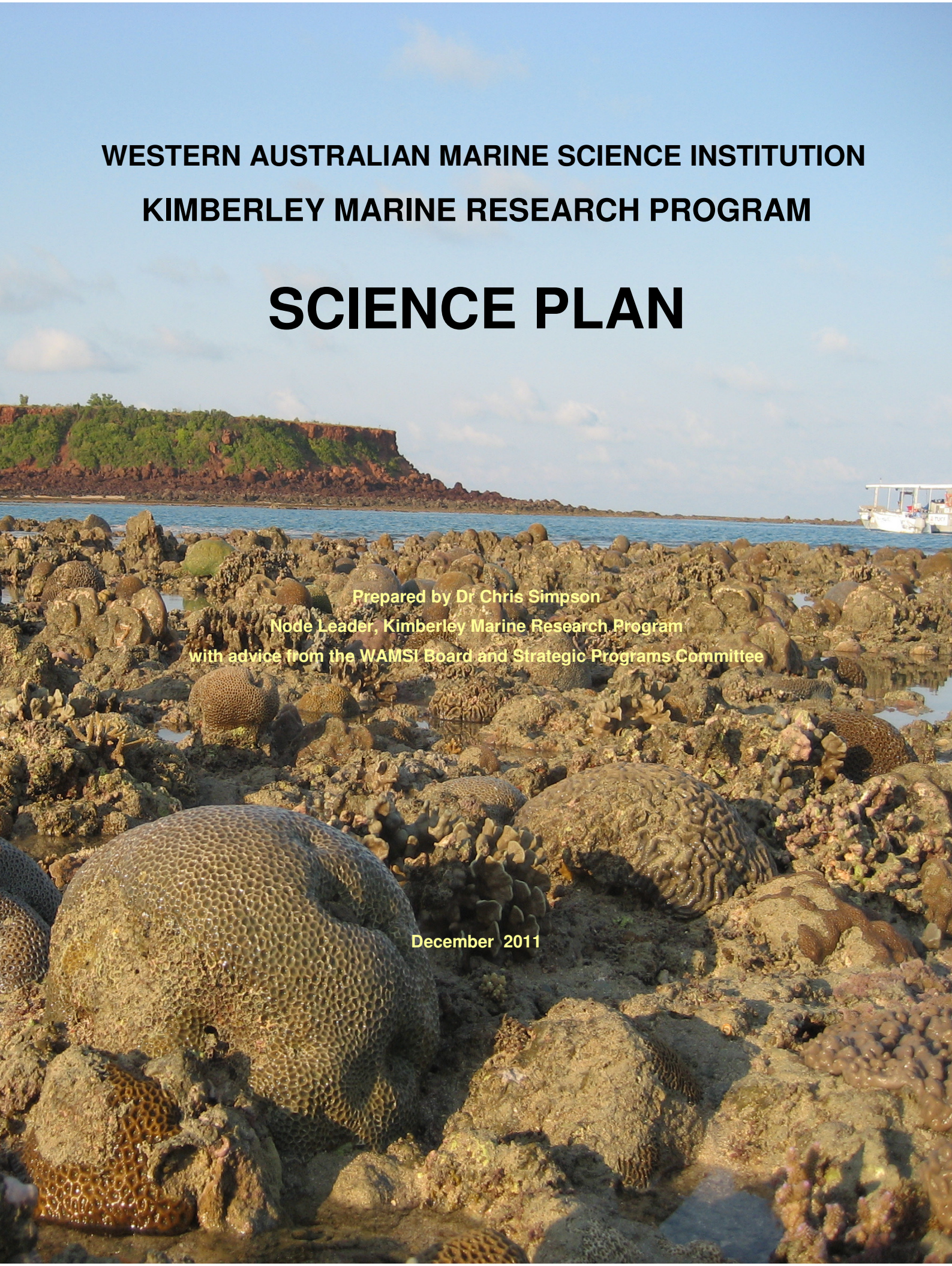

WESTERN AUSTRALIAN MARINE SCIENCE INSTITUTION

KIMBERLEY MARINE RESEARCH PROGRAM

SCIENCE PLAN

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with advice from the WAMSI Board and Strategic Programs Committee

December 2011

Cover photograph: High diversity, inter-tidal coral reef off the Maret Islands, North Kimbrerley. Courtesy of DEC.

This report can be found on the WAMSI website: (www.wamsi.org.au)

EXECUTIVE SUMMARY

The Kimberley Marine Research Program Science Plan (KMRP Science Plan) outlines the proposed integrating science projects and research areas, management information requirements/questions, nominal spatial scale, collaborating institutions, proposed WAMSI funding and the process to develop the Science Project Plans by 31 May 2012. The KMRP Science Plan is a key element of the State Funding Agreement to be signed between WAMSI and the Western Australian Government in November/December 2011. The Science Plan has been considered at a joint meeting of the WAMSI Strategic Programs Committee, R&D Committee and the Operational Group on the 24 October 2011 prior to being presented and approved at the 3 November 2011 meeting of the WAMSI Board.

1. INTRODUCTION

In June 2011 the Western Australian Government released the Kimberley Science and Conservation Strategy (KSCS)[1] "… *to recognize and conserve one of the world's last great wilderness areas*". Funding for the KSCS was announced as part of the State budget on 19 May and included $12 M over 6 years, from 2011/12, for the Kimberley Marine Research Program (KMRP)[2]. The goal of the KMRP is to undertake a program of marine research to support the management of the proposed State marine parks at Camden Sound, North Kimberley, Roebuck Bay and Eighty Mile Beach and the coastal waters outside of these proposed marine parks (Figure 1). Other related State funding for the Kimberley includes funding for the Integrated Marine Observing System (IMOS) of $2.2M for research infrastructure and ~ $15.2 M over 4 years[3], from 2011/12, for DEC and DoF to manage the proposed Camden Sound and Eighty Mile Beach marine parks. These latter allocations include funding for marine monitoring and research activities within these marine parks. Funding for the proposed North Kimberley and Roebuck Bay marine parks will be considered in future State budgets.

Dr Chris Simpson of DEC was appointed Interim Node Leader for the KMRP at the WAMSI Board meeting on the 26 May 2011. Dr Simpson was requested to "*Write a background paper outlining key information requirements, broad research areas and indicative levels of State Government funding* [for a program of marine research in the Kimberley] …." The purpose of the KMRP Strategy was to outline, to the WAMSI Board, the general intent, directions and process to develop the KMRP Science Plan. The KMRP Strategy provides additional context and should be considered as a companion document for the KMRP Science Plan (this document).

The KMRP Science Plan is due for inclusion in the State Funding Agreement for sign-off in November/December 2011. The KMRP Science Plan is consistent with the KSCS and the KMRP Strategy and the research themes are based on the December 2010 State Government Strategic Marine Research Priorities report[4] which includes much of the WAMSI MRI proposal to Department of Commerce in October 2010 and other documents such as the WAMSI report *A Turning of the Tide: Science Decisions in the Kimberley-Browse Marine Region*.

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[1] Kimberley Science and Conservation Strategy, Government of Western Australia, May 2011.

[2] Referred to in the WA Government 2011/12 Budget as the Kimberley Science and Conservation Strategy- Western Australian Marine Science Institution.

[3] Further ongoing funding of $3.7M p.a. will be provided from 2015/16.

[4] State Government Strategic Marine Research Priorities in relation to the Kimberley Science and Conservation Strategy and WAMSI 2, Departments of Environment and Conservation, Fisheries, Commerce and Office of the EPA, December 2010.

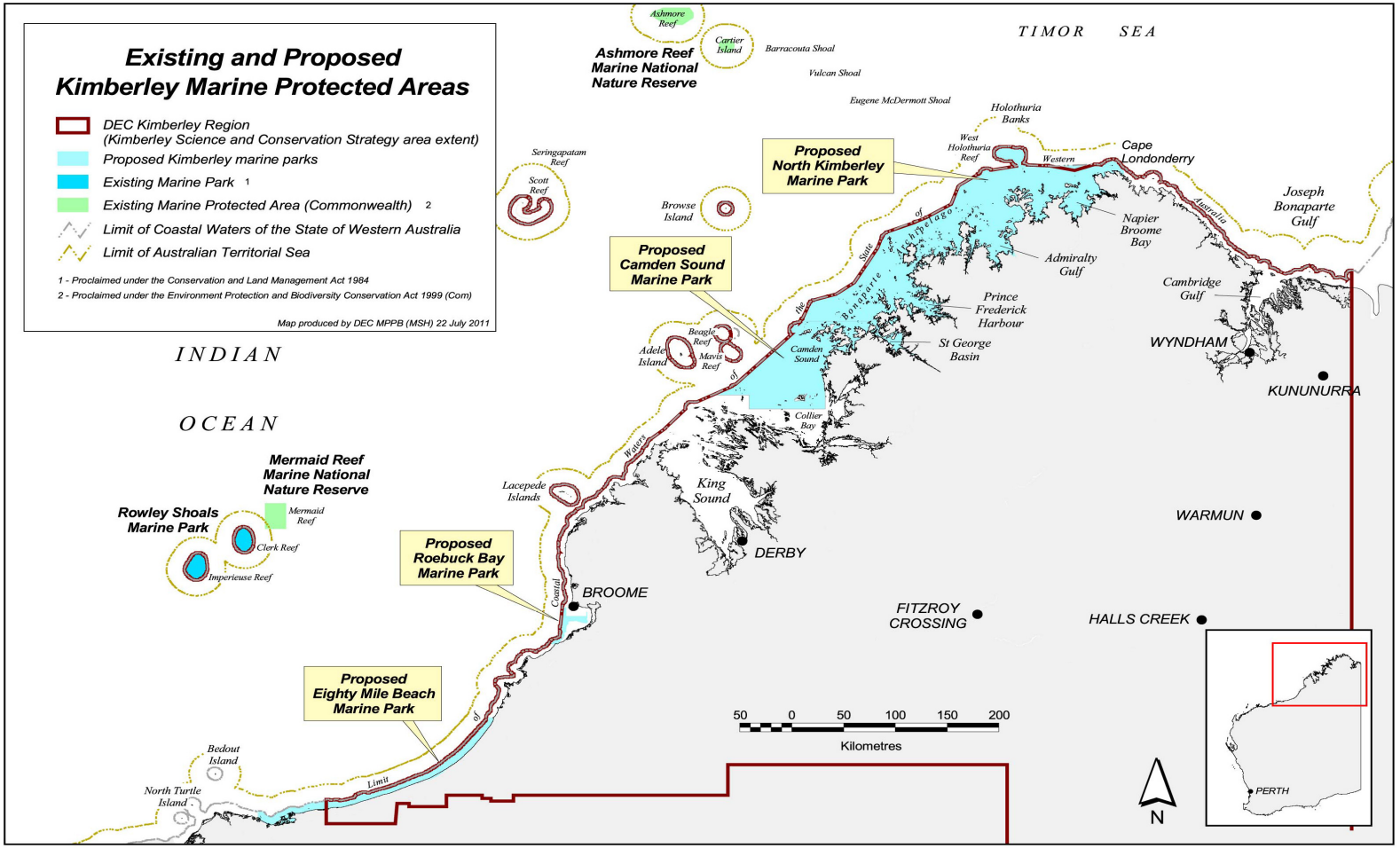

Figure 1: Map of the Kimberley showing Kimberley Science and Conservation Strategy boundary and existing and proposed Marine Parks.

While the KMRP Science Plan reflects the marine research priorities of the State, it also aligns with the institutional priorities of AIMS and CSIRO (representing the Commonwealth) and the research interests of local universities. Further input from WAMSI partners has been provided through the WAMSI Board, Strategic Programs Committee (SPC) and Operational Group (OP)[5] meetings. The formal response by AIMS and CSIRO to the December 2010 State priorities document confirmed the high degree of alignment between State and Commonwealth marine research priorities in the Kimberley. Further consultation has been undertaken via a KMRP workshop on 5 September and through informal meetings and discussions between the Node Leader and WAMSI partners and local research providers. A summary table of the draft Science Plan was sent out to WAMSI partners for comment in mid-October. The interests of these organizations and others[6] will be further considered through direct consultation in the development of the Science Concept Plans and the Science Project Plans.

The KMRP Science Plan has three main objectives:

(i) To provide information to the WAMSI Board on the broad direction and intent of the KMRP for their consideration and approval at the 3 November, 2011 Board meeting;
(ii) To provide information to the WA Government on the broad direction and intent of the KMRP as part of the WAMSI 2 State Financial Agreement; and
(iii) To provide guidance to WAMSI partner research providers in relation to the development of KMRP Project Plans.

For the purposes of developing the KMRP Science Plan, a minimum overall 'cash'[7] co-investment ratio of 1:1 is assumed[8]. For individual projects this ratio is likely to range from 1:1-2+. The KMRP Science Plan includes broad management information requirements, indicative research areas, potential collaborators[9], links and synergies, nominal duration, timing and level of WAMSI investment.

2. GEOGRAPHICAL FOCUS

The coastal waters of the Kimberley are extensive, remote and ecologically complex. In addition, scientific knowledge about most of the area is limited. While the total investment by State and Commonwealth governments is likely to significantly exceed the $14.2M[10] State Government's WAMSI/IMOS investments in Kimberley marine science, the total area of coastal waters is too large to investigate in its entirety. Therefore, the relative geographical emphasis of the KMRP is a critical consideration to maximize the benefits of the public investment in marine research in the Kimberley region.

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[5] The WAMSI Operational Group will help oversee the development of the KMRP Science Plan and has representatives from WAMSI, DEC, DoF, DoC, DPC and the Commonwealth agencies.

[6] Other organizations such as Customs, GA, Coastwatch, Navy, RMP and int'l initiatives in N. Australia (e.g. Arafura Timor Sea Environment Assessment) will be assessed for synergies with the KMRP.

[7] 'cash' co-investment = actual cost of staff participation from any of the JV partners in a WAMSI project (salary + on-costs); cash contributions from other sources such as State and Commonwealth Govt. (excl. WAMSI funding), JV partners and from external sources; actual cost of provision of research infrastructure (e.g. vessel time, etc) by JV Partners; by contrast 'in-kind' co-investment is defined as the nominal $ value of existing data, existing office/laboratory facilities etc.

[8] Based on WAMSI 1 Benefit-Cost Analysis i.e. for every new MRI $ invested, an additional $1 + of co-investment will be secured. Overall co-investment in WAMSI 1 significantly exceeded this ratio and this is likely to be the case in WAMSI 2.

[9] The workshop held at DEC on 5 September identified the attending organizations' interest in the nominal research areas of the KMRP. Organizational interest in the research is outlined in Appendix 2.

[10] Includes $2.2 M for IMOS but not the DEC, DoF allocations for proposed Kimberley MPAs.

The geographical 'boundary' of the KSCS is shown in Figure 1 and includes all the State coastal waters from the south-western end of Eighty Mile Beach to the Northern Territory border. As outlined above, a primary focus of the State Government funding for marine research in the Kimberley is to support the management of the proposed marine parks at Eighty Mile Beach, Roebuck Bay, Camden Sound and North Kimberley (Figure 1). The locations of these proposed marine parks should therefore be a key consideration for the geographical focus of the KMRP.

Over the past five years, significant marine environmental research has been funded by Woodside and the State and Federal Governments to understand the ecology of the coastal waters off the Dampier Peninsula. This research was focused on providing an improved understanding of the potential marine environmental impacts associated with the development of an industrial hub at James Price Point. Over the same period, a major research program funded by Woodside and the Australian Institute of Marine Science investigated aspects of the ecology of Scott Reef, the largest emergent offshore coral reef ecosystem in the Kimberley. The Australian Government has also funded significant research in the offshore waters of the Kimberley to support the Commonwealth regional marine planning process. The resources company INPEX Pty. Ltd. also undertook extensive marine environmental studies at the Maret Islands and surrounds in the north Kimberley. The research focused on improving the understanding of the potential impacts of developing the offshore oil and gas resources in the Browse Basin.

Further marine environmental research off the Dampier Peninsula and offshore will be required and funded by industry to support the approvals process as specific development proposals undergo environmental impact assessment (EIA). Furthermore, the EIA conditional approvals process will impose marine monitoring requirements and, potentially, environmental offsets that will likely include funding for marine research and enhanced on-ground management (e.g. compliance programs). The State Government would seek to align these environmental offset marine research and monitoring programs with the KMRP.

While acknowledging the entire area of the KSCS is worthy of some level of research attention, it appears from the above that the highest geographical priority of the KMRP would logically be the area from Carnot Bay[11], on the central Dampier Peninsula, to Cape Londonderry, particularly the proposed Camden Sound and North Kimberley marine parks (Figure 1). This is the most ecologically complex and representative area of the majority of the Kimberley coastal waters and relatively little is known, scientifically. In addition, marine parks are proposed over much of this area and it is extensively used by Indigenous groups and for tourism, iron ore exports, commercial and recreational fishing, aquaculture and pearling.

The extensive recent research programs in the waters off the southern Dampier Peninsula and the offshore reef systems have already developed a comprehensive knowledge base to help manage resource development in these areas. More research will be needed and funded by industry to support resource development approvals in these areas. The KMRP will also provide an important regional perspective for the recent and future site-specific studies around the southern Dampier Peninsula. In particular, the KMRP will provide a more detailed understanding of current and future human usage, particularly recreational fishing, and current and future impacts on fish stocks and habitats in this area (and across

[11] Carnot Bay is on the mainland just south of the Lacepede Islands (Figure 1).

the region). This will inform the development of compliance programs to manage the significant increase in projected use.

While the areas off Eighty Mile Beach and Roebuck Bay are ecologically less complex than most of the Kimberley, both have high conservation significance, support high recreational use, are relatively poorly studied and are proposed as marine parks. Hence, both deserve some level of attention from the KMRP. The least known of the Kimberley coastal waters is the area east of Cape Londonderry to the NT border, although significant research has been undertaken in the nearby Joseph Bonaparte Gulf and the impacts of the damming of the Ord River on downstream mangroves are well known. As such, some level of research effort should occur in this area of the Kimberley.

The principal interests of the State Government lie within the limits of State waters (Figure 1), however Commonwealth interests extend more broadly into offshore waters as do the spatial scales of some key ecological processes. For this research, it is essential to consider the scales of the ecological processes (including large-scale ocean dynamics) rather than be constrained by administrative boundaries.

3. RESEARCH PRIORITIES

3.1 Overview

The current major uses of the Kimberley coastal waters include traditional Indigenous use, marine tourism, commercial and recreational fishing, pearling, aquaculture and oil and gas and iron ore port facilities. The large area, small population, limited land access and remoteness and the relatively low level and localized nature of most of the commercial and non-commercial activity has resulted in minimal anthropogenic disturbance to much of the Kimberley marine environment. This is unlikely to change significantly over the next five or so years, with marine tourism as the most likely major Kimberley-wide growth industry.

With due consideration of the above, the KMRP Science Plan will focus on obtaining a regional perspective through two major areas of research:

- ***Bio-physical and social characterization*** - to provide the foundational datasets required for marine park and marine resource management as well as better understanding and managing current human impacts; and
- ***Understanding key ecosystem processes*** – to provide the scientific understanding of ecosystem functioning and response to a range of potential human impacts that are likely to arise in the future, including climate change.

The underlying logic of the above approach is that a more comprehensive description of the Kimberley marine ecosystems and the existing and future uses of this area will provide the necessary information and regional context needed to assess and manage current impacts and risks to these resources. This knowledge base will also inform planning and management of the region's proposed marine parks, fisheries[12] and the tourism industry. Building on the extensive existing knowledge of tropical ecosystem functioning in northern Australia, the proposed process studies will enhance the fundamental ecosystem understanding needed to better address a range of current and future pressures on this region. The above understanding will be integrated within an ecosystem model with a focus on predicting the likely biological implications and social responses to climate

[12] Including commercial and recreational fishing and pearling and aquaculture.

change, probably the greatest threat to the Kimberley marine environment in the coming decades.

The research will answer key questions directly relevant to the conservation and multiple-use management of this marine region and is consistent with the research strategies outlined in the existing and proposed State marine park management plans, the Western Australian Government's KSCS and the Commonwealth Government's marine priorities (Appendix 4). A summary of the KMRP Science Plan is shown in Table 1.

3.2 Integrating Projects

The KMRP Science Plan outlines the research areas and the management information requirements/questions needed to support the management of the State coastal waters of the Kimberley, in particular the proposed state marine parks at Camden Sound, North Kimberley, Roebuck Bay and Eighty Mile Beach. The KMRP Science Plan is consistent with the broad Commonwealth imperative to support the sustainable development of Australia's marine resources. WAMSI has the opportunity to further develop tools and approaches to assess and manage the range of pressures on the region's marine environment. These pressures include increased human uses such as coastal developments, resource extraction and climate change. These pressures can impact on biodiversity, ecological integrity and social amenity through habitat loss or changes to ecosystem function.

To address the State and Commonwealth priorities and to maximize scientific and operational integration two large integrating projects are proposed:

- Integrating project 1: Habitat, biodiversity assessments and baselines;
- Integrating project 2: Human use, ecological processes, knowledge integration and prediction.

Integrating project 1 (IP1) will provide the essential characterization, distribution and 'drivers' of marine biodiversity, including large marine fauna, of the Kimberley coastal ecosystems. IP1 will also address research of reef growth over the Holocene and initiate baseline studies of key reef processes and water and sediment quality. Integrating project 2 (IP2) will provide information on human use and impacts in the region and also include collating and integrating Indigenous coastal knowledge. IP2 will focus on providing a core understanding of physical, biological, biogeochemical processes at appropriate temporal and spatial scales. IP2 will also provide the vehicle to integrate outputs between the various project components through the use of a range of appropriate quantitative models to predict future management scenarios, including the biological implications and potential adaptations to climate change. Additional notes on the two integrating projects are provided in Appendix 5[13].

3.3 Research Areas and Projects

The two integrating science projects are divided into 13 research areas and the management information requirements/questions for each research area are outlined in Table 1. The management information requirements/questions are intended to provide key guidance in developing the Science Concept Plans and Science Project Plans of the projects/major sub-projects for each research area. Some of these questions are likely to have already been answered or are being addressed by current research projects. These

[13] An edited version of notes provided by CSIRO is included in Appendix 5.

Table 1: Summary of the Kimberley Marine Research Program Science Plan

Integrating Project	Coordinating organization	Research area	Management information requirements/questions (to be used to develop research projects)	Spatial scale	Collaborating organizations[14]	WAMSI investment	Links to external programs (incomplete)	Nominal Timing[15]	Comments
IP1. Habitats, biodiversity assessments and baselines	**Australian Institute of Marine Science**	1.1 Distribution, species composition and environmental 'drivers' of benthic biodiversity.	1. What is the distribution, extent, species composition, condition and conservation significance of the major benthic marine habitats (e.g. beaches, coral reefs, filter-feeders, mangroves, sediment in-fauna, inter-tidal communities etc)? 2. What environmental factors are 'driving' the above distribution patterns? 3. How do the major habitats interact? 4. How will these 'drivers' respond to climate change? 5. Where are the marine biodiversity 'hotspots'? 6. **How** do the geomorphology, sediment composition and turbidity influence habitat and biodiversity distribution? 7. What are the main natural pressures on the key benthic habitats and biodiversity? 8. What taxa are good surrogates (indicators) for the benthic biodiversity of major habitats? 9. How representative is the biodiversity in the sanctuary zones of the proposed MPAs? 10. What is the current condition of targeted demersal finfish stocks/communities? 11. What is the current condition of other harvested species (e.g. trochus, sea cucumbers etc)? 12. What are the appropriate spatial management units for priority targeted species? 13. What are sustainable levels of 'take' (management targets) for targeted species?	Inter-tidal: Regional[16] Sub-tidal: Representative [17]	**AIMS,** CSIRO, CU, UWA, DEC, ECU, WAM, MU, Woodside, DoF	$3M	Proposed DEC/DoF marine park management programs; AIMS/CSIRO 'Hub' study; AIMS surveys; WAM/Woodside marine biodiversity surveys; Woodside and INPEX habitat surveys etc	2-5	DoF research funding for the proposed Camden Sound Marine Park to do 'target' species component (Q 10-13)?
		1.2 Distribution, abundance, movement patterns and habitat utilization of large marine fauna.	1. What are the priority species of large marine fauna in the Kimberley and why (e.g. whales, dugong, snub-fin and humpback dolphins, turtles, migratory waders, sea-snakes etc)? 2. What are the distribution, abundance and movement patterns of these populations? 3. What, when and where are their critical habitats? 4. What are the appropriate spatial management units for priority species? 5. What environmental factors are 'driving' the above distribution patterns and population characteristics? 6. How will they likely respond to climate change? 7. On what scales are large marine fauna connected both within and outside the Kimberley (genetics, tracking, tagging) 8. What are the major pressures on marine fauna in this region and how can they be measured using key indicators over the long-term (e.g. marine debris) 9. What role can marine fauna play in identifying areas of high productivity (e.g. tracking key species to hotspots). 10. What cost-effective methods can be developed to enable effective condition monitoring of priority species.	Regional	MU, **DEC,** AIMS, CU, Woodside, WAM, ECU, DoF, CSIRO	$1.2M	Proposed DEC/DoF marine park management programs; AIMS/CSIRO 'Hub' study; AIMS surveys; Woodside and INPEX whale, turtle and habitat surveys;	2-5	
		1.3 Reef growth and maintenance	1. How have the Kimberley reefs developed over the Holocene? 2. How does this information help predict reef responses to climate change? 3. Have coral calcification/growth rates changed over the past 50 years? 4. What are the major factors controlling current reef growth? 5. How might these respond to climate change?	Representative	**CU,** CSIRO, AIMS, CC, DEC, DoF	$0.8M		2-5	
		1.4 Developing cost-effective remote sensing MER indicators and methods and constructing historical time-series from existing data.	1. What existing data can be used to construct historical time-series of key biodiversity asset condition and pressure? 2. What indicators of asset condition and pressure can be cost-effectively monitored by remote sensing? 3. What methods and temporal and spatial scales are most appropriate?	Regional	DEC, DoF, **CU**, AIMS, CSIRO, WAM, MU	$0.5M			
		1.5 Establishing a long-term, cross-shelf monitoring transect to assess natural variability of key processes.	1. What are current baseline levels of fish and coral recruitment at representative reference sites? 2. What are current baseline levels of herbivory, predation and disease at representative coral reef reference sites?	Representative	**AIMS,** DEC, CSIRO, DoF, CU	$0.3M		2-4	DEC WAMMP to assist?
		1.6 Hydrocarbons in waters, sediments and biota.	1. What are the baseline concentrations of hydrocarbons in waters, sediments and biota?	Representative	**CC,** DEC, CU, DoF, CSIRO	$0.3M		2-3	NB: 2010 OEPA survey of the Kimberley re Montara

[14] Institution nominated to start SCP process in bold
[15] 2011/12 = Year 1; 2015/16 = Year 6
[16] Regional = at the Kimberley regional scale
[17] Representative = at representative locations of the Kimberley region (e.g. proposed Camden Sound Marine Park, North Kimberley Marine Park)

IP2. Ecological processes, knowledge integration and prediction	**CSIRO *Wealth from Oceans***	2.1 Human use, values, aspirations and impacts.	1. What are the historical, current and future patterns and trends of human use? 2. What impacts and risks did/does/will this use pose to the marine biodiversity? 3. What management response is needed to address these impacts? 4. What does the community value and what are their aspirations for the area? 5. What are the anticipated effects of increased access to remote locations? 6. How might climate change influence human use? 7. What human use 'indicators' are best used to monitor human pressure on marine resources?	Regional	**MU**, DEC, DoF, CC, CSIRO, UWA, ECU,	$0.9M	DEC marine park planning programs; DoF recreational fishing surveys; DoF Biosecurity program; Coastwatch data; Marine tourism and pearling industries; coastal Indigenous communities; EIA reports;	2-4	DoF biosecurity funding to contribute? Include IUU fishing? Include oral history of fishing and hunting?
		2.2 Collating and integrating Indigenous coastal knowledge for marine conservation and management.	1. What systems can be developed to collect Indigenous coastal knowledge and integrate this knowledge with western science into co-operative marine management frameworks? 2. What barriers exist to limit integration of Indigenous knowledge and western science (e.g. language, cultural differences)? 3. What are the similarities and fundamental differences between Indigenous knowledge and western science for this region? 4. How can we ensure Indigenous knowledge is appropriately collected and archived? 5. How can we develop cross-discipline approaches to implementing dual knowledge systems for marine conservation and management?	Regional	**ECU,** CSIRO, WAM, MU, DEC, DoF	$0.5M		2-5	
		2.3 Physical and biological oceanography.	1. What are the rates of pelagic primary productivity and how does this compare with other areas of and elsewhere? 2. Are there large spatial (e.g. inshore-offshore) and temporal (e.g. seasonal, inter-annual) variations in pelagic primary productivity in this region? 3. What processes are 'driving' this variation? 4. How significant is pelagic primary productivity to the maintenance of Kimberley ecosystems? 5. How are large-scale oceanic processes related to local physical and biological oceanography? 6. How does the distribution of fauna and flora relate to large and small scale oceanographic processes? 7. How do large tides influence inshore and estuarine ecosystems, how might modification (e.g. damming, water extraction etc) effect these ecosystems? 8. How will changes in climate (e.g. rainfall) affect tropical estuaries in terms of discharge, and how will this influence other physical processes (e.g. sedimentation)? 9. How might we best monitor changes in physical and biological oceanography, particularly in relation to climate change? 10. What will be the trajectory of oil spills under typical oceanographic conditions?	Representative	CSIRO, AIMS, WAM, **UWA,** CU, DEC, DoF, MU	$1.0M	IMOS	2-5	NB: Current Thompson et al project in the Kimberley using RV Southern Surveyor
		2.4 Benthic primary productivity	1. Where are major benthic primary producer habitats located? 2. What processes are 'driving' benthic primary productivity? 3. What is the relative significance of different benthic primary producers, and where are areas of major benthic primary production? 4. How do key physical (e.g. oceanography, temperature, estuarine discharge etc) and biological (e.g. nutrients, herbivory, etc) processes influence primary productivity? 5. What is the ecological significance of herbivory across major habitats? 6. What are appropriate & cost-effective methods for long-term monitoring of benthic primary producer habitats (e.g. seagrass, algae) and associated processes (e.g. herbivory)? 7. How are key benthic primary producer habitats linked through trophic webs to broader marine communities, particularly those that include commercially significant species and threatened marine fauna? 8. How will climate change impact on benthic primary productivity?	Representative	**ECU,** UWA, CU, AIMS CSIRO, DEC, DoF, MU	$0.6M	IMOS	2-5	Potential link to Collaborative Research Networks Programme (ECU and UWA).
		2.5 Ecological connectivity	1. How do macro-tidal systems influence ecological connectivity of key taxa (e.g. fish and coral)? a. What is the extent of fine-scale connectivity within coastal and offshore reefs? b. What is the extent of larger-scale along shore connectivity in coastal and offshore reefs? c. What is the extent of larger-scale connectivity between coastal and offshore reefs? d. What are the dispersal distances of key taxa? e. Are there hotspots for spawning and recruitment for reef fish and are these hotspots in ecologically resilient or sensitive areas? 2. Are proposed management areas sufficient for ecological connectivity to support populations of key taxa? 3. What are the influences of major disturbance events on ecological connectivity of key taxa? 4. How will climate change (e.g. oceanography, primary productivity, temperature, salinity, rainfall runoff) affect dispersal patterns of key taxa? 5. How can genetic data be best incorporated into emerging oceanographic models for the region to provide more robust and detailed inferences about patterns of connectivity throughout North-west WA? 6. What role does the Kimberley play in the maintenance of systems outside of the region? 7. How is the condition of the Kimberley influenced by external biological and anthropogenic influences (e.g. recruitment, connectivity, use pressures in SE Asia)?	Representative	**AIMS,** CSIRO, CU, DEC, DoF, ECU, WAM, MU	$0.6M	IMOS	2-5	NB: Current Thompson et al project in the Kimberley using RV Southern Surveyor Potential link to Collaborative Research Networks Programme (ECU and UWA).

		2.6 Catchment - ocean interactions	1. How does seasonal and cyclonic riverine discharge (e.g. nutrient, freshwater and sediments) influence inshore marine ecosystems? 2. What is the relative significance of terrestrially-derived nutrient in sustaining inshore marine food webs? 3. How do human use of rivers and catchments affect estuarine and inshore marine ecosystems? 4. What is the biodiversity significance of estuarine habitats and communities? 5. What is the significance of estuaries in the life-cycles of marine species, particularly commercially significant species and threatened marine fauna? 6. How will climate change impact on catchment to ocean interactions?	Representative	AIMS, **CSIRO,** UWA, CC, DEC, DoF, CU, MU, CC, ECU	$0.6M	IMOS, KSCS	2-5	NB: Current Thompson et al project in the Kimberley using RV Southern Surveyor Potential link to Collaborative Research Networks Programme (ECU and UWA).
		2.7 Knowledge Integration and predicting biological and social responses to climate change	1. What are the main climate change threats to the marine biodiversity of this region (e.g. air and sea temperature rise, cyclone intensification, acidification, etc? 2. How will existing marine habitats and communities and large marine fauna populations change? 3. What are good potential indicators of asset condition and pressure in relation to climate change? 4. What are the stakeholders (incl. management agencies) capacities and requirements for adapting to climate change? 5. How will climate change threats manifest in the Kimberley? 6. Which species and communities are threatened? 7. How they will respond e.g. shifts in distribution patterns, adaptation or local extinction. 8. How will key biological and physical processes (e.g. calcification, connectivity, herbivory, predation) be influenced by climate change	Regional	**CSIRO,** AIMS, UWA, DEC, CU, ECU, WAM, MU, DoF	$1.0M	IMOS; Themes 1, 2 and 3	2-5	Potential link to Collaborative Research Networks Programme (ECU and UWA).
Node Administration and Knowledge Transfer (Science co-ordinator; 0.8 FTE)					**DEC**	**$0.7M**			
TOTAL						**$12M**			

Key: AIMS= Australian Institute of Marine Science; CC = WA Chemistry Centre; CSIRO = Commonwealth Scientific and Industrial Research Organization; CU = Curtin University; DEC = Department of Environment and Conservation; DoF = Department of Fisheries;
ECU = Edith Cowan University; MU = Murdoch University; NDU = Notre Dame University; OEPA = Office of the EPA; UWA= University of Western Australia; WAM = Western Australian Museum

will be identified in the review of existing information and current research which is required as part of each Science Concept Plan. Further scientific and operational integration will proceed as an integral part of the project planning process.

4. KMRP GOVERNANCE

4.1 Program Co-ordination, Administration and Knowledge Transfer

The administration, scientific co-ordination, communication and knowledge transfer of the KMRP Science Plan are the primary responsibility of the Node Leader and Science Co-ordinator. A Kimberley Research Co-ordinating Committee will be formed and consist of the KMRP Node Leader and Science Co-ordinator, WAMSI CEO and the two Integrating Project Co-ordinators to assist with these tasks.

4.2 Integrating Projects

The two large integrating projects will promote scientific and operational integration of the KMRP and will be led by the Australian Institute of Marine Science (Integrating project 1) and CSIRO Wealth from Oceans (Integrating project 2). Both organizations will be expected to appoint an Integrating Project Co-ordinator[18] who will have overall operational responsibility for the administration (incl. data management) of the integrating projects which will be subject to formal agreements (e.g. a MOU) with WAMSI.

4.3 Research Areas

Thirteen research areas are outlined in Table 1. Their associated management information requirements/questions provide key guidance for developing projects and major sub-projects for each research area.

4.4 Research Projects

The research projects developed from the research areas, outlined in Table 1, will be planned by the participant organizations outlined in Appendix 2, in collaboration with the KMRP Node Leader and Science Co-ordinator and the Integrating Project Co-ordinators. Nominations to initially lead this process for each research area will be sought from the nominated lead organizations in Table 1. The lead organization and the project leader for each research project/major sub-project will be determined through consensus between the participating organizations as part of the concept planning process. Science Concept Plans, concise reviews and Science Project Plans will be required for research projects and major sub-projects. All opportunities to improve the integration of projects should be explored during the project planning phase. Formal project agreements between WAMSI and the organizations leading the research projects will be required.

4.5 Data Access during the KMRP

All proposed State marine parks and reserves in the coastal waters of the Kimberley are currently in the establishment phase and are likely to be gazetted over the next few years. The data produced in the KMRP will assist both the establishment and initial management phase of these MPAs. Similarly, current frameworks for managing tourism, recreation, commercial and recreational fishing and the resources industry will also potentially benefit from these data. Hence access to data by management/regulatory agencies for these purposes may be required during the KMRP. Conditions will be included in the formal project agreements to ensure access to and appropriate use of the data.

[18] Time commitment for the Integrating Project Co-ordinators is estimated to be in order <0.2 FTE in 2011/12 and < 0.1 FTE thereafter.

5. INDICATIVE FUNDING AND DURATION

A summary of the indicative level and duration of WAMSI funding for each of the themes are shown below in Table 2. The duration and scheduling of projects will be an important element of the overall planning process to ensure annual project requirements are reconciled with the funding available.

Table 2: Summary of nominal funding and duration of integrating projects

Integrating Project	Funding ($M)	Duration (yrs)
1	6.1	3-4
2	5.2	3-4
Administration/Knowledge transfer	0.7	5
Total	**12**	-

Additional State funding for marine research and monitoring in the Kimberley from marine park budgets includes:

- $2.3 M over 6 years research funding to DoF from 2011/12 for the Camden Sound Marine Park; and
- $780,000 over 6 years monitoring funding to DEC from 2011/12 for the Camden Sound and Eighty Mile Beach marine parks.

Funding for the proposed North Kimberley and Roebuck Bay marine parks will be considered in future State Government budgets.

In addition to State funding, co-investment opportunities with existing Commonwealth programs should be explored, where possible, through the collaborative planning process described above. This may take advantage, where appropriate, of Commonwealth interests in bioregional planning for marine protected areas, environmental impact assessment and review under the EPBC Act 1999, as well as existing programs such as the National Environment Research Program (NERP) Marine Biodiversity Hub to name a few. The task of describing and justifying linkages to additional external initiatives and frameworks will be left to project leaders.

6. EXPECTED OUTCOMES

The expected outcomes are outlined below and are consistent with the priorities outlined in the Western Australian Government's KSCS and the Department of Commerce's Evaluation Framework for Science and Innovation Investments in Western Australia, both key considerations. The primary expected outcomes are in bold.

1. **Improved capacity to plan and manage the regional network of Kimberley marine parks and reserves;**
2. **Enhanced capacity to identify and manage current human impacts and predict risks in the coastal waters of the Kimberley;**
3. **Enhanced capacity to understand, adapt and mitigate climate change impacts in the coastal waters of the Kimberley;**
4. **Improved capacity to plan and manage tourism, recreational and commercial fisheries, pearling and aquaculture in the coastal waters of the Kimberley;**
5. **Enhanced use of Indigenous knowledge and participation in marine management;**
6. Increased capacity to respond to and mitigate the impacts of oil spills;

7. Improved regional understanding, context and relative ecological and conservation significance of the key marine biodiversity assets of the Kimberley;
8. Increased capacity to assess the regional environmental significance of resource development projects ;
9. Improved capacity for marine science knowledge transfer and uptake into policy, planning and management in Western Australia;
10. Enhanced capacity to determine 'value for money' and assess management efficiency and effectiveness of Government-funded conservation and management programs in the coastal waters of the Kimberley;
11. Improved knowledge base for environmental planning and management by industry, NGOs and community;
12. Improved links and collaboration in marine science between State and Commonwealth agencies, universities, industry and NGOs in Western Australia ;
13. Improved community understanding and support for Government conservation and management programs in the coastal waters of the Kimberley;
14. Enhanced marine scientific capacity (including student training) in Western Australia; and
15. Improved facilities and infrastructure for marine research and management in the Kimberley.

The extent to which the delivery of these outcomes will succeed depends strongly on the degree of collaboration by the partners as well as the development and integration of aligned projects from additional funding sources. Whilst the Science Plan is ambitious in its scope there is a reality that the level of direct funding and high costs of field operations in the Kimberley will limit the detail of what can be achieved. This will require particular attention to priority setting by the WAMSI Board.

7. LINKS TO OTHER PROGRAMS

A key element in the developing the KMRP Science Plan will be to gain a good understanding of recent, current and planned marine research in the Kimberley. A 'mapping' exercise of WAMSI partners has been undertaken to help develop this understanding. Furthermore, concise reviews of historical and current research are required in the initial phase of project planning. These reviews will help identify key research gaps. Links will be established with other organizations and programs to build upon, complement and leverage other local, regional and national initiatives, frameworks and activities to maximize opportunities to enhance funding, capacity and expertise. Some current initiatives are outlined below.

7.1 Government Programs

State marine conservation and fisheries management programs and the Commonwealth Government's regional marine planning process are currently underway in the waters off the Kimberley. In addition, the Western Australian Government has allocated $15.2M over 4 years[19], from 2011/12, to DEC and DoF for the management of the proposed Camden Sound and Eighty Mile Beach marine parks. Funding for the proposed North Kimberley and Roebuck Bay marine parks will be considered in future State budgets. The marine parks funding is provided for the implementation of the strategies, including marine ecological and social research and monitoring, outlined in the marine park management plans. The development of the KMRP Science Plan will align with the funding allocated for marine science and monitoring in the marine park budgets to ensure the programs are integrated. A further $1.105 M over 4 years from 2011/12 was also allocated to DoF for marine education in the Kimberley.

[19] Further ongoing funding of $3.7M p.a. will be provided from 2015/16.

7.2 Integrated Marine Observing System

The State Government budget included $2.2M for IMOS in the Kimberley. This funding will be to provide further research infrastructure in the Kimberley and will contribute significantly to research themes 3 and 4. The data flows from this investment will assist in facilitating understanding of the operating ocean environment which directly impacts on a range of national and state objectives at regional and local scales.

7.3 Industry

As outlined above, Woodside and the State and Commonwealth Governments have contributed to significant marine research off the Dampier Peninsular and at Scott Reef over the past five years. Similarly, INPEX has undertaken extensive marine environmental research around and offshore from the Maret Islands, in the northern Kimberley, over the same period. Knowledge of the scope and outputs of these programs will be sought in the development of the KMRP. Further marine environmental research off the Dampier Peninsula and offshore will be required and funded by industry to support the approvals process as specific development proposals undergo EIA. Furthermore, the EIA conditional approvals process will impose marine monitoring requirements and, potentially, environmental offsets that will likely include marine research.

7.4 Other

Other organizations and initiatives in the Kimberley include other State Government Departments, Customs, Coastwatch, the Australian Navy, Commonwealth Regional Marine Planning processes, Indigenous Protected Area programs and international initiatives, such as ATSEA, will be considered in the development of the Science Project Plans. Additional links with Commonwealth programs such as the National Environment Research Program (NERP) Marine Biodiversity Hub will be explored.

8. LOGISTICS

The remoteness and inaccessibility of much of the coastal waters of the Kimberley means that research vessel access is the only option for many types of research in these areas and routine access to the AIMS vessel RV Solander and other suitable vessels will be critical. The presence of research facilities on the mainland at Cygnet Bay, on the northern Dampier Peninsula, will be potentially very useful for a range of studies, particularly process research. Research facilities in Kuri Bay are also likely to be useful provided reliable access by seaplane is routinely available. Fisheries and marine park patrol boats and Customs vessels also provide opportunities to be used as research platforms[20].

Overcoming the logistic constraints to deliver the strategic research outcomes from the KMRP will depend, therefore, upon the goodwill, good planning, co-operation and collaboration and sharing of research and management (e.g. marine park and fisheries patrol vessels) infrastructure between the participating organizations. Co-ordination will be the key to success.

9. PROCESS TO DEVELOP PROJECTS AND THE SCIENCE CONCEPT PLANS AND PROJECT PLANS

Once the KMRP Science Plan is approved by the WAMSI Board, the process outlined below will be used to develop detailed Science Project Plans for the KMRP.

1. Distribute the KMRP Science Plan to potential participants listed in Appendix 2.

[20] For example, the State Government has allocated $2.24 M over four years for the DoF patrol vessel PV Walcott for compliance activities in the proposed Camden Sound Marine Park.

2. Seek representatives from nominated organizations (see Table 1) who will act as co-ordinators for the integrating projects and initial co-ordinators for the development of research project Science Concept Plans (SCP)[21];
3. KMRP Node Leader to meet with the co-ordinators in (2) above to explain the process;
4. SCP co-ordinators, in collaboration with the Integrating Project co-ordinators, to develop the draft SCP for each project/sub-project with the organizations and individuals identified in the Table 1 and Appendix 2[22]. The draft SCPs are to be completed and forwarded to the KMRP Node Leader by the Integrating Project co-ordinators by 31 January 2012. The KMRP Node Leader and KMRP Science Co-ordinator will assist as required;
5. A concise, 'stand-alone' review (~5000 words)[23] of existing information and current research relevant to each project/major sub-project will be attached to the draft SCP;
6. Undertake a preliminary assessment of the SCPs by the KMRP Node Leader, KMRP Science Co-ordinator and Integrating Project Co-ordinators and further consultation, if necessary, with the nominated lead organizations to finalise the draft SCPs[24];
7. KMRP Node Leader makes recommendations by 15 February to the WAMSI 2 R&D Committee for their consideration in late February 2012;
8. WAMSI Board review and approval regarding the science priority setting, funding allocation and emphasis etc, based on feedback from the WAMSI 2 R&D Committee, by late February 2012;
9. Collaborators of approved SCPs are notified as soon as possible after the WAMSI Board approval process (8 above) and asked to develop detailed Science Project Plans (SPP)[25] by 30 April 2012;
10. KMRP Node Leader, KMRP Science Co-ordinator and the Integrating Project co-ordinators will assist in the development of the SPPs as required. All opportunities to improve integration across projects should be explored during the project planning phase;
11. SPPs will be assessed by the KMRP Node Leader and Science Co-ordinator and recommendations made to WAMSI 2 Board (via the WAMSI R&D Committee) by 31 May 2012; and
12. Project agreements are developed and signed off by 30 June 2012.

The above timeline is predicated on the assumption that it does not compromise co-investment by WAMSI partners and will help ensure research projects begin by mid-2012 or earlier.

10. ASSESSMENT CRITERIA FOR SCIENCE PROJECT PLANS

The following criteria have been approved by the WAMSI Board for evaluating all WAMSI Science Project Plans:

- Quality of proposal – from a scientific basis;
- Science Project Team capability/ capacity available;
- Reference to State priorities and those listed in the Science Plan;

[21] The draft SCP should preferably be 2-3 pages but no more than 5. A proforma outlining the information required will be provided (see Appendix 1) to guide the process.

[22] The KMRP Node Leader has nominated an organization to start the process (see Table 1). An early task for the project collaborators is to nominate the lead organization and Project Leader to lead the process to undertake the review and develop the SCP.

[23] See Appendix 3 for Review guidelines. Consideration will be given to publishing the reviews as the first major output of the KMRP.

[24] To ensure SCPs address KMRP priorities and to reconcile timing and available funding.

[25] An SPP proforma will be provided.

- Level of collaboration evident;
- Level of co-investment available;
- Experience and track-record of delivery;
- '*Path to Adoption*'[26] of research findings;
- Management agency involvement in the '*Path to Adoption*'; and
- Linkages with other projects in the KMRP.

11. SUMMARY OF MAJOR MILESTONES

The timing of the major milestones to develop the KMRP Science Plan through to the signed-off KMRP Project Agreements is outlined below in Table 3.

Table 3: Summary of KMRP milestones

Milestone	By	To
1. Science Plan sign-off	3/11/2011	WAMSI Board
2. Science Plan process sign-off	3/12/2011	WAMSI SPC
3. Science Concept Plans	31/1/2012	Node Leader
4. Science Concept Plans sign-off	Mid- February	WAMSI Board
5. Science Project Plans completed	30/4/2012	Node Leader
6. Science Project Plans sign-off	31/5/2012	WAMSI Board
7. Project Agreements sign-off	30/6/2012	WAMSI Board

12. SUMMARY

The KMRP Science Plan outlines the proposed geographical emphasis, the major research areas and management information requirements/questions, nominal funding and process to develop the KMRP Science Project Plans by 31 May 2012. The Science Plan is a key element of the State Funding Agreement to be signed between WAMSI and the WA State Government in November /December 2011. The Science Plan has been considered at a joint meeting of the WAMSI Strategic Programs Committee, R&D Committee and the Operational Group on the 24 October 2011 prior to being presented and approved at the 3 November 2011 meeting of the WAMSI Board.

[26] '*Path to Adoption'* will address knowledge transfer and uptake into management policy and practice.

USEFUL DOCUMENTS AND LINKS

Brocx M and Meney K (eds) (2011). Symposium on Kimberley Marine and Coastal Science. Proceedings of a Joint Royal Society of Western Australia / WAMSI Symposium. (www.wamsi.org.au)

Masini RJ, Sim CB, Simpson CJ, McKenzie NL, Start AN, Burbidge AA, Kenneally KF, Burrows, ND (2009). Protecting the Kimberley: a synthesis of scientific knowledge to support conservation management in the Kimberley region of Western Australia. (www.dec.wa.gov.au/content/view/5180/2191)

Simpson CJ (2011). Kimberley Marine Research Program Strategy. Report to the WAMSI Board. (www.wamsi.org.au)

WA Government (2011). Kimberley Science and Conservation Strategy. (www.dec.wa.gov.au/kimberleystrategy)

WA Government (2010). State Government Strategic Marine Research Priorities in relation to the Kimberley Science and Conservation Strategy and WAMSI 2. (www.wamsi.org.au)

Waples K (2007). Kimberley Biodiversity Review 2007. (www.wamsi.org.au).

Wood M and Mills D (2008). A turning of the tide: science for decisions in the Kimberley-Browse marine region. (www.wamsi.org.au).

Appendix 1: Science Concept Plan[27] Proforma

1. **Project title:**
2. **Rationale:**
3. **Management information requirements/questions[28]:**
4. **Specific objectives:**
5. **Management Implications:**
6. **Expected generic outputs:**
7. **Expected outcome(s)[29]:**
8. **Proposed period of the project:**
9. **Lead organization and recommended Project Leader:**
10. **Collaborating organizations and recommended sub-Project Leaders:**
11. **Indigenous involvement (if appropriate):**
12. **Links with other KMRP projects:**
13. **Links with external programs/projects:**
14. **Propose period of the project:**
15. **WAMSI funding sought:**

Year	2012/13	2013/14	2014/15	2015/16	2016/17	TOTAL
WAMSI ($'000)						

16. **Co-investment[30]**

Staffing (actual costs):

Organization[31]	2012/13		2013/14		2014/15		2015/16		2016/17		Total
	FTE	($'000)	FTE	($'000)	FTE	($'000)	FTE	($'000)	FTE	($'000)	($'000)
Total											

[27] Science Concept Plans preferably should be 2-3 pages but not longer than five.

[28] Select from list in Table 1.

[29] Select from list of KMRP expected outcomes in s5.

[30] WAMSI co-investment has 4 categories: actual cost of staff participation from any of the JV partners in a WAMSI project (salary + on-costs); cash contributions from other sources such as State and Commonwealth Govt. (excl. WAMSI funding), JV partners and from external sources; actual cost of provision of research infrastructure (e.g. vessel time, etc) by JV Partners; and 'in-kind' contributions (nominal value of access to existing data, existing office/laboratory facilities etc).

[31] Names of participating staff will be included in the Science Project Plans.

Cash and research infrastructure (actual costs):

Organization	2012/13		2013/14		2014/15		2015/16		2016/17		Total
	Cash ($'000)	Infra ($'000)	Cash ($'000)	Infra ($'000)	Cash ($'000)	Infra ($'000)	Cash ($'000)	Infra ($'000)	Cash ($'000)	Infra ($'000)	($'000)
Total											

In-kind (nominal value):

Organization	2012/13	2013/14	2014/15	2015/16	2016/17	Total
	In-kind ($'000)	In-kind ($'000)	In-kind ($'000)	In-kind ($'000)	In-kind ($'000)	($'000)
Total						

17. **Operational requirements:**
18. **Data management:**
19. **Proposed arrangements for dealing with Native Title access:**
20. **Additional comments:**

Appendix 2: LIST OF ORGANIZATIONS AND COLLABORATING SCIENTISTS FOR EACH KMRP RESEARCH AREA[32]

KIMBERLEY MARINE RESEARCH PROGRAM		
RESEARCH AREAS	**ORGANIZATION**	**COLLABORATING SCIENTISTS**
Integrating Project 1 – Habitats, biodiversity and baselines **Integrating Project Co-ordinator: Andrew Heyward , AIMS**		
1.1 Benthic biodiversity	CU	Lindsay Collins, Merv Lynch, Peter Fearns, Iain Parnum, Miles Parsons, Glen Whisson, Kliti Grice
	AIMS	**Andrew Heyward**, Christine Schoenberg, Martial Depczynski, Ben Radford
	OI-UWA	Gary Kendrick, Peta Clode, Michael Stat, Kimberly Van Niel, Dan Smale, Tom Wernberg
	ECU	Glenn Hyndes (to be confirmed)
	WAMSI	Steve Blake
	WAM	Jane Fromont, Sue Morrison, Andrew Hosie
	CSIRO	John Keesing, Roland Pitcher
	DEC	Kim Friedman, Kevin Bancroft, Stuart Field, Shaun Wilson
	MU	Halina Kobryn, Lyn Beckley
	DoF	Steve Newman, Lynda Bellchambers, Mike Travers
1.2 Large marine fauna	CU	Chandra Salgado, Robert McCauley
	AIMS	Mark Meekan, Michelle Heupel
	ECU	Richard Campbell
	OI-UWA	Shaun Collin, Euan Harvey, Jessica Meeuwig, Nicola Mitchell
	WAMSI	Steve Blake
	WAM	Ron Johnstone
	CSIRO	Chris Wilcox, Russ Babcock
	DoF	Steve Newman, Lynda Bellchambers, Mike Travers
	DEC	**Kelly Waples**, Scott Whiting
	MU	Lars Bejder, Simon Allen, David Morgan
1.3 Reef growth	AIMS	Janice Lough
	CU	**Lindsay Collins**, Merv Lynch, Peter Fearns, Chandra Salgado, Iain Parnum
	OI-UWA	Malcolm McCulloch, Peta Clode, Michael Stat, Jens Zinke, Jim Falter
	CSIRO	John Keesing
	DoF	Steve Newman, Lynda Bellchambers
	WA Chem Centre	Neil Rothnie, Mike North, Shao Fang Wang
	DEC	Chris Simpson
1.4 Remote sensing	CU	Lindsay Collins, Merv Lynch, **Peter Fearns**, Chandra Salgado, Iain Parnum, Miles Parsons, Rob Mc Cauley
	AIMS	Ben Radford, Miles Furnas
	OI-UWA	Chari Pattiaratchi, Anya Waite
	CSIRO	Arnold Dekker, Nick Hardman-Mountford
	WAM	Jane Fromont, Glenn Moore
	DoF	Steve Newman, Lynda Bellchambers
	DEC	Kim Friedman, Kathy Murray, Kev Bancroft
	MU	Halina Kobryn
1.5 Cross-shelf monitoring transect	CU	Chandra Salgado, Iain Parnum, Miles Parsons
	AIMS	**Martial Depczynski**, Andrew Heyward, James Gilmour
	OI-UWA	Anya Waite, Euan Harvey
	CSIRO	Russ Babcock, Mat Vanderklift

[32] Initial Research Area Co-ordinator in bold.

	WAM	Jane Fromont, Sue Morrison
	DoF	Steve Newman, Lynda Bellchambers, Mike Travers
	DEC	Kim Friedman
1.6 Hydrocarbon baselines	CU	Brent McGuinness, Kliti Grice
	OI-UWA	Susana Agusti
	DoF	Steve Newman, Lynda Bellchambers
	CSIRO	Andy Ross
	DEC	Kev Bancroft
	WA Chem Centre	**Neil Rothnie**, Leith Cooper, Ibrahim Jambol,
Integrating Project 2 – Human use, ecological processes, knowledge integration and prediction **Integrating Project Co-ordinator: Peter Thompson , CSIRO**		
2.1 Human use	ECU	Andrew Guilfoyle, Trudi Cooper
	CSIRO	Fabio Boschetti, Hector Lozano-Montes
	OI-UWA	Michael Burton, Alistair Paterson, Peter Davies, Atakelty Hailu, Julian Clifton
	DoF	Brent Wise
	MU	Halina Kobryn, **Lynnath Beckley**, Sue Moore
	DEC	Stuart Field, Kim Friedman, Amanda Smith
	WA Chem Centre	Neil Rothnie, Leith Cooper, Ibrahim Jambol, Mike North
2.2 Indigenous coastal knowledge	ECU	**Colleen Hayward** (to be confirmed), Andrew Guilfoyle
	CSIRO	Peter Bayliss, Emma Woodward, Hector Lozano-Montes
	WAMSI	Steve Blake
	WAM	Moya Smith
	OI-UWA	Alistair Paterson, Peter Davies
	DoF	Brent Wise, Steve Newman
	DEC	Stuart Field, Scott Whiting, Amanda Smith
	MU	Rhonda Marriot
2.3 Oceanography	CU	Lindsay Collins, Merv Lynch, Peter Fearns, Chandra Salgado, Sasha Gavrilov, Iain Parnum
	AIMS	Richard Brinkman, Miles Furnas, Dave McKinnon
	OI-UWA	**Greg Ivey**, Anya Waite, Ryan Lowe, Susana Agusti, Chari Pattiaratchi, Nicole Jones, Carlos Duarte
	WAM	Clay Bryce, Glenn Moore
	CSIRO	Graham Symonds, Peter Thompson, Chaojiao Sun, Jim Greenwood
	DoF	Steve Newman, Lynda Bellchambers
	DEC	Chris Simpson
	MU	Lyn Beckely
2.4 Benthic primary productivity	CU	Merv Lynch, Peter Fearns, Chandra Salgado, Kliti Grice, Iain Parnum
	AIMS	Andrew Heyward, Ben Radford
	CSIRO	Martin Lourey, Mat VanderKlift
	OI-UWA	Carlos Duarte, **Gary Kendrick**, Ryan Lowe, Jim Falter, Nicole Jones
	ECU	Paul Lavery, Glenn Hyndes
	DoF	Steve Newman, Lynda Bellchambers
	DEC	Al Kendrick, John Huisman
	MU	Mike van Kuelen, Jennifer Verduin
2.5 Ecological connectivity	CU	Chandra Salgado, Kliti Grice, Iain Parnum, Miles Parsons
	CSIRO	Ming Feng, Olly Berry, Russ Babcock
	OI-UWA	Euan Harvey, Kimberley Van Neil, Ryan Lowe, Tom Latessier, Peter Davies
	AIMS	**James Gilmore**, Richard Brinkman
	ECU	Kathryn McMahon, Glenn Hyndes

	WAM	Jane Fromont, Glenn Moore, Sue Morrison
	DoF	Steve Newman, Lynda Bellchambers, Mike Travers
	DEC	Richard Evans, Shaun Wilson
	MU	Fiona Valesini, Chris Hallett, James Tweedley, David Morgan, Lynnath Beckley
2.6 Catchment – Ocean interactions	CU	Lindsay Collins, Merv Lynch, Peter Fearns, Chandra Salgado, Kliti Grice, Miles Parsons, Iain Parnum
	AIMS	Richard Brinkman, Britta Schefelke
	ECU	Kathryn McMahon, Glenn Hyndes, Paul Lavery
	OI-UWA	Greg Ivey, Chari Pattiaratchi, Nicole Jones, Ryan Lowe
	WAM	Clay Bryce, Glenn Moore
	CSIRO	**Kevin Petrone**, Andy Reville, Barbara Robson
	DoF	Steve Newman, Lynda Bellchambers, Mike Travers
	DEC	Alan Kendrick, Mike Rule
	WA Chem Centre	Neil Rothnie, Mike North
	MU	Fiona Valesini, Chris Hallett, James Tweedley, David Morgan, Lynnath Beckley
2.7 Knowledge integration and predicting responses to climate change	CU	Lindsay Collins, Merv Lynch, Peter Fearns, Chandra Salgado, Kliti Grice, Michael Hughes, Iain Parnum, Miles Parsons, Sasha Gavrilov
	AIMS	Ken Anthony, Janice Lough, Christine Schoenberg
	OI-UWA	Malcolm McCulloch, Greg Ivey, Jessica Meeuwig, Anya Waite, Chari Pattiaratchi, Tom Wernberg
	ECU	Kathryn Mc Mahon
	WAM	Jane Fromont, Andrew Hosie, Sue Morrison
	CSIRO	**Mat Vanderklift**, Ming Feng
	DoF	Steve Newman, Lynda Bellchambers
	DEC	Shaun Wilson, Tom Holmes
	MU	Fiona Valesini, Chris Hallett, James Tweedley, David Morgan

Appendix 3: GUIDELINES FOR A REVIEW OF EXISTING INFORMATION AND CURRENT RESEARCH

1. Within 10 pages (~5000 words)

2. Provide an introduction to the topic, identifying why it is important, particularly in the Kimberley.

3. Identify inventory, baseline (quantitative) or process type data collected on the topic in the Kimberley.

4. How has this information been collected spatially and temporally? Where appropriate a map may be used to indicate where previous marine research and monitoring has been carried out.

5. Are there any problems (e.g. ownership, accessibility etc) with the available information that would invalidate or limit its use in future research and management programs?

6. Where are the key information gaps with respect to the topic area? Can these gaps be addressed by information from other locations or are Kimberley-specific studies warranted?

Appendix 4: COMMONWEALTH GOVERNMENT PRIORITIES AND ALIGNMENT WITH THE KMRP INTEGRATING PROJECTS.

1. **Improving the operating environment and situational awareness for the RAN** – improved real-time and forecast oceanographic information across the shelf.
2. **Improved approvals, operating environment and risk mitigation for the offshore oil and gas industry** - improved real-time and forecast oceanographic information across the shelf, including ecosystem condition baselines and environmental impact forecasting.
3. **Improved readiness for emergency oil spill response** - e.g. plume detection and quantification, forecasting, ecological studies to identify vulnerable species and processes.
4. **Monitoring the effectiveness of MPAs in delivering conservation objectives** - monitoring trends in condition and effects on regional biodiversity.
5. **Developing Regional Assessments as prescribed under a revised EPBC Act** – the AG now expects regional assessments of cumulative impacts, pressures and responses to developments at ecosystem level, but the means to do this are undemonstrated to date in marine environment.
6. **Improving the understanding of ocean climate dynamics and their implications for the regional environment** - building on IMOS data and potential further investment in monitoring infrastructure with appropriate analysis and synthesis.
7. **Improved understanding of land-sea interactions in the coastal zone** - including their links to shelf-edge processes
8. **Assessing and monitoring marine biodiversity –** documenting the composition and dynamics of poorly described habitats; understanding the processes that sustain and threaten them.

Commonwealth Priorities	Integrating Project 1	Integrating Project 2
1		✓
2	✓	✓
3	✓	✓
4	✓	✓
5	✓	✓
6	✓	✓
7	✓	✓
8	✓	✓

Appendix 5: FURTHER NOTES ON ASPECTS OF THE KMRP INTEGRATING PROJECTS *(edited version of notes provided by CSIRO)*

Integrating project 1: Habitat, biodiversity assessments and baselines

Overall objective

To describe the distribution of habitats and biodiversity including critical habitats of threatened marine fauna and biodiversity hot spots across a representative range of environmental settings and hierarchy of spatial scales, to identify habitat dependencies and usages of important marine species and to identify the processes which structure these spatial patterns.

Introduction

For integrated planning and management to achieve sustainability outcomes, it is critical to describe the distribution of key habitat types and their biodiversity throughout the region. A program of research using a nested approach and a variety of methodologies at appropriate scales, to describe and map habitat and biodiversity distributions within the marine parks and throughout the region is suggested. Approaches which use a wide range of physical (e.g. depth, current shear, sediment composition), environmental data (e.g. light climate, water quality and productivity) coupled with surrogate indicators of biodiversity will be needed in order to model and predict habitat and biodiversity distributions outside the areas of intensive investigation. Even with these approaches large parts of the region will have sparse information upon which to base highly accurate habitat predictions. However, extensive experience in these approaches has been gained during previous projects that mapped seabed habitats and biodiversity in the Great Barrier Reef and at national scale in the CERF Marine Biodiversity Hub.

Understanding of the influence of biophysical factors and their temporal variability in determining habitat type is fundamental to achieving this goal and the use of both biophysical models (see integrating project 2, (IP2)) and adequately ground-truthed mapping of water quality using ocean colour satellite data will be important. In terms of the latter it will be necessary to prove or improve the applicability of available case II water algorithms for this region. While some of the IP1 information needs can be met through the use of hyperspectral remote sensing and aerial photography; however, many of these habitats will be located at depth or in turbid waters where the use of multibeam acoustic mapping and perhaps towed underwater hyperspectral sensors will be required. Further, these methods can discriminate only a very limited range of habitat types and to ensure adequate habitat classification and identification of biodiversity, tow video/drop camera and direct sampling will be required. Nevertheless, these approaches can only be undertaken at a fraction of the scale of satellite and airborne systems and as such, habitat and biodiversity modelling (underpinned by properly designed "ground truth" sampling) will be essential to achieve the required levels of regional coverage. Biodiversity of each of the key habitat types should be determined by properly designed sampling of the key taxonomic and functional groups of primary producers (phytoplankton, algae and seagrass), filter feeders (zooplankton, sponges, ascidians and cnidarians), mobile benthic invertebrates (echinoderms, molluscs and crustaceans) and fish. The identification of biodiversity hotspots of regional relevance will require an understanding of within habitat diversity as well as the variety and arrangement of habitats at the regional landscape scale.

Mapping habitat and biodiversity

The propose a program of research using a nested approach and a variety of methodologies at appropriate scales to describe and map the habitat and biodiversity distributions throughout the region will need to be done collaboratively among institutions. It will need to integrate with existing programs of work (e.g. 5 year, $5 million, WA Museum surveys of biodiversity for Woodside) and also make use of existing data where possible (e.g. Maret islands data held by Chevron). There will

need to be a targeted field program to fill in gaps in biodiversity and habitat data where necessary. There should be a significant overlap in the areas where habitat and biodiversity is mapped primarily for inventory purposes and those areas selected as important for biophysical and ecological process studies. The location of these studies should be designed in the context of the regional patterns of habitats and biodiversity, and their biophysical drivers.

Habitat usage and habitat structuring processes
Just as mapping and classifying habitats in different areas is a key element of the research so too will be an understanding of how these habitats are used by key species. Integrating biodiversity assessment with trophodynamics and ecological studies (see IP2) is one way to achieve this for relatively sedentary species, however for mobile taxa this use of acoustic arrays will be important in determining patterns of movement, residence and exchange between habitats and locations. This will be especially important for species which are of particular commercial, recreational or conservation importance. It will also be important to determine what physical and ecological processes structure the patterns of habitat and biodiversity distribution. Some of this will come from integrating with IP1 but IP2 may include some research which specifically targets understanding the processes which govern spatial patterns.

Monitoring
Development of effective monitoring tools will rely on the integration of our understanding of physical drivers of the system as well as ecological responses of the system. The first goal must be the establishment of baseline information on the key habitats, processes and species. This would be achieved through a carefully designed sampling program in each of the marine parks. A range of modelling approaches will be used in order to evaluate the reliability and utility of potential methods for assessing trends in ecosystem condition and biodiversity status. Methods to be evaluated are likely to include the use of remote sensing as well as indicator species or other assemblage or system-level metrics. The use of recently developed molecular methods for assessing biodiversity, ecological processes and ecosystem health as applied in WAMSI Node 1 could be explored in the Kimberley. Modelling will also be important in order to develop and evaluate indicators of management efficiency and effectiveness. Close linkages and integration are required with human use studies (see IP2) in order to achieve this.

Regional mapping of climate change threat/risk to benthic biodiversity (done as part of IP2)
Climate change risk mapping for shelf seabed biodiversity composition under selected IPCC scenarios for selected future years (eg. 2050, 2100), using Bluelink downscaled model outputs to drive predictive distribution modelling of biodiversity composition, using an extension of methods developed in MBH1. Suitably reliable Bluelink predictions are expected to be delivered in 1-2 years from now. The risk maps would identify areas and assemblages subject to potential change, and hence prioritize monitoring and guide adaptation strategies. The suggested approach is similar to that proposed for 'inferential monitoring', though has a longer term outlook and use modelled future environmental driver data, rather than actual (updated) environmental driver data.

The following tasks are suggested for establishing and undertaking IP1:

- Review of existing spatial data sets including physical, environmental and biological data (this to include current studies especially Museum/Woodside study).
- Assessment of appropriate resolution of spatial habitat and biodiversity data required at regional, shelf and coastal scales and matching these to sensor/sampling methodologies, including consideration of the following:
    - Identification of particular areas of geographic focus;

- Alignment of spatial data collection with studies of physical, biogeochemical and ecological processes;
- The design of habitat usage studies;
- The design of monitoring programs;
- Identifying processes that determine spatial patterns of habitat and biodiversity;
- Predictive modelling requirements;
- Regional mapping of climate risk;

- Design of new surveys and data collection; and
- Undertake new surveys and data collection.

Ultimately the project will deliver outcomes of improved environmental assessment and decision-making and better spatial management and planning for conservation and biodiversity protection addressing many of the questions posed in the KMRP Science Plan (see Table 1).

Integrating project 2: Human use, ecological processes, knowledge integration and prediction Introduction

Overall objective

To provide quantitative descriptions of Kimberley coastal and shelf ecosystems, and the linkages between broad scale and smaller scale physical, biogeochemical and ecological processes, knowledge integration and prediction

Introduction

This project aims to integrate the primary physical drivers of the marine environment of the Kimberley with the corresponding ecosystem responses. The primary physical drivers and ecosystem responses are summarized in Figure 1

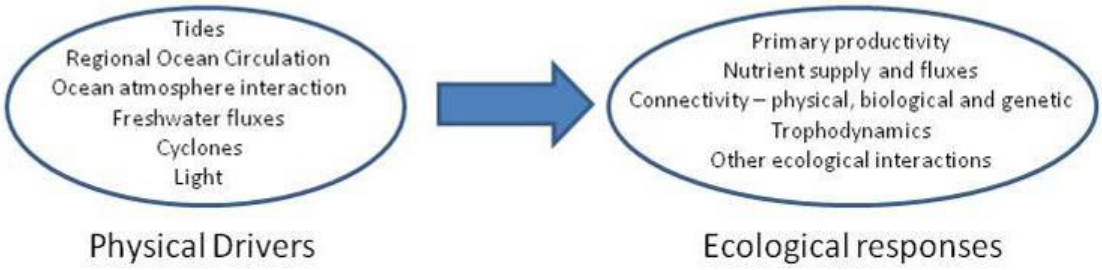

Figure 1: Primary physical drivers and ecosystem responses

IP2 will investigate the key biogeochemical and biological processes which, together with the physical processes, govern patterns of biological productivity and biodiversity from the nearshore to the shelf scale and across time scales from days to interannual. This project would include, but not necessarily be limited to, the following research topics;

- Hydrodynamic and biogeochemical modeling using fully coupled models
- Quantification of benthic and pelagic productivity
- Sources of nutrients and the importance of benthic/pelagic coupling
- Ecological connectivity
- Catchment-ocean interactions – Regions of freshwater Influence

- Climate impacts
- Trophodynamic interactions
- Transport and fate of nutrients and other potential contaminants from dredging and oil spills

This project focuses on developing an understanding of the region's response to broad scale ocean-climate forcing. Within this regional context the project will also investigate the role of fine scale process – physical, biogeochemical and ecological – for selected locations of agreed high priority. The project necessarily requires an integrated field measurement, remote sensing and numerical modeling program to characterize physical, biogeochemical and ecological processes that govern patterns of biodiversity, biological productivity, water circulation, marine connectivity and sediment mobility. Within selected high priority areas, such as proposed development areas or high conservation value areas, undertake high resolution modeling and observation e.g. physical energetics, water column variability, benthic habitat and community dynamics, food web interactions and other ecological linkages. Catchment-ocean interaction will be an important component at both the regional and local scales affecting coastal water quality and the health and resilience of nearshore ecosystems, including coral reefs.

Expected outcomes would be an improved capacity to plan and manage marine parks and reserves and to identify and manage current human impacts and future environmental change. The project would increase capacity to assess the regional environmental significance of resource development projects including an increased capacity to respond to and mitigate the impacts of oil spills.

Integrated process studies

This aspect of IP2 would investigate the important biophysical processes from the scale of the Kimberley shelf down to inshore regions, integrating physical, biological, bio-geochemical and sediment transport processes using a 3D biophysical regional model. Integration across spatial scales would be achieved through nesting high resolution domains centered on agreed areas of high priority, for example Camden Sound. Open boundary conditions would be provided by a larger scale ocean model (including tides) and atmospheric forcing from ECMWF ERA archives. Downscaling of climate change projections on the Kimberley shelf could be achieved by nesting the regional model inside an eddy resolving ocean model forced by climate model outputs. This physical characterization and modelling effort will drive the biogeochemical observation and process components ultimately leading to coupled hydrodynamic /biogeochemical models at either nested scales or geographically focused locations. There will be a need to characterize spatial and temporal (seasonal and interannual) patterns in both benthic and pelagic primary production. It will be important to integrate these with the habitat assessments (see below) and to complement them with flux measurements which ensure a clear understanding is developed about the source of nutrients and the influence of the physical environment and seasonal cycle on this. The factors which limit primary production, for example light climate, need to be clearly defined. These works in turn will feedback into the modeling to deliver nutrient budgets at a range of local to regional scales.

Studies linking higher order trophodynamics to the dynamics of the nutrient sources and key carbon producers will be an important component of the study. Again these need to be considered in the context of important habitat types as both benthic to pelagic coupling (e.g. MPB) and pelagic to benthic coupling (e.g. filter feeders) will be important in the Kimberley in addition to the more obvious coral, algae and sea grass habitats.

Given the undoubted importance of coastal scale physical forcing, especially tidal currents, the wetting/drying cycle, sediment transport and the light climate, the interactions between the physics and ecology will be important habitat structuring processes to understand. Processes which

determine the dispersal of larvae will be an important component of this and studies which use both hydrodynamics and genetics to explore these processes will be important.

Each of the three types of processes described above is an important facet of connectivity within the system. This connectivity of the linkages between habitats is one of the key factors responsible for the biodiversity and productivity of marine and coastal habitats These linkages present in the form of subsidies and flows of energy and nutrients between each habitat type and between the land and the sea, the transport of larvae among habitats, and active movements of mobile fauna such as crabs and fish, and megafauna such as sharks, reptiles and mammals. Linkages and connectivity studies will target key biodiversity hotspots, necessarily using a range of methodologies appropriate to different processes; biochemical and isotopic tracers, hydrodynamic modelling, genetics, and tracking studies will be key tools for this component of the project. Based on understanding of these patterns and processes conceptual models will be developed that will encapsulate key processes and how they are influenced by seasonal factors as well as how the ecosystem may be potentially impacted by human-induced changes whether from locally increased visitation, pollution and habitat changes from coastal/catchment or offshore development, or due to climate change. This information is a prerequisite for effectively protecting and managing marine coastal environments such as these. Again there should be a strong focus on integration of existing programs being undertaken by WAMSI partners such as the recent AIMS/CSIRO/UWA post-docs appointments which explicitly focus on key processes in the Kimberley.

Knowledge integration and prediction

This aspect of IP2 focuses on the use of numerical models to 1) quantify and identify the likely impacts of human use on a range ecosystem attributes; 2) engage different stakeholder groups (including local shires, relevant planning departments, indigenous people, industry representatives and other users) to ensure their views, inputs, values and concerns are accounted for; 3) integrate the understanding of biophysical, ecological, socio-economic processes, as produced by other aspects of IP2; 4) assess the possible outcome of likely and desired future scenarios and identify the key opportunities for intervention in order to inform management decisions; and 5) assess the capability of the proposed monitoring programs (from IP1) to assess the efficiency and effectiveness of future management intervention.

A ‘multi-model approach’ was successfully developed and applied in the WAMSI-1 Ningaloo Management Strategy Evaluation project. This involves the staged use of models of increasing size and complexity which provide considerable flexibility in adapting to project needs as they arise. For example, relatively simple numerical models can be developed at the outset using a participatory modelling approach that facilitates strong engagement between stakeholders and the WAMSI-2 Kimberley research teams. Preliminary model results can be made available quickly to inform model development, ensure its relevance and identify critical knowledge and data gaps in other WAMSI-2 Kimberley projects. This can considerably simplify the progress towards full-system modelling and understanding.

An approach to this aspect of the project is:

Stage 1 – Quantify the distribution, type and intensity of current and future proposed human activity in the Kimberly as well as the management issues and needs through interviews with key stakeholders. This approach will also a) recognise Indigenous coastal knowledge and help bridge the gap between the two knowledge domains that underlie the Kimberley region and b) build on the human use survey as might be carried out by Murdoch University.

Stage 2 – Low complexity models will be used as demonstrations tools and will help initiate the exploration of possible tradeoffs between potentially conflicting natural and cultural resource management objectives. These include pressures arising from industrial and urban development (port development, increased transport on land and sea, land degradation, habitat loss, land and marine pollution) as well from fishing (on biomass, biodiversity and iconic species).

Stage 3 - Medium complexity models will provide a preliminary understanding of the functioning of the land (via the ALCES model) and marine (via Ecosim with Ecopath) systems and an appreciation of the likely impacts of different patterns of human use, which will be relevant to regional planning.

Stage 4 – full-system coupling of ALCES and InVitro (previously used in the Gascoyne and Pilbara regions of WA), in order to develop a fully integrated land and marine modelling platform for regional Management Strategy Evaluation.
