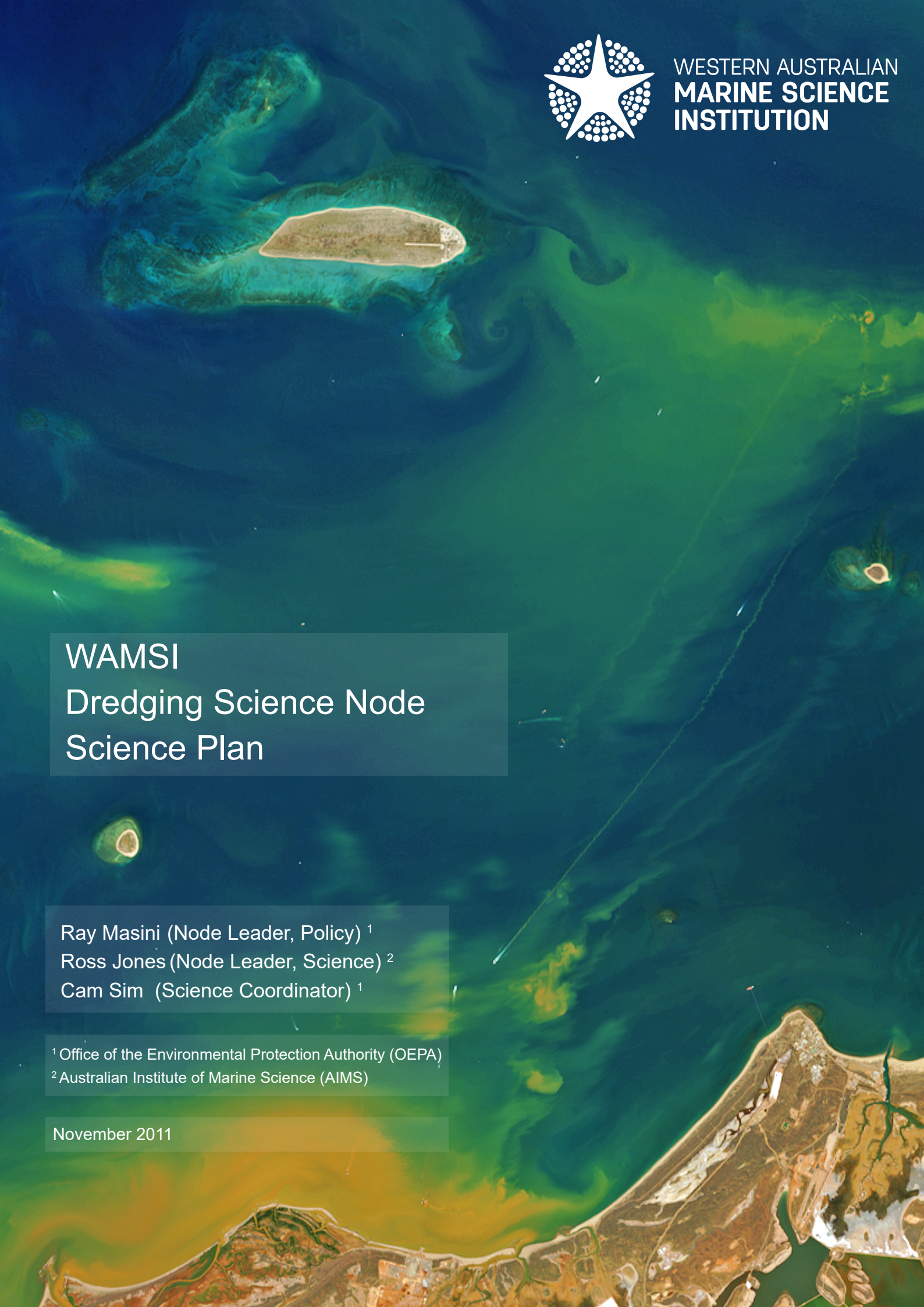

WESTERN AUSTRALIAN
MARINE SCIENCE
INSTITUTION

WAMSI
Dredging Science Node
Science Plan

Ray Masini (Node Leader, Policy) [1]
Ross Jones (Node Leader, Science) [2]
Cam Sim (Science Coordinator) [1]

[1] Office of the Environmental Protection Authority (OEPA)
[2] Australian Institute of Marine Science (AIMS)

November 2011

WAMSI Dredging Science Node

The WAMSI Dredging Science Node is a strategic research initiative that evolved in response to uncertainties in the environmental impact assessment and management of large-scale dredging operations and coastal infrastructure developments. Its goal is to enhance capacity within government and the private sector to predict and manage the environmental impacts of dredging in Western Australia, delivered through a combination of reviews, field studies, laboratory experimentation, relationship testing and development of standardised protocols and guidance for impact prediction, monitoring and management.

Funding Sources

The $20 million Dredging Science Node is delivering one of the largest single-issue environmental research programs in Australia. This applied research is funded by **Woodside Energy, Chevron Australia, BHP Billiton and the WAMSI Partners** and designed to provide a significant and meaningful improvement in the certainty around the effects, and management, of dredging operations in Western Australia. Although focussed on port and coastal development in Western Australia, the outputs will also be broadly applicable across Australia and globally.

This remarkable **collaboration between industry, government and research** extends beyond the classical funder-provider model. End-users of science in regulator and conservation agencies, and consultant and industry groups are actively involved in the governance of the node, to ensure ongoing focus on applicable science and converting the outputs into fit-for-purpose and usable products. The governance structure includes clear delineation between end-user focussed scoping and the arms-length research activity to ensure it is independent, unbiased and defensible.

And critically, the trusted across-sector collaboration developed through the WAMSI model has allowed the sharing of hundreds of millions of dollars worth of environmental monitoring data, much of it collected by environmental consultants on behalf of industry. By providing access to this usually **confidential data,** the **Industry Partners** are substantially enhancing WAMSI researchers' ability to determine the real-world impacts of dredging projects, and how they can best be managed. Rio Tinto's voluntary data contribution is particularly noteworthy, as it is not one of the funding contributors to the Node.

Funding and critical data **Critical data**

Citation: Masini R, Jones R, Sim C (2012) Western Australian Marine Science Institution (WAMSI) Dredging Science Node (DSN) Science Plan. WAMSI, Perth, Western Australia, 16 pp.

Front cover image: Atmospherically corrected, colour corrected, pan sharpened satellite image from the United States Geological Survey (USGS) Operational Land Imager (OLI) instrument showing sediment plumes caused by dredging and dredge material placement near Onslow in the Pilbara region of Western Australia (courtesy of Mark Broomhall and Peter Fearns, Curtin University of Technology, Perth, WA)

Executive Summary

Dredging is a critical and costly component of most major marine infrastructure developments in Western Australia's coastal waters. There are many examples of dredging programs that are planned or in progress in WA that are significant by world standards. Sediments generated by dredging can have widespread impacts on marine environments and large-scale dredging proposals are therefore subject to environmental assessments, approvals and regulatory processes, which rely on predictions of impact and strategies to monitor and manage those impacts. There is, however, surprisingly little convincing information in the scientific literature that can be used to make scientifically sound predictions of the likely extent, severity and persistence of environmental impacts associated with dredging or efficiently and effectively monitor and manage impacts during dredge operations. This generates uncertainty that can cause delays through the assessment and approvals processes and lead to onerous and costly regulatory regimes. The Dredging Science Node will conduct world-class marine research ***to enhance capacity within Government and the private sector to predict and manage the environmental impacts of dredging in Western Australia*** and in turn deliver outcomes to increase the confidence, timeliness and efficiency of the assessment, approval and regulatory processes associated with dredging projects. This Science Plan sets out 9 broad themes of inter-disciplinary research under the 4 broad categories (shown below with notional cash investment) to be delivered through a combination of reviews, field studies, laboratory experimentation, relationship testing and development of standardised protocols and guidance for impact prediction, monitoring and management.

CATEGORY 1 — REVIEW AND CONSOLIDATION		
Objective: To better understand the pressure gradients and range of measured biological responses associated with dredging in a range of biophysical settings		
Theme 1	Review and consolidation of available environmental data collected for dredging projects	$0.2M
CATEGORY 2 — PRESSURE FIELD PREDICTION AND CHARACTERISATION		
Objective: To better predict, measure and monitor relevant pressure-field parameters associated with dredge-generated sediments		
Theme 2	Predicting and measuring the characteristics of sediments generated by dredging	$0.75 M
Theme 3	Characterisation and prediction of dredge-generated sediment plume dynamics and fate	$1.25 M
CATEGORY 3 — ECOLOGICAL RESPONSE PREDICTION		
Objective: To establish quantitative relationships between pressure and response for key groups of ecologically important organisms		
Theme 4	Defining thresholds and indicators of coral response to dredging-related pressures	$2.0 M
Theme 5	Defining thresholds and indicators of primary producer response to dredging-related pressures	$1.5 M
Theme 6	Defining thresholds and indicators of filter feeder responses to dredging-related pressures	$1.5 M
CATEGORY 4 — CRITICAL ECOLOGICAL PROCESSES AND WINDOWS		
Objective: To identify the critical ecological processes in marine communities in that could be affected by dredging programs		
Theme 7	Effects of dredging-related pressures on critical ecological processes for coral	$0.5 M
Theme 8	Effects of dredging-related pressures on critical ecological processes for finfish	$0.2 M
Theme 9	Effects of dredging-related pressures on critical ecological processes for other organisms (including potential to facilitate the establishment of invasive species)	$0.1M

Contents

1 INTRODUCTION

Dredging is a critical component of most major marine infrastructure developments in Western Australia, particularly where they involve export of products and commodities such as liquified natural gas (LNG) and iron ore. Most large-scale dredging proposals are subject to environmental impact assessment (EIA) as part of the process of gaining approvals. Environmental impact assessment is based on predictions of environmental impacts and judgements about the degree to which monitoring and management strategies are likely to be effective at controlling impacts.

It is anticipated that subject to relevant approvals, several large-scale marine infrastructure developments will come on line over the next five years in the lower Kimberley, Pilbara, mid-west, southwest and south coast regions of WA[1]. The combined volume of dredging associated with projects currently passing through WA's approvals and/or regulatory systems is approximately 200 million cubic meters of sediment. These dredge volumes are large by world standards, and the proponents predict that in some cases, the area of influence of individual dredging projects can exceed 1000 square kilometres.

In order to make scientifically sound predictions of the likely extent, severity and persistence of environmental impacts associated with dredging, it is necessary to first predict the pressure fields generated by dredges operating in a range of environments and how they vary in space and time, and then predict the responses of the biological assemblages to those pressure fields. The approvals for dredging projects generally reflect these predictions and set out the impact limits that must be complied with. Proponents are then required to monitor and manage to ensure compliance with these limits.

Although dredging is undertaken in a range of environments all over the world, there is surprisingly little convincing information in the scientific literature that can be used to establish quantitative relationships between dredging-relating pressures and the responses for key biota that are required to underpin impact predictions and environmental monitoring and management strategies.

The uncertainty associated with predicting and managing the environmental impacts of dredging has flow-on effects through subsequent approvals and regulatory processes that are required to be met for the project to proceed. This uncertainty can lead to costly delays in the granting of approvals and subsequent final investment decisions.

Furthermore, this uncertainty can lead to the imposition of monitoring and management regimes that proponents find onerous and costly.

In recognition of the critical importance of this issue, the *Dredging Science Node* has been established to conduct world-class marine research to address the following overarching objective:

To enhance capacity within Government and the private sector to predict and manage the environmental impacts of dredging in Western Australia.

The Node's work will directly benefit proponents of marine dredging proposals, the EPA and Government approvals and regulatory agencies through scientific innovation and mechanisms designed to facilitate continual improvement of information and approaches used to inform relevant approvals and regulatory processes. Key benefits to these stakeholders are expected to include greater certainty, efficiency and timeliness to dredging approvals and delivering better environmental outcomes for WA's marine environment. The scientific research undertaken by this Node will be ground-breaking in its own right and deliver long-lasting benefits to the marine science community. This research initiative will increase the scientific capacity within WA and Australia more broadly, and the Node has the potential to gain international recognition as a centre of excellence for dredging-related marine research and innovation. Outputs of

[1] Subject to the granting of relevant approvals potential new dredging projects in WA include Wheatstone LNG, Port Hedland Outer Harbour, Anketell Point port and Browse LNG on the Pilbara and Kimberley coasts, and Oakajee Port, Fremantle, Bunbury and Albany port developments on the west and south coasts.

the research will not only benefit WA but will also contribute to the knowledge base applied to environmental assessment and management of dredging projects nationally and abroad.

2 RESEARCH PLAN

This plan sets out nine broad themes of inter-disciplinary research, to be delivered through a combination of reviews, field studies, laboratory experimentation, relationship testing and development of standardised protocols and guidance for impact prediction, monitoring and management.

The breadth of this plan is complete and has been designed to allow the depth of research conducted under the broad themes to be scalable based on the quantum of funds available. Although it is estimated that a cash investment of approximately $20M would be required to address the Node's overarching objective, there is currently $8.2M available[3]. Accordingly, the Science Plan will be implemented in phases, with Phase 1 (i.e. based on the initial $8.2M cash investment) having an initial focus on the tropical marine ecosystems of north Western Australia, with the depth of research needing to be matched with the current level of investment and associated leverage.

Any future phases would require new funding (i.e. in addition to the initial $8.2M) that would allow any residual gaps from Phase 1 to be filled and an extension of research focus to other regions of WA and elsewhere.

From here on, this document deals with Phase 1 of the implementation of this Science Plan. The outputs of the biological components of the Plan are likely to be relevant and transferable to other tropical environments in Australia and elsewhere. The outputs of the physical components of the research, and the best-practice assessment and monitoring protocols, are expected to be more generic and broadly relevant to both tropical and temperate regions. High level descriptions of the nine component research themes to be addressed by the Node are set out below under the four broad categories of Review and Consolidation, Pressure Field Prediction and Characterisation, Ecological Response Prediction, and Critical Ecological Processes and Windows. Broad guidance and descriptions of the overarching objectives/management needs are provided for each category of research. Each research theme within the broad categories has a notional budget allocation and is comprised of a set of inter-related tasks that provides the basis for the development of research project concept plans and ultimately the project plans that would detail project specifications, budgets, milestones and deliverables.

The combined outputs of this research program will provide the basis to significantly improve confidence in the prediction, assessment and management of dredging-related impacts and increase certainty in both the approvals and implementation phases of dredging projects in Western Australia and elsewhere.

2.1 REVIEW AND CONSOLIDATION

Guidance: Despite the fact that there has been a number of large-scale dredging campaigns in Western Australia and elsewhere, there has been little in the way of targeted research to establish quantitative relationships between dredging pressures and the responses of key biota. However, there has been considerable effort directed towards monitoring compliance with environmental conditions of approval for these dredging projects. These dredging projects have been undertaken in a range of environmental [biological and geo-morphological] settings, utilising a range of monitoring techniques and approaches.

There have been variable degrees of effort and scope associated with these programs. Most have focused on the biological response to dredging pressure, measured using a range of techniques and approaches. Some have also monitored pressure associated with dredging, using a range of automated and/or manual techniques. However, there is little consistency in the way in which monitoring data are synthesised, interpreted and reported. Furthermore, there has not been any comprehensive review of the data generated across this range of programs to develop and improve knowledge and understanding of actual dredging impacts or to compare the efficacy of the different monitoring techniques and approaches.

In order to maximise the benefit from this previous work, and to provide focus for the subsequent field and laboratory studies, the Node will identify and critically review available monitoring data from a broad range of localities and habitat types and across gradients of dredging pressure intensity.

Overarching objectives/management need: The objectives of these reviews are to better understand the actual pressure gradients and range of measured biological responses associated with dredging in a variety of biophysical settings in order to tease out any broad pressure:response relationships that may be revealed by existing monitoring data, provide context for laboratory and field experiments, and to evaluate the efficacy of the various monitoring approaches to inform the development of standard monitoring protocols.

Theme 1: Review and consolidation of available environmental data collected for dredging projects

Notional Node investment: $0.2M

1.1 Review available environmental data collected during dredging programs undertaken in WA, with particular attention to approaches, techniques and resultant data associated with:

- pressure parameter monitoring;
- monitoring relevant non-dredging environmental variables (e.g. ocean currents,
- wind speed and direction, wave heights);
- biological response monitoring; and
- monitoring ecological impact and recovery.

1.2 Prepare a report containing an inventory of monitoring activities, locations and durations, and a synthesis of relevant data to contribute to the overarching objective of the Dredging Science Node (above), and including, where possible, measured pressure intensities, measured ecological responses, environmental thresholds, and other environmental information to inform the reviews in Themes 4.1, 5.1, 6.1 and 7.1 (below)

2.2 PRESSURE FIELD PREDICTION AND CHARACTERISATION

Guidance: The pressure field prediction and characterisation component of the research program is about better understanding, quantifying and modelling the generation at source of the sediments produced by dredging activities and then the hydrodynamic transport and fate of these sediments once released by the dredging process.

For the purpose of describing research tasks associated with pressure field characterisation and prediction, the sediment released during dredging and dredge material placement activities is termed 'dredge-generated sediments' and should be interpreted as meaning the range of sediment types (e.g. defined by their physical characteristics, particle size distributions (PSDs) and associated settling velocity distributions) typically generated by the different dredge types (e.g. cutter suction, trailer suction, backhoe) and operating modes across a range of geotechnical settings (i.e. native substrate properties) relevant to WA.

Approaches to the pressure field prediction and characterisation research themes may involve laboratory and field experimentation (including in commercial settings), and the use of fixed *in situ* sensors (e.g. turbidity, light, PSD, sediment deposition sensors and telemetry systems), mobile *in situ* sensors (e.g. gliders, drifters and ROVs), remote sensing (e.g. airborne and satellite), and considerations include cost-effectiveness, reliability, practicability and the measurement-interpretation response time.

Overarching objectives/management needs: The objectives of this research are to be able to better predict, measure and monitor relevant pressure-field parameters associated with dredge-generated sediments, and allow pressure-field data to be collected in a consistent and effective manner to test and validate this predictive capacity in laboratory and real-world applications.

Theme 2: Predicting and measuring the characteristics of sediments generated by dredging

Notional Node investment: $0.75M

2.1 Review the state of knowledge regarding the characteristics of dredge-generated sediments, considering the application of that knowledge to Western Australian settings;

2.2 Develop an improved understanding of the factors and processes that influence the characteristics of dredge-generated sediments through laboratory and/or *in situ* studies;

2.3 Based on outcomes of the sub-programs above and having regard for the input requirements of Theme 3 below, develop detailed protocols for:

- predicting the characteristics of sediments generated by dredging in forms that can be used as input data for models used to predict the dynamics and fate of dredge-generated sediment plumes; and
- measuring source sediment characteristics in order to verify and fine tune the predictions.

Theme 3: Characterisation and prediction of dredge-generated sediment plume dynamics and fate

Notional Node investment: $1.25M

3.1 Review relevant published and accessible un-published data to establish the range and variability of environmental quality conditions generally associated with the type and scale of dredging programs and the geotechnical and metocean conditions that typically occur in Western Australia;

3.2 Review the state of knowledge regarding:

- the application of sediment dispersion models (which are generally coupled to hydrodynamic circulation and wave models) to predict the dynamics and fate of dredge-generated sediment, with particular attention to factors that control settlement and re-suspension processes, and
- approaches for the incorporation of dynamic ambient background sediment into dispersion models;

3.3 Develop an improved understanding of key physical processes that control the extent and intensity of dredge-generated sediment plumes, including:

- the release rates of dredge-generated sediments;
- sediment particle aggregation/disaggregation;
- particle size-class interactions (e.g. flocculation) and their implications for the
- behaviour of resultant particles;
- particle settling velocities;
- critical shear stress; and
- sediment flux rates for erosion (re-suspension) and deposition, including consideration of sediment cohesion, consolidation, sea-bed armouring and other factors controlling the load, fate and persistence of dredge-generated sediments deposited on the sea-bed.

3.4 Critically examine how relevant processes and factors in 3.3 above vary with distance from the source of dredge-generated sediments under a range of metocean conditions, geomorphic settings and bio-habitat types;

3.5 Apply the understanding generated from 3.3 and 3.4 above to improve algorithms and the parameterisation of representative numerical models; and

3.6 By applying improved understanding and having regard for the form of model outputs needed to predict ecological impacts of dredge-generated sediments (e.g. effects on the benthic light fields), develop protocols for:

- the incorporation of contemporary understanding, algorithms and
- parameters in representative numerical models;
- the collection of data needed to optimise plume modelling, and
- the process of testing and validating model assumptions and predictions.

2.3 ECOLOGICAL RESPONSE PREDICTION

Guidance: The ecological response component is about better understanding and describing the pressure:response relationships of important groups of marine organisms such as corals, seagrasses, algae, and filter feeders such as sponges. In order to do this we need to understand how these groups of organisms respond to typical gradients in intensity of pressure, and the durations of exposure to these pressure intensities. Furthermore, it will be necessary to consider the frequency of exposure to the varying intensities and durations of pressures that are typical of contemporary dredging practices. This information can be generated through laboratory and *in situ* experimentation. By necessity, the research will need to focus on indicator species from each group, selected on the basis that they cover the biogeographic range, are ecologically-relevant [e.g. selecting seagrass and algal species that are critical food resources for important wildlife such as dugong and turtles] and likely to span the range of responses that might be expected of each group of marine organisms [i.e. including both sensitive and resilient species]. These relationships would need to be in forms that allow pressure thresholds associated with critical responses such as sub-lethal stress, recoverable impact and mortality, to be determined.

Overarching objectives/management needs: The overarching objectives of the ecological response components of the research program are to establish quantitative relationships between pressure and response for indicator species that are representative of each of the key groups of ecologically important marine organisms of relevance to WA. These relationships, derived thresholds and approaches for prediction and measurement will be translated into tools and protocols to be used in real-world applications.

Theme 4: Defining thresholds and indicators of Coral response to dredging-related pressures

Notional Node investment: $2.0M Tasks

4.1 Review the current state of knowledge regarding the effects of dredging-related 'pressure' on hard corals, considering the range and variability of environmental quality conditions associated with dredging programs in WA (determined in Theme 1);

4.2 Identify which hard coral taxa and/or growth morphologies, that collectively cover the bio-geographic range of corals in WA, are most appropriate for the focus of subsequent research into thresholds and indicators of response to dredging-related pressures [considering both tropical and temperate areas];

4.3 Determine the pressure:response relationships associated with mortality, moderate recoverable (sub-lethal) impact and lowest observable effect, that relate the effects (including cumulative effects) of dredging-generated sediments on tropical hard corals, including testing the effects of pressure parameters individually and in combination as appropriate;

4.4 Examine the pathways, rates and timeframes of recovery from impacts;

4.5 Identify and examine the effects of key environmental variables (e.g. temperature, seasonality etc) on the pressure:response relationships (4.3) and recovery rates and/or pathways (4.4); and

4.6 Provide guidance and protocols for the application of the research outputs (e.g. pressure:response relationships, recovery timelines and key variables) to environmental impact prediction, assessment, monitoring and/or management, as appropriate.

Theme 5: Defining thresholds and indicators of Primary Producer response to dredging-related pressures

Notional Node investment: $1.5M Tasks

5.1 Review the current state of knowledge regarding the effects of dredging-related 'pressure' on primary producers, considering the range and variability of environmental quality conditions associated with dredging programs in WA (determined in Theme 1);

5.2 Identify which primary producers (e.g. ephemerals/annuals/perennials) or different functional groups, that collectively cover the bio-geographic range of key primary producers in WA, are most appropriate for the focus

of subsequent research into thresholds and indicators of response to dredging-related pressures; [considering both tropical and temperate areas];

5.3 Determine the pressure:response relationships associated with mortality, moderate recoverable (sub-lethal) impact and lowest observable effect, that relate the effects (including cumulative effects) of dredging-generated sediments on tropical primary producers, including testing the effects of pressure parameters individually and in combination as appropriate;

5.4 Examine the pathways, rates and timeframes of recovery from impacts;

5.5 Identify and examine the effects of key environmental variables (e.g. temperature, seasonality etc) on the pressure:response relationships (5.3) and recovery rates and/or pathways (5.4); and

5.6 Provide guidance and protocols for the application of the research outputs (e.g. pressure:response relationships, recovery timelines and key variables) to environmental impact prediction, assessment, monitoring and/or management, as appropriate.

Theme 6: Defining thresholds and indicators of Filter Feeder responses to dredging-related pressures

Notional Node investment: $1.5M Tasks

6.1 Review the current state of knowledge regarding the effects of dredging-related 'pressure' on filter feeders, considering the range and variability of environmental quality conditions associated with dredging programs in WA (determined in Theme 1);

6.2 Identify which components of the filter feeder assemblages (e.g. sponges and other invertebrates), that collectively cover the bio-geographic range in WA, are most appropriate for subsequent research into thresholds and indicators of response to dredging-related pressures [considering both tropical and temperate areas];

6.3 Determine the pressure:response relationships associated with mortality, moderate recoverable (sub-lethal) impact and lowest observable effect, that relate the effects (including cumulative effects) of dredging-generated sediments on tropical filter feeders, including testing the effects of pressure parameters individually and in combination as appropriate [It is recognised that fundamental ecological research may be needed for some taxa as an intermediary step before research into pressure:response relationships can commence];

6.4 Examine the pathways, rates and timeframes of recovery from impacts;

6.5 Identify and examine the effects of key environmental variables (e.g. temperature, seasonality etc) on the pressure:response relationships (6.3) and recovery rates and/or pathways (6.4); and

6.6 Provide guidance and protocols for the application of the research outputs (e.g. pressure:response relationships, recovery timelines and key variables) to environmental impact prediction, assessment, monitoring and/or management, as appropriate.

2.4 CRITICAL ECOLOGICAL PROCESSES AND WINDOWS

Guidance: Environmental Windows (EWs) are periods of importance to the life history of a marine species, such as those associated with reproduction and recruitment, where the impact of a given activity such as dredging may be significantly greater than would be the case if the activity occurred outside these environmental windows.

There are many examples where environmental windows are used to trigger management responses to reduce risk of adverse impact. In the US, for example, resource agencies often have restrictions on dredging during winter and spring months to protect larval and juvenile fish. In WA, multi-specific, synchronous mass spawning of corals [and other coral reef species] has been identified as a critical ecological process for tropical coral reef communities. It can be predicted with considerable accuracy, far in advance, and controls are often put on dredging around the likely spawning dates to reduce the impact on this important process.

Environmental windows can also have a spatial component, where mobile marine species congregate at specific locations during the temporal windows. Knowledge of these locations is important for risk avoidance and reduction. Other sensitive ecological processes where environmental windows exist could include seasonal or cyclic spawning aggregations of fish or invertebrates, and fish and marine mammal migration patterns. In addition to effects caused by increased turbidity and sedimentation rate, dredging-related activities that could affect critical ecological processes include general marine traffic, vessel strikes, underwater noise etc. Dredging vessels work in coastal waters world-wide and have the potential to translocate exotic species to our coastal waters through hull fouling or ballast water discharge. Under certain circumstances, and if an appropriate environmental niche is available, these species could establish and cause irreparable damage to our marine resources and the activities that depend upon them.

Knowledge of environmental windows is an important management tool but has significant cost implications for dredging programs. It is essential that relevant critical ecological processes are identified and that appropriate levels of management intervention are put in place at the necessary spatial and temporal scales to avoid or minimise potential impacts but not un-necessarily constrain dredging activities.

Overarching objectives/management needs: The objectives of this research are to identify the critical ecological processes in marine communities in WA that could be affected by dredging programs, the likely cause:effect pathways, and the significance of those processes at local and regional scales. The research will develop field monitoring and evaluation protocols to guide and target management to minimize disruption to both the critical ecological process and dredging programs.

Theme 7: Effects of dredging-related pressures on critical ecological processes for Coral

Notional Node investment: $0.5M

7.1 Review the current state of knowledge with respect to multi-specific mass spawning and reproductive seasonality of corals that occur in WA [considering both tropical and temperate areas];

7.2 Review the current state of knowledge regarding the effects of dredging-related 'pressure' on key tropical coral reproductive processes (e.g. gametogenesis, spawning, embryogenesis, larval survival, settlement/recruitment, and early post-recruitment growth and survival), considering published literature and the contemporary understanding of the environmental quality conditions that occur during dredging programs;

7.3 Determine the likely effects of dredge-generated sediments, on key tropical coral reproductive processes (from 7.2); and

7.4 Provide a critical appraisal of research outputs, and produce guidance and protocols for the application of research outputs for monitoring and managing dredging programs during associated critical ecological windows for coral reproductive processes.

Theme 8: Effects of dredging-related pressures on critical ecological processes for Finfish

Notional Node investment: $0.2M Tasks

8.1 Review the current state of knowledge regarding the effects of dredging-related 'pressure' on key finfish reproductive processes (such as spawning, larval survival, recruitment, and early post-recruitment growth and survival) with consideration of the relevance of past, published literature and given the contemporary understanding of the environmental quality conditions that occur during dredging programs [considering both tropical and temperate areas];

8.2 Determine the effects of dredging and dredge-generated sediments on key tropical finfish reproductive processes (from 8.1); and

8.3 Provide guidance and protocols for the application of the research outputs (e.g. pressure:response relationships) to environmental impact predictions, monitoring and/or management, as appropriate.

Theme 9: Effects of dredging-related pressures on critical ecological processes for Other Organisms (including potential to facilitate the establishment of invasive species)

Notional Node investment: $0.1M

9.1 Identify critical ecological processes relevant to WA for marine organisms other than coral and finfish with a particular focus on those that occur during discrete, predictable periods and review the state of knowledge regarding potential effects of dredge-generated sediments and other dredging-related pressures on these key ecological processes; and

9.2 Provide guidance on the application of the research outputs (e.g. pressure:response relationships) to environmental impact predictions, monitoring and/or management, as appropriate.

3 OUTCOMES

The Node will conduct inter-disciplinary collaborative research with the aim of delivering a tangible improvement in the ability to predict, assess and manage the environmental impacts of dredging, thereby increasing confidence in impact prediction and assessment and commensurately reducing the monitoring and management burden. Furthermore, it is expected that more efficient approaches for monitoring and managing dredging impacts will flow from the research undertaken by the Node. In turn, these outputs are expected to significantly improve the certainty, cost-effectiveness and timeliness of the relevant approvals, regulatory and management processes.

By addressing fundamental issues associated with project approvals and regulation, the Node's activities are strategically aligned with the WA Government's approvals reform agenda and its outputs offer great potential to enhance environmental protection while also improving the certainty, cost-effectiveness and timeliness of key approvals and regulatory processes (i.e. improved triple bottom line outcomes). The expected scientific outcomes and resultant societal benefits are summarised below:

- Enhanced capacity to predict and manage impacts of dredging in WA;
- Enhanced capacity to predict and manage impacts of dredging in other parts of Australia;
- Improved certainty and timeliness of key approvals and associated regulatory processes;
- Improved cost-effectiveness of environmental monitoring programs;
- Improved capacity to plan and manage impacts of dredging on other marine industries including tourism, recreational and commercial fisheries, pearling and aquaculture;
- Improved understanding of the key marine biodiversity assets, their ecological significance, habitat requirements and resilience to natural pressures;
- Increased capacity to respond to and mitigate the impacts of dredging;
- Increased capacity to assess the regional environmental implications of marine infrastructure development projects;
- Improved links and collaboration between State and Commonwealth agencies, universities, industry and NGOs; and
- Enhanced marine scientific capacity (including student training) in Western Australia.

4 OUTPUTS

This section outlines the generic outputs that are expected from the implementation of the research program, keeping in mind that they will be expanded and refined through project planning and approval processes.

Reviews of the current state of knowledge with respect to key components of dredging-related science based on relevant information in peer-reviewed scientific literature and the available monitoring data associated with dredging programs conducted in WA. **(Tasks 1.1, 2.1, 3.1, 4.1, 5.1, 6.1, 7.1, 8.1 and 9.1***)*

A set of relationships, approaches and protocols for predicting source characteristics of dredge-generated sediment by different types of dredges working under different operating conditions (including marine conditions) and in different

geotechnical settings (i.e. sediment properties) relevant to WA. Protocols for measuring the characteristics of source sediments generated by dredging to allow validation and fine tuning of predictions. **(Theme 2)**

A set of algorithms that describe the relationships between bottom shear stress and sediment settlement and re-suspension rates to improve the numerical modelling of the dynamics and fate of dredge-generated sediment plumes. These will be in generic forms suitable for inclusion in sediment transport and fate models used to predict the dynamics of dredge plumes and sediment deposition fields. They will also provide the ability to consider the relative contributions of natural and dredge-related sediments concurrently. **(Theme 3)**

A list of ecologically relevant indicator species, spanning their geographic distribution and likely range of responses that might be expected of each group of marine organisms. **(Tasks 4.2, 5.2 and 6.2)**

The relationships between key pressure parameters [e.g. turbidity, sediment deposition, light attenuation], both individually and in combination, and the health of ecologically relevant indicator species. These relationships will also consider the effects of key environmental variables such as temperature and seasonality. **(Tasks 4.3, 5.3 and 6.2)**

Numerical thresholds of pressure parameters associated with mortality, moderate recoverable (sub-lethal) impact and lowest observable effect. **(Tasks 4.3, 5.3, 6.3, 7.3 and 8.2)**

The pathways and timeframes for recovery from dredging impacts. **(Tasks 4.4, 5.4 and 6.4)**

Approaches/techniques to measure/monitor pressure parameters over ecologically meaningful timeframes (eg. Sediment deposition). **(Themes 2 and 3)**

Approaches/techniques to generate outputs of dredge-plume simulations in terms that are directly relevant and linked to the pressure:response relationships for key indicator species. **(Tasks 3.5 and 3.6)**

Guidance and protocols for the application of the research outputs (e.g. pressure:response relationships, pressure thresholds, recovery) to environmental impact prediction, assessment, monitoring and/or management (e.g. monitoring methods, pressure and response indicators and associated criteria, procedures for interpretation of data), as appropriate. **(All)**

An inventory of different types of ecological windows and the key ecological processes associated with those ecological windows for key indicator species [or groups of species]. **(Themes 7, 8 and 9)**

Guidance on the sensitivity of key ecological processes that are relevant to the environmental windows and strategies to avoid and minimise impacts on those processes. **(Themes 7, 8 and 9)**

5 LINKAGES TO EXISTING RESEARCH PROGRAMS

Research to be conducted by this Node does not depend on outcomes/outputs from other WAMSI Nodes. A proportion of the Node's work will, however, benefit other programs, such as parts of the Kimberley Node and the Multiple-use Management component of the non-Kimberley Node. For example, an improved understanding of the response of primary producers, filter feeders and corals to elevated total suspended sediment concentrations (and associated light reduction and increased sediment deposition) will increase knowledge of the biology of the turbid, macro-tidal reef communities of the Pilbara and Kimberley coast, and increase understanding of the principal drivers of the local and regional distribution patterns in those areas. Similarly, the outputs from research conducted by these Nodes will be of relevance to Dredging Science.

6 UPTAKE/IMPACT

To maximise pathways to adoption, research outputs will be presented in forms that are 'fit for purpose' and accompanied by clear guidance and protocols for the application of key findings of the research. The protocols will include detailed methods for the prediction and monitoring of sediment source characteristics for a range of dredging equipment types and substrate combinations. These, in combination with the modeling protocols developed around the quantitative pressure:response relationships and critical pressure thresholds for key biota, will improve confidence in impact prediction. In addition, environmental monitoring protocols will be developed to provide cost-effective and

high value information, ideally with a reduced overall cost. Collectively, the standard methods and protocols generated through this research program will represent a compendium of contemporary best practice for dredging impact prediction, monitoring and management for Western Australia.

Promoting the use of these standard methods and protocols by stakeholders and end-users will be facilitated by the Node Leader-Policy from the Office of the EPA, in collaboration with the Node Leader Science who is principally responsible for science quality and direction. A Dredging Science Advisory Committee (DSAC) chaired by the General Manager of the Office of the EPA - with membership drawn from private sector financial contributors to the Node, key public sector recipients, the Node Leaders and WAMSI - will oversee the Node's operation and also facilitate uptake of the research outputs. The end-users include industry and private consultants that work for industry, and government agencies responsible for approvals, industry regulation and natural resource management.

As outputs will be generated at various points through the research period it will be of benefit to put in place strategies to disseminate these outputs to relevant end-users as they become available rather than on completion of the entire program of research. It is proposed to use an internet-based approach for this purpose, whereby the outputs, once ratified by the DSAC, will be lodged to form a publicly-accessible 'best practice' compendium for dredging impact prediction, monitoring and management. The compendium would contain the key outputs generated by the Node's research including:

- Protocols
- Indicators
- Thresholds/criteria
- Relationships
- Verification data

A process will be established to allow these to be reviewed and updated as new or improved information comes to light. This task will also need to be resourced on an ongoing basis [costs to be determined].

7 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;
- Level of collaboration evident;
- Level of co-investment available;
- Experience & track-record of delivery;
- *'Path to adoption'* of research findings;
- Management agency involvement in the *'Path to adoption'*; and
- Linkages with other Projects in the Dredging Science research portfolio.

8 APPENDIX 1: Science Concept Plan Proforma

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

1 Project title:

2 Rationale:

3 Management information requirements/questions10:

4 Specific objectives:

5 Management Implications:

6 Expected outputs and outcomes11:

7 Proposed period of the project:

8 Lead organization and recommended Project Leader:

9 Collaborating organizations and recommended sub-Project Leaders:

10 Links with other Dredging Science projects:

11 Links with external programs/projects and other WAMSI programs:

12 Propose period of the project:

13 WAMSI funding sought:

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

14 Co-investment (Staffing):

Organization[12]	2012/13		2013/14		2014/15		2015/16		2016/17		Total
	FTE	($'000)	FTE	($'000)	FTE	($'000)	FTE	($'000)	FTE	($'000)	($'000)
Total											

15 Co-investment (Cash and in-kind):

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

WAMSI Co-Investment Categories include: Cash contributions from WA State Govt (excl. WAMSI funding); Cash contributions from any of the JV partners; Cash contributions from external sources; Costs of funding towards staff from any of the JV partners to a WAMSI project; Funding of staff from external sources; In-kind contributions through the provision of infrastructure by JV Partners or external sources.

14 Operational requirements:

15 Data management:

16 Additional comments:

9 APPENDIX 2: Guidelines for a review of existing information

1 Within 10 pages (~5000 words);

2 Provide an introduction to the topic, identifying why it is important, particularly in the Western Australian context;

3 Identify data collected on the topic, how applicable these data are to the overarching objectives of the Node and its relevance to WA;

4 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?; and

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 specific Dredging Science studies warranted?