WESTERN AUSTRALIAN
MARINE SCIENCE
INSTITUTION

WAMSI WESTPORT MARINE SCIENCE PROGRAM

Science Plan 2022 – DRAFT

GOVERNMENT OF WESTERN AUSTRALIA

WESTPORT

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1 The WAMSI Westport Marine Science Program

1.1 Introduction

Westport is the Western Australian (WA) State Government's long-term program to investigate, plan and build a new container port in the existing Outer Harbour in Kwinana with integrated road and rail transport networks.

Protecting the Cockburn Sound marine environment, and the social and cultural values that depend on it, is an important priority for the Westport program. Taking a science-based approach to inform planning as the program progresses, Westport is undertaking a major marine science program in Cockburn Sound to identify opportunities to improve its management for this generation, and generations to come. The program includes a significant partnership with the Western Australian Marine Science Institution (WAMSI) to independently and transparently address knowledge gaps and to research and trial restoration initiatives that will maintain ecosystem integrity into the future.

Westport's investment in understanding the environment will help inform sustainable design, ensure a robust environmental impact assessment process, and aim to leave a legacy of a greater scientific understanding of Cockburn Sound to help its environmental and social value management in the future.

1.2 What is WAMSI?

WAMSI was established by the WA Government more than 15 years ago as a collaborative marine science research partnership that operates to benefit all Western Australians. It is a research collaboration comprised of partners including the university sector (UWA, Murdoch University, Curtin University, Edith Cowan University), the Commonwealth Australian Institute of Marine Science, and a number of WA Government agencies (Departments of Biodiversity, Conservation and Attractions (DBCA); Water and Environmental Regulation (DWER); Primary Industries and Regional Development (DPIRD), the WA Museum and ChemCentre), and funded by the Department of Jobs, Tourism, Science and Innovation (JTSI), which together represent a broad section of marine science expertise and experience in WA.

1.3 Westport Program

After the independent Westport Taskforce, operating from 2017 to 2020, assessed a range of options for a future container terminal to meet the State's trade needs for the next 50 to 100 years, in August 2020 the WA Government endorsed the recommendation to commence planning for a new container port at Kwinana in Cockburn Sound. An input into this recommendation was a WAMSI produced *Literature review and preliminary risk assessment of the marine environment for the Westport port and environs strategy,* which focussed on:

- Assessing the risks directly associated with harbour development, as well as cumulative risks such as climate change, and industrial and urban development;
- Identifying opportunities for avoiding, mitigating and/or improving impacts on environmental and social values; and
- Identifying key information gaps currently constraining environmental management of the Sound.

Following this decision, the Westport Office was established within the Department of Transport in 2020 to progress a Business Case that will recommend to Government high-level designs and best timing and means to transition from the Inner Harbour in Fremantle to the Outer Harbour in Kwinana.

This will include planning for a container terminal aligned with an upgraded and extended Anketell Road, located to the south of the existing Alcoa Jetty. This terminal will require an access channel across the Kwinana Shelf to the Cockburn Sound basin, and a channel to the north of the basin across the Parmelia and Success Banks.

Recognising the importance of Cockburn Sound to the community, Westport has committed to one of the largest-ever research programs to understand this marine environment to inform designs and construction methodologies in a way that protects environmental values, support preparing environmental assessment documentation and leave a legacy of a greater scientific understanding of Cockburn Sound to help its environmental and social value management in the future.

Beyond environmental approvals, Westport has committed to a PIANC Working with Nature approach to its planning and development which imbeds the creation of environmental opportunities into the design and engineering process. Baseline information is necessary to understand what measures and designs will succeed in delivering benefits in the specific conditions of Cockburn Sound.

1.4 WAMSI Westport Marine Science Program (WWMSP)

The WAMSI Westport Marine Science Program (WWMSP) is a $13.5 million body of research being delivered by WAMSI to fill knowledge gaps in our understanding of Cockburn Sound. In addition to the $13.5 million Westport investment, WAMSI's partners have also contributed approximately $10 million in in-kind support across the program.

The WWMSP was developed in collaboration with Westport and its Program Partners with the dual objectives of improving Westport's capacity to avoid, mitigate and offset environmental impacts and increasing Government's ability to manage other pressures acting on Cockburn Sound into the future. Most WWMSP projects are expected to conclude in June 2024.

While most of the funds will be focused on research to help better understand, mitigate and offset port-specific impacts, the funds provided also allow a start to be made on developing an ecosystem model and other tools to improve the ongoing environmental management of Cockburn Sound. WAMSI intends to build on this by expanding the research program with funds from other stakeholders.

The specific role of the WWMSP is to enhance knowledge and understanding of Cockburn Sound that will:

1. Establish environmental baselines for important environmental and social values.
2. Improve understanding of key ecological processes in Cockburn Sound.
3. Provide a broad scientific basis as an input for consideration in the design of the terminal and channel footprint and underpinning impact prediction and environmental assessment of the project.
4. Inform mitigation and offset strategies to maximise environmental and social outcomes and assist in building environmental resilience of Cockburn Sound in the medium to long-term.

1.5 WAMSI Westport Marine Science Plan (Science Plan)

The Science Plan describes delivery of the WWMSP by WAMSI and its partners. This includes a description of the program scope, marine science research themes and individual projects.

The individual projects and deliverables of the Marine Science Plan will be delivered by Collaborative Project Agreements between WAMSI and its research partners. Such agreements are WAMSI's standard contract and project management tool.

Prior work undertaken by WAMSI and Westport identified key areas where good environmental outcomes are critical to maintain integrity and function of this ecosystem and to appropriately address community concerns. The key focus areas include the following:

1. Marine environmental quality – understanding the potential for impact on water and sediment quality from port-related construction, dredging of shipping channels and operating activities in the context of current and emerging pressures (e.g. climate change) is critical for developing mitigation measures to reduce this impact in both intensity, spatial extent and duration.
2. Benthic Communities and Habitats – the ecosystem has endured major changes over recent decades and there is strong consensus that improving habitat diversity and increasing benthic primary productivity are ways to effectively re-build natural resilience in Cockburn Sound. Work in this area is critical to ensure a healthy and biodiverse marine ecosystem.
3. Marine Fauna – Cockburn Sound provides significant regional habitat for marine animals that are ecologically important and/or are highly valued by the community. Key species include pink snapper, blue swimmer crab, little penguins and bottlenose dolphins. Ensuring healthy populations continue to thrive in Cockburn Sound requires a better understanding of habitat use, pressure-response relationships and food webs.

2 Cockburn Sound

Cockburn Sound is a semi-enclosed embayment, located between Garden Island and the WA mainland, on Perth's southern metropolitan coastline between Rockingham and Coogee. The Sound provides sheltered and relatively deep marine waters on the otherwise typically exposed and high-energy south-western Australian coast. Cockburn Sound's physical environment primarily comprises of soft sediments with some hard reef habitat. Shallower waters were dominated by meadow-forming temperate seagrasses prior to the 1960s.

Notable features that shield Cockburn Sound from prevailing ocean conditions are the mostly submerged Five Fathom Bank and the Garden Island Ridge, which comprises Carnac, Garden and Penguin islands and many submerged reefs and emergent rocks. The extensive shallow waters and relatively unique organically enriched silty basin of Cockburn Sound, which has a depth of up to 20 metres, are enclosed to the south by Cape Peron and the narrow South Channel, and to the north by Parmelia and Success banks.

Cockburn Sound has long been designated to support WA's premier industrial area and freight import and export shipping operations. Today it is surrounded by a complex mix of industry, port facilities and urban development and is the most intensely used embayment in WA. It is highly valued for its recreational, ecological and aesthetic attributes, and supports commercial and recreational fisheries, aquaculture and tourism. It supports a high diversity of invertebrates, fishes and larger fauna like penguins and dolphins, and is a nursery habitat for many species. Notably it supports key spawning aggregations of pink snapper.

Heavy industry was built along this coast following creation of the Kwinana Industrial Area in the 1950s and this has since expanded to include developments like the Garden Island naval base (HMAS Stirling) and causeway, and the Australian Marine Complex in Henderson. Physical modification to the environment associated with this industry includes wharves, jetties, breakwaters, shipping channels and basins, the Garden Island causeway and industrial and domestic water intakes and waste outflows. A shipping channel providing access for larger ships to Cockburn Sound extends northward through Parmelia and Success banks.

Intense and poorly regulated use of Cockburn Sound between the 1960s and 1980s caused considerable pressure on ecological and social values. By the 1970s, industrial and sewage discharge into Cockburn Sound led to declining water quality and the loss of more than three quarters of seagrass in the system.

The WA Government established the Cockburn Sound Management Council (CSMC) in 2000 in recognition of the urgent need for effective multiple use management. The CSMC developed an Environmental Management Plan for the system, which was effectively implemented through the State Environmental Policy for Cockburn Sound (SEP), developed by the Environmental Protection Authority and given effect in 2005. The focus of the SEP is to protect a set of identified values and uses long-term and to achieve a series common, aspirational goals for Cockburn Sound. The resulting improved management practices have seen water quality markedly improve in recent decades, and seagrass extent increase slowly. However, the extent of seagrass remains low compared to the original distribution and additional concerns remain about persistent declining trends in meadow density (State of Cockburn Sound Marine Area Report, Cockburn Sound Management Council, 2018).

3 Scope and methodology

Numerous comprehensive studies and reviews have been undertaken in Cockburn Sound in the past. These were reviewed for Westport by WAMSI in the 2018 *Westport Literature review and preliminary risk assessment,* which has been used to identify gaps and risks and inform this Science Plan. As well as filling knowledge gaps, the science program provides the opportunity to synthesise this past information into a useful form for Westport, as well as the various other government agencies responsible for the ongoing management of the Sound.

The Science Plan was developed in consultation with the Westport Program, WAMSI partners and expert scientists.

Nine themes of research focus for the WWMSP were identified and investigated:

- Theme 1: Ecosystem modelling.
- Theme 2: Benthic habitats and communities.
- Theme 3: Water and sediment quality.
- Theme 4: Fisheries and aquatic resources.
- Theme 5: Hydrodynamic modelling.
- Theme 6: Social values.
- Theme 7: Noise.
- Theme 8: Apex predators and iconic species.
- Theme 9: Coastal processes.

Westport, WAMSI staff, WAMSI Partners and other invited participants discussed these themes over 16 workshops. Draft proposals for research projects within each theme were then developed by nominated Theme Leaders in consultation with WAMSI Partners. These proposals were reviewed by the Westport Mitigation Working Group (WMWG) to assess their relevance to addressing knowledge gaps for Environmental Impact Assessment (EIA), mitigation, social license, or longer-term management of the Cockburn Sound environment. Recommendations of the WMWG were then reviewed by the Westport Environment and Social Program Coordinating Group, before final approval of WWMSP scope and associated budget by Westport.

Final proposals were assessed against Westport EIA/mitigation priorities and reviewed by the Science Program Leadership Team (SPLT) in relation to the following key aspects of science quality:

- Are the research questions clearly stated?
- Is the team capacity/capability adequate and do they have a record of research project delivery?
- Are the methods clearly described and appropriate?
- Are the timing and milestones clearly stated and can the project be delivered in the time required?
- What is the level of co-investment?
- Does the project clearly link to other WWMSP projects, including integrated fieldwork where possible?
- Are the outputs/deliverables clearly started and do they align with the aims?

The research will be focused on Cockburn Sound, where the proposed terminal will be located, and the areas of Parmelia and Success banks, Owen Anchorage, and Gage Roads which provide shipping access to the Sound. In some instances, ecological or other factors may justify that research activity may extend beyond these areas.

The nine themes are supported by a focus on data management, with emphasis on making the information collected in the program, as well as historical data, open and accessible to all.

The research projects and deliverables that comprise the WWMSP were developed before documents such as an Environmental Scoping Document or Public Environmental Review have been produced as part of a formal EIA process. Hence, while deliverables were developed through consultation with WAMSI scientists, Westport and high-level advice from State Government agencies where appropriate, some risk exists that key issues raised during a formal EIA process may not be addressed by the Science Program.

The following sections describe each theme, identify Theme Leaders and participants, detail research projects in that theme, discuss the knowledge gaps that the theme will address and the project deliverables. Details of the budget and project leaders and teams are also provided.

3.1 Theme 1: Ecosystem modelling.

To establish an Integrated Ecosystem Modelling Framework for Cockburn Sound to facilitate Westport cumulative EIA and make progress towards the development of a Strategic Assessment Framework for the Environment (SAFE).

Theme Leader: Associate Professor Matthew Hipsey (UWA). Total funding: $1,278,964.

Project 1.1 Integrated Ecosystem Modelling platform ($500,000).		
Knowledge gap	**Project deliverables**	**Project leader/s**
Connecting complex model workflows and datasets with direct needs for scenario assessment and risk quantification of decisions.	• Model and field data integration roadmap, to integrate with model workflows. • Curated datasets processed for use with the relevant modelling tools. • Online repository of model input files and supporting materials. • Archive of essential model outputs used to inform decisions, or for later use by future models. • Workflows necessary to undertake the number and scope of model scenario testing.	Matt Hipsey (The University of Western Australia, UWA).
Project 1.2 Pathways to productivity: Development of a water quality response model for Cockburn Sound ($683,964).		
Knowledge gap	**Project deliverables**	**Project leader/s**
The nutrient budget in Cockburn Sound and how benthic communities and water quality will respond to diverse pressures.	Cycle I model to deliver: • Initial simulations needed for port design questions and dredging campaign design. • Support for researchers in themes who need early outputs (e.g. seagrass restoration, habitat modelling). • Links to shared analytics platform for designing/optimising model workflows and model-data integration. • Information for reporting relevant water quality and seagrass habitat metrics. • Communicate key aspects of Cockburn Sound dynamics to the Westport team and stakeholders. Cycle II model to deliver: • Comprehensive assessment requirements for cumulative EIA. • Detailed nutrient budgeting. • Communicating prediction uncertainty. • Optimisation of operational or management strategies. • Assessment of mitigation option portfolios and climate change risks.	Matt Hipsey (UWA).
Project 1.3 Using conceptual, qualitative and quantitative ecosystem models to characterise the trophic structure, ecosystem attributes and functioning of Cockburn Sound ($95,000).		
Knowledge gap	**Deliverables**	**Project leader/s**
Links between human activities, biological communities, and ecosystem function.	• Workshop to establish understanding of key processes by constructing qualitative conceptual models; identify hypotheses to be tested by the quantitative models. • Theme leader meetings/communication to ensure integration. • Final synthesis report.	Hector Lozano-Montes (Murdoch University, MU) and Neil Loneragan (MU).

3.2 Theme 2: Benthic habitats and communities.

To deliver EIA knowledge requirements (e.g. benthic habitat mapping), improve understanding of key benthic communities and processes, and test high value opportunities/initiatives critical for the Westport Mitigation Strategy (e.g. seagrass restoration/rehabilitation).

Theme Leaders: Associate Professor Kathryn McMahon (ECU) and Professor Gary Kendrick (UWA). Total funding: $3,699,925.

Project 2.1 Benthic habitat mapping ($600,000)		
Knowledge gap	**Project deliverables**	**Project Leader/s**
Adequate recent benthic habitat mapping of Cockburn Sound, Owen Anchorage and Gage Roads.	• Workshop and geodatabase of historical data. • Develop a current benthic habitat map of Cockburn Sound, Owen Anchorage and Gage Roads (boundaries defined by EPA-accepted Local Assessment Units), including species-specific maps of meadow-forming seagrasses in Cockburn Sound and Owen Anchorage. Benthic habitat categories definitions to be consistent with EPA guidance and prior EPA-accepted habitat mapping (e.g. Kwinana Quay and PSDP2 proposals).	Renae Hovey (UWA) and Kieryn Kilminster (Department of Water and Environmental Regulation, DWER).
Project 2.2 Pressure-response relationships, building resilience and future proofing seagrass meadows ($1,200,000).		
Knowledge gaps	**Project deliverables**	**Project Leader/s**
Cumulative pressures effect on tolerance thresholds for seagrass. Causes of long-term decline of seagrass condition in Cockburn Sound. Methods to reverse this decline and build resilience in seagrass meadows.	• Workshop and report to refine knowledge gaps and identify factors for pressure/response experiments. • Controlled experiments to identify tolerance thresholds and management triggers for single and multiple pressures within the expected range of conditions and pressure during Westport relevant activities (e.g. dredging). • Report/publications of experiments. • Workshop and report/publication to identify drivers of seagrass condition. • Report/publication on genetic diversity and connectivity of *Posidonia sinuosa* to inform potential mitigation / future proofing trials. • Risk-based model to assess seagrass resilience in relation to cumulative pressures. • Report/publication on *Posidonia sinuosa* resilience in relation to cumulative pressures. • Risk-based model to assess probability of success of seagrass future-proofing and restoration. • Field trials to test ability to improve seagrass condition and health. • Report/publication on possible scalable seagrass future-proofing strategies with feasibility assessment.	Kathryn McMahon (Edith Cowan University, ECU) and Simone Strydom (Department of Biodiversity, Conservation and Attractions, DBCA).
Project 2.3 Seagrass restoration program ($1,300,000).		
Knowledge gap	**Project deliverables**	**Project Leader/s**
Methods to undertake enduring seagrass restoration at the Kwinana Shelf and Owen Anchorage area at a scale commensurate with historic loss, and potential loss associated with the Westport Program.	Stage 1 • Database of previous seagrass restoration in Cockburn Sound & Owen Anchorage, including current assessments of restoration success. • Review of seagrass restoration focused on previous and present activities in Cockburn Sound and Owen Anchorage and compared to other temperate WA and Australian programs. • Guidelines for establishing restoration trials on Kwinana Shelf and Owen Anchorage and monitoring recommendations.	Gary Kendrick (UWA) and Jennifer Verduin (MU).

	• A detailed *seagrass restoration plan* setting out the methodology for the field trials. Stage 2 • Large scale restoration program with annual update reports and a Final Report and Recommendations from seeding experiments • Evaluation of habitat modification approaches using multispecies seagrass shoots, reef and hessian tubes, informing restoration suitability modelling, including a report of experimental plantings across Kwinana Shelf, experiments on dredge spoil and priming areas for planting, hydrodynamics and hessian tubes and reef structure to break hydrodynamic flows and a report on monitoring of habitat modifications. • Assessment of dredge products and their use in seed and shoot based restoration activities, including a workshop and Report, a Report on sediment manipulations and a Final Report with Recommendations. • Development of citizen science and community involvement in seagrass restoration utilising the present relationship between OZFISH, Recfishwest and UWA and expanding on it.	
Project 2.4 Benthic communities in soft-sediment and hard substrates: baseline data, pressure-response relationships of key biota for EIA, and mitigation strategies for artificial reefs ($599,925).		
Knowledge gaps	**Project deliverables**	**Project Leader/s**
The composition of soft sediment and hard substrate communities. Pressure-response relationships of key macroinvertebrate in relation to EIA. Optimal locations and materials for potential mitigation strategies using artificial reefs.	• A report and associated data on macroinvertebrate biodiversity including genetic reference material. • Baseline data on benthic communities to feed into ecosystem models and future monitoring. • Habitat index for benthic communities to feed into ecosystem models and future monitoring. • Thresholds of sensitivity of key species (e.g. macroalgae and filter feeders) through pressure-response relationships to feed into development of trigger levels and ecosystem models. • Identification of environmental factors that influence reef communities. • Optimal substrates, locations, and deployment times for settlement of native benthic communities on artificial reefs. • 190 new specimen-anchored genetic sequences in support of future molecular based project such as eDNA biomonitoring or gut-content metabarcoding. • A curated photographic database of the benthic invertebrates of Cockburn Sound including field and/or laboratory photos to support the compilation of an illustrated field guide that will benefit on-going monitoring activities.	Glenn Hyndes (ECU) and James Tweedley (MU).

3.3 Theme 3: Water and sediment quality.

To deliver baseline monitoring and knowledge to address recognized knowledge gaps (e.g. a nutrient budget for Cockburn Sound) to adequately inform a cumulative EIA assessment and the effective ongoing environmental management of Cockburn Sound.

Theme Leader: Dr Matthew Fraser (UWA). Total funding: $1,713,244.

Project 3.1 Water and sediment quality monitoring ($394,561).		
Knowledge gap	**Project deliverables**	**Project Leader/s**
Baseline water and sediment quality information is required for areas of interest in Cockburn Sound, Owen Anchorage and Gage Roads (incl impact sites, reference sites, potential dredge material disposal sites).	• Development of water quality data collation and review and monitoring program focused on EIA requirements. • Water quality monitoring program implementation and management. • Water quality baseline report. • Development of Sediment quality data collation and review and survey focused on EIA requirements. • Sediment quality survey implementation. • Sediment quality baseline report.	Krzysztof Wienczugow (Marine and Freshwater Research Laboratory, MAFRL).
Project 3.2 Processes governing nutrient and contaminant cycling in Cockburn Sound ($572,000).		
Knowledge gaps	**Project deliverables**	**Project Leader/s**
Biogeochemical fluxes (nutrient and oxygen) between sediments and water column across different habitats and under differing environmental conditions. Thresholds of sulfide intrusion in Cockburn Sound seagrasses.	• Workshop to determine what should be priority areas for the EIA of the Westport development and inform specific site selection. • Fieldwork to determine high-resolution estimates of nutrient and contaminant flux measurements between sediment-water interface across a range of habitat types, and under different environmental scenarios. • Mesocosm measurements of biogeochemical fluxes between sediments and water columns across the variety of habitats found in Cockburn Sound, and under differing environmental conditions. • Determine the thresholds of sulfide intrusion in Cockburn Sound seagrasses using dose-response relationships in controlled mesocosm conditions. • Assess the health of biological communities in sediment habitats across a gradient of nutrient enrichment in Cockburn Sound.	Matthew Fraser (UWA).
Project 3.3 Elements of the groundwater/surface water flux into Cockburn Sound ($746,683).		
Knowledge gaps	**Project deliverables**	**Project Leader/s**
Adequately assess and quantify the ground water and surface water flux into Cockburn Sound.	• Assessment of nutrient fluxes into Cockburn Sound from surface water and groundwater. • A calibrated regional groundwater model and a local-scale reactive transport model that estimates nutrient attenuation along selected, representative transects. • A database of nutrient and other concentrations and locations of freshwater discharge across key regions of Cockburn Sound. • Measurements across the sediment-water interface that validate nutrient attenuation at the sediment water interface and/or nutrient cycling. • Reports crystalising data, key findings and outcomes.	Michael Donn (CSIRO).

3.4 Theme 4: Fisheries and aquatic resources.

To deliver knowledge of key marine species, including those of key recreational and commercial significance which will inform EIA and assist Westport to avoid, mitigate and offset impacts on important environmental and social values of the Cockburn Sound area.

Theme Leader: Dr Gary Jackson (DPIRD) and Professor Glenn Hyndes (ECU). Total funding: $2,177,106.

Project 4.1 Snapper connectivity and evaluation of juvenile stocking ($375,000).		
Knowledge gaps	**Project deliverables**	**Project Leader/s**
The significance of snapper spawning aggregations in Cockburn Sound in relation to the broader west coast stock. The longevity of hatchery-reared juvenile snapper in the wild in relation to re-stocking as a potential mitigation strategy.	A report describing: • Patterns of connectivity and the contribution made by Cockburn Sound snapper spawning aggregations to the broader lower WA coast stock. • Whether aggregating snapper and juvenile recruits exhibit local adaptation in Cockburn Sound environment, and how much they differ from snapper of the lower WA coast stock. • If hatchery-reared juvenile snapper used in stocking activities contain levels of genetic diversity and adaptive potential like those found in the Cockburn Sound population of origin. • A DNA-based cost-effective method to monitor connectivity and the contribution of Cockburn Sound spawning aggregations and hatchery-reared snapper. • Recommendations on the potential of a re-stocking program to boost stock resilience and/or offset impacts on snapper from future adverse natural or anthropogenic events.	David Fairclough (Department of Primary Industries and Regional Development, DPIRD).
Project 4.2.1 Spatial distribution and temporal variability in life stages of key fish species in Cockburn Sound ($474,890).		
Knowledge gaps	**Project deliverables**	**Project Leader/s**
Spatial and temporal patterns in the distributions of different life stages of key fishes. Habitat use by key fishes in relation to environmental variables in Cockburn Sound. Recruitment patterns of key fish species.	• Description of the spatio-temporal patterns of key species within Cockburn Sound and Owen Anchorage and their overlap with Westport activities. • Description of key habitat-types and sensitive/critical time periods for different species and life-stages. • Identification of the environmental factors governing species distribution and abundance and recommendations regarding potential thresholds. • Assessment of risks to key fishery species from the overall port footprint, the construction of the dredge channels and changes in hydrology throughout Cockburn Sound and Owen Anchorage due to port operation Testing of a novel method for long-term monitoring of changes in the relative abundance of adult snapper in spawning aggregations. • Potential mitigation strategies such as stocking, habitat restoration and artificial reefs as well as providing information about sensitive time periods and 'ecological windows' for dredging. • Comprehensive quantitative data at appropriate spatial and temporal scales that can be used to predict the impact of the Westport development for EIA (e.g. informing Theme 1 work). Provide a baseline for on-going monitoring of key fishery species during construction and future operation of the port	Danielle Johnston (DPIRD).

Project 4.2.2 Zooplankton in Cockburn Sound ($353,945).		
Knowledge gaps	**Project deliverables**	**Project Leader/s**
Spatial and temporal patterns in the distributions of zooplankton and drivers of change. The distribution of fish larvae in relation to environmental factors. Methods to identify and monitor disturbance and change in zooplankton communities.	• Updated and contemporary baseline of the spatial and temporal patterns of zoo- & ichthyoplankton (e.g. early life stages of key species) assemblages and micronekton in Cockburn Sound. • Distribution maps of larval assemblages in the study area which will be compared with associated benthic habitat maps and physical oceanography to demonstrate where 'hotspots' occur spatially and at different times of the year. • Improved understanding of key drivers/variables that regulate assemblage structure. • Stable isotope values for zooplankton and grazing rates on phytoplankton and microzooplankton to trace importance of zooplankton as food source for commercially and ecologically important pelagic and benthic species. This provides critical information for parameterising ecosystem models used in ecosystem-based management. Includes: o Characterisation of the trophic pathways. o Grazing rates and prey selectivity. o Plankton mortality rates. • Biomass size spectra in Cockburn Sound to use as rapid monitoring tool for detecting climate change and environmental disturbance. • Ecological indices relevant for ecosystem functioning: e.g. species richness, species diversity and eveness index.	Jennifer McIlwain (Curtin University, CU)
Project 4.2.3 Trophic pathways and food web structure ($326,349).		
Knowledge gap	**Project deliverables**	**Project Leader/s**
The trophic structures and processes in Cockburn Sound.	• The relative contributions of primary production to drive secondary production and biodiversity. • The development of conceptual models improving the capacity to inform impact assessment and mitigation with respect to ecosystem processes. • Improved understanding of the flow of nutrients and energy (trophic pathways) through benthic and pelagic food web, particularly fisheries species such as whiting, snapper and crabs and iconic fauna such as dolphins and penguins.	Glenn Hyndes (ECU) and James Tweedley (MU)
Project 4.3 Investigating effects of climate change on biota in Cockburn Sound ($80,000).		
Knowledge gap	**Project deliverables**	**Project Leader/s**
How will climate change impact the Cockburn sound environment and key species?	• A risk assessment of direct and indirect effect of environmental changes on different life history stages of the key biota, including recreationally and commercially important, iconic and protected, and introduced species. • Predictions of the long-term trends in the environment and key biota using climate modelling projections from the hydrodynamic modelling study downscaled to the coastal environment.	Nick Caputi (DPIRD) and Neil Loneragan (MU)
Project 4.4 Effects of total suspended sediments on key fish species ($250,000).		
Knowledge gap	**Project deliverables**	**Project Leader/s**

The possible impacts of suspended sediments generated by building and operating Westport on key fishes.	• Literature reviews of the spawning, pelagic larval duration, recruitment times and essential habitat/areas for priority species and the effects of TSS on different life stages for priority species or congeners. • Up-to-date risk-based assessment of the possible effects of different sizes of TSS on different life stages of key species. • New data on the susceptibility of key species to TSS concentrations (within expected thresholds during relevant Westport activities, e.g. dredging). • Advice to guide managers on best practice and thresholds.	Euan Harvey (CU) and Stephen Newman (DPIRD)
Project 4.6 Investigating effect of Westport Development on invasive species risks ($316,922).		
Knowledge gap	**Project deliverables**	**Project Leader/s**
What invasive marine species inhabit the project area and what are the risks of facilitating new introductions?	• Understand the current state and distribution of introduced marine species in the Cockburn Sound area as a baseline for future monitoring. • Predict the likelihood of new invasive marine species arrival from anticipated changes to environmental characteristics and future maritime activities. • Identify any management activities that can be implemented to reduce the likelihood of new invasive introductions associated with the Westport development. • Investigate strategies to minimise the probability of new invasive species establishing on artificial habitats created by Westport infrastructure.	Chad Hewitt (MU) and Justin McDonald (DPIRD).

3.5 Theme 5: Hydrodynamic modelling.

To provide a range of boundary conditions for the hydrodynamic modelling for the EIA and collect field data for calibration and validation.

Theme Leader: Professor Chari Pattiaratchi (UWA). Total funding: $400,000.

Project 5.1 Hydrodynamic modelling ($400,000).		
Knowledge gap	**Project deliverables**	**Project Leader/s**
The bathymetric changes in Cockburn Sound and Owen Anchorage caused by the Westport development may change flushing and circulation regimes.	• Ocean boundary conditions for the 2000-2020 time period to inform TuFlow model. • Ocean boundary conditions for the Resolving forcing for the 2050-70 time period. • Collection of hydrodynamic data at six locations. • Implementation of meteorological station in Cockburn Sound for wind, light and other parameters.	Chari Pattiaratchi (UWA)
Project 5.2 Wave modelling ($ to be allocated).		
	• This project is still in development.	

3.6 Theme 6: Social values.

To develop improved knowledge of how the community values and prioritises various qualities in Cockburn Sound and provide outputs to inform Westport cumulative EIA and Business Case, and to quantitatively evaluate mitigation options.

Theme Leader: Dr Abbie Rogers (UWA). Total funding: $612,000.

Project 6.1 Community values for changes in environmental conditions ($135,000).		
Knowledge gap	**Project deliverables**	**Project Leader/s**
How the community perceives environmental and social values in Cockburn Sound, and how it positively and negatively perceives impacts relating to the Westport development.	• Westport engagement workshop series to socialize research methodologies, facilitate opportunities to utilise data outputs in prioritising mitigation options, and support interpretation of the port development's environmental outcomes. • Report on community perceptions of qualities, attributes, and functions of the coastline. • Report on the community's non-market values for, and acceptable trade-offs associated with, changes in specific environmental outcomes. • Baseline measurement of Westport's social licence to operate and provision of a survey instrument to monitor social licence to operate over time.	Michael Burton (UWA).
Project 6.2 Opportunities and impacts for recreational fishing from the Westport development ($115,000).		
Knowledge gap	**Project deliverables**	**Project Leader/s**
The potential impacts and opportunities for recreational fishing associated with the Westport development.	• Westport engagement workshop series to socialise and co-develop research methodologies to foster a deeper understanding of how project results can be interpreted and used to improve decision making for the Port development. • Decision support tool to help inform optimal design and offset strategies to improve fishing experience. • Database with baseline data to inform long-term monitoring to assess forecasted benefits and costs. • Final report on magnitude and nature of negative impacts on fishing experiences, and net benefits of potential offset strategies to improve fishing experiences.	Matthew Navarro (UWA) and Clara Obregón (MU).
Project 6.3 Recreation, amenity and aesthetic values ($130,000).		
Knowledge gap	**Project deliverables**	**Project Leader/s**
Non-fishing recreational uses in the Cockburn Sound area and how these may be affected by the Westport development.	• Westport engagement workshop series to socialise research methodologies and outputs with the Westport Project Office and facilitate appropriate use of project results. • Spatially explicit heat maps of non-fishing recreational activities and assigned values across Cockburn Sound. • Final report on spatial analysis of values for recreational sites and activities, and potential impacts of Westport on recreational activities. • Final report on economic analysis of the value per "trip" to key recreational sites.	Michael Hughes (MU).
Project 6.4 Benefit-cost framework for environmental port design features. ($232,000).		
Knowledge gap	**Project deliverables**	**Project Leader/s**

A benefit-cost framework to enable economic evaluation of environmental design options that aim to improve environmental outcomes, integrating benefits and costs associated with financial, social and environmental outcomes that might result from different environmental interventions.	• Westport engagement workshop series with Theme 6 to support socialisation of socio-economic research methodologies, demonstrate integration of non-market valuation data with economic decision support tools, facilitate understanding and interpretation of Theme 6 outputs, and identify opportunities for utilisation of socio-economic data in Westport decision making processes. • Conceptual benefit-cost analysis framework for evaluation of environmental port design options. • Report on how to implement framework and spreadsheet tool for demonstration of framework (if plan A). • Benefit-cost analysis report and spreadsheet tool evaluating environmental port design options (if plan B). • Guidance note on future research needs.	Abbie Rogers (UWA).

3.7 Theme 7: Noise.

To develop knowledge that will address specific knowledge gaps currently limiting how underwater noise is considered in relation to EIA. It will also provide deliverables that will inform the Westport Mitigation Strategy in relation impacts of underwater noise on marine species.

Theme Leaders: Associate Professor Chandra Salgado Kent (ECU) and Professor Christine Erbe (CU). Total funding: $343,000.

Project 7.1 Baseline soundscape, sound sources and transmission ($240,000).		
Knowledge gap	**Project deliverables**	**Project Leader/s**
What is the soundscape (including sound sources and transmission) of the Cockburn Sound area and how may it change due to the Westport development?	• Report on the soundscape. • Deliver data on fauna presence/absence and activity level by site and date-time. • Final report on the soundscape, sources, and transmission. • Deliver data on baseline soundscape levels and statistics, sound sources, fauna presence/absence and activity level by site and season. • Deliver catalogue of noise source signatures. • Deliver sound propagation data and model input parameters for future modelling.	Christine Erbe (CU).
Project 7.2 Hearing sensitivity of Australian sea lions, little penguins, and fish ($65,000).		
Knowledge gap	**Project deliverables**	**Project Leader/s**
Audiogram data is required to understand potential acoustic impacts on species and the ranges over which this could happen.	• Report on data collection and analyses for the sensitivity of Australian sea lions, little penguins, and Cockburn Sound fishes to sound. • Data on hearing sensitivity in the above species (in digital format).	Christine Erbe (CU).
Project 7.3 Behavioural fish audiogram (snapper and another species) ($38,000).		
Knowledge gap	**Project deliverables**	**Project Leader/s**
The hearing sensitivity of key fish species and identifying noise levels that may impact them.	• Laboratory-based experimental behavioural audiogram tests. • Project report.	Miles Parsons (Australian Institute of Marine Science, AIMS).

3.8 Theme 8: Apex predators and iconic species.

To address knowledge gaps relating to protected and iconic species in the Cockburn Sound area. This recognises the conservation status of these species and/or the high value placed on such species by the community, and their importance for EIA.

Theme Leaders: Dr Delphine Chabanne (MU) and Dr Kelly Waples (DBCA). Total funding: $961,936.

Project 8.1a Determining the diet, causes of mortality, foraging habitat and home range of little penguins ($215,000).		
Knowledge gaps	**Project deliverables**	**Project Leader/s**
Key foraging locations and home ranges of little penguins in Cockburn Sound, and the importance of the Kwinana Shelf to breeding little penguins. Temporal patterns in the dietary composition of little penguins in Cockburn Sound. Rates and causes of mortality of little penguins.	• Model of the seasonal and annual environmental factors influencing diet composition of penguins. • Determination of inter-annual differences in penguin diet during non-breeding. • Annual causes of mortality and interannual differences in causes of mortality of penguins, and how this may be related to environmental factors. • Habitat maps identifying core foraging areas and home range (*after seeking permission to use Department of Defence funded data)*. • Intra- and interannual differences in core foraging areas and home range, and determination of the importance of the Kwinana Shelf to the penguins (*after seeking permission to use Department of Defence funded data)*.	Belinda Cannell (UWA).
Project 8.1b Mitigation options for little penguins ($100,000).		
Dredging associated with the Westport development may impact penguin prey species in Cockburn Sound.	• Report on potential actions to mitigate impacts from dredging and/or other key pressures (e.g. climate change) on resident penguin populations.	Belinda Cannell (UWA).
Project 8.2 Australian sea lions in the Perth Metropolitan area (abundance; movement, habitat use and diet) ($264,803).		
Knowledge gap	**Project deliverables**	**Project Leader/s**
The extent to which Australian sea lions (ASL) use Cockburn Sound and Owen Anchorage as habitat, especially given the proximity of key haul-out sites at as Carnac Island and Shoalwater Bay.	• An estimate based on mark-recapture methods of the number of ASL that inhabit the Perth metropolitan area during the peak of the breeding and migration cycle. • Maps of distribution and habitat use for Australian sea lions using Perth metropolitan waters. • Determination of to what extent Cockburn sound represents a foraging habitat for ASL. • A description of prey items consumed by ASL and their relative importance in the diet.	Chandra Salgado-Kent (ECU) and Kelly Waples (DBCA).
Project 8.3 Spatio-temporal distribution of key habitat-uses and key prey species for Indo-Pacific bottlenose dolphins in Owen Anchorage and Cockburn Sound, including a fine-scale understanding of the use of the habitats in the Kwinana Shelf ($282,233).		
Knowledge gap	**Project deliverables**	**Project Leader/s**

Key habitats used by Indo-Pacific bottlenose dolphins in Cockburn Sound and Owen Anchorage, and the diet and key prey species of Indo-Pacific bottlenose dolphins in this area.	• Use recent data and surveys focused on the Kwinana Shelf area to describe the temporal and spatial use of Cockburn Sound and Owen Anchorage by dolphins and where possible identify key habitat-use for nursing and foraging. • Improved understanding of key prey species and feeding ecology of bottlenose dolphins in Cockburn Sound and Owen Anchorage (via diet analyses using stable isotopes).	Delphine Chabanne (MU).
Project 8.4 Spatio-temporal distribution of syngnathids in Cockburn Sound ($99,900).		
Knowledge gap	**Project deliverables**	**Project Leader/s**
Diversity and habitat use of syngnathid fishes in the project area.	• An accurately identified description of syngnathid diversity in the Cockburn Sound and Owen Anchorage area. • A description of distribution and habitat preferences as determined from available data. • New specimen-anchored genetic sequences to support taxonomic verification and species discovery. • eDNA processes and assays to contribute to biodiversity assessments and as a tool for long term monitoring. • Potential future taxonomic work to describe any newly identified species. • A review and recommendations of potential mitigation actions such as re-location of key/iconic species. • Planning and implementation of a pilot trial if possible.	Glenn Moore (Western Australian Museum, WAM).

3.9 Theme 9: Coastal processes.

To address EIA requirements and inform the Westport Mitigation Strategy in relation to coastal erosion and deposition, especially in relation to potential impacts on amenity, shoreline stability, marine ecosystems, and shipping channel stability. This includes the potential beneficial use of dredge material.

Theme Leader: Dr Jeff Hansen (UWA). Total funding: $620,000.

Project 9.1 Coastal processes and sediment movement in Cockburn Sound and Owen Anchorage (620,000).		
Knowledge gap	**Project deliverables**	**Project Leader/s**
Processes associated with coastal erosion and deposition to inform EIA of the Westport Program and potential mitigation actions (including habitat restoration and beneficial reuse).	• Development of historical record of shorelines, quantify rates of change, identify dominant drivers of change (natural and anthropogenic), and provide interpretation around likely trends associated with climate change. • Quantify sediment sources, transport pathways, and transport rates as well as inform Westport mitigation actions including the beneficial reuse of dredged sediment. Provide interpretation around likely trends/changes in sediment transport associated with climate change. • Predictions of the impact of Westport infrastructure (based on provided designs) and dredging on shoreline changes and the transport pathways and rates. • Design guidelines for cost-effective coastal monitoring program.	Jeff Hansen (UWA).

4 PROGRAM MANAGEMENT

4.1 Governance Structure

A Financial Assistance Agreement (FAA) between Department of Transport and UWA (as Centre Agent for WAMSI) for the development and delivery of the WWMSP was signed on 31 March 2021. The FAA also endorsed the Governance Structure and roles and responsibilities for delivery of the WWMSP (Figure 1).

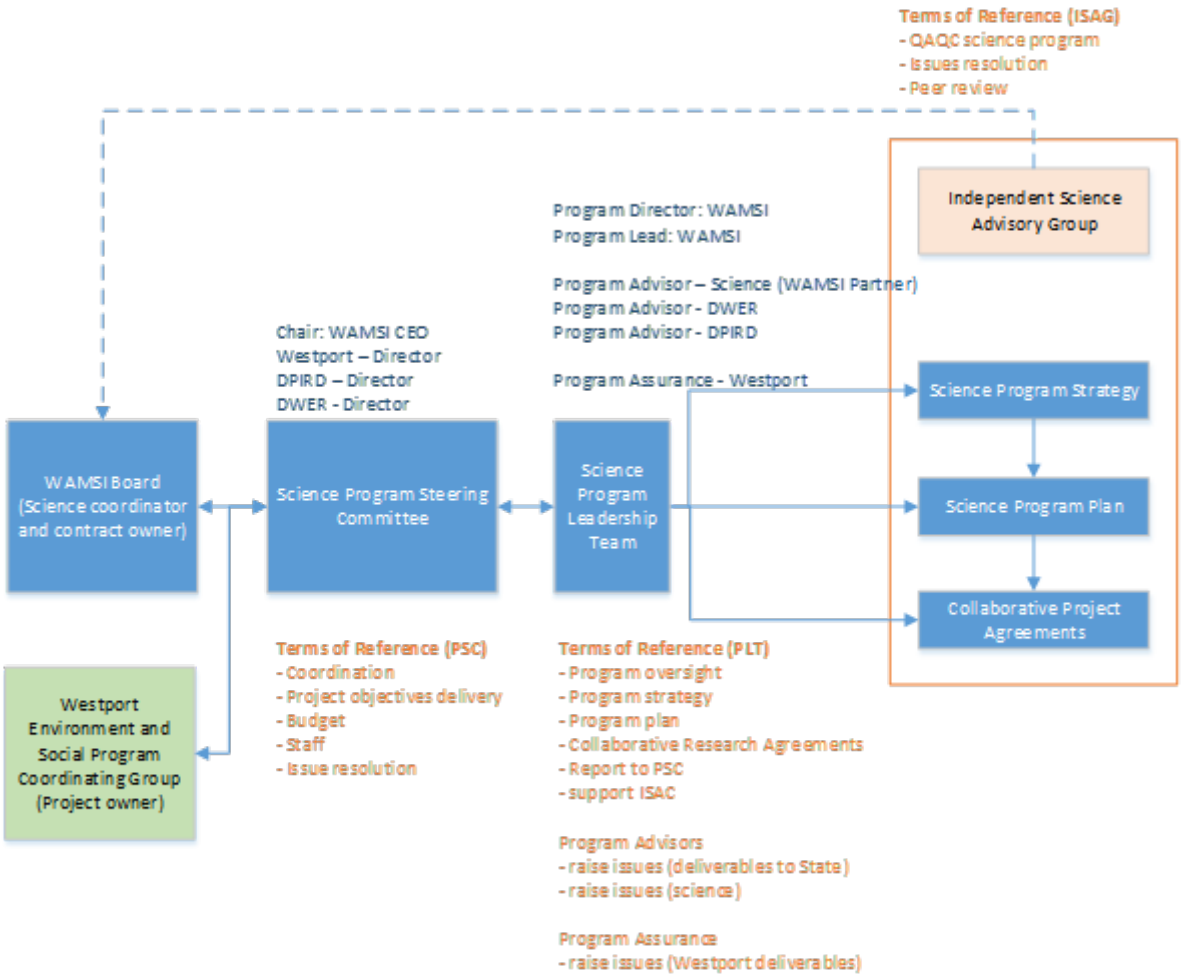

Figure 1. Governance Structure for delivery of the WAMSI Westport Marine Science Program.

4.2 Roles and Responsibilities

Science Program Steering Committee (SPSC): Chaired by the CEO of WAMSI and comprising membership of (or nominated representative for) Managing Director Westport, WAMSI Science Program Director, DPIRD Director, DWER Director, the SPSC has high level responsibility for delivery of the Science Program. It reports to the WAMSI Board and to the Westport Steering Committee (via the Westport Environment and Social Coordinating Group). It has responsibilities for coordination, delivery of program objectives, budget, staffing, risk management, dispute resolution/escalation, and change authorisation.

Science Program Leadership Team (SPLT): Chaired by the WAMSI Science Program Director, the SPLT comprises membership of the WAMSI Science Program Director and Manager, and nominated Program Advisors from DWER, DPIRD, DBCA and Westport. It will provide day-to-day program management, oversight and strategy

regarding delivery of the WWMSP. The SPLT will also provide quality assurance through the Westport representative, implement risk treatment plans, review planning documents, project proposals (regarding science design and outputs), progress and financial reports.

Independent Science Advisory Group (ISAG): The ISAG consists of highly experienced senior leaders and/or scientists who will convene to assist with matters of peer-review, quality control/assessment, adjudication, and conflict resolution over the duration of the Science Program.

WAMSI Science Program Director: Provides high-level advice and support to planning delivery of the WWMSP. Provides direction to the WAMSI Science Program Manager.

WAMSI Science Program Manager: Project manages delivery of the WWMSP, including development of the Science Plan and Collaborative Project Agreements, and overseeing budgets, schedules, integration, reporting and performance.

4.3 Science Program Themes, Projects and Collaborative Project Agreements

Science Program Themes: Nine themes of research focus for the WWMSP have been identified (Section 3). Each Science Program Theme has a Theme Leader appointed from the WAMSI partners. Theme Leaders are senior academics with an expert understanding of the theme subject and strong record of research project delivery in that field. They demonstrate a strong history of productive multi-institutional collaboration with researchers in their field of expertise and science program planning and delivery. Theme Leaders oversee the research program for each theme (comprising several projects), facilitate collaboration, provide Theme progress and financial reporting in accordance with FAA requirements and are the lead authors of a final Theme synthesis report at completion of the program.

Science Program Projects: Each theme contains a number of related projects. Each of these projects have a Project Leader who is directly responsible for delivering the project and managing the project team. Project Leaders manage budgets and assist Theme Leaders in progress and financial reporting in accordance with FAA requirements. Project Leaders assist the Theme Leader to compile a final Theme synthesis report at completion of the program.

Collaborative Project Agreements: Each project is subject to a Collaborative Project Agreement (CPA) between WAMSI and the Project Leader's Institution. These CPAs are the fundamental project delivery mechanism for delivery of the WWMSP.

Project delivery schedules in the Collaborative Project Agreements will be planned such that outputs are able to be provided to inform key Westport design milestones, such as Port Design (by October 2022), Dredging Strategy (by April 2023) and Business Case (by December 2023).

4.4 Change Management

Requests to vary a CPA during the delivery of any project will be reviewed by the SPLT and advice provided to the WAMSI Board. Any CPA variation (schedule, budget, scope) will be documented on a standard WAMSI Variation Agreement signed by all contractual parties. To vary operational aspects of a CPA, requests will be reviewed by SPLT and approved by the WAMSI Board. Where requests are made that may influence Project deliverables, approval will be sought from the Westport ESCG.

5 DATA MANAGEMENT

Westport has adopted a Westport Data Management Plan and Technical Standard Data and Analytics Deliverables, in recognition that effective and efficient data management will underpin the Program. To comply with the Westport Data Management Plan, all data/metadata used/produced by all participants in the WWMSP must conform to standards in the *Westport Technical Standard: Data & analytics Deliverables*.

The Data Management Plan provides for a Location Intelligence Support Team that is split between the Westport Program Office and WAMSI. WAMSI will provide the following resources to Westport through to June 2022, at which time Westport may review this structure. The key roles that will deliver this function are:

- **Principle Information Management Advisor,** who provides ongoing support and advisory services to the Westport Program Office.
- **Data Analytics and Platform Lead**, who manages the technical platform and deliverables of the WWMSP.
- **GIS Analysts**, who provide GIS support for the Westport Program Office

Project delivery in the WWMSP will be planned such that data acquisition will align with being available to inform key Westport design milestones, such as Port Design (by October 2022), Dredging Strategy (by April 2023) and Business Case (by April 2023).

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