WAMSI Biannual Progress Report to 30 June 2009 for

WAMSI Node 1 Project 2 (WAMSI Code 1.2): Coastal ecosystem characterisation, benthic ecology, connectivity and client delivery modules

EXECUTIVE SUMMARY

WAMSI Project Reference No: 1.2

Project title: Coastal ecosystem characterisation, benthic ecology, connectivity and client delivery modules

Node Leader: John Keesing

Project Leader: John Keesing

Project duration: 1 July 2006 to 30 June 2011

Due date for current milestone report: 30 June 2009

Project Objectives: To better characterise the south west Australian marine coastal and shelf ecosystem structure and function, and enhance our shared capacity to understand, predict and assess ecosystem response to anthropogenic and natural pressures by:

2.1. An assessment of the importance of physical forcing and ecological interactions among key functional groups in determining patterns of spatial mosaics in benthic habitats.
2.2. An assessment of ecosystem processes with particular relevance to contrasting fished and non-fished areas.
2.3. An assessment of likely dispersal patterns for marine organisms based on hydrodynamic and population genetic models.
2.4. Electronic delivery of data and models to management agencies, building on the development of the Data Interrogation and Visualisation Environment (DIVE) in SRFME.

WAMSI Node 1 Project 2 (WAMSI Code 1.2) Coastal ecosystem characterisation, benthic ecology, connectivity and client delivery modules

Executive Summary

2.1 An assessment of the importance of physical forcing and ecological interactions among key functional groups in determining patterns of spatial mosaics in benthic habitats.

The correlation between wave energy at the sea floor and gap size and frequency in kelp canopy habitats (larger and more frequent on the outer edge of the reefs than they are elsewhere) provides the potential to make predictions about how changing climate may impact on the structure and function of temperate reef ecosystems in south western Australia.

Since climate change will affect both wave- and temperature-regimes off the WA coast, understanding of gap formation processes is essential to predicting how this key primary producer will react, and assessing the resilience of WA coastal ecosystems. While a limited number of studies have attempted to summarise recent trends in wave climate in south west WA, and to understand and predict changes in swell wave generation in the southern ocean, the likely future wave climate in WA under climate change is far from certain, and there is a lack of targeted information on this question for southwest WA.

Experimentally created gaps continue to be monitored in order to better parameterise models of gap formation and infilling. With more than one year elapsed since experimental gap clearance, all gaps a dominated by a similar assemblage of macroalgae and none have yet returned to kelp forest habitat.

Further progress has been made on the development of habitat models aimed at understanding and predicting system dynamics, including the production of a draft manuscript describing the cellular automaton model. The model will allow inter-comparison of both field and model investigations conducted at different resolution in time and space since it is able to account for how changes in the spatial resolution lead to different interpretation of spatial structure. In particular, as the resolution is reduced, that is, as spatial cells are aggregated, the apparent dominance of one habitat type over the other increases.

<u>Specific milestones to be reported on in this period</u>

Milestone 2.1.4 Comparison of model behaviour with reference to observed patterns of patch distribution and modelled wave climate. MS preparation

The findings are summarised above and in detail including with illustrations on page 17 of the full report. A manuscript has been prepared from this work: Craig, P.D.(2009): Imposed and inherent scales in cellular automata models of habitat (in internal review).

2.2 An assessment of ecosystem processes with particular relevance to contrasting fished and non-fished areas

Timely decision-making for ecologically sustainable management requires the ability to rapidly and cost-effectively address the condition of resources and the ecosystems that sustain them. Research in this component of WAMSI Node 1 Project 2 has been directed at assessing the patterns of abundances of key groups of species that are important commercially or ecologically, and at key ecosystem processes that influence, and are influenced by, these patterns. Because one likely important modifying process on the temperate west coast of Australia is fishing by humans, surveys have been structured in a way that uses management units that aim to provide spatial refuges from fishing (sanctuary zones in DEC and RIA managed marine parks).

Surveys of abundance have encompassed finfish, rock lobsters, and large invertebrates, and were conducted at 26 sites during 2007 and 2008. Where possible, surveys encompassed reef, and seagrass and bare sand habitats. In addition, surveys of rates of herbivory and rates of predation have been performed. Sites have included six sanctuaries, two each at Rottnest Island, Marmion Lagoon, and Jurien Bay – these sanctuaries include a range of sizes from ~1 ha to >1,300 ha, and a range of ages from 3 years to 20 years.

Analyses suggest that key targeted taxa (rock lobsters and finfish) are generally more abundant inside sanctuaries that in the same area of equivalent habitat in areas open to fishing. This was especially evident for rock lobsters (5 of 6 sanctuaries). Abundance of rock lobsters and targeted finfish was not simply related to the size and age of a sanctuary, but size and age together explain a statistically significant proportion of the variation in abundance. The greatest responses were in sanctuaries that were old (20 years) or large (>1,300 ha). The weakest responses were observed in small sanctuaries.

In addition, the effects are somewhat context-dependent, with variation in assemblage composition due to differences in habitat (seagrass vs reef) and geography (three different regions: Rottnest, Marmion, Jurien) influencing the results. The underlying processes are complex – for example the compositional differences in Marmion might reflect a greater intensity of fishing pressure over a sustained period rather than true geographical gradients.

The spatial patterns in abundance of targeted taxa were not reflected by the rates of predation on mussels. There was little difference in the rates of survival between sanctuary and fished areas. However, the was a very strong difference between caged and uncaged mussels - uncaged mussels showed very low survival (30%) while caged mussels showed high survival (93%). This result suggests that predation (at least on organisms such as mussels) is likely to be a ubiquitously important process, and is high even where abundances of some predators have been depleted.

Specific milestones to be reported on in this period

Milestone 2.2.3 Draft MS on indicators of resource condition for selected WA coastal benthic systems

Research conducted towards understanding spatial gradients in community composition related to marine park zoning is intended to provide insights into what might be the best indicators of resource condition. The coastal ecosystems of Western Australia provide many resources, but those most germane to our study relate to fish and invertebrate resources accessed by the commercial and recreational fishing and tourism sectors. Analyses of these data is ongoing, but results of analyses to date do indicate that simple indicators might be misleading. For example, spatial gradients in fishing are overlain on geographical gradients in community composition. In addition, indicators that are appropriate for one type of habitat are perhaps not appropriate for other habitats – for example, indicators that are appropriate for reef habitats are not likely to be appropriate for seagrass habitats. Some of these data are presented in the full report on page 33. Analyses of the data will further develop these context dependencies. A manuscript is in preparation that contains summary statistics and comparisons of a range of metrics that have been proposed as indicators of resource condition. This work is still in progress.

2.3 An assessment of likely dispersal patterns for marine organisms based on hydrodynamic and population genetic models.

Sea urchins were sampled between Jurien and Esperance for assessment of population structure using DNA sequence variation. This phylogeographic analysis will be coupled with hydrodynamic dispersal modelling to determine biological connectivity under the influence of the Leeuwin Current system.

We have now developed protocols for reliable DNA sequencing of the Cytochrome Oxidase I mitochondrial gene and four nuclear exon-primed intron crossing (EPIC) regions to assay phylogeographic structure in West Australian urchins. Potentially suitable DNA sequence variability exists across the full sampling range in two species *H. erythrogamma* and *P. irregularis* and these form the basis of the comparative study based on samples at four widely spaced sights (Jurien, Marmion, Albany and Esperance). Sequencing should be completed late in 2009.

To model the influence of hydrodynamic processes on urchin larval dispersal, a deterministic particle tracking model has now been implemented in Matlab for the BLUELink Re-analysis (BRAN) model outputs during 1997-2002. Particle tracking experiments have been carried out to quantify the fate of the Leeuwin Current waters and the modelled larval dispersal patterns among the four urchin sample sites.

Preliminary results show that a significant portion of the Leeuwin Current particles, representing more than one third of the Leeuwin Current southward volume transport, are advected around Cape Leeuwin and eastward into the Great Australian Bight. The rest of the particles are dispersed by the Leeuwin

Current eddies and interaction with the continental shelf. Particle dispersal from sampling sites was generally southward on the west coast and eastward on the south coast, however, substantial northward dispersal was also observed in summer from the west coast sites when the Leeuwin Current flow is weakest and eddy activity is greatest. Dispersal distances were greater in winter when Leeuwin Current activity is greatest. Areas of higher retention or lower flushing rates are visible at several points along the coast indicating potential for the accummulation of larvae. The ecological implications of this result invite further investigation.

Specific milestones to be reported on in this period

Milestone 2.3.5 Population genetic modelling of likely dispersal patterns and generation of null models for comparison with observed genetic structure patterns. Draft MS on observed patterns of genetic structure and what it reveals about potential versus realised dispersal.

With the hydrodynamic modelling now complete (milestone 2.3.2) parameterisation of the population modelling (degree of spatial structure, rates and direction of gene flow and larval migration) awaits completion of the spatial genetic sequencing in milestone 2.3.4. Sequencing of COI and ANT genes in all available specimens from the four sampling regions has been completed and a preliminary analysis of genetic connectivity in one species *H. erythrogamma* has been conducted. Lodgement of these data with GenBank is now possible but effort is currently focussed on completing sequencing at the other loci so that the full genetic analysis can be conducted.

Sequencing is still underway at the other nuclear loci and while this was expected to be completed by March 09, unforeseen delays resulting from reduced quality of PCR amplification and DNA have occurred. Efforts to identify the cause(s) included complete replacement of experimental reagents and repetition of the PCR amplification in another laboratory (courtesy of Murdoch University) and these appear to have succeeded. We now expect to be able to complete sequencing at ATPs alpha within weeks. Lodgement of sequences with GenBank and the full multilocus genetic analysis can then be conducted.

Once this work has been completed, the proposed comparison of hydrodynamic estimates of connectivity with spatial genetic patterns and modelling will then be made and written up. Milestone 2.3.5 is now not expected to be completed ~~until the end of 2009~~.

2.4 Electronic delivery of data and models to management agencies, building on the development of the Data Interrogation and Visualisation Environment (DIVE) in SRFME.

Upgrades to DIVE in 2008/9 (updated from previous milestone report)

New features in DIVE since the June 2008 milestone report are as follows:

- The user can now select the time-zone in which the data are displayed.
- Data can be viewed in "single steps" through the time series or vertical layers.
- There have been many interface and consistency improvements:
    - A "busy indicator" shows users when DIVE is active but busy.
    - Improved display of data for multiple datasets and multiple variables, through the use of colour and line styles.
    - Hiding and display of data depending on the selected viewing time.
- Improved animation exporting:
    - more options on time-range to export.
    - export of AVI format as well as animated gif.
- Files in GeoTIFF format (e.g. navigation charts) can be used as backdrops.
- The user-preference system has been improved.
- The "lift-out" function has been improved .
- DIVE now has the ability to read multiple files in folder-based datasets as a single source.
- Ability to read ROMS (Regional Ocean Modeling System) output.
- The DIVE manual is updated.
- Improvements to facilitate improved display of biological and underway datasets including high-resolution glider data. For underway measurement, hovering the cursor over the vessel track will produce detail of the data

Modifications in progress include:

- An import facility for incorporation of non-continuous, non-contextual data (effectively by copy and paste from a spreadsheet).These data are insufficiently located, in time or space, in the data file, requiring additional user-input through the import facility.
- User-facility to create and edit symbols, and to add text to annotate DIVE output.

Scoping is currently underway for a "wizard tool" that will enable biological scientists to create relational database records from arbitrarily formatted data in documents such as Excel spreadsheets. DIVE will be able to display data from the relational database records so created.

DIVE will also be extended to use OGC (Open Geospatial Consortium) Catalogue Services standards to access data sets across the web. This capability will enable DIVE to access data sets archived by the Australian Oceanographic Data Network (AODN), and the Australian Integrated Marine Observation System (IMOS), which have both adopted OGC standards.

Specific milestones to be reported on in this period

There were no specific milestones related to this Output in this reporting period