

Overarching themes and key questions identified by workshop participants during Session 3 (14 March 2017)

A total of 50 responses indicating suggested overarching themes and key questions were received from participants in the session. These are listed below, preliminarily grouped by theme.

Overarching theme	Key questions
INTER- AND MULTIDISCIPLINARY STUDIES (10)	
Promoting interdisciplinary research (data sharing emphasized) and securing funding for such (but not at the cost of gathering foundational information)	<ul style="list-style-type: none"> • How can we improve interdisciplinary climate change research, including sharing of data, research facilities and equipment? • How is the Agulhas Bank system changing and what are the effects of this change on the immediate climate conditions (?) and fisheries in that region? • To what extent can we unpack the complex interactions between different trophic levels to improve understanding of ecosystem changes arising from climate change? • How do we incentivise academic scientists (and others) to participate in collaborative research (present system is that incentives for academic scientists are based on publication and student graduation rates, which promotes individual outputs rather than collaboration in multi-disciplinary studies)
Developing an interdisciplinary approach to study the ecosystem from primary production to human exploitation and dependency	<ul style="list-style-type: none"> • Can resources off the Eastern Cape be (further) exploited to increase economic stability of the province? • How will the highly dynamic Agulhas Bank be influenced by the influx of new species? • Can unique, realistic adaptation strategies be developed for sustainable management of South African marine fisheries?
Integrated laboratory (physiology) and modelling studies to investigate the effects of changes in pH, dissolved oxygen on local fish and invertebrate species to better inform predictions, management and adaptation options of these resources	<ul style="list-style-type: none"> • What are the effects of acidification on local fish and invertebrate species? • What are the effects of temperature on local fish and invertebrate species (optimal ranges, maximum critical temperature, etc)? • What are the effects of dissolved oxygen minima on local fish and invertebrate species?
???	<ul style="list-style-type: none"> • Do we need other science themes to complete the 'big picture'? • Which institutions are able to create job or postgrad and postdoc opportunities? • Need process-oriented studies to disentangle various processes and identify their impacts
From pattern to process and prediction –	<ul style="list-style-type: none"> • What are the patterns of change in our marine ecosystems (from molecular to ecosystem

understanding the impacts of climate change on marine ecosystems and ecosystem services	<p>level)?</p> <ul style="list-style-type: none"> • What are the processes/mechanisms driving these changes? • How is climate change going to influence the ecosystem and ecosystem-services of the SA marine environment?
Understanding trophic interactions	<ul style="list-style-type: none"> • What is the influence of the environment on fish? • How are these influences modulated, if at all, by intermediate trophic levels? • Are these regional differences in these (influences or intermediate trophic levels or both?) that will have regionally-specific impacts on food production and food security?
Developing mitigation plans against predicted changes in climate in key marine species	<ul style="list-style-type: none"> • Characterise the resilience to change of key exploited species in order to better predict their responses to climate change
Vulnerability of organisms/species to climate change impacts (pH, temperature, extreme events)	<ul style="list-style-type: none"> • How well are individual species adapted to climate change? • What will this (differential adaptive capacities?) mean for distribution/regime shifts? • Can we link environmental drivers to species responses/change?
What are important tipping points in SAs marine ecosystems?	<ul style="list-style-type: none"> • What are the tipping / pressure points we need to know about to be able to adapt and respond to climate change?
Including top predators in whole ecosystem response to climate change	<ul style="list-style-type: none"> • Determine important predictors (top predators?) of climate change • Do we have sufficient data and resources to answer overarching questions?
MONITORING (6)	
Synchronized and 'clever' long-term monitoring	<ul style="list-style-type: none"> • How do we develop/retain current technical expertise within DAFF (detailed knowledge of data collection methods and sites etc)
Monitoring using natural sources	<ul style="list-style-type: none"> • Who are the stakeholders and what do they want to achieve? • Are negative impacts of research on the environment ever considered?
Long-term monitoring	<ul style="list-style-type: none"> • Can we keep the 'best' long-term monitoring going? • Use case studies (e.g. rock lobster influx into the Overberg region) to compare long-term monitoring data with model-derived predictions. • Is (direct) human impact greater than climate change impacts?
Monitoring of inshore environments	<ul style="list-style-type: none"> • Investigate and interpret long-term changes in cpue/size composition/sex ratios/ growth of species supporting inshore fisheries • Develop early-warning systems of and explain distribution shifts in fishery resources • Assist in aquaculture planning
Monitoring and Modelling	<ul style="list-style-type: none"> • Need to adequately monitor important physical and biological parameters of selected

	<p>species identified as likely to indicate climate change effects (copepods, small pelagics, kelp)</p> <ul style="list-style-type: none"> • Need to develop adequate models for these species to answer questions regarding how different aspects of climate change (warming, acidification, dissolved oxygen) will impact species/communities/ecosystems together
Monitoring of the Agulhas Current	<ul style="list-style-type: none"> • What are the impacts on exploited resources of shelf-edge upwelling on the Agulhas Bank and is this changing through time?
LIVELIHOODS, ECONOMICS etc (6)	
Alternative livelihoods (opportunities RE SSF programme, tree planting)	<ul style="list-style-type: none"> • How can we use our existing resources in DAFF together to create jobs and alleviate poverty?
Developing new food products as a response to climate change	<ul style="list-style-type: none"> • Can we develop and utilize 'new' products to enhance food security (e.g. fortifying low cost foods such as bread, maize meal) with anchovy or kelp meal? • Would these nutrients be readily taken up by the human body? • Can public perception be moved towards acceptance and utilization of such products?
Climate smart aquaculture	<ul style="list-style-type: none"> • Investigate adaptation and mitigation plans to enhance aquaculture-provided food security • Conduct research into improving culture technology and production of freshwater and marine mussels, including feed development and comparisons with culture systems elsewhere)
Economic opportunities of climate change	<ul style="list-style-type: none"> • Can we identify and plan for economic opportunities that climate change will bring about?
Limiting the adverse impacts of climate change	<ul style="list-style-type: none"> • What measures can be taken to limit adverse impacts of climate change and how should these be implemented? • How will these measures contribute to job creation, and food security and nutrition
Utilization of industry data and resources in research	<ul style="list-style-type: none"> • Where does the socio-economic impact of shifting/changing resources fall? • How to mitigate impacts on local communities? Develop alternative livelihoods eg aquaculture, utilization of different species • What are the impacts of changing ecosystems on already-limited industries and how should these be managed in light of competition for resources? • Should we focus on management of the ecosystem or multiple species to provide a buffer to changes in individual species yields (dual crop harvesting?)
COMMUNICATION, CO-OPERATION AND CAPACITY	

(6)	
Empower our future	<ul style="list-style-type: none"> • How can historical data be standardized and made available in easily-accessible time-series? • What data need to be collected? • What will these data tell future generations – need educational paradigm shift
Dealing with uncertainty and developing story lines	<ul style="list-style-type: none"> • How do we reduce the uncertainty (in predictions?) of the impacts of climate change/variability on marine ecosystems • How do we develop storylines that best find a common thread across all disciplines with regard to change?
Capacity	<ul style="list-style-type: none"> • Does SA have sufficient capacity to deal with the impacts of climate change on our oceans?
Informing research and technologies around fisheries	<ul style="list-style-type: none"> • Can we pool resources to collectively identify priority issues on which to focus the climate change discussion? • What is the potential of marine resources such as kelp for biofuel? (could mitigate greenhouse gas emissions as renewable) and contribute to the skills/technology sector and potential jobs)
Integrating local indigenous knowledge (fishers) into fisheries research and management	<ul style="list-style-type: none"> • How can we integrate local indigenous (fishers) knowledge (fine spatial and temporal scales) into our research to better understand local and regional processes and responses (job creations)? • How is climate change perceived by local people (users of the coast, fishers, etc) • What changes have local people observed in marine ecosystems?
Citizen science	<ul style="list-style-type: none"> • How do we go about bringing together science/scientists and the general public (create more collaboration with the 'man on the street')?
DISTRIBUTIONAL CHANGES (4)	
Effects of environmental changes on the distribution of key species	<ul style="list-style-type: none"> • What are the key species? • What environmental changes are they most sensitive to? • Are any of these changes occurring or likely to occur due to climate change?
Ecosystem shifts (spatial?) in response to climate change (distribution)	<ul style="list-style-type: none"> • What are the implications of such shifts for marine resource management? • What are the implications of such shifts for present and future MPAs and marine spatial planning? • What are the socio-economic implications of such shifts?
?? distribution shifts??	<ul style="list-style-type: none"> • Do we understand linkages between fish abundance (and distribution) and oceanographic

	<p>conditions?</p> <ul style="list-style-type: none"> • Can industry be pressurized (persuaded perhaps a better word) to create jobs by moving canning (fish processing) factories to the south coast?
Predicting future distributions of harvested living marine organisms	<ul style="list-style-type: none"> • For which important harvested species do we have environmental characterizations of habitat occupancy? • Can we predict future distributions of species using niche/bioclimate envelope models and simulated future states of SA marine environment • Are abiotic and biotic characteristics of the Agulhas Bank changing (or have they changed in recent years?)
DISEASE (4)	
Impacts of climate change on disease epidemiology (disease dynamics impacted by a dynamic equilibrium between the host, pathogen and the environment)	<ul style="list-style-type: none"> • What impacts will environmental shifts due to climate change have on pathogens and their hosts (possible impacts on hosts include density changes resulting in an increase or decrease of susceptible hosts and distributional shifts; possible impacts on pathogen include changes in symbiont community structure and alteration of host range and virulence)?
Climate change and disease	<ul style="list-style-type: none"> • What are the impacts of climate change on disease/pathogen distribution, prevalence, and ?? – focus on commercially relevant species and/or OIE (Office of Infectious Epizootics?) diseases. • What are the effects of climate change on host/pathogen interactions – (??); focus on acute and chronic exposure as well as individual and combinations of stressors
Impacts of climate change on marine fish diseases and parasitic infection	<ul style="list-style-type: none"> • What are the impacts of climate change on marine fish diseases and parasitic infection? • Will climate change cause fish to be exposures to (new?) diseases in the future? • If climate change will result in increased fish disease can this be prevented/mitigated?
Combined effect of climate change and disease on exploited fish and shellfish	<ul style="list-style-type: none"> • Conduct research to investigate combined effects of climate change and disease on exploited species
COASTAL ZONE (3)	
Change in the nearshore (<50m) coastal zone	<ul style="list-style-type: none"> • What is the impact of sea level rise on coastal ecosystems (rocky shore, estuaries etc), coastal livelihoods and coastal infrastructure? • What are the impacts of HABs on coastal ecosystems, inshore fisheries and socio-economics?

	<ul style="list-style-type: none"> • What are the impacts of extreme events (storm surges, marine heat waves, etc) on coastal ecosystems and socioeconomics and can we develop early warning systems for these?
Quantifying direct human impacts (pollution, mining, dumping, etc) (on the coastal zone?)	<ul style="list-style-type: none"> • What effects does pollution have on inshore species, especially those harvested for food? • What are the impacts of recreational and subsistence fishing on inshore species, especially those harvested for food? • How can data be stored long-term and which institutions should do this?
Addressing illegal fishing	<ul style="list-style-type: none"> • Can we quantify illegal fishing, particularly in the nearshore zone? • Are climate change impacts on inshore resources going to outweigh current fishing pressure there?
ATTRIBUTION (3)	
Distinguishing between climate change and other anthropogenic impacts (pollution, eutrophication, freshwater extraction, fishing)	<ul style="list-style-type: none"> • How do estuarine-coastal systems respond over time to combined changes in freshwater flow and climate (e.g. KZN event-scale run-off vs increasing number of dams trapping sediment) • How much sediment is reaching the coast and will this change in future (role of sediment in habitat formation)
Identifying direct influences of climate change on the ocean environment	<ul style="list-style-type: none"> • Are our oceans warming? • Are our oceans becoming more acidic? • Is hypoxia/anoxia increasing in coastal waters?
Identify climate change impacts	<ul style="list-style-type: none"> • Investigate climate change impacts on fish production, fishery management implications, conservation implications, and ecological implications.
CONNECTIVITY (2)	
Interconnectivity between regions	<ul style="list-style-type: none"> • What mediates connectivity between the SA south and west coast (e.g. important for transport of small pelagic fish spawning products) • How do changes in oceanography (chemistry etc) impact the lower trophic levels that fuel exploited species
Connectivity of large and regional-scales in the context of climate change and variability	<ul style="list-style-type: none"> • How does variability in the SAA affect variability in the Benguela system?
POLICY (2)	
Developing national and regional adaptation	<ul style="list-style-type: none"> • Can we develop policies (including well-defined action plans) that address likely

policies for climate change	<p>implications of climate variability and change?</p> <ul style="list-style-type: none"> • Can we put adaptation actions into practice in selected, highly vulnerable fisheries?
Research prioritization	<ul style="list-style-type: none"> • Identified research prioritized into immediate, medium- and long-term so as to facilitate budget allocation
FRESHWATER FLOWS (1)	
Changes in freshwater flows (frequency, duration, volume) to estuaries and the marine environment	<ul style="list-style-type: none"> • What are the responses of near-shore and estuarine ecosystems to changes in freshwater flow? • What are the physiological responses of key fisheries species to the changes (salinity, dissolved oxygen, pH, temperature) • Quantitative simulation of all flow data from all catchments countrywide at monthly and annual time-scales
ACIDIFICATION, TEMPERATURE, DISSOLVED OXYGEN etc (1)	
Ocean acidification	<ul style="list-style-type: none"> • Is ocean acidification changing steadily? • What are the implications of acidification for resources and fisheries? • Can we ameliorate negative implications of acidification?
HARMFUL ALGAL BLOOMS (1)	
HABs at regional scales	<ul style="list-style-type: none"> • Have there been significant increases in HAB events across various biogeographic regions? • Will predictive modelling (presumably regarding HAB occurrence) be an option in the future (needs skills development, appropriate technology, etc)? • Can HAB species composition be related to environmental cues (and re these related to climate change drivers?) • Is HAB toxicity related to environmental/biological stress factors?
OTHER (1)	
What are the impacts of large-scale and long term (climate changes?) on the utilisation of seawater for desalinisation?	<ul style="list-style-type: none"> • Need to monitor long-term impact of desalination (likely to start given freshwater shortages) beyond EIAs