WAMSI Biannual Progress Report (Concise Version) to 30 November 2009 for

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

WAMSI Project Reference No: 1.2

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

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Project duration: 1 July 2006 to 30 June 2011

Due date for current milestone report: 30 November 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. Other factors that might potentially influence these patterns, such as reef rugosity, are not correlated with gap structure at the cross-coast scale, 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. Compilation of data required for model parameterization is progressing well. Preliminary data from Marmion has been used to develop a simple one-dimensional model of patch dynamics which has produced results consistent with the hypothesis that gaps in kelp canopy are long-lived, with mean duration of approximately 8 years. The distribution of sessile invertebrates in these patches, and the estimated ages of corals align closely with the model estimates. We expect ongoing data collection and analysis to further corroborate these conclusions. The fact that kelp forest habitats do not adhere to a simple pattern of disturbance and succession has significant implications globally for studies of kelp forest dynamics, as well as for regional issues related to resource management.

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.

Specific milestones to be reported on in this period

None – next milestone due June 2010 however this report provides a significant update on the research

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 28 sites during 2007 and 2008 – 13 in Sanctuary zones, and 15 in 'General Use' or 'Recreation' zones. 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 5 ha to >1,300 ha, and a range of ages at date of surveys from 4 years to 19 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 (19 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. Summaries of patterns in abundance and biomass of fish and invertebrates, and rates of grazing and predation, are presented in accompanying data reports.

Specific milestones to be reported on in this period

Milestone 2.2.2: Field data collected at all sites. Draft MS on predator gradients in relation to spatial management regimes and size of management unit. Draft MS on variation in ecological processes in relation to spatial predator gradients.

This milestone is complete. The two reports have now been finalised and are provided separately.

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

We have established a provisional list of indicators against which our data is being tested. This is the focus of current efforts and while much of the work is complete the report MS has not been completed. However, it will be before the end of the next reporting period.

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

Sea urchins were sampled at Jurien, Perth, Albany and Esperance for assessment of population structure using DNA sequence variation. This phylogeographic analysis is currently being compared with hydrodynamic dispersal modelling to determine biological connectivity under the influence of the Leeuwin Current system.

Three genes in *H. erythrogramma* and two genes in *P. irregularis* have been sequenced in individuals from all four localities, revealing substantial levels of variation among individuals. Sequence diversity at nuclear genes was higher than for the mitochondrial gene COI. Substantial diversity exists within sites and most of the variation is partitioned among individuals rather than among sites as reflected in Φst values close to or below zero in most genes. No significant differentiation among sites was observed in either species at the COI gene, however, population structure is evident in *H. erythrogramma* at ANT and ATPsα.

Overall, genetic diversity patterns indicate that substantial gene flow occurs between the west and south coasts. There appears to be reduced geneflow in *H. erythrogramma* compared with *P. irregularis* that has led to populations structure at the geographical scale covered in this study. We are currently inferring bidirectional migration rates among all sites for statistical comparison with hydrodynamic connectivity estimates discussed below.

To model the influence of hydrodynamic processes on urchin larval dispersal and to evaluate its potential contribution to genetic patterns we have described, 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 accumulation of larvae. The ecological implications of this result invite further investigation.

Specific milestones to be reported on in this period

Milestone 2.3.4 Completion of genetic sequencing of samples and lodgement of data with GenBank.

This milestone has now been completed with three genes in *H. erythrogramma* and two genes in *P. irregularis* have been sequenced in individuals from all four localities, revealing substantial levels of variation among individuals. Sequences are lodged with GenBank with a moratorium on their release until publication of the genetic analysis in the peer reviewed literature.

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.

Results of the population modelling are presented in this report the basis of which will form the manuscript report. This is expected to be in draft form by the end of 2009 when the milestone is due.

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 2009/10 (updated from previous milestone report)

- An import tool that allows data to be read from a csv (comma-delimited) text file, or pasted from a spreadsheet, is nearing completion.
- DIVE can now connect to MEST (Metadata Entry and Search Tool) servers, select from available on-line datasets, and download and plot these datasets.
- It has improved capability for reading and displaying ROMS model output.
- The representation of vertical (depths/height) axes has been streamlined.
- The display of biological data sets is now easier – as the data to be displayed and the styles defining the symbols can be contained in a single file.
- The manual was updated as of September 2009.
- The DIVE installer has been improved and is now based on IzPack. This allows installations of DIVE onto all platforms supporting Java. The previous installer supported only windows PC, but DIVE can now be easily installed onto Linux and MacOSX platforms.

Specific milestones to be reported on in this period

There were no specific milestones related to this Output in this reporting period however a significant update on the upgrades to DIVE are provided at the end of the report