Department of Ichthyology and Fisheries Science

Research Report Series 2009

RHODES UNIVERSITY
Department of Ichthyology and Fisheries Science
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(Version 1)

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Edited by: C.L.W. Jones & T.G. Paulet

Schedule of Events/Table of Content

Wednesday 14 October 2009

08h20-08h30: Welcome by Prof. Peter J. Britz (Head of Department)

Honours seminars (Chair: Prof. P.J. Britz)

08h30-08h50: Dave Landey (BSc Honours student) - Metabolic rate of the River Goby *Glossogobius callidus* and its level in response to harmful substances in the water

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

Funders: Rhodes University JRC

The River Goby is an abundant, endemic fish species found in South African fresh water systems and estuaries. Very little is known about the metabolic requirements and the physiological responses of this species to the growing threat of pollution and invasive fish species. This study examined this species' metabolic requirements, and, using these as reference points, the physiological responses to the introduction of harmful substances; i.e., pollution in the form of raw brewery effluent and an invasive predator species, by using Largemouth Bass (*Micropterus salmoides)* skin extracts. The hypothesis set for this experiment was that the dissolved oxygen consumption would be the same prior and subsequent to the fish's exposure to the harmful substances.
The objectives of the study were to:

- Determine the basal metabolic rate of the River Goby *G. callidus*;
- Determine the metabolic response to the introduction of harmful substances, such as an effluent and the simulation of the presence of a predator.

Using an intermittent flow respirometer to quantify metabolic rate and to test the effect of raw brewery effluent and the simulated presence of an invasive predator, the metabolic rate of each fish was recorded. By running a linear regression on the oxygen levels in the intermittent flow respirometer, and fitting the output data to a mass and time corrected model, the oxygen consumption of the fish (mg O_2 /g/m) was estimated.
The average basal dissolved oxygen consumption was calculated at 0.0395 mg/g/m. In the second and third parts of the study, i.e. before and after the introduction of harmful substances, the dissolved oxygen consumption ranged between 0.012 and 0.051 mg O_2/g/m and 0.0013 - 0.062 mg O_2/g/m respectively. There was no significant difference in mean oxygen consumption of *G. callidus* before and after the introduction of the test substances (p values > 0.05).
Although there was no significant response to the introduction of harmful substances , the metabolic response of the river goby to the introduction of naturally occurring fish species as well as conspecific skin extracts should be quantified. This will determine if the fish have physiological responses to species which are their natural predators, and if *G. callidus* reacts in the presence of an injured individual of the same species.

08h50-09h10: Jerraleigh Kruger (BSc Honours student) - The taxonomy of the Southern African *Atractoscion* fishes

Supervisors: Dr P.C. Heemstra (p.heemstra@saiab.ac.za) and Dr W.M. Potts (w.potts@ru.ac.za)

Funder: National Research Foundation (GUN 66957)

Genetic and life history studies showed differences between populations of Angolan and South African of *Atractoscion aequidens* as part of a southern African west coast inshore fisheries study. These results motivated a taxonomic study to establish if these populations are different species.

A total of 33 South African (mean = 522 mm, min = 323 mm, max =825 mm) and 52 Angolan specimens (mean= 334, min= 230, max= 556 mm) were collected from various localities in each country. Seven meristic and 24 morphometric characters were measured per fish. Morphometric measurements were converted to ratios of standard length or head length and arc-sine transformed. The arc-sine transformed data was tested for differences between their means using a student t-test. A principal component analysis (PCA) was used to distinguish if the populations were different species and give statistical significance to the differences between components. To exclude potential sex or maturity bias, a PCA was first run with each of these as test factors.

The PCA did not allow us to discriminate between males and females indicating that there was no sexual dimorphism in this species. Similarly, the PCA did not discriminate between juvenile and adult fishes suggesting that there are no significant morphometric changes after sexual maturity. While 14 of the 24 morphometric characters (58 %) were significantly different between the populations, the principal component scores on the first three axis (except PC1 which was a proxy for size) overlapped for specimens from both regions. The principal component scores of the Western Cape and Eastern Cape samples overlapped completely, confirming the previous assumption of a single South African *A. aequidens* stock.

While these preliminary findings suggest that the South African and Angolan fishes cannot be classified as different species based on the morphological species concept, Sciaenid's characteristically have a highly conservative morphology. By adding additional smaller South African specimens to the taxonomic analysis, it is hoped that the size bias (with many larger fish from South Africa) will be removed and a final decision on speciation can be made.

09h10-09h30: Denham Parker (BSc Honours student) - *Anguilla mossambica* populations and their associated parasites from three river systems in the Eastern Cape, South Africa

Supervisor: Dr O.L.F. Weyl (o.weyl@saiab.ac.za)

Funder: Rhodes University JRC

The African longfin eel, *Anguilla mossambica,* is a catadromous species found only in the south-western Indian Ocean. The species is likely to be an important component of river ecosystems in the Eastern Cape because it is the only truly endemic predatory fish in many rivers. There is little literature on *A. mossambica* and the parasites which are associated with the species. This study was designed to identify and quantify populations of the parasites associated with *A. mossambica* in three river systems of the Eastern Cape: the Sundays River, Great Fish River and Nahoon River and study aimed to determine a parasite baseline which may later be used for long term comparisons.

A total of 189 eels were caught using non-baited fyke nets and transported live to DIFS laboratory where they were dissected. This involved the removal and microscopic examination of the gills, swimbladder, stomach and intestine. Parasites were identified to the lowest taxonomic, and a sample of each preserved in 70% ethanol or 100% DESS. Four parasite species were assessed in the study: *Peudodactylogyrus anguillae* (gill monogenean), *Anguillicola papernai* (swimbladder nematode), *Heliconema longissimum* (stomach nematode) and *Paraquimperia africana* (intestinal nematode)

The parasite *P. anguillae* is alien to South African rivers and was found to have a high prevalence in eels from the Great Fish River (68%) and its tributary the Koonap River (77%), as well as relatively high mean intensities (91 ± 14 and 76 ± 15 parasites.fish^{-1}, respectively). However *P. anguillae* was not found in any other rivers, indicating that the hypothesized human assisted introductions were restricted to the Great Fish River and Koonap River. The stomach nematode *H. longissimum* was found at high mean intensities in Slagboom Dam (322 ± 422 parasites.fish^{-1}), Koonap River (51 ± 49 parasites.fish^{-1}) and Nahoon River (109 ± 120 parasites.fish^{-1}). Absence of *H. longissimum* in Great Fish River and Sundays River indicates the deficiency of specific secondary hosts (macroinvertebrates) in these systems. Parasites prevalence of *A. papernai* and *P. africana* were similar at all sample sites, and mean intensities of both species did not differ between sample sites. No significant correlation was found between parasite intensity and Fulton's condition factor (Spearman's ranked correlation; $p>0.05$).

Multidisciplinary ecological studies which incorporate parasitological factors are essential to gaining further knowledge of complex ecological interactions, and are a vital step in the transition to better understanding ecosystems and ultimately the management of the species *A. mossambica.*

09h30-09h50: James McCafferty (BSc Honours student) - On the feasibility of a *Clarias gariepinus* longline fishery on Darlington Dam, Eastern Cape, South Africa

Supervisors: Dr O.L.F. Weyl (o.weyl@saiab.ac.za) and Prof. A.J. Booth (t.booth@ru.ac.za)

Funders: SAN-Parks, National Research Foundation, Rhodes University JRC

The feasibility of developing a longline fishery for sharptooth catfish, *Clarias gariepinus*, was investigated on Darlington Dam, situated in Addo Elephant National Park in the Eastern Cape. The study comprised an assessment of longline catch per unit effort (CPUE) data as well as analyses of angling competition- and longline length frequency data. This information as well as other biological data was used to apply yield-per-recruit and spawner biomass-per-recruit models to assess the potential for developing a fishery and provide management recommendations to the Park. Four sampling trips were conducted in March, April, May and August of 2009. The dam was divided into 15 areas incorporating bays and open water. Four longlines rigged with 20 9/0 circle hooks were set over a day and at night in a randomly selected area. Captured fish were measured (mm TL), weighed (kg), sexed and released. Data from longlines was compared to boat angling competition data to compare length frequency and selectivity. Biological reference points (BRP's) were investigated to determine the maximum yields that could be attained such that profits were maximised within sustainable levels for the fishery. Weight-at-age was estimated as $W_{(t)} = 0.00030L_{(t)}^{2.9235}$. Length-at-50% selectivity was estimated at 760mm on the longlines and 822mm using angling gear which corresponded to ages of 8.44 and 11.42 years respectively. Mean CPUE was not significantly different across season, sampling period, or diel period (ANOVA, $p < 0.05$). The following biological reference point estimates were calculated using per-recruit analysis: $F_{max,}$ F_{SB30}, F_{SB40}, and F_{SB50} = never be attained; $F_{0.1}$ = 1.80 years^{-1}, $F_{0.2}$ = 1.37 years^{-1} (longlines); $F_{0.1}$ = 1.49 years^{-1}, $F_{0.2}$ = 1.13 years^{-1}. Potential harvest for the longline fishery was estimated at 21 tonnes. An economic evaluation estimated start-up expenses for a small longline fishery enterprise as approximately R348 000. Annual income was estimated at R132 000. The BRP's indicated that a longline fishery would be sustainable yet would not maximise yields to the extent that a fishery enterprise of this scale would become economically viable. Recreational angling pressure is currently also sustainable and, given the importance of this venue for recreational angling, it is recommended that the park continue to manage Darlington Dam as a fishery catering predominantly for recreational angling.

09h50-10h10: Malcolm Anderson (BSc Honours student) - The effect of propolis on rainbow trout *Oncorhynchus mykiss* egg survival and fungal infection

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

Funders: Beonics (Pty) Ltd, Rhodes University JRC

The rainbow trout, *Oncoryhnchus mykiss*, industry in South Africa is plagued by fungal infections of the eggs, especially during the early egg and hatching phases. Prophylactic measures in rainbow trout hatcheries are based on the use of formaldehyde and malachite green. The purpose of this work was to determine whether propolis could be an alternative antifungal agent for the prevention of saprolegniasis as well as to see whether the presence of propolis affects the survival rate of the eggs.

The experiment was carried out over 22 days. There were 60 experimental units and the independent variables were either fertilized or unfertilized eggs and either a 0.1% propolis concentration, a 0.2% propolis concentration, a 0.1% ethanol concentration, a 0.2% ethanol concentration or a control of spring water. Each experimental unit contained 20 fertilized or unfertilized eggs and was treated with one of the concentrations.

Propolis reduced the occurrence of fungal growth with a mean number of 8.1 ± 4.15 (fertilized eggs) and 6.0 ± 3.94 (unfertilized eggs) at the 0.1% concentration. Similarly there was a mean number of 7.1 ± 2.05 (fertilized eggs) and 4.33 ± 7.92 (unfertilized eggs) for the 0.2% concentration. Ethanol was not effective with a mean number of 19.9 ± 19.67 (fertilized eggs) and 20 ± 0 (unfertilized eggs) for the 0.1% concentration. There was also a mean number of 19.5 ± 18.73 (fertilized eggs) and 20 ± 0 (unfertilized eggs) at the 0.2% concentration. The control treatments showed similar results to the ethanol treatments with a mean number of 20 ± 0 (fertilized eggs) and 20 ± 0 (unfertilized eggs).

While propolis was effective in suppressing fungal growth it may reduce egg survival. The eggs treated with ethanol or the control were able to survive longer than the eggs in the propolis treatments. The 0.1% concentration of propolis was harmful to the eggs. It is thus recommended that further studies are undertaken with lower concentrations of propolis, to find a concentration that will not only hinder fungal growth but also ensure egg survival. Research could also look into the possibility of using propolis as a dip treatment.

10h10-10h30: Matthew Parkinson (BSc Honours student) - The effect of water turbidity on the foraging success of the river goby *Glossogobius callidus*

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

Funders: Rhodes University Prestigious Honours Scholarship, National Research Foundation Block Grant Scholarship, National Research Foundation (FA2007043000021)

Particles suspended in water attenuate light, impacting on the optic nature of the environment and affecting primary productivity. As rivers and estuaries are becoming ever increasingly degraded, it is therefore prudent to understand the potential impact increased turbidity might have on the resident flora and fauna.

This study investigated the effects of turbidity on the foraging success of the river goby, *Glossogobius callidus* (Smith 1937), a cosmopolitan species with a widespread southern African distribution. Mobile and stationary prey, backswimmers and damselfly nymphs respectively, were used in the experiments to examine the interaction between prey mobility and turbidity on the goby's foraging success.

In the experiment, a single goby was placed in a bucket containing either clear or turbid water with or without detritus at the base. Each bucket contained either 10 backswimmers or 5 damselfly nymphs. After a period of six hours the buckets were inspected to determine how many prey individuals were consumed by the gobies.

Neither water turbidity nor refuge had a significant effect on the proportion of water boatmen consumed ($F_{1,21}$ = 0.0001, p = 0.9; $F_{1,21}$ = 0.25, p = 0.62 respectively). Gobies consumed a significantly greater proportion of damselfly nymphs in turbid water compared to clear water (t = 2.5, df = 14, p = 0.03). On average there was no significant difference between the proportion of water boatmen and damselfly nymphs consumed in clear water (t = 0.42, df = 12, p = 0.67), however in turbid water the mean proportion of damselfly nymphs consumed was higher than that of the backswimmers (t = 3.17, df = 12, p = 0.008).

Turbidity did not affect the foraging success of gobies on mobile prey due to high predator-prey encounter rates. Foraging efficiency was only sensitive to the effects of turbidity where stationary prey were involved, with a higher success rate observed in turbid water. The motivation hypothesis may explain this, assuming that the gobies perceive a lower risk of predation in more turbid water resulting in a higher success in foraging, despite impaired vision.

Different fish species are influenced differently by changes in the turbidity of their environment. Some species have a reduced foraging ability with increasing turbidity. Other species show no difference in their foraging success rate with an increase in water turbidity. Furthermore, other species tend to have a higher foraging rate in more turbid water. Flexible foraging modes exhibited by certain fish species may be advantageous in a dynamic environment. With an increase in turbidity it can be predicted that predator-prey interactions involving gobies, and stationary prey especially will be affected, with an increase in encounter rates a potential outcome. The rate of encountering mobile prey is unlikely to be significantly reduced by increasing turbidity.

10h30-10h55: Tea break

Honours seminars continued (Chair: Prof. P.J. Britz)

11h00-11h20: Micheen Thornycroft (BSc Honours student) - The thermal preference of goby *Glossogobius callidus*

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

Funder: Rhodes University JRC

Rivers and estuaries are greatly influenced by up-stream occurrences which alter salinity, nutrient level, temperature, water quality and quantity (Russell 1999, Strydom and Whitfield 2000). There is an increase in human demand for fresh water, and so dams are constructed (Strydom and Whitfield 2000). This results in a decrease in the depth and flow rate downstream possibly causing a gradual increase in water temperature, which affects the ichthyofauna in the streams (Strydom and Whitfield 2000, Skelton 2007). Bulldozing is also occurring around river beds removing vegetation and cover (Simms 2007). No studies have been published to show the effect that this has on *G. callidus.*

The aim of this study was to determine the thermal preference of *G. callidus* which will contribute to our knowledge and understanding of the species biology. The final temperature preference of the river goby, *G. callidus,* was determined using horizontal temperature choice chamber tanks. Trials were conducted over a 6-day period with the temperature gradient ranging from 22 ^{o}C to 27 ^{o}C. The control trial was run for the same length of time in isothermal conditions. Experiment 2 was run directly after the control using the same fish (n=10) and tanks allowing analysis of the *G. callidus* movement when a temperature gradient was introduced. The temperature gradient was introduced while the *G. callidus* were present in the tanks. In both experiments the temperature preference of *G. callidus* was found to be between 24 ^{o}C to 26 ^{o}C, which falls in the upper end of the temperature tolerance range of *G. callidus* which is 0 ^{o}C to 30 ^{o}C.

Previous experiments have been conducted whereby the fish were introduced into an already existing temperature gradient (Reynolds et al. 1977, Barila and Stauffer 1980, Tongiorgi et al. 1985, Haro 1990, Chen and Chen 1991, Bernatzeder and Britz 2007, Mortensen et al. 2007). Although this method has been widely used in the determination of the thermal preference of fish, it does not allow a control to which you can compare the experimental results. Experiment 2 made it possible to use the data from a control experiment as ‘expected values’ when analyzing the data from experiment 2. Further studies should be done using the same method used in experiment 2, and a cold finger should be introduced in order to create a wider temperature range.

11h20-11h40: Nicholas Riddin (BSc Honours student) - The effect of dietary lipid on carcass lipid levels in juvenile dusky kob, *Argyrosomus japonicus* (Pisces: Sciaenidae)

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

Funder: Marifeed (Pty) Ltd, THRIP

The dusky kob, *Argyrosomus japonicus*, is a fast-growing, predatory fish which, due to its high demand, is being overfished. It is possible to manipulate the flesh quality and growth and health of animals by altering their diets. Dietary lipid has been found to have negative effects on growth and health in other fish species. The overall aim of this trial was to understand the effect that dietary lipid level has on lipid accumulation in the bodies of juvenile kob. The objectives of the study were to compare the carcass lipid contents, feed conversion ratio (FCR) and growth, health and nutrition of juvenile kob fed diets with different lipid levels.

Thirty six juvenile dusky kob were placed into 12 closed systems with three fish in each. These fish were fed on one of four dietary treatments for 53 days. The diets ranged from 6 – 18 % lipid by weight. Fish were measured (TL) and weighed before and after the trial. A whole carcass lipid analysis was carried out for each fish. Feed conversion ratio (FCR) and growth, health and nutrition were calculated. A haematocrit was conducted. Non-parametric Kruskal-Wallis ANOVA ($p < 0.05$) was used for each variable to determine whether dietary lipid level had a significant influence on the variables.

Dietary lipid level had a significant influence on carcass lipid composition ($H_{3,24} = 21.6$, $p = 0.0001$) with an increase in carcass lipid from 10.7 ± 2.6 % lipid to 22.4 ± 1.4 % lipid ($y = -0.0259x^2 + 1.789x – 4.0808$, $R^2 = 0.97$), abdominal fat index (Regression analysis: $F = 5.19$, $p = 0.04$, $y = 0.0087x^2 - 0.0988 + 4.2593$, $R^2 = 0.37$) and haematocrit value ($H_{3, 22} = 8.57$, $p = 0.04$). Dietary lipid level did not significantly affect feed conversion ratio (overall mean = 4.1 ± 1.3; Kruskal-Wallis ANOVA: $H_{3,12} = 5.05$, $p = 0.17$), percentage weight gain (overall mean = 57.5 ± 30.3 %; Kruskal-Wallis ANOVA: $H_{3,36} = 6.43$, $p = 0.09$), specific growth rate (overall mean = 0.9 ± 0.1 % body weight per day; Kruskal-Wallis: $H_{3,36} = 4.94$, $p = 0.18$) and condition factor (overall mean = 2.8 ± 0.1; Kruskal-Wallis ANOVA: $H_{3,36} = 4.34$, $p = 0.23$) of juvenile dusky. There was no significant difference between hepatosomatic index and visceral index values between dietary treatments (Kruskal-Wallis ANOVA: $H_{3,36} = 1.95$, $p = 0.58$ and Kruskal-Wallis ANOVA: $H_{3,36} = 3.33$, $p = 0.34$, respectively), with an overall mean HSI of 1.9 ± 0.4 and an overall mean VSI of 8.8 ± 1.1.

Carcass lipid can be manipulated through changes in dietary lipid. Some of this fat is deposited in the abdominal cavity, surrounding the organs. The deposition of the remainder of the lipid may be in the fillets since there was evidence of proportional increases in weight in other parts of the body, *viz.* the viscera and liver. Dietary lipid level had no significant effect on growth. However, there is evidence to suggest that an increase in dietary lipid may negatively affect health in juvenile dusky kob. It is possible to manipulate the carcass lipid composition of juvenile dusky kob reared on artificial feeds without affecting growth, but increased dietary lipid may have a negative effect on fish health.

11h40-12h00: Reece Wartenberg (BSc Honours student) - On the biology of *Clarias gariepinus* (Burchell, 1822) in a temperate Eastern Cape reservoir, South Africa

Supervisors: Prof. A.J. Booth (t.booth@ru.ac.za) and Dr O.L.F. Weyl (o.weyl@saiab.ru.ac.za)

Funders: National Research Foundation, Rhodes University JRC

Clarias gariepinus (Burchell, 1822) is a widely distributed species occurring naturally from as far north as Turkey to the Orange River in South Africa. Due to human induced introductions *C. gariepinus* now occurs on the five continents Africa, Asia, Australasia, Europe, and South America. In South Africa, largely due to the implementation of water transfer schemes in the late 1970's, *C. gariepinus* has invaded many river systems outside its natural range including the Great Fish River and Sundays River in the Eastern Cape. Understanding the biology of this widespread alien invasive is directly relevant to fisheries management and conservation.

Darlington Dam (33° 10' 31" S, 25° 09' 13"E) is situated in the Eastern Cape of South Africa and has a large population of alien *C. gariepinus* as a result of introductions via South Africa's Orange River Project water transfer scheme opened in 1978. This study investigated the Darlington Dam population using data collected from July 2007 to August 2009. Fish were captured using longlines, gill nets, and fyke nets (n = 1056).

By counting post fluorescent mark increments on otoliths from 21 fish that were injected with 0.5 mg/kg oxytetracycline hydrochloride, marked with dart tags, released into the wild and recaptured 244 - 537 days later, the annual deposition of a single growth increment was validated. Examination of sectioned otoliths from 193 fish revealed that the oldest fish, a 1074 mm Total Length (TL) male, was 25 years old. Length-at-age was subsequently described using the von Bertalanffy growth model. There was no difference between growth of males and females and combined-sex growth was best described as $L_t = 920.6\ (1 - \exp(-0.16(t - 2.22)))$ mm TL. Length at maturity was determined by macroscopically staging the gonads of 93 fish. Length-at-50%-maturity was calculated as 528 mm TL and fish matured after their third year of life. Total mortality (Z) was estimated at $0.3.yr^{-1}$, natural mortality (M) at $0.22.yr^{-1}$ and fishing mortality F at $0.08\ yr^{-1}$.

These results show that *C. gariepinus* are long lived with the oldest fish in this study being ten years older than previously described and are subject to relatively low rates of mortality. Length-at-maturity is in agreement with other temperate Southern African *C. gariepinus* populations. A high frequency of older year classes (>12), corresponding to the time of completion of the Orange River Project water transfer scheme suggesting that *C. gariepinus* was able to invade Darlington Dam rapidly.

12h00-12h20: Richard Peel (BSc Honours student) - Estimation of *Clarias gariepinus* abundance and movement in Darlington Dam, Eastern Cape, South Africa

Supervisors: Prof. A.J. Booth (t.booth@ru.ac.za) and Dr O.L.F. Weyl (o.weyl@saiab.ac.za)

Funders: SAN-Parks, National Research Foundation, Rhodes University JRC

The African sharptooth catfish, *Clarias gariepinus*, has been translocated intentionally and unintentionally into many aquatic systems outside of its natural range. Its life history traits and generalist feeding habits have allowed it to successfully invade systems where it has been introduced. The objectives of this study were to contribute towards the understanding of the ecology of *C. gariepinus* in invaded impoundments. A mark-recapture study was used to investigate the population dynamics of *C. gariepinus* in the 4350 ha^{-1} Darlington Dam (33° 10' 35.64"S, 25° 08' 55.40"E) with the aim of contributing towards the development of proactive approaches to manage invasions.

Fish were captured using two methods (1) longlines and (2) angling during fishing competitions. Fish were tagged using a single numbered PDL plastic-tip dart tag. Fish were injected with oxytetracycline tetrachloride at a dosage of 0.5ml.kg^{-1} body weight for a separate age and growth study, measured, sexed, weighed and released. Recaptured fish had their tag numbers recorded, were measured, sexed, weighed and released. Some recaptures were sacrificed and their otoliths removed for the age and growth study. An adjusted mark-specific Cormack-Jolly-Seber model was used to estimate the probability of capture, survival and population size after each sampling event.

A total of 8683 fish were captured over 10 sampling events between October 2007 and August 2009. Of these, 1758 fish were tagged and 89 fish were recaptured giving an observed recapture rate of 1.03%. The longest time at liberty was 659 days and the average was 227±171days. The sex ratio of fish in this study was skewed towards males (69%). Movement of tagged fish was random, with no correlation between the number of days at liberty and the approximate linear distance moved (R^2 = 0.064). The Cormack-Jolly-Seber model estimated the abundance of adult *C. gariepinus* to be 27937 [95% CI = 20541 : 51512], corresponding to a density of 17.78 [95% CI = 13.08 : 32.89] fish.ha^{-1} and a biomass of 69.26 [95% CI = 50.95 : 128.1] kg.ha^{-1}. The estimated natural mortality rate was high at 1.13 .$year^{-1}$ (CV = 24%).

The population density of adult fish in Darlington Dam is considerably lower than the estimate from Hartebeespoort Dam in Gauteng (88 adult fish.ha^{-1}), but similar to the estimate from Glen Melville Reservoir in the Eastern Cape (22.49 adult fish.ha^{-1}). Biomass estimates from Lake Kariba (5.5 kg.ha^{-1}) are however considerably lower than that of Darlington Dam. The relatively low population density and high natural mortality of adult fish targeted in this study, as well as high vulnerability to sampling gear mean that the population may be at risk of overfishing.

12h20-12h40: Shelley Moss (BSc Honours student) - Determination of dose-response relationships for rotenone on gill-respiring and plastron-respiring invertebrates

Supervisors: Prof. A.J. Booth (t.booth@ru.ac.za) and Dr O.L.F. Weyl (o.weyl@ru.ac.za)

Funder: Rhodes University JRC

Fishery managers have relied on a wide variety of tools for the removal of alien invasive species including piscicides. The piscicide rotenone, derived from the legume *Derris elliptica*, is the most commonly used. Rotenone interferes with cellular respiration by preventing the uptake of oxygen in fish and many invertebrates, this is achieved by affecting cellular energy production. Fish have a high susceptibility of rotenone due to the efficient entry of the toxicant through the gills but aquatic insects have gill-like tracheae, cuticles and a mid-gut that allows them to be just as susceptible as fish to the toxic effects of rotenone. Unfortunately, little is known on the effects of rotenone on the environment as well as on the aquatic invertebrates, an important taxa in aquatic food webs. This is due to many studies being primarily focused on fish.

The first objective of this study was to determine the lethal concentration of rotenone to an invasive species, Mozambique tilapia (*Oreochromis mossambicus).* The second objective was to determine the dose-response relationships for rotenone on gill-respiring and plastron-respiring invertebrates at the concentrations found to be lethal to *O. mossambicus.*

Fish (*Oreochromis mossambicus*), gill-respiring (Order Odonata) and plastron-respiring invertebrates (Family Corixidae) were exposed to six different concentrations of rotenone: 0, 0.05, 0.15, 0.25, 0.5 and 1.5 mg/L. The susceptibility to rotenone was tested at two different temperatures: 20 and 28^0C. Observations of the fish condition were made up until the end of 30 minutes. Observations of the insects were recorded at 2, 5, 9, 19, 23, 44 and 48 hours. Survival was taken up to the cessation of movement.

Oreochromis mossambicus were more susceptible to the lower concentrations of rotenone, especially at the higher temperatures when compared to the two different types of insects. Yet the insects, especially the gill-respiring insects are similarly affected to the toxicant however the effects simply take longer. The slow rate of degradation of rotenone once in the system creates an adverse affect on the invertebrate community due to the delayed response from the two groups of insects. The full effects of rotenone should be considered to greater extents before it is used for fisheries management. Through limited research as well as this laboratory study it is shown that the non-target organisms such as aquatic insects, gill-respiring as well as plastron-respiring are negatively affected.

12h40-13h00: Taryn Murray (BSc Honours student) - An evaluation of the illegal coastal fishing effort in the Tsitsikamma National Park Marine Protected Area, South Africa

Supervisors: Dr P.D. Cowley (p.cowley@saiab.ac.za) and Mr M.K.S. Smith (kyles@sanparks.org)

Funders: South African National Parks, South African Institute for Aquatic Biodiversity

The absence of fishing pressure in Marine Protected Areas (MPAs) has contributed to fisheries management in many ways. Research conducted in South Africa and elsewhere has revealed that the benefits of "no-take" zones extend from the species level through to the ecosystem level. However, studies of MPAs rarely take into consideration the potential negative effects of non-compliance and illegal fishing activities. In an attempt to address this shortcoming, the present study evaluated when, where and how much illegal fishing is taking place within South Africa's oldest and largest MPA, the Tsitsikamma National Park (TNP).

This evaluation made use of aerial surveys conducted from the Kaaimans River (Wilderness) to the Groot River (eastern boundary of the TNP) and roving creel surveys conducted within the TNP (Klip River to Bloukranz River), between January and September 2009. Additionally, information was obtained from law enforcement patrol log books and interviews with research anglers.

Aerial surveys revealed that angler densities in the TNP (0.03 – 0.14 anglers.km^{-1}) were significantly less than in adjacent open access areas (0.07 – 1.51 anglers.km^{-1}). Distinct "hot spots" were identified during the creel surveys and these localities were confirmed by interviews with research anglers. Evidence of fishing activities (e.g. fish scales, bait packets etc.) used as a proxy for fishing effort showed no significant difference between three identified "hot spots" within the TNP compared to a popular site (Salt River) outside the park. This suggests that illegal fishing is prevalent in the TNP, which was noticeably higher on weekend days and more concentrated over the summer months (February – April). Analysis of fish scales collected during the creel surveys indicated that at least eight different species were captured. It was also evident that considerable effort is placed on targeting species that become vulnerable during summer-dominated upwelling events (e.g. santer *Cheimerius nufar*). Examination of law enforcement patrol log books suggested that records were poorly maintained and that most patrols took place during daylight hours on week days. Surprisingly, there was no significant difference between surveillance effort and the recorded number of angling incidents.

It was concluded that high levels of illegal angling takes place within certain areas of the TNP and that effort was more intense during summer and on weekend days. Recommendations are made to improve monitoring and surveillance efforts in an attempt to counteract the potential impacts of illegal fishing within the TNP.

Thursday 15 October 2009

Humphrey Greenwood Guest Speaker (Chair: Prof. P.J. Britz)

08h30-09h10: Professor Terrance J. Quinn II – School of Fisheries and Ocean Sciences, University of Alaska, Fairbanks – Incorporating biological and environmental realism into fisheries stock assessment models

Aquaculture (Chair: Ernst Thompson)

09h10-09h30: Matthew Naylor (MSc student, second year) - Water quality and abalone production in a serial-use raceway system

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

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

Water quality in intensive and semi-intensive aquaculture can be controlled by stocking density and flow-rate. This requires knowledge of the concentrations at which specific water quality variables may affect growth, an aspect not well documented in the culture of *Haliotis midae*. Extrapolating data from toxicity experiments is difficult, as the majority are single factor experiments where only the variable in question has been altered. In production systems water quality parameters are altered simultaneously by the metabolic activity of the culture animals. A serial-use raceway provides an opportunity to observe growth and water quality under various production scenarios.

Trial 1 described the changes in water quality between tanks in a serial-use raceway in relation to accumulated biomass and water flow and estimated the flow rate (L h^{-1} kg^{-1}) at which growth was reduced in 60-70 mm large *H. midae*. Three serial-use raceways each with seven 300 L tanks in series were set-up. All tanks held one basket stocked with 8.0±0.1 kg of abalone. Water quality variables were measured twice a week. A sample of 50 abalone per tank were individually weighed and measured at the start and end of the 101-day trial. Water quality became progressively degraded due to the metabolic activity of the abalone. Significant growth reductions (ANOVA; $F_{(6,\ 14)}$ = 13.924, p = 0.00003) and increased FCR values (Kruskal-Wallis test; $H_{(6,\ 21)}$ = 16.34632, p = 0.0120) were observed for abalone in the lower tank positions. Temperature and suspended solid concentration was similar between tanks in series. pH and dissolved oxygen were negatively correlated with tank position. FAN and nitrite concentration were positively correlated with tank position. Flow rates less than 7.2 – 9.0 L h^{-1} kg^{-1} are likely to cause significant growth reductions in *H. midae*.

The aim of trial 2 was to determine 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 in this experiment. The system was set-up as six raceways with three tanks in series. Temperature, pH and TAN were measured daily for 17 days. TAN concentrations in tanks fed the 26% and 22% diets, were on average 43% and 65% lower then TAN concentrations in tanks fed the 33% protein diet. Assuming that growth rates will be similar, it would be advantageous to reduce the percentage protein in artificial diets for >50g *H. midae*, as this will reduce feed costs and lead to an improvement in water quality.

Ongoing trials aim to determine the first limiting water quality parameter in the serial-use raceway and validate the conclusions drawn from trial 1. These results will enable the design of tank systems and management protocols that make the most efficient use of the available water.

09h30-09h50: Albert Esterhuizen (PhD student, fourth year) - An investigation into dietary protein and energy requirements for juvenile *Haliotis midae* at weaning

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

Funders: Norwegian Agency for Development (NORAD), THRIP, University of Namibia, Marifeed Pty (Ltd), Aquafarm Development (Pty) Ltd, HIK Abalone Farm (Pty) Ltd, Rhodes University JRC

Inconsistent growth and survival of post-settled abalone remains a bottleneck in worldwide abalone production when weaned from a natural diet onto an artificial feed. Results from a baseline study investigating gut enzyme dynamics during weaning suggested that dietary lipid may contribute significantly more to the energy requirements of juvenile *Haliotis midae* during weaning than previously thought. A subsequent study showed that during weaning juvenile *H. midae* were capable of digesting diets containing dietary fat levels as high as 16 % and showed no significant differences between iso-nitrogenous diets containing dietary fat ranging between 2 and 16 %. In the light of the experience described above, a study was formulated to address the protein and energy requirements of juvenile *H. midae* during weaning. The study also aimed at addressing the essential fatty acid requirements of juvenile *H. midae*.

Five agar bound diets were formulated to contain graded levels of protein and energy ranging between 30-37 % and 1.51-1.86 MJ/kg respectively. The protein:energy ratio was kept constant at 20 g/MJ in all experimental diets. Two control diets (high protein:low energy and low protein:high energy) were formulated to eliminate a possible masking effect of increased protein on growth. Also, an agar bound diet containing Abfeed® S34 was fed to juvenile *H. midae* as a reference to the performance of the experimental diets. At the end of the 42 day trial, abalone were sampled for muscle glycogen content, protein, lipid and fatty acid analyses. Results showed that increased dietary lipid negatively influenced growth (ANOVA, $p < 0.05$) and that growth was independent of dietary protein. From this study, it was clear that juvenile *H. midae* at weaning are unable to effectively utilise dietary lipid as an energy source. Diet 1 (30% protein and 1.5MF, low protein: low energy) yielded similar growth compared to the reference diet (Abfeed® S34), but foot muscle glycogen in abalone fed diet 1 was significantly higher compared to abalone fed the reference diet indicating a better physiological condition (1.51% and 0.8% for abalone fed diet 1 and the reference diet respectively) (ANOVA, $p < 0.05$).

Interestingly, results suggest that imbalances in the ratio of iecosapentanoic acid 20:5n-3,EPA) and arachidonic acid (20:4n-6,ARA) might be the reason that wean age abalone were unable to utilize lipid as an energy source in artificial feeds used in this study, even though juvenile abalone in the wild prefer diatoms which in certain species are high in lipid. This hypothesis will be discussed and further work will investigate bridging this “gap” using novel feed technologies.

09h50-10h10: Siyabonga Maliza (MSc student, first year) - Development of probiotic diets for the South African abalone *Haliotis midae* industry

Supervisors: Prof. H. Kaiser (h.kaiser@ru.ac.za), Dr C.L.W. Jones (c.jones@ru.ac.za) and Prof. P.J. Britz (p.britz@ru.ac.za)

Funders: THRIP, Marifeed (Pty) Ltd, Department of Agriculture, National Research Foundation

Farm-cultured abalone are frequently exposed to various stressor such as temperature fluctuations, high stocking densities, periods of elevated ammonia concentration and depleted oxygen, for example. These stressors negatively affect the abalone, thereby reducing farm production efficiency. The immune system can be enhanced using probiotics. Probiotics can also improve growth through improved feed utilisation of cultured organisms. *In vitro* screening of three probionts has been conducted in recent research and has shown to be beneficial to laboratory reared abalone. However these bacteria strains have not been tested on abalone under controlled farm conditions, with the aim of quantifying their effect on farm production.

The aim of this study is to: - produce an abalone feed that contains a suite of probiotics that promote abalone growth and health under the stress of farming conditions. The objectives were to:- compare growth, survival and physiological differences of abalone fed Abfeed®S 34 and probiotics (i.e. probiotic diet) to abalone fed the conventional Abfeed®S 34 without the addition of probiotics (i.e. control diet), either subject to additional stress or not.

Three experiments are currently being conducted:

(1) To determine the effect of probiotic diet on abalone growth and health under stressful conditions, the growth of abalone fed either the test or control diet will be compared. In addition, treatments fed these diets will either be subject to normal farm handling or to additional handling stress. This trial is currently being carried out at HIK Abalone Farm (Pty Ltd) on 30–40 g abalone and will last for a period of 120 days, to be concluded on 24 November 2009. Haemolymph will be drawn from abalone samples to examine blood parameters i.e. total haemocyte count, phagocytosis and respiratory burst (Nitroblue tetrazolium reduction assay) at the end of the trial.

(2) A similar trial is being carried out at Aquafarm Development (Pty) Ltd, but the probiotic diet is being fed to different abalone at various frequencies in order to
determine the required frequency that the probiotic diet needs to be fed. This trial will be concluded on 04 January 2010.

(3) The third trial includes a comparison of the test and control diet only at Roman Bay Sea Farm (Pty) Ltd where all the abalone in the trial are subject to stressful conditions due to limited water flow rates at this facility. This trial will be concluded on 17 December 2009.

10h10-10h30: Rory Scheepers (MSc student, first year) - Treated brewery effluent as a water source for the culture of the ornamental fish Xiphophorus helleri (swordtail)

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

Funder: South African Breweries Ltd

Globally large industries utilize large volumes of water and the byproduct is water that has been polluted by cleaning detergents and other harmful chemicals. This water is then of little use to the industry and is either sent to sewer where the local municipalities have to deal with the contaminated water or in the case of Ibayi Brewery (SAB Ltd, Port Elizabeth), partially treat the water through biological, mechanical and chemical treatments. This is an expensive process due to the high cost of chemicals and capital outlay. A pilot-scale volume of brewery effluent is currently being treated using a biological facultative and algal ponding processes, after the effluent has undergone mechanical screening and anaerobic digestion. This removes the high levels of toxins in the effluent, such as ammonia. The aim of this project is to establish if this treated effluent is suitable for fish culture. In order to test whether or not the treated effluent is safe to use for fish production, it was hypothesised that there is no significant difference in growth, reproduction, mortality and health of fish grown in treated brewery effluent compared to those grown in un-used water as the control.

Water quality analysis will be carried out to determine the level of phosphate, nitrate, nitrite, ammonia, pH, dissolved oxygen, chemical oxygen demand (COD) and water temperature. The condition, feed conversion ratio and growth of fish in both treatments will be compared by measuring fish length (0.1 mm) and weight (0.001 g) over a period of eight to 12 weeks. Fish survival and health will also be monitored by comparing the physiology and/or histology of the gills, gut, liver, blood and skin.

A second trial will compare the reproductive output and reproductive biology of fish grown in treated brewery effluent and un-used water. Egg quality (e.g. egg size, yolk volume and density, and lipid content), fecundity and survival of juveniles that are produced in treated brewery effluent compared to those that are grown in un-used water will also be recorded.

The aim of the study is to determine whether brewery effluent is a suitable water source for the culture of fish. The possibilities of expanding the operation on a larger more productive scale will be determined and socio-economic analysis will be carried out to determine if fish farming remains an effective way of utilising large volumes of brewery effluent with the added benefit of job creation.

10h30-10h55: Tea break

Marine Fisheries and Management (Chair: Henning Winker)

11h00-11h20: Amber Childs (PhD student, second year) - Ontogenetic habitat use and movement behaviour of dusky kob *Argyrosomus japonicus*

Supervisor: Dr P.D. 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 catadromous 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.

11h20-11h40: Bruce Donovan (MSc student, fourth year) - A retrospective assessment of the Port Alfred/Kenton-on-Sea/Boknes linefishery

Supervisors: Prof. T. Hecht (t.hecht@ru.ac.za) and Dr O.L.F. Weyl (o.weyl@saiab.ac.za)

Funder: Marine and Coastal Management

In 1985/87 the Port Alfred fishery was the third largest fishery along the south and south-east coast of South Africa (excluding snoek and yelllowtail) (Hecht and Tilney 1989). A total of 54 commercial vessels were licensed in the area and of these 23 operated on a full-time basis. Based on their work, Hecht and Tilney (1989) showed that the fishery was under pressure and recommended that further growth in the fishery be curtailed.

The aim of this study was to evaluate the effectiveness of linefish management strategies that were implemented by Marine and Coastal Management (MCM) since 1987; and to assess the behaviour of the fishery in response to the new management environments. Significant changes have occurred in this fishery over the past two decades. There has been a 78% drop in the number of full-time commercial operators from 23 in 1986/7 to five in 2009. The fishery is now numerically dominated by recreational fishers at a ratio of 30:1. GLM standardized CPUE data show that there were two well defined periods in the fishery. The first period from 1985 to 1998 is characterised by declining CPUE. The second period for 2001 to 2008 on the other hand shows an increase in CPUE. At first glance, it would appear that the 80% reduction in commercial effort between 1999 and 2002 has led to a rapid increase in catches by the few remaining commercial operators. However, the apparent increases in CPUE are largely due the high abundance of geelbek particularly in 2004/5 and 2007/8, which contributed significantly to the increasing CPUE trend from 2001/2 onwards. While silver kob was and still is the mainstay species of the fishery that is subject to a consistent and sustained fishing pressure the commercial fishers capitalize strongly on the migratory runs of geelbek. This supposition is strongly supported by the catch composition analysis and monthly landings. The strong recruitments of geelbek has masked the general decrease in CPUE of the major species in the fishery such as silver kob, panga, santer, red roman and dageraad. Griffiths (2000) reported a declining CPUE of silver kob for the South Eastern Cape region during the late nineties. The continuing negative trends in the CPUE observed in this study indicated a further decline in silver kob stocks.

Despite the reduction in commercial effort and implementation of various fishing output regulations, the fishery is currently unstable and reliant on strong recruitments of migratory geelbek. Based on the available evidence it was postulated that the fishery would currently be in a poorer state if the reduction in commercial effort had not occurred.

11h40-12h00: Hylton Newcombe (MSc student, third year) - The contribution towards the development of a management plan for the baitboat and sportfishery for tuna in South Africa

Supervisors: Prof. W.H.H. Sauer (w.sauer@ru.ac.za) and Dr O.L.F. Weyl (o.weyl@ru.ac.za)

Funders: World Wildlife Foundation-SA, Fresh Tuna Exporters Association, Claude Leon Foundation

Tuna are of significant global economic importance and a prime food source. Increased fishing intensity has lead to a near collapse of the stocks and fishery. The South African tuna industry comprises of three sectors: baitboat, sport and longline. Information from South Africa is very limited. This information will aid the development of a management plan for the fishery and towards South Africa's contribution at the international convention for the conservation of Atlantic Tunas and the Indian Ocean Tuna Convention.

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, life history parameters, and genetic analysis.

The age and growth of yellowfin tuna (*Thunnus albacares*), in the south eastern Atlantic and south western Indian oceans, off the South African coastline was investigated, using growth increments on whole vertebrae. The purpose of the study was to determine mean length at age for *T. albacares* across the Atlantic and Indian Ocean boundary (20° E) as no prior studies on age – growth for *T. albacares* for this region exists. The vertebrae age technique was employed due to the ease of obtaining each structure, readability of growth increments, time required for processing and high precision of age estimates (Filmalter *et. al.*, 2009; Alves *et. al.*, 2002). 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. The estimated reading error (IAPE) between examiners was 4.46 % for the overall sample. 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.

12h00-12h20: Timothy Richardson (MSc student, first year) - Morphological differences between two populations of *Diplodus capensis* (Smith, 1849), with a description of the biology and stock assessment of this species in southern Angola

Supervisors: Dr W.M. Potts (w.potts@ru.ac.za), Prof. W.H.H. Sauer (w.sauer@ru.ac.za) and Mr B.Q. Mann (bruce@ori.org.za)

Funder: National Research Foundation (GUN 66957)

Globally, the genus *Diplodus* is represented by 19 species. The blacktail, *Diplodus capensis*, is accepted to have a distribution from Angola to Mozambique. However, there is molecular evidence to suggest that a population in Angolan and South Africa are allopatric and have been separated for over two million years (Novo-Henriques, unpublished data). By certain species definitions, allopatric populations with morphological differences may be classified as separate species. This prompted a morphological study to compare these two populations. As *D. capensis* is by far the dominant species in the subsistence fishery, a biological and stock assessment study was initiated to assist with informed management strategies for the species.

Taxonomic samples were collected from 5 locations in Angola and 9 locations in South Africa. A total of 45 measurements and 14 counts were carried out on each specimen. Results were compared using multi-dimensional scaling (MDS) and the significance of clusters was tested using analysis of similarities (ANOSIM). Biological samples of *D. capensis* were collected monthly from April 2008 - March 2009, from a 30km stretch of coastline south of Namibe, southern Angola, following standard biological sampling methods.

Preliminary results suggest that there are two populations of blacktail that occur in Angolan waters, one in the south (area A) and one in the middle (area B) of the coast line, both of which are different to the South African (area C) blacktail (ANOSIM, 0.1% significance level). Of the 45 measurements taken, 37, 34 and 24 differed significantly (t-test, $p<0.05$) between areas B&C, A&C and A&B, respectively. Of the 14 counts taken, 8 differed significantly between areas A&C and B&C and 2 between areas A&B.

Biological results show that blacktail in Angola are omnivorous, feeding predominantly on algae, barnacles and mussels. There is a shift in feeding strategy, with small individuals feeding mainly on algae and large individuals on barnacles and mussels. Maximum GSI was displayed during June and July. The overall sex ratio (F:M) was 4.7:1 and 50% maturity was attained at 149.5mm FL. Blacktail in Angola exhibit very slow growth with the maximum age observed being 28 years. The parameters of the Von Bertalanffy growth function were L_∞ = 407.5mm FL, K = 0.045 year^{-1} and t_0 = -4.0 years.

Further taxonomic analysis will include a comparison of *Diplodus sargus cadenati* from North West Africa, with *D. capensis* in Angola. Morphological differences will be further assessed to decide whether *D. capensis* in Angola should be named as a new species. Further biological analysis will facilitate the application of per recruit models to *D. capensis* in Angola, in order to make workable management recommendations for its sustainable exploitation.

12h20-12h40: Rhett Bennett (PhD student, second year) - Habitat use, movement patterns and stock delineation of an important endemic coastal fishery species, *Lithognathus lithognathus*

Supervisor: Dr P.D. 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.

12h40-13h00: Russell Chalmers (PhD student, fourth year) - Coastal bays, MPAs and fisheries – trying to balance conservation and socio-economic objectives through multi-use zoning and management

Supervisor: Prof. W.H.H. Sauer (w.sauer@ru.ac.za)

Funders: South African National Parks, South African Environmental Observation Network – Elwandle Node

Coastal bays consist of several sensitive habitats in need of protection, yet due to their sheltered nature, are subject to high levels of exploitation from diverse user groups. Balancing the need for conservation with the existing socio-economic activities is complex, particularly in developing countries. Multiple-use management plans incorporating MPAs within coastal bays have been proposed as a means to achieving this balance, thereby ensuring sustainable resource use. An MPA has been proposed in Algoa Bay which will include habitat types currently poorly represented in existing South African MPA's. This will affect a number of recreational and commercial activities, therefore a spatially based multiple-use MPA is being designed to meet both conservation and social objectives.

Key areas within the proposed MPA were identified and sampling was randomly stratified across area, season, depth and reef profile within Algoa Bay. Ichthyofaunal communities were assessed by means of controlled angling, underwater visual census techniques, or a combination of both. Macro-benthic invertebrate communities were assessed using photo quadrants. Creel, access point and aerial surveys were conducted to assess the spatial distribution of recreational shore and ski-boat fishing effort and obtain catch, effort and economic information. Vessel Monitoring System (VMS) data and reported catches were obtained from Government to assess the commercial fishery sectors active within Algoa Bay.

Linefish density differed significantly between reef areas ($F_{6,205}$=5.48; $p<0.001$) with Bell Buoy having significantly lower densities than Bird Island and Woody Cape, and St Croix significantly lower densities than Bird Island. Species diversity differed between areas ($F_{6,205}$=6.42; $p<0.0001$) with Riy Banks having higher diversity than Bell Buoy, St Croix and Woody Cape, and Bird Island and Cape Padrone also having higher diversity than Woody Cape. Analysis of the linefish community structure using ANOSIM indicated significant differences in species composition between areas ($p<0.001$). Recreational shore fishing effort was found to be concentrated close to beach 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 was limited by the locality of launch sites and weather conditions. Travel distances, CPUE and catch composition differed between launch sites. Relatively low levels of squid fishing effort occurred within Algoa Bay. Contrary to this, high levels of fishing effort from the linefish and pelagic trawl sectors occurred within Algoa Bay.

Results from ecological and socio-economic studies will be integrated using MARXAN software which will aid in developing a conservation plan designed to meet the conservation objectives for the MPA while minimizing impacts on the fisheries thereby contributing towards an ecosystem approach to management within Algoa Bay.

13h00-13h20: Moqebelo Morallana (MSc student, first year) - Regional connectivity, differentiation and biogeography of the three species of the genus *Lutjanus* in the South Western Indian Ocean

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

Funders: DST-NRF African Coelacanth Ecosystem Programme

The biogeography of the Western Indian Ocean has not been widely explored despite the fact that South Western Indian Ocean is recognized as an area of endemism. Most fish species in the area are coral and reef fishes. To have an idea of the fish fauna of the South Western Indian Ocean, mitochondrial and nuclear markers will be employed to assess the genetic diversity, connectivity, patterns of differentiation and origins of the fauna of the three species of the genus *Lutjanus* (*Lutjanus fulviflamma, L. bohar and L. lutjanus*). These species are sought after for their meat by commercial, recreational anglers and people in the area whose livelihood depend on marine resources. It will give an indication of the species stock in different areas and develop strategies for conservation of these species.

The aim of the study is to:

- Determine the relationships, interaction and evolutionary history among different regions of the South Western Indian Ocean for the three species of the genus *Lutjanus* to determine processes influencing diversity and distribution.
- Determine how these different regions relate to the wider Western Indian Ocean , possibly elucidating the origin of regional faunas
- Determine the taxonomic status of the three species which are widespread in the South Western Indian Ocean.

Five to ten samples will be collected from 8 regions (South Africa, Mozambique, Kenya, Mauritius, Reunion, Seychelles, Tanzania and Madagascar). These regions were selected because it may be expected that due to physical barriers, oceanographic barriers and habitat preferences, biogeographic boundaries each of the species will be different from each region. DNA will be extracted using commercial kits, standard Polymerase Chain Reaction and Fluorescent-dye terminator cycle sequencing procedures will be used to amplify and sequence genes fragments of interest (*Cytb*, *ND2* and *S7*). These protein genes will allow us to examine genetic structure and possible regional differentiation in each region. Data analysis will be based on phylogenetic and biogeographic approaches to have an idea of genetic diversity, connectivity and gene-flow. It may be predicted that species show different patterns in response to biogeographic discontinuities and transition zones due to habitat preferences and different distributions.

PCR conditions have been optimized for the three genes and 16 samples have been analyzed from South Africa, Mozambique and Mauritius. Collaborators will be providing samples from some of the other sites (Reunion, Madagascar, Seychelles, Rodrigues) and from peripheral areas outside the SWIO. Laboratory work is expected to be finished by June 2010 , analysis and thesis write up by December 2010.

Friday 16 October 2009

Freshwater ecology, conservation and fisheries & Estuarine ichthyology (Chair: Rhett Bennett)

08h40-09h00: Albert Chakona (PhD student, second year) - Comparative phylogeography of *Pseudobarbus*, *Barbus*, *Sandelia* and *Galaxias* species in the Breede and associated river systems

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

Funders: National Research Foundation, International Foundation for Science, Rufford Small Grants Foundation and World Wildlife Fund International

The freshwater fishes of the Cape Floristic Region have been declining mainly due to the introduction of alien invasive fishes and habitat destruction. These impacts have been particularly severe in main-stem and lower gradient areas of mountain tributary streams and have effectively fragmented and isolated indigenous fish populations in upper mountain tributaries. Despite recent genetic investigations, we still know very little about intraspecific genetic diversity required for effective conservation management.

Three major field surveys, each a month long, were conducted from November 2008 to May 2009. The objectives of the surveys were to collect tissues for genetic analysis, compare the range of each species in mountain tributary streams, determine population sizes, collect ecological information and identify potential threats to future survival of the indigenous populations. Over 120 localities across 38 tributary streams in the Breede, Duiwenhoks and Goukou River sytems have already been sampled, mainly through snorkel surveys that has a minimum impact on the environment. In addition, the upper and lower limits for *Sandelia*, *Galaxias* and *Pseudobarbus* were successfully determined and mapped for fourteen of the rivers. Population density was measured through relative abundance in the turbid habitats of the southern region of the study area (river systems in the Agulhas area) where snorkel surveys were not possible. Two further major surveys are scheduled for October to December 2009.

Preliminary results from the surveys suggest that there is variation in fish species composition along longitudinal gradients within the rivers. The surveys have led to the discovery of some new populations of threatened fishes, but we unfortunately also found new alien fish invasions and extensive habitat destruction mainly through bulldozing. The major floods experienced in the winter of 2008 across the Cape Floristic Region may have facilitated the new alien fish invasions.

Optimisation of the mitochondrial cytochrome *b* gene was successfully completed in January 2009 for *Galaxias* and more than 60 individuals have already been sequenced. More recently, genes have been optimized for *Sandelia* as well. Preliminary genetic results suggest that there are more lineages of *Galaxias* than previously thought, with potentially critically endangered lineages restricted to tributaries of the Upper Breede and Riviersonderend catchments. Preliminary results also suggest that the different species of *Galaxias* and *Pseudobarbus* followed independent evolutionary histories.

09h00-09h20: Wilbert Kadye (PhD student, first year) - Assessment of impact of introduced sharptooth catfish *Clarias gariepinus* in Great Fish and Sundays Rivers

Supervisors: Prof. A.J. Booth (t.booth@ru.ac.za) and Dr O.L.F. Weyl (o.weyl@saiab.ac.za)

Funder: National Research Foundation (FA2007043000021)

Sharptooth catfish, *Clarias gariepinus*, was introduced from the Orange River into the Great Fish River, Eastern Cape in 1975 via the Orange-Fish interbasin water transfer scheme. Translocated sharptooth catfish have subsequently reached the Sundays River and have also been transported by anglers in many rivers in the Eastern Cape province. Almost all populations are now established. There is increasing concern about the conservation status of indigenous fishes and other biota due to generalised feeding habits and mobility of the non-native sharptooth catfish. The overall objective of this project is to determine the impact of the sharptooth catfish by assessing the distribution patterns, trophic and foodweb structure, feeding and movement patterns. This report summarises preliminary experimental study of invertebrates as potential indicators of sharptooth catfish impact.
A pilot Control-Impact experiment was conducted on the Ecca River that flows intothe Glen Melville dam. Three treatment cages, each containing 18 artificial substrate samplers (each with a volume of $10cm^3$), were set up in the river covering a distance of 50m. Sharptooth catfish was introduced in one of the treatment cages at the beginning of the experiment. All treatment cages were left undisturbed for 3 weeks to allow for invertebrate colonisation. Three artificial substrates were randomly sampled from each treatment cage on six occasions. In the laboratory, all macroinvertebrates were isolated, identified to family level and counted. In addition, an indigenous fish, moggel (*Labeo umbratus*), was introduced in one of the treatment cage on the first sampling occasion, leaving one treatment cage as a control. Three additional samples were collected using a SASS scoop net from the stream for comparison.

Invertebrate densities were found to be high in the catfish treatment cage on all sampling occasions, with the highest mean density of 133.0 ± 19.1 compared to 38.7 ± 9.2 and 29.3 ± 9.5 for moggel and control treatments respectively. The high density of invertebrates in catfish treatment was mainly due to dominance of the ancylid limpets, which accounted for more than 80% of numbers while generally accounting for no more than 50% in the moggel and control treatments. Invertebrate diversity was generally high in control treatment, intermediate in moggel treatment and low in catfish treatment. A Principal Component Analysis (PCA), which explained 61.3% of variation on the first 3 axis, showed an overlap between control and moggel treatments, and the latter separated, with little overlap, from the catfish treatment on PC 1. The limpets (Ancylidae), pond snails (Lymnaeidae) and midges (Chiromonidae) were strongly correlated to PC 1, with loadings of -0.68, -0.46 and -0.37 respectively. These results suggest differences in colonisation rates of invertebrates in the presence and absence of sharptooth catfish. Invertebrate taxa that are less vulnerable to predation, such as the limpets, appeared to colonise and increase in abundance in catfish treatments. On the other hand, colonisation rates in the other treatments appeared to maintain high diversity and low abundances of most invertebrate families.

09h20-09h40: Mpho Ramoejane (MSc student, second year) - The impact of inter-basin water transfer schemes on the genetic integrity of *Labeo umbratus* and *L. capensis* (Cyprinidae) in Southern Africa

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

Funder: National Research Foundation

The Orange-Fish and Cookhouse tunnels act as pathways for invasion by several fish species from the Orange River system to the Great Fish and Sundays River systems. This includes *Labeo umbratus* and *Labeo capensis*. *Labeo umbratus* was found naturally in the Great Fish and Sundays River systems before the inter-basin water transfer scheme (IBTs) was built. *Labeo capensis* on the other hand used to be found only in the Orange River system. The two species are reported to hybridize in Hardap Dam (Namibia). There are also anecdotal reports of hybridization between these two species in Darlington dam (Sundays River system).

The overall aim of the research was to assess whether introgression of *L. umbratus* lineages and hybridization between *L. capensis* and *L. umbratus* has occurred in Darlington and in Hardap dams. The objective was to differentiate between the two species using mitochondrial (mtDNA) cytochrome *b* and nuclear (nDNA) S7 introns and to use these markers to assess hybridization.

A total of 291 individuals were analysed from the Orange (Hardap dam, Onseepkans, Kanoneiland, Gariep Dam, Vaal River and Brak River) Great Fish (Kat River dam) Sundays (Darlington and Slagboom dams) Bushmans, Nahoon, Gamtoos and Gouritz River systems. The analysis of mtDNA and nDNA revealed that Orange River and the Eastern Cape populations of *Labeo umbratus* populations and *Labeo capensis* could be distinguished from each other. It also showed that there is mixing of all three lineages from these three river systems in Darlington Dam. Two specimens that were morphologically classified as *L. umbratus* had *L. capensis* mtDNA alleles and one specimen had nDNA alleles from both species, indicating that hybridization has occurred. In Hardap dam, however, it appears that only *L. capensis* mtDNA alleles persisted. This is despite field identifications suggesting that both morphs and hybrids of the two species occur and despite the persistence of nDNA alleles of both species.

The genetic integrity of these *Labeo* species has been compromised in at least Hardap and Darlington dams. The Eastern Cape stock is considered to be under threat of complete introgression. This may be due to habitat modification or a lack of historical contact between the Eastern Cape populations of *L. umbratus* with *L. capensis*, until the inter-basin water transfer. For these lineages of *L. umbratus* to be protected from ongoing hybridization, further translocations should not be permitted, particularly into the tributaries of the Great Fish and Sunday River systems that are protected by dams that were built before IBTs.

09h40-10h00: Thethela Bokhutlo (MSc student, first year) - Life history and stock assessment of *Clarias gariepinus* and *Clarias ngamensis* in the Okavango delta, Botswana

Supervisors: Dr O.L.F. Weyl (o.weyl@saiab.ac.za) and Mr K. Mosepele (kmosepele@orc.ub.bw)

Funder: Ministry of Environment Wildlife and Tourism, Botswana Government

Catfishes are ubiquitous and abundant in major river systems of Africa. In the Okavango, *C. gariepinus* and *C.ngamensis* play an important ecological role and are harvested in considerable proportions by subsistence fishers. These species are therefore an important source of protein for the rural poor communities of the delta and yet little is known about the biology and population dynamics of the species in the Okavango Delta.

The current study aims to determine those biological and population dynamic parameters that are pertinent for the application of analytical fisheries models used for the determination of management recommendations. Specifically this study will:

- Use otoliths to assess length at age for *C. gariepinus* and *C. ngamensis* in the Okavango Delta.
- Use edge analysis from otoliths collected for the two species on a monthly basis to validate growth zone deposition rate.
- Fit a vonBertalanffy growth model to the age at length data for the two species and compare growth rates.
- Use back-calculation techniques to attempt to link annual growth rates to flooding cycles in the Okavango.
- Develop an age-at-length key for converting length-frequencty data to age frequency data.
- Use various sources of age frequency data to estimate population structure and mortality rates for the two Clariids.
- Estimate total harvests of the two species in the Okavango delta
- Estimate selectivity at age for various harvesting gears.
- Estimate length and age at maturity for the two species.
- Use these data to fit yield-per-recruit and spawner biomass-per-recruit models to assess the response of the stocks to fishing and make suitable management recommendations for the two species.

The proposed methods involve monthly collection of at least 50 *C. gariepinus* and 50 *C. ngamensis* from commercial and recreational fishers as well as through the use of independent surveys for a one-year period. Each specimen will be weighed to the nearest 0.1g, measured to the nearest mm total length (TL) and standard length (SL), sexed and gonads will be removed and weighed (g). The stage for gonadal development will be assessed. Catch trends from fisheries monitoring survesy will also be assessed and evaluated with regard to flooding cycles and intensity in the Okavango Delta.

10h40-10h20: Henning Winker (PhD student, third year) - Uncoupling the life history of common carp *Cyprinus* carpio L. in South Africa's largest impoundment: Are common carp growing faster than we think?

Supervisors: Dr O.L.F. Weyl (o.weyl@saiab.ac.za) and Prof. A.J. Booth (t.booth@ru.ac.za)

Funder: National Research Foundation (FA2005021600012)

Although, common carp (*Cyprinus carpio* L.) is one of the better studied cyprinids, detailed ageing studies based on formal validation of growth zone deposition are rare. This is surprising as accurate aging is crucial for determining growth, age at sexual maturity and mortality - life history traits regarded as directly related to the fitness of a species in a given environment.

Throughout the study period more than of 2500 carp were measured, close to 1500 were sexed and staged and more than 800 otolith pairs were collected. Approximately 80% of these data were sampled from shore angling competitions. Three validation methods (fluorescent marking, edge analysis and length frequency analysis) suggested that growth zone deposition occurs biannually in the astericus otoliths of common carp from Lake Gariep, South Africa. Based on in this finding, length-at-age was best described by fitting the Schnute growth model. Initial growth was rapid with specimens predicted to grow 310 mm within their first two years of life. The majority of the population attained sexual maturity at this age and length-at-(50%)-maturity was estimated at 335 mm and 296 mm for females and males, respectively. Total mortality was estimated at 0.72 $year^{-1}$, natural mortality at 0.60 $year^{-1}$ and the corresponding fishing mortality at 0.12 $year^{-1}$. Considering the shape and relatively large size of carp, predation by piscivorous birds and fish can be assumed minimal so that the relatively high mortality rates are likely the cost for the overall fast growth rate, a trade-off typically observed in many finfish.

The life history of common carp from Lake Gariep is consistent with traits perceived for a successful invasive fish. The results of this study provide a basis for further investigation into the role of common carp as powerful invader and strongly suggest that age validation is a prerequisite for uncoupling its life history.

10h20-10h40: Michelle Kruger (MSc student, second year) - Larval fish dynamics in the Kowie Estuary, Port Alfred

Supervisor: Dr N. A Strydom (Nadine.Strydom@nmmu.ac.za)

Funder: National Research Foundation

Larval fishes were collected in the Kowie Estuary using a variety of methods to assess 1) spatial and temporal variability; 2) tidal exchange and 3) tidal front use. The spatio-temporal patterns are described in this seminar, with notes on tidal exchange and tidal front use as these components are still in progress. Larval fish were collected seasonally over a two year period using boat-based plankton tows at 14 different sampling stations located along the length of the estuary and within the marina. A total of 11 128 larval fish were recorded over the two year composition study period, representing 23 different fish families and 38 different species. Clupeidae (*Gilchristella aestuaria*) and Gobiidae (*Caffrogobius gilchristi*) dominated the catches, contributing 47 % and 24.7 % respectively. Spatial trends indicate a high dominance of certain resident species in the estuary and a clear switch in dominance between the lower and upper reaches. Temporal trends were evident in seasonal peaks in abundances. The artificial channels of the marina and lower reaches have resulted in an absence of a shallow, marginal water habitat. A lack of flexion and postflexion larvae and early juveniles in these areas may be indicative of increased predation or an avoidance of deep-water channels due to the lack of marginal refuge. In the tidal exchange component, drifting light traps were used to assess exchange of larvae and compare the composition of this data set to traditional towed net studies. A total of 553 larval fish were recorded during the tidal exchange component of the study. Blenniidae contributed 43 % to the total catch, followed by Clupeidae (32 %) and Clinidae (17 %). The catch was dominated by two main species; these were *Omobranchus woodii* (42 %) and *Sardinops sagax* (31 %). Dominance of these species generally changed with tide. Postflexion larvae dominated the catches, which is typical for light trap sampling. Catches by the drifting light trap are significantly different when compared to the results of WP2 nets in the same estuary and other similar estuaries in the region, highlighting species and size selectivity by sampling gear. Tidal fronts on the flood tide were sampled using WP2 nets and the full range of biotic and abiotic variables were collected to do a complete planktonic ecosystem appraisal in association with tidal fronts in the system. Initial evidence indicates that larval fishes, zooplankton, phytoplankton and physic-chemical variables show spatial heterogeneity with frontal regions.

10h40-11h15: Tea break

Finfish Mariculture (Chair: Amber Childs)

11h20-11h40: Ernst Thompson (PhD student, fifth year) - Modelling the digestibility of *Artemia franciscanis* '*in vitro*' during the early larval stages of marine finfish: A novel approach

Supervisor: Prof. T. Hecht (T.Hecht@ru.ac.za)

Funders: National Research Foundation, DAAD

Establishing feeding strategies that match the nutritional needs of marine finfish larvae are essential to ensure normal development and optimal growth under culture conditions. Co-feeding strategies remain the most common practice, despite attempts to rear larvae exclusively on artificial diets. Understanding the digestibility of live food organisms is important for successful larviculture and could contribute towards designing improved replacement diets.

Various studies have shown that determining the digestibility of diets '*in vitro*' can complement, and in some instances precede or substitute '*in vivo*' digestibility techniques. This is largely due to biochemical techniques that offer a wide range of practical applications and are quick, simple and relatively inexpensive in comparison to standard digestibility studies. The aim of this study was to design an '*in vitro*' protocol to estimate the digestibility of *Artemia franciscanis* in the larvae of three warm temperate, marine fish species namely, *Sarpa salpa* (Sparidae), *Diplodus sargus capensis* (Sparidae) and *Argyrosomus japonicus* (Sciaenidae).

'*In vitro*' trials (n=64) were performed by digesting newly hatched and enriched (DHA Selco, INVE) *Artemia franciscanis* nauplii at a pH of 7.7 for 15, 30, 45, 90, 120, 150, 210 and 270min for each fish species. A defined number (1828±487) of *Artemia* nauplii was used, while the source of digestive enzymes was obtained from crude larval extracts. The degree of protein, lipid and carbohydrate digestion in the digesta was determined with a modified Ninhydrin colourometric method for amino acids, the Korn method for glycerol (by-product of triglyceride digestion) and a modified Somogyi-Nelson method for reducing sugars, respectively. '*In vitro*' digestion of *Artemia* was then analysed and modelled using a generalised linear model which showed that both protein and carbohydrate digestion is strongly correlated to the time of digestion, and the preparation method of the *Artemia*.

Both models demonstrated good predictive power for '*in vitro*' digestion of *Artemia* for another warm temperate species, *Dagetichthys marginatus* (Soleidae) (DPD, X^2=2.8, p=0.83 and DCD, X^2=1.8, p=0.94). The Korn method showed no detectable levels of glycerol and consequently a lack of triglycerides in both newly hatched and enriched *Artemia*, despite the reasonably high levels of triglycerides in fish oil emulsions like DHA Selco. This can partially be explained by the fact that other copepods generally store fats as wax esters and only maintain small amounts in a triglyceride form for use as a metabolic energy reserve. A more suitable biochemical assay is thus required to quantify the degree of lipid digestion.
Debate exists over the contribution by exogenous enzymes from *Artemia* towards digestion in first feeding larvae. This study showed that exogenous enzymes contributed significantly (40.0±12.7%) to carbohydrate digestion and protein digestion (14.6±7.6%). This work confirms the usefulness of 'in vitro' studies to compliment or possibly even replace 'in vivo' digestibility studies.

11h40-12h00: Nani Rossetti (MSc student, first 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.J. Britz (p.britz@ru.ac.za)

Funders: THRIP, Marifeed (Pty) Ltd

Fish oil is the main lipid source in aquafeeds for cultivated carnivorous fish. However, fish oil sources are finite and may not meet the increasing demand for animal feed. Thus, there is a need for the exploration of alternative ingredients to supplement or replace conventional components with higher prices reducing the cost of the food. Vegetable oil is an alternative to fish oil in aquafeeds since the world production of vegetable oil is forty times that of fish oil and this source of lipid is readily catabolised by fish for growth and as an energy source. This study will evaluate the effect of partial substitution of fish oil by vegetable oil in formulated feed for *Argyrosomus japonicus,* a promising species of increasing interest in the South African mariculutre sector. The objectives will be to compare fish growth, food conversion ratio, health and survival of fish fed diets with graded replacement of fish oil.

The experiment will be carried out at the Rhodes University Laboratory in Port Alfred, using a recirculating water system. The fish were obtained from Espadon Marine (Pty) Ltd (Eastern Cape, South Africa) and are being acclimatized and fed an imported fish food (50 % crude protein; 15 % crude lipid) prior to the experiment. The temperature of the water is about 24 ^{o}C. Six isonitrrogenous and isoenergetic diets have been formulated with a total lipid content of 18 % and a protein content of 46 %, with fish meal and soya as the main protein sources. With the exception of the lipid source, all diets include the same basal composition, formulated on a dry weight basis. 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 1.2, 14.0, 28.0, 42.0, 56.0 and 70.0 % replacement. Soybean oil was used as the replacement since it is available in South Africa for an affordable price and has been tested in other marine carnivorous fish with positive results.

The aquafeed produced by some aquaculture industries in South Africa for marine finfish relies on expensive diet ingredients and processes that makes the product expensive. This study may contribute to the development of a more cost effective diet for the South African marine finfish industry.

The second experiment of this study will analyze the effect of diets on *A. japonicus* with different starch binding technology and different equipment to bind the pellets. In this experiment too, cheaper ingredients will be used, and the basis of the diets will remain the same as in the first experiment.

12h00-12h20: Siviwe Babane (MSc student, second year) - Effect of size-sorting and crowding density on aggressive behaviour of juvenile dusky kob *Argyrosomus japonicus*

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

Funder: Marine and Coastal Management (Department of Environmental Affairs and Tourism)

Size-sorting is a rearing technique which aims to improve weight gain by all fish and to increase survival rate. This results in increasing fish production per tank. This is routinely exercised to improve growth of small fish, reduce cannibalism, decrease size variability and improve feed uptake. Dusky kob juveniles are aggressive and cannibalistic and this can lead to high mortality. The dusky kob has many attributes beneficial for aquaculture and commands high prices. Many studies have been conducted on the effect of size-sorting in other fish species, however, there is a paucity of information on the effects of size-sorting in the rearing of dusky kob. Thus, a study on the effects of size-sorting will be conducted to reduce aggression and improve growth in this species.

The overall aim of this work is to better understand factors determining aggressive behaviour so they can be controlled to reduce aggression in this species. The objectives of this study are to determine the effects of size-sorting on aggression in dusky kob based on behavioural observations; to determine to what extent size-sorting can be used to reduce cannibalism in dusky kob juveniles under intensive rearing conditions. Behavioural observations were made to study aspects of aggressive and feeding behaviour. At the beginning of this study, behaviours were identified and defined in order to quantify behaviour under a variety of culture conditions. These include chasing, biting, intimidating and feeding behaviours. Dusky kob juveniles of an average weight of 3.6 g/fish were obtained from the hatchery stock of Espadon Marine in East London. They will be individually measured and weighed after the behaviour observations. In each treatment, the largest fish will be selected and observed for 30 minutes to record the frequency of aggressive behaviour toward smaller fish. Fish will be size-sorted visually in attempt to achieve two levels of size variability expressed by the coefficient of variation (CV), i.e., low and high size variability. Each treatment will have 10 replicates. The stocking density will be made up of 28.8 g of fish biomass per 7.2-L glass tank fish observed once.

No study that has been done to quantify the effect of crowding density on dusky kob behaviour, hence this work includes testing the effect of crowding density with respect to aggressive behaviour. Two density treatment levels, 4 kg m^{-3} and 10 kg m^{-3} will be used with a loading density being maintained at 33 kg / m^3 / h. A similar procedure to the first experiment regarding behavioural observations will be followed with 10 replicates for each treatment.

This study, thus, consists of 2 x 2 x 10 factorial design and repeated measures ANOVA will be applied for data analysis.

12h20-12h40: Joseph Ginindza - The effect of dietary lipid on finfish carcass lipid levels

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

Report not available.

12h40-13h00: Maryke Musson (MSc student, second year) - Prediction of larval viability and the ontogenetic development of the digestive system in dusky kob *Argyrosomus japonicus* larvae

Supervisors: Prof. H. Kaiser (h.kaiser@ru.ac.za) and Dr N.G. Vine (niall@espadonmarine.co.za)

Funders: Frontier Programme, Department of Environmental Affairs and Tourism, Marine and Coastal Management, Espadon Marine

Egg and larval quality can be determined by assessing various physical and chemical egg and larval characteristics. The aim of this experiment was to determine whether egg and larval characteristics, such as morphology, size, fertilization and hatching rate, together with larval performance in stress tests, could be indicative of larval quality and viability. Fertilized eggs and newly hatched larvae from 15 different cohorts were evaluated. An egg quality ranking index (RI) was formulated incorporating egg size, shape, colour, blastomere development and oil globule number and size. Newly hatched larvae were exposed to four different stress tests (formalin, temperature, salinity and exposure to air), which were optimized for dusky kob. After 138 degree days, larvae from cohorts with higher egg quality RI's and with better stress test survival (above 65% after 24 hours), showed better survival and growth than those from cohorts with lower RI's and poorer stress test survival. It is thus possible to predict long-term larval viability for dusky kob using egg and larval characteristics combined with appropriate stress tests.

An understanding of the ontogenetic development of the digestive system of commercial aquaculture species can help in the development of appropriate weaning strategies.
The aim of this study was to describe the major histological changes occurring during the development of dusky kob larvae under culture conditions in an effort to improve current weaning strategies and husbandry practices. Morphological and histological ontogenetic development of the digestive tract and associated organs was followed from hatching to 30 days after hatch. Larval samples were collected daily and embedded in paraffin wax from which sections were made and stained with haemotoxylin-eosin for histological examination. Degree days (DD) were used to compare larval growth and development between different spawnings. A total of 4500 larvae were collected from 15 different spawning batches and either morphologically examined or histologically prepared. Based on the histological and morphological characteristics of the larval digestive tract it would be physiologically possible for dusky kob larvae to be weaned onto an artificial diet after 100 DD.

Espadon Marine and Irvin and Johnson (I&J) are thanked for their donation of larvae for these studies.

Non-presenting students

Jessica Escobar-Porras (MSc student, final year) - Movement patterns and population dynamics of four endemic catsharks from South Africa

Supervisors: Dr W. Sauer (w.sauer@ru.ac.za) and Dr P. Cowley (P.cowley@ru.ac.za)

Sharks are particularly vulnerable to over-exploitation. Although catsharks are an important component of the near-shore marine biodiversity in South Africa and most of the species are endemic, little is known about their movement patterns, home range and population size. With an increasing number of recreational fishers and bycatch by commercial operators, this information is crucial for their conservation. The aims of this study were threefold. Firstly, to identify and analyze existing data sources on movement patterns and population dynamics for four catshark species: pyjama (*Poroderma africanum*), leopard (*P. pantherinum*), puffadder (*Haploblepharus edwarsii*) and brown (*H. fuscus*). This highlighted a number of shortcomings of existing datasets, largely because these studies were not aimed solely at catsharks, and had diverse objectives. Secondly, a dedicated study was carried out over a limited area, and the data was analyzed to determine movement patterns and population numbers. Thirdly, the most appropriate methodology was identified for future studies with similar objectives and the results obtained were used to propose a number of conservation measures. All four species of catsharks exhibited strong site fidelity and limited dispersal for extended periods. However, some individuals revealed the capacity to travel distances in excess of 150 km. Trends in temporal abundance were not observed, however, catches were higher from September to December. Resident catshark population estimates were small. Schnabel closed population estimates showed that *P. africanum* had the smallest population while *H. fuscus* had the highest population size within a restricted study site. Limited movements, high site fidelity and small population sizes emphasize their vulnerability and suggest that catsharks would benefit from no-take marine protected areas.

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) and Dr P.D. Cowley (p.cowley@saiab.ac.za)

Funder: Institut de Recherche pour le Developent (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.

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

Supervisors: Dr P.D. Cowley (p.cowley@saiab.ac.za) and 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.

Justin Kemp (PhD student, second year) - Assessment of the effect of algal, formulated and combination diets on the growth and metabolism of juvenile red abalone *Haliotis rufescens* in Chile

Supervisors: Prof. P. Britz (p.britz@ru.ac.za) and Dr. Pedro Toledo (ptoledo@ucn.cl)

Funders: Skye Foundation, National Research Foundation Scholarship Program, Rhodes University JRC, Marifeed (Pty) Ltd

Abalone culture in Chile, centered on the red abalone *Haliotis rufescens*, has developed rapidly, with an approximate annual increase of 50 % in the three years to 2006. The industry relies on seaweed (harvested kelp and *Gracilaria*) as its main form of feed, however regulations restricting kelp harvest, and irregular supply, have shifted attention towards adopting formulated feeds. While algae are still available, farmers are reluctant to switch completely to formulated feeds, and interest has thus arisen into the feasibility of mixed algal / artificial feeding regimes. Supplementation of fresh seaweed with pelleted feed requires modification of existing tank designs, as the culture systems currently employed are designed for feeding seaweed. The aim of this study is to assess the effect of seaweed, formulated and combination diets on the growth of juvenile *H. rufescens* using a culture system optimized for use with artificial feeds.

A six-month feeding trial is currently underway in a flow-through raceway system at the AWABI research facility, Universidad Catolica del Norte, Coquimbo. Four dietary regimes are being investigated namely algae (*Macrocystis integrifolia* and *Lessonia nigrescens*), 50% algae ration with artificial feed, 10% algae ration with artificial feed and artificial feed. Algae ration was calculated on abalone consuming 15% body weight.day^{-1}. The artificial diet was formulated using fishmeal and soya-oil cake as the primary protein sources (34%) with a dietary lipid content of 3 %, and was fed in excess. A vitamin and mineral mix and starch carbohydrates were also included based on a commercial formulation (Marifeed Pty Ltd, South Africa). Rehydrated algae (*Macrocystis integrifolia* at 5%) was included in the diet as a feeding attractant. 420 juvenile abalone (1.1±0.3g; 20.54±1.7mm) were stocked into each mesh basket (38x30x45cm) and provided with a vertical plate HDPE refuge (4 plates per refuge; 0.7m2 surface area). A corrugated fiber-cement plate (30x22cm) was placed on the upper surface of the refuge, providing a feeding surface for the artificial feed. Four replictate baskets per treatment were used.

After the first 8 weeks of the 24 week trial, all treatments exhibited excellent survival (> 96%). Abalone fed a 50% ration of algae combined with artificial feed had a significantly higher ($P < 0.05$) weight gain than the other treatments. However, there was no significant difference in either shell length gain or specific growth rate (SGR) at this point in the trial. These preliminary results suggest that the substitution of 50% of an algal diet with artificial feed in a culture system designed for artificial feed yields commercially acceptable growth performance. Metabolic measurements will be conducted at the conclusion of the trial to determine the effect of the dietary regimes on routine abalone metabolism.

Vusi Mthombeni (MSc student, third year) - The biology of *Austroglanis gilli* and *Austroglanis barnardi* in the Olifants River system, South Africa

Supervisors: Dr O.L.F. Weyl (o.weyl@saiab.ac.za) and Mr I.R. Bills (r.bills@saiab.ac.za)

Funders: Water Research Commission (K8 592), Rhodes University JRC

This study investigated age and growth, reproduction and feeding biology of the IUCN-listed vulnerable *Austroglanis gilli* and endangered *Austroglanis barnardi*. A total of 474 *A. gilli* and 330 *A. barnardi* museum specimens collected by SAIAB from the Rondegat and Noordhoeks rivers were used for analysis.

Growth was slow and differed with species and with site and was best described by von Bertalanffy as $L_t = 119(1 - \exp(-0.37(t - 0.88)))$ for *A. gilli* from the Rondegat River and $L_t = 99.5(1 - \exp(-0.54(t - 0.26)))$ and $L_t = 70.9(1 - \exp(-0.25(t - 3.2)))$ for *A. gilli* and *A. barnardi* from the Noordhoeks River, respectively. The oldest specimen of *A. gilli* was aged using otoliths at 12+ years and *A. barnardi* was 14+ years. The average annual mortality rates estimated using catch curve analysis were 0.37 ± 0.12 yr^{-1} for *A. gilli* from the Rondegat River, 0.71 ± 0.05 yr^{-1} and 0.39 ± 0.04 yr^{-1} for *A. barnardi* from the Noordhoeks River, respectively. Macroscopic assessment of the state of gonads and the average Gonado-somatic index indicated that both species have a protracted summer spawning season. This assessment was validated by histology. Ovaries sampled from November to January comprised oocytes of all developmental stages suggesting a serial spawning. The resorption of vitellogenic oocytes were observed from ovaries collected in February and March, and no yolk development was evident until September. Maturity is attained at the age of 2–3 years for each *Austroglanis* species. The two species produce large egg sizes with maximum diameter of 2 mm and the relative fecundity was estimated at 60.2 ± 17.8 ova $^{-1}$. fish-g $^{-1}$ for *A. gilli* and 65.4 ± 23.9 ova $^{-1}$. fish-g $^{-1}$ for *A. barnardi*. Diet analysis revealed that *A. gilli* feeds predominantly on the benthic larvae of Ephemeroptera (Baetidae), Diptera (Simuliidae and Chironomidae) and Trichoptera. *Austroglanis barnardi* feeds predominantly on the Chironomidae. Diet differed between species and rivers.

The life-history traits of *A. gilli* and *A. barnardi* characterized by slow growth, long life-span, low adult mortality, late sexual maturity, large egg size and low relative fecundity indicate that both species are relatively precocial and *K*-selected. This suggests that populations are vulnerable to population reducing events because the recovery rate after such events would be slow. Such events may include agro-chemicals, habitat loss and the altered river hydrology which may also impact macro-benthic invertebrate distribution and abundance which are important diet for both *Austroglanis* species. Conservation measures should, therefore, consider a holistic approach so as to incorporate the maintenance of habitat complexity and invertebrate diversity.

Terrence Stonier (MSc student, fourth year) – Population study of the chokka squid *Loligo reynaudic*

Supervisor: Dr W.H.H. Sauer (w.sauer@ru.ac.za)

An intuitive assumption made regarding population structuring in marine organisms is that species with highly mobile adults and/or planktonic larval stages have high dispersal potential and will display panmixia (i.e. interbreeding leading to little or no structuring) over large distances.

Molecular markers have proved useful for testing genetic structuring and although widespread panmixia has been confirmed in many species a growing number of cases in both vertebrates and invertebrates have demonstrated that realised dispersal is often much less than potential predicted from life history characteristics. Understanding genetic sub-structuring of species is important both for understanding how populations evolve, for example in response to changing environments, and also for the management of exploited species of commercial value.

This study investigated sub structuring within Loligo reynaudii, using both molecular and morphological methods. Results were surprising, with both molecular and morphological evidence for separate populations of loligo reynaudii exist on the western Agulhas Bank and the south east coast of South Africa.

These results necessitate fundamental changes in the management of this species, necessitating a revision of the existing stock assessment methods used.

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