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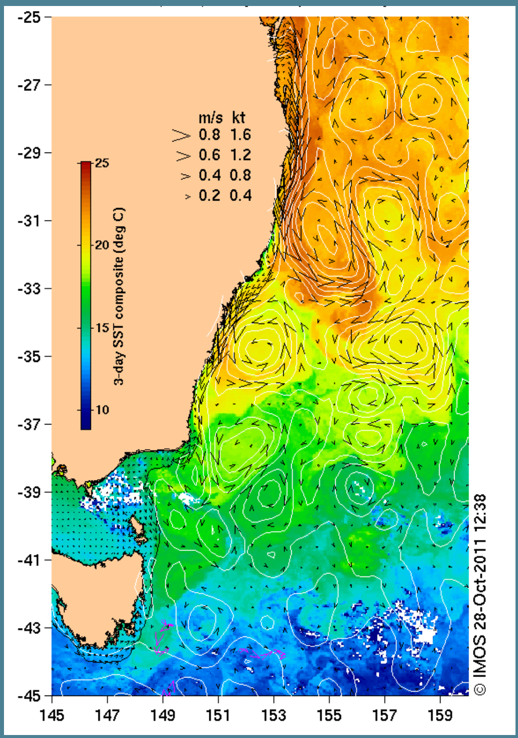
Marine climate change in South East Australia



WORKSHOP REPORT
4th of November 2011

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IMAS
INSTITUTE FOR MARINE AND ANTARCTIC STUDIES

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REPORT ON MEETING OF PRIMARY INVESTIGATOR'S WORKING ON MARINE CLIMATE CHANGE PROJECTS WITHIN THE EASTERN SEABOARD OF SOUTH EAST AUSTRALIA

NOVEMBER 4TH 2011

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This is an informal report prepared to accommodate timely reporting of recently collected information. It has only undergone limited review and consequently should not be cited without permission of the authors. The opinions expressed in this report are those of the authors and are not necessarily those of the Institute for Marine and Antarctic Studies or CSIRO Marine and Atmospheric Research.

Acknowledgements

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EXECUTIVE SUMMARY

Waters in south-eastern Australia are responsible for 50% of Australia's fisheries production, host a high level of endemic species and offer no land mass further south for species that find themselves in unable to cope with increasing water temperature. Several dozen species from a range of taxa have exhibited major climate related distributional shifts in recent decades, and there have been significant climate-related changes in key fisheries. Consequently, the south east region of Australia, particularly within the East Australian Current (EAC) system found along the eastern seaboard, has been the focus of much research effort over recent years. This research effort has been, and continues to be, relevant at State, Regional and National levels with the diversity of issues examined reflected in the 27 presentations delivered at the '*Meeting of primary investigator's working on marine climate change projects within the eastern seaboard of south- east Australia'* on November 4th, 2011.

The purpose of this meeting report is to provide an informal document that summarises much of the research activity currently occuring within the southeast region of Australia, and provide the contact details of key researchers, to facilitate better networking and communication between relevant researchers working in the region. Additionally, it was considered a priority to document the outcomes of the discussions held on the day.

Discussion topics included 'synergies with regard to data requirements – project needs and wants' and issues around 'engagement, communication and extension'. Many participants felt that there was a miss-match between the spatial resolution of models and oceanographic data that was more readily available (better off-shore) and that which was required for many biological projects (most of which are concentrated closer to the coast). Many projects also require social and economic data although most of these projects were at initial stages and it was unclear to what extent projects could collaborate in the sourcing or production of suitable data.

Several participants noted that many current projects in the south-east, particularly those working in the adaptation area, involved participatory approaches (e.g. workshops and surveys with industry). With this in mind, and considering that adaptation options when/if implemented require the support of industry and community, ongoing community and industry engagement is essential. Support for the development of extension networks and stronger collaborations and communication between researchers and extension officers was identified as a need and incorporating financial support for extension officers in research grant budgets was considered an option.

Given this meeting brought together over 40 researchers working on marine climate change within the south-east, it presented a unique opportunity to conduct a 'gaps analysis' of the National Adapation Research Plan for Marine Biodiversity and Resources. The second two discussion items, 'Identifying critical gaps and opportunities that deserve additional attention' and 'Potential for future collaboration' related directly to this gaps analysis.

Improving monitoring capacity in the south-east was identified as critically important. This included establishing priorities for monitoring in a cost effective program and extension into social and economic domains, and better coordination of existing monitoring already being conducted. Long term datasets will be of key importance for addressing issues of attribution, validating the projection models presently being developed and in determining our success in decades to come in terms of developing and implementing adaptation options in the south-east region of Australia.

If participants at this meeting now have a greater awareness of each other's projects and will consider synergies and future opportunities to address the challenges presented by climate change, then this workshop will have been valuable. Future meetings of a similar style may be convened in future.

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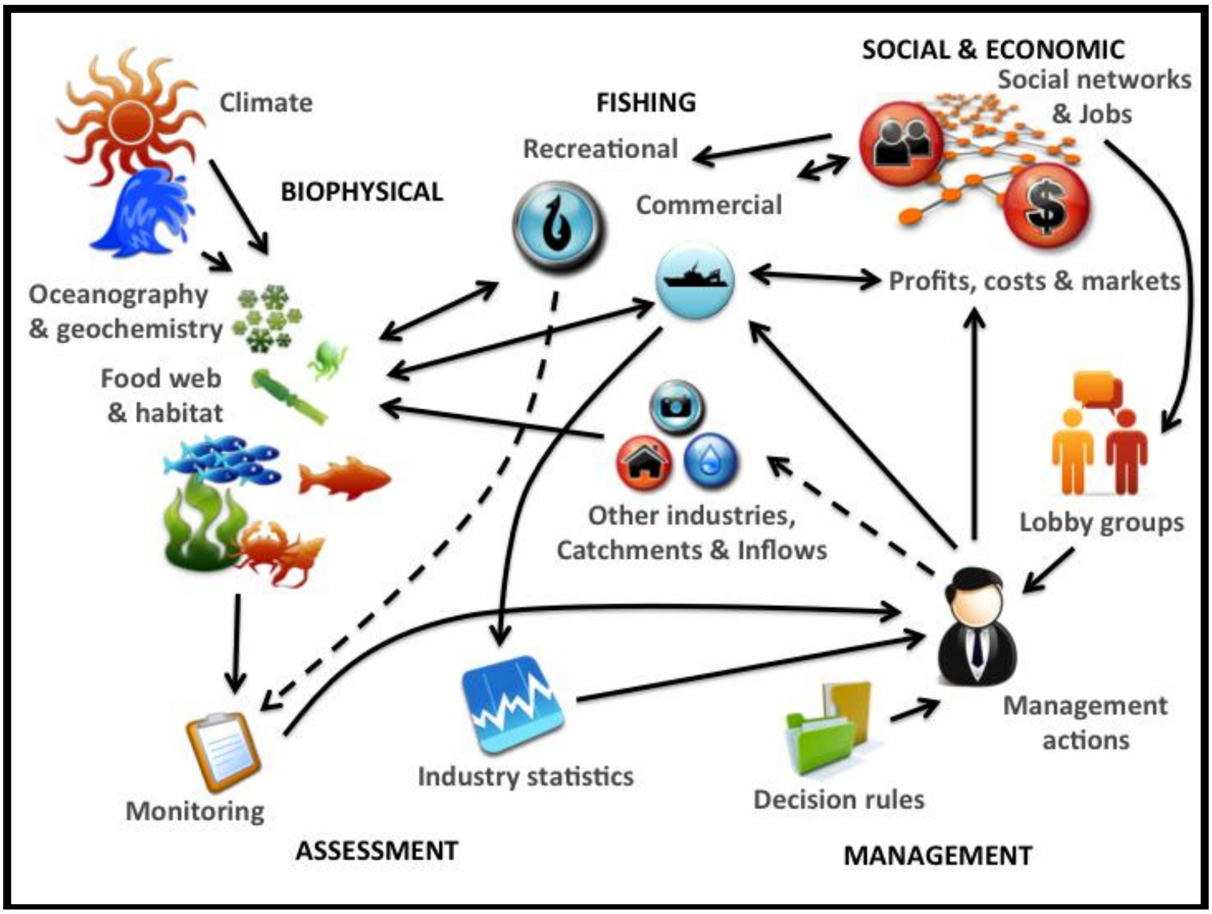
BACKGROUND AND INTRODUCTION

There is a great deal of activity directed towards addressing marine climate change issues within the East Australian Current (EAC) system off the south-east region of Australia. Whilst there is collaboration and mechanisms for communication amongst some project clusters, within National Adaptation Research Plan (NARP) projects and within the South East Australia Program (SEAP) for example, there are a number of other initiatives and projects with strong potential for collaborative connections. The meeting included:

- A brief synopsis of national and regional networks, plans and programs relevant to climate change.
- An overview of key projects operating within the south-east, including details of the scale, scope, questions addressed and key people involved
- Discussion sessions
    - Synergies with regard to data requirements – project needs and wants
    - Engagement, communication and extension:
    - Identifying critical gaps and opportunities that deserve additional attention
    - Potential for future collaboration (and conversely, minimising overlap)



Key elements and connections relevant to marine climate change (taken from Fabio Boschetti's presentation based on Fulton et al FRDC project)

AGENDA

09:00 – 9:10AM

Opening

Prof Mike Coffin, IMAS Executive Director

9:10 – 10:00AM

Introductions and plan for the day, Dr Gretta Pecl and Dr Alistair Hobday

Overviews
Chair: Dr Gretta Pecl

- National Adaptation Research Plan (NARP), **Colin Creighton** - FRDC (10 min)
- Marine Adaptation Network, **Assoc Prof Neil Holbrook** - IMAS (10 min)
- South East Australia Program (SEAP), **Dr Dallas D'Silva** - Fisheries Victoria (10 min)
- Marine climate change aspects of NERP, **Dr Piers Dunstan** - CSIRO (10 min)
- IMOS activities in the EAC/southeast Australian region, **Dr Katy Hill** - IMOS (10 min)

10:00 – 10:30AM

State based project overviews
Chair: Dr Neville Barrett

- New South Wales, **Dr Alan Jordan** - NSW Environment (10 min)
- Victoria, **Dr Daniel Spooner** – Fisheries Victoria, DPI (10 min)
- Tasmania, **Assoc Prof Stewart Frusher** - IMAS (10 min)

10:30 – 10:50AM

Morning tea

10:50 – 11:30AM

Project overviews
Chair: Dr Daniel Spooner

- Preparing for climate change in marine systems of Australia and India (Australia-India Strategic Research Fund project), **Assoc Prof Stewart Frusher** - IMAS (10 min)
- Changing currents in marine biodiversity governance and management: responding to climate change (NARP project), **Dr Julie Davidson** - UTAS (10 min)
- Modelling of physical drivers (currents, temperatures and upwellings) in the south eastern Australia region (SEAP project), **Dr Alistair Hobday** - CSIRO (10 min)
- A climate change adaptation blueprint for coastal regional communities (NARP project), **Dr Ingrid van Putten** - CSIRO (10 min)

11:30 – 12:40AM

Project overviews
Chair: Dr Ingrid van Putten

- Preparing fisheries for climate change: identifying adaptation options for four key fisheries in South Eastern Australia (NARP/SEAP project), **Assoc Prof Tim Ward** - SARDI (10 min)
- Quantitative testing of fisheries management arrangements under climate change using Atlantis (FRDC/SEAP), **Dr Fabio Boschetti** - CSIRO (10 min)

- Ensuring that the Australian oyster industry adapts to a changing climate: a natural resource and industry spatial information portal for knowledge action and informed adaptation frameworks (NARP project), **Dr Pia Winberg** - University of Wollongong (10 min)
- Impact of climate change on habitat forming seaweeds, ARC discovery, **Dr Jeff Wright** - IMAS (5 min)
- Effects of climate change on temperate benthic assemblages on the continental shelf in eastern Australia—AUV related, Super science fellowship, **Dr Neville Barrett** – IMAS (5 min)
- Redmap Australia: an early warning system for range shifting species (Australian National Data Service Project), **Dr Gretta Pecl** - IMAS (10 min)
- Understanding the global impacts and implications of range-shifting species in marine systems (ANNiMS project), **Dr Amanda Bates** - IMAS (10 min)
- Understanding climate drivers and predicting the future for coastal Australian ecosystems (ANNiMS project), **Dr Jayson Semmens** - IMAS (10 min)

12:40 - 1:20PM

Lunch

1:20 – 2:00PM

Project overviews
Chair: Assoc Prof Tim Ward

- Long-term changes in the EAC, as inferred from the coral/tree rings/otoliths data (NARP project), **Dr Ron Thresher** - CSIRO (10 min)
- Adaptive management of temperate reefs to minimise effects of climate change: developing effective approaches for ecological monitoring and predictive modeling (NARP project), **Dr Neville Barrett** - IMAS (10 min)
- Pre-adapting a Tasmanian coastal ecosystem to ongoing climate change through reintroduction of a locally extinct species (NARP project), **Dr Ruth Casper** - IMAS (10 min)
- Development and testing of a national integrated climate change adaptation assessment framework (FRDC/SEAP), **Dr Vincent Lyne** - CSIRO (10 min)
- CSIRO Flagship Cluster: Institutional and Social Barriers To Science Impact (CSIRO Collaboration Fund), **Assoc Prof Marcus Haward** - IMAS (10min)

2:10 - 2:50PM

Discussion chair: Dr Alistair Hobday

Synergies with regard to data requirements – project needs and wants

- What physical data do you need that you don't have?
  - Historical
  - Future
  - Selecting scenarios
- What biological data do you need that you don't have?
- What social or economic data might you need?

2:50 - 3:15PM

Discussion chair: Assoc Prof Stewart Frusher

Engagement, communication and extension:

- Who are the targeted audiences?
- How do we differentiate/co-ordinate messages but prevent information overload?
- What opportunities to improve effectiveness and/or consolidate industry contacts (e.g. surveys) and outputs.

3:15 - 3:30PM

Afternoon tea

3:30 - 4:10PM

Discussion chair: Assoc Prof Neil Holbrook

Identifying critical gaps and opportunities that deserve additional attention

- Review of the NARP priorities
- Stakeholder workshops – what we've learned from consultation so far
- International linkages (e.g. Global Marine Hotspots Network)

4: 10 - 4:50PM

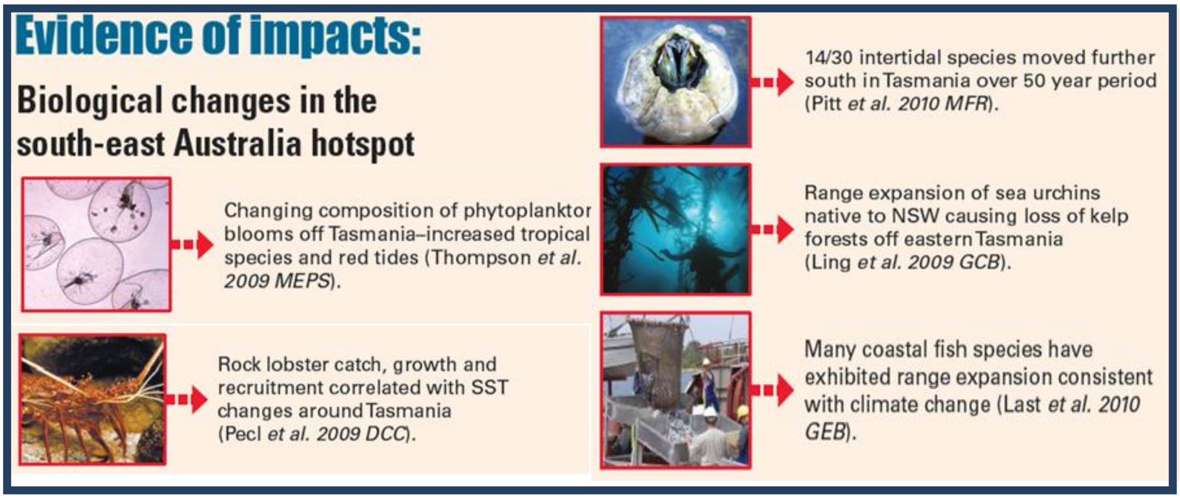
Discussion chair: Dr Neville Barrett

Potential for future collaboration (and conversely, minimising overlap)

- Identifying useful adaptation approaches for science uptake
- Collaborative arrangements, facilitating networking, upcoming conferences and workshops
- Potential for larger collaborative projects

4:50 - 5:00PM

Closing, Dr Gretta Pecl and Dr Alistair Hobday



DISCUSSIONS

SYNERGIES WITH REGARD TO DATA REQUIREMENTS

This discussion focused on the availability of physical data from models and observations, and the synergy between what was available and what was required for the range of projects operating within the south-east region. Historical data from national reference stations and a small range of satellite products are now available through the IMOS portal. A range of spatial data (such as underwater video) is also available via the IMOS portal. Historical and future ocean model data, from global climate models and downscaled models (e.g. Bluelink, CSIRO/Ocean Forecasting Australian Model - OFAM) are available in a range of formats. Please see Hobday and Lough (2011), for an overview of available model types including the pros and cons of each approach. Fine-scale hydrodynamic models (e.g. Huon model, SAROM, East coast, GBR) might be most useful for biology projects, but coverage is very patchy, and temporal coverage is typically over a short historical period. Many participants felt that there was a miss-match between the spatial resolution of models and oceanographic data that was more readily available (better off-shore) and that which was required for many biological projects (most of which are concentrated closer to the coast). For fine scale models there is no nesting in future climate projections known or available at this time.

Discussion around the types of data that would be useful to projects included physical, biological, social, and economic.

1. Physical data – wide use was noted, for two main purposes (illustrative and analytical). Participants noted that although much data was available on the Australian Ocean Data Network (AODN) , many state agencies had large quantities of high resolution data (e.g. coastal lidar data) that was not deposited with the AODN and perhaps these state based agencies needed more encouragement to make such data available through the AODN. Katy Hill of IMOS highlighted that IMOS needed feedback on what plots and products researchers needed more routinely so that they could create the most appropriate range of useful products. IMOS will have a new website by the end of the year with new plotting capacity.
    a. Two thirds of meeting participants highlighted that 'illustrative' physical data was required for their projects – e.g. for use in stakeholder workshops, for guiding planning, to explain potential patterns.
        i. General pictures (might be available in the literature)
        ii. Specific for a region, variables etc. This was the type of physical data/graphic that 80% of participants said they required.

    b. Approximately 75% of participants indicated that their projects required physical data for analytical purposes – e.g. for use in models, experiments etc.
        i. General value (e.g. +2 C)
        ii. Specific values and scenarios (e.g. average temperatures are projected to be 25C ± 3C at this location in 2050). This is the type of analytical data all participants said they required, rather than using the general values as indicated above.
2. Biological data
    a. Project specific, but some commonly available, such as IMOS plankton, video data
    b. Data sharing for supporting project outreach is anticipated, use of fact sheets and project summaries, plus shared powerpoints already occurring between some attendees.
3. Economic data – up to 15 of the participants identified that they would use economic data – but there was little discussion of the details.
4. Social data – up to 18 of the participants identified that they would use social data – but due to time constraints, again there was little discussion of the details. However, several participants noted that whilst some economic data was readily available there were more ethics controls around social data. De-identification of social data is often required and re-use by other projects often not permitted and this may limit the capacity of data sharing between projects with respect to social data.

Reference:

Hobday and Lough (2011) Projected climate change in Australian marine and freshwater environments. [Marine and Freshwater Research 62, 1000-1014].

ENGAGEMENT, COMMUNICATION AND EXTENSION (E, C & E)

The discussion focused on two main themes

- How do we get the message across?
- Who is the target audience?

How do we get the message across?

It was recognised that E, C & E was an essential part of any research and that, in general, researcher outputs (e.g. scientific publications and presentations) seldom meet the needs of stakeholders. In the south-east there were examples of projects that used participatory approaches (e.g. Dr Pia Winberg - Oyster project and Dr Ingrid van Putten – Coastal Communities project), and others that use expert panels (e.g. Dr Julie Davidson – MPA Governance). Another form of communication was through Networks (A/ Prof Neil Holbrook – NCCARF's Marine Biodiversity and Resources Network). Only one project had a specific focus on communication and this used citizen science and an interactive website (Dr Gretta Pecl – Redmap).

Concern was raised that, similar to monitoring in biophysical systems, E, C & E required an ongoing commitment and that funding was almost non-existent for any form of longer term projects. However, there are networks of extension people (e.g. SeaNet Officers with OceanWatch) but these tend to have limited on-going support and it was felt that the connections between researchers and these groups are currently generally weak. A NARP project associated with the Coastal Communities project (Dr Ingrid van Putten) is trialing the use of SeaNet Extension Officers to engage with and communicate results to coastal communities. Support for the development of extension networks and stronger collaborations and communication between researchers and extension officers was identified as a need. Incorporating financial support for extension officers in research grant budgets was considered an option.

There was also discussion about the format of communication and, similar to marine observing systems, whether technology could assist in E, C & E. Social networks established through networking technologies such as Facebook, Twitter, Smartphone applications and blogs should be explored as cost effective measures although it was recognised that they still require a minimal amount of "person time" to ensure timely feedback. However, this time is the equivalent of researchers downloading and analysing automated data capture in other scientific disciplines. It was suggested that other disciplines, such as the arts may offer additional ways of communicating which could be investigated as part of an E, C & E package.

Who is the target audience?

While there are a range of audiences from communities, industries, governments, the discussion focused on policy makers as the most influential people to target. More direct links to senior officials or ministers were often required as the middle manager that most researchers work with is often "over-ridden" by more upper levels of Government. In many cases, the middle managers are supportive of issues but lack the ability to argue the science behind the issues when confronted with alternative political agendas.

In addition to senior policy people in government, there was also the need to ensure that communities were across the issues so that they could influence their government representatives. The need for people skilled in communication and the potential to use other media avenues (visual and written media, new technologies [see above] etc) was identified as a current gap.

Several participants noted that many current projects in the south-east, particularly those working in the adaptation area, involved participatory approaches (e.g. workshops and surveys with industry). With this in mind, and considering that adaptation options when/if implemented required the support of industry and community, ongoing community and industry engagement is essential.

IDENTIFYING GAPS AND OPPORTUNITIES FOR SOUTHEAST AUSTRALIAN CLIMATE CHANGE ADAPTATION RESEARCH FOR THE BENEFIT OF AUSTRALIA'S MARINE BIODIVERSITY AND RESOURCES

Facilitator: A/Prof Neil Holbrook

Aim

To identify gaps and opportunities for southeast Australian climate change adaptation research for the benefit of Australia's marine biodiversity and resources

Approach

This relatively brief 40-minute workshop with invited researchers and stakeholders interested and working on research projects or programs in Australia's southeast region – a global 'hotspot' – revisited the key questions identified in the National Climate Change Adaptation Research Plan (NARP) for Marine Biodiversity and Resources (2010). The questions considered in the workshop were those listed in the first three theme areas of Appendix 2 of the NARP corresponding to the marine biodiversity and resources (MBR) sectors: marine aquaculture (6 questions), commercial and recreational fishing (8 questions), and conservation management (5 questions).

The participants remaining in the room from the earlier presentations and workshops were broken up into four groups of similar size. The four groups were:

1. marine aquaculture
2. commercial and recreational fishing 1
3. commercial and recreational fishing 2
4. conservation management

Each group work-shopped and populated a table drawn up on butcher's paper (which was later transcribed into Excel spreadsheets) of the form indicated here below, for the example of the 'conservation management' group.

Priority Question #	**Is this question being answered?**	**Research underway**	**Knowledge gaps**	**Any opportunities**
3.1 Which ecosystem species of conservation priority …?	Yes/No	Identify project(s) and PIs	Identify knowledge gaps that remain	Identify opportunities for, for example, collaborative projects

Finally, one member from each group provided a brief report, to the forum as a whole, of their discussions and identified thematic gaps and opportunities for the southeast of Australia, but informed in relation to the NARP questions identified in Appendix 2.

AQUACULTURE	Is this question being answered?	Research underway	Knowledge gaps	Opportunities
1.1 Which farmed species in which locations are most likely to be impacted as a result of climate change?	• Shotgun approach (see research underway presented in this and other fora) • Vulnerability study - 1st pass only	Salmon (Tas), oyster (Winberg et al., NSW), Abalone (pH in SA), barramundi (Dean, JCU)	• Where are the best estuarine locations and future sites, for species such as SBT, YTK, prawns • Expansion strategy for aquaculture (see FRDC and P. Hone ideas) and C.C. and catchment interaction risks.	• Multispecies farming? Diversification? (Integrated Multi-Trophic Aquaculture IMTA) → there is somewhat of a barrier to research on these integrated topics b/c FRAB based research planning • Intensification to increase production in focused regions
1.2 What are the most likely effects of climate change on key environmental variables affecting aquaculture operations, including ocean temperature, stratification and oxygenation, freshwater runoff or availability, and extreme wind and wave events and which regions are most vulnerable to such changes?	• Coastal/Estuarine: rainfall, T^{o}, oxygenation • Offshore: T^{o}	• Monitoring, forecasting, selective breeding • Oyster industry portal establishing links between environmental variables and oyster industry productivity and therefore links to climate change risks	• what is the cost effectiveness of engineering solutions to address climate impacts: offshore cages, moving racks • Limited understanding of important environmental variables that affect aquaculture today across all species sectors and locations - the link between science, policy and industry is not "normal science" and not supported well within research institutions nor are there resources with natural resource managers for this work - who should undertake it? • Zoning "changes": how are they limited by policy?	• Selective breeding: barramundi, prawn, salmon (robust) • Improved access to environmental data from all data custodians (not just researchers) and interpreted information from the data for aquaculture and fisheries industries - especially in coastal zone - for informed and pre-emptive response (short term) / adaptation (longer term) (=applying science) • Diversification
1.3 What are likely policy changes driven by climate change that will affect aquaculture businesses either directly through changes in access to suitable locations, and natural resources such as freshwater or marine-based feeds or indirectly because of changes in harvest marine policies, affecting feed supplies or non-marine climate adaptation and mitigation policies?	No	Changes in feed composition, consultation with communities (e.g. salmon), future zoning	• Biosecurity restrictions may have an impact, or be needed in future • Low carbon requirements and carbon sequestration opportunities in aquaculture • No overview of spatial policy information (i.e. a map of government agency responsibilities and geographical boundaries)	• Food - conversion rates improvements • New species and integrated multi-trophic aquaculture concepts can deliver on reducing carbon and nutrient footprints of industry. Add to existing industry investment and infrastructure rather than create new ones. • Need marine/coastal jurisdictional and industry area spatial information to align with biophysical portal initiatives (e.g. AODN, IMOS, models)

1.4 Which local or regional communities or economies are most dependent on aquaculture businesses and how will changes in aquaculture production (especially decline in activity) affect those vulnerable communities socially and economically?	ABARE state stat's (no longer as critical a question)	• Community consultation… • St Helens - (NARP communities) • NARP - Oyster (Winberg et al)	• Would communities dependent on aquaculture agree to move their location? • Where would good locations be? • Can aquaculture aid carbon sequestration? • Can aquaculture be used to supplement wild stocks?	• ↗ food production • ↗ ecosystem services (e.g. nutrient ↘) • Stock enhancement • Which regional economies hold potential for expansion of aquaculture industry and integrated aquaculture solutions - marine farming, turquoise revolution concepts suitable for specific regions/climates • Indigenous marine farming and ranching opportunities to address carbon sequestration, including marine access rights
1.5 What options are there for businesses to adapt to climate change effects either by minimising adverse impacts or taking advantage of opportunities, including through selective breeding, changing or diversifying farmed species, relocating, expanding or contracting business sites or improving environmental control through infrastructure development? What are the barriers to implementing such changes and how might they be overcome?	Yes: • Prawn forecasting (Hobday) • Salmon forecasting • Monitoring (INFORMD)	• ICT water quality for real time monitoring • Selective breeding: oysters, salmon, prawn • Diet "optimization": salmon, prawn	• Diversification of species • Responses: changes are often commercial in confidence • How to "access" the "data" on business response • Barriers include governance structures and • Investment stuck with established aquaculture species and not innovative in light of climate change difficulty of industry funding contributions to greater good research (industry not united)	• Enhancement • IMTA • Seaweed for nutrient and carbon regeneration to offset inputs to fed species • Sequestration → aquaculture as potential sink for sequestration • Carrying capacities not established and need to be known
1.6 What significant changes in aquaculture have already occurred because of extrinsic factors and what can be learned from those changes that will inform adaptation to climate change?	• Disease in salmon • Pa • Yes • Shotgun	Observation: • Abalone - AVG disease in Victoria → Tasmania • Oyster diseases and harmful algal bloom occurrence • Dinoflagellates on the ↑		• Review of changes • Diversification of farmed species and variety of lease locations • Function of fallow periods • Productivity of waters - establish phytoplankton to higher food chain productivity in fisheries and aquaculture

COMMERCIAL AND RECREATIONAL FISHING	Is this question being answered?	Research underway	Knowledge gaps	Opportunities
2.1 Which fishery stocks, in which locations, are most likely to change as a result of climate change? What will those changes be (e.g., in distribution, productivity) and when are they likely to appear under alternative climate change scenarios?	• Parts of this questions are being addressed for selected species. However, we are at the initial stages of assessing to what extent prediction is going to be reliable/possible. • Stocks most likely to change were identified under recent SEAP Risk Assessment project, however, this did not identify HOW and WHEN these would change.	Multiple projects to various extents, see project list from meeting. Examples include: two ANNiMS projects (Range Shifts and Climate Driven Changes on Stocks), NARP Temperate Reefs, ARC projects, NSW Vagrants Monitoring, Redmap Australia	• Poor baseline information on distribution and abundance, factors that determine range limits in the first place, natural variation • Lack of consistent large-scale and long-term monitoring and limited planning and funding for appropriate future capacity • → Limited but unknown detection capacity to identify range shifts • → Limited and superficial understanding of range shift process (depth/slope issues , coarse physical model resolution, shift in range edge vs. centroid) • Large but unknown uncertainty around ability to predict population responses	• Development/application of tools to predict and adapt to responses, various approaches include: SDM's to indicate regional vulnerability and mechanistic modelling for species specific work, identify early warning species/regions, qualitative models to assess impact of shifts, resilience modeling • Identifying and making model connections, improving interfaces, e.g. ALA + IMOS to integrate biological and physical information • SE is an area of higher vulnerability (exposure and sensitivity in terms of level of endemnism and lack of habitat further south of Tasmania)- could use approach of natural assemblages, whole of ecosystem (possibly social network analysis, what species go with what species), resilience modelling
2.2 What and where are the most likely effects of climate change on key variables affecting fishery access, including wind and wave climatologies and boating access?	Partially, often by local government		Downscaling of physical data and forecasting	
2.3 Which local or regional communities or economies, if any, are dependent on commercial or recreational fishing? How will changes in fisheries (especially decline in activity) affect those vulnerable communities socially and economically?	• Many little projects • Disparate, not connected	• John Harkin (from TCCO) • SLR & increased storm surges examine at local scale by Councils • NARP Communities Blueprint project is examining 3 rural communities across Australia	• Connecting to biophysical world • Communication with industry and community • Challenges in engaging economists in marine sphere, particularly fisheries and aquaculture, lack of relevant expertise • Terminology barriers and other challenges for interdisciplinary work	• First stage – High level screening across Australia for vulnerability + possible indicators • Second stage - Hotspots approach, examining at risk regions as a priority • Developing and testing models + approaches for connecting socio-economic + biophysical realms

2.4 What are the likely policy changes driven by climate change that will affect commercial fisheries either directly through changes in harvest policies or indirectly because of changes in non-harvest marine policies or changes in non-marine climate adaptation or mitigation policies?	*(this question was not addressed by the workshop participants)*			
2.5 What options or opportunities are there for commercial fishers in identified impacted fisheries to adapt to climate change effects through changing target species, capture methods and management regimes, industry diversification, relocation or disinvestment?	Partly for some species e.g. rock lobster and abalone	Pecl & Ward et al SEAP project	Trawled finfish species	To develop methods for examining potential opportunities for data poor species
2.6 What options or opportunities exist or might become available for recreational fishers in identified vulnerable fisheries to adapt to climate change effects through changing target species or preferred fishing method or travelling to pursue their preferred target species or method?	Options and opportunitites still being identified partially addressed through NARP and associated projects.	E.g. NARP recreational fisher engagement project, impacts on coastal tourism.	Recreational fishes are a diverse groups and therefore can be difficult to engage, but programs such as Redmap are helping	Modifying existing surveys and broadening citizen science
2.7 What are the barriers to fishers implementing such options, including reliability of information about species changes; cost–benefit analyses of different options; current or prospective availability of support industries and services	Partially, but it is often difficult to predict what the barriers will be	• Redmap • NARP rec fisher engagement • Rock lobster • SEAP	• Economics • Infrastructure • Flow-on effects	• Economic modelling • Other target species • Bycatch • Marketing

in new locations; prospects of adjustment and flexibility; jurisdictional, legal, administrative or regulatory uncertainties or constraints; and market drivers and constraints?				
2.8 How might barriers to adaptation be overcome? What significant changes in fisheries have occurred before because of extrinsic factors and what can be learned from those changes that will inform adaptation to climate change?	Some research looking at changes in target species through population decline e.g. small pelagics. We need better grass-roots engagement with fishers (rec & commercial) if we're to get support for initiatives, especially given the future rate of change.	• Redmap • NARP rec fisher engagement • Rock lobster • SEAP	Determining key species for implementing management regimes (e.g. range shifting species). Open dialogue to understand fishers concerns and needs.	Modelling Approaches, better engagement, better ownership of challenge & solutions

CONSERVATION MANAGEMENT	Is this question being answered?	Research underway	Knowledge gaps	Opportunities
3.1 Which ecosystems and species of conservation priority most require adaptation management and supporting research, based on their status, value, vulnerability to climate change and the feasibility of adaptive responses?	Coastal reefs: algal dominated	Yes	Yes: Food web linkages, environment and biological changes, social and governance, phenology and life-history	Yes: Linking with other interdisciplinary projects ensuring coastal reefs (eco./soc./gov.)
	Mid-shelf: Invertebrate dominated	Yes - at selected locations	Yes: temperature variation, range distribution, spatial distribution	Yes: NERP, NSW MER, IMOS
	Estuarine macrophytes (wetlands)	Yes (in NSW) Victoria? Tasmania? - Smaller scale	Yes: historical data (recent benchmarking)	Could be: needs better integration
	Vulnerable species: Algae, fish, invertebrates - threatened species	Some	Taxonomy and distribution	
3.2 What are the critical thresholds to ecosystem change and how close is the ecosystem to such 'tipping points'? How can we improve our measurement of marine ecosystems to account for ecosystem dynamics and processes?	Yes but not for all habitats	Patterns (NERP, CERF, State agencies) + processes (ARC/Kelp, FRDC/RL)	sign. more threshold analysis required, but being pursued for some species	ensuring project linkages with ARC, FRDC, state agencies
3.3 How will goals and governance for conservation of Australia's marine biodiversity need to change to adapt to climate change impacts? What are the barriers, limits and costs to implementing adaptation and effective policy responses to climate change?	Yes	Yes (NARP)	• Appropriate institution arrangements • Expansion to areas outside the east coast	• Requires ongoing stakeholder discussion • → NERP??
3.4 How should conservation managers and planners adapt their practices to ameliorate climate change risks and enhance adaptation options? What intervention strategies will increase system resilience and improve the time within which biological systems can adjust to a future climate?	Yes	Yes: MPA monitoring, modelling (NARP)	• Are the existing monitoring programs capable of detecting a climate change signal above that of natural variability? • Connectivity of MPA's	• More integrated monitoring program + reserves • Tropical methods into SE
3.5 What are the major sources of social resilience, and the processes by which stakeholders and organisations interact, negotiate, and build alliances? What roles do varying perceptions among stakeholders play in adaptive management and how do they change over time?	No but in some fisheries it is being developed	No	• Social network analysis • Leadership: industry and community • Effective communication • Translation skill development	• NERP (knowledge broker) • Build stakeholder alliances • Engagement with NRM, CMA's etc..

POTENTIAL FOR FUTURE COLLABORATION (AND CONVERSELY, MINIMISING OVERLAP)

Discussion focused on the fact that after the review was conducted under the previous discussion item, it was obvious that there was clearly no overlap between the existing project proposals, and all addressed important information and knowledge gaps. In some cases though, such as the provision of physical datasets on past and future climate scenario's, data generated by projects such as the Temperate Reef project (Barrett et al), the Super Science ARC project, and the work of Alistair Hobday and others at CSIRO, will likely make a useful contribution to a broader range of projects. We need to work together to make sure that such data is widely available to all interested users.

In a show of hands, all participants agreed that improving monitoring capacity in the south-east was critically important. This included establishing priorities for monitoring in a cost effective program and extension into social and economic domains. Also raised was the need for better coordination of existing monitoring with many smaller monitoring and assessment projects underway but with poor coordination between these projects. The importance of long term datasets was considered of key importance for addressing issues of attribution between different drivers of change, and in a futuristic context, for validating the utility of projection models and the evaluating the success of any adaptation options implemented.

There was some discussion about a possible mechanism to keep researchers in the marine climate change space in touch with each other, and it was suggested that the annual meeting of NARP projects could act as a framework for perhaps broadening the range of projects presented at that meeting, to include the SEAP projects, and others such as the ARC-related and ANNiMS projects listed herein. A south-east marine climate change email list was also discussed.

OVERVIEW AND PROJECT SUMMARIES

CLIMATE CHANGE ADAPTATION – MARINE BIODIVERSITY & FISHERIES, OVERVIEW OF STATUS AND WHAT'S ON FRDC'S RADAR? Presented by Colin Creighton – Fisheries Research and Development Corporation

Chair, Climate change Adaptation – Marine Biodiversity and Fisheries
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This talk briefly focused on 3 key issues – smarter adaptation, mitigation and marine management.

1 - Increasing profitability through smart adaptation

The challenge of responding to a changing climate by building smarter fisheries & aquaculture industries & marine biodiversity management

As background, under the National Adaptation Research Plan [administered by NCCARF] there are 8 Networks and 8 Research Plans or "NARPs". The "NARPs" specify the priority knowledge needs. These 8 areas are Marine Biodiversity and Resources, Terrestrial Biodiversity, Human Health, Settlements and Infrastructure, Primary Industries, Freshwater Resources and Biodiversity, Emergency Management, Social Economic and Institutional Dimensions.

FRDC coordinates the Marine "NARP" – covering fisheries, aquaculture, recreational fishing, tourism and marine biodiversity. Following is a summary list of the R&D activities underway:

- ❑ Adapting marine governance (National) – Lockwood et al
- ❑ Coastal Communities (National) – Frusher and Marshall et al
- ❑ Outreach (National) – Shaw et al
- ❑ Deep sea corals – Thresher et al
- ❑ Temperate reefs – Barrett et al
- ❑ Translocation for ecosystem resilience - Bax et al
- ❑ Oyster industry – Davis et al
- ❑ Recreational fishing adaptation – Gledhill et al
- ❑ Adaptation options for seabirds and mammals (national) – Hobday et al
- ❑ Coral trout impacts (not SE) – Pratchett et al
- ❑ Beach and surf tourism (not SE) – Raybould et al
- ❑ Barramundi aquaculture (not SE) – Jerry et al
- ❑ Western Fisheries (not SE) – Caputi et al
- ❑ Northern Fisheries (not SE) – Welch et al
- ❑ Recreational Fisheries Adaptation (part SE)
- ❑ South Eastern Australia Vulnerability– Pecl and Ward et al
- ❑ Estuaries (National)– Sheaves and Dichmont et al
- ❑ Growth in Fisheries Production (National)– Hobday et al

Key criteria in selecting these R&D investments included that the projects provided methods that were systems based in approach, furthered the biophysical understanding [or climate impacts] only where this informs management, have a strong adaptation focus and fitted within a conceptual framework to cover the marine issues as well as possible with the limited investment available.

2 – Mitigation as an opportunity

Smart systems thinking would benefit fisheries, marine biodiversity & Australia's carbon sequestration goals

About 55% of all biological carbon capture is "blue" carbon – i.e.: in the world's ocean ecosystems. Some 93% of the earth's CO2 is stored and cycled through our oceans. Between 50% to 71% of all carbon storage in the ocean's sediments occurs in just 0.5% of the ocean area – the wetlands & estuaries. Wetlands, lakes & estuaries comprise less than 5% of the world's land based plant biomass.

For Australia, recognising much of Australia is arid the % figures for wetland contribution to carbon sequestration are probably even more favourable. Clearly optimisation is essential – for carbon sequestration + fisheries habitat + biodiversity + productivity + shore protection + aquaculture. This role of estuaries and wetlands for a climate outcome has yet to play out in the Australian Government's funding scheme – called *Clean Energy Future* which includes under the *Land Sector* package

- ❑ *Closing the Gap R&D* for primary industries - $201M [no mention of marine or estuarine]
- ❑ *Action on the Ground* - $99M [no mention of marine or estuarine]
- ❑ Extension & Outreach- $64M [no mention of marine or estuarine]
- ❑ Biodiversity Fund- $946M [does mention wetlands]

As the Australian Government develops Resourcing Strategies for these important initiatives FRDC will work to ensure "the wet bits" not forgotten and will seek enhancement of public policy to give pre-eminence to retaining and repairing coastal habitat as the key to marine conservation & carbon sequestration.

3 – Climate change, fisheries policy and management

Climate change impacts and interest provides opportunities to improve fisheries management for increased profitability

The National Climate Change Action Plan for Fisheries & Aquaculture, as developed by the Australian Fisheries Management Forum includes:

- ❑ Regional Management Approaches – Australian fisheries proposed to be managed in 3 regions – South East, Tropical and Western
- ❑ Substantial Implications – e.g. role of AFMA / Commonwealth Fisheries + cross-jurisdictional processes
- ❑ Changing, more flexible management systems – entitlements, TAC, zones, multi-species enterprises
- ❑ Going beyond "sustainable yield" – seeking optimisation across ecological, economic & social objectives

This recognises that it is timely to Improve fisheries management policy & regulations and that climate change is one of the drivers for improvement in fisheries management. Criteria for improving fisheries management policy & regulations might include

- ❑ Flexible population-based management for maximum economic yield [and underpinned by robust stock prediction models]
- ❑ Stock-based entitlements across their geographic range
- ❑ Encouraging multiple entitlements
- ❑ Recognition of the win-win opportunities for marine conservation & fisheries
- ❑ Habitat repair to become a national imperative
- ❑ All coupled with emphasis on responsible fisheries practices & reporting.

Fisheries RDC perceives that this transition to more effective and certainly less input driven fisheries management as an emerging and increasingly important area for R&D.

4 - In summary

- ❑ Smart adaptation strategies will deliver <u>multiple wins</u>
- ❑ Fisheries habitat protection, restoring tidal processes and habitat repair provide the <u>highest sequestration opportunities</u> for Australia
- ❑ Improving fisheries and marine biodiversity management policy and regulations is <u>overdue</u> - would advantage Australia's marine environments, industries & fish stocks

EL NEMO, SOUTH EAST AUSTRALIA PROGRAM (SEAP), presented by Dr Dallas D'Silva - Fisheries Victoria

"El-nemo - South Eastern Australia" is a program aimed at coordinating climate change related projects to prepare fisheries and aquaculture sectors and fisheries management to adapt to change in South-Eastern Australia.

This Program recognises that Australian marine commercial, indigenous and recreational fisheries and aquaculture sectors will be affected by climate change and the types of effects and opportunities will depend on how well prepared and adaptable the sectors and fisheries managers are to respond.

The Program will cover the marine region (including State and Commonwealth waters from approximately the South Australia/ Western Australia border to approximately the New South Wales/Queensland border). It will provide information to help those the fishing and aquaculture sectors and fisheries managers manage risk their own risks and opportunities.

The South Eastern program is the first to be established. Coordination of this program will be undertaken by the Victorian Department of Primary Industries. Information on the South East Program will be updated and placed on its webpage. In addition, a Stakeholder Advisory Group will ensure that the program's activities are targeted to the needs of those (industry, managers and the public) that will use the information.

This Program was developed by State and Commonwealth fisheries agencies, and research institutes including the CSIRO, the University of Tasmania and South Australian Research and Development Institute in recognition of the need for a coordinated, multi-jurisdictional, outcome focused program in South-Eastern Australia to facilitate adaptation of fisheries and aquaculture businesses and management to climate change.

The program will focus on the south-eastern region, and will be a key component of a national approach to climate change and fisheries and aquaculture.

The South Eastern Australia Program Plan

This Program aims to prepare marine fisheries and aquaculture sectors and fisheries management arrangements to adapt to future changes. This is vital for meeting the challenges and capturing opportunities ahead.

This is not a strategy or a plan, but a program to coordinate projects to implement action and answer priority questions, and coordinate work across jurisdictions.

Link: **The South Eastern Australia Program Plan**

El Nemo South East work commenced

The following projects allocated for 2009/10 financial year are already underway in the South Eastern region:

1. Regional modelling of physical drivers
2. Risk assessments of fisheries and aquaculture species in the region
3. Risk assessment of social and economic elements of fisheries and aquaculture in the region
4. Development of a vulnerability framework
5. Testing of responsiveness of management arrangements

The following projects from the 2009/10 financial year are yet to be completed and are intended to be included in the 2010/11 and later financial years:

1. Social Surveys to understand needs of stakeholders
2. Case studies to learn from past responses / adaptation
3. Information products of climate change implications for the sectors
4. Identification of barriers to adaptation

MARINE ADAPTATION NETWORK, presented by Assoc Prof Neil Holbrook - IMAS

July-Dec 2011

The **Marine Adaptation Network** has awarded seven **Research Support Grants** to Honours and Masters students studying in 2011. The grant scheme provides funding for honours and masters students to cover research costs of selected eligible projects focused on climate change adaptation in Marine Biodiversity and Resources.

The **Second National Marine Climate Change Adaptation Network Graduate School** was recently held from the 5-6 September 2011, at the University of the Sunshine Coast, introducing 24 research post graduates and early career researchers to climate change adaptation of marine biodiversity and living marine resources.

Alongside the graduate school, the Marine Adaptation Network held its debut **public forum: Climate Story – from Impact to Adaptation**. An initiative in response to the enthusiasm from the stakeholder community to increase communication and education between the researcher community, stakeholders and general public towards understanding climate change, impacts and adaptation for marine stakeholders. Focused on climate and the marine environment it was presented by leading Australian research scientists in climatology, ecology and social science: Associate Professor Neil Holbrook, Dr Gretta Pecl and Professor Tim Smith.

The **National Adaptation Research Plan** identifies research priorities in five main areas. These are marine aquaculture, commercial and recreational fishing, conservation management, tourism and recreational uses, and cross-cutting issues. The Marine Adaptation Networks role includes updating the “existing knowledge” (advances in research knowledge) section, i.e., gap analysis; supporting implementation of the NARP for Marine Biodiversity & Resources and facilitate outreach of relevant updates from underway Adaptation Research Grant projects. Outreach has involved dissemination in the Marine Adaptation Bulletin, network e-bulletins and information sheets.

The Marine Adaptation Network **website** is currently in the process of being restructured to allow for better connectivity and pathways to access content for stakeholders, research scientists and the general public.

The network is supporting two **workshops** to develop two issues papers that synthesise existing and emerging research to address key marine climate change adaptation knowledge gaps. The workshops will be conducted by **Russell Richards**, 23-25 November 2011 (Tim Lynam is the social scientist at the workshop, who will bring extensive “adaptation” knowledge. He will speak about adaptation as a form of social change); and **Morgan Pratchett**, 3-5 December 2011.

The Network is partnering the development of the **Marine Climate Change Report Card (MRC) 2012**, advocating that the next version has greater emphasis on social factors and regional adaptation options and providing access by recruiting the skill mix of contributing researchers using the Network registry. The 2012 MRC is essentially an 'update and revision' of the 2009 MRC.

The network publishes the quarterly bulletin entitled the **Marine Adaptation Bulletin** nationally with the main theme of: *Marine Adaptation to Climate Change* (addressing Marine Adaptation Network Summary July-Dec 2011 2

biodiversity, communities, fisheries, tourism, conservation or policy) which is distributed nationwide to our members that consist of government departments, universities, research teams, industry including fisheries and marine aquaculture, recreational fishing groups, conservation groups, tourism and other marine stakeholders. Since July 2011 the Winter Marine Adaptation Bulletin has currently been published with Spring and Summer in the editing process.

The **Marine Adaptation Information Sheets** report on marine climate change adaptation around Australia. Current published information sheets include Info Sheet 4 *Climate Change & the Marine Environment: South Australia*, Info Sheet 7 *Pre-adapting Tasmanian Coastal Reefs to Climate Change*, Info Sheet 8 *The Markets Toolkit*.

The network has grown its **membership** by 55 individuals, meeting its 6 monthly target of 50 individuals. The network is currently composed of the following groups: 1 Indigenous, 2 International Government, 4 Local Government, 18 Not-for-profit, 27 Government, 28 Non-University research organisations, 36 Private enterprise, 43 Peak Body organisations, 47 State/Federal Government , 49 Universities.

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ADAPTIVE MANAGEMENT OF TEMPERATE REEFS TO MINIMISE EFFECTS OF CLIMATE CHANGE: DEVELOPING EFFECTIVE APPROACHES FOR ECOLOGICAL MONITORING AND PREDICTIVE MODELING (NARP PROJECT), presented by Dr Neville Barrett – IMAS

Neville Barrett[1], Graham Edgar[1], Neil Holbrook[1], Maria Beger[2], David Booth[3], Stefan Howe[4], Brendan Kelaher[5], Nathan Knott[5], Colin Buxton[1], André Couto[1]

[1]IMAS
[2]University of Queensland
[3]University of Technology, Sydney
[4]Parks Victoria
[5]NSW Marine Parks Authority

Climate change necessitates management adaptation on temperate reefs in Australia

Waters along Australia's most densely populated east coast are warming at 3.8 times the global average – the most rapid change in the Southern Hemisphere [1]. Ecosystems in this region are severely threatened and significant biodiversity changes are anticipated [2], including loss of diversity [3]. Ecosystem changes associated with climate change will require wise decisions about where, how and when to apply particular adaptive management interventions [4].

Theoretical frameworks and laboratory experiments dominate climate change adaptation science, but the associated simplification of complex social and ecological processes means that potential adaptive management decisions still lack a scientific foundation underpinned by in situ measurements [4]. This project combines long-term and spatial ecological datasets from temperate reefs with remotely sensed environmental characteristics to determine climate forced signals in ecological responses, to better inform predictions of likely future changes and the practical adaptive management responses that may build resilience to such change. Unless protocols for tracking and predicting ecological changes are well informed, the remote nature of marine habitats, with associated difficulties and expense when mapping biodiversity assets, will inevitably translate to poorly-conditioned management response.

Objectives of the project

GOAL	BENEFIT
1. To build a database of remotely-sensed and other physical environmental data that corresponds to locations included in long-term Marine Protected Area and Reef Life Survey monitoring programs.	→ enable easy access to ecological and environmental databases for temperate reefs.
2. To identify climate change impacts on inshore communities and also environmental predictors of those impacts that are relevant to managers.	→ benchmark changes to the environment, and to enable an assessment of possible adaptive responses.
3. To identify indicator species/ groups for monitoring that respond measurably to the climate.	→ Identify triggers to inform the need to adapt management.
4. To engage with stakeholders to develop adaptive management of temperate reefs to manage climate change impacts, and assess the monitoring requirements necessary to inform this process.	→ develop practical frameworks for managers that integrates scientific information and managerial constraints.

20 year quantitative reef surveys and environmental data explain past changes

Central to the project is the spatial and temporal analysis of a unique dataset compiled by the Institute for Marine and Antarctic Studies (IMAS) dating back to 1992, involving quantitative surveys of reef fishes, macro-algae, coral, urchins, abalone, rock lobsters and other macro-invertebrates at >600 sites off southeast Australia [5]. Data include long-term series at Marine Protected Area (MPA) locations along the latitudinal gradient from NSW to southern Tasmania. This represents one of the longest ecological monitoring records worldwide for contrasting ecological changes within a regional MPA network with controls at fished locations in a region subject to prolonged warming over the past 60 years. Thus, when coupled with environmental data, the ecological datasets will allow an unprecedented analysis of marine species' distributional change over the past two decades. Broad-scale environmental data (sea-surface temperature, salinity, wave exposure) will be related to the marine ecological record across all sites to identify ecological changes associated with:

(i) the marine physical condition during years of significant climatic anomalies (e.g., El Niño and La Niña);
(ii) protection from fishing; and
(iii) interactions between these two factors.

The latter will be particularly important in identifying how fishing and climate changes interact.

Modelling sensitive species and robust locations to inform monitoring for climate change

Species distribution models serve to statistically estimate relationships between species abundance records and environmental predictors. The usual assumptions that ecological interactions between species can be ignored in models, and that distributional responses to climatic shifts are rapid, will be tested by cross-validating climatic envelope models developed on the basis of latitudinal distributional patterns with measurements of temporal ecological change at sites surveyed in anomalously hot and cold years. Underpinning the need to continually observe temperate reefs in our region to provide the necessary feedback for management agencies to both detect and understand the nature and magnitude of changes occurring [2], the projects' findings aim to inform monitoring. Given that such monitoring programs are expensive, and often have specific objectives (such as MPA management) they need to be refined with respect to providing cost-effective yet robust detection of biotic responses to climate change [4]. This project will identify the locations, species subsets, monitoring frequency and replication that have provided the strongest signal so far, and be used to make recommendations about future observing protocols to guide funding bodies and management agencies.

Alternative management recommendations

Where increased protection from fishing is shown to increase/decrease resilience or resistance to climate change, the ecological benefits/costs of the existing MPA network in SE Australia will be contrasted with alternative adaptive management strategies, including alterations to catch rates of key species, and increased spatial management, either via MPAs or other spatially based fishery management controls. In all determinations of potential future adaptive management arrangements, possible options will be scoped with state biodiversity conservation and fisheries management agencies, to ensure options are realistic and feasible.

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UNDERSTANDING THE GLOBAL IMPACTS AND IMPLICATIONS OF RANGE-SHIFTING SPECIES IN MARINE SYSTEMS (ANNIMS PROJECT), presented by Dr Amanda Bates – IMAS

ANNiMS (Australian National Network in Marine Science) Springboard initiative

Stewart Frusher[1], Gretta Pecl[1], Amanda Bates[1], Thomas Wernberg[2], Dan Smale[2], Renae Tobin[3], Alistair Hobday[4]

[1] University of Tasmania
[2] University of Western Australia
[3] James Cook University
[4] CSIRO

In addition to broader interdisciplinary team

Climate change driven changes in the distribution and abundance of marine species are being reported around the globe; however, much of the present focus has been on documenting these biological responses. Less well recognized is that many of the changes will affect the utilization of marine resources with ramifications that range from fishers' profitability and livelihoods to food security, poverty and social cohesion. Species 'range shifts' are considered one of the most significant and immediate effects of global warming in the marine domain. Overcoming limitations in the detection and prediction of range shifts are critical for policy adaptation to manage shifting marine resources .

Ocean warming "hotspots", or regions where ocean temperatures are rising most rapidly represent an opportunity to quickly advance our understanding of factors limiting detection of range shifts and to formulate predictions of future changes. Synthesising available data on biological responses and subsequent human impacts across marine hotspots will provide the basis for a comprehensive assessment of the dynamics and implications of range-shifting species. With two significant hotspots in Australia that are supported by existing IMOS data streams, Australia is well positioned to lead this inter-disciplinary study to provide the most comprehensive analysis to date of the dynamics and implications of marine range shifts. Such knowledge will enable researchers, industry, communities and governments to optimize of the opportunities and minimize the environmental and economic risks that will arise as some species "win" and others "lose" under climate change.

Objectives

1. Synthesise the latest biophysical (including IMOS data) and ecological data to generate a thorough process-based understanding of recent range shifts in Australia's two marine hotspots, namely SE and SW Australia.
2. Develop projections of future range shifts in key fisheries and biodiversity resources in SE and SW Australia, based on the mechanistic understanding generated above.
3. Synthesise the information from global hotspots to determine the generic similarities and specific differences across hotspot regions and to validate hypotheses regarding the mechanisms that regulate range shifts, the traits that favour range shifts and how communities, industry and governments are adapting.
4. Model the predicted effects of marine species range shifts on the social and economic components of linked human systems at various scales (e.g. fisher, fishery, community) and across marine resources in developed and developing countries.
5. Identify key challenges for marine resource management and governance arising from predicted marine species range shifts and provide a framework for developing contextually relevant adaptations.

QUANTITATIVE TESTING OF FISHERIES MANAGEMENT ARRANGEMENTS UNDER CLIMATE CHANGE USING ATLANTIS (FRDC/SEAP), presented by Dr Fabio Boschetti – CSIRO

SEAP project 5.2.

Primary Project Team (and speciality/role in team)

Fabio Boschetti [1] (complex systems, stakeholder engagement, MSE)
Penny Johnson[1] (ecosystem modeller)
Beth Fulton[1] (ecosystem model developer, MSE, EBM)

[1] CSIRO

The aim of this project was to assess the challenges for fisheries (recreational and commercial) and aquaculture management arrangements within a changing climate. The method being used is Management Strategy Evaluation, which is a simulation technique based on modelling each part of the adaptive management cycle (biophysical, resource users, monitoring, assessments and management decisions and regulations). The method is widely accepted as a best practice approach for examining single stock and ecosystem-level management questions. The strength of the MSE approach is that it does not try to find some optimal solution based on a single model; instead alternative hypotheses (typically management strategies) are evaluated using multiple candidate models (e.g. biological parameterisations or scenarios of the magnitude of climate change). The consequences of the alternate hypotheses can then be evaluated across the models to check for the robustness of the results. The other key strength of the MSE process is that it is consultative – all interested parties can have input into the candidate models and management scenarios. Effectively the MSE becomes a 'flight simulator' to help people interested in a system understand its potential responses to proposed actions and their associated trade-offs.

The information generated using the Atlantis models in this project should not only identify potential ecosystem changes and barriers to adaptation, but also support the implementation of management arrangements that provide for sustainable resource use, provide for efficient operation of markets, foster industry adaptation and enable businesses to manage challenges and take advantage of any emerging opportunities in the face of the uncertainty associated with climate impacts.

The evolution of the project is to first update the existing Atlantis models in the southeast of Australia based on the outcome of other SEAP projects (e.g. the biological and socioeconomic vulnerability assessments). The updated models will then be used to run plausible potential futures and evaluate their performance vs. ecological, economic and social management objectives. Workshops (intended to be done in conjunction with other SEAP projects requiring consultation with management agencies) will be used to define the management strategies to apply.

Project Status Summary

To date the project is largely on schedule. The Atlantis code has been refined to better represent biophysical components of climate change. For instance, nonlinear physiological limits around salinity, temperature and pH effects have been added; as well as improved representation of stratification, hypoxia and the effects of sea level rise on coastal habitats.

Environmental time series to use as forcing states for the model simulations have also been drawn together to provide best possible representation of broader climate trajectories. The most important of these has been the creation of hydrodynamic files based on global climate projections, regionally downscaled using the OFAM model that supplies ocean forecasts to the Bluelink program). These forcing projections will supply nutrient delivery, winds and currents for the Atlantis runs.

The model implementation has also been updated to allow use of the new code. The model parameters have also been updated based on new literature, data collected since the model was first built and information in the SEAP report "Risk

Assessment of Impacts of Climate Change for Key Marine Species in South Eastern Australia". These updates have been most extensive for: abalone and southern rock lobster (both of which have been implemented as size and age structured to allow for subtle size-based dynamics); snapper; small pelagic fish; large pelagic fish; tuna; flatheads; banded morwong; squid; mesopelagic fish; gummy sharks; and sea urchins. The diet connections for all biological groups in the model have also been substantially revised to reflect more realistic predator/prey interactions, based on recent updates on feeding relationships and the flexibility of diets in temperate ecosystems (as seen on the North Sea, Pinnegar et al in 2011).

Another part of the model update was to switch the base model being used. Originally Atlantis-SE (a model covering the entire SESSF fishery area and focused on the shelf and slope waters) was to be the basis of the project. However, after careful consideration of the species SEAP now proposes to focus on and the species listed as vulnerable and of management concern or interest in the SEAP ecological risk analysis, it was decided to switch focus to the Atlantis-SM model for use in this simulation project. This was because the majority of the species marked as of interest in the other SEAP projects are inshore, often reef associated species – in particular abalone, rock lobster and snapper. While Atlantis-SM does not have as broad a spatial extent (with little if any coverage of New South Wales and South Australia) it does a much better job of dealing with these inshore species than the larger scale Atlantis-SE model. This is true both in terms of spatial scales and associated processes and the species lists, as Atlantis-SM was specifically developed for modelling these inshore areas. If the socioeconomic SEAP project (when completed) points to the need to use a larger scale model for social or economic reasons the updating done for Atlantis-SM can be used to facilitate the rapid updating of the biological components of Atlantis-SE and the extra code added to allow a more effective representation of climate relevant projects will be equally valid for use with Atlantis-SE. The lessons learnt from Atlantis-SM can be generalised easily, but it should also be straightforward to extend the spatial domain of Atlantis-SM based on discussion with representatives from each jurisdiction.

Originally it was intended that management strategies to be tested were to be elicited in joint workshops with other SEAP projects (so that mangers don't get workshop burn out). However delays in the other projects meant joint workshops weren't possible. Initial management options to be tested have been discussed with a few representatives of the relevant fisheries and management bodies, with more extensive contacts initiated in September-October 2011 (workshops to follow in the next few months). Discussion of social and economic facets will be developed along with social scientists and economists working on other SEAP projects in the coming year within this project as managers get to see early outcomes of the simulations. We have also identified which of the fisheries in Atlantis-SE are likely to need to be ported to Atlantis-SM and data requests on updated costs have been made. However, the socioeconomic components have not been completely updated as yet, as we are waiting on the outcome of the socioeconomic project, to avoid having to update again once that project is complete.

Delays of the kind experienced so far are typical in large multi-project collaborative research plans. Consequently the project team has long experience in working around such delays without jeopardising the modelling project. Consequently, there should be no delay to delivery timetable of the project.

MODELLING PREDATOR/PREY INTERACTIONS UNDER CLIMATE CHANGE: IMPLICATIONS FOR A KEY COMMERCIAL FISHERY IN TASMANIA (PHD PROJECT), Felipe Briceño - Quantitative Marine Science (QMS), UTAS

Supervisors

Gretta Pecl[1], Caleb Gardner[1], Jeff Dambacher[2], Jessica Andre[1] and Stewart Frusher[1]

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This PhD project aims to evaluate how the predator-prey interactions of rock lobster and octopus are likely to alter under climate change scenarios. Importantly, this work will result in practical adjustments and improvements to the rock lobster stock assessment model and will help make the fishery more robust to climate change impacts.

Tasmania produces 23% of the total Australian commercial aquaculture and fishery yield. Southern rock lobster (SRL), *Jasus edwardsii*, is the second most important fishery resource in Tasmania, and has been identified as an "early warning signal" for how Australian fisheries may be impacted by climate change. Quantitative stock models have already been developed that can project, in a very simplistic way, potential impacts of climate change for the Tasmanian Southern rock lobster fishery (TSRF). However, to achieve a broader understanding of future climate change impacts on the SRL fishery, there is an urgent need to integrate other responses related to ecosystem functions, structure or quality ('ecosystem surprises and ecological thresholds'). For example, the interaction between SRL and its predators are likely to change as well, with some evidence that octopus, key predator of rock lobster, may increase in abundance under climate change.

This project will evaluate how the predator-prey interactions of rock lobster and octopus are likely to alter under climate change scenarios. Using innovative approaches, the project will focus on the following aims: (i) to define those biotic and abiotic key components related to highest levels of octopus predation over various spatial and temporal scales; (ii) to define/assess the predator and prey behaviour under specific environmental scenarios; (iii) to define the thermal niche of each species based on thermal physiological experiments; (iv) to model projected prey/predator distribution and abundance using mechanistic modelling approaches.

This project is embedded within a fisheries adaptation project (Pecl & Ward et al) and as such will contribute to tangible and practical adaptation outcomes for the rock lobster fishery. In addition, the current PhD project will provide a strong ecological framework that can be integrated into bioclimatic models developed for SRL populations in order to reach a broader understanding of suggested stock rebuilding strategies for this important fishery in Tasmania.

PRE-ADAPTING A TASMANIAN COASTAL ECOSYSTEM TO ONGOING CLIMATE CHANGE THROUGH REINTRODUCTION OF A LOCALLY EXTINCT SPECIES (NARP PROJECT), presented by Dr Ruth Casper – UTAS

Ruth Casper[1,3], Alistair Hobday[2], Nic Bax[3], Neville Barrett[3], Neil Holbrook[3]

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RE-INTRODUCING AN ICONIC FISH SPECIES, THE EASTERN BLUE GROPER (*ACHOERODUS VIRIDIS*), COULD MAKE TASMANIAN REEF ECOSYSTEMS MORE RESILIENT TO THE IMPACTS OF CLIMATE CHANGE.

Waters off eastern Tasmania are warming much faster than the global average

The warm East Australian Current now extends 350km further south than 60 years ago[1]. This shift in the East Australian Current is associated with significant changes to marine ecosystems in eastern Tasmania. Warm temperate species from the north, including the invasive long-spined sea urchin (*Centrostephanus rodgersii*), have become more abundant since the 1970s. Areas where long-spined sea urchins have aggregated in high densities, known as barrens, have shown a loss of at least 150 species normally associated with macroalgal beds[2,3]. Such declines in biodiversity may have flow-on effects to the rest of the ecosystem.

Biodiversity is positively linked to marine ecosystem stability and productivity4-7

Species and genetic diversity have both been found to enhance the ability of marine ecosystems to withstand recurrent perturbations[4,5,8]. Regions with higher species richness may also have more stable fisheries productivity[4,9]. In addition, loss of native species diversity is related to an increase in species invasions[4,10]. In Tasmanian Marine Protected Areas where fishing pressure is removed long term, abundances of large fishes and southern rock lobsters (*Jasus edwardsii*) are significantly increased while long-spined sea urchin populations are dramatically reduced[11].

Loss of top predators is associated with undesirable changes

Some of Tasmania's largest predatory reef fishes, including the eastern blue groper, have become functionally extinct since the late 1800s. Other large fish species have been greatly reduced in abundance[3]. The ability of long-spined sea urchin populations to reach levels where destructive grazing occurs may be associated with ecological overfishing of its primary predator in eastern Tasmania, the southern rock lobster[12].

Implications for managers and decision makers

Tasmanian fisheries account for 23% of total Australian fisheries production[13]. Reef associated fisheries, including abalone (*Haliotis rubra*), southern rock lobster and some finfish species, are most likely to be impacted by sea urchin barrens formation[14]. Native species diversity appears to buffer the stability and recovery potential of ecosystem services against rapid environmental change[4,10]. Maintaining or enhancing locally adapted populations of large fishes and other top predators may promote the resilience of Tasmanian reef ecosystems to adverse impacts of climate change, such as species invasions, loss of biodiversity and reduced productivity.

Re-introducing the eastern blue groper could pre-adapt Tasmanian coastal reefs to ongoing warming of waters off eastern Tasmania

The eastern blue groper is a temperate wrasse that grows to 18kg, and currently occurs on the east coasts of NSW and Victoria. Using the blue groper as a test case, the FRDC-DCCEE has funded a 2 year project to investigate the scientific, legal and social feasibility of re-introducing locally extinct top predator species where this would benefit the receiving ecosystem.

The 'blue groper' project – our objectives

1. Establish under what conditions re-introductions might be considered

2. Develop a national framework to evaluate potential reintroductions of native marine species

Image: Richard Ling; Source: Used under Creative Commons CC BY-NC-SA 2.0 from http://www.flickr.com/photos/rling/438035922/

3. Design a monitoring program to determine the effects of a trial re-introduction

4. Reach a critical decision point on whether to re-establish blue groper in Tasmania or to take an alternate approach to enhance top predators on temperate reefs as indicated by the research

Key features of the 'blue groper' project

- This test case is within a region undergoing rapid climate change: the process has national and global relevance

- We will develop risk assessment procedures and protocols for adaptive management

- Heighten awareness of climate change issues in Tasmanian waters through collaboration with local communities

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REVIEW OF THE EASTERN BLUE GROPER (*ACHOERODUS VIRIDIS*), Dr Ruth Casper - UTAS

Dr Ruth Casper[1,2], Dr Neville Barrett[1], Dr Nic Bax[3] and Dr Alistair Hobday[3]

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In this project, we are investigating translocation as an adaptation strategy to offset the impacts of climate change on coastal ecosystems. Specifically, we are examining the scientific, legal and social feasibilities of managed translocation of locally extinct top predator species or likely future climate migrants, where this would benefit the receiving ecosystem in terms of enhancing resilience to climate change. As a test case, we are considering the managed translocation of the Eastern Blue Groper (EBG; *Achoerodus viridis*) as a means of pre-adapting coastal reefs to ongoing warming of waters off eastern Tasmania.

As part of this process, the purpose of this report is to: review the history of EBG in Tasmania, review the known ecology of EBG, assess the potential for EBG to benefit Tasmanian coastal reefs, and identify important knowledge gaps.

Close examination of the historical evidence, together with a review of the ecology of the EBG, has led us to conclude that it is unlikely that the EBG was present in Tasmania in the 1800s, and if present, was certainly not common. However, EBG are currently present in very small numbers in north-eastern Tasmanian waters. It is likely that this reflects a southward range expansion of EBG as a result of the southerly movement of the East Australian Current. The EBG is a fish species adapted to warm temperate coastal reef environments. The EBG present in Tasmania are currently at the southern edge of their range. In addition, EBG are protogynous hermaphrodites which change sex from female to male at around 10 years of age. Consequently, it is expected that it would take many years for a reproductively viable population of EBG to establish naturally in Tasmania. This process could be speeded up by managed translocation of EBG into Tasmanian waters, following demonstration of clear environmental benefits and jurisdictional agreement.

The east coast of Tasmania is warming much faster than the global average. Associated changes to the community structure and function of some Tasmanian coastal reef communities have been rapid and dramatic. A prominent example is the southward range expansion of the long-spined sea urchin *Centrostephanus rodgersii* into Tasmanian waters since the 1970s. In parts of eastern Tasmania, the establishment of C. rodgersii in high densities has resulted in a shift from macroalgal habitat to urchin grazed barrens habitat, with a loss of over 150 species normally associated with macroalgal forests. One untested hypothesis is that reproductively viable populations of mature EBG could mitigate some of the effects of climate change on Tasmanian coastal reef communities. Of particular interest is the influence that EBG may have in reducing the negative ecosystem impacts of *C. rodgersii*. In NSW, adult EBG are commonly seen in association with urchin grazed barrens and are thought to be a key predator of *C. rodgersii*. Based on evidence from NSW, populations of EBG in Tasmania may have greater potential to improve the resilience of macroalgal habitat against an ecological shift to urchin grazed barrens habitat, than to reverse a stable urchin grazed barrens habitat back to macroalgal habitat. This suggests that any proposed translocation of EBG for this purpose would need to be part of a larger integrated management plan.

Although adult EBG in mainland waters appear to tolerate a range of habitats that vary in depth and degree of shelter, the requirements of larval and juvenile EBG are more specific. Establishing ecologically viable populations of EBG in Tasmania would depend on the availability of suitable juvenile habitat in shallow, sheltered seagrass or kelp. It is not known where EBG spawn, how larvae move from the continental shelf to seagrass beds, or how juveniles move from inner estuarine reefs to adult habitat on open coastal reefs. Linkages between estuaries and rocky reefs are important for sustaining populations of EBG, but the specific connectivity required, such as distances, movement corridors, stepping stones of natural habitat, are not known. EBG are particularly susceptible to spearfishing and gillnetting. It is therefore unlikely that EBG populations will become ecologically significant in Tasmanian coastal reefs, either naturally or through managed translocation, unless they are protected from fishing.

INFORMD STAGE 2: RISK-BASED TOOLS SUPPORTING CONSULTATION, PLANNING AND ADAPTIVE MANAGEMENT FOR AQUACULTURE AND OTHER MULTIPLE-USES OF THE COASTAL WATERS OF SOUTHERN TASMANIA, Dr Scott Condie - CSIRO

Scott Condie[1], Mark Hepburn[1], Rich Little[1], Wendy Proctor[1], Karen Wild-Allen[1], Catriona MacLeod[2] and Jeff Ross[2]

[1]CSIRO, [2]IMAS

A range of human activities influence water quality and other marine environmental values in southern Tasmania. For example, cage based salmon farming is currently restricted to the Huon Estuary, D'Entrecasteaux Channel and Tasman Peninsula, with other activities in these waters having the potential to be affected by, or have an effect on, aquaculture (e.g. industrial processes, urban development, municipal services, fisheries, recreation, tourism). Given the multi-user nature of the marine environment, it is important to recognise the diverse needs and expectations of the broader community when identifying values and evaluating trade-offs in the system as a whole. For example, water quality issues such as eutrophication and nuisance algae are important to both the aquaculture industry and the wider community, while issues such as public access, views and maintenance of recreational assets may be of particular concern to local communities. There is an urgent need to develop and apply innovative tools based on the best available scientific knowledge (e.g. INFORMD) to support consultation, planning and management of aquaculture and other uses of southern Tasmanian coastal waters.

Objectives

1. For the marine environment of southern Tasmania, characterise key environmental, social and economic values and aspirations from industry, government and community perspectives.
2. Relate these values to measurable indicators based on understanding of key biophysical and socio-economic processes.
3. Develop a framework to support spatial risk assessment for planning of future development within the system, with an initial focus on aquaculture leases.
4. Develop a framework for developing and evaluating spatial risk management strategies, with an initial focus on managing aquaculture leases.
5. Integrate the planning framework (objective 3) and risk management framework (objective 4) into an online tool accessible to stakeholders.

Approach

The project has been divided into five tasks corresponding to the five objectives:

1. Participatory workshops will be used to define key values associated with the southern Tasmanian region from industry, planning and community perspectives.
2. These values will be placed within a qualitative modelling framework that will link all the key system components and existing (or proposed) monitoring programs. This modelling will build on our current understanding of ecological and socio-economic system processes gained through stakeholder knowledge and scientific information.
3. The qualitative model will be used as the conceptual basis from which to design and implement a spatial decision support model capable of estimating the risk of proposed (or hypothetical) developments within the context of other natural processes and anthropogenic activities. For example, it will allow the impact of nutrient loads from an expansion in aquaculture to be compared with those associated with changing land-uses in the catchment. This model will be calibrated and tested against water quality data and model outputs from INFORMD and other projects in southern Tasmania.
4. The spatial model will be extended to include options for managing risks (e.g. relocating aquaculture cages in response to monitoring outcomes). It will also allow cross-sectoral strategies to be explored in detail (e.g. investment in "nutrient offsets" to mitigate aquaculture impacts through reductions in land-based inputs).

5. The spatial models will be integrated into a comprehensive online planning and management tool. It will provide a convenient platform to support consultation and planning processes, as well as the ongoing management activities of both industry and government. The online system will be designed as far as practical to be used by non-expert users, and appropriate training modules will be developed and deployed.

RESEARCH UPDATE: REMOVING URCHINS TO RECOVER ABALONE HABITAT, Dr Dallas D'Silva - Fisheries Victoria

Fisheries Victoria and the Eastern zone abalone industry have joined forces to tackle a prickly problem. Black urchins are undergoing a climate driven range extension, with numbers increasing in Eastern Victoria. The urchin's voracious grazing has reduced many abalone reefs from complex habitat to 'barrens' affecting abalone stock.

To combat the urchin invasion, Fisheries Victoria and the abalone industry are currently undertaking an experimental urchin reduction in previously productive abalone reefs. This project aims to assess the effectiveness of urchin removal in recovering abalone habitat and inform industry about the cost-benefits of removing urchins in association with commercial abalone harvesting operations.

Eight fixed-site transects were installed at Island Point near Mallacoota; four sites within in a designated urchin reduction zone and four control sites outside the zone. The Eastern Zone abalone Industry Association (EZAIA) provided commercial divers to remove urchins from the reduction zone and maintain the reduced urchin densities throughout the trial. Fixed photo quadrants were surveyed at each site at pre-reduction, post-reduction and 6 months post-reduction time scales. Currently, three urchin reduction sweeps have been undertaken by the abalone industry, with an estimated 196000 urchins removed from the reduction zone.

Fisheries Victoria has completed survey work, and photo quadrat processing and are set to begin statistical analysis to be completed early 2012.

Key contact

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CHANGING CURRENTS IN MARINE BIODIVERSITY GOVERNANCE AND MANAGEMENT: RESPONDING TO CLIMATE CHANGE (NARP PROJECT), presented by Dr Julie Davidson - School of Geography & Environmental Studies, UTAS

Michael Lockwood[1], Marc Hockings[2], Marcus Haward [3], Lorne Kriwoken[1], Julie Davidson[1], Robyn Allchin (project assistant)

[1] School of Geography and Environmental Studies, University of Tasmania
[2] University of Queensland
[3] Institute for Marine and Antarctic Studies

Funded by

This project is NARP funded. It is supported by technical and agency advisory panels. The technical advisory panel contains a broad mix of experts on marine ecology, a climate oceanography, modelling, fisheries biology, biodiversity conservation and ocean governance. The agency advisory panel comprises representatives from each of partner agencies from Great Barrier Reef Marine Park Authority, Queensland Parks and Wildlife Service, Office of Environment and Heritage, Department of Premier and Cabinet, NSW Government, Tasmanian Parks and Wildlife Service, and the Marine Division, Department of Sustainability, Environment, Population and Communities, Australian Government.

Context

The background to this NARP-funded project concerns the implications for marine biodiversity conservation in the context of climate change-induced shifts in the structure and composition of marine ecosystems – from impacts such as ocean warming, acidification, sea level rise, increased disturbance from storm activity, changes in water quality from catchment-based effects, and changes in major climatic systems (e.g. ENSO). Biophysical effects are also interacting synergistically with human impacts such as fishing effort facilitating invasion of pest species. Two impacts of particular concern for biodiversity conservation are coral bleaching and species range shifting.

These changes raise the question of the adequacy of current marine biodiversity governance and management arrangements – how will they accommodate both present and future species and ecosystem distributions? Authorities are faced with a situation of great uncertainty and complexity. The main problem is that current regimes were not designed for changing conditions and they may not be flexible enough to accommodate the changes that are occurring. Climate change therefore presents a challenge to current conservation norms which are mainly founded on reserves with fixed boundaries.

One of our arguments is that if ecosystems are to be sustainable, then governance and management should support and indeed restore their natural resilience to give them time to adapt to the changes that are occurring and will occur over the coming decades.

Aims/objectives

The objectives of the project are to:

- identify the requirements for adaptive marine biodiversity conservation governance and management in the context of climate change;
- assess how well current regimes, with a particular focus on marine protected areas, meet these requirements, and determine any necessary changes ;
- identify alternatives to current regimes that are likely to enhance adaptivity and assess their governance and management effectiveness; and
- offer advice to governance and management authorities on how regime reform might be achieved.

Scope and scale

The project is founded on three case studies – the Whitsundays in tropical waters, the Tweed-Moreton bioregion in the transition zone between tropical and temperate waters, and the Freycinet bioregion in the cool temperate waters of Tasmania's east coast.

The key time frames are 2030 and 2070 to align the project's outputs with other NARP projects. There are five project phases:

- Confirmation of approach and methodology
- Identifying the requirements for adaptive marine biodiversity governance and management
- Assessing how well current regimes meet these requirements and determining any changes
- Identifying alternatives to current regimes that are likely to enhance adaptivity; assessing their governance and management effectiveness
- Offering advice to governance and management authorities on how regime reform might be achieved\

The first two phases have been completed and work is proceeding on the third. The first phase involved working with the advisory panels to confirm and redesign the research approach while the second phase entailed development of a set of adaptive governance and management requirements from the literature, obtaining feedback from the advisory panels on the adequacy of the requirements, and undertaking an Delphi (expert panel) process as an alternative approach to determining appropriate marine biodiversity governance and management requirements. The third phase comprises scenario workshops for each case study area, modelling of the social-ecological system, testing of existing governance and management frameworks against the governance requirements and recommendations for reforms. Phase four will include scoping the limitations of the current regime and identification of needs, opportunities, potential innovations and reforms. The innovations will be confirmed by a second Delphi process. All through these phases data will be collected to inform the system model. Phase five will focus on how the best-performing alternative regime can be implemented and will investigate how to tailor the suggested adaptive governance and management regime to suit the various jurisdictional, resource and environmental contexts on Australia's east coast and enable them to meet the current and emergent challenges for biodiversity conservation.

Methods

The main methods used in the research project include:

- Delphi (expert panel) process
- Scenario development
- System modelling
- Deliberative engagement

The Delphi process is an iterative, multistage process that is aimed at transforming individual expert opinion into a group consensus. Two iterations of the Delphi process will be utilized. The first use of the process will involve driving a consensus among governance experts on the research team's adaptive governance requirements. The second Delphi survey will be used to confirm the potential governance and management innovations and reforms.

Scenario planning or scenario development is a useful tool to help in coping with uncertainty, and especially uncertainty that is not controllable. In this project we will be working with explorative scenarios and asking what can happen if the current marine biodiversity governance and management regime does not change even as the biophysical conditions are changing.

We will also be undertaking some modelling of the social-ecological system for each case study area using Bayesian Belief Networks (BBNs). The BBNs will be used to build and assess the system model – i.e. performance and obstacles to achieving a desired condition, improvements in performance as obstacles are removed, and assessment of management interventions.

For this project, deliberative engagement between researchers and decision-makers involves the opportunity to influence the research design (i) to ensure policy relevance and (ii) to build collective ownership of the knowledge and outputs. The main input of the advisory panels has been in confirming the governance requirements. They will also be involved in scenario workshops in November and next year in workshops to test the case study governance and management arrangements against the suggested requirements.

MARINE CLIMATE CHANGE ASPECTS OF NER, presented by Dr Piers Dunstan – CSIRO

Piers Dunstan[1] and Nic Bax[1]

[1]CSIRO

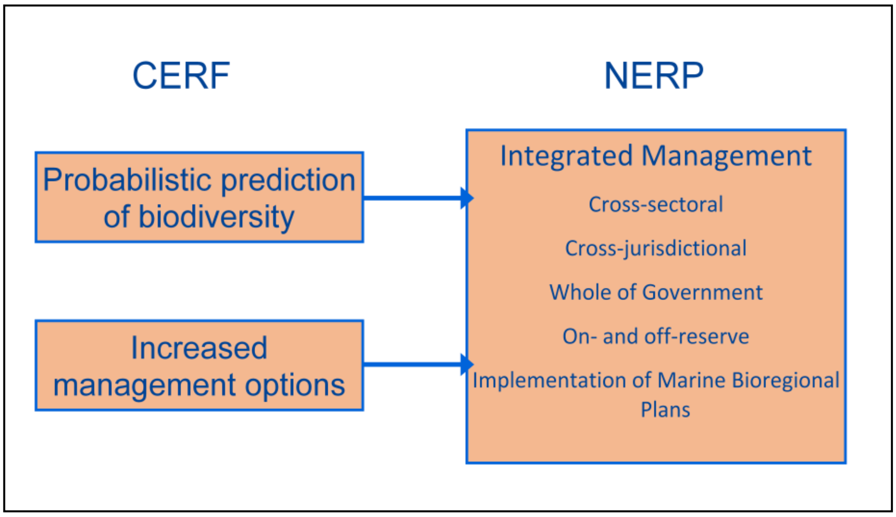
The CERF hub and its successor, the NERP Marine Biodiversity Hub do not have climate change as an explicit element, but many of the products and discoveries can be used in climate research.

THE CERF HUB WAS CONCERNED WITH DESCRIBING AND PREDICTING BIODIVERSITY
Environment Minister Peter Garrett said in 2009: *"Limited information about Australia's marine biodiversity, especially for the species and ecosystems of the more remote and deeper areas, has been a barrier to developing a strategic approach to the sustainable management of our oceans."*
Outputs relevant to this meeting include:

- National maps of 37 physical variables on a 1 km2 grid
- All available biological surveys going back to Soviet trawl surveys in the 1960s
- New statistical methods for predicting biodiversity

NERP Marine Biodiversity Hub 2011-2014

This builds on the CERF goals to focus on integrated management:



The partners are: UTAS, CSIRO, AIMS, GA, Museum Victoria, UWA, CDU

There are 4 Themes, as follows:

National Monitoring Evaluation and Reporting

Two Projects: Development and testing of approaches for monitoring Marine Reserves and Key Ecological Features; Analysis of existing datasets to test predictions of monitoring models for national ecosystem health

Integrated Management of Marine Biodiversity

Four Projects: Integrating social, economic and environmental values; Integrating threats, values and assets for management; Integrated management of priority conservation values; Integrated management of euryhaline elasmobranchs.

National Ecosystems Knowledge

Two Projects: Shelf and canyon ecosystems – Northern Australia; National maps of connectivity and biodiversity

Regional Biodiversity Discovery

One Project (so far): 21-day survey on RV Solander – North or Coral Sea

Some SEWPaC Areas of Interest that shaped the NERP goals

- A strategic understanding of biodiversity. How do we recognise areas of importance and have this information in advance to respond to proposed oil and gas (or other) developments.
- Define biodiversity values and classify what can be done with respect to those values? How would we identify the most significant areas for protection?
- Strategic assessments – what is a significant impact? How do we measure the cumulative impacts of developments? What are the important pressures – now and in the future? What is a suitable offset?
- Monitoring – how to do it well and complete it economically;
- The need for good information – oil and gas industry was seen as a potential source of much useful information.

PREPARING FOR CLIMATE CHANGE IN MARINE SYSTEMS OF AUSTRALIA AND INDIA (AUSTRALIA-INDIA STRATEGIC RESEARCH FUND PROJECT), presented by Assoc Prof Stewart Frusher - IMAS

Assoc Prof Stewart Frusher[1], Dr Gretta Pecl[1], Assoc Prof Neil Holbrook[1], Assoc Prof Marcus Haward[1], Dr Sarah Jennings[2], Dr Alistair Hobday[3], Dr Melissa Nursey-Bray[4], Dr G. Syda Rao[5], Dr E.V. Radhakrishnan[5], Dr E. Vivekanandan[5], Dr T.V. Sathianandan[5], Dr C. Ramachandran[5], Dr Shyam S. Salim[5], Ms Muktha Menon[5]

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Summary

Climate change is a major challenge facing Governments, Industries and Communities and requires an inter-disciplinary approach. Marine resources in both southern India and southeastern Australia provide substantial social and economic benefits which flow into many rural communities. Both regions have been identified as global warming hotspots with the rate of climate warming predicted to be greater than 90% of the global average. This project, based on two workshops, will bring together inter-disciplinary researchers from both India and Australia with expertise in physical, biological, social, economic and governance climate change research to develop a strategic research plan for future collaborative research. The workshops will identify the key physical drivers (e.g. temperature, currents) that are predicted to affect species abundance and distributions, develop biological, social and economic indices that can be used to monitor impacts on species, industries and rural communities and investigate options for policy and management of marine resources.

India
~ 6 million people were employed in fishing and aquaculture in 2000
Produced approx 3,000,000 tons of fish (aquaculture and capture)

Australia
~14,000 people employed in fishing and aquaculture
Produced approx 300,000 tons of fish (aquaculture and capture)
(Earthtrend, World Resource Institute)

Outcomes

The strategic plan developed by the project will prioritise collaborative research projects for future funding, including AISRF (Australia-India Strategic Research Fund). Projects will cover the oceanography, biology, social science, economics and governance disciplines as well as inter-disciplinary approaches. The plan will include a mix of research projects and PhD projects. In addition to addressing the key needs of both countries in terms of climate change impacts and adaptation on marine resources, the project will increase the strategic alliances between Indian and Australian researchers in the priority area of marine science. By combining the expertise of both Australian and Indian marine climate researchers, the strategic plan will become a “blue print” for adaptation scenarios to minimise the impacts of climate change on industries and associated communities and for maximising opportunities that will maintain and build the social and economic benefits that can be derived from sustainable use of marine resources.

IDENTIFICATION OF CLIMATE-DRIVEN SPECIES SHIFTS AND ADAPTATION OPTIONS FOR RECREATIONAL FISHERS: LEARNING GENERAL LESSONS FROM A DATA RICH CASE (NARP), Daniel Gledhill, CSIRO

Daniel Gledhill[1], Alistair Hobday[1], Matt Lansdell[1], Peter Last[1], David Welch[2], Adam Smith[2], Steve Sutton[3], Matt Koopman (project liaison for the Southern Freedivers, Vic.), and Adrian Jeloudev (project liaison for the Underwater Skindivers and Fishermen's Association, NSW)

[1] CSIRO
[2] Australian Underwater Federation
[3] James Cook University

Background

Fishing is an important recreation activity for over five million Australians (DAFF, 2009). Managing recreational fisheries is likely to become increasingly complex due to changes induced by global warming, for example, extensions of species ranges are already being recorded for recreationally targeted species in Australian waters (Last et al., 2010). There is limited understanding of how these changes will impact on the fishing experience of recreational fishers.

Long-term, statistically robust datasets of marine organisms are rarely available. Incidental and non-quantitative data sets are therefore increasingly being utilised to address this knowledge gap (e.g. Gartside et al. 1999, McClenachan 2009).

Spearfishers have collected their own data over many decades, and therefore have ownership and trust for these data. Importantly, spearfishers also have a long history of adaptation and marine stewardship. Self-regulation has occurred, for example, through changes to the competition scoring systems (e.g. when species have become rarer, or more common), and by the removal of vulnerable species from competition score cards.

Members of the executive of the Australian Underwater Federation (AUF) were approached to determine the breadth and availability of historic data from spearfishing competitions held on Australia's eastern seaboard since the 1970s. In working with members of the AUF, the level of interest expressed by the spearfisher community suggested this would be a unique opportunity to work with a proactive, organised and well-defined group of recreational fishers to collaboratively develop adaptation options to assist management, and to develop a model that may be suitable for engaging other sectors of the recreational community.

Objectives

1. Determine changes in distributions of rocky reef fish in eastern Australia over the past four decades, and establish correlation of these changes to climate induced environmental change (e.g. temperature).
2. Determine perceptions of the test group regarding climate-induced changes to fish distributions and abundance and identify adaptation options.
3. Develop and test a "process model" for engagement and development of climate change adaptation options suitable for deployment to other fishing sectors and user groups, including commercial fishers.

CSIRO FLAGSHIP CLUSTER: INSTITUTIONAL AND SOCIAL BARRIERS TO SCIENCE IMPACT (CSIRO COLLABORATION FUND), presented by Assoc Prof Marcus Haward – IMAS

Co-Leader Knowledge Systems Theme

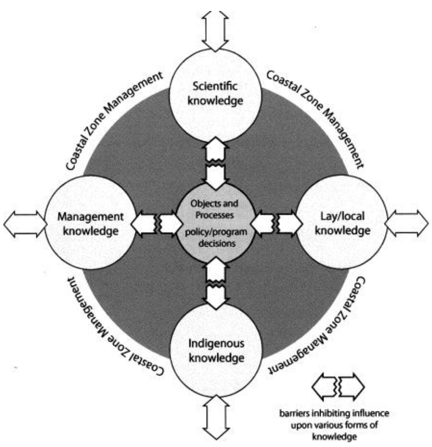
The Coastal Collaboration Cluster

The Coastal Collaboration Cluster, supported by CSIRO's Flagship Collaboration Fund is a major three-year research program involving seven universities to develop approaches to better our coastline for future generations by enabling them to make better use of the connect science with the needs knowledge produced by scientific research. The cluster partners will identify the factors that inhibit the uptake of science in the coastal zone. They will look at ways to introduce and apply the best knowledge available to coastal policy and planning processes so that Australia can better manage changing coastal pressures. The cluster brings together researchers from across Australia with a wide range of expertise. The cluster is coordinated by Curtin University, with participation by groups at Deakin University, Flinders University, University of Adelaide, and University of the Sunshine Coast, University of Wollongong and the University of Tasmania, working with CSIRO's Wealth from Oceans and Climate Adaptation flagships. The Cluster is composed of five themes: governance, socio-cultural context, knowledge systems and adaptive leaning, linked through an integration and synthesis theme.

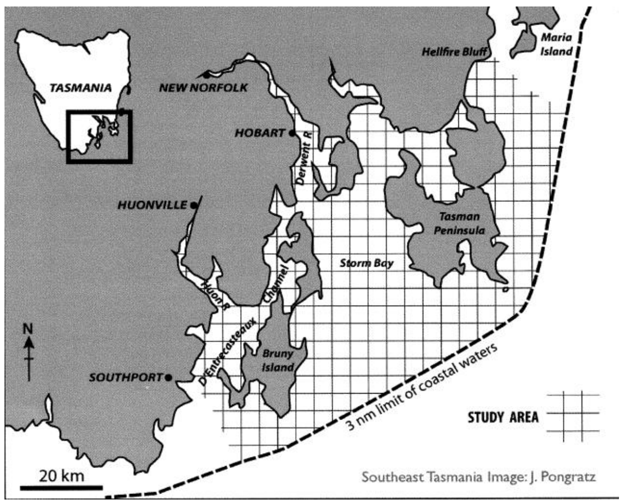
Knowledge Systems Theme

The Knowledge Systems Theme analyses the process of knowledge integrations and exchanges as it presently affects coastal zone management. It addresses both barriers to uptake, and how the different forms of knowledge – scientific, managerial, lay and indigenous – can better influence the decision-making process and outcomes for end users of that knowledge. It addresses of knowledge systems in two regions: the Derwent-Huon region in South Eastern Tasmania and the South West Victoria region in Victoria.

CERF



NERP



The research aims of the theme are to: • develop a model of current coastal knowledge systems • identify constraints to knowledge communication (resulting from, for example, power, funding, complexity of the knowledge system in the uncertainty, scale and self-referentialism) • investigate whether systems of knowledge can be more open and communicative with governance and decision-making processes; and more reflexive and civic in orientation • understand how situated and relational knowledge affect the specific outcomes of decision-making in particular areas. Key outputs include: •A model of credible, communicative, reflexive, valid and transdisciplinary knowledge system capable of supporting change in the coastal zone; • A report presenting a critical analysis coastal zones under study •Papers published in scholarly journals and presented at conferences.

AUSTRALIA'S INTEGRATED MARINE OBSERVING SYSTEM (IMOS) – OPPORTUNITIES FOR UNDERSTANDING CHANGES AND VARIABILITY IN THE SOUTH EAST AUSTRALIAN MARINE REGION, presented by Dr Katy Hill – IMOS

The Integrated Marine Observing System (IMOS) was established under the National Collaborative Research Infrastructure Strategy (NCRIS), with initial funding of $50M in 2007. With an additional $52M from the Education Investment Fund (EIF) provided in the 2009 Federal Budget, IMOS will be extended to mid-2013 and is enhancing its monitoring in the Southern Ocean and northern Australian waters. It has successfully deployed a range of observing equipment in the oceans around Australia, and is making all data freely and openly available through the IMOS Ocean Portal (http://imos.aodn.org.au/webportal/).

Observations being undertaken are guided by science plans developed within the marine and climate science community. These plans address five major research themes: multi-decadal ocean change, climate variability and weather extremes, major boundary currents, continental shelf processes and biological responses. IMOS is designed to be a fully-integrated, national system, with regional specific foci; guided by a National Science and Implementation Plan that has been developed collaboratively with the open-ocean 'Bluewater and Climate' Node, and the five regional Nodes covering Australia's coastal oceans i.e. NSW-IMOS, QIMOS, WAIMOS, SAIMOS and TasIMOS.

Evidence for changes and variability in the East Australian Current system, and the resultant southward range shifts of species along the east coast is mounting. IMOS is delivering data-streams to support research into processes at regional and national scales, and linking physical processes to biogeochemistry and ecosystem responses. The deployment of a full depth mooring array to monitor the heat and mass transport of the East Australian Current off of Brisbane is planned for first quarter 2012. The deep-water moorings are connected to a shelf array and will provide the upstream boundary condition for observations along the SE Australian, supporting research into changes and variability in shelf processes and ecosystem responses along the Southeast Australian seaboard.

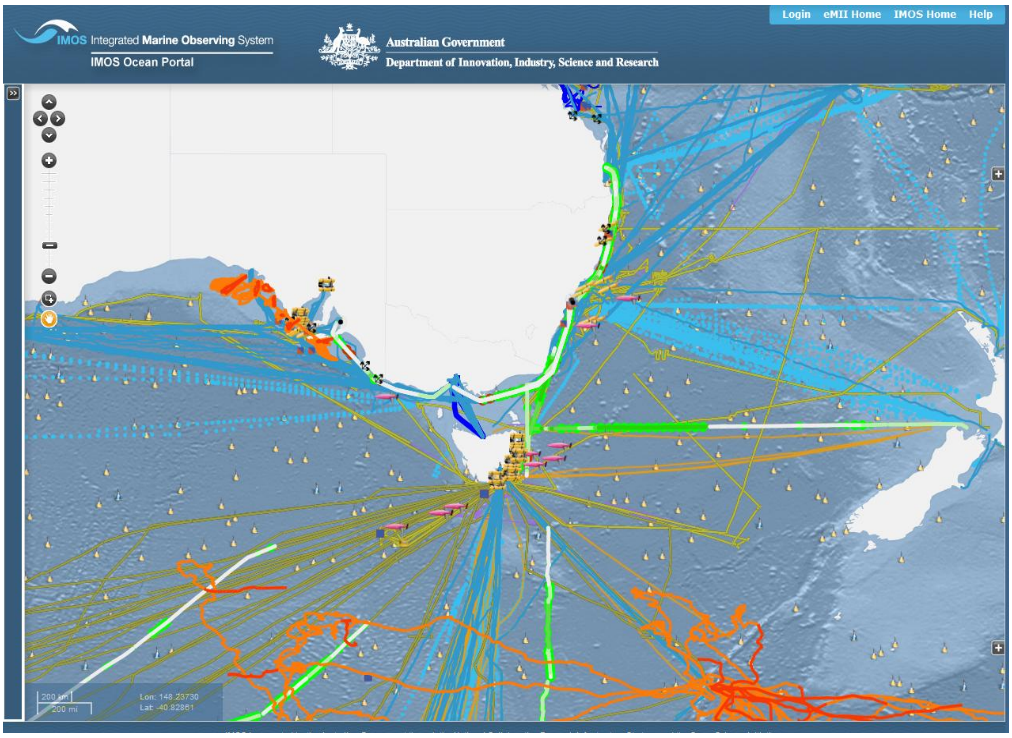


Figure: IMOS Observations in SE. Australian region in the IMOS Ocean Portal

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IMOS Integrated Marine Observing System

IMOS DATA-STREAMS AVAILABLE IN THE SOUTHEAST AUSTRALIAN REGION, Dr Katy Hill, IMOS Office

November 2011

This summarises IMOS data-streams in the Southeast Australian region data is available through the IMOS Ocean Portal http://imos.aodn.org.au

If you have any questions of have feedback on

- IMOS data delivery formats and priority data products (i.e. boundary current heat transports, Mixed layer depths, etc). http://imos.aodn.org.au
- Priority data to be delivered through the AODN. http://portal.aodn.org.au
- Feedback on IMOS Ocean Current as it develops http://imos.org.au/oceancurrent

Please contact katy.hill@imos.org.au or info@emii.org.au

Argo Australia

Argo floats provide broad-scale observations of temperature and salinity profiles every 3x3 degrees down to 1500-2000m. Selected floats also carry oxygen sensors.

Ships of Opportunity

High Density Expendible Bathythermograph (XBT) lines provide temperature profiles down to 800m every 25km between Brisbane to Fiji and Sydney to Wellington 4 times per year. This data has been used to derive transports for components of the East Australian Current system.

The continuous Plankton recorder is towed from Brisbane through to Melbourne and onwards to Auckland.

Bio-acoustic observations for estimating mid-trophic biomass are made across the Tasman Sea between Burnie (Tas) and Nelson (NZ), and between Hobart and south of New Zealand. Other regional lines are under development.

Underway observations of temperature, salinity and fluorescence are daily taken across the Bass Strait on the Spirit of Tasmania.

Deep-water Moorings

A deep mooring array of 5 moorings will be deployed off Brisbane in April 2011 along the XBT line, to measure the full depth transport of the East Australian Current

National Mooring Network

National Reference Stations at North Stradbroke Island (QLD), Port Hacking (NSW), and Maria Island (Tas). NRS's comprise a mooring (temperature, salinity, fluorescence, turbidity, oxygen), and monthly sampling (temperature, salinity, nutrients, phyto and zooplankton). Maria Island also has a pCO2 mooring. When combined with observations at the NRS, the full carbonate chemistry can be determined.

A shelf array of 2 moorings, will be deployed between the NRS at North Stradbroke and the deep array to observe the interaction between the EAC and continental shelf processes.

Along the New South Wales coast, shelf moorings are deployed along the NSW coast at Coffs Harbour (2), Sydney (3), and Batemans Bay (2).

Ocean Gliders

Slocum gliders operate in shelf waters down to 200m. These are deployed along the NSW coast off of Coffs Harbour and Sydney to criss-cross the NSW Shelf.

Sea gliders operate in deeper waters, down to 800m and are deployed into the EAC Eddy field and extension off Sydney and off Bicheno/St Helens, Tasmania.

All gliders deliver temperature, salinity, and bio-optical data (fluorescence and C-DOM).

HF Radar

A HF Radar array is being deployed off of Coffs Harbour, which will deliver surface current maps, and some wave information.

Animal Tagging (AATAMS)

Curtains of acoustic receivers are deployed around the coast (both IMOS funded and non-IMOS funded). We are in the process of developing a database to make available information on the tags which have crossed these lines. In this model, IMOS is deploying the acoustic receivers, and PI's are deploying the tags.

Autonomous Underwater Vehicle (AUV)

The AUV is deployed to deliver stereo imagery of benthic reference sites around the country, which are revisited every 1-2 years. In the South East, these sites are off of SE Queensland, along the coast of NSW, and along the east coast of Tasmania. The primary motivation is to monitor the impact of changes in the EAC system (current strength and temperatures) on benthic assemblages.

Satellite Remote Sensing

The role of IMOS in remote sensing is two-fold:

- To deliver high quality calibration/validation data to the global repositories so we have confidence in the quality of global products in our region.
- To deliver high quality regional products to meet the needs of the Australian user community.

IMOS is focusing on 3 data types:

Sea Surface Temperature (SST)

Sea surface temperature data is delivered as part of the Group for High Resolution SST (GHRSST www.ghrsst.org) program. Regional in situ SST data for calibration is collected on ships of opportunity using hull contact sensors. The products delivered are 14 day composite (gridded) bulk SST data back to 2001, and single day/night single sensor composite (gridded) data.

Sea Surface Height (SSH)

IMOS has invested in 2 calibration altimeter sites in Bass Strait and Storm Bay, which form the only calibration sites in the Southern Hemisphere. Gridded altimeter data is currently available through the Ocean Current project (http://imos.aodn.org.au/oceancurrent) and will soon be available through the portal.

Ocean Colour

Calibration of Ocean Colour is a challenge with a shortage of "match up" calibration data. Therefore, IMOS is developing a bio-optical database, to pull together all bio-optical data in the Australian region and make it available to the global repositories NASA SeaBASS and ESA Globcolour. A regionally calibrated ocean colour product for case 1 waters will soon be available. In addition, the bio-optical database will enable more research into the optical properties of case 2 waters.

The Australian Ocean Data Network

The Australian Ocean Data Network aims to deliver Australian marine data through a single portal (http://portal.aodn.org.au). The major federal agencies have signed up to making their data available through this system, with the mantra "publically funded data, publically available" and the AODN is also gaining traction with state agencies and the private sector.

Example data available includes:

- Coastal meteorology data from the Bureau of Meteorology.
- Underway data from Australian research vessels
- Historical CTD data from the Marine National Facility (including Southern Surveyor and Franklin).
- Bio-regionalisation data from CSIRO.

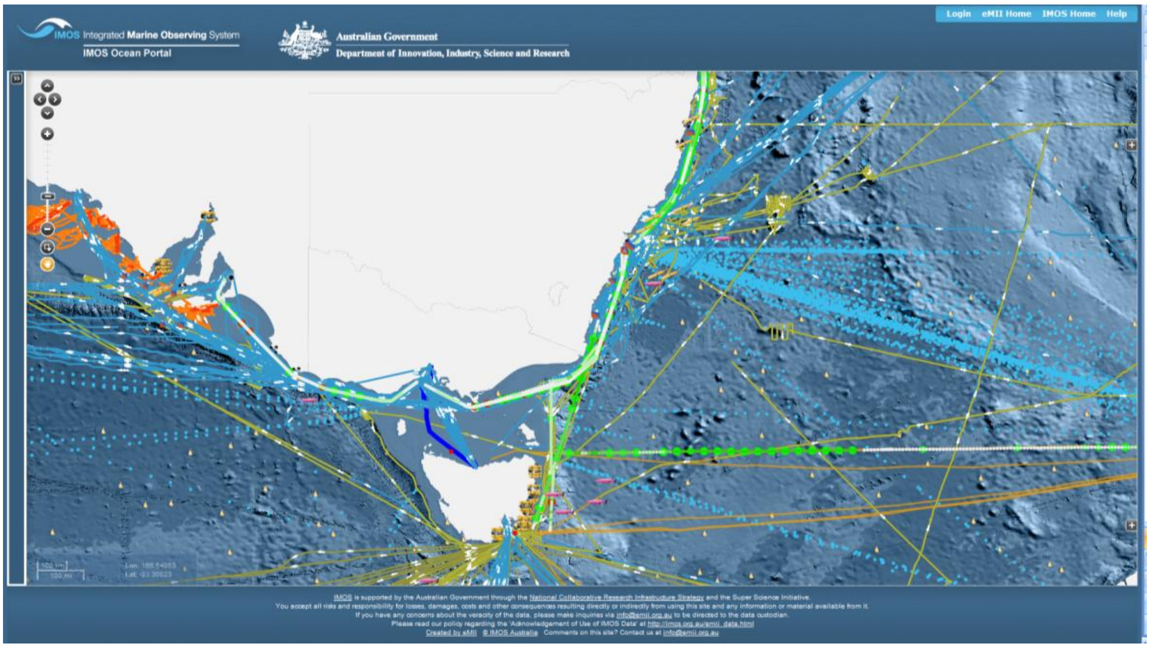


Figure 1. A snapshot of the portal.

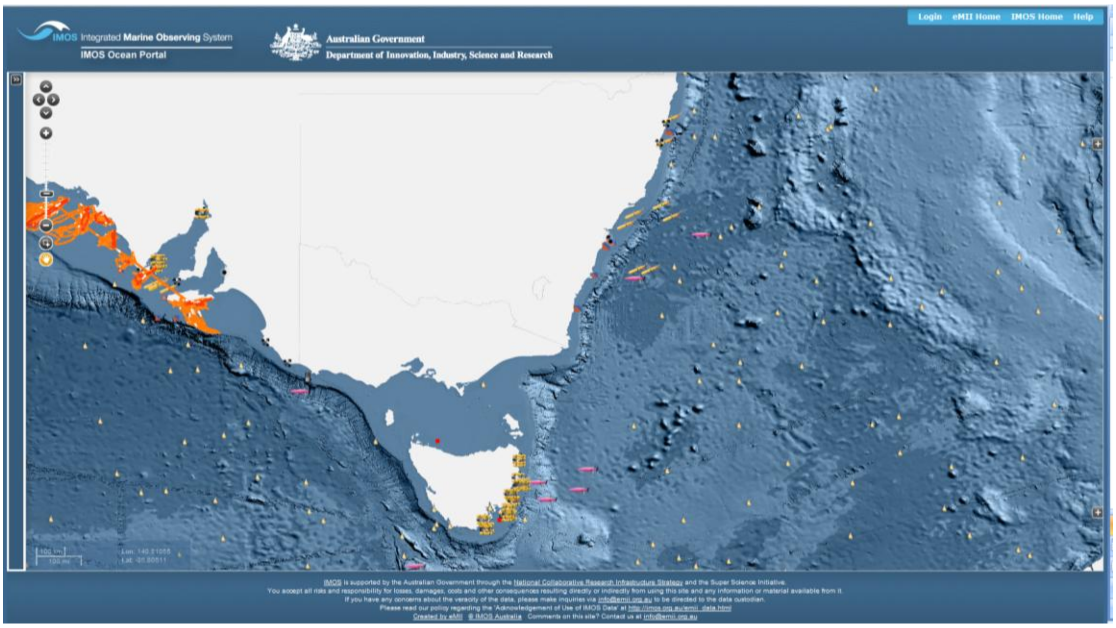


Figure 2. A snapshot of the portal, with Ships of Opportunity lines removed.

UNDERSTANDING THE BIOPHYSICAL IMPLICATIONS OF CLIMATE CHANGE IN SOUTHEAST AUSTRALIA: MODELLING OF PHYSICAL DRIVERS AND FUTURE CHANGES (SEAP), presented by Dr Alistair Hobday - CSIRO

SEAP Project (FRDC 2009/056) – delivered draft final September 19, 2011

Alistair Hobday[1], Jason Hartog[1], John Middleton[2], Richard Matear[1], Scott Condie[1]

[1] CSIRO
[2] SARDI

Objectives

1. Extract variables from Bluelink and GCM's for fishery regions around the SE
2. Validate variables derived from the Bluelink model against the IMOS and other historical data
3. To complete development of SAROM and validation against the IMOS and historical data for the February 2008 - March 2010 period
4. Compare the predictions of the two models to each other and to GCMs
5. Derive, extract and examine model outputs on derived variables, including acidification levels, in the SE region.
6. Provide these data in written and visual format to the biological and review teams for consideration
7. Consider historical changes in connectivity in the south-east

This project set out to improve the understanding of change in the physical environment and determine if further oceanographic model development was required to support biological, social and economic aspects of the SEAP. The objectives of this project were met. Oceanographic data for the entire south-east region were extracted and archived from the Bluelink ocean model hindcasts for comparison with observations (Objective 1) and can be used to examine historical patterns of change. These variables included sea surface temperature, temperature at depth (200 m), surface salinity, and currents. The Bluelink model variables were compared with observations at a range of distances from the coast (i.e. "do they sufficiently represent reality") (Objective 2), which showed that SST was the best performing variable, and the currents were the poorest at the spatial and temporal scales considered. Development of the South Australian Regional Ocean Model (SAROM) model, which covers a smaller region in South Australia, was completed and comparison with in situ IMOS data showed the performance was very good in the regions considered (Objective 3). Qualitative comparison of the regional models was completed (Objective 4) and we recommend that both models will be useful for a range of biological uses. Projections of future acidification levels were completed (Objective 5). There are few studies on the impact of ocean acidification for the south-east region to date. Implications for commercial fishes and invertebrates (e.g. rock lobster and abalone) in the south-east region are unknown, and there is a need for more experiments and field studies before impacts can be more specifically determined. We have provided some future estimates of pH levels, such that critical experiments using realistic values can proceed. Finally, methods to determine marine connectivity in the south-east for the recent past were detailed and patterns of change reported (Objective 7). These analyses showed a recent trend towards increasing southward transport off eastern Tasmania, consistent with the documented increase in the strength of the East Australian Current and the associated warming of waters off eastern Tasmania that is predicted to continue over the next half century. We conclude and advise that:

1/ Data can be extracted from the existing set of physical ocean models that is suitable for retrospective analysis of biological patterns; 2/ There is no single best ocean model for all purposes; careful selection and validation should be part of each use of model-based environmental variables. Each model does have strengths and will be appropriate for different uses. We suggest that case studies of fishery species in the south-east discuss their modeling needs with physical oceanographers; 3/ Development and improvement of the existing models is not a roadblock to further fishery adaptation planning in the south-east; and 4/ The suite of available physical data is sufficient to support the next phase of biological case studies as part of SEAP.

FORECASTING OCEAN TEMPERATURES FOR SALMON AT THE FARM SITE (FRDC – TRF), Dr Alistair Hobday - CSIRO

FRDC TRF Project No. 2010/217 – Final report delivered October 17, 2011

Alistair Hobday[1], Vincent Lyne[1], Ron Thresher[1], Claire Spillman[2], Ana Norman-Lopez[1]

[1] CSIRO
[2] Bureau of Meteorology

Objectives

Generate site specific seasonal water temperature statistical forecasts for three nominated farm sites.
Generate and test the skill of dynamical regional ocean forecasts using the BOM seasonal prediction model (POAMA)
Undertake cost-benefit analysis of the value of these short-term predictions for the salmon industry

OUTCOMES ACHIEVED TO DATE

Development of seasonal water temperature forecasting methods for the farmed salmon industry allows future planning and risk management against predicted environmental conditions. Monthly forecasts were delivered for the period September 2010 to March 2011, for four sites in Tasmania (south-east and Macquarie Harbour). These forecasts can be used to inform a wide range of tactical farm management decisions, and represent an investment in best practice for the industry – as occurs for a number of land-based farming operations. The cost of forecasts is very low in real terms, and relative to the potential benefit. The salmon industry has indicated that these forecasts can inform planning for the coming months, and offer considerable returns in cost savings relative to the investment. Delivery of forecasts in the coming years is now possible, and the individual salmon companies are deciding on their on-going operational requirements for the coming year.

Many marine businesses, including aquaculture, are impacted by environmental conditions at a range of time scales. Information about the future weather or climate conditions, commonly called forecasting, is useful for risk management, business planning, and if used correctly, improving overall business performance, leading to increased profitability. Recent partnerships with the Tasmanian salmon industry have raised awareness about the potential impacts of climate change, and in particular, warm summers are a potential risk. This risk can be managed if information about the future were available. There are a range of operational decisions that could be modified on the basis of forecasts of environmental conditions. Advances in seasonal ocean forecasting –information about the ocean state at a time scale of weeks to months – means such warning is now possible.

We examined several approaches to delivery of seasonal forecasts of water temperature for the Tasmanian salmonid industry. Data on water temperature at the farm sites was provided and varied in length. Both statistical (Objective 1) and dynamical (Objective 2) forecasting approaches were tested for skill and accuracy, using historical hindcasting. Longer time series are expected to provide more robust statistical forecasts. We also developed a generic cost-benefit model to evaluate the economic benefit to farms that used the forecasts.

A statistical approach based on time series analysis of historical and recent data from each of four farm sites was used to deliver monthly forecasts of average monthly temperature. A total of seven monthly forecasts (Sept 2010 to March 2011) were delivered for each site. The accuracy of forecasts was greatest for the Tasman site (mean difference between forecast and actual observation overall lead times of 0.28°C), followed by Dover (mean difference between forecast and actual observation overall lead times of 0.3°C), Huon (mean difference between forecast and actual observation overall lead times of 0.45°C), and Macquarie Harbour (mean difference between forecast and actual observation overall lead times of 0.62°C). The forecasts for the year 2010-11 correctly predicted above or below average temperatures for all lead times 100% of the time for Tasman, 87% for Dover, 80% for Huon, and only 60% for Macquarie Harbour.

The exploration of dynamical forecasting based on the Australian Bureau of Meteorology (BOM) seasonal forecast model; Predictive Ocean Atmosphere Model for Australia (POAMA). This state-of-the-art seasonal to inter-annual seasonal forecast system is based on a coupled ocean/atmosphere model and ocean/atmosphere/land observation assimilation systems, and used for coral bleaching and tuna habitat forecasting in other regions of Australia. We evaluated the potential for forecasting water temperatures using the dynamical model to project regional temperatures and then downscaled these to the farm site. The forecasting of average regional temperature around Tasmania generally showed good skill for up to three months into the future, during both summer and winter months, although as expected, skill declined with increasing lead time. Measured sea surface temperature anomaly (SSTA) values at the farms and the observed regional Tasmanian SSTA index (ITAS) were strongly correlated for 1991-2010, with $r = 0.76$ and $r = 0.83$ for Huon and Dover, respectively. The high correlations between the regional index and the farm data indicated that the index is a useful predictor of farm conditions. The model demonstrates useful skill up to lead-times of 1-2 months throughout the year. Overall, the forecast skill for ITAS, coupled with the observed relationship between ITAS and the farm locations, resulted in a lower skill in predicting conditions at the farm sites. However these results still show the model has useful skill in predicting farm temperatures within the upcoming season (e.g. a forecast could be skilful for December when issued 1 October).

Suggested citation

Hobday AJ, Lyne V, Thresher R, Spillman C, Norman-Lopez A (2011) Atlantic Salmon Aquaculture Subprogram: Forecasting ocean temperatures for salmon at the farm site. FRDC report 2010/217.

HUMAN ADAPTATION OPTIONS TO INCREASE RESILIENCE OF CONSERVATION-DEPENDENT SEABIRDS AND MARINE MAMMALS IMPACTED BY CLIMATE CHANGE (NARP), Dr Alistair Hobday - CSIRO

NARP project: FRDC 2010/0533

Alistair Hobday [1], Lynda Chambers[2], John Arnould[3]

[1] CSIRO
[2] Bureau of Meteorology
[3] Deakin

Climate change is already impacting the oceans and marine life around Australia. In recent years, shifts in species distribution have been documented at a range of lower trophic levels in Australia, including phytoplankton, zooplankton, intertidal and subtidal invertebrates such as snails and sea urchins, and more than 40 species of coastal fish. However, responses to climate variability and change for Australia's iconic higher trophic level marine taxa are poorly understood, including for many conservation-dependent seabirds and marine mammals.

These species are protected throughout Australia and in some cases populations are recovering from previous human exploitation. Resolution of climate change impacts versus other non-climate threats is needed for these species in order to implement appropriate and timely adaptive management responses. Unfortunately, for most species, there are few records demonstrating responses to environmental variability, however, some examples have recently emerged. The inter-annual variation in the number of Australian fur seal pups born in central Bass Strait is one such example, and was found to be negatively correlated with the sea surface temperature in western Bass Strait recorded from up to 10 months previously (Gibbens and Arnould 2009). Similarly, timing and success of breeding in Little Penguins is also correlated with ocean temperatures in Bass Strait many months in advance of the breeding season (Cullen et al. 2009). The processes driving these relationships are largely unknown, which is seen by managers as a major impediment to ongoing conservation management and planning in the face of climate variability and change. In addition, monitoring approaches for some of these species may also need to be reassessed and modified in order to better detect the impacts of climate change, and assess the management responses.

The overall objectives of this NARP funded project are to:

1. Connect researchers, managers and policy makers, to focus on climate-ready monitoring and adaptation options for conservation-dependent seabirds and marine mammals.
2. Link ongoing monitoring programs around Australia for seabirds and marine mammals with relevant wildlife and conservation management agencies.
3. Extract climate signals for selected time series data around Australia using cutting-edge statistical approaches.
4. Develop protocols for monitoring impacts of environmental variation on indicator species and develop an indicator suite of spatial and temporal metrics for climate change impacts.
5. Combine the indicator metrics to develop multi-species productivity indicators for Australian regions.
6. Provide practical adaptation guidelines for science and management, including on-ground monitoring protocols

EFFECTS OF CLIMATE CHANGE ON TEMPERATE BENTHIC ASSEMBLAGES ON THE CONTINENTAL SHELF IN EASTERN AUSTRALIA (SUPER SCIENCE FELLOWSHIP), Dr Craig Johnson – IMAS

Craig Johnson[1], Neil Holbrook[1], Neville Barrett[1], Peter Steinberg[2]

[1]IMAS
[2]UNSW

The broad objectives of this strongly multidisciplinary work are to (1) relate patterns in physical parameters on the continental shelf reflecting meso-scale oceanographic circulation and its variability with the structure of benthic assemblages that are at once important reservoirs of biodiversity and vital habitat for significant commercial species, and (2) predict changes in these benthic assemblages associated with predicted shifts in climate. The work depends on and builds from extensive existing and proposed observations obtained through the Integrated Marine Observing System (IMOS) initiative.

The work will focus on the continental shelf in southeast Australia from southern Queensland – Tasmania, where the specific aims are to:

1. relate the current distribution of the key biogenic habitat-forming seaweeds *Ecklonia radiata* and *Phyllopsora comosa* in relatively shallow water (~0-45 m) to physical environmental variables;
2. describe variation in deep water benthic assemblages (20-200 m) at multiple scales and relate this to physical environmental variables;
3. use a combination of ocean observations (remotely sensed and in situ), climatology data, reanalysis data, and state-of-the-art high resolution climate models to estimate spatial patterns of physical variables (temperature and nutrients) and their variability (mean, interannual variance and extremes) over the continental shelf during the past two decades;
4. estimate future changes in these physical variables over the continental shelf based on downscaled climate change projections;
5. develop bio-climate envelope models for *E. radiata* and *P. comosa*, and for selected key taxa from deeper reefs, to predict changes in benthic assemblages associated with changing climate on the shelf; and
6. integrate data from the associated ARC Discovery project DP1096573 (which focuses on an experimental approach to effects of climate change on biogenic habitat-forming seaweeds; commencing 2010) to test the efficacy of current approaches to bioclimate prediction.

Key outcomes of the work will be:

1. A rigorous quantitative prediction of responses of deep-water (20-200 m) benthic fauna and key shallow water habitat-forming species to climate change.
2. A refined methodology to apply AUV technology to describe benthic assemblages, quantify their spatial and temporal variability and, in the context of long-term monitoring, assess climate-related responses.
3. For photosynthetic species (marine macroalgae), an assessment of the efficacy of existing approaches to bioclimate envelope modelling, which is based solely on distributional information and physical parameters, against those able to additionally include features of ecological stoichiometry and heritability of traits.
4. Quantification of the temperature and nutrient means, seasonal and interannual variances (including composite El Niño and Southern Annular Mode variability maps), and extremes across the East Australian Current and continental shelf over the past two decades (and longer) from observations, reanalysis data and high resolution model simulations.
5. Estimated future changes in the means, variances and extremes of temperature and nutrients based on high-resolution OFAM downscaled simulation over the decade 2060-2070 forced by AR4 climate model simulations with enhanced greenhouse gases.

NEW SOUTH WALES MARINE CLIMATE CHANGE PROJECTS, presented by Dr Alan Jordan - NSW Environment

MONITORING OF SEA TEMPERATURE CHANGE AND VARIABILITY IN THE SOLITARY ISLANDS (NSW MPA)

Low levels of coral bleaching have occurred throughout the past 10 years in the marine park, with occasional minor elevation of bleaching in some species at some sites. A major bleaching event did not occur during that time, although one did occur on the Great Barrier Reef. Sea temperature is being monitored at 7 sites in the SIMP (2 inshore, 2 mid-shelf, 3 offshore), and at other sites in northern NSW to gain an understanding of variability in sea temperature both spatially and temporally. This will enable a natural assessment of temperature thresholds and bleaching should a bleaching event occur.

Sea temperature is predicted to become more variable associated with climate change. Sea temperature is easy to monitor and will provide valuable insight into changes over long (decadal) periods in the future.

The primary objectives are to:

- Increase knowledge of spatial and temporal sea temperature patterns in the SIMP
- Use these to help interpret patterns in the EAC within the SIMP
- Use these data to examine coral bleaching thresholds if a major event should occur

Key Contact

Hamish Malcolm - NSW Marine Parks Authority

AUSTRALIAN COASTAL OBSERVATION NETWORK: MONITORING AND FORECASTING COASTAL EROSION IN A CHANGING CLIMATE (ARC LINKAGE)

The report 'Managing Our Coastal Zone in a Changing Climate' identified the need to better understand the risks of coastal erosion. As beaches occupy around 50% of the coast it is important that these This project will establish a new capability for automated measurement of local wave climate and coastal erosion at many sites along the NSW coast, and a new method for forecasting shoreline changes will be tested and extended. The study addresses the knowledge gap between advancing climate change science, and the lagging development of the ability to assess and forecast coastal change.

The overall objective of this research is to fast-track the delivery of broad-scale coastal monitoring and coastal-change forecasting tools to coastal engineers, managers and policymakers, for assessing and quantifying the sensitivity and impacts to Australian beaches to rising sea-levels & changing wave climate.

Key Contacts

Assoc. Prof Ian Turner – University of New South Wales
Assoc Prof Ian D. Goodwin - Macquarie University

NSW STATE WIDE SEA LEVEL RISE RISK ASSESSMENT

This project aims to assess New South Wales' exposure to current ocean inundation hazard as well as the potential effects of sea level rise. The project involves mapping of potential inundation areas within low lying areas including all major estuarine systems and quantification of risk.

The mapping will utilise:

- The best available digital elevation data.
- Existing tidal gauging results (where available) to represent current inundation levels within major estuarine systems and to form the starting point for the addition of sea level rise.

The primary objectives are to:

- Develop a tidal attenuation model for estuaries with no tidal data based on analysis of existing tidal plane data from different estuarine types and characterisation of typical tidal modification including amplification and attenuation up to the tidal limit.
- Develop a berm height model for intermittently open and closed lakes and Lagoons
- Conduct sensitivity testing for selected systems (representative of the range of NSW estuary types) using a 2D hydrodynamic model to examine potential changes in tide range (and resultant inundation) as a product of sea level rise utilising different entrance response scenarios.

Key Contact

David Hanslow – NSW Office of Environment and Heritage

CHANGING CURRENTS IN MARINE BIODIVERSITY GOVERNANCE & MANAGEMENT: RESPONDING TO CLIMATE CHANGE (FRDC)

Australia's marine systems and biota are known to be exposed to a range of likely impacts from human-induced climate change: ocean acidification, warming sea surface temperatures, rise in sea level, increases in cyclone intensities, changes in rainfall and run-off of land-based pollutants and sediments, and modified El Niño-Southern Oscillation regimes. There is an emerging need to implement governance and management systems, particularly marine protected areas, that can accommodate present and future ecosystem and species distributions. This may involve improvements in the implementation of current and management arrangements, but research is also needed to examine potential alternative adaptive governance and management responses to climate change induced changes in the structure and composition of marine ecosystems and habitats.

This project addresses a significant need to review the capacity of current conservation governance and management to ensure responsiveness to conservation needs to allow building of ecosystem resilience. An important component of this relates to ensuring that ecosystem management is operationalised in day-to-day activities. This suggests that there is a need for coherent and adaptive systems of marine biodiversity governance, planning and management, and this project aims to develop the understandings and strategies to implement such systems.

The primary objectives are to:

- To identify the requirements for adaptive marine biodiversity conservation governance and management in the context of climate change
- To assess how well current regimes, with a particular focus on marine protected areas, meet these requirements, and determine any necessary changes
- To identify alternatives to current regimes that are likely to enhance adaptivity and assess their governance and management effectiveness
- To offer advice to governance and management authorities on how regime reform

Key Contacts

Dr Michael Lockwood - University of Tasmania
Assoc. Prof. Marc Hockings - University of Queensland
Assoc. Prof. Marcus Haward - University of Tasmania

MONITORING OF SEA SURFACE TEMPERATURES ON LORD HOWE ISLAND (AIMS, NSW MPA)

The long-term recording of ocean temperature is important for establishing baseline data and monitoring short-term and long-term ecological changes over time. Sea temperature is one of the most important environmental variables governing the abundance and distribution of marine life in coastal seas. Reef corals, for example, have a very narrow range of thermal and temperature tolerance and can largely influence what species grow where.
The long-term monitoring of water temperature around Lord Howe Island will provide valuable information on climate change and potential impacts on reef species and ecology. Prolonged exposure to warm sea temperatures has been linked to an increase in the frequency of mass coral bleaching, outbreaks of coral disease and plagues of crown-of-thorns starfish.

The primary objectives are to:

- To record long-term ocean temperature data at eight sites around LHI to provide information on climate change and potential ref impacts
- To record pressure data at eight sites around LHIMP to provide information on tides and storm activity
- Perform analysis on annual downloaded data and upload into SST Observing System

Key Contacts

Ray Birkelmans – Australian Institute of Marine Science
Ian Kerr – Manager, Lord Howe Island Marine Park

THE CELLULAR BASIS OF THERMAL SUSCEPTIBILITY IN LORD HOWE ISLAND CORALS (VICTORIA UNIVERSITY)

A recent coral bleaching event on Lord Howe has confirmed that Lord Howe's corals are not immune to changes in temperature, and that a fundamental understanding of the cellular and physiological mechanisms that determine bleaching susceptibility is crucial to better understand, predict and manage the fate of corals at this location. Reef building corals host algal symbionts (dinoflagellates of the genus Symbiodinium, also called zooxanthellae), which in a balanced symbiosis translocate a significant fraction of photosynthetically-fixed carbon to their coral host. In return, they are provided with inorganic nutrients. This symbiosis is essential for the survival and growth of coral reefs.

The overall aim is to characterise protective mechanisms in Symbiodinium spp. at Lord Howe, and hence provide a basis for thermal tolerance versus sensitivity of a range of common coral species at this important site. Specific objectives are:

- Isolation of zooxanthellae from various coral species around Lord Howe for cultivation purposes and subsequent detailed physiological analysis
- Measurement of zooxanthellae pigment pools in response to temperature stress
- Analysis of the relationship between thylakoid lipid composition and thermal tolerance/sensitivity and the capacity for thermal adaptation
- Elucidation of the role of antioxidants in determining the degree of thermal resistance

Key Contact

Stefanie Pontasch - Victoria University Wellington, NZ

CORAL HEALTH, FLUORESCENCE AND BLEACHING IMPACTS (UNIVERSITY OF WESTERN SYDNEY)

Stressful events, such as instances of seawater warming associated with climatic changes, are known to cause mass coral bleaching events. Bleaching episodes are increasing in frequency and severity on reefs worldwide and threaten the survival of corals. It has been shown that GFP-type coloured proteins reduce the impacts of bleaching in studied species. The project is investigating the biology of photoregulation of these proteins in corals and the cellular protective mechanisms that enhanced the survival of corals during bleaching events. Understanding the biology of fluorescent protein regulation and their roles in influencing corals' survival following bleaching are important in understanding whether corals have the capability to adapt to climatic changes.

Therefore, the primary objective of the project is to analyse optical properties, expression patterns of fluorescent proteins in response to light and during mass coral bleaching.

Key Contact

Anya Salih – University of Western Sydney

ADAPTATION OF FISHING AND AQUACULTURE SECTORS AND FISHERIES MANAGEMENT TO CLIMATE CHANGE IN SOUTH EASTERN AUSTRALIA WORK AREA 4, PROJECT 1 DEVELOPMENT AND TESTING OF A NATIONAL INTEGRATED CLIMATE CHANGE ADAPTATION ASSESSMENT FRAMEWORKK (FRDC/SEAP), presented by Dr Vincent Lyne – CSIRO

SEAP Project (FRDC 2009/055)

Objectives

1. To develop a integrating climate change adaptation assessment framework for fisheries and aquaculture, suitable for use regionally and at a national level.
2. To test and apply this framework in the south eastern region to evaluate adaptation response options for stakeholders (managers, fishers, aquaculturalists)
3. To assess the application of the framework to apply to other regions around Australia.

Summary

Informed fisheries and aquaculture sectors and management arrangements and prioritisation processes based on understanding of the overall vulnerability of fishing and aquaculture sectors in the region.

This project will develop a national integrated climate change adaptation framework based on the IPCC (Intergovernmental Panel on Climate Change) approach, by taking into account biophysical changes to species, adaptive capacity of the sectors, and the performance of alternative management options in mitigating those potential impacts.

The results of these studies will be used in this project to determine priorities for industry and government action on adaptation within the fishery and aquaculture enterprises. This framework will be tested in the South Eastern Australia region and applicability for use at a national level assessed.

AN EVALUATION OF THE OPTIONS FOR EXPANSION OF SALMONID AQUACULTURE IN TASMANIAN WATERS (SEAFOOD CRC/ FRDC), Dr Catriona MacLeod - IMAS

Catriona Macleod[1], Andrew King[1], Nick Elliott[2]

[1]IMAS
[2]CSIRO

Background

To remain competitive and sustainable the TSGA recognised the need for growth in its Strategic Plan to 2030. They and their stakeholders also acknowledge that this needs to be in an innovative and ecologically sustainable manner. Expansion is however constrained by limited inshore marine farming sites around Tasmania, and alternative and new technologies should be critically evaluated. In addition, industry development has to incorporate environmental and community considerations, the predicted impacts of climate change, and increased energy costs.

The industry and its stakeholders recognised that a critical examination of alternate farming and resourcing technologies and strategies, had to be based on an appropriate understanding and rigorous scientific and economic evaluation of global best practice, innovation and emerging technologies. This project was therefore developed through opportunity and discussions between the industry, government and researcher providers (UTas and CSIRO). The project has been developed to fulfil strategic needs for all stakeholders. It will provide opportunity for capability development; provide knowledge and potential technologies that will lead to improved productivity in an efficient and ecologically sound manner, and provide a sound basis for planning future R&D that will support such industry growth.

The project is unique in being based around an experienced researcher and project manager offering to undertake the essential review as part of a PhD project. The capability developed by the individual and the project team will be of benefit to the Atlantic salmon and greater Australian aquaculture community. The new knowledge, technologies and innovative processes will include the areas of offshore and on-shore (re-circulation) farming, renewable energy and species integration opportunities and efficiency.

The project addresses four strategic challenges and is designed to encourage new ideas for scientific, industry and community initiatives to assist the industry meet its future needs. This includes strategies for managing competition between users, and for mitigation of potential climate and energy source changes. The strategic challenge areas are:

- Growth and profitability of a major seafood industry, through new technologies and innovation practices.
- Ensuring ecological sustainable use of aquatic natural resources.
- Helping the aquaculture industry to adapt to and mitigate the effects of climate change and practices.
- Ensuring ecological sustainable use of aquatic natural resources.
- Helping the aquaculture industry to adapt to and mitigate the effects of climate change and environmental variability.
- Minimising the effects of aquaculture operations on aquatic habitats and ecosystems

Objectives

- To review existing and emerging options for the expansion of the Tasmanian Atlantic salmon industry
- To develop a holistic risk based model to assess the viability of production expansion options and undertake an options analysis; making recommendations for further evaluation
- With stakeholder approval and financial support, test the analysis recommendations by employing engineering / environmental modelling, and then evaluate the preferred option(s) in pilot sites applications

INVESTIGATING THE EFFECTS OF LONG-TERM ENVIRONMENTAL CHANGE ON THE GROWTH RATES OF AUSTRALIA'S FISHES, Dr John Morrongiello - CSIRO

John Morrongiello[1,2], Ron Thresher[1,2] and David Smith[2]

[1]Marine Ecological Processes and Prediction, CSIRO Marine and Atmospheric Research, Hobart, Australia
[2]Wealth from Oceans Flagship, CSIRO Marine and Atmospheric Research, Hobart, Australia

Background

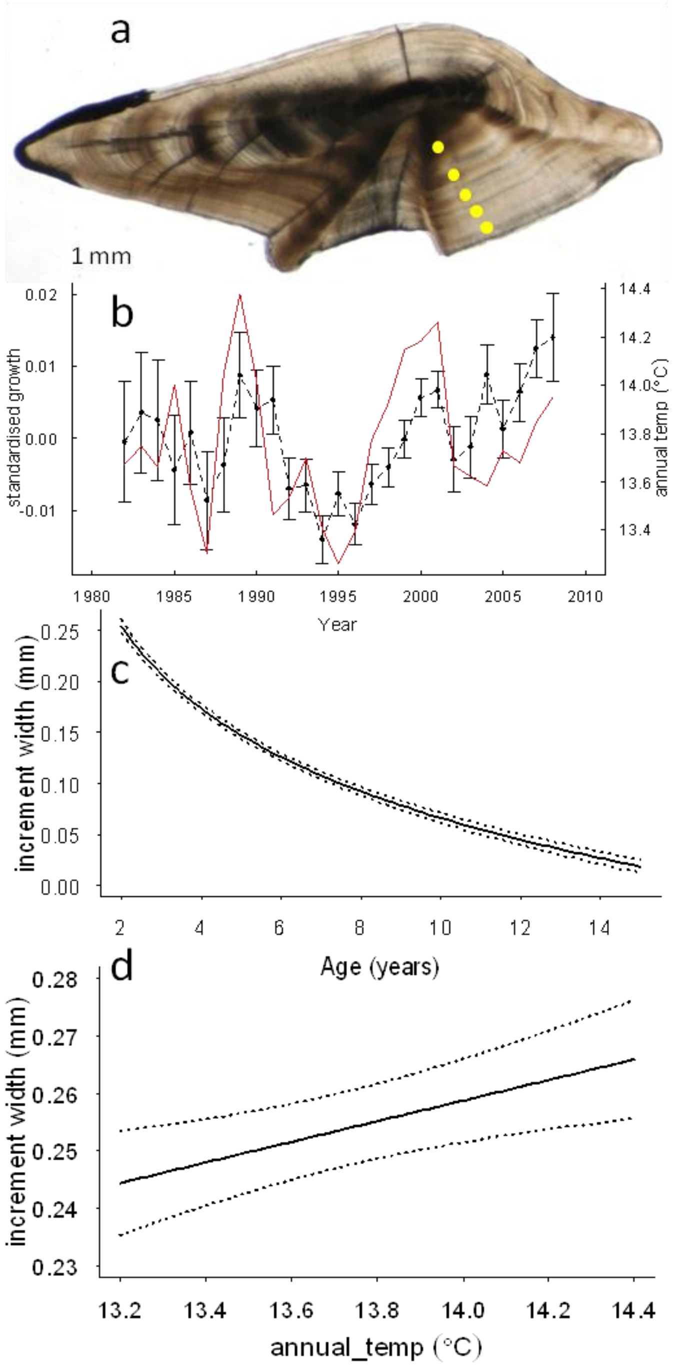
Environmental, biological and anthropogenic drivers all affect fish growth rates, but disentangling the relative importance of each can be difficult. This is especially the case in many marine systems where there is often inadequate observational or experimental data available. Fish possess bony structures called otoliths that contain regularly deposited material (analogous to tree rings), providing a novel and valuable source of long-term biological data. Age (based on otolith increment counts) and size information is routinely collected by fisheries scientists for stock assessment purposes. Increment widths, however, are generally underutilised in both ecological and management studies despite their obvious potential as chronometers of inter-annual and age-specific growth variation.

Aims and scope

Recent work using otolith biochronologies has identified significant inter-annual growth variation in a number of Australia's fish species related to long-term environmental change[1-3]. There is a real need to explore the generality of these growth patterns and identify their key drivers across a range of species and regions.

Our project will provide the first continental-scale analysis of long-term changes in fish growth rates by developing otolith growth biochronologies for marine and freshwater fishes around Australia. Results of these historical analyses will be used to quantitatively forecast the likely impacts of climate change on Australia's fishes, facilitating the identification of populations, species and regions that may be vulnerable to, or benefit from, future environmental change.

Example: 26 year growth biochronology for west-Tasmanian tiger flathead, *Platycephalus richardsoni*



[1] Thresher et al., (2007). *PNAS* **104**, 7461-7465.
[2] Neuheimer et al., (2011). *Nature Clim. Change* **1**, 110-113.
[3] Morrongiello et al., (2011). *Glob. Change Biol*. **17**, 745-755.

OVERVIEW OF VICTORIAN PROJECTS, presented by Dr Daniel Spooner – Fisheries Victoria, DPI

ENVIRONMENTAL DETERMINANTS OF RECRUITMENT SUCCESS OF SNAPPER, *PAGRUS AURATUS*: CRITICAL INFORMATION FOR MANAGEMENT OF A KEY RECREATIONAL AND COMMERCIAL FISHERY

Time Frame: 2010-2012

Summary

Understanding the causes of fluctuations in the recruitment of young to fish populations is a key scientific need for sustainable fisheries management. Snapper are a key fishery species in southern Australia that show high recruitment variability from year to year and will act as a model species for this study. This project aims to combine physical and biological information on the early life stages of snapper into a sophisticated modelling framework that will lead to an understanding of the processes that determine recruitment variability in Port Phillip Bay. This information will allow prediction of future trends in fishery recruitment in the short term based on measurement of climatic variables, and in the long term based on climate change predictions.

This research will contribute to the sustainable management of the snapper resource to both protect the population and also provide long-term sustainability in terms of the ecosystem goods and services provided by the fishery, and associated social and economic benefits. Results will have wider applicability than just the snapper fishery as the critical environmental factors identified are likely to influence other species as well. Understanding the environmental factors underpinning recruitment variation in snapper will also allow inferences to be on recruitment levels based on climatic variables in the short term, and also longer-term effects of climate change on the population, for incorporation into future management assessments.

We hypothesise that inter-annual variation in recruitment of snapper is a result of inter-annual variation in larval growth rates that are in turn dependent on the availability of suitable planktonic prey. Data on larval abundance, growth and survival will be available for eight consecutive years. Continuous measurements of chlorophyll a will also be collected over this period. Five years of data will be available on larval diet together with zooplankton abundances. We will also examine alternative hypotheses related to predation and unfavourable physical transport. The analysis will be further extended by utilising individual-based modelling in conjunction with a hydrodynamic/productivity numerical model to test scenarios and provide predictions for comparison with field data. Finally, we will incorporate modelled climatic conditions for Port Phillip Bay in the future provided by the Victorian EPA to investigate the long-term trend in snapper recruitment under climate change.

Project Team

1 . Jenkins GP (PI) Marine and Freshwater Fisheries Research Institute, Department of Primary Industries, Victoria
2 . Swearer SE, The University of Melbourne
3. Hamer, P., Marine and Freshwater Fisheries Research Institute, Department of Primary Industries, Victoria

FISHERIES ADAPTATION TO CLIMATE CHANGE – MARINE BIOPHYSICAL ASSESSMENT OF KEY SPECIES

Time Frame: Complete in 2010

Summary

Climate change has important implications for the sustainability of Victoria's marine and estuarine recreational, commercial and indigenous fisheries and aquaculture industries. An understanding of the risks to key Victorian fisheries is necessary to adequately respond to these challenges and to guide management efforts.

There are a number of predicted changes to the Victorian environment under climate change that have important consequences for key fish species. Both air and water temperature is expected to rise by 2–3 C by 2070. Rainfall will decline by 5–10%, but in spring the deficit will be 20–30%. Solar radiation and evaporation will also increase. The prevailing westerly winds are expected to decline in strength. The East Australian Current is expected to strengthen (20% by 2010) while the Leeuwin Current may weaken slightly. Sea level will rise 20–80 cm by 2100.

The marine biophysical assessments, including this study, are aimed at understanding the biophysical implications of future climate change to better inform decision making. These assessments aim to determine the degree of exposure that key species are likely to experience due to climate change, to inform assessments on how vulnerable Victoria's fishing and aquaculture sectors are to these changes. This report uses literature review and statistical analyses to better inform the understanding of the environmental data and the biophysical implications of climate change for four key bay and inlet fish species; black bream, King George whiting, snapper and sand flathead.

Project Team

1 . Jenkins GP (PI), Marine and Freshwater Fisheries Research Institute, Department of Primary Industries, Victoria

STRESS TRANSCRIPTOMICS: DEVELOPMENT OF TESTS TO REDUCE THE INCIDENCE OF SUMMER MORTALITY IN ABALONE (ARC), Jan Strugnell - La Trobe University

Jan Strugnell, Department of Genetics, La Trobe Institute for Molecular Science, La Trobe University, Melbourne.
Project Duration – 3 years

Abalone are a high value shellfish and their export is worth over AU$200 million per year to the Australian economy. Mass mortality of farmed abalone during the summer, termed summer mortalities, has been frequently reported in Australia in recent years. This disease is related to increased stress in animals due to high water temperatures and it is likely to become more widespread with predicted rising water temperatures. This ARC funded research will investigate the molecular basis of stress and disease in abalone and the genetic mechanisms used to fight them. The results will allow the development of early warning tests of stress and stress resilience resulting in production and economic benefits to the Australian abalone aquaculture industry.

Aims

Using green lip abalone (*Haliotis laevigata*) as a model organism, this proposal will take advantage of ultra-high throughput second generation sequencing technology in order to:

1. identify gene pathways that respond to environmental stressors and disease
2. develop and validate tests that can be used to select for stress/disease resilience
3. develop and validate early warning tests for impending stress, infection and disease
4. investigate specific water quality parameters, or combinations of parameters, which result in a gene expression response associated with summer mortality

REDMAP AUSTRALIA: AN EARLY WARNING SYSTEM FOR RANGE SHIFTING SPECIES (AUSTRALIAN NATIONAL DATA SERVICE PROJECT), presented by Dr Gretta Pecl

What is Redmap?

It stands for ‘Range Extension Database & Mapping Project’.

Each year 120,000 Tasmanians go fishing. Imagine… 120,000 potential ‘citizen scientists’ collecting data on the marine environment and how it may be altering as the climate changes. We did: Welcome to Redmap.

Redmap invites fishers, divers and scientists to report uncommon marine species they encounter along our coast. These sightings are mapped (with photos) on the Redmap website. Over time, Redmap will be able to sketch a picture of how marine species are extending their ranges as the climate changes.

Redmap is a large-scale, cost-effective way to monitor marine environments: ‘plugging the gaps’ in marine research. But just as importantly, Redmap engages an often-skeptical audience with the issue of climate change. Studies show traditional scientific messages are not being accepted by large segments of the population. For example, many commercial fishers don’t believe global warming is an issue for their industry. Redmap lets community members discover for themselves how the seas are changing by collecting their own ‘data’; and over time will show which species are on the move.

Why Redmap is a success!

Since its launch in December 2009, Redmap’s citizen scientists have logged 350+ sightings of 70 marine species, sometimes from as far afield as New South Wales. More than 650 people have subscribed to the quarterly Redmap newsletter. Redmap has been the focus of 70+ articles in newspapers, magazines and newsletters; and more than a few stints on radio and television. Redmap won the 2010 Whitley Award for Excellence for an Interactive Resource, received an external nomination for NCCARF’s ‘Climate Adaptation Champion’ and was awarded the University of Tasmania’s Vice Chancellor’s Award for Outstanding Community Engagement 2011.

Redmap’s interactive website is engaging in this age of public information sharing – think Wikipedia and YouTube – and Redmap’s appeal lies in its citizen science approach: fishers, divers, boaters, scientists, schools and the public all play a crucial role in the discovery of how Tasmania’s marine environments are changing. Redmap’s success is also reflected in how it’s been embraced by all levels in the community. Redmap is coordinated by the Institute for Marine and Antarctic Studies, with enthusiastic input and support throughout the marine industry (e.g. commercial fishers, Tasmanian Seafood Industry Council, TARFISH, Fishwise, Mures Fishing, OceanWatch), management (DPIPWE), research (UTas, IMAS, CSIRO), government (Tasmanian Climate Change Office) and the general community (recreational fishers, boaters, divers, dive clubs and schools).

Redmap’s popularity and success are illustrated by:

1. **The Redmap Website: A Hit**

The Redmap website has an attractive ‘look’ and makes it easy to log a sighting and see on a map which marine species have been spotted beyond their usual range. The site also supplies general information on marine climate change and the website statistics for the past 19 months indicate Redmap's popularity:

- 35,000+ discrete website hits or visits.
- 100,000+ website pages downloaded (approx. 4700 per month).
- Web viewers from 152 countries.
- 650+ people subscribe to the quarterly Redmap newsletter (from 20 countries).
- 350+ sightings of 70 marine species, some as far as 470km south of their 'known' distribution.
- The most downloaded web pages are "Species of interest", "Tasmanian sightings" and "What is climate change?" suggesting Redmap is engaging the community with climate change and marine science.

These are just some of the photos submitted by 'Redmappers' when they logged a sighting. Photos are verified by marine experts, giving more weight to the 'community science'.

2. Public feedback

Another gauge of Redmap's success is the spectacular response to the project:
- Invitations to talk at 30+ seminars, forums and conferences – and to set up the Redmap stall at events like the Wooden Boat Festival, Agfest and industry events.
- Interest from scientists and organisations around Australia to develop their own Redmap.
- Redmap's school resources pages were developed – and are now used – by many teachers across Tasmania.

3. Reaching marine industries

Redmap aims to demonstrate to Tasmania's fishing industry that climate change is a genuine business risk, so they can better adapt to changes. As we collect more data, Redmap will act as an early warning system of species that might act as pests; or present new fishing opportunities. We've made head roads by:

- Getting sponsorship from one of Tasmania's most respected fishing industries: MURES
- Speaking at Tasmanian seafood industry events
- Invited to feature in the Tasmanian Seafood Industry Council's *Seaing Change* climate change booklet
- Having a regular column in *Fishing Today*, read by many Tasmanian commercial fishers

4. Science communication and acknowledgement

- Redmap sightings have been used in 3 scientific papers thus far (Last et al, Johnson et al 2011, Madin et al in press)
- Members of the Redmap team have been invited to speak at 4 science conferences (including some funded travel, e.g. Royal Institute of Australia in Adelaide Aug 2010 & Colorado in Nov 2011), and have made presentations at many more.

The Future

With are now planning to hoist Redmap onto the national stage and develop 'Redmap Australia'. We have started gathering a team of scientists and organisations keen to be a part of Redmap Australia. The program has received funding to create a national Redmap database and website shell – through the Australian National Data Service – so that other Australian states can develop their own Redmap under the one banner. We are now looking at opportunities further afield – please contact us if you would like to discuss this in more detail.

A GLOBAL NETWORK OF MARINE HOTSPOTS

Stewart Frusher[1], Gretta Pecl[1], Alistair Hobday[2], Warwick Sauer[3]

[1]Institute for Marine and Antarctic Studies, University of Tasmania, Australia
[2]Climate Adaptation Flagship, CSIRO, Hobart, Tasmania, Australia
[3]Rhodes University, Grahamstown, South Africa

Background

The world's oceans are important sources of protein and livelihoods for coastal communities. From food security and poverty, to regional and national balance sheets, fishing activity affects countries in a range of ways. There is an urgent need to understand the impacts of climate change on marine resources and the people and communities they support. Identifying opportunities and threats, and developing adaptation options is essential to optimising the benefits that society can continue to derive from the goods and services provided by marine resources.

The oceans are not warming evenly and those areas that are warming the fastest will become the world's natural laboratories to provide the knowledge and tools to enable us to adapt wisely, efficiently and effectively to meet the challenges of a warming environment. Water temperature is only one variable responding to climate change but it is the major driver of distribution, abundance, phenology and life history of marine organisms. Based on historical (last 50 years) and projected (next 50 years) rates of ocean warming, 24 regional hotspots – areas that are warming faster than 90% of the oceans – have been identified (see map). These hotspots occur in all regions of the globe, from polar to tropical, and affect developed and developing countries. In these regions:

(i) Impacts associated with global warming will likely be observed earlier,
(II) Models developed for prediction can be validated earlier than in other slower changing regions, and
(III) Adaptation options can be developed, implemented and tested first.

The Benefits

Research, development, management and communication can all be delivered faster and with greater certainty through a coordinated network across global hotspots:

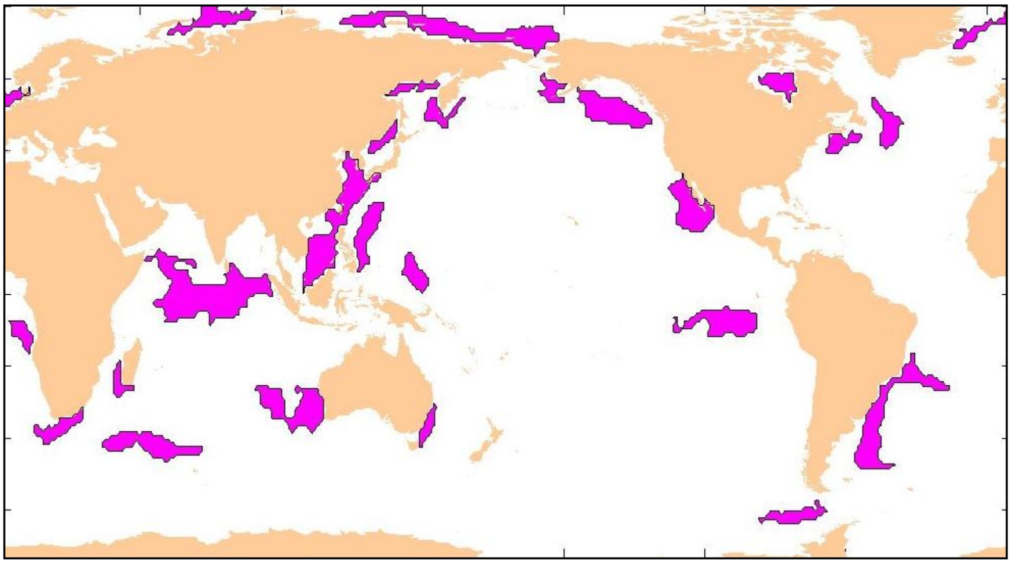
(1) Scientists, managers and policy makers can communicate on how science is being translated into policy and practical adaptive management measures.
(2) Networking across these regions can facilitate comparative studies through:
    - promotion of consistency in data collection, analysis and reporting
    - the potential for greater certainty in model projections through first opportunities for validation.
(3) Comparisons between regions can provide greater certainty in the understanding of impacts for stakeholders.
(4) Shared learning and capacity building about adaptation science can generate insights into the impacts, model validation and the success or failures of adaptation planning for the broader global community.

International Hotspots Workshop

Scientists from the most rapidly warming marine regions met at a workshop at Sendai in April 2010 to share their observations, experience and knowledge on the current impacts of global warming. A summary of current observations reinforced that marine ecosystems and the fisheries that they support are changing, with ramifications for fishers (subsistence to industrial), fishing fleets and local and national economies. A global communication network was proposed, to ensure consistency in approach and reporting so that experience, knowledge and understanding gained from these regions could provide guidance globally.

The path forward:

- Seek commitment from policy makers, resource managers and researchers working in regional hotspots, and their associated institutions, to support participation in a global network of marine hotspots.
- Undertake a synthesis of knowledge across hotspot regions.
- Host an initial workshop to determine a strategic and operational plan for the network. The plan would identify communication options, resource implications (threats and opportunities), collaborative linkages with other international agencies, and potential funding opportunities.
- Develop proposals for targeted workshops on identified areas of need such as monitoring methodologies and inter-disciplinary approaches for linking science to practical management etc.
- Establish demonstration projects such as:
- selection of key monitoring sites for comparisons that consider a range of ecosystem types and global locations
- Evaluation of tools and approaches for implementation of adaptation options that identify and balance the trade-offs in ecological, social and economic indices in hotspot regions.



Global Marine Hotspots, taken from Hoday & Pecl, (in review)

LIFE-HISTORY AND POPULATION DYNAMICS OF THE RANGE EXTENDING *OCTOPUS TETRICUS* GOULD, 1852 IN SOUTH-EASTERN AUSTRALIA (PHD PROJECT), Jorge Ramos - IMAS

Jorge Ramos[1], Gretta Pecl[1], Jayson Semmens[1], Natalie Moltschaniwskyj[2] & Jan Strugnell[3]

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[2] School of Environmental and Life Sciences. The University of Newcastle. University Drive Callaghan, NSW. 2308
[3] School of Molecular Sciences. La Trobe University. Kingsbury drive Bundoora, VIC. 3086

Anthropogenic climate change is resulting in warmer waters that are in turn altering the distribution, abundance and life history of marine species. In south eastern Australia, the East Australian Current is extending further into Tasmanian waters and persisting for longer periods throughout each year resulting in warming of the Tasman Sea at 3–4 times the global average. Associated changes in biodiversity and the functioning of ecosystems are thus impacting both fisheries and conservation management. Consequently, there is increasing interest from scientists, resource managers, conservationists and people dependent on marine resources to understand how species will respond to climate change.

Cephalopods are known for their flexible life histories, short life cycles, high growth rates, and rapid turnover of populations; and thus the potential to respond quickly to environmental changes. *Octopus tetricus* is an abundant species and important fishery resource in eastern Australia. Until recently it was distributed from southern Queensland to NSW, but as waters have warmed, in the last few years it has been detected off Victoria and the northeast of Tasmania. In the waters around mainland eastern Australia it is an important fishery resource that accounts for 10–20% of the total octopus landings and recently more than 40% of the Sydney Fish market octopus sales. The incursion of *O. tetricus* into Tasmanian waters could mean additional losses for the rock lobster fishery through predation on rock lobster in the fishing traps, as it has been recorded with *O. maorum*. On the other hand, the increasing abundance of *O. tetricus* is attractive for local octopus fishers as it achieves higher market prices compared to *O. pallidus*, a normally occurring species that maintains the octopus fishery around Tasmania.

Although range shifts are being documented all over the world, there are large gaps in our understanding of the mechanisms underpinning range-shifting dynamics and the evolutionary consequences of such shifts. The rapid warming of the Tasman Sea, the life history characteristics and population dynamics of *O. tetricus* provide a great opportunity to understand the mechanisms that underpin range shifts and the consequences for ecosystems; determinant to enable the management of ecologically and commercially important range shifting species. Using a multi-faceted approach founded on invasion ecology we examine the biological mechanisms and processes that are facilitating the range shift and establishment of *O. tetricus* in south-eastern Australia. Assessment of life history characteristics and thermal tolerances of key life stages, in combination with an examination of relevant genetic processes will allow us to elucidate mechanisms behind the range expansion of *O. tetricus* and its response to ocean warming at an individual and population level.

UNDERSTANDING CLIMATE DRIVERS AND PREDICTING THE FUTURE FOR COASTAL AUSTRALIAN ECOSYSTEMS (ANNIMS PROJECT), presented by Dr Jayson Semmens - IMAS

1. Principal Co-Investigators

Peter Strutton[1], Jayson Semmens[1], Caleb Gardner[1], Colin Simpfendorfer[2], Michelle Heupel[2] and Anya Waite[3]

[1] UTAS, [2] JCU, [3] UWA

2. Summary

Through national investment in the Integrated Marine Observing System (IMOS), the Australian marine science community is beginning to accumulate data sets that can identify key physical mechanisms driving ecosystem processes, from primary productivity to the response of higher trophic levels. This proposal will use data from IMOS and other sources, including satellite and acoustic animal tracking, research voyages, ships of opportunity, moorings and satellite remote sensing to understand the climate drivers of higher trophic levels in coastal Australian ecosystems. We will use state of the art data analysis and modelling techniques to achieve a new synthesis of information on the functioning of these ecosystems, including understanding of migration, phenology and population variability. This enhanced understanding will enable us to predict the response of these ecosystems to climate change and localised anthropogenic perturbations. Our approach is to compare recently observed interannual variations and future projected trends in Australia's two major boundary currents: The Leeuwin and East Australian Current. We will quantify the response of these systems from modes of climate variability spanning interannual (El Niño) to decadal (global warming) time scales. The project will result in at least one high profile synthesis publication that describes the impact of these changes on Australian coastal ecosystems.

3. Outline of the project

3.1. MOTIVATION

More than 85% of Australians live within 50km of the coast. Australia's EEZ is the world's third largest. It supports fisheries, aquaculture, tourism and mining, and is intimately linked to the Australian psyche and way of life. Yet coastal ecosystems are under increasing threat from climate change and other human activities. Impacts include increased stratification and changes in large-scale coastal currents due to warming, over-fishing, point source pollution, coral bleaching and ocean acidification. The response of coastal ecosystems to these changes is not well understood. There exist some mature data sets which have been synthesized to look at components of the ecosystem (e.g. Thompson *et al*., 2009; 2010 for phytoplankton). What is lacking from our current understanding is how oceanographic changes have impacted and will impact coastal ecosystems from physical drivers through primary productivity to fisheries. This has been identified as a key uncertainty limiting environmental risk assessment in the 2011 Australian State of the Environment assessment process.

3.2. GOALS

This proposal will analyse historical fisheries data (spanning decades) and tagging/tracking data (spanning several years) in the context of physical, chemical and biological measurements from the IMOS infrastructure, satellite remote sensing, ship observations and model outputs. We seek to understand the impact that the following processes have on coastal ecosystems: 1/ Seasonal to interannual variability in the range and strength of boundary currents; 2/ Changes in the strength and variability of winds over the major boundary currents, with respect to driving upwelling and mixing; 3/ Changes in the proliferation and physical characteristics of mesoscale eddies that interact with the continental shelf; and 4/ The effect that these changes have on primary productivity (as quantified by satellite chlorophyll, in situ pigments and oxygen data) through to higher trophic levels.

LONG-TERM CHANGES IN THE EAC, AS INFERRED FROM THE CORAL/TREE RINGS/OTOLITHS DATA (NARP PROJECT), presented by Dr Ron Thresher - CSIRO

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1. Long-term changes in strength of the EAC

Data are being compiled from long-lived deep-water corals, long-lived fish species and tree ring analysis to assess historical variability in water temperatures off the east coast of Tasmania, in particular, and the warming trend in SE Australia in general. Models suggest that the warming trend documented at the CSIRO Maria Island monitoring station is due at least in part to the effects of anthropogenic climate change, and hence is of relatively recent origin and potentially unprecedented in the modern (Holocene?) ecological record. The time course of the warming trend could indicate whether biotic changes in the SE region are part of a long-term shift in communities and ecosystems, or a recently imposed novel pressure on regional ecology and fisheries. The long-term record would also allow more accurate attribution of the regional warming to anthropogenic and natural factors.

The proxy records to date match closely those of the MI SST record, deviating in the case of the otolith analysis only after 1990 when there was a marked density-dependent effect of fishing on juvenile growth rates. Both the coral and otolith proxies suggest that the warming trend dates from at least the early 1900s, and that there may have been a period around 1930 during which temperatures off the Tasmanian east coast were similar to those at present. Additional samples spanning this period are being dated. Samples exist to extend the coral time series back several hundred years and over a larger area (e.g., coast of NSW), but are not being worked on due to lack of funds.

2. Adapting to the effects of climate change on Australia's deep marine reserves

Australia's highly endemic deep-water coral communities are under a current and accelerating threat of being squeezed out of existence, between seamount summits typically deeper than 1000 m. and carbonate levels that are falling and pushing the saturation horizon towards the surface. This horizon, below which the reef-forming corals apparently cannot grow has already shoaled by 50-130 m in the last 200 years due to industrial CO2 emissions. There is real risk that the reef is already stressed and may even be dying. The problem will only get worse. Under a "business-as-usual" scenario, even the tops of the seamounts will be under-saturated in the next 50-100 years. With nowhere to go, Australia's cold-water reefs could "simply disappear".

There are presently no adaptation strategies for dealing with this threat. This project, developed in consultation with DEWHA, will evaluate the magnitude of the threat to Australia's key reef-forming species, and identify and test management options for adapting to it. The project seeks to (1) develop and validate a biologically realistic model of the distribution of Australia's principal reef-forming deep-sea coral, *Solenosmilia variabilis*, that includes information on its sensitivity to environmental factors such as temperature, salinity and carbonate saturation state, (2) use this model to forecast the coral's potential distribution under different climate change scenarios, (3) identify possible refugia for the community, which could be considered for management protection, if needed, and (4) liaise with DEWHA regarding management implications and strategies.

A CLIMATE CHANGE ADAPTATION BLUEPRINT FOR COASTAL REGIONAL COMMUNITIES (NARP PROJECT), presented by Dr Ingrid van Putten - CSIRO

Sarah Metcalf[1], Ingrid van Putten[2, 3], Stewart Frusher[3], Nadine Marshall [2], Malcolm Tull[1]

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What is the problem

The marine environment is exposed to a broad range of climate change effects which are likely to influence activities dependent on marine ecosystems such as commercial and recreational fishing, tourism, and aquaculture, as well as fish processing, transport and other associated industries. Many marine-dependent activities take place in or around small- to medium-sized rural coastal communities. These coastal communities are expected to be significantly affected by climate-induced changes in the marine environment. Consequently, the need for effective adaptation in these coastal communities has been recognised.

What needs to be done

Developing tools that provide relevant information to reduce risks and increase capacity to cope with, and benefit from, change is urgently needed for these coastal communities. Adaptation decisions in these coastal communities will be influenced by the level of understanding of the needs, priorities, perceptions, and attitudes of stakeholders. Without such information, the ability to make timely and effective adaptation decisions will be limited. These tools include models that need to cross disciplinary boundaries and provide linkages between expected climatic changes, the vulnerabilities of the biological and human systems. Three case studies, including St. Helens (Tas.), Geraldton (WA) and Bowen (Qld) have been selected for the collection of information and the development of these tools.

What do we do at the moment

In the past, bio-physical models of climate or marine systems were developed with specific purposes in mind. For instance, many marine models with a biology focus were traditionally developed to identify appropriate catch limits and ideal management strategies for commercial fisheries. These models focussed largely on single species, which, with the inclusion of an economic component, were referred to as bio-economic models. These models have not been sufficient to allow the incorporation of all ecological, social and economic aspects of systems and the need for end-to-end ecosystem models has been widely recognised. Consequently, single-species marine models, are slowly developing to incorporate a wider ecosystem focus. These end-to-end ecosystem models link the biological and climatic environments and incorporate a human domain.

What needs to be done in the future

The blueprint that this project will develop will enable industries, governing bodies and individuals to make informed decisions based on the best information available so as to maximise opportunities for the future. If these models are going to help develop strategically targeted marine adaptation in the face of climate change, several issues need to be kept in mind. It is important that:

- other human (non-economic) drivers and behaviour (including governance) are included in the models;

- the models are selected based on data availability, timeframes and funding and able to identify strategic marine adaptation strategies;
- the models can be re-created and replicated in different coastal communities (blueprint);
- the models are easy to use and interpret by non-experts.

What we propose to do

An in-depth study of three coastal rural communities around Australia will be undertaken using methods developed to identify specific adaptation strategies for climate change impacts. For each case study, the relevant human, biological, and physical interactions will be modelled and the results will be compared and synthesised. The broad representativeness of the blueprint to address the needs and priorities of coastal rural communities throughout Australia will also be assessed.

PREPARING FISHERIES FOR CLIMATE CHANGE: IDENTIFYING ADAPTATION OPTIONS FOR FOUR KEY FISHERIES IN SOUTH EASTERN AUSTRALIA (NARP/SEAP PROJECT), presented by Assoc Prof Tim Ward – SARDI

Gretta Pecl[1], Dallas D'Silva[2], Caleb Gardner[1], Philip Gibbs[3], Andrew Goulstone[3], Klaas Hartmann[1], Alistair Hobday[4], Greg Jenkins[2], Stephen Mayfield[5], Daniel Spooner[6], Tim Ward[5]

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Background

South-eastern Australia has been identified as a global hotspot for marine climate change and Governments of the five jurisdictions within the region have been proactive in establishing a formal collaborative structure (SEAP) to facilitate effective adaption of fisheries to potential impacts.

This proposal was developed using the results of a formal assessment of the relative risk to climate change impacts of key fisheries species of south eastern Australia. Species selected as case studies in the proposed project were identified as being at high (rock lobster, abalone, blue grenadier) or medium (snapper) risk to climate change impacts and having high commercial value and/or recreational importance. The case study species were also identified as being likely to provide useful insights into change impacts of key fisheries species of south eastern Australia and being likely to provide useful insights into how fisheries can adapt to changes in productivity (rock lobster) and distribution (snapper). Two species (rock lobster and abalone) are considered potential ecological indicators for rocky reefs, whereas snapper is an important component of the coastal fish assemblages that occur in the region's estuaries and large embayments, and blue grenadier is an important Commonwealth pelagic species. Ensuring that the fisheries of South-eastern Australia adapt effectively to climate change will require the development of management systems that will allow negative impacts to be mitigated and opportunities that arise to be seized.

The scientific working groups will identify the: (1) likely effects of climate change on the biology/ecology of the three case study species; (2) implications for current stock assessment systems, harvest strategies and management frameworks; and (3) options for addressing these limitations.

Need

A project to inform fisheries adaptation to climate change is needed in the South East region because:

1) it is an international 'hotspot' for marine climate change, which is currently displaying signs of perturbation and where further shifts, shrinkages and expansions of ecosystems and species distributions are expected;

2) it produces >50% of Australia's seafood and is home to 60% of the Australian population;

3) a formal risk assessment identified fisheries species at highest risk from climate changes are also those with highest economic importance to the region;

4) its fisheries are managed by five separate jurisdictions whose adaption responses will need to be well coordinated if negative impacts are to be reduced effectively and opportunities that arise are to be

Objectives

1. Identify likely key effects of climate change on four major fisheries species in SE Australia (rock lobster, abalone, snapper and blue grenadier), particularly where these effects may impact the harvest strategies for these species.

2. Identify options for improving assessment and management frameworks (e.g. fisheries models, performance measures, decision rules, and harvest strategies) to ensure that they perform effectively under likely climate change scenarios (e.g. account for assumptions of temporal stability in temperature-influenced parameters such growth and recruitment).

3. Evaluate options for adjusting management arrangements to reduce negative impacts and maximise uptake of opportunities that climate change may provide to commercial and recreational fisheries (including improvements in coordination and consistency among jurisdictions).

4. Identify improvements to current monitoring systems for rock lobster, abalone and snapper and their habitats to ensure that they are suitable for measuring the likely impacts of climate change and other drivers.

Benefits

This project provides the scientific information on the likely effects of climate change on rock lobster, abalone and snapper that is needed (see National Climate Change Action Plan) to ensure that: 1) stock assessment procedures and harvest strategies can be established that perform effectively under predicted scenarios; 2) management arrangements can be refined to allow the profitability of commercial fisheries and participation in recreational fisheries to be maximised and 3) monitoring systems can be established that are suitable for measuring the likely impacts of climate change and other drivers on these key species. The establishment of a steering committee for each species that involves fishers, fisheries managers and scientists ensure that options for improving stock assessment procedures and harvest strategies, management arrangements and monitoring systems that are evaluated and recommended are suitable for adoption by stakeholders. The establishment of scientific working groups for each species that include fisheries scientists, marine ecologists, oceanographers and climate change scientists from State and Commonwealth research agencies and universities throughout south-eastern Australia ensures that this project adopts a collaborative approach utilising the best capability available, consistent with the approach taken in the SEAP/FRDC risk assessment project.

ENSURING THAT THE AUSTRALIAN OYSTER INDUSTRY ADAPTS TO A CHANGING CLIMATE: A NATURAL RESOURCE AND INDUSTRY SPATIAL INFORMATION PORTAL FOR KNOWLEDGE ACTION AND INFORMED ADAPTATION FRAMEWORKS (NARP PROJECT), presented by Dr Pia Winberg - University of Wollongong

2010/534 FRDC/DCCEE

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OYSTER INFORMATION PORTAL – AN INNOVATIVE TOOL TO BETTER MANAGE THE OYSTER INDUSTRY

The Australian oyster industry has already highlighted the need to consolidate natural resource information that is currently dispersed and inaccessible, but that is of high relevance to the resilience of the industry in light of climate change (Leith and Haward, 2010). By accessing information from this data and aligning oyster performance, the oyster industry can identify key environmental stressors that are rendering the industry more vulnerable to climatic change, as well as identify long term trends that can provide for pre-emptive response rather than reactive adaptation responses in the future.

This project aims to address the challenge of bringing together and aligning the rich but inaccessible environmental data, and take stock of and consolidate environmental and industry knowledge. This information will then be translated and delivered through an online, map-based internet portal in a format with relevance to the oyster industry; the Oyster Information Portal (OIP). This portal aims to serve industry members and stakeholders with information to make practical and adaptive responses to current and future changes in environmental conditions. The value of the OIP will be demonstrated through a prototype that encompasses four key and diverse oyster producing estuarine systems in NSW; the Camden-Haven, Hawkesbury River, Shoalhaven River and Pambula Lake. Once the value of OIP as an climate change adaptation tool has been established, then the concept will be pushed to develop across all oyster producing estuaries throughout Australia.

To date this project has identified extensive environmental data from the coastal land and water interface that reside across multiple sectors and jurisdictions that operate around catchments and estuaries in NSW. This suite of water quality, catchment, climatic, industry and governance related information that is of potential relevance to the oyster industry has been categorised and prioritised through 4 NSW workshops and one national workshop. The priority data/information category needs were found to be consistent within both industry and across governance agencies and are primarily temporal trends of chemical, biological and physical parameters of water condition. As such, data on water quality, catchment impacts and oyster industry management will form the base of the OIP in its prototype phase, based on industry priorities to provide for an industry that is both resilient to climate change and that can track long term trends to inform strategic decisions.

Selected metadata and raw data for this information has been sourced from custodians, and where meta data is lacking, the OIP project has triggered the creation of metadata by data custodians. This data consists of 100’s of separate files which are currently being aligned and structured for effective and useful delivery through an online map based portal. The prototype of the portal will be delivered internally to industry stakeholders and the project steering committee to refine and consider the value and implications of the prototype in mid-2012, and a final prototype is planned to be available online for broader trials in late 2012.

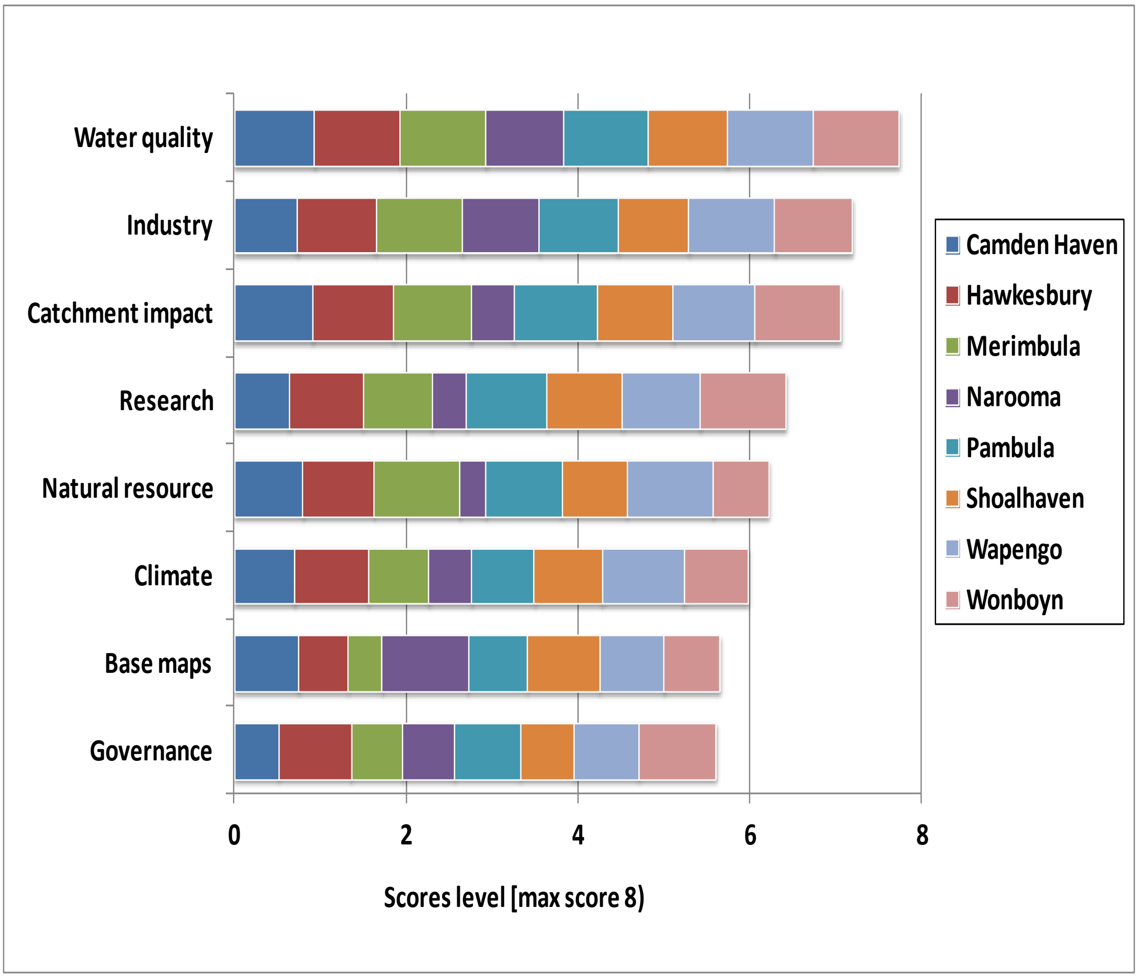

Figure 1: Industry and stakeholder information priorities across selected NSW estuarine systems.

References

Leith, P. and M. Haward (2010), 'Climate adaptation in the Australian Edible Oyster Industry: an analysis of policy and practice'. Adaptation Research Network for Marine Biodiversity and Resources, Commonwealth of Australia.

IMPACT OF CLIMATE CHANGE ON HABITAT FORMING SEAWEEDS IN SOUTH EAST AUSTRALIA (ARC DISCOVERY), presented by Dr Jeff Wright – Australian Maritime college

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ARC Discovery project (2010-2012)

This project examines the impact of climate change on habitat-forming seaweeds in Tasmania and New South Wales. It focuses on three large brown seaweed species: *Ecklonia radiata, Phyllospora comosa* and *Macrocystis pyrifera*. The effects of climate change on seaweeds are expected to be particularly severe in eastern Tasmania because of synergistic effects of ocean warming and reduced nutrient loading. The overall research approach is to measure the physiological potential of two species of seaweed (*Ecklonia* and *Phyllospora*) in both Tasmania and NSW under conditions expected through climate change. The research on *Macrocystis* will be conducted in Tasmania only. There are four main hypotheses being tested:

H1. *Effects of climate change on seaweeds will be particularly severe in Tasmania because of synergistic effects of ocean warming and reduced nutrient loading*.

H2. *Performance of species at lower latitudes (in NSW) will not indicate their response to climate change at higher latitudes (in Tasmania)*.

H3. *The potential of E. radiata to adapt to climate change is constrained by low heritability for key traits.*

H4. *Thinning of the P. comosa and E. radiata canopies will result in marked shifts in the structure of seaweed communities*.

These hypotheses will be tested using a combination of field surveys in Tasmania and NSW to measure physiological potential of seaweed; lab experiments to examine the effects of light, temperature and nutrients on seaweed grown from spores; field experiments to examine the effects of increasing nutrients *in situ*; heritability experiments to determine the evolutionary potential of seaweed response to climate change and; canopy-thinning experiments to examine whether ecologically realistic thinning of seaweed canopies causes shifts in the structure of associated communities.

The Institute for Marine and Antarctic Studies (IMAS), established in 2010, comprises the University of Tasmania's internationally recognised expertise across the full spectrum of temperate marine, Southern Ocean and Antarctic research and education.

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