Community values for environmental assets in Cockburn Sound

Theme: Social Values

WAMSI Westport Marine Science Program

WESTERN AUSTRALIAN MARINE SCIENCE INSTITUTION

WESTPORT

Better science **Better decisions**

WAMSI WESTPORT MARINE SCIENCE PROGRAM

WESTERN AUSTRALIAN MARINE SCIENCE INSTITUTION

WESTPORT

ABOUT THE MARINE SCIENCE PROGRAM

The WAMSI Westport Marine Science Program (WWMSP) is a $13.5 million body of marine research funded by the WA Government. The aims of the WWMSP are to increase knowledge of Cockburn Sound in areas that will inform the environmental impact assessment of the proposed Westport development and help to manage this important and heavily used marine area into the future. Westport is the State Government's program to move container trade from Fremantle to Kwinana, and includes a new container port and associated freight, road and rail, and logistics. The WWMSP comprises more than 30 research projects in the biological, physical and social sciences that are focused on the Cockburn Sound area. They are being delivered by more than 100 scientists from the WAMSI partnership and other organisations.

FUNDING SOURCES
The $13.5 million WAMSI Westport Marine Science Program was funded by the Western Australian Government, Department of Transport. WAMSI partners provided significant in-kind funding to the program to increase the value to >$22 million.

DATA
Finalised datasets will be released as open data, and data and/or metadata will be discoverable through Data WA and the Shared Land Information Platform (SLIP).

YEAR OF PUBLICATION
September 2024

This report is part of the project: Community values for changes in environmental conditions.

CITATION
Burton, M., Paull, N., Clifton, J., Nejati Ajibisheh, M., Kim, M., Rogers, A. (2024). Community values for environmental assets in Cockburn Sound. Prepared for the WAMSI Westport Marine Science Program. Western Australian Marine Science Institution, Perth, Western Australia. 65 pp.

FRONT COVER IMAGE
Theme: Socials values
Front cover image: Windsurfer (pexels.com).

Contents

List of Figures

List of Tables

Appendices (*as a separate document*)

The WAMSI Westport Marine Science Program is a $13.5 million body of research that is designed to fill knowledge gaps relating to the Cockburn Sound region. It was developed with the objectives of improving the capacity to avoid, mitigate and offset environmental impacts of the proposed Westport container port development and increase the WA Government's ability to manage other pressures acting on Cockburn Sound into the future. Funding for the program has been provided by Westport (through the Department of Transport) and the science projects are being delivered by the Western Australian Marine Science Institution.

Community values for environmental assets in Cockburn Sound

Authors
Michael Burton, Centre for Environmental Economics and Policy, The University of Western Australia
Natasha Pauli, School of Agriculture and Environment, The University of Western Australia
Julian Clifton, Department of Geography, University of Lincoln
Mehran Nejati Ajibisheh, School of Business and Law, Edith Cowan University
Milena Kiatkoski Kim, Adjunct Research Fellow, Centre for Environmental Economics and Policy, The University of Western Australia
Abbie Rogers, Centre for Environmental Economics and Policy, The University of Western Australia

Project
Project 6.1: Community values for changes in environmental conditions

Acknowledgments
We would like to acknowledge the input and support from the many scientists who participated in workshops and gave feedback on the descriptions of environmental assets and judgements about potential impacts, which supported the development of the survey. The final responsibility for the choices made lies with the project team, but the task was made easier by their generous use of time. We also acknowledge the support of Alaya Spencer-Cotton, who assisted in the programming of the online survey under tight deadlines.

Executive Summary

This project provides an assessment of the Perth community's values associated with marine environmental assets in Cockburn Sound that may be affected by a port development.

The project had three broad objectives:

- To evaluate social values associated with the Sound using an end-state values framework, identifying why people may value differing aspects of the environment.
- To quantify values in a monetary metric, using economic non-market valuation techniques.
- To evaluate the social license to operate given by the community to the Westport project.

The values were identified through an online survey with a sample of 1,340 people from the Perth metropolitan area. The sample included people who are considered 'users' of Cockburn Sound, but also people who might not visit and interact with the Sound, noting the study has a focus on existence values which may be held by the broader Perth community. We note that the values the community may hold for the Sound for recreational fishing and other recreational uses are considered in Projects 6.2 and 6.3.

The social value analysis indicates that overall environmental quality in Cockburn Sound is important for a large majority of respondents (Table E1). This was especially true in relation to value-statements concerning the importance of the marine flora and fauna in terms of: the contribution it makes to the history and cultural heritage of the region, and to education and science; the local ecology; the right for it to exist; and, its protection for future generations and other people to enjoy.

The economic non-market valuation analysis revealed that the average Perth household is willing to pay to achieve better outcomes for Cockburn Sound's marine flora and fauna, with 'per unit' values derived for seagrass, artificial reefs, bottlenose dolphins, little penguins and species of Syngnathidae (i.e., seahorses, seadragons and pipefish). However, there is a diversity of values: three different groups of people were identified, who held quite distinct values for different aspects of the Sound presented to them. Table E2 reports the annual willingness to pay for each of these environmental assets per household, and in aggregate for the 0.81 million Perth households, using recommended assumptions about average preferences across the three groups.

The social licence to operate for Westport was relatively neutral. A factor analysis of the responses to a set of 15 questions using a scale of 1 (strongly disagree) to 5 (strongly agree) revealed two factors, with slightly higher social licence awarded in terms of extended economic legitimacy compared to the social legitimacy factor (Table E3). This was likely driven by the low levels of community awareness of the proposed development, with only 42% of respondents stating that they were aware of the port development, and only 20% aware of the Westport organisation prior to taking part in the survey.

There was alignment in preference orientation between the economic and social valuations, with the consistency offering validation of the results delivered through each approach. This provides confidence that the information provided can assist in guiding the planning process for the proposed port development in Cockburn Sound, including through the use of the willingness to pay values ($) in benefit-cost analyses to quantify the impacts of the development and prioritise possible environmental enhancement projects.

Table E1. Summary of average Likert-scale responses across all end-state values.

Indicative statement* and [end state value]	Strongly agree (%)	Agree (%)	Unsure (%)	Disagree (%)	Strongly disagree (%)
I enjoy and/or rely on eating Cockburn Sound fish for food [adequate resources]**	25.5	32.7	14.6	18.5	8.8
[Marine species] contribute to my enjoyment of the Cockburn Sound marine environment [aesthetically pleasing environment]	36.4	39.3	16.5	5.9	1.9
Seagrass contributes to my enjoyment of a pleasant and healthy environment by improving water quality [benign physical environment]***	33.1	41.3	17.0	6.2	2.3
[Marine species] are an important part of the history and cultural heritage of the area [knowledge-heritage fulfilment]	49.0	39.0	10.3	1.3	0.4
[Marine species] are important for scientific research and education [knowledge-heritage fulfilment]	49.5	40.7	8.7	0.7	0.3
I could see myself having a meaningful occupation (e.g., working in tourism or volunteering) due, partly, to [marine species] existing in the area. [meaningful occupation]	15.3	21.6	32.4	20.5	10.2
[Marine species] are important for my recreation in the area. I enjoy seeing and/or interacting with them [recreational satisfaction]	29.4	40.6	18.6	9.0	2.4
[Marine species] contribute to my strengthening of social bonds – for example, when volunteering […] [social fulfilment]	23.5	30.6	27.1	14.5	4.4
I personally value [marine species]' role in the local ecology. [spiritual-philosophical fulfilment]	47.6	41.9	8.3	1.5	0.7
[Marine species] are important in their own right, even if I might never see them or interact with them [spiritual-philosophical fulfilment]	57.8	36.4	5.1	0.4	0.3
It is important that [marine species] are around for people other than myself to enjoy or benefit from [altruistic value]	48.7	37.5	10.3	2.7	0.8
It is important to ensure that [marine species] are still around for future generations [bequest value]	64.0	30.6	4.5	0.6	0.2
I care about [marine species]	55.1	36.7	7.4	0.6	0.4

Notes

* For this comparison, responses for all marine species were combined (penguins, dolphins, seagrass, "Seahorses" and fish) for all but two end-state values (adequate resources, and benign physical environment). The actual wording of questions seen by respondents stated each group of species separately.

** Statement answered for fish only, no other marine species groups.

*** Statement answered for seagrass only, no other marine species groups.

Colour coding :

>60	50-60	40-50	20-40	10-20	<10

Table E2. Average WTP estimates in 2023AUD for a one unit change in each environmental asset.

	$/household/year	Aggregate $millions/year
Seagrass (per ha)	0.17	0.14
Penguins (per individual)	0.52	0.42
Dolphins (per individual)	2.68	2.17
"Seahorses" (per species)	4.65	3.77
Reef (per ha)	1.23	0.99

Notes: Average estimates are based on the assumption that 'Class 2' respondents from the latent class choice model have a willingness to pay equivalent to the average willingness to pay of 'Class 1' and 'Class 3' respondents combined.

Table E3. Summary statistics measuring social licence to operate.

	Mean	**Standard deviation**	**Number of observations**
Extended Economic Legitimacy	3.28	0.75	1340
Social Legitimacy	2.95	0.71	1340

Wilcoxon signed-rank test for equality of means: Pr>|*z*|<0.0000).

1 Introduction

This project provides an assessment of the Perth community's values associated with marine environmental assets in Cockburn Sound that may be affected by a port development. As populations and trade volumes continue to grow in Western Australia, the feasibility of operating a functional container port in Perth that can handle such volumes without some form of expansion will diminish (Westport, 2020). The WA Government is developing a proposal to build a new container port in Cockburn Sound to manage for predicted future growth, following a consultation process that determined the most appropriate location for the port in the Greater Perth region.

Cockburn Sound, traditionally known as the *Derbal Nara* to the Noongar people who remain the spiritual and cultural custodians of their land and sea Country, is a multi-use environment recognised as being important for a wide range of stakeholders, commercial and recreational activities, and for its natural attributes (The Government of Western Australia, 2015). Environmental attributes in Cockburn Sound include a range of fauna such as little penguins, bottlenose dolphins, Australian sea lions, seahorses, seadragons, pipefish, a range of other fish and crustaceans, and flora including seagrass meadows.

The industrial setting and activities occurring in associated water catchments led to a decline in water quality in the Sound over several decades, which has negatively affected the marine environment and its flora and fauna. In particular, the extent of seagrass meadows was reduced by over 75% in the period between 1967 and 1999, with the greatest rate of loss occurring between 1967 and 1972 (Kendrick et al., 2002; The Government of Western Australia, 2015). More recently there have been a range of programs aimed at restoring seagrass in Cockburn Sound (e.g., the 'Seeds for Snapper' program delivered by UWA, Ozfish and their sponsors), demonstrating the potential to increase seagrass coverage. However, new development in Cockburn Sound can be expected to generate additional negative impacts on the marine environment that will require careful management (Westport 2020).

While environmental regulations ensure that efforts are made to avoid and mitigate negative marine environmental impacts as far as possible for any new development, large-scale port developments inevitably have a net negative impact, at least in the short-term. This includes through the direct loss of habitat within the construction footprint and through associated disruption to the surrounding environment. For example, the turbidity caused by sediment plumes when dredging shipping channels can be detrimental to seagrass meadows and other wildlife (Westport, 2020). Longer-term negative impacts can also be sustained, for example, if seagrass meadows do not recover following the initial dredge campaign, or where the operational activities of the port – including maintenance dredging, and increased vessel traffic and noise – can lead to further habitat loss and behavioural or physiological impacts on marine fauna.

Where negative impacts cannot be avoided or mitigated, environmental regulations may require that they should be offset, for example, through environmental enhancement projects, including things like seagrass restoration activities (see The Government of Western Australia, 2011, Principle 2). Depending on the scale of these sorts of activities, it is theoretically possible to go beyond offsetting negative impacts and aim to deliver a net positive environmental outcome, although this has not been demonstrated in practice in the marine environment to our knowledge, and it has been noted that the marine environment presents additional challenges to implementing offsets (Jacob et al., 2020). Of course, large-scale restoration and other environmental enhancements can be costly. It is therefore important to establish a firm understanding of whether the investment required to deliver net positive outcomes is justified, relative to the additional costs of moving beyond any required offsetting activities.

Community values for Cockburn Sound are important to consider in evaluating the case for focussing investment on avoiding, mitigating, offsetting negative environmental impacts and for enhancements.

Hughes et al. (2023) identify that the Perth community engages in a wide range of land- and water-based recreational activities in Cockburn Sound, indicating its importance as a natural environment for use-related (physical and mental) wellbeing. Elrick-Barr & Rogers (2023) conducted a survey to identify the attributes that the Perth community place as a priority to underpin a future vision for Cockburn Sound. The top two vision priorities included 'Care: Environmental stewardship informs all actions in the Sound, from environmental protection to industrial development', and 'Pristine: Environmental condition is not only maintained but enhanced'.

Participants in Elrick-Barr & Rogers, (2023) clearly prioritised the need for environmental stewardship, but also recognised the importance of Cockburn Sound for its industrial activities and contributions to economic development. This aligns with an evaluation conducted by Burton and Rogers (2019), which identified that Cockburn Sound was a preferable location for the port relative to expanding Fremantle (i.e., the wider Perth community was indifferent to the port being located in the Sound, while Fremantle residents had clear preferences to avoid further expansion of Fremantle port), but which also identified that the community was particularly concerned about negative marine environmental impacts that might occur as a result of a port development: survey respondents were willing to pay roughly three times as much to avoid an increase in negative marine environmental impact relative to an equivalent terrestrial one (noting that they preferred to avoid all negative environmental impacts).

The recent work above demonstrates the general importance of the marine environment to the Perth community, but is limited to an understanding of values contextualised by: how Cockburn Sound is used in a setting depicted by current environmental conditions, as in Hughes et al. (2023); a future unconstrained vision for Cockburn Sound, as in Elrick-Barr et al. (2023); and, a scenario that constrains the context to values affected by a port development, as in Burton and Rogers (2019), but one that does not reveal values for specific environmental attributes.

To properly inform an understanding about the value of undertaking environmental enhancement and related activities, data is required that provides value measures that are: (i) context specific, in relation to potential environmental changes – both positive and negative – that could occur in Cockburn Sound due to a port development; (ii) granular, in terms of revealing values associated with particular environmental attributes in order to form an understanding of relative environmental priorities; and, (iii) not limited to measuring values associated with use of Cockburn Sound's environment, recognising that many people have values for environmental protection based on maintaining the pure existence and integrity of natural systems and flora and fauna species.

Generating context-specific measures of value using quantitative metrics, and in particular economic metrics, is especially useful to provide the data needed to underpin the identification of priorities and acceptable trade-offs that frequently need to be made in major urban planning projects (e.g., through application in benefit-cost analysis or multi-criteria analysis). The acceptability of a project can be further depicted through measuring the 'Social licence to operate' (SLO) afforded to the proponent responsible for delivering the project. SLO refers to the implicit contract formed between a community and an organisation, that defines the degree of trust and acceptance the community places on the organisation's activities (Richert et al. 2015).

In this report, we provide a quantification of the Perth community's values associated with the positive and negative social externalities that may result from the port development and how it impacts the natural environment. We measure values using a range of theoretical approaches including the following:

- End-state values framework to measure social values. Using an established framework that has identified nine end-state values which influence people's wellbeing, a suite of questions is asked for each of the environmental assets to identify which are important to people, and to which end-state(s) they contribute.

- Economic non-market valuation. By asking people to choose between possible development options, with differing environmental impacts, we quantify the value of changes in the environmental assets in monetary terms, or 'willingness to pay'.
- Social License to Operate. Using a bank of questions that have been developed to measure the social license to operate held by the public for different institutions, we evaluate the SLO for the Westport governance team. We explore the respondent characteristics that are determinants of economic and social perspectives of SLO.

These values were identified using an online survey with a sample of 1340 people from the Perth community, enabling a large-scale representative assessment of community values. The study has a focus on existence values – which are not limited to users of Cockburn Sound, but which may be held by the broader Perth community.

2 Materials and Methods

2.1 Study area

The study area for the research was Cockburn Sound (Figure 2a, b), encompassing the waters between Woodman Point, Garden Island, Point Peron and the Kwinana coastline (with the marine environment being the main focus of the study), as well as a surrounding buffer of coastal land in the suburbs of Coogee, Henderson, Naval Base, Kwinana Beach, East Rockingham, Rockingham and Peron (noting that some survey questions asked about coastal land-based activities). Maps of the study area as seen by participants in the online survey are depicted in Figure 2a, b.

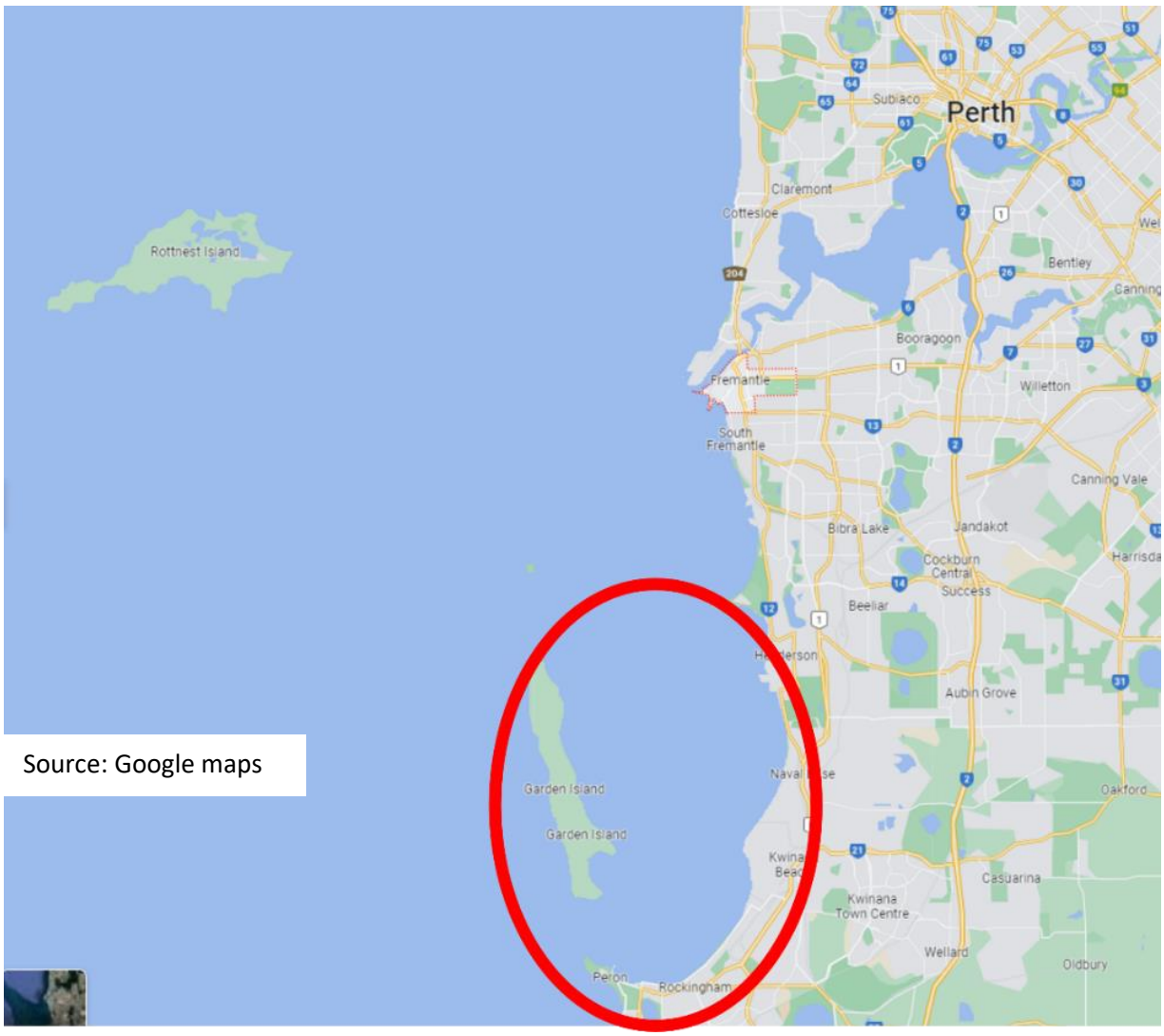


Figure 1a. Study area: Map of Cockburn Sound in context to local reference points, as included in the survey

Source: WESTPORT

Figure 2b. Study area: Map of Cockburn Sound (satellite image) as included in the survey

2.2 Overall approach

The research proceeded in stages, culminating in an online survey to gather the research data. The project commenced with a literature review to ascertain the environmental features that are at greatest risk of impact from the Westport development. A workshop and follow up consultations were held with a range of subject matter experts (including Theme and Project leads from across the other themes of the WAMSI Westport Marine Science Program), in order to confirm and refine the likely range of possible impacts on key environmental features.

A subset of key environmental features that were identified as being of concern and for which there was general agreement on the possible range of impacts, were included for discussion in community focus groups. The focus groups provided clarification about the features of interest for an online survey.

An online survey was developed by the research team and distributed by a third-party survey provider to a panel of respondents. The respondents were drawn from across the Perth metropolitan area, including people who may or may not be familiar with the Cockburn Sound region. The online survey comprised three sections: 1) the qualitative values associated with each of the environmental features; 2) a discrete choice experiment in which participants are asked to select their preferred scenario from a range of options (featuring combinations of environmental features, impact levels, and mitigation

costs); and 3) social licence to operate. The analysis of the full dataset allows for an interrogation of the positive and negative social externalities associated with the Westport development.

Each stage of the research process is described in detail in the following sections.

2.3 Development of survey themes

2.3.1 Literature review on environmental impacts

Relevant reports specific to the impacts of a port development in Cockburn Sound were reviewed, to gain an understanding of the likely impacts of the development. Additionally, the team reviewed project documentation submitted by various proponents to the Western Australian Environmental Protection Authority (EPA) on port and outer harbour developments, to understand the environmental themes and factors that were recommended for impact assessment by the EPA.

Table 1 lists the EPA Factors (Environmental Protection Authority, 2021) that were at least preliminary factors for port or outer harbour developments, as well as projects local to Cockburn Sound. The most commonly assessed factors were:

- Benthic Communities and Habitats
- Coastal Processes
- Marine Environmental Quality
- Marine Fauna
- Social Surroundings

The Westport Stage 2 report (Westport, 2020) highlighted particular key issues around fauna and flora including impacts on seagrass, pink snapper, blue swimmer crabs, little penguins and bottlenose dolphins. Environmental impacts can be considered as short-term (construction only), medium term (construction effects with lag time), and long-term (operation and impacts that cannot be mitigated). During the construction phase, the major impacts on seagrass meadows and marine fauna are associated with excavation and turbidity during the dredging of a second access channel. During the operational phase, seagrass meadows and marine fauna will likely suffer further habitat loss, and marine fauna will additionally be exposed to increased vessel movements and potential cascading ecological effects. There may also be impacts on broadscale flushing and water circulation regimes in Cockburn Sound (including stratification and water quality issues), which may impact key ecological processes such as spawning (Westport, 2020).

The preliminary list of possible impacts were summarised and used as the basis for an expert workshop to identify to the potential range of impacts for each of the environmental factors of interest.

Table 1. Preliminary environmental factors determined by the EPA for recent and current port developments in Western Australia, as well as projects in the geographic vicinity (Cockburn Sound).

THEME, Factor and *Objective*		Single Jetty Deep Water Port & Renewable Hub (Gascoyne Gateway) 2022b	Albany Port Expansion 2022a	Oakajee Port 2020a	Port Rockingham Marina, Cockburn Sound 2020b	Koolan Island Iron Ore Mine and Port Facility 2019	Port of Broome Channel Optimisation* 2018	Pilbara Iron Ore & Infra-structure Project: Port and North-South Railway 2014	Port Hedland Outer Harbour 2012	James Point Stage One Port, Kwinana 2004
SEA	**Benthic Communities and Habitats** *To protect benthic communities and habitats so that biological diversity and ecological integrity are maintained.*	■	■	■	■		■	■	■	
	Coastal Processes *To maintain the geophysical processes that shape coastal morphology so that the environmental values of the coast are protected.*	■	■	■	■	■			■	■
	Marine Environmental Quality *To maintain the quality of water, sediment and biota so that environmental values are protected.*	■	■	■	■	■	■	■	■	■
	Marine Fauna *To protect marine fauna so that biological diversity and ecological integrity are maintained*	■	■	■			■		■	■
LAND	**Flora and Vegetation** *To protect flora and vegetation so that biological diversity and ecological integrity are maintained.*	■		■				■	■	
	Landforms *To maintain the variety and integrity of significant physical landforms so that environmental values are protected.*									
	Subterranean Fauna *To protect subterranean fauna so that biological diversity and ecological integrity are maintained.*	■								
	Terrestrial Environmental Quality *To maintain the quality of land and soils so that environmental values are protected.*								■	
	Terrestrial Fauna *To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.*	■		■				■		
WATER	**Inland Waters** *To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.*	■						■		
AIR	**Air Quality** *To maintain air quality and minimise emissions so that environmental values are protected.*			■				■		■
	Greenhouse Gas Emissions** *To reduce net greenhouse gas emissions in order to minimise the risk of environmental harm associated with climate change*.									
PEOPLE	**Social Surroundings** *To protect social surroundings from significant harm*	■		■			■	■		■
	Human Health *To protect human health from significant harm*			■				■		

* Not assessed due to non-significant impacts

** Factor reviewed in 2021. The Policy is intended to apply to new significant proposals that meet the criteria of a designated large facility under the Australian Government's Safeguard Mechanism. Generally, GHG emissions from a proposal will be assessed where they exceed 100,000 tonnes of scope 1 emissions each year measured in CO_2-e.

2.3.2 Stakeholder workshop

An expert stakeholder workshop was held online in July 2022. The purpose of the two-hour workshop was to gain an understanding of the broad environmental impacts and opportunities presented by the Westport project, in order to inform research on social values. The focus of the workshop was on identifying the potential range and magnitude of impacts, based on expert judgement and preliminary analytical work.

Representatives from each of the WAMSI Westport Marine Science Program themes were invited to attend. Representatives from the following themes attended the meeting:

- Theme 1: Ecosystem modelling and integration
- 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
- Theme 10: Environmental data management

The workshop was conducted as a virtual round table. In the first session, each participant was asked in turn to spend up to two minutes highlighting what they believed to be the one or two main environmental impacts of the Westport development, and the major environmental assets or features that could be impacted. In the second session, each participant was asked in turn to reflect on what opportunities or solutions exist that could lead to positive impacts for environmental assets in Cockburn Sound. For each option, participants were asked to indicate the feasibility and likelihood of success for positive outcomes. In the final session of the workshop, attendees were asked to contribute information on the ranges of positive and negative impacts on environmental assets that might plausibly be expected, given the current knowledge of the port's design and footprint, and solutions identified during the second session.

Detailed notes were kept by the research team and later shared with all workshop attendees. Where specific questions could not be answered by the experts present at the workshop, follow-up one-on-one conversations were held by members of the research team and the relevant expert.

2.3.3 Community focus groups

Community focus groups were conducted in two stages. Firstly, to inform the survey design, and then after the survey instrument was drafted, a further focus group was conducted, discussed in Section 2.5.1 below.

Before survey development was undertaken, two focus groups were conducted with members of the public to ascertain broad levels of understanding about the environment of Cockburn Sound and potential impacts of the port development. These were conducted on 13th and 14th of September 2022 with 10 and eight respondents, respectively, sourced by Thinkfield, a Perth market research company. The responses indicated that very few people had heard of the port development, but when described to them, in general terms, they indicated that the main negative impacts that they would be concerned about included:

- Impacts on/destruction of marine life (general), habitats, breeding grounds, ecosystems, ecological issues, marine ecology, cycle of life)

- Penguins, seagrass, dolphins, fish, coral, crabs (seals, sharks and seabirds after prompt)
- Water quality (polluted water), air quality, land-based impacts (bushland, coastline)
- Impacts on fishing industry, on residents (e.g. traffic, infrastructure)

Potential positive impacts were largely around jobs, potential improved environmental conditions in Fremantle, and an opportunity to invest in research and addressing existing environmental issues.

These results confirmed that the issues identified through the consultation with the experts in the WAMSI Westport Marine Science Program and the literature review were also key issues for (this small sample of) the public.

2.4 Survey design

2.4.1 Social values

Environmental management is undertaken with the objective of improving or sustaining human wellbeing, which is a broad term but can be generally taken to refer to a set of conditions which are associated with a good state of life. The concept of 'value' is therefore integral to environmental management as it is through measures of what people value that we can identify appropriate environmental management policies. The term 'value' is, however, complex as it may denote a numerical quantity (e.g. mean value) or a material value (e.g. monetary value). Choice experiments and other economic valuation tools provide a means to quantify the latter. However, it is necessary to understand individual motivations behind the material values expressed in economic valuation exercises. In this sense, value may be also defined as reflecting an individual's judgement of what is important to wellbeing.

There are a range of models in the literature through which values associated with wellbeing may be classified and quantified through individual or group participatory processes. This research uses the framework proposed by Wallace et al. 2021 and Wallace et al. 2020 which explores the relationship between wellbeing and values to identify 'end state values'. These end state values are defined as '*enduring beliefs concerning the preferred end states of human existence, including those required for survival and reproductive success, which taken together determine human wellbeing (p2)*' (Wallace et al., 2020). A set of nine end state values were proposed by Wallace et al. (2020) as illustrated in Table 2 below.

Table 2. 'End state values' proposed by Wallace et al. (2020)

Value	Description
Adequate resources	Having sufficient food, air, and water to support energetic needs, growth, and structural maintenance.
Aesthetically pleasing environment	Living in, and having access to, aesthetically pleasing environments – i.e., places where the structure and composition of elements give sensory pleasure.
Benign physical environment	An environment in which the physical properties lie within minimum and/or maximum boundaries (e.g., lead concentrations, temperature) that are conducive to wellbeing.
Knowledge-heritage fulfilment	Having sufficient access to the information contained in nature to support knowledge-heritage needs. Includes scientific research, educational uses, and heritage-related purposes. For example, plants, animals, and rock formations are one source of indigenous cultural knowledge.
Meaningful occupation	Broadly defined here as work occupation or equivalent that provides one or more people with satisfying tasks.
Protection from other organisms	The security that comes from living in an environment in which the presence of other organisms, including disease organisms and humans, does not harm wellbeing.
Recreational satisfaction	The fulfilment that people derive from leisure activities.
Social fulfilment	The fulfilment one achieves through strong family and community relationships.
Spiritual-philosophical fulfilment	The fulfilment that arises from meeting, to a sufficient extent, one's spiritual-philosophical needs to achieve wellbeing. Includes concepts such as a biodiversity conservation ethic.

Importantly, the categories developed by Wallace et al. (2020) are based on broad concepts of needs and wellbeing and are therefore universally applicable rather than reflecting specific societal perspectives. The derivation of these categories therefore provides a starting point to construct surveys which systematically explore individual perceptions of these end state values.

Westport (2020) identified the need to ascertain impacts of the proposed port development on a number of particular species and habitats in the Sound. This information was used as the basis to collate information from a workshop with scientific experts to identify species and habitats of high scientific value and public interest in the Sound (see preceding section). The research team used the results of the literature review, workshop and focus groups to produce a final list comprising 1) little penguins (*Eudyptula minor*); 2) bottlenose dolphins (*Tursiops adunctus*); 3) seahorses, pipefish and sea dragons *(*Syngnathidae family, which in places in this report are simplified to "seahorses"*);* 4) fish species, including those of commercial and recreational value and 5) seagrasses.

This list was used to explore respondents' values associated with each species or habitat using statements corresponding to the nine categories of end state values identified in Table 2. A brief paragraph outlining the significance and status of each (grouping of relevant) species in the Sound was

given to contextualise the question. Survey participants were then asked to respond to each statement through a five-point Likert scale (participants could select from Strongly Agree, Agree, Unsure, Disagree, and Strongly Disagree). An example of the questions relating to values associated with little penguins is given in Table 3, with the relevant end state value indicated in parentheses. It should be noted that it was not always possible to frame statements relating to all end state values. For example, 'protection from other organisms' or 'adequate resources' end state values were not always applicable in this context. The final two statements were included, additional to the statement aligned with the end-state values to ascertain respondents' perceptions of altruistic and bequest values to assist in interpreting the economic valuation outputs.

Table 3. Example of question set and associated end state and economic interpretation values

Question seen by participant	End state value (Wallace et al. 2020)	Values for economic interpretation
Penguins contribute to my enjoyment of the Cockburn Sound marine environment	Aesthetically pleasing environment	
Penguins are an important part of the history and cultural heritage of the area	Knowledge-heritage fulfilment	
Penguins are important for scientific research and education	Knowledge-heritage fulfilment	
I could see myself having a meaningful occupation (e.g., working in tourism or volunteering) due, partly, to penguins existing in the area.	Meaningful occupation	
Penguins are important for my recreation in the area. I enjoy seeing and/or interacting with them.	Recreational satisfaction	
Penguins contribute to my strengthening of social bonds – for example, when volunteering with penguins.	Social fulfilment	
I personally value penguins' role in the local ecology.	Spiritual-philosophical fulfilment	
Penguins are important in their own right, even if I never see them or interact with them.	Spiritual-philosophical fulfilment	
It is important that the penguins are currently around for other people to enjoy or benefit from.		Altruistic value
It is important to ensure the penguins are still around for future generations.		Bequest value

It is important to recognise that the species and habitats identified as being important and of concern by the literature review, Westport, scientific experts or the limited representation of participants in

the community focus groups may not correspond with broader public perceptions. Accordingly, the survey encompassed other potential foci of values through posing open-ended questions soliciting views on individual perceptions of important marine animals and plants in the Sound, together with important physical environmental qualities associated with the Sound. These open-ended questions allowed respondents to identify which (if any) they considered of value and explain why this was the case.

2.4.2 Non-market valuation

Non-market valuation is a process whereby people's preferences towards goods and services that are not traded through markets can be valued. The approach is widely applied in the area of environmental valuation, where access to the services that natural capital provides are not limited by market mechanisms, typically because: they are non-excludable (e.g. it is impossible to restrict access because the values are existence values, that do not require physical access); it would be prohibitively expensive to secure access; or, because it is public policy to provide open access (e.g. to local parks).

Although there are several framings for the types of questions that can be used to elicit these non-market preferences, there are two defining features of them: people are asked to make constrained choices among alternatives, and they are framed so that values can be represented in monetary terms (i.e. as 'willingness to pay'). The benefit of identifying monetary values is that these provide a common metric whereby values can be compared across environmental assets in a consistent way, and those values can be incorporated into other decision metrics, such as benefit-cost analysis. Using monetary values does not imply that the asset itself will be monetarised, rather that the values are measured in a metric that allows comparison across assets.

Discrete choice experiments are a non-market valuation approach that allows multiple components (or attributes) of the environment to be valued jointly. They are particularly useful when a policy process may involve changes (both negative or positive) across a number of elements, when the evaluation is occurring before the change has occurred (i.e. a prospective evaluation rather than an retrospective one), and when it is possible for the final policy evaluation to vary across the extent of changes. Measuring values across a range of extents for the multiple components of the environment means that the full environmental impacts of a project can be evaluated, even if they were not known at the time of the valuation study. As long as the relevant attributes and the potential ranges are included in the survey instrument, the discrete choice models can be used to subsequently value any bundle of environmental changes.

An issue with discrete choice design is that the number of attributes that can be considered is limited: typically 4-6 attributes are used including a cost attribute. As respondents have to make choices over options that include all attributes (see Figure 3 below) extending the number can make it difficult for respondents to make choices.

In identifying the attributes used here, the design was guided by the literature review, expert consultations, and the exploratory focus groups undertaken with public members. The choice experiment attributes were also aligned with the attributes developed for the social values section, to enable comparison of results. Five environmental attributes were identified:

- The number of little penguins
- The area of seagrass
- The number of dolphins
- The area of artificial reefs present
- The number of species of "Seahorses" (Syngnathidae) present

The final selection of attributes balanced a number of issues, including relevance for the public as well as need for values in subsequent analysis of design options for the port. The charismatic species emerged as focal points for concerns about changes in the ecosystem for the focus groups, and are also a prominent issue in discussions about potential impacts of dredging. Seagrass is both itself a focal species, but may also be viewed as a measure of the environment that may support the broader ecosystem in the Sound. It is also likely that a mitigation activity that could be undertaken in the development of the port is replanting of seagrass, and hence understanding values for this attribute will support the evaluation of this. There are limited artificial reefs in the Sound, however, they are being investigated as a potential mitigating feature within other WAMSI programs, and hence identifying their community value would be useful for guiding any future implementation. While fish are included in the social value analysis, they are not a focus of the choice experiment, as it was thought difficult to represent the diversity of fish species within the sound in a meaningful way as an attribute. The economic values associated with recreational fishing are considered in WWMSP Project 6.2.

There is also a need for a monetary attribute that can be used to recover monetary values for the environmental assets. This is typically represented as a cost to the respondent. The cost attribute must be represented through a plausible payment vehicle; that is, the mechanism through which the cost would be hypothetically applied should be feasible to implement and relevant to the community being asked to pay. We indicate that any additional costs of managing environmental impacts will be borne by industries using the new port facility and passed on to consumers, described as an increase in annual household costs (i.e. the payment vehicle is broadly applicable to the Perth community who will purchase goods that arrive through the port).

Table 4 reports the initial values used for the environmental attributes and cost, and the adjusted levels for seagrass and cost which were modified following piloting of the survey, as noted further below. The levels represent positive and negative changes around what is considered the current levels of the attributes, apart from cost and reefs where the current levels are already (effectively) zero. The positive changes are included because of the possibility that mitigation activity may potentially lead to higher levels of these attributes if sufficient investment is made.

Table 4 Attribute levels

Attribute	level	Adjusted level	'Current' level as shown
Cost ($/year)	20, 50, 100, 150, 200, 300	20, 50, 100, 150, 300, 500	na
Seagrass (area in ha)	800, 900, 1000, 1100, 1200	700, 900, 1000, 1100, 1300	1000
Penguins (number of individuals)	550, 600, 650, 700, 750		600
Dolphins (number of individuals)	40, 50, 60, 70, 80		65
"Seahorses" (number of species)	13, 15, 17, 19, 21		17
Reefs (area in ha)	0, 10, 20, 30, 40, 50		0

The discrete choice framework does not require there to be a single specific prediction of the change in the environmental assets because of any future port development; it simply requires that the range of changes presented in the survey are feasible. Extensive consultation with the other science programs was used to define these ranges, although there was considerable uncertainty expressed about what they may be. To some extent the uncertainty on the future changes is not a constraint to the discrete choice approach: it is estimating people's *preferences over* changes, not asking them to validate possible changes.

The discrete choice approach requires respondents to make choices between specified options. These are organised into 'choice sets' which contain two or more options, where the levels of the attributes vary. The combinations of attribute levels presented within the choice sets are derived from an experimental design, that combines attribute levels in a way that enables preferences to be retrieved. We used an efficient design software to create 48 questions, each with two alternatives (ChoiceMetrics, 2012). Figure 3 below gives an example of one choice question. Each respondent saw eight of these choice sets.

The efficient design process assumes (and statistically it is required) that the attribute levels are not correlated. Environmentally it is likely that the levels of attributes will move together (i.e., impacts of dredging are likely to affect both penguins and seagrass) so it is important to inform respondents that, within the framing of the survey, there are management options which could improve levels of one attribute independently of the others (e.g., penguins could be supported by construction of fish aggregation devices, which does not imply a direct benefit to seagrass extent).

	Option 1	Option 2	Current level
Number of Penguins in Cockburn Sound	500	650	600
Number of Dolphins in Cockburn Sound	70	50	65
Total area of seagrass (ha)	800	1,100	1,000
Number of "Seahorse" species present	13	17	17
Area of hard habitats added (ha)	0	50	0
Increased cost to your household, each year	$50	$100	
Which one would you prefer?	☐	☐	

Figure 3 Example choice question

Note that there is no 'status quo' or 'do nothing' option available for selection in the choice design. This would typically be included if it were clear that there was an option to continue with the current position into the future, without further policy intervention/development, and hence there would be no additional cost. The issue with this case is that there is no clear description of what the 'do nothing' option is. Demand for port facilities in WA will continue to grow, putting increased pressure on the environment in the existing Fremantle container port, both off- and on-shore. It is likely there will be increased costs as the port reaches capacity. To include the 'status quo' realistically in the design would require an agreed statement as to what the future changes in environmental impacts and associated management cost would be: there is no obvious path where the current situation can be maintained in the long run. Effectively, respondents are being asked to make choices across alternative forms of port development, with different impacts (potentially positive and negative) on the environment.

In the survey, respondents had been previously been presented with a short description of the species, and there status within the Sound. In the choice experiment section, there was a brief statement of how the species might be impacted by the port development, and the opportunities to improve the environment that could offset and potentially improve the status of the species. They then complete the 8 choice questions assigned to them. They were then asked a number of debriefing questions about their experience answering the choice questions, including whether they found it difficult to make the choices, whether they ignored any of the attributes when making choices, how likely they thought the survey would influence decisions about the port, whether they would refer the port not to proceed at all, and, if that was the case, why they had always selected the option that had the lowest cost.

2.4.3 Social licence to operate

Social license to operate (SLO) refers to the ongoing acceptance and approval by local community members and other stakeholders for a development (Prno & Slocombe, 2012) which can ensure ongoing viability of a development (Voyer & van Leeuwen, 2019) and avoid costly conflicts (Moffat & Zhang, 2014). It is granted to an organisation, either for a development program or ongoing operations when there is alignment with the populations' interests and/or when the population trusts the organisation. SLO was coined in the mid-1990s within extractive industries but has since been applied across various industries and sectors including government and state-owned projects see for example: Stephens & Robinson (2021).

SLO has been used in relation to blue economy (Voyer & van Leeuwen, 2019) and is therefore applicable to the Westport development project. According to The Economist 2015, port infrastructure and associated services are among the main sectors that contribute to the ocean economy (also regarded as blue economy or marine economy). Ocean economy refers to 'that portion of the economy which relies on the ocean as an input to the production process or which, by virtue of geographic location, takes place on or under the ocean' (Kildow & McIlgorm, 2010, p. 368).

Boutilier & Thomson (2011) developed a system of questions that they use to identify four levels of SLO. These are:

1) "*Economic legitimacy*", which is achieved if people believe that they could economically benefit from the development;
2a) "*Socio-political legitimacy*", which is achieved if a company or project is perceived to be able to improve the well-being of the region and respects people's expectations and values;
2b) "*Interactional trust*", which is when the organisation and people perceive their relationship is based on mutual dialog and reciprocity; and
3) "*Institutionalized trust*", which is achieved when people believe their relationship with the organisation is built on a real consideration of each other's interests.

Boutilier & Thomson (2011) hypothesize that there will be a hierarchical relationship between these levels (Figure 4), where *Economic legitimacy* is the easiest to achieve (if meeting self-interest of the population is ensured). *Socio-political legitimacy* and *Interactional trust* are harder to achieve and require development of a relationship between the organisation and the population, and that there are benefits beyond the individual who may be engaged with the project into the wider community. The highest level is *Institutionalized Trust*, where there is perceived to be complete alignment between the interests and values of the organisation and population.

Figure 4. Structure of elements within Social License to Operate (SLO) (Source: Boutilier and Thomson, 2011)

In the original paper, Boutilier and Thomson (2011) develop the system of questions in the context of a specific mining company and the intended population of interest granting/withholding SLO are in the local area. Here, the interest is in the general Perth population's perceptions of a development that will have widespread impacts and benefits. As such, the questions needed to be adapted to fit this context, much as was done for the earlier applications of this approach to the oil and gas industry in Australia (see Richert et al., 2015; Rogers and Burton, 2017). This involved attempting to maintain the intention to the original question while making it appropriate for this context. The questions were presented and discussed with the focus groups, and responses checked in the pilot (see following section). The final set of 15 questions used is listed in Table 5 below. The original questions from Boutilier and Thomson (2011) are reported in **Error! Reference source not found.**.

Table 5. Statements used to measure different levels of SLO for Westport

Number	Statements and levels of social license to operate
Statements measuring the level of "Economic legitimacy"	
EL1	The people of Western Australia can economically benefit from the development of The Port.
EL2	Without the development of The Port, the people of Western Australia will not be able to achieve their most important goals
Statements measuring the level of "Interactional trust"	

IT1	Westport can be relied on to do what they say they will do in the media.
IT2	I am very satisfied with the process by which Westport is developing The Port.
IT3	The development and operation of The Port will be a benefit to the Western Australian population.
IT4	Westport listens to the Western Australian population's concerns about The Port's development and operation.
Statements measuring the level of "Socio-political legitimacy"	
SL1	In the long-term, the development of The Port will make a positive contribution to the well-being of the people of Western Australia
SL2	Westport treats everyone fairly.
SL3	Westport respects the Western Australian way of doing things.
SL4	The Western Australian population and Westport have a similar vision for the future of Western Australia
Statements measuring the level of "Institutionalized trust"	
IsT1	Westport will give support to those who will be negatively impacted by the Port Development.
IsT2	Westport provides opportunities for the Western Australian population to have input into decision making.
IsT3	Westport takes into account the interests of the Western Australian population.
IsT4	Westport is concerned about the wellbeing of the Western Australian population.
IsT5	Westport openly shares information that is relevant to the Western Australian population.

When asking these questions, the context was defined using a framing question given as follows:

Your views on the way the Cockburn port proposal has been developed

In the following questions we ask for your attitudes towards the development of the proposed new port, and the process involved.

We will use the term **"The Port"** to describe the physical infrastructure being proposed.

We will use the term **"Westport"** to describe the Western Australia State government departments involved in developing and operating the port.

If you feel you do not have a view about the question, or are unsure, then answer "neither agree nor disagree.

Respondents then answered on a 5-point Likert scale for each question, ranging from 1 to 5: Strongly disagree (1), Disagree, Neither agree nor disagree; Agree; Strongly agree (5).

2.5 Survey testing and deployment

2.5.1 Focus groups and survey pilot

Once a draft survey was completed, a third focus group was undertaken to review the survey. This was completed on January 18th, including 8 participants and involved a section by section review of the

survey and discussion about interpretation. The main issues raised were around clarity of wording, which were addressed in a revision.

2.5.2 Survey deployment

The survey was opened to the public on the 10th of February, and closed on March 13th, 2023, using respondents provided from the PureProfile WA panel. After an initial sample of 122 respondents was complete, sampling was paused to allow for an initial check on the performance of the survey, with initial estimates of the discrete choice model generated. It was decided to increase the range of the cost as there were significant numbers of respondents who were still selecting options with the highest cost, suggesting the range was not wide enough (i.e. it is expected that the proportion of people selecting options with a high cost level will be small). The upper values of $200 and $300 were replaced with $300 and $500. Due to a potential insensitivity in responses to the area of seagrass in the initial model, the range of the seagrass attribute was also extended: the upper and lower values of 800ha and 1200ha were replaced with values of 700ha and 1300ha respectively. The initial estimates of the discrete choice model provided information about the anticipated preferences for the attributes (specifically, in the form of new coefficient 'priors' for parameters), which was used to generate a new efficient experimental design (i.e. a more efficient design than the original piloted design, given the design was better informed by the preliminary estimates), and the choice sets re-coded, and sampling recommenced. There were no negative comments recorded in the open-ended questions, and no other aspects of the survey were changed.

A copy of the full survey is available at **Error! Reference source not found.**.

2.6 Sample size and data cleaning

A total of 1802 individuals entered the survey. Twenty-six were dropped due to identified irregularities in their response pattern. Forty-five did not proceed past the consent page, and 18 did not meet the inclusion criteria (i.e., they were below 18 years of age, or did not currently live in a Perth postcode). Of the remainder, 230 did not complete the survey, dropping out at some point or entering the survey when their quota group was full, leaving a sample of 1483 individuals who completed all compulsory questions in the survey.

A potential issue with panel survey samples is that some people do not consider all the questions but 'speed' through, simply to earn the reward. On checking the time for completion, the median time was 15.01 minutes, with 1% completing faster than 4.45 minutes, and 10 percent faster than 7.5 minutes. Some literature suggests that those completing faster than 60% of the median should be considered as not having paid attention to the survey (Rossmann, 2010, cited in Greszki et al., 2015). However, Greszki et al. (2015) find that removing "too fast" responses (defined as 30, 40 or 50% of the median) has negligible impact on marginal distribution: they simply add 'noise' to the sample.

In this research, respondents who completed in less than 50% of the median time (i.e. faster than 7.5 minutes) were dropped from the analysis, leaving a final sample of 1340 respondents. In the final sample, the median completion time was 16.02 minutes.

Respondents not paying attention may still be a concern, and one indication may be 'straight-line' responses; that is, those who select the same answer in tables of Likert questions (i.e. they go down the table giving the same answer each time). This phenomenon was investigated for the five sets of 'values' questions, where there are banks of between 11 and 12 Likert questions. In the five question blocks, 103, 201, 162, 210 and 203 respondents exhibited straight-line behaviour. Forty-two respondents gave the same answer in all five sets, at the highest level (Strongly Agree). However, when the time for completion for this set of respondents was analysed, it had the same structure as the overall sample: a median of 15.8.

At the end of the survey, there are two blocks of social licence to operate questions, each with seven and eight questions. Again, these were investigated for straight line behaviour, as it is possible it will

manifest itself at the end of the survey due to fatigue. 147 respondents followed a straight-line strategy in both blocks, with 106 selecting the middle (Neither agree nor disagree) in both. The completion time for this group was also very similar to the whole sample: a median of 13.6 minutes.

The project team concluded that this behaviour represents considered responses (and given the relative lack of awareness of Westport as detailed in the results later, selecting the mid-point may be understandable for a large proportion of the population). There is no evidence that respondents were following a simplified answering strategy to complete the survey.

2.7 Data analysis

2.7.1 Social values

Respondents' answers to the questions relating to social values detailed in Table 3 were analysed according to the Likert scale options (strongly agree; agree; unsure; disagree; strongly disagree). These were classed as percentages and are presented in Section 3.2.1. A summary of the open-ended responses exploring perceptions of other aspects of the physical and environmental quality of Cockburn Sound is also presented.

2.7.2 Non-market valuation

There are two main ways in the literature that heterogeneity in preferences can be modeled. The first is to assume that the parameters that's reflect preferences are not constant across the population but follow a distribution, typically a normal distribution. This suggests that there is a central tendency for preferences, but that there are some who may hold stronger or weaker preferences, but the proportion who hold this decline as the view moves further away from the central measure. The location and distribution of preferences is inferred from the responses given (i.e. its possible to infer that the normal distribution has a zero variance if preferences for an attribute are consistent: the methods does not impose that preferences are heterogeneous). Issues with this approach are that preferences may not follow this form (e.g. the distribution may be bimodal) and it can be difficult to explain what causes people to have different preferences.

Here we focus on a description of the modelling approach used with the discrete choice experiment that is applied in this study, and in particular the application of the latent class model.

At its core is the assumption that respondents make choices between options based on the relative utility that the options give (see Train, 2003; Mariel et al., 2021). Given the multiple-attribute form of the DCE one can specify that the utility that individual *i* gains from option *j* can be represented by

$$U_{ij} = \sum_{k=1}^{K} \beta_k x_{kj} + \varepsilon_{ij} \quad (1)$$

Where *x* is a set of *K* attributes that describe the option, β the associated marginal values of the attributes and ε_{ij} an unobservable random component that varies across individuals and options. It is typically assumed that the random component follows an extreme value Type II distribution. In that case, if an individual is asked to make a selection from *J* options, and does so on the basis that they select the one that gives the greatest utility, then the probability that they select option *f* from the set is given by:

$$P(Y_i = f) = \frac{\exp\left(\sum_{k=1}^{K} \lambda \beta_k x_{kf}\right)}{\sum_{j=1}^{J} \exp\left(\sum_{k=1}^{K} \lambda \beta_k x_{kj}\right)} \quad (2)$$

λ is the scale parameter, and is related to the variance of the random component of utility, ε. Typically this is unobservable and is normalised to equal 1 (or effectively, the marginal utilities estimated are scaled marginal utilities).

Given the choices they made, and the attributes in the options available, estimation of the maximisation of the log likelihood associated with (2) allows one to identify the parameters β, i.e., the implied marginal values of the attributes.

If one of the attributes *x* is a monetary or cost attribute, then one can identify the marginal willingness to pay (WTP) to achieve a unit increase in the attribute *j* by:

$$WTP_k = -\frac{\beta_k}{\beta_{\text{cost}}} \tag{3}$$

where β_{cost} is the estimated parameter on the cost attribute. Note that the WTP estimate is not affected by the scale parameter, so the normalization used is irrelevant.

This basic conditional logit model assumes that the parameters (marginal utilities) are the same across all individuals, and the only variation in choice is due to differences in the random component of utility.

However, it is possible to assume that the parameters vary across individuals. The latent class model, which we employ here, assumes that there are a discrete number of classes of respondents (*C*), and that the utility for a particular individual, conditional upon them being a member of class *c*, can be specified as:

$$U_{ij}\,|c = \sum_{k=1}^{K} \beta_{kc} x_{kj} + \varepsilon_{ij} \tag{4}$$

The unconditional probability that an individual will select option *j* from a set of J items now depends on the probability of an individual being in each class; that is:

$$P(Y_i = f) = \sum_{c=1}^{C} P_{ic} \left(\frac{\exp\left(\sum_{k=1}^{K} \lambda \beta_{kc} x_{kf} \right)}{\sum_{j=1}^{J} \exp\left(\sum_{k=1}^{K} \lambda \beta_{kc} x_{kj} \right)} \right) \tag{5}$$

Where P_{ic} is the probability that individual *i* is in class *c*.

These probabilities can be estimated as single parameters, or they can themselves be made a function of attributes of the individual, and this function jointly estimated with the choice model. Typically, the model of class membership is specified as a multinomial logit model.

Finally, one can make the scale parameter individual specific as well. Rather than assuming that one should normalise all individuals to have a single value, it is possible to specify a latent class structure for the scale parameter as well; that is, for there to be a number of classes that have different error variances, and hence scale parameters. An advantage of employing the scale-adjusted latent class model is that it may be possible to reduce the number of implied preference classes (*C*) if in fact part of the variation being observed is in the degree of randomness in peoples' choices.

An issue to be resolved is: how many (C) preference classes should be included (and how many scale classes also). This has to be determined empirically. The normal process is to estimate models with a wide range of class sizes, and then select the model with the best fit based on information criteria. Here we use BIC and CAIC criteria to guide model selection (Nylund et al., 2007). Formally, BIC is defined as k.ln(n)-2LL, where k is the number of parameters estimated, n the number of observations

and LL the log likelihood value of the model. The CAIC is defined as k.(ln(n)+1)-2LL. The two methods differ in the penalty applied for the number of parameters estimated in the model. The latent class models are estimated using Latent Gold (Vermunt & Magidson, 2021).

As noted above, the design employed here does not include an opt-out, or status quo option. As a consequence of this, the model is only able to retrieve the *marginal* values of attributes in relation to how their levels might change as a result of the port development (including the additive marginal value of changes that could occur in multiple attributes simultaneously): it cannot identify the overall value people hold for the port development (i.e., they were never given an option that did not include the port going ahead, so values cannot be measured relative to that position). This is not an issue here as the purpose of this analysis is not to provide an overall evaluation of the port development, but to value its consequences on the environment.

2.7.3 Social licence to operate

Initially, an exploratory factor analysis was conducted on the 15 SLO questions, to see if there were unique factors that could be identified that explain answers to the questions, and which can be associated as latent SLO measures.

Formally, the SLO held by respondents is a latent variable: it is not directly observable, nor measurable. Instead, one has to infer what it might be from responses to related questions. Structural Equation Models (SEMs) formally evaluate the relationships between variables and allow for latent, or unobserved variables to be considered. This allows us to treat the SLO measures as strictly latent, or unobserved, and their values can only be inferred from observed answers to questions. An example of a basic SEM structure used is illustrated in Figure 5 below. Here there are three latent variables identified for demonstration, but the actual number is determined by the exploratory factor analysis. Each latent variable is assumed to explain a sub-set of questions (from Q1-Q8 in the example): again, this structure is guided by the results of the exploratory factor analysis. Because of the 5-point response Likert questions used in our SLO questions, these relationships are modelled as ordered logit models.

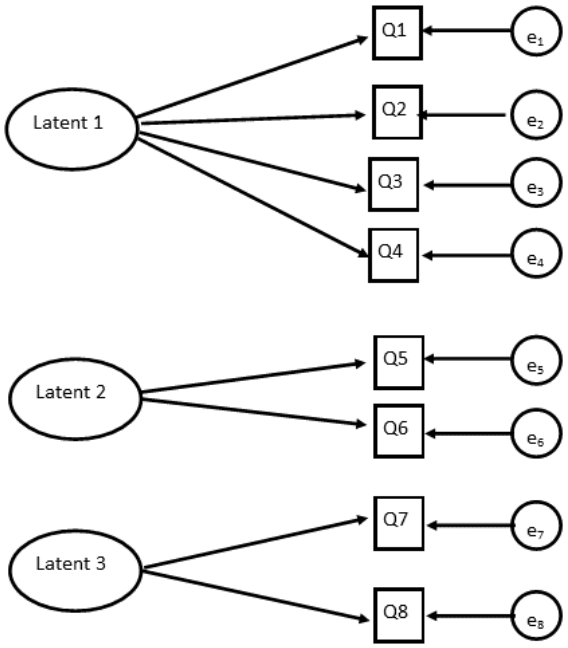


Figure 5. Example of a SEM analysis of responses, assuming 3 latent factors

This model is extended in

Figure 6, to indicate that it is possible to treat the SLO variables as endogenous latent variables, which in turn can be explained by exogenous demographic and attitudinal variables (Z1-Z5). Not all of the characteristics of the individuals (the Zs) will necessarily explain variations in the SLO held by individuals (the latents), but that will be revealed by the significance (or otherwise) of the estimated coefficients of the relationship between them. There will be some degree of variation in the latent that is unexplained: denoted by the residuals e9, e10 and e11. The possibility of correlation in the unobserved residual in the latent equations is indicated by the curved line between the two errors e9 and e10: in this example one might expect that if an individual has greater-than-expected values of SLO on Latent 1, then this may be correlated with the error process for Latent 2. Again, although this may be specified in the model, whether it is required will be determined statistically.

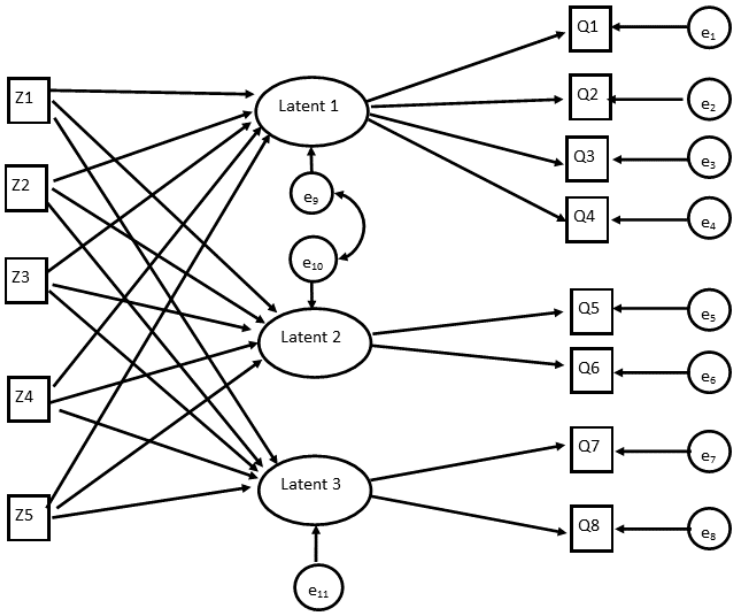


Figure 6. Example of a SEM analysis of responses, assuming 3 latent factors, and explaining determinants of social license using socio-demographics and other variables.

3 Results

3.1 Summary information

A complete tabulation of question responses is given in **Error! Reference source not found.**.

Table 6 and

Table 7 provide some summary statistics for the whole sample (i.e., the sample remaining after data cleaning; n=1340).

Table 6. Distribution by age, for Greater Perth and sample (n=1340)

Age bracket	Greater Perth region** (%)	Sample (%)
20-29	17.5	16.8*
30-39	20.5	21.3
40-49	17.6	17.7
50-59	16.3	17.3
60-69	13.5	14.6
70-79	9.4	10.1
80+	5.2	2.2

*Within the sample, 18-29

** Source for Perth values https://www.abs.gov.au/census/find-census-data/quickstats/2021/5GPER

Table 7. Distribution by highest education, for Greater Perth and sample (n=1340)

Age bracket	Greater Perth region** (%)	Sample (%)
Primary+	20.1	9.9
Year 12	16.0	19.7
Trade	26.7	27.5
Undergraduate	26.5*	26.3
Postgraduate		13.3
Prefer not say	10.5	3.3

* Combined undergraduate and postgraduate with ABS statistics

** Source for Perth values https://www.abs.gov.au/census/find-census-data/quickstats/2021/5GPER

The age distribution closely matches the population. The sample is slightly more qualified than the population, with a higher representation of those with university degrees (39.6% compared to a population average of 26.5%), and a smaller proportion of respondents who have not completed Year 12 compared with the general population.

Median household income is $1,450 per week, which is lower than the Perth median of $1,865/week, but respondents were told to report their individual income if they made financial decisions based on their own circumstances, or if they were unsure about total household income. Gender representation slightly favours females (54.4%, compared to 50.6% for the population).

Almost 80% of the respondents had first-hand experience of visiting Cockburn Sound (Table 8). Of those who had visited, 55% had visited the Sound a 'few times a year' or more. Within the sample, 12% of respondents were regular recreational fishers (i.e., fishing more than once a month). It is estimated that 25% of the Western Australia population undertake recreational fishing more than once a year (Ryan et al., 2021), indicating that the proportion of recreational fishers within the survey sample is likely to be commensurate with the wider population. Seven per cent of survey respondents were members of environmental groups, 40% had heard of the proposed port development in Cockburn Sound and 81% had not heard of Westport as an organisation prior to the survey. Forty-five per cent

would prefer there not to be a port development in Cockburn Sound, 22% supported the idea and 34% were unsure.

Table 8. Visitation rates to Cockburn Sound (*n*=1340)

Frequency	Sample (%)
Every day	1.7
A few times a week	4.2
About once a week	4.8
About once a fortnight	4.7
About once a month	9.4
A few times a year	29.8
Less than once a year	22.9
I have not visited Cockburn Sound in the last 5 years	22.5

3.2 Social values

3.2.1 End state values associated with species and habitats

Table 9 summarises the average percentage responses for all of the marine flora and fauna considered in the survey with respect to each end-state value, taking into account the 1340 respondents used in the final sample. Overall, there is strong support for all end state values explored in this survey. The bequest value reflecting the presence of marine species for the benefit of future generations received the strongest level of agreement, with 64% of respondents indicating they strongly agreed with the statement. Respondents also prioritised the spiritual – philosophical value associated with the importance of species in their own right, which 58% of respondents strongly agreed with. This demonstrates that respondents were strongly sensitive to a biodiversity conservation ethic which prioritised species for their own sake and for the enjoyment of future generations. The lower ranking attributed to values derived from a meaningful occupation would likely reflect the limited range of occupations which afford regular exposure to marine flora and fauna, which is also indicated by the high proportion of 'unsure' responses to this value statement.

In the following sections, the data for each end-state value are explored in turn. These results are discussed further in Section 4.

Adequate resources

Fish were the only category among the marine flora and fauna considered in the survey that would be a source of 'adequate resources' in Cockburn Sound, and hence this is the only group of species considered for this end-state value. As illustrated in Table 9, 58% of respondents agreed or strongly agreed with the statement that they eat or rely on fish from Cockburn Sound for food. It should be noted that this response could encompass respondents buying fish which are locally caught, as well as those directly engaging in fishing activity.

Table 9 Summary of average Likert-scale responses across all end-state values.

Indicative statement* and [end state value]	Strongly agree (%)	Agree (%)	Unsure (%)	Disagree (%)	Strongly disagree (%)
I enjoy and/or rely on eating Cockburn Sound fish for food [adequate resources]**	25.5	32.7	14.6	18.5	8.8
[Marine species] contribute to my enjoyment of the Cockburn Sound marine environment [aesthetically pleasing environment]	36.4	39.3	16.5	5.9	1.9
Seagrass contributes to my enjoyment of a pleasant and healthy environment by improving water quality [benign physical environment]***	33.1	41.3	17.0	6.2	2.3
[Marine species] are an important part of the history and cultural heritage of the area [knowledge-heritage fulfilment]	49.0	39.0	10.3	1.3	0.4
[Marine species] are important for scientific research and education [knowledge-heritage fulfilment]	49.5	40.7	8.7	0.7	0.3
I could see myself having a meaningful occupation (e.g., working in tourism or volunteering) due, partly, to [marine species] existing in the area. [meaningful occupation]	15.3	21.6	32.4	20.5	10.2
[Marine species] are important for my recreation in the area. I enjoy seeing and/or interacting with them [recreational satisfaction]	29.4	40.6	18.6	9.0	2.4
[Marine species] contribute to my strengthening of social bonds – for example, when volunteering […] [social fulfilment]	23.5	30.6	27.1	14.5	4.4
I personally value [marine species]' role in the local ecology. [spiritual-philosophical fulfilment]	47.6	41.9	8.3	1.5	0.7
[Marine species] are important in their own right, even if I might never see them or interact with them [spiritual-philosophical fulfilment]	57.8	36.4	5.1	0.4	0.3
It is important that [marine species] are around for people other than myself to enjoy or benefit from [altruistic value]	48.7	37.5	10.3	2.7	0.8
It is important to ensure that [marine species] are still around for future generations [bequest value]	64.0	30.6	4.5	0.6	0.2
I care about [marine species]	55.1	36.7	7.4	0.6	0.4

Notes

* For this comparison, responses for all marine species were combined (penguins, dolphins, seagrass, "Seahorses" and fish) for all but two end-state values (adequate resources, and benign physical environment). The actual wording of questions seen by respondents stated each group of species separately.

** Statement answered for fish only, no other marine species groups.

*** Statement answered for seagrass only, no other marine species groups.

Colour coding :

>60	50-60	40-50	20-40	10-20	<10

Aesthetically pleasing environment

On average, 76% of respondents agreed or strongly agreed with the statement that the five selected groups of marine flora and fauna (penguins, dolphins, seagrass, "Seahorses" and fish) contributed to their enjoyment of Cockburn Sound, whilst an average of 8% disagreed or strongly disagreed (Table 9). The proportion agreeing or strongly agreeing with the statement was highest for dolphins (89%) and lowest for seagrass (56%) (Figure 7). An average of 17% of respondents across all categories were unsure, with a maximum of 29% of respondents responding 'unsure' with respect to seagrass.

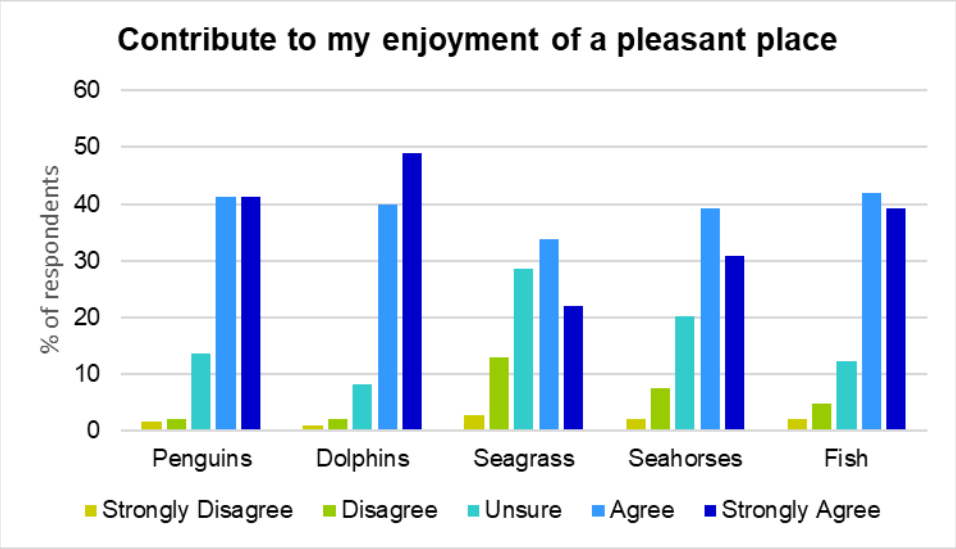


Figure 7. Perceptions of marine species' contribution to an aesthetically pleasing environment

Benign physical environment

Seagrass were the only category of marine flora or fauna considered for their contribution to a benign physical environment as an end-state value. As illustrated in Table 9, 74% of respondents agreed or strongly agreed that seagrass contributes to improved water quality, as an element of a benign physical environment.

Knowledge-heritage fulfilment

On average, 88% of respondents agreed or strongly agreed that marine flora or fauna were important for the region's history and/or cultural heritage values, with an average of 2% disagreeing or strongly disagreeing with this statement (Table 9). The proportion agreeing or strongly agreeing with the statement was highest for dolphins and penguins (93%) and lowest for seagrass (77%) (Figure 8). An average of 10% of respondents across all categories were unsure, with a maximum of 19% of respondents responding 'unsure' with respect to seagrass.

On average, 90% of respondents agreed or strongly agreed that marine flora or fauna in Cockburn Sound were important for research and education, with an average of 1% disagreeing or strongly disagreeing with this statement Table 9. The proportion agreeing or strongly agreeing with the statement was highest for fish (93%) along with dolphins (92%) and lowest for seagrass (87%) (Figure 9). An average of 9% of respondents across all categories were unsure, with a maximum of 12% of respondents responding 'unsure' with respect to seagrass.

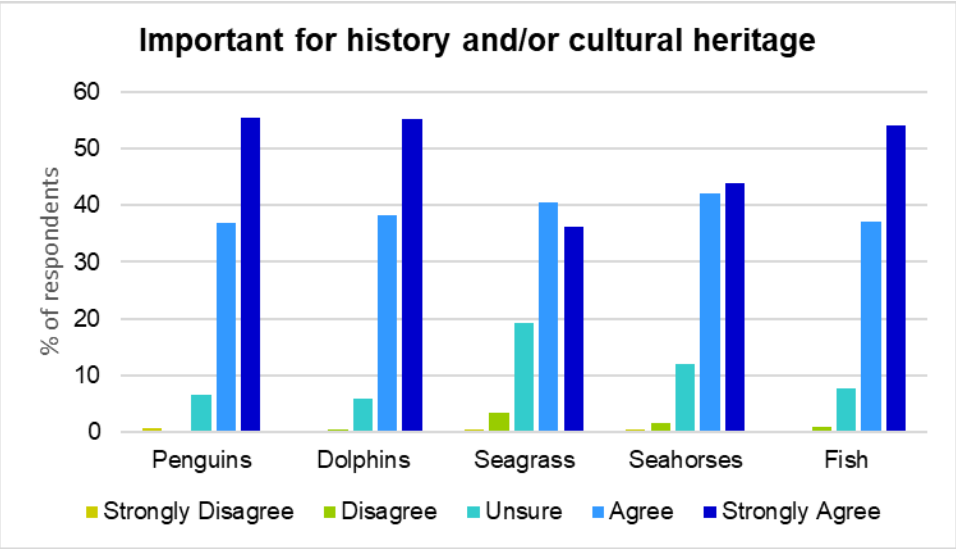


Figure 8. Perceptions of marine species' contribution to history and cultural heritage

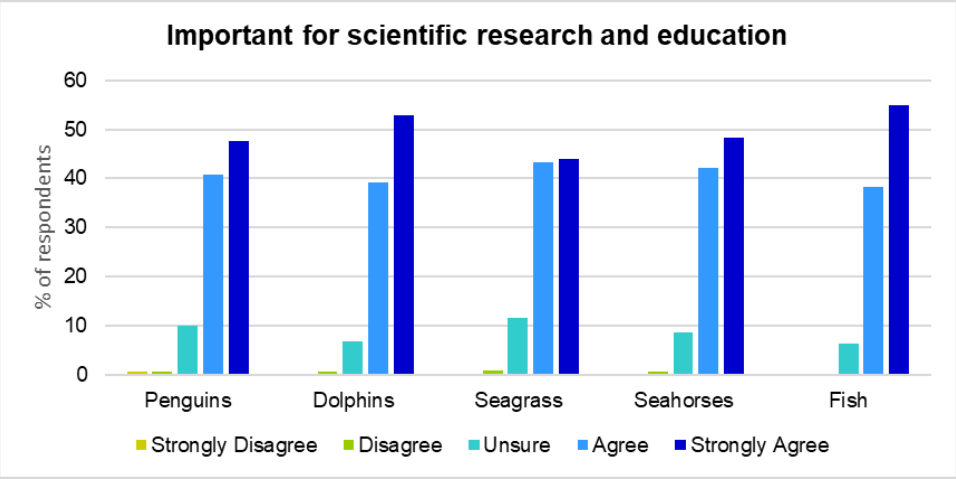


Figure 9. Perceptions of marine species' contribution to education and scientific research

Meaningful occupation

On average, 35% of respondents agreed or strongly agreed with the statement that marine flora or fauna in Cockburn Sound were important contributors to a meaningful occupation, with an average of 32% disagreeing or strongly disagreeing with this statement (Table 9). The proportion agreeing or strongly agreeing with the statement was highest for dolphins (42%) and lowest for seagrass (29%) (Figure 10). An average of 32% of respondents were unsure of their response to this statement, with an even distribution across all five categories.

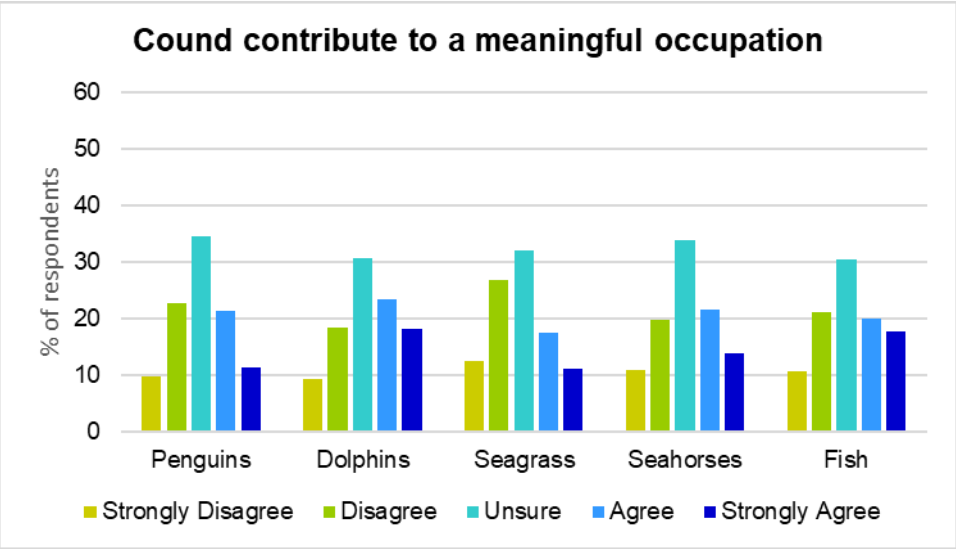


Figure 10. Perceptions of marine species' contribution to having a meaningful occupation

Recreational satisfaction

On average, 70% of respondents agreed or strongly agreed with the statement that marine flora or fauna were important for their recreational experiences in Cockburn Sound, whilst an average of 11% disagreed or strongly disagreed (Table 9). The proportion agreeing or strongly agreeing with the statement was highest for dolphins (85%) and lowest for seagrass (50%) (Figure 11). An average of 19% of respondents across all categories were unsure, with a maximum of 29% of respondents responding 'unsure' with respect to seagrass.

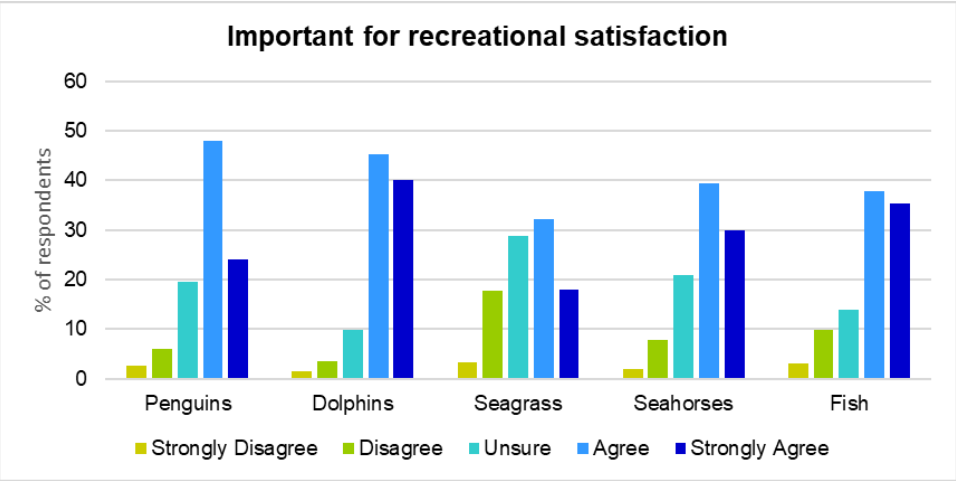


Figure 11. Perceptions of marine species' contribution to recreational satisfaction

Social fulfilment

On average, 54% of respondents agreed or strongly agreed with the statement that the presence of marine flora or fauna in Cockburn Sound contributed to their social bonds in Cockburn Sound, whilst an average of 19% disagreed or strongly disagreed (Table 9). The proportion agreeing or strongly agreeing with the statement was highest for dolphins (72%) and lowest for seagrass (35%) (Figure 12). An average of 27% of respondents across all categories were unsure, with a maximum of 35% of respondents responding 'unsure' with respect to penguins.

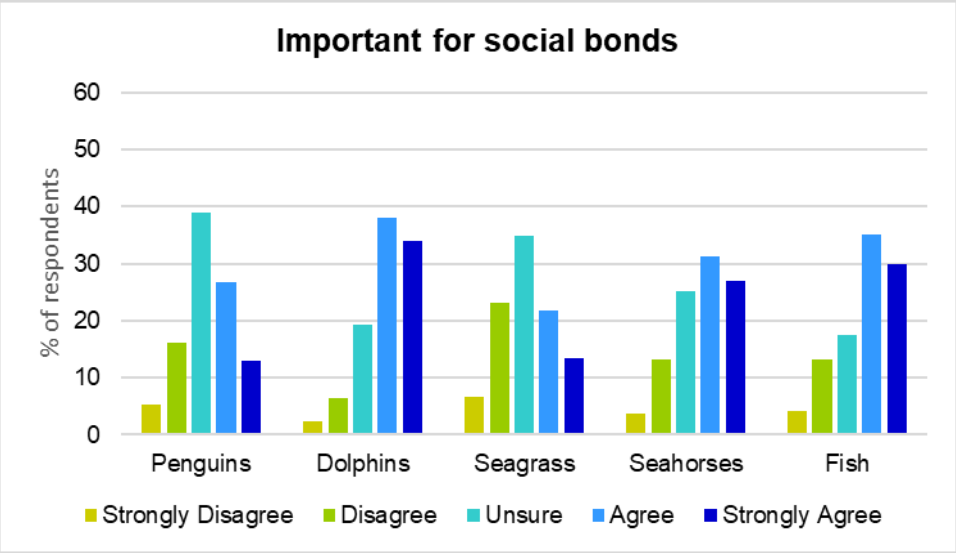


Figure 12. Perceptions of marine species' contribution to social fulfilment

Spiritual-philosophical fulfilment

On average, 90% of respondents agreed or strongly agreed that marine flora and fauna in Cockburn Sound were important for the local ecology, with an average of 2% disagreeing or strongly disagreeing with this statement (Table 9). The proportion agreeing or strongly agreeing with the statement was highest for dolphins (94%) along with fish (93%) and lowest for seagrass (84%) (Figure 13). An average of 8% of respondents across all categories were unsure, with a maximum of 13% of respondents responding 'unsure' with respect to seagrass.

On average, 94% of respondents agreed or strongly agreed that marine flora and fauna in Cockburn Sound were important in their own right, with an average of <1% disagreeing or strongly disagreeing with this statement (Table 9). The proportion agreeing or strongly agreeing with the statement was highest for dolphins (97%) along with fish and penguins (96%) and lowest for seagrass (90%) (Figure 14). An average of 5% of respondents across all categories were unsure, with a maximum of 10% of respondents responding 'unsure' with respect to seagrass.

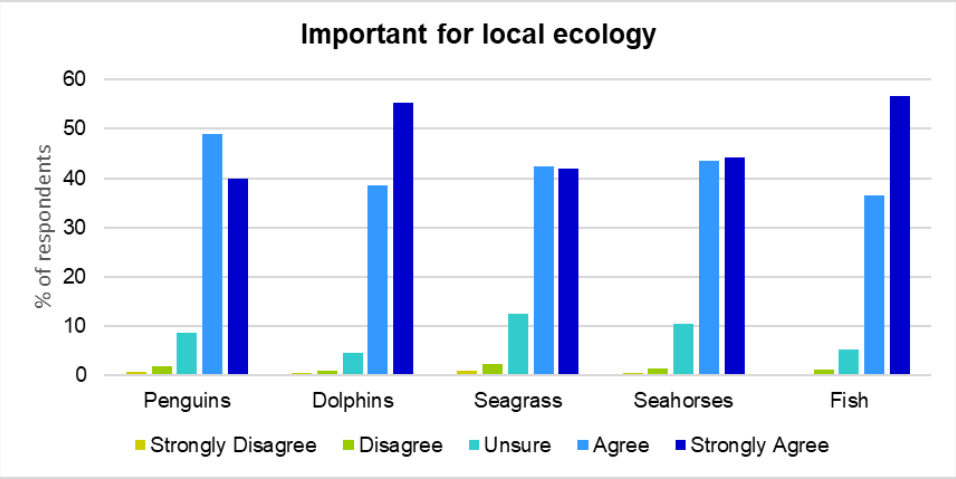


Figure 13. Perceptions of marine species' importance to local ecology

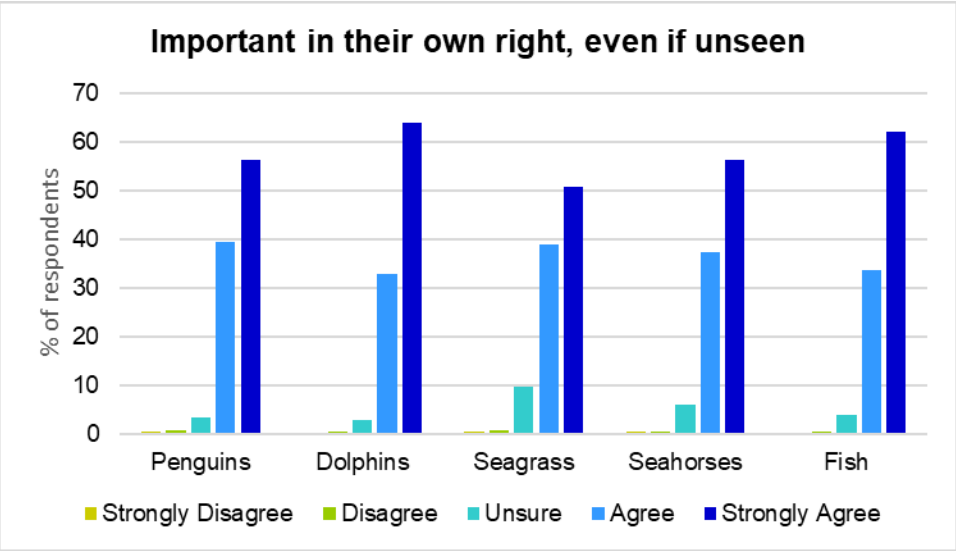


Figure 14. Perceptions of marine species' importance in their own right, even if not seen

3.2.2 Altruistic, bequest and existence values associated with flora and fauna

On average, 86% of respondents agreed or strongly agreed that it was important that marine flora and fauna in Cockburn Sound were around for other people in the present day, with an average of 4% disagreeing or strongly disagreeing with this statement (Table 9). The proportion agreeing or strongly agreeing with the statement was highest for fish (92%) and lowest for seagrass (78%) (Figure 15). An average of 10% of respondents across all categories were unsure, with a maximum of 17% of respondents responding 'unsure' with respect to seagrass.

On average, 95% of respondents agreed or strongly agreed that it was important that marine flora and fauna in Cockburn Sound were around for future generations, with an average of <1% disagreeing or strongly disagreeing with this statement (Table 9). The proportion agreeing or strongly agreeing with the statement was highest for penguins, dolphins and fish (97%) and lowest for seagrass (89%) (Figure 16). An average of 5% of respondents across all categories were unsure, with a maximum of 10% of respondents responding 'unsure' with respect to seagrass.

On average, 92% of respondents agreed or strongly agreed that they cared about marine flora and fauna Cockburn Sound, with an average of <1% disagreeing or strongly disagreeing with this statement (Table 9). The proportion agreeing or strongly agreeing with the statement was highest for fish (95%) and dolphins (94%) and lowest for seagrass (86%) (Figure 17). An average of 7% of respondents across all categories were unsure, with a maximum of 12% of respondents responding 'unsure' with respect to seagrass.

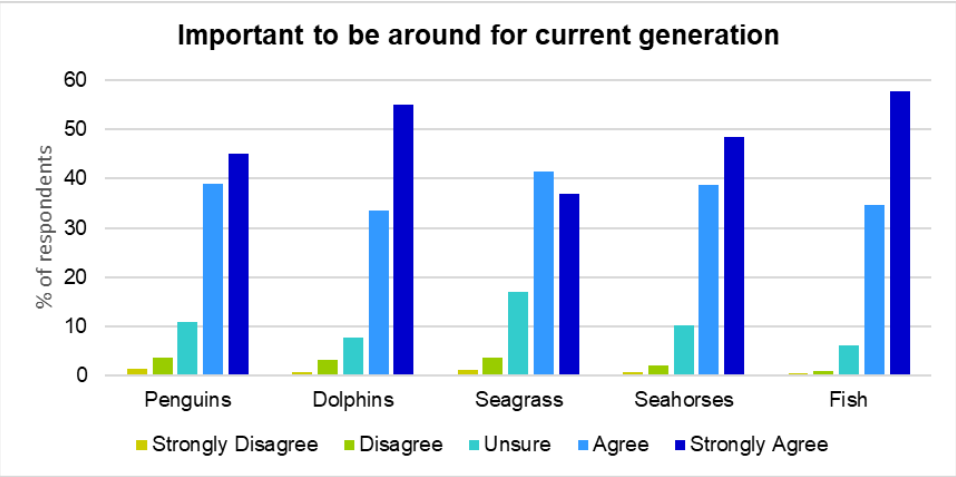


Figure 15. Perceptions of marine species' importance for current generation of people

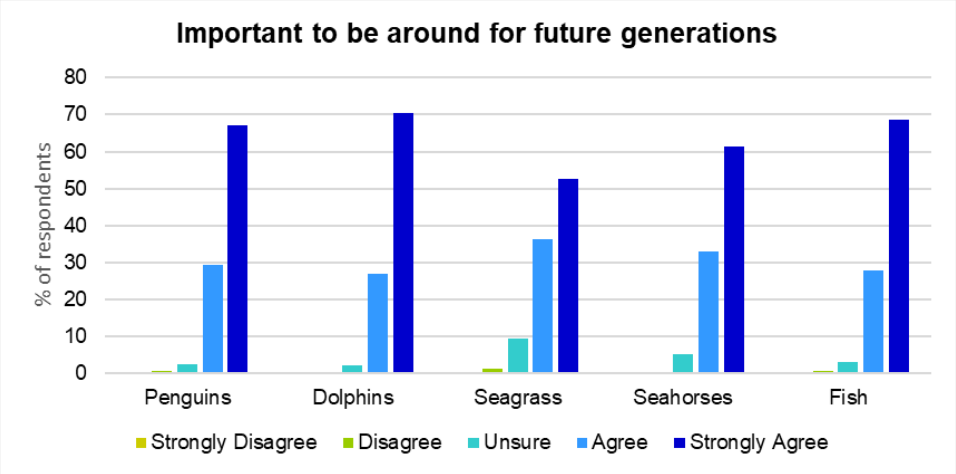


Figure 16. Perceptions of marine species' importance for future generations

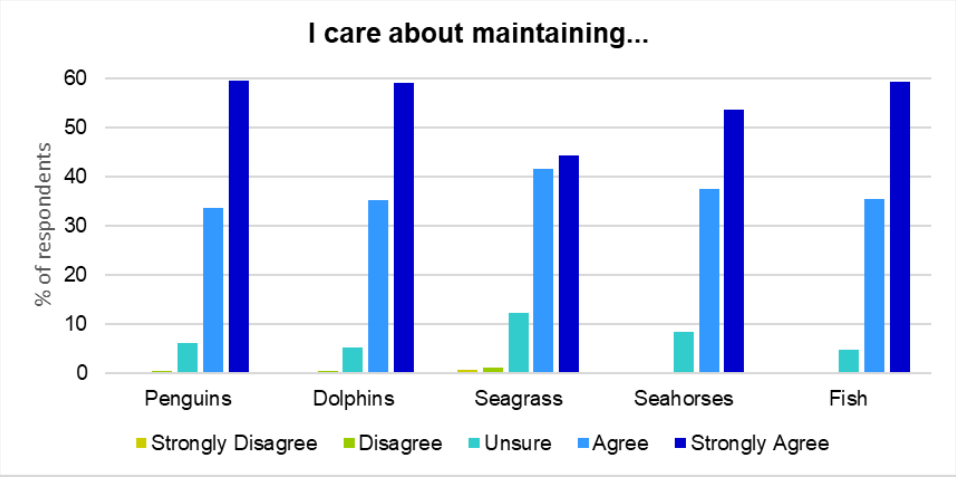


Figure 17. Distribution of responses to caring about maintaining particular species in Cockburn Sound

3.2.3 Other feedback from respondents

Survey respondents were invited to provide additional information concerning which species or habitats other than the five detailed above were of value, regardless of whether they will ever use, see, or interact with them. A total of 583 responses were recorded. Respondents mostly referred to birds (N=64), followed by sharks (N=58), seals (N=49), and crabs (N=42). The following word cloud (Figure 18) offers a visual representation of responses.

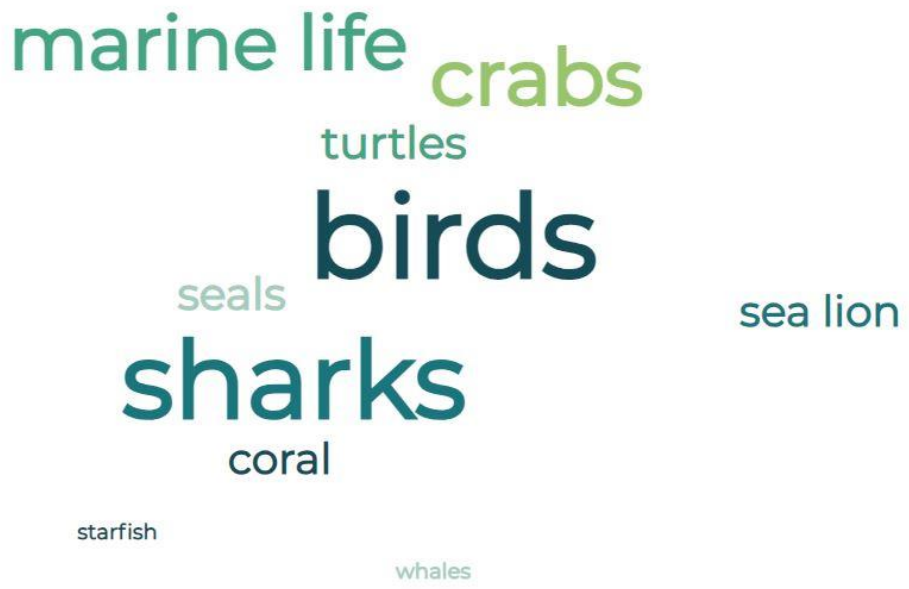


Figure 18 Word cloud of open ended responses

The prevalence of charismatic species such as sharks and whales is to be expected, but it is also notable that marine life in general along with commonly observed species such as birds or crabs are mentioned by a large number of respondents. Apart from those listed above, a total of 55 other species or habitats were mentioned encompassing subtidal, intertidal and supratidal environments.

3.3 Non-market valuation (discrete choice experiment)

3.3.1 Awarness of attributes

As respondents read information about the marine fauna and flora and artificial habitat attributes that were used in the DCE, they were asked questions about their awareness of them.

Table 10 Awareness of little penguins

Have you ever seen little penguins along the Perth coastal region?	N	Percent
Yes, I have seen them	592	44.18
No, I have never seen them	670	50.00
Unsure	78	5.82
Total	1340	100.00

Table 11 Awareness of bottlenose dolphins

Have you ever seen dolphins in the water along the Perth coast region?	N	Percent
Yes, I have seen them	1070	79.85
No, I have never seen them	236	17.61
Unsure	34	2.54
Total	1340	100.00

Table 12 Awareness of Seagrass conservation

Have you ever been involved in seagrass conservation or restoration in any way?	N	Percent
Yes, I have	273	20.37
No, I have not	993	74.10
Unsure	74	5.52
Total	1340	100.00

Table 13 Awareness of Seahorses, seadragon or pipefish

Have you ever seen a seahorse, sea dragon or pipefish along the beach, coast or in the waters in WA?	N	Percent
Yes, I have seen them	282	21.04
No, I have never seen them	993	74.10
Unsure	65	4.85
Total	1340	100.00

Table 14 Awareness of artificial reefs

Have you heard about people creating artificial reefs along the coast of WA?	N	Percent
Yes	826	61.64
No	401	29.93
Unsure	113	8.43
Total	1340	100.00

3.3.2 *Analysis of DCE questions.*

Before estimating the choice model, we identified whether there were any 'protest' responses that needed to be removed from the data set. Protest responses occur when respondents do not adhere to the instructions and intent of the choice experiment. To identify protest responses, we first isolated 330 respondents who were identified as having always selected the cheapest cost option in all eight choice sets. A concern is that these respondents were not considering all of the attributes when making their choices (as is the intent) and focussing only on the level of the cost attribute. In the debriefing questions, these respondents were asked why that was the case. Two of the possible responses are consistent with making considered choices: "Considering the levels of the environmental attributes and the cost these were best"; and, "Currently I have little money to spare, and that was the most important thing when making my choices". The alternative response: "I would prefer not to have to make these choices, and so selected the cheapest one" implies that their choices did not reflect their preferences for the environmental outcomes, but for the decision process itself (i.e., in protest of the choice experiment). As a result, 72 respondents who selected this alternative response were dropped from the estimation data set.

The analysis of the choice experiment data acknowledges that there are likely to be different groups within the population who hold different preferences for the attributes under consideration. As discussed above, we use a latent class analysis to allow for heterogeneity among groups of people.

This assumes that there are discrete classes people with different of preferences, and individuals are assigned (probabilistically) to a class based on their responses. This allows the distribution of preferences to follow any pattern, and it is relatively simple to model what may predict class membership.

Table 15 reports the BIC and CAIC measures for models with 1-6 preference classes, assuming a single scale class, and for 1-6 classes assuming 2 scale classes. Allowing for there to be multiple latent variance classes often simplifies the final class structure, as it allows for *differences in the certainty* of responses to be distinguished from *differences in preferences*.

Based on the minimal values of the BIC and CAIC values, assuming homogeneous variances one would select a 4-class model. Considering the 2-Scale class model, the preferred structure is 3-Preference classes. Comparing across the 1- and 2- Scale models, in all cases the 2-Scale model is preferred, and globally the '2-Scale: 3-Preference' structure is preferred (highlighted). Because attribute levels were both reduced and increased relative to the current situation, a statistical test was conducted on the preferred model to see if there was a linear response to the attribute levels, or if there was a difference in preferences for increases versus decreases. In this test the attribute levels were identified as factors, rather than numerical variables. The linear model was preferred based on the BIC and CAIC estimates of the two models.

Table 15 Information criteria for Preference and Scale class models

	LL	BIC(LL)	AIC(LL)	AIC3(LL)	CAIC(LL)	Npar
1-Preference	-6086.18	12215.22	12184.37	12190.37	12221.22	6
2- Preference	-5471.09	11049.31	10972.18	10987.18	11064.31	15
3- Preference	-5364.50	10900.40	10776.99	10800.99	10924.40	24
4- Preference	-5317.67	10871.04	10701.35	10734.35	10904.04	33
5- Preference	-5286.63	10873.23	10657.27	10699.27	10915.23	42
6- Preference	-5268.84	10901.92	10639.68	10690.68	10952.92	51
2-Scale 1- Preference	-5865.08	11787.3	11746.16	11754.16	11795.30	8
2-Sclae 2- Preference	-5404.67	10930.75	10843.33	10860.33	10947.75	17
2-Scale 3- Preference	-5326.34	10838.37	10704.67	10730.67	10864.37	26
2-Scale 4- Preference	-5294.70	10839.38	10659.41	10694.41	10874.38	35
2-Scale 5- Preference	-5271.23	10856.7	10630.45	10674.45	10900.70	44
2-Scale 6- Preference	-5257.00	10892.52	10619.99	10672.99	10945.52	53

Table 16 reports the preference parameters associated with the preferred model, and their associated Z statistic. Recalling that the model is estimating marginal utilities per unit change in the attribute (with units defined in Table 4):

- Class 1 represents individuals who hold positive preferences for increases in all environmental attributes as reflected by the positive and statistically significant coefficients, and who dislike increased costs (negative and significant coefficient).
- Class 2 represents individuals who hold positive preferences for all environmental attributes but who do not appear respond to the cost attribute, which is not statistically significant. The implications of this will be considered below.

- Class 3 represents individuals who place no weight upon changes in areas of seagrass and artificial reef structures (coefficients are not statistically significant), but who do value increases in the other environmental attributes (positive coefficients) and prefer not to pay higher costs (negative coefficient).

Comparison of parameters across classes is made difficult, as the error variance (and hence scale) may be different in each class. Estimating the willingness to pay for the attributes avoids this issue, as it normalises the parameter estimates by the cost coefficient. However, this is only valid if the cost coefficient is itself significant, which it is not in the case of Class 2. Table 17 reports the willingness to pay estimates for classes 1 and 3, and associated Z statistics.

Table 16 Preference parameters for the 2-scale: 3-preference class model

Attributes	Class1	z-value	Class2	z-value	Class3	z-value
Cost	-0.0119	-6.4047	0.0001	0.1174	-0.0946	-4.1373
Seagrass	0.0036	5.1623	0.0029	4.919	0.0001	0.0543
Penguins	0.0105	7.3599	0.0129	6.5782	0.0047	3.1075
Dolphins	0.053	6.6719	0.0614	5.2569	0.0397	3.5088
"Seahorses"	0.0897	5.533	0.1677	7.1648	0.0902	3.6915
Reef	0.0249	4.8613	0.0121	2.5431	0.0116	1.3983

Table 17 Willingness to Pay (WTP) estimates for Class 1 and 3: 2023AUD/household/year/unit change in attribute

	Class 1	z	Class 3	z
$ per ha of Seagrass	$0.30	7.66	<$0.00	0.05
$ per Penguin	$0.88	8.20	$0.05	2.98
$ per Dolphin	$4.46	5.69	$0.42	3.64
$ per species of "Seahorses" present	$7.55	5.34	$0.95	3.05
$ per ha of Reef	$2.09	6.40	$0.12	1.64

The WTP values need to be interpreted relative to the units of the variables. Seagrass and reefs are measured in hectares, so the interpretation is that Class 1 is willing to pay $0.30 and $2.09 for an additional hectare of each of these features, respectively. The relative size of these may be influenced by the size of ecosystem: the area of seagrass presented ranges from 700 to 1300 hectares, so a 1 unit change may be seen as a relatively small environmental improvement, whereas as reefs ranged from zero to 50 hectares. The interpretation would be that a unit change in reefs may be seen as having a much greater impact.

Penguins and dolphins were measured as the number of individuals present in the Sound, and marginal value per individuals is greater for dolphins in Class 1 and Class 3. Again, the relative size of the populations described in the choice sets (500-700 for penguins, 40-80 for dolphins) may explain the difference in WTP for unit changes in population.

The "seahorse" attribute was described as changes in number of multiple species from the family Syngnathidae likely to be present in the Sound, and the relatively high WTP per unit change ($7.55 for Class 1; $0.95 for Class 3) reflects that, relative to other attributes which are about area of, or individuals within a (group of) species and not absolute presences or absences of whole species.

For Class 3, the values associated with seagrass and reefs are not significant, in line with the insignificant preference parameters in Table 16 above. The relative ordering of the other environmental attributes in Class 3 is the same as for Class 1 ("Seahorses" > dolphins > penguins) but the absolute values are much lower: around a tenth of the values for Class 1.

Although it is usual to normalise preference parameters by cost, giving WTP values, it is also possible to identify relative rankings using any attribute. In Table 18 we report the relative weight of the environmental attributes using penguins as a numeraire. These values can be interpreted as: what is the relative value of an attribute measured in terms of changes in the number penguins? Because penguins are significant in all three classes, these weights can be calculated for all three classes.

Table 18 Relative value of environmental attributes, normalised by the value of penguins in terms of the number of penguins that deliver an equivalent value relative to one unit of the other attribute

Attributes	Class1	z-value	Class2	z-value	Class3	z-value
Seagrass (per ha)	0.34	7.31	0.22	5.53	0.01	0.05
Dolphins (per dolphin)	5.04	7.26	4.77	8.42	8.43	2.41
"Seahorses" (per species present)	8.53	6.05	13.03	10.41	19.13	2.52
Reefs (per ha)	2.36	6.11	0.94	2.57	2.45	1.33

The results of the relative values imply, for example, that individuals in Class 1 value five penguins a similar amount as one dolphin, or that a hectare of seagrass is only worth about a third of one penguin (or one penguin is as valuable as three hectares). What this analysis shows is that Class 2 has the same relative ranking as that of Class 1, in terms of the order "seahorses" (most highly valued per unit), dolphins, reefs, and seagrass (least valued per unit). However, Class 2 places a higher weight on "Seahorses", and a lower weight on reefs relative to Class 1. Note that Class 3 does not value seagrass or reefs at all (not significant), but within the other three species/family of species Class 3 places a much higher relative weight on "Seahorses" and dolphins than other classes.

Table 19 below reports the model of class membership, which helps to identify what type of person is likely to belong to a particular preference class. Note this model is estimated simultaneously with the preference parameters reported above. Only two variables were found to predict class membership: being a member of an environmental group (1 if yes, 0 if no), and whether they self-reported that they considered the cost attribute (1 if yes, 0 if no). The latter may not be seen as a particularly insightful variable to include: one would expect that this will influence the probability of being in Class 2, which has an insignificant cost coefficient. However, it is a useful form of internal consistency check. Other variables, such as income, age and gender did not affect class membership.

The table reports both the estimated parameters and the marginal effects. The latter are much more useful for interpretation: they show the change in the estimated probability of being in a particular class if the variable is changed by one unit from a 0 to a 1.

Table 19 Class membership model

Attributes	Class1	z-value	Class2	z-value	Class3	z-value
Constant	0.285	3.074	-0.256	-2.211	-0.029	-0.301
Member Env. Group	0.034	0.115	0.854	3.910	-0.888	-2.935
Attend cost	-1.385	-3.799	1.221	5.715	0.164	0.754
Marginal effects						
Member Env. Group	0.02		0.25		-0.27	
Attend cost	-0.44		0.37		0.07	
Class shares	37%		34%		29%	

Being a member of an environmental group increased the probability of an individual being in Class 2 (the class that valued all of the attributes, but did not consider cost) by 25 percentage points, and reduced the probability of being in Class 3 by a similar amount (27 percentage points). Being a member of an environmental group did not have a significant effect on membership of Class 1.

Having self-reported that they did not attend to cost increases the probability that individuals would be in Class 2 (the class which did not consider cost) by 37 percentage points, as expected. The probability that they would belong to Class 1 was reduced by 44 percentage points and it was not a significant factor for explaining membership of Class 3.

The overall predicted class membership indicates that the sample is relatively evenly spread across the three classes.

Table 20 reports the model for the scale class. This is of relatively little interest from a policy perspective, noting it does not influence the estimates of WTP, but is reported for completeness. The scale estimation requires one class to have a class membership coefficient restricted to be zero (Scale Class A), and then the other class be estimated relative to it. The results imply that Scale Class B has a smaller scale (0.202 relative to 1), and hence a higher error variance (i.e. there is more noise in their choices). The population is relatively evenly distributed across the two classes, with 59% in Scale Class A and 41% in Scale Class B.

Table 20 Estimates of scale class and scale.

	Scale Class A	Z value	Scale Class B	Z value
Class membership	0	.	-0.353	-1.108
Class share	59%		41%	
Ln Scale estimate	0	.	-1.602	-8.124
Scale	1		0.202	

3.3.3 Aggregation of WTP.

We identify that there are differences in preferences across the sample, and hence in WTP. Although identifying these groups is useful, one also needs to identify a population average WTP. One could consider a weighted average of the values, with the weights being the estimated sample sizes. However, Class 2 presents a challenge in doing this, as it reports a zero weight on costs. This is implicitly suggesting that the value attached to an increase in this attribute is infinite (there is no increase in costs that would offset an environmental improvement). This is clearly not likely. An alternative is to make some assumption about the values of this group, assuming that they do indeed have a value less than infinity. There are two approaches that are typically used, framed to provide conservative estimates of aggregate WTP.

The first is to assume that individuals belonging to this Class have the same value as the rest of the population. This would imply that the average WTP for any household would be calculated by assuming all households are either Class 1 or Class 3, thus use relative weights of 37/66 and 29/66 to relevant WTP estimates, respectively (i.e., reflecting the class shares in each, and ignoring the share of households that would be Class 2). For example, the average household WTP for penguins would be \$0.52 (i.e., (37/66) x \$0.88 + (29/66) x \$0.05).

The alternative is to assume that a WTP of zero should be applied to Class 2. This would imply that the average WTP for any household would be calculated by assuming that a WTP of zero be applied with a weighting of 34/100 (for any attribute), and weights of 37/100 and 29/100 should be used for relevant WTP values for classes 1 and 3. For example, the average household WTP for penguins using this approach would be \$0.34 (i.e., (37/100) x \$0.88 + (34/100) x \$0.00 + (29/100) x \$0.05)

Table 21 below reports the values using both of these approaches. These are annual estimates of value, for a unit change in the attribute, per household, per year.

Table 21 Average WTP estimates in 2023AUD, using two assumptions about Class 2

	Class 2= average WTP	Class 2 =0 WTP
Seagrass (\$ per ha)	0.17	0.11
Penguins (\$ per individual)	0.52	0.34
Dolphins (\$ per individual)	2.68	1.77
"Seahorses" (\$ per species)	4.65	3.07
Reef (\$ per ha)	1.23	0.81

With approximately 0.81 million households in the Greater Perth area, this implies annual values for unit changes in the attributes as reported in Table 22 below.

Table 22 Aggregate annual WTP estimates in 2023AU \$millions, assuming 0.81m Perth households

	Class 2= average WTP	Class 2 =0 WTP
Seagrass (\$m per ha)	0.14	0.09
Penguins (\$m per individual)	0.42	0.28
Dolphins (\$m per individual)	2.17	1.43
"Seahorses" (\$m per species)	3.77	2.49
Reef (\$m per ha)	0.99	0.66

3.3.4 Debrief questions

After the discrete choice experiment questions, there were a number of debrief questions. Table 23 shows the response to how difficult they found it to complete the choice questions. Approximately 40% reported that it was difficult to some extent. This is likely to reflect that the task can be challenging when there are multiple attributes that a respondent might care about, and so they need to carefully consider the trade-offs across them all.

Table 23 Did you find it difficult to make choices between the 2 options?

	Freq.	Percent
1 Very Difficult	133	9.93
2	140	10.45
3	250	18.66
4	315	23.51
5	229	17.09
6	124	9.25
7 Not Difficult	149	11.12
Total	1340	100.00

Table 24 shows the responses to a question on how likely the results of the survey will influence decisions about the environmental management of the port. The modal response is 'unsure' but a significant proportion thought that the survey would be influential.

Table 24 How likely do you think the results of this survey will influence the decisions about managing the environmental impacts of the port?

How likely do you think the results of this survey will influence the decisions	Freq.	Percent
1 Very Unlikely	141	10.52
2	128	9.55
3	204	15.22
4	391	29.18
5	275	20.52
6	112	8.36
7 Very likely	89	6.64
Total	1340	100.00

3.4 Social Licence to Operate

3.4.1 Results overview

Figure 19 reports the results for each of the 15 SLO questions, identified using the labels in Table 5. What is notable is the preponderance of results around the "Neither agree nor disagree" category. This may not be surprising given the relative lack of awareness of the port development and Westport as an organisation: only 42% said they were aware of the port development, and only 20% were aware of the Westport organisation prior to taking part in the survey.

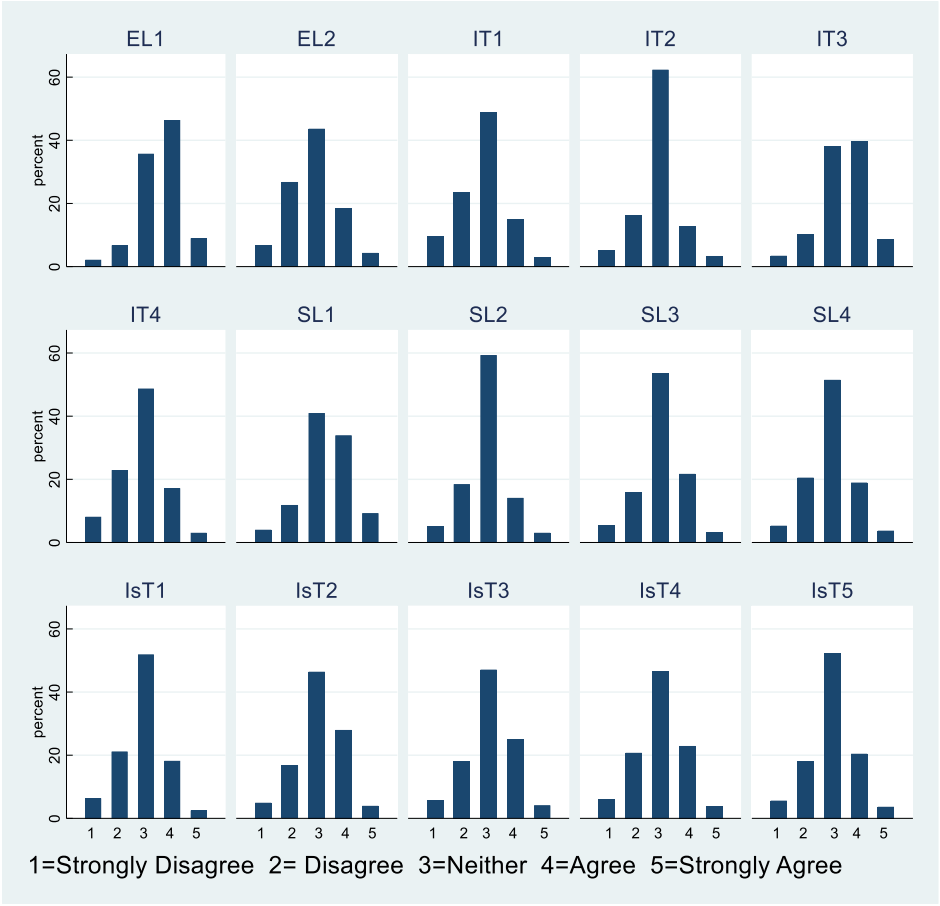


Figure 19. Distribution of responses to the SLO questions

3.4.2 Factor analysis

The data was then analysed using factor analysis to identify whether there were sub-measures of SLO as proposed by Boutilier and Thomson (2011). This was undertaken using an exploratory factor analysis. Kaiser's criterion to define the significant factors is to keep factors with an eigenvalue greater than 1 Kaiser, 1960. We found that our questions loaded on two factors, with eigenvalues of 8.39 and 0.97: the third factor had an eigenvalue of 0.27. The internal consistency of these two factors is given by their Cronbach alpha coefficient, which estimates the part of the variance shared by the questions and is an indicator of their homogeneity Cronbach, 1951. It is generally accepted that a value of Cronbach alpha above 0.7 indicates that the questions measure a single construct Nunnally & Bernstein, 1994. We had values of 0.85 and 0.95 for the two measures. We generated weights associated with each item with the factor by applying an orthogonal varimax rotation. These weights are reported in

Table 25 below.

The identification of only two factors is not consistent with the suggestion by Boutilier and Thomson (2011) that there are four sub-SLO measures. However, it is consistent with the previous work by Richert et al. 2015 and Rogers & Burton, 2017, and the questions that align onto the factors exactly match the results reported by them. EL1, EL2 and IT3 and SL1 are all measures that relate to economic legitimacy and form the second factor, while the remaining questions relate to the higher order measures. We follow Richert et al and Rogers and Burton, 2017 in identifying Factor 2 as "extended economic legitimacy", and Factor 1 as "social legitimacy".

Table 25. Estimated weights for two significant factors obtained from an exploratory factor analysis

Level of SLO	Variable	Factor 1	Factor 2
Economic legitimacy	EL1	0.179	**0.704**
	EL2	0.341	**0.470**
Interactional trust	IT1	**0.531**	0.261
	IT2	**0.514**	0.381
	IT3	0.296	**0.798**
	IT4	**0.664**	0.322
Socio-political legitimacy	SL1	0.370	**0.747**
	SL2	**0.733**	0.218
	SL3	**0.777**	0.294
	SL4	**0.673**	0.360
Institutional trust	IsT1	**0.727**	0.238
	IsT2	**0.727**	0.320
	IsT3	**0.771**	0.293
	IsT4	**0.780**	0.279
	IsT5	**0.706**	0.258

Notes: The values written in bold in the "Factor 1" and "Factor 2" columns indicate that the corresponding variables belong to Factor 1 or Factor 2, respectively.

A prediction by Boutilier and Thomson (2011) is that the higher order measures of SLO are dependent on prior award of the lower levels, which can be interpreted in our context as meaning that one would expect values of social legitimacy to be lower than that awarded for extended economic legitimacy. If an aggregate measure of each is obtained by averaging the relevant scores (EL1 EL2 IT3 and SL1 for extended economic legitimacy, and the remaining 11 questions for social legitimacy), one would expect the second average to be strictly lower than the first. This pattern is to some extent revealed in Figure 20, although the pattern is less clear-cut than that seen in the previous applications of the approach. However, the average score for the extended economic legitimacy is significantly greater than that for social legitimacy (Table 26).

Table 26. Summary statistics for SLO measures

	Mean	Standard deviation	Number of observations
Extended Economic Legitimacy	3.28	0.75	1340
Social Legitimacy	2.95	0.71	1340

Wilcoxon signed-rank test for equality of means: Pr>|z|<0.0000).

One can also show this result graphically (Figure 20). If Boutilier and Thomson's prediction was met completely, then all points would be above the 45^0 line, which they are not, but the tendency for a greater coverage in the upper half of the figure is clear.

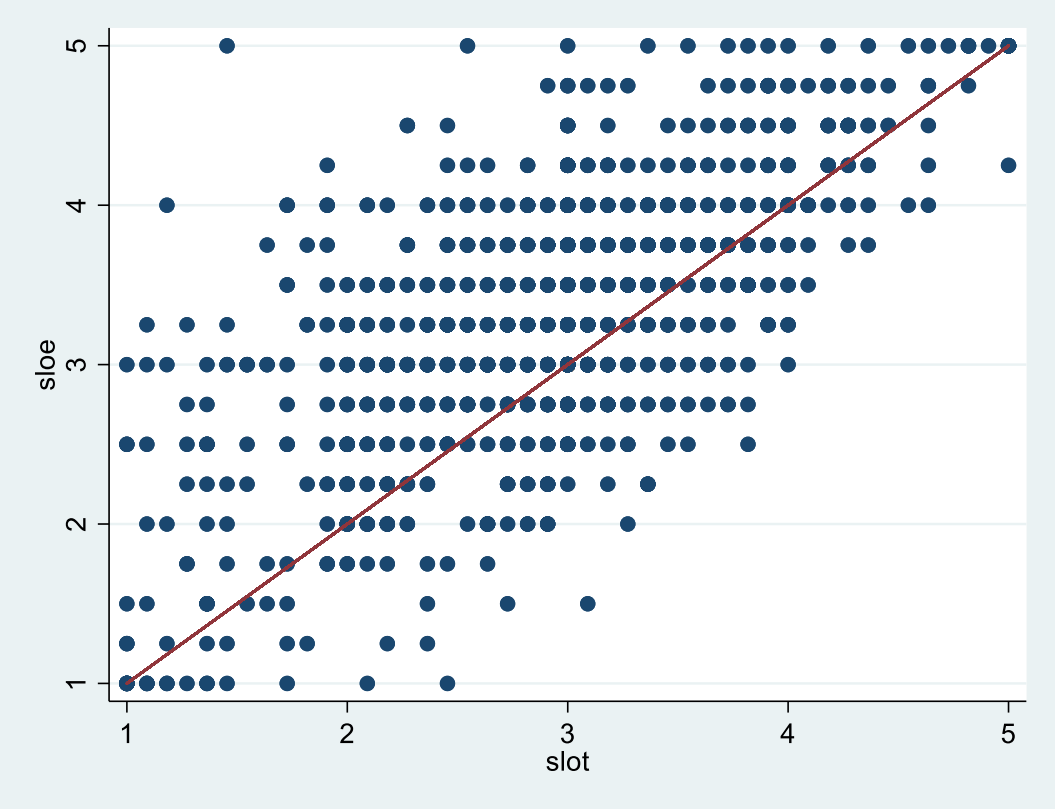
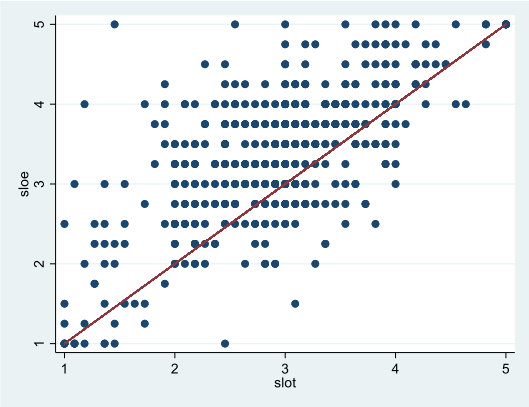
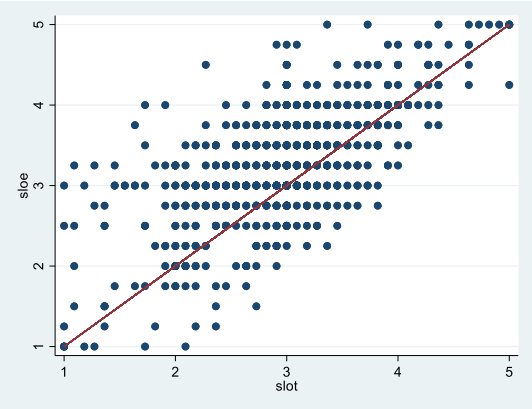


Figure 20. Scatter of Extended Economic Legitimacy (sloe) score and Social Legitimacy (slot) score.

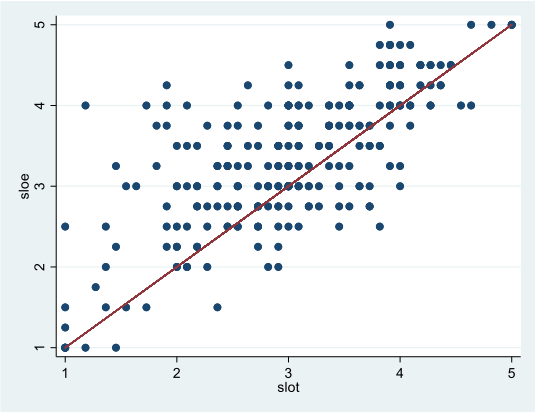
Given the lack of awareness about the port and Westport, it may be of interest to see if the pattern differs for those who are aware. Figure 21 below gives figures for those who were and were not aware of the port development, and who were and were not aware of Westport. These figures show relatively little difference across the groups (i.e., the patterns look very similar). Formal statistical analysis is conducted in the next section to identify differences in SLO across a range of socio-demographic variables.



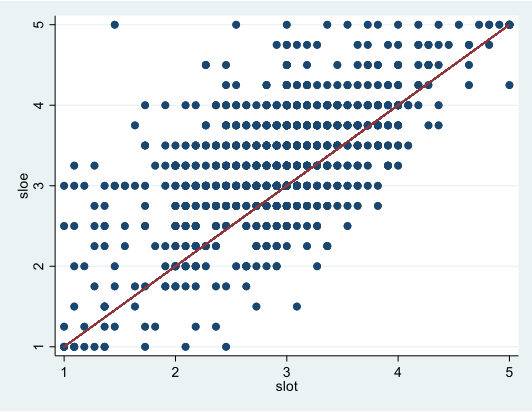
A: Those who had heard of port development



B: Those who had not heard of port development



C: Those who had heard of Westport



D: Those who had not heard of Westport

Figure 21. Scatter of Extended Economic legitimacy score and Social legitimacy score depending on prior knowledge

3.4.3 SEM analysis

In estimating the SEM StataCorp, 2023 we assume there are two underlying SLO measures, associated with extended economic legitimacy and social legitimacy, and these measures are linked to the groups of questions (four and 11 respectively) identified in the factor analysis (i.e., we use a confirmatory SEM approach).

The full set of results from estimating this model are reported in **Error! Reference source not found.**. In all cases, the latent SLO measures have a significant positive relationship with the answers given, and there is a positive correlation between the two measures of SLO.

Of more interest here is the significance and sign of the determinants of the level of the latent SLOs. We report variables that were significant in explaining t least one of the (Table 27); other variables that were included but subsequently dropped from the model because of lack of significance in both relationships are: gender, education level, whether they are a member of an environmental group or recreational fisher, visitation rates and whether they have previously heard of Westport. The set of sociodemographic variables retained are age, income, whether they believe the survey results will influence decisions, and whether they have previously heard of the port development. Income and age increase the economic SLO but have no effect on social legitimacy. Belief that the survey will have

an impact on decisions, which may be a proxy for increased institutional trust in general, leads to higher levels of SLO for both factors. Having heard about the port development prior to the survey increases the extended economic legitimacy, but not social legitimacy.

Table 27. Factors influencing Extended economic and social legitimacy: partial results from SEM analysis

		Extended economic legitimacy		Social legitimacy	
		Coefficient	Standard error	Coefficient	Standard error
Heard of proposed port	Yes	0.285**	0.130	-0.128	0.123
Likely survey will impact outcomes	1-7	0.273***	0.042	0.543***	0.044
Income	’0,000 per year	0.522***	0.130	0.097	0.119
Age	Years	0.009***	0.004	-0.005	0.004

Notes: Full results reported in Appendix 2; ***, ** indicates significance at the 99%, 95% level of confidence, respectively.

3.5 Synthesis of DCE and Social value results

The social values and the discrete choice methods have addressed similar questions about similar environmental issues, with the same sample, using alternative approaches. It is of interest to see how the results compare. The discrete choice approach using the latent class model allocates individuals (probabilistically) to three classes with quite different preference structures. In this section we see if membership of classes (which reflects the choices made in the choice experiment) correlate with answers to the social values questions.

To formally test this, we regress the level of the response given to the Likert questions (coded 1-5) against probability of class membership, for each of the 13 questions asked about wellbeing associated with the five attributes. **Error! Reference source not found.** reports the full set of results: **Error! Reference source not found.** below gives a summary. A ”-ve” indicates that a higher probability of being in that class reduces the score given for the wellbeing question. A ”+ve” indicates a higher probability of being in the class increases the score given to the wellbeing question. A blank cell indicates no significant effects. Two of the wellbeing questions were unique to fish and seagrass.

Because the probabilities by definition sum to one, the value for Class 1 is dropped. Note that these are not whether they value the item, but whether they value it more/less than those who were in Class 1 the base. Recall that Class 1 held relatively high values for all the attributes in monetary terms.

Class 3 do tend to score things lower on the wellbeing measures than Class 1, which is consistent with their having smaller WTP values across the board. However, on the wellbeing scores this is not a large numerical change (i.e., about a 0.5 point shift on a 1-5 scale).

Table 28 Effects of predicted class membership on wellbeing responses, by environmental attribute.

	Penguins		Dolphins		seagrass		"Seahorse"		fish	
	C2	C3	C2	C3	C2	C3	C2	C3	C2	C3
I enjoy and/or rely on eating Cockburn Sound fish for food	na	na	na	na	na	na	na	na		
# contribute to my enjoyment of the Cockburn Sound marine environment		**-ve**		**-ve**						
Seagrass contributes to my enjoyment of a pleasant and healthy environment by improving water quality	na	na	na	na			na	na	na	na
# are an important part of the history and cultural heritage of the area		**-ve**		**-ve**				**-ve**		**-ve**
# are important for scientific research and education		**-ve**				**-ve**		**-ve**		**-ve**
I could see myself having a meaningful occupation due, partly, to # existing in the area.		**-ve**								
# are important for my recreation in the area. I enjoy seeing and/or interacting with them				**-ve**		**-ve**				
# contribute to my strengthening of social bonds – for example, when volunteering		**-ve**								
I personally value # role in the local ecology.				**-ve**	**+ve**		**+ve**			**-ve**
# are important in their own right, even if I might never see them or interact with them				**-ve**	**+ve**			**-ve**		**-ve**
It is important that # are around for people other than myself to enjoy or benefit from				**-ve**				**-ve**		**-ve**
It is important to ensure that # are still around for future generations		**-ve**		**-ve**	**+ve**			**-ve**		**-ve**
I care about #		**-ve**		**-ve**	**+ve**			**-ve**		**-ve**

Note: C2 and C3 represent the probability of being assigned to Class 2 and 3, respectively, in the latent class analysis. -ve imply significant negative correlation, +ve a significant positive correlation, blank implies no significant correlation.

The Class 2 effect is largely limited to seagrass and suggests that individuals in this class value the broad contributions of seagrass more highly relative to Class 1. Recall that seagrass tended to be less valued overall compared to the other attributes, so this may just reflect that this group of individuals is going against that trend, for some items. This may be associated with the higher representation of environmental group members in Class 2.

The synthesis across the social and economic valuation approaches suggests that the survey results are largely consistent across the two approaches, but the differentiation is starker in the case of the discrete choice results, which may reflect the nature of the explicit choices that have to be made in that approach.

4 Discussion

4.1 Community values of environmental attributes

This section will explore the implications of the results relating to social values presented in Section 3.2. These will be integrated with an interpretation of comments entered by respondents in free form in answer to the survey question 'Are there any other species or environmental attributes that are important to you in Cockburn Sound, regardless of whether you will ever use, see, or interact with them?'.

Table 9 demonstrates that there is a distinct and strong preservationist ethic amongst survey respondents, with majorities expressing agreement with all social value statements. This indicates that the end state values explored in the survey, comprising whether Cockburn Sound constitutes an aesthetically pleasing environment which fulfils knowledge, heritage, social and spiritual-philosophical needs are highly valued by a large majority (i.e., by around 75% or more of the sample). It is particularly notable that the more abstract values, reflecting spiritual and philosophical fulfilment and the importance of maintaining environmental quality for future generations, received the strongest level of support (i.e., around 90% or more of the sample agreed these were important). This overall attitude is well summarised by one respondent who stated: '*No matter what, the marine life on the coast of Western Australia should always be protected*'. However, we note that the framing of the social value questions is aimed at eliciting the importance of environmental attributes in the absence of other constraints; they do not allow for respondents to consider how important the particular attribute is relative to other (less/equally/more) important things (e.g., other flora and fauna species that require protection, or other human benefits). The choice experiment applies that constrained approach and reveals that approximately two thirds of respondents were prepared to make trade-offs related to protection, suggesting that there is a more nuanced and diverse set of public opinions regarding the appropriate management of the Sound.

Considering the individual value statements illustrated in Figures 5-15, it is evident that seagrass tended to be ranked lowest of all the species and habitats. When examining the free text entries available to respondents, seagrass was mentioned by 11 respondents and the overall focus of comment was on the importance of seagrass in the food chain. This is reflected in one statement that 'if you remove one part of the equation then the rest fall'. Others voiced concern over the decline in seagrass coverage, which has received extensive publicity in recent decades. Some respondents noted a personal dislike for seeing or feeling seagrass or 'seaweed' when swimming or snorkelling. The relatively lower significance accorded to seagrass in the social values survey may therefore reflect an overall diminished degree of direct or indirect experience of seagrass habitat compared with the other species in the survey, rather than indifference or ignorance. It should be borne in mind, however, that despite the overall lower ranking, 84% of respondents agreed or strongly agreed that seagrass was important for the local ecology (Table 9). Thus, whilst seagrass ranked relatively low in most end state values compared with other species and habitats, there was still a strong conservation ethic expressed in association with this habitat.

Dolphins were most frequently ranked in the highest position across the social value statements, although in many cases there was less than 3% difference between dolphins and penguins when considering the total 'strongly agree' and 'agree' responses (Table 9). However, penguins were ranked lowest with respect to the end-state value concerning how marine species contributed towards a meaningful occupation. Given that most little penguins are found on islands with strictly controlled public access (notably Penguin Island in Shoalwater Bay Marine Park and Garden Island in Cockburn Sound), this is not particularly surprising. Dolphins were mentioned by 22 respondents in the free form responses, and often coupled with penguins which were mentioned by 18 respondents. There was little indication as to why respondents mentioned either dolphins or penguins other than them being 'important' or 'amazing' but several respondents did highlight plastic in the marine environment as a threat to both species.

"Seahorses" and fish species were consistently ranked below dolphins and penguins but above seagrass with regards to each end-state value. The exception to this involves the highest ranking of fish in response to the statement relating to the importance of species being around for other people (Figure 13). This could relate to the value attributed to recreational fishing, with numerous species of recreational and commercial value being found across various marine habitats in Cockburn Sound. A total of 24 respondents mentioned fish species in free form responses, often in the context of other species such as turtles or shellfish. Respondents expressed specific concerns relating to entanglement in fishing lines and the overall need for protection.

When invited to identify other species or habitats of value through open-ended responses, respondents cited a very wide range of marine, intertidal and terrestrial species including those which commonly observed (e.g. birds, crabs) as well as charismatic species such as whales or sharks. This seems to confirm that respondents value Cockburn Sound for the wide variety of species and habitats it supports and these need not necessarily be charismatic or visually exceptional. This would be consistent with the above observation that overall environmental quality is a highly ranked attribute amongst respondents and that individual perceptions of this will reflect experience and opinions relating to a diverse set of environmental indicators.

4.2 Non-market values

The economic valuation exercise suggests that the population can be split into three roughly equal segments, with each segment exhibiting different average preferences for the environmental attributes. What is common across all three is the positive support held for the charismatic species represented in the survey: dolphins, penguins, and "seahorses". Where they differ is in the value held for the seagrass and artificial reefs, and treatment of costs. 'Class 1' valued increased provision of all environmental attributes, and responded to the cost attribute (i.e., they preferred to avoid increased costs). 'Class 2' valued increased provision of all environmental attributes also, but did not consider financial costs to them when they made choices. 'Class 3' did not place a value on increasing provision of either seagrass of reefs, but valued other environmental attributes positively and increases in cost negatively. There was a roughly even share of membership across the three classes, suggesting that the population is split into thirds with respect to their preferences.

What is notable is that Class 2 tended to have a higher representation of individuals who were members of environmental groups. This suggests it is possible that they considered it more important to 'signal' support for the environment, and hence they may have under-reported the importance of costs. The fact that income was not relevant in explaining class membership supports this view: if higher income increased the probability of being in this class, then one could argue that the additional cost was considered not significant within their budget; however, the fact that all income levels will be represented similarly in this class as for other classes makes that unlikely (particularly given the highest level of the cost attribute ($500 per year), and the survey being undertaken in a period with rising cost of living pressures prevalent in the sampled community). The implication is that this group's support for the environment should be noted, but it is not possible to quantify that support in money terms.

Willingness to pay (WTP) for the environmental attributes was estimated for classes 1 and 3, and then two methods were used to estimate an average WTP per household, accounting for the non-responsiveness to the cost attribute in Class 2. The first approach assumes individuals in Class 2 hold average values, as estimated from averaging the WTP values from Class 1 and 3; the second approach assumes individuals in Class 2 have a zero value for the environmental attributes. If the WTP values are to be used, for example, as inputs in a benefit-cost analysis then one of the approaches needs to be selected; however, we would recommend using the WTP values from the alternative approach in sensitivity analysis.

To inform selection of the appropriate set of values to use, one needs to consider supporting information about the respondents. The WTP values from the first approach would be appropriate to

use if there is evidence to suggest that individuals in Class 2 do in fact have positive preferences for the environmental attributes and may have ignored the cost for some reason, as opposed to having a genuine preference to not pay for improved environmental outcomes. In the absence of such evidence, the more conservative values estimated by the second approach would be more appropriate.

Other evidence from the choice model and the social values analysis suggests that the first set of values are appropriate to use. There is an alignment of membership in Class 2 with membership of environmental groups (who are unlikely to have a true zero WTP), and the social values analysis revealed that very small proportions of people disagreed that the marine flora and fauna were important. This was particularly the case for the value-statements that related to protection of the marine flora and fauna themselves (e.g. for their own right to exist, or to protect for future generations), where disagreement was stated by less than 1% of respondents. Even the addition of those who were unsure about the importance of the flora and fauna with those who disagreed does not offer a proportion that could account for the roughly one third of people who are members of Class 2. This presents a strong case that some form of decision heuristic was driving the non-responsiveness to cost, and that assuming the true WTP for these individuals would be at least that of an average household.

The WTP values are highest for "seahorses" at $4.65 per species present, per household, per year. This is followed by values of $2.68 per dolphin, $1.23 per hectare of reef, $0.52 per penguin and $0.17 per hectare of seagrass (all per household, per year, in AUD2023). If the more conservative average household values are adopted, they reflect WTP estimates that are about 65% of these.

The implied ranking of the attributes by the WTP can be explained by the importance of the attributes to individuals, and the scale or scope of each attribute relative to the others. Referring to the social value analysis, it is clear that the dolphin, penguin and "seahorse" attributes are more important than seagrass, as reflected by the WTP rankings. Depending on the value statement, however, the differences between dolphins, penguins and "seahorses" in the social valuation are often not the same as the WTP rankings. This is likely because the choice experiment introduces additional context and framing about the attributes, including their current extent or abundance and by how much that might be impacted by the port development, as well as different measurement units. The extent reflects the relative scarcity of the different flora and fauna, where less abundant resources are often valued more highly per unit. For example, there are more individual little penguins in Cockburn Sound than there are individual bottlenose dolphins; there are numerous hectares of seagrass in the Sound, while artificial reefs are rare and novel. Further, the measurement units for "seahorses" are based on the absolute presence of entire species of Syngnathidae, implying more than one individual animal is captured within that presence, and this is likely driving up their WTP relative to the other per animal or per hectare attributes. These responses to WTP are appropriate: they show that respondents were sensitive to the scale and scope of different attributes presented to them in the choice experiment, and accounted for this when making trade-offs between them.

4.3 Social licence to operate

The social license to operate implemented a bank of questions that have been used elsewhere to measure, at a macro level, support for specific industries. The application here conformed with the results of previous studies: two forms of social licence can be identified, one based on agreement that Westport supports the economic development of the state, the second that Westport aligns with higher order social values. The conjecture by Boutilier and Thomson (2011) that there is a hierarchy of support, with people unwilling to award the higher social SLO until they award the lower economic SLO, is confirmed. We also identify predictors of the level of support offered: those who are older, have higher incomes and had heard previously of the port development gave a higher level of economic SLO (as well as a belief that the survey would have an impact on decision making). There was no predictor of what may cause variation in the level of social SLO, other than believing that the survey

would have an impact on decision making. There was a concentration of responses in the centre of the distribution (an answer of neither agree nor disagree) which may reflect the relatively low level of current awareness about Westport. It would be of interest to see how the SLO evolves over time as the development proceeds by implementing a subsequent survey repeating the bank of questions.

5 Conclusions and recommendations

The social value analysis indicates that overall environmental quality in Cockburn Sound is important for a large majority of respondents. This was especially true in relation to value-statements concerning the importance of the marine flora and fauna in terms of: the contribution it makes to the history and cultural heritage of the region, and to education and science; the local ecology; the right for it to exist; and, its protection for future generations and other people to enjoy.

The economic valuation through the discrete choice experiment revealed that the average Perth household is willing to pay to achieve better outcomes for Cockburn Sound's marine flora and fauna, with 'per unit' values derived for seagrass, artificial reefs, bottlenose dolphins, little penguins and species of Syngnathidae.

The social licence to operate for Westport was reasonably neutral, and likely driven by the low levels of community awareness of the proposed development. A stronger focus on community awareness may be needed to build positive social licence as the planning process proceeds, and the opportunity exists to measure trends in Westport's social licence through repeated applications of the relevant survey questions.

There was alignment in preference orientation between the economic and social valuations, with the consistency offering validation of the results delivered through each approach. This provides confidence in the information provided can assist in guiding the planning process for the proposed port development in Cockburn Sound, including the use of the willingness to pay values ($) in benefit-cost analyses to quantify the impacts of the development and prioritise possible environmental enhancement projects.

6 References

Boutilier, R. G., & Thomson, I. S. L.-. (2011). *Modelling and measuring the social license to operate: fruits of a dialogue between theory and practice*. https://www.socialicense.com/publications/Modelling%20and%20Measuring%20the%20SLO.pdf

ChoiceMetrics. (2012). *Ngene 1.1.1 User manual & Reference Guide*, Sydney, Australia.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, *16*(3), 297-334. https://doi.org/10.1007/bf02310555

Elrick-Barr, C. E., & Rogers, A. (2023). A Vision for Cockburn Sound: Summary Report. *Report prepared for the Department of Water and Environmental Regulation (DWER), Government of Western Australia.*

Environmental Protection Authority. (2004). *James Point Stage One Port, Kwinana* Retrieved 30/05/2023 from https://www.epa.wa.gov.au/proposals/james-point-stage-one-port-kwinana

Environmental Protection Authority. (2012). *Port Hedland Outer Harbour*. Retrieved 20/05/2023 from https://www.epa.wa.gov.au/proposals/port-hedland-outer-harbour-development

Environmental Protection Authority. (2014). *Pilbara Iron Ore and Infrastructure Project: Port and North-South Railway*. Retrieved 30/05/2023 from https://www.epa.wa.gov.au/proposals/pilbara-iron-ore-and-infrastructure-project-port-and-north-south-railway-stage

Environmental Protection Authority. (2018). *Port of Broome Channel Optimisation*. Retrieved 30/05/2023 from https://www.epa.wa.gov.au/proposals/port-broome-channel-optimisation-project

Environmental Protection Authority. (2019). *Koolan Island Iron Ore Mine and Port Facility*. Retrieved 29/05/2023 from https://www.epa.wa.gov.au/proposals/koolan-island-iron-ore-mine-and-port-facility

Environmental Protection Authority. (2020a). *Oakajee Deepwater Port, Oakajee, Shire of Chapman Valley (S46)*. Retrieved 22/05/2023 from https://www.epa.wa.gov.au/proposals/oakajee-deepwater-port-oakajee-shire-chapman-valley-s46-2171

Environmental Protection Authority. (2020b). *Port Rockingham Marina, Cockburn Sound*. Retrieved 22/05/2023 from https://www.epa.wa.gov.au/proposals/port-rockingham-marina-cockburn-sound-s46-2234

Environmental Protection Authority. (2021). *Statement of environmental principles, factors, objectives and aims of EIA*. Environmental Protection Authority. https://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/Statement%20of%20environmental%20principles%2C%20factors%2C%20objectives%20and%20aims%20of%20EIA_0.pdf

Environmental Protection Authority. (2022a). *Albany Port Expansion Project (S46)*. EPA. Retrieved 22/05/2023 from https://www.epa.wa.gov.au/proposals/albany-port-expansion-project-s46-2262

Environmental Protection Authority. (2022b). *Single Jetty Deep Water Port & Renewable Hub (Gascoyne Gateway)* EPA. Retrieved 22/05/2023 from https://www.epa.wa.gov.au/proposals/single-jetty-deep-water-port-renewable-hub

Greszki, R., Meyer, M., & Schoen, H. (2015). EXPLORING THE EFFECTS OF REMOVING "TOO FAST" RESPONSES AND RESPONDENTS FROM WEB SURVEYS. *Public opinion quarterly*, *79*(2), 471-503. https://doi.org/10.1093/poq/nfu058

Hughes, M., Kobryn, H., Henningsen, S., Burton, M., Rogers, A., Pauli, N., Clifton, J., & Kim, M. (2023). *Spatial mapping of non-fishing recreational activities and associated values in Cockburn Sound, Western Australia*. WAMSI Westport Marine Science Program, Perth, Australia.

Jacob, C., van Bochove, J. W., Livingstone, S., White, T., Pilgrim, J., & Bennun, L. (2020). Marine biodiversity offsets: Pragmatic approaches toward better conservation outcomes. *Conservation Letters*, *13*(3). https://doi.org/ARTN e1271110.1111/conl.12711

Kaiser, H. F. (1960). The application of electronic computers to factor analysis. *Educational and Psychological Measurement*, *20*, 141–151. https://doi.org/ 10.1177/001316446002000116

Kendrick, G. A., Aylward, M. J., Hegge, B. J., Cambridge, M. L., Hillman, K., Wyllie, A., & Lord, D. A. (2002). Changes in seagrass coverage in Cockburn Sound, Western Australia between 1967 and 1999. *Aquatic Botany*, *73*(1), 75-87. https://doi.org/Pii S0304-3770(02)00005-0

Kildow, J. T., & McIlgorm, A. (2010). The importance of estimating the contribution of the oceans to national economies. *Marine Policy*, *34*(3), 367-374. https://doi.org/https://doi.org/10.1016/j.marpol.2009.08.006

Mariel, P., Hoyos, D., Meyerhoff, J., Czajkowski, M., Dekker, T., Glenk, K., Jacobsen, J. B., Liebe, U., Olsen, S. B., Sagebiel, J., & Thiene, M. (2021). *Environmental Valuation with Discrete Choice Experiments: Guidance on Design, Implementation and Data Analysis.* Springer Briefs in Economics. https://doi.org/10.1007/978-3-030-62669-3

Moffat, K., & Zhang, A. (2014). The paths to social licence to operate: An integrative model explaining community acceptance of mining. *Resources Policy*, *39*, 61-70. https://doi.org/10.1016/j.resourpol.2013.11.003

Nunnally, J. C., & Bernstein, I. H. (1994). *Psychometric theory (3rd Edition)*. McGraw-Hill, Inc.

Nylund, K. L., Asparouhov, T., & Muthén, B. O. (2007). Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study. *Structural Equation Modeling*, *14*(4), 535-569. https://doi.org/10.1080/10705510701575396

Prno, J., & Slocombe, D. S. (2012). Exploring the origins of 'social license to operate' in the mining sector: Perspectives from governance and sustainability theories. *Resources Policy*, *37*(3), 346-357. https://doi.org/10.1016/j.resourpol.2012.04.002

Richert, C., Rogers, A., & Burton, M. (2015). Measuring the extent of a Social License to Operate: The influence of marine biodiversity offsets in the oil and gas sector in Western Australia. *Resources Policy*, *43*, 121-129. https://doi.org/10.1016/j.resourpol.2014.12.001

Rogers, A. A., & Burton, M. P. (2017). Social preferences for the design of biodiversity offsets for shorebirds in Australia. *Conservation Biology*, *31*(4), 828-836. https://doi.org/10.1111/cobi.12874

Rossmann, J. (2010). Data Quality in Web Surveys of the German Longitudinal Election Study 2009. *Paper presented at the 3rd ECPR Graduate Conference, Dublin, Ireland.*

Ryan, K. L., Desfosses, C. J., Denham, A. M., Taylor, S. M., & Jackson, G. (2021). Initial insights on the impact of COVID-19 on boat-based recreational fishing in Western Australia. *Marine Policy*, *132*, 104646-104646. https://doi.org/10.1016/j.marpol.2021.104646

StataCorp. (2023). *Stata Statistical Software: Release 18.* StataCorp LLC.

Stephens, S., & Robinson, B. M. K. (2021). The social license to operate in the onshore wind energy industry: A comparative case study of Scotland and South Africa. *Energy Policy*, *148*, 111981. https://doi.org/10.1016/j.enpol.2020.111981

The Economist. (2015). *The blue economy: Growth, opportunity and a sustainable ocean economy*. The Economist Intelligence Unit. https://impact.economist.com/perspectives/sites/default/files/Blue%20Economy_briefing%20paper_WOS2015.pdf

The Government of Western Australia. (2011). *WA Environmental Offsets Policy*. Perth

The Government of Western Australia. (2015). *State Environmental (Cockburn Sound) Policy* 2015.

Train, K. E. (2003). *Discrete choice methods with simulation*. https://doi.org/10.1017/cbo9780511753930

Vermunt, J. K., & Magidson, J. (2021). Latent GOLD Choice 6.0.

Voyer, D. M., & van Leeuwen, D. J. (2019). 'Social license to operate' in the Blue Economy. *Resources Policy*, *62*, 102-113. https://doi.org/10.1016/j.resourpol.2019.02.020

Wallace, K. J., Jago, M., Pannell, D. J., & Kim, M. K. (2021). Wellbeing, values and planning in environmental management. *Journal of Environmental Management*, *277*, 111447. https://doi.org/10.1016/j.jenvman.2020.111447

Wallace, K. J., Kim, M. K., Rogers, A., & Jago, M. (2020). Classifying human wellbeing values for planning the conservation and use of natural resources. *Journal of Environmental Management*, *256*, 109955. https://doi.org/10.1016/j.jenvman.2019.109955

Westport. (2020). *Westport: Future port recommendations, Stage 2 Report*. https://www.transport.wa.gov.au/mediaFiles/marine/PROJ_P_Westport_Future_Port_Recommendations_Stage_2_Report_May_2020.pdf

Submitted as draft	6/11/2023
Review completed	29/11/2023
Submitted as revised draft	14/8/2024
Approved by Science Program Leadership Team	29/8/2024
Approved by WAMSI CEO	4/9/2024
Final report	4/9/2024

WESTERN AUSTRALIAN
MARINE SCIENCE
INSTITUTION