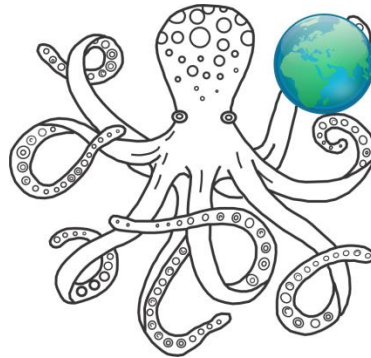


15th Southern African Marine Science Symposium

Incorporating the African Marine Mammal Colloquium



Welcome to Stellenbosch University, proud hosts of the 15th Southern African Marine Sciences Symposium. The theme “Waves of Change” drew over 400 abstract presentations and we are pleased to share these with you over the next few days. Marine systems play vital roles for humanity, yet they remain largely understudied. In a rapidly changing world, it is therefore important to understand their natural states, the processes that regulate them and the drivers that may be doing irreparable damage. The number and diversity of special sessions once again highlight the world-class research carried out in southern Africa and we can guarantee that there is something of interest for everyone!

I sincerely thank the organising and scientific programme committees for all their hard work and dedication in making SAMSS 2014 a success. Special thanks to Rheta Venter for her organising and thinking ahead! Many thanks to all our sponsors who have helped make SAMSS happen, keeping the costs manageable for our student attendees and highlighting some of Stellenbosch’s other assets!

I hope that you have a stimulating and rewarding meeting over the next few days and that you enjoy some good Stellenbosch hospitality.

Sincerely,
Sophie von der Heyden
Chair of the Organising Committee

Organising Committee

Sophie von der Heyden (Chair) *SUN*

Aletta Bester-van der Merwe *SUN*

Carmen Visser *SANCOR*

Carol Simon *SUN*

Carl van der Lingen *DAFF*

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Lara van Niekerk *CSIR*

Merle Sowman *UCT*

Paul Cowley *SAIAB*

Pavs Pillay *UCT*

Ross Wanless *BIRDLIFE*

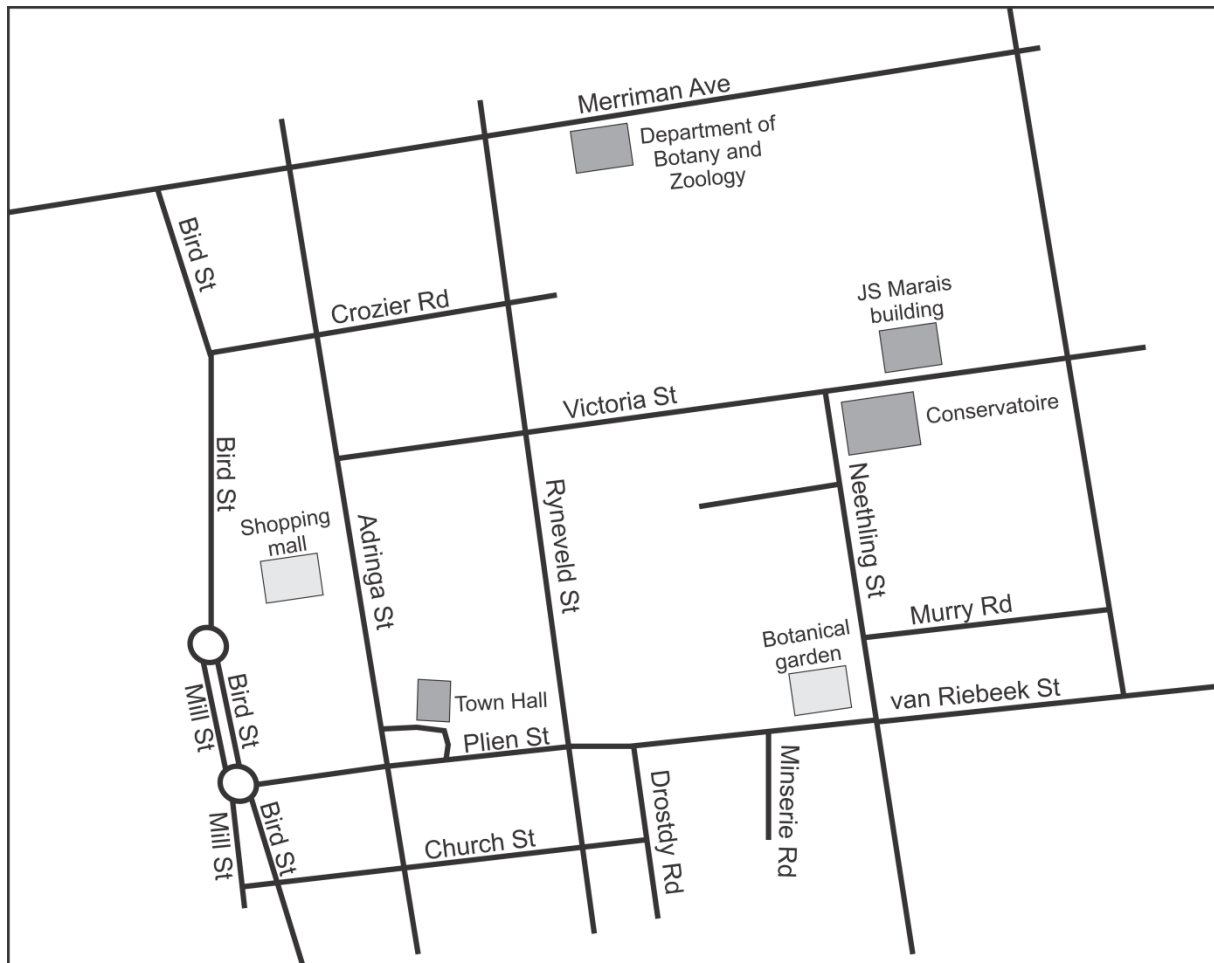
Simon Elwen *UP*

Sophie von der Heyden *SUN*

Tammy Robinson *SUN*

Yunne Shin *IRD*

Find your way around Stellenbosch



Emergency contact numbers

Ambulance: 10177

Campus security: 021 808 2333

Police: 10111

Stellenbosch Medi-clinic: 021 886 9999

Conference contact details

Conference organiser:

Ms Retha Venter: 082 656 7088

Instructions for oral presenters

This conference has a very full programme. In order to ensure the sessions run smoothly presenters are asked to please:

- Load your presentations at the dedicated desk by 17:00 the day before your talk. Delegates presenting on the first day are asked to register and load their talks by 13:00 on 15th July.
- Be present in your venue 5 minutes before your session starts. This will give you time to meet all presenters and the designated technical support person.
- Keep to your time allocation. Each presenter is allocated 15 min (12 min talk and 3 min questions). The session chair will stop all talks at 15 min.

Information for session chairs

In order to ensure that sessions run on time, chairs are asked to please do the following:

- Be present in your venue 5 minutes before your session starts. This will give you time to meet all presenters and the designated technical support person.
- Help keep presenters to their allocated time allowance by signalling five minutes before time is up.
- Encourage discussion and constructive debate between delegates during question time.
- Please identify student presenters to the audience as they will be assessed for the student presentation awards.
- At the start of your session please draw the audience's attention to the posters that are associated with the session. Please note that for each session poster abstracts follow those of the oral presentations in the abstract book.

Session chairs are thanked for performing this vital role and contributing to SAMSS 2014.

Instructions for poster presenters

Due to the large number of posters being presented at this year conference there will be two poster groups. Presenters are asked to please take note of the following:

- Group 1 posters must be put up during registration. These posters must be removed between 7:30 and 8:00 on Thursday 17th July.
- Group 2 posters should be put up between 7:30 and 8:00 or during that morning tea break on Thursday 17th July and removed after the closing ceremony Friday 18th July.
- All presenters are asked to be present at their poster during their allocated poster session. Student posters will be assessed for the student awards.

Awards

The following four prestigious awards will be made at the symposium dinner:

Gilchrist Memorial Medal

The medal is awarded to distinguished scientists and serves as recognition of the recipients' contributions to marine science, to further stimulate excellence in South African marine science, and to focus attention on South Africa's marine and coastal environments.

The Derek Krige Medal

The medal is awarded in recognition of outstanding achievements in the field of technical support to marine science in South Africa. The award of this medal serves to emphasize the valuable contribution to marine science made by those who provide the technical and logistical support services that make research possible.

Marine and Coastal Communicators Award

These awards are made to individuals or groups of individuals in recognition of their outstanding contributions towards communication of information about the marine and coastal environment to the public. The award serves as an acknowledgement of, and symbol of appreciation for, the dedication, enthusiasm and diligence of the persons performing such communication. The awards are based on the nominees' activities within the last five years and a broad definition of method of communication is used, including but not limited to public talks, popular articles, books, videos and hands-on education.

SANCOR Emerging Scientist Award

This new award has been established to promote capacity development, acknowledge a new generation of scientists and to encourage research excellence in science in the marine and coastal environment.

Student Awards

Awards for the best student oral and poster presentations will be made at the closing ceremony.

Plenary Speakers

Plenary I: Professor Manuel Barange is Director of Science and Deputy Chief Executive of the Plymouth Marine Laboratory in the UK. He is also Professor at the College of Life and Environmental Sciences, University of Exeter. Manuel did a PhD on euphausiid ecology off Namibia, a post-doc on Antarctic krill using data from the FRS Africana and the R/S Agulhas, and had an early career in fisheries ecology, assessment and acoustics at the Sea Fisheries Research Institute (and then MCM). He moved to the UK in 1999, spending ten years coordinating the international GLOBEC (Global Change Ecosystems Dynamics) programme. Since then his research has primarily focused on modelling the impacts of climate change and economic globalization on marine ecosystems and marine-based commodities, on the oceans contribution to future food security and on the role of ecosystem services to alleviate poverty in populated deltas affected by climate change. Manuel has published over 100 peer-reviewed publications and has edited two books. He combines his science with the management of an independent research institute, with management responsibilities in ICES, and advisory portfolios in the European Horizon 2020 programme and UK government departments. In 2010 Manuel was awarded the UNESCO-IOC Roger Revelle Medal for his contribution to ocean science. He is married and has three children.

Feeding the world in 2050: Impacts of climate change on fish production in fisheries dependent communities

M Barange¹, G Merino^{1, 2}, J Scholtens³, EH Allison⁴, JL Blanchard⁵, J Harle⁶, JI Allen¹, J Holt⁶, S Jennings⁷

¹ Plymouth Marine Laboratory, Plymouth, UK

² AZTI Tecnalia, San Sebastian, Spain

³ Amsterdam Institute for Social Science Research, University of Amsterdam, Amsterdam, The Netherlands

⁴ University of Washington, Seattle, USA

⁵ University of Sheffield, Sheffield, UK

⁶ National Oceanography Centre, Liverpool, UK

⁷ CEFAS, Lowestoft, UK

Growing human populations and changing dietary preferences are increasing global demand for animal protein, including fish. This is expected to add concerns over the sustainability of fisheries as a provider of food, livelihoods and income. In addition, climate change is expected to alter the productivity, distribution and seasonality of fish stocks, both directly and as a result of underlying food web processes. Recent assessments have discussed the differential expected impacts of climate change on global and regional fish and fisheries resources, and on how these impacts may affect food security targets at global and national level. However, the significance of the expected biological impacts to the economies of the countries exploiting them is less known. Here we will answer the “so what?” question by linking models of physical, biological and human responses to climate change in 67 marine national Exclusive Economic Zones (EEZ). We estimated relative ‘fisheries dependency’ to climate change using quantified indicators of the contribution of fisheries to employment creation, to economic value-adding and to food security. Combining “dependency” with projected climate change impacts provides a more complete picture of the consequences of climate change, and an indication of the urgency nations will need when considering their adaptations to climate change in the fisheries sector.

Plenary II: Dr Lynne Shannon is chief researcher at the Marine Research (MA-RE) Institute of the University of Cape Town (UCT), undertaking ecological research and modelling in support of the Ecosystem Approach to Fisheries (EAF). She has published over ninety papers in peer-reviewed journals. Having a broad appreciation of the dynamics and issues through the food web, she has constructed trophic models of the Benguela region to provide an understanding of structure and functioning and changes in the marine food webs off South Africa and Namibia, with a view to providing a basis for EAF. One particular focal area has been examination of the relative and combined effects of fishing and environmental forcing on the ecosystem dynamics of the Benguela, including regime shifts. Dr Shannon is exploring practical ways in which ecosystem considerations might be incorporated into fisheries management in the Benguela, especially the use of ecological indicators. She arranged an internationally-attended workshop in December 2002, to start putting some of these ideas into practice in South African fisheries management, and was instrumental in the formation of the South African Working Group on Ecosystem Approaches for Fisheries Management, which was initiated in August 2003 to take this process further. Since 2006, Dr Shannon has co-chaired a multi-disciplinary international working group “IndiSeas” (Indicators for the Seas, www.indiseas.org), which aims to evaluate the effects of fishing and natural variability on marine ecosystems by means of a suite of ecological, environmental, biodiversity and human dimension indicators using a comparative approach across a broad range of ecosystem types. She fulfils a leadership and research role as part of Prof Jarre’s research team at UCT under the South African Research Chair Initiative in Marine Ecology and Fisheries, where she further explores frameworks for using ecosystem indicators for EAF, providing information on the anthropogenic and natural drivers of ecosystem change, and integrating this into management.

Trophic level-based indicators to track fishing impacts across marine ecosystems

L Shannon¹, M Coll², A Bundy³, D Gascuel⁴, JJ Heymans⁵, K Kleisner⁶, CP Lynam⁷, C Piroddi⁸, J Tam⁹, M Travers-Trolet¹⁰, Y Shin¹¹

¹ Marine Research Institute and Department of Biological Sciences, University of Cape Town, Private Bag X3, Rondebosch, 7701, South Africa

² Institut de Ciències del Mar (ICM-CSIC). Passeig Marítim de la Barceloneta, n° 37-49. 08003. Barcelona, Spain & UMR EME 212 IRD/UM2/IFREMER. Centre de Recherche Halieutique Méditerranéenne et Tropicale. IRD - IFREMER & Université Montpellier II. Avenue Jean Monnet, BP 171. 34203 Sète Cedex. France

³ Bedford Institute of Oceanography, Population Ecology Division, PO Box 1006, Dartmouth, NS B2Y 4A2, Canada

⁴ Université Européenne de Bretagne, UMR 985 Écologie et santé des écosystèmes, 65 route de Saint Brieuc, CS 8421, 35042 Rennes cedex, France

⁵ Scottish Association for Marine Science, Scottish Marine Institute, Oban, Argyll, PA371QA, UK

⁶ National Oceanographic and Atmospheric Administration (NOAA), Northeast Fisheries Science Center, 166 Water Street, Woods Hole, MA 02543-1026

⁷ Centre for Environment, Fisheries & Aquaculture Science (Cefas), Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk NR33 0HT, United Kingdom

⁸ Joint Research Centre, European Commission, Via E. Fermi 2749, Ispra (VA) I-21027, Italy

⁹ Instituto del Mar del Perú (IMARPE), Esquina Gamarra y Gral. Valle s/n, Apartado 22, Callao, Lima, Peru

¹⁰ IFREMER, Fisheries Laboratory, 150 quai Gambetta, BP699, 62321 Boulogne/mer, France

¹¹ Institut de Recherche pour le Développement (IRD), UMR EME 212, CRH, avenue Jean Monnet, CS 30171, 34203 Sète cedex, France and Marine Research Institute and Department of Biological Sciences, University of Cape Town, Private Bag X3, Rondebosch, 7701, South Africa

Trophic level-based indicators have been widely used to examine fishing impacts and induced biodiversity changes in aquatic ecosystems. However, much debate has ensued as to discrepancies and challenges arising from the use of landings data from commercial fisheries to calculate trophic level indicators. Subsequent studies have started to look at survey-based and model-based trophic level indicators. In this paper, we undertake an extensive evaluation of a variety of trophic level indicators across nine well-studied marine ecosystems by making use of model-based as well as survey-based and catch-based trophic level indicators. Using detailed regional information and data on fishing history, fishing intensity, and environmental conditions, we ask how well TL indicators capture fishing effects at the community level of marine ecosystems. Our results highlight that the differences observed between TL indicator values and trends is dependent on the data source and cut-off TL point included in the calculations, not attributable to an intrinsic problem with TL-based indicators. All three data sources provide useful information about the structural changes in the ecosystem as a result of fishing, but only model-based indicators were found to represent fishing impacts at the whole ecosystem level.

Plenary III: Dr Stewart Grant earned his PhD in fishery genetics from the University of Washington, Seattle, and an MSc in marine biology from the University of Maine. He spent 15 years in South Africa beginning in the early 1980s, first as a post doc and researcher in Cape Town working as part of the Benguela Ecology Programme, then as an associate professor at Wits University in Johannesburg. He has published about 120 research articles and book chapters focused largely on the population genetics and biogeography of marine fishes and invertebrates, but also on mammals, birds, reptiles and insect. After leaving South Africa, he has worked on Pacific salmon conservation problems with the US National Marine Fisheries Service, in Seattle, and on genetics issues in aquaculture at the World Fish Center in Malaysia.

The future of Alaska's fisheries

WS Grant

Commercial Fisheries Division, Alaska Department of Fish and Game, Anchorage, AK, USA

The shelf waters of the North Pacific support massive fisheries on mid-pelagic and bottom fishes, on invertebrates and on five species of salmon that spawn in coastal rivers. In addition to a large export market, Alaska supplies about 60% of all the seafood consumed in the United States. Fisheries in Alaska and along western North America are greatly impacted by climatic shifts driven by the Pacific Decadal Oscillation. A regime shift in the late 1970s transformed a crustacean-dominated marine ecosystem into a fish-dominated ecosystem. Together with intense harvests, stocks of king crabs and salmon collapsed in some areas and have been slow to recover after several decades, even in areas closed to harvesting. Because of the collapse in the salmon fisheries in the 1970s, the State of Alaska developed massive salmon hatcheries to supplement the productivity of wild populations. Currently, attempts are also being made to rehabilitate depressed stocks of invertebrates with hatchery-reared individuals. Stock supplementations, however, come at a cost to wild populations. Artificial culture inevitably changes the genetic makeup of the individuals, and persistent releases of hatchery stock can lead to the loss of genetic diversity within and between wild populations. The loss of fitness may make natural populations particularly vulnerable to high latitude environmental shifts due to climate change.

Plenary IV: Professor Mark Gibbons obtained his BSc(Hons) in Marine Biology from the University of Liverpool back in 1983 when that institution still had a marine biology research station on the Isle of Man: alas no more. He subsequently worked on Fijian Hydroids for Prof John Ryland at Swansea University (whilst “on the dole”), before coming to UCT in 1984 to do a PhD with Charles Griffiths on rocky shore meiofauna. Mark subsequently joined the “plankton bums” at Seapoint in 1989 where he worked on non-copepod zooplankton (e.g. euphausiids, chaetognaths & salps) in the southern Benguela ecosystem, under the loose command of Larry Hutchings. He was seconded by the FRD to the University of the Western Cape in 1995, where he became a full-time staff member late in 1996. Since then he has worked his way progressively through the ranks, having survived retrenchments and attempted coups, but not management. Mark’s research is still largely focused on zooplankton, but he has been involved in attempts to revitalise work on a number of benthic invertebrate groups including sponges, bryozoans, nematodes and foraminifera, as well as polychaetes. His current research mainly concerns medusozoans (aka jellyfish), which he has studied through collaboration with colleagues across the world, controversially contributing to both regional and international debates on the “rise of slime”. He has a special interest in the marine ecosystem off Namibia, which he considers to represent an important global “What if?” experiment. He is married, with three children, and lives in Cape Town.

How can we, as a southern African Marine Science Community, improve our ability to understand SEACChange? An illustrative case study

MJ Gibbons

Department of Biodiversity and Conservation Biology, University of the Western Cape, Private Bag X17, Bellville 7535, RSA

*In order to understand and perhaps ultimately predict change in biological systems we need to integrate information generated from the three pillars of field work, experiments and modelling, and we obviously need to do it in an inter-disciplinary way. Here I review the origin of what we know about the biology of a recently well-known species, the bearded goby *Sufflogobius bibarbatus*, by way of a case study, and show that our understanding of change in this species has come about only through outside interventions. I subsequently review who we are, as a community of marine biologists, and suggest that our inability to understand change without external assistance reflects who we are not, as a community. The impediments to independence are discussed and strategies for self-sufficiency are suggested.*

Public Lectures

In an effort to include the greater Stellenbosch community in this important conference there will be two exciting public lectures. Please feel free to bring along any family or friends.

Emeritus Professor George Branch

George and his wife Margo Branch are authors of the award-winning books *Living Shores of southern Africa* and *Two Oceans – a Field Guide to the Marine Life of Southern Africa*. They have also published over 250 scientific papers on marine biology. George's lifetime contributions to marine science have been recognized in the form of Gold Medals from the Zoological Society of southern Africa, the Gilchrist medal for Marine Science, the International Temperate Reefs Award, Fellowships of the University of Cape Town. He has a passionate interest in the biology and management of the sea life, and a natural flair for communicating this passion. George has supervised over 70 Masters and Doctoral students. He is the recipient of a Distinguished Teachers' Award from the University of Cape Town and cherished teaching courses on marine biology, ecology and evolution for more years than he prepared to admit in writing. At heart, though, he is best described as 'beach bum par excellence'.

Estuaries: life blood of our coasts. Sharing the excitement of scientific discoveries about the roles of estuaries

A past Minister of Water Affairs once said "every drop of freshwater that enters the sea is wasted water". Wow! Hopefully such a view is a thing of the past, for the last 30 years of research have transformed our attitudes to estuaries. My talk will focus on how estuaries function and the services they provide mankind, and the excitement of scientific discoveries that have revealed these functions and services. Many people will be aware of how estuaries serve as nursery grounds for marine life, but recent findings demonstrate that they play much wider roles as sources of nutrients, sanctuaries during times of harsh marine conditions, and as a means of sustaining marine fish populations. South African has enshrined remarkably progressive environmental policies in its constitution, and the examples I will present of the roles of estuaries will leave no doubt about the wisdom of ensuring these policies are implemented.

Dr Kerry Sink

Kerry heads up the Marine Programme at the South African National Biodiversity Institute (SANBI), a position she has occupied since 2006. Kerry has a long history of involvement in South African coelacanth and other offshore research, starting with the Wright Canyon Coelacanth Expedition in 1998. From 2003-2006, she worked as a marine ecologist on the African Coelacanth Ecosystem Program (ACEP) and is currently collaborating on new offshore ACEP research projects. Kerry manages the catalogue of individual coelacanths in South Africa and she pioneered the use of a Remotely Operated Vehicle for researching coelacanths and their deep water habitats in South Africa. Kerry works across the science-policy continuum with research on marine ecosystem classification and mapping,

biodiversity assessment; Marine Spatial Planning and Marine Protected Areas. She is committed to the translation of science into decision making and is actively involved in the local and international arena in this regard. Kerry also initiated the Southern African Sustainable Seafood Initiative in 2002 and is passionate about public participation in South African marine science.

Stories and science of South Africa's Coelacanths

This public lecture tells the modern South African coelacanth story, from the remarkable discovery of this thought-extinct fish in 1938 to the most recent collaborative research expedition in the iSimangaliso Wetland Park, 75 years later. This includes the first deep mixed gas diving expeditions there in 1988, the discovery of coelacanths in the canyons of Sodwana Bay in 2000, the Jago submersible research expeditions and recent adventures with Remotely Operated Vehicles (ROVs). Coelacanths are individually marked with distinct white spots and the presentation will tell the stories of some of the individual fish sighted over the last 14 years. The 2013 expedition obtained beautiful footage of the unique locomotion of these lobe finned fishes and scientists tagged a coelacanth with a pop-up satellite tag for the first time. Kerry tells the story of the recovery of this egg sized tag from the open ocean nine months later and overviews current knowledge of these iconic fish in South Africa. Footage and recent research highlights will be shown. This presentation is dedicated to Peter Timm (1963-2014) who discovered Sodwana's coelacanths and was passionate about South African Marine Science and Exploration.

Programme Outline

Tuesday 15 th				Wednesday 16 th		
<u>Endler Hall</u>		<u>Jannasch</u>	<u>Fismer</u>	<u>Endler Hall</u>	<u>Jannasch</u>	<u>Fismer</u>
08:00				Estuaries and Change (Part 1: Trophic shifts) Pg 21	Intertidal Ecology Pg 46	African Marine Mammal Colloquium (Part 2) Pg 71
10:00				Tea		
10:30				Estuaries: Restoring St Lucia Pg35	Fish Ecology Pg 53	Biodiversity and Taxonomy Pg 76
12:00				Plenary II - Dr Lynne Shannon Pg v		
13:00	Registration			Lunch		
13:30						
14:00	Opening & Planary I - Prof Manuel Barange Pg iv			Freshwater Requirements of Marine Systems Pg 40	Fish Ecology Pg 57	Biodiversity and Taxonomy Pg 79
15:00	Tea			Tea		
15:30	Marine Management and Economics Pg 1	Climate Change Impacts Pg 6	African Marine Mammal Colloquium (Part 1) Pg 11	Estuaries & Change (Part 2: Fish in flux) Pg 44	Seabirds Pg 65	Biodiversity and Taxonomy Pg 83
17:00	Poster session: Group 1			Poster session: Group 1		
18:00	Icebreaker			Public Lectures		

	Thursday 17 th			Friday 18 th			
	<u>Endler Hall</u>	<u>Jannasch</u>	<u>Fisner</u>	<u>Endler Hall</u>	<u>Jannasch</u>	<u>Fisner</u>	<u>JS Marais Building (Rm 1002)</u>
08:00	Genetic Approaches Pg 92	Seabirds Pg 115	Outreach Pg 134	Monitoring the Marine Environment Pg 152	Modelling the Marine Environment Pg 172	Strengthening the Role of Science Pg 182	Historical Perspectives Pg 190
10:00	Tea			Tea			
10:30	Genetic Approaches Pg 96	Seabirds Pg 119	Marine Pollution Pg 139	Monitoring the Marine Environment Pg 156	Modelling the Marine Environment Pg 176	Strengthening the Role of Science Pg 186	Plankton Ecology Pg 196
12:00	Plenary III Prof Stewart Grant Pg vi			Plenary IV: Prof Mark Gibbons Pg vii			
13:00	Lunch			Closing ceremony			
13:30				Lunch			
14:00	Genetic Approaches Pg 99	Marine Protected Areas Pg 123	Marine Geology, Geophysics and Mining Pg 147				
15:00	Tea						
15:30	Genetic Approaches Pg 103	Marine Protected Areas Pg 126	Marine Geology, Geophysics and Mining Pg 150				
17:00	Poster session: Group 2						
19:00	Banquet Evening						

Tuesday 15 July			
Time	Endler Hall	Jannasch	Fisner
12:00	Registration Group 1 Poster Set-up		
14:00	Opening address		
14:15	Plenary I: Prof Manuel Barange: Feeding the world in 2050: Impacts of climate change on fish production in fisheries dependent communities		
15:00	Tea		
	Marine Management and Economics	Climate Change Impacts	African Marine Mammal Colloquium (Part 1)
15:30	Bruce Mann: The KwaZulu-Natal Boat Launch Site Monitoring System: A novel approach for improved management in the coastal zone	Mike Lucas: Should we worry about ocean acidification impacts in South African marine systems	Mduduzi Seakamela: Re-colonisation of Vondeling Island (west coast, South Africa) by the Cape Fur Seal (<i>Arctocephalus pusillus pusillus</i>): its conservation and management implications
15:45	Rachel Cooper: An Analysis of the Structural and Export Changes in the Offshore Demersal Hake (<i>Merluccius capensis</i> and <i>M. paradoxus</i>) Trawl Fishery in SA	Nina Lester: Impacts of low pH and warming on the South African abalone and mitigation thereof	Stephen Kirkman: Foraging behavior of a marine mammal confirm efficiency of a marine reserve's design: subAntarctic fur seals at Prince Edward Island
16:00	Jade Maggs: Long-term declines in CPUE of an iconic recreational species along the South African east coast	Astrid Jarre: Climate effects on biodiversity, abundance and distribution of marine organisms in the Benguela large marine ecosystem: a synthesis	Stephanie Plön: Phylogeography of the dugong (<i>Dugong dugon</i>) based on historical samples
16:15	Genevieve Maharaj: Abalone in deep water	Jarred Knapp: Short-term response mechanisms of the West coast rock lobster (<i>J. lalandii</i>) to decreased seawater pH	Ken Findlay: Can tourism alleviate fisheries pressure on dugongs (<i>Dugong dugon</i>) in the Bazaruto Archipelago?
16:30	Henning Winker: Proof of concept for a novel procedure to standardize multispecies catch and effort data	Martin Phillippe Emanuel: Interactive effects of pH and temperature on native and invasive mussels from the West Coast of South Africa	Greg Hofmeyr: Spatial and temporal distribution of beaked whale strandings on the South African coast
16:45	Amos Barkai: Olrac-RTI: A new and operational approach to holistic management of fisheries for multiple commercial species and ecosystem objectives.	Simone Baldanzi: Climatic variability shapes thermal plasticity in populations of the South African sandhopper <i>Talorchestia capensis</i>	Peter Best: Patterns of scarring on baleen whales on the west coast of South Africa attributed to a cookie-cutter shark <i>Isistius</i> spp
17:00	Poster session: Group 1		
18:00	Ice-breaker		

Wednesday 16 July			
Time	Endler Hall	Jannasch	Fisler
	Estuaries and Change (Part 1: Trophic shifts)	Intertidal Ecology	African Marine Mammal Colloquium (Part 2)
08:00	William Froneman: Ecological impacts of overtopping on the plankton food web structure of a temporarily open/closed estuary	Francesca Porri: Early spatial signals for a switch in ecosystem state: an example from fine scale variability of intertidal assemblages	Simon Elwen: Namibia's cetaceans - patterns of biodiversity in the Northern Benguela ecosystem
08:15	Jessica Dawson: Terrestrial-aquatic trophic transfers: the role of hippopotamus dung in estuarine food webs	Motebang Dominic Vincent Nakin: Marine reserve effects on the reproductive biology of commonly and rarely exploited limpet species	Bridget James: Abundance and residency of humpback dolphins (<i>Sousa chinensis</i>) in Mossel Bay, South Africa
08:30	Daniel Lemley: Assessment of eutrophic conditions in estuaries under high flow conditions	Eleonora Puccinelli: Spatial scales of variation in the dietary regime of filter feeders along the South African rocky coast	Kirsty Venter: The distribution of Antarctic blue whales and other cetacean species encountered along the Queen Maud Land coast of Antarctica.
8.45	Gavin Snow: Microalgae in freshwater dominated estuaries: uMzimvubu and Orange River estuaries freshwater requirement studies	Christopher McQuaid: Hidden benefits of genetic diversity: interactions between invasive and indigenous species	Fannie Shabangu: Acoustic estimations of Antarctic blue whale <i>Balaenoptera musculus intermedia</i> relative abundance and distribution using IWC sonobuoy data from 1995 to 2009
09:00	Anusha Rajkaran: Mangrove recovery and expansion in temperate estuaries of SA – drivers of population dynamics and consequences for other macrophyte communities	Morgana Tagliarolo: The thermal physiology of invasive and native mussels on South Africa shores	Tess Gridley: Passive Acoustic Monitoring of Cetaceans in Namibia - a case study involving bottlenose dolphin signature whistles
09:15	Kelly Ortega-Cisneros: Comparative analysis of carbon and nitrogen dynamics of three estuaries on the east coast of South Africa using ecological network analysis	Zanne Zeeman: Life-history strategies of the invasive mussel <i>Semimytilus algosus</i> on the West Coast of South Africa	Leonie Hofmeyr-Juritz: Revealing southern right whale vocalisations in False Bay, South Africa
09:30	Ryan Wasserman: Mesocosms as experimental tools for assessing trophic interactions in the estuarine plankton	Nicolas Weidberg: Mechanisms of nearshore retention and offshore export of mussel larvae over the Agulhas Bank	Katja Vinding: Non-offspring nursing in the southern right whale: a first for baleen whales
09:45	Jeffrey Hean: Seasonal diet changes and shifts in trophic niche of waterbirds in an Eastern Cape estuary	Tammy Robinson: Has low predation pressure enabled the spread of the alien barnacle <i>Balanus galindula</i> along the South African coast?	Ryan Reisinger: Social structure of killer whales at Marion Island, Southern Ocean
10:00	Tea		

Time	Endler Hall	Jannasch	Fisner
	Estuaries: Restoring St Lucia	Fish Ecology	Biodiversity and Taxonomy
10:30	Nicolette Forbes: The restoration of Lake St Lucia	Janet Coetzee: Thirty years of hydro acoustic pelagic biomass estimation surveys – what have we learnt?	Saachi Sadchatheeswaran: Changes in habitat complexity resulting from sequential invasions of a rocky shore: implications for community structure
10:45	Schalk du Plooy: Role of nutrient assimilation in facilitating prolonged bloom persistence of <i>Cyanothece</i> spp in Lake St Lucia, iSimangaliso Wetland Park	Hilkka Ndjala: Comparing temporal variability in relative weight of sardine, anchovy, and round herring in the southern Benguela	Melissa Boonzaier: Species richness and biogeographical distribution of South African Bryozoa
11:00	Salome Jones: Does turbidity at the St Lucia Estuary trigger reverse predation between dinoflagellates and copepods?	Carl van der Lingen: Starving in the midst of plenty: anomalous environmental conditions and the Cape Town sardine run of spring 2011	Mhairi Alexander: Predicting and explaining impacts of invasive mussels in South Africa: comparative functional responses in applied invasion ecology
11:15	Nicola Carrasco: Phase shift effects on the zooplankton community structure of Lake St Lucia, South Africa	Cecile Reed: An overview of applied marine parasitology in sub-Saharan Africa	Koebraa Peters: Patterns and drivers of marine bioinvasions in eight Western Cape harbours
11:30	Nche-Fambo Fru Azinwi: The dynamics of nano- and microplankton in the St. Lucia estuarine lake system, KwaZulu-Natal.	Irfan Nunkoo: Snoek and squatters	Aiden Biccard: The detection, occurrence and spread of marine alien species in Saldanha Bay
11:45	Vuli Zikhali: Wind-driven waves and turbidity in a shallow estuarine lake with muddy substrates: St Lucia, South Africa	Rabi'a Rykklief: Population dynamics of the white shark (<i>Carcharodon carcharias</i>) at Mossel Bay, South Africa	Andrew David: Temperature dependent development of two poecilogonous polychaetes, <i>Polydora hoplura</i> and <i>Boccardia proboscidea</i> (Polychaeta: Spionidae) with implications for life history theory, establishment and range expansion
12:00	Move to Plenary		
12:15	Plenary II: Dr Lynne Shannon: Trophic level-based indicators to track fishing impacts		
13:00	Lunch		
	Freshwater Requirements of Marine Systems	Fish Ecology	Biodiversity and Taxonomy
14:00	Roy van Ballegooyen: A proposed assessment framework and scientific approach to determine freshwater requirements in nearshore and coastal shelf marine ecosystems: a southern African perspective	Keshnee Pillay: Using stable isotope analysis to understand a demersal foodweb on west coast of South Africa	Sarah Collocott: Ichthyoplankton of the KwaZulu-Natal Bight, South Africa
14:15	Lara Van Niekerk: The role of freshwater inflows to coastal ecosystems: evaluating the responses of the marine abiotic processes to inflow from the Orange-Senqu catchment	Johannes Litembu: Can muscle fatty acid signatures be used to distinguish diets of two sympatric hake species (<i>Merluccius capensis</i> and <i>M. paradoxus</i>) off Namibia?	Sean Fennessy: Patterns in demersal ichthyofauna in the KZN Bight
14:30	Stephen Lamberth: The role of freshwater inflows in coastal ecosystems: fish and invertebrate response to flow from the Orange-Senqu catchment	Casey Broom: Thermal tolerance of South African clinid fishes: a comparison of three species occupying contrasting intertidal habitats	Alexander Dyer: The ichthyofauna of Walter's Shoal, a shallow seamount in the south-western Indian Ocean

Time	Endler Hall	Jannasch	Fisler
	Freshwater Requirements of Marine Systems	Fish Ecology	Biodiversity and Taxonomy
14:45	Karen Tunley: Relationship between river flows and sole (<i>Austroglossus</i> spp) biomass trends in South Africa	Stuart Dunlop: Movement behaviour of the giant guitarfish <i>Rhynchobatus djiddensis</i> off southern Africa based on conventional tag-recapture data	Camilla Floros: The importance of <i>Acropora austera</i> as nursery and refuge areas for fish species on South African coral reefs
15:00	Ursula Scharler: How freshwater influences system-level function of estuarine and nearshore marine ecosystems – a summary of recent research in subtropical South Africa	Taryn Murray: Estuarine movements and habitat connectivity by juvenile leervis <i>Lichia amia</i> (Carangidae), determined by passive acoustic tracking	Paula Pattrick: Assemblage dynamics of larval fishes associated with various shallow water nursery habitats in Algoa Bay, South Africa
15:15	Ander Martinez de Lecea: What drives the ecosystem of the KwaZulu-Natal Bight? Processes controlling the marine ecosystem of a mesotrophic bight revealed by stable isotope and C:N ratio analyses	Wendy West: Movement patterns of swordfish in the south-west Indian Ocean revealed by pop-up satellite archival tags	Lauren De Vos: Baited remote underwater video system (BRUVs) survey of the relative abundance and seasonal diversity of ichthyofauna in False Bay
15:30	Tea		
	Estuaries and Change (Part 2: Fish in flux)	Seabirds	Biodiversity and Taxonomy
16:00	Amber-Robyn Childs: Could diverse behavioural strategies of estuarine-dependent fishery species confer resilience to exploitation?	Antje Steinfurth: Seasonal variability in foraging behaviour and habitat use of African penguins, <i>Spheniscus demersus</i> , breeding on Dassen Island, Western Cape: Do some like it hot?	Samantha Ockhuis: The “Suitcase Hypothesis” – can eddies provide a pathway for gene flow between Madagascar and KZN?
16:15	Yanasivan Kisten: Recruitment dynamics of Cape stumpnose, <i>Rhabdosargus holubi</i> , into the Swartkops and Sundays River estuaries, South Africa	Bronwyn Maree: Significant reductions in mortality of threatened seabirds in a South Africa trawl fishery	Zo Rasoloarijao: Distribution and abundance of zooplankton along the southern shelf of Madagascar
16:30	Timothy Leslie: Assessing nursery habitats for juvenile Cape stumpnose (<i>Rhabdosargus holubi</i>) in the Bushmans Estuary, Eastern Cape	Lorien Pichegru: Experimental fishing exclusions for penguins in South Africa – a success story	Alicia Sutton: Influence of oceanography on the euphausiid assemblage of the Leeuwin Current system, south-east Indian Ocean
16:45	Guy Bate: The Mgobezeleni Estuary, a small black water system in northern KwaZulu Natal	Dominic Rollinson: Diving behaviour of white-chinned petrels and its relevance for mitigating longline bycatch	Toufiek Samaai: Patterns of species richness and biodiversity hotspots of sponges in the Benguela and ACLME: Its importance for bioregionalisation and conservation planning
17:00	Poster session: Group 1		
18:00	Public Lectures		

Thursday 17 July

Poster swop

Time	Endler Hall	Jannasch	Fismer
	Genetic Approaches	Seabirds	Outreach
08:00	Peter Teske: Beyond barcoding: genetics for non-taxonomists	Ross Wanless: Tracking changes for managing tuna longline bycatch on the high seas	Judy Mann: The Role of Aquariums in Inspiring Care for our Marine Environment – some research results
08:15	Lindile Cele: The Phylogeography of <i>Echinometra mathaei</i> in the Southeast African Region	Bokamaso Lebepe: Hook Pods: Silver lining for seabirds in pelagic longline fisheries	Georgina Jones: Role of scuba divers in the discovery of new and unusual marine species
08:30	Johan Groeneveld: Connectivity patterns in seven lobster species at islands, seamounts and shelf habitats in the SW Indian Ocean and South Atlantic	Stefan Schoombie: Breeding success and foraging ecology of sooty and light-mantled sooty albatrosses on Marion Island	Caroline Bell: Up-skilling biodiversity professionals in marine conservation: Learning in, through and for the workplace
08:45	Jenna Keightley: Feral Pacific oysters <i>Crassostrea gigas</i> in Southern Cape estuaries: population size and structure	Katrin Ludynia: The Dyer Island Penguin Pressure Model – an interdisciplinary tool for understanding population trends	Penny Haworth: Sink or swim - surfing waves of technological change in communicating marine science
09:00	Torsten Struck: Global phylogeography of <i>Stygocapitella subterranea</i> (Parergodrilidae, Annelida) and the first record from South Africa	Christina Hagen: Establishing a new African Penguin colony: insights from population modelling	Sibongile Mokoena: Assessing the impact of a science education outreach programme
09:15	Caitlynne Francis: Biogeography and phylogenetic diversity of the <i>Laurencia complex</i> (Rhodophyta) in the South West Indian Ocean	Pierre Pistorius: Sex specific time-activity budgets in a colonial seabird assessed through VHF technology	Debbie Hargreaves: Keeping the public informed about KZN Sharks Board activities and research
09:30	Nikki Gartrell: Molecular analyses confirms genetically distinct populations of two indigenous estuarine fish species in an isolated coastal lake: implications for the management of exotic ichthyofauna	Sven Ragaller: Stony Point: African penguin management in a residential area	Heidi Kilian: The value of scientific research in education – how ORI is making a difference
09:45	Tshoanelo Miya: Re-evaluation of the taxonomic status of three nototheniid fishes that are distributed on both sides of Antarctic Polar Front	Lauren Waller: Developing a national management plan for the African penguin in South Africa	Fatima Parker-Allie: Developing the field of biodiversity informatics in South Africa through the use of primary data and informatics tools to address key biodiversity challenges
10:00	Tea		

Time	Endler Hall	Jannasch	Fisner
	Genetic Approaches	Seabirds	Marine Pollution
10:30	Aletta van der Merwe: Genetic approaches to fisheries management and conservation efforts of Southern African shark species	Alistair McInnes: Foraging strategies of breeding African Penguins <i>Spheniscus demersus</i> in relation to fine-scale distribution and abundance of pelagic fish species	Megan Laird: Toxicity testing as a tool to evaluate impacts of pollution on marine life
10:45	Sara Andreotti: How many are there? - An integrated approach for estimating the size of the white shark population in South Africa	Andrea Thiebault: Social foraging in Cape gannets	Brent Newman: Chemical concentrations in fish and mussels in the eThekweni area of KwaZulu-Natal and potential health risks to human consumers
11:00	Lee-Gavin Williams: Genetic spatial variation of three polychaetes (Polychaeta: Spionidae) infesting <i>Crassostrea gigas</i> in southern Africa and a comparison to the more widely distributed endemic <i>Boccardia polybranchia</i>	Maelle Connan: Trophic overlap between African penguins, Cape gannets and Cape fur seals in Algoa Bay (Eastern Cape): multi-indicator approaches	Trishan Naidoo: Plastic pollutants within the marine environment of Durban, KwaZulu-Natal, South Africa
11:15	Romina Henriques: Two species, three concepts: Population Isolation, Speciation and Hybridization	Davide Gaglio: Linking the foraging ecology and population dynamics of swift terns to the availability of forage fish	Ruwen Pillay: Relationship between benthic macrofauna community structure and sediment contamination in South African ports
11:30	Simo Maduna: Evaluating genetic connectivity amongst <i>Mustelus mustelus</i> populations across the Indian/Atlantic boundary	Jonathan Handley: Animal-borne camera loggers: investigation for use in Gentoo penguin foraging ecology	Adina Bosch: Evaluation of mercury accumulation in Yellowfin tuna (<i>Thunnus albacares</i>) muscle with regards to muscle type and muscle position
11:45	Karien Bezuidenhout: Genetic connectivity among pill bug (<i>Tylos capensis</i>) populations	Daniel Danckwerts: The trophic ecology of the endangered endemic Barau's Petrel (<i>Pterodroma barau</i>) at Réunion Island, South-western Indian Ocean	Conrad Sparks: Antioxidant responses in <i>Mytilus galloprovincialis</i> exposed to copper
12:00	Move to Plenary		
12:15	Plenary III: Prof Stewart Grant: The future of Alaska's fisheries		
13:00	Lunch		
	Genetic Approaches	Marine Protected Areas	Marine Geology, Geophysics and Mining
14:00	Thierry Hoareau: Climate change provides insight on the evolutionary history of marine organisms around Southern Africa over the last 20 000 years	Denham Parker: Spatial variability associated with long-term monitoring of subtidal reef fish in Tsitsikamma National Park Marine Protected Area	Leslee Salzmann: The anatomy of subtropical submerged shorelines: A South African perspective
14:15	Jessica Toms: Variation in paleo-shorelines explains population genetic structure and vicariance on the southern coast of SA	Linda Harris: Rich diversity, strong endemism, but poor protection: addressing the neglect of sandy beach ecosystems in coastal conservation planning	Andrew Green: The Holocene evolution of Maputo Bay
14:30	Chenelle de Beer: Genetic and morphometric variation of <i>Octopus vulgaris</i> in the Benguela Current Region	Lieze Swart: Twenty-nine years of surf-zone fish monitoring at De Hoop reveals population trends, targeting information and micro-scale spatial variability	Hayley Cawthra: Quaternary evolution of the Mossel Bay continental shelf, South Africa

Time	Endler Hall	Jannasch	Fismer
	Genetic Approaches	Marine Protected Areas	Marine Geology, Geophysics and Mining
14:45	Luca Mirimin: A kabeljou's tale – Unravelling inter- and intra-specific barriers to gene flow in depleted sciaenid species occurring along the South African coast	Sophie von der Heyden: Connectivity of South African marine species is lower than expected: insights from molecular tools and implications for biodiversity planning in the region	Errol Wiles: Anatomy, high frequency seismic character and depositional processes of the lower Zambezi Channel, Mozambique Basin, SWIO
15:00	Mark Rothman: A molecular investigation into species relationships in the genus <i>Ecklonia</i> (Phaeophyceae, Laminariales) with special focus on the Southern Hemisphere	Elodie Heyns: Depth related changes in fish community composition in the Tsitsikamma Marine Protected Area, South Africa	Maria Ferentinou: Coastal slumping as a result of chronic coastal erosion at Richards Bay, KwaZulu Natal
15:15	Maya Pfaff: Do viruses terminate red tides and cause severe anoxic events in the Benguela upwelling region?	Ken Hutchings: Limited recovery of a resident reef fish population a decade after depletion sampling within the Maputaland MPA	Shannon Dixon: Storm swash terraces from Morgan Bay, South Africa
15:30	Tea		
	Genetic Approaches	Marine Protected Areas	Marine Geology, Geophysics and Mining
16:00	John Bolton: The importance of molecular sequencing in detecting seaweed introductions into South Africa	Rhett Bennett: The evolution of a fishery: perspectives from East Africa's coral reefs	Lauren Pretorius: The influence of extreme events on an embayed coastline: Morgan Bay, South Africa
16:15	Brent Chiazzari: Population connectivity of sardines (<i>Sardinops sagax</i>) of the KZN sardine run using meristic, morphological and genetic data	Mbulelo Dopolo: Reliability of unverified catch returns (fisheries logbook) data in gillnet fishery, Langebaan Lagoon marine protected area	Andrea Pulfrich: Using diamond-mined sediment discharges to test the paradigms of sandy-beach ecology
16:30	Kerry Reid: Evaluating environmental factors affecting the colonization history and connectivity along the west coast of Africa: Perspectives from a globally distributed species, the elf <i>Pomatomus saltatrix</i>	Sven Kerwath: Marine protected area improves yield without disadvantaging fishers	Kate Munnik: The importance of assessing bioavailability in determining heavy metal toxicity risks
16:45	Angus MacDonald: Identifying the drivers of genetic structure: a multi-species approach	Matt Dicken: An investigation into the occurrence and movement patterns of white sharks (<i>Carcharodon carcharias</i>) within the proposed Marine Protected Area of the Addo Elephant National Park	Natasha Karenzi: How fundamental benthic macroinfauna research informs management of marine mining
17:00	Poster session: Group 2		
19:00	Banquet Evening		

Friday 18 July				
Time	Endler Hall	Jannasch	Fismer	JS Marais Building Rm 1002
	Monitoring the Marine Environment	Modelling the Marine Environment	Strengthening the Role of Science	Historical Perspectives
08:00	Mbongeni Tyesi: Interannual variability in upwelling favorable wind field along the Benguela Upwelling System	Bjorn Backeberg: Assimilating along-track SLA data using the EnOI in an eddy resolving model of the Agulhas system	Warwick Sauer: The urgency of translating science into effective governance in the western Indian Ocean	Colin Attwood: Critical moments for marine conservation in South Africa
08:15	Raissa Philibert: A comparative study of nitrogen cycling in the Southern Ocean and the Benguela upwelling system	Obadias Cossa: Ocean circulation from a regional model of Delagoa Bight and surroundings	Merle Sowman: A new Small-scale Fisheries Policy for South Africa – an opportunity for fostering greater collaboration between the natural and social sciences?	Jock Currie: A century of change: comparing historical and recent trawl survey records
08:30	Seb Swart: The Southern Ocean Seasonal Cycle Experiment (SOSCEX): Towards resolving the seasonal cycle of upper ocean physics and biogeochemistry using autonomous gliders	Neil Malan: How well do the current generation of Ocean Models represent the impacts of Agulhas current variability on upwelling and circulation of the Eastern Agulhas Bank?	Serge Raemaekers: Mind the Gap – Governance dilemmas in South Africa's Western Cape traditional line fishery	Tickey Forbes: How have estuarine benthic invertebrate studies contributed to an understanding of these systems and their biological processes? A perspective on 60 years of research
08:45	Marcel du Plessis: Using high-frequency glider data to understand effects of sub-mesoscale processes and atmospheric forcing on the mixed layer in the Subantarctic Zone	Kyle Cooper: Key validation methods for global operational ocean models for the Agulhas Current	Gregory Duggan: On water temperature on the Agulhas Bank – a case study into collaboration between small-scale fishers and academic researchers	Charles von der Meden: Has the long-term southward shift of the sub-Antarctic Front affected epibenthic fauna at the Prince Edward Islands?
09:00	Mike Roberts: The physical oceanography of the Agulhas Bank: Can its physics explain the observed ecosystem events and shifts on the South African shelf?	Katrin Tirok: Wind-driven circulation and species dispersal in a shallow estuarine lake: Lake St Lucia, South Africa	Louis Celliers: Knowledge for coastal governance: an experiment in the co-production of knowledge	Ameil Harikishun: Establishing a weight-length baseline for evaluating changes in yellowfin tuna (<i>Thunnus albacores</i>) body condition in the Western Indian Ocean
09:15	Lisa Guastella: Importance of the Durban Breakaway Eddy to the Agulhas Current ecosystem	Christo Rautenbach: The influence of a space varying wind field on wind-wave generation in False Bay, South Africa	Morag Ayers: An approach towards evaluating trade-offs between ecological, social, economic and governance objectives in Algoa Bay, South Africa	Charles Griffiths: Repeat photography as a tool for monitoring historical changes in coastal ecosystems
09:30	Aadila Omarjee: Nutrient uptake in the KwaZulu-Natal Bight	Ffion Atkins: The importance of cell size in nitrogen nutrition in phytoplankton assemblages at upwelling/downwelling cycles in the southern Benguela upwelling system	Emily McGregor: Communicating an Ecosystem Approach to Fisheries management with stakeholders in the South African small pelagics fishery: A tool for boundary crossing and social learning	Kerry Sink: Tracking change in South Africa's hake trawl fishery with recommended management modifications

Time	Endler Hall	Jannasch	Fismer	JS Marais Building Rm 1002
	Monitoring the Marine Environment	Modelling the Marine Environment	Strengthening the Role of Science	Historical Perspectives
09:45	Tamaryn Morris: The vertical structure of mesoscale eddies in the southern Mozambique Channel using Argo float technology: The biological 'suitcase' scenario	Moagabo Roagasha: Influence of short-term fine physical processes on the Southern Benguela/Agulhas Bank connectivity	Lisolomzi Fikizolo: The relationship between science and monitoring, control and surveillance (MCS) in fisheries management	Alan Whitfield: Is the sun rising or setting on science in South African estuaries?
10:00	Tea			
	Monitoring the Marine Environment	Modelling the Marine Environment	Strengthening the Role of Science	Plankton Ecology
10:30	Jenny Huggett: Zooplankton sampling in the 21st century: new fangled ways to assess the distribution, diversity and production of planktonic critters	Coleen Moloney: Food webs and biogeochemistry in a changing marine environment	Andrew Cockcroft: Progress and problems in providing scientific advice for the management of the West Coast rock lobster fishery, and the history of scientific advice.	Tommy Bornman: Environmental drivers, ecosystem response and socio-economic impact of the 2014 Harmful Algal Bloom in Algoa Bay
10:45	Margaux Noyon: Size structure of zooplankton in a cyclonic eddy formed on the southern shelf off Madagascar, estimated using a Laser Optical Particle Counter (LOPC)	Louis du Buisson: Vertical distribution of micronekton in pelagic marine ecosystems: a dual acoustic and modelling approach	Doug Butterworth: Use of operational management procedures to address the biological, social and economic objectives of the West Coast rock lobster fishery	Grant Pitcher: Causes of anoxia in St Helena Bay
11:00	Paul Cowley: The development of South Africa's Acoustic Tracking Array Platform (ATAP): history, status, challenges and opportunities	Dawit Yemane Ghebrehwet: Stage dependent variation in environmental niche space of two small pelagic fish species in the southern Benguela	John Duncan: Carrots, sticks and fish: understanding the role of consumers and the market in fisheries policy and management	Tarron Lamont: Phytoplankton production and acclimation on the Natal Bight shelf of the Agulhas ecosystem
11:15	Lara Atkinson: What lies beneath and does it change? New tools to quantify our seabed	Kate Watermeyer: A frame-based modelling approach to understanding changes in the distribution and abundance of sardine and anchovy in the southern Benguela	<i>Panel discussion on strengthening the role of human and natural sciences in fisheries policy and management</i>	Sarah Nicholson: Primary production in the Southern Ocean: sensitivities to synoptic atmospheric forcing and sub-mesoscale ocean dynamics using state of the art high-resolution numerical models
11:30	Yonela Geja: Assessing the use of otolith morphometrics for age estimation of redeye round herring (<i>Etrumeus whiteheadi</i>)	Jérôme Guiet: Environmental effects on the dynamic size-spectrum using a DEB- and trait-based approach	<i>Panel discussion on strengthening the role of human and natural sciences in fisheries policy and management</i>	Olwethu Duna: Vertical distribution of benthic invertebrate larvae in relation to the structure of the water column
11:45	Justin Lathlean: Using biomimetic loggers to investigate whether intraspecific aggregations ameliorate rocky intertidal limpets and mussels from multiple abiotic stresses	Francis Marsac: Trends in tuna fisheries in the Agulhas system with emphasis on inter-annual environmental variability	<i>Panel discussion on strengthening the role of human and natural sciences in fisheries policy and management</i>	Thorsten Werner: Diel vertical migration of euphausiids and their contribution to the vertical flux of organic carbon in the northern Benguela Upwelling System off Namibia
12:00	Move to Plenary			
12:15	Plenary IV: Prof Mark Gibbons: How can we, as a southern African marine science community, improve our ability to understand SEACHange? An illustrative case study			
13:00	Closing ceremony			
13:30	Lunch			

Tuesday 15 July

Endler Hall: Marine Management and Economics

Oral Presentations

The KwaZulu-Natal Boat Launch Site Monitoring System: A novel approach for improved management in the coastal zone

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KwaZulu-Natal (KZN) has a large recreational and commercial boating industry, which includes line-fishing, scuba diving and other activities. Most of the vessels used are relatively small (<10 m long) and capable of being launched directly through the surf. For beach launching, these vessels may only launch from officially registered beach launch sites. Provincial government is responsible for the management of these sites, primarily in terms of national legislation controlling beach driving. Stakeholders in these launch sites are the KZN Department of Agriculture and Environmental Affairs, Ezemvelo KwaZulu-Natal Wildlife, KwaZulu-Natal Sharks Board, the Oceanographic Research Institute, the launch site licence holders (i.e. normally the local municipality), the launch site operators (i.e. normally the local ski-boat club) and the boat users themselves. Collaboration between the various stakeholders in KZN has resulted in the development of a Boat Launch Site Monitoring System (BLSMS) which includes maintenance of a daily launch register at all registered launch sites. Launch sites within the Durban and Richards Bay harbours (under the jurisdiction of the National Ports Authority) and those within the iSimangaliso Wetland Park (under the jurisdiction of the iSimangaliso Wetland Park Authority) have agreed to voluntarily comply with this initiative. All records from the launch registers are captured onto the BLSMS database providing comprehensive resource-use statistics. This is the first attempt at a province-wide monitoring initiative for boat launch sites in South Africa. It is an example of unique, mutually beneficial co-operation between different stakeholders towards the common goal of improved management of small craft launch sites in KZN. Highlights and some of the challenges of this monitoring programme for the period 2005-2012 will be presented.

An Analysis of the Structural and Export Changes in the Offshore Demersal Hake (*Merluccius capensis* and *M. paradoxus*) Trawl Fishery in South Africa

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The hake (*Merluccius capensis* and *M. paradoxus*) directed offshore demersal trawl is the most economically important fishing sub-sector in South Africa, generating ~30 000 jobs and comprising more than 50% of fisheries value. The industry changed to long term rights (LTRA), allocated in 2006 for a 15 year period. This study investigates the structure of the industry half-way between allocations, as well as hake export data in view of the 2008 economic banking crisis. Data obtained through government and industry consultation are used to generate a structural representation of this subsector, its fleet, vertical integration level, consolidation extent including horizontal clustering e.g. catch-share agreements, product value-adding and heterogeneity in business models. Export

data were sourced from TradeMap (2004-2011) and industry was consulted. Exports initially declined post-crisis then recovered, and shifted from fresh to frozen and processed product dominance, largely driven by Spain. Export volumes correlated to Rand/Euro exchange rate. Vertical integration is an important characteristic of the industry. Nine business clusters were identified, of which three represent 75.7% of rights and 70% of vessels. Findings indicate consolidation is likely at a higher level than rightsholder numbers imply, due to horizontal clustering. This is consistent with an economically mature industry of scale. Retirement and industry led effort-restriction in relation to MSC certification, catch-cost efficiency and a shift to frozen product, led to declining vessel numbers, especially wetfish vessels. Industry's response to a broadening of rights access has been to maintain efficiency and profitability through economies of scope and scale by forming clusters, retiring old vessels and engaging in MSC certification to broaden or retain market access. The trend of consolidation since the 2006 LTRA and the record of consolidations and absorptions of smaller businesses suggest consolidation is probable to continue at a slow but steady pace.

Long-term declines in CPUE of an iconic recreational species along the South African east coast

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Garrick *Lichia amia* is a large piscivorous carangid fish species, which is highly prized as a trophy in all sectors of the South African recreational fishery. *L. amia* migrates annually up the east coast of South Africa into KwaZulu-Natal, where it spawns and is heavily targeted by fishers. In light of perceived and empirically-based concern over the status of the *L. amia* stock, this study presents an analysis of *L. amia* CPUE from the recreational fishery along South Africa's east coast. Shore and boat-based angling, as well as spearfishing CPUE data from the National Marine Line fish System (NMLS) was standardised using generalised linear models and the delta-X approach. Year, month and locality were included as factors in the models and were found to be statistically significant in explaining the variance in *L. amia* CPUE. The year effect was extracted and was the focus of the analysis. Despite previous management efforts, which include the implementation of size and bag limits in 1973, an increase in the minimum size limit in 1974, decommercialisation in 1988 and a reduction in bag limit in 2005, the long-term trends in standardised CPUE over the period 1971-2012 were mostly downward. Presently *L. amia* is regulated with a minimum size limit of 700 mm TL, a bag limit of two per person per day and no sale in South Africa. However, owing to the open-access nature of the South African recreational fishery, the popularity of this species and those fishers are learning to target spawning aggregations in KwaZulu-Natal, the current regulations may not be sufficient in managing the fishing mortality on this species. Potential amendments to the current suite of regulations will be discussed.

Abalone in deep water

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Fishery Independent Abalone Surveys (FIAS) undertaken by the Department of Agriculture, Forestry and Fisheries provide a relative index of abundance and are used in the assessment of the abalone *Haliotis midae* resource. Fixed band transects were positioned mainly within the shallow (0-5 m) depths, representing the 'inshore' component of the population. Sampling was concentrated at shallower depths on the basis that more than 70 % of surface-visible kelp and the highest abalone

densities occurred at these depths. The FIAS data show steep declines in density of 80 - 90 % in the main fishing zones from 1995 to the present. An abalone assessment model is fitted to the FIAS abundance data, as well as to fishery catch-per-unit-effort and catch-at-age data for different spatial strata. The availability of the FIAS data in shallower waters leads to greater confidence in the model-estimated state of the 'inshore' component of the abalone population. Divers often allege that scientists underestimate the available abalone resource, whilst there are others who are concerned that the resource may be overestimated. Since 2009 additional sampling of the deeper (> 6 m) depths has been undertaken. It is the intention that once sufficient data are available these will be included in the assessment model to improve the estimate of the deeper 'offshore' component of the abalone population and in turn improve the reliability of the overall biomass estimates. Predictably, provisional offshore FIAS results show low densities in the offshore reaches, of similar magnitude to current inshore FIAS densities. However, there is a higher proportion of larger abalone in the offshore waters and such differences in population size structure between depths will also need to be factored in to the model. These results leave little doubt that there is a greatly diminished abalone resource in deep water.

Proof of concept for a novel procedure to standardize multispecies catch and effort data

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There is potentially much useful information for stock assessment in the over two million individual catch records available for the South African hand-line fishery and other long-term multispecies fisheries datasets, including demersal trawl, tuna longline and shore angling. However, to unlock this information, the effect of variability in targeting needs to be removed from catch-per-unit-effort (CPUE) data to estimate reliable abundance indices. We test a Generalized Additive Model (GAM) that includes principal component scores (PCs) derived from the species composition in the catch, called the 'Direct Principal Component' (DPC) procedure, for its ability to remove the effect of variable targeting. Biomass trends are simulated for two multispecies, multi-habitat fishery scenarios: (i) four species distributed differentially across two habitats and (ii) ten species distributed differentially across four habitats. These scenarios broadly resemble the habitat associations and catch rates of several common target species in the multispecies hand-line fishery off the South African south coast. Tweedie distributed CPUE records are generated from the biomass trends for a fishery with constant targeting (control scenarios) and time-varying targeting (test scenarios). The DPC procedure is simulation-tested for its ability to estimate the underlying biomass trends for all species relative to the non-standardized CPUE index. The DPC procedure proved to be more accurate compared to nominal CPUE trends in the test scenarios. Even in the control scenarios, the DPC procedure offers greater accuracy for the estimated year effect by removing substantial variation from the data, with a small penalty on the accuracy of the underlying abundance trend. A selection procedure based on eigenvalues of the PCs is suitable to identifying the best-performing number of PCs to include in the GAM. The DPC procedure should be applicable for a variety of multispecies fisheries.

Olrac-RTI: A new and operational approach to holistic management of fisheries for multiple commercial species and ecosystem objectives. Part 2

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In the recently proposed Real-Time Incentives (RTI) fisheries management system, described in Part 1, fishers would be allocated fishing-impact credits ('RTIs') to spend according to spatiotemporally varying tariffs, replacing the conventional landings quota. Olrac SPS has developed and manufactured a complete electronic logbook and vessel tracking and data recording and reporting system (Dynamic Data Logger, DDL) linked to an onshore data management system (Dynamic Data Manager, DDM). Olrac SPS is now developing a customised version of DDL-DDM to suit the requirements of the RTI approach. The system will provide the onboard software with the up-to-date tariff maps. Once a fishing trip has started the Olrac DDL eLog will record the time the vessel spent in each of predefined RTI management rectangles. This information will be sent to the Olrac DDM and will be used together with any available VMS data to automatically calculate the amount of RTIs utilised by the vessel during its fishing trip. This amount will then be automatically deducted from the vessel's annual RTI-account. Olrac DDM will also integrate the vessels' reported catch data from the Olrac DDL vessel units and combine them, using a tested algorithm, to update the spatial tariffs as appropriate, so that the updated tariff maps could reflect our understanding of the exploited ecosystem. Olrac DDM will also provide the managers with detailed and summary reports of RTI uptake and reported catches in time and space. This management approach provides fishers with a practical and simple management regime, in contrast to the current micro-management.

Poster Presentations

Poster # 66

An Agent Based Model of South African Demersal Hake Trawling Industry: Examining the Dynamics of the Industry between Target Resource and Markets

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The offshore demersal hake trawling industry is the largest sub-sector accounting 85% of the catch, of South Africa's most valuable fishery, the hake (*Merluccius capensis* and *M. paradoxus*) directed fishery. The companies involved in extraction and processing of hake in the offshore demersal hake trawling sector are completely heterogeneous, with different structures, vessel fleets, product types, sizes and proportions of quota and presumably markets. We therefore hypothesize that changes in market forces in terms of volume, price, product type demanded (e.g. fresh vs frozen) will have dissimilar effects on different types of companies and on the hake resource. Modelling provides one way of exploring scenarios of such changes. We aim to gain a preliminary understanding of the dynamics of the industry of this sub-sector, i.e. the post-harvest industry between target resource and market, with regard to its structure and the relative importance of internal and external drivers, such as consumer preferences/demand for fresh or frozen fish. We produced an agent based model prototype of the post-harvest industry that is capable of taking into account the heterogeneity of fishing companies, their fleets and behaviours, since it models individual agents, and used it to examine a range of scenarios. We emphasize the importance of a prototyping approach in developing this type of model, particularly where the ultimate aim is to use it in conjunction with ecological models in an ecosystem approach to fisheries framework.

Poster # 67

South Africa's National Coastal Management Programme

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In the 1990s a significant shift occurred in South Africa's coastal management regime from a predominantly biophysical and bureaucratic view to a participatory approach driven by human development imperatives and sustainable development. The shift led to the promulgation of the National Environmental Management: Integrated Coastal Management Act in 2008. This act views coastal management programmes (national, provincial and municipal) as its primary tool to facilitate cross-sectoral, integrated management of the coast across the three tiers of government. This paper introduces South Africa's national coastal management programme (NCMP) that provides the direction and guidance on a structured and standardised approach to coastal management, including an appropriate cooperative governance framework – a critical element for effective implementation of integrated coastal management (ICM). First the ecosystem-based (versus strongly sector-based) framework, developed to facilitate the “integrated, coordinated and uniform approach” is introduced, as well as the process that was followed in the development of the NCMP. Thereafter specific priorities in the NCMP are detailed within the context of the framework. Finally the future implementation of the NCMP is discussed, including some of the key challenges.

Poster # 68

Consumptive and non-consumptive resource use along sections of the Garden Route coastline

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Coastal resource use, with particular emphasis on the recreational and subsistence line fishery, between Wilderness and the Goukamma Marine Protected Area was assessed over a 24 month period through the Working for the Coast Public Works Programme. Results have emphasized the importance of this coastline to both locals and tourists as a recreational area. Both non-consumptive and consumptive use was heterogeneously distributed through the study area with increased use occurring near access points and the villages of Wilderness and Sedgefield. Non-consumptive resource use comprised over 90% of all activities and showed strong seasonal patterns. The line fishery was dominated by local males and showed the usual temporal trends of increasing fishing effort over holiday periods. Total annual fishing effort was estimated as 48 167 angler hrs⁻¹ and although the fishery was dominated by anglers fishing for recreational purposes (76%) the overall retention rate was high with an estimated annual catch between five and six thousand fish. Blacktail was the dominant fish species caught comprising 12.7% of the total observed catch. Although dusky kob was targeted on 13% of angling trips this species only comprised 1.9% of the total catch and of concern is that 80% of the retained kob measured were below the legal size limit (60cm). The roving creel surveys have provided important information on coastal resource use and recommendations are made as to how to improve coastal monitoring and law enforcement activities by South African National Parks.

Should we worry about ocean acidification impacts in South African Marine systems?

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Ocean acidification lowers seawater pH as well as the calcium carbonate saturation state of seawater, both of which are already evident. The first oceans to experience these effects will be the cold Arctic and Southern Oceans. The west coast Benguela, Californian, Peruvian and Canary upwelling systems will be almost as vulnerable to lowered ocean pH because of the deep origin of CO₂-rich upwelling water. Predicted calcite and aragonite saturation states in the Benguela will mirror those of polar oceans, probably becoming undersaturated this century. Combined with other stressors such as low-oxygen water and higher sea temperatures, lowered ocean pH can affect reproduction, growth and mortality in juvenile shellfish, fish and squid populations. South Africa has a growing commercial aquaculture fishery based on mussels, Pacific oysters and abalone – all calcifying shellfish. Juvenile 3-month old abalone exhibit signs of serious shell erosion within 48 hours at a pH of 7.5; equivalent to an atmospheric CO₂ concentration of about 750ppm, which is anticipated before 2100. In kelp-beds, day-night fluctuation in pH is due to alternate cycles of photosynthesis and respiration, which subjects abalone to considerable pH variability. Even so, some organisms, such as corals and some sea urchins, appear able to regulate their internal pH, which offsets lowered pH in the seawater, but at an energetic cost that affects growth rates. Further afield in the Southern Ocean, there is mounting evidence that falling pH is negatively affecting krill larvae, which become malformed. Since Krill underpin almost the entire Southern Ocean food web, this is potentially serious. Such negative effects are equally felt by delicate pteropods, another keystone species of both the Arctic and the Southern Ocean. In this review, we examine the above examples in greater detail and assess future impacts, particularly for the aquaculture industry.

Impacts of low pH and warming on the South African abalone and mitigation thereof

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Ocean acidification is causing changes in marine organisms' physiology, metabolism and growth is resulting in the dissolution of calcifying structures. Predicted global seawater pH declines are already occurring in the North Pacific upwelling regions and is impacting shellfish hatcheries and aquaculture farms. The Southern Benguela upwelling region is host to many aquaculture farms in South Africa, particularly abalone farms which are the most economically productive. The Southern Benguela may likely experience the same fate as the Northern Pacific farms if South African abalone farmers do not find a way to fully mitigate the problem before seawater pH reaches toxic levels. Warmer water results in faster growth of abalone, however the compounding effects of warm, low pH water is expected to negatively impact abalone acid-base balance and, in turn, their metabolism and growth. This research presentation will reveal the impacts of ocean acidification and warming on abalone morphology, shell mineralogy and physiology. It will also present the effects of incorporating *Ulva* raceways into aquacultural systems to mitigate low pH waters and improve abalone growth.

Climate effects on biodiversity, abundance and distribution of marine organisms in the Benguela large marine ecosystem: a synthesis

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The NansClim project (2010-2013) represented a regional collaboration to assess the effects of climate on Benguela dynamics. Based on *in situ* (since the 1960s in Namibia and South Africa and 1985 in Angola) and satellite (since the 1980s) observations, the project focussed on four subsystems, namely the Angola subtropical, northern Benguela upwelling, southern Benguela upwelling, and Agulhas Bank. This contribution summarises the findings for selected key questions, ranging from changes in the physico-chemical habitats, plankton, pelagic and demersal fish communities, to cross-cutting evaluation at subsystem and regional scales. Fishing has been at least as important a driver of long-term ecosystem change as climate variability and change. Each subsystem currently continues to function largely as a separate entity as described in earlier reviews. However, some changes have been observed across several subsystems, e.g., a coherent shift from one relatively stable period to another occurred in the northern and southern Benguela in the mid-1990s. Future climate change could weaken the boundaries between the four subsystems. The findings underline the need for continued regional research collaboration, and regional surveys focussed at ecosystem, rather than resource, assessment. Our conclusions include implications for ecosystem-based fisheries management, and recommendations for future regional research.

Short term response mechanisms of the West coast rock lobster (*J.lalandii*) to decreased seawater pH

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The West Coast rock lobster (WCRL) supports one of South Africa's most valuable marine fisheries, valued in excess of 260 million rand annually and is relied upon by some 4000 individuals for employment. However, South Africa's coastal environment could be considered unforgiving as organisms are exposed to large temperature fluctuations, pH, algal blooms and low oxygen. Upwelling plays a large role in the Benguela ecosystem, as cold, nutrient-enriched, "acidic" water is transported from the depths on to the coastal shelf. However, this upwelling is often associated with some of the extreme conditions mentioned. Specifically during algal blooms, respiration in the water column and very limited water movement may lead to high pCO₂ seawater, although pH data is lacking it is believed that the lobsters may be exposed to extremely acidic pH values. There is also growing evidence that the intensity of upwelling events is growing globally. Little is known about the WCRL (*Jasus lalandii*) with regards to its capabilities and the mechanisms involved in dealing with a

decreased seawater pH. Therefore, the physiological response of *J. lalandii* to decreased seawater pH (7.3) was assessed *in vivo*, during a series of acute exposure experiments (32 hours), as well as establishing the *in vitro* effect an increased pCO₂ would have on the functioning of the respiratory pigment of the lobster's haemolymph, haemocyanin, with regards to oxygen affinity, co-operativity and dialysis. As a result of a decreased seawater pH due to addition of CO₂ gas, haemolymph pH dropped sharply initially by 0.3 units. Lobsters reacted rapidly with an increase of the haemolymph bicarbonate concentration by 2.6mmol.l⁻¹, with full compensation occurring within 5 hours post exposure and after 24 hours, a net pH increase of 0.07 units was recorded. Haemocyanin showed an expected decreased affinity for O₂ when exposed to increased pCO₂.

Interactive effects of pH and temperature on native and invasive mussels from the West Coast of South Africa

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Global warming and ocean acidification can negatively impact marine calcifying organisms. Shells of marine calcifying organisms protect their internal soft tissue from these environmental stressors. This study investigated the individual and interactive effect of pH and temperature on the performance of native and alien mussels. Listed in order of decreasing shell thickness, we compared shell dissolution, shell growth, shell breaking force and condition index of *Aulacomya ater*, *Choromytilus meridionalis* (both native), *Mytilus galloprovincialis* and *Semimytilus algosus* (both invasive) from the Western Cape coast of South Africa were compared. Live mussels and bare shells were exposed to seawater temperatures of 14°C and 20°C set at two pH levels (7.5 and 8.0) for roughly 40 days. Findings indicate that shell thickness determines the susceptibility of mussels to environmental stressors, in terms of shell dissolution and breaking force, but does not affect internal growth. Invasive mussels showed increased shell dissolution at low pH but their growth rates and condition indices were unaffected. Thicker shelled native mussels showed no significant changes in shell dissolution among the treatments and exhibited increases in growth rates in low pH treatments. *C. meridionalis*, being cold water adapted, exhibited a reduction in condition index in high temperature treatments. This study indicates that native and invasive mussels have different compensatory mechanisms to respond to changing temperature and pH, allowing them to maintain their specific life history strategies under short term exposure to warming and acidification.

Climatic variability shapes thermal plasticity in populations of the South African sandhopper *Talorchestia capensis*

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Given the high rate at which climate change is altering natural fluctuations in climatic variables, the ability of animals to cope with variation in environmental conditions is central to determining the persistence and success of species. Temperature is by far the most important environmental variable governing species distributions and patterns of abundance, and its fluctuations may cause within-species differences in physiological responses. Thermal plasticity is, therefore, a powerful evolutionary mechanism for coping with challenging/thermally variable environments and can determine the response of populations and organisms to temperature changes. We investigated the

thermal physiology of the sandhopper *Talorchestia capensis*, testing differences in aerobic performance among geographically separated populations encompassing three bioregions with contrasting climatic conditions. We evaluated whether individual plastic responses to temperature could be related to natural long-term variability in environmental temperatures. Metabolic rate was used as a proxy for performance under gradually increasing and decreasing temperatures. *T. capensis* showed different responses to changing temperatures, with intra- and inter-population variability in thermal physiology and sensitivity. These differences in thermal plasticity may reflect adaptation to local conditions, as the thermal sensitivity of populations was negatively correlated with air temperature variability over the past 23 years. The results suggest that climatic fluctuations experienced over multiple generations may shape current responses to temperature, contributing important population differences. The persistence of such “climatic memory”, acquired across multiple generations, indicates, as well as absolute temperatures, that the predictability of environmental temperature variation should be considered when forecasting how climate change will influence natural populations.

Poster Presentations

Poster # 26

Potential climate change effects on subtropical fisheries species of the Western Indian Ocean

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A number of range-restricted fish species are targeted by commercial fisheries in the subtropical Western Indian Ocean. Climate change is predicted to have a significant influence on both range-restricted and exploited fish species and as such predicting the effects of climate change on these species is important. The most obvious changes associated with increased sea surface temperatures around the Western Indian Ocean will be shifts in the distribution and abundance of individual species or species assemblages according to their thermal tolerance and ability to adapt. In this study we used species distribution models to project the potential future climatic niches of six species that occur in the subtropical Western Indian Ocean, namely: *Chrysoblephus puniceus*, *Chrysoblephus anglicus*, *Epinephelus andersoni*, *Epinephelus albomarginatus*, *Polysteganus praeorbitalis* and *Rhabdosargus holubi*. Bioclimatic modelling suggests that climate change may have an adverse effect on the range of these three of these species. Rather than showing a marked range shift from north to south, the northern range margin of *C. puniceus*, *E. andersoni* and *P. praeorbitalis* is projected to shift poleward and the southern range margin to contract resulting in range contractions. Projections for 2030 are that range size of these species will decrease by between 20% (*C. puniceus*) and 8% (*P. praeorbitalis*). *C. anglicus*, *E. albomarginatus* and *R. holubi* were projected to gain up to 20% geographic range. Although these species ranges expanded into southern Mozambique it's likely that further into the future the ranges of these winner species may contract as temperatures become too warm. Changes in fish distribution and abundance may have large implications for coastal communities that depend on marine and coastal species for food and income.

Poster #27

Female physiology and embryonic development in the West Coast rock lobster, *Jasus lalandii*, under hypercapnic conditions

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The fishery of the West Coast rock lobster, *Jasus lalandii*, is one of the most valuable fisheries in South Africa (260 million Rand/year) and provides employment to more than 4000 people, mostly from previously disadvantaged, poor communities. The habitat of the *J. lalandii*, the Benguela Current ecosystem, is characterised by periodic upwelling events that bring cold, high $p\text{CO}_2$ seawater up from deeper water layers to the surface. Historic pH data is lacking but currently, lobsters are exposed to extremely low pH levels during these events. From other, similar systems, there is evidence that frequency and intensity of upwelling events is growing as a result of climate change (ocean acidification and warming). Changes in the carbon chemistry of the seawater, resulting in acidification, will most likely affect various aspects of the biology of the *J. lalandii*, including acid base regulation and exoskeleton formation. These impacts will, in turn, influence reproduction, development and growth of the lobster. The fishing resource of *J. lalandii* will, therefore, be affected by an increase in frequency and/or severity of hypercapnic upwelling events and it is important to assess potential threats beforehand to estimate economic consequences. Hence, it is important to know as many impacts of these environmental changes as possible to predict *J. lalandii* response capacity. In the present study, we investigated acid base physiology and calcification of the exoskeleton of adult female WCRL as well as growth and development of early life stages of offspring that were exposed to hypercapnic conditions for up to 60 days. Our data revealed that female *J. lalandii* are well equipped to adjust their acid base state to hypercapnia and that calcification of the exoskeleton is not affected. Moreover, there was no measureable influence of hypercapnia on embryonic growth and development.

Poster # 28

Are South Africa's Coral Communities in Hot Water?

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Coral reef ecosystems directly suffer large-scale mortality as a result of global warming and in the face of rising sea surface temperatures, their future is uncertain. During the Western Indian Ocean's largest mass coral bleaching event in 1998 relatively insignificant coral bleaching (<1% of hard corals) was recorded in South Africa. Since 1998, the frequency and intensity of coral bleaching has increased in the iSimangaliso Wetland Park with estimates of up to 37% of coral colonies showing some bleaching in peak bleaching season in 2007 and 39% in 2013. This study examines South African coral bleaching monitoring data from 2005 to 2013, providing an initial analysis of trends for the period between 2007 and 2013. The bleaching response indices between 2005 and 2013 revealed periods of high and low bleaching. Taxon explained 40% of the bleaching responses over time with genera *Coscinaria*, *Montipora*, *Anomastrea* and *Astreopora* being the most susceptible to coral bleaching. *Turbinaria*, *Oulophyllia* and *Gyrosyllia* were the most resilient taxa to coral bleaching over this period. Periods of high bleaching response did not correspond with thermal stress at the

one site where temperature data was available. Finer-scale temperature- and light data is needed to examine the high variability and complexity in bleaching response between sites. New approaches in coral monitoring are under development including additional fixed monitoring stations and a new citizen science component that builds on previous efforts to involve dive operators in the monitoring of reef health. Some evidence of other biological changes occurring on these reefs was also detected including bleaching of soft corals and sponges, mortality of *Tridacna* clams and increased milleporid fire coral abundance at one site. Future studies need to monitor additional taxa, include analysis of depth effects and track potential changes and impacts of ocean acidification.

Poster # 29

Physiological response of farmed South African abalone, *Haliotis midae*, to hypercapnic events

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Aquaculture of the South African abalone, *Haliotis midae*, is the most important marine farming activity in South Africa. The annual production of about 1000 t contributes substantially to earnings in foreign currency and to employment. Most of the farms are situated in the Western Cape and are exposed to fluctuations of water parameters of the Benguela Current Upwelling System. In other, similar systems (for example the California system), climate change has increased frequency and intensity of upwelling events. During upwelling, CO₂-rich water from the deep leads to a decrease in pH and under-saturation of calcite and aragonite. These factors alone, or in combination with additional stressor, will most likely affect acid base regulation and the ability to calcify shells which, in turn, will impact reproduction, growth and mortality. The latter are key issues when farming abalone economically and any increase in frequency and/or severity of hypercapnic upwelling events will potentially impact employment stability of whole coastal communities. It is therefore necessary to evaluate the ability of abalone to deal with such environmental changeability. Here, we present data from chronic experiments that evaluated acid base changes and mortality during episodes of artificial hypercapnia. The data show that abalone have little capacity to adjust acid base state and that their haemolymph pH remains below that in normal conditions. There is also a size effect: Smaller abalone are more vulnerable than larger ones. Our data suggest that there is a need to investigate possible ways to mitigate the effects of upwelling events to secure undisturbed farming operations.

Fismer: African Marine Mammal Colloquium (Part 1)

Oral Presentations

Re-colonisation of Vondeling Island (west coast, South Africa) by the Cape Fur Seal (*Arctocephalus pusillus pusillus*): its conservation and management implications

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The Cape fur seal (*Arctocephalus pusillus pusillus*) colony at Vondeling Island, (South Africa, west coast), together with other colonies (i.e. Robberg Peninsula), were wiped out by harvesting in the late 1800's. Improved management of the species has resulted in the recovery of the population. Changes in key prey availability associated with climate variability and fishing pressures have resulted

in northward distributional shifts of populations and re-colonisation of old rookeries such as Vondeling Island. Pups count trends carried out since 2003 at Vondeling Island indicate an exponential growth of the colony, although recent surveys suggest that the colony has reached its growth potential. Seals cohabit Vondeling Island with seabirds, some of which (i.e. bank cormorant) are endangered. Aerial photographic data indicates that seals now cover ~80% of the colony, inevitably limiting breeding space of seabirds. Seals and seabirds also compete for fish, which is the major dietary component for both groups. To monitor interactions, eight satellite tracking instruments were deployed on lactating seal females. Data collected between July 2012 and Jan 2013 indicates a tempo-spatio shift in the selection of foraging grounds by seals. Within the first three months of the study they foraged north of the rookery and during the remainder of the period they foraged south of the rookery. Tracking data from tagged seabirds of Malgas Island however, indicates a possible disassociated temporal feeding pattern between seals and seabirds during the year. The combined effect of lack of breeding space at the island and depleted prey stock for on the west coast is worrisome to conservation managers of seabirds.

Foraging behaviour of a marine mammal confirm efficiency of a marine reserve's design: Subantarctic fur seals at Prince Edward Island

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Making provision for the foraging requirements of seals and seabirds was a specific motivation for the marine protected area (MPA) that was recently proclaimed for the Prince Edward Island archipelago (PEIA), which includes Marion Island (MI) and Prince Edward Island (PEI). Foraging areas of southern elephant seals *Mirounga leonina* and certain seabird species were taken into account in the MPA design, based on satellite tracks of individuals tagged at MI. A recommendation of the planning process was that foraging patterns of top predators should be further monitored to provide indicators of climate change responses that could impact the boundaries of the MPA. It was also acknowledged that more information on seals, especially fur seals *Arctocephalus spp*, and seabirds from the less studied of the two islands, PEI, was required (elsewhere, e.g. the Kerguelen Islands, it has been shown that foraging grounds of top predators can differ considerably between sub-populations of seals or seabirds within an archipelago). Therefore a sample of twelve lactating females of the Subantarctic fur seal *A. tropicalis* were fitted with satellite transmitters during an expedition to PEI, to investigate their at sea movements and habitat utilisation. Movements were modelled from Argos locations using first difference switching correlated random walk state space models. The different behavioural states, foraging or transit, were related to the occurrence of oceanographic features and processes, and with the MPA boundaries. Preferred foraging locations tracked the migration of the Subantarctic Front (SAF) over the course of the year, and were also associated with bathymetric features (ridges/rises) in the Northwest and Northeast arms of the MPA, the latter of which is also favoured by the MI subpopulation of this species. The results support the importance of SAF for top predator foraging and the effectiveness of the reserve design for capturing the shifting frontal position.

Phylogeography of the dugong (*Dugong dugon*) based on historical samples

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The dugong (*Dugong dugon*) is a marine herbivore that inhabits near-shore tropical and sub-tropical waters extending over some 140,000km of coastline across 38 countries in the Indo-Pacific region from Mozambique to East Australia and Vanuatu. The overall conservation status of the dugong is currently classified as 'vulnerable' by the International Union for the Conservation of Nature (IUCN), although the species may in fact be 'endangered' or 'critically endangered' in some parts of its range. As a result, contemporary samples are extremely difficult to obtain due to the scarcity, low numbers, and relative inaccessibility of animals. However, data on population genetic structure are needed to inform the design and implementation of sound and effective *in situ* conservation and management strategies to protect the last remaining viable populations. Unfortunately a scarcity of samples has to date prevented a range wide examination. In the present study we investigated the phylogeography of the dugong using 208 samples from bones and teeth of specimens housed in 12 European natural history museum collections. These samples range in date from 1869 to 1995 and span the entire historical range of the dugong. Using six custom designed primers we were able to successfully amplify overlapping fragments of the d-loop region of the mitochondrial DNA (mtDNA) from 208 samples. The resulting fragments ranged in length between 364 and 132 bp. Preliminary analysis revealed that the sequences concurred with those obtained through biopsy of contemporary animals and showed a fair amount of variation in the 364bp fragment. In addition, geographical structuring was found within the Indian Ocean populations. Results will be compared to studies from Australia and Thailand on contemporary material in an effort to quantify changes in population structure over time. Detailed results on population genetic structuring will be discussed.

Can tourism alleviate fisheries pressure on dugongs (*Dugong dugon*) in the Bazaruto Archipelago

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The Bazaruto Archipelago is the last known stronghold of dugongs in the Western Indian Ocean. Anthropogenic use (including tourism, subsistence and commercial fisheries and potential hydrocarbon exploration) places considerable pressure on the Archipelago's marine environment. Rapid surveys (of dugong distribution and mortalities, seagrass distribution, economic evaluation of fisheries, fishing gear and catch composition) were undertaken in the mainland fisheries communities around the archipelago in an attempt to quantify impacts on dugongs. Additionally, assessments extended to resource-use by tourism industry and potential alternative-livelihood opportunities within the tourism sector for fishers. One and five focal group meetings were held with the fishing and tourism communities respectively. 156 questionnaire interviews were conducted across 13 fishing communities and 12 individual interview meetings were held with tourism establishments. Fisheries (diving collection, beach and small purse seine, gill-netting and hand-lining activities) were estimated to be worth 2 million USD per annum. Average catches and values of these per fishing day were estimated at 186 kg (205 USD) per beach seine net, 60 kg (30 USD) per gill net, 25 kg (17 USD) per small purse seine net, 17 kg (43 USD) per hand-lining boat and 20 kg (67 USD) for

diving collection. Occupancy rates for tourism facilities and consequent annual tourism values were not forthcoming. Gillnet fisheries result in by-catch of dugongs (14 over 7 years) and beach-seine fisheries result in dugong habitat destruction. Tourism engagement with communities was identified as of concern as was fishery access to restaurant markets. Both community fisher and tourism groups identified the need for a common forum to alleviate latent conflict between groups. Alternative livelihood opportunities for fishers identified in the tourism sector included market gardening, crafting and refuse management and recycling and direct ecotourism participation. Operators were reluctant to involve communities in cultural tourism opportunities.

Spatial and temporal distribution of beaked whale strandings on the South African coast

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Despite their physical size, the beaked whales (Family Ziphiidae) are perhaps the least known group of mammals. Studies of their biology are made difficult by their offshore distribution, deep subsurface habitat, apparent rarity and shy behaviour. Populations in the Southern African Subregion are no exception. We used data collected along the South African coast over the past 50 years by various stranding attendance programmes to infer aspects of their spatial and temporal distribution. Over 200 stranding incidences from nine species have been recorded since 1964 (*Mesoplodon densirostris*, *M. layardii*, *M. mirus*, *Ziphius cavirostris*, *M. grayi*, *Hyperoodon planifrons*, *M. hectori*, *Berardius arnuxii* and *Indopacetus pacificus*), with the first five accounting for 87% of records. While approximately equal numbers have been recorded in the cool temperate and warm temperate biogeographic regions, very few have been recorded along the subtropical coastline. The distribution of some species is also uneven, with 84 % of *M. layardii* found along the cool-temperate coastline and 74 % of *M. densirostris* recorded along the warm-temperate coastline. St. Helena Bay, Western Cape recorded the greatest number of incidences (15 % of all strandings). Inter-annual changes indicate a gradual increase in the number of strandings to the mid 1980's, with a subsequent decline for all regions. The year 1984 was exceptional for strandings, primarily due to large numbers of *M.densirostris* found ashore. While some species strand aseasonally, *M. densirostris* and *M. layardii* strandings were strongly seasonal. Biases in term of sex and age class were apparent for some species. While both spatial and temporal results are influenced by an uneven search effort, they indicate that the various species of beaked whales have different habitat preferences and distributions in the subregion and suggests that some may be migratory. This study indicates the value of long-term stranding datasets in assessing the biology of little known marine species.

Patterns of scarring on baleen whales on the west coast of South Africa attributed to a cookie-cutter shark *Isistius* spp

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Counts of unhealed wounds attributed to the bites of a small warm-water shark *Isistius* spp. were made on 1,680 whales landed at the Donkergat whaling station, Saldanha Bay, March to October 1963. These included 687 sei, 58 offshore Bryde's, 22 inshore Bryde's and 55 fin whales. Sei whales carried the most unhealed wounds (mean 33.2 ± 0.96 SE per whale), followed by offshore Bryde's whales (15.2 ± 1.5), fin (10.3 ± 1.4), and inshore Bryde's whales (0.1 ± 0.1). For each "species" the incidence of unhealed wounds was investigated relative to date, length, water depth, and reproductive condition, using Generalised Additive Models (GAMs) in R with the mgcv package. Model selection was executed by exploring all possible subsets of covariates, using the dredge function in the MuMIn package. The data for the four baleen whale "species" were combined and modelled with species as a random effect. The full model had the highest weighting (70%) and explained 40% of the variability in the data. The strongest predictor was date, with a peak in mid-September. Lactating females had the highest overall number of unhealed wounds and adults had significantly more wounds than immature animals of both sexes. The incidence of healed wounds assessed qualitatively was lowest in inshore Bryde's whales, followed by fin, sei and offshore Bryde's whales with the highest. These findings agree with perceived patterns of distribution and migration. If bites are only incurred outside the Antarctic, their relative abundance reflects residence times in lower latitudes, with immature animals having shorter residence times than matures and lactating females the longest residence times, while inshore Bryde's whales are outside *Isistius*' range and offshore Bryde's whales do not migrate to the Antarctic.

Poster Presentations

Poster # 1

Sexual dimorphism and geographic variation in striped dolphin (*Stenella coeruleoalba*) crania along the South African coast

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Sexual dimorphism and geographic variation in morphology is evident in a number of cetacean species, but few studies have attempted to determine the extent of these aspects in striped dolphins (*Stenella coeruleoalba*). Striped dolphin strandings occur along the entire South African coastline, but it is unknown whether these animals represent a single population. The aim of this study was to assess the extent of sexual dimorphism and geographic variation in striped dolphin cranial size and shape off the South African coast. Ten dorsal and ten ventral features of 50 striped dolphin crania (29 males; 21 females) from both the western and eastern coasts of South Africa were analysed using landmark-based geometric morphometrics. Although there was no evidence of dimorphism or geographic variation in cranial size, small, but significant, variation in cranial shape was found between the sexes ($P = 0.01$) and between the eastern and western geographic regions ($P < 0.001$). Male striped dolphins tend to exhibit contraction in the areas around the paraoccipital process and the basioccipital on the ventral cranial surface, while females tend to show expansion in these areas. Both these features are associated with the functioning of the hyoid apparatus, which serves as a major attachment point for many of the muscles and ligaments involved in feeding and sound

production. These findings suggest the possibility of differences in feeding strategies and/or vocalizations between the sexes. There is also evidence for a greater degree of dimorphism in western striped dolphins. Geographic variation in cranial shape was found in both dorsal and ventral cranial features. The differences in cranial shape between the geographic regions suggest that western striped dolphins belong to a separate population in the Atlantic Ocean. Information on population or stock structure is important for management and conservation, as well as future research on this species.

Poster # 2

An abundance estimate for the inshore Bryde's whale population based on photo-identification data from False Bay and Plettenberg Bay, South Africa

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Obtaining a current abundance estimate for the inshore South African Bryde's whale population (*Balaenoptera brydei spp*) is a conservation imperative. The entire population was estimated at approximately 600 individuals in 1984 and less than 300 from the Plettenberg Bay area in 2008. A two year project was launched in 2012 to obtain an updated abundance estimate for the population throughout its known range. Six dedicated small-boat survey periods were conducted throughout 2012 and 2013 in Plettenberg Bay (PB) and False Bay (FB), South Africa. These two bays represent geographically distant areas near the eastern and western limits of the known range of the population. From 82 sea days, a total of 386 hrs were spent searching during which time 225 Bryde's whale encounters were made. Individual whales were identified from dorsal fin photographs. Sixty seven individuals were identified from Plettenberg Bay and 27 from False Bay. No matches were found between the two areas suggesting some spatial structuring within the population. Separate abundance estimates were made for each area as well as a combined estimate. Closed population models implemented in program MARK were chosen as the best models due to the restricted movements of this population and the lack of matches between areas. The results of the analysis for PB were; $\hat{N} = 190$, SE 52, 95% CI 122-341 and for FB were; $\hat{N} = 68$, SE 27, 95% CI 39-161. The combined abundance estimate was; $\hat{N} = 324$, SE 78.5, 95% CI 214-335). These results represent the number of marked animals in the population and the estimate can be expected to increase when the numbers of unmarked animals are accounted for. However, the results support current thinking that the population is small and that correct management of the coastal environment in which they are resident is essential.

Poster # 3

Cetacean data collection from commercial whale watching vessels: consistency, validity, and value in local habitat monitoring

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Whale watching is a growing industry worldwide. Whale watching vessels (WWVs) constitute a valuable and cost-effective platform of opportunity for collection of information on the species, distribution, number, and behaviour of cetaceans encountered. In South Africa, licensed WWVs are required to submit trip summary data, including cetaceans encountered to the responsible government agency, the South African Department of Environmental Affairs, Oceans and Coast (O&C). This study analyses the consistency and validity of collected data from thirteen years (2000-

2012) of observations by a single company 'Dyer Island Cruises', operating between Danger Point and Quoin Point, Western Cape. The records were completely consistent with respect to information on date and skipper and guide ID (reported in 100% of cases), less so with respect to weather and oceanographic information (from 12% for water depth to 88% for sea state). The trip duration as well as route (spatial effort) was only recorded in less than 5% of cases, making spatial distributional analyses difficult. The validity of species identification was excellent with 100% agreement between observer records and photographic documentation in 366 cases of 7 cetacean species. Location data were erroneous in 1.5% of cases. Behavioural data were described in overly subjective terms making a post-hoc analysis impossible. Despite these problems, the data provide valuable information on the long term presence and distribution of cetaceans in the area in the absence of dedicated scientific surveys. To secure collection of useful and precise data from WWV we strongly encourage the development of worldwide standards, which should include log sheet key criteria, online data entry, and recommended data analysis approaches. In particular, poorly studied areas such as in many developing countries would benefit from improved WWV data collection standards. Formal guidelines would also enable and encourage a worldwide comparison of data.

Poster # 4

Foetal Growth in Humpback Whales (*Megaptera novaeangliae*) from the Southern Hemisphere

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6841 pregnant humpback whales are recorded within the International Whaling Commission Southern Hemisphere catch database, including one record of triplets, 30 records of twins and 6810 records of single fetuses. 6805 records have associated data of date and region of capture, and the number, length and sex of foetus (es). The sex ratio of fetuses differed by trimester, with overestimation (0.594/0.406) of male fetuses through probable misidentification in early pregnancy compared to a slight male bias (0.511/0.489) in the final trimester. Lengths of fetuses taken at known Julian dates provided an estimation of foetal growth over the year, although determination of gestation age of each foetus is compromised by the rounding of the lengths of small fetuses to 1 inch or 1 cm. A core dataset determined from the mean foetal length each month included the smallest fetuses rounded at 1 inch (September), whilst the largest was 5.4 m (August), with the literature reporting natal lengths of between 4.5 and 5 m. Assuming a reference date of conception at 15 August from the literature, a uniform foetal growth curve of $0.00002 * (\text{Julian Day})^{2.1023}$ calculated from the core data (excluding the 49 rounded 1cm and 1 inch sizes), resulted in gestation periods of 352 days and 370 days for natal lengths of 4.5 and 5 m respectively. Back projections of foetal lengths at this growth rate, placed some 72% of conceptions within the highly seasonal period of August to September, with peak conceptions (16%) spanning the ten day decade of 25 August to 5 September. 3.9 percent of conceptions occurred outside of 90 days of this peak conception period, with such asynchronous conceptions probably occurring during migration, or on the southern feeding grounds. Asynchronous conceptions were evenly distributed by longitude and not linked to any of the seven Southern Hemisphere Breeding Stocks.

Poster # 5

Interspecific interactions between three marine top predators, Indo-Pacific bottlenose dolphins, humpback dolphins and white sharks, in Mossel Bay, South Africa

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Interactions between top predators within an ecosystem include inter-specific competition for prey and predation upon each other. As sharks increase in size, their diet shifts from predominantly fish and cephalopod based, which dolphins may compete for, to high energy, blubber-rich prey such as marine mammals. This study investigates competitive and predatory interactions between two coastal dolphin species, humpback (*Sousa chinensis*, *plumbea* form) and bottlenose (*Tursiops aduncus*) dolphins, with white sharks (*Carcharodon carcharias*) in a known white shark aggregation site in Mossel Bay, South Africa. Data on dolphin presence and behaviour from land-based observations of dolphin movements (1167 hrs), were combined with data on shark presence from boat-based chumming surveys (1571 hrs) collected between February 2011 and March 2013. The highest mean number of white sharks was observed in the vicinity of a Cape fur seal (*Arctocephalus pusillus pusillus*) colony at Seal Island. At this site humpback dolphin groups were at their largest while bottlenose dolphin groups were larger at the adjacent site, Hartenbos, a known white shark resting area. At these two sites both species of dolphin spent most of their time travelling with little time spent resting or socialising. Generalised additive modelling of dolphin group sizes showed a positive relationship between humpback dolphin group size and the number of bottlenose dolphins, with a positive relationship also present between bottlenose dolphin group size and the number and size of white sharks present and number of humpback dolphins present. This study suggests that bottlenose dolphins may be adjusting their group sizes in response to the presence of both predators (large white sharks) and competitors (smaller white sharks and humpback dolphins); while humpback dolphins may instead respond to the presence of competitive bottlenose dolphins.

Poster # 6

Toxic metals and the occurrence of cutaneous fungi on *Pseudorca crassidens*

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False killer whales (*Pseudorca crassidens*) are upper-trophic level predators in the marine food chain and are therefore vulnerable to biomagnification effects, including elevated levels of potentially toxic trace elements such as aluminium (Al), mercury (Hg) and nickel (Ni). A number of detrimental effects, including a compromised immune system and infections by opportunistic microbial pathogens, have been associated with elevated levels of these metals in mammalian tissues. We utilised the rare opportunity presented by a mass stranding in South Africa to investigate the effect of these toxic metals on the presence of opportunistic fungal inhabitants on cetacean skin. In this study, skin samples from 40 false killer whales (FKWs) that mass stranded were analysed using culture techniques, micro-PIXE and ICP-mass spectroscopy. Skin samples from 22 of the FKWs yielded representatives of various fungal taxa, of which the majority were found to be clinically significant cutaneous fungal species. Although the mean levels of Al, Hg and Ni in the analysed skin samples

were found to be notably higher compared to related studies, the AI levels in the skin samples that yielded fungal isolates were significantly higher than that of the skin that bore no fungal isolates. This study corroborates the sentiments of many authors that the presence of toxic metals contributes to detrimental effects including immuno-toxicity which may in turn again lead to colonisation by opportunistic microbes, such as fungi.

Poster # 7

Challenges of detecting dolphins using automated click detector in a noisy environment

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Static acoustic monitoring is a cost effective method to gather large amounts of continuous data on acoustically active cetaceans. This study incorporated the use of visual land survey techniques to investigate the use of a C-POD, (which detects echolocation clicks of dolphins and porpoises) for monitoring two species of dolphins that occur in Mossel Bay, South Africa, namely the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) and the Indo-Pacific humpback dolphin (*Sousa chinensis*, *plumbea* form). During the study it became evident that the deployment area was a particular noisy environment. Background noise from snapping shrimp, surf and sand movement filled up the recordings with 49.27% of recordings reaching their maximum number of clicks (n=4096) before the minute ended resulting in 33.66% - 66.00% (SE=0.65) lost recording time per deployment. Subsequently, data from 3 out of 6 deployments were suitable for further analysis. Tests were performed and a new location in deeper waters was selected reducing time lost to 2.69% (SE=0.33). We present preliminary analysis of CPOD recordings (125d, 21hr) and simultaneous visual observations (186d) resulting in 23 tracking events of dolphins around the CPOD (*T. aduncus*: 22 events, 14hr, 28min; *S. chinensis*: 20 events, 5hr, 49min). To investigate potential acoustic differentiation of species, we analysed a dataset of 230 simultaneous visual/acoustic periods when dolphins were actively producing sound around the CPOD. Mean clicks per second was higher in bottlenose dolphins (mean=33.22) than humpback dolphins (mean=23.8). Seven trains were identified as possible feeding buzzes (inter-click interval <2ms). Both species had peak visual detections between 10-11am, whilst peak acoustic detection time was between 12-1am. Mean train duration per species was 635.64us (*T. aduncus*) and 835.75us (*S. chinensis*). Preliminary results indicate that it might be possible to separate these species based on CPOD detections.

Poster # 8

The abundance, distribution, habitat use and genetic characteristics of the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) along the southeast coast of South Africa

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The Indo-Pacific bottlenose dolphin *Tursiops aduncus* is currently listed as a data deficient species by the IUCN. Limited information on the population status, habitat use, movement patterns and genetic characteristics of *T. aduncus* is matched by a poor understanding of the effectiveness of marine protected area (MPA) networks in ensuring the protection of these marine top predators. The current study addresses these gaps focusing mainly on the south east coast of South Africa, in particular Plettenberg Bay and nearby areas including the Tsitsikamma and Goukamma MPAs. Preliminary results from the first few months of the study (2013-14) indicate that habitat use and preferred areas of *T. aduncus* have remained constant, relative to a previous assessment in 2002-03,

but that there has been a decrease in the presence of the species in this area concomitant with a decrease in average group size. Low re-sighting rates of known individuals based on fin characteristics seem to confirm that *T. aduncus* in the study area are migratory, however further validation is required.

Poster # 9

Abundance, habitat use and residency of the endemic Heaviside's dolphin (*Cephalorhynchus heavisidii*) in Namibia

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Heaviside's dolphins (*Cephalorhynchus heavisidii*) are endemic to the Benguela current ecosystem, and are currently defined as 'Data Deficient' on the IUCN Red List. Lack of knowledge increases their vulnerability to anthropogenic threats in their environment including eco-tourism, harbour expansion and large-scale mining projects. This study examines the population ecology of Heaviside's dolphins in the waters surrounding the two main ports of Lüderitz (LDZ) and Walvis Bay (WVB) Namibia. Here we report preliminary mark-recapture abundance estimates for both sites. A series of closed population models were run for each site using the Huggins log-likelihood method in MARK. Abundance was estimated at 499 (95% CI: 367 – 678, 14 capture days spread over one year) animals in Lüderitz and 468 (333-657; 95% CI, 19 capture days over 2 months) in Walvis Bay. These likely underrepresent the total population size and longer-term data will increase estimate accuracy. Residency of animals to both sites was high with no interchange observed. Effort-corrected boat-based survey data were used to determine area use of animals in both bays. In Lüderitz, high use areas were near-shore (mean depth = 11.9 m), in north-facing bays protected from predominant winds and characterized by rocky coastline and the presence of kelp beds. Animals aggregated in these areas were often observed engaging in social and foraging behaviours. In Walvis Bay, Heaviside's dolphins occurred predominantly in deeper water (mean depth = 27.2 m) near the mouth of the bay where oceanic and bay water mixed rather than along the exposed coast or in the bay. The contrasting patterns of habitat use indicate behavioural adaptation to local foraging conditions. This study provides baseline information that is important for mitigating anthropogenic activities within the dolphins' habitat. The use of inshore areas is a particular concern as coastal development could overlap with high use areas identified.

Poster # 10

Habitat uses and seasonal availability of African manatee (*Trichechus senegalensis*, Link 1795) in Lake Ossa Wildlife Reserve, Littoral Cameroon

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The West African manatee (*Trichechus senegalensis*) is one of many threatened marine mammals in Africa, with a wild population estimate of less than 10,000. The wide distribution of the African manatee along the west coast of Africa, from Mauritania to Angola, contrasts with the low level of information about the ecology of the species, particularly in Cameroon. This project aims to determine the season, station, time of day and water physical characteristics effects on manatee sighting in Lake Ossa Wildlife Reserve Littoral region of Cameroon. Between October 2012 and March 2013, data were collected using boat-based point scan methods with the assistance of volunteer.

Presence/absence method ensured consistency of data collection. The results indicate that the probability of sighting a manatee was high at Mevia with ($p = 0.53$, $n = 30$ scans) than in plantation ($p = 0.3$, $n = 30$ scans). It is more common to encounter manatee in Lake Ossa during dry season (56%, $n = 30$ scans) than wet season (26%, $n = 30$ scans). The hours between 0500-0800, and 1100-1400 were the best period of the day for sighting a manatee during the wet season and dry season respectively, with 1100-1300 and 1700-1900 hours being the worst periods for sighting them during both wet and dry season. Water pH has a positive significant effect on the detectability of manatee indices in Lake Ossa, while the depth has a negative significant effect. Current reports of sighting of *T. senegalensis* became less frequent than previous reports. The ecological information obtained through this project are vital for conserving and understanding *T. senegalensis* and also recommending the establishment of Lake Ossa as manatee sanctuary during dry season, conservation actions and improved management of the area by all stakeholders with a vested interest in the perpetuation of the endangered species.

Wednesday 16 July

Endler Hall: Estuaries and Change (Part 1: Trophic shifts)

Oral Presentations

Ecological impacts of overtopping on the plankton food web structure of a temporarily open/closed estuary

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The ecological impact of an overtopping event on the plankton food web structure in the temporarily open/closed Kasouga Estuary located on the Eastern Cape coastline of South Africa was assessed in summer 2010. The inflow of marine waters into the estuary contributed to significant increase in salinity and a significant decrease in water temperatures ($p < 0.05$ in both cases) in the lower reach of the system. The inflow of marine waters was associated with a shift in both the size structure and community composition of zooplankton reflecting the increased contribution of larger marine breeding species to the total zooplankton counts within the system. In particular, the inflow was associated with a three-fold increase in the abundance and biomass of the mysid *Mesopodopsis wooldrigei* within the lower reach of the estuary. Results of carnivory experiments indicate that the predation impact of the mysids was equivalent to up to 18% (range 3-18%) of the total zooplankton abundances. Results of the study highlight the importance of overtopping events in contribution to the spatial and temporal variability in the food web structure of temporarily open closed estuaries.

Terrestrial-aquatic trophic transfers: the role of hippopotamus dung in estuarine food webs

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Cross-system trophic transfers, or the movement of food resources between ecosystems, are important processes governing food web dynamics in coastal ecosystems. This study investigated the effects of hippos as agents of cross-system transfer between terrestrial and aquatic environments in the St Lucia Estuary of Northern KwaZulu-Natal. Hippos consume terrestrial grasses at night and

defecate this material into the estuary, thereby providing significant carbon and nitrogen pulses that subsidize estuarine food webs. Stable carbon and nitrogen isotope and fatty acid analyses were used to identify signatures of dominant food web components in the benthic and pelagic ecosystems. Stable Isotope Mixing Models (SIMMs) will be used in order to assess the contribution of hippo dung in the diets of consumers relative to other food sources. The St Lucia Estuary is one of the few remaining estuarine systems globally where dense populations of hippos occur. The study thus offers a unique opportunity to broaden understanding of the roles hippos play in estuarine ecosystems. By quantifying the importance of hippo dung as a food source in benthic and pelagic food webs, this study may also increase our understanding of the consequences of large-scale losses of hippos on aquatic-terrestrial linkages.

Assessment of eutrophic symptoms in estuaries under high flow conditions

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Water quality and ecological integrity of estuaries reflect activities within the entire upstream catchment. Much emphasis has been placed on the response of estuaries to anthropogenic stressors through the use of monitoring programmes. Key to the success of these programmes is the use of indicators as they transform data into useful information. The aim of this study was to identify eutrophic symptoms in selected estuaries in the Gouritz Water Management Area (WMA). The study sites were the Hartenbos, Klein Brak, Great Brak, Gwaing, Kaaimans and Goukamma estuaries. Total daily nutrient loads and flushing times of each estuary were determined using long-term flow and water quality monitoring data provided by the Department of Water Affairs (DWA). The 'state' of each estuary was assessed using a variety of indicators, including: inorganic nutrients, phytoplankton, epiphytes and microphytobenthos. The Gwaing (281.11 kg DIN d⁻¹; 78.85 kg DIP d⁻¹) and Hartenbos (38.33 kg DIN d⁻¹; 21.51 kg DIP d⁻¹) estuaries received the highest daily inorganic nutrient loads. However, the Hartenbos Estuary had a longer flushing time (*ca.* 30 days) compared to the Gwaing Estuary (*ca.* 3 days), suggesting a greater vulnerability to eutrophication as the mouth would stay closed for a longer period of time. Field data confirmed these findings as the indicators measured in the Hartenbos Estuary exceeded all the 'thresholds' of a eutrophic system. The Great Brak Estuary provided an interesting example where eutrophic symptoms were only detected when assessing the primary producers (i.e. high biomass and low diversity). This study demonstrated the importance of adopting a holistic approach when assessing the condition and water quality status of estuaries.

Microalgae in freshwater dominated estuaries: uMzimvubu and Orange River estuaries freshwater requirement studies

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Microalgae are primary producers, forming the base of food chains in estuaries. A reduction in river flow and an increase in nutrients through pollution favours their growth; increasing biomass and changing community structure. Environmental flow requirement studies were conducted on the freshwater-dominated Orange River and uMzimvubu estuaries to determine their ecological health and to predict responses to future flow scenarios. The Orange River Estuary, located on the cold temperate west coast at Alexander Bay, was sampled in August 2012. The uMzimvubu Estuary, located on the sub-tropical east coast at Port St. Johns, was sampled in August 2012 and January 2013. Samples were analysed for chlorophyll *a*, phytoplankton group composition, and benthic diatom community composition. Elevated nutrients in the Orange River Estuary supported a high biomass of microalgae; average phytoplankton chlorophyll *a* was 15.7 ± 1.9 µg l⁻¹. There were blooms

(>10 000 cells ml⁻¹) of flagellates in the middle reaches, and diatoms and chlorophytes in the upper reaches. Benthic chlorophyll *a* was high (>100 mg.m⁻²) in the intertidal and subtidal zones. The vast majority of benthic diatom taxa were tolerant of polluted water, indicating eutrophic conditions. Elevated nutrients had little effect on microalgal growth in the fast flowing and turbid uMzimvubu Estuary. Average phytoplankton chlorophyll *a* was low (<6.0 µg l⁻¹) on both sampling occasions. A bloom of diatoms was present in the upper reaches of the estuary in August 2012 but in January 2013 the total cell density was low throughout (<1000 cells ml⁻¹) as a result of strong river flow (>30 m³.s⁻¹). Benthic chlorophyll *a* was generally low, <10 mg.m⁻², except at sites near Port St. Johns. Unlike the Orange River estuary where the vast majority of benthic diatoms were indicators of eutrophic conditions, diatoms in the uMzimvubu Estuary showed a broad range of tolerances.

Mangrove recovery and expansion in temperate estuaries of South Africa – drivers of population dynamics and consequences for other macrophyte communities

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Globally the expansion and reduction of mangrove forests have been attributed to climatic and anthropogenic factors. While tropical regions have experienced large scale deforestation due to mangrove utilization and habitat degradation, the temperate regions of several countries have seen the expansion of mangroves into salt marsh habitats. Changes in temperatures and sea level rise (SLR) have facilitated this expansion and it is sustained by the dispersal properties of these specialised plants. In South Africa, mangrove forests are negatively affected by harvesting, long term inundation, coastal squeeze and cattle grazing and are positively affected by natural or anthropogenic dispersal of propagules. Mangroves and saltmarsh share the lower intertidal zone of permanently open estuaries. The interactions between the two vegetation types range from competition for resources to nurse plant relationships. This study focused on *Avicennia marina* and poses the following questions: what determines the type (sink or source) of mangrove population in temperate forests; what factors determine successful mangrove establishment in areas where salt marsh already exists; and finally, is intertidal salt marsh at risk from mangrove expansion in temperate? Results indicate that this species is self-compatible and is pollinated by generalist pollinators. Salt marsh density negatively affects growth and establishment of *Avicennia* propagules. Climatically suitable areas for mangrove are expected in the warm temperate zone of South Africa as climate change progresses. The development of new mangrove stands will also be dependent on the local conditions such as the mouth status of the estuary, rate of disturbance in the intertidal zone and sediment characteristics such as sediment deposition and most importantly propagule dispersal from established stands. The co-existence of these two vegetation types warrants more observation as both provide important ecosystem services and contribute to biodiversity conservation.

Comparative analysis of carbon and nitrogen dynamics of three estuaries on the east coast of South Africa using ecological network analysis

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Ecological network analysis provides information on whole-system functioning and important ecosystem-level features such as nutrient recycling and trophic dynamics. Seasonal carbon and nitrogen ecosystem models based on quantified trophic links were built to examine the flow and cycling of energy and material through three estuaries. Ecological networks were constructed for the

temporarily open/closed East Kleinemonde and Mpenjati estuaries and the permanently open Mlalazi Estuary. The analysis of the seasonal networks of these systems evidenced higher dependency over direct and indirect pathways on phytoplankton and microphytobenthos during the closed phase in the East Kleinemonde and Mpenjati estuaries, which was concurrent with the very high carbon and nitrogen throughput of these compartments during the closed phase in these estuaries. The production of fish compartments contributed the most to the nutrient requirements of the temporarily open/closed East Kleinemonde and Mpenjati estuaries food webs during the closed phase, and a higher contribution by macrobenthos was identified during the open phase. Similarly, the production of macrobenthic and fish compartments contributed the most to the nutrient requirements of the Mlalazi Estuary food web among all seasons. The seasonal fluctuations in river inflow influenced the amount of detritivory and the detritivory: herbivory ratios in the three estuaries, with higher values recorded during the wet season. Higher trophic efficiencies were recorded for nitrogen than carbon networks, indicating that nitrogen is more efficiently transferred through the food web of all three estuaries. Cycling indices showed that nitrogen was recycled to a higher degree than carbon in these systems and that more nitrogen was recycled during the dry season or closed phase of TOCEs. These results highlighted the importance of seasonal variations in rainfall and freshwater inflow to the functioning of the study estuaries.

Mesocosms as experimental tools for assessing trophic interactions in the estuarine plankton

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The greatest uncertainty when predicting repercussions of future perturbations on ecosystems is determining their effects on interactions among species. This is particularly pertinent for South African estuarine plankton ecology given the relative scarcity of sufficient baseline information in this regard. Indeed, the role of zooplanktivorous predators in structuring planktonic communities in estuarine environments has been largely overlooked. By using a suite of *in situ* mesocosm experiments in an estuary, a number of hypotheses, pertaining to the major research themes associated with predator-prey interactions were tested. These themes included trophic cascading, risk effects associated with predation events and the importance of predator diversity in maintaining prey communities. Apex predation pressure was shown to have consequences for multiple trophic levels, through trophic cascading. In addition, the mere threat of predation was shown to have repercussions for prey organisms, reducing reproductive output and altering behaviour, with consequences for population abundances over time. Furthermore, predation regimes were shown to organize communities through alternate trophic cascade pathways, emphasizing the need to maintain predator diversity. The results of these experiments highlight the importance of “top-down” control in an environment thought to be largely driven by “bottom-up” processes.

Seasonal diet changes and shifts in trophic niche of waterbirds in an Eastern Cape Estuary

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Food webs have peaked the interest of ecologists for decades, and have been used to examine structure, dynamics and overall functioning of rivers and estuaries throughout the world. While aquatic habitats may be considered to be isolated ecosystems, they are inescapably linked through cross-habitat transfers. Consumers from terrestrial habitats that ingest diet items from aquatic habitats may have exert significant pressures on aquatic food webs. Waterbirds in estuaries are prime examples of consumers that connect aquatic and terrestrial ecosystems through their feeding habits. We wished to determine the seasonal diet of Cape Shoveler, Yellow-bill Duck, Cape Teal, Ruff

and Little Egret in the lower reaches of the Kowie River estuary, while also determining the trophic niche space occupied by each species. Individuals of each species were collected during winter and spring of 2013, and summer and autumn of 2014. Using $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ stable isotopes from blood and liver samples, the diet of each species was determined, while Bayesian ellipses and convex hulls were created in order to determine isotopic niche size. The diet of Cape Shoveler and Little Egret varied little between seasons, while Yellow-bill Duck and Cape Teal showed a distinct shift in diet items. Bayesian ellipses and convex hulls revealed that, converse to popular literature, Cape Shoveler, Cape Teal and Little Egret showed a significant contraction in their isotopic niche. Conversely, the isotopic niche of Yellow-bill Duck exhibited a significant increase in size. The shift in diet of Cape Shoveler and Cape Teal may be directly influenced by the arrival of large numbers of Ruff that migrate from Europe and Asia. These data reveal some resource partitioning among the waterbird species, enabling them to maximise their energy intake and reduce inter-specific competition for resources.

Poster Presentations

Poster # 30

Effects of environmental conditions on the nutritional status of southern Africa estuarine fish larvae

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Because of its abundance and its essential role as a mid-trophic level species in estuaries, the estuarine round-herring, *Gilchristella aestuaria*, is an excellent candidate to assess the ecological status of estuaries. One of the most widely used approaches to quantitatively evaluate how fish are influenced by their environment is the assessment of the nutritional condition of their larvae through the estimation of the RNA/DNA ratio. This technique is extensively utilized because of its high sensitivity to variations under critical environmental factors, and can be interpreted as a proxy for growth rate and mortality and, ultimately, recruitment success. By assessing and comparing the nutritional condition of *G. aestuaria* fish larvae from different estuaries in South Africa, this study intends to comprehend which environmental factors, such as food quality, prey availability and temperature, are the major conditioners of the mortality and recruitment of estuarine fish larvae. Preliminary results have shown that neither the availability of food nor the temperature are correlated with the nutritional condition of the estuarine round-herring larvae. We therefore hypothesize that the energetic value of the available prey in each estuary might play a crucial role in the nutritional condition of these larvae.

Poster # 31

Preliminary results from selected estuaries monitored as part of the National Estuarine Monitoring Programme (NESMP) in South Africa

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The design of the National Estuarine Monitoring Programme of Department of Water Affairs was initiated in 2008 and has progressed to pilot testing on selected South African estuaries. This programme is anchored in the National Water Act (Act No. 36 of 1998) which mandates the DWA to collect long term water quantity and quality data of South African water resources. At the same time it is also anchored in the Integrated Coastal Management Act (Act No. 24 of 2008) which recognizes

the co-operative governance of coastal resources. The paper presents physico-chemical data collected from selected estuaries, indicating the importance of the collection of basic robust data for water resource management. Technical problems of the implementation of estuary specific monitoring are identified and solutions proposed, based on this preliminary data.

Poster # 32

KwaZulu-Natal's estuaries in management limbo: Interim assessment tools to go from pause to play

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Although legislation governing the protection and management of South Africa's estuaries is in place, management plans in general have been slow to take place and even slower to be implemented. This is attributed to a number of factors including a lack of current estuarine biophysical information and other management capacity constraints. Estuaries fall within the boundaries of the coastal zone and given increasing human development pressures there, natural resource management which has forecasting power relating to provision of goods and services is a priority. Risk assessment techniques are widely used to support decision-making in the business world, and recognising the complicated nature of natural resource management in social-ecological systems, have become common practice in ecological settings. Internationally, in its Water Framework Directive, the European Union makes use of the framework DPSIR (Driver – Pressure – State – Impact – Response) to address water management options across political and geographical boundaries. The applicability of this framework as an interim tool for use by estuarine authorities in the KwaZulu-Natal context is of interest. As well as ascertaining the risk associated with management decisions made using this tool, the question arises at which step in the governance level is it most powerfully applied? Used at the biophysical (estuary) level it is reactive, but it is possible that greater forecasting opportunities and therefore a proactive approach presents itself if this tool is applied for governance. Using the example of six intermittently open estuaries in KwaZulu-Natal, the DPSIR framework is tested firstly to elucidate the appropriateness of applying this method as an interim support tool for management decisions, as well as ascertaining the level of application at which it has the most powerful forecasting capacity.

Poster # 33

Effects of anthropogenic activities on the stable isotopic dynamics of particulate organic matter ($\delta^{15}\text{N}_{\text{POM}}$) along Mbashe River, Eastern Cape, South Africa

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The Mbashe River in the Eastern Cape, South Africa passes through three districts with catchments that have been modified by anthropogenic activities. To determine the effects of anthropogenic activities on the river, $\delta^{15}\text{N}$ of particulate organic matter was determined. Six sampling sites from three sections of the river were identified according to anthropogenic activities occurring close to the river and sampled over a period of twelve months from September 2012 to July 2013. The $\delta^{15}\text{N}$ values varied significantly ($p < 0.001$), revealing that POM was derived from different sources along the river catchment. Different human activities had significant effects on the POM stable isotope dynamics, resulting in distinctly unique $\delta^{15}\text{N}$ stable isotope signatures varying both temporally and spatially. Our findings revealed that the upstream section of the river was more affected by anthropogenic activities with depleted isotopic values (4.5 ‰) than the midstream and downstream sections. The downstream section of the river showed fewer effects from anthropogenic activities

but more evidence of phytoplanktonic production. Further and continued research is recommended and required to check whether isotopic dynamics observed can be replicated and determine whether the effects of anthropogenic activities are increasing or decreasing.

Poster # 34

Estuarine mesozooplankton community sampling: comparison between mid-water net and epibenthic sled sampling methods

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Both epibenthic sled (D-net) and mid-water plankton net sampling are currently used to sample the mesozooplankton communities in South African estuaries. Both methods are also recommended by DWAF as appropriate for the determination of the ecological water requirements for estuaries. Net sampling is normally done during night-time and sled sampling more often during day-time, to compensate for the vertical migration behaviour of some plankton. The aim of the present study was to investigate the differences in the mesozooplankton community structure determined using net and epibenthic sled sampling methods. Replicate net and sled samples were collected in the Mlalazi estuary. Sampling took place at similar tide conditions during night-time and day-time in mid estuary. The sled and net were deployed simultaneously. Both samplers were equipped with calibrated flow meters to quantify the samples. Results indicated important differences between the two methods: The sled sampled the strongly migratory copepod *Pseudodiaptomus spp.* better than the net, even during the night session. The other dominant calanoid, *Acartiella natalensis*, was better sampled by the sled during day-time and by the net during night-time. Mysids were best sampled by the sled, and meroplankton such as crab zoea and cirriped nauplii were more efficiently sampled by the net. It is recommended that the strengths and limitations of the two sampling methods be taken in consideration when planning and interpreting estuarine mesozooplankton community structure.

Poster # 35

Microhabitat resource use by mangrove crabs in the Mgazana estuary, South Africa

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Mangrove forests are one of the most productive ecosystems on the planet, with numerous marine and estuarine species utilising mangrove habitat as nursery grounds. Globally, mangrove systems are under continuous threat from anthropogenic impacts and climate-mediated change, resulting in a staggering loss of over 20% of global mangrove forests since the 1980's. A principal component of any mangrove ecosystem is the widely abundant sesarmid crab, which as an ecosystem engineer, plays a key role in nutrient cycling in mangrove forests. Sesarmid crabs are reported to feed on the leaf litter of mangrove trees, making them an ideal model for the comparison of diet related resource use associated with microhabitat preference. Using stable isotopes, this study compared dietary resource use by different populations of the crabs *Parasesarma catenata* and *Neosarmatium africanum*, in the Mgazana estuary, KZN, in order to investigate the possibility of differences between microhabitats. Stable isotope analysis provided clear insights into microhabitat dietary resource use of sesarmid crabs, suggesting a trophic position for both *P. catenata* and *N. africanum* consistent with a detritivorous, rather than herbivorous diet. Both species of crab showed clear differences among populations occupying different microhabitats with isotopic niche width comparisons using

SIBER analysis indicating minimal overlaps of some occupied niches. Dietary resource use for both crab species clearly varies between microhabitats, with some populations assimilating different pools of resources which are not utilised and/or not available to others. The potential link between crab isotopic values and those of POM in some microhabitats however, may suggest that isotopic differences between microhabitat populations are driven by differing microbial communities and/or detrital food webs.

Poster # 36

***Mytilus galloprovincialis*, a successful invader of the Knysna estuarine embayment**

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Since its introduction to South Africa in the late 1970's, *Mytilus galloprovincialis* (Bivalvia) has spread along the intertidal of the south coast. It is now well established on most man-made structures in the Knysna estuary from the mouth (The Heads) to the N2 road bridge (about 10 km from the mouth). To begin to understand why this species is so successful in this estuary, we investigated aspects of its biology, measuring growth rate at four sites (The Heads, Leisure Isle, Thesen Island wharf, Thesen Island Marina), and condition index, reproductive condition, attachment strength, and byssus production at six sites (the four mentioned above, plus an additional marina site, and the Railway Bridge). All sites were in the lower reach of the estuary where mussel abundance was greatest. Mussel growth at each site was significantly faster during autumn and summer when compared to spring and winter. Furthermore, in each season, mussels grew more rapidly on Thesen Island wharf and in the marina compared to The Heads and Leisure Isle. Mussels within the embayment had higher condition and gonad indices, lower attachment strengths and smaller diameter byssus threads when compared to mussels at The Heads (where wave action was high) and Leisure Isle. Results suggest that because mussels living within the embayment where there is no wave action expend less energy on attachment, they can channel more resources into growth and reproduction. This has probably contributed to their success in the estuary.

Poster # 37

The impacts of coastal storm weather events on the behaviour of estuarine-associated fishes

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Over the past decade, South Africa has experienced some of its worst rough sea events on record, with coastal wave heights exceeding seven meters. To assess the effects of these events on estuarine-associated fishes we explored existing acoustic telemetry datasets containing information on the movement behaviour of three important fishery species. Observed changes included displacements, home range abandonment and habitat departures. All eight of the acoustically tagged white steenbras *Lithognathus lithognathus* in the predominantly closed East Kleinemonde Estuary responded to a rough sea event that opened the estuary mouth in September 2008, by exhibiting shifts in their home range (37.5%), undertaking erratic estuarine movements (25%), ceasing diel movement behaviour (25%), or entering the marine environment (12.5%). Similarly, during a rough sea event in December 2008, 28% of the 25 tagged spotted grunter *Pomadasys commersonnii* in the permanently open Kariega and Bushmans estuaries exhibited home range shifts within the estuary, while 40% left the estuary for the marine environment. Acoustically tagged dusky kob *Argyrosomus japonicus* in the Sundays Estuary also responded to rough sea events, with eleven fish (50%)

exhibiting home range shifts in September 2008 and three (50%) leaving the estuary for the marine environment in December 2008. Additionally, eighteen (62%) dusky kob showed temporary changes in movement behaviour during a rough sea event in June 2009. Many of these responses were initiated up to 48 hours prior to each rough sea event suggesting that the observed behavioural changes were in response to changes in barometric pressure. Notwithstanding the physical disturbances caused by these extreme storm weather events, they could also influence biodiversity within the South African coastal environment and the consequent displacement of fishes could have ecological implications for fish communities.

Poster # 38

Habitat use by early stage fishes in the Swartkops Estuary, South Africa, with reference to the growth of two Sparidae species

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Habitat availability in estuaries is a key criterion for the success of any fish nursery area. In South Africa, knowledge of the importance of habitat types for young fishes is limited. The aim of this study was to assess the relative importance of four common habitat types for young fishes in the warm temperate, permanently open Swartkops Estuary. In addition, the growth of two dominant Sparidae species was recorded in order to determine the relationship between temperature and growth rate. Sampling was conducted over a one year period, sampling twice per season and growth studies were confined to a period of 15 weeks during peak recruitment of *Rhabdosargus holubi* and *Diplodus capensis*. Habitats with submerged aquatic vegetation and shallow creeks supported the highest diversity and abundance of fish species. Catches peaked during the summer period. Sand and mud habitats, tended to be dominated by specific species. Growth of *D. capensis* and *R. holubi* was mediated by warmer estuary temperatures and highlighted the importance of shallow water nurseries for fish growth.

Poster # 39

The physical and biological effects of a tidal creek on a mangrove forest at Nahoon Estuary

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The Nahoon Estuary is thought to represent the southern limit of mangrove forests in South Africa. Tidal creeks are an important part of estuarine environments, playing a role in conveying freshwater runoff including nutrients and terrestrial sediment from the surrounding catchment to the intertidal area. The study was aimed at assessing the physical and biological effects of the tidal creek at Nahoon Estuary by assessing nutrient levels, sediment accretion, biomass and distribution of algal mats and sediment deposition on mangrove populations and faunal communities. Nutrient levels entering the mangroves were generally low (ammonium $0.26 \pm 0.15 \mu\text{M}$) compared to levels exiting the system (ammonium $4.17 \pm 1.83 \mu\text{M}$). Total suspended solids entering the creek were low across the tidal cycle ($161 \pm 53 \text{ mg/L-1}$). The mangrove population structure along the tidal creek was dominated by seedlings, with a seedling to adult ratio of 6:1. *Ulva intestinalis* and *Cladophora glomerata* were found at Nahoon, with biomass ranging from 34 ± 9 to $72 \pm 13 \text{ g m}^2$, their presence was influenced by nutrients from point sources but their distribution did not affect crab burrow abundance ($200 \pm 36.1 \text{ m}^2$). This study showed the importance of nutrient and sediment dynamics on the structure of intertidal flora and fauna communities. Algal biomass was higher in areas with standing waters covering pneumatophores and the sediment, possibly affecting both mangrove physiology and sediment fauna.

Poster # 40

Climbing and homing behaviour of *Cerithidea decollata* at the southernmost limits of mangrove distribution

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The heavy exploitation of mangrove trees in Mngazana estuary threatens a population of *Cerithidea decollata* there which depends on these trees for survival. The climbing and homing behaviour of *C. decollata* on the trunks of three mangrove tree species (*Avicennia marina*, *Rhizophora mucronata* and *Brugueira gymnorhiza*) at the Mngazana estuary was investigated over a period of five days in May 2013. The objectives of the study were to gather information on the population structure of *Cerithidea decollata* and to further understand its patterns of migration, preference and the distance these gastropods travel on mangrove trees. The study was conducted in two sites, each with three areas. Preference for mangrove species was assessed using chemical cues, and animal density, movement and population size structure were also recorded. Results from Chi-squared tests showed a significant preference for brushed (chemically cued) trees compared to unbrushed trees and also for *B. gymnorhiza* than *A. marina*. ANCOVA results using diameter as a covariate showed that snails move to a significantly higher height in *A. marina* than in the other mangrove tree species, and regression results revealed a positive relationship between the distance travelled by a snail and its shell length with larger animals travelling a longer distance than the smaller animals. No significant difference on density was observed. The results of this study highlight the importance of the conservation of mangrove tree species for the population sustainability of *C. decollata* in the Mngazana estuary.

Poster # 41

The impact of global and climate change on the salt marshes of the Swartkops Estuary

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Salt marshes are coastal wetlands that are highly productive and biologically diverse ecosystems. These systems are under threat from rising sea levels which are predicted to accelerate in the future. Salt marsh habitats within the Swartkops Estuary were examined to determine their structure along an elevation gradient and how this structure has changed over the past six decades, what the primary drivers of this structure were and whether the salt marsh surface is stable, rising or declining relative to predicted sea level rise of 1.48 mm.y^{-1} . It was found that the salt marsh habitat occupy the elevation zone between a Mean Sea Level of -0.86 to 2.42 AMSL. GIS analyses showed that during the last 60 years, losses of floodplain, intertidal and supratidal saltmarsh for Swartkops were 573.40 ha, 74.31 ha and 30.23 ha respectively. These losses are mainly attributed to developmental pressure, although there are indications that rising sea levels are becoming more influential in the lower reaches. The main environmental drivers for the Swartkops estuary salt marsh were shown to be soil moisture and elevation. Elevation dictates tidal inundation periodicity and frequency, and thus acts to influence all edaphic factors driving vegetation distribution. Rod Surface Elevation Table

results over the past 6 years indicate that the salt marsh surface elevation of the lower and middle reaches is generally declining relative to sea level. Results from the GIS mapping showed that since 1939, deposition above the railway bridge had elevated the salt marsh relative to mean sea level and this was confirmed by the RSET results. The implication of these research findings are that the salt marshes of the lower and middle reaches of the Swartkops Estuary will be inundated and flooded if the current ratio of sediment deposition and sea level rise is maintained.

Poster # 42

Potential effects of altered salinity on the respiration of the mangrove ocypodid crab, *Uca urvillei* (H. Milne Edwards) in the sub-tropical permanently open Mngazana Estuary, Eastern Cape (South Africa)

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In estuaries, salinity is a crucial physico-chemical parameter which, influenced by unpredictable rainfalls, increased flooding events and human impact results in altered freshwater inflow. Thus, salinity is bound to fluctuate and may affect the functioning of estuarine systems. Mngazana Estuary is regularly subjected to flooding which exposes the system to freshwater for about two/three weeks. Mangrove crabs occupy limiting habitats in terms of salinity tolerance and, therefore, salinity alterations could pose serious physiological problems. This study examined the metabolism of the mangrove ocypodid crab, *Uca urvillei*, by measuring oxygen consumption under different salinity conditions. Crabs were exposed to a range of salinities (experienced under natural conditions, as well as lower salinities, which are likely to be experienced by the crabs during flooding events). Each crab was maintained at 12hr light cycle for 2 days prior to experimental trials. Crabs were then exposed to different salinities (5psu, 20psu and 35psu) and several time exposures (from 12hr up to 4 weeks). Oxygen consumption was measured after an eight-hour acclimation in individually darkened Perspex chambers exposed to an intermittent flow respirometer. An oxygen sensor, glued on the wall of each chamber and connected to a single channel oxygen transmitter, was used to measure respiration at the beginning of the trial (T_0) and at the end (T_1), which corresponded to the time at which an approximate decrease of 20% of oxygen saturation was detected. The shortest term exposures suggest no salinity effect on respiration of crabs. These preliminary observations are expected, while we envisage that the longer time exposures to low salinities (two to four weeks) will have an influence on the physiology of crabs and overall give an indication of the degree of vulnerability of this population of crabs to the freshwater input experienced by the natural populations.

Poster # 43

Aspects of the ecology of small temporally open estuary on the south east coast of South Africa

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The study was conducted at Nkanya estuary, which is a small temporally open/closed system situated between Xhora and Mbashe estuaries on the south-east coast of South Africa in the Eastern Cape. The estuary is characterized by rocky upper reaches, rocky/muddy middle reaches and a sandy mouth. The estuary normally closes in late summer to winter and probably opens in Spring following early rainfall. The study is aimed at determining aspects of the ecology of Nkanya estuary. The objectives were to determine physico-chemical properties of the estuary, to determine spatial and temporal distribution, abundance of fish and to determine biodiversity of fish in the estuary. The results indicated that the estuary served as a marine pocket with salinity levels reaching 38‰ during the dry season. Temperatures increased from winter to summer with a small difference of about 1°C between the surface and bottom waters of the system. The estuarine water was slightly basic with an average pH value of 7.8. There were 24 fish species representing fourteen families recorded in the estuary; marine species numerically dominated both seine net and gill net catches. *Glossogobius callidus* dominated seine net catches in terms of abundance with 41% while *Argyrosomus japonicus* dominated gill net catches with 23% in abundance. *G. callidus*, *Therapon jarbua*, *Arothron hispidus* and *Arothron immaculatus* appeared in summer while *Psammogobius knysnaensis*, *Rhabdosargus holubi* and *Myxus capensis* were frequently recorded. About 85% of species recorded in the estuary were captured in the middle reaches.

Poster # 44

Effect of salinity on bacterial symbionts associated with mangrove crabs

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Symbiosis is of general importance for both partners involved in the process and it significantly influences ecology, physiology and evolution. There are several factors however, that may affect this relationship, particularly in aquatic systems, and these include temperature, pH, and salinity. Amongst these, salinity is of specific interest for estuaries, as its variation can affect the functioning of estuarine systems. The ocypodid crab, *Uca urvillei*, is a key bioengineer of mangrove systems. Recently, it has been reported that this species harbours bacterial symbionts in the gills and hindguts. The effect of salinity variation on bacterial community composition hosted by these crabs is however not yet well understood. This study investigated the effect of different salinity ranges on microbial symbionts associated with *U. urvillei* males collected from Mngazana Estuary. Specimens were exposed to three different constant salinities (5psu, 20psu, and 35psu). At different time intervals (from 3 days to a maximum of 4 weeks exposure), animals were removed and stored in ethanol and changes in the bacterial community were examined using molecular techniques i.e. PCR and pyrosequencing. Preliminary results showed that crabs had high survival rate throughout all time treatments and replicates. Understanding how these bacterial symbionts respond to fluctuations in salinity and how long it takes for the community to react, may help determining the degree of vulnerability of selected ectotherms to sudden and localised changes in environmental conditions.

Poster # 45

The distribution and abundance of benthic fish, with emphasis on spotted grunter and dusky kob, in the Great Fish and Kariega estuaries

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As part of an on-going project the distribution and abundance of spotted grunter and dusky kob as well as associated benthic fish communities were investigated monthly in the Great Fish and Kariega estuaries using a beam trawl. The Kariega and Great Fish estuaries differ markedly in respect of their freshwater inflow and turbidity and there is a paucity of research comparing the benthic fish species of the two estuaries. The present study aims to (i) determine the temporal and spatial changes in benthic fish communities within these two systems and (ii) examine the role of turbid and clear estuaries as nursery habitats for these two important fishery species. Otolith microchemistry analyses on young-of-the-year dusky kob have suggested that early juveniles recruit primarily into freshwater-dominated estuaries and then either remain in these important estuaries or move to marine-dominated estuaries. Fish were sampled using a beam trawl net during neap tide on a monthly basis for a period of 12 months. At each site physico-chemical parameters were measured monthly and sediment samples collected seasonally. Preliminary findings indicate that more species were caught in the marine-dominated Kariega Estuary and were highly abundant in the upper and middle reaches. In contrast, in the freshwater-dominated turbid Great Fish Estuary most species were caught in the lower reaches and mouth region. There was a higher abundance and smaller size range distribution of early juvenile dusky kob in the Great Fish Estuary (range: 21-100 mm SL) compared to the Kariega Estuary (range: 75-230 mm SL), lending support to the otolith microchemical hypothesis. In contrast, the size class distribution of spotted grunter was smaller in the Kariega Estuary, (range: 25-260 mm SL), compared with the Great Fish Estuary, which consisted of mostly late juveniles, (range: 62-380 mm SL).

Poster # 46

The decline of the Siyaya Estuary, an intermittently open system on the northern KZN coast

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The Siyaya Estuary is a small intermittently open estuary situated on the sub-tropical KwaZulu-Natal east coast within the provincially protected Umlalazi Nature Reserve. This system is the northernmost estuary of this type along the KZN coastline and provides an important nursery function for estuary dependent marine species. However, the estuary has declined in ecological health from the 1970's through to the early 2000's at which point the environmental freshwater flow requirements for the estuary were determined (Ecological Reserve). Change in the abiotic and biotic characteristics of the Siyaya Estuary were documented and earlier rehabilitation efforts tried to address the downward trajectory in health. Recent monitoring has indicated further deterioration. These changes have been linked to altered mouth conditions with prolonged periods of mouth closure over the past two decades as a result of reduced and diminishing freshwater flows to the estuary. This has effectively isolated the system from marine influence and has removed estuarine function. The changes in the estuary structure and function have been assessed against changing land-uses in the catchment of the estuary. Given that 75% of KZN's estuary resource has suffered significant degradation and the regulatory imperative to uplift the status of these water resources in a water

scarce country, recommendations include a catchment scale approach to achieve a reinstatement of estuarine function and marine connectivity.

Poster # 47

Life history strategies under threat for marine species in riverine ecosystems

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Rivers and estuaries are well known as productive feeding and refuge areas for many larval and juvenile marine spawned species. These habitats are also critical conduits for catadromous species. The lower risk of predation and rich feeding make these habitats integral in early life history strategies in South Africa. Unfortunately, these areas are subject to unabated anthropogenic alteration. The capacity of these habitats to serve as nurseries is under threat. Reduction of freshwater supply and the introduction and spread of alien species are of particular concern. Many rivers in South Africa now have some sort of barrier (weir, dam) which alters flow dynamics, decreases the supply of cues necessary to stimulate migration and impedes upward movement of fishes into low salinity waters. Introduction or spread of alien species leads to increased predation by species as Bass (*Micropterus spp.*), as has been found in the Kowie River, and by direct competition with smaller cichlid species, namely Banded tilapia (*Tilapia sparrmanii*) and Southern mouthbrooder (*Pseudocrenalibrus philander*). The challenges affecting marine migrants with advanced life history strategies involving river access are not receiving enough research and conservation attention. Alterations to freshwater environments have dire consequences for marine and freshwater fish diversity and conservation.

Poster # 48

Environmental health of Mzintlava River and its watershed

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Human activity has continuously disturbed the natural environment; particularly the aquatic ecosystems. For instance, the use of heavy metals in industry has led to widespread environmental contamination. The presence of metals in aquatic ecosystems has caused much attention. The acquired knowledge relating to their fate and effects, and how this relates to the risk they present to ecosystem health, is growing rapidly. The aim of the study was to investigate the health status of Mzintlava River and its watershed using biological parameters of the Banded Tilapia (*Tilapia sparrmanii*). Water, soil and sediments were sampled and analyzed for heavy metal presence using AAS. *T sparrmanii* was used a biomonitoring tool during the study. Results will be presented.

Poster # 49

Thermal tolerance of the truncated mangrove snail, *Cerithidea decollata* (Gastropod; Potamidae), along a sub-tropical to a warm temperate gradient on the south east coast of South Africa

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The South African coastline is governed by four bio-regions, largely differing in their climate. The warm temperate region is characterised by a distinct seasonality, while the sub-tropical region is generally warm and humid with mild winters. Two populations of *Cerithidea decollata* (Mngazana Estuary, sub-tropical boundary and Knysna Estuary, warm-temperate regions) were selected to investigate their upper and lower thermal tolerance and performance across increasing and decreasing temperatures (rate of 2°C/h). Both ramps started from an acclimation temperature of 20°C. The two populations of snails were collected from each location and subjected to two sets of experiments: an LT₅₀ experiment and an oxygen consumption experiment. The LT₅₀ experiment consisted of increasing/decreasing ramp, using three sets of replicates (10 snails each). Every 2°C interval, the animals were monitored for signs of stress or death and the experiment was continued until half of the set population had not survived. For the oxygen consumption experiment, 10 replicates were used, each placed in a single respiratory chamber with a sensor spot attached. Oxygen consumption was measured using an optic oxygen meter across an increasing/decreasing ramp similar to the one used for the LT₅₀ experiment. At a 2°C interval, the temperature was kept constant for four hours, allowing oxygen detection. Preliminary results on the sub-tropical population showed that the thermal range was between 4°C and 52°C. All of the snails showed 100% of mortality with no intra-population variability in the response to heat stress. The oxygen consumption experiments will bring more light on the metabolic performance of these snails within their range of tolerance. Investigating inter-population responses to temperature under increasing/decreasing values will also help clarifying the effect of climate change on the spatial ecology and ecophysiology of intertidal species, such as *C. decollata*.

Endler Hall: Estuaries: Restoring St Lucia

Oral Presentations

The Restoration of Lake St Lucia

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The Lake St Lucia system is the largest estuary in the country. The effects of a separate mouth policy, which removed the uMfolozi from the system in 1952, were exacerbated during the first decade of this century when the isolation of the uMfolozi coincided with a period of below average rainfall and the lake dried up for the first time in recorded history. More recently (2012) a decision was taken by the iSimangaliso Authority to reverse the separate mouth policy and re-link the two systems during a period when the uMfolozi mouth was closed resulting in a substantial input of fresh water into the

system. These actions have been coupled with investigations undertaken by iSimangaliso and funded by the Global Environmental Facility to assist the development of a long-term policy to guide the future conservation of this Ramsar and World Heritage site. This paper reports on the work done on iSimangaliso's GEF Project since 2011 and provides the first detailed quantification of the physical characteristics of the system. To this end, LIDAR and bathymetric surveys of the system have been carried out to accurately delineate estuary boundaries and local contour lines. This has underpinned the development of complex hydrological and hydrodynamic models to provide insights into mouth behavior, salinity profiles and sediment dynamics. The results of the physical investigations are fed through an ecological response model to allow system health to be assessed and socio-economic consequences to be described allowing for an integrated management approach.

Role of nutrient assimilation in facilitating prolonged bloom persistence of *Cyanothece* spp. in Lake St Lucia, iSimangaliso Wetland Park (South Africa)

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Worldwide, persistent cyanobacterial blooms are becoming more frequent and are often associated with effects of global climate change. In June 2009, a widespread bloom of the unicellular cyanobacterium, *Cyanothece* spp., appeared in North Lake and False Bay of Lake St Lucia - a large (360 km²) estuarine lake system in KwaZulu-Natal, South Africa - and persisted for 18 months. It remains unclear how the bloom status was maintained for so long. This study investigates aspects of the nutrient (N and P) assimilation of *Cyanothece* spp. and how this process may relate to maintaining a persistent bloom state during hypersaline conditions. The effects of salinity and nutrient limitations on the nutrient uptake dynamics by *Cyanothece* spp. were evaluated with ¹⁵NO₃⁻ uptake, PO₄⁻ uptake and ¹⁵NO₂ fixation experiments. The effects of salinity and nutrient limitations on the nutrient uptake dynamics by *Cyanothece* spp. were evaluated with ¹⁵NO₃⁻ uptake, PO₄⁻ uptake and ¹⁵NO₂ fixation experiments. Nitrogen fixation was observed in this *Cyanothece* spp. isolate from St Lucia. Highest nutrient assimilation rates in all experiments were recorded at the lowest salinities, decreasing progressively up to a salinity level of 120, with very little activity observed above this. No ¹⁵NO₂ fixation was measured above this salinity threshold. Additionally, ¹⁵N uptake rates were significantly influenced by environmental variables, particularly salinity, which suppressed uptake rates, and temperature, which facilitated them. Results indicate that *Cyanothece* spp. is well suited to take advantage of the conditions present during the onset of the bloom. However, once salinity increased above 120, cells would have drastically reduced their nutrient uptake abilities, while still surviving under extreme salinities when most of their potential grazers and autotrophic competitors disappeared from the St Lucia Estuary.

Does turbidity at the St Lucia Estuary trigger parasitism of copepods by epibiont ciliates?

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Turbidity is widely regarded as being amongst the most important water quality characteristics affecting aquatic biota. Among its effects, turbidity has been shown to limit primary and secondary production, influence competitive dominance, and alter predator-prey interactions. The St Lucia

Estuary is Africa's largest estuarine lake system. Due to its shallow nature, this system is naturally turbid, as during windy conditions particles are rapidly resuspended. However, due to anthropogenic activities, this system is also exposed to external sources of silt, particularly from the Mfolozi River, one of its main freshwater sources. The services provided by estuaries are facilitated by their generally high zooplankton biomass, with secondary production supporting higher trophic level organisms. Numerous studies have therefore been conducted (2006-present), aimed at determining the effect of turbidity on the respiration, ingestion, and mortality of several dominant St Lucia Estuary zooplankters. An overall detrimental turbidity effect has been unravelled. However, since 2013, another observation has been made. Sampling events undertaken during high *in situ* turbidity have been yielding copepods covered in what was at first thought to be a mixture of autotrophic algae and silt. Closer inspection has revealed that these are epibiont ciliates, that is, ciliates that live attached to the surface of other organisms. After the most recent such observation (March 2014), zooplankton surveys have been taken at *ca.* two week intervals and have revealed a corresponding decline in copepod abundance. Furthermore, laboratory experimentation has revealed that these epibionts are parasitic to their copepod hosts, as survival has been lowest in ciliate-hosting copepods. As the ciliates have consistently been found attached to the copepods during turbid conditions, this brings up the question of whether turbidity itself is triggering this parasitism. Several hypotheses and implications are discussed.

Phase shift effects on the zooplankton community structure of Lake St Lucia, South Africa

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Lake St Lucia, Africa's largest estuarine lake system, has recently experienced an unprecedented crisis resulting from freshwater deprivation. This 9-year dry phase (2002-2010) recently came to an end as increased rainfall in the region, coupled with the reconnection of the Mfolozi River with Lake St Lucia, resulted in significant freshwater input into the system. This study therefore aimed to investigate the changes in zooplankton community structure, as the system transformed from a hypersaline to an oligo/mesohaline state. Not only did the increased freshwater supply introduce a number of freshwater taxa into the system, but the connection with the ocean via the beach spillway allowed marine recruits to once again enter St Lucia, increasing the overall diversity of the system. Most notable though, was the shift in community structure with the commencement of the wet phase. During the dry/hypersaline state, the system was dominated by the mysid *Mesopodopsis africana* and the calanoid copepods *Pseudodiaptomus stuhlmanni* and *Acartiella natalensis*, which together accounted for > 90% of the total zooplankton abundance. During the wet phase however, in addition to the previously dominant copepods, taxa such as the cyclopoid copepod *Oithona* sp., the rotifer *Brachionus rotundiformis* and bivalve and gastropod larvae also emerged as dominants. This study not only emphasises the importance of the Mfolozi connection, but also contributes significantly to the overall understanding of the system's ecology, especially in response to climatic shifts.

The dynamics of nano- and microplankton in the St. Lucia estuarine lake system, KwaZulu-Natal

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St. Lucia estuarine lake system experienced extended droughts from 2001-2012 which led to extreme environmental conditions such as low water depth and hypersalinity that influenced the community

structure of nano- and microplankton which are main primary energy synthesisers in aquatic systems. This project aimed to characterise community composition and biomass of nano-and microplankton under the extreme physico-chemical conditions in order to characterise the energy basis of the planktonic food web in St. Lucia. Water samples were collected monthly from October 2010 to September 2011 at Lister's Point, Charters Creek and the mouth representing the northern, southern lakes and estuary channel respectively. Chlorophyll a and physico-chemical parameters were also measured *in situ*. The Utermöhl method and microscopy were used to analyse the samples. 97 taxa were recorded: 56 diatoms, eight green algae, one cryptophyte, seven cyanobacteria, six dinoflagellates and 19 ciliates. There was generally a high temporal and spatial variability in community composition. There were no significant differences in the community composition, biovolume and biomass between seasons however, there were significant differences between sites. Cyanobacteria dominated in the northern embayment, green algae and cryptophytes in the channel, green algae and diatoms in the South Lake. Ciliate biological variables were highest in the northern embayments due to limited grazing pressure. Autotrophic:heterotrophic biomass ratio was lowest in the northern embayment. Salinity was the main variable accountable for the variation in nano- and microplankton biological variables followed by the depth in the system. The South Lake and Channel had the highest available energy for higher trophic organisms because of the high biomass of diatoms and green algae.

Wind-driven waves & turbidity in a shallow estuarine lake with muddy substrates: St Lucia, South Africa

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Wind-waves in shallow lakes or estuaries with muddy substrates can drive sediment re-suspension and cause high turbidities that can negatively impact the productivity of photosynthetic organisms. This investigation evaluated the efficacy of simple semi-empirical models for predicting wave characteristics and turbidity in these systems in order to include their effects in ecosystem models. The southern basin of the St Lucia estuarine lake in South Africa was used for a case study, where average depths are about 1 m with fetches up to approximately 10 km. Substrate materials vary from sandy to muddy with deeper locations predominantly the latter. An array of pressure sensing wave poles was deployed to measure significant wave heights and turbidity to compare with model predictions. The influence of the wind speed, fetch, fetch-averaged depth, and substrate composition were evaluated. Most of the observed waves were fetch limited during the conditions that prevailed during study period. The results indicate that the models can adequately capture the high energy wave events for persistent wind speeds and directions, but that there is considerable variability in model performance generally. Some of this variability can be attributed to difficulties in estimating appropriate fetch and depth parameters for variable winds and in the context of a lake with compound shape and variable bathymetry. There was no clear evidence of significant wave attenuation due to the muddy substrates. Turbidities were strongly linked to wave energy but there is a significant time delay associated with the settling and re-suspension processes.

Poster Presentations

Poster # 71

The effect of salinity on the survival and distribution of two dominant bivalve species, *Solen cylindraceus* and *Brachidontes virgiliae*, within the St Lucia estuarine system, South Africa

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The St Lucia estuarine system, Africa's largest estuarine lake, is characterised by cyclic changes from hypersaline to oligo/mesohaline conditions in response to alternations between drought and wetter than average years. In addition, St Lucia also experiences stochastic disturbances, such as flooding events that rapidly decrease salinity levels. Due to their sessile and slow moving nature, bivalves are particularly vulnerable to rapid or prolonged changes in the physico-chemical environment. The infaunal razor clam, *Solen cylindraceus*, and the epifaunal brackwater mussel, *Brachidontes virgiliae*, are currently the dominant bivalve species within St Lucia. Experiments revealed that *S. cylindraceus* can tolerate salinities between 15 and 65, while *B. virgiliae* prefers salinity levels ranging from freshwater to 20. The varying tolerance limits, therefore, dictate the distribution of these species during different climatic conditions as well as within the estuarine lake. During wet periods, *S. cylindraceus* is restricted to the northern reaches, unable to tolerate the oligohaline conditions present in the rest of the system. Conversely, *B. virgiliae*, often restricted to the Narrows, becomes ubiquitous throughout the system during these conditions. It is thus essential to understand the effects that these climatic shifts have on key estuarine species, as flood and drought events are predicted to increase in frequency, intensity and duration as a result of global climate change.

Poster #72

Temporal and spatial dietary dynamics of the Longspine Glassy (*Ambassis ambassis*) in the St Lucia estuarine system, South Africa

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Among the 155 species of fish recorded in the St Lucia estuarine lake, *Ambassis ambassis* is one of the most prominent. After a decade dominated by dry and hypersaline conditions, the St Lucia system has changed dramatically in terms of prevailing environmental conditions, as a result of higher than average rainfall in 2011 and the onset of a wet phase in 2012. In response, *A. ambassis* has expanded its distribution throughout the estuarine system. Stable isotope analysis of $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ was used in conjunction with gut content analysis to elucidate the diet of this species at five sampling localities spanning the geographical range of the system. Zooplankton species as well as terrestrial and aquatic insects were prevalent in the diet of this species. Non-metric multidimensional scaling (NMDS) analysis revealed considerable dietary overlap for the fish collected at the different sampling localities. Seasonally, trophic position was found to differ significantly, with the dry season having consistently higher isotopic signatures at all five sites. A significant relationship was identified between trophic position and salinity and temperature, indicating the effect of these variables on the diet. *A. ambassis*, therefore, occupies a vital role in the food webs of the St Lucia system.

Poster # 73

The effect of a flood event on the meiofauna of sandy beaches adjacent to the St Lucia Estuary, South Africa

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The increase in rainfall on the north-east coast of KwaZulu-Natal has led to an increase in flood events and the inflow of silt-laden freshwater from the Mfolozi River. This has raised concern regarding the effect of silt loading on the St Lucia Estuary, via the recent St Lucia-Mfolozi linkage, and on the adjacent beach systems. The study aimed to determine the impact of a flood event on meiofauna community structure and abundance in sandy beaches adjacent to the St Lucia Estuary. The study incorporated responses to the disturbance between communities in different tidal zones by sampling along the gradient of the flood plume from the Mfolozi River mouth towards the beach berm of the St Lucia Estuary, dissipating at the Iphiva Beach. Samples were collected from both intertidal and subtidal zones at each beach as 15 cm cores of sediment (4.5 cm diameter). There were significant differences in meiofauna densities between tidal zones and among all sites. Meiofaunal densities were generally higher in intertidal zones and were found to increase from Mfolozi to St Lucia, and Iphiva showed intermediate density. Species richness varied significantly between site and tidal zones; generally richness was reduced at Mfolozi, while Iphiva had intermediate levels of richness. Multivariate community analysis revealed that meiofaunal communities differed between all sites. These findings may tentatively be explained by the low salinity and high turbidity and TSS experienced at Mfolozi, the more stabilized environmental conditions at St Lucia, and the coarser grain size at Iphiva. The results of this study provide information regarding meiofaunal response to two forms of disturbance; that of a flood event and turbulence as a result of exposure. The results pertaining to salinity and silt variation provide useful information pertaining to the current GEF rehabilitation project to monitor and restore the St Lucia estuarine lake.

Endler Hall: Freshwater Requirements of Marine Systems

Oral Presentations

A proposed assessment framework and scientific approach to determine freshwater requirements in nearshore and coastal shelf marine ecosystems: A southern African perspective

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While it has long been recognised that the modification (mainly reduction) in freshwater flows into South African rivers and estuaries have a significant impact on the associated ecosystems, more recent is a growing realisation and acceptance that modification in freshwater flows also have a potentially significant effect on nearshore and coastal shelf marine ecosystems of southern Africa. In contrast to river, wetland, groundwater and estuarine environments of South Africa, where appropriate methods for determining freshwater requirements have been developed, no similar methods presently exists for nearshore and coastal shelf marine environments. Here an assessment

framework is proposed to determine the freshwater requirements of nearshore and coastal shelf marine ecosystems, focusing on the southern African situation. In particular the paper proposes appropriate scientific procedures and a structured approach to assessing the role of freshwater inflows and associated fluxes in specific systems, as well as the potential effects of the modifications thereof under likely global change scenarios - a key component of such an assessment framework.

The role of freshwater inflows to coastal ecosystems: Evaluating the responses of the marine abiotic processes to inflow from the Orange-Senqu catchment

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The UNDP-GEF Orange-Senqu Strategic Action Programme is supporting the Orange-Senqu River Commission (ORASECOM) in developing a basin-wide plan for the water resources in the region. As part of the larger integrated project there has been an assessment of the role of freshwater inflows and associated fluxes in the adjacent coastal marine ecosystem and the potential effects that changes in these fluxes may have on the nearshore marine environment. The study focussed on understanding and hind/forecasting changes in habitat-forming sediment and hydrodynamic processes, and the responses of selected invertebrate and fish species on these. Whilst the study area is characterised by high levels of primary production, related water column processes were judged to be of lesser importance as measured data indicated that freshwater inflow was often depleted of nutrients whereas major nutrient input came from the Lüderitz-Orange River Cone upwelling cell. To hind/forecast the effects of water resource development in the larger catchment, freshwater inflow, dissolved reactive silicate (DRS), turbidity and sediment export to the nearshore marine environment were evaluated for a range of future scenarios using numerical modelling. Changes in these parameters were then used to assess the implications of flow alteration on key species. The study found that most significant shifts in abiotic processes (e.g. sediment deposition) had already occurred in moving from the Natural flow conditions (i.e. before dam development) to the Present conditions. The study also concluded that possible changes in abiotic processes associated with the proposed future development scenarios are nearly indistinguishable from one another due to the wide envelope of variability presently experienced along this coast.

The role of freshwater inflows in coastal ecosystems: fish and invertebrate response to flow from the Orange-Senqu catchment

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Historical changes in discharge from the Orange-Senqu catchment and temporal shifts in flow have resulted in seasonal reversals of some abiotic drivers with potentially serious consequences for the adjacent marine environment. Diversity, distribution and abundance of benthic fish and invertebrate communities in the mixed terrigenous and marine deposits of the coastal zone are controlled by both the granulometric properties of the sediments and complex interactions between physical and biological factors at the sediment–water interface. Many marine communities in the Benguela are frequently exposed and adapted to naturally elevated suspended-sediment levels with the effects on juvenile and adult fish and invertebrates usually beneficial, occasionally negative but at sub-lethal

levels. However, altered freshwater flow and the nature and distribution of sediments have resulted in changes in fish and invertebrate community structure. Reduced salinity and increased turbidity in the surface layers associated with the Orange plume are discernible in a 50 km radius from the mouth but may expand to 100 km or more with floods. High densities of larval and juvenile small pelagic fish are associated with the turbidity plumes off the Orange and other west coast estuaries. Although on average only 10-20% of juvenile density can be explained by flow, higher densities of juveniles persist off the Orange and other river mouths in years when they're in low abundance or absent from other parts of the Namibian and South African coast. The southward distribution and exchange between Namibian and South African populations of some linefish species depends on the availability of warm-water refugia offered by estuary mouths and plumes. Consequently, a reduction in river flow may influence the distribution of these species by reducing the extent and availability of these refugia. This said, the predictability of aggregations associated with these plumes and increased catchability make these fish vulnerable to over-exploitation.

Relationship between river flows and sole (*Austroglossus* spp.) biomass trends in South Africa

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River outflows provide a source of terrestrial sediments to the marine environment and are important for maintaining benthic habitats. The muddy inshore habitats on the west coast of South Africa and on the Agulhas Bank are influenced by several river systems. These habitats support the commercially exploited west coast sole (*Austroglossus microlepis*) and Agulhas sole (*A. pectoralis*). Commercial landings of the west coast sole (endemic to the west coast of southern Africa) fluctuated since the commencement of the fishery and the fishery eventually collapsed during the 1970s. Annual catch rates of Agulhas sole (endemic to the Agulhas Bank) similarly have undergone substantial inter-annual variability; however long-term data suggests that the Agulhas sole population is stable. A likely reason behind the contrasting population trends of these two *Austroglossus* species since the 1970s is differing levels of alteration to their benthic habitats caused by changes in the volume and nature of sediment output from the estuaries. The Orange River, the primary source of terrigenous sediment along the west coast, has been subjected to extensive damming, while the Gourits and Breede Rivers, which feed the muddy habitats on the Agulhas Bank, have not. Sediment grain size is known to be one of the key environmental variables that influence the distribution of flatfish. Indeed a study has revealed that the catch rates of Agulhas sole varied according to sediment type on the Agulhas Bank. Moreover fishers in the sole trawl industry have long used rainfall as a predictor of catches in the following season, suggesting a relationship between run-off and sole populations. This study investigates the relationships between river flows and the abundance of each species using long-term demersal survey data and flow data from key estuaries. Preliminary findings indicate a positive relationship between Orange River flows and west coast sole biomass trends.

How freshwater influences system-level function of estuarine and nearshore marine ecosystems – a summary of recent research in subtropical South Africa

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Estuaries and marine systems are dependent on freshwater pulses to receive new nutrients and detritus and to help shape habitats in which species can thrive. In the subtropical region of South Africa, a spring/summer rainfall climate causes breaching of temporarily open/closed estuaries during this season, whereas the larger permanently open estuaries and river mouths deliver higher amounts of nutrients and detritus to the nearshore environment. This study presents an overview of changes that arise during dry and wet seasons in terms of standing stocks of nutrients and biota, and ecosystem-level attributes such as resilience and other measures arising from network analysis. Differences between the various types of estuaries as well as the nearshore environment are discussed. Secondly, we present some of the modelled freshwater related impacts to selected fisheries and ecosystem components of the KwaZulu-Natal Bight. Results from data analyses and modelling showed that there are distinct differences in carbon, nitrogen and phosphorus standing stocks of abiotic and biotic components, as well as in productivity of estuaries between seasons and open/closed inlet conditions. Ecosystem-level attributes such as efficiency of nutrient transfer in food webs, resilience, degree of recycling as well as other attributes differed between seasons and open/closed inlet conditions. In the KwaZulu-Natal Bight, recruitment patterns, ecosystem functioning and modelled fishery yields are directly linked to the functioning and state of connected estuarine habitats, as well as to nutrient delivery from the major terrestrial sources. As an example of the inshore prawn fishery shows, it is not only the fishery yields that are affected by a loss of habitat connectivity, but also other biotic components of the KwaZulu-Natal Bight that are not part of the target fishery. The freshwater debate should therefore be inclusive of catchments, estuaries as well as the nearshore, recognising these as components of an interconnected ecosystem.

What drives the ecosystem of the KwaZulu-Natal Bight? Processes controlling the marine ecosystem of a mesotrophic bight revealed by stable isotope and C:N ratio analyses

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The KwaZulu-Natal Bight is considered oligotrophic/mesotrophic with distinct sources of nutrients entering the system as a series of oceanographic phenomena, including an upwelling cell, and through several estuaries, most importantly the Thukela River. The upwelling cell is suggested to be the main factor controlling the Bight's biology. The aims of this study were to i) elucidate the nutrient/organic matter (OM) source driving the pelagic and benthic system of the Bight and ii) produce a food web to aid in understanding the trophic interactions in the demersal ecosystem. For this marine and riverine sediment samples, total suspended solids (TSS), marine zooplankton and demersal organisms were collected across the Bight, and their carbon and nitrogen signatures ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$ and C:N ratio) determined for two seasons in 2010. Results suggest that for the pelagic environment, rivers played an important role in the wet but not the dry season. Similarly, mixing models indicate that in the demersal environment i) the OM in the sediments was dominated by riverine input in both seasons and ii) the benthic food web was controlled predominantly by input of

riverine TSS. Omnivory appeared to be a widespread strategy for demersal organisms throughout the Bight, a finding supported by the lack of clear $\delta^{15}\text{N}$ enrichment between prey and predators and the low variability of trophic positions across a wide array of organisms. Omnivory has been suggested as an important strategy in the marine environment, especially for the deep-sea and low productivity areas; this study provides solid evidence for the latter. This study highlights the importance of riverine nutrient inputs for the nearby coast and suggests that any important changes to riverine input (e.g. damming) could have serious implications for the ecology of the area, in this case the Bight.

Endler Hall: Estuaries and Change (Part 2: Fish in flux)

Oral Presentations

Could diverse behavioural strategies of estuarine-dependent fishery species confer resilience to exploitation?

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Exploitation pressures of recreational fishing on aquatic ecosystems, particularly estuarine nursery habitats, can have dramatic effects on estuarine fish stocks. Although the estuarine-dependent spotted grunter *Pomadasys commersonnii* is considered over-exploited, it is still in a relatively healthy state when compared to other estuarine-dependent species such as the dusky kob *Argyrosomus japonicus*. Fish movement ecology is complex, with estuarine-dependent species exhibiting diverse life cycles and complex behavioural strategies throughout their life histories. We examined existing telemetry datasets collected from five estuaries, and compared the mortality rates and movement behaviours among these two species, to test the hypothesis that differing behavioural traits provide resilience to the impacts of overfishing. Fishing mortality was four times higher for dusky kob (42%), than for spotted grunter (10%). Differences in their behavioural traits were also observed - dusky kob exhibit high levels of residency to their estuarine nursery areas and low levels of connectivity among estuaries, while spotted grunter use multiple estuaries. The level of connectivity displayed by spotted grunter (85% of individuals) was more than seven times the 12% exhibited by dusky kob. However, when in the estuary, unlike dusky kob, spotted grunter exhibit high levels of site fidelity and residency to particular areas. It is possible that besides the obvious benefits from their life-history (e.g. early maturation, ~ 3 years old), the high level of connectivity makes spotted grunter less susceptible to exploitation as the versatility and variability in habitat use make them unpredictable to anglers and thus reduce their catchability. Therefore, for a species that has an obligatory estuarine-dependent phase and vulnerable within-estuary movement patterns, adopting a migratory strategy that involves a high degree of connectivity among estuaries, may help to prevent estuarine population declines resulting from anthropogenic influences such as overfishing and habitat loss.

Recruitment dynamics of Cape stumpnose, *Rhabdosargus holubi*, into the Swartkops and Sundays River estuaries, South Africa

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To assess the possible impact of environmental change on fish recruitment, it is important to assess the current conditions under which recruitment occurs. *Rhabdosargus holubi* (Family: Sparidae) is an important marine spawning species endemic to South Africa and predominantly associated with freshwater rich estuaries. *R. holubi* larvae recruit from the nearshore into estuaries, which are nursery areas for both larvae and juveniles. Although estuaries are environmentally dynamic, they are subject to further anthropogenic disturbance such as changing land use practices and possible climate changes. This study aimed to assess the effect of environmental variables on the recruitment dynamics of *R. holubi* larvae and juveniles into the Swartkops and Sundays River estuaries. Over a period of two years, fyke nets were set at each estuary mouth, to monitor movement into and out of the estuary at each tidal phase over a 24 hour cycle during each season. *Rhabdosargus holubi* larvae and juveniles recruited into the Swartkops primarily during flood tides. In addition, *R. holubi* individuals were also moving in and out of the mouth during ebb tides at night, particularly in the Sundays. Recruitment peaked in summer and autumn, under conditions of higher temperatures and lower turbidity. Temperature, turbidity and pH were the most important factors affecting *R. holubi* presence and abundance in fyke nets, with salinity, conductivity and total dissolved solids having no significant effect. Turbidity is strongly affected by rainfall and land use patterns and has a major influence on the distribution of species, such as *R. holubi*. The early life history stages of *R. holubi* are dependent on estuaries. Consequently, a combination of turbidity, temperature, pH and salinity changes in estuaries may place *R. holubi* populations at risk in the future, as a result of land use and climate changes.

Assessing nursery habitats for juvenile Cape stumpnose (*Rhabdosargus holubi*) in the Bushmans Estuary, Eastern Cape

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Juvenile *Rhabdosargus holubi*, which are abundant in Eastern Cape estuaries, depend on shallow, protected and food rich habitats for protection from predators, growth and ultimately recruitment to adult populations. As such, habitats within estuaries function as critical nursery areas for *R. holubi*. However these habitats vary in their degree of nursery function and few studies have quantitatively assessed the relative nursery value of several different habitat types within estuaries for juvenile fish species. This study aims to assess the nursery value of dominant habitats, namely submergent *Zostera capensis* beds, emergent *Spartina maritima* beds and sand flats in the Bushmans Estuary in two ways: 1) using multiple complexity indices to quantify habitat complexity and hence the degree of protection from predators offered by various habitat types and; 2) using underwater video cameras to determine abundance and behaviour of *R. holubi* individuals in the different habitat types. Biomass and stem density are sampled seasonally to gain insight into the dynamics of eelgrass and salt marsh beds. Aerial cover, canopy height and underwater camera imagery are used to develop multiple complexity indices for prioritizing habitat complexity. Underwater camera work is conducted at spring high tides at low turbidity at three sites within each habitat type to assess abundance and behaviour of *R. holubi*. Preliminary results indicate that *Z. capensis* beds offer the

greatest degree of habitat complexity and have the highest *R. holubi* abundances. *Spartina maritima* have been shown to also possess an important degree of complexity and may offer an alternative nursery habitat at spring high tides.

The Mgobezeleni Estuary, a small black water system in northern KwaZulu Natal

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The groundwater from the Mgobezeleni Catchment discharges through a small estuary that drains an area of ~8000ha in a region that receives between 700 – 1100 mm of rainfall a year. The estuary is immediately downstream of two lakes (Mgobezeleni and Shazibe) which buffer the flow variability of the groundwater fed feeder streams providing a very consistent inflow to the system. The catchment falls partly into the iSimangaliso Wetland Park and supports the town of Mbazwane and Sodwana that have both recently expanded greatly by people lured by the financial stimulus of tourism created by the fishing activities at Sodwana Bay. The estuary is a temporarily open/closed system and less than a km long, but despite the small size it is important, being the only estuary between St Lucia and Kosi Bay. The estuary breaches naturally when the water level is sufficiently high and not necessarily because of rainfall events, which are buffered by the lakes. Because of a large tourism population, management is periodically required to breach the mouth artificially. The water in the estuary is black and oligotrophic and the estuary phytoplankton and phytomicrobenthic biomass is accordingly low. However, the permanent and rapidly expanding population in the catchment may cause this steady state to alter in the future unless steps are taken soon to install formal sewage systems and thus prevent irreversible change and possibly long-term damage to the estuary.

Jannasch: Intertidal Ecology

Oral Presentations

Early spatial signals for a switch in ecosystem state: an example from fine scale variability of intertidal assemblages

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The dynamic interplay between localised biological processes and the environmental physical forcing drives spatial structure and the functionality of ecosystems. Synchronisation and/or mismatching effects at different time scales additionally influence the spatial outcome of such interactions. As patterns develop, the geometry of patches provides an indication of habitat quality and continues to influence the development and fate of individuals and the larger scale population dynamics. Self-organisation patterns mostly occur in those systems with limitation of resources and are proposed to serve as early warning signals of habitat degradation. Since localised arrangements can translate in larger scale patterns, early/fine scale detection of self-organisation could underline cues for early signals of state transition. Measurements of adult mussel assemblages along the south coast of South Africa have produced contrasting results from previous studies, with no topographic differences. Fine scale patterns in relation to the binary topographic scale have nevertheless emerged with a differential topographic effect for the variability of the shape of the patches, resulting in higher spatial redundancies in the less wave-disturbed areas. Following the topographic

effect of observed patterns of mussel cover at open coast and bays, we developed a spatially-explicit model that investigates the suitability of fine scale variability in intertidal patchiness as early signalling for the set off of self-organisation and/or reaching of criticality.

Marine reserve effects on the reproductive biology of commonly and rarely exploited limpet species

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The reproductive biology of two commonly exploited (*Helcion concolor* and *Scutellastra longicosta*) and two rarely exploited (*Cellana capensis* and *S. granularis*) limpet species was investigated at two reserve (Dwesa and Cwebe) and two non-reserve (Nqabara and Xhora) sites in Transkei. We tested three hypotheses: for exploited species i) Limpets outside reserves will mature earlier than those inside reserves because of reductions in density and intraspecific competition and ii) Population reproductive output will be higher inside than outside reserves as a result of increased biomass. iii) For rarely exploited species sex ratios will be the same inside and outside reserves since all populations are subject to similar natural processes. ANOVA revealed reserve effects on the reproductive output of the commonly exploited but not the rarely exploited species. Mean Gonado Somatic Index values of exploited species were greater in reserves than non-reserves. The ratio of male to female differed significantly from 1:1 among species. Although there were monthly variations in sex ratios, they were relatively constant among sites, suggesting that sex ratios are likely to be set by the biology of the species, rather than whether it is exploited. Size at sexual maturity showed relatively little difference between males and females in all species. Reserves have a strong effect on reproductive biology of these limpet species.

Spatial scales of variation in the dietary regime of filter feeders along the South African rocky coast

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Benthic filter feeders have a key functional role in coastal food webs dynamics. These ecosystems are influenced by several factors (e.g. hydrographic regime), that can affect the composition of the water column and thus the availability of food and nutrients for benthic populations. Food availability can affect growth, reproductive rates and survival of benthic organisms, and consequently, can influence the functioning of the entire ecosystem. This study aimed to evaluate spatial scales variability in filter-feeder diets, particularly the influence of biogeographic regions and upwelling. The dietary regimes of two mussel species (*Mytilus galloprovincialis*, *Perna perna*) and one barnacle species (*Chthamalus dentatus*) were investigated using fatty acid (FA) and stable isotope (SI) analyses across 13 sites. Both SI and FA signatures showed a similar pattern for all three species. $\delta^{15}\text{N}$ increased from the East to the West coast, with no upwelling effect, while $\delta^{13}\text{C}$ signature significantly decreased in upwelling sites relative to non-upwelling sites. FA signatures among the biogeographical regions showed significant differences (Permanova analysis, $p < 0.01$); samples from the West were dissimilar from the South and East coasts, with no differences between the latter two. We identified an effect of the upwelling on the FA signature of the filter feeders only on the West coast, where they were enriched in polyunsaturated fatty acids (PUFAs). The decrease in $\delta^{13}\text{C}$ associated with upwelling suggests that upwelling plays an important role in carbon availability, and indicates

different food sources for filter feeders in upwelling conditions compared to non-upwelling conditions. However it revealed to be difficult to identify the primary food source of these species, probably because they are non-selective feeders. These results highlight the profound effect that hydrographic regime and biogeographic location can have on benthic ecosystems, and how the factors influencing diet differ across spatial scales.

Hidden benefits of genetic diversity: interactions between invasive and indigenous species

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A critical driver of long-term change in natural ecosystems is biological invasion. Invasive species necessarily interact with indigenous species and can profoundly alter biodiversity. Definitions of biodiversity can include genetic diversity, yet the direct benefits of conserving genetic diversity are assumed, rather than demonstrated. We examined the interaction between an invasive and an indigenous mussel, including the effect of genetic resolution. The Mediterranean mussel, *Mytilus galloprovincialis*, is invasive on every continent except Antarctica, encountering a wide variety of native mussel species. In South Africa, it has displaced the indigenous mussel *Aulacomya ater* on the cool-temperate west coast, but on the warm-temperate south coast it interacts with the indigenous *Perna perna*. The two show partial habitat segregation by height on the shore, while overlapping and co-existing in the middle of the zone occupied mussels. On the south coast, *M. galloprovincialis* reaches a distributional limit towards the east that coincides with a phylogeographic break in *P. perna*. This limit lies precisely in the region where two genetic lineages of *P. perna*, an eastern and a western lineage, overlap. *In situ* competition and translocation experiments, coupled with records of recruits, indicate that *M. galloprovincialis* is capable of living farther east than it presently occurs. However, on the midshore, where the two species can co-exist in mixed mussel beds, it is outcompeted by the eastern lineage of *P. perna* and not the western lineage with which it presently co-exists. The results provide a clear example of a hidden benefit of genetic diversity with the spread of *M. galloprovincialis* towards the east limited not by abiotic conditions, but by interaction with a different genetic lineage of *P. perna*.

The thermal physiology of invasive and native mussels on South Africa shores

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Most predictions of shifts in distributional range under climate change are based on climate envelope models that omit species interactions. Invasive species are evidence that interactions can be critical and the ability of introduced species to become invasive will reflect the difference between their responses to environmental change and those of indigenous competitors. Effects on ecosystem engineers are particularly critical as they create habitat for many other species. The two dominant, habitat-forming mussels in South Africa are the indigenous *Perna perna* and the invasive *Mytilus galloprovincialis*. They have similar live styles and resource requirements but different distribution patterns. *M. galloprovincialis* dominates the cool temperate west and *P. perna* the subtropical east coast. *P. perna* is absent from the west coast, but co-exists and competes with *M. galloprovincialis* on the south coast. Moreover, two genetic lineages of *P. perna* exist in South Africa and overlap on the south-east coast. The thermal tolerances of marine ectotherms relate closely to environmental temperatures and can explain species distributions. We investigated the effects of acute temperature change on heart rate, oxygen consumption and anaerobic end product production for *M. galloprovincialis* and both *P. perna* lineages under immersed and emersed conditions in the laboratory. During emersion, heart rate and oxygen consumption were significantly

reduced and not correlated with temperature for all three classes of mussel. During immersion, temperature had powerful and similar effects on metabolic rate, but the ranking of heart rates reversed between heat and cold stress. Unexpectedly, the western *P. perna* lineage appeared better adapted to rising temperatures, while *M. galloprovincialis* showed higher heart rates during cooling. These different responses will shape their interactions and distributions under climate change.

Life-history strategies of the invasive mussel *Semimytilus algosus* on the West Coast of South Africa

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At least 86 alien marine species occur in South Africa, some profoundly influencing ecosystem structure and functioning. The mussel *Semimytilus algosus* was first detected in South Africa at Elands Bay in 2009, and currently occupies a range of 500 km along the West Coast and dominates the low shore. As such, it must be added to the Mediterranean mussel *Mytilus galloprovincialis* and the barnacle *Balanus glandula* as species that have significant ecosystem effects over a large geographic scale. On intertidal shores, competition for space has substantial influences on zonation, community structure and diversity. Certain characteristics may enable species to outcompete others, such as high reproduction and recruitment rate, fast growth and strong shell and attachment strengths. To shed light on the competitive capabilities of *S. algosus*, caging experiments undertaken at three shore heights, and values of various of its life-history parameters were determined and compared with those of the indigenous mussels *Aulacomya ater* and *Choromytilus meridionalis* and the invasive mussel *M. galloprovincialis*. Recruitment and growth of *S. algosus* diminished up the shore; and relative to other species it has a moderate growth rate, high mortality rate and low shell and byssus strengths. Recruitment and reproduction rates are, however, highest for *S. algosus*. This allows *S. algosus* to recolonise space faster after displacement by storms, which could explain its fast range expansion along the West Coast, as well as how it manages to dominate the low shore but is excluded from the upper portions of the shore.

Mechanisms of nearshore retention and offshore export of mussel larvae over the Agulhas Bank

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Ecological connectivity is a critical aspect of population dynamics but in many benthic species it is complicated by a planktonic larval phase, the dispersal of which remains poorly understood. We used a plankton pump to examine the distribution of the larvae of intertidal mussels along three axes: alongshore, cross-shelf and by depth during a large scale (600km) cruise over the Agulhas Bank off southern Africa in August/September 2010. As a general pattern, higher veliger abundances were found close to the coast. Our analyses of nearshore flow, estimated from ADCP data, and the vertical distribution of larvae show that onshore larval retention may be mediated by active vertical swimming behaviour through the water column guided by light and wind-induced turbulence. A massive offshore exportation of larvae off St Francis Bay was, however, observed during an Agulhas Current meander which influenced inner shelf waters. We hypothesize that, by increasing flow and homogenizing it through the water column, the Agulhas Current may erase the effects of larval

vertical positioning on onshore retention and transport larvae offshore. Our study highlights the need to integrate the effects of complex, region-specific physical dynamics with the swimming behaviour of larvae in order to explain their spatial distribution, population connectivity and the consequences for population dynamics.

Has low predation pressure enabled the spread of the alien barnacle *Balanus glandula* along the South African coast?

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Since it was recognised in 2007, the invasive barnacle *Balanus glandula* has progressively spread along the South African west coast. In 2012 it was first found to have breached the Cape Point biogeographic break and spread east into False Bay. This calls into question the role of biotic resistance in regulating this invasion. We employed field observations and laboratory experiments to assess the relative predation pressure on *B. glandula* and the native barnacle *Notomegabalanus algicola* by the native whelks *Nucella cingulata* and *Burnupena lagenaria*. In the mid-shore both whelks fed on *N. algicola* significantly more often than on *B. glandula* despite the alien covering 86% (± 2.4 SE) of the shore. Lower on the shore *N. algicola* was spatially dominant, covering 41% (± 0.7 SE) of the zone and both whelks still fed on the native significantly more often. Feeding experiments revealed that small (13.9 mm ± 0.3 SD) and large (19.6 mm ± 0.5 SD) *N. cingulata* consumed up to 70 % more *N. algicola* than *B. glandula*, displaying a significant avoidance of the alien. While small (15.5 mm ± 0.5 SD) *B. lagenaria* displayed the same pattern as *N. cingulata*, large individuals (27.7 mm ± 0.4 SD) consumed equal numbers of the two barnacles. The overall avoidance of *B. glandula* may be explained by this species possessing significantly thicker shell and opercular plates than *N. algicola*, while a narrow margin of vulnerable soft-tissue around the circumference of the opercular plates may make the native an attractive prey choice. These results demonstrate that a lack of predation is likely to have aided the expansion of *B. glandula* and highlights that predation driven biotic resistance can reflect a complex interplay between the reaction of native predators and the relative defences of alien and native prey.

Poster Presentations

Poster # 61

Assessing density and size structures of intertidal grazers in rock pools of exploited and unexploited areas

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Intertidal rock pools are regarded as important habitats providing protection and nursery areas for invertebrates. However, relevant to emergent rocks, little information is available on the processes governing community interactions in these microhabitats. Limpets, which inhabit these rock pools, are intertidal grazers that play an important role in structuring rocky shore communities and are often harvested by coastal communities as a food source and bait. This study investigated the effects of marine reserves on limpet density and size structure in rock pools of reserve and non-reserve sites along the southeast coast of South Africa. Sampling was done along the southeast coast in two reserve (Dwesa-Cwebe and Hluleka Nature Reserves) and two adjacent non-reserve (Nqabara and Presley's Bay) sites for 12 months. Limpet densities in rock pools were site- and species-specific as greater densities of rarely exploited species were found in non-reserve than reserve sites, while

heavily exploited species exhibited greater densities in the latter. Mean and mean maximum sizes were significantly greater in rock pools of reserve than non-reserve sites. The greater limpet sizes found inside reserve sites were attributed to protection from exploitation. These results highlight not only the importance of considering rock pools in designing marine reserves but also understanding population structures in rock pools for biodiversity management. This is essential in ensuring viable populations are conserved in order to sustain current and future livelihoods on the southeast coast.

Poster # 62

The impact of increasing substrate temperature on the settlement, recruitment, mortality and growth of the alien barnacle, *Balanus glandula*, and its native comparator, *Chthamalus dentatus*

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As marine invasions become increasingly prevalent, it is important to understand how climate change may moderate the spread of invasive species and their interactions within native communities. *Balanus glandula* is an invasive intertidal barnacle along the South African coast. This species is currently the dominant barnacle on the west coast and has recently spread east past the biogeographic break of Cape Point. This newly invaded area has historically supported high densities of the native barnacle, *Chthamalus dentatus* and there are concerns that this species may be negatively impacted by the invasive *B. glandula*. In light of predicted climate warming along the south coast, we aimed to assess the impact of increasing substrate temperature on the settlement, recruitment, mortality, and growth of both barnacle species. Sites were established along the west and south coast to ensure settlement of both species. At each site, substrate temperature was manipulated using PVC plates of different colours (black, grey, white and clear) that were secured onto the substrate in the mid-shore and contrasted with bare rock. Barnacles showed complete spatial separation: *B. glandula* recruited only on the west coast and *C. dentatus* only on the south. Although this prevented direct comparisons between species, their relative responses to substrate temperature could be assessed. Unexpectedly, increasing substrate temperature had no systematic effects on settlement, recruitment or mortality of either species. While regional differences between west and south coasts must be acknowledged, the fact that settlement and recruitment of *B. glandula* were higher, mortality was lower and growth was greater on natural substrate than that of *C. dentatus* is notable. This suggests an innate competitive advantage held by *B. glandula* may be more important in determining its' future impacts on the south coast than climate related changes in substrate temperature.

Poster # 63

Current distribution and impact of the alien anemone *Sagartia ornata* within the West Coast National Park

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The West Coast National Park (WCNP) is one of only two marine protected areas along the west coast of South Africa. One of the threats faced by the park is the invasion of alien marine species. *Sagartia ornata* is an alien anemone native to the Mediterranean Sea, Britain and Western Europe, but now occurs intertidally within Langebaan Lagoon in the WCNP. While baseline distributional data was gathered in 2001 the range and abundance of this alien has not been reassessed and the status of the invasion remains unknown. In light of this, the present study aimed to determine the current

status and distribution of this anemone, assess its diet so as to establish the role it may play as predator and to investigate its impact on sandy shore communities. *S. ornata* was found to be restricted to within the WCNP where it occurred in densities of up to 508 ± 218 individuals/m². Within the park the distribution of this anemone had changed. New populations were recorded in *Zostera capensis* beds for the first time while the alien was absent from two areas in which it had previously occurred. Diet analysis revealed indigenous polychaete worms and amphipods as the dominant prey items consumed by *S. ornata*. This alien was found to significantly alter sandy-shore community structure, with differences caused primarily by changes in the relative abundance and biomass of the tanaid *Anatanaïs gracilis* and the polychaete *Orbinia angrapequensis*. Additionally, invaded areas supported significantly greater diversity, density and biomass, even when the contribution of the anemones was excluded. While this anemone affects native biota it is currently restricted in distribution. This invasion should, however, be routinely monitored as in its native range *S. ornata* occurs on rocky shores and kelp holdfasts, suggesting a potential for spread along the west coast.

Poster # 64

Effects of harvesting sand and mud prawns in Langebaan Lagoon MPA, West Coast National Park

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The harvesting of invertebrates such as sand prawn *Callinassia kraussi* and mud prawn *Upogebia africana* by recreational and subsistence angler's takes place virtually along the South African coastline. This may have severe unintended impacts on these species, (e.g. exposure of unused species to avian predation, changes to species assemblages, etc.). In this study we compare population densities of targeted species, particularly the sand and mud prawns and the invertebrate species assemblages in harvested versus protected areas. Sampling was conducted monthly in Langebaan Lagoon from a heavily impacted site; Sandbaai, two moderately impacted sites; Maart se plaar, Oestewaal and two reference sites Kraalbaai and Kliphoek. A 0.25 m² quadrant was placed along a 20 m transect line, 5 m apart during spring low tide. Prawns were sucked using a prawn pump and stored in formalin for later analysis. Preliminary result suggests that Oestewaal has highest number of sand prawns (22 ind/m²) followed by Kraalbaai. Mud prawns only occurred in Sandbaai. Kliphoek had the overall lowest prawn densities, which is counter intuitive.

Poster # 65

Meso-scale mechanisms of larval transport in relation to water flow: a topographic approach

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Most intertidal invertebrates produce larvae that undergo pelagic development. Since larvae, must return to the coast to settle following a dispersive planktonic phase, processes influencing their retention close to or export from the natal site are important in regulating population dynamics. This study coupled physical meso-scale oceanographic data from the very near shore region, with the distribution of larvae of key intertidal benthic organisms, including bivalves and crustaceans. We took an explicitly topographic approach, comparing bays and the open coast, to identify the small

scale distribution patterns of larvae and link these to the physical oceanography. The study was conducted along the nearshore region of Algoa and St Francis Bays where two bay and adjacent two open coast sites were each sampled using two parallel transects running perpendicular to the coast. Each transect had stations at 200, 400, 900 and 2400m offshore. At each station, surface, middle and bottom depths were sampled using a plankton pump (60µm mesh). Current speed and direction were monitored simultaneously using an ADCP. Preliminary results, suggest significant differences between bay and open coast sites in terms of species abundance and distribution. Balanoid nauplius stages generally had greater abundances on the open coast sites and different distribution patterns from bay sites. Analysis of the physical data will clarify the mechanisms behind these topographic-effects on larval distribution.

Jannasch: Fish Ecology

Oral Presentations

Thirty years of hydro acoustic pelagic biomass estimation surveys – what have we learnt?

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In November 2013, the 30th consecutive pelagic biomass survey conducted by DAFF was completed, an incredible milestone for an acoustic survey program initiated in 1982. This program, which consists of biannual winter recruitment and summer adult biomass surveys is the cornerstone of sustainable management of South Africa's commercially important small pelagic fish species. Initially designed to measure the biomass of anchovy, these surveys have been expanded and adapted to estimate the biomass of most pelagic and mesopelagic fish. Technological advances have been incorporated and biomass estimates adjusted to take account of improvements in equipment performance and increased knowledge over time. Large, and sometimes unexplained, variations in the biomass of pelagic fish biomass and recruitment have been observed. Insight into distribution patterns and changes in these over time has improved our knowledge of fish life cycles and population structure. As the key input into management of pelagic fish, these surveys have allowed for adaptive management in response to altered biomass levels. Outputs from these surveys have been used in countless studies of ecosystem functioning, most notably to explain changes in abundance and distribution of predators that rely on small pelagic fish. No other method has consistently provided a more robust estimate of pelagic fish abundance, recruitment variability and insight into fish distribution patterns and behaviour. For this reason, these surveys have continued to be prioritized despite budget and other constraints – ensuring that this survey program continues to provide the basis for sustainable harvest of South Africa's pelagic fish species. In this presentation, we highlight some of the major changes in the survey program, provide updated information on the status of small pelagic fish and offer insight into current acoustic research and improvement.

Comparing temporal variability in relative weight of sardine, anchovy, and round herring in the southern Benguela

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Body condition is important in fish reproduction, particularly for small pelagic species where gonad maturation and the reproductive output of females (both in terms of egg quantity and egg quality) are dependent to a large extent on stored energy. Body condition can also be used as a proxy for habitat quality within an ecosystem. We used length and weight data from three coexisting small pelagic fish off South Africa (sardine *Sardinops sagax*, anchovy *Engraulis encrasicolus* and redeye round herring *Etrumeus whiteheadi*) collected from commercial catch samples off the west coast, from the mid-80s to the mid-90s to assess temporal dynamics in body condition of these species over that decade. We used relative weight as a measure of body condition and computed these using species-specific standard weight equations. All three small pelagics showed a coherent downward trend in relative weight over the study period, suggesting that the driver/s behind this decline acted equally on these three species, even when they experienced different population trajectories. This also suggests that environmental processes were likely responsible, and most plausibly a declining system productivity, although density dependent effects cannot be excluded. However, this observation is in agreement with some (decline in upwelling intensity) but in contrast with others observations (e.g. an increase in copepod abundance) off the western coast. The reasons why some of these signals show different trends are unclear, but we consider fish relative weight to be an integrative measure of their recent trophic history. Monitoring the body condition dynamics of these commercially and ecologically important coexisting species contributes to an ecosystem approach to fisheries management, as well as towards the identification of indicator species of ecosystem status.

Starving in the midst of plenty: anomalous environmental conditions and the Cape Town sardine run of spring 2011

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Sardine in the near-shore zone and wash-ups of this species in and around Cape Town were reported during November 2011 in what became known as the Cape Town sardine run. These fish were in poor condition, and sardine in poor condition were also observed in inshore waters between Cape Infanta and Port Alfred during DAFF's 2011 pelagic biomass survey, whereas those further offshore were in markedly better condition. In contrast, anchovy and west coast round herring sampled during that survey did not show a cross-shelf gradient in condition. We investigated the poor condition of sardine in inshore waters by analysing phytoplankton samples and hydrographic data collected during the survey as well as wind data from four sites around the coast. Dense blooms of dinoflagellates dominated by *Gonyaulax polygramma* were found in the inshore region along much of the south coast. Whereas water temperatures in spring 2011 were not anomalous, salinity and bottom dissolved oxygen levels were, with much of the continental shelf east of Cape Point occupied by high salinity water and bottom waters of the inshore region of the central Agulhas Bank being hypoxic. Wind data suggested that these anomalous environmental conditions resulted from sustained westerly winds that continued after winter and pushed South Atlantic surface water onto the south coast shelf, resulting in strongly stratified conditions. This favoured the formation of

dinoflagellate blooms which resulted in low dissolved oxygen conditions following their decay. We hypothesize that sardine in inshore waters were “trapped” there by the dinoflagellate blooms, through which they could not swim because their finely-meshed branchial basket retained some dinoflagellates which inhibited feeding and possibly also respiration, and hence engendered an avoidance response. Anchovy and round herring have coarser branchial baskets than sardine which would explain that they were not impacted.

An overview of applied marine parasitology research in sub-Saharan Africa

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Scattered records of parasitic species infecting commercially important marine fishes are known from just a few sub-Saharan African countries (e.g. Senegal, Nigeria and South Africa). Most of these consist of taxonomic records or general surveys of parasite faunas associated with marine hosts, which may or may not have been of commercial value. Little to no multi-disciplinary research has been conducted in most parts of the sub-continent and unlike many parts of the world parasitological data is not commonly used to advise fisheries management procedures. In southern Africa the parasite assemblages of seven commercial fish hosts (*Engraulis encrasicolis*, *Sardinops sagax*, *Trachurus capensis*, *T. trecae*, *Merluccius capensis*, *M. paradoxus*, *Thyrsites atun*) have recently been studied from an applied or product quality point of view. Most other parasite records known from commercial fishes are related to taxonomic or parasite community type studies. The recent research on parasites of commercial fishes in South Africa has highlighted the usefulness of these data, particularly in the applications of parasites as biological tags, indicators of environmental pollution, physiological effects on hosts, seasonal and temporal variations in infection, effects on product quality and also the possibility of human health concerns.

Snoek and squatters

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Parasites are an often overlooked component of biodiversity. Marine parasites have been shown to be ecologically significant, economically detrimental and more recently, useful in fisheries science and environmental monitoring. In southern Africa, few studies have investigated the host-parasite relationships of commercially important marine fishes. A yearlong (March 2013 – March 2014), monthly survey of the parasite fauna of snoek (*Thyrsites atun*), a major target species of the inshore linefishery, caught off South Africa revealed sixteen parasite taxa (Copepoda, Cestoda, Nematoda, Myxozoa). Amongst these, 10 were identified to species level and eleven taxa constitute new host records. Descriptive infection statistics for each parasite taxon are presented. Spatial and temporal trends in the parasite assemblage are analyzed using Generalized Linear Models (GLMs) and multivariate techniques (MDS, ANOSIM). The results of GLMs suggested that six of the 16 parasite species (*Caligus dakari*, *C. brevicaudatus*, *Hatschekia conifera*, *Corynosoma spp.*, *Tentacularia coryphynae*, *Hepatoxylon trichiuri*) exhibited significant variation in seasonal prevalence. Community analyses revealed a seasonal increase in parasite diversity, with summer and autumn exhibiting the highest and lowest parasite species diversity respectively. The MDS and ANOSIM (Global R = 0.231, p

= 0.0001) suggested a small but significant seasonal difference in the community structure of snoek parasites in the southern Benguela. The seasonal trend in parasite species diversity could be explained by the nomadic nature of snoek, their offshore spawning migration, their varied diet and the lag time needed for a trophically transmitted parasite to be detectable in the fish host. The results suggest that snoek off South Africa constitute a single stock. Future research will include examination of parasite assemblages of snoek from the northern Benguela and comparing them to that of snoek in the southern Benguela in an attempt to elucidate its stock structure in the South East Atlantic.

Population dynamics of the white shark (*Carcharodon carcharias*) at Mossel Bay, South Africa

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The white shark is a highly mobile coastal apex predator. Despite its circum-global distribution, white sharks display a degree of site fidelity to specific localities along the South African coast. At Mossel Bay, four sites (Seal Island, Hartenbos, Kleinbrak and Grootbrak) within the bay were sampled to investigate spatial and seasonal patterns in relative abundance and size composition of white sharks. Data were collected from February to December for 2008 – 2010. Inter-annual variation in relative abundance was significant with 2008 having a higher sighting rate than subsequent years. Similarly, spatial variation in relative abundance was significant with Seal Island having the highest and Hartenbos having the lowest sighting rates. Seasonal variation in relative abundance was only significant when combined with site. Sighting rate was highest during summer and autumn at Grootbrak and Kleinbrak, whilst winter and spring had the highest sighting rate at Seal Island. This is likely due to seasonal and spatial variation in prey availability across the three years. Body size composition was dependent on season but not on site. Most size-classes were present year-round, however, there was a predominance of individuals ranging between 2 – 3m total length. It is thus hypothesised that Mossel Bay represents a nursery-like area for a subset of the greater metapopulation. Furthermore, an effort was made to improve population abundance estimation by distinguishing between permanent and temporary emigration. Photographic identification techniques were applied to the dorsal fin of white sharks and a total of 261 unique individuals were identified. Results from this study indicate that when emigration is considered to be permanent, derived population estimates were 2.7 times larger than those produced from a temporary emigration model. This highlights the importance of sound population abundance estimation for species of conservation concern.

Assessment of South African sardine (*Sardinops sagax*) population structure using a multi-method approach

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An understanding of population structure is needed for effective fisheries management and implementation of stock rebuilding programs, and identification of fish stocks is typically based on the observation of differences in genetic and/or phenotypic characteristics between fish from discrete stocks. In South Africa, management of the sardine fishery currently assumes a mono-stock population, although there have been recent deliberations on the existence and management of multiple sardine stocks following studies that have documented spatial variability in several phenotypic characteristics of this species around South Africa. Those studies typically examined spatial variability in a single characteristic (e.g. gill raker morphology and meristics, body shape, vertebral count, parasite loads), but the application of multiple stock identification methods to the same individual fish has been advocated in order to maximize the likelihood of correctly inferring and identifying fish stocks. This study seeks to assess the stock structure of South African sardines using a combination of stock identification methods that are all applied to the same individual fish, namely meristic, morphometric and parasite markers. Here, we present preliminary findings from a combination of stock identification methods applied to sardine samples collected off the West and South coasts during the pelagic recruit survey conducted in May 2013 by the Department of Agriculture, Forestry and Fisheries.

Can muscle fatty acid signatures be used to distinguish diets of two sympatric hake species (*Merluccius capensis* and *Merluccius paradoxus*) off Namibia?

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Fatty acid (FA) signatures are increasingly being used to study the feeding ecology of marine species. The feeding ecology of *Merluccius capensis* and *Merluccius paradoxus* has been studied mainly by using stomach content analyses. Neutral FAs profiles of hake (n = 110) muscle and total FAs (TFAs) profiles of known prey (n=58) were analysed to provide insights into the two hake species' dietary relationships. The samples were collected during January 2011 and December 2011 from bottom trawl surveys off Namibia. The FA profiles of the two species (*M. paradoxus* and *M. capensis*) and potential prey were similar to those typically abundant in marine fish. Palmitic acid (16:0) was the dominant saturated fatty acid, oleic acid (18:1n-9) was the dominant monounsaturated fatty acid and docosahexaenoic acid (22:6n-3) was the dominant polyunsaturated fatty acid in both hake species. FA profiles in the neutral storage lipids of *M. paradoxus* and *M. capensis* were significantly different, an indication of hake species' dietary resource partitioning, although some overlap was apparent. There was a significant temporal effect on hake FA compositions, reflecting temporal variations in quantity and quality of dietary resources. The comparison of hake neutral FAs and TFAs of potential prey, showed their relative associations. Among the potential prey considered, *Synagrops microlepis*, *Epigonus denticulatus* and *Chlorophthalmus agassizi* showed closer association

with both hake species. *Engraulis capensis*, *Helicolenus dactylopterus*, *Todarodes sagittatus*, *Nezumia micronychodon*, *Paracallionymus costatus*, and *Sufflogobius bibartus* showed closer associations with *M. paradoxus* samples than with *M. capensis* samples. This study showed the potential benefits of using neutral FAs of predators and TFA of prey to investigate their trophic relationships, and how the FA signature approach can complement conventional methods of diet analyses.

Thermal tolerance of South African clinid fishes: a comparison of three species occupying contrasting intertidal habitats

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Coastal organisms have been recognised as sentinels of climate change owing to their vulnerability to temperature shifts and related climatic effects. This study examined three clinid species (*Muraenoclinus dorsalis*, *Clinus cottoides* and *C. superciliosus*), that have different vertical distributions on South African rocky shores. Such differences in zonation may reflect differing temperature tolerances among species. Standard critical thermal limit protocols were used to assess the end-point of coordinated behaviour at high (critical thermal maximum-CTmax) and low (critical thermal minimum-CTmin) temperatures of the three species. Fish were collected from Sea Point, Cape Town, and held for acclimation at 18°C. Individual fish were exposed to an increase or decrease in temperature of 0.05°C min⁻¹ and the temperature at which a loss of righting response occurred was recorded. Critical limits and tolerance breadth were best predicted by species of fish. CTmax was highest for *C. cottoides*, *M. dorsalis* being intermediate and *C. superciliosus* having the lowest CTmax. CTmin values were lowest for *C. superciliosus*, higher for *C. cottoides* and highest for *M. dorsalis*. *M. dorsalis* has the narrowest tolerance breadth and thus, may be the most vulnerable to changing climates as it inhabits the most variable portion of the intertidal zone. Further research directions are discussed, with particular focus on temperature gradient-related differential responses between west, south and east coast populations of the *C. superciliosus* species complex.

Movement behaviour of the giant guitarfish *Rhynchobatus djiddensis* off southern Africa based on conventional tag-recapture data

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Movement data collected in southern Africa through the Oceanographic Research Institute's Cooperative Fish Tagging Project (ORICFTP) was used to describe movement patterns of the giant guitarfish *Rhynchobatus djiddensis*. This species is the seventh most commonly tagged elasmobranch on the project with 4 080 individuals tagged by the end of 2013, of which 202 (5%) have been recaptured. The number of *R. djiddensis* tagged per year has decreased considerably since the start of the project in 1984, with an average of fewer than 90 individuals tagged per year since 2000. The majority of the tagging effort for *R. djiddensis* takes place along the KwaZulu-Natal coast (95%), with very few fish tagged in the Eastern Cape (3.6%); although some tagging effort is recorded in Mozambique, this is generally discouraged as per instruction of the ORICFTP. Within KwaZulu-Natal, there is a distinct increase in the number of *R. djiddensis* tagged and recaptured during the summer months (Oct-Mar). There was no clear size-based distinction between fish that moved and those that remained in the same vicinity. The data presented suggests that movement behaviour is generally nomadic and although catches are seasonal, no seasonal migration is evident as has previously been

suggested. Since the flesh and particularly the fins of *R. djiddensis* are highly sought after in Asian fish markets and the fact that the life history of this species makes it vulnerable to overexploitation, investigation of the stock status of this species is required, especially since anecdotal evidence suggests that catch rates have declined. Recommendations for the improved management of *R. djiddensis* are briefly discussed based on their movement behaviour.

Estuarine movements and habitat connectivity by juvenile leervis *Lichia amia* (Carangidae) determined by passive acoustic tracking

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Leervis, *Lichia amia*, is a sought-after estuarine-dependent fishery species targeted by recreational line- and spearfishers and coastal subsistence fishers throughout its local distribution. Although aspects of the biology, population dynamics and migration patterns of this species are known, limited information exists on habitat use patterns, particularly in estuaries and the movement behaviour of juveniles. Adult leervis, most commonly found in nearshore surface waters, undertake a winter spawning migration to KwaZulu-Natal waters, with a return migration to Eastern and Western Cape waters during the summer. Despite evidence of overlap in the use of estuaries and the nearshore coastal zone, particularly by juveniles, limited information exists on the area use within estuaries as well as the movements between these habitats. Therefore, this study aimed to (i) describe spatial and temporal movements and area use patterns of juvenile leervis within an estuary, and (ii) investigate the degree of connectivity between their estuarine and neighbouring marine environments. Twenty individuals (303–464 mm fork length) were surgically equipped with coded acoustic transmitters and monitored for one year using an array of stationary acoustic receivers ($n = 20$, spaced 1 km apart) in the Kowie Estuary, Eastern Cape Province. Results suggest that daily movements corresponded with the tide and its associated changes in salinity and temperature. Preliminary results suggest that tagged fish display distinct circatidal activity patterns, with certain individuals utilising longer stretches of the estuary on the spring tides. Eleven individuals left the Kowie Estuary during the monitoring period and were recorded on acoustic receivers in eight nearby estuaries from the Keiskamma Estuary (70 km northwards) and the Kromme Estuary (244 km southwards) and one harbour in Algoa Bay (Port of Ngqura). The preliminary findings of this study have provided insight into the estuarine movements, residency and multiple habitat connectivity of this important coastal fishery species.

Movement patterns of swordfish in the South-West Indian Ocean revealed by pop-up satellite archival tags

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Eleven longline-caught swordfishes were tagged with pop-up satellite (PSAT) tags off the coast of South Africa. Although post-release mortality rates were high, five fishes (36%) yielded datasets longer than two months. Fish condition based upon visual assessment or duration hooked on the longline was a poor indicator of release success. All five swordfish undertook periodical diel diving behaviour, but one fish dived mainly at night. Basking behaviour was not observed as all fishes

stayed below 8 m of water depth. Bathymetry and moon phase did not seem to influence diving depth, but dives seemed to be restricted by a temperature ceiling of ca. 8°C. Maximum and minimum water temperature encountered by the fish generally matched those found in other studies around the world. Diving patterns did not change with average swimming speed, but longer presence in shallow waters during faster swimming was observed in one fish. All swordfish tagged in South Africa remained within the region but one fish crossed the 20 degree longitude boundary twice indicating that there might be a degree of connectivity with the Southern Atlantic stock. One swordfish travelled from south of Reunion Island into Mozambique Channel. Estimated swordfish horizontal movement do not reveal any clear link with bathymetry or chlorophyll-a, however two fishes tracked in the Mozambique Channel seemed to trace the edge of meso-scale eddies. When analysed in parallel to fisheries data, the horizontal movements showed by those tagging experiments (still scarce) suggest that the Mozambique Channel might be a prime habitat for Indian Ocean swordfish population and would deserve a particular attention in terms of spatial management.

Poster Presentations

Poster # 50

Spatial variation and the influence of sea temperature on the parasite assemblages of two contrasting fish species along the South African coastline: the nosestripe klipfish (*Muraenoclinus dorsalis*) and the South African sardine (*Sardinops sagax*)

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Reports of diseases affecting marine organisms have increased globally and studies linking climate change and emerging parasitic diseases have highlighted some of the challenges that the near future may bring. Parasites play central roles in fish biology; they can influence individual host survival and reproduction, alter fish behaviour and migration patterns, and can even regulate fish populations and affect fish community structure. A major goal in the field of parasite ecology is to determine whether parasite assemblages are the result of stochastic events or predictable processes and to find out which factors might be contributing to composition patterns observed within a community. Although several climatic or anthropogenic factors are possible, there is accumulating evidence that sea temperature is an important component influencing the prevalence of marine diseases. Here, the South African coastline offers a unique natural setting to study the effect of temperature as an important environmental factor on parasite load. The warm Agulhas Current which flows southwards from Mozambique along the eastern coast of the country, and the cold Benguela Current that runs northwards along the west coast, as well as the mix of cool and warm water around the South Coast offer a rare natural temperature gradient in which one can test the effect of temperature on host-parasite systems. In this study we investigated parasite communities and the potential influence of different temperature regimes of two contrasting fish species as our host models: the widely distributed, pelagic South African sardine (*Sardinops sagax*) and the South African endemic shore-living clinid species, the nosestripe klipfish (*Muraenoclinus dorsalis*). These two species were chosen because of their overlapping distributions, but very different life-histories and population dynamics. Results will be presented in this talk.

Poster # 52

Feeding of juvenile hake along the west coast of South Africa

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The feeding of hake *Merluccius capensis* and *M. paradoxus* along the west coast of South Africa was investigated. The composition of zooplankton prey only was determined and lengths of dominant zooplankton in terms of numbers were measured from 300 hake stomachs. Amphipods and euphausiids were the dominant prey ingested by juvenile hake. *M. capensis* consumes more euphausiids, while amphipods dominated *M. paradoxus*'s diet. Phytoplankton was also found in the stomachs, albeit in small quantities. The percentage of amphipods, euphausiids and other prey items varied in the stomachs of juvenile hake. Juvenile hake have a broad diet characteristic in terms of the size of amphipods and euphausiids they feed on. In cases where euphausiids were ingested together with amphipods, their length sizes overlapped. These results substantiate the belief that juvenile hake select their prey on the basis of availability and/or spatial distribution

Poster # 53

The ecology of stingrays at a remote Indian Ocean atoll

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Globally very little information is available on the ecology of tropical stingrays. Several species, particularly, *Himantura granulata*, *Urogymnus asperrimus* and *Pastinachus sephen* are abundant in the St. Joseph Atoll (S 5°24.9'; E 53°17.9') on the Amirantes Bank, Republic of Seychelles, where it is hypothesized that they play a vital role in the ecosystem through linking trophic levels and affecting community structure through predation and bioturbation. This study aims to investigate aspects of the spatial and trophic ecology of stingrays at this remote atoll, where the proclamation of a no-take MPA is imminent. To date, 30 stingrays have been surgically implanted with acoustic transmitters and will be monitored by an array of 70 receivers deployed across the atoll's lagoon and fringe reef as well as reef slope areas around St. Joseph Atoll, the neighbouring D'Arros Island and other sites on the Amirantes Bank. To further understand the role of these stingrays in the ecosystem, diet sampling will be conducted using gastric lavage. In addition, sediment samples will be taken where the rays have been feeding to assess the availability of all benthic infaunal prey items to determine if they are feeding selectively. In this poster we will describe the methods employed to achieve the project's objectives and present preliminary findings. Although the St. Joseph Atoll is relatively isolated from anthropogenic activities it is still impacted by global change and pollution. Anecdotal evidence suggests that stingray numbers have been subject to fluctuations and there has been an overall decline in abundance over the past two decades. It is thus important to better understand interactions between the dominant species and the role they play in atoll ecosystems.

Poster # 54

A preliminary investigation evaluating geographical and bathymetric overlap between co-occurring catsharks (Scyliorhinidae) and dogfish (Squaliformes)

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In southern Africa, catsharks (Scyliorhinidae) and dogfish (Squaliformes) form one of the most diverse components of the demersal chondrichthyan fauna. A total of 17 catsharks and 21 dogfish occur in South Africa, with most species inhabiting rather similar geographic and bathymetric distributions. Perhaps the most common co-occurring species around South Africa are *Holohalaelurus regani*, *Scyliorhinus capensis*, *Squalus megalops* and *Squalus mitsukurii*. In addition to occurring in common habitats, these four species are known to have similar diets, comprising mainly teleost, cephalopods, crustaceans and other invertebrates. In a first effort to understand co-existence amongst these four species of sharks, we here map the distribution of each species, by size, using data collected by DAFF during the period of 1990 – 2014. This information will be particularly useful in helping us make informed decisions as to where to focus subsequent efforts examining the diets of these sharks using stable isotope analysis.

Poster # 55

Movement behaviour of cape stumpnose *Rhabdosargus holubi* in the Kowie Estuary, South Africa

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Cape stumpnose, *Rhabdosargus holubi*, is a ubiquitous estuarine-dependent fishery species endemic to southern Africa. Adult *R. holubi* almost exclusively inhabit the marine environment where they spawn. Once hatched, early juveniles migrate into estuaries where they spend at least the first year of their lives, and with the onset of sexual maturity they migrate back to sea. Although aspects of the recruitment dynamics of *R. holubi* from sea to estuary have received considerable research attention, little is known about their area use patterns and movement behaviour within estuarine systems. Making use of acoustic telemetry, this study aims to gain a better understanding of the spatial ecology of juvenile *R. holubi* within the permanently open Kowie Estuary. The study will be split into two components: 1) a laboratory experiment to test for internal and external effects of transmitter implantation and presence, and 2) a field experiment to monitor the movement patterns and habitat utilization of acoustically-tagged individuals. The objectives of the laboratory study will be to evaluate tag retention and the effects of the transmitters on recovery, growth and survival. The objectives of the field study will be to determine whether *R. holubi* exhibit site fidelity or ranging behaviour, and to assess the effects of diel, circatidal, lunar and other environmental factors (e.g. water temperature and barometric pressure) on movement behaviour. Fishery surveys have revealed that *R. holubi* is a dominant species in the catches of recreational and subsistence fisheries within several temperate estuaries in South Africa. Therefore, investigating movement behaviour is fundamental to understanding its ecology and implementing effective fisheries management strategies.

Poster # 56

Diet and trophic ecology of the east coast round herring, *Etrumeus teres*

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The Benguela Current system is one of the world's major upwelling systems and supports large populations of small pelagic fishes, which are of substantial economic importance. Four species of small pelagic fish occur off the coast of South Africa: sardine (*Sardinops sagax*), anchovy (*Engraulis encrasicolus*), west coast round herring (*Etrumeus whiteheadi*) and east coast round herring (*Etrumeus teres*). It has been shown that anchovy eat mostly zooplankton (by particulate feeding), whilst sardine feeds on both phytoplankton (by filter-feeding) and zooplankton (by filter- and particulate feeding). Dietary overlap between these two species in sympatry is limited, with anchovy eating larger prey than sardine. Information on the diet of west coast round herring indicates that it eats large copepods, euphausiids and decapods, so dietary overlap with other west coast clupeids is similarly limited. Our understanding of the diet of the east coast round herring is limited to one local study, wherein it was noted that the 30 individuals examined ate mostly fish eggs and large crustacean zooplankton. This too suggests that dietary overlap with anchovy and sardine along the east coast is limited. Here we present the preliminary results of a study that aims to improve our understanding of the feeding ecology of *E. teres* using a combination of gut content analysis, stable isotope analysis and gill raker morphology.

Poster # 57

Spatial patterns in infection of South African anchovy *Engraulis encrasicolus* by a digenean “tetracotyle” type metacercarian parasite

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South African sardine *Sardinops sagax* is host to a digenean “tetracotyle” type metacercarian parasite found in the humours of the fish’s eyes. Spatial variation in infection rates of sardine by this parasite have provided strong support for the hypothesis of multiple sardine stocks off South Africa, with fish from the putative western sardine stock having higher infection levels than those from the putative southern stock. We examined samples of South African anchovy *Engraulis encrasicolus* collected during a survey undertaken in May/June 2013 to determine if this parasite also infects anchovy and, if so, whether spatial patterns in infection are similar to those shown by sardine. More than 1 000 anchovy from 45 localities between Port Nolloth and Port Elizabeth were examined, and their caudal length (CL) recorded and the total number of parasites in each fish recorded. Three indices of infection were calculated per sample; prevalence (% of sample infected), mean infection intensity (number of parasites.infected fish⁻¹) and mean parasite abundance (number of parasites.fish⁻¹). As expected, anchovy showed a clear size-based distribution pattern with smaller fish (recruits) off the west coast and larger fish (recruits and adults) off the south coast. Infection by “tetracotyle” type metacercarian parasites was related to anchovy size, with no parasites observed in fish of <8cm CL, and no or low numbers of parasites in fish >8 cm CL. A spatial pattern in infection of larger anchovy was evident, with those on the western Agulhas Bank showing higher infection levels than fish further east, which is broadly similar to the pattern shown by sardine. In contrast, infection

levels in anchovy appear to be lower than those observed in similar-sized sardine. Research to document temporal variability in infection of anchovy on the western Agulhas Bank is underway.

Poster # 58

Additional parasite data corroborates the multistock hypothesis in South African sardine, and may provide a basis from which to estimate movement

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A “tetracotyle” type metacercarian parasite has been successfully used as a biological tag to elucidate the population structure of sardine off the South African coast. Using data from 2011 and 2012, significant differences in three indices of parasite infection (prevalence of infection, mean infection intensity and mean parasite abundance) between the western stock of sardine (to the west of Cape Agulhas) and the southern stock of sardine (to the east of Cape Agulhas) have convincingly supported the multi-stock hypothesis of this species, with all indices being higher in western fish in comparison to southern fish. Those results have stimulated further developments of stock-specific assessment models for the putative western and southern sardine stocks off the coast of South Africa, but estimating movement between the stocks in these models is a challenge. Here we include additional parasite infection data from 2013 and present results from updated GLM analyses. The additional data corroborate our previous results, indicating that stock still explains the majority of variation in the data for all three indices and providing strengthened support for the sardine multi-stock hypothesis. Additionally, interannual variability in parasite loads is larger than previously estimated, and the length: year interaction has become a significant parameter indicating that there is a difference in the pattern of infection at length by year within each stock. The potential for estimating annual movement of fish from the western to the southern stock using prevalence of parasite infection-at-age is discussed and a preliminary approach is presented.

Poster # 59

Spatial and seasonal variation in the fatty acid composition of sardine *Sardinops sagax* off South Africa

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Fatty acids are a major source of energy for fish and they play a major role in growth and reproduction. Fish do not biosynthesise fatty acid *de novo*, so their fatty acid composition depends on their diet. This linkage provides an opportunity for fatty acids to be used as trophic biomarkers. In this study, we examined seasonal (autumn vs. spring) and spatial (west vs. south coast) fatty acid composition of sardines collected off South Africa during research surveys in 2010. The results show that the docosahexaenoic acid (DHA; C22:6n-3), palmitic acid (C16:0) and eicosapentaenoic acid (EPA; C20:5n-3) are the major components of sardine’s fatty acids with average values of 26.96%, 22.96% and 16.01%, respectively. The t-test shows that the EPA was significantly different in sardines collected from the west and the south coast and in autumn and spring season. The carnivory biomarker oleic acid (C18:1n-9) was found to be higher in sardines from the west coast than from the south coast in spring. Sardines from the south coast had the same polyunsaturated/saturated fatty

acids (PUFA/SFA) ratio of 1.43 in both autumn and spring suggesting that they feed on the same food sources. The PUFA/SFA ratio mainly indicates a predatory or omnivorous feeding. The results also show that the EPA/DHA ratio was high in sardines collected from west coast in spring whilst the south coast ratio is significantly low.

Poster # 60

Diel vertical migration of larval fishes in the nearshore waters of Algoa Bay, South Africa

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Shallow nearshore vertical migration of ichthyoplankton has been well documented around the world. Previous studies have, however, shown inconsistencies in the diel movements of larval fishes, with limited research being done in South Africa. Assemblages of larval fish, driven by different physical mechanisms, can be complex in both species composition and distribution. Investigation into the larval fish assemblages in nearshore waters of Algoa Bay, South Africa was carried out in December 2012, and again in April and October 2013. Larvae were collected by towing bongo nets with mouth diameter of 0.57m and mesh aperture of 500µm behind a boat for three minutes. Tows were carried out along the surface and close to the bottom, at an average depth of 12m. This was repeated twice during the day and again twice during the night, during each sampling session. At the same time bongo flow rate, temperature, depth, and current speed and direction were recorded at the surface and bottom. Samples were fixed in Formalin and later transferred to 70% ethanol, after which they were sorted and counted. Preliminary results suggest that larvae were more abundant at the bottom during the night than during the day, suggesting a descending migration as evening falls. Further analysis with incorporation of the physical data and full species identification of the larvae will be conducted to understand these mechanisms of the fish larval distribution and diel migration patterns better.

Jannasch: Seabirds

Oral Presentations

Seasonal variability in foraging behaviour and habitat use of African penguins, *Spheniscus demersus*, breeding on Dassen Island, Western Cape: Do some like it hot?

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Birds are expected to adjust the timing of their breeding to when environmental conditions are favourable and food is abundant so that their reproductive success is maximized. Thus breeding is typically synchronized to the pattern of optimal and predictable availability of food in the proximity

of the colony. Although the African penguin (*Spheniscus demersus*) can be found breeding throughout the year, a well-defined breeding peak is observed in the austral winter (May to August) for penguins off South Africa's West Coast, which has been attributed to the high abundance of post-larval anchovy (*Engraulis encrasicolous*) from April-September. However, and in contrast to all other breeding sites in the Western Cape, the species' largest breeding colony, at Dassen Island (33 25' S, 18 05' E), shows a historically consistent additional breeding peak in the austral summer (December to February). Seasonal alterations in oceanographic conditions are likely to result in a different assemblage and distribution of prey and thus we hypothesize that these changes in the marine environment will be reflected in the penguin's foraging behaviour. To test this hypothesis and in order to assess to what extent birds can adapt to their changing environment we investigated seasonal variability and spatial changes in habitat use and foraging strategy of chick-rearing African penguins on Dassen Island during winter and summer in three successive years (2010/11, 2011/12 and 2012/13). The use of GPS-TD loggers provides us a three-dimensional view of the penguin's behaviour during foraging that can be related to prevailing ambient oceanographic features. In addition, concurrent small-scale hydro-acoustic surveys were conducted around the island to assess the distribution and abundance of the small pelagic fish on which penguins prey, and diet samples were collected from penguins.

Significant reductions in mortality of threatened seabirds in a South Africa trawl fishery

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Globally, many thousands of seabirds are killed accidentally in demersal trawl fisheries, through cable interactions and net entanglements. However, multi-year datasets for estimating seabird-trawl interactions robustly are scarce. In 2004/05, an estimated 15 500 (7000-26 000) seabirds were killed annually through cable strikes in the South African deep-sea hake trawl fishery; the majority were albatrosses. We reanalysed this using logbook data (previously unavailable). The new estimates are ~40% lower across all taxa: ~9300 birds were killed in 2004 of which ~7200 were albatrosses. We compare this to new data from 2006-10 for wet-fish vessels using a single measure (bird scaring lines) to reduce seabird mortality. From 64 trips and 690 hours of observation, 41 seabirds were observed killed due to cable strikes, of which 22% were albatrosses. Fatal cable interactions occurred overwhelmingly when vessels discarded offal, with the highest rates (birds killed per hour of observation, b/hr) in winter and during setting. Rates in the winter/discard strata were significantly lower after the introduction of bird scaring lines (all seabirds: 0.56 b/hr before, 0.15 b/hr after, $p < 0.001$; albatrosses: 0.44 b/hr before, 0.02 b/hr after, $p < 0.001$). Estimated mortality (mean and 95% CIs) in this fishery in 2010 was 990 (556-1633) seabirds, including 83 (38-166) albatrosses, a reduction in albatross deaths of almost 99%. This dramatic result is ascribed primarily to bird scaring line effectiveness and a halving of the annual fishing effort from 2004-05 to 2010. Bird scaring lines cost <US\$200 each in South Africa, a trivial expense per vessel for a measure that reduces fatal interactions with threatened seabirds so effectively. Our results provide a strong case for the mandatory adoption of bird scaring lines in trawl fisheries with high densities of scavenging seabirds.

Experimental fishing exclusions for penguins in South Africa – a success story

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No-take zones may enhance sustainable use of marine resources and restore the integrity of marine ecosystems, but it is not clear whether they benefit top predators that rely on mobile pelagic fish. Following a >70% decrease of African penguin *Spheniscus demersus* numbers since 2004 in South Africa, experimental exclusions of purse-seine fishing were initiated in 2008 around some of their largest colonies. Fishing within a 20 km radius around one of each pair of colonies was excluded for 2-3 consecutive years while the area around its neighbouring colony (<50km away) remained open. We studied penguin foraging behaviour and breeding output in relation to fishing catches and small-pelagic fish distribution. Results varied strongly between colonies, but for the world's largest African penguin colony, chick growth and breeding success were negatively affected by fishing catches in the vicinity, and foraging effort decreased by 30% during the closure. Re-opening to fishing had dramatic consequences on that population, thereby demonstrating the benefits of relatively small no-take zones for a marine top predator relying on pelagic prey. As a result, a permanent purse-seine fishing exclusion zone was declared in 2014 around the largest African penguin colony. Spatial management of small pelagic fisheries is also currently being considered to reduce catches elsewhere where penguin prey is scarce. The present scientific evidence based conservation strategies benefit local endangered marine predators.

Diving behaviour of white-chinned petrels and its relevance for mitigating longline bycatch

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The white-chinned petrel (*Procellaria aequinoctialis*) is the seabird species most commonly killed by longline fisheries across the Southern Hemisphere. Mitigation measures for seabird bycatch in longline fisheries universally recommend line weighting, to overcome diving seabirds' ability to retrieve sinking baits. Despite the importance of diving ability for mitigating longline bycatch, little is known of this species' diving behaviour. We obtained data from temperature-depth recorders (TDRs) from nine white-chinned petrels breeding on Marion Island, southwestern Indian Ocean, during the late incubation and chick-rearing period. Maximum dive depth (16 m) was slightly deeper than the previous estimate (13 m), but varied considerably among individuals (range 2-16 m). Males dived deeper than females and birds feeding chicks dived deeper than incubating birds, but dive rate did not differ between the sexes. Time of day had no significant effect on dive depth or rate. Our findings will help the design and performance characteristics of mitigation measures aimed at reducing seabird bycatch in longline fisheries. These results will aid in the design of new mitigation devices and improve existing mitigation measures, such as the calculation of minimum line sink rates and optimum aerial coverage of bird-scaring lines.

Poster # 74

Data management technology for monitoring bycatch in international fisheries: A case study

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The incidental capture or bycatch of non-target species in marine fisheries is occurring at an unsustainable level. Seabirds are particularly affected, with fishery interactions considered the key threat to most species. Longline and trawl fisheries have been recognised as having a significant impact on albatross, petrels and shearwaters. Seventeen of the 22 species of albatross are currently threatened with extinction. In 2006 BirdLife International founded the Albatross Task Force (ATF): an international team of mitigation instructors working directly with the fishing community to demonstrate the best practice design and use of mitigation measures. To monitor and record seabird interactions, mortality events and technical aspects of mitigation design effectively, BirdLife International has retained the services of Olrac SPS to customize its GIS based Olrac Dynamic Data Logger software to meet the data collection and reporting needs of the ATF team's, on-board observers. The ATF version of Olrac allows observers to capture 320 different fields including target and bycatch species, fishing gear configuration, mitigation measure configuration plus wildlife surveys and extensive environmental variables. Data can be collected in many forms and formats including pictures, video clips and free text. The ATF is currently using Olrac DDL in eight countries in southern Africa and South America. In addition the ATF deployed three shore units of the Olrac system as a central hub of data in each country plus a centralised meta-unit capable of integrating data from all countries into a master database.

Poster # 75

Heat tolerance in the African Penguin in the face of climate change

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The African Penguin was classified as 'Endangered' by the IUCN in 2010, due to the loss of >50% of its global population since 2004. The major threats occur at sea, from oil spills and low prey availability. However, habitat loss on land due to former guano scraping can be a major issue for African Penguins, as it exacerbates heat stress. Historically, most African Penguins bred in burrows in guano that provided protection from aerial predators, as well as providing a buffered microclimate. Penguins are generally sensitive to heat stress and, during extremely high temperatures, leave their nests unattended to cool down in the sea. This is often fatal for the broods in exposed surface nests, which are subject to predation, over-heating, and rain. Since climate change increases the frequency of extreme weather events, the situation is worsening for an already stressed species. Previous studies and pilot data indicate that these effects can be improved by artificial nests or nest-covers. However, it is still unknown whether these structures can fully replace natural burrows and provide sufficient protection in the face of climate change. In order to understand potential consequences of climate change on African penguins, it is crucial to understand their physiological and behavioural capacities and the limitations of their abilities to thermoregulate. This study seeks to (1) pinpoint the temperature where heat stress begins in adult African Penguins, (2) understand the behavioural responses of penguins to increased temperatures, (3) estimate inter-colony and nest type differences to temperature, (4) determine how extreme weather events can affect African Penguin breeding

success and (5) evaluate the effectiveness of artificial nests and make suggestions for design improvements. The results will help to predict how African Penguin populations may be affected by future climate changes, as well as informing management actions to limit such impacts.

Poster # 76

Evidence for phenotypic assortative mating in the red-footed booby (*Sula sula*) at Tromelin Island, South-Western Indian Ocean

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The Red-footed Booby (*Sula sula*) is a strongly polymorphic species with four definite colour morphs and various intermediate forms represented throughout its range. A ratio-cline, defined as graded alternations in the frequency of morphs within a polymorphic system, exists in this species where most populations are dominated by a single morph at one extreme of the cline. The colony at Tromelin Island, in the western Indian Ocean, shows an unusual, yet stable, mix of the plumage types however. We investigated the mating pattern in this population so as to identify the potential forces that might act to maintain such a high degree of polymorphism. The colour morphs of 1 335 breeding adults were identified, most of which were either all-white (62%) or white-tailed brown (26%) individuals. The three intermediate forms all occurred in low abundance ($\leq 6\%$). Mating pairs consisted mainly of birds of the same morph (54%), whilst white-tailed brown birds also frequently mated with intermediate forms (9%). These results differed from the expected pairing pattern suggesting that mating is assortative and, as such, we propose that the morph ratio at Tromelin Island has remained stable over time because of biological segregation of the different morphs.

Poster # 77

Penguin parenting: assortative mating and nest attendance patterns on Bird Island, Algoa Bay

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The African Penguin (*Spheniscus demersus*) is an iconic top marine predator that breeds nowhere else besides 27 colonies off the coast of southern Africa. Its unprecedented population decline to only 26 000 breeding pairs has cemented the species' "Endangered" status. It is thus of critical importance to understand the population dynamics of this threatened seabird. Bird Island (33°50'29"S 26°17'13"E), the largest of the Algoa Bay islands, is home to approximately 3 000 breeding pairs of African Penguins and was the location for this study, the aim of which was to determine if breeding adults on this island mate assortatively (according to particular morphometric characteristics) and whether or not this confers an advantage to their fitness. The sex of adult birds was validated by a universal molecular-sexing technique, making use of feathers collected from all handled birds. Chicks were sexed as well, to determine any gender-based hatching asynchronies, and weighed and measured every five days to determine growth rate. As we know that female African Penguins suffer higher adult mortality, we investigated parental investment in offspring, according to the number, sex composition, nest attendance patterns (with the aid of three CCTV surveillance video cameras) and rate of growth of the brood to assess if female-biased mortality could be reflected in differential investment. It appears that larger birds as well as better assorted pairs are

the best parents, raising larger broods and faster-growing chicks than smaller, mismatched pairs. Breeding biology parameters such as these lend themselves to detailed assessments of the reproductive capabilities and limitations of the breeding population as a whole.

Poster # 78

Major histocompatibility complex (MHC) diversity in African Penguins *Spheniscus demersus*

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Major histocompatibility complex (MHC) genes are among the most variable in the vertebrate genome and play a pivotal role in immune-competence, in triggering appropriate immune responses. A large body of data supports a model of MHC evolution under positive selection, with polymorphisms maintained by balancing selection. Selection is thought to be mediated via pathogens and/or mate-choice. Both coding and non-coding regions of the genome are subject to the effects of neutral evolutionary processes, but MHC genes are additionally subject to selection, reflecting adaptive changes in populations. It is important to characterize this adaptive genetic variation, as it represents a species' ability to respond to changing environments. Reduced MHC variability following long-term population decline, especially in combination with strong selective pressure, can have repercussions for the overall fitness of populations, and can significantly limit population-wide responses to novel pathogens. The African Penguin *Spheniscus demersus* is a breeding endemic to southern Africa and the population has decreased by more than 95% since the turn of the 20th century. Levels of neutral genetic diversity indicate that the genetic risks associated with bottlenecked populations do not pose an immediate threat to African Penguins. However, as the wild population continues to decline, captive breeding programs are increasingly being considered as potential management tools, and are being implemented by a number of institutions South Africa. Accordingly, there is a clear need to understand factors which influence survival and breeding success of captive birds once they are released. To better understand the adaptive significance of the African Penguin population decline, this project aims to (i) identify expressed loci at the MHC of the African Penguin (Class I and Class II), and (ii) estimate and compare MHC diversity at these loci (in terms of copy number and genetic diversity) among breeding regions of wild African Penguins.

Poster # 79

A system dynamics approach to modelling multiple drivers of the African penguin population on Robben Island, South Africa

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The African penguin (*Spheniscus demersus*) population in southern Africa has experienced rapid decline in the 20th century. There is an urgent need for decision support tools to enable effective management of colonies. We present a system dynamics model of the penguin population on Robben Island, South Africa, that combines a demographic simulation with the modelling of multiple pressures including food availability and food competition by commercial fisheries, oil spills, predation by terrestrial and marine predators, and extreme climate events. The model is stochastic, stage-specific and resource-driven, and incorporates both well-defined, quantitative field data and qualitative expert opinion. Survival rates for eggs, chicks, immatures and adults were adapted from field data and an earlier model of this population to create a simulation of a stable population used in a variety of scenarios and sensitivity tests. The modelled population was found to be strongly driven by food availability and to a lesser degree by oiling and marine predation, while climate events and terrestrial predation had low impacts. Food biomass levels (small pelagic fish) in the penguins' foraging area around the island (used during nesting) and further afield (used during the rest of the year) had an equal influence in driving population development in the short and long run. The impact of short-term (three years) fishing restrictions currently being trialled around the island was found to be generally beneficial to the modelled population, but easily masked by food-driven variability in population growth. The model is being extended to other populations, starting with the Dyer Island colony, to provide tools for specific management decisions and to enable the study of meta-populations by modelling migration between colonies. Our results suggest that improving food availability and mitigating the impact of oiling would have the highest beneficial impact on this penguin population.

Fismer: African Marine Mammal Colloquium (Part 2)

Oral Presentations

Namibia's cetaceans - patterns of biodiversity in the Northern Benguela ecosystem

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The cetacean community around southern Africa is among the most diverse in the world, but has been poorly studied. No data on broad scale patterns of diversity are available since the late 1980s

despite considerable changes in the marine ecosystem since this time and increasing human impacts. We present an updated cetacean faunal list for Namibia for records since 1990 and describe patterns of spatial and temporal variability therein. Data have been collated from a range of sources including stranding records, 6 years of dedicated inshore surveys in Walvis Bay and Lüderitz, 3 years of shelf wide surveys in the Namibian Islands Marine Protected Area, 3 aerial surveys of the coast, and opportunistic data from observers on research, survey, fishing and tour vessels. Data from opportunistic platforms were filtered and weighted for confidence based on observer experience and ease of species identification. Cetacean diversity in Namibian waters is highest at the shelf break with 16 species identified of an overall 25 recorded since 1990. Only 8 species of cetacean were recorded at sea within 5km of the coast. All species recorded at sea were also recorded stranded except Risso's dolphins. Two new species were recorded; a single stranded dwarf sperm whale and a vagrant North Pacific gray whale. Baleen whales were present year round with clear seasonal peaks, which differed with latitude. Dolphins in the coastal zone of Namibia show clear differences in habitat use and seasonality between Walvis Bay and Lüderitz. These results provide an important update to biodiversity assessment in southern Africa, but are only a baseline. We conclude by providing a critical assessment of the data gaps and discussing potential cost-effective solutions to cetacean biodiversity assessment in the region.

Abundance and residency of humpback dolphins (*Sousa chinensis*) in Mossel Bay, South Africa

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Indo-Pacific humpback dolphins (*Sousa chinensis*, *plumbea* form) inhabit near shore waters from South Africa to eastern India. Humpback dolphins are vulnerable to conservation threats due to their naturally small population sizes and use of near shore habitat bringing them into contact with high levels of human activity including bycatch, vessel activity, pollution and coastal development. The population using the south coast of South Africa is at the western limit of the species range and potentially isolated from populations to the north east by a low density area off the Transkei coastline. We assessed the abundance and residency of humpback dolphins using Mossel Bay (MB) (22° 08'E) between April 2011 and November 2013 using photographic mark-recapture and compared our catalogue with data collected opportunistically in Plettenberg Bay (PB) (23° 20'E) between 2006 and 2013. We identified 72 individuals in MB and 44 in PB, with 9 seen in both locations. A series of closed capture models using the Huggins log-likelihood method was run to produce within year population estimates (2011: 103, 95% CI: 49 – 216; 2012: 48, 28 – 81; 2013: 64, 33 – 124). Partially-time dependent open population modelling using the POPAN parameterisation produced a 'super-population' estimate of 113 animals (95% CI: 53 – 240) using MB. Residency of individuals was variable with two seen more than 10 times but 29 seen only once suggesting limited use of MB. Low resightings and common use of both MB and PB by some individuals supports previous findings of long range movements in the species and highlights the necessity of a broad scale, multi-location study to accurately assess this population's total abundance and ranging patterns. This study provides the first abundance estimate for the species in southern African waters in over 15 years and provides an important baseline from which to assess future impacts on the population.

The distribution of Antarctic blue whales and other cetacean species encountered along the Queen Maud Land coast of Antarctica

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The International Whaling Commission's IDCR and SOWER programmes carried out between 1968 and 2010 established that the 0 - 20°E ice edge area of the Antarctic contained high concentrations of Antarctic blue whales during their summer feeding period. Such concentrations provided an ideal opportunity to assess both Antarctic blue whale distribution in this area and how they are dispersed relative to other cetacean species. Line transect survey data were collected from the *SA Agulhas II* on 16 transects between 0 – 17.5°E and out to 60 nautical miles from the ice edge, over a period of 9 consecutive days in January 2014. A total of 82 hours of survey effort was conducted with a further 40.3 hours spent confirming and closing in on whale groups during a total of 851 nautical miles, and 214 sightings of cetaceans were made. Seventeen of these were of Antarctic blue whales with a total of 26 whales seen aggregated in three main areas centred on 007°30', 010° and 015°E. The most commonly encountered cetacean species were minke whales (92 groups of 238 individuals), the majority (95%) of which were observed east of 008°E. Fourteen groups of 31 fin whales were encountered (84% of which were seen west of 010°E). The majority of the 21 humpback whale sightings (of 39 individuals) were associated with the ice edge and distributed across the longitudinal area of this study. Two groups of sei whales and three killer whale sightings were also associated with the ice edge. Besides eight groups of 22 southern bottlenose whales, one group of unidentified dolphins and one group of unidentified small whales no other small cetaceans were seen. The distributions of sightings are discussed in relation to environmental parameters, including water depth, temperature, salinity and distance from the ice edge.

Acoustic estimations of Antarctic blue whale *Balaenoptera musculus intermedia* relative abundance and distribution using IWC sonobuoy data from 1995 to 2009

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Antarctic blue whales are one of the endangered large baleen whales recovering from the extensive whaling pressure experienced in the 20th century. Blue whales are very vocal marine mammals capable of producing powerful sounds that can travel from a hundred to thousand or so kilometres, and these sounds can be used to estimate the relative abundance of the blue whales population. This study uses acoustic data collected from 409 of over 700 sonobuoys deployed between 1995 and 2009, on IWC research cruises (the International Decade of Cetacean Research and Southern Ocean Whale and Ecosystem Research circumpolar cruises) in the Southern Ocean south of 60°S in summer, when co-incident visual observations of blue whales were made during line transect surveys. Blue whale presence/absence shows a high correlation between the visual and acoustic data. Both the quantity and call type of blue whale vocalisations detected from sonobuoys varied significantly between years although was dependent on recording effort. The characteristics of both the Z- and D-calls of blue whale calls detected using automatic detection algorithms are described from a total of 1505.09 hours acoustic monitoring. The relative abundance, movement and distribution of blue whales were estimated from demultiplexed acoustic data, and found to vary significantly between years. This study verifies the population status and recovery rate by estimating the relative abundance of blue whales over years while highlighting important habitats of blue whales in the Southern Ocean. Relative abundance estimation of blue whales from acoustic data remains an

important new technology for improving the management and protection of this depleted and cryptic whale species.

Passive Acoustic Monitoring of Cetaceans in Namibia - a case study involving bottlenose dolphin signature whistles

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The field of bioacoustics is becoming increasingly important in conservation biology. Passive acoustic monitoring (PAM) is particularly amenable to cetaceans, which rely heavily on acoustic channels for their daily interactions with each other and their environment. When applied correctly PAM can be highly cost effective and is particularly suitable for use in Africa where finances are often limited but large data gaps exist. The Namibian Dolphin Project uses a range of PAM devices to generate information on individual and species occurrence, distribution and behaviour. During this presentation we will describe the methods we use and share our experiences of applying this technology. We focus on the results of a recent study to identify and describe bottlenose dolphin signature whistles using a single element hydrophone. A signature whistle is a learned, individually distinctive whistle type in a dolphin's repertoire that broadcasts the identity of the whistle owner. Signature whistles remain stable throughout life and recent studies have suggested that signature whistles could be used in mark-recapture analysis to investigate individual habitat use or ranging patterns. We identified 28 signature whistles from a population of approximately 100 wild common bottlenose dolphins (*Tursiops truncatus*) inhabiting Walvis Bay. The acoustic parameters were consistent with those of signature whistles from Sarasota Bay (Florida, USA). Whistle structure apparently remained stable over time and location, with most types (82%) recorded in 2 or more years, and 4 identified at Walvis Bay and a second field site approximately 450 km away. More signature whistle types were recorded in larger groups and groups with calves present. We used this simple, low-cost system to generate novel data on the acoustic behaviour of bottlenose dolphins, but highlight limitations if using signature whistles to replace photo-identification in a mark-recapture framework.

Revealing southern right whale vocalisations in False Bay, South Africa

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The vocalisations of southern right whales are an important functional aspect of their behavioural ecology, and changes in whale vocal behaviour are indicative of other changes – both in their daily activities over a 24-hour cycle (diel vocalisations), and in their acoustic habitat over the short and the long term (indicating seasonal and potentially more permanent changes, respectively). Using passive acoustic monitoring techniques, underwater sounds, including vocalisations of southern right whales, were recorded continuously over 30 days (720 hours) in October, 2012 in False Bay, South Africa, in order to investigate southern right whale acoustic communication and habitat use over this period (when the whales mass in numbers in bays off southern Africa to mate and calve). The focus was on both temporal variation and call types, with an emphasis on up calls. Calls were automatically extracted based on call parameters using dedicated software (Raven 5.1, Cornell Laboratory of Ornithology), and later verified both aurally and by inspection of spectrograms. This study provides the first baseline data for diel vocal activity of southern right whales in False Bay,

against which the vocal patterns of southern right whales at other times and in other habitats may be compared, with the potential to reveal both unexpected activities and presence at unexpected times and locations, and damaging changes in the acoustic environment. In the future a comparison of the vocal activity of southern right whales in False Bay with that off St Helena Bay on the west coast of South Africa (where they are believed to remain in the area for longer periods to feed in the nutrient-rich waters off Cape Columbine) will add to our understanding of the lives of southern right whales and the challenges they face.

Non-offspring nursing in the southern right whale: a first for baleen whales

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During the austral winter, female southern right whales *Eubalaena australis* enter South African coastal waters to give birth and raise their young. Most births take place over a four-month period, when the females congregate in favoured coastal nursery grounds for up to a recorded maximum of 105 days. At such times and places the density of cow-calf pairs can reach as high as 3.2 pairs/km² over 26 km of coastline. Although a single young is born and suckled exclusively for seven months to a year, recent observations on nursery grounds include three incidents where apparently abandoned/orphaned calves-of-the-year have been seen associating with a minimum of 2 - 3 different cow-calf pairs over periods of 11-38 days. Attempts to suckle from these females have been noted in two of the cases, with the response of the female varying from extreme avoidance to apparent tolerance. In one instance where the observations of the same trio extended over 21 days, the non-offspring appeared to out-compete the real calf, even though the mother directed her evasive tactics more at the non-offspring than her own calf. At the same time both of the calves exhibited some growth in length when compared with the size of the adult female. The subsequent survival of the non-offspring and real calves is unknown. Non-offspring nursing in monotonous species is generally rare, and the costs to the female potentially high: this is certainly the case for seasonally feeding mysticetes such as the right whale, where the costs of lactation cannot be recovered until the cow resumes feeding about 4 months after parturition. Hence it is perhaps not surprising that these are the first recorded observations of simultaneous nursing attempts by offspring and non-offspring of a mysticete.

Social structure of killer whales at Marion Island, Southern Ocean

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Killer whale populations that have been studied to date have matrifocal social structures with long-term, stable associations among animals. Features such as group size and dispersal, however, appear to be linked to foraging specializations. Killer whales at Marion Island, Southern Ocean, feed on penguins and seals, and some individuals depredate Patagonian toothfish from longline vessels. We analysed more than 40,000 identification images taken over the period 2006-2013 to describe aspects of the social structure of killer whales at Marion Island. We identified 56 individuals; most (84%) were seen in multiple years and seven animals were born during the study period. Average group size (2,821 sightings) was 3 individuals. Only good quality photographs were used for analyses

in SOCPROG, Gephi and UCINET. By defining co-occurrence of individuals in the same group as an association, the Half Weight association index was calculated for each pair of animals. Analysis based on 40 animals (2,176 identifications) indicated a highly differentiated society and a null hypothesis of no preferred or avoided companionships was rejected. We identified 8 clusters of individuals using a community detection algorithm (average size = 4, range = 3-10); most clusters appeared to correspond to matrifocal social units within the community. Genetic relatedness was significantly, but weakly correlated with association index, although a few negatively related dyads had high association indices. Standardised lagged association rates indicated long-term, stable social units which associate with each other but rapidly disassociate. Comparison of network measures of different age-sex classes provided no evidence for 'roving males' in the community. Social dispersal of some individuals was documented. Overall these aspects are similar to those in mammal-eating *transient* killer whales and point towards constraints imposed by diet.

Fismer: Biodiversity and Taxonomy

Oral Presentations

Changes in habitat complexity resulting from sequential invasions of a rocky shore: implications for community structure

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Worldwide, marine rocky shores are being modified by alien species, but their sequential impacts are rarely recorded. We documented sequential invasions of Marcus Island on the west coast of South Africa by comparing communities from 1980 (pre-invasion), 2001 (after invasion by the mussel *Mytilus galloprovincialis*) and 2012 (following invasions by another mussel *Semimytilus algosus* and the barnacle *Balanus glandula*). Their influence on habitat complexity was measured with a novel and retroactive method in Blender, a 3D graphics program. In 1980, habitat complexity, invertebrate abundance and species richness increased from the highshore to the lowshore, but became more homogenous in 2001 when *M. galloprovincialis* elevated complexity across most of the shore. In 2012, these variables returned to pre-invasion values after *M. galloprovincialis* declined on the high shore, where it was replaced by *B. glandula*, and *S. algosus* has appeared in the low shore. Community composition differed significantly among nearly all years and zones. Some once-dominant native species were negatively affected by the invasions. One indigenous mussel, *Choromytilus meridionalis*, disappeared by 2012, while another, *Aulacomya atra*, declined overall while increasing in some zones, and abundance of the limpet *Scutellastra granularis* rose and fell with the arrival and then waning of *M. galloprovincialis*. Changes in habitat complexity induced by the sequential invasions could reliably predict changes to invertebrate abundance and species richness, but could not alone predict changes in community composition.

Species richness and biogeographical distribution of South African Bryozoa

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Previous studies on South African bryozoans, especially those collated from earlier sampling expeditions in the late 18th and early 19th century. South African bryozoans literature dates back to the mid-19th century, and although approximately 290 species have been identified, the inventory is characterised by high levels of synonymy and a tendency to assign European names to local species. Historically, sampling effort was focussed mainly from the waters of the south and east coasts and shallow waters of the west coast. Evidently, there is a sampling gap from deep off-shore regions of the west coast and taxonomic revision of this phylum has been neglected due to lack of interest and scarcity of taxonomists. The project aims include updating bryozoan biodiversity by identifying species from existing collections housed in natural history museums (e.g., Iziko South African Museum, Cape Town and Natural History Museum, London); analyse current regional bryozoan biogeography, mainly focussing on bathymetric distribution, through collating existing literature and primary biodiversity data (published and museum records). To date, approximately 405 specimens (of approximately 600 unsorted specimen lots) have been sorted from existing museum material from south- and west coast deep-sea surveys, comprising more than 150 species. Preliminary analysis of species richness and biogeographical distribution along the South African coast will be conducted.

Predicting and explaining impacts of invasive mussels in South Africa: comparative functional responses in applied invasion ecology

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There is a pressing need to understand the processes associated with the impacts of alien invasive species. Invasive species are characteristically more rapid and efficient in utilising resources than natives. Therefore comparing resource use among known, emerging and potential invaders and trophically analogous natives could allow for more reliable predictions of impact. Similarly by investigating resource use under different environmental contexts, such as climate change scenarios, predictions may be made on future invasive species impacts. In South Africa, *Mytilus galloprovincialis* is an invasive mussel that has transformed wave-exposed shores and has subsequently altered population structure of the native mussel *Aulacomaya atra*. Currently, South Africa is experiencing a second mussel invasion with the recent detection of *Semimytilus algosus* that is resulting in competitive exclusion of the native species at wave-exposed sites. While *M. galloprovincialis* occurs along the entire west coast and up to East London, *S. algosus* has not yet breached the biogeographic break at Cape Point and remains restricted to the west coast. Moving eastward, sea temperatures become warmer and it is unknown how *S. algosus* will perform in this range. In addition, temperatures on the west coast are predicted to cool in future with unknown impacts on each of the mussel species. We will therefore report on the comparison of resource utilisation by each mussel species (*M. galloprovincialis*, *S. algosus* and *A. atra*) over a range of resource availabilities, that is, their functional responses. These functional responses will be related to field abundances of the three mussels. In addition we will investigate the effect of temperature by experimenting under a range of conditions that reflect forecasted future climate changes. By including warmer temperatures we will also determine the relative potential impact of *S. algosus* if it is to become established along the south coast.

Patterns and drivers of marine bioinvasions in eight Western Cape harbours

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In South Africa fouling is the dominant vector of marine invasions, being responsible for 48% of the 86 alien introductions that are known. This study aimed to document alien species in fouling assemblages in eight Western Cape harbours and to assess patterns and potential drivers of these invasions. In each harbour, 10 visual (1 m × 1 m) and 10 scrape (15 cm × 15 cm) subtidal samples were randomly collected at depths between 1 and 5 m. In total, 22 marine alien species were detected and although no statistical differences were evident in the number of alien species recorded per harbour, the number of alien species per m² differed significantly among harbours, with Hout Bay Harbour having the highest. The brachiopod *Discinisca tenuis*, documented for the first time outside of aquaculture facilities, was found to have spread from Saldanha Bay to St Helena Bay. A previously unknown alien amphipod, *Erichthonius difformis*, was detected in Simon's Town Harbour. CART (classification and regression tree) analyses revealed that relatively small harbours with yachts supported more alien fouling species than other harbours. This finding could be useful for managers wishing to prioritise Western Cape harbours for monitoring.

The detection, occurrence and spread of marine alien species in Saldanha Bay

A Biccard

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An estimated 86 marine species have been recorded as introduced to South African waters (Mead *et al.* 2011). At least 62 of these are thought to occur in Saldanha Bay and Langebaan Lagoon. Since the inception of a long-term annual monitoring programme, which evaluates the health of Saldanha Bay and Langebaan Lagoon, the presence of 42 introduced marine alien species can be confirmed. A variety of methods are employed in order to monitor the health of this system. These range from intertidal rocky shore surveys to benthic macrofauna samples retrieved on SCUBA and beach seine netting. Covering all these habitats provides an ideal opportunity to detect newly introduced alien species and to monitor the spread of known introduced species. Major findings include the spread of the pea crab, *Pinnixa occidentalis* throughout Small Bay and its encroachment into Big Bay and Langebaan Lagoon and a new invasive sessile cirripede, *Menesiniella regalis*, which has recently been detected on the rocky shore and has spread rapidly throughout the system. These two species and at least another three which are as yet unidentified constitute new additions to the fauna of South Africa. Their respective impacts on the indigenous biota and ecosystem are not yet apparent. Further monitoring is required in order to gain an understanding of any potential impacts of these introduced taxa. Most importantly, in order to increase detection of introduced alien species, an increase in the output of experts in the field of taxonomy is needed together with sustained sampling effort in hotspot areas.

Temperature dependent development of two poecilogonous polychaetes, *Polydora hoplura* and *Boccardia proboscidea* (Polychaeta: Spionidae) with implications for life history theory, establishment and range expansion

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Marine invasions are recognized as an important threat to global biodiversity and predicting the establishment and spread of an introduced species can aid efforts to mitigate the damage incurred by these species. To determine if the recently introduced polychaete *Boccardia proboscidea* can establish itself along the South African coast and subsequently expand its range we assessed its reproductive output, larval survivorship, developmental time and developmental rate under temperature regimes reflective of the South African coast. For comparison, we also investigated development in the well-established non-indigenous polychaete *Polydora hoplura*, which can serve as a control for our predictions. Worms were cultured under five different temperature treatments and planktotrophic and adelphophagic larvae were tracked from oviposition to settlement. Temperature had no significant effect on brood size for *B. proboscidea* or for *P. hoplura* producing planktotrophic larvae. However, *P. hoplura* producing adelphophagic larvae had smaller broods at the highest temperature treatment. Temperature had no significant effect on the size at emergence of planktotrophic larvae of *P. hoplura* while higher temperatures resulted in a larger size at emergence for adelphophagic larvae of this species and also for both larval types of *B. proboscidea*. In *P. hoplura* survivorship was highest at the intermediate to high temperature treatments and lowest at the extreme temperatures. In *B. proboscidea*, both larval types showed different survival optima with planktotrophic larvae exhibiting its highest survivorship at the colder temperatures and lowest at the warmer temperatures while adelphophagic larvae had its highest survivorship at intermediate temperatures and its lowest at the extreme temperatures. There was an inverse relationship between temperature and developmental time and consequentially a positive relationship between temperature and developmental rate. Our results indicate that *B. proboscidea* will be capable of producing viable populations at different points along the South African coast including those where *P. hoplura* has already been established.

Fismer: Biodiversity and Taxonomy

Oral Presentations

Ichthyoplankton of the KwaZulu-Natal Bight, South Africa

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Little is known of the marine larval fish community of the KwaZulu-Natal Bight, with the only previous study dating back to 1990/1991. The African Coelacanth Ecosystem Programme (ACEP) KZN Bight Functioning Project, which examined nutrient sources and trophic ecology of the Bight, presented an opportunity to examine larval fishes in this area. This study reports on preliminary results from a subset of samples from two synoptic surveys conducted in January (summer) and July (winter) of 2010. Oblique bongo nets (2 x 500µm) were towed at inshore (~30m depth), mid-shelf (60 - 400m depth) and offshore (~1000m depth) stations along coast-perpendicular transects off Durban, Thukela mouth and Richards Bay. In the 18 samples examined, 417 fish larvae, representing 65 taxa from 39 families were found. Highest abundances occurred in winter at the inshore Thukela station followed by the offshore Durban stations. Myctophidae were the most abundant (18.3% of all larvae) followed by Scombridae (8%) and Bregmacerotidae (7.5%). Results indicate that larvae occurred in

spatially coherent distributions. For example, Myctophidae were consistently predominant in winter at all stations, with particularly high abundance in a single inshore station off Thukela. Scombridae generally occurred in the offshore waters, with the exception of a peak in abundance at inshore and mid-shelf stations off Richards Bay in summer. Bregmacerotidae consistently occurred at mid-shelf stations across both seasons and offshore in winter with highest abundances off Richards Bay. Results are presented in the light of physio-chemical parameters measured concurrently with the biological sampling and are discussed in the light of the limited historical studies.

Patterns in demersal ichthyofauna in the KwaZulu-Natal Bight

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Unlike other coastal provinces, KwaZulu-Natal (KZN) does not support substantial marine fisheries and there have been few investigations of demersal organisms over unconsolidated sediments here. The trawl grounds comprise <40% of the sea bed area between Durban and Richards Bay, so the biodiversity of a considerable part of this habitat is poorly known. The ACEP KZN Bight project was therefore a welcome opportunity to examine, *inter alia*, the demersal fauna from hitherto largely unexplored areas of the KZN shelf. Demersal trawls were undertaken in transects through four nutrient-source focus areas in March and August 2010. In the 41 successful trawls, fishes comprised 60% and 70% of catches by number and weight respectively, and 165 fish taxa (78 families) were caught. Broadly, trawls in the upper and mid-slope depths caught the highest number of species; shallower trawls on the shelf and on the slope caught more than deeper trawls in those areas, but with considerable variability. As expected, the composition of the KZN Bight demersal ichthyofauna differed markedly from that found on the Cape south and west coasts; the Western Australian slope-trawled ichthyofauna are similar to those in this study, with many coincident genera. However, there are striking affinities with communities from the East African coast. No obvious separation of samples on the basis of season or focus area was apparent, but depth was clearly a factor. However, substratum also played a role - the Thukela River has a marked influence on the composition of the Bight's demersal fishes, particularly in shallower water, corroborated in trophic studies by de Lecea et al. (also being presented at SAMSS). The unique nature of fish communities off the Thukela River is part-motivation for a large MPA in the area, which is increasingly the focus of change-inducing disruptions such as impoundments and mining.

The ichthyofauna of Walter's Shoal, a shallow seamount in the south-western Indian Ocean

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Seamounts are isolated and abrupt topographic features that rise up more than 1000m in height from the abyssal plane to provide unique island-like habitats within oceanic waters. Walter's Shoal, an isolated shallow seamount on the Madagascar Ridge, is the only known seamount in the south-western Indian Ocean that rises to within the photic zone. Previous investigations identified a shallow-water ichthyofauna comprised mostly of wide-spread temperate species common to the West Wind Drift islands and tropical Indo-West Pacific species, but included some endemics. During a

30-day cruise aboard the *RV Algoa*, we deployed baited remote underwater stereo-video systems (stereo-BRUVs) to investigate the ichthyofaunal distribution in relation to depths, diel patterns and current regimes on the seamount. Together with the use of physical samples (fishing and diver collections), we provide a detailed inventory of the ichthyofaunal distribution in relation to inhabiting the different habitats on Walter's Shoal. Distribution patterns are compared to those of the adjacent coastal shelf habitats and islands of the West Wind Drift chain to place the ichthyofauna of Walter's Shoal within a regional biogeographic context.

The importance of *Acropora austera* as nursery and refuge areas for fish species on South African coral reefs

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Many coral reef fish species use mangrove and seagrass beds as nursery areas. However, in certain regions, the absence or scarcity of such habitats suggests that juvenile coral reef fish may be seeking refuge elsewhere. The underlying biogenic substratum of most coral reefs is structurally complex and provides many types of refugia; however, for young or subtropical coral reefs, species may be more reliant on the living coral layer as nursery areas. Such is the case on the high-latitude coral reefs of South Africa where the coral communities consist of a thin veneer of coral overlaying late Pleistocene bedrock, which rarely extends deeper than 30 cm. Thus the morphology of coral species may be a major determinant in the availability of refuge space. *Acropora austera* is a branching species that forms large patches with high structural complexity. Associated with these patches is a diverse community of fish species, particularly juveniles. Over the past decade, many of the large *A. austera* patches (>100 m²) at Sodwana Bay have been diminishing rapidly for unknown reasons. To investigate the importance of *A. austera* patches as refugia and nursery areas, eight patches of varying sizes were selected and monitored for 12 months using visual surveys. Results indicated that there are significant differences in fish communities between *A. austera* patches and areas of normal coral cover. In total, 121 species were recorded within the patches compared to 104 species outside the patches. Labrids and pomacentrids were the dominant species, while juvenile scarids, acanthurids, chaetodonts and serranids were also abundant. Diversity and abundance of fish species increased significantly with patch size. As the most structurally complex coral species on the reefs, the loss of *A. austera* may have significant implications for the recruitment and survival of certain fish species.

Assemblage dynamics of larval fishes associated with various shallow water nursery habitats in Algoa Bay, South Africa

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The success of the larval stage in fishes plays a critical role in structuring adult fish populations. The larval phase however, particularly pertaining to nursery habitat use, remains poorly understood in South Africa. One of the present concerns of fish biologists globally, involves defining and identifying nursery habitats in the context of conservation and resource management strategies. Although information exists on the use of nursery habitats by juvenile fishes, there is a general lack in knowledge of the relative value of coastal habitats as nursery areas for fish larvae. A mosaic of coastal habitats exists however which are available as nursery areas for larval fishes in coastal waters. For this reason, a mixed-method, larval and juvenile fish study was conducted in the warm-temperate shallow coastal waters of Algoa Bay, South Africa. Two years (2010 – 2012) of seasonal

sampling at 27 stations at various habitat types revealed distinct spatio-temporal patterns in larval fish composition and abundance. The relative importance of subtidal reef, sand, nearshore, surf and estuarine mouth habitats as larval fish nursery areas was assessed. This effort was accomplished within the framework of community composition, developmental stages and the associated environmental variables of each habitat type structuring the larval fish community. Distinct larval fish communities were identified within each of the coastal habitat types sampled in Algoa Bay. Coastal habitats such as those occurring in Algoa Bay are highly dynamic environments that are subjected to a variety of physical processes operating on numerous spatial and temporal scales. These processes had a profound influence on larval fish distribution and composition. A critical area in which knowledge of the linkages between larval fish and environmental processes is lacking, is the coastal environment. It is within coastal ecosystems that spawning, accumulation, retention and settlement of larvae occur.

Baited remote underwater video system (BRUVs) survey of the relative abundance and seasonal diversity of ichthyofauna in False Bay

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Increasing anthropogenic pressures on our oceans have amplified the global focus on an ecosystem-based approach to conservation. This has renewed focus on elucidating how fish are distributed across a region and which environmental factors aid understanding of differences in community assemblages. Establishing this baseline information for regions and species of interest informs sustainable monitoring efforts, and contributes towards evidence-based marine spatial planning. False Bay in the Western Cape of South Africa has a long history of human-use, with consequences for the state of its fish diversity and abundance. Adequate sampling in False Bay to assess fish populations, and indeed, long-term monitoring along the South African coastline, is limited largely by the logistical challenges presented by traditional monitoring methods. Underwater visual census (UVC) is restricted by depth, sampling (dive) duration and the availability of skilled labour. Controlled angling surveys (CAS) do not achieve equally efficient representation of species in a region and catch-per-unit-effort measures must account for variation in fisher skill and species' catchability. Baited remote underwater video systems (BRUVs) offer low impact assessment whilst eliminating inter-observer variability and increasing statistical power. This study provides baseline BRUVs data on the relative abundance and diversity of ichthyofauna in False Bay. 186 sites were sampled across seasons and habitat, and depth and season emerged as key predictors of differences in community composition. Records of *Petrus rupestris* and *Chrysolephus gibbiceps* were important, given that non-extractive sampling is now imperative to their long-term assessment. The endemic *Haploblepharus edwardsii* emerged as most abundant of the chondrichthyans and important shark records included *Triakis megalopterus* and *Galeorhinus galeus*, which were identified by a recent study as decreasing populations. This study suggests that the increased efficiency in low impact data collection, together with representation of species typically undetected by traditional monitoring methods, recommends BRUVs for sampling in False Bay.

The “Suitcase Hypothesis”: can eddies provide a pathway for gene flow between Madagascar and KZN?

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Similarities in fauna found off the coasts of southern Madagascar and KwaZulu-Natal led to the development of the “Suitcase Project”, with the aim of establishing whether eddies that form off southern Madagascar may package and transport biological material, as if in a suitcase, across the Mozambique Channel. In pursuit of this question, the *RV Algoa* sailed from Durban in July 2013 to undertake a sampling transect through a cyclonic eddy which originated off the southern tip of Madagascar, as well as to sample at reference stations on the southern Madagascan shelf. Zooplankton sampling was conducted using two types of plankton net: (a) Bongo nets fitted with 200 and 500 µm mesh towed obliquely through the water column between the surface and 200 m, and (b) a Neuston Net fitted with 900 µm mesh towed horizontally at the surface. Samples were sorted for meroplankton (rock lobster, fish larvae etc.) under a stereo microscope, particularly seeking species known to be common to both the east coasts of Madagascar and South Africa and thus potential indicators of connectivity between these regions. Selected organisms will be used for DNA barcoding. We also compare zooplankton biomass and abundance between the eddy core, eddy perimeter and outer regions, as well as at reference stations on the Madagascan shelf. Initial results indicate much larger zooplankton stocks on the Madagascar shelf (1.16 ml m⁻³) compared to the eddy transect (0.26 ml m⁻³). Rock lobster (phyllosoma) larvae were more abundant on the Madagascan shelf, with few larvae found in the eddy, whereas fish eggs and larvae were abundant both on the Madagascan shelf as well as in the eddy. More phyllosoma larvae were caught with the Neuston than the Bongo (500 µm) net, whereas more fish larvae were caught with the Bongo (500 µm) than the Neuston net.

Distribution and abundance of zooplankton along the southern shelf of Madagascar

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The ACEP 3 “Suitcase Project” aims to assess whether mesoscale eddies are potential vectors of connectivity between Madagascar and South Africa. One area of focus in this project is the zooplankton community. The aim of our study is to measure the horizontal distribution, abundance, biomass and species composition of the mesozooplankton, especially the copepod community, and their relationships to physical oceanography and phytoplankton variability in the southern region of Madagascar. During the Cruise, conducted in July 2013, twenty (20) zooplankton samples were collected off the southern Madagascar shelf using a Bongo net fitted with 200 µm mesh, and towed obliquely from several metres above the bottom to the surface. All samples were preserved with 4% buffered formaldehyde. The settled volume of each sample was measured to estimate the biovolume

of zooplankton in the water column. The samples were then split with one half used to measure dry weight, and the other half for microscopic species identification. Zooplankton were identified to taxon, apart from copepods which were identified to genus and species where possible. Environmental data were acquired by in-situ measurement using a CTD (Conductivity Temperature Depth) sampler fitted with a fluorometer. Mean zooplankton biovolume on the southern Madagascar shelf was 1.16 ml.m^{-3} . The zooplankton community was dominated by copepods, in particular the families Paracalanidae and Eucalanidae (Calanoida), and Oithonidae and Oncaeaidae (Cyclopoida). Other abundant zooplankton taxa included the Siphonophora, Appendicularia (*Oikopleura* spp.) and Mollusca (gastropod and bivalve larvae). Multivariate analysis was used to explore patterns in the mesozooplankton community and relationships with environmental parameters. This is the first known study of the zooplankton community off southern Madagascar.

Influence of oceanography on the euphausiid assemblage of the Leeuwin Current system, south-east Indian Ocean

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Investigations into euphausiid (krill) distribution and diversity in the Leeuwin Current system of the eastern Indian Ocean are lacking, and for a system that supports commercial fisheries, migratory baleen whale populations, and globally important seabird colonies, knowledge of their euphausiid prey is necessary. Within the Leeuwin Current system, euphausiids were collected using bongo nets at every degree of latitude between 22-34°S at shelf, shelf break and oceanic stations, and correlated with a suite of environmental variables to ascertain drivers of euphausiid distribution. Twenty seven euphausiid species constituted the Leeuwin Current assemblage, of which five were identified as new records for the south-east Indian Ocean. This diversity can be largely attributed to southward range extensions of species from tropical surface waters. In particular, it is proposed that the tropical coastal species, *Pseudeuphausia latifrons*, can be used as a biological tracer of alongshore and cross-shelf transport within the system. Euphausiid assemblages were significantly correlated with physical properties of the water column, indicating affiliations with the specific water masses sampled in the study area, e.g. sub-tropical surface water and Leeuwin Current water. Increased euphausiid concentrations coincided with patches of high chlorophyll *a*, such as those in eddies and along the shelf and shelf break. This study of the euphausiid assemblage of the Leeuwin Current system identifies previously unknown zoogeographic patterns in the south-east Indian Ocean, and enhances the understanding of euphausiid zoogeography across the whole Indian Ocean.

Patterns of species richness and biodiversity hotspots of sponges in the Benguela and Agulhas Somali Current Large Marine Ecosystem: Its importance for bioregionalisation and conservation planning

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The marine environment is heterogenous and living organisms tend to be patchily distributed in terms of abundance and diversity. Given their potential in terms of biodiversity conservation or maintaining natural processes (especially in the light of predicted climate change effects), identifying species “hotspots” and determining which factors govern and maintain them is a growing area of marine research. We used species distributional data (presence-absence) to assess biodiversity

patterns of sponges in two large marine ecosystems (LMEs), namely the BCLME (Benguela Current LME) and ASCLME (Agulhas Somali Current LME) on either side of southern Africa, and to identify sponge hotspots in terms of species richness and other diversity measures (entropy and evenness). Generalized Additive Models (GAMs) were used to predict the diversity measures from available predictors, namely depth, latitude and longitude. The predicted biodiversity patterns were assessed in terms of whether they conformed to the predictions of theoretical models, including Rapoport's rule, the Mid-domain effect and Peninsula effect. Species turnover was greatest at the southern extreme of the study grid, i.e. at the boundary between Cape Point and Natal-Delagoa/south-western cape bioregion. However, the predicted species richness pattern was contradictory to Rapoport's rule (stating that species' range sizes decrease towards lower latitudes) therefore this theory was not upheld across the latitudinal gradient of this study. The relationship between species richness and the predictors was inconsistent between countries, but generally hotspots of species richness were associated with shallower waters and cooler temperatures. We considered the relevance of the predicted sponge biodiversity patterns in particular the hotspot areas for spatial biodiversity conservation in the two LMEs.

Poster Presentations

Poster # 11

The biogeography of the Western Indian Ocean epipelagic copepods

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Published information on the distribution of calanoid copepods from the Western Indian Ocean are consolidated and combined with new data collected from the South West Indian Ocean Ridge, in order to generate an updated biogeography for this order of copepods in the region. This pattern is compared with those generated from other taxa.

Poster # 12

Multi-scale variation in the importance of biodiversity drivers from local to regional scales

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Spatial patterns in biodiversity and their potential drivers have been the subject of numerous studies at various spatial scales. It is known that variation in biodiversity at local, regional and global scales are affected by different variables. In the Benguela Current Large Marine Ecosystem (BCLME) recent studies have characterized and identified hotspots of demersal fish biodiversity. This study takes the work further by investigating the variation in biodiversity at multiple spatial scales (small, medium and large scales). It attempts to identify the relative importance of various drivers of biodiversity patterns at the different spatial scales and in doing so determine the consistency in the importance of drivers between the different scales.

Poster # 13

Biodiversity of the South African non-geniculate coralline red algae

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Non-geniculate coralline red algae are important occupiers of space in shallow, hard-bottom, marine environments. The South African rocky intertidal and subtidal habitats are rich in diversity and often high in cover of these algae. However, despite their ubiquity they are a poorly known and poorly understood group of marine organisms. Few records of non-geniculate coralline red algae from South Africa were published before 1993 and most of these provided less than adequate descriptions that have not been of modern use in delimiting them. Although much progress has been made since 1993, ongoing collections and their reporting as well as molecular analyses have revealed a number of new and cryptic species. Using traditional histological methods supplemented by molecular data, taxonomic and systematic investigations are being undertaken of the intertidal and shallow subtidal species of non-geniculate coralline alga from the SA coast. Our findings demonstrate that we have highly underestimated the diversity of the South African non-geniculate coralline red algae.

Poster # 14

Some highlights of a biodiversity and biogeographic study of the brittle stars (Echinodermata: Ophiuroidea) of South Africa

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The last major review of the echinoderms of the region, published in 1976, reported 115 species of brittle star (Echinodermata: Ophiuroidea) from southern Africa. By 2014, a total of 165 species have been recorded (including the Prince Edward Islands), as well as 40 new distribution records. Collections in KwaZulu-Natal between 1999 and 2011 contributed to the majority of these new records, which is a clear indication that the South African coast still remains poorly explored for this group. Data records in the Iziko South African Museum and photographic records by divers have also proven to be valuable source of new distribution records. A large contribution to new and extended distribution records have been from the coral reef associated family Ophiocomidae. In addition to this, the first account of parental care in *Ophiocoma brevipes* was also reported. Another highlight of this study was finding an orphaned echinoderm collection at the Durban Natural Science Museum where two holotypes of the endemic brittle star *Asteroschema capensis* Mortensen, 1925 and the starfish *Anthenoides marleyi* Mortensen, 1925 were found. The discovery of these two holotypes is a significant contribution to global echinoderm taxonomy. As a result of the re-examination of *A. capensis*, a new combination was proposed with the genus *Asteromorpha*. This presentation focuses on some highlights during a review on the biogeography, biodiversity and taxonomy of brittle stars of South Africa.

Poster # 15

Laboratory experiments to determine the effects of temperature on the polyps of *Chrysaora fulgida* (Cnidaria: Scyphozoa)

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The life cycle of most scyphozoans comprises an alteration between a large, pelagic medusa phase that is responsible for dispersal and sexual reproduction, and a minute, benthic polyp stage that reproduces asexually to either bud off more polyps or to liberate ephyrae. The biomass of jellyfish (including *Chrysaora fulgida*) off Namibia is thought to have increased since the collapse of the fisheries for small clupeids. Whilst part of the reason for their success in the region can be attributed to the medusa, it is likely that the polyp too has an important role in influencing population size. As an upwelling ecosystem, the Benguela is subject to considerable changes in inshore water temperatures and this project aims to investigate the response of *C. fulgida* polyps to varying temperatures. Laboratory maintained cultures of polyps were exposed to a range of different temperatures (12 - 24 °C) for a period of three months. Polyps were fed *ad libitum* once every three days, on a diet of enriched *Artemia* nauplii. Polyp proliferation was monitored (encystment, proliferation, strobilation, death) every three. The data suggest that at lower temperatures the growth of the polyp population is significantly slower than at higher temperatures. These results suggest that any warming of inshore waters off Namibia have the potential to exacerbate the problem of jellyfish there.

Poster # 17

Sex determination on the hyperbenthic sand shrimp *Palaemon peringueyi* Macpherson, 1990 (Decapoda: Caridea): an ontogenetic approach

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Understanding the realistic patterns of sex ratios in ecology is important to give real estimates of potentials for population growth and prediction of population dynamics. Despite several studies that have been conducted on *Palaemon peringueyi*, there are still discrepancies about the size of the carapace length (CL) as an accurate estimation of sex for this shrimp. Previous studies have relied on size of the carapace length (larger than 9mm CL) to sex *P. peringueyi* individuals. Sex determination of *P. peringueyi* was investigated in Swartkops Estuary, South Africa. Shrimps were collected using a seine net (mesh size of 4mm and 2m long), individually measured and sexed. Results showed that female shrimps were larger than male shrimps, thus confirming sexual dimorphism in *P. peringueyi*. Male and female *P. peringueyi* showed an effect of sex on the *appendix interna* (a.i.) for all sizes. This is, however, indirectly related to the fact that CL is related to a.i. In shrimps < 9mm CL, results showed an effect of sex on size of this group with males and females having a significantly different a.i. Size of a.i. can be used as an additional parameter to sex *P. peringueyi*, but only in shrimps larger than 9mm CL. This is, however, an indirect estimation of sex and it is possible only because there is a strong and significant relationship between CL and sex. This study has shown that *P. peringueyi* can be sexed at CL less than 9mm. The sex of *P. peringueyi* appears to have a significant effect on the length of this shrimp. Use of absence or presence of *appendix masculine* (am) to determine sex in previous studies may have underestimated the presence of males in the population. Thus, further studies on gonadal development are also required for more accurate gender definitions of *P. peringueyi*.

Poster # 18

Are genus or family level identifications a good proxy for species in studies of marine free-living nematodes?

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Nematodes, the most abundant of the Eumetazoa, frequently dominate marine benthic habitats both in abundance and richness. Identification is laborious resulting in limited full nematode species lists, therefore higher taxonomic levels (genus and family) are commonly used in nematode studies. We report on the use of genus and/or family as proxy for species in local distribution of nematodes. From a study of nematode communities along a transect in Saldanha Bay, patterns generated from genus data were highly congruent with those from species (RELATE statistic $\rho = 0.99$, $p = 0.001$). Family level data were also similar but agreement was obviously lower ($\rho = 0.966$, $p = 0.001$). In other words, at the local level, and from an ecological point of view, higher taxonomic levels are suitable proxies for species.

Poster # 19

Taxonomy and diversity of the sponge fauna from Walter's Shoal, a shallow seamount in the Western Indian Ocean region

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To date, the sessile invertebrate fauna of Walter's Shoal has not been researched. Thus, as a component of the third phase of the African Coelacanth Ecosystem Project (ACEP), this study aims to investigate the sponge diversity of this seamount located on the South Madagascar Ridge. Moreover, the possible connectivity between Walter's Shoal and adjacent regions will also be assessed with regards to the surrounding coastal and deep-water sponge fauna. Specimen collection will be undertaken on a single cruise aboard the FRS Algoa in 2014, where sponges will be sampled via SCUBA divers and an epibenthic sled, both from the peak and down two opposing slopes. In combination with oceanographic data, and complemented by various photographic and video sources (ROV's, SkiMonkey benthic camera, SCUBA photo quadrates and jump camera), this study is expected to discover range extensions and species new to science, while providing further insights into the zoogeographical affiliations of this shallow seamount.

Poster # 20

Spatial patterns in the diversity of sponges off the west and south coasts of South Africa

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The South African coast is a dynamic environment with different attributes on both the east and west coasts. This gives rise to the high biodiversity that is found in the region. The known number of

species recorded is constantly changing and increasing and some taxa have been better studied giving rise to greater numbers, such as Porifera. However, most work on South African marine benthic fauna has focused on shallow sub-tidal and inter-tidal hard substrata, and our knowledge of the deep water fauna (especially from soft sediments) is relatively poor. The shelf areas along the south and west coasts of South Africa are subject to intensive trawling and mining activities and there is a need to more fully understand their faunal diversity and composition for management purposes. Here we investigate sponge communities from this region using data collected from a series of trawl surveys (2007-2012). The preliminary results reveal greater numbers of species in families and orders. It also shows distinct populations on each coast with an area mixing in the southern region. The results are discussed in the context of offshore marine protected areas.

Poster # 21

The distribution of euphausiids across the Western Indian Ocean during spring 2008 and 2009

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Euphausiids are part of the zooplankton that forms the base of marine food chains and an improved understanding of their abundance and distribution will improve not only our understanding of the food environment for fishes but also of biodiversity in the region. Forty-eight zooplankton samples were collected across the Mascarene Plateau in the Western Indian Ocean (WIO) during 2008 and 2009: environmental variables (depth, sea surface temperature, sea surface salinity, fluorescence, latitude and longitude) were concurrently measured from 25 of these samples. A total of 37 species were recovered, of which *Euphausia diomedea*, *Stylocheiron carinatum*, *E. gibba* group, *Thysanoessa gregaria* and *E. recurva* were most abundant. The number of species was greater than previously reported for the area and, given the small number of samples collected, indicates that the region is deserving of greater attention. There were significant negative relations between both latitude and longitude with surface temperature and sea surface salinity, and this appeared to be linked to local upwelling in the part of the sample area. Multiple regression analysis suggested that only food availability (fluorescence) was linked to absolute abundance but that sea surface temperature, depth and fluorescence were correlated with species richness.

Poster # 22

Distribution of flora and fauna along the rocky shores of Silaka Nature Reserve in the Eastern Cape Province of South Africa

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Rocky intertidal areas are transitional areas between the terrestrial and marine ecosystems where solid rock predominates. Normally, diversity of organisms along the intertidal zone increases in a downward direction from the upper reaches of the shore. This vertical distribution of organisms tends to be in distinct bands referred to as zonation patterns. This study thus aimed to identify and quantify the species along the rocky shore of Silaka Nature Reserve. Species diversity and density were quantified using square quadrats (0.4x0.4m²) subdivided into 25. A total of 47 sampling stations were sampled randomly along the intertidal rocky shore. The morphological species concept was used to identify species down to the species level. A total of 25 seaweed species (9 Chlorophyta, 7 Rhodophyta and 9 Phaeophyta) were found throughout the intertidal zone of this nature reserve. There were 33 invertebrate species (2 sponges, 5 cnidarians, 2 annelids, 5 arthropods, 13 molluscs,

and 6 echinoderms) found in the reserve. *Hypnea spicifera* and the various corallines (*Amphirhoa ephedraea* and *Jania spp.*) dominated the lower infratidal zone. The mid-shore was dominated by the barnacles and oysters, while *Leptophytum foveatum* was dominant in intertidal rock pools and the littorina zone was dominated by a single species of periwinkles. The PCA results showed a positive correlation among various seaweed species as well as among invertebrate species, also showing a positive correlation between some seaweed species and invertebrates. The AHC results showed three clades of dissimilarities between the sample stations for the combined study of both seaweeds and invertebrates. This accounted for three zones, while the diversity of seaweeds was negatively correlated to that of the invertebrates.

Poster # 23

Taxonomy, systematics and biogeography of South African Echinoidea (Echinodermata)

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The South African Echinoidea (Echinodermata) were last reviewed by Clark & Courtman-Stock (1976) and numerous unidentified specimens and records have accumulated since then. This study, the first of its kind in 37 years, aims to update knowledge on the diversity and distribution patterns of South African echinoids and to provide a user-friendly guide to the group. Specimens, particularly those within the extensive collections of the Iziko South African Museum (SAM), were morphologically examined and identified, and were added to a database. Other data considered in this study included; historic data from the SAM and UCT catalogues, imagery from the EchinoMap VM open-online database, trawl by-catch data from the DAFF, and data from published literature. These resulted in 19 new records for the region raising the total known species to 71. All species were photographically illustrated and a field guide is presented which included synonymy and previous literature for each species, a distribution map, description and global distribution. In terms of biogeography the regional echinoid fauna comprises 26.8 % endemics, 1.4 % introduced, and 71.8 % non-endemics; across 14 orders and 29 families. As expected, species richness pattern increased from west to east coast. The east coast displayed the lowest number of records; the South coast had the highest. Endemism peaked on the south coast and the west and east coast both supported equal levels of endemics. The only introduced species, *Tetrapyga niger*, was from the west coast region. In terms of depth; species richness was highest in < 500 m and lowest in > 500 m. This may be a result of the deep-seas (> 500 m) being severely under-sampled. The lack of taxonomic experts to review this group may have contributed to the high number of new records.

Poster # 24

Linking patterns in biodiversity to exploitation and environmental drivers

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Patterns in biodiversity, both in space and time, and their potential drivers have been the subject of numerous studies. It is generally known that the observed patterns in biodiversity are the result of evolutionary processes and the interplay with environmental variation and biotic interactions operating at different spatial and temporal scales. Such studies have gained momentum currently within the context of future climate change, its potential impact on biodiversity (e.g. via effects on individual species distribution), and hence the implications for conservation. In this study we looked at the spatial patterns in biodiversity of demersal fish species at a regional scale, focusing on the Benguela Current Large Marine Ecosystem (BCLME), with the aim of linking the spatial patterns of biodiversity to environmental and exploitation drivers. We show the relative importance of exploitation related pressures and environmental variables on the spatial patterns of biodiversity via comparative analysis of the Northern and Southern components of the BCLME.

Poster #25

Diversity and endemism in marine benthic faunal communities off Southern Namibia

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Southern Africa supports a rich marine biodiversity, the distribution of which broadly reflects prevailing oceanography and biogeography. Along the east coast, tropical and sub-tropical provinces are characterised by high diversity though endemism is comparatively low and many species are characteristic of the wider Indo-Pacific. Diversity tends to decrease in a westward direction, through the warm temperate south coast to reach a minimum in the cool waters of the Benguela upwelling system. By contrast with the east coast, endemism tends to be higher along the south and west coasts, and may peak at breaks between biogeographic provinces. These are generalisations, of course, as some taxa display patterns at odds with others. Further, our understanding is restricted to taxa and environments and organisms we have studied – there is still much that remains poorly known. Here we look at patterns of species richness and endemism of the benthic infaunal macro-invertebrates off southern Namibia, an area where diversity is assumed to be relatively low, using data collected for De Beers Marine Namibia.

Thursday 17 July

Endler Hall: Genetic Approaches

Oral Presentations

Beyond barcoding: genetics for non-taxonomists

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During the past decade, genetic methods have become an integral component in the toolkit of southern African marine biologists. Particularly those genetic approaches that are of interest to taxonomists, such as DNA barcoding and phylogenetics, are being used by an increasing number of researchers. I discuss recent developments in the way genetic research is being conducted, and how novel technological and analytical approaches can benefit fields of marine science in which genetic methods are comparatively rarely employed. I particularly focus on oceanography, fisheries research, conservation biology and the study of invasive species.

The Phylogeography of *Echinometra mathaei* in the Southeast African Region

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Investigating the phylogenetic relationships among species can give insight to the historical distributions of populations. In the present study, the phylogeography of a sea urchin (*Echinometra mathaei*) in the south west Indian Ocean is examined. A DNA marker from the mitochondrial DNA (Cytochrome oxidase I) was used to determine the phylogeographic relationship and gene flow between *E. mathaei* populations in the region. Samples were collected from Isipingo Beach (n = 5) and Treasure Beach (n = 11), KwaZulu-Natal; 3 sites in Umgazana, Eastern Cape (n = 13; 15; 10) and Taolagnaro (Talinjoo), Madagascar (n = 7). The haplotype network revealed the occurrence of two separate haplogroups (HI and HII in Figure 1), where most South African haplotypes were clearly separated from Madagascan haplotypes. The phylogenetic analysis revealed the formation of a strongly supported separate clade consisting of the Madagascan haplotypes, as well as a few South African haplotypes (Figure 2). The AMOVAs (Analysis of Molecular Variance) showed that populations of *E. mathaei* are significantly different from one another (PhiPT = 0.301; p = 0.001), regional populations were observed to be significantly different (PhiPT = 0.389; p = 0.001) and national populations were found to be significantly different (PhiPT = 0.620; p = 0.001). These results demonstrate a high level genetic isolation between South African and Madagascan populations of *E. mathaei*. This was confirmed by the pairwise analysis of gene flow and genetic differentiation (F_{st} = 0.332 – 0.709 for all analyses involving the Talinjoo population). Populations that were geographically close to each other were found to exchange genetic information, but genetic flow at varying levels was also shown to occur among the populations along the South African coast.

Connectivity patterns in seven lobster species at islands, seamounts and shelf habitats in the SW Indian Ocean and South Atlantic

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Lobsters are excellent models for studying the influence of ocean processes on gene flow, because they have restricted benthic distribution patterns, and drifting larval lifespans that range from a few hours or days in some clawed lobsters (*Nephropidae*) to many months at sea in spiny lobsters (*Palinuridae*). Recent studies of genetic connectivity of six spiny and one clawed lobster species in the SW Indian Ocean and South Atlantic, combined with life-history and oceanographic information, have suggested great contrast in inferred dispersal patterns, and also questioned the taxonomic status of previously-recognized species. An apparent lack of barriers to dispersal and gene flow over thousands of kilometres of southern waters indicates that *Jasus paulensis* (St Paul and Amsterdam Islands; SW Indian Ridge seamounts) and *J. tristani* (Tristan archipelago, South Atlantic) should be synonymised as *J. paulensis*. Three closely-related *Palinurus* species have evolved in the SW Indian Ocean; two occur along the continental shelf-edge of SE Africa, where panmictic (*P. gilchristi*) and genetically structured (*P. delagoae*) populations are maintained through the inter-relationship of strong directional currents, eddies, hydrographical boundaries, and life-history adaptations such as long-distance migrations. *Palinurus barbarae* appears to be widely distributed on SW Indian Ocean seamounts. Distinct African and Madagascar lineages of the shallow-water spiny lobster *P. homarus rubellus* suggest that Mozambique Channel eddies and currents form a barrier to cross-channel larval dispersal, rather than facilitating gene flow. The clawed lobster *Metanephrops mozambicus* (short larval development) exhibited genetically well-structured populations over short geographical distances along the coasts of Mozambique, Madagascar and South Africa. Based on genetic data, recent demographic expansion (<25,000y ago) was observed for most species, confirming that the last glacial maximum had a major effect on lobster taxa in southern waters.

Feral Pacific oysters *Crassostrea gigas* in Southern Cape estuaries: population size and structure

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The Pacific oyster, *Crassostrea gigas*, is favoured for culture worldwide and is invasive in several countries in which it has been introduced. In South Africa, the species has been cultured for more than 30 years and in 2003, feral populations were reported in three Southern Cape estuaries. Our objectives were threefold: to update previous population estimates using directly comparable surveys, and to compare genetic diversity within and between estuaries, and between the non-indigenous Pacific and co-occurring indigenous Cape rock oyster (*Striostrea margaritacea*). In 2012, the estimated total of 23 760 Pacific oysters in the Breede River estuary was approximately 12% of the 2003 value (184 206). *Crassostrea gigas* was completely absent from the Knysna estuary, and 15 individuals were found and removed during comprehensive surveys of the GouKou River estuary. Condition Index was higher for *C. gigas* collected 9.5 km upriver in the Breede River (77.5 ± 3.7 , $n = 32$) than for those at the estuary mouth (66.2 ± 3.6 , $n = 33$), possibly as a result of seston enrichment from terrestrial sources. Haplotype (h) and nucleotide diversity (Π) within the GouKou population (0.38 ± 0.18 and 0.0010 ± 0.0010 respectively) were higher than those in the Breede (0.14 ± 0.08 and 0.0005 ± 0.0006). In the Breede estuary, *C. gigas* had lower genetic diversities than had indigenous *S. margaritacea* (0.90 ± 0.05 and 0.0058 ± 0.0034). *Crassostrea gigas* was either introduced only once to these estuaries, the source population from which they originate is not genetically diverse, or has experienced recent population bottlenecks (flood-induced mortality in the Breede River in 2008). A

later observation in 2013 revealed a vast population of *C. gigas* in the Swartkops Estuary, which suggests that this species is likely to settle in estuaries rather than in open coastline; continued monitoring of populations is necessary.

Global phylogeography of *Stygocapitella subterranea* (Parergodrilidae, Annelida) and the first record from South Africa

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Stygocapitella subterranea is a small interstitial annelid inhabiting the upper intertidal of sandy beaches all around the world. However, records from tropical and subtropical regions are still lacking. As is the case for many interstitial species *S. subterranea* does not possess pelagic larval stages or good active swimming capacities as juveniles or adults. Hence, potential for long-distance dispersal is lacking and, thus, given the global distribution it is very likely that gene flow is limited between these populations. Nonetheless, no morphological differences can be found between the different populations and even analyses of sperm ultrastructure of populations from the northern hemisphere revealed no differences. This contradiction is known as the Meiofauna paradox and morphological stasis. Herein we report new localities for *S. subterranea* from South Africa, Scotland, Brittany (France) and Sylt as well as sequence data of the mitochondrial COI and 16S rRNA and the nuclear ITS1 and ITS2 from populations in the Northern and Southern Atlantic as well as one from the Northern Pacific. Despite the strong morphological similarity between populations from the Northern and Southern Atlantic and Northern Pacific the results show that cryptic speciation occurred within *S. subterranea*. Interestingly, the populations of the Northern hemisphere were more closely related to each other than the populations to the Southern hemisphere and hence populations from the same ocean (i.e., Atlantic) were not a monophyletic group. Thus, the gap in the tropical and subtropical regions might not represent a sampling gap, but a true gap. Additionally, these results indicate that morphological evolution in *S. subterranea* was static for a relatively long time. Moreover, we will show that the evolution of *S. subterranea* is more complicated than only being an isolation-by-distance process and other factors such as grain size and glaciations are also relevant.

Biogeography and phylogenetic diversity of the *Laurencia* complex (Rhodophyta) in the south west Indian Ocean

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The *Laurencia* complex encompasses six genera, namely *Chondrophyucus*, *Laurencia sensu stricto*, *Laurenciella*, *Osmundea*, *Palisada* and *Yuzurua*. The diversity of the complex in South Africa has been recently revised using morphology, anatomy and plastid *rbcL* sequence data. Seventeen morphotypes were identified: Fourteen belong to the genus *Laurencia sensu stricto*, and at least one each to the genera *Palisada*, *Chondrophyucus* and *Laurenciella*. Five morphotypes are described as new species: *Laurencia dehoopiensis*, *L. dichotoma*, *L. digitata*, *L. multiclavata* and *L. sodwaniensis*. However, not much is known about the *Laurencia* complex in the South Western Indian Ocean (SWIO) and no DNA sequences are available. The present study compares the diversity of the South African *Laurencia* complex to the rest of the region. Methods include a molecular phylogenetic analysis of sequences from South Africa, Madagascar, Mozambique, Reunion, Mauritius and the Europa and Glorioso Islands in the SWIO. Analyses thus far provided support for the monophyly of

the six genera of the *Laurencia* complex alongside early molecular evidence for two new genera, one of which is restricted to the SWIO. Diversity within *Laurencia sensu stricto* in South Africa increases from west to east i.e. cool-to-warm-temperate, with higher endemism in the warm-temperate regions of the south coast (~5 spp.). Common species in KwaZulu-Natal, such as *Laurencia complanata*, *L. natalensis* and *L. multiclavata* are shared with Madagascar and Glorioso Island. Furthermore, *Laurencia natalensis* is one of the most widely distributed species in the SWIO, alongside *L. multiclavata* and the undescribed species, *Laurencia* spp. 'morphotype K'. Species of the genus *Palisada* appear to have a narrower distribution range in the SWIO, restricted either to the Mozambique Channel or around the Mascarene Islands.

Molecular analyses confirms genetically distinct populations of two indigenous estuarine fish species in an isolated coastal lake: implications for the management of exotic ichthyofauna

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Groenvlei is a coastal, near-freshwater lake in the Garden Route region of South Africa which became isolated from the ocean about 4,000 years ago due to sea level regression during the Pleistocene glaciations. This lake supports two native fish species, *Atherina breviceps* and *Gilchristella aestuaria*, as well as several introduced fish species including most recently, the common carp (*Cyprinus carpio*). As management options for eradicating alien fish in Groenvlei are being considered it is pertinent that the conservation status of *A. breviceps* and *G. aestuaria* be assessed. Analysis of the mitochondrial control region for five populations of both species revealed Groenvlei populations of *A. breviceps* ($\Phi_{ST} = 0.22$; $p < 0.05$) and *G. aestuaria* to be significantly different ($\Phi_{ST} = 0.12$; $p < 0.05$). *Atherina breviceps* exhibited less structured populations than *G. aestuaria*. Both species displayed slightly lower haplotype diversity and much lower nucleotide diversity in Groenvlei (*A. breviceps*: $h = 0.689$, $\pi = 0.003$; *G. aestuaria*: $h = 0.836$, $\pi = 0.004$) than in sampling localities from nearby estuaries. Given that Groenvlei hosts genetically unique populations of *A. breviceps* and *G. aestuaria*, any large scale extermination actions aimed at the exotic ichthyofauna in this lake that would impact on the two indigenous species are not recommended, unless adequate plans are made to establish and maintain viable populations elsewhere. Our results highlight the importance of incorporating a genetic approach to understanding not only the evolutionary history of southern African estuarine species, but also to supporting biodiversity planning decisions in the region.

Re-evaluation of the taxonomic status of three nototheniid fishes that are distributed on both sides of Antarctic Polar Front

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Notothenioid species that are found south and north of the Antarctic polar front (APF) have previously been split into separate species and/or subspecies in their respective localities. These splits were largely based on morphological characteristics. However, the analyses of more recent morphological studies disagreed with these taxonomic acts. Molecular systematic studies conducted on notothenioid species so far have concentrated largely on the Atlantic Ocean sector. This study

aimed to re-evaluate the taxonomic status of the three nototheniids, *Lepidonotothen squamifrons*, *L. larseni* and *Gobionotothen marionensis* at the DNA level, by comparing specimens from different localities in the Southern Ocean. Sequence divergences using two mitochondrial genes (ND2 and COI) and one nuclear gene (S7 intron 1) were estimated among different taxonomic levels of notothenioid species focusing on the genera *Lepidonotothen* and *Gobionotothen*. *Lepidonotothen kempfi* was nested within *L. squamifrons* in the phylogeny of *Lepidonotothen* with sequence divergences, for all genes, between these two species ranging from 0% to 0.5%, suggesting that *L. kempfi* and *L. squamifrons* are populations of one species. The sequence divergence between *L. squamifrons* and other *Lepidonotothen* species was higher (0.8% to 18.7%) indicating that they are different species. The *L. larseni* specimens also represented one population (0.3% to 0.6%) with low geographic variation between Atlantic and Indian Ocean specimens. This study therefore does not support the splitting of *L. squamifrons* and *L. larseni* into different species. The phylogeny of *Gobionotothen* clearly separated individuals of *G. acuta* from Heard and MacDonald Islands from *G. marionensis* individuals into different clades, with sequence divergence of 1.4% (COI) between these clades suggesting they are different species. Therefore, this study supports the existence of two species in Balushkin's (1991) 'marionensis' group, *G. marionensis* and *G. acuta*, and suggests that the populations which were called *G. angustifrons* belong to *G. marionensis*.

Endler Hall: Genetic Approaches

Oral Presentations

Genetic approaches to fisheries management and conservation efforts of Southern African shark species

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Southern Africa is a global shark biodiversity hotspot, hosting high species richness, high endemism and functional richness. Anthropogenic threats to sharks are increasing, largely fuelled by fisheries and a growing demand for shark products. Furthermore, South Africa has a large shark recreational fishery and growing shark eco-tourism sector that provides additional economic benefits from sharks. Life history traits such as slow growth rates, late age at maturity, low fecundity and small litter sizes, make it difficult for many shark populations to recover from anthropogenic pressures. Given the ecological and economic value of sharks in South Africa, sustainable utilisation, management and conservation is imperative. Sustainable exploitation of these resources rely heavily on the knowledge of species interactions and ecosystem functioning, which again depends on the abundance, distribution and genetic structuring of species. Molecular genetic techniques, such as barcoding and genotyping, are increasingly being used in order to achieve these goals. Molecular techniques that are used to assist in the identification of species, assessment of stock structure, reproductive modes, cryptic speciation and possible inter-species hybridisation of endemic, commercially and ecologically important sharks of Southern Africa will be presented. The emphasis will be on the development and application of genetic resources in shark species mostly affected by fisheries including, *Mustelus mustelus*, *Galeorhinus galeus* and *Carcharhinus brachyurus*. Novel DNA sequencing approaches and application thereof in high throughput development of molecular markers and investigation of ecological specialization of locally adapted populations will also be discussed.

How many are there? An integrated approach for estimating the size of the white shark population in South Africa

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White sharks (*Carcharodon carcharias*) are a vulnerable species with a wide geographic distribution. The elusive nature of this predator makes its monitoring, and thus conservation, extremely challenging, particularly when attempting to estimate population abundance. In this study we propose an integrated approach combining, for the first time, genetic as well as mark-recapture (photo identification-based) techniques on free ranging sharks, in order to assess population estimates on both regional and national scales in South Africa. Two-hundred and seventy one biopsy samples were collected (between 2010 and 2013) from 219 white sharks in five sampling locations with known shark aggregations. The analyses of eight polymorphic microsatellite markers for *C. carcharias* reveal a contemporary effective population size (CNe) of 580 individuals (95% confidence, $p_{crit} = 0.01$) for the South African coastline and a CNe of 490 individuals when only analysing Gansbaai (95% confidence, $p_{crit} = 0.02$). Additionally, between 2009 and 2011, 4389 dorsal fin photo identifications in the vicinity of Gansbaai were collected, from which we could confidently identify 426 individual sharks, to obtain a population estimate based on mark-recapture. Saturation of new sightings occurred once 400 individuals were catalogued. Notably, the estimate based on 877 re-sightings (1304 total capture events) obtained with the open population model POPAN ranges between 353-522 individuals (95% confidence), which is similar to that obtained using genetic approaches. Both population estimates are an order of magnitude less than expected. Based on the results of this study we strongly suggest maximizing and reinforcing protection measures currently in place, as well as the continued monitoring of population sizes at regional and international levels.

Genetic spatial variation of three polydorids (Polychaeta: Spionidae) infesting *Crassostrea gigas* in southern Africa and a comparison to the more widely distributed endemic *Boccardia polybranchia*

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The South African oyster industry depends on the importation of oyster (*Crassostrea gigas*) spat from Chile, Namibia and USA, and after introductions, oysters are often moved among farms within the country. This could lead to the importation and spread of pest polydorids. The most prevalent polydorids infesting farmed southern African *C. gigas* are the indigenous *Boccardia pseudonatrix*, the invasive *Polydora hoplura* and another yet unidentified *Polydora* species. To determine if the movement of oysters facilitates the spread of these worms, we compared population genetic structure among worms from six farms and, where possible, from multiple suitable substrates (molluscs, sponges, coralline algae etc.) collected at nearby wild sites. As a control for natural dispersal, we selected *B. polybranchia*, a widely distributed endemic species that is not a pest of cultured oysters. A maximum of 30 individuals were sequenced per sampling site. Haplotype networks constructed using mitochondrial *Cytochrome b* and nuclear *ATP5α* data show genetic structure between populations of *B. pseudonatrix*, suggesting independent sources of infestation and some localized between wild and farmed individuals. *Polydora hoplura* and *Polydora spp* show strong indications of anthropogenic movement or multiple introductions at the same site. Populations of *B. polybranchia* showed a fair amount of genetic structure between east and west coast populations

respectively. Structure between east and west coast populations is concordant with documented barriers to gene-flow at Cape Point and Cape Agulhas. Furthermore, the distribution of genetic lineages in *B. polybranchia* suggests that dispersal is primarily influenced by regional ocean currents, as opposed to anthropogenic movement associated with aquaculture activities. These preliminary results suggest that caution should be exercised with the movement of oysters in southern Africa, since it will more than likely facilitate the spread of parasitic worms.

Two species, three concepts: population isolation, speciation and hybridization

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The Cape Hakes (*Merluccius capensis* and *M. paradoxus*) are demersal species with sympatric distributions and overlapping life histories. Their geographic distribution ranges from northern Namibia to the Eastern Cape in South Africa. Both species dominate demersal catches in regional commercial fisheries, being targeted by a multi-user industry, which combined with their transboundary nature, provides an additional challenge to effective management. Accurate knowledge of population dynamics and structure is therefore necessary not only to ensure the establishment of sustainable management measures, but also to maintain the evolutionary potential of both species. Previous molecular studies, based on allozymes and mitochondrial DNA markers, revealed different evolutionary histories, with *M. capensis* exhibiting a highly diverse panmitic population, while *M. paradoxus* shows evidence of a past population contraction and shallow genetic divergence between Namibia and South Africa. However, there is still a limited knowledge of contemporary levels of genetic diversity and population connectivity. Furthermore, a recent survey using cross-specific nuclear microsatellites suggested that extensive hybridization may occur in northern Namibia. Hybridization events have increasingly been reported between closely related marine species and will add an additional layer of complexity to on-going management efforts. As such, in on-going effort for understanding their complex evolutionary histories, we employed species-specific microsatellite markers combined with extensive temporal and geographical sampling of both species, in order to understand contemporary patterns of population sub-structuring, gene flow and the possibility of hybridization between the two species. Preliminary results point to contrasting evolutionary histories based on nuclear and mitochondrial markers, and the occurrence of sporadic hybridization events between the two species. Such findings have the potential to unravel which processes shape patterns of genetic diversity and population structure of the Cape hakes, as well as contribute to the establishment of accurate fisheries management plans.

Evaluating genetic connectivity amongst *Mustelus mustelus* populations across the Indian/Atlantic boundary

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In marine organisms genetic connectivity is generally negatively correlated with dispersal ability. The patterns of dispersal may be affected by the oceanic surroundings attributed to the influence of climate, hydrodynamics and biogeographic barriers. In South Africa, the Benguela Barrier may impact genetic connectivity of regional commercial shark populations since it restricts mixing of Atlantic and Indian Ocean populations of tropical species due to a cold current running around the southern tip of Africa. Deciphering patterns of genetic connectivity and population genetic structuring in commercial shark species at a species-specific and regional scale is essential for an integrated fisheries management approach. The common smoothhound, *Mustelus mustelus*, is an overexploited, commercially and recreationally important shark species in South Africa. Considering the vulnerable status of the common smoothhound shark and due to very limited available genetic information, this

study aimed to assess patterns of genetic connectivity and genetic variation at a spatial scale along the South African coast using multilocus data generated from the mitochondrial gene, *NADH dehydrogenase subunit 4 (ND4)* and 12 microsatellite markers. Moderate levels of genetic diversity based on the heterozygosity, allelic richness and haplotype diversity were found and estimates for pairwise population differentiation, F-statistics, AMOVA and Factorial correspondence analysis (FCA) indicated significant genetic structure within and between west- and east coast populations. Additionally, Bayesian clustering analyses detected two ancestral gene pools in the study populations; further supporting the presence of a biogeographic barrier between the Indian and Atlantic Ocean regions. These results could increase our understanding of the influence of fisheries activity on these potentially differentiated stocks of *M. mustelus* while in addition contributing to a more integrated conservation management regime for demersal sharks in South Africa.

Genetic connectivity among pill bug (*Tylos capensis*) populations

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Pill bugs (Isopoda, *Tylos spp.*) inhabit the high shore of sandy beaches where they play an important role in nutrient recycling as scavengers of allochthonous material. *Tylos spp.* are direct developers, with females brooding their young. Pill bugs furthermore actively avoid contact with the swash zone by displaying tidal and lunar rhythmicity (i.e. activity peaks during low tides and neap tides). As a result of these attributes, pill bugs are considered to have low vagility. Such low dispersal potential could cause populations to become demographically and even genetically isolated over time, with a limited ability to (re)colonise suitable habitats. Beach habitats globally are facing threats ranging from trampling to coastal development, sea level rise and erosion, which could result in habitat fragmentation. Already anecdotal evidence indicates that a number of *Tylos spp.* around the world are in decline, largely because of habitat loss due to coastal development. An understanding of population connectivity is therefore important in order to assess the impacts of these threats on the persistence of beach macrofauna. Here we estimate genetic differentiation (F_{ST}) - as an indication of gene flow - of the gene cytochrome c oxidase subunit I (COI) among five populations of *Tylos capensis* along the south coast of South Africa. Preliminary analyses indicated significant genetic differentiation (limited gene flow) between the western and eastern-most populations ($F_{ST}=0.94$, $P < 0.05$). Mismatch analysis deviated somewhat from a population expansion model, with a bimodal distribution, although Harpending's Raggedness Index and Sum of Squared Deviation did not reject the null hypothesis of a population expansion. At least two clades were evident along the south coast. The implications of this study to population connectivity and the persistence of *T. capensis* are discussed.

Endler Hall: Genetic Approaches

Oral Presentations

Climate change provides insight on the evolutionary history of marine organisms around Southern Africa over the last 20 000 years

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Over the last 20 000 years, climate changes in Northern hemisphere deeply affected the distribution range and demography of species, sometimes leading to extinction. The drop in temperature during

the Last Glacial Maximum (LGM) induced a severe marine regression (120-130 m) and restriction in suitable habitats (extended ice sheet). Inversely, the increase in temperature at the end of the LGM released new habitats, and favoured a northern colonisation and a demographic expansion in most species including marine and terrestrial organisms. Much less is known around Southern Africa that was affected by the low sea-level stand but not by ice sheet coverage. To verify whether the marine organisms around Southern Africa were equally affected by the LGM climate changes, I investigated the evolution of population size in multiple species over the period. I first retrieved previously published sequences from a wide range of taxa (mollusc to mammal) and applied a new method, based on a coalescent framework and providing more appropriate molecular clock calibration for population genetics. The results confirmed that the recent climate changes also deeply affected the demography of species inhabiting the Southern African marine ecosystem. Contrasted demographic patterns are described but further in-depth studies will be needed to clearly identify the factors involved. The results stress the importance of applying appropriate molecular rate to circumvent strong biases on estimates of evolutionary events. The findings have direct implications in conservation biology as traditional molecular rates provide overestimation of effective population size and migration rate.

Variation in paleo-shorelines explains population genetic structure and vicariance on the southern coast of South Africa

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Processes driving and maintaining disjunct genetic populations in coastal marine systems surrounding South Africa are poorly understood, due to a lack of evidence of hard barriers that could have shaped patterns of extant population structure. Here we analyse the distribution of two genetically divergent lineages of a live-bearing, obligate rocky shore fish, *Clinus cottoides*, along 440 km of coastline. A restriction enzyme digestion approach was used to identify individual fishes belonging to each genetic lineage. Models of sea-level changes and coastline composition during the last 200 000 years were also constructed, which show that lowered sea-levels during glacial periods caused drastic losses of the favourable rocky intertidal habitat. This led to the isolation of two populations in rocky shore refugia, which separated lineages for at least 40 000 years. Further, contemporary coastal dynamics on the southern coastline explain secondary contact between lineages. The combined approach of reconstructing paleo-shorelines and molecular techniques provide a good explanation for the origin and maintenance of population genetic breaks, despite the lack of obvious geographical barriers.

Genetic and morphometric variation of *Octopus vulgaris* in the Benguela Current Region

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The Benguela Current is a cold eastern boundary current located on the south-western coast of the African continent. The establishment of its present day features ~2Mya triggered allopatric events driving genetic and/or phenotypic differentiation in many warm-temperate species that previously had continuous distributions along the south and west coast of southern Africa. However, since many of these species have responded differently, despite similar isolation times, research in this region

provides a unique opportunity to increase our understanding of evolutionary processes. *Octopus vulgaris* is a coastal, sedentary species, rarely occurring to depths of up to 200m. In spite of its worldwide distribution, very little research has been conducted on *O. vulgaris* in southern Africa. In order to gain a holistic understanding of the effects of the Benguela Current on the population structure, evolutionary history and phenotypic diversity of *O. vulgaris*, a comparative genetic and morphological study was conducted across the region. *Octopus vulgaris* genetic population structure and evolutionary history was investigated using a 580bp fragment of the mitochondrial cytochrome b (*cytb*) gene for 76 individuals located within the Benguela region, yielding 10 different haplotypes. AMOVA and pairwise F_{ST} analyses revealed significant genetic differentiation suggesting a northern-southern Benguela divergence. Estimates of time since most recent common ancestor, based on biogeographical calibrators and coalescent analyses, indicated that isolation between the Angolan and South African population occurred between ~231 Kya and 1 Mya, corresponding with the Pleistocene epoch. While the molecular analysis indicated a significant northern-southern Benguela structure, results from the principle component analysis (PCA) and discriminate function analysis (DFA) were unable to distinguish between *O. vulgaris* from different sampling localities. The lack of phenotypic variation, despite significant genetic divergence, highlights the importance of multi-method approaches in gaining a holistic understanding of the taxonomy and biogeography of species.

A kabeljou's tale – Unravelling inter- and intra-specific barriers to gene flow in depleted sciaenid species occurring along the South African coast

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The use of genetic data has been increasingly important in studying cryptic population structure and barriers to gene flow in the marine environment. In the present study we investigate levels of intra- and inter-specific genetic differentiation between two commercially and ecologically important sciaenid marine fish species that co-occur in South African waters: dusky kob (*Argyrosomus japonicus*) and silver kob (*A. inodorus*). Once considered a single taxon, morphological and life history comparative studies have conclusively distinguished these two species as separate con-generics since 1995. At the intra-specific level, morphological, behavioural and life-history data have suggested one stock for dusky kob (as a consequence of a yearly mass migration of adult fish to spawning areas in KwaZulu Natal) and three stocks for silver kob (namely South Western, Eastern and South Eastern stocks). A combination of high fishing pressure and life history characteristics (such as late maturation) has led to the collapse of natural stocks, resulting in critically low spawner biomass levels. The application of existing and newly discovered genetic markers (using a Next Generation Sequencing approach) confirmed a clear distinction between the two species. Nonetheless, a 0.7% inter-specific hybridization rate was detected, with all hybrids being first generation offspring of silver kob females and dusky kob males. On the other hand, lack of population differentiation at the intra-specific level for both species is in agreement with the previously hypothesised single-stock structure of dusky kob, but contrasted the multiple stock hypothesis for silver kob. These findings will be discussed in view of pressure from human activities as well as environmental changes, hence providing important insights for future stock recovery and fisheries management of these species.

A molecular investigation into species relationships in the genus *Ecklonia* (Phaeophyceae, Laminariales) with special focus on the Southern Hemisphere

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Kelps are one of the most important groups of inshore primary producers in temperate regions. Since the advent of molecular analyses, the taxonomic relationships of the Laminariales have begun to receive more attention, and the status of some genera has been questioned. For instance, the relationships of *Ecklonia*, *Eckloniopsis* and *Eisenia*, recently transferred to the family Lessoniaceae, remain unclear. Two species of *Ecklonia* occur abundantly in South Africa, *E. maxima* (the type of the genus) and *Ecklonia radiata*. The genus has a very interesting biogeographical distribution: *E. radiata* is also the most widespread kelp in Australasia, there are three species of *Ecklonia* in Japan, and isolated populations of *Ecklonia* in upwelling regions in North Africa and Oman. Morphological distinctions between species are often unclear. The main aim of our study was to assess molecularly *E. radiata* and *E. maxima* in the southern hemisphere. We also included samples of Japanese species in the analyses. To gain an understanding of relationships in the genus, we sequenced regions from the nuclear (ITS), mitochondrial (trnW and atp8) and chloroplastic (Rubisco) genomes and constructed a phylogeny of *Ecklonia* including available GenBank sequences for various localities as well as new sequences from South Africa, Australia and Japan. Our results support *E. maxima* and *E. radiata* as two distinct species in South Africa, and *E. radiata* as a single species throughout the southern hemisphere. We further discuss the status of the Japanese species of *Ecklonia* as well as *Eckloniopsis* and *Eisenia*.

Do viruses terminate red tides and cause severe anoxic events in the Benguela upwelling region?

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Harmful algal blooms - also known as Red Tides - are natural phenomena in coastal waters of nutrient-rich upwelling systems; however, their frequencies have been increasing globally in the recent decades. Red Tides are dense phytoplankton blooms often dominated by a single species, and commonly lead to anoxia after their death and bacterial decay. Such anoxic events have led to mass mortalities of commercially important stocks (such as fish and rock lobsters) in the Benguela upwelling region; therefore it is of societal concern to gain understanding of the underlying causes. The classic paradigm for the decay of red tides has been death due to nutrient limitation, but several studies have shown that the dominant species of dinoflagellates thrive under conditions of low-nitrate and high ammonia associated with the regenerated production in dense blooms. Our study tests an alternative hypothesis, that blooms are terminated by viruses, which are the most abundant biological entities in the world's oceans, and are particularly infective in high population densities. Here we present data from the termination of blooms of *Ceratium balechii* in 2009 and *C. furca* in 2013, both of which led to severe anoxia, prior also causing a mass mortality of coastal organisms in St Helena Bay. Using a combination of metagenomics and PCR-based sequencing tools, we first characterized viral diversity, which has never been done in the region. Further, we identify viruses

associated with respective *Ceratium* blooms, and through time-series studies of oxygen consumption, nutrient availability and viral abundance provide evidence that the termination of blooms was caused by viral infection and not – as previously hypothesized – by nutrient limitation. This study contributes significantly to our functional understanding of coastal ecosystems and provides a first account of the underexplored molecular diversity of marine viruses and their phytoplankton hosts.

Endler Hall: Genetic Approaches

Oral Presentations

The importance of molecular sequencing in detecting seaweed introductions into South Africa

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There have been very few documented records of introduced seaweeds into South Africa using traditional morphological identification, with the first only in 2005. The South African seaweed species list includes many names which are widely used globally, and could be hypothesized to be cryptogenics, locally. '*Grateloupia filicina*' is an example of a supposedly cosmopolitan rhodophyte species, which has been shown by molecular methods to exhibit local endemism throughout its range, with South African material now known as *G. capensis*. Similarly, '*Ulva lactuca*' is a green alga recorded worldwide, but South African material previously given this name, grown widely in local aquaculture, is not identical with the likely type material. Alternatively, two likely introductions of Japanese species of *Grateloupia* have recently been discovered in Saldanha Bay by sequencing, one of them being a major invader in north-eastern America. Other likely introduced taxa which have been detected in this way include an invasive strain of *Codium fragile*, and three separate introductions of different lineages of *Asparagopsis*, of which one has shown to be invasive elsewhere. We have reached the stage where it is very unusual to be able to verify a seaweed introduction without molecular evidence. Global molecular systematic studies being carried out on a number of seaweed groups suggest that many widespread taxa have a much greater degree of local endemism than suspected by morphological studies, which will enable easier molecular identification of introductions in the future.

Population connectivity of sardines (*Sardinops sagax*) of the KZN sardine run using meristic, morphological and genetic data

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The Sardine run occurs annually when large schools of sardine (*Sardinops sagax*) travel from the Agulhas Bank towards KwaZulu-Natal, and has significant ecological and anthropogenic importance. Recent investigation has highlighted the nature and mechanisms resulting in the sardine run, however, critical questions about why the sardine run occurs remain unanswered. Therefore, the aim of this project was to elucidate the population diversity, connectivity and structure of sardines

undertaking the sardine run. Sardines were sampled at four sites along the South African coast, and their morphology assessed using meristic data and geometric morphometrics. Nine exon-primed, intron-crossing (EPIC) DNA markers and the mitochondrially encoded cytochrome oxidase I (mtCOI) region of DNA were used for population and phylogeographic genetic analyses. Morphological analyses revealed significant differences between head size and shape of sardine run stock compared with other regions, and supports the delineation of a Western Cape and Agulhas bank stock. Phylogeographic analysis using cytochrome oxidase I data, supported the idea that the *Sardinops* genus is monotypic despite current taxonomy. Genetic analyses confirmed low levels of segregation between sardines from the sardine run and the Western Cape stock. However, larvae spawned in KwaZulu-Natal demonstrated moderate levels of isolation from the Western Cape stock. The results reveal that there is successful recruitment of KwaZulu-Natal juveniles to the adult stock undertaking the sardine run, but not to the Western Cape population. This suggests that although sardines from the West Coast and Agulhas Bank may partake in the sardine run, only a certain subpopulation of the Agulhas Bank stock spawn successfully in KwaZulu-Natal. These results support the hypothesis that the sardine run represents a subpopulation spawning migration of *S. sagax* in South Africa.

Evaluating environmental factors affecting the colonization history and connectivity along the west coast of Africa: Perspectives from a globally distributed species, the elf *Pomatomus saltatrix*

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Widespread species with disjunct distributions provide an excellent model for understanding the role of environmental factors (oceanographic features and climate change) influencing connectivity in the marine environment. Our study focuses on an important line fish *Pomatomus saltatrix* (commonly known as elf or bluefish). This species has a widespread distribution range and is found in the Atlantic, Indian and Pacific Oceans. It is especially prevalent in the Atlantic occurring along the coasts of South America, North America, the North Atlantic (Portugal, Mauritania and Senegal), Mediterranean Sea, Angola and Southern Africa. To understand the environmental factors at play in such a disjunct distribution, we investigated the colonization history of this species, with a particular focus along the west coast of Africa. Samples from a large range of locations (Brazil, USA, Portugal, Senegal, Angola, South Africa and Australia) were assessed using 16 microsatellites and cytochrome *b* sequences. Almost all the locations could be distinguished as distinct populations within the species. However, recent gene flow between distant locations was identified, especially a recent connection along the west coast of Africa with ongoing gene flow between Portugal, Senegal and Angola. We then used a coalescent framework with a molecular clock approach to reconstruct the colonization history of *P. saltatrix* and investigated the potential historical factors involved. Our findings indicate a complex history with deep divergences and contemporary gene flow.

Identifying the drivers of genetic structure: a multi-species approach

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Marine animal populations of the south west Indian Ocean are being subjected an increasingly large suite of anthropogenic insults. In addition to the direct effects of climate change, pollution and extraction of resources (fisheries) on these populations the indirect and synergistic effects of these perturbations are beginning to be understood by researchers. The best practice for the sustained

utilization of these living resources is thought to be through the demarcation of areas containing populations of animals that may recover and limiting extractive effort in these areas, these areas are termed marine protected areas. Identifying populations of organisms appropriate for this protection is not always intuitive. Genetic methods allow us to identify populations, species and lineages that are of importance. Phylogeographic patterns reflect the historical processes that lead to the partitioning of species and populations within species. These patterns may be tested further at time-scales that may be relevant to current resource users by employing population genetic methods. A suite of species from south west Indian Ocean coastal waters have been examined using genetic methods. The taxa chosen for this research are from various trophic levels in the coastal marine ecosystem and reflect multiple life strategies. In order to ascertain the drivers of observed genetic structure we employed presence data to derive factors determining the observed distribution of taxa. All taxa indicate high levels of population structure at local scales. However, there was also evidence of regional connectivity of populations. This disparity may be explained either by habitat specificity or selection due to the local environment. The distributions of taxa in this study are explained in terms of their ecology and genetics.

Poster Presentations

Poster # 84

Phylogeographic analysis of *Sarcophyton* in the south-western Indian Ocean using genetic markers cytochrome oxidase I (COI), bacterial MutS homologue (msh1), and signal recognition particle 54kDa (SRP54) nuclear marker

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The alcyonacean soft coral genus *Sarcophyton* is a conspicuous, ecologically important member of shallow reef communities throughout the Indo-West Pacific. Biodiversity and gene flow amongst these reef communities are essential for their survival. Reef corals display a continuum of connectivity from Mozambique to Northern KwaZulu-Natal (Maputaland). Despite their abundance and significance, little research has focused on *Sarcophyton* as the study of their ecology is confounded by inconclusive taxonomic knowledge. Preliminary phylogeographic and molecular analyses were conducted in order to address connectivity and spatial distribution at both evolutionary and demographic levels using genetic markers for Octocorallia. *Sarcophyton* populations were sampled from the Chagos Archipelago, Inhaca island (Mozambique) and Sodwana Bay, South Africa. Genetic markers for Octocorallia were used to amplify fragments of the COI-COII intergenic spacer region (257bp), msh1 (735bp) and SRP54 (244bp) in order to construct a phylogeny for 50 specimens identified to 4 species of *Sarcophyton*. Molecular and morphological analyses identified amongst others, *S. glaucum*, *S. trocheliophorum* and *S. gemmatum*, the latter species previously not recorded in this geographical region. Phylogeographic analysis and the majority of pair-wise comparisons among these locations indicated that gene flow between populations was not limited, although significant variation was found between the Chagos archipelago and the Maputaland reefs. Phylogenetic analysis revealed clades that showed evidence of species assortment as well as hybridization and possible evolutionary reticulation.

Poster # 85

Genetic discrimination between two morphologically distinct subspecies of *Panulirus homarus*

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The classification of two subspecies of *Panulirus homarus* based on morphological and colour differences are challenged using genetics. A fragment of a COI-like gene was sequenced and 10 representatives each from the microsculpta form (*P. homarus homarus*) and megasculpta form (*P. homarus rubellus*) used for the present study. An assortment of intra- and inter-population and phylogenetic analyses was carried out to test whether or not subspecies were genetically different. Results indicate that the subspecies are indeed genetically different from one another as evident from the AMOVA, the haplotype network, genetic distance comparisons, as well as character and distance phylogenetic tree based analyses. Both, *P. homarus homarus* and *P. homarus rubellus* were monophyletic with respect to the out-group taxa and each subspecies was placed in well supported sister clades (BI: 1.00, ML: 93%, P: 100%, NJ: 100%). Mismatch distribution plots, Fu's F_s and Harpending's Raggedness Index indicate both subspecies have undergone a historic population expansion, likely a range expansion estimated to have occurred during the mid-Holocene Epoch. An assortment of genetic analyses and nucleotide divergence (3%) showed marked genetic differences between *P. homarus homarus* and *P. homarus rubellus* and were comparable to species differences. Historic range expansion may account for the present day marginal overlap in distribution of *P. homarus homarus* and *P. homarus rubellus* in southern Mozambique. In terms of management, these subspecies have been found to be genetically distinct and should therefore be managed separately.

Poster # 86

The genetic structure of shared fishery species in the subtropical and warm temperate Western Indian Ocean

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Southern African marine linefish species are important recreational and subsistence fisheries in Mozambique and South Africa. However, the fisheries stocks of most of these subtropical and warm temperate species have experienced declines in recent history even with species-specific management interventions in these countries. This study evaluated the genetic diversity and stock structure of three commercially important shared fishery species that are endemic to the subtropical Western Indian Ocean: slinger *Chrysolephus puniceus*; scotsman *Polysteganus praeorbitalis* and the catface rockcod *Epinephelus andersoni*. Comparative analyses among species with similar range limits but different life history strategies was done to identify the physical and biological processes that generate population genetic structures in this region. Nuclear and mitochondrial DNA analyses indicated limited or no genetic differentiation with high levels of geneflow among areas for the two sparids (*C. puniceus* and *P. praeorbitalis*). However, the scotsman had lower levels of genetic diversity in comparison to the slinger suggesting that this species may be more vulnerable to exploitation and subsequently climate change. In contrast, analyses of the catface rockcod, indicated high levels of genetic variation and significant geographic structuring, with the northern and southern range limits being genetically isolated. The barriers to gene flow at range limits were

associated with areas of upwelling and reduced habitat availability for the species. The predicted range contractions and shifts (all species) and their effects on genetic diversity and spatial structure (catface and scotsman) make these species more vulnerable to exploitation and are a potential threat to their fisheries.

Poster # 87

Are there widely distributed non-geniculate coralline species (Corallinales and Sporolithales, Rhodophyta)? Insights from sequencing topotype or type specimens

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Recent molecular studies of non-geniculate corallines have suggested that some widely distributed species are really different species passing under one name. However, only by sequencing topotype specimens, or, much preferred, type specimens themselves, can names be assigned unequivocally. A *psbA* sequence obtained from a topotype specimen of *Heydrichia woelkerlingii* (Sporolithales) from South Africa differs by over 8% from a New Zealand specimen under that name in GenBank. An *rbcl* sequence from type material of *Spongites yendoii* (Corallinales) from Japan differs by over 10% from specimens given this name in South Africa. An *rbcl* sequence from type material of *Mesophyllum erubescens* (Corallinales) from Ilha Fernando de Noronha off Brazil is an exact match to only one of four species passing under this name from Brazil; it differs by over 8% in *psbA* from New Zealand specimens under that name in GenBank. We question all reports of non-geniculate coralline species said to be widely distributed based on anatomical/ morphological features. Our DNA sequencing results strongly imply that the number of extant species of both geniculate and non-geniculate coralline algae has been substantially underestimated.

Poster # 88

A genetic assessment of the spangled emperor, *Lethrinus nebulosus*, in the south west Indian Ocean reveals two distinct stocks

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The spangled emperor (*Lethrinus nebulosus*) is a widespread and common fish in the Indo-West Central Pacific. The species is a major component of artisanal, subsistence, recreational and commercial fisheries throughout this distribution, including the south west Indian Ocean (SWIO). These fisheries are mostly overexploited and data to inform their management are scarce. Differences in growth and life-history features suggest regional or ecological variation across the species' full distribution and the possibility of discrete, independent stocks. This study aimed to determine whether *L. nebulosus* represents a single unit stock in the SWIO or whether there are geographically-discrete stocks, requiring independent management. Tissue samples were collected from 242 *L. nebulosus* specimens from eight SWIO sampling regions. DNA sequence data were generated for a 422 nucleotide fragment of the highly variable portion of the mitochondrial control region and individuals were genotyped for 14 nuclear microsatellite loci. Data were analysed using conventional population genetic and phylogeographic approaches. Through these, two divergent and distinct genetic stocks were identified in *L. nebulosus*. The first was widespread across the SWIO, but rarer in Mozambique and South Africa. Although certain regions (the Mozambique Channel and Mauritius) showed evidence of reduced connectivity, geographic distance did not limit gene flow and

this stock can be considered homogenous and panmictic. The second stock was restricted to southern Mozambique and South Africa. This stock may represent a novel, cryptic species, requiring further investigation. These findings have important fisheries management implications. Both stocks are shared resources and co-operative, co-ordinated, trans-boundary management is required. Mixed stocks are found in both Mozambique and South Africa; it is imperative that these stocks are identified and that biological studies and assessments of stock dynamics are undertaken for each stock, independently.

Poster # 89

Assessing the population genetic structure of *Marphysa corallina* (Polychaeta: Eunicidae) found along the east coast of South Africa

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The Annelida are one of the most diverse, successful and evolutionary ancient taxa among invertebrates. Traditionally Annelida have been divided into two monophyletic sister groups, Clitellata and Polychaeta. Majority of the diversity from the Annelida taxon can be found in Class Polychaeta. Polychaete worms are well represented and are an integral part of the benthos of all marine habitats such as estuaries, rocky shores, continental shelves, deep sea hydrothermal vents as well as in the water column. The ability of Polychaetes to easily adapt to a whole range of habitats and variable environments is displayed by their numerous feeding modes such as free-living predators, filter feeders, parasites and scavengers. Over the years, polychaetous annelids have been classified into approximately 80 families however, the phylogenetic relationships between the families are poorly understood and the monophyly of the families are still under much debate. Order Eunicida forms one of the best morphologically defined higher taxa within Class Polychaeta. *Marphysa* is one of 9 currently accepted genera in Family Eunicidae (Order Eunicida); and species belonging to this genus have been found to be cryptic sibling species. Therefore the aim of my study is to look at the genetic structure of populations of *M. corallina* from various different sites along the East coast of South Africa. Diagnostic taxonomic characters will be used to identify them to species and a suite of 4 genes (3 nuclear and 1 mitochondrial) will be used to assess the genetic structure of each population. Thereafter, due to the lack of barcoded polychaete sequences available, all species collected will be barcoded.

Poster # 90

Population structure of Blacktail (*Diplodus capensis*), Natal Stumpnose (*Rhabdosargus sarba*) and Stonebream (*Neoscorpis lithophilus*) fish populations in the southeast African region using RAD tag sequencing

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The Blacktail sea bream (*Diplodus capensis*) is an inshore fish species, distributed from Angola to Mozambique and Madagascar. The Natal Stumpnose (*Rhabdosargus sarba*), is also an inshore reef species. The Blacktail sea bream and the Natal Stumpnose are both from the family Sparidae. The Natal Stumpnose has a wide global distribution in both the Indian Ocean and in Indo-Pacific waters. Stonebream (*Neoscorpis lithophilus*) is an inshore fish species of the family Kyphosidae. This rocky shore species is found along South Africa's east coast, Mozambique and the southeast Madagascan

coast. These three fish species are important in the recreational fishing sector in South Africa and the subsistence fishing sector in South Africa, Mozambique and Madagascar. For a species that has a wide distribution, knowledge of population connectivity is essential to the understanding of population dynamics. This connectivity is important in maintaining population abundance as well as genetic diversity of the species. This project aims to determine the genetic connectivity of populations of these three fish species in South Africa, and between South Africa and Madagascar using Next-Generation sequencing techniques. Genome-wide sequencing, as undertaken by Next-Generation techniques, allows researchers to examine the effect of evolutionary processes across the whole genome. Specifically, restriction-site associated DNA tags (RAD tags), which are short DNA sequences flanking recognition sites of particular restriction enzymes, will be used. These will allow the targeted sequencing of complete genetic markers such as microsatellites (SSRs) to reveal the process of evolution on this rapidly evolving marker, and elucidate processes driving connectivity. The information gained can be incorporated into management strategies for these.

Poster # 91

Molecular revision of Zoantharia (Anthozoa: Hexacorallia) on the east coast of South Africa

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Despite the global distribution of zoanthids and their ecological importance in marine systems, zoanthids have largely been ignored in ecological surveys due their taxonomy. Issues with their taxonomy are largely caused by the morphological plasticity of species and the inadvertent re-descriptions of the same species. Zoanthids cover large patches on the rocky shores of South Africa and no molecular revision has been carried out on these zoanthids. The aim of this investigation was to construct a phylogeny and revise the diversity of zoanthids found on the East Coast of South Africa. The molecular markers used were 16S mitochondrial DNA and the internally transcribed spacer region of ribosomal DNA. The 16S sequences were conservative and therefore had to be supplemented with ITS r-DNA data. The ITS r-DNA region of the *Symbiodinium* sp. of specimens was amplified. Previous work using the above molecular markers showed that *Zoanthus natalensis* is conspecific to *Z. kuroshio* and *Z. durbanensis* is conspecific to *Z. vietnamensis*. Both of these species are found in the Pacific, and therefore the internal histology of *Z. natalensis* and *Z. durbanensis* was detailed to draw comparisons between the congeners. Results indicate that the diversity of zoanthids in South Africa was relatively low despite the diversity in morphotypes, and there is a potential synonymy with *Palythoa nelliae* and the Pacific species *P. mutaki*. Further study should include sampling at subtidal depths to include greater diversity.

Poster # 92

Evolutionary and phylogenetic patterns of Diplodus fishes in the Eastern Atlantic: use of nuclear markers for resolving biogeographic hypotheses

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The *Diplodus* genus (*Sparidae*) is composed by 15 inshore fish species, which occur from cold-temperate to sub-tropical regions in the Atlantic Ocean, the Mediterranean Sea and the Indian Ocean. Based on the control region of the mitochondrial DNA, the genus is thought to have originated in the central Atlantic region, from which it dispersed colonizing both sides of the Atlantic Ocean and the western Indian Ocean. While some species display a narrow distribution range confined to the sub-tropical region, the majority of temperate species appears to have evolved to colonize different habitats, and have extensive distribution ranges in the eastern Atlantic. In

particular, *D. sargus*, *D. cervinus*, *D. bellottii* and *D. vulgaris* have widespread distributions that are likely to be influenced by the presence of strong oceanographic barriers such as the Atlantic-Mediterranean transition, the Canary Current, the tropical region in central Atlantic, and the Benguela Current. However, previous phylogenetic studies were conducted based solely on mitochondrial DNA and using a limited number of individuals, not reflecting the extensive geographical distribution of these species. As representative sampling is essential to accurately infer phylogenetic relationships and understand the role of biogeographical barriers in the evolution of marine fish, we obtained samples of all the *Diplodus* species occurring in the eastern Atlantic from different latitudinal regions, covering their distribution range. Phylogenetic relationships were reconstructed based on nuclear markers (18S, S7, Idh-b) and compared to the previously obtained mitochondrial DNA trees. The widespread latitudinal distribution of this genus makes it an ideal candidate to investigate the weight that different oceanographic barriers may have on shaping population connectivity and the evolutionary history of marine species.

Poster # 93

Connectivity of *Perna perna* populations from Madagascar and South Africa

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The terrestrial biota of Madagascar is characterised by a large number of endemics. This divergence has not been mirrored in the marine environment, with many organisms apparently shared with the east coast of Africa. This would suggest that, unlike the terrestrial system, a level of genetic connectivity persists. A proposed mechanism for this connectivity is transport by large open-ocean eddies. Conservation of potential vorticity and a change in topography of the south Eastern Madagascar Current results in the generation of cyclonic and anticyclonic eddies. *Perna perna* has a relatively long larval period (15-20 days) and is suggested, like other members of the Mytilidae family, to be able to delay settlement for up to 3 months during unfavourable conditions. This, and their ability for substrate attachment, makes them an ideal candidate to investigate connectivity between Madagascar and south east Africa. *Perna perna* samples have been collected from two Madagascar sites (Lokaro and Tôlanaro) and three sites along the KwaZulu-Natal/Transkei coastline (Sodwana, Clansthal and Umgazana). Size classes and sex have been recorded in order to determine whether genetic structure is affected by age or sex. By implementing Next Generation Sequencing (NGS) in order to identify single sequence repeats (SSRs), it is expected that in the region of 100 SSR sites will be identified. This high-throughput sequencing and associated large data outputs will allow for a resolution of the dynamics of *P. perna* populations beyond the scope of more classic molecular methodologies.

Poster # 94

MEEP across the Seas: a South African perspective on connectivity, demography and speciation of marine organisms

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The marine team of the Molecular Ecology and Evolution Programme focuses on a wide range of wild populations of marine organisms and cutting-edge statistical approaches. To improve knowledge that can contribute to natural resource management and biological conservation, we use information from a variety of molecular genetic markers to address fundamental and applied research questions in ecology and evolutionary biology at both population and species level. Our research aim is to

identify processes that influence the evolution of species and populations through space and time. The research also involves the development and application of novel molecular markers, analytical frameworks and methodologies for the study of marine organisms. Our emphasis is on marine fish (including, amongst others, sparids, siganids, serranids and sciaenids), but we also work on invertebrates (brittle stars) and mammals (whales, seals). Geographically, our main focus is on the South West Indian Ocean and the South East Atlantic but we also work at broader spatial scales. Here, we present an overview of our research on connectivity, demography and speciation. We have identified contrasted patterns of connectivity among local and distant populations, covering the continuum from nearly panmictic to completely isolated gene pools. We also identified effects on demography, such as expansions coinciding with past climatic changes and recent genetic bottlenecks linked to anthropogenic factors. More recently we have started addressing questions related to speciation in marine organisms linked to environmental drivers and selection pressures. We wish to expand our research within a multi-disciplinary collaborative framework.

Poster # 95

Determining the correct identity of South African *Marthasterias* (Echinodermata: Asteroidea)

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Marthasterias glacialis are found in the cool temperate waters of the north-eastern Atlantic, the subtropical Mediterranean Sea and along the south-western tip of Africa. The South African *Marthasterias* population includes two morphotypes, a smooth, spineless *rarispinga* form and a spiny *africana* form and these have been described as separate species, subspecies, or *forma* by various authors over the last century. To test whether these two morphotypes represent separate species, and whether either, or both, are conspecific with the Northeast Atlantic species, 78 *Marthasterias* were collected from the Cape Peninsula of South Africa. Morphological comparisons between individuals of the two forms showed no significant clustering of samples, indicating that there is no morphological separation of the two South African forms into distinct groupings. The *africana* and *rarispinga* forms were also shown to be genetically indistinguishable, using a fragment of the mitochondrial Cytochrome c oxidase subunit I (COI) gene and the nuclear internal transcripser spacer I (ITS1). These sequences were also compared to those from European specimens, and phylogenetic reconstruction and intra and interspecific levels of divergence demonstrated that the South African specimens formed a single species genetically distinct from the European *M. glacialis*, and should be raised to species status under the previously used name, *Marthasterias africana*. True *M. glacialis* have a spine armament pattern of a series of regular spine rows down the length of each arm whilst *M. africana* are either covered in many irregularly-spaced spines, or have an extraordinarily bare surface of only two spine rows per arm. *Marthasterias africana* may also have an actinal spine simulating the presence of a third inferomarginal spine. This work resolves the taxonomic dispute, separation and amalgamation of the two African forms and establishes a single, uniquely South African *Marthasterias* species distinct from the north Atlantic *M. glacialis*.

Poster # 96

Will the real *Pseudopolydora antennata* please stand up? Towards unravelling the species complex

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Pseudopolydora antennata was originally recorded in Naples in 1869. Since then it has been recorded in Mediterranean, Black Sea and European waters and in South Africa, India, the Marshall Islands, Australia, Grand Caribbean, New Zealand, Japan and China. Such a wide distribution suggests that either this species is a complex of morphologically similar species, or an alien invader. However, while it was abundant in some places, it has never been considered an alien invader anywhere in its distribution. We examine specimens from South Africa and Australia and compare the molecular structure of specimens from South Africa and Japan. The results show that the South African and Australian specimens are not the same species. Although they conform to the general diagnosis of the species, they differ with respect to body size and the structure of the prostomium. Additionally, analysis of 18S and 28S nuclear markers show that there are two species in Japan currently known by this name, and both species differ from the South African species. Thus we conclude that *Ps. antennata* is a complex of morphologically similar species. Additional information of specimens from India will also be included.

Poster # 97

Genetically-guided taxonomic studies of the goatfish genus *Upeneus* (Perciformes: Mullidae) in the Western Indian Ocean

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Goatfishes (family Mullidae) are ecologically- and economically-important inhabitants of sand-associated, shallow-water habitats. The genus *Upeneus* contains approximately 30 species, occurring in coastal subtropical and tropical environments in all major oceans. The single review, published in 1984, of the genus in the Western Indian Ocean (WIO) recorded nine species occurring in this region. That more taxonomic research is needed is reflected in the recent description of six species from the Western and Central Indian Ocean alone, and observations of regional differentiation in many known species. As such, an integrated research “pipeline” was adopted to address taxonomic questions in WIO *Upeneus*, using analyses of sequence data from the “barcoding” fragment of the cytochrome *c* oxidase (COI) gene to guide further morphometric analyses, morphological examinations and eventual taxonomic studies. Typically, this involved the generation and phylogenetic analysis of in excess of 540 nucleotides of COI and the morphometric analysis of more than 50 morphometric, meristic and colour characters, collected from a large number of specimens. This poster presents results from three case studies. Genetic evidence and a combination of morphological characters provided evidence for the recognition and description of a new species, *Upeneus heemstra* n. spp, as being distinct from a congener, *U. tragula*, within a complex of “dark freckled” goatfish. Secondly, this approach demonstrated the validity, albeit with limited differentiation, of two morphologically-similar but allopatrically-distributed species (*U. suahelicus* from the WIO and *U. supravittatus* from Sri Lanka and southern India). Lastly, a wider phylogenetic analysis demonstrated that five species groups, defined on the basis of phenotypic similarity in order to facilitate species comparisons, are artificial and not indicative of evolutionary relationships. This may indicate homoplasy in certain of the morphological characters considered. Collectively, the integration of these techniques appears to be a rationale approach for dealing with understudied and morphologically-complex groups.

Poster # 98

Scyphozoan diversity around South Africa

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The number of described species of Scyphozoa is ~200. Although this number is low, and may reflect the planktonic nature of their life-cycle, almost 1 000 species of mero- and holo-planktonic Hydrozoa are recognised (~32% of all species). South Africa is a biologically diverse country yet only 10 species of Scyphozoa have been formally described from the region. This number represents ~5% of the global species pool. By contrast, almost 300 species of mero- and holoplanktonic hydrozoans are known from the region: which equates to ~28% of the global species pool. This suggests that the diversity of regional Scyphozoa has been severely underestimated. The aim of this study is to better understand scyphozoan diversity around South and southern Africa by a) creating an inventory of published and unpublished South African material, b) updating the catalogue of specimens from the Iziko Museum of South Africa and c) identifying tissue samples collected by DAFF and DEA using molecular methods (Co1 and ITS 1). Preliminary results are shown.

Poster # 99

Benguela: Will the real *Chrysaora fulgida* please stand up!

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Comprising 96% water and having few distinguishing features, jellyfish are hard to identify and confusion in the taxonomic literature abounds. Two species of *Chrysaora*, *C. fulgida* Reynaud 1830 and *C. africana* Vanhöffen 1902 have been formally described from along the west coast of South Africa, but which is which and whether either (or both) is another (*C. hysoscella* Linnaeus 1767), is as yet unresolved. To add to the confusion, a distinct morphotype is seen along the south coast which has characteristics of both *C. fulgida* and *C. africana*. Here we present the results of a detailed study examining the morphology and genetics (ITS1 and COI) of all the species, and unambiguously demonstrate their specific identities. Further, following examination of type specimens of both *C. fulgida* (Paris) and *C. africana* (Berlin), we are in a position, once and for all, to put names to faces.

Poster # 100

Diversity studies on South African *Hypnea* (Cystocloniaceae, Rhodophyta)

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Some of the species in the genus *Hypnea* are economically important as both food and sources of carrageenan. Out of the 113 species listed worldwide, around half that number is currently accepted taxonomically. There are currently 8 recognised species in South Africa (*Hypnea arenaria*, *H. ecklonii*, *H. intricata*, *H. musciformis*, *H. rosea*, *H. spicifera*, *H. tenuis* and *H. viridis*). Found globally, mostly on tropical and subtropical shores, the genus is shrouded in taxonomic confusion because of the morphological plasticity of species and a general lack of clear morphological characters. Axes and branches are terete, branches have pointed apices, and almost all species have few to many characteristic apical hooks which entangle them with other seaweeds. Some species are difficult to

tell apart and appear to differ only in dimensions, which often overlap between species. In addition we have found that some entities do not clearly fit the species descriptions already in existence. In South Africa *Hypnea* is ecologically prominent on many shores. *H. spicifera* is often dominant in the lower intertidal, particularly on the south coast, and is the most widespread along the Southern African coastline, recorded from northern Namibia to northern KwaZulu-Natal. *H. spicifera* is highly variable ranging from a 2-3cm high, bright green turf to dark purple stands comprising 50cm long thalli. Other genera of red algae in South Africa have been shown to have more species than originally thought. In this study, morphological and molecular techniques using the chloroplast gene sequence *rbcL* will be used to re-examine South African taxa in this genus and the following questions will be investigated: 1) How many *Hypnea* species occur in South Africa?; 2) Is *H. spicifera* one species?; 3) What are the biogeographical affinities of South African *Hypnea* species?

Poster # 101

A taxonomic re-evaluation of *Serranus cabrilla* and *S. knysnaensis* (Family: Serranidae) in South Africa

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Serranus Cuvier 1816 is the only genus of the subfamily Serraninae that is found in South Africa, with its species being distributed from around the Cape of Good Hope to Kwa-Zulu Natal. Although 20 species of *Serranus* are recognised, only two are found in South Africa namely; the barred rock cod *S. novemcinctus* Kner 1865 and comber *S. cabrilla* (Linnaeus 1758). However, there is taxonomic uncertainty among these South African species. *Serranus cabrilla* which is the most common and widely distributed is a species complex with numerous synonyms. Most of these synonyms however have no type material and were described from unknown localities, with a few being described from Mediterranean Sea, the type locality of *S. cabrilla*. There is only one synonym described from South Africa (Knysna), the African sea bass *S. knysnaensis* Gilchrist 1904. It has been stated that there is confusion between the two species as *S. knysnaensis* is likely to be endemic to South Africa compared to *S. cabrilla* which is distributed in various areas. South African *S. cabrilla* also has different DNA barcodes using the mitochondrial DNA cytochrome *c* oxidase subunit I (COI) gene suggesting the presence of two species. The aim of the present study is to therefore re-evaluate the taxonomic status of *S. cabrilla* and its synonym *S. knysnaensis* in South Africa using morphological and genetic data. Selected meristic (including x-rays for osteological examination) and morphometric characteristics of South African *Serranus* species will be examined. DNA sequences will be generated from the barcode of life database (BOLD) system for inter specific genetic diversity analyses. The results from the current study should determine whether *S. cabrilla* and *S. knysnaensis* are different and whether South African populations of *Serranus* are different from other populations in other regions.

Tracking changes for managing tuna longline bycatch on the high seas

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The Tristan Albatross *Diomedea dabbenena* is Critically Endangered. Over 99% of adults breed at Gough Island, central South Atlantic Ocean, where chicks are threatened by introduced predators. At sea birds mostly remain within the South Atlantic Ocean, where they are threatened by incidental capture in longline fisheries. Conservation measures to reduce seabird mortality in pelagic longline fisheries are confined largely to fishing effort south of 25°S. This covers the core range of breeding Tristan Albatrosses, but the distribution of non-breeding adults and immature birds is unknown. We tracked 14 non-breeding adult Tristan Albatrosses from Gough Island for up to three years, from 2004-2006, using geolocating loggers. All birds remained in the South Atlantic or southern Indian Oceans, and showed distributions centered on the Sub-Tropical Convergence. They used the south-west Atlantic during the austral summer, and the south-east Atlantic and Indian Oceans as far east as Australia during the austral winter. Foraging effort was concentrated in areas of upwelling and increased productivity. The distribution of the tracked birds overlapped with a range of pelagic longline fisheries, especially off southern Africa. Of particular concern was that two birds spent several months off the coast of Namibia and adjacent high seas north of 25°S, where currently there are inadequate regulations to reduce seabird bycatch during pelagic longline fishing operations.

Hook Pods: Silver lining for seabirds in pelagic longline fisheries?

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A major threat to many albatross and petrel species, including some which breed in or migrate to South Africa, is accidental mortality from longline fishing. Measures to avoid or reduce seabird bycatch are under development and testing. Critical to effective bycatch mitigation is that a measure/device/system is easy to use, safe, cost-effective and has no operational/economic drawbacks (i.e. does not reduce catch rates of target species). The hook pod has all these ingredients and has the potential to virtually eliminate seabird bycatch in industrial pelagic longline fisheries. Hook pods were tested against standard fishing gear (80 g swivel) onboard a South African longline vessel during the peak seabird period with more than 1500 observations made from a deployment of 15,300 experimental hooks in 24 longline sets conducted over 2 trips in 2012. Catch rates of target (tuna/swordfish) and non-target (sharks) species, as well as seabird bycatch and bird attack rates on hooks were recorded for comparison. More than 950 target species fish and nearly 500 sharks were caught on experimental lines. There were no significant differences ($t_{(950)}=1.65$; $p=0.94$) in catches of target species between the treatments. Similarly, there were no significant differences ($t_{(500)}=1.69$; $p=0.67$) in the number of sharks caught between treatments. High numbers of seabirds were present during setting of the longline gear during booth trips but no seabird mortalities were recorded. The

hook pod is a device that is inexpensive, effective and easily adopted into standard fishing operations and which addresses a critical conservation issue.

Breeding success and foraging ecology of sooty and light-mantled sooty albatrosses on Marion Island

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The sub-Antarctic Prince Edward Islands are one of two archipelagos where dark-mantled sooty (*Phoebastria fusca*; DMSA) and light-mantled sooty (*P. palpebrata*; LMSA) albatrosses breed sympatrically in substantial numbers. The DMSA is currently listed as endangered and its population at Marion Island, the larger of the two Prince Edward Islands, has been declining at 2% per year since 1996, whereas the LMSA is near threatened and its population at Marion is thought to be increasing at 5% per year since 1996, but confidence in counts and resultant trends is low. Little is known of the species' demography on Marion Island, with only one study of their breeding biology in 1979. We studied the breeding success of both sooty albatrosses, and investigated their foraging ecology using GPS loggers during both incubation and chick-rearing in summer 2013/14. Three DMSA and two LMSA colonies were monitored from the start of incubation to fledging of the chicks and breeding success for both species were 60%, substantially higher than the 1979 estimate of 35%. A total of 32 DMSA and 8 LMSA complete foraging trips were tracked. DMSA mostly foraged north of the island and LMSA to the south. Trip duration and distance travelled decreased from during incubation to chick-provisioning trips. Our study provides new data on the status of both albatross species on Marion Island and on movements of the adults during the breeding season. This updated information is crucial for conservation purposes as Marion Island is a marginal breeding ground for both species and the effects of climate change may be seen here sooner than at other sites.

The Dyer Island Penguin Pressure Model – an interdisciplinary tool for understanding population trends

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The African penguin (*Spheniscus demersus*), endemic to Namibia and South Africa, is currently listed as “Endangered” due to dramatic declines of its global population. The number of breeding pairs at Dyer Island, Western Cape, formerly one of the largest colonies, has decreased from over 20,000 breeding pairs to less than 2,000 in the last three decades. A large number of factors have been identified as potential reasons for this population decline. Reduced prey availability around Dyer Island could be caused by intensive fishing but also by a shift in fish distributions along the South African coast. Other factors include disturbance, oiling, predation by seals and gulls as well as climatic effects such as heat stress and flooding. We will present recent breeding success and survival rates for penguins breeding on Dyer Island as well as estimates for other parameters. We will show

how an interdisciplinary group of experts, consisting of biologists, fisheries scientists, modellers, conservation managers and social anthropologists can help to understand the potential drivers of penguin population dynamics at Dyer Island, and propose potential management interventions for further considerations. The qualitative and quantitative data presented will be used on a systems model approach which aims for a better understanding of the interacting processes and will be used as a tool to advise the fisheries management working groups applying an Ecosystem Approach to Fisheries as well as for the implementation of the African Penguin Biodiversity Management Plan.

Establishing a new African Penguin colony: insights from population modelling

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African Penguins (*Spheniscus demersus*) breed only in South Africa and Namibia where they are limited to breeding on islands or mainland sites that are protected from predators. Of the South African colonies, most are island colonies on the west coast. Eastward from Dyer Island there are no suitable islands for nesting penguins until St Croix Island in Algoa Bay, ca 600 km to the east. While the presence of suitable breeding islands may be lacking, long term surveys of pelagic fish abundance show consistently high abundance of sardine and anchovy (the penguins' preferred prey) in the vicinity of Mossel Bay. We investigated the feasibility of establishing a new penguin colony using a simple population model. We modelled the numbers of penguins that would need to be translocated and the likely level and timeframe of supplemental translocations required to create a self-sustaining population, large enough to overcome the stochastic effects that plague small populations. We also present preliminary results of a modified model which examines the effects on existing colonies of removing chicks and juvenile birds. The rate at which translocated penguins recruit to the new colony will determine the numbers of birds translocated, both initially and subsequently. Translocations are expected to be a major cost (both financially and in terms of impacts of removals from source colonies). To reduce those costs, we suggest methods for encouraging penguins to recruit at the chosen site. If successful, the new colony will increase the species' resilience in South Africa, by reducing the distance between the two regional subpopulations.

Sex specific time-activity budgets in a colonial seabird assessed through VHF technology

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Seabird proxies have the potential to act as useful and cost-effective indicators of the state of the marine environment. Seabird time-activity budgets, in particular, reflect short-term changes in prey conditions. In this study an automated technique for long-term continuous recording of Cape gannet, *Morus capensis*, time-activity budgets using VHF transmitters was tested. Our results demonstrate that radio-transmitters attached to leg-rings had no impact on adult foraging trip and nest attendance durations, breeding success or chick growth. Furthermore, frequencies of nest attendance and foraging trip durations estimated by the VHF logging system were no different to those estimated from hourly direct observations. Using Time-Depth Recorders we were able to assess the time that birds rested on the sea surface in relation to foraging trip duration. The VHF monitoring system provides a simple method of accurately assessing the time-activity budget of a colonially breeding seabird. This approach has wide-scale applicability for many colonially-breeding

seabirds, and can provide sensitive, real-time indicators of prey abundance for fisheries management. Foraging trip duration and chick provisioning rate was clearly sex-specific and associated with chick developmental stage. Females made significantly longer but fewer foraging trips and spent less time at the nest during chick provisioning. These sex-specific differences became increasingly apparent with chick development. This study thereby provides new insight into the foraging behaviour of breeding seabirds, particularly during the post-guarding phase.

Stony Point: African Penguin management in a residential area

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Since 2010 a number of changes have occurred in the conservation management for the endangered African penguin, *Spheniscus demersus*, at Stony Point, Betty's Bay. Stony Point has lived through numerous types of land-use and management authorities, both before and after the arrival of penguins. While this colony's population is growing the story for the rest of the African penguin population is dire, and led to the formulation of a biodiversity management plan which was gazetted in 2013. Stony Point presents an unusual situation as penguins began nesting here some 150 years after people began frequenting and inhabiting this area. Starting in 2010, ethnographic fieldwork over the last two years has revealed some of the implications of these continual changes for both human and penguin residents of Stony Point. The colony has been managed as an income generating tourist attraction with little or no focus on conservation or engagement with neighbours. Only in 2010 was the land rezoned from Municipal Open Space to Open Space 1 Nature Reserve. Being able to monitor and protect the penguins effectively while also managing their attempts at expanding into residential areas requires good working relationships with residents. Tracking these changes is important to document and allows the management plan under development to exist within a context. The Stony Point management plan will need to address both social and biophysical challenges. We argue that the social challenges making up Stony Point are opportunities that can create and sustain a management approach which residents are as much a part of as are penguins.

Developing a national management plan for the African Penguin in South Africa

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The present population of the African Penguin (*Spheniscus demersus*) in South Africa is approximately 2.5% of its level 80 years ago and the species is listed as Endangered. Many organisations, both national and international, governmental and non-governmental (NGO) are involved in the conservation of the African Penguin, all of which have an important role to play. Achieving a common goal with such a diversity of role-players requires that activities are co-ordinated and aligned. In South Africa, the National Environmental Management: Biodiversity Act (No. 10 of 2004) provides the framework for the coordination of the conservation of protected species through the compiling of a Biodiversity Management Plan for Species (BMP-S). In 2010, the process was initiated to develop a BMP-S for the African Penguin, the first such plan that has been developed for a threatened seabird species in South Africa. This management plan aims to provide a coordinated national approach to all aspects involved with African Penguin conservation. The presentation will discuss the motivation for developing the BMP-S, outline the process followed to

develop it and highlight the vision, objectives and anticipated outcome of the BMP-S for the African penguin. While the development of the BMP-S to completion was driven by the South African government, it would not have been possible without a number of inputs from NGOs. Thus, the need for stakeholders engaging with policy and governance will also be discussed, as will be the manner in which stakeholders such as scientists, conservation managers NGOs are contributing to the implementation of this particular plan. Challenges faced in developing and implementing the management plan is highlighted.

Jannasch: Seabirds

Oral Presentations

Foraging strategies of breeding African Penguins, *Spheniscus demersus*, in relation to fine-scale distribution and abundance of pelagic fish species

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To optimize energy gain, animals need to adapt their foraging strategies to the scale of variability of the environment in which they feed. Determining these strategies for inshore marine species is complicated by scale-related discrepancies in interpreting the variation in their food supply. For instance, African Penguins forage within ca. 50 km of their colonies during the breeding season. To examine the foraging strategies adopted by this species, we deployed 172 chick-rearing individuals with GPS loggers between 2012 and 2013, while simultaneously surveying pelagic fish schools within their foraging ranges around St Croix and Bird islands. Machine-learning algorithms were used to predict the behavioural state of penguins using dive descriptors from 229 birds equipped with both GPS and depth loggers between 2007 and 2013 to classify foraging and commuting modes. During periods of lower prey abundance, birds frequented distinctive areas of predictable prey availability. When pelagic fish were abundant, penguins foraged over a wider range of directions, likely limiting intra-specific competition, while remaining close to their colony. Foraging path metrics were inversely related to overall fish abundance. Differences in foraging strategies between sites are discussed with reference to the influences of ocean physical processes and purse-seine fishing activities.

Social foraging in Cape gannets

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In the marine environment, seabirds are commonly observed foraging in groups. The mechanisms underlying these behaviours, and their consequences on the foraging success of individuals, are poorly understood due to the difficulties in studying their behaviour at sea. The marine environment is vast and highly dynamic. The resources are aggregated in hierarchical patches of which the location is constantly changing. The marine environment therefore favours the evolution of foraging group strategies to increase the success of individuals. We studied social interactions during the foraging trips of a seabird, the Cape gannet (*Morus capensis*) and their effects on the foraging decisions of individuals. Breeders were equipped with GPS devices and video-cameras on Bird Island (Algoa Bay, South Africa) in order to study their movement at sea in relation to their proximate environment. All the individuals interacted with conspecifics at sea, and several types of interactions were observed to affect their foraging capacities. While searching for prey, gannets reacted to conspecifics by changing their flight direction thereby reducing the time to find prey. Gannets were attracted to aggregations of conspecifics, and the detection and joining of foraging groups increased their abilities to find and hunt for inconspicuous prey. Furthermore, from underwater video footages of pelagic fish schools under predation we showed that successive attacks by several predators disorganized the schools and increased the feeding success of individual birds. We highlight the important role of social interactions along all stages of a foraging trip in Cape gannets: when choosing a direction from the colony to orientate towards a patch of food, in order to locate inconspicuous prey, and to capture fish in schools. Competition between seabirds should therefore be moderated, as facilitation during foraging seems to play a crucial role in enhancing feeding success of individuals.

Trophic overlap between African penguins, Cape gannets and Cape fur seals in Algoa Bay (Eastern Cape): multi-indicator approaches

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Three species of marine top predators endemic to Southern Africa share their breeding and feeding grounds in Algoa Bay (Eastern Cape, South Africa). The bay hosts the world's largest colony of Cape gannets *Morus capensis* (CG; ~100 000 breeding pairs, increasing), > 40% of the endangered African penguin *Spheniscus demersus* (AP) breeding population (~10 000 breeding pairs, decreasing), and the eastern-most Cape fur seal *Arctocephalus pusillus pusillus* breeding colony (CFS; annual pup production ~600, stable). These three species are central place foragers for part of their lives and typically limit competition for resources through spatial, temporal, and/or trophic segregation. We combined direct and indirect approaches to examine resource partitioning among the three species

in both the summer and the winter of 2013. We conducted (1) scat (CFS) and stomach content (GC, AP) analyses (information about the last few meals), (2) stable isotope ratios of carbon (foraging area) and nitrogen (trophic level) of blood (diet information about the last few weeks), and (3) of fur/feathers (diet information during previous moult). In addition, potential prey were collected concurrently from fisheries for use in mixed-models to estimate the predators' diet from $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ signatures. Anchovy were the main prey items of adults and chicks of both seabird species in both seasons. The trophic overlap was less pronounced with CFS since they relied primarily on both small pelagics and tongue-fish. Tight dependence of the seabirds on small pelagics availability might make them more vulnerable to environmental changes, especially AP, and which might be linked to their recent population decline. The dietary flexibility observed in CFS may explain their stable population. Multi-species approaches combined with various dietary techniques allow a better understanding of the ecosystem dynamics in Algoa Bay, crucial information for conservation purposes.

Linking the foraging ecology and population dynamics of swift terns to the availability of forage fish

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Localised purse-seine fishing effort in combination with environmental forcing is considered the main cause of the decrease of several endemic species of seabirds in the Benguela ecosystem. However, the population of Swift Terns *Thalasseus bergii* has increased over the last few decades. The reasons for these conflicting trends are poorly understood. The nomadic characteristic of Swift Terns allows them to choose the best breeding locality based on cues such as spatial variability in food abundance. This flexibility, in conjunction with high juvenile survival due to a strong dispersal capability, is thought to be a contributing factor explaining the positive trend in this species. However, they continue to breed successfully at islands off the west coast, where other species feeding on pelagic fish are in decline. Our study investigates the foraging ecology of Swift Terns in the Western Cape. During the first breeding season more than 3000 photographs of prey items were collected. The most abundant prey was Anchovy (*Engraulis encrasicolus*, 83.3%) but a wide range of different prey was also captured including molluscs and arthropods. Foraging effort was monitored by 600 hours of video recordings at-nest. Analysis of trip duration and time budget showed adults make more trips per day during the chick-rearing period than during incubation. Hatching success monitored through time-lapse photography was approximately 50%. Five hundred chicks were banded with individually engraved colour-rings. Marked birds were re-sighted along the Namibian and Eastern Cape coasts. Combining this information with a large database of marked Swift Terns will provide further insight on population dynamics, survival, breeding site-fidelity and movement patterns in general. Understanding the coping mechanisms of Swift Terns to the reduction in food availability is key to assess the impact of commercial fisheries on seabird populations and fish stocks, and to develop programmes for their conservation.

Animal-borne camera loggers: Investigation for use in Gentoo penguin foraging ecology

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Miniaturised devices for studying marine vertebrate ecology have been employed for many years. Many of these devices rely on underlying assumptions when making inferences (e.g. prey capture rate, feeding events) from the data. Direct observations, through the use of animal-borne camera

loggers, have been limited to larger animals. The aim of this study was to test the effectiveness of miniaturised video cameras, in studying Gentoo penguin (*Pygoscelis papua*) foraging ecology at the Falkland Islands. Specifically, this study trialled video cameras for potential use in future studies, at sites with concurrent dietary investigations using stomach content analysis. We investigated potential duration of cameras, image quality and the possibility of (i) detecting prey capture events (ii) identifying intra/interspecific interactions (iii) identifying potential prey. Cameras were deployed at two sites across the Falklands (Cow Bay, n=6; Bull Roads, n=2). Cameras were attached to the back of the bird anteriorly to the ridge of the thoracic vertebrae. Cameras recorded for 30mins to 3hours. Image quality was clear, and prey capture events, intra/interspecific interactions and potential prey items were identified. These results indicate that, video cameras for the use of studying Gentoo penguin foraging ecology are a viable option. Factors such as light intensity and ocean turbidity may hinder the use of cameras; however, with improvements in technology these concerns may be overcome. It is clear that camera deployments could lead to a better understanding of the trophic ecology and behaviour of penguins.

The trophic ecology of the endangered endemic Barau's Petrel (*Pterodroma barau*) at Réunion Island, South-Western Indian Ocean

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Réunion is the only tropical island supporting two endemic species of Gadfly Petrel. These two birds, the Mascarene Petrel (*Pseudobulweria aterrima*) and Barau's Petrel (*Pterodroma barau*), are considered critically endangered and endangered respectively. Various authors have identified the need to quantify the threats that these species face on land and at sea so that appropriate conservation measures can be implemented wherever necessary. The Mascarene Petrel is sure to face extinction but the future of Barau's Petrel is not nearly as dire. All the major threats the birds face on land have been quantified and protection measures implemented. Virtually nothing is known about their at sea biology however. Therefore, using a combination of stable carbon and nitrogen isotope signatures from various tissue groups, as well as qualitative fatty acid signature and stomach content analyses, this study aimed at providing new data on the diet and trophic position of Barau's Petrel. Colonies were visited periodically throughout the breeding season and samples gathered from adult and immature birds. Historical samples were also sourced, permitting both inter- and intra-annual comparisons within and between ontogenetic stages. The results will be discussed and will address the dearth of knowledge about this species' at-sea biology, facilitating further conservation efforts. Furthermore, its endemic status and various life history and behavioural characteristics render this species suitable as a candidate as an indicator of climate associated changes to the South-western Indian Ocean so that this study can provide baseline data from which to assess long term changes in the South-western Indian Ocean.

Spatial variability associated with long-term monitoring of subtidal reef fish in Tsitsikamma National Park Marine Protected Area

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Tobler's (1970) First Law of Geography states "everything is related to everything else, but near things are more related than distant things". This Law describes a fundamental property of most ecological datasets, that of spatial dependence. The presence of spatial dependence in the form of autocorrelation introduces numerous deviations from the assumptions of classical statistics that warrant attention, particularly the violation of independence of observations (sample units). The aim of this study was to assess the importance of the spatial component in marine ecological long-term monitoring, which is often poorly investigated or completely neglected. Multivariate analyses of CPUE provided an overview of species' distribution, partitioning the sample area into four ichthyological communities distinguished by the variables *substrate*, *latitude* and *longitude*. General additive models were used to develop specific distribution maps for the five most abundant species. The spatial and temporal variables linked to these distributions were then ranked using Random Forest analyses, and spatial variables were found to be consistently more important than their temporal counterparts. The degree of spatial autocorrelation was investigated using Moran's statistic, and spatial abundance data for roman, dageraad, smooth-hound, steentjie and red steenbras were all characterized by high levels of autocorrelation. Correlograms illustrated that positive autocorrelation for roman and dageraad abundance data was limited to a distance of 450 m, which translates to within two adjacent cells within the sampling grid. The current sampling grid therefore produced redundant data and sampling cells should be doubled in size to optimise sampling. General Additive Mixed Models with spatial residual correlation structures were introduced to account for this violation of independence. This study substantiates the paradigm shift of viewing spatial dependency as a statistical obstacle to a source of ecological information by creating a new avenue of data inference.

Rich diversity, strong endemism, but poor protection: addressing the neglect of sandy beach ecosystems in coastal conservation planning

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Sandy shores are rarely considered in conservation-planning initiatives because they are poorly recognised as ecosystems. Consequently, beaches and their associated biota may be insufficiently protected, which is of concern given the myriad of threats to which this ecosystem is exposed. Therefore, we quantify spatially-explicit trends in species richness and endemism on South African sandy shores to assess representation of beach ecosystems in existing reserve networks. Here, a network of coastal reserves putatively provides moderate protection to nearly all beach habitats. Species distribution maps of beach-dependent vertebrates, macrofauna, microflora, and foredune vegetation were compiled from existing sources or modelled using standard techniques. While some

data were available for the latter analyses, additional sampling was required to improve bioregional coverage. Each species' distribution was coded to a detailed map of the South African shoreline. Representation of habitats and species in various configurations of existing reserves was determined. Overall, 535 species have been recorded on the South African sandy shores, including 139 common species. Endemism is variable among taxonomic groups. Notably, two-thirds of the macrofauna are regional endemics, half of which are endemic to South Africa. For almost all of the common species, less than 20 % of their distributions are protected in land-sea reserves. Protection of beach habitats is similarly poor; conservation targets were not met in all cases, and most habitat types are considered Poorly Protected. Sandy beach communities are considerably more diverse than they are generally acknowledged to be, and comprise a unique suite of biota. Given the species' narrow distributions and high degree of exposure to threats, many probably qualify as threatened/ endangered. In spite of this, beaches are poorly represented in coastal reserve networks. To redress this issue, conservation planners need to account for beaches specifically, and to ensure they are represented in contiguous land-sea protected areas.

Twenty-nine years of surf-zone fish monitoring at De Hoop reveals population trends, targeting information and micro-scale spatial variability

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No-take marine protected areas (MPAs) play an important role in serving as a benchmark for fisheries and for the study of marine processes. Monitoring of surf-zone fishes by fishery-independent, standardised angling in the no-take De Hoop MPA commenced one year before its closure to fishing in 1985, and provides the longest unbroken time-series of relative abundance of South African surf-zone fishes. Fifty-four species of fish were captured at De Hoop MPA throughout the sampling period at two sites, using three different targeting techniques. Fifty % of the catches were made up by galjoen *Dichistius capensis* and 23% by blacktail *Diplodus sargus*. Seventeen species were represented by ten or less, out of a total of 71 563 fish. Elasmobranchs constituted 6.5%. Species composition separated significantly according to site, season and fishing target. GLM standardised trends for the top ten species revealed long-term cycles for galjoen and blacktail, short-term cycles for elf *Pomatomus saltatrix*, a downward trend in white steenbras *Lithognathus lithognathus*, and stable but variable trends for others. Coefficients of variation of CPUE of the five most abundant species ranged from 0.27 to 0.79. Serial correlation in annual CPUE measurements, together with trends in size-structure data, suggests that recruitment is the largest source of variation in abundance. The appearance of extralimital species such as catfaced rock-cod *Epinephelus andersoni* and stone bream *Neoscorpis lithophilus*, are also suggestive of sporadic recruitment. Detailed spatial referencing of catches reveal interesting micro-scale variability in habitat, which could be useful in conservation planning. The measured effects of targeting on annual trends provide information for testing multivariate methods to remove the influence of targeting in roving creel shore-angler surveys.

Connectivity of South African marine species is lower than expected: insights from molecular tools and implications for biodiversity planning in the region

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In the face of human-induced pressures on marine systems, Marine Protected Areas (MPAs) are seen as a valuable tool in protecting biodiversity and fishery resources. It is recognized that in order to be effective, networks of MPAs should be established and that these should be connected. Measuring connectivity between marine populations is difficult, as many species have larvae that are small and that have a vast dispersal potential. However, genetic approaches can be used to measure connectivity in marine species using measures of population genetic structuring, isolation-by-distance and analyses of gene flow. Here I review several recent studies which show that using molecular analyses, dispersal in South African marine species is low (less than 10km/generation), even for some broad-cast spawning species. Further, the South African west coast, which currently is mostly unprotected, harbours numerous species with highly structured populations, with low levels of gene flow between them. Essentially, these studies highlight the need for incorporating genetic approaches into MPA and biodiversity planning and I argue that protected areas need to protect not only patterns of extant biodiversity or species of commercial interest, but also the evolutionary processes that have shaped and continue to shape such patterns. This requires a reanalysis of how to approach biodiversity planning in the region, including a conciliation of terminology and the different time-scales (contemporary versus evolutionary) of conservation planning.

Depth related changes in fish community composition in the Tsitsikamma Marine Protected Area, South Africa

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A key component of ecosystem based fisheries management is no-take Marine Protected Areas (MPAs). The majority of no-take MPAs in South Africa are confined to shallow near-shore reefs, leaving deeper near-shore reefs open to exploitation. Current management strategies for near-shore reefs are driven by our knowledge of how shallow reefs function and are not necessarily applicable for deeper reefs. This study employed baited remote underwater stereo video systems (stereo-BRUVs) to compare the fish communities on shallow (<30m) and deep (45 – 80m) reefs within the Tsitsikamma MPA. Fish communities were also compared to reef macrobenthic cover to establish associations between fish and invertebrate communities. Analyses of similarity (ANOSIM) indicated that fish communities differed significantly between the shallow and deep reefs ($R = 0.64$, $p < 0.001$). These differences were caused by high abundances of steentjie (*Spondyllosoma emarginatum*) and fransdamam on the shallow reef compared to deep reefs. In contrast, the abundance of panga (*Pterogymnus laniarius*) was significantly higher on the deep reefs compared to the shallow reefs. Species richness decreased with an increase in depth, with 45 fish species recorded on the shallow reefs and 21 on the deep reefs. However, there was an increase in abundance, biomass and size of commercially important reef fish on the deep reefs. Despite their greater abundance on shallow reefs, blue hottentot and steentjie occurred at a higher biomass on deep reefs. Ichthyofaunal composition was influenced by depth and the change in percentage cover of macrobenthic taxonomic groups, which explained 76% of the observed fish distribution. This suggests fish species are closely associated with their habitat. This study highlights the differences in both community

composition and ecosystem functioning of near-shore shallow and deep reefs, and in doing so emphasizes the need to consider both ecosystems in future management plans.

Limited recovery of a resident reef fish population a decade after depletion sampling within the Maputaland MPA

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Umbrina robinsoni is a medium size sciaenid fish with an inshore (0-40m depth) distribution along the east African coast from Cape Point to Oman. Within South African waters, the species shows notable variation in life history strategies, with fish sampled from the subtropical Maputaland MPA having the fastest growth rate, youngest maximum age (12 years) and youngest age at 50% maturity (2.8 years) of the four populations sampled during 2001-2002. Long-term mark recapture studies indicate that the species has small (<100m) home ranges. Fish counts during depletion sampling of *U. robinsoni* shoals at six different reef patches within the northern reef complex of the Maputaland MPA confirmed their strongly philopatric nature with no movement between sampled shoals over a 12 month period. A total of 306 fish were sampled at the six sites over an eight month period between May 2001 and January 2002. A follow up monitoring trip 12 months later recorded very little recovery with only 19 individuals present at two of the six sampling sites, equivalent to just six percent of the “pristine biomass” originally sampled. Ten years later, in October 2013, a monitoring trip conducted fish counts at the same six sampling sites. A total of 64 fish were found at five of the sites, equivalent to just 21 % of the original “pristine biomass”. This slow rate of recovery needs to be taken into consideration when designing sampling methodology within MPAs, and should also inform the management of the recreational fishery for resident fish species.

Jannasch: Marine Protected Areas

Oral Presentations

The evolution of a fishery: perspectives from East Africa’s coral reefs

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Diver-operated stereo video technology was used to survey the shallow-water (<25 m) coral reefs from Ponta do Ouro in southern Mozambique to Malindi in central Kenya, to provide a baseline dataset of East Africa’s coral reef fish communities. In total, 208 sites were surveyed across thirteen coastal regions, including open access and protected areas. Significant differences in fish diversity (Shannon’s H’) were recorded among Mozambique (2.84 ± 0.43), Tanzania (2.59 ± 0.49) and Kenya (2.97 ± 0.36) (ANOVA, $F = 9.60$, $p < 0.001$). Significant differences in mean fish density (# fish/100m⁻²), mean fish biomass (kg fish/100m⁻²) and the average mass per fish were also recorded among countries (ANOVA, density: $F = 8.16$, $p < 0.001$; biomass: $F = 4.10$, $p = 0.018$; average fish mass: $F = 15.63$, $p < 0.001$). Tanzania boasted the greatest mean fish density (102 ± 84 fish/100m⁻²), more than double that of Kenya (44 ± 23 fish/100m⁻²), but exhibited the lowest average mass per fish (54.0 ± 28.6 g), less than half that of Mozambique (116.7 ± 98.2 g). No-take zones exhibited significantly higher average mass per fish (116.7 ± 119.4 g), than restricted use (98.4 ± 73.7 g) or open access areas (78.0 ± 59.6 g) (ANOVA, $F = 4.20$, $p = 0.016$). However, mean fish density was lower, although not significantly (ANOVA, $F = 2.21$, $p = 0.112$), within no-take zones (53.1 ± 35.1 fish/100m⁻²) than

restricted use (77.8 ± 50.6 fish/100m⁻²) or open access areas (79.8 ± 88.9 fish/100m⁻²). While certain areas represent healthy ecosystems, overall East Africa's coral reefs exhibit widespread structural damage and ecological devastation from overexploitation and destructive fishing practices. The data are available on an open-source platform at www.movingsushi.com, and will hopefully contribute to the improved management and conservation of East Africa's coral reef fishes.

Reliability of unverified catch returns (fisheries logbook) data in gillnet fishery, Langebaan Lagoon marine protected area

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Rapid, low cost, and reliable assessment methods are needed to detect trends in the abundance and use of resources. In fisheries, logbook data has been seen as a source of data since it became widely recorded and compiled, and in many instances the catch data is used in place of scientific research when none is available. The use of data recorded in logbooks without being verified for doing rigorous scientific analysis to recommend life changing management decisions is a challenge. Alternative fishery-independent data collection is costly; it is thus obvious foregoing logbook records as a source of fisheries data is not a viable option. In order to still perform analysis on this important data and maintain a level of confidence and integrity in the results, in Langebaan lagoon marine protected area gillnet fishery; unverified logbook catch return data was compared with a *in situ* observation and community-based fishery monitor for the period July 2010 until June 2013. Preliminary results indicate substantial difference between logbook catch data in relation to an *in situ* observation and community-based fishery monitor data. Such results thus suggest a need to have a correction factor, and or use such data with greater caution in drawing management decisions.

Marine protected area improves yield without disadvantaging fishers

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Potential fishery benefits of Marine Protected Areas (MPAs) are widely acknowledged, yet seldom demonstrated, as fishery data series that straddle MPA establishment are seldom available. Here we postulate, based on a 15-year time series of nation-wide, spatially referenced catch and effort data, that the establishment of the Goukamma MPA (18 km alongshore; 40 km(2)) benefited the adjacent fishery for roman (*Chrysoblephus laticeps*), a South African endemic seabream. Roman-directed catch-per-unit-effort (CPUE) in the vicinity of the new MPA immediately increased, contradicting trends across this species' distribution. The increase continued after 5 years, the time lag expected for larval export, effectively doubling the pre-MPA CPUE after 10 years. We find no indication that establishing the MPA caused a systematic drop in total catch or increased travel distances for the fleet. Our results provide rare empirical evidence of rapidly increasing catch rates after MPA implementation without measurable disadvantages for fishers.

An investigation into the occurrence and movement patterns of white sharks (*Carcharodon carcharias*) within the proposed Marine Protected Area of the Addo Elephant National Park

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This study provides information on the occurrence and movement patterns of white sharks (*Carcharodon carcharias*) within the proposed Marine Protected Area of the Addo Elephant National Park. A variety of survey techniques were employed including helicopter surveys of the near-shore zone, boat trips to the Bird Island Marine Protected Area, as well as monitoring the movement patterns of acoustically tagged sharks with an array of listening stations. Between October 2010 and March 2012, a total of 50 sharks were spotted during 43 aerial surveys. The majority (96.0%) were less than 2.5 m in length and immature. Almost all of the sharks (98.0%) were sighted in the spring and summer months between October and March. Over a similar time period twenty two boat trips were made to Bird Island to chum for sharks. A total of 53 sharks were observed ranging in size from 1.5 to 4.5 m. In contrast to inshore sightings sharks were only present in the winter months between April and November. To date, a total of 74 white sharks have been fitted with acoustic V16 tags as part of a collaborative project with "Ocearch". Their movement patterns have been monitored using an array of 50 VR2w receivers deployed in collaboration with the South African Institute of Aquatic Biodiversity (Acoustic Tracking Array Platform). Detections to date indicate that white sharks are transient at inshore sites and are constantly moving throughout the entire proposed MPA. Results from the project have identified the near-shore environment as a possible inshore summer nursery area and the Bird Island region as an important winter aggregation site for white sharks. Defining key habitats, especially for young of the year and juvenile white sharks is critical to their conservation in South Africa and improves our understanding of white-shark distribution and biology.

Poster Presentations

Poster # 143

Spatial tools to support conservation of migratory species: identifying a network of sites of importance for sea turtles in the Western Indian Ocean

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Protecting migratory species is recognised globally as a conservation priority, particularly because many of these species are listed as threatened. However, achieving their protection is challenging, especially in the marine environment, because these animals move through the oceanic territories of multiple countries and the remote high-seas. Therefore, any conservation strategy requires multi-national agreements and co-operation, of which a good example is the Indian Ocean and South East Asia Marine Turtle Memorandum of Understanding (IOSEA MoU). Recently, Signatory States to the IOSEA MoU have resolved to establish a Network of Sites of Importance for Marine Turtles in the IOSEA Region. Establishing this network requires identification and nomination of appropriate candidate sites for possible inclusion in the network. Although the formal nomination process is undertaken by focal points of the Signatory States, we present a comparison between two approaches to support the site-nomination process, which were applied to the Western Indian Ocean (WIO) region as a test case: first, an expert-driven approach, and second, a spatially-explicit

mathematical approach. Based on a suite of *a priori* criteria, experts selected 19 sites for nomination, spanning most of the countries in the WIO, all of which are under a nation's jurisdiction. In comparison, multiple areas were highlighted using a modified conservation-planning methodology (for different levels of protection to both sea turtles and their associated habitats), many of which sites were also in the high seas. These results showed that spatially-explicit analyses can be a valuable tool in the context of the IOSEA Site Network, with the products intended to guide, not replace, expert judgement. While the input maps used here are currently the best available data, some are outdated and/or represent key features in a sub-optimal format, and thus are being refined in a current project.

Poster # 144

Metal concentrations in the Helderberg Marine Protected Area, False Bay

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The release of metals is increasing in industrial and urban areas and the impact thereof are poorly understood. In an attempt to protect areas from anthropogenic impacts, certain areas are declared protected. The assumption thus could be that protected areas are free from the impacts of pollutants. The Helderberg Marine Protected Area (HMPA) is situated in an urbanised region of False Bay. Although considered a protected area, the question is raised whether the metals from the surrounding area are affecting the coastal environment of the MPA. The study assessed the concentrations of six heavy metals (Zn, Cd, Cu, Co, Mn and Fe) in the water, sediment and mussel *Mytilus galloprovincialis*. Samples were collected from two sites within the MPA and one outside the MPA (Strand) in August 2012. The results showed that metal concentrations were higher in the sediment than ambient coastal waters. In the mussels, metal concentrations were higher in the soft tissues than the shell. Cadmium and Cu concentrations were higher in the soft tissue than the sediment, suggesting that the mussel accumulated these metals. The most important result was that Cd, Cu and Zn concentrations were similar in and outside the HMPA. The results suggest that the HMPA is influenced by contaminants (metals) from areas outside the MPA and management authorities should consider the effects of these and other contaminants in management plans of MPA's.

Poster # 145

Assessment of epifaunal diversity, abundance and community structure in the TMNP MPA, Karbonkelberg Area

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Epifaunal species richness, abundance and community structure in the Karbonkelberg Restricted Zone (KRZ) and adjoining areas in the Table Mountain National Park Marine Protected Area (TMNP MPA) were assessed during dive surveys in 2013. Twelve successful dives were performed over the entire survey, four in each of three study sites including two per depth stratum (shallow, 10-15m; deep, 25-30m), and a total of 360 photo-quadrat samples were collected and analysed. A total of 60 species were identified across all the samples. A rapid technique that was developed to assess spatial epifaunal community structure was applied and found to be successful in terms of adequately representing the diversity of the study area. Despite differences in management zones between sites and distances between sites, there were no significant differences between the epifaunal

communities inside the KRZ and those in the unrestricted area of the TMNP MPA. Results showed clear differences in community structure between depth strata, in terms of species richness and abundance.

Poster # 146

SANParks Cape Cluster Knowledge Collation Project

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SANParks is mandated to develop, manage, and promote a system of national parks that represents the biodiversity and heritage assets by applying best practice, environmental justice, benefit sharing and sustainable use. Research is conducted internally by SANParks Scientific Services to inform management and uphold this mandate. Historically SANParks had three Research nodes. A fourth node, the Cape Research Centre (CRC) was established in 2008 to focus and manage research specifically within the Cape Floristic Region. The key role of the CRC is to provide science support to the national parks within the SANParks Cape Cluster. One of the gaps identified since the establishment of this new node is the absence of collated historical data and research that has been conducted within the five Cape Cluster Parks: Agulhas, Bontebok, Table Mountain, Tankwa Karoo, West Coast and Namaqua National Park. As such, there is a need to capture and store historic data of scientific and management importance that exists for these parks. The current project was therefore initiated to gather all records of existing research and important changes that have occurred within the parks. To accomplish this, the six parks will be visited and generate an inventory of what is in the Parks archives. All relevant information is captured in a reference database (Endnote) and housed within the CRC library. An expected outcome of this project is an annotated bibliography of all research conducted within the above mentioned parks. An overview of the project is presented here, with the hope of increasing awareness of the project and opportunities to share information. In order to make this database as complete as possible a request is made to anyone who has conducted research or been part of a research team that worked within the Cape Cluster Parks to contact Carly Cowell carly: cowell@sanparks.org

Poster # 147

A study of the distribution of the Knysna seahorse (*Hippocampus capensis* Boulenger, 1900: Syngnathidae) in the Thesen Islands Marina and the ecological factors influencing this species

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The aim of this study is to assess the contribution of a new tidal water marina, Thesen Islands Marina, to the distribution and survival of the Knysna seahorse in the Knysna estuary. And so gain an holistic understanding of the Knysna seahorse's habitat requirements, preferences and, in particular, the role marinas and small boat harbours may play in protecting the species, its congeners and macro-invertebrates. The 27 ha of new tidal habitat created by Thesen Islands Marina is the study location of a resident Knysna seahorse population. The first step involved a description of the aquatic macrophytes present in the canals in order to identify habitat types in the marina (Curtis et al., 2004). Six habitat types based on dominant macrophyte species are identified: 1. *A. taxiformis* and/or *C. filiformis* attached to exposed gabion wire mesh 2. Dense *C. tenue* beds 3. Barren canal floor with scattered vegetation 4. Mixed vegetation of *H. ovalis*, *Z. capensis*, *C. filiformis*, *C. tenue* and/or *A. taxiformis* on sediment 5. Algae, macrophyte and sessile animal communities on jetties 6.

Scoured/barren gabion wire mesh. The seahorse population within Thesen Islands Marina will be surveyed using mask and snorkel, and SCUBA within the identified habitat types for which habitat specific survey methods are being developed.

Poster # 148

MPA vs open coast: Contamination and bioaccumulation of metals on the South African south coast

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The aim of the study was to determine if an MPA could serve as an *in situ* control site with regards to metal contamination and bioaccumulation when compared to coastal sites exposed to anthropogenic activities. Water, sediment and oyster (*Striostrea margaritecea*) tissues were collected seasonally from sites in the Goukamma MPA and metal concentrations (Al, Fe, Cu, Zn) were compared to sites at Witsand and Wilderness. Metals were analyzed by means of acid digestion and ICP-MS. Aluminium concentrations found in the water column at all sites were considered as low. Iron, zinc and copper concentrations within the water column can on the other hand be considered as high when comparisons are drawn with other studies and data sets. Sediment concentrations for all the metals within the present study were considered to be low when compared to other studies and guidelines. Within oyster tissues', the metal ranges are considered to be low when compared to other studies. Generally, there were not many significant differences recorded between sites and no seasonal patterns were present. Results revealed that the hydrology of the surrounding water bodies plays a vital role when sites are selected and hydrology charts should be incorporated before choosing possible field study control sites. In conclusion, the selected sites on the south coast do not seem to be contaminated with metals. A field study in conjunction with a laboratory experiment should yield more reliable results.

Poster # 149

Land-based boat monitoring of commercial and recreational fishing effort and catches in Table Mountain National Park marine protected area

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A land-based boat monitoring programme was undertaken from June 2012 to August 2013 to assess trends in catches, catch composition, optimal sampling and fishing effort. At each slipway / harbour Environmental Monitors (EMs) interviewed skippers, recorded and counted the number of the fish that was being offloaded. The number of boats showed a multi-modal distribution with a primary peak in November 2012. Fishing effort peaked in November, then June and July 2012. Catch composition was dominated by snoek (*Thysites atun*, >90%), hottentot (*Pachymetopon blochii*), katonta, chokka (*Loligo vulgaris*), panga (*Pterogymnus laniarius*), galjoen (*Dichistius capensis*) and yellowtail (*Seriola lalandi*). The sampling effort was high during the initial phase of the monitoring, but declined in December 2012, and this could be attributed to high enthusiasm by both marine staff personnel and EMs. The distribution of start times reflected preference for working during the day, avoiding early mornings or late afternoons.

Poster # 150

Movement and dispersal patterns of dusky kob *Argyrosomus japonicus* in Algoa Bay, assessed using conventional tagging techniques

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Dusky kob *Argyrosomus japonicus* is an important coastal fishery species that has faced high levels of exploitation in estuarine nursery habitats and ineffective management regulations have led to a stock collapse. Therefore, a better understanding of the movement and dispersal patterns, particularly in estuaries, is crucial in making better management decisions for this species. In this study, conventional tag and recapture data with high spatial resolution was collected from five sites within Algoa Bay (Sundays Estuary, Swartkops Estuary, Sundays surf-zone, Cape Recife and Woody Cape) to assess the movement and dispersal patterns of dusky kob within and out of the bay. The effects of fish size, geographic location, time at liberty and seasonality on movement and dispersal patterns will be evaluated. Results from the Oceanographic Research Institute's (ORI) national tagging project indicate that dusky kob exhibit limited dispersal throughout their distribution. However, the pitfalls of the ORI project are that the spatial resolution is too low to evaluate fine scale coastal movements and movements within estuaries. Therefore, high resolution mark-recapture data from the dedicated Algoa Bay tagging program was used to test the hypotheses that dusky kob (i) exhibit limited dispersal from the tagging sites in Algoa Bay and (ii) exhibit fidelity to the nursery estuary in which they were tagged.

Poster # 151

An evaluation of a spatially-based conservation planning framework for the management of estuarine-dependent fishery species

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Estuaries are productive habitats and biologically important ecosystems as juvenile nursery areas and feeding grounds for adults from a host of fish species. However, they are also threatened habitats, exposed to increasing human disturbance and exploitation. The stocks of several South African estuarine-dependent linefish species are considered as either overexploited or collapsed, including four of the major targeted species; spotted grunter *Pomadasys commersonnii*, dusky kob *Argyrosomus japonicus*, white steenbras *Lithognathus lithognathus* and leervis *Lichia amia*. It is clear that their dependence on estuaries would warrant the inclusion of these ecosystems into marine reserve planning exercises. Since traditional management strategies (e.g. bag and size limit restrictions) have proven ineffective for estuarine fisheries, there is a need for alternative management to ensure increased survival of juveniles and recovery of adult breeding populations. A better understanding of spatial characteristics of these species such as; estuarine dependency, habitat use patterns and connectivity are required for effective management. Systematic conservation planning for estuaries adopts a holistic approach by including factors such as biological, socio-economic pressure and ecosystem indicators. This study will investigate the potential effectiveness of the spatial-based management software, Marxan for the conservation of important estuarine-dependent fishery species. This software is specifically designed to aid systematic zoning and spatial management appraisals. Ultimately, this project will identify priority areas for conservation and will be used to develop and improve fisheries management strategies for these four species and other estuarine-dependent fishery species in South Africa.

Poster # 152

Macro-benthic invertebrate assemblage patterns in the Betty's Bay Marine Protected Area, Kogelberg region

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The Betty's Bay Marine Protected Area (MPA), located on the south-west coast of South Africa, was established to protect, among others, the endangered African penguin (*Spheniscus demersus*), abalone (*Haliotis midae*) and the west coast rock lobster (*Jasus lalandii*). Other than information regarding the protection of these species, to date very little is known about the sessile macro-benthic fauna of Bettys Bay MPA. For more effective management and possible expansion of the MPA, an assessment of the macro-benthic biodiversity in the area is needed. In order to achieve this, a photo-quadratic survey was conducted at various sites inside and outside the MPA. Representative samples were also collected to assist in species identification. Photographs were analysed to determine abundance, percentage cover and diversity. Significant differences in diversity, percentage cover and abundance were found to occur between deep and shallow sites, with a greater algal percentage cover in shallower sites. Significant differences in diversity, abundance, percentage cover and evenness were also found between sites inside and outside the MPA, which could be attributed to increased protection inside the MPA. The area comprises mainly of colonising taxa such as porifera, cnidaria and algae and contains generally low numbers of semi-motile mollusca. This, as suggested by other literature on studies in the area, may be attributed to an increase in predator activity by *J. lalandii*, which has shown a distribution shift into the area from the west coast.

Poster # 153

Towards standardized biodiversity monitoring in MPAs; the effect of bait type on reef-fish assemblage structure observed with stereo-video techniques

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In recent years it has become evident that both, the management and monitoring of fish resources have been inadequate, or inappropriate, to ensure the sustainable utilization of target species, and the conservation of biodiversity. The single and multi-species approach of traditional management is now considered outdated, particularly for reef fish, and there is a drive to implement holistic ecosystem based fisheries management, such as Marine Protected Areas (MPAs). Long-term monitoring and research is crucial for adaptive and effective management of MPAs and suitable methods must be comprehensive, easily standardized, non-invasive, non-destructive and without depth restrictions. Baited remote underwater stereo-video systems (stereo-BRUVs) are a relatively new tool that satisfies such method requirements. Stereo-BRUVs were developed to determine fish abundance and size structure in an unbiased and relatively non-invasive manner across a broader range of depths and habitats than conventional methods (i.e. controlled angling, underwater visual census and fish traps), characteristics particularly useful in MPA research. The method is novel to South Africa and the methodology is yet to be fine-tuned for the warm-temperate Agulhas ecoregion and its fish communities. One key component of the methodology is that it requires bait to attract fish into the field of view. Whilst it is an accepted standard to use pilchard in stereo-BRUVs, its suitability has never been tested comparatively to other bait types for local conditions. This project aimed to investigate the effect of bait type (pilchard (*Sardinops sagax*), squid (*Loligo reynaudi*) and

bivalves (*Perna perna* and *Crassostrea gigas*) on fish assemblage structure and determine which bait type provided the most comprehensive and cost-effective assessment of reef fish biodiversity. Preliminary analyses suggest that although squid appeared suitable bait, pilchard was more cost-effective. Data using bivalves as bait were highly variable and sampling with this bait can be expected to represent the least cost-effective option.

Fismer: Outreach

Oral Presentations

The Role of Aquariums in Inspiring Care for our Marine Environment – some research results

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The fundamental role of a public aquarium is to act as a powerful centre for conservation through focussed research, practical conservation and effective education. However, given the current state of environmental degradation, there is strong need to change focus from simply creating an awareness of animals and conservation. Aquariums, with their unique ability to generate strong emotional bonds between people and marine animals, must inspire visitors firstly to care for our marine environment, and then to think about their actions in order to encourage them to behave in a more environmentally responsible manner. Internationally, there is a growing body of research that uses social science tools to understand the emotional connection between people and animals inspired by a visit to an aquarium, as well as the interests, knowledge, motivations and decision making processes of visitors. In an effort to inspire visitors more effectively, SAAMBR, based at uShaka Sea World, has embarked on an ambitious Visitor Studies Research Programme. This paper will present the initial results of the programme.

Role of scuba divers in the discovery of new and unusual marine species

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South African scuba divers have a long history of pioneering in areas like diving development and diver discoveries. Recreational divers are far more numerous than professional marine biologists and collectively spend much more time underwater. The proliferation of relatively inexpensive and high quality underwater cameras has also greatly enhanced their ability to record and report on unusual observations. Several Virtual Museums have been developed to archive and catalogue these images and their associated distribution records. This has resulted in the discovery of many animals unknown to science, or previously unknown from the region. This presentation describes a few of the many recent discoveries of undescribed species, new records and unknown behaviours of marine animals made by local scuba divers. Notable examples among the invertebrates include commensal shrimps and myzostomid worms, both of which are commensal on crinoids; an unusual 'stargazer' mysid, several *Stenopus* cleaner shrimps, a stalked jellyfish, various sea and tube anemones, echinoderms, and many deep discoveries, including new sponge records, black corals, and winged oysters. There have also been discoveries among the vertebrates, including a new klipfish, an undescribed scorpaenid, new records of deep goldies and butterflyfish and of course, the coelacanths of Sodwana Bay. Interesting behavioural observations include brightly-coloured

amphipods which sequester protective toxins from a bryozoan that lives commensally on whelk shells and 'jumping sand', another amphipod, which builds a mobile shelter that it propels backwards using its antennae. Divers provided the first photographs of the mounds of shell and coral rubble that are home to a deep-dwelling tile fish and are assisting with research on the coral diet of certain butterflyfish. These contributions not only build the knowledge base to support species and ecosystem classification, mapping and assessment but play an important role in changing the public understanding of science.

Up-skilling biodiversity professionals in marine conservation: Learning in, through and for the workplace

CM Bell

Environmental Learning Research Centre, Rhodes University

One major area where skills development and improved practices is needed is in the marine and coastal conservation sector. Due to recent heightened awareness of marine and coastal issues, my proposed research focusses on the opportunities available to the managers, scientists and other professionals in marine conservation organisations. As South African environmental policies take a people-centred approach to sustainable development, the research incorporates the ecological and conservation aspects of the work of these professionals into the policies in place that encourage 'up-skilling'. The Human Capital Development Strategy for the biodiversity sector of South Africa lists one of its strategic objectives as "extending the existing capacity by improving the skills of those already in the workplace". This concept of 'up-skilling' reflects a substantial shift in the nature of work and learning in developed and developing countries. South Africa has a strong history of continuing education, non-formal adult education and short courses. However, despite the many years of enhancing workplace learning (mostly since 1994) there is still much talk in popular media about the "skills crisis" or "skills shortages". The need for appropriately skilled, knowledgeable and adaptable professionals in the right places and positions in marine conservation organisations is critical. The ultimate goal of the study is to inform policy and improve workplace practices through investigating up-skilling opportunities and professional practices, in the marine sector of South Africa. This will improve marine conservation by equipping professionals in the field, with the relevant skills and knowledge to perform their jobs more effectively.

Sink or swim - surfing waves of technological change in communicating marine science

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The SABC TV programme, 50I50's logo juxtaposes two words 'Human' and 'Nature'; its tag line is 'Because we need to know'. The website states: "For three decades, we have been Hard-hitting... Powerful... Informative... Relevant... Entertaining... Compelling... and educational [sic]" - a description which encapsulates the challenges faced by science communication and scientific endeavour in general. The past 30 years have witnessed exponential change in virtually every aspect of life on earth. Human population growth has systematically burdened the natural environment. In the 1960s and 70s environmental advocacy began to sensitise people to such issues as nuclear proliferation; deforestation and desertification; and the plight of whales among others. Although digital media as we know it did not exist, organisations such as Green Peace managed to influence public opinion to the extent that whaling was banned by most maritime nations. Today whales are still an icon species for marine conservation. In recent years 50I50 has had its challenges. In 2009 the programme was threatened with cancellation after 25 years. Critics felt that because water scientist Anthony Turnton had used 50I50 as a channel to tell South Africans about the country's rapidly deteriorating water quality, the programme was cancelled because it had been critical of the government. In response,

viewers started an online petition which carried more than 8 000 signatures. A Facebook group drew almost 800 members and 50150 is still on air. The list of campaigns to maintain balance in our relationship with nature is large but, in the radically changed and seemingly shrunken technological world, pitted against an overwhelming deluge of information, instant gratification, complacency and apathy how do we promote knowledge acquisition and make marine science accessible? This interactive presentation will encourage audience participation to promote discussion about a variety of innovative ways for science to find its voice.

Assessing the impact of a science education outreach programme

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Reporting on the number of activities and number of participants has been the traditional approach used to measure and evaluate the effectiveness and success of science education outreach programmes. However, assessing the impact of an education outreach programme poses new challenges which require far more than quantitative reporting. Assessing the impact of education outreach activities calls for a strategy to plan, observe, collect, analyse and interpret the data that will indicate the long-term impact of the outreach programme. The first step towards assessing the impact of a science education outreach programme is to distinguish between science awareness activities and science education outreach activities. The former seeks to raise awareness and an interest in science whilst the latter aims for an ongoing and targeted science engagement programme with schools and communities. Understanding of “long-term” in an education outreach programme may differ from what a scientist regards as “long term”. Research suggests that three to five years is a feasible and acceptable time period in which to assess the impact of an education programme. This period may cover a complete phase of a learner entering and exiting an education programme. . In that time, a learner who has been exposed to and engaged in the same programme may provide a reliable indication of the impact of the programme on the learner’s understanding of and interest in science and the influence of the programme on the learner’s choice of career. The paper aims to share lessons from the SAEON Environmental Science Education Outreach Programme which engaged in the issues of impact assessment and produced a model that is well documented to be able to measure the impact of the programme on Grade 9 -12 learners.

Keeping the public informed about KZN Sharks Board activities and research

D Hargreaves

KwaZulu-Natal Sharks Board, Maritime Centre of Excellence

The coastline of KwaZulu-Natal, with its sandy beaches and mild sea temperatures throughout the year, has great appeal to the swimming public. Beach tourism is a significant contributor to the economy of the province with approximately 65% of all visitors utilising the beaches. Historically, however, shark attacks reduced public confidence in the safety of the beaches and this has negatively affected tourism. The KwaZulu-Natal Sharks Board Maritime Centre of Excellence (KZNSB) is mandated by the provincial government to protect beach users against shark attack, which is achieved through the deployment of shark fishing gear offshore of the beaches. The beach protection programme has been successful in bringing about a substantial reduction in the occurrence of shark attacks but the capture of sharks and other animals in the gear represents an environmental cost. Therefore measures have been put in place to reduce catches while still fulfilling the mandate. The KZNSB, through its Education Programmes, informs the public about its activities as well as the valuable role that sharks play in the marine ecosystem. Tourists, local and foreign, attend these programmes at the KZNSB complex in Umhlanga Rocks, near Durban. In addition, learner groups from all over South Africa visit the complex throughout the year and learn not only

about safe bathing practices, but also about shark diversity and life history. There is also an extensive push to reach learners who are unable to travel to the complex through an outreach programme conducted not only in KZN but in other parts of South Africa as well.

The value of scientific research in education – how ORI is making a difference

H Kilian

uShaka Sea World Education, South African Association for Marine Biological Research

With the demands of the 21st Century, it is essential to have students who have a solid foundation in Science, Technology, Engineering and Maths (STEM). Therefore science needs to be made attractive to students showing them that science is everywhere, that science contributes to the decision making of policy makers and that science is relevant in everyday life. Education programmes can be vital in promoting science, and enticing students to pursue or further themselves in the field of Science and Technology. It is through education programmes that scientific research can be translated into layman's understanding and create learning opportunities that encourage students and make science appealing. The Oceanographic Research Institute (ORI) has successfully contributed their scientific research to three of uShaka Sea World's Education Programmes. This has resulted in career awareness, creating a positive image of what a scientist is, for learners participating in National Science Week. It has promoted marine science by translating 'theory into practice' for nature conservation students, and provided skills and training for Esemvelo KZN Wildlife law enforcement officers in terms of creating an understanding of the bigger picture of why they do what they do. Data from evaluation forms of the Education Programmes gathered over a 5 year period were analysed and showed that ORI has had significant input into these programmes promoting scientific research and proving that the inclusion of science does make a valuable contribution to education and promotion of science as a whole.

Developing the field of biodiversity informatics in South Africa through the use of primary data and informatics tools to address key biodiversity challenges

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"Target 19" of the 2020 Convention on Biological Diversity indicates that, by 2020, *knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, will be improved, widely shared and transferred, and applied*. This goal can realistically be achieved only through broad implementation of Biodiversity Informatics, which in South Africa, as in other parts of the world, is a young and dynamic field of science. Here, I present an overview of Biodiversity Informatics and discuss ways that SANBI, through the South African Biodiversity Information Facility (SABIF), aims to assist SA in reaching its target. SABIF presently supports a knowledge-management platform, and is a major publisher of biodiversity data, making >11 million data records available to the global community. Because it is important that the data have direct relevance to science and key policy issues related to biodiversity, I illustrate these ideas via examples of how SABIF data can be relevant to current research questions. In particular, I assess impacts of climate change on the distribution, diversity, and species richness of fish faunas off the coast of South Africa, exploring implications for fisheries and food security. I will use ecological niche models to characterize current, past, and likely future geographic ranges, thereby permitting identification of range contractions and expansions under different climatic scenarios, particularly as a function of specific life history strategies of individual fish species. This project will involve the

entire 'life cycle' of the data, to improve "fitness for use" of data, for analysis, interpretation, and assessment. This work is novel, as the biodiversity informatics techniques used have not been applied to the marine environment in South Africa and few studies have been done globally.

Poster Presentations

Poster # 69

Marine science and climate change – 'Elevating excellence in school sciences'

T Mtontsi

South African Environmental Observation Network (SAEON)

This project is a learner science support initiative that sought to encourage and develop science skills of Grade 11 learners. Forty Grade 11 learners from approximately 20 different schools were invited to participate in the marine science programme over a seven day period. Their involvement included attending and participating in workshops on different marine science disciplines and a science camp. The Marine Science Programme was designed to meet the needs of learners who wished to gain an in depth understanding of the marine sciences. The programme included a study of the physical, chemical, and geographical aspects of oceanography, marine biology, and meteorology. Interactions with expert scientists in the different disciplines, SAEON's Argo Floats Programme, NOAA's Adopt a Drifter Programme and visiting research and academic institutions were among the methods used to facilitate the development of science skills. Finally, learners spent the last three days on a marine science camp working at applying all the knowledge and skills acquired through interactions with the different discipline experts. When comparing their understanding on a pre-programme test and a post programme test, learners showed a significant improvement in their understanding of the marine science disciplines. This was accompanied by an increased interest in the discipline. This was corroborated by the learner feedback given at the end of the programme.

Poster # 70

Kalk Bay harbour: food quality and food safety training service learning project

SStC Henning

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The consumption of fish has been linked to many health benefits, such as, reduced risk of coronary heart disease. Moreover, fish is an affordable source of protein, particularly for consumers living in poor communities in the Cape metropolis. However, fish is a highly perishable food of which spoilage is influenced by different factors, such as species, catching methods, fishing season, and post-harvest handling. At Kalk Bay harbour, fish-sellers purchase fresh fish from fishing boats. The fish-sellers give the fish to fish-cleaners to fleck and clean according to customer needs. These fish-cleaners, many whom are women, are an important link in the post-harvest processing chain at Kalk Bay harbour, and play an important role in the hygiene and safety of fish sold to the public, and contribute to the general image of Kalk Bay harbour. The Kalk Bay harbour project, a community service project, was initiated by Mr. Fred Martin of DAFF (Department of Agriculture, Fisheries and Forestry) and the Department of Food Technology, CPUT; where with the need for training fish-cleaners was identified. The transfer of basic food technology knowledge to these fish-cleaners took place in the form of two half-day workshops at Kalk Bay harbour. Training was done by second year ECP (Extended Curriculum Programme) Food Technology students from CPUT. The aims of the project were (1) to present workshops to fish-cleaners at Kalk Bay harbour, indirectly assisting in sustainable supply of quality and safe fish to the public, tourists, and restaurants who specifically visit Kalk Bay harbour to purchase fresh fish; and (2) to teach CPUT Food Technology second year ECP students basic and

advanced communication skills, giving them an opportunity to gain hands-on experience as course presenters.

Fismer: Marine Pollution

Oral Presentations

Toxicity testing as a tool to evaluate impacts of pollution on marine life

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Due to the nature of coastal development, time constraints are usually a major factor limiting risk assessment studies. Under these circumstances, toxicity tests provide a snapshot before and after disturbance to help determine the extent of rehabilitation needed. South Africa is a signatory to the London Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter (1972) and to the 1996 Protocol to the London Convention regulating the deliberate disposal of waste materials in the marine environment. There are seven categories of waste and other material that are regulated under ICMA, where dredged material derived mostly from Ports is by far the most common waste encountered during development. Toxicity testing is one of the tools required to assess the suitability of offshore dumping of dredge spoil containing high concentrations of trace metals. This study demonstrates the effectiveness of using the echinoderm species, *Parechinus angulosus*, as a test organism in fertilisation experiments to indicate toxicity of sediment samples in the Port of Durban. Dredge spoil was agitated in seawater and the supernatant extracted. Rates of fertilisation were examined in serial dilutions of the supernatant to assess the level of dilution required to reduce toxicity to an acceptable level. High levels of inhibition were evident in the undiluted supernatant (35.2% in 100% contaminated water vs. 96.8% for normal seawater), but were not significantly different to that observed in the control samples at anything greater than 50% dilution. These results suggested that while unconfined open-water disposal of the dredge spoil was acceptable in terms of South African law, taking precautions during dredging would be advisable to protect sensitive fauna and flora in the Port of Durban.

Chemical concentrations in fish and mussels in the eThekweni area of KwaZulu-Natal and potential health risks to human consumers

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Fish and shellfish are useful sentinels for evaluating the status and trends of contaminants introduced to aquatic ecosystems. This is because many contaminants have a high bioaccumulation and biomagnification potential. Evaluating contaminant concentrations in fish and shellfish tissue has the additional advantage of providing an estimate of the health risks posed by contaminants accumulated by these organisms to human consumers. This study evaluated the concentrations of metals, polycyclic aromatic hydrocarbons, pesticides, polychlorinated biphenyls, and butyltins in fish and mussels in Durban Bay, in fish in the Mngeni and Isipingo estuaries, and in mussels along the shoreline of the eThekweni area of KwaZulu-Natal. Chemical concentrations in the tissue of mussels along the eThekweni shoreline were far lower compared to Durban Bay, clearly reflecting the higher exposure of mussels in Durban Bay to contaminants. Chemical concentrations in fish caught in Durban Bay were generally higher compared to the Isipingo estuary, which in turn were generally higher compared to fish in the Mngeni estuary. The highest concentrations of several chemicals were detected in glassfish (Ambassidae), which was unexpected based on their small size a low trophic position. These fish may prove to be particularly useful sentinels for contaminant monitoring in

South African estuaries considering their abundance and that they are easy to sample compared to other fish. The concentrations of chemicals in mussels and fish in Durban Bay and to a lesser degree in the Isipingo and Mngeni estuaries pose potential chronic and carcinogenic health risks to human consumers, to the extent that in some cases only a single meal of mussels and certain fish collected and caught in Durban should be consumed per month to avoid such health risks.

Plastic pollutants within the marine environment of Durban, KwaZulu-Natal, South Africa

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Plastic pollution levels have increased exponentially worldwide since industrialised production commenced in the 1950s. Microplastics (fragments < 5 mm in size) have become a ubiquitous pollutant of marine systems globally, with pollution levels being higher around densely populated areas. This project aimed to assess the levels of plastic pollution within and around five estuaries along the KwaZulu-Natal coastline. It was found that both sediment and water samples collected at Durban Harbour, closest to the city center, had significantly higher levels of plastic pollutants overall (stations and tidal levels combined: $F = 14.528$, $df = 4$, $p = < 0.0005$ and $F = 25.23$, $df = 4$, $p = < 0.0005$, respectively). The station that had the highest mean number of plastic particles was a sheltered embayment at the head of the Durban Harbour (745.4 ± 129.7 plastic particles per 500 ml of supratidal sediment). The mean number of plastic particles per 1000 L of water found at the iSipingo (31.1 ± 11.1) and uMgeni (25.3 ± 5.9) estuaries were higher than that of the Mdloti (11.0 ± 11.1) and iLovu (7.4 ± 3.4) estuaries; which are further away from the city. Estuarine sediment samples taken at all five sites also displayed attenuating plastic concentrations (plastic particles per 500 ml sediment) away from the city center. Beach sediment taken at Durban Harbour and iSipingo showed higher levels of plastic pollution closer (500 meters north and south) to the mouth of the estuary compared to sites further away from the city (with the exception of the uMgeni estuary).

Relationship between benthic macrofauna community structure and sediment contamination in South African ports

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Many contaminants are particle reactive and preferentially partition to sediment in aquatic systems. Under continual input and little sediment remobilisation the contaminants may accumulate to such high concentrations that they pose a risk to bottom-dwelling organisms. Port environments are particularly susceptible to contaminant accumulation because their sheltered nature promotes the accumulation of fine-grained material, onto which most contaminants preferentially adsorb. Also, there are numerous and significant sources of contaminants to ports, including port-associated activities and surface runoff. Consequently, contaminant concentrations in sediment in ports are often substantially higher than in surrounding aquatic ecosystems. The traditional approach to assessing the ecological significance of sediment contamination in South African ports is to chemically analyse the sediment and to then compare chemical concentrations to sediment quality guidelines derived to be protective of bottom-dwelling organisms. There are several limitations to this approach, including that it is unknown what fraction of the contaminant concentrations are in a bioavailable form and that for South African coastal waters only metal sediment quality guidelines have been derived. Benthic invertebrates provide a direct tool for assessing the significance of contaminant concentrations in sediment to bottom-dwelling organisms. This study examined the relationship between benthic invertebrate community structure and composition and the

contamination of sediment by a wide suite of chemicals in seven South African ports. Relationships between sediment contaminant concentrations and the degree of community impairment are discussed. The estimated community impairment (based on the comparison of contaminant concentrations to sediment quality guidelines) and the actual degree of impairment observed (based on benthic community composition) is discussed.

Evaluation of mercury accumulation in yellowfin tuna (*Thunnus albacares*) muscle with regards to muscle type and muscle position

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Fish is increasingly promoted as a healthy food source worldwide, but more recently awareness about the possible consumer health hazards of contaminants such as heavy metals that accumulate in certain fish (eg. tuna, shark and swordfish) has developed. In particular, mercury (Hg) in its various chemical forms has gained publicity due to its serious neurological effects. Fish sold commercially for consumption is currently only monitored for levels of total Hg in order to assess food safety and not for methylmercury (MeHg) which is its most toxic form. There is also currently no standard protocol for sampling as to which fish and which parts of the fish to sample in order to obtain results that are representative. The focus of this study was to evaluate concentrations of total Hg and MeHg at six different carcass sites in 14 tuna using ICP-MS and HPLC-ICP-MS techniques respectively. The six carcass sites were distributed across the fish from back to front and dorsal to ventral, including light and dark muscle samples. Results showed that five of the fourteen fish had levels above the regulatory maximum limit (1mg/kg) for total Hg in tuna. Even though there was no significant difference ($P > 0.05$) in MeHg concentrations between any of the carcass sites within the fish, the average total Hg concentrations were significantly higher ($p = 0.007$) in dark muscle (0.88 ± 0.06 mg/kg) than in light muscle (0.73 ± 0.03 mg/kg). It is therefore suggest that sampling for Hg be restricted to light muscle in which there is little variation, with the dark muscle being cut away and not used for commercial sales with the rest of the light meat. MeHg and its ratio to total Hg need to be further investigated in order to accurately determine the true toxicity of this organic form of Hg in fish.

Antioxidant responses in *Mytilus galloprovincialis* exposed to copper

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A laboratory experiment was conducted to investigate correlations between the concentrations of Cu in *Mytilus galloprovincialis* and antioxidant responses caused by potential stress induced by Cu exposure. The results of the experiment indicated that Cu accumulated in *M. galloprovincialis* during a 21-day exposure period. Mussels exposed to low dosages (40 µg/L) of Cu showed a 4-fold increase in Cu, whereas mussels exposed to high dosages (100 µg/L) of Cu showed a 10-fold increase. The potential of oxidative stress as a biomarker was investigated using a battery of antioxidant

assays/methodologies in the mussels exposed to Cu. Total antioxidant capacity was measured using FRAP and ORAC, antioxidant enzyme activity was determined by measuring catalase, superoxide dismutase, and the oxidative stress status was assessed by measuring the glutathione (GSH) content and lipid peroxidation marker levels of conjugated dienes (CD) and thiobarbituric acid reactive substances (TBARS). The results showed that *M. galloprovincialis* exposed to high dosages of Cu had significantly ($P < 0.05$) increased levels of TBARS, indicative of increased oxidative stress. Interestingly, both GSH levels and ORAC capacity were significantly higher ($p < 0.05$) at day 21 than at the start of the experiment. No significant differences could be shown for the various antioxidant enzymes measured. There were significant differences between exposure groups and times but these differences did not change consistently over time. The results suggest that oxidative stress responses in *M. galloprovincialis* can be considered as biomarkers of toxicity in southern Africa and it is recommended that future research considers mixtures of contaminants that reflect metals found in the natural environment.

Poster Presentations

Poster #107

The effect of known concentrations of microplastics on gut histology and health of Mullet (*Mugil cephalus L*) from Durban Bay

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Plastic pollution is currently considered to be one of the greatest threats to marine life. A large component of this pollution is microplastic particles. As a result of their small size and their presence in both the water column and benthic environment, these microplastics are highly prone to ingestion by a variety of organisms. Ingested microplastics may affect these organisms' physical processes such as digestion, assimilation and gut evacuation. Additionally, persistent organic pollutants (POPs) and other toxins are prone to adhere to microplastic particles, leading to the possibility of the bio-accumulation of these toxins further up the food web. Retention of microplastics in a fish gut may have several effects on gut histology as well as the physiology of the fish. There is currently very little research focusing on the evacuation time of microplastics, or their effects on gut histology and physiology. This study aims to investigate the effects of known concentrations of microplastic on the gut evacuation time, gut histology, and growth of mullet a long gut fish. Samples were collected from the Durban Bay, and kept on depuration diets for one month, to remove existing microplastics and to allow the gut time to heal. They were fed a diet containing known concentrations of microplastic particles in order to determine gut evacuation rate. Preliminary data on long term physiological and histological effects of feeding known concentrations of microplastics will be presented.

Poster #108

Trace metal concentrations of two mussel species *Mytilus galloprovincialis* and *Perna perna* at Witsands, South Africa

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Witsands, on the south coast of South Africa, is a popular seaside destination close to the Breede River, but the effect of increasing human activity in this area is unknown. Mussels are commonly used as indicators of pollution in the environment, however the historical data from the musselwatch programme of South Africa has not always identified which species of mussel was used. Therefore,

sampling of *Perna perna* (brown mussel) and *Mytilus galloprovincialis* (Mediterranean mussel), sediment and water took place at three sites, Witsands, Infanta and Witsands harbour (Mediterranean mussel only) in August 2013 to determine whether these two species accumulated trace metals differently. Almost all of the trace metals in the sediment and water samples of the Witsands harbour were higher than at the other two sites. The concentration of trace metals in the Mediterranean mussel tissue was found to be generally higher than in those of the brown mussel. However, some metals were higher in the brown mussel, indicating that these mussel species differ in their accumulation of different metals. Implications for monitoring are therefore that one species should be decided on for collection in order to standardize results and make them comparable.

Poster # 109

Isolation, identification and antibiogram of pathogenic bacteria in the gut and gill of *Perna perna*

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Infectious diseases attributable to the consumption of raw and lightly cooked molluscan shellfish are caused by bacterial agents that are associated either with human waste disposed into the ocean or those of marine origin. Samples of *Perna perna* collected from Algoa Bay in Port Elizabeth were dissected and homogenized for bacterial isolation. The isolates were scanned, identified and confirmed by Gram reaction, catalase and oxidase tests, and application programming interface, and evaluated for their *in-vitro* antibiogram. The microbial counts obtained from the gut samples were 131, 123, 113, 90, 74 and 60 cfu/mls for *Staphylococcus* spp., *Salmonella* spp. *Escherichia coli*, *Shigella* spp., *Listeria* spp. and *Vibrio* spp., respectively. Microbial counts from the gills were 148, 132, 125, 95, 80 and 72 cfu/mls, for *Staphylococcus* spp., *Salmonella* spp. *Escherichia coli*, *Shigella* spp., *Listeria* spp. and *Vibrio* spp., respectively. All the isolates were catalase and oxidase positive except *Vibrio* spp. that was negative to the latter. Clearer images for the isolates were observed under scanning electron microscope. Chloramphenicol and ciprofloxacin were the most effective antibiotics against all the isolates, each exhibiting 100% efficacy. The highest resistance to ampicillin was observed in *Salmonella* spp., *Shigella* spp., *Listeria monocytogenes* and *Staphylococcus aureus*. Similarly, *V. cholerae*, *L. monocytogenes* and *S. typhi* were resistant to nalidixic acid. This is an indication that marine habitats are reservoirs of bacterial pathogens with increased resistance to antibiotic therapy thereby constituting risks to public health. The implications of this in terms of the need for the development of appropriate and proper surveillance measures to safeguard the health of molluscan shellfish consumers are discussed.

Poster # 110

A tool to aid management of total suspended solids monitoring during dredging

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Total suspended solids (TSS) is an important parameter for determining water quality as high concentrations pose adverse ecological effects such as low light conditions due to increased turbidity that inhibit the ability of visual predators (e.g. piscivorous birds) to pursue and capture prey. Dredging in ports increases suspended solids concentrations and needs to be regulated by Transnet National Ports Authority. However, the time consuming process of measuring TSS makes it difficult to provide timely information for decision-making during dredging. The purpose of this study was to determine whether turbidity, which is faster and cheaper to measure, can be used as a surrogate

measure of TSS for dredging compliance monitoring within the ports of Durban, Richards Bay and Ngqura. A laboratory study using sediment collected from each port was used to simulate dredging conditions. This formed the basis for defining the relationship between turbidity and TSS. *In situ* monitoring was performed in the three ports to determine if the relationships are valid under non-dredging conditions. The relationships for each port were compared. Each port produced a different relationship between turbidity and TSS, probably due to differing sediment properties. Thus, a model must be produced for individual ports. The *in situ* data for each port fell within the prediction limits of and thus validate the models, although the prediction limits for *in situ* data are narrower compared to simulated dredging conditions. The models are available for use by Transnet National Ports Authority, researchers and consultants involved in compliance and impact monitoring for dredging projects. The major benefit of the models is that they provide a substantial cost saving, by eliminating the need to monitor TSS, and importantly can be used to provide almost instantaneous decision-making. This will reduce the ecological impact of increased TSS from dredging, by allowing timely compliance monitoring information.

Poster # 111

Bacteriology of the gastrointestinal tract of marine fish

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Compared to water, the digestive tract is an ecosystem far richer in nutrients and therefore more favourable for the growth of the majority of bacteria. However not all bacteria that enter the digestive tract of hydrobionts establish themselves there, with some adapting to conditions in the digestive tract whereas others are digested by the enzymes produced there. We investigated the abundance of bacterial pathogen populations in the gastrointestinal tract of marine fishes found in waters from Kenton on Sea and Port Elizabeth. The Apsilon Index (API) kit was used to confirm the identity of the isolates and the isolated pathogens were subjected to antibiogram characterisation in order to determine their sensitivity to a range of antibiotics. Most isolated bacteria were human pathogens, the most abundant being *Klebsiella pneumonia*, *Serratia plymuthica*, *Rhanella aquilitis* and *Pseudomonas aeruginosa*. More infected fish were found at Kenton on Sea than at Port Elizabeth. Ceftriaxone, ceftazidime and ciprofloxacin were the most effective antibiotics against all isolates, exhibiting 100% sensitivity. However, almost half of the isolates were resistant to ampicillin. The results from this study have demonstrated a diverse population of pathogenic bacteria in the gastrointestinal tract of marine fishes from Kenton on Sea and Port Elizabeth that pose a health risk.

Poster # 112

The assessment of organic pollutant exposure and effects along the KwaZulu-Natal coastline

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There is a lack of both current and historical data regarding organic pollutant contaminants, their levels and biological effect in marine environments in South Africa. In accordance the need for assessments of current levels and effects of organic contaminants is recognized. The aim of this study was therefore to evaluate the application of artificial monitoring devices together with transplanted and resident brown mussels (*Perna perna*) as indicators of organic pollution exposure along the KwaZulu-Natal coastline. Semi-permeable membrane devices (SPMDs) and reference mussels from an unpolluted site were transplanted to two South African harbours (Richards Bay and Durban) for the assessment of organic exposure. Following a deployment period of six weeks, the

SPMDs and mussels were removed and transferred to the laboratory for bioaccumulation and effect analyses. The biological effects of organic pollutant exposure were tested using a suite of biomarkers of exposure and effect in the transplanted and resident mussels. Different levels of biological organization, ranging from DNA damage to whole organism energetics and condition, were determined during the assessment. Concentrations of organochloride contaminants (i.e. PCBs, PAHs and DDTs) were determined in the SPMDs and mussels using GC-MS techniques. Biomarkers of exposure (Cytochrome P450) and effect (oxidative stress, cellular energy allocation and condition) were determined using biochemical assays of the digestive gland. Preliminary results indicate that levels of organic pollutants, particularly PAHs were significantly higher in the SPMDs and mussels from Durban harbour. These increased levels are reflected in the biomarker responses in both the resident and transplanted mussels. This study demonstrated the application value of a combination of exposure and effects assessment in marine monitoring programmes.

Poster # 113

Fish parasites as bio-indicators of heavy metals in South African marine ecosystems

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Certain organisms provide valuable information about the chemical state of their environment, not only through their presence or absence but also through their ability to concentrate environmental toxins within their tissues. Free living invertebrates, commonly bivalve molluscs, are employed in this role as 'sentinel organisms' to monitor the concentrations of bio-available metals in aquatic ecosystems. Similarly, certain parasitic species are known to accumulate heavy metals to concentrations orders of magnitude higher than those in the host tissues or the environment. Our study analysed concentrations of metals in host and parasite tissues from the St. Joseph shark (*Callorhincus capensis*) collected in False Bay during winter of 2013. Specimens were collected from commercial beach seine fishers, dissected, and had their parasite load analysed and tissues sampled. Dissections indicate infection by 5 species of macroparasites (Cestoda, Monogenea and Isopoda). The *Gyrocotyle* sp. was highly prevalent in shark specimens (prevalence: 100%, intensity: 2.09) and was used in metal analysis. Tissue samples were dried and analysed by an ICP-MS for metal concentrations. Metal analysis of zinc showed increased concentrations in parasites (median: 2.09ppm, n: 11) compared to other host tissues (median: 0.81ppm, n: 11). These preliminary data indicate that parasites can be used as early warning mechanisms for heavy metal accumulation in marine systems. This can have direct implications for aquatic conservation, commercial marine fisheries and ultimately provide long term monitoring for anthropogenic impacts on the marine ecosystems of South Africa.

Poster # 114

Chemical contamination of sediment and mussels in South African ports

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Ports provide a sheltered environment for the safe off-loading and loading of cargo from vessels. However, this sheltered environment promotes the accumulation of fine-grained material, onto which particle reactive contaminants may adsorb and be retained. There are numerous and significant sources of contaminants to ports, including port-associated activities and surface runoff.

With continued input and little sediment remobilisation the contaminants may accumulate to such high concentrations that they pose a risk to bottom-dwelling organisms. Although it is relatively easy to identify contaminated sediment based on the concentrations of chemicals in sediment, chemical analyses provide no information on contaminant bioavailability. This is important since contaminants can only exert an adverse biological effect if they are in a bioavailable form. This study examined the degree of sediment contamination, and the bioaccumulation by mussels of a range of chemicals, including metals, polycyclic aromatic hydrocarbons, pesticides, polychlorinated biphenyls and butyltins. With few exceptions sediment in the Ports of Durban, Cape Town and Port Elizabeth were the most contaminated. Of concern in these ports were high polychlorinated and butyltin concentrations. There were contamination trends in other ports that were linked to specific activities in these ports. Mussels in the Ports of Durban, Cape Town and Port Elizabeth also accumulated the highest contaminant concentrations. The potential significance of the contaminants in sediment to bottom-dwelling organisms was estimated using various approaches. This showed that numerous chemicals in sediment in some ports were present at concentrations that may be adversely impacting bottom-dwelling organisms through direct toxic effects. Contaminant concentrations in mussels in some ports pose a health risk to human consumers, and probably by implication also organisms consuming mussels. The implications of the findings in terms of dredging are discussed.

Poster # 115

Contamination of Cape snoek (*Thyrstites atun*) during capture and on-board storage

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The majority of snoek (*Thyrstites atun*) sold in supermarkets in the Western Cape is imported from New Zealand and not locally-caught Cape snoek. Although there is sufficient availability of Cape snoek from fishermen or road side sellers when in season, the supermarkets prefer to stock the New Zealand (natively known as Barracouta) equivalent due to two main reasons. Firstly, a constant supply: the commercial fishery in New Zealand can meet the constant demand of the supermarkets while the artisanal fishermen in South Africa cannot. Secondly, superior quality: the large commercial fishing vessels of New Zealand practice Standard Operating Procedures (SOPs) for hygiene and handling. The present study aimed to identify the current handling techniques for locally-caught snoek and its effect on snoek quality. A simulated storage experiment was conducted to identify the present level of vessel-related contamination whilst also identifying optimal short term (<12 hours on board vessel) storage conditions for snoek. Two holds on the vessel were used; one contained ice while the second had no ice (normal practice). Microbial swab samples were taken from the head, middle and tail region of the fish immediately after capture and during off-loading of the fish on land. Snoek stored in ice displayed lower bacterial counts compared to those stored without ice. The highest count found on the tail suggests that contamination may have originated primarily from the food handlers (fishermen). The bacterial numbers quantified adhere to South African Bureau of Standards (SABS) specifications for acceptable consumption. However, training and the development of SOPs to improve current handling and storage conditions is beneficial as it would lead to a better quality snoek with the potential to enhance the market value and scope of markets that the local small-scale fishermen can reach.

The anatomy of subtropical submerged shorelines: A South African perspective

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This paper examines the geomorphology and seismic stratigraphy of the high-energy KwaZulu-Natal shelf offshore Durban, South Africa. Particular attention is paid to a laterally persistent (30 km) Holocene submerged shoreline located at 60 m water depth. Five major seismic units are identified (Units 1-5). Unit 1 comprises a series of infilled incised valleys that formed during the sea level lowering towards the Last Glacial Maximum. Unit 2 comprises an aeolianite/beachrock core that forms the -60 m postglacial barrier complex. Unit 3 comprises lake-lagoon depressions in the back-barrier that formed simultaneously with the barrier system. These are backed to landward by several relict parabolic dunes preserved in Unit 2. Several relict weathering features (Unit 4) are associated with the barrier and reflect similar processes observed in contemporary aeolianite/beachrock outcrops on the adjacent coastline. These are draped by a thin veneer of post-transgressive Holocene sediment that caps the shelf stratigraphy (Unit 5). This paper contends that the facies identified in the seismic section are representative of a unique subtropical setting where early cementation of the shoreline, coupled with a lengthy still stand in sea level, have produced a number of key features to be found in similar climatic settings and with comparable Global Isostatic Adjustment worldwide

The Holocene evolution of Maputo Bay

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Maputo Bay comprises a large semi-enclosed lagoon with a macrotidal range. Six main seismic stratigraphic units are recognized in the area. These comprise an acoustic basement of late Cretaceous age (1); thin pinnacles and ridges of calcite-cemented sandstones (2), a series of infilled incised valley networks with complex infilling packages (3); and a modern lagoonal sediment body that caps the previous successions (4). It is thought that unit 2 correlates with a global sea level still stand preceding a sharp rise in sea level ~ 8200 to 7600 years ago. The uppermost stratigraphy has been intersected by 48 cores, revealing a number of rapid environmental changes to the system since the initiation of Inhaca Island to seaward. Very high resolution seismics, tied to core data, show a progressive shallowing and desiccation of the lagoon, followed by an overall drowning of the system to present day. The drowning trend is similarly punctuated by a particularly rapid transgression that preserved a series of intact tidal flats landward of the old drowned shoreline (2) and erosionally truncated a series of large tidal bedforms by landward shifting of the tidal channel base levels. Recent sedimentation has been imprinted by a series of high energy marine incursions that have produced several well-defined shelly tempestites comprising *Crassostrea* Sp oysters, indicating a return to fully open conditions and an increasingly stormy climate.

Quaternary evolution of the Mossel Bay continental shelf, South Africa

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This work was undertaken to understand the evolution of the terrestrial landscape now submerged by high sea levels offshore of Mossel Bay. Two marine geophysical surveys and scuba diving were used to examine evidence of past sea-level fluctuations and interpret seafloor geological deposits. Geological mapping of coastal outcrops was carried out to link land and sea features and rock samples were dated using Optically Stimulated Luminescence (OSL). Eight seismic sequences characterise the shelf. Oscillation in sea level between ~2.7 and 0.9 Ma likely resulted in the formation of the prominent -45 m terrace, which separates a relatively steep inner from a low-gradient mid shelf. Beach and dune deposits span from Marine Isotope Stage 15 (MIS 15) (582 ka) to Recent based on an age model that integrates OSL ages and the established eustatic sea-level record. The most prominent deposits date from the MIS 6 glacial to MIS 5 interglacial periods and include incised lowstand river channels and regressive aeolianites. The MIS 5 deposits include transgressive beachrock, an extensive foreshore unit which prograded on the MIS 5e highstand, and regressive beach and dune deposits on the shelf associated with the subsequent fall in sea level. MIS 4 lowstand incised river channels were infilled with sediment truncated during rapid landward shoreface migration at the MIS 4 termination. Back-barrier MIS 4/3 sediments are preserved as a result of overstepping associated with meltwater pulses of the MIS 2 termination. The MIS 1 sediment wedge comprises reworked sediment and is best developed on the inner shelf. Accommodation space for coastal deposits is controlled by antecedent drainage pathways and the gradient of the adjacent inner continental shelf. The geological deposits on the emergent shelf indicate an expanded glacial coastal plain that potentially received more rain feeding low-gradient meandering rivers and wetland lakes.

Anatomy, high frequency seismic character and depositional processes of the lower Zambezi Channel, Mozambique Basin, SWIO

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Deep-sea channels represent preferential sediment transport conduits to the deep ocean floor, funnelling gravity flows from canyons towards deep-sea fans. Deposits associated with these deep-sea channels may accumulate over millions of years, providing longstanding records of changing climate, hinterland tectonics, and ocean circulation. In the southwest Indian Ocean (SWIO), where tectonic activity has a complex and protracted history, such systems are especially important. To this end we investigate the anatomy and shallow seismic character of the lower Zambezi channel in order to better understand this system. New swath bathymetric and sub-bottom data collected in the northern Mozambique Basin reveal an unprecedented view of the lower 530 kilometres of the Zambezi channel. Due to apparent morphological differences between the Zambezi channel and other deep-sea channels, a number of questions are raised regarding the evolution of this system as well as how it should be classified. Findings show a straight (1.08 sinuosity) deep-sea channel which exhibits a down slope change in seismic character and channel morphology. Initially 4.2 km wide in the north, the channel floor widens to 10 km wide before opening in to a frontal splay in the south. This downstream widening is accompanied by a reduction in channel relief with depth. Several levees and terraces suggest a history of vertical erosion, with little horizontal movement of the channel axis over time. A knick point (1.1 ° change in gradient) in the main channel is associated with the confluence of the Zambezi and Tsiribihina Channels. This confluence is classified as a pure, unequal,

asymmetrical type, with a confluence width to tributary width ratio of 1.05, comparable to channels of the Niger Delta, and examples from the US Atlantic margin.

Coastal slumping as a result of chronic coastal erosion at Richards Bay, KwaZulu Natal

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The dune cordon along the KwaZulu-Natal north coast comprises Quaternary sediments with a Miocene-Pliocene core. At Richards Bay, the oldest observed lithology is the Pleistocene Port Durnford Formation, exposed by dune failure and wave erosion. Seaward dune failure is caused by seepage along a clay-sand interface, accentuated by wave excavation of the toe. Dune slumping has left spectacular scars, of varying ages, on the seaward margin of this 50m high dune cordon. At present, in places, there is no high tide beach and the progressively landward dune failure is putting infrastructure, such as the Richards Bay Lighthouse, at risk. Prior to 2005 dune failure resulted in this structure becoming vulnerable, then between 2005 and 2007 a dune collapse removed the remaining 25m of dune frontage, increasing the vulnerability. Historic analysis suggests that Richards Bay coastal erosion is endemic, but that it has been interspersed with periods of coastline accretion. Strong erosion was evident between 2005 and 2007, after which the coast appears to have stabilized to some extent. We intend to investigate the various agents driving this coastal erosion (i.e. large swells, storms, tides, sea level rise, sediment scarcity and human intervention) using both field observations and historical analysis. The aim is to perform a synthetic approach investigation by defining all the possible parameters involved in the system of coastal erosion and investigating cause and effect relationships, such as interaction intensity and relative importance. We will also, assess whether this coastal erosion is episodic or cyclic. From this we will establish recurrence intervals and assess the long term stability of the coastal dune slopes.

Storm swash terraces from Morgan Bay, South Africa

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Storm swash terraces mark the most distal, landwards deposition of a storm wave event. This paper examines several newly discovered storm swash terraces located in various areas along a headland bound coastal embayment within Morgan Bay, Eastern Cape, South Africa. They form as steeply seaward dipping (30°-60°), partially vegetated features comprising alternating organic rich sand, mud and marine derived gravel. The basal elevations of the Morgan Bay terraces range from 0.5 m.amsl within the embayment, to 6.5 m.amsl at the headlands. Regardless of location, these are always fronted by a rocky shore platform. The storm swash terraces consist of a range of facies (facies 1-6) delineated on the basis of their lithological and palaeontological characteristics together with the nature of each bounding surface. It was found that terraces located in areas exposed to higher energy regimes tend to consist of thick coarser grained constituents when compared to terraces forming under lower energy embayed environments. The composition of the material present within the depositional terrace reflects that of the fronting shore platform, indicating a short source to sink transport distance. High sedimentation rates and limited accommodation indicate that these terraces can form very quickly with the thickest storm swash terrace forming where the backing topography is sufficiently high and accommodation limited. We consider that storm swash terraces have a high preservation potential with successive large storms depositing material in an aggradational manner, with reworked material forming part of the successive depositional phases.

The spatial controls on facies partitioning within each terrace appear to be a function of positioning within the embayment, the availability of material from either a riprap fronting or weathered shore platform to seaward and availability of accommodation space. Particularly limited accommodation space may produce aggradational storm sequences that will form especially good archives of marine storminess.

Fismer: Marine Geology, Geophysics and Mining

Oral Presentations

The influence of extreme events on an embayed coastline: Morgan bay, South Africa

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This paper documents the occurrence of a raised boulder ridge within an embayed coastline at Morgan Bay, Eastern Cape. The boulder ridge at Morgan Bay appears to be the product of an unusually high magnitude event that resulted in the stranding of the ridge at > +6 m elevation. The boulder source was a raised shore (+ 6 m) platform immediately seaward of this ridge. Boulders are angular and form an interlocked and armoured deposit that formed in a limited accommodation setting. Occasional well rounded boulders occur seaward of the ridge on the raised shore platform and are sourced from a gully in the intertidal zone. Small discrepancy in platform joint spacing and the boulder size suggests minimal reworking. Numerical modelling of the transporting wave heights and velocities show that the largest boulders required extreme wave heights and velocities to emplace them, at odds with the contemporary swell regime for the area. The calculated transport envelopes showed that, under the modelled velocity conditions, the expected mechanisms of transport embayment-wide would be lifting and/or saltation in either a sub-aerial or joint bounded scenario. The raised shore platform boulder ridge would be unlikely to move in either of these scenarios due to the limited accommodation space and interlocked nature of the clasts. It appears this ridge was deposited by a single event of extreme magnitude, the scale of which has not been experienced since.

Using diamond-mined sediment discharges to test the paradigms of sandy-beach ecology

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Elizabeth Bay diamond mine, near Lüderitz in Namibia, started modern operations in 1991. Since then, 30.8 million tons of waste 'fine tailings' (<1.4 mm) have been discharged onto the beach. The physical and biological impacts were monitored over 20 years, covering (1) an initial phase of mining at moderate intensity (1993-2003), (2) an upgrade phase when discharges intensified (2004-2008), (3) temporary cessation of discharges (2009-2011), and (4) after seawall mining began (2012-2013). These operations constituted a unique opportunity to explore long-term responses of beaches and their infauna to manipulations of physical conditions equivalent to a large-scale experimental perturbation. We compared the physical and biological responses, with those at control sites at Grossebuch where no mining takes place. The physical impacts of the discharge included massive beach accretion (~620 m) and increases in beach slope and mean sand particle size, particularly

opposite the discharge points in the centre of the bay. This resulted in east-to-west gradients in beach slope, wave height and beach state and led to significant changes in the beach macrofauna, with the community structure in the centre of the bay shifting from one dominated by sand mussels to a different state dominated by small peracarid crustaceans, and reductions in diversity, biomass and abundance. At the control sites, physical conditions changed little, and biotic communities were constant, more diverse and had higher abundances and biomasses. Cessation of tailings disposal resulted in rapid responses in both the physical factors and biological parameters, manifesting in increased macrofaunal diversity, abundance and biomass. Following seawall construction, however, the communities again showed negative responses to physical changes at sites near the seawalls. All biotic responses upheld the paradigm that sandy beach communities are dictated by physical conditions and exhibit decreasing gradients of diversity, abundance and biomass as one moves from dissipative to reflective conditions.

The importance of assessing bioavailability in determining heavy metal toxicity risks

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Marine sediments containing heavy metals at concentrations exceeding known toxicity concentrations are considered to represent an environmental risk when disturbed by dredging or mining activities. During these processes, sediment is disturbed and metals may be released into the water column where they may exert toxicity effects. These are mainly dependent on bioavailability, and metals in the soluble phase generally represent higher toxicity risks than those in the particulate phase or bound with, for example iron and/or manganese organic complexes. Environmental factors controlling this are complex and may be difficult to determine but require consideration in toxicity assessments. This presentation highlights this through the contrasting of apparent heavy metal bioavailability in the industrialised Port of Cape Town and a natural continental shelf setting off Namibia where pelletal phosphate mining may take place. In both environments heavy metal concentrations in surficial sediments exceeded published toxicity thresholds but elutriation tests and considerations of AVS/SEM ratios indicate low toxicity risks in both locales. The generality of these results is discussed.

How fundamental benthic macro-infauna research informs management of marine mining

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Although the environmental impacts of marine mining in the Southern Benguela have been monitored for the last 30 years, the lack of foundational knowledge regarding biodiversity patterns have limited the interpretation of these impacts. This study investigated biodiversity patterns in marine unconsolidated sediments on the South African west coast to address this limitation. Macro-infauna and sediment samples were collected at 48 sites along the South African west coast continental shelf by beach excavation, diver suction- and grab sampling maintaining a standardised area. A total of 44 828 individuals from 469 taxa were identified from 231 samples representing 46.2 m² of seafloor. Species richness patterns across various physical gradients, including depth and sediment grain size were investigated. Seven distinct macro-infaunal communities formed the basis for the first data-driven marine sediment habitat classification for the west coast. Quantitative biodiversity targets were set for each habitat using the species-area relationship. Then priority areas for protection of these habitats were identified using systematic planning software that minimised costs to users. This fundamental research was used to make recommendations for management and

identify research opportunities related to the mining sector. This study demonstrates the application of foundational research in decision-support for management of the marine mining sector.

Poster Presentations

Poster # 106

Impediments to understanding the effects of marine mining: natural variability in the communities of infaunal macro-invertebrates off southern Namibia

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In order to be able to usefully interpret the effects of marine mining operations on the environment, monitoring studies need to be placed into the context of natural variability. After all, if background levels of variability in faunal community composition and structure are of the same magnitude as mining impacts then it becomes hard to argue that, in this respect at least, mining has an impact on the environment. De Beers Marine Namibia has been mining diamonds from the seabed off southern Namibia for ~20 years now, and the company has been routinely collecting benthic grabs samples from across its license areas in order to try and understand its mining impacts on the environment, but also to get an understanding of the natural background variability. Here we use more than eight years of data (>500 samples) from areas in the license area that up-to-date have remained unaffected by mining and show that at best, the measured environment (depth and sediment characteristics) can explain only 25% of the spatial variability observed, although this improved if the spatial extent of samples is reduced. Whilst there are often pronounced temporal changes in the structure and composition of biological samples, this is only weakly linked to changes in the measured environment. The implications of these results are discussed.

Friday 18 July

Endler Hall: Monitoring the Marine Environment

Oral Presentations

Interannual variability in upwelling favourable winds along the Benguela Upwelling System

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In the Benguela Upwelling System, the role played by alongshore equatorward wind stress in inducing coastal upwelling is well documented. The influence of seasonal variability in meteorological features such as the South Atlantic Anticyclone (SAA) on the intensity and persistence of upwelling favourable winds has been investigated. Local temperature gradients are known to have a contribution on the persistence of upwelling. This study aims to investigate the potential strengthening of local upwelling magnitude in the Southern Benguela System. Dominant periods of variability and shifts in upwelling favourable winds are addressed by decomposing the signal using a wavelet analysis method. Results of upwelling indices show that upwelling at Hondeklip Bay is strengthening where as in other areas it remains normal.

A comparative study of nitrogen cycling in the Southern Ocean and the Benguela upwelling system

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Nitrification is the oxidation of ammonium to nitrate through biological processes. It is a two-step process where ammonium is converted to nitrite and then oxidised to nitrate. Nitrification in the euphotic zone has, in the past, been considered negligible. However, quantifying this process correctly is important when linking carbon export to nitrate uptake by phytoplankton. However there are very few studies showing nitrate uptake and nitrification rate together in surface waters. This paper presents such data for the Southern Ocean and St Helena, which is located in the Southern Benguela upwelling system. Nitrogen uptake and regeneration rates for the Southern Ocean were estimated during a winter cruise in July 2012 and a summer cruise in February-March 2013. Similar estimates were done in St-Helena Bay during three studies in November 2011, March 2012 and March 2013. By comparing different environmental conditions and seasons, this study aims to provide a better understanding of factors controlling nitrification and nitrogen uptake. Such a understanding can contribute to the refining of carbon export and climate models. In St-Helena Bay, the controls on nitrogen uptake are well-known and are linked to the upwelling cycle. During winter, in the Southern Ocean, light and ammonium availability were found to be the most important factors while in the late summer, changes in the mixed layer depth had a larger effect. Nitrification (both ammonium and nitrite oxidation) was detected both at the start of an upwelling (and phytoplankton bloom) and at the end of a bloom in St-Helena Bay. In contrast, in the Southern Ocean, nitrification was more patchy and only detected at five stations out of fifteen. The varying importance of nitrification shows that the use of uniform carbon export model needs to be revised.

The Southern Ocean Seasonal Cycle Experiment (SOSCEX): Towards resolving the seasonal cycle of upper ocean physics and biogeochemistry using autonomous gliders

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In March 2013, South African scientists made huge progress in ocean research and observation techniques by completing a six-month continuous mission of robotic ocean gliders in the heart of the remote and harsh Southern Ocean. The state-of-the-art autonomous vehicles were carefully navigated and controlled remotely, via satellite communication systems, by glider pilots in Cape Town. The gliders sampled the ocean from the surface to one km depth collecting valuable climate-carbon measurements of temperature, salinity, dissolved oxygen, light and chlorophyll that were relayed back in real-time, to researchers. By the end of SOSCEX, the gliders had managed to complete over 5000 profiles of the water column and cover a total horizontal expanse of 7000 km – equivalent to the distance between Cape Town and Rio de Janeiro. The unprecedented, high-resolution data set that covered the entire growth period of phytoplankton in the Sub-Antarctic region is used to understand the sensitivity of ocean primary production to changes in ocean physical conditions. Results show, for the first time, the role ocean eddy-driven stratification has in determining the timing of the spring phytoplankton bloom. In addition, wind-driven upper ocean mixing appear to sustain phytoplankton blooms for longer periods of time than previously thought possible.

Using high-frequency glider data to understand effects of sub-mesoscale processes and atmospheric forcing on the mixed layer in the Subantarctic Zone

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Traditional understanding of mixed-layer (ML) dynamics in the African sector of the Southern Ocean suggests that seasonal summer stratification is determined by the onset of a positive net heat flux. However, the impact of intra-seasonal variability on the ML is still relatively unknown. Recent research in the North Atlantic has highlighted the role of sub-mesoscale dynamics (mixed-layer eddies, or MLE) on ML stratification. It is now understood that horizontal density gradients drive these sub-mesoscale eddies, which result in the ‘early’ onset of spring phytoplankton blooms. To test the MLE hypothesis in the Subantarctic Zone (SAZ), we use high-resolution (~3km, 4 hourly) glider measurements that exhibit contrasts between a highly variable spring ML and strongly stratified summer ML. We propose that among other parameters such as wind stress and mesoscale features, MLE have a large effect on stratification in the austral spring, whereas solar heating dominates control during the austral summer months. As the MLE are governed by the horizontal buoyancy gradient and ML depth, we examine and compare distributions of the observationally inferred gradients in spring, with those from summer, as well as those from the spring North Atlantic Bloom (NAB) model (where MLE are present). Additionally, the time series of glider parameters are examined to understand event scale behaviour of the ML.

The physical oceanography of the Agulhas Bank: Can its physics explain the observed ecosystem events and shifts on the South African shelf?

M Roberts

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Recent events, shifts and trends in marine mammals, seabirds, fisheries and red tides signal changes in the performance of the ecosystems on the South African shelf. Whilst the west coast supports much of the marine biomass in the form of a feeding ground, the Agulhas Bank (AB) is favoured by many species as a spawning ground. As spawning is considered one of the most sensitive phases of the life cycle to the environment, the AB has been labelled the “Achilles heel” of the major South African marine systems. This has led to a major re-examination of the fundamentals of this ecosystem. Understanding of the physics of the AB has progressed over several spurts of research. The first during the 1980’s was strongly dominated by the CSIR, highlighting characteristics of the east-west sloping thermocline, intrusions of warm Agulhas plumes, coastal upwelling and Coastal Trapped Waves. This was followed by Boyd and Shillington in 1994 who produced a synthesis of the physical forcing and circulation on the AB, but also added new knowledge on the Cold Ridge. Despite these gains, little progress has been made on linking the observed ecosystem changes to the fundamental physics. This has led to a renewed examination of the physical oceanography of the AB. Through the Agulhas Bank Large Integrated Project (ABLIP), it has become clear that the real core of this marine system is the nutrient-rich bottom mixed layer. Observations suggest that this water is formed by shelf upwelling of Indian Ocean Central Water from the Agulhas Current near Port Alfred that flows westwards on the widening eastern AB. Production on the AB is supported by the vertical movement of this water via diapycnal mixing at the thermocline, wind-driven coastal upwelling and the formation of the cold ridge, all of which vary on seasonal, inter-annual and decadal time scales. These dynamics are the link to the upper trophic fluctuations.

Importance of the Durban Breakaway Eddy to the Agulhas Current ecosystem

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The Durban Eddy is a mesoscale, lee-trapped, semi-permanent, cold core cyclonic eddy that occurs south of Durban (29.87°S; 31.03°E), inshore of the Agulhas Current off the east coast of South Africa. Acoustic Doppler Current Profilers (ADCP's) deployed offshore of Durban during the ACEPII KZN Bight research programme from March 2009 to September 2010 indicate consistently strong south-westward flow associated with the Agulhas Current 40 km offshore of Durban, while the inshore regions are characterised by frequent current reversals associated with transient eddies which have an average lifespan of 8.6 days. A thermistor string deployed in the eddy centre and ship CTD data indicate upward doming of the thermal structure in the eddy centre associated with cooler water and nutrients being advected higher up in the water column, which stimulates primary production. During dissipation, the eddy breaks away from the Durban area, becomes more elongate in shape and flattens against the shelf as it weakens and propagates downstream at speeds varying from 7 - 35 km/day, some eddies reaching as far as Port Alfred (33.60°S; 26.90°E), approximately 600 km south of Durban, in the form of lateral waves. Downstream propagation of the eddy is evident in MODIS satellite imagery as an increase in surface chlorophyll_a and in ADCP data at Sezela (30.40°S, 30.69°E), Cape Morgan (32.51°S, 28.83°E), East London (33.15°S, 28.08°E) and Port Alfred (33.70°S, 27.30°S) as a short-term current reversal and decrease in current speeds, accompanied by a decrease in bottom temperature associated with the upslope movement of cooler water rich in nutrients. The breakaway eddy thus increases primary production and contributes to ecosystem functioning as it propagates southwards along the inshore edge of the Agulhas Current, sustaining rich and diverse marine life.

Nutrient uptake in the KwaZulu-Natal Bight

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The KwaZulu-Natal Bight is subject to nutrient inputs from terrigenous features such as the Tugela River and ocean processes such as bathymetry-induced upwelling and surface return eddies. The aim of this paper is to examine the influence of nutrient sources on phytoplankton uptake dynamics and to relate this to rainfall patterns. Experiments looked at rate processes involving nitrate and ammonium acquisition using ¹⁵N isotopic tracers. During the wet season a large variation in chlorophyll-*a* fluorescence was observed across the KZN Bight, while natural abundance isotope data indicated a seasonal change in the nutrient source available. For the wet season nutrient concentration varied with site and depth, however nitrate uptake rates ($\mu\text{g N.l}^{-1}.\text{h}^{-1}$) were not significantly different with site and depth. Alternatively, the dry season showed a significant difference in uptake rates between sites at surface waters. In the wet season the mid shelf area had the highest uptake rate and phytoplankton biomass while the Richards Bay north site dominated in the dry season, with regard to the previously mentioned factors. The phytoplankton within the KZN Bight system are adapted to a variable environment. The KZN Bight is an oligotrophic environment that receives spurts of nutrients throughout the year from oceanographic processes and a large input of nutrients from terrestrial inflow, mainly during the wet season, influencing productivity in the nearshore ecosystem of the region.

The vertical structure of mesoscale eddies in the southern Mozambique Channel using Argo float technology: The biological 'suitcase' scenario

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Seven Argo floats executing daily vertical profiles and four floats set on a five-day profile, were deployed between April and December 2013, into three mesoscale eddies which were propagating westwards across the southern Mozambique Channel. The floats profiled from 1000 m to the surface, with track depths varying between 300 and 1000 m in order to measure the vertical structure of these mesoscale eddies. The trajectories of the eleven floats are presented in relation to their track depths to explore the retention of water masses within mesoscale eddies and by association, their biological material. The retention in two cyclonic eddies (clockwise) was strong, particularly at depth. The floats only spun completely out of the cyclonic eddies once they merged with the Agulhas Current. In the single anti-cyclonic eddy deployment, the floats spun out relatively quickly into the interstitial area between the mesoscale eddies; an area considered to be a potential feeding ground and transport 'raceway' for eggs and larvae. We also present some initial results of the mixing of water masses at these eddy boundaries as Argo floats leave the mesoscale structures, further impacting the suitability of mesoscale eddies to carry within their core biological material from the south east Madagascan shelf to the east African coastline.

Endler Hall: Monitoring the Marine Environment

Oral Presentations

Zooplankton sampling in the 21st century: new fangled ways to assess the distribution, diversity and production of planktonic critters

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For decades zooplankton have been sampled routinely using one or more of a variety of nets, from vertical hauls with simple conical nets to depth-stratified tows with multiple opening-closing rectangular samplers. Samples are then traditionally analysed using a microscope, requiring hours of dedication and considerable (para-) taxonomic expertise. In recent years, however, acoustic and optical instrumentation designed to measure plankton abundance at increasingly higher levels of spatial resolution, or to provide *in situ* or laboratory-automated images of individual planktonic organisms, have become increasingly available for use by scientists in southern Africa. Also becoming more widely used are biochemical techniques, previously under development, to measure secondary production, an important component of ecosystem health and functioning. These new methods are particularly appealing, since conventional methods are not globally applicable and are rarely practical when community-level rates are required. In this presentation we evaluate a range of novel techniques used recently to assess zooplankton distribution, abundance, diversity and production

associated with mesoscale eddies in the greater Agulhas Current system. These include two *in situ* samplers - the Rolls Royce LOPC™ (Laser Optical Plankton Counter) and the Tracor Acoustic Profiling System (TAPS), two benchtop imaging systems – the Hydroptic ZooSCAN and the Fluid Imaging Technologies FlowCAM®, as well as a biochemical technique - the chitobiase (enzymatic) assay for estimation of crustacean zooplankton secondary production. We also introduce a new project to conduct DNA barcoding of meroplankton to investigate eddies as potential vectors of genetic connectivity between SE Madagascar and KwaZulu-Natal, a component of the ASCLME/ACEP “Suitcase Project”.

Size structure of zooplankton in a cyclonic eddy formed on the southern shelf off Madagascar, estimated using a Laser Optical Particle Counter (LOPC)

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Mesoscale eddies occur in many oceans and are prominent at the ends of western boundary currents. They represent areas of high production which are of paramount importance for oligotrophic areas such as the South West Indian Ocean (SWIO). Eddies can also act as transportation cells for plankton over long distances. One of the main objectives of the “Suitcase Project” (part of the third phase of African Coelacanth Ecosystem Programme, ACEP 3) is to test this last aspect in the area south of Madagascar. Similarities in marine fauna observed between the south-east coast of Madagascar and the east coast of South Africa led to the hypothesis that eddies may provide a mechanism for this apparent connectivity, by transporting planktonic larval stages across the Mozambique Channel, as if in a suitcase. A cyclonic eddy that formed south of Madagascar was sampled extensively in July 2013 (10 nm horizontal resolution) using a Laser Optical Plankton Counter (LOPC) mounted on a Hydrobios Multinet fitted with five depth-stratified nets (0.25 m² mouth area; 200 µm mesh). Additional samples were collected on the shelf south of Madagascar to explore the possibility that zooplankton from the shelf may be entrained by an eddy and subsequently transported within the eddy across the Mozambique Channel. Zooplankton biovolume, distribution and size spectra were assessed using LOPC data and compared to biovolume and vertical distribution of zooplankton collected with the nets. We explore relationships between the zooplankton and different features of the eddy (e.g. core, perimeter and outer region) as well as with the abundance of phytoplankton (estimated by fluorescence) and microzooplankton. We expect this work to further our understanding of physical and biological mesoscale processes associated with eddies in the SWIO.

The development of South Africa’s Acoustic Tracking Array Platform (ATAP): history, status, challenges and opportunities

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A commitment made in 2011 by the Canadian-based global Ocean Tracking Network (OTN) project to loan telemetry hardware to the South African Institute for Aquatic Biodiversity (SAIAB) led to the development of a large-scale acoustic monitoring array in South African coastal waters. Additional capital equipment support from the National Research Foundation formalised the establishment of the Acoustic Tracking Array Platform (ATAP), managed by SAIAB. The ATAP collects data from more than 170 receivers moored at key monitoring, including Hout Bay, False Bay, Gansbaai, Mossel Bay, Algoa Bay, Port Alfred, Port St Johns, Sodwana and Ponto Do Ouro. In addition, 15 estuaries are equipped with acoustic receivers. A registry of tagged animals maintained by ATAP and its

collaborating partners from 17 research agencies suggests that the network currently collects data from approximately 350 tagged fish belonging to 12 species. A total of 308 tagged fish have been recorded by the array yielding approximately 1.75 million detections. The development of this marine research platform has past and future challenges, which include: working in a hostile marine environment, securing buy-in by researchers to ensure broader collaboration efforts, servicing and maintaining equipment, developing a local database that integrates with the global OTN project and securing adequate long-term funding. SAIAB is however committed to maintain the ATAP receiver network until the end of 2018, thereby providing an unprecedented opportunity to gather long-term fish movement/migration and environmental data. In this presentation I will provide an overview of ATAP's history, current status, collaboration opportunities, data policy and data sharing arrangements. Lastly, by making use of selected examples, I will highlight the opportunities that exist to improve our understanding of the spatial ecology of marine animals. Such information is much needed to assist with the corrective management of over-exploited fishery species and conservation of threatened or endangered species.

What lies beneath and does it change? New tools to quantify our seabed

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Offshore benthic biodiversity and ecosystem functioning are poorly understood in South Africa. Understanding the impacts of offshore activities, specifically demersal trawling, on these ecosystems is a national research priority. The impacts of demersal fishing have been cited as one of the largest global anthropogenic sources of disturbance to the seabed and its biota but does this apply in the context of the 100+ year-old South African hake trawl fishery? Trawling impacts are known to vary with habitat and trawling practice, necessitating a site specific experimental approach to assess such impacts. The eco-certification initiative of the Marine Stewardship Council has been driving changes in the knowledge base and associated management of South Africa's trawl fishery since 2004. Through conditions set during the certification process, the fishery has allocated a 6x15 nm experimental area within the west coast fishing grounds for research on trawl impacts relating specifically to this sector. The first baseline seabed survey was recently conducted in the experimental area using the new, deep-sea research platform, the SkiMonkeyIII camera, and a benthic grab. This survey enabled the first visual verification of South Africa's Southern Benguela shelf habitats using epifaunal data. Species diversity, abundance and distribution were used to characterise the habitats. Subsequent to the baseline survey, a portion of the experimental area was closed to trawling, thereby removing associated impacts and enabling a long-term assessment of potential changes in benthic communities. With baseline conditions now captured, annual surveys will track benthic changes that may occur, improving our knowledge of trawl impacts in this habitat type. This experiment highlights the opportunities for long-term, co-operative research through collaborations between industry and scientists.

Assessing the use of otolith morphometrics for age estimation of redeye round herring (*Etrumeus whiteheadi*)

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Redeye round herring (*Etrumeus whiteheadi*) is a small pelagic fish that is caught by South Africa's pelagic fishery and converted to fish meal and oil, fish paste and pet food. The fishery for this species is currently managed using an annual Precautionary Upper Catch Limit (PUCL) of 100 000 tons, but this resource is presently considered to be underexploited. Expansion of the fishery for redeye will require the development of population assessment models, and accurate age determination of this species will be required for those models. We assessed the use of otolith morphometrics for estimating redeye age by comparing otolith length and otolith weight with age (assigned using counts of putative annual growth rings) for > 400 fish collected during the 2007 pelagic spawner biomass survey. Significant relationships between both otolith morphometric parameters and assigned age were found. The goodness of fit being slightly better for the otolith weight versus age relationship compared to the otolith length versus age relationship. Given the time-consuming nature of using counts of otolith annuli to generate age estimates as opposed to the appreciably less time and effort required to measure and/or weigh otoliths, we consider that either of these relationships may be used as reliable alternative methods of estimating redeye age and producing age length keys for use in stock assessment models.

Using biomimetic loggers to investigate whether intraspecific aggregations ameliorate rocky intertidal limpets and mussels from multiple abiotic stresses

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Intraspecific aggregations are frequently observed across a range of both marine and terrestrial taxa. Several hypotheses have been proposed to explain this reoccurring phenomenon including reduced predation pressure, increased reproductive fitness and amelioration from harsh abiotic conditions. On exposed rocky shores many benthic invertebrates form large aggregations. This is primarily thought to be a behavioural response to multiple physical stresses including wave exposure and heat and desiccation stress. However, few studies have empirically tested these assumptions or the importance of multiple stresses for individuals within an aggregation. In the present study, we take advantage of recently developed biomimetic technology to measure multiple abiotic stresses (i.e. wave force, body temperature, desiccation stress) at the individual level for two aggregating species with differing life history strategies, that is, the limpet *Scutellastra argenvillei* and the mussel *Mytilus galloprovincialis*. Biomimetic loggers were placed within the centre and edge of mussel beds and limpet aggregations at two sites, one exposed and one sheltered, along the west coast of South Africa where both species display strong aggregating behaviour. We present preliminary results that highlight the importance of measuring variability at the individual level and different responses of the two study species to similar levels of abiotic stress. This study has significant implications for predicting the future impact of climate change on rocky shore communities since species that aggregate may find refuge from further increases in heat and desiccation stress and altered hydrodynamic forces.

Poster # 120

The dynamics of meso-scale features along the east coast of South Africa: Application of coastal altimetry

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Recent scientific research shows that Satellite Altimeter Observations are useful in describing the nature and evolution of mesoscale features (lee eddy, upwelling and alongshore counter current) in the Delagoa Bight. Similar features are known to exist south of the bight, along the continental shelf of the South African east coast. Improved understanding of temporal frequencies, strength and propagation of these features were hampered by the inability of the altimeter data products to resolve spatial scales of less than 50km resolution. Here, we intend to demonstrate the significance of coastal altimetry in providing useful information about mesoscale features along the Agulhas continental shelf. A review of material and methodologies to be used will be presented, as well as preliminary results obtained from analysis of coastal altimetry data sets available for this region. We will show how global coastal altimetry research has improved the re-processing of altimeter signal to produce data sets that can provide information at 3km high spatial resolution near the coast.

Poster # 121

Development of a flow injection analyzer with chemiluminescence for the determination of iron in seawater and its applications

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Iron is an essential micronutrient for all phytoplankton and is found in seawater at picomolar-level concentrations. These low concentrations and potential contamination while sampling from a ship-based platform, makes accurate Fe analyses difficult. For the first time in South Africa, a technique that utilizes a flow injection analyzer (FIA) coupled with a chemiluminescence reaction has been developed for the analysis of Fe in seawater samples. The developed method is an improvement on similar available methods and uses commercially available resin (IDA) as opposed to the one that requires synthesis in the laboratory. Furthermore, the method requires reduced reagent concentrations thereby providing better results in a cost-efficient and easy manner. The improvements resulted in better precision while eliminating the loss of resin through bleeding, a common problem when using 8-HQ resin as per prior methods. Method validation was performed using internationally calibrated reference material provided by GEOTRACES and the values obtained were within the error limits of the certified range. An inter-lab calibration was also conducted as part of the verification of the system. Subsequently, the method was implemented on the SANAE 53 voyage on board the SA Agulhas II, to assess trace metal sampling protocol for any contamination issues, as well as for the analyses of collected samples. Current results suggest some contamination during collection stages, but this is still to be verified by complementary data on macro nutrients and chlorophyll.

Poster # 122

Absorption signatures of primary production and phytoplankton pigments in the Agulhas and Benguela ecosystems

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Investigations of primary production, phytoplankton pigments and absorption properties were conducted during four research cruises on the continental shelf around southern Africa. The Benguela ecosystem is characterized by wind-driven upwelling processes across a broad shelf, while the Agulhas ecosystem is driven by shelf-edge current and eddy flow entraining nutrients onto a narrow shelf. Chlorophyll *a* concentrations ranged from 1-30 mg.m⁻³ and photosynthetic rates from 3.2-105.3 mg C m⁻³.h⁻¹ on the Benguela shelf. For the Agulhas system, chlorophyll *a* concentrations ranged from 0.5-4 mg.m⁻³ and photosynthetic rates from 0.9 to 20.3 mg C m⁻³.h⁻¹. Daily integrated production varied from 0.8-8.7 g C m⁻².d⁻¹ and 0.3-3.7 g C m⁻².d⁻¹ for the Benguela and Agulhas systems respectively. Data from within the upper 10 m were synthesized to examine the relationships between absorption, pigments and productivity, and assess the utility of absorption-based measurements for environmental monitoring. The slope of the linear regression of photosynthesis versus chlorophyll *a* yielded an assimilation number of 4.23 mg C (mg Chl)⁻¹ h⁻¹. The spectrally averaged (400-700 nm) phytoplankton absorption coefficient (*a_{ph}*) varied between 0.02 and 0.34 m⁻¹ and the regression of photosynthesis versus *a_{ph}* yielded a positive slope with 63% of the variance being explained. The power relationships between absorption and chlorophyll *a* for the blue and red maxima (*a₄₄₀*; *a₆₇₆*) displayed positive functions similar to those reported for other oceanic areas. Trends between *a_{ph}* and chlorophyll *a*, photosynthetic pigments and total pigments were also examined and found to yield positive power functions where 86-90% of the variance was explained. The results suggest that phytoplankton absorption maybe very useful for predicting primary production and phytoplankton pigments in the Agulhas and Benguela ecosystems, with potential application for remote sensing and in situ monitoring.

Poster # 123

Estimating the acoustic target strength of round herring *Etrumeus whiteheadi* through the application of multi-frequency techniques

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The biomass of commercially important small pelagic fish off the coast of South Africa has been estimated biannually in May and November each year since 1984. These estimates, derived from hydro-acoustic survey methods, are key inputs for the management of the fishery for anchovy *Engraulis encrasicolus*, sardine *Sardinops sagax* and round herring *Etrumeus whiteheadi*. Quantitative hydro-acoustic survey estimates, however, rely on knowledge of the acoustic scattering properties of the various fish species assessed. A scaling factor known as the target strength (TS) is required to convert the measured acoustic energy reflected from fish targets into a quantitative estimate of fish density. Target strength estimates have been determined for anchovy, sardine and horse mackerel (*Trachurus capensis*) but not for round herring. Round herring estimates are currently derived using the TS estimate of sardine based on the assumption that similar sized fish of these two species have

similar sound-scattering properties. With the intent of improving survey estimates of the biomass of round herring for use in the development of round herring assessment models and management procedures, it is important that the accuracy of round herring estimates be considered more adequately. This study presents preliminary results for the TS of round herring and demonstrates how relatively simple noise reduction, zooplankton filtering and single target screening methods can be used to improve these estimates. The effect of using a new TS value for round herring on the estimated biomass of this species, as well as those of other co-occurring pelagic fish species, is demonstrated.

Poster # 124

Remote identification of small pelagic fish schools during acoustic surveys using classification models

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Small pelagic fish species including anchovy, sardine and round herring are of economic and ecological importance in the southern Benguela where they form schools that are easily detected using echo-sounders. Biomass estimates derived from hydro-acoustic surveys are key inputs for the management of South Africa's small pelagic fish stocks and are used directly in the Operational Management Procedure (OMP) for setting the annual Total Allowable Catch (TAC). Improving the accuracy of survey estimates is therefore very important. Classification of schools to species is, however, not straightforward and largely depends on concurrent trawl sampling of detected schools. Time and financial constraints, however, limit the amount of trawling that can be accomplished during a survey and some degree of interpolation between trawl samples is necessary to apportion the acoustic energy from schools to the different species. Information related to morphometric, bathymetric and energetic features of schools can, however, be extracted from the acoustic data and can be used to classify fish species through the development and use of classification methods. In this study we employ four of the most common classification methods; Linear and Quadratic Discriminant Function Analysis (LDA and QDA), Artificial Neural Network (ANN) and Classification Tree Analysis (CTA). We assess the relative importance of the different predictors, compare the performance of the four models, and determine their temporal transferability. We found the performance of the models to be similar and of the large number of school descriptor variables only a few were important in classifying fish schools to species. The addition of more variables in most cases did not result in higher overall accuracy. This study demonstrates the potential for improved estimates of biomass from the use of classification models but also reveals potential issues regarding the transferability of models over time.

Poster # 125

Realtime underwater acoustic relay network deployed in False Bay, Cape Town

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Acoustic modems have been used in oceanographic research for a number of decades; however fundamental issues and limitations have plagued this form of data collection. For example, acoustic modems are highly sensitive to and easily affected by environmental factors. This project aims to alleviate such restrictions, as well as reducing time at sea and monetary constraints by producing

real-time data obtained from Nortek™ Acoustic Wave and Current profilers (AWAC) which are transferred from one acoustic modem to another, in a relay configuration. Three sub surface moorings were designed to house one AWAC each, a datalogger and an acoustic modem. The moorings were deployed in Simons Town at a set distance of one nautical mile apart and seated on the sea bed at similar depths (25m-29m) to ensure a constant line of sight for the acoustic modems. A surface buoy equipped with an acoustic modem suspended below the surface; receives the final data set from all three sub surface moorings. The surface buoy is situated relatively close to the shoreline and the AWAC data can be sent to the land station via a Global System for Mobile Communications (GSM) signal. The deployment and configuration of this underwater acoustic relay network has proven successful in terms of data transfer along the acoustic modem array and up to the surface buoy and the data server. The study is invaluable as it not only benefitted the students involved (in a developmental capacity) but also provides a framework for future physical oceanographic research. A project of this nature has not been attempted before hence its novelty in terms of physical instrumentation and development. Essentially the number of individual acoustic modems can be increased and adapted to operate efficiently for larger mooring arrays which serves to benefit the oceanographic community on a global scale.

Poster # 126

Probing a new era

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An important component of marine systems is zooplankton that exists within specific temperature ranges affecting all aspects of their life cycle. It is important that the ambient temperature data, collected concomitantly when sampling zooplankton, are reliable. Biologists have been reliant on oceanographic instruments that are deployed independently from zooplankton sampling instruments. The most commonly used oceanographic instrument is the CTD (conductivity, temperature and depth) profiler. With technology moving at a rapid pace instruments that sample plankton have evolved from a simple net scooping an unknown volume of water to a sophisticated, opening-closing multiple net system with flow meters quantifying water volume filtered and that also incorporates a CTD profiler, such as the commonly utilized MultiNet™. The aim of this study was to make a comparison between the temperature data that are measured by an on board CTD profiler and those monitored by a usually less sensitive probe on board a MultiNet™. In total 359 data pairs derived from the same depth, from around Marion Island, were assembled in a 2-6°C temperature range between 500 m and the surface. On average, there was a difference of 0.03912°C between the CTD and the MultiNet™ sensors, with MultiNet™ measurements on average lower than CTD temperatures. Statistical analysis showed that this difference is significant (t-test, n=359, p<0.001). Although there is a significant discrepancy, this difference is negligible for the purposes of making use of temperature profiles obtained from the MultiNet™ on the downcast to guide depth-stratified sampling of zooplankton on the upcast, as required in current zooplankton research projects. But it means that the MultiNet™ could be deployed at the very beginning of a station, or at the end, thereby saving costly ship's time. Whether there are also differences between measurements of the oxygen and fluorescence probes remains to be tested.

Poster # 127

The efficiency of trawl sampling for apportioning acoustic density between South African pelagic species

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South African pelagic fish species are of economic importance and also play a vital role in the functioning of the ecosystem. Acoustic surveys are used to estimate the density and map the distribution of important pelagic fish species, namely anchovy (*Engraulis encrasicolus*), sardine (*Sardinops sagax*) and round herring (*Etrumeus whiteheadi*). The effectiveness of trawl sampling for identifying pelagic species during acoustic surveys was evaluated at different times of the day and for different surveys. Biases associated with trawl sampling were investigated through comparisons of the Simrad FS20/25 netsounder (mounted on the trawl net) data and Simrad EK60 38 kHz echosounder (mounted on the ship) data from the routine bi-annual acoustic surveys. Echosounder data before, during and after trawling was analysed to determine the response of pelagic fish to the midwater trawling gear. An index of trawl efficiency was formulated and assigned to each trawl. It was observed that the accessibility of pelagic fish to the trawling gear varied between day and night, and the catchability varied between species. The aggregation patterns of the fish species also differed between day and night and between surveys and seemed to influence the reaction of fish to the trawling gear. Optimizing the placement and timing of trawls may therefore improve the efficiency of trawling while minimizing the bias associated with species identification during acoustic surveys – ultimately resulting in improved accuracy and better management.

Poster # 128

Quantification of the bias associated with the inclusion of sound scattered by zooplankton in acoustic estimates of sardine and anchovy using the bi-frequency method

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The management of South African pelagic fish species has relied heavily on the use of hydro-acoustic surveys to estimate the biomass of commercially important anchovy *Engraulis encrasicolus* and sardine *Sardinops sagax* for over three decades. These surveys typically use a minimum threshold value of -65dB to discriminate between fish and other non-targeted organisms. Although the biomass estimates derived from these surveys are relatively precise, their accuracy is dependent on several factors, many of which are difficult to quantify. The bias associated with target discrimination remains one of the major challenges of the acoustic survey method. In this context, scattering from targets other than fish can contribute appreciably to the total acoustic energy measured and result in positively biased fish abundance estimates. This is of particular concern in highly productive ecosystems such as the southern Benguela, where zooplankton aggregations and fish shoals disaggregate into dense sound-scattering layers at night. A bi-frequency method, originally

developed for the Humboldt Current System, has been adapted to improve the ability to discriminate between acoustic echoes emanating from zooplankton and fish. This method essentially compares the acoustic response (backscattering strength) of fish and zooplankton at 38 and 120 kHz frequencies and utilizes this information to discriminate between fish and other targets. Acoustic data from two surveys conducted in 2011 are re-analyzed and fish density estimates derived from the minimum threshold method are compared to those derived using the bi-frequency algorithm. The influence of variables such as the time of day, season and region (West Coast vs South Coast) on differences in density estimates obtained is also illustrated. The results indicate that in some circumstances, the accuracy of fish abundance estimates can be significantly improved through the use of the bi-frequency method and also that the use of a single minimum threshold level is not appropriate for all conditions.

Poster # 129

Chemical lipid-extraction and lipid correction techniques: their use in stable isotopic trophodynamic studies of deep-water species of the KwaZulu-Natal Bight

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Stable-isotopes are important markers for trophic-linkage studies. Isotope analysis is possible because $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ in organism's tissues are higher than those of its diet, since lighter isotopes are preferred for metabolic functions. However, tissues contain lipids, which are ^{13}C depleted and could alter carbon isotope results. To avoid bias errors, chemical procedures and mathematical models for lipid removal from tissues have been developed. Unfortunately, previous studies show that chemical lipid removal methods alter not just $\delta^{13}\text{C}$ but also $\delta^{15}\text{N}$ necessitating samples to be analysed twice. Mathematical models avoid the extra cost, but the final results are questionable. The aim of this study is to evaluate the effects of chemical lipid extraction methods (Bligh & Dyer, the Folch extraction and the Soxhlet extraction) on the $\delta^{13}\text{C}$, $\delta^{15}\text{N}$ and C:N signatures in various tissues of marine organisms (six teleost, one cephalopod and one crustacean species). The $\delta^{13}\text{C}$ values of lipid-extracted tissues will then be compared with $\delta^{13}\text{C}$ obtained from lipid normalisation and mass balance approaches. Preliminary results indicate significant differences between the $\delta^{15}\text{N}$ ratios of untreated tissues and treated tissues for all species. Only the fish species *Synagrops japonicas* and cephalopod *Veladona togata* had significant differences between treated and untreated tissues for $\delta^{13}\text{C}$, whilst only one lipid normalization model was able to accurately predict the $\delta^{13}\text{C}$ ratios obtained from Bligh & Dyer for most species. However this model was not found to be suitable for the cephalopod species, *V. togata*, although another widely used model was applicable. The study also assesses the discrepancies between treated and model obtained results. This work will allow for a better interpretation of isotopic analyses in ecological studies and help shed some light over discrepancies found in other studies.

Poster # 130

Large scale cultivation of macroalgae for green energy production in South Africa

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Investigations into seaweeds as a food source for the South African abalone (*Haliotis midae* L.) have led to knowledge about their growth and aquaculture conditions. *Ulva* are grown on a large scale in double-ended-D paddle wheel ponds. From 2007 to present, they are South Africa's largest aquaculture product by volume, yet their value and production statistics are seldom reported as they are used for abalone feed. Objectives were to investigate the potential for large scale anaerobic digestion of *Ulva spp* to produce methane gas from a readily available aquaculture product under worst case scenario conditions. Experiments were carried out at Benguela Abalone Group® on the South African West Coast in four, 32m X 8m X 0.55m, 180m³, lined concrete seaweed paddle ponds, filled with unfiltered seawater, on a flow through system (2 VE.d⁻¹), in winter. Initial starting biomass of 500 kg was stocked in each pond, and growth rates measured every 21 days for a period of 3 months. Three ponds were fertilized (every 7 days) with a mixture of (10:16:0) Maxiphos® and Ammonium sulphite at 100g/kg at different amounts. Samples were anaerobically digested in batch cultures for 25 days at the University of the Western Cape for biomethane analysis. This trial illustrated a worst case scenario, i.e. the lowest growth rates that would be obtained. Large scale cultivation systems could fit 39 ponds in a hectare, with a worst case production of 1029.6 t.ha⁻¹.a⁻¹ (containing about 53% methane), if this is compared to open micro algal ponds, with best case production of 50-300 t biomass ha⁻¹. yr⁻¹, *Ulva* cultivation is preferable in biomass terms alone. Other benefits for large scale renewable energy production and CO₂ capturing systems are its high growth rate, ease of harvesting, resistance to contamination by other algal species and minimal production loss.

Poster # 131

Opportunistic use of beach webcam imagery to monitor and manage the coast: examples from KwaZulu-Natal

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The internet provides a wealth of information, amongst this, the availability of beach webcam imagery at selected sites via various tourism, surfing, weather and aviation websites and a cell-phone network provider. Beach webcams can be used to gather regular short- to long-term imagery of the coastline. They can be a useful tool for assessing changes in coastal morphology and coastal processes over hourly, semi-diurnal, diurnal, synoptic, seasonal and inter-annual time periods that sporadic aerial and satellite imagery are not capable of showing. The province of KwaZulu-Natal (KZN), South Africa, has a high energy, dynamic coastline and beach change can be quite rapid and dramatic, sometimes resulting in erosion problems and threats to coastal infrastructure. Imagery from beach webcams located in KwaZulu-Natal, is used to examine coastal variability and illustrate seasonal beach rotation, lagoon mouth dynamics and erosion hotspots. In particular, webcams at the south coast beaches at Margate and Amanzimtoti, backed up by on-site photography, are used to illustrate different coastal management practices, where breaching of a lagoon outlet at Margate averted damage to coastal infrastructure, while lack of action by authorities at Amanzimtoti resulted in a costly train derailment disaster. Beach webcams can be used by managers to assist in planning

and as an early warning system of erosion problems which may affect coastal infrastructure. It is recommended that local, provincial and national government adopt this technology and apply dedicated beach webcams to improve our knowledge and management of the coast, especially at known erosion hotspots.

Poster # 132

Comparing the variability in catch efficiency of different plankton sampling gear

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The SARP (Sardine and Anchovy Recruitment Programme) monitoring line was initiated in August 1995, with the aim to provide high-frequency coverage of the transport by the Benguela jet current of early life history stages of pelagic fish, from their South Coast spawning grounds to the West Coast nursery area. Forming part of this sample archive is an 18-year zooplankton collection of samples that remain to be analysed. In 2013 the SARP project came to an end, however, sampling on the line has continued to monitor the physics, chemistry and zooplankton of the equatorward flowing shelf-edge jet current off the Cape Peninsula. This monitoring line is now one of four transects which form part of the Integrated Ecosystem Programme: Southern Benguela (IEP: BC). This IEP aims at enhancing our understanding of mechanisms and processes that influence the Southern Benguela ecosystem structure and functioning, including the impact of climate variability. Coupled to this change in objective is a move from using old technology for plankton collection (mini-Bongo net) that sampled an unknown volume of water in oblique tows from an approximate depth of 70 m to the surface, to using the more modern MultiNetTM, a multiple opening-closing net system with flow meters quantifying water volume filtered and that also incorporates a CTD profiler. To ensure the integrity of the long-term zooplankton data series the catch efficiency of both samplers is compared in this study. Data presented here are seasonal abundances of eggs and larvae of anchovy (*Engraulis encrasicolus*), sardine (*Sardinops sagax*) and redeye roundherring (*Etrumeus whiteheadi*) for 2011 collected at 70 m by both the mini-bongo and the MultiNetTM, both towed in an oblique mode.

Poster # 133

Assessing potential bias resulting from applying trawl based species split model to longline data in the South African hake fishery

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The hake resource off South Africa, *Merluccius capensis* and *M. paradoxus* is targeted by four sectors in the hake fishery: offshore trawl, inshore trawl, hake long-line and hake hand-line. The two trawl sectors together account for about 90% of the landed catch per annum. There is a broad overlap in the distribution of the two species they cannot be targeted separately and are generally caught together. As it is difficult to distinguish between the two species, especially the processed product, they are marketed as a single commodity and the commercial hake catch is not identified and recorded by species. The relative contribution per species to the hake catch differs among sectors therefore, although it is not practical to manage the hakes species separately, it is important that they are assessed separately. This requires species disaggregated catch data. *Merluccius capensis* prefers shallower, warmer water than *M. paradoxus* and in both species mean size increases with depth. The relationship between species, size and depth in research trawl catches has been used to derive a trawl-based species splitting model to disaggregate trawl catches to species. We used species-specific catch information collected by observers onboard hake long-line vessels since 2000

to investigate the potential bias of applying the trawl-based species splitting model to the hake long-line catch.

Poster # 134

Agulhas Current Retroflexion anomalies as derived from daily Argo profiling

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Along the east coast of Southern Africa the Agulhas Current forms a free jet when it leaves the southernmost tip of Africa. The current travels towards the South Atlantic Ocean and reverses direction and retroflects towards the Indian Ocean. At the point of retroflexion, warm-core eddies and filaments are detached and spin off into the southern Atlantic. These eddies are responsible for the heat and salt exchange around the region. The position of the Agulhas Retroflexion does not show any geographic permanence, the most consistent position is found at 20°E, making the Agulhas Current the most intensely variable region in the ocean. Three SOLO II Argo floats that were donated by Woods Hole Oceanographic Institute for a study on mesoscale eddy dynamics were deployed off the northern KwaZulu-Natal coast in April 2013. These floats were setup to do daily profiling from 1000m and at various park depths. Each float will be treated as a separate case study, looking at their resultant trajectories. All three floats became entrained within the Agulhas Retroflexion but their trajectories were determined by different features – the Agulhas Return Current moving eastwards away from Africa, the recirculation around the South West Indian Ocean sub-gyre and one float travelled southwards towards the Southern Ocean. The float trajectories and resultant features were plotted against sea surface height satellite imagery and bathymetric maps to determine what influenced their trajectory and how the setup of the Argo float mission impacted this further. No floats advected into the South Atlantic, thus showing no leakage of the Agulhas Current at these depths for this study.

Poster # 135

Intermediate water masses in the Mozambique Channel and their distribution

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There are two main intermediate water masses found in the Mozambique Channel (MC), i.e. Antarctic Intermediate water (AAIW) and Red Sea Water (RSW). AAIW travels from the Antarctic Polar Front equatorward, while RSW travels south from the Red Sea via the Arabian Sea into the MC. This study investigated the distribution of these water masses in the MC and determined whether there was dipycnal mixing between them. The potential temperature, salinity and density from historical Argo data from 2002 to 2010 were used to investigate these water masses. AAIW was defined in the MC with ranges of 34.3-34.7 psu, 4-7° C and a density of ~27.4, while RSW was defined as 34.7-34.9 psu, 5-7° C with a density of ~27.5. AAIW was found to be abundant in the south of the MC with very little making it to the middle of the MC. Some AAIW was found at the north of the MC, but travelled via the eastern boundary of Madagascar assumedly with the East Madagascar Undercurrent. RSW can be found throughout the MC but decreases in amount as it travels south. The intermediate water masses in the MC are affected by mesoscale eddies that frequent the region which reaches an intermediate depth thus affecting the path of AAIW and RSW. These mechanisms play a role in the heat and salt exchange through the MC and thus the thermohaline circulation.

Poster # 136

Opportunities for South African scientists and students in the new Mega International Indian Ocean Expedition 2015-20 (IIOE-2)

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The IIOE, coordinated by the Scientific Committee on Oceanic Research (SCOR) and IOC, was one of the greatest early international inter-disciplinary oceanographic research efforts to date, involving over 45 research vessels under 14 different flags to explore through pioneering voyages of discovery the ecological and physical mysteries of the Indian Ocean. The IIOE brought a focus of importance to this region giving insight into the oceanic and climatic phenomena which profoundly impacted on the Indian Ocean rim countries and islands. It also began to illuminate the Indian Ocean's far reaching influences on surrounding regions and the globe through teleconnected ocean/climate processes. It brought the attention of the scientific world's interest to the Indian Ocean in a coordinated, collaborative manner for the first time embracing marine physical and chemical oceanography, meteorology, biology, geology and geophysics. The IIOE included Capacity Building as a key objective which led to the birth of the Indian National Institute of Oceanography in Goa and the Meteorology Centre in Bombay. The IIOE adopted the Indian Ocean Standard Net for zooplankton measurements, led to the establishment of some 15 SCOR/UNESCO Reference Stations and generally began to unlock the idiosyncrasies of the Indian Ocean's bio-physical traits. The new IIOE-2 planned for 2015-20 is designed, through a 50th celebration, to once again refocus the international scientific community on the Indian Ocean but now with modern technologies. One of the overarching themes will be upwelling in the Indian Ocean. This presentation will give the latest developments and opportunities in this mega initiative for South African scientists and students. The IIOE-2 will be sanctioned by the IOC in June 2014.

Poster # 137

Seasonal variability and long-term trends in sea temperatures of Algoa Bay

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Sea temperatures in Algoa Bay show large temporal variability, both in the horizontal and vertical. Seasonal differences in temperature are investigated using 5 years of data from SAEON's Algoa Bay Sentinel Site Long-term Research Programme, while longer-term trends are determined from 30 years of satellite imagery. Results show that depth-averaged temperatures in the water column across Algoa Bay (between Cape Recife and Cape Padrone) have a marked seasonal variability. The east side of the bay is cooler than the west side during summer, while during winter it is reversed with the west side being cooler than the east side. This is attributed to wind-driven upwelling which occurs preferentially along the south side of prominent capes, caused by easterly-component winds during summer. The extent of the upwelled water then expands westwards from the capes into the bays. During winter the easterly-component winds decrease in intensity and frequency, allowing the westerly's to upwell cooler water on the west side of the bay. The hourly, daily mean and monthly mean temperatures of the majority of the thermistor strings at 30 m and 80 m depth show a rise in

temperature over a 5 year period. Linear trend lines on these data show an increase of between 0.5 °C and 2.3 °C which occurred throughout the water column, although differences between sites were evident. Seasonal satellite climatologies show that surface temperatures are lowest during winter and spring, slightly elevated during autumn, and highest during summer. A similar pattern is observed offshore across the Agulhas Current, with lower temperatures during winter and spring, and higher temperatures in summer and autumn. While the satellite data shows the same pattern as the in situ data within Algoa Bay during winter, the pattern is different during summer, with the coolest water observed in the centre of the bay.

Poster # 138

Dynamics of the Port St Johns cyclonic “lee-trapped” eddy

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This project forms part of an in-depth investigation into the dynamics of the cyclonic (lee-trapped) eddy found along the coast off Port St Johns (PSJ). The objectives of the study are to: (1) investigate the driving force(s) and the formation of the PSJ lee-trapped eddy and (2) to determine the biological implications of the PSJ lee trapped eddy on the shelf area by investigating (i) upwelling events - isothermal doming and cooling; (ii) chlorophyll-a biomass; and (iii) zooplankton biomass. Three research surveys were conducted during May, June and December 2013 onboard the FRS Algoa. Hydrographic data were collected along transects off Rames Head, PSJ and Waterfall Bluff. Preliminary results show pronounced isothermal doming was evident off PSJ during all three cruises. Subsurface oxygen minima were also observed, particularly off PSJ and Waterfall Bluff. Maximum chlorophyll concentration across all transects ranged between 0.4 to 0.5 mg/m³ during June, and between 0.2 to 0.8 mg/m³ during December. Maximum zooplankton biomass was observed off Rames Head (113 mg/m³) during June and off PSJ (27.18 mg/m³) during December. Moored ADCP measurements collected at 80m off PSJ, revealed maximum current velocities of approximately 1.25 m/s: current reversals were also observed.

Poster # 139

Effect of a barrier reef on waves and currents at Xai-xai beach

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Giant waves and strong currents occur in Xai-Xai Beach which are hazardous to swimmers and fishermen. On average 7 deaths by drowning are reported to occur in Xai-Xai Beach per year. Two field experiments were conducted in Xai-Xai Beach: October 2011 during neap tides and in October/November in 2012 during spring tide aimed at observing the waves and currents. Wave heights were measured using a pressure gauge, an accelerometer and an ultrasonic altimeter. Currents were measured using an Anderaa Seaguard Current-meter and a Lagrangian drifter. In addition, standard meteorological parameters were measured using a portable meteorological station. The observed waves outside the reef varied from 2 to 8 m and in the inner beach varied from 1 to 2 m, during relatively calm weather with winds of about 5 m s⁻¹ and in rough weather conditions winds of about 9 m s⁻¹ were measured. The alongshore currents ranged between 1 and 1.5 m s⁻¹, unidirectional and towards the North all the time. Strong and permanent rip currents with velocities of about 1.5 – 3.5 m s⁻¹ were observed. The reef barrier is up to 75 cm above the mean seal level,

and constrains the water movement back to sea resulting in pressure gradient force between the inner beach, the sea and along the beach. These result in strong rip and alongshore currents. It is concluded that the observed alongshore and rip currents are so strong that even the experienced swimmers are endangered. It is, therefore, recommended that warning signs be placed along the beach.

Poster # 140

Proximate composition of cooked vs raw South African Cape snoek (*Thyrsites atun*)

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Cape snoek (*Thyrsites atun*) is an important affordable source of animal protein within the Western Cape region of South Africa, but limited information about the nutritional value of raw and cooked Cape snoek is available. This study examined the proximate composition of raw and cooked Cape snoek in order to quantify the nutritional value and make the information available to consumers and processors, and the nutritional tables for South African Foodstuffs. The crude percentage moisture, ash, total lipids and protein content of ten flecked Cape snoek were determined according to official AOAC methods. Total carbohydrates were calculated as the difference of protein, total lipids, and ash from the dry matter. Samples from the left hand sides were kept raw, while samples from the right hand sides were cooked in a water bath at 80°C for one hour. The mean moisture, ash, total lipids, protein and carbohydrates for raw snoek were 72.75 ± 1.86, 1.25 ± 0.09, 3.99 ± 1.16, 21.48 ± 1.35, and 0.54 ± 0.80%. With the exception of total lipids, cooking in water had a significant effect on the proximate composition of Cape snoek; cooked samples showed lower moisture (69.40 ± 2.03%), lower ash (1.12 ± 0.12%), higher protein (24.47 ± 1.39%), and higher carbohydrate (0.66 ± 1.60%) content. From these results it is concluded that Cape snoek is very high in protein (as compared to other fish species in the literature) and can be classified as a lean fish (total lipid < 5%) and is thus a healthy source of affordable animal protein.

Poster # 141

The screening of different shark livers for antimicrobial properties

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The growing problem of antimicrobial resistance prevents the effective treatment of bacterial and fungal infections. Traditional antibiotics such as penicillin have been rendered ineffective against most microbial pathogens. This has led to the development of new and improved drugs. The marine environment contains a great array of organisms with unique biological properties but it still remains one of our most underutilized biological resources. The liver extracts of three different shark species, namely; the Dogfish shark, the Catfish shark and the Hammerhead shark, were screened for antimicrobial properties. The livers were homogenised using a homogenization buffer (0.05M Na₂PO₄, 0.25M Sucrose at pH 7). The disc diffusion technique was used to screen for antimicrobial activity of the different shark liver extracts against *Helicobacter pylori* ATCC 43526, *Escherichia coli* ATCC 8739 and *Staphylococcus aureus* NCTC 6571. The active extracts were then purified by application to a C-18 reverse phase High Performance Liquid Chromatography Column. The minimum inhibitory concentration of the most active extract was determined by broth dilution method. The results of the primary screen showed only two of the extracts were active against the bacterial strains used in this study, namely the Dogfish and the Catfish shark extracts.

Poster # 142

The effects of effluent grown *Ulva* on growth, immunity and glucose regulation of the cultured abalone *Haliotis midae*

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In the wild, abalones consume a mixed diet of seaweeds containing a range of complex carbohydrates. In contrast, many abalone culture facilities utilize fishmeal-based formulated feeds with refined carbohydrates, such as maize starch, as an energy source (polymers of glucose). Numerous studies have documented enhanced growth of cultured abalone when fed a combination of seaweeds and artificial feeds however there are several metabolic pathways which require further investigation and integration to better understand the whole-organismal response which can be observed from dietary shifts. In this study, we investigated the potential of effluent-grown *Ulva* as a dietary supplement to reduce a farm's reliance on pelleted feeds, and whether this supplement has an impact on the immunity, glucose metabolism and resident bacteria in the gastrointestinal tract (GIT) of cultured abalone. *Ulva* demonstrated good potential as a partial substitute for the fishmeal-based pelleted feed Abfeed® S34, showing significantly enhanced overall consumption and growth when fed alongside Abfeed® in farm trials. Abalone maintained on a diet of fresh *Ulva* exhibited a more pronounced immune response, as observed by an enhanced circulating haemocyte count and bacterial clearance efficiency compared with abalone maintained on Abfeed®. Basal (starved) haemolymph glucose concentrations were significantly lower for abalone maintained on an *Ulva* diet for both large (120g) and small (55g) animals. The community structure of resident gut bacteria will be investigated along the GIT as well as various enzymatic activities. Collectively, these findings will provide a basis for further investigation into specific roles of extracts obtained from fresh *Ulva* on the growth, health and physiology of abalone.

Jannasch: Modelling the Marine Environment

Oral Presentations

Assimilating along-track SLA data using the EnOI in an eddy resolving model of the Agulhas system

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The greater Agulhas Current is one of the most energetic current systems in the global ocean. It plays a fundamental role in determining the mean state and variability of the regional marine environment, affecting its resources and ecosystem, the regional weather and the global climate on a broad range of temporal and spatial scales. In the absence of a coherent in-situ and satellite based observing system in the region, modelling and data assimilation techniques play a crucial role in both furthering the quantitative understanding and providing better forecasts of this complicated western boundary current system. In this study we use a regional implementation of the Hybrid Coordinate Ocean Model and assimilate along-track satellite sea level anomaly (SLA) data using the Ensemble Optimal Interpolation (EnOI) data assimilation scheme. This study lays the foundation towards the development of a regional prediction system for the greater Agulhas Current system. Comparisons to independent in-situ drifter observations show that data assimilation reduces the error compared to a

free model run over a two-year period. Mesoscale features are placed in more consistent agreement with the drifter trajectories and surface velocity errors are reduced. While the model based forecasts of surface velocities are not as accurate as persistence forecasts derived from satellite altimeter observations, the error calculated from the drifter measurements for eddy kinetic energy is significantly lower in the assimilation system compared to the persistence forecast. While the assimilation of along-track SLA data introduces a small bias in sea surface temperatures, the representation of water mass properties and deep current velocities in the Agulhas system is improved.

Ocean circulation from a regional model in Delagoa Bight and surroundings

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The management of marine resources require an understanding of the processes that take place in the ocean across disciplines. In this context we aim to better understand the ocean circulation in Delagoa Bight in southern Mozambique. Delagoa Bight is an important area in terms of shrimp fisheries, which is one of the most exported products in Mozambique. For the present study we investigate the dynamics of the Delagoa Bight Lee Eddy, a key element for the local upwelling and primary productivity, in a place that constitutes the second most important marine ecosystem in Mozambique. Very few oceanographic studies have been carried out in this region so far. We investigate the processes of generation and behaviour of the Delagoa Bight Lee Eddy through a modelling approach, using the Regional Ocean Modelling System (ROMS). The model results are compared against available observed data sets, and it is shown that the model reproduces the patterns of the Delagoa Bight circulation and surroundings. Furthermore, the model shows the impact of anticyclonic eddies on Delagoa Bight dynamics. These anticyclonic eddies originate in the northern Mozambique Channel and south of Madagascar. The results indicate that the Delagoa Bight cyclonic lee eddy is not a permanent feature. Moreover, another cyclonic eddy seems to be generated off Inhambane, as the anticyclones from the north interact with the coast. This feature which we named Inhambane Cyclone, propagates southwards.

How well do the current generation of Ocean Models represent the impacts of Agulhas Current variability on upwelling and circulation of the Eastern Agulhas Bank?

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Recently, numerical modelling and satellite remote sensing studies have suggested that the Agulhas Current core and its variability are changing in response to basin-scale wind changes that drive it. Such changes may impact the upwelling cells and mesoscale variability along the southern African east coast, which has implications for the nutrient dynamics and advection of eggs and larvae on the Agulhas Bank, an important spawning area of pelagic fish. In light of the sparse observations available, a modelling approach is necessary in order to provide the spatial and temporal resolution to understand the linkages between the large scale drivers and the regional and local response in a changing climate. However, in order to address these questions, model simulations need to be adequate to place the available observations into context and to accurately represent the important

physical processes on the shelf edge. Here we use the Eastern Agulhas Bank, with its strong gradients and dynamic upwelling cells, as a case study to assess the skill of the current generation of ocean models, when compared to observations, on the shelf edge. Two existing 1/10th degree models are used, INALT01 and Agulhas HYCOM, and their ability to simulate the interaction between the inshore edge of the Agulhas Current and the shelf, including the effects that Natal Pulses, dynamic upwelling regions and warm plumes extending over the Agulhas Bank have on the physical environment of the region, is investigated.

Key validation methods for global operational ocean models for the Agulhas Current

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The Agulhas Current plays an important role in regional and global climate, impacts economic activities (shipping and the petroleum industry) and influences environmental disasters (algal blooms and oil spills). Currently no dedicated operational system exists over Southern Africa to better understand the consequences of these issues, and eventually forecast them. Recently, significant effort has been placed on providing accurate reanalysis products combining global ocean models and data assimilation techniques. These reanalysis products are central in a forecast system and need to be properly evaluated for the Agulhas region. Presently, there are no regionally-specific methods to independently and objectively assess and quantify the performance of these systems. The aim of this study is to evaluate the global operational system of MyOcean (Mercator-Ocean GLORYS2V1) and extend these methods to others such as HYCOM (U.S Naval Research Laboratory) and OFAM3 (BlueLINK). Due to the difficulties in simulating the greater Agulhas Current, major oceanographic features are validated against current literature and independent (i.e. non-assimilated) observations. The vertical structure is analysed using PAGO (Physical analysis of ocean data) that allows for inter-model comparisons of oceanographic transects in a consistent manner. We focus on the velocity and transport in the greater Agulhas Current at 32°S (ACE), the Mozambique Channel (LOCO), and the Crossroads transect. Synthetic Aperture Radar (SAR) assesses the overall surface structure and strength. The development of regional validation methods is a crucial step toward an accurate and operational regional forecasting system.

Wind-driven circulation and species dispersal in a shallow estuarine lake – Lake St Lucia, South Africa

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Lake St Lucia is a large shallow system with complex morphology. It is part of a UNESCO World Heritage Site and a RAMSAR wetland of international importance. The system is highly variable in terms of water level and structure. During periods with low freshwater input Lake St Lucia can divide into individual subsystems. Areas that become isolated from the rest of the system can experience extreme environmental conditions unsuitable for many species, whereas other parts can serve as refugee areas. Periods with high freshwater inflow lead to high water levels and a more homogenous and fully connected lake system. Wind driven circulation is the main factor influencing the exchange between lake basins. We use a 2DH hydrodynamic model to simulate these circulations to provide insights into their role in transport and mixing processes. A strong diurnal pattern of wind speeds

together with directional switching between two dominant directions, drives intermittent water exchanges and mixing between the lake basins. Mixing time scales are non-homogeneous with some basin extremities having relatively long residence times. Coupling the circulation model with a particle transport model gives insights into the re-colonisation potential of e.g. macro-zoobenthos and other groups after disturbances such as extreme hypersalinity and desiccation.

The influence of a space varying wind field on wind-wave generation in False Bay, South Africa

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False Bay has been the topic of numerous studies in the past mainly due it densely populated periphery. Coastal vulnerability of the False Bay periphery is an important factor that has to be considered for future and existing coastal infrastructure development and protection. Tools that are frequently utilized in assessing future scenarios and/or climate change question are numerical packages. In the present study one aspect of accurate numerical wave modelling will be investigated. It is common practise to assume a uniform wind field over a coastal area of interest, when setting up a numerical wave model. In False Bay however, the topography of the bay periphery brings this assumption into question. This study aims to evaluate the influence of a space varying wind field on the wind-wave generation in False Bay. These results will be compared with a non-spatial varying (uniform) wind field, extrapolated from the closest NCEP point. The quantification of the results will be made using historical buoy data in False Bay of the same time period. The spatial varying wind field will be based on a Conformal-Cubic Atmospheric model developed at the CSIR and Delft3D-WAVE (SWAN) will be utilized for the wave modelling components. The wave results will be presented on a 200m resolution spatial grid and comparison will be made at the particular location of the wave-rider buoy. A variety of nested wave models will also be employed. Conclusions and recommendations are made regarding the appropriate assumptions for a spatially varying wind field in False Bay for wave modelling.

The importance of cell size in nitrogen nutrition in phytoplankton assemblages at upwelling/downwelling cycles in the Southern Benguela upwelling system

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The structure of phytoplankton communities has large implications to the fate of biogenic carbon and nitrogen in the marine environment. The representation of phytoplankton diversity in biogeochemical (BGC) models still poses many questions within the BGC modeling community. One hypothesis of this research is that cell size is an accurate representation of functional diversity within the marine ecosystem and that the flux of nutrients within the marine environment can be estimated by means of allometric scaling. Examples of monospecific blooms measured off Lamberts Bay are used to quantify the importance of cell size in the cycles between new and regenerated primary production in the southern Benguela upwelling system. In addition, a time series from Saldanha Bay is used to explore uptake kinetics of NH₄, NO₃, Urea and PO₄ in relation to cell size, community composition and physical forcing. These results are used to assess the applicability of trait-based modelling in accurate representations of nutrient and energy pathways in the Southern Benguela.

Influence of short-term fine physical processes on the southern Benguela/Agulhas bank connectivity

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Small pelagic fisheries in the Southern Benguela play an important role both economically and ecologically. Hydro-acoustic surveys of the area, since 1983 have shown that there is inter-annual variability in the anchovy abundance. The recruitment of fish larvae, namely their transport from their spawning region on the Western Agulhas Bank to their nursery region in St Helena Bay may explain part of that variability. This study aims to establish whether short-term fluctuations of the atmospheric wind can have an impact on the connectivity between the Agulhas Bank and the Southern-Benguela Shelf. We compare two ROMS simulations forced with different wind fields; one considers seasonal monthly climatology winds and the other 6-hourly winds. Passive particles, mimicking fish larvae behaviour, are randomly released over the western Agulhas Bank, and followed for 60 days. Our results show a marked seasonal signal, with an increase of recruitment success in summer and a great loss occurs during the first 15 days following their release. The presence of short-term fluctuations in the wind field triggers greater variability on the pathways taken by the passive particles. Different routes can be identified, one following the shelf edge and one located more offshore.

Jannasch: Modelling the Marine Environment

Oral Presentations

Food webs and biogeochemistry in a changing marine environment

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A challenge in marine global change research is to understand how biogeochemical cycles and food webs interact in the oceans. Different processes that influence the storage of material in living and non-living forms and its transformation between inorganic and organic states need to be quantified within and across systems. One of the main tools to accomplish this has been the use of ecosystem models that include biogeochemical pathways and marine food webs. Potentially adding further complexity to these models in recent years has been the identification of new metabolic pathways in the ocean, the emerging role of ocean acidification, a new emphasis on microbial groups such as viruses and archaea, and renewed interest in previously-neglected trophic processes like mixotrophy and parasitism. This presentation aims to describe some approaches that have been adopted in modelling marine biogeochemistry and food webs. It will address questions being asked of the models and try to provide answers to some of these. In the process, it aims to identify current gaps in understanding global change in the oceans and possible ways forward.

Vertical distribution of micronekton in pelagic marine ecosystems: a dual acoustic and modelling approach

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Understanding and predicting the functional role of biodiversity in marine ecosystem dynamics and how physical variability of the ocean affects ecosystem functioning is a key issue. The focus of this study is to use acoustic data to estimate the physiological and behavioural parameters associated with the diel vertical distribution of the three generic communities (epipelagic, migrant mesopelagic and non-migrant mesopelagic) of the end-to-end ecosystem model APECOSM (Apex Predators ECOSystem Model). In APECOSM, the vertical distribution of organisms in the generic communities is critical since it controls the spatial co-occurrence and hence the trophic interactions of the different communities. In the model, vertical distributions of communities are assumed to result from a size-dependent advection-diffusion process. The parameterisation of the three generic APECOSM communities was conducted using environmental (ambient light, oxygen, temperature, etc.) and acoustic data collected in the Western Indian Ocean. An observation model reproducing the available 1D data was built. Parameter estimation was conducted using a standard maximum likelihood approach with the Automatic Differentiation Model Builder (ADMB) package. According to the mechanistic basis of APECOSM, regional estimates are then assessed against observations in other regions to test and potentially improve the parameterisation, and eventually validate the global scale predictions of APECOSM's vertical distributions of communities.

Stage dependent variation in environmental niche space of two small pelagic fish species in the southern Benguela

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The spatial distribution of fish populations is affected by various factors and processes, amongst others, the spatio-temporal variability in the environment. Changes in the environment affect fish populations throughout various stages of their life cycles and the relative effects of environmental variables vary across life-history stages. The effect of environmental variables on the spatial distribution of sardine and anchovy in the southern Benguela has been the subject of several studies of varying complexity. In this study, the environmental niches of three life-history stages (eggs, juveniles, adults) of sardine *Sardinops sagax* and Anchovy *Engraulis encrasicolus* are determined. Such types of studies are crucial in the southern Benguela, especially considering the current effort dedicated to understand how and to what extent long-term climate change and variability affect fish spatial distribution, with potential impacts on the productivity of the ecosystem and hence the goods and services it provides. Generalized Additive Models (GAM) was used to assess the relative importance of different environmental variables on the distribution of eggs, juveniles and adults of sardine and anchovy. The GAMs were then used to generate maps of suitable habitats from which we could calculate the total area as an index of habitat suitability. The temporal variation in habitat

suitability was linked to time series of biomass estimates of adults and recruits of both species. This study shows how readily available environmental data from satellite remote sensing can be successfully used to characterize the suitable habitats of major species in the southern Benguela ecosystem.

A frame-based modelling approach to understanding changes in the spatial distribution and abundance of sardine and anchovy in the southern Benguela

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A number of ecologically and economically important species in the southern Benguela, including sardine *Sardinops sagax* and anchovy *Engraulis encrasicolus*, have undergone southward/eastward shifts in their distribution in recent decades. In addition to the effects of changes in prey availability to top predators such as seabirds, the spatially-distinct nature of the system - the West coast characterised by seasonal, wind-driven upwelling, and the South coast with characteristics of both a shelf system and an upwelling system - means the location of a stock has implications for its productivity. The spatial dynamics of small pelagic fish are of particular importance because they are thought to exert wasp-waist trophic control on the system. An objective-driven frame-based model was constructed to investigate the ability of the approach to represent the spatial and population dynamics of sardine and anchovy, and to explore the implications of possible management options. Climate variability and fishing pressure were assumed as drivers. A frame-based approach appears to be useful within this context. Results suggest that the productivity of the sardine resource within the model is highly dependent on the spatial distribution of fishing pressure. The role of anchovy within the model system has not yet been fully developed. Increasing our understanding of the relative suitability of environmental conditions of different regions of the southern Benguela is important if we are to increase our capacity to predict trends in abundance and distribution of major fish resources.

Environmental effects on the dynamic size-spectrum using a DEB and trait-based approach

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Physical and bio-geochemical changes of the oceans have intricate effects on marine ecosystems. Long term variations of environmental temperature and primary production affect metabolic rates at the individual scale, biomass fluxes at the population scale, and trophic structure at the community level. Essentially the full range of fundamental services that marine ecosystems provide to humanity will be affected by climate-associated changes. Using a DEB-based and trait-based mechanistic model of the community spectrum of upper trophic levels, we assess the impact of temperature and primary production changes on the structure, metabolism and diversity of fish communities. In this model, individual level metabolic processes derived from the dynamic energy budget theory are associated to opportunistic trophic interactions to derive size-spectra for any species characterized by a maximum specific size. The community spectrum is then obtained by integrating species size-spectra along the maximum size dimension. The environment impacts the individual level and we observe the response of ecosystems at various complexity levels, from individuals to species to aggregated communities. We confront the performances of the model to general properties of fish

communities, such as the scales and magnitudes of major traits such as growth, fecundity and mortality, and then develop a set of indicators characterizing the response to climate change at the various levels considered. We use these metrics to assess the sensitivity of marine ecosystems structure and function to temperature and primary production for both steady and transient perturbations.

Trends in tuna fisheries in the Agulhas system with emphasis on inter-annual environmental variability

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Satellite remote sensing and models have brought evidence of intensification and warming of the Agulhas Current in response to an increase in wind stress curl in the South Indian Ocean during the past 30 years. They also depict considerable inter-annual sea surface temperature (SST) variability. Preliminary analyses have shown that longline tuna catches in the Agulhas current have also fluctuated, up to twofold about the mean during the past decade, and that such variability is coherent with SST anomalies. The working hypothesis is that a stronger and warmer Agulhas current will favour the pole ward expansion of pelagic tropical or sub-tropical tunas (e.g. yellowfin, skipjack, bigeye) and that pulses in the SST signal (and presumably anomalies in the intensity of the surface flow) will increase locally the biomass of tunas in the South African Exclusive Economic Zone and favour stock mixture between the Atlantic and Indian Oceans. If such changes in the marine ecosystem are linked to changes in the physical environment this could be used to mimic potential responses of large pelagic fisheries to climate change. On a shorter timescale, understanding the interannual availability of tuna in the South African waters can be useful to incorporate environmental factors in stock assessment models and to implement an adaptive management of the fishery. We use the DRAKKAR hind casts and Mercator-ocean GLORYS reanalysis to characterize the environmental variability in the Agulhas system since the middle of the 20th century, complemented by sea color imagery (from SeaWifs and Modis since 1997) and satellite measured SST (from Modis since 2011 and from Pathfinder 5.2 since 1982). The biological environment is represented through simulations of the APECOSM ecosystem model. Proxies of tuna abundance are estimated through detailed catch and effort data available from the log books of the longline and pole and line fleets.

Poster Presentations

Poster # 116

Impacts and implications of ambient environmental variables on the spatial distribution of squid (*Loligo reynaudii*) on the Agulhas Bank: implications under a changing climate?

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Understanding the functional relationship between species spatial distribution and their associated environmental conditions can greatly contribute to sustainable exploitation of our fisheries resource in the context of climate change. Here, we examined environmental (temperature, dissolved oxygen, turbidity, depth), time (time of day, season), location (longitude, region) effects on the distribution and abundance of adult and juvenile squid *Loligo vulgaris* on the Agulhas Bank, southern Africa. Generalized additive models (GAMs) were used to test the effect of these covariates on data

collected from routine research trawl surveys. Results show that mean *L. vulgaris* densities were highest in autumn in shallow waters and lowest in autumn in deep waters. GAM results showed that for all years, depth, total trawl catch, and most importantly, turbidity were significant covariates affecting adult and juvenile squid spatial distribution. Location in terms of region was important for all categories but explained very little of the variation, while location in terms of oceanographic province was important for all squid and adults but not juveniles. Temperature was a significant covariate for adult squid but not for juveniles and oxygen was a significant covariate for juveniles but not for adult squid. The final selected model showed that *L. vulgaris* presence was highest between depths of 60 to 120m, with bottom turbidity lower than 2.0NTUs ($0.035\text{ml}^{-1} \text{PMC}_{\text{turb}}$) in locations between 20 and 23°E in the western to central Agulhas Bank.

Poster # 117

The influence of biomass on the habitat preference of three small pelagic fish species in the southern Benguela

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Environmental factors that govern habitat preference and impact on fisheries resources can be determined by linking prevailing environmental conditions to the abundance and distribution of individual species. Spatially-explicit estimates of the abundance of anchovy (*Engraulis encrasicolus*), sardine (*Sardinops sagax*) and round herring (*Etrumeus whiteheadi*) during the adults life history stage were combined with oceanographic data to reveal the habitats utilized by these three species at different biomass levels in the southern Benguela upwelling ecosystem. These species are of great socio-economic and ecological importance to the region and are vulnerable to population fluctuations in response to environmental variability. To understand the preferred environmental envelop of each species and how habitat usage is affected by biomass, a single parameter quotient (SPQ) method with randomization was used. The analysis was conducted using three subsets of fish density data; firstly including data from a period when the total combined biomass of small pelagic fish was high, secondly using data from a period of average biomass and thirdly using only data from a period when the combined biomass was low. Results indicated variable habitat use by these small pelagic species across gradients of environmental variables. During low and high biomass levels anchovy preferred slightly different bottom temperatures ranging between 16.0-19.0°C and 15.0-18.5°C, respectively. Sardine on the other hand preferred a broad range of warmer temperatures (15.5-20.0°C) at high biomass levels and a narrower range of cool temperatures (15.5-18.5°C) during the low biomass period. Compared to sardine, anchovy occurred over a broader range of depths (15 to 65 m) at high biomass levels. This basic biological information is an essential step towards understanding habitat partitioning and population responses, and hence the role that environmental change may play in regulating the distribution, abundance and hence management of these species.

Poster # 118

Evaluation of an eddy resolving HYCOM simulation in the South Atlantic Ocean

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The Agulhas Current plays an important role in global climate, by its contribution to the “warm water route” of the thermohaline circulation through the leakage of Agulhas rings, eddies and filaments into the South Atlantic. Although observational efforts in the South Atlantic are improving with projects such as SAMOC, long term data sets are still lacking, leading to the need for using modelling to study the relationship of the Agulhas System with the South Atlantic. In this light, a high resolution eddy resolving (1/12°) Hybrid Coordinate Ocean Model (HYCOM) simulation of the Agulhas system and South Atlantic from 1960-2010, forced by NCEP Reanalysis products, is analysed. The general features of the South Atlantic Ocean basin are well resolved, and the mean Atlantic Meridional Overturning Circulation (AMOC) at 26.5N is 18.3Sv, corresponding well within the range of observations from the RAPID mooring array. The eddy properties and eddy dispersion from the Agulhas into the South Atlantic are assessed using an automatic eddy detection algorithm and are found to be well represented by HYCOM, demonstrating the utility of this model configuration for further studies on the relationship of the Agulhas System with the South Atlantic.

Poster # 119

A Dynamic Energy Budget (DEB) model of the growth and reproduction of anchovy (*Engraulis encrasicolus*)

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Anchovy (*Engraulis encrasicolus*) constitutes a major resource of the small pelagic fishery in South Africa. There are numerous factors that can determine recruitment success in small pelagic fish and understanding recruitment variability in these fish populations can be a major challenge for fisheries scientists. Dynamic Energy Budget (DEB) theory has been successfully used to describe the growth and reproduction of Bay of Biscay anchovy. Adult spawning patterns can potentially influence recruitment success of small pelagic fish in the Benguela ecosystem, by determining the environmental conditions that larvae experience after hatching and that can influence their survival. The objective of this study is to investigate the effect of environmental conditions (such as food availability) on the energy available to individual anchovies for growth and reproduction throughout their life cycle. DEB theory is suitable to study these processes and allows us to identify the specifics and common processes of each life stage. Model parameters were estimated from published material and available fisheries data and applied to the standard DEB model. This model used a deterministic approach to link the individual fish to the environment through bioenergetic processes and will form the basis for developing models for other small pelagic fish in the Benguela. These models offer perspectives in exploring how small pelagic fish species compete for resources and how they could be affected by climate change as they grow and reproduce.

The urgency of translating science into effective governance in the western Indian Ocean

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An estimated 65 million people depend on the marine and coastal resources of the western Indian Ocean region. Population pressure, exacerbated by impacts from climate change and habitat degradation, is posing severe threats to the survival of coastal communities and the economies of maritime states. In the context of food security alone, lack of information hampers innovative approaches to managing and conserving fisheries in the region; for example it has recently been demonstrated that the so-called “small scale” artisanal and subsistence fisheries produce catches that may well have been under-reported in official government statistics by as much as 500%. These previously unreported catch levels could dwarf that of “industrialised” fisheries throughout the region. The extent to which decisions can be taken in the short to medium term is therefore marred by inadequacy of scientific information and lack of mechanisms for science to inform decision-making in choosing strategic management options. Many of the threats to our coastal and oceans are expanding geometrically while the response in terms of increased investment in time, labour and finances are not linear. Clearly there is an urgent need for prioritisation and for fast-tracked adaptive management decisions. The technical/scientific aspects of ‘knowledge’ capture, although often labour-intensive and time-consuming, are in actuality fairly straightforward. The real challenge lies in evolving effective mechanisms to prioritise and process that knowledge and to deliver rapid responses in terms of management and policy reforms in relation to the more urgent needs of countries and regions that depend on sustainable living resources and healthy marine ecosystems and are therefore highly vulnerable to changes and threats within those ecosystems.

A new small-scale fisheries policy for South Africa – an opportunity for fostering greater collaboration between the natural and social sciences?

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Over the past 20 years there has been increasing recognition of the importance of taking a more holistic and systems-orientated approach to fisheries management and governance. Yet, despite commitments to EAF and a variety of soft law instruments that demand consideration of ecological dimensions alongside human dimensions as well as integration of different knowledge sources, management decisions in South Africa have been dominated by the natural sciences. The promulgation of the new Small-scale Fisheries Policy in South Africa in 2012 represents a significant paradigm shift in fisheries governance from a largely technocratic and natural science-based approach to a more developmental and people-centred approach based on human rights principles. An order from the Equality Court of South Africa in 2007, charged the Minister responsible for fisheries management to develop a policy that specifically addressed the socio-economic needs of traditional small-scale fishers. This policy has been informed by international thinking and best practices, lessons from small-scale fisheries contexts elsewhere, as well as inputs from a range of stakeholders that participated in the policy formulation process. This paper provides a brief overview of the key principles and features of the new policy and discusses how its implementation seeks to overcome traditional disciplinary barriers and neglect of local and indigenous knowledge. However, there are several challenges to implementing this new approach including the need to convince natural scientists of the merits of this approach, gaining genuine commitment from politicians and

senior government officials to the principles and approaches contained in the policy, and building capacity, trust and tolerance amongst managers, scientists and resource users to work collaboratively to manage fisheries resources.

Mind the Gap – Governance dilemmas in South Africa’s Western Cape traditional line fishery

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The Western Cape traditional line-fishery is one of South Africa’s oldest fisheries. Unified only in terms of extraction mode – the fishery is almost exclusively a boat-based, hook and hand line operation. The sector is marked by substantial complexity, diversity, dynamics and operates at a variety of scales. In this paper, we use the theoretical framework presented by the Interactive Governance Approach to discuss governance of the Western Cape’s line-fishery. In unpacking the line-fishery system, we point to the emergence of two seemingly distinct groups within a single fishery as a result of a divisive governing system. The first group, characterized by a highly competitive and mobile small-scale commercial fishing fleet, is governed by the existing traditional line fish policy, a series of individual rights allocation processes and the overarching Marine Living Resources Act (MLRA). The second group is a collection of coastal communities and small-scale fishers that target line fish as part of their traditional livelihood practices. This segment, marginalised through Apartheid and largely left out of post-Apartheid fishery reform under the MLRA, is seeking redress and recognition through a newly minted small-scale fisheries policy. In this paper we argue that both sets of policies need reform and perhaps even convergence given the contemporary ecological and economic realities of line-fishing, as well as the traditional rights of small-scale fishers. The current mismatches have given rise to governance dilemmas and questions about the governability of the fishery as a whole.

On water temperature on the Agulhas Bank – a case study into collaboration between small-scale fishers and academic researchers

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The extent to which climate change is taking place over the Agulhas Bank is currently contested among scientists and fishers alike, where different data sets under scrutiny in academic research yield contradictory results. Using this shared problem as a starting point, a method is being developed to measure water temperatures on commercial ski boat operations as part of the Southern Cape Interdisciplinary Fisheries Research project (SCIFR). This contribution discusses the role of the instrument development process in fostering collaboration and dialogue between different stakeholders and knowledge positions within a small-scale fishery. We suggest that the instrument has served as a ‘boundary object’, which has brought different individuals and expert fields together in co-design and development, serving as a means of moving beyond personal agendas and facilitating dialogue and collaboration. We argue that the collaborative co-design and development process is a useful means of facilitating collaboration, developing appropriate technology for context. Furthermore, joint problem sharing and solution development brings citizen

science and fishers' knowledge into more symmetrical dialogue with government science and the research-based knowledge of fisheries scientists and oceanographers, a necessary step in overcoming previous barriers to communication and implementation of management processes in South Africa's small-scale fisheries. We also discuss the challenges of the co-development process and explore some of the difficulties and methods by which these are being resolved.

Knowledge for Coastal Governance: an experiment in the co-production of knowledge

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In the context of climate change, governance is increasingly being recognised as the critical element for transitioning towards a sustainable future. Conventionally, scientific knowledge has formed the basis for coastal zone governance and management. Literature shows that with the global shift from government to governance over the last three decades the public has become included in policy making processes necessitating the inclusion of other knowledges. Scientific explanations of and solutions for environmental issues are increasingly being challenged, giving rise to 'environmental controversies'. This paper presents the work in progress of an experiment to co-produce knowledge about the main issues for coastal zone governance along the Durban Beachfront. A competency group of knowledge holders of scientific, lay and embedded knowledge of this section of the coastal zone of the eThekweni Municipality was set up and facilitated to achieve this goal. The paper describes the application of the co-production knowledge model in this research process by outlining the underlying theoretical assumptions of this model; the methodology adopted and some tentative results. The study illustrates some of the challenges experienced in co-producing knowledge in the context of a transforming, developing country and the implications of the entrenched domination of the mandated representative 'stakeholder processes' in policy making for developing a more inclusive knowledge base for coastal zone management.

An approach towards evaluating trade-offs between ecological, social, economic and governance objectives in Algoa Bay, South Africa

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Despite multiple resources, users and impacts in marine ecosystems, the classical single-species or single-sector approach continues to dominate fisheries management. In contrast, ecosystem-based management (EBM) aims to incorporate interactions within and between ecological and human (social, economic and governance) subsystems, and to explicitly consider the trade-offs between management objectives for multiple sectors. The hierarchical tree approach, recommended by the FAO for an ecosystem approach to fisheries, is a useful way to cut through the complexity of management objectives and interactions of processes. Using Algoa Bay as a case study, a hierarchical tree approach was taken to clarify and group ecological, social, economic and governance objectives, and as a basis for future investigations of trade-offs between them. Indicators were determined for as many objectives as possible. Whereas time series' of indicator values are available for objectives relating to the utilisation of specific fisheries stocks, ecosystem-level indicators of ecological wellbeing currently are not well defined. We suggest using a specialised ecosystem modelling approach to complement the set of indicators, and to provide a basis for future trade-offs through management strategy evaluation.

Communicating an Ecosystem Approach to Fisheries management with stakeholders in the South African small pelagics fishery: A tool for boundary crossing and social learning

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A knowledge-based tool (expert system) has been developed to evaluate the effectiveness of implementation of an ecosystem approach in the South African small pelagics fishery, the largest fishery by volume in the country. The knowledge-based tool models the ecological well-being dimension of an ecosystem approach (EAF) in the sardine-directed fishery through an objectives hierarchy, linking a suite of eleven ecological indicators to seven management objectives. To meet management requirements, the knowledge-based tool presents a transparent, repeatable and scientifically defensible method. A participatory modelling approach was used to engage with a broad group of stakeholders in indicator selection, model design and interpretation. Rapid prototyping allowed stakeholders to engage with iterations of the knowledge-based system, facilitating buy-in and improved understanding around EAF. The modelling approach was useful in bringing diverse stakeholder groups together in discussion on management objectives and has helped to bridge the boundary between the traditional resource-orientated management and the ecosystem approach to fisheries management research groups, identified as a barrier to implementing an ecosystem approach. Continued focus on communication and bridge-building between management and stakeholders is essential and facilitated social learning through model iterations that can enhance the outcomes of this process and provide support in bridging boundaries to EAF implementation. In this research social learning is seen as a process to facilitate learning and social cohesion among a group of stakeholders with diverse interests and backgrounds, helping to create a shared vision and move towards joint action in implementing EAF.

The relationship between science and monitoring, control and surveillance (MCS) in fisheries management

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Globally, marine capture fisheries produced nearly 80 million tonnes in 2010. The sector contributes to the livelihoods of between 660 and 820 million people or 10-12% of the global population. Not all the resources are being utilised sustainably and approximately 30% of the world's fish stocks are considered to be over-exploited. Illegal, unregulated and unreported (IUU) fishing is an important contributor to overexploitation. Recent estimates indicate that IUU can equal between 13% and 31% of reported catches, with a value of between US\$10 and 23.5 billion per year. IUU fishing is a significant problem in southern Africa. This presentation draws on examples from the region and considers some of the major challenges to effective law enforcement in the region. These include limited resources, lack of infrastructure and hardware such as harbours, airstrips, patrol vessels and aircrafts, limited accessibility to authorities of stretches of coastline, large numbers of slipways and landing sites and others. In order to be successful, a Monitoring, Control and Surveillance (MCS) system needs to be adapted to the scale and particular characteristics of the fishery concerned but also should be an integral part of the whole management system. Without effective MCS there will always be doubts about the reliability of any fisheries-dependent data, while the best made regulations will be ineffective if they cannot be enforced. Therefore, while MCS is frequently regarded as being at the end of the chain for fisheries management, this presentation argues that it

could be seen, instead, as being at the beginning. Approaches to improving the planning of MCS as an integrated component of management will be explored.

Fismer: Strengthening the Role of Science

Oral Presentations

Progress and problems associated with providing scientific advice for the management of the West Coast rock lobster fishery

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The West Coast rock lobster fishery is managed by a number of measures including catch limits, size limits, closed seasons, gear restrictions, prohibition on the possession of berried females, daily bag limits for recreational fishers amongst others. A tail-mass production quota was replaced by a whole lobster (landed mass) quota, and management by means of an annual Total Allowable catch (TAC) was introduced in the early 1980s. The use of Scientific Working Groups to provide scientific advice on resources was introduced under the then Sea Fisheries Research Institute in the mid-1980s. While the Rock Lobster Scientific Working Group (RLSWG) was tasked to provide advice on a wide range of management issues, the provision of advice on the annual TAC soon dominated the agenda. Progress and problems associated with providing scientific advice for the Total Allowable Catch for the West Coast rock lobster fishery will be reviewed, focussing *inter alia* on the following themes: The history of scientific advice and the role of the Rock Lobster Scientific Working Group; The change from *ad hoc* scientific advice to the use of an Operational Management Procedure approach; and the data used to provide the scientific advice.

Use of operational management procedures to address the biological, social and economic objectives of the West Coast rock lobster fishery

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Since 1997, scientific management advice for the West Coast rock lobster fishery has been based on Operational Management Procedures (OMPs). These are pre-agreed formulae which provide values for catch limits based on incoming data from resource monitoring indices such as commercial catch rates and abundance estimates from research surveys. The formulae are chosen based on simulation testing to best achieve an appropriate trade-off between improved social and economic returns in the form of increased catches, and longterm conservation of the population reflected by a recovery target for this depleted resource together with low risk of a further reduction in abundance. The history of experiences with this process will be summarised, focussing *inter alia* upon: What recovery targets have been selected, why, and how successfully have they been achieved?; The problems that have arisen related to poaching and its probable recent increase; How acceptable has the OMP process proved amongst user groups and managers, and what is currently seen as the way forward for managing the resource?

Carrots, Sticks and Fish: Understanding the role of consumers and the market in fisheries policy and management

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Effective fisheries management requires a mix of regulatory (sticks) and non-regulatory including market-based (carrots) mechanisms in order to deliver both equitable and sustainable fisheries management outcomes. While the impacts of regulatory mechanisms are generally better understood and often easier to identify, the impacts of market-based mechanisms tend to be more difficult to quantify. Consequently, their value is often underestimated. Yet evidence gathered both globally and locally, increasingly shows that market-based mechanisms are powerful tools in determining fisheries policy and management. In the South African context, the WWF-SA’s Southern African Sustainable Seafood Initiative (SASSI) and the Marine Stewardship Council’s (MSC) eco-labelling programme have been active for over a decade and there is growing evidence that they are playing an increasingly important role in driving improved practices, both on the water and throughout the seafood supply chain. With the aid of key examples from Southern African fisheries, such as the West Coast rock lobster and hake trawl fisheries, this presentation aims to highlight the role that the market has played, both in incentivising responsible practices through purchasing decisions and through granting or withholding seafood businesses’ social ‘licenses to operate’. While it is evident that market-based mechanisms can play a valuable role in fisheries policy and management, it is also important to be clear that there are some critical roles that the ‘invisible hand’ of the market cannot fulfil. Better understanding of the limits of a market-based approach remains an important, and often neglected, exercise. Being explicit about these limits will not only help to reduce ineffectual market interventions but also help to guide regulatory authorities in focusing limited resources in areas where there is no alternative to the big stick.

Panel Discussion on strengthening the role of human and natural sciences in fisheries policy and management

This panel discussion is proposed to close the session on strengthening the role of science. It could occupy between 45 and 60 minutes depending on the total time available for the session. The panel will consist of five speakers, each of whom will be given five minutes to comment on the presentations in the session (oral and poster) and add any thoughts of their own. The remaining time for the panel event will be open for questions to panellists and discussion from the floor. Profs. Merle Sowman and Doug Butterworth, both of UCT, will be on the panel, together with managers and senior scientists.

Poster # 80

Linking social and ecological systems: Long term monitoring of small-scale fisheries along the Eastern Cape coastline

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Sustaining small-scale fisheries is increasingly recognized as essential for maintaining the nutritional status of low-income households. Monitoring catch and catch composition not only elucidates resource fluctuations but can contribute information to improve natural resource management and support rural development policies and practice that seek to recognize the seasonal and cyclical complexity of livelihood strategies. A national, provincial and local government initiative was set up to monitor and elucidate daily catches and composition of small-scale fisheries in the Eastern Cape. Key objectives include: job creation, skills transfer and to collect critical fisheries catch-data for a period of two years from across the Eastern Cape. Data monitors have been employed to observe and record total catch of oyster, line fish, mussels and East Coast Rock Lobster catches. Where appropriate, data monitors also record the bait-digging landings and total net fish landings. Ultimately, results obtained from the monitoring initiative will contribute to responsible management and conservation of resources.

Poster # 81

Assessing the implementation of an Ecosystem Approach to Fisheries in the South African sardine fishery

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A number of tools have been developed worldwide to facilitate the implementation of an Ecosystems Approach to Fisheries (EAF). In South Africa, indicators and participatory modelling through expert system design have been used to track the efficacy of EAF implementation in the fishery for small pelagics. Focussing on the ecological well-being dimension of EAF I have developed a knowledge-based tool to assess the effectiveness of EAF implementation from 1989-2009 in the South African sardine fishery. Stakeholders identified seven objectives, reflecting pressure or state, for EAF implementation in this fishery that were linked to eleven ecological indicators. Using a fuzzy logic approach indicators were transformed to a common scale and combined through the hierarchy using a weighted mean equation. The resulting outputs were discussed in detail with a broad group of stakeholders to ensure that the model represented their understanding of the system. Stakeholder participation at each step of modelling process ensured buy-in and improved understanding around EAF.

Poster # 82

Overview of the Southern Cape Interdisciplinary Fisheries Research project (SCIFR)

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The Southern Cape Interdisciplinary Fisheries Research project (SCIFR) originates out of an integrated approach to understanding the complexities, vulnerabilities and variability of marine social-ecological system under global change. Broadly speaking, the project poses the questions: How are natural and social changes in the fisheries shaping and impacting on social-ecological systems in the southern Cape region between Witsands and Mossel Bay? How are fishers in this region coping with change, vulnerability and variability (bureaucratic, political, economic, ecological, climatological) and what systems of support might be established to facilitate these strategies whilst fostering collaborative research and management programmes which safeguard the future of fishing and fish stocks? Working with multiple perspectives and disciplines within a broader interconnected social-ecological system, our intention is to contribute new and innovative, appropriate means of working with different knowledge positions and concerns (fishers, researchers and managers) and generating new understandings. These, in turn will result in more appropriate, adaptable and timeous means of dealing with restructuring processes as and when these arise, aiming at improving well-being with respect to all three dimensions of a systems approach to management in the Benguela. This poster introduces the current research team (comprising academic researchers and local representatives), the approaches and methods currently underway, and intended developments in the near future.

Poster # 83

Global learning for local solutions: Reducing vulnerability of marine-dependent coastal communities (GULLS): A Belmont Coastal Vulnerability Theme Project

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To address the broad issues contributing to coastal vulnerability and the marine and coastal environment, this project connects leading researchers from around the world with focus on applications in several natural and social “hotspots” – ocean regions experiencing fast warming and those with heightened social tensions as a result of change. The team, led by Kevern Cochrane includes scientists from 10 countries and 16 institutions. Research will focus on five southern hemisphere hotspots: southern Africa, southern and western Australia, Mozambique channel, southern India, and Brazil. Using a vulnerability assessment framework, researchers will identify both the ecological and socio-economic aspects of climate change impacts, with the purpose of developing adaptation actions. The overall project objectives are to (1) build regional skill-sets that can reduce coastal vulnerability by evaluating and characterizing likely impacts, (2) create predictive systems that will inform decision makers about the expected consequences of coastal changes; (3) deliver alternative options in terms of adaptation and transformation within coastal communities; and (4) define the long-term implications of selecting a particular option in terms of economic, social and environmental outcomes. This project endeavours to reduce the vulnerability of marine-dependent communities to climate change through the development of implementable actions and influencing government policy.

Critical moments for marine conservation in South Africa

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This brief and selective history traces events and ideas that shaped marine conservation in South Africa. Sailing ships introduced alien species, but the imposters went unnoticed for 400 years. Dutch administrators are credited for the first fishery closure. Whales, seals and penguins bore the first wave of exploitation in the 1700s. Restraints on whaling came two centuries later. A report lamented the demise of hake - in 1872! A plethora of issues around 1900 prompted investigations and debate: Americans decimating forage fish, trawlers destroying fish spawn, trains driving fish away. It was obvious to Von Bonde in 1929 that part of the inshore trawl grounds should be closed. Sanctuaries were created for the recovery of west coast rock lobster and a translocation programme followed. A plan to introduce herring, 20 years before our pelagic fishery boomed, was aborted and another to decimate seabird populations to save forage fish was defeated. The first marine protected area was declared in 1964, and many followed in the next four decades, but their real value was articulated only in 1989. Foreign trawlers scraped the Agulhas Bank. The busiest year was 1977: the EEZ was extended, the first marine conservation NGO emerged, Venpet collided with Venoil and the shad bag limit was reduced to 2! Quotas came in 1978. The linefishery crisis was tackled in 1984 and 2000. The post-democracy fishery act facilitated ecosystem management, but poaching approached mass civil disobedience. In the new millennium, sharks became the new dolphins. Eco-labels changed market and regulatory dynamics in coastal and industrial-scale fisheries. Marine spatial planning was initiated in 2004. South Africa has yet to meet the challenge of managing offshore mining impacts. Management has consistently increased its responsiveness to critical biodiversity losses and threats: the time lag has improved from 105 years to eight.

A century of change: comparing historical and recent trawl survey records

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Both globally and in South Africa, historical reference points in the marine environment are generally lacking. The reason is a scarcity of adequate quantitative data from historical periods. As a result, we have a poor understanding of what marine ecosystems and fisheries resources looked like before they were influenced by anthropogenic impacts such as fishing and climate change. Yet South Africa has a wealth of under-utilized historical marine data, exemplified by the recent digitization of an exceptional set of research survey data, collected during 1897-1904 and 1920-1949. In this study we compared these historical trawl survey records with those from recent decades, to investigate changes that may have taken place during the 20th century. Trawl catch rates were standardized by the swept area method and compared within selected areas that contain adequate sampling densities in both periods. Evolution in fishing gear and associated technologies make these comparisons challenging to interpret, yet some striking differences emerge, which cannot be explained by gear changes or increases in fishing power alone. Changes in catch rates of hake (*Merluccius capensis* and *M. paradoxus*), east coast sole (*Austroglossus pectoralis*) and silver kob

(*Argyrosomus inodorus*) are presented for multiple study areas. The implications of these changes are discussed, in terms of historical reference points and their implications to South African fisheries and ecosystem management. The results are presented within the framework of a broader research project, and their use in developing improved sampling and analytical procedures for follow-on investigations is introduced.

How have estuarine benthic invertebrate studies contributed to an understanding of these systems and their biological processes? A perspective on 60 years of research

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Knowledge and understanding gathered over many years is often telescoped into a one dimensional picture with little appreciation of the many small steps along the way. Research initiated in the late 40's and early 50's tackled the question of the nature of our estuarine fauna and eventually categorized it as basically marine groups with a requirement for a sheltered environment. The high energy South African coastline has forced these organisms to exploit estuarine environments. The complex and variable nature of the environment where rivers meet the sea translates into variable invertebrate faunal communities that are indicative of the history and conditions within particular systems. The discovery of a relict estuarine benthic fauna in Lake Sibaya in the 60's was the first indication of the original nature of this freshwater coastal lake and was instrumental in stimulating an early paper on the geomorphological evolution of northern KZN coastal lakes. The dependencies of various migrant fish on estuarine nursery habitats has long been known but possibly less known is the similar dependence of various crustaceans such as the crabs *Scylla serrata* and *Paratyloidiplax blephariskios*, the penaeid prawns and the anomuran mudprawn *Upogebia africana*. While the fundamentals of marine larval development and maturation of juveniles in estuaries are common features, the variations in the processes involved have proven quite remarkable. The variation in the physico-chemical environments in different estuarine types allows for a spectrum of community interactions from total physical control to a high relative level of biological determination as has been shown by the habitat engineering performed by the sand prawn *Callinassa kraussi*. A final point relates to the nature of the benthic fauna as an indicator of conditions in estuarine systems and how this might give direction in the appreciation of the role of particular estuaries in coastal processes. Details of these processes will be described in the presentation.

Has the long-term southward shift of the sub-Antarctic Front affected epibenthic fauna at the Prince Edward Islands?

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Climate-driven long-term change in offshore benthic assemblages is little known and difficult to study. Recent evidence from long-term isotope data indicates fundamental changes in the balance of allochthonous and autochthonous trophic pathways in benthic and hyperbenthic fauna at the Prince Edward Islands. It is suggested that these changes are due to southward shifts in the influential Sub-Antarctic Front. Isotopic changes were found in several benthic suspension and deposit feeders but, critically, not in the hydrozoa or sponges, meaning that oceanographic conditions are affecting taxonomic groups differently. We used a new benthic camera system (SkiMonkey III) to determine quantitatively if changing conditions have affected benthic biodiversity and abundances around the

islands. To do this we compared digitally-reprocessed benthic photographs from 1988 with new photographs taken in 2013. We hypothesised that asymmetric changes in abundances of epibenthic invertebrate groups would have occurred over time. The comparative data showed significant differences in the relative abundances of epifauna over time, but only at certain stations. At these stations differences were largely due to increased abundances of bryozoan and hydroid groups. These changes were consistent with altered flow-through conditions in the inter-island region, and provide quantitative evidence of regional climate effects on benthic biota. It is clear, however, that the responses to altered conditions are localised, and that they are perhaps contingent on other factors such as the suitability of substratum type for colonization by responding species.

Establishing a weight-length baseline for evaluating changes in yellowfin tuna (*Thunnus albacores*) body condition in the Western Indian Ocean

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Standard weight (W_s) equations were established for yellowfin tuna (*Thunnus albacares*) in the Western Indian Ocean and used as a baseline for calculating relative weight (W_r) indices. Length-weight data for yellowfin tuna were obtained from the Indian Ocean Tuna Commission (IOTC) for 1984 to 1991 and 2003 to 2013. Four quadratic standard weight equations were established (based on mean, median, first and third quartile statistics for each length class) using \log_{10} -transformed weight (W , in grams) and fork length (FL, in mm) data. The median W_s equation ($\log_{10}(W) = -3.903 + 2.425(FL) + 0.103(FL)^2$) was the preferred baseline for the W_r analysis. Relative weight estimates for individual fish ranged from 92 to 110. Annual and monthly W_r estimates ranged from 99 to 101 and 99.9 to 100.5 respectively. Correlations between environmental variability and yellowfin tuna condition were observed. Concentrations of suitable prey in 2003 and 2004 correlated to above average condition, although 2005 and 2006 were below average condition during similar prey availability and environmental conditions. Relative weight followed an increasing trend from 2008 to 2013 despite lower biological enrichment. Mechanisms such as a shallower thermocline and reduced fishing pressure are proposed explanations. This study provided a reference study for body condition studies of yellowfin tuna in the Indian Ocean. It also provided support for the application of the W_r index to other tuna species in the Indian Ocean managed by the IOTC.

Repeat photography as a tool for monitoring historical changes in South African coastal ecosystems

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We use repeat photography to illustrate long-term changes occurring along coastal ecosystems in the Western Cape, South Africa. Historic images were sourced from books, the public and subject specialists, and repeat photographs taken. Visible changes could be categorized into four types; changes in species ranges, biological invasions, sea-level changes and direct engineering impacts. In terms of range changes, the images depict a progressive easterly spread of the cold-water kelp *Ecklonia maxima* and parallel easterly contraction of the warmer-water mussel *Perna perna*, both evidence for declining water temperatures in the region. Since circa 1980 most shores have become conspicuously invaded by alien Mediterranean mussels, *Mytilus galloprovincialis*, while those on the west coast are also invaded by the more-recently introduced Pacific barnacle *Balanus glandula*. No changes in vertical zonation due to changing sea levels could be detected, despite suitable images being available. Construction along the shore has radically altered the appearance and ecological attributes of the shoreline in urban areas. Repeat photography thus proved a useful tool for both

detecting and graphically illustrating long-term changes that have taken place on South African shores.

Tracking change in South Africa's hake trawl fishery with recommended management modifications

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Demersal trawling in South Africa began in the late 1880s and has seen many changes in effort, spatial extent and potential impact over the last 120 years. This research identifies key moments in the demersal hake fishery over this period including its development, advances in vessel power, fishing gear and processing technology, the arrival of foreign fleets and the expansion of fishing grounds. Management objectives and measures have also evolved during this time and an analysis of the changing fishing footprint suggests that new measures may be needed to keep pace with changes in fishing strategies and potential impacts. Historical maps and reports were used to provide an overview of changes in fishing activity and support an assessment of the timing, duration and intensity of impact in different habitat types. In 2008, the South African hake trawl fishery mapped and "froze" its footprint as part of the actions motivated by eco-certification conditions. Spatial analysis of the trawl footprint, fishing effort data and marine habitat maps was undertaken. A total of 27 habitat types occur within this footprint. Potential habitats of concern were identified by considering, for each habitat type: 1) its vulnerability and resilience to otter trawling; 2) the total habitat extent and the proportion that occurs within the trawl footprint and 3) the relative trawling effort within the footprint. Nine priority habitat types were identified. Fourteen new proposed trawl closures were developed based on relevant systematic analyses undertaken through the Offshore Marine Protected Area project. These closures represent proposed management actions for all of the nine priority habitat types and, if implemented, would contribute to the protection of 27 habitat types including 16 of the 19 unprotected habitats that are currently exposed to trawling in South Africa.

Is the sun rising or setting on science in South African estuaries?

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The recently published SANCOR Occasional Report by Whitfield and Baliwe (2013) highlights some important findings. Out of a total of approximately 280 functional South African estuaries, the status of information on 79% of these systems was classified as nil or poor, with 10% having moderate information and 11% having good or excellent information. Given the above figures, one would assume that increasing human and financial resources are in the pipeline to address the shortcomings of our knowledge base on estuaries. Unfortunately that is not the case and a long-term analysis of the number of references per decade over the past century revealed that all outputs went from strength to strength from the 1950s until the beginning of the 1990s, after which they entered a steep decline. This decline appears to be directly related to a decrease in the number of highly productive researchers from the beginning of the 1990s onwards. Overall, there appears to have been similar outputs in terms of the number of references from each of the major coastal regions.

The majority of estuarine theses covered biological and ecological topics (69%), followed by physical and chemical studies (21%), environmental management and fisheries (8%), and socio-economics (2%). Indications are that the numbers of graduating students in the estuarine science field has been increasing over the past two decades but that the relative number of publications emanating from these theses has been declining. Clearly we need career paths to permanent positions for these young estuarine scientists and the re-establishment of the Western Cape as a hub for fundamental and applied estuarine studies. This will require short, medium and long-term financial backing by central and provincial government authorities to facilitate the growth of existing centres of estuarine research excellence and the establishment of new research projects and programmes.

Poster Presentations

Poster # 102

History of utilization of Cape rock lobster *Jasus lalandii* by humans along the west coast of South Africa from pre-historic times to the present

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A chronological record of the exploitation of the Cape rock lobster *Jasus lalandii* by humans along the west coast of South Africa is provided, from pre-historic times to the present, based on available literature. Excavations of shell middens in caves and shelters at the coast suggest increased reliance on marine shellfish (limpets, mussels, whelks, chitons, rock lobsters) in a 'megamidden' period between 3000 and 2000 BP. This coincides with increased human habitation in the area after 3500 BP. Rock lobster remains in shell middens comprise calcareous mandibles and exoskeleton fragments, and lobster size has been estimated from preserved mandibles. Human occupation waned after the megamidden period, but pre-colonial foragers (1000–500 BP) relied on large numbers of rock lobsters as part of their diet. The latter part of this period is characterized by opportunistic short occupations during a period of high marine productivity. The arrival and expansion of European settlers in the 15th and 16th centuries effectively ended traditional foraging in the area. In the 19th and 20th centuries lobsters were 'easily caught in vast numbers all the year round' and were known as 'food for the poor'. Commercial exploitation began in 1875, when a processing plant was established in Cape Town to can lobsters for export to Europe. The fishery expanded rapidly from the early 1900s and peaked in the early 1950s at about 17 000 tons. Commercial landings have since declined to <10% of what they were at the height of the commercial fishery.

Poster # 103

Past and present acoustic studies of Antarctic krill *Euphausia superba* in South Africa: from echo rolls to echograms

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Antarctic krill is an essential component of the Southern Ocean ecosystem, forming an integral part of the prey assemblages of numerous marine mammals and seabirds. Hydro-acoustic technology is an effective method for assessing the diurnal and seasonal abundance, distribution and behaviour of planktonic organisms in hostile environments like the Southern Ocean. This study presents results from investigations of Antarctic krill using acoustic tools conducted since the 1980s up until the most

recent research conducted in 2014. Echosounders employing analogue systems and paper recorders in the earlier years have been replaced with modern digital systems. Various models of Simrad echosounders operating mainly at 38 and 120 kHz have been used to collect information on krill dynamics. Antarctic krill surveys were conducted between 60°-65°S and 0°-20°E of the Antarctic sector in various years through various South African research programmes. Some years demonstrated significant diurnal krill vertical migrations while no vertical migrations were observed in other years. The biomass of the Antarctic krill decreased significantly with the distance away from the ice edge and a correlation between the distribution of Antarctic krill and various whale species was observed. The output of this research communicates knowledge of past and present abundance and distribution dynamics of Antarctic krill in the Southern Ocean. The conservation and management of the recovering whale stocks in the Southern Ocean is potentially enhanced through these predator-prey relationships.

Poster # 104

Long-term changes in the abundance and community structure of demersal fishes off the south coast of South Africa

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Currently it is widely publicized, although contested, that fish populations/communities globally are facing threats from overexploitation, climate change and variability and their joint impact. In this study we analysed the trawl data from the long-term bottom trawl survey conducted on the south coast of South Africa. We analysed both the temporal changes in the abundance of the most common teleosts, cephalopods and chondrichthyes and long-term changes in the community structure. Long-term changes in abundance were assessed based on standardized indices of abundance. To generate these latter, four types of models that are commonly used to standardize catch rates from fisheries data were used: Generalized Linear Model (GLM), Generalized Additive Model (GAM), delta-GLM and delta-GAM. To analyse the changes in the community structure a combination of multivariate and univariate methods was used. In this study we show how a combination of the population and community level analysis of demersal fishes and cephalopods can be used to get better picture of long-term changes in the abundance of demersal species.

Poster # 105

Every angler's dream: Do 70 years of trophy fish catches reported in a Garden Route newspaper reflect known trends in linefish stocks or indicate baseline shifts?

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In fisheries science there is a growing interest in using alternative data sources (e.g. logbooks, historical accounts, and photographs) to document long-term changes in catches of fish species, distributions, capture rates, and sizes, especially in the absence of other catch data. This approach is particularly invaluable for tracking changes in localised recreational catches where formal data collection is lacking and in some cases has helped to identify the phenomenon of shifting baselines - an intergenerational change in anglers' perceptions about target species and sizes. Despite dramatic declines in the stocks of many South African linefish species, recreational angling remains a popular

pastime and important economic activity in coastal regions, including the Garden Route of South Africa. One potential motivation for anglers to go fishing there is the possibility of capturing large individuals of iconic fish species such as dusky kob or white musselcracker. This may stem from the personal sense of pride derived from successfully capturing and displaying such a specimen, and the recognition of achievement, or elevation of angling status among fellow anglers. As such, local newspapers often receive and publish photographic submissions of anglers posing with their “exceptional catches”. Here, we use the catches reported in text or photographically in archived copies of the region’s oldest newspaper “The George [& Knysna] Herald” (circa. 1881) from 1940 - 2010 to examine trends in the local recreational shore fishery. We identify the main trophy angling species, trends in reporting frequency, species, sizes, angling sites, and infer whether there has been a shift in baselines (or “anglers’ dreams”) of what is considered a trophy or large fish over this time. The findings are compared to known stocks trends of major linefish species, allowing us to evaluate whether newspapers can serve as viable data sources to detect historic trends in recreational fisheries.

JS Marais Building Rm 1002: Plankton Ecology

Oral Presentations

Environmental drivers, ecosystem response and socio-economic impact of the 2014 Harmful Algal Bloom in Algoa Bay

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Oceanographic conditions during December 2013 were typical for summer in Algoa Bay, with a strongly stratified water column and the periodic decrease in water temperatures in response to easterly-component wind induced upwelling. The upwelling enriched surface waters triggered a phytoplankton bloom around 17 December 2013. True colour satellite images suggest that the surface waters of Algoa Bay were advected offshore and returned inshore near Mossel Bay. The introduction of nutrient rich waters and possibly biological material induced a bloom of dinoflagellates, creating a red tide. The dominant species in the bloom was *Lingulodinium polyedrum* (F.Stein) J.D.Dodge and this was the first recording of a bloom of this species in South Africa. The red tide moved up the coast from west to east and reached Algoa Bay on 11 January 2014, around the same time as there was a large increase in temperatures throughout the water column. Conditions in Algoa Bay favoured the dinoflagellate bloom with surface water temperatures in excess of 20°C and limited wind, current or upwelling induced mixing. *Chl-a* biomass of the surface water often exceeded 50 µg.l⁻¹ and the persistence of the bloom in Algoa Bay for more than three months had a significant impact on the ecosystem. As the bloom decayed the decomposition of the cells reduced the bottom oxygen concentrations to below 1 mg.l⁻¹ and these anoxic conditions resulted in several separate instances of marine organism mortality. The production of temporary planktonic cysts meant that cysts were able to re-seed the area and initiate another red tide event after each subsequent upwelling event. The paper will describe the environmental drivers that led to the

formation of the HAB, the response of the physico-chemical environment, phytoplankton, zooplankton, fish and marine top predators as well as the socio-economic impact on the Nelson Mandela Bay Metropolitan area.

Causes of anoxia in St Helena Bay

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Increasing events of anoxia are considered to have had a major impact on living resources of the nearshore zone of St Helena Bay in the southern Benguela upwelling system. The acquisition of high resolution time series of water column and bottom dissolved oxygen (DO) concentrations has improved understanding of the dynamics of oxygen depletion in the Bay at several scales of variability. The Bay is characterized by a seasonally persistent deep pool of cold, oxygen-depleted water, while episodic anoxia is driven by the decay of red tides in warm inshore waters. Coastal wind forcing influences DO concentrations in the nearshore zone through its control of water column stratification and mixing, through inshore advection of the bottom pool of oxygen-depleted water as determined by the upwelling-downwelling cycle, and through its influence on productivity and the development of red tides. A seasonal decline in bottom DO concentrations of ~1.2 ml l⁻¹ occurs with a concurrent expansion of the bottom pool of oxygen-depleted water. Upwelling of this water into the nearshore zone causes severe drops in DO concentration (to <0.2 ml l⁻¹), particularly during end-of-season upwelling, resulting in a significant narrowing of the habitable zone. Episodic anoxia through the entire water column is caused by localized degradation of red tides within the confines of the shallow inshore environment. Bloom decay is attributed to the inaccessibility of subthermocline nutrients under persistent downwelling, and the high oxygen demand leading to anoxia results from the exceptional carbon load contributed by the red tide in a relatively small volume of water. The roles of micro-zooplankton grazing and virus-mediated cell lysis in episodic bloom termination are explored as plankton mortality processes.

Phytoplankton production and acclimation on the Natal Bight shelf of the Agulhas ecosystem

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Studies of phytoplankton photosynthesis, absorption and pigments were conducted during summer at five focus sites on the Natal Bight to estimate primary production and examine photoacclimation processes. At four of the sites, phytoplankton biomass ranged from 0.10-1.44 mg m⁻³, and integrated PP ranged between 0.35 and 2.58 g C m⁻² d⁻¹. The highest biomass and PP, comparable to that observed in wind-driven upwelling systems, was associated with a diatom bloom observed at the mid-shelf site, varying from 0.26-4.27 mg.m⁻³ and 7.22-9.89 g C m⁻².d⁻¹, respectively. Generalised Additive Models (GAMs) revealed that irradiance, temperature, and biomass levels were the most important parameters influencing photosynthesis rates, and were able to account for 97.53 % of the deviance. Phytoplankton chlorophyll-specific absorption at 440 nm [a*_{ph}(440)] and reconstructed absorption spectra for chlorophyll pigments (*TChla*, *TChlb*, *TChlc*) and photosynthetic and photoprotective carotenoids (PSC, PPC) were used to assess photoacclimation. The proportion of *TChla* absorption was generally similar for diatoms, flagellates and prokaryotes, but relationships

between a*ph (440) and the proportion of pigment group absorption indicated that diatoms had low a*ph, elevated PSC and *TChlc* absorption and low PPC absorption. In contrast, prokaryotes had high a*ph, low PSC absorption, but high PPC absorption. Flagellates had intermediate a*ph, elevated PSC absorption, and intermediate *TChlc* and PPC absorption. It appeared that the phytoplankton classes each had different strategies for photoacclimating to changing irradiance conditions on the Natal Bight.

Primary production in the Southern Ocean: sensitivities to synoptic atmospheric forcing and sub-mesoscale ocean dynamics using state of the art high-resolution numerical models

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The presence of intense storms and sub-mesoscale variability in the Southern Ocean has the potential to strongly impact upper ocean mixing. Atmospheric depressions drive strong turbulent convection and modulate wind stress at the intra-seasonal scale, while meso- to sub-mesoscale ocean eddies and fronts enhance vertical stratification and alter stratification. We hypothesize that in the Southern Ocean the effects of sub-mesoscale dynamics and atmospheric depressions on the vertical mixing and stratification will modulate the supplies of light and iron at critical time-scales that impact phytoplankton growth, thereby driving variability in seasonal bloom dynamics. To examine these intra-seasonal links between upper-ocean physics and biogeochemical responses we employ a high-resolution physical-biogeochemical numerical model. Understanding the sensitivity of primary productivity to the variability of the mixed layer is key to better understanding the sensitivities of the carbon cycle to both short-term variability and long-term trends in large scale atmospheric forcing.

Vertical distribution of benthic invertebrate larvae in relation to the structure of the water column

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Many marine benthic invertebrates undergo a planktonic larval stage during their development and their transport depends on several factors. Tides, winds and light are among the major forces that affect larval distribution and dispersal. The first two lead to upwelling and downwelling of the water masses thus affecting the direction and extent of larval transport. Light may be the main cue for diel vertical migration by which planktonic organisms reach surface waters during the night. Due to the high taxonomic diversity within larvae of benthic invertebrates however, and the presence of different ontogenic stages in the water column, we may expect different taxa-specific swimming abilities and behaviours. The aim of this study is to understand possible links between physical oceanographic processes, diel vertical migration and other larval behaviours. Larval sampling was done in March 2013 at two nearshore sites (<1 km off the coast) inside an embayment (Algoa Bay) and at the open coast (Skoenmakerskop) on the south-east coast of South Africa. By means of a plankton pump different depths were sampled in search of larvae (0, 4, 8, 12 m in the bay and 0, 8, 20, 28, 32 m on the open coast) during day and night periods. Preliminary results on vertical

distributions indicate that some common crustacean larvae perform diel vertical migrations even in shallow bay waters.

Diel vertical migration of euphausiids and their contribution to the vertical flux of organic carbon in the northern Benguela Upwelling System off Namibia

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In the highly productive northern Benguela Upwelling System (nBus), euphausiids can dominate the zooplankton community and may contribute substantially to the vertical flux of carbon. The predominant vertical transport of carbon produced by phytoplankton in the upper water layers of the ocean to deeper layers takes place by sinking of particulate organic carbon (POC). Several processes mediated by the zooplankton community can either enhance or limit the vertical carbon flux and regulate the efficiency of the biological carbon pump. Main biological pathways by which carbon is exported to deeper water layers are the active transport of carbon by vertical migration of pelagic animals, such as krill, and the passive transport of faecal pellets. A conceptual model will be introduced, combining diel vertical migration (DVM) patterns of dominant krill species, with environmental parameters such as temperature, food availability and with physiological constraints such as species-specific respiration rates, which may explain seasonal adaptations of DVM to changes in water temperature, oxygen and food availability. Energetic considerations based on the DVM model showed that temperature acted as the controlling and limiting factor with food abundance further modifying the vertical positioning of krill species. Variable spatial and temporal distributions of krill will lead to seasonal and regional differences in the export of organic carbon to deeper water layers. We will show how the different krill species contribute to the downward transport of organic carbon by vertical migration, and assess its importance relative to other vertical carbon fluxes in the nBUS.

Poster Presentations

Poster # 154

Copepod biomass and gut pigment concentration measured at five focus sites located in the KwaZulu-Natal Bight

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Zooplankton samples were collected in the KwaZulu-Natal Bight, in January/February 2010 (summer season) and July/August 2010 (winter season), as part of the ACEP II project. "Focus site surveys" were conducted: off Durban, the Thukela River mouth, Richards Bay (North and South) and at a mid-shelf site. This study aims to investigate (1) the difference in zooplankton biomass between the focus sites, and (2) the gut pigment concentration of different size classes of copepods to investigate diel feeding patterns. Sampling was conducted at midday (12h00) and midnight (00h00) over a period of 5-10 consecutive days. Samples for biomass analysis were collected using a vertical bongo net and were split to allow for two kinds of analysis as follows. Dry weight samples were size fractionated into four size classes: 200-500 µm, 500-750 µm, 750-1600 µm and >1600 µm. Live copepods for gut pigment analysis were collected using a drift net (200µm) during both the day and night time sampling. Samples were washed using filtered seawater and filtered (vacuum<1cm Hg) onto GF/C filters. Filters were frozen and later in the laboratory 10-50 large, medium and small-sized copepods were picked from the filters for chlorophyll pigment extraction. Zooplankton biomass concentration was significantly different between focus sites; with highest and lowest biomass recorded during the winter survey at the Richards Bay North (25.76 mg DW m⁻³) and Durban eddy (7.30 mg DW m⁻³) sites

respectively. There were significant seasonal effects with regards to the size structure but there were no diel effects observed. Gut pigment concentration was significantly different between sites and within seasons between the different sites. Gut pigment concentration was highest in winter in Richards Bay (21.82 ng Chl *a* copepod⁻¹), and the lowest concentration was recorded in summer at the Durban eddy site (2.72 ng Chl *a* copepod⁻¹).

Poster # 155

Phytoplankton characteristics of a cyclonic eddy southwest of Madagascar

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While Madagascar is widely known for its unique terrestrial flora and fauna, the connectivity between its marine species and the coast of southern Africa is only beginning to be explored. It has recently been discovered that many inshore marine species found in south-eastern Madagascar co-occur on the KZN coast of South Africa. These include fish from the Sparidae family as well as invertebrates, including mussel and lobster species. The mechanism to support this connection over a distance of 800km is as yet unknown, but the most compelling hypothesis proposed is that transport of larvae occurs by means of westward propagating mesoscale eddies. In addition, eddies have been demonstrated to enhance biological productivity, which could assist in the maintenance of larval populations as they are transported between Madagascar and the coast of South Africa. The ACEPIII 'Suitcase Project' was designed to test this hypothesis during a series of land and sea-based studies during July 2013. This paper will report on the physical, chemical and phytoplankton characteristics of a cyclonic eddy located southwest of Madagascar. Twenty-five stations set 10nm apart were sampled across the eddy in a south-westerly direction for physical and chemical characteristics. Samples for chlorophyll *a*, microscopic analysis, and flow cytometry were taken at each station at the surface and at the fluorescence maximum. Chlorophyll *a* measurements show low values (<0.5 mg.mg⁻³) at the edges of the eddy, but enhanced chlorophyll *a* concentrations of up to 2.5 mg.mg⁻³ at the centre. Results from flow cytometry show a similar pattern with a four-fold increase in cell counts between the outer edges and centre of the eddy. These results, as well as the phytoplankton community structure, are discussed in the context of the proposed role of the eddy as a support mechanism for the transport of larval organisms across the Mozambique Basin.

Poster # 156

Phytoplankton patterns on the coasts of South Africa and Madagascar, and across the Mozambique Basin

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Surface phytoplankton distribution was assessed along the coasts of South Africa and Madagascar, and across the Mozambique Basin. Surface temperature, salinity, and chlorophyll *a* samples were collected underway, along the cruise track, between 26 June 2013 and 31 July 2013. In the Mozambique Basin, sampling was conducted along a transect through a cyclonic eddy located south west of Madagascar. The highest chlorophyll *a* concentrations were observed along the coasts of South Africa and Madagascar, with no significant difference in the mean value between the two coasts. Although chlorophyll *a* concentrations in the cyclonic eddy were significantly lower than

those observed along the coasts, values at the centre of the eddy were elevated, while lower concentrations were observed at the edges of the eddy. Significantly lower surface temperatures were observed along the coast of South Africa, while those along the coast of Madagascar and in the eddy were significantly higher. The relationship between chlorophyll *a* and temperature indicated that elevated chlorophyll *a* concentrations were associated with lower temperatures, while lower chlorophyll *a* was observed at higher temperatures. Along the coast of South Africa, the highest chlorophyll *a* concentrations were observed in cooler water in the region of the Port Alfred upwelling cell. Similarly, along the coast of Madagascar, the highest chlorophyll *a* concentrations were found in the vicinity of the upwelling cell off Fort Dauphin, inshore of the southern limb of the East Madagascar Current.

Poster # 157

Variability of daily egg production rate of four dominant Southern Ocean copepods

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Up to 80% of the zooplankton biomass in the Southern Ocean food web is comprised of copepods. Herbivorous copepods in these polar waters experience marked seasonal fluctuations in light and ice cover, and hence primary production, and have developed species-specific strategies to survive during winter when food is scarce. Some species hibernate at depths of >500 m in a diapausal state, while others remain active throughout the year in the epipelagic layers, switching to a more opportunistic, omnivorous diet in winter. We participated in four cruises in the Southern Ocean to measure copepod fecundity, i.e. the rate of daily egg production of females, essential for estimating secondary production. Measurements were made during austral summer (December 2011) aboard the German RV *Polarstern*, and in winter (July 2012) and autumn (April-May 2013, 2014) on South Africa's polar research and supply vessel MV SA *Agulhas II*. Daily egg production rates (EPRs) were determined experimentally using a simple bottle incubation technique. The four copepod species examined were *Calanoides acutus* and *Rhincalanus gigas*, two diapausing species, and *Calanus propinquus* and *Calanus simillimus*, two perennially active species. Summer EPRs were generally elevated compared with autumn and winter values. *C. acutus* and *R. gigas* were absent in autumn and winter surface catches, clearly hibernating at greater depths. Furthermore, there was evidence both of active feeding and recent mating and copulation in all species at all times, although the latter did not always result in eggs being spawned (e.g. *C. propinquus* produced no eggs during winter). Our observations suggest continual reproduction by the omni-present *C. simillimus* with clear seasonality of a summer maximum and winter minimum, the ability to take advantage of any available food source (phytoplankton, detritus, etc.) and possibly also to switch to tapping their stored lipid reserves when ambient food resources become scarce or absent.

Poster # 158

Effect of mate-guarding on the swimming behaviour of female *Euterpina acutifrons* (Copepoda: Harpacticoida)

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During copulation bouts, *Euterpina acutifrons* males grasp females and cling for extended periods as a form of mate-guarding. The present study assessed the effects of such mate-guarding on the

swimming behaviour of grasped females using 3-D video analysis techniques. Mate-carrying female (CF) *E. acutifrons* spent significantly more time swimming at slower speeds than non mate-carrying females (NCF). In addition, CF's did not attain the maximum swimming-speeds attained by their NCF counterparts. Carrying females, however, displayed more complex swimming trajectories and were observed swimming in tight helical loops. We postulate that CF's were attempting to dislodge guarding males with this behaviour, as a form of mate-guarding interference. Notes are made on these findings within the context of predation threat.

Poster # 159

Do toxic *Pseudo-nitzschia* species pose a threat to aquaculture in Saldanha Bay?

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Pseudo-nitzschia is a globally-distributed diatom genus, some species of which produce the neurotoxin domoic acid (DA) responsible for the human poisoning syndrome known as Amnesic Shellfish Poisoning (ASP). The number of *Pseudo-nitzschia* isolates shown to produce DA has increased in recent years to 14, partly owing to the gain in sensitivity of analytical methods for detecting toxins. Species of this genus are common members of the coastal phytoplankton communities of eastern boundary upwelling systems, but their impacts vary between systems. The negative impacts of DA are realized almost annually in the California Current system through direct toxicity of shellfish and through the effects on the health of marine life, including sea lions, sea otters and birds; whereas in the Benguela upwelling system, domoic acid has no recorded impact on marine life and has yet to be measured in shellfish. Our study investigates the threat posed by *Pseudo-nitzschia* spp. to shellfish culture operations in Saldanha Bay. Initiated in 2012, the study undertakes identification of the *Pseudo-nitzschia* spp. present within Saldanha Bay, assessment of their frequency of occurrence, their ability to produce DA, and the uptake of DA by the cultured mussel *Mytilus galloprovincialis*. Preliminary results show *Pseudo-nitzschia* spp. to be an important component of the phytoplankton community of Saldanha Bay. Particulate DA concentrations exceeding $2 \mu\text{g L}^{-2}$ are similar to those observed in the California Current system and are attributed to *Pseudo-nitzschia australis*.

Poster # 160

The case of the calanoid copepod *Pseudotiaptomus hessei* - a new candidate live-feed organism for marine larviculture?

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Currently available live-feed organisms (rotifers & *Artemia*) are not universally suitable as a larval first feed due to their relatively large size and poor nutritional value. In an effort to assess the potential of difficult or new aquaculture species, copepods are being investigated as an alternative live-feed option. The selection and choice of a suitable copepod species to be grown as a live-feed must be based on a combination of specific larval nutritional requirements and the ease/flexibility in culturing the organism. The calanoid copepod *Pseudotiaptomus hessei* dominates the zooplankton of temperate southern African estuaries. The species is capable of adapting to a wide range of temperatures and salinities and makes a significant prey contribution to the diet of many estuarine larval fish and invertebrates. The nauplii and early copepodite stages of *P. hessei* are planktonic and are significantly smaller than rotifers while the amino acid and fatty acid profiles of other Pseudodiaptomids suggest that *P. hessei* could meet the larval nutritional requirements of many

potentially aquaculturable species. Long-term sustained population growth and development of *P. hessei* has been demonstrated in the laboratory suggesting the culture potential of the species. The combined characteristics of adaptability, small size, good nutritional profile and culture potential strongly suggest that the species could be a viable alternative live-feed choice for increasing the diversity of species farmed by the South African mariculture industry.

Poster # 161

The effect of acute salinity shock on the survival of the calanoid copepod *Pseudodiaptomus hessei*: implications for aquaculture

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The calanoid copepod *Pseudodiaptomus hessei* is found in African coastal estuaries and is typically the most dominant zooplankton species by biomass. *P. hessei* has been identified as a potential livefood candidate for use in local marine larviculture, however, there is no information available regarding its large-scale culture. The species can adapt to fluctuating environmental conditions such as temperature and salinity having been found at salinities from 0 to 75 ppt. In aquaculture, the maintenance of *P. hessei* involves the mixing of water of varying salinities (i.e. different microalgae prefer certain salinities) which could impact on the health of copepods. Therefore, the aim of the study is to test the effect of an acute salinity shock on the survival of *P. hessei*. The experiment will involve three initial salinities: 15, 25, 35 ppt with three replicates for each. *P. hessei* will be exposed to acute salinity shocks between the starting salinities and 5, 15, 25 and 35ppt. Controls will be included and mortality will be recorded over 48 hours. The results will provide information to assist with refining the husbandry conditions for the successful large-scale culture of the species. The information could also serve to assist the Department of Water Affairs with the scheduling and quantity of freshwater released into estuaries based on the possible impact this may have on copepod survival.

Poster # 162

Designing the optimal live-feed organism: the effect of dietary microalgae on the fatty acid profile of the calanoid copepod *Pseudodiaptomus hessei*

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The traditional live-feed for marine fish larvae are rotifers and *Artemia nauplii* which are not suitable for some species of marine finfish because of their poor nutritional profile and large size. Marine copepods, especially calanoids have successfully been used as live food for many cultured marine larvae, having shorter life-history stages and a better balanced nutritional profile compared to rotifers and *Artemia*. *Pseudodiaptomus hessei* has been identified as a potential livefood candidate for use in local marine larviculture however there is no information on the culture of the species. The aim of this study is to determine the effect of dietary microalgae on the fatty acid profile of *P. hessei*. Experiments whereby copepods are fed different microalgae for a period of three weeks before a full fatty acid analysis is performed are currently underway. In particular, the highly unsaturated fatty acids: eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) which are important for developing marine larvae, will be of significant interest. The results of this study will assist aqua-culturists on how to manipulate aspects of the nutritional profile of *P. hessei* based on the needs of the fish larvae.

Poster # 163

Predation of the calanoid copepod *Pseudodiaptomus hessei* on the rotifer *Brachionus plicatilis* under culture conditions

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The calanoid copepod, *Pseudodiaptomus hessei* is commonly found in the temperate estuaries of Southern Africa. The species is under investigation as a potential candidate for use as a live food in aquaculture however, information on the feeding biology of *P. hessei* in the wild is limited. Calanoid copepods are generally considered to be herbivorous, feeding on phytoplankton. Ecological studies on other calanoid species (*Acartia tonsa* and *Pseudodiaptomus annandalei*) have suggested a more omnivorous diet, which includes predation on the surrounding zooplankton such as rotifers. The aim of this study was to develop a better understanding of the feeding biology of *P. hessei*, particularly assessing the possibility of omnivory. Laboratory experiments involved presenting both male and female *P. hessei* with rotifers (*Brachionus plicatilis*) with/without an alternative feed source (*Tetraselmis suecica*) including copepods which had been either starved or fed (satiation status) prior to the introduction of the rotifers. Each treatment was performed in five replicates and the rate of rotifer consumption was determined over 24 hours. Both sexes of *P. hessei* actively prey on the rotifer with no differences between males and females. Rotifer predation was significantly greater ($p=0.033$) when copepods were starved (9.69 ± 0.09) compared to those that were satiated (6.56 ± 0.97). The availability of an alternative food source reduced (7.5 ± 0.97) rotifer predation compared to those without the microalgae (8.75 ± 0.97). The interaction between satiation status and the presence/absence of *T. suecica* was significant ($p=0.027$) suggesting that when available, copepods consume rotifers in addition to microalgae. The study clearly shows that *P. hessei* are capable of actively preying on rotifers and that the feeding biology of *P. hessei* may be more omnivorous than previously thought. Apart from the ecological significance, this understanding has implications for its large-scale culture and use in marine larviculture as a candidate live-feed organism.

Poster # 164

Lower trophic pelagic ecosystem of Algoa Bay, South Africa

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Algoa Bay, on the south-east coast of South Africa, is subjected to various mesoscale and sub-mesoscale oceanographic processes, the most important of which are current and wind driven upwelling. Nutrients forced into the photic surface layers of the water column are known to set in motion a positive biological response starting with an increase in productivity of phytoplankton at the base of the food chain. It was hypothesized that the pelagic ecosystem of Algoa Bay is driven by these upwelling events. In 2010, the South African Environmental Observation Network (SAEON) established the Pelagic Ecosystem Long-Term Ecological Research Programme (PE-LTERP) to sample monthly eight stations within Algoa Bay. Results thus far show little correspondence between biomass and upwelling activity, neither in space nor time. Upwelling intensifies in magnitude and frequency during the summer months in the eastern sector of Algoa Bay in response to persisting easterlies. Frequent upwelling results in a positive east-west temperature trend in summer, shifting west to east at the onset of winter when westerly winds start to dominate. Westerly wind fields

induce upwelling south of prominent capes that forces cold waters into the western sector of Algoa Bay. Phytoplankton and zooplankton biomass seem to follow a similar summer to winter spatial shift. For the most part, peak values occur in the western sector in summer where water is warmer and upwelling least intensive. The opposite trend was evident during the winter months when peak values associated with warmer conditions occur in the eastern sector. Despite high variability, a significant peak in biomass for both phytoplankton and zooplankton was evident from spring to late summer at all stations. Minimum biomass values are consistently recorded in July and August. These results suggest mechanisms other than upwelling may be responsible for driving the lower-trophic level pelagic ecosystem of Algoa Bay.

Poster # 165

Seasonal variability of zooplankton abundance in the St Helena Bay area and its links to pelagic fish abundance

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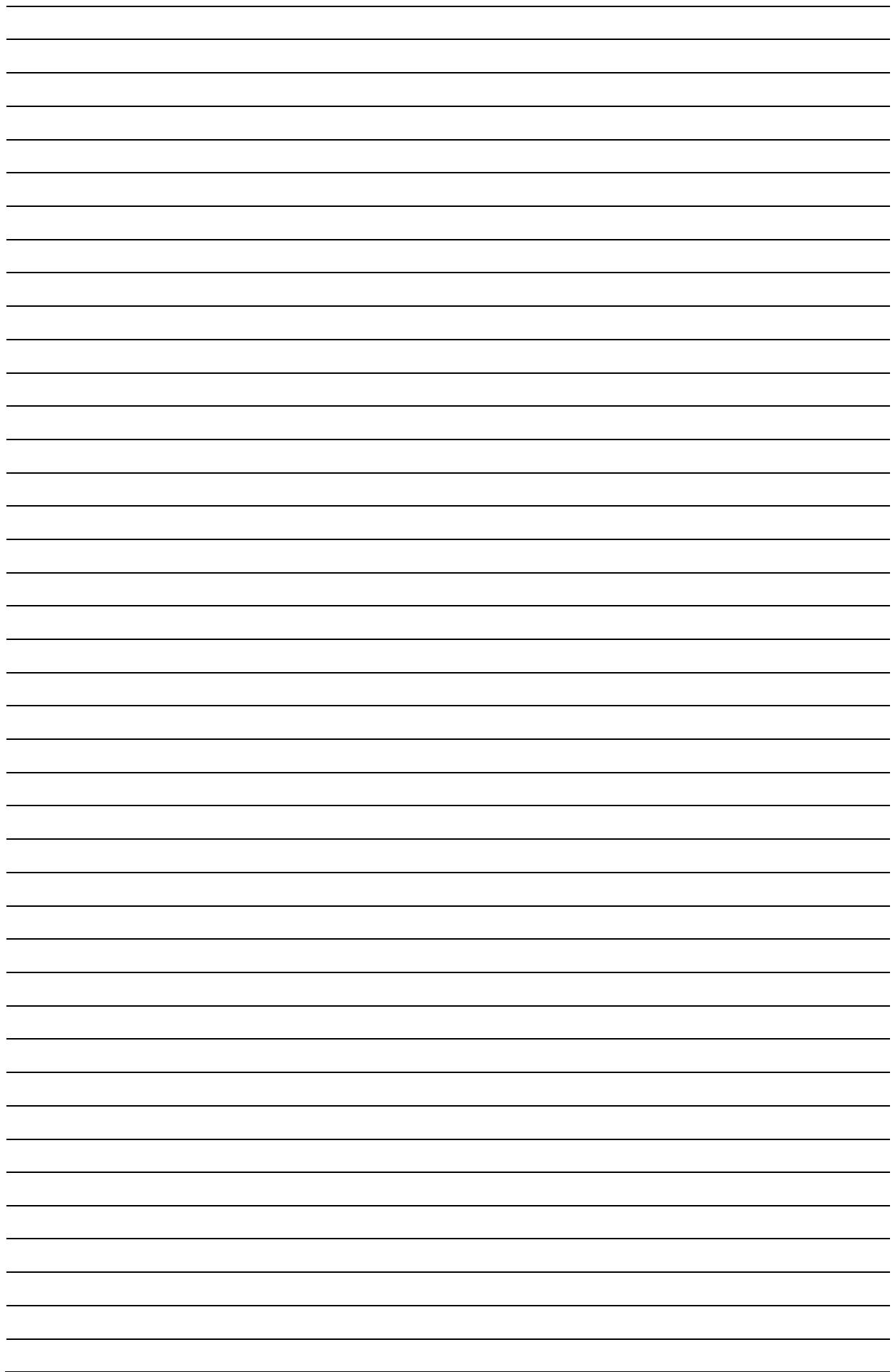
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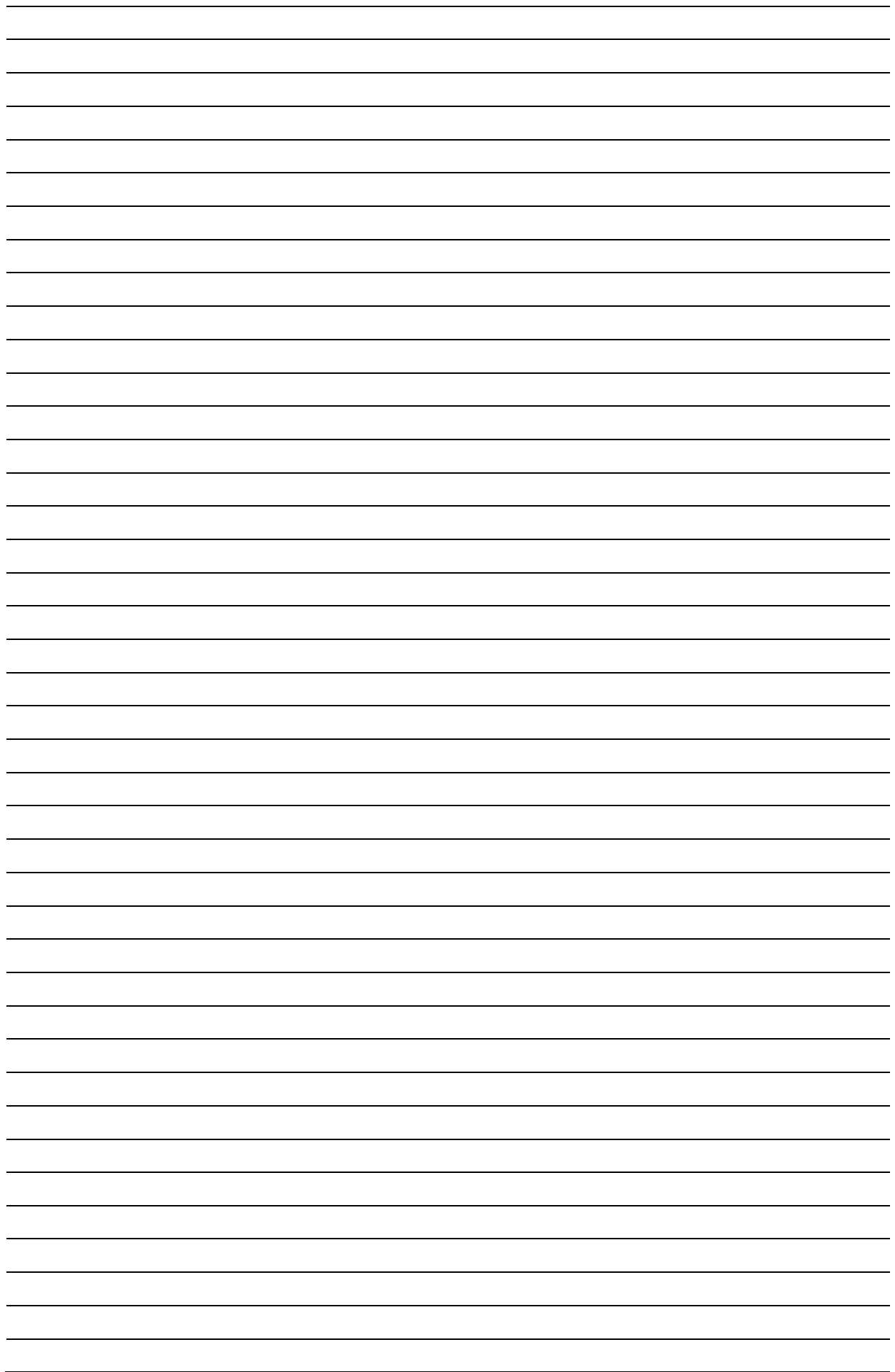
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The St Helena Bay Monitoring Line (SHBML) is a sampling transect that runs from close inshore to beyond the shelf edge on the west coast of South Africa. This transect encompasses areas of importance to early life history stages of pelagic fishes such as anchovy and sardine, namely a transport (of eggs and larvae) region offshore and the nursery grounds inshore. In this area, larger mesozooplankton, notably copepods and euphausiids, are the major grazers of diatoms and form the main trophic link with fish and other higher trophic levels. Sampling of zooplankton and environmental variables was conducted monthly between 2000 and 2011, as part of a long term project on environmental monitoring. Hydroacoustic data on pelagic and mesopelagic fish occurrence were collected concurrently. Vertical Bongo net samples collected along the SHBML transect have been analysed to obtain comprehensive information on the zooplankton distribution. In this study acoustic data collected along the SHBML during autumn (May) and spring (November) are compared with zooplankton data to investigate whether observed seasonal variation in zooplankton abundance can be linked to seasonal variation in pelagic fish abundance in this area. Results showing the effects of zooplankton abundance on schooling dynamics of small pelagic fish, seasonal patterns in the density of pelagic fish and zooplankton, and diel changes in their distributions will be presented.





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