FINAL WAMSI PROJECT REPORT

Project 4.3 Trophic interactions and ecosystem modelling

Project Details

Project Number and Title:	4.3 Trophic Interactions and Ecosystem Modelling
Node Leader:	Dr Rick Fletcher
Project Leader:	Professor Neil Loneragan
Project Team:	4.3.1a Trophic interactions: Dr Lynda Bellchambers, Dr Matt Pember, Associate Professor Glenn Hyndes, Dr Pippa Moore 4.3.1b Fish food webs: Professor Ian Potter, Professor Norm Hall, Mr Ben French, Ms Thea Linke 4.3.2a Qualitative ecosystem modelling: Professor Norm Hall, Dr David Blockley, Dr Sarah Metcalf, Dr Jeffrey Dambacher 4.3.2b Quantitative ecosystem modelling: Professor Norm Hall, Ms Sarah Fretzer, Dr Hector Lozano-Montes, Dr Ben Chuwen, Professor Neil Loneragan
Project Start Date:	June, 2007
Project End Date:	July, 2011
Due Date for Final Report:	July, 2011

1. Project Objectives and Achievement Criteria

Confirmation of the project objectives and the delivery of milestones against the Key Performance Indicators:

This project had two major components of research: investigating trophic interactions in the marine environment; and developing an understanding of the value and application of ecosystem models for the Peel-Harvey estuary. The major management questions being addressed by the research were:

1. What are the possible indirect impacts of fishing on food webs and trophic interactions?
2. What types of experimental studies would be needed to examine the indirect effects of fishing on food webs and trophic interactions?
3. For ecosystems that have changed significantly (i.e., estuaries), can models increase understanding of the impacts? and
4. Can models be used to assess management changes (e.g., fisheries vs. other management) and long-term effects of factors, such as climate change and population growth?

The milestones for each of the sub-projects are listed in the Table below. Each of the milestones was achieved, noting that the milestones for sub-project 4.3.2 were revised at the direction of the WAMSI Board in 2010.

#	Milestone	Planned				
		Original Date	**Revised Date**	**Agency**	**Cost**	**Cumulative cost**
	4.3.1a Trophic interactions (DoF, ECU)					
1	Appoint postdoctoral researcher (DoF)	Jun 2007				
2	Complete outline of relevant issues for both finfish and invertebrate fisheries Draft literature review completed Hold workshop to identify needs Refine project milestones base on workshop Finalise research directions for extended project Submit external funding application (FRDC) Advertise for post doctoral position based at ECU	Dec 2007		DoF		
3	Appoint ECU postdoctoral fellow Publish literature synthesis Produce technical document to update risk assessments 1. If FRDC application is successful, planning will take place initiate extended project in July or 2. If unsuccessful, WAMSI-scale project will continue. Commenced field work	Jun 2008		DoF		
4	Field work ongoing (details to follow in external funding application)/ Final draft of document to update risk assessment produced Lobster sampling initiated Shallow water field work ongoing	Dec 2008		DoF ECU		
5	Field work ongoing/ Assessment and negotiation of suitable areas for closure complete. Shallow water field work ongoing	Jun 2009		DoF ECU		
6	Field work ongoing/ Detailed habitat map produced Shallow water field work ongoing	Dec 2009		DoF ECU		
7	Field work ongoing/ Monitoring of benthic communities in reference areas underway Shallow water field field work ongoing	Jun 2010		DoF ECU		

8	Draft final reports in review	Dec 2010	Mar 2011	ECU		
9	Final reports submitted	Jun 2011		ECU		
	4.3.1b Marine Demersal Food Webs (MU, DoF)	**Original Date**	**Revised Date**	**Agency**		
1.	Tabulate available dietary composition data for demersal marine community	Jun 2008		DoF		
2.	Preliminary food webs constructed and interim report completed. Note: gut samples of snapper will be collected by DoF throughout the study.	Dec 2008		DoF		
3.	Recently published dietary data included in a revised food web. Honours project to examine diets of two species commenced.	Feb 2009		DoF		
4.	Samples of guts of snapper and silver trevally from spring collected and winter of 1st year snapper collected by DoF) and processed.		Jan 2010	MU		
5.	Samples of guts of snapper and silver trevally for summer and autumn of 1st year collected and processed. Preliminary food web developed.		Jul 2010	MU		
6.	Samples of guts of snapper and silver trevally for winter and spring of 2nd year collected and processed.		Jan 2011	MU		
7.	Presentation of draft results to Node 4, for incofporation in synthesis report for Node.		Mar 2011	MU		
8.	Submission of final report to WAMSI		May 2011	MU		
	4.3.2 Ecosystem modelling	**Original Date**	**Revised Date**	**Agency**		
1	Postdoctoral position advertised and appointment offered. Preliminary structure of qualitative and quantitative models developed. Completion of first year of PhD top-up for Sarah Fretzer. Completion of first year of PhD top-up for Thea Linke.	Dec 2008		MU		
2.	First Peel-Harvey workshop held. First draft of qualitative models produced. Fishery data extracted, collated and summarised.	Mar 2009		MU		
3.	Balanced Ecopath model for Peel-Harvey produced. Completion of 2nd year of PhD top-up for Sarah Fretzer.	June 2009		MU		
4.	Completion of 2nd year of PhD top-up for Thea Linke.	Aug 2009		MU		
5.	Ecosim model created and diagnostics/behaviour explored.	Dec 2009		MU		
6.	**4.3.2a Qualitative modelling** Workshop to develop conceptual understanding of Peel-Harvey estuary ecology, socio-economics and management held (12-13 april). Development of qualitative models and report from the workshop.	Jun 2010		MU		
7.	**4.3.2b Quantitative modelling** Develop objectives, background information and structure for workshop, identify participants for the workshop and set date for workshop.		Jul 2010	MU		
8	**4.3.2a Qualitative modelling**	Sept 2010		MU		

	Progress report on qualitative modelling to WAMSI CEO **4.3.2b Quantitative modelling** Progress report on quantitative modelling to WAMSI CEO					
9.	**4.3.2a Qualitative modelling** Refinement of models through follow-up meetings with different organisations and individuals. Report on refined models produced. Possible second workshop to provide feedback to selected people. **4.3.2b Quantitative modelling** Hold workshop and produce draft report on findings from the workshop. Complete draft report on 4.3.2 Quantitative Ecosystem Modelling.	Dec 2010		MU		
10.	**4.3.2a Qualitative modelling** Final report on qualitative modelling produced. **4.3.2b Quantitative modelling** Revise draft report and produce the final report to WAMSI on Quantitative Ecosystem Modelling.		Mar 2011	MU		

2. Overview

To meet the objectives of the Project, the following Sub Projects were undertaken. Full accounts of these can be found in the Sub Project Reports and Attachments.

4.3.1 Trophic interactions and aquatic food webs

a) Trophic interactions of lobster in:
   Deep water (DoF, UWA – Lynda Bellchambers, Matt Pember)
   Shallow water (Edith Cowan University – Glenn Hyndes)
b) Marine demersal food webs (DoF – Dan Gaughan, Sarah Metcalf
   Murdoch University – Ian Potter, Norm Hall, Ben French)

Management questions addressed:

1. What are the possible indirect impacts of fishing on food webs and trophic interactions?
2. What types of experimental studies would be needed to examine the indirect effects of fishing on food webs and trophic interactions?

4.3.2 Ecosystem modelling of the Peel-Harvey estuary

a) Qualitative models (MU, DoF, CSIRO – Sarah Metcalf, Jeffrey Dambacher)
b) Quantitative modelling for the Peel-Harvey (MU, DoF, CSIRO – Norm Hall, Neil Loneragan, Ben Chuwen, Hector Lozano-Montes) PhD studies of Sarah Fretzer and Thea Linke

Management questions addressed:

3. For ecosystems that have changed significantly (i.e., estuaries), can models increase understanding of the impacts? and
4. Can models be used to assess management changes (e.g., fisheries vs. other management) and long-term effects of factors, such as climate change and population growth?

3. Summary

Half page to full page Executive Summary of results from each Sub Project. Must link directly to Objectives of Project.

4.3.1 Trophic interactions and marine and estuarine food webs

Research in this component focused on the ecosystem effects of lobster fishing in deep (>40 m depth) and shallow waters (< 20 m). In shallow waters it was possible to compare areas with different levels of fishing (open and closed) and different levels of lobster density, while in deep waters, a major achievement of the research was establishing a scientific closure to fishing in the Jurien region, adjacent to an area that had been studied in detail.

4.3.1 a) Deep water effects of lobster fishing (Department of Fisheries – Lynda Bellchambers/Matt Pember), University of Western Australia)

- Surveys of the designated closed area, prior to closure, and adjacent open area found similar densities and sizes of lobster and similar habitat types. This information provides critical information for comparison after the closure is implemented and established a three year baseline for future comparisons.
- Detailed maps of benthic habitats were obtained for the closed area prior to closure and are available from previous research for the open area.
- Major funding was obtained from the Fisheries Research and Development Corporation to extend the research to allow comparisons of the closed and open area after the closure has been implemented. Comparisons will be made between lobster populations and the ecosystem in the closed and open area.
- Qualitative models were developed to provide a conceptual understanding of lobster fishing and identify potential indictors of ecosystem change attributable to western rock lobster fishing, including both the harvest of removal and the addition of bait into the system. These models identified two potential indicator groups for lobster fishing: one responsive to the removal of lobster - small fish of low economic value, such as old wife (*Enoplosus armatus*), footballer sweep (*Neatypus obliquus*), and king wrasse (*Coris auricularis*); and the other responsive to the addition of bait to the ecosystem – small crustaceans (amphipods and isopods). The cost-effectiveness of these potential indicators will be evaluated as part of the FRDC project using stereo baited remote underwater videos (BRUVs) and baited scavenger traps.
- Links with the Monitoring project (WAMSI 4.2) have provided the basis for using an Autonomous Underwater Vehicle (AUV) to survey habitats and assemblage structure inside and outside the closed area as part of the FRDC project. The AUV is an Integrated Marine Observation System (IMOS) facility operated by the Australian Centre for Field Robotics (ACFR) based at The University of Sydney.
- A thorough understanding of the types and distribution of benthic habitats and the relationships between habitats and exploited species, and the fisheries they support, increases the capacity for fisheries management to be adaptive and ecologically sustainable. All stakeholders, including the wider community, benefit from marine resources being managed in an ecosystem based manner.
- The results from research in the deep water provide the basis to further evaluate the ecosystem effects of lobster fishing and meet a criterion for continued certification of the fishery by the Marine Stewardship Council.

4.3.1a) Shallow water effects of lobster fishing (Edith Cowan University – Glenn Hyndes)

This research used series of integrated field surveys and experiments, including:

1) A broad-scale survey of *P. cygnus* abundance in the Perth Metropolitan Area;
2) A correlative study that used existing gradients of *P. cygnus* density (sanctuary vs. non-sanctuary zones) to determine if temporal and spatial patterns in seagrass assemblage structure could be attributed to *P. cygnus* foraging behaviour;
3) Experiments to determine if there were density-dependent effects on *P. cygnus* diet using stomach contents analysis and stable isotope techniques;
4) Radio-acoustic positioning technology to continuously track the foraging patterns of *P. cygnus*; and
5) Controlled caging experiments to determine the role of *P. cygnus* in structuring shallow-water benthic assemblages.

The outcomes of the research were:

- Changes in *P. cygnus* densities may influence the abundance of some important prey species – densities of the molluc grazer *Cantharidus* spp. were lower at higher densities of lobster.
- No evidence was found of any flow-on effects through the food web or any evidence that *P. cygnus* plays a role in structuring benthic assemblages as a whole. This results is probably due to the diverse benthic fauna found in most locations, the diversity of the lobster diet and the high

levels of variability in benthic communities within short distances (metres).

- The high resolution acoustic tracking showed that the foraging period of *P. cygnus* is limited to approximately one hour per night and that the home range of lobster in this part of its distribution (Perth metropolitan area) is relatively small.
- Lobster diets and the source of nutrition assimilated by lobster did not change with lobster density over the range of densities studies.
- An Honours student, Karina Inostroza, completed an Honours Thesis in 2009/10 entitled "Do different levels of fishing pressure, through spatial management, influence communities and ecological interactions in seagrass meadows in south Western Australia?" Edith Cowan University.

b) Marine demersal food webs (Murdoch University – Ian Potter/Norm Hall, Department of Fisheries)

The objectives of this research were:

1. To determine the ways in which the diets of Snapper and Silver Trevally change with body size, region, and season on the lower west coast of Australia.
2. To construct a reliable food web derived from dietary data for a wide range of demersal fish species off the lower west coast of Australia.

The scope of this study was extended greatly with additional funding from the FRDC Support for a study "Determination of the diets of Snapper and Silver Trevally and construction of a food web for the demersal fish community in south-western Australia" (FRDC 2009/006, Final report due on Jan 31, 2012).

- Qualitative models were developed to identify indicators of change in the demersal ecosystem due to fishing. Two alternative models of the demersal trophic web in the West Coast Bioregion were produced with small invertebrate feeding fish and decapods identified as potential indicators of change due to fishing. Small invertebrate feeding fish were also the most sensitive variable to change in the demersal finfish and rock lobster fisheries. As a result of this sensitivity, as well as the ease of monitoring, small invertebrate feeding fish were identified as a better indicator of the effects of fishing than decapods.
- The production of qualitative models also highlighted the need for data collection to increase the understanding of general ecosystem dynamics.
- The analysis of the stomach contents show that Snapper feed primarily on benthic invertebrates and teleosts, while the Silver Trevally feed mainly on both benthic and epibenthic invertebrates. The diets of each species differed among individuals of different size classes, and to a lesser extent between regions and marginally with seasons. The study has also compared the dietary compositions of co-occurring populations of Snapper and Silver Trevally, taking into account the influence of body size, region, and season. When they co-occur, Snapper feed to a greater extent on ophiuroids, asteroids and echinoids than does Silver Trevally where as the latter species feeds to a greater degree on littorinids, carids and amphipods.
- A preliminary food web has been produced using historical data. Following completion of the research on diets of Snapper and Silver Trevally, these data will be entered on the database and the food web will be revised food web for the demersal fish in the waters off the coast of the West Coast Bioregion between Lancelin and Mandurah.
- These data will allow comparisons with future dietary data, *i.e.* the relative volumetric compositions of prey items in the guts of individuals of Snapper and Silver Trevally, to determine whether dietary compositions have changed and, if so, the nature of those changes.
- Analyses of the dietary data and construction of the demersal fish food web show that the Department of Fisheries does not need to modify its current risk assessment of the effects of fishing on demersal fish communities and food webs.

4.3.2 Ecosystem modelling of the Peel-Harvey estuary

The Peel Harvey estuary is one of Australia's fastest growing residential areas and is a popular location for recreational activities such as fishing, bird watching and boating. The social and economic wellbeing of the local community is linked to the health of the estuary and evidence is beginning to appear that without changes in overall catchment management (including types of land-use, nutrient input, ecological management and governance), estuarine health will decline, potentially causing serious social and economic issues. The models and approaches developed in this component of research have potential

applications to estuaries of south-western Australia.

4.3.2 a) Qualitative models

Workshops with stakeholders, including community groups, government agencies, researchers, managers and non-government organisations, and discussions with individuals or small groups following the workshops, were used to identify the values and issues for the Peel-Harvey estuary.

- Qualitative models were developed for water quality, wading birds, blue swimmer crabs and governance of the Peel-Harvey estuary. Each model was used to assess the current situation and the drivers of change that were negatively impacting the focal asset.
- All models identified the need to improve water quality throughout the estuary and nearby rivers by reducing nutrient input from various sources, and the need to alter current governance structures to allow effective environmental management.
- Overlapping responsibilities between different departments and agencies was identified as a significant issue in the region. A potential risk of this overlap is that a lack of clarity of the role of departments/agencies can result in issues being 'lost between the cracks'.
- Future governance models were produced to examine the consequences of clear lines of responsibility and feedbacks between departments and their assets (i.e. water quality, agriculture, industry etc.), and to represent mutual accountability. This accountability was shown to clarify paths of governance and provide better delivery of economic, social and environmental outcomes. Strong environmental and nutrient management were integral to these models. These modeled changes, incorporated in the future governance models, ensured that effective management occurred, thereby stimulating an increase in environmental quality, the local economy and real estate values.
- Trade-offs between different types of land use (i.e. residential, industrial, agricultural and conservation) were identified as critical to allow improved environmental management. For instance, a reduction in total resource use from urban development, agricultural and industrial land use, in conjunction with strong environmental management was necessary to improve environmental quality.
- This study focussed on assets and priorities identified by workshop participants and while some progress has been made towards identifying key drivers of ineffective governance, further work on governance in this region is important.
- The use of qualitative modelling should be considered more widely by other agencies to identify key dynamics and to prioritise resources towards key drivers of change. This technique is useful as it stimulates communication between stakeholders and easily incorporates different stakeholder opinions using any type of information (i.e. ecological, social and economic etc.). These models are relatively quick to produce, are a cost-effective method of focusing further investigations, and provide an effective tool to facilitate early evaluation of complex.
- During the progress of WAMSI Node 4, Dr Sarah Metcalf further developed her modelling expertise from her PhD studies and provided very effective input and leadership to the modelling workshops across a range of projects.

4.3.2 b) Quantitative modelling for the Peel-Harvey

Research on quantitative modelling of the Peel-Harvey ecosystem included the PhD studies of Sarah Fretzer, using Ecopath and a workshop, with ensuring discussions to consider alternative modelling platforms and pathways for development of a quantitative ecosystem model for the Peel Harvey estuarine system. This modelling framework and models were to have broad applicability to other south-western Australian estuaries and produce reliable predictions of the outcomes of alternative management strategies.

The workshop participants agreed that such modelling:

- Must be undertaken in a staged approach with separate modules considered for catchment(s), hydrodynamic, biogeochemical, ecological/food web, human use and socio-economic sub-models.
- Modules should be capable of being developed in parallel and the sub-models must be able to

take into account the pressures of population growth and climate change.

- The modelling task will require a long-term commitment, and the key to its success will be the establishment of an appropriate organisational structure with the necessary personnel, responsibilities, and funding to lead and coordinate modelling activity and facilitate cross-disciplinary collaboration.
- The workshop participants considered that the pathway for the development of a quantitative ecosystem model for the Peel Harvey should involve:
    1. the establishment of a estuarine modelling reference group,
    2. the use of the outcomes of qualitative modelling to produce conceptual models of the various ecosystem components,
    3. a "report card" or condition report to engage community and stakeholders,
    4. the parallel development of the sub-models, preferably using open source code, and
    5. concomitant investment in monitoring and data collection.
- The Final report outlines a series of recommendations which evolved from the workshop and which will enable the development of a quantitative ecosystem model for the Peel Harvey Estuary.

4. Discussion

Implications for Management and/or Advancement of the Field – Describe the key findings as they relate to the objectives and the management questions discussed at the outset of the project.

4.3.1 Trophic interactions and marine and estuarine food webs

4.3.1 a) Deep water effects of lobster fishing

- The establishment of the scientific closure and baseline monitoring of this closed area and open area, with future research, provides the basis for understanding the ecosystem effects of fishing in deep water, and the effects of fishing on lobster populations. This information will enhance the management and sustainability of the very valuable lobster fishery.
- Indicator groups were identified for monitoring the effects of lobster fishing on the deepwater ecosystem that will be evaluated in the FRDC project, the first attempt to establish non-fishery indicators for the lobster effects of fishing.
- New technologies (Autonomous Underwater Vehicle) are being applied to develop rapid, cost-effective assessment techniques for surveying ecosystems in the lobster fishery.
- This research has increased the capacity for fisheries management to be adaptive and ecologically sustainable. All stakeholders, including the wider community, benefit from marine resources being managed in an ecosystem based manner.
- The results from research in the deep water provide the basis to further evaluate the ecosystem effects of lobster fishing and meet a criterion for continued certification of the fishery by the Marine Stewardship Council.

4.3.1a) Shallow water effects of lobster fishing

- No evidence was found of major impacts of lobster fishing on the food web and ecosystem of shallow waters.
- The variation in benthic communities in shallow waters is large over small areas which means that experiments need to be well designed with appropriate levels of replication.
- An Honours student, Karina Inostroza, completed an Honours Thesis in 2009/10 entitled "Do different levels of fishing pressure, through spatial management, influence communities and ecological interactions in seagrass meadows in south Western Australia?" Edith Cowan University.

4.3.1 b) Marine demersal food webs

- Qualitative models have identified that small invertebrate feeding fish have potential identified as an indicator of the effects of fishing than decapods and that further data needs to be gathered to

increase our understanding of general ecosystem dynamics.

- Diets of Silver Trevally and Snapper changed as they increased in size. They also differed when they they co-occurred in the same region, thus reducing the potential for competition.
- The revised food web and information on diets of Snapper and Silver Trevally provide valuable baselines for future comparisons. Currently, they show that the risk that fishing is impacting the demersal food web is low.

4.3.2 Ecosystem modelling of the Peel-Harvey estuary

4.3.2 a) Qualitative models

- Qualitative models identified the need to improve water quality throughout the estuary and nearby rivers by reducing nutrient input from various sources, and the need to alter current governance structures to allow effective environmental management.
- Overlapping responsibilities between different departments and agencies was identified as a significant issue in the region. A potential risk of this overlap is that a lack of clarity of the role of departments/agencies can result in issues being 'lost between the cracks'.
- Future governance models that had clear lines of responsibility and feedback between Departments and the condition of their assets have the potential to ensure that management is more effective. This is likely to lead to an increase in environmental quality, the local economy and real estate values.
- Trade-offs between different types of land use (i.e. residential, industrial, agricultural and conservation) were identified as critical to allow improved environmental management. For instance, a reduction in total resource use from urban development, agricultural and industrial land use, in conjunction with strong environmental management was necessary to improve environmental quality.

4.3.2 a) Quantitative models

This project identified a modelling framework and sub-components of models that would be valuable for development in the Peel-Havey estuary. The key steps in the pathway for the development of a quantitative ecosystem model for the Peel Harvey should involve:

1. the establishment of a estuarine modelling reference group,
2. the use of the outcomes of qualitative modelling to produce conceptual models of the various ecosystem components,
3. a "report card" or condition report to engage community and stakeholders,
4. the parallel development of the sub-models, preferably using open source code, and
5. concomitant investment in monitoring and data collection.

- The development of a quantitative mode requires a long-term commitment, and the key to its success will be the establishment of an appropriate organisational structure with the necessary personnel, responsibilities, and funding to lead and coordinate modelling activity and facilitate cross-disciplinary collaboration.

Problems encountered (if any) – Describe any major problems/issues encountered during the study and how they were addressed.

4.3.1 Trophic interactions and marine and estuarine food webs

4.3.1 a) Deep water effects of lobster fishing

Negotiations with the Rock Lobster industry took some time to establish an area closed to fishing. This was resolved by obtaining significant additional funding from the FRDC to survey the system after the establishment of the closure.

4.3.1a) Shallow water effects of lobster fishing

The postdoctoral fellow appointed on this project, Dr Pippa Moore, resigned at the end of 2010, before the completion of the project report. Research assistants were appointed to assist in the completion of the data analyses and report writing.

4.3.1 b) Marine demersal food webs

The funding for this component of research was small. Additional funds were obtained from FRDC to support the research on Marine demersal food webs. Initially, the project was designed for an Honours project but no suitable student was found. The additional funding allowed a PhD student, Mr Ben French, to become involved with the research.

4.3.2 Ecosystem modelling of the Peel-Harvey estuary

4.3.2 a) Qualitative models

Major problems were encountered in finding a suitable post-doctoral research fellow, and then retaining them, for this component of research. After sometime, Dr David Blockley was appointed to the project but resigned in less than 12 months. The qualitative modelling element of ecosystem modelling was achieved by gaining agreement for Dr Sarah Metcalf (MU/DoF Postdoctoral research fellow) and Dr Jeffrey Dambacher (CSIRO) to complete this research. Professor Norm Hall retired from Murdoch University in 2009 but fortunately, retained some involvement with this component of research. Professor Neil Loneragan took over other roles that had previously been completed by Professor Hall. These changes influenced progress on the qualitative and quantitative ecosystem modelling.

4.3.2 b) Quantitative models

The major issue for this project, however, was in the choice Ecopath as the quantitative modelling package for the Peel-Harvey estuary. Following the February 2010 presentation of the Project progress, the WAMSI Board directed that the current direction of the quantitative modelling stop and be re-scoped to assess and evaluate the frameworks and approaches that would be suitable for the Peel-Harvey estuary and other estuaries of south-western Australia. This component was completely revised, with new milestones and new people involved on it including, Professor Neil Loneragan, Dr Hector Lozano-Montes, and Dr Ben Chuwen.

New Research Directions (if any) – Identify new research directions pursued during the course of the project and reasons for modifying original research plans. Describe how the changed research agenda improved the project.

4.3.1 Trophic interactions and marine and estuarine food webs

4.3.1 a) Deep water effects of lobster fishing

The sampling methods developed in this project provide the basis for developing a long-term monitoring strategy of lobster effects of fishing for the research closure (closed initially for five years). Future research will need to include work on determining appropriate temporal scales for sampling.

The zoning of the closed area has also provided researchers with the opportunity to investigate aspects of lobster biology and ecology in the absence of exploitation. The high resolution habitat information produced during this study will be valuable in parameterising tracking and movement studies using acoustic tagging to validate lobster habitat use and home ranges.

If gradients of lobster abundance are established over time with the implementation of the closed area, future work should concentrate on determining the role of large western rock lobster, particularly in deep-water food webs. These trophic studies should incorporate contemporary techniques including stable isotope, lipid or molecular analyses.

The research in this project needs to be expanded to cover the extent of the fishery and include other key life stages, e.g., what are the key habitat parameters influencing the settlement and subsequent survival of early juveniles?

4.3.1a) Shallow water effects of lobster fishing

This study focussed on the metropolitan region and needs to be replicated in other regions where high levels of fishing effort on lobster in shallow waters are found. This will give greater certainty on the conclusions form this study i.e., that rock lobster fishing is not posing an unacceptable risk to benthic assemblages over the range of the fishery.

4.3.1b Marine demersal food webs

This study has provided detailed information on dietary items that have been ingested but it is not known whether this is due of prey selection (preference) or the availability of preference and the transfer of energy from prey to predator. Valuable insight into the contribution of prey to the sustenance of the

predator, and the structure of the food web, may be provided by stable isotope analyses. Such analyses should be considered to provide the baseline data required for a full understanding of the food web of the demersal fish community in the waters of the West Coast Bioregion.

4.3.2 Ecosystem modelling of the Peel-Harvey estuary

4.3.2 a) Qualitative models

- This study focussed on assets and priorities identified by workshop participants and while some progress has been made towards identifying key drivers of ineffective governance, further work on governance in this region is important.
- The use of qualitative modelling should be considered more widely by other agencies to identify key dynamics and to prioritise resources towards key drivers of change. This technique is useful as it stimulates communication between stakeholders and easily incorporates different stakeholder opinions using any type of information (i.e. ecological, social and economic etc.). These models are relatively quick to produce, are a cost-effective method of focusing further investigations, and provide an effective tool to facilitate early evaluation of complex.

4.3.2 b) Quantitative models

Directions and the pathway for the development of a quantitative ecosystem model of the Peel-Harvey estuary have been clearly identified in the Final technical report for the sub-project.

5. Overall Project Accomplishments

Students supported – Record the name of each student involved with the project. Indicate whether PhD or other (give details) and briefly describe their role.

PhD students

Mr Ben French. Demersal food webs and the diets of Silver Trevally and Snapper in the west coast bioregion of Western Australia. Murdoch University. PhD in progress. Ben's research provides the core information for 4.3.1b on marine demersal foodwebs.

Ms Thea Linke. Trophic interactions of fish in a permantly open (Swan-Canning estuary) and a seasonally open estuary (Wilson Inlet) in south-western Australia. Murdoch University. PhD to be submitted in December 2011. Thea's top-up scholarship has supported her research to understand trophic interactions and food webs of estuaries. This is providing additional understanding to the ecosystem modelling approaches used in 4.3.2.

Ms Sarah Fretzer. Quantitative ecosystem modelling of the Peel-Harvey estuary. Murdoch University. PhD submitted in 2011. Currently under examination. Initially, Sarah's PhD was a core element of 4.3.2b on Quantitative modelling of the Peel-Harvey estuary. As part of her Thesis, she coordinated workshops which were valuable for drawing a range of people together and providing an understanding of the available data for the Peel-Harvey estuary.

Honours

Karina Inostroza, (2010). Do different levels of fishing pressure, through spatial management, influence communities and ecological interactions in seagrass meadows in south Western Australia? Edith Cowan University. Karina provided valuable input to the research on shallow water effects of lobster fishing .

PhD theses, Dissertations and Student Placement – Please give complete citation for theses and dissertations (student's name, month and year completed or expected, level of degree, institution). Please provide a copy of the abstract of the thesis or dissertation when complete.

Final abstracts of PhD These are not available yet.

Publications - List in standard academic format the citations of literature produced during the reporting period. Include journal articles, book chapters, reports, etc. submitted, in press and printed. Please provide a paper and electronic version copy of each publication resulting from the project. If there is a link to the journal electronically, please also include this.

Department of Fisheries report (FOR 053) on outcomes from workshop on lobster effects of fishing in deepwater that includes the closed area selection criteria formulated by the Ecosystem effects of fishing Scientific Reference Group.

Metcalf, S. J., Pember, M. B. and Bellchambers, L. M. 2011. Identifying indicators of the effects of fishing using alternative models, uncertainty, and aggregation error. *ICES Journal of Marine Science*, **68**: 1417–1425.

Sarah Metcalf is also preparing a manuscript on governance of the Peel-Harvey estuary.

Metcalf, S.J., Dambacher, J.M., Rogers, P., Hall, N., Loneragan, N. and Gaughan, D.J. (draft manuscript) Identifying key dynamics and ideal governance structures for successful ecological management.

Presentations - Cite any presentations resulting from the project, including conferences, symposiums, etc.

Project overviews have been given at all WAMSI Node 4 symposia, to the WAMSI project review process and the Final WAMSI Symposium. In addition, oral presentations were made at the following conferences/symposia:-

Deep water lobster

The 9th International Conference and Workshop on Lobster Biology and Management (Bergen, Norway)

The 9th International Temperate Reef Symposium (Plymouth, UK)

The 48th Australian Marine Sciences Association (AMSA) Conference (Fremantle, Australia).

Shallow water lobster

8th International Temperate Reefs Symposium, Adelaide SA, 12-16 January 2009.

WAMSI symposium: Monitoring for Action: Understanding WA's changing marine and coastal environment, 24 November 2009.

WAMSI show and tell, Fremantle. February 9th, 2010.

Effects of Fishing Advisory Group 2nd-3rd Nov 2010

WAMSI Node 4 annual meeting 6th Dec 2010

Marine demersal food webs

Ninth International Temperate Reefs Symposium, June 2011, Plymouth, UK.

Ecosystem modelling

Metcalf, S.J. & Dambacher, J.M. Simple goverence models for EBFM. Lowel Wakefield symposium Anchorage, Alaska November 8-11, 2010. Sarah Metcalf presented models from WAMSI 4.3.2.1 at this conference. Full details of the presentation can be found in the abstract book which is available from http://seagrant.uaf.edu/conferences/2010/wakefield-ecosystems/abstract-book.pdf

Other Communications Achievements - Interviews, press releases, etc.

6. Overall Project Benefits Please note: Benefits go beyond Results and Accomplishments to provide information on direct physical, environmental, economic or social gains realised as a result of a research project or outreach activity.

Discovery and Application of New Products and Processes (if applicable) - Describe any actual or anticipated products or processes discovered or developed in the project.

Not applicable

Tools, Technologies and Information for Improved Ecosystem Management - Describe how project results are being (or will be) translated into sustainable use and management of coastal and ocean

ecosystems. Tools might include benthic habitat maps or environmental sensitivity indicators. Technologies might include remote and bio-sensing, genetic markers, and culture systems. Information might include technical assistance, training and educational materials.

- Detailed benthic habitat maps of open and closed areas in the lobster fishy for future monitoiring
- Development and application of new technology (Autonomous Underwater Vehicle) for rapid, cost-effective monitoring in deep water
- Application of acoustic tags to determine behaviour of lobster in shallow water reefs. Provides information required to understand habitat requirements of lobster and contribute to the design of Marine Protected Areas.
- Development of new multivariate approaches for evaluating similarities in fish diets
- Information and use of qualitative models for evaluating diverse issues and the functioning of the Peel-Harvey estuary. Provided a basis for developing a map of governance arrangements and evaluating their potential effectiveness. Also provided the basis for considering alternative governance arrangements.
- Information and evaluation of model platforms and components of models to be applied to the Peel-Harvey estuary and estuaries of south-western Australia in general.

Forecasting for Natural Resource Management Decisions - Describe how results already are being used - or are expected to be used after project completion - by natural resource management to make decisions based on project forecasts. Forecasts may be due to field and laboratory studies and models. Examples include hypoxia forecast models, algal bloom alerts, forecasts of fishery harvest, and prediction of impacts from ecosystem stressors such as pollutants or invasive species.

Impacts - Impacts are higher order, usually long-term results of a project's activities that have significant scientific, economic or social benefits. Impacts may involve behavioural, policy or economic changes. Describe impacts (anticipated or realized. These impacts may involve behavioural, policy or economic changes. Seminal contributions to science are considered impacts especially if the research findings lead to major progress in a particular field, implementation of new technologies or have a substantive bearing on an economic or societal issue.

7. Project Metadata and Data Generated

These must be available at an open access repository/data centre/iVEC.

Sub-project metadata have been lodged or are being lodged with i-Vec.

8. Linkages to Associated Projects – can be WAMSI and non-WAMSI

4.3.1 Trophic interactions and marine and estuarine food webs

4.3.1 a) Deep water effects of lobster fishing

FRDC 2008/13

FRDC 2011/21: Development of an industry-based habitat mapping/monitoring system.

4.3.1 b) Marine demersal food webs

FRDC 2009/006 - Determination of the diets of Snapper and Silver Trevally and construction of a food web for the demersal fish community in south-western Australia

4.3.2 Ecosystem modelling of the Peel-Harvey estuary

Peter Rogers, Norm Hall, and Fiona Valesini worked with the Peel-Harvey Catchment council to develop a Science Strategy for the estuary. They produced the following report:

Rogers P, Hall N and Valesini F (2010). Science Strategy for the Peel-Harvey Estuary. Prepared for the Peel-Harvey Catchment Council, July 2010.

9. Other Comments and General Discussion

Deep water lobster:

A number of papers are currently in preparation, based on the information that has arisen from the larger WAMSI/FRDC project. It is expected that the submission of these manuscripts will continue well past the December 2012 end date for FRDC 2008/13.

The baseline habitat work provided by this project and FRDC 2008/13 will now be expanded through close ties between FRDC 2008/13 and a new project FRDC 2011/21: Development of an industry-based habitat mapping/monitoring system.

The Department of Fisheries plans to seek funding in the future to expand the work investigating the drivers affecting the spatial ecology of lobster to cover a wider extent of the fishery and other key life stages, i.e. newly settled juveniles.

Marine demersal food webs

The preparation of scientific papers describing the diets of Snapper and Silver Trevally has commenced, however the results of analyses of recently collected samples will need to be incorporated before these can be completed.

10. Annexures

- Sub-project reports presented
- Additional attachments

All sub-project milestone reports have been submitted and Final sub-project reports were provided with the final milestone report. No additional attachments.