

Department of Ichthyology and Fisheries Science



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Research Report Series 18



RHODES UNIVERSITY

Department of Ichthyology and Fisheries Science
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**Department of Ichthyology
and Fisheries Science**

Research Report Series 18

October 2006

Edited by: C.L.W. Jones

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Wednesday 3 October 2006

08h20-08h30: Welcome by Prof. A.J. Booth (Acting Head of Department)

Honours seminars (Chair: Dr O. Weyl)

08h30-08h40: Graham Traas (BSc Hon. student) - Abundance of an alien invasive species, *Clarias gariepinus* in a large reservoir in the Eastern Cape, South Africa.

Supervisors: Prof. A.J. Booth, Dr O.L.F. Weyl

Estimating population abundance is central to any ecological study, particularly those focussing on the impacts of an alien species on an ecosystem. A multiple mark-recapture study was therefore initiated in March 2005 in the 76 hectare Glen Melville Reservoir (33° 11' 42.13" S, 26° 38' 45.80" E) to investigate the size of the *Clarias gariepinus* population.

Two estimators were employed in the study: (1) the non-mark-specific Schnabel estimator and (2) the mark-specific Jolly-Seber estimator. The former estimates capture probability and population size. The latter, in addition, estimates survival probability between sampling occasions. *C. gariepinus* were captured by angling and with longlines. Fish were double-tagged, injected with oxytetracycline tetrachloride, measured, sexed and released. Recaptured fish had their tag numbers recorded, were measured, sexed and released.

A total of 388 fish were captured over nine sampling events occurring between the 9th of March 2005 and the 15th of September 2006. A total of 32 fish were recaptured, giving a recapture rate of 8.2%. Sex ratio of sampled fish was skewed towards males (64%). The abundance estimate given by the Schnabel model was 2277 [95% CI = 1547 : 3008] fish, which equates to 30 fish/ha. The Jolly-Seber model gave a survival rate of 67.85% over the 18 month period and a recapture rate of 7.35%. The population size, as estimated by the Jolly-Seber model, was 3575 fish, which equates to 47 fish/ha. Tag loss occurred in one fish.

Based on the relatively low abundance estimate, it would be prudent to consider a trophic level analysis of the *C. gariepinus* population in order to understand the true impacts this alien invasive species is having on the species indigenous to this region.

08h40-09h00: Steven Benjamin (BSc Hon. student) - The effects of pellet size on the behaviour and growth of juvenile dusky kob (*Argyrosomus japonicus*).

Supervisor/s: Prof. P.J. Britz; Dr C.L.W. Jones

Fish feed contributes considerably to production costs in finfish mariculture. Pellet design (i.e. form/presentation) can affect ingestion, which in turn influences production costs through growth, survival, and the volume of wasted feed. The aim of this study was to develop a better understanding of juvenile dusky kob (*Argyrosomus japonicus*) feeding behaviour in captivity and thus contribute to towards developing a pellet suitable for the finfish industry in South Africa. It was hypothesized that pellet size would have an effect on feeding behavior, and that that pellet size would affect fish growth and food conversion. The objectives of this experiment were to compare the feeding behavior of fish fed different size pellets and to determine the most suitable pellet size for the three size classes examined.

Captive bred fish with initial (i.e. at the start of the experiment) weights of 8.53 ± 1.69 g (small) and 18.5 ± 2.71 g (medium) and 43 ± 8.64 g (large) were obtained from a local fish farm. Each size class was randomly stocked into six tanks that formed part of a temperature controlled recirculating system with biological filtration. Tank shape, water volume, exchange rate and the quality of the seawater, and stocking density in the tanks of each size class were standardized, and each size class was treated as a separate experiment. Fish were acclimated to the system for one month during which time they were fed a 3-mm trout pellet currently used as a feed for marine finfish in South Africa.

Maximum and minimum pellet sizes were determined for each size class based on average mouth-gape and preliminary behavioural observations. Three randomly selected tanks of small fish were fed 5-mm pellets and the remaining three were fed 3-mm pellets. Similarly, the medium fish were fed either 6-mm or 4-mm pellets and the large fish were fed either 4-mm or 8-mm pellets. All pellets were manufactured using the same feed formulation, i.e. 50% protein and 8% lipids on dry weight basis. Fish were fed to apparent satiation twice daily. Any uneaten food was removed and dry weight recorded. The large fish were weighed after 31-days and the small and medium fish were weighed after 41 days. Feeding behaviour of the small and medium fish was recorded on video at random intervals over the duration of the trial.

There was no difference in growth between fish fed a large or small pellet in all experiments, with average weight gains (\pm standard error) of 12.7 ± 1.04 g (Kruskal-wallis: $H_{(1,6)}=0.048$, $p=0.83$), 15.23 ± 0.34 g (Kruskal-wallis: $H_{(1,6)}=0.048$, $p=0.83$;) and 22.45 ± 1.35 g (Kruskal-wallis: $H_{(1,6)}=0.43$, $p=0.51$) for the small, medium and large fish respectively. Similarly, there was no difference in food conversion ratio (FCR) between treatments, with an average (\pm standard error) of 0.89 ± 0.05 , 0.95 ± 0.05 and 0.74 ± 0.07 for the small, medium and large fish respectively (Mann-Whitney U; $p > 0.05$)¹.

Video footage was used to identify and describe six feeding behaviours (i.e. manipulation, hold, spit, carry, drop and snap) and three feed accessing behaviours (i.e. shoal feeding, pass and incomplete pass). The frequency of occurrence of these behaviours was influenced by pellet size (χ^2 ; $p < 0.05$). These results are discussed.

This study has shown that pellet size does not significantly influence growth but does have an effect on feeding behaviour of juvenile dusky kob.

¹ Printed incorrectly in first edition – corrected here.

09h00-09h20: C.M. Muller (BSc Hon. student) - Larval and small juvenile fishes of the East Kleinemonde Estuary, with particular reference to the influence of freshwater input and mouth state.

Supervisor: Dr N.A. Strydom

The larval and early juvenile fish dynamics of the East Kleinemonde intermittently open estuary (IOE) system (Eastern Cape coast, South Africa) were investigated, over a period of one year, as part of a holistic project for the Water Research Commission (WRC) of South Africa, which aims to establish the freshwater requirements of intermittently open Cape estuaries. Despite the available information on recruitment of young fishes into estuaries worldwide, there is a paucity of information describing the factors driving the recruitment process. Current larval and juvenile fish composition, abundance, spatial and temporal distribution and their relationship to physico-chemical conditions within the estuary were investigated, along with the magnitude of the recruitment response of these fishes during opening events. The East Kleinemonde Estuary has a navigable surface area of 175 000m² and is situated approximately 15km north-east of Port Alfred in the Eastern Cape Province of South Africa and reaches the sea on the co-ordinates 33°32' S and 27°03' E. Spring, summer, autumn and winter samples were collected. During the day littoral water sampling were carried out at seven sites (S1-S7) along the lower, middle and upper reaches of the East Kleinemonde Estuary by means of a 1.5m deep × 4.5m long modified beach-seine net with a mesh aperture of 0.5mm. At night mid-channel plankton samples were collected by boat at five sites (P1-P5) throughout the estuary using two slightly modified WP2 plankton nets (570mm mouth diameter and 0.2mm mesh aperture size) fitted with Kahlsico 005 WA 130 flow meters. *In-situ* vertical temperature and salinity profiles were obtained using a Valeport CTD instrument, while water transparency readings were taken using a secchi disc. Data analysis is currently in progress, however certain trends have been observed. CPUE for the seine net catches were observed to be highest during summer when the mouth of the estuary was open and a connection with the sea was established. The highest density of larval and early juvenile fishes was also evident during the same time period. After the final analysis has been completed, we hope to be able to address the research questions posed at the outset of this study and so meet our objectives.

09h20-09h40: Greg Tutt (BSc Hon. student) - The effect of increased concentrations of Na₂SO₄ and NaCl on the oxygen consumption of two freshwater fish species.

Supervisors: Dr N. Muller and Dr H. Kaiser

South Africa is a water scarce country and much emphasis is placed on management of water resources. Aquatic resources are threatened by, amongst others, elevated levels of pollution emanating from the industrial and agricultural sectors. Some of this pollution occurs in the form of inorganic salts such as sodium sulphate (Na₂SO₄) and sodium chloride (NaCl). These salts cause increased salinization in freshwater sources and may result in detrimental impacts on the biota in these systems with affects occurring at both lethal and sub-lethal levels. Water quality guidelines for aquatic resources exist for various water quality constituents, such as Na₂SO₄ and NaCl, but these have been largely derived using toxicity test data with lethality as an experimental endpoint. The validity of these water quality guidelines is in question and it has become necessary to develop toxicity tests using sub-lethal experimental endpoints to refine guideline values.

The objective of this experiment was to determine whether oxygen consumption in guppies (*Poecilia reticulata*) and zebra danios (*Danio rerio*) is affected by exposure to elevated concentrations of Na₂SO₄ and NaCl. Fish were exposed to increasing concentrations of the salts in static respirometers under controlled environmental conditions. Each experiment ran for a period of 96 hours, with 10 replicates being removed every 24 hours for each concentration. The dissolved oxygen concentration, pH, electrical conductivity, temperature and water hardness was measured. Surviving fish were weighed and measured to calculate the rate of oxygen consumption. Preliminary data analysis (using ANOVA) indicates that both fish species showed a response to increased salt concentrations. Further data analysis will yield a Lowest Observed Effect Concentration which can be used to assess and possibly refine the current water quality guidelines for Na₂SO₄ and NaCl.

09h40-10h00: Sally Button (BSc Hon. student) - The effect of temperature and live food regime on the survival of larval peppermint shrimp (*Lysmata wurdemanni*).

Supervisor: Dr N. Vine

Demand for marine ornamental shrimp species such as peppermint shrimp (*Lysmata wurdemanni*) is growing worldwide, despite the lack of commercial production of the species. Efforts to rear *L. wurdemanni* are necessary to stem the harvest of wild specimens from coral reefs, a potentially destructive activity. The aim of the study was to establish the effect of temperature and feeding regime on survival of larval *L. wurdemanni*.

The experiment was conducted by rearing groups of larvae at two temperatures, 25°C and 28°C, and two feeding regimes (A: feeding *Artemia* from the first larval stage or B: feeding rotifers first and weaning larvae onto *Artemia* at day five), and counting the number of surviving larvae every two days. Each treatment was replicated three times, and the experiment was duplicated.

Preliminary results show no significant difference between survival related to either temperature (95% confidence, $p < 0.05$) or live food regime (95% confidence, $p < 0.05$). This suggests that *L. wurdemanni* larvae could be reared at 25°C, which is more cost-effective than keeping water temperatures at 28°C, and can be fed by the livefood regime that is less expensive or easier to maintain for the aquaculturist.

An ongoing experiment aims to test growth of groups of larvae reared at 25°C. Two groups of larvae will be fed the *Artemia* only diet, and another two fed the rotifer and *Artemia* diet, and the growth of these groups compared.

10h00-10h20: Hylton Newcombe (BSc Hon. student) - Does *Micropterus salmoides* stunt in small farm dams?

Supervisors: Prof. A.J. Booth and Dr O.L.F. Weyl

Studies on stunted growth in fish species are limited mainly due to crude definitions and lack of experimental investigation. The objective of this project is therefore to provide a working definition for growth stunting in fish and, using *Micropterus salmoides* as a candidate species, investigate possible stunting in small farm dams situated in the Makana Municipality.

In this study, stunting is defined as "... a population of a species that are significantly smaller in its first year when compared with the populations of the same species from geographically neighbouring systems." It is hypothesized that fish of the most abundant mean length (150 – 300 mm) in small dams are significantly older than fish at the same mean length (150 – 300 mm) in large dams.

A total of 181 largemouth bass were sampled between April and October 2006 mainly using hook-and-line. Full biologicals were conducted and pairs of sagittal otoliths removed for age determination. Sagittae were burnt using a methanol flame, cast in polyester resin, transversally cut, slide-mounted with DPX and interpreted. Ages ranged from zero to nine years. Gonadosomatic indices and maturity schedules were calculated from biological data.

Growth was modelled with the von Bertalanffy model as $L(t) = 422.54(1-\exp(-0.62(-age)))$ mm TL for Milner, $L(t) = 309.16(1-\exp(-1.04(-age)))$ mm TL for Committees Drift, $L(t) = 257.69(1-\exp(-1.60(-age)))$ mm TL for Dames, and $L(t) = 367.50(1-\exp(-0.97(-age)))$ mm TL for Strowan dams. Milner was used as the reference population for comparing mean age for a selected mean length (150 – 300 mm). There are greater numbers of smaller fish prevalent in Milner than in the other three dams. There was evidence of growth during late winter/early spring, with no growth during winter.

There was a difference in fish growth among dams (ANOVA; $F = 6.05$; $p < 0.01$), with only growth in Strowan (1.72 ± 0.72 years) being significantly greater than that in Milner (1.16 ± 0.25 years). We can conclude that there is zero evidence for growth-stunting within small farm dams.

Further research could be conducted to clarify whether intraspecific competition and the effects of edaphic and morphometric oligotrophy have any positive correlation with growth-stunting in *M. salmoides* in small farm dams.

10h20-11h45: Tea break (extended)

Guest student (Chair: Prof. A.J. Booth)

11h50-12h10: Caswell Mavimbela (MSc student, Limpopo University) - Molecular phylogeny of the South African genus *Caffrogobius* and intraspecific genetic variation of *Caffrogobius gilchristi* using cytochrome b sequences.

Supervisor: Dr. O. Gon and Ms M. Mwale

Report not available.

Honours seminars continued (Chair: Dr O. Weyl)

12h10-12h30: Bruce Ellender (BSc Hon. student) - Temporal and spatial distribution of *Oreochromis mossambicus* in the intermittently open East Kleinemonde estuary, South Africa.

Supervisors: Dr O.L.F. Weyl and Dr P. Cowley

The study forms part of a greater study by the Water Research Commission, highlighting the freshwater requirements of estuaries. *Oreochromis mossambicus* is essentially a freshwater species that, due to its high salinity tolerance, has been able to invade and establish populations in estuaries. In certain estuaries *O. mossambicus* has been found to contribute significantly to the littoral ichthyofaunal community. However, the contribution and role of this freshwater species to the estuarine ichthyofauna has been largely ignored in ecological studies on estuaries. As a result, the ecology of this species in estuaries is poorly understood. The objectives of this study were to contribute to the understanding of the ecology of *O. mossambicus* in estuaries by: (1) Assessing species composition and the relative contribution of juvenile *O. mossambicus* to the littoral community ichthyofauna of the East Kleinemonde estuary; (2) Determining spatial and temporal distribution of juvenile *O. mossambicus* in the East Kleinemonde estuary; (3) Describing the size composition of juvenile *O. mossambicus* in the East Kleinemonde estuary.

A 5m long, 2m deep, knotless seine net with a 3mm stretch mesh size was used to sample the littoral fish community on a bi monthly basis from September 2005 to July 2006. On each sampling day a seine net was hauled six times in each of the four regions of the estuary: mouth, lower, middle and upper. Historical data from 2005 using identical methods and sites was included in the data set.

Preliminary results indicate that *O. mossambicus* CPUE was higher in the Upper (6.2 +- 10.76) than in the Lower reaches (2.6+-7.86) of the East Kleinemonde estuary. A significant difference was found between numbers of *O. mossambicus* in the Mouth and the Upper region of the estuary (Kruskal-Wallis non-parametric ANOVA, $p < 0.05$). Temporal differences in CPUE were also noted. Summer CPUE was 5.13 ± 4.91 fish/haul and winter CPUE was 0.2 ± 0.2 fish/haul. Frequency of occurrence (hauls containing *O. mossambicus*) was higher in the summer months (Mean=40, 9%, Range=16-80%) than the winter months (0-5%).

Historical length frequency data indicate a small adult population relative to the juvenile population. This together with large temporal changes in CPUE indicates winter mortality. In addition mouth opening during the breeding season may also impede spawning success by limiting spawning sites for adults, and by washing juveniles out to sea.

12h30-12h50: Imtiyaz Ismail (BSc Hon. student) - Movement towards the development of an artificial weaning diet for the South African abalone (*Haliotis midae*).

Supervisors: Prof. P.J. Britz, Dr C.L.W. Jones, and Mr J.A. Esterhuizen

A weaning diet has not been developed for the South African abalone (*Haliotis midae*) industry. Current hatchery management includes weaning juvenile abalone (3-5 mm) on benthic diatoms, which is a major constraint since diatom growth has to be carefully monitored to maintain a balance between food availability and post larval growth. As a result juvenile abalone (5-10 mm) are weaned onto Abfeed®, which was developed for the grow-on of larger animals. The development of an effective weaning diet to support this change has become an essential step in abalone aquaculture. Growth and survival of juvenile abalone (4-5 mm shell length) fed a gel diet containing spirulina, fishmeal, or fishmeal and spirulina, each with a protein content of 48%, were compared. In addition, agar gel only was fed as a control and Abfeed® was fed as a reference diet.

Solid leaching of the fishmeal, spirulina and fishmeal and spirulina gel diets was similar, with an overall mean loss of 0.02 ± 0.07 g per gram on a dry weight basis after 48 hours in sea water. These differed significantly from agar alone, which gained average weight of 1.34 ± 0.16 g over the same period (ANOVA; $F_{(3,8)} = 5.74$; $P = 0.02$).

There was a significant difference in shell length, weight gain, and survival between treatments after 27 days (ANOVA; $p < 0.05$). The low survival rate over the first five days was similar in all treatments with an overall mean of 38 ± 2.23 % (ANOVA; $F_{(4,15)} = 0.97$; $P = 0.45$), and was attributed to handling/transport stress. Mortality was negligible in all treatments after day five (79.8 ± 19.87 %), with the exception of agar only (18.6 ± 5.53 %) (ANOVA; $F_{(4,15)} = 12.93$; $p = 0.00$).

The length (overall mean = 4.99 ± 0.65 mm), weight (15.49 ± 0.63 mg) and condition factor (0.7 ± 0.01) were similar among treatments at the start of the trial (Kruskal-Wallis; $p = 0.68$, $p = 0.70$, $p = 0.84$, respectively). However, after 27 days abalone fed fishmeal and spirulina gel gained significantly more length (2.30 ± 0.05 mm) than abalone fed agar gel only (0.19 ± 0.14 mm) (Kruskal-Wallis; $H_{(4, N=20)} = 15.67$; $p = 0.004$). Similarly, there were differences in mean weight gain between abalone fed fishmeal and spirulina gel (36.87 ± 2.19 mg) and agar gel only (1.26 ± 2.03 mg) (Kruskal-Wallis; $H_{(4, 20)} = 14.58$; $p = 0.00$). The condition factor of abalone fed Abfeed® (0.91 ± 0.02) was on average significantly greater than those of animals fed agar gel only (0.70 ± 0.06) and fishmeal and spirulina (0.75 ± 0.01) (Kruskal-Wallis; $H_{(4, 20)} = 12.28$; $p = 0.01$).

In conclusion, fishmeal and spirulina gel resulted in superior shell growth. However, the exclusion of fishmeal resulted in poorer weight gain. It can be recommended that spirulina be included in the weaning diet to promote shell growth, but cannot totally substitute fishmeal.

12h50-13h10: Billy Coombs (BSc Hon. student) – Digestive staging as a technique for dietary analysis in largemouth bass.

Supervisors: Dr O.L.F. Weyl and Prof. A.J. Booth

Accurate quantification of dietary composition of carnivorous fish requires knowledge of the rate at which different prey items are digested. Prey items that remain in the fore-gut for relatively longer periods are overrepresented in gut samples compared to items which are rapidly digested. This leads to a bias in samples collected, which in turn affects the accuracy and type of conclusions workers can draw from sample sets. Largemouth bass (*Micropterus salmoides*) are an exotic predator of indigenous fishes. Accurate quantification of the diet of this species, particularly with respect to fish, is therefore of considerable conservation interest. Digestion (rate and effect of temperature) was investigated with the aim of gaining a better understanding of digestive processes in this species. Ultimately it is hoped that the information generated will enable more accurate quantification of the diet of bass in South African systems.

Twenty four bass, held in glass aquaria, were each fed three different species of fish. After lapse of pre-determined time periods, the bass were sacrificed and their stomach contents analysed. The experiment was repeated at three temperatures representative of typical seasonal values experienced in the Eastern Cape province of South Africa. A model, detailing qualitative characteristics of ingested remains after set periods of time, was developed for each of the five species of fish used. Linear regression was used to analyse changes in mass over time for different species at different temperatures.

Thursday 4 October 2006
Invertebrate mariculture (Chair: S. Raemaekers)

08h40-09h00: Caryn McNamara (PhD student) - Abalone Haematology and Stress Response.

Supervisors: Prof. P.J Britz and Dr H. Kaiser

South Africa is the largest abalone producer outside of Asia. The South African abalone (*Haliotis midae*) is intensively cultured and contributes to a large portion of the national aquaculture sector. Stressors (temperature, ammonia, dissolved oxygen, inadequate nutrition, handling stress and immune-related events) can affect abalone physiology, blood biochemistry and metabolism moderating growth rate and quality of the abalone product. Hence, a thorough understanding of the biology and physiology of this species is needed to minimise the effects of potential culture-related stressors.

Currently, abalone health management requires highly skilled staff monitoring abalone using a destructive sampling method that requires a long analysis time. Ideally, a simple and non-destructive on-farm diagnostic test would be beneficial to the farmers to accurately gauge the level of stress of their abalone stocks.

Haematological classification of abalone haemolymph will be done separating haemocytes using density gradient centrifugation and the use of light microscopy, SEM and TEM. Reference haematological values will be determined for wild-caught, lab-kept and farmed abalone under various conditions that are assumed not to stress the abalone. These reference values will then be compared to values from stressed abalone to determine whether they can act as indicators for stress.

Similarly, various endocrine hormones (biogenic amines, and hormones such as CRH, ACTH and cytokine-like molecules) will also be studied for their role in the immune response. In addition, assays performed on other molluscs will be adapted to monitor processes such as phagocytosis, respiratory bursts, and antimicrobial activity in abalone.

I will also attempt to identify the site of haematopoiesis so as to identify the mechanism of action for haemacytopenia under stress conditions once more is understood about abalone physiology and the species' immune response mechanisms.

09h00-09h20: Rowan Yearsley (MSc student) - Water quality on South African abalone farms and the potential for polyculture.

Supervisors: Dr C.L.W. Jones and Prof. P.J. Britz

A lack of knowledge regarding water quality on South African abalone *Haliotis midae* farms and which water quality variables affect abalone growth motivate my master's research. My research also aims to test the suitability of abalone effluent for culturing fishes and the bloodworm *Arenicola loveni*.

Experimental work using two size classes of *H. midae* (20.1 – 30 g and 40.1 – 50 g) kept in commercial raceways has shown that total ammonia-nitrogen (TAN) production is higher in raceways at 16h00 than at 08h00 and 12h00 for both size classes (Kruskal-Wallis ANOVA by Ranks, 20.1 – 30 g: $H = 28.1$, $n = 48$, $p = 0.0000$; 40.1 – 50 g: $H = 25.2$, $n = 47$, $p = 0.0001$). TAN production at 20h00, 24h00 and 04h00 did not differ significantly from production at 16h00, 08h00 or 12h00 ($p > 0.05$). The reasons for this pattern of TAN production are still unsolved but will be investigated in future experiments. *H. midae* of 20.1 – 30 g produced TAN at a rate of $9.3 \pm 4.1 \mu\text{g NH}_4\text{-N min}^{-1} \text{kg}^{-1}$, while larger animals of 40.1 – 50 g produced $6.9 \pm 2.6 \mu\text{g NH}_4\text{-N min}^{-1} \text{kg}^{-1}$. Nitrite production of raceways holding the smaller size class averaged $0.8 \pm 0.6 \mu\text{g NO}_2\text{-N min}^{-1} \text{kg}^{-1}$, while those containing the larger animals averaged $0.4 \pm 0.4 \mu\text{g NO}_2\text{-N min}^{-1} \text{kg}^{-1}$ – nitrite production was not significantly influenced by time of day (Kruskal-Wallis ANOVA by Ranks, 20.1 – 30 g: $H = 5.0$, $n = 46$, $p = 0.417$; 40.1 – 50g, $H = 5.7$, $n = 44$, $p = 0.336$).

Seasonal changes in water quality on abalone farms and farms' incremental water quality (i.e. the change between influent and effluent) are being monitored at HIK Abalone Farm (Pty) Ltd in Hermanus, at 09h00 and 16h00 roughly every three days. This sampling began in May 2006 and will continue till April 2007. The concentrations of TAN, $\text{NO}_2\text{-N}$ and dissolved oxygen in farm influent have averaged 13.7 ± 3.8 ppb $\text{NH}_4\text{-N}$, 4.5 ± 2.5 ppb $\text{NO}_2\text{-N}$ and 8.3 ± 0.8 ppm O_2 , respectively. This contrasts with average concentrations of 41.9 ± 11.8 ppb $\text{NH}_4\text{-N}$, 7.8 ± 3.2 ppb $\text{NO}_2\text{-N}$ and 7.4 ± 0.3 ppm O_2 in the farm effluent. Temperature of the influent and effluent has been similar at 14.8 ± 0.6 °C and 14.7 ± 0.6 °C respectively. The pH of the farm influent averages 8.16 (min: 8.01, max: 8.27) while the effluent has a lower pH of 7.97 (min: 7.79, max: 8.14). Considering the effects of pH and temperature the influent has a mean Free Ammonia-Nitrogen (FAN) concentration of 0.4 ± 0.1 ppb FAN, and the effluent averages 0.8 ± 0.2 ppb FAN. Data on incremental water quality i.e. the change between influent and effluent will be combined with data on flow volumes and farm biomass to generate values for TAN production ($\text{g NH}_4\text{-N hr}^{-1} \text{ton}^{-1}$), nitrite production ($\text{g NO}_2\text{-N hr}^{-1} \text{ton}^{-1}$), and dissolved oxygen consumption ($\text{g O}_2 \text{hr}^{-1} \text{ton}^{-1}$) under commercial farm conditions. At the same farm a growth experiment is being used to test the influence of water quality variables on abalone growth.

An experimental system has been built at Roman Bay Sea Farm (Pty) Ltd for culturing finfishes and bloodworm and will soon test the suitability of abalone effluent for these species by comparing their growth and/or survival in abalone effluent to those grown in unused seawater.

09h20-09h40: Alistair. J. Green (MSc student) - The development of temperature specific diets for the South African abalone *Haliotis midae*.

Supervisors: Prof. P.J. Britz and Dr C.L.W. Jones

South Africa is currently the second largest producer of abalone in the world. However there is an increase in abalone production worldwide which threatens to lower the market price. Feed costs constitute a major proportion of production costs and it is therefore essential to ensure that abalone receive a nutritionally complete feed source that optimises growth rates that do not negatively affect water quality and optimises production.

Research has shown that the optimal dietary protein level for abalone is influenced by both abalone size and water temperature. The optimal temperature range for the growth of *H. midae* lies between 14-20 °C. Optimal protein levels are reported to range from 34% for smaller abalone (i.e. less than 50mm) and 26% for larger (i.e. greater than 50mm). However, the relationship between protein and energy and temperature has not been studied for different size abalone.

There is also a requirement from industry for a diet that can be fed to abalone at higher water temperatures. Abalone growth is maximised at a water temperature of 20 °C. However, abalone growth rates decline significantly at temperatures in excess of 20 °C. In addition to this abalone fed high protein diets and exposed to high water temperatures can suffer from a condition referred to as “bloat”. Therefore, there is a need for a high temperature maintenance diet that can be used during periods of elevated temperatures.

The objectives of this study are to compare the growth and survival of abalone fed a range of low protein diets (18, 22 and 26%) and a range of protein and energy ratios, all at 20, 22 and 24 °C. The second objective is to compare growth and survival of abalone fed diets with a range of protein (20% through to 50%) at either 14, 16 or 18 °C. This shall be repeated for 10-15 mm, 50 mm and 80 mm abalone.

09h40-10h00: Guy Paulet (PhD student) - Development of a practical diet for on-growing the East coast rock lobster *Panulirus homarus*.

Supervisors: Prof. P.J. Britz and Dr A. Cockcroft

The East coast rock lobster, *P. homarus*, has been chosen as a potential candidate for mariculture based on its high retail value and availability for sustainable harvesting. This research will promote the domestication and cultivation of an indigenous species, which will benefit subsistence fishers involved in the collection of juvenile lobsters for on-growing. On-growing of other spiny lobster species in ponds, cages and tanks has been successful when adequate supplies of juveniles or under-sized lobsters can be obtained. In India wild-caught juveniles (50g) readily accept various diets and are grown to market size (250g) in 5 months. The aim of this research is to determine the viability of on-growing juveniles in shore-based systems.

As the intensity of on-growing increases, so does the reliance on compounded feeds whose composition must be tailored to the nutritional demands of the species being cultured if rapid growth is to be achieved. Limited research conducted since 1980 has highlighted the essential nature of certain micro-nutrients, in particular cholesterol and certain fatty acids, which lobsters have no or only limited ability to synthesise *de novo*. Four fatty acids have been identified as particularly important dietary ingredients in crustaceans: linolenic (18:2 n-6), linolenic (18:3 n-3), eicosapentaenoic (20:5 n-3) and docosahexaenoic (22:6 n-3). Complete fatty acid and amino acid profiles of tissue from the muscle and hepatopancreas will be compared with various fresh and prepared diets in order to determine a starting point for development of a gel or pelleted diet. Standardised FAME analysis and Gas chromatography will be used to identify fatty acids and Amino acid analysis will be performed on aqueous solutions containing free amino acids or on proteins and peptides following hydrolysis to release the amino acids.

Diet composition, preparation, use of water stable binding agents, interactions between ingredients, dietary energy content, processing and storage of diets will all be investigated. Lobsters will be individually marked using fluorescent elastomere tags placed in a conserved section of the thorax in order to track the growth and survival of individual animals. Spiny lobsters are known to be communal and are thus suitable for on-growing in groups. Animals kept in isolation have been shown to grow more slowly. Freshly ground squid, freeze-dried squid, fresh mussels, and freeze-dried mussels will be incorporated into pelletised or gel diets using different binding agents. These diets will be compared to a reference diet of fresh mussels and growth and survival over a 3-6 month period will be measured. Growth trials will be conducted using lobsters of various sizes and the data analysed using ANOVA and/or repeated measures tests.

Production trials will be conducted after a suitable formulated diet has been tested. The effect of culture tank design on growth and survival will be tested with replicates under different environmental conditions such as flow rate. Recirculating raceway systems will be built and lobsters will be housed in cages and crates suspended in these raceways. Hides will be supplied and different configurations tested.

10h00-10h20: Justin Kemp (MSc student) - A physiological investigation into enhancing the survival and growth of wild caught East coast rock lobster *Panulirus homarus* for aquaculture.

Supervisors: Prof. P.J. Britz and Dr. A. Cockcroft

Aquaculture has been the fastest growing food production system for over 10 years, yet spiny lobsters have contributed only a small proportion to this and culture techniques remain in their infancy. Despite lucrative markets for whole live lobster (\$100.kg⁻¹) and research interest in a number of countries including Australia, New Zealand, USA and Japan, production has remained low. This is generally attributed to the difficulties associated with growing species through all larval stages. As a result, the majority of culture effort to date has focused on the growing out of wild caught pueruli and juveniles. Natural mortality at this life stage is high (80-90%) and studies conducted on both *P. cygnus* and *Jasus lalandii* indicate that this harvesting is both viable and sustainable.

Subsequently, interest has arisen regarding the potential of growing out the East coast rock lobster *P. homarus*, a high value indigenous species. This spiny lobster is commonly taken by local subsistence fisherman along the Transkei coast, South Africa, predominantly for sale to tourists or for personal consumption. Non-compliance with the minimum size limit and inefficient law enforcement, in part due to lack of staff and poor accessibility, results in the regular removal of sub legal sized animals. However this practice appears to be sustainable as no commercial fishery exists and the majority of the population occurs on offshore reefs, in effect inaccessible to subsistence fishers. A number of benefits present themselves if these small individuals could be grown out to a marketable size under permit from Marine and Coastal Management (MCM). Apart from reducing pressure on an already strained enforcement network, value would be added to the resource resulting in cascading socio-economic benefits.

The aim of this project is to gain an understanding of lobster survival, growth and transport from a physiological perspective in order to assess the biological and economic feasibility of lobster grow out and thereby inform the development of protocols for the culture of *P. homarus* in South Africa. Initial effort was aimed at refining collection techniques and gathering experimental animals, with retrieval from offshore reefs in the Mdumbi region using SCUBA being the most effective. Current research is focusing on the effect of temperature on growth and survival in the form of a growth trial. The experimental design consists of five treatments (18, 21, 24, 27, 30°C) with 5 replicates per treatment and two animals per replicate (n = 50). Animals are being fed to satiation three times weekly on a diet of fresh mussel (*Perna perna* and *Mytilus galloprovincialis*) with food resident in the tank for 24 hours. Moulting increment (carapace length and wet weight), intermoult duration and food consumption of individual animals are being recorded and data will be analysed using a repeated measures analyses.

Future research will examine the effect of a number of intrinsic and extrinsic factors on the oxygen consumption rate (mg O₂/g/h) and total ammonia nitrogen (TAN) excretion of *P. homarus* using intermittent respirometry and associated methods. These factors include acute temperature change, body weight, diurnal rhythm, activity, handling and feeding. Furthermore, the incidence of cannibalism within mixed size groups will be investigated and methods to reduce this potential loss will be developed.

10h20-10h55 Tea break

Invertebrate and marine finfish mariculture (Chair: R. Chalmers)

11h00-11h20: J. Albert Esterhuizen (PhD student) - Towards the development of an artificial weaning diet for the South African abalone, *Haliotis midae*.

Supervisors: Prof. P.J. Britz and Dr C.L.W. Jones

Recently the abalone (*Haliotis midae*) industry reported reduced survival and highly variable growth rates during the weaning stages of abalone farming. Following several discussions with various abalone farms, it was decided to conduct a baseline study during the weaning phase to investigate digestive development of juvenile abalone, with the aim of developing an abalone weaning diet. In this study, abalone were exposed to several dietary treatments which included abalone fed diatoms, kelp, Abfeed (fed in normal daylight) and Abfeed fed in 24 hr darkness. The study was conducted at HIK Abalone Farm in Hermanus for a period of 21 days. Preliminary results indicated that diatoms and Abfeed fed in the dark had similar growth rates (1.24 ± 0.16 and 1.28 ± 0.11 respectively; Kruskal-Wallace, $p = 1.00$) while kelp (0.57 ± 0.19) did not match growth rates to any of the other diets (Kruskal-Wallace; $p < 0.000005$). It was observed that abalone fed Abfeed in the dark exhibited significantly faster growth than abalone fed Abfeed in the light (1.28 ± 0.11 and 1.13 ± 0.34 respectively; Kruskal-Wallace, $p=0.006$). Samples of abalone fed the different diets have been sent off to the National Health Services Laboratory (NHSL) for histological analysis to verify digestive tract development. Qualitative results on enzyme work indicate amylase and trypsin are present in juvenile abalone. It has been verified that both amylase and trypsin have optimum digestive activity at pH 7.5. Further enzyme analysis will be conducted which will include the identification and quantification of pepsin, chymotrypsin, total proteases and lipases.

11h20-11h40: Ernst Thompson (PhD student) - Larval and histochemical development of *Dagetichthys marginatus*.

Supervisor: Prof. T. Hecht

Larval development of the soleids is associated with complex morphological and behavioural changes during metamorphosis. It is critical to understand and predict these changes when setting up protocols for larval rearing under intensive culture conditions, i.e. when to start feeding artificial diets with a complex protein structure. This project aims to investigate external and internal morphological and physiological larval development of *Dagetichthys marginatus*. A thorough larval description was completed, which was also the first description for the genus. This description was then related to gut histology.

Eggs were obtained from females by strip spawning approximately 38 hrs after induction by hormones (Aquaspawn ®, a GnRH analogue). Males were sacrificed and the testes were homogenized in a small volume (1 ml) of saline solution (0.9 ppt). Eggs were fertilized with the testicular homogenate. After fertilization and hardening, eggs were thoroughly washed with seawater and divided among 60 L black upwelling incubators at a density of 20 eggs / L for egg incubation and larval rearing. Larvae were fed twice daily on newly hatched brine shrimp, *Artemia salina* nauplii from first feeding to 16 dah. After this, larvae were fed two-day old, Super Selco (INVE) enriched *A. salina*. Ten larvae were collected at specific intervals representing developmental endpoints after hatching. All samples were fixed in 5 % buffered formaldehyde for 24 hrs and then transferred into 70 % ethanol. Gut histology was completed by staining sections with H-E, Pas and Alcian blue to colour different components of the gut.

Larval development in *D. marginatus* is typical of Soleidae. *Dagetichthys marginatus* larvae are heavily pigmented with four characteristic melanophore “blotches” on the finfold. These larvae are easily distinguished from other soleid larvae commonly encountered in temperate South Africa based on the large size at flexion (5 – 7.06 mm BL) and the heavily pigmented body. Gut histology show an increase in complexity from a straight undifferentiated tube like gut to a coiled gut with a clear stomach and intestine. Various cells responsible for enzyme secretion are also visible. In the future the histology will be related to enzyme activity. Currently the enzyme assays are being optimized to ensure comparability with other species at maximum activity.

11h40-12h00: Mike Markovina (MSc student) - Ultrastructure of the testis and spermatozoa in *Austroglossus pectoralis* (Kaup, 1858).

Supervisors: Prof. T. Hecht and Dr. H. Kaiser

Aquaculture continues to diversify by expanding and culturing new high-value species. Constraints such as seasonal availability of broodstock and small sperm volume in *Austroglossus pectoralis* are likely to require cryopreservation techniques to achieve spawning under captive conditions. Cryopreservation involves the freezing, cryogenic storage and thawing of living material, i.e., gametes, and it is routinely applied in animal husbandry. Gamete cryopreservation from aquatic organisms is a novel field, and research is needed to achieve commercial-scale successes. A cryopreservation protocol offers benefits to both aquaculture and fisheries conservation programs. Benefits to aquaculture include a continuous supply of gametes for hatchery production, easy and economic transportation of gametes, improved selective breeding potential and production of hybrids, and an increased number of offspring from genetically superior individuals. Benefits to fisheries conservation programs include the opportunity of compiling gene banks of vulnerable and endangered species.

The objectives are to: develop a cryopreservation protocol for *Austroglossus pectoralis* sperm; investigate a method of sex determination using the barr body of neutrophils to identify females; describe the external and internal anatomy of the testis; and describe the morphology of *A. pectoralis* spermatozoa and the process of spermatogenesis to understand gamete maturation and spawning potential.

Austroglossus pectoralis were sampled on a sole trawler operating from Mossel Bay towards Stilbaai. Sole were sampled at a depth ranging from 48-65 m. Trawls were conducted every 3 hours during the day and every 5 hours during the night. The testis was removed from fish, sliced in quarters and placed into a test tube with 4 ml of extender solution (Modified Mounibs Medium). 270 µl sperm extender solution were pipetted into 4-vial series, containing 30 µl solution containing 10% DMSO, 30 µl glycerol and 30 µl extender (control), respectively. Samples were placed 5cm above the surface of liquid nitrogen for 10 minutes. This lowered the temperature to -90°C. Samples were then plunged and stored in liquid nitrogen at -196°C. Fluorescence analysis combining Rhodamine 123, SYBR 14 and Propidium iodide will be used to assess the potential viability of post-thawed spermatozoa using flow cytometry. Testis samples were fixed in 10% buffered formaldehyde for 24 hours, and then transferred into 70% ethanol for histological analysis. Testis and sperm samples were fixed in 2.5% glutaraldehyde buffered solution for Scanning Electron Microscopy and Transmission Electron Microscopy.

The spermatozoa of *Austroglossus pectoralis* has an acrosome-less ovoid head, a short mid-piece, containing 7 irregularly shaped mitochondria forming a ring structure within the cytoplasm. The flagella have two lateral fin-like projections. Cross-sections of the flagella show the axenome to have a 9+2 microtubule configuration. The proximal and distal centriols are coaxial and are situated deep within nuclear fossa. The structure of *A. pectoralis* spermatozoa conforms to type 1 sperm, which is suggested to be the plesiomorphic form in Neopterygians. Spermatozoa dimensions are compared to other species. The testis is a paired structure encased in a membrane (*Tunica albuginea*). The primary testis is located on the dorsal surface of the rib cage and the secondary testis on the ventral side. The testis is of unrestricted spermatogonial type, and it appears to change from a red hard structure to a white milky structure at the onset of spawning.

12h00-12h20: Stephan Ende (MSc student) - Feeding functional morphology of the white-margined sole *Dagetichthys marginatus*.

Supervisor: Prof. T. Hecht

Stimulated by high market prices and increasing demands for flatfish in South Africa the white margined sole *Dagetichthys marginatus* is currently been investigated on its culture potential for marine aquaculture. This study examined the form and function of morphological elements involved in feeding in order to provide a better understanding of feeding mechanisms and hence maximise feed utilisation under culture conditions. *D. marginatus* showed remarkable asymmetries among elements of the neurocranium, the suspensoria and the upper and lower jaws. Elements of the opercular series and the hyoid showed little asymmetries. Based on the morphology of the feeding apparatus and our current knowledge on the feeding behaviour it is suggested that *D. marginatus* is highly specialized for feeding exclusively on benthic organisms. The present results contribute first information on the feeding functional morphology of *D. marginatus*. Further investigations on the quantitative analysis of kinematics are needed to verify the current hypotheses and to determine in which ways the anatomical system moves.

12h20-12h40: Paul Collett (MSc student) - The effect of environmental factors on growth of juvenile dusky kob (*Argyrosomus japonicus*) under culture conditions.

Supervisors: Prof. H. Kaiser and Dr N. Vine

The South African mariculture industry is currently looking to develop finfish mariculture technology to include new indigenous species. Dusky kob (*Argyrosomus japonicus*) is one such species with high quality flesh and a potentially good market demand. However, to assess the species' potential for commercial mariculture, it is necessary to develop the technology needed to facilitate their culture. In doing so, research is needed to determine the environmental requirements under which growth of dusky kob is optimised. To date, there is a general paucity of information on this subject.

The overall aim of this programme is to quantify those environmental conditions that are important for growth of juvenile dusky kob. According to a protocol developed by Deacon (1997), the environmental requirements of juvenile marine fish must be determined in a particular sequence, namely; temperature, light intensity, feeding regime and stocking density.

The result of this investigation will provide the South African mariculture industry with the opportunity to assess the economics and hence potential of this species as an aquaculture candidate. In addition, the results will help develop protocols and therefore lay the platform for other candidate aquaculture species such as; silver kob, yellowtail, white-stumpnose and sole.

The objectives are to determine the effect of environmental factors such as temperature (reported in this abstract), light intensity, feeding frequency, ration size and stocking density on the growth, survival and FCR of juvenile dusky kob.

The effect of temperature on growth and mortality was assessed at 14 constant temperatures (17 – 28°C) in a 56-day trial. Groups of fish (initial average weight 23.7g) were held in 14, 100 L plastic tanks all connected to one biological and mechanical filter. Fish were fed to apparent satiation and the amount of food fed per tank determined. The fish from each tank were measured (standard length in mm) and weighed (to 0.1g) every 14 days.

Preliminary analyses show a definite relationship between temperature and growth of juvenile dusky kob. Growth increased as temperature increased from a minimum at 17.5°C up to a plateau at 24 – 26°C followed by a decrease until 28.5°C. Feed conversion ratio also increased as temperature increased with a plateau at 21 – 23°C. This study illustrates, for the first time, temperature dependent growth of juvenile dusky kob when food and oxygen are not restricted. This thermal response is in line with other studies on marine teleosts. Of particular interest is the similarity in the current study results to those of Bernatzeder (2005) who identified the thermal preference of juvenile dusky kob to be in the range 25 – 26.4°C.

Determination of the temperature range that does not limit growth of dusky kob is a prerequisite for the assessment of the relationship between growth and other environmental parameters such as light intensity, feeding regime and stocking density. In addition, this result is significant for industry applications where the culture temperature that maximises growth is vital and consequently, all future experiments will be run at a temperature of $\pm 25.6^\circ\text{C}$.

12h40-13h00: Andrea Bernatzeder (MSc student) - Salinity induced physiological responses in dusky kob, *Argyrosomus japonicus*.

Supervisors: Dr P. Cowley and Prof. T. Hecht

Dusky kob, *Argyrosomus japonicus*, is an important commercial and recreational fisheries species that is targeted throughout its distribution range. Fisheries management regulations have failed to ensure the sustainability of this species and the stock is considered to be collapsed (SB/R = 2%). Research is needed to gain more insight into the life history, biology and distribution of the species to assist with its management. Griffiths (1995) found that early juvenile dusky kob recruit into estuaries and appear to remain in the upper reaches of estuaries at low salinities until they grow to about 150 mm TL. Larger juveniles are found in the middle and lower reaches of the estuary and surf zone. Despite a lack of empirical evidence it has been suggested that early juveniles remain confined to the upper reaches of estuaries due to food availability and predator avoidance. To date research has not incorporated the physiological responses of dusky kob to various biological and environmental variables, which is especially important in dynamic estuarine environments that are exposed to significant daily changes in abiotic conditions such as temperature, salinity and turbidity as well as unpredictable freshwater intrusions following periods of high rainfall. This study aims to investigate the role of physiological responses and adaptations to salinity on the distribution, abundance and habitat utilization of early juvenile dusky kob. The objectives of the study are to investigate: (i) the effect of salinity on growth, (ii) the physiological response of juvenile dusky kob to various rates of changes in salinity, (iii) the direct effect of ambient salinities on blood physiology and (iv) the histological changes as a result of long-term exposures to different salinity and adaptations with age.

A laboratory experiment was designed to investigate the effect of salinity on growth, plasma osmolality and the histology of the primary osmoregulatory organs. Hatchery reared fish from Espadon Marine Hatchery in Hermanus were acclimatized to 35‰ at the Rhodes University marine hatchery. This included treating endoparasites, regular size grading and general husbandry. In this experiment, twelve independent holding tanks were designed and built with a submersible pump, biological filter, heaters and shade coverings. Prior to the experiment, the plasma osmolality of 12 fish was measured to determine the salinity isosmotic to the blood. The salinities tested were 5‰, isosmotic and 35‰ with four replicates of each. After the initial weigh and measure, salinity was changed gradually over two days from 35‰ to the respective salinities. On the third day, five fish per tank were sacrificed to determine plasma osmolality and attain tissue samples of the gills, kidney and urinary bladder. The experiment was discontinued after mass mortalities occurred from the tenth day onwards at the lower salinities. Subsequently the systems were modified with the addition of protein skimmers and bigger pumps, improving the air supply and filtration. The experiment will be repeated in November and run for at least six weeks, during which plasma osmolality and histological samples will be taken every two weeks. In the interim, a preliminary study to investigate daily changes in plasma osmolality was conducted. Literature suggests that plasma chloride concentrations vary during the day. Plasma osmolality was measured at 4 different times of the day; each sample consisted of five fish from three different tanks at 35‰. These findings are important as plasma osmolality will be measured at different times of the day for the salinity change experiment.

Plasma osmolality of juvenile dusky kob at 35‰ was 358.4±9.1 mOsm/l, corresponding to a salinity of 12.3±0.3 ‰ (isosmotic). A rheology apparatus has been built and will be used to study the effect of salinity on the red blood cells, such as burr cells (burst cell) at higher salinities. Future experiments include investigating the response of plasma osmolality to short term changes in salinity. Finally, depending on and the availability of funds, juveniles will be tagged with acoustic tags to determine activity and distribution patterns within a natural nursery habitat.

13h00-13h55 Lunch break

Fresh water and estuarine ecology (Chair: E. Thompson)

14h00-14h20: Hylton Lewis (MSc student) - Investigation into the suitability of the vertical slot or sloping baffle fishway for use at the ebb and flow region of rivers in the Eastern Cape, South Africa.

Supervisors: Prof P.J. Britz and Mr M. Davies

Fishways are devices that are now commonly employed worldwide to assist aquatic biofauna to surmount man-made perturbations in rivers such as gauging weirs, dams and causeways. They generally consist of low gradient channels with a number of pools that will allow the fish to move between pools and in doing so move through or around the barrier without undue stress. The need to provide fishways on these manmade barriers has been recognised as being highly important. Unfortunately the implementation has been slow in the absence of defined assessment methods necessary to support policy on the provision of fishways.

The majority of fishway designs that have been implemented to date are unsuccessful at passing many native fish species due to them being designed for salmonids. As part of a larger research initiative supported by the WRC it was the aim of this project to determine the most suitable design of fishway for use by catadromic juvenile fish on regulated coastal rivers. This would be achieved through a series of controlled tests with captive fish and field testing where wild fish would be used.

Two model fishways were built for use in the controlled tests and field tests, these could be manipulated to alter the gradient and flow rate through the channel. Two species of fish (*Myxus capensis* and *Monodactylus falciformis*) were used in the controlled tests, being placed into the fishway and allowed a limited time to navigate the fishway. The fish's abilities to navigate the fishways were tested at various flow rates and gradients, with success being recorded for each condition.

Overall results indicate a significantly higher level of success in the vertical slot fishway than in the sloping baffle fishway under all conditions ($F= 82.157$; $p< 0.001$). There is a slow decline in levels of success with increasing discharge in the vertical slot fishway. This is in contrast to the sloping baffle, where success increases as discharge increases at a steep gradient ($F= 74.849$; $p< 0.005$). The level of success in mullet was related to the size of the fish for both systems with success increasing from the small fish to the large fish ($F= 17.755$; $p< 0.001$). For moonies increased levels of success were found to occur in the vertical slot fishway over the sloping baffle ($F=11.792$; $p< 0.00086$), with no significant differences being found with an increase in discharge. Field data indicates similar trends with higher success in the vertical slot fishway and higher success in the mullet over the moonies. Overall levels of success were higher for both species in the field than under controlled conditions.

It was determined that the vertical slot fishway is a more suitable design for passing juvenile catadromous fish. The true swimming ability of the test species is not however suitability reflected by their performance in captivity and steeper gradients may be passable. Further work is also needed in determining the effects of added substrate in the fishways as this seemed to improve the success of small fish, especially at low discharge, and on the sighting of the fishway entrance, maximising exposure to the structure.

14h20-14h40: Naomi Richardson (MSc student) Biomarkers and community indices as a measure of fish community health in intermittently open Eastern Cape estuaries.

Supervisors: Dr A. Whitfield and Dr N. Muller

Pollutant stressors are likely to affect fish at lower biological organisation levels before effects become apparent at a population or community level. This research investigated the possibility of extrapolating pollution induced biological changes at the cellular and organ level of a fish population to the community level. Three structurally similar intermittently open Eastern Cape estuaries (East Kleinemonde, Old Woman's and Mtana estuaries) were used as experimental sites and a widely distributed and dominant fish, the Cape stumpnose (*Rhabdosargus holubi*), was selected as an indicator species. For each estuary, an estuarine fish community index (EFCI) was calculated and 100 *R. holubi* were collected for analysis. At an organism level, a condition factor, relating length to wet weight, was calculated for each fish. At a sub-organism level liver histology was used to determine organ deterioration. At a sub-cellular level, two biomarker assays were used to assess whether there had been exposure to environmental stressors. An acetylcholinesterase assay (AChE assay) and a lipid peroxidation (LPx assay) assay were used on brain and liver tissue respectively. The EFCI rating placed the East Kleinemonde and Old Woman's estuaries in a 'good' category, while the Mtana was in a 'moderate' category. The condition factor analyses of the *R. holubi* sampled showed that the Old Woman's fish were in a significantly poorer condition than the other two estuaries (ANOVA, $F_{(2,296)}=76.88$, $p<0.01$). Liver histology analyses indicated that the East Kleinemonde *R. holubi* were in good condition, but fish from the Mtana and Old Woman's estuaries showed signs of long term chronic exposure to one, or more, low dose pollutants. AChE inhibition was significantly higher in the Old Woman's estuary than in the other two systems (Kruskal-Wallis, $H = 49.19792$, $df =245$, $p<0.0001$). LPx values were significantly higher in the Mtana and Old Woman's estuaries when compared to the East Kleinemonde (Kruskal-Wallis, $H =25.37459$, $df =270$, $p<0.0001$). The results will be used to describe the relative sensitivity and appropriateness of the different methods in determining the health of these three estuaries.

14h40-15h00: Bronwyn O'Connell (MSc student) - Movement behaviour and space use patterns of spotted grunter (*Pomadasys commersonnii*) in an intermittently open estuary, using acoustic telemetry.

Supervisor: Dr P. Cowley

Investigating movement behaviour and space use patterns of exploited fishery species is essential for the development of effective management plans. The spotted grunter *Pomadasys commersonnii* is the most important estuarine-dependent fishery species in South Africa and is heavily targeted by recreational and subsistence fishers within estuaries throughout its distributional range. Although much is known about the biology and ecology of this species, reliable information on their movements and space use patterns is still lacking. The localized movements of spotted grunter have been studied in the Great Fish Estuary; a permanently open system subject to large daily fluctuations in environmental conditions such as temperature, salinity and turbidity. However, this species also utilizes intermittently open estuaries (IOEs), with no tidal influence and limited fluctuations in environmental conditions, as nursery areas. Considering that IOEs are the most dominant (~80%) estuary type in South Africa an investigation of the space use and movement patterns within IOEs will enhance our understanding of the ecology of spotted grunter and contribute to the management needs of this important estuarine-dependent fishery species.

Due to the limitations of using conventional tagging data, this study will make use of telemetry methods to investigate fine-scale temporal and spatial movement patterns of spotted grunter in the intermittently open East Kleinemonde Estuary. The objectives of this study are to (i) investigate seasonal space use patterns, (ii) quantify home range sizes, and (iii) investigate daily (diurnal) activity patterns of spotted grunter in the East Kleinemonde Estuary.

This study made use of acoustic telemetry equipment manufactured by Vemco (Halifax, Canada). A total of 14 fish were surgically equipped with V8 coded transmitters and were manually tracked with a VR60 receiver to obtain both day and night positional fixes on six consecutive days every second month from March to November 2004. In addition, five stationary receivers (VR2's) were moored at specific locations from the mouth to the top of the estuary. These receivers logged continuous data on the presence (or absence) of each fish, within a variable reception range, from March 2004 to February 2005. In addition to the long-term data, a further six fish will be caught in early 2007, and tagged with continuous transmitters (pingers). These fish will be manually tracked for several 24 hour periods from an electrically motorized boat using a VR60 to quantify diurnal activity patterns. Home range estimates were calculated using the GIS software Arcview ® and the Animal Movement Analysis Extension (AMAE).

Home range sizes with a 95% utilization distribution (UD; area in which the fish will be found with a 95% probability) varied between 15 377m² and 186 500m², while the core areas (50% UD) ranged between 9 894m² and 30 568m². The number of core area sites occupied by each fish ranged between 1 and 3. Home range lengths ranged from 280m to 2 770m (n = 14). Home ranges were all, except one, confined to the lower reaches of the estuary and many of the core areas of the tagged fish overlapped. This region of the estuary is characterized by a sandy substrate with a high abundance of sand prawns (*Callinassa kraussii*). Despite showing fidelity to specific sites most (71%) of the tagged fish used much of the estuary (roaming behaviour), while only 29% exhibited restricted movements (resident behaviour). Data on seasonal space use patterns and daily activity patterns still need to be analysed.

15h00-15h20: Nicola James (PhD student) - A study of fish population dynamics in the East Kleinemonde Estuary, South Africa.

Supervisors Dr A. Whitfield and Dr P. Cowley

Variation in estuarine fish communities has been well studied on a spatial and seasonal scale (with studies ranging in duration from 1 to 3 years). However, far less is known about estuarine fish community structure over the medium to long-term. This study includes the analysis of long-term data on the fish assemblages of the intermittently open East Kleinemonde Estuary and an analysis of the olfactory cues thought to influence postflexion larval recruitment into estuaries. The fishes of the East Kleinemonde Estuary have been sampled in summer and winter, using seine and gill nets since December 1994. Fish assemblages showed a degree of stability with the dominant species caught being represented each year. However, the contributions made by each species to the catch varied on an annual basis. Although it was hypothesized that annual patterns of marine fish abundances are driven by the timing, frequency and duration of mouth opening events, it was found that the timing of mouth opening events was the most important driver, with species richness increasing when the mouth opened during spring.

Records of several new tropical species were made in the East Kleinemonde Estuary from 1999 onwards. Mean annual sea temperatures recorded at Port Alfred and East London have been increasing steadily over the past decade and this has facilitated the southward extension of tropical marine species into the warm-temperate biogeographic zone.

Data are also presented on long-term changes in the timing of recruitment, the period of residence, growth and habitat use of *Rhabdosargus holubi* and *Lithognathus lithognathus* (Family Sparidae) while in the estuarine environment. A number of aspects of the biology and life-history of *R. holubi* and *L. lithognathus* are very different which in turn was found to affect their response to fluctuations in environmental variables. The dominance of *R. holubi* in the East Kleinemonde and other intermittently open estuaries can be attributed to the extended breeding season of this species and its ability to use both overwash events and openings to recruit into estuaries. In contrast, a number of aspects of the biology of *L. lithognathus* make it vulnerable to estuarine degradation and over fishing and these include a short recruitment period and inability to access estuaries during overwash events.

Attraction of postflexion *Rhabdosargus holubi* larvae to different water masses was tested using a rectangular choice chamber. In two sets of experiments, conducted to assess the factors guiding recruitment of postflexion *R. holubi* larvae into estuaries, postflexion *Rhabdosargus holubi* larvae from both the surf zone and estuary mouth region selected estuary water with a significantly higher frequency than the sea water control. Larvae collected in the mouth region showed a stronger preference for river water than those collected in the surf zone, thus indicating that these fish are more attracted to freshwater influenced nursery areas once they have entered the estuary than those in the surf zone. Larvae collected in the marine environment also selected surf zone water with significantly higher frequencies than estuary and seawater thus confirming the importance of the surf zone as an interim nursery area for postflexion *R. holubi*. This study has highlighted the importance of long-term studies to understanding community changes in estuaries that are caused by local or global environmental variations and demonstrates that larvae are able to recognise different water masses based on odour and are probably responding to different olfactory cues when accumulating in surf zones or estuary mouths, prior to moving into shallow nursery areas within estuaries.

15h20-15h40: Phanor Montoya-Maya (MSc student) - Dynamics of ichthyoplankton and zooplankton from selected cool and temperate estuaries in South Africa.

Supervisor: Dr N.A. Strydom and Dr T.H. Wooldridge

At present, there is a gap in the understanding of larval fish and zooplankton dynamics associated with cool temperate estuaries along the south and west coasts of South Africa. This study aims to provide baseline information on composition, abundance, and distribution of ichthyo- and zooplankton in selected (nine) cool temperate estuaries as well as provide some insight into the interactions between these organisms in these systems. Larval fishes and zooplankton were collected by plankton towing at approximately equidistant sites along the length of each estuary using two WP2 plankton nets (570 mm mouth diameter and 0.5 mm mesh aperture size) fitted with flow meters. Two sub-surface samples were collected (replicates) per site, per estuary, during all four seasons for a period of one year between 2004 and 2005. Temperature (°C), salinity (‰) and turbidity (CTU) profiles were obtained at each site using a YSI multiparameter meter. Recordings were made at intervals of 0.5 m between the surface and bottom of the water column. Samples were preserved on site with 5 % buffered formaldehyde.

Approximately 300 samples are now being sorted in the laboratory and all ichthyo- and zooplankton are being identified, counted and measured. New larval fish and zooplankton descriptions will be made. Densities of all species, from each estuary will be standardized to numbers per 100 m³ for larval fishes and numbers per m³ for zooplankton. These data as well as physical data will then be placed in species/samples and physical-variable/station matrices. Biological and physical data will be processed statistically to assess differences between seasons, sites and salinity zones sampled during this period using PRIMER v5 (Plymouth Routines in Multivariate Ecological Research). Diversity indices (i.e. Shannon-Wiener's Diversity Index and Pielou's Evenness Index) will be calculated per station and processed in the same way. Multivariate community analysis will be conducted to link the data and assess trends. A classification analysis based on the Bray-Curtis Similarity measure will be used to delineate groups with distinct community structure. To identify the specific composition of each group formed and to examine the contribution of individual species to the similarity measure used, an inverse analysis will be conducted using the program SIMPER. Non-metric multidimensional scaling (MDS) will be used for ordination.

Three scientific papers will be produced from this thesis: A paper dealing with composition, abundance and distribution of zooplankton in these estuaries; a similar paper on ichthyoplankton dynamics; and one covering the dynamics between these two plankton groups.

Friday 6 October 2006
Marine resources and management (Chair: A. Esterhuizen)

08h40-09h00: Paula Pattrick (MSc student) - Dynamics of larval fishes in the shallow nearshore environment of the eastern sector of Algoa Bay.

Supervisor: Dr N.A. Strydom

The dynamics of larval fishes in the shallow nearshore environment is poorly understood in South Africa. This project aims to determine the composition, density, seasonality and distribution of larval fishes along two depth contours (5/6m and 15/16m) in the shallow nearshore region of the eastern sector of Algoa Bay. Larvae were collected by means of boat-based bongonet tows in autumn, winter, spring and summer between March 2005 and July 2006. Salinity, temperature and turbidity were recorded. Shallow water current profiling was also conducted within the study area. Nine transect lines were sampled in the nearshore perpendicular to the shore on 4 typical winter days. Long-term ADCP monitoring is underway with the deployment of an ADCP at a fixed point within the study site during May. A multi-lane swimming chamber was used to test critical speeds of postflexion *Diplodus capensis* and *Sarpa salpa* larvae. In total, 4716 larval fishes were collected representing 27 families and 74 species. Gobiidae and Clupeidae were the dominant fish families. The Gobiidae made a total contribution of 61.9%, with the Clupeid, *Sardinops sagax* contributing 5.6% to the total catch. Seasonal variations in larval density were observed. The highest mean larval fish density of 48.3 larvae/100m³ was recorded in Spring with the lowest mean density of 9.2 larvae/100m³ recorded in Summer. Mean larval fish density in Autumn was 36 larvae/100m³ and 32.3 larvae/100m³ in Winter. Mean larval density in the 5/6m zone was 31.6/100m³ and 31.3/100m³ in the 15/16m zone. Current velocities in winter varied from 3 cm/s to 18 cm/s. Critical speeds of *D. capensis* ranged from 2.7 to 35.1 cm/s and from 4.1 to 33.3 cm/s in *S. salpa*.

09h00-09h20: Peter Watt-Pringle (MSc student) - Movement behaviour of three South African endemic coastal fishery species, *Diplodus sargus capensis*, *Diplodus cervinus hottentotus* and *Sparodon durbanensis*.

Supervisor: Dr P. Cowley

Knowledge of fish movement behaviour is fundamental to understanding their role in the ecology of aquatic ecosystems and in designing management strategies for their conservation and human use. Blacktail (*Diplodus sargus capensis*), zebra (*Diplodus cervinus hottentotus*) and white musselcracker (*Sparodon durbanensis*) are common inshore sparid (seabream) species important to South African coastal fisheries. Long-term tagging projects have collected data on their adult movement patterns. However, no information exists on movements of juveniles during their early life history when they are dependent on intertidal rockpool habitats. The overall aim of this study was to describe the movement behaviour of these three species throughout ontogeny. Juvenile fish movement was examined through a marking and relocation experiment with the objectives of quantifying 1) any lateral movement between adjacent intertidal gullies and 2) site fidelity to particular areas. Existing data from the SFW/ORI national tagging program and two MPA monitoring programmes was analysed with the objective of describing adult movement behaviour. In January 2006, 12 blacktail, 12 zebra, 6 white musselcracker and 7 Cape stumpnose (*Rhabdosargus holubi*) between 100 and 150 mm FL were marked using VIFE (Visual Implant Fluorescent Elastomer) tags in an intertidal gully at Schoenmaker's Kop, near Port Elizabeth. This system allowed individuals to be distinguished by observers. The area was subsequently revisited twice a month over spring tides and the marking site, as well as three nearby areas of similar habitat, was snorkelled and the presence and position of marked fish noted. Duration of snorkelling observations was standardised. In this experiment two of the study species, as well as juvenile Cape stumpnose, exhibited high levels of site fidelity and persistence over the study period. 8 months after marking 11 (92%) zebra, 5 (83%) white musselcracker and 5 (71%) Cape stumpnose continued to be regularly resighted during snorkelling surveys. Of these only one Cape stumpnose displayed any significant displacement from its marking locality. In contrast to these figures, rates of resighting for marked juvenile blacktail were low, with only 1 individual (8%) regularly observed, at the marking site. However, other individuals were occasionally seen in the study area, suggesting a shift to slightly deeper adult subtidal habitat for blacktail of the size marked, but that this was to areas in close proximity to the marking site and that this species also displays strong site fidelity in the juvenile stage. The results for juvenile movement in the nursery habitat are similar to trends in the movement of adult individuals tagged in the national tagging program, where the mean displacement of recaptured blacktail is only four kilometres and for zebra only one kilometre. Mean displacement distance for white musselcracker is larger (seventy two kilometres), but appears to be size dependent, with only larger, sexually-mature individuals showing large displacement from their tagging locality. These results show that these species display strong fidelity to their nursery habitats. Rocky intertidal habitats represent "critical habitats" and their protection is therefore important for conservation and management of these species. Movement from juvenile to adult habitats needs to be further quantified, but information from this study will be useful in designing more effective management strategies for these species.

09h20-09h40: Ryan Palmer (MSc student) - Feasibility of using stock enhancement for the management of *Argyrosomus japonicus*, in South Africa.

Supervisor: Prof. P.J. Britz

With *Argyrosomus japonicus* stocks dwindling to dangerously low levels as a result of the failure of current management measures to protect these stocks and facilitate their recovery, the need for an alternate management plan is becoming apparent. Stock enhancement has been identified as a possible management tool to assist with the recovery of this important linefish species in South African waters. Stock enhancement is often seen as a “quick fix” to an over fished population; however, it is not so simple. The potentially adverse genetic and ecological impacts of stock enhancement can far outweigh the benefits to the fish stock, if not managed on principals based on sound science. The aims of this study were to review the ecological and genetic issues relevant to stock enhancement and identify areas of research that are required to develop a management plan for a responsible program, identify a suitable tagging method for use in post release monitoring and to assess the potential of funding a stock enhancement program through recreational fishing permits. In this talk I will discuss briefly the genetic and ecological impacts of stocking, but will focus on the results from the tag retention study and willingness-to-pay survey that were conducted.

Lack of evidence of the effectiveness of stocking programs has lead to failure of many such programs. Post-release monitoring is an important part of the management of a stock enhancement program and the ability to distinguish hatchery produced fish from wild fish is therefore essential. Various tagging methods are available to fisheries managers; however, their suitability is often species specific and should be evaluated prior to use in a stocking program. This part of the study aimed to identify the tag that exhibited the best retention rates. Coded wire tags (CWT), visual implant fluorescent elastomers (VIFE), and Oxytetracycline (OTC) were evaluated as possible tagging methods for *A. japonicus*. OTC appeared to be the most suitable as it produced 100% retention over a five month period compared to 62% and 61% for VIFE and CWT respectively.

A priority in determining the feasibility of any project is that of economic feasibility. Based on a “user pays” approach, using recreational fishing permits as a payment vehicle, a willingness-to-pay survey was conducted among 102 recreational anglers in the Plettenberg Bay area. The median maximum amount that frequent fishers would pay for a fishing permit was R 155 and R 100 for non-frequent fishers. However, a fee in excess of R 100 would exclude up to 50% of anglers. A fee of R 100 would only exclude 28% of anglers, and was therefore decided upon as an acceptable annual fee. This would generate an additional R 12 882 000 annually which far exceeds the estimated expenses of a stock enhancement program.

09h40-10h00: Jessica Escobar-Porras (MSc student) - To investigate the home range and migration patterns of catsharks in the Eastern Cape.

Supervisors: Dr W. Sauer and Dr P. Cowley

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 and home range. With an increasing number of recreational fishers and illegal targeting by commercial operators, this information is crucial for management purposes. The aims of this project are to identify the home range and movement patterns of Pyjama (*Poroderma africanum*), Leopard (*Poroderma pantherinum*), and Brown (*Haploblepharus fuscus*) catsharks. The research is concentrated on a lightly exploited area of about 1km of coastline near St Francis Bay, comprising a number of shallow bays, and a shallow reef area in Plettenberg Bay. This is to ensure that these areas can be covered in enough detail, rather than spreading the research over a wide portion of the coast. It is anticipated that these results will be applicable to the wider distribution areas of these sharks.

Scientific objectives are to map the bottom profile and habitat type of the research areas; to directly observe sharks through snorkel diving; to capture and recapture individuals using hook and line and cages; to carry out acoustic tracking of selected individuals and to investigate, over two 30 day periods, inshore/offshore movement using a research skiboat and hook and line and cages. The use of various methods will increase the accuracy of the information. Movement will be correlated to various environmental variables, including temperature, which is recorded continuously in the study area. To date 12 sharks have been tagged (*Poroderma africanum* (1), *P. pantherium* (7) and four *Haploblepharus fuscus* (4)), and a recapture obtained.

10h00-10h20: Charlene da Silva (MSc student) - The smoothhound shark fishery-prognosis and status.

Supervisors: Prof. A.J. Booth and Dr M. Smales

Smoothhound sharks are commonly caught off southern African waters by commercial trawlers, long-lining operations, line-fishing boats, shore based anglers and recreational fishermen. The decline in linefish species has led to increased exploitation of demersal sharks such as smoothhounds. Smoothhound sharks have been shown to have *k*-selected life histories which makes them particularly vulnerable to anthropomorphic influences. Unfortunately little is known about life-history characters, population size and localities. The aim of this study is therefore to adequately validate growth, to determine catch rates and elucidate stock structure in order to estimate management parameters.. Factories in the south-eastern and south-western Cape coast were visited, background information on the fishery was obtained and three shark processors and exporters were identified. For the implementation of a successful precautionary approach to a management plan with regards to the *Mustelus* spp. fishery an understanding of the biology, stock structure and the history of the fishery is of pivotal importance.

10h20-10h55 Tea break

Marine resources and management (Chair: C. McNamara)

11h00-11h20: Allan Andrew (PhD student) - Lead-radium dating of Patagonian toothfish (*Dissostichus eleginoides*).

Supervisors: Dr P. Cowley and Prof. Caillet

The Patagonian toothfish (*Dissostichus eleginoides*) is one of the dominant fishes in the Antarctic belonging to the family Nototheniidae, the Antarctic cods. Age estimates from otolith growth zone counts indicate the Patagonian toothfish may live to at least 50 years; however, attempts to validate these estimates have been met with limited success. Regular interpretations of age using otoliths in the international community have been used to determine life history characteristics, but observed differences in derived growth parameters have raised the question of whether the differences are real or an artifact of methodological differences. To address the problem age estimates must be validated, but typical validation techniques have limited applicability to deep-water and long-lived fishes. One technique that has been successful is lead-radium dating, which uses the disequilibria of lead-210 and radium-226 in otoliths as a natural chronometer. In this study, otolith age estimation methods used at the Center for Quantitative Fisheries Science (CQFE) in the USA and the Central Ageing Facility (CAF) in Australia have been evaluated using lead-radium dating. The findings provide insight on between facility similarities and differences for the respective ageing methodologies. Both facilities appear to have an ageing bias of just a few years depending on what ages are considered. In general, the trend for both facilities supports agreement on age interpretation with only minor differences. For the oldest age groups (about 26 to 30 years) age estimation was accurate and the findings provide support for age estimates approaching 50 yr using the same age estimate methodology.

11h20-11h40: Terrence Stonier (MSc student) - Do spatially separate spawning aggregations of the South African squid *Loligo vulgaris reynaudii* represent genetically distinct sub-populations?

Supervisor: Prof. W. Sauer and P. Shaw

Accurate information about population (stock) structuring within a commercially exploited species is fundamental to the management of such a resource. This information is especially important in annual species, as for *Loligo vulgaris reynaudii* where each new generation depends entirely on the previous year's survivors. This species spawns in shallow waters along the South African coast, forming large, spatially separate spawning aggregations. Spawning sites appear to be in geographical positions consistent from year to year, although the individuals using them are not the same (each adult spawns then dies). Until recently, it has been assumed that individuals from different spawning sites freely mix, interbreed and therefore form a single large population, however recent genetic data from a related squid species (*Loligo pealei*), has suggested that geographically distinct spawning sites may be used by genetically distinct groups of individuals and therefore comprise distinct sub-populations. As such, stock structuring information is very important as over-exploitation of localised, differentiated groups may lead to irreversible alterations to genetic structure and diversity. This in turn could have a significant negative impact on the very valuable commercial South African *L. v. reynaudii* fishery.

Genetic (DNA-based) markers have demonstrated considerable utility in helping to define population structuring in many species, including commercially fished marine species such as fish and cephalopods and the aim of this research project is to test, using molecular genetic markers, whether spatially distinct spawning aggregations represent genetically similar or distinct populations of *L.v.reynaudii*.

Samples were collected in the form of tentacle clippings from 5 areas along the South African Coast, Port Alfred, Algoa Bay, Krom, Tsitsikamma and the Aghulas bank. These were then preserved in 80% ethanol and stored in a cool room until they were to be used. DNA material was extracted from individual samples using a CTAB extraction protocol and PCR protocols were then set up. Microsatellite markers had previously been developed for use on *L. vulgaris reynaudii* and primers for 8 loci were available for use in this project. Of these 8 loci, 5 were eventually selected for screening, LVR21, LVR27, LVR43, LF1 and LF3, and these were chosen on the basis of reliability and best product. PCR reactions were then run for 48 individuals from each sample area, and the screening is currently being carried out on an ALF sequencer. DNA material was extracted from a further 80 Angolan squid, and PCR's were set up for the same 5 loci. This group is to be used as an out-group for comparison to the South African results. Results from the screening will then be analyzed using 2 programs, Fstat and Genepop, and will show whether there is any significant genetic differentiation between squid individuals caught at the different spawning locations.

The South African squid stock has been assumed to be a large, single, interbreeding population; however the results from this project could indicate otherwise, which could have implications for the fishery. This study also forms the basis for future work, whereby samples can be collected from the same locations over a number of years, providing interesting data on stock structuring over a temporal scale.

11h40-12h00: Rhett Bennett (MSc student) - Aspects of the population ecology of selected offshore linefish species in protected and unprotected areas along the south-eastern Cape coastline of South Africa.

Supervisors: Prof. W. Sauer and Dr P. Cowley

The poor status of fish stocks worldwide provides testimony of the failures and inefficiencies of traditional management measures such as bag and size limit restrictions. Consequently, there has been a global trend towards resource management at the ecosystem level and Marine Protected Areas (MPAs) have been advocated as they provide protection for the ecosystem as a whole rather than a single species. MPAs have been shown to be particularly suitable for the protection of K-selected reef fishes, and evidence for their effectiveness is widely available in the literature. The offshore marine environment in Plettenberg Bay (south-eastern Cape) has been subject to fishing pressure from commercial, recreational and charter boat sectors and resulted in the decline of reef fish abundance in the area.

The aim of this study is to provide guidelines for the management of reef associated linefish species in Plettenberg Bay, as part of an integrated coastal management plan for the area. The study incorporated five methods to answer a number of key questions. What is the abundance and biomass of reef associated linefish species within the Bay, in particular Roman *Chrysoblephus laticeps*? What is the diversity, relative abundance of species and population structure of these fishes? Do these differ from those within the nearby Tsitsikamma National Park MPA? Is there a need to protect linefish stocks within Plettenberg Bay, and would a MPA be effective?

Tag-recapture and underwater visual census techniques were used to estimate abundance and density of reef associated linefish species, and measure ecological indicators at sites within Plettenberg Bay (exploited sites) and the Tsitsikamma National Park MPA (protected sites). Preliminary analysis from underwater visual census (point and transect count surveys) and research fishing showed that Roman were more abundant at the protected sites than at the exploited sites. Similarly, length-frequency distributions for all species combined, and for Roman showed higher frequencies of larger size classes at the protected sites. However, species diversity (Margalef's overall index and Shannon-Weiner H') and evenness (Pielou's J) indices were higher for all three methods at the exploited sites.

The linefish communities of two similar exploited sites within the Bay were compared using research fishing (*cpue*) and underwater census counts. One site was identified for closure, while the other would remain open and act as a control. These 'before' results will be used in a before-after-control-impact comparison to assess the effectiveness of the area, should it become closed.

Due the lack of available information and little development framework to follow, this study will provide an evaluation of the methods used and make suggestions on suitable methods for estimating abundance and measuring ecological indicators of temperate reef linefish communities. The implementation of such a protocol will unique and form part of the first 'Bay Management Plan' to be developed for South Africa's coastline.

12h00-12h20: Bruce Donovan (MSc student) - Evaluation of the Port Alfred commercial and recreational linefishery.

Supervisors: Prof. T. Hecht and Dr O.L.F. Weyl

Since the Port Alfred/Kenton-on-sea/Bokness linefishery was assessed in 1984/5 (Hecht and Tilney 1989), it has regressed from being the third largest South African linefishery (excluding snoek and yellowtail) in the mid- 1980's to a largely unstable, nondescript industry today. Significant changes in the management environment² and a shift in fishing effort has resulted in a reduction of 44 commercially licensed vessels in 1987, to a mere 10 commercial vessels currently licensed in the area. This decrease in the commercial effort has, however, been coupled with an increased effort in the recreational sector. There are several plausible reasons for this shift in effort. It could be simply a reflection of natural growth in that sector, or a reaction to the re-allocation of fishing rights in 2002. It could also be due to more abstract reasons such as the beach vehicle ban resulting in shore-angling effort shifting to deep-sea, or any combination of any of the aforementioned reasons.

Consequently, there is a need to evaluate the effectiveness of the management changes that have been implemented with respect to the 'health' of the exploited fish stocks. This study is therefore aimed at re-assessing the fishery from a biological point of view 21 years subsequent to the previous assessment. This will be done by quantifying catch composition, effort, size distribution of species, estimates of changes in the spawner-biomass of non-migratory species and possible changes in life history strategies of a key indicator species in the operating area. Traditional per-recruit methods will be used for analysis together with multivariate analysis to assess long term changes in size composition, dominance structures using K-dominance curves, size spectra analysis and abundance biomass curves. In addition, differences between the commercial and recreation sector in this fishery will be investigated by examining the species composition, size composition and CPUE (total and species directed CPUE) of each sector. This will result in a thorough statistical basis that, together with historical data collected from the fishery, will allow for the quantification and description of changes that have occurred in the fishery over a 21 year period.

Random sampling of both the commercial and recreational sectors is conducted over a period of 21 days a month (and is also determined by weather conditions allowing vessels to be put out to sea). To date a total number of 32 samples have been taken from both the recreational (23) and commercial (9) linefisheries over a 3 month period. On average the commercial vessels fish for 6.8 hours with a mean number of 6.3 fishers. The recreational vessels fish an average of 4.7 hours with 4.1 fishers. The commercial catch consists of 6 species in total, and is dominated by catches of silver kob (*Argyrosomus inodorus*) and Panga (*Pterogymnus laniarius*) which contribute 37.0% and 33.4% of the total catch respectively. The recreational catch has a greater species richness (13 species) and is dominated by catches of elf (*Pomatomus saltatrix*) (23.4%), kob (21.9%) and panga (17.2%). There is no significant difference between the mean sizes of dominant species (kob and panga) caught commercially and recreationally ($p < 0.05$). It is important to note that, due to the short sampling time-frame, these preliminary results do not reflect any seasonal changes in species composition that are inherent in this particular multispecies fishery.

The outcomes from this study will indicate the effectiveness and consequences of the current management environment with respect to the geographically discreet Port Alfred linefishery from a biological perspective.

² New Linefish management protocol, 1999; Re-allocation of fishing rights, 2002; New linefish regulations, 2005; and the pending second linefish regulations, 2006.

12h20-12h40: Serge Raemaekers (PhD student) - The abalone poaching boom near the urban centres of the Eastern Cape. Part II: mismanagement or no management?

Supervisor: Prof. P.J. Britz

Over the last decade, the Eastern Cape Province has become a major source of supply for the illicit abalone trade. A large illegal and highly organized network has developed from the urban centre of Port Elizabeth. At first, only the abalone resource between Cape Recife and Kini Bay was targeted, but poachers rapidly stretched their efforts to the reefs around the Bird Island Group of islands and along the Sunshine Coast.

This talk presents the latest findings of a two-year project which aims to assess fishing effort and behaviour in the illegal abalone industry. Focus is given to obtaining indicators of effort and stock status, and assessing the various management interventions by Marine and Coastal Management (MCM) and other law enforcement agencies.

It is argued that truly effective fisheries management is still beyond MCM's grasp. MCM persists to work in isolation and appears to avoid the devolvement of certain governance functions to provincial or local municipal level, despite this approaches potential to alleviate their already stretched financial and human capital. A multi-agency approach and a cooperative governance strategy, which integrates the local social and institutional dynamics, are however seen by many stakeholders as the only means to curb the poaching problem and sustain the abalone resource.

12h40-13h00: Russell Chalmers (PhD student) - Baseline biodiversity and resource use assessment within the proposed Greater Addo Marine Protected Area for the development of a management and long-term monitoring strategy

Supervisor: Prof. W. Sauer

In order to meet national and international conservation targets SANParks are actively involved in the establishment of new, and the expansion of existing protected areas to ensure the protection of a representative network of natural habitats. The Greater Addo Elephant National Park currently awards protection to a large section of the coastline between Sundays River and Cannon Rocks, including the Bird and St Croix island groups and the Bird Island Marine Protected area. However, the existing Bird Island MPA only awards protection to a small component of the marine environment within Algoa Bay and SANParks propose to expand the MPA in order to increase the diversity of habitats awarded formal protection through MPA status. SANParks therefore wish to develop a management plan for the proposed MPA as well as a long-term monitoring strategy which can be used to measure the conservation effectiveness of the MPA in the future. A baseline assessment of the biodiversity and resource use within the proposed MPA is being undertaken to allow an informed management plan to be developed and to design an effective long-term monitoring strategy.

Four offshore study areas have been selected to assess the marine biodiversity in key areas of the proposed MPA. These include representative areas around the Bird and St Croix Island groups and off the Woody Cape and Cape Padrone headlands. The substrate type and depth profiles in each area were determined through bathymetry mapping and sampling effort within each study area was stratified over depth and profile. Controlled angling surveys and underwater visual census techniques have been used to assess the species compositions and relative abundances of the linefish stocks within each area. Abalone stock densities and size distributions are being assessed by means of quadrants and line transects.

Roving creel, access point and aerial surveys are being used to assess the commercial, recreational and subsistence fisheries and resource use within the boundaries of the proposed MPA.

Preliminary results from the controlled angling survey indicate that the species composition at the St Croix study area was significantly different to the Bird Island, Cape Padrone and Woody Cape study areas. Thus far twenty-six linefish and six shark species have been caught in the four study areas while forty linefish and three shark species were identified during the underwater visual census.

In total 357 people have been encountered during the roving creel surveys of which 58 were engaged in fishing activities. A total of 81 fish from 14 different species have been caught by the recreational shore-based fishers with an average catch-per-unit-effort of 0.14 fish per angler hour.