IDEEA Group

Ocean accounting pilot for Geographe Marine Park

Data assessment report

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1 Introduction

The Australian Government Department of Agriculture, Water and the Environment is leading the implementation of *Environmental Economic Accounting: A common National Approach Strategy and Action Plan* whereby all Commonwealth, state and territory governments have agreed to work together to develop a consistent approach to environmental-economic accounting across Australia. The 'Ocean accounting pilot for Geographe Marine Park' project is a pilot project under this strategy. The project has three key objectives:

1) Provide structured environmental, cultural, social, and economic information to contribute to the Monitoring, Evaluation, Reporting and Improvement (MERI) system informing ongoing management of Geographe Marine Park
2) Improve understanding of how ocean accounts can assist the sustainable management of marine resources
3) Trial the internationally accepted frameworks and Technical Guidance on Ocean Accounting in an Australian marine context and assess feasibility for broader application.

This report, compiled by IDEEA Group and Hydrobiology for the Australian Government Department of Agriculture, Water and the Environment, is an assessment of the data available to populate Ocean Accounts for Geographe Marine Park. This report is the second in a series of five reports:

1) Geographe Marine Park – Ocean Accounting: Data Inventory Report

2) Geographe Marine Park – Ocean Accounting: Data Assessment Report

3) Geographe Marine Park – Ocean Accounting: Methodologies Assessment Report

4) Geographe Marine Park – Ocean Accounting Report: Initial accounts

5) Geographe Marine Park – Project Synthesis Report

Together, the data assessment and the methodologies assessment provide the foundations for compiling ocean accounts for Geographe Marine Park. The data assessment covers three areas: (i) a review of data as it pertains to Geographe Marine Park, (ii) an assessment of the suitability of existing datasets to be included in an account, (iii) the potential to use datasets at a national level. The data assessment is supported by a data inventory, which records the sources of data for Geographe Marine Park. A draft set of primary and secondary accounts were selected at the beginning of the project and form the basis for this data assessment report (see section 2.2 for more information).

This report is structured as follows:

- A description of the approach to the data assessment, including the project area, the primary and secondary account series, the engagement process, and the process for determining the suitability of datasets to be included in an account including a framework for describing the quality of the data
- A description of the data as it pertains to Geographe Marine Park

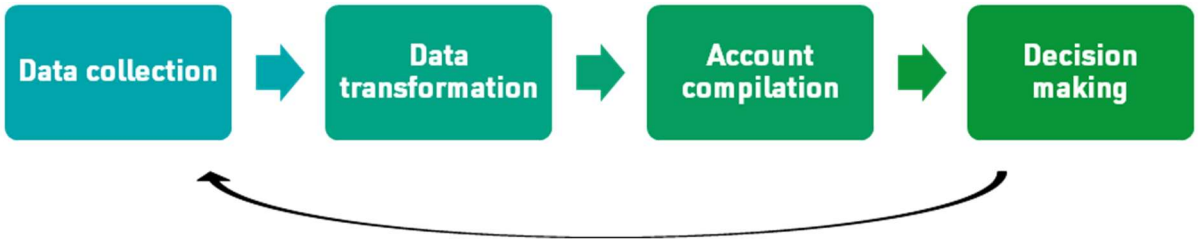
- An assessment of the datasets that can be used to populate accounts for Geographe Marine Park. Commentary is provided on the expected effort to produce account ready data, strategies for populating absent datasets, and the potential to use data in national accounts.

2 Methods

Ocean accounting involves recording, organizing, communicating, and using environmental, cultural, social, and economic information about marine and coastal environments. A key benefit of ocean accounting is that it produces a coherent set of information across different policy domains (environmental, social, and economic). For this report, the environmental domain is measured in terms of stocks of natural capital (for example ecosystems, fish, seaweed) and flows from natural capital (for example, carbon sequestration, recreation), enabling decision makers to manage sustainable outcomes with a single holistic information set.

The objective of the data assessment is to assess the suitability of existing data sets for Ocean Accounting for Geographe Marine Park. There are four steps to ocean accounting: data collection, data transformation and account compilation and decision making (Figure 1). This assessment focusses on the data collection phase and provides options for the data transformation phase. The Methodologies Assessment Report will describe the methods required to transform the data for account compilation in more detail.

Figure 1 Accounting process



2.1 Project area

Geographe Marine Park is located within Geographe Bay, about 8 kilometres west of Bunbury, Western Australia (see Figure 2). Geographe Marine Park is 977 km^2 and the water depth ranges between 15 m and 70 m, with the average depth being 30 m. The inner park boundary begins 3 Nautical Miles (NM) from the Territorial Sea Baseline (TSB) with the entire marine park located within Commonwealth waters which, in turn, lie within Australia's territorial sea area.[1] Geographe Marine Park is adjacent to Ngari Capes Marine Park, which is managed by the State of Western Australia and is located in State Coastal Waters (CW).[2] Thus, Geographe Bay contains (i) an Australian Marine Park (Geographe Marine Park) (ii) a state marine park, Ngari Capes Marine Park, (iii) other Commonwealth waters, and (iv) other State waters.

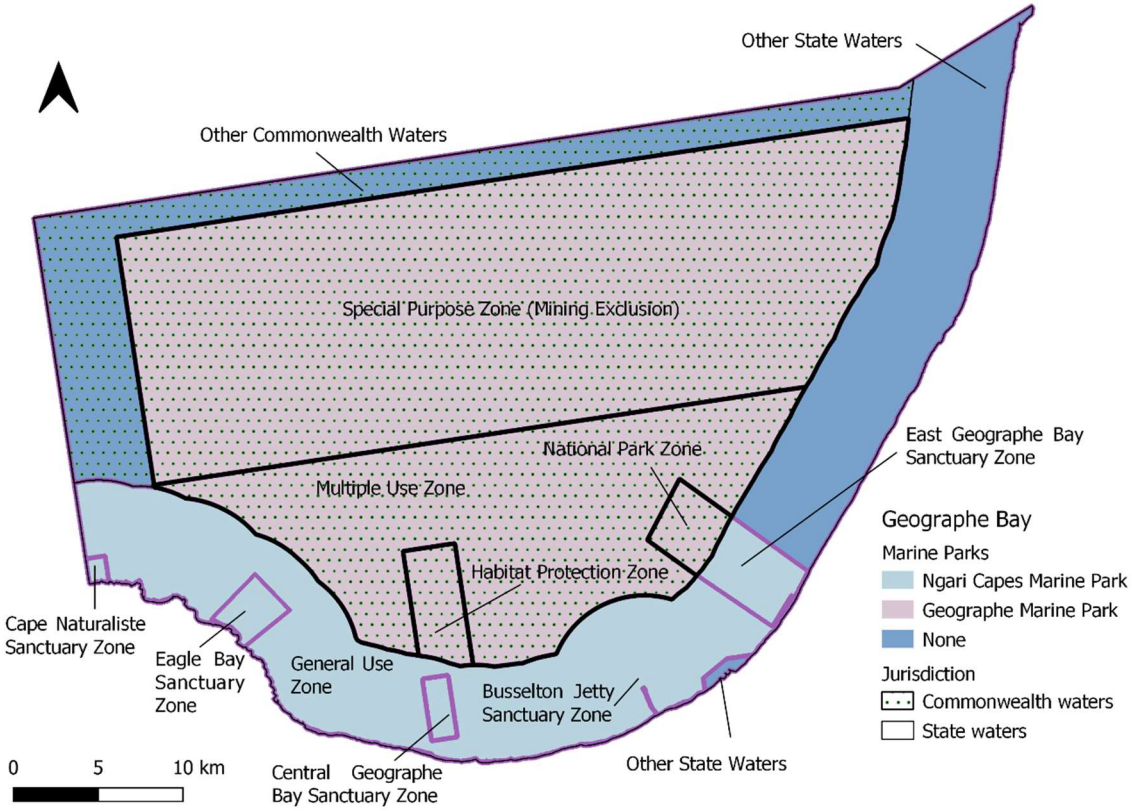
Geographe Marine Park is zoned according to the IUCN marine protected area categories. There are four zones in Geographe Marine Park: National Park Zone (IUCN II), Habitat Protection Zone

[1]The territorial sea extends to 12 nautical miles from the TSB. Australia's sovereignty extends to the territorial sea, its seabed and subsoil, and to the air space above it.

[2] Coastal waters extend between the TSB and 3 nautical miles from the TSB

(IUCN IV), Multiple Use Zone (IUCN VI) and Special Purpose Zone (Mining Exclusion) (IUCN VI). The National Park Zone is managed to protect and conserve ecosystems, habitats, and native species in as natural a state as possible. It does not allow extractive or harvesting activities, but permits non-extractive activities including science, tourism, education, and recreation. The Habitat Protection Zone is also managed to protect ecosystems, habitats, and native species in as natural a state as possible but allows for some extractive or harvesting activities including commercial and recreational fishing and aquaculture. The Multiple Use Zone allows for ecologically sustainable use while conserving ecosystems, habitats, and native species. The Special Purpose Zone allows for specific activities through special purpose management arrangements.

Figure 2 Geographe Marine Park



Note: Spatial data on Australian Marine Parks has been used to create this map. No transformations have been applied to the data.
Source: Department of the Environment and Energy, 2018.

2.2 Proposed accounts

Prior to the commencement of the project, The Department of Agriculture, Water and the Environment developed a list of primary and secondary accounts that may be compiled for Geographe Marine Park (see Table 1). The list of accounts took into consideration relevant ecosystem assets, ecosystem services, uses and pressures, and management issues within the marine park. The distinction between primary and secondary accounts relates to expectations about their compilation. Based on a preliminary data assessment, it was highly likely that data will be available for primary accounts while there is some uncertainty about data availability for the compilation of secondary accounts.

Table 1 Primary and secondary accounts

Priority	Account
Primary account series	• Seagrass meadow ecosystem extent account • Carbon stock and flow account • Seagrass meadow ecosystem condition account, including up to six condition indicators • Carbon sequestration and storage ecosystem service physical supply and use accounts (two tables) • Carbon sequestration and storage ecosystem service monetary supply and use accounts (two tables)
Example secondary account table series compilation (limited to 10 account tables)	• Extent of rocky reef • Condition of rocky reef • Asset stock account – western rock lobster (rocky reef provisioning service) by zone • Tourism vessel behaviour – transit and anchoring by vessel type • Tourism visitation – number of vessels, visits, passengers, and activity type (for example whale watching, charter fishing, diving) • Tourism employment (by season) • Tourism expenditure (by season) • Number of recreational fishing visits and time spent • Seagrass meadow nursery services supporting a key fish species (indicator species if possible) • Economic value of nursery service for the key fish species

2.3 Scope of data assessment

The data assessment starts out broadly considering the whole of Geographe Bay to ensure full consideration is given to key assets, services, uses and pressures, and management issues. This means that data on marine and coastal environments and the social, cultural, and economic activities (both market and non-market) across Geographe Marine Park, Ngari Capes Marine Park and other coastal waters within Geographe Bay are considered in this assessment. There are three reasons for taking a broad approach to the scoping of the data assessment:

1) There is a need to evaluate our expectations about the priority and secondary accounts. The accounts are useful within the context of the broader system and the selection of accounts needs to be informed by research
2) Limiting the data collection process to Geographe Marine Park may impede our ability to produce accounts where data is missing or incomplete
3) The discovery process will enable us to give clear reasons why some data sets are in or out of the spatial scope of Geographe Marine Park. This information can be used to inform ongoing data collection and a national strategy on ocean accounting more generally.

Data sets that cover or intersect Geographe Bay, including local, regional, state, national and global data sets are within the scope of the data assessment.

2.4 Data collection framework

The data collection framework is based on the United Nations' Economic and Social Commission for Asia and the Pacific (UNESCAP) data inventory (Global Ocean Accounts Partnership, 2019a) which provides the structure for organising data on the Geographe Bay system. The data collection framework comprises 5 main components and a number of subcomponents to

support the organisation and assessment of data (see Table 2). The data collection framework covers pressures and threats in across ocean context, use and ocean condition. Nutrient runoff for example is covered in ocean condition, chemical characteristics.

Table 2 Data collection framework

Component	Subcomponent	Definition	Examples
Ocean Extent	Physical extent	Relates to the physical extent of the area in terms of depth, area, coverage, and arrangement	Topography, geoid, bathymetry, geography, islands
	Institutional extent	Relates to the extent of institutional zoning such as regulatory and planning areas	Maritime boundaries, coastal communities, IUCN Zones
	Ecosystem extent	Relates to the extent and composition of the ecosystem types	Seagrass meadow, rocky reef, mangrove and saltmarshes
	Context	Relates to contextual information that makes up the broader socio-ecological system	Agricultural land, river connections, cities, towns
Use	Designated	Areas designated for use relating to the marine environment	Ports, piers, fisheries management
Ocean Condition	Physical characteristics	Relates to the system quality and conditions in terms of physical attributes	Temperature/sea surface temperature, ocean circulation, sea level, waves, tides, winds, sea ice/ glacier, salinity, heat content, mean sea surface, mean dynamic topography, turbidity (reflectance), mixed layer thickness, water pressure, water density
	Chemical characteristics	relates to the system quality in terms of chemicals and nutrients	Phosphate, nitrate, silicate, alkalinity, pH, CO2, oxygen/hypoxia, tritium, oil-spill trajectory
	Biological characteristics	relates to the system quality and conditions in terms of biological attributes	Plankton, chlorophyll, ocean colour, algal bloom, plastics, water quality, pests (starfish, sea urchins), bleaching
	Ecological characteristics	Relates to the system quality in terms of ecological characteristics	Cover, density, diversity of species
Ocean Asset	Biotic assets	Relates to living natural assets	Aquatic plants, algae, seaweeds, plankton, whales, dolphins, sea turtles, fish stock, other marine species
	Abiotic assets	Relates to nonliving natural assets	Minerals, oil/ petroleum/ gas, seafloor sediments and rocks
Ocean services supply and use	Biotic physical services	Relate to services that living components of the system provide	Fish catch (recreational, commercial - aquaculture and wild), coastal protection, habitat services, carbon sequestration and storage, harvesting of seaweed, recreational services (whale and dolphin watching, swimming, surfing, scuba diving), cultural services
	Biotic monetary services	Valuation perspective	Valuation perspective
	Abiotic physical services	Relate to services that non-living components of the system provide	Transport services (shipping), wind and wave energy, mining
	Abiotic monetary services	Valuation perspective	Valuation perspective
	Ocean use	Relates to use of the marine environment	Tourism, fishing, boating

Note: Framework adapted from UNESCAP data inventory

Source: United Nations ESCAP, 2019

2.5 Data quality assessment

A framework for assessing the quality of data was developed in accordance with the ABS data quality framework (see Table 3).The framework enables a score to be generated based on a subjective assessment of each data set. A score ranging from 0 – 2 is very low, 2 – 4 is low, 4 – 6 is average, 6 – 8 is high and 8 – 10 is very high. The ability to make judgements across each of these components of the framework is quite variable and based on the information captured to date. With further time and resources additional information may be found which could influence the scores given.

Table 3 Data quality framework

Section	Sub-section	Explanation
Interpretability	Availability of information regarding the data:	the availability of key material to support correct interpretation, such as concepts, sources, and methods; manuals and user guides; and measures of accuracy of data.
Institutional environment	Impartiality and objectivity:	whether the production and dissemination of data are undertaken in an objective, professional and transparent manner.
	Professional independence:	the extent to which the agency producing statistics is independent from other policy, regulatory or administrative departments and bodies, as well as from private sector operators, and potential conflict of interest.
	Mandate for data collection:	the extent to which administrative organisations, businesses and households, and the public at large may be compelled by law to allow access to, or to provide data to, the agency producing statistics.
Relevance (for accounting in GMP)	Geographic detail:	the extent to which there is information about the level of geographical detail available for the data (for example, postcode area, Statistical Local Area, geographic projection) and the actual geographic regions for which data are available.
	Scope and coverage:	the extent to which the purpose or aim for collecting the information is relevant to ocean accounts in GB, including identification of the target population and/or area, discussion of whom the data represent, who/what areas are excluded and whether there are any impacts or biases caused by exclusion of particular people, areas or groups.
	Reference period:	the extent to which the period for which the data were collected (for example, the September-December quarter of the 2008-09 financial year) is consistent for account integration (for example, has seagrass meadows extent been collected annually in September or randomly when funding was available)
	Main outputs/data items:	whether the data measures the concepts meant to be measured for its intended uses. Is it a direct measure or a proxy measure for its intended use? For example, measuring number of fishermen as a proxy for fish stock.
	Classifications and statistical standards:	the extent to which the classifications and standards used reflect the target concepts to be measured. For example, was a formal classification used to classify seagrass meadows?
	Other cautions:	information about any other relevant issue or caution that should be exercised in the use of the data.
Timeliness	Frequency of survey	the extent to which the survey or data collection was conducted on a one-off basis, or whether it is expected to be ongoing. If it is expected to be ongoing, frequency also includes information about the proposed frequency of repeated collections and when data will be released for subsequent reference periods.

Accuracy	Sample error:	the extent to which the impact of sample error can be assessed using information about the total sample size and the size of the sample in key output levels (for example, number of sample units in a particular geographical area), the sampling error of the key measures, and the extent to which there are changes or deficiencies in the sample which could impact on accuracy.
	Other sources of errors:	The degree to which other serious accuracy problems with the statistics exist. These may include errors caused by incorrect processing of data (for example erroneous data entry or recognition), alterations made to the data to ensure the confidentiality of the respondents (for example by adding "noise" to the data), rounding errors involved during collection, processing or dissemination, and other quality assurance processes.
	Revisions to data:	the extent to which the data are subject to revision or correction, in light of new information or following rectification of errors in processing or estimation, and the period in which revisions are produced.
Accessibility	Accessibility to the public:	the extent to which the data are publicly available, or the level of access restrictions. Additionally, special data services may include the availability of special or non-standard groupings of data items or outputs, if required.
	Data products available:	the usability of the specific products available (for example, publications, spreadsheets), the formats of these products, their cost, and the available data items which they contain.

Note: Framework adapted from ABS data quality framework

2.6 Approach to data collection

The approach to collecting data across the Geographe Bay system includes desktop research and stakeholder engagement. Desktop research was used to identify and review key public sources of environmental, social, and economic data that could be used to populate ocean accounts. A range of stakeholders were then engaged to record and collect private data sets or to understand research activities that could potentially provide data. Engagement was undertaken by phone and email, with an initial email sent to approximately 45 potential data suppliers and stakeholders. Potential data suppliers were followed up by phone if they did not respond to the email. It was originally intended for potential data suppliers and other stakeholders to attend an information session in Perth, Western Australia. However, travel plans were interrupted by Covid-19.

The data inventory (see Data inventory for Geographe Marine Park) is a repository for each of the data sources (both public and private) reviewed or collected across Geographe Bay. This assessment report contains information on each of the datasets, including the source of the data, data type and spatial and temporal coverage. The data inventory is structured according to the data collection framework described in Table 2. The entries in the inventory include sources from global, national, state, and local data of relevance, such as databases, online portals, reports, and websites.

The data inventory can be added to over time and the data assessment can be used with other information as a basis for future data collection. Not all entries have an associated data set. It would take a significant investment and an extremely long time to track down all data. The collection of source data to use in the accounts has been prioritised based on IDEEA Group's understanding of what is needed to produce primary and secondary accounts. Data collection is an iterative process as new data sets are revealed and as stakeholders respond to requests at different times.

2.7 Criteria for account ready data

Criteria for determining the transformations to the data is required before the suitability of data can be assessed for ocean accounting. The effort required to produce the accounts can be described by assessing what transformations are required. Each dataset needs to be investigated individually to determine if it can be used to produce accounts and to describe whether it is incomplete.

There are three objectives of the account transformation phase: (i) spatial coverage, (iii) temporal coverage and (iii) compliance with accounting principles. The spatial coverage objective requires the alignment of spatial data to the accounting area (Geographe Marine Park). Temporal coverage requires the alignment of temporal data sets where possible, for example by removing any seasonality effects. The accounting compliance objective requires the application of accounting principles and definitions to transform data.

Determining the transformations required for spatial data requires the categorisation of different data sets according to their spatial characteristics. These characteristics include spatial coverage, type of spatial data and spatial resolution. The type of spatial coverage, for example, full, partial or no coverage for a given area, can affect the transformation required. Data that has full spatial coverage does not require transformation, interpolation may be required when there is partial coverage, and extrapolation may be required when there is no coverage of the accounting area.

The type of spatial data also affects the type of transformation required. Polygonal data is low transformation effort while point data needs to be interpolated or extrapolated to produce estimates for an accounting area. The resolution of spatial data also affects the transformation required. Aggregation is required when data is finer resolution than the accounting area, while disaggregation is required when the data is broader than the spatial area.

Temporal transformation is the alignment of different data sets to accounting periods. Controlling for seasonality is particularly important for data sets collected in different months across different years. For example, the condition of seagrass meadows may be different in summer months compared to winter months due to varied levels of rainfall and runoff. Interpolation techniques may also need to be used to produce accounts between two time periods. For example, a linear relationship could be assumed to interpolate annual data between 2010 and 2020.

Account compliance is the process of ensuring that data complies with accounting definitions and standards. Different standards and definitions are defined in the United Nations' System of Environmental-Economic Accounting (SEEA) (United Nations et al., 2014b, 2014a, 2018) and the Technical Guidance on Ocean Accounting (Global Ocean Accounts Partnership, 2019b), respectively. The purpose of account compliance is to ensure that accounts are comparable, can be scaled up, and are coherent with other accounts. The approach to ensuring account compliance is described in the methodologies assessment report.

Account coherence is the final consideration when it comes to transforming data. Coherence refers to the balancing of different accounts so they each support an overarching narrative. This project will focus on coherence between the stock and flow accounts and the supply and use

accounts particularly in biophysical terms. Table 4 shows the accounting considerations for each of the accounting components.

Table 4 Accounting considerations

Component	Consideration
All	Consistent definition of spatial units across all components of accounting area
Ocean extent	Classifications and crosswalks of ecosystems and consideration of context
Use	Classifications and complementarity with extent
Ocean condition	Reference periods and aggregation of condition measures
Ocean Asset	Measurement units Balancing of stocks and flows
Ecosystem services (physical)	Measurement units Balancing of supply and use
Ecosystem services (monetary)	Market prices Non-market prices reflect the preferences of those that use the service Balancing of supply and use

3 Geographe Bay data assessment

This section describes the results of the data collection process and summarises the information for the different components and subcomponents of the data collection framework (Table 2). This broad framing can be used to assess gaps in data across Geographe Bay. It provides an opportunity to assess other accounts that may be relevant to the project and provides reason why things are in or out of scope. This section links to the data inventory by the unique codes that have been assigned during the inventory process (for example OE_001).

3.1 Ocean extent

3.1.1 Physical extent

Seventeen entries were classified as Physical Extent, with ten of the entries covering multiple sub-components. The Busselton Coastal Protection report (OE_005) covers the topic of coastline erosion in Geographe Bay, which is of fundamental importance given the industry, populations and ecosystems which depend on the productive coastal zone. Coastal protection was not deemed to be a critical service provided by ecosystems in Geographe Marine Park due to the distance from the coastline and the depth of water. Bathymetry (OE_013 and OE_014), morphology (OE_006) and physical oceanography (MUL_005) are covered by the inventory, providing a base information on the physical functioning of Geographe Bay. Marine ecological studies, for example seagrass meadows studies (see section 3.1.3), commonly include the physical parameters of the seabed and water column. These studies generally include information on the quality of the vegetation (for example substrate type, wave heights) and include some level of physical measurements at a local scale.

Most physical extent sources covered Geographe Bay's full extent. However, high-resolution bathymetry and morphology files only covered shallow waters (around 30 metres in depth). Other reports contained in the inventory covered Geographe Bay, but the raw data was not available, only maps. The source data ranged from 1994 to 2020. However, most data sets were from reports taken at a discrete moment in time and did not include follow up studies. Only the shallow water bathymetry and morphology data (OE_014) were of resolution suitable for assessment of Geographe Marine Park. All entries classified under Physical Extent are publicly available.

3.1.2 Institutional extent

Seven entries were classified as Institutional Extent. The report on the South-West Marine Parks (OE_010) was developed through a comprehensive body of work by the Commonwealth government. A management plan for a ten-year period for the Ngari Capes Marine Park (OE_024) addresses many of the challenges that exist for Geographe Marine Park. OE_019 provides the extent of Ngari Capes Marine Park.

Information on the Institutional Extent has wide spatial coverage across Geographe Bay. The Ngari Capes Marine Park extent and management zones have been formally gazetted and will not be updated until at least 2023. The different zones that have been in place at Geographe Marine Park are mapped in two data entries (OE_018 and OE_027). The entries are high quality as they have been mapped by Government agencies. All entries for Institutional Extent were publicly available.

3.1.3 Ecosystem extent

Twenty-seven entries contain information on Ecosystem Extent. These were primarily studies drawn from Commonwealth databases covering topics of seagrass meadows and rocky reef cover and quality, fisheries, and species diversity indices. Much of the research conducted to date in Geographe Bay focuses on either seagrass meadows health or fisheries, which potentially biases the record towards these topics.

Thirteen entries were classified as Ecosystem Extent with an additional fourteen data entries overlapping with other sub-components. Important ecosystem data can be drawn from reports which show the change in seagrass meadows cover between 2004 and 2007 in the coastal waters of Geographe Bay (OE_001). Qualitative inferences can be made from seagrass meadows presence around the Australian Coastline. These include high quality geospatial data created by the Department of Parks and Wildlife (OE_004). Additional ecosystem data were found for rocky reefs on the Australian continental shelf: one is Geospatial data of biota in specific areas in Western Australia (OE_016); one is Geospatial data of Australian species of national environmental significance (OE_020); and the final entry is Geospatial data of biologically important areas of regionally significant marine species (OE_021).

Of the eleven entries where ecosystem extent was not the focus but still relevant, two entries reported and mapped the broadscale benthic habitats of the Ngari Capes Marine Park (Mul_001 and Mul_002), one entry was a report detailing the benchmarks of seagrass meadows communities and water quality (Mul_003) and another detailed the modelling of seagrass meadows wrack dynamics in Geographe Bay (Mul_004). Three entries were fisheries reports pertaining to the economically important rock-lobster fishery, which included benthic habitat maps (Mul_025, Mul_026 and Mul_027).

Additional ecosystem mapping data covered the entire South-west Marine Region, which included ecosystem information and maps, one data entry was a GIS file which mapped the extent and density of seagrass meadows in the Leschenault Inlet (Mul_034). Two BRUV datasets which were used to create point data of benthic habitat extent were also included. One dataset was outside the marine park in the shallow waters of Geographe Bay (Mul_035) while the other was inside Geographe Marine Park (Mul_036). The final dataset was seagrass meadows shoot density at seven locations in coastal waters of Geographe Bay from 2012 to 2020 (Mul_037).

Information on ecosystem extent varies in coverage and spatial resolution across Geographe Bay. seagrass meadow presence has been mapped extensively in shallow waters, including the Leschenault Inlet. High-resolution GIS data is restricted to half of the Geographe Bay – Ngari Capes Marine Park section. Very little mapping has been done in the deeper waters of Geographe Bay and publicly available data on the mapping is difficult to find. One study in 2016 by National Environmental Research Program (now known as NESP) produced point data of benthic habitat extent and seagrass meadows coverage within Geographe Marine Park (Mul_028). This data is not publicly available but was supplied privately. Ecosystem Extent entries ranged from 2000 to 2019. Most GIS data has been updated and reports are based on localised studies at one point in time.

3.1.4 Context

Three entries focussed on context only: the ecological aspects of the Vasse-Winecup Wetlands Ramsar Site located on the coastline of Geographe Bay (OE_009); a database of navigable water

regulation areas in Western Australia including Geographe Bay (OE_015); and geospatial data of Australian Coastal Waterways Geomorphic Habitat which included Geographe Bay (OE_017).

Four additional entries contain relevant contextual information. This included an overview of National Environmental Research Program Marine Hub survey methodology within the Geographe Bay Commonwealth Marine Reserve (Mul_028). The Australian Exposure Information Platform (AEIP) (Mul_033) provides information on building, businesses, and people; public facilities and infrastructure assets; agricultural commodities, and environmental holdings within the Geographe Bay region.

3.2 Ocean use (designated)

Aquaculture sites in Western Australia are also presented along with the previously mentioned commercial fishing zones. The Exposure Report generated from the Australian Exposure Information Platform, present a wide range of census data such as populations, area and value of agricultural land, primary industries and many other features relevant to the mapping of building, businesses and people; public facilities and infrastructure assets; agricultural commodities, and environmental holdings within the region.

The spatial specificity of data related to the use of Geographe Bay is variable but there are examples of fine level information (for example AMSA). Many data entries contained reports which only summarised and mapped results with no raw data. Entries for this sub-component ranged from 1979 to 2020. Most datasets were based on discrete studies at one moment in time.

3.3 Ocean condition

3.3.1 Physical characteristics

Twelve entries relate to physical characteristics of ocean condition, with six of these sources overlapping with other components. This is not surprising given the link this component has with, for example, the Ocean Extent – Ecosystem component. These data sources were primarily scientific reports which cover the seagrass meadows ecology of Geographe Bay, along with The Busselton Jetty Temperature Dataset (OC_011) and the MARVL3 temperature and salinity dataset (OC_013) which included sites in Geographe Bay. Particular focus is given to the surveys conducted by the Keep Watch group (OC_002 and OC_003) and a collection of university and government published seagrass meadows studies in recent years. These have measured localised physical characteristics which may be interpretable to the assessment of Geographe Marine Park or add relevance to any inferences on climate change in Geographe Marine Park. There is a significant report on the Physical Oceanography of Geographe Bay published in 1994 (Mul_005). While the data inputs may be considered old, these data do supply baseline information against which newer reports can be compared. Several of the sources are limited to state waters, but this information is still representative of seagrass meadows condition making them useful as supporting material.

3.3.2 Chemical characteristics

Six entries relate to chemical characteristics of ocean condition. Two of these sources were the surveys conducted by the Keep Watch group in recent years (OC_002 and OC_003). These sources where focussed on seagrass meadows monitoring, but as is typical in this type of survey, additional measurements referencing the abiotic conditions at each site were taken. Information about nutrients in the water column will be useful to this study.

The other two sources are for an older scientific paper about the status of shallow seagrass meadows (OC_001) and an investigation on herbivory of fish common in seagrass meadows habitats (OC_004). As per the Keep Watch reports (OC_002 and OC_003), these sources contain peripheral information about the chemical conditions at their study areas. Additional sediment quality data were found on the Marine Sediment (MARS) database (OC_014). These data provide information on seabed sediment characteristics for samples collected within Geographe Bay. The final two datasets are the National Outfall Database (OC_017) which monitors data from wastewater outlets around the country and a historical reconstruction of Ocean Acidification in Australian waters from 1870 to 2013 (OC_018). The National Outfall Database has 3 wastewater outlet sites in Geographe Bay. The temporal and spatial resolution of the Chemical related entries was variable, but the scientific nature of collection significantly improves the overall quality of these sources.

3.3.3 Biological characteristics

Seven entries relate to biological condition (OC_016, Mul_003, Mul_004, Mul_029, Mul_030, Mul_031 and Mul_032). All these sources cover multiple sub-components, except for the MODIS Primary Productivity Hotspots (OC_016) which are generated from satellite derived inferences based on chlorophyll-a measurements. As per other components of the inventory, many of these sources are related to seagrass meadows investigations which took place within the last 10 – 15 years and have been published as scientific papers or government reports.

Seagrass meadow quality makes up the predominant theme within the biological context providing consistent temporal coverage, albeit at discrete points in time between 2006 and 2020 (for example Mul_003 and Mul_004). As seagrass meadows is one of the most sensitive and biologically important habitats within the greater Geographe Bay area, federal and state research funding have naturally been concentrated on seagrass meadows. The spatial resolution of the data within this component is generally low, focusing on bioregions, as opposed to localised ecosystems within Geographe Bay. Some of the data found were publicly available.

3.3.4 Ecological characteristics

Of all the accounts related to Ocean Condition, Ecological Condition is the most consistently covered in the source inventory with twenty-three entries. Of these, twelve overlap with other components, but still retain some important information relevant to the Ecological Characteristics of Geographe Bay. The temporal coverage is also good, with most data sets covering the preceding 10 – 15 years.

The data sources, while primarily focused on seagrass meadows ecology, also included investigations on fish species assemblages, the influence on geology, on algal cover and other marine habitats in the greater Geographe Bay area. The Reef Life Surveys (OC_006 and OC_007) and Keep Watch surveys (OC_002 and OC_003) offer annually repeated data sets. Species diversity is well represented in these entries and while the spatial resolution of the data varies between sources, broad inferences may be derived for the entire Geographe Marine Park.

3.4 Ocean asset

3.4.1 Biotic

Thirty-six entries related to the biotic assets of Geographe Bay and the South-west (SW) bioregion. Given that Biotic assets shares many attributes with components such as ecosystem extent and biological characteristics, twenty-seven of these entries were found to overlap with

other components. Of the nine entries that were specifically classified as Biotic Assets, five focussed on cetacean research within Geographe Bay (OA_001, OA_002 and OA_004 to OA_006), one reported the economic contribution of the western rock lobster to the fishing industries in Bunbury and Busselton (OA_003), two global online databases (FishBase and AlgaeBase) (OA_010 and OA_011) describe the ecology of fish species and algae species found in Geographe Bay and the final dataset recorded fish species found in a BRUV survey in the Geographe Commonwealth Marine Reserve (OA_014).

Entries which overlapped with other components included fisheries science reports on fish stock, nursery, recruitment, and detailed areas where fishing was being performed or were vital to fishing in Geographe Bay. Biological data from the broadscale benthic habitats of the Ngari Capes Marine Park was also available, with one entry reporting seagrass meadows communities and water quality (Mul_003) and another presenting a modelling approach to seagrass meadows wrack dynamics within Geographe Bay (Mul_004). The marine industries of Australia's South-west Marine Region are detailed (Mul_026), and although the data are from 2006, it includes information on marine tourism, commercial and recreational fishing, aquaculture, and other living components within the region. These data entries cover Geographe Bay, though higher resolution maps and geospatial data were not accessible. Most data entries were from the preceding 10 – 15 years with little replication between studies and datasets. Global fishing watch provides an indication of fishing effort (which can be a proxy for fish stocks), but this data did not cover Geographe Marine Park (Global Fishing Watch, 2016).

3.4.2 Abiotic

Six entries relate to Abiotic Assets and included geospatial information on marine benthic substrates in Australia (OA_007), Western Australia mining tenements (OA_008), petroleum releases, applications and titles (OA_009) and the final two datasets were 2D and 3d Marine Seismic Surveys (OA_012 and OA_013). There was one data inventory entry classified as Multiple which contained an Abiotic Asset in its classification. It was a report detailing the marine industries of Australia's South-west Marine Region (Mul_024) and although dated, provides some context on oil and gas activities, and other nonliving components within the region.

Geographe Bay was adequately covered by these entries as they were either specific to the region or were state government datasets that fully covered the area. The mining and petroleum datasets are updated as frequently as possible, but the benthic substrate data set was last updated in 2015 and the socio-economic report was published in 2006.

3.5 Ocean services supply and use

3.5.1 Biotic physical

There are twenty-one entries that relate to Biotic Physical Services. Many entries also relate to the other components, with a strong focus on commercial and recreational fisheries. Some of the more common fisheries enjoyed by recreational fishers and targeted by commercial operations include rock lobster (Mul_024 to Mul_027), herring (Mul_007), salmon, crabs (Mul_006 and Mul_009) and squid (Mul_011). While these data sources do not specifically focus on the marine park, the distribution of such species across Geographe Bay in different seasons, migrations, and spawning periods, indicate their importance to the physical biota of the region. Most of the

entries were published in the past 10 – 15 years, but older data are known and can also provide valuable context prior to the expansion of industry and population within the region.

3.5.2 Abiotic physical

There was only one data source, a socio-economic analysis of the marine industries within the region, that met the criteria for abiotic physical (MUL_024). This report contains information that is relevant to other components and presents statistics and maps regarding various socio-economic assets from the South-west Marine Region. The data underlying this 2006 report was collected between the 1990s and 2005 and gives sound if now slightly dated information.

3.5.3 Ocean use

Shipping data was sourced from the Australian Maritime Safety Authority Automatic Identification System (AMSA AIS; OS_013) which contains data on speed, direction, type of vessel, length, breadth, time and latitude and longitude. The temporal resolution of these data ranges from annually (1999-2012) to monthly (2012 onwards) and provides important context on the use of different shipping types throughout the Geographe Bay area. Some fundamental links to Geographe Marine Park can be made with, for example the presence of Cruise ships passing through, the passage of commercial vessels from Bunbury Port and the movement of smaller commercial vessels within the coastal zone.

There are datasets (OS_001 and OS_002) related to commercial fishing, but these do not indicate use at a fine spatial scale. Information on recreational use has been collected as part of a boat ramp survey (MUL_041). Satellite data (Mul_043) could be used to identify recreational fishing vessels but this is a speculative option (see annex 3). The effort required to develop a methodology to process the data is high and testing would be required to validate the methodology.

Tourism data was very difficult to collect (refer to section 3.6.2 for more information). Busselton Jetty, which is one of the most high-profile tourist destinations, provided extensive data on tourist activities, visitor numbers and expenditures at Busselton Jetty and customer feedback from June 2018 to present (OS_009 to OS_012). Data from Tourism Research Australia which included indices such as average visits, activities, nights spent and expenditure in four-year periods from 2005 to 2018 (OS_014) were obtained along with two Department of Transport GIS datasets mapping coastal infrastructure such as boat ramps (DU_003 and DU_004). Information from the ABS data lab (OS_005) and on tourism accommodation (Mul_040) also provides more information on tourism at the LGA level.

3.6 Geographe Bay data assessment gap analysis

3.6.1 Ocean extent

Physical Extent entries have full spatial coverage of Geographe Bay, but their temporal coverage and resolution were poor, with much of the research in Geographe Bay focusing on either seagrass meadows health or fisheries leaving gaps in ecosystems in Geographe Bay other than seagrass meadows. This lean towards these scientific disciplines (as opposed to, for example general ecological investigation on rocky reefs) may bias the inventory, however it is noted that many entries features a multi-disciplinary approach with many topics covered. For example, fisheries research is more likely to be focussed on either commercially viable or recreationally popular species. From a temporal perspective, data ranged from 1994 to 2020, but there were no replicated surveys or studies while fine scale resolution existed only in shallow waters of

Geographe Bay. This resulted in poor coverage of deeper, offshore waters. Given the importance the Indian Ocean and the Leeuwin Currents play, this presents a significant gap in knowledge.

Institutional Extent entries were strongly represented across all categories. This is due to the broad-scale nature of the zones present within Geographe Bay. The entirety of Geographe Bay was covered spatially, along with data being up to date and accurate. All Institutional Extent data is available publicly.

The key gaps identified for Ecosystem Extent were related to their spatial and temporal coverage. Ecosystem Extent entries primarily covered the eastern half of Geographe Bay's coastal waters in high resolution. Coverage everywhere else was either lacking or was poor in coverage and resolution. The most recent survey which mapping benthic habitats was in the NESP 2016 (MUL_028) with finer scale data not being updated in over 10 years. Mapping of benthic coverage within Geographe Marine Park was not publicly available but was provided privately with the most accessible information being textual descriptions in reports.

Ocean Context accounts were limited as the data inventory entries focused on data within Geographe Bay's marine area. Land based datasets, such as Ecological description of RAMSAR wetlands (OE_009), Geomorphic habitats of coastal waterways (OE_017) and the Australian Exposure Information (Mul_033), detail the coastal area of Geographe Bay extensively as there are several key inlets, wetlands, and estuaries in the region.

3.6.2 Use

Other use aspects covered were shipping lanes, aquaculture areas and fishery management boundaries. All these datasets were produced or updated recently and are quite accurate with spatial coverage of the entire Geographe Bay area. Further information on the type and intensity of use could be collected to provide more context to use accounts. Filling in the gaps is not considered possible with the current data entries available on marine use, for example interpolation of datasets across time/space. Options for collecting primary data are discussed in the appendix.

3.6.3 Ocean condition

Ocean Condition was reasonably well covered in comparison with the other components. The primary concern, and one which is a common theme across the components, is that most of the studies were conducted, in relation to an impact (for example seagrass meadows reports pertaining to desalination plant) and at a very small scale. The sum of these reports provides an important perspective on ocean condition and many parameters are recorded including physical, chemical, biological, and ecological parameters. Ocean Condition entries were biased towards seagrass meadows monitoring, which reflects the sensitivity of this part of the ecosystem within Geographe Bay. The temporal coverage in the past decade is good, though older time-series data sets that would enable a time series approach were not readily accessible. This limited the analysis of themes such as climate change and invasive marine pests.

Localised data which may not necessarily cover Geographe Marine Park, could be expanded to a regional level, thus facilitating inferences on ocean condition within Geographe Marine Park. The underlying parameters of such models would have to be robust and relevant to conditions within Geographe Marine Park and a measurement of error would ensure a decision on the appropriateness of such approaches could be made. Other parameters on Ocean Condition can

be developed from global databases of satellite indices. For example, ocean colour, sea surface temperature, turbidity can be estimated, however the spatial resolution may be too low to inform Ocean Accounting at the scale of the marine park. For example, historical sea surface temperature and pH has been reconstructed for Australia (for example OC_018). However, the resolution is one degree which covers the entirety of Geographe Bay. While this may be considered low resolution in relation to Geographe Marine Park, the value of including historical time series when establishing ocean condition outweighs the limitation.

Other data is known to exist but was not received in time. This includes oil spill trajectory modelling held by the Department of Transport (DoT). In addition, the DoT has an oil spill response plan for Geographe Bay which focussed not only on the spill itself, but also has studied the impact a spill would have on the natural and anthropogenic functions of the bay. One of the most important gaps found for Geographe Bay, was a lack of climate change model specific to Geographe Bay. This gap could be filled using inferences from studies on a national scale (Hobday & Lough, 2011).

3.6.4 Ocean assets

Generally, the biotic and abiotic sub-components of Ocean Asset were well represented and covered within the marine park. Biotic information overlapped with other components and data was readily available to describe aquatic plants, marine species, algae, seaweeds, plankton, cetaceans, and fish stock. Geographe Bay has a rich history of whale research, some of which have been identified by the literature review.

From an abiotic perspective, the primary theme investigated was the natural resource sector. In Western Australia, petroleum and mining is mandated by the Department of Mines, Industry Regulation and Safety. They hold one of the most comprehensive spatial datasets on resource tenements, exploration, production (for example OA_008 and OA_009). Given the minimal resource-sector offshore activity in the Southwest (a cursory search on National Offshore Petroleum Safety Environmental Management Authorities historic environmental approvals returned zero entries), there are no gaps in the data entries for this sub-component.

3.6.5 Ocean services supply and use

Geographe Bay contributes to 13 commercial fisheries with management plan boundaries found within the Geographe Bay region. Numerous data entries relate to ocean supply and use. These datasets vary in their relevance to Geographe Marine Park and their spatial resolution. OS_001 to OS_008 are most relevant for the accounts. Biotic services are covered in greater detail than abiotic services because of a lack of human activity related to abiotic services.

Use entries focused on tourism data for the region. Unfortunately, very little tourism data is publicly available for Geographe Bay, as this is typically private business information. Busselton Jetty data and Tourism Research Australia (OS_014) data for the Busselton region was obtained. Anecdotal evidence provided by some tourism operators suggest that tourism activity in Geographe Marine Park is minimal. More information across key tourism activities relevant to Geographe Marine Park, for example, diving, could be obtained by surveying local businesses.

3.6.6 Other

The entries for all components are absent of any input from the Traditional Owners of Southwest Australia as they were deemed to be out of scope. All components can benefit greatly from direct input from traditional owners.

4 Assessment of data for accounting

Section 3 indicates that there is a wealth of data in Geographe Bay that can be used for ocean accounting. However, there are gaps in both the spatial and temporal coverage of these datasets. The purpose of this section is to assess the suitability of existing datasets to be included in specific ocean accounts (see Table 1) for Geographe Marine Park. Commentary is provided on the effort required to produce account ready data, missing data, and strategies for populating absent datasets.

This section also comments on the production of national scale accounts using the data provided in the inventory. Accounts can be generated at varying degrees of accuracy. Decision makers should consider the level of accuracy that is required for national accounts when selecting datasets. Greater accuracy and greater spatial heterogeneity in the data that underpins the accounts will require more effort.

4.1 Ocean extent

The compilation of extent accounts is pivotal to compiling ocean accounts. Complete extent accounts require polygonal or raster data that has full coverage of Geographe Marine Park. Extent accounts can be compiled with areas classified as "missing" where polygonal data does not exist. Modelling can be employed to fill the missing data. The classification of marine ecosystems will be described in the methodologies report.

4.1.1 Seagrass meadows

There are three datasets (OE_001 and OE_003, OE_004) that contain polygonal seagrass meadows extent data for Geographe Marine Park. Seamap Australia (OE_025) combines extent datasets (for example, OE_004) from different sources to produce a national dataset (see Table 5). It does not provide additional coverage to OE_001 and OE_003, OE_004. The spatial coverage of OE_001 and OE_003, OE_004 datasets is low, and the area they cover overlap. The data can be merged, with OE_004 used as the primary dataset due to the increased detail.

MUL_036 contains presence absence data for Geographe Marine Park. The point data is extensive and extends into areas of the marine park which OE_001 and OE_003 do not. Presence absence data is not account ready, but it can be used to understand the ecosystems that exist in areas not covered by polygonal data.

There is missing data for seagrass meadows extent in Geographe Marine Park. It is of high importance to cover this gap as the delineation of different ecosystems is central to the production of other accounts.

Table 5 Seagrass meadows extent data

Approach	Input data	Data type	Transformation	Effort	Coverage	Quality score
1	OE_001	Polygonal	Merge OE_001, OE_003 and OE_004	Low	Partial inshore part of park	87%
	OE_003	Polygonal				68%
	OE_004	Polygonal				80%
2	MUL_036	Point	None	Low	Extensive point data	72%

The low coverage of Geographe Marine Park can be extended by modelling. There are different options for doing this (see Table 6). A crude but low effort option is to use the presence absence data (MUL_036) to estimate coverage. This approach involves multiplying the proportion of observations that are seagrass meadows by the area of the marine park. It does not produce a spatial layer. Another option is to determine relationships between polygonal data (OE_001 and OE_003) and other datasets, for example bathymetry (OE_013 and OE_014) and primary productivity (OC_016), and then use this to extrapolate existing polygonal data. The bathymetry and primary productivity data have full coverage of Geographe Marine Park and depending on the strength of the relationship between these layers and the extent layers, coverage of Geographe Marine Park could be high. The resulting dataset is a spatial layer. Alternatively, the presence absence data can be interpolated using advanced geostatistical procedures (for example kriging) to generate an estimated coverage layer.

Table 6 Seagrass meadows extent modelling options

Approach	Input data	Data type	Modelling	Effort	Coverage
1	MUL_036	Point	Proportional estimate	Medium	All
2	OE_001 OE_003 OE_004 OC_013 OC_016	Polygonal Polygonal Raster Raster	Determine relationship and extrapolate	High	Partial or all, depending on the relationship that can be determined between key datasets
3	MUL_036	Point	Interpolate – Kriging	Very high	All

Due to the low coverage of Geographe Marine Park and the small number of samples, the results of the modelling approaches could be improved. Additional sampling would assist. An additional survey was intended to sample and model habitats in GMP in 2020. This would have been a valuable input, but it did not proceed due to Covid-19.

4.1.2 Rocky reef

There are three datasets (OE_004, OE_007 and OE_008) that contain polygonal rocky reef extent data for Geographe Marine Park. The spatial coverage of OE_004, OE_007 and OE_008 is low, and the area they cover overlap. The data can be merged, with OE_004 used as the primary dataset due to the increased detail (Table 7).

MUL_036 contains presence absence data for Geographe Marine Park. The point data is extensive and extends into areas of the marine park which OE_004, OE_007 and OE_008 do not. Presence absence data is not account ready, but it can be used to understand the ecosystems that exist in areas not covered by polygonal data.

There is missing data for rocky reef extent in Geographe Marine Park. It is of high importance to cover this gap as the delineation of different ecosystems is central to the production of other accounts.

Table 7 Rocky reef extent data

Approach	Input data	Data type	Transformation	Effort	Coverage	Quality
1	OE_004 OE_007 OE_008	Polygonal Polygonal Polygonal	Merge OE_004, OE_007 and OE_008	Low	Partial inshore part of park	80% 90% 88%
2	MUL_036	Point	None	Low	Extensive point data	72%

The approach to modelling is consistent with the description in Table 6, replacing OE_001 and OE_003, with OE_007 and OE_008 in approach 2.

4.1.3 Macroalgae

There is one dataset (OE_004) that contains polygonal macroalgae extent data for Geographe Marine Park (Table 8). The spatial coverage of OE_004 is low. MUL_036 contains presence absence data for Geographe Marine Park. The point data is extensive and extends into areas of the marine park where OE_004 does not. Presence absence data is not account ready but can be used to understand the ecosystems that exist in areas not covered by polygonal data.

There is missing data for extent in Geographe Marine Park. It is of high importance to cover this gap as the delineation of different ecosystems is central to the production of other accounts.

Table 8 Macroalgae extent data

Approach	Input data	Data type	Transformation	Effort	Coverage	Quality
1	OE_004	Polygonal	OE_004	Low	Partial inshore part of park	80%
2	MUL_036	Point	None	Low	Extensive point data	72%

The approach to modelling is consistent with the description in Table 6, removing OE_001 and OE_003 in approach 2.

4.1.4 Sandy bottoms

There is one dataset (OE_004) that contains polygonal sandy bottom extent data for Geographe Marine Park (Table 9) The spatial coverage of OE_004 is low. MUL_036 contains presence absence data for Geographe Marine Park. The point data is extensive and extends into areas of the marine park where OE_004 does not. Presence absence data is not account ready but can be used to understand the ecosystems that exist in areas not covered by polygonal data.

There is missing data for extent in Geographe Marine Park. It is of high importance to cover this gap as the delineation of different ecosystems is central to the production of other accounts.

Table 9 Sandy bottoms extent data

Approach	Input data	Data type	Transformation	Effort	Coverage	Quality
1	OE_004	Polygonal	OE_004	Low	Partial inshore part of park	80%
2	MUL_036	Point	None	Low	Extensive point data	72%

The approach to modelling is consistent with the description in Table 6, removing OE_001 and OE_003 in approach 2.

4.1.5 Providing context to extent accounts for Geographe Marine Park

The relative scarcity or abundance of different ecosystem types in Geographe Marine Park is understood by accounting for ecosystems outside of the accounting area. It is suggested that ecosystem extent accounts are compiled for Geographe Bay, by the State (0-3nm) and Commonwealth waters (3nm outwards). Extent accounts could also be populated for the State and Australia.

4.1.6 National accounts

Seamap Australia could be used as a priority dataset to produce national accounts. Seamap contains data on ecosystem extent across the marine and coastal areas of Australia. However, there is missing data and data is stronger for State waters than Commonwealth waters. There could be other data sets available to classify ecosystem extent that have not been added to Seamap. A more targeted approach to data collection would be required to understand the types of data that exist to model data in each state and territory. It would involve the use of a number of local datasets. Where local data does not exist, surveys are likely to be necessary to fill in the gaps.

4.2 Ocean condition

Complete condition accounts require polygonal or raster data that has full coverage of Geographe Marine Park. However, condition accounts can be compiled with areas classified as "missing" where polygonal data does not exist, or modelling can be employed to fill the missing data.

The approach to measuring condition using different metrics (for example, fish stock abundance, indicator species), determining a reference level for condition, how to aggregate condition accounts for the accounting area will be presented in the methodologies report.

4.2.1 Seagrass meadows condition

There are three data sets with point data for Geographe Marine Park that could be used to compile seagrass meadows condition accounts. OE_026 provides information on ecological characteristics (cover and water quality) for four locations in Geographe Marine Park (Table 10). MUL_003 can also be used to compile seagrass meadows condition accounts. It contains four points within Geographe Marine Park. However, the data is copyrighted and requires permission from the authors to use. Condition indicators that could be compiled from MUL_003 include the mean abundance of fish and water quality, but the spatial coverage is low. MUL_036 contains presence absence data on fish assemblages for Geographe Marine Park. The point data is extensive and extends into areas of the marine park where MUL_036 does not. Condition

indicators that could be compiled from MUL_036 include the mean abundance of fish and diversity of fish, presence of indicator species, and seagrass meadows coverage. Point data is not account ready as it does not refer to a polygon. OC_15 is a measure of species richness but is low resolution and covers the entire Geographe Marine Park.

There is missing data for seagrass meadows condition in Geographe Marine Park. It is of high importance to cover this gap as measures of condition provide an indication of degradation of natural systems.

Table 10 Seagrass meadows ecosystem condition data

Approach	Input data	Data type	Transformation	Effort	Coverage	Quality
1	OE_026	Point	Compile condition indicator	Medium	4 points – low coverage	68%
2	MUL_003	Point	Compile condition indicator	Medium	4 points – low coverage	88%
3	MUL_036	Point	Compile condition indicator	Medium	Extensive point coverage	72%
4	OC_15	Grid	Compile condition indicator	Medium	Geographe Marine Park	78%

The condition data referred to in approach 1, 2 and 3 is point data for Geographe Marine Park. To get complete coverage, it is necessary to extrapolate the condition measures by ecosystem type. This could be done using the extent layer formed in section 4.1. An alternative approach is to interpolate OC_15 (Table 11).

An alternative option for seagrass meadow is to use change in extent as a measure of condition. For example, where seagrass meadows ecosystems have been converted to bare sediment and then has been reconverted to seagrass meadows ecosystem could be low condition. This approach would require a time series of ecosystem extent at high spatial resolution. Repeat sampling for ecosystem extent in Geographe Marine Park does not exist.

Table 11 Seagrass meadows condition modelling options

Approach	Input data	Data type	Modelling	Effort	Coverage
1	MUL_003	Point	Extrapolate by extent layer	High	Partial (small) coverage – small number of points
2	MUL_036	Point	Extrapolate by extent layer	High	Partial - full coverage
3	OC_15	Grid	Interpolate	High	All

Measures of species presence/absence proxy for condition. Observations from the KeepWatch Seagrass Meadow Monitoring Program (OC_002) in Ngari Capes Marine Park and other coastal waters in Geographe Bay, can be used as an example to demonstrate ecological condition accounts for Geographe Marine Park (Table 12). The data provides seagrass meadow shoot density, algal epiphyte cover and seagrass meadows leaf nutrient content, and nitrogen isotope signals from 2012 to 2019.

Table 12 Seagrass meadow ecosystem data, state waters

Approach	Input data	Data type	Transformation	Effort	Coverage	Quality
1	OC_002	Point	Compile condition indicator	Medium	8 points - outside of GMP	83%

4.2.2 Rocky reef condition

There are four data sets with point data for Geographe Marine Park that could be used to compile condition accounts (Table 13). OC_008 includes 4 points with invertebrate species and OC_009 includes four points with fish species. Both datasets are collected in 2017 and 2019, providing an opportunity to do condition accounts at two points in time. Count, presence of key species and diversity could be used as an indicator of condition. OC_007 provides information on one location in GMP where three indicators of reef condition were calculated: the biomass of large reef fishes, the community temperature index, and an IUCN threatened species index. Two transects at one site were taken in Geographe Marine Park, with two transects taken at six other sites in Geographe Bay.

MUL_036 contains presence absence data on fish assemblages for Geographe Marine Park. The point data is extensive and extends into areas of the marine park where OC_008, OC_009 and OC_006 does not. Condition indicators that could be compiled from MUL_036 include the mean abundance of fish and diversity of fish. Point data is not account ready as it does not refer to a polygon. OC_15 is a measure of species richness but is low resolution and covers the entire Geographe Marine Park.

There is missing data for rocky reef condition in Geographe Marine Park. It is of high importance to cover this gap as measures of condition provide an indication of the degradation of natural systems.

Table 13 Rocky reef condition data

Approach	Input data	Data type	Transformation	Effort	Coverage	Quality
1	OC_007	Point	Compile condition indicator	Medium	1 point – low coverage	88%
2	OC_008	Point	Compile condition indicator	Medium	4 points – low coverage	95%
3	OC_009	Point	Compile condition indicator	Medium	4 points – low coverage	95%
4	MUL_036	Point	Compile condition indicator	Medium	8 points - outside of GMP	72%
5	OC_15	Grid	Compile condition indicator	Medium	Geographe Marine Park	78%

The condition data referred to in Table 13 is point data for Geographe Marine Park. It is necessary to extrapolate the condition measures by ecosystem type to get complete coverage.

This could be done using the extent layer formed in section 4.1. An alternative approach is to interpolate OC_15 (Table 14).

Table 14 Rocky reef condition modelling options

Approach	Input data	Data type	Modelling	Effort	Coverage
1	OC_007 OC_008 OC_009	Point	Extrapolate by extent layer	High	Partial (small) coverage – small number of points
2	MUL_036	Point	Extrapolate by extent layer	High	Partial (high) - full coverage
3	OC_15	Grid	Interpolate	High	All

4.2.3 Other condition measures

Information on other elements of condition such as temperature (OC_013) and primary productivity (OC_016) could be used to produce condition accounts for Geographe Marine Park (Table 15). While not a direct measure of ecosystem health or water quality, these variables suggest the climate context – an important driver of ecosystem condition. Temperature data does not have complete spatial coverage Geographe Marine Park. It is of high importance to cover this gap. Primary productivity measures have complete spatial coverage.

Table 15 Other condition accounts data

Approach	Input data	Data type	Transformation	Effort	Coverage	Quality
1	OC_013	Point	Compile condition indicator	Medium	Extensive coverage	87%
2	OC_016	Grid	Compile condition indicator	Low	Full coverage	85%

To get complete coverage, it is necessary to interpolate the condition measures for Geographe Marine Park (Table 16).

Table 16 Other condition accounts modelling options

Approach	Input data	Data type	Modelling	Effort	Coverage
1	OC_013	Point	Interpolate	Medium	Full coverage
2	OC_016	Grid	Interpolate	Medium	Full coverage

4.2.4 Carbon stock and flow

Observations from MUL_038 can be used to compile carbon stock accounts for seagrass meadows ecosystems in Geographe Marine Park (Table 17). Only one of the core samples is located within the limits of Geographe Marine Park, with three other cores sampled in other areas of the bay. It is of high importance to cover this gap.

Table 17 Carbon data

Approach	Input data	Data type	Transformation	Effort	Coverage	Quality
1	MUL_038	Point	None	Low	One point - partial	92%

The low coverage of Geographe Marine Park can be extended by modelling (Table 18). Carbon stocks for seagrass meadows can be estimated on a per hectare basis using average soil stocks for the climate region that contains Geographe Marine Park. Stock accounts require an opening and a closing balance. Measurement of net carbon flows into Geographe Marine Park can be estimated by levels of soil sequestration.

Table 18 Carbon modelling options

Approach	Input data	Data type	Modelling	Effort	Coverage
1	MUL_038	Point	Extrapolate	Medium	Seagrass meadow ecosystems

Due to the low coverage of Geographe Marine Park and the small number of samples, the results of the modelling approaches could be improved. Additional sampling would assist.

4.2.5 National accounts

No national dataset exists for seagrass meadows condition. A coordinated approach across each state and territory would be required to collect data for national seagrass meadows condition accounts. Data from the Reef life surveys could be used to produce national rocky reef condition accounts. Information from photoquadrat would provide additional robustness to measures of condition. However, the spatial coverage of processed photoquadrat information is poor compared to of fish and invertebrate observations. Time is required to process this information. Similar to the experience in Geographe Marine Park, methodological issues associated with extrapolating these observations will exist. Carbon stock and flow accounts could be measured nationally for seagrass meadows, Mangrove and Saltmarsh ecosystems using MUL_038. Additional sampling will strengthen the accuracy of accounts.

4.3 Ocean asset

4.3.1 Western rock lobster

There are two datasets with grid data for Geographe Marine Park that could be used to compile rock lobster asset accounts. OS_001 and OS_002 contain data on catch (kg) for each species by 10 by 10 NM and 60 by 60 NM grids respectively (see Table 19). Data ranges from 2015 to 2019. There are high number of unreported quantities due to the lack of commercial fishing activity in the area. Data is not reported where there are less than three operators in a block.

Anecdotal evidence suggests GMP is on the southern edge of the distribution of western rock lobster and there would only be a small proportion of the catch taken in Geographe Marine Park. The Department of Primary Industries and Regional Development has a stock assessment model, but it does not produce information at the fine resolution of the Geographe Marine Park area. There is no data reported for the western rock lobster at 10 by 10 nm blocks. Data is available for the 60 by 60 NM blocks.

Data exists that can be used for western rock lobster stock accounts. The upper section of Geographe Marine Park intersects the 60 by 60 nm block. Catch rates can be followed over time to understand how stocks are changing, given other information is accounted for (for example, effort and number of vessels).

Table 19 Western rock lobster data

Approach	Input data	Data type	Transformation	Effort	Coverage	Quality
1	OS_001	Grid	None	Low	No data for 10 by 10 NM blocks within GMP due to low number of operators	90%
2	OS_002	Grid	None	Low	Data for 60 by 60 NM block contains upper portion of GMP. No data for lower area of GMP.	87%

The data referred to in Table 19 is grid data for a spatial area that is larger than Geographe Marine Park. It is necessary to interpolate data to get the required spatial resolution for accounting in Geographe Marine Park (see Table 20).

Table 20 Western rock lobster modelling options

Approach	Input data	Data type	Modelling	Effort	Coverage
1	OS_001	Grid	Interpolate using per hectare estimate	Medium	Upper portion of Geographe Marine Park

4.3.2 Whales

Observations from "first evidence supporting the classification of Geographe Bay as a southern right whale aggregation area (2019)" could be used to compile seasonal stock accounts for the southern right whale (see Table 21). The study recorded more than 40 unique individuals over the eight-year period, including >10 nursing females. At least 2-7 nursing mothers were recorded during five of the years. However, this data has not been published yet. Additional conversations are required with the authors.

Transformation for this account is expected to be low if data is available for use. Additional discussions with the data custodian are required to proceed with this account. The data refers to a portion of Geographe Marine Park only.

Table 21 Whale data

Approach	Input data	Data type	Transformation	Effort	Coverage	Quality
1	OA_001: OA_002 & OA_004: OA_006	Point	None	Low	Partial	92%

4.3.3 Other species

There are two datasets with grid data for Geographe Marine Park that could be used to compile several other asset accounts across different species. OS_001 and OS_002 contain data on catch (kg) for each species by 10 by 10 NM and 60 by 60 NM grids, respectively. Data ranges from 2015 to 2019 (see Table 22). There are high number of unreported quantities due to the lack of commercial fishing activity in the area. Data is not reported where there are less than three operators in a block.

Data is reported for a 10 by 10 nm block which contains the north western section of GMP. The species reported on are dhufish (2015-2019), pink snapper (2015-2019), bight redfish (2019) and dusky whaler (2016). There is data reported for a 10 by 10 nm block which contains a very small area of the small south western section of GMP. The species reported on are dusky whaler (2016), gummy shark (2016), hammerhead shark (2016) and roe's abalone (2019). Data is available for the 60 by 60 NM blocks. There are a range of species that are covered including octopuses, Australian herring, sandy sprat, Australian dhufish, west Australian salmon, and yellowfin whiting.

The upper portion of GMP is approximately 10 % of the upper 60 by 60nm block while the lower portion of GMP makes up 60 % of the lower 60 by 60 nm block. Catch rates can be followed over time to understand how stocks are changing, given other information is accounted for (for example, effort and number of vessels).

Table 22 Other species data

Approach	Input data	Data type	Transformation	Effort	Coverage	Quality
1	OS_001	Grid	None	Low	Some data for blocks which have partial coverage of Western area of the park	90%
2	OS_002	Grid	None	Low	Data for large blocks that cover GMP	87%

The data referred to in Table 22 is grid data for a spatial area that is larger than Geographe Marine Park. It is necessary to interpolate data to get the required spatial resolution for accounting in Geographe Marine Park (see Table 23).

Table 23 Other species modelling options

Approach	Input data	Data type	Modelling	Effort	Coverage
1	OS_001	Grid	Interpolate using per hectare estimate	Medium	All

4.3.4 National accounts

None of the suggested datasets could be used individually to compile national accounts. However, they can be used to produce state accounts. A coordinated effort across the different states and territories would be required to piece together the different information sets to produce national accounts.

4.4 Ocean Services Supply and Use

4.4.1 Carbon related services

Observations from MUL_038 can be used to compile carbon sequestration accounts for seagrass meadows ecosystems in Geographe Marine Park (see Table 24). The data provides estimates of seagrass meadows sequestration rates across 36 different locations in Australia. None of these are in Geographe Bay. It is of high importance to cover this gap.

Table 24 Carbon related services data

Approach	Input data	Data type	Transformation	Effort	Coverage	Quality
1	MUL_038	Point	None	Low	No points	92%

The low coverage of Geographe Marine Park can be extended by modelling (see Table 25). Carbon stocks for seagrass meadows can be estimated on a per hectare basis using average sequestration rates for the climate region that contains Geographe Marine Park, calculated by Serrano et al., (2019).

Table 25 Carbon related services modelling options

Approach	Input data	Data type	Modelling	Effort	Coverage
1	MUL_038	Point	Extrapolate	Medium	Seagrass meadow ecosystems

Due to the low coverage of Geographe Marine Park and the small number of samples, the results of the modelling approaches could be improved. Additional sampling would assist. Carbon stock and flow accounts could be measured for both Mangroves and Saltmarsh using this dataset.

4.4.2 Economic value of commercial fisheries

There are two datasets with grid data for Geographe Marine Park that could be used to compile the value of commercial fisheries (see Table 26). OS_001 and OS_002 contain data on catch (kg) and value ($) for each specie by 10 by 10 NM and 60 by 60 NM grids, respectively. Data ranges from 2015 to 2019. Trends in catch can be used to infer asset quantities. There are high number of unreported quantities due to the lack of commercial fishing activity in the area. Data is not reported where there are less than three operators in a block.

Anecdotal evidence suggests GMP is on the southern edge of the distribution of western rock lobster and there would only be a small proportion of the catch taken there. There is no data reported for the western rock lobster at 10 by 10 nm blocks. Data is available for the 60 by 60 NM blocks. The upper portion of GMP makes up approximately 10 % of that 60 by 60 nm block.

Data is reported for a 10 by 10 nm block which contains the north western section of GMP. The species reported on are dhufish (2015-2019), pink snapper (2015-2019), bight redfish (2019) and dusky whaler (2016). There is data reported for a 10 by 10 nm block which contains a very small area of the small south western section of GMP. The species reported on are dusky whaler (2016), gummy shark (2016), hammerhead shark (2016) and roe's abalone (2019). Data is available for the 60 by 60 NM blocks. There are a range of species that are covered including octopuses, Australian herring, sandy sprat, Australian dhufish, west Australian salmon, and yellowfin whiting.

Data exists that can be used to estimate the economic value of commercial fisheries for a range of species. Geographe Marine Park intersects the 10 by 10 NM and the 60 by 60 NM blocks. Data needs to be apportioned to Geographe Marine Park.

Table 26 Commercial fisheries data

Approach	Input data	Data type	Transformation	Effort	Coverage	Quality
1	OS_001	Grid	None	Low	Some data for blocks which have partial coverage of Western area of the park	90%
2	OS_002	Grid	None	Low	Data for large blocks that cover GMP	87%

The data referred to in Table 26 is grid data for a spatial area greater than Geographe Marine Park. It is necessary to interpolate data to get the required spatial resolution for accounting in Geographe Marine Park (see Table 27).

Table 27 Commercial fisheries modelling options

Approach	Input data	Data type	Modelling	Effort	Coverage
1	OS_001	Grid	Interpolate using per hectare estimate	Medium	All

A report by ACIL Allen can also be used to understand the economic value of rock lobster in Geographe Marine Park (OA_003). There are approximately three boats operating near the South West region, which is inclusive of Busselton and Bunbury. These account for approximately 1% of the total western rock lobster annual catch.

4.4.3 Economic value of recreational fisheries

Information on the value of recreational fisheries (catch) could be improved. Engagement with RecFishwest and the Department of Primary Industries and Regional Development is ongoing. Public information on recreational fishing provided by DPIRD is at a bioregional scale (OS_006) (Table 28). Businesses were contacted for information on recreational fishing activities but did not respond. Information from BLADE (OS_005) could be used to gauge employment and income associated with recreational fishing activities. Information on the proportion of trips to Geographe Marine Park (MUL_041) could be used to apportion income generated by recreational fishing to that area.

Table 28 Recreational fisheries data

Approach	Input data	Data type	Transformation	Effort	Coverage	Quality
1	OS_006	Polygon - bioregion	None	Low	GMP is contained within the south west bioregion.	72%

Estimates of the recreational catch and effort range can be prorated using an average per hectare estimate (Table 29).

Table 29 Recreational fisheries modelling options

Approach	Input data	Data type	Modelling	Effort	Coverage
1	OS_006	Polygon - bioregion	Interpolate using per hectare estimate	Medium	GMP

4.4.4 Seagrass meadows nursery services supporting a key fish species

A recently published academic paper can be used to estimate nursery services provided by seagrass meadows (see Table 30). OS_008 can be used to estimate nursery services for tarwhine, sea mullet and King George whiting. OS_008 is preferred to OS_007 which is a slightly more dated paper.

Table 30 Seagrass meadows nursery services data

Approach	Input data	Data type	Transformation	Effort	Coverage	Quality
1	OS_008	per hectare value	None	Low	None	90%

Per hectare figures can be used to determine the nursery service provided by seagrass meadows presence (see Table 31). Care is required when counting seagrass meadows nursery services as they are generally captured in recreational and commercial fish catch.

Table 31 Seagrass meadows nursery services modelling options

Approach	Input data	Data type	Modelling	Effort	Coverage
1	OS_008	per hectare value	Multiply by seagrass meadows area	Low	Seagrass meadows ecosystems

4.4.5 Number of recreational fishing visits and time spent

Number of recreational fishing visits and time spent is a current gap. Recfishwest do not collect data on visitation. The Australian Recreational Fishing Foundation (ARFF) launched an initiative named the Tackle Box project in 2019. The project uses recreational fishing citizen science and digital approaches to optimise sustainability and engagement of recreational fishers in Australian Marine Parks on a national scale. Investigation into this data is ongoing.

GPS data can be collected from phone applications when people provide consent to providers (MUL_039). This data could be used by to determine a lower bound to all activities in marine areas. The data does not contain an activity field so there is no way of determining the user's activity type. For example, the phone user could be on a cruise ship, could be a local diver or a recreational fisher. The sample obtained from Predicio did not display many observations for the marine environment as compared to the terrestrial environment.

There is no modelling approach that can be used to estimate recreational fishing in Geographe Marine Park with accuracy. Surveys are used to ascertain visitation numbers as visitation is highly variable. Building a model to estimate recreational fishing visitation spatially using other

factors (for example, population, tourism visitation, distance from shore), would require a large investment and would need to be verified using survey information.

4.4.6 Recreational activities

Data on recreational activities in Geographe Marine Park is scarce. Information provided by a tourism operator suggests there are 20,000 people who go on whale watching trips in Geographe Bay each year. Anecdotal evidence suggests there is little other paid recreational activities, for example diving, in Geographe Marine Park. Other recreational activities that are not part of the tourism economy, for example diving and recreational fishing by locals, have not been captured.

Discussions with one tourism operator indicated that they service 5000 people per year. There are four operators. The tourism dataset (OS_013) suggests that 28,000 domestic tourism activities were recorded as "Go whale or dolphin watching - Go on guided tours - Charter boat / cruise / ferry - Visit the Reef". Not enough information has been obtained to be able to apportion whale watching trips to Geographe Marine Park.

4.4.7 Tourism

ABS data (OS_005) contains information on employment and visitor expenditure across Busselton businesses. MUL_041 also contains information on accommodation in the Busselton LGA including establishments, room nights occupied and average takings per room night occupied. Apportioning this information to Geographe Marine Park appears to be difficult without additional information. It is highly likely that only a small amount of the employment and expenditure could be attributed to Geographe Marine Park with whale watching being the key activity that occurs there.

Tourism data from Tourism Research Australia (OS_013) has been provided for Busselton by activity. These activities have been grouped together due to sample size. As discussed earlier in the report, there are a small number of tourism activities that take place in Geographe Marine Park. Visitation numbers presented in Table 32 are likely to be a subset of total activities as they do not include international visitors or local recreational activities. OS_013 also links activities to average stay and expenditure.

Table 32 Average domestic visitors by activity, Busselton local government area, 2015 to 2018

Fishing (000's)	Water activities / sports (000's)	Go whale or dolphin watching (000's)
77.5	43.75	27.75

Note: Water activities/sports includes "sailing, windsurfing, kayaking, scuba diving, snorkelling" and go whale or dolphin watching includes "go on guided tours, charter boat / cruise / ferry – visit the reef"

Prices could also be used to determine the revenue associated with fishing activities. However, it is not clear how many fishers actually use Geographe Marine Park compared to the rest of the area. Prices could be used to estimate visitor expenditure on whale watching with the caveat being that this activity may not be specific to Geographe Marine Park. Valuation of whale watching is possible using per trip information from online – $90 AUD per adult and $50 AUD per child (All Sea Charters, 2019).

4.4.8 National accounts

Carbon services (MUL_038) and tourism related services (OS_005, MUL_041 and OS_013) can be measured at a national level. A coordinated effort across the different states and territories would be required to piece together the different information sets for the other accounts.

4.5 Ocean use

Use accounts cover a range of human activities for Geographe Marine Park and show the environmental dependencies of business across the marine park. Polygonal (aquaculture license areas) and point data (number of visitors) can be used to represent these dependencies. Ideal use accounts should show the area of use, the intensity of use and the type of use/management activity. There should be a distinction between the types of use. For example, a small fishing boat is likely to have a different type of potential pressure on the marine environment compared to a large fishing boat.

The classification of use data will be described in more detail in the methodologies report.

4.5.1 Vessel use

Observations from the Australian Maritime Safety Authority (AMSA) Automated Identification System (AIS) can be used compile vessel use accounts for in Geographe Marine Park (Table 33). The dataset contains point data on speed, direction, type of vessel, length, breadth, time from 2012 to 2020. This dataset provides an indication of use within Geographe Marine Park for passenger, commercial fishing, and other commercial vessels, but will not pick up smaller vessels such as recreational fishing and diving vessels. It is common for fishing vessels to turn their AIS off. Vessels do this to evade pirates, or not have their location known by competitors or illegal fishers. Knowing where the vessels travel, and harvest is valuable information.

Table 33 Vessel use data

Approach	Input data	Data type	Transformation	Effort	Coverage	Quality
1	OS_013	Point	None	Low	Extensive point data	98%

There is missing data for smaller vessels and some potentially commercial fishing vessels. A request for data has been made to the Australian Fisheries Management Authority to fill this gap. No modelling approaches exist for the estimation of use patterns by small vessels.

4.5.2 Expenditure accounts

The intention is to attribute Parks Australia management expenditure to different spatial areas of Geographe Marine Park. This could be expenditure on staff costs associated with patrols or expenditure on fixed and variable costs associated with restoration and rehabilitation works. Expenditure on staff costs will need to consider the fixed costs associated with non-project officers and their role in supporting project officers.

The extent to which this is possible, depends on how expenditure data is recorded by Parks Australia. Spatially explicit information on expenditure will enable notions of return on investment (expenditure), where investment in the marine environment is correlated with a change in the services provided. For example, expenditure on ecosystem rehabilitation may be correlated with increased fish assemblage, because of improved condition of seagrass meadows habitats which in turn provides nursery services to fish. The expenditure account does not

measure these benefits but can be linked to accounts that do. The key feature in integrating accounts is the consistent spatial units (discussed in more detail in the methodologies report).

At the time of writing this report, there is missing data for expenditure. Transformation for this account is expected to be low effort if data is of high spatial resolution. Data will be harder to use and less useful if it is low resolution.

4.5.3 Commercial and Recreational fishing use

Information associated with fish catch (OS_001 and OS_002) can be used to estimate use of Geographe Marine Park by commercial fisheries. The data is low resolution (10 by 10 nm blocks) and does not give exact locations of fishing vessels. The data can be used in to infer the number of commercial fishery operators that operate in the area, but not the frequency of their visits (Table 34). There are also issues with apportioning the information from OS_001 and OS_002 which will be described in more detail in the methodologies report.

Australian Commonwealth fishers are required to install Vessel Monitoring Systems (VMS), a dedicated satellite monitoring system that cannot be switched off. This system, rather than the Automatic Identification Systems monitored by AMSA, is used by the Australian Fisheries Management Authority (AFMA) to monitor vessel position, course, and speed. Australian commercial fishers may turn their AIS off for a range of reasons while VMS must be kept on while at sea. This data is not accessible to anyone other than AFMA; it would be commercially valuable information to know where each fisher goes to harvest.

Recreational fishing data is available for Geographe Marine Park as part of a recent boat ramp survey (MUL_041). This data provides an indication of the relative use of different areas within Geographe Marine Park, but it does not provide an estimate of total numbers of users. Satellite data (Mul_043) could also be used to identify recreational fishing vessels but this is a speculative option. The effort required to develop a methodology to process the data is high and testing would be required to validate the methodology.

Table 34 Commercial and recreational fishing activity

Approach	Input data	Data type	Transformation	Effort	Coverage	Quality
1	OS_001 OS_002	Grid	None	Low	Larger area which contains GMP	90% 87%
2	MUL_041	Polygonal	None	Low	GMP	97%
3	MUL_043	Raster	Process data	Extremely high	Australia	97%

The data referred to in Table 34 as part of approach 1 is grid data for a spatial area greater than Geographe Marine Park. It is necessary to interpolate data to get the required spatial resolution for accounting in Geographe Marine Park (see Table 35). No modelling is required for approach 2.

Table 35 Commercial and recreational fishing activity modelling options

Approach	Input data	Data type	Modelling	Effort	Coverage
1	OS_001	Grid	Interpolate using per hectare estimate	Medium	Upper portion of Geographe Marine Park
2	MUL_041	Polygonal	None	Low	GMP

4.5.4 Other recreational activities

There are no high-resolution spatial datasets that contain information on visitation to Geographe Marine Park. Anecdotal evidence suggests that little tourism activities occur in the marine park. Water activities such as sailing, windsurfing, and kayaking occur inshore, with scuba diving and snorkelling mainly occurring within coastal waters near Busselton Jetty and the HMAS Swan wreck site. The 4-mile reef is one area within the marine park where locals dive and hunt fish but there is no quantitative information on this activity. One tourism company suggested that they only visited the 4-mile reef site twice each year since 2018.

Whale watching is one activity where vessels venture into the marine park. Four whale watching operators were found on Trip Advisor. Whale watching only occurs between September and November, approximately 90 days. Websites of the operators suggest that they make 2 trips per day. There is no information about where the activity takes place. Assuming that each whale watching trip ventures into the marine park, there are 720 trips to the marine park per year.

Tourism Research Australia provides information on domestic visitor activities (OS_014) by LGA. It does not specify where the activity takes place, but assumptions can be made to infer where the activity occurs. For example, the majority of beach activities, snorkelling and whale watching that occur in the Busselton LGA can all be assumed to occur in Geographe Bay. However, most of these activities will not be associated with Geographe Marine Park.

GPS data can be collected from phone applications when people provide consent to providers (MUL_039). This data could be used by to determine a lower bound to all activities in marine areas. The data does not contain an activity field so there is no way of determining the user's activity type. For example, the phone user could be on a cruise ship, could be a local diver or a ranger. The sample obtained from Predicio did not display many observations for the marine environment as compared to the terrestrial environment.

There is missing data for precise locations of recreational activities in Geographe Marine Park. Modelling approaches do not exist for the estimation of use patterns by small vessels associated with recreational activities.

4.5.5 National accounts

The Australian Maritime Safety Authority (AMSA) data can be used to produce national accounts on vessel use as it is a national dataset. Tourism Research Australia's survey could be used to populate accounts for ocean related tourism activities by LGA. This survey is does not show spatial use in the marine environment. However, it provides a measure of use associated with each LGA that could be apportioned to broad scale marine areas. GPS data could also be used in national scale accounts, but the utility of the dataset is not clear given the lack of observations in marine areas and difficulties attributing the data points to an activity.

5 Potential Accounts

The accounts that can be produced are provided in Table 36. The expected transformation effort is associated with the option that produces complete spatial coverage of Geographe Marine Park. It is not guaranteed that this option will be taken, nor that it is the best option. The transformation process will be described in detail in the methodologies report and the set of accounts will recommend that fit the needs of the Parks Australia MERI system.

Table 36 Potential accounts

Account	Expected transformation effort	Spatial coverage	Temporal coverage
Ecosystem extent accounts • Seagrass meadow • Rocky reef • Macroalgae • Sandy bottoms	Very high	Geographe Bay	A range of data sources and methods have been combined to produce habitat maps. This will be combined to produce a habitat map.
Seagrass meadow condition	High	Geographe Bay	2014
Rocky reef condition	High	Geographe Bay	2014 2017 and 2019 for four-point locations
Other condition accounts Temperature Primary productivity	Medium	Geographe Bay	Temperature - 2003, 2008 to 2013 Primary productivity - 2014
Carbon stock and flow accounts	Medium	Geographe Bay (seagrass meadows)	2015 – current
Whale stock	Low	Geographe Bay	Data ranges from 2012 – current
Carbon sequestration (quantity and value)	Medium	Geographe Bay (seagrass meadows)	2015 - current
Economic value of commercial fisheries, multiple species (quantity and value)	High	Geographe Bay	2015 to 2019
Economic value of recreational fisheries (quantity and value)	Medium	Geographe Bay	2017
Seagrass meadow nursery services (quantity and value)	Low	Geographe Bay (seagrass meadows)	2015 - current
Whale watching (quantity and value)	Low	Geographe Bay	2019
Tourism (expenditure and employment) associated with whale watching	Medium	Geographe Bay	2019
Vessel use	Low	Geographe Bay	2012 - 2019
Commercial fishing use	Medium	Geographe Bay	2015 - 2019

Appendix

Primary data collection for recreational fishing

Indices of recreational fishing usage could be constructed from satellite imagery over time, examining boat ramps at weekends and national holidays. Semi supervised classification could be applied to automatically quantify the number of boat trailers across the popular boat ramp car parks of Geographe Bay. In addition, on clear days with moderate swell it is very easy to identify boats at sea. These could also be automatically classified, enumerated, and analysed based on their location within the bay. While each satellite image will only represent a discrete temporal unit; building up a time series of these data could provide a very useful independent source of information about recreational boat use within Geographe Bay. Sentinel-2 multispectral imagery is freely available, and an RGB image could be generated with 10m resolution on the ground, enough to capture most moderate to large size boat and tow vehicle combinations as well as actual boats at sea. Previous experience has shown that even the wake of faster moving craft can be identified, and this would be an indication of speed and direction of travel at the time the satellite imagery was acquired.

List of data sets

Inventory Code	Name of dataset	Description
OE_001	Seagrass Meadow Mapping, Geographe Bay 2004 – 2007 (2009)	Seagrass meadow coverage (presence/absence) within the shallow waters of Geographe bay
OE_002	Seagrass Meadow Presence Absence (ACEAS), Australia (2013)	Presence and absence of seagrass meadows in 10km2 tiles around the Australian Coastline.
OE_003	Seagrass Meadow Mapping (CAMRIS), Australia (2015)	Seagrass meadow distribution around the Australian Coastline.
OE_004	Marine Habitat Mapping (Department of Parks and Wildlife), Western Australia (2006)	Marine habitats of selected areas in Western Australia.
OE_005	Coastal protection, Busselton (2011)	Coastal geomorphology, sediment transport, coastal protection, impacts of climate change and coastal management.
OE_006	Geomorphic Features, Australia (2006)	Geomorphic features of the Australia Exclusive Economic Zone
OE_007	Reef habitat mapping (Marine Futures Project), Western Australia (2008)	Fine scale reef habitats across 9 locations.
OE_008	Reef habitat mapping on the continental shelf, Australia (2019)	Rocky reef locations across the Australian Continental Shelf.
OE_009	Ecological Description of Vasse-Wonnerup Wetlands Ramsar Site (2007)	Geomorphology, soil, hydrogeology, hydrology, water quality, fauna, wetland process, wetland services and conceptual models of the Vasse Wonnerup Wetlands Ramsar Site.
OE_010	South-west Marine Parks Network Management Plan (2018)	Boundary of South West Marine parks
OE_011	Coastal Hazard Mapping (Peron Naturaliste Partnership) (2012)	Coastal hazard mapping for the Peron Naturaliste Coastal Region of Western Australia
OE_012	Coastal Erosion Maps and Coastal Hazard Mapping (Peron Naturaliste Partnership) (2012)	Coastal recessions for low, moderate, and high scenarios at 2030, 2040, 2050, 2070 and 2110.

Inventory Code	Name of dataset	Description
OE_013	Bathymetry and Topography, Australia (2009)	Bathymetry in the Australian EEZ in 250m grids
OE_014	Bathymetry and Morphology, Geographe Marine Park (2020)	5m resolution of Geographe Bay Marine Park bathymetry and morphology
OE_015	Navigable Water Regulation Areas, Australia (2019)	Navigable Water Regulation Areas including Closed Waters, Speed Restriction Areas, Water Ski Areas, Jet Ski Areas, Swimming Prohibited Areas
OE_016	Reef habitat mapping (Marine Futures), Australia (2008)	Fine scale biota extent across 9 locations.
OE_017	Coastal Waterway Geomorphic Habitat, Australia (2005)	Australian coastal waterways.
OE_018	Australian Marine Park Extent (2019)	Extent of Australian Marine parks.
OE_019	Ngari Capes Marine Park Extent (2013)	Extent of Ngari Cape Marine Park
OE_020	Species of National Environmental Significance Database, Australia (2019)	Species distributions
OE_021	Biologically Important Areas of Regionally Significant Marine Species (2016)	Species coverage (for example, presence/absence).
OE_022	Key Marine Ecological Features, Australia (2015)	Marine Key Ecological Features
OE_023	Desalination Plant Seagrass Meadow Health Monitoring Report, Geographe Bay (2019)	Seagrass meadow shoot density (shoots/m2), percent cover (%), leaf length (cm) and water quality (salinity PSU and dissolved oxygen mg/L).
OE_024	Ngari Capes Marine Park management plan (2013)	Extent of marine park.
OE_025	Seafloor Habitat Classification Scheme (Seamap Australia), Australia (2017)	Broad-scale regional marine habitats of Australia
OE_026	Seagrass Meadow Communities and Water Quality, Geographe Bay (2007)	Benthic habitat types and seagrass meadows species.
OE_027	Ngari Capes Management Zones (2018)	Management zones in Ngari Capes Marine Park
OE_028	Seas and Submerged Lands Act	Jurisdictional boundaries
OE_029	DPIRD Fishing Blocks	Fishing blocks used to collect and report data in WA
DU_001	Aquaculture Sites, Western Australia (2019)	Extent of all marine locations of aquaculture licenses including application sites in state waters.
DU_002	Fisheries Management Plan Boundaries, Western Australia (2019)	Consolidated Management Plans (CMP) boundaries for WA fisheries
DU_003	Coastal Infrastructure Mapping Part 1, Western Australia (2017)	Department of Transport assets with details on structure type and last updates.
DU_004	Coastal Infrastructure Mapping Part 2, Western Australia (2017)	Department of Transport assets with details on structure type and last updates
DU_005	Management Zones Ngari Capes (2019)	Extents of management zones within the Ngari Capes Marine Park
OC_001	Condition of shallow Seagrass Meadows habitat, Geographe Bay (1997)	Measures of condition such as water quality results, biomass values and presence absence
OC_002	Seagrass Meadow Condition Monitoring (Keep Watch), Geographe Bay (2019)	Measures of condition such as water quality results, density values and nutrient content values
OC_003	Seagrass Meadow Condition Monitoring (Keep Watch), Geographe Bay (2018)	Measures of condition such as water quality results, density values and nutrient content values

Inventory Code	Name of dataset	Description
OC_004	Fish herbivory patterns in Seagrass Meadows, Geographe Bay (2011)	Herbivory rates of seagrass meadows species, fish assemblages and nitrogen content (total nitrogen) of seagrass meadows leaves.
OC_005	Sand and Seagrass Meadow Wrack Modelling Study, Port Geographe (2011)	Model-predicted bed levels in the vicinity of Port Geographe, sand accretion, seagrass meadows wrack transport
OC_006	Reef Marine Biodiversity (Reef Life Survey), Geographe Bay (2020)	Average abundance of fish, invertebrate, cryptic fish species and average benthic coverage
OC_007	Reef Biodiversity (Reef Life Survey), South West Marine Region (2017)	List of benthic functional groups, numbers and biomass of fish species, abundance of invertebrate species.
OC_008	Rocky Reef Invertebrate Data (Reef Life Survey) (2020)	Global counts of invertebrate species at sampled sites
OC_009	Rocky Reef Fish Species Data (Reef Life Survey) (2020)	Global counts of fish species at sampled sites.
OC_010	Species Data Busselton Jetty (2019)	Counts of marine species at the Busselton Jetty Observatory
OC_011	Temperature Data Busselton Jetty (2019)	Daily temperature data
OC_012	Sightings of range shifting Marine Species (Redmap) (2020)	Records of marine species sightings.
OC_013	Shelf temperature and salinity data (MARVL3), Australia (2015)	Temperature (°C) and salinity (PSU) records
OC_014	Marine Sediment data (MARS), Australia (2006)	Carbonate content, grain size, substrate type, water depth, sample description.
OC_015	Species Richness, Australia (2018)	number of different species
OC_016	Derived Primary Productivity Hotspots (MODIS), Australia (2018)	Primary production/chlorophyll with values (between 0 and 1.0) representing the likelihood of the location being a primary productivity hotspot
OC_017	Water quality at wastewater outlets, Australia (2019)	Water quality data by year for each wastewater outlet around Australia
OC_018	Ocean acidification, Australia (1870-2013)	Reconstructed time series of monthly mean aragonite, calcite, and pH together with distribution of dissolved inorganic carbon, total alkalinity, sea surface temperature and salinity
OC_019	Chlorophyll-a, Australia (2019)	Chlorophyll-a concentrations
OC_020	Sea Surface Temperature, Australia (2019)	Sea Surface temperature
OA_001	Passive acoustic monitoring of baleen whales, Geographe Bay	Frequencies of song vocalisations.
OA_002	Non-song vocalizations of pygmy blue whales, Geographe Bay	Non-song vocalizations of migrating pygmy blue whales
OA_003	Economic Contribution of the western rock lobster Industry, Western Australia (2017)	Gross value add and employment numbers relating to the western rock lobster industry by region
OA_004	Geographe Bay as a resting and migratory area for baleen whales (2014)	Number and locations of whales detected each year/season
OA_005	Geographe Bay as a southern right whale aggregation area (2019)	Whale sightings over an eight-year period

Inventory Code	Name of dataset	Description
OA_006	Pygmy blue whale responses to vessel traffic during migration in Geographe Bay (2013)	Pygmy blue whale sightings
OA_007	Marine Benthic Substrate Database (CAMRIS), Australia (2015)	Extent of broad-scale benthic substrate classes in Australian waters.
OA_008	Mining tenements, Western Australia (2020)	Mining tenements
OA_009	Petroleum Releases/Applications/Titles, Western Australia (2020)	Petroleum related information
OA_010	Global biodiversity information on fish (FishBase) (2020)	Comprehensive species data, including information on taxonomy, geographical distribution, biometrics and morphology, and behaviour and habitats
OA_011	Global biodiversity information on algae (AlgaeBase) (2020)	Information on algae that includes terrestrial, marine, and freshwater organisms.
OA_012	2D Seismic Surveys, Western Australia (2020)	Seismic data for petroleum exploration
OA_013	3D Seismic Surveys, Western Australia (2020)	Historical 3D seismic surveys up to 2020
OA_014	Fish Species, Geographe Marine Park (2014)	information on habitat type and the species composition, relative abundance, and length of demersal fishes.
OS_001	Commercial Catch and Value Data (10NM Blocks), Geographe Marine Park	Catch (kg), price ($/kg) and value ($) by 10 by 10 NM fishing block, by species
OS_002	Commercial Catch and Value Data (60NM Blocks), Geographe Marine Park	Catch (kg), price ($/kg) and value ($) by 10 by 10 NM fishing block, by species.
OS_003	Collector fisheries activity (10NM Blocks), Geographe Marine Park	Species caught by collection harvest fisheries
OS_004	Tour operator fisheries (10NM Blocks), Geographe Marine Park	Species caught by tour operator fisheries
OS_005	Business financial information Australia (BLADE)	Business tax data and information
OS_006	Boat survey of recreational fishing, Western Australia (2015)	Effort and catch by recreational fisheries
OS_007	Commercial fish enhancement by Seagrass Meadows habitat, Southern Australia (2014)	Mean enhancement, total annual enhancement, price, and economic enhancement for multiple species.
OS_008	Fisheries enhancement from coastal vegetated ecosystems, Australia (2020)	Mean enhancement and economic enhancement for 23 commercially relevant species.
OS_009	Visitor Survey Results Busselton Jetty (2019)	International visitors, domestic visitors, customer information and customer feedback.
OS_010	Visitor Survey Annual Report Busselton Jetty (2019)	International visitors, domestic visitors, customer information and customer feedback.
OS_011	Customer Survey Results Busselton Jetty (2018)	International visitors, domestic visitors, visitor demographics, bookings and accommodation, reasons for visit, first visitors, online booking customer information and customer feedback
OS_012	Visitation Data Busselton Jetty (2020)	Counts of visitors using services of the Busselton Jetty.
OS_013	Shipping data (Australian Maritime Safety Authority), Australia (2020)	Speed (knots), direction (degrees), type of vessel (class),

Inventory Code	Name of dataset	Description
OS_014	Tourism visitation and expenditure by activity, Busselton (2020)	4-year averages for numbers and expenditure for visits to national parks, fishing, water activities/sports, guides/tours, surfing, and beach visits for the Busselton Region
Mul_001	Habitat Mapping and Biological Data, Geographe Bay to Flinders Bay (2000)	Benthic habitats from the western side of Geographe Bay down to Flinders Bay
Mul_002	Marine Habitat mapping, Geographe Bay to Capes-Hardy Inlet Marine Conservation Reserve (2000)	Benthic habitats from the western side of Geographe Bay down to Flinders Bay.
Mul_003	Seagrass Meadow communities and water quality, Geographe Bay (2007)	Seagrass meadow communities and water quality
Mul_004	Seagrass Meadow wrack dynamics, Geographe Bay (2010)	Seagrass meadow values (cover, shoot density, leaf characteristics), wrack generation and coastal dynamics
Mul_005	Physical Oceanography, Geographe Bay (1994)	Bathymetry, wind, temperature and rainfall statistics, water level and water circulation, coastal geomorphology, historical hydrodynamic studies, numerical models.
Mul_006	Recreational Crab fishing, Geographe Bay (2017)	Blue swimmer crab catch rates stock and growth
Mul_007	Stock of Australian herring, South-West Australia (2004)	Stock of Australian herring in Southern Australia
Mul_008	Marine Resources, Bunbury Marine Area and Geographe Bay (1979)	Information on species by spatial block, including catch rates and commercial value
Mul_009	Blue swimmer crab fishery, Geographe Bay (2006)	Fishery landings and catch rates for blue crab caught in commercial and recreational fisheries
Mul_010	Non-estuarine Nursery Habitats for Commercial and Recreational Fish Species, South-West Australia (1982)	Relative abundance indices for juvenile fish
Mul_011	Dynamics of squid populations, Western Australia (2016)	Catch numbers of squid
Mul_012	Fish biodiversity in artificial reefs, Geographe Bay (2016)	Presence/absence of fish species at reefs
Mul_013	Octopus stock Assessment, Western Australian (2018)	Commercial catch numbers by zone and by fishing method.
Mul_014	The impact of the Leeuwin Current on Coastal fisheries, Western Australia (1991)	Bycatch records from Salmon fishery in 1990 and 1991
Mul_015	Fisheries and aquatic resources, Western Australia (2012)	Fisheries statistics pertinent to the assessment of fish stocks in Western Australia
Mul_016	Spatial predictions of the distribution of demersal fishes, Geographe Bay (2017)	Fish occurrence (presence/absence)
Mul_017	Environmental drivers of temperate fish communities, South-West Australia (2017)	Fish assemblages
Mul_018	Habitat characteristics of adult and juvenile targeted fishes, Geographe Bay (2018)	Distributions of various fish species
Mul_019	Critical habitats for juvenile dhufish, Geographe Bay (2012)	Statistics including fishing effort and catch rates and other parameters for Dhufish in the region

Inventory Code	Name of dataset	Description
Mul_020	Non-estuarine Nursery Habitats for commercial and recreational fish species, South-west Australia (1982)	Distribution and relative abundance of the 0 + year classes of 16 commercially and recreationally important fish species
Mul_021	Black Bream abundance after a fish kill, Vasse-Wonnerup Wetlands (2016)	Black bream abundance and catch rates
Mul_022	Black Bream abundance after a fish kill, Vasse-Wonnerup Wetlands (2018)	Black bream abundance and catch rates
Mul_023	Geology as a significant indicator of algal cover and invertebrate species on intertidal reefs, Ngari Capes Marine Park (2018)	Geology as a significant indicator of algal cover and invertebrate species on intertidal reefs
Mul_024	Socio-economic analysis and description of marine industries, South-West Australia (2006)	Statistics and maps regarding various assets from the South-west Marine Region
Mul_025	western rock lobster Ecology, Western Australia (2012)	Rock lobster and benthic habitat distribution, bycatch species and abundance, descriptions of benthic habitats and maps and maps of berried females
Mul_026	Western rock lobster in ecosystem processes, South-West Australia (2007)	Catch data, predator and prey species, summaries of the role of western rock lobsters in ecosystem processes within the South-west Marine Region.
Mul_027	western rock lobster Resources, Western Australia (2017)	Rock lobster and benthic habitat distribution, bycatch species and abundance, descriptions of benthic habitats and maps and maps of berried females
Mul_028	Habitat survey methodology, Geographe Marine Park (2016)	Presence absence of reef and seagrass meadows
Mul_029	An eco-narrative of Geographe Marine Park (2018)	Bathymetry, oceanography, morphology, summaries of fauna, fisheries, and benthic fauna.
Mul_030	Marine Ecosystems and Key Species, South-West Australia (2006)	Physical oceanography, biodiversity, food webs, pelagic and benthic production, seasonal cycles, and ecological links to ocean circulation processes
Mul_031	Marine Ecosystems and Key Species, South-West Australia cont. (2006)	Descriptions of 25 key species groups present in the South-west Marine Region
Mul_032	Bioregional Profile, South-West Australia (2008)	Summaries on the marine environment, conservation values and human activities of the South-west Marine Region
Mul_033	Exposure Information Platform, Australia (AEIP)	Multiple records of land-based resources
Mul_034	Seagrass Meadow extent, Leschenault (2009)	Abundance of biota, percentage cover of seagrass meadows and benthic habitat.
Mul_035	Seagrass Meadow Communities and Water Quality, Geographe Bay (2006)	Point data, benthic classifications, seagrass meadows percent cover and fish species data.
Mul_036	Benthic Habitat data, Geographe Marine Park (2014)	Point data, benthic classifications, percent coverage and benthic habitat descriptions
Mul_037	Shoot Density Data (KeepWatch), Geographe Bay (2012-2020)	Shoot counts by location
Mul_038	Coastal ecosystems carbon data, Australia	C stocks and sequestration rates in Australian tidal marshes, Mangrove forests and seagrass meadows
Mul_039	Phone User GPS data (Predicio), Australia (2020)	Location by device id, operating system, and manufacturer
Mul_040	Tourist Accommodation, Australia (2020)	Tourism data, such as establishments, rooms, bed spaces, room nights occupied, room nights available

Inventory Code	Name of dataset	Description
Mul_041	Recreational use and management survey, Geographe Bay and Ngari Capes (2020)	Number of recreational trips and percentage of total trips
Mul_042	Multi spectral satellite imagery	Satellite Imagery

6 References

All Sea Charters. (2019). *Busselton whale watching tour*. https://www.whalewatchingcharters.com.au/busselton-whale-watching-tour/

Global Fishing Watch. (2016). *Global Fising Watch map*. https://globalfishingwatch.org/our-map/

Global Ocean Accounts Partnership. (2019a). *Global Ocean Data Inventory* (Version 1.). United Nations Economic and Social Commission for Asia and the Pacific.

Global Ocean Accounts Partnership. (2019b). *Technical Guidance on Ocean Accounting for Sustainable Development* (1st editio, Issue September). United Nations. https://www.oceanaccounts.org/technical-guidance-on-ocean-accounting-2/

Hobday, A. J., & Lough, J. M. (2011). Projected climate change in Australian marine and freshwater environments. *Marine and Freshwater Research*. https://doi.org/10.1071/MF10302

Serrano, O., Lovelock, C. E., B. Atwood, T., Macreadie, P. I., Canto, R., Phinn, S., Arias-Ortiz, A., Bai, L., Baldock, J., Bedulli, C., Carnell, P., Connolly, R. M., Donaldson, P., Esteban, A., Ewers Lewis, C. J., Eyre, B. D., Hayes, M. A., Horwitz, P., Hutley, L. B., … Duarte, C. M. (2019). Australian vegetated coastal ecosystems as global hotspots for climate change mitigation. *Nature Communications*, *10*(1), 1–10. https://doi.org/10.1038/s41467-019-12176-8

United Nations, European Commission, Food and Agriculture Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-Operation and Development, & Bank, W. (2018). *System of Environmental-Economic Accounting for Agriculture, Forestry and Fisheries* (White Cove). http://www.fao.org/fileadmin/templates/ess/ess_test_folder/Publications/Agrienvironmental/SEEA_AFF_White_Cover.pdf

United Nations, European Commission, Food and Agriculture Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-Operation and Development, & World Bank. (2014a). *System of Environmental-Economic Accounting 2012 Central Framework*. United Nations. https://seea.un.org/sites/seea.un.org/files/seea_cf_final_en.pdf

United Nations, European Commission, Food and Agriculture Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-Operation and Development, & World Bank. (2014b). *System of Environmental-Economic Accounting 2012 Experimental Ecosystem Accounting*. United Nations. https://unstats.un.org/unsd/envaccounting/seeaRev/eea_final_en.pdf