bay, Port Alfred, Port St Johns, Aliwal Shoal (Umkomaas) and the Mozambique border (all forming part of South Africa's Acoustic Tracking Array Platform) will detect these tags and this information will be used to identify (a) key spawning areas, (b) if individuals spawn every year, and (c) whether they home back to areas where they were tagged. Estuarine protected areas (EPAs) have been advocated to be a solution to over-exploitation of estuarine fishery species during their juvenile dependence of these habitats. A detailed telemetry study, determining whether partial estuarine area protection can reduce the vulnerability of leervis, will be initiated at the end of October 2012 in the Goukou Estuary (the only no-take EPA in South Africa). Fifteen leervis (varying in size) will be tagged with acoustic coded transmitters and monitored for one year using an array of acoustic receivers.

By adopting the proposed methods in a holistic approach, this ongoing study will provide an improved scientific basis for the management of leervis and a platform for research on other estuarine-associated coastal fishery species.

12h20-12h40: Amber Childs (PhD student) - Estuarine-dependency and multiple habitat use by dusky kob *Argyrosomus japonicus*

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

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

Dusky kob *Argyrosomus japonicus* is one of South Africa's most valuable estuarine-dependent coastal fishery species. High levels of juvenile exploitation in estuaries have led to stock collapse, highlighting the need to understand the spatial and temporal aspects of estuarine-dependency and multiple habitat use. Connectivity is a critical property of estuarine-associated fishes and knowledge of this link is fundamental in understanding population dynamics and the nursery roles of estuarine or marine habitats. While dusky kob occur in both estuaries and nearshore coastal zones, limited information on connectivity among these habitats exists. The aim of this study was to assess the role of estuarine nursery habitats in the life cycle of the dusky kob by assessing multiple habitat connectivity and determining the drivers associated with estuarine use.

A total of 96 dusky kob (237-1280 mm TL) were tagged with acoustic transmitters in both the estuarine and marine environments of Algoa Bay and their movements were monitored using an array of 47 acoustic receivers. Sixteen were deployed in the Sundays Estuary from the mouth to the river-estuary interface (REI) region, 13 were deployed in the inshore coastal environment of Algoa Bay and 18 were deployed in the mouths of eight neighbouring estuaries and two harbours.

Tagged dusky kob exhibited significantly high levels of residency to their habitat of capture (estuary vs. coastal zone). However, a high degree of connectivity was observed with between 30 and 40 % of the tagged fish visiting the adjacent marine or estuarine habitats. Additionally, 38 % of estuarine-tagged juveniles visited the REI region. All tagged dusky kob exhibited circadian and circatidal rhythms that facilitated their estuarine-coastal connectivity. All excursions occurred at night and in the same direction of the tide. Circatidal rhythms also facilitated riverine connectivity, but a crepuscular activity pattern was observed in the use of the REI region. Several other environmental, seasonal and ontogenetic factors influenced estuarine use. Almost all excursions undertaken by tagged juveniles occurred in summer and by tagged adults in spring, while almost all visits to the REI region occurred in spring. Increased river temperatures in summer and changes in weather patterns owing to wind-driven upwelling events appeared to be drivers for marine and estuarine excursions, respectively. Based on the results, it appears that juvenile dusky kob tagged in the estuarine and marine environments within Algoa Bay display different behaviours (i.e. exist as distinct contingents). The existence of separate contingents coupled with the presence of different behavioural strategies (retentive and exploratory) allows for population regulation, which is essential for the maintenance of the dusky kob stock. The high recapture rate of the estuarine contingent (35 %) compared with the marine contingent (15 %) and within the estuarine contingent, the higher recapture rate of estuarine residents (41 %) compared with those that exhibited estuarine-coastal connectivity (23 %), highlights the importance of adopting a life history strategy that involves contingents and retentive versus migratory behavior. It also highlights the vulnerability of the estuarine contingent, particularly the resident individuals, to exploitation and the need for urgent management attention.

Marine Ichthyology/Taxonomy/Ecology

12h40-13h00: Enrico Gennari (PhD student) - Thermal physio-ecology of the white shark *Carcharodon carcharias*

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

Funders: Oceans Research; SAIAB; PADI Aware

The white shark is one of few elasmobranch species capable of maintaining parts of its body warmer than the surrounding environment. This ability enhances among other things, its neural activity, vision, swimming stamina and decreases digestion time, making it an effective apex predator. Very little is known about the thermal physiology of white sharks in the wild, since studying these large, highly mobile and potentially dangerous predators, often in rough sea conditions, is challenging.

This project has made use of anatomical dissections and acoustic telemetry to understand the thermal anatomy of white sharks and to determine their habitat use and movement patterns in Mossel Bay (South Africa), and whether they are not only able to maintain a higher body temperature but also thermoregulate depending on the ambient conditions.
A new prototype acoustic transmitter was designed and manufactured to monitor the muscle temperature of the tagged sharks. At the same time, a tag (with temperature and depth sensors) was externally attached and a transmitter (with a temperature sensor) was fed (in a piece of bait) to each of the studied sharks. This provided, for the first time, a means to assess simultaneously the complete thermal profile of a white shark from water temperature through the warmer white muscle to the warmest body core temperature of the stomach.

To date, sixteen white sharks have been dissected to look at the morphology and distribution of the suprahepatic and subcutaneous *retia mirabilia*. At the same time, six white sharks (TL = 1.5, 2.0, 2.5, 3.0, 3.5, 4.0 m size classes) have been triple tagged with an accumulative tracking effort of 775 hours. This included two continuous tracking sessions of 107 and 106 hours on two individuals. The intensive tracking protocol has produced large amount of data (> 5.2 million rows) that were filtered and analysed using a protocol created in R. The movement patterns of tagged sharks were described in three dimensions by combining data from positional fixes (X and Y co-ordinates) taken with a GPS on board the tracking boat and the swimming depth sensor (Z co-ordinate). Behavioural patterns (e.g. hunting, resting and moving) were described using three dimensional rates of movement, which were then linked to the thermal variables (stomach and muscle temperature).
Preliminary analysis of the physiological data indicates that white sharks are able to raise body core (stomach) temperature and white muscle temperature by up to 15 ºC and 10 ºC above ambient water temperature, respectively (1 and 5 ºC more than previously recorded). Muscle temperature resembled environmental conditions and fluctuations, whereas stomach temperature appeared to be independent of environmental conditions and ontogenetically constant.

13h00-14h00: Lunch break

Marine Ichthyology/Taxonomy/Ecology (Chair: Georgina Robinson)

14h00-14h20: Sisanda Mayekiso (MSc student) - Population genetic structure and biogeography of three wrasse (Labridae) species in the Western Indian Ocean

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

Funders: DST-African Coelacanth Ecosystem Programme (ACEP); SAIAB

Two competing biogeographic paradigms, involving dispersal and vicariance, have been proposed to explain the establishment of the various endemic regional components of the Western Indian Ocean (WIO). The complex interaction of historical events, oceanographic and life history features in shaping patterns of differentiation and genetic variation in marine fish species is largely unresolved. The WIO is an outstanding model for studying the influence of physical complexities and biogeographic breaks in defining patterns of regional differentiation. Reef associated labrid fish, with different distributions across the WIO regions, were selected from the genera *Thalassoma* and *Cheilio* to examine the factors that influence the contemporary and historical connectivity. These fish species are ideal models for studying broad-scale biogeography and connectivity as they are strongly reef-associated and distributed over a large geographic range. Molecular genetic approaches were used to shed a light on patterns of contemporary and historical connectivity, isolation of biogeographic regions, and the origins and relationships of the regional WIO faunas. This has a potential implication for biodiversity assessments as well as for the accurate interpretation of the origins of the WIO regional faunas.
The objectives of this study were:

(1) to examine patterns of genetic differentiation among the geographic regions of the WIO for each target species
(2) to determine the relationships among these areas of the WIO for each species and,
(3) to explore the factors that might have influenced these relationships

Specimens were collected from numerous WIO localities. Polymerase chain reaction (PCR) and fluorescent dye terminator sequencing were used to amplify and sequence two mitochondrial genes (cytochrome *b* and ATPase 6) and one nuclear gene (first intron of the nuclear S7 ribosomal protein gene) from individuals. Statistical analyses were done under phylogenetic and biogeographic frameworks. Traditional population genetic analyses were used to calculate haplotype diversity and nucleotide diversity within and comparing between species. Population structure was analysed using AMOVA. Phylogenetic relationships were analysed using neighbor joining and a median joining network.

Haplotype diversity values were observed to be high (*h:* 0.98 and 0.84) but with low nucleotide diversity indices (π: 0.008-0.004) for each species, suggesting high levels of genetic differentiation. Pairwise F_{ST} revealed values ranging from 0.15 to 0.96, suggesting genetic structuring among regions. AMOVA showed evidence of regional differentiation (> 0.39 % of variation was found among grouped localities). Mitochondrial DNA data of the monotypic *C. inermis* indicated two widespread and sympatric lineages, which may represent different species. A unique lineage of *Thalassoma hebraicum* was found in the Seychelles, which might be maintained by the South Equatorial current (SEC), whereas connectivity was observed among the eastern and southern mainland. These results provide evidence of connectivity with some genetic structuring, supporting both dispersal and vicariant hypotheses in producing these observed patterns.

14h20-14h40: Tshoanelo Moloi (PhD student) - Molecular systematics and antifreeze biology of sub-Antarctic notothenioid fishes

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

Funders: South African National Antarctic Program/ National Research Foundation; United States National Science Foundation-Office of Polar Program grant; SAIAB

The perciform suborder Notothenioidei is composed of mostly Antarctic and sub-Antarctic fishes that dominate the benthic fish fauna of the Southern Ocean. The water temperature near the Antarctic continent is below freezing point with sea ice present throughout the year. To avoid freezing, notothenioid fishes residing here have evolved antifreeze glycol-proteins (AFGP) that prevent their body fluids from freezing. The water temperatures at the sub-Antarctic region are higher and species here have lower levels of AFGP activities in their blood as opposed to those of coastal Antarctica. For example, *Notothenia angustata* of New Zealand has low serum AFGP activity of 0.06 °C whilst Antarctic Peninsula *N. coriiceps* has high antifreeze activity of 1.11 °C. This phase of the project aims to compare levels of AFGP in the blood serum of the widely distributed *N. rossii* which gets exposed to different water temperatures. The specific objective is to find out if *N. rossii* possesses the same levels of AFGP regardless of the temperature and ice conditions of its habitat. *N. rossii* specimens were collected from three Islands in the Southern Ocean; Marion Island, South Georgia and Brabant Island. These Islands experience different weather patterns with Marion Island being warmer and ice-free year round whilst the other two Islands get below freezing point and Brabant has sea ice during winter season. Serum AFGP activity was determined in terms thermal hysteresis using a Cifton Nanoliter osmometer, and osmolality using a Wescor freezing point osmometer. The serum AFGP size isoforms were resolved on a polyacrylamide gel electrophoresis (PAGE). Marion Island *N. rossii* appeared to have low thermal hysteresis and high osmolality of about 0.44 °C and 530 mOsm, respectively, as opposed to specimens from South Georgia and Brabant Island. This specimen has serum AFGP concentration of ~4.9 µg/ml, which is about half that of the other two specimens. These results suggest that Marion Island specimen possesses low levels of AFGP in its blood as opposed to the other specimens. PAGE analyses of the Marion Island specimen appeared to have a stronger molecular band for the smaller AFGP 8 isoform which is the most abundant isoform making about two-thirds of AFGPs circulating in the blood. The serum of the Brabant Island specimen carries all AFGP size isoforms including the largest isoforms which are the most effective in lowering serum's freezing point. Although the Marion Island specimen had lower AFGP activity and concentration compared to the other specimens, the estimated levels were high enough to suggest that this specimen possesses substantial levels of functional AFGP in its blood. Therefore, *N. rossii* maintains high levels of AFGP in the blood, regardless of the temperatures of the environment it occupies.

14h40-15h00: Chenelle de Beer (MSc student) - Comparative morphology and biology of *Octopus vulgaris* in the Benguela region

Supervisors: Dr WM Potts (w.potts@ru.ac.za); Prof. W Sauer (w.sauer@ru.ac.za)

Funders: NRF-KFD-South African Biosystematics Initiative (74457)

The cold Benguela Current, which formed approximately two million years ago, is located on the south western side of the African continent. The formation of this eastern boundary current triggered an allopatric event for many of the warm water organisms that had continuous distributions along the south and west coast of southern Africa. However, since many of these species have responded differently, despite similar isolation times, research in this region provides a unique opportunity to increase our understanding of evolutionary processes.

The common octopus (*Octopus vulgaris*, Cuvier) is a coastal, sedentary species, inhabiting coral reefs or rocky environments at depths of up to a 100 m. It is often considered to be one of the more extensively studied cephalopod species due to its worldwide distribution. However, very little research has been conducted on *O. vulgaris* within southern Africa.

The project aims to increase our understanding of the consequences of allopatric isolation on *O. vulgaris*, in the Benguela region, as well as to identify and provide methodical descriptions of any new species identified. The objectives of this project are to conduct a morphometric and biological comparison between *O. vulgaris* in southern Angola and along the south coast of South Africa.

Octopuses were obtained between the Cunene River and Namibe in Angola and between Cape Point and the Transkei in South Africa. Specimens were collected from the intertidal zone, euthanized, clipped for genetics and frozen for later laboratory analysis. Standard morphometric and meristic analysis which includes 96 measurements will be conducted. Biological data such as reproduction, ageing and feeding will also be collected in order to assess viability.

To date, 86 octopus have been collected in two different locations in Angola, 31 in the Eastern Cape and three in the Western Cape. Laboratory analysis, in the form of morphometric, meristic and biological data, is currently being conducted.

15h00-15h20: Jerraleigh Kruger (MSc student) - A morphological comparison of *Spondyliosoma* species, *Lithognathus mormyrus* and *Atractoscion aequidens* between Angola and South Africa

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

Funders: National Research Foundation – South African Biosystems Initiative (74457); SAIAB

The Luderitz upwelling cell associated with the Benguela current is responsible for the genetic isolation of various species between Angola and South Africa. This genetic isolation has resulted in morphological differences between these species. This study aims to test if there is morphological differentiation between populations of *Spondyliosoma cantharus* and *Spondyliosoma emarginatum*, *Atractoscion aequidens* and *Lithognathus mormyrus* from Angola and South Africa.

A total of 90 *Spondyliosoma cantharus*, 73 *Lithognathus mormyrus* and 52 *Atractoscion aequidens* were collected from four localities in Angola. A comparative sample of 107 specimens of *S. emarginatum*, 76 *L. mormyrus* and 33 *A. aequidens* were collected from South Africa. A total of 29 characters including 23 measurements and 6 counts were done on each individual. The data was standardised to eliminate the effect of allometric growth and analysed using linear regression, principal component analysis (PCA) and discriminant function analysis (DFA).

The results of the PCA indicated that there was a high degree of variation within populations of *L. mormyrus* and *Spondyliosoma* which suggested that these species are phenotypically plastic. Conversely, the PCA showed little variation within the populations of *A. aequidens* supporting the theory that they are phenotypically robust. The PCA showed that there were many similarities between the South African and Angolan populations of *A. aequidens*, *L. mormyrus* and *Spondyliosoma*. However, the DFA separated the *Spondyliosoma* by species identifying a few diagnostic characters. The DFA also separated the South African and Angolan populations of *L. mormyrus* and *A. aequidens* into different groups.

The DFA confirmed the current taxonomic classification of the two *Spondyliosoma* species. This suggests that *S. cantharus* is distributed from Angola northwards and including the Mediterranean. The data also suggested that the South African and Angolan *L. mormyrus* populations and *A. aequidens* populations may be different species. However, molecular confirmation is sought before species descriptions can be made. These results add to a growing body of evidence showing that Sparids are phenotypically plastic, while Scienids are phenotypically robust.

15h20-15h40: Michelle Soekoe (PhD student) - Allopatric variation in *Triakis megalopterus* populations isolated by the Benguela Current

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

Funder: National Research Foundation

The formation of the cold Benguela Current approximately 2 million years ago led to a marked change in the distribution and abundance of fishes along the west coast of southern Africa. Warm water fishes were restricted to either side of the Benguela Current as its cold water formed a barrier to gene flow between these populations. With the timing of the allopatry similar across species, it is possible to quantify the rate of adaptation of the populations in response to the disparate environmental conditions across a range of marine species. The objective of this study is to quantify and compare the differences in evolutionary adaptations of various marine species in order to better understand the evolutionary processes affecting regional biodiversity. With 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 will concentrate on aspects of the biology, including reproduction and feeding.

A total of 49 *T. megalopterus* were collected during a winter (n = 21) and summer (n = 28) sampling event between the Cunene River and Baia dos Tigres, southern Angola. For comparative purposes, reproductive and feeding analyses methods followed Smale and Goosen (1999). Each specimen was assigned a maturity stage using standard methods. Diets were quantified according to frequency of occurrence (%F), numerical importance (%N), gravimetric importance (%M) and index of relative importance (%IRI).

Total length (TL) of Eastern Cape (EC) and Angolan (ANG) specimens ranged between 576 mm – 2075 mm and 687 mm – 1830 mm respectively. In EC males start to mature at 1210 mm and were fully mature at 1345 mm while males in ANG matured at 1066 mm TL. Females matured at a smaller size in ANG, the smallest pregnant female (1448 mm) was 17 mm smaller than in the EC (1465 mm). ANG females gave birth to fewer young (n = 11) than EC individuals (n = 16). However, EC individuals birthed when embryos reached 420 mm – 450 mm compared with ANG embryos, which still possessed yolk and umbilical cords at 459 mm.

The diets of both populations were similar, mostly comprising crustaceans, cephalopods and teleosts. Elasmobranchs were, however, also present in the diets of individuals from the EC but not ANG. Teleosts were the main prey in ANG (IRI = 90 %) followed by cephalopods (IRI = 34 %) and crustaceans (IRI = 9 %). Diet appeared dependent on predator size in both EC and ANG populations with larger sharks opting for larger teleosts and crustaceans. Bigger individuals also had a broader range of food items than their smaller counterparts.

Smale MJ and Goosen AJJ (1999) Reproduction and feeding of spotted gully shark, Triakis megalopterus, off the Eastern Cape, South Africa. *Fishery Bulletin* 97: 987 – 998.

15h40-16h00: Tea Break

Marine Ichthyology/Taxonomy/Ecology (Chair: William Selapa)

16h00-16h20: Denham Parker (PhD student) - The impact of climate change on the subtidal reef fish community of South Africa's warm-temperate (Agulhas) bioregion

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

Funders: DAAD/NRF Postgraduate Scholarship; South African Environmental Observation Network

Tsitsikamma is the oldest, and one of the largest (350 km^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 project which monitors the subtidal reef fishes in the Tsitsikamma MPA. The research project uses standardised controlled angling methods to sample fish communities in the nearshore reef ecosystems and is in its 6^{th} 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. The primary objective of the research project will be to assess the possible impacts that climate change may have on the relatively fragile subtidal reef fish communities in the Tsitsikamma MPA.

Climate change is undeniably regarded as the largest environmental predicament faced by humans, yet the science needed for global-scale ecological understanding is immature and thus the magnitude and extent of effects remain largely unknown. This is further hindered by a lack of long-term ecological data, as the timescales of research projects are generally minute when compared to that of global climatic events. In an attempt to overcome these limitations, more feasible methods of assessing the possible impacts of climate change on fish communities are being explored. These include the use of isolated sporadic climatic events which are linked to long-term climate change such as El Niño and La Niña. These events are well recorded globally, and *in situ* temperature loggers have provided records of significant deviations from 'typical' water temperatures in Tsitsikamma during such events. These abnormal fluctuations have been shown to impose changes in fish species and size compositions, abundance and recruitment ability. It is thought that these types of sporadic climatic events will intensify and become more frequent as the global climate continues to change.

In addition, the suitability of stereo-baited remote underwater video (stereo-BRUV) as a fisheries independent monitoring technique will be assessed. This innovative method will investigate patterns in demersal fish abundance, community, size structure and fish fauna biomass. The data will also facilitate a comparison of long- and short-term spatial and temporal variability between the conventional controlled angling method and the stereo-BRUV technique.

16h20-16h40: Alexander Winkler (MSc student) - Aspects of the biology of an inshore sparid (*Diplodus cervinus*) (Lowe 1841) off the southern coast of Angola

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

Funders: NRF/DAAD Freestanding Bursary; NRF - KFD – South African Biosystems Initiative (SABI), Grant Number 74457

Diplodus cervinus hottentotus is found in the warm temperate inshore waters off South Africa and Angola. These populations appear to be isolated by the permanent Lüderitz Upwelling cell on the Namibian coast, which is thought to have formed 2 million years ago. There is evidence suggesting that this cold water driven isolation has resulted in phenotypic and/or genetic divergence in certain fish species between the two regions. The aim of this study was therefore to conduct a biological analysis of an unexploited population of *D. c. hottentotus* in southern Angola. For comparison and to remove the confounding consequences of fishing pressure, the results were compared with a study conducted in a longstanding Marine Protected Area in South Africa.

A total of 408 fish were sampled from southern Angola over a twelve month period. Fish were aged by counting the opaque bands on sectioned sagittal otoliths. A marginal zone analysis was used to validate the periodicity of opaque band formation and based on the results of a periodic logistic regression (χ^2 = 1.32, d.f. = 1, P > 0.05), the hypothesis that one opaque zone was deposited annually was accepted. Growth was modelled using a three parameter von Bertalanffy growth equation and significant difference where found for all parameters between the sexes (LRT, d.f. 3, p < 0.05). Males matured at 220 mm FL and females at 200 mm FL. The overall adult M:F sex ratio of was 1:1.4 and was significantly female biased (χ^2 = 8.2, d.f. = 2, P < 0.05) with females dominating the size classes below length-at-50% maturity (χ^2 = 5.6, d.f. = 1, P < 0.05). Macroscopic staging of sample gonads was validated through histological analysis of gamete development. The macroscopic staging and GSI results confirmed that this species has a protracted winter spawning season (May - October). Length frequency, age frequency, adult sex ratios and histological analysis suggested that this spp is a rudimentary hermaphrodite.

There was little difference in the age and growth between the Angolan and South African *D. c. hottentotus* populations. However, the spawning seasonality and the reproductive life history style were different between the populations.

Friday 12 October 2012

Marine Fisheries (Chair: Denham Parker)

08h00-08h20: Murray Duncan (MSc student) - The genetic stock structure of *Chrysoblephus puniceus*, a commercially important sparid in the South Western Indian Ocean

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

Funders: Western Indian Ocean Marine Science Association; South West Indian Ocean Fisheries Project; Deutscher Akademischer Austausch Dienst

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

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

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

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

08h20-08h40: Christine Coppinger (MSc student) - Assessing the genetic diversity of catface rockcod *Epinephelus andersoni* in the subtropical Western Indian Ocean and modeling the effects of climate change on their distribution

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

Funders: Western Indian Ocean Marine Science Association; National Research Foundation

Epinephelus andersoni is restricted to the south-east coast of Africa ranging from Quissico in Mozambique (subtropical) to Knysna in South Africa (warm-temperate). Its complex life history, long-lived nature and high residency make *E. andersoni* potentially vulnerable to overexploitation. *E. andersoni* is an important fishery species and has shown signs of depletion. Due to inadequate information necessary for management and conservation, further research is vital, particularly in the face of potentially significant climatic changes which could put further pressure on *E. andersoni*. The aims and objectives of this study were to describe the genetic structure and diversity of *E. andersoni* and to determine possible range shifts of *E. andersoni* with future changes in sea surface temperature. Genetic samples were collected throughout the distribution of *E. andersoni*. Standard DNA extraction protocols were used and PCR was done using universal primers. Nuclear (S7 intron 1) data was analysed to determine the genetic diversity of the *E. andersoni* population. Mitochondrial (cytochrome b) data is currently being analysed. A combination of nuclear and mitochondrial markers was used to ensure that the results are robust. S7 haplotype diversity was high (0.927) and an AMOVA on the S7 data showed significantly high among group variation (Φ_{CT} = 0.265, $p < 0.01$) between three groups: Eastern Cape; KwaZulu-Natal and Transkei; and Mozambique. This geographic structuring could be attributed to low gene flow across barriers such as the Mbashe-Port Alfred upwelling cell and the Mozambique Channel eddies. These results will be confirmed with the cytochrome b data which is especially sensitive to population subdivision. Niche modelling techniques were used to determine range shifts of *E. andersoni* with future temperature trends using species distribution and climatic data. The model illustrated a contraction of the *E. andersoni* distribution as well as future intensification of the Mbashe-Port Alfred upwelling cell. Due to the low gene flow across these barriers this intensification could decrease the resilience of *E. andersoni*, as its range becomes more limited with global change. The genetic data and modelling results combined will provide useful information on which to base future fisheries management.

08h40-09h00: Nicola Downey (PhD student) - A first description of the offshore reef environment off the Eastern Cape coast, South Africa, with reference to deep spawning chokka squid (*Loligo reynaudi* D'Orbigny, 1839)

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

Funders: National Research Foundation (KFD2008062700004); South African Squid Management Industrial Association

The South African chokka squid, previously thought to be a shallow water inshore spawner, has also been found to spawn at depths of 71 to 270 m. Mid-shelf spawning is still very much an unknown phenomenon. This project aims to determine where (substrate and general morphology of mid-shelf spawning grounds) and why (environmental conditions) squid spawn offshore, further our knowledge of mid-shelf spawning, assess the importance of mid-shelf spawning (recruitment) and determine whether mid-shelf spawning is a separate process from that which occurs inshore or is an offshore continuum. Studies conducted to date include filament and acoustic telemetry tagging studies, collection of environmental data, mapping of bathymetry and substrate types and determining potential paralarvae survival (individual-based modelling). Mid-shelf spawned eggs were found to contribute an estimated 18 % to total squid egg biomass. An analysis of environmental data showed fewer turbidity events to occur on the mid-shelf compared to inshore. Bottom temperatures on the mid-shelf were generally colder and more stable than inshore. On occasion, due to downwelling, the mid-shelf bottom temperatures were slightly warmer than bottom temperatures inshore. Substrate types and morphology differ substantially between the two spawning environments, with the mid-shelf consisting mainly of rocky reef. The movement of squid between these two areas indicates the existence of a single population as opposed to an inshore and offshore population. The survival of deep spawned paralarvae was found to be highest during the winter months, and for those paralarvae hatched off the Tsitsikamma and Knysna coasts.

09h00-09h20: Devin Isemonger (MSc student) - Modelling the spatial and structural response of the endemic sparid *Polysteganus Praeorbitalis* to climate change in the Agulhas system in the context of its genetic diversity

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

Funders: SAIAB; Western Indian Ocean Marine Science Association (WIOMSA)

Climate change has resulted in recorded shifts in both the longitudinal and depth ranges of marine fish species through related changes in sea surface temperatures, ocean chemistry and primary production. These shifts are likely to affect the abundance of certain species and the community structure and functioning of marine ecosystems in which they occur, with sociological and economic impacts for communities that harvest living resources. *Polysteganus praeorbitalis* is an important fisheries species that ranges from Beira in Mozambique to Algoa Bay in South Africa. Targeted by several different fisheries within its range, *P. praeorbitalis* has been severely overexploited, leading to a 90 % decline in CPUE in South Africa since 1941.

Stock structure was investigated through genetic analyses of the mitochondrial control region and intron 1 of the nuclear S7 ribosomal protein coding gene of 118 tissue samples collected from nine localities. An ensemble species distribution model, calibrated using presence records and remotely sensed sea surface temperature data, was projected onto a predicted climate change scenario 30 years into the future.

Species distribution models predicted both northerly and southerly contractions in range as well as some range fragmentation, attributed to warming and intensification of upwelling systems. While juveniles showed panmictia, genetic analyses of the nDNA dataset revealed that large (FL > 300 mm) specimens from the Eastern Cape and southern KwaZulu-Natal differ significantly ($P < 0.05$), although weakly ($FST = 0.033 – 0.02$), from those collected in the Transkei and northern KwaZulu-Natal. These differences were hypothesised to be due to the effects of upwelling events on gene flow in this species, due to their perceived influence on spawning events and life history stages. In combination, the species distribution models and genetic analyses highlight the importance of upwelling cells as a barrier to gene flow for this species and predict that the intensification of these cells due to climate change will have a negative effect on the distribution, abundance and genetic diversity of *P. praeorbitalis*.

09h20-09h40: 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)

Funders: National Research Foundation (NRF) (IFR2011032500017); SAIAB

Santer is a common commercial species off the South African coast, its range extending from east of Cape Agulhus to Mozambique and beyond to the Gulf of Aden. Santer mainly occurs on offshore reefs up to 200 m deep, moving inshore during cold upwellings. They reach 50 % sexual maturity at 250 mm (2 years) and maximum maturity at 340 mm (4 years). Santer is currently on the green list and is considered abundant; however, empirical assessments are generally lacking.
So far only basic studies on santer have been conducted to determine spawning times, feeding habits, larval development and sexual maturity. No information is yet available to determine the current state and distribution of the santer stock(s) in South Africa. This information is vitally important to fisheries management to determine what regulations and measures need to be put in place for long term survival of the stock(s) and to ensure a sustainable fishery for the future.

The stock assessment will be done in three parts:

- Analyses of fisheries data, provided by the NMLS (DAFF) and ORI to determine changes in biomass, length and catch per unit effort over time;
- Mark-recapture data from ORI and other tagging programmes will be analysed to determine residence and whether santer undergoes any movement and/or migration;
- The genetic variability and stock structure of santer will be determine using control region mtDNA sequence data from individuals collected along the South African coast;

The fisheries and tagging data has been collected and collated and over 600 genetic samples in the form of fin clips have been obtained. For the analysis of the fisheries data the South African coast line was divided into seven equidistant areas. The average lengths of santer in the 7 areas ranged from 30.7 cm to 37.6 cm with an overall overage of 35.1 cm for the NMLS data. The CPUE (kg/angler/hr) has remained fairly constant until 2000, where the CPUE begins to increase sharply from ± 0.42 to ± 0.70 kg/angler/hr ($p < 0.05$) after the reissuing of commercial licenses. The mark and recapture data (tagging) is currently being processed, but preliminary results suggest that santer is highly resident. Since santer are being caught at over their maximum maturity, they will have had time to breed at least once in their life time and ensure the sustainibility of the species despite the increase in CPUE rates.

A set of newly designed primers that will amplify the entire Sparid control region using the flanking tRNAs: tRNAPhe and tRNAPro in the mtDNA has been tested and they work within a tested range of 47 ° - 51 °C for santer, and should work as general primers for all Sparidae. Several santer mtDNA sequences will be amplified this way and sequenced bi-directionally to obtain a sequence for the whole control region. A second primer will be designed to maximise the length of sequence that can be obtained from a single direction Sanger sequencing. These sequences will be used for the genetic stock analysis to be conducted during early 2013.

09h40-10h00: Johan (Frikkie) van der Vyver (MSc student) - Investigating area-disaggregated models for management of the chokka squid *Loligo reynaudii* resource

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

Funder: South African Squid Management Industrial Association

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

Specific objectives are to:

- Test for separated squid stocks between Tsitsikamma and the Western Agulhas Bank using morphometric techniques.
- Evaluate the feasibility of assessment of the resource on an area-disaggregated basis.

1085 morphological samples were collected from 68 localities on the west and southern Cape coast, and from southern Angola, between April 2011 and July 2012. Samples were collected onboard research trawl vessels and commercial jig vessels. Angolan samples were collected at a fish market in Namibe, Angola. Forty-three hard and soft part morphological characters were measured using the bodies, arms, sucker rings, gladius, beaks, and statoliths. The morphological measurements were analysed using multivariate techniques (linear and quadratic discriminant function analysis, principal component analysis, and some other relevant multivariate visualization and analytic tools) to assess the existence of distinction among groups of samples collected from the different localities.

A base case using the existing model on an area-aggregated basis will be developed by using the best jig, trawl and survey input data determined through validation. Using this validated catch, CPUE, as well as old genetic and new morphological information, the current model will be assessed on an area-disaggregated basis. Based on a number of alternative scenarios, different sets of possible boundaries for the jig and trawl fisheries will be created to separate stocks. Data from these various scenarios will be used in a Bayesian model to generate results for the different area-disaggregated scenarios. Results may then be analysed and a number of hypothesis developed to determine which scenario yields the best plausible alternative to the current area-aggregated assessment of the resource.

10h00-10h20: Tea break

Aquaculture (Chair: Taryn Murray)

10h20-10h40: Justin Kemp (PhD student) - Thinking inside the box – exploring the mechanisms behind nutrient utilization in abalone

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

Funders: National Research Foundation; Marifeed (Pty) Ltd; Rhodes University Henderson Fund; Rhodes University Research Committee; DAFF; THRIP

Abalone are herbivores in their natural rocky shore environment, consuming a wide 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. Despite the availability of a locally produced abalone feed, and significant research on nutritional formulations, including the reduction of the dietary fishmeal and protein content, we know surprisingly little about the molluscan digestive process, particularly the utilisation of seaweed.

When compared to formulated feed, seaweed can be considered as a nutrient-poor feed, particularly in terms of protein and energy content. Despite this, abalone have been shown to grow particularly well on a diet of mixed seaweeds under culture conditions. Furthermore, protein utilization of formulated feed has been shown to improve with fresh seaweed supplementation. A 12-month growth trial assessing the role of fresh seaweed supplementation into the diet of animals fed a formulated feed in currently nearing completion at the Port Alfred Marine Research Laboratory. Five graded supplementation levels of a “mixed bag” of fresh seaweed (ulva, gracilaria and kelp) are being tested and production, health, metabolic, histological and product quality indicators assessed. Preliminary results from this trial will be presented. Complimentary to this trial, a second growth experiment assessing the supplementation of fresh seaweed, but this time into the formulated feed, will be conducted.

This trial will also is essence form the extended acclimation period for a range of metabolic and structural studies investigating the effect of diet on the metabolic costs of digestion, glucose metabolism in abalone and gut form and structure. The approach to these experiments will be presented.

10h40-11h00: Nicholas Riddin (MSc student) - Growth and gonad size in cultured South African abalone *Haliotis midae*

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

Funders: THRIP (TP2009082600019); Aquafarm Development (Pty) Ltd; HIK Abalone Farm (Pty) Ltd; Marifeed (Pty) Ltd; Roman Bay Sea Farm (Pty) Ltd; Rhodes University Research Committee

According to farm records, cultured *Haliotis midae* (50-70 g.abalone^{-1}) were growing 10 % slower in winter compared to summer. This reduction in growth rate also coincided with enlarged gonads. Initial trials showed that there were differences in mean monthly growth rates ranging from 1.97 – 5.14 g abalone^{-1} month^{-1}, and gonad bulk index (GBI) also varied between months (GBI range: 26.88 ± 12.87 to 51.03 ± 34.47). The investment of energy into gonad tissue growth did not compromise whole body growth as the abalone continued to gain weight throughout the reproductive periods, probably due to gonadal growth. Growth of this size class of abalone was not influenced by water temperature or day length, suggesting favourable on-farm culture conditions (regression analyses, $p > 0.05$).

Cultured *H. midae* were fed formulated diets with different protein sources, including soya, fishmeal, or a combination of soya and fishmeal, and these were compared to kelp-fed abalone. Kelp-fed abalone grew slower than those fed artificial feeds ($p < 0.05$). Gonad growth was the greatest when soya meal was included in the diet (average GBI: 74.91 ± 23.31), while the average gonad size of abalone fed the fishmeal-based diet had gonads which were 38 % smaller, and kelp-fed abalone had gonads which were 75 % smaller than those of the abalone fed on diets containing soya meal. The increased gonad mass in abalone fed on diets including soya meal might be attributed to phytoestrogenic activity, as a result of the presence of isoflavones found in the soya plant; this remains to be tested.

The influence of dietary protein to energy ratio (1.41 – 2.46 g MJ^{-1}) on growth and gonad size was tested. Protein and energy levels within the ranges tested (22 and 33 % protein; 13.5 and 15.6 MJ kg^{-1}) did not interact to influence growth rates of cultured *H. midae*. GBI increased from 50.67 ± 4.16 to 83.93 ± 9.35 units as a function of dietary protein to energy ratio ($y = 42.02\ x^{0.81}$; $r^2 = 0.19$; regression analysis: $F_{1.38} = 8.9$; $p = 0.005$). In addition, protein level influenced gonad size, with gonad growth being greater in abalone fed the high protein diet (factorial ANOVA: $F_{(1, 32)} = 7.1$, $p = 0.012$).

It was possible to determine monthly changes in growth and gonad size, although these two were not related. It was also possible to manipulate the gonad size of cultured abalone depending on the dietary protein source or protein and energy levels.

11h00-11h20: Devin Ayres (MSc student) - The effect of diet and sex sorting on gonad development and histology of farmed South African Abalone, *Haliotis midae*

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

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

Abalone, *Haliotis midae*, farmers in South Africa that rely on the locally produced formulated feed, i.e., Abfeed®, reported a periodic drop in growth likely to be due to increased gonad growth. This reduced rate of growth appears to occur just after winter. Since abalone that are fed formulated feeds show increased gonadal growth, it was hypothesized that formulated abalone feeds, which include compounds such as soya, enhance gonadal development. This problem will be investigated by a physiological assessment of abalone fed different diets, histological examination and sorting by sex over all seasons.

All experiments are conducted in flow-through systems on HIK Abalone farm in Hermanus, Western Cape. Abalone (50-70 g abalone^{-1}) were fed to satiation every day on a diet containing either soya and fishmeal (SF) or another isonitrogenous and isoenergetic diet without soya (F). For each diet, abalone were stocked at a density of 18% of surface area per basket into nine tanks with each tank containing 12 baskets. Every month three males and three females were randomly selected from each tank for gonad bulk index (GBI) analysis where the animals were weighed and measured and shell mass, meat mass and visceral mass were obtained. Viscera were stored in fixative for further linear measurements from both the exterior and interior (the dimensions of each tissue in cross section) of the gonad and digestive gland were made to calculate the GBI. Another three males and three females are randomly sampled every month from each tank to obtain weight and length measurements of the whole abalone, dry mater of meat and visceral mass, and shell mass. Another three males and three females were randomly sampled every month from each treatment for histological examination of the gonad tissue.

The sex sorting experiment was conducted in 18 tanks (0.9 x 0.6 x 0.6 m) stocked at a density of 17 % and abalone (71-80 g abalone^{-1}) were fed to satiation daily with the SF diet. Abalone were sorted into three groups of males only, females only and mixed sexes with equal numbers of males and females, each group replicated six times. Every month four randomly selected abalone were sampled for GBI analysis, weight and length measurements of the whole abalone, dry mater of meat and visceral mass, and shell mass.

Trials commenced in July 2012 and will run through to June 2013. Animals were acclimated to the diets in June. Preliminary results show there was a significant difference in the visceral mass as a percentage of whole mass between the two diets for July, August and September, with animals fed on the SF diet showing a higher visceral mass than F diet ($p = 0.02$). After three months these differences between the two diets did not give a clear indication of gonad development and therefore further results are required over all seasons.

11h20-11h40: Gareth Nicholson (MSc student) - The effects of stocking density on the health, growth and production of farmed South African abalone *Haliotis midae*

Supervisor: Dr CLW Jones (c.jones@ru.ac.za)

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

Abalone farm profitability is influenced by production per unit grow-out space. With farms having expanded to the maximum, and with increasing production costs, the only way for many farms to increase production is through optimizing stocking densities. The affect of stocking density on *Haliotis midae* performance is undocumented and optimal stocking densities for this species have not been determined. This study aims to develop a better understanding of optimal stocking densities for different size abalone, by determining the effect of stocking density on the growth, health and production of *H. midae*, when water quality is not a confounding factor. The study also investigated the behaviour of abalone under different densities.

The effects of four different stocking densities (16 %, 20 %, 22 % and 24 % of available surface area) were tested under farm conditions on three size-classes of abalone (15 - 35 g, 45 - 65 g, and 70 - 90 g start weight). Each treatment was replicated four times and trials ran for eight months with measurements made at four month intervals.

Weight gain per abalone decreased with an increase in density for all size-classes (35.76 ± 0.86 - 28.75 ± 0.86; 40.54 ± 0.93 - 30.71 ± 0.96; 57.86 ± 1.05 - 44.86 ± 0.96 g.abalone^{-1} for the 15 - 35, 45 - 65 and 70 - 90 g classes respectively, with an increased density of 16 - 24 %; ANOVA, $F_{(6, 324)} = 2.527$; $p = 0.021$). However, total biomass gain (kg/tank) remained unaffected in the 15 - 35 g (10.32 ± 0.15 kg/tank) and 45 - 65 g (7.75 ± 0.15 kg/tank) treatments ($p > 0.05$) but increases significantly from 8.66 ± 0.18 to 10.66 ± 0.16 kg/tank with an increase in density from 16 % to 24 % for the 70 - 90 g size-class (ANOVA; $F_{(6, 36)} = 2.830$, $p = 0.023$). Food conversion ratio did not differ significantly between densities across all size-classes (ANOVA; $p = 0.016$).

A higher proportion of animals were observed above the feeder plate, and on the feeder plate at higher densities (8.10 ± 0.70 - 19.00 ± 1.33 % with an increased stocking density from 16 - 24 %; ANOVA; $F_{(3, 552)} = 105.32$ $p < 0.0001$). Despite this, the proportion of animals on feeder plates which were feeding on Abfeed® remained the same in all densities (33.90 ± 2.21 %; ANOVA; $p = 0.832$). Animals above the feeder plate were significantly more active and more likely to have their access to feed restricted at higher densities compared to lower densities (ANOVA; $p < 0.05$).

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

11h40-12h00: Georgina Robinson (PhD student) - Effect of substrate and tank design on growth of the sea cucumber *Holothuria scabra*

Supervisors: Dr CLW Jones (c.jones@ru.ac.za); Prof. S Stead (selina.stead@newcastle.ac.uk); Dr M Slater (m.slater@newcastle.c.uk)

Funders: HIK Abalone Farm (Pty) Ltd; THRIP (TP2011070800007)

Sea cucumbers, once dried and processed into *bêche-de-mer*, are a high value niche product in the East. Global sea cucumber stocks are severely depleted and aquaculture is considered the only viable means of bridging the gap between supply and demand in the future. The sea cucumber *Holothuria scabra* is a commercially valuable aquaculture species; however viable intensive tank-based aquaculture techniques have not yet been developed. The overall aim of the research is to develop technologies for high density cultivation of *H. scabra* in recirculating aquaculture systems (RAS). A preliminary growth trial (Trial 1) was conducted to determine the role of sand as a substrate and dietary component on growth of *H. scabra*. Trial 2 then compared growth of *H. scabra* in a multi-factorial experiment with three factors: 1) tank design (plenum or no plenum); 2) sand depth (0, 2 and 4 cm) and 3) sand particle size (fine: 125 – 250 μm and medium: 250 - 500 μm).

All trials were conducted at HIK Abalone Farm Pty (Ltd) in experimental aquaria (455 x 327.5 x 175 mm) supplied with seawater (24 L min^{-1}) filtered through a heated recirculation system. Juvenile sea cucumbers were suspended in mesh bags for 24 h to ensure gut contents were evacuated prior to weighing and photographed for individual photo-identification. Animals were fed once daily (16:00 hours) at approximately 1 % body weight.

Trial 1: Forty-eight individuals with a mean weight of 8.33 ± 0.2 g $individual^{-1}$ (mean ± SE) were allocated to 12 groups of four individuals per group. After 28 days, mean growth rate of *H. scabra* in the bare tanks was significantly lower than that of juveniles reared in tanks with a sand substrate (-0.12 ± 0.16 g day^{-1} SE and 0.03 ± 0.01 g day^{-1} respectively; $F_{(1,2)} = 1.91$, $p < 0.001$). However mean growth rate of *H. scabra* in bare tanks, fed a formulated diet containing 20 % and sand was not significantly different to juveniles fed a standard formulated diet (-0.13 ± 0.01 and -0.12 ± 0.16 g day^{-1} respectively; $F_{(1,2)} = 1.26$, $p = 0.42$).

Trial 2: Juveniles (n = 160) with a mean weight of 7.30 g ± 0.7 g $individual^{-1}$ (mean ± SE) were allocated to 10 groups of four individuals. A multifactor ANOVA was used to test for differences in mean growth rate between treatments. A significant interaction existed between all three factors at day 27 ($F_{(1, 24)} = 21.03$, $p = 00012$) and day 54 ($F_{(1, 24)} = 4.81$, $p = 0.04$). By day 81, only tank design had a significant effect on growth rate ($F_{(1, 24)} = 19.59$, $p = 0.00018$) with faster growth in standard tanks 0.20 ± 0.02 g day^{-1} compared to tanks with a plenum 0.12 ± 0.01 g day^{-1}. The standard tank design with 4 cm fine sand gave the best overall growth rate of 0.24 ± 0.04 g. Multiple regression analysis showed that differences in growth between treatments was related to the depth of the anoxic-oxic interface of the sediment which explained a majority of the variation ($r^2 = 0.40$; $\beta = 0.63$; $p = 0.0001$).

In conclusion, results confirm the reported positive effect on sandfish growth when sand is provided as a substrate and indicate that inclusion of sand in formulated diets is unlikely to compensate for lack of sand as a substrate. The optimum substrate for growth of juvenile *H. scabra* in RAS appears to be 4cm of fine sand (125 – 250 μm) in standard tanks.

12h00-12h20: Kerry Pieterse (MSc student) - Fish haematology – Haematological characteristics of dusky kob, *Argyrosomus japonicus* and investigating the use of an immunostimulant in fish culture of dusky kob

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

Funders: Welbedagt Research and Manufacturing; Rhodes University Research Committee; Oceanwise (Pty) Ltd

Despite continuous research and advancements in aquaculture technologies and husbandry techniques, fish diseases continue to be a major limitation in the aquaculture industry. Fish are exposed to repeated and variable stressors in the aquaculture environment, which leads to physiological responses that can negatively impact on growth, reproduction and immune capacity. The evaluation of haematological parameters is useful for assessing the physiological status of fish and will provide diagnostic information once reference values are established under standardised conditions.

A health study was conducted on dusky kob, *Argyrosomus japonicus*, on site at DIFS. Growth, hepatosomatic index (HSI) and blood parameters haematocrit and differential leucocyte counts were measured from all fish in the experiment and compared to determine baseline and reference figures of this species. A mean haematocrit from the experiment measured at 29.04 ± 4.33 %, HSI at 2.77 ± 0.43 %, which is similar to previous work on this species by other authors. A differential leucocyte count determined a small to large lymphocyte ratio of 4.56 ± 5.11. The morphology and size of leucocytes in this species were established.

Additionally, the study evaluated the efficacy of an immunostimulant Fish Assist® on fish health. The immunostimulant was administered via the artificial feed. No significant differences were found between the experimental treatments of fish fed Fish Assist® and the control for growth-related variables, haematocrit values and differential leucocyte cell counts.

Basic knowledge from this study is important for haematological research and clinical diagnosis. This will benefit the aquaculture industry to monitor the health status of fish and the presence of disturbance in the aquaculture environment. The next experiment will compare baseline data obtained with haematological parameters of fish under stressful conditions, as would likely be experienced on a fish farm.

12h20-12h40: William Selapa (PhD student) - The development of a dusky kob (*Argyrosomus japonicus*) least cost diet: protein, amino acid and energy requirements

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

Funders: Agricultural Research Council; THRIP; Marifeed (Pty) Ltd

Although dusky kob has good flesh quality, a high market demand and potential for growth in the South African aquaculture industry, the challenge remains the lack of a locally manufactured marine feed that cater for its metabolic needs. The processes of developing a "practical diet" for dusky kob in South Africa started in the early 2000s. Earlier studies investigated, among others, species' rearing protocol, with focus on the pellet structure, feeding frequency, and gross protein and lipid requirements. Currently, an important factor that needs to be addressed is the nutrient composition of the feeds and availability of these nutrients to the cultured species. Therefore, this study aims at developing the dusky kob diet from practical ingredients with emphasis on the species' protein, amino acid and energy requirements. The objectives of the study include: (1) to assess selected plant protein sources that are found in South Africa as potential fish meal replacements in formulated feeds for dusky kob, (2) to determine the digestibility of the protein and limiting amino acids in those protein sources that can be used as fishmeal replacements in dusky kob, (3) to determine the essential amino acid (EAA) requirements of the dusky kob, and (4) to determine the protein / amino acid to energy ratio requirements for the dusky kob.

A literature review suggests that practical feed ingredients suitable for inclusion on kob diets may include lupins (i.e. yellow, broad and narrow leaf), casein, sunflower, cotton meals, soyameal, torula yeast, spirulina and brewery waste. The nutrient composition of this sources and their nutrient availability to dusky kob will be investigated and evaluated for usage and sustainability of the commercial nature for the mariculture industry.

12h40-13h00: Sean Power (MSc student) - Hydroponic crop production in treated brewery effluent

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

Funders: Water Research Commission (K5/2008); Rhodes University Research Committee

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

The brewery effluent is treated in an anaerobic digester (AD) and a high rate algal ponding (HRAP) system as part of an alternative waste water treatment strategy. Previous work used this HRAP treated water to produce hydroponic lettuce. The observed growth deficiencies, nutrient deficiency symptoms and specimen mortalities showed that this was not an ideal nutrient source for some lettuce plants.

This project will build on the previous hydroponic research by investigating whether HRAP treatment of the effluent is either necessary or beneficial when using the effluent as a hydroponic medium. It will also test whether pH is influencing nutrient availability and subsequently limiting plant productivity. Finally the experiment will determine whether the effluent, and in what form (post-AD, post-HRAP and with or without pH correction), can support flowering and fruiting in tomato plants. The rate of nutrient removal from the effluent and water consumption of the plants will also be determined. This will allow for an estimation of the total productive potential of the brewery effluent resource.

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

Initial tests have suggested that the anaerobic digestate, without additional nutrients or pH correction, can support the flowering and fruiting of at least three different cultivars of tomato (*Moneymaker, Heinz 1370* and *Rodade*).

Monday 22 October 2012

Brittany Oliver (BSc Hons student) - An evaluation of alternative management strategies for the chokka squid fishery in the Eastern Cape: an assessment of current economic and social data

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

Funder: South African Squid Management Industrial Association (SASMIA)

The South African squid fishery based on a single species, *Loligo reynaudi*, locally referred to as chokka. This species is commonly found around South Africa on the Agulhas Bank and West Coast shelf. The South African squid fishery contributes directly to the local economy of the Eastern Cape Province as it provides high level of employment opportunities. Participation in the South African squid industry is currently managed by the Department of Agriculture, forestry and fisheries (DAFF). Squid long term rights expire at the end of 2013 and, with the imminent implementation of the new Small-Scale Fisheries Policy (SSFP), DAFF may consider changes in the existing rights allocations in this fishery. This study was initiated to better understand the current structure and functioning of the squid jig sector, placing it into the broader context of the fishing industry in South Africa, to inform future policy choices.

Several methods were used for this assessment. A questionnaire was compiled to assess the structure of the sector, covering 35 % of the current participants. Results were compared to those from the DAFF Performance Review (2009/2010) of the fishery. A number of financial models were compiled, covering the different vessel categories, in conjunction with Business Partners, a financial institution currently involved in financing a section of the squid fishery. Further social and economic data were compiled from available literature. The results indicated a total of 2423 crew and 138 vessels currently employed in the squid fishery. An average of 8000 tons of squid is caught per annum. Ninety-eight per cent of the annual commercial catch is exported into the European market generating foreign exchange in the order of R450-500 million. In terms of BEE data, the results of the questionnaire closely matched those of the Performance Review. Previously disadvantaged individuals (PDI) make up 98 % of the total work force within the industry and 92 % of the total work force is from the Eastern Cape. PDI shareholding has increased since 2009 to 49.8 %, whilst female shareholding still remained low at 18.81 %. Thirty three per cent of the top salary earners are PDI. The financial models indicate that a 26 man vessel purchased with a loan of R6 million (vessel cost) and an owners own contribution of R2.6 million (value of permits and R300 000 running costs) would make a marginal profit, based on an historical average catch for a vessel of this size, while a 16 man vessel, under similar but scaled-down funding and average catch assumptions would not be a viable business venture. The overall performance of the existing industry will be compared with possible future restructuring options using a suite of criteria based on the principles and objectives of the Small-Scale Fisheries Policy.

Melissa Mayo (BSc Hons student) - The behavioural response of chubbyhead barb, *Barbus anoplus*, to refugia, and its effect on maintenance metabolism

Supervisor: Prof. AJ Booth (t.booth@ru.ac.za)

Funder: Rhodes University Research Committee

Chubbyhead barb, *Barbus anoplus*, is a small minnow endemic to South Africa. Despite potential predation threats alien fishes they have managed to maintain a broad distribution south of the Limpopo river system. It is assumed that it prefers inhabiting areas with refugia. This project tested this hypothesis and examined its choice and behavioural responses to refugia. Computer-automated intermittent-flow respirometry was used to assess the presence-absence of refugia on its resting metabolic rate (RMR) under the null hypothesis that if refugia are actively chosen then fish within refugia will have a lower RMR.

Wild *B. anoplus* were captured and placed into experimental tanks, weaned onto flake food and maintained at a photoperiod of 12L : 12D and temperature of 15 ^{o}C. Experimental tanks contained two different types of refugia (artificial plants and logs) in three different configurations. One experiment investigated individual fish within a tank over time and the second with four fish per tank over time. The individual fish experiment was conducted over 48 hrs with three observations made per diel cycle. A total of 60 fish were examined. The conspecific experiment had a similar experimental design except 15 groups of four fish were investigated over 48 hours. Respirometry experiments consisted of two treatments: one with and one without refugia (artificial plants). RMR was determined for five fish per refugia treatment with each trial conducted over during the day and night.

Barbus anoplus selected to utilise refugia more, particularly artificial grass, during the day than at night ($p < 0.01$) for both individuals or as groups. Fish were found to be diurnal as they were significantly more active during the day than at night, whether or not they were on their own or in the presence of conspecifics ($p < 0.01$). RMR did not significantly between the absence and presence of refuge ($p > 0.05$), except at night, when RMR was found to be significantly higher than that found during the day ($p < 0.01$). These results suggest that *B. anoplus* are using avoidance mechanisms to remain undetected by potential visual predators. At night, when predators may switch to an alternative form of detecting prey, such as use of their lateral line system, *B. anoplus* may be reducing its movement accordingly to remain undetected.

Non-presenting students

Craig Midgley (MSc student) - Long-term changes in the fish assemblages in three South African transition-zone estuaries - can these trends be linked to climate change?

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

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

Estuarine environments and their associated fish taxa are not uniformly distributed along the South African coastline, their distribution is defined by three biogeographic regions: subtropical, warm-temperate and cool-temperate. Estuaries occurring between two biogeographical regions are areas of ecological transition and have flora and fauna from both regions. These "biodiversity hotspots" are often areas of high species richness, as species overlap their range margins at these sites. However, the ichthyofauna in transition-zone estuaries are more susceptible to long term climatic events such as global warming by virtue of their location in these transition zones. These estuaries are ideally placed to document shifts in species diversity, distribution and abundance arising from climate change. However, the effects of global climate change on estuarine fish populations occurring in the transition-zones between biogeographical regions are not well researched in South Africa. The aim of this study was to identify long-term changes in the abundance and diversity of tropical, temperate and widespread species in three South African estuaries. The Breede Estuary, which occurs near the cool-temperate and warm-temperate biogeographic break and the Mbashe and Mbhanyana estuaries which occur near the biogeographic break of the subtropical and warm-temperate regions.

The estuarine ichthyofauna of the permanently open Mbashe Estuary and temporarily open/closed Mbhanyana Estuary were sampled with a seine net in spring 1997 and 2010. Seasonal (summer and winter) seine net data collected between 2003 and 2012 were analysed for the permanetly open Breede Estuary. Although no clear trends were observed in either the number of tropical species recorded or the proportion of tropical species in the catch in the Mbashe Estuary, there was a slight decrease in the abundance of temperate species at the northern limit of their distribution from 1997 to 2010. In the Mbhanyana Estuary an increased contribution of tropical marine species to the total catch and a corresponding decrease in the contribution of temperate species was recorded. In the Breede Estuary, tropical species increased their contribution to the catch in summer and winter, while temperate species remained fairly constant over the study period. The highest abundance of tropical species was recorded in summer.

The results from this study highlight changes in the distribution and abundance of tropical species in some transition zone estuaries, in time a decline in the number of temperate species in all these systems may occur associated with climate change.

Moqebelo Morallana (MSc student) - Regional differentiation and phylogenetic relationships within the genus *Lutjanus* in the Western Indian Ocean

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

Funders: DST-African Coelocanth Ecosystem Programme (ACEP); SAIAB

Lutjanids (snappers) are reef- and bottom-associated fish occurring in tropical and sub-tropical marine waters worldwide. The genus *Lutjanus* has 65 species with 15 of these found in the Western Indian Ocean (WIO). Snappers form a major component of the subsistence fisheries of the WIO countries and contribute substantially to coastal livelihoods. While studies have shown limited spatial genetic differentiation in certain snapper species (e.g. *Lutjanus kasmira*) in the WIO, it is unclear whether other snapper species show the same patterns. Two molecular phylogenies were published for the genus, focussing on specimens from the South China Sea and West-Pacific; thus, only a part of the range of most species was considered and not all species were represented. Differentiation of additional species across the WIO and the relationship between WIO individuals and their West Pacific counterparts, thus, require investigation.

The aim was to (1) determine phylogeographic patterns in *Lutjanus fulviflamma*, *L. bohar* and *L. lutjanus* in order to understand the origins and factors influencing the distributions of diversity in the WIO, (2) examine how physical, environmental, biological and ecological features influence genetic diversity, (3) determine the placement of WIO snappers in the context of the wider Indo-Pacific (IP), as well as the phylogenetic placement of taxa not included previously, and (4) examine the extent of differentiation among WIO representatives and IP representatives of the same species and among the three species. This information will help in understanding levels of genetic connectivity in the WIO, with implications for conservation and management.

Samples were sourced from across the WIO and from peripheral localities. DNA sequence data were generated from two mitochondrial gene regions (Cyt-*b* and ND2) and a nuclear gene (first intron of the S7 gene) for the three species. Data was analysed under a phylogeographic framework to examine genetic structure, diversity, and differentiation among the identified regions, for each of the three species. Other sequence data were generated from mitochondrial gene regions (COII and 16S) to determine the phylogenetic placement of WIO snappers in context of the wider Indo-Pacific.

High genetic diversity and variation were detected for *L. fulviflamma* and *L. bohar* with restricted lineages occurring in South Africa, Mozambique, Tanzania, and Mauritius for *L. fulviflamma*, and Mozambique and Maldives for *L. bohar*. Low genetic diversity and variation was found in *L. lutjanus* with no genetic differentiation among localities detected. Currents seem to play major role in differentiating lineages in the WIO. A lack of differentiation was also observed among certain localities in the three species. Generated phylogenies were similar to those published, with the additional taxa not altering these groupings. Levels of genetic differentiation between conspecifics from the WIO and Western Pacific varied, depending on the species.

Rory Scheepers (MSc student) - Treated brewery effluent as a water source for the culture of swordtail *Xiphophorus helleri*

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Funders: SAB Ltd; Water Research Commission (K5/2008); THRIP (TP2009082100041)

Large industries utilize and discard large volumes of effluent. This "polluted" water is sent to local municipalities for treatment, with economic and environmental costs. The aim of this work is to establish if alternative, environmentally sustainable water treatment methods such as high rate algal ponding and constructed wetlands can be used to treat brewery effluent to a standard suitable for fish culture. The growth, reproductive output and health of swordtail grown in treated brewery effluent were compared to those of fish grown in a control group grown in a conventional water source.

No significant difference in standard length of adult males kept in treated effluent and control was found, with a combined mean (± standard error) of 64.36 ± 1.72 mm ($p = 0.46$). Average female length did not differ between treatments (67.95 ± 1.14 mm; $p = 0.49$). Mean weight (males = 2.48 ± 0.23 g, females = 4.52 ± 0.28 g) and condition factor (males = 0.92 ± 0.06 and females = 1.46 ± 0.09) were similar between treatments ($p > 0.05$). There was no significant difference in the number of juvenile fish harvested between treatments (646 ± 19 juveniles $month^{-1}$, $p = 0.99$), and no differences in brood size (33.3 ± 3.2 $juveniels.female^{-1}$; $p = 1.0$). Mean number of broods did not differ for the effluent and control systems (4.8 ± 1.16 $broods.tank^{-1}$: $p = 1.0$).

No significant differences in juvenile length at the start of the growth trial were found between treatments (15.32 ± 0.73 mm; $t = -1.93$, $p = 0.89$). Similarly, condition factor was the same between treatments (0.0017 ± 0.000178; $t = 0.33$, $p = 0.07$). After 206 d there were no significant differences in mean weight (1.30 ± 0.12 g; $t = -0.43$, $p = 0.68$), standard length (44.59 ± 0.97 mm; $t = 0.20$, $p = 0.85$), and weight gained (0.48 ± 0.15 g; $t = 0.36$, $p = 0.73$) between juveniles grown in the effluent and control treatments.

A qualitative analysis of the gill and liver tissue found abnormalities as common features between treatments. Effluent fish showed better gill architecture, fewer hyperplasia cases and blood congestion. Similar trends were seen for gill lamellae fusion, lamellar aneurysms, lamellar disorganization and epithelial detachment and ruptures. Control fish showed better liver architecture, fewer intravascular hemolysis cases, more centrally located hepatocyte nuclei, less hepatocyte degeneration and ceroid pigment. Effluent kept fish livers showed more evidence of fat and glycogen storage, less melanine in bile ducts, and centrally located nuclei. Similar melano-macrophage centres sizes and very few lipid droplet zones were seen in both treatments.

The similarity of fish size, condition factor, reproductive output and growth between treatments suggests that treated brewery effluent is a suitable water source for the culture of swordtails. This conclusion was partly supported by the histological analysis, where fish in the treated effluent largely had healthier gill tissue, and were storing more energy as fat or glycogen in the liver. The liver tissue of these fish, however, showed evidence of environmental stress, so effluent might have a long-term negative effect on fish health.

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

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

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

Behavioural investigations will cover the fine scale behavioural patterns during periods of association with a FAD through the use of acoustic tags (V13 and V13P, Vemco, Canada) and satellite-linked acoustic receivers (VR4-GLOBAL, Vemco, Canada) as well as large-scale horizontal behaviour using pop-up archival satellite tags (mini-PATs, Wildlife Computers, Redmond, USA). Tagging experiments will be carried out at several drifting FADs during scientific cruises around the Seychelles and in the Mozambique Channel. Sharks will be caught using baited hand lines and tagged on board the research vessel. After tagging is complete a VR4-Global acoustic receiver will be attached to the FAD and abandoned. Data will be obtained remotely via the Iridium satellite system. Similarly miniPAT tags will be attached to several individuals at the same time. These will detach from the animal at a pre-determined date and the data will be transmitted via the ARGOS satellite system. The dietary analysis will be conducted using dead sharks incidentally captured under FADs by tuna purse seine vessels in the Indian Ocean. A minimum of 250 individuals will be sampled.

The results from these tagging experiments will aid in developing practical mitigation methods to reduce the capture of this species. Furthermore, through the combination of dietary and behavioural results, the importance of floating objects in the ecology of these juvenile sharks will be assessed. This information can then be integrated into the management strategies of regional fisheries management authorities (RFMOs) for the regulation of FAD-based fisheries.

Siviwe Babane (MSc student) - Report not available

Emmanuel Mbaru (MSc student) - Report not available

Lara Crous (MSc student) - Report not available

Siyabonga Maliza (MSc student) - Report not available

Fabien Forget (PhD student) - Report not available

Index

H

I

J

K

L

M

N

O

P

R

S

T

U

V

W