Department of Ichthyology and Fisheries Science

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Research Report Series 2010

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

October 2010
(Version 1)

Sincere thanks to the following for supporting its student research:

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Edited by: CLW Jones & NA Rossetti

Schedule of Events/Table of Content

Wednesday 13 October 2010

Welcome by WHH Sauer (Head of Department)

Honours seminars (Chair: Warren Potts)

08h00-08h20: Murray Duncan (BSc Honours student) – The effect of fish oil substitution level with soya oil in fish feed on the growth, health and carcass composition of dusky kob, *Argyrosomus japonicus* (Pisces: Sciaenidae) Temminck & Schegel 1843

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

Funders: Espadon Marine (Pty) Ltd.; Rhodes University JRC

The recent trend in marine finfish feed production has been to produce high lipid, energy- dense diets that allow for the protein sparing effect. These diets have led to improvements in growth, feed utilisation and nutrient retention. Increasing lipid levels in fish feed through fish oil sources is undesirable as fish oil is expensive and from an unsustainable source. The partial substitution of fish oil with vegetable oil can lead to less expensive diets with the same amount of digestible energy as a 100% fish oil diet but may reduce fish growth and health. The inclusion of vegetable oil as an alternative lipid source may lead to an imbalance of the n-3:n-6 essential fatty acid ratio resulting in changes in fish metabolism and health status. This study investigates the level of fish oil substitution that does not cause significant changes in fish growth and health compared to a 100% fish oil diet.

The objectives of the study are to assess certain variables relating to fish growth, health and carcass composition of *A. japonicus* fed diets varying in the percentage replacement of fish oil with soya oil.

The study was conducted in twelve recirculating tanks. Fish were fed three diets containing various levels of soya oil substitution. Diet 1 = 100% fish oil, diet 2 = 14% soya oil and 86% fish oil, diet 3 = 28% soya oil and 72% fish oil. The growth trial was split into two separate experiments following the outbreak of a bacterial disease. Fish were weighed and measured at the beginning and end of each experiment and growth and feed utilization variables were calculated. At the end of the second experiment hepatosomatic indices and haematocrit levels were determined. Carcass composition proximate analysis and glycogen levels still need to be quantified.

In both experiments specific growth rates were significantly better in diets containing soya oil substitutions than the control diet 1 (one way ANOVA: $p = 0.007$ for experiment 2 and Kruskal-Wallace ANOVA: $p = 0.03$ for experiment 2). In experiment two, protein efficiency ratios and food conversion ratios were significantly higher for diet 2 than for diet 1 or 3 (one way ANOVA: $p = 0.01$ for FCR and $p = 0.01$ for PER). There were no significant differences between any other variables except for percentage survival in experiment 2 where mortality was significantly higher for diet 3 than diets 1 and 2, respectively (one way ANOVA: $p = 0.02$). The results suggest that *A. japonicus* grew and utilise their food better when part of the fish oil lipid source was substituted with soya oil. A longer study needs to be done to confirm these findings since detrimental effects to fish growth and health may occur after a longer time period.

Key words: marine; aquaculture; dusky kob; soya oil; lipid; growth; health

08h20-08h40: Alexander Winkler (BSc Honours student) - The effect of dietary kelp and protein level on abalone (*Haliotis midae*) growth, canning yield

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

Funder: THRIP, Marifeed (Pty) Ltd., Aquafarm Development (Pty) Ltd., HIK Abalone (Pty) Ltd., Roman Bay Sea Farm (Pty) Ltd.

South African Abalone farms use fishmeal based high protein formulated feeds (HPFF) to achieve what they perceive as the best growth rates and feed conversion ratios. But low protein formulated feeds (LPFF) are cheaper to produce, increase water quality and decrease farm effluent pollution. It has now also been found in studies that lower protein diets, give equivalent growth rates to current higher protein commercial feeds. It has also been found that that abalones fed on kelp (15 % protein) only, lost allot more weight during canning compared to animals fed artificial diets. The question is then: how do these low protein diets or a kelp dietary additive effect product canning yield if growth rates are not compromised and does kelp its self have an effect on yield?

Two different size classes of abalone where grown on two separate abalone farms, In experiment 1 abalone where fed two different diets one with a kelp additive and one without a kelp additive both diets had a constant dietary protein level (26 % protein). In experiment 2 abalone where fed three different diets with varying grades levels of dietary protein (34 %, 26 % and 22 % protein). The feeding trial lasted 117 days, after which abalone where processed and canned; the effect of the different diets on weight loss during the canning process was assessed.

The kelp additive significantly increased smaller abalone (38 g) growth, with a mean specific growth rate (SGR) of 0.33 ± 0.03 % body weight (b).d^{-1} compared to 0.3 ± 0.01 % $b.d^{-1}$ (Students t-test: t=2.675; p=0.028) but had no effect on larger abalone (73 g) growth (Students t-test: t=1.015; p=0.349). While the opposite was found with weight loss during canning where there was no effect on 38 g abalone (Students t-test: t=1.091; p=0.354) but there was a significantly higher meat yield 53.50 ± 1.86 % (Students t-test: t=3.66; p=0.022) in 73 g abalone fed the diet with the kelp additive. The 38 g abalone fed the lowest protein diet (22 % protein) had significantly reduced growth compared to abalone fed the 26 % and the 34 % protein diets, with a SGR of 0.24 ± 0.02, 0.3 ± 0.0 and 0.31 ± 0.0 % $b.d^{-1}$, respectively (ANOVA: $F_{(2,12)}$=11.83; p= 0.001). Canning yields were unaffected by protein level in the 38 g abalone (ANOVA: $F_{(2,16)}$=0.649; p= 0.535). A similar effect on growth rate was found in 73 g abalone where abalone were fed the 22 % protein diet had the lowest growth, with a SGR of 0.22 ± 0.02 % $b.d^{-1}$ (ANOVA: $F_{(2,12)}$=4.27; p= 0.049). Abalone (73 g) fed the lowest protein diet had the highest meat yield: 53.55 ± 0.30 compared to abalone fed the higher protein diets: 49.3 ± 0.44 to 50.7 ± 0.51 % (ANOVA: $F_{(2,6)}$=26.24; p= 0.018).

In conclusion, the 22 % protein diet reduced abalone growth rates; however, the 22 % protein diet increased canning yields. The addition of kelp in a formulated feed had canning yield and growth benefits.

08h40-09h00: Kerry Pieterse (BSc Honours student) - Investigating the age at which it would be most effective to cull slow-growing and shell damaged abalone, *Haliotis midae* (Linnaeus, 1758)

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

Funder: Rhodes University JRC, THRIP, Aquafarm Development (Pty) Ltd., HIK Abalone (Pty) Ltd., Marifeed (Pty) Ltd., Roman Bay Sea Farm (Pty) Ltd.

Commercially farmed South African abalone, *Haliotis midae* is a high-value product that is in demand worldwide; however, farming is expensive and time consuming as a consequence of the species being slow growing. Maximization of growth is thus plays a pivotal role in successful commercial production. To date there has been no indication as to whether growth rates of *Haliotis midae* can be improved by identifying and culling slow-growing individuals and only continuing to farm with the fastest growing proportion of the stock. This study determines the accuracy of using growth parameters to predict future growth of juvenile abalone and offers inference as to the growth paradigm of abalone categorized into slow, intermediate and fast growers. The effects of damage and deformities of the abalone shell on growth rate were also examined.

The research was conducted on an abalone farm and was split into two experiments: the first experiment involved determining at what age it is possible to identify slow-growing abalone and the second experiment compared the growth between undamaged abalone and abalone with induced damage. Damage was induced using a sharp knife to create a nick at the growing edge of the shell and/or mantle. Weight and length of abalone were recorded at 10, 14 and 18 months (experiment 1) and 10 and 14 months (experiment 2). Data recorded were used to analyze growth over time.

Abalone growth between 0-302 days could not be used to accurately predict future growth, using regression analysis ($P > 0.05$); while weight gain per month between 302-415 days was used to predict future growth rates with 49 % accuracy ($R^2 = 0.492$; $P = 0.0001$). However, when abalone were grouped as either slow (< 0.1 g/month), intermediate (0.10 – 0.18 g/month) or fast growing (> 0.18 g/month) at 302 days, the growth rates between these groups remained significantly different after 415 and 544 days, with the fast growers gaining significantly more weight than the slow and intermediate growers (Repeated measures ANOVA; $P = 0.01$).

Under normal farm conditions, abalone with damaged or deformed shells grew significantly slower than undamaged abalone, at 0.49±0.08 and 0.81±0.05 g/month, respectively (ANOVA; $P = 0.0001$). There was no significant difference in growth between abalone with induced shell and/or mantle damage and undamaged animals (ANOVA; $P > 0.05$), possibly due to low level of damage induced.

In conclusion, weight gain data over the first 302 days of production can be used to accurately predict the future growth of abalone. These data could be used to determine the extent of the benefits to be gained by culling slow growing abalone on an economic timescale on commercial farms.

Keywords: marine; aquaculture; perlemoen; juvenile; growth rate; Aquafarm Development

09h00-09h20: Morgan Brand (BSc Honours Student) - Evaluation of algae, grown in brewery effluent, as a dietary ingredient in abalone feed

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

Funders: SAB Ltd; WRC K5/2008

Aquaculture accounted for 47 % of the total food fish produced in 2006 and it has been growing at approximately 9 % annually. One of the biggest problems facing aquaculture and fish nutrition in general is that feed accounts more than half of the variable operating cost and therefore improving feed efficiency in industrial systems has a high priority. Alternative protein sources that are locally available, and that satisfy the nutritional requirements of the animal, need to be sourced. The aim of this investigation is to determine if unicellular algae harvested from a brewery waste-water treatment facility is a suitable protein source for juvenile abalone.

Two experiments were conducted simultaneously where either soya (Experiment 1) or fishmeal (Experiment 2) protein source was substituted with algal protein source. Algal inclusion level ranged from 0 % (control) to a maximum of 75 % in Experiment 1 and 50 % in Experiment 2. All diets were isonitrogenous (32.8 % protein) and were fed to replicate baskets of abalone under farm-like conditions at the DIFS Port Alfred laboratory for a period of 75 days.

There were no significant differences in length or weight gain among treatments in Experiment 1 (i.e. soya replacement), with an overall mean (± standard deviation) of 1.82±0.19 $mm.month^{-1}$ and 0.4±0.04 $g.month^{-1}$ (ANOVA; p=0.054 p=0.36 respectively). There was however, a general drop in food conversion ratio (FCR), specific growth rate (SGR), and protein efficiency ratio (PER) as the level of algal inclusion increased, with significant differences between the 75 % algal inclusion compared to the control (ANOVA; $p<0.05$).

In Experiment 2 (i.e. fishmeal replacement) there were significantly lower mean length gain at 75 % algal inclusion (1.24±0.16 mm.month-1) than at 0 % algal inclusion (2.1±0.17 mm.month-1) (ANOVA; $F_{(2, 6)}=9.66$; p=0.01). Similarly, weight gains at 0 % and 25 % algal inclusion were significantly more than at 50 % algal inclusion, with means of 0.44±0.06, 0.40±0.04, and 0.28±0.01 $g.month^{-1}$ respectively (ANOVA; $F_{(2, 6)}=13.28$; p=0.01) The FCR, SGR and PER also declined with an increase in algal inclusion, with significantly lower FCR, SGR and PER between 50 % algal inclusion and the control (ANOVA; p=0.05).

It is possible to substitute soya or fishmeal with effluent grown algae in formulated feeds for juvenile abalone, provided the substitution does not exceed 50 % for soya and 25 % for fishmeal.

Key words: Marine; aquaculture; abalone; protein; microalgae; growth; health

09h20-09h40: Rogan Field (BSc Honours Student) - Fish physiology; the effect of diet on the excretion of ammonia-nitrogen in juvenile dusky kob, *Argyrosomus japonicus*

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

Funders: Espadon Marine (Pty) Ltd.; Rhodes Joint Research Council; Marifeed (Pty) Ltd.

In the past decade dusky kob have become an increasingly popular aquaculture species; in order to develop this industry and reduce the running costs associated with it, it is essential that optimal diet formulations be developed. This research project investigates the effects of protein to energy (P:E) ratio in formulated diets on water quality related to the excretion of ammonia-nitrogen in juvenile dusky kob in order to understand this aspect of the physiological response to diet.The aims of this study were to determine whether the excretion of ammonia-nitrogen in juvenile dusky kob is affected by diet and to quantify and analyse the effect of diet on water quality as well as to develop a model whereby the excretion of ammonia-nitrogen and concentration of NH_3 can be predicted as a function of biomass.

Ninety juvenile dusky kob, in a recirculation system comprised of 16 80L tanks were used to investigate the effects of diet formulation on the excretion of ammonia-nitrogen. Water samples were taken at feeding and at two-hour-intervals after feeding for twelve hours. The ammonia concentration was measured using a double beam spectrophotometer. The concentrations of ammonia where converted to NH_3 as a function of salinity, pH and temperature and compared statistically using repeated measures analysis of variance.

Results suggest that the production of ammonia-nitrogen is independent of diet, as no differences between treatments were found ($p = 0.96 - 0.12$). The excretion of ammonia-nitrogen increased rapidly for two hours after feeding, after which the rate of excretion decreases. A second experiment investigating the effect of adding pure oxygen, in order to maintain constant oxygen saturation above 90% saturation, showed no significant difference in the build up of ammonia-nitrogen between treatments ($p=0.83$).

It is thus hypothesised that the production of ammonia-nitrogen in kob was not related to the diet in this study, but rather is a process of protein metabolism. These results suggest that substitutions of fish oil or fishmeal with vegetable products may not effect water quality through the excretion of ammonia. Growth trials should be used to test the effect of diet oin water quality in closed systems. Since the production of ammonia-nitrogen is greatest in the first two hours after feeding; increasing the flow rates during this time could improve general water quality, which may have implications on growth and feeding efficiency and should be the focus of future studies.

Keywords: Mariculture, dusky kob, diets, ammonia-nitrogen excretion, water quality

09h40-10h00: Gareth Nicholson (BSc Honours Student) - Effluent grown algae as an alternative protein source in *Oreochromis mossambicus* (Peters, 1852) feeds

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

Funders: SAB Ltd; WRC K5/2008; National Research Foundation

Fish meal is conventionally a large component of commercial fish feeds, but is expensive and often short in supply. In intensive fish farming operations, feed costs may account for up to 60 % of expenses and in recent years, a vast amount of research has been aimed towards identifying alternative protein sources with potential use in fish feeds. Algae forms part of the natural diet of *Oreochromis mossambicus*, and reports have shown that tilapia are able to grow well on plant protein diets. As such, algae have potential as an alternative protein source, particularly in areas of high algal production. In Port Elizabeth, brewery effluent is being treated using an alternative, environmentally sustainable method of treatment, high rate algal ponding (HRAP), which produces large volumes of unicellular algae.

The aim here was to evaluate the use of algae, grown in brewery effluent, as a soya and fish meal replacement in diets for Mozambique tilapia. The objectives were to test for differences in fish growth and health when algal protein was used to replace soya and fishmeal protein at different levels in *O. mossambicus* diets.

A total of 240 juvenile tilapia were housed in 24 stand-alone tanks. Seven isonitrogenous diets (32.3 % protein) were prepared using fishmeal**,** soya meal and algae as protein sources. A control diet contained no algae. Three diets were prepared with increasing substitution levels of algae for soya meal (25-75 %), and three diets were prepared with increasing substitution levels of algae for fishmeal (25-75 %) on an equivalent protein basis. A commercial tilapia feed was included in the experiments as a reference. Each diet was fed to three tanks of fish for a period of six weeks. Fish in each tank were anaesthetised, collectively weighed (g) and individually measured (mm) every two weeks. Growth was analysed using the following indices: weight gain, specific growth rate (SGR), feed conversion ratio (FCR), condition factor (CF) and protein efficiency ratio (PER). Health was assessed using hepatosomatic index (HSI) and gonadosomatic index (GSI).

Results showed no significant differences between diets (ANOVA/ Kruskal-Wallis; $p>0.05$), suggesting that effluent grown algae possesses adequate nutritional value to be used in the diets of *O. mossambicus* at substitution levels of up to 75 % for both fishmeal and soya meal. Pooled means (± standard error) were calculated: Percent weight gain (408.89 ± 11.43), SGR (3.86 ± 0.06), FCR (16.11 ± 0.49), CF (x 100) at the end of the experiments (0.16 ± 0.013), PER (0.19 ± 0.01), HSI (1.71 ± 0.09) and GSI (1.22 ± 0.18). Previous studies have shown that the growth rates of *O. mossambicus* have remained similar up to 40 % replacement of fishmeal for algal protein.

In conclusion, algae harvested from HRAP brewery effluent treatment facility, may be used as an effective protein replacement in the diets of Mozambique tilapia.

Keywords: Freshwater; aquaculture; tilapia; growth; health

10h00-10h20: Frikkie van der Vyver (BSc Honours student) - Can blood plasma cortisol levels inform us about the temperature avoidance of fishes – a case study on *Rhabdosargus holubi* (Cape stumpnose)

Supervisors: Dr W Potts (w.potts@ru.ac.za), Dr N James (n.james@saiab.ac.za), Prof. H Kaiser (h.kaiser@ru.ac.za)

Funders: Department of Ichthyology and Fisheries Science, Rhodes University JRC

Understanding the potential impact of climate change to fish and fisheries is critical for social, economic and conservation planning. With changing temperatures in our oceans and estuaries, one of the likely effects of climate change is a shift in the distribution of fish species. Determining the avoidance temperatures of fish species is critical for predicting their future distribution patterns. However, no standardised methods have been developed for this purpose. While in situ information is desirable, laboratory experiments provide the advantage of control and replication. The aim of this study was to evaluate the use of blood plasma cortisol levels to determine the avoidance temperature of fishes. *Rhabdosargus holubi* was selected as a test species as juveniles are readily available in Eastern Cape estuaries. *R. holubi* were captured in the East Kleinemonde estuary using a 50 meter seine net. Fish were acclimated at 19°C in a controlled temperature room in the Department of Ichthyology and Fisheries Science. Sixty fish were kept in four 100L experimental glass tanks. The temperature in two tanks (control) remained at 19°C for the duration of the experiment, while the temperature was increased by 3°C from 08:00 every morning for 7 consecutive days in the treatment tanks. Fish behaviour was monitored for two minutes using digital video once the temperature had stabilised in the day (08:00 & 16:00) and at night (19:00 & 22:00). Blood plasma cortisol was measured daily at 11:00. Over all days the average cortisol levels of fish in the treatment tanks (99.17 ng/ml) was significantly higher than those in the control tanks (26.52 ng/ml), showing a significant interaction between day and treatment ($p<0.01$). On day 7 CTMax was achieved at 35.9°C, with the average cortisol levels in the treatment tanks over 10 times higher than those in the control tanks. The findings suggest that blood plasma cortical is a suitable technique to quantify the stress response to a temperature increase and have provided insight to the design of future temperature avoidance studies for this and other fish species.

Key words: estuarine; ecology; climate change; distribution patterns

10h20-11h00: Tea break

Honours seminars continued (Chair: Warren Potts)

11h00-11h20: Devin Isemonger (BSc Honours student) - The relationship between diet and feeding morphology in the Sparid: *Sarpa salpa*, off the East coast of South Africa

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

Funders: Rhodes University JRC; Department of Ichthyology and Fisheries Science

The Strepie (*Sarpa salpa*), a ubiquitous member of the family *Sparidae* is an important target species in many coastal fisheries. While aspects of the biology of this species have been studied, there is little information on its feeding biology. A feeding study conducted in seagrass beds showed that there was an ontogenic dietary shift in the species. Since fish feeding apparatus are designed to optimize feeding, one may therefore expect a shift in diet to coincide with morphological changes to the feeding apparatus. This study aimed to investigate the existence of an ontogenetic dietary shift and related morphological changes in *Sarpa salpa*. It was hypothesized that this species underwent a dietary shift and that this resulted in morphological changes to the head and jaw apparatus.

A dietary study was undertaken using a total of 251 specimens obtained from monthly sampling events conducted in Cape St. Francis and Kenton. Stomachs were preserved in 5% formalin after which the contents were weighed and the food items assigned a percentage of the total mass based on visual estimates. Gut lengths and standard lengths were also recorded. A further 87 specimens were preserved for use in the morphological study. These fish were subjected to 13 measurements of the head and jaw apparatus as well standard length. These measurements included Head length, snout length, inter-orbital distance, orbital width, orbital to maxilla, orbital to opercular, upper jaw length, lower jaw length, jaw width, gape height and gape width. The data obtained from the feeding study was analyzed using both the frequency of occurrence method and the percentage mass method. An index of importance was calculated by multiplying percent frequency of occurrence by average percentage of total stomach mass for each food item. The morphology data was analyzed using regression analysis in conjunction with a student's T-test with the null hypothesis that the slope was equal to 1 at a 95% level of confidence. The diet of *S. salpa* of all sizes was dominated by seaweeds. Red algae dominated the diet in all length classes (87.6% FO, 57.05% Mass). Green algae was more important in the diet of smaller fishes, while red algae was more important in the diet of larger fishes, providing some evidence for a shift in diet. Coralline and brown algae were present in low frequencies in all fishes. There was significant negative allometry ($p<0.05$) for jaw related measurements and for head length, which are indicative of a smaller but more powerful feeding apparatus. This correlates with an increase in the proportion of the tougher, red algae in the diet of larger fishes, further supporting the hypothesis.

Key Words: marine; ecology; coastal; herbivore; ecomorphology; dietary shift

11h20-11h40: John Ayliff (BSc Honours student) - Aspects of the life history of *Sarpa salpa* in the Eastern Cape, Southern Africa

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

Funders: Department of Ichthyology and Fisheries Science; Rhodes University JCR

The sparid *Sarpa salpa* is a widely distributed species and is an important target species in many coastal fisheries. While the biology of this species has been described in several locations including South Africa, researchers have used whole otoliths to determine the age of the fish. Since this method is thought to underestimate the age of individuals, this study used the more contemporary methods of sectioned otoliths to determine the age, growth of this species. The objectives of this study were to describe the age, growth and maturity of *S. salpa* in the Eastern Cape. Fish were collected from three sites in the Eastern Cape. In the laboratory, fish were weighed, measured, sexed macroscopically and had their otoliths removed. A pilot study was conducted to determine the best method of preparing the otoliths for reading. It was decided that unburned, transversally sectioned otoliths were the most readable and would provide the best age estimation for *S. salpa*, therefore all otoliths were prepared using this method. The timing of opaque zone deposition was validated using a marginal zone analysis (MZA). The length and age-at-50% maturity was calculated by fitting a logistic ogive to the observed proportion of mature fish. The MZA showed that opaque zones were primarily deposited in winter, however because of the limited duration, this study could not validate the periodicity of opaque zone formation. Assuming that one opaque zone is deposited per year, a maximum age of 14 years was recorded. The parameters of the Von Bertalanffy growth equation were $L\infty$ = 206.76 mm, k = 0.24 and t_0 = −1.78 years. Phi prime values, which provide a comparative measure of growth rate between populations or species, were lower than was calculated for the Eastern Adriatic region and higher than that of Italy. Length at 50 % maturity of 189 mm and 160 mm was observed for females and males respectively. Age at 50% maturity was 7 and 9 years for females and males respectively, substantially higher than that found in previous studies. Although not conclusive, the length frequency distributions, adult sex ratios and age frequency distributions provided some evidence to concur with previous findings that this species is a protandrous hermaphrodite. The slower growth rate and higher maximum age found in this study has implications for the management of this species. It is recommended that the stock assessments of these species be reviewed, beginning with a re estimate of growth using sectioned otoliths.

Keywords: marine sparid, fisheries, maximum age, sectioned otoliths, length at 50% maturity

11h40-12h00: Kirsten Bray (BSc Honours student) - A comparative age and growth study on largemouth bass, *Micropterus salmoides,* in different dams across the Eastern Cape

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

Largemouth Bass are an alien invasive species which were introduced into South Africa for angling purposes. They are primarily piscivorous and thus have a direct negative impact on native biodiversity. This is however counteracted by their economic importance as an angling species. Bass are a fairly robust species which are found all over South Africa. Populations exist in all kinds of water bodies including swamps, large rivers and dams. they are found in both large dams and in small farm dams. It is important to learn about the biology and ecology of this species as it has not been widely studied especially in small water bodies. An understanding of bass age and growth in such small dams can help lead to management measures being implemented.

The overall aim of this study is to evaluate how different physical dam properties affect bass populations and to determine how the age, growth and maturity of bass populations differ in different dams.

Bass were sampled from four different dams (Bladen, Committees Drift and Kowie river weir) using a hook and line sampling technique with artificial lures. They were weighed, measured and dissected obtain sex data, otoliths and stomach contents. The bass were aged using sagittal otolith analysis. This data could then be used to compare the age, growth and maturity between the four dams in this study as well as with other dams.
The growth rates of the different dams were assessed using the Schnute growth model. The main differences in this model occurred due to the b parameter. A phi prime test was also done to compare the different growth rates. This test showed that Committees drift had the best growth performance of all populations.

A logistic ogive test was done to see if the fish in the different dams mature at a similar rate and it was found that Wriggleswade and Committees Drift had very similar lengths at 50% maturity ($P = 0.77$) but they have significantly different rates at which this maturity is reached ($P = 5.45e-05$).

These results show that the growth of bass in small farm dams are similar to each other as well as being similar to large dams (such as Wriggleswade). Dam size also seems to have no effect on the age at maturity of bass. This is shown by Committees Drift having equal length at 50% maturity to Wriggleswade dam. These results can be compared to other dams throughout Africa and the world in order to get a better understanding of bass population ecology and biology.

Key words: freshwater, ecology, Eastern Cape, otolith analysis, maturity, Schnute test

12h00-12h20: Carl Huchzermeyer (BSc Honours student) - Evaluation of acoustic transmitter implantation and determination of post-translocation behaviour of largemouth bass *Micropterus salmoides*

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

Funders: South African Institute for Aquatic Biodiversity; Norwegian Institute for Nature Research; Stutterheim Aquatics Club; Wriggleswade Bassmasters; Department of Ichthyology and Fisheries Science

Largemouth bass *Micropterus salmoides* is an alien invasive freshwater fish species that supports an economically important recreational fishery in South Africa. Large boat-based angling tournaments that attract hundreds of participants are common. Typically during a tournament, bass are caught, held alive and brought to a single point for weighing and release. These single site releases may influence the behaviour of bass as studies conducted in the USA have shown that bass occupy defined home ranges, the size of which varies by locality. Making use of acoustic telemetry methods, this study explored the post-translocation behaviour of bass displaced over different distances to test the hypothesis that they would return to their initial catch sites.

Initially a laboratory experiment was conducted to assess the potential health effects that surgically implanted transmitters have on bass. Ten fish were surgically equipped with dummy tags (Thelma Biotel MP-9-LONG) and ten control fish subjected to the same aneasthetic procedures were distributed randomly between two ponds. After 20 weeks the fish were humanely killed, x-rayed, and dissected to assess various health parameters. It was shown that surgically implanted transmitters did not negatively affect survival and health in this species. No mortalities occurred, and transmitter wounds healed well. X-rays showed that the transmitters had not shifted within the body cavity. There were no significant differences (t-test; $p > 0.05$) between treatment and control fish for condition factor, hepatosomatic index, gonadosomatic index, abdominal fat, percent weight change and liver colour.

A field study was then conducted in Wriggleswade Dam, Eastern Cape. In this field study five automated data-logging acoustic receivers (VEMCO VR2) were deployed at 1.5 km intervals. A total of ten fish between 310-385mm FL were then caught at five different sites within the receiver array and released at a common site. This resulted in displacements of two fish each from 0.1, 1.3, 2.7, 3.4 and 4.3 km from the capture site. Movement data was obtained using a passive receiver array. Subsequent to release only four fish returned and spent the majority of their time in the area where they were caught. Fish were able to make occasional movements of up to 3km a day, suggesting that they occupy fairly large home ranges. The only three fish that displayed homing behaviour were those that were furthest displaced, suggesting that all other individuals (displaced 1-3 km) were released within their initial home ranges. With the onset of cold winter conditions all fish vacated their home ranges and moved towards the deeper basin of the dam. Thus, the findings support the hypothesis that translocated bass home to their capture sites. Surprising, however, was that the bass in Wriggleswade Dam bass appear to occupy much larger home ranges and undertake larger daily movements than those reported in the literature. This may be due to the importance of the pelagic Estuarine Roundherring *Gilchristella aestuaria* as a primary food source.

Keywords: freshwater; fisheries; post-release behaviour; acoustic telemetry; transmitter effects; passive receivers

12h20-12h40: Christine Coppinger (BSc Honours student) - Comparisons of fish assemblages and behaviour between bare sand and seagrass habitats within the Bushmans Estuary using an underwater video camera

Supervisors: Dr A Becker (a.becker@saiab.ac.za), Prof. A Whitfield (a.whitfield@saiab.ac.za)

Funder: National Research Foundation

Literature discussing the importance of littoral estuarine habitat for fish productivity is plentiful and a widely accepted paradigm is that estuarine seagrasses act as "nurseries". There is little information about the usage of patches of estuarine habitat over the tidal cycle by nekton. If usage of these habitats is better understood, it would be possible to conserve important habitat more effectively.

The objectives of this study were to determine the effect of tides (i.e. water depth) on the fish assemblages (in terms of feeding guilds), abundance and behaviour in littoral sand and seagrass habitats in Bushmans Estuary.

An underwater video camera was used to film a total of 18 four hour long deployments, consisting of three replicate deployments at each of six (three sand and three seagrass) littoral sites in a backwater of the Bushmans Estuary. Deployments were started at the beginning of the incoming tide and within a standardized depth range. Sites were sampled randomly throughout the year to minimize temporal bias.

Footage was watched on a laptop computer and the MaxN of the fish feeding guild that was sighted (i.e. the frame containing the highest number of fish for that species) was recorded. The behaviour of fish was also recorded as one of four broad categories.

An ANOVA was done to analyse the differences in total abundances (MaxN) among habitats and sites and no significant difference was found. ANOVAs were done for each of the four feeding guilds that were sighted in the footage. There was no significant difference in fish assemblages between sand and seagrass habitats but there were significantly more sightings of detritivores ($p < 0.005$) in the fourth hour than in the first hour of the deployments. The opposite trend was observed for zoobenthivores which were sighted more in the first hour than the fourth, although not significantly so.

A χ^2 test was done to determine whether behaviour was significantly different between sand and seagrass habitats with a highly significant result ($\chi^2 = 103.8$, $df = 3$, $p > 0.005$). Slow meandering behaviour was more common in seagrass and stop-start behaviour was more common at sand sites.

The results seem to show that fish behaviour as well as abundance is a good indicator of the utilization patterns of nekton between estuarine seagrass and sand habitats. More deployments need to be done in order to provide a sufficient dataset to determine the effect of tide (i.e. depth) on fish behaviour within each guild. This will hopefully provide further insight into the utilization patterns of fish throughout the tidal cycle.

Key words: estuarine, fish ecology, estuarine habitat, tide, fish behaviour

12h40-13h00: Geraldine Taylor (BSc Honours student) - Age and growth of largemouth bass (*Micropterus salmoides*) in Wriggleswade Dam South Africa: Why are there so few large fish?

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

Funders: South African Institute for Aquatic Biodiversity; Rhodes University; Stutterheim Aquatics Club; Wriggleswade Bassmasters

In South Africa largemouth bass (*Micropterus salmoides*) is both an alien invasive species, and an economically important angling species. Wriggleswade Dam is a largemouth bass angling hub, however there are concerns that fish are small for their age, and there are few large fish. This study aimed to address this question through an analysis of the biology and age and growth of this population using sectioned otoliths. Out of the 221 fish sampled, the maximum age recorded was 11 years, and from this data growth was described by the three parameter von Bertalanffy growth model as $L_t = 38.0(1\text{-}e^{-0.51(t + 0.52)})$ cm total length, and the length-weight relationship as $W = 0.022\text{Length}^{2.856}$ in grams. Maturity did not differ between sexes and the length at 50 % maturity was 27 cm TL at an age of approximately 2 years for the combined sex sample. The instantaneous rate of total mortality (Z) was estimated using catch curve analysis and the Butterworth equation, and on average Z was $0.43yr^{-1}$, natural mortality (M) calculated using empirical relationships, was estimated at 0.42 yr^{-1} resulting in a negligible fishing mortality rate. Gut contents were analyzed for three size classes (<25 cm TL, 25-35cm TL and >35 cm TL) of fish. Fish remains were the most common food item in all fish. The most common identifiable fish species in bass stomachs was *Gilchristella aestuaria*. Plastic lures were also found in the stomachs of some large fish (>35 cm).

In order to assess if the Wriggleswade population differs in growth rate and length-weight relationship from other populations, it was compared to largemouth bass populations from many USA states, some European water bodies, and three African populations. On comparison, the growth performance of the Wriggleswade population was comparable to that of the temperate populations but significantly lower (t-test; $p<0.05$) than two of the three more tropical African populations. Growth performance correlated with both annual air temperature and latitude (multiple linear regression; $p<0.05$). The length-weight relationship and condition factor for largemouth bass from Wriggleswade Dam were compared to a range of other dams. Again, the Wriggleswade Dam population had a lower weight at length and condition factor than the three African bass populations and most of the temperate populations. This suggests that Wriggleswade Bass are thin for their length.

In conclusion the growth rate of largemouth bass of Wriggleswade Dam is as expected for temperate bass populations. The bass from this dam are, however, in low condition which could be a result of food limitation.

Key words: Largemouth bass; *Micropterus salmoides*; South Africa; Wriggleswade Dam; age and growth; temperature; latitude.

13h00-14h20: Lunch break

Freshwater conservation / environment (Chair: Amber Childs)

14h20-14h40: Mpho Ramoejane (MSc student, third year) - The genetic integrity of *Labeo* species (Cyprinidae) in southern Africa in relation to inter-basin water transfer schemes

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

Funders: National Research Foundation

The Orange-Fish and Cookhouse tunnels act as an introduction pathway for *Labeo capensis* and *Labeo umbratus* from the Orange River system into the Great Fish and Sundays River systems in the Eastern Cape. *Labeo capensis* is endemic to the Orange-Vaal systems while *L. umbratus* occurs naturally in both the Orange and in southern flowing River systems. Such introductions increase the risk of hybridization between these species.

The overall aim of this research was to assess whether hybridization between *L. capensis* and *L. umbratus* occurs in Darlington Dam (Sundays River system) and in Hardap Dam (Orange River system). A total of 275 specimens collected across the geographical range of the two species were tested using morphology (morphometrics and meristics), nuclear (nDNA) S7 introns and mitochondrial (mtDNA) cytochrome *b*, to for assess hybridization.

The two species were distinguished with morphometric (dorsal fin base, inter-orbital width and operculum to the eye distance) and meristic (lateral line, origin of the dorsal fin to lateral line, origin of the pelvic to lateral line and caudal peduncle scales counts) characters. Hybrids were placed between the two species clusters with principle component analysis (PCA) in both dams. The two species were also distinguished from each other by six nDNA mutations and hybrids could be identified based on being heterozygous at most of these sites in both dams. Suspected pure *L. umbratus* from the Orange River and southern flowing Rivers grouped together compared to *L. capensis* based on morphology and nDNA, but the mtDNA results revealed that Orange River and the Eastern Cape *Labeo umbratus* lineages differed by 5 mutations, with *L. capensis* grouping with the *L. umbratus* lineage could be differentiated from both lineages. Even though mtDNA could not be used to identify hybrids on its own, 10 specimens with Orange River *L. capensis alleles* and four with Orange River *L. umbratus* alleles were found in the dam. In Hardap Dam, however, it appears that only *L. capensis* mtDNA alleles persisted, despite field identifications suggesting that both morphs and hybrids of the two species occur.

The genetic integrity of *L. capensis* and *L. umbratus* have therefore been compromised in at least Hardap dam and Darlington Dam and the results indicate that the southern lineage of *L. umbratus* is under threat of introgression. To protect this lineage from this ongoing hybridization, sanctuaries have been identified in the Great Fish and Sunday River systems above dams that were build before IBTs.

Keywords: Freshwater; Conservation; Hardap Dam; Darlington Dam; Inter-basin water transfer schemes; hybridization; morphology; nDNA; mtDNA

14h40-15h00: James McCafferty (MSc Student, first year) - How predictable are alien fish distributions and abundances in South African dams?

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

Funders: Water Research Commission

Alien invasions are currently viewed as the key driver behind the "human-induced biodiversity crisis" the consequences of which include impacts on ecosystem functioning and integrity. South Africa has recently been recognised as an alien fish invasion hotspot - this has given impetus to both the need for intensified research regarding the ecological impacts these aliens have on freshwater ecosystems, as well as the formulation of potential management solutions for these species.

While alien invasive species do present several conservation issues their economic influence in South Africa is considerable - alien species (e.g. carp, bass, trout) are the primary targets of the majority of the freshwater recreational angling fraternity in South Africa, an industry worth an estimated ZAR 900 million. In addition alien species form the backbone of the freshwater aquaculture industry valued at approximately ZAR 40 million. Recent recognition of subsistence fisheries in South Africa has emphasised the important contribution of alien fishes in providing food security to rural fishing communities. Quite clearly, some of South Africa's alien fishes represent a considerable valuable commodity and their successful management poses a dilemma which must consider their existing and potential contribution to livelihoods and economies while minimising their deleterious impacts to ecosystems and indigenous biota. Such a trade-off requires a proactive, and ultimately predictive, research approach which enables management solutions to be formulated before the establishment of alien fishes in new areas.

My research is based on correlating presence and relative abundance with lake productivity, environmental conditions and the environmental preference limits of different alien species in order to develop a predictive model based on the relationship between these factors. Data for the model includes national fish collection data from the South African Institute for Aquatic Biodiversity (SAIAB); angling competition data; Department of Water Affairs databases and direct assessments. Productivity analyses will be based on empirical models that incorporate chemical and physical parameters with which comparisons of productivity in different impoundments can be made.

Field trips to organised angling competitions have been undertaken since the beginning of the year in order to establish contacts with organised anglers and obtain catch data from competitions held at all tiers (club, divisional, national) on different impoundments across South Africa. This data is being used to determine the level of use of different dams in South Africa and the importance of different alien species to different recreational angling facets. This information will provide important existing resource use knowledge pertaining to South African impoundments and, coupled with a predictive modelling approach, may contribute to the formulation of management solutions which can be realistically implemented, reduce conflict between current and future resource users, and address the issue of sustainable utilisation of alien fishes while ensuring biodiversity and conservation concerns are not compromised.

Keywords: Alien fishes, angling, catch data

15h00-15h20: Wilbert Kadye (PhD student, second year) - Mixing models to quantify food web sources and pathways in Great Fish and Sundays Rivers

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

Funders: National Research Foundation (FA2007043000021), Rufford Small Grants Foundation

Stable isotopes are increasingly becoming an important tool in determining sources and pathways of organic matter through food webs. Isotopic mixing models, which allow for the estimation of the proportional contribution of dietary items (sources) to consumer's tissue (mixture), and inference on diet composition, have facilitated much progress in the assessment of diets and food web structure. Quantitative knowledge about food web structure from these isotopic mixing models is important in assessing environmental impacts. Such information is critical in the Great Fish and Sundays River systems where the introduced sharptooth catfish, *Clarias gariepinus*, has become established.

Sampling was conducted at 35 sites along the Great Fish and Sundays Rivers and their dominant tributaries. Sharptooth catfish was present in the main stream sections of the Great Fish and Sundays Rivers, and absent in the upper catchment tributaries of Winterberg and Zuurberg in Addo Elephant National Park. A total of 624 samples, which included algae, macrophytes, invertebrates, amphibia and fish, were analysed for $\delta^{13}C$ and $\delta^{15}N$. The distributions of feasible catfish diet proportions were well− constrained, with ranges of 0− 30%, 0− 40% and 0− 65% respectively for algae, invertebrates and fish in two river systems. Major contributors to catfish diets were *Anguilla mossambica* (mean proportion = 16±10 %) and *A. marmorata* (10±6 %) in the lower Great Fish, and *Gambusia affinis* (19±8 %) and *A mossambica* (13±8 %) in the middle Great Fish. All major dietary sources contributed between 7− 9 % to catfish diets in the upper Great Fish. *Anguilla marmorata*, *A. mossambica* and shrimps, with mean proportions of 15±6 %, 12±6 % and 11±6 % respectively, were the major contributors in lower Sundays, while *A. mossambica* (13±7 %), *Barbus pallidus* (12.6±7 %) and *Glossogobius callidus* (12±6 %) were the major contributors to sharptooth catfish diets in upper Sundays River.

An analysis of the food webs in the different sections of the two river systems showed that the catfish is generally less target specific, with each of the major sources contributing < 20 % to the catfish diet. This suggests that catfish impacts are likely to be on all major components of the food webs, making trophic cascades less likely. In comparison, the indigenous eel, *A. mossambica*, was the top predator that appears to influence intermediate group in catfish− free food webs of Winterberg and Addo.

Key words: freshwater, ecology, sharptooth catfish, isotopes, food web

Thursday 14 October 2010

Marine Ecology (Chair: Albert Chakona)

08h20-08h40: Taryn Murray (MSc student, first year) - Movement behaviour and genetic stock delineation of the poenskop *Cymatoceps nasutus*

Supervisors: Dr G Gouws (g.gouws@saiab.ac.za); Dr PD Cowley (p.cowley@saiab.ac.za); Mr BQ Mann (bruce@ori.org.za)

Funders: International Foundation for Science (A/4530-1F); National Research Foundation (IFR20100430040); South African Institute for Aquatic Biodiversity

The poenskop or black musselcracker *Cymatoceps nasutus* is an endemic South African sparid distributed from south of Saldanha Bay in the Western Cape, to Cape Vidal in northern KwaZulu-Natal. This distribution is shared by adults and juveniles, while spawning locations and the occurrence of larvae are unknown. Poenskop are slow-growing, long-lived, sex changing, late maturing and show a high degree of residency at certain life-history stages. This residency makes the species acutely sensitive to over-exploitation. Poenskop form a small but important component of a major recreational fishery and spearfishery along the southern and eastern coasts of South Africa. Despite interventions such as the imposition of size and bag limits, *cpue* trends reflect a severe and consistent stock decline over the last two decades. Management is compromised by the deficiency of information regarding stock integrity and heterogeneity (genetic structure and diversity), and movement behaviour (migration and residency patterns).

The aim of the project is to provide some baseline information on the stock status of poenskop in South Africa and more specifically to investigate movement behaviour and genetic stock structure of this species. The specific objectives include:

- Evaluate current and historic trends in catch and *cpue* of poenskop using available fishery records as well as published and unpublished survey and research data
- Determine patterns of residency and movement of juvenile, sub-adult and adult poenskop by analysing existing tag-recapture data from several dedicated tagging studies
- Determine spatial and temporal genetic diversity of poenskop across its distribution, identifying possible stock substructure.

Data on the stock status and trends in *cpue* of poenskop have been gathered from various sources, ranging from popular magazines to personal angling diaries. Data will also be analysed from various available on-going monitoring projects (e.g. Tsitsikamma National Park inshore linefish monitoring project). All available tagging databases have been identified and information will be collated and analysed in 2011. Fin clips were taken from poenskop during tagging work, fishing competitions and recreational shore and boat fishing. These samples were collected from the northern Eastern Cape coastline (Transkei), and from the central Eastern Cape coastline (Haga-Haga to Boknes). DNA has been extracted, PCR conditions optimised and a fragment of the mitochondrial control region amplified using PCR. DNA sequence data have been generated for 25 samples, from 12 localities. Preliminary analyses reveal high genetic diversity, but little spatial structure. Results from the present study will be contrasted with those from completed and ongoing studies on similarly exploited species e.g. dusky kob *Argyrosomus japonicus*, white steenbras *Lithognathus lithognathus* and bronze bream *Pachymetopon grande*, and will provide a scientific basis for the future management of poenskop and other coral reef-associated endemic fishery species with similar life history traits.

Key words: marine; ecology; Sparidae; mtDNA; control region

08h40-09h00: Kate Munnik (MSc student, second year) - Oceanographic features and the movement patterns of *Argyrosomus coronus* on the west coast of southern Africa

Supervisors: Dr WM Potts (w.potts@ru.ac.za); Dr I Ansorge (isabelle.ansorge@uct.ac.za); Prof. W Sauer (w.sauer@ru.ac.za)

Funder/s: National Research Foundation; ACDI

Although upwelling occurs semi-permanently in the central Benguela, the southern sector has a strong seasonal signal and the northern sector experiences slight upwelling maxima during the austral winter. The "permanent" cold water Luderitz upwelling cell, situated at 26°40' S, is considered to be the division between the northern and southern Benguela, where vigorous upwelling creates a potential dispersion barrier between the two sectors. Molecular and taxonomic analyses suggest that the 2 million dispersion barrier has led to speciation in several fish species, including the Sciaenid fishes, *Argyrosomus japonicus* and *A. coronus*. *A. coronus* has an inshore distribution from central Namibia to Northern Angola. It is known to prefer warm (16-19°C) waters and exhibits a return migration that coincides with the movement of the Angola Benguela Frontal Zone. The southward distribution of this species is thought to be restricted the cold waters of the Luderitz upwelling cell. However, recent observations of the *A. coronus* in the Olifants estuary (on the west coast of South Africa) have led to speculation of the existence of corridors/pathways across the Luderitz upwelling cell dispersion barrier. The movement of this species across the dispersion barrier may have significant ecological and evolutionary consequences as previously isolated *Argyrosomus* species may begin to occupy the same environment. The aim of this study is to identify the anomalous pathway events which lead to the southward dispersal of *A. coronus*, to explore the causal oceanographic mechanisms of these events and to determine if there has been a recent increase in the frequency of these events. A time series analysis of variability in salinity (ppt), water temperature (°C) and dissolved oxygen (mg/l) values collected between 2003 and 2009 from the Luderitz region (24-29°S and 13-16°E) is currently being developed for this purpose. Moderate-Resolution Imaging Spectroradiometer (MODIS) satellite derived sea surface temperature (SST) data, provided by the remote sensing unit at the University of Cape Town, is being used to explore offshore oceanographic conditions during identified anomalous events as well as upwelling activity at Luderitz as a supplement to the scarce in situ data. As the satellite imagery is unable to accurately estimate SST in the inshore zone, a comparison between in situ temperature data from Flamingo lodge (2005-2009) and Luderitz Bay (2000-2002) and corresponding satellite derived daily SST values on cloud free days, for the same location (pixel value, 15°34'12-48''S and 12°0'18-54''E) was undertaken in order to gauge the validate the accuracy of the satellite derived data on the west coast of southern Africa. Preliminary results from the time series analysis show that anomalous values of these parameters occur in correspondence with known warming events (Benguela Nino's). The intensified warm water pulse during these events may be the oceanographic mechanism responsible for the southerly movement of west coast dusky kob individuals.

Key words: marine; oceanography; *Argyrosomus coronus*; Benguela Nino; MODIS

09h00-09h20: Enrico Gennari (PhD student, second year) - Thermal physio-ecology of the white shark *Carcharodon carcharias*

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

Funders: OCEANS Research; South African Institute for Aquatic Biodiversity; PADI AWARE

The white shark is one of the few elasmobranchs 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 decreased digestion time, making it an effective apex predator. Studying these large, highly mobile and potentially dangerous predators in nature is challenging. Very little is known about the thermal physiology of white sharks in the wild, since it requires being able to physically track individuals for several weeks or months. The simultaneous collection of different data also requires that the shark remains in the same area for extended periods. White sharks in Mossel Bay, on the southern coast of South Africa, typically exhibit long residency periods, making this location an ideal site to study the thermal physio-ecology of this species.

This project started in 2008 with an assessment of the horizontal and vertical movements and habitat use patterns of white sharks within Mossel Bay. A total of 16 sharks were manually tracked for over 900 hours gaining information on external water temperature at each swimming depth, rate of movement and a linearity index which allowed for the categorisation of different behaviours, namely resting, hunting for fish, hunting for pinnipeds, inter-site travelling (within the bay) and migratory travelling (outside the bay).

In July 2009, a new prototype external transmitter with a tethered anchor dart equipped with a temperature sensor was deployed. This new technology allowed for the monitoring of internal muscle temperature of the tagged sharks. At the same time, a transmitter (with temperature and depth sensors) was externally attached to the shark and an additional transmitter (with a temperature sensor) was fed to the shark with a piece of bait. This provided, for the first time, a means to assess the complete thermal profile of a white shark from ambient water temperature through the warm white muscle to the warmest body core temperature of the stomach. The ingested tags, anchored with small treble hooks, have provided data for over two weeks in same tagged sharks, thereby providing long-term information of stomacal thermal patterns. Preliminary analysis of the data suggests that white sharks are able to maintain core body temperatures and white muscle temperatures about 9 ºC and 7 ºC above ambient water temperature, respectively. To date, no feeding bouts (noticed by the sudden decrease in the stomach temperature) of the tagged individuals have been witnessed. Such events would represent the first opportunity of assessing the metabolic rate of a free-swimming white shark. The ultimate goal is to determine whether white sharks are not only able to maintain a higher core body temperature but also to control it (warm its body up, cool it down or maintain it constant) depending on the ambient. Such information paired with data obtained from cross-sectional dissections made on caught white sharks (n = 8 so far) will reveal information about ontogenetic patterns in the thermal physio-ecology of these large charismatic predators.

09h20-09h40: Rhett Bennett (PhD student, second year) - Habitat use, movement patterns and stock delineation of an important endemic coastal fishery species, *Lithognathus lithognathus*

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

Funders: Marine and Coastal Management Provincial Research Projects; South African National Biodiversity Institute; South African Institute for Aquatic Biodiversity

White steenbras *Lithognathus lithognathus* has traditionally been an important target species in South African recreational shore and estuarine fisheries and, until recently, a dominant component of the commercial beach seine fishery in the Western Cape. Over-exploitation by both sectors, coupled with ineffective management regulations, has resulted in stock collapse. A contributing factor to the failure of existing management measures is the lack of empirical knowledge on movement, migration and habitat use patterns, as well as genetic stock integrity of this species.

This study aims to determine and describe the status, habitat use, movement behaviour and genetic diversity of white steenbras in South Africa, by achieving the following objectives:

- Determine habitat use, home range dynamics and movement patterns of juvenile white steenbras within estuarine nursery areas, using acoustic telemetry methods.
- Evaluate longshore movement and dispersal patterns of sub-adult and adult white steenbras in the marine environment through acoustic telemetry and conventional tag-recapture techniques.
- Assess estuarine dependency in juveniles through microchemical analysis of two otolith trace elements (Strontium and Calcium).
- Determine temporal and spatial genetic variability of juvenile and adult white steenbras along the South African coastline using mitochondrial and microsatellite DNA analyses.
- Elucidate trends in catch, effort and catch-per-unit-effort of white steenbras over the last c50 years, using available fishery, survey and research data.

Manual tracking of juvenile white steenbras in the intermittently open East Kleinemonde estuary indicated a distinct diel movement pattern. Automated tracking of juveniles in the permanently open Kariega estuary indicated station-keeping behaviour, with restricted area use. Juveniles appear to be highly resident within estuaries, showing little tendency to migrate to sea. To date, 15 white steenbras have been tagged with acoustic transmitters and almost 300 with conventional dart tags in the surf zone along the Eastern Cape coast. Results indicate high levels of sub-adult residency, with adults undertaking larger scale movements. Otoliths of at least 30 individuals have been collected from selected estuaries for microchemical analysis. Laboratory analysis of otolith microchemistry will be initiated in 2010. Genetic samples have been collected from over 800 white steenbras (19-1130 mm fork length) from Dwesa-Cwebe in the east, to False Bay in the west. Analysis of genetic samples was initiated in September 2009, and will be completed by early 2010. Commercial and recreational white steenbras catch data have been obtained for certain areas, and will be analysed towards the end of the study. By incorporating all proposed methods in a holistic approach, this project will provide an improved scientific basis for the management of white steenbras and a platform for research on other estuarine-associated coastal fishery species.

09h40-10h00: Matthew Parkinson (MSc student, first year) - The trophic dynamics and energy flow of the tidal, subtidal and canyon regions of Sodwana Bay, KwaZulu-Natal, South Africa

Supervisors: Prof. AJ Booth (t.booth@ru.ac.za); Dr S Kaehler (s.kaehler@ru.ac.za)

Funders: National Research Foundation; Rhodes University Prestigious Masters Scholarship

Sodwana Bay lies within the iSimangaliso Wetland Park, on the northern KwaZulu-Natal coastline. This part of our coast is home to the southernmost known population of coelacanths, which reside in caves in the submarine canyons, and Africa's southernmost corals making it an area of high conservational value in addition to its recreational importance to the many divers and fishermen which regularly visit the area. Understanding the feeding dynamics and trophic structure of the ecosystem in Sodwana Bay will contribute to informed management of the system.

My study intends to broaden our understanding of the trophic dynamics and energy flow in Sodwana Bay, largely through the use of soft-tissue stable isotope analysis. I am investigating the relative importance of inshore vs offshore productivity, whether upwelling occurs over the canyon heads, specifically Jesser Canyon, and what effects this has on the physico-chemistry of the water and how this affects primary production, and how organisms are trophically organized in the food web in the bay.

Preliminary results suggest that the rocky shore and shallow subtidal fauna derive their organic carbon largely from seaweeds. Sponges, unlike the other nearshore filter feeding invertebrates, appear to source their organic carbon from phytoplankton. Seaweeds are a major source of organic carbon for the reef fauna, with phytoplankton possibly also of importance especially to filter feeding invertebrates such as mussels and oysters. Pelagic invertebrates derive their organic carbon from phytoplankton production, while pelagic game fishes possess relatively enriched $\delta^{13}C$, indicating a possible tendency of these fish to prey on inshore fauna which ultimately obtain their organic carbon from inshore phytoplankton and macroalgae.

Future efforts will be aimed at the collection of samples of algae and macroinvertebrates from the deeper habitats in the bay, beyond the reach of standard SCUBA gear, by means of a remotely operated vehicle and/or specialist deep divers. Included in the deep habitats are the canyons, in which the coelacanths reside.

An upwelling event is yet to be recorded in this study over the heads of Jesser canyon.

10h00-10h20: Timothy Richardson (MSc student, second year) - The taxonomy, biology and stock assessment of *Diplodus capensis* in southern Angola

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

Funder: National Research Foundation (GUN 66957), Rhodes University, Ernst and Ethel Eriksen Trust

The blacktail (*Diplodus capensis*) is a member of the family Sparidae and is distributed from Mozambique to southern Angola. It is an important component of many coastal fisheries, none more so than the southern Angolan subsistence fishery. While there has been no taxonomic study, molecular evidence suggests that the Angolan and South African blacktail (*Diplodus capensis*) populations have been separated by the Benguela current for about two million years, prompting a morphological comparison to investigate whether there is evidence for allopatric speciation. With its importance in the local fisheries, a biological study and stock assessment was conducted to provide information for the management of this species. A total of 46 morphometric measurements and 18 counts were carried out on specimens collected from various locations in southern Angola and South Africa. Results were analysed using multi-dimensional scaling (MDS) and the significance of clusters was tested using analysis of similarities (ANOSIM). Biological samples of blacktail were collected monthly from an unexploited area from April 2008 - March 2009. Additional biological samples were collected from an exploited area during May, June and December 2009. Standard laboratory techniques were employed for the life-history comparison between the two areas. A per-recruit analysis was conducted using life-history parameters from both areas in order to investigate potential short-falls of this approach. The morphometric comparison showed that the Angolan and South African blacktail were separate stocks, but not species. Blacktail is omnivorous, feeding predominantly on algae, barnacles and mussels. An ontogenetic shift from algae to barnacles and mussels was correlated with allometric growth patterns in feeding apparatus. Blacktail is a rudimentary hermaphrodite in Angola with peak spawning in June and July. The overall sex ratio (M:F) was 1:4.7 and 50% maturity was attained at 149.5mm FL and 5 years. Blacktail in Angola exhibit very slow growth with the maximum age observed being 31 years. Growth differed significantly between males and females. In the exploited area, the length and age frequencies were severely truncated and the sex ratio was less female biased at 1:2.2. There was an increase in the proportion of small females in the exploited area. As a result of reduced longevity, alterations in life-history parameters and different natural mortality rate estimates, pristine spawner biomass-per-recruit (SBR) was underestimated by 92% in the exploited area. An assessment based on the actual pristine SBR estimate from the unexploited area revealed that the subsistence fishery had reduced blacktail to 20% of its pristine SBR levels. This highlights the value of pre-exploitation life-history information for the application of per-recruit models. Blacktail displays life-history characteristics that render it susceptible to overexploitation, even at low levels of fishing pressure. The current lack of enforcement capacity renders traditional linefish regulatory tools such as size and bag limits and closed seasons inappropriate. Suitably designed marine protected areas recommended as the best management option for this species.

Key words: marine; life-history; feeding; age and growth; reproduction; effects of exploitation

10h20-11h00: Tea break

Estuarine Ecology (Chair: Russell Chalmers)

11h00-11h20: Alexis Olds (MSc student, first year) - Introduction pathways, distribution and abundance of alien invasive fish species in a South African RAMSAR wetland, Wilderness Lakes

Supervisors: Dr OLF Weyl (o.weyl@saiab.ac.za); Mr MKS Smith (kyles@sanparks.org)

Funders: SAN-Parks; South African Institute for Aquatic Biodiversity; Centre for Invasion Biology

The Wilderness Lakes system is comprised of the Island Lake, Langvlei, Rondevlei and the Serpentine Channel of the Touw River and is a RAMSAR site that falls under the management jurisdiction of South African National Parks. The introduction of alien species can have a drastic effect on ecological communities and has contributed to species extinctions worldwide, particularly in freshwater fish. Four of the world's 100 most invasive fish species have been reported in the Wilderness Lake system, namely, an extralimital population of the Mozambique Tilapia *Oreochromis mossambicus*, though occurring naturally in estuaries down to the Bushmans River in the Eastern Cape, is not native to the Wilderness Lakes system, the Central American mosquitofish *Gambusia affinis*, the Eurasian common carp *Cyprinus carpio* and the North American largemouth bass *Micropterus salmoides*. Understanding introduction pathways, distribution, abundance and movement of these invasive fish species within the system is therefore an essential component to conservation planning and management of this RAMSAR site.

The overall aim of this research project is to contribute to the understanding of the dynamics of alien invasive fishes in the Wilderness Lakes and to contribute to an effective alien invasive management strategy for SANParks. Specific project objectives include the identification of introduction pathways as well as source populations of alien invasive fish. Assess the spatial, temporal distribution and relative abundance of endemic and alien fish species throughout the system and finally to investigate various physico-chemical parameters and assess their relation to the abundance and distribution of alien invasive fish.
In this research the lakes system is sampled seasonally using a range of gear types. Each lake, two interconnecting channels and the Touw Estuary are sampled by means of fyke nets, multi-meshed gill nets, 30m and 10m seine nets to determine the abundance and distribution of fish within the lakes. Various physio-chemical parameters are also collected to correlate the data to environmental variables. Once off sampling using fyke nets and electrofishing will be used to determine the source populations and introduction pathways of alien invasive fish. The data collected will be compared with a study conducted on the Wilderness Lakes system in 1985.

Preliminary results show that the alien *C. carpio, M. salmoides, O. mossambicus* and *G. affinis* are present in the Wilderness lakes system. There appear to be strong spatial and temporal variations in the distribution and abundance of fish within the lakes. The final data set will provide a thorough and complete understanding on the status of alien invasive fish in the Wilderness Lakes system and will contribute to the development of an alien species management plan.

Key words: estuarine, invasion biology, freshwater fish, RAMSAR site

11h20-11h40: Craig Midgley (MSc student, first year) - Estuarine fish assemblages in the subtropical/warm-temperate and warm-temperate/cool-temperate transition zones of South Africa - possible effects of global 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)

Funder: National Research Foundation

Estuarine environments and their associated fish taxa are not uniformly distributed along the South African coastline. The distribution of estuarine fish fauna on the subcontinent is defined by three biogeographic regions: a subtropical, warm-temperate and cool-temperate regions. Estuaries occurring between two biogeographical regions are areas of ecological transition. They have flora and fauna from two regions and consequently these biodiversity "hotspots" are often areas of high species richness where species ranges overlap. However, the ichthyofauna in these estuaries are more susceptible to long-term climatic events such as global warming by virtue of their location in these transition zones.

Estuaries occuring in transition-zones are ideally placed for us to monitor the importance of these zones to shifts in species diversity, distribution and abundance arising from climate change. However, there have been limited long-term studies conducted on estuaries within South African transition zones. The overall aim of this study will be to identify recent temporal changes in fish assemblages and species diversity within two transition-zone estuaries: the Mbashe Estuary which is situated within the subtropical/warm-temperate transition zone, and the Breede Estuary which is situated within the warm-temperate/cool-temperate transition zone.

The Mbashe Estuary will be sampled with a 30m x 1.7m x 15mm bar mesh seine net with a 5mm bar mesh purse and the Breede Estuary using a 30m x 2m x 10mm bar mesh seine net with a 10mm bar mesh purse. Fish data collected during the 1990s using the above gears will be analysed from both the Mbashe and Breede estuaries for comparitive purposes.

As was the case in the above earlier studies, seine netting will be carried out during daylight hours. Specimens will be identified, as far as possible, in the field and released back into the system. Those that cannot be identified will be preserved in 10% formalin for later identification. Small, abundant species that have numbers too large to count in the field will have a sub-sample taken and these will be preserved in 10% formalin for further analysis. The following physico-chemical variables will be measured at sites in the upper, middle and lower reaches using a YSI multiparameter meter: salinity (Practical Salinity Scale-PSS), temperature (°C), dissolved oxygen (mg/l), turbidity and pH.

No results at this stage. Field work and data capturing are currently underway.

Key words: estuaries; ecology; biogeography; temporal changes

11h40-12h00: Amber Childs (PhD student, second year) - Ontogenetic habitat use and movement behaviour of dusky kob *Argyrosomus japonicus*

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

Funders: National Research Foundation and Norwegian Research Council (SA/Norway programme for research co-operation), Rhodes University Atlantic Philanthropies Scholarship, DAAD In-Country and In-Region Scholarship

The dusky kob *Argyrosomus japonicus* is a large (max. 75kg) estuarine-dependent sciaenid and is one of South Africa's most sought-after coastal fishery species. The major factors contributing to the collapse of this catodromous species include its juvenile dependence to estuaries, adult spawning aggregations, delayed maturity, habitat degradation and high levels of fishing exploitation in estuarine environments. Current management regulations have failed to arrest a decline in exploitation pressure. Consequently, alternative management strategies need to be investigated to ensure the sustainability and rehabilitation of the dusky kob stock. Such procedures, amongst other things, require empirical knowledge on the movement patterns of the target species. While the general life-history of dusky kob is understood, limited information exists on the extent, timing, and duration of movements between their estuarine nursery habitats and the marine environment. Using a multi-faceted approach, including acoustic telemetry, otolith micro-chemistry and conventional tag-recapture methods, this project aims to examine estuarine-dependency and multiple habitat use of dusky kob. The study area includes the Sundays Estuary, its coastal embayment (Algoa Bay) within the Eastern Cape Province, and selected estuaries along the South African coastline. To date, 49 data-logging receivers (VR2s) have been deployed along 300 km of the South African coastline. Sixteen VR2s have been deployed in the Sundays Estuary, and two VR2s have been deployed in the mouths of six adjacent estuaries (Great Fish, Kowie, Bushmans, Swartkops, Gamtoos, Kromme), as well as the Port Elizabeth Harbour, Coega Harbour and offshore of the Kowie Estuary. Ninety-four dusky kob (237-1110 mm total length) have been tagged with acoustic transmitters in the Sundays and Gamtoos estuaries and the marine environment adjacent to the Sundays Estuary.

Preliminary results have revealed that while dusky kob utilise a range of habitats within Algoa Bay, including inshore zones, harbours and adjacent estuaries, the majority have remained resident in the habitat (estuary/sea) where they were tagged. Of the 66 dusky kob tagged in the Sundays Estuary, only 16 (24%) went to sea and of the 26 tagged at sea, 6 (23%) have entered the Sundays Estuary. While preliminary analysis have shed some light on the habitat use and movements of dusky kob, more data extending over longer periods (currently being collected) is required to address the management needs for this species.

The magnitude of the telemetry data already collected (5 369 502 data points) poses a mathematical and statistical challenge; from acquiring an interface large enough to manage the dataset to identifying the necessary statistical models and framework in which to analyse the data. A multinomial logit model (programmed in *R*) has been proposed to overcome this analytical hurdle. This, together with the multi-faceted approach adopted in this PhD, will hopefully provide a platform to better understand the spatial and temporal aspects of estuarine-dependency and movements of this and other estuarine associated fish species.

Freshwater Ecology (Chair: Rhett Bennett)

12h00-12h20: Albert Chakona (PhD student, third year) - Habitat features associated with occurrence of an imperiled fish fauna in minimally disturbed upland streams in the Cape Floristic Region, South Africa

Supervisors: Dr E Swartz (e.swartz@saiab.ac.za); Dr G Gouws (g.gouws@saiab.ac.za); Prof. P Bloomer (p.bloomer@up.ac.za)

Funders: National Research Foundation; Rufford Small Grants Foundation, International Foundation for Science, WWF International Prince Bernhard Scholarship

The need for appropriate intervention to reverse the accelerated depletion of freshwater fishes has long been recognized. However, in many cases, the paucity of information on the ecology and biology of freshwater species has been cited as a major impediment to effective conservation management. The situation is particularly dire for small, rare and endemic fish species, especially those that have no commercial or recreational value. This is mainly because much of the previous research efforts on the ecology and biology of freshwater fishes has often been biased towards more common and often larger-sized species, particularly those that are commercially exploited. Ironically, small body size and rarity have often been linked to greater extinction risk. Cryptic species with low or no economic value therefore suffer the risk of being pushed to extinction without being noticed. Knowledge of fish habitat-relations is a fundamental first step towards identifying and protecting critical habitat features. The present study evaluated the association of local habitat features with patterns of occurrence of *Sandelia capensis, Galaxias* 'saluroides', *G.* 'nebula' and *Pseudobarbus burchelli* from 116 sites located in 51 unimpacted mountain streams in the Cape Floristic Region (South Africa). For each species, preference indices were used to test the null hypothesis of random association (proportional to availability) with respect to habitat, and logistic regression was used to develop resource selection function models which predicted the probability of occurrence for local and landscape habitat features. The species exhibited distinct habitat associations, with *Sandelia capensis* and *Galaxias* 'saluroides' being strongly influenced by elevation and gradient. Both species were restricted to reaches with low elevation (< 420 m.a.s.l) and gradient (< 25 m km^{-1}). *Pseudobarbus burchelli* occurrence was positively associated with wider streams (mean width > 1.5m) and deeper habitats (max depth > 20 cm). *Galaxias* 'nebula' was the most widely distributed species and exhibited poor associations with habitat features. Interestingly, logistic regression models predicted that all four species can utilise larger and deeper habitats than those considered in the present study. This suggests that these species possibly once occurred in main-stem reaches, which are now heavily impacted by invasive species. Findings from the present study have important implications for inferring the species' historical distribution patterns, their evolutionary history and informing effective conservation management.

Key words: freshwater; ecology; *Sandelia*; *Galaxias*; *Pseudobarbus*; preference models; Cape Floristic Region; conservation

12h20-12h40: Bruce Ellender (PhD student, first year) - Ecological consequences of non-native fish invasion in Eastern Cape headwater streams

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

Funders: The CIB DST-NRF Centre of Excellence for Invasion Biology; Water Research Commission (K5/1957//4), Rhodes University

Non-native fish invasion is considered a primary threat to freshwater fishes, particularly in headwater streams which typically have low species diversity but a high degree of endemism. Introduction of non-native fishes is, however, often a matter of risk perception rather than real risk analysis and an introduction can only be considered harmful if it leads to measurable loss of biodiversity or changes in ecosystem functioning. This research therefore attempts to investigate the ecological consequences of non-native fish invasion in the headwaters of two Eastern Cape river systems, the Swartkops and Keiskamma River systems.

The Swartkops River, contains the endangered *Pseudobarbus afer* and the alien *Micropterus salmoides*, *Micropterus dolomieu* and the catfish *Clarias gariepinus*. Headwater streams of the Keiskamma River system where *Barbus trevelyani* are threatened by *M. salmoides, M. dolomieu, Oncorhynchus mykiss* and *Salmo trutta*. The research is multi-disciplinary and includes: (1) assessments of the distribution and abundance of indigenous fishes in relation to alien invasive fishes; (2) assessing the impact on other taxa in stream ecosystems; (3) food web and trophic level assessments using diet analysis and Stable Isotope Analysis; (4) genetic assessments to determine the size of evolutionary significant units of endangered species to assess whether range restriction resulting from alien fish predation will impact on the genetic diversity of the indigenous fishes; and (5) economic assessments such as contingent valuation methods will be used to assess for economic and biodiversity tradeoffs.

Progress to data includes (1) an experiment on suitable sampling methods for endangered fishes and distribution surveys and (2) the identification of find replicate sites for invaded and non-invaded streams in the Eastern Cape.

The experiment to determine whether remote underwater video analysis (RUVA) could be used as an alternative to depletion electro-fishing for estimating species diversity and abundance in upper catchment streams was undertaken. Five sites in each of two tributary streams of the Swartkops River were used in the experiment. At each site two half hour video replicates were filmed (on two consecutive days), and three pass depletion electro-fishing was conducted (on the third day). Preliminary analysis indicates that RUVA is a suitable yet time-consuming tool for estimating occurrence and relative abundance of some fish species in clear water environments.

Initial surveys have identified replicate streams for experimental work on invasions.
In the Groendal Wilderness Area a total of 50 sites were surveyed (electrofishing and snorkelling surveys) in six tributary streams of the Swartkops River, as well as in the Mainstream Swartkops and Kwazunga Rivers. Exploratory surveys to determine access, identification of sampling sites and logistical problems on the Keiskamma River system are also complete.

Key words: biodiversity, conservation, headwater streams, non-native fish invasion

12h40-13h00: Pholoshi Maake

13h00-14h20: Lunch break

Marine ichthyology / conservation (Chair: Bruce Ellender)

14h20-14h40: Moqebelo Morallana (MSc student, second year) - Regional connectivity, differentiation and biogeography of three species of the genus *Lutjanus* in the South Western Indian Ocean

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

Funders: African Coelocanth Ecosystem Programme II; South African Institute for Aquatic Biodiversity

Knowledge of Western Indian Ocean marine fish biodiversity and taxonomy is advancing, yet the biogeography of the WIO is still poorly understood. Areas of substantial diversity and endemism have been identified but there is little understanding of the origins of the faunas and the relationships among the various regions of the Western Indian Ocean. Knowledge of distributions, scales of connectivity and patterns of intraspecific differentiation is critical to understand the processes that have generated regional biodiversity, and to formulate strategies for the long-term conservation of the diverse fish fauna. The aim of the current study is to investigate the biogeographic and phylogeographic patterns of three species of snapper of the genus *Lutjanus* (*Lutjanus bohar*, *Lutjanus fulviflamma*, and *Lutjanus lutjanus*) in the South Western Indian Ocean. Considering the target species as typical representatives, this will provide an understanding of the relationships and interactions of regional reef fish faunas, identify the processes driving regional variation and diversification, allow for the consideration of the interaction of life history and the physical features of the environment in producing the patterns observed, and elucidate the placement of this fauna in the context of the wider Western Indian Ocean and Indo-Pacific.

Samples of the three species have been collected from various localities in Western Indian Ocean, including Kenya, Madagascar, Mozambique, Red Sea, Seychelles, South Africa and Tanzania. These were selected due to the expectations that populations of each species will differ between localities due to biogeographic discontinuities and transition zones and that species will show different patterns in response to these due to habitat preferences and different distributions. Samples from Tonga, Fiji and Australia were also included. DNA has been extracted from 5-10 individuals of each species per locality. Polymerase Chain Reaction and fluorescent dye-terminator cycle sequencing were used to amplify fragments of the cyt-*b* and ND2 mitochondrial genes, and the first intron of the S7 nuclear gene. Data was analysed under phylogeographic and phylogenetic contexts, with genetic diversity, differentiation among localities and the evolutionary relationships among region being considered.

Preliminary analyses of data from the cyt-*b* gene indicates high genetic connectivity in the Western Indian Ocean with no specific regional faunas identified in *Lutjanus fulviflamma* and *L. bohar*. Migration and gene flow seem to occur among localities. Some regional differentiation is apparent in *L. lutjanus*, with a separation between Kenya-Tanzania and Mozambique. These results are preliminary and may change with more data added, with the results of the analyses of the remaining gene fragments currently being interpreted.

Keywords: marine; genetics; phylogeography; mitochondrial DNA; nuclear DNA

14h40-15h00: Denham Parker (MSc student, first year) - The biology and life history of the largespot pompano, *Trachinotus botla* (Pisces: Carangidae), on the KwaZulu-Natal Coast, South Africa

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

Funders: National Research Foundation

Trachinotus botla is one of approximately 50 carangid species distributed off the southern African coast and forms an important component of recreational and subsistence linefisher's catches along beaches in northern KwaZulu-Natal. Over the past two decades this species has been exposed to an increase in fishing effort. The effects that the increase in exploitation will have on the population is not fully understood as there is currently no information regarding any aspects of its general biology or life history traits within South Africa. Further investigation into the biology of this species is warranted to ensure its sustainability. The aim of the project is to develop and improve the understanding of all biological and life history aspects of *T. botla* and includes estimating important biological characteristics regarding age and growth, reproductive strategies, feeding biology and movement patterns.

The project is currently in its fifth month of the data collection phase. A total of 144 fish have been collected with a size range of 119–313 mm FL. Preliminary results indicate that *T. botla* are opportunistic feeders which prey on species such as engraulid fish, zooplankton and copepods. Incidents of extreme stomach fullness indicate that the species makes full use of temporally "superabundant" prey species, feeding vigorously during these natural aggregations.

Reproductive activity is yet to be observed, with gonads of all the fish captured thus far falling into one of the three following macroscopic categories: immature, resting/juvenile or developing.

A parasitic tongue-replacing isopod, *Cymothoa* sp. has been found on 55.6% of fish sampled. Larger females are found on the tongue of the host and the smaller male on the gill rakers of one gill chamber. *Cymothoa* sp. occupy almost the entire oral cavity. Condition factor of infected fish did not differ significantly between infected and uninfected fish (t-test; $t = 0.80$, $df = 71$, p-value = 0.43) suggesting that the host may modify its diet to consume smaller prey items.

Key words: marine; fisheries; opportunistic feeders; reproductive activity; *Cymothoa*; parasite

15h00-15h20: Reece Wartenberg (MSc Student, First Year) - Depth related community structure of reef fishes in the iSimangaliso Wetland Park, a tropical East Indian Ocean marine protected area, South Africa

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

Funder: National Research Foundation

The iSimangaliso Wetland Park, declared a world heritage site in 1999, is comprised of the Maputaland and St Lucia marine protected areas. To date, however, there have been few fish-specific scientific studies. This study, therefore, intends to provide baseline information regarding the depth related community structure of fishes occurring on one of the largest patch reefs within the iSimangaliso Wetland Park; Two-Mile Reef.
As research is being conducted within a marine protected area, field methods can not be destructive. SCUBA-based Underwater Visual Census (UVC) was therefore selected as the primary survey method. Field work has been structured into two phases. Phase 1 was designed to determine which of three UVC transect types; visual-, photographic-, or video-transects would be best suited to achieving the most accurate and precise data while providing the broadest range of information. Phase 2 was designed to compare the depth related community structure of fishes on Two-Mile Reef between winter and summer. Field work for Phase 1 has been completed while only the winter field work for Phase 2 has been completed.

The preliminary results of Phase 1 show that across all three transect types, 12708 fishes consisting of 189 species from 36 families were positively identified. Visual transects provided the lowest overall abundance of 3880 fishes but the highest species count of 146 species. For photographic and video transects two analyses types were implemented; Standard counts and *MaxN*. Standard counts have shown abundances of 4492 and 4336 fishes for photographic and video transects respectively. *MaxN* have shown abundances of 2027 and 1667 respectively. Both analyses types provided species counts of 118 for photographic- and 138 for video-transects. Total analysis time for photographic and video transects was 234 hours with each transect type taking 106 and 128 hours respectively. Statistical analyses on these preliminary results are currently underway.

Analysis of footage from the winter sampling from Phase 2 is still to take place with the summer sampling of Phase 2 scheduled for February 2011.

The results of this research will provide essential baseline information for the development of a long term monitoring program within the iSimangaliso Wetland Park. Contributions to the development of UVC techniques for implementation on other tropical coral reef ecosystems will also be made.

15h20-15h40: Russell Chalmers (PhD student, fifth year) - Towards ecosystem based management – overcoming data deficiency for marine spatial planning in the coastal zone

Supervisors: Prof. WHH Sauer (w.sauer@ru.ac.za)

Funders: SAN-Parks; South African Environmental Observation Network – Elwandle Node

The failure of traditional fisheries management approaches is now widely recognized and ecosystem based approaches are advocated as viable alternatives for management of marine ecosystems. This requires a holistic cross-sectoral approach integrating biological and socio-economic aspects to achieve desired social benefits within the limits of sustainable utilization. Although these approaches have been adopted in principle, implementation has been poor due to cross cutting issues and lack of a clear way forward. Marine spatial planning is recognized as a key managerial tool and the basis for implementation of ecosystem based management. Knowledge of the spatial distribution of habitats, physical attributes and associated biological communities, as well as resource utilization patterns within the planning domain is required. However, detailed information is often lacking preventing adequate justification for the need for spatial closures and development of marine protected areas. This project aims to develop a marine spatial plan for Algoa Bay thereby facilitating the implementation of ecosystem based management on a localized scale, and provide recommendations for evaluating the effectiveness in achieving the desired objectives through long-term ecological monitoring.

Key habitats, biological communities and fisheries activities were identified in Algoa Bay and available sources of data were reviewed. Baseline surveys were designed to obtain data on the reef ichthyofaunal and marco-benthic communities as well as the recreational fisheries. Reef ichthyofaunal communities were assed with controlled angling surveys, while diving surveys were conducted to assess both ichthyofaunal and macro-benthic communities. Research trawl data was obtained from Marine and Coastal Management for the assessment of ichthyofauna communities over trawlable areas. Roving creel, access point and aerial surveys were conducted to assess recreational shore and skiboat fisheries. Annual catch and effort, vessel monitoring and observer data was obtained from Marine and Coastal Management for the assessment of six commercial sectors which utilize Algoa Bay. Biological and fisheries data was imported into GIS and a spatial prioritization exercise was conducted using MARXAN.

Reef fish diversity, relative abundance and composition differed spatially and two distinct communities were identified. Ichthyofaunal composition over trawlable grounds was primarily driven by depth. Recreational shore fishing effort was found to be concentrated close to access points, and catch composition and catch per unit effort (CPUE) was influenced by substrate type and varied spatially along the coastline. Spatial distribution of recreational ski-boat fishing effort, CPUE and catch composition differed between launch sites. The intensity and spatial distribution of commercial fishing effort varied between sectors and key areas of utilization for each sector were identified. The suitability of the baseline survey and data sources utilized are discussed in light of the spatial planning outcomes and recommendations for future assessments presented.

Key words: Marine; conservation; Algoa Bay; MARXAN; MPA; monitoring

Friday 15 October 2010

Mariculture (Chair: Henning Winkler)

08h20-08h40: Nicholas Riddin (MSc student, first year) - Gonad development and growth in farmed South African abalone *Haliotis midae*

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

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

The economic viability of commercial abalone farming depends on the system used for grow-out, and, due to the long culture period and slow growth of abalone, profit can be marginal in land-based systems. Thus, maximizing growth rate and minimizing grow-out period it was expected that profit margin could be improved. According to farm records, abalone on farms appear to be growing slower during certain periods of the year. This is mostly affecting the abalone in the weight range of 50-70 g / abalone, with winter growth rates being 10% lower than those in summer. This reduction in growth rate seems to coincide with enlarged gonads in the farmed abalone. It should be tested whether ingested energy is being spent on gonad development instead of somatic growth. The aim of this research was to understand the environmental or dietary causes for the above-mentioned phenomenon, and to find a method of controlling it with an economically viable farm-scale solution.

Growth of individual abalone (50-60 g / abalone) will be measured monthly for one year to determine differences in growth between months. These data will be correlated to environmental variables such as day length, water temperature and pH to determine whether any of these factors influence abalone growth on the farm. Data will be analysed further using periodic regression analysis to identify the effect of season on growth. The gonads of abalone will be analyzed both macro- and microscopically from regular samples taken throughout the year over a range of size classes to determine the age / size at first maturity and to describe the reproductive development of farmed abalone.
Gonad development is an energetically expensive process. As a result, the last component of this study will determine the effect of dietary energy level on gonad growth and development. Maturing abalone will be fed seven diets with a range of protein : energy ratios and protein sources for 10 months, after which growth rates, condition factor, foot glycogen levels and gonadosomatic index values will be compared between treatments.

A decrease in growth was observed for July and September. Growth rates decreased from 2.2 mm and 3.75 g to 0.95 mm and 2.78 g per month. This is a reduction in growth rate by nearly 25 % by mass and over 50 % by shell length. The sex of the abalone had no effect ($p=0.87$) on the mass of the foot muscle as a percentage of body weight for animals collected in September 2010. These gonad tissues are currently undergoing fixation. Feeding trials will commence in November with all trials expected to be completed in August 2011.

Keywords: marine; aquaculture; reproduction; protein : energy ratio; soy; phytoestrogen

08h40-09h00: Matthew Naylor (MSc student, third year) - Water quality and abalone production in a serial-use raceway system

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

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

The concentrations at which specific water quality variables affect abalone growth are not well documented. Extrapolating data from toxicity experiments is difficult, as the majority of studies are single factor experiments where only the variable in question has been altered. In production systems water quality parameters are altered by the metabolic activity of the culture animals and the microbes.

Trial 1 described the changes in water quality between tanks in a serial-use raceway in relation to accumulated biomass and water flow. Three serial-use raceways each with seven tanks in series were used. Fifty abalone per tank were individually weighed and measured at the start and end of the trial. Water quality variables were measured twice weekly. Growth reductions (ANOVA; $F_{(6, 14)} = 13.92$, $p < 0.0001$) and increased FCR values (Kruskal-Wallis test; $H_{(6, 21)} = 16.35$, $p = 0.012$) were observed for abalone in the lower tank positions. Weight gain dropped from 13.1 ± 1.3 g in position one, to 6.83 ± 1.6 g in position seven. pH and dissolved oxygen were negatively correlated with tank position. Free ammonia nitrogen (FAN) and nitrite concentrations were positively correlated with tank position, increasing from ± 0.67 µg L^{-1} FAN and ± 6.77 µg L^{-1} nitrite in position one, to 2.79 µg L^{-1}FAN and 30.23 µg L^{-1} nitrite in position 7. It is estimated that a flow index of 7.2 – 9.0 L h^{-1} kg^{-1} will cause significant growth reductions in *H. midae*.

Trial 2 determined the effect of dietary protein level on TAN and FAN concentrations in a serial-use raceway. Three iso-energetic diets containing 33%, 26% and 22% protein were used. The system was set-up as six raceways with three tanks in series. Temperature, pH, TAN and FAN were measured over 17 days. TAN and FAN concentrations were correlated with dietary protein ($t = 6.63$, $p < 0.0001$ and $t = 6.41$, $p < 0.0001$, respectively) and flow index (FI = L h^{-1} kg^{-1}) ($t = 5.42$, $p < 0.0001$ and $t = 3.9$, $p < 0.0002$, respectively). Mean FAN concentrations in tanks fed the 22% and 26% protein diets, were 66% and 41% lower than in tanks fed the 33% protein diet.

Using the results from trial 2, the third experiment aimed to determine the effect of FAN concentration on *H. midae* growth. Two iso-energetic diets, containing 33% and 26% protein were used to create a high FAN and low FAN treatment, respectively. The effect of dissolved oxygen on growth was also tested. Operational methods followed those of trial 1. No significant differences were observed between treatments (ANOVA; $F_{(1, 14)} = 0.47$, $p = 0.51$), however, growth was significantly reduced with increasing water use (i.e. position) (ANOVA; $F_{(2, 14)} = 85.61$, $p < 0.0001$). Supplementation with pure oxygen to ± 100% saturation did not significantly improve growth (t-test; $t = 2.61$, $df = 4$, $p = 0.06$) in abalone exposed to high FAN(2.4 ± 1.1 µg L^{-1}) and low pH (7.6 ± 0.13). It is likely that pH is the first limiting variable in serial-use systems and should form the focus of future trials.

09h00-09h20: Siyabonga Maliza (MSc student, Second year) - Development of probiotic diets for the South African abalone (*Haliotis midae*) industry

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

Funders: THRIP, Marifeed (Pty) Ltd.; Department of Agriculture Forestry and Fisheries

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

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

Growth experiments were conducted at HIK Abalone Farm (Pty Ltd) and Roman Bay Sea Farm (Pty) Ltd after which haemocyte and phagocytosis counts were done. (1) To determine the effect of probiotic diet on abalone growth and health under presumed stressful conditions, abalone at HIK Abalone Farm were fed either the test or the control diet and subjected to normal farm handling or to additional handling stress.

At HIK there was no significant interaction between diet and handling on average length and weight gain $month^{-1}$ after 4 and 8 months ($p>0.05$). Average length (stressed = 73.9 ± 0.52, unstressed = 75.8 ± 0.57 mm) and weight gain (mean: stressed = 68.5 ± 1.20, unstressed =7.3 ± 1.86) increased significantly in unstressed animals after 8 months ($p<0.02$). After 8 months phagocytosis count was significantly different between dietary treatments with values of 74 and 53.5 counts per sample for the probionts and control treatment, respectively ($p<0.02$). There was no effect of stressor application ($p = 0.14$) and no interaction between dietary treatment and stressor application for this variable ($p = 0.61$).

At Roman Bay Sea farm, average length (68.183±1.46 mm) and weight (53.560±4.272 $g.month^{-1}$) of animal fed probiotic diet significantly increased over time ($p<0.00001$), compared to those fed the control (length: 67.856±1.516 mm and weight: 52.450±3.616 g) after 8 months. Abalone fed the probiotic diet had a significantly faster growth rate ($g.month^{-1}$) than those fed the control after 8 months ($p<0.05$). There was no significant difference in haemocyte counts between animals fed either probiotic or control diet after 4 and 8 months ($p>0.05$).

09h20-09h40: Justin Kemp (PhD student, second year) - Towards understanding carbohydrate digestion and metabolism in abalone – some insights from a growth trial conducted in Chile

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

Funders: Marifeed (Pty) Ltd.; National Research Foundation; Rhodes University JRC

Abalone are herbivores in their natural environment, feeding on a variety of green, brown and red seaweeds and have been shown to grow particularly well on a mixed algal diet under culture conditions. Despite protein levels being generally low in seaweed (< 20%), abalone are extremely efficient at utilizing the available protein for growth. Since abalone are essentially unable to use lipid for energy, this highly efficient use of protein suggests that their energy metabolism is carbohydrate based. The carbohydrate profiles of seaweeds show marked differences to that of their land plant counterparts, the current source of carbohydrate (pectin and amylopectin based starches) in formulated feeds. Apart from unique storage carbohydrates such as laminarin, and floridean starch, seaweeds also contain high proportions of sulphated polysaccharides such as galactans (agar) in red seaweeds and alginic acid in the brown seaweeds. Growth of abalone fed live seaweed is better than it theoretically should be if just the gross nutrient content of the seaweed is considered. Furthermore, dried seaweed is poorly assimilated and growth much reduced. Within the Chilean context of dwindling seaweed supplies and a reluctance to switch entirely to pelleted feeds, an experiment was designed to test the effect of dietary regimes that combined fresh seaweed and formulated feed on the growth of the red abalone *Haliotis rufescens*.

A six-month feeding trial was conducted using four dietary regimes namely 100% seaweed ration (*Macrocystis integrifolia* and *Lessonia nigrescens*), 50% seaweed ration with formulated feed, 10% seaweed ration with formulated feed and 100% formulated feed. Seaweed ration was calculated on abalone consuming 15% body weight.day^{-1} and was fed on day 2 and 5 while pellets were fed on-demand on days 1-6 according to the previous day's consumption. 420 juvenile abalone (1.1±0.3 g; 20.54±1.7 mm) were stocked into mesh baskets (38 x 30 x 45 cm; 4 replicates per treatment) located in a commercial-scale flow-through raceway and provided with a vertical plate HDPE refuge (4 plates per refuge; 0.7 m^2 surface area). A corrugated fiber-cement plate (30 x 22 cm) was placed on the upper surface of the refuge, providing a distribution surface for the formulated feed. Animals were weighed and measured every two months.

Growth, as measured by both length and mass gain, was significantly greater ($p<0.05$) for the 100% seaweed and 50% seaweed treatments compared to the 10% seaweed and 100% artificial feed regimes. Furthermore, protein efficiency ratio (PER) followed a similar trend, with the 100% seaweed (4.01±0.18) and 50% seaweed treatments (3.53±0.11) exhibiting significantly ($p<0.05$) elevated utilisation efficiencies. These results suggest that live seaweed likely possesses properties (physical or chemical) which enhance the assimilation of nutrients when fed in conjunction with pelleted feeds.

Key words: abalone; carbohydrate; seaweed; formulated feed; Chile; growth trial

Humfrey Greenwood lecture (Chair: Warwick Sauer)

09h40-10h20: Prof. T Hecht - Looking back at where the DIFS came from

10h20-10h50 Tea break

Guest speaker (Chair: Peter Britz)

10h50-11h20: Mike Markovina

Mariculture (Chair: Wilbert Kadye)

11h20-11h40: Siviwe Babane Elvis (MSc student, third year) - Effect of size variation on aggressive and feeding behaviour of juvenile dusky kob Argyrosomus japonicus

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

Funders: Marine and Coastal Management (Department of Environmental Affairs and Tourism), Espadon Marine (Pty) Ltd.

Grading fish based on size is a common rearing practice to improve weight gain and to increase survival. This technique is used to improve growth of small fish, reduce cannibalism, and improve feed uptake. Dusky kob juveniles are aggressive and this can lead to high mortality. There is a paucity of information on the effects of size-grading in rearing dusky kob.

The aim of this work was to better understand factors determining cannibalism in this species. The objective of this study was to determine the effects of size variation on dusky kob behaviour under intensive rearing conditions.

Dusky kob juveniles were donated from the hatchery stock of Espadon Marine in East London. Fish were size-sorted and coefficient of variation (CV) was used to determine the size variation in each treatment. Each focal fish was exposed to four treatments and the sequence of observations was randomised. Treatments were (a) fish with a mean weight less than that of the focal fish and a low CV; (b) fish having a mean weight less than that of the focal fish and a high CV value; (c) fish with a mean weight similar to that of the focal fish and a high CV value and (d) fish with a mean weight higher than that of the focal fish and a low CV value. Thirty-minute behaviour observations conducted 12 hours after feeding adressed aspects of aggressive and feeding behaviour.

Repeated measures ANOVA showed that size variation influenced aggressive and feeding behaviour of dusky kob. Treatment with fish of a high CV value and a mean weight less than the focal fish weight significantly differed to all treatments, with increased aggressive and feeding behaviour recorded except for the treatment that had high CV value and a mean weight similar to that of the focal fish. While, these initial findings suggest that juvenile dusky kob of high size variability behave more active and aggressive to each other when reared together, more studies will be needed to confirm this hypothesis.

Following results from the previous work, a trial is undertaken with small juveniles to study the influence of the aggressor’s size on behaviour. The largest fish has been observed before and after feeding to record its aggression. Preliminary analyses suggested that the time at which fish were observed affects aggression, with higher mean frequencies recorded in observations conducted 12 hours after feeding in the evening than observations made before feeding in the morning. Further observations will be needed to test how size variation and aggressive behaviour are correlated to each other.

Key words: marine; aquaculture; Espadon marine; cannibalism; behaviour observations; ANOVA; regression

11h40-12h00: Nani Adami Rossetti (MSc student, second year) - The development of a "least-cost" diet for dusky kob, *Argyrosomus japonicus* (Pisces: Sciaenidae)

Supervisors: Dr C.L.W. Jones (c.jones@ru.ac.za) and Prof. P. Britz (p.britz@ru.ac.za)

Funders: THRIP; Marifeed (Pty) Ltd.

Fish meal and fish oil are commonly used as ingredients in finfish feed and, with declining fisheries resources worldwide, such ingredients are becoming more expensive. Therefore it is essential to explore the utilization of alternative ingredients. The aim of this study is to investigate the use of vegetable oil as an alternative to fish oil in aquafeeds since the currently world production of vegetable oil is greater then that of fish oil.

Six isonitrrogenous and isoenergetic diets (with a total lipid content of 18 % and a protein content of 46 %, with fish meal and soya as the main protein sources) were fed to dusky kob, *Argyrosomus japonicus*, an increasingly popular mariculture species in South Africa. The lipid source was altered in each diet, with a decrease in the contribution of fish oil and a corresponding increase in vegetable oil at 1, 14, 28, 42, 56 and 70 % replacement. Fish weight and length were measured at the start of the experiment and monthly for three months. After four months of feeding the same diets, blood samples were taken and fish were sacrificed for liver and fat analysis.

There were no significant differences in fish weight and length between treatments after 84 days, with overall means (± standard error) of 239.9 ±13.26 g (Kruskal-Wallis: $H = 9.9$; $p = 0.08$), and 25.23 ±0.43 cm (ANOVA: $F = 3.14$; $p = 0.07$), respectively. However, there was a significant trend that showed a decrease in specific growth rate (SGR) (range: 0.2 ±0.01 to 0.3 ±0.02) with an increase in vegetable oil replacement ($r^2 = 0.35$, $p = 0.019$). Similarly, condition factor (CF) decreased from 1.59 ±0.03 to 1.53 ±0.02 with an increase in vegetable oil level in the diets ($r^2 = 0.32$, $p = 0.027$) and hepatossomatic index (HSI) increased significantly from 0.83 ±0.07 to 1.80 ± 0.12 with an increase in vegetable oil replacement (ANOVA: $F = 9.9$, $p = 0.0006$; $r^2 = 0.5$, $p = 0.001$), as well as the visceral fat index (VFI) from 1.28 ±0.2 to 2.24 ±0.1 (ANOVA: $F = 5.24$, $p = 0.009$; $r^2 = 0.54$, $p = 0.0005$). There were no differences in red blood cell counts, haematocrit and haemoglobin concentration, with overall means of 2.75 ±0.08 (x10^12/l, $X^2 = 0.03$, $p = 0.99$), 0.27 ±0.009 l/L (Kruskal-Wallis: $H = 3.8$, $p = 0.6$); 6.9 ±0.2 g/dL (ANOVA: $F = 0.4$, $p = 0.8$), respectively.

Growth is negatively affected when the vegetable oil contribution to total lipid increases. The increase in HSI and VFI with increasing oil replacement suggests that dusky kob were less able to metabolise soybean oil, which would account for the poorer growth. This hypothesis will be confirmed using proximal analyses and histology.

Key words: marine, aquaculture, soybean oil, replacement

Freshwater aquaculture (Chair: Wilbert Kadye)

12h00-12h20: Anneke Cilliers (MSc, first year) - An exploratory study investigating the dynamics of high rate algal ponding systems in treating brewery effluent for subsequent use in aquaculture

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

Funders: SAB Ltd; WRC K5/2008; THRIP

High rate algal ponding (HRAP) systems are used throughout the world to treat a variety of effluents derived from mining, sago-factories and breweries, for example. The application of HRAP systems was tested in this study as an alternative, environmentally sustainable effluent treatment process and water recycling technology to treat brewery effluent. The aim was to describe seasonal changes in nutrient removal using a HRAP system, at a constant effluent flow rate and at fluctuating flow rates (i.e. to optimise retention time), and to determine whether it is possible to reduce "pollutant" concentrations in brewery effluent to determine if treated effluent can be used as a potential water source in aquaculture.

The water quality standards that were used as a benchmark were based on Department of Water Affairs (DWA) general standards for discharging industrial effluent into a natural water resource: chemical oxygen demand (COD): <75 mg/l; ammonia: < 6 mg/l; nitrate/nitrite: <15 mg/l; phosphate: <10 mg/l; electrical conductivity: 700 -1500 µS/cm; pH: 5.5-9.5. Effluent flow rate from the anaerobic digester (AD) into two HRAP systems was kept constant for 10 months, after which it was adjusted based on nutrient concentrations.

Results from May 2009 to August 2010 indicate that COD concentration was reduced from an average of 175 mg/l post-Anaerobic Digester (AD) to 118 mg/l post-HRAP ($p=0.0004$) and to below 75 mg/l when algal cells were filtered from the water samples. The mean ammonia concentration was reduced from 44 mg/l post-AD to 1.2 mg/l post-HRAP ($p<0.0001$). The mean nitrate concentration increased from an average of 1.5 mg/l post-AD to 15 mg/l post-HRAP ($p<0.0001$), but this was reduced to an average of 5 mg/l in a constructed wetland. Nitrite concentrations remained very low throughout the system, and increased only slightly from an average of 0.04 mg/l post-AD, to 0.45 mg/l post-HRAP ($p=0.34$). Phosphate was reduced from 18 mg/l post-AD to 3.5 mg/l post-HRAP ($p<0.0001$). Electrical conductivity remained between 2000 and 3000 µS/cm throughout the experiment. The pH increased from an around 7.4 – 8.0 post-AD to 9.5 post-HRAP, due to the photosynthetic activity of the algae. The wetland was successful in subsequently reducing pH to between 8.4 and 9. The efficiency of nutrient removal varied at different flow rates and seasonally; this data is still being analysed.

Preliminary results show that the HRAP system is effective at reducing the nutrient load in brewery effluent to levels that are within the tolerance range of some fishes, and most parameter were within the DWA range for discharge of treated industrial effluent into natural water resources. The data for the optimisation of HRAP retention time and seasonal variation of nutrient uptake must be analysed before conclusions can be drawn.

Keywords: Freshwater; aquaculture; high rate algal ponds, brewery effluent, nutrient uptake efficiency

12h20-12h40: Rory Scheepers (MSc student, second year) - Treated brewery effluent as a water source for the culture of the ornamental fish *Xiphophorus helleri* (swordtail)

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

Funder: SAB Ltd, WRC K5/2008, THRIP

Large industries utilize and discard large volumes of effluent, globally. This "polluted" water is sent to the local municipalities for treatment, at massive costs to the industry and the environment. The aim of this work is to establish if alternative, environmentally sustainable water treatment methods such as high rate algal ponding and wetlands can be used to treat brewery effluent to a standard suitable for fish culture.

In preliminary trials, there was no significant difference in the standard length of male swordtails grown in treated effluent and municipal water, with means (± standard error) of 63.43±1.57 and 65.29±1.90 mm, respectively ($p=0.46$). Similarly, average female fish length of 67.49±0.18 mm and 68.4±2.09 mm did not differ between treatments ($p=0.49$). Mean weight (2.49±0.23 and 2.47±0.23 g for males and 4.37±0.28 and 4.67±0.28 g for females) and condition factor (0.97±0.09 and 0.86±0.03 for males and 1.42±0.08 and 1.50±0.09 for females) did not differ significantly between treatments ($p>0.05$). The number of juvenile fish harvested in the treated brewery effluent and municipal water control did not differ significantly, with means 631±11 and 660±26 juveniles per month ($p=0.99$). There were no significant differences in brood size (32.6 ± 2.2 and 34±4.2) for treated brewery effluent and municipal water systems ($p=1.0$). Similarly, the mean number of broods did not differ significantly with 5.6±0.20 and 4±2.11 and for the effluent and municipal systems ($p=1.0$).

The similarity of fish size, condition factor and reproductive output between swordtails cultured in the different treatments, suggests that treated brewery effluent may be a suitable water source for the culture of swordtails and can be used to culture fish without negative effects, provided mitigating measures are adopted to ensure that fish health is not affected by unscheduled upstream dumping of brewery waste.

In addition, reproductive biology, survival and health will be monitored in future trials by comparing the physiology and/or histology of the gills, gut, liver, blood and skin. Egg quality (e.g., egg size, yolk volume and density, and lipid content), fecundity and survival of juveniles between treatments will be compared.Water quality analysis will determine the level of phosphate, nitrate, nitrite, ammonia, pH, dissolved oxygen, chemical oxygen demand (COD) and water temperature.

Freshwater conservation (Chair: Wilbert Kadye)

12h40-13h00: Henning Winkler (PhD student, fourth year) - Differential colonisation patterns of two indigenous riverine cyprinids and non-native common carp *Cyprinus carpio* in South Africa's largest impoundment, Lake Gariep

Supervisors: Dr OLF Weyl (o.weyl@saiab.ac.za); Prof AJ Booth (t.booth@ru.ac.za)

Funder: National Research Foundation (FA2005021600012)

A notable example of the complex interactions between river alteration and an increased risk of aquatic invasions is the construction of reservoirs. This study examines the underlying processes of long-term population demographics for non-native carp *Cyprinus carpio* and two large endemic riverine cyprinids, Orange River mudfish *Labeo capensis* and smallmouth yellowfish *Labeobarbus aeneus*, in Lake Gariep, by coupling stable isotope analysis, life history traits, historical and present gillnet catch data, changes in population structures, and ecological niche theory.

Stable nitrogen and carbon isotope analysis showed that zooplankton likely forms the primary food source of *L. aeneus*, while *L. capensis* and *C. carpio* predominantly fed on benthic food sources. In comparison to *C. carpio*, however, *L. capensis* seemed to utilise lower trophic levels of the benthic food web more effectively. The null hypothesis that there was no significant difference between the species-specific trophic niche space was rejected by two-dimensional Kolmogorov-Smirnov tests ($p < 0.05$), which generally suggested limited competition among the three species.

Otolith growth zone deposition was validated as biannual for *C. carpio* and annual for *L. capensis* and *L. aeneus*, which allowed for reliable estimation of lengths-at-age upon which growth, age-at-maturity and mortality rates were estimated. An age-structured production modelling (ASPM) approach was adapted to explore potential consequences of the different life history parameters estimated for *L. capensis*, *L. aeneus* and *C. carpio* on their long-term post-impoundment population demographics.

The population trajectories predicted that, depending on the steepness *h* of the assumed spawner-recruitment relationship, it would take 16 to 23 years *L. capensis*, 13 to 18 years for *L. aeneus* and 8 to 12 years for *C. carpio* to increase from an assumed initial biomass of 3% in 1970 to 80% of the populations' theoretical biomass at carrying capacity. These results were generally in accordance with the standardised gillnet catch per unit effort (CPUE) for *L. capensis* and *L. aeneus*, which increased slowly from < 1 kg.100 m net night^{-1} in summer 1971/72 to 15.93 [95% CI = 8.88 – 24.91] kg.100 m net^{-1}.night^{-1} and 23.00 [95% CI = 13.53 – 32.29] kg.100 m net night^{-1} in summer 2007/2008, respectively. However, although *C. carpio* exhibited the fastest initial increase in CPUE from 3.05 kg.100 m net^{-1}.night^{-1} in 1971/72 to 9.83 kg.100 m net^{-1}.night^{-1} in 1976/1977, as predicted by the ASPM, the next years showed a rapid decrease in CPUE, which then reached a relative minimum of 1.39 kg.100 m net night^{-1} by the end of the initial survey period in 1979/80. Four decades after impoundment the CPUE was found to be similarly low, with 1.44 [95% CI = 0.61 – 2.44] kg.100 m net^{-1}.night^{-1} in summer 2007/2008, suggesting that a "boom and bust" cycle occurred during the early colonisation phase of the *C. carpio* population. This is fairly common among introduced species during establishment, and could be explained by increased growth and reduced density-dependent mortality rates during the first five years after inundation. Other factors that may explain the differential colonisation patterns observed for the three species are explored.

Keywords: freshwater, impoundment ecology, population dynamics, life history, food web

Non-presenting students

Hylton Newcombe (MSc student, fourth year) - A contribution towards a management plan for the tuna baitboat and sportfishery in South Africa

Supervisors: Prof. WHH Sauer (w.sauer@ru.ac.za) and Dr OLF Weyl (o.weyl@ru.ac.za)

Funder: World Wildlife Foundation-SA; ; Claude Leon Foundation

The objective of this research is to contribute to the development of a management plan for the Western and Eastern Cape commercial and recreational tuna sectors by providing a qualitative and quantitative assessment of the size and shape of the tuna fishing industry; including total catch, effort, cpue, socio-economic and economic information and investigating stock structure through comparative estimates of age and growth, population structure and genetic analysis.

Vertebrae were collected from *T. albacares*, ranging from 59 to 175 cm FL, landed in the Western and Eastern Cape, and Kwa – Zulu Natal. A total of 190 whole vertebrae were prepared and age estimates were based on the analysis of yearly growth. The results of this study indicated that the growth of *T. albacares* in the south eastern Atlantic and south western Indian Oceans is best described by the von Bertalanffy growth model, growth parameters were $FL_{\infty} = 251.76$, $k = 0.17$, and $t_0 = -0.71$ year. Comparisons with the von Bertalanffy parameters from other studies indicated no statistical differences among all growth curves (F (4, 29) = 0.9274, P = 0.4617), further substantiated using phi – prime (Φ'), yielding similar results.
Twenty *T. albacares* individuals per sampling site (where available) were sequenced for a fragment of the mitochondrial DNA cytochrome oxidase I gene (COI). Phylogeographic tests of mtDNA COI gene frequencies across a range of samples within South Africa and in the Indian and Atlantic Oceans indicated no clear pattern of genetic structuring. However, results from this test are compromised by a lack of statistical power resulting from low haplotype diversity at this gene and small sample sizes from some sites and further analysis of broad geographic patterns requires more extensive sampling. Both Exact tests of allele frequencies and F_{ST} tests indicated no substantial differences among the South African samples. However, values of F_{ST} between the Western Cape and Eastern Cape samples were high enough to be marginally significant in one test. Although at this stage there is no strong evidence for a genetic split between Western and Eastern Cape populations.

The mean weight of fish caught within inshore waters is significantly different and region specific with juvenile fish in Kwa – Zulu Natal, sub-adult fish in the Eastern Cape and adult fish in the Western Cape. However, the mean weight of fish caught offshore is not significantly different. *T. albacares* caught by the large pelagic long-line fleet are adults of mostly similar size. A *CPUE* peak within each region is offset by two months suggesting a seasonal movement from Kwa – Zulu Natal in November to the West coast in May. There is some evidence of a return movement towards Kwa – Zulu Natal from June onwards.
Catches of yellowfin tuna inshore varies geographically. The results show that the Western Cape ski boat fishers target tuna over a larger part of the year but also have lower regional species diversity from which to target. The tuna pole sector predominantly targets albacore, accounting for more than 80% of total vessel catches. Being an active gear fishery, few other species are harvested and these are predominantly caught as by-catch, namely yellowtail *S. lalandi*, and snoek *T. atun*. In 2007, a high abundance of yellowfin tuna off the Western Cape increased directed targeting for this species. The commercial tuna pole fleet has subsequently grown from 82 vessels employing 2173 fishers in 2002 to 200 vessels and 3600 crew (DEAT 2009b) In 2009, 110 actively recorded vessels fished an average of 46 days. Amongst the South African commercial tuna sectors, the tuna pole sector accounted for 92% of total albacore catches made in 2004 (FAO 2007).

Maryke Musson (MSc student, third year) - Application of research on the prediction of larval quality based on various egg and larval characteristics for dusky kob, Argyrosomus japonicus, as well as the ontogenetic development of the digestive system of *A.japonicus* larvae

Supervisors: Prof H Kaiser (h.kaiser@ru.ac.za); Dr N Vine (niall@performanceunlimited.co.za)

Funders: Marine and Coastal Management Frontier Programme; Espadon Marine (Pty) Ltd.

Argyrosomus japonicus, commonly known as dusky kob, kabeljou or mulloway, is one of the best known angling fishes around the South African coast. Due to its high quality flesh, relative fast growth rates and high market demands, *A. japonicus* carries high potential for large scale commercial production.

Results suggest that larval viability can be predicted by using a ranking index which was developed based on assessing various physical and biological egg and larval quality characteristics. Stress tests were also developed specifically for *A. japonicus*, and larval performance during stress tests were correlated to larval growth and survival during the hatchery phase. The ranking index is now in use in a commercial hatchery to assist in the early discrimination between cohorts which could produce good strong fingerlings, and those that present poor performing larvae that would not be financially viable to rear. This directly contributes to the appropriate allocation of resources in a commercial hatchery.

Together with the above, the ontogenetic development of the digestive tract of *A. japonicus* was studied and described after histological examinations of 4500 larvae between 0 and 30 days post hatch. Based on the histological and morphological characteristics of the larval digestive tract, a new weaning protocol was developed where the use of rotifers has been extended, while the use of *Artemia* has been greatly reduced. *A. japonicus* larvae are now being weaned at a younger age in a commercial hatchery with very good success. It has been shown that it is physiologically possible for *A. japonicus* larvae to ingest and digest complex proteins, as in artificial diets, at 100 degree days, where 15ºC was used as a developmental threshold temperature.

We can thus conclude that the successful application of the above research has been achieved in a commercial production environment.

Key words: *Argyrosomus japonicus*; egg and larval quality; organogenesis; aquaculture

JD John Filmalter (MSc student, first year) - Movement behaviour and habitat use patterns of sicklefin lemon shark *Negaprion acutidens* in the St. Joseph's Atoll and D'Arros Island complex, Seychelles

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

Funder: Institut de Recherche pour le Developpent (IRD, France)

The sicklefin lemon shark *Negaprion acutidens* is a large-bodied (> 3m) coastal shark species, widely distributed in tropical and sub-tropical Indo-Pacific waters. Despite its large size and wide distribution, very little is known about its movement behaviour throughout ontogengy. However, it has been suggested that shallow lagoon habitats represent important nursery areas for this species. Making use of acoustic telemetry methods, this study aims to investigate the movement behaviour and habitat use patterns of the sicklefin lemon shark population in the St. Joseph's Lagoon adjacent to D'Arross Island (Seychelles, Indian Ocean). Although the lemon sharks of St. Joseph's have been commercially exploited in the past, the lagoon still supports a relatively healthy population, thus providing an ideal environment to study this species.

Owing to the remote nature of the study site and the difficulties involved in accessing the area, the study has been divided into three study periods. During the first study period (April – June 2009) eight automated data-logging receivers (Vemco VR2s) were deployed on concrete moorings around the outside perimeters of St. Joseph's Atoll and D'Arros Island, while a single receiver was placed in the centre of St. Joseph's Lagoon. In early April eight large juvenile sharks (129 – 155cm fork length) were tagged (surgically implanted) with coded transmitters (Vemco V13s). Surgery was conducted while the shark was in the water and in a state of catatonic immobility. Sharks were also tagged with conventional spaghetti tag for identification in case of subsequent recapture. During the second study period (June/July – October 2009) 12 more lemon sharks of a similar size were equipped with V13 transmitters.

Preliminary results from the first study period of three months indicated that none of the eight sharks were detected by the receivers on the outer perimeter of the lagoon and D'Arros Island. However, seven individuals were detected by the single receiver within the lagoon. The frequency of these detections varied greatly between individuals, from only a single detection soon after tagging to regular detection on a near daily basis. Based on these findings, an additional two VR2 receivers and one VR4-Global receiver were moored in the lagoon for the second study period.

The data from the second study period will be downloaded during early October. This will also mark the start of the third study period. A further six VR2s will be added to the internal lagoon network, bringing the total to nine VR2s and one VR4-Global. A further six sharks will be tagged during this period. However, these animals will be double-tagged with internal V13 coded transmitters and external V16 continuous pingers with depth sensors. These six sharks will be tracked continuously for as long as possible, using a kayak. The use of a kayak will also allow the animals to be tracked across the shallow sand-flats within the lagoon. The combined use of passive and active tracking techniques will hopefully lead to a better understanding of the movements of sicklefin lemon sharks within and around the St. Joseph and D'Aross Island complex. Similarly, more insight will be gained into the role that St. Joseph's Lagoon (a proposed Marine Protected Area) plays in the life-history of this coastal top predator.

Thethela Bokhutlo (MSc student, second year) - Life history and stock assessment of *Clarias gariepinus* and *Schilbe intermedius* in the Okavango delta, Botswana

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Funders: Ministry of Environment Wildlife and Tourism - Botswana Government

The flood pulse is the most important agent that controls adaptations of many organisms in river floodplains. In the Okavango delta, the influence of the flood pulse on the abundance of *S. intermedius* and *C. gariepinus* in perennial flood plain connected lagoons (Matsaodi, Korao and Guma) was investigated.

Long-term monitoring data collected by the Department of Wildlife and National Parks (Fisheries Division) was analysed for the period 1999 to 2009 to assess for trend changes in abundance of the two species with relation to the flood regime. Inter annual, intra annual and between lagoons changes in abundance were assessed. It was found that *C. gariepinus* was the most abundant species from the three lagoons combined (CPUE = 507g/set) while *S. intermedius* had the highest catch rates at Guma lagoon. *S. intermedius* exhibited significant variation in abundance between lagoons (One way ANOVA; $P<0.05$) while there was no significant variation in abundance between lagoons for *C. gariepinus* (One way ANOVA; $P>0.05$). Generally catch rates increased during periods of low floods and decreased during periods of high floods. There was no significant variation in CPUE between months for both species (One way ANOVA; $P> 0.05$). The correlation between CPUE and mean monthly flow was significant and negative. This relationship could be modeled as ($CPUE = 140.29-0.27MM_F$, $r^2 = 0.63$, $P = 0.002$) where MM_F = Mean monthly flow. There was significant variation in CPUE between years for *S. intermedius* (One way ANOVA; $P<0.05$) while *C. gariepinus* exhibited no significant variation in CPUE between years (One way ANOVA; $P>0.05$).

Variations in abundance were more pronounced for *S. intermedius* than for *C. gariepinus*, indicating the hardy nature of *C. gariepinus* and its ability to adapt to different environmental conditions. In terms of abundance, *S. intermedius* can therefore be used as an indicator species in the Okavango delta due to is sensitivity to the flood pulse. The results indicate that perennial flood plain connected lagoons in the Okavango delta are important habitats that act as a refuge for fish biomass during low floods.

Key words: freshwater; fisheries; flood pulse; floodplain; lagoon; abundance; Okavango delta

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